

MAPTHEMATICS
GEOCART® 3

User's Manual



Credits

Application design & programming Daniel “daan” Strebe & Paul J. Messmer.

Manual design & authorship Daniel “daan” Strebe, with Paul J. Messmer (Chapter 1, Appendices G&H.)

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Dedicated to the memory of
John Parr Snyder
extraordinary researcher of and historian of map projections.
He encouraged me. — daan

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- Adobe InDesign™ CS4
- Geocart™
- Adobe Photoshop™
- Adobe Illustrator™

This manual is typeset primarily in **Adobe Garamond Pro** with headings in **Myriad Pro**.

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Chapter 1: Setup

Geocart 3 runs on most modern Macintosh and Windows computers. The Geocart **Installation Disk** contains installers for both platforms. You may run Geocart on your platform of choice; your license key works for either. **You must install from an account with administrator privileges.**

[Macintosh Information](#)

[Windows Information](#)

[Licensing Geocart](#)

[Technical Support](#)

Macintosh Information

Necessary Equipment

Geocart is designed to run on PowerPC G4, PowerPC G5, or Intel Macintosh computers, with a minimum of 512 MB of RAM. 1 GB of memory is recommended for efficient performance, and large maps may require more.

Geocart has not been tested on PowerPC G3 Macintosh.

Geocart is compatible with the following Macintosh operating systems:

- Mac OS X 10.4 (Tiger)
- Mac OS X 10.5 (Leopard)
- Mac OS X 10.6 (Snow Leopard).

Geocart should also run, but is not officially supported, on Mac OS X Server 10.4 and later server versions.

Installing Geocart on Macintosh

To run Geocart 3 on your computer, you need to:

1. Identify your operating system version.
2. Install the Geocart 3 application.
3. Install the Required Databases.

Your **Installation Disk** also includes a number of supplemental databases that you can install at your discretion.

If you have a previous version of Geocart 3 on your computer, it will be updated by the installation process. If you are running Geocart 2, the installation process will not affect your old version of Geocart.

The Geocart 3 application for Macintosh comes in two versions: one intended for OS X 10.4 (Tiger), and another for OS X 10.5 (Leopard) and later. The 10.4 version of Geocart should work on newer versions of OS X; the 10.5 version is preferable (particularly for PowerPC G5 and Intel Macs), as it is faster and can use more than 3 GB of RAM.

Identifying your operating system version

- On the **Apple** menu, click *About This Mac*.
Result: The version number will be shown under the Apple logo and Mac OS X text.

Installing the new Geocart 3 application on Macintosh

1. Insert the Geocart **Installation Disk** into your Computer. If a window showing the contents of the DVD does not appear, double-click the Geocart DVD icon on your desktop. For Geocart to work correctly, you must install both the application and the required databases.
2. View the contents of the **Installation Disk**.
3. Double-click the `Application Installers` folder.
4. Double-click `Mac OS X 10.4` or `Mac OS X 10.5` as appropriate for your computer.
5. Follow the prompts to install the application on your system.

Installing the Required Databases on Macintosh

1. Open the Geocart **Installation Disk**.
2. Double-click the `Required Databases` folder.
3. Double-click the `Macintosh` folder.
4. Double-click the file `Geocart 3 Databases.pkg`.
5. Follow the prompts to install the databases onto your system.

Once the application and databases installation is complete, you can start Geocart.

If this is the first time you have installed Geocart, the icon will be in the `Applications` folder of your system disk. On start up, you will be prompted to enter your license key (refer to [Licensing Geocart](#) for more information).

If you had a previous version of Geocart 3 on your computer, it will have been updated in-place by the installation process. If you are unable to see the Geocart icon, click the spotlight icon in the upper right corner of the menu bar to search for the Geocart application.

Installing the Sample Documents on Macintosh

Geocart 3 comes with sample documents and images for use in following the examples in [Chapter 5: Examples](#) as well as for general use. The installer for this material is contained in the `Sample Documents` directory on the Installation Disk.

To install the sample documents:

1. Insert the Installation Disk.
2. Double-click the `Sample Documents` folder.
3. Double-click the `Macintosh` folder.
4. Double-click the file `Geocart 3 Sample Documents.pkg`.
5. Follow the prompts to install the sample documents onto your system.

Once the installation is complete, you will be able to access the sample documents from the [Help menu, Sample Documents](#) command.

Installing Supplemental Databases on Macintosh

Geocart 3 comes with many optional geographic databases. They consume many gigabytes of disk space and are therefore not installed by default. The databases are contained in the `Supplemental Databases` directory on the **Installation Disk**. The professional edition of Geocart includes an **Extra Databases** disk with more databases. You can install any of the supplemental databases during the initial installation, or at any later time.

To install supplemental databases:

1. Insert either the **Installation Disk** or the **Extra Databases** disk.
2. Double-click the `Supplemental Databases` folder.
Result: Folders for each installable data set are displayed (for example, `World Databank II`).
3. Double-click on a data set folder to display its contents. Each data set contains a `Read Me.txt` file that describes the databases contained in the data set (for example, `World Databank II.txt`), and a Mac Installer file (for example, `Double click me.command`).
4. Double-click the `.command` file.
5. In the text-based installer window, select whether you want the databases to be accessible only to you, or to everyone who uses your computer.

Note: The database files are compressed, and some data sets are over one gigabyte in size. The installation may take several minutes to complete.

Uninstalling Geocart on Macintosh

In addition to throwing away the Geocart application that was installed into your `Applications` folder, you may want to find and remove the additional support files (such as the sample documents), that were installed.

To delete additional files available to all users:

1. On the top level of your system disk, double-click `Library`.
2. Double-click `Application Support` to open it.

If you want to expunge Geocart from the computer:

3. Delete the `Mapmathematics` folder.

Or, if you want to delete specific database files:

3. Double-click `Mapmathematics` to open it.
4. Double-click `Databases` to open it.
5. Delete the files you no longer need.

To delete additional files available only to you:

1. On the top level of your system disk, double-click the `Users` folder.
2. Double-click your account folder to open your application data folders.
3. Double-click `Library` to open it.
4. Double-click `Application Support` to open it.
5. Double-click `Mapmathematics` to open it.
6. Double-click `Databases` to open it.
7. Delete the files you no longer need.

Windows Information

Necessary Equipment

Geocart is designed to run on a Pentium II, AMD K6, or AMD Athlon CPU or newer.

The minimum RAM requirement is 512 MB. However, at least 1 GB of memory is recommended for efficient performance, and large maps may require greater than 1 GB.

Geocart is compatible with the following Windows operating systems:

- Windows XP
- Windows Vista
- Windows 7

Geocart should also run, but is not officially supported, on Windows Server 2003 and later server versions.

Installing Geocart 3 on Windows

If you have a previous version of Geocart 3 on your computer, you must uninstall the old version and its required databases before installing the new version. To uninstall old versions, refer to [Uninstalling the Geocart Application and Required Databases](#) in the **Uninstalling Geocart** section below before installing your new version.

Geocart 3 for Windows comes in both 32-bit and 64-bit versions. The 32-bit version works on any version of Windows but cannot make use of more than 2 GB of RAM. The 64-bit version is preferable as it is faster and can use all available memory (to draw larger maps). However, it requires you to have a 64-bit version of Windows.

Identifying your Windows version

For Windows XP:

1. Click **Start**.
2. Right-click on *My Computer*.
3. Click *Properties*.

Result: The **System Properties** dialog will be displayed. If you are running a 64-bit version of Windows, you will see *Professional x64 Edition* in the *System* section near the top.

For Windows 7 and Windows Vista

1. Click **Start**.
2. Right-click on *Computer*.
3. Click *Properties*.

Result: The **View basic information about your computer** dialog will appear. If you are running a 64-bit version of Windows, you will see either *System type: 64-bit Operating System* or *System type: 32-bit Operating System* in the *System* section in the middle of the dialog box.

Note: If you are still unsure about which version of Geocart to choose, try installing the 64-bit version. If your computer does not have a compatible operating system, the installer will display an error message: “*This installation package is not supported by this processor type. Contact your product vendor.*” If you see this error message, it means that you can only install the 32-bit version of Geocart on your computer.

Installing the new Geocart 3 application on Windows

1. Insert the **Installation Disk** into your computer. For Geocart to work correctly, you must install both the application and the required databases.
Note: If a window showing the DVD content does not appear, use the Windows Explorer to show it.
2. For Windows XP, click **Start > My Computer**.
– OR –
For Windows 7 or Vista, click **Start > Computer**.
3. From the top level of the **Installation Disk**, double-click on the `Application Installers` directory.
4. Double-click either the `Windows 32-bit` or `Windows 64-bit` directory as appropriate for your computer.
Result: You will see two files: `Geocart.msi` and `setup.exe`
5. Double-click `setup.exe` and wait for the installer to start.
6. Follow the prompts to install the application on your system.

Windows Vista Users: You will receive a **User Account Control** dialog that says *“An unidentified program wants access to your computer.”* This is expected behavior as the installer is not digitally signed. Click *Allow*.

Windows 7 Users: You will receive a **User Account Control** dialog warning that says *“Do you want to allow the following program from an unknown publisher to make changes to this computer?”* This is expected behavior as the installer is not digitally signed. Click *Yes* to install the program.

Installing the Required Databases on Windows

1. From the top level of the **Installation Disk**, double-click on the `Required Databases` directory.
2. Double-click the `Windows` directory.
Result: You will see two files: `Geocart Databases.msi` and `setup.exe`.
3. Double-click `setup.exe` and wait for the installer to start.
4. Follow the prompts to install the required databases on your system.

Windows Vista Users: You will receive a **User Account Control** dialog that says *“An unidentified program wants access to your computer.”* This is expected behavior as the installer is not digitally signed. Click *Allow* to install the program.

Windows 7 Users: You will receive a **User Account Control** dialog warning that says *“Do you want to allow the following program from an unknown publisher to make changes to this computer?”* This is expected behavior as the installer is not digitally signed. Click *Yes* to install the program.

Once the application and required databases installation is complete, you can start Geocart:

- Click the shortcut icon  on your desktop.
– OR –
- Click **Start > All Programs > Geocart**.

Installing the Sample Documents on Windows

Geocart 3 comes with sample documents and images for use in following the examples in [Chapter 5: Examples](#) as well as for general use. The installer for this material is contained in the `Sample Documents` directory on the Installation Disk.

To install the sample documents:

1. Insert the Installation Disk.
2. Double-click the `Sample Documents` folder.
3. Double-click the `Windows` folder.
Result: You will see two files: `Geocart Sample Documents.msi` and `setup.exe`.
4. Double-click `setup.exe` and wait for the installer to start.
5. Follow the prompts to install the sample documents onto your system.

Windows Vista Users: You will receive a **User Account Control** alert that says “*An unidentified program wants access to your computer.*” This is expected behavior as the installer is not digitally signed. Click *Allow* to install the sample documents.

Windows 7 Users: You will receive a **User Account Control** alert that says “*Do you want to allow the following program from an unknown publisher to make changes to this computer?*” This is expected behavior as the installer is not digitally signed. Click *Yes* to install the sample documents.

Once the installation is complete, you will be able to access the sample documents from the [Help menu, Sample Documents](#) command.

Installing Supplemental Databases on Windows

Geocart 3 comes with many optional geographic databases. They consume many gigabytes of disk space and are therefore not installed by default. The databases are contained in the `Supplemental Databases` directory on the **Installation Disk**. The professional edition of Geocart includes an **Extra Databases** disk with additional databases. You can install any of the supplemental databases during the initial installation, or at any later time.

To install supplemental databases:

1. Insert either the **Installation Disk** or the **Extra Databases** disk.
2. Double-click the `Supplemental Databases` directory.
Result: The directories for each data set that can be installed are displayed (for example, `World Databank II`).
3. Double-click on a data set directory to display its contents. Each data set contains a `readme` file that describes the databases contained in the data set (for example, `World Databank II.txt`), and a `Win Installer` file (for example, `Double click me.cmd`).
4. Double-click the `.cmd` file.
5. In the text-based installer window, select whether you want the databases to be accessible only to you, or to everyone who uses your computer.

Note: The database files are compressed, and some data sets are over 1 GB in size. The installation may take several minutes to complete.

Uninstalling Geocart on Windows

Uninstalling the Geocart application, Required Databases, and Sample Documents

To remove Geocart from a computer using the **Windows XP** operating system:

1. On the **Start** menu, click **Control Panel**.
2. Double-click *Add or Remove Programs*.
3. For 32-bit Windows: Select **Geocart** and click *Remove*.

– OR –

For 64-bit Windows: Select ***Geocart for 64-bit Windows*** and click *Remove*.

4. Select ***Geocart Databases*** and click *Remove*.
5. Select ***Geocart Sample Documents*** (if present) and click *Remove*.

To remove Geocart from a computer using **Windows Vista or Windows 7** operating systems:

1. On the **Start** menu, click ***Control Panel***.
2. Double-click **Programs**.
3. Click *Uninstall a program*.
4. For 32-bit Windows: Select ***Geocart*** and click *Uninstall*.

– OR –

For 64-bit Windows: Select ***Geocart for 64-bit Windows*** and click *Uninstall*.

5. Select ***Geocart Databases*** and click *Uninstall*.
6. Select ***Geocart Sample Documents*** (if present) and click *Uninstall*.

Windows Vista Users: You will receive a **User Account Control** alert that says “*An unidentified program wants access to your computer.*” This is expected behavior as the installer is not digitally signed. Click *Allow* to uninstall the program.

Windows 7 Users: You will receive a **User Account Control** alert that says “*Do you want to allow the following program from an unknown publisher to make changes to this computer?*” This is expected behavior as the installer is not digitally signed. Click *Yes* to uninstall the program.

Uninstalling Supplemental Databases

The Geocart uninstallers will not remove any additional databases that you may have installed manually or by using the **Supplemental Database** installers. These databases take up a large amount of disk space, so there may be times when you wish to remove them to free up space.

To remove the Geocart supplemental databases from a computer using the Windows XP operating system:

1. On the **Start** menu, click ***My Computer***.
2. Double-click the *Address* field at the top (it will default to *My Computer*).
3. In the *Address* field, enter `C:\Documents and Settings\All Users\Application Data\Mapmathematics\Databases` to see databases that are accessible to all users.
4. Press **ENTER** to display the directory.
5. Delete or move the database files.
6. In the *Address* field, enter `C:\Documents and Settings\YourAccountName\Local Settings\Application Data\Mapmathematics\Databases` to see databases that are only accessible to you.
7. Press **ENTER** to display the directory.
8. Delete or move the database files.

To remove the Geocart supplemental databases from a computer using Windows Vista or 7 operating systems:

1. On the **Start** menu, click ***Computer***.
2. Double-click the *Location* field at the upper left (it will default to *> Computer >*).

3. In the *Location* field, enter `C:\ProgramData\Mapthematics\Databases` to see databases that are accessible to all users.
4. Press **ENTER** to display the directory.
5. Delete or move the database files.
6. In the *Location* field, enter `C:\Users\YourAccountName\AppData\Local\Mapthematics\Databases` to see databases that are only accessible to you.
7. Press **ENTER** to display the directory.
8. Delete or move the database files.

Licensing Geocart

When you start the Geocart application for the first time, you will be prompted to enter your name and license key. You can find your license key printed on a sticker on the back of the case for the Geocart **Installation Disk**. Until you enter your name and key, Geocart will run in a 30-day demonstration mode, making some functionality unavailable.

Geocart does not have any heavy-handed product activation technology that may impede your legal use of the software, but it does require you to enter your license key to use the software on a particular computer—so don't lose this number! The software will not display your license key to you after you have entered it, and you will need it again to install and use the software on other computers. Keep it in a safe place.

To enter your license key after installation:

1. Start Geocart.
2. In the **License** dialog, enter your name and license key exactly as it appears, including all dashes.

Contained within your license key is your encrypted serial number. After you have entered your name and license key, you will see your name and decrypted serial number in the bottom right of the startup screen.

You can also see your name and decrypted serial number by accessing the:

- **Apple** menu > *Geocart* (Macintosh)
– OR –
- **Help** menu > *About Geocart* (Windows)

Please keep your license key secret, and abide by the licensing terms spelled out in **Help** menu's *Licensing Terms*. If your license key leaks out, or we discover that you are abusing your licensing terms, your licensing key may be revoked—which means that it will not function with future updates of the software. A product as specialized as Geocart, without an onerous activation scheme, will not succeed unless you do your part.

Technical Support

For technical support, or help with how to use Geocart:

- Refer to our online support page for FAQs and Forums at <http://www.mapthematics.com/Support.php>.
- Send e-mail to Mapthematics at support@mapthematics.com.

Note: If you contact Mapthematics LLC for Geocart support, you will need to provide the serial number that appears in the startup screen.

Chapter 2: Introducing Geocart

This chapter introduces you to Geocart's capabilities. First we show how to make a map, step by step. Following the sample map construction, you can find tables listing each of the menus and their commands. Each command is described briefly. For details about a command, please see its entry in the chapter for the menu it is found on.

An Example Map

You may not understand much of what you see or do when making the example map. Don't worry; each operation is explained in another section. We recommend that you just relax for now and watch the effects of each step. To launch Geocart:

Macintosh

1. In the Finder, select *Applications* from the **Go** menu at the top of the screen.
2. A new Finder window will appear, displaying all the application programs that have been installed on your computer by normal means, and arranged according to your chosen view and arrangement. Geocart should appear in that list of applications.
3. Double-click the Geocart icon.

Result: Geocart will launch, displaying the startup screen and menu bar. You may click on the startup screen at any time to dismiss it. It will disappear after several seconds in any case.

Windows

1. From the Windows **Start** menu, select *All Programs*.
2. Select Geocart from the (possibly very long) list of programs.

Result: Geocart will launch, displaying the startup screen and application window. You may click on the startup screen at any time to dismiss it. It will disappear after several seconds in any case.



Geocart startup screen

Note: If you cannot find the Geocart icon or program, ensure that it is installed on your computer. Refer to [Chapter 1: Setup](#).

Using the menus

At the top of the screen you can see Geocart's menu bar.



Macintosh menu bar



Windows menu bar

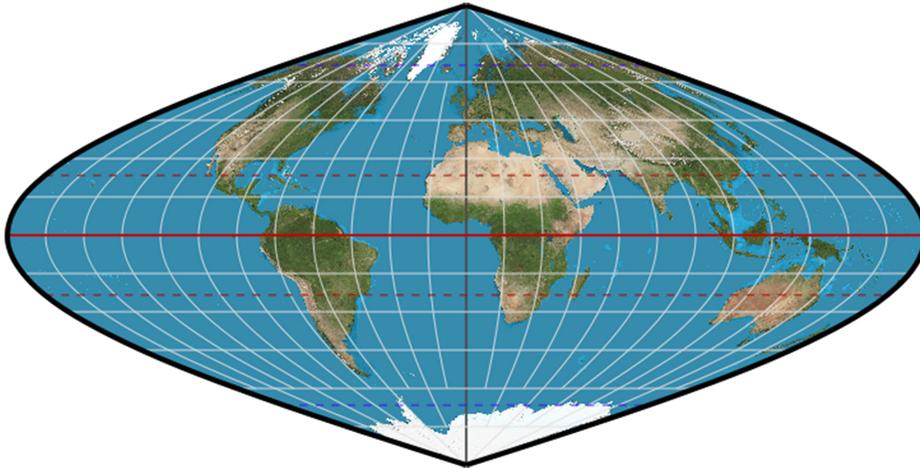
Your menu bar may differ slightly depending upon the configuration of your system software.

Creating a map:

1. From the **File** menu, select *New* to create a document.
2. From the **Map** menu, select *New*.

Result: Geocart will draw a default world map using the sinusoidal projection.

Note: You do not need to create a new document if you already have a document open. You may create any number of maps in one document.



Default map projection: sinusoidal

Moving a map in the document

1. Click anywhere on the map to select it.
2. Click and drag the map around in your document.

Editing the map

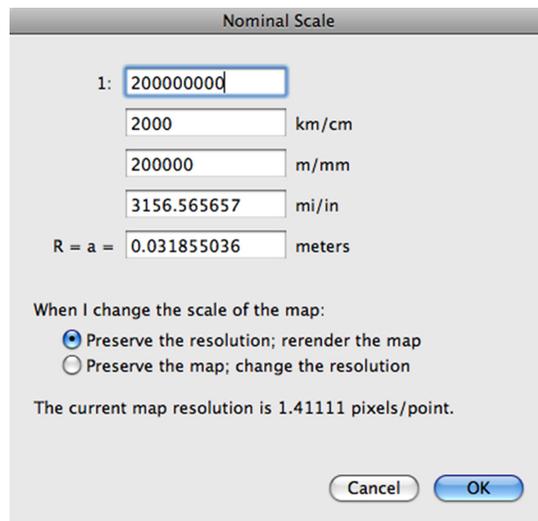
1. From the  **Pseudocylindric** menu select *loximuthal*. Geocart will redraw the map in the new projection.
2. From the **Projection** menu, select *Parameters*.
3. In the **Projection Parameters** dialog, enter 0 as the *Latitude of origin*.

4. Click *OK*. Geocart will redraw the map; allow it to finish before moving on to the next step so that you can see the effect of your actions. The map should become symmetric about the equator, whereas previously it was bottom-heavy.
5. From the **Projection** menu, point to *Interruptions* and select *Segmented*.
6. Allow Geocart to finish redrawing the map.
7. From the **Map** menu, select *Graticule* to open the **Graticule** dialog.

Graticule dialog

8. Enter 20 for *Parallel spacing*.
9. Enter 20 for *Longitude spacing*.
10. In the *Pruning Options* section, enter 20 for *North pole, primary*.
11. In the *Pruning Options* section, deselect *North pole, secondary*.
12. In the *Pruning Options* section, enter 20 for *South pole, primary*.
13. In the *Pruning Options* section, deselect *South pole, secondary*.
14. Click *OK*.
15. From the **Map** menu, select *Line Styles* to bring up the **Line Styles** dialog.
16. In the left pane, click on *Equator* within the *Parallel* section of the *Graticule* section.
17. In the *Definitions for this coverage* section, click on the pop-up menu that presently says *Define new attributes*.
18. Select *Use parent's attributes*.
19. Click *OK* and watch the map draw. The red equator should change to light gray like the rest of the graticule.
20. From the **Map** menu, select *Nominal Scale*.

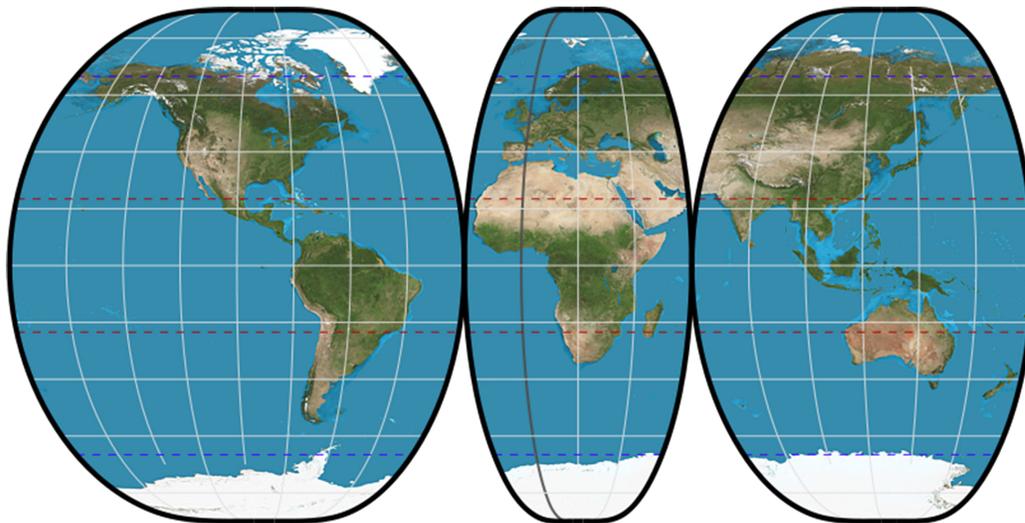
21. In the top field of the *Nominal Scale* dialog, enter 200000000. Click *OK*.



Nominal Scale dialog

22. From the **Map** menu, select *Final Quality* and allow Geocart to redraw the map.

After redrawing, your map should look like this:



Loximuthal projection with segmented interruption

23. From the **Edit** menu select *Copy*.

24. From the **Edit** menu select *Paste*.

25. Drag the new map away from the old so that they do not overlap.

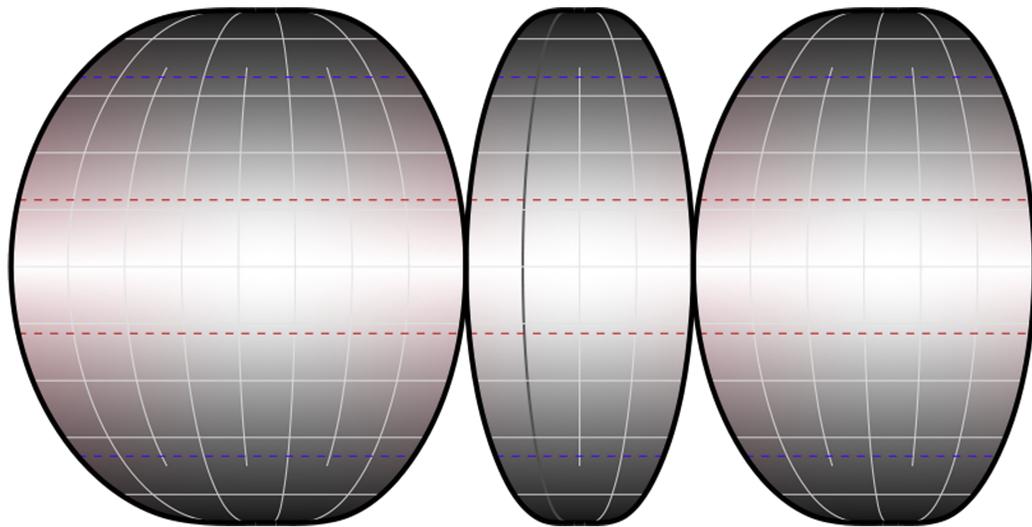
26. From the **Map** menu, select *Distortion Visualization*.

27. In the **Distortion Visualization** dialog, click the *Finitized scale for indefinite limits* radio button.

28. Click *OK* and let the map redraw.

29. From the **File** menu select *Size Document to Content*.

30. Click *OK* to accept the default margin and resize the document.



Distortion visualization

The remainder of this chapter will provide a brief introduction to most of the menu items you saw as you created the example maps.

The Projection Class Menus

When first making a map it is helpful to decide which projection to use. The guidelines from [Appendix A: Which projection is best?](#) can help. You may always change the projection later. The projections are divided between six menus representing the following categories.



The **Cylindric** projection menu contains projections whose meridians and parallels are straight lines when viewed from the equator.



The **Pseudocylindric** projection menu contains projections with straight parallels, and curved meridians with equal spacing along a parallel, when viewed from the equator.



The **Conic** projection menu contains projections whose meridians are straight lines and whose parallels are portions of concentric circles when viewed from the equator. It also covers certain variations (such as pseudoconic and polyconic).



The **Azimuthal** projection menu contains projections that, when viewed from a pole, have straight meridians that converge to the pole and have constant angle between each meridian. It also includes many relatives derived from them.



The **Lenticular** projection menu contains projections whose meridians and parallels curve away from the equator, when viewed from the equator. The distance between parallels does not increase when progressing from equator to pole.



The **Miscellaneous** projection menu contains projections unclassified by any of the above schemes.

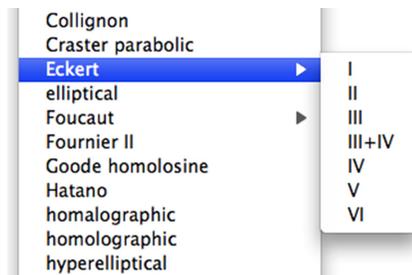
Every Geocart map has a projection. A map acquires a default projection when you create a new map if you do not specify a projection at time of creation. It acquires the projection of the source map if it was a copy of the source map. Or, you set the projection directly. You can see what projection a map uses by looking in the projection menus. If you have one map selected, or several maps of the same projection, then one of the projection menus will have a projection name with a check mark next to it. If you have more than one map selected involving more than one projection, then

each projection of the multiple selection will be indicated by a dash next to the projection name in the menu of its projection class.

To change a map's projection, select the projection you want from one of the six menus. Immediately Geocart will begin redrawing the map according to your selection. It will try to preserve as many traits of the old map as it can. However, sometimes the new map cannot be drawn with the same boundaries as the old map, for example. In such cases the projection change will fail, typically giving an error alert stating that the map is too big. See [Change Projection explanation](#) in Chapter 10: *Projection menu* for ways to resolve this.

Some of the projection names, such as Eckert, expand to a family of projections. To access these projections, open the sub-menu. For example:

1. Click on the  **Pseudocylindric** menu icon. The menu appears.
2. Find **Eckert** in the menu. Move the pointer over it. The submenu appears.
3. Select your specific Eckert projection (such as Eckert IV) from the submenu at right.



Projection menu excerpt with Eckert family sub-menu

A simple explanation of each of Geocart's menu functions follows. Many of the functions in the menus are available without using the menus but instead through keyboard combinations. These keyboard combinations are called "shortcuts". The **Shortcut keys** column of each table use these conventions:

Symbol	Explanation
⌘	(Mac only) command key
^	(Windows only) control key
⇧	shift (Macintosh) or SHIFT (Windows) key
⌥	(Mac only) option key
⌘	(Windows only) ALT key

To use control keys, depress all of the keys shown as the shortcut for the menu function you want. For example, for the **Save As** menu command from the **File** menu is shown in the table below like this:

Command	Shortcut keys	Action
Save As	⇧ ⌘ S ⇧ ^ S	Saves the front document to a new file, and with a different name if you choose.

To access the command from the keyboard, on Macintosh you would depress the shift key, the command key, and the S key simultaneously. On Windows you would depress the shift key, the control key, and the S key simultaneously.

The Geocart Menu (Mac only)

Command	Shortcut keys	Action
<i>About Geocart</i>		Displays the splash screen, giving version number, product configuration, and licensing information.
<i>Preferences</i>	⌘ ,	<p>> General —Opens the Preference dialog.</p> <p>> New Map Databases —Opens the Databases dialog to let you set up the databases you want added automatically for every new map.</p> <p>> New Map Graticule —Opens the Graticule dialog to let you configure the graticule for every new map.</p> <p>> New Map Line Styles —Opens the Line Styles dialog to let you configure the line styles for every new map.</p> <p>> Reset New Map Databases —Clears any configuration you earlier performed from New Map Databases. From this point only databases in the <code>Default</code> folder of the installed databases folder will get added automatically to new maps.</p> <p>> Reset New Map Graticule —Clears any configuration you earlier performed from New Map Graticule. From this point new maps' graticules will get set up automatically according to the original defaults.</p> <p>> Reset New Map Line Styles —Clears any configuration you earlier performed from New Map Line Styles. From this point new maps' line styles will get set up automatically according to the original defaults.</p>
<i>Service</i>		System-level services. Geocart does not provide any services. Please refer to Macintosh documentation.
<i>Hide Geocart</i>	⌘H	Hide Geocart's windows, palettes, and menu bar, and switch to the last application you used.
<i>Hide Others</i>	⇧⌘H	Hide all the windows of other applications.
<i>Show All</i>		Bring all the windows of other applications back into view, though possibly obscured by Geocart's windows and palettes.
<i>Quit Geocart</i>	⌘Q	Ends the Geocart session. If you have unsaved documents, Geocart will first ask if you want to save them.

The File Menu

Command	Shortcut keys	Action
<i>New</i>	⌘N ^N	Creates a new Geocart document.
<i>Open</i>	⌘O ^O	Displays the Open File Picker so that you can select a Geocart document to open.
<i>Open Recent</i>		Lets you to select a Geocart document to open from a list of recently opened documents.
<i>Close</i> (Mac)	⌘W	Closes the front document.
<i>Save</i>	⌘S ^S	Saves the front document. If this is the first time it has been saved, Geocart will ask you to name it.
<i>Save As</i>	⇧⌘S ⇧^S	Saves the front document to a new file, and with a different name if you choose.
<i>Save a Copy</i> (Windows only)		Creates a new copy of the document on disk, but does not change the document's name.
<i>Revert</i>		Discard all changes to the document since it was last saved.
<i>Close</i> (Windows)	^W	Closes the front document.
<i>Export Document</i>		Exports the entire contents of the front document to TIFF, JPEG, PSB (Adobe Photoshop® native) or PDF format. The exported document will have the same dimensions as the Geocart document, regardless of content.
<i>Export Selected Items</i>		Exports any items selected in the front document to TIFF, JPEG, PSB (Adobe Photoshop® native) or PDF format. The exported document's dimensions will be large enough to accommodate the selected content.
<i>Export Database</i>		Creates a raster database from the front document. The document should contain exactly one placed image and one reference map. The reference map describes the projection, scale, resolution, and orientation of the placed image. Once exported, you may use the raster database like any other raster database.
<i>Export Animation Frames</i>		Active when exactly two maps are selected. Opens the Export Animation Frames dialog so that you can configure an automated generation of animation frames, blending the two maps in successive proportions.
<i>Place Image</i>		Opens the Place Image file picker for you to choose a TIFF, JPEG, or PSD/PSB (Adobe Photoshop® native) image to place onto Geocart's front document.
<i>Set Placed Image Resolution</i>		Forces the selected placed image to a resolution you specify. If the resolution is higher than its original resolution, this will shrink the size of the image and increase its pixel density. If lower, this will expand the size of the image and decrease its pixel density.

Command	Shortcut keys	Action
<i>Document Layout</i>		Opens the Document Layout dialog to let you to set the front document's dimensions.
<i>Size Document to Content</i>	⌘T ^T	Resizes the front document to fit the maps within it. You can specify a margin size.
<i>Page Setup</i> (Mac only)	⇧⌘P	Opens the Page Setup dialog to let you configure your printer's media for the front document.
<i>Print</i>	⌘P ^P	Prints the front document. See your computer's documentation for instructions; Geocart does not customize the print operation.
<i>Preferences</i> (Windows only; see <i>Geocart</i> menu for Mac)	^ ,	<ul style="list-style-type: none"> > General —Opens the Preference dialog. > New Map Databases —Opens the Databases dialog to let you set up the databases you want added automatically for every new map. > New Map Graticule —Opens the Graticule dialog to let you configure the graticule for every new map. > New Map Line Styles —Opens the Line Styles dialog to let you configure the line styles for every new map. > Reset New Map Databases —Clears any configuration you earlier performed from New Map Databases. From this point only databases in the <code>Default</code> folder of the installed databases folder will get added automatically to new maps. > Reset New Map Graticule —Clears any configuration you earlier performed from New Map Graticule. From this point new maps' graticules will get set up automatically according to the original defaults. > Reset New Map Line Styles —Clears any configuration you earlier performed from New Map Line Styles. From this point new maps' line styles will get set up automatically according to the original defaults.
<i>Exit</i> (Windows only)	^Q	Ends the Geocart session. If you have unsaved documents, Geocart will first ask if you want to save them.

The Edit Menu

Command	Shortcut keys	Action
<i>Undo</i>	⌘Z ^Z	Undoes the previous action.
<i>Redo</i>	⇧⌘Z ^Z	Redoes the last undone action.
<i>Cut</i>	⌘X ^X	Removes the selected object or objects from the document and places them on the clipboard.
<i>Copy</i>	⌘C ^C	Copies the selected object or objects onto the clipboard. Thence you may paste the clipboard contents.
<i>Paste</i>	⌘V ^V	Copies the most recent clipboard object onto the document.
<i>Delete</i>	delete DEL	Deletes the selected object or objects.
<i>Select All</i>	⌘A ^A	Selects all objects of the front document.
<i>Deselect All</i>	⌘D ^D	Deselects all objects of the front document.
<i>Copy Info Palette Text</i>	⇧⌘X ⇧^X	Copies the contents of the Information palette so that you can paste the text into other applications.
<i>Find</i> (Mac only)		This is provided by the Mac OS. It does not function in Geocart.
<i>Spelling</i> (Mac only)		This is provided by the Mac OS. It does not function in Geocart.
<i>Special Characters</i> (Mac only)	⌘T	This is provided by the Mac OS. It does not function in Geocart.

A map is a graphical object that you can move around, duplicate, or delete. There is no particular limit to the number of maps you may create or paste into a document.

To add a second map to a document:

1. From the **Edit** menu, select *Copy*.
 2. From the **Edit** menu, select *Paste*.
- OR –
- From the **Map** menu, select *New*.

Notes: Your new map may not be apparent as it may overlay your existing map. Drag the new map to see your original map.

The Map Menu

The commands on this menu let you tailor your map. The commands always apply to the selected map or maps of front document. Some can only operate on one map, and will not be available if multiple maps are selected.

Command	Shortcut keys	Action
<i>New</i>	⇧⌘N ⇧^N	New creates a map using default settings for databases, line styles, and graticule. To change these defaults, see the <i>Preferences</i> command on the Geocart menu (Mac) or the File menu (Windows). The default projection is sinusoidal and cannot be changed.
<i>New Blended</i>		Active when two maps are selected. Opens the Blend dialog to let you specify how to blend the two selected maps, creating a third map and possibly synthesizing a new projection.
<i>Databases</i>	⇧⌘B ⇧^B	Opens the Databases dialog to let you to add and remove databases, operating on the selected map or maps. Databases contain map information, such as coastlines or boundaries, for Geocart to construct a map from.
<i>Nominal Scale</i>	⌘K ^K	Opens the Nominal Scale dialog to let you to set the selected map's scale. You may specify the scale as a ratio (e.g., 1: 100,000) or as real distance per map distance.
<i>Map Size and Resolution</i>		Opens the Map Size and Resolution dialog to let you set the overall size of the selected map and/or its level of detail.
<i>Scale to Window</i>		Scales the selected map or maps to fit your document layout window.
<i>Scale to Document</i>		Scales the selected map or maps to fit your document's size.
<i>Boundaries</i>	⌘B ^B	Opens the Boundaries dialog to let you specify the extents of the selected map.
<i>Graticule</i>		Opens the Graticule dialog to let you configure the network of parallels and meridians of the selected map or maps.
<i>Line Styles</i>	⌘L ^L	Opens the Line Styles dialog to let you set the drawing traits of the different kinds of lines on the selected map.
<i>Distortion Visualization</i>		Opens the Distortion Visualization dialog to let you configure a distortion diagram to draw in place of raster databases of the selected map.
<i>Tissot Indicatrices</i>		When checked, draws an ellipse at each graticule intersection showing the distortion characteristics at that point. Longer, flatter ellipses indicate more angular deformation. Differences in ellipse area indicate comparative inflation in size.
<i>Copy Attributes</i>	⇧⌘C ⇧^C	Copies all of the attributes from the selected map and places them on the clipboard. You may then use Paste Attributes to transfer some or all of those attributes to other maps.
<i>Paste Attributes</i>	⇧⌘V ⇧^V	Pastes the map attributes from the clipboard to the selected map or maps.
<i>Vector Generalization</i>		Accesses vector generalization choices for the selected map or maps. Line artwork consists of "vectors" retrieved from the databases you have specified from the <i>Databases</i> command. If the vectors in the database contain too much detail to be useful for your map, generalization will prune away excess detail. The default Douglas-Peucker method should serve most purposes well enough. Select <i>None</i> to preserve all detail.

Command	Shortcut keys	Action
<i>Draft Quality</i>	⌘2 ^2	Sets rapid rendering trait for the selected map or maps, yielding low quality. This setting does not affect line work from vector databases.
<i>Proof Quality</i>	⌘3 ^3	Sets better render quality for the selected map or maps, but at the expense of longer rendering times. This setting does not affect line work from vector databases.
<i>Final Quality</i>	⌘4 ^4	Sets best render quality for the selected map or maps, but at the expense of longest rendering times. This setting does not affect line work from vector databases.

The Projection Menu

Every map projection has attributes that you can modify. These attributes are controlled from the **Projection** menu. The commands on this menu always apply to the selected map or maps of the front document. Some can only operate on one map, and will not be available when multiple maps are selected.

Command	Shortcut keys	Action
<i>Change Projection</i>		Opens the Change Projection dialog to let you change the map projection of the selected map or maps. You can configure which traits of the existing map you want to retain when you change projections. Also gives detailed information and pictures of each map projection.
<i>Reset Projection</i>		Resets the selected map or maps to default traits appropriate for the projection.
<i>Projection Center</i>		Opens the Projection Center dialog to let you change the aspect of your map; that is, whether it is viewed from the equator or pole or elsewhere.
<i>Parameters</i>		Opens the Parameters dialog to let you configure the map projection of the selected map. If the projection has no special configuration parameters, this command will not be available.
<i>Stretch and Rotation</i>		Opens the Stretch and Rotation dialog to let your rotate the selected map on the page and to stretch the height and/or width independently of the nominal scale.
<i>Datum</i>		Opens the Datum dialog to let you select an ellipsoid and a geodetic datum for the selected map.
<i>Interruptions</i>		Accesses the map Interruption options. Some map projections can be sliced up, or <i>interrupted</i> , in order to reduce distortion in areas of the map deemed important to its narrative.

The Object Menu

These commands operate on objects, whether images or maps. All operations apply to single or multiple objects. If objects are grouped, then they are considered to be a single object for these operations. Every object has a position in the stack of objects: It is either the back object, the front object, or is in front of and behind two other objects. This is true even if the objects do not overlap.

Command	Shortcut keys	Action
<i>Bring to Front</i>	⌘ } ^ }	Brings the selected objects to the front of the stack of objects.
<i>Send to Back</i>	⌘ { ^ {	Sends the selected objects to the back of the stack of objects.
<i>Bring Forward</i>	⌘] ^]	Brings each selected object upward one position in the stack of objects.
<i>Send Backward</i>	⌘ [^ [Sends each selected object down one one position in the stack of objects.
<i>Group</i>	⌘R ^R	Groups the selected objects so that they can be selected and positioned as if they were a single object. All selected objects will be brought to a position just behind the frontmost selected object when this command is given.
<i>Ungroup</i>	⇧⌘R ⇧^R	Separates grouped objects into their original components.
<i>Align Multiple</i>		Aligns the selected objects so that upper left corners coincide.
<i>Center in Window</i>		Centers the selected objects in the window.
<i>Center in Document</i>		Centers the selected objects in the document.
<i>Cancel Drawing</i>		Cancel any drawing waiting or in progress of any selected map.
<i>Redraw</i>		Forces any selected maps to redraw. This is useful if you change some configuration outside of Geocart, such as changing the contents of a database.

The View Menu

Command	Shortcut keys	Action
<i>New</i>	⌘N ⇧^N	Creates a new window into the front document. The content is the same; this just lets you view the same content in different ways—for example, using different magnifications.
<i>Zoom In</i>	⌘= ^=	Zooms in the window magnification.
<i>Zoom Out</i>	⌘- ^-	Zooms out the window magnification.
<i>Fit in Window</i>	⌘O ^O	Change the zoom level so that the entire document can be seen at once.
<i>Actual Size</i>	⌘1 ^1	Changes the zoom level to 100%.
<i>Actual Pixels of Selected Object</i>		Changes the zoom level so that a pixel of the selected map or image corresponds to a pixel of the display.
<i>Rulers</i>		Toggles to show/hide the document rulers.
<i>Page Boundaries</i>		Toggles to draw/hide gray rectangles delineating page boundaries. A page's size is determined by <i>Page Setup</i> (Mac) or <i>Print</i> (Windows).

The Window Menu (Windows)

Command	Shortcut keys	Action
<i>Cascade</i>	⇧F5	Arranges all document windows within the applicaiton window in cascading layers.
<i>Tile</i>	⇧F4	Arranges all document windows within the application window in a tiled fashion.
<i>Arrange Icons</i>		Arranges any minimized document windows within the application window.
<i>Close All</i>		Close all documents.
<i>Navigator</i>	F5	Opens the Navigator palette to give you a miniature view of the entire document, and allows you to use a slider to select the zoom extent.
<i>Information</i>	F6	Opens the Information palette which shows detailed information about the object under your mouse pointer.

The Window Menu (Mac)

Command	Shortcut keys	Action
<i>Minimize</i>	⌘M	Moves the front window into the dock and sets the next window back to be the front window.
<i>Zoom</i>		Sets the front window to the maximum size your display will allow.
<i>Bring all to Front</i>		Brings all Geocart windows to the front of any other application's windows, but does not change the front-back ordering of Geocart windows.
<i>Navigator</i>	F5	Opens the Navigator palette to give you a miniature view of the entire document, and allows you to use a slider to select the zoom extent.
<i>Information</i>	F6	Opens the Information palette which shows detailed information about the object under your mouse pointer.

The Help Menu

Command	Shortcut keys	Action
<i>About Geocart</i> (Windows only)		Provides details of the Geocart version and license. (On Macintosh, this appears on the Geocart menu.)
<i>Available Fonts</i>		Displays the set of fonts installed on your system that are usable by Geocart.
<i>Sample Documents</i>		Switches to the Finder (Macintosh) or Explorer (Windows) and opens the folder containing sample documents placed there by the Geocart installer.

Command	Shortcut keys	Action
<i>Release Notes</i>		Opens a window in your default Web browser with a page on the Maphematics Web site for information about the version of Geocart you are using.
<i>Check for Updates</i>		Opens a window in your default Web browser with a page on the Maphematics Web site to inform you of any updates to your Geocart version.
<i>Geocart Forums</i>		Opens a window in your default Web browser with the Geocart Forums page on the Maphematics Web site.
<i>Report a Bug</i>		Opens a window in your default Web browser with a page on the Maphematics Web site for information about how to report a bug.
<i>Credits</i>		Displays a window containing information about the developers of Geocart and all component technologies used by Geocart.
<i>License</i>		Allows you to enter your name and license key to unlock the full functionality when Geocart is running in demonstration mode.
<i>Relinquish License</i>		Allows you to relinquish your license and return Geocart to demonstration mode so you can install your licensed version of Geocart on another computer.
<i>Licensing Terms</i>		Displays a window containing the Geocart Software License Agreement.

Chapter 3: Essentials

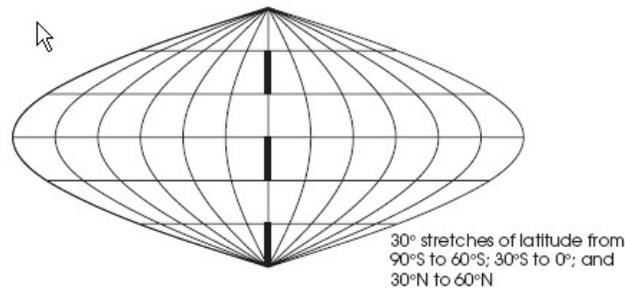
The science of map projections is detailed and complex. Geocart makes this process easy for you; however you do need to understand some background information so that you can choose the most appropriate projections. This chapter explains some of the basic concepts of map projections. If you are already familiar with map projections, this chapter may still be useful to you because it describes how concepts relate to Geocart.

The Globe

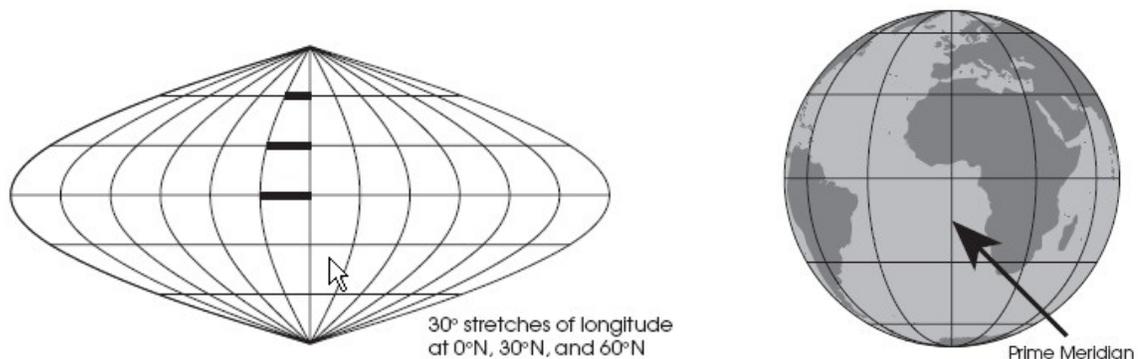
You may find it useful to refer to a model globe or to Google™ Earth while reading this chapter.

Latitude and longitude

You will see that the globe has a network of vertical and horizontal lines overlaid on it. The horizontal lines are called *parallels* or lines of *latitude* because they run parallel to each other. Each location along a parallel has the same latitude, or distance from the equator.



The vertical lines are called *meridians* or lines of *longitude*. Any one shows all the places that have the same local time. Each location along a meridian has the same longitude, or angle between it, the north pole, and the prime meridian¹.



Tip: To show parallels and meridians on Google Earth: on the **View** menu, select **Grid**.

Latitude and longitude are two very different things: On the surface of the earth, latitude is a distance, while longitude is an angle. You cannot tilt the earth on its side and expect the latitude lines to match the old longitude lines. The meridians converge to two points: the north and south poles, but the parallels don't converge anywhere; they stay the same distance apart everywhere.

¹ The meridian you can see running through western Africa, western Europe, and England. The meridian was chosen in 1884 at the International Meridian Conference in Washington, D.C. It has no physical significance.

The coordinate system

Every point on the globe has a meridian running through it from north to south, and a parallel running through it from east to west. Maps and globes only show some of the meridians and parallels, because if they showed all of them, then the map would be black with lines and not very useful.

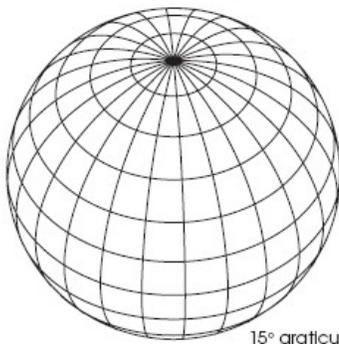
Longitude and latitude are measured in *degrees* ($^{\circ}$), *minutes* ($'$) and *seconds* ($''$). There are 360 degrees of longitude, measured 180 degrees east and west of the prime meridian, and 180 degrees of latitude, measured 90 degrees north and south of the equator.

Taking the earth to be perfectly spherical, one degree of latitude along a meridian (from one parallel to the next one 1° away) always measures the same distance because latitude measures distance. That distance amounts to about 111.1 km (69.1 mi) for the earth.

A degree of longitude, on the other hand, measures angle, so the distance covered by 1° of longitude is a different distance at every latitude. Again taking the earth to be a sphere, then at the equator 1° of longitude is the same as 1° of latitude; at 60° north or south the distance is half of that (55.6 km or 34.5 mi); and at either pole the distance is zero.

Minutes and seconds measure smaller parts of a degree. There are 60 seconds in a minute, and 60 minutes in a degree. Hence on the equator, one minute is about 1.85 km (1.15 mi) and one second is about 0.0309 km or 30.9 m (101 ft).

The *coordinate* of a location is given by the intersection of the parallel and meridian that pass through that location, along with a direction stating north or south for latitudes, or east or west for longitudes. Typically the latitude is given first. For example the point $35^{\circ}40'45''\text{N}$, $139^{\circ}46'14''\text{E}$ is on the grounds of the emperor's palace in Tokyo.



15° graticule

Graticule

The network of meridians and parallels is called the *graticule*. Usually a globe will have a 10° or 15° graticule resolution, which means it shows meridians and parallels every 10° or 15° . Maps have widely varying graticule resolutions depending on their use and on the size of the area they are covering. Usually the meridians and parallels have the same resolution, but not always.

Scale

The earth is very nearly a sphere 10,002 km (6,215 mi) from equator to pole.² A typical globe is only about 0.00024 km (0.00015 mi) from equator to pole, which is economically sound, but there is a bit of a size difference. The ratio of the two sizes is called the *scale* of the globe, which in this case is 0.00024: 10,002 or 1: 41,675,000—in other words, the earth's circumference is 42 million times that of a 12-inch globe.

Great circle



Great circle route through Washington, D.C., and London. Azimuth of $49^{\circ}21'18''$ from D.C.

If the earth were flat then the shortest distance between two points would be a straight line, but since there is no such thing as a straight line on a sphere, then something else must show the shortest distance. That something is a *great circle*, and if it is drawn completely then it goes all the way around the earth to the *antipode*, or point on the opposite side, and back to the starting point. The center of a great circle is the center of the earth, and great circles may be thought of as paths on the surface of the earth where planes cut through the center of it.

All meridians are great circles, but no parallels are except the equator. A great circle going in a particular direction as

² In fact, the meter originally was defined to be $\frac{1}{10,000,000}$ that distance, but the survey was off by 1,966 meters. It was a valiant effort for the 18th century.

seen from some point is called an *azimuth* (muth, not myooth), and usually its direction is measured as a number of degrees clockwise from north.

Rhumb

Mariners who have only a compass to help them prefer to travel paths whose direction does not change: a course of constant bearing, called a *rhumb*, or, mathematically, a *loxodrome*.

A loxodrome crosses each meridian at the same angle. A loxodrome is a great circle only if it is the equator or a meridian; any other rhumb between two points is longer than the great circle route between the same two points.



Loxodromic route through Washington, D.C., and London. Bearing of $76^{\circ}48'26''$

Small circle

Another important geometrical element on the globe is *small circles*. These are circles made by slicing through the earth with a plane at any angle such that the plane does not go through the center of the earth. All of the parallels except the equator are small circles, but none of the meridians are. Because a small circle is a circle it shows all of the points on the surface of the globe that are the same distance from the center of the small circle.

Direction

Here we address the problem of *direction*. Direction means what you think it means in a local sense, but probably not in a global sense. The common perception of direction goes something like this: You determine which way is east, for example, by measuring 90° clockwise from north. Then, you point in that direction to another person who is due east of you. He points due east of himself to another person, and so on to form a chain all away around the world. You would probably say that everyone in the chain and every point between is east of you. This is actually false, and technically none of the people in the chain are east of you. Your chain has made a rhumb line, a loxodrome, which is an interesting and useful measure of direction, but it is not the official definition.

According to the official definition, east follows the great circle that crosses your meridian at a 90° angle: the eastern azimuth. At first, this azimuth will be very close to your chain, but if you live in the northern hemisphere you will find the azimuth gradually dipping south, reaching the equator and going below it until it reaches the latitude of opposite sign: the latitude that is as far south as you are north. It continues circling the back side of the earth and eventually returns to you after crossing the equator again.

When a projection has properties based on direction, you must understand clearly that these directions refer to the official meaning based on azimuths. Therefore, the *retroazimuthal* projections: those that let you find the direction to a center point from any other, for example, may not give you what you think you want. If you need maps that show intuitive direction then you should use those that have loxodromic properties: Mercator and loximuthal.

Earth's shape

As mentioned earlier, the earth is nearly a sphere—but not quite. In the language of mathematics the earth's shape is closer to an *ellipsoid*, which is an ellipse (oval) rotated in three dimensions. Ellipsoids that are nearly spheres are sometimes called *spheroids*. Astronomers call a body shaped like the earth an *oblate spheroid*, which is a specific kind of ellipsoid made by rotating an ellipse in three dimensions around its shorter axis. But the earth has irregularities that keep it from being a simple geometric solid. The shape of its mean sea level is called the *geoid*.

Although a perfectly spherical globe is not quite accurate in representing the earth, when making globes the difference is too small to worry about since variations in manufacturing technique can be proportionally greater than the geoid's deviation from a sphere. However, accurate regional maps require the earth to be modeled on an ellipsoid.

Hemisphere

The largest part of a globe that you can see at one time is a *hemisphere*, or half of it. Any half of the globe is a hemisphere but some of them are named. The *northern hemisphere* is all areas north of the equator and the *southern hemisphere* is all areas south of it. The *eastern hemisphere* and *western hemisphere* are not so rigorously defined. Normally the eastern hemisphere means a bit more than a hemisphere: all of Africa, Australia, and Eurasia, and the western hemisphere means North and South America.

Projections

Problems with globes

Globes are the best representation of the earth because all distance, areas, and shapes are proportionally correct. Unfortunately globes of any size are rather inconvenient to tote about and store, and detailed images of even a large country would require globes larger than a room. Using portions of a globe would work, but they still don't lie down flat and would be like trying to store large potato chips (potato crisps) of all different sizes in book form.

Developable surface

To deal with this problem, ancient peoples created maps. The earliest maps only showed very small portions of the earth and were very serviceable without worrying about spheres and such nonsense; indeed, they were not made as replacements for globes at all. But the Greeks had grander plans, and by at latest 600 BC, the idea arose of projecting the globe onto a *developable surface*.³ This launched cartography, the science of mapmaking.

A developable surface is a surface that is capable of being unrolled onto a plane. Without allowing a surface having ripples, creases, or tears (all of which have critical drawbacks), a cylinder; a cone, and a plane (which was 2-dimensional to start with) are the only three objects that can be developed.

Distortion

Maps always show a distorted view of the earth because they are not curved in three dimensions. The cartographer (mapmaker) usually tries to make as accurate a map as possible, and that is why there are so many different projections: each projection distorts the earth in a different way and the cartographer tries to pick one that works best for the area being mapped.⁴

Types of distortion

These distortions come in two principal varieties. *Areal inflation* causes different regions on the map to have disproportionate sizes with respect to each other. For example, many maps show Greenland to be larger than South America, when really it is less than 1/7th the size. Distortion of shape technically is called *angular deformation*, and it usually manifests itself as *shearing*, which means that map features are twisted or bent. Since globes have many properties and any of those properties can be destroyed by the projection, there are many other possible kinds of distortion. Some of these are *scale distortion*, which means that distances are not shown correctly with respect to each other; *direction distortion*, which means that directions are not shown correctly; and *interruption*, which means that two points next to each

3 Yes, the Greeks knew the earth was a sphere, and they knew its exact size. In fact, so did medieval Europeans. The myth that people thought the earth is flat owes most of its life to fanciful American biographer Washington Irving and French Academy scholar Antoine-Jean Letronne, who promoted the myth to illustrate how enlightened society had become. The subject that Columbus tried to turn into an issue was the size of the earth, not the shape. Columbus was wrong, and the scholars knew it. [Russell, *Inventing the Flat Earth* 1991]

4 At least, that is the theory. Actually most maps have been created using the best projection that also happens to be easy to draw. Until recently cartographers had no computers, so for practicality's sake they used tables of coordinates that had been computed laboriously for a few common projections applied to certain areas of the earth.

other on the globe are separated on the map.

Scale distortion

Areal distortion and angular distortion can exist independently of each other, so a given projection might have only one of those two kinds of distortion. However all projections have *scale distortion* so it often is used as a convenient measure for the accuracy of a map. The amount of scale distortion is indirectly related to the amounts of angular and areal distortion. A map has a stated scale called the *nominal scale* or *principal scale*, which is somewhat arbitrary but usually equals the scale of the center of the map.⁵ At any point of the map the scale may vary from the nominal scale, and the ratio of the two is called the *scale factor* at that point. Unless the projection has no angular distortion at the point being measured, the scale factor at that point will vary according to direction, and in that case the scale distortion could be defined in many different ways.

Geocart defines scale distortion at a point to be a complex average of scale error in every direction from that point. When computing the average, distortion is always positive; i.e., negative values cannot cancel positive values.

You should strive to be aware of scale distortion in maps. On maps that cover large areas of the globe you simply cannot measure the distance from any point on a map to another, multiply by the nominal scale, and expect to have obtained a correct distance. The measured distance on a map depends upon the real distance, the projection, the nominal scale of the map, the orientation of the globe before projecting, and the extent of the map. You can rely on measured distances only if the scale distortion along the path you measure is constant and if you happen to know what that constant is. There are special maps used for measuring distances from a specific point to any other point on the globe, so you should use them instead whenever possible.

Tissot indicatrix

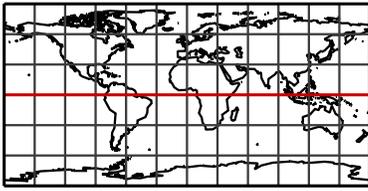
A map's distortion at a point can be shown conveniently by the *Tissot indicatrix*, an ellipse whose size and amount of squash show you how much distortion the map has at the ellipse's center. If the ellipse is a circle then it signifies no angular deformation. Change in the areas of the ellipses across the map signifies relative differences in areal inflation. Usually Tissot indicatrices are drawn at regular intervals on the graticule, rather than in isolation, so that you can compare them in order to understand how distortion is distributed across the map.

Natural projections

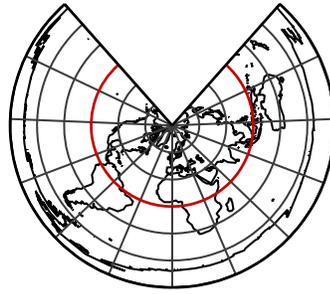
The three developable surfaces give rise to the three natural projection classes that have members—true projections—which can be displayed physically by projecting a light source through a transparent globe onto a developable surface used as a screen. The classes are called *cylindric*, *conic*, and *azimuthal* (because all azimuths from the center are straight lines and their directions are true).

Within the natural projection classes are many projections that cannot be projected physically, but rather are derived mathematically. They still fit within the three classes because they have similar appearances and obey certain critical mathematical rules. Any representation of the globe or part of the globe on a flat surface, such as a sheet of paper, can be called a projection.

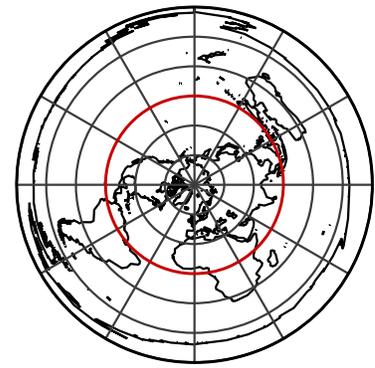
⁵ Or, more precisely, the scale of the globe from which the map is being projected.



Cylindric



Conic



Azimuthal

Mathematical projections

Other categories of projections arise as modifications of the basic three groups or as mathematical abstractions. Many taxonomic systems have been devised to describe them. The *pseudocylindric* group is universally accepted, being projections whose meridians curve toward the poles and whose parallels are each straight and scale-invariant (scale is constant along its length). There are also references to *pseudoazimuthal*, *polyconic*, *polycylindric*, *pseudoconic*, and others.



Pseudocylindric

Geocart's projection classes

Geocart's projection menus consist of the  cylindric,  pseudocylindric,  conic, and  azimuthal groups mentioned before. In addition, a class of mathematically derived projections has been added that are both numerous and useful enough for their own designation:  *lenticular*, or lens-shaped. These are projections whose meridians and parallels curve toward the poles and maintain or decrease their distances from each other going from the center of the map to the edges. Some writers herd some of these into the polyconic class and others into the pseudoazimuthal or miscellaneous classes, but this author has found their similarities to each other to be more useful than their lineage in describing their properties and has thus named and grouped them into a new class. One final  *miscellaneous* class covers any that don't fit into the others.



Lenticular

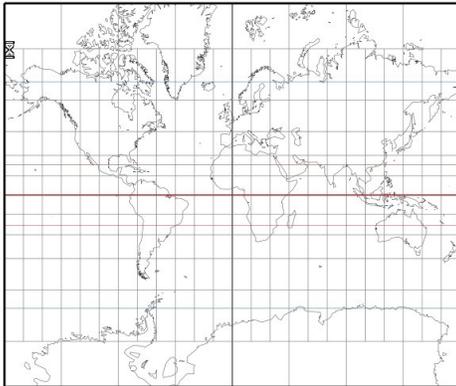


Miscellaneous

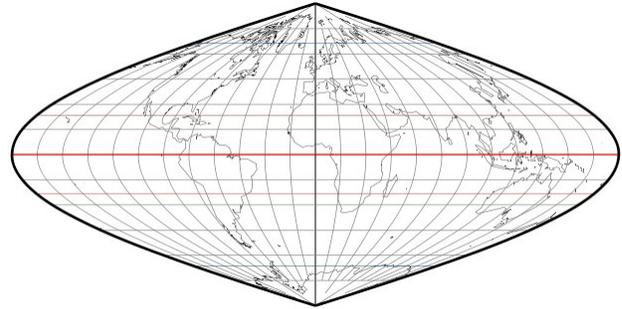
In practice the distinction between true projections and mathematical projections is not so useful. Indeed, many true projections are cartographically useless while many mathematical projections are valuable, which is why they were developed. All projections are described mathematically in the end, otherwise Geocart could not plot them.

Projection properties

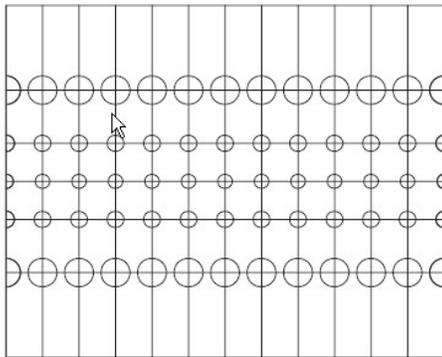
The map on the left of the next page is *conformal*, which means it has no angular distortion: any small area's shape is correct. But as you look toward the poles from the equator you see the circles becoming larger and larger, and in fact the poles cannot be shown because they are infinitely far from the equator. So a large area looks incorrect even though a small area does not because the different parts of the large area have the wrong sizes with respect to each other. On the other hand the map on the right has almost no correct shapes anywhere, but it has no areal distortion so it is called *equal-area*. If you measure the area of any region of the globe and then measure the area of the projected region on an equal-area map that has the same scale as the globe, you will find the two areas to be exactly equal.



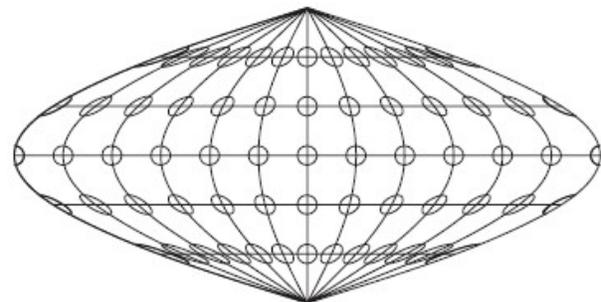
**Correct local shapes but
Severe area distortion**



**Correct areas but
severe shape distortion**



Tissot indicatrix



Tissot indicatrix

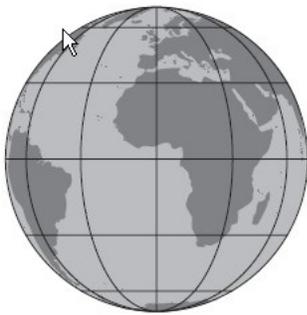
No map can be both conformal and equal-area. Many maps are neither. *Conformality* (the property of being conformal) is important in surveyors' maps because conformal maps have no angular distortion and therefore local directions coincide with angles from map north. Conformality is also important for showing correct shapes in maps smaller than a hemisphere. *Equivalence* (the property of being equal-area) is important in maps approaching or exceeding a hemisphere in scope. At this size, areal inflation in conformal maps becomes plainly visible and should be avoided. Equal-area maps will distort the shape, but conformal maps will distort large shapes also. It is better to preserve sizes than to preserve neither shapes nor sizes.

One may choose a compromise projection that is neither equal-area nor conformal but that has some other desirable property. There are many other interesting properties: *minimum error*, which provides the least scale (or some other) distortion possible for the mapped area; *azimuthal*, which gives correct directions to all locations from the center; *retroazimuthal*, which gives correct direction to the center from all locations; *equidistant*, which gives correct distances to all locations from one or two points (or, another meaning which states that all meridians have correct scale); *perspective*, which provides a natural view of the earth from high altitude; *loxodromic*, which provides straight rhumb lines;

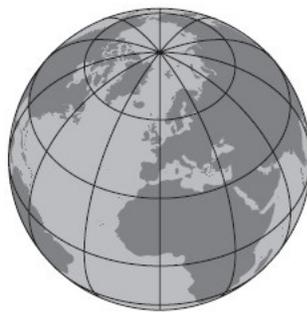
gnomonic, providing straight great circles. Or perhaps a particular shape is interesting or more æsthetic than another. All of these are legitimate reasons for choosing a specific projection. Some projections can have more than one of these properties, but many properties are mutually exclusive in the same way that conformality and equivalence are.

Aspect

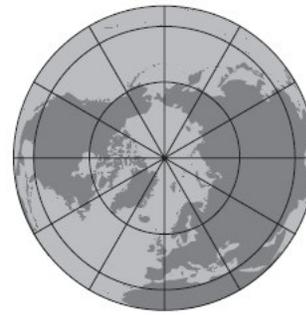
An *aspect* must be chosen when projecting the globe. Simply speaking, the aspect is the position from which the earth is viewed when it is projected. Historically the aspects have been divided into *equatorial*, or seen from the equator; *polar*, or seen from one of the poles; or *oblique*, which means seen from anywhere else. For example, in the middle map below the aspect is oblique, being centered at 45°N, 0°E. The aspect always corresponds to the point at the center of the map if the map is bilaterally symmetrical (the graticule is symmetrical about both the horizontal and vertical axes). In reality the idea of aspect is somewhat arbitrary because the polar aspect occurs at only two points, the equatorial aspect covers an entire great circle, and the oblique aspect covers everything except one great circle and two points. These unbalanced definitions made sense from a computational standpoint in times past: conics and cylindrics are easily computed in the equatorial aspect and azimuthals are simple in polar aspect.



Equatorial aspect



Oblique aspect



Polar aspect

But programs like Geocart obviate the old reasons for doing things. Now any aspect is as feasible as any other. Because the concept of aspect is, in a sense, outdated, Geocart uses the idea of the *projection center* instead. The projection center is a numerically precise expression of aspect. The polar aspects have projection centers of 90°N or 90°S with any longitude. The equatorial aspect's projection center is 0°N with any longitude, and the oblique aspects have any other projection center. You may consider the polar and equatorial aspects to be special cases of the oblique aspect, and Geocart always to be working in oblique aspect. Most projections default to a projection center of 0°N, 0°E or 90°N, 0°E.⁶ The exceptions are those few projections whose centers are important in the definition of the projection, such as Briesemeister or GS50. Some projections have no clear notion of projection center because they have no symmetry.

If a projection is a simple perspective, like the circular ones in this chapter, then its oblique aspect looks perfectly natural—just like what you see when you look at a globe. But almost all projections are mathematical, not perspective, and since the shapes of their graticules were made for the equatorial aspect they often look unusual when displayed in oblique and polar aspects (azimuthal projections look normal in polar as well). Of the following maps, the first is equatorial aspect, the last is polar, and the remainder are oblique.



Center 0°N, 0°W

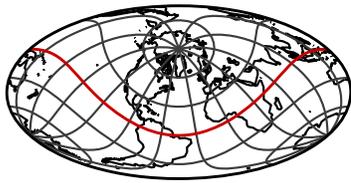


Center 15°N, 15°W



Center 30°N, 30°W

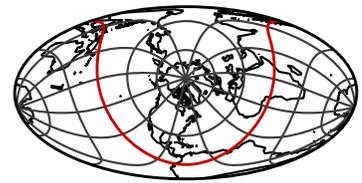
⁶ As a matter of fact, Geocart does not base any actions or computations on a projection's category.



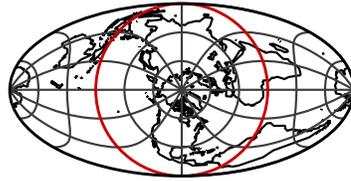
Center 45°N, 45°W



Center 60°N, 60°W



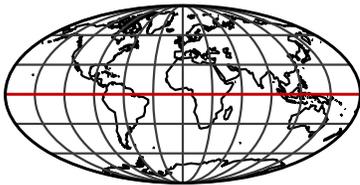
Center 75°N, 75°W



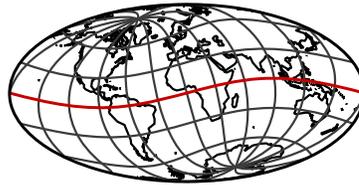
Center 90°N, 90°W

Transversal rotation

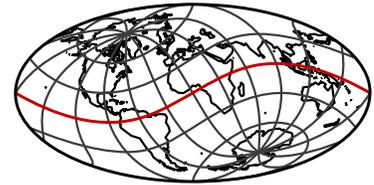
Besides changing the center of the projection, it is possible to rotate the globe around the projection center before projecting. This is called *transversal* rotation. If the aspect is equatorial and the rotation is 90° then a *transverse projection* results wherein the poles of the globe lie on the original equator of the projection. Of the following maps the first is a standard equatorial aspect and the last is a transverse projection.



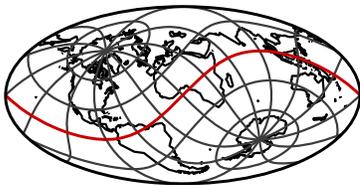
Rotate 0°



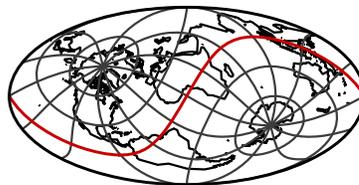
Rotate 15°



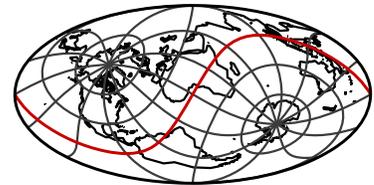
Rotate 30°



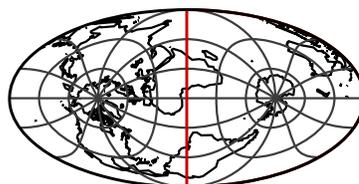
Rotate 45°



Rotate 60°



Rotate 75°

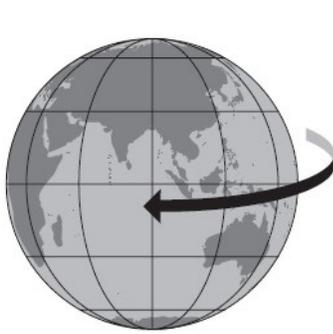


Rotate 90°

Most texts and mapping programs have you specify the coordinate on the original globe that you will be moving the north pole to when rotating the globe. As shown above, Geocart requires a rotational angle instead.

To restate, you can rotate the globe three independent ways before projecting: *longitudinal*, spinning the globe on its natural axis to bring a particular meridian to the projection center; *latitudinal*, bringing a particular latitude to the

projection center; and *transversal*, spinning the earth around the axis formed by the projection center and the center of the globe. Longitudinal and latitudinal rotations are automatic when you specify the projection center.



Longitudinal rotation



Latitudinal rotation



Transversal rotation

As you may have noticed by now, none of the rotations applied to the globe ever change the shape of the map's outline. If the rotation is only longitudinal then even the graticule looks the same (if the angle of rotation is an integer multiple of the graticule's resolution). Latitudinal and transversal rotations both change the appearance of the graticule.

Chapter 4: Documents, Windows, Maps

This chapter describes Geocart documents, their display in windows, and how to place maps.

Documents

Geocart works with *documents* as its fundamental medium. A document is the space upon which you lay out your artwork, such as maps and images. When saved, a single document corresponds to a single file on disk. A document has a title, which is the file name, or, if you have not saved it yet, a title of `Untitled`. (On Macintosh, there will be only one document `Untitled`, and after that they will be `Untitled X`, where *X* is some number intended to make the name unique amongst open documents that have not yet been saved.)

You use the **File** menu to open and close documents. The number of documents you can have open at once is limited only by the amount of memory your machine has. You may freely specify the dimensions of a document (see [Document Layout](#)). You will want your document to be at least as large as the map you are making. If you intend to print onto paper medium, you probably want your document size to coincide with the sheet size.

A document may contain any number of images and maps. Collectively these, and groups of these (see the [Group command of the Object menu](#)), are *document objects*. To help you position them, you can display [rulers](#) at the top and left edges of the document's window.

You may move document objects around in the document's space by [selecting them](#) and dragging them to where you want them to be. Releasing the mouse button finishes the drag operation. There is no way to move a document object entirely outside the document's area, though it may hang partially off. You may also use the arrow keys to "nudge" document objects in the direction of the arrow by one pixel on-screen. Hold down the **shift** key to nudge by 10 pixels.

Document objects have an implicit front-to-back ordering, in a stack. This ordering determines the order in which objects get drawn, and therefore which will be seen when opaque objects overlap. You can change the front-to-back ordering in the stack using commands from the [Object](#) menu.

Document objects, maps in particular, often contain fully and partially transparent parts. The position of the document object in the front-to-back stack determines how these areas of transparency will render.

Windows

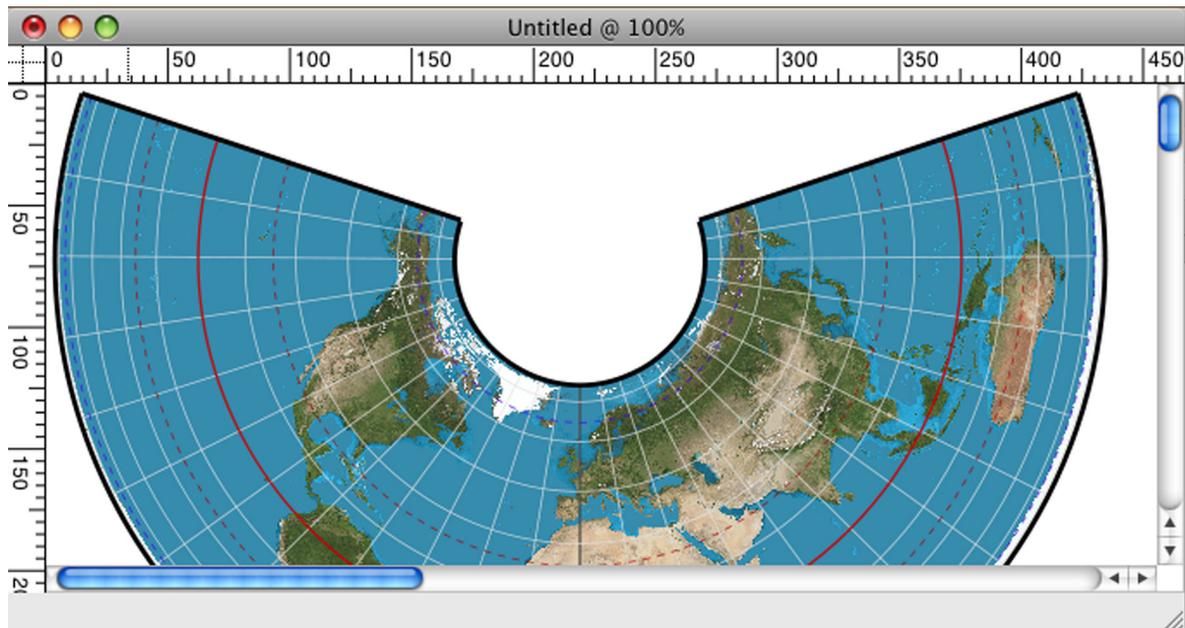
Every open document has its own window, or possibly several (see [View > New](#)). A window is a view into a document's contents. The space of the document is represented as a white background within the window. Areas outside of the document are represented as gray, and have no function.

The window may be smaller or larger than the document. If smaller, the window will have a scroll bar along the dimension in which it is smaller. Scroll bars let you to shift the view around so that you can see areas of the document that were out of sight. See your operating system's instructions for detailed information on sizing, rearranging, and scrolling around in windows.

A document window has a magnification factor. At 100%, your document displays at real-world size according to your display settings (see [Preferences > Display](#)). At 50%, your view into your document is half of real size. You may change the window's magnification using the [magnifying glass](#).

Because you may specify your maps to be any reasonable resolution, a window may show less detail than actually exists in the map. Or, it may magnify the map beyond the level of detail it actually contains, giving a large, blurry representation. You can see a map at the resolution it is specified, so that one map pixel corresponds to one screen pixel, using [Actual Pixels of Selected Objects](#).

Besides document windows, Geocart has several palette windows. Palettes float above document windows, so they are never obscured when Geocart is the front application. When you work in other applications, so that Geocart is no longer in front, the palettes disappear. They reappear when you resume work in Geocart.



A document window

Tool palette

The **Tool** palette, which is always present, contains tools for controlling what mouse gestures do. The tools are modal; that is, when you select a different tool, the meaning of a click or drag changes. You select a tool by clicking on it in the palette window.

Arrow pointer

The arrow pointer is for selecting document objects. It works just like the arrow pointer in any normal context on your computer. As with all tools, as you move the arrow pointer over a map, information for each point gets displayed in the **Information** palette.

Type **S** to switch to the arrow pointer using the keyboard.

Grabber tool

The grabber tool is for panning around within a window. It is akin to using scroll bars but can be faster, especially if your document is large or you view it under high magnification. Select the grabber tool in the **Tool** palette to use it, and then, clicking in the document window and holding down, “drag” the document in the opposite direction of the contents you want to reveal. Release the mouse button when you have finished dragging. If a window already contains a document’s edge, then you cannot drag further away from that edge. Hence if the window’s view already shows the entire document then the grabber tool has nothing to do and will be inoperative.

Type **H** to switch to the grabber tool using the keyboard, or depress the space bar to use it while the space bar is down.

Magnifying glass

The magnifying glass zooms the window view in or out. After you select the magnifying glass, you can click in a window. The magnification of the window’s view will increase to the next increment, and the content at the location you

clicked will shift to the center of the window if it can. Used alone, the magnifying glass zooms in the window's view, blowing up the pixel's sizes up to a limit of 4,000%. This does not increase the detail of the map; it merely allows you to uncover whatever detail it has, and beyond that, to examine that detail in larger and larger pixels. If you hold down the **option** key (Mac) or **ALT** key (Windows) when clicking, then the magnifying glass becomes a shrinking glass, ratcheting down the magnification in increment with each click. The minimum magnification is 5%.

You may click-and-drag instead of just clicking: Continue pressing the mouse button from your original click and drag the pointer around. Click-and-drag magnifies the window view so that the area you dragged across fills the window.

Type **Z** to switch to the magnifying glass using the keyboard.

Crosshairs

The crosshairs lets you pinpoint a location on your map for which you want detailed information, such as geographic coordinates. As you move the crosshairs over a map, information for each point gets displayed in the **Information** palette. While this is true of all tools, the crosshairs lets you see more easily just which point you are hovering over. Unlike other tools, clicking has no effect when you are using the crosshairs, and neither does dragging.

Type **M** to switch to the crosshairs using the keyboard.

Navigator

The navigator gives you a shrunken view of the entire document and the ability to quickly pan to any section of it. See [Navigator](#) for details.

Information palette

The **Information** palette displays information about the document object over which the mouse tool is hovering. See [Information](#) for details.

Maps

A document may contain any number of maps. Maps are drawn from a collection of *attributes*, all of which you have control over. Attributes are things like the projection, the graticule characteristics, the line styles, and the geographic databases used in the map. You can choose to turn on or off the drawing of any of these attributes. Hence a map may even be present but not visible.

You can add a map to a document in several ways:

- By using the [New](#) command from the **Map** menu.
- By holding down the **shift** key (Mac) or **SHIFT** key (Windows) while selecting a projection from one of the six projection menus.
- By pasting a map that you previously copied or cut. (See [Copy](#) and [Cut](#)).

Map layers

A map consists of up to three layers of content:

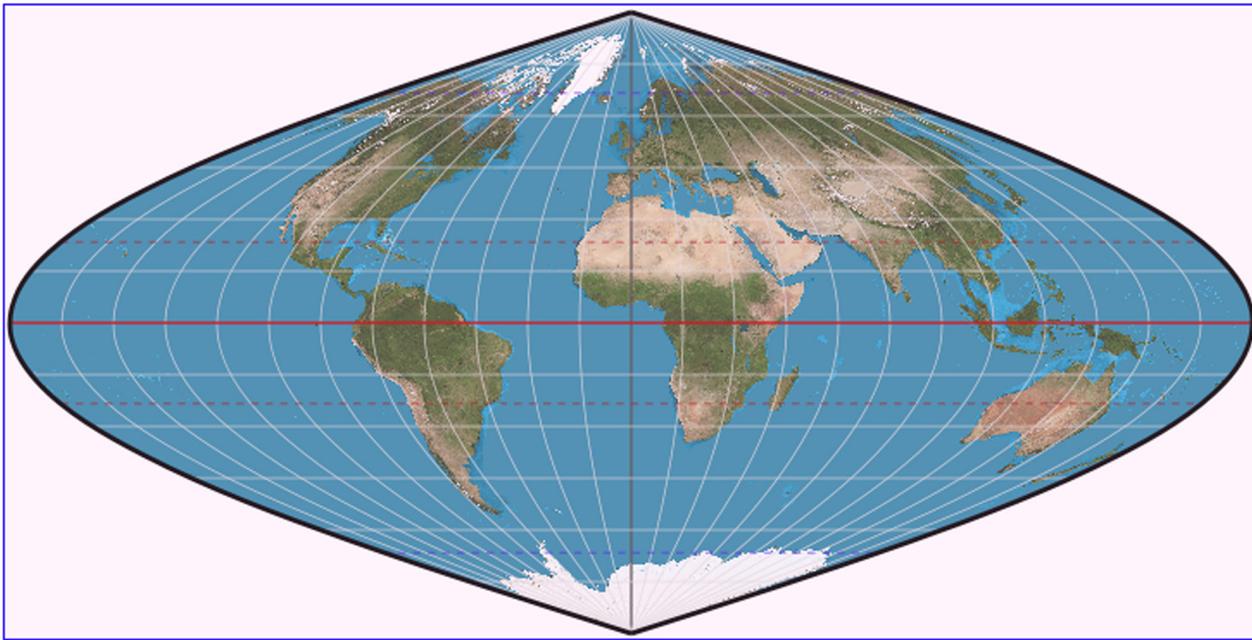
- Raster imagery. (Lowest layer, drawn first.)
- Vector imagery. (Middle layer, drawn second.)
- Graticule, text, and metric line layer. (Upper layer, drawn last.)

You cannot manipulate the layers directly. If you change the settings or databases used to draw the content of a layer, then the affected layers will get rendered anew.

Selecting maps

A map must be in the document of the front window in order to make changes to it. The map (or maps) you want to change also must be selected. You select a map by positioning the mouse pointer over the map and clicking the mouse button. To select two maps, you can click somewhere away from both maps, and, holding down the mouse button, dragging the highlight rectangle over both maps. This works for more than two maps as well. If some maps are already selected and you want to select more, click on each of the other maps you want selected while holding down the shift key. This also works for dragging. These instructions apply to any document object.

A map has a bounding rectangle that is a little larger than the smallest rectangle that can contain the map. It is this bounding rectangle that comprises the document object, not the shape of the map. Hence, when you click or otherwise select a map, it suffices to click anywhere in the bounding rectangle even if the area you click on appears empty. When selected, the entire contents of the bounding rectangle turns a light pink.



Bounding rectangle

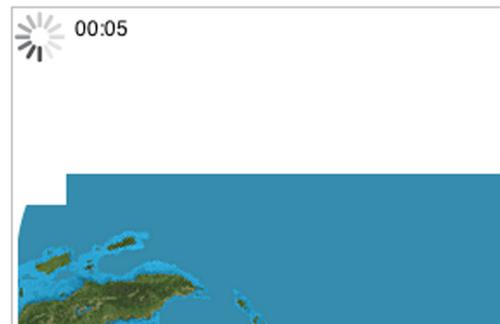
Modifying maps

You will use menu commands to make changes to maps. Some changes may only apply to one map at a time; in those cases the menu command for that change will not be available when multiple maps are selected.

Undrawn areas of a map are transparent. Maps may overlap each other. In fact there is no way to tell that two maps are superimposed if they have the same attributes. If a map that you want to select is obscured by another map, you must first move the top map or send it behind the other maps (see [Send Backward](#)) before you click on the map you want.

Geocart begins drawing a map after every change you make in its attributes. Scrolling, map movement, and most operations from the menus can occur in parallel with map drawing; thus you need not wait for drawing to finish before manipulating the map. Drawing also occurs in the background while you are using another application.

You can tell whether a map is drawing or queued up for drawing: The upper left corner will contain a rotating indicator. When Geocart is able to estimate a completion time span, it will note it to the right of the indicator. The indicator disappears when the map has finished drawing.



Chapter 5: Examples

This chapter shows you how to create lots of different kinds of maps, step-by-step. Besides being a good way to familiarize yourself with Geocart, there is a good chance that a map similar to the one you are trying to make appears here.

Examples consists of all or part of:

Theme or general description of the desired map.

Analysis of the attributes of the ideal projection for the map.

Conclusion to select a particular projection.

Requirements of the map outside of the projection itself.

Process to give step-by-step instructions for constructing the map.

Technical Note that explains calculations that led to the Conclusion.

You should examine [Appendix A: Which projection is best?](#) and [Appendix B: Projection gazetteer](#) in order to understand why the Conclusion of each example chooses the specific projection.

The earlier examples contain most of the information needed for printing or exporting the map for an illustration or image editing program.

The Examples

1. [A base map for world mineral deposits.](#)
2. [A general reference world map.](#)
3. [A base map for showing world precipitation statistics.](#)
4. [A base map from which to make a globe.](#)
5. [A base map for showing corporate sales activity.](#)
6. [A set of globe views to show the entire earth 'naturally'.](#)
7. [A map to measure distances and directions from Mecca.](#)
8. [Two hemispheric maps to show the world accurately.](#)
9. [A base map of the Americas for reference.](#)
10. [A base map of Eurasia for showing railroads.](#)
11. [A political map of Africa.](#)
12. [A base for a road map of the United States.](#)
13. [A high-accuracy map of Japan.](#)
14. [A base for a cultural map of France.](#)
15. [Small-scale, high resolution raster reprojection.](#)
16. [Large-scale reprojection with datum shift.](#)

Example One

A base map for world mineral deposits

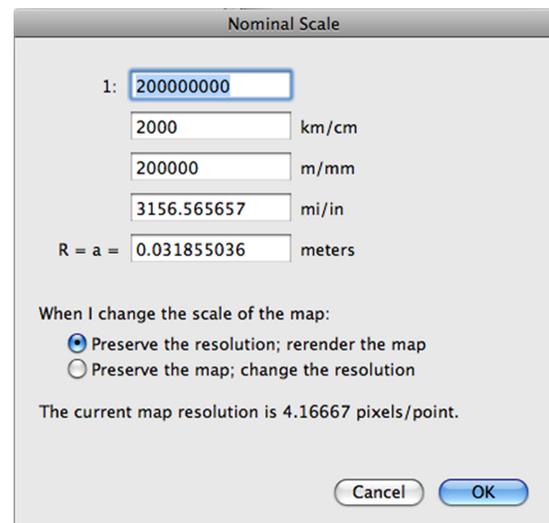
Analysis Mineral deposits do not depend on latitude, so we are not forced to use a cylindrical, pseudocylindrical, or even equatorial aspect projection. But this kind of theme map presents spatial data, so it should be equal-area. We can emphasize land masses since very little mining occurs at sea. The distribution of some mineral deposits depends somewhat on the primeval Pangæan land mass, so it would be nice to display the map in a fashion that emphasizes the common origin of the continents.

Conclusion Briesemeister fits all the above requirements.

Requirements There is little need for a graticule, lakes, or river data. The base map is to be exported for embellishment using a graphics program, suitable for print.

Process

1. Start Geocart.
2. From the **File** menu, select *New*.
3. From the **Map** menu, select *New* to create a map.
4. From the  (Lenticular) menu, select *Briesemeister*.
5. From the **Map** menu, select *Nominal Scale* to open the **Nominal Scale** dialog box.
6. Enter 200000000 as your map scale into the top field. This give a map scale of 1: 200,000,000. Click *OK*.
7. From the **Map** menu, select *Line Styles* to open the **Line Styles** dialog box.
8. Select the top level *Graticule* coverage at the left. At the right, under *Definition for this coverage*, select *Hide coverage and all children* from the pop-up menu. This removes the graticule from the map. Click *OK*.
9. From the **File** menu, select *Save As*, and save your map as *World Mineral Deposits*.
10. From the **Map** menu, select *Map Size and Resolution*. In the *Resolution* field, select *pixels/inch* from the pop-up menu, and enter a value of 300. This provides detail for printing Click *OK*.



