Fri. Jan. 26, 2018

- Demonstration of QGIS with GPS tracks
- Types of data, simple vector (shapefile) formats
- Map projections, Coordinate Reference Systems
- Demonstration of QGIS with geologic map

Raster vs. Vector Data

- Raster data:
  - An matrix of cells, each of which contains some value
    - Good for:
      - Intensity in an image
      - Radar reflectivity vs. position
      - Height vs. position
  - There is some implicit relationship between row and column index (i, j) and position in space (x, y)
    - If there is a constant scale the relationship is simple and linear

- Vector data:
  - A list of (x, y) coordinates, and often some value specified at that coordinate
    - Good for:
      - Plotting lines in space (roads, rivers, borders, contours, etc)
      - Heights of discrete locations such as mountain peaks
      - Locations of discrete features

Coordinates

- “Geographic” vs. Projected
  - “Geographic” coordinates usually mean (longitude, latitude)
  - Projected coordinates are (x,y) values on some “map”
    The relationship between (x,y) and (long., lat) depends on the type of “projection”
- Datums: Set of assumptions about the shape of the Earth and the location of the reference points which go into determining the coordinates of a given spot on the surface:
  - Would be simple if the earth were a sphere of perfectly known size, but it is not.
  - The same location can have different coordinates in different “datums”.
- Coordinate Reference System (CRS): Choice of datum, geographic vs projects values, etc., which are inherent in the location information given with a vector or raster data set.
- On-the-fly projection: The ability of a GIS system to simultaneously display multiple data sets that have different CRS's, without you first having to “reproject” them to a common CRS.

Datums

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  - Some of the assumptions:
    - Location of the "prime" meridian (i.e. Greenwich, Paris, etc.)
    - Equatorial and Polar Diameter or Equatorial + Flattening (or some other combination)
    - Non-ellipsoidal terms (usually ignored)
    - Planetographic vs. Planetocentric Latitude
      (not really part of "Datum" choice, but explanation fits here)

  - NAD27 = North American Datum of 1927 (Used on most printed USGS maps)
  - NAD83 = North American Datum of 1983
  - WGS84 = Wold Geographic System of 1984 (common default for GPS devices -- but they can be switched to use others)

  - Differences between NAD27 and WGS84 "UTM" coordinates are 100's of meters near Laramie -- can be km in places
  - Latitude and Longitude values for a given spot also change with datum -- although typically not as much
  - Changes with time: NAD83 fixed to North American Plate -- WGS84 is a "world average"

Map Projections

- If region covered is large enough, you must consider the curvature of the Earth

- Impossible to display curved surface on flat paper (or computer screen) without some distortion.

- Standard map "projections" define the distortion
  - Can be geometric "projection" or more complicated math formulae
    - "Project" sphere (or ellipsoid) onto a (rolled up) plane (then if necessary unroll plane)
  - Different projections have different advantages/disadvantages
    - Mercator good for navigation because azimuth (compass) directions correct
    - Mercator bad for estimating size of regions – exaggerates high latitudes

  - All can be reduced to a pair of formula for converting (latitude, longitude,) = (λ,ϕ) into (x, y)

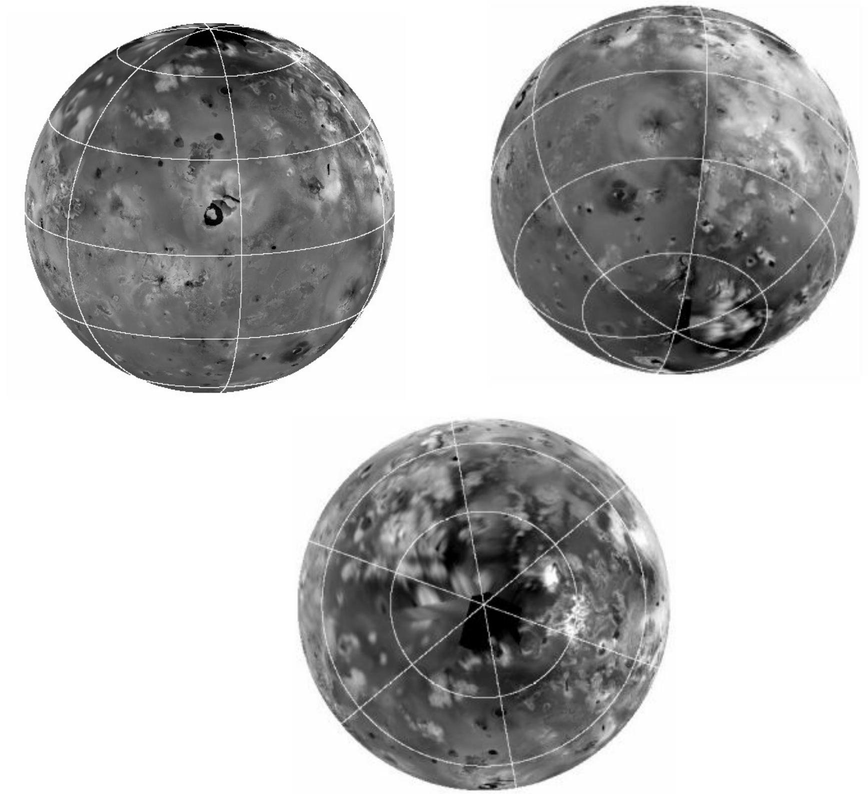
  - Notation: Lines of latitude = "parallels", Lines of longitude = "meridians"

