Geographical Information System

Lecture slides - II

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MAP CONCEPT

- MAP defined as a representation, usually on a flat surface, of a whole or part of an area.
- Maps are used by various types of people and professions for many different purposes.
- Maps are the primary tools by which spatial relationships are visualized.
- Maps are produced by cartographers. Cartography refers both the study of maps and the process of map-making.

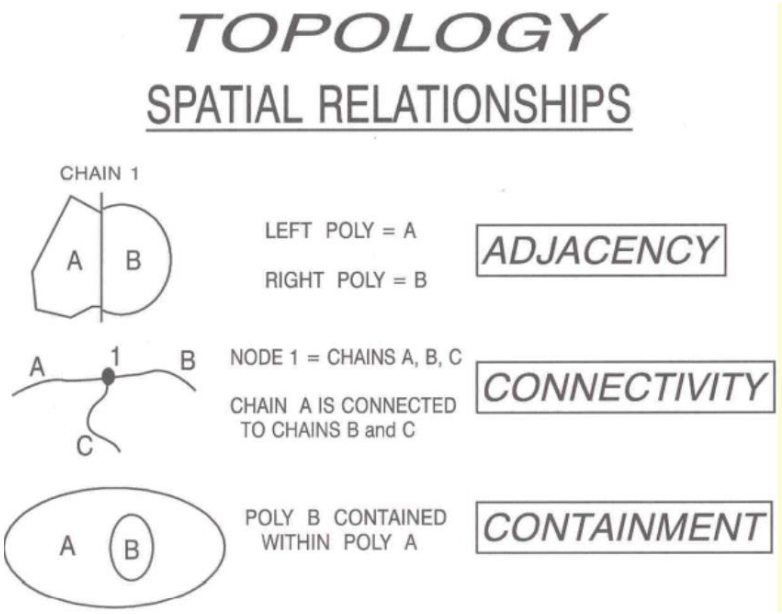
MAP CONCEPT

- **Geographic features or spatial information presented graphically**
- Conveys information about location and attributes
- Maps are the primary tools by which spatial relationships are visualized.
- There are several key elements that should be included each time a map is created in order to aid the viewer in understanding the communications of that map and to document the source of the geographic information used.

MAP CONCEPT

TOPOLOGY

- Topology in Maps Topology is a spatial relationship between features or objects of map. It refers the geometrical relationship between communities, network, segment, connectivity



MAP CONCEPT

TOPOLOGY

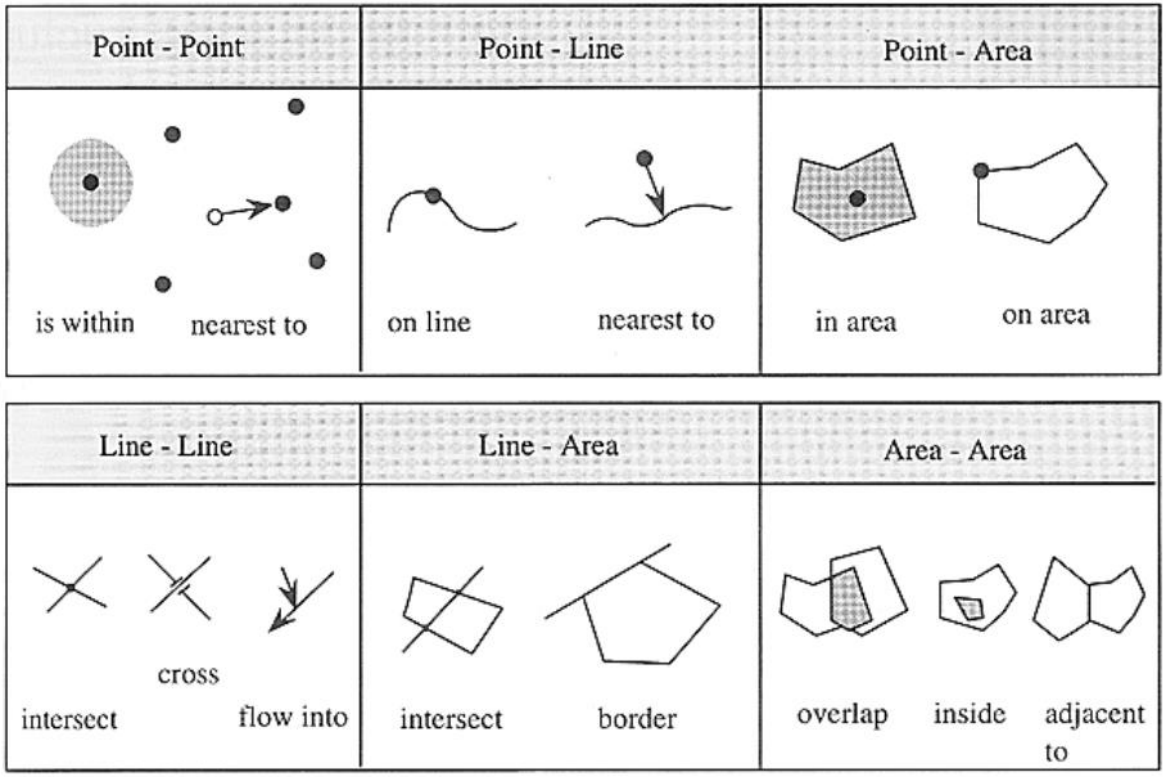
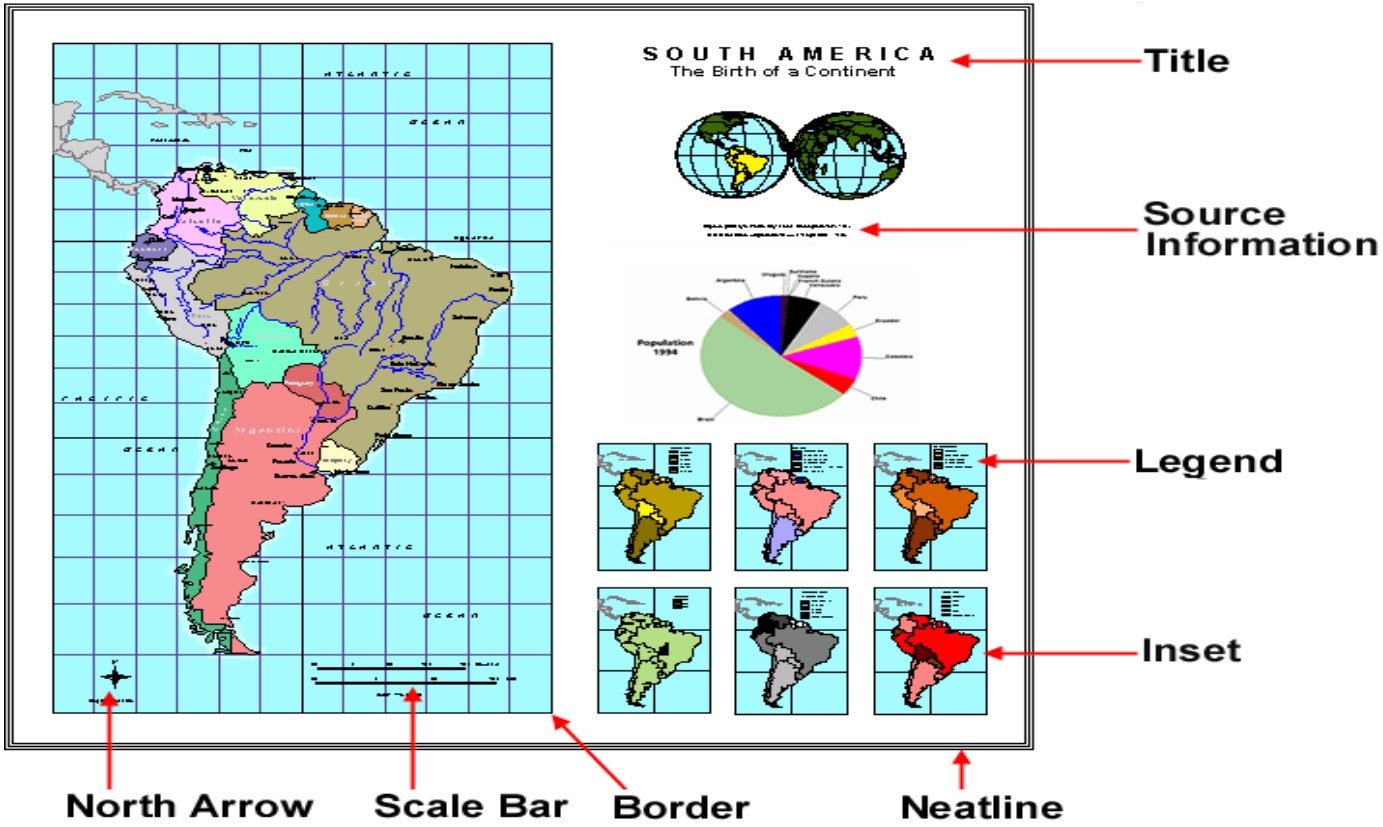


Figure 2.4 Topological Relationships Between Spatial Objects

ELEMENT OF MAP



ELEMENT OF MAP

- **Title (and subtitle):** Usually draws attention by virtue of its dominant size; serves to focus attention on the primary content of the map. Should be an answer to "What? Where? When?".

  Tips: Never underline a title (or a subtitle), and never put a colon after a title.

- **Legend:** The principal reference to the map symbols; subordinated to the title. However, this is still a key element for map reading; describing all unknown or unique map symbols used. Tips: Only the word "Legend" should be written on your map (and not "Map Legend", or "Switzerland Legend", etc.).

- **Map Scale:** Provides the reader with important information regarding linear relations on the map. A scale can be numerical (for example 1:50000) or graphical.

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ELEMENT OF MAP

- **Credits:** Can include the map source, the author, indication of the reliability of accuracy of the map, dates, or other explanatory material.
- **Mapped Areas:** Objects, land, water, and other geographical features important to the purpose of the map.

- **ap Symbols:** Wide variety of forms and functions; the most important element of the map, along with the geographic areas rendered.

- **lace name and Labelling:** The chief means of communicating with maps; serve to orient the reader on the map and provide important information regarding its purpose.

