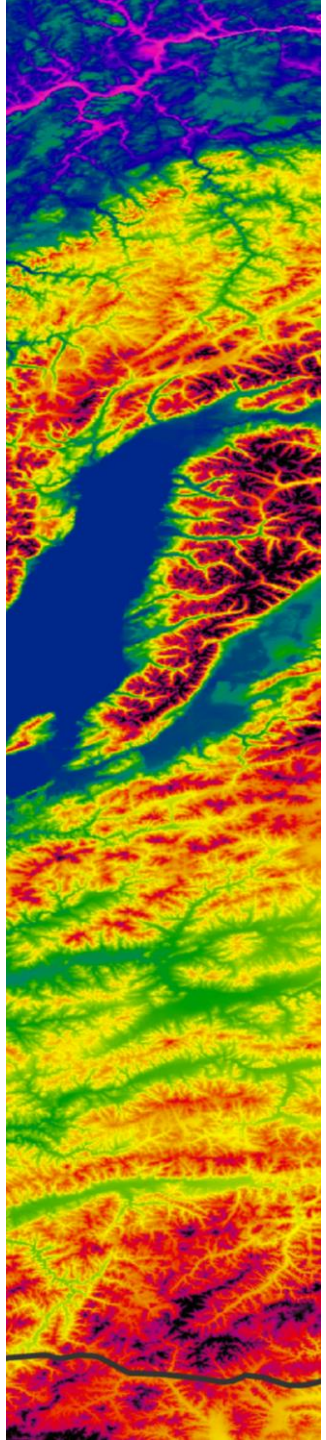


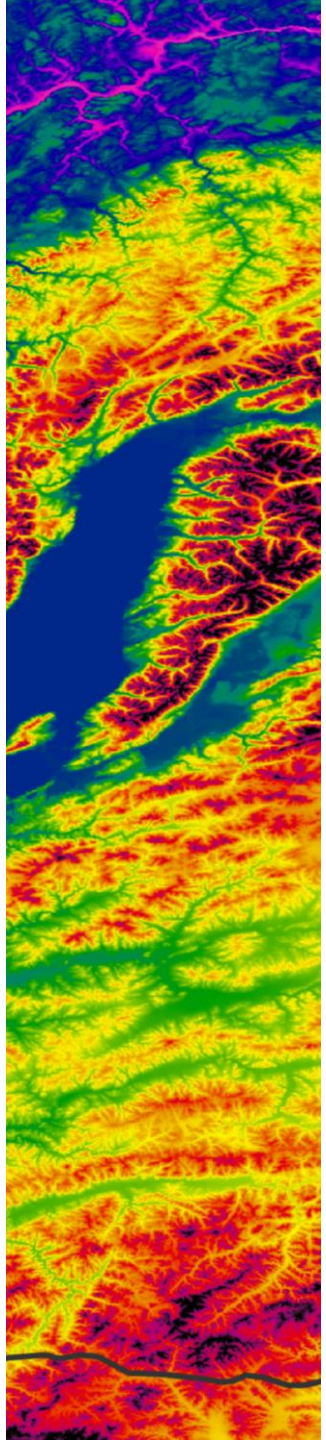
Digital Elevation Modelling

- Introduction, International Data Bases -

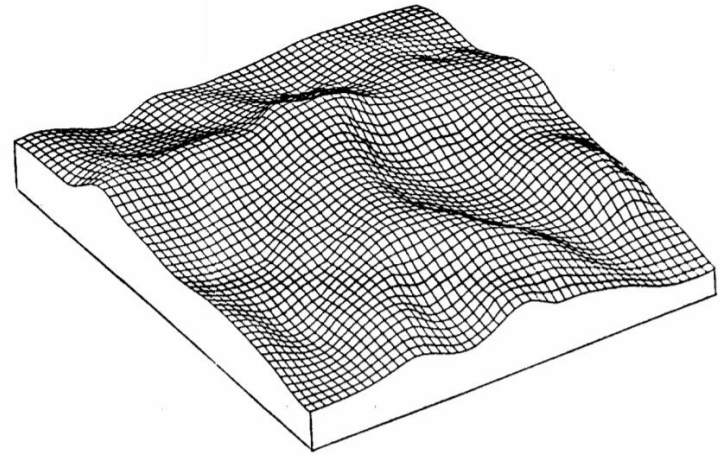
Pecsmány Péter, PhD

Research fellow

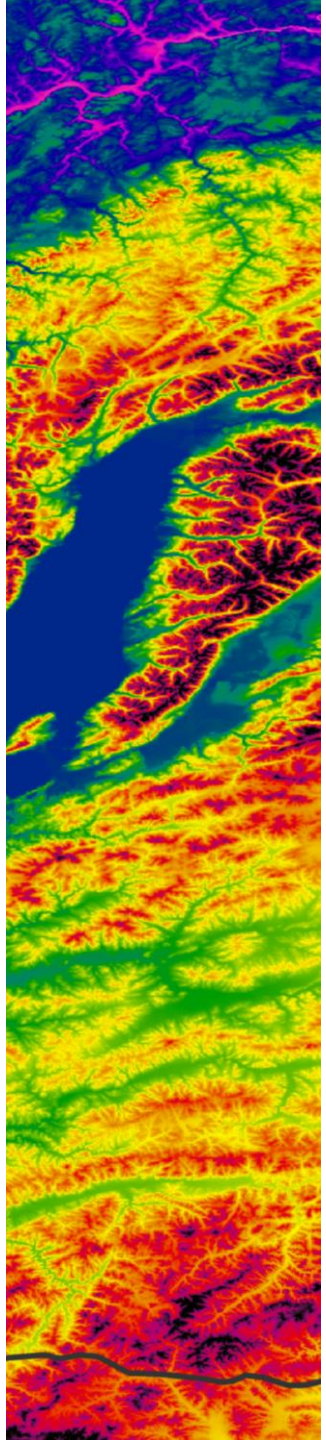
University of Miskolc
Department of Physical Geography and Environmental Science



DEMs and DTMs

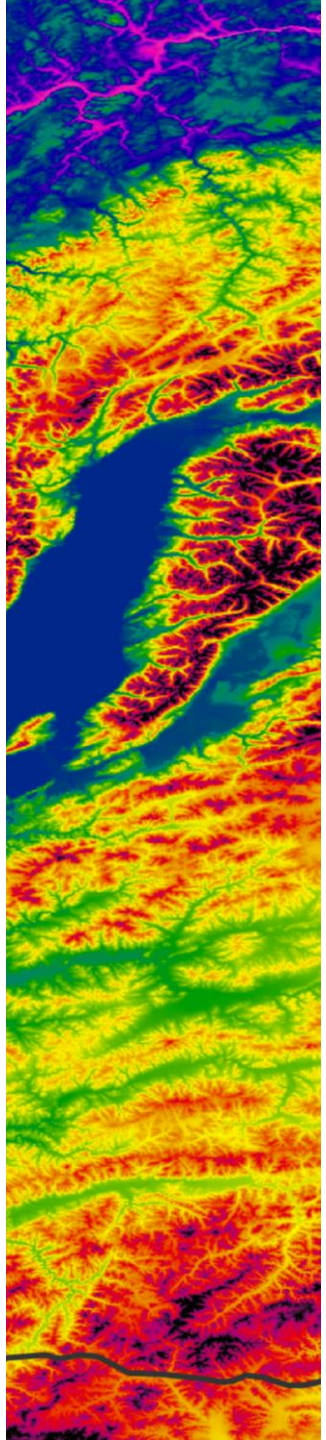


- Some definitions…
  - DEM (Digital Elevation Model)
    - set of regularly or irregularly spaced height values
    - no other information
  - DTM (Digital Terrain Model)
    - set of regularly or irregularly spaced height values
    - but, with other information about terrain surface
    - ridge lines, spot heights, troughs, coast/shore lines, drainage lines, faults, peaks, pits, passes, etc.
    - Terrain function: h(x, y) with continuous partial derivatives, excepting some special cases:
    - the function is not continuous (bench).
    - partial derivatives are not continuous (breakline).



