

# MAP GUIDE

## Map Projections

### *Summary*

**What are map projections?** The planet Earth is roughly the shape of a sphere. Actually it's a somewhat lumpy ellipsoid. To represent the entire surface of our three-dimensional Earth using only two dimensions has challenged geographers and cartographers ever since it was discovered that the world is not flat. In order to represent the spherical Earth in flat map form – so that we can all carry maps instead of globes when we travel - map projections are used.

**Why are different map projections created?** The geographers who design projections attempt to preserve certain physical properties and features of the Earth. In particular, they try to preserve the relationships between distance, area, scale, direction, and shape. However, no two-dimensional projection can accurately represent the Earth at all points, so compromises must be made. The problem is often illustrated by using an orange peel as an example. When the peel is intact on the orange, it makes a seamless, cohesive ball. Even if you get the peel off in one piece, you can't lay it flat on a table without discontinuities – somewhere, two points that were adjacent on the orange will be separated. Some projections minimize distortions in some relationships at the expense of maximizing errors in others. Some projections are attempts to only moderately distort all of these relationships. Different types of projections have been developed to preserve different physical features of the Earth.

Map projections can be grouped together based on three primary characteristics: aspect, properties, and case. *Aspect* identifies the basic layout of the projection. Three general aspects have evolved – cylindrical, azimuthal, and conic – with some projections falling outside of these. Cylindrical projections result from projecting a spherical surface onto a cylinder. Conic projections result from projecting a spherical surface onto a cone. Azimuthal projections result from projecting a spherical surface onto a plane.

Projections are also classified in terms of their *properties*. A conformal projection maintains the shape of small regions, so angles at any point are correct, although sizes will change. An equal-area projection maintains size at the expense of shape. An equidistant projection preserves linear distance but will distort size and shape.

To understand the *case* of a projection, think of the lines of latitude and longitude on a globe as being movable. Moving the lines of latitude and longitude, collectively referred to as the graticule, enables you to draw a map of a shifted world. Depending on the degree of shift, the case may be defined as conventional, transverse, equatorial, or oblique.

As a result of these attributes some projections, like Robinson, are better for a global view while others, like Albers Equal-Area Conic, are better for a local view.

**How are the TerraViva!® thematic maps reprojected?** The digital map data used to produce TerraViva!® thematic maps was originally laid out according to various map

projections. Because of their digital origins these maps consist of pixels, each of which represents a value associated with one point on the earth's surface (obtained from remote sensors, statistical data, or some other measurement), and which collectively create the image you see. Individual pixels may also vary in resolution – specifically, with respect to size and shape. *TerraViva!*<sup>®</sup> enables users to select from a variety of projections when viewing geospatial data. The following projections may be included in your *TerraViva!*<sup>®</sup> product:

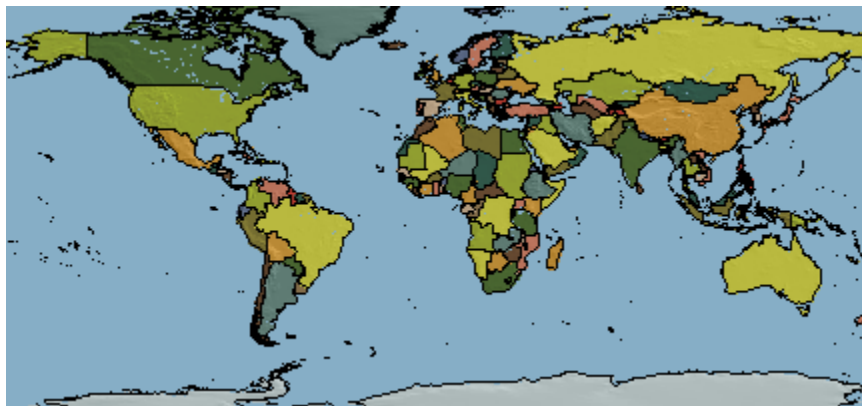
<b><i>Cylindrical and Pseudocylindrical Projections</i></b>	<b><i>Azimuthal Projections</i></b>	<b><i>Conic Projections</i></b>	<b><i>Other Projections</i></b>
Geographic Lat/Lon	Azimuthal Equidistant	Lambert Conformal Conic	Van der Grinten
Aitoff	Lambert Azimuthal Equal-Area	Albers Equal-Area Conic	
Goode Interrupted Homolosine	Orthographic		
Mercator	Stereographic		
Miller Cylindrical			
Plate Carree			
Robinson			
Sinusoidal Equal-Area			
Cylindrical Equal-Area			

### ***Using Map Projections.***

**Commonly used map projections.** Three commonly used projections, discussed in detail below, are: Geographic Lat/Lon, Goode Interrupted Homolosine, and Robinson.

