PDHonline Course L154G (5 PDH)

Data in GIS

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2020

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Slide 1

Lecture 5 Content

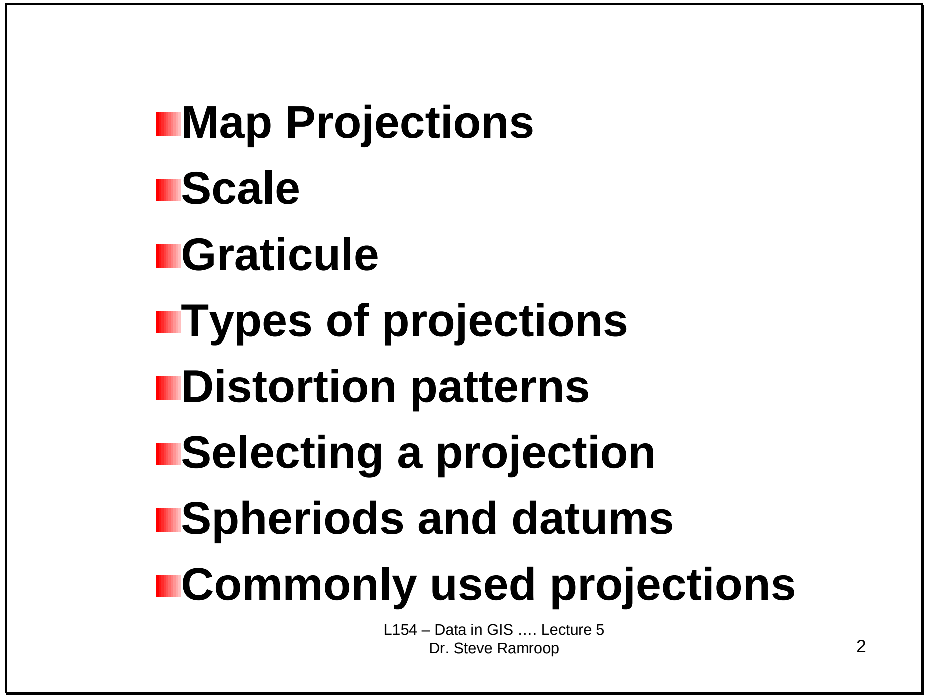
- **Geographic Information Systems (GIS)**

Data in GIS – Acquisition and input

L154 – Data in GIS …. Lecture 5
Dr. Steve Ramroop 1

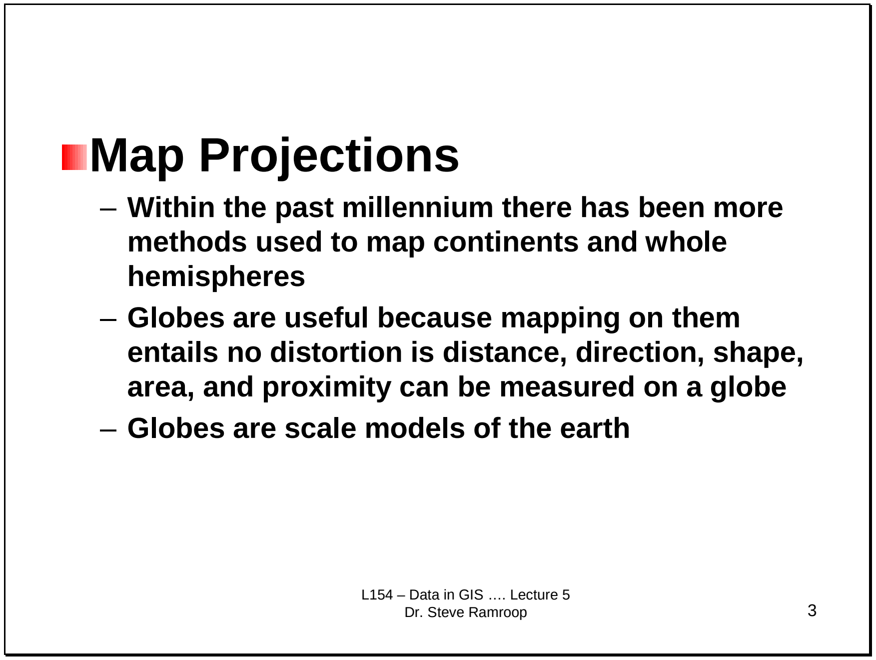
This lecture is a continuation of the data in GIS topics identified in the course description, that is data in GIS – Acquisition and input. In this lecture is presented map projections and coordinate systems.

