GIS and Map

2.1 Map and their characteristics

2.2 Mapping concepts and Techniques

2.3 Coordinate Systems

2.4 Map projection

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Map concept: map elements, map layers, map scales and representation

Map concept:

- A map is a visual representation of an entire area or a part of an area, typically represented on a flat surface.
- Maps are the primary tools by which spatial relationships are visualized.
- The work of a map is to illustrate specific and detailed features of a particular area, most frequently used to illustrate geography.

Real Maps vs Virtual Map

- Real map is a cartographic product, which can be handled product, which can be handled physically and carried around with relative ease.
- Virtual map: Information that can be converted into a real map, i.e. information on a computer screen, mental images, field information, notes, and remote sensing information.

Map Resolution:

- A 'small' scale map is one in which a given part of the Earth is represented by a small area on the map.
- Small scale maps generally show less detail than large scale maps, but cover large parts of the Earth. e.g. a map scale of 1:1
- A 'large' scale map is one in which a given part of the Earth is represented by a large area on the map. Large scale maps generally show more detail than small scale maps because at a large scale there is more space on the map in which to show features.
- Large scale maps are typically used to show site plans, local areas, neighborhoods, towns etc. 1:2,500 is an example of a large scale.

Maps gain their value in three ways:

1. As a way of recording and storing information: Governments, businesses, and society as large must store large quantities of information about the environment and the location of natural resources, capital assets, and people.

- Included are plat, parcel, and cadastral maps to record property, maps of society's infrastructure or utilities for water, power, and telephone, and transportation, and census maps of population.

2. As a means of analyzing locational distributions and spatial patterns: Maps let us **recognize** spatial distributions and relationships and make it possible for us to **visualize** and hence **conceptualize** patterns and processes that operate through space.

3. A method of presenting information and communicating findings: Maps allow us to convey information and findings that are difficult to express verbally. Maps can also be used to convince and persuade, or even propagandize(promote).

Map Features : Points, lines, and polygons

Geographic features can occur naturally (such as rivers and vegetation), can be constructions (such as roads, pipelines, wells, and buildings), and can be subdivisions of land (such as counties, political divisions, and land parcels).

- **Points** define discrete locations of geographic features too small to be depicted as lines or areas, such as well locations, telephone poles, and stream gauges. Points can also represent locations such as address locations, GPS coordinates, or mountain peaks.
- **Lines** represent the shape and location of geographic objects too narrow to depict as areas (such as street centerlines and streams).
- **Polygons** are enclosed areas (many-sided figures) that represent the shape and location of homogeneous features such as states, counties, parcels, soil types, and land use zones.

Elements of map

- 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.

Scales: Scales represents the ratio of a distance on the map to the actual distance on the ground.

Scale = distance on a map / distance on the ground

- different ways: ratio, statement or equation, bar or graph.

1) Representative Fraction (RF) -1:50 000, where 2 cm on the map represents 1 km on the ground. (2cm/1km)

2) Verbal Scale -‘1 cm represents 1 km’

3) Graphic Scale - a line labelled with the distance it represents.

Title : The map title reflects the subject of the map.

Directions:

1. **True North** (from the latitude - longitude grid).

-Points exactly at the north geographic pole (axis of rotation).

2. Magnetic North (the direction a compass needle points).

-Points along magnetic field lines, roughly towards the north magnetic pole.

-Differs from True North in most places because magnetic and geographic poles are not the same.

-Magnetic north pole moves due to changing geophysical conditions of the earth's crust and core.

Legend:

- A **map key** or **legend** is included with a map to unlock it. It gives you the information needed for the map to make sense.
- Maps often use symbols or colors to represent things, and the map key explains what they mean.
- Map keys are often boxes in the corner of the map, and the information they give you is essential to understanding the map.

