Plotting Coordinates and Projections

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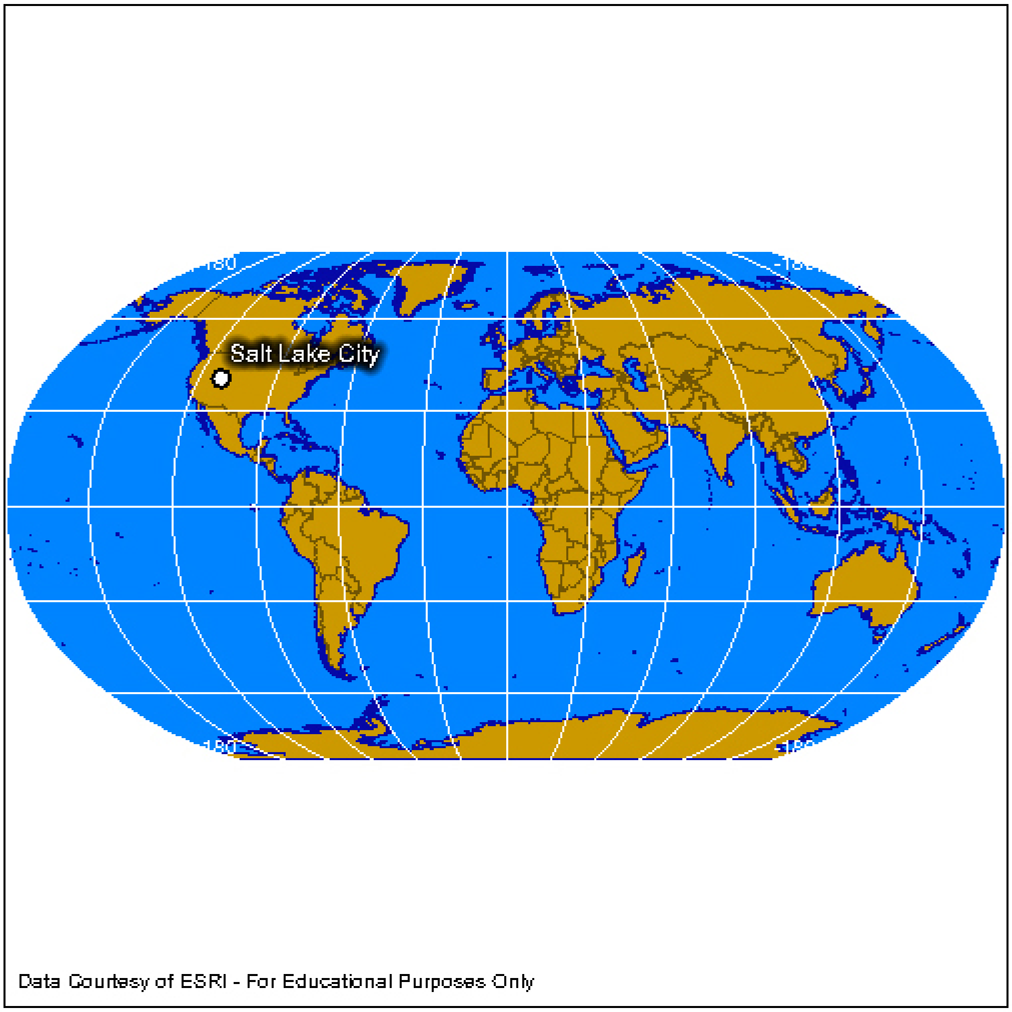

