Coordinate systems, etc. primer

J Ramón Arrowsmith
School of Earth and Space Exploration
Arizona State University

Christopher J. Crosby
UNAVCO

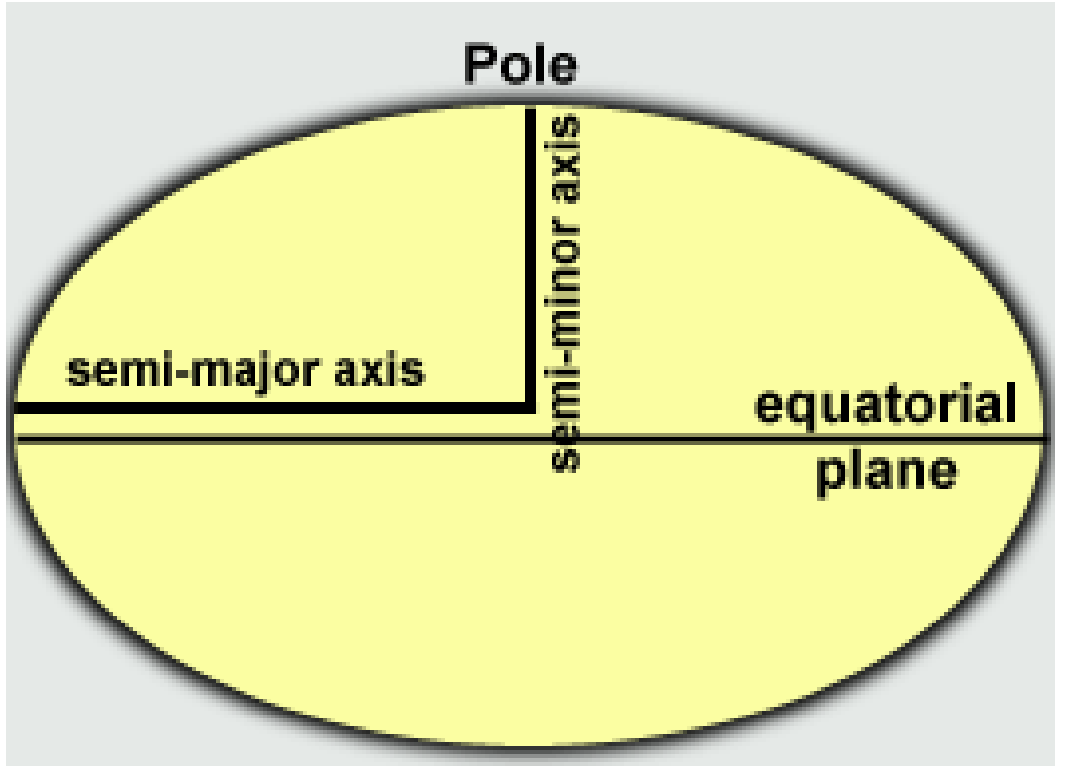
Tutorial notes
September 19, 2019

OpenTopography
High-Resolution Topography Data and Tools

Reference Datum

Represents the same surface or elevation at all points on the earth and that remains constant over time.

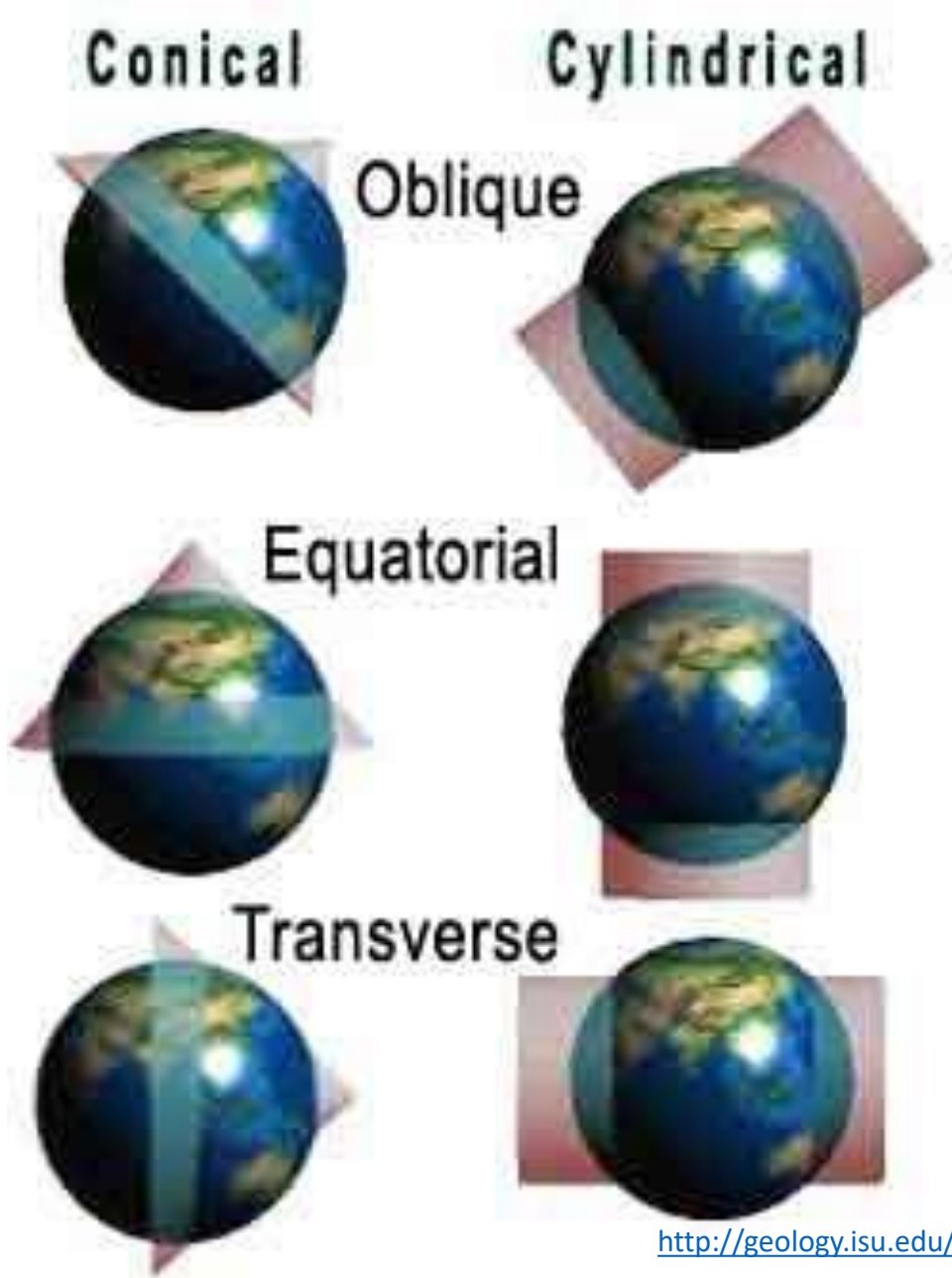
By using an oblate ellipsoid as a datum for the earth we have a shape that approximates the shape of the earth fairly well and provides a datum to which points all over the earth's surface can be referenced (hence the term 'reference datum').