Title
Mexico - Major Habitat Types
Inset map
Main map
Gulf of Mexico
Pacific Ocean
Orientation indicator
Scale indicator
Legend
Major Habitat Types
Tropical and Subtropical Moist Broadleaf Forests
Tropical and Subtropical Dry Broadleaf Forests
Tropical and Subtropical Coniferous Forests
Temperate Conifer Forests
Tropical and Subtropical Grasslands, Savannas and Shrublands
Flooded Grasslands and Savannas
Montane Grasslands and Shrublands
Mediterranean Forests, Woodlands, and Scrubs
Deserts and Xeric Shrublands
Mangroves
0 50 100 200 300 Miles
N
Map created January, 2005
ESRI Virtual Campus
Source note
Graphics

Characteristics of Maps

- The word ‘Map’ is derived from the Latin word ‘Mappe’ which means Napkin of cloth cover. The whole or part of the earth can be represented on a map.
    1. A map is much smaller than the earth that it represents. Altitudes, Longitudes and Scales are very essential to draw maps.
    2. Every map should have a bold title on the top. There is an arrow mark in one corner of the map showing north. With the help of this mark other directions are known.
    3. Index or legend is necessary for every map. Universally accepted conventional symbols are used on every map like RF (Reserved Forest), etc.
    4. Maps are shaded with different colours also. White indicates ice caps, Blue for water, Green for forest, Yellow for agricultural belt, etc.

Types of maps are classified on the basis of two characteristics:

(i) Large scale and Small scale maps.

(ii) Thematic maps.

(i) Large Scale Maps:

- Fields, gardens, estates, tanks, wells and buildings are shown on large-scale maps. These maps are very useful.
- The local administrations like city survey, taxation, management of estates, etc., are done on large-scale maps. These maps cover less area and give more details.
- The scale may be 1 cm = 1 km or so.

Small Scale Maps:

- These maps cover vast area and represents broad features. Large mountains appear as spots. Rivers are shown as black or blue lines. Towns appear as black dots. While small villages, streams and roads are not shown.
- These maps are very useful for Atlas and wall maps are prepared on small scale.

(ii) Thematic Maps:

- These maps are used for different purposes. Relief, drainage climate, population distribution and land use patterns are shown on thematic maps.

Globes:

Globes are representation of features of the earth's surface. Latitudes and longitudes, axis of the earth, land and water distribution, season and world timing can be easily understood from the globes.

Map Layers

- 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

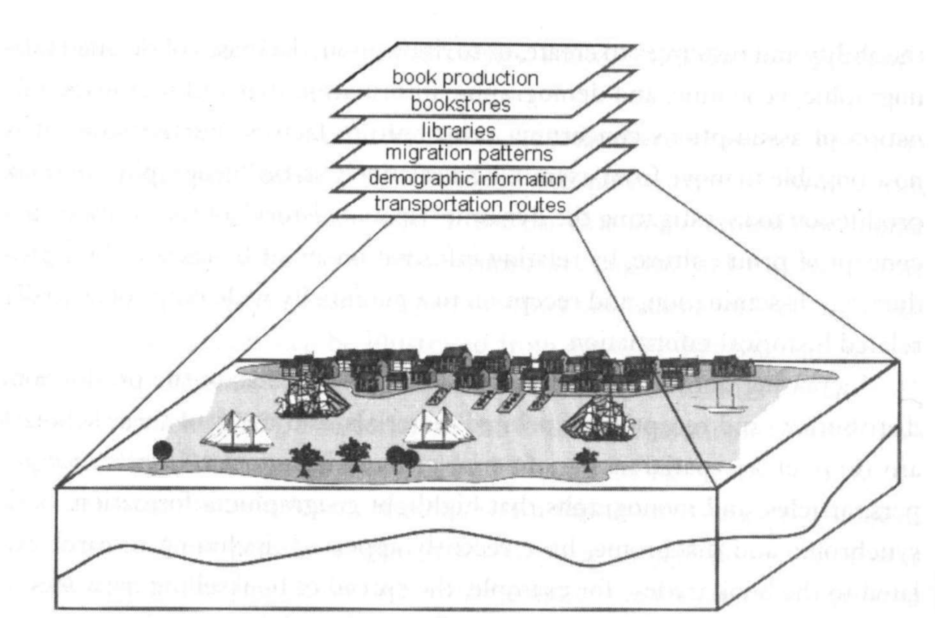


Figure: Shows how they can abstract the real world into layers in order to create a GIS that will allow them to explore book culture.