Slide 2



These are the topics which will be covered in this lecture. This lecture will provide you with the basic understanding of map projections and coordinate systems. It forms the basis upon which data from the real world is represented using mathematics and is translated to a smaller scaled version in the computer. This involves the understanding of coordinate systems which is similar to drawing a graph in mathematics. It requires the understanding of the listed items as shown on this slide which is presented in further details in the following slides.

Slide 3



A map projection is any method of representing the surface of a sphere or other shape on a plane. Map projections are necessary for creating maps. All map projections distort the surface in some fashion. Depending on the purpose of the map, some distortions are acceptable and others are not; therefore different map projections exist in order to preserve some properties of the sphere-like body at the expense of other properties. There is no limit to the number of possible map projections. There are many map projections and this lecture will identify the reason why there are so many projections. Map Projections are needed to be able to map the earth surface as accurate as possible. Globes are scale models of the earth.

Slide 4

- **Some impracticalities of globes:**
  - **Globes are bulky and are not very functional for mapping detailed features**
  - **Distance and area computations on a globe are more complex because they require spherical geometry**
  - **Because of these impracticalities, *projections* were developed to transform spherical coordinates to planar coordinates**

This slide shows some of the impracticalities of a globe. We cannot prepare our maps on a globe and expect the end user to make use of a globe. Maps are prepared on a flat piece of paper and to do this map projections are used to be able to project the spherical nature of the earth onto a planar surface.

Slide 5

- **Projections are a systematic rendering of the latitude and longitude graticule, and allow the sphere to be transformed to a planar (flat) surface**
- **There are potentially an infinite number of projections**

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Dr. Steve Ramroop
5

This slide gives a practical definition of map projections. Apart from referring to lines of longitude and latitude, projections also refer to other Cartesian coordinates for example lines of easting and northing.

Slide 6

Scale

- The size of geographic features is typically reduced to enable features to be represented on a map
- The amount of reduction is called the ***"map scale"***
- The scale of a map is the ratio of the distance on a map to a distance on the earth
- Point, lines and polygons are the three cartography primitives used to draw features on a map →they are influenced by the map scale
- For example: a city can be a point at a small scale, while at a large scale it is represented by a polygon

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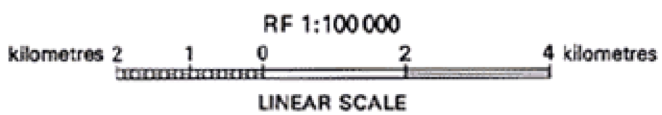
Dr. Steve Ramroop 6

We cannot map the earth surface at a 1 to 1 ratio. That is 1meter distance in the real world is represented by 1 meter on the map. We will not have enough paper to map the earth surface. Therefore, the notion of Map Scale is used where one unit on the paper represents and number of units out in the real world. For example 1cm on the map represents 1000km out in the real world.

Slide 7

– **The scale of a map is expressed using four methods:**
  - **Geographers (and occasionally others) are trained to refer to maps as "large" or "small" scale. Example 1:50,000 is large scale while 1:1,000,000 is small scale**
  - **Scales can also be expressed using words, such as "1 inch equals 1 mile"**
  - **Use a representative fraction, such as 1:24,000**
  - **Use a graphic scale**



This slide show the four methods used to represent map scale. Note the understanding of what is referred to as a small scale versus a large scale. All maps must show its scale.

Slide 8

- **It is important to know the scale of the map you are working with and to understand the associated resolution and recognition of features used in the map**
- **Determining the points, lines and polygons that have sizes smaller than the that of the minimum-detectable size feature will help you understand what features can be represented on the map**
- **For a given data set you cannot get any better detail resolution at the scale in which the data set was collected**

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8

This slide identifies some of the considerations taken in determining a map scale. Note that the original map scale at which data was collected and stored is the limiting detail map and for the given application the best representation of the data. Therefore, if for a given map scale only cities were collected as point data sets then users cannot get any more detail information if they were to zoom into the point location of individual cities. That is users will not be able to see buildings if they were to zoom into the point location of the cities.

Slide 9

Graticule

- A "*graticule*" is a set of meridians and parallels that represent the locations of lines of latitude and longitude
- A "*meridian*" is a line on the earth formed by the intersection of a plane passing through both poles
- A "*parallel*" is a line on the earth's surface formed by the intersection of a plane that is normal (perpendicular) to a line drawn through both poles

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Dr. Steve Ramroop
9

This slide defines the curvilinear lines of the spherical earth surface. Definitions of parallel and meridians are given. The earth as we know it is not flat. We are able to locate features on the earth by using a common global coordinate system which is known by its lines of longitude and latitude. Depending upon the projection system, lines of latitude and longitude can vary – which will be explained starting with the next slide of this lecture.