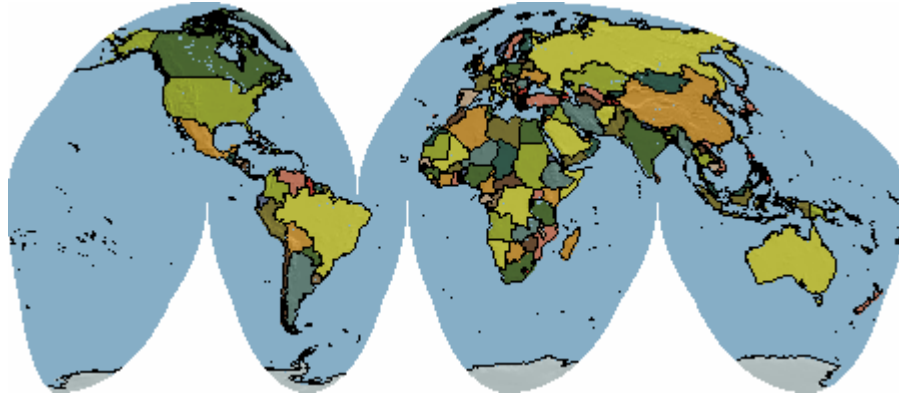
***Geographic Lat/Lon*** The Geographic Lat/Lon Projection creates a rectangular map by spacing the lines of latitude and longitude equally. It distorts scale, distance, area, and shape with the distortion increasing with distance from the equator (the horizontal center of the map). Greenland and Antarctica, for example, are exaggerated in size. Pixel sizes will vary accordingly. This projection does, however, result in a nice rectangular shape that is easy to present on a computer. It also has the added advantage of allowing easy indexing to any position on the map or to any particular geographic feature using x,y coordinates.

Geographic Lat/Lon



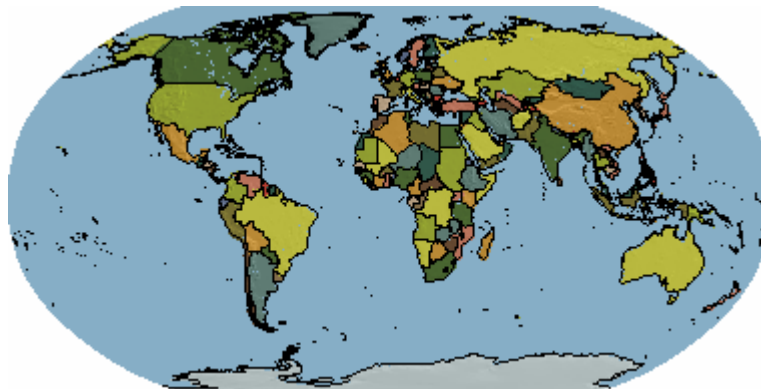
*Goode Interrupted Homolosine* The Goode Interrupted Homolosine Projection is often used to represent global satellite and map data sets. One characteristic of this projection is that it has the appearance of a 3-D globe that was cut with scissors and laid flat. Statistical resampling techniques are used to create pixels. Each pixel is approximately equal area, with the horizontal and vertical pixel edges the same length. And, though specific pixel size will vary depending upon resolution, pixel size will remain consistent at consistent resolution. So, no matter what part of the earth you are viewing, the screen pixels in that region closely correspond to those in other regions of the map.

Good Interrupted Homolosine



*Robinson* The Robinson Projection distorts shape, area, scale, and distance in an attempt to balance the errors of projection properties - resulting in a rather pleasing presentation of the Earth's terrestrial features.

Robinson



**Choosing an appropriate map projection.** The choice of which projection to use is determined by the location of the area being studied, the size, and the shape. As a general rule of thumb, countries in the tropics are best viewed using a cylindrical projection; countries in the temperate zone are best viewed using a conical projection; and, a polar area is best viewed using an azimuthal projection. If you move between global and local views you may prefer Geographic Lat/Lon or Robinson for the global

view, but a conformal projection for a local view. For example, Russia and China appear misshapen when viewed in Geographic Lat/Lon, but retain their shape in Lambert Conformal Conic or Stereographic. (Note: The spatial query and masking tools in TerraViva!® always use Geographic Lat/Lon projection, and these tools automatically take into account varying pixel size so the results will be the same regardless of what projection the map window is using when either tool is launched.)

The following brief guidelines are provided to help you select a projection appropriate for your area of study. For more detailed information please consult the *References* cited below.

*Cylindrical and Pseudocylindrical Projections* Cylindricals are true at the equator and distortion increases toward the poles.