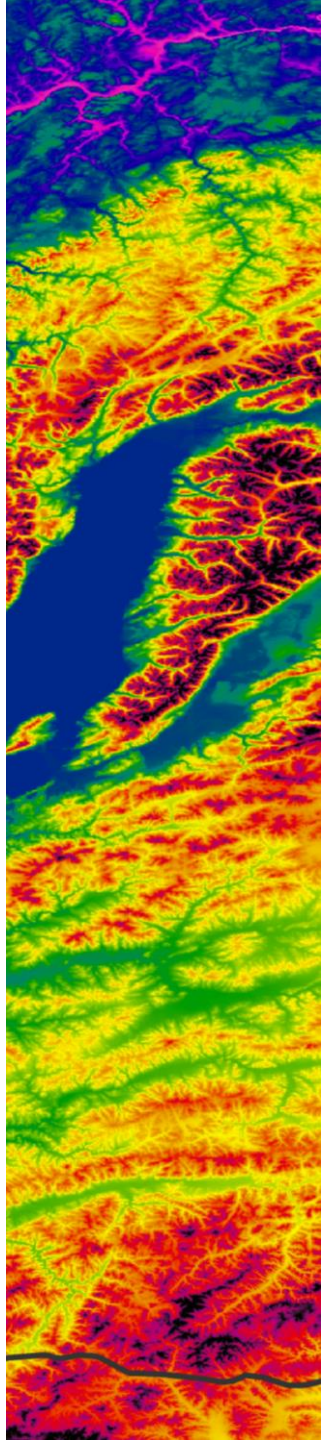
Conversion of printed contour lines

- Existing map plates are scanned
- Resulting raster is vectorized and edited contours are "tagged" with elevations
- Additional elevation data are created from the hydrography layer (e.g. shorelines provide additional contours)
- Algorithm is used to interpolate elevations at every grid point from the contour data