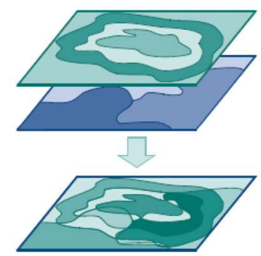


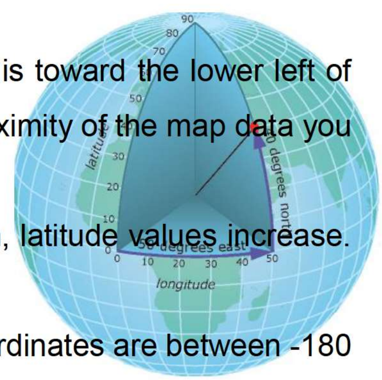
Figure: Two different object layers can be overlaid to look for spatial correlations, and the result can be used as a separate (object) layer.

Coordinate Systems

- Two different types of Coordinate Systems in GIS:

1. **Geographic coordinate systems:** Coordinate systems that span the entire globe (e.g. latitude / longitude). Two most common GCSs are WGS 1984 and NAD 1983.

- It’s shaped like a globe—spherical. Its units are angular, usually degrees.
- The geographic system (latitude-longitude), which is based on angles measured on a sphere, is not valid for measurements on a plane.
- Therefore, a Cartesian coordinate system is used, where the origin (0, 0) is toward the lower left of the planar section. The true origin point (0, 0) may or may not be in the proximity of the map data you are using.
- **Latitude** lines run east-west and are parallel to each other. If you go north, latitude values increase. Finally, latitude values (Y-values) range between -90 and +90 degrees.
- **longitude** lines run north-south. They converge at the poles. And its X-coordinates are between -180 and +180 degrees.



2. Projected coordinate Systems: A projected coordinate system is a flat, two-dimensional representation of the Earth. coordinate systems that are localized to minimize visual distortion in a particular region (e.g. Robinson, UTM, State Plane).

- A **Projected Coordinate System** (PCS) is flat, it's converts that GCS into a flat surface, using projection algorithm and other parameters. Its units are linear, most commonly in meters.
- A projected coordinate system is built on a map projection. Projected coordinate systems and map projections are often used interchangeably..
- For example, the Lambert conformal conic is a map projection but it can also refer to a coordinate system.
- In practice, however, projected coordinate systems are designed for detailed calculations and positioning, and are typically used in large-scale mapping such as at a scale of 1:24,000 or larger (Box 2.3).
- Coordinate systems in general are often called projections – kind of confusing.
- Different coordinate systems do make a difference in display as well as impact the accuracy of analyses so it's important to know which system your data are in.

Projected Coordinate Systems are:

The Universal Transverse Mercator Grid System:

- Used worldwide, the UTM grid system divides the Earth's surface between 84° N and 80° S into 60 zones. Each zone covers 6° of longitude and is numbered sequentially with zone 1 beginning at 180° W.
- All measurements are positive. There are two starting points (all measurements in meters north and east); one at the equator and another at 80˚ south (1000,000,000 meters south of the equator).
- UTM is used for remote sensing (satellite and aerial imagery analysis) because it allows precise measurement using the metric system.
- Each zone is further divided into the northern and southern hemispheres. The designation of a UTM zone therefore carries a number and a letter.
- For example, UTM Zone 10N refers to the zone between 126° W and 120° W in the northern hemisphere.

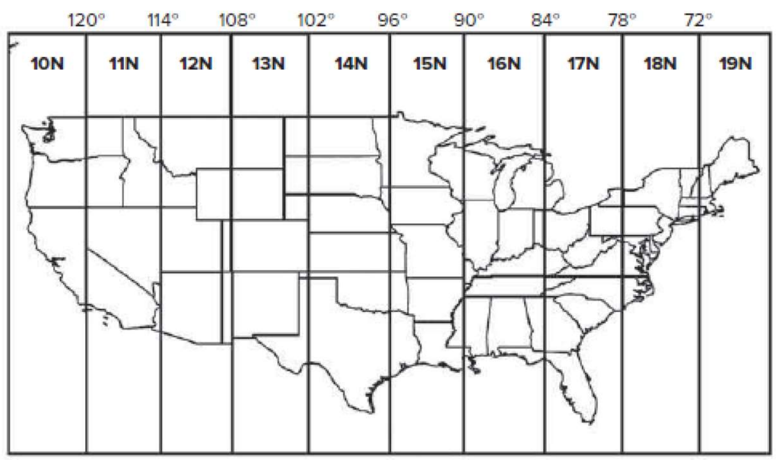


Figure : UTM zones range from zone 10N to 19N in the conterminous United States.