- John P. Snyder, 1987 "Map Projections – A Working Manual"
  - USGS Professional Paper 1395, available on USGS web site

Orthographic Projection

- "True perspective" image – as if taken from a very large distance
- "Sub-satellite" location is presented "without distortion"
- Locations towards the "limb" are badly foreshortened

Orthographic projection of earth – from location over equator. From Wikipedia



Orthographic projections of Io from different locations

Distortion: "Tissot's Indicatrix"

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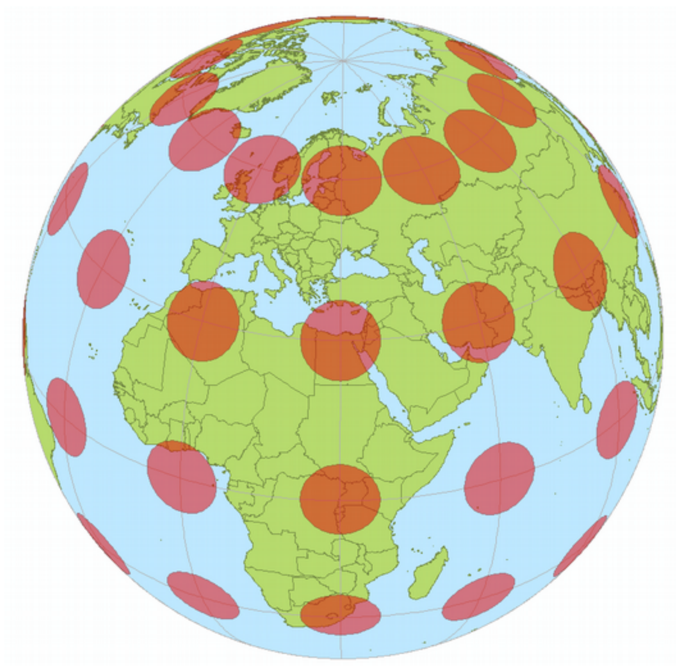
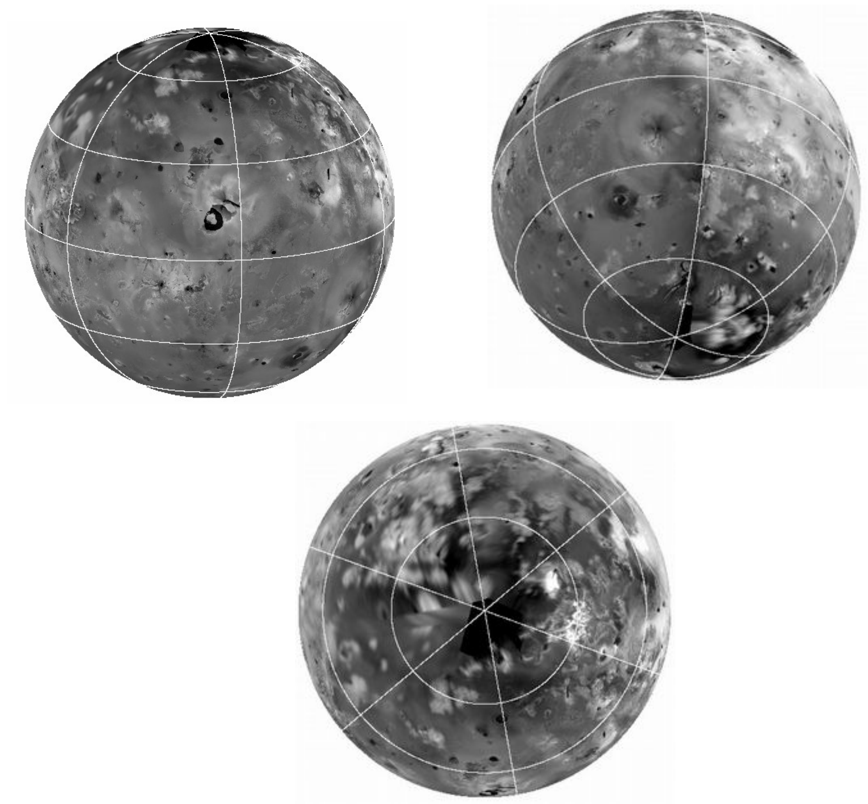
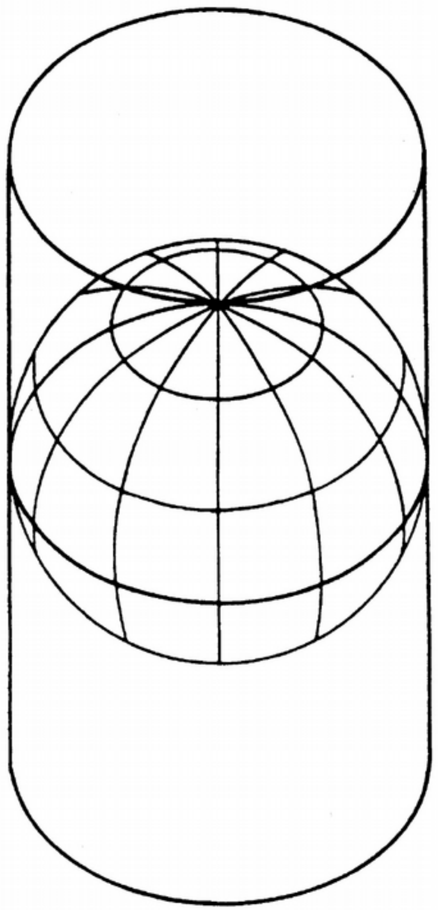




