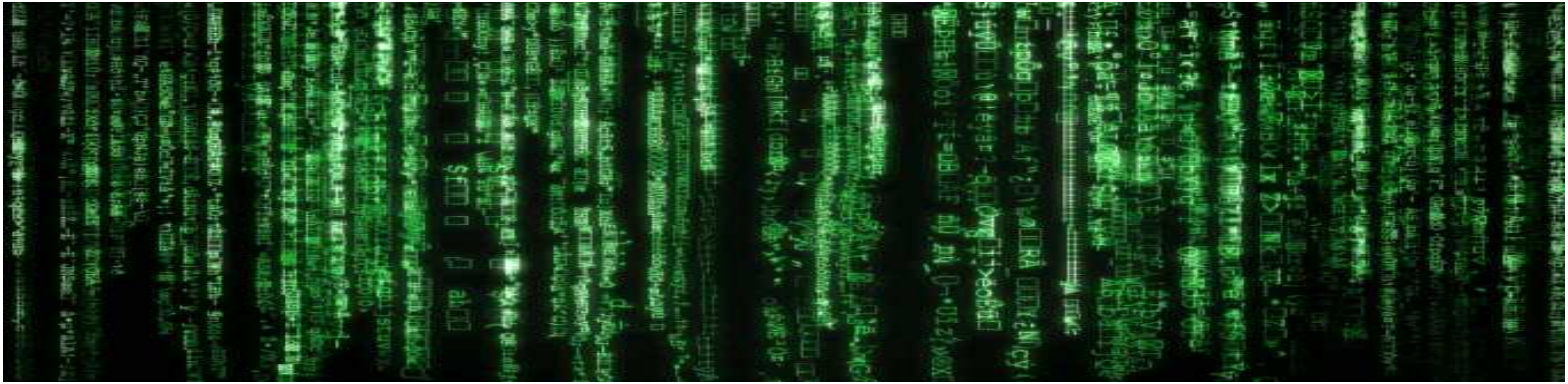


INF 110 Discovering Informatics

Maps

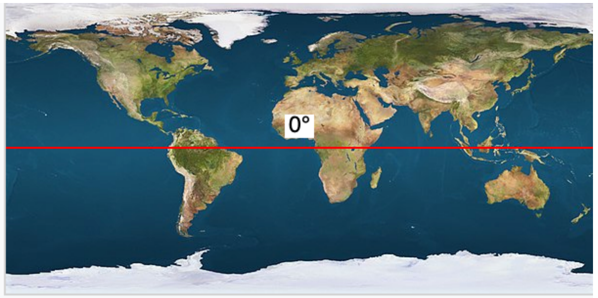
NAU NORTHERN ARIZONA UNIVERSITY

Latitude and Longitude

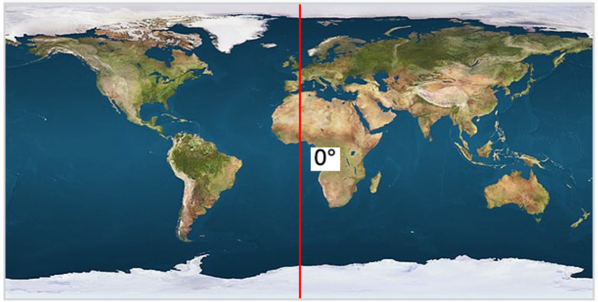
How do you locate a point on the surface of the earth?

- Latitude – 0 to 90^o
- Longitude – 0 to 180^o

- Minutes ' (divide by 60)
- Seconds " (divide by 60*60)



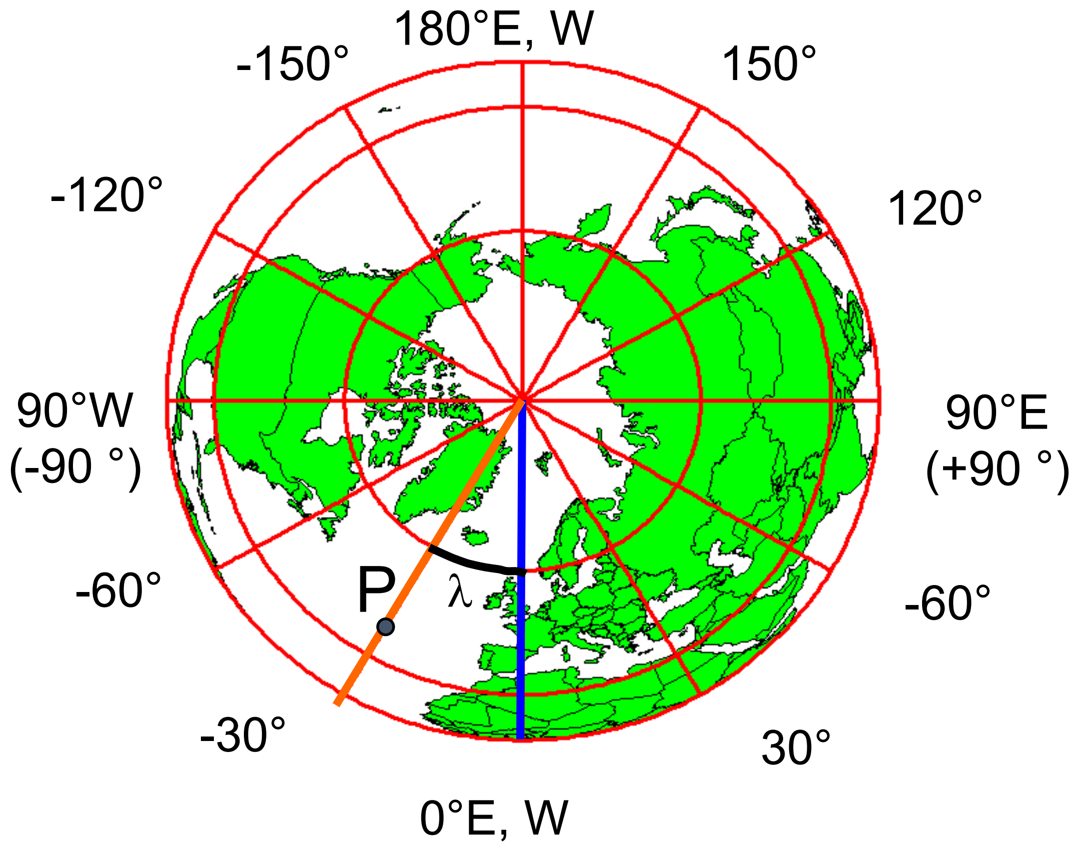
Equator, the 0° parallel of latitude



Prime Meridian, the 0° of longitude

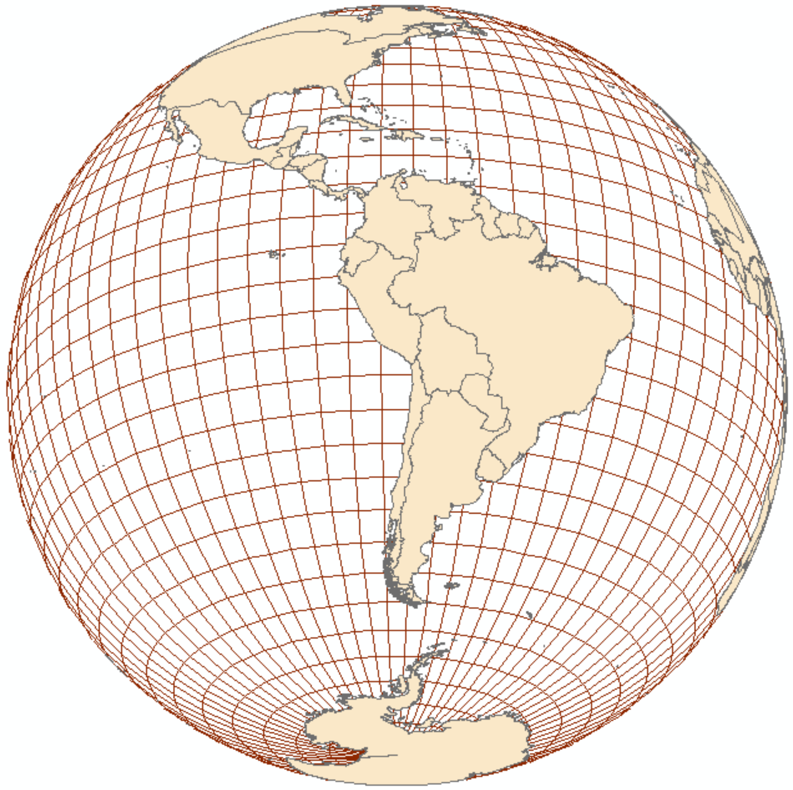
Definition of Longitude, λ

λ = the angle between a cutting plane on the prime meridian and the cutting plane on the meridian through the point, P



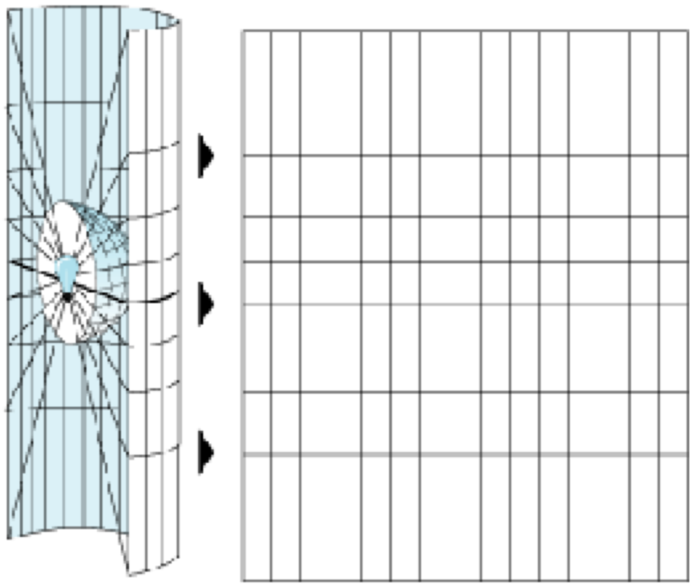
Map Projections

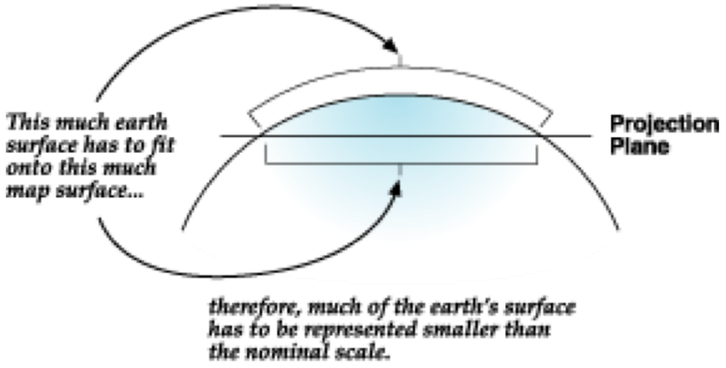
How do we display a three dimensional surface on a two dimensional display?



Map Projections

- A *map projection* is a systematic rendering of locations from the curved Earth surface onto a flat map
- Distortions are unavoidable
  - Some areas will be compressed others will be stretched





Map projections..