We typically use WGS84 as it is the basis of GPS

http://geology.isu.edu/wapi/geostac/Field_Exercise/topomaps/ref_datum.htm

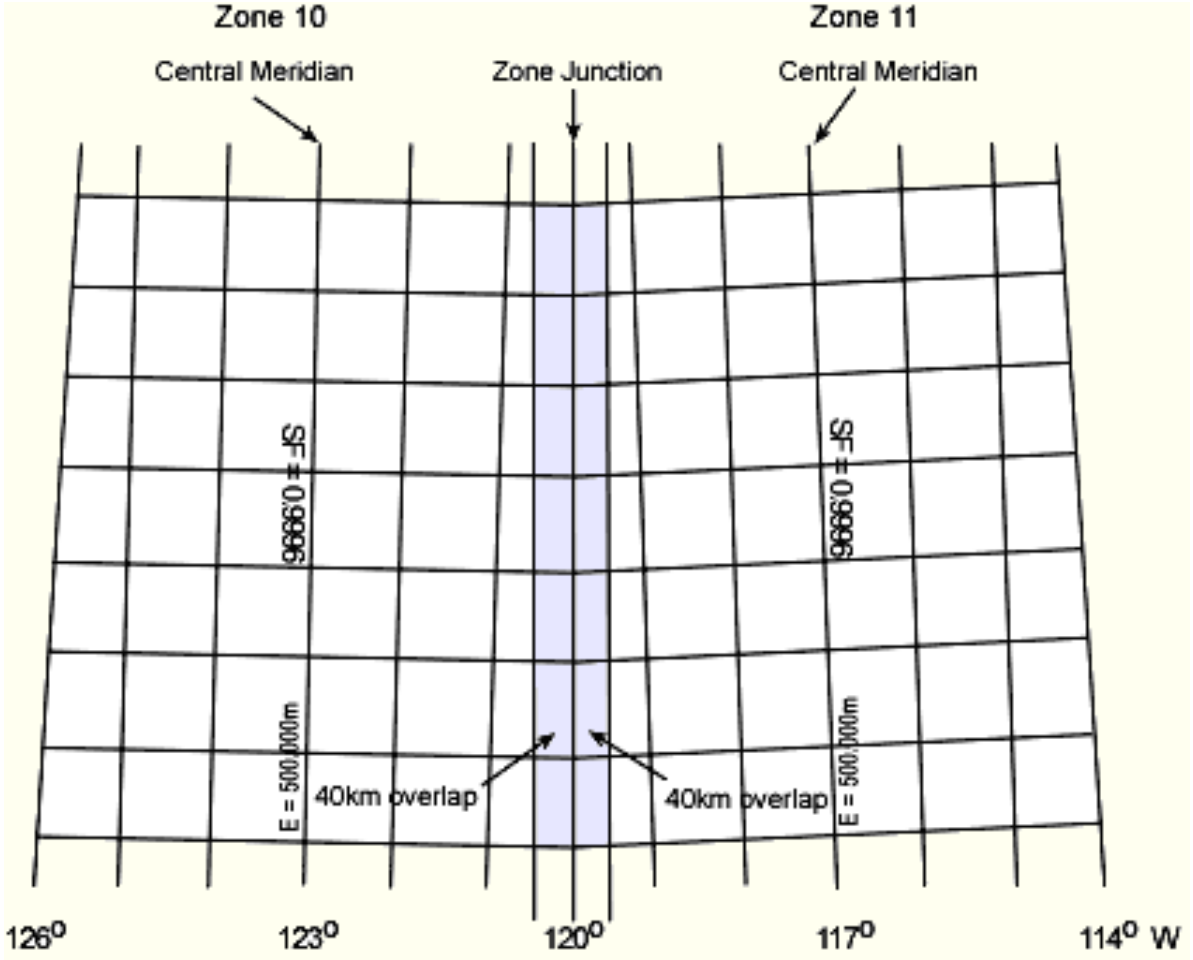
Map Projections

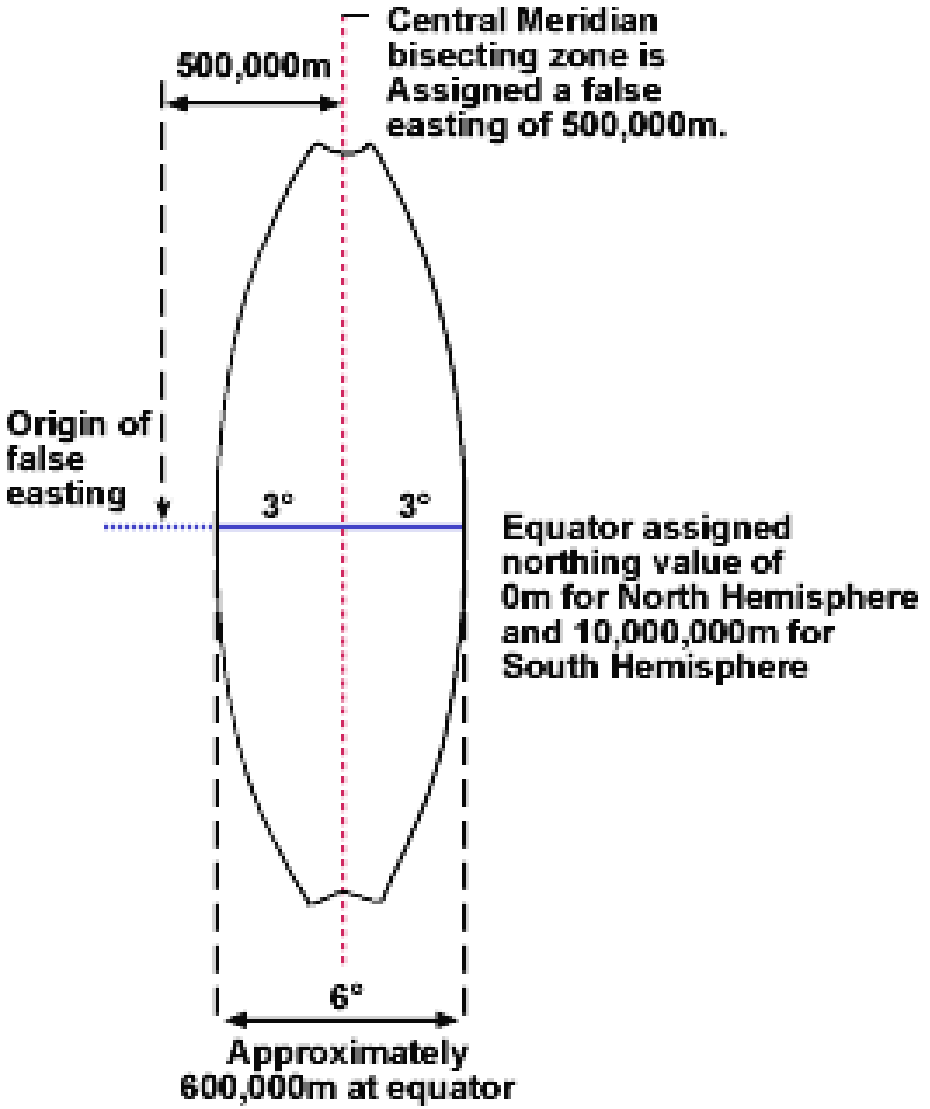


http://geology.isu.edu/wapi/geostac/Field_Exercise/topomaps/map_proj.htm