Tisso't Indicatrix for orthographic projection
From Wikipedia

Orthographic projections of Io from different locations

“Regular” Cylindrical Projections

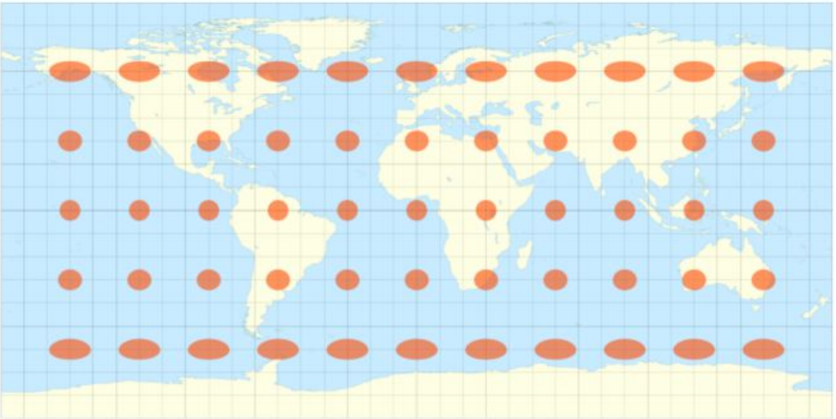


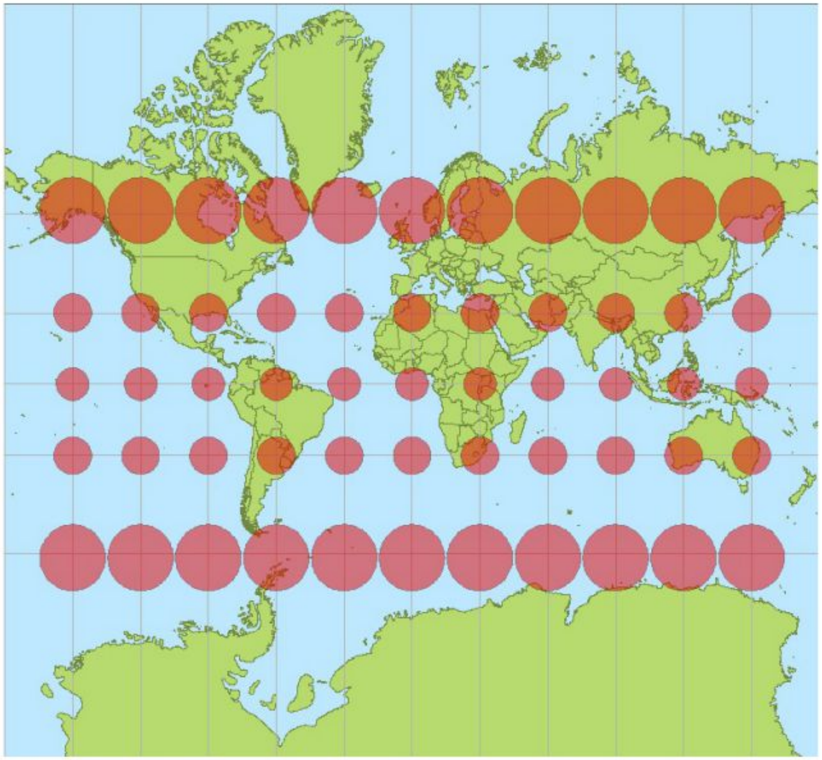
C. Regular cylindrical (Mercator).

- “Regular” cylindrical projections align cylinder with rotation axis
- Different versions plot latitudes differently
- Only one or two latitudes (usually equator) can be plotted without distortion
  - Equirectangular Plate Carrée (flat square)
    - $x = \phi$, $y = \lambda$ produces 2 x 1 rectangle
    - Simple conversion (useful for computer storage)
  - Mercator
    - Preserves azimuth (compass) directions
    - Can’t extent to poles (y would be infinite)
  - Miller
    - Compromise between above two

From our text by Sabins

Distortion in Cylindrical Projections

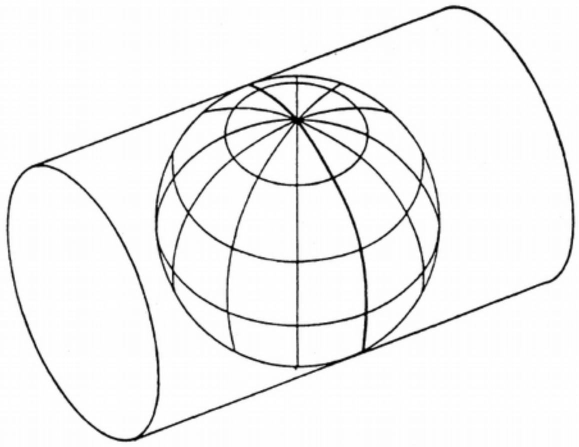




- In all regular cylindrical projections the horizontal scale becomes "infinitely large" as you approach latitudes $\pm 90^{\circ}$
- Plate Carrée keeps the vertical scale constant for all latitudes
  - Different horizontal and vertical scales means shapes and directions are distorted
- Mercator stretches the vertical scale just as much as the horizontal scale as you increase latitude
  - Shapes and directions remain correct (i.e. they are "conformal") but sizes grow infinitely large at high latitudes
- True circles of constant size are "Tissot's Indicatrix", used to indicate amount of distortion

Images from Wikipedia

Transverse Cylindrical Projections



D. Transverse cylindrical (Transverse Mercator).

From our text by Sabins

- Regular cylindrical has distortion at arbitrary latitude.
- Transverse cylindrical projections use a sideways cylinder
  - Line of contact between sphere and cylinder is some (arbitrary) meridian (line of longitude) instead of the equator
- Instead of being distortion free along the equator, it is distortion free along that line of longitude
- Transverse Mercator" maps are transverse cylindrical, with "Mercator-like" projections in the opposite direction
- Universal Transverse Mercator maps are Transverse Mercator, with a set of standard choices for different lines of longitude (zones) and other constants
  - Used for some USGS 7.5 minute quad series
  - Basis for UTM coordinate systems