Nominal Scale

1: 200000000

2000 km/cm

200000 m/mm

3156.565657 mi/in

R = a = 0.031855036 meters

When I change the scale of the map:

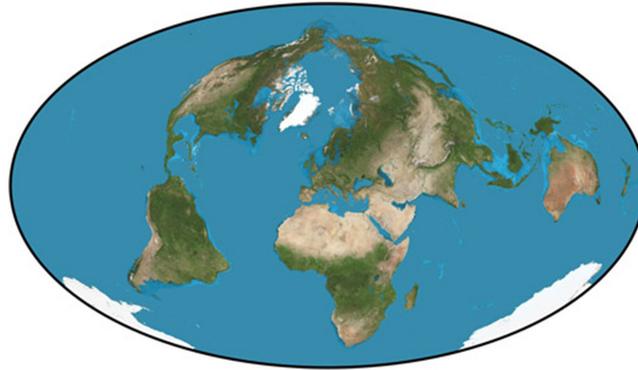
Preserve the resolution; re-render the map

Preserve the map; change the resolution

The current map resolution is 4.16667 pixels/point.

Cancel OK

Result



Example One Result—Base map for world mineral deposits

11. From the **File** menu, select *Export Selected Items*.
12. Enter `World Mineral Deposits` as the file name.
13. Select *JPEG* as the export file type. Click *Export*.
14. Click *OK* to accept the default settings for the JPEG export.
15. You can now open this file into Adobe Illustrator or another graphics editing program to complete the map details.

Note: You can set your preferences for the units of measure for displaying and working with documents from the **File, Preferences, General** window. For more information on how to change these settings, refer to the **Preferences** dialog box.

Example Two

A general reference world map

- Analysis** A general reference world map requires many compromises, but it is not clear that compromising area fidelity gains anything, so we will require an equal-area map. Since we will display the graticule, we will allow mildly curved parallels in order to help reduce angular distortion. We will also allow the poles to be stretched into lines for the same reason. It would be nice to keep any continent from having breaks in it. It also would be nice if the map were vaguely rectangular in shape since the paper is. We don't want anything to look too odd.
- Conclusion** Juggling this wish-list is not easy. Avoiding breaks in continents requires a slight reorientation of the globe before projecting it, so that it is centered on 11°E, 11°S. A rectangular shape (a cylindrical projection) is blatantly incompatible with the other requirements, but we can come close by choosing Strebe-Kavrayskiy V.
- Requirements** The map needs a graticule, international borders, lakes, and river data in addition to physiography, in detail suitable for Web graphic presentation. The map will be completed in an illustration program, and requires colored lines to distinguish features.

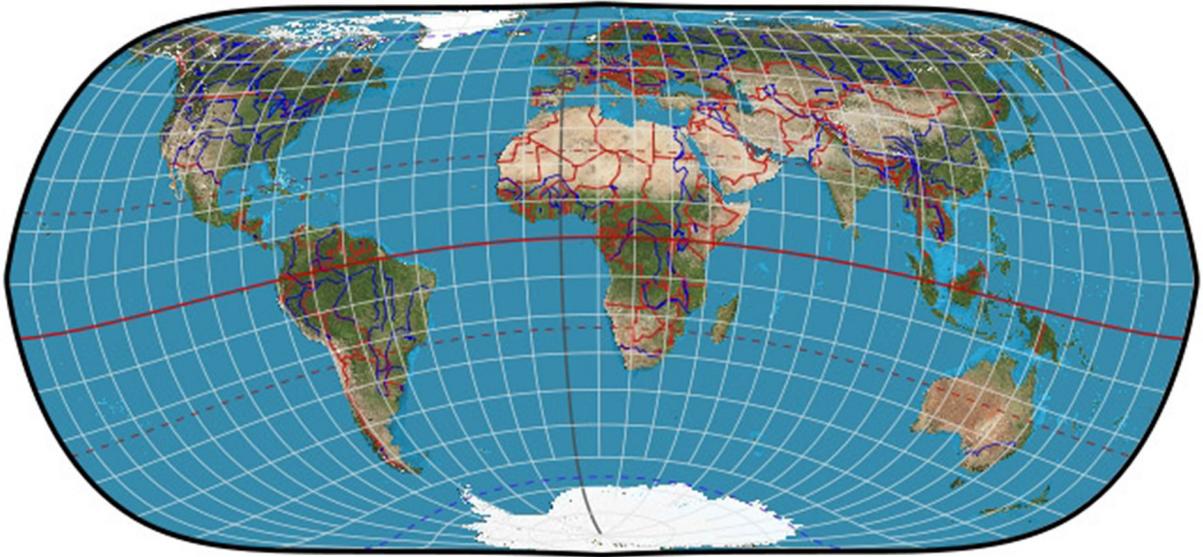
Process

1. Start Geocart.
2. From the **File** menu, select *New*.
3. From the  (Lenticular) menu, hold down **shift** and select *Strebe equal-areas: Kavraiskiy V*. Allow Geocart to finish drawing the map.
4. From the **Map** menu, select *Databases* to open the **Databases** dialog box.
5. Click *Add Installed Database*.
6. Hold down the **command** (Mac) or **CTRL** (Windows) key and select the following files:

```
intl borders.mcam
lakes.mcam
major rivers.mcam
```
7. Click *Open*.
8. You should now see the four selected databases in the *Databases to draw on the map* list with the default Stylized World Topo 5400x2700.raw file.
9. Click *OK*. Allow Geocart to finish redrawing the map.
10. From the **Projection** menu, select *Projection Center*. Enter 11°E into the *Latitudinal* field and 11°S into the *Longitudinal* field. This procedure centers the projection at a place that prevents any land masses from being broken up.
11. Click *OK*. Allow Geocart to finish redrawing the map.
12. From the **Map** menu, select *Line Styles* to open the **Line Styles** dialog box.
13. From the left, select *Coverage: Political: International de facto*, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Click on the *Stroke color* control below to open the **Color picker**. Select some shade of red for international borders.
14. Click *OK* to close the **Line Styles** dialog box and allow Geocart to finish redrawing the map.
15. From the **Map** menu, select *Graticule* to open the **Graticule** dialog box.

16. Enter 10° for both *Parallel spacing* and *Meridian spacing*.
17. In the *Pruning Options* section, enter 20° for *North pole, primary* and *South pole, primary*, then enter 10° for *North pole, secondary* and *South pole, secondary*. This will remove some of the meridians as they approach the poles and will keep the map less crowded. Click *OK*.
18. From the **Map** menu, select ***Scale to Document***. Allow Geocart to finish redrawing the map.

Result



Example Two Result—General reference world map

19. From the **File** menu, select ***Save As*** and save the map as General Reference Map.
20. From the **File** menu, select ***Export Selected Items***.
21. Enter General Reference Map as the file name.
22. Select *PDF* as the export file type.
23. You can now open this file with Adobe Illustrator or another graphic editing application to complete the map details.

Example Three

A base map for showing world precipitation statistics

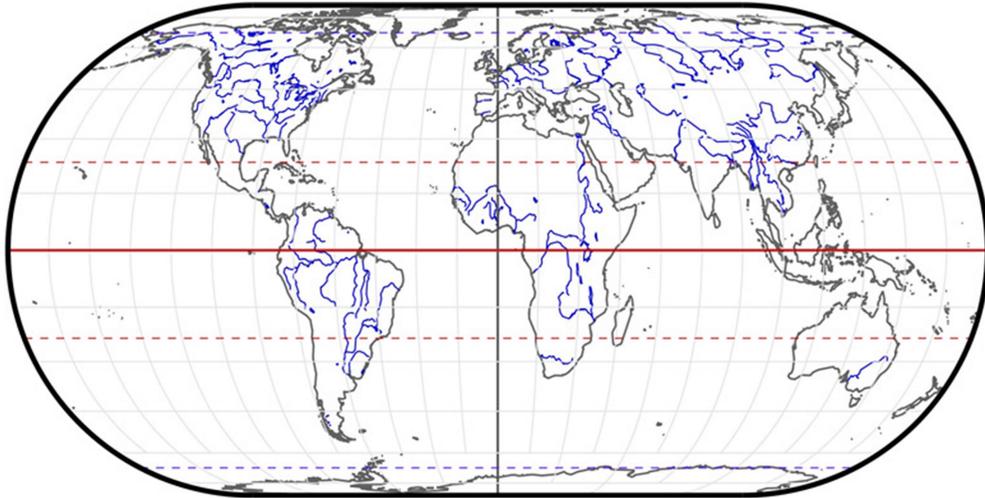
- Analysis** Precipitation at some location depends on many factors, one of which could be latitude (prevailing winds and ocean currents depend somewhat on latitude). Thus we should choose a projection that shows parallels as straight lines. The relationship of land forms to ocean is important, so we probably ought not interrupt the map. Precipitation levels are a form of spatial datum and properly require an equal-area map.
- Conclusion** Eckert IV meets the demands.
- Requirements** The map needs a graticule, lakes, and river data in addition to coastlines. The map must be 13 cm (5") wide with a resolution suitable for textbook printing, will be completed in an image editing program, and requires colored lines to distinguish features.

Process

1. Start Geocart.
2. From the **File** menu, select *New*.
3. From the **Map** menu, select *New* to create a map.
4. From the  (Pseudocylindric) menu, select *Eckert: IV*.
5. From the **Map** menu, select *Databases* to open the **Databases** dialog box.
6. Click *Add Installed Database*.
7. Hold down the **command** (Mac) or **CTRL** (Windows) key and select the following files:

```
coastlines.mcam
lakes.mcam
major_rivers.mcam
```
8. Click *Open*.
9. Select *Stylized World Topo 5400x2700.raw* from the *Databases to draw on the map* list. Click *Remove*.
10. You should now see just the three selected databases in the *Databases to draw on the map* list. Click *OK*.
11. From the **Map** menu, select *Line Styles*.
12. Select *Coverage: Ocean: Coast*, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Click on the *Stroke color* control below to open the **Color picker**. Select a medium gray for coastlines.
13. Click *OK* to close the **Line Styles** dialog box.
14. From the **Map** menu, select *Map Size and Resolution*. Set the *Width* units to *cm*. Enter 13 into the *Width* field. Set the *Resolution* units to *pixels/inch*. Enter 300 into the *Resolution* field. Click *OK*. Allow Geocart to finish drawing the map.

Result



Example Three Result—Base map for world precipitation statistics

15. From the **File** menu, select **Save As** and save the map as World Precipitation Statistics.
16. From the **File** menu, select **Export Selected Items**.
17. Select *JPEG* as the export file type.
18. You can now open this file into an image editing program to complete the map details.

Example Four

A base map from which to make a globe

- Analysis** We need a projection whose meridians are evenly spaced and whose poles are the correct distance from the equator. Parallels should meet the meridians at right angles to form a smooth joint with the next neighboring segment when curled around a ball.
- Conclusion** Rectangular polyconic is ideal.
- Technical Note** Using the *Distortion Visualization* facility from the **Map** menu, the distortion characteristics of the rectangular polyconic within the 30° central segment were verified to be as good or better than other obvious candidates, such as sinusoidal, transverse plate carrée, or American polyconic.
- Requirements** This will be a base map to glue onto a ball of 20 cm circumference. It requires only physiography and graticule, and will be printed on a 2400 dpi inkjet printer, yielding better than 300 dpi contone.

Process

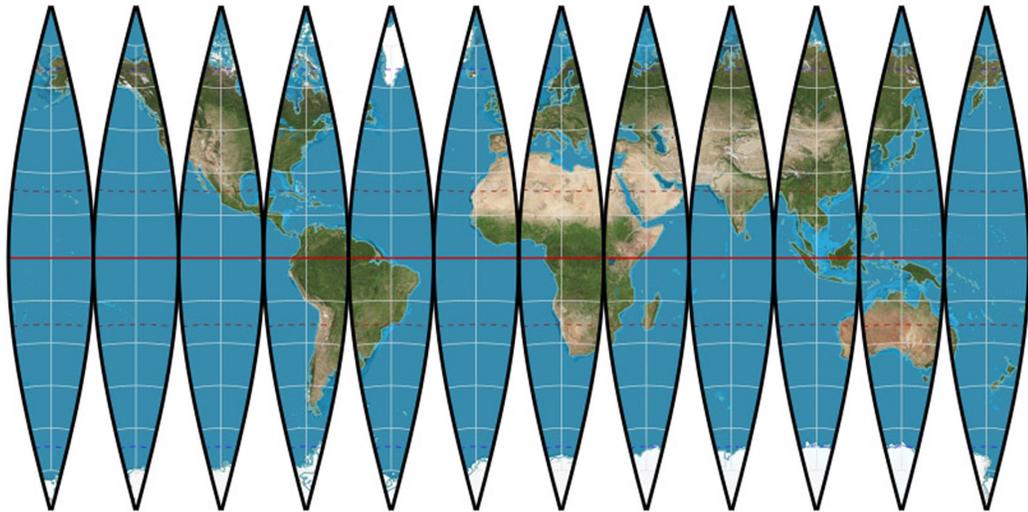
1. Start Geocart.
2. From the **File** menu, select *New*.
3. From the  (Conic) menu, hold down **shift** and select *rectangular polyconic*.
4. From the **Map** menu, select *Nominal Scale* to open the **Nominal Scale** dialog box. The earth's radius is 6,371,007 meters, or 637,100,700 cm. (You can see this in the **Datum** dialog box, *Semiminor axis*, accessible off the **Projection** menu by selecting *Datum*.) That gives a circumference of $2 \times \pi \times 637,100,700 \text{ cm} = 4,003,021,757 \text{ cm}$. The ball is 20 cm, so the map's scale will be 20: 4,003,021,757 = 1: 200,151,087.
5. Enter 200151087 as the scale. Click *OK*.
6. From the **Projection** menu, select *Parameters*. Enter a *Standard Parallel* of 0°. The *Latitude of origin* does not matter. Click *OK*.
7. From the **Map** menu, select *Graticule*. Enter 15° in both *Parallel spacing* and *Meridian spacing* fields.
8. In the *Pruning* section, enter 15° for *North pole, primary* and *South pole, primary*. Deselect *Secondary* for both north pole and south pole. Click *OK*.
9. From the **Map** menu, select *Databases* to open the **Databases** dialog box.
10. Click *Add Installed Database*.
11. Select the following file:

```
coastlines.mcam
```
12. Click **Open**. You should now see *coastline.mcam* in the *Databases to draw on the map* list with the default *Stylized World Topo 5400x2700.raw* file. Click *OK*.
13. From the **Map** menu, select **Line Styles**.
14. On the left, under *Line Type / Coverage*, Select *Graticule* coverage. Type 4 2 as the *Dash pattern*.
15. Select the *Coverage: Ocean: Coast* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Click on the *Stroke color* control below to open the **Color picker**.
Set

<i>Red:</i>	100
<i>Green:</i>	170
<i>Blue:</i>	180

16. Click *OK*. This gives a light halo to the coastlines.
17. From the **Map** menu, select *Final Quality*.
18. From the **Projection** menu, select *Interruptions: Gores*, and set the number of gores to 12.
19. From the **File** menu, select *Save*, and save your map as `Globe`.

Result



Example Four Result—Globe gores

20. If you wish to print: From the **Map** menu, select *Map Size and Resolution*. In the *Resolution* field, select *pixels/inch* from the pop-up menu, and enter a value of 300. Click *OK*. This increases the detail of the map to make it suitable for printing. Wait for the map to image. Select *Print* from the **File** menu and follow the usual instructions for your operating system.

Example Five

A base map for showing corporate sales activities

- Analysis** No technical aspect of a corporate sales map needs to be especially accurate. A pleasing overall shape combined with recognizable land shapes suffices. Oceans and Antarctica are irrelevant.
- Conclusion** Armadillo is fine.
- Requirements** The map needs no graticule and no physiography other than coastlines. International and U.S. state borders should be emphasized. Level of detail should be suitable for overhead presentation.

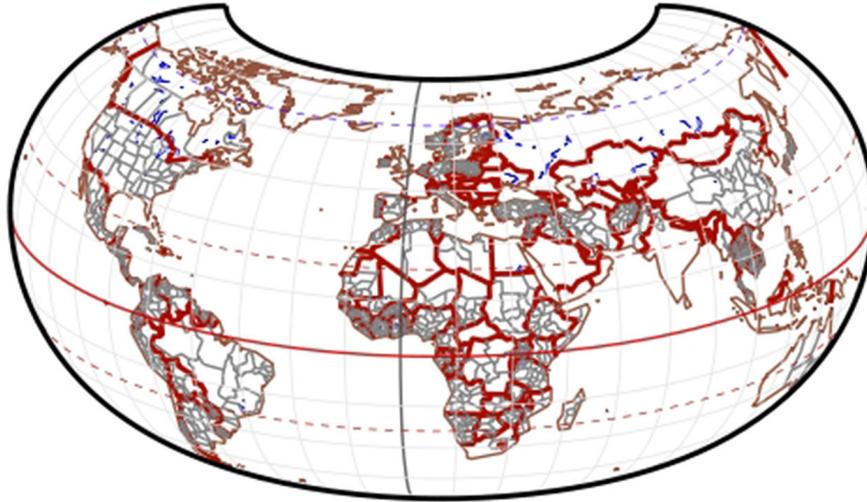
Process

1. Start Geocart.
2. From the **File** menu, select *New*.
3. From the **Map** menu, select *New* to create a map.
4. From the  (Miscellaneous) menu, hold down **shift** and select *armadillo*.
5. From the **Map** menu, select *Databases* to open the **Databases** dialog box.
6. Select the default Stylized World Topo 5400x2700.raw database that is already listed under *Databases to draw on the map*. Click *Remove* so that the database does not get drawn.
7. Click *Add Installed Database*.
8. Hold down the **command** (Mac) or **CTRL** (Windows) key and select the following files:
 - Intl borders.mcam
 - coastlines.mcam
 - lakes.mcam
 - provinces.mcam
9. Click **Open**. We include lakes so that the Great Lakes and other major bodies will be present. The coastlines.mcam database does not include them.
10. You should now see Intl borders.mcam, coastline.mcam and provinces.mcam in the *Databases to draw on the map* list. Click *OK*.
11. From the **Projection** menu, select *Projection Center*.
12. Enter 11° for *Longitudinal*. This will show more of Australia on the map.
13. From the **Map** menu, select *Line Styles*.
14. Select the *Graticule* line type, and at the right, under *Definition for this coverage*, select *Hide coverage and all children* from the pop-up menu.
15. Select the *Coverage: Ocean: Coast* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to something brownish. (You can click on the rectangle to the right of *Stroke color* to bring up a color picker.) Enter 1 for the *Width (points)*.
16. Select the *Coverage: Political boundary: International de facto* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to something reddish. Enter 2 for the *Width (points)*.
17. Select the *Coverage: Political boundary: Provincial* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to a medium gray. Enter 1

for the *Width (points)*.

18. Click OK.
19. From the **File** menu, select **Save**, and save your map as Corporate Sales Activities.

Result



Example Five Result—Corporate sales activities base map

20. From the **File** menu, select **Export document**.
21. Export the file as Corporate Sales Activities, and select *JPEG* for the *Save As Type*.
22. Click *Save*.
23. Your map can now be imported into a graphics program for finishing.

Example Six

A set of globe views to show the entire earth ‘naturally’

Conclusion Orthographic is the only “globe view” from a distance.

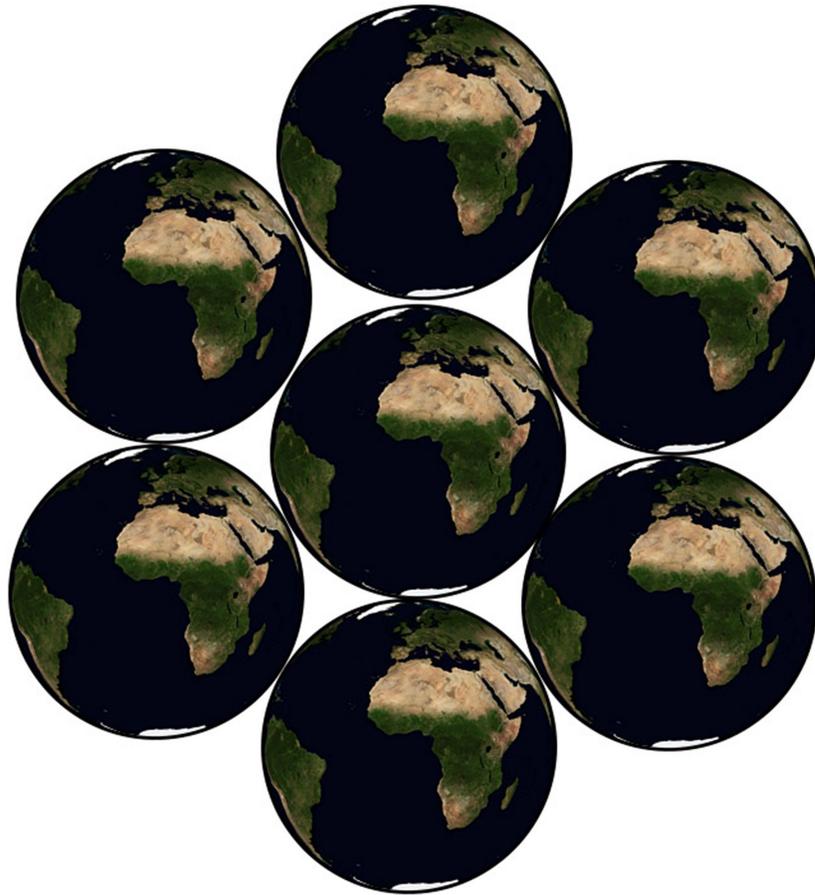
Requirements The basic map will be a cloudless satellite view. We will form a ring of six hemispheric views surrounding a seventh. The maps are to be read into an image editing program.

Process

1. Start Geocart.
2. From the **File** menu, select **New**.
3. From the  (Azimuthal) menu, hold down **shift** and select **orthographic**.
4. From the **Map** menu, select **Databases**. In *Databases to draw on the map*, select the default:

```
Stylized World Topo 5400x2700.raw
```
5. Click *Deactivate* so that the database does not get drawn.
6. Click *Add Installed Database*.
7. Select the following file:

```
world.topo.2004.3x2700x1350.raw
```
8. Click **Open**. You should now see the `world.topo.2004.3x2700x1350.raw` database with a + sign beside it, and the `Stylized World Topo 5400x2700.raw` database with a – sign beside it in the **Databases** dialog box. Click *OK*.
9. From the **Map** menu, select **Line Styles**.
10. Select the *Graticule* line type, and at the right, under *Definition for this coverage*, select *Hide coverage and all children* from the pop-up menu. Click *OK*.
11. From the **Edit** menu, select **Copy**.
12. From the **Edit** menu, select **Paste**.
13. From the **Edit** menu, select **Paste** or type **command+V** (Mac) or **CTRL+V** (Windows) another five times so that you have a total of seven identical maps.
14. Drag one of the maps to the 12:00 position, repeat this step, moving the maps to 2:00, 4:00, 6:00, 8:00, and 10:00 positions. Your arrangement should resemble this:



Seven identical orthographic maps

15. Select the map at the 12:00 position.
16. From the **Projection** menu, select *Projection Center*. Enter the values:

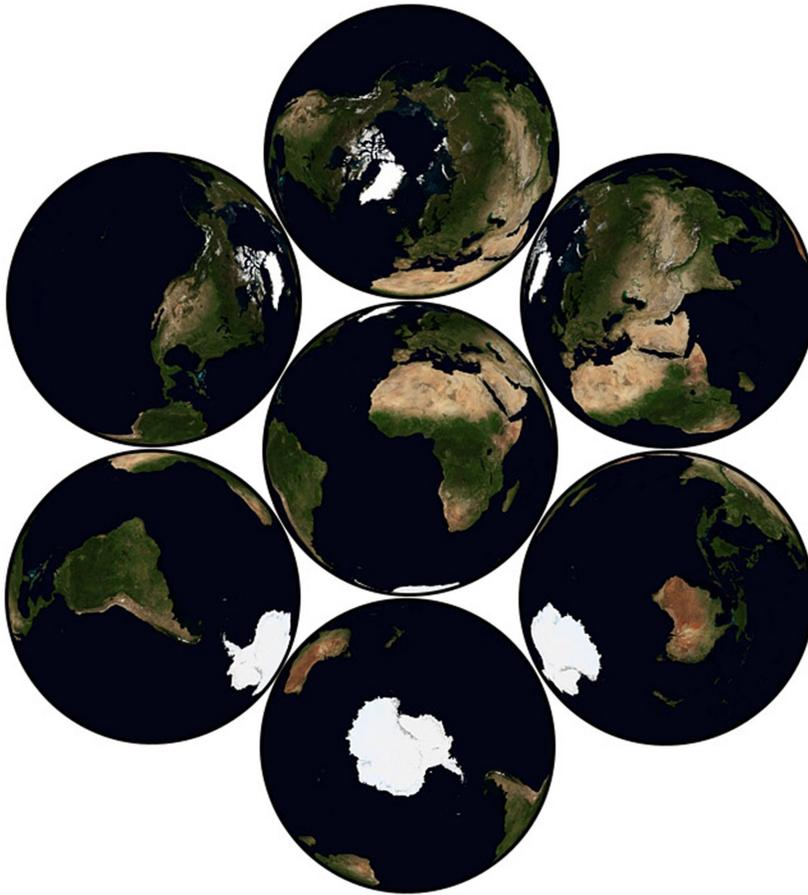
<i>Latitudinal:</i>	90N
<i>Longitudinal:</i>	30N
<i>Transversal:</i>	0

17. Click *OK*.
18. Repeat the last step for the remaining maps according to the settings below:

Position	Latitudinal	Longitudinal	Transversal
center	0°N	0°N	0°
02:00	30°N	60°E	60°
04:00	30°S	120°E	-60°
06:00	90°S	180°E	0°
08:00	30°S	60°W	60°
10:00	30°N	120°W	-60°

19. From the **Edit** menu, select *Select All*.
20. From the **Map** menu, select *Final Quality*.
21. From the **File** menu, select *Size Document to Content*. Accept the default values and click *OK*.
22. Your layout should now look like the result.

Result



Example Six Result—Orthographic hemisphere views

23. From the **File** menu, select *Save*, and save your map as `Views of Earth`.
24. From the **File** menu, select *Export document*.
25. Export the file as `View of Earth`, and select *JPEG* for the *Save As Type*.
26. Click *Save*.

Example Seven

A map to measure distances and directions from Mecca

- Analysis** For correct distances and directions there are two reasonable candidates: plate carrée and azimuthal equidistant. Azimuthal equidistant requires a protractor to measure directions between displayed azimuths, whereas plate carrée requires only a ruler. Plate carrée, however, badly distorts the region around the point of interest.
- Technical Note** Note that this is an inversion of the usual “Qibla problem”. The usual problem is to find the direction *to* Mecca for the Muslim prayer. Use one of the retroazimuthal projections for that purpose.
- Conclusion** Plate carrée, with Mecca moved to the south pole, makes trivial direction measurements.
- Requirements** The map does not need the regular graticule, but only one for showing distance and direction. There is no need for political borders and waterways. The map will be printed.

Process

1. Start Geocart.
2. From the **File** menu, select *New*.
3. From the **Map** menu, select *New* to create a map.
4. From the  (Cylindric) menu, select *plate carrée*.
5. From the **Map** menu select *Map Size and Resolution*. Select *pixels/inch* from the *Resolution* pop-up menu. Set the *Resolution* value to 300. Click *OK*.
6. From the **Edit** menu, select **Copy**.
7. From the **Edit** menu, select *Paste* to create a copy of your map.
8. Select the new map.
9. From the **Map** menu, select *Databases*. Select

Stylized World Topo 5400x2700.raw

10. Click *Deactivate*. Click *OK*.
11. From the **Map** menu, select *Graticule*. In the *Pruning Options* section, uncheck *North pole, primary* and *South Pole, primary*. At the upper right, uncheck *Tropics* and *Polar circles*. Click *OK*.
12. You should now have one map that shows only graticule lines. Drag this map so that it does not overlap the original map.
13. Select the original map.
14. From the **Map** menu, select *Graticule*. Uncheck *Draw parallels* and *Draw meridians*. Click *OK*.

Referring to an atlas, we find that Mecca is located at 25°21'N, 39°49'E. To place Mecca at the south pole, we must add 90° to its latitude to determine which location must become the center of the map.

$$\varphi_{\text{center}} = 25^{\circ}21'N + 90^{\circ} = 115^{\circ}21'N$$

But this value is greater than 90°, which means we have moved to the back side of the globe. We subtract the latitude from 180° to get the real latitude, and subtract 180° from the longitude to compute the longitude at the other side of the globe:

$$\varphi_{\text{center}} = 180^\circ\text{N} - 115^\circ 21'\text{N} = 64^\circ 39'\text{N}$$

$$\varphi_{\text{center}} = 39^\circ 49'\text{E} - 180^\circ\text{E} = 140^\circ 11'\text{W}$$

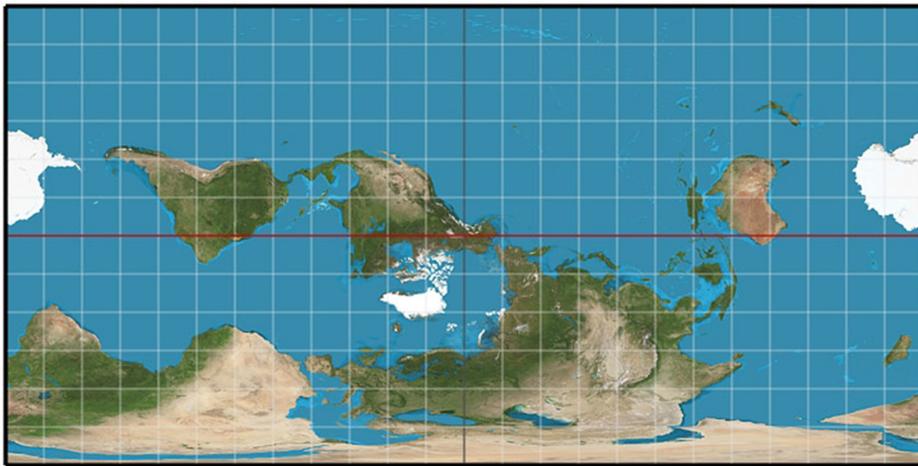
Further, when we went to the back side, we reversed our orientation, so we need to rotate the projection 180°.

15. From the **Projection** menu, select *Projection Center*. Enter the values:

<i>Latitudinal:</i>	64/39N
<i>Longitudinal:</i>	140/11W
<i>Transversal:</i>	180

16. Click *OK*.
17. From the **Edit** menu select *Select All*.
18. From the **Object** menu select *Align Multiple*.
19. From the **File** menu, select *Save*, and save your map as *Globe*.

Result



Example Seven Result—Distances from Mecca base map

20. From the **File** menu, select *Print*.
21. Follow your normal procedures for printing.

Note: Mecca is stretched into the line at the bottom of the map. Compute distances from Mecca by measuring the length of the vertical line from the destination to the bottom of the map, and then multiplying by the map's scale. Compute direction to the destination by measuring the horizontal distance from the central vertical line to the destination point (points to the left of center are negative). Divide that by the map's width, and then multiply by 360°. That gives the distance in units of arc. Multiply by 111.1 km for kilometer values.

Example Eight

Two hemispheric maps to show the world accurately

- Analysis** Many projections exist which could be used for hemispheres, but the prime concern here is overall map accuracy rather than some specific feature.
- Conclusion** Airy is a good choice, with a 90° optimization radius from center.
- Requirements** We will show waterways, international borders, and graticule in addition to coastlines. The map will be exported to an illustration program for completion, with resolution suitable for Web presentation.

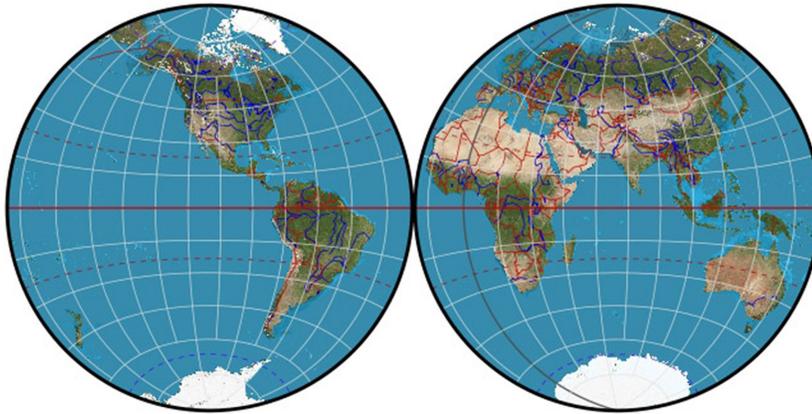
Process

1. Start Geocart.
2. From the **File** menu, select *New*.
3. From the **Map** menu, select *New* to create a map.
4. From the  (Azimuthal) menu, select *Airy*.
5. From the **Map** menu, select *Boundaries*. In the *Boundaries (Before Projecting)* pane, *Small Circle* item, set the *Radius* to 90. This pares down the map to a hemisphere. Click *OK*.
6. From the **Map** menu, select *Databases* to open the **Databases** dialog box.
7. Click *Add Installed Database*.
8. Hold down the **command** (Mac) or **CTRL** (Windows) key and select the following files:

```
intl borders.mcam
lakes.mcam
major rivers.mcam
```
9. Click **Open**.
10. You should now see the three selected databases in the Databases dialog box with the default *Stylized World Topo 5400x2700.raw* file.
11. Click *OK*. Allow Geocart to finish redrawing the map.
12. From the **Map** menu, select *Line styles*.
13. Select the *Coverage: Political boundary: International de facto* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to something reddish. (You can click on the rectangle to the right of *Stroke color* to bring up a color picker.) Enter 0.5 for the *Width (points)*.
14. From the **Projection** menu, select *Parameters*.
15. In the **Parameters** dialog box confirm that 90° is set as the *Radius of minimum error*. This will optimize the projection for a radius of 90 arc degrees from the center in all directions, which is a hemisphere. Click *OK*.
16. From the **Map** menu, select *Graticule*.
17. Ensure that the *Pruning Options* for the *North pole, primary* and *South pole, primary* are selected and that they are pruned at 30°. Ensure that the *Pruning Options* for the *North pole, secondary* and *South pole, secondary* are selected and that they are pruned at 15°. Click *OK*.

18. From the **Edit** menu, select *Copy* and then *Paste*.
19. Drag the copy of your new map adjacent to the original map.
20. Ensure that your second map is selected.
21. From the **Projection** menu, select *Projection Center*.
22. Enter 0° as the *Latitudinal* rotation. This gives centers the projection on the equator. Enter 70°E as the *Longitudinal* rotation. This centers the projection in the eastern hemisphere. Click *OK*. Allow Geocart to finish drawing the map.
23. Select the first map.
24. Select *Projection Center* from the **Projection** menu.
25. Enter 0° as the *Latitudinal* rotation. This gives centers the projection on the equator. Enter 110°W into the *Longitudinal* box. This centers the map in the western hemisphere. Click *OK*.
26. Allow Geocart to finish drawing the map. Now arrange the two maps so that they resemble the result.

Result



Example Eight Result—Double hemispheric map

27. From the **File** menu, select *Export Document*.
28. Enter `Hemispheres` as the file name.
29. Select *PDF* as the export file type.
30. You can now open this file into Adobe Illustrator or another graphics editing program to complete the map details.

Example Nine

A reference base map of the Americas

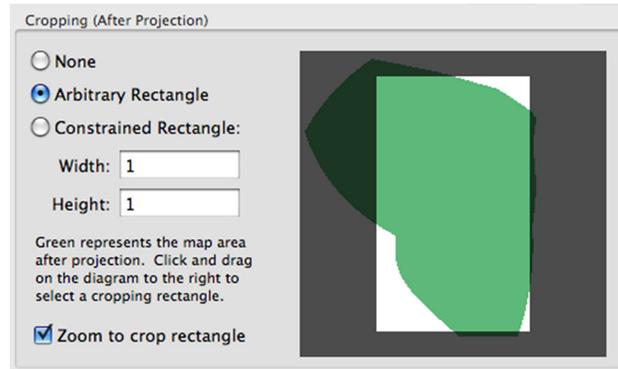
- Analysis** Again, the primary concern here is overall map accuracy.
- Conclusion** Bipolar oblique conic conformal was created exactly for this task.
- Requirements** We will show waterways, international borders, and graticule in addition to physiography.

Process

1. Start Geocart.
2. From the **File** menu, select *New*.
3. From the **Map** menu, select *New* to create a map.
4. From the  (Conic) menu, hold down **shift** and select *bipolar oblique conic conformal*.
5. From the **Map** menu, select *Databases* to open the **Databases** dialog box.
6. Click *Add Installed Database*.
7. Hold down the **command** (Mac) or **CTRL** (Windows) key and select the following files:

```
intl borders.mcam
lakes.mcam
major rivers.mcam
```
8. Click *Open*.
9. You should now see the three selected databases in the **Databases** dialog box with the default Stylized World Topo 5400x2700.raw file.
10. Click *OK*. Allow Geocart to finish redrawing the map.
11. From the **Map** menu, select *Line Styles* to open the **Line Styles** dialog box.
12. Select the *Map: Boundary* line type, and at the right, under *Definition for this coverage*, select *Hide coverage and all children*. This turns off drawing of the outer boundary.
13. Select the *Coverage: Drainage: Lake* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Enter 0.2 for the *Width (points)*.
14. Select the *Coverage: Drainage: River* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Enter 0.5 for the *Width (points)*.
15. Select the *Coverage: Political boundary: International de facto* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to red. (You can click on the rectangle to the right of *Stroke color* to bring up a color picker.) Enter 0.5 for the *Width (points)*.
16. Click *OK*.
17. From the **Map** menu, select *Nominal Scale* to open the **Nominal Scale** dialog box.
18. Enter a value of 1500 km/cm. Click *OK*.
19. From the **Map** menu, select *Graticule* to open the **Graticule** dialog box.
20. Ensure that *Draw parallels* is checked and enter 10° for the *Parallel spacing*.
21. Ensure that *Draw meridians* is checked, and enter 10° for the *Meridian spacing*.

22. In the *Pruning Options* section, ensure that *North pole, primary* and *South pole, primary* are checked, and enter 10° . Deselect *North pole, secondary* and *South pole, secondary*.
23. Click *OK*. Allow the map to draw to completion. It should look like this:
24. From the **Map** menu, select **Boundaries**.
25. In the *Cropping (After Projection)* section, drag out a rectangle to clip out bulging portions of the map, similar to this:



26. Click *OK*. Allow the map to draw to completion.

Result



Example Nine Result—Bipolar oblique conic map of the Americas

Example Ten

A base map of Eurasia for showing railroads

Analysis The primary requirement for a railroad map is minimum scale distortion. There is no need for special directional properties nor even, technically, any need for strictly correct shapes (conformality). Unfortunately, Eurasia is both huge and uncooperatively shaped.

Conclusion Classically, such a map would be based on Albers equal-area conic, Lambert conformal conic, or Lambert azimuthal equal-area. But we can wring the most accuracy out of Chamberlin trimetric, which excels in minimizing scale error in oval-shaped regions. The bounding points will be west of the Iberian Peninsula at 35°N, 15°W; beyond the tip of the Malaysian Peninsula 1°N, 105°E; and east of the Kamchatka Peninsula at 55°N, 165°E. The points with the most distortion will lie outside that triangle: the Arabian peninsula and the Chuckchee (eastern Siberian) Peninsula, neither possessing substantial railroads.

Requirements As a base map, nothing is required but the physiographic imagery and graticule.

Process

1. Select *New* from the **File** menu.
2. From the  (Azimuthal) menu, hold down **shift** and select *Chamberlin trimetric*.
3. Select *Parameters* from the **Projection** menu. Set the three anchor points as follows:

<i>Anchor point 1:</i>	35, -15
<i>Anchor point 2:</i>	0, 105
<i>Anchor point 3:</i>	55, 165

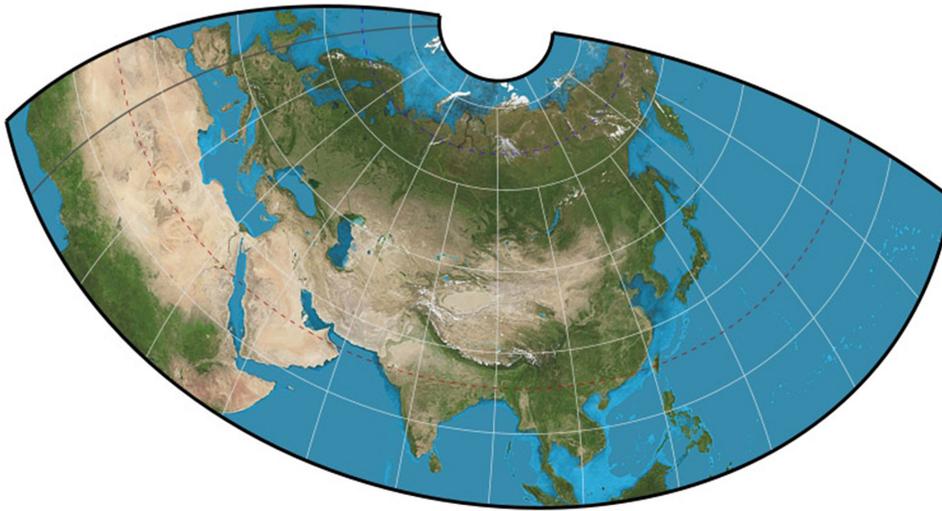
The great circles connecting these points roughly delimit the area of minimal scale error.

4. Select *Boundaries* from the **Map** menu. Select *Boundaries are defined relative to graticule* so that the boundaries you enter next will be the graticule extents that form the boundary of the map. In the *Corners* palette, enter these values:

<i>North:</i>	80°N	<i>South:</i>	1°N
<i>West:</i>	11°W	<i>East:</i>	179°E

5. Click *OK*. This defines the extent of the map.
6. Select the *Nominal Scale* item from the **Map** menu.
7. Set a nominal scale of 1: 100,000,000 by typing 100000000 into the top field. Click *OK*.

Result



Example Ten Result—Base map of Asia

Continuation for Pro version

8. If you purchased the Professional edition and have installed the DCW data set, you may continue on to add railroads. **Warning:** This will make an enormous map that can take many minutes to image.
9. From the **Map** menu, select **Databases**. Select from *Databases to draw on the map*:

Stylized World Topo 5400x2700.raw

10. Click *Remove*.
11. Click *Add Installed Database*.
12. From the list of available databases, select:

Stylized World Topo 21600x10800.raw

13. Click *Open*.
14. In the list of available databases, you should see the DCW folder. Open that. Two subfolders of interest should be visible: *Eurnasia* and *Sasaus*, meaning “Europe and Asia” and “South Asia and Australia”. You will perform the same steps for both.
15. Open the *Eurnasia* folder. You should see a list of folder, one names *RR*. Open that folder. Select all of its contents. Click *Open*.
16. Repeat the last step except with the *Sasaus* folder.
17. Click *OK*.
18. From the **Map** menu, select **Line Styles** to open the **Line Styles** dialog box.
19. Select the *Coverage: Railroad* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to some dark yellow. (You can click on the rectangle to the right of *Stroke color* to bring up a color picker.)
20. Select the *Coverage: Railroad: Multiple track: Inoperative* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to red. (You can click on the rectangle to the right of *Stroke color* to bring up a color picker.)

21. Select the *Coverage: Railroad: Single track: Inoperative* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to red. (You can click on the rectangle to the right of *Stroke color* to bring up a color picker.)
22. Click *OK*.
23. Select the ***Nominal Scale*** item from the **Map** menu. Set a nominal scale of 1: 7,400,000 by typing 7400000 into the top field. Click *OK*.
24. Select ***Final Quality*** from the **Map** menu.
25. From the **File** menu, select ***Size Document to Content***. Accept the default values and click *OK*. Confirm that you can see the network of railroads.

Example Eleven

A political map of Africa

- Analysis** A political map usually needs minimal scale distortion so that a viewer can measure distances reasonably accurately. There is no need for special direction properties. The region is vaguely circular or triangular in shape when viewed from a north-south perspective. But if we throw away a north-south prejudice and instead view it from northwest to southeast, including Madagascar, we find it to be roughly rectangular or oval.
- Conclusion** Miller obliterated stereographic, rotated -35° , centered on 3°N , $18^\circ30'\text{E}$, with east-west minimum-error radius of 33° and a north-south radius of 41° , will show all of Africa and Madagascar conformally and with distortion under 5.3%.
- Technical Note** The center of this projection is also the center of the region of interest, and it was found as follows: The Miller obliterated stereographic, having been chosen as the map projection, was set up with the default parameters. The boundaries were cropped to just the African continent with some margin. A guess was made for the center of the region of interest, and entered as the projection's center. Distortion visualization (**Map** menu) was turned on in order to see the distortion pattern. The projection center and rotation were adjusted until the distortion pattern looked symmetrical around the extreme points of the continent and Madagascar. The projection parameters were experimented with until the scalar distortion at the center point and at the extremities were the same value. The result looks like this:
- Requirements** The map will include all available geographical and geopolitical data. Final output will be to an illustration program for finishing. The purpose is a Web graphic.

Process

1. Select **New** from the **File** menu.
2. From the  (Azimuthal) menu, hold down **shift** and select **obliterated stereographic**.
3. Select **Projection Center** from the **Projection** menu. Type 3 into the *Latitudinal* field and 18.5 into the *Longitudinal* field. Type -35 into the *Transversal* field. This centers the projection in the middle of the low-distortion oval and orients it along the semi-major axis of the ellipse that will circumscribe the African continent.
4. Select **Boundaries** from the **Map** menu. In the *Boundaries (Before Projection)/Small Circle* section, enter the values:

Center:	3N	18/30N
Radius:	45	

5. Click **OK**. This defines the extent of the map as a small circle of radius 45 degrees of arc centered at the same place we centered the projection.
6. Select **Parameters** from the **Projection** menu. Type 33 in the *East/west elliptical radius in degrees* field and 41 in the *North/south elliptical radius in degrees* field. These values are half the major and minor axes of the oval within which scale error is to be minimized.
7. Select **Graticule** from the **Map** menu. Type 5 into the *Parallels spacing* and *Meridian spacing* fields. Click **OK**.
8. Select **Scale and Rotation** from the **Projection** menu. Type 35 into the *Rotate (CCW)* field. Click **OK**. This compensates for the -35° rotation around the projection axis, keeping north oriented toward the top.

of the page.

9. Select the **Nominal Scale** item from the **Map** menu. Type 50000000 in the topmost field. Click *OK*. This sets the nominal scale of the map to 1: 50,000,000.
10. From the **Map** menu, select **Databases**. From *Databases to draw on the map*, select

```
Stylized World Topo 5400x2700.raw
```
11. Click *Remove*.
12. Click *Add Installed Database*. In the list of available databases, you should see the Natural Earth folder. Open that. A folder named 50 Million should be visible; open that.
13. Open the NE2_50M_SR subfolder, and from within it, select the NE2_50M_SR.tif database, and click *Open*.
14. Click *Add Installed Database*. Navigate into the Natural Earth folder again, and the 50 Million folder within again, and open the cultural subfolder.
15. Hold down the **command** (Mac) or **CTRL** (Windows) key and select the following files:

```
50m_admin_0_boundary_breakaway_disputed_areas.shp  
50m_admin_0_map_units.shp  
50m_urban_areas.shp
```
16. Click *Open*.
17. Click *Add Installed Database*. In the list of available databases, you should see the Labels folder. Open that.
18. Hold down the **command** (Mac) or **CTRL** (Windows) key and select the following files:

```
Nations labels.txt  
World capitals labels.txt
```
19. Click *Open*. Click *OK*.
20. From the **Map** menu, select **Line Styles** to open the **Line Styles** dialog box.
21. Select the *Graticule: Meridian: Normal* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to medium gray. (You can click on the rectangle to the right of *Stroke color* to bring up a color picker.)
22. Select the *Graticule: Parallel: Normal* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to the same gray you used for meridians.
23. Select the *Coverage: Political boundary: International de facto: Disputed area* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to a deep red. In the dash pattern below, type 6 3 to define a dash of length 6 points with spaces of 3 points.
24. Select the *Coverage: Territorial shape: Country* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to the same red as the *Disputed area* line type. Set its *Alpha* value to 128 to make it halfway transparent. In the *Width (points)* field below, type 2 to create a line weight of 2 points.
25. Select the *Coverage: Territorial shape: Urban* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to a purple.
26. Select the *Coverage: City* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to a maroon. Set the *Width (points)* field below to 4. Click *OK*.

27. From the **Map** menu select *Final Quality*.

Result



Example Eleven Result—Political map of Africa

Example Twelve

A base for a road map of the United States

- Analysis** The United States is divided into three major geographical sections: the contiguous 48 States, Alaska, and Hawaii. Nobody drives to Hawaii, so it need not be spatially connected with the main map. For practical purposes, Alaska need not be connected either since automobile traffic between there and the Lower 48 is very light. Thus each region may be represented by its own, independent map, but they should all have the same scale. For measuring distances scale error is the prime concern, and if the whole United States were to be represented on one map then GS50 would be the correct choice. For the 48 states a conic is better.
- Conclusion** Equidistant conic with standard parallels at $29^{\circ}30'$ and $45^{\circ}30'$ has the least scale error, slightly beating Albers equal-area conic and Lambert conformal conic. Alaska, being roughly circular, will take Airy, centered at 63°N and $148^{\circ}30'\text{W}$, and using a minimum-error radius of 8° . The Hawaiian archipelago is quite narrow and roughly follows a great circle route, so we will use a plate carrée centered at 23°N , $157^{\circ}30'\text{W}$ and rotated transversally 30° in order to attain correct scale along the center of the chain and perpendicular to it.
- Technical Note** The standard parallels given above for the equidistant conic have been used for decades in Albers maps of the United States. They were verified to give the least scale error in the equidistant conic map by using the *Distortion Visualization* function off the **Map** menu to compare to other similar candidate parallels, all of which produced higher distortion figures. The minimum-error range for Airy was determined in the same fashion as described by the Technical Note of Example Eleven. The rotation for Hawaii was measured by making the same map without rotation and then using *Scale and Rotate* to rotate the map until the archipelago became roughly horizontal. The needed value is the negative of that angle.
- Requirements** The map will include all available geographical and geopolitical data. Final output will be printed. Alaska and Hawaii will appear true to scale but be placed directly above the mainland map.

Process

1. Select **New** from the **File** menu.
2. Select **New** from the **Map** menu.
3. Select equidistant (equidistant conic) from the  (Conic) menu.
4. Select the **Nominal Scale** item from the **Map** menu. Type 15000000 into the topmost field. Click **OK**. This sets the nominal scale of the map to 1: 15,000,000.
5. Select **Boundaries** from the **Map** menu. In the *Boundaries (Before Projection)* pane, *Corners* item, fill in the values:

North:	<input type="text" value="50N"/>	South:	<input type="text" value="24N"/>
West:	<input type="text" value="128W"/>	East:	<input type="text" value="64W"/>

6. Click **OK**. This defines the extent of the mainland map.
7. Select **Projection Center** from the **Projection** menu. The average of the east and west extents of the map is $\frac{1}{2}(-128^{\circ} + -64^{\circ}) = -96^{\circ}$, so set the *Longitudinal* rotation to -96 to bring the center of the projection to the center of the map extents. Click **OK**.
8. From the **Projection** menu select the **Parameters** item. Enter the parameters:

Standard parallel 1:	29/30
Standard parallel 2:	45/30

9. Click *OK*. This optimizes the equidistant conic projection for the conterminous US.
10. Select **Graticule** from the **Map** menu. Type 5 into the *Parallel spacing* field and also into the *Meridian spacing* field. Click *OK*.
11. From the **Map** menu, select **Databases**. From Databases to draw on the map, select:

Stylized World Topo 5400x2700.raw

12. Click *Remove*.
13. Click *Add Installed Database*. In the list of available databases, you should see the `Natural Earth` folder. Open that. A folder named `10 Million` should be visible; open that.
14. Open the `NE1_HR_LC_SR_W_DR` subfolder, and from within it, select

NE1_HR_LC_SR_W_DR.tif

15. Click *Open*. This gives us a shaded-relief background with lakes and rivers.
16. Click *Add Installed Database*. Navigate into the `Natural Earth` folder again, and the `10 Million` folder within again, and open the `cultural` subfolder.
17. Hold down the **command** (Mac) or **CTRL** (Windows) key and select the following files:

10m_admin_0_boundary_lines_land.shp
 10m_admin_0_boundary_lines_maritime_indicator.shp
 10m_admin_1_states_provinces_shp.shp
 10m_urban_areas.shp

18. Click *Open*.
19. Click *Add Installed Database*. Navigate into the `Natural Earth` folder again, and the `10 Million` folder within again, and open the `physical` subfolder.
20. Select the following file:

10m_river_lake_centerlines.shp

21. Click *Open*. This adds rivers. We already have rivers in the raster layer from the `NE1_HR_LC_SR_W_DR.tif` database, but we want the rivers to ride above the political boundaries. We used the `NE1_HR_LC_SR_W_DR.tif` database for its lakes, not its rivers.
22. Click *Add Installed Database*. In the list of available databases, you should see the `Labels` folder. Open that.
23. Hold down the **command** (Mac) or **CTRL** (Windows) key and select the following files:

US states labels abbrev.txt
 US cities labels.txt

24. Click *Open*. At this point the databases are ordered like this:

NE1_HR_LC_SR_W_DR.tif
 10m_admin_0_boundary_lines_land.shp
 10m_admin-0_boundary_maritime_indicator.shp
 10m_admin_1_states_provinces_shp.shp
 10m_urban-areas.shp

```
10m_rivers_lake_centerlines.shp
US_states_labels_abbrev.txt
US_cities_labels.txt
```

25. But we want international boundaries to draw above state/provincial boundaries. Hold down the **command** (Mac) or **CTRL** (Windows) key and select the following from the list of installed databases:

```
10m_admin_0_boundary_lines_land.shp
10m_admin_0_boundary_maritime_indicator.shp
```

26. There is a down arrow button (Mac) or *Down* button (Windows) just below the *Add any database* button. Click twice on the down button to move the international boundaries downward and force their draw sequence to be later than urban areas. We want rivers to be last so that they draw on top of any boundaries. Because we will leave their line width to be narrow, we will still be able to see the boundaries underneath.
27. Click *OK*. The vector databases are now added to the map and ordered front-to-back how we want them.
28. From the **Map** menu, select **Line Styles** to open the **Line Styles** dialog box.
29. Select the *Graticule: Meridian: Normal* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to dark gray, so that each of *Red*, *Green*, and *Blue* are at 75. Set the *Alpha* to 225.
30. Select the *Graticule: Parallel: Normal* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to dark gray, so that each of *Red*, *Green*, and *Blue* are at 75. Set the *Alpha* to 225.
31. Select the *Coverage: City* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to a dark maroon. Set the *Width (points)* field below to 4. Click *OK*.
32. Select the *Coverage: Political boundary: International de facto* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to the a deep red. In the *Width (points)* field below, type 2 to create a line weight of 2 points.
33. Select the *Coverage: Territorial shape: Provincial* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to mauve (*Red* = 210, *Green* = 50, *Blue* = 95). Set the *Width (points)* field below to 1, and set the *Alpha* to 196. Click *OK*.
34. Select the *Coverage: Territorial shape: Urban* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to a deep purple. Set the *Width (points)* field below to 1. Click *OK*.
35. From the **Map** menu select **Final Quality**.
36. Wait for Geocart to finish, and verify that the map looks like this:
37. Select **Copy** from the **Edit** menu, and then **Paste** from the same menu.
38. Select **Airy** from the  (Azimuthal) menu.
39. Select **Boundaries** from the **Map** menu. Enter the following values in the *Corners* item of the *Boundaries (Before Projecting)* pane:

North:	<input type="text" value="72N"/>	South:	<input type="text" value="50N"/>
West:	<input type="text" value="170W"/>	East:	<input type="text" value="128W"/>

40. Click *OK*. This defines the extent of the Alaska map.
41. From the **Projection** menu, select **Projection Center**. Set *Latitudinal* to 61N, and *Longitudinal* to 150W.

We center on Anchorage rather than the center of the map extents, since most of Alaska is not accessible by road. Click *OK*.

42. From the **Projection** menu select the *Parameters* item. Type 8 into the *Radius of minimum error* field. Click *OK*. This sets the radius of the optimized area. Again, since most of Alaska is not accessible by road, we concern ourselves with the region around Anchorage. Click *OK*.
43. From the **Projection** menu select the *Stretch and Rotation* item. Set the *Rotate (CCW)* field to 8.25. This compensates for the tilt the map acquired as a consequence of the projection center not coinciding with the center of the extents of the map. This value was not computed, but merely homed in on visually. Click *OK*.
44. Wait for Geocart to finish, and verify that the map looks like the one at right. Then click anywhere on the map and, holding the mouse button down, drag it away from the mainland map.
45. Select *Copy* from the **Edit** menu, and then *Paste* from the same menu.
46. From the  (Cylindrical) menu, select *plate carrée*.
47. Select *Boundaries* from the **Map** menu. Enter the following values in the *Corners* item of the *Boundaries (Before Projecting)* pane:

<i>North:</i>	<input type="text" value="24N"/>	<i>South:</i>	<input type="text" value="18N"/>
<i>West:</i>	<input type="text" value="162W"/>	<i>East:</i>	<input type="text" value="152W"/>

48. Click *OK*. This defines the extent of the Hawaii map.
49. From the **Projection** menu select the *Projection Center* item. Enter these values:

<i>Latitudinal:</i>	<input type="text" value="23N"/>
<i>Longitudinal:</i>	<input type="text" value="157/30W"/>
<i>Transversal:</i>	<input type="text" value="30"/>

50. Click *OK*. This centers the projection and sets the line of constant scale along the axis of the islands.
51. From the **Projection** menu, select *Stretch and Rotation* and type -30 in the *Rotation (CCW)* field. This compensates for reorientation caused by the projection rotation. Click *OK*.
52. Wait for Geocart to finish, and verify that the map looks like the one at right. Then click anywhere on the map and, holding the mouse button down, drag it away from the mainland map.
53. Arrange the three maps so that they look like the result.

Result



Example Twelve Result—Base for a road map of the US

Example Thirteen

A high-accuracy map of Japan

- Analysis** Japan is small enough that the choice of map projection begins to become irrelevant. However, even though it is narrow it is also quite long, so we must be careful to make a projection having low distortion along its axis. We will not concern ourselves with the amount of distortion away from the main islands.
- Conclusion** Mercator, based on the WGS 84 ellipsoid, centered at 36°N, 136°30'E, rotated by -50°, and scaled up by a factor of 1.00055, will give a conformal map with distortion below 0.08% across the main islands. This is only one fourth the distortion of a transverse Mercator.
- Technical Note** The center point of the map is an estimation. The rotation angle was determined in the same way as described in the Technical Note of Example Twelve. The optimum scale factor can be determined by formula, but in the absence of a formula it can be decided empirically, using the Distortion Visualization facility. The scale distortion along the spine of the projection should equal the distortion at the edges of the region of interest.
- Requirements** The map will include national and subnational boundaries on satellite imagery. Final output will be to an illustration program for finishing.

Process

1. Start Geocart.
2. From the **File** menu, select **New**.
3. From the **Map** menu, select **New** to create a map.
4. From the  (Cylindric) menu, select **Hotine**. This is an ellipsoidal oblique form of the Mercator. Notice that the datum has automatically changed to WGS 84. (See the **Information** palette.) There is no spherical form for Hotine. We could achieve the same results by selecting Mercator, setting an ellipsoidal datum, and then changing the projection center to create an oblique aspect.
5. From the **Map** menu, select **Boundaries**. Click *Boundaries are defined relative to graticule*. We do this so that the boundaries we set won't move when we change the projection center later. In the *Boundaries (Before Projection)* pane, set the *Corners* values:

North:	<input type="text" value="49N"/>	South:	<input type="text" value="15N"/>
West:	<input type="text" value="120E"/>	East:	<input type="text" value="150E"/>

6. Click **OK**.
7. From the **Projection** menu, select **Projection Center**. Enter the values:

Latitudinal:	<input type="text" value="36N"/>
Longitudinal:	<input type="text" value="136/30E"/>
Transversal:	<input type="text" value="-50"/>

8. Click **OK**. This sets up the oblique aspect with axis down the spine of Japan.
9. From the **Projection** menu, select **Stretch and Rotation**. Enter 51/45 as the *Rotation (CCW)*, meaning 51°45'. This undoes the projection rotation to orient the map with north up. It is not exactly 50° because the map is not symmetrical about the projection center. The value was found by trial, so that the upper left and upper right corners align horizontally. Click **OK**.

10. From the **Map** menu, select **Databases**. From *Databases to drawn on the map*, select:

Stylized World Topo 5400x2700.raw

11. Click *Remove*.

12. Click **Add Installed Database**. From the list of available databases, select:

Stylized World Topo 21600x10800.raw

13. Click *Open*.

14. Click *Add Installed Database*. Navigate into the `Natural Earth` folder, and within that, the `10 Million` folder. Open the `physical` subfolder.

15. Hold down the **command** (Mac) or **CTRL** (Windows) key and select the following files:

10m_lakes.shp
10m_river_lake_centerlines.shp

16. Click *Add Installed Database*. Navigate into the `Natural Earth` folder again, and the `10 Million` folder within again, and open the `cultural` subfolder.

17. Hold down the **command** (Mac) or **CTRL** (Windows) key and select the following files:

10m_admin_0_boundary_maritime_indicator.shp
10m_admin_0_breakaway_disputed_areas.shp
10m_admin_1_states_provinces_lines_shp.shp

18. Click *Open*. The disputed areas are relevant to Japan, so we have installed the database for them. We do not install international boundaries over land because they are not relevant to Japan and they would superpose over the disputed areas boundaries.

19. Click *Open*. Click *OK*.

20. From the **Map** menu, select **Line Styles** to open the **Line Styles** dialog box.

21. Select the *Coverage: Political boundary: International de facto* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to:

<i>Red:</i>	196
<i>Green:</i>	0
<i>Blue:</i>	0
<i>Alpha:</i>	196

22. This sets the international boundaries color to a partially transparent red. In the *Width (points)* field below, type 3 to create a line weight of 3 points.

23. Select the *Coverage: Political boundary: Provincial* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to:

<i>Red:</i>	196
<i>Green:</i>	196
<i>Blue:</i>	0
<i>Alpha:</i>	196

24. This sets the prefecture boundaries to a partially transparent yellow. In the *Width (points)* field below, type

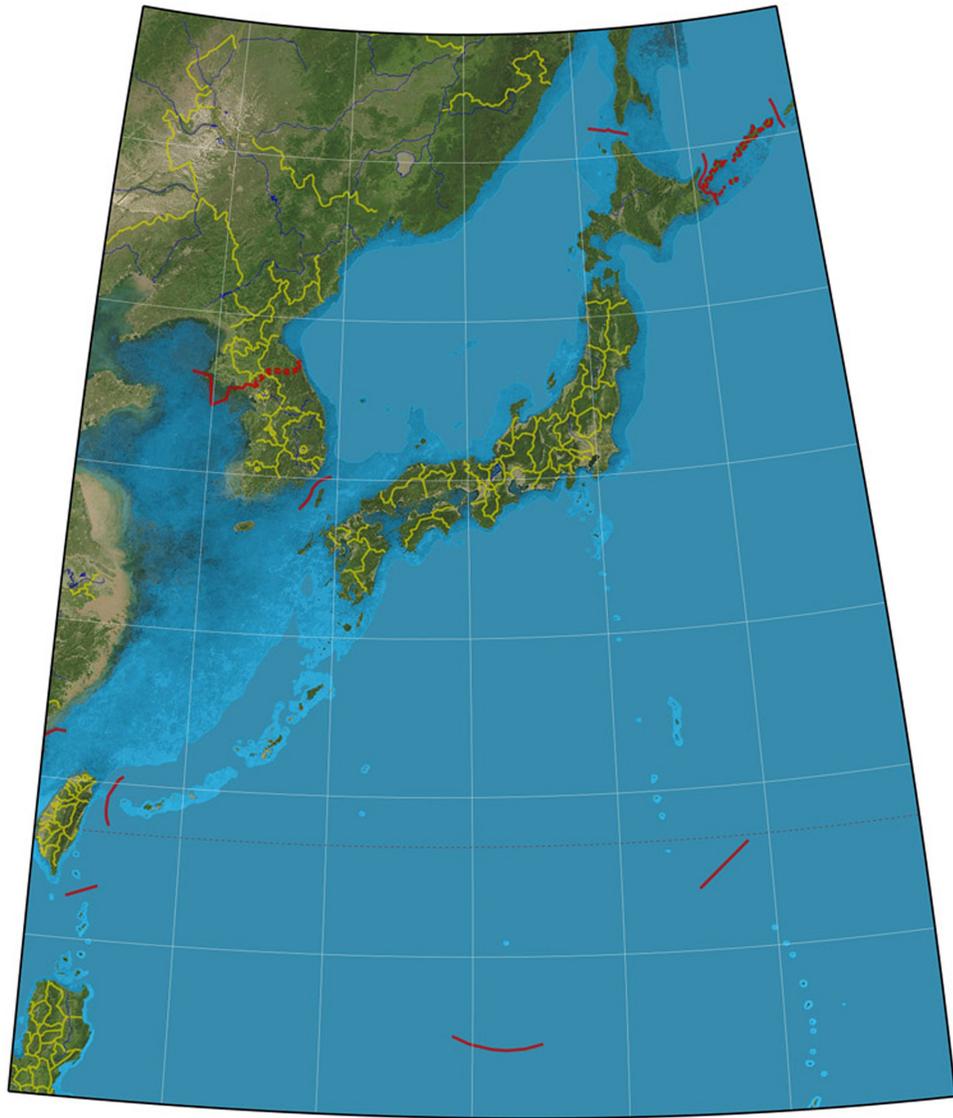
2 to create a line weight of 2 points.

25. Select the *Coverage: Territorial shape: International de facto: Breakaway or disputed area* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to:

<i>Red:</i>	196
<i>Green:</i>	0
<i>Blue:</i>	0
<i>Alpha:</i>	196

26. Set the *Width (points)* field below to 3, and set the *Dash pattern* to 6 3. Click *OK*.
27. From the **Map** menu, select **Graticule**. Ensure that *Draw parallels* is selected, and enter 5° as the *Parallel spacing*. Ensure that *Draw meridians* is selected, and enter 5° as the *Meridian spacing*. Click *OK*.
28. Select **Final Quality** from the **Map** menu.
29. From the **Map** menu, select **Nominal Scale**. Enter 10000000 into the top field to set a scale ratio of 1: 10,000,000. Click *OK*.
30. From the **File** menu, select **Size Document to Content**.

Result



Example Thirteen Result—High-accuracy map of Japan

Example Fourteen

A base for a cultural map of France

- Analysis** A cultural map has no need of high accuracy, and France is not very large anyway. Any projection with correct scale at its center will do fine.
- Conclusion** Use the azimuthal equidistant projection.
- Requirements** The map will consist of a hypsometric background with international and departmental borders superposed. It will be completed in an illustration program, suitable as a Web graphic.

Process

1. Start Geocart.
2. From the **File** menu, select *New*.
3. From the  (Azimuthal) menu, hold down **shift** and select *equidistant* (azimuthal equidistant).
4. From the **Projection** menu, select *Projection Center*. Set *Latitudinal* to 47 and *Longitudinal* to 1.5. The centers the projection at the average of the boundaries we will use below. Click *OK*.
5. From the **Map** menu, select **Boundaries**. In the **Boundaries (Before Projection)** pane, select **Corners** and enter the following coordinates:

North:	52N	South:	42N
West:	6W	East:	9E

6. Click *OK*.
7. From the **Map** menu, select *Databases*. From *Databases to draw on the map*, select:
Stylized World Topo 5400x2700.raw
8. Click *Remove*.
9. Click *Add Installed Database*. In the list of available databases, you should see the Natural Earth folder. Open that. A folder named 10 Million should be visible; open that.
10. Open the HYP_HR_SR_W_DR subfolder, and from within it, select:
HYP_HR_SR_W_DR.tif
11. Click *Open*. This gives us a shaded-relief background with lakes and rivers.
12. Click *Disable filtering*. The supplied databases do not need filtering, which would render them slightly more blurry.
13. Click *Add Installed Database*. Navigate into the Natural Earth folder again, and the 10 Million folder within again, and open the physical subfolder.
14. Hold down the **command** (Mac) or **CTRL** (Windows) key and select the following files:
10m_coastline.shp
10m_lakes.shp
10m_river_lake_centerlines.shp
15. Click *Open*. This adds rivers. We already have rivers in the raster layer from the HYP_HR_SR_W_DR.tif database, but we want the rivers to ride above the political boundaries. We used

the HYP_HR_SR_W_DR.tif database for its lakes, not its rivers.

16. Click *Add Installed Database*. Navigate into the Natural Earth folder again, and the 10 Million folder within again, and open the cultural subfolder.

17. Hold down the **command** (Mac) or **CTRL** (Windows) key and select the following files:

```
10m_admin_0_boundary_lines_land.shp
10m_admin_1_states_provinces_shp.shp
10m_urban_areas.shp
```

18. Click *Open*.

19. Because we want the urban areas to draw earlier, so that the other coverage obscure them if they overlap, click on 10m_urban_areas.shp and, using the arrow buttons below, maneuver the database to the top of the list of vector databases. Its position with respect to HYP_HR_SR_W_DR does not matter; raster databases always get drawn before vector. Click *OK*.

20. From the **Map** menu, select **Line Styles**. Select the *Graticule* line style and select *Hide coverage and all children* from the pop-up menu under *Definition for this coverage*.

21. Select the *Coverage: Ocean: Coast* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to:

<i>Red:</i>	120
<i>Green:</i>	155
<i>Blue:</i>	200
<i>Alpha:</i>	255

22. This sets a slate blue transition between the land and water. In the *Width (points)* field below, set a line weight of 2.5 points. We will use this coverage to obscure the coastal segments of the provincial coverage. We could have chosen the 10m_admin_1_states_provinces_lines_shp.shp database instead, which does not contain coastal segments, but then the French *departments* would not be polygons. If we wish to color the departments in a graphics editing program, we will want polygons.

23. Select the *Coverage: Political boundary: International de facto* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to:

<i>Red:</i>	196
<i>Green:</i>	0
<i>Blue:</i>	0
<i>Alpha:</i>	196

24. This sets the international boundaries to a partially transparent red. In the *Width (points)* field below, type 6 to create a line weight of 6 points. Overlaying the wider international boundary on top of the narrower departmental boundaries will give a cased-line effect.

25. Select the *Coverage: Territorial shape: Provincial* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to:

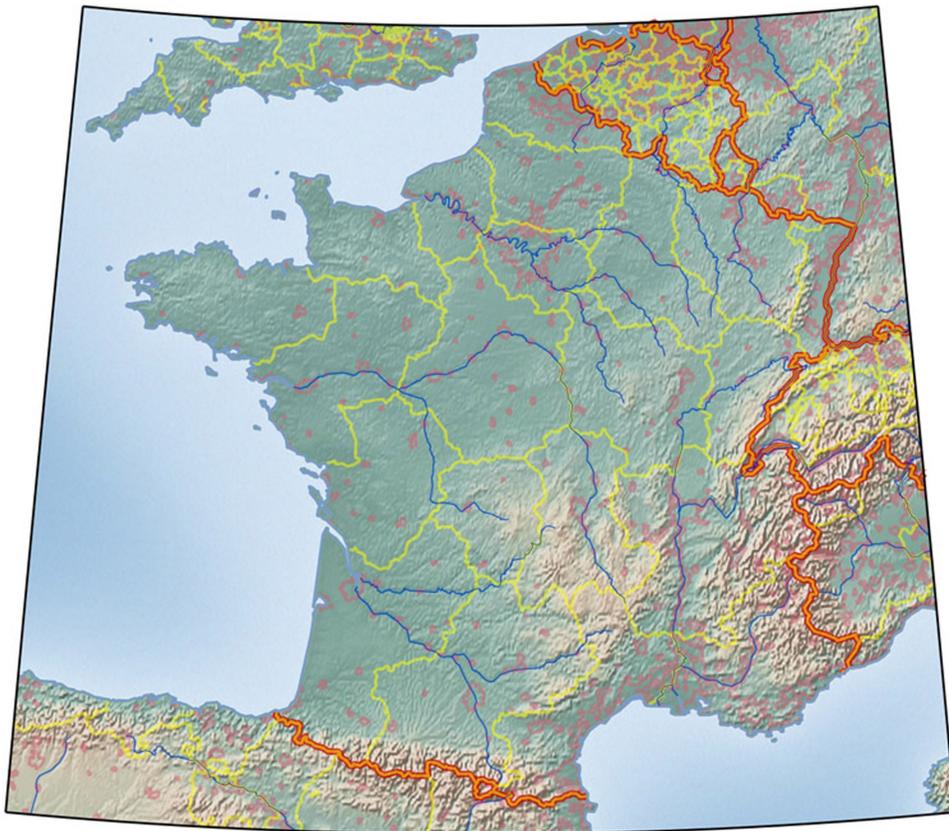
<i>Red:</i>	255
<i>Green:</i>	255
<i>Blue:</i>	0
<i>Alpha:</i>	128

26. Set the *Width (points)* field below to 2 . 5. Click *OK*. This gives a bright, but translucent, yellow line for department boundaries.
27. Select the *Coverage: Territorial shape: Urban* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to:

<i>Red:</i>	210
<i>Green:</i>	95
<i>Blue:</i>	115
<i>Alpha:</i>	128

28. Set the *Width (points)* field below to 3. This gives a translucent light salmon coloring for urban areas.
29. Click *OK* to close the **Line Styles** dialog box.
30. Select ***Final Quality*** from the **Map** menu.
31. From the **Map** menu, select ***Nominal Scale***. Enter 4000000 in the top field to set a nominal scale of 1: 4,000,000. Click *OK*.

Result



Example Fourteen Result—A base for a cultural map of France

Example Fifteen

Small-scale, high resolution raster reprojection

Requirements You will start with a high resolution image called `MCR0001_circumpolar_2008.jpg`, an image from the Natural Resources Canada's *Atlas of Canada*.¹ The resolution of the image is 2.08333 pixels per point, with dimensions of 6,135 x 5,154 pixels. The map states that it has a nominal scale of 1: 9,000,000 on the azimuthal equidistant projection. The task is to create a raster reprojection database so that maps of other projections can be made from the image. In particular, you need an equal-area map.

Creating the database

1. Start Geocart.
2. From the **File** menu, select *New*.
3. From the **Geocart** menu (Mac) or the **File** menu (Windows), open the *Preferences* submenu and select **General**. In the *General* tab, select *points (72/inch)* as the *Unit of measure for rulers and display*.
4. Click *OK*.
5. From the **Window** menu, select *Information* to open the **Information** palette. You will refer to the info palette during subsequent operations. It will also be helpful to use the **Navigator** palette. Select *Navigator* from the **Window** menu.
6. From the **File** menu, select *Place Image*. Navigate to:
 - (Mac)
Library/Application Support/Mapthematics/Geocart/Version 3/
Sample Documents/MCR0001_circumpolar_2008.jpg
 - (Windows XP)²
C:\Documents and Settings\All Users\Application Data\
Mapthematics\Geocart\Version 3\Sample Documents\
MCR0001_circumpolar_2008.jpg
 - (Windows Vista+)³
C:\ProgramData\Mapthematics\Geocart\Version 3\Sample Documents\
MCR0001_circumpolar_2008.jpg
7. Click *Open*. You should see a detailed polar map filling your document.
8. Move your cursor over the image and note that the **Information** palette details the location of the file, the pixel size of the image, the color format of the image, and the resolution (2.08333 pixels/point).
9. From the **File** menu, select *Size Document to Content*. Accept the default values by clicking *OK*.
10. Examining the map, note that the parallel spacing is 5° and the meridian spacing is 10°. Note that the map does not extend further south than 35°N. Note that the central meridian is 90°W.
11. From the  (Azimuthal) menu, hold down **shift** and select *equidistant* (azimuthal equidistant).
12. From the **Map** menu, select *Databases*. Select any databases present and click *Remove*. Click *OK*.

1 NRC makes this image available "... with the intent that it be readily available for commercial, personal and public use and may be reproduced, in part or in whole and by any means, without charge or further permission from Natural Resources Canada."

2 Windows hides this directory, ostensibly for your protection. See [Appendix G](#) for how to make it visible.

3 Windows hides this directory, ostensibly for your protection. See [Appendix G](#) for how to make it visible.

13. To match the graticule spacing of your projection to the base image, select **Graticule** from the **Map** menu. Ensure that *Draw parallels* and *Draw meridians* are selected. Set *Parallel spacing* to 5 and *Meridian spacing* to 10. Click *OK*.
14. From the **Projection** menu select **Projection Center**. Set the *Longitudinal* field to 90W so that the central meridian coincides with the base image's.
15. From the **Map** menu select **Boundaries**. We noted the southernmost extent of the map was 35°N, which is 55° from the north pole. Select *Small circle*, and set its fields:

<i>Center:</i>	90N	0N
<i>Radius:</i>	55	

16. Click *OK*. Your overlay map now has approximately the same extents as the image.
17. To make your projection overlay's graticule stand out, select **Line Styles** from the **Map** menu. Select the *Graticule* line type, and at the right, under *Definition for this coverage*, select *Define new attributes* from the pop-up menu. Set the *Stroke color* to:

<i>Red:</i>	255
<i>Green:</i>	0
<i>Blue:</i>	0
<i>Alpha:</i>	128

18. Set the *Width (points)* field below to 0.48. This is 1/2.08333 so that the line width will be one pixel wide at full resolution. The line will be translucent because of the medium alpha value.
19. Click *OK* to close the **Line Styles** dialog box. You will receive a graticule transparency warning; ignore it.
20. From the **Map** menu select **Map Size and Resolution**. At the *Resolution* field, select *pixels/point* from the pop-up menu. Enter 2.08333 in its field in order to match the map image. Click *OK*.
21. From the **Map** menu select **Nominal Scale**. Set the first field to 9000000 for a scale ratio of 1: 9,000,000. Click *OK*. The overlay map will take some time to image.
22. From the **View** menu select Actual Pixels of **Selected Object**. This lets you position your overlay precisely.
23. Click around in the **Navigator** palette until you find the center of your overlay image, where the meridians converge at the north pole. Drag your overlay so that its north pole coincides with the underlying image's north pole. Precision is important. Clicking around in the **Navigator** palette or scrolling around, confirm that the overlay's graticule aligns precisely with the underlying map's graticule throughout the map.
24. From the **File** menu, select **Export Database**. Choose a folder to export your database into. Title your database AtCanPolar. Click *Export*. You may now use your database to create maps on other projections.
25. Close your database document.

Using your database

26. From the **File** menu select **New**.
27. From the  (Conic) menu, holding down the **shift** key, select **Albers**.
28. From the **Map** menu select **Boundaries**. Like the database map, set the boundaries by *Small circle*:

<i>Center:</i>	90N	0N
<i>Radius:</i>	55	

29. Click *OK*.
30. From the **Projection** menu select **Parameters**. Because this is a map of only the northern countries, high standard parallels are appropriate. Ignore *Latitude of origin*. Enter these values:

<i>Standard parallel 1:</i>	55
<i>Standard parallel 2:</i>	70

31. Click *OK*.
32. From the **Map** menu select **Graticule**. The database image already has a graticule, so deselect *Draw parallels* and deselect *Draw meridians*. Click *OK*.
33. From the **Map** menu select **Database**. Select any databases present in the *Databases to draw on the map* section, and click *Remove*. Click *Add any database* and navigate to the `AtCanPolar.geo3db` database you created. Click *Open*. Click *OK*.
34. From the **Map** menu select **Map Size and Resolution**. Select *pixels/point* from the pop-up menu on the *Resolution* field. Enter 2 into the *Resolution* field to set 2 pixels/point. Click *OK*.
35. From the **Map** menu select **Nominal Scale**. Enter 8000000 into the first field to set a scale ratio of 1: 8,000,000. Click *OK*. The map will take a long time to draw.
36. At any time while drawing or after, select **Size Document to Contents** from the **File** menu. Click *OK*, accepting the default values.

Result

You will have converted a non-equal-area azimuthal map to an equal-area conic, and changed its scale and resolution. The results are publication quality throughout the map except in the regions of highest distortion, where the text looks odd, but remains legible.



Example Fifteen Result—Reprojected circumpolar map

Example Sixteen

Large-scale reprojection with datum shift

Requirements You will start with an image called `Sample UTM NAD27.tif`. The resolution for this image is 4.16667 pixels/point, and the geographical coordinates for its corners are:

N = 33°59'30"N
S = 33°56'0"N
E = 124°13'12"W
W = 124°19'00"W

The parallels are spaced at every 30" (note: seconds rather than degrees); and the meridians are spaced at 36". The map projection is UTM on a NAD27 datum. Your task is to create a new map from this image rendered against the NAD83 datum at a scale of 1: 12,000.

In this exercise you will:

- Convert a TIFF image of a topographic map as a database.
- Reproject the database.
- Apply a datum shift.

The TIFF image you will be using is a *large scale map*, meaning that it has a low scale ratio (e.g. 1: 25,000). These maps are typically used to convey detailed information such as topography, or city planning schemes.

Creating a database

1. Start Geocart.
2. From the **File** menu, select *New* to create a new document.
3. From the **Geocart** menu (Mac) or the **File** menu (Windows), open the *Preferences* submenu and select **General**. In the *General* tab, select *points (72/inch)* as the *Unit of measure for rulers and display*.
4. Click *OK*.
5. From the **Window** menu, select *Information* to open the **Information** palette. You will refer to the info palette during subsequent operations.
6. From the **File** menu, select *Place Image*. Navigate to:

(Mac)
Library/Application Support/Mathematics/Geocart/Version 3/
Sample Documents/Sample UTM NAD27.tif

(Windows XP)⁴
C:\Documents and Settings\All Users\Application Data\
Mathematics\Geocart\Version 3\Sample Documents\
Sample UTM NAD27.tif

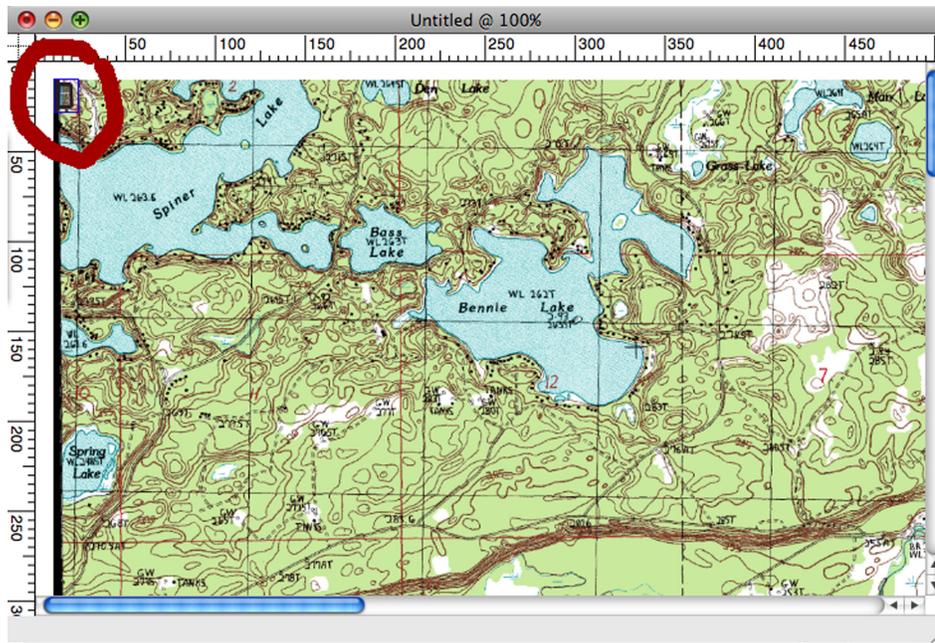
(Windows Vista+)⁵
C:\ProgramData\Mathematics\Geocart\Version 3\Sample Documents\
Sample UTM NAD27.tif

7. Click *Open*.

⁴ Windows hides this directory, ostensibly for your protection. See [Appendix G](#) for how to make it visible.

⁵ Windows hides this directory, ostensibly for your protection. See [Appendix G](#) for how to make it visible.

8. Move your cursor over the image and note that the **Information** palette details the location of the file, the pixel size of the image, the color format of the image, and the resolution (4.16667 pixels/point).
9. Holding down the **shift** key, select **UTM** from the  (Cylindrical) projection menu. **Result:** A tiny rectangular map appears at the top left of your screen, overlaying the topographic map image.



Screenshot of step 9 showing inserted UTM projection

10. From the **Projection** menu, select **Parameters**. Enter 10S as the *UTM Zone*. This is the UTM zone that covers the region of the map. See [Appendix B: Projection gazetteer for information on UTM](#). Click *OK*.
11. From the **Map** menu, select **Databases**. Select any databases present, and click *Deactivate* or *Remove*. Click *OK*.
12. From the **Projection** menu, select **Datum**. In the *Datum* section, select from the pop-up menus:

<i>Datum:</i>	North American Datum 1927
<i>Transform:</i>	1175: USA West Molodensky

13. Click *OK*.
14. From the **Map** menu, select **Boundaries**. Select *Boundaries are defined relative to graticule*.
15. In the *Boundaries (Before Projection)* section, select *Corners*, and enter the following coordinates:

<i>North:</i>	34°1'20"N	<i>South:</i>	33°58'15"N
<i>West:</i>	124°17'0"W	<i>East:</i>	124°11'35"W

Notes: You can use / between degrees, minutes and seconds. For example, 33/59/30. Ensure that you add the hemisphere (E or W) after the coordinate.

16. Click *OK*.
17. From the **Map** menu, select **Nominal Scale**. Enter 27090 into the top field to set a scale ratio of 1: 27,090. Click *OK*.
18. From the **Map** menu, select **Graticule**. Ensure that *Draw parallels* is selected, and enter 30" as the *Parallel*

spacing. Ensure that *Draw meridians* is selected, and enter 36" as the *Meridian spacing*.
Note: The default values will be degrees (°); ensure that you overwrite this with seconds (").

19. Click *OK*.
20. From the **Map** menu, select **Line Styles**. Select *Graticule* and enter 0.2 as the *Width (points)* value.
21. Click *Stroke Color*, and select black on the **Color picker**. Click *OK*.
22. From the **Map** menu, select **Map Size and Resolution**. Enter 4.16667 *pixels/point* as the *Resolution*. Ensure that *Preserve the value I don't change; rerender the map* is selected. Click *OK*.
23. From the **View** menu, select **Actual Pixels of Selected Object**. This sets your view of the image to be the full resolution of the image to help you refine the operation.
24. Move the top graticule you have created over the topographic image so that the lowest left-most graticule intersection coincides with the image's lowest left-most graticule intersection. There should be no complete graticule square off of the image all around.
25. From the **File** menu, select **Export Database**.
26. Export the file as `Sample_NAD27`. This creates the database that can be projected to any other map projection.

Using your database

27. From the **File** menu, select *New*.
28. From the **Window** menu, select **Information** to display the **Information** palette.
29. Holding down the **shift** key, select **UTM** from the  (Cylindric) projection menu.
30. From the **Projection** menu, select **Datum**. In the *Datum* section, select from the pop-up menus:

<i>Datum:</i>	North American Datum 1983
<i>Transform:</i>	1580: Molodensky

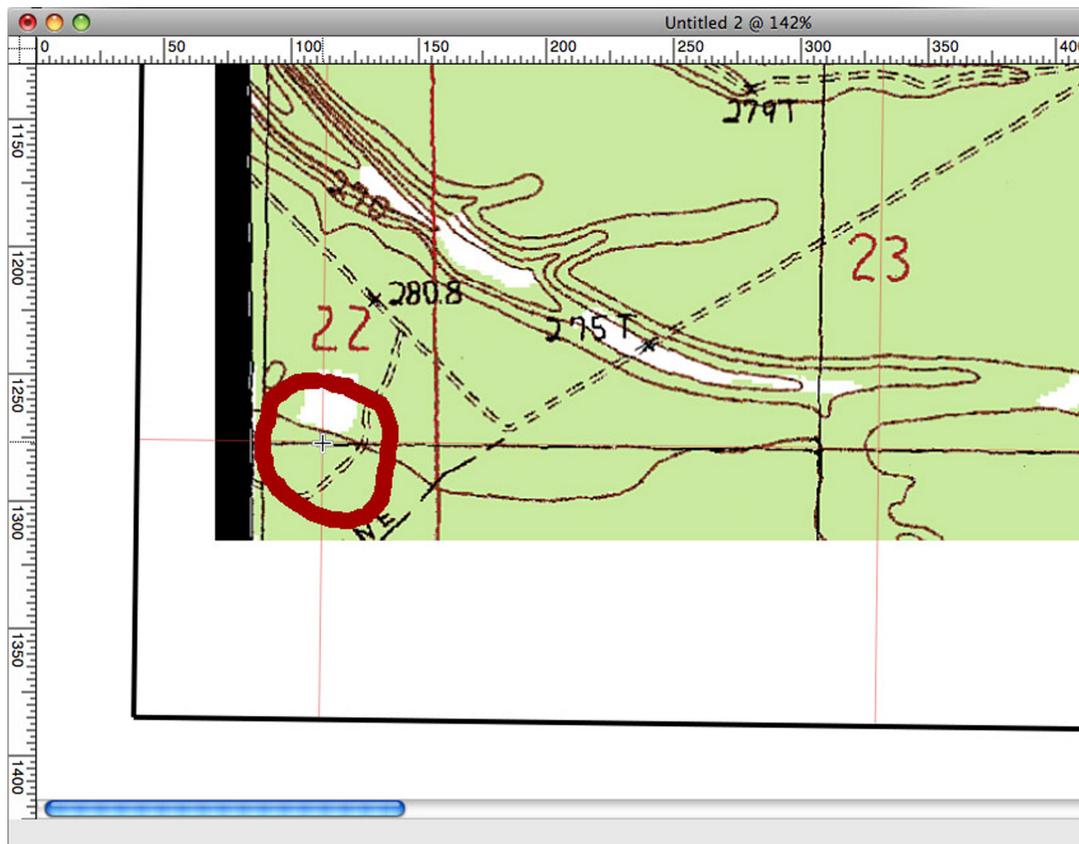
31. Click *OK*.
32. From the **Projection** menu, select **Parameters**. Enter 10S as the *UTM Zone*. Click *OK*.
33. From the **Map** menu, select **Boundaries**. Click *Boundaries are defined relative to graticule*.
34. In the *Boundaries (Before Projection)* section, select *Corners*, and enter the following coordinates:

<i>North:</i>	34°1'20"N	<i>South:</i>	33°58'15"N
<i>West:</i>	124°17'00"W	<i>East:</i>	124°11'35"W

Notes: You can use / between degrees, minutes and seconds. For example, 33/59/30. Ensure that you add the hemisphere (E or W) after the coordinate.

35. Click *OK*.
36. From the **Map** menu, select **Nominal Scale**. Enter 12000 in the top field to give a scale ratio of 1: 12,000. Click *OK*.
37. From the **File** menu, select **Size Document to Content**. Accept the default values by clicking *OK*.
38. From the **Map** menu, select **Graticule**. Ensure that *Draw parallels* is selected, and enter 30" as the *Parallel spacing*. Ensure that *Draw meridians* is selected, and enter 36" as the *Meridian spacing*. **Note:** The default values will be degrees (°); ensure that you overwrite these with seconds (").

39. Click *OK*.
40. From the **Map** menu, select **Line Styles**. Select *Graticule* and enter 0.5 as the *Width (points)* value.
41. Click *Stroke Color*, and select some shade of red on the **Color picker**. Enter 128 as the *Alpha* transparency value.
42. The following message box will be displayed: Graticule Transparency Warning. You've chosen different transparency (alpha) values for different parts of the graticule. Only the Graticule: Normal value will be used. You may ignore it. Click *OK*.
43. From the **Map** menu, select **Map Size and Resolution**. Enter 2 pixels/point. Click *OK*.
44. From the **Map** menu, select **Draft Quality**. **Note:** If you want a printable version of the map, select **Final Quality**, but depending on your computer's system speed, selecting this option may make the next step take a few minutes for the map to render.
45. From the **Map** menu, select **Databases**. Select any databases present, and click *Deactivate* or *Remove*.
46. Click *Add any database*. In the *Select database to add dialog box*, navigate to where you saved the file Sample NAD27.
47. Click *Open*. Click *OK*.
48. Allow Geocart to finish redrawing the map.
49. From the **View** menu, select **Actual Pixels of Selected Object**. This sets the full resolution of the image to help you refine the operation.
50. From the **Tool** palette, select the crosshairs cursor.
51. Position the cursor over the lower left red graticule intersection on the map. Parallels should coincide with the black pixels underneath, so it may be difficult to see. The meridians should be seen easily.



Graticule intersection with crosshairs.