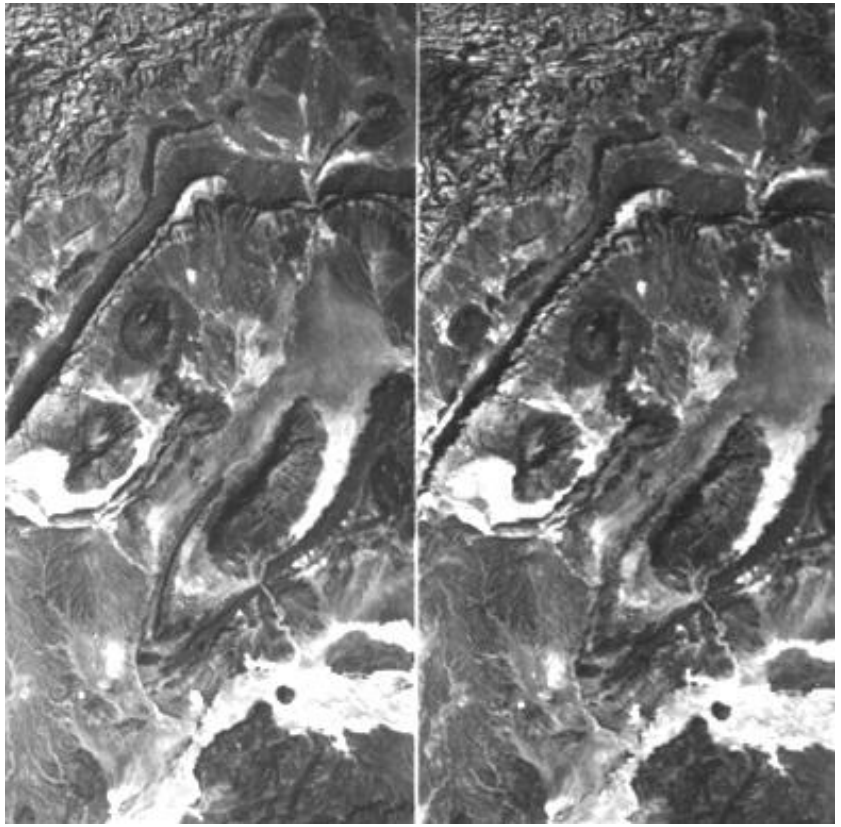
Photogrammetry

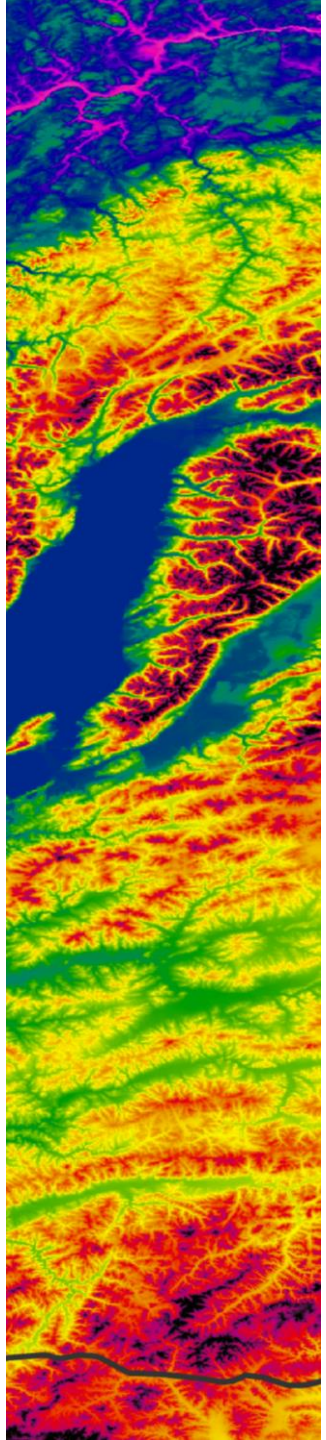
- Manually: an operator looks at a pair of stereophotos through a stereoplotter and must move two dots together until they appear to be one lying just at the surface of the ground
- Automatically: an instrument calculates the parallax displacement of a large number of points (e.g. for USGS 7.5 minute quadrangles, the Gestalt Photo Mapper II correlates 500,000 points)
- Correction of elevation from photographs: water bodies are assumed to be flat.



Stereo Satellite

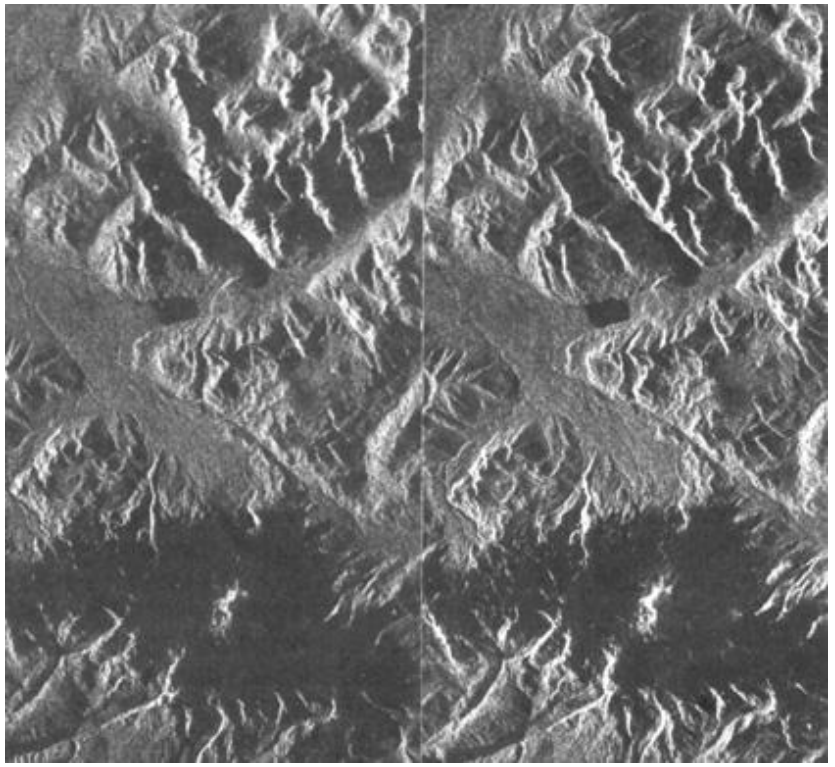
- Two satellite passes are combined to get effective “stereo” view