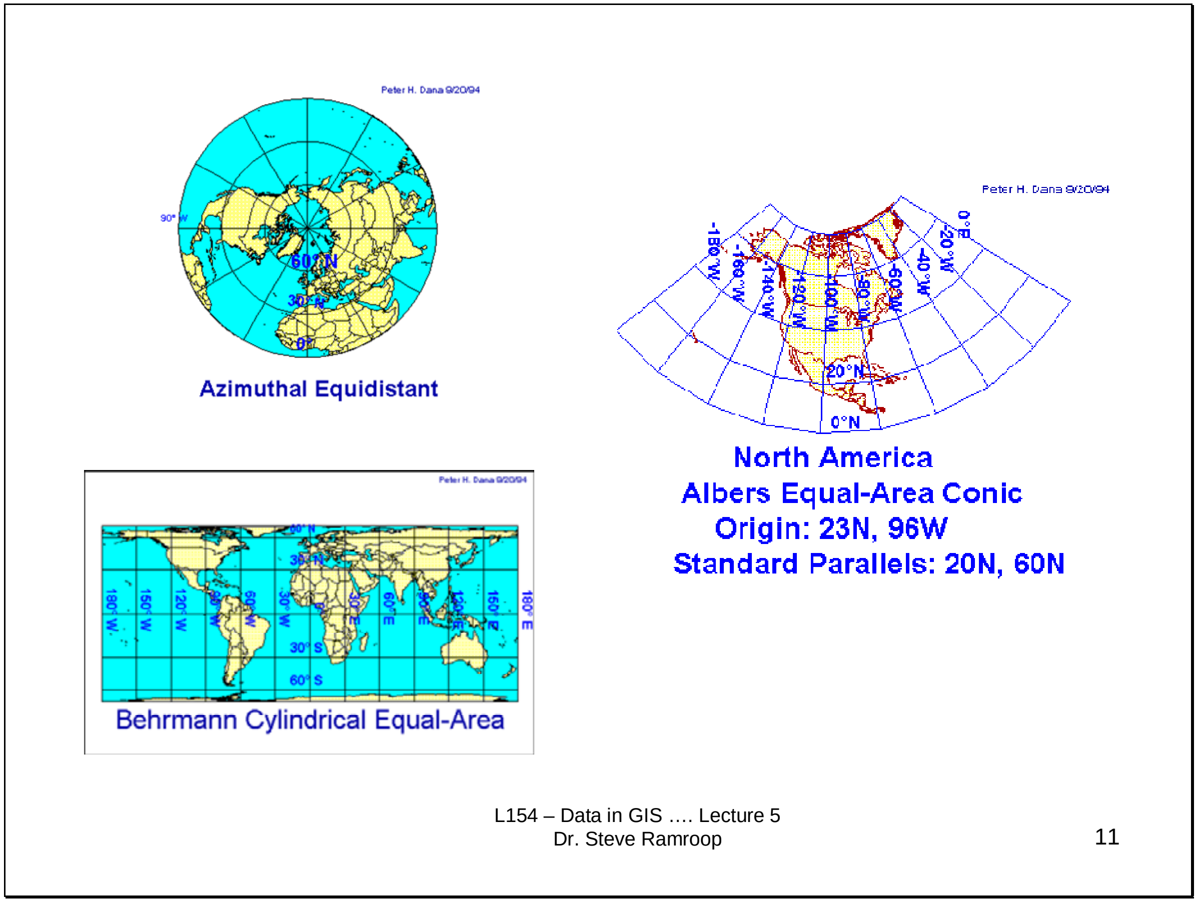
Slide 10

Types of projections

- There are three geometric projection surfaces: the plane, cylinder, and cone
  - **Plane:**
    Work simply laying a plane on top of the globe, touching at only one point
  - **Cylinder**
    Work by wrapping a piece of paper around the globe, then unrolling it to make a map
  - **Cone**
    Work by making a "hat" (cone) and placing it on a globe

There are various map projections. This is because there is no single map projection which has zero errors of distortion. A distortion is errors in the accuracy of representing features on a map which can be errors in the shape or size or direction. The following explanation presents map projections at a general level. The various general types and variations will be presented. This slide identifies the three basic projection surfaces used in defining map projections – Plane, Cylindrical, and Cone. Note that the plane projection surface is also called azimuthal.

Slide 11



This slide shows example of map projections developed using the three basic projection surfaces.