The Universal Polar Stereographic Grid System:

- The UPS grid system covers the polar areas. The stereographic projection is centered on the pole and is used for dividing the polar area into a series of 100,000-meter squares, similar to the UTM grid system.
- The UPS grid system can be used in conjunction with the UTM grid system to locate positions on the entire Earth's surface.
- **The State Plane Coordinate System:**
- The SPC system was developed in the 1930s to permanently record original land survey monument locations in the United States.
- To maintain the required accuracy of one part in 10,000 or less, a state may have two or more SPC zones.
- This coordinate system is highly accurate (four times as accurate as UTM).
- An examples, Oregon has the North and South SPC zones and Idaho has the West, Central, and East SPC zones (Figure below).

Figure : SPC83 zones in the conterminous United States. The thin lines are county boundaries, and the bold lines are SPC zone boundaries.

- Each SPC zone is mapped onto a map projection. Zones that are elongated in the north–south direction (e.g., Idaho's SPC zones) use the transverse Mercator and zones that are elongated in the east–west direction (e.g., Oregon's SPC zones) use the Lambert conformal conic.
- Point locations within each SPC zone are measured from a false origin located to the southwest of the zone, because of the switch from NAD27 to NAD83, there are SPC27 and SPC83. Besides the change of the datum, SPC83 has a few other changes. SPC83 coordinates are published in meters instead of feet.

The Public Land Survey System:

- The PLSS is a land partitioning system (Figure below).
- Using the intersecting township and range lines, the system divides the lands mainly in the central and western states into 6 × 6 mile squares or townships. Each township is further partitioned into 36 square-mile parcels of 640 acres, called sections.

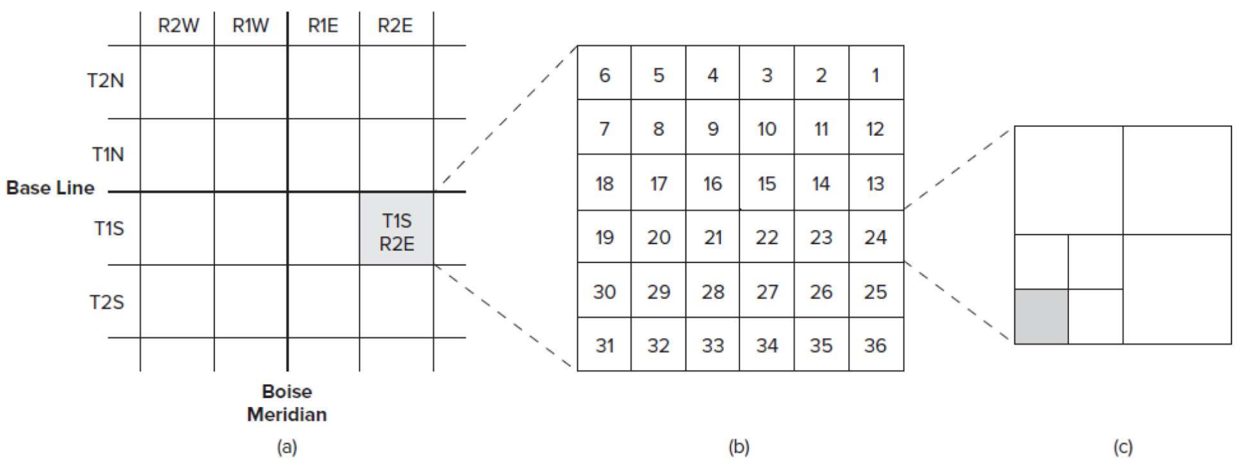


Figure: The shaded survey township in (a) has the designation of T1S, R2E. T1S means that the survey township is south of the base line by one unit.

R2E means that the survey township is east of the Boise (principal) meridian by two units. Each survey township is divided into 36 sections in (b).

Each section measures 1 mile × 1 mile or 640 acres and has a numeric designation. The shaded square in (c) measures 40 acres and has a legal description of the SW 1/4 of the SW 1/4 of Section 5, T1S, R2E.

- (In reality, many sections are not exactly 1 mile by 1 mile in size.)
- Land parcel layers are typically based on the PLSS. The U.S. Bureau of Land Management (BLM) has been working on a Geographic Coordinate Data Base (GCDB) of the PLSS for the western United States.