52. Copy the information from the **Information** palette using **command+shift+X** (Mac) or **CTRL+SHIFT+X** (Windows) and paste into a text editor.

53. The coordinate should resemble this:

$$\phi, \lambda = 33^{\circ}58'29.987''N, 124^{\circ}16'47.989''W$$

Probably it will not be identical, but it should be close.

54. In the Web browser of your choice, navigate to the following Web site:

<http://www.ngs.noaa.gov/cgi-bin/nadcon.prl>

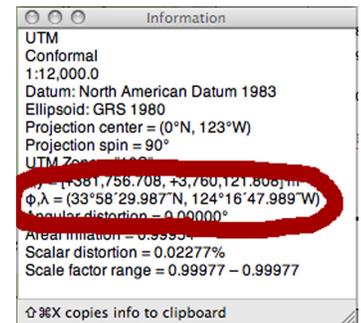
55. Paste the latitude into Web page's *Enter Latitude* field, and the longitude into the *Enter Longitude* field.

56. Edit the values you pasted to replace the degree, minute and second symbols with spaces, and remove the N and W. Round the figures to the nearest second because the graticule parallels and meridians are spaced on even seconds. For example, the values used above, should now look like:

<i>Enter Latitude:</i>	33 58 30.0
<i>Enter Longitude:</i>	124 16 48.0

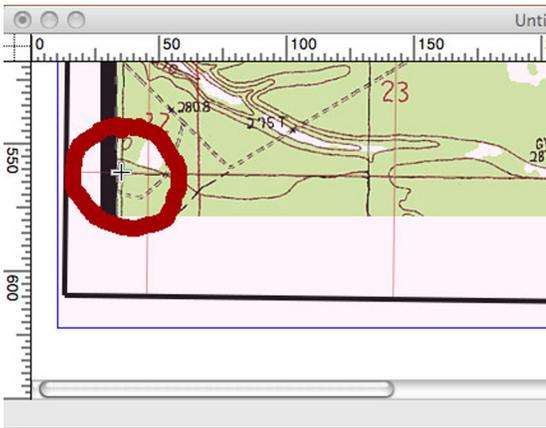
57. Click the Web page button *Compute Datum Shift for a Single Location*.

58. **Result:** You will be given a conversion from NAD 27 to NAD 83, with the new NAD 83 values listed on the *NAD 83 datum values* row.



	<i>Latitude</i>	<i>Longitude</i>	
<i>NAD 27 datum values:</i>	33 58 30.00000	124 16 48.00000	
<i>NAD 83 datum values:</i>	33 58 30.00978	124 16 51.94301	
<i>NAD 83 - NAD 27 shift values:</i>	0.00978	3.94301	(secs.)
	0.30100	101.21700	(meters)
<i>Magnitude of total shift:</i>		101.217	(meters)

59. On your Geocart map, position the crosshairs over the black graticule intersection at the map's lower left, just to the right of the thick black margin, and a short way left of the red graticule intersection you examined before.



60. With the cursor precisely aligned to the cross of the graticule, note the coordinate shown in the **Information** palette. Confirm that it is within 1 second of the value given on the NADCON site. This shows that the NAD27 map has been converted successfully to NAD83.

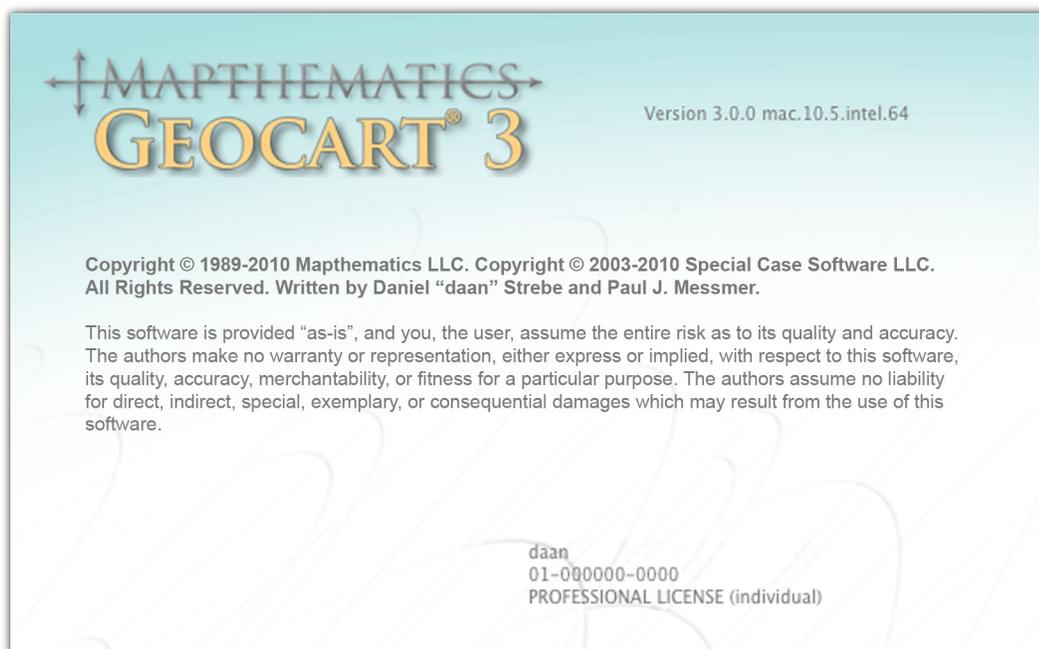
Chapter 6: Geocart menu (Mac)

This chapter describes the **Geocart** menu, which is found only on the Macintosh version. The **Geocart** menu pertains to settings and operations for the entire application.

Geocart	
About Geocart	
Preferences	▶
Services	▶
Hide Geocart	⌘H
Hide Others	⇧⌘H
Show All	
Quit Geocart	⌘Q

About Geocart

This command displays the About Box, which gives information about the Geocart product. You may need any or all of this information if you contact Mapmathematics for support. In the upper right, you can find the version number of Geocart, which operating system, and which computer processor architecture the Geocart application was created for. At lower right, the name of the license holder appears, as recorded by the person who entered the license key. Beneath that is the serial number, and beneath that is the type of license tied to the license key.



About box

Preferences

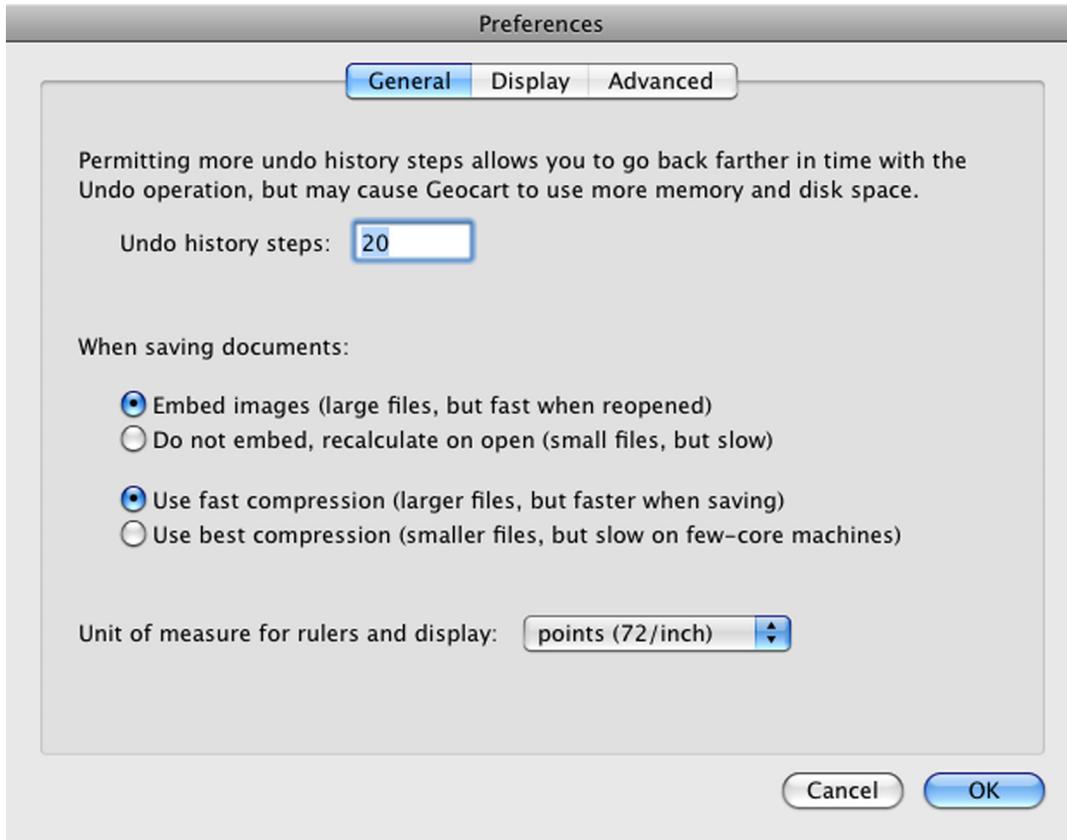
The settings available from this submenu determine how your Geocart environment behaves and what happens automatically when you create a new map.

Preferences > General

The **Preferences** dialog contains three panes for setting Geocart's environment: *General*, *Display*, and *Advanced*.

General

You can instruct Geocart to make certain trade-offs to improve your experience, depending on your computer's power and your own preferences. You can select your preference of measurement unit for rulers and dialog boxes.



General panel of Preferences dialog

Undo history steps: Geocart has an undo facility (see [Undo](#)), letting you step back through your changes in case you need to return to a previous state of your map. You can step back as far as is permitted by this control's setting. If your computer is equipped with lots of memory, you may wish to increase the number of undo steps permitted. Ultimately how much memory is consumed by an undo step depends on the map content. Generally the larger the map, the more memory it takes, both when current and when in the undo history. If you work with maps many thousands of pixels on a side, but you only have a gigabyte or two of RAM, you should cut down the number of undo steps to some minimum that you think will work well with your style of work.

Embed images: When Geocart finishes drawing a map, it keeps the completed image until you change something that requires it to redraw the map. This option instructs Geocart to retain completed images when you save your document. When you have Geocart open the document again, it won't have to redraw the map because it can just read its image out of the document's file.

vs.

Do not embed, recalculate on open: The file for a document containing a single map 10,000 x 5,000 pixels, for example, might take up 150 MB of disk space. If you are concerned about the storage space or the Internet transmission time of documents that large, you may not wish to have Geocart store the completed image into the document's file when you

save. The disadvantage is the amount of time Geocart might require to redraw the map when you open the document.

Use fast compression: Geocart always compresses images it saves in documents in order to conserve space. The compression is *lossless*, meaning the decompressed, or restored, image is identical to the saved image. Geocart supports two levels of compression: faster, or more compressed. If you are more concerned with how quickly Geocart saves documents than you are about the size of documents' files, then select *Use fast compression* option.

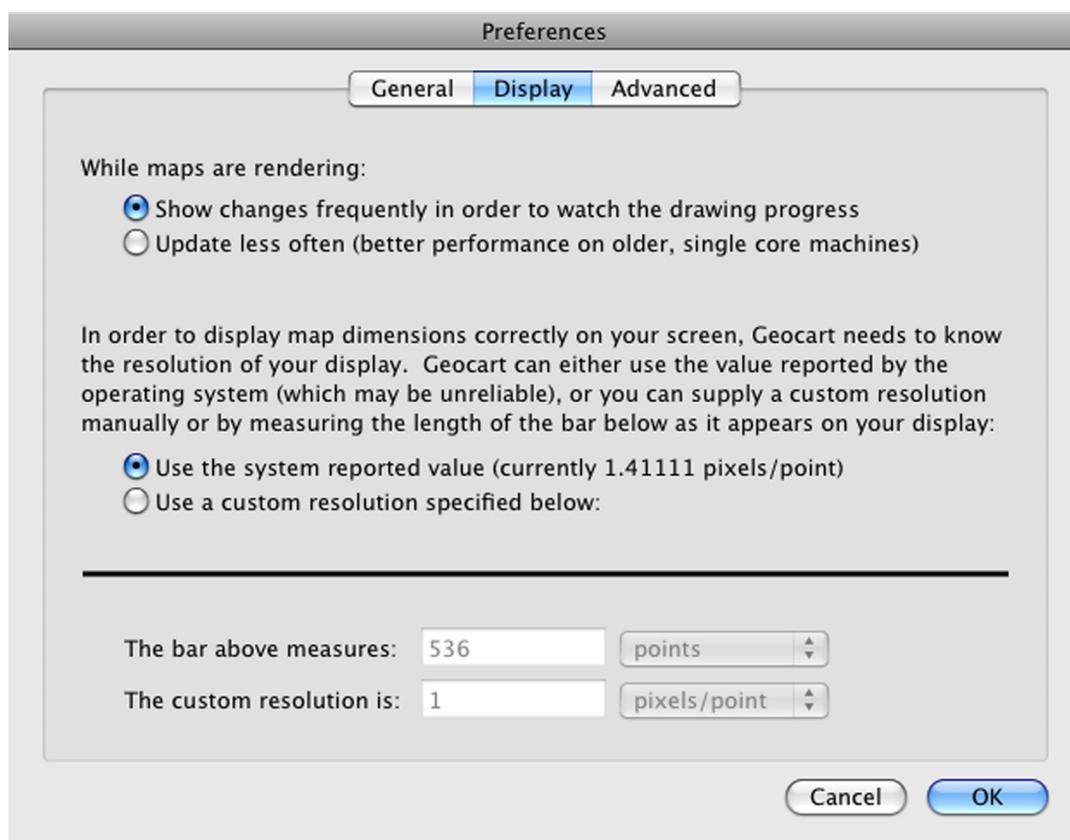
vs.

Use best compression: If you are more concerned about the size of documents' files than you are about how quickly they save to disk, then select this option.

Unit of measure for rulers and display: Choose your measurement units throughout Geocart's UI here.

Display

Settings in this panel pertain to Geocart's behavior in rendering maps.



Display panel of Preferences dialog

Show changes frequently: Geocart does not update the screen for every pixel it renders. That would slow it down drastically. Instead, it updates the screen periodically in chunks. If you prefer more of a real-time view of the map drawing, pick this option. The disadvantage is that more of the computer's processing power is stolen away from rendering the map in order to update the screen frequently.

vs.

Update less often: If you have a slow computer (for example, under 1 GHz), you should consider using this option. It will complete the drawing of your map faster, but it will update the screen with its progress less often.

A map's scale is important. Representing scale reliably can be difficult on a computer. Because computers store

information digitally, images have no real-world length or height. They just have pixels. Image formats contain extra information that states how dense the pixels are supposed to be, and therefore the real world dimensions of the image.

Computer monitors are problematic in this regard. Depending on the operating system, the monitor, and on what kind of connection it has to the computer, the operating system may be unable to determine the size of the pixels on the screen. Or, even if it knows, for many purposes it will still treat one pixel as a fixed size, no matter how tiny or large the pixel is. Or the monitor may not report the size of its pixels accurately. And so on. Using the remaining controls in this panel you can get as accurate as you want.

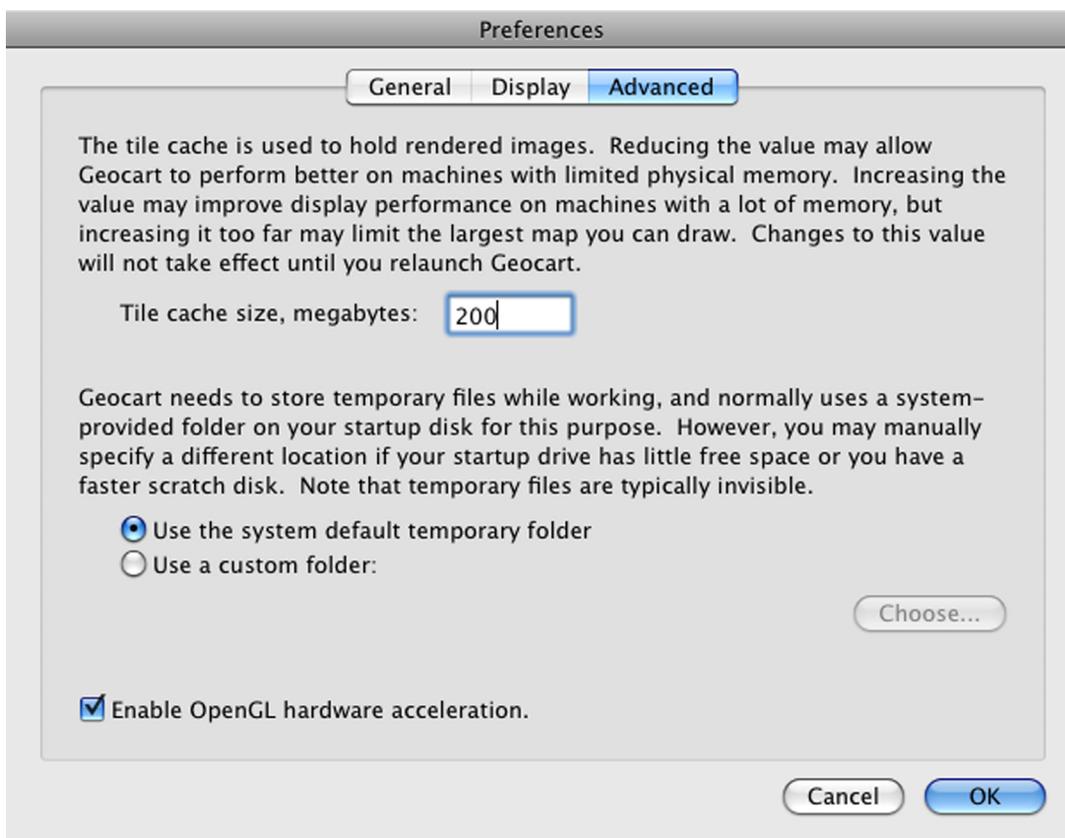
Use the system reported value: If you wish to defer to the operating system's notion of your screen's pixel density, select this. You might do this if you know it's correct, or because it's good enough, or because you don't care.

vs.

Use a custom resolution: If you find that Geocart's rulers and the maps Geocart produces don't seem to match real-world measurements when you print or when you measure them with a ruler on-screen, you should calibrate Geocart's understanding of the screen's pixel density using this control. Measure the black bar using a real ruler pressed up against your screen, and enter its precise width in *The bar above measures* field. Or, if you know the pixel size from the monitor's documentation, you can enter it into *The custom resolution is* field.

Advanced

The on-screen instructions suffice for most of the functionality controlled by this pane. With regard to *Enable OpenGL hardware acceleration*, some computers, particularly older ones or ones with exotic graphics cards, may not draw or update their screens reliably when this option is checked. If you experience bizarre screen behavior unrelated to a specific map or projection, try turning off this option.



Advanced panel of Preferences dialog

Preferences > New Map Databases

When you first install Geocart and create a new map, the map will get drawn with default settings, one of which is geographic databases. You may have a collection of databases that you use commonly, and therefore you might prefer that those databases get automatically added to each new map you create. You specify those databases using this command. It brings up the [Databases](#) dialog, where you can add and configure as many databases as you like.

Although the databases you specify here will get added automatically to new maps, you can still go back into the [Databases](#) dialog to add or remove databases if your usual collection isn't right for a map or if they need adjusting.

Use [Preferences > Reset New Map Databases](#) to undo the settings you have made with this command, reverting to the settings from the time you first installed Geocart 3.

Preferences > New Map Graticule

When you first install Geocart and create a new map, the map will get drawn with some default settings. One of those settings is the graticule that will get drawn on your map. You may commonly work with a particular style or scale of map and therefore prefer some other graticule setting by default. You can set a preferred graticule configuration using this command. It brings up the [Graticule](#) dialog.

Although the graticule you specify using this command will get drawn automatically on new maps, you can still go back into the [Graticule](#) dialog for each map to customize it if your common configuration isn't right for that map or if it needs some adjusting.

Use [Preferences > Reset New Map Graticule](#) to undo the settings you have made with this command, reverting to the settings from the time you first installed Geocart 3.

Preferences > New Map Line Styles

When you first install Geocart and create a new map, the map will get drawn with some default settings. One of those settings is the line styles that will get used to draw the vector elements of your map. You may have a distinctive graphical style that you give most maps, and therefore you might prefer that style be present automatically in each new map you create. You can set up line styles appropriate to your graphical style using this command. It brings up the [Line Styles](#) dialog, where you can customize all line styles available.

The normal **Line Styles** dialog only presents you with line styles actually in use in your document (as determined by the databases you have added to the document) in order to avoid clutter. In contrast, the **Line Styles** dialog you are presented with by this *New Map Line Styles* command contains all the line styles Geocart knows about, as determined by the coverage mapping files you have installed. The presentation of line styles may be extensive. You need only modify those line styles you care about.

Although the line styles you specify using this command will get used automatically in drawing new maps, you can still go back into the [Line Styles](#) dialog for each map to change line styles if your usual graphical style isn't right for that map or if it need some adjusting.

Use [Preferences > Reset New Map Line Styles](#) to undo the settings you have made with this command, reverting to the settings from the time you first installed Geocart 3.

Preferences > Reset New Map Databases

You revert your [Preferences > New Map Databases](#) changes using this command. This restores the list of databases

that will be added to new maps to the state it was in when you installed Geocart. If you made no changes, then this command will not be available.

Preferences > Reset New Map Graticule

You revert your [Preferences > New Map Graticule](#) changes using this command. This restores the specification of the graticule that is to be drawn on new maps to the state it was in when you newly installed Geocart. If you made no changes, then this command will not be available.

Preferences > Reset New Map Line Style

You revert your [Preferences > New Map Line Styles](#) changes using this command. This restores the list of line styles that will be used for new maps to the state the state it was in when you newly installed Geocart. If you made no changes, then this command will not be available.

Services

This menu item is provided by the Mac OS. Please refer to Mac OS documentation for instructions on how to use it. Its contents should not affect Geocart in general.

Hide Geocart

This command hides Geocart's windows, palettes, and menu bar, and switches to the last application you used. You can return to Geocart by finding it in the Finder's Dock.

Hide Others

This command hides all the windows of all other applications you have running. If you switch applications often, you may find that Geocart's windows become interleaved with those of the other applications, obscuring some of Geocart's windows. Use this command to move all of Geocart's windows to the front.

Show All

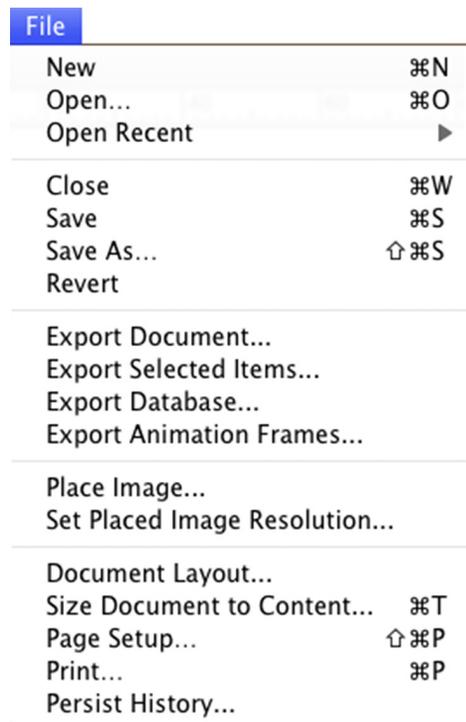
This command brings all the windows of other applications out of hiding, though they will still be obscured by Geocart's windows and palettes.

Quit

This command shuts down Geocart. If you have any documents whose contents have changed since the last time you saved them, then this command first asks if you wish to save them.

Chapter 7: File menu

The **File** menu offers document and file controls, such as creating, saving, opening, and closing them.



New

This command creates a new Geocart document with no content. If rulers were set to visible on the previous window opening (see [Rulers](#)), then the new window will have rulers; otherwise it won't. The new document's window will be placed in front.

Open

This command displays the **Open File Picker** so that you can select a Geocart document to open. It operates as any other application's **Open File Picker**. Consult your operating system's documentation for instructions. You may open any Geocart document, whether of standard .geo3 format, .geo3db reprojection database format (see [Export Database](#)), or Geocart 2 format.

If the newly opened document was of Geocart 2 format, it will get converted to Geocart 3 format and renamed to the same name plus (converted). If you save this document, it will save as Geocart 3 format. There is no way to save back to Geocart 2 format.

Upon opening, Geocart will redraw any maps that were not completely drawn at the time the document got saved. It will redraw all maps if the document was saved without image embedding. (See [Do not embed](#).)

Open recent

The submenu displayed off this menu item provides a list of Geocart documents you recently opened. Just select the name of the document you want to open. From there the document will open as normal and will become the front window.

Close (Mac)

If the front window's document has not changed since it was last saved, this command simply closes all windows associated with the document. If the document's contents have changed since it was last saved, Geocart asks if you wish to save the document. You may:

- *Don't Save*, which discards changes and closes.
– OR –
- *Cancel*, which aborts the close and returns to whatever Geocart was doing.
– OR –
- *Save*. If the document has been saved before, it saves and closes. If it has never been saved before, you will be asked to provide a name for the document and a location to save to. Then Geocart closes the document.

Save

If the document of the front window has been saved before, this command saves the document in its current state. If any maps have not finished drawing, then their images will not get put into the file. When Geocart opens the document the next time, it will redraw any maps without images.

If the document has never been saved before, then the standard **Save File** dialog displays, requesting you to provide a name for the file and to specify a location in your file system to save it into. Consult your operating system's documentation for instructions.

Save As

Use this command if you want to save the document to a file of a different name. You may want to do this to, for example, preserve the prior version of the document.

Save As always brings up the standard **Save File** dialog, requesting you to provide a name for the file and to specify a location in your file system to save it into. Consult your operating system's documentation for instructions.

Once you create a copy by performing a **Save As**, the open document is associated with the new file on disk. The original file is closed. You may open it as a separate document if you like.

Save a Copy (Windows only)

Use this command to create on disk a new file containing the document's contents, giving the file another name or location. The name and location are only for the copy and do not affect the open document's name or location.

Revert (Windows only)

Discards all changes made to the front window's document since the last save, with the effect of closing the document without saving, and then opening it anew.

Close (Windows)

See [Close \(Macintosh\)](#).

Export Document

Exporting a document converts it to a standard format that other applications can read. The entire document, including all maps, all images and all blank areas, will be represented in the output, which will have the dimensions of the document. Any document objects hanging off the page will be cut off and not visible in the resulting image. The background will be transparent if the export format allows (PSB, TIFF).

When you choose **Export Document**, a **Save File** dialog displays, requesting you to provide a name for the exported file. At the bottom of the **Save File** dialog you can select the format of the exported file. Which format you export to depends on what you intend to do with the exported document, and to some extent on the content of your map.

Raster

Graphical content can be represented two fundamentally distinct ways on a computer: as *raster*, or as *vector*. Raster imagery is comparable to a photograph. The amount of detail is fixed at the time the image is created and cannot be usefully increased. The image consists of cells of color of a consistent size called *pixels*. If you peer carefully at your computer's screen, each tiny dot you see is a pixel.

Raster imagery can be scaled up to create a larger image, but that does not result in more detail. While it can look smooth, the greater you increase its size, the blurrier it gets because the same amount of detail gets smeared over more and more pixels. Raster imagery can be scaled down, generally without bad effects. The important concept in raster is the amount of detail present in the original image.

Vector

Where raster imagery is comparable to a photograph, vector line work is comparable to the process of painting. The characteristics of each stroke are recorded: Its thickness, color, and whether areas in between get painted solid and in what color. In the end, in order to display it, vector line work gets rendered into a raster image. Everything on your screen is raster, regardless of whether it originated as raster or as vector. The advantage of vector, however, is that you can scale up or down from the original dimensions *before* you render it in raster. That means, regardless of size, you can achieve a sharp, pleasing graphic.

If the image consists largely of lines, such as a map's graticule, or administrative boundaries, or roads, then vector is an appropriate format. If the image consists largely of land cover, for example, then raster is probably more appropriate. Maps being maps, it is very common to mix both raster and vector to create a map.

Picking a format

If you need to preserve the distinction between raster and vector sources in your map, you must choose PDF as your export format, since it is the only such format that Geocart supports. Adobe Illustrator™ can read Geocart's PDF output, leaving raster as raster and vector as vector. More general PDF-consuming software can read Geocart's files as well, but often only with the intent to render, as opposed to further editing. PDF has nothing to configure when you export

to it.

If your map is complete in the form Geocart rendered it, or if you will only be adding elements to it after importing it into other software (as opposed to changing elements already on the map), then any of several raster formats might be appropriate.

TIFF

If you need to retain the highest fidelity raster output, TIFF is a good choice. It retains every pixel Geocart creates, exactly as it was created. It retains any color transparency inherent in your image. Compression without loss of fidelity is part of the TIFF format, so it works well as a portable format. Almost any software that deals with raster imagery can read Geocart's TIFF output. The only caveat with TIFF is that it cannot adequately represent the largest images Geocart is able to create. For those you must use PSB.

At export time you can elect to employ lossless compression. Compression does not affect image quality. It just takes longer to write the files, but generally results in a significantly smaller file. It may increase or decrease the time to read the file, depending on your processor and hard disk characteristics.

PSB

PSB is Adobe Photoshop's™ native large-document format. Geocart provides the PSB export option because it is the only reliable, portable raster format for the largest raster images. If your image exceeds 2 GB, you must use PSB. An example of a 2 GB image is 15,800 x 31,600 pixels in 8-bit per channel RGB + alpha. (The alpha channel carries transparency information.) At publication quality (300 dpi continuous tone), that amounts to a 2,675 mm x 1,338 mm (= 105 in x 53 in) map. If the size and resolution of your map approach these dimensions, you will be using PSB format.

Why not use PSB all the time? PSB format is not nearly as widely read as TIFF. PSB's format is not compressed, so it generally consumes far more disk space than TIFF. Finally, Geocart essentially must embed two copies of the image into the file, making an already enormous file yet twice as large.

JPEG

Images posted on the Web need to be the smallest files possible while retaining the essence of their content. Disk storage consumption can also be a consideration, particularly with maps because of their large size. JPEG is a *lossy* compression format. Lossy means that the full fidelity of the original image is not preserved. Instead, compromises are made in the image quality in order to squeeze down the size of the resulting file. Depending on what level of quality you choose, you may notice no difference from the original, or you may notice considerable degradation.

Geocart exposes three quality levels: Good, better, and best. How much compression you can expect depends on too many factors to give confident numbers. But, for example, on the default map Geocart creates, "good" JPEG compression results in a 9:1 compression over lossless TIFF compression. "Best" results in a file two-thirds the size. Whether you can tolerate the degradation in image quality in either case depends on your use and constraints.

Color space

Each of the raster output formats let you choose a color space, either RGB or grayscale. RGB (= red, green, blue) just means full color. Grayscale means levels of gray from black to white. If the map as drawn on the screen is in full color and you select grayscale, Geocart will convert the map to grayscale at the time it exports it. This does not affect the map in the document. If the image is grayscale in the document and you export to RGB, then Geocart will produce an image that looks like the original grayscale map but consists of the red, green, and blue channels mixed to result in gray colors.

A reason you might want or need these kinds of conversions is you may have several maps in your document, and they may be of different color spaces. At export time, since you are creating a single image out of what was several images, you will need to choose a single color space for the entire image.

Bits per sample

Or bits per channel. This is how much detail each of the red, green, blue, and alpha channels can hold. 8 bits is common and suffices for many purposes. TIFF and PSB also allow 16 bits per sample. If your original raster databases were only 8 bits per sample then you won't gain any benefits by selecting 16 bits per sample. You will only increase the size of the file you generate. Also, many TIFF readers cannot properly handle files with 16 bits per sample.

If, on the other hand, one or more of your raster databases contains 16-bit-per-sample imagery, Geocart will have rendered the map in 16-bit-per-sample color, and it would be best to preserve the detail if you will print the map. (It does not matter for purely screen representation because computer monitors only display 8-bit samples.) The deficiencies of 8-bit samples are most evident in gradations such as are often seen in water or sky hues. If you do choose 16-bit samples, be sure the consuming application properly reads them.

Resolution

All of the raster export formats let you choose the output resolution. Normally this should be the same as the map you are exporting, and that will be the default value when you export. If you don't need all the detail of the original map when you export, you can choose to downsample it by selecting a lower value. You may also select a higher value, but that does not cause Geocart to render the map anew at higher detail. Geocart will just interpolate, much like blowing up a photograph in Photoshop. There is rarely any reason to do this for a single map.

If you have several maps of mixed resolution, however, you will need to decide on a single output resolution. Normally this should be the highest resolution present in your maps. This is the default value presented to you when you export.

Export Selected Items

Often you don't need the entire document's area in your export. Most commonly you will only have one map in your document, and that's what you want exported. Whether one map or several, or mixed with placed images, this command exports all selected document objects. The resulting image will be of a size needed to contain all the selected objects. The background will be transparent if the export format allows it.

See [Export Document](#) for details. Unlike [Export Document](#), however, all of the content of all selected document objects will appear in the resulting image, even those partially hanging outside the document's area.

Export Database

Using [Export Database](#), you can create a geographic database out of raster imagery you acquired from whatever source. The database you create then can be added to Geocart maps and projected into any map projection. This kind of database is called a *general reprojection database*.

Two components are needed to set up a document so that it can be exported as a general reprojection database. The first is the source image in the form of a [placed image](#). Normally the placed image will be a map: one that you want to transform to a different projection, or one that you want to be able to reproject to any projection.

The second component is a Geocart map that you overlay onto the source image to serve as georeferencing. This is called the *reference map*. Normally you would remove all databases from the reference map, using just the graticule as an overlay. However, the graphical content of the map, such as line styles and geographic databases, are not relevant for the purposes of georeferencing. You are free to configure them how you like. The important elements are the projection details and the boundary.

Setting up a document to export as a database consists of these steps:

- Placing the source image.

- Creating the reference map to match the projection characteristics of the source image.
- Aligning the reference map to the source image.
- Running the *Export Database* command from the **File** menu to save the document as a database.

In practice, finding the right projection characteristics so that your reference map aligns perfectly to your source image can be arduous. Occasionally it is impossible. Here are some factors that can interfere in setting up the reference map:

- You do not know the projection of the source image.
- You know the projection but not the parameters.
- You do not know the geographic coordinates of any place on the source image (because it has no graticule, for example).
- The source map was warped, since all paper is subject to dimensional instability.
- The scan of the source map lost fidelity or introduced positional errors.
- Geocart does not support the projection of the source image.

For material that has not already been georeferenced at the time it was digitized, you are effectively going to be georeferencing it yourself as you iterate toward a suitable reference map. In practice it does not matter if you do not know the projection characteristics of the source map, and it may not even matter if Geocart does not support the projection of the source map. What matters is that geographic coordinates in the reference map match the known geographic coordinates in the source image to sufficient precision for your needs. If you are able to improvise a projection that meets those criteria, then you will have succeeded.

Once you have created the general reprojection database, you add it to your maps like any other geographic database using the *Databases* command. Geocart automatically reprojects the general reprojection database's source image to the projection of the map you have added the database to.

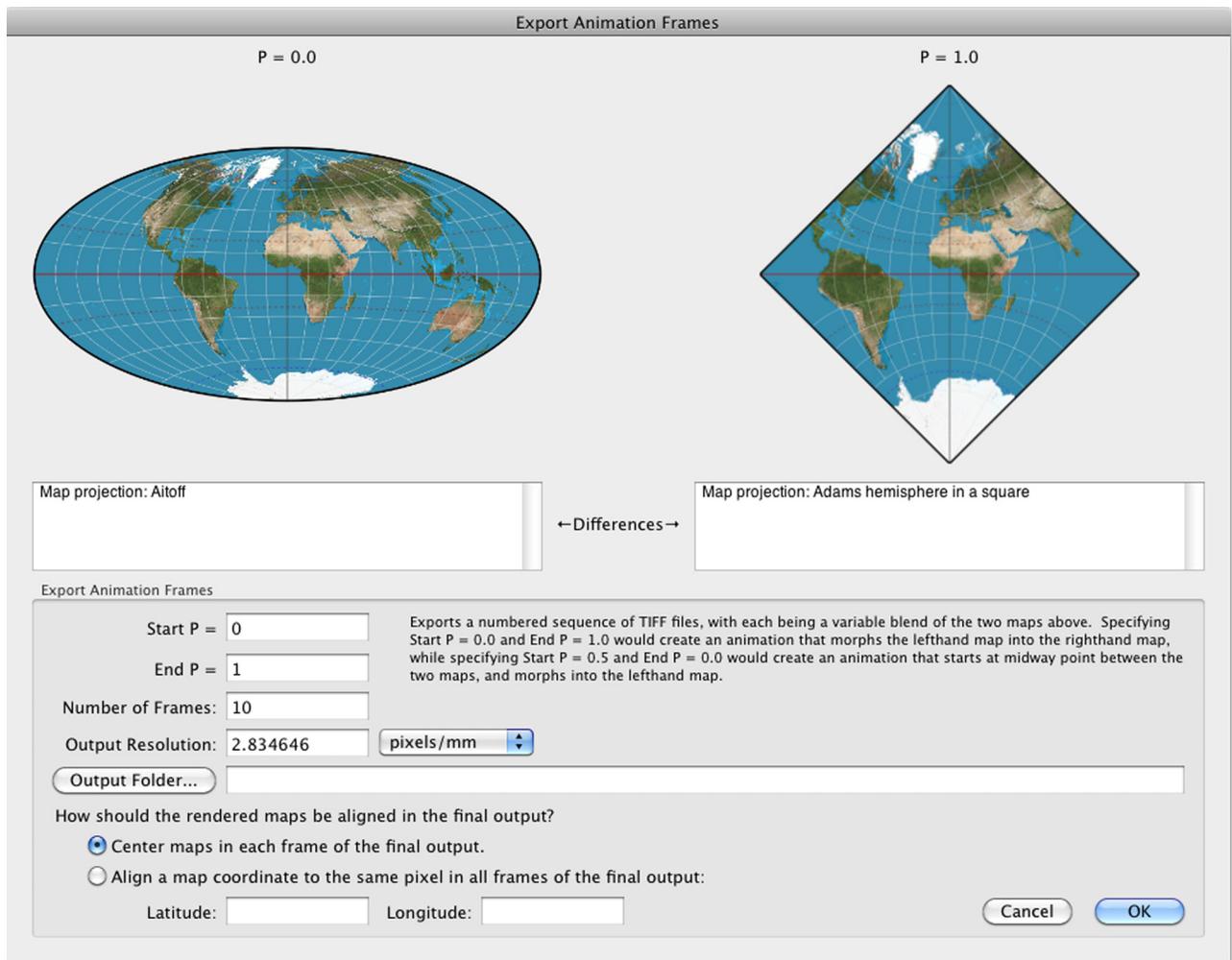
See Chapter 5, [Example 15](#) and [Example 16](#), for detailed tutorials on using this powerful facility.

Export Animation Frames

This command is available when two maps are selected. Using *Export Animation Frames*, you can create a sequence of maps that you can use other software to turn into an animation clip. The basic process is the same as blended maps, repeated across a change of proportion. Please see the explanation at [New Blended](#). When you open the dialog, the map whose left edge was more left in the document will be presented on the left side in the dialog.

In creating the animation frames, you choose a starting parameter and an ending parameter. A parameter specifies the proportion of the map on the right used in creating the blend. The proportion of the map on the left to use in the blend thereby becomes $1 - P$. The starting parameter is the parameter value to use for the first frame of animation. The ending parameter is the parameter value to use for the final frame of animation. The intermediate frames will be created by stepping linearly between the start and end parameters. You may specify a *Start P* greater than the *End P*. Hence if you want to start the animation with the map on the right side and progress toward the map on the left side, then set *Start P* to 1 and *End P* to 0.

Besides the start and end parameters, you can specify the number of frames, the resolution to render the maps at, a folder to dump the resulting frames into, and relative positioning of the frames. There is no practical limit to the number of frames you can instruct Geocart to create, but creating a high-quality animation can take hours or even days, if many thousands of frames are involved. You can specify the output resolution independently of the resolution of the original maps, but in general it is not a good idea to increase the resolution significantly beyond that of the source maps. Geocart must synthesize an outer boundary for the blended map at the resolution of the source maps, so if you specify something significantly greater, you may end up with an outer boundary that is not sufficiently detailed for the blended map.



Export Animation Frames dialog

You must designate an output folder before you begin creating frames. It is best to designate a folder that is empty. Geocart populates the folder with TIFF images whose file names contain the frame number. Software that creates animation clips can read sequences of still graphic images thus numbered in order to create an animation sequence. Geocart first generates all the frames; then situates each image within a standardized frame size that can be determined only once all the frames have been generated. Therefore the folder will be populated first with a sequence of temporary frames with names that include `-tempframe`, and then with the final frames. It is the final frames which you should use to generate your animation from. Geocart retains the temporary frames in case you need to restart the animation. If you specify an output folder which already contains temporary frames, then Geocart will only generate the missing frames, if any.

You can align the animation frames as deposited in their final form either by specifying to center the map images in each frame, or that a given geographic coordinate should fall on the same pixel location. Which you should choose depends on the details of your animation intent. In some cases, neither choice is best, and you will only be able to achieve your intent using animation editing software.

For best results, use [Final Quality](#) rendering mode by giving both source maps that setting. This is particularly important in animations in order to prevent shimmering and speckling artifacts during playback. You cannot export frames if the quality settings differ between the two source maps. See the documentation for your animation software in order to choose settings and a codec appropriate to your animation within the animation software.

Place Image

You may place images from your disk into your document, and move them around on your document space wherever you want once they are placed. Some reasons you might do this are to:

- Create a [general reprojection database](#).
- Provide an image to georeference against.
- Add external content to your map.
- Compare your map to an existing map.

The image formats you may place are all raster formats:

- TIFF (.tiff, .tif, .TIFF, .TIF)
- JPEG (.jpg, .jpeg, .JPG, .JPEG)
- Photoshop native format (.psd, .PSD)
- Photoshop large document format (.psb, .PSB)

The TIFF format provides enormous diversity of structure and content. Geocart may not be able to read some of the less commonly used variants. If you run into difficulty, try opening the TIFF file in another image reader and then saving it out again. Geocart may be able to read the newly saved version.

Set Placed Image Resolution

You may need to match the resolution (pixel density) of a placed image to the resolution of a map you are creating. You can control the resolution of a placed image using this command. Geocart will not resample the image; that is, Geocart will not change the pixels in the image. Instead it will change the dimensions of the image in order to increase the interpretation of the pixel density of the image.

If, for example, you place an image of 2,000 x 1,000 pixels and a stated width of 200 mm, then the image has a resolution of 10 pixels/mm. If you need to match the image to a map whose resolution is 5 pixels/mm, then you can decrease the image's resolution to 5 pixels/mm using this command. The effect will be to double the size of the image because the pixel density will have become half what it was without changing the pixels themselves. Hence the result will be an image still 2,000 x 1,000 pixels but with width 400 mm.

Document Layout

Use this command to set the dimensions of the document's space. You can set the width and height in your choice of units. The [rulers](#) will resize to match if you have them turned on.

One of the units available is "pages". Using [Page Setup](#) (Mac) or [Print](#) (Windows), you can select the paper medium you will print on. The size of the paper medium you select is the "page size". Hence in the **Document Layout** dialog you can set your document's size in terms of the number of pages you will print to.

Size Document to Content

Your map or maps commonly will not fit your document size just right. You can force the document size to fit the expanse of the content using this command. A dialog appears with a setting for the amount of margin you want around the document's content. You may set the margin to any non-negative value.

Page Setup (Mac only)

Page Setup tells Mac OS about the medium you intend to print on: which printer, the size of the paper, scaling, and so forth. You should set these values before you print. Geocart does not control the content or appearance of this dialog. See your Mac OS documentation for details.

Print

Geocart does not modify the **Print** dialog. Refer to your operating system's documentation and your printer's manual for instructions on how to configure and use the print facilities.

On Windows, printing is constrained to a maximum resolution of 300 dpi contone. (Contone means *continuous tone*. It refers to the fact that a given hue can be expressed in hundreds of levels of brightness [hence, nearly continuous] the way a computer display works. This is in contrast to half-toning, where the printer deposits clusters of tiny dots of saturated colors mixed with empty space in order to simulate levels of brightness.) In contone, 300 dpi is generally considered equivalent to 2540 dpi half-toning in printers, and is therefore suitable for publication. If you need higher resolution, you can instead create and [export the document](#) at higher resolution and use another program to print it.

Preferences (Windows)

See the explanation at the [Macintosh Geocart menu Preferences](#).

Exit (Windows only)

This command shuts down Geocart. If you have any documents whose contents have changed since the last time you saved them, then this command first asks if you wish to save them.

Chapter 8: Edit menu

The **Edit** menu offers standard edit controls, which in Geocart operate on document objects.

Edit	
Undo	⌘Z
Redo	⇧⌘Z
<hr/>	
Cut	⌘X
Copy	⌘C
Paste	⌘V
Delete	
Select All	⌘A
Deselect All	⌘D
<hr/>	
Copy Info Palette Text	⇧⌘X
<hr/>	
Find	▶
Spelling	▶
<hr/>	
Special Characters...	⌘T

Edit	
Undo	Ctrl+Z
Redo	Ctrl+Shift+Z
<hr/>	
Cut	Ctrl+X
Copy	Ctrl+C
Paste	Ctrl+V
Delete	Del
Select All	Ctrl+A
Deselect All	Ctrl+D
<hr/>	
Copy Info Palette Text	Ctrl+Shift+X

Undo

If you do not like the effect of the last step you took in creating your map, you can reverse it with **Undo**. This applies to any kind of operation that makes changes to the contents of a document, but not to other kinds of operations, such as resizing a document window, or opening, closing, or saving a document. These latter operations neither can be undone, nor do they affect your ability to undo earlier operations that were undoable.

Geocart keeps track of each operation in its undo history. You can backtrack as far as the number of steps set in the [Undo history steps](#) preference. That is, if your mistake were five operations past, you can undo five times to restore the state before the error.

Redo

If you do not like the effect of undoing an operation, you can restore the effect of that operation using **Redo**. In other words, a sequence of **Undo**, then **Redo**, will return you to the point before the undo. You can redo back as many steps as you have undone.

Cut

Cutting removes all selected objects from the front window's document, and puts them into the clipboard so that you may [paste](#) them if you wish. You may paste what you have cut into any Geocart document. This is a way to transfer document objects from one document to another.

The clipboard is an invisible storage area whose only function is to hold things you have cut or [copied](#).

Copy

This command copies all selected objects from the front window's document, and puts the copies into the clipboard so that you may [paste](#) them if you wish. You may paste what you have copied into any Geocart document. This is a way to transfer document objects from one document to another.

The clipboard is an invisible storage area whose only function is to hold things you have [cut](#) or copied.

Paste

The clipboard is an invisible storage area whose only function is to hold things you have [cut](#) or [copied](#). If you have transferred anything into the clipboard, you may subsequently paste those items into any Geocart document using this command. The pasted items will be identical to what you cut or copied other than perhaps their positions in the document. (Their relative positions will be preserved.)

In some programs you may paste items you cut or copied from other programs. Presently Geocart has no public data formats that can be copied from the clipboard into other programs other than text that you copy out of dialogs. Nor are there any public formats that Geocart recognizes for pasting into Geocart documents.

Delete

This deletes all selected objects from the front window's document without putting the deleted objects into the clipboard.

Select All

Use this command to select every document object of the front window's document.

Deselect All

If anything is selected in the front window's document, this command will change it so nothing is selected. Most of the menu commands will become unavailable with nothing selected.

Copy Info Palette Text

The [Information](#) palette contains useful information about the map or image under the mouse pointer. You may want a copy of that information to freeze it in time or to excerpt parts for use in other applications. This command copies the text to the system's clipboard, whence you may paste it into any standard text editing application, such as TextEdit on Macintosh or Notepad on Windows.

Note that this command is not useful as a menu item, since you must move the mouse to access it. Moving the mouse changes the **Information** palette content. Instead use the keyboard shortcut **shift+command+X** (Mac) or **SHIFT+CTRL+X** (Windows).

Find (Mac only)

This is provided by the Mac OS. It does not function in Geocart.

Spelling (Mac Only)

This is provided by the Mac OS. It does not function in Geocart.

Special Characters (Mac Only)

This is provided by the Mac OS. It does not function in Geocart.

Chapter 9: Map menu

The **Map** menu offers settings for constructing your maps.

Map	
New	⇧ ⌘ N
New Blended...	
Databases...	⇧ ⌘ B
Nominal Scale...	⌘ K
Map Size and Resolution...	
Scale to Window	
Scale to Document	
Boundaries...	⌘ B
Graticule...	
Line Styles...	⌘ L
Distortion Visualization...	
Tissot Indicatrices	
Copy Attributes	⇧ ⌘ C
Paste Attributes...	⇧ ⌘ V
Vector Generalization	▶
Draft Quality	⌘ 2
Proof Quality	⌘ 3
Final Quality	⌘ 4

Map	
New	Ctrl+Shift+N
New Blended...	
Databases...	Ctrl+Shift+B
Nominal Scale...	Ctrl+K
Map Size and Resolution...	
Scale to Window	
Scale to Document	
Boundaries...	Ctrl+B
Graticule...	Ctrl+Shift+G
Line Styles...	Ctrl+L
Distortion Visualization...	
Tissot Indicatrices	
Copy Attributes	Ctrl+Shift+C
Paste Attributes...	Ctrl+Shift+V
Generalize Vectors	▶
Draft Quality	Ctrl+2
Proof Quality	Ctrl+3
Final Quality	Ctrl+4

New

New creates a new map in the document of the front window, placing it toward the upper left of the document. The map's projection will be the sinusoidal. The geographic databases used in the map will come from the settings in [New Map Databases](#). The graticule will render according to the settings specified in [New Map Graticule](#). The line styles used in the new map will come from the settings specified in [New Map Line Styles](#). If any of these preferences have never been set or have been reset, then the corresponding elements of the map will get drawn according to standard defaults present from Geocart installation time.

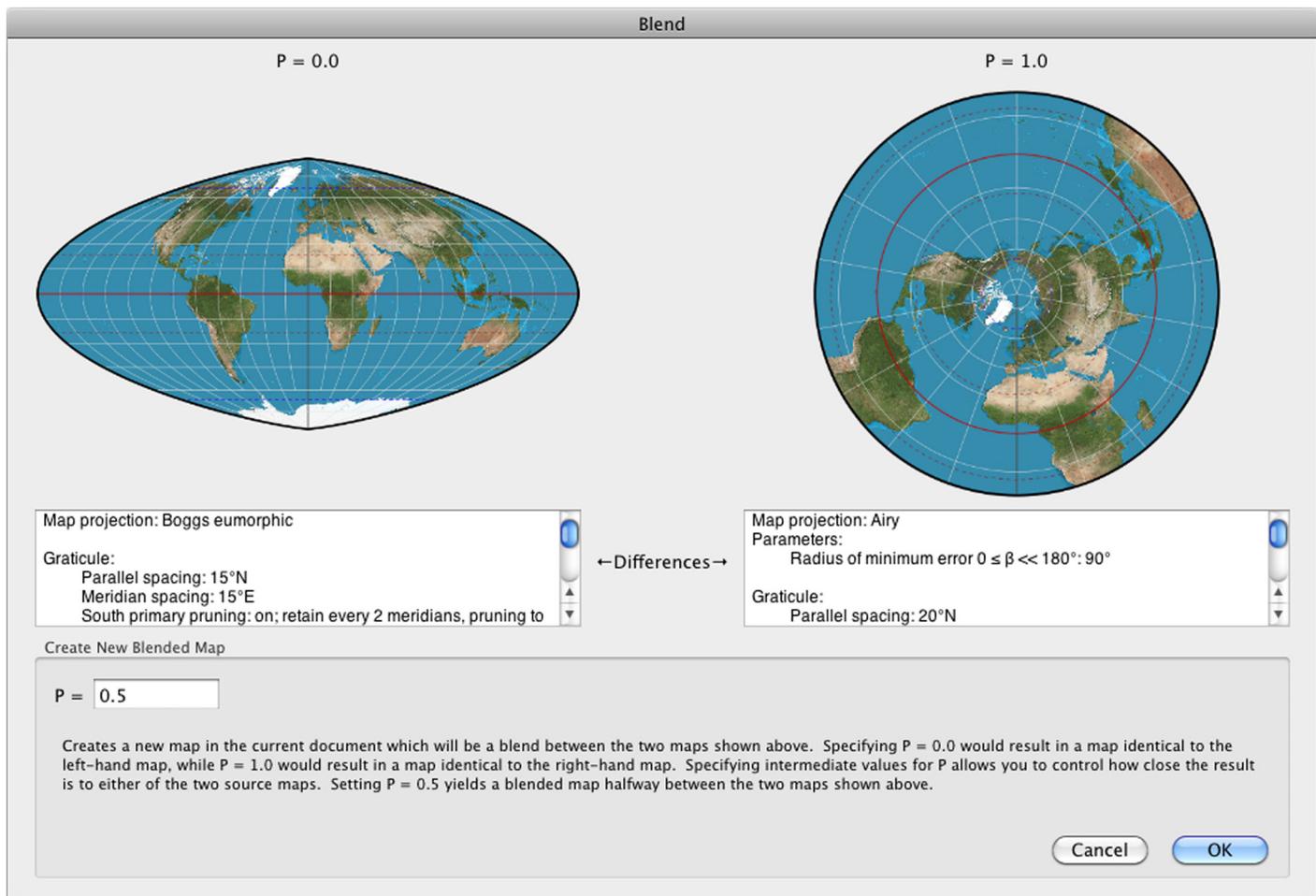
Once the map is created, you may change any of its characteristics, including projection. However, when you change projections Geocart tries to preserve as many traits of the original map as possible. Sometimes those traits don't yield a meaningful map in the target projection. Boundaries can be particularly problematic.

Another way to create a new map is to hold down the **shift** key (Mac) or **SHIFT** key (Windows) while selecting the projection of choice from any of the projection menus. This method is actually preferred over the **New** command because the map will get drawn according to defaults known to work well with the chosen projection.

New Blended

This is available when you have two maps selected. The purpose of **New Blended** is to create a new map by blending attributes from the two selected map. The new map's projection will be synthesis of the two selected maps' projections. Selecting **New Blended** brings up a dialog to give you information on how the synthesis will take place (or even if it

can take place) and to allow you to control the proportions of the contributions of the two maps.



Blend dialog

The informational portion of the dialog shows the differences between the two maps. Differences may participate in creating the blended map, or they may disqualify the two maps from being able to blend. Differences shown in red are irreconcilable. Differences shown in black will contribute proportionately from the two maps. The proportion of the contribution from the map on the right side is the P value that you may set, ranging from $0 \dots 1$. If $P = 0.0$ then the resultant map is just the left map. If $P = 1.0$ then the resultant map is just the right map. If $P = 0.5$ then the resultant map receives equal contribution from both source maps.

It is common for maps not to be blendable even if they have no differences flagged in red. These will show up after you hit the OK button. In such cases, the mathematics are not reconcilable, generally because the resulting map would have overlapping (folded-over) regions, for example. Differing projection centers often cause such problems.

If the two maps have the same map projection then they generally can blend. This is because the blending comes from weighting the projection parameter values and the projection centers, which normally can vary freely. However, a parameter that only takes discrete values will not blend for any arbitrary P .

A difference in projection center normally results in a blend that puts the projection center along the great-circle path between the two centers. However, if the source and destination maps have the latitude for their projection centers, and the transversal rotation is also the same, then the resulting projection center will be along the common parallel.

You can use the blending principle to create animation frames. See [Export Animation Frames](#).

Databases

This command functions for all selected maps. The databases and their state from the map created earliest are what populate the dialog upon entry. If you confirm the dialog by clicking the *OK* button, then the databases for all selected maps will update to become the same, reflecting the state of the dialog when confirming it.

Databases contain the geographic information Geocart uses to draw maps. If your map shows rivers, roads, toponyms, or satellite imagery, for example, then those features were all extracted from databases. Some kinds of map features do not come from databases, but instead are computed. The outside boundaries of the map, for example, are always computed. The configurable graticule is also computed. Drawing of computed features is controlled elsewhere (see [Boundaries](#) and [Graticule](#)).

A new map will get constructed according to defaults (if you have not set up preferences) or preferences (if you have), including what geographic databases the map has to draw from. (See [New Map Databases](#).) Using this command, you can change the databases used to draw the map. Since the geographic information in a map largely determines the character of the map, what you do in this dialog will profoundly impact your map's purpose and appearance.

Geographic features in a database are always associated with geographic coordinates. Geocart knows where to draw the features because of these coordinates. You may add any databases you like to your map, but Geocart will only draw features from those databases whose coordinates lie within the boundaries of the map (see [Boundaries](#)).

Geocart's installer placed many geographic databases in a canonical location on your hard drive to use with Geocart. (See [Appendix G: Managing your databases](#).) You can use those in maps, but you can also use any recognizable file available to your computer anywhere.

The diversity of geographic data cannot be represented in a single way that works well for all circumstances. Hence databases you use with Geocart come in several varieties. *Raster* databases contain geographic information arranged in a regular grid of squares, or *pixels*. If you peer carefully at your computer's screen, each tiny dot you see is a pixel. Satellite imagery is an obvious example of raster.

Vector databases contain geographic information encoded as sequences of lines to be drawn. The reason to use vectors is that you can control the thickness and color (or weight) of their lines at the time they get drawn, allowing for considerable flexibility in map design. This contrasts with raster, where you have no control over individual features. Some example uses for vector databases are administrative boundaries, roads, and coastlines.

Typesetting databases contain instructions for placing text. Normally you do not want your text in raster form because it will get warped by projection and because you cannot manipulate its placement. Similarly you do not want it in vector form because you will not be able to search for words or to change the font they get drawn in.

Metric lines databases contain instructions for drawing lines that express map projection distortion or computed paths on earth's surface. Distortion metrics come in the form of *isocols*, which show points having the same measure of distortion, and *Tissot indicatrix* ellipses, which show how little circles on the sphere get distorted when projected. Computed paths include great circles, small circles, geodesics, and rhumbs. Point locations are also considered to be metric lines.

The following list describes the kinds of databases you can add to your Geocart maps.

Database type	Filename extensions	Description
Editable polygon (<i>vector</i>)	.txt	These are simple lists of polygons. You may find them useful when you need to manually or programmatically construct some line work. See Appendix E: Creating vector databases . Geocart does not install any editable polygon databases.
SMSB (<i>vector</i>)	.smsb	This is a binary format now little used in computer mapping. Geocart 3 installs some databases in this format for compatibility with Geocart 2.

MCAM (<i>vector</i>)	.mcam	This is a binary format from the public domain MicroCAM project. Geocart 3 installs some databases in this format for compatibility with Geocart 2.
ESRI® Shapefile (<i>vector</i>)	.shp .dbf .prj .shx	This format is well known in computer mapping. The vector data is held in the .shp file. Metadata is held in the accompanying mandatory sidecar files. You may add any or all of the sidecar files; Geocart will automatically choose only the .shp file. While Geocart does not use information from the sidecar files, it does check for the presence of all sidecar files required by the specification and rejects any Shapefile database missing them. Geocart can read only a subset of Shapefiles, as follows: It parses the entire .prj file, requires it to be correctly formed, and requires the PROJCS coordinate system to be GEOGCS. The PROJCS AXIS must be one of NORTH, SOUTH, EAST, or WEST. If an AUTHORITY is declared for the PROJCS, it must be EPSG, and it must be one of 9101, 9201, or 9122. If it is 9122, then the supplier-defined definition of degree must match 0.01745329 to within ± 0.0000001 .
Raw raster	.raw	This format consists of RGB samples, 8-bit each, non-interlaced, with the imagery assumed to be in “ geographic ” projection. Two variants exist. If the file has no header, then the image is assumed to be of global extent and must have twice as many pixels horizontally as vertically; otherwise it will be rejected. If a 128-byte header is present with the first four bytes comprising a GeOR signature, then the header describes the west, north, east, south extents of the image.
Global raster	.tif .tiff .jpg .jpeg .psd .psb	Files of these types are assumed to be in “ geographic ” projection and of global extent. If the horizontal pixel count is not twice the vertical pixel count, the file will be rejected, since a geographic projection of the whole earth is twice as wide as it is high. Conversely, if that condition is met then the file will be accepted regardless of graphical content.
General reprojection (<i>raster</i>)	.geo3db	These are databases that you create from raster imagery of any projection, such as scanned maps. See Export Database .
Typesetting	.txt	These place text according to geographic location. Geocart installs a small suite of toponyms in this format. See Appendix F: Typesetting databases for information about the structure of these databases.
Metric lines	.metric	These are databases that you create to instruct Geocart to draw metric lines. See Appendix J: Metric line databases to learn how to make these databases.

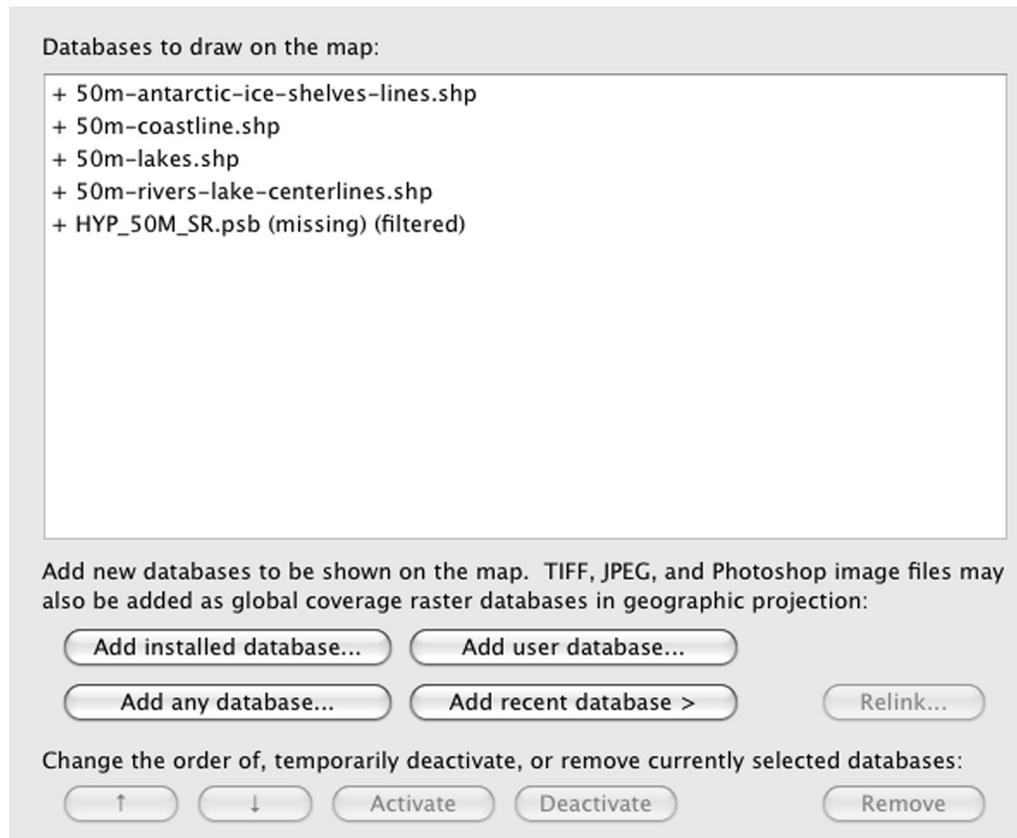
You may add as many databases as you want to be drawn into your map. Regardless of what order you add them in, raster databases will be drawn first, then vector, then typesetting and metric lines on top. Raster imagery that is opaque will obscure any other raster imagery below it. Hence it is uncommon to add more than one raster database to a map unless they cover different regions without overlap.

The upper left section of the **Databases** dialog is where you control what databases are present in the map, what order they will get drawn, and even whether or not they will get drawn. *Databases to draw on the map* is the list of databases that have been added to the map. The order in the list is significant: Entries higher in the list will get drawn first. You may select multiple entries using standard selection techniques: **shift**-clicking for contiguous spans; **command**-clicking (Macintosh) or **CNTL**-clicking (Windows) for discontinuous entries. Move selected entries higher in the list using the up-arrow dialog button (not your keyboard arrow keys). Move them lower by using the down-arrow dialog button.

Add installed database

You add new databases from Geocart’s shared-use database location using this button. It presents you with a standard

file picker already navigated to Geocart's shared-use database location. (See [Appendix G: Managing your databases.](#)) Any of the supported database types will be available for selection. You may select multiple files at once.



Databases list portion of Database dialog

Add user database

You add new databases from your private-use database location using this button. It presents you with a standard file picker already navigated to your private-use database location. (See [Appendix G: Managing your databases.](#)) Any of the supported database types will be available for selection. You may select multiple files at once.

Add any database

You add new databases from any location using this button. It presents you with a standard file picker navigated to the last location you chose a database from. Any of the supported database types will be available for selection. You may select multiple files at once.

Add recent database

This button presents you with a list of the most-recently added databases. Choosing one adds it to the *Databases to draw on the map* list.

Relink

If Geocart cannot find a database that you have added (because you have moved it or because you are opening the document on a different computer, for example), it will append (missing) to the name of the database in the list. You can show Geocart where to find the database using this button.

Activate

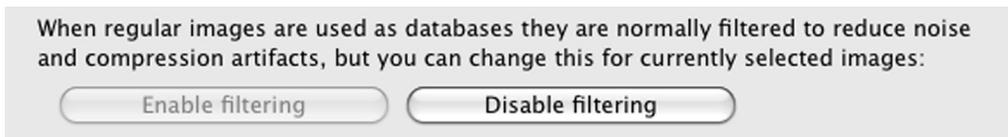
If any of the selected databases have been deactivated, this button will reactivate them. An activated database shows with a + to the left of its name.

Deactivate

You can keep databases in the list without having them draw by deactivating them. Deactivated databases show with a - to the left of its name.

Remove

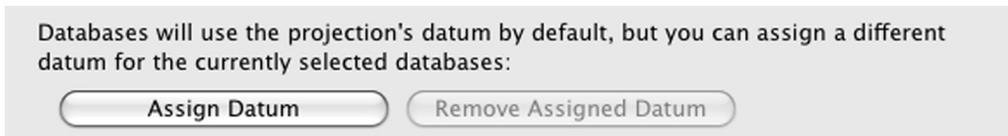
Remove all selected databases in the list from the map using this button.



Filtering portion of Databases dialog

Filtering

Filtering is an image-processing technique for removing speckly artifacts from an image. It is something like a slight blurring. Many scanned images and JPEG images contain such artifacts, so Geocart assumes it should filter them. You can control whether a global raster database should be filtered or not using these buttons. Databases slated for filtering have (filtered) appended to their name as displayed in the databases list.



Datum portion of Databases dialog

Assign Datum

Databases encode the latitude/longitude coordinates of the information they contain either implicitly, as the pixel position, or explicitly, as coordinates. But latitude and longitude do not suffice for high-accuracy mapping. The earth has been mapped by thousands of surveys over the centuries, each with its own model of the earth's shape and origin for its coordinate system. Hence two different surveys might assign slightly different coordinates to the exact same location on the earth's surface. The *datum* of a map projection describes the model it uses for the earth along with the location of the coordinate system's origin. (See [Datum on the Projection menu](#).) It is irrelevant for small-scale mapping, such as world or continental maps. It is critical in large-scale maps, such as town surveys or topographic quadrangles.

By default Geocart assumes that the datum of a database you have added to a map matches the datum of the projection you have set up. However, you may be aggregating databases from many sources. Or, you may want a different datum for your map than your databases were recorded in. Clicking the *Assign Datum* button will bring up the **Datum** dialog. You specify the datum by which you want the selected databases to be interpreted.

When a database's datum differs from a map's datum, Geocart performs a *datum conversion*. How it converts depends on the datum details. See [Datum on the Projection menu](#). The *Selected database details* pane shows you what datum a database is interpreted by.

Assign Coverage

Coverages for databases are typically specified by coverage mapping files, but you can assign different coverages or revert to the original mapping for the selected databases:

Assign Coverage...

Revert Coverage

Coverage portion of Databases dialog

When you have selected vector databases in the database list, you will be able to assign *coverages* to them to override Geocart's normal interpretation. A coverage is a description of the geographic meaning of the vectors in the database. It may be "rivers" or "coastlines", for example. Normally coverages are determined by *coverage mapping files* installed in your shared-use or private-use database locations. (See [Appendix D: Coverage mapping files](#) for information about where these files reside and how they are constructed. See [Line Styles](#) for information about how coverages are drawn.)

Coverage mapping files decide coverages by examining the file names of the vector databases. You may have vector databases whose names do not match any pattern recognized by your coverage mapping files, and you may find it easier to assign the coverage here than to deal with coverage mapping files. Or, you may have a database whose name matches a pattern that the coverage mapping files recognize, but whose associated coverage is not appropriate to your file. Or you may wish to override the coverage mapping file's interpretation for some other reason.

You can revert any coverage assignment you have made to the selected databases using the *Revert Coverage* button. Geocart will thence interpret the coverage through its normal mechanisms: the coverage mapping files when recognized, or *Coverage/Unspecified* if the file name matches no known pattern.

Nominal Scale

This command functions when one map is selected.

Nominal scale is how you tell Geocart what size to draw the selected map. It establishes the baseline for measuring distortion and for any special properties the map projection has, such as correct scale along parallels. Essentially, it is the scale of the globe which you are projecting to create your map.

Because scale varies across all maps, sometimes drastically, you must not think of nominal scale as something you can use for accurately measuring distances. While maps of large enough scale on appropriate projections can yield accurate (enough) distance measurements, any map of global coverage is completely unreliable for distance measurement.

You may set a map's scale in your choice of units. As you type in the field of your choice, the others will update to equivalent values automatically. The *meters* setting means the radius or semimajor axis of the globe from which you are projecting.

Normally when you change scale, Geocart will redraw the map, enlarging or shrinking it according to your new selection. That is the *Preserve resolution* option.

Nominal Scale

1: 222390103.9505

2223.90104 km/cm

222390.10395 m/mm

3509.944822 mi/in

R = a = 0.02864789 meters

When I change the scale of the map:

Preserve the resolution; rerender the map

Preserve the map; change the resolution

The current map resolution is 1.41111 pixels/point.

Cancel OK

You may wish not to change the pixels in your map at all, but only to change the interpretation of its real-world size by increasing or decreasing the density of pixels. That is the *Preserve map* option. Its effects are largely instantaneous, since it does not redraw the map but only scales it for display.

Map Size and Resolution

This command functions when one map is selected.

Geocart lets you state a real-world size for your map. It also lets you state a resolution (pixel density). You can state them separately in order to redraw the map at a new size and pixel density, yielding new pixels to represent the map. Or, you can force one to change in response to changes in the other so that the map will still contain the same pixels. This causes the interpretation of pixel size to change.

Typically you set a pixel resolution according to the needs of the medium, regardless of the size of your map. To print, for example, you might want 300 dpi so that your map contains as much detail as the eye can easily resolve. This would be true whether the map were 10 cm wide or 100 cm wide as long as the expected viewing distance from the map were the same. For a Web map you might want 96 dpi, which is similar to most computer displays, and irrespective of the size of the map. This typical usage corresponds to *Preserve the value*.

With *Preserve the value*, you may change *Width* or *Height* without affecting the *Resolution* field, and conversely you may change the *Resolution* field without affecting the *Width* and *Height* fields. When you confirm the dialog, Geocart will resize the map if you have changed its size, and render it at the requested resolution.

Occasionally you may simply want to impose a different interpretation for the size of the pixels that are already in the map, without rendering the map anew. This practice corresponds with *Preserve the map*. Since the same pixels will compose the map, and since you have stated a different size for them, then the size of the map itself must change. Hence, when *Preserve the map* is selected, changing the *Resolution* field will also change the *Width* and *Height* fields. When you confirm the dialog, Geocart will not render the map again; it will just change its real-world size and scale its representation on the screen to match.

Width and *Height* affect each other in all cases because otherwise the map's proportions would change. Normally that would be undesirable.

Map Size and Resolution

Width: 1000 points

Height: 502 points

Resolution: 1 pixels/point

When I change the dimensions or the resolution:

Preserve the value I don't change; re-render the map

Preserve the map; change the other value

Cancel OK

Scale to Window

This command functions for all selected maps. Each selected map gets scaled and positioned so as to fit snugly in the window.

Scale to Document

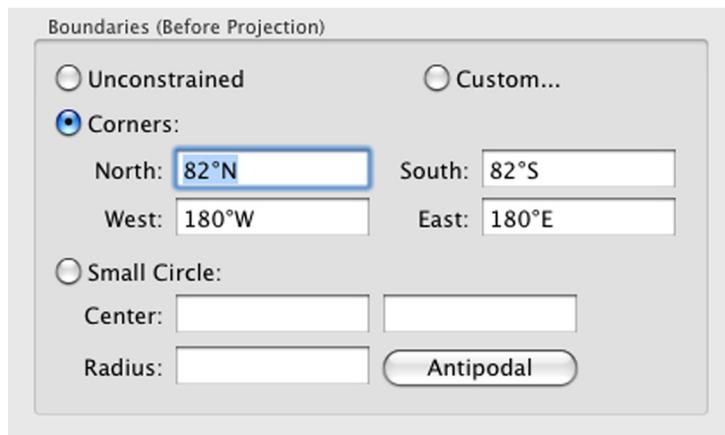
This command functions for all selected maps. Each selected map gets scaled and positioned so as to fit snugly in the document space.

Boundaries

This command functions when one map is selected.

Boundaries are the extents of your map. A map projection has a natural boundary, which is the maximum extent that Geocart can draw. Then it has the boundaries you specify here. That map that gets drawn will be the portions that are common to both the interior of the natural boundary and the interior of the boundary you specify.

A common way to specify boundaries is to give the north, west, south, east (NWSE) extents. That works well for many situations, but not all. Another simple way to express boundaries is to choose a center point and a radius, such that all regions within the radius will get drawn. These two methods take care of most needs.



Boundaries (Before Projection)

Unconstrained Custom...

Corners:

North: South:

West: East:

Small Circle:

Center:

Radius:

Unconstrained

Click on the unconstrained button to remove any specified boundaries. The map will be left with the natural boundaries of the projection.

Corners

To specify NWSE, enter the extents into the *Corners* section of the *Boundaries (Before Projection)* pane. North must be greater than south to be meaningful. West and east, however, wrap around the globe; there is no requirement of ordering. For simplicity, you may type slashes between degrees, minutes, and seconds. So, for example, if you wished to enter $47^{\circ}30'40.457''S$, you may type $47/30/40.457S$. Be sure to append S or W to your numbers if they are in the southern or western hemispheres.

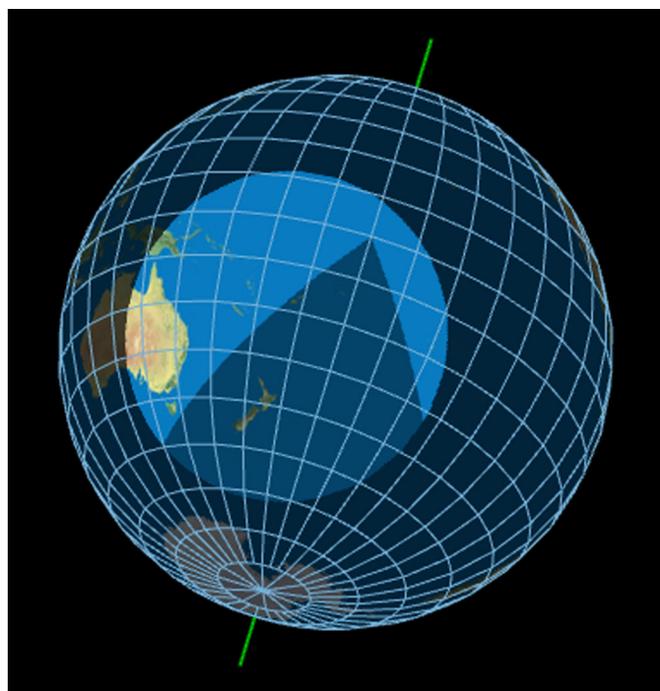
You can also drag out the boundaries in the map pane of this dialog. After clicking the *Corners* radio button, click on the map at one corner of your desired boundaries. Hold down the mouse button and drag to the other corner.

Small Circle

To specify a center point with radius as the boundary for your map, click on the *Small Circle* radio button. (A small circle is the path on the globe that is a fixed distance from a chosen center point.) Enter the center point of the region, latitude in the left field and longitude in the right. Enter the radius, in degrees of arc, in the *Radius* field. A degree of arc is the same distance as a degree of latitude.

You can also drag out a small circle in the map pane of this dialog. Click at the center of the region and, holding the mouse button down, drag away from it until you have covered the region of interest.

Use *Antipodal* to “invert” the small circle so that regions outside become interior, and regions inside become exterior. This is useful for defining what you want to exclude from the map, rather than what you want to include.



Custom

In some unusual circumstances you may need to specify more elaborate boundaries. Using the *Custom* option you can specify a boundary of arbitrary complexity, building it up from small circle segments. See [Appendix H: Defining custom boundaries](#) for details.

Map pane

The map pane of the dialog will update as you edit your boundaries. The bright regions of the map show the portions that will appear on your map. The dark regions show the portions that are outside of the boundaries you have chosen.

Some map projections cannot map the entire earth, so the entire map will not brighten even if you choose *Unconstrained*. In this case, you will be able to specify boundaries that lie outside the natural boundaries, but those outside the natural boundaries will have no effect. Regions inside your specified boundary but outside the natural boundary will be displayed in intermediate brightness. See the example at right, showing a small-circle boundary that overlaps a wedge region outside the map projection's natural boundaries. Only the brightest region will get drawn in the final map.

As described above, if you have *Corners* or *Small Circle* selected, you may click and drag directly on the map view to create your boundary.

View type

The map pane has several display modes. These modes do not affect the boundary, but only your view of the space on which you describe the boundary. Select the view most useful to your mapping.

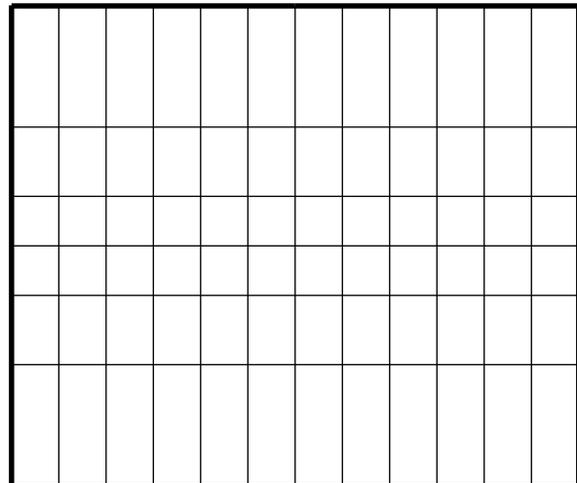
- **Physiographic.** This shows a the world with continents colored by terrain and vegetation.
– OR –
- **Political.** This shows the world as sovereign nations.
- **2D.** This shows the world in a simple rectangular projection.
– OR –
- **3D.** This shows the world in two hemispheres whose orientation you can control. To spin a globe transversally, click and drag at one of the axes. Or, use the controls in the upper left corner for a complete suite of manipulations. Both globes will move so that you always see the entire earth in two hemispheres.

Boundaries relative to graticule

Consider the normal equatorial Mercator projection at right. It is bounded north and south at the 82nd parallel. The reason the Mercator is bounded north and south at 82° latitude by Geocart's default is because the projection is not naturally bounded: It would naturally extend infinitely upward and downward. One way to think about the boundary is as NWSE (north/west/south/east) extents:

North:	82°N	South:	82°S
West:	180°W	East:	180°E

This means that the boundaries lie along the graticule. The pieces of the boundary follow some parallels and some meridians. If the graticule moves (because we changed the projection center), then the same meridians and parallels will continue to describe the boundary, even though they have moved. This is what it means to



say the *Boundaries are defined relative to graticule*.

Normally you would use this setting if some specific geographic region of the earth is the subject of your map. If, for example, you intend to show Australia, you need the boundaries to circumscribe Australia regardless of what you do with the projection.

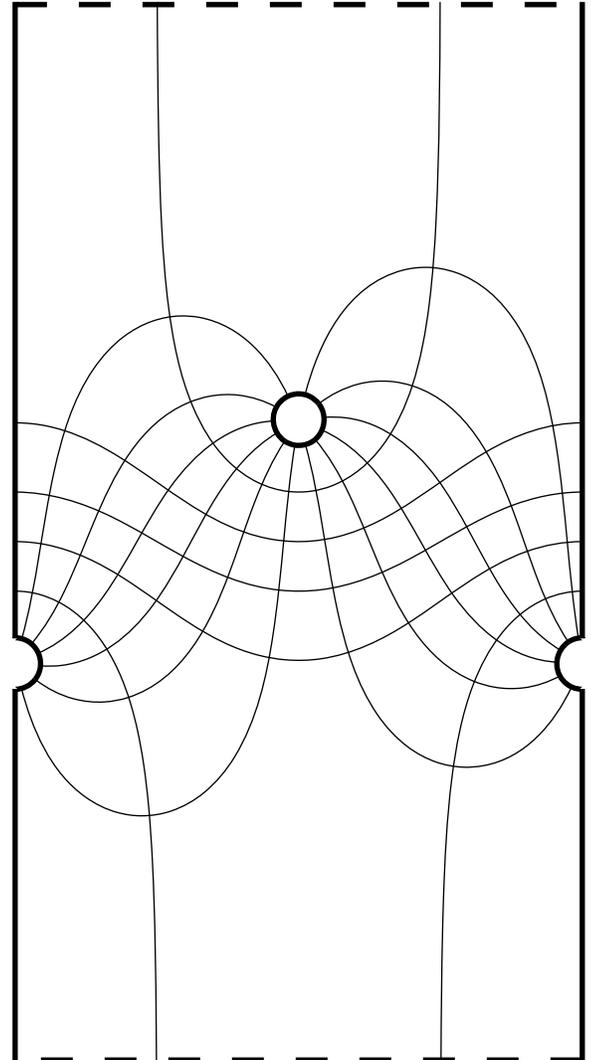
Boundaries move with center

If we think of the boundaries as tied to the graticule and then change the projection center to an oblique aspect, notice what happens: The latitude 82° boundaries become holes in regions that could otherwise be mapped. Meanwhile the portions of the map that are infinite do not receive proper bounding. (The illustration at right is clipped off for practicality; in actuality Geocart would draw a very large map.)

We cannot find a NWSE boundary that works for this oblique case. Nor can we find a small circle case that works, either. However, that the original boundaries on the normal Mercator would work just fine for the oblique aspect if we left the boundary in equatorial aspect while we changed the interior of the projection to oblique.

We can do this by declaring that the *Boundaries move with projection center*. This means that boundaries glide over the surface of the globe in response to changes in the projection center so that their position remains unchanged with respect to the natural boundaries of the projection, instead of unchanged with respect to the graticule. They are no longer necessarily NWSE descriptions; they are instead a path described by a sequence of four pieces of small circles. Hence “corners” rather than NWSE.

Geocart can work with arbitrarily complex boundary descriptions composed of sequences of pieces of small circles. The *Small Circle* option is one small circle, complete. The *Corners* option is pieces of four small circles. (Meridians are great circles, but great circles are also a kind of small circle.) If you need some other way to describe a boundary, see [Appendix H: Defining custom boundaries](#).



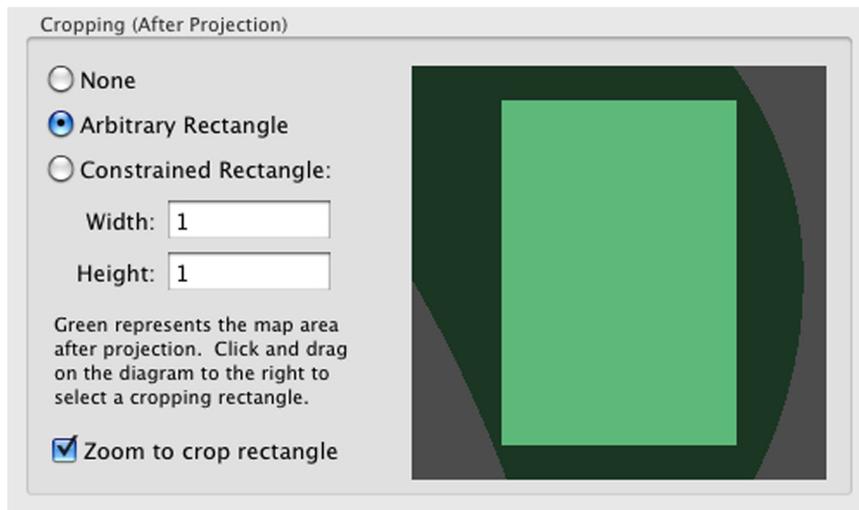
Cropping

Needing a rectangular map is common. Meanwhile the boundaries you selected may not provide a map of convenient shape, and could end up with substantial portions you don't care about but that cost render time anyway. The purpose of *Cropping* is to give you a chance to pare down the expanse of your map to a rectangular shape before actually drawing it.

The view of the regions you see in the large map pane is the view on the globe (3D) or on the geographic projection (2D), not on your final map. You can see the effect of your boundary choice in the *Cropping (After Projection)* pane. The green regions are a caricature of your map as it will be drawn in your document. Within the white portion of the circle, the shape will be faithful. If it extends into the pink ring, the shape will be distorted because it portrays your entire map, even if infinite in extent, within a finite space.

Zoom to crop rectangle

If your crop rectangle is a small part of the caricature, you can improve your accuracy by zooming into it and refining your rectangle. Check this control to zoom in. Uncheck to restore the diagram to the full boundary display.



Cropping section of Boundaries dialog

None

This turns off cropping. The map will be rendered according to your boundary choice.

vs.

Arbitrary Rectangle

With this choice, you drag out a rectangle in the caricature box. Understand that this is a rough operation because normally the caricature box is much smaller than the map you are constructing. You won't necessarily be able to place the edges precisely where you want them. You should err on the side of too much rather than too little.

vs.

Constrained Rectangle

You can specify an aspect ratio for the rectangle you drag out, retaining the height-to-width proportions, if the map you are constructing needs to be of some specific proportion. This way you need only focus on one dimension as you drag out the rectangle; the other dimension will be taken care of automatically.

Gaticule

This command functions for all selected maps. It is the map created earliest whose values populate the dialog on entry.

Many maps need no more than the basic controls: whether to draw parallels and meridians or not, and how far apart. These controls are found in the upper section of the dialog box. *Pruning* options are found in the middle. Because meridians converge at the poles, they can become too dense for practicality and aesthetics on some projections. The pruning options let you specify that some meridional sections toward the poles should be weeded out from drawing. This is common practice in polar maps particularly. The lower section of the dialog box provides some advanced, uncommon controls.

If your work has you making a particular style of map with a standardized gaticule, you may find the [Preferences > New Map Gaticule](#) settings to be useful. You can set up a gaticule that all new maps will inherit.

Draw parallels

When checked, Geocart will draw all parallels (lines of latitude) specified to get drawn.¹ Unchecked disables drawing of all parallels, including tropics and polar circles and any custom additions, even if they are otherwise set to be drawn. Parallels will be drawn as specified by the *Gaticule > Parallel* line style (see [Line Styles](#)) and its descendents.

<input checked="" type="checkbox"/> Draw parallels	Parallel spacing: <input type="text" value="15°"/>	<input checked="" type="checkbox"/> Tropics
<input checked="" type="checkbox"/> Draw meridians	Meridian spacing: <input type="text" value="15°"/>	<input checked="" type="checkbox"/> Polar circles

Graticule basic controls

Draw meridians

When checked, Geocart will draw all meridians (lines of longitude) specified to get drawn.¹ Unchecked disables drawing of all meridians, including custom additions, even if they are otherwise set to be drawn. Meridians will be drawn as specified by the *Graticule > Meridian* line style (see [Line Styles](#)) and its descendents. Note that the prime meridian's line style can be specified separately as the *Graticule > Meridian > Prime meridian*.

Parallel spacing

This field specifies the spacing of the automatically generated set of parallels. Units are degrees. When set to 15°, for example, a parallel will be drawn every 15 degrees. By default the spacing gets counted from the equator, but you can set it to whatever you wish. (See [Origin of latitude spacing](#).) The line style attributes of parallels in this automatic set are specified by the *Graticule > Parallel > Normal* line style (see [Line Styles](#)).

Meridian spacing

This field specifies the spacing of the automatically generated set of meridians. Units are degrees. When set to 15°, for example, a meridian will be drawn every 15 degrees. By default the spacing gets counted from the prime meridian, but you can set it to whatever you wish. (See [Origin of longitude spacing](#).) The line style attributes of meridians in this automatic set are specified by the *Graticule > Meridian > Normal* line style (see [Line Styles](#)).

Tropics

When checked, the tropics of Capricorn and Cancer will be drawn unless *Draw parallels* is unchecked.¹ The line style attributes of the tropics are specified by the *Graticule > Parallel > Tropic* line style (see [Line Styles](#)).

Polar circles

When checked, the arctic and antarctic circles will be drawn unless *Draw parallels* is unchecked.¹ The line style attributes of the polar circles are specified by the *Graticule > Parallel > Polar circle* line style (see [Line Styles](#)).

Pruning Options			
<input checked="" type="checkbox"/> North pole, primary:	<input type="text" value="30°"/>	degrees; retain every	<input type="text" value="3"/> meridians
<input checked="" type="checkbox"/> Secondary:	<input type="text" value="7°30'"/>	degrees; retain every	<input type="text" value="2"/> meridians
<input type="checkbox"/> South pole, primary:	<input type="text" value="30°"/>	degrees; retain every	<input type="text" value="3"/> meridians
<input type="checkbox"/> Secondary:	<input type="text" value="7°30'"/>	degrees; retain every	<input type="text" value="2"/> meridians

Graticule pruning controls

¹ Line drawing styles for different components of the graticule can be specified in the [Line Styles](#) dialog. Note that one setting for any line style is to *Hide coverage and all children*. Selecting that in the [Line Styles](#) dialog will turn off drawing for that graticule component even if the setting here in the **Graticule** dialog is to draw it.

North pole, primary

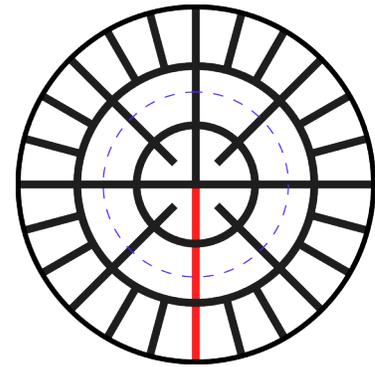
When checked, Geocart will not draw some meridians within the specified degree radius of the north pole. It will draw some, as specified in the *retain* field. For example, if the retain field holds a 3 as shown above, then Geocart will draw every third meridian all the way to the pole (unless further constrained by the Secondary checkbox; see below). In a graticule of 15° spacing, and considering just the 0°, 15°, 30°, 45°, 60°, 75° 90° meridians, normally all would get drawn from pole to pole. But if this *primary* checkbox is checked, and the *degrees* field is 30°, and we *retain* every 3 meridians, then only the 0°, 45°, and 90° meridians from that set will get drawn above 60°N latitude. The others will stop at 60°N latitude.

The *retain* value must be an integer 0 or greater. A value of 1 disables pruning, in effect. Retain counts start from the prime meridian in both directions.

North pole, secondary

We can further prune meridians as they get closer to the pole. This checkbox and settings prune away survivors of the primary pruning. The settings shown in the **Graticule pruning controls** illustration above yield the effect shown at right. (The prime meridian is shown in red; parallel and meridian spacing are both 15°.)

Notice that most meridians stop at 60°N. This is because the *North pole, primary degrees* field is set to 30°, forcing meridians to stop drawing within 30° of the north pole. Notice that every third meridian continues beyond 60°N. Of those that continue, however, some still stop short of the north pole. That is a consequence of the *Secondary degrees* field being set to 7°30', cutting off some meridians at 82°30'. Of those that survived the first pruning, every second meridian also survived the secondary pruning, by virtue of the *retain 2 meridians* setting.



The *Secondary degrees* field's value need not be less than the *Primary degrees* field, though the effect probably is not useful. The *retain* value must be an integer 0 or greater. A value of 1 disables secondary pruning, in effect. Retain counts start from the prime meridian in both directions.

South pole, primary

See discussion at **North pole, primary**. Mention of the north pole and “the pole” will mean the south pole instead.