Tips: Use the same font for the map frame, the map layout, and the map

ELEMENT OF MAP

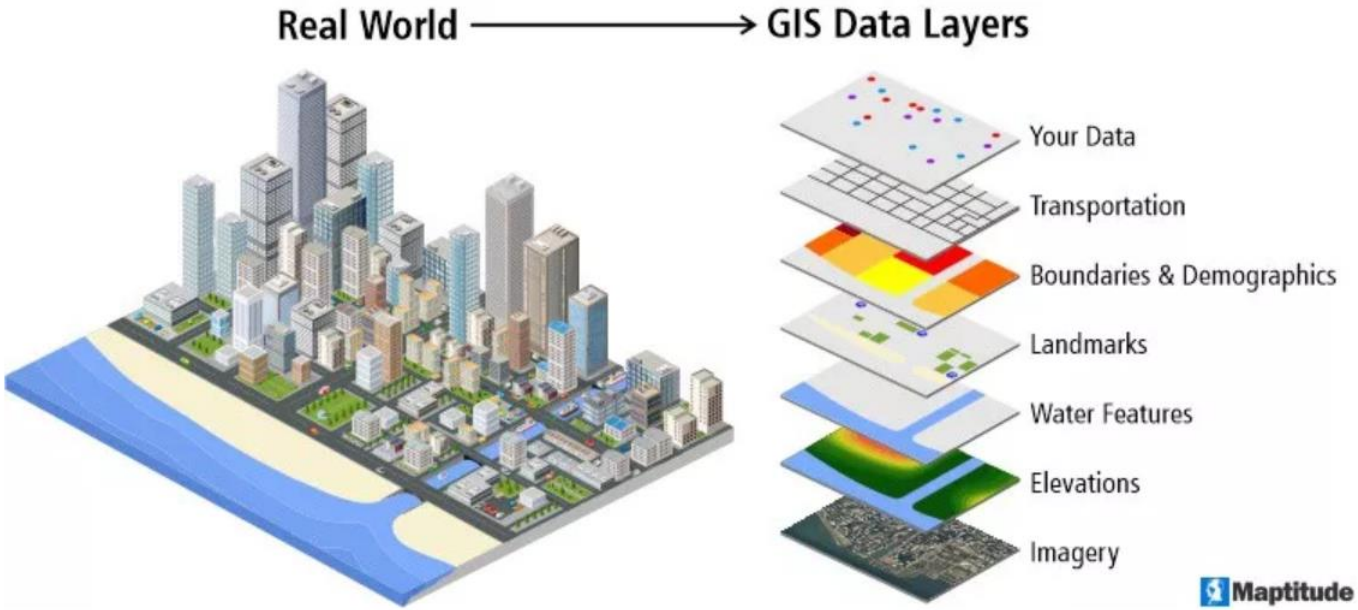
- **North arrow:** According to the rules, each map should have a north arrow. But if the map is north oriented, or if the geographical co-ordinate are already on the map the north arrow can be omitted.

- **Border and Neatlines:** Both optional; borders can serve to restrain eye movements. Neatlines are finer lines than borders, drawn inside them and often intra-parallelism, rendered as part of the graticule; used mostly for decoration.

- **Graticule:** Often omitted in maps today; should be included if the location information is crucial

MAP LAYER

- Layers are mechanisms used to display geographic datasets on maps. They contain groups of points, lines, or area (polygon) features and define how a geographic dataset is symbolized on a map.

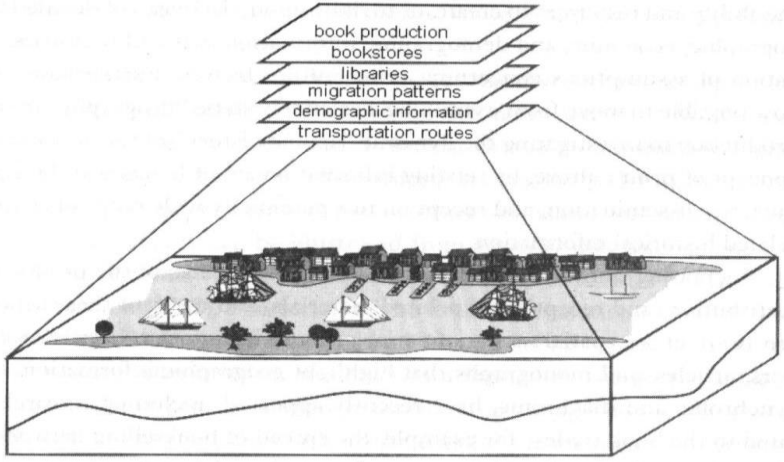


A GIS map combines layers of data representing real world locations and entities

MAP LAYER

- Map layer forms the fundamental unit while doing analysis on maps. Not only it makes data expression clearer and intuitive but makes the overlay of geographic data possible. Visualizing and seeing the distribution of data in each region makes it easier to mine for deeper and specific information and make better decisions.
- A data layer set is a collection of individual spatial data layers. An individual file; a single layer can be added to a GIS project. Potentially many data layers make up a single data set Usually, spatial data is acquired in large sets. There may be as many as 150 individual data layers that make up a data set.
- Data on different themes are stored in separate “layers”
- As each layer is geo-referenced, layers from different sources can easily be integrated using location
- This can be used to build up complex models of the real world from widely disparate sources

MAP LAYER



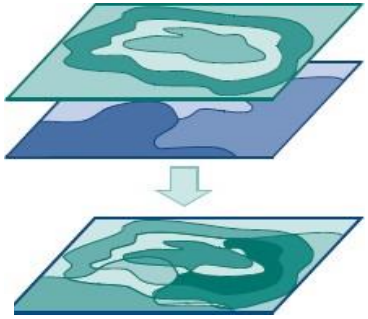


Figure : Two different object layers can be overlaid to look for spatial correlations, and the result can be used as a separate (object) layer.

MAP LAYER

WHY DO WE NEED MAP LAYERS?

1. Adds context to your maps

Layers make maps more contextual and help you focus on specific aspects like assets, roads, and points of interest. Map layers make it easier for you to work on a specific set of objects in your map. For example, using map layers you could pin-point and evaluate only a handful of points or building in an area for your case.

2. Helps you detect change faster

Maps are after representation of what is happening on the ground. With a map layer, you see how various measures and metrics are changing over time.

For example, the commercial property team in an insurance company could use it to track the household/property owners who are making modifications to their properties or in different cases, geographic scientists use it to study changes in land cover.

MAP CHARACTERISTICS

- Scale
- Resolution
- Accuracy
- Projection

MAP CHARACTERISTICS

MAP SCALE

It is the ratio in which the real objects are reduced on to a map illustration

1 cm = 1000 m

1 cm = 100, 000 cm

1 : 100, 000

Representative Fraction (RF)

1 unit on map equivalent to how many units on Earth

Small Scale Maps (1:250, 000; 1:500, 000)
Medium Scale Maps (1:50, 000)
Large Scale Maps (1:7500; 1: 3000)

MAP CHARACTERISTICS

MAP RESOLUTION

- How accurately the location and shape of map features can be depicted for a given map scale
- In larger scale maps - features more closely matches real world features
- It is difficult to show features with size less than 1/8 inch on map so 1 inch = 1 mile
- It would be difficult to show a feature less than 1/8 of a mile)

MAP CHARACTERISTICS

MAP ACCURACY

1. Factors affecting accuracy of the map
2. Map resolution
3. Quality of source data
4. Map scale
5. Drafting skill
6. Width of line used to depict features

TYPE OF MAP

There are two main types of maps, based on their design purpose:

Reference Maps

(General Purpose Map)

Thematic Maps

(Specific Purpose Map)

TYPE OF MAP

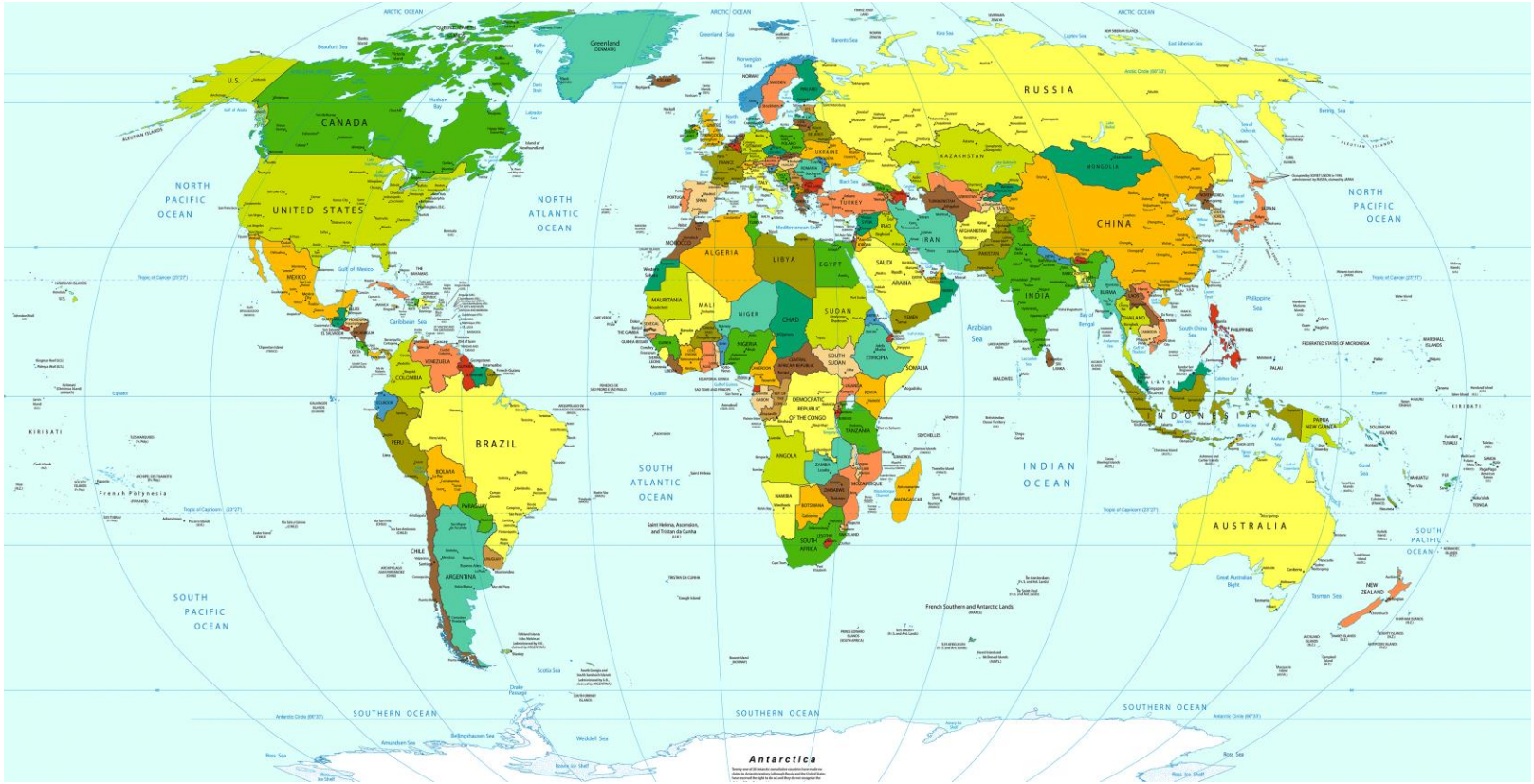
REFERENCE MAPS

Reference maps use symbols to locate and identify important landmarks and geographic features.