Geographic vs Projected Coordinate Systems

- Geographic Coordinate System defines **where** the data is located on the earth's surface. Projected Coordinate System tells the data **how** to draw on a flat surface.
- A GCS is necessary for data to know where exactly on earth's surface it is located. A PCS is necessary to draw the data on a flat map.

Map Projection

- A **map projection** transforms the geographic coordinates on an ellipsoid into locations on a plane. The outcome of this transformation process is a systematic arrangement of parallels and meridians on a flat surface representing the geographic coordinate system.
- Or
- A **map projection** is a systematic rendering of locations from the curved Earth surface onto a flat map.
- Define the spatial relationship between locations on earth and their relative locations on a flat map.
- A map projection provides a couple of distinctive advantages.
  - A map projection allows us to use two-dimensional maps, either paper or digital.
  - A map projection allows us to work with plane coordinates rather than longitude and latitude values.
- The transformation from the surface of an ellipsoid to a flat surface always involves distortion, and no map projection is perfect.
- The earth can be modeled as :sphere, oblate ellipsoid, geoid.

Types of Map Projections

- Map projections can be grouped by either the preserved property or the projection surface.
- Depending on their intended use, projections are chosen to preserve a particular relationship or characteristic.
- Cartographers group map projections by the preserved property into the following four classes: conformal, equal area or equivalent, equidistant, and azimuthal or true direction.

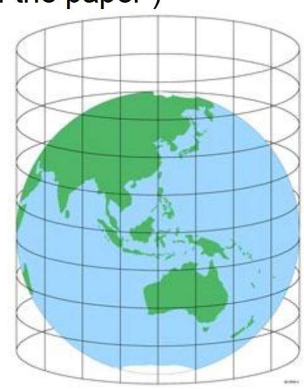
  {Basic Projection Types}

  - A **conformal projection** preserves local angles and shapes.
  - An **equivalent projection** represents areas in correct relative size.
  - An **equidistant projection** maintains consistency of scale along certain lines. and
  - An **azimuthal projection** retains certain accurate directions.

- Map projections fall into three general classes:
  (1) Cylindrical Projection
  (2) Conical Projection
  (3) Planar or Azimuthal Projection
- A map projection is called a cylindrical projection if it can be constructed using a cylinder, a conic projection if using a cone, and an azimuthal projection if using a plane.

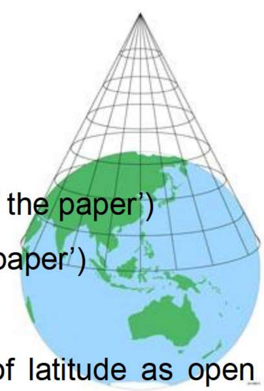
Cylindrical projection:

- This projection is based on the concept of the ‘piece of paper’ being rolled into a cylinder and touching the Earth on a circular line.
- These projections usually:
  - are rectangular or oval shaped – but this projection technique is very variable in its shape
  - have lines of longitude and latitude at right-angles to each other
  - have distortions increasing away from the central circular line (the ‘touch point of the paper’)
  - have very small distortions along the central circular line (the ‘touch point of the paper’)
  - show shapes correctly, but size is distorted.
- Examples of some cylindrical projections are: Cylindrical Equal Area, Behrmann Cylindrical Equal-Area , Stereographic Cylindrical, Peters, Mercator, and Transverse Mercator.



Conical Projections:

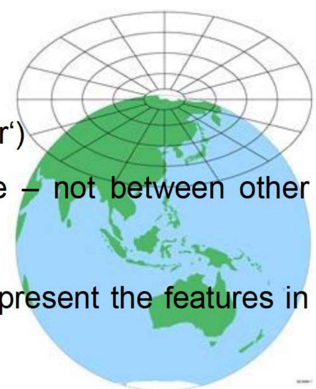
- This projection is based on the concept of the ‘piece of paper’ being rolled into a cone shape and touching the Earth on a circular line. Most commonly, the tip of the cone is positioned over a Pole and the line where the cone touches the earth is a line of latitude; but this is not essential.
- The line of latitude where the cone touches the Earth is called a Standard Parallel.



