

28. Geometric Properties Preserved and Distorted



Many types of map projections have been devised to suit particular purposes. No projection allows us to flatten the globe without distorting it, however. **Distortion ellipses** help us to visualize what type of distortion a map projection has caused, how much distortion has occurred, and where it has occurred. The ellipses show how imaginary circles on the globe are deformed as a result of a particular projection. If no distortion had occurred in the process of projecting the map shown below in Figure 2.29.1, all of the ellipses would be the same size, and circular in shape.

When positions on the graticule are transformed to positions on a projected grid, four types of distortion can occur: distortion of sizes, angles, distances, and directions. Map projections that avoid one or more of these types of distortion are said to preserve certain properties of the globe.

Equivalence

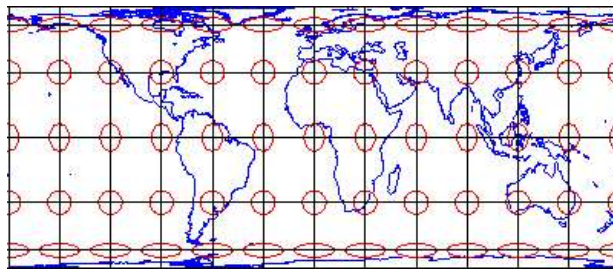


Figure 2.29.1 Equal-Area Distortion

So-called **equal-area** projections maintain correct proportions in the sizes of areas on the globe and corresponding areas on the projected grid (allowing for differences in scale, of course). Notice that the shapes of the ellipses in the Cylindrical Equal Area projection above (Figure 2.29.1) are distorted, but the areas each one occupies are equivalent. Equal-area projections are preferred for small-scale thematic mapping, especially when map viewers are expected to compare sizes of area features like countries and continents.

Conformality

The Nature of Geographic Information

Chapters

► [Chapter 1: Data and Information](#)

▼ [Chapter 2: Scales and Transformations](#)

- 1. Overview
- 2. Scale
- 3. Scale as Scope
- 4. Map and Photo Scale
- 5. Graphic Map Scales
- 6. Map Scale and Accuracy
- 7. Scale as a Verb
- 8. Geospatial Measurement Scales
- 9. Coordinate Systems
- 10. Geographic Coordinate System
- 11. Geographic Coordinate Formats
- 12. Horizontal Datums
- 13. Geoids
- 14. Ellipsoids
- 15. Control Points and Datum Shifts
- 16. Coordinate Transformations
- 17. Plane Coordinate Transformations

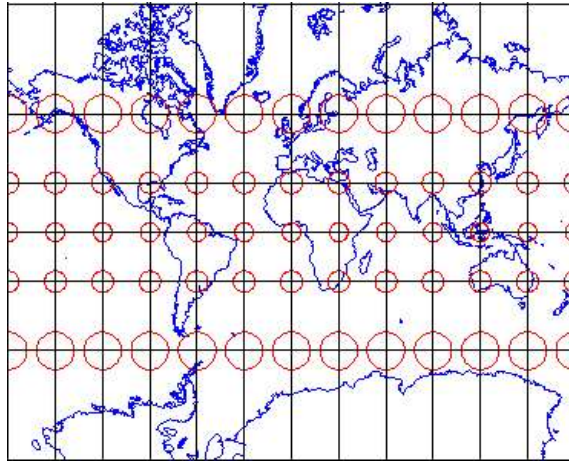


Figure 2.29.2 Conformal Projection Distortion

The distortion ellipses plotted on the **conformal** projection shown above in Figure 2.29.2 vary substantially in size, but are all the same circular shape. The consistent shapes indicate that conformal projections (like this Mercator projection of the world) preserve the fidelity of angle measurements from the globe to the plane. In other words, an angle measured by a land surveyor anywhere on the Earth's surface can be plotted on at its corresponding location on a conformal projection without distortion. This useful property accounts for the fact that conformal projections are almost always used as the basis for large scale surveying and mapping. Among the most widely used conformal projections are the Transverse Mercator, Lambert Conformal Conic, and Polar Stereographic.

Conformality and equivalence are mutually exclusive properties. Whereas equal-area projections distort shapes while preserving fidelity of sizes, conformal projections distort sizes in the process of preserving shapes.