UTM - Universal Transverse Mercator Geographic Coordinate System

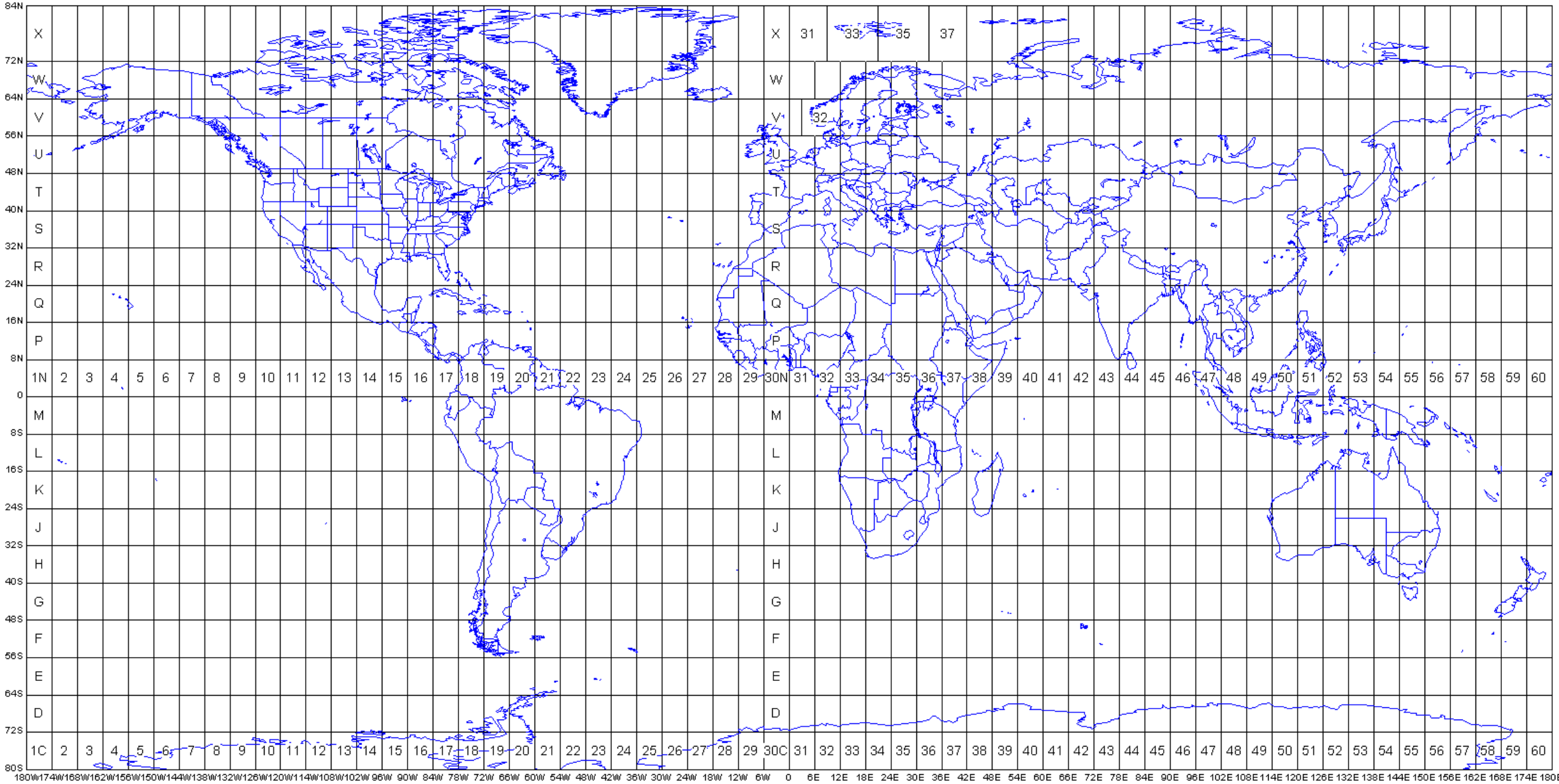
Transverse





http://geology.isu.edu/wapi/geostac/Field_Exercise/topomaps/utm.htm

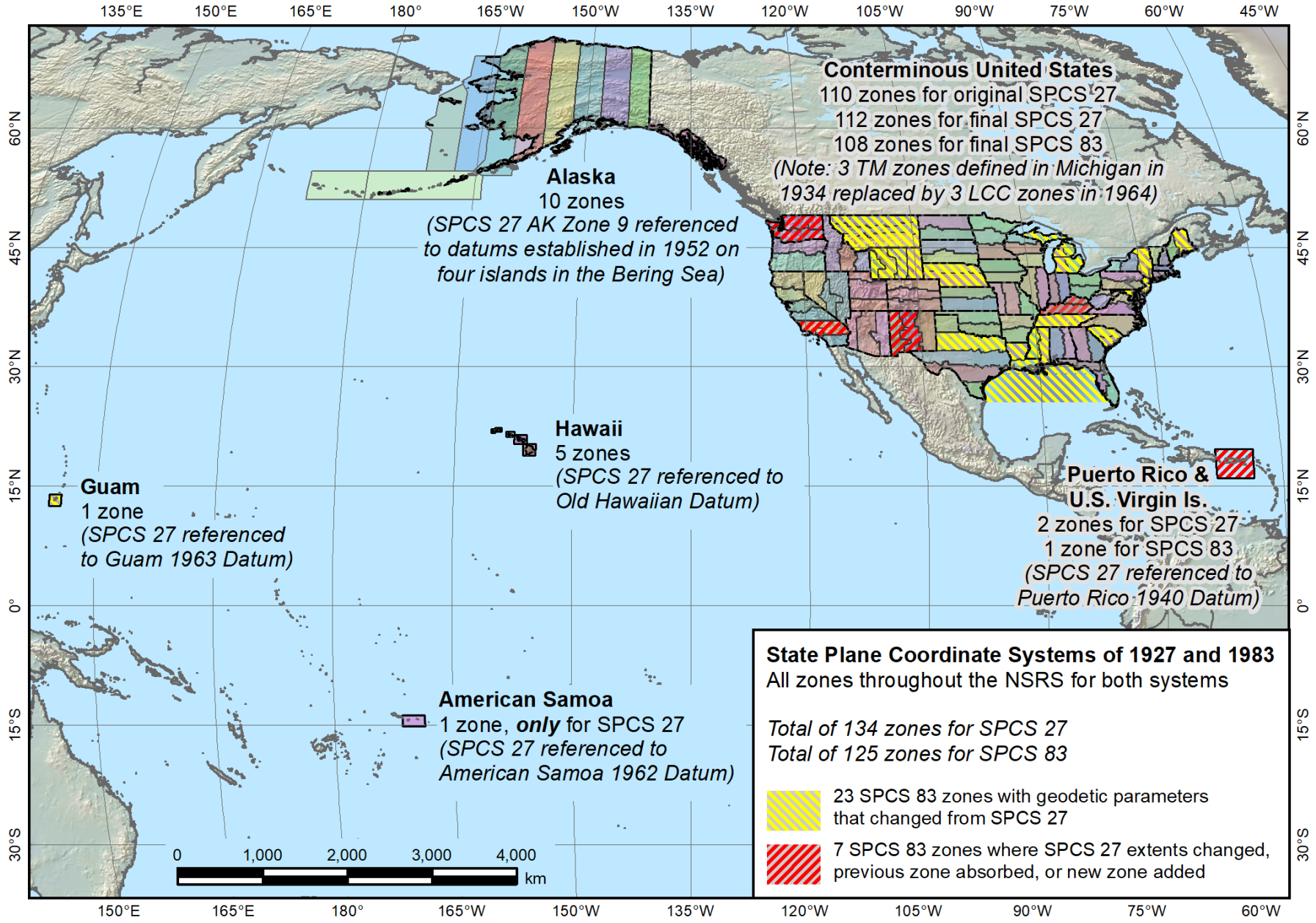
UTM Zones of the World



http://www.dmap.co.uk/utmworld.htm