South pole, secondary

See discussion at **North pole, secondary**. Mention of the north pole and “the pole” will mean the south pole instead.

Advanced Options

Prime meridian, as offset from Greenwich:	<input type="text" value="17°39'46\"/>		
Origin of latitude spacing:	<input type="text" value="0°N"/>		
Origin of longitude spacing:	<input type="text" value="17°39'46\"/>		
Additional parallels:	<input type="text"/>	Excluded parallels:	<input type="text"/>
Additional meridians:	<input type="text" value="17°39'46\"/>	Excluded meridians:	<input type="text"/>

Graticule advanced options

Prime meridian

Some maps, particularly historical maps, do not use the Greenwich meridian as the prime meridian. You can draw then entire graticule to be referred against some other prime meridian. In the **Graticule advanced options** illustration above, the meridian at Ferro in the Canary Islands is given as the prime meridian, which was Claudius Ptolemy's choice of prime meridian. The given value is the modern meridian of Ferro.

This setting *only* affects the drawing of the graticule. It has no bearing on the map projection's coordinates. If, for example, you hover the mouse pointer over a coordinate, the [Information](#) palette will deliver the map projection coordinate for that point, not the graticule coordinate.

Origin of latitude spacing

If your graticule's parallel spacing is not evenly divisible into 360°, then which parallels should be drawn becomes ambiguous. For example, if your map spanned 30°N to 42°N, and you specified 4° parallel spacing, does that mean you want the 30°N, 34°N, 38°N, and 42°N parallels drawn? By default, the 32°N, 36°N, and 40°N parallels will be drawn instead, because, considering the progression of parallels all the way from the equator, that is how they fall out with 4° spacing. Using this setting, you can change where parallel drawing starts. In this example, you could specify to start it at 2°N or 30°N; the effect would be the same because the difference between 30°N and 2°N is 28°, which is evenly divisible by 4°.

Origin of longitude spacing

If your graticule's meridian spacing is not evenly divisible into 360°, then which meridians should be drawn becomes ambiguous. For example, if your map spanned the globe, and you specified 20° meridian spacing, does that mean you want the 170°W, 150°W ... 10°W, 10°E ... meridians drawn? By default, the 180°W, 160°W ... 20°W, 0°W ... meridians will be drawn instead, because, considering the progression of meridians all the way from the prime meridian, that is how they fall out with 20° spacing. Using this setting, you can change where meridian drawing starts. In this example, you could specify to start it at 170°W, or any meridian an even multiple of 20° away from it.

Additional parallels

You may need to have other parallels drawn than would be generated automatically by the [parallel spacing](#) you set. For instance, if you want to have the latitude of some special city drawn as a parallel, you can specify that here. The values in this field are a list of parallels separated by semicolons (;). So, for example, if you wished to draw 42°30'N and 51°19'S in addition to the regular graticule, you would type 42/30; 51/19S into this field.

Additional meridians

You may need to have more meridians drawn than would be generated automatically by the [meridian spacing](#) you set. For instance, if you want to have the longitude of some special city drawn as a meridian, you can specify that here. The formatting follows the rules given in the explanation of *Additional parallels*.

Excluded parallels

You can prevent Geocart from drawing any of the regular parallels by listing them here. The formatting follows the rules given in the explanation of *Additional parallels*. If you list parallels that would not have been drawn in any case, the spurious entries will be ignored.

Excluded meridians

You can prevent Geocart from drawing any of the regular meridians by listing them here. The formatting follows the rules given in the explanation of *Additional parallels*. If you list meridians that would not have been drawn in any case, the spurious entries will be ignored.

Line Styles

This command functions when one map is selected.

You control how computed lines and vectors from vector databases get drawn using this command. (Computed lines include the graticule and the outside border of the map.) You can specify the color, transparency, width, and dash-line attributes of these lines. In aggregate the attributes are called the *line style*. You specify line styles by *coverage*. Coverage is the geographic meaning of the line, such as coastline or international border.

In Geocart, coverages are hierarchical. For example, a map has a graticule. The graticule consists of parallels and meridians. Graticule is a coverage, and so are parallels and meridians, but the latter are lower in the hierarchy. Usually you will want the color and thickness of the parallels and meridians to be the same, so you would set the line style at the level of the graticule. However, if you need to set them separately, you can instead set the line style at the level of parallels or meridians. Further, you may want yet a different style for the equator specifically, even though it is a parallel. Since equator is lower down in the hierarchy, you can set its line style independently of parallels without affecting them or the graticule at large.

The graticule and the outside border of the map are computed lines. They are always present in the **Line Styles** dialog and so are not listed under the *Coverages* umbrella, even though technically they are coverages. The coverages of lines extracted from vector databases, on the other hand, are determined by descriptive files called *coverage mapping files*. (See [Appendix D: Coverage mapping files](#).) What coverages show up in this dialog depends on the contents of those files. Geocart's installer places a suite of coverage mapping files into your computer's shared-use databases folder. You may create and add your own as well.

If you reached the **Line Styles** dialog from the [Preferences > New Map Line Styles](#) command, then all the coverages found in the all the coverage mapping files will be present in the *Line Types / Coverage* pane. If you reached it through the **Line Styles** command, then only the computed lines and the coverages from the databases present in the map will show up. This keeps the clutter down.

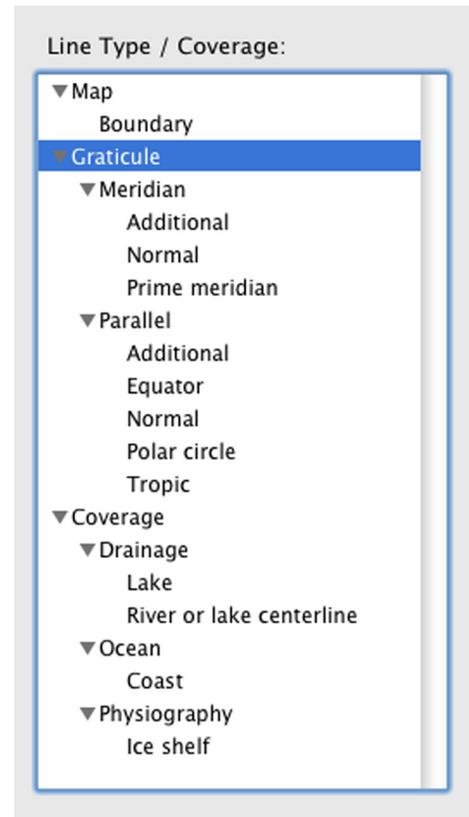
When you select a coverage in the *Line Type / Coverage* pane, the *Definition for this coverage* pane to the right updates to reflect the present line style settings for that coverage. The pane has three states:

- **Define new attributes.** This lets you set the attributes of the coverage and all its descendents in the hierarchy who otherwise have not specified their own attributes.
- **Use parent's attributes.** This disables any attributes that you have set for this coverage, and instead uses the parent's attributes. This does not affect descendents if they have specified their own attributes.
- **Hide coverage and all children.** This turns off drawing the coverage and any descendents of the coverage.

The rightmost panel, *Final style coverage*, describes how, ultimately, the coverage will get drawn, regardless which state of the *Definition for this coverage* pane is active. It could differ from the *Define new attributes* settings because you are free to leave any of those attributes blank, for example, so that some of the parent's settings come through. You cannot change the values in the *Final style coverage* pane. They are an effect, not a control.

Stroke color

Clicking on the *Stroke color* well brings up the **Color Picker**. You can choose any RGB value; the *Red, Green, Blue* fields below will update in response. Or, you may fill in those fields directly. A value of 0 means no contribution of



that color; a value of 255 means maximal contribution. *Red, Green, Blue* all set to 0 make black. *Red, Green, Blue* all set to 255 make white.

Alpha is the amount of transparency the color will have. An alpha of 0 means the color is completely transparent, resulting in no color, not even black. An alpha of 255 means the color is completely opaque; nothing below will show through.

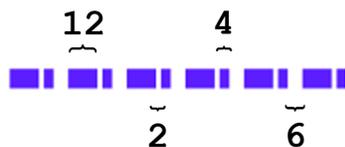
You may freely set the alpha value for most coverages. The graticule, however, must be a uniform transparency throughout its hierarchy. You can set differing values, but if you do the dialog will warn you at the time you confirm the dialog and will only use the top-most level's value.

Stroke width

You set the width, or weight, of the coverage's vector stroke here. Units are points (= 0.3528 mm = 1/72 in). The stroke is drawn centered along on the line's definition.

Dash pattern

You may instruct the stroke to be dashed rather than solid. In this case you supply a sequence of lengths to describe a repeating pattern for the dashed line. Each length is in points. The first is the length of a visible stroke. If there is no second value, then the gap between visible strokes will be the same as the length of the strokes. Otherwise: The second value is the length of the gap between visible strokes. The meaning of each successive value alternates between stroke length and gap length as long as there are any values left. So, for example, the sequence 12 2 4 6 yields the following dashed line:



Clear coverage AND children

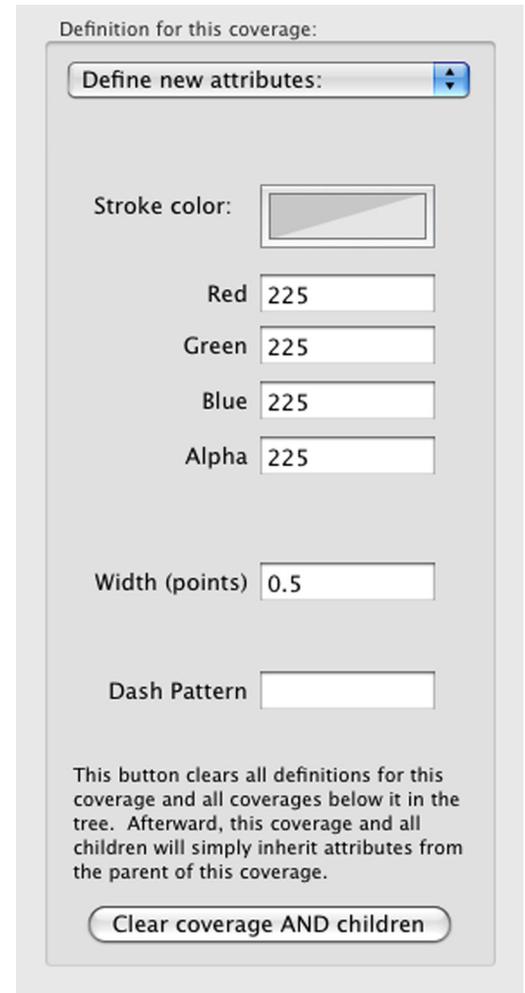
This command resets all the values in the *Definition for this coverage* pane, with the effect of inheriting the line style attributes from the parent in the hierarchy. It also clears all descendents in the hierarchy, so that they, too, inherit the same parent's attributes.

Distortion Visualization

This command functions when one map is selected.

Distortion is inevitable in a map. It affects the accuracy of a map. How distortion is distributed across a map is an important matter in map projections. (See [Chapter 3: Essentials, distortion.](#)) You can get precise readings on the distortion at any point on the map by opening the [Information palette](#) and hovering the mouse pointer over the point of interest. Using this *Distortion Visualization* command, you can create a univariate or bivariate color representation of the map's distortion characteristics so that you can understand the map's distortion holistically.

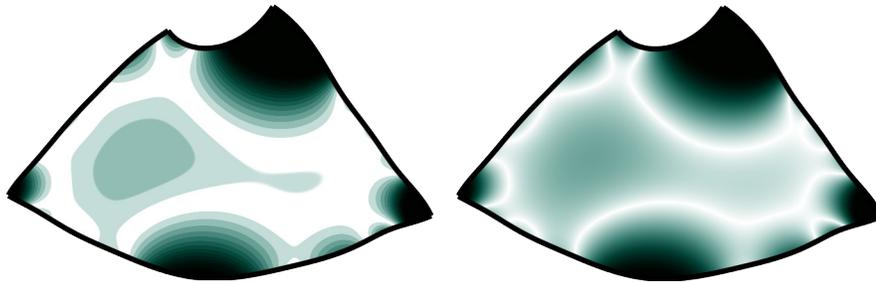
(Other methods of displaying map distortion characteristics in Geocart are the [Tissot Indicatrices](#) command and [Metric line databases](#). Use *Distortion Visualization* when you want to see the distortion as patterns, particularly in



comparing angular deformation against areal inflation/deflation. Use *Tissot Indicatrices* when you want to compare areas on a map to each other or to another map. Use a metric line database in order to draw Tissot indicatrices and distortion isopleths, much like contour lines, whose measures you have explicit control over.)

You may draw the raster databases on the map, or you may render its distortion characteristics. They are mutually exclusive. Turn on raster database rendering by clicking the *Draw the raster database on the map* button. Turn on distortion visualization by clicking any of the other radio buttons.

You can show angular deformation, areal inflation/deflation, or a combined “scale factors” as univariate maps using gradations. Or, you can show a bivariate representation of angular deformation and areal inflation/deflation using continuous tones. Regardless of how you configure your distortion map, lighter hues mean less distortion. Darker hues mean more distortion.



Gradations vs. continuous tones

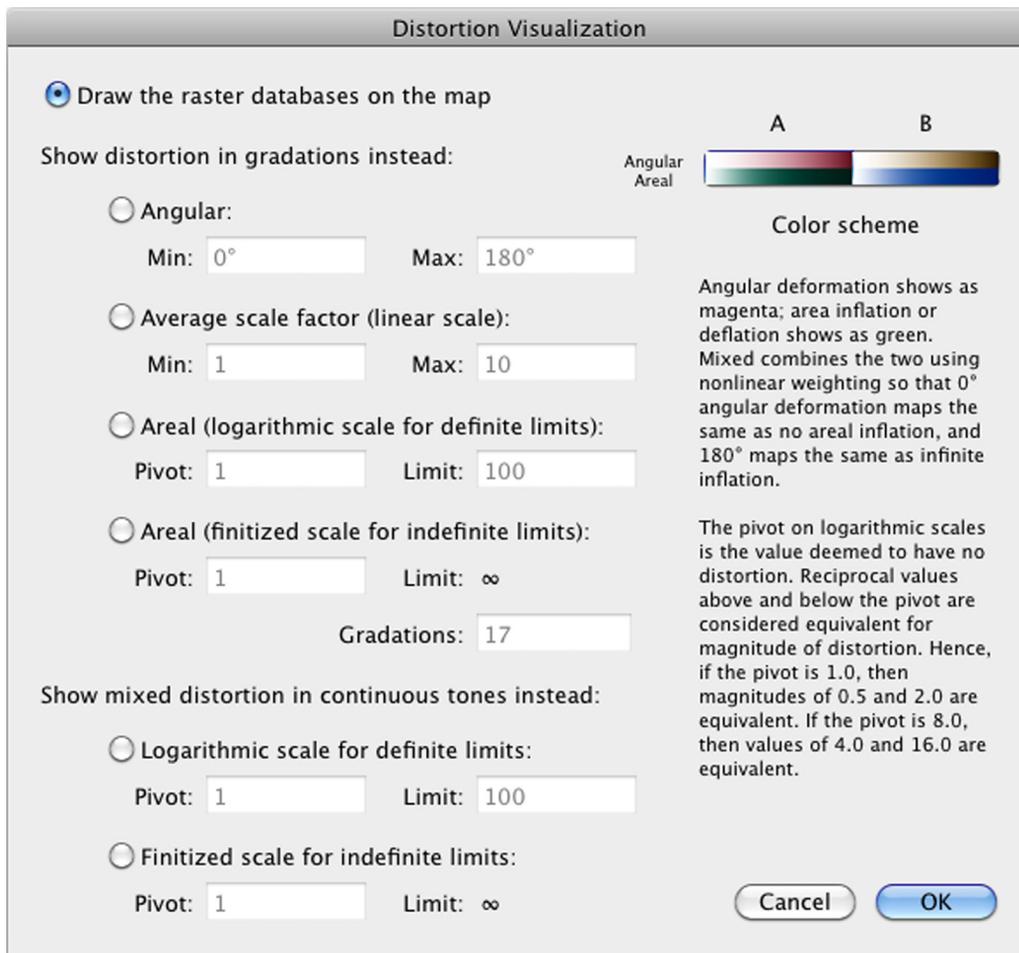
To understand what these diagrams mean, note that angular deformation is absolute. It does not depend on the scale of the map. Angular deformation of 0° means no angular deformation, and you cannot get any less than that. Areal inflation/deflation, on the other hand, are relative to whatever area is considered to be correct. Normally that would be a region whose area measurement matches the nominal scale’s square area. If an infinitesimal region’s area exceeds the nominal area, then it is inflated. If it is smaller than the nominal area, then it is deflated. A region with double the nominal area is as “bad” as one with half the area. But since the choice of nominal region is in some sense arbitrary (because the nominal scale itself is arbitrary), merely changing the choice of the nominal region will change which regions of the map are deemed more and less distorted. This same freedom of choice does not exist with areal deformation, which is absolute. Therefore you must understand that a bivariate map comparing areal inflation/deflation to angular deformation comes with this arbitrary element that compromises the meaning of the comparison.

Put another way, to compare the angular deformation of two locations on a map, you would subtract one angular deformation from the other. That tells you how different they are. To compare areal in-/deflation of two locations on a map, a better method is to divide one by the other. The ratio tells you how severely the inflation varies between the two. Comparing differences (angular deformation) to ratios (areal in-/deflation) is an apples and oranges proposition.

Dialog options

Now we can meaningfully describe the operation of the dialog. Regardless of which options you choose, the color white will correspond to the *Min* or *Pivot* field, whichever is available. Black will correspond to *Max* or *Limit*, whichever is available. In the gradations section, the *Gradations* field describes how many distinct shades of color must represent the all the distortion values from white to black, inclusive.

The reason these values for min/pivot and max/limit can be set is so that you can achieve meaningful contrast and number of gradations regardless of the amount of distortion and the extent of the map. Some maps, if they are only of a tiny section of the earth, for example, will vary very little across the map. Hence *Min* and *Max* might be very close together in order to still represent the small range of distortion across the map as varying between white and black.



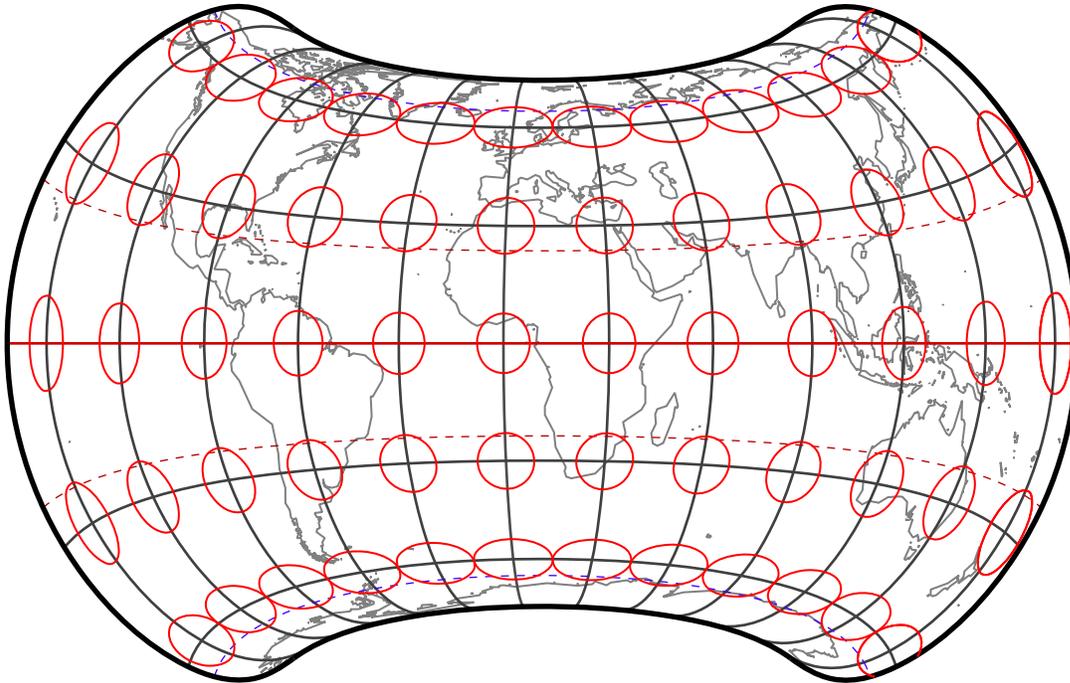
Distortion Visualization dialog

You can choose between two color schemes. The explanatory text in the dialog box refers to Scheme A. It generalizes to Scheme B. Scheme B may be better for some forms of color vision deficiency.

- *Angular* displays the angular deformation across the map.
- *Average scale factor* displays an average scale factor at each point. On a conformal map this corresponds to *scale factor*. The resulting image is grayscale. “Average” means the average of scale factors in all directions distributed evenly on the sphere. While possible for a point with modest angular deformation to have an average scale factor of 1.0, even moderate angular deformation results in values away from 1.0 because angles on the sphere become disproportionately distributed toward the major axis of the Tissot ellipse.
- *Areal (logarithmic)* displays the relative inflation/deflation across the map. If *Pivot* is 1.0 then distortion is measured against the nominal scale. Other values of *Pivot* represent multiples of the nominal scale. This setting is unsuitable for maps with a vast range of distortion.
- *Areal (finitized)* allows unbounded distortion to be mapped into a finite range.
- *Mixed Logarithmic* combines the angular and areal metrics and maps them into a logarithmically advancing scale. This setting is unsuitable for maps with a vast range of distortion.
- *Mixed Finitized* combines the angular and areal metrics and maps zero to infinity into a finite scale.

Tissot Indicatrices

This command functions on all selected maps. If all selected maps have the *Tissot Indicatrices* attribute set, then this command removes the attribute; otherwise it sets the attribute on all selected maps.



Tissot indicatrices

Maps distort the space they represent, as described in [Chapter 3, Distortion](#). You can understand at a glance how a map distorts its space by having Geocart draw Tissot indicatrices. Geocart will choose a size for the indicatrices such that they generally will have a reasonable amount of space between them. The absolute sizes of the indicatrix ellipses are not important, but, rather, how their sizes change across the map. An indicatrix will get drawn at each regular graticule intersection, ignoring pruning, extra graticule lines, tropics, and polar circles.

A more oblong shape in an indicatrix indicates more angular deformation. A more circular shape indicates less angular deformation; where perfectly circular, the map has no angular deformation. A conformal map will display all Tissot indicatrices as circles, albeit of different sizes. An equal-area map, on the other hand, will show indicatrices of all the same area, but varying in how oblong they are.

Copy Attributes

You can selectively transfer attributes from one map to others using *Copy Attributes* and *Paste Attributes*. This command functions when you have one map selected in the front window. It copies attributes of the selected map.

Paste Attributes

After copying attributes, you may paste them to all selected maps. You can specify which attributes to paste, since you may only want some of them or some may be inappropriate for the destination projection. The paste operation will incite each map whose attributes have changed to redraw.

Select the attributes you want to past by clicking each. Holding down the mouse button and dragging will toggle the

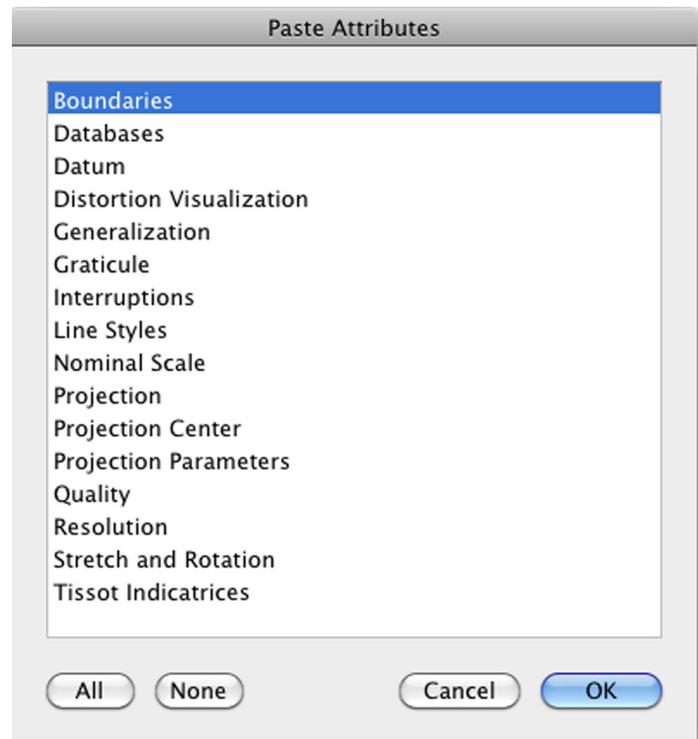
status of each attribute entry you pass over. You may select all attributes for pasting by clicking the *All* button. You may clear out any selection so that you can start over by clicking *None*.

The attributes in the list correspond to the attributes that can be set using the menu command of the same name. See the individual commands for details. *Resolution* means [Map Size and Resolution](#).

Descriptions for [Boundaries](#), [Databases](#), [Distortion Visualization](#), [Generalization](#), [Graticule](#), [Line Styles](#), [Nominal Scale](#), [Quality](#), [Resolution](#), and [Tissot Indicatrices](#) all can be found in the **Map** menu. *Generalization* includes both the generalization style and level.

Descriptions for [Datum](#), [Interruptions](#), [Projection Center](#), [Projection Parameters](#), and [Stretch and Rotation](#) all can be found in the **Projection** menu. Datum includes the auxiliary latitude, if any.

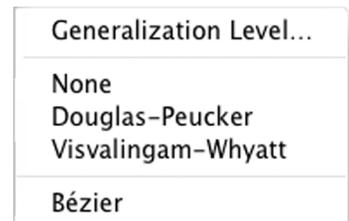
Projection means the map projection as found in any of the six projection menus.



Generalize Vectors

These commands operate on all selected maps. *Bézier* operates independently of the others. *None*, *Douglas-Peucker*, and *Visvalingam-Whyatt* all exclude each other. If any of the selected maps had the generalization style you chose off or in a mixed state, then all will go to on. Otherwise they will go to off.

Generalization is the technique of pruning out excess detail or of synthesizing acceptable, less detailed replacements for excess detail. Vector databases, such as rivers or administrative boundaries, come with an inherent level of detail that might not closely match the detail you need for your maps. When a database carries too much detail, the wiggles in line caricatures pile up on top of each other to no benefit, cluttering the map and even making it useless.



Generalization Level

When you set the generalization level, you instruct Geocart to render vectors from [vector databases](#) at a specific level of detail relative to the map's declared resolution (see [Map Size and Resolution](#)). A value of 1.0 means the line caricature can change meaningfully at the granularity of a pixel. The higher the value, the coarser the line caricature will become. Values lower than 1.0 generally result in too much detail for the resolution of the map, but can be useful in vector illustration editing programs, where the notion of "resolution" carries less meaning.

The amount of detail will be similar for all styles of generalization at a given generalization level, but the generalization level value is not precise in any local sense, since line segments will vary in length considerably regardless. Think of the generalization level as a way to specify about how much detail you wish the vector components of the map to have in relation to any raster imagery behind it. A value of 1.0 indicates parity.

Generalization styles

Many vector generalization algorithms have been proposed in the literature. Geocart 3.1 offers several; their properties are summarized in the table below the example here:



No generalization



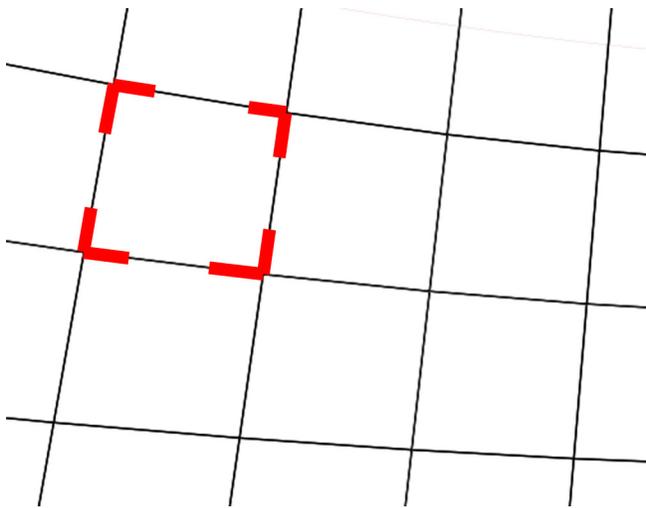
Douglas-Peucker



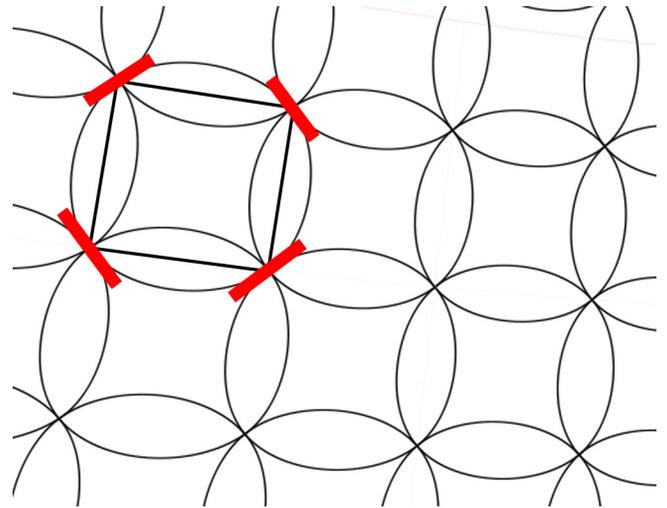
Visvalingam-Whyatt

Generalization type	Description
<i>None</i>	Turns off straight-line generalization but does not affect Bézier generalization. All vectors present in the vector database will be rendered as line work in the map if the coverage settings permit (see Line Styles). Use this if the level of detail in the vector database closely matches the scale at which the map will be drawn and if you do not want anything removed from it (such as tiny islands). This setting is rarely appropriate for world maps because a world map is far, far from constant scale.
<i>Douglas-Peucker</i>	This method retains extreme features and results in efficient line caricatures. Under generalization levels higher than 1.0, however, the the caricature will appear spiky in the presence of features like fjords. All points in the resulting paths will have come from the original database; none are synthesized.
<i>Visvalingam-Whyatt</i>	This method achieves a good caricature without the objectionable spikiness of Douglas-Peucker, but discounts the importance of extreme features. All points in the resulting paths will have come from the original database; none are synthesized.
<i>Bézier</i> (May be used alone or in conjunction with another.)	<p>When used alone, the Bézier method retains similar features as Douglas-Peucker. However, its line caricatures differ qualitatively from the other methods. The others weed out excess points but still represent a path as a sequence of straight lines. Bézier conversion, on the other hand, replaces the original path of straight lines with a curved path approximating it.</p> <p>There are two reasons to use Bézier curves. One, Bézier curves can impart a more natural look to a coastline under magnification. This does not mean more accurate; in fact it usually means less, since it is a caricature of a caricature. However, as long as the original data comes at higher detail than the scale of the map you are drawing, this should not be a problem.</p> <p>Two, Bézier curves represent line work efficiently. This could make the difference between being able to represent a continent as a single path, and having to split it due to point count limitations in PDF or an illustration program.</p> <p>On the other hand, Bézier curves are not suitable for representing coverages likely to include long, straight lines, particularly when used in concert with other generalization methods. See the text for description.</p>

You can specify the Bézier curve method alone or you can specify it with any of the others. If you select it with another, the basis for the Bézier curves will be the generalized line rather than the original. This can work well, or it can be disastrous, depending on the characteristics of the coverage. Consider:



No generalization

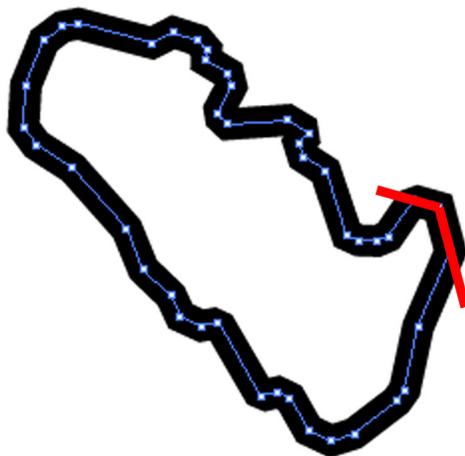


Generalization as Bézier curves

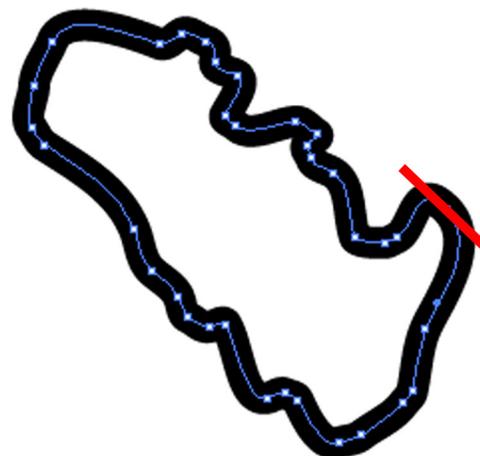
The image above, on the left, is the coverage as it ought to be drawn. On the right is the network after generalization with Bézier curves. How did this happen?

The image on the left consists of square-like polygons. Each is represented in the data set as a sequence of four points defining the vertices. The simplest thing to do is to draw straight lines between vertices. However straight lines don't occur in a natural coverage, so we should not assume straight lines are best. On a real coastline the shore may meander arbitrarily between two sample points. Meanwhile in this example the only information presented to the Bézier generalization algorithm is the four vertices. If the coverage were a coastline instead of a square, then the proper angle a line would make through a point would be a compromise between the approach angles on either side of the point. The approach angles are shown in red on the left. The compromise is diagonal lines, as shown on the right. When the final shape is supposed to be curved, and the entire shape is defined by only four points, the result will approximate a circle.

Contrast the images above with these below, where Béziens yield a superior caricature. Notice the red "tangent" of the protuberance at the lower right. It is, in effect, the average of the angles formed by the two red lines in the original caricature at the left. The lesson is that Bézier generalization works well for natural lines, but poorly for deliberate angles.



No generalization



Generalization as Bézier curves

Draft Quality

Selecting this menu item will deselect *Proof Quality* and *Final Quality*. It applies to all selected maps.

This setting yields the most rapid rendering of raster databases. It has no effect on other kinds of map databases. It uses a technique called *nearest neighbor* to select the best pixel in the source database to place into the projected map. The method does not blend pixels, and therefore can result in considerable *aliasing*. Aliasing corresponds to speckling caused by adjacent pixels being unrelated to each other in color.

If the respective map projections of the source image and the destination map are similar throughout the map, and the resolutions are similar, results of draft quality may be acceptable for many uses. These conditions are met most commonly in very large scale maps.

Proof Quality

Selecting this menu item will deselect *Draft Quality* and *Final Quality*. It applies to all selected maps.

This setting yields results intermediate between draft and final quality, improving the rendering but at the cost of render time. While quality will always exceed that of draft, and render time will always be faster than final, where along the line each falls depends on the vagaries of the respective projections of the source image and destination map.

If the respective map projections of the source image and the destination map are similar throughout the map, and the resolutions are similar, results of proof quality likely suffice for any use. These conditions are met most commonly in very large scale maps.

Final Quality

Selecting this menu item will deselect *Draft Quality* and *Proof Quality*. It applies to all selected maps.

This setting yields the most accurate rendering of raster databases, at or near the theoretical optimum. The drawback is that many pixels in the source could get blended to create a single pixel in the map you are creating. Even thousands of pixels might get blended. The number of pixels that get blended depends on how much more detailed the source image is than the destination pixel, and how different the characteristics of the source and destination projections are at the pixel being rendered. Each source pixel costs some computation to blend.

Because of the high quality this setting yields, you may find that you can convert publication quality maps from one projection to another with acceptable results, even if they include text, and even if the projections differ significantly. The method is not complete magic, however. It cannot manufacture detail from nothing, and it cannot correct warpage and spread in text and line work that arise when the projections differ too much. Whether a result is usable depends upon use and tolerance.

Chapter 10: Projection menu

The **Projection** menu offers settings for adjusting the projections of your maps. If you need to choose a projection, use the six projection menus instead:



[Cylindrical](#)



[Pseudocylindrical](#)



[Conic](#)



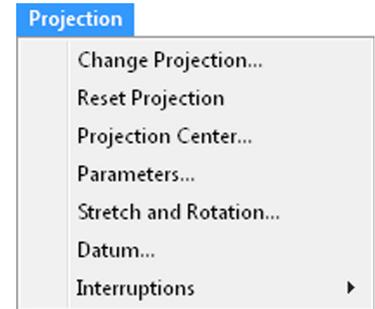
[Azimuthal](#)



[Lenticular](#)

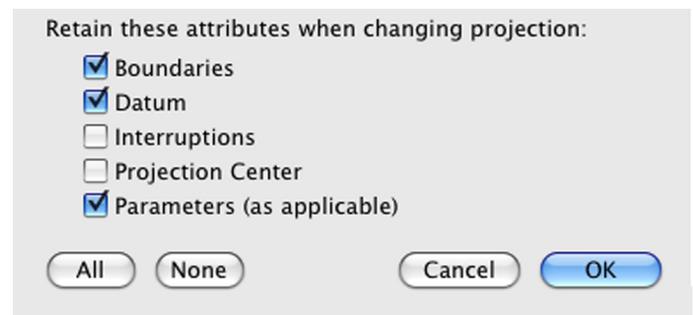


[Miscellaneous](#)



Change Projection

This command changes the projection of all selected maps to one projection you pick. The list view you pick from contains information about and illustrations of each projection to help you choose. At the top of the information pane you can see all synonymous names for the projections. Geocart's preferred name is at the top, but the preferred name has no particular significance within the Geocart application. A projection's listing in [Appendix B: Projection gazetteer](#) can be found under its preferred name.



The operational portion of the dialog lets you select the kinds of attributes to retain when changing projections. All are selected when you enter the dialog. If you don't want to carry over some attribute, then uncheck the box for that attribute.

Parameters

If you leave *Parameters* checked, Geocart will try to carry over parameters from the old projection to the new one to the extent they seem meaningful in the new context. If the old and new projection are both a typical conic, for example, then the parameters will match well. If you change from an azimuthal projection to a conic projection, on the other hand, typically there won't be anything useful to carry over in the projections. Parameters in the new projection not having evident analogues in the old projection will take default values.

All

Click this button to check all attributes.

None

Click this button to uncheck all attributes.

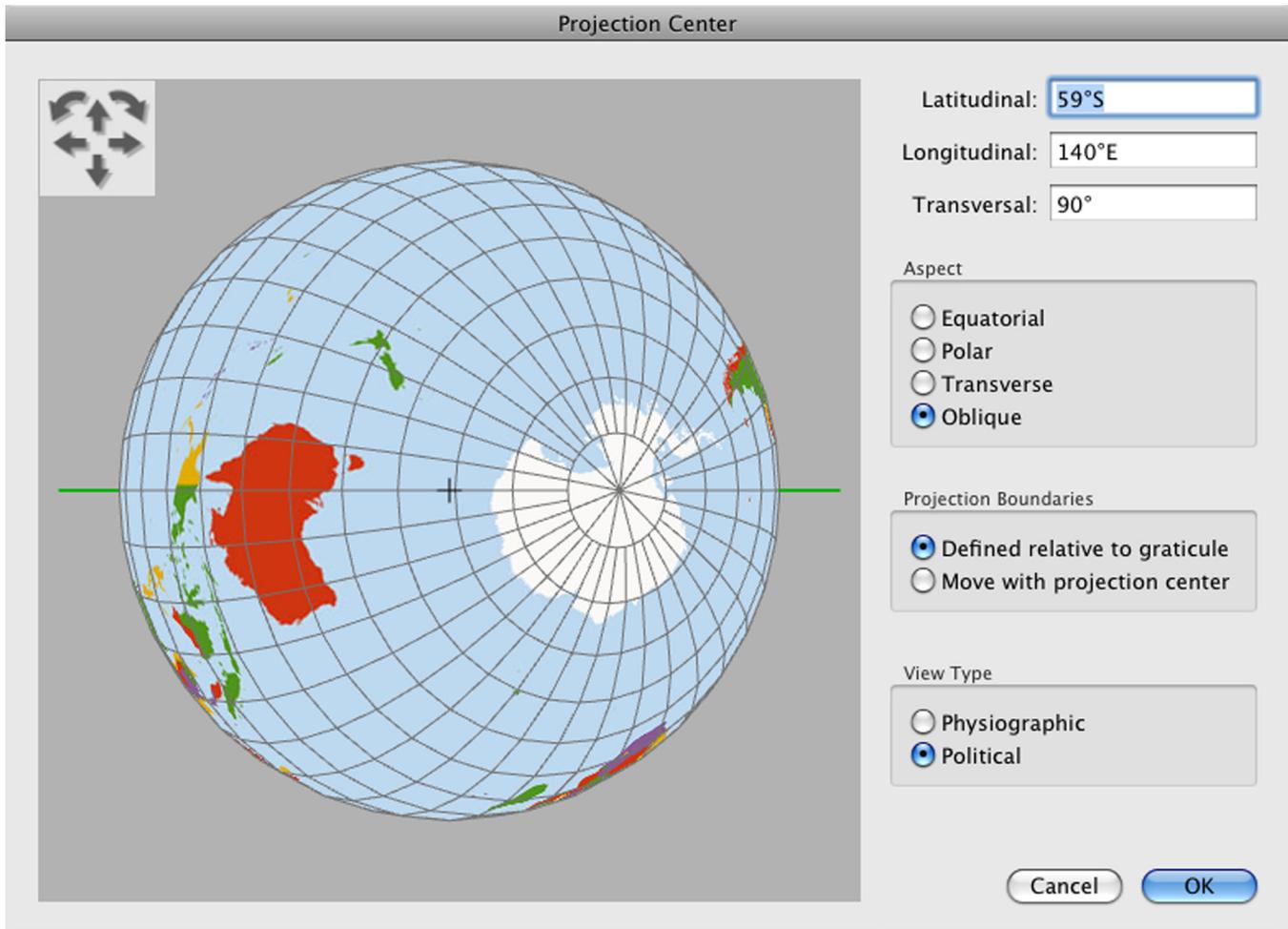
Reset Projection

This command resets the projections all selected maps in the front window, such that each projection takes default settings known to work well for that projection. These settings include any parameters the projection has, the projection center, any interruptions recommended for the projection, boundaries, and stretch and rotation.

A common time to use this command is after changing projections. Sometimes the new projection differs so radically from the old that it's best to just start fresh.

Projection Center

Map projections are formulated with a specific presentation in mind. That presentation varies according to the class of projection. Cylindric and pseudocylindric projections, for example, are normally formulated for equatorial aspect. That is, the map will be oriented so that the equator is straight and horizontal. Azimuthal projections, on the other hand, are most simply formulated in polar aspect. However, there is no reason a cylindric projection cannot be presented in polar aspect, and no reason an azimuthal projection cannot be presented in equatorial aspect. It is just a matter of rotation the globe before projecting. This kind of rotation is called *coordinate system rotation*.



Projection Center dialog

The controls in this dialog let you perform coordinate system rotations. There are many reasons you may want to do this. For instance, most projections have a region of lowest distortion. If you limit yourself to the default presentation

of the projection, the region you are mapping may not fall into a low distortion region on the projection you want to use. You can correct this using coordinate system rotations to bring the region you are mapping to the low-distortion region of the map projection. Another reason might be to bring some particular country or region to the center of a world map. It is common in Japan, for example, to center world maps on a meridian through Japan. It used to be common in the United States to center world maps on a meridian through the USA.

If you model the earth on a sphere, you can rotate the coordinate system freely. A sphere is symmetric in all directions, so any point on its surface can be rotated to any other point. If you model the earth on an ellipsoid, however, you can only rotate the earth around its natural axis while keeping any particular surface point on the surface. Any other rotation would move points off the surface and into space, or beneath the surface. Hence only longitudinal rotations are normal in ellipsoidal projections.

Warning: Do not recenter your projection indiscriminately. Understand the projection and how it is used. For example, in normal usage you would not change any rotation except longitudinal in a conic projection. The correct usage is to center the projection's longitude in the region of interest but leave the latitude alone. Then change the standard parallels to reasonable values within in the region of interest, using the [Parameters](#) command.

Latitudinal

Consider the axis formed by the center of the earth and the 90° meridian at the equator. The value in this field describes how far the globe is to be rotated northward around this axis before projecting. A value of $\pm 90^\circ$ results in a standard polar projection. The rotation brings the supplied parallel front and center. That is, a value of 23°N will bring the 23°N parallel to the center of the projection.

Longitudinal

The value in this field describes how far the globe is to be rotated westward on its natural axis before projection. It brings the supplied meridian value to front and center. That is, a value of 23°W will bring the 23°W parallel to the center of the projection.

Transversal

Consider the axis formed by the center of the earth and the prime meridian at the equator. The value in this field describes how far the globe is to be rotated counterclockwise around that axis before projecting. A value of $\pm 90^\circ$ when the *Latitudinal* field is 0° results in a standard transversal projection.

Aspect

The projection's aspect is determined completely by its latitudinal, longitudinal, and transversal rotations. The radio buttons in the *Aspect* group update according to your entries in the *Latitudinal*, *Longitudinal*, and *Transversal* fields. However, you may also force the latitudinal, longitudinal, and transversal rotations by pressing a radio button in this *Aspect* group.

- **Equatorial.** This button is selected when the *Latitudinal* and *Transversal* fields are both 0°. If this button is not selected, then you may select it to force the *Latitudinal* and *Transversal* fields to 0°.
vs.
- **Polar.** This button is selected when the *Latitudinal* field is either 90°N or 90°S. If this button is not selected, then you may select it to force the *Latitudinal* field to be 90°N and *Transversal* to 0°.
vs.
- **Transverse.** This button is selected when the *Latitudinal* field is 0° and the *Transversal* field is 90° or -90°. If this button is not selected, then you may select it to force the *Latitudinal* field to 0° and the *Transversal* field to 90°.

vs.

- **Oblique.** This button is selected when none of the other three in the group are. If you select another button, the dialog will remember the previous settings and restore them the next time you select the *Oblique* button.

Projection boundaries

As described in [Boundaries](#), a projection's boundaries may be referred to the graticule or to the projection center. It is common to change the projection center without changing the boundaries. It is also true that not changing the *Defined relative/Move with* setting here when you change the projection center could cause your map to be unable to draw. Therefore you may change the setting here. It is the same as setting it in the **Boundaries** dialog.

View type

Select *Physiographic* or *Political*, whichever is convenient to your work.

Parameters

This command is active when one map is selected in the front window, and only if the map's projection has any parameters.

Parameters are specific to the projection. See the projection's entry in [Appendix B: Projection gazetteer](#) for information about any given projection's parameters. See [Projection parameters](#) at the beginning of Appendix B for a discussion of projection parameters in general.

Stretch and Rotation

This command is active when one map is selected in the front window.

Using the settings in this dialog, you can increase the width and height of the projection independently of each other, and you can rotate the map in the document. There are two primary reasons for changing the width or height: You wish to change the distortion characteristics of the map; or you need to match your projection to a scanned image you have placed into the document. The latter reason is also a reason you might need to rotate the map. If you change the width or height and also rotated the map, Geocart first applies the width/height changes and then the rotation.

Changing the width or height of a projection implies changing the scale of the map in those directions. However, Geocart computes distortion as referred against the [nominal scale](#) of the map. Hence these settings can affect the calculation of distortion even if the scaling is uniform for width and height. If the scaling is uniform, angular deformation will not be affected, but scalar and areal metrics for distortion will be.

You can constrain the width and height values against each other by pressing the *Equal-area* or *Conformal* radio buttons. With one of those buttons selected, changing the value in the *Width* or *Height* field will automatically update the value in the other field.

If the *Equal-area* radio button is selected, then the field you do not edit will take the reciprocal value of the field you do edit. This ensures that an equal-area map will remain equal-area after your adjustments.

The image shows a dialog box titled "Stretch and Rotation". It contains the following elements:

- Width Multiplier:** A text input field containing the value "1.01".
- Height Multiplier:** A text input field containing the value "0.99009901".
- Radio buttons:** Three radio buttons are arranged vertically:
 - Unconstrained
 - Equal Area (Height = 1 ÷ Width)
 - Conformal (Height = Width)
- Rotation (CCW):** A text input field containing the value "0.01°".
- Buttons:** Two buttons are located at the bottom right: "Cancel" and "OK".

If the *Conformal* radio button is selected, then the field you do not edit will take the same value as the field you do edit. This ensures that a conformal map will remain conformal after your adjustments.

Width Multiplier

Set this value directly, or let it update automatically as you change the *Height Multiplier* field with either of the *Equal-area* or *Conformal* radio buttons selected.

Height Multiplier

Set this value directly, or press the *Equal-area* or *Conformal* radio buttons to compute the value from the *Width* field, or let it update automatically as you change the *Width Multiplier* field with either of the *Equal-area* or *Conformal* radio buttons selected.

Rotation (CCW)

Specify any rotation in degrees. The rotation will be counterclockwise if positive and clockwise if negative. Geocart applies rotation after width/height adjustments.

Datum

This command operates on all selected maps of the front window's document. The map created earliest is the one whose values populate the dialog upon entry.

The settings in the *Datum* dialog are largely unnecessary unless you are working with maps on a scale of 1: 1,000,000 or larger, such as 1: 5,000 or 1: 50,000. Coordinates for drawing maps at large scale are generally given on some specific datum. If you do not use the proper datum, distortion figures will not be correct, and you may not be able to usefully aggregate geographic data from different datums.

An *ellipsoid* is a squashed sphere, symmetric around its axis of rotation. It is characterized by its *major axis* and *minor axis*. With judicious choices of those axes, an ellipsoid can be a fairly accurate description of the shape of the earth, considerably more accurate than a sphere. The major axis is the diameter at the equator, and the minor axis is the length from pole to pole.

A *datum* is a model of the earth or a portion of the earth. A datum consists of an ellipsoid chosen to model the earth's surface, and a description of how that ellipsoid relates to the real earth's surface. Hundreds of datums (*datums* is the correct plural in this context) have been developed over the centuries. They use scores of ellipsoidal models. Each datum has a slightly different notion of where the prime meridian is and how the ellipsoid is oriented against the earth's surface. These differences were inevitable because there was no way to measure absolute positions on the earth's surface accurately. The best surveyors could do was declare, on the basis of the best evidence available, that a survey station had a particular coordinate. Then they would base the local survey around it.

Geocart lets you select a datum for your map here. Your choice of datum normally depends on the datum of the source data you will use to draw your map. It is best not to use a different datum if you have no reason to. If you do use a different datum than the datum of your sources, Geocart will convert the source datum to your map's datum. See [Database, Assign Datum](#) to learn

Datum

North American Datum 1927

Pick by name 1 or EPSG code → 4267

Transform 1175: USA West Molodensky

Local ellipsoid center to WGS 84:

ΔX -8 m

ΔY 159 m

ΔZ 175 m

Axis rotations to WGS 84 (Position Vector):

X-axis 0 "

Y-axis 0 "

Z-axis 0 "

Scale change to WGS 84:

0 ppm

how to declare the datum of your source data.

How do you know the datum of your source data? That depends on the source data. Most locales historically had some standard datum in use at the time the map was made. You will have to find that out for yourself.

Datum

You can select a datum by name or by EPSG code. The EPSG database is maintained by the OGP at <http://epsg-registry.org/>. Geocart knows about a lot of datums, but no attempt has been made to support every datum ever used or described. You may enter the ellipsoidal and transform parameters manually if you cannot find the datum you seek. When you select a datum, the ellipsoid at left will be updated as well, since the ellipsoid is part of the datum specification.

Transform

In isolation a datum is little more than an ellipsoidal description for Geocart's purposes. The transform describes how to convert from the datum to the WGS 84 coordinate system, which is the Global Positioning Satellite (GPS) coordinate system. You should find the location that most closely matches the location of your source data in the drop-down list. Or, you may enter transform parameters directly if you know them. If you enter your own parameters, please understand the conventions involved. Geocart requires "Position Vector" convention for rotations.

In performing datum conversions, Geocart will compute the equivalent of a Molodensky 3-parameter shift, but slightly more accurate, if only the local ellipsoid center to WGS 84 parameters are given. If the datum contains seven parameters for center translation, scaling and 3-axis rotation, then Geocart will perform a "Bursa-Wolf" transformation using the EPSG Operation Method 9606 "Position Vector 7 parameter transformation". Presently Geocart does not perform any other kinds of more specialized datum shifts, but for maps at 1:5,000 scale or smaller, nothing else should be required anyway.

Ellipsoid

Normally the ellipsoid will get chosen for you when you select a datum. However, you may choose any ellipsoid or specify parameters for one not listed. The pop-up list contains dozens of ellipsoids, including several spherical models at the top. Like the datum, you can choose by name or by EPSG code. While Geocart comes with many ellipsoids, no attempt has been made to supply all of them ever developed.

If you enter your own ellipsoidal parameters, you will select one of semimajor axis, semiminor axis, or flattening to hold constant. Then as you edit one of the other two parameters, the third will update automatically. Normally an ellipsoid is specified as semimajor axis and semiminor axis, or else as semimajor axis and inverse flattening. To enter the semimajor axis, first select the *Semiminor axis* or *Flattening* radio button so that you will be able to edit the *Semimajor axis* field. Once you have entered the semimajor axis value, click on the *Semimajor axis* radio button to lock it down. Next, if you have a semiminor axis value, click in the *Semiminor axis* field to type it in. Or, if you have a flattening value, click in the $1 \div$ field to type it in. The remaining values will update automatically.

The eccentricity field is informational only; you cannot change it directly.

Ellipsoid

Clarke 1866

Pick by name 1 or EPSG code → 7008

Constrain:

Semimajor axis 6378206.4 m

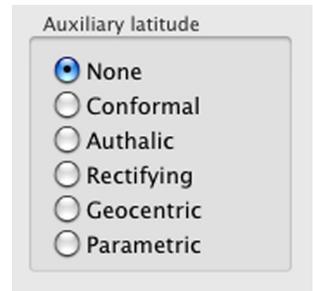
Semiminor axis 6356583.8 m

Flattening 1 ÷ 294.978698

Eccentricity: 0.0822718542

Auxiliary latitude

When you specify an ellipsoidal datum, Geocart uses ellipsoidal formulæ tailored for preserving crucial properties of the projection on the ellipsoid if it can. For example, consider the spherical form of the transverse Mercator. Its relevant properties are that it is conformal and that the central meridian is straight and of constant scale. There is no transverse form of the ellipsoidal Mercator in exactly the same sense as the spherical because coordinate rotations other than axial are not possible on the ellipsoid. However, an ellipsoidal projection that fulfills the same conditions can be developed: that is, conformal and having a straight central meridian of constant scale.



But other forms of the transverse Mercator are possible on the ellipsoid, unlike on the sphere. On the sphere, constant scale along a straight central meridian coincides with equally spaced parallels along a straight central meridian. That is not true on the ellipsoid; the two properties diverge there. Hence, it is possible to construct a conformal map with straight central meridians such that the parallels are equally spaced along the central meridian. Such a map would differ from the one described in the preceding paragraph. Yet it would have just as reasonable a claim to being a transverse Mercator on the ellipsoid. There are other possibilities.

In point of fact, the version of the transverse Mercator with constant scale along the central meridian is the one generally considered most useful, since constant scale relates directly to the measurement of distances. This is the form that Geocart programs specifically and chooses when you pick an ellipsoidal transverse Mercator. Those projections which have been used historically for large-scale mapping generally have specific properties that need to be preserved when moving to an ellipsoidal form, properties beyond just being equal-area or conformal. Such specificity requires explicit and generally quite complex formulæ.

However, most of Geocart's projections were not developed for survey work but rather for small-scale mapping. Most of them were developed for the spherical model and have no ellipsoidal development because they have no particular property that must be preserved on the ellipsoid. Yet any spherical projection can also be used for ellipsoidal projection work because you can project an ellipsoid onto a sphere. In fact, you can do so while preserving important properties. The usual technique for this is to use an *auxiliary latitude* in place of the coordinate's geodetic latitude. The auxiliary latitude amounts to projecting the ellipsoid onto the sphere.

Several auxiliary latitudes are available. Which you choose depends on your use.

- *None*. This option is only available if Geocart has explicit ellipsoidal formulæ to project directly from the ellipsoid. If this option is available, normally you should choose it.
- *Conformal*. This converts geodetic latitude to the *conformal latitude*. Choose this if the spherical form of the projection is conformal; that property will be preserved when mapping from the ellipsoid.
- *Authalic*. This converts geodetic latitude to the *authalic latitude*. Choose this if the spherical form of the projection is equal-area; that property will be preserved when mapping from the ellipsoid.
- *Rectifying*. This converts geodetic latitude to the *rectifying latitude*. Choose this if the spherical form of the projection has constant scale along meridians; that property will be preserved when mapping from the ellipsoid.
- *Geocentric*. This converts geodetic latitude to the *geocentric latitude*, which is what satellites measure. In the context of Geocart it is of more academic interest than practical.
- *Parametric*. This converts geodetic latitude to the *reduced latitude*, such any parallel on the ellipsoid will have the same radius on the sphere. In the context of Geocart it is of more academic interest than practical.

Interruptions

This command operates on all selected maps of the front window's document.

Interruptions carve up a map into segments, adding gaps to the map so that it isn't the map that fills the gaps. The gaps soak up distortion that would otherwise have been present. In essence, interruptions reduce distortion within the segments by increasing it between them. The disadvantage is the fragmented presentation.

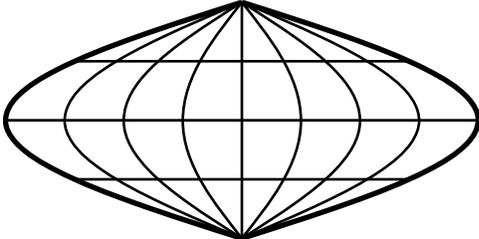
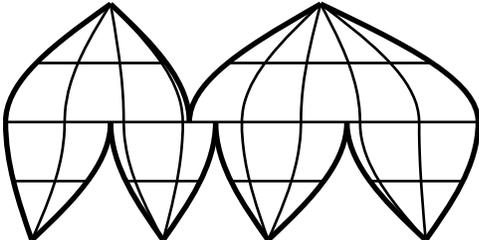
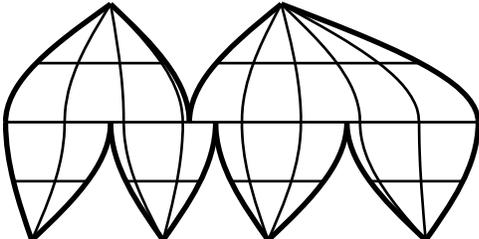
You should not use interruptions indiscriminately. Their purpose is to reduce distortion in specific regions for specific reasons. For example, a map of the world's oceans would be a good candidate for interruption, and so would thematic maps which display global data having no intercontinental meaning, such as highway networks or forests.

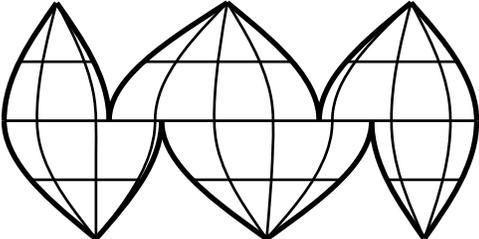
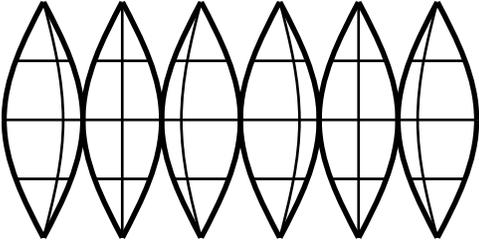
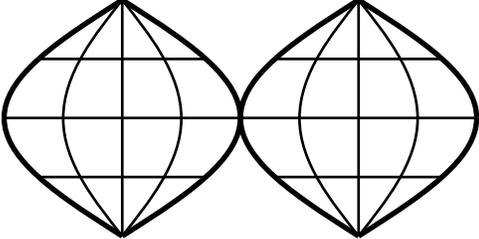
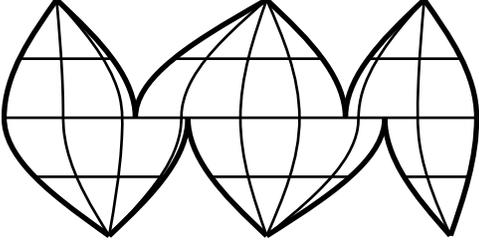
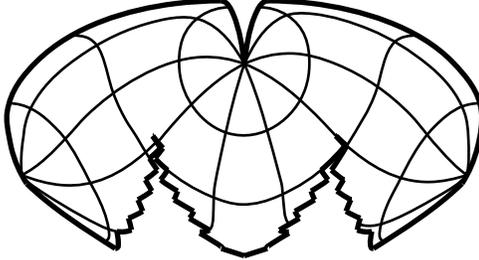
Geocart provides two basic classes of interruption: equatorial and polar. Equatorial lays the equator out straight in equatorial aspect. Polar lays the projection out in two hemisphere, as wheels with spokes. Only one of the interruption schemes is polar, that being *Rosette*. The remainder are equatorial. (While the *Philbrick* is obliques, it is based on equatorial mathematics.)

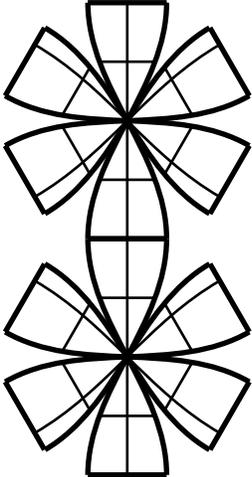
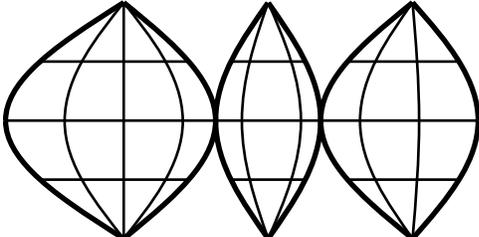
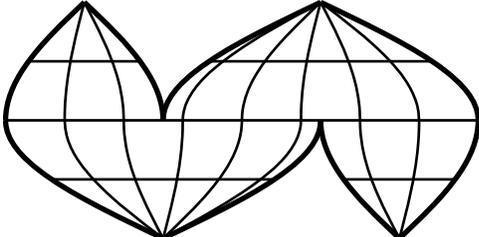
Only some projections are interruptible using Geocart's interruption schemes. Most notably, all pseudocylindrics can be interrupted using the equatorial interruption schemes. More generally, most projections with a straight equator and equally-spaced meridians along the equator can be interrupted successfully using the equatorial interruption schemes. Projections interruptible by the rosette scheme are those with pointed pole in equatorial aspect and meridians equally spaced around the pole in polar aspect.

Geocart does not decide *a priori* what maps may be interrupted. You are free to try to apply interruptions to any map. Usually, if the operation is nonsensical, Geocart will simply notify you of the failure and return your map to the previous state. Sometimes Geocart will succeed "well enough" by its own assessment, but the results will be bizarre.

Choosing an interruption scheme will also reset the central meridian to the default for that interruption scheme. This is because the interruption schemes have a purpose that is defeated by other choices of central meridian. However, you are free to change the central meridian again after you select the interruption scheme.

Interruption scheme	Example	Description
None		This is the default state for most projections. Though considered uninterrupted, every map is interrupted at least one point. In this example the interruption is an entire meridian at the left and right edges of the map.
Boggs		This interruption scheme is most commonly associated with the Boggs eumorphic projection, which it interrupts by default in Geocart. It is for presenting the continents with low distortion.
Goode continental		This interruption scheme is most commonly associated with the Goode homolosine projection, which it interrupts by default in Geocart. It is for presenting the continents with low distortion.

Interruption scheme	Example	Description
Good oceanic		<p>This interruption scheme is most commonly associated with the Goode homolosine projection. It is for presenting the oceans with low distortion.</p>
Gores		<p>This is the usual interruption for creating globe gores. It interrupts the globe gores projection by default. The number of gores can be set, ranging between 3 and 45. For two gores, see <i>Hemispheric</i>.</p>
Hemispheric		<p>This is the classic double hemisphere interruption scheme.</p>
McBryde		<p>This interruption scheme is most commonly associated with the McBryde S3 projection. It is for presenting the oceans with low distortion, moving the central meridian into the Pacific.</p>
Philbrick		<p>This interruption scheme was created for the Philbrick Sinu-Mollweide projection.</p>

Interruption scheme	Example	Description
Rosette		<p>The number of petals of the two polar roses can be set between 2 and 45. Projections interruptible with this scheme include, for example:</p> <ul style="list-style-type: none"> <i>sinusoidal</i> <i>equidistant conic</i> ($\varphi_2 = 90^\circ$) <i>Albers</i> ($\varphi_2 = 90^\circ$) <i>Werner</i> <i>American polyconic</i> <i>rectangular polyconic</i> <i>Bonne</i> <i>isoperimetric cordiform</i> <i>lateral equidistant</i>
Segmented		<p>This scheme is for presenting the continents with low distortion and symmetry about the equator. It splits the Eurasian landmass approximately at the conventional division of Europe and Asia.</p>
Sinoidal		<p>This is a simple, symmetric interruption scheme useful for presenting most of the continents with low distortion. South America does not fare well, however, and neither do the extremes of the Eurasian landmass.</p>

Chapter 11: Projection menus

See [Appendix B: Projection gazetteer](#) for information about individual projections and about how the projection menus are structured.



[Cylindric](#)



[Pseudocylindric](#)



[Conic](#)



[Azimuthal](#)



[Lenticular](#)



[Miscellaneous](#)

Selecting a projection from one of the projection menus sets all selected maps on the document of the front window to have that projection. Geocart will try to retain as many of the attributes of the original map as possible, including boundaries, for example. Sometimes that is not possible, forcing Geocart to prohibit the projection change. In such cases, use [Change Projection](#), deselecting *Boundaries* in the *Retain these attributes* pane. If that still does not work, deselect all of the attributes to retain. The resulting map will still carry the databases, graticule, and line attributes of the original map.

The projections of all selected maps are marked on the menus that hold their projections. If the selected maps are all the same projection, then the projection menu holding the projection name will have a check mark next to it. Otherwise, each of the projections will have a dash next to its name, wherever it might be in the six projection menus.

Many projections have alternate names, or synonyms. In such cases, all synonyms of the projections of the selected maps will be marked on the menu of the relevant projection class. The mark will be a check mark if only one projection is present amongst the selected maps. Otherwise it will be a dash. You can find all synonyms of a projection in the [Change Projection](#) dialog.

Chapter 12: Object menu

The **Object** menu offers control over document objects, each treated as a graphical element in its entirety without respect to content. This includes how document objects are positioned relative to each other.

Object	
Bring to Front	⌘}
Send to Back	⌘{
Bring Forward	⌘]
Send Backward	⌘[
Group	⌘R
Ungroup	⇧⌘R
Align Multiple	
Center in Window	
Center in Document	
Cancel Drawing	
Redraw	

Object	View	Window	Test	Script	Help
Bring to Front					Ctrl+}
Send to Back					Ctrl+{
Bring Forward					Ctrl+]
Send Backward					Ctrl+[
Group					Ctrl+R
Ungroup					Ctrl+Shift+R
Align Multiple					
Center in Window					
Center in Document					
Cancel Drawing					
Redraw					

Bring to Front

This command brings the selected document objects to the front of the stack of document objects so that they render last, and therefore are the most visible when overlapping. The relative order of the selected objects in the stack, if more than one is selected, does not change; only their order with respect to the unselected objects.

Send to Back

This command sends the selected document objects to the back of the stack of objects so that they render first, and therefore are the least visible when overlapping. The relative order of the selected objects in the stack, if more than one is selected, does not change; only their order with respect to the unselected objects.

Bring Forward

This command brings each of the selected document objects one position forward in the stack of document objects so that they render later, and therefore are more visible when overlapping.

Send Backward

This command sends each of the selected document objects one position backward in the stack of document objects so that they render earlier, and therefore are less visible when overlapping.

Group

This command works if you have two or more document objects selected in the front window. It groups the selected document objects so that subsequently they can be selected and positioned as if they were a single object. In composing the group, all selected document objects will be brought to a front-back position just behind the frontmost selected object.

A grouped object works as any other document object for the purposes of grouping. Therefore, you may further group two groups, for example, or a group and a map.

Ungroup

This command works if you have one or more document objects selected, where each document object is a [group](#). The command releases each grouping. It does not release groups of groups.

Align Multiple

This command works if you have two or more document objects selected in the front window. It repositions the selected document objects so that their upper left corners coincide.

Center in Window

Use this command to reposition the selected document objects so that their centers coincide with the center of the front window.

Center in Document

Use this command to reposition the selected document objects so that their centers coincide with the center of the document.

Cancel Drawing

Use this command to cancel rendering of all selected maps.

To avoid using computer resources inefficiently, Geocart only draws one map at a time. It will devote all processors to the map it is drawing. If more maps are pending to draw, they will be drawn serially. Cancelling one map's drawing means the next pending map will begin drawing. Hence you can use this command to change the order of drawing if you decide you need one map to finish rendering before another, for example.

Redraw

This causes all selected maps of the front document to redraw. You may want to do this because, for example, outside of Geocart you have made changes to a geographic database that the map uses to draw with. Geocart does not automatically detect changes in files that a map is dependent on.

Chapter 13: View menu

The view menu controls how Geocart documents are presented to you.

View	
New	⌘N
Zoom In	⌘=
Zoom Out	⌘-
Fit in Window	⌘0
Actual Size	⌘1
Actual Pixels of Selected Object	
Rulers	
Page Boundaries	

View	
New	
Zoom In	Ctrl+=
Zoom Out	Ctrl+-
Fit in Window	Ctrl+0
Actual Size	Ctrl+1
Actual Pixels of Selected Object	
Rulers	
Page Boundaries	

New

A window is just a view into a document, not the document itself. You may want several windows into a document so that you can view it different ways at the same time. For example, you may need to see the entire document at a time, so you would want one window for that. You may need to see the individual pixels of your map at the same size as your screen's pixels, so you would want another window for that. You may need to see a zoomed-in view of some piece of the map you are interested in, so you would want another window for that. These windows can all coexist.

Use this command to create a new window into the front window's document. The new window will have a zoom level of 100%. All operations you perform on the document will be reflected in all windows into the document.

Zoom In

Use this command to increase the zoom level, or magnification, of the front window. The amount of the increase depends on the present zoom level. You cannot increase the zoom level beyond 4,000%.

Other ways of changing the zoom level are the zoom control of the [Navigator palette](#), [Fit in Window](#), [Actual Size](#), and [Actual Pixels of Selected Objects](#).

Zoom Out

Use this command to decrease the zoom level, or magnification, of the front window. The amount of the decrease depends on the present zoom level. You cannot decrease the zoom level below 5%.

Other ways of changing the zoom level are the zoom control of the [Navigator palette](#), [Fit in Window](#), [Actual Size](#), and [Actual Pixels of Selected Objects](#).

Fit in Window

Your document area may be larger than the window you are viewing it in. With this command you can set the front window's zoom level so that its entire document's area is visible within the window.

Actual Size

You must have one document object selected for this command to be available. This command may not work well if you have not calibrated Geocart's understanding of your display's resolution (see [Display panel of Preferences](#)).

You can specify a map to be any reasonable resolution you like (see [Map Size and Resolution](#)). You may set a [placed image](#) to be any reasonable resolution you like (see [Set Placed Image Resolution](#)). You may have multiple document objects, each of different resolution. You may set the zoom level to any value you like (see [Zoom In](#)). Hence a document object's size within a window may be very different than the size it will ultimately print to or export to. Use this command to zoom the front window's view so that document object is viewed at its real-world size.

Actual Pixels of Selected Object

You must have one document object selected for this command to be available.

You can specify a map to be any reasonable resolution you like (see [Map Size and Resolution](#)). You may set a [placed image](#) to be any reasonable resolution you like (see [Set Placed Image Resolution](#)). You may have multiple document objects, each of different resolution. You may set the zoom level to any value you like (see [Zoom In](#)). Hence a document object's pixels within a window may be a very different size than your computer display's pixels. If you want to view a particular document object, whether map or placed image, such that one pixel of the document object coincides with one pixel of your display, use this command. This gives the clearest, most accurate representation.

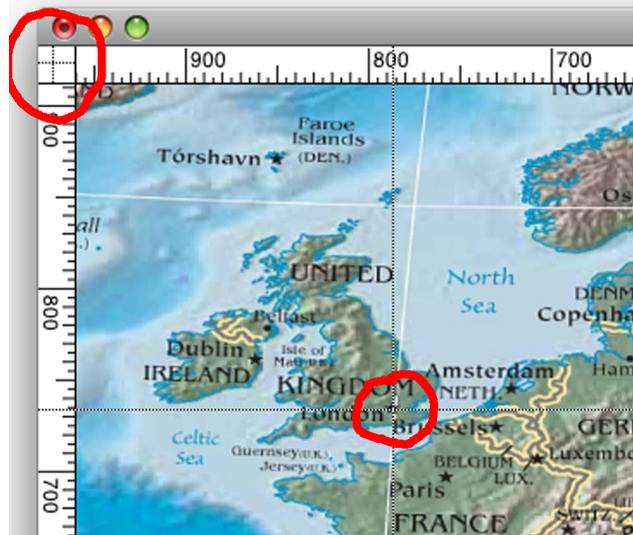
Rulers

This command is a toggle switch. If the front window presently does not display rulers, then it will turn on ruler display. Otherwise it will turn off ruler display. The ruler's measurement units are controlled by your setting in the [General panel of the Preferences dialog](#).

The ruler system consists of two rulers: horizontal and vertical ruler. The horizontal runs along the top of the content area. The vertical runs along the left edge of the content area.

By default the upper left corner of the document is the ruler origin, where the measurement starts. You can change the origin by clicking in the upper left corner of the window, where there is a crosshairs, and dragging the crosshairs to the point within the window where you want the origin to be. In the illustration, the top left corner shows where to drag from.

The lower right red circle shows the crosshairs that drags along with your mouse pointer. Releasing the mouse button as shown sets London as the origin, so that both the horizontal and vertical rulers would start measuring from there. You can restore the origin to the upper left corner by double-clicking on crosshairs in the upper left corner.



Page Boundaries

Using [Page Setup](#) (Mac) or [Print](#) (Windows) you can choose the size of paper you intend to print to. The paper size need not coincide with the document area. If the document area is larger than the paper size, your document will print on several pages. This command will show the page boundaries as gray lines in the document area. If the document already displays page boundaries, this command turns them off.

Chapter 14: Window menu

The **Window** menu offers window controls standard for the operating system and manipulations of Geocart windows. Besides the commands described below, at the bottom of the **Window** menu you will find an entry for each document window you have open. Selecting a window name from the list will make it the front document window.

For instructions specific to Windows, see the [Windows](#) section. For instructions specific to Macintosh, see [Macintosh](#). The **Navigator** and **Information** palettes are common to both and are described first.

Navigator

If the **Navigator** palette is not presently displayed, this command will display it.

The **Navigator** palette gives you a view of the entire area of the front window's document, in a size that you can set. The red rectangle corresponds to the portion of the document visible in the front window.

Besides showing the entire document, the Navigator lets you quickly pan the front window's view to wherever you want in the document. Clicking anywhere on the palette will center the red rectangle there. The front window's view will pan to match. You may also click and hold on the rectangle, dragging it around in order to change the front window's view into the document.

The lower border of the palette contains a slider for zooming in and out. The zooming applies to the front window, not to the **Navigator** palette. Therefore in the Navigator palette, the effect is to change the red rectangle's size. The zoom is the same as the [View menu's zoom functions](#), but you can control the zoom level in much finer increments here.



Information

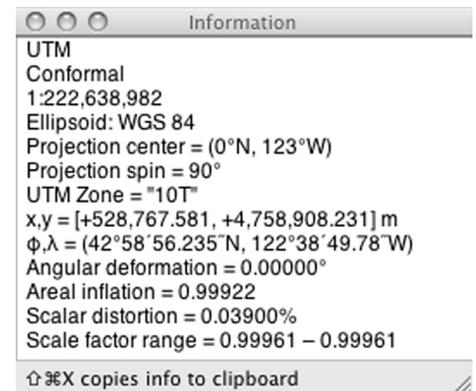
If the **Information** palette is not presently displayed, this command will display it.

The **Information** palette notes information about the front window's document (only). Specifically, it describes what is under the mouse pointer. In the case of a [placed image](#), it describes the image format, color space, pixel dimensions, and the resolution.

If the pixel the pointer hovers over is within the bounding box of a map, but outside the map's boundaries, then the palette will describe the map projection, any special properties, nominal scale, any parameters, the ellipsoidal datum, the projection aspect, and the x,y coordinate of the mouse pointer. The coordinate is given in meters, computed from the nominal scale applied to the pixel distance of the mouse pointer from the projection's origin. This is *not* a distance on the earth's surface except in very limited cases.

If the pixel the pointer hovers over (called the *reference point*) is within the boundaries of a map, the info palette will further state the geographic coordinate under the mouse pointer along with distortion characteristics of the projection at the reference point.

Angular deformation means how much the map is "twisted" at the reference point. A value of 0° means the map



has no twisting or shearing at the point. Conformal maps show a value of 0° everywhere. (See [Types of distortion, Chapter 3: Essentials](#).) The value may range between 0° and 180°, with 180° meaning, in essence, infinite twisting. Angular deformation will vary over the map if it is not conformal.

Areal inflation means how much larger or smaller than nominal scale the reference point is. A value of 1.0 means that the projection, at that point, neither inflates or deflates areas. Equal-area maps show a value of 1.0 everywhere. (See [Types of distortion, Chapter 3: Essentials](#).) Values larger than 1.0 mean the map is inflated at that point; less than 1.0 means it is deflated. Areal inflation will vary over the map if it not equal-area.

Scalar distortion is a measure that combines angular deformation and areal inflation into a single metric. There are many ways to do this, and none of them are “correct” in any absolute sense. The purpose is to give a reasonable basis for comparison. A value of 0° means the map has no angular deformation and no inflation or deflation at the reference point. An infinite value means the distortion is unbounded at that point, whether as angular deformation or inflation/deflation, or both.

Scale factor range gives you more specific information about how the scalar distortion is composed. Distortion can vary by direction at a single point. Knowing what the greatest amount of stretching is and the least amount completely characterizes distortion at the point. If the greatest and least values are both 1.0, then the point is undistorted. If the greatest and least are the same value, then the point has no angular deformation. If the greatest is the reciprocal of the least, then the point has no inflation or deflation.

You can copy the contents of the Information palette onto the clipboard so that you can paste into a text editor by using the [Copy Info Palette Text](#) command.

Macintosh

Window	
Minimize	⌘M
Zoom	
Bring All to Front	
Navigator	F5
Information	F6

Minimize

Minimizing means moving the front window out of the way and putting an icon for it into the dock. The next window down in the stack of windows becomes the front window. You can restore the window to full size and functionality by clicking on its icon in the dock. For information about the dock, how to configure it, and how to use it, see your Mac OS documentation.

Zoom

Zooming increases the front window’s size as large as it can get while still fitting on the screen. Or, if the window has already been zoomed, **Zoom** reduces it to its previous size. This command is unrelated to the [View menu’s zoom functions](#).

Bring All to Front

This brings all Geocart windows to be in front of any other application's windows, while leaving the relative order of the Geocart windows the same. On the Mac OS, windows from different applications can be interleaved in front-back order. That is a natural consequence of working with several applications, clicking on their visible windows to switch from application to application. Usually it is what you want, but sometimes you might want to sort the windows by application. This command is useful because it eliminates the interleaving when you need to.

Windows

Window	
Cascade	Shift+F5
Tile	Shift+F4
Arrange Icons	
Close All	
Navigator	F5
Information	F6

Cascade

This resizes all document windows to the same size and arranges them in a staggered overlap so that each window has its top and left side exposed. The window that was in front will remain in front.

Tile

This resizes all document windows to arrange them in an array so that no part of any window overlaps any other. If you have many windows, each could end up quite small. The window that was in front will appear as the upper left window and will still be the front window.

Arrange Icons

This command applies only to windows that have been minimized. (See your Windows operating system documentation for information about minimizing windows.) *Arrange Icons* arranges the minimized icons so that they progress from left to right, bottom to top, with no gaps. There is no effect if the icons are already arranged or if no windows have been minimized.

Close All

This closes all open document windows. For each document that has never been saved or has changes that have not been saved, you will be asked if you want to save it first.

Navigator

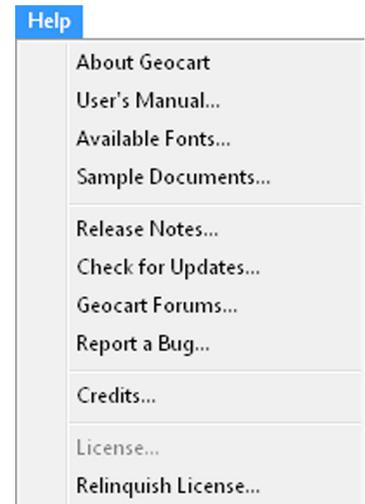
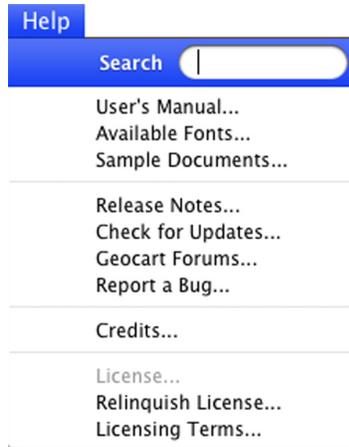
See the [Macintosh Navigator](#) palette description.

Information

See the [Macintosh Information](#) palette description.

Chapter 15: Help menu

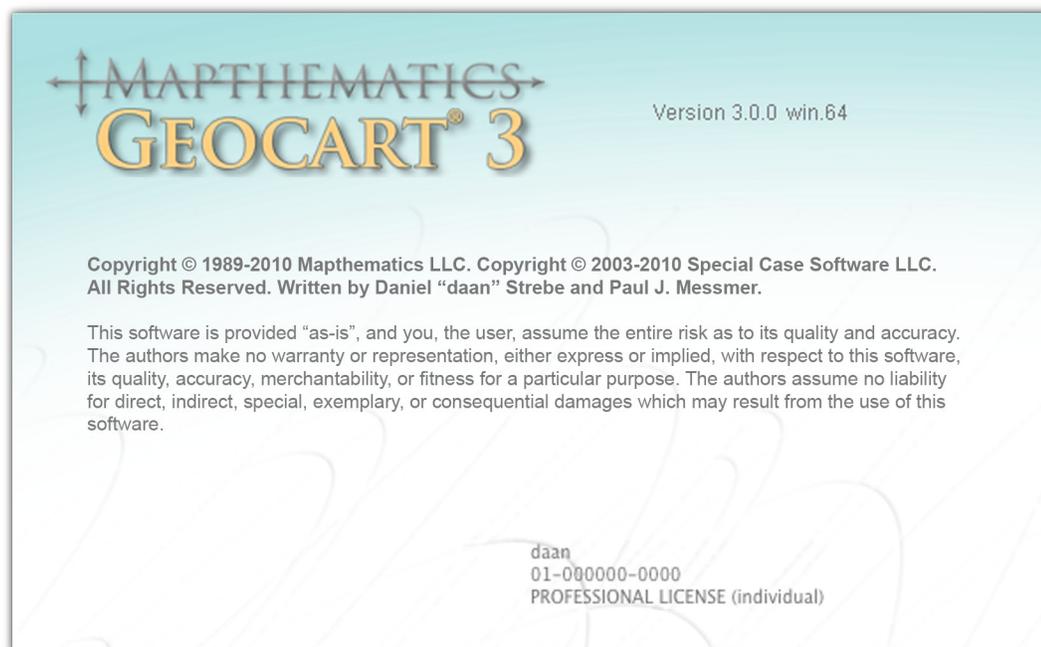
The Help menu supplies information and licensing operations.



Search (Mac only)

This is a Mac OS service with no function in Geocart. Please see your Macintosh documentation for explanation.

About Geocart (Windows)



About Box

The Macintosh form of this command is found in the [Geocart menu](#).

This command displays the About Box, which gives information about the Geocart product. You may need any or all of this information if you contact Mapmathematics for support. In the upper right, you can find the version number of Geocart, which operating system, and which computer processor architecture the Geocart application was created for. At lower right, the name of the license holder appears, as recorded by the person who entered the license key. Beneath that is the serial number, and beneath that is the type of license tied to the license key.

User's Manual

This command finds the Geocart User's Manual installed with your Geocart files, and launches it for display in a suitable PDF reader if available. The manual is installed here:

(Mac)

Library/Application Support/Mapmathematics/Geocart/Version 3/Geocart Manual.pdf

(Windows XP)

C:\Documents and Settings\All Users\Application Data\Mapmathematics\Geocart\Version 3\Geocart Manual.pdf

(Windows Vista+)

C:\ProgramData\Mapmathematics\Geocart\Version 3\Geocart Manual.pdf

Available Fonts

One kind of database you can add to maps is a [typesetting database](#). This is a database that places text at projected coordinates. The typesetting database format contains instructions about what typefaces (fonts) to use when drawing text. In order to work properly for print and export to PDF, Geocart does not support all the different formats and format variants that the operating system might allow or provide. It only supports TrueType™ and OpenType™ fonts.

When you modify or [create a typesetting database](#), you will need to provide the names of the fonts you want the text to draw in. Fonts have many names. The menu name often differs from the file name. The PostScript™ name usually differs from the menu name. The font may have family and style names. The font may have names in different languages.

Only the PostScript name will work in typesetting databases. So that you know what TrueType and OpenType fonts are available, and what their PostScript names are, you can access a list of the eligible fonts using this command. Any of the fonts you find in this list should work properly for typesetting databases.

Sample Documents

Selecting this command will switch the front application to the Finder (Macintosh) or Explorer (Windows) and open Geocart's `Sample Documents` folder. In this folder you can find Geocart documents for each of the examples in [Chapter 5: Examples](#). You can also find files to use as source images for [general reprojection databases](#).

Release Notes

Selecting this command will switch away from Geocart and into your default Web browser, and load a status page that supplies the release notes for your version of Geocart. The URL depends on the version of Geocart you are running.

Check for Updates

Selecting this command will switch away from Geocart and into your default Web browser, and load a status page that will tell you of any updates to Geocart. The URL depends on the version of Geocart you are running.

Geocart Forums

Selecting this command will switch away from Geocart and into your default Web browser, and load the Geocart Forums Web page if your computer is connected to the Internet. The URL is:

<http://mapthematics.com/geocart3weblinks/forums/>

Report a Bug

Selecting this command will switch away from Geocart and into your default Web browser, and load the Geocart bug report Web page if your computer is connected to the Internet. The URL is:

<http://www.mapthematics.com/geocart3weblinks/reportabug.html>

Credits

Selecting this command will display a dialog box that credits the Geocart authors along with the various open-source technologies used in Geocart.

License

Use this command to enter your license key when you receive one. You will be asked for a name to register the product to. However, the license will be tied to the machine, not the person. This means that people with different accounts on the machine are allowed to use the Geocart license as long as only one uses it at a time. Please see [Licensing Terms](#) for details of the Geocart license.

Relinquish License

Use *Relinquish License* to remove the Geocart license from your computer. Subsequent launches will run in demonstration mode. Reasons for relinquishing your license are to move your license to another computer or to transfer it to someone else. You may use [License](#) to restore the license to your computer or insert a new one.

Licensing Terms

Selecting this command displays a dialog box with the complete terms of your Geocart license.

Appendix A: Which projection is best?

When you are crafting a map it is important that you choose the projection that is best suited for the job. This chapter can help inform your decision.

Kinds of Maps

Usually your map will fall into one or more of these categories:

- Technical
- Graphic
- Decorative

The lower you go on the list the more freedom you have to choose.

Technical maps include general reference maps of the world and of specific regions. They also include topographic maps, meteorological maps, planetary maps, distance maps, physiography maps, globe gores, satellite tracking maps, galactic maps, ocean current maps, shoal maps, military range maps, direction maps, forestry maps, navigational maps, road maps, drainage maps, land ownership maps, and many others.

Technical maps must be strictly correct because the people who use them depend very much on the map's detailed information.

Graphic maps present their information in a more visual, less measurement-oriented fashion. They often rely on the brain's ability to roughly compare areas, shapes, and colors. The major category of graphic maps is the thematic map. It is used to display statistical information such as population or production, or geologic information such as mineral deposits or climate. Sometimes it comes in the form of cartograms, which show relative data by distorting land areas, so that China, for example, would cover almost $\frac{1}{3}$ of the earth's surface and Canada only $\frac{1}{200}$ of it by virtue of their respective populations. Other graphic maps may come in the form of unlabeled outline maps for educational use, puzzles, travel or tour maps, or posters.

The remaining maps are classified as **decorative maps**. These could be almost anything imaginable: posters, logos, tiles, T-shirts—even shower curtains. They are not designed or used for information but rather for art. The choice of projections then becomes an aesthetic question rather than a technical one.

Projections for Technical Maps

In designing technical maps your choice of projections is considerably restricted but that does not make it easier. Choosing the correct projection becomes a delicate dance of conflicting demands that necessarily forces you to compromise something desirable.

But *you* must choose. You cannot even presume that you should copy the projections that you find in published works because often they are inappropriate, especially those in wall maps.

Generally you can start by classifying the map according to its size of the area it will display. Whole-world maps have different needs than hemispheric maps, which have entirely different needs than larger scale maps of continents or huge nations, which in turn have different needs than national maps, which are themselves different from local maps.

World Maps

Reference maps of the entire earth present the most vexing cartographic problem. The amount of distortion inherent in any global projection is much higher than the minimum that the eye can discern and therefore all of them fail to a

Which projection is best? A.1

large degree. Some, however, fail worse than others, so there are some guidelines that can be used.

First, no conformal projection should be used for world reference maps. The *Mercator* has been used for centuries but, while it has navigational value, it is unsuited to reference maps because it cannot display the poles and because it horribly exaggerates scale away from the equator. All conformals suffer from the problem of exaggerated scale.

The past century has seen a push toward equal-area maps. While the size of any area is correct in relation to any other, shapes are always badly distorted somewhere, particularly in those projections having some other constraint, such as straight parallels or meridians. Nevertheless many professionals agree that size is more important than shape because correct sizes prevent people from getting funny ideas about how important or unimportant some piece of land is.

A number of projections are compromises, neither equal-area nor conformal. These maps were created in the belief that relaxing the constraint of area or shape could produce a map with better overall qualities. While this is open to question, some of these maps have proven histories and can be relied on.

Some scholars prefer maps with straight parallels, ostensibly because they show latitudinal information which can be important for contrasting climate and vegetation. We think, however, that most map viewers know that the parallels indicate latitude and naturally use them to reference the latitude. Furthermore, altitude, prevailing winds, surrounding land forms, and oceans all contribute strongly to a region's climate, reducing the importance of latitude. Therefore we believe that maps with moderately curved parallels are better because they reduce the amount of shearing in the map. However, if your map will not show the graticule then you should consider using a projection with straight parallels.

Some projections, most notably the pseudocylindrics, can be interrupted. This usually means cutting the globe from the poles to the equator in several places and then projecting the slices individually as if each were at the center of the globe. An interrupted map is not really a world map, but rather an assemblage of more local maps. It reduces distortion inside a slice by tremendously distorting the area between slices. Sometimes such projections are appropriate for physiography and thematic maps.

Then there is the problem of pole-lines: in order to reduce a form of shape distortion called shearing, many projections stretch the poles into lines from their original points. While this can help other areas of the map quite a bit, many map viewers cannot picture what has happened to the pole.

Use the decision tree at the end of the chapter to help you select a projection for your technical world map.

Hemispheric Maps

Hemispheric maps can be much more accurate than whole world maps and involve fewer compromises. Strangely, there are only a few projections suitable for this purpose. You should decide which of conformality, area, scale distortion, perspective, distance, or direction is important, and once you have done so you can use the decision tree at the end of the chapter to mechanically pick a projection since there are clear bests in each of these categories. Normally only azimuthal projections are suitable for hemispheres.

Huge nation, continental, oceanic, national, regional, local

This is another difficult category. Historically there have been rules of thumb based on the position of the region on the sphere—was it polar, temperate, or equatorial?

These rules restricted the number of suitable projections and made it easy to construct the graticule. But now we have computers and programs like Geocart that can easily rotate the globe however we like before projecting it. This means that the correctness of the map can take priority over its ease of computation, but it also means we need a new set of rules to handle the new freedom.