- Define the spatial relationship between locations on earth and their relative locations on a flat map
- Are mathematical expressions
- Cause the distortion of one or more map properties (scale, distance, direction, shape)

Classifications of Map Projections

Conformal – local shapes are preserved

Equal-Area – areas are preserved

Equidistant – distance from a single location to all other locations are preserved

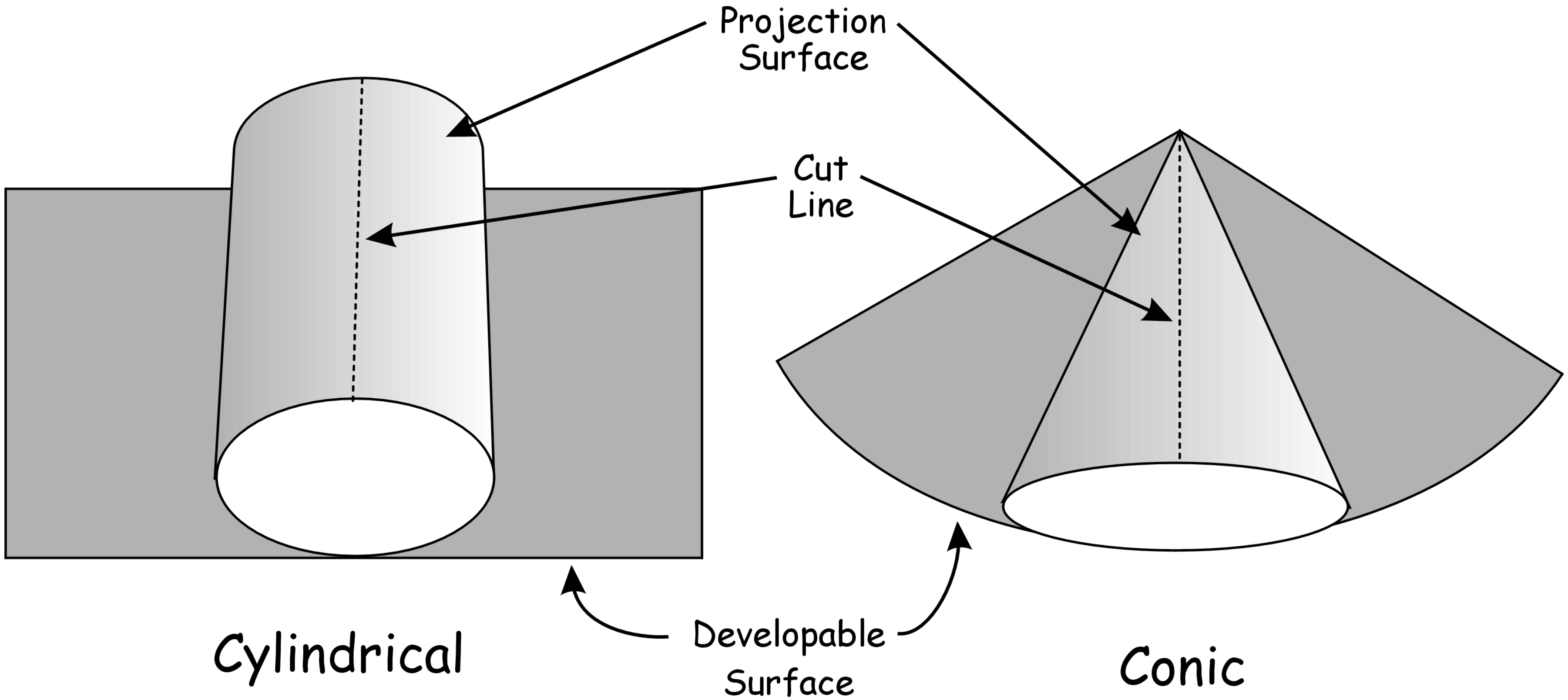
Azimuthal – directions from a single location to all other locations are preserved

Another classification system

By the geometric surface that the sphere is projected on:

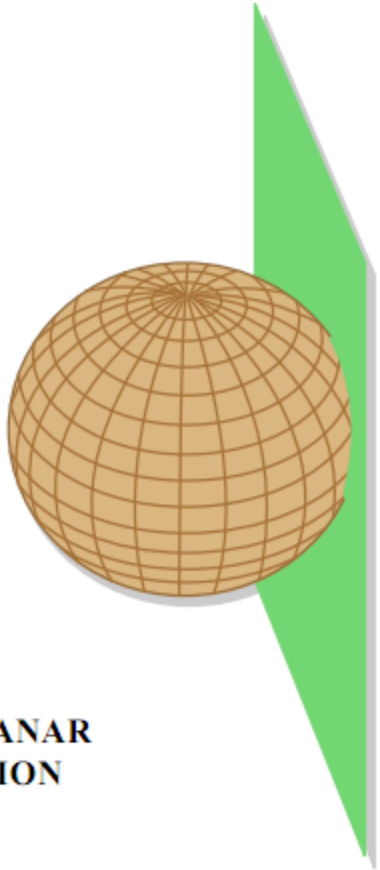
- Planar
- Cylindrical
- Conic

Developable Surfaces



Bolstad 2002

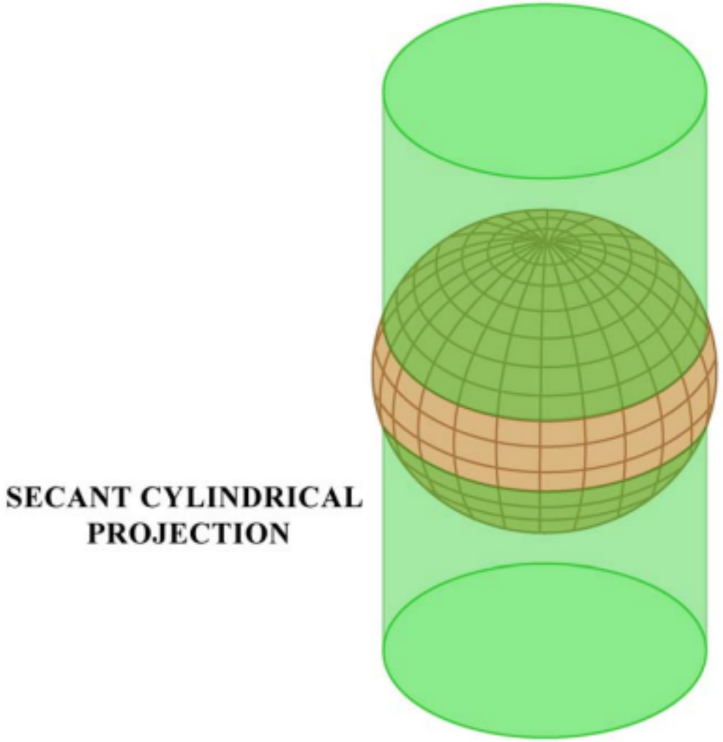
Planar surface



SECANT PLANAR
PROJECTION

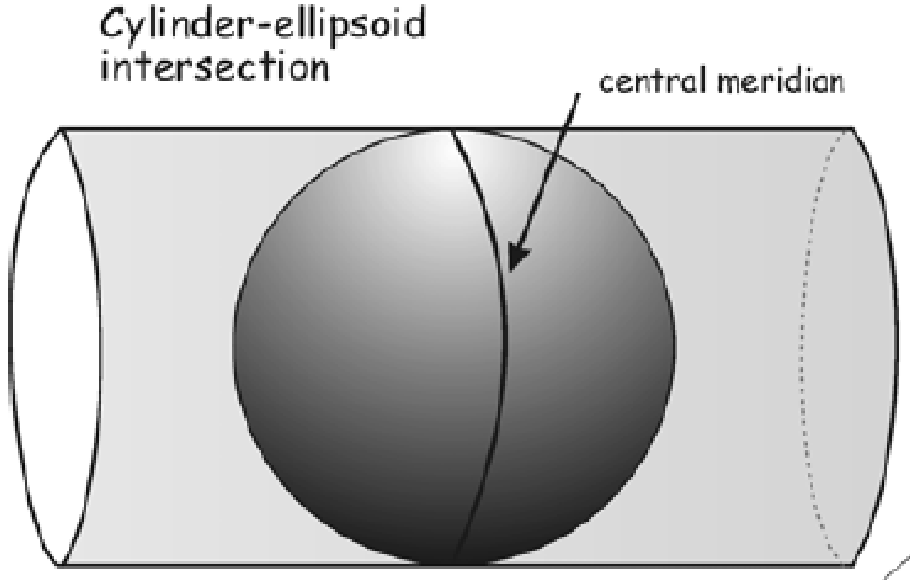
Earth intersects
the plane on a small
circle. All points on
circle have no scale
distortion.

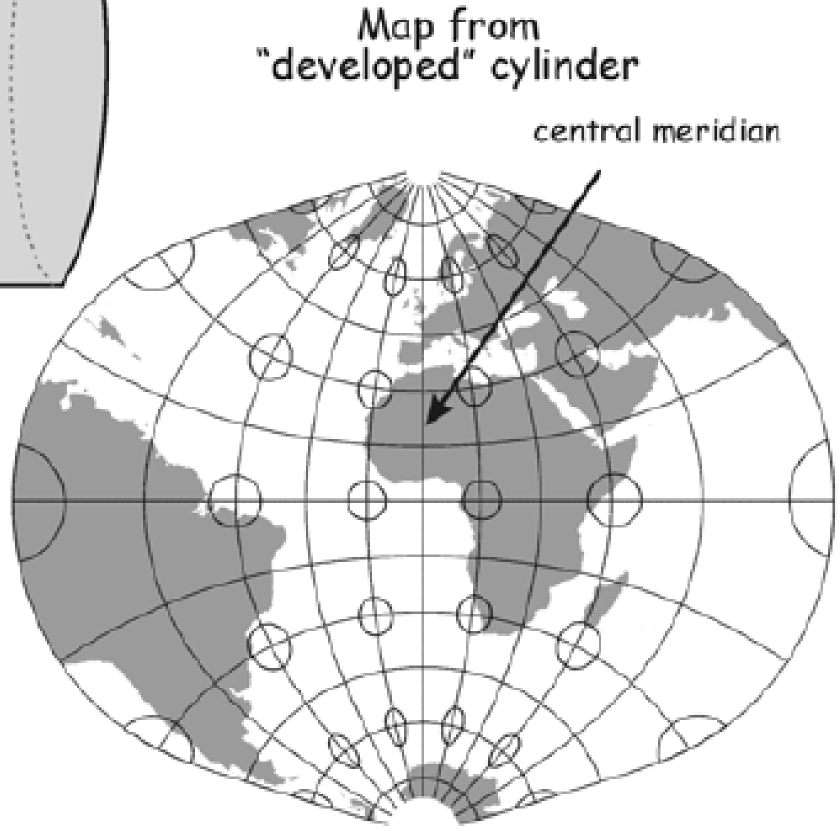
Cylindrical surface



Earth intersects the cylinder on two small circles. All points along both circles have no scale distortion.