- Political Map
- Physical Map
- Topographic Map
- Satellite Map

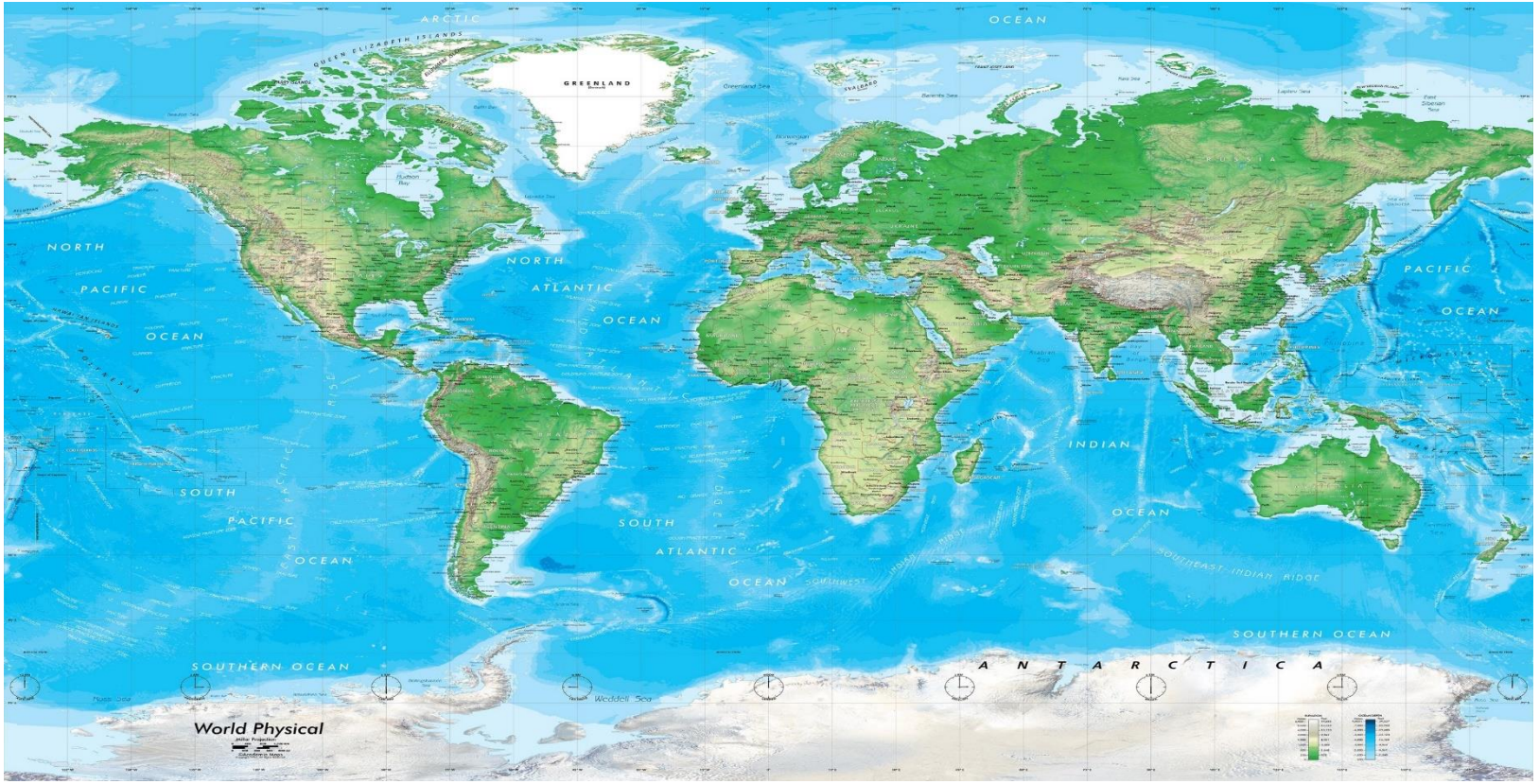
TYPE OF MAP

Reference Map: Political Map



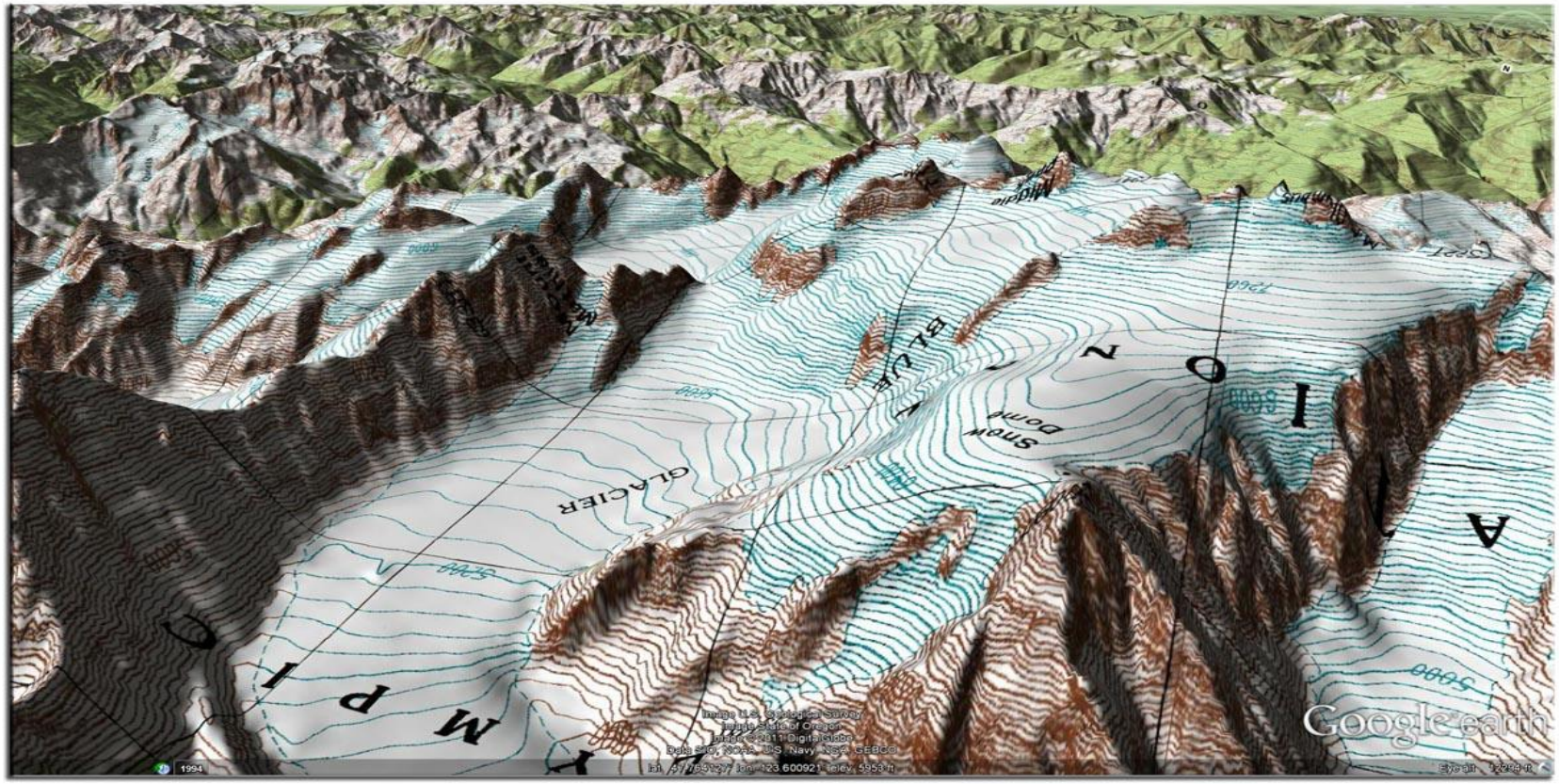
TYPE OF MAP

Reference Map: Physical Map



TYPE OF MAP

Reference Map: Topographic Map



TYPE OF MAP

Reference Map: Satellite Map

TYPE OF MAP

Reference Map: Satellite Map

TYPE OF MAP

Thematic Maps

Thematic Maps display distributions—or patterns—over Earth's surface, and emphasize on some particular feature or set of data .