These maps deal with areas greater than the size of Brazil, about 5,000,000 km² (2,000,000 mi²). First, what is the shape of the region? Is it roughly circular, like Antarctica or Australia? Is one direction much longer than the other, like the former Soviet Union or South America?

Second, are there parts of the area of interest whose accuracy is not so important? For instance, many map designers would be willing to sacrifice strict accuracy in the Queen Elizabeth Islands of Canada's Northwest Territory if they

could achieve more accuracy in the economically important areas of the country. Eastern Siberia would sometimes be considered less important than south-central or western Asia. The Pacific Ocean south of Alaska and west of North America may need less accuracy than the continent and Hawaii itself. How does the shape of the region change when these less-important areas are subtracted?

A major issue here is shape versus area. A trained observer will immediately spot shearing or stretching on any equal-area map of Eurasia. On the other hand, a well-planned conformal map of the same area will not show objectionable area distortion, even though it is substantial. For this reason, conformal maps are often chosen for these kinds of regions. But a map of the entire Pacific Rim will show shape or area distortion no matter what projection is chosen, so many recent maps have used non-conical equal-area projections or minimum error compromise projections.

In general, conic projections should not be used when the region covers more than about 70° in both directions, but they are very useful for long regions along a small circle. Some cylindrics can be used in oblique form for long but very narrow areas along a great circle. Except, perhaps, for the sinusoidal, pseudocylindrics are not appropriate for anything other than world maps.

National and Provincial Maps

These maps have areas greater than about $50,000 \text{ km}^2$ ($20,000 \text{ mi}^2$) and less than $5,000,000 \text{ km}^2$ ($2,000,000 \text{ mi}^2$), and are easy to choose projections for. At this scale you need not worry about equal-area versus conformal since the difference between the two is often less than the warpage of the paper the map is printed on. Perhaps your most important task is to reduce overall scale error to a minimum.

You can get the most accurate maps by using projections which project the globe onto a surface slicing through the earth at a distance about $\frac{1}{2}$ the distance from the center to the outside boundary of the area of interest.

If the map's scale will be very large, you should consider modeling the earth as an ellipsoid rather than a sphere if you know the ellipsoidal datum that your coordinate or pixel data are referred against.

Local Maps

Local maps, such as county and city maps, show areas less than about $50,000 \text{ km}^2$ ($20,000 \text{ mi}^2$). You can choose any projection which has true scale at the center of the map. At this size, however, you should consider the earth to be an ellipsoid if you want truly accurate maps, and you should choose data sets based on a known ellipsoid.

Projections for Graphic Maps

Typically you should use an equal-area projection for thematic maps of the world. If you will not be showing the graticule then you might restrict your choice to a pseudocylindric projection. You may choose to interrupt your map since you can gain more accuracy in land shapes that way, and often you are not interested in the spatial relationship between countries, but only in the graphic information within each country.

Geocart cannot construct cartograms for you, but it can help you prepare base maps that you can then piece together yourself. You will most likely use the *Stretch and Rotation* command from the **Projection** menu. To ease your work you might choose a cylindric projection so that you don't have to worry about matching the edges of adjacent local maps, since the graticule is a network of straight lines.

Unlabeled regional or national maps should have correct shapes, so you should use a conformal projection centered on the area of interest. Puzzle and game maps follow the rules for technical maps, but you can choose projections that are easy to deal with since the accuracy of the map is not so critical. The same goes for travel or tour maps and posters. For all these types you can use the decision tree at the end of the chapter to help you.

Projections for Decorative Maps

The most enjoyable group of projections for some people is the decorative maps that may not be so useful but that fit some shape or have an unusual property. You may need a world map that you can duplicate and fit together in every direction for tiling. Or one in the shape of a triangle or star or heart. You may need to fit the world into a circle. All of these shapes, and others, are available.

Using the Decision Tree

The decision tree can help you decide what map projection to use when making a map. Sometimes your choices need not be restricted by what is in this chart, but in general the chart provides a comprehensive guide for most usual needs. Keep in mind that sometimes there are no best choices.

At each level of the tree, ask yourself about the map's requirements. If the requirements match one of the headers at that level then proceed to the next level.

Once you have selected a projection, use [Appendix B: Projection gazetteer](#) to help you correctly prepare the map. Often you will need to recenter the map to attain the desired effect, but some maps should not be recentered. The Gazetteer can help you in such cases.

For example, let's say you need a map of the Pacific Ocean that measures distance and direction to Honolulu, Hawaii, from anywhere in the ocean. First, decide which of technical, graphic, or decorative the map will be. In this case, the map is clearly technical. Under the [(1) Technical] heading we find five items:

- a. World – section 1.1
- b. Hemisphere – section 1.2
- c. Continent, ocean, huge nation – section 1.3
- d. Nation/province – section 1.4
- e. Local – section 1.5

Our map is an oceanic map, so we choose the [(c) Continent, ocean, huge nation] header. From there we see the following fourteen choices:

- 1.3.1 Aerial view
- 1.3.2 Circles on sphere are circles on map
- 1.3.3 Distance chart
- 1.3.4 Direction chart
- 1.3.5 Navigational chart
- 1.3.6 North and South America
- 1.3.7 Region is vaguely circular in shape
- 1.3.8 Region is vaguely elliptical shape
- 1.3.9 Region lies along meridian or equator (or follows great circle)
- 1.3.10 Region lies along a parallel (or follows small circle)
- 1.3.11 Great circles are straight (shortest route)
- 1.3.12 Rhumbs are straight lines
- 1.3.13 Triangulating chart

1.3.14 USA map

Our map is concerned with distance and direction, so we can choose either. If we arbitrarily choose [(2.3.3) Distance] Chart we see the following four choices:

- i. Azimuths from center are straight, correctly scaled, and have radially measurable directions.
- ii. Azimuths to center have radially measurable directions, and distances to center are correct.
- iii. Distances are correct from two centers.
- iv. Rhumbs from center are straight and correctly scaled.

The second choice, [(ii) Azimuths to center have radially measurable directions, and distances to center are correct] is exactly what we are looking for. It points us to the *Hammer retroazimuthal* projection.

From here we refer to the [Appendix B: Projection gazetteer](#) for information about the *Hammer retroazimuthal*. We discover that we are supposed to center the projection on the meridian of interest using the **Projection Center** menu command, and then use the **Parameters** menu command to specify the center latitude. Looking at a globe we find that Honolulu is at 21°18'N, 157°54'W.

First we open a new document. Then we select *Hammer retroazimuthal* from the projections presented by the retroazimuthal submenu of the Azimuthal menu. We don't want a whole-earth map, so we use the **Boundaries** command from the **Map** menu to select the Pacific region—65°N, 99°E, 86°S, 67°W for NWSE coordinates will do. As per the Projection Gazetteer, after selecting the **Projection Center** command from the **Projection** menu, we type 157°54'W into the *Longitudinal* field, and click OK. Then we select the **Parameters** command from the same menu and type 21°18'N to specify the standard parallel. We now have finished the basic map and can embellish it however we like from here.

Map projection selection tree

Use this key to decide which projection is most appropriate for your map.

Is the main purpose of your map —

- a. [Technical](#) - Go to Section 1.
- b. [Graphic](#) - Go to Section 2.
- c. [Decorative](#) - Go to Section 3.

Section 1. Technical Maps

What is the extent of your map?

- a. [World](#) – section 1.1
- b. [Hemisphere](#) – section 1.2
- c. [Continent, ocean, huge nation](#) – section 1.3
- d. [Nation/province](#) – section 1.4
- e. [Local](#) – section 1.5

1.1 Technical world maps

Does your map need to be a –

- 1.1.1 [Coordinate chart](#)
- 1.1.2 [Direction chart](#)
- 1.1.3 [Distance chart](#)
- 1.1.4 [Edge-matchable along meridians](#) (providing greater than 360° coverage)
- 1.1.5 [Extruded globe](#) (flat map on plastic to heat and form into hemisphere)
- 1.1.6 [General reference](#)
- 1.1.7 [Globe gores](#) (for making a globe)
- 1.1.8 [Navigational chart](#)
- 1.1.9 [Oceanic chart](#)
- 1.1.10 [Recenterable map](#)
- 1.1.11 [Time zone map](#)

1.1.1 Coordinate chart (coordinates linearly measurable)



“Geographic” projection

1.1.2 Direction chart

- i. Azimuths to center have radially measurable directions, and distances to center are correct



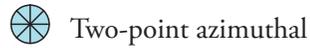
Hammer retroazimuthal

- ii. Azimuths from center/s are straight and have radially measurable directions

Distances from center are correct



Two centers



- iii. Rhumbs have radially measurable directions

All rhumbs are straight



Rhumbs from center are straight and correctly scaled

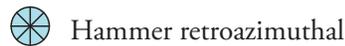


1.1.3 Distance chart

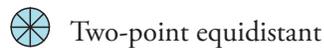
- i. Azimuths from center are straight, correctly scaled, and have radially measurable directions



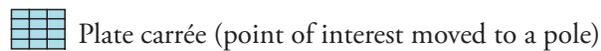
- ii. Azimuths to center have radially measurable directions, and distances to center are correct



- iii. Distances from two centers are correct



- iv. Azimuths from center are straight and have linearly measurable directions



- v. Equal-area

Parallels are correctly scaled



Distances from center point are correct



- vi. Rhumbs from center are straight, correctly scaled, and have radially measurable directions



1.1.4 Edge-matchable along meridians (providing greater than 360° coverage)



1.1.5 Extruded globe (flat map on plastic to heat and form into hemisphere)



1.1.6 General reference



Strebe 1995



Wagner VII



Strebe-Kavrayskiy (centered on 11°E, 11°S)



Winkel tripel



Robinson

1.1.7 Globe gores (for making a globe)



(Transverse) plate carrée (by piercing together twelve 30° segments)



Rectangular polyconic (standard parallel 0°)



American polyconic

1.1.8 Navigational chart

- i. Azimuths from center/s are straight and have radially measurable directions

Distances are correct from center



Azimuthal equidistant

Two centers



Two-point azimuthal

- ii. Distances from center/s are correct

Azimuths from center are straight and have radially measurable directions



Azimuthal equidistant

Two centers



Two-point equidistant

- iii. Straight rhumbs

Rhumbs from center are straight, correctly scaled, and have radially measurable directions



Loximuthal

All rhumbs are straight



Mercator

1.1.9 Oceanic chart



McBryde S3 (central meridian 180°W) See patent information in [Notices](#).



Mollweide (central meridian 180°W)

1.1.10 Recenterable map

 Equal-area cylindrical

 Miller

1.1.11 Time zone map

 Plate carrée

 Miller cylindrical

1.2 Technical hemisphere maps

Does your map need to be a –

1.2.1 [Circles on sphere are circles on map](#)

1.2.2 [Conformal map](#)

1.2.3 [Direction chart](#)

1.2.4 [Distance chart](#)

1.2.5 [Equidistant map](#)

1.2.6 [Equal-area map](#)

1.2.7 [Extruded globe](#) (flat map on plastic to heat and form into hemisphere)

1.2.8 [General reference](#)

1.2.9 [Minimum scale error](#)

1.2.10 [Rhumbs from center point are straight](#)

1.2.11 [Solar eclipses](#)

1.2.12 [Space view](#)

1.2.1 Circles on sphere are circles on map

 Stereographic

1.2.2 Conformal map

 Stereographic

1.2.3 Direction chart

- i. Azimuths to center have radially measurable directions

Distances to center are correct

 Hammer retroazimuthal

Meridians are straight

 Craig retroazimuthal

- ii. Azimuths from center have radially measurable directions

Azimuths from center are correctly scaled

 Azimuthal equidistant

Conformal

 Stereographic

Equal-area

 Lambert azimuthal equal-area

Minimum error

 Airy

- iii. Rhumbs from center are correctly scaled and have radially measurable directions

 Loximuthal

All rhumbs are straight

 Mercator

1.2.4 Distance chart

- i. Azimuths from center are straight, correctly scaled, and have radially measurable directions

 Azimuthal equidistant

- ii. Azimuths to center have radially measurable directions, and distances to center are correct

 Hammer retroazimuthal

- iii. Distances are correct from two centers

 Two-point equidistant

- iv. Equal-area

Parallels are correctly scaled

 Sinusoidal

All distances from center point are correct

 (Oblique) Werner

- v. Rhumbs from center are straight, correctly scaled, and have radially measurable directions

 Loximuthal

1.2.5 Equidistant map

 Azimuthal equidistant

1.2.6 Equal-area map

 Lambert azimuthal equal-area

1.2.7 Extruded globe (flat map on plastic to heat and form into hemisphere)

 Extruded globe

1.2.8 General reference

 Airy (Minimum error range from center = 90°)

 Lambert azimuthal equal-area

1.2.9 Minimum scale error

 Airy (Minimum error range from center = 90°)

1.2.10 Rhumbs from center point are straight

 Loximuthal

1.2.11 Solar eclipses

 Stereographic

1.2.12 Space view

 Orthographic

1.3 Technical continent, ocean, huge nation maps

Does your map need to be a –

- 1.3.1 [Aerial view](#)
- 1.3.2 [Circles on sphere are circles on map](#)
- 1.3.3 [Distance chart](#)
- 1.3.4 [Direction chart](#)
- 1.3.5 [Navigational chart](#)
- 1.3.6 [North and South America](#)
- 1.3.7 [Region is vaguely circular in shape](#)
- 1.3.8 [Region is vaguely elliptical in shape](#)
- 1.3.9 [Region lies along meridian or equator](#)
- 1.3.10 [Region lies along a parallel](#)
- 1.3.11 [Great circles are straight](#)
- 1.3.12 [Rhumbs are straight lines](#)
- 1.3.13 [Triangulating chart](#)
- 1.3.14 [USA map](#)

1.3.1 Aerial view

i. Deep space

 Orthographic

ii. High altitude or orbit

 Vertical perspective

iii. Lateral view

 Tilted perspective

1.3.2 Circles on sphere are circles on map

 Stereographic

1.3.3 Distance chart

i. Azimuths from center are straight, correctly scaled, and have radially measurable directions.

 Azimuthal equidistant

ii. Azimuths to center have radially measurable directions, and distances to center are correct.

 Hammer retroazimuthal

iii. Distances are correct from two centers.

 Two-point equidistant

iv. Rhumbs from center are straight and correctly scaled.

 Loximuthal

1.3.4 Direction chart

i. Azimuths from center(s) are straight and have radially measurable directions

Conformal

 Stereographic

Distances from center are correct

 Azimuthal equidistant

Equal-area

 Lambert azimuthal equal-area

Minimum Error

 Airy

Two centers

 Two-point azimuthal

ii. Azimuths to center have radially measurable directions

Distances to center are correct

 Hammer retroazimuthal

Meridians are straight

 Craig retroazimuthal

Conformal

 Littrow

iii. Rhumbs from center are straight and have radially measurable directions

 Loximuthal

iv. All rhumbs are straight

 Mercator

1.3.5 Navigational chart

i. Azimuths from center(s) are straight and have radially measurable directions

Distances from center are correct

 Azimuthal equidistant

Straight great circles

 Gnomonic

 Two-point azimuthal

Two centers

 Two-point azimuthal

ii. Azimuths to center have radially measurable directions

Distances to center are correct

 Hammer retroazimuthal

Meridians are straight

 Craig retroazimuthal

Conformal

 Littrow

iii. Distances from center(s) are correct

Azimuths from center are straight and have radially measurable directions

 Azimuthal equidistant

Two centers

 Two-point equidistant

iv. Great circles are straight

 Gnomonic

 Two-point azimuthal

- v. Rhumbs are straight

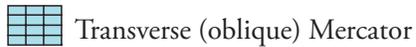
Rhumbs from center are straight, correctly scaled, and have radially measurable directions



All rhumbs are straight



1.3.6 North and South America



1.3.7 Region is vaguely circular in shape

- i. Conformal



- ii. Equal-area



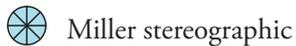
- iii. General



- iv. Minimum scale error



1.3.8 Region is vaguely elliptical in shape



1.3.9 Region lies along meridian or equator (*or follows great circle*)



1.3.10 Region lies along a parallel (*or follows small circle*)

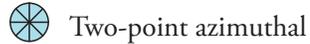


1.3.11 Great circles are straight (*shortest route*)

- i. Azimuths from center are straight and have radially measurable directions



- ii. Azimuths from two centers are straight and have radially measurable directions



Two-point azimuthal

1.3.12 Rhumbs are straight lines

- i. Rhumbs from center point are straight and correctly scaled



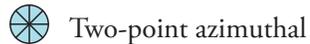
Loximuthal

- ii. All rhumbs straight



Mercator

1.3.13 Triangulating chart



Two-point azimuthal

1.3.14 USA map

- i. 50 states



GS50



Lambert conformal conic

- ii. 48 states



Equidistant conic



Albers



Lambert conformal conic

1.4 Technical nation, province map

Does your map need to be a –

- 1.4.1 [Aerial view](#)
- 1.4.2 [Edge-matching](#)
- 1.4.3 [Region is vaguely circular in shape](#)
- 1.4.4 [Region is long, slender and curved](#)
- 1.4.5 [Region is long, slender and straight](#)
- 1.4.6 [Region is vaguely oval](#)

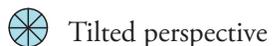
1.4.1 Aerial view

- i. Straight down



Vertical perspective

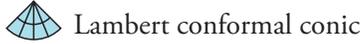
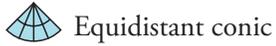
- ii. Lateral view



Tilted perspective

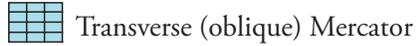
1.4.2 Edge-matching

- i. East-west edge-matching (match along a small circle)

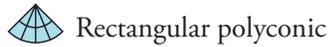


- ii. North-south edge-matching (match along a great circle)

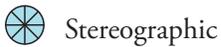
Conformal



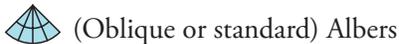
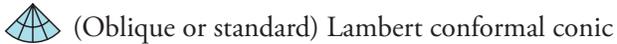
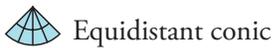
General



1.4.3 Region is vaguely circular in shape



1.4.4 Region is long, slender and curved



1.4.5 Region is long, slender and straight



1.4.6 Region is vaguely oval



1.5 Technical local map

Does your map need to be a –

1.5.1 [Aerial view](#)

1.5.2 [General](#) (any well-behaved projection with unity scale factor in center)

1.5.3 [Edge-matching](#)

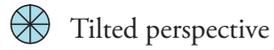
1.5.4 [Survey chart](#)

1.5.1 Aerial view

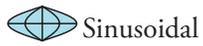
Straight down



Lateral view

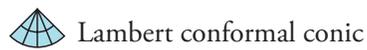
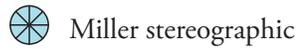


1.5.2 General (any well-behaved projection with unity scale factor in center)



1.5.3 Edge-matching (See National, provincial map Edge Matching)

1.5.4 Survey chart



Section 2. Graphic Maps

What is the extent of your map?

- a. [World](#) – section 2.1
- b. [Hemisphere](#) – section 2.2
- c. [Continent, ocean, nation, region, local map](#) – Section 2.3

2.1 Graphic world map

Does your map need to be a –

- 2.1.1 [Climate, forestry or geology map](#)
- 2.1.2 [Comparative statistics display](#)
- 2.1.3 [Distance map](#)
- 2.1.4 [Trade routes](#)
- 2.1.5 [Time zones](#)
- 2.1.6 [Unmarked base map](#)

2.1.1 Climate, forestry and geology maps



Boggs eumorphic



Goode homolosine



Eckert IV

2.1.2 Comparative statistics display (*population, manufacturing, birth rates, etc.*)



Eckert IV



Boggs eumorphic



Goode homolosine

2.1.3 Distance map



Azimuthal equidistant

2.1.4 Trade routes



Mercator

2.1.5 Time zones



Miller cylindrical



Plate carrée

2.1.6 Unmarked base map



Winkel tripel

 Mollweide

 Robinson

2.2 Graphic hemisphere map

Does your map need to be a –

2.2.1 [General view](#)

2.2.2 [Moon or planet view](#)

2.2.3 [Space view](#)

2.2.1 General view

 Lambert azimuthal equal-area

 Airy

2.2.2 Moon or planet view

 Orthographic

2.2.3 Space view

 Orthographic

2.3 Graphic continent, ocean, nation, region, local map

Does your map need to be a –

2.3.1 [Aerial view](#)

2.3.2 [Air flight routes](#)

2.3.3 [Direction map](#)

2.3.4 [Distance map](#)

2.3.5 [General map](#)

2.3.6 [Portolan chart](#)

2.3.7 [Unlabelled base map](#)

2.3.1 Aerial view

i. From deep space

 Orthographic

ii. From high altitude or orbit

 Vertical perspective

iii. Laterally from high altitude

 Tilted perspective

2.3.2 Air flight routes

 Gnomonic

2.3.3 Direction map

i. Direction from somewhere to anywhere

 Azimuthal equidistant

ii. Direction from anywhere to somewhere

 Craig retroazimuthal

2.3.4 Distance map

 Azimuthal equidistant

2.3.5 General map

 Lambert equal-area

2.3.6 Portolan chart

 Mercator

2.3.7 Unlabelled base map

 Stereographic

Section 3. Decorative Maps

What is the extent of your map?

- a. [World](#) – section 3.1
- b. [Hemisphere](#) – section 3.2
- c. [Continent, ocean, nation, region, or local map](#)– section 3.3

3.1 Decorative world map

Does your map need to be a –

- 3.1.1 [Antique look](#)
- 3.1.2 [General map](#)
- 3.1.3 [Live view](#)
- 3.1.4 [Schoolroom wall map](#)
- 3.1.5 [Shaped map](#)
- 3.1.6 [Tiled map](#)

3.1.1 Antique look

-  Al-Bīrūnī (paired for both hemispheres)
-  Stereographic (paired for both hemispheres)
-  Ortelius oval
-  Werner

3.1.2 General map

-  Robinson
-  Armadillo
-  Hammer
-  Briesemeister
-  Strebe-Snyder pointed-pole

3.1.3 Live view

-  Orthographic (paired for both hemispheres)

3.1.4 Schoolroom wall map

-  Denoyer semi-elliptical

3.1.5 Shaped map

- Apple:  Quaziazimuthal equal-area apple

- Circle:  Lagrange;  Van der Grinten I, II, III
- Clam:  August epicycloidal;  Eisenlohr;  American polyconic
- Diamond:  Adams world in a square II;  Lateral equidistant
- Heart:  Heart;  Bonne;  amulet;  shield
- Orange peel:  Goode homolosine (interrupted)
- Ornament:  Strebe-sinusoidal (cartouche);  Foucaut stereographic
- Oval:  Elliptic conformal;  Mollweide;  Apian II
- Pinwheel:  Wiechel
- Pumpkin:  Loximuthal;  van der Grinten IV
- Rectangle:  Miller;  plate carrée;  Guyou
- Square:  Peirce quincuncial;  Adams world in a square I
- Star:  Berghaus star
- Tire:  Armadillo
- Triangle:  Collignon
- UFO:  Goode homolosine (uninterrupted)

3.1.6 Tiled map

- Diamond:  Adams world in a square II
- Rectangle:  Guyou;  Adams hemisphere in a square
- Square:  Peirce quincuncial;  Adams world in a square I

3.2 Decorative hemisphere map

Does your map need to be a –

- 3.2.1 [Antique look](#)
- 3.2.2 [Real view](#)
- 3.2.3 [Shaped map](#)

3.2.1 Antique look

-  Al-Bīrūnī
-  Ptolemy II
-  Stereographic
-  Werner

3.2.2 Real view

 Orthographic

3.2.3 Shaped map

Apple:  Quasiazimuthal equal-area apple (half)

Circle:  Al-Birūnī;  stereographic;  orthographic

Pinwheel:  Wiechel (half)

Square:  Adams hemisphere in a square;  Guyou (half)

Diamond:  Peirce quincuncial (northern hemisphere)

3.3 Decorative continent, ocean, nation, region, local map

Does your map need to be a –

3.3.1 [Aerial view](#)

3.3.2 [Anything else](#)

3.3.1 Aerial view

i. From deep space

 Orthographic

ii. Aerial, orbital

 Vertical perspective

 Tilted perspective

3.3.2 Anything else

 Plate carrée

 Sinusoidal

 Airy

 Azimuthal equidistant

 Lambert azimuthal equal-area

 Orthographic

 Stereographic

Appendix B: Projection gazetteer

This chapter describes the map projections in Geocart and how to use them. Map projections are grouped within the six Geocart classes of projections:



[Cylindric](#)



[Pseudocylindric](#)



[Conic](#)



[Azimuthal](#)



[Lenticular](#)



[Miscellaneous](#)

...and then alphabetically within each. All projections and their synonyms are listed. The informational entry for a projection is given at Geocart's preferred name for that projection. Keep in mind that projection names are not standardized. Even what ought to be considered a separate, named projection is open to debate. Menu names sometimes deviate from formal names. Menu names appear in brackets to the right of the preferred name.

You can create a new map directly by holding down the **shift** key while selecting a map projection from one of the six menus. A map with default parameters and projection center appropriate to that projection will be drawn.

Special properties of the projections are noted. Beware that many of these properties apply only in certain aspects of the projection. For instance, the sinusoidal has correct scale along each parallel but only when the map is centered along the equator. In any other aspect the scale is correct along any line parallel to the long axis, but the parallels follow paths of varying scale. Some projections have only historical or academic value and are noted as such.

Descriptions and information for many of the projections are adapted in part from: Snyder, J.P. And Voxland, P.M. 1989. *An Album of Map Projections*. US Geological Survey Professional Paper 1453. US Government Printing Office.

Projection parameters

Some projections have parameters, or settings to control the appearance of the projection. The purposes of these parameters vary from projection to projection. All are controlled from the **Parameters** item in the **Projection** menu.

Conic projections have one or two *standard parallels* which control the accuracy of the projection over the region you want to map. A cone can sit on a globe like a hat, and when a conic has one standard parallel, that parallel tells at what latitude the cone contacts the globe. When the projection has two standard parallels it means the cone slices through the globe instead of sitting on it. The two parallels tell where the cone cuts into the globe and where it comes back out. Normally you will choose standard parallels within the region you are mapping.

Other projections can have standard parallels as well. The exact purpose differs between projections, but it usually means the latitude at which the scale is correct.

Some projections have a point whence a special property, such as correct direction, emanates. You must specify both a latitude and longitude, in that order. Other projections have a range over which a special property is effective, and usually you must specify the range in degrees of arc. A degree of arc is about 111 km (69 mi) on the earth's surface. A hemisphere is 90° of arc, and the entire earth is 180° of arc. There are other kinds of parameters as well; they will be explained as needed for each projection.

The notations << and >> are used to mean that a parametric value should be well away from some forbidden value. Although there is no measurably precise meaning for them, in general you can take it to mean that the map is not very useful when the parameters are near the forbidden value. In contrast, < and > are normally used to mean that the forbidden value is a singularity. Any value not equal to the forbidden value is mathematically allowable, but keep in mind that the computer only works with a finite number of decimal places and cannot always distinguish between two values that are very close together.

The symbol ϕ (phi) always refers to a latitude and λ (lambda) always refers to a longitude.

Cylindric projections

Б.С.А.М.—See [B.S.A.M.](#)

Карченко-Шабанова—See [Karchenko-Shabanova](#)

Павлова—See [Pavlov](#)

Урмаева III—See [Urmayev III](#)

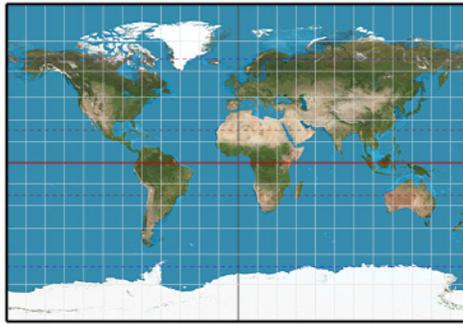
B.S.A.M.

Description

Similar to the *Gall stereographic*, but with standard parallels at 30°N/S.

Use

Historical.

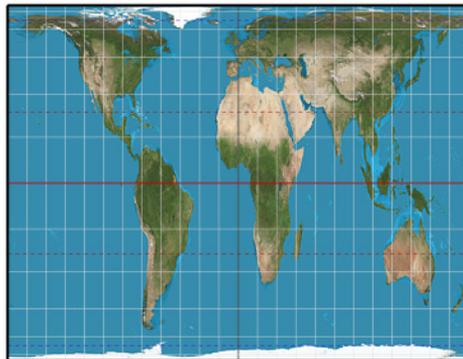


B.S.A.M

Balthasart

Description

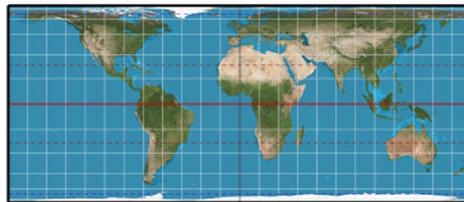
Is *equal-area cylindrical* with standards parallels of 50°N/S.



Balthasart

Behrmann equal-area

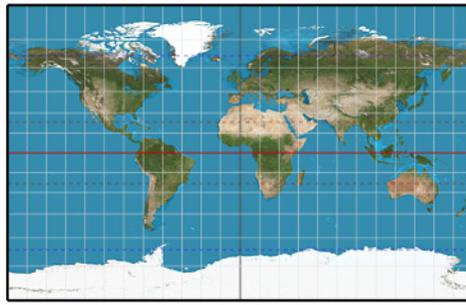
Description	<p>Cylindric, equal-area, perspective.</p> <p>The same as the <i>Lambert cylindric equal-area</i> projection, except for horizontal compression and vertical expansion to achieve no distortion at latitudes 30°N and 30°S instead of at the equator. It is equivalent to a projection of the globe using parallel lines of projection onto a cylinder secant of 30°N and 30°S.</p>
Similar projections	<p><i>Lambert cylindric equal-area</i> <i>Gall orthographic</i> <i>Trystan Edwards</i> <i>Gall-Peters</i> <i>Hobo-Dyer</i> <i>Smyth equal-surface</i> <i>Balthasart</i></p>
Graticule	<p>Meridians: Equally-spaced, straight parallel lines 0.42 as long as the equator.</p> <p>Parallels: Unequally-spaced straight lines, farthest apart near the equator, perpendicular to the meridians.</p> <p>Poles: Straight lines equal in length to the equator.</p> <p>Symmetry: About any meridian or the equator.</p>
Scale	<p>True along latitudes 30°N and 30°S. Too small along the equator, and too large at the equator along the meridians. The scale is the same at the parallel of opposite sign.</p> <p>Scale increases with distance from the equator in the direction of parallels and decreases in the direction of meridians to maintain equal-area.</p>
Use	<p>Historical. Presented by Walter Behrmann (1822-1955) of Berlin in 1910.</p>



Behrman equal-area

Braun cylindric

Description	<p>Similar to the <i>Miller cylindric</i> or <i>Mercator</i>, depending on parameter.</p>
Parameters	<p>One enumeration for selecting the projection perspective point. <i>Antipodal</i> results in a Miller-like presentation; <i>From $\frac{2}{5}R$</i> results in a Mercator-like presentation, but with finite poles.</p>
Use	<p>Historical.</p>



Braun

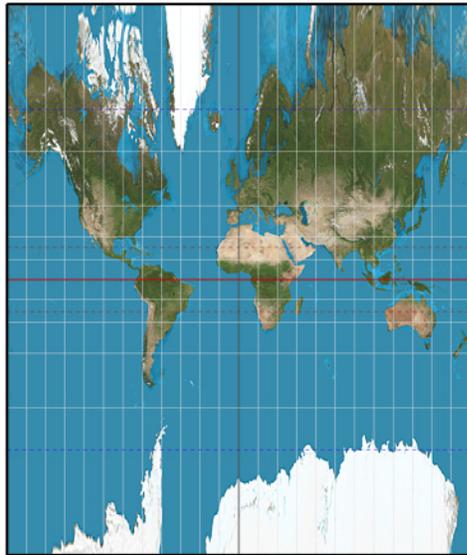
Cassini—See [transverse plate carrée](#)

Cassini-Soldner—See [transverse plate carrée](#)

central—See [central cylindric](#)

central cylindric [*central*]

Description	<p>Cylindric, perspective, neither conformal nor equal-area.</p> <p>This projection is produced geometrically by projecting the earth's surface perspectively from its center onto a cylinder tangent at the equator. It should not be confused with the Mercator, which is not perspective.</p>
Synonyms	<p><i>perspective cylindric</i> <i>simple perspective cylindric</i></p>
Similar projections	<p><i>Mercator</i>, which is not perspective, also cannot show the poles, but the poleward increase in the spacing of the parallels does not occur as rapidly as it does on the <i>central cylindric</i> projection.</p> <p><i>Gall</i> and other perspective cylindric projections can be produced by moving the point of perspective away from the center of the earth. The poles can then be shown.</p> <p><i>Gnomic</i> projection is projected perspectively from the center of the earth onto a tangent plane rather than a cylinder and is very different in appearance.</p>
Graticule	<p>Meridians: Equally-spaced, straight parallel lines.</p> <p>Parallels: Unequally-spaced, straight parallel lines, closes near the equator, but spacing increases poleward at a much greater rate than it does on the Mercator. Perpendicular to meridians.</p> <p>Poles: Cannot be shown.</p> <p>Symmetry: About any meridian or the equator.</p>
Scale	<p>True along the equator. Increases with distance from the equator to infinity at the poles. Changes with direction at any given point, except at the equator, but scale in a given direction is constant at any given latitude or at the latitude of opposite sign.</p>
Distortion	<p>Shape, area, and scale distortion increase rapidly away from the equator where there is no distortion.</p>
Use	<p>Academic. The distortion is too great for any usage except for showing the appearance of the earth when so projected and contrasting with the <i>Mercator</i>.</p>
Limitations	<p>Cannot show the poles.</p>

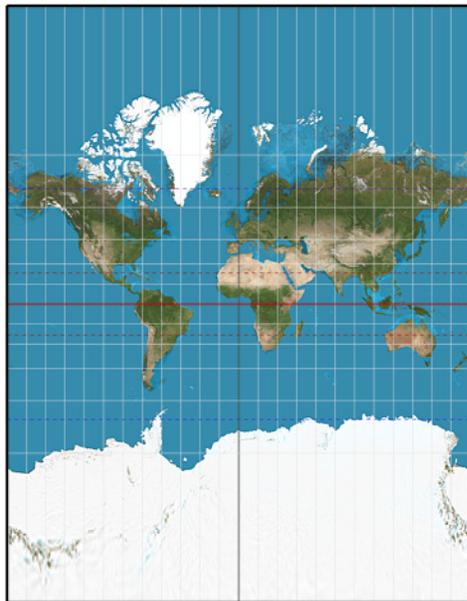


central cylindrical

Craster equal-area—See [Smyth equal-surface](#)

ellipsoidal Mercator

Description	Ellipsoidal development the equatorial Mercator projection. Cylindric and conformal.
Scale	True along equator. Becomes infinite at the poles.
Use	Large-scale mapping along the equator.

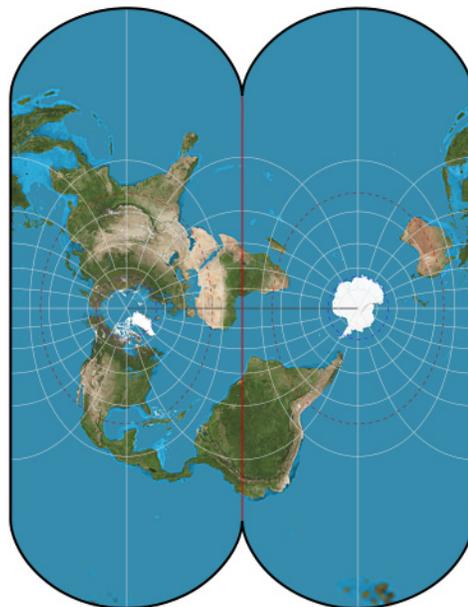


ellipsoidal Mercator

ellipsoidal oblique Mercator—See [Hotine](#)

ellipsoidal transverse Mercator

Description	Ellipsoidal transverse aspect of the <i>Mercator</i> projection. Cylindric and conformal.
Synonyms	<i>Gauß (Gauss) conformal</i> <i>Gauß-Krüger</i> <i>transverse cylindric orthomorphic</i>
Other features	Cannot be geometrically (or perspeively) projected. Unlike equatorial <i>Mercator</i> , rhumb lines generally are not straight lines.
Parameters	Scale factor along central meridian.
Graticule	Meridians and parallels: Central meridian, each meridian 90° from the central meridian, and the equator are straight lines. Other meridians and parallels are complex curves, concave toward the central meridian and the nearest pole, respectively. Poles: Points along the central meridian. Symmetry: About any straight meridian or the equator.
Scale	Constant along the central meridian.
Origin	Increases with distance from central meridian, but unlike spherical form, remains finite. Spherical form of the transverse Mercator presented by Johann Heinrich Lambert (1728-1777) of Alsace in 1772. Formulas for ellipsoidal use developed by Carl Freidrich Gauß of Germany in 1822 and by L. Krüger of Germany, L.P. Lee of New Zealand, and others in the 20 th century.
Use	Many of the topographic and planimetric map quadrangles throughout the world at scales of 1: 24,000 to 1: 250,000. Basis for Universal Transverse Mercator (UTM) grid and projection. Basis for State Plane Coordinate System in US states having largely north-south extent. Recommended for conformal mapping of areas having predominantly north-south extent.

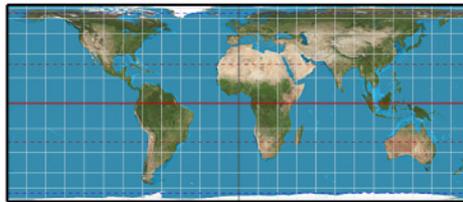


ellipsoidal transverse Mercator

equal-area—See [equal-area cylindric](#)

equal-area cylindrical [*equal-area*]

Description	Equal-area.
Parameters	One standard parallel φ_1 for setting the latitude along which the scale will be correct. A higher latitude will make a narrower, taller map.
Specializations	<i>Balthasart</i> ($\varphi_1 = 50^\circ$) <i>Behrmann cylindrical equal-area</i> ($\varphi_1 = 30^\circ$) <i>Gall orthographic</i> (= <i>Gall-Peters</i> = <i>Peters</i>) ($\varphi_1 = 45^\circ$) <i>Hobo-Dyer</i> ($\varphi_1 = 37^\circ 30'$) <i>Smyth equal-surface</i> (= <i>Craster rectangular</i>) ($\varphi_1 = 37^\circ 4'$) <i>Trystan Edwards</i> ($\varphi_1 = 37^\circ 24'$)
Range	$0^\circ \ll \varphi_1 \ll 90^\circ\text{N}$.
Usual	$30^\circ\text{N} \leq \varphi_1 \leq 50^\circ\text{N}$.
Use	When an equal-area, rectangular world map is needed. Set the standard parallel to the latitude at which you want correct scale.

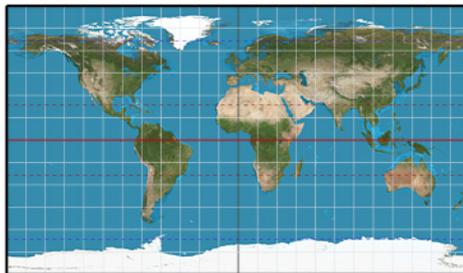


equal-area cylindrical

equidistant—See [equidistant cylindrical](#)

equidistant cylindrical [*equidistant*]

Description	Cylindric and equidistant.
Synonyms	<i>equirectangular</i> <i>rectangular</i> <i>la carte Parallelogrammatique</i> <i>die Rechteckige Plattkarte</i> <i>projection of Marinus</i>
Other features	Simple modification of <i>plate carrée</i> having east-west compression. Conceptually projected onto a cylinder secant to the globe along the chosen standard parallels. Not perspective.
Parameters	One standard parallel φ_1 for setting the latitude along which the scale will be correct. A higher latitude will make a narrower, taller map.
Range	$90^\circ\text{S} \ll \varphi_1 \ll 90^\circ\text{N}$.
Usual	$0^\circ\text{N} \leq \varphi_1 \leq 50^\circ\text{N}$.
Specializations	<i>Plate carrée</i> ($\varphi_1 = 0^\circ$) <i>Gall isographic</i> ($\varphi_1 = 45^\circ$)
Scale	True along two standard parallels $\pm\varphi_1$ and along all meridians. Too small along the equator, but increases with distance from the equator along the parallels. Constant along any given parallel; same scale at the parallel of opposite sign.
Graticule	Meridians: Equally-spaced, straight parallel lines more than half as long as the equator. Parallels: Equally-spaced, straight parallel lines, perpendicular to, and having wider spacing than, meridians. Poles: Straight lines equal in length to the equator. Symmetry: About any meridian or the equator.
Origin	Marinus of Tyre in about AD 100.
Use	Simple outline maps of regions, or of the world, or for index maps. Used only in the spherical form.

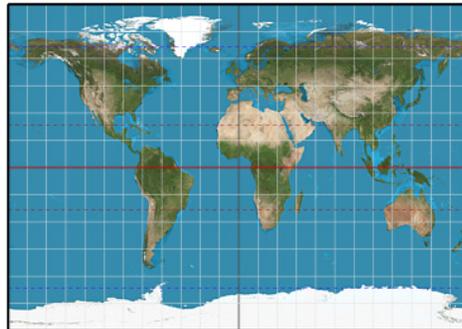


equidistant cylindrical

equirectangular—See [equidistant cylindrical](#)

Gall isographic

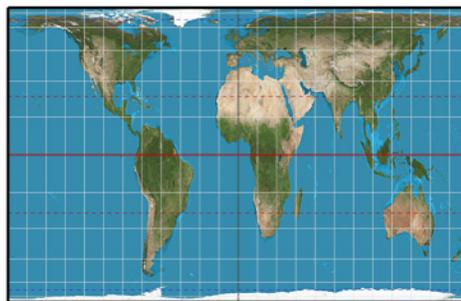
Description	Cylindric and not perspective. Equidistant along meridians.
Graticule	Is <i>equidistant cylindric</i> with standard parallels at $\pm 45^\circ$. Meridians: Equally-spaced, straight parallel lines 0.707 as long as the equator. Parallels: Equally-spaced, straight parallel lines. Perpendicular to meridians. Poles: Straight lines equal in length to the equator. Symmetry: About any meridian or the equator.
Scale	True along latitudes 45°N/S in all directions. Constant along any parallel in any given direction.
Distortion	None at latitudes 45°N and S. Shape, area and scale distortion increase moderately away from these latitudes, but become severe at the poles.
Origin	Presented by James Gall of Edinburgh in 1855 as his <i>isographic</i> (equidistant), along with his <i>stereographic</i> and <i>orthographic</i> cylindric projections, all secant at latitudes 45°N and S.



Gall isographic

Gall orthographic

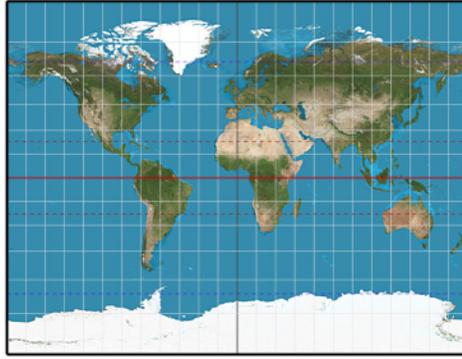
Description	Cylindric and not perspective. Equal-area. Is <i>equal-area cylindric</i> with standard parallels at $\pm 45^\circ$.
Synonyms	<i>Gall-Peters</i> <i>Peters</i>
Similar projections	<i>Smyth equal-surface</i> , <i>Trystan Edwards</i> , <i>Hobo-Dyer</i> , and <i>Balthasart</i> are closely related, being scaled moderately in height and width from this projection.
Aspects	Only the equatorial aspect is used.
Graticule	Meridians: Equally-spaced, straight parallel lines 0.64 as long as the equator. Parallels: Unequally-spaced, straight parallel lines, closest near the standard parallels. Perpendicular to meridians. Poles: Straight lines equal in length to the equator. Symmetry: About any meridian or the equator.
Scale	True along latitudes 45°N and S in all directions. Constant in any given direction along any other given latitude or the latitude of opposite sign. Changes with latitude and direction, but is always too small between latitudes 45°N and S , and too large beyond them.
Distortion	None at latitudes 45°N and S . Shape, area and scale distortion increase moderately away from these latitudes, but becomes severe at the poles.
Origin	Presented by James Gall of Edinburgh in 1855 as his <i>orthographic</i> , along with his <i>stereographic</i> and <i>isographic</i> (equidistant) cylindric projections, and also based on cylinders secant at latitudes 45°N and S . Reintroduced in 1972 by Arno Peters as a new invention and promoted as the map projection of social justice. Adopted by several social advocacy organizations.
Use	Can be found in world maps involving social advocacy.



Gall orthographic

Gall stereographic

Description	<p>Cylindric and perspective. Neither conformal nor equal-area.</p> <p>Earlier versions of Geocart referred to this projection as just <i>Gall</i>.</p>
Similar projections	<p><i>Miller cylindric</i> projection has different spacing of the parallels, and the line of no distortion is the equator rather than latitudes 45°N and S.</p> <p><i>B.S.A.M.</i> (Great Soviet World Atlas) projection of 1937 is the same, except that the cylinder is secant at latitudes 30°N and S.</p> <p>VA Kameneskiy used an identical projection for Russian population density in 1929, except that the cylinder was made secant at latitudes 55°N and S.</p> <p>Guy Bomford of Oxford University in England about 1950 devised a <i>modified Gall</i> projection, which is like the regular <i>Gall</i> in spacing, except meridians are slightly curved at higher latitudes to decrease scale exaggeration at the poles.</p> <p>Moir devised <i>The Times</i> projection in which the straight parallels are spaced as they are on the <i>Gall</i> projection, but the meridians are distinctly curved.</p>
Other features	<p>Projection is produced geometrically by projecting the earth perspective from the point on the equator opposite a given meridian onto a secant cylinder, cutting the globe at latitudes 45°N and S.</p>
Aspects	<p>Only the equatorial aspect is used.</p>
Graticule	<p>Meridians: Equally-spaced, straight parallel lines 0.77 as long as the equator.</p> <p>Parallels: Unequally-spaced, straight parallel lines, closest near the equator, but spacing does not increase poleward as fast as it does on the Mercator. Perpendicular to meridians.</p> <p>Poles: Straight lines equal in length to the equator.</p> <p>Symmetry: About any meridian or the equator.</p>
Scale	<p>True along latitudes 45°N and S in all directions. Constant in any given direction along any other given latitude or the latitude of opposite sign.</p> <p>Changes with latitude and direction, but is always too small between latitudes 45°N and S, and too large beyond them.</p>
Distortion	<p>None at latitudes 45°N and S. Shape, area and scale distortion increase moderately away from these latitudes, but becomes severe at the poles.</p>
Origin	<p>Presented by James Gall of Edinburgh in 1855 as his <i>stereographic</i>, which he preferred to his <i>orthographic</i> (equal-area), and <i>isographic</i> (equidistant) cylindric projections presented at the same time, and also based on cylinders secant at latitudes 45°N and S.</p>
Use	<p>Historical. World maps in British atlases and some other atlases, as a projection somewhat resembling the <i>Mercator</i>, but having less distortion of area and scale near the poles.</p>



Gall stereographic

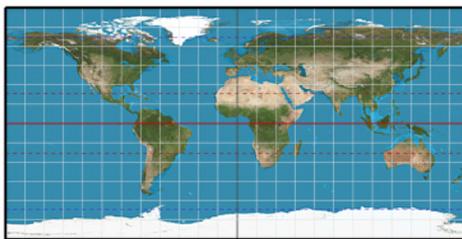
Gall-Peters—See [Gall orthographic](#)

Gauß conformal (Gauss conformal)—See [ellipsoidal transverse Mercator](#)

Gauß Krüger (Gauss Krüger)—See [ellipsoidal transverse Mercator](#)

geographic projection

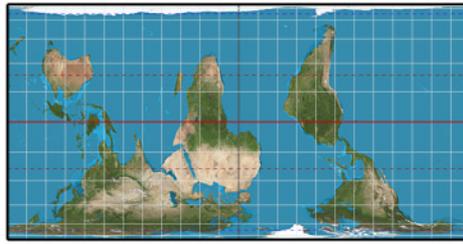
Description	Parallels are evenly spaced along the meridians, regardless of ellipsoidal model. Spacing of parallels is the same as the spacing of meridians, so each graticule “cell” is a square.
Similar projections	Identical to plate carrée when the earth is modeled as a sphere. Very similar to plate carrée when the earth is modeled as an ellipsoid, but plate carrée keeps correct distances along meridians, where as the “geographic” projection keeps equal spacing of parallels.
Aspects	Equatorial only, since the important trait for Use evaporates in other aspects.
Use	Imagery (such as satellite imagery), so that the latitude and longitude can be determined from the pixel position by nothing more than multiplying by nominal scale.



“geographic” projection

Hobo-Dyer

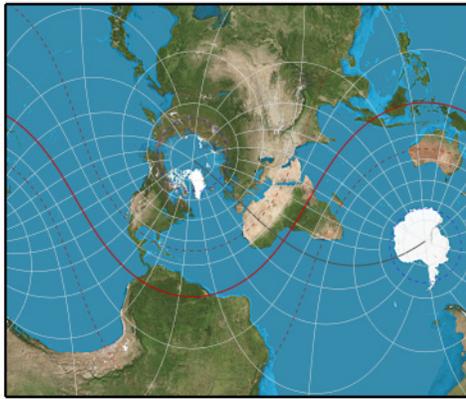
Description	Is the <i>equal-area cylindric</i> with standards parallels of $\pm 37^{\circ}30'$. Created for ODT Maps as an alternative to the <i>Peters</i> projection. Generally presented south-up.
Similar projections	<i>Trystan Edwards</i> and <i>Smyth equal-surface</i> are nearly identical, and <i>Behrmann equal-area</i> and <i>Gall orthographic</i> are close.



Hobo-Dyer

Hotine

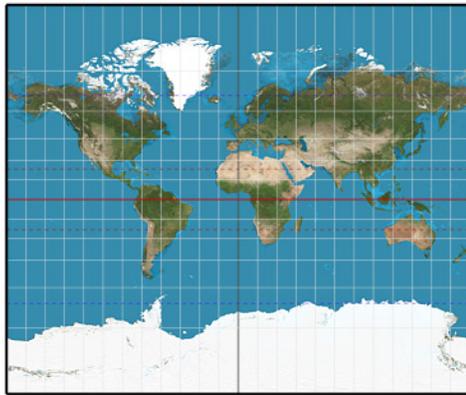
Description	Ellipsoidal oblique aspect of the <i>Mercator</i> projection. Cylindric and conformal.
Synonyms	<i>ellipsoidal oblique Mercator</i> <i>rectified skew orthomorphic</i> <i>oblique cylindric orthomorphic</i>
Similar projections	<i>Laborde</i> , a very similar development specifically for Madagascar.
Limiting forms	<i>Mercator</i> , if the equator is the central plane. <i>Transverse Mercator</i> , if a meridian is the central line.
Other features	Conceptually projected onto a cylinder wrapped around the globe tangent to an oblique great circle, or secant along two small circles equidistant from and straddling the central great circle. Cannot be geometrically (or perspectively) projected. There are various means of adapting to the ellipsoid, but none can simultaneously maintain both perfect conformality and constant scale along the central line.
Parameters	Central scale factor.
Scale	True along a chosen central line (a great circle at an oblique angle), or along two straight lines on the map parallel to the central line. Constant along any straight line parallel to the central line. (The scale for the projection of the ellipsoid varies slightly from these patterns). Increases with distance from the central line. Becomes infinite 90° from the central line.
Origin	Developed for various applications, chiefly large-scale mapping of the ellipsoid, by M. Rosenmund of Switzerland in 1903, J. Laborde of France in 1928, Martin Hotine of England in 1947 and others during the 20 th century.
Use	Large-scale mapping in Switzerland, Madagascar and Borneo.



Hotine

Karchenko-Shabanova

Native name	<i>цилиндрическая Карченко-Шабанова</i>
Description	Similar to <i>Miller cylindric</i> away from the poles.
Use	Historically, in the Soviet Union.

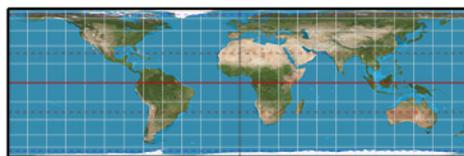


Karchenko-Shabanova

Lambert equal-area—See [Lambert equal-area cylindric](#)

Lambert equal-area cylindrical [*Lambert equal-area*]

Description	<p>Cylindric, equal-area, and perspective.</p> <p>Created by stretching each parallel to the same length as the equator and then locally shrinking each meridian by the same factor.</p> <p>Is <i>equal-area cylindrical</i> with the equator as standard parallel.</p>
Similar projections	See specializations of the <i>equal-area cylindrical</i> .
Other features	Simple graticule, perspective projected in lines perpendicular to the axis onto a cylinder wrapped around the globe, tangent to the equator.
Aspects	<p>Equatorial is described here.</p> <p>Transverse and oblique aspects are rarely used, but are recommended for equal-area mapping of predominantly north-south regions, or regions extending obliquely.</p>
Graticule	<p>Meridians: Equally-spaced, straight parallel lines 0.32 as long as the equator.</p> <p>Parallels: Unequally-spaced, straight parallel lines, farthest apart near the equator, perpendicular to meridians.</p> <p>Poles: Straight lines equal in length to the equator.</p> <p>Symmetry: About any meridian or the equator.</p>
Scale	<p>True along the equator.</p> <p>Increases with distance from the equator in the direction of parallels and decreases in the direction of meridians to maintain equal area.</p> <p>Same scale at the parallel of opposite sign.</p>
Distortion	Infinitesimally small circles (indicatrices) of equal size on the globe are ellipses, except at the equator, where they are circles. The areas of all the indicatrices are the same. Thus, there is shape distortion, but no area distortion. Shape distortion in polar regions is extreme.
Origin	Presented by Johann Heinrich Lambert (1728-1777) of Alsace in 1772.
Use	<p>Academic.</p> <p>Minimal, except to describe basic principles in map projection texts.</p> <p>Prototype for <i>Behrmann</i> and other modified cylindrical equal-area projections.</p> <p>Recommended for equal-area mapping of regions predominantly bordering the equator.</p>

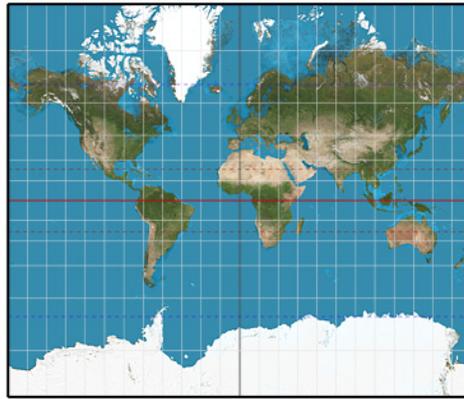


Lambert equal-area cylindrical

Mercator

Description	Cylindric and conformal.
Synonyms	<i>Wright</i> (rare), after Edward Wright of England, who developed the mathematics in 1599.

Similar projections	<p><i>Central cylindric</i> projection also cannot show the poles, but it is not conformal, and the spacing of parallels changes much more rapidly.</p> <p><i>Miller cylindric</i> and <i>Gall</i> projections show the poles, are not conformal, and have more gradual spacing of parallels.</p>
Special properties	In equatorial aspect, loxodromes are shown as straight lines.
Other features	<p>All loxodromes or rhumb lines (lines that make equal angles with all meridians and are therefore lines of constant true bearing) are straight lines.</p> <p>Meridians can be geometrically projected onto a cylinder, the axis of which is the same as that of the globe. Parallels cannot be geometrically (or perspectively) projected. Meridians cannot be compressed relative to parallels, as they can on <i>equal-area cylindric</i> and <i>equiarectangular</i> projections, since conformality would be lost.</p>
Aspects	<p>Equatorial is described here.</p> <p>Transverse and oblique aspects are listed separately because of importance and common treatment as separate projections.</p>
Limitations	Cannot show the poles: typically cut off in the high arctic.
Graticule	<p>Meridians: Equally-spaced, straight parallel lines.</p> <p>Parallels: Unequally-spaced, straight parallel lines, closest near the equator, perpendicular to meridians.</p> <p>Poles: Cannot be shown.</p> <p>Symmetry: About any meridian or the equator.</p>
Scale	<p>True along the equator, or along two parallels equidistant from the equator.</p> <p>Increases with distance from the equator to infinity at the poles.</p> <p>Constant along any given parallel; same scale at parallel of opposite sign (north +, south -).</p> <p>Same in all directions near any given point.</p>
Distortion	Infinitesimally small circles (indicatrices) of equal size on the globe appear as circles on the map (indicating conformality), but increase in size away from the equator (indicating area distortion). Great distortion in polar regions. Conformality (and therefore local angle preservation) fails at poles.
Origin	Presented by Gerardus Mercator (1512-1594) of Flanders in 1569 on a large world map 'for use in navigation'.
Use	<p>When a map is needed to show paths of constant bearing (equatorial aspect only). Also, conformal mapping along a great circle path. Center the projection on the point of interest and rotate the projection to the azimuth of the great circle path. With Stretch and Rotation, shrink the projection slightly to minimize the scale error in the region of interest.</p> <p>Designed and recommended for navigational use because of straight rhumb lines; standard for marine charts. (Equatorial aspect only.)</p> <p>Recommended and used for conformal mapping of regions neighboring the equator.</p> <p>Often and inappropriately used as a world map in atlases and for wall charts. It presents a misleading view of the world due to excessive distortion of area.</p>

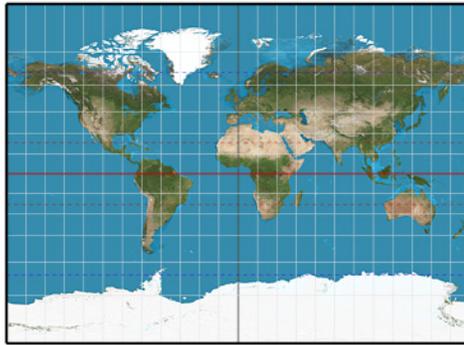


Mercator

Miller—See [Miller cylindrical](#)

Miller cylindrical [*Miller*]

Description	Cylindric. Neither conformal nor equal-area.
Other features	Almost identical to Mercator near the equator.
Aspects	Equatorial aspect is commonly used. Oblique aspect has been used by the National Geographic Society.
Similar projections	<i>Gall</i> projection has different spacing of parallels; its lines of no distortion are at latitudes 45°N and S rather than at the equator. Miller proposed other alternatives in 1942, including one identical with his preferred cylindric, but using two-thirds instead of 0.8.
Graticule	Meridians: Equally-spaced, straight parallel lines 0.73 as long as the equator. Parallels: Unequally-spaced, straight parallel lines, closest near the equator, but spacing does not increase poleward as fast as it does on the Mercator. Perpendicular to meridians. Poles: Straight lines equal in length to the equator.
Scale	Symmetry: About any meridian or the equator. True along the equator in all directions. Constant in any given direction along any other given latitude; same scale at the latitude of opposite sign. Changes with latitude and direction.
Distortion	None at the equator. Shape, area and scale distortion increases moderately away from the equator, but becomes severe at the poles.
Origin	Presented by Osborn Maitland Miller (1897 -1979) of the American Geographical Society in 1942.
Use	When a rectangular map of the world is needed. World maps in numerous American and some other atlases, as a projection resembling the <i>Mercator</i> , but having less distortion of area and scale, especially near the poles.

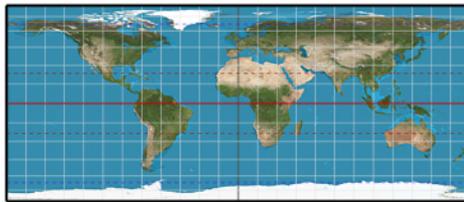


Miller cylindrical

Pavlov—See [Pavlov cylindrical](#)

Pavlov cylindrical [*Pavlov*]

Native name	<i>цилиндрическая Павлова</i>
Description	An intermediate between the <i>Lambert cylindrical equal-area</i> and the <i>plate carrée</i> .
Use	Historical.



Pavlov cylindrical

perspective cylindrical—See [central cylindrical](#)

Peters—See [Gall orthographic](#)

plane chart—See [plate carrée](#)

plate carrée

Description	Cylindric and equidistant. Created by plotting the latitude and longitude as if they were x, y coordinates.
Synonyms	<i>plate carée</i> <i>plane chart</i> <i>simple cylindric</i>
Similar projections	If meridians are compressed relative to parallels, the <i>equidistant cylindric</i> projection results.
Other features	Most simply constructed graticule of any projection. Conceptually projected onto a cylinder wrapped around the globe tangent to the equator. Not perspective.
Aspects	Equatorial is described here. Transverse aspect is the <i>transverse plate carrée</i> projection, described separately.
Graticule	Meridians: Equally-spaced, straight parallel lines half as long as the equator. Parallels: Equally-spaced, straight parallel lines, perpendicular to, and having same spacing as, meridians.
Scale	True along the equator and along all meridians. Increases with distance from the equator along parallels.
Distortion	Constant along any given parallel; same scale at the parallel of opposite sign. Infinitesimally small circles of equal size on the globe (indicatrices) are ellipses, except along the equator, where they remain circles. Areas of the ellipses also vary. Thus, there is distortion of both shape and area.
Origin	May have been originated by Eratosthenes (275?-195? BC). Marinus of Tyre also credited with its invention in about AD 100.
Use	Many maps during the 15 th and 16 th centuries. Simple outline maps of regions, or of the world. In equatorial aspect for maps from which the latitude and longitude are easily measured or indexed. By moving a point of interest to one of the poles (whereupon the point becomes a line), an equidistant map can be made such that all points a given distance from that point are shown by a straight line parallel to the (untransformed) pole line, and azimuths from that point are shown by straight lines perpendicular to the untransformed pole line.

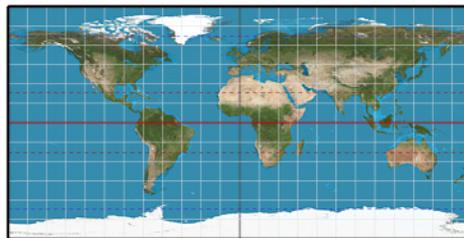


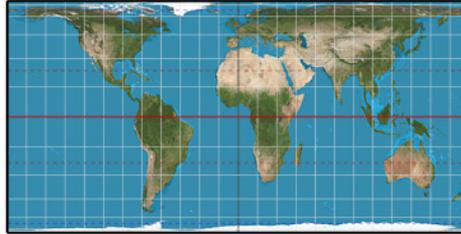
plate carrée

simple cylindric—See [plate carrée](#)

simple perspective cylindric—See [central cylindric](#)

Smyth equal-surface

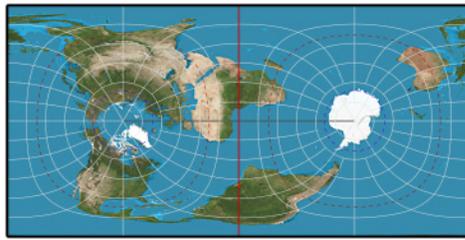
Description	Is <i>equal-area cylindrical</i> with standard parallels of $\pm 37^{\circ}4'$.
Synonyms	<i>Craster rectangular equal-area</i>
Similar projections	<i>Hobo-Dyer</i> and <i>Trystan Edwards</i> are nearly identical, and <i>Behrmann equal-area</i> and <i>Gall orthographic</i> are close.
Use	World maps showing statistical distributions.



Smyth equal-surface

transverse plate carrée

Description	Transverse aspect of the <i>plate carrée</i> . Cylindric, equidistant. Conceptually projected onto a cylinder tangent to the globe at the central meridian. Can be compressed north-south to provide a <i>transverse equirectangular</i> projection, but this is rarely done.
Synonyms	<i>Cassini</i> , though this normally applies only to the ellipsoidal form. <i>Cassini-Soldner</i> , though this normally applies only to the ellipsoidal form.
Graticule	Meridians: The central meridian, each meridian 90° from the central meridian, and the equator, are straight lines. Other meridians and parallels are complex curves, concave toward the central meridian and the nearest pole, respectively. Poles: Points along the central meridian. Symmetry: About any straight meridian or the equator.
Scale	True along the central meridian, and along any straight line perpendicular to the central meridian. Scale increases with distance from the central meridian, along a direction parallel to the central meridian.
Distortion	A function of the distance from the central meridian. No distortion occurs along the central meridian, but there is area and local shape distortion elsewhere.
Use	Historical. Developed by Cesar Francois Cassini de Thury (1714-1784) for topographic mapping of France in the middle 18 th century. Topographic mapping (ellipsoidal form) of British Isles before the 1920s, replaced by the transverse <i>Mercator</i> . A few countries still use this projection for topographic mapping.



transverse plate carrée

Trystan Edwards

Description

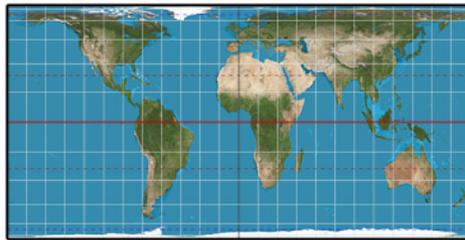
Is *equal-area cylindrical* with standard parallels of $\pm 37^{\circ}24'$.

Similar projections

Hobo-Dyer and *Smyth equal-surface* are nearly identical, and *Behrmann equal-area* and *Gall orthographic* are close.

Use

Academic.



Trystan Edwards

Universal Transverse Mercator—See [UTM](#)

Urmayev III

Native name

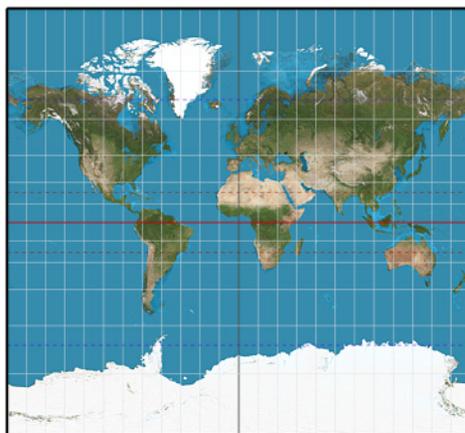
цилиндрическая Урмаева III

Description

Quite similar to *Mercator*, but shows the poles.

Use

Historical use in the Soviet Union.



Urmayev III

UTM

Description

Earth is divided into a grid of zones for large-scale mapping. Based on *ellipsoidal transverse Mercator*, zones are scaled down slightly so that its central meridian has scale 0.9996.

Synonyms

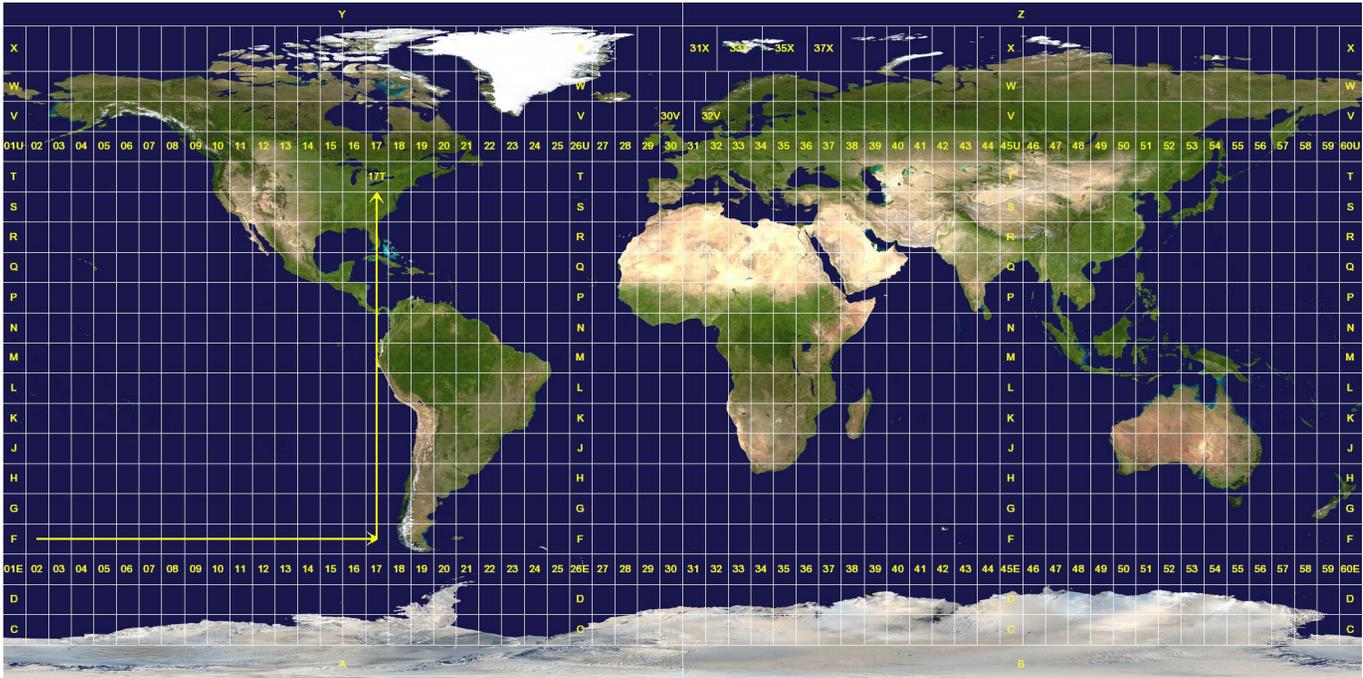
Universal Transverse Mercator

Parameters

UTM zone, a number/letter combination such as “10T”. See chart below.

Use

Topographic mapping in the United States; US military mapping of the world.



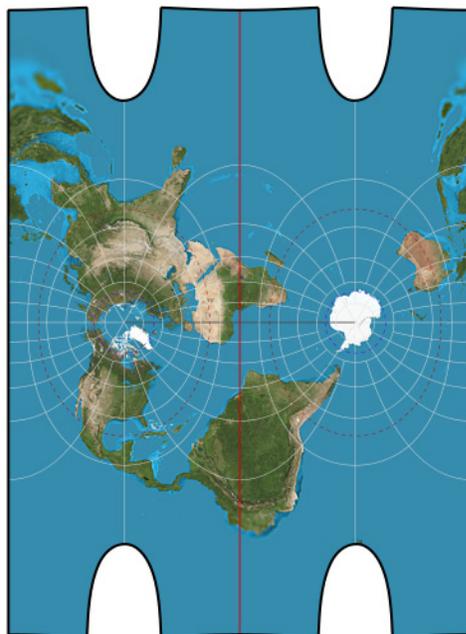
UTM Zones



UTM

Wallis 1 transverse Mercator

Description	<i>Ellipsoidal transverse Mercator</i> variant with equally-spaced parallels along central meridian.
Other names	<i>complex latitude plane</i>
Origin	R. König & K.H. Weise, 1951
Use	Academic.



Wallis 1 transverse Mercator

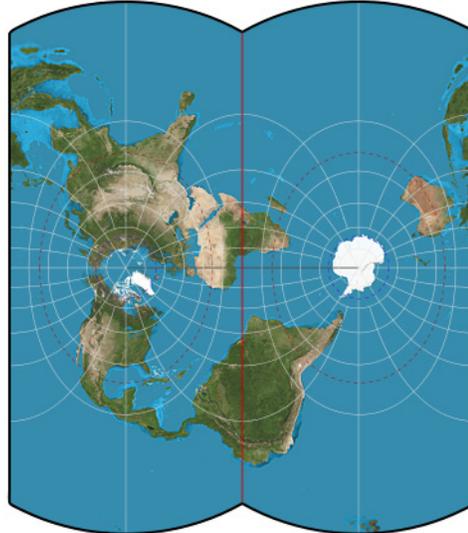
Wallis 2 transverse Mercator

Description

Ellipsoidal transverse Mercator variant with parallels spaced along the central meridian such that supplying the projection's coordinates as complex-valued parameters to the rectifying latitude results in the the standard *ellipsoidal transverse Mercator*.

Use

Academic.



Wallis 2 transverse Mercator

Web maps Mercator

Description

Formulae for the spherical *Mercator* are used for ease of calculation, but the ellipsoid is the WGS 84 model. Hence the projection is not quite conformal.

Similar projections

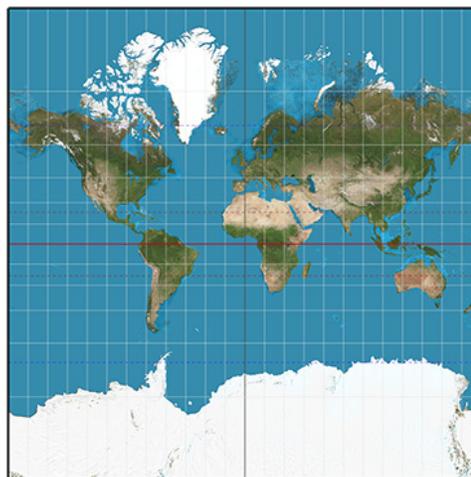
Mercator in equatorial aspect is very similar.

Aspects

Equatorial only, which is the aspect deployed in **Use**.

Use

Web maps, such as Google™ Maps, Bing™ Maps, Yahoo!™ Maps, OpenStreetMap. Its near-conformality provides for nearly undistorted presentation in large-scale maps while affording continuity across all scales.



Web maps Mercator

Wright—See [Mercator](#)

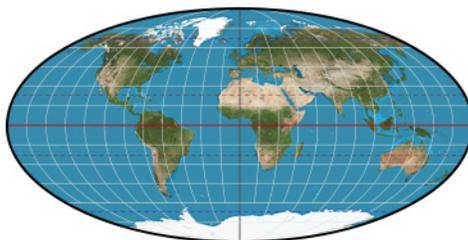
Pseudocylindrical projections

Урмаева I—See [Urmayev I](#)

Урмаева II—See [Urmayev II](#)

Apian II

Description	Pseudocylindrical. Created by stretching each parallel to fit a 2:1 ellipse. Similar to Mollweide, but not equal-area.
Use	Historical.



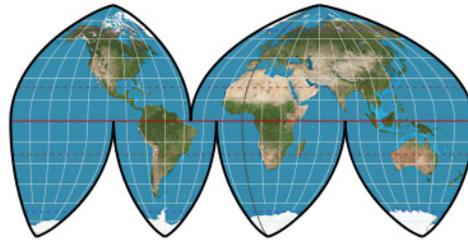
Apian II

Apianus II—See [Apian II](#)

Babinet—See [Mollweide](#)

Boggs eumorphic

Description	Pseudocylindrical, equal-area.
Similar projections	Several pseudocylindricals, such as the <i>sinusoidal</i> and <i>Craster parabolic</i> .
Other features	Designed as the arithmetic mean of the <i>sinusoidal</i> and <i>Mollweide</i> projections for north-south (y) coordinates only, when drawn with the same area scale.
Graticule	Meridians: Central meridian is a straight line half as long as the equator. Other meridians are equally-spaced complex curves intersecting at the poles and concave toward the central meridian. Parallels: Unequally-spaced, straight parallel lines perpendicular to the central meridian. Poles: Points. Symmetry: About the central meridian or the equator.
Scale	True along latitudes 40°15'N and S. Constant along any given latitude; same for the latitude of opposite sign.
Distortion	Distortion is severe near outer meridians at high latitudes, but can be substantially reduced by interruption. Free of distortion only at latitudes 40°15'N and S at the central meridian.
Origin	Presented by S. Whittemore Boggs (1884-1954) of the US Department of State in 1929.
Use	Thematic world maps in atlases and textbooks, usually in interrupted form.



Boggs eumorphic

Collignon

Description

Pseudocylindric, equal-area.

Similar projections

Eckert I and *II* also use straight lines for both meridians and parallels, but meridians are broken at the equator.

The *trapezoidal* projection has equidistant straight parallel lines for parallels and converging straight meridians equally-spaced along each parallel (top and bottom parallels, and perpendicular central meridians true to scale). It was used for numerous maps from the 15th to 18th centuries, but is neither equal-area nor conformal.

Polyhedric projection, formerly used for large-scale mapping in various parts of central Europe. There were various forms, all resembling the *trapezoidal* projection, but applied to the ellipsoid.

Graticule

Meridians: Equally-spaced straight lines converging at the north pole.

Parallels: Unequally-spaced, straight parallel lines, farthest apart near the north pole, closest near the south pole. Perpendicular to the central meridian.

Poles: north pole is a point; south pole is a line 1.41 times as long as the equator.

Symmetry: About the central meridian.

Scale

True along latitudes 15°51'N. Constant along any given latitude, different for each latitude.

Distortion

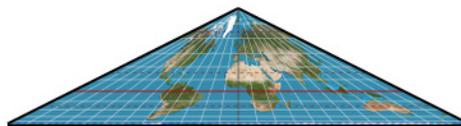
Severe in many regions. Free of distortion only at latitude 15°51'N at the central meridian.

Origin

Presented by Edouard Collignon of France in 1865.

Use

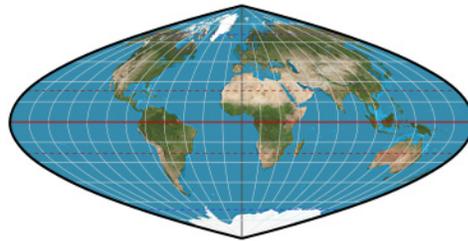
Academic, decorative.



Collignon

Craster parabolic

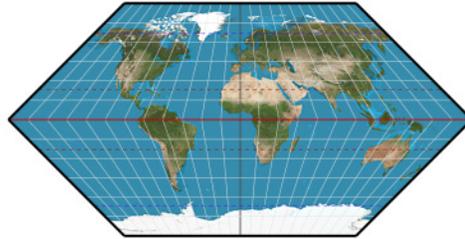
Description	Pseudocylindric, equal-area.
Synonyms	<i>Putniņš P4</i> , independently presented in Latvia in 1934.
Similar projections	Several pseudocylindrics, such as the <i>sinusoidal</i> and the <i>Boggs eumorphic</i> . <i>Putniņš P3</i> projection (1934) has meridians, poles, and equator identical to those of the <i>Craster</i> , but parallels are equally-spaced.
Aspects	Oblique aspect used for map of Asia by National Geographic Society.
Graticule	Meridians: Central meridian is a straight line half as long as the equator. Other meridians are equally-spaced parabolas intersecting at the poles and concave toward the central meridian. Parallels: Unequally-spaced, straight parallel lines, farthest apart near the equator, spacing changes very gradually, perpendicular to the central meridian. Poles: Points. Symmetry: About the central meridian or the equator.
Scale	True along latitudes 36°46'N and S. Constant along any given latitude, same of latitude of opposite sign.
Distortion	Distortion is severe near outer meridians at high latitudes, but somewhat less than that of the <i>sinusoidal</i> projection. Can be substantially reduced by interruption. Free of distortion only at latitudes 36°46'N and S at the central meridian.
Origin	Presented by John Evelyn Edmund Craster (1873-?) of England in 1929. Developed further by Charles H. Deetz and O.S. Adams in 1934.
Use	Academic and thematic world maps in text books.



Craster parabolic

Eckert I

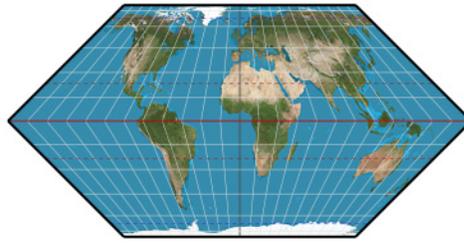
Description	Pseudocylindric, equally-spaced parallels. Neither conformal nor equal-area.
Similar projections	<i>Eckert II</i> positions all meridians identically, but its parallels are spaced for equal-area.
Graticule	Meridians: Equally-spaced converging straight lines broken at the equator. Central meridian is half as long as the equator. Parallels: Equally-spaced, straight parallel lines, perpendicular to the central meridian. Poles: Lines half as long as the equator. Symmetry: About the central meridian or the equator.
Scale	True along latitudes $47^{\circ}10'N$ and S. Constant along any given latitude, same for the latitude of opposite sign. Constant along any given meridian.
Distortion	No point free of distortion. Break at the equator introduces excessive distortion there. Discontinuous ellipses are shown there owing to the plotting algorithm. The shape is indeterminate on the equator.
Origin	Presented by Max Eckert (1868-1938) of Germany in 1906.
Use	Novelty showing straight line graticule.



Eckert I

Eckert II

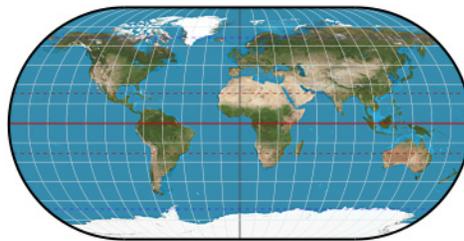
Description	Pseudocylindric, equal-area.
Similar projections	<i>Eckert I</i> positions all meridians identically, but its parallels are equidistant. <i>Collignon</i> projection has straight meridians and is equal-area, but meridians are not broken at the equator, and the poles are different.
Graticule	Meridians: Equally-spaced straight lines broken at the equator. Central meridian is half as long as the equator. Parallels: Unequally-spaced, straight parallel lines, widest separation near the equator. Perpendicular to the central meridian. Poles: Lines half as long as the equator. Symmetry: About the central meridian or the equator.
Scale	True along latitudes $55^{\circ}10'N$ and S. Constant along any given latitude, same for the latitude of opposite sign.
Distortion	Free of distortion only at latitudes $55^{\circ}10'N$ and S at the central meridian. Break at the equator introduces excessive distortion there. Discontinuous ellipses are shown there owing to the plotting algorithm. The shape is indeterminate on the equator.
Origin	Presented by Max Eckert (1868-1938) of Germany in 1906.
Use	Novelty showing straight line equal-area graticule.



Eckert II

Eckert III

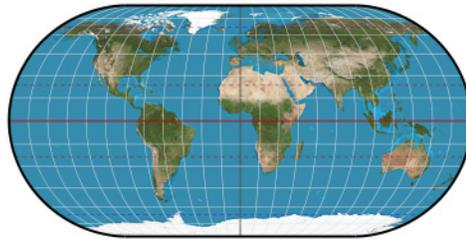
Description	Pseudocylindric, equally-spaced parallels. Neither conformal nor equal-area.
Similar projections	<i>Eckert IV</i> positions all meridians identically, but its parallels are spaced for equal-area. <i>Putninaš P1'</i> has meridians that are only portions of semi-ellipses, but parallels are equidistant.
Graticule	Meridians: Central meridian is a straight line half as long as the equator. Other meridians are equally-spaced semi-ellipses, concave toward the central meridian. The outer meridians (180° east and west of the central meridian) are semi-circles. Parallels: Equally-spaced, straight parallel lines. Perpendicular to the central meridian. Poles: Lines half as long as the equator. Symmetry: About the central meridian or the equator.
Scale	True along latitudes 35°58'N and S, if the world map retains correct total area (area varies locally). Constant along any given latitude, same for latitude of opposite sign.
Distortion	No point is free of all scale distortion, but the equator is free of angular distortion.
Origin	Presented by Max Eckert (1868-1938) of Germany in 1906.
Use	Academic.



Eckert III

Eckert III + Eckert IV

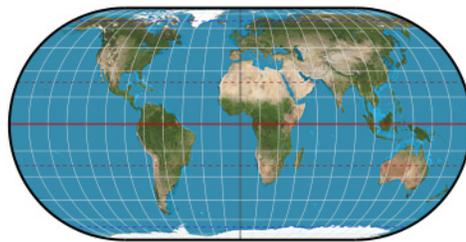
Description	Pseudocylindric. Arithmetic average of <i>Eckert III</i> and <i>Eckert IV</i> .
Similar projections	Resembles <i>Robinson</i> , but has slightly more rounded shape in the outer meridians.
Use	Reference world maps.



Eckert III + IV

Eckert IV

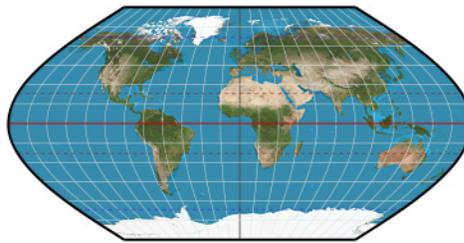
Description	Pseudocylindric, equal-area.
Similar projections	<i>Eckert III</i> positions all meridians identically, but its parallels are equally spaced. <i>Putninaš P2'</i> has meridians that are only portions of semi-ellipses, but parallels are also spaced for equal-area.
Aspects	Like most projections, transverse and oblique aspects can be prepared, although they are seldom used in this case.
Graticule	Meridians: Central meridian is a straight line half as long as the equator. Other meridians are equally-spaced semi-ellipses, concave toward the central meridian. The outer meridians (180° east and west of the central meridian) are semi-circles. Parallels: Unequally-spaced, straight parallel lines, widest separation near the equator. Poles: Lines half as long as the equator. Symmetry: About the central meridian or the equator.
Scale	True along latitudes 40°30'N and S. Constant along any given latitude, same for the latitude of opposite sign.
Distortion	Free of distortion only at latitudes 40°30'N and S at the central meridian.
Origin	Presented by Max Eckert (1868-1938) of Germany in 1906.
Use	Thematic and other world maps in numerous atlases and text books, and for sheet maps.



Eckert IV

Eckert V

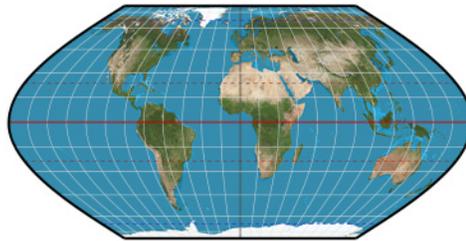
Description	Pseudocylindric, equally-spaced parallels. Neither conformal nor equal-area.
Similar projections	<i>Eckert VI</i> positions all meridians identically, but its parallels are spaced for equal-area. <i>Winkel I</i> is an average of coordinates of the <i>sinusoidal</i> and <i>equiangular</i> projections. <i>Wagner III</i> projection uses part rather than all of the sinusoidal curve for meridians.
Graticule	Meridians: Central meridian is a straight line half as long as the equator. Other meridians are equally-spaced sinusoids, concave toward the central meridian. Parallels: Equally-spaced straight, parallel lines, perpendicular to the central meridian. Poles: Lines half as long as the equator. Symmetry: About the central meridian or the equator.
Scale	True along latitudes 37°55'N and S is the world map retains correct total area. Constant along any given latitude, same for latitude of opposite sign.
Distortion	No point free of all distortion, but the equator is free of angular distortion.
Origin	Presented by Max Eckert (1868-1938) of Germany in 1906. The projection is an arithmetical average of the <i>x</i> and <i>y</i> coordinates of the <i>sinusoidal</i> and <i>plate carrée</i> projections.



Eckert V

Eckert VI

Description	Pseudocylindric, equal-area.
Similar projections	<p><i>Eckert V</i> positions all meridians identically, but its parallels are equally-spaced.</p> <p><i>Wagner I</i> projection (1932) is almost identical Eckert VI, but Wagner I uses only part of the sinusoidal curve.</p> <p><i>Kavrayskiy VI</i> projection (1936) is identical to Wagner I. Werenskiold II projection (1944) is the same as Wagner I, except for scale.</p> <p><i>McBryde-Thomas flat-polar sinusoidal</i> uses the full sinusoid and is equal-area, but the poles are one-third the length of the equator.</p>
Graticule	<p>Meridians: Central meridian is a straight line half as long as the equator. Other meridians are equally-spaced sinusoids, concave toward the central meridian.</p> <p>Parallels: Equally-spaced straight, parallel lines, widest separation near the equator. Perpendicular to the central meridian.</p> <p>Poles: Lines half as long as the equator.</p> <p>Symmetry: About the central meridian or the equator.</p>
Scale	True along latitudes 49°16'N and S. Constant along any given latitude, same for the latitude of opposite sign.
Distortion	Free of distortion only at latitudes 49°16'N and S at the central meridian.
Origin	Presented by Max Eckert (1868-1938) of Germany in 1906.
Use	Thematic world maps in Soviet World Atlas. Some recent use for climatic maps by US publishers.

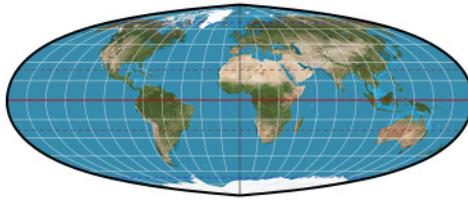


Eckert VI

elliptical—See [Mollweide](#)

Foucalt equal-area

Description	Pseudocylindric. Equal-area.
Use	Academic.
Parameters	One parameter β which describes the weight of the <i>sinusoidal</i> with respect to the <i>Lambert cylindrical equal-area</i> .
Range	$0 \leq \beta \leq 1$
Usual	None. When $\beta = 0$, the projection is the <i>Lambert cylindrical equal-area</i> . When $\beta = 1$, the projection is the <i>sinusoidal</i> .



Foucaut equal-area

Foucaut stereographic

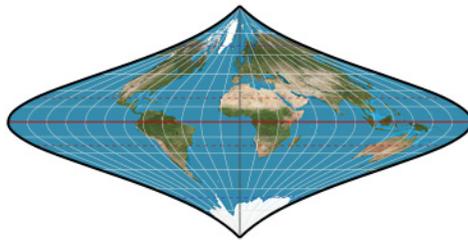
Description

Pseudocylindric, equal-area.

Parallel spacing along the central meridian corresponds to that of the equatorial aspect of the *stereographic*.

Use

Academic.



Foucaut stereographic

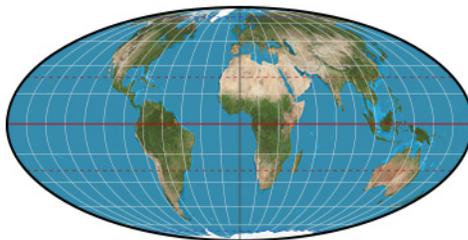
Fournier II

Description

Pseudocylindric.

Use

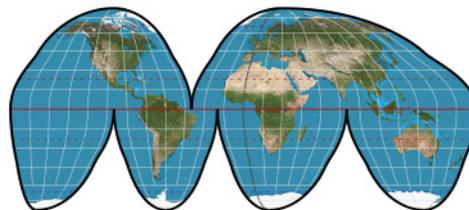
Historical



Fournier II

Goode homolosine

Description	Pseudocylindric, composite, equal-area.
Graticule	<p>Meridians: In the interrupted form, there are six central meridians, each a straight line 0.22 as long as the equator, but not crossing the equator. Other meridians are equally-spaced sinusoidal curves between latitudes 40°44'N and S and elliptical arcs elsewhere, all concave toward the central meridian. There is a slight bend in meridians at the 40°44' latitudes.</p> <p>Parallels: Straight parallel lines, perpendicular to the central meridians. Equally-spaced between latitudes 40°44'N and S. Gradually closer together beyond these latitudes as a pole is approached.</p> <p>Poles: Points.</p> <p>Symmetry: None in the usual interrupted form. If uninterrupted, there is symmetry about the central meridian or equator.</p>
Scale	True along every latitude between 40°44'N and S and along the central meridian within the same latitude range. At higher latitudes, scale varies but is the same for the latitude of opposite sign.
Distortion	Same as <i>sinusoidal</i> projection between latitudes 40°44'N and S. Same as <i>Mollweide</i> projection beyond this range.
Origin	The <i>Goode homolosine</i> projection is almost always presented interrupted, as the inventor originally intended.
Use	Developed in 1923 by J. Paul Goode (1862-1932) at the University of Chicago as a merging of the <i>Mollweide</i> (or <i>homolographic</i>) with the <i>sinusoidal</i> at the parallels of identical scale, latitudes 40°44'N and S, hence the name <i>homolosine</i> . Frequently plotted with some northern regions repeated on different interrupted sections to reduce discontinuities of land.
	Numerous world maps, especially in Goode's Atlas (Rand McNally).