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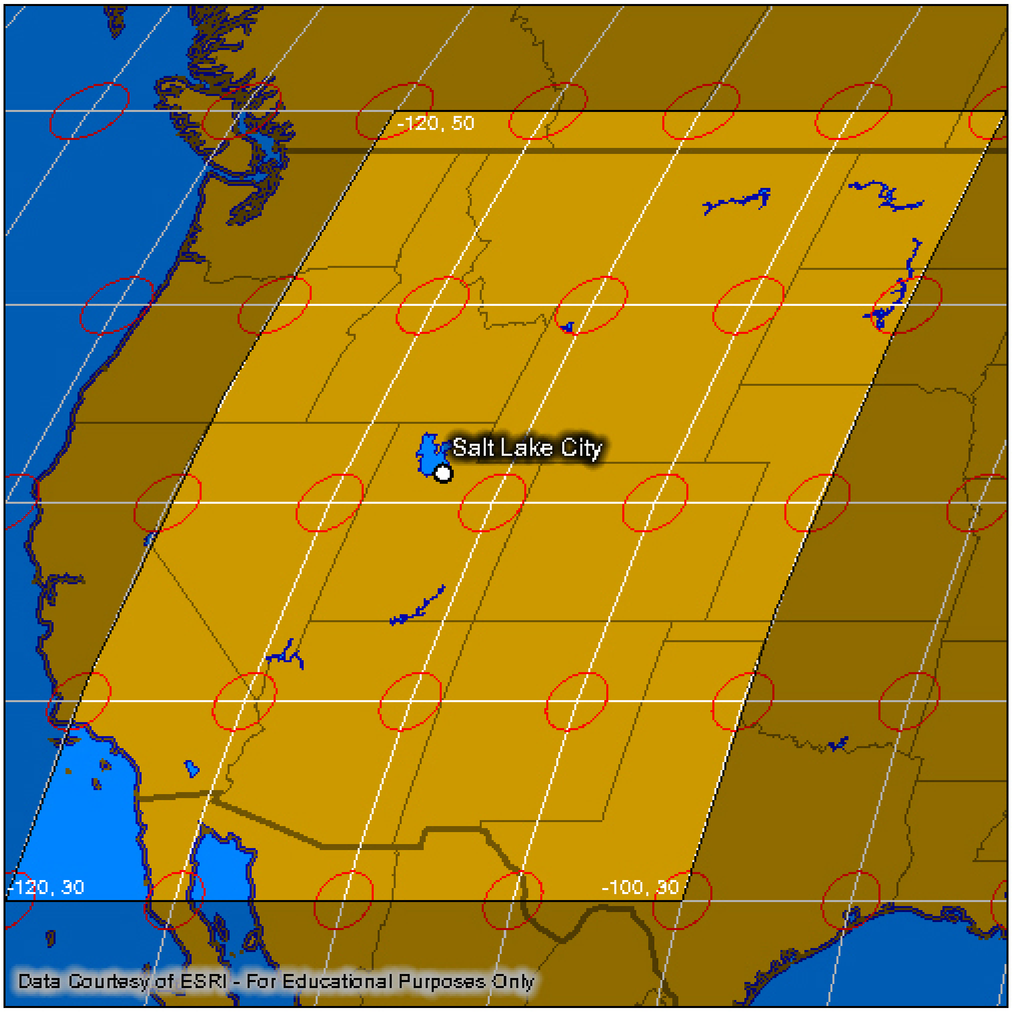
The first map shows the whole world, and each successive map presents a closer view of a specific location. This first map show the world using the Robinson map projection with the location of Salt Lake City highlighted. The Robinson projection is pseudocylindrical, meaning it unwraps the globe as a rough cylinder. This type of projection is a compromise between a conformal and equal area map (DiBiase, 2007). This type of projection has some distortion in shape and some distortion in the area (Snyder 1994).