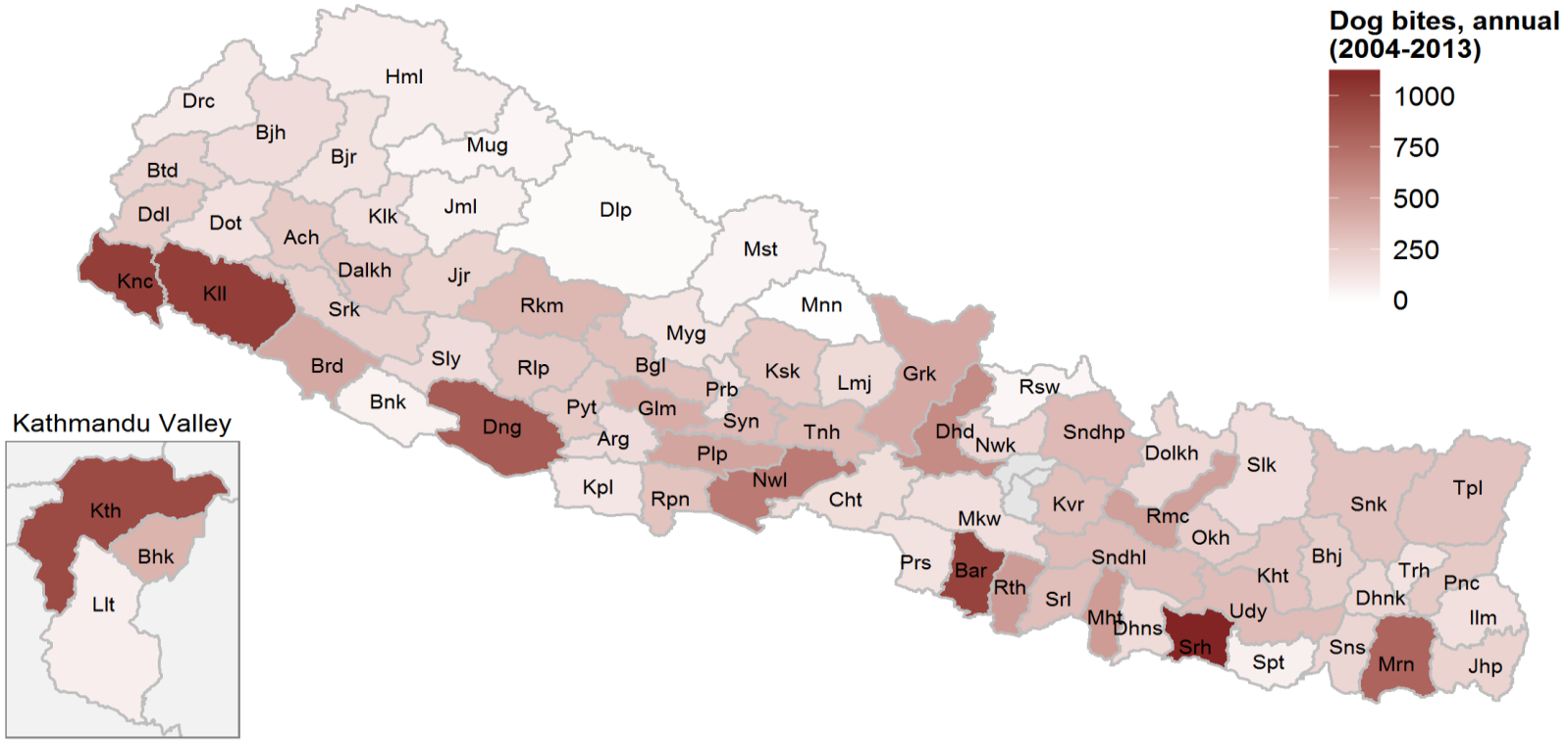
Rather than attempting to map the landscape or help to show you where to go, thematic maps are designed instead to highlight information on specific topics

Thematic Maps: Types

- Choropleth Map
- Cartogram Map
- Dot-density Map
- Isoline Map
- Graduated Symbol Map