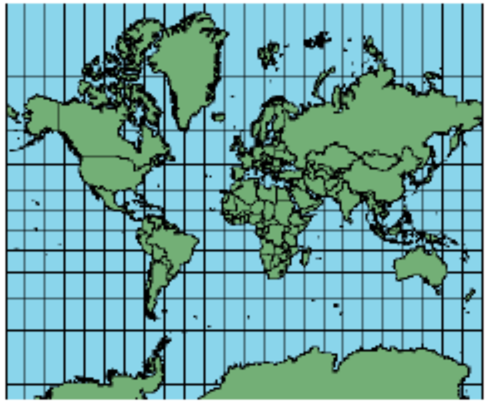
Transverse Mercator



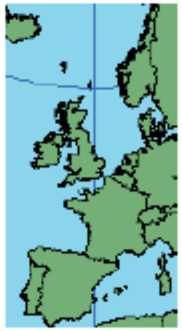


Bolstad 2002

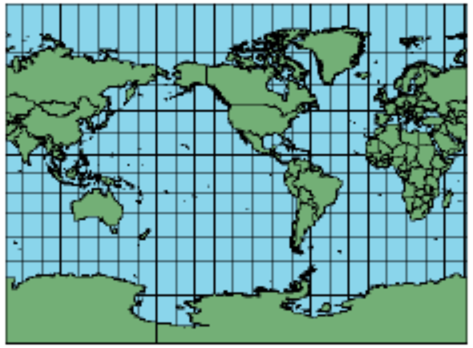
Common cylindrical projections



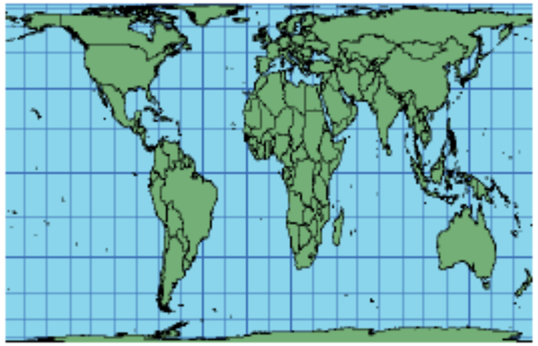
Mercator



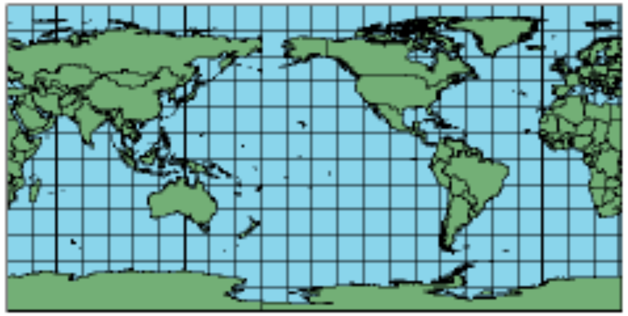
Transverse Mercator



Miller Cylindrical

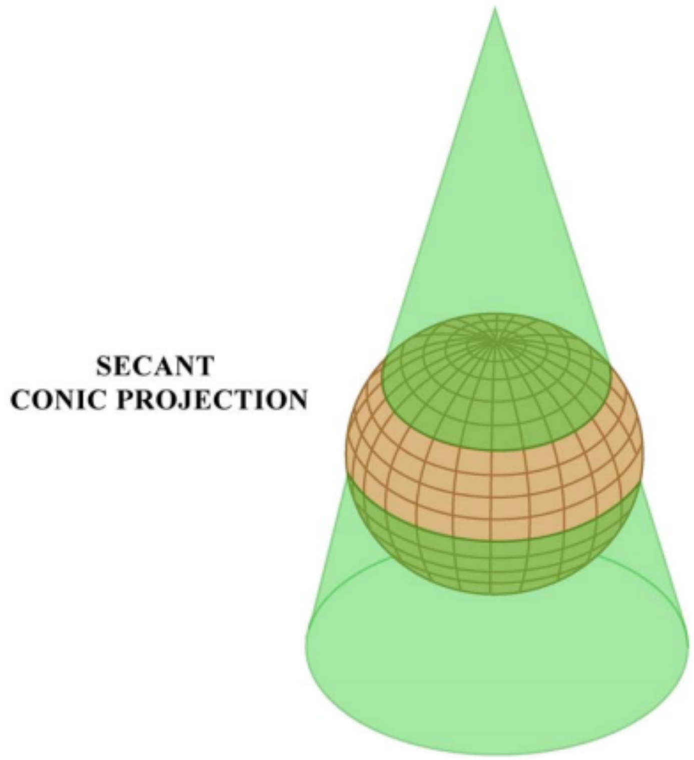


Cylindrical Equal Area

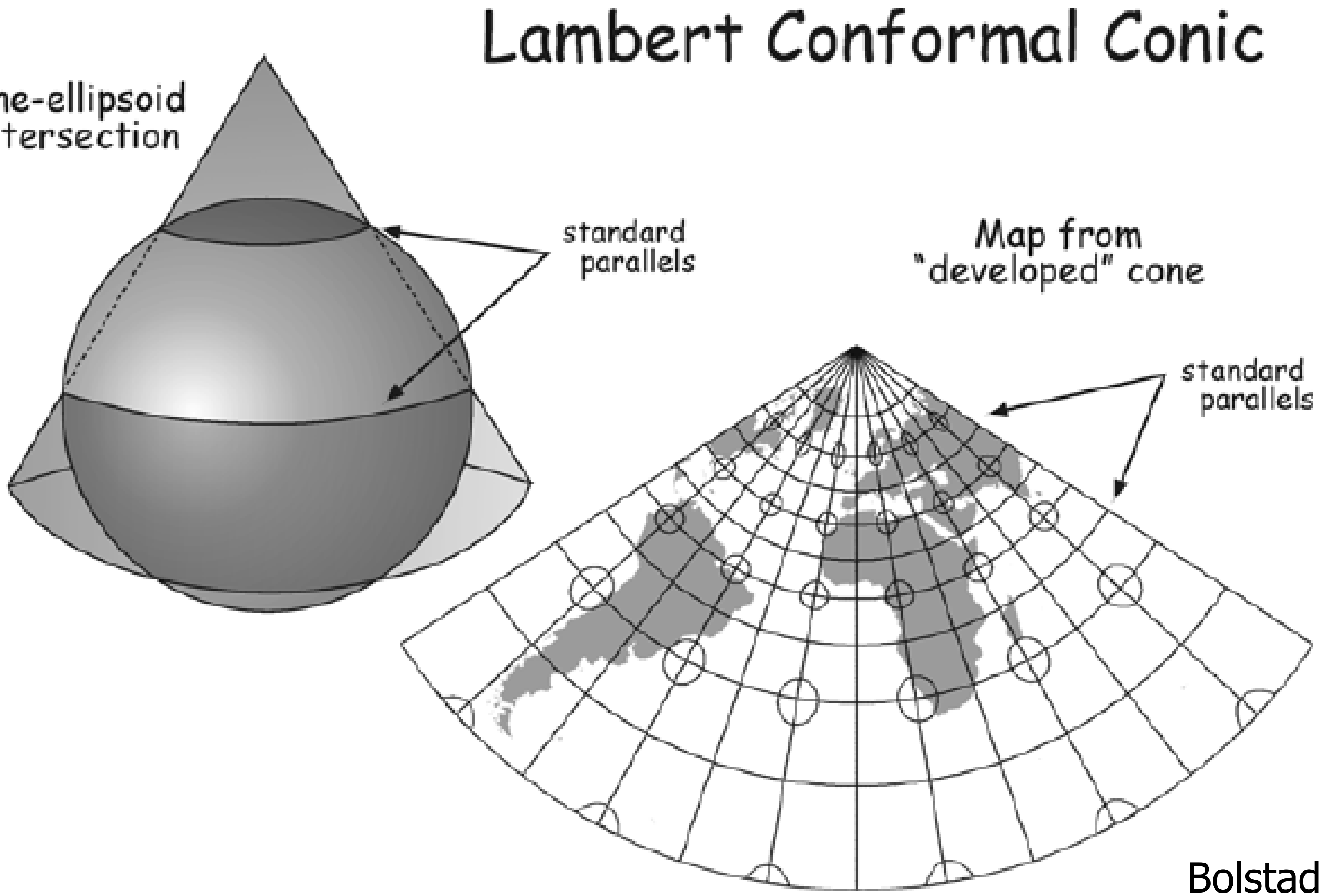


Equirectangular

Conic surface



Earth intersects the cone at two circles. all points along both circles have no scale distortion.



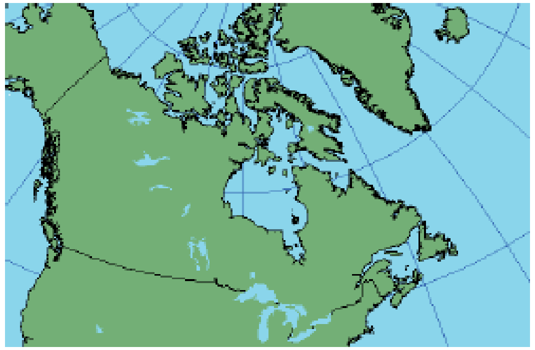
Bolstad 2002

Common conic projections

Lambert Conformal Conic

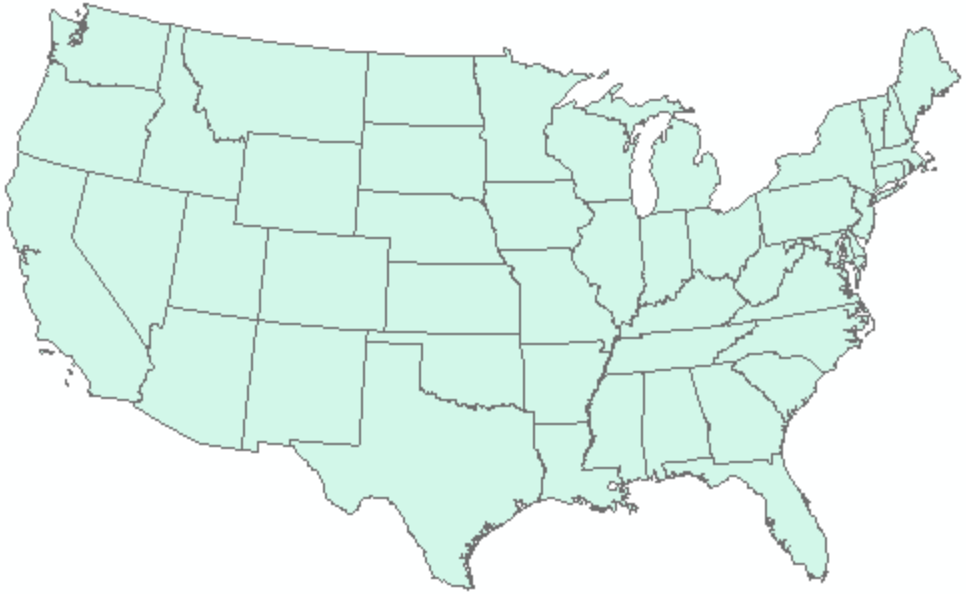
Equidistant Conic

Albers Equal Area
Conic



Polyconic

Conic projection implemented



Contiguous 48 states represented as we are accustomed to seeing them and areas are approximately accurate