Slide 12

- Projection characteristics can be classified by the light source location
  - Gnomonic:
    - that is the light source is located at the center of the globe.
    - This means that any great circle – the shortest distance between two points on a globe is a straight line on the gnomonic projection.
    - Typically used for aviation
  - Stereographic:
    - Light source is located at the point exactly opposite the point of tangency of the projection surface
  - Orthographic:
    - Light source is from infinity

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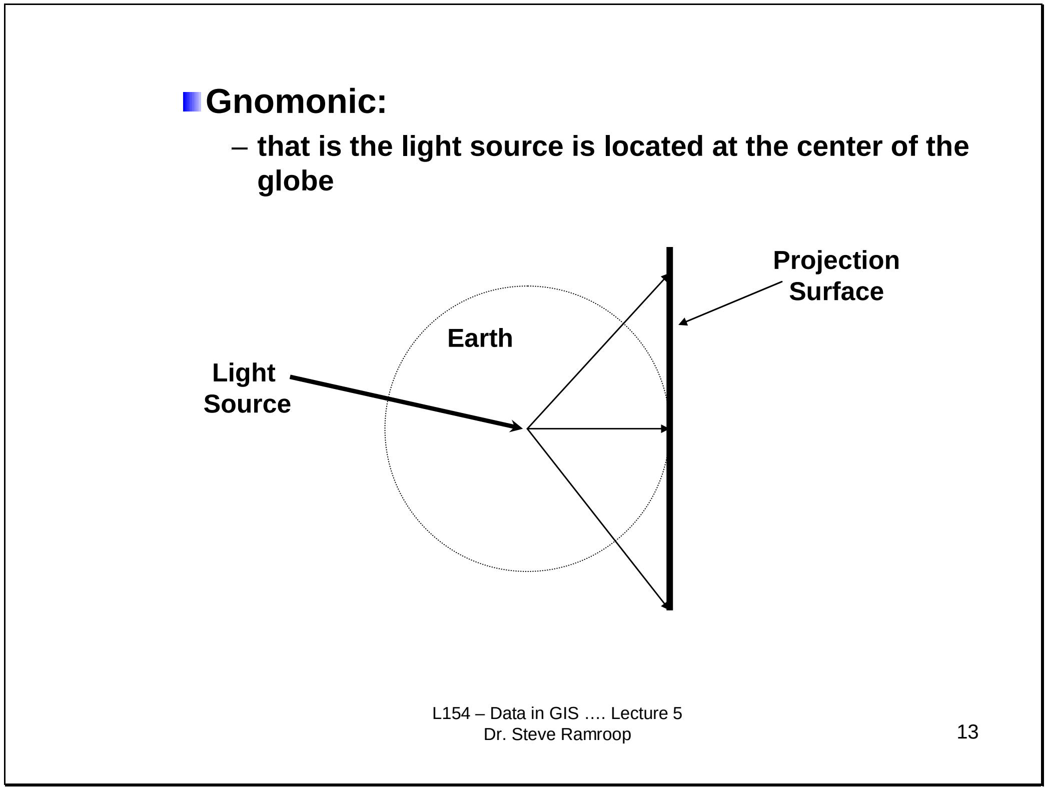
Dr. Steve Ramroop 12

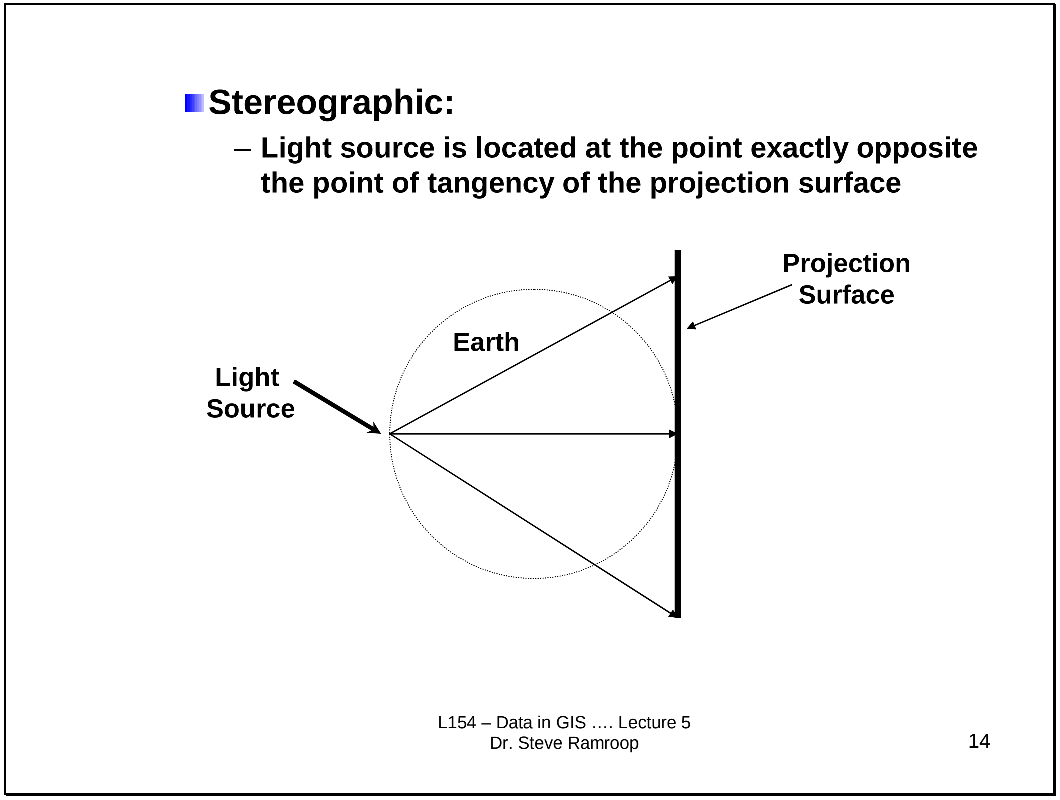
The three projection surfaces can have further projection characteristic variations which are shown on this slide. The following slides give a diagram for each of the variations of projections by changing the light source. The variations are typically applied to azimuthal projection surfaces. Azimuthal projections preserve the azimuth from a reference point (the conceptual center of the map), thus presenting true direction (but not necessarily distance) to any other points.