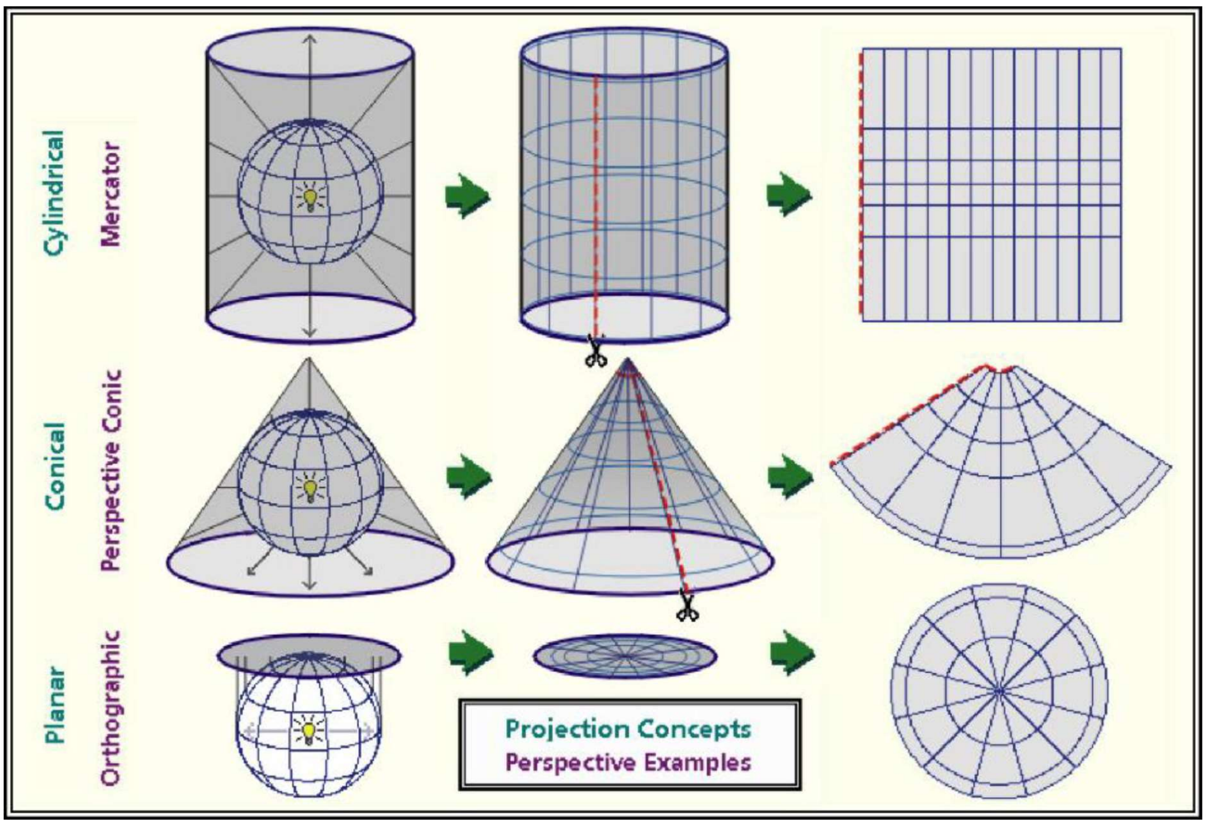
- These projections:
    - are fan shaped when used to map large areas
    - have distortions increasing away from the central circular line (the ‘touch point of the paper’)
    - have very small distortions along the central circular line (the ‘touch point of the paper’)
    - shapes are shown correctly, but size is distorted
    - usually have lines of longitude fanning out from each other and have lines of latitude as open concentric circles.
- Examples of some conic projections are: Albers Equal Area Conic, Equidistant Conic, Lambert Conformal Conic, and Polyconic (one of the more common).

Planar or Azimuthal Projections:

- This projection is based on a ‘flat piece of paper’ touching the Earth at a point.
- Azimuth is a mathematical concept with relates to the relationship between a point and the ‘flat piece of paper’ that ’touches‘ the Earth. It is usually measured as an angle. The word itself is believed to have come from an Arabic word mean the way – referring to the way or direction a person faces.
- These projections:
  - have distortions increasing away from the central point
  - have very small distortions near the centre point (the ’touch point of the paper‘)
  - compass direction is only correct from the centre point to another feature – not between other features
  - are not usually used near the ***Equator***, because other projections better represent the features in this area.



- Examples are: Azimuthal Equidistant, Lambert Azimuthal Equal Area, Orthographic, and Stereographic (often used for Polar regions).


Cylindrical
Mercator
Conical
Perspective Conic
Planar
Orthographic
Projection Concepts
Perspective Examples