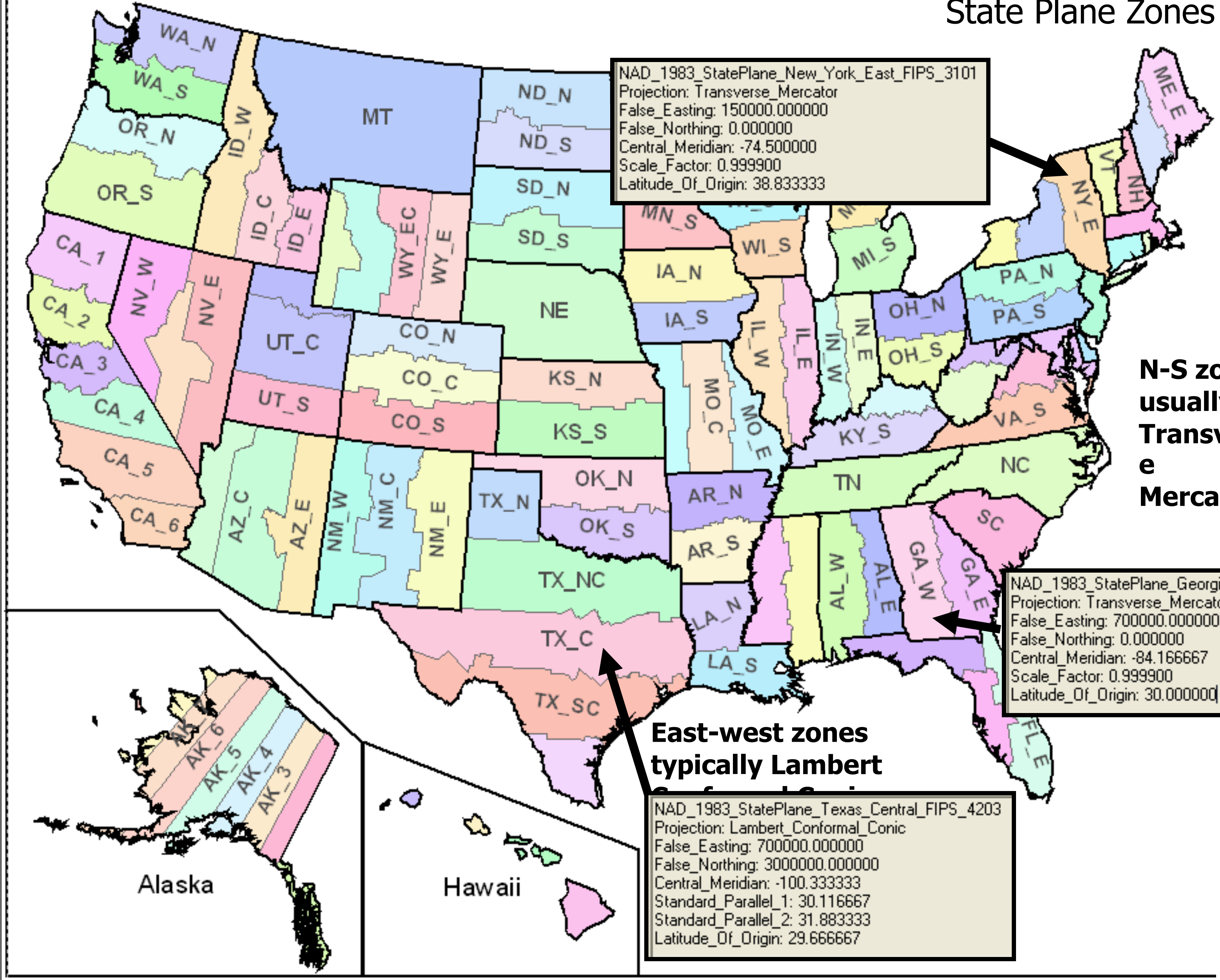
State Plane System

- States divided into one or more zones
- A projection and parameters are established for each zone to achieve desired accuracy
  - Transverse Mercator, Lambert Conformal Conic, and Oblique Mercator are standard projections used
- Several varieties in common use
  - State Plane NAD 1927 uses feet
  - State Plane NAD 1983 uses meters
  - Some choose to use NAD 1983 (feet)

NAD_1983_StatePlane_Hawaii_3_FIPS_5103
Projection: Transverse_Mercator
False_Easting: 500000.000000
False_Northing: 0.000000
Central_Meridian: -158.000000
Scale_Factor: 0.999990
Latitude_Of_Origin: 21.166667

NAD_1983_StatePlane_Texas_Central_FIPS_4203
Projection: Lambert_Conformal_Conic
False_Easting: 700000.000000
False_Northing: 3000000.000000
Central_Meridian: -100.333333
Standard_Parallel_1: 30.116667
Standard_Parallel_2: 31.883333
Latitude_Of_Origin: 29.666667

State Plane Zones



NAD_1983_StatePlane_New_York_East_FIPS_3101
Projection: Transverse_Mercator
False_Easting: 150000.000000
False_Northing: 0.000000
Central_Meridian: -74.500000
Scale_Factor: 0.999900
Latitude_Of_Origin: 38.833333

N-S zones usually Transvers e Mercator

NAD_1983_StatePlane_Georgia_West_FIPS_1002
Projection: Transverse_Mercator
False_Easting: 700000.000000
False_Northing: 0.000000
Central_Meridian: -84.166667
Scale_Factor: 0.999900
Latitude_Of_Origin: 30.000000

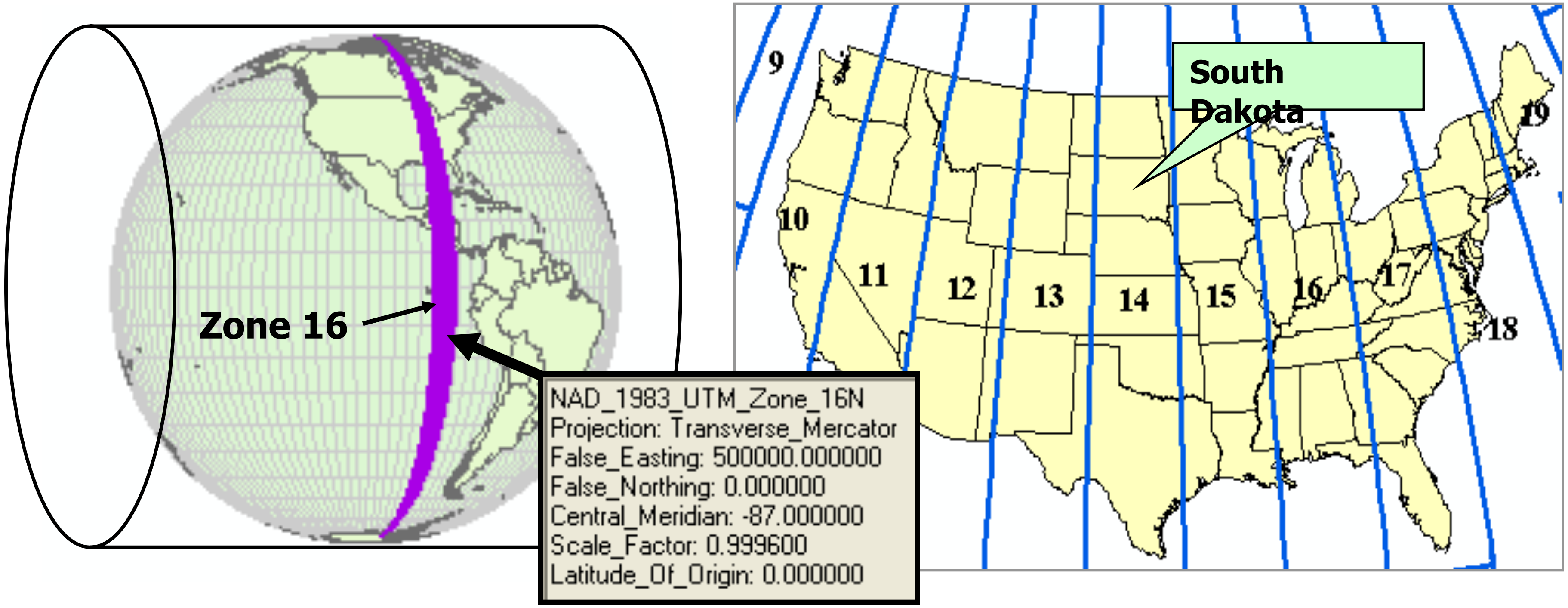
East-west zones typically Lambert

NAD_1983_StatePlane_Texas_Central_FIPS_4203
Projection: Lambert_Conformal_Conic
False_Easting: 700000.000000
False_Northing: 3000000.000000
Central_Meridian: -100.333333
Standard_Parallel_1: 30.116667
Standard_Parallel_2: 31.883333
Latitude_Of_Origin: 29.666667

UTM Coordinate System

- Used as a global coordinate system based on the transverse Mercator projection
  - Divides the earth into zones that are 6 degrees of longitude wide.
- This system is used for study areas spanning large regions