Slide 13



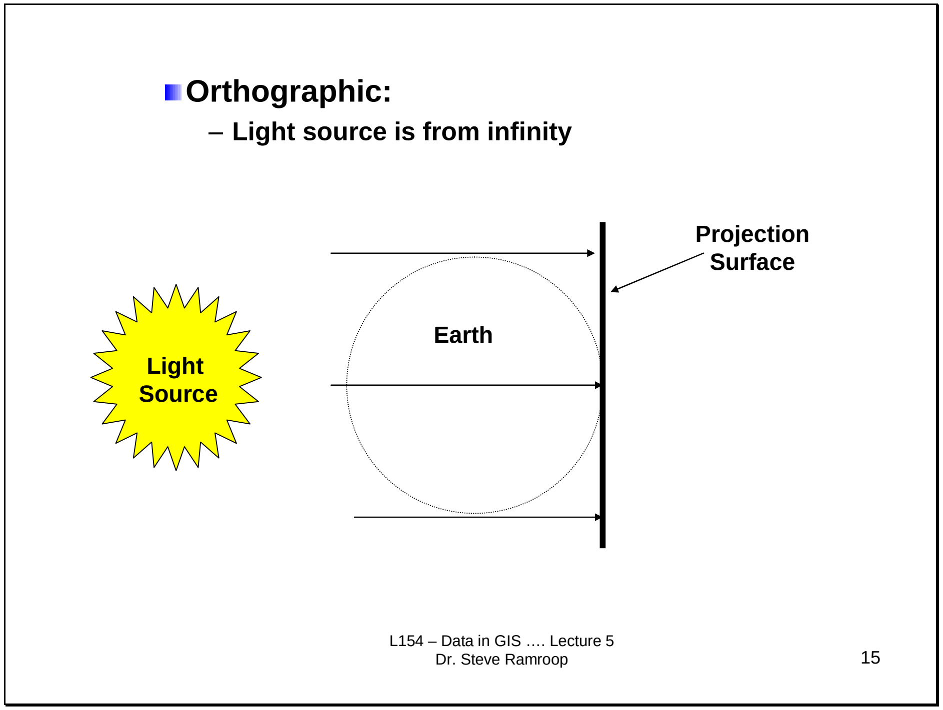
This slide shows the Gnomonic light source assumed to be located at the center of the earth and applied to an azimuthal projection surface. The point of zero distortion is the point at which the plane touches the surface of the earth. Features that are away from the central point will have increased distortion the further away they are from the central point.

Slide 14



This slide shows the Stereographic light source assumed to be located at the opposite side of the point of tangency and applied to an azimuthal projection surface. The point of zero distortion is the point at which the plane touches the surface of the earth which is in this case the same as the Gnomonic light source. However, in the Stereographic light source the features that are away from the central point will have larger increased distortion the further away they are from the central point.

Slide 15



This slide shows the Orthographic light source assumed to be located at infinity and applied to an azimuthal projection surface. The point of zero distortion is the point at which the plane touches the surface of the earth which is in this case the same as the Gnomonic and Stereographic light source. However, in the Orthographic light source the features that are away from the central point will have smaller but still increased distortion the further away they are from the central point.