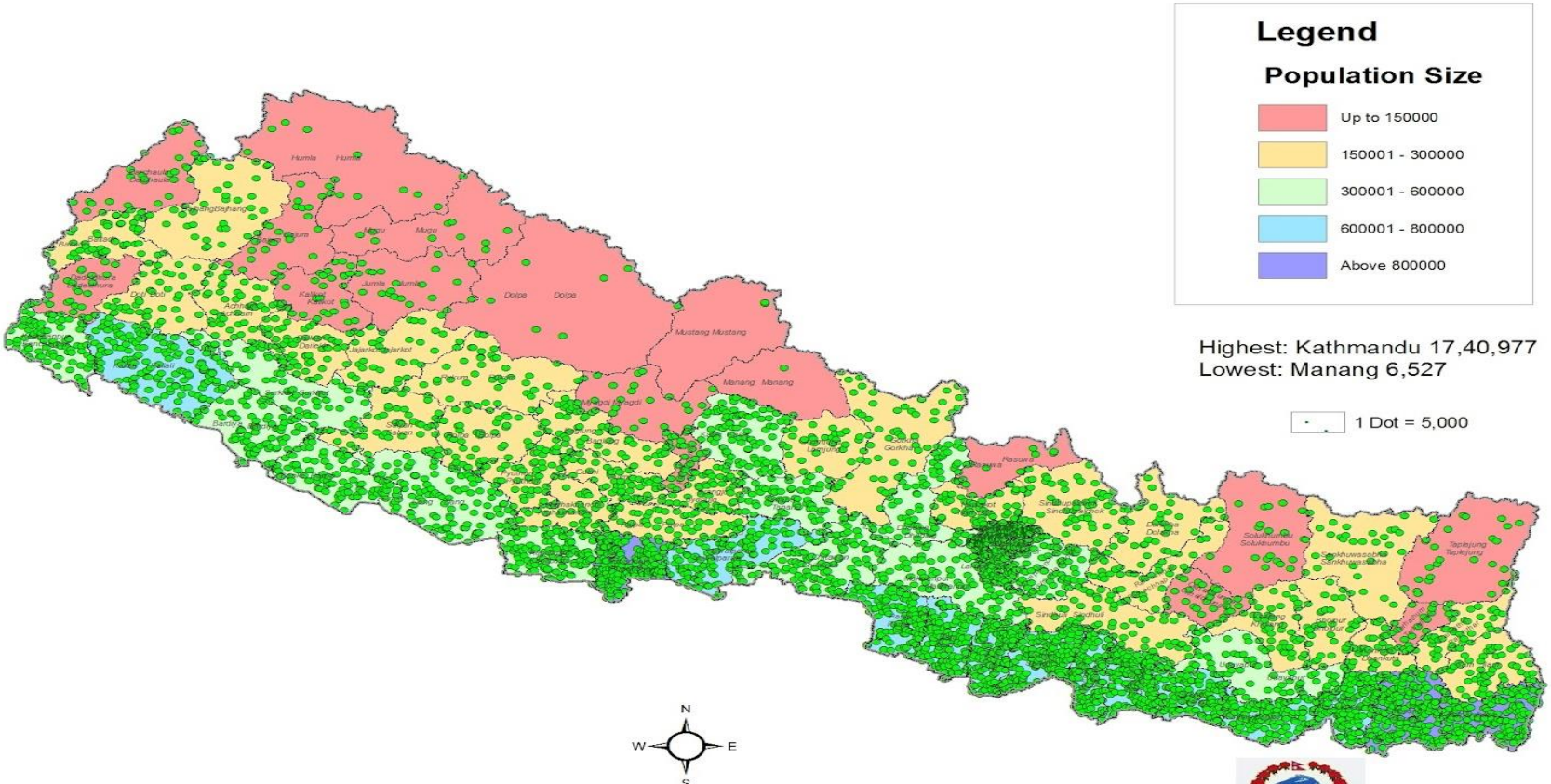
TYPE OF MAP

Thematic Map: Choropleth Map



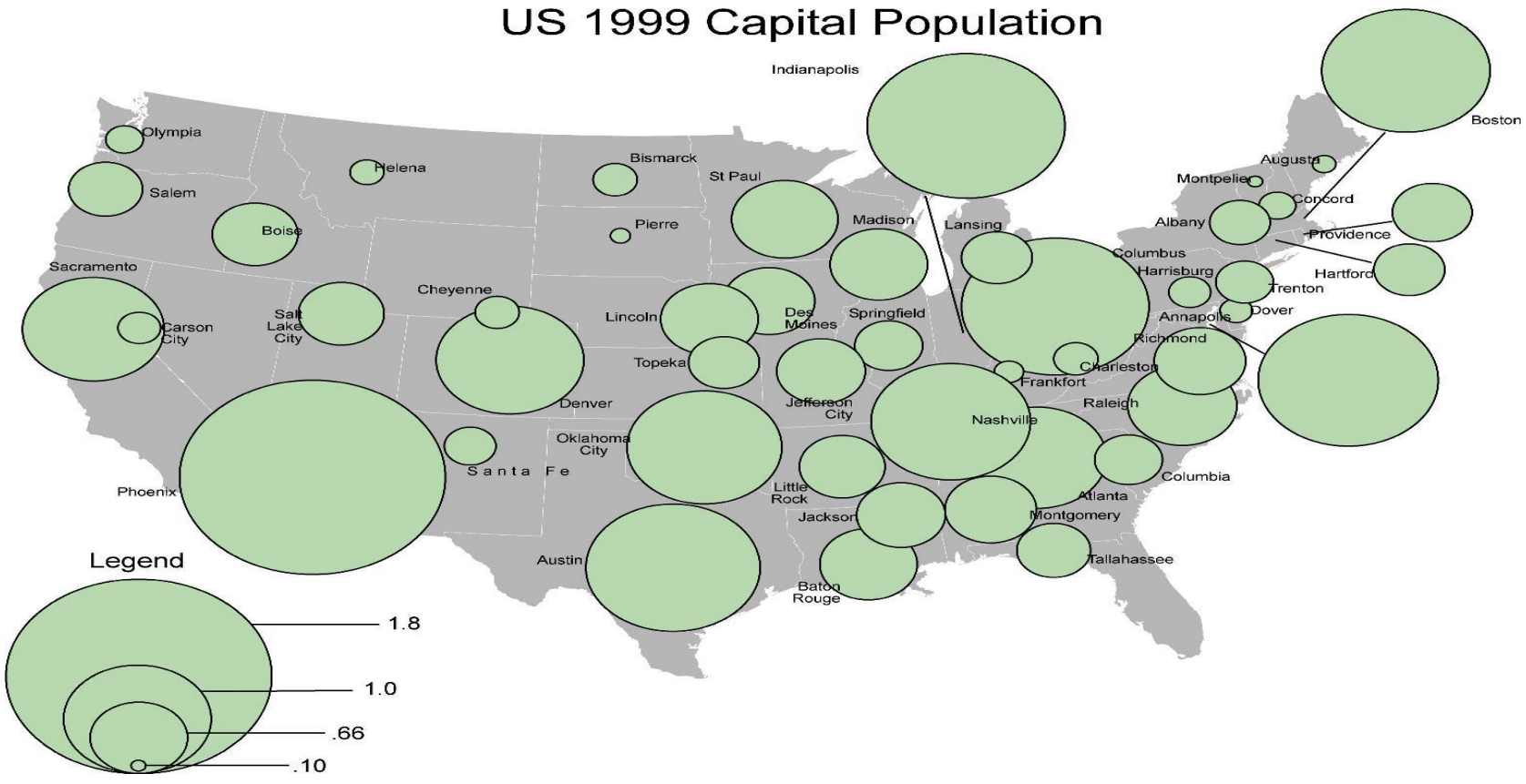
TYPE OF MAP

Thematic Map: Dot-Density Map



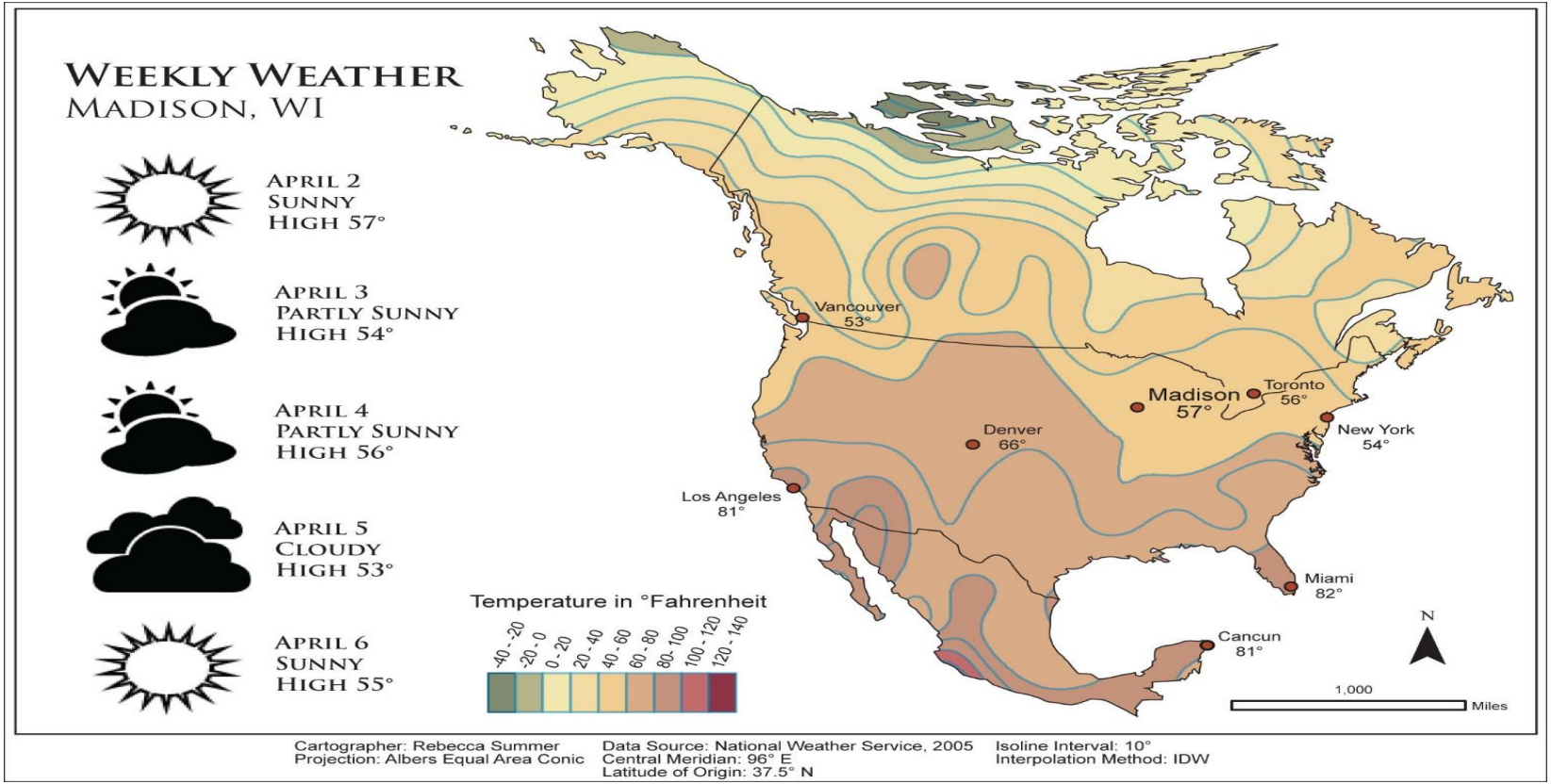
TYPE OF MAP

Thematic Map: Graduated Symbol Map



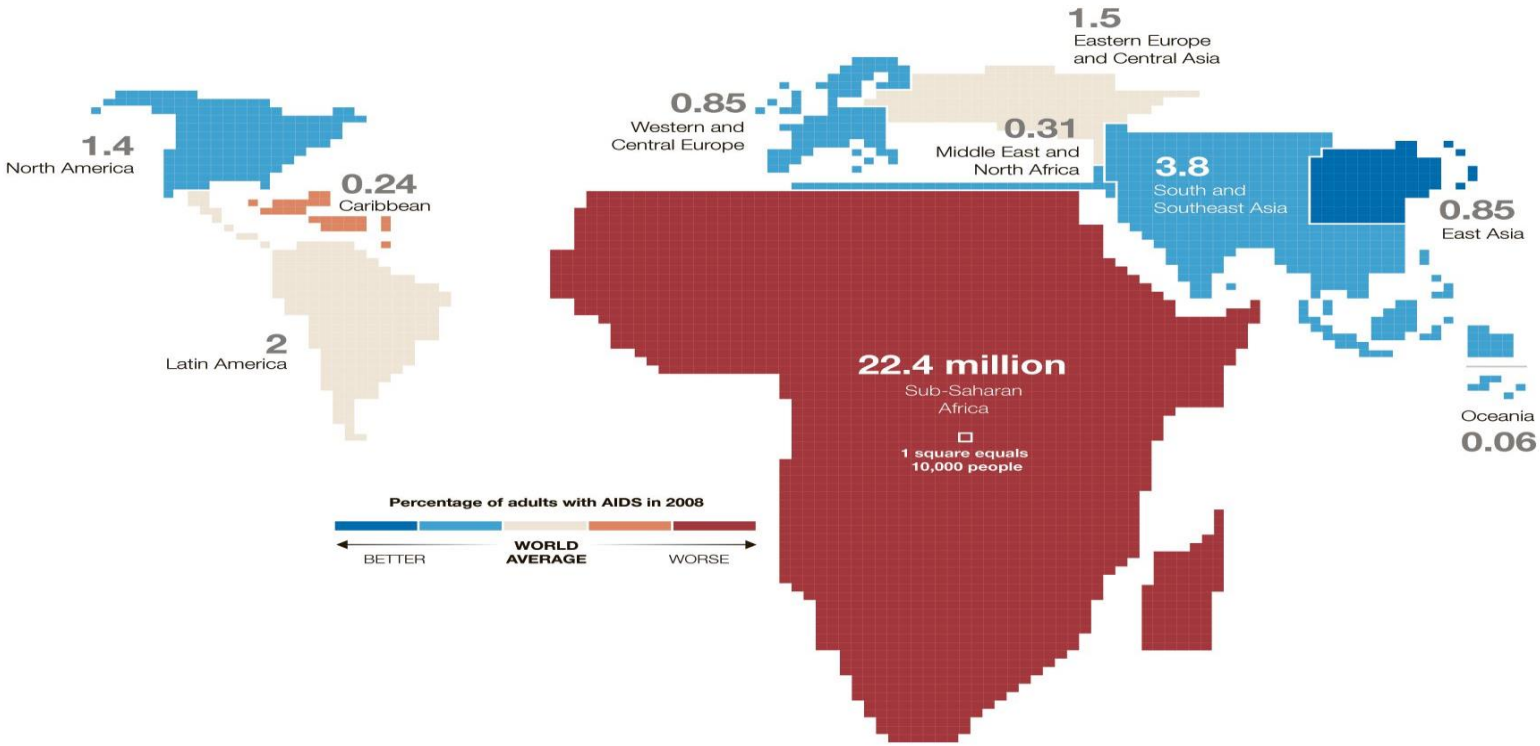
TYPE OF MAP

Thematic Map: Isoline Map



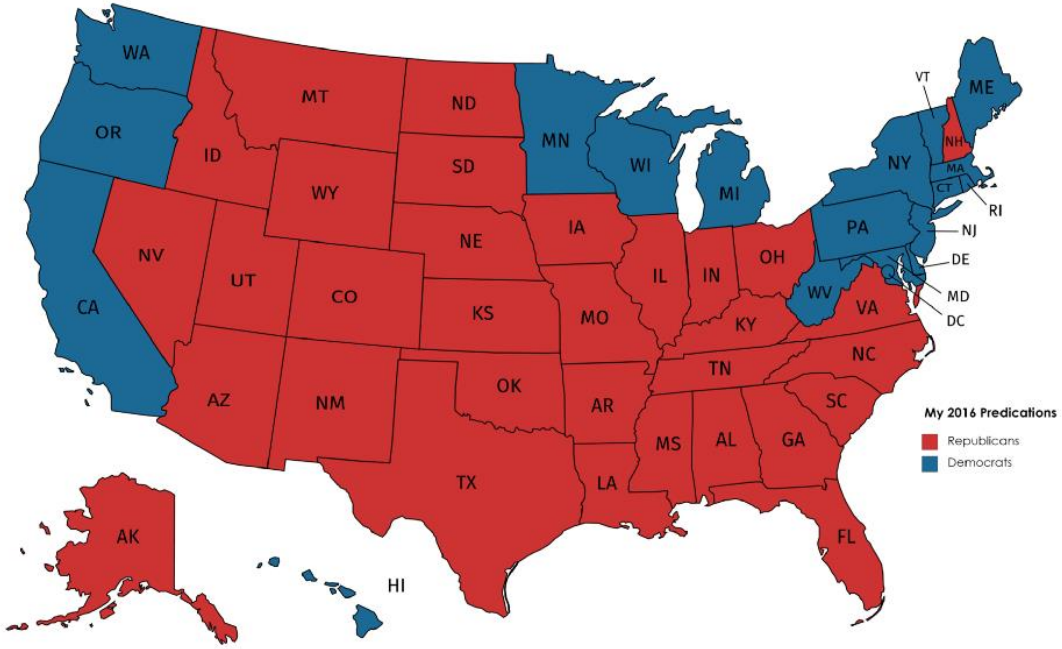
TYPE OF MAP

Thematic Map: Cartogram Map



TYPE OF MAP

Thematic Map: Cartogram Map



Created with mapchart.net

COORDINATE SYSTEM

- A coordinate system is a grid used to identify locations on a page or screen that are equivalent to grid locations on the globe

- The coordinates are (x, y) pairs that are based on some universal origin point for reference.
- The most commonly used is latitude and longitude
- It is a reference system used to represent the locations of geographic features within a common geographic framework

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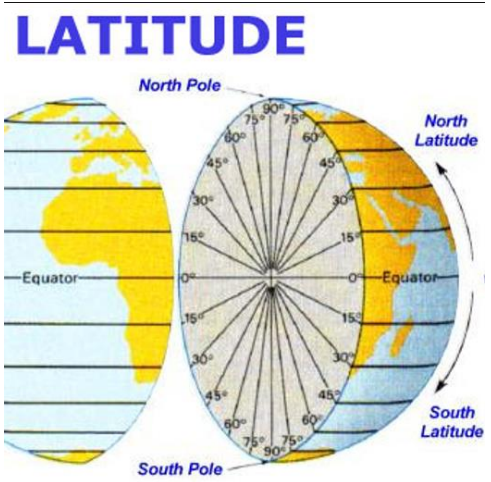
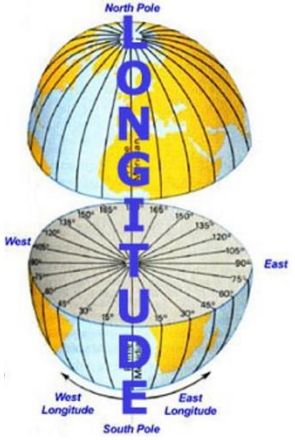
COORDINATE SYSTEM