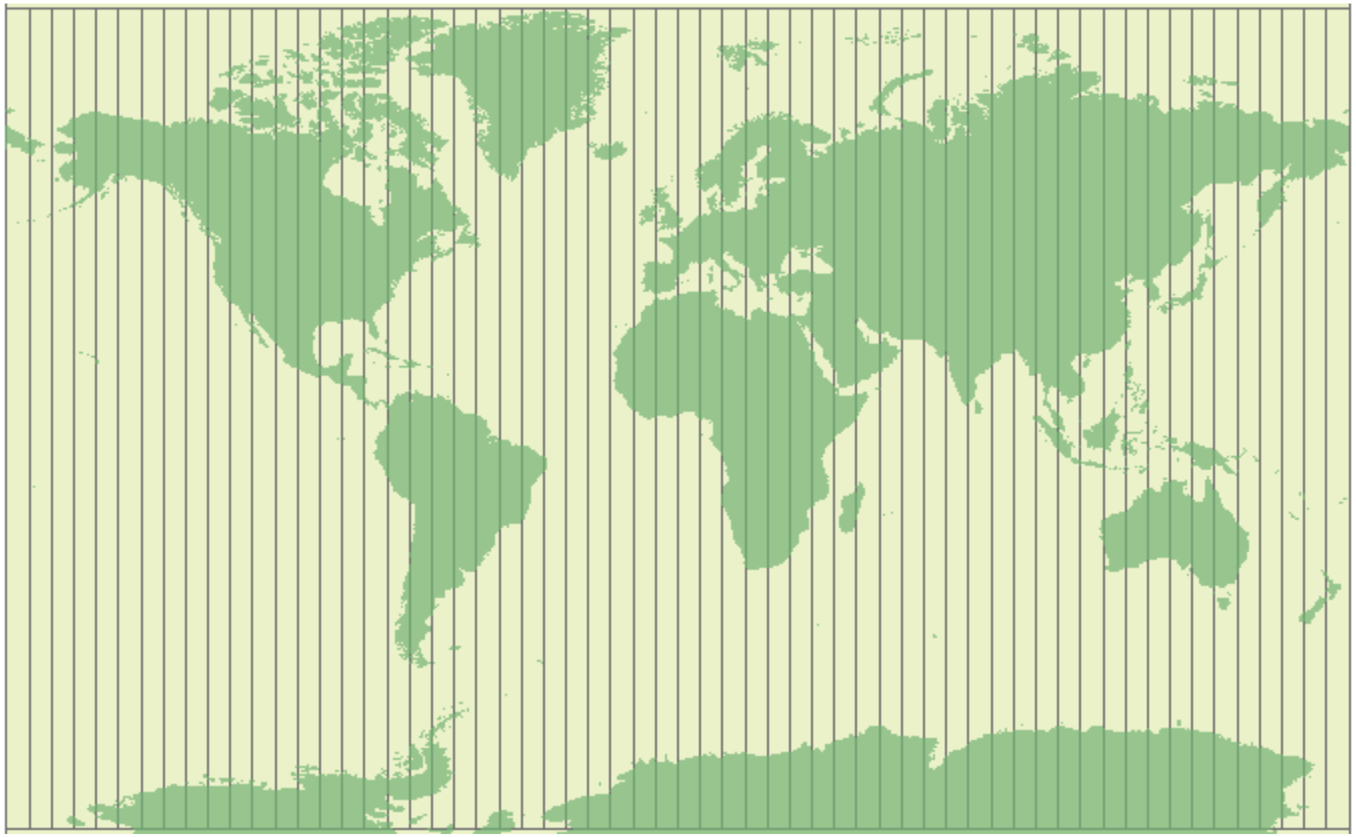
Universal Transverse Mercator



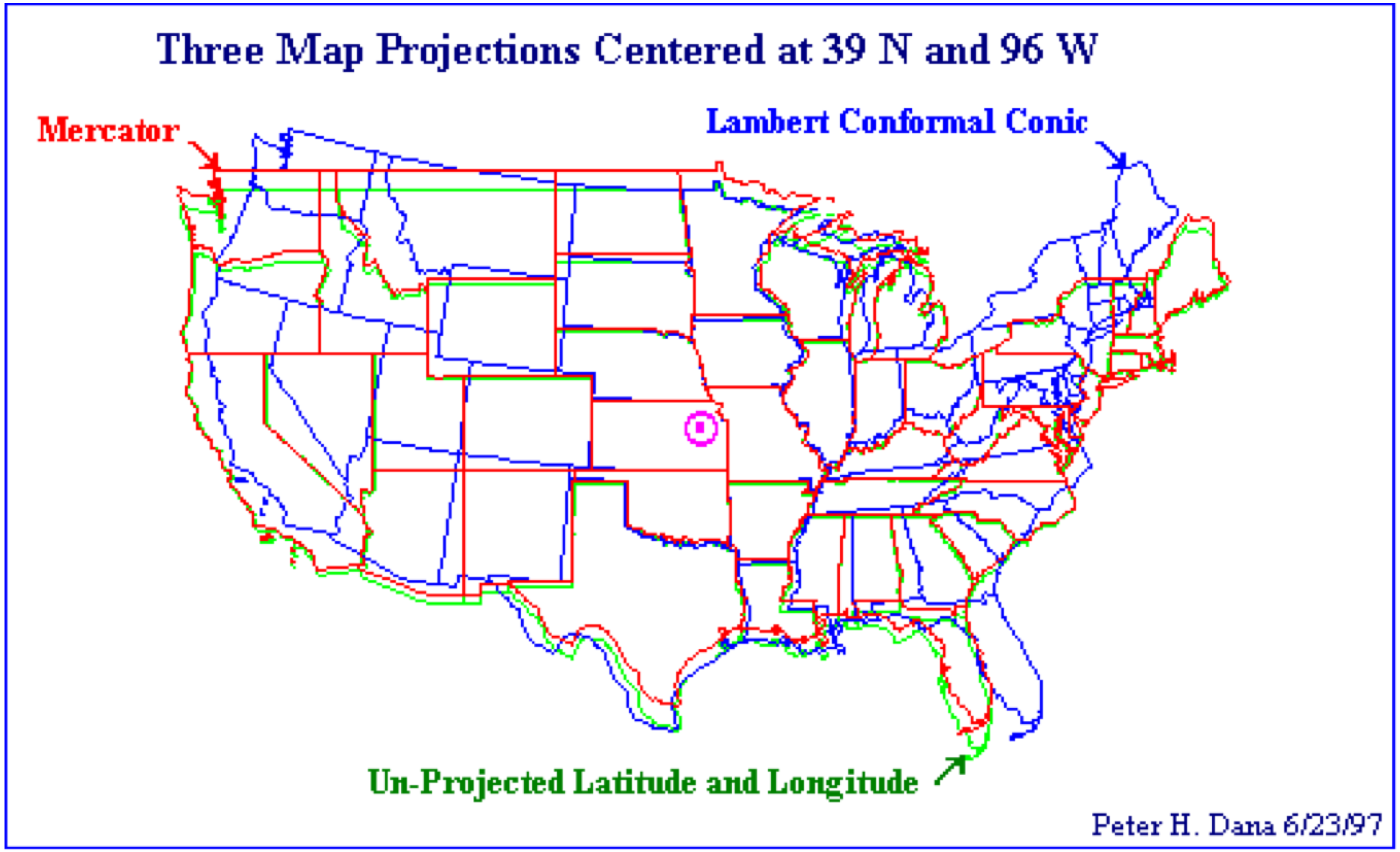
- Based on Transverse Mercator (cylindrical) projection
- Distortion is minimal within each zone
- Maps of different areas use best zone

UTM zones

Numbered 1 through 60 from Longitude 180

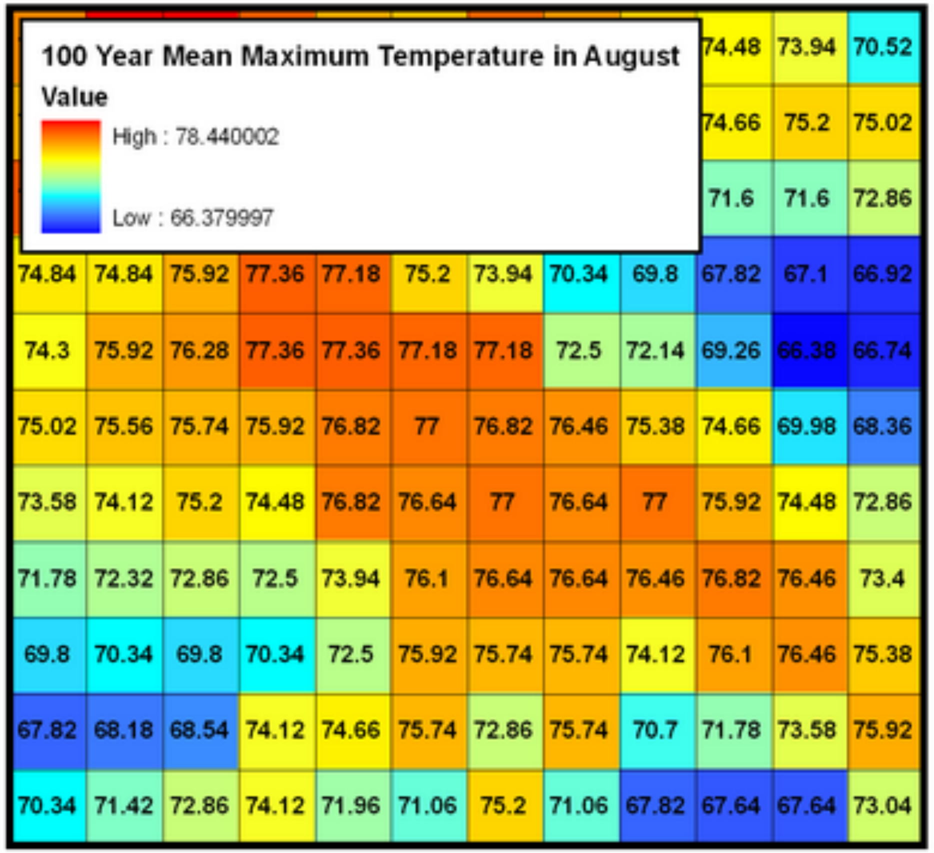


How Different are these map projections?



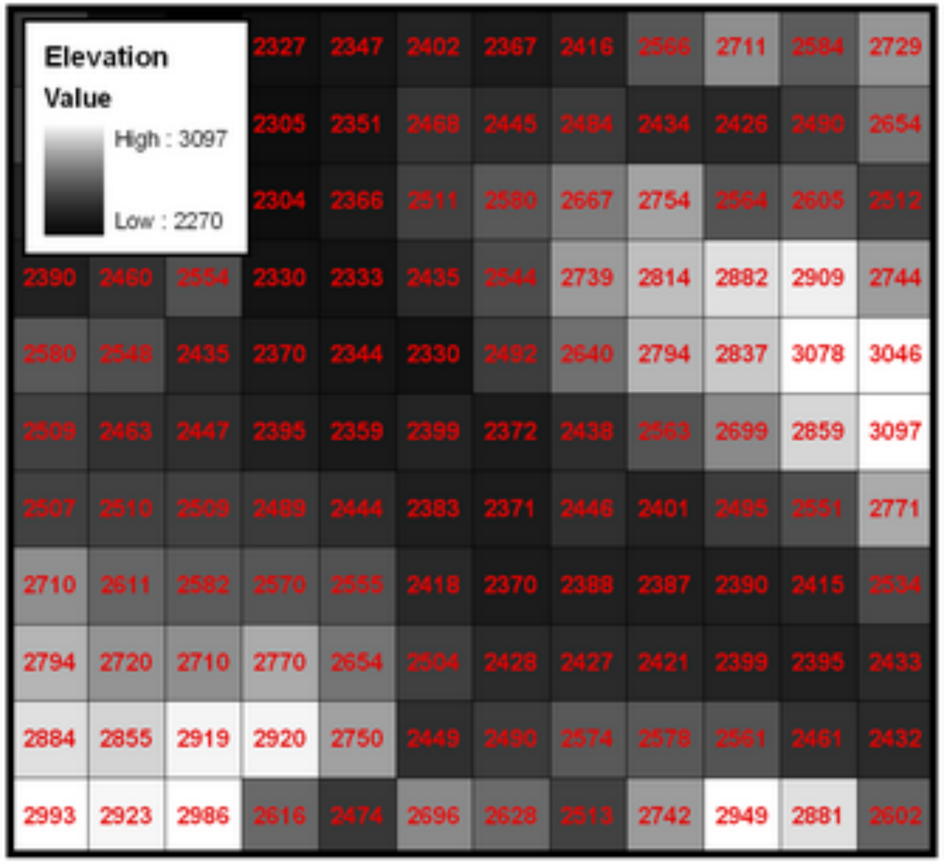
The Raster Data Model

- The Raster Data Model is used to model spatial phenomena that vary continuously over a surface and that do not have discrete dimension
  - Elevation
  - Temperature
  - Rainfall
  - Noise Levels



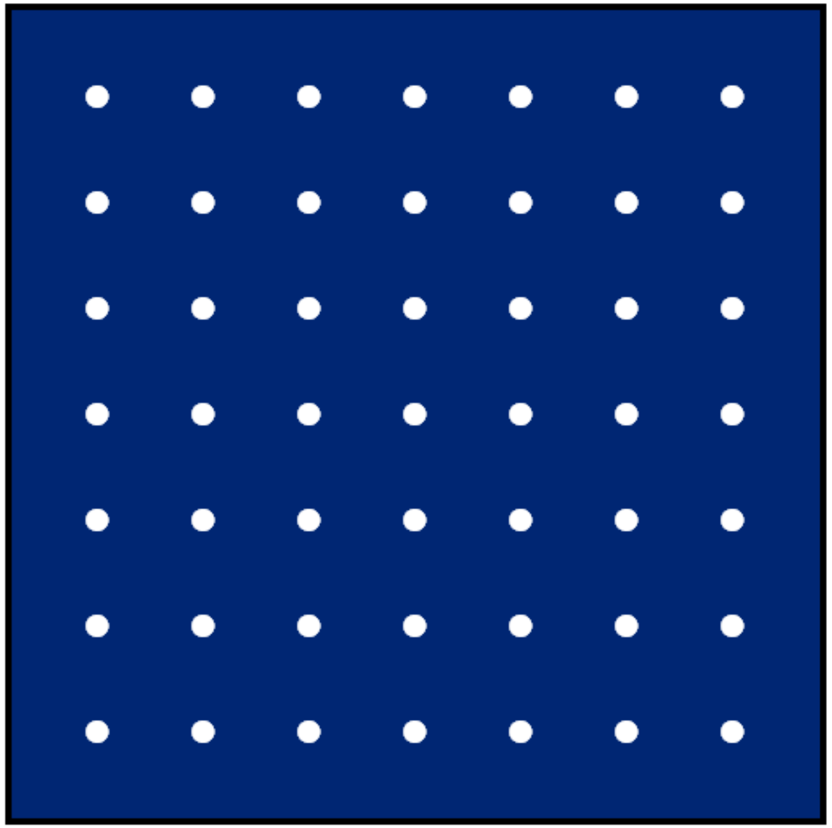
Surfaces Have *Numeric Values*

- Things like elevation, temperature, slope and precipitation have measurable values for any particular location on the earth's surface.



Surfaces Have *Numeric Values*

- To model these phenomena, an area of interest is divided into an array of identically sized squares
- The centers of these squares then become the ‘sample points’



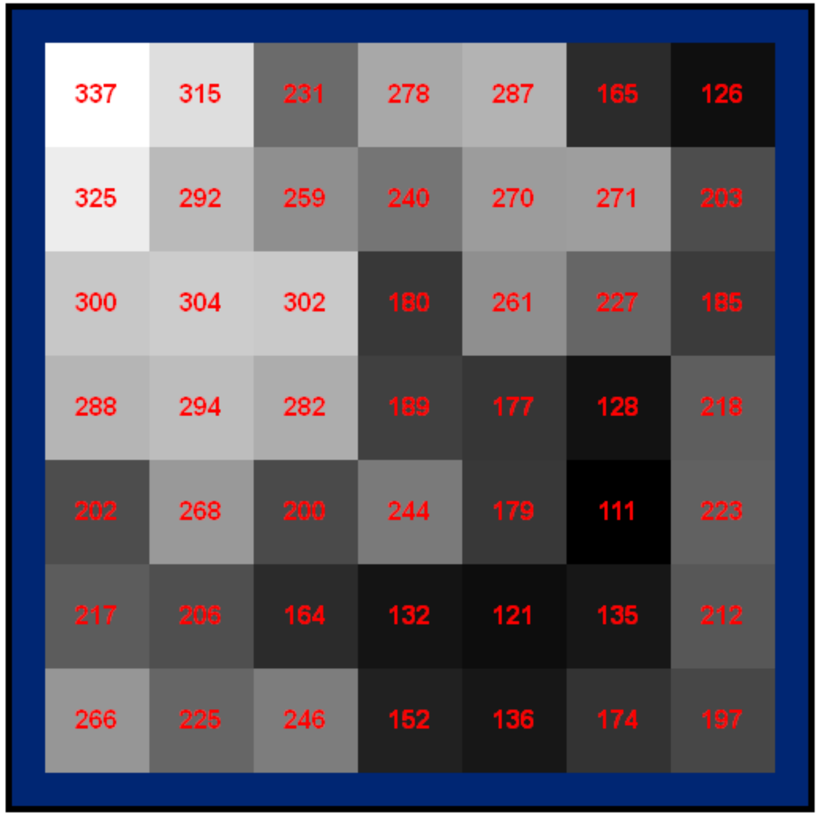
Surfaces Have *Numeric Values*

- The values of the variable of interest are recorded, or estimated, at each of the sample points.