*Aitoff* An alternate projection for viewing global data. It avoids the discontinuities of Goode's Interrupted Homolosine, but without the same degree of area distortion as the Geographic or Mercator projections. Only the central parallel and meridian are straight lines. Shapes and areas are distorted, with the distortion increasing further from the central meridian.

*Mercator* Often used for marine navigation because all straight lines on the map are lines of constant azimuth. The Mercator projection has straight meridians and parallels that intersect at right angles. Scale is true at the equator or at two standard parallels equidistant from the equator.

*Miller Cylindrical* The Miller projection has straight meridians and parallels that meet at right angles, but straight lines are not of constant azimuth. Shapes and areas are distorted. Directions are true only along the equator. The projection avoids the scale exaggerations of the Mercator map.

*Plate Carree* The Plate Carree projection has straight meridians and parallels that meet at right angles, but straight lines are not of constant azimuth. Shapes and areas are distorted. Directions are true only along the equator. All parallels are equally spaced, as are all meridians, but the spacing of meridians and parallels are not the same. Scale exaggeration is less than with the Mercator projection, and shape distortion is less than the Geographic projection.

*Robinson* The Robinson projection is based on tables of coordinates, not mathematical formulas. The projection distorts shape, area, scale, and distance in an attempt to balance the errors of projection properties.

*Sinusoidal Equal Area* Often used in countries with a larger north-south than east-west extent. Sinusoidal equal-area maps have straight parallels at right angles to a central meridian. Other meridians are sinusoidal curves. Scale is true only on the central meridian and the parallels.

*Cylindrical Equal-Area* An equal area projection with straight meridians and parallels that meet at right angles. Shapes and distances are distorted, but area is preserved. Directions are true only along the equator.

*Azimuthal Projections* Azimuthals are true only at their center point, but generally distortion is worst at the edge of the map.

*Azimuthal Equidistant* Sometimes used to show air-route distances. Distances measured from the center are true. Distortion of other properties increases away from the center point.

*Lambert Azimuthal Equal-Area* Sometimes used to map large ocean areas. The central meridian is a straight line, others are curved. A straight line drawn through the center point is on a great circle.

*Orthographic* Used for perspective views of hemispheres. Area and shape are distorted. Distances are true along the equator and other parallels.

*Stereographic* Used for navigation in polar regions. Directions are true from the center point and scale increases away from the center point, as does distortion in area and shape.

*Conic Projections* Conics are true along some parallel somewhere between the equator and a pole and distortion increases away from this standard.

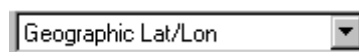
*Albers Equal-Area Conic* Used in the United States and other large countries with a larger east-west than north-south extent. A conic projection that distorts scale and distance except along standard parallels. Areas are proportional and directions are true in limited areas.

*Lambert Conformal Conic* Used for maps of North America. Area, and shape are distorted away from standard parallels. Directions are true in limited areas.

#### *Other Projections*

*Van der Grinten* An older projection that distorts area, shape, distance, and scale but attempts to present a pleasing compromise for world maps. It is based on mathematical formulas, and has generally been replaced by the Robinson projection. Central meridian and equator are straight lines, while all other parallels and meridians are arcs of circles.

**Setting map projections.** The Set Map Projection function in *TerraViva!*<sup>®</sup> enables you to reproject a *TerraViva!*<sup>®</sup> thematic map. You can set a map projection from the projections drop-down menu on the toolbar, shown below, or from the MapLibrary > Map Options > Set Map Projection menu.



If you have more than one map open on your desktop click on the desired map to make it the “active” map. Use the projections drop-down menu on your toolbar to click on the desired projection.

To change projection parameters, go to MapLibrary > Map Options >Set Map Projection. This opens the Set Projection window. De-select *Automatic Projection Parameter Setting* by clicking on it to remove the checkmark. The Set Projection window expands, allowing you to define parameter settings for the active map.

To customize projection parameters, go to Tools > My TerraViva! >Projection Options. Enter your preferred projections parameters and click “OK.” This action changes projection parameters for all maps. Customized parameters remain in effect until you manually

change the parameters (described above), set new customized parameters, or restore the default parameters (Tools > My TerraViva! >Projection Options).

### **Sources and Acknowledgements**

We are deeply indebted to Peter H. Dana and The Geographer's Craft Project for producing the excellent resource *Map Projection Overview*, developed at the Geography Department, University of Colorado at Boulder. This tutorial on projections offers a thorough treatment of the subject and is enhanced by the use of helpful graphics. We recommend that users consult *Map Projection Overview*, available online at <http://www.colorado.edu/geography/gcraft/notes/mapproj/mapproj.html>.

### **References**

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