Latitude refer to degree, minutes and seconds of arc from reference lines that run East-West (Latitude: Equator)



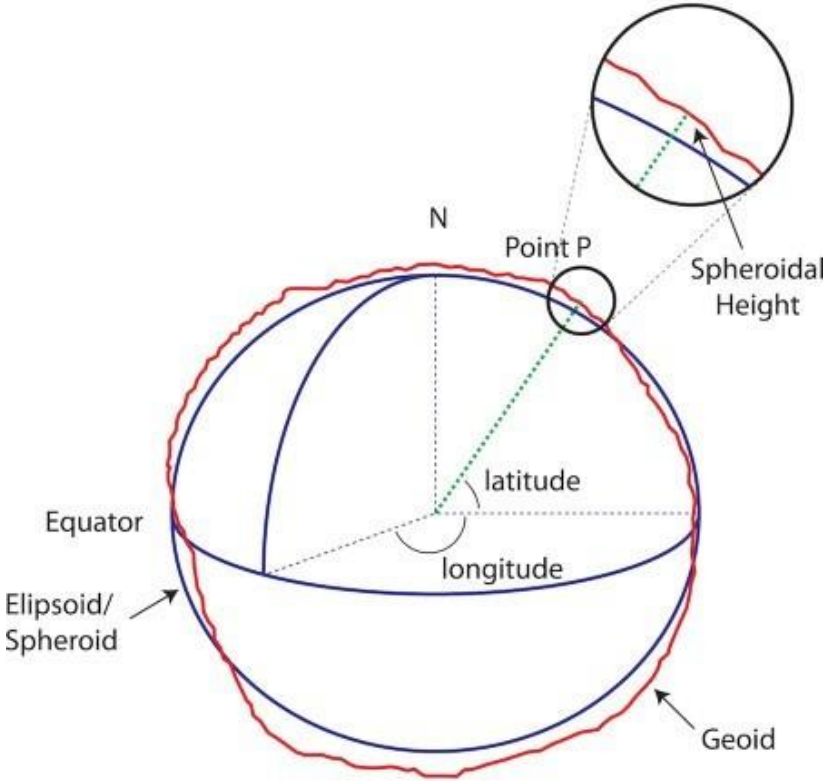
Longitude refer to degree, minutes and seconds of arc from reference lines that run North-South (Longitude: Prime Meridian)



Coordinate System

to position objects in a two- or three-dimensional space

- Coordinate System is the most general term for a system that includes coordinates. It is a way to *locate the position of objects* in two or three dimensions.
- Data is defined in both *horizontal and vertical coordinate systems*.
- Horizontal coordinate systems *locate data across the surface* of the earth.
- Vertical coordinate systems locate the relative *height or depth* of data.

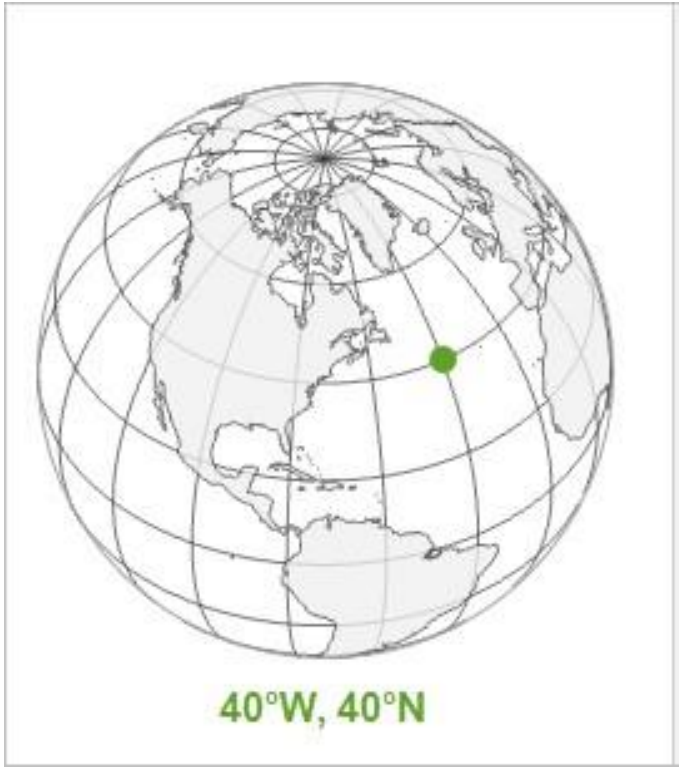


https://res.cloudinary.com/dyyck73ly/image/upload/w_0.5,h_0.5,c_fill,g_center/v1471893887/a1ka1sqyg7nonqjfhq48.jpg

Spatial Reference Systems or Coordinate Systems, include two common types:

- A geographic coordinate system measured in angular units is compared to a projected coordinate system measured in linear units.

Geographic coordinate system

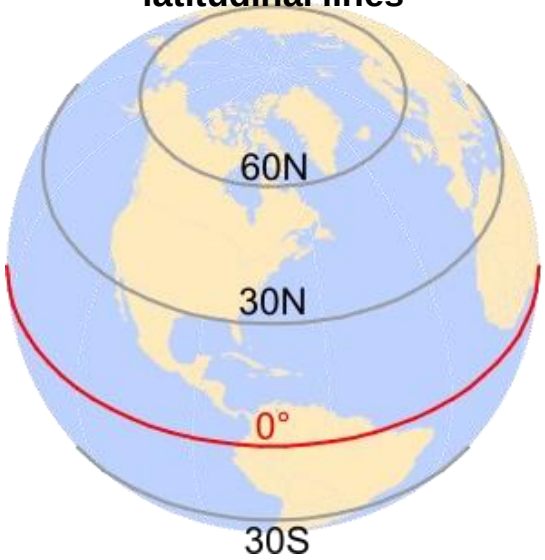


Projected coordinate system

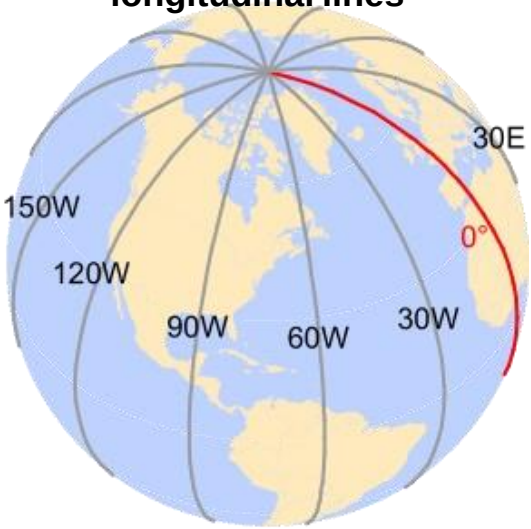
https://pro.arcgis.com/en/pro-app/latest/help/mapping/properties/GUID-70E253E7-407E-469E-91DA-975B382EA6C9-web.png

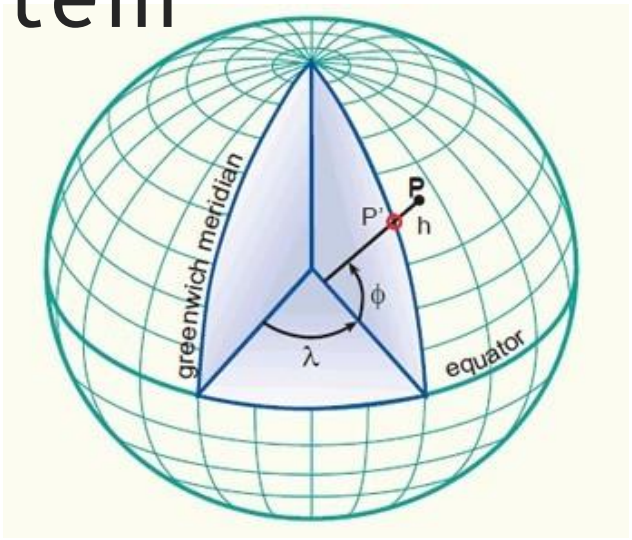
Geographic Coordinate System

latitudinal lines



longitudinal lines





geographic latitude (phi or f or j)
Geographic longitude (lambda or l).
3D geographic coordinates (f, l, h)
2D geographic coordinates (f,l)

The 0° degree reference lines for each are shown in red (equator for latitudinal measurements and prime meridian for longitudinal measurements)

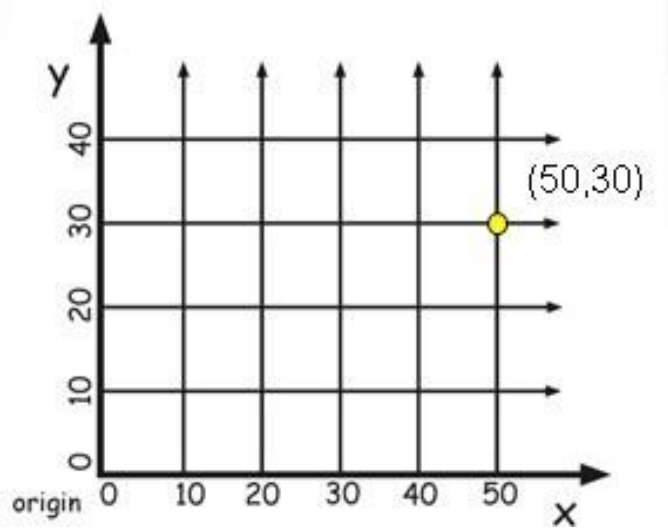
The latitude (f) and longitude (l) angles and the ellipsoidal height (h) represent the 3D gegraphic coordinate system.

