GEOSPATIAL INNOVATION FACILITY
Cutting-Edge Mapping Technology at UC Berkeley

Projections:
What You Need To Know for GIS

WHAT IS PROJECTION?

Projection is how the 3D earth is mapped on a 2D planar surface (paper map or digital GIS). All projections have some error, but each differs in the type of error. Listed below are projection characteristics:

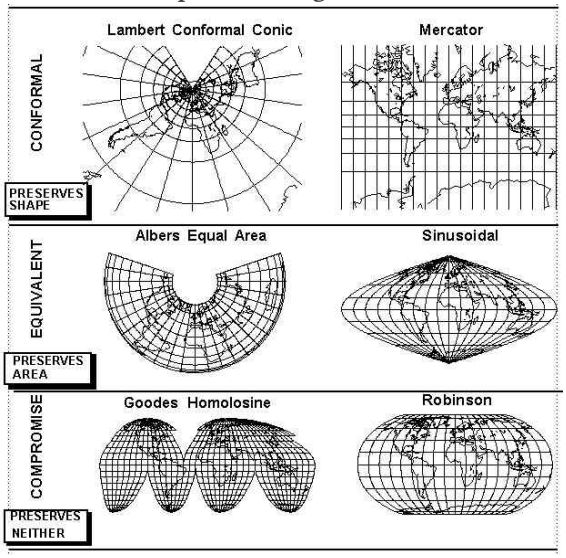
- Conformality, or "Conformal" projections
  - Preserves **shape.**
  - When the scale of a map at any point on the map is the same in any direction, the projection is conformal. Meridians (lines of longitude) and parallels (lines of latitude) intersect at right angles.
- Area, or "Equivalent" projections
  - Preserves **area.**
  - When a map portrays areas over the entire map so that all mapped areas have the same proportional relationship to the areas on the Earth that they represent, the map is an **equal-area**, or equivalent, map.
- Distance
  - A map is equidistant when it portrays distances from the center of the projection to any other place on the map.
- Direction
  - A map preserves direction when azimuths (angles from a point on a line to another point) are portrayed correctly in all directions.

COMMON CALIFORNIA PROJECTIONS

1. **Universal Transverse Mercator (UTM)**
   - Calif. is split between zones 10 & 11 of the UTM grid.
   - Global coverage, grid with false local origins, which minimizes error for each region.
   - UTM requires that error must not exceed 1/1000 (0.1%) anywhere on the map. At the center of the zone, the error is 1/2,500 (0.04%).
   - The scale factor at center is 99.96, at edges is 100.04. That is, a feature measuring 100 meters on the ground would measure 99.96 meters if it were in the center of a zone and 100.04 meters if at the edge of a zone.
2. **Stateplane**
   - In Calif. Stateplane, we use the Lambert Conformal Conic projection (each state uses diff. type).
   - State plane requires that error must not exceed 1/10,000 (0.01%). That is, a feature measuring 100 meters on the ground would measure 99.99 meters or 100.01 meters depending on position on map.
3. **Teale-Albers**
   - Albers is an equal-area conic, with 2 parallels.
   - Projection error must not exceed 1.25%.
   - The "Teale" Albers projection is used for all distributed state-wide spatial data.

COMMON GLOBAL PROJECTIONS

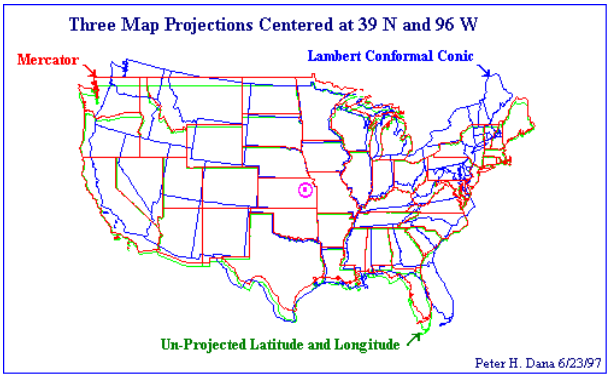
- Geographic
  - 1° Latitude = 1° Longitude
- Mercator (i.e. Universal Transverse Mercator, UTM)
  - Developed for navigation.