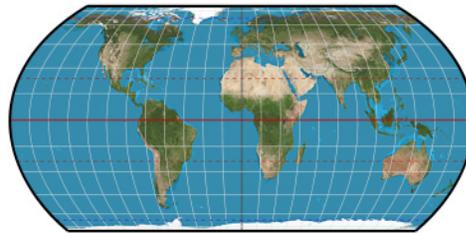


Goode homolosine

Hatano—See [Hatano asymmetric](#)

Hatano asymmetric [*Hatano*]

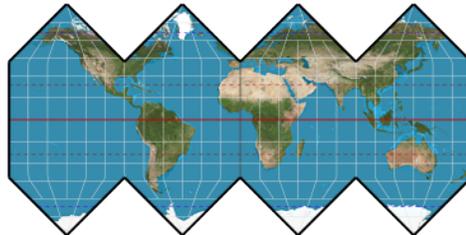
Description	<p>Pseudocylindric, equal-area.</p> <p>Northern and southern hemispheres are composed of two different custom projections joined at the equator.</p>
Similar projections	<p><i>Mollweide</i> projection uses full symmetrical semi-ellipse for meridians, and poles are points.</p> <p><i>Putniņš P2'</i> projection uses arcs less than semi-ellipses for meridians, but they are symmetrical about the equator, and poles are lines half the length of the equator.</p> <p><i>Hatano symmetrical equal-area</i> projection (1972) uses the same graticule for the northern hemisphere. The southern hemisphere is symmetrical (the south pole is also two-thirds the length of the equator).</p>
Graticule	<p>Meridians: The central meridian is a straight line 0.48 as long as the equator. Other meridians are equally-spaced elliptical arcs, concave toward the central meridian, but the eccentricity of each ellipse changes at the equator.</p> <p>Parallels: Unequally-spaced straight, parallel lines. Perpendicular to the central meridian. Spacing not symmetrical about the equator.</p> <p>Poles: Lines. The north pole is two-thirds as long, and the south pole is three-quarters as long as the equator.</p> <p>Symmetry: About the central meridian but not about the equator.</p>
Scale	<p>True along latitudes 40°42'N and 38°27'S. Constant along any given latitude, normally different for the latitude of opposite sign.</p>
Distortion	<p>Free of distortion only at latitudes 40°42'N and 38°27'S at the central meridian.</p>
Origin	<p>Presented by Masataka Hatano of Japan in 1972 as a modification of the <i>Mollweide</i> and <i>Putniņš P2'</i> projections.</p>
Use	<p>Japanese world thematic maps, usually centered in the Pacific.</p>



Hatano asymmetric

HEALPix

Description	Pseudocylindric, equal-area. Latitudes above $41^{\circ}48'37''$ N/S are equivalent to portions of <i>Collignon</i> projection. The lower latitudes are on the <i>equal-area cylindric</i> projection.
Parameters	One parameter H giving the number of interruptions in the high latitudes of one hemisphere.
Range	$1 \leq H \leq 12$
Usual	$H = 4$
Graticule	Meridians: Straight and parallel from equator to $41^{\circ}48'37''$ N/S. Straight and angling inward to the poles from there. Parallels: Equally spaced, straight parallel lines between $41^{\circ}48'37''$ N/S. Unequally spaced, straight parallel lines above those latitudes. Poles: Each pole consists of H points. Symmetry: About the central meridian and the Equator.
Scale	If $H = 3$, scale is true along the $37^{\circ}4'$ parallels N/S. If $H = 4$, scale is true along the $22^{\circ}53'$ parallels N/S. Otherwise, nowhere true.
Distortion	Free of distortion nowhere.
Origin	The projection evolved out of a spherical pixelization scheme presented by K. M. Górski, E. Hivon, A.J. Banday, B.D. Wandelt, F.K. Hansen, M. Reinecke, & M. Bartelman in 2005 and further elaborated on by M. R. Calabretta in 2008. The name means <i>Hierarchical Equal Area and isoLatitude Pixelisation</i> .
Use	Used by NASA for processing and storing large cosmological data sets. Satellites collect radiation measurements all across the celestial sphere. The data are saved on a raster grid for analysis.



HEALPix

homalographic—See [Mollweide](#)

homolographic—See [Mollweide](#)

hyperelliptical

Description

Pseudocylindric, equal-area.

Use

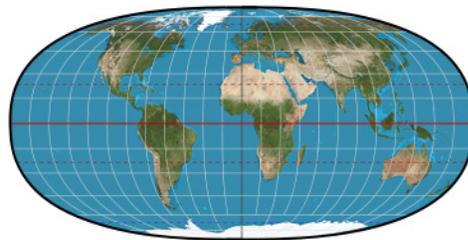
Thematic world maps; reference world maps.

Parameters

Three parameters: weighting α of the *Lambert cylindric equal-area* projection; the portion γ of the hyperellipse to use in the meridional curves; and the polynomial order κ of the meridional curves.

Range

α is not limited; $\gamma > 1.0$; $\kappa \gg 0$. Minimum value of γ depends on κ and α ; computing it in advance is impractical. Try and err... or succeed.



hyperelliptical

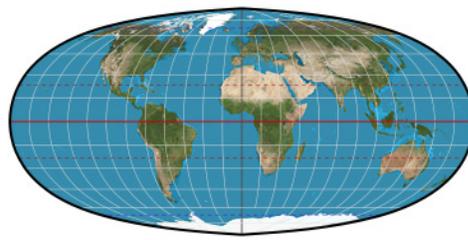
Kavrayskiy V

Description

Pseudocylindric, equal-area.

Use

World maps with points for poles.



Kavrayskiy V

Kavrayskiy VI—See [Wagner I](#)

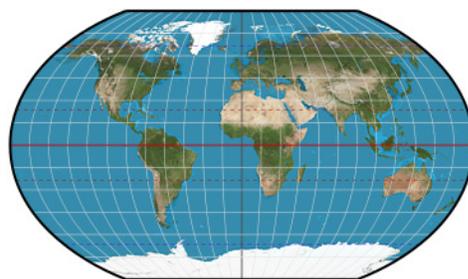
Kavrayskiy VII

Description

Pseudocylindric.

Use

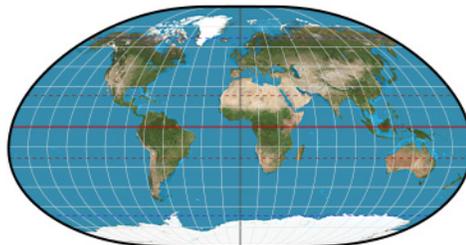
Reference world maps.



Kavrayskiy VII

loximuthal

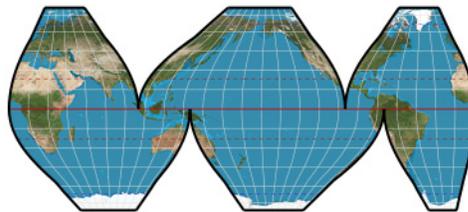
Description	Pseudocylindric, equally-spaced parallels, neither conformal nor equal-area.
Similar projections	Loxodromes are shown straight and at the correct azimuth between any two points on the regular <i>Mercator</i> projection, but they are not at true scale. The <i>Bordone oval</i> projection of 1520 is similar to the <i>loximuthal</i> projection having the equator as the central latitude.
Parameters	Latitude of origin. One parameter φ_1 which, along with the central meridian, form a point from which all loxodromes (rhumb lines) are shown as straight lines and at correct scale (in equatorial aspect).
Special properties	A higher latitude produces an increasingly triangular map with a shorter base line. Loxodromes (rhumb lines) from the central point (at the intersection of the central meridian and the central parallel) are shown straight, true to scale, and correct in azimuth from the center. Because of angular distortion on the map projection, the azimuths with respect to other points along a rhumb line are not shown correctly.
Range	$90^\circ\text{S} \ll \varphi_1 \ll 90^\circ\text{N}$.
Graticule	Meridians: Central meridian is a straight line generally over half as long as the equator, depending on the central latitude. If the central latitude is the equator, the ratio is 0.5, if it is 40°N or S, the ratio is 0.65. Other meridians are equally-spaced complex curves intersecting at the poles and concave toward the central meridian. Parallels: Equally-spaced straight, parallel lines. Perpendicular to the central meridian. Poles: Points. Symmetry: About the central meridian. Symmetry occurs about the equator if the specified central latitude is the equator.
Scale	True along the central meridian. Constant along any given latitude, normally different for the latitude of opposite sign.
Distortion	Distortion is moderate to extreme, but the projection is intended for the special property of the loxodromes, not as a normal world map. Free of distortion only at the central latitude on the central meridian.
Origin	Presented by Karl Siemon (?-1937) of Germany in 1935. Independently presented as <i>loximuthal</i> by Waldo R. Tobler (1930-) of the University of Michigan (1966).
Use	Maps that show constant bearing and distance from a particular point. Using the <i>Projection Center</i> command set the center point of the projection to the meridian of interest and the equator (not the parallel of interest). Then use the <i>Parameters</i> command to set φ_1 to the point of interest.



loximuthal

McBryde S3

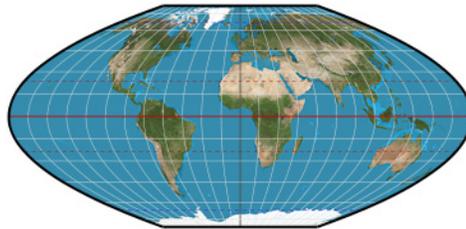
Description	Pseudocylindric, equal-area, composite.
Similar projections	Identical to the <i>sinusoidal</i> between latitudes 55°51'N and S, identical to the <i>McBryde-Thomas flat-polar sinusoidal</i> poleward of those latitudes, except that those portions are closer to the equator than they are on the <i>McBryde-Thomas flat-polar sinusoidal</i> projection.
Graticule	<p>McBryde merged projections in several other similar combinations, also in 1977.</p> <p>Meridians: Where the central meridian extends across the equator, it is a straight line 0.44 as long as the equator. Other central meridians in the usual interrupted form are straight and half as long. Other meridians are equally-spaced sinusoidal curves, bending slightly at latitudes 55°51'N and S, and all are concave toward the local central meridian.</p> <p>Parallels: Straight parallel lines, perpendicular to the central meridian(s). Equally-spaced between latitudes 55°51'N and S. Gradually closer together beyond these latitudes.</p> <p>Poles: Interrupted straight lines totaling 0.31 the length of the equator.</p> <p>Symmetry: About the central meridian or the equator (in uninterrupted form).</p>
Scale	True along every latitude between 55°51'N and S and along the central meridian within the same latitude range. Constant along any given latitude, same for the latitude of opposite sign.
Distortion	Same as the <i>sinusoidal</i> projection between latitude 55°51'N and S. Same as the <i>McBryde-Thomas flat-polar sinusoidal</i> projection beyond this range. <i>McBryde S3</i> is almost always used in the interrupted form and has several central meridians.
Origin	Developed by F. Webster McBryde (1908-) of Potomac, Md, in 1977 as a merging of the <i>sinusoidal</i> with the <i>McBryde-Thomas flat-polar sinusoidal</i> projection at the parallels of identical scale on the two projections, latitudes 55°51'N and S. US patent by McBryde.
Use	World map interrupted to show oceans or land masses, by McBryde.
	Note: Use of this projection may be restricted. See Notices for details.



McBryde S3

McBryde-Thomas flat-polar parabolic

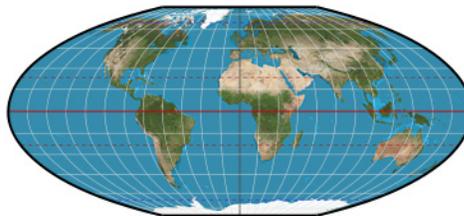
Description	Pseudocylindric, equal-area.
Similar projections	<p><i>Craster parabolic</i> projection, equal-area with parabolic meridians but with pointed poles and a central meridian that is half the length of the equator.</p> <p><i>Putniņš P4'</i> projection (1934), equal-area with parabolic meridians but with poles and a central meridian that are all half the length of the equator.</p> <p><i>Werenskiold I</i> (1944) is identical to <i>Putniņš P4'</i> except for the scale. <i>Putniņš P3</i> projection (1934) has meridians, poles and equator identical to those of <i>Putniņš P4'</i>, but parallels are equally-spaced.</p>
Graticule	<p>Meridians: Central meridian is a straight line 0.48 as long as the equator. Other meridians are equally-spaced parabolic curves, concave toward the central meridian.</p> <p>Parallels: Unequally-spaced straight, parallel lines, farthest apart near the equator. Perpendicular to the central meridian.</p> <p>Poles: Lines one-third as long as the equator.</p> <p>Symmetry: About the central meridian or equator.</p>
Scale	True along latitudes 45°30'N and S. Constant along any given latitude, same for latitude of opposite sign.
Distortion	Distortion is severe near the outer meridians at high latitudes, but less than the corresponding distortion on pointed-polar projections. Free of distortion only at latitudes 45°30'N and S at the central meridian.
Origin	Presented by F. Webster McBryde and Paul D. Thomas through the US Coast and Geodetic Survey in 1949.
Use	Academic. Basis of merged projections by McBryde.



McBryde-Thomas flat-polar parabolic

McBryde-Thomas flat-polar quartic

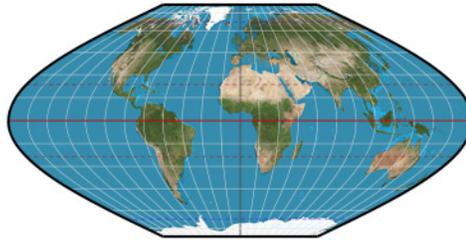
Description	Pseudocylindric, equal-area.
Synonyms	<i>Flat-polar quartic projection</i>
Similar projections	<i>Quartic authalic</i> projection, the basis of this projection, has pointed poles. Other McBryde-Thomas projections also have poles one-third the length of the equator and otherwise resemble this projection.
Graticule	Meridians: Central meridian is a straight line 0.45 as long as the equator. Other meridians are equally-spaced curves fitting a fourth-order (quartic) equation and concave toward the central meridian. Parallels: Unequally-spaced straight, parallel lines, farthest apart near the equator. Perpendicular to the central meridian. Poles: Lines one-third as long as the equator. Symmetry: About the central meridian or equator.
Scale	True along latitudes 33°45'N and S. Constant along any given latitude, same for latitude of opposite sign.
Distortion	Distortion is severe near outer meridians at high latitudes, but less than the corresponding distortion on pointed-polar projections. Free of distortion only at latitudes 33°45'N and S at the central meridian.
Origin	Presented by F. Webster McBryde and Paul D. Thomas through the US Coast and Geodetic Survey in 1949.
Use	Examples in various geography text books. Basis of merged projections by McBryde.



McBryde-Thomas flat-polar quartic

McBryde-Thomas flat-polar sinusoidal

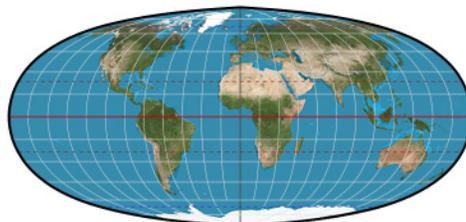
Description	Pseudocylindric, equal-area.
Similar projections	<i>Sinusoidal</i> projection uses sinusoids for meridians, but poles are points. <i>Eckert VI</i> projection uses sinusoids for meridians and is equal-area, but the poles are lines half as long as the equator.
Graticule	Meridians: Central meridian is a straight line half as long as the equator. Other meridians are equally-spaced sinusoids concave toward the central meridian. Parallels: Unequally-spaced straight, parallel lines, farthest apart near the equator. Perpendicular to the central meridian. Poles: Lines one-third as long as the equator. Symmetry: About the central meridian or equator.
Scale	True along latitudes 55°51'N and S. Constant along any given latitude, same for latitude of opposite sign.
Distortion	Free of distortion only at latitudes 55°51'N and S at the central meridian.
Origin	Presented by F. Webster McBryde and Paul D. Thomas through the US Coast and Geodetic Survey in 1949.
Use	Basis of merged projections by McBryde (see McBryde S3).



McBryde-Thomas flat-polar sinusoidal

McBryde-Thomas I

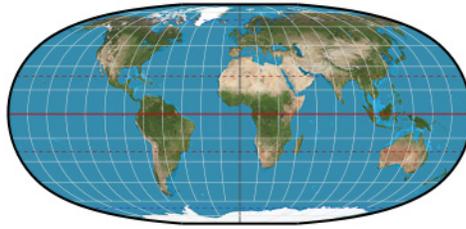
Description	Pseudocylindric, equal-area.
Use	Thematic world maps.



McBryde-Thomas I

McBryde-Thomas II

Description	Pseudocylindric, equal-area.
Use	Thematic world maps.

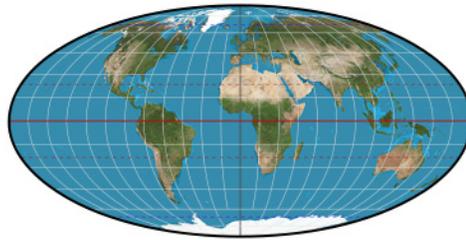


McBryde-Thomas II

Mercator equal-area—See [sinusoidal](#)

Mollweide

Description	Pseudocylindric. Equal-area map in an ellipse.
Synonyms	<i>Mollweide</i> <i>homolographic</i> <i>homalographic</i> <i>elliptical</i>
Similar projections	<i>Goode homolosine</i> (<i>Mollweide</i> merged with <i>sinusoidal</i>) <i>Boggs Eumorphic</i> (<i>Mollweide</i> averaged with <i>sinusoidal</i>) <i>Bromley</i> by Robert H. Bromley in 1965 (<i>Mollweide</i> compressed from north to south with east-west expansion to achieve no distortion along the equator). <i>Hyperelliptical</i> by Waldo R. Tobler in 1973 (equal-area pseudocylindric having ‘hyperelliptical’ meridians that lie between the <i>Mollweide</i> ellipses and have a circumscribed rectangle).
Aspects	For educational purposes, it has been shown in various aspects as examples of equatorial, transverse, and oblique aspects of almost any pseudocylindric projection. The transverse aspect has also been used by John Bartholomew in <i>The Times Atlas in England</i> in 1958.
Graticule	Meridians: Central meridian is a straight line half as long as the equator. Meridians 90° E and W of the central meridian form a circle. Others are equally-spaced semi-ellipses intersecting at the poles and concave toward the central meridian. Parallels: Unequally-spaced straight, parallel lines, farthest apart near the equator, spacing changes gradually. Perpendicular to the central meridian. Poles: Points. Symmetry: About the central meridian or the equator.
Scale	True along latitudes 40°44’N and S. Constant along any given latitude, same for the latitude of opposite sign.
Distortion	Severe near outer meridians at high latitudes, but can be substantially reduced if interrupted with several central meridians. Free of distortion only at latitudes 40°44’N and S on the central meridian.
Origin	Presented by Carl B. Mollweide (1774-1825) of Germany in 1805.
Use	Occasional world maps, especially thematic maps. Combined with <i>sinusoidal</i> projection to develop other projections such as the <i>Goode homolosine</i> and the <i>Boggs</i> .

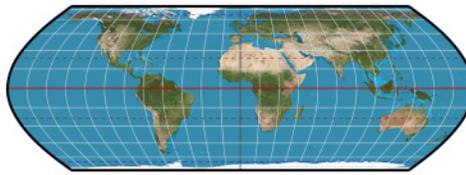


Mollweide

Nell

Description
Use

Pseudocylindric, equal-area.
Historical.

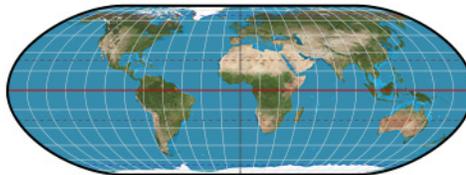


Nell

Nell-Hammer

Description
Use

Pseudocylindric.
Historical.

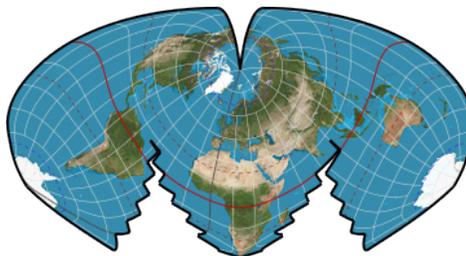


Nell-Hammer

Philbrick Sinu-Mollweide

Description
Origin
Use

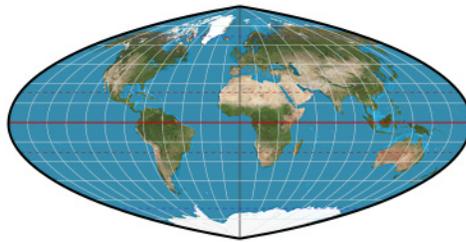
Pseudocylindric.
Presented by Allen K. Philbrick in 1953 as an oblique fusion of the Mollweide and sinusoidal projections.
For thematic maps displaying distributions across the world.



Philbrick Sinu-Mollweide

Putniņš P1

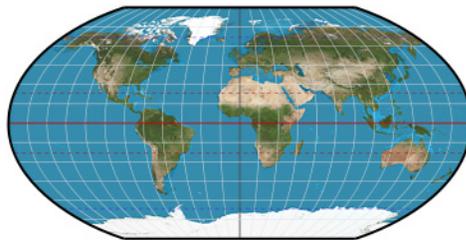
Description	Pseudocylindric.
Use	Academic.



Putniņš P1

Putniņš P1'

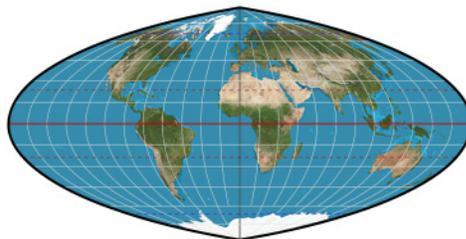
Description	Pseudocylindric.
Use	Reference world maps.



Putniņš P1'

Putniņš P2

Description	Pseudocylindric, equal-area.
Use	Academic.

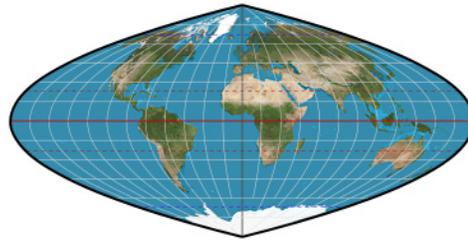


Putniņš P2

Putniņš P2'—See [Wagner IV](#)

Putniņš P3

Description	Pseudocylindric.
Use	Academic.

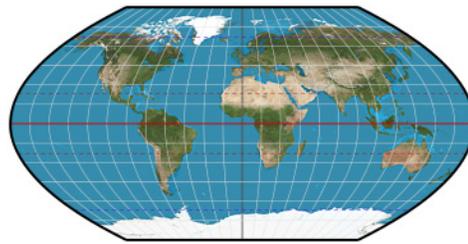


Putniņš P3

Putniņš P3'

Description
Use

Pseudocylindric.
Academic.



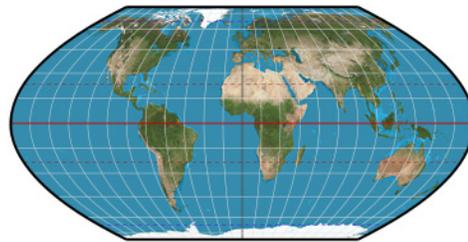
Putniņš P3'

Putniņš P4—See [Craster parabolic](#)

Putniņš P4'

Description
Use

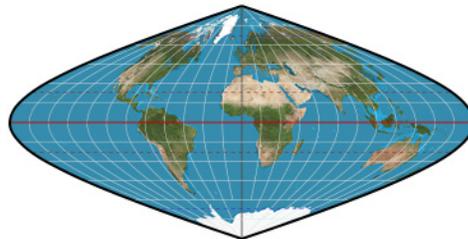
Pseudocylindric. Equal-area.
Thematic world maps.



Putniņš P4'

Putniņš P5

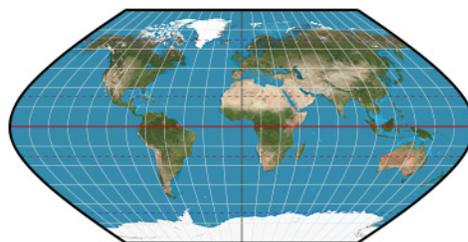
Description	Pseudocylindric. Equally-spaced parallels. Neither conformal nor equal-area.
Similar projections	<i>Putniņš P6 equal-area</i> projection (1934) has hyperbolic meridians identical in shape to those of the pointed-polar P2; parallels are straight but are spaced for equal-area. <i>Putniņš P2'</i> projection (1934) has hyperbolic meridians, but the poles are straight lines half the length of the equator. Parallels are equally-spaced. The projection is not equal-area.
Graticule	Meridians: Central meridian is a straight line half as long as the equator. Other meridians are equally-spaced portions of hyperbolas, concave toward the central meridian. Parallels: Equally-spaced straight, parallel lines, perpendicular to the central meridian. Poles: Points.
Scale	Symmetry: About the central meridian or the equator. True along latitudes 21°14'N and S. Constant along any given latitude, same for latitude of opposite sign. Constant along the central meridian.
Distortion	Distortion is similar to other pointed-polar pseudocylindrics, but not free of distortion at any point.
Origin	Presented by Reinholds V. Putniņš of Lavia in 1934.



Putniņš P5

Putniņš P5'

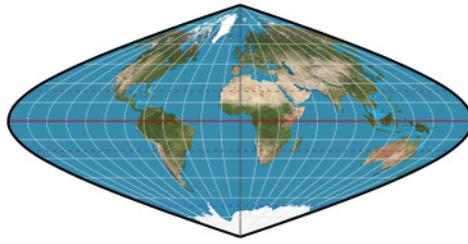
Description	Pseudocylindric.
Use	Academic.



Putniņš P5'

Putniņš P6

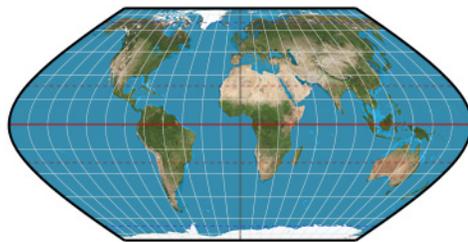
Description	Pseudocylindric. Equal-area.
Similar projections	Quite similar to the <i>sinusoidal</i> .
Use	Academic.



Putniņš P6

Putniņš P6'

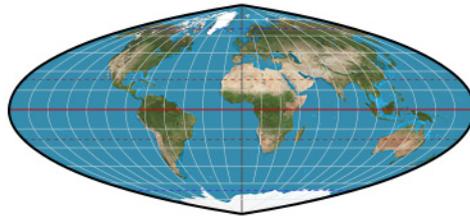
Description	Pseudocylindric. Equal-area.
Similar projections	Very similar to <i>Eckert VI</i> .
Use	Thematic world maps.



Putniņš P6'

quartic authalic

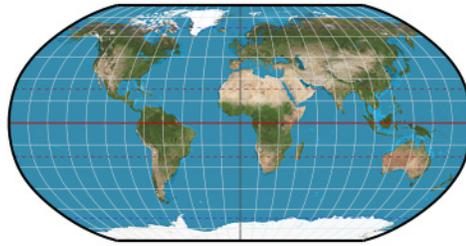
Description	Pseudocylindric, equal-area.
Similar projections	Several pseudocylindrics, such as the <i>sinusoidal</i> . <i>Eckert-Greifendorff</i> has slightly curved parallels.
Graticule	Meridians: Central meridian is a straight line 0.45 as long as the equator. Other meridians are equally-spaced curves fitting a fourth-order (quartic) equation and concave toward the central meridian. Parallels: Unequally-spaced straight, parallel lines, farthest apart near the equator. Spacing changes gradually. Perpendicular to the central meridian. Poles: Points. Symmetry: About the central meridian or the equator.
Scale	True along the equator. Constant along any given latitude, same for latitude of opposite sign.
Distortion	Distortion is severe near outer meridians at high latitudes, but somewhat less than that of the <i>sinusoidal</i> projection. Distortion can be substantially reduced by interruption. Free of distortion along the equator.
Origin	Presented by Karl Siemon (?-1937) of Germany in 1937. Independently presented by Oscar Sherman Adams (1874-1962) of the US Coast and Geodetic Survey in 1945.
Use	Basis for <i>McBryde-Thomas flat-polar quartic</i> projection.



quartic authalic

Robinson

Description	Pseudocylindric, neither conformal nor equal-area.
Synonyms	<i>orthophanic</i> (“right appearing”).
Similar projections	<i>Putnins P2'</i> , an equal-area projection on which meridians are elliptical arcs. <i>Eckert III+EckertIV</i>
	In 1968, Janos Baranyi presented seven pseudocylindric projections characterized by various graduated tabular spacings of the parallels. The poles are usually points but occasionally are lines, and the outer meridians 180° from the central meridian are circular arcs combined in some cases with straight lines. His projections are neither equal-area nor conformal.
Parameters	An enumeration to describe the interpolation model.
Range	interpolation, spline, polynomial
Usual	interpolation for maps; polynomial for distortion analysis.
Graticule	Meridians: Central meridian is a straight line 0.51 times as long as the equator. Other meridians resemble elliptical arcs, are equally spaced, and are concave toward the central meridian. Parallels: Straight parallel lines, equally-spaced between latitudes 38°N and S, space decreases beyond these limits. Poles: Lines 0.53 as long as the equator. Symmetry: About the central meridian or the equator.
Scale	True along latitudes 38°N and S. Constant along any given latitude, same for the latitude of opposite sign.
Distortion	No point is completely free of distortion, but distortion is very low within about 45° of the center and along the equator. Considerable distortion near the poles.
Origin	Presented by Arthur H. Robinson (1915-) of the University of Wisconsin in 1963, at the request of Rand McNally and Company.
	Uses tabular coordinates rather than mathematical formulas to make the world map “look” right.
Use	By Rand McNally in Goode’s Atlas for thematic world maps, and in numerous other publications.



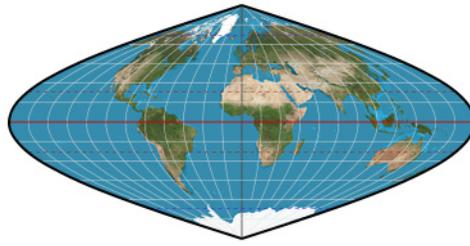
Robinson

Sanson-Flamsteed—See [sinusoidal](#)

Sinu-Mollweide—See [Philbrick Sinu-Mollweide](#)

sinusoidal

Description	Pseudocylindric, equal-area, equally-spaced parallels.
Synonyms	<i>Mercator equal-area</i> <i>Sanson-Flamsteed</i>
Similar projections	Several other pseudocylindric projections, such as <i>Craster parabolic</i> and <i>Boggs eumorphic</i> , are very similar, but parallels are not equally-spaced, and meridians are curved differently. <i>Eckert V</i> and <i>VI</i> have sinusoidal meridians but have lines for poles.
Special properties	In equatorial aspect, scale is correct along all parallels and along the central meridian.
Aspects	For educational purposes, it has been shown in various aspects as examples of equatorial, transverse and oblique aspects of almost any pseudocylindric projection.
Graticule	Meridians: Central meridian is a straight line half as long as the equator. Other meridians are equally-spaced sinusoidal curves intersecting at the poles and concave toward the central meridian. Parallels: Equally-spaced straight, parallel lines perpendicular to the central meridian. Poles: Points. Symmetry: About the central meridian or the equator.
Scale	True along every parallel and along the central meridian.
Distortion	Severe near outer meridians at high latitudes, but can be substantially reduced by interruption with several central meridians. Free of distortion along the equator and along the central meridian.
Origin	Developed in the 16 th century. Used by J. Cossin in 1570 and by J. Hondius in Mercator atlases of the early 17 th century. Often called <i>Sanson-Flamsteed</i> projection after later users. Oldest current pseudocylindric projection.
Use	Atlas maps of South America and Africa. Occasionally used for world maps. Formerly used for other continental maps and star maps. Combined with <i>Mollweide</i> projection to develop other projections such as the <i>homolosine</i> and the <i>Boggs eumorphic</i> .



sinusoidal

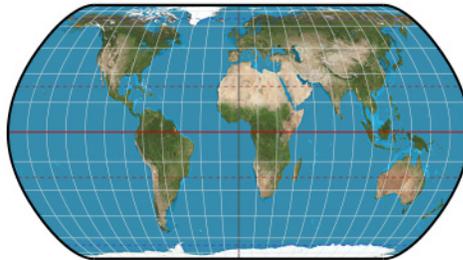
Snyder minimum-error flat-pole

Description

Pseudocylindric. A minimum-error pseudocylindric with flat pole lines.

Use

Thematic maps of the world requiring straight parallels.



Snyder minimum-error flat-pole

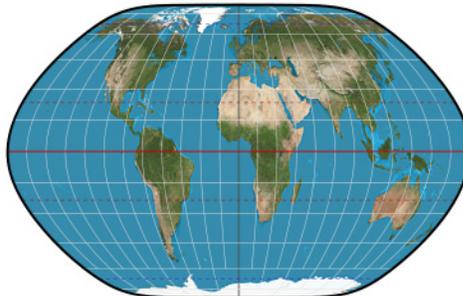
Snyder minimum-error pointed-pole

Description

Pseudocylindric. A minimum-error pseudocylindric with points for poles.

Use

Thematic maps of the world requiring straight parallels.



Snyder minimum-error pointed pole

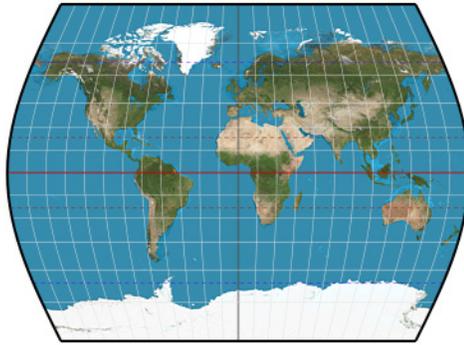
The Times

Description

Pseudocylindric.

Use

Historical.



The Times

trapezoidal

Description

Pseudocylindric.

Use

Historical.

Parameters

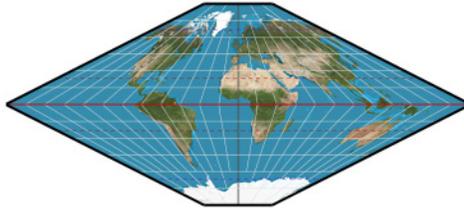
Two standard parallels φ_1 and φ_2 along which scale will be correct. If both standard parallels are in the same hemisphere the map will reflect around the equator and the scales along the parallels of the opposite sign also will be correct.

Range

$90^\circ\text{S} \leq \varphi_1, \varphi_2 \leq 90^\circ\text{N}$.

Usual

None. When $\varphi_1 = \varphi_2$ the projection is equivalent to *quirectangular*.



trapezoidal

Urmayev I

Native name

цилиндрическая Урмаева I

Description

Pseudocylindric. Equal-area.

Use

Academic.

Parameters

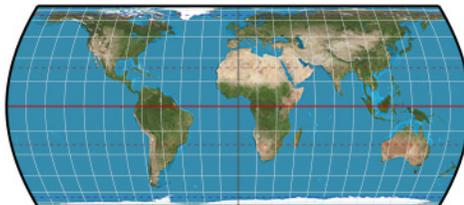
Length of the pole-line $0.0 \leq \beta \leq 1.0$

Range

$0 \leq \alpha \leq 1$

Usual

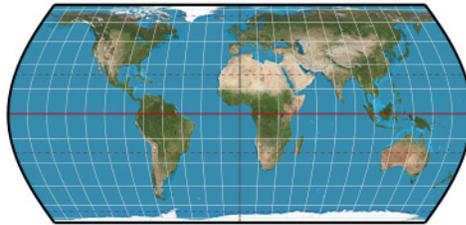
None.



Urmayev I

Urmayev II

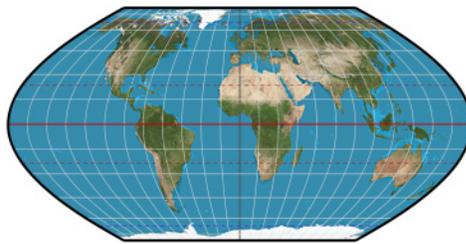
Native name	<i>цилиндрическая Урмаева II</i>
Description	Pseudocylindric.
Use	Historical
Parameters	Length of the pole-line $0.0 \leq \beta \leq 1.0$ Scale along the equator $0.0 << s << 1.0$
Range	$0 \leq \beta \leq 1$; $0 \leq s \leq 1$
Usual	None.



Urmayev II

Wagner I

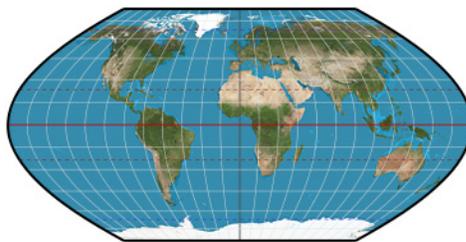
Description	Pseudocylindric. Equal-area.
Synonyms	<i>Kavraiskiy VI</i>
Use	Thematic world maps.



Wagner I

Wagner II

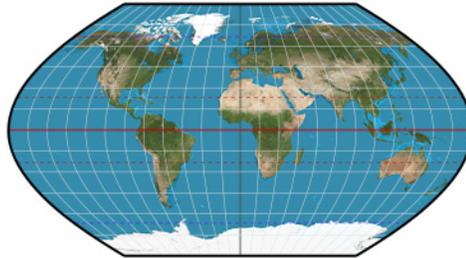
Description	Pseudocylindric.
Use	Academic.



Wagner II

Wagner III

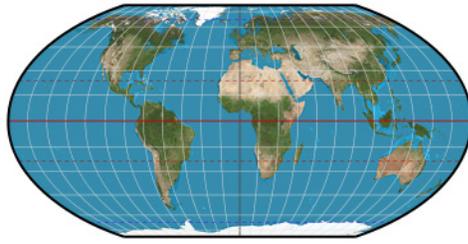
Description	Pseudocylindric.
Use	Academic.
Parameters	One parameter φ_1 , a parallel along which scale will be correct.
Range	$90^\circ\text{S} \ll \varphi_1 \ll 90^\circ\text{N}$



Wagner III

Wagner IV

Description	Pseudocylindric, equal-area.
Synonyms	<i>Putniņš P2'</i>
Similar projections	<i>Werenskiold III projection</i> (1944) is very similar, except that true scale is maintained along the equator by enlarging the map. <i>Putniņš P2 equal-area</i> projection (1934) uses the same portions of ellipses, but the poles are points. <i>Putniņš P1 and P1'</i> projections (1934) have meridians identical in shape and position to those of <i>Putniņš P2</i> and <i>P2'</i> respectively, but parallels are equally-spaced, and the projections are not equal-area. <i>Robinson</i> projection is not equal-area, meridians are not elliptical and parallels are spaced differently.
Graticule	Meridians: Central meridian is a straight line half as long as the equator. Other meridians are equally-spaced portions of ellipses (less than semi-ellipses) that would intersect beyond the poles and are concave toward the central meridian. The meridians at $103^\circ55'$ east and west of the central meridian are circular arcs. Parallels: Unequally-spaced straight, parallel lines, widest separation near the equator. Perpendicular to the central meridian. Poles: Lines half as long as the equator. Symmetry: About the central meridian or the equator.
Scale	True along latitudes $42^\circ59'\text{N}$ and S. Constant along any given latitude, same for latitude of opposite sign.
Distortion	Distortion is not as extreme near outer meridians at high latitudes as it is on pointed polar pseudocylindric projections, but there is considerable distortion throughout polar regions. Free of distortion only at latitudes $42^\circ59'\text{N}$ and S at the central meridian.
Origin	Presented by Reinholds V. Putniņš of Lavia in 1934.
Use	Thematic world maps.

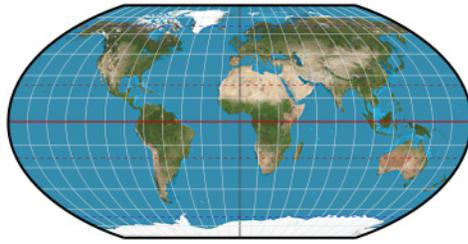


Wagner IV

Wagner V

Description
Use

Pseudocylindric.
Academic.

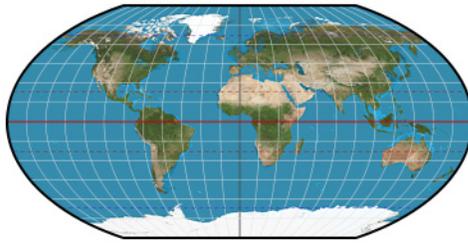


Wagner V

Wagner VI

Description
Use

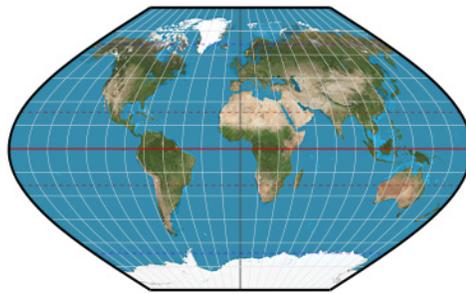
Pseudocylindric.
Academic.



Wagner VI

Winkel I

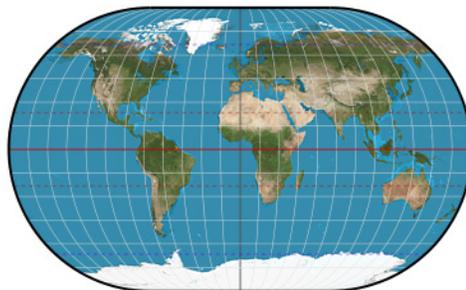
Description	Pseudocylindric. Equally-spaced parallels, neither conformal nor equal-area.
Limiting forms	<i>Eckert V</i> , if the equator is the standard parallel.
Parameters	One parameter φ_1 , a parallel along which scale will be correct.
Range	$90^\circ\text{S} \ll \varphi_1 \ll 90^\circ\text{N}$.
Graticule	Meridians: Central meridian is a straight line 0.61 (or other value) as long as the equator. Other meridians are equally-spaced sinusoidal curves, concave toward the central meridian. Parallels: Equally-spaced straight, parallel lines. Perpendicular to the central meridian. Poles: Line 0.61 (or other value) as long as the equator. Symmetry: About the central meridian or the equator.
Scale	True along latitudes $50^\circ28'\text{N}$ and S (or other chosen value). Constant along any given latitude, same for latitude of opposite sign.
Distortion	Not free of distortion at any point.
Origin	Developed by Oswald Winkel (1873-1953) of Germany in 1914 as the average of the <i>sinusoidal</i> and <i>equirectangular</i> projections in both x and y coordinates. When the standard parallels of the Equirectangular projection are varied, the standard parallels and appearance of <i>Winkel I</i> vary. Use of latitudes $50^\circ28'\text{N}$ and S results in a map at the correct total-area scale, but the local-area scale varies.



Winkel I

Winkel II

Description	Pseudocylindric.
Use	Academic.
Parameters	One parameter φ_1 , a parallel along which scale will be correct.
Range	$90^\circ\text{S} \ll \varphi_1 \ll 90^\circ\text{N}$.
Usual	None.



Winkel II



Conic projections

Albers—See [Albers equal-area conic](#)

Albers equal-area conic [*Albers*]

Description	Conic, equal-area.
Similar projections	Various methods of determining optimum standard parallels have been proposed by N.A. Tissot in 1881, V.V. Vitkovskiy (projection 11) in 1907, N. Y.A. Tsinger in 1916, and F.N. Krasovskiy (projection 1) in 1922. Once the standard parallels are selected, all these projections are constructed by using the same formulas used for the <i>Albers equal-area conic</i> with two standard parallels.
Limiting forms	<p><i>Polar Lambert azimuthal equal-area</i> projection, if a pole is made the single standard parallel. The cone of projection thereby becomes a plane.</p> <p><i>Lambert equal-area conic</i> projection if the pole and another parallel are made the two standard parallels.</p> <p><i>Lambert cylindric equal-area</i> projection if the equator is the single standard parallel. The cone of projection thereby becomes a cylinder.</p> <p><i>Behrmann</i> or other cylindric equal-area projections if the two standard parallels are symmetrically placed north and south of the equator.</p> <p>Standard conic formulas must be rewritten for the third and fourth limiting forms.</p>
Parameters	<p>Latitude of origin φ_0, the latitude whose intersection with the central meridian forms the origin of the projection. Has no effect except on cartesian coordinates in the Info palette.</p> <p>Two standard parallels φ_1 and φ_2 along which scale will be correct. Although the attributes of the map are determined by both parallels, in general the higher of the two latitudes controls the length of the pole-line: the higher it is the shorter the pole line.</p> <p>The lower of the two controls the angle that the final map will have from the pole to the west and east boundaries: the lower it is the more squarish the map.</p>
Range	$90^\circ\text{S} \leq \varphi_1, \varphi_2 \leq 90^\circ\text{N}$.
Aspects	Rarely used in oblique aspect, but occasionally proposed in journal articles.
Usual	None. When $\varphi_1 = \pm 90^\circ$ and $\varphi_2 \neq \pm 90^\circ$, the projection is <i>Lambert equal-area conic</i> . When $\varphi_1 = \varphi_2 = \pm 90^\circ$, the projection is <i>Lambert azimuthal equal-area</i> . When φ_1 approaches $-\varphi_2$ the projection approaches <i>cylindric equal-area</i> .
Graticule	<p>Meridians: Equally-spaced straight lines converging at a common point, which is normally beyond the pole. The angles between them are less than the true angles.</p> <p>Parallels: Unequally-spaced concentric circular arcs centered on the point of convergence of the meridians. The meridians are therefore radii of the circular arcs. Spacing of parallels decreases away from the central latitudes.</p> <p>Poles: Normally circular arcs enclosing the same angle as that enclosed by other parallels of latitude for a given range of longitude.</p> <p>Symmetry: About any meridian.</p>

Scale

True along one or two chosen standard parallels, usually, but not necessarily, on the same side of the equator. As a rule of thumb, these parallels can be placed at one-sixth and five-sixths of the range of latitudes, but there are more refined means of selection. Scale is constant along any given parallel. The scale factor at any given point along the meridian is the reciprocal of that along the parallel, to preserve area.

Distortion

Free of angular and scale distortion only along one or two standard parallels. Distortion is constant along any given parallel.

Origin

Presented by Heinrich Christian Albers (1773-1833) of Germany in 1805.

Use

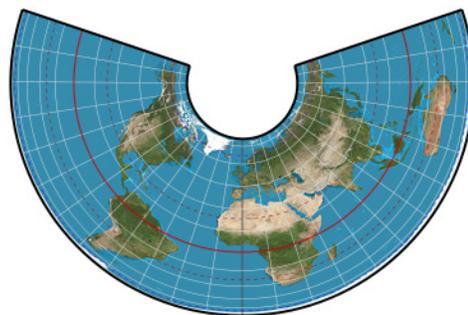
Frequently used in the ellipsoidal form for maps of the United States in the National Atlas of the United States, for thematic maps and for world atlases.

Also used and recommended for equal-area maps of regions that are predominantly east-west in extent.

Low distortion of regions between two concentric small circles.

For simple maps, use the *Boundaries* command to select the region of interest. Then use the *Parameters* command to set φ_1 and φ_2 so that they are about $\frac{1}{6}$ th the distance from the northern-most and southern-most parallels of interest.

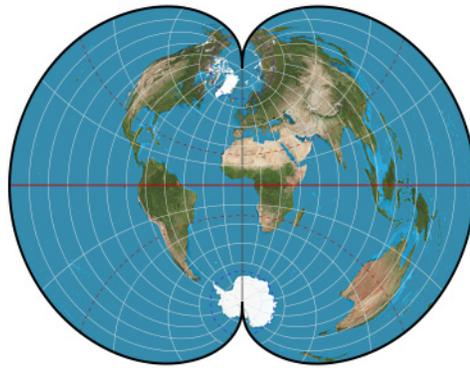
In oblique maps, the projection should be centered 90° away from the center of the small circles with the central meridian at the longitude of the center of the small circle for ease of computation. The two standard parallels should be about $\frac{1}{6}$ th the distance from the north and south small circles. For example, a map of Australia can be made by selecting 58°S , 122°E as the center of two standard parallels that meet the 122°E meridian at 30°S and 16°S . The projection should be centered on $58^\circ\text{S} + 90^\circ = 32^\circ\text{N}$, 122°E . Since 58°S is being used as the south pole, α_1 would be at $90^\circ\text{S} - (58^\circ\text{S} - 30^\circ\text{S}) = 62^\circ\text{S}$, and α_2 would be at $90^\circ\text{S} - (58^\circ\text{S} - 16^\circ\text{S}) = 48^\circ\text{S}$. Also see *Lambert conformal conic* notes.



Albers equal-area conic

American polyconic

Description	Polyconic, neither conformal nor equal-area.
Synonyms	<i>polyconic</i>
Similar projections	<p><i>Rectangular polyconic</i> projection has identical parallels of latitude, but meridians are plotted to intersect parallels at right angles.</p> <p>The <i>modified polyconic</i> projection for the International Map of the World series has two meridians that are true to scale.</p> <p>An <i>equidistant polyconic</i> projection was used by the US Coast and Geodetic Survey for coastal charts in the 19th century. Its construction is unclear, but it was apparently different from other polyconics.</p> <p><i>Equal-area polyconic</i> projections were presented by Hans Maurer in 1935 in Germany and by Albert H. Bumstead of the National Geographic Society in 1937.</p> <p>Other modified polyconics have been presented by G.T. McCaw in England in 1921, by G.A. Ginzburg and T.D. Salmanova in the Soviet Union in 1949 and 1951, and by G.E. Bousfield in Canada in 1950.</p>
Parameters	<p>Polyconic is a term sometimes applied to all projections having circular arcs for parallels of latitude, including regular conics and the <i>stereographic</i>, but this usage is not common.</p> <p>Latitude of origin φ_0, the latitude whose intersection with the central meridian forms the origin of the projection. Has no effect except on cartesian coordinates in the Info palette.</p>
Aspects	<p>Transverse aspect was proposed by Charles H. Deetz of the US Coast and Geodetic Survey in the early 20th century.</p> <p>The National Geographic Society has used the transverse aspect for maps of Eurasia and the Soviet Union.</p>
Graticule	<p>Meridians: Central meridian is a straight line. All other meridians are complex curves, spaced equally along the equator and along each parallel and concave toward the central meridian.</p> <p>Parallels: equator is a straight line, poles are points, and all other parallels are non-concentric circular arcs spaced at true distances along the central meridian. Each parallel has a curvature identical to its curvature on a cone tangent at that latitude. Many cones are involved, hence the name <i>polyconic</i>.</p>
Scale	True along the central meridian and along each parallel.
Distortion	Free of distortion only along the central meridian. Extensive distortion if the range extends very far east or west.
Origin	Apparently originated in about 1820 by Ferdinand Rudolph Hassler (1770-1843), first director of the Survey of the Coast (later the US Coast and Geodetic Survey).
Use	<p>The sole projection used for large-scale mapping in the ellipsoid form (topographic quadrangles) of the United States by the US Geological Survey until the 1950s.</p> <p>Basis for Progressive Military Grid used by the US Army until the 1940s.</p> <p>Projection for many early coast charts by the US Coast and Geodetic Survey.</p> <p>Not recommended for regional maps, because there are better projections.</p> <p>Can be used for local maps requiring edge-matching in the north-south direction (or along a great circle in oblique form), in which case the center meridian should be moved to the meridian at the middle of the area of interest, and the center parallel should be left at 0°.</p> <p>Also can be used for model globes when projecting in interrupted form.</p>



American polyconic

amulet

Description

Equal-area.

Created by joining the *Albers equal-area conic* and *Bonne* projections along the parallel of correct scale.

Use

Decorative maps.

Parameters

One standard parallel α_1 along which scale is correct.

Range

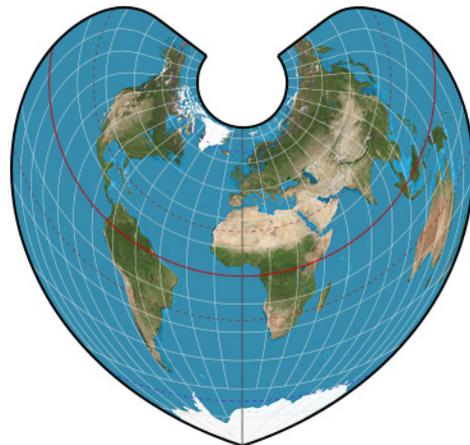
$90^\circ\text{S} \leq \varphi_1 \leq 90^\circ\text{N}$.

Usual

About $40^\circ \leq \varphi_1 \leq 60^\circ$. When $\varphi_1 = 90^\circ\text{N}$ the projection is *Werner*. When $\varphi_1 = 90^\circ\text{S}$, the projection is *Lambert azimuthal equal-area*, centered on the south pole. When φ_1 approaches 0° , the northern hemisphere approaches *Lambert cylindrical equal-area*, and the southern hemisphere approaches *sinusoidal*.

Origin

Developed by Daniel “daan” Strebe in 1991.



amulet

bipolar oblique conformal—See [bipolar oblique conic conformal](#)

bipolar oblique conic conformal [*bipolar oblique conformal*]

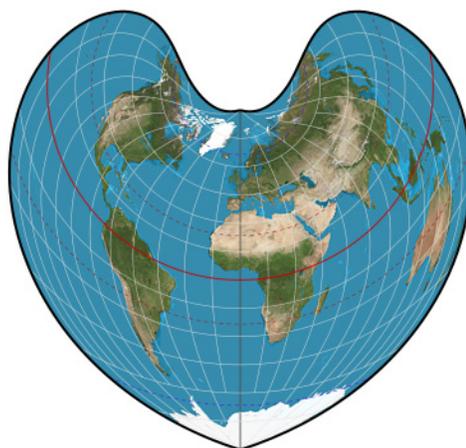
Description	Conic, conformal.
Graticule	Meridians: Unequally-spaced curved lines, except for two straight meridians from the transformed poles to the nearest geographic pole. Parallels: Unequally-spaced curved lines. Poles: Points. Symmetry: None.
Scale	True along four circular arcs joined to form two S curves. These arcs do not follow any parallel or meridian. Scale is constant along circular arcs centered on each transformed pole for part of the map. The pole for most of North America is in the North Atlantic, and that for South America is in the South Pacific.
Distortion	Low throughout North and South America. None along the lines of true scale and constant along circular arcs centered on the transformed pole for the given part of the map. Slight non-conformality near the line joining the two transformed poles.
Origin	Presented by Osborn Maitland Miller (1897-1979) and William A. Briesemeister of the American Geographical Society in 1941.
Use	Designed specifically for a low-error map of North and South America, constructed by the American Geographical Society. Other organizations, including the US Geological Survey, have used the American Geographical Society map as a base for maps of North and South America alone, but since the advent of computer plotting, other projections are preferable and practical for regional maps.



bipolar oblique conic conformal

Bonne

Description	Pseudoconic, equal-area.
Limiting forms	<i>Werner</i> projection if a pole is made the standard parallel. <i>Sinusoidal</i> projection if the equator is made the standard parallel. The pseudoconic projection thereby becomes a pseudocylindric projection, but the Bonne formulas must be rewritten.
Similar projections	John Bartholomew combined the <i>Bonne</i> projection with the <i>equidistant conic</i> projection with two standard parallels. In his 1942 <i>kite</i> and 1958 <i>regional</i> projections, the <i>equidistant conic</i> is used in the north temperate zone, and the <i>Bonne</i> is used south of the Tropic of Cancer in interrupted form. The more northern regions are based on the <i>Bonne (kite)</i> and <i>conic (regional)</i> projections. These two projections emphasize land masses, and Bartholomew's 1958 <i>lotus</i> projection emphasizes the oceans by using a southern version of the <i>regional</i> projection.
Parameters	One standard parallel φ_1 along which scale is correct.
Range	$90^\circ\text{S} \leq \varphi_1 \leq 90^\circ\text{N}$.
Usual	About $40^\circ \leq \varphi_1 \leq 60^\circ$. When $\varphi_1 = 90^\circ\text{N}$ or 90°S the projection is <i>Werner</i> . When φ_1 approaches 0° the projection approaches <i>sinusoidal</i> .
Graticule	Meridians: Central meridian is a straight line. Other meridians are complex curves connecting points equally-spaced along each parallel of latitude and concave toward the central meridian. Parallels: Concentric circular arcs spaced at true distances along the central meridian. The curvature of the central or standard parallel is identical to its curvature on a cone tangent at that latitude. Poles: Points. Symmetry: About the central meridian.
Scale	True along the central meridian and along each parallel. Free of all distortion along the central meridian and the central parallel.
Origin	Developed in rudimentary form by Claudius Ptolemy (about AD 100). Further developed by Barnardus Sylvanus in 1511. Used considerably by Rigobert Bonne (1727-1795) of France, especially in 1752; the name is taken from him.
Use	Frequently used until recently for atlas maps of continents. Used in the ellipsoidal form for topographic mapping of France in the early 19 th century.

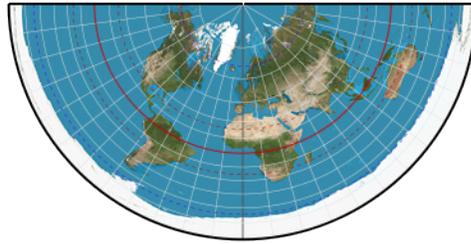


Bonne

Boole—See [ellipsoidal Lambert conformal conic](#)

Braun stereographic conic

Description	Conic projection in a semicircle. Neither equal-area nor conformal.
Origin	Presented by Carl Braun (1831–1907) in 1867.

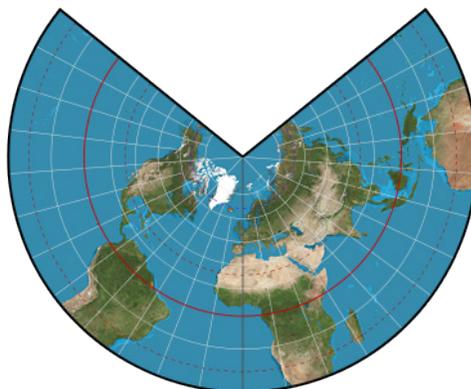


Braun stereographic conic

conical orthomorphic—See [Lambert conformal conic](#)

ellipsoidal Lambert conformal conic

Description	Ellipsoidal form of Lambert conformal conic .
Synonyms	<i>Gauss conformal conic</i> , <i>Gauß conformal conic</i> , <i>Boole</i>
Parameters	Latitude of origin φ_0 , the latitude whose intersection with the central meridian forms the origin of the projection. Has no effect except on cartesian coordinates in the Info palette. Two parameters φ_1 and φ_2 , which are parallels along which scale will be correct.
Range	$90^\circ\text{S} \ll \varphi_1, \varphi_2 < 90^\circ\text{N}$.
Usual	None. When φ_1 and φ_2 approach $\pm 90^\circ$, the projection approaches <i>stereographic</i> . When φ_1 approaches $-\varphi_2$ the projection approaches <i>Mercator</i> .
Use	See notes for Lambert conformal conic . Extensively used for large-scale mapping of regions of predominantly east-west extent, including topographic quadrangles (1:24,000 and 1: 62,000 scale) for many of the US State Plane Coordinate System zones, many maps in the International Map of the World (1: 1,000,000 scale) series, the US State Base maps (1: 500,000 scale) and topographic mapping in many other nations.



ellipsoidal Lambert conformal conic

equidistant—See [equidistant conic](#)

equidistant conic [*equidistant*]

Description	Conic, equally-spaced parallels, neither conformal nor equal-area.
Synonyms	<i>simple conic</i>
Similar projections	Various methods of determining optimum standard parallels have been proposed by Patrick Murdoch (projections <i>I, III</i>) in 1758, Leonhard Euler in 1777, British Ordnance in the late 19 th century, Dmitir I. Mendeleev in 1907, Wilhelm Schjerner (projection <i>I</i>) in 1882, V.V. Vitkovskiy (projection <i>I</i>) in 1907, and V.V. Kavrayskiy (projections <i>II, IV</i>) in 1934. Once the standard parallels are selected, all these projections are constructed by using formulas used for the <i>equidistant conic</i> with two standard parallels. John Bartholomew combined the <i>equidistant conic</i> with the <i>Bonne</i> projection.
Limiting forms	<i>Polar azimuthal equidistant</i> projection if a pole is made the single standard parallel. The cone of projection thereby becomes a plane. <i>Plate carrée</i> if the single standard parallel is the equator. The cone of projection thereby becomes a cylinder. <i>Equirectangular (cylindric)</i> projection if two standard parallels are symmetrically placed north and south of the equator.
Parameters	Standard conic formulas must be rewritten for the second and third limiting forms. Latitude of origin φ_0 , the latitude whose intersection with the central meridian forms the origin of the projection. Has no effect except on cartesian coordinates in the Info palette. Two standard parallels φ_1 and φ_2 along which scale is correct. Although the attributes of the map are determined by both parallels, in general the higher of the two latitudes controls the length of the pole-line: the higher it is the shorter the pole line. The lower of the two controls the angle that the final map will have from the pole to the west and east boundaries: the lower it is the more squarish the map.
Range	$90^\circ\text{S} \leq \varphi_1, \varphi_2 \leq 90^\circ\text{N}$.
Special properties	The scale along all meridians is correct in equatorial aspect.
Usual	None. When φ_1 approaches $-\varphi_2$ the projection approaches <i>equirectangular</i> . When φ_1 and φ_2 approach $\pm 90^\circ$ the projection approaches <i>azimuthal equidistant</i> .
Graticule	Meridians: Equally-spaced straight lines converging at a common point, which is normally beyond the pole. The angles between them are less than the true angles. Parallels: Equally-spaced concentric circular arcs centered on the point of convergence of the meridians, which are therefore radii of the circular arcs. Poles: Normally circular arcs enclosing the same angle as that enclosed by the other parallels of latitude for a given range of longitude. Symmetry: About any meridian.
Scale	True along each meridian and along one or two chosen standard parallels, usually but not necessarily on the same side of the equator. As a rule of thumb, these parallels can be placed at one-sixth and five-sixths of the range of the latitudes, but there are more refined means of selection. Scale is constant along any given parallel.
Distortion	Free of distortion only along the two standard parallels. Distortion is constant along any given parallel. Compromise in distortion between equal-area and conformal conic projections.

Origin

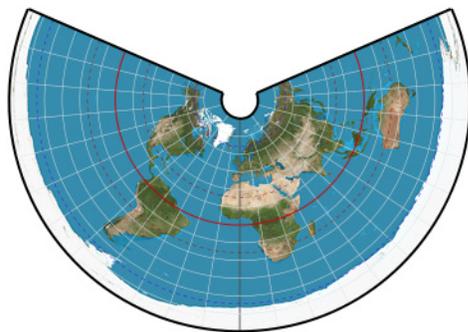
Rudimentary forms developed by Claudius Ptolemy (about AD 100).

Improvements by Johannes Ruysch in 1508, Gerardus Mercator in the late 16th century, and Nicolas de L'Isle in 1745.

Use

The most common projection in atlases for small countries. Also used by the Soviet Union for mapping that nation.

Low distortion maps along small circle routes with meridians of correct scale. Since the chief virtue is the constant scale along the meridians the projection normally is pointless with a center point away from the equator. See usage notes for *Albers equal-area conic*.



equidistant conic

Gauss conformal conic—See [ellipsoidal Lambert conformal conic](#)

Gauß conformal conic—See [ellipsoidal Lambert conformal conic](#)

globe gores

Description

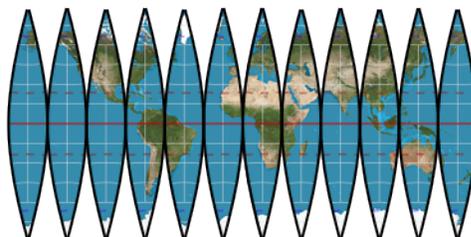
Optimized for construction of globe gores.

Similar projections

Rectangular polyconic with standard parallel of 0° is similar.

Parameters

Warpage k , such that $1 \leq k \leq 3$. This value must be determined empirically according to the paper medium. Set the gore count via **Projection > Interruptions > Gores**.

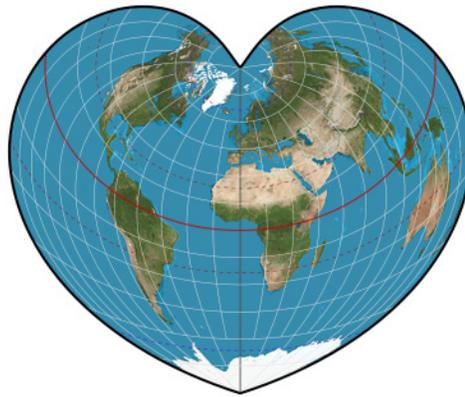


globe gores

Harding—See [Lambert conformal conic](#)

heart

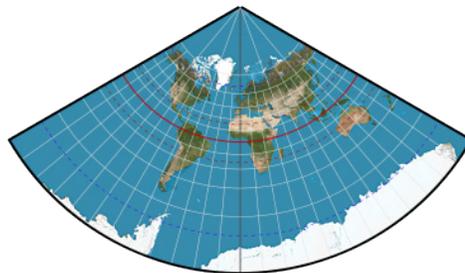
Description	Equal-area.
Use	Decorative maps.
Parameters	A standard parallel φ_1 which relates to the amount of poleward curvature, and a meridian duplication factor x which describes a countering bend toward the equator.
Range φ_1	$90^\circ\text{S} \leq \varphi_1 \leq 90^\circ\text{N}$.
Usual φ_1	About $55^\circ < \varphi_1 < 90^\circ$.
Range x	$0 \ll x < \infty$.
Usual x	$1.1 < x < 2.0$. When $x = 1.0$ the projection is <i>Bonne</i> .
Origin	Developed by Daniel “daan” Strebe in 1991.



heart

Herschel conformal conic

Description	Equivalent to <i>Lambert conformal conic</i> in spherical development with a cone constant of $\frac{1}{3}$, yielding a standard parallel of $19^\circ 28' 16''$.
Parameters	Latitude of origin φ_0 , the latitude whose intersection with the central meridian forms the origin of the projection. Has no effect except on cartesian coordinates in the Info palette.
Origin	Presented by John F.W. Herschel (1792–1871) in 1859.

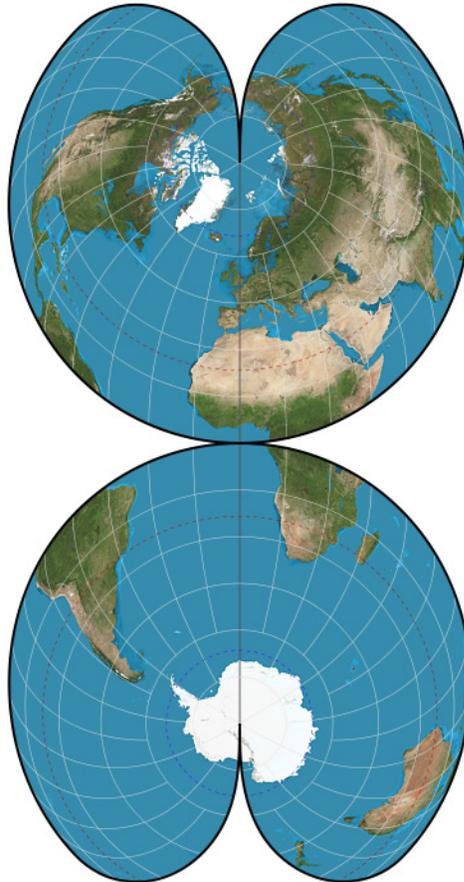


Herschel conformal conic

isoperimetric—See [isoperimetric cordiform](#)

isoperimetric cordiform [*isoperimetric*]

Description	Scale is correct along all parallels and along all meridians.
Similar projections	<i>Isoperimetric azimuthal</i> is another projection on which scale is correct along both parallels and meridians.
Origin	Presented by Leszek Pernarowski in conceptual form with approximate formulæ, 1970.



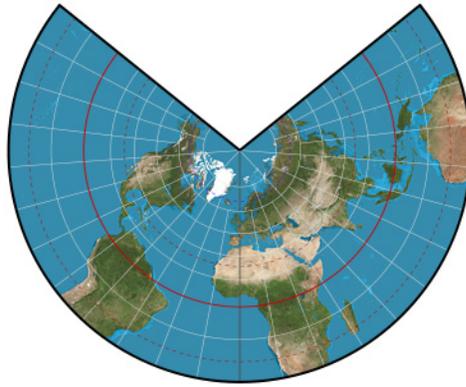
isoperimetric cordiform

Lambert conformal—See [Lambert conformal conic](#)

Lambert conformal conic [*Lambert conformal*]

Description	Conic, conformal. The projection's pole is always a point.
Synonyms	<i>conical orthomorphic</i> , <i>Harding</i> , <i>Gauss conformal conic</i> (ellipsoidal development), <i>Boole</i> (ellipsoidal development)
Similar projections	Various methods of determining optimum standard parallels have been proposed by John Herschel in 1860, V.V. Vitkovskiy (projection <i>III</i>) in 1907 N.Y.A. Tsinger in 1916, and V.V. Kavrayskiy (projection <i>III</i>) in 1934. Once the standard parallels are selected, all these projections are constructed by using the same formulas used for the <i>Lambert conformal conic</i> with two standard parallels. <i>Bipolar oblique conic conformal</i> projection consists of oblique aspects of two <i>Lambert conformal conic</i> projections laid end-to-end.

Limiting forms	<p><i>Polar stereographic</i> projection if a pole is the single standard parallel. The cone of projection thereby becomes a plane.</p> <p><i>Mercator</i> projection if the single standard parallel is the equator, or if two standard parallels are symmetrically placed north and south of the equator. The cone of projection thereby becomes a cylinder. Standard conic formulas must be rewritten.</p>
Aspects	<i>Bipolar oblique conic conformal</i> projection is the only common oblique aspect.
Limitations	Can only show one pole; should be used for no more than a hemisphere.
Parameters	<p>Latitude of origin φ_0, the latitude whose intersection with the central meridian forms the origin of the projection. Has no effect except on cartesian coordinates in the Info palette.</p> <p>Two parameters φ_1 and φ_2, which are parallels along which scale will be correct.</p>
Range	$90^\circ\text{S} \ll \varphi_1, \varphi_2 < 90^\circ\text{N}$.
Usual	None. When φ_1 and φ_2 approach $\pm 90^\circ$, the projection approaches <i>stereographic</i> . When φ_1 approaches $-\varphi_2$ the projection approaches <i>Mercator</i> .
Graticule	<p>Meridians: Equally-spaced straight lines converging at a common point, which is one of the poles. The angles between them are less than the true angles.</p> <p>Parallels: Unequally-spaced concentric circular arcs centered on the pole of convergence of the meridians, which are therefore radii of the circular arcs. Spacing of parallels increases away from the central latitudes.</p> <p>Poles: The pole nearest a standard parallel is a point, the other pole cannot be shown.</p> <p>Symmetry: About any meridian.</p>
Scale	True along one or two chosen standard parallels, usually, but not necessarily, on the same side of the equator. As a rule of thumb, these parallels can be placed at one-sixth and five-sixths of the range of the latitudes, but there are more refined means of selection. Scale is constant along any given parallel and is the same in all directions at any given point.
Distortion	Free of distortion only along the one or two standard parallels. Distortion is constant along any given parallel. Conformal everywhere except at the poles.
Origin	Presented by Johann Heinrich Lambert (1728-1777) of Alsace in 1772.
Use	<p>For low distortion of regions between two concentric small circles. See notes for <i>Albers equal-area conic</i>.</p> <p>Extensively used in ellipsoidal form for large-scale mapping of regions of predominantly east-west extent, including topographic quadrangles (1:24,000 and 1: 62,000 scale) for many of the US State Plane Coordinate System zones, many maps in the International Map of the World (1: 1,000,000 scale) series, the US State Base maps (1: 500,000 scale) and topographic mapping in many other nations.</p> <p>Also used for atlas maps of some countries.</p> <p>Recommended for conformal mapping of regions of predominantly east-west extent.</p> <p>If neither equivalence nor conformality are a concern, then either the <i>Lambert conformal conic</i> or the <i>Albers equal-area conic</i> can be used, because for small regions the difference is negligible.</p> <p>For large regions differences are visible but the choice depends on the scope of the map. In general very large regions should use <i>Lambert</i>, because the shape distortion of <i>Albers equal-area conic</i> is more obvious than the area distortion of <i>Lambert</i>.</p> <p>For a map of the continental U.S. or smaller, either will work well.</p>

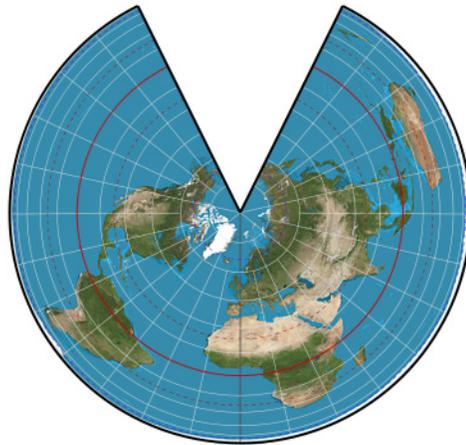


Lambert conformal conic

Lambert equal-area—See [Lambert equal-area conic](#)

Lambert equal-area conic [*Lambert equal-area*]

Description	Conic, equal-area.
Similar projections	<i>Albers equal-area conic</i> projection also has concentric circular arcs for parallels and straight meridians, but it has two standard parallels close to the latitudes of interest. If just one of its standard parallels is made a pole, it becomes the <i>Lambert equal-area conic</i> projection, but that pole is not free of distortion, as the usual standard parallel is.
Limiting forms	<i>Polar Lambert azimuthal equal-area</i> projection if the central pole is the standard parallel. The cone of projection thereby becomes a plane.
Parameters	One parameter φ_1 which is a parallel along which scale will be correct.
Range	$90^\circ\text{S} \ll \varphi_1 \ll 90^\circ\text{N}$.
Usual	None. When φ_1 approaches 90°N , the projection approaches <i>Lambert azimuthal equal-area</i> . See Albers equal-area conic .
Graticule	<p>Meridians: Equally-spaced straight lines converging at a common point, which is one of the poles. The angles between them are less than the true angles.</p> <p>Parallels: Unequally-spaced concentric circular arcs centered on the pole of convergence of the meridians. The meridians are therefore radii of the circular arcs. Spacing of parallels decreases away from the pole of convergence.</p> <p>Poles: One pole is a point, the other pole is a circular arc enclosing the same angle as that enclosed by the other parallels of latitude for a given range of longitudes.</p> <p>Symmetry: About any meridian.</p>
Scale	True along the chosen standard parallel. Scale is constant along any given parallel. The scale factor at any given point along the meridian is the reciprocal of that along the parallel, to preserve area.
Distortion	Free of scale and angular distortion only along the standard parallel. Severe stretching near each pole. Scale distortion and angular distortion are constant along any given parallel.
Origin	Presented by Johann Heinrich Lambert (1728-1777) of Alsace in 1772.
Use	Academic.
	Note: Albers Equal-Area Conic always produces a better map.



Lambert equal-area conic

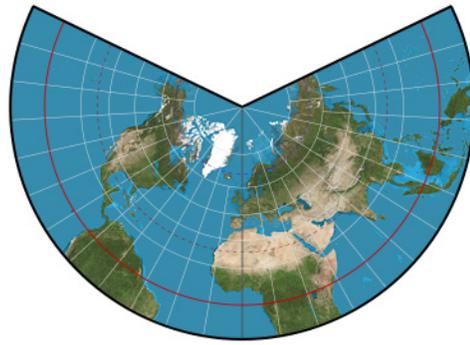
optimized Albers—See [Tissot equal-area conic](#)

périgonale equal-area conic—See [Tissot equal-area conic](#)

perspective—See [perspective conic](#)

perspective conic [*perspective*]

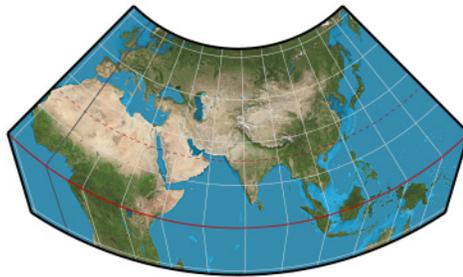
Description	Conic, perspective, neither conformal nor equal-area.
Similar projections	A stereographic perspective conic was presented by Carl Braun in 1867. The map is projected from the south pole onto a cone tangent at latitude 30°N.
Limiting forms	<p><i>Polar gnomonic</i> projection, if the pole is the single standard parallel. The cone of projection thereby becomes a plane.</p> <p><i>Central cylindric</i> projection if the equator is the single standard parallel. The cone of projection thereby becomes a cylinder.</p> <p>Standard conic formulas must be rewritten.</p>
Other features	The projection is produced geometrically by projecting the earth perspective from the center (or from some other point) onto a cone tangent or secant along the standard parallels.
Limitations	Can only show one pole.
Parameters	Latitude of origin φ_0 , the latitude whose intersection with the central meridian forms the origin of the projection. Has no effect except on cartesian coordinates in the Info palette.
Range	Two parameters φ_1 and φ_2 , which are parallels along which scale will be correct.
Usual	90°S << φ_1 , φ_2 < 90°N.
Graticule	None. When φ_1 and φ_2 approach $\pm 90^\circ$, the projection approaches <i>gnomonic</i> . When φ_1 approaches $-\varphi_2$ the projection approaches <i>central cylindric</i> .
Scale	Meridians: Equally-spaced straight lines converging at a common point, which is one of the poles. The angles between them are less than the true angles.
Distortion	Parallels: Unequally-spaced concentric circular arcs centered on the pole of convergence of the meridians. The meridians are therefore radii of the circular arcs. Spacing of parallels increases away from the central latitudes.
Use	Poles: One pole is a point, the other pole cannot generally be shown, but under some conditions, it is a circular arc.
	Symmetry: About any meridian.
	True along one to two chosen standard parallels, which may be on the same side, or both sides of the equator.
	Scale is constant along any given parallel.
	Free of distortion only along one or two standard parallels. Distortion is constant along any given parallel, but changes more rapidly in a north-south direction than it does on conformal or equal-area conics, and the <i>perspective conic</i> has no compensating advantage. Other projections should be used instead.
	Academic.



Perspective conic

polyconic—See [American polyconic](#)

Ptolemy I

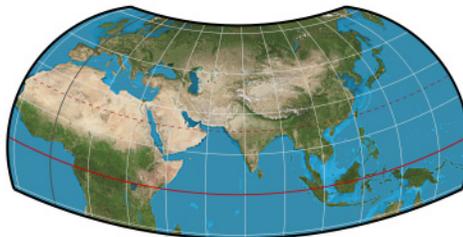


Ptolemy I

Ptolemy II

Synonyms

Ptolemy's homeotheric

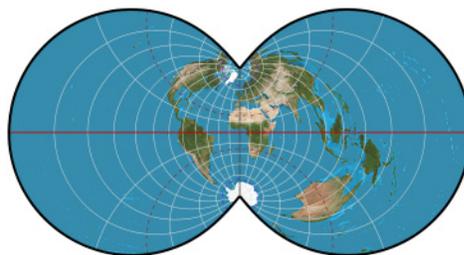


Ptolemy II

Ptolemy's homeotheric—See [Ptolemy II](#)

rectangular polyconic

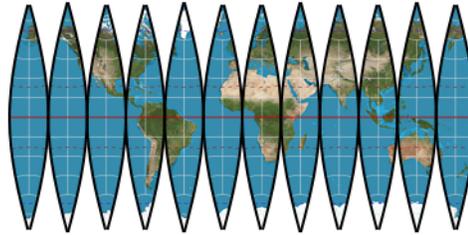
Description	Polyconic. Meridians meet parallels at right angles, but not conformal.
Synonyms	<i>War Office</i> (British)
Similar projections	<i>American polyconic</i> projection has identical parallels of latitude, but meridians do not intersect parallels at right angles except along central meridian. The <i>modified polyconic</i> projection for the International Map of the World series has two meridians that are true to scale. An <i>equidistant polyconic</i> projection was used by the US Coast and Geodetic Survey for coastal charts in the 19 th century. Its construction is unclear, but it was apparently different from other polyconics. <i>Equal-area polyconic</i> projections were presented by Hans Maurer in 1935 in Germany and by Albert H. Bumstead of the National Geographic Society in 1937. Other modified polyconics have been presented by G.T. McCaw in England in 1921, by G.A. Ginzburg and T.D. Salmanova in the Soviet Union in 1949 and 1951, and by G.E. Bousfield in Canada in 1950. <i>Polyconic</i> is a term sometimes applied to all projections having circular arcs for parallels of latitude, including regular conics and the <i>stereographic</i> , but this usage is not common.
Parameters	Latitude of origin φ_0 , the latitude whose intersection with the central meridian forms the origin of the projection. Has no effect except on cartesian coordinates in the Info palette. One standard parallel φ_1 along which scale is correct.
Range	90°S << φ_1 << 90°N.
Usual	None. When φ_1 approaches $\pm 90^\circ$ the projection approaches two hemispheric circles, but balloons in size.
Graticule	Meridians: Central meridian is a straight line. All other meridians are complex curves, equally-spaced along the equator or along two chosen parallels symmetrical about the equator. Meridians intersect all parallels at right angles. Parallels: equator is a straight line, poles are points, and all other parallels are non-concentric circular arcs spaced at true distances along the central meridian. Each parallel has a curvature identical to its curvature on a cone tangent at that latitude. Many cones are involved, hence the name Polyconic projection.
Scale	True along the central meridian and along the equator, or two chosen parallels of true scale.
Distortion	Free of distortion only along the central meridian. Although meridians intersect parallels at right angles, there is some angular distortion at all points other than along the central meridian.
Use	Model globes and large-scale military mapping in Great Britain. See notes for <i>American polyconic</i> .



rectangular polyconic

rectangular polyconic gores

Parameters Gore count



rectangular polyconic gores

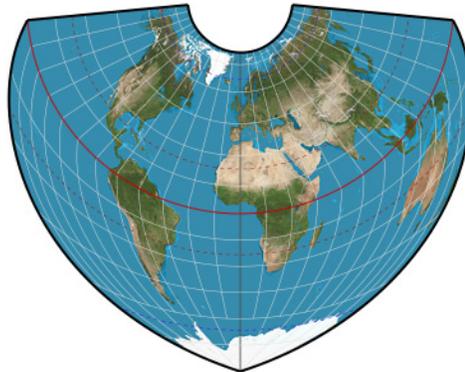
shield

Description Equal-area.
Created by joining *Albers equal-area conic* and *Bonne* projections along the equator.

Use Decorative maps.

Parameters Standard parallel.

Origin Developed by Daniel “daan” Strebe in 1991.



shield

Stab-Werner—See [Werner](#)

Tissot equal-area conic [*Tissot*]

Description A formulation yielding the optimal *Albers* for given northern and southern limits.

Other names *périgonale equal-area conic*, *optimized Albers*

Similar projections See notes for [Albers equal-area conic](#).

Parameters Two parallels θ_1 and θ_2 giving the northern and southern limits of the portion of the map to be optimized.

Range $90^\circ\text{S} \leq \theta_1, \theta_2 \leq 90^\circ\text{N}$.

Graticule

Meridians: Equally-spaced straight lines converging at a common point, which is normally beyond the pole. The angles between them are less than the true angles.

Parallels: Unequally-spaced concentric circular arcs centered on the point of convergence of the meridians. The meridians are therefore radii of the circular arcs. Spacing of parallels decreases away from the central latitudes.

Poles: Normally circular arcs enclosing the same angle as that enclosed by other parallels of latitude for a given range of longitude.

Symmetry: About any meridian.

Scale

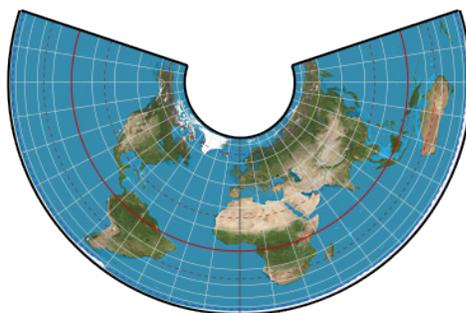
True along one or two chosen standard parallels, usually, but not necessarily, on the same side of the equator. Scale is constant along any given parallel. The scale factor at any given point along the meridian is the reciprocal of that along the parallel, to preserve area.

Distortion

This is the optimal *Albers* for a chosen northern and southern latitude limit. Free of angular and scale distortion only along one or two standard parallels. Distortion is constant along any given parallel.

Origin

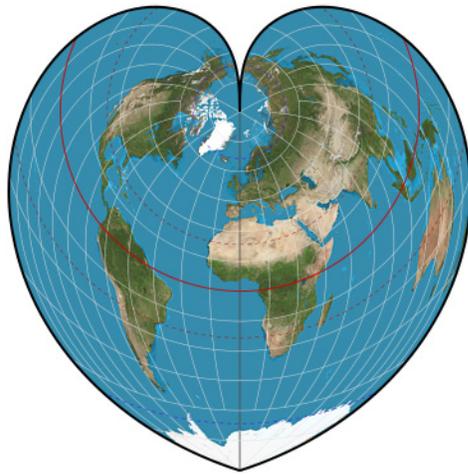
Presented by Nicolas Auguste Tissot (1824–1897) of France in 1881.



Tissot equal-area conic

Werner

Description	Pseudoconic, equal-area, cordiform (heart-shaped). Bonne with φ_1 of 90° .
Synonyms	<i>Werner</i>
Similar projections	<p><i>Bonne</i> projection is a general form on which the parallels are also circular arcs, but are not generally centered on a pole. The <i>Werner</i> is the polar limiting form.</p> <p>In 1904, Wilhelm Schjerner interrupted the <i>Werner</i> projection, centered on the south pole, with three central meridians and three ‘petals’ for a world map emphasizing the oceans.</p> <p><i>Goode polar equal-area</i> projection, presented by John Paul Goode in 1928, is an interrupted <i>Werner</i> projection, centered on the north pole and using several central meridians to display continents in a flower-like pattern.</p> <p><i>Tetrahedral</i> projection, presented by John Bartholomew in 1944, is a combination of the <i>Polar azimuthal equidistant</i> projection from the pole to the tropic line of the same hemisphere and an interrupted <i>Werner</i> from there to the opposite pole, some adjustment being made to obtain a fit. The north pole is the center for a map of land masses, and the south pole is the center for an ocean map.</p> <p>In 1968, W. William-Olsson of Sweden combined the northern <i>Polar Lambert azimuthal equal-area</i> projection, extending to latitude 20°N with four identical lobes extending to the south pole. The lobes are based on the <i>Werner</i> projection, but are compressed north-south and expanded east-west to fit the <i>Lambert</i> and to retain equality of area.</p>
Graticule	<p>Meridians: Central meridian is a straight line. Other meridians are complex curves connecting points equally-spaced along each parallel of latitude and concave toward the central meridian.</p> <p>Parallels: Concentric circular arcs spaced at true distances along the central meridian. One pole (usually the north pole) is the center for these circular arcs.</p> <p>Poles: Points.</p> <p>Symmetry: About the central meridian.</p>
Scale	True along the central meridian and along each parallel.
Distortion	Free of all distortion only along the central meridian.
Origin	Developed by Johann Stabius (Stab) (?-1522) of Vienna in about 1500, and promoted by Johannes Werner (1466-1528) of Nuremberg in 1514.
Use	<p>Frequently used for world maps and some continental maps of the 16th and 17th centuries. Replaced by the <i>Bonne</i> projection for continental maps.</p> <p>No longer used except as a novelty.</p>



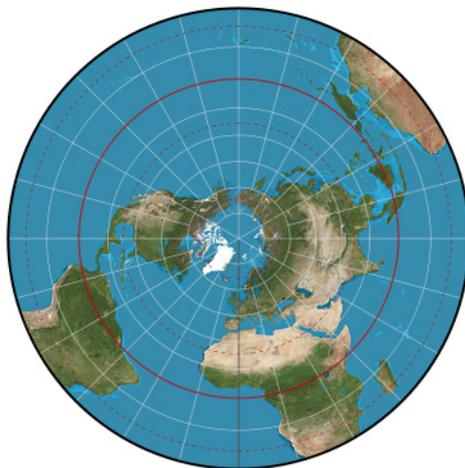
Werner

Azimuthal projections

Airy

Description	Azimuthal, minimum-error, non-perspective, neither conformal nor equal-area.
Similar projections	<p>Clarke and James minimum-error perspective azimuthal projections were inspired by Airy's work.</p> <p>The <i>azimuthal equidistant</i> projection closely resembles the <i>Airy</i>, but scale is constant along radii from the center.</p> <p>In 1892, A. Breusing proposed the low-error geometric mean of the <i>stereographic</i> and <i>Lambert azimuthal equal-area</i> projections.</p> <p>In 1920, A.E. Young of England modified the <i>Breusing</i> (geometric mean) projection to provide a balance between the <i>stereographic</i> and <i>azimuthal equidistant</i> projections, called the <i>Breusing harmonic</i> projection.</p> <p>In 1950, N.A. Urmayev of the Soviet Union proposed two other low-error azimuthal projections.</p>
Limitations	Should not be used for more than about $\frac{2}{3}$ of the globe.
Parameters	One parameter β which describes the small circle within which scale error is to be minimized.
Range	$-180^\circ << \beta << 180^\circ; \beta \neq 0$.
Graticule	<p>Polar aspect</p> <p>Meridians: Equally-spaced straight lines intersecting at the central pole. Angles between them are the true angles.</p> <p>Parallels: Nearly, but not quite, equally-spaced circles, centered at the pole, which is a point. Spacing increases slightly away from the center.</p> <p>Symmetry: About any meridian.</p> <p>Equatorial aspect</p> <p>Meridians: Central meridian is a straight line. Meridians 90° away are circles. Other meridians are complex curves, unequally-spaced along the equator and intersecting at each pole. Spacing increases slightly away from the central meridian.</p> <p>Parallels: equator is a straight line. Other parallels are complex curves concave toward the nearest pole. They are unequally-spaced along the central meridian, and spacing increases slightly away from the equator. At the meridian 90° from the central meridian, parallels are equally-spaced.</p> <p>Symmetry: About the central meridian or the equator.</p> <p>Oblique aspect</p> <p>Meridians: Central meridian is a straight line. Other meridians are complex curves intersecting at each pole.</p> <p>Parallels: Complex curves unequally-spaced along the central meridian, spacing increases slightly away from the center of projection.</p> <p>Symmetry: About the central meridian.</p>

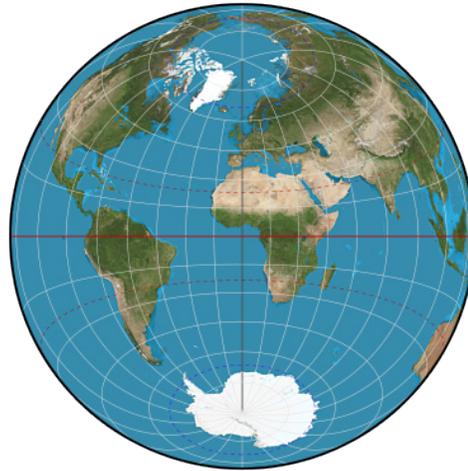
Scale	Scale increases gradually in all directions with distance from the center, but there is no point at which the scale is correct in all directions.
Distortion	Distortion is moderate throughout the range chosen. No point is completely free of distortion, although the center is free of shape distortion.
Origin	Presented by George Biddell Airy (1801-92), British astronomer and geodesist, in 1861.
Use	Medium-scale Ordnance Survey map of the United Kingdom. Low-distortion maps of circular regions of hemisphere or less size, such as the Pacific Basin. Center the projection in the area of interest and set the β parameter to the size in degrees of the small circle, centered in the same place, that circumscribes the area of interest.



Airy

AMS lunar

Description	Azimuthal, perspective, neither conformal nor equal-area (except in <i>stereographic</i> form).
Graticule	See far-side perspective .
Scale	True at the center. Scale varies away from the center.
Distortion	Only the center is free of distortion. Distortion is severe near the outer limit of the projection, but moderate within a wide range of the center.
Use	The Army Map Service <i>AMS lunar</i> projection is a <i>far-side perspective</i> formulated by Albert L. Nowicki in 1963 to show slightly more than a hemisphere of the moon, as seen over a period of time from Earth. The point of projection is 1.53748 times the radius from the center.