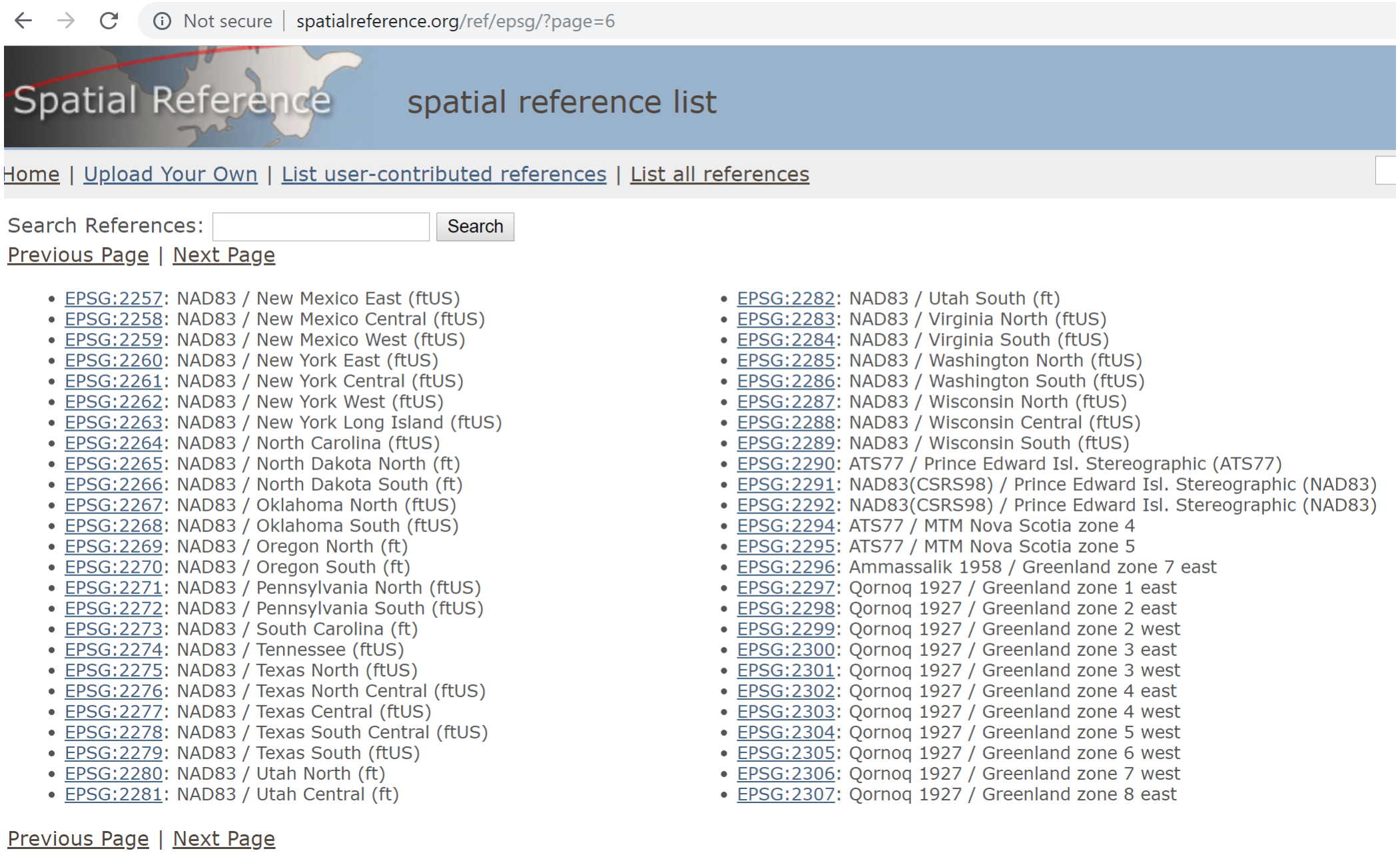
https://www.ngs.noaa.gov/SPCS/index.shtml

State Plane Coordinate System (US-agencies…)



The EPSG Geodetic Parameter Dataset is a structured dataset of Coordinate Reference Systems and Coordinate Transformations

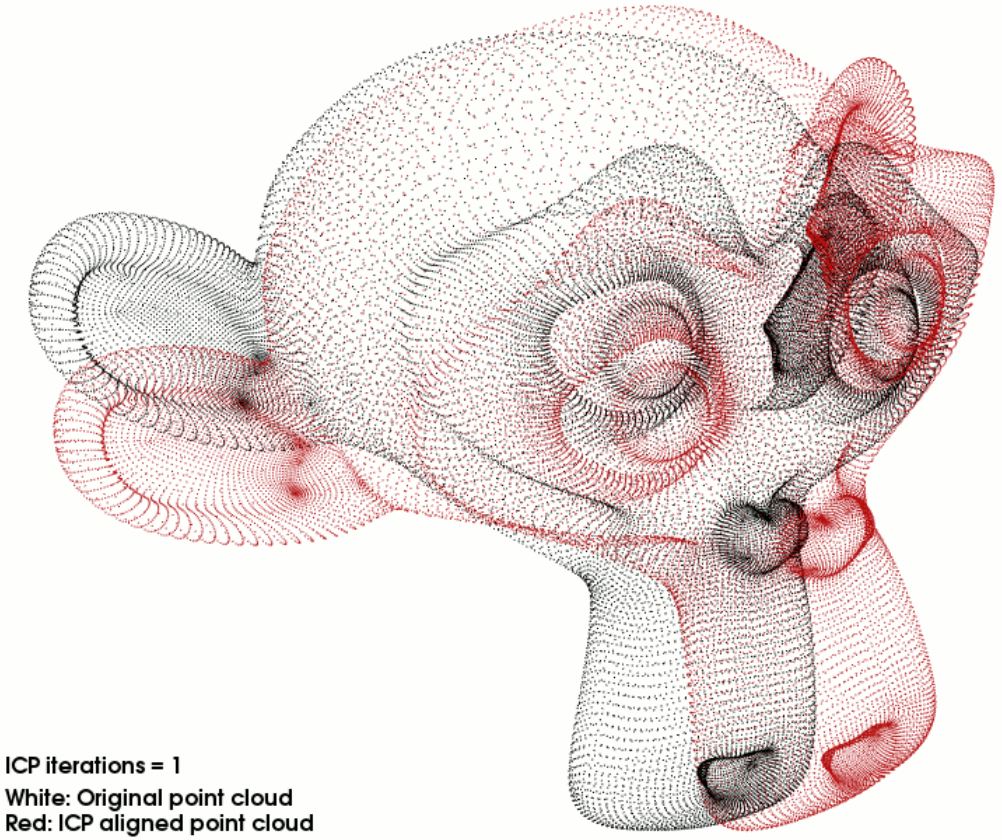
http://www.epsg-registry.org/



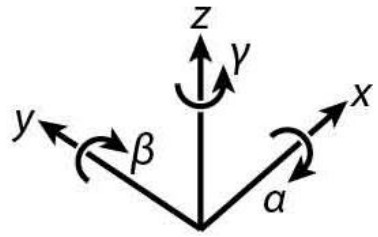
Aligning point clouds—Manual or ICP

• The **iterative closest point** algorith (ICP) is a method for registering (aligning) irregular point clouds, well known in computer vision and medical imaging