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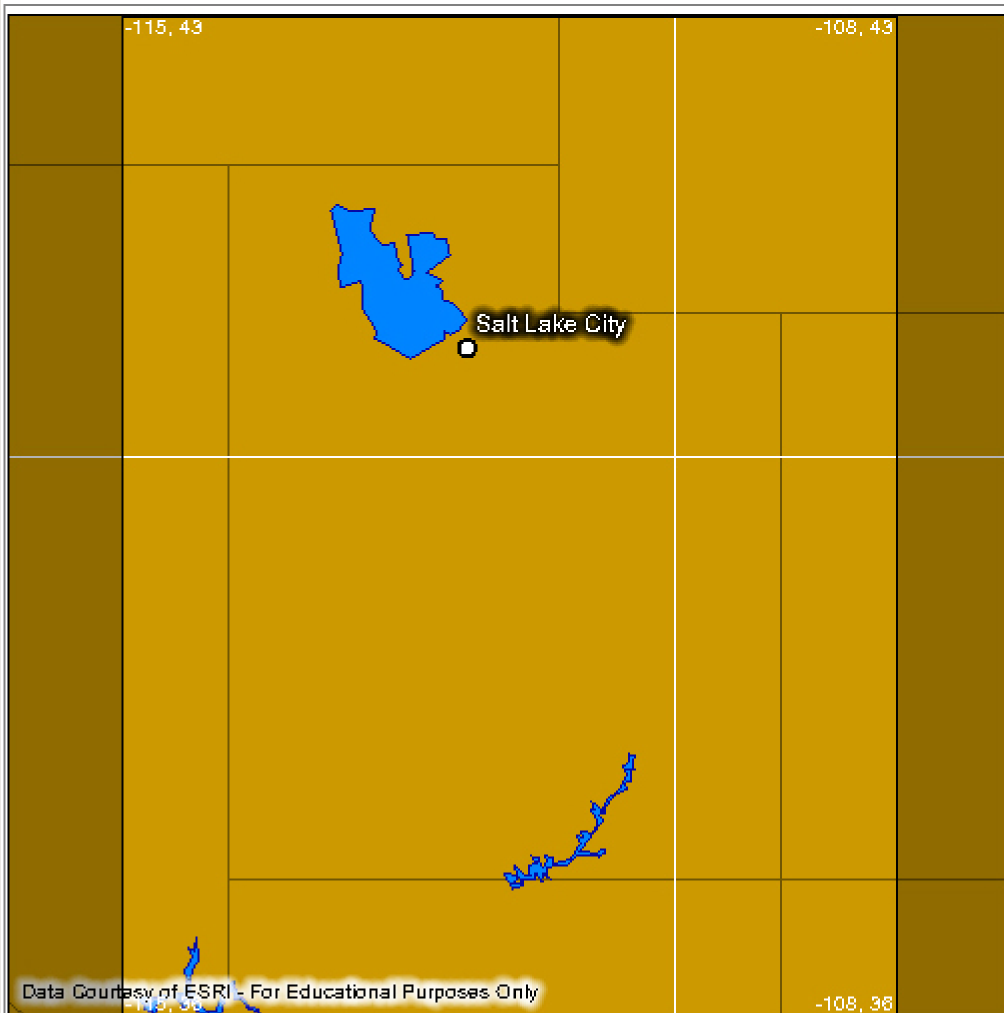
The second map presents a closer look at the Western United States. This also uses the Robinson projection and is bound from 30 to 50 degrees North Latitude and -100 to -120 West Longitude. These coordinates are displayed in white at the corners of the light colored area. This second map also shows distortion ellipsis to try and visualize the distortion. They display "a graphical representation of the spatial distortion" caused by converting a 3 dimensional object to a 2 dimensional map (Wade 2006). On a globe these red ellipsis would be circles.



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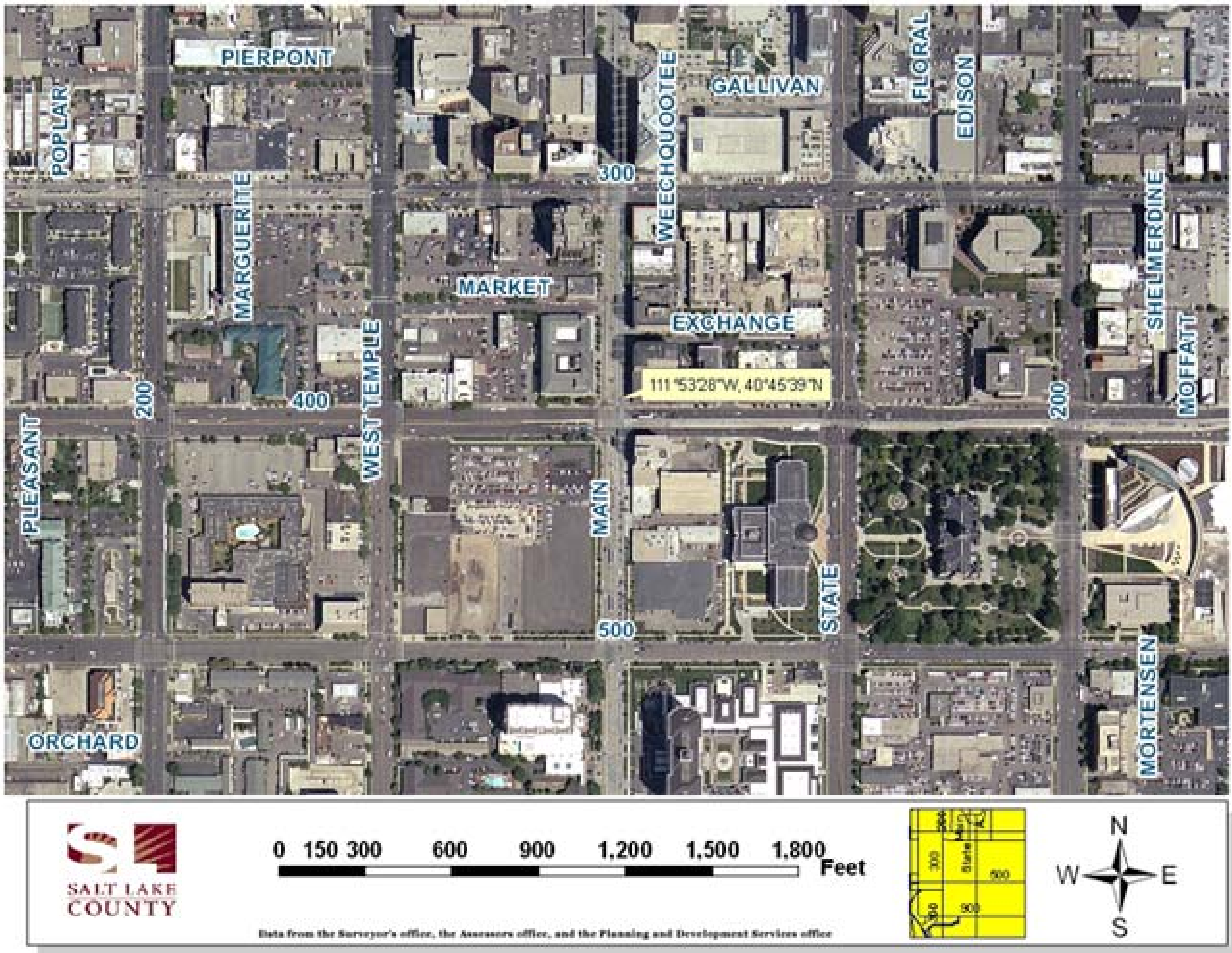
The third map above has an even a closer extent bound by 43 to 36 degrees North latitude and -115 to -108 longitude, again these can be seen in white text at the corners of the highlighted box. This map uses Mercator Projection which is Conformal (Snyder 1994). A conformal map projection "preserve the fidelity of angle measurements from the globe to the plane" and shapes are preserved but area and size is distorted (DiBiase 2007).