AMS lunar

apple—See [quasiazimuthal equal-area apple](#)

azimuthal equidistant [*equidistant*]

Description	Azimuthal, equidistant, non-perspective.
Synonyms	<i>Postel</i> (in France and Russia, for Guillaume Postel, who was considered an originator, although he first used it in 1581). <i>zenithal equidistant</i>
Similar projections	<i>Two-point azimuthal</i> shows correct azimuths (but not distances) from either of two points to any other point. <i>Two-point equidistant</i> shows correct distances (but not azimuths) from either of two points to any other point. <i>Chamberlin trimetric</i> shows approximately true distances from three chosen points to any other points (cannot be exact). The three points are placed near the edges of the region being mapped to reduce overall distortion. <i>Airy</i> and <i>Breusing azimuthal</i> projections have spacings similar to those of the <i>azimuthal equidistant</i> if the extent is less than one hemisphere. <i>Berghaus star</i> projection uses the <i>polar azimuthal equidistant</i> projection for the northern hemisphere. <i>Tetrahedral</i> projection combines the <i>polar azimuthal equidistant</i> projection with an interrupted <i>Werner</i> projection.
Special properties	The distance between any two points on a straight line passing through the center of projection is shown at true scale. This feature is especially useful if one point is the center. Compromise in distortion between <i>stereographic</i> (conformal) and <i>Lambert azimuthal equal-area</i> projections.

Graticule**Polar aspect**

Meridians: Equally-spaced straight lines intersecting at the central pole. Angles between them are the true angles.

Parallels: Equally-spaced circles, centered at the pole, which is a point. The entire Earth can be shown, but the opposite pole is a bounding circle having a radius twice that of the equator.

Symmetry: About any meridian.

Equatorial aspect

Meridians: Central meridian is a straight line. Meridian 90° away is a circle. Other meridians are complex curves, equally-spaced along the equator and intersecting at each pole.

Parallels: equator is a straight line. Other parallels are complex curves concave toward the nearest pole and equally-spaced along the central meridian and the meridian 90° from the central meridian.

Symmetry: About the central meridian or the equator.

Oblique aspect

Meridians: Central meridian is a straight line. Other meridians are complex curves intersecting at each pole.

Parallels: Complex curves equally-spaced along the central meridian.

Symmetry: About the central meridian.

Scale

True along any straight line radiating from the center of projection. Increases in a direction perpendicular to the radius as the distance from the center increases.

Distortion

Only the center is free from distortion. Distortion is moderate for one hemisphere, but becomes extreme for a map of the entire Earth.

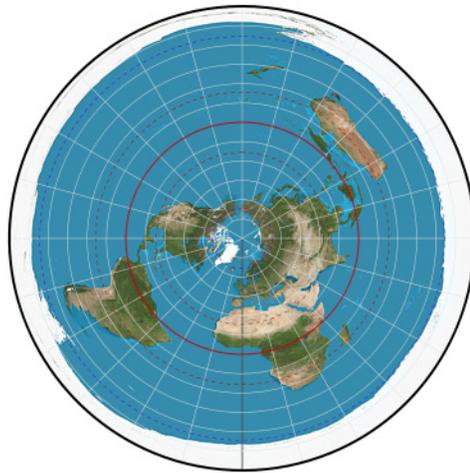
Origin

Possibly developed in the polar aspect by Egyptians for star charts. Used in China by the 11th century for star charts. Several users during the 16th century.

Use

Distance maps. Center the projection on the location from which distances are to be measured.

Commonly used in the polar aspect for maps of polar regions, the northern and southern hemispheres, and the 'aviation-age' Earth. The oblique aspect is frequently used for world maps centered on important cities, and occasionally for maps of continents. The ellipsoidal form is used for topographic mapping of Micronesia and Guam.



azimuthal equidistant

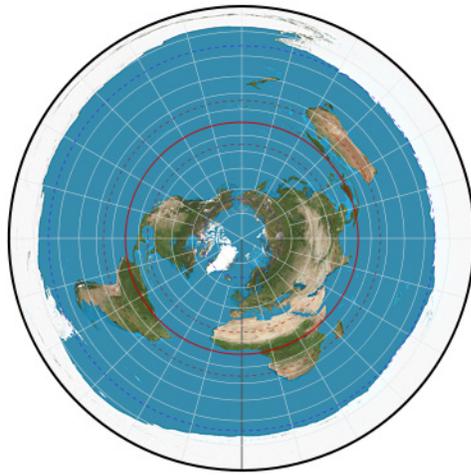
azimuthal extruded globe [*extruded globe*]

Parameters

- Radius of 85° parallel (any scale, any units)
- Radius of 80° parallel (same scale & units as 85°)
- Radius of 75° parallel (same scale & units as 85°)
- Radius of 70° parallel (same scale & units as 85°)
- Radius of 65° parallel (same scale & units as 85°)
- Radius of 60° parallel (same scale & units as 85°)
- Radius of 55° parallel (same scale & units as 85°)
- Radius of 50° parallel (same scale & units as 85°)
- Radius of 45° parallel (same scale & units as 85°)
- Radius of 40° parallel (same scale & units as 85°)
- Radius of 35° parallel (same scale & units as 85°)
- Radius of 30° parallel (same scale & units as 85°)
- Radius of 25° parallel (same scale & units as 85°)
- Radius of 20° parallel (same scale & units as 85°)
- Radius of 15° parallel (same scale & units as 85°)
- Radius of 10° parallel (same scale & units as 85°)
- Radius of 5° parallel (same scale & units as 85°)
- Radius of equator (same scale & units as 85°)

Use

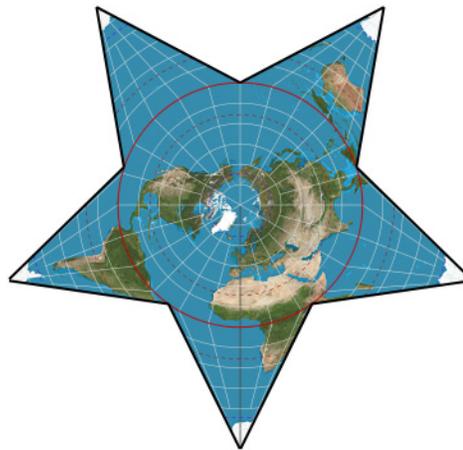
For printing on flat plastic for extruding into a globe. This projection provides the inverse of the deformation caused by extruding, cancelling it out on the finished hemisphere. Set it up by measuring how the extrusion process deforms the plastic.



azimuthal extruded globe

Berghaus star

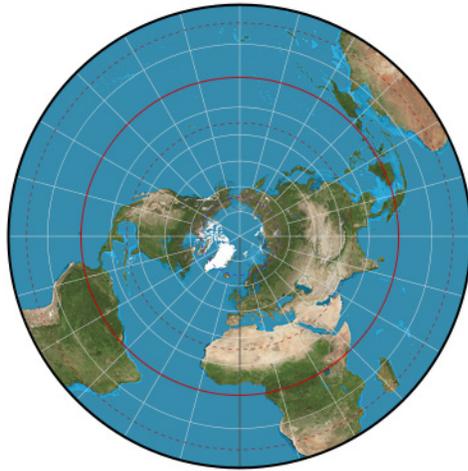
Description	Equidistant, composite, modified azimuthal, interrupted. 5-point case of <i>regular star</i> .
Similar projections	<i>Peterman star</i> (Germany, 1865) has eight unequal points, parallels are concentric circular arcs. <i>Jager star</i> (Austria, 1865) has eight unequal points, parallels are in straight segments. <i>Azimuthal equidistant</i> is the projection for the northern hemisphere for the <i>Berghaus star</i> .
Other features	The northern hemisphere is a <i>polar azimuthal equidistant</i> projection. The southern hemisphere is divided into five equal triangular lobes.
Aspects	Polar only.
Graticule	Meridians: Straight lines, broken at the equator. Parallels: Concentric circular arcs, north pole at the center. Poles: Points. Symmetry: Radial about the north pole.
Scale	Correct along meridians in the northern hemisphere and along the central meridians of triangular points in the southern hemisphere.
Distortion	Moderate throughout.
Origin	Presented by Heinrich Berghaus (1797-1884) of Germany in 1879.
Use	Largely for artistic map forms. Landforms do not readily fit into the lobes or arms of the star pattern. Used for the logo of the Association of American Geographers.



Berghaus star

Breusing geometric

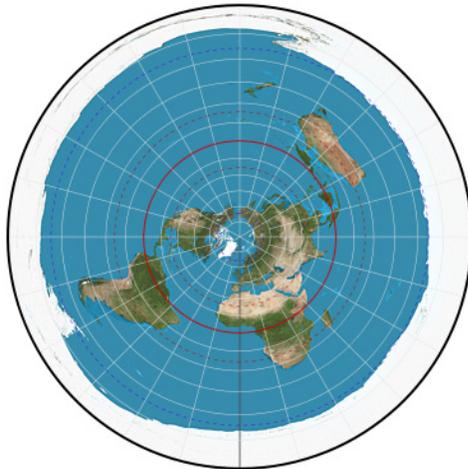
Description	Geometric mean of <i>Lambert azimuthal equal-area</i> and <i>stereographic</i> .
Use	Historical.
Limitations	Should not be used for more than about two-thirds of the globe.



Breusing geometric

Breusing harmonic

Use	Academic.
Parameters	One parameter β which describes the small circle within which scale error is to be minimized.
Range	$-180^\circ \ll \beta \ll 180^\circ; \beta \leq 0$.
Usual	None.



Breusing harmonic

Canters EU

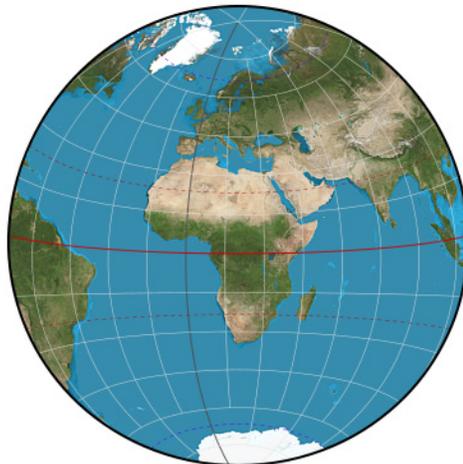
Description	Equal-area projection optimized for the European Union.
Use	Equal-area maps of the European Union.
Parameters	Enumeration describing the polynomial order.
Range	First order, second order, third order, fifth order.
Usual	Fifth order gives lowest distortion specific to the EU.



Canters EU

Chamberlin trimetric

Description	Modified azimuthal, modified equidistant, neither conformal nor equal-area.
Similar projections	<i>Azimuthal equidistant</i> projection, true distance and direction from one point. <i>Two-point equidistant</i> projection, true distance but not direction from two points.
Limitations	Cannot show entire globe.
Parameters	Three anchor points that describe an oval within which distortion is to be minimized. The exact relationship of the oval to the anchors has not been well studied.
Range	The points should all be in the same hemisphere.
Graticule	Meridians: Complex curves. Parallels: Complex curves. Poles: Points. Symmetry: Normally none.
Scale	Approximately correct from three selected widely-spaced points on the map to any point on the map. Cannot be exactly correct.
Distortion	Low distortion throughout map if the anchors are properly placed near map limits.
Origin	Presented by Wellman Chamberlin (1908-1976) of National Geographic Society in 1946.
Use	Low-distortion maps of any region roughly oval in shape and of hemisphere or less size, such as North America or Africa. The three points should be chosen so that they enclose the region of interest.



Chamberlin trimetric

Clarke twilight

Description

Azimuthal, perspective, neither conformal nor equal-area.

Graticule

See [far-side perspective](#).

Scale

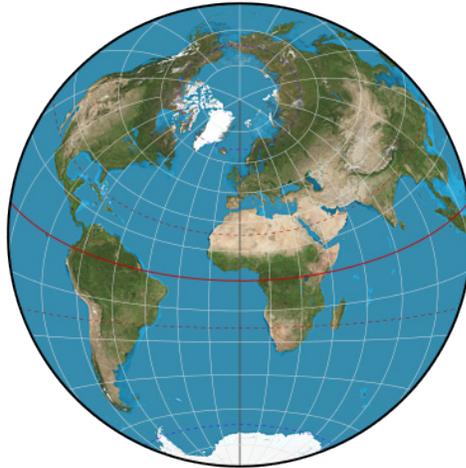
True at the center. Scale varies away from the center.

Distortion

Only the center is free of distortion. Distortion is severe near the outer limit of the projection, but moderate within a wide range of the center.

Use

The *Clarke twilight* projection is a *far-side perspective* formulated by Alexander Ross Clarke (1828–1914) in 1879 to show the range of astronomical twilight. The point of projection is 1.4 times the radius from the center, and the boundary is cut to 108° from center because astronomical twilight officially ends when the sun is 18° below the horizon, or 108° from zenith. The projection and some variants appeared in some British weather maps prior to 1955.

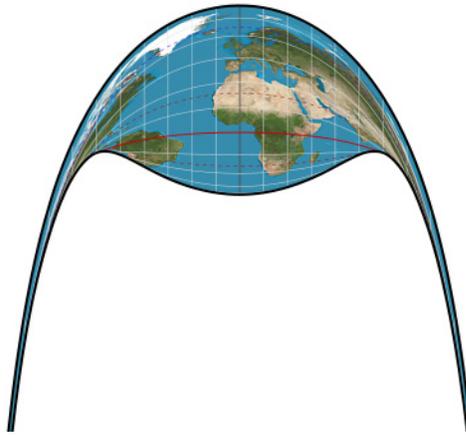


Clarke twilight

Close—See [two-point azimuthal](#)

Craig retroazimuthal

Description	Retroazimuthal, modified azimuthal, neither conformal nor equal-area.
Synonyms	<i>Mecca</i>
Similar projections	<i>Hammer retroazimuthal</i> has curved, unequally-spaced meridians. Hans Maurer of Germany in 1919 and J.E. Jackson of England in 1968 devised retroazimuthal projections characterized by straight, parallel, unequally-spaced meridians. Carl Schoy presented a projection in 1913 having meridians that are straight, equidistant, and parallel, but the parallels are curved so that all great circles passing through the central point are straight lines at their true azimuths from center. It is not retroazimuthal, nor is its distortion only a function of distance from the center, unlike most azimuthal projections.
Other features	The direction is correct from any location on the map to a central point. Considerable overlapping when the entire sphere is shown.
Limitations	Should not be used for more than half a hemisphere.
Parameters	One parameter φ_0 that describes the latitude of the central point to which all directions will be measured.
Range	$-90^\circ \ll \varphi_0 \ll 90^\circ$.
Special properties	In equatorial aspect, the direction from any point of interest to the central point can be measured as the angle formed by the meridian of the point of interest and a line connecting the two points.
Graticule	Meridians: Equally-spaced, straight parallel lines. Parallels: Curved. Poles: Curved lines. Symmetry: About the central meridian.
Distortion	Extreme distortion of shape and area.
Origin	Presented by James Ireland Craig (1868-1952) of the Survey of Egypt in 1909.
Use	To show, for example, the correct direction toward Mecca, from any point on the map, by measuring the angle from north. As the meridians are straight parallel lines, this angle can be readily measured. Use the <i>Boundaries</i> command to select the region of interest. Using the <i>Projection Center</i> command set the projection center to the meridian of the central point and the equator (not the parallel of the central point). Use the <i>Parameters</i> command to set φ_0 to the latitude of the central point to which all directions will be correct.



Craig retroazimuthal

doubly azimuthal—See [two-point azimuthal](#)

doubly equidistant—See [two-point equidistant](#)

equidistant—See [azimuthal equidistant](#)

extruded globe—See [azimuthal extruded globe](#)

far-side perspective

Description

Azimuthal, perspective, neither conformal nor equal-area (except in *stereographic* form, which is conformal). It is the same as the [vertical perspective](#), but slightly reformulated to represent the height as multiples of the radius originating at the center of the sphere, and moving toward the far side. The *vertical perspective*, on the other hand, accepts the height from the surface, with positive moving toward the near side.

Limiting forms

Gnomonic projection, if the point of perspective is at the center of the earth.

Stereographic projection if the point of perspective is on the surface of the earth opposite the center of projection (perspective point = 1).

Orthographic projection if the point of perspective is at infinity.

In turn, the *far-side perspective* is a limiting form of the *tilted perspective* projection.

Specializations

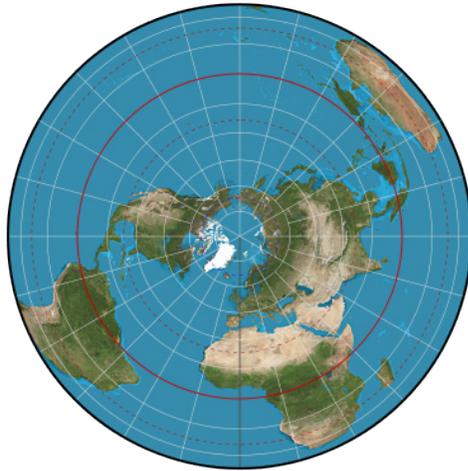
In 1701, Philippe de la Hire of France suggested a point of projection at 1.7071 times the radius. This distance is measured from the center in a direction away from the surface of projection and gives the equator of the polar aspect twice the radius of 45° latitude.

Antoine Parent in 1702, Ernst Hammer about 1890, H.F. Gretschel in 1873, and Hans Maurer in 1935 were among others proposing points of projection for low-error perspectives.

A.R. Clarke and Henry James, in 1862 and later, calculated points of projection (on the far side, below the surface of projection) for minimum-error perspective azimuthal projections of regions, such as continents, bounded by a given great or small circle on the earth.

The Army Map Service *AMS Lunar projection* is a far-side perspective selected by Albert L. Nowicki in 1963 to show slightly more than a hemisphere of the Moon, as seen over a period of time from the earth. The point of projection is 1.53748 times the radius from the center. See also the Airy non-perspective azimuthal projection.

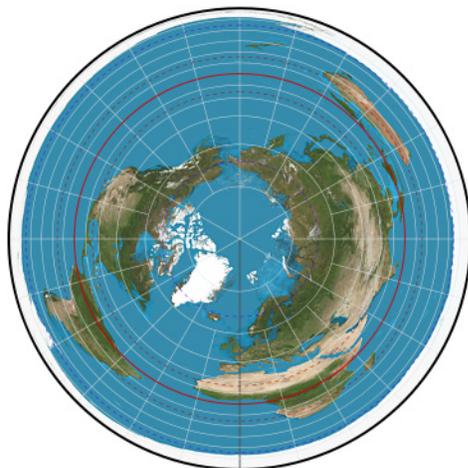
Special properties	The <i>far-side perspective</i> projection shows the sphere geometrically as it appears from any point above or below the surface when it is projected onto a tangent or secant plane perpendicular to the straight line connecting the point of perspective with the center of the earth.
Parameters	One parameter v , the distance from center of sphere in multiples of the radius, with positive values directed toward the far side of the surface. A value less than -1 indicates a near-side perspective above the surface.
Range	$1 \ll v < \infty$; $v \ll 0$ or $v \gg 0$.
Usual	$1 \ll v < 2$.
Graticule	<p>Polar aspect</p> <p>Meridians: Equally-spaced straight lines intersecting at the central pole. Angles between them are the true angles.</p> <p>Parallels: Unequally-spaced circles centered at the pole, which is a point. If $v < -1$, the spacing of parallels decreases away from the pole, and the equator cannot be shown. Otherwise, the spacing may increase or decrease away from the pole, and part of the opposite hemisphere can be shown.</p> <p>Symmetry: About any meridian.</p> <p>Equatorial aspect</p> <p>Meridians: Central meridian is a straight line. Other meridians are generally unequally-spaced elliptical arcs intersecting at the poles (which may not be visible).</p> <p>Parallels: equator is a straight line. Other parallels are usually elliptical arcs. If point of perspective is beneath the surface, the parallels can be elliptical, parabolic, or hyperbolic arcs.</p> <p>Symmetry: About the central meridian or the equator.</p> <p>Oblique aspect</p> <p>Meridians: Central meridian is a straight line. Other meridians are generally unequally-spaced elliptical arcs intersecting at each pole.</p> <p>Parallels: Generally elliptical arcs.</p> <p>Symmetry: About the central meridian.</p>
Scale	True at the center, if the projection is onto a tangent plane. Scale varies away from the center, depending on the point of perspective.
Distortion	Only the center is free of distortion, if projection is onto a tangent plane. Distortion is severe near the outer limit of the projection, although $v > 1$ can result in moderate distortion within a wide range of the center.
Origin	Aside from the earlier limiting forms listed above, the projection was studied in the 18 th and 19 th centuries as a source of low-distortion projections having geometric construction.
Use	Stylized perspective views, generally of regions greater than a hemisphere.



far-side perspective

fisheye

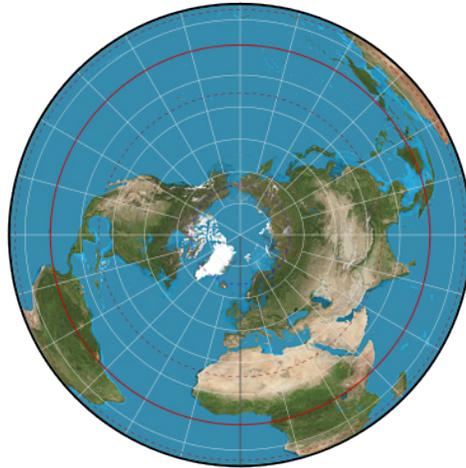
Description	The center of the map can be emphasized or de-emphasized by proportionally increasing or decreasing its scale. The region of magnification steeply drops off until there is no magnification at the edge of the map, and the extent of the region of magnification can be controlled.
Use	Maps required to show the whole earth but emphasizing some portion of it.
Parameters	A scale factor β for the center of the map, and the range of the magnification μ . Central magnification: $0 << \beta << \infty$, spread (integer) $0 \leq \mu << \infty$
Range β	$0 << \beta < \infty$. When $\beta < 1.0$, the center is de-emphasized; when $\beta > 1.0$, center is emphasized. When $\beta = 1.0$, the <i>azimuthal equidistant</i> results.
Usual β	About $2 < \beta < 10.0$.
Range μ	An integer $\mu \leq 0$. The greater μ 's value, the smaller the region of magnification. Very high values can localize the region of magnification to tiny areas, but such values require more computation time.
Usual μ	None.



fisheye

Fischer far-side perspective

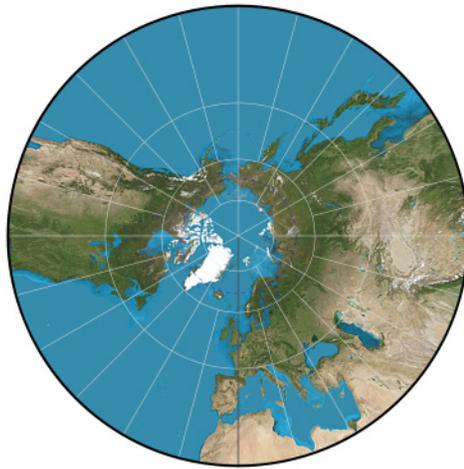
Description	Azimuthal, perspective, neither conformal nor equal-area (except in <i>stereographic</i> form).
Graticule	See far-side perspective .
Scale	True at the center. Scale varies away from the center.
Distortion	Only the center is free of distortion. Distortion is severe near the outer limit of the projection, but moderate within a wide range of the center.
Use	Proposed by Philipp Fischer (1818–1887) around 1850. It is a <i>far-side perspective</i> with a radius of perspective chosen as $2/(\pi-2) \approx 1.7519$, so that the bounding circle of a hemispheric map would be placed at its true distance from the center.



Fischer far-side perspective

gnomonic

Description	Azimuthal, perspective, neither equal-area nor conformal.
Synonyms	<i>central</i>
Similar projections	<i>Two-point azimuthal</i> projection is a <i>gnomonic</i> projection that has been compressed in one direction.
Special properties	<p>All great-circles (including all meridians and the equator) are shown as straight lines. Therefore, the path of the shortest distance between any two points on the map is a straight line.</p> <p>Perspective projection from the center of the globe onto a plane tangent at the central point of projection.</p> <p>Less than a hemisphere can be shown on a map.</p>
Graticule	<p>Polar aspect</p> <p>Meridians: Equally-spaced straight lines intersecting at the central pole. Angles between them are the true angles.</p> <p>Parallels: Unequally-spaced circles centered at the pole, which is a point. The equator and the opposite hemisphere cannot be shown. Spacing increases rapidly away from the pole.</p> <p>Symmetry: About any meridian.</p> <p>Equatorial aspect</p> <p>Meridians: Unequally-spaced, straight parallel lines. Only meridians within 90° of the central meridian can be shown. Spacing increases away from the central meridian.</p> <p>Parallels: equator is a straight line perpendicular to the meridians. Other parallels are hyperbolic arcs concave toward the nearest pole. Spacing increases rapidly away from the equator. Poles cannot be shown.</p> <p>Symmetry: About the central meridian or the equator.</p> <p>Oblique aspect</p> <p>Meridians: Unequally-spaced straight lines intersecting at the pole nearest the center of the projection.</p> <p>Parallels: equator is a straight line perpendicular to the central meridian. If the central parallel is a north latitude, its co-latitude (90° minus the central latitude) is shown as a parabolic arc, more northern parallels are ellipses, and more southern parallels are hyperbolas, all concave toward the nearest pole. If the central parallel is a south latitude, opposite signs apply.</p> <p>Symmetry: About the central meridian.</p>
Range	Less than one hemisphere centered on a given pole of projection or map origin.
Scale	True only where the central parallel crosses the central meridian. Increase rapidly with the distance from the center.
Distortion	Only the center is free from distortion. Distortion increases rapidly away from the center.
Origin	Possibly developed by Thales (c. 580 BC) of Greece. Name derived from the gnomon of a sundial, since meridians radiate like the hour markings on a sundial.
Use	To show great-circle paths as straight lines and thus to assist navigators and aviators in determining appropriate courses. Too much distortion of many kinds for regular geographic maps. Used in the past for some star maps and for world globes in the shapes of polyhedra.



gnomonic

Gretschel

Description

Azimuthal, perspective, neither conformal nor equal-area (except in *stereographic* form).

Graticule

See [far-side perspective](#).

Scale

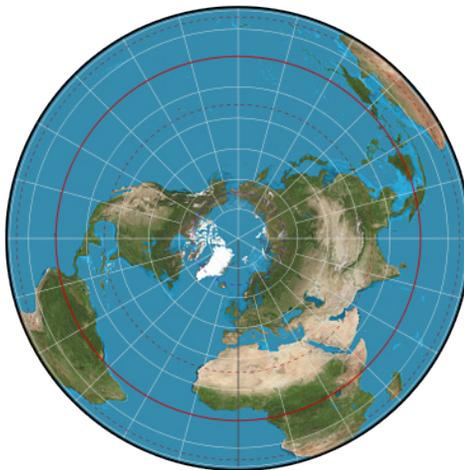
True at the center. Scale varies away from the center.

Distortion

Only the center is free of distortion. Distortion is severe near the outer limit of the projection, but moderate within a wide range of the center.

Use

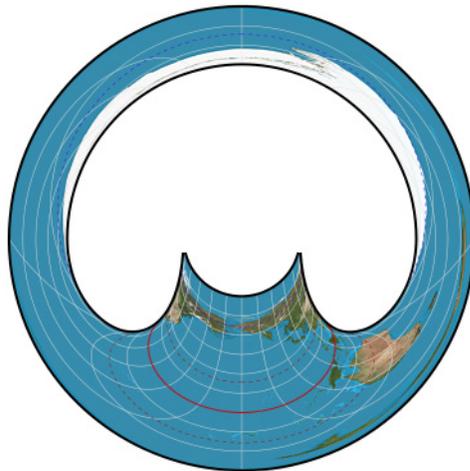
Proposed by Heinrich Friedrich Gretschel (1830–1892) in 1873. It is a *far-side perspective* with a radius of perspective chosen as $\frac{1}{2}(1 + \sqrt{5}) \approx 1.6180$.



Gretschel

Hammer retroazimuthal back hemisphere

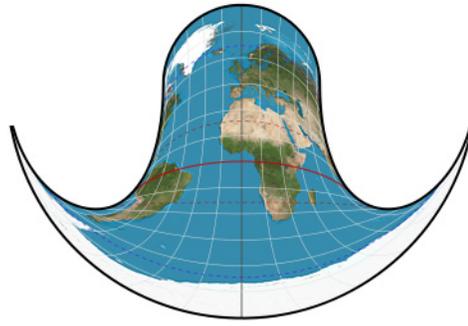
Description	Retroazimuthal, modified azimuthal, neither conformal nor equal-area. This is the back hemisphere of the complete <i>Hammer retroazimuthal</i> , which would otherwise overlap itself.
Similar projections	<i>Craig retroazimuthal</i> has straight, equally-spaced meridians.
Other features	The direction from any point to the center of the map is the angle that a straight line connecting the two points makes with a vertical line. This feature is the basis of the term 'retroazimuthal'. Scimitar-shaped boundary. Considerable overlapping when the entire sphere is shown.
Parameters	Latitude of origin.
Graticule	Meridians: Central meridian is straight. Other meridians curved. Parallels: Curved. Poles: Curved lines. Symmetry: About the central meridian.
Distortion	Extreme distortion of area and shape.
Origin	Presented by H.H. Ernst von Hammer (1858-1925) of Germany in 1910. Independently presented by Edward A. Reeves (1862-1945) and Arthur R. Hinks (1874-1945) of England in 1929.
Use	To determine the direction of a central point from a given location.



Hammer retroazimuthal back hemisphere

Hammer retroazimuthal front hemisphere

Description	Is the front hemisphere of the complete <i>Hammer retroazimuthal</i> , which would otherwise overlap itself. See <i>Hammer retroazimuthal back hemisphere</i> for complete description.
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Hammer retroazimuthal front hemisphere

Immler—See [two-point azimuthal](#)

isoperimetric—See [isoperimetric azimuthal](#)

isoperimetric azimuthal [*isoperimetric*]

Description

Scale is correct along all parallels and along all meridians.

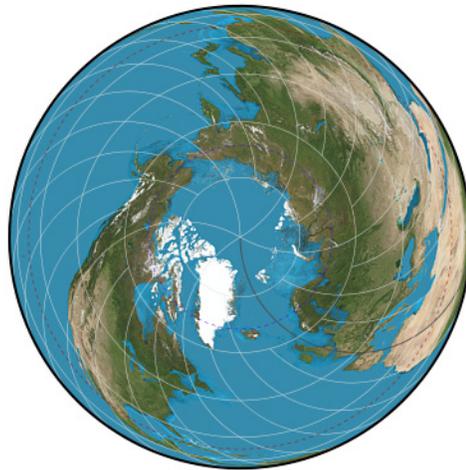
Similar projections

Wiechel is the same geometry applied to the entire sphere instead of hemisphere; hence the spiral of the meridians is half as tight in *Wiechel*.

Isoperimetric cordiform is another projection on which scale is correct along both parallels and meridians.

Origin

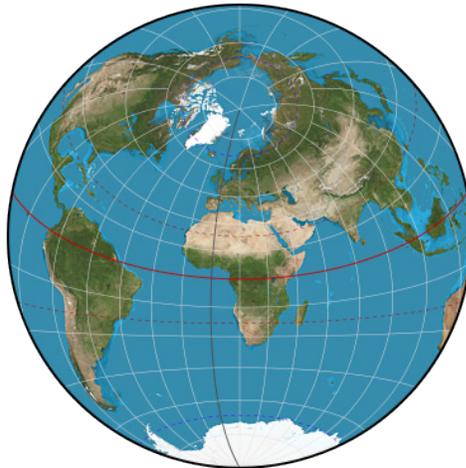
Presented by Leszek Pernarowski, 1970.



isoperimetric azimuthal

James far-side perspective

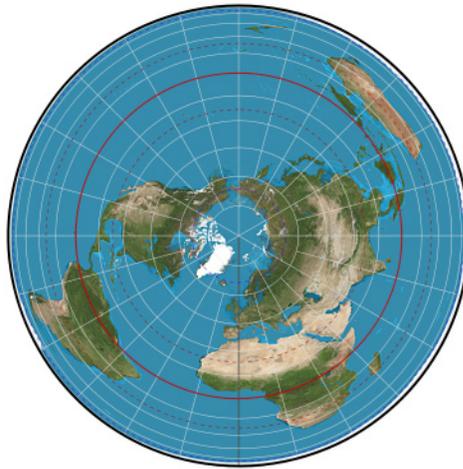
Description	Azimuthal, perspective, neither conformal nor equal-area (except in <i>stereographic</i> form).
Parameters	One enumeration to select either the original James perspective radius (= 1.5) or Clarke's corrected radius (= 1.368).
Graticule	See far-side perspective .
Scale	True at the center. Scale varies away from the center.
Distortion	Only the center is free of distortion. Distortion is severe near the outer limit of the projection, but moderate within a wide range of the center.
Use	The <i>James far-side perspective</i> projection is a <i>far-side perspective</i> formulated by Henry James (1803–1877) in 1857 to lower distortion of the $\frac{2}{3}$ of surface area showing in the map, which he limited to a range of $113^{\circ}30'$. (Actual area is 0.699, not the $\frac{2}{3}$ he quoted.) He chose 1.5 times the radius from the center as the point of perspective, but his colleague A.R. Clarke later showed 1.368 to be better. James published maps on his projection, generally centered on $23^{\circ}30'N$, $15^{\circ}E$ to show most continents except Australia and parts of Antarctica.



James far-side perspective

Lambert azimuthal equal-area [*Lambert equal-area*]

Description	Azimuthal, equal-area, non-perspective.
Synonyms	<i>Lorgna</i> (for polar aspect, due to independent derivation, 1789) <i>zenithal equal-area</i> <i>zenithal equivalent</i>
Similar projections	W. William-Olsson's projection combines the <i>Lambert azimuthal equal-area</i> with a modified <i>Werner</i> .
Range	Entire Earth.
Graticule	Polar aspect Meridians: Equally-spaced straight lines intersecting at the central pole. Angles between them are the true angles. Parallels: Unequally-spaced circles centered at the pole, which is a point. Spacing of the circles gradually decreases away from the pole. The entire Earth can be shown, but the opposite pole is a bounding circle having a radius 1.41 time that of the equator. Symmetry: About any meridian. Equatorial aspect Meridians: Central meridian is a straight line. Meridian 90° away is a circle. Other meridians are complex curves, unequally-spaced along the equator and intersecting each pole. Spacing decreases away from the central meridian. Parallels: equator is a straight line. Other parallels are complex curves concave toward the nearest pole. They are unequally-spaced along the central meridian, and spacing decreases away from the equator. Along the meridian 90° from the central meridian, parallels are equally-spaced. Symmetry: About the central meridian or the equator. Oblique aspect Meridians: Central meridian is a straight line. Other meridians are complex curves intersecting at each pole shown. Parallels: Complex curves unequally-spaced along the central meridian, spacing decreases away from the center of projection. Symmetry: About the central meridian.
Scale	True only at the center in all directions. Decreases with distance from the center along radii. Increases with distance from the center in a direction perpendicular to radii.
Distortion	Only the center is free from distortion. Distortion is moderate for one hemisphere but becomes extreme for a map of the entire Earth.
Origin	Presented by Johann Heinrich Lambert (1728-1777) of Alsace in 1772.
Use	Frequently used in the polar aspect in atlases for maps of polar regions and of northern and southern hemispheres. The equatorial aspect is commonly used for atlas maps of the eastern and western hemispheres. The oblique aspect is used for atlas maps of continents and oceans. The equatorial and oblique aspects are used by the US Geological Survey in cooperation with others for maps of the Circum-Pacific Map Project. Recommended for equal-area maps of regions approximately circular in extent.

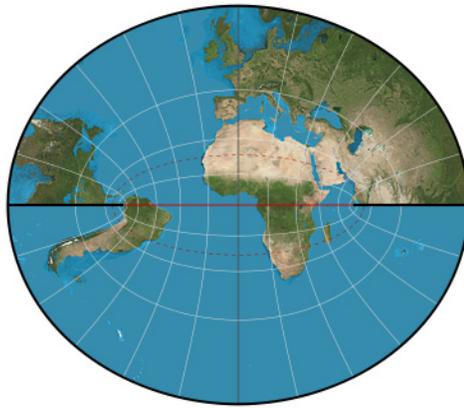


Lambert azimuthal equal-area

Lambert equal-area—See [Lambert azimuthal equal-area](#)

Littrow

Description	Retroazimuthal, conformal.
Similar projections	<i>Littrow</i> projection is the transverse aspect of a <i>Lagrange</i> projection having certain parameters.
Special properties	In equatorial aspect, the direction from any point of interest to any point on the central meridian can be measured as the angle formed by a vertical line at the point of interest and a line connecting the two points.
Other features	Cannot show the entire sphere. Shows the correct direction from any point on the map to any point along the central meridian as the angle between a straight line connecting the two points and a vertical straight line parallel to the central meridian.
Graticule	<p>Meridians: Central meridian and meridians 90° away are straight. Other are hyperbolas convex toward the central meridian.</p> <p>Parallels: equator is straight. Other parallels are ellipses, the equator lies along their major axes.</p> <p>Poles: Not shown.</p> <p>Symmetry: About the central meridian and the equator.</p>
Scale	Varies rapidly.
Distortion	Extreme distortion of area.
Origin	Presented by J.J. Littrow of Austria in 1833.
Use	<p>Maps showing the correct direction from anywhere to a particular place, such as Mecca.</p> <p>Used by the British Navy in the 19th century to determine directions to a central point from other locations.</p> <p>Using the <i>Boundaries</i> command select the region of interest.</p> <p>Using the <i>Projection Center</i> command set the projection center to the desired meridian and the equator.</p>

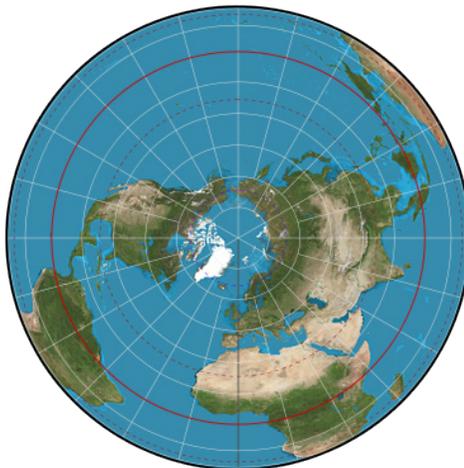


Littrow

Lorgna—See [Lambert azimuthal equal-area](#)

Lowry

Description	Azimuthal, perspective, neither conformal nor equal-area (except in <i>stereographic</i> form).
Graticule	See far-side perspective .
Scale	True at the center. Scale varies away from the center.
Distortion	Only the center is free of distortion. Distortion is severe near the outer limit of the projection, but moderate within a wide range of the center.
Use	Proposed by John Lowry in 1825. It is a <i>far-side perspective</i> with a radius of perspective chosen as 1.6858, which is the geometric mean of the eighteen values of the perspective radius required at each 5° increment of latitude from 0° to 85° to place the parallel at its true proportionate distance from the north pole.



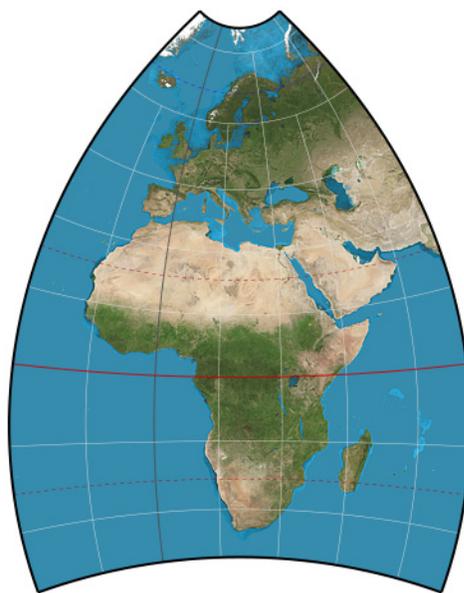
Lowry

McCaw—See [two-point azimuthal](#)

Mecca—See [Craig retroazimuthal](#)

Miller obliterated stereographic [*obliterated stereographic*]

Description	Modified azimuthal, conformal.
Synonyms	<i>Miller proliterated stereographic</i> <i>obliterated stereographic</i> <i>proliterated stereographic</i>
Similar projections	<i>Stereographic</i> projection has lines of constant scale that are concentric circles.
Limitations	Should not be used for more than a hemisphere.
Parameters	Two parameters β_1 and β_2 to describe the ellipse that circumscribes the area of interest; β_1 is the east-west arc distance of the ellipse and β_2 is the north-south.
Range	$-180^\circ \ll \beta_1, \beta_2 \ll 180^\circ$. Negative values are the same as positive.
Graticule	Meridians: Complex curves. Parallels: Complex curves. Poles: Points. Symmetry: About the central meridian as applied to the map of Europe and Africa.
Scale	A line of constant scale bounds an oval region.
Distortion	Scale variations within the oval-shaped region covered are less than variation on standard conformal projections, such as an oblique <i>Mercator</i> or oblique <i>stereographic</i> projection.
Origin	Osborn Maitland Miller (1897-1979) of the American Geographical Society in 1953.
Use	Used for oval regions to minimize the scale distortions in the region. Applied by O.M. Miller to Africa and Europe in 1953, and to other eastern hemisphere regions in conjunction with several non-conformal fill-in projections in 1955. Used by L.P. Lee for the Pacific Ocean in 1974. Maps of oval regions smaller than a hemisphere when shape is more important than area. Center the projection in the region of interest. Choose an ellipse on the globe that completely surrounds the region of interest. Set β_1 to the east-west arc distance in degrees of the oval, and set β_2 to the north-south arc distance in degrees.



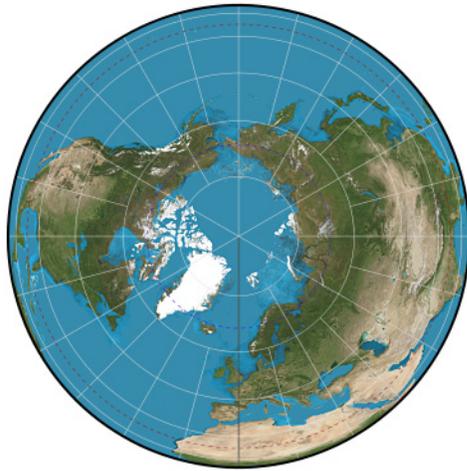
Miller obliterated stereographic

oblated stereographic—See [Miller oblated stereographic](#)

orthodromic—See [two-point azimuthal](#)

orthographic

Description	Azimuthal, perspective, neither conformal nor equal-area.
Similar projections	<i>Vertical perspective</i> , when projected from more than a few thousand kilometers above Earth.
Special properties	Perspective projection of the globe onto a tangent plane from an infinite distance (that is, orthogonally); thus the map has a look of a globe. All great or small circles (including all meridians and parallels) are shown as elliptical arcs or straight lines.
Range	No more than one hemisphere at a time.
Graticule	Polar aspect Meridians: Equally-spaced straight lines intersecting at the central pole. Angles between them are the true angles. Parallels: Unequally-spaced circles centered at the pole, which is a point. Spacing decreases away from the pole. Symmetry: About any meridian. Equatorial aspect Meridians: Central meridian is a straight line. Outer meridians 90° away are circles. Other meridians are unequally-spaced elliptical arcs intersecting at each pole and concave toward the central meridian. Spacing decreases away from the central meridian. Parallels: Unequally-spaced, straight parallel lines perpendicular to the central meridian. Spacing decreases away from the equator. Parallels intersect the outer meridian, however, at equal intervals. Symmetry: About the central meridian or the equator. Oblique aspect Meridians: Central meridian is a straight line. Other meridians are semi-ellipses intersecting at each pole. Spacing decreases away from the central meridian. Parallels: Complete or partial ellipses, all of the same shape (or eccentricity); their minor axes lie along the central meridian. Spacing decreases away from the center of projection. Symmetry: About the central meridian.
Scale	True at the center and along any circle having its center at the projection center, but only in the direction of the circumference of the circle. Scale decreases radially with distance from the center.
Distortion	Only the center is free of distortion, which increases rapidly away from the center. Extreme distortion near the edge of the hemisphere.
Origin	Apparently developed by Egyptians and Greeks by the 2nd century BC.
Use	Hemispheric maps showing the earth as it is seen from space.

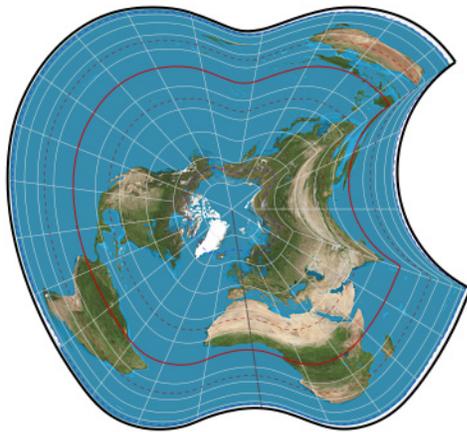


orthographic

Postel—See [azimuthal equidistant](#)

quasiazimuthal equal-area apple [*apple*]

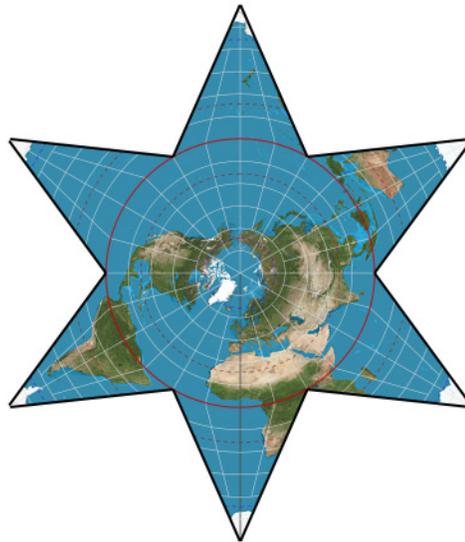
Description	Equal-area.
Special properties	Quasiazimuthal: the great-circles emanating from the center follow straight-line paths, but the angles between them are not constant.
Use	Decorative. Note: Use of this projection is restricted. See Your Rights for details.
Origin	Developed by Daniel “daan” Strebe in 1993.



quasiazimuthal equal-area apple

regular star

Description	Equidistant, composite, modified azimuthal, interrupted.
Similar projections	<i>Berghaus star</i> is the five-point case. <i>Peterman star</i> (Germany, 1865) has eight unequal points, parallels are concentric circular arcs. <i>Jager star</i> (Austria, 1865) has eight unequal points, parallels are in straight segments. <i>Azimuthal equidistant</i> is the projection for the northern hemisphere for the <i>Berghaus star</i> .
Other features	The northern hemisphere is a <i>polar azimuthal equidistant</i> projection. The southern hemisphere is divided into equal triangular lobes.
Parameters	One parameter n to specify the number of points. $3 \leq n \leq 18$.
Aspects	Polar only.
Graticule	Meridians: Straight lines, broken at the equator. Parallels: Concentric circular arcs, north pole at the center. Poles: Points. Symmetry: Radial about the north pole.
Scale	Correct along meridians in the northern hemisphere and along the central meridians of triangular points in the southern hemisphere.
Distortion	Moderate throughout.
Use	Largely for artistic map forms.



regular star

retroazimuthal: Craig retroazimuthal—See [Craig retroazimuthal](#)

retroazimuthal: Hammer back hemisphere—See [Hammer retroazimuthal back hemisphere](#)

retroazimuthal: Hammer front hemisphere—See [Hammer retroazimuthal front hemisphere](#)

retroazimuthal: Littrow—See [Littrow](#)

retroazimuthal: Mecca—See [Craig retroazimuthal](#)

stereographic

Description	Azimuthal, conformal, perspective, polyconic (general).
Special properties	All great or small circles (including all meridians and parallels) on the globe are shown as circular arcs or straight lines. Perspective projection of the globe onto a tangent (or secant) plane from a point on the surface just opposite the point of tangency or the projection center. The straight parallel of latitude passes through this point.
Range	One hemisphere conveniently, most, but not all, of the other hemisphere at accelerating scale.
Graticule	<p>Polar aspect</p> <p>Meridians: Equally-spaced straight lines intersecting at central pole. Angles between them are the true angles.</p> <p>Parallels: Unequally-spaced circles centered at the pole, which is a point. Opposite pole cannot be shown. Spacing gradually increases away from the pole.</p> <p>Symmetry: About any meridian.</p> <p>Equatorial aspect</p> <p>Meridians: Central meridian is a straight line. Other meridians are unequally-spaced circular arcs intersecting at each pole. Spacing gradually increases away from the central meridian.</p> <p>Parallels: equator is a straight line. Other parallels are unequally-spaced circular arcs concave toward the nearest pole. Spacing gradually increases away from the equator along the central meridian, but spacing is equal along the meridians 90° from the central meridian.</p> <p>Symmetry: About the central meridian or the equator.</p> <p>Oblique aspect</p> <p>Meridians: Central meridian is a straight line. Other meridians are circular arcs intersecting at each pole and having their centers on the straight parallel opposite in sign to the central latitude. Spacing gradually increases away from the central meridian.</p> <p>Parallels: The parallel opposite in sign to the central latitude is a straight line perpendicular to the central meridian. All other parallels are circular arcs concave toward the pole on the same side of the straight parallel.</p> <p>Symmetry: About the central meridian.</p>
Scale	True only where the central latitude crosses the central meridian, or alternatively, along a circle concentric about the projection center (or a parallel on the polar aspect). Scale is constant along any circle having its center at the projection center, but scale increases moderately with distance from the center within a hemisphere.
Distortion	Only the center or the circle of true scale (if not the center) is free from all distortion.
Origin	Apparently developed in polar aspect by Egyptians and Greeks in the 2nd century BC.

Use

Conformal maps of regions approximately circular in shape. Also, radio transmission and other ranges on a sphere that have circular boundaries will map to circles on this projection.

Commonly used in the polar aspect for topographic maps of polar regions.

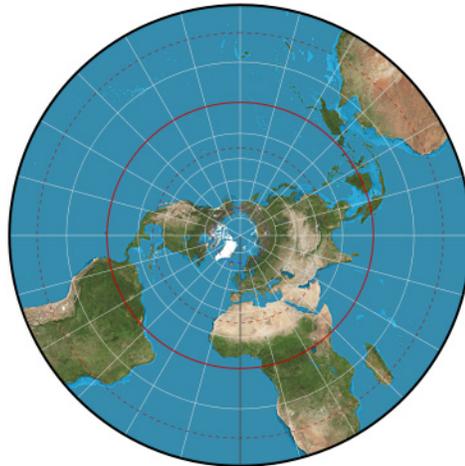
The equatorial aspect was used regularly for maps of the eastern and western hemispheres in the 17th and 18th centuries.

Oblique aspects are used to show paths of solar eclipses.

Recommended for conformal mapping of regions approximately circular in shape. Basis of modified Stereographic conformal projections using complex algebra, such as the Miller oblated stereographic.

Use the ***Boundaries*** command to select the region of interest.

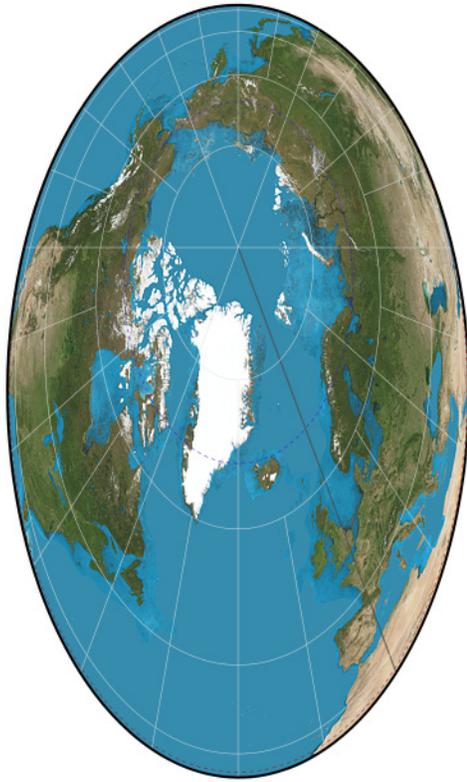
Use ***Stretch and Rotation*** to decrease both the width and height of the map by equal amounts to minimize the scale error measurement.



stereographic

tilted perspective

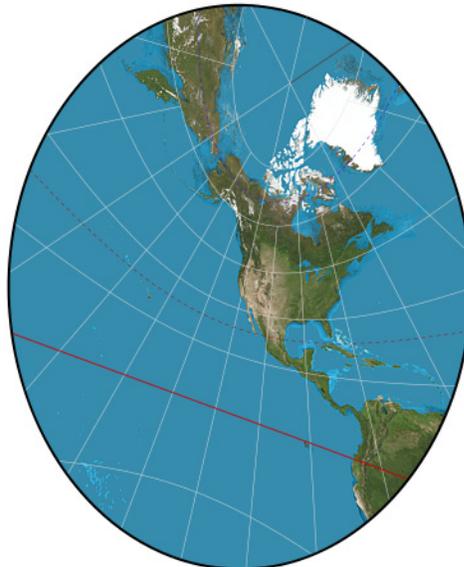
Description	Modified azimuthal, perspective, neither conformal nor equal-area.
Limiting forms	<i>Vertical perspective</i> projection. <i>Orthographic</i> projection, if the point of perspective is at infinite distance.
Special properties	Projection shows the earth geometrically as it appears when photographed or otherwise imaged onto a plane from any point in space with any pointing of the 'camera'.
Limitations	At maximum can show less than one hemisphere.
Parameters	Three parameters: <ul style="list-style-type: none">• λ_1 that describes the meridian which is tilted enough to intersect the top of the map at its center.• d which is the distance of the view from the surface of the earth, in kilometers.• ψ which is the number of degrees that the view is tilted from vertical.
Range λ_1	Depends on d . λ_1 must be visible.
Usual λ_1	None.
Range d	$0 << d < \infty$.
Usual d	None.
Range ψ	Depends on d . As d approaches ∞ , ψ may approach 90° . The higher ψ 's value, the more vertically oblong the projection becomes. ψ of 0° and λ_1 of 0° results in <i>vertical perspective</i> .
Usual ψ	None.
Graticule	Meridians: Central meridian is straight, the point of perspective is in its plane, but this meridian may not appear on the map. Other meridians are normally elliptical arcs, but for certain angles of tilt or centers, they may be straight lines, parabolas, or hyperbolas. Parallels: One parallel, normally nearer to the pole than is the center of projection (depending on the position of the point of perspective), is a straight line. Other parallels are normally elliptical arcs, but for certain angles of tilt, may be parabolas or hyperbolas. Poles: Points. Symmetry: Normally none, but there is symmetry about the central meridian if the direction of view is north or south.
Scale	Normally varies widely if a large area is covered.
Distortion	Substantial distortion of shape, area and scale if a large area is covered.
Origin	Developed primarily during the 20 th century to relate to aerial and space photography and photogrammetry.
Use	Pictorial views of the earth, resembling those seen from space.



tilted perspective

two-point azimuthal

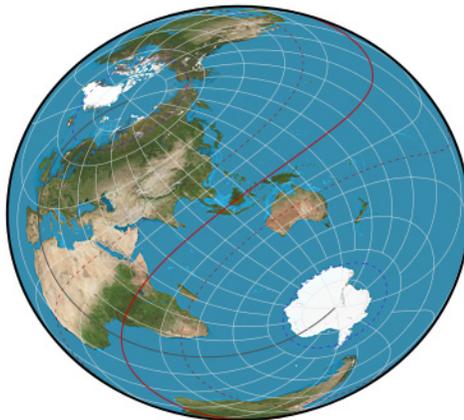
Description	Modified azimuthal, neither conformal nor equal-area.
Synonyms	<i>Close</i> <i>McCaw</i> <i>Immler</i> <i>doubly azimuthal</i> <i>orthodromic</i>
Similar projections	<i>Gnomonic</i> , which can be compressed to produce the <i>two-point azimuthal</i> projection.
Other features	Great circles are shown as straight lines. This projection can be obtained by compressing a <i>gnomonic</i> projection in the direction parallel to the line joining the two central points.
Parameters	Two “anchor points” from which all directions are correct.
Aspects	Typically oblique.
Limiting forms	If the two central points are identical, the <i>gnomonic</i> projection results.
Graticule	Meridians: Straight lines. Parallels: equator is straight. Other parallels are ellipses, parabolas, or hyperbolas. Poles: Points (if shown). Symmetry: Generally none.
Scale	Varies considerably. Projection should not be used for measuring distance.
Distortion	Direction is correct to all other points from two central points at which there is no distortion.
Origin	Presented by Hans Maurer (1868-1945) of Germany in 1914 and Charles F. Close (1865-1952) of England independently in 1922.
Use	Could be used to locate a ship at sea, for example, if the exact location of two radio transmitters and the direction from the ship to the transmitters are known.



two-point azimuthal

two-point equidistant

Description	Modified azimuthal, neither conformal nor equal-area.
Synonyms	<i>doubly equidistant</i>
Similar projections	<i>Azimuthal equidistant</i> , on which distance is correct from only one point. <i>Donald elliptical</i> , developed by Jay K. Donald of the American Telephone and Telegraph Company in 1956. Used by telephone companies to establish long-distance rates, the Donald is a <i>Two-point equidistant</i> projection specially modified for the ellipsoid and confined to the United States and southern Canada. <i>Chamberlin trimetric</i> , an approximate three-point equidistant projection. <i>Two-point azimuthal equidistant</i> , presented by Charles F. Close in 1922, has true azimuths from one point and true distances from a second point to all other points.
Limiting forms	If the two central points are identical, the <i>azimuthal equidistant</i> projection results.
Parameters	Two “anchor points” from which all distances are correct.
Aspects	Typically oblique.
Graticule	Meridians: Complex curves. Parallels: Complex curves. Poles: Normally points. Symmetry: Normally none.
Scale	True along a straight line from either of two central points.
Distortion	No point is free of distortion.
Origin	Presented by Hans Maurer (1868-1945) of Germany in 1919, and Charles F. Close (1865-1952) of England independently in 1921.
Use	Map of Asia by the National Geographic Society. Could be used to determine the distance of a ship at sea at a known location from the start and end of a voyage.



two-point equidistant

vertical perspective

Description	Azimuthal, perspective, neither conformal nor equal-area (except in <i>stereographic</i> form, which is conformal).
Limiting forms	<i>Gnomonic</i> projection, if the point of perspective is at the center of the earth. <i>Stereographic</i> projection if the point of perspective is on the surface of the earth opposite the center of projection. <i>Orthographic</i> projection if the point of perspective is at infinity. In turn, the <i>vertical perspective</i> is a limiting form of the <i>tilted perspective</i> projection.
Specializations	In 1701, Philippe de la Hire of France suggested a point of projection at 1.7071 times the radius. This distance is measured from the center in a direction away from the surface of projection and gives the equator of the polar aspect twice the radius of 45° latitude. Antoine Parent in 1702, Ernst Hammer about 1890, H.F. Gretschel in 1873, and Hans Maurer in 1935 were among others proposing points of projection for low-error perspectives. A.R. Clarke and Henry James, in 1862 and later, calculated points of projection (on the far side, below the surface of projection) for minimum-error perspective azimuthal projections of regions, such as continents, bounded by a given great or small circle on the earth. The Army Map Service AMS Lunar projection is a far-side perspective selected by Albert L. Nowicki in 1963 to show slightly more than a hemisphere of the Moon, as seen over a period of time from the earth. The point of projection is 1.53748 times the radius from the center. See also the Airy non-perspective azimuthal projection.
Special properties	The <i>vertical perspective</i> projection shows the earth geometrically as it appears from any point above or below the surface when it is projected onto a tangent or secant plane perpendicular to the straight line connecting the point of perspective with the center of the earth.
Parameters	One parameter d giving the altitude of the viewpoint in kilometers. Negative values give views from the interior of the earth.
Range	$-6400 \ll d < \infty$; $d \ll 0$ or $d \gg 0$.
Usual	$d \gg 0$.

Graticule**Polar aspect**

Meridians: Equally-spaced straight lines intersecting at the central pole. Angles between them are the true angles.

Parallels: Unequally-spaced circles centered at the pole, which is a point. If the usually perspective from above the surface is projected, the spacing of parallels decreases away from the pole, and the equator cannot be shown. If point of perspective is beneath the surface, the spacing may increase or decrease away from the pole, and part of the opposite hemisphere can be shown.

Symmetry: About any meridian.

Equatorial aspect

Meridians: Central meridian is a straight line. Other meridians are generally unequally-spaced elliptical arcs intersecting at the poles (which may not be visible).

Parallels: equator is a straight line. Other parallels are usually elliptical arcs. If point of perspective is beneath the surface, the parallels can be elliptical, parabolic, or hyperbolic arcs.

Symmetry: About the central meridian or the equator.

Oblique aspect

Meridians: Central meridian is a straight line. Other meridians are generally unequally-spaced elliptical arcs intersecting at each pole.

Parallels: One parallel, normally nearer the pole than is the center of projection, depending on the position of the point of perspective, is a straight line. Other parallels are normally elliptical arcs.

Symmetry: About the central meridian.

Scale

True at the center, if the projection is onto a tangent plane. Scale varies away from the center, depending on the point of perspective.

Distortion

Only the center is free of distortion, if projection is onto a tangent plane. Distortion is severe near the outer limit of the projection, although special locations for the points of projection on the opposite side of the earth's center result in moderate distortion within a wide range of the center.

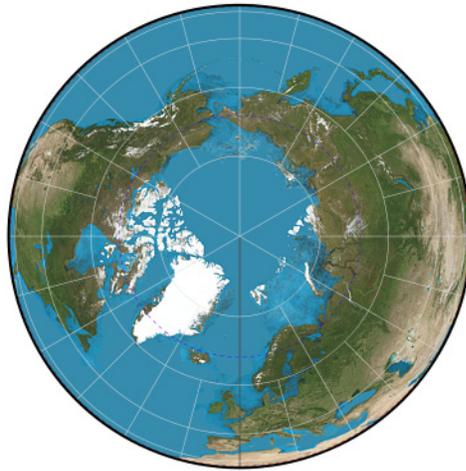
Origin

Aside from the earlier limiting forms listed above, the *perspective* projection from a point on the opposite side of the earth's center was studied in the 18th and 19th centuries as a source of low-distortion projections having geometric construction.

Use

Pictorial views of the earth, resembling those seen from space.

Maps showing regions of the earth smaller than a hemisphere as they appear from high altitudes. The smaller the region to be viewed, the lower the value that d should take. As d approaches ∞ , the projection approaches *orthographic*.



Vertical perspective

Wiechel

Description

Modified azimuthal, pseudoazimuthal, equal-area.

Similar projections

Lambert azimuthal equal-area projection has the same spacing of parallels in the polar aspect, but the meridians are straight.

Ginzburg III is a general series of pseudoazimuthal projections developed by C.A. Ginzburg of the Soviet Union in 1952. The lines of constant distortion are ovals rather than the usual circles of azimuthal projections. This feature is achieved by the manner in which the lines of constant initial azimuth are curved. The projection series has been used only in the oblique or equatorial aspect.

Isoperimetric azimuthal has the same amount of twist applied to just one hemisphere.

Aspects

Generally only polar.

Graticule

Polar aspect

Meridians: Semicircles if extended to a world map.

Parallels: Concentric circles.

Poles: Central pole is a point, other pole is a circle.

Symmetry: Radial about the central pole.

Scale

Correct along meridians.

Distortion

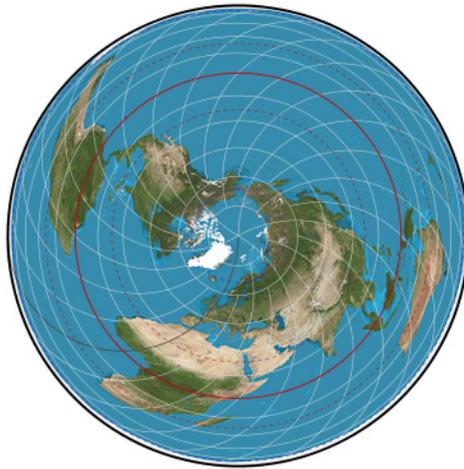
Considerable distortion of shape at the map edge.

Origin

Presented by H. Wiechel in 1879.

Use

A novelty map that in its polar aspect, has semicircular meridians arranged in a pinwheel.



Wiechel

zenithal equal-area—See [Lambert azimuthal equal-area](#)

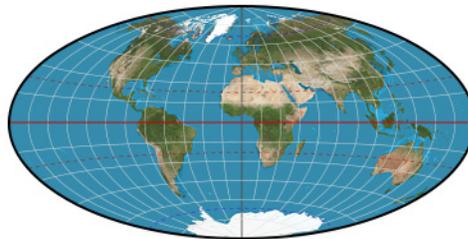
zenithal equidistant—See [azimuthal equidistant](#)

zenithal equivalent—See [Lambert azimuthal equal-area](#)

Lenticular projections

Aitoff

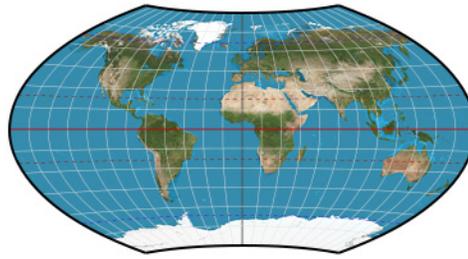
Description	Modified azimuthal, neither conformal nor equal-area.
Similar projections	<i>Hammer (elliptical) equal-area</i> mistakenly called <i>Aitoff</i> in the early 20 th century. <i>Briesemeister</i> , an oblique modification of the <i>Hammer</i> . <i>Eckert-Greifendorff</i> , a modification of the <i>Lambert azimuthal equal-area</i> projection inspired by the <i>Hammer</i> . <i>Winkel tripel</i> is a combination of the <i>Aitoff</i> and <i>equidistant cylindrical</i> projections.
Other features	Elliptical border. An equatorial aspect of one hemisphere of the <i>azimuthal equidistant</i> projection, on which horizontal coordinates have been doubled and meridians have been given twice their original latitudes.
Graticule	Meridians: Central meridian is a straight line half the length of the equator. Other meridians are complex curves, equally-spaced along the equator and concave toward the central meridian. Parallels: equator is straight. Other parallels are complex curves, equally-spaced along the central meridian and concave toward the nearest pole. Poles: Points. Symmetry: About the equator and central meridian.
Scale	True along the equator and central meridian.
Distortion	Moderate shape and area distortion.
Origin	David Aitoff (or Aitow) (1854-1933) in 1889.
Use	Design inspired H.H. Ernst von Hammer to develop his <i>elliptical</i> projection.



Aitoff

Aitoff-Wagner

Use Reference world maps.



Aitoff-Wagner

Briesemeister

Description Modified azimuthal, equal-area.

Similar projections *Hammer*, the equatorial aspect of the *Briesemeister*, but having an axis ratio of 2:1.

Nordic, by John Bartholomew, is the same as the *Briesemeister* projection, except that the axis ratio is 2:1 and the central meridian is 0°.

Other features An oblique Hammer projection centered at latitude 45°N and longitude 10° E and bounded by an ellipse having an axis ratio of 1.75:1 instead of 2:1, after the vertical coordinates are expanded and the horizontal coordinates are contracted.

Graticule Meridians: Central meridian is straight. Other meridians are complex curves.

Parallels: Complex curves.

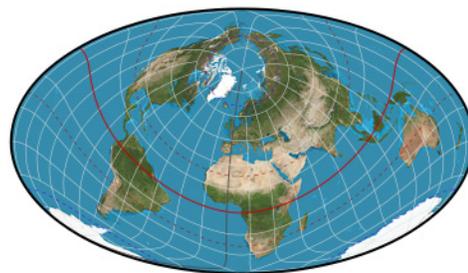
Poles: Points.

Symmetry: About the central meridian.

Scale True scale at latitudes 3.6° and 86.4°N at central meridian.

Distortion None at latitudes 3.6° and 86.4°N at central meridian.

Use Whole-world maps showing continents grouped near the center.



Breisemiester

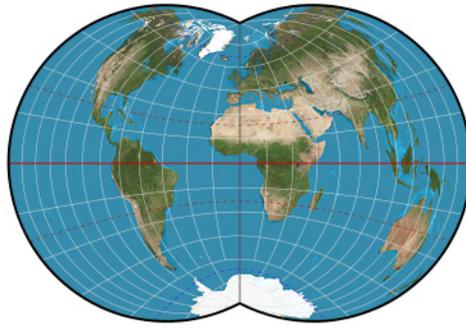
cartouche—See [Strebe-sinusoidal](#)

Dietrich-Kitada

Description Equal-area. Meridians are circular arcs in equatorial case.

Use Thematic world maps.

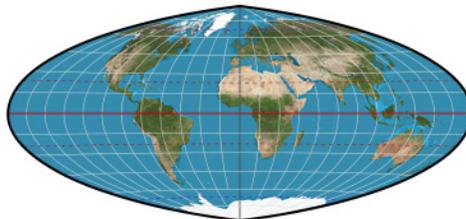
Origin Map appears in Bruno Dietrich's 1927 text. Formulæ published by Kōzō Kitada, 1958.



Dietrich-Kitada

Eckert-Greifendorff

Description	Modified azimuthal, equal-area.
Similar projections	<i>Hammer</i> , a different modification of the <i>Lambert azimuthal equal-area</i> projection. <i>Quartic authalic</i> has straight parallels.
Other features	An equatorial aspect of the <i>Lambert azimuthal equal-area</i> projection for 90° of longitude, on which the horizontal coordinates have been quadrupled and the meridians have been given four times their original longitudes.
Graticule	Meridians: Central meridian is a straight line 0.46 of the length of the equator. Other meridians are curved, unequally-spaced along the equator and concave toward the central meridian. Parallels: equator is straight. Other parallels are curved, unequally-spaced along the central meridian and concave toward the nearest pole. Poles: Points. Symmetry: About the central meridian or the equator.
Scale	Decreases steadily along the equator and the central meridian with distance from the center of the projection.
Distortion	Moderate near center, but considerable shape distortion near outer meridians.
Origin	Max Eckert-Greifendorff (formerly Max Eckert) (1868-1938) of Germany in 1935.
Use	Whole-world map.

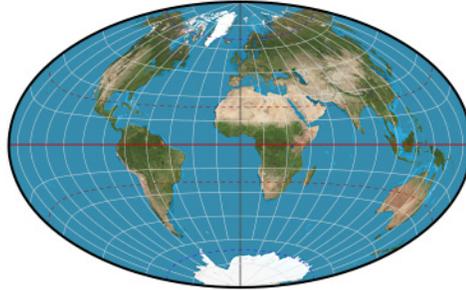


Eckert-Greifendorff

Gott elliptical—See [Gott elliptical equal-area](#)

Gott elliptical equal-area [*Gott elliptical*]

Description	Equal-area.
Use	Thematic world maps.
Origin	Presented by J. Richard Gott, III, Charles Mugnolo, and Wesley N. Colley in 2006.

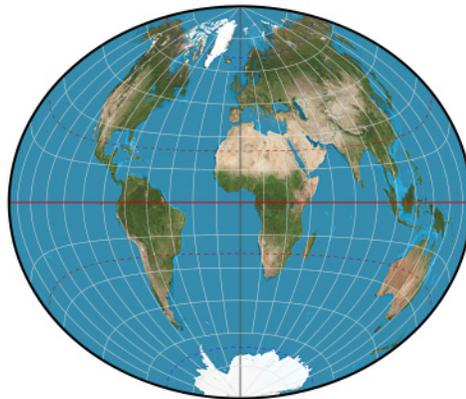


Gott elliptical equal-area

Gott-Mugnolo elliptical—See [Gott-Mugnolo elliptical equal-area](#)

Gott-Mugnolo elliptical equal-area [*Gott-Mugnolo elliptical*]

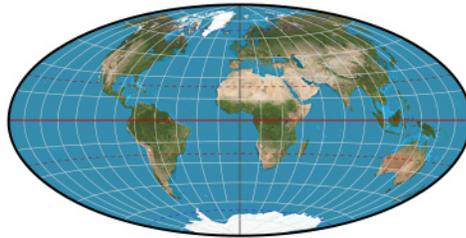
Description	Equal-area.
Use	Thematic world maps.
Origin	Presented by J. Richard Gott, III, Charles Mugnolo, and Wesley N. Colley in 2006.



Gott-Mugnolo elliptical equal-area

Hammer

Description	Modified azimuthal, equal-area.
Synonyms	<i>Hammer-Aitoff</i> Mistakenly called <i>Aitoff</i> projection in the early 20 th century.
Similar projections	<i>Briesemeister</i> , a modified oblique <i>Hammer</i> . Eckert-Greifendorff, with parameter $w = 0.25$.
Other features	Elliptical border. An equatorial aspect of one hemisphere of the Lambert azimuthal equal-area projection, on which horizontal coordinates have been doubled and meridians have been given twice their original longitudes.
Parameters	Parallel curvature W , with Hammer describing the case of $W = 0.5$. $0 << W \leq 0.5$.
Aspects	Equatorial and oblique are both in use.
Graticule	Meridians: Central meridian is a straight line half the length of the equator. Other meridians are complex curves, unequally-spaced along the equator and concave toward the central meridian. Parallels: equator is straight. Other parallels are complex curves, unequally-spaced along the central meridian and concave toward the nearest pole. Poles: Points. Symmetry: About the central meridian and the equator.
Scale	Decreases along the central meridian and the equator with distance from the center.
Distortion	Moderate. Less shearing action on the outer meridians near the poles than there is on pseudocylindric projections.
Origin	Presented by H.H. Ernst von Hammer (1858-1925) of Germany in 1892.
Use	Reference world maps where poles need to be shown as points. Also in interrupted and condensed forms.



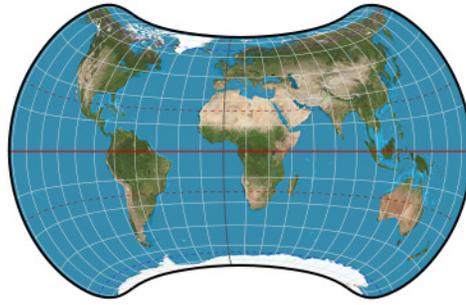
Hammer

Hammer-Aitoff—See [Hammer](#)

Strebe—See [Strebe 1995](#)

Strebe 1995

Synonyms	<i>Strebe</i>
Description	Equal-area.
Parameters	Fitting factor γ , determining the amount of curvature.
Range	$0.963 \leq \gamma \leq 2.0$
Usual	$\gamma = 1.35$
Origin	Daniel “daan” Strebe, presented at NACIS 1995.



Strebe 1995

Strebe equal-areas: cartouche—See [Strebe-sinusoidal](#)

Strebe equal-areas: Hammer—See [Strebe-Hammer](#)

Strebe equal-areas: Kavrayskiy V—See [Strebe-Kavrayskiy V](#)

Strebe equal-areas: Mollweide—See [Strebe-Mollweide](#)

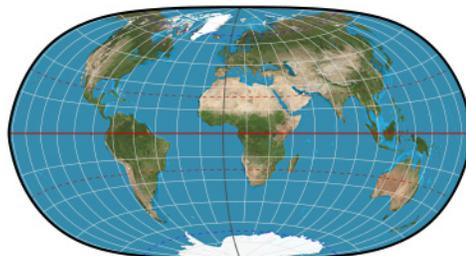
Strebe equal-areas: sinusoidal—See [Strebe-sinusoidal](#)

Strebe equal-areas: Snyder flat-pole—See [Strebe-Snyder flat-pole](#)

Strebe equal-areas: Snyder pointed-pole—See [Strebe-Snyder pointed-pole](#)

Strebe-Hammer

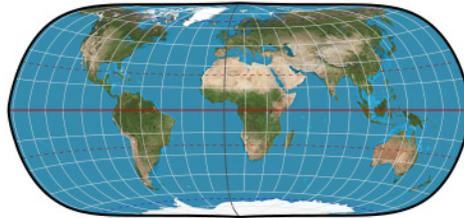
Description	Equal-area.
Use	Academic.
Parameters	Parameter W , which controls the parallel curvature. Parameter μ which controls the curvature of the pole line.
Range W	$0 << W \leq 0.5$.
Usual W	$W = 0.5$.
Range μ	$29^\circ\text{S} \leq \mu \leq 42^\circ\text{N}$.
Usual μ	$10^\circ\text{N} \leq \mu \leq 20^\circ\text{N}$.
Origin	Developed by Daniel “daan” Strebe in 1991.



Strebe-Hammer

Strebe-Kavrayskiy V

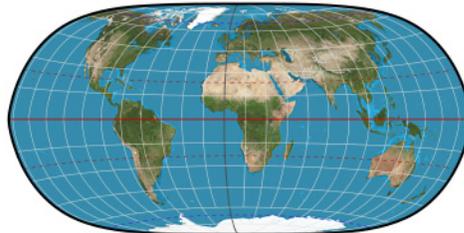
Description	Equal-area.
Use	Academic.
Parameters	One parameter μ which controls the curvature of the pole-line.
Range	$29^{\circ}\text{S} \leq \mu \leq 44^{\circ}\text{N}$.
Usual	$10^{\circ}\text{N} \leq \mu \leq 20^{\circ}\text{N}$.
Origin	Developed by Daniel “daan” Strebe in 1991.



Strebe-Kavrayskiy V

Strebe-Mollweide

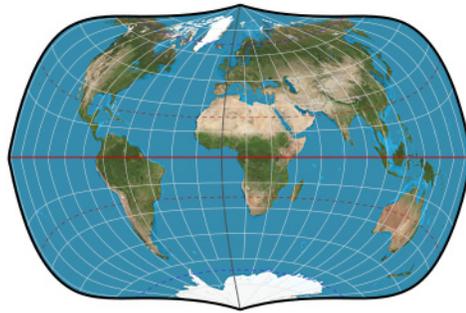
Description	Equal-area.
Use	Academic.
Parameters	One parameter μ which controls the curvature of the pole-line.
Range	$29^{\circ}\text{N} \leq \mu \leq 43^{\circ}\text{N}$.
Usual	$10^{\circ}\text{N} \leq \mu \leq 20^{\circ}\text{N}$.
Origin	Developed by Daniel “daan” Strebe in 1991.



Strebe-Mollweide

Strebe-sinusoidal

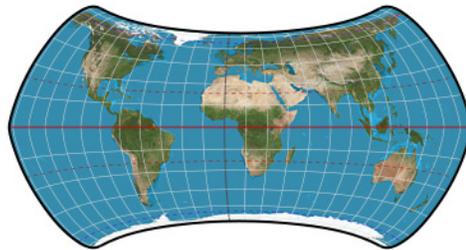
Description	Equal-area.
Synonyms	<i>cartouche</i>
Use	Academic.
Parameters	One parameter μ which controls the curvature of the pole-line.
Range	$29^{\circ}\text{S} \leq \mu \leq 36^{\circ}\text{N}$.
Usual	$15^{\circ}\text{N} \leq \mu \leq 26^{\circ}\text{N}$.
Origin	Developed by Daniel “daan” Strebe in 1991.



Strebe-sinusoidal

Strebe-Snyder flat-pole

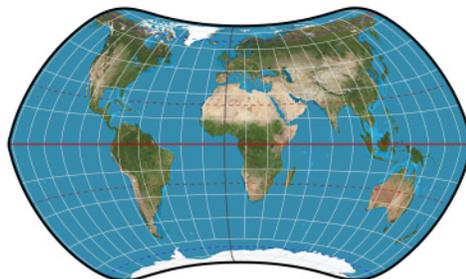
Description	Equal-area.
Use	Academic.
Parameters	One parameter μ which controls the curvature of the pole-line.
Range	$33^{\circ}\text{S} \leq \mu \leq 63^{\circ}\text{N}$.
Usual	$13^{\circ}\text{N} \leq \mu \leq 22^{\circ}\text{N}$.
Origin	Developed by Daniel “daan” Strebe in 1991.



Strebe-Snyder flat-pole

Strebe-Snyder pointed-pole

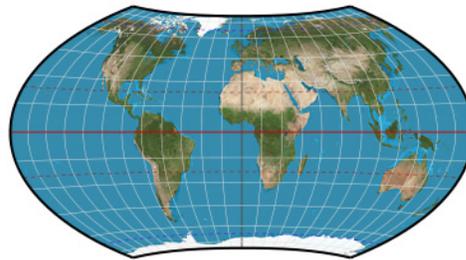
Description	Equal-area.
Use	Academic.
Parameters	One parameter μ which controls the curvature of the pole-line.
Range	$35^{\circ}\text{S} \leq \mu \leq 90^{\circ}\text{N}$.
Usual	$13^{\circ}\text{N} \leq \mu \leq 25^{\circ}\text{N}$.
Origin	Developed by Daniel “daan” Strebe in 1991.



Strebe-Snyder pointed-pole

Wagner VII

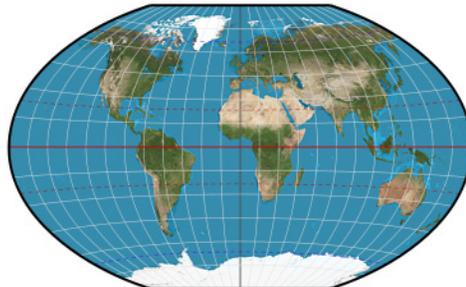
Description	Modified azimuthal, equal-area.
Synonyms	<i>Hammer-Wagner</i>
Similar projections	<i>Hammer (elliptical)</i> truncated and otherwise modified for the <i>Wagner VII</i> .
Other features	A modification of the <i>Hammer</i> projection, the poles correspond to the 65 th parallels on the <i>Hammer</i> , and meridians are repositioned.
Graticule	<p>Meridians: Central meridian is straight and half the length of the equator. Other meridians are curves, unequally-spaced along the equator and concave toward the central meridian.</p> <p>Parallels: equator is straight. Other parallels are curves, unequally-spaced along the central meridian and concave toward the nearest pole.</p> <p>Poles: Curved lines.</p> <p>Symmetry: About the central meridians or the equator.</p>
Scale	Decreases along the central meridian and the equator with distance from the center of the projection.
Distortion	Considerable shape distortion in polar areas.
Origin	Presented by Karlheinz Wagner of Germany in 1941.
Use	World maps, such as climatic maps prepared by the US Department of Commerce.



Wagner VII

Winkel tripel

Description	Modified azimuthal, neither conformal nor equal-area.
Other features	Equally-spaced central meridian and equator.
Parameters	Enumeration which describes the style of the projection.
Range	Winkel's style Bartholomew's style
Graticule	Meridians: Central meridian is straight. Other meridians are curved, equally-spaced along the equator and concave toward the central meridian. Parallels: equator and the poles are straight. Other parallels are curved, equally-spaced along the central meridian and concave toward the nearest pole. Poles: Straight lines about 0.4 as long as the equator, depending on the latitude of the standard parallels of the base Equidistant cylindrical projection. Symmetry: About the central meridian or the equator.
Scale	True along the central meridian. Constant along the equator.
Distortion	Moderate except near outer meridians in polar regions.
Origin	Presented by Oswald Winkel (1873-1953) of Germany in 1921. Obtained by averaging coordinates of <i>equidistant cylindrical</i> and <i>Aitoff</i> (not <i>Hammer-Aitoff</i>) projections. Winkel applied the name 'tripel', normally meaning triple.
Use	Whole world maps.



Winkel tripel

Miscellaneous projections

ЦНИИГАиК—See [TsNIIGAiK](#)

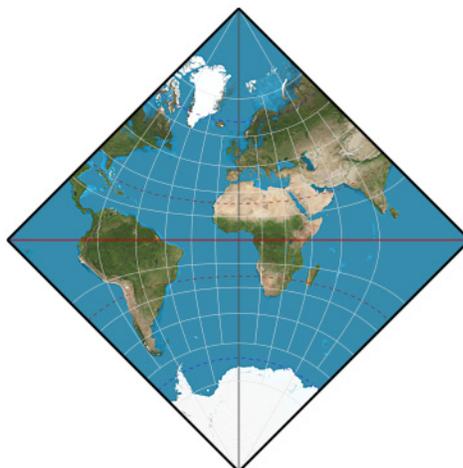
Adams: hemisphere in a square—See [Adams hemisphere in a square](#)

Adams: world in a square I—See [Adams world in a square I](#)

Adams: world in a square II—See [Adams world in a square II](#)

Adams hemisphere in a square

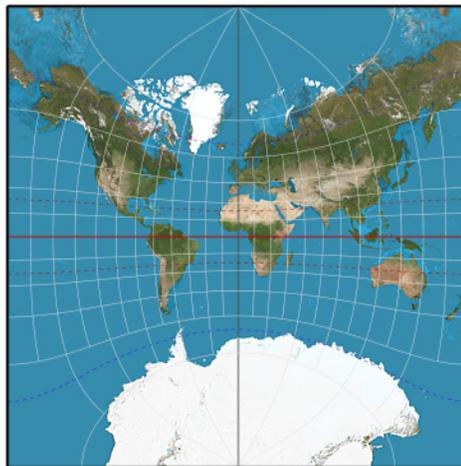
Description	Conformal.
Similar projections	One transverse aspect is the <i>Peirce quincuncial</i> , another is a rotation of the original projection. An oblique aspect is the <i>Guyou</i> projection.
Other features	Hemisphere is enclosed in a square. World can be enclosed in a 2 x 1 rectangle.
Aspects	One transverse aspect is the <i>Peirce quincuncial</i> , another is a rotation of the original projection.
Graticule	Meridians: Central meridian is straight. The 90 th meridians are straight lines bend at the equator. Other meridians are curved. Parallels: equator is straight. Other parallels are curved. Poles: Points, in opposite vertices of a square. Symmetry: About the central meridian or the equator.
Scale	Varies along each meridian and each parallel.
Distortion	Great distortion of the area at the poles or the intersection of the 90 th meridians with the equator. At these four points, conformality fails.
Origin	Presented by Oscar Sherman Adams (1874-1962) of the US Coast and Geodetic Survey in 1925.
Use	Novelty map of a hemisphere.



Adams hemisphere in a square

Adams world in a square I

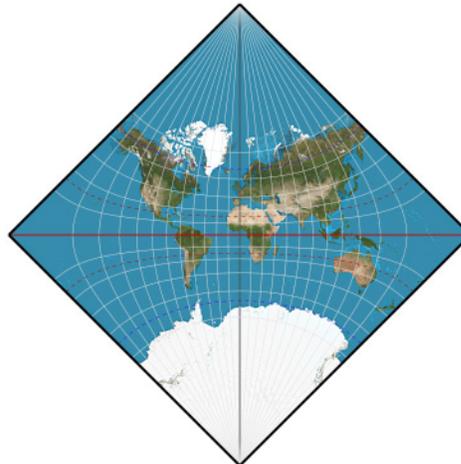
Description	Conformal.
Similar projections	A general formula for representing the whole sphere or a segment of the sphere conformally in a regular polygon of three or more sides can be used to create this map and other conformal maps.
Graticule	Meridians: Central meridian is straight. The 180 th meridians are straight lines bent at the latitudes 70°31'N and S. Other meridians are complex curves. Parallels: equator is straight. Other parallels are complex curves. Poles: Points in midpoints of opposite sides. Symmetry: About the central meridian or the equator.
Scale	Varies along each meridian and each parallel.
Distortion	Great area distortion at the higher latitudes. Conformality fails at the poles and at two points on each of the 180 th meridians.
Origin	Presented by Oscar Sherman Adams (1874-1962) of the US Coast and Geodetic Survey in 1925.
Use	Novel whole-world maps.



Adams world in a square I

Adams world in a square II

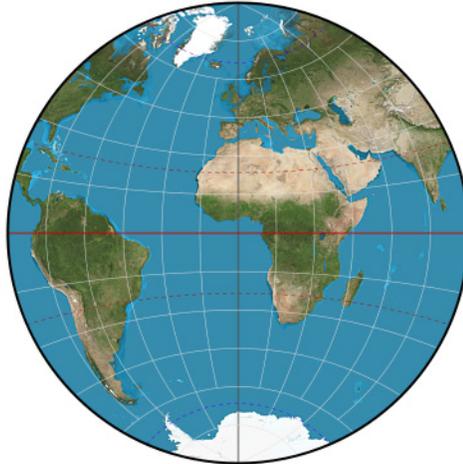
Description	Conformal.
Similar projections	One transverse aspect is the <i>Peirce quincuncial</i> , another is a rotation of the original projection. An oblique aspect is the <i>Guyou</i> projection.
Graticule	Meridians: Central meridian is straight. The 180 th meridians are straight lines bent at the equator. Other meridians are complex curves. Parallels: equator is straight. Other parallels are complex curves. Poles: Points in opposite vertices. Symmetry: About the central meridian or the equator.
Distortion	Great area distortion near the 180 th meridians or at higher latitudes. Conformality fails at the poles and at the intersections of the 180 th meridians with the equator.
Origin	Presented by Oscar Sherman Adams (1874-1962) of the US Coast and Geodetic Survey in 1925.
Use	Novel whole-world maps.



Adams world in a square II

Al-Birūnī

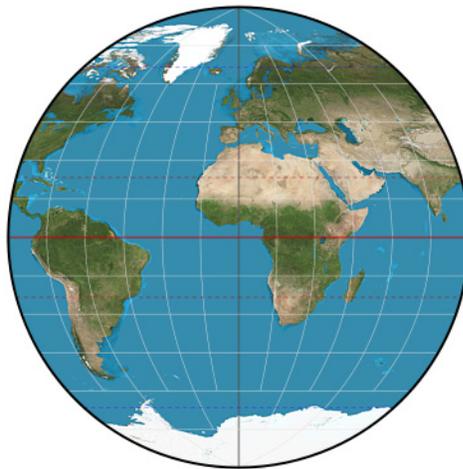
Description	Globular, polyconic, neither conformal nor equal-area.
Native name	ابوریحان بیرونی
Synonyms	<i>Arrowsmith globular</i> <i>Nicolosi globular</i>
Similar projections	<i>Van der Grinten IV</i> has parallels of different curvature and is extended to a world map. <i>Azimuthal equidistant</i> (equatorial aspect) has complex curves for meridians and parallels. <i>Fournier globular I</i> has elliptical arcs for meridians.
Graticule	Meridians: Central meridian is straight. Other meridians are circular arcs, equally-spaced along the equator, but not along other parallels. Parallels: Parallel straight lines equally-spaced on the meridians 90° from the center. Poles: Points. Symmetry: About the central meridian or the equator.
Scale	True along the central meridian and the equator.
Distortion	Moderate for a hemisphere. Considerable area and shape distortion if used beyond the 90 th meridians.
Origin	Presented by Giambattista Nicolosi (1610-1670) of Rome in 1660.
Use	Hemispheric maps, common in atlases between 1850 and 1925.



Al-Birūnī

Apian globular I

Description	Globular, neither conformal nor equal-area.
Similar projections	<i>Glareanus</i> (Loritz) has identical meridians, but straight parallels are equally-spaced on the 90 th meridians. <i>Apian globular II</i> has identical parallels, central meridian, and 90 th meridians, but other meridians are equally-spaced ellipses. <i>Ortelius oval</i> is identical within 90° of the central meridian.
Graticule	Meridians: Central meridian is straight. Other meridians are circular arcs equally-spaced along the equator but not along other parallels. Parallels: Straight lines, equally-spaced along the central meridian. Poles: Points. Symmetry: Along the central meridian or the equator.
Scale	True along the central meridian and the equator.
Distortion	Moderate.
Origin	Presented by Peter Apian (Petrus Apianus or Peter Bienewitz) (1495-1552) of Saxony in 1524.
Use	Early maps of hemispheres.



Apian globular I

Apian globular II

Description	Neither conformal nor equal-area. Hemispheric version of pseudocylindric Apian II.
Similar projections	<i>Apian globular I</i> has identical parallels, central meridian, and 90 th meridians, but other meridians are arcs of circles.
Graticule	Meridians: Central meridian is straight. Other meridians are elliptical arcs equally-spaced along all parallels. Parallels: Straight lines, equally-spaced along the central meridian. Poles: Points. Symmetry: Along the central meridian or the equator.
Scale	True along the central meridian and the equator.
Distortion	Moderate.
Origin	Presented by Peter Apian (Petrus Apianus or Peter Bienewitz) (1495-1552) of Saxony in 1524.
Use	Early maps of hemispheres.