• ICP minimizes closest point pair distances using iterative **rigid-body transformations,** each one comprising a **translation** [t_x t_y t_z] and a **rotation** [**α β γ**]



$$\Phi = \begin{pmatrix} 1 & -\gamma & \beta & t_x \\ \gamma & 1 & -\alpha & t_y \\ -\beta & \alpha & 1 & t_z \\ 0 & 0 & 0 & 1 \end{pmatrix}$$



pointclouds.org/documentation/tutorials/interactive_icp.php

Digital Elevation Models

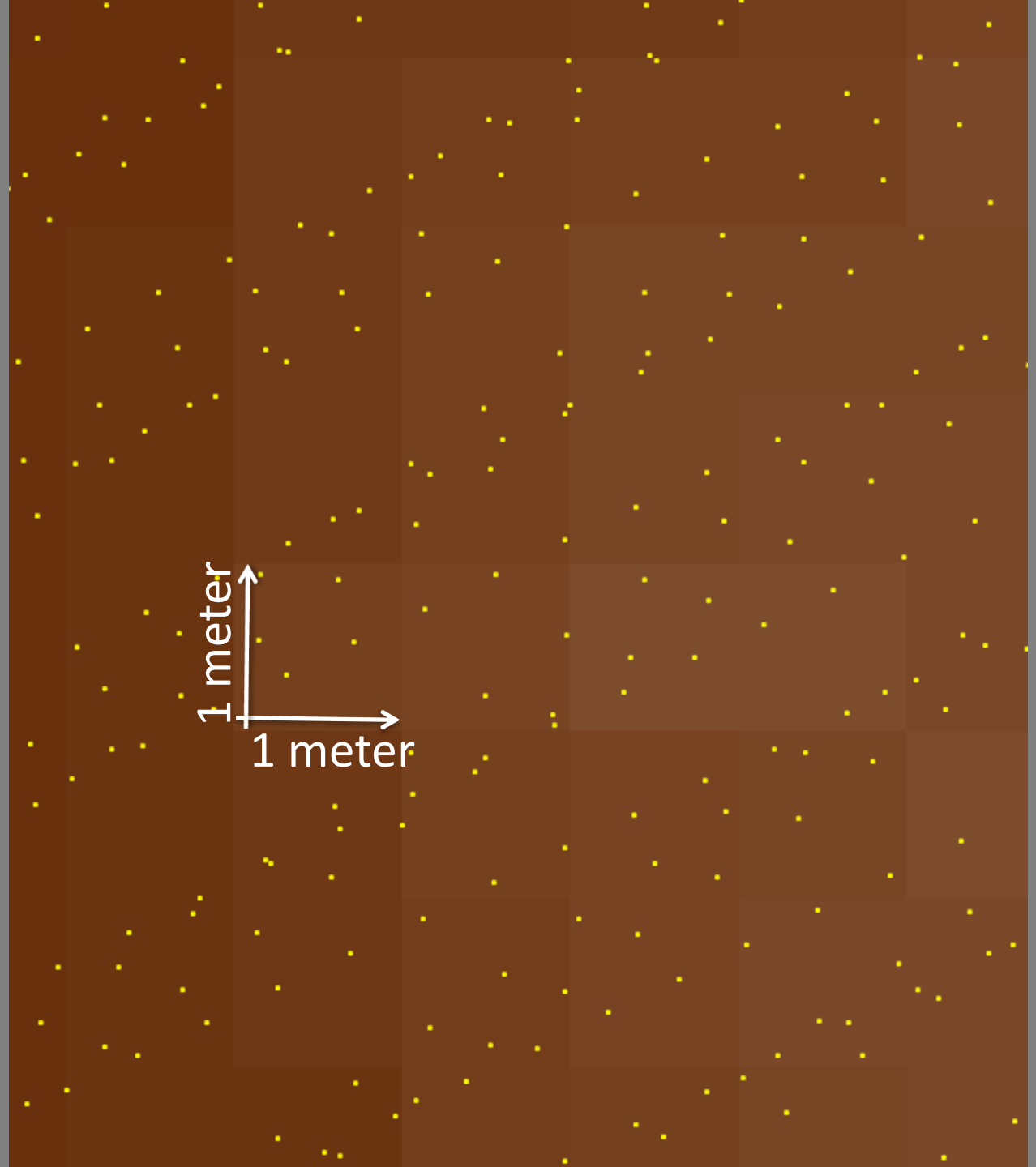
- Digital representation of topography / terrain
  - "Raster" format – a grid of squares or "pixels"
  - Continuous surface where Z (elevation) is estimated on a regular X,Y grid
  - "2.5D"

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	0
0	50	100	100	100	100	100	100	100	100	100	100	100	100	100	50	0
0	50	100	150	150	150	150	150	150	150	150	150	150	150	100	50	0
0	50	100	150	200	200	200	200	200	200	200	200	200	150	100	50	0
0	50	100	150	200	250	250	250	250	250	250	250	200	150	100	50	0
0	50	100	150	200	250	300	300	300	300	300	250	200	150	100	50	0
0	50	100	150	200	250	300	350	350	350	300	250	200	150	100	50	0
0	50	100	150	200	250	300	350	400	350	300	250	200	150	100	50	0
0	50	100	150	200	250	300	350	350	350	300	250	200	150	100	50	0
0	50	100	150	200	250	300	300	300	300	300	250	200	150	100	50	0
0	50	100	150	200	250	250	250	250	250	250	250	200	150	100	50	0
0	50	100	150	200	200	200	200	200	200	200	200	200	150	100	50	0
0	50	100	150	150	150	150	150	150	150	150	150	150	150	100	50	0
0	50	100	100	100	100	100	100	100	100	100	100	100	100	100	50	0
0	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