Slide 16

Distortion patterns

- **Because all projections have distortion, it is important to understand how the geometry of the projection leads to minimal distortion in one location and maximal distortion in others**
- **In the tangent case, distortion is minimal at the point of tangency and increases with increasing distance from the tangent**
- **In the secant case (that is the effect of cutting the earth's surface), there is minimal distortion at the line of tangency, and distortion increases at locations toward the center of the map away from the line of tangency**
- **This holds for planar, cylindrical, and conical surfaces**

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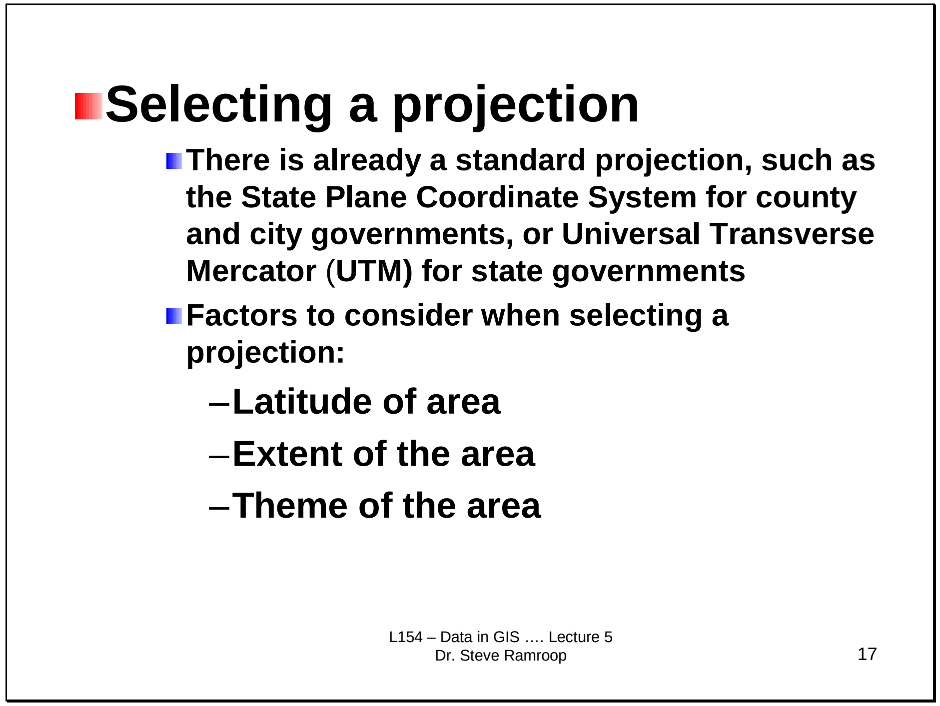
16

If the projection surface is assumed to touch the earth surface then there will be one point of zero distortion, however, if we were to assume that the projection surface cuts into the earth surface, and then we will have a line of zero distortion. This assumed cutting into the earth is called **secant** and you will find some map projections stating that they are a secant map projection. Now, using the three projection surfaces, there can be tangent and the secant projections.