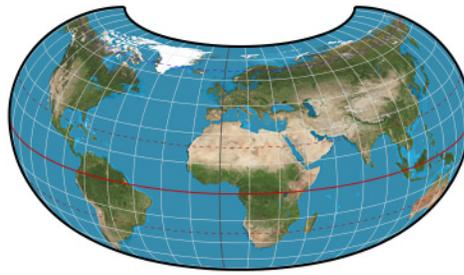
Apian globular II

Apianus globular I—See [Apian globular I](#)

Apianus globular II—See [Apian globular II](#)

armadillo

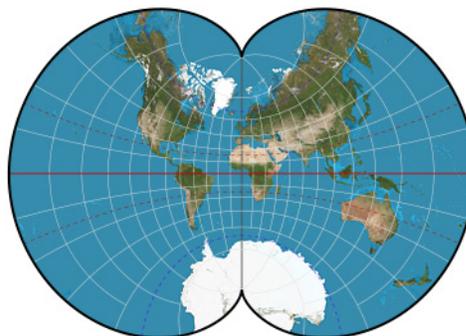
Description	Orthoapsidal (term coined by originator), neither conformal nor equal-area.
Synonyms	<i>Raisz</i>
Similar projections	Other ‘orthoapsidal’ projections proposed by Raisz in 1943. Raisz coined this term from orthographic and apsidal.
Other features	An oblique orthographic projection of the world plotted with equidistant meridians and parallels onto a portion of a torus ring (similar to a doughnut). Antarctic region cannot be shown, but the projection was claimed to have ‘more land in proportion to sea than any other world map’. Often plotted with New Zealand, normally hidden from view, appended to Australia as a ‘pigtail’.
Aspects	Oblique is the basic aspect.
Graticule	Meridians: Central meridian (10° or 15°E) is straight. Other meridians are elliptical arcs, concave toward the central meridian. Parallels: Elliptical arcs of the same eccentricity, concave toward the north pole. Poles: north pole is a semi-ellipse, south pole cannot be shown. Symmetry: About the central meridian.
Scale	Gradually decreases with distance from the center.
Distortion	Distortion is moderate in central positions.
Origin	Presented by Erwin J. Raisz (1893-1968) of Harvard University in 1943.
Use	Pictorial maps of the world.



armadillo

August epicycloidal

Description	Conformal.
Synonyms	<i>August</i>
Similar projections	<i>Eisenlohr</i> has a boundary of constant scale. <i>Van der Grinten IV</i> is not conformal and has circular arcs for meridians and parallels.
Other features	Boundary of the world map is a two-cusped epicycloid. Like the <i>Eisenlohr</i> projection, this projection has no 'singular' point at which conformality fails. Unlike the <i>Eisenlohr</i> , the map boundary as a varying scale.
Graticule	Meridians: Central meridian is straight. Other meridians are curved and concave toward the central meridian. Parallels: equator is straight. Other parallels are curved and concave toward the central meridian. Poles: Points. Symmetry: About the central meridian or the equator.
Scale	Increases rapidly with distance from the center.
Distortion	Great distortion of area toward the 180 th meridians in comparison with the center.
Aspects	Transverse oblique aspect used by Athelstan F. Spilhaus in 1942 to show a map of the world oceans.
Origin	Presented by F. August and G. Bellerman in Germany in 1874.
Use	Novelty world maps.

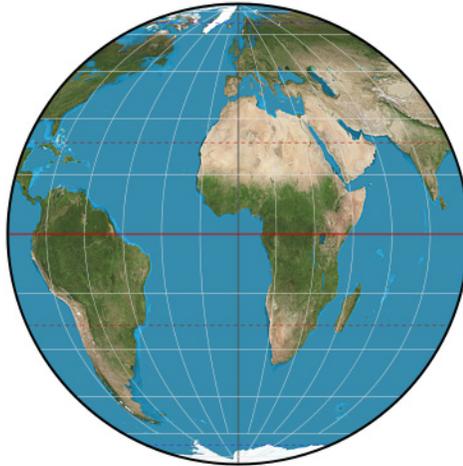


August epicycloidal

Bacon—See [Bacon globular](#)

Bacon globular *[Bacon]*

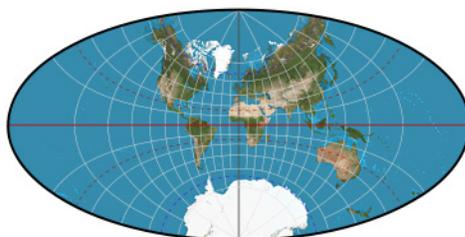
Description	Globular, neither conformal nor equal-area.
Similar projections	<i>Glareanus (Loritz globular)</i> projection of 1527 is identical. <i>Apian globular I</i> hemisphere of 1524 has straight parallels equally-spaced along the central meridian.
Graticule	Meridians: Central meridian is straight. Other meridians are circular arcs equally-spaced along the equator but not along other parallels. Parallels: Parallel straight lines equally-spaced on the meridians 90° from center. Poles: Points. Symmetry: About the central meridian or the equator.
Scale	True along the equator.
Distortion	Extreme area and shape distortion near the poles.
Origin	Presented by Roger Bacon (1214-1294) of England, about 1265, but unclear.
Use	Early hemispheric maps.



Bacon globular

conformal world in an ellipse *[elliptic conformal]*

Description	Conformal.
Similar projections	Lagrange would result with a β parameter of 0°, but that value is prohibited in Geocart.
Use	Academic, decorative.
Parameters	A parameter β describing the flatness of the ellipse.
Range	0° << β << 90°. Negative values produce an upside-down, reversed map.
Usual	20 << β << 50.

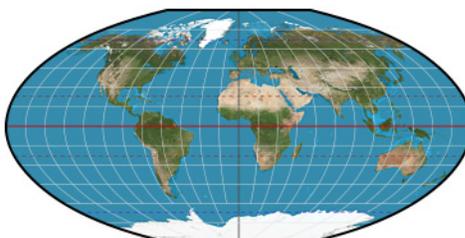


conformal world in an ellipse

Denoyer—See [Denoyer semi-elliptical](#)

Denoyer semi-elliptical [*Denoyer*]

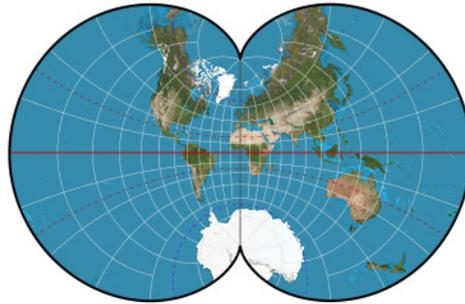
Description	Modified pseudocylindric, equally-spaced parallels, neither conformal nor equal-area.
Graticule	<p>Meridians: Central meridian is a straight line half as long as the equator. Other meridians are curves that are nearly elliptical arcs and nearly equally-spaced, with some spreading near the outer limits; all are concave toward the central meridian.</p> <p>Parallels: Equally-spaced, straight parallel lines. Perpendicular to the central meridian.</p> <p>Poles: Lines about 0.31 times the length of the equator.</p> <p>Symmetry: About the central meridian or the equator.</p>
Scale	True along the central meridian and the equator. Constant along any given latitude, same for latitude of opposite sign.
Distortion	Free of distortion along the equator.
Origin	Developed by L. Philip Denoyer of Chicago about 1920. Exact design basis not known. Empirical approximations are used for computer plots.
Use	By Denoyer-Geppert in thematic maps and atlases of the early and middle 20 th century.



Denoyer semi-elliptical

Eisenlohr

Description	Conformal.
Similar projections	<i>August epicycloidal</i> has a boundary of varying scale. <i>Van der Grinten IV</i> is not conformal and has circular arcs for meridians and parallels.
Other features	Because the boundary of a world map is at a constant scale, the projection provides the minimum overall scale variation for a conformal world map. Like the <i>August epicycloidal</i> projection, the <i>Eisenlohr</i> has no 'singular' points at which conformality fails.
Graticule	Meridians: Central meridian straight. Other meridians are curved and concave toward the central meridian. Parallels: equator is straight. Other parallels are curved and concave toward the nearest pole. Poles: Points. Symmetry: About the central meridian or the equator.
Scale	Increases rapidly with distance from the center. Constant scale around the boundary of a world map.
Distortion	Great distortion of area near the 180 th meridians in comparison with the center.
Origin	Presented by Friedrich Eisenlohr of Germany in 1870.
Use	Novelty whole-world maps.

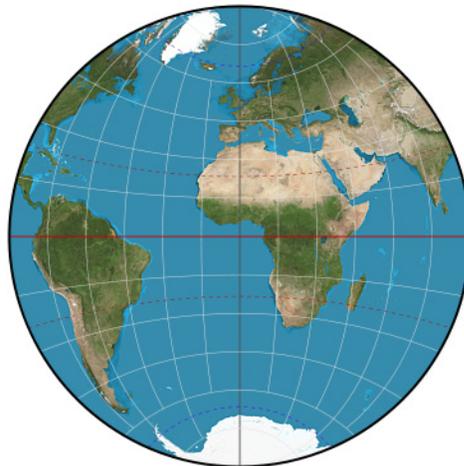


Eisenlohr

elliptic conformal—See [conformal world in an ellipse](#)

Fournier globular I

Description	Globular, neither conformal nor equal-area.
Similar projections	<i>Nicolosi globular</i> has circular arcs for meridians. <i>Mollweide</i> has straight parallels and is used for world maps, but meridians within one hemisphere are the same as those on <i>Fournier I</i> . <i>Azimuthal equidistant</i> (equatorial aspect) has complex curves for meridians and parallels.
Limitations	Unsuitable for more than a hemisphere.
Graticule	Meridians: Central meridian is straight. Other meridians are semi-ellipses equally-spaced along the equator but not along other parallels. Parallels: Parallel straight lines equally-spaced on the meridians 90° from center. Poles: Points. Symmetry: About the central meridian or the equator.
Scale	True along the central meridian and the equator.
Distortion	Moderate for a hemisphere.
Origin	Presented by Georges Fournier of France in 1643.
Use	Early whole-world or hemispheric maps.

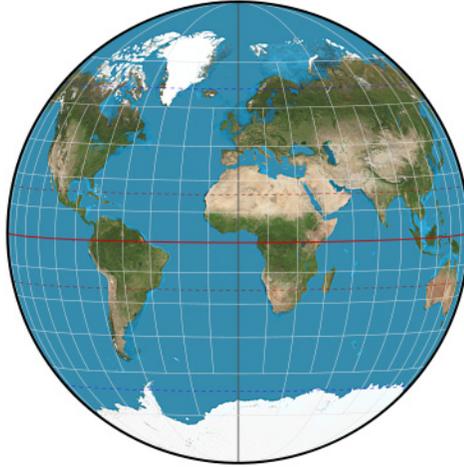


Fournier globular I

Gilbert two-world—See [Gilbert two-world perspective](#)

Gilbert two-world perspective [*Gilbert two-world*]

Description	Neither conformal nor equal-area. Presentation of nearly the entire globe in a perspective-looking circle.
Use	World maps.
Origin	Described by E.N. Gilbert of the USA around 1973. Expounded on by DeLucia & Snyder.



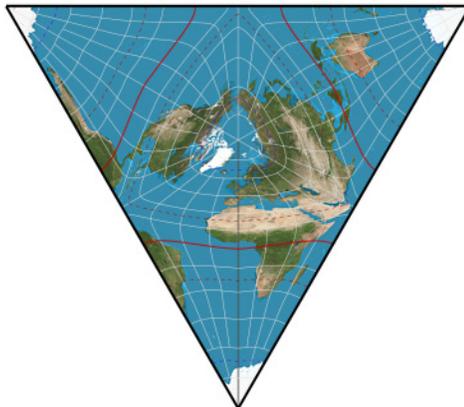
Gilbert two-world perspective

Ginzburg VIII—See [TsNIIGAiK](#)

Glareanus—See [Bacon globular](#)

great circle equal-area tetrahedron

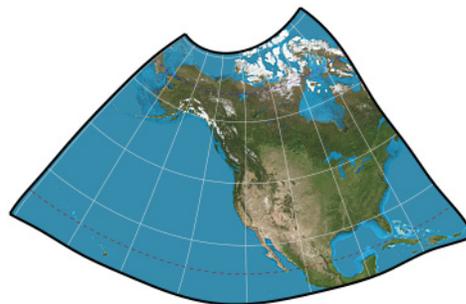
Description	Equal-area.
Similar projections	<i>small circle equal-area tetrahedron, Snyder equal-area tetrahedron</i>
Use	Fold-up tetrahedral “globe”.
Origin	Presented by Diederik van Leeuwen and Daniel “daan” Strebe in 2006.



great circle equal-area tetrahedron

GS50

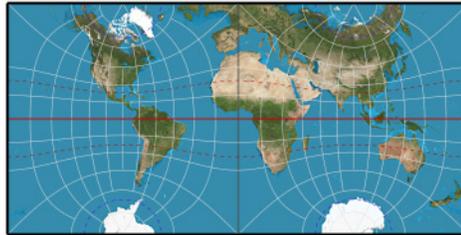
Description	Conformal.
Similar projections	<p><i>Oblated</i> (or <i>prolated</i>) stereographic projections by O.M. Miller in 1953 and by L.P. Lee in 1974 are equivalent to third-order complex-algebra polynomial modifications of the oblique <i>stereographic</i>, applied to continents or the Pacific Ocean.</p> <p><i>New Zealand Map Grid</i> presented by W.I. Reilly in 1973 is a sixth-order complex-algebra polynomial modification of the <i>Mercator</i>, applied to New Zealand.</p> <p><i>Modified stereographic conformal</i> projection developed by Snyder in 1983 is a sixth-order complex-algebra modification of the oblique <i>stereographic</i>, applied to Alaska.</p>
Limitations	Unsuitable for areas outside of the default boundaries.
Special properties	Portrays irregular region of 50 States at about one-fourth the variation in scale of the best standard projections. Uses tenth-order complex-algebra polynomials to modify the Stereographic projection and is practical only with a computer. Conformality is precise in these cases even though finite polynomial series are used. The coefficients are useful only for this design of a 50-state map.
Graticule	Meridians: Complex curves at slightly varying intervals. Parallels: Complex curves at slightly varying intervals. Poles: Points beyond the useful range of the map. Symmetry: None.
Scale	True along an irregular line approximately encompassing the regions of the 50 States of the United States. Varies less than 2% from true scale throughout the 50 States and adjacent bodies of water.
Distortion	Shape and scale distortion is very low for 50-State region. Greater distortion for regions away from 50 States.
Origin	Developed by John P. Snyder (1926-) of the US Geological Survey in 1982.
Use	Very low distortion maps of the entire United States.



GS50

Guyou

Description	Conformal.
Similar projections	The <i>Peirce quincuncial</i> in transverse aspect. The <i>Adams hemisphere in a square</i> in oblique aspect.
Other features	Shows hemisphere conformally in a square and the world in a 2 x 1 rectangle. Hemispheres can be applied in mosaic form to form a continuous map indefinitely.
Graticule	Meridians: Central meridian is straight. The 90 th meridians are straight, but bent at the 45 th parallels N and S. Other meridians are complex curves. Parallels: equator is straight. Other parallels are complex curves. Poles: Points, in the midpoint of opposite sides of a square bounding a hemisphere. Symmetry: About the central meridian and the equator.
Scale	Varies considerably along each meridian and parallel.
Distortion	Great distortion of area, especially near the 90 th meridian at latitudes 45°N or S where conformality fails.
Aspects	A transverse aspect is the <i>Peirce quincuncial</i> projection. An oblique aspect is the <i>Adams hemisphere in a square</i> .
Origin	Presented by Emile Guyou of France in 1887.
Use	Novelty maps of a hemisphere or the world.

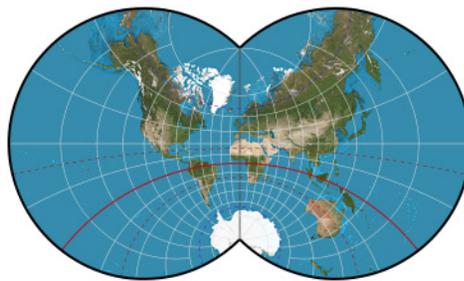


Guyou

Loritz globular—See [Bacon globular](#)

Lagrange

Description	Polyconic, conformal.
Similar projections	<i>Van der Grinten I</i> is not conformal.
Special forms	Equatorial or oblique <i>stereographic</i> projection. <i>Littrow</i> projection.
Other features	The general formula can be used to create a variety of conformal maps.
Parameters	Two parameters, φ_1 giving the parallel of the center line, and β describing the \pm longitude that forms a circle.
Range φ_1	$-90 \ll \varphi_1 \ll 90$.
Usual φ_1	$\varphi_1 = 0^\circ$.
Range β	$-180^\circ \leq \beta \leq 180^\circ$; $\beta \neq 0$. A negative value results in an upside-down map. $\beta = 90^\circ$ results in Stereographic. With $ \beta \leq 90^\circ$ the outside boundary must be decreased from the full globe because the map's size becomes infinite.
Usual β	$90^\circ \ll \beta \leq 180^\circ$.
Graticule	Meridians: Central meridian is straight. Other meridians are circular arcs, concave toward the central meridian. Parallels: One parallel, often the equator, is straight. Other parallels are circular arcs, concave toward the pole which is on the same side of the straight parallel. Poles: Points. Symmetry: About the central meridian. Also about the equator, if the equator is straight.
Scale	Increases rapidly with distance from the center.
Distortion	Great distortion of area and scale when the center is compared with poles and other outer limits. Conformality fails at the poles.
Origin	Johann Heinrich Lambert (1728-1777) of Alsace presented the world conformally in a circle in 1772. However, this projection is usually called the <i>Lagrange</i> projection after Joseph Louis Lagrange (1736-1813) of France, who generalized Lambert's concept in 1779.
Use	Whole-world maps and conformal maps within a circle of smaller portions of the world.



Lagrange

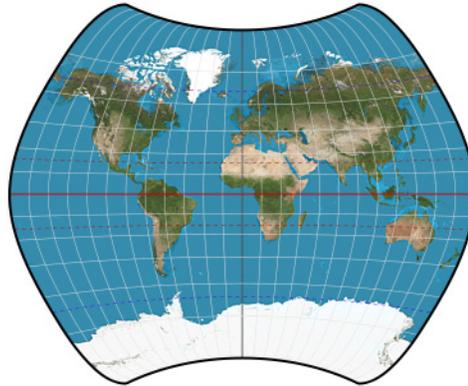
Larrivée

Description

Neither conformal nor equal-area.

Use

Reference world maps.



Larrivée

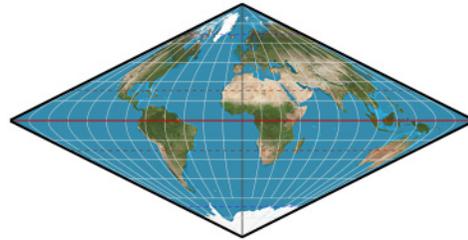
lateral equidistant

Description

Academic, decorative.

Special properties

In equatorial aspect, distances from any point on the central meridian to a second point at the same latitude are correct.



Lateral equidistant

Loritz globular—See [Bacon globular](#)

Nicolosi globular—See [Al-Birūnī](#)

Ortelius oval

Description

Oval, modified pseudocylindric, neither conformal nor equal-area.

Synonyms

Often confused with *Eckert III*, which has elliptic arcs for meridians.

Apian globular I is the same for one hemisphere.

Bordone oval projection of 1528 has points for poles and near-ellipses or ovals for meridians, but is otherwise very similar.

Graticule

Meridians: Central meridian is straight. Other meridians are circular arcs, becoming semicircles between the meridians 90° and 180° from the central meridian. Equally-spaced along the equator, but not along other parallels.

Parallels: Straight lines, equally-spaced on the central meridian.

Poles: Lines half the length of the equator.

Symmetry: Along the central meridian or the equator.

Scale

True along the central meridian and the equator.

Distortion

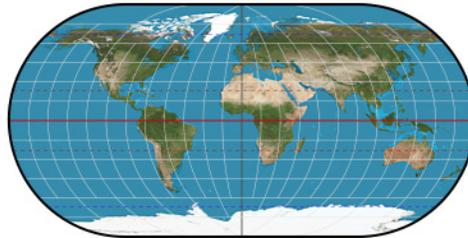
Moderate.

Origin

Battista Agnese (1514-1564) used the projection in 1544, but the name comes from Abraham Ortelius (1527-1598) of Flanders, who used it in 1570.

Use

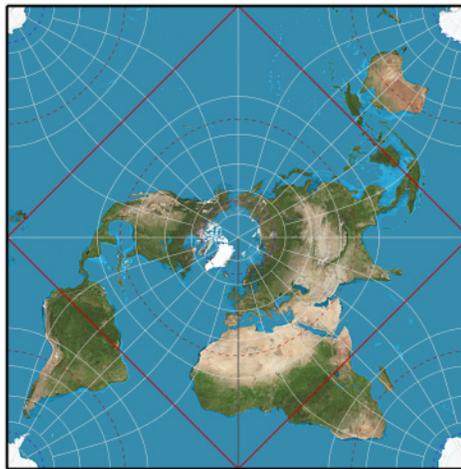
16th century whole-world maps.



Ortelius oval

Peirce quincuncial

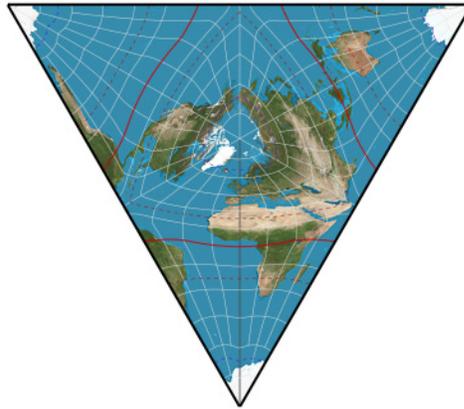
Description	Conformal.
Synonyms	<i>Quincuncial</i> , name applied by Peirce, because there are normally five parts within a square (the northern hemisphere is in the center, and four parts of the southern hemisphere are in the corners).
Similar projections	<i>Guyou</i> <i>Adams hemisphere in a square</i> (refer to Aspects section below).
Other features	A 'star' projection in the polar aspect. Shows a polar hemisphere conformally in a square and the world in a larger square. The first use of elliptic functions for a map projection.
Graticule	Meridians: Every 90 th meridian is straight but bent at the equator. Other meridians are complex curves. Parallels: equator is a square, bent at the straight meridians. Other parallels are complex curves. Poles: Points at the center of each hemispherical map. Symmetry: About the central meridian or the equator.
Scale	Varies considerably along each meridian and parallel.
Distortion	Great distortion of area, especially near each 90 th meridian at the equator, where conformality fails.
Aspects	In polar form, the pole is at the center of a square. In transverse form, placing the pole at the midpoint of one side of a square results in the <i>Guyou</i> projection. Placing the pole at the corner of the square results in the Adams projection of a hemisphere in a square.
Origin	Presented by Charles Sanders Peirce (1839-1914) of the US Coast and Geodetic Survey in 1879.
Use	Novelty whole-world maps.



Peirce quincuncial

small circle equal-area tetrahedron

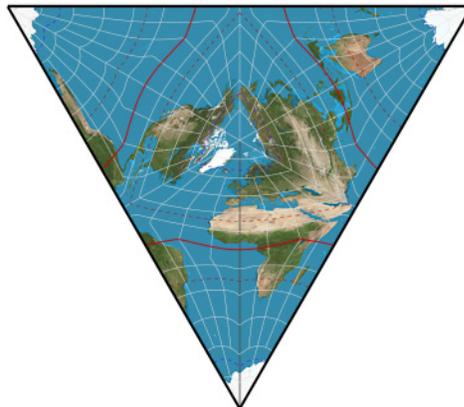
Description	Equal-area. One instance of the more general <i>van Leeuwen</i> projection.
Similar projections	<i>great circle equal-area tetrahedron</i> , <i>Snyder equal-area tetrahedron</i>
Use	Fold-up tetrahedral “globes”.
Origin	Presented by Diederik van Leeuwen and Daniel “daan” Strebe in 2006.



small circle equal-area

Snyder equal-area tetrahedron

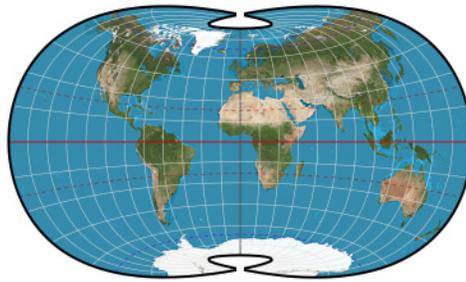
Description	Equal-area. One instance of the more general <i>van Leeuwen</i> projection.
Similar projections	<i>great circle equal-area tetrahedron</i> , <i>small circle equal-area tetrahedron</i>
Use	Fold-up tetrahedral “globes”.
Origin	Presented by John P. Snyder in 1992.



Snyder equal-area tetrahedron

tri-optimal

Description	A good balance between equivalence, conformality, and scale fidelity.
Use	Academic.
Origin	Presented by Piotr Laskowski, 1991.



tri-optimal

TsNIIGAiK

Native name

ЦНИИГАиК

Synonyms

Ginzburg VIII

Description

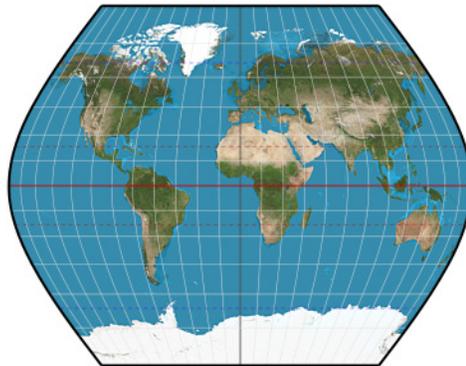
Called *TsNIIGAiK pseudocylindric* in Russia, the projection is not actually pseudocylindric because meridian spacing along parallels is inconstant. The name is the initials of the *Tsentrāl'nyy Nauchno-issledovatel'skiy Institut Geodezii, Aerofotošemki i Kartografii* = *Central Scientific Research Institute of Geodesy, Aerial Photo Survey and Cartography*.

Origin

Presented by G.A. Ginzburg in 1944.

Use

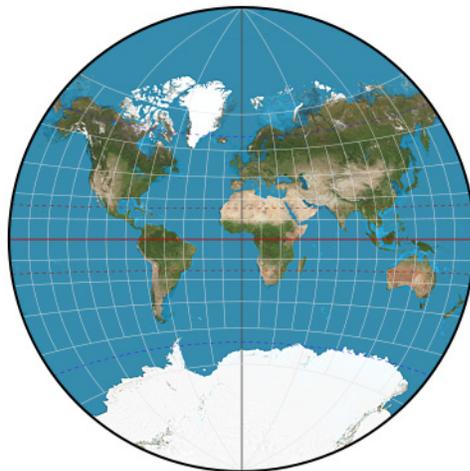
Maps from the Soviet Union with central meridian set to 70°E.



TsNIIGAiK

van der Grinten I

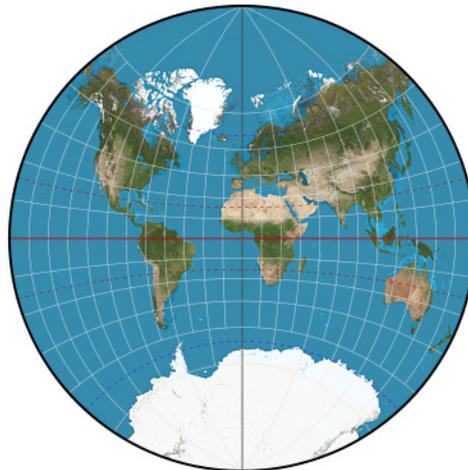
Description	Polyconic, neither conformal nor equal-area.
Synonyms	<i>van der Grinten</i>
Similar projections	<i>Lagrange</i> is conformal. <i>Van der Grinten II</i> has parallels curved to intersect meridians at right angles. <i>Mercator</i> is conformal and has straight meridians and parallels.
Other features	The world is enclosed in a circle.
Graticule	Meridians: Central meridian is straight. Other meridians are circular, equally-spaced along the equator and concave toward the central meridian. Parallels: equator is straight. Other parallels are circular arcs, concave toward the nearest pole. Poles: Points. Symmetry: Along the central meridian or the equator.
Scale	True along the equator. Increases rapidly with distance from the equator.
Distortion	Great distortion of area near the poles.
Origin	Presented by Alphons J. van der Grinten (1852-?) of Chicago in 1898. US patent obtained in 1904.
Use	World maps by the US Department of Agriculture, the US Geological Survey, the National Geographic Society and others. Usually a frame limits the north/south extent of the map.



van der Grinten I

van der Grinten II

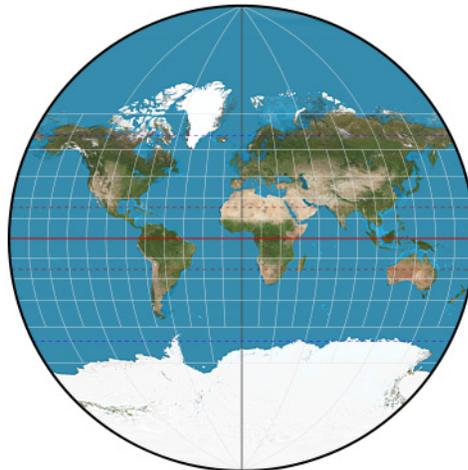
Description	Polyconic, neither conformal nor equal-area.
Similar projections	<i>Lagrange</i> is conformal. <i>Van der Grinten I</i> has parallels that do not intersect meridians at right angles.
Other features	The world is enclosed in a circle. All meridians intersect parallels at right angles, but projection is not conformal. Spacing of parallels along the central meridian is the same as that for <i>van der Grinten I</i> .
Graticule	Meridians: Central meridian is straight. Other meridians are circular, equally-spaced along the equator and concave toward the central meridian. Parallels: equator is straight. Other parallels are circular arcs, concave toward the nearest pole. Poles: Points. Symmetry: About the central meridian or the equator.
Scale	True on the equator. Increases rapidly with distance from the equator.
Distortion	Great distortion of area near the poles.
Origin	Presented by Alphons J. van der Grinten (1852-?) of Chicago in 1904.
Use	World maps, but rarely.



van der Grinten II

van der Grinten III

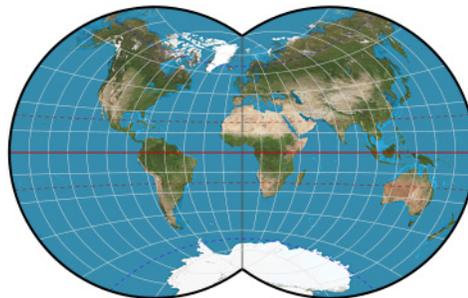
Description	Modified pseudocylindric, neither conformal nor equal-area.
Similar projections	<i>Van der Grinten I</i> has curved parallels. <i>The Times</i> by Moir, has nearly elliptical meridians, but straight parallels are spaced like those of the <i>Gall</i> projection.
Other features	The world is enclosed in a circle. Spacing of parallels along the central meridian is the same as that for <i>van der Grinten I</i> .
Graticule	Meridians: Central meridian is straight. Other meridians circular, equally-spaced along the equator but unequally-spaced along other parallels and concave toward the central meridian. Parallels: Straight lines. Poles: Points. Symmetry: About the central meridian or the equator.
Scale	True along the equator. Increases rapidly with distance from the equator.
Distortion	Great distortion of area near the poles.
Origin	Presented by Alphons J. van der Grinten (1852-?) of Chicago in 1904.
Use	World maps, but rarely.



van der Grinten III

van der Grinten IV

Description	Polyconic, globular, neither conformal nor equal-area.
Synonyms	<i>apple-shaped</i>
Similar projections	<i>Eisenlohr</i> is conformal. <i>August epicycloidal</i> is conformal.
Other features	The 90 th meridians form a complete circle.
Graticule	Meridians: Central meridian is straight. Other meridians are circular, equally-spaced along the equator and concave toward the central meridian. Parallels: equator is straight. Other parallels are circular, equally-spaced on the central meridian and concave toward the nearest pole. Poles: Points. Symmetry: About the central meridian or the equator.
Scale	True along the central meridian and the equator.
Distortion	Great distortion of area near the 180 th meridians at higher latitudes.
Origin	Presented by Alphons J. van der Grinten (1852-?) of Chicago in 1904.
Use	World maps, but rarely.



van der Grinten IV

van Leeuwen

Description

Equal-area.

Use

Fold-up tetrahedral “globes”.

Parameters

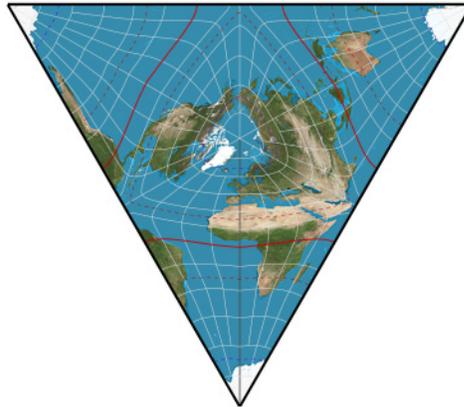
Enumeration of variants: small-circle, great circle, and Snyder.

Usual

Great-circle yields mildest kinks at the quadrant boundaries, and low distortion.

Origin

Presented by Diederik van Leeuwen and Daniel “daan” Strebe, 2006.



van Leeuwen

Appendix C: Working with Adobe Illustrator®

Geocart's primary purpose is to provide you with the best possible base map so that you can complete your map using whatever graphics program suits your map's needs. If you will be manipulating the line work of the map to add extra details such as area coloring and place names, you will probably finish your map using an illustration program such as Adobe Illustrator.® This appendix describes how to work with such illustration programs.

To edit the line work in your map, you need to export it to PDF format. The graphics editing program must be able to edit PDF files.

Resolution

Before exporting, you should change the horizontal and vertical resolution of the map to the final values you need by modifying the values in the *Resolution* section of the [Map Size and Resolution dialog](#) from the **Map** menu. Larger values will give more detail, up to the limit of the detail in the database. Larger numbers will also take proportionately longer to save and will create bigger files. In choosing an appropriate resolution, you may have to experiment to find the correct balance between the detail you need and a file size you can tolerate. Usually, when exporting for completion in an illustration program, you will want to leave the *Generalize Vectors* option checked in the **Map** menu.

Exporting

You may export selected maps, or you may export the entire document. To export maps for use in an illustration program:

1. Select the map or maps you wish to export. On the **File** menu, select *Export Selected Items*. That will cause the **Choose a file name and type to export to dialog** to be displayed.

– OR –

On the **File** menu, select *Export Document*. That will cause the **Choose a file name and type to export to dialog** to be displayed.

2. In the file browser, navigate to the folder in which you want to save your document.
3. In the *Export as* field, enter a file name (Geocart will give it a default file name of *Untitled*).
4. In the *Export Format* section, select the *PDF* export data format. Click *OK*.

You should experiment to find line weights that work best with your printing or imaging environment. What works well on a published map is unlikely to suit a Web JPEG image, for example. You have complete control over line weights for the vector database coverages and computed lines that you tell Geocart to draw. Please see the description of the [Line Styles facility in Chapter 9: Map menu](#).

Geocart does not participate in a color-managed workflow. It does not embed color profiles in the TIFF and JPEG images it produces; nor does it utilize the profiles in imagery it consumes. This omission stems largely from the lack of color management in most source imagery that Geocart works with. You should treat output from Geocart as if it had the same color profile as the input, and assume by default that output created from input lacking a color profile is best treated as sRGB colorspace, and adjust your downstream workflow accordingly. When using multiple sources of imagery in a single map, ensure all inputs are in the same colorspace for best results. Please see the documentation for your illustration software if you need managed color.

Cleaning up the PDF

Because Geocart cannot write files in the native Illustrator format, you might find the structure of the raw PDF file cumbersome to work with inside of Illustrator. Geocart's installation includes a script that, when applied to PDF files created by Geocart, rearranges their structure. Specifically, each group is moved into its own layer and clipping masks are removed. You can find the script here (Macintosh):

```
/Library/Application Support/Mapthematics/Geocart/Version 3/  
Sample Documents/GeocartLayers.jsx
```

Windows XP:

```
C:\Documents and Settings\All Users\Application Data\Mapthematics\  
Version 3\Sample Documents\GeocartLayers.jsx
```

Windows Vista/Windows 7:

```
C:\ProgramData\Mapthematics\Geocart\Version 3\  
Sample Documents\GeocartLayers.jsx
```

To run the script, from Illustrator, open the PDF you exported from Geocart. If you have more than one document open in Illustrator, make sure the document you want to clean up is the current document that you are editing. From Illustrator's **File** menu, select **Scripts -> Other Script...** . Navigate to the the GeocartLayers.jsx file and select it. The script should complete momentarily, and the document will be restructured. You may commence editing it.

Creating closed polygons before filling a shape with color

Except for islands or lakes, the shapes you want to color may not be completely connected all the way around. For instance, when you use the *intl borders* database, the borders between countries are not explicitly connected to the shoreline. In the example below, the lines defining the state of California are unconnected segments. If you want to fill the state with color, you must connect the lines to form a closed path.

One method for doing this using Adobe Illustrator is shown below.

1. **Copy** all the lines that make up the shape.
2. Create a new document and place the lines into it by using **Paste in Front**. This will ensure that the objects in the new document are in register with the old.
3. Use the scissors tool to cut off all the lines that are not part of the border of the shape.

As you are working, you may be confronted with the following error message:

Can't split the path. Please use the scissors tool on a segment or an anchor point (but not an endpoint) of a path.

The problem is that the end of one line is in front of the line you are trying to cut.

1. Select the line you want to cut with the arrow tool.
2. On the **Object»Arrange** menu, select **Bring to Front**.

Result: You should now be able to cut the line.

After deleting all the unwanted line segments, you must join the lines to form a closed shape.

1. Start by clicking on a line segment. You will be able to see where it starts and ends.
2. As in the example below, use the arrow tool to draw a marquee around one end of the selected line. This will select the end points of the two lines.

3. You can now use the Join command from the Arrange menu to join the two lines. If the two end points happen to be exactly in the same spot, you will get a dialog box asking which type of corner point to use. The default is usually the one you should choose.
4. Continue until you have closed all the shapes.

When you have finished one shape, use *Cut* on the **Edit** menu and paste it into another document to store it and the other shapes you will be finishing. You may find that working with three documents is very efficient. The first holds the original map, the second holds each shape as you edit it, and the third is for storing the finished shapes. Be sure to clear the second document every time you start a new shape. In this particular example, it takes about half an hour for an experienced user to color and assemble all the states.

Appendix D: Coverage mapping files

Vector databases come from a variety of sources. You might even make your own. Geocart needs to know what line styles, such as the line thickness and color, to use when drawing the objects from a vector database. Line styles are assigned by *data coverage*. Coverages are the various kinds of lines with distinct geographic semantics, such as “rivers”, “contours”, “coastlines”, “national boundaries” and so forth. You can control how Geocart interprets the coverage of a vector database either by forcing it to a specific coverage in the *Database* dialog using the *Assign Coverage...* button, or by matching the file name to a pattern in a *coverage mapping file*. This appendix describes how to make and use coverage mapping files.

As described in Chapter 9: *Map menu*, the [Line Styles](#) dialog presents a hierarchy of coverages to assign line styles to. A sample of a coverage hierarchy might look like this:

```
Rivers
  Perennial
    Major rivers
    Minor rivers
    Streams
  Seasonal
    Rivers
    Streams
  Subterranean
```

Geocart installs a standard set of coverage mapping files that reflect the databases Mapthematics supplies. You may edit these files if wish, or you may add new files that reflect the attributes of databases from other sources. In aggregate, these files determine the coverage *schema*, meaning the complete set of coverages with their hierarchical relationship, recognized by Geocart at the time it launches.

Consider this first set of database file names:

```
10m-admin-0-boundary-disputed-areas.shp
10m-admin-0-boundary-lines-land.shp
10m-admin-0-boundary-lines-map-units.shp
10m-admin-0-boundary-lines-maritime-indicator.shp
10m-admin-0-boundary-lines-maritime.shp
10m-admin-0-breakaway-disputed-areas-with-scale-ranks.shp
10m-admin-0-breakaway-disputed-areas.shp
10m-admin-0-countries.shp
10m-admin-0-map-subunits.shp
10m-admin-0-map-units.shp
10m-admin-0-pacific-groupings.shp
10m-admin-0-scale-ranks-with-minor-islands.shp
10m-admin-0-scale-ranks.shp
10m-admin-0-sovereignty.shp
10m-admin-1-states-provinces-lines-shp.shp
10m-admin-1-states-provinces-shp.shp
10m-populated-places.shp
10m-urban-area.shp
50m-admin-0-boundary--breakaway-disputed-areas.shp
50m-admin-0-boundary-lines-land.shp
50m-admin-0-boundary-lines-maritime-indicator.shp
50m-admin-0-boundary-map-units.shp
50m-admin-0-breakaway-disputed-areas.shp
50m-admin-0-countries.shp
50m-admin-0-map-subunits.shp
50m-admin-0-map-units.shp
50m-admin-0-pacific-groupings.shp
50m-admin-0-scale-ranks.shp
50m-admin-0-sovereignty.shp
50m-admin-0-tiny-countries.shp
50m-admin-1-states-provinces-lines-shp.shp
50m-admin-1-states-provinces-shp.shp
50m-populated-places.shp
50m-urban-area.shp
```

The 10m- designation refers to data suitable for mapping at 1:10,000,000 scale. Likewise the 50m- designation refers to data suitable for mapping at 1:50,000,000 scale. But stripping off those prefixes, we see identical file names, and we can tell they mean the same coverage.

Now consider this second set of database file names as well:

```
Noamer folder
  PO-88-9 Connect, tile
  PO-11-2 Ocean/Ice, approx
  PO-13-9 Date, tile
  PO-10-2 Coast, approx
  PO-10-6 Coast, ice cliff
  PO-9-2 Ice, approx
  PO-10-1 Coast, def
  PO-7-9 Coast closure, tile
  PO-8-8 Ocean, connect
  PO-6-1 DMZ, def
  PO-4-7 Prov, riv bound
  PO-4-8 Prov, connect
  PO-4-2 Prov, approx
  PO-4-1 Prov, def
  PO-1-8 Nation, connect
  PO-1-7 Nation, riv bound
  PO-1-2 Nation, approx
  PO-1-1 Nation, def
  PO-?-9 Misc, tile
Eurnasia folder
  PO-?-9 Misc, tile
  PO-1-1 Nation, def
  PO-1-2 Nation, approx
  PO-1-3 Nation, indef
  PO-1-7 Nation, riv bound
  PO-1-8 Nation, connect
  PO-4-1 Prov, def
  PO-4-7 Prov, riv bound
  PO-4-8 Prov, connect
  PO-5-1 Sub Prov, def
  PO-5-7 Sub Prov, riv bound
  PO-5-8 Sub Prov, connect
  PO-6-1 DMZ, def
  PO-6-3 DMZ, indef
  PO-7-4 Coast closure
  PO-7-9 Coast closure, tile
  PO-8-8 Ocean, connect
  PO-9-2 Ice, approx
  PO-10-1 Coast, def
  PO-10-2 Coast, approx
  PO-10-3 Coast, indef
  PO-10-4 Coast
  PO-11-2 Ocean/Ice, approx
  PO-12-4 Seawall
  PO-13-9 Date, tile
  PO-88-9 Connect, tile
```

These two sets of files are from different sources. They have their own internal logic for how files get named and completely different notions of coverages, but in both cases the filenames reflect the coverage. Coverage mapping files express how to map a file name to a coverage. In both sets we see that there is more in the name than just the coverage. 10m-admin-0-, for example, reflects other information that is (perhaps) irrelevant to coverage; it is what comes afterward that is important. Likewise in the second set, we see some identical file names in both folders. Those coverages are the same. The basic idea in a coverage mapping file is that a pattern appearing in a file name gets mapped to a named coverage. So, for example, these two lines in a coverage file...

```
"Coverage|Political|Countries", "*countries.shp"
"Coverage|Political|Countries", "*Nation, def"
```

...state that files with names that end in countries.shp and Nation, def are to be treated as Countries within the taxon of Political coverages. The asterisks (*) are "wildcards", meaning they will match any sequence of characters in that position as long as the file name ends in countries.shp.

Coverage mapping files are found in a folder called Coverages within either or both of the installed database location or the user database location, as follows.

Macintosh user-specific:

`/Users/<account name>/Library/Application Support/Mapthematics/Geocart/Databases/Coverages/`

Macintosh all users:

`/Library/Application Support/Mapthematics/Geocart/Databases/Coverages/`

Windows XP user-specific:

`C:\Documents and Settings\<account name>\Application Data\Mapthematics\Databases\Coverages\`

Windows XP all users:

`C:\Documents and Settings\All Users\Application Data\Mapthematics\Databases\Coverages\`

Windows Vista+ user-specific:

`C:\Users\<account name>\AppData\Local\Mapthematics\Databases\Coverages\`

Windows Vista+ all users:

`C:\ProgramData\Mapthematics\Databases\Coverages\`

Geocart aggregates all coverage files in both the user-specific location and the all-users location in order to create the schema. When editing the *New Map Line Style* preference, the entire schema will appear in the *Line Styles* dialog. However, when editing line styles for a given map, only the coverages that show up in that map's databases will appear in the *Line Styles* dialog. This keeps the list of styles manageable and relevant.

Coverage mapping file syntax

A coverage mapping file is a UTF-8-encoded text file consisting of lines of text. A line may end in CR (U+0D), LF (U+0A), or both. A line may be a *comment* or a *declaration* or empty. A comment is denoted with a line whose first character is colon (:); such a line is ignored by Geocart.

If a non-empty line does not start with colon, then it is a declaration. A declaration may have one or two fields. Each field is a string of characters within straight double quotes (“”). If there are two fields, they are separated by a comma (,). Any whitespace before, between, or after each field is ignored up until the line ending. If a double quote is needed within a field, it must be “escaped” by using two double quotes in succession (“”).

The first field is the coverage declaration. The text between double quotes declares a coverage lineage, with the most general taxon to the left and progressing to the most specific taxon at the right. Taxons are separated by the vertical bar (|).

If there is a second field, then it is the file name pattern. The text between double quotes declares a pattern to match in file names. Any file that matches the pattern will be assigned the coverage declared in the first field. A pattern consists of literals, single-character wild cards, and arbitrary-length wild cards. Literals are simply the characters that are to match a portion of the file name exactly. The single-character wild card, question mark (?), will match any single character. The arbitrary-length wild card, asterisk (*), will match any number of characters.

A coverage mapping file's name in the file system must end with .coverage.txt.

Appendix E: Creating vector databases

You can create your own line work (vector) databases to use with Geocart. The databases are written as a text file, with records in a strict format. The records typically describe polygonal regions. You can assign the coverage trait for a text database just like any other database; see the [Databases functionality described in Chapter 9: Map menu](#). If you do not assign a coverage there, it will have the *Coverage/Unspecified* coverage by default.

You can use any standard text editor or word processor to create such file, but you must save the resulting file as a text (.txt) file, rather than in the native format of the word processor. Refer to your word processor or text editor manual for details on how to do this.

Each record begins with two names:

1. The first name is an identifier composed of 16 characters or less that is shared by no other object in any file that you will be using at the same time. A **tab** follows the identifier.
2. The second name is whatever title you would like the feature to have when it is printed on a map. A **tab** also follows the second name. At present, Geocart ignores both of these names, but future versions may make use of them.
3. Following the second **tab** is the number n of line segments in the polygon that defines the named region.
 - If $n < 0$, then the region is unclosed (such as a river), rather than a polygon.
 - If $n = 1$, then the region is a point, but Geocart does not treat it specially.
 - If $n = 2$, then the region is a circle with the radius given by the second point, but at present Geocart handles this case incorrectly; rather it interprets the radius as another coordinate, giving unpredictable results.
 - If $n \geq 3$, then the region is a polygon, in which case the final coordinate should equal the initial. Geocart does not treat polygons any differently than unclosed regions at present.
4. After n comes the end-of-line character **eol** (character 13 = 0D₁₆) or line-feed **lf** (character = 0A₁₆) or both. Typing `return` in any text editor should be usable.
5. The next n lines hold the longitude/latitude coordinates of the line segments in the polygon. The left number gives the longitude and the right number gives the latitude, and the two are separated by a **tab**. The numbers are in floating point format (not ° ' ") with any number of digits, and west and south are denoted by negative values. The first coordinate of a record will have the pen moved to it and following coordinates will all be drawn to.

A file consists of a consecutive set of these records. The final coordinate of the final record must be followed by an **eol**.

The following illustrates two simple records:

```
continent:Hexland      Hexland      7
-6.0                  -10.3923
-12.0                 0.0
-6.0                  10.3923
6.0                   10.3923
12.0                  0.0
6.0                   -10.3923
-6.0                  -10.3923
city: Triangle        Triangle      4
0.0                   0.0
-6.0                  -10.3923
6.0                   -10.3923
0.0                   0.0
```


Appendix F: Typesetting databases

Geocart 3 can read typesetting databases: files that contain text to be placed on a map. The databases contain the coordinates at which to place the text, details for the typeface, font size, color, and other attributes. This section documents the database format. Geocart will be able to read files that follow these conventions, but the subset of features actually supported is less. Currently unsupported features are marked with [INOPERATIVE].

Geocart supports only TrueType and OpenType fonts. These generally have filename extensions of .ttf or .otf. Refer to **Available Fonts** on the **Help** menu in Geocart for a list of fonts in your environment that Geocart can use.

A typesetting database consists of ASCII text. Line ends may be **carriage return** or **carriage return + line feed**. The first line must be as follows:

```
Geocart Typesetting Data Base Version x
```

This specification constitutes Version 1.

Fonts may be declared as a header to the file by using a “%” annunciator as the first character of the line. Each font declaration consumes one line, and the fields of the declaration are separated by white space. Fields may not be omitted.

fontCode	An identifying code for this font declaration [<i>Integer</i> ≥ 0]. Consecutive ordering is not required.
typeface	The PostScript name of the typeface for the name or symbol. The PostScript name can be found by clicking Available fonts on the Help menu in Geocart. Correct names can be obtained by having the printer print a font list. [<i>Quoted string</i>]
fontSize	Point size of the name or symbol. [<i>Floating point</i>]
fontStyle	A code for the style of the geographic name. [<i>Bit field</i>] 0 = no style 1 = all capitals 2 = outline characters 4 = underline 8 = dashed underline 16 = follow curvature of parallel [INOPERATIVE]
fontColor	Color for the name or symbol. Four integers separated by white space in CMYK order representing CMYK values, each $0 \leq \text{color} \leq 100$.
fontTracking	The amount of space between characters of the name or symbol. [<i>Floating point</i>]

The body of the database also has fields separated by white space and each field consumes one line. Fields may be omitted starting with the field to the furthest right, but the coordinate and the place name are required. Omitted fields assume values of the last declared values in that field. A line may be declared to be a comment by setting a colon “:” to be the leading character.

λ	Longitude in degrees expressed as a decimal; negative is west.
φ	Latitude in degrees expressed as a decimal; negative is south.
name	The geographic name to be placed. [<i>Quoted string</i>] Note: The text encoding of geographic names must be in Unicode UTF-8.

pos	Position of name with respect to coordinate. 1 is top left, and digits proceed from left to right, top to bottom. A value of 0 signifies automatic placement, which is [INOPERATIVE]. [<i>Single digit</i>]
nameFont	The code of the styled font to be used for the geographic name. [<i>Integer</i>]
symbol	Actual symbol to place at <i>pos</i> with respect to the coordinate. <i>Unquoted String</i> or "" to signify no symbol. Back-slash "\ (without quote marks) to render a point location for a city. Size and color of the point is controlled by the <i>Coverage/Cities</i> coverage in the Line Styles dialog box on the Map menu in Geocart. Note: The text encoding must be in Unicode UTF-8.
symbolFont	The code of the styled font for the symbol. [<i>Integer</i>] Style and tracking values are ignored.
rotation	Degrees to rotate text counterclockwise using <i>pos</i> as a pivot. This setting overrides the parallel curvature setting of the font. [INOPERATIVE]
arc	Radius of arc to weld text to, measured in millimeters. A value of 0.0 defeats the setting. This setting overrides the parallel curvature setting of the font. [INOPERATIVE]

Example database

Geocart typesetting Data Base Version 1

```

%0      "Times-Roman"          9.5  17   0   0   0   100  3
%1      "AvantGarde-BookOblique"  16  16  100  100  0   0   5
%2      "Symbol"              12   0   0   0   0  100  0
: End of font declarations
0      -90.0      "South Pole"          1   2   +   2
17.32  23.492    "Africa"              3   0   ""
-180   30.0      "North Pacific Ocean"  5   1   ""   0   0   200

```

Appendix G: Managing your databases

Database files contain the raster imagery and vector data that Geocart uses for drawing maps. You can select a file from anywhere on your computer to use as a database by clicking *Add Any Database* in Geocart's **Databases** dialog. However, Geocart recognizes two special places for databases on your computer:

- A system-wide folder, where databases can be installed for all users. This is the folder you'll first see if you click *Add Installed Database* in the **Databases** dialog.
- A per-user folder appropriate for personal databases. This is the folder you're taken to when you click *Add User Database* in the **Databases** dialog.

The advantage of keeping database files in these special folders is that it helps Geocart find databases used in saved Geocart documents. Geocart can find those databases automatically even when you move documents between machines. If instead you use a database from some arbitrary folder on your computer, and then move the document to another machine, Geocart will not be able to find the database unless it is in an identical location on the other machine. In that case, Geocart will tell you the database is missing and you will have to use the *Relink* option in the **Databases** dialog to show Geocart new location.

The remainder of this appendix will explain where these two folders are located are on your computer, and how to make them visible on Windows (they're not hidden on the Mac). If you know where they are, you will be able to manage the files manually from the Macintosh Finder or Windows Explorer. In particular, if you want to make changes to the coverage definition files, you will need to be able to find them. Unlike databases, they must reside in the *Coverages* folder of system or user database folder, and not in an arbitrary location.

Macintosh Information

Databases Installed for All Users

The database files in the folder:

```
/Library/Application Support/Mapthematics/Databases
```

are available to all user accounts on the computer. This is the folder displayed when you click *Add Installed Database* in the **Databases** dialog. Geocart's **Required Databases** installer (see [Installing Required Databases, Chapter 1: Setup](#)) installed its database files here, and so did any Supplemental Databases installers that you opted to install for all users. You can add other databases and coverage mapping files for all users here, or delete databases that you no longer need.

To reach this folder from the Finder:

1. Select **Go to Folder** from the **Go** menu on the Finder's menu bar.
2. Type:

```
/Library/Application Support/Mapthematics/Databases
```
3. Click *Go*.

If you know for certain which volume is your system start-up disk, you can also simply double-click the icon for the disk, and then:

1. Double-click the `Library` folder.
2. Double-click the `Application Support` folder.
3. Double-click the `Mapthematics` folder.

4. Double-click the Databases folder.

Personal Databases

Any database files in the folder:

```
/Users/YourUserName/Library/Application Support/Mapthematics/Databases
```

are accessible only to you because of the file permissions set up by OS X. This is the folder displayed when you click *Add User Database* in the **Databases** dialog. If you opted to install Supplemental Databases for your use only (see [Installing Supplemental Databases, Chapter 1: Setup](#)), the database files were placed here. You can add new databases for yourself here, or add coverage mapping files whose contents will override those present in the system-wide folder.

To reach this folder from the Finder:

1. Select **Home** from the **Go** menu on the Finder's menu bar.
2. Double-click the Library folder.
3. Double-click the Application Support folder.
4. Double-click the Mapthematics folder.
5. Double-click the Databases folder.

Windows XP Information

Databases Installed for All Users

The database files in the directory:

```
C:\Documents and Settings\All Users\Application Data\Mapthematics\Databases
```

are available to all users on the system. This is the directory displayed when you click *Add Installed Database* in the **Databases** dialog. Geocart's Required Databases installer (see [Installing Required Databases, Chapter 1: Setup](#)) installed its database files here, and so did any Supplemental Databases installers that you opted to install for all users. You can add other databases and coverage mapping files for all users here, or delete databases that you no longer need.

To reach this directory from the Windows Explorer:

- On the **Start** menu, select **My Computer**.

The directory where databases are stored is hidden by default on Windows. If you don't want to change any settings but instead just navigate there directly, then:

1. Double-click the *Address* field at the top (it will default to *My Computer*).
2. In the *Address* field, type:
C:\Documents and Settings\All Users\Application Data\Mapthematics\
Databases
3. Press **ENTER** to display the directory.

If you'd like to make this folder visible, then:

1. From the **Tools** menu, select **Folder Options**.
2. In the **Folder Options** tabbed dialog, select the *View* tab.
3. Under *Advanced Settings*, click the *Show hidden files and folders* radio button.
4. Click **OK**.

Now you can navigate to the databases directory more easily, like this:

1. Double-click your C : drive icon.
2. Double click Documents and Settings.
3. Double-click All Users.
4. Double-click Application Data.
5. Double-click Mapthematics.
6. Double-click Databases.

Personal Databases

Any database files in the directory:

```
C:\Documents and Settings\YourAccountName\Local Settings\Application Data\  
Mapthematics\Databases
```

are accessible only to you because of the file permissions set up by Windows. This is the directory displayed when you click *Add User Database* in the **Databases** dialog. If you opted to install Supplemental Databases for your use only (see [Installing Supplemental Databases, Chapter 1: Setup](#)), the database files were placed here. You can add new databases for yourself here, or add coverage mapping files whose contents will override those present in the system-wide folder.

To reach this directory from the Windows Explorer:

- On the **Start** menu, click *My Computer*.

The directory where databases are stored is hidden by default on Windows. If you don't want to change any settings but instead just navigate there directly, then:

1. Double-click the *Address* field at the top (it will default to *My Computer*).
2. In the *Address* field, type:

```
C:\Documents and Settings\YourAccountName\Local Settings\Application Data\  
Mapthematics\Databases
```
3. Press **ENTER** to display the directory.

If you'd like to make this folder visible, then:

1. Select *Folder Options* from the **Tools** menu.
2. In the **Folder Options** tabbed dialog, select the *View* tab.
3. Under *Advanced Settings*, click the *Show hidden files and folders* radio button.
4. Click *OK*.

Now you can navigate to the databases directory more easily, like this:

1. Double-click your C : drive icon.
2. Double-click Documents and Settings.
3. Double-click the folder with your account name.
4. Double-click Local Settings.
5. Double-click Application Data.
6. Double-click Mapthematics.
7. Double-click Databases.

Windows Vista and Windows 7 Information:

Databases Installed for All Users

The database files in the directory:

```
C:\ProgramData\Mapthematics\Databases
```

are available to all users on the system. This is the directory displayed when you click *Add Installed Database* in the **Databases** dialog. Geocart's Required Databases installer (see [Installing Required Databases, Chapter 1: Setup](#)) installed its database files here, and so did any Supplemental Databases installers that you opted to install for all users. You can add other databases and coverage mapping files for all users here, or delete databases that you no longer need.

To reach this directory from the Windows Explorer:

- On the **Start** menu, click **Computer**.

The directory where databases are stored is hidden by default on Windows. If you don't want to change any settings but instead just navigate there directly, then:

1. Double-click the *Location* field at the top (it will default to > *Computer* >)
2. In the *Location* field, type:
C:\ProgramData\Mapthematics\Databases
3. Press **ENTER** to display the directory.

If you'd like to make this folder visible, then:

1. Press and release the **ALT** key to reveal the menu bar for the window.
2. From the **Tools** menu that appears, select **Folder Options**.
3. In the **Folder Options** tabbed dialog, select the *View* tab.
4. Under *Advanced Settings*, click the *Show hidden files and folders* radio button.
5. Click *OK*.

Now you can navigate to the databases directory more easily, like this:

1. Double-click your C: drive icon.
2. Double click ProgramData.
3. Double-click Mapthematics.
4. Double-click Databases.

Personal Databases

Any database files in the directory:

```
C:\Users\YourAccountName\AppData\Local\Mapthematics\Databases
```

are accessible only to you because of the file permissions set up by Windows. This is the directory displayed when you click *Add User Database* in the **Databases** dialog. If you opted to install Supplemental Databases for your use only (see [Installing Supplemental Databases, Chapter 1: Setup](#)), the database files were placed here. You can add new databases for yourself here, or add coverage mapping files whose contents will override those present in the system-wide folder.

To reach this directory from the Windows Explorer:

- On the **Start** menu, click **Computer**.

The directory where databases are stored is hidden by default on Windows. If you don't want to change any settings but instead just navigate there directly, then:

1. Double-click the *Location* field at the top (it will default to > *Computer* >)
2. Type:
C:\Users*YourAccountName*\AppData\Local\Mapthematics\Databases
3. Press **ENTER** to display the directory.

If you'd like to make this folder visible, then:

1. Press and release the **ALT** key to reveal the menu bar for the window.
2. From the **Tools** menu that appears, select **Folder Options**.
3. In the **Folder Options** tabbed dialog, select the *View* tab
4. Under *Advanced Settings*, click the *Show hidden files and folders* radio button.
5. Click *OK*.

Now you can navigate to the databases directory more easily, like this:

1. Double-click your C : drive icon.
2. Double-click *Users*.
3. Double-click the folder with your account name.
4. Double-click *AppData*.
5. Double-click *Local*.
6. Double-click *Mapthematics*.
7. Double-click *Databases*.

Appendix H: Defining custom boundaries

Geocart's **Boundaries** dialog offers the ability to specify the region of the earth to be projected when drawing a map. There are three simple options (already described in [Chapter 9: Map menu, Boundaries](#)) available: *Unconstrained*, *Corners* (for spherical quadrilaterals), and *Small Circle*. There is also a fourth option *Custom*, which allows you to define a region of more complex shape to be projected.

The region to be projected is defined in an XML syntax. When you click the *Custom* button in the **Boundaries** dialog, you are presented with an additional **Custom Boundaries** dialog that shows you the current definition for the custom boundaries, and allows you to edit them. The first time you do this for a map without custom boundaries, the dialog is populated upon entry with a commented example to explain how the mechanism works. You can select and delete all of that text, and type or paste in new XML for your own boundaries.

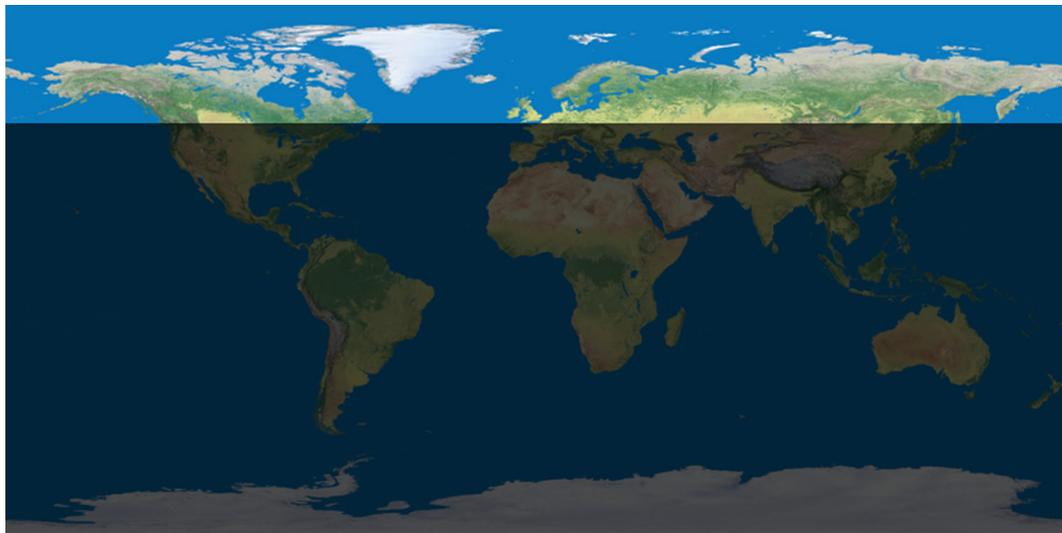
The XML that defines a region specifies:

1. A point on the earth that is inside the region to be projected.
2. One or more closed paths that define the region boundaries.

The region to be projected is then considered to be the set of all points p such that a path from p to the known interior point crosses the boundary an even number of times, or not at all. Let's look at a simple example. Make a new Geocart document, place a new map, select **Boundaries** from the **Map** menu, and click *Custom*. Then enter the following XML into the dialog:

```
<boundary inside='90,0'>
  <path>
    <segment start='50,0' middle='50,90' end='50,180' />
    <segment start='50,180' middle='50,-90' end='50,0' />
  </path>
  <!-- Hello, world! -->
</boundary>
```

and click *OK*. By this you will have specified that the region of interest is everything north of the 50°N parallel:



Everything north of the 50th parallel

If there was a problem with the XML you've entered, Geocart will display an error message and allow you to go back and edit the XML until it's correct. Let's look at the XML line by line:

1: `<boundary inside='90,0'>`

All definitions must begin with a boundary element (excepting XML comments, see below). The boundary element contains a single attribute, `inside`, which defines a coordinate that shall be considered to be inside the region.

2: `<path>`

The path element begins the definition of a closed path that provides a boundary for the region. A legal path is comprised of two or more segments, and each segment is a piece of a small or great circle. The endpoint of each segment must be the starting point of the next segment, and the endpoint of the final segment must be the starting point of the first segment; this ensures that the path is closed.

3: `<segment start='50,0' middle='50,90' end='50,180' />`

The segment element defines a piece of either a small or great circle. Any three unique points on the sphere lie along exactly one great or small circle. The segment element has three attributes `start`, `middle`, and `end` that specify these three unique points. The segment they define begins at `start`, passes through `middle`, and finishes at `end`. The coordinate you provide for `middle` need not lie exactly halfway between `start` and `end`; any point along the desired circle will suffice. This first segment element in the XML provides three points that lie on the small circle that is the 50°N parallel. The segment starts at (50,0), passes through the eastern hemisphere and through (50,90), and finally ends at (50,180).

4: `<segment start='50,180' middle='50,-90' end='50,0' />`

Similar to the above, this segment element defines the part of the 50°N parallel that runs through the western hemisphere. Note that the start of this segment is the same as the end of the previous segment. Because the path only has two segments, the end of this segment is also the start of the prior one as well.

5: `</path>`

This ends the path element that contains the two segments above. Note that the segment elements above don't need explicit closing tags like `</segment>` because they end in `/>` and not `>`, which is XML shorthand used to close elements that don't contain other elements.

6: `<!-- Hello, world! -->`

Anything that comes between `<!--` and `-->` is an XML comment and is ignored (but retained) by Geocart. You can use comments to annotate parts of a complex boundary definition so you can remember the details later.

7: `</boundary>`

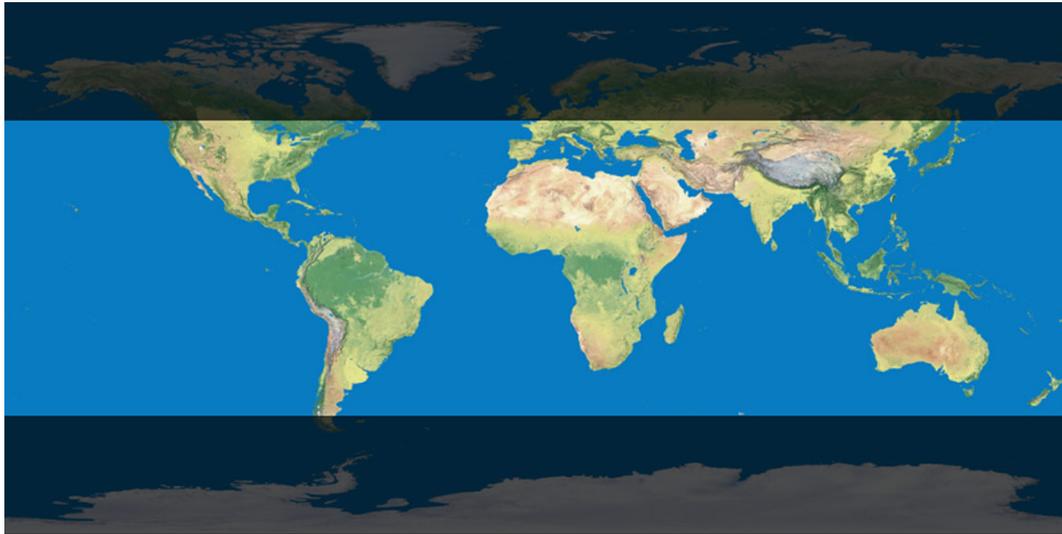
Ends the boundary definition.

Multiple Paths and Discontiguous Regions

You can provide more than one closed path to define the boundary region. To follow along, click *Custom* in the **Boundary** dialog and enter this boundary XML:

```
<boundary inside='0,0'>
  <path>
    <segment start='50,0' middle='50,90' end='50,180' />
    <segment start='50,180' middle='50,-90' end='50,0' />
  </path>
  <path>
    <segment start='-50,0' middle='-50,90' end='-50,180' />
    <segment start='-50,180' middle='-50,-90' end='-50,0' />
  </path>
</boundary>
```

Click *OK*. You will see that you have specified the region that is south of the 50°N parallel, and north of the 50°S parallel:

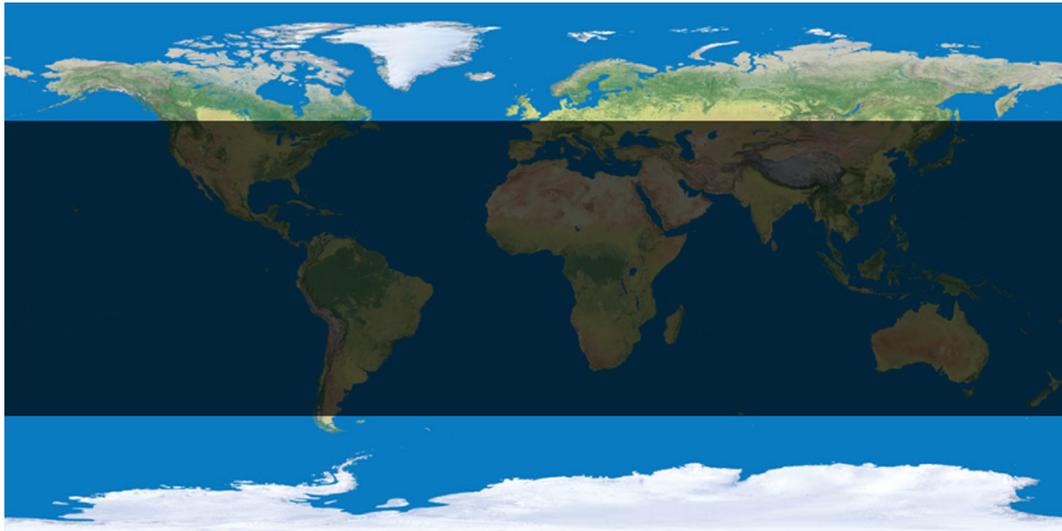


North of 50°S and south of 50°N

There is no requirement that the final region you have defined be contiguous. To continue, click *Custom* and change the first line to:

```
<boundary inside='90,0'>
```

Click *OK*. You will see that the region of the earth for projection is now comprised of two discontinuous parts:



North of 50°N and south of 50°S

The region to be projected is considered to be the set of all points p such that a path from p to the known interior point crosses the boundary an even number of times, or not at all. Paths from the known interior point (90, 0) to the area north of the 50°N parallel don't cross a boundary path at all, so all of those points are considered to be within the region. Paths from (90,0) to the area between the two parallels cross one defined boundary path (the 50°N parallel) and so are considered outside the region. And paths from (90,0) to all points south of 50°S cross both boundary paths, and are once again considered inside the region.

Geocart can handle path definitions of moderate complexity, but the visualization for very complex regions will cause the **Boundaries** dialog and **Projection Center** dialog to become slow. Even on a fast machine, a path comprised of 100 separate segments will add about a ten second delay to these dialogs.

Specifying Coordinates

Coordinates in the XML boundary definition can be specified in most of the formats that Geocart accepts, and you can use single or double quotes around them. All of the examples below are legal and identical:

```
<boundary inside='-20.5, 30'>
```

```
<boundary inside="20/30S, 30E">
```

```
<boundary inside="-20/30, 30E">
```

```
<boundary inside='20.5S, +30'>
```

When specifying latitude or longitude in degrees/minutes/seconds, use slashes between the values to avoid confusion between the minutes or seconds mark and the quotes surrounding the coordinate. Lines like

```
<boundary inside='1°2'3N'>
```

will not work. Geocart does not currently support escaping minute or second marks with the standard XML escape sequences `"` or `'`.

Appendix J: Metric line databases

Geocart can draw *metric lines*, which are points, paths, or symbols that describe analytic characteristics of the map projection or that show computed paths of geodetic interest. Geocart can draw the following kinds of metric lines:

- **Great circle:** the shortest path between two points on the sphere.
- **Geodesic:** the shortest path between two points on the ellipsoid.
- **Small circle:** all the points of constant distance from a designated center point.
- **Rhumb:** a path of constant bearing.
- **Point location:** a dot at the designated coordinate.
- **Areal inflation/deflation isocol:** all locations of the map having the designated amount of areal inflation or deflation. (This is meaningless on an equal-area map, where all points have the same area.)
- **Angular deformation isocol:** all locations of the map having the designated amount of angular deformation. (This is meaningless on a conformal map, where no points have angular deformation.)
- **Average scale isocol:** all locations of the map having the designated average scale.
- **Tissot indicatrix:** an ellipse whose flatness (eccentricity), area, and orientation depict the distortion at the designated coordinate.

You describe the metric lines you want Geocart to draw by recording their characteristics in a text file that you save and then add as a database using the *Databases* command. The file name of a metric line database must end in `.metric.txt`. The file must be saved as UTF-8 character encoding, but you do not need to do anything particular to mark it as such. You may add any number of metric line databases to a map. Metric lines are drawn on the same layer as the graticule.

A metric line's line style is determined by one of three mechanisms.

- If the metric line database declares a style for the line within the database, then the line will be drawn in that style.
- If the metric line database declares a coverage for the line within the database, then the line will be drawn according to the line style for that coverage.
- Otherwise it will be drawn according to the style associated with that kind of metric line as shown in the *Line Styles* dialog.

The decision of which mechanism to use is yours. If you have created the metric line database purely for the geometry it represents, then you probably would not record line styles in it. If, on the other hand, you want different metric lines even of the same kind to draw differently, then you must record the line styles in the database. You might also record line styles in the database if the database is meant to convey a distinctive design style.

In all these descriptions, the azimuth convention sets north to 0°, increasing clockwise.

Metric line types

Great circle

A great circle is a path on a sphere showing the shortest route between any two points along the path. It goes all the way around the earth and returns to where it started. Its center is the center of the earth; the great circle path cuts the earth into two equal hemispheres. The highest latitude it rises to in the northern hemisphere is also the highest latitude it rises to in the southern hemisphere; that is, if 50°N is the highest latitude it rises to in the northern hemisphere,

then 50°S is the highest latitude it rises to in the southern hemisphere. Unless the great circle is the equator, the great circle will cross the equator twice. All meridians are great circles. The equator is the only parallel that is a great circle.

If the map you draw a great circle on uses an ellipsoidal datum instead of a spherical datum, the great circle route will have little meaning except for meridians. Use a [geodesic](#) metric line instead.

You can describe a great circle in different ways in a metric line database:

1. By giving a point on earth's surface as the center of the great circle. Every point on the great circle thus described will be equally distant from the center point. In this case the entire great circle will be drawn.
2. By giving two points between which to draw the great circle. In this case, a great circle segment will be drawn, rather than the entire great circle. Use this when you want to show the shortest path between two points on the sphere. If the two points are antipodal (which means exactly on the other side of the globe), then you must give a third point between them in order to describe which of the infinite number of great circles you actually want.
3. By giving a center point, as described above, along with an azimuth (direction) to the start of the great circle segment and a sweep angle. In this case, a great circle segment will be drawn, rather than the entire great circle, unless the sweep angle is 360°.

Geodesic

A geodesic is a path on an ellipsoid (of which a sphere is a special case) showing the shortest route between any two points along the path. Unless the geodesic is the equator or a meridian, if drawn in its entirety, it would go around the ellipsoid at least twice but generally an infinite number of times. The highest latitude it rises to in the northern hemisphere is also the highest latitude it rises to in the southern hemisphere; that is, if 50°N is the highest latitude it rises to in the northern hemisphere, then 50°S is the highest latitude it rises to in the southern hemisphere. All meridians are geodesics. The equator is the only parallel that is a geodesic.

You may specify a sphere to be the surface upon which you draw the geodesic. However, in some situations the great circle metric line provides more convenient controls if you work with a spherical datum.

You can describe a geodesic in different ways in a metric line database:

1. By giving two points between which to draw the geodesic. Use this when you want to show the shortest route between two points on the ellipsoid. Generally there is more than one geodesic connecting two points, but Geocart will always draw the shortest.
2. By giving a starting point, an azimuth (direction), and a distance in meters. The distance means meters on the ellipsoidal surface given the semimajor and semiminor axis dimensions from the datum you have chosen for your map.
3. By giving a starting point, an azimuth, and a number of cycles. The cycle count means how many times the geodesic should return to the same latitude. (The cycle count is meaningless if the geodesic is the equator.) Because most geodesics do not return to the same point when going around the earth, a cycle count of greater than 1.0 results in a sinoidal pattern across the globe surface.

Small circle

A small circle is a path on the sphere or ellipsoid showing the points that are a specified distance from a specified center point. It is useful for showing the territory that is within a specific radius of a central location, for example.

You can describe a small circle in different ways in a metric line database:

1. By giving the center of the small circle and a radius in degrees. In this case, the entire small circle will be drawn. The degree value means arc distance on the sphere, or, on an ellipsoid, a distance corresponding to the degree value ÷ 360° along the equator.

2. By giving the center of the small circle, a radius in degrees, an azimuth to start the small circle at, and a sweep angle in degrees. In this case, a segment of the small circle will get drawn unless the sweep angle is 360° , in which case a full circle will get drawn. The description of the radius is as given above. The azimuth describes the direction from the center point in which the small circle segment will start. The start azimuth plus the sweep describes the azimuth of the endpoint from the center point.
3. By giving the center of the small circle and a radius in meters. In this case, the entire small circle will be drawn. The distance means meters on the ellipsoidal surface given the semimajor and semiminor axis dimensions from the datum you have chosen for your map.
4. By giving the center of the small circle, a radius in meters, a starting azimuth, and a sweep angle in degrees. In this case, a segment of the small circle will get drawn unless the sweep angle is 360° . The radius is as described in (3). The start azimuth and sweep are as described in (2).
5. By giving start, middle, and endpoints of the small circle. In this case, a segment of the small circle will get drawn. The location of the middle point along the path is not critical insofar as it is not extremely close to either endpoint. That is, it need not be in the exact middle of the segment.

Rhumb

A rhumb is a path of constant bearing. Though a rhumb between two points is generally longer than a great circle, traversing a rhumb is simpler because the navigator never needs to change direction. A rhumb starting at a point either follows a parallel if it runs due east or west, follows a meridian if it runs straight north or south, or spirals ever closer to a pole otherwise.

You can describe a rhumb in different ways in a metric line database:

1. By giving a start and endpoint. While generally an endless number of rhumbs can connect two points, Geocart draws the shortest in this case.
2. By giving a start point, a bearing in degrees, and a distance in meters. The bearing is the direction from the start point, in degrees clockwise from north. The distance means meters on the ellipsoidal surface given the semimajor and semiminor axis dimensions from the datum you have chosen for your map.
3. By giving a start point, a bearing in degrees, and a cycle count. A cycle means the point where the rhumb returns to the same meridian. (The cycle count is meaningless if the rhumb runs north or south.)

Point location

A point location places a circular dot at the coordinate you supply.

Areal inflation/deflation isocol

Unless your map is equal-area, the ratio of area on the map to area on the globe having the same nominal scale varies continuously across the map. An areal isocol shows a path of constant ratio. When you request an areal inflation/deflation (or “flation”) isocol, Geocart seeks out and draws all paths on the map having the ratio you designate. A value of 1.0 means no inflation or deflation. A value of 2.0 means the paths on the map whose points have twice the size as the corresponding areas on the globe.

Angular deformation isocol

Unless your map is conformal, angles on the map get skewed in comparison to the globe. At any given point, the amount of skewing varies between none and some maximum amount, depending on which angle one examines. It is the maximum value that completely characterizes the deformation at that point, so it is used as the metric of angular deformation.

An angular deformation isocol shows a path of constant maximum angular skewing, or deformation. When you

request an angular deformation isocol, Geocart seeks out and draws all paths on the map having the maximum angular deformation that you designate. A value of 0.0 means no deformation. A value of 10 means the paths on the map whose points have maximum angular deformations of 10°. The greatest possible value for angular deformation is 180°, which means infinite distortion.

Average scale isocol

Some maps have no areal inflation or deflation (“flation”). Such maps always have angular deformation. Some maps have no angular deformation. Such maps always have areal inflation or deflation. Meanwhile all maps distort most distances, and this distortion depends upon the contributions of flation and deformation. Hence it can be convenient to combine the two into a single metric of “scale error”. Many different ways can be devised to compute the scale error metric. Geocart uses the average value of all unit radii evenly distributed on the sphere as projected onto the plane at each point.

An average scale isocol shows a path of constant average scale. When you request an average scale isocol, Geocart seeks out and draws all paths whose every point has the average scale that you designate. A value of 1.0 means the average unit vector through the point remains 1.0 and indicates low distortion in general, though does not necessarily mean no distortion. If the map is conformal, average scale corresponds to the scale factor. If the map is not conformal, large angular deformations tend to result in large average scale because the distribution of radii gets skewed toward the major axis of the Tissot ellipse.

Tissot indicatrix

A Tissot indicatrix is the elliptical result of projecting an infinitesimal circle from the sphere to the plane. Its flatness, area, and orientation characterize the distortion at the designated coordinate. If you want to show Tissot indicatrices in a regular network across the map, it is convenient to use the [Tissot indicatrices](#) functionality. If you want control over placement and line styles for individual Tissot ellipses, you should use a metric line database.

When you request a Tissot indicatrix, Geocart draws an ellipse centered at the geographic coordinate you supply. You can describe a Tissot indicatrix two different ways:

1. By giving a coordinate and a radius for the indicatrix in degrees. The degree value means arc degrees, a distance meaning the degree value $\div 360^\circ$ along the equator. The degree value represents the radius the projected circle would have if the point had no distortion. The resulting Tissot ellipse’s semimajor and semiminor axes will be scaled accordingly.
2. By giving a coordinate and a radius for the indicatrix in millimeters. The millimeter value means the radius the projected circle would have if the point had no distortion. The resulting Tissot ellipse’s semimajor and semiminor axes will be scaled accordingly.

Defining a metric line database

Metric lines and their styles are defined in an XML syntax and saved into a file whose name must end in `metric.txt`. The XML that defines metric lines specifies:

1. A metric line type and its parameters.
2. Optionally, comments that annotate the XML code but which have no operational effect.
3. Optionally, directives to separate groups of metric lines into layers.
4. Optionally, line styles for drawing the metric line.
5. Optionally, directives to assign a [database coverage](#) to metric lines.
6. The type of metric line (great circle, Tissot ellipse, isocol &c.) and the parameters describing them, such as the center of the great circle or the measure of the isocol.

```

<metric_lines>
  <!-- Put all the lines in a layer with 50% transparency. -->
  <layer alpha='0.5'>
    <style stroke_color='255,0,0' width='2.7' dashes='3 1 2'>
      <small_circle center='20,120' radius='15' />
      <great_circle center='-45,45' azimuth='-45' sweep='90' />
      <geodesic start='0,-135' azimuth='54' cycles='2' />
      <rhumb start='-20,-20' end='60,130' />
      <tissot_ellipse coord='0,-150' radius_mm='5' />

      <style coverage='Coverage/Railroad'>
        <isocol scale='1.2' />
      </style>
    </style>
  </layer>
</metric_lines>

```

Let's look at the XML line by line:

1: <metric_lines>

Definitions must begin with a `metric_lines` element (except XML comments, see below). The `metric_lines` element contains no attributes and is terminated by `</metric_lines>`, which is required.

2: <!-- Put all the lines in a layer with 50% transparency. -->

Anything that comes between `<!--` and `-->` is an XML comment ignored by Geocart. You can use comments to annotate parts of a metric line data set so you can remember the details later. Use of comments is optional.

3: <layer alpha='0.5'>

The `layer` element begins the definition of a grouping of metric lines and assigns a transparency value to the group. The transparency value ranges between 0 (completely transparent; i.e., invisible) to 1.0 (completely opaque). The grouping is useful after exporting the document as PDF. When you edit the resulting PDF document in graphic editing software such as Adobe Illustrator, you can manipulate all of the elements within the group as if they are a single element. You might wish to group all metric lines of a single type, such as isocols, to distinguish them from all rhumb lines, for example. A layer declaration is terminated by `</layer>`, which is required. Use of layers is optional.

4: <style stroke_color='255,0,0' width='2.7' dashes='3 1'>

The `style` element defines a line style for the metric line elements that it brackets. The `stroke_color` parameter defines the RGBA (red, green, blue, alpha) values of the line to be drawn. It must consist of either three elements, in which case it represents the red, green, and blue components, or else four elements, in which case it represents RGB and alpha, or transparency. These elements, along with the `width` and `dashes` element, correspond to how you define line styles in the [Line Styles](#) dialog. In this case the XML declares a red line of with 2.7 points and a repeating dash sequence of 3 points drawing and one point gap.

Note that the transparency value you provide here ranges from 0...255, not the 0...1 that you would give for the `layer` element. The transparency effect of the layer is compounded by style definition; for example, a `layer alpha='0.5'` declaration in effect with a `stroke_color='255,0,0,128'` declaration would give translucence of 25%, since the layer alpha's 0.5 declarations amount to a 50% transparency, and so does the stroke

color's 128 alpha declaration.

Declaring line styles is optional. If you do not assign line styles explicitly in the XML, then the line style as set in the Line Styles dialog will get used for each corresponding type of metric line. A style declaration is terminated by `</style>`, which is required.

```
5: <style coverage='Coverage/Railroad'>
```

Another way the `style` element can be used is to declare a coverage for the enclosed metric lines. In this example, the coverage declaration overrides the earlier `<style ...>` definition with respect to the `<isocol .../>` definition because the coverage declaration is the last style declared before reaching the `<isocol .../>` definition. The rendered line representing the isocol metric line will be drawn according to the instructions for 'Coverage/Railroad' as found in the [Line Styles](#) dialog.

```
6: <isocol scale='1.2' />
```

This element defines a metric line. The example above is for an average scale error isocol. The complete list of metric line elements is:

```
small_circle
great_circle
geodesic
rhumb
tissot_ellipse
isocol
point
```

These are examples of all the different declarations possible for `small_circle`:

```
<small_circle center='20,120' radius='15' />
```

A complete small circle centered on (20°N, 120°E) and having an arc radius of 15°.

```
<small_circle center='20,120' radius='15' azimuth='90' sweep='45' />
```

A portion of a small circle centered on (20°N, 120°E), having arc radius of 15°, starting due east (azimuth = 90°) of the center, and arcing an eighth of the way around the circle (sweep = 45°/360°).

```
<small_circle center='20,120' radius_meters='150000' />
```

A complete small circle centered on (20°N, 120°E) and having a radius of 150,000 meters.

```
<small_circle center='20,120' radius_meters='150000' azimuth='90' sweep='45' />
```

A portion of a small circle centered on (20°N, 120°E), having arc radius of 150,000 meters, starting due east (azimuth = 90°) of the center, and arcing an eighth of the way around the circle (sweep = 45°/360°).

```
<small_circle start='20,120' middle='30,130' end='20,140' />
```

The portion of the small circle defined by the three points, drawn from the start to end.

These are examples of all the different declarations possible for `great_circle`:

```
<great_circle center='20,120' />
```

A complete great circle such that all points on the great circle are the same distance from (20°N, 120°E), which is half a hemisphere away.

```
<great_circle center='20,120' azimuth='90' sweep='45' />
```

A portion of the great circle defined such that all points on the great circle are the same distance from

(20°N, 120°E). The portion starts due east (azimuth = 90°) of the center, and arcs an eighth of the way around the circle (sweep = 45°/360°).

```
<great_circle start='20,120' end='20,140' />
```

The portion of the great circle that runs through the two points (20°N, 120°E) and (20°N, 140°E), drawn from the start to end. This definition must not be used if the two points are antipodal or nearly antipodal, such as (20°N, 120°E) and (20°S, 60°W), since antipodal points do not uniquely specify a great circle. In this case, use the three-point form below.

```
<great_circle start='20,120' middle='0,30' end='-20,-60' />
```

The portion of the great circle that runs through the three points (20°N, 120°E), (0°N, 30°E), and (20°S, 60°W), drawn from the start to end. This definition must be used only if the three points actually define a great circle, and need only be used if start and end are antipodal. If start and end are antipodal then any middle point will define a great circle as long as the middle point differs significantly from either endpoint.

These are examples of all the different declarations possible for `geodesic`:

```
<geodesic start='20,120' end='20,140' />
```

The portion of the shortest geodesic that runs through the two points (20°N, 120°E) and (20°N, 140°E), drawn from the start to end.

```
<geodesic start='20,120' azimuth='40' distance_meters='150000' />
```

The portion of the geodesic that runs from the point (20°N, 120°E) in the direction of 40° east of north, for a distance of 150,000 meters.

```
<geodesic start='20,120' azimuth='40' cycles='3.3' />
```

The portion of the geodesic that runs from the point (20°N, 120°E) in the direction of 40° east of north, for 3.3 cycles. One cycle means to go all the way around the globe, returning to the same latitude as the start. A portion of a cycle has no specific meaning for distance, other than a greater number means farther along the geodesic than a lesser number.

These are examples of all the different declarations possible for `rhumb`:

```
<rhumb start='20,120' end='20,140' />
```

The portion of the shortest rhumb that runs through the two points (20°N, 120°E) and (20°N, 140°E), drawn from the start to end.

```
<rhumb start='20,120' bearing='40' distance_meters='150000' />
```

The portion of the rhumb that runs from the point (20°N, 120°E) in the direction of 40° east of north, for a distance of 150,000 meters.

```
<rhumb start='20,120' bearing='40' cycles='3.3' />
```

The portion of the rhumb that runs from the point (20°N, 120°E) in the direction of 40° east of north, for 3.3 cycles. One cycle means to go all the way around the globe, returning to the same longitude as the start. A portion of a cycle has no specific meaning for distance, other than a greater number means farther along the rhumb than a lesser number.

These are examples of the two different declarations possible for `tissot_ellipse`:

```
<tissot_ellipse coord='20,120' radius='5' />
```

A tissot ellipse illustrating the distortion at (20°N, 120°E). If the point has no distortion, the ellipse would be a circle of radius 5° of arc as determined by the nominal scale of the map. For any other distortion measure, the circle will be squashed and scaled according to the characteristics of the distortion.

```
<tissot_ellipse coord='20,120' radius_mm='3' />
```

A Tissot ellipse illustrating the distortion at (20°N, 120°E). If the point has no distortion, the ellipse would be a circle of radius 3 mm. For any other distortion measure, the circle will be squashed and scaled according to the characteristics of the distortion.

These are examples of all the different declarations possible for `isocol`:

```
<isocol area='2' />
```

All isocols on the map illustrating all points with areal inflation of 2x.

```
<isocol max_deformation='20' />
```

All isocols on the map illustrating all points with a maximum angular deformation of 20°.

```
<isocol scale='1' />
```

All isocols on the map illustrating all points with average scale factor of 1.0.

This is an example of the `point` declaration:

```
<point coord='20,120' />
```

A point drawn centered on (20°N, 120°E).

Specifying Coordinates

Coordinates in the XML boundary definition can be specified in most of the formats that Geocart accepts, and you can use single or double quotes around them. All of the examples below are legal and identical:

```
<small_circle center='-20.5, 30' radius='15' />
```

```
<small_circle center="20/30S, 30E" radius='15' />
```

```
<small_circle center="-20/30, 30E" radius='15' />
```

```
<small_circle center='20.5S, +30' radius='15' />
```

When specifying latitude or longitude in degrees/minutes/seconds, use slashes between the values to avoid confusion between the minutes or seconds mark and the quotes surrounding the coordinate. Lines like

```
<small_circle center='1°2'3N' radius='15' />
```

will not work. Geocart does not currently support escaping minute or second marks with the standard XML escape sequences `"` or `'`. Instead write:

```
<small_circle center='1/2/3N' radius='15' />
```

Sample metric line database

You can find a sample metric line database in your Geocart installation at (Macintosh):

```
/Library/Application Support/Mapthematics/Geocart/Version 3/  
Sample Documents/Sample.metric.txt
```

Windows XP:

```
C:\Documents and Settings\All Users\Application Data\Mapthematics\  
Version 3\Sample Documents\Sample.metric.txt
```

Windows Vista/Windows 7:

```
C:\ProgramData\Mapthematics\Geocart\Version 3\  
Sample Documents\Sample.metric.txt
```