UTM Zone System

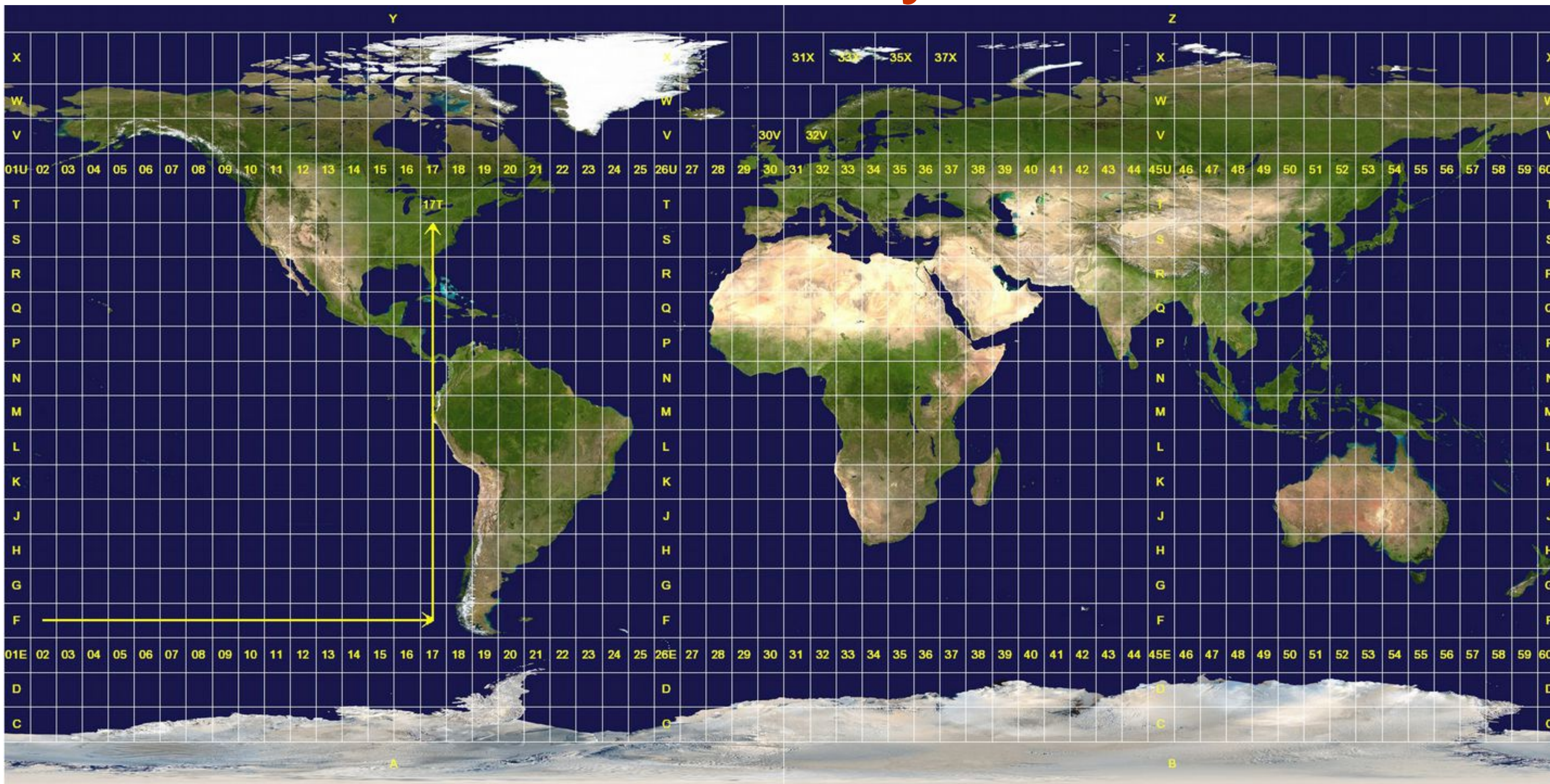


Image from Wikipedia

- UTM System has
  - 60 standard longitudes zones 1 – 60
  - 20 standard latitude zones denotes by letters
- UTM coordinates measure “projected” distance N from equator, and E within that zone relative to the zone’s standard meridian