https://mgimond.github.io/Spatial/chp09-0.html

https://kartoweb.itc.nl/geometrics/Coordinate%20systems/coordsys.html

Projected Coordinate System

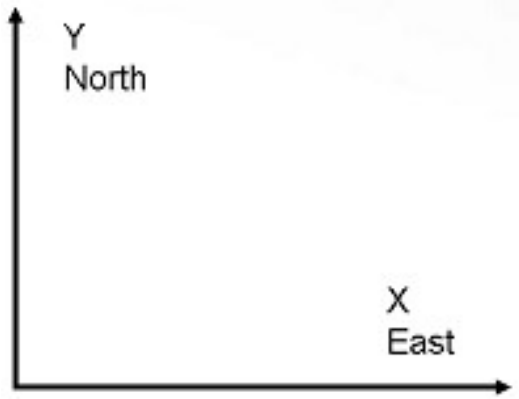
- Location on a flat surface
- Defined by Cartesian coordinates (i.e., x and y)
  - that specify horizontal and vertical position



http://gis.humboldt.edu/olm/Lessons/GIS/03%20Projections/Images2/projectedcs.png

Projected Coordinate System

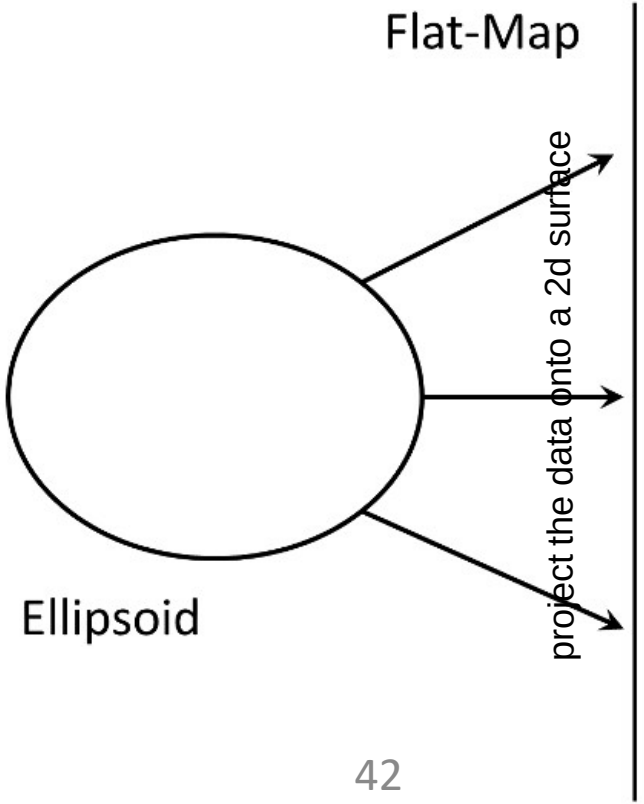
- Projected Coordinate Systems consist of:
  - Geographic Coordinate System
  - Projection Method
  - Projection Parameters
  - Units
- Projected coordinate systems use rectangular or Cartesian Coordinates.
  - uses X and Y as the values.
  - In GIS, we use X and Y but also "Easting" for X and "Northing" for Y.



http://gis.humboldt.edu/olm/Lessons/GIS/Images/pcs.png

Map Projection

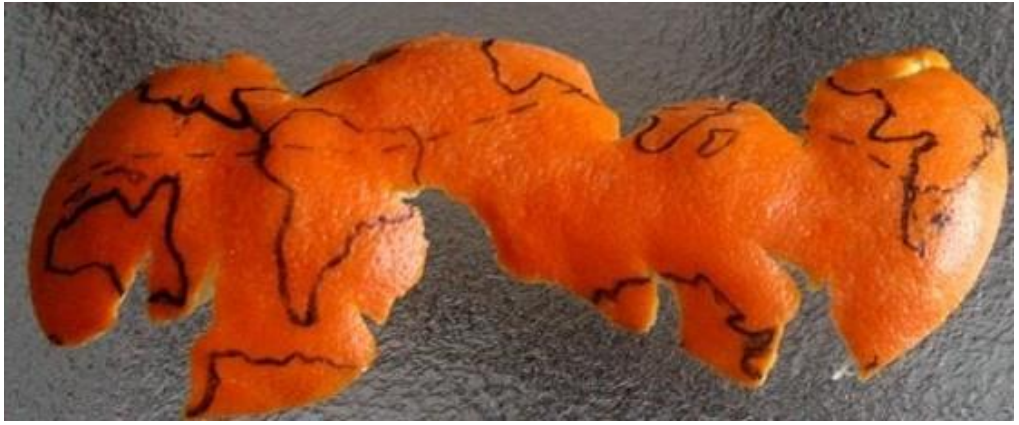
- mathematically described technique
- To represent the Earth's curved surface on a flat map (or computer screen)
- To represent parts of the Earth surface on a flat paper map, the curved horizontal reference surface must be mapped onto the 2D mapping plane.
- The reference surface for:
  - large-scale mapping is usually an oblate/flattened ellipsoid,
  - small-scale mapping, a sphere.



http://gis.humboldt.edu/olm/Lessons/GIS/03%20Projections/Images2/Projecting.png

Map Projection

- **Why ?**
  - If we are mapping a portion of the Earth's surface it is impossible to project it on a flat piece of paper without scale distortions.
  - Map projections deals with the scale distortions and limits within certain range



A sphere's surface cannot be represented on a plane without distortion.

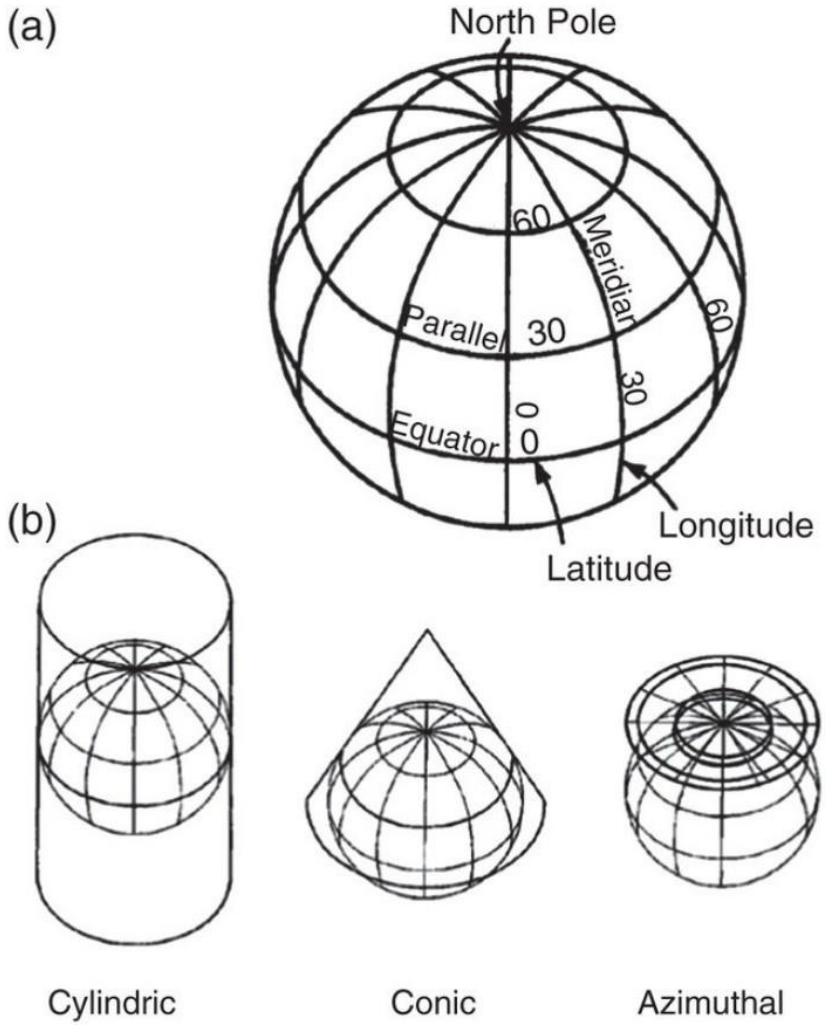
https://raw.githubusercontent.com/SciTools/cartopy-tutorial/master/static/orange_peel.jpg

Map Projection: How

- Map projections can be classified in terms of:
  - their class
  - their property
  - their aspect
  - and its tangent or secant map surface.

Map Projection: How

- Map projections classes
  - cylindrical, conical, Azimuthal

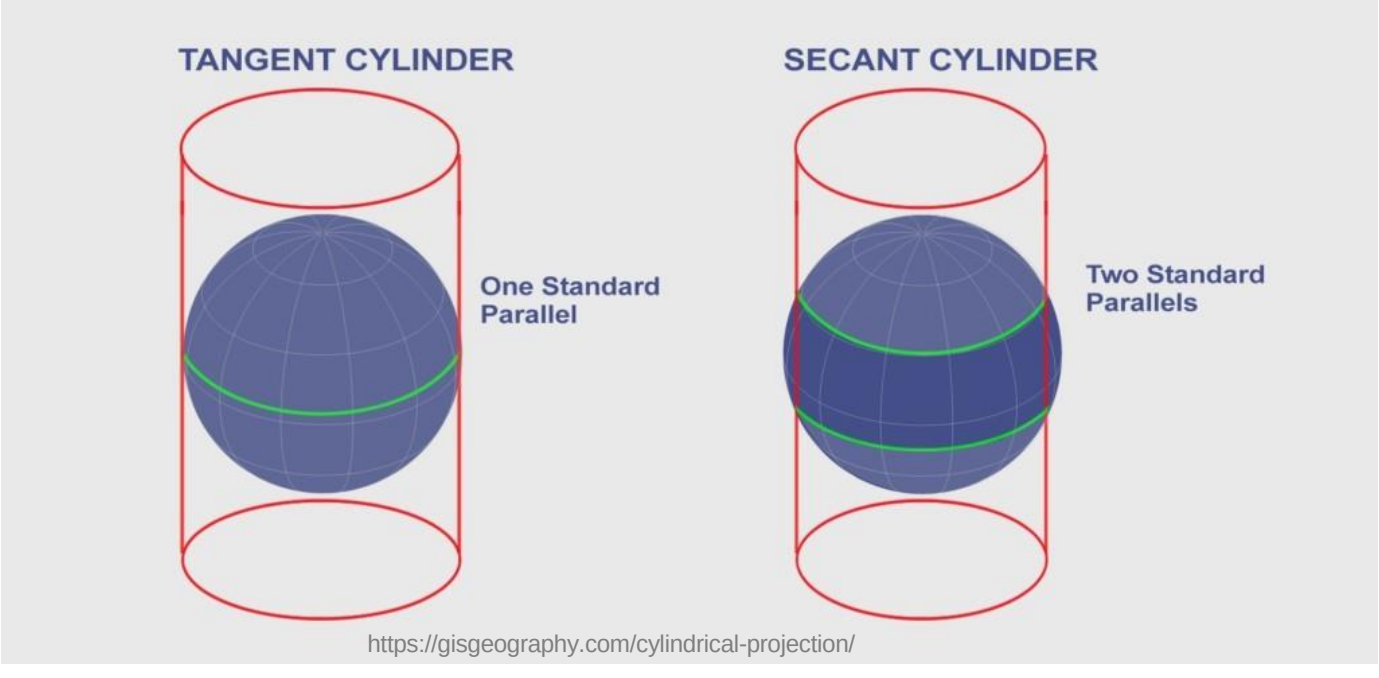


https://www.researchgate.net/publication/306021503_Custom_Map_Projections_for_Regional_Groundwater_Models