337	315	231	278	287	165	126
325	292	259	240	270	271	203
300	304	302	180	261	227	185
288	294	282	189	177	128	218
202	268	200	244	179	111	223
217	206	164	132	121	135	212
266	225	246	152	136	174	197

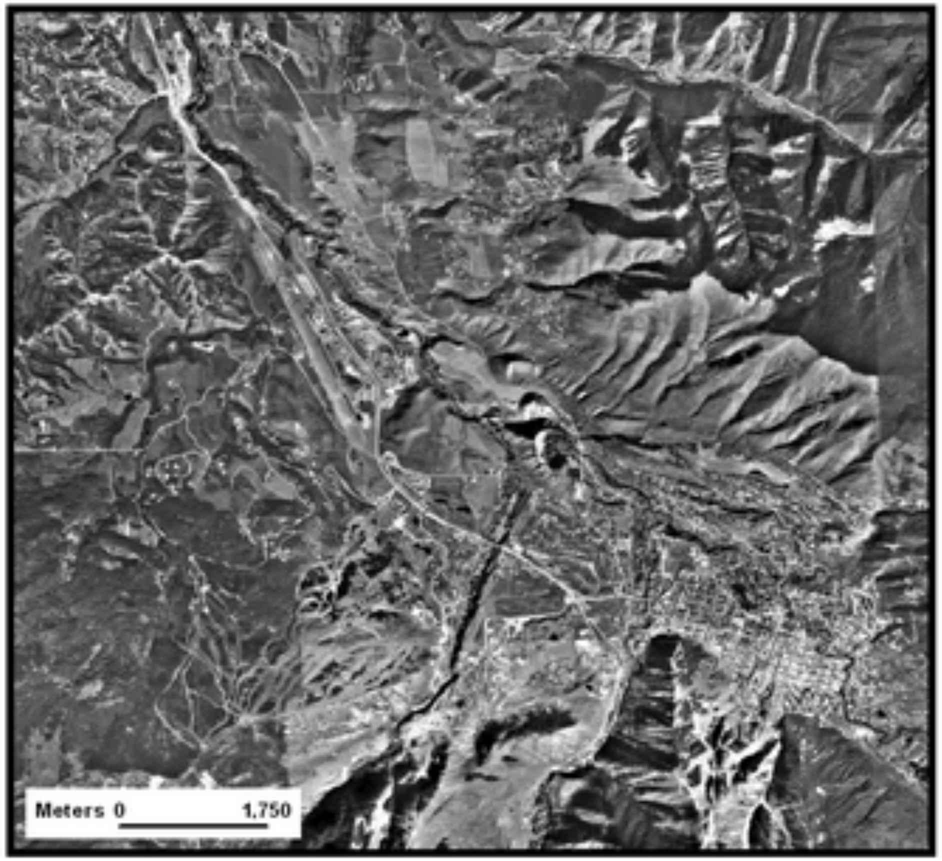
Surfaces Have *Numeric Values*

- These values can then be assigned colors, or shades of gray, in order for them to be visualized



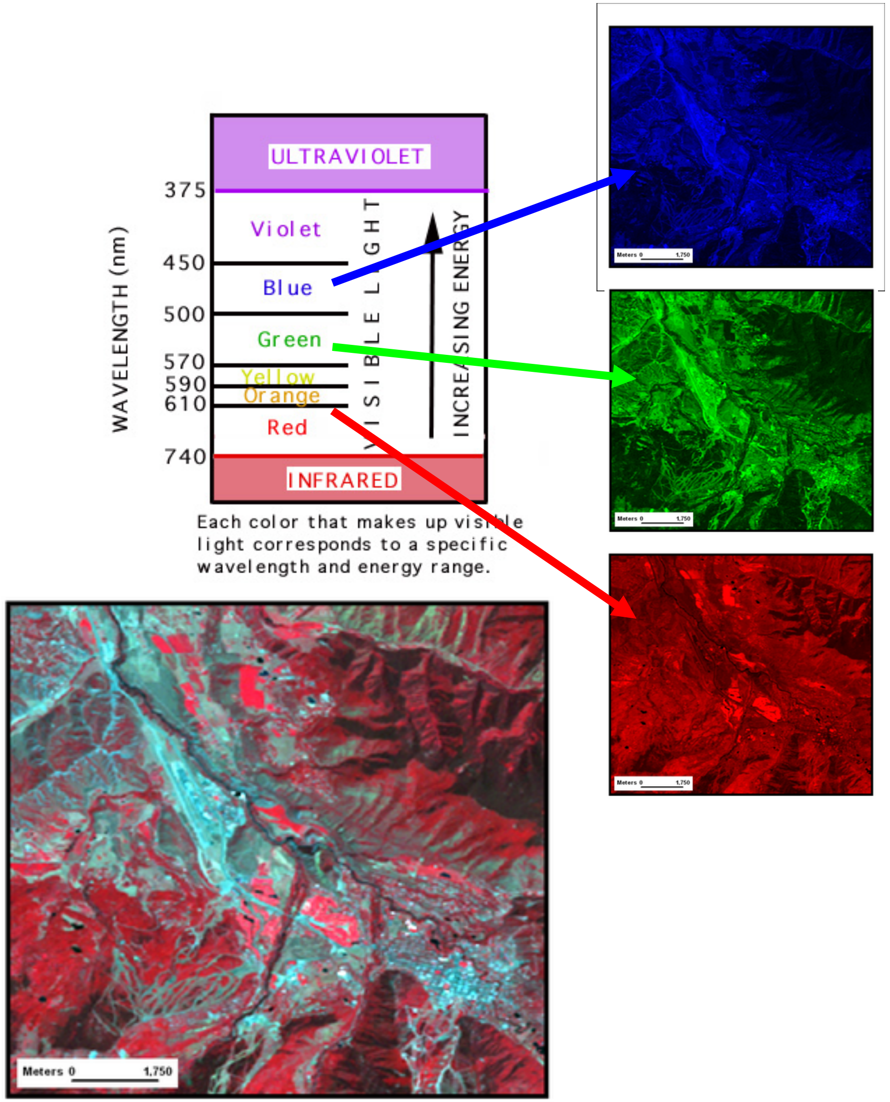
Digital Photos

- The most familiar type of Raster Data is the **digital photograph.**
- **Digital Photos** are raster datasets that record the relative amount of light being reflected off of a surface.



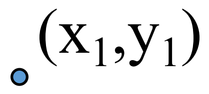
Color Digital Photos

- Color Digital Photos are actually made up of three Raster Datasets, each of which describes the amount of reflected Red, Green & Blue light, respectively.
- These 3 raster datasets are combines (by the computer) into the R-G-B color image we are used to seeing.

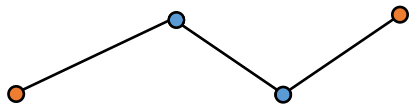


Two fundamental ways of representing geography are discrete objects and fields.

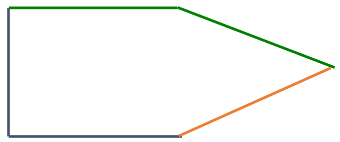
The **discrete object view** represents the real world as objects with well defined boundaries in empty space.



Points

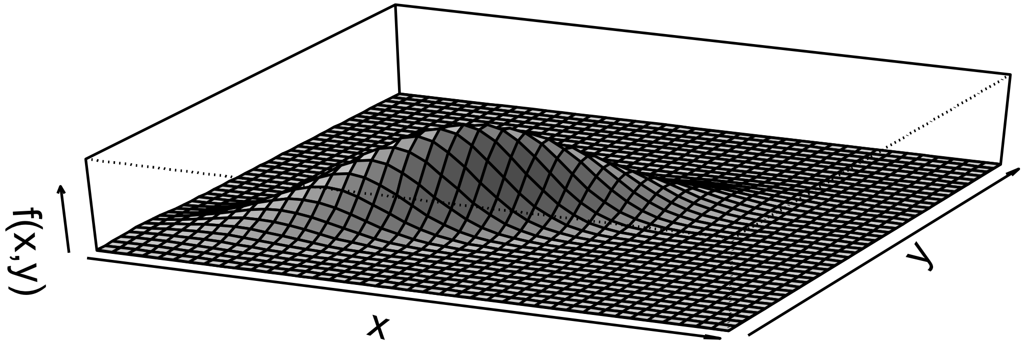


Lines



Polygons

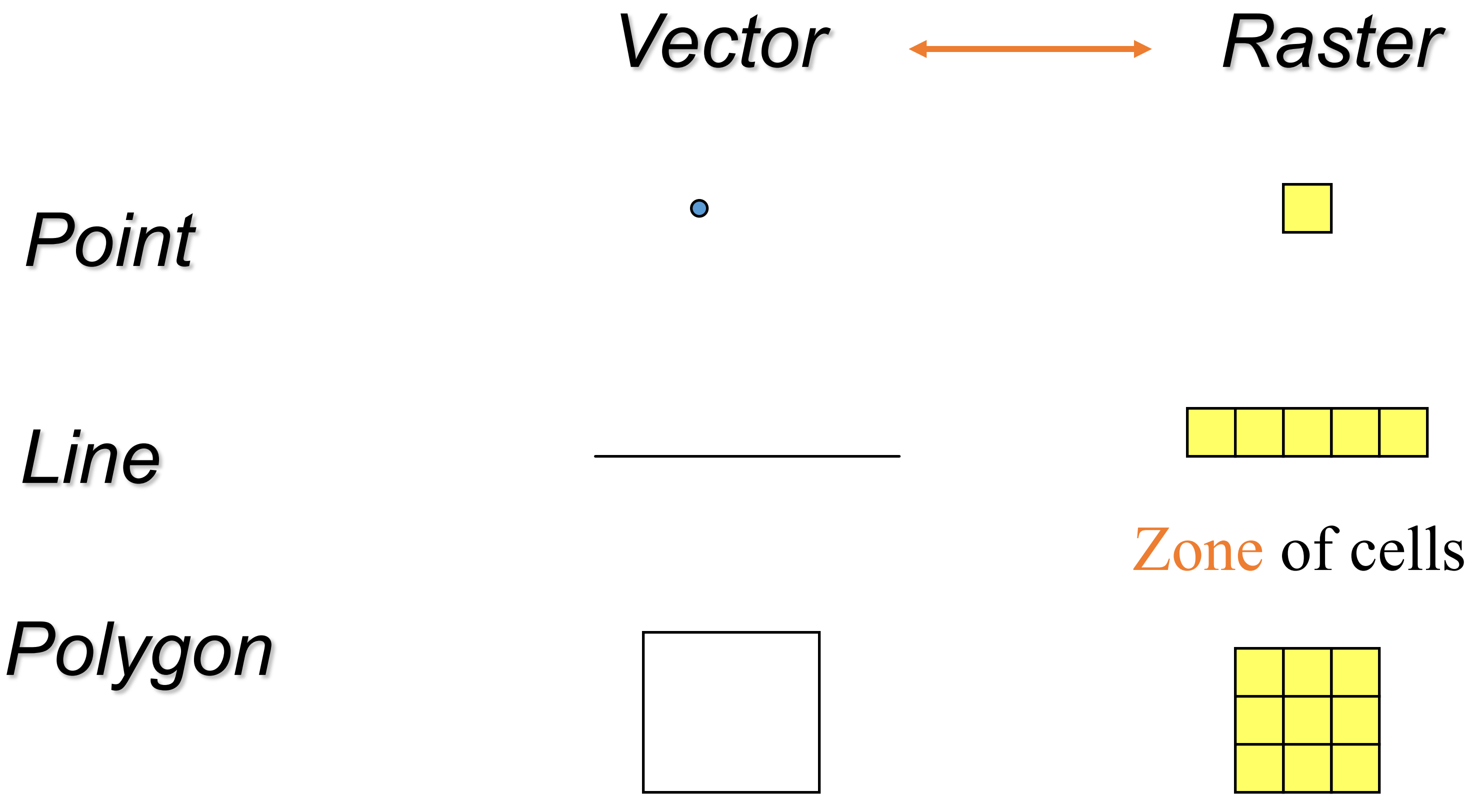
The **field view** represents the real world as a finite number of variables, each one defined at each possible position.