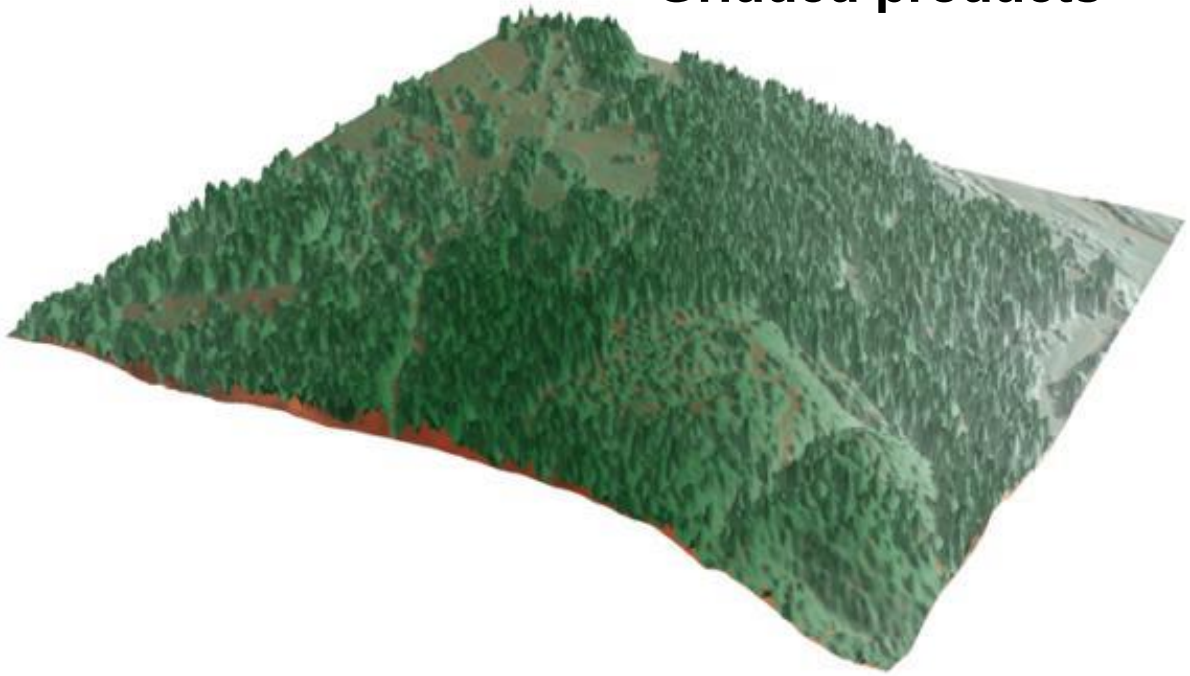
Source: http://www.ncgia.ucsb.edu/giscc/extra/e001/e001.html

- Grid resolution is defined by the size in the horizontal dimension of the pixel
  - 1 meter DEM has pixels 1 m x 1m assigned a single elevation value.

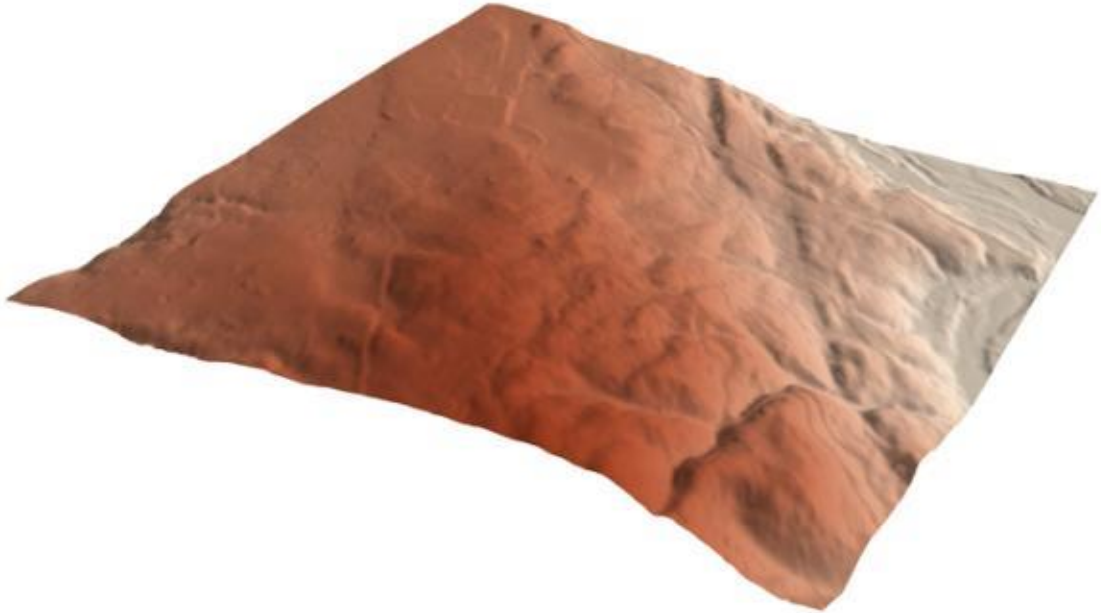
- 1 meter grid
- LiDAR returns from EarthScope data collection
- Example from flat area with little or no vegetation so ground is sampled approx. 5+ times per square meter
- How do we best fit a continuous surface to these points?
- Ultimately wish to represent irregularly sampled data on a regularized grid.