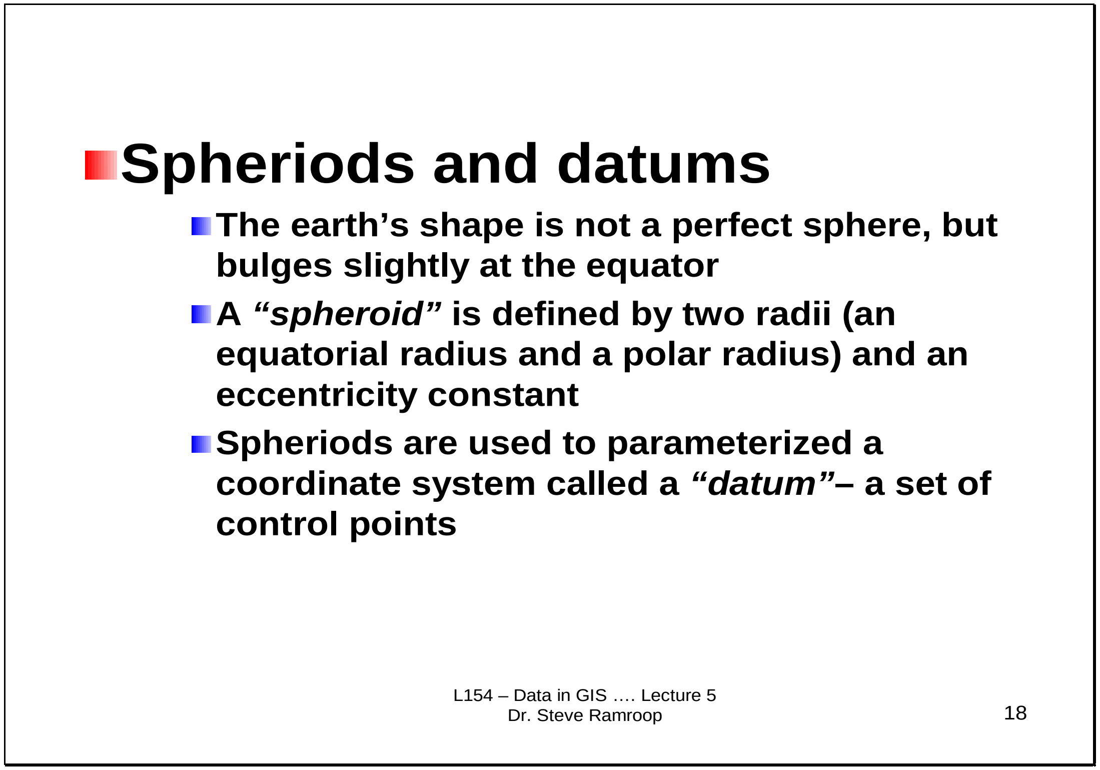
Slide 17



Two common projections are used in the US which are: State Plane Coordinate System for county and city government, or Universal Transverse Mercator (UTM) for state governments.

Since it may appear obvious that there is multitude of map projections, then this slide seeks to address the criteria considered in selecting a projection. The criteria includes: the location which is defined by the latitude and longitude; the size of the area which is defined by the extent of the area; and the theme of the area which is defined by phenomena being mapped.

Slide 18



This slide identifies the mathematical representation of the earth's surface. They are spheroid, and datum. These are defined by parameters and are used in mathematical formulae which transform real world ground control coordinates into map coordinates which can be used on hardcopy and in the computer models.

A **datum** is a reference from which measurements are made. In Geomatics, a **datum** is a set of reference points on the earth's surface against which position measurements are made, and an associated model of the shape of the earth ellipsoid to define a coordinate system.

Slide 19

Commonly used projections

- Universal Transverse Mercator (UTM)
- State Plane Coordinate System

This slide identifies two map projections used in the US. The following slides will give details on each.

Slide 20

- **UTM**
  - **Acronym for Universal Transverse Mercator**
  - **Extends a flat grid from 80°N to 80°S**
  - **There are 60 zones starting at 180°longitude and wrapping around the earth**
  - **Each zone is 6°longitude wide, with an additional 0.5°of overlap on each other**
  - **The x coordinate within each zone starts at a false easting located 500,000m west of the center of the zone**

This slide gives some of the common characteristics and the definition of the UTM projection system.

Slide 21

- **The y coordinate starts at a false northing located at the Equator for the northern hemisphere and 10,000,000m south of the Equator in the southern hemisphere**
- **To correctly specify a UTM coordinate, there is the need to specify the easting, northing, zone, and hemisphere (e.g. 100,000mE; 3,700,000mN; Zone 13, Northern Hemisphere)**

Some more characteristics for the UTM map projection system.

Slide 22

UTM Zones of the world

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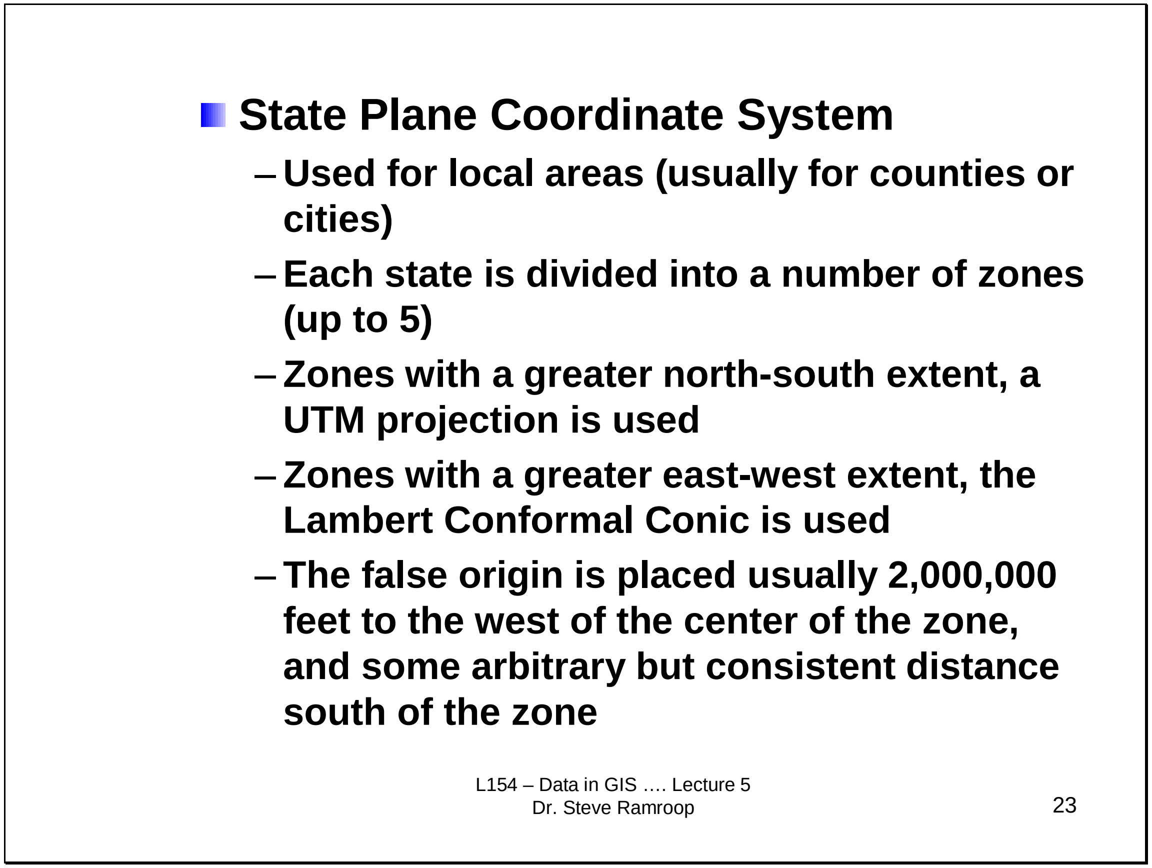
22