Continuous surface

Raster and Vector Data

Raster data are described by a cell grid, one value per cell

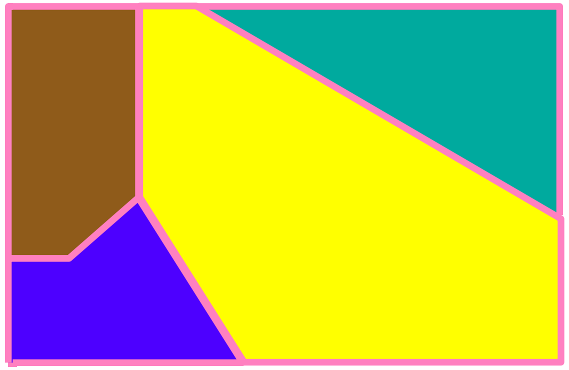


Raster and Vector are two methods of representing geographic data in GIS

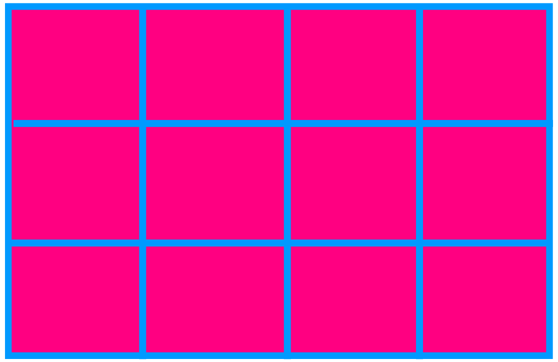
- Both represent different ways to **encode** and **generalize** geographic phenomena
- Both can be used to code **both** fields and discrete objects
- In practice a strong association between **raster and fields** and **vector and discrete objects**

Vector and Raster Representation of Spatial Fields

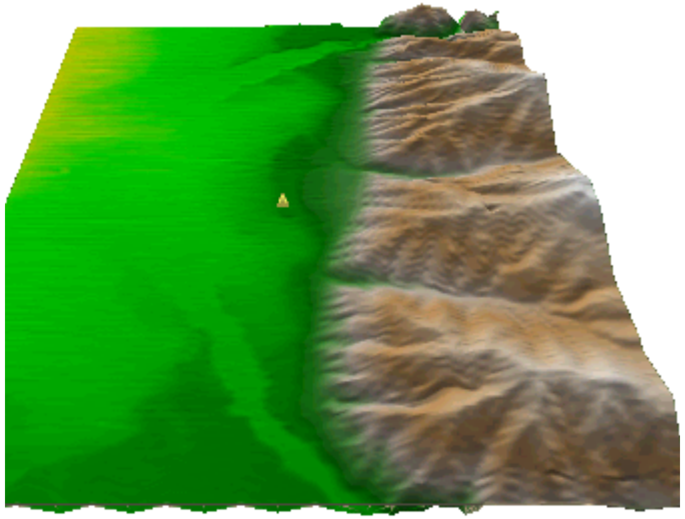
Vector



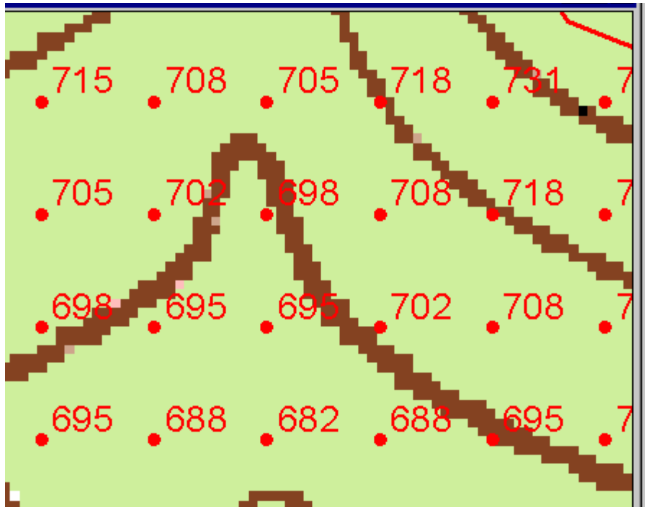
Raster



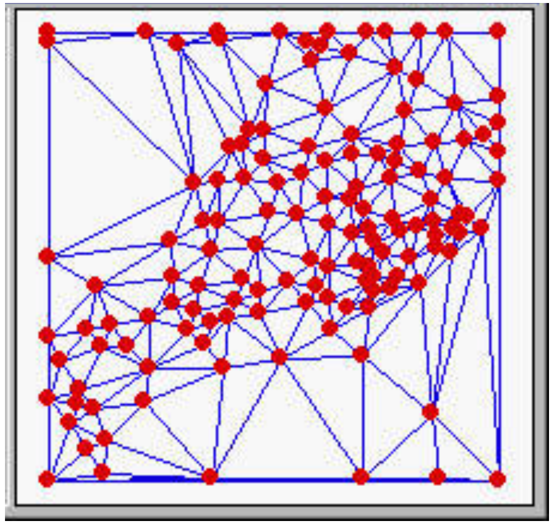
Numerical representation of a spatial surface (field)