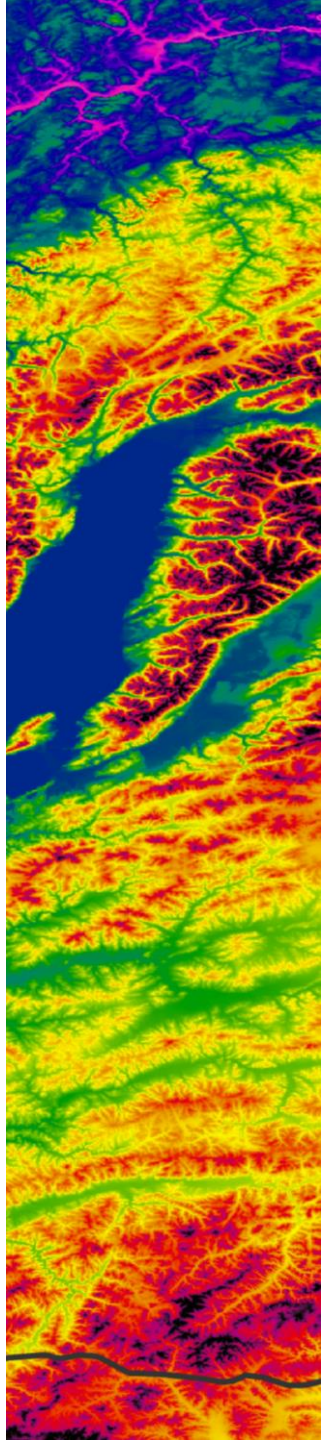




Stereo Radar

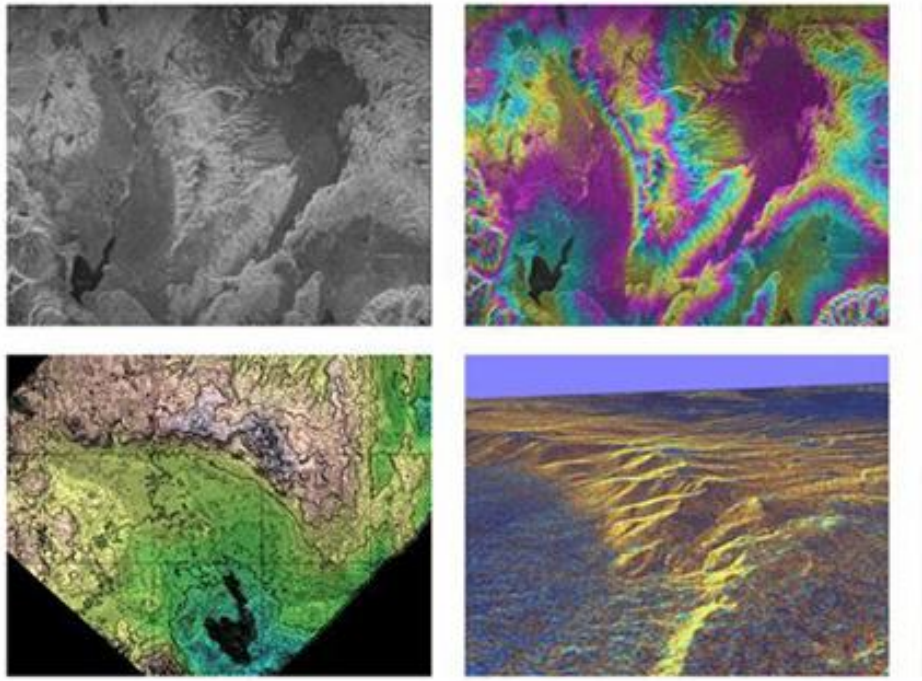
- Works like photogrammetry but use radar wave instead.
- Can be done from space or airborne with side-looking-airborne-radar (SLAR)
- Can penetrate vegetation canopy