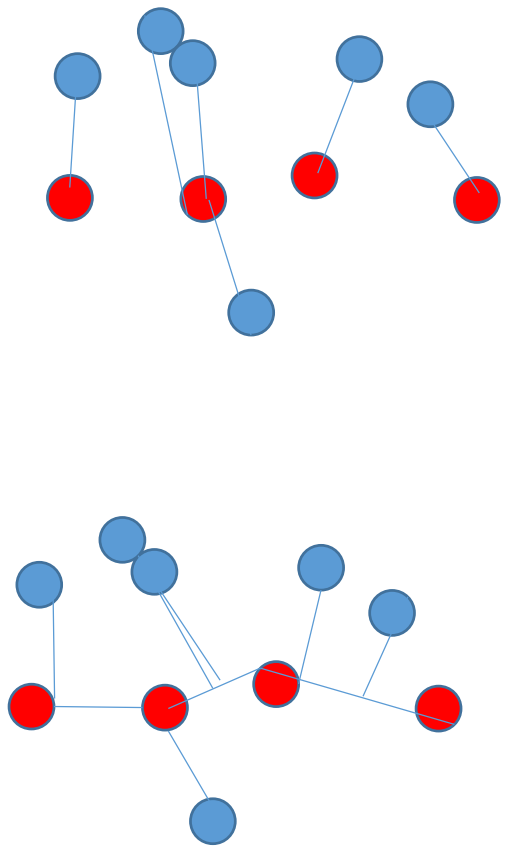
Gridded products



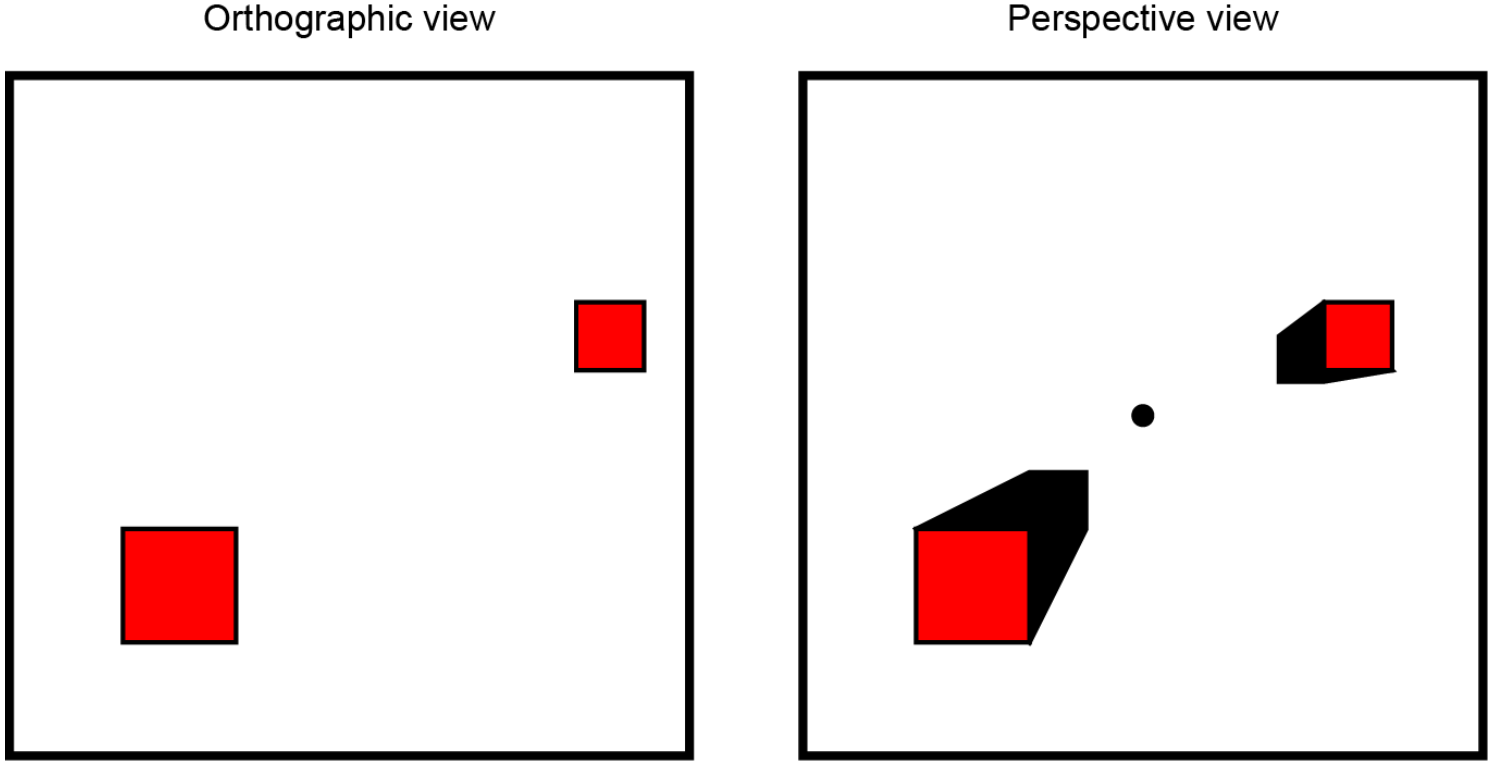
Digital surface model—Mostly what we are getting in SfM



Digital terrain model



Attempt to explain cloud to cloud and cloud to plane



An orthophoto, orthophotograph or orthoimage is an aerial photograph or satellite imagery geometrically corrected ("orthorectified") such that the scale is uniform: the photo or image has follows a given map projection. Unlike an uncorrected aerial photograph, an orthophoto can be used to measure true distances, because it is an accurate representation of the Earth's surface, having been adjusted for topographic relief,[1] lens distortion, and camera tilt.