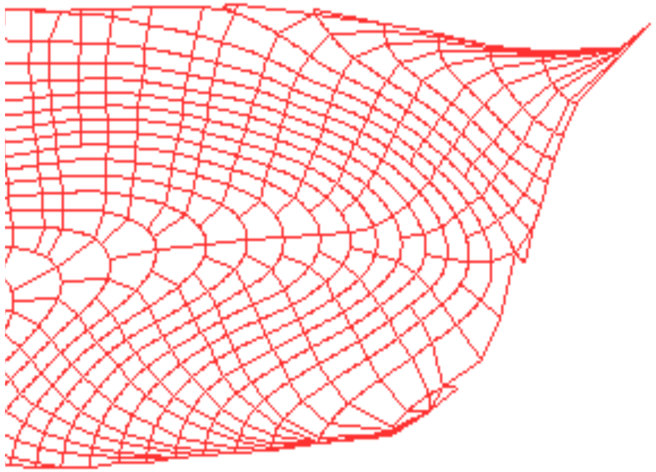
Grid



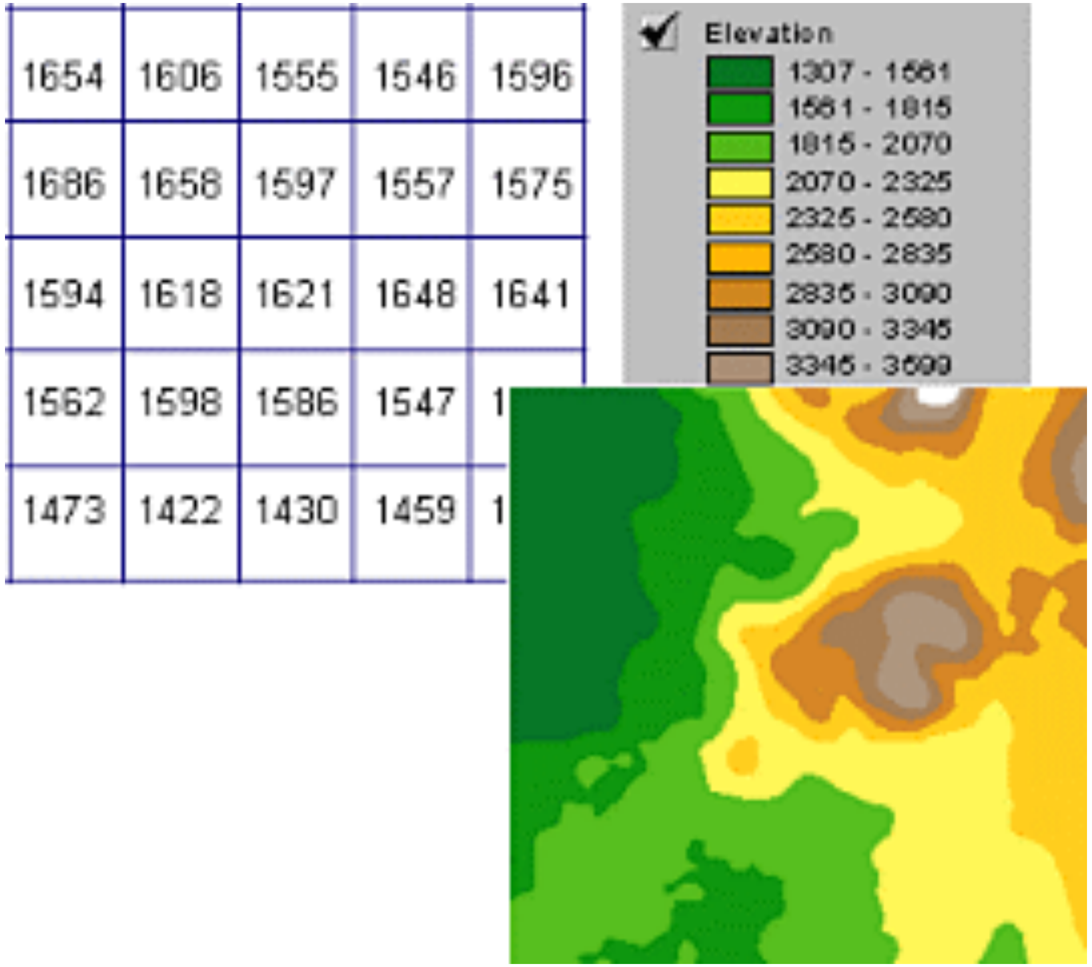
TIN



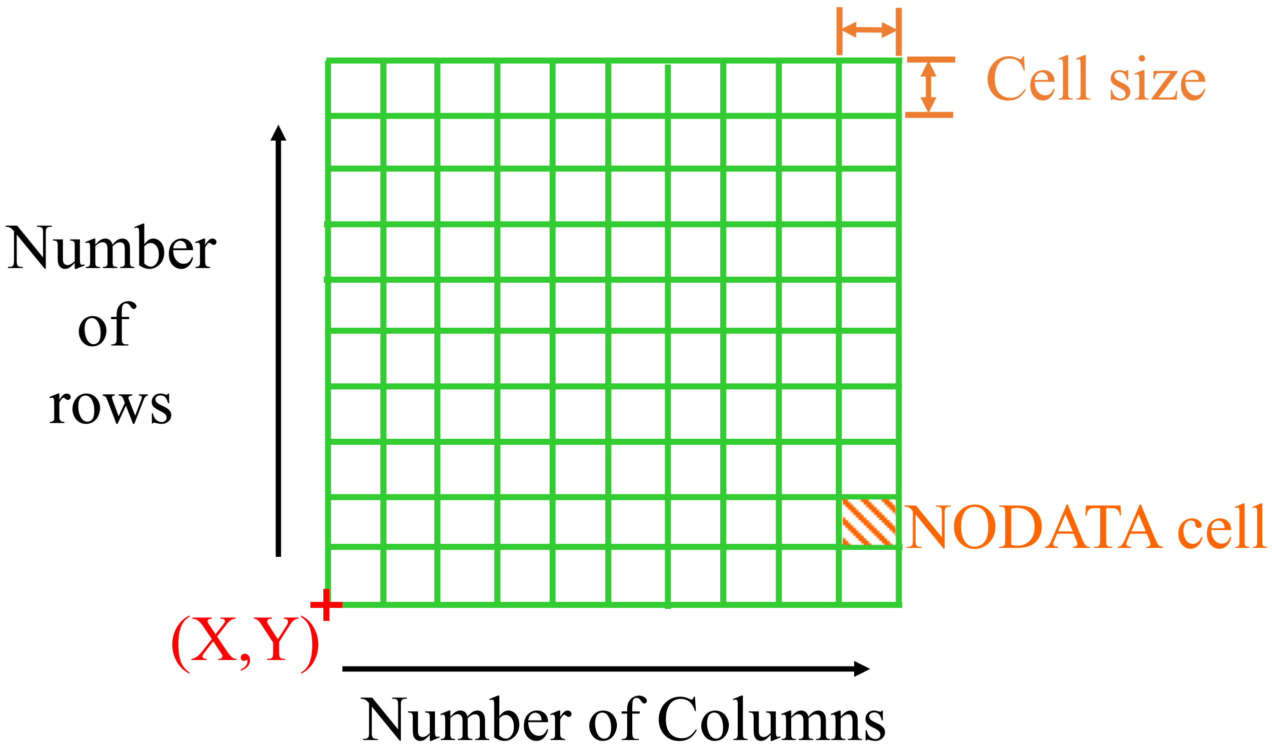
Contour and flowline



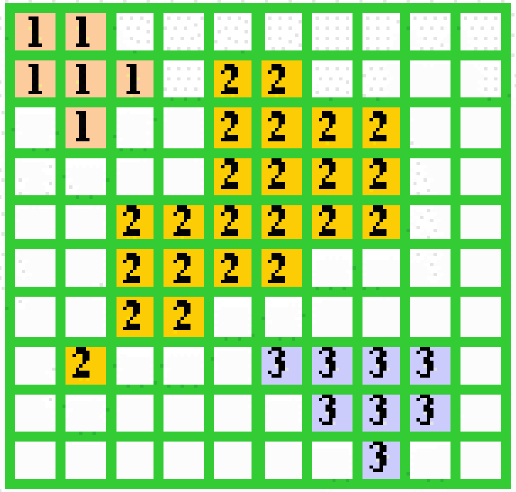
A **grid** defines geographic space as a matrix of identically-sized square cells. Each cell holds a numeric value that measures a geographic attribute (like elevation) for that unit of space.



Definition of a Grid



Value attribute table for categorical (integer) grid data



Treetype Grid

Value	Count	Type	Code
1	6	Maple	200
2	23	Oak	400
3	8	Pine	300

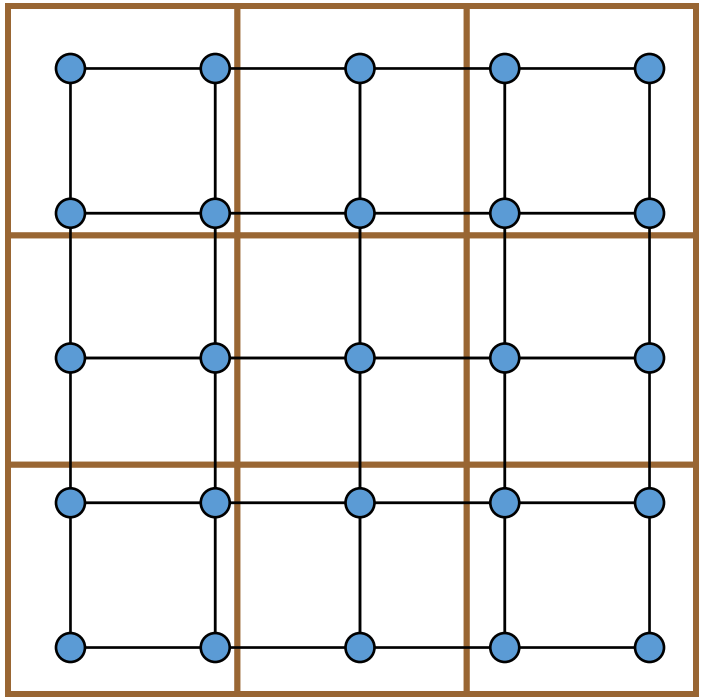
Treetype.vat

Attributes of grid zones

Interpolation

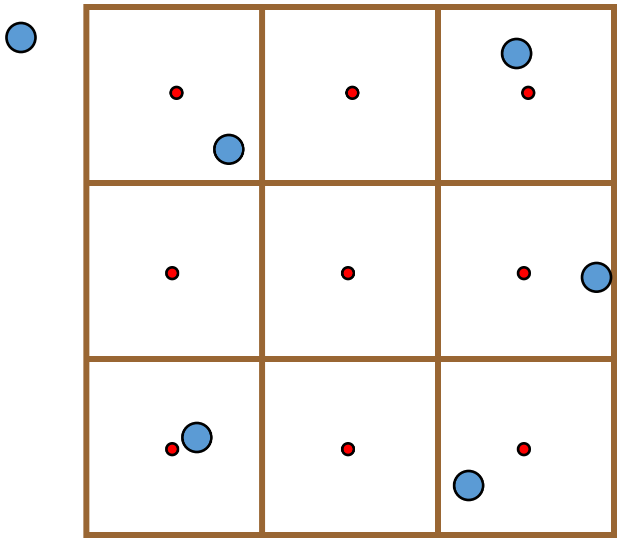
Estimate values between known values.

A set of spatial analyst functions that predict values for a surface from a limited number of sample points creating a continuous raster.



Apparent improvement in resolution may not be justified

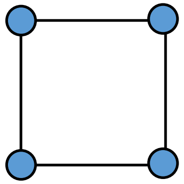
Interpolation methods



- Nearest neighbor
- Inverse distance weight
- Bilinear interpolation
- Kriging (best linear unbiased estimator)
- Spline

$$z = \sum \frac{1}{r_i} z_i$$

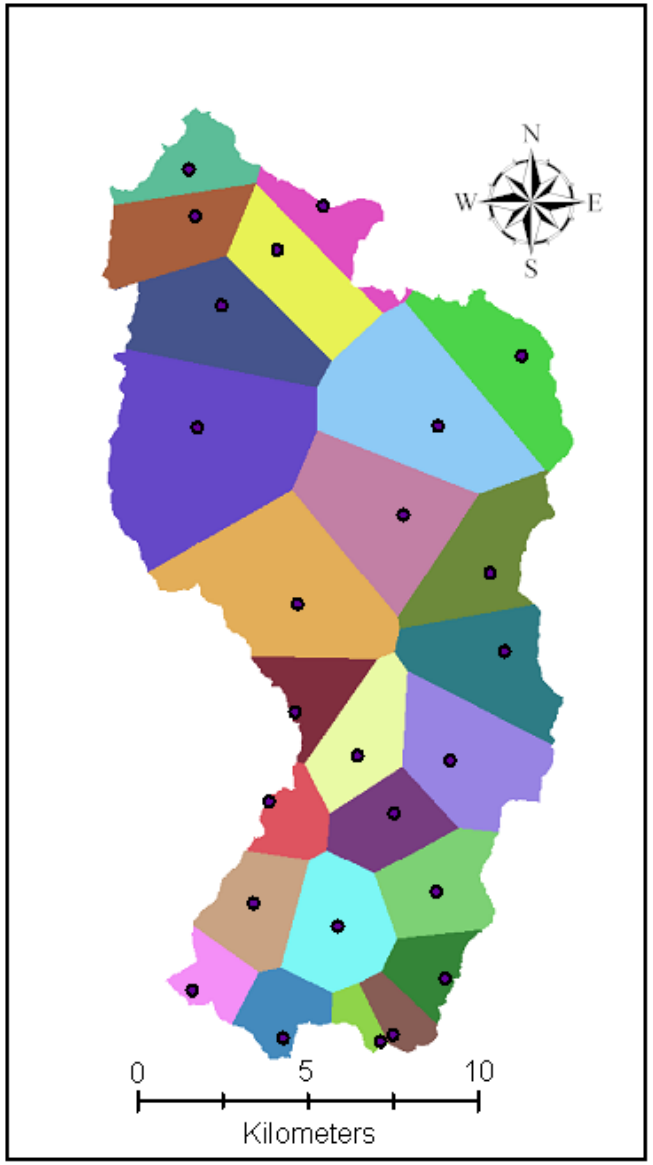
$$z = (a + bx)(c + dy)$$



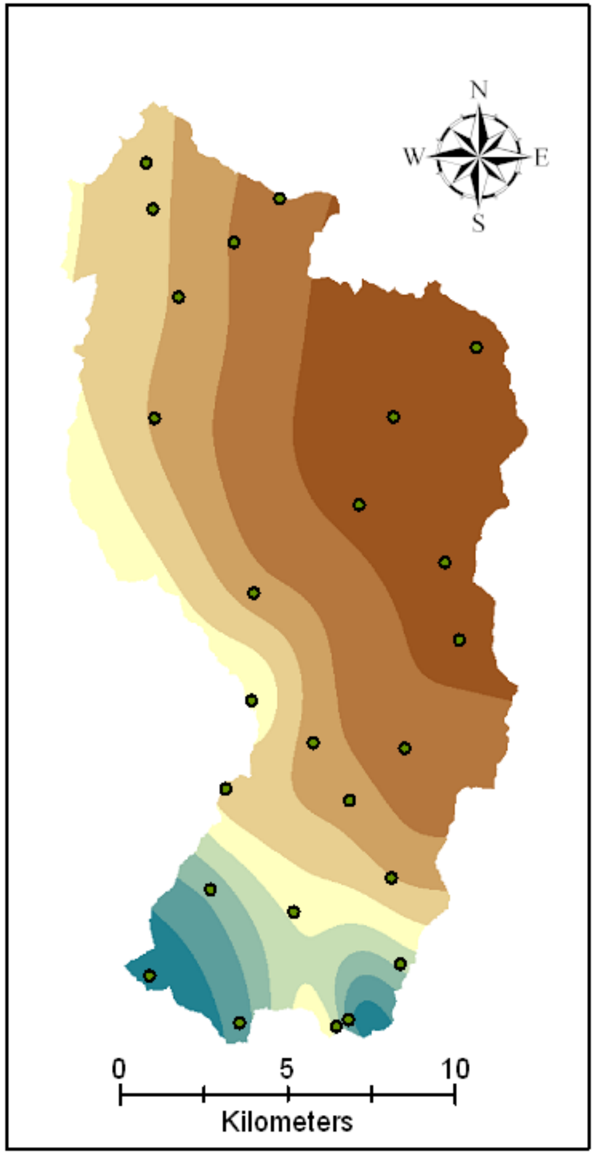
$$z = \sum w_i z_i$$

$$z = \sum c_i x^{e_i} y^{e_i}$$

Nearest Neighbor “Thiessen” Polygon Interpolation



Spline Interpolation



Live Code Mapping Data

Tasks: Map our table of favorite places using the Marker class

Marker.map_table(t)

Learning Outcomes

- Creating maps
- Using latitude and longitude

Overlaid Charts

- It's often useful to look at multiple variables in a single chart.
- The code to do this looks like:

```
t.chart_method(column_label_of_common_axis,
               array_of_labels_of_variables_to_plot)
```

- But the datascience module can usually figure out the variables from the table automatically (omit the last argument).

end