The forth map is an aerial of the same location at a ratio of 1:4,000, meaning that 1 map unit is 4,000 ground units. This image I created using ArcMap 9.2 with using NAD 1983 State Plane Utah Central and the Lambert Conformal Conic Projection. State Plane will be described below, and Lambert Conformal is a projection that preserves shapes and angles at a sacrifice of size. I used data from the Salt Lake County Surveyor's office, the Assessors office, and the Planning and Development Services office (Salt Lake 2007).

Geographic Coordinates

The coordinates used in the above maps for Salt Lake City were the found at the USGS' Geographic Names Information System at http://geonames.usgs.gov. At the USGS web site I started by selecting the Domestic Names button then searched GNIS. I initially searched for South Salt Lake City, the city I actually live in, but there was no location for a populated area. Not using a populated search parameter produced a larger list but this mainly contained coordinates for radio transmitter towers. I then searched for Salt Lake City and this is what I used for the maps here. The name shown on the maps represents the location of Salt Lake City using the geographic coordinates of Latitude: 40° 45' 39 " N and Longitude: 111° 53' 28 " W. These numbers represent the geographic coordinates of this location. The geographic coordinate system is a way to locate position on the Earth's surface. This uses latitude and longitude coordinates, and are expressed in degrees rather than distance units because the Earth is spherical.

> Latitude and Longitude is a "reference system used to locate positions on the earth's surface. Distances east–west are measured with lines of longitude (also called meridians), which run north–south and converge at the north and south poles. Distance measurements begin at the prime meridian and are measured positively 180 degrees to the east and negatively 180 degrees to the west. Distances north–south are measured with lines of latitude (also called parallels), which run east–west. Distance measurements begin at the equator and are measured positively 90 degrees to the north and negatively 90 degrees to the south" (ESRI 2007).

In the strict sense latitude and longitude are only used to define a location a sphere. As part of a sphere they can then projected to a plane. The problem with this is there are several distortion that may occur, and different projection types keep or distort different elements. Projections are discussed more below. Horizontal datum refers to a coordinate system grid and it's relation to an ellipsoid, and when discussing the Earth here we are using a Latitude and Longitudinal grid system. An ellipsoid is a squashed circular shape that is used as a rough approximation of the Earth for mapping purposes because of the Earth's shape (DiBiase 2007).

UTM Coordinates

The Horizontal Datum, discussed above, is then used when dividing up the Earth in to UMT zones. UTM stands for Universal Transverse Mercator, and is a projection that divides the Earth in to 60 zones East to West covering 84° North to 80° South Latitude.

> A transverse Mercator projection "transfers positions on the globe to corresponding positions on a cylindrical surface, which is subsequently cut from end to end and flattened...the cylinder is tangent to the globe along one line, called the standard line...(Transverse) refers to the fact that the cylinder... has been rotated 90° from the equatorial aspect of the standard Mercator projection, in which a single standard line coincides with 0° latitude" (DiBiase 2007).