Equidistance

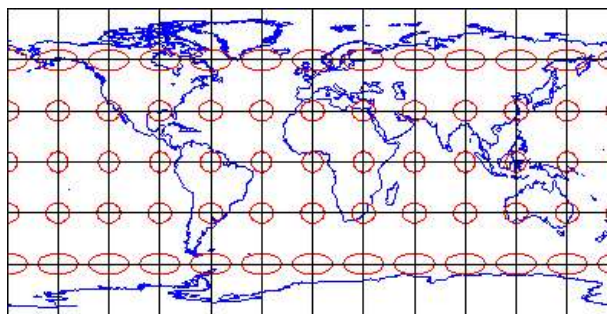


Figure 2.29.3 Equidistant projection distortion

Equidistant map projections allow distances to be measured accurately along straight lines radiating from one or two points only. Notice that ellipses plotted on the Cylindrical Equidistant (Plate Carrée) projection shown above (Figure 2.29.3) vary in both shape and size. The north-south axis of every ellipse is the same length, however. This shows that distances are true-to-scale along every meridian; in other words, the property of equidistance is preserved from the two poles. See chapters 11 and 12 of the online publication [Matching the Map Projection to the Need](#) to see how projections can be customized to facilitate distance measurements and to effectively depict ranges and rings of activity.

Azimuthality

- 18. Datum Transformations
- 19. Map Projections
- 20. UTM Coordinate System
- 21. The UTM Grid and Transverse Mercator Projection
- 22. UTM Zone Characteristics
- 23. National Grids
- 24. State Plane Coordinate System
- 25. The SPC Grid and Map Projections
- 26. SPC Zone Characteristics
- 27. Map Projections
- **28. Geometric Properties Preserved and Distorted**
- 29. Classifying Projection Methods
- 30. Summary
- 31. Bibliography
- ▶ Chapter 3: Census Data and Thematic Maps
- ▶ Chapter 4: TIGER, Topology and Geocoding
- ▶ Chapter 5: Land Surveying and GPS
- ▶ Chapter 6: National Spatial Data Infrastructure I
- ▶ Chapter 7: National Spatial Data Infrastructure II
- ▶ Chapter 8: Remotely Sensed Image Data
- ▶ Chapter 9: Integrating Geographic Data

Navigation

- [login](#)

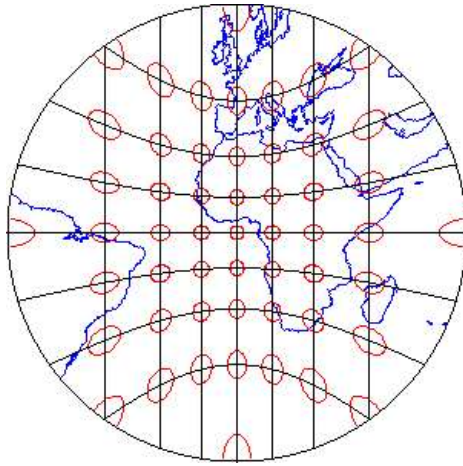


Figure 2.29.4 Azimuthal projection distortion

Azimuthal projections preserve directions (azimuths) from one or two points to all other points on the map. See how the ellipses plotted on the gnomonic projection, shown above in Figure 2.29.4, vary in size and shape, but are all oriented toward the center of the projection? In this example, that's the one point at which directions measured on the globe are not distorted on the projected graticule.

Compromise

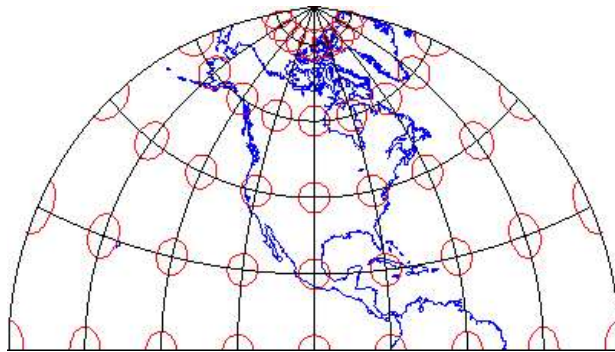


Figure 2.29.5 Polyconic projection distortion

Some map projections preserve none of the properties described above, but instead seek a compromise that minimizes distortion of all kinds. The example shown above in Figure 2.29.5 is the Polyconic projection, which was used by the U.S. Geological Survey for many years as the basis of its topographic quadrangle map series until it was superceded by the conformal Transverse Mercator. Another example is the Robinson projection, which is often used for small-scale thematic maps of the world.



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