Map Projection

Cylindrical projection:

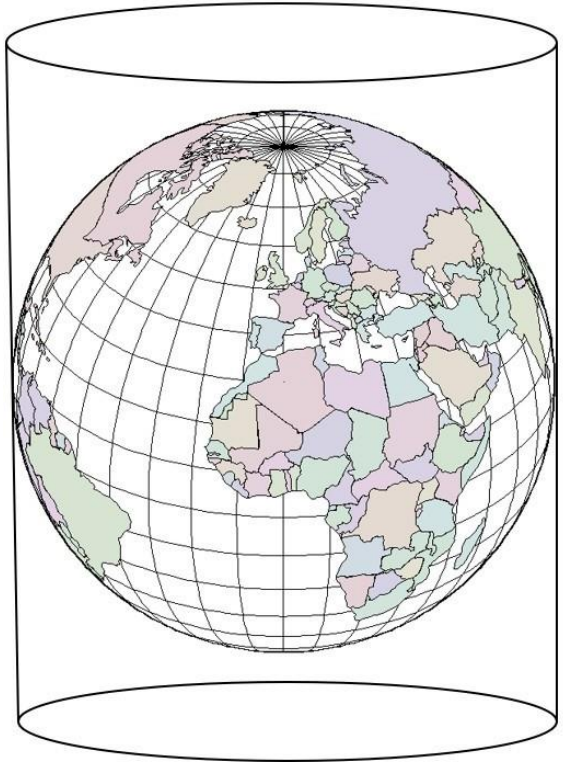
- transfers the grid of parallels and meridians into a cylinder.
- Best method to represent the low latitudes between the Equator and the tropics.

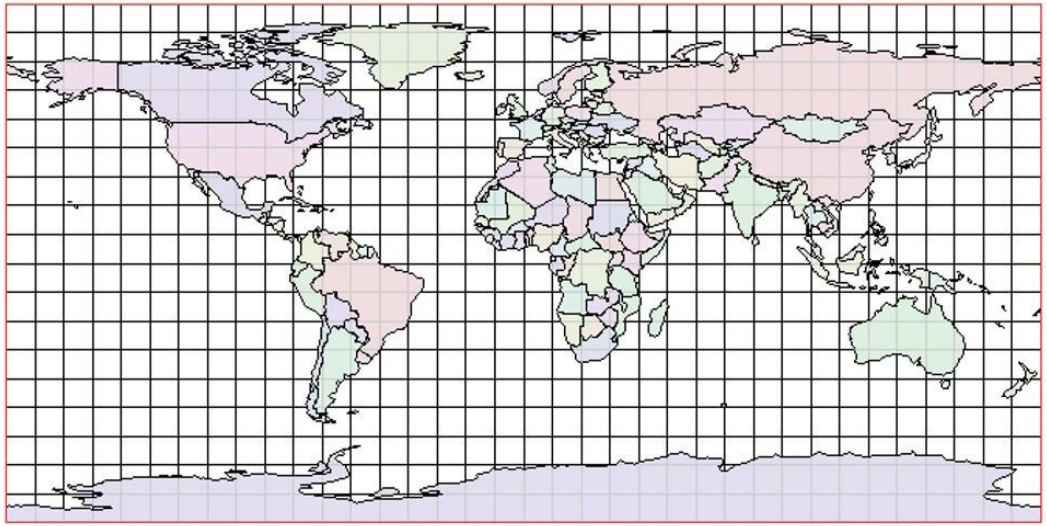


https://gisgeography.com/cylindrical-projection/

Map Projection

Cylindrical projection:

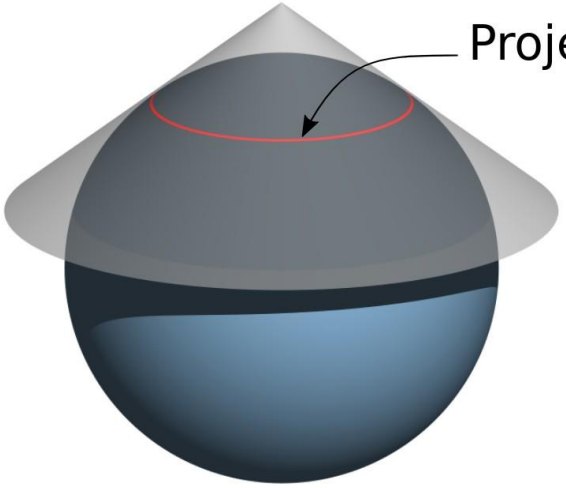




http://gis.humboldt.edu/olm/Lessons/GIS/03%20Projections/ProjectionFamilies3.html

Map Projection

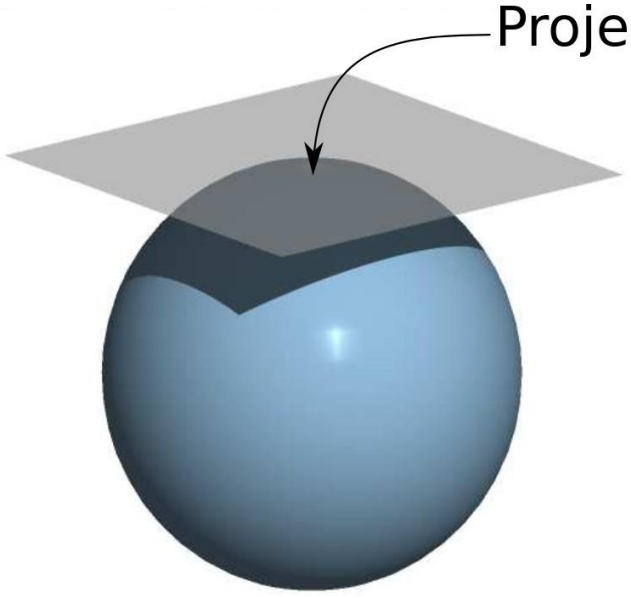
- Conic projection:
  - transfer the grid of parallels and meridians into a cone.
  - Best method to represent the mid latitudes .



Projected plane touches earth surface along one circle

Map Projection

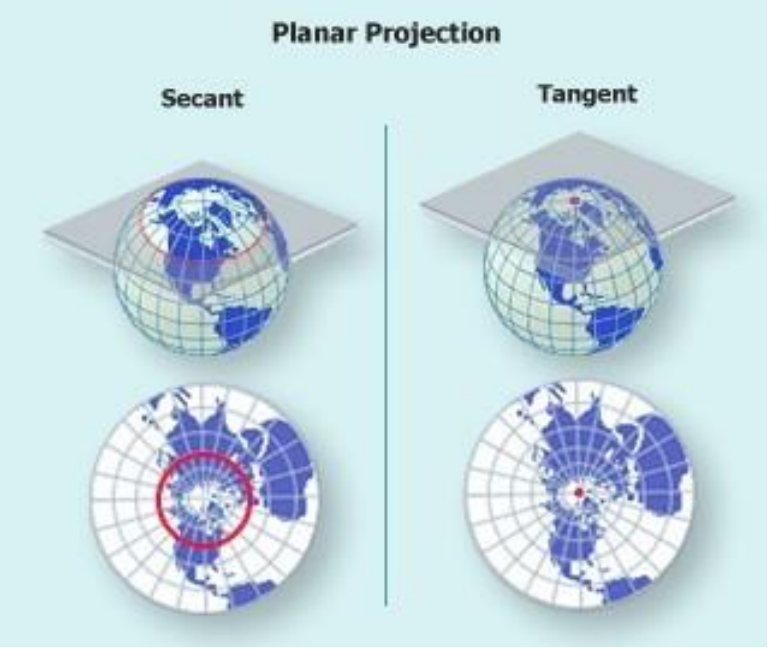
- Azimuthal or Plane projection:
  - transfers the grid of parallels and meridians into a flat surface.
  - Best method to represent the polar areas.



The orthographic projection is a special azimuthal projection that makes it look like we are looking at the earth in a photo graph.
GoogleEarth uses this projection

Map Projection

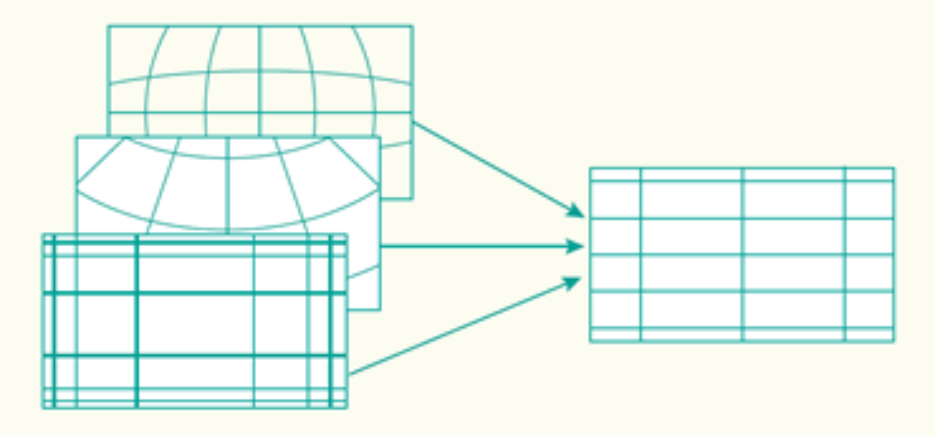
- Azimuthal or Plane projection:



https://geoarc.blogspot.com/2013/02/map-projections.html

Coordinate Transformations

- A coordinate transformation is a conversion of coordinates from one to another coordinate system.
- Transformations can be between plane coordinate systems, between geographic and plane coordinate systems, between geographic coordinates and geocentric coordinate systems, etc.



Integration of spatial data into one common coordinate system.

Datum transformations are also important, usually for mapping purposes at large and medium scale. An example, map and GIS users are often collecting spatial data in the field using satellite navigation technology and need to represent this data on published maps on a local horizontal datum.

Coordinate Transformations