Left. Several different examples of projection types, including conformal, equivalent, and a compromise between the two.

COMMON U.S. PROJECTIONS

- Geographic
- Albers
- Lambert
- Mercator



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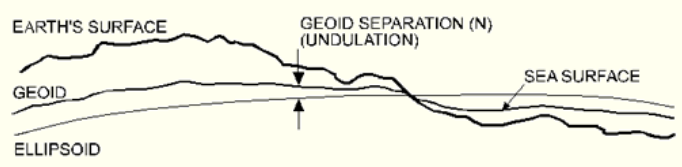
Datum:
What You Need To Know for GIS

WHAT IS A DATUM?

A datum is the mathematical model that fits the earth to an ellipsoid. It is a reference from real-world to this ellipse.



Above. The earth's surface is not perfectly round. Instead, it is ellipsoid, with mountains and valleys. Datum are used to correct for these undulations.

Common global ellipsoids are:
- WGS84 (World Geodetic Survey, 1984)
- GRS80 (Global Reference System, 1980)
- Clarke 1866 ellipsoid (used with California's State-wide Teale Albers projection)

In North America, the horizontal datums are:
- NAD83 datum (North American Datum, 1983) – same as WGS84.
- NAD27 datum (North American Datum, 1927) – same as Clarke 1866.

HORIZONTAL DATUM SHIFT

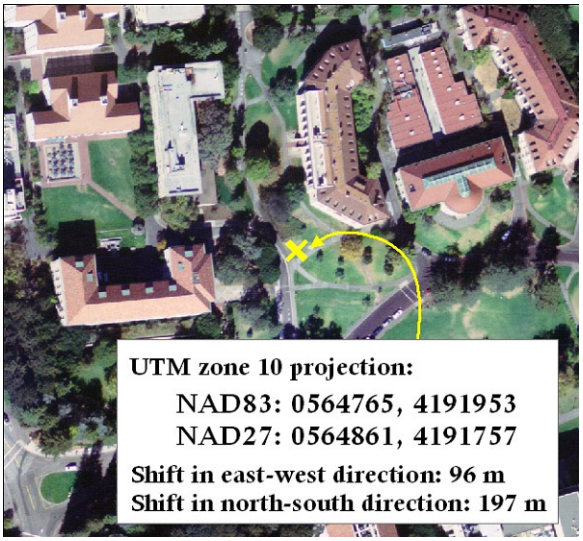
Datum shifts are differences in the mathematical formulas between datum. Datum shifts ***must*** be taken into account when re-projecting data, or comparing data of different datum, or else error will be introduced:

- Datum shift in California:
  - 100 m shift in the eastward direction
  - 200 m shift in the northward direction

USGS Topo maps are NAD27

Most GPS are set to WGS84 out-of-the-box (same as NAD83).

You convert between datum using NADCON transformation → do this in ArcGIS!



WHICH DATUM DO YOU USE?

All of them are correct, it just depends on whatever is appropriate for your area:

- WGS84: if you are going to compare with GPS data you have collected elsewhere in the world.
- NAD83: if you are in N. America, and are collecting raw data.
- NAD27: if you are in N. America, and want to match your NAD27 topo maps.

VERTICAL DATUM SHIFT

- Sea level for an area is measured over a period of time. This is called a tidal epic.
- Sea level is rising
- These tidal epics are used to develop the vertical datum for an area
  - NGVD 29 (The National Geodetic Vertical Datum of 1929) derived from measurements at 26 tide stations along the coasts of the US and Canada
  - NAVD 88 (The North American Vertical Datum of 1988) was created in 1991 from measurements in Mexico, the US, and Canada
- In our area, vertical datum shifts are ~1m. This is crucial, as tide heights have legal ramifications.