This a diagram of the different UTM zones worldwide.

Slide 23



This slide gives some of the common characteristics and the definition of the state plane coordinate system.

Slide 24

1983 Stet Plane Coordinate System Zone

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24

This is the zones for the 1983 state plane coordinate system zone.

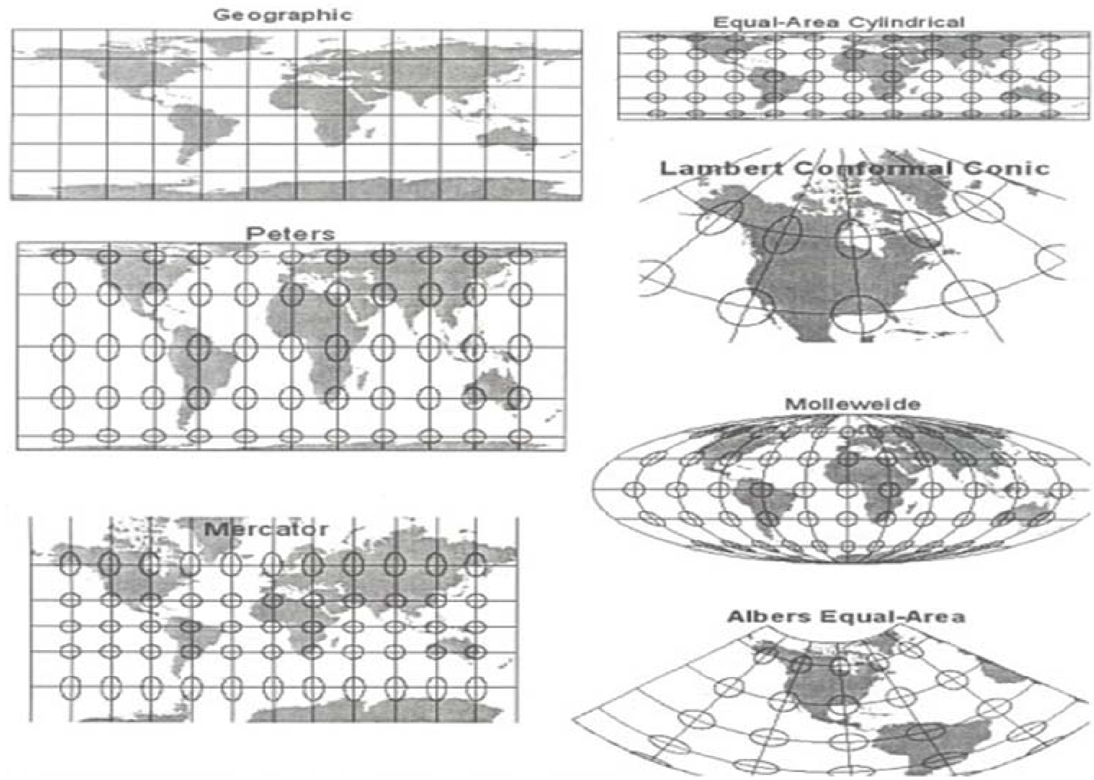
Slide 25

1983 State Plane Coordinate System Zones for the Eastern US with counties

More detail look at the 1983 state plane coordinate system zones for the Eastern US with the counties.

Slide 26

Examples of commonly used projection systems



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26

This slide shows some examples of different map projection coordinate systems.

Slide 27

… The End …