Each of these 60 Zones has a North and South halve with each zone covering 6° of Longitude. The coordinates for this system are no longer in Lat / Lon but in Eastings and Northings and they are expressed in meters. This is done because the coordinates are now projected or transformed in to plane or flat map. A "false" origin is created for each zone. By doing this all coordinates are now positive and become North and East (DiBiase 2007). The UTM coordinate for Latitude: 40° 45' 39 " N Longitude: 111° 53' 28 " W in NAD83 is Easting: 424785.492 meters, Northing: 4512589.744 meters, Zone: 12.

State Plane Coordinates

Even with the 60 UTM zones the size is too large for some uses. The United States was divided into smaller zones called the State Plane Coordinate System or SPC. The State Plane Coordinate System needed to have a small enough size to have minimal distortion and still be large enough to useful. It was designed so calculating distances and areas would be easy by using positive values, and have a low maximum error rate (DiBiase 2007). Latitude and Longitude coordinates are projected to the plane coordinates In order to get the best possible results a different mathematical formula was used for each zone. In the SPC the initial 0,0 origin point for calculating coordinates is south of the counties in the zone, and the value at the origin is a large number so all values in the zone are positive, meeting one of the goals stated above. Because of the different formulas used in the different zones, coordinates from one zone do not relate to another zone with out conversion. The

State Plane Coordinates in NAD83 for Latitude: 40° 45' 39 " N Longitude: 111° 53' 28 " W is Easting: 466974.267 meters, Northing: 2269583.868 meters in the Utah Central Zone.

Nearly all of the zones in SPC use a Transverse Mercator or Lambert Conic Conformal projection. Tall zones use aTransverse Mercator projection and wide states use a Lambert Conic Conformal projection, and the long pan handel of Alaska uses an oblique projection. Each of these projections preserves conformality, meaning there is some scale distortion but the shapes are preserved and more importantly angles are preserved. This preservation of angles is important for survey work. The coordinates are expressed in meters because these are projected on to a plane rather than on a ellipsoid or sphere. Each zone in the SPC uses a Horizontal Datum that may not be the same as another zone. Each zone uses an ellipsoid that best represents the Earth in its area (DiBiase 2007, Wade 2006).

Summary

Geographic Coordinates use degrees and describe a position on a sphere or ellipsoid Because it is difficult to carry around a sphere in your pocket that is large enough to be useful propel tend to use flat paper maps. Since these 2 thing are obviously different shapes a way to represent one shape on another is needed. A map projection is converting geographic coordinates to a flat map. "A horizontal datum is the combination of positioning a lat-lon grid system on an ellipsoid, and a projected coordinate system uses a geographic coordinate system" (Kennedy 2000).

There are many types of projection available and this creates different types of distortion. The projection types include Equivalence, Conformality, Equidistance, and Azimuthality. Equivalence projections preserve the area at but shapes become distorted. Conformality preserves the shape but sacrifices the area integrity. An Equidistance map projection preserves distance along straight lines with some distortion in shape and size (DiBiase 2007). Azimuthality preserves directions between two points (Kennedy 2000).

The UTM coordinates are presented in meters because they have been projected. The UTM system does not cover the entire planet like Geographic Coordinates do, and the SPC covers an even smaller area of the globe, namely the United States. UTM and SPC both use positive numbers, and both use a False Northing origin, but where UTM has a false easting with a value of 0 at the origin, the SPC easting origin is such a large number that all other values for that zone are positive.

> "A projected coordinate system is defined on a flat, two-dimensional surface. A projected coordinate system, unlike a geographic one, has the advantage that lengths, angles, and areas are constant across the two dimensions. This is not true when working in a geographic coordinate system. A projected coordinate system is always based on a geographic coordinate system that can use a sphere or spheroid (Kennedy 2000).

The older system of NAD 27 used feet and used Meades ranch in Kansas as the origin point, but the newer NAD 83 uses a global ellipsoid that has the Earths center of mass as the origin (DiBiase 2007). Because of the difference in the formulas there is a datum shift in the control points. This means the coordinates are different not that the points have moved on the Earth surface. This also illustrates the importance of knowing what system a map was made in. Where it came from lets you know what you need to do to the data for it to be useful

There are different horizontal datum in use and each may have a different grid system specialized for different areas of the world. Those discussed above cover just a few of the types of maps, terms and limitation associated with GIS.

Sources

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