Oblique Cylindrical Projections

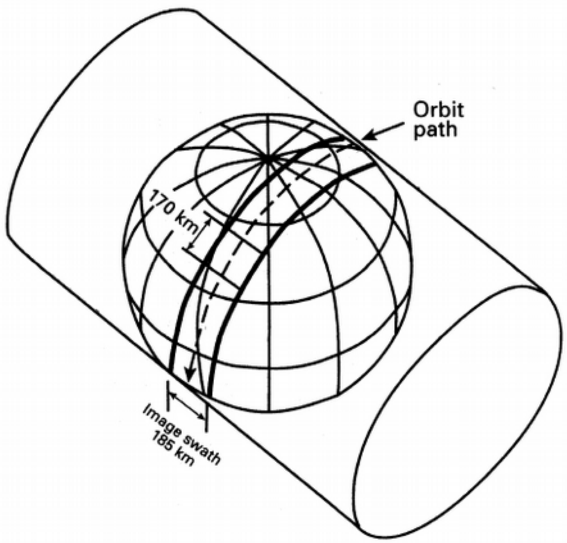
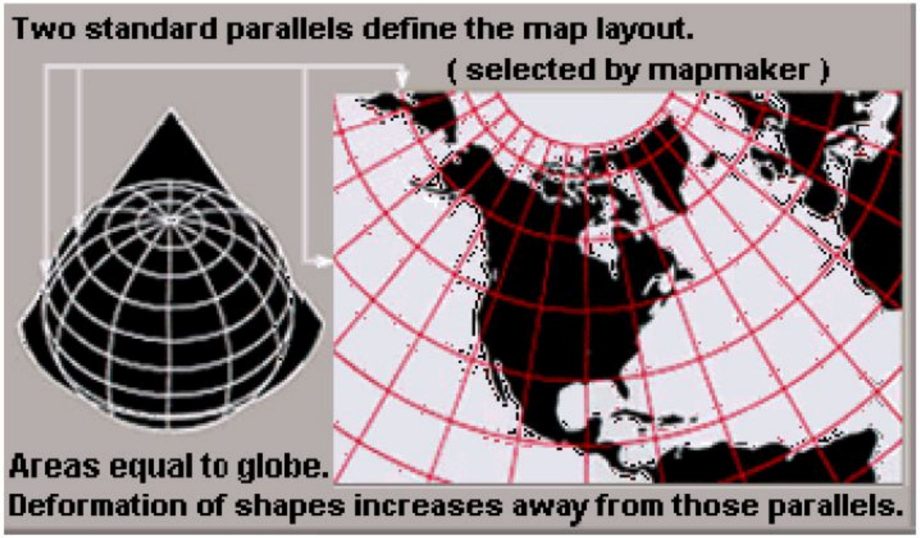


Figure 8-13 Space Oblique Mercator projection of Landsat images.

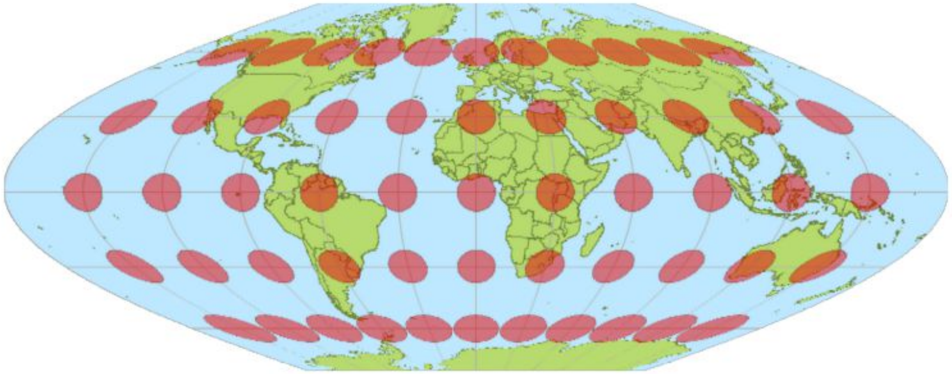
From Sabins text

- Oblique cylindrical projections use a contact circle between the sphere and the cylinder which is neither a line of latitude or a line of longitude
  - No distortion along that "great circle"
- Choosing the circle which matched a satellite's orbit plane would be ideal for satellite mapping except the Earth rotates beneath the orbit plane.
- Space Oblique Mercator projections contain additional "fudges" to compensate for the Earth's rotation.
  - Used for Landsat
  - Scale constant over 185-km swath by 170-km length to within 0.015%
- QGIS and other software can convert images to different projections if needed.

Other Projections



- Conical – project onto cone then "unroll" the cone



From Wikipedia

- Various pseudo-cylindrical projections typically limit the stretching of the horizontal scale as one approaches the poles – as a compromise between distorting shapes and stretching sizes.
- "Sinusoidal" keeps E-W scale constant, preserving area at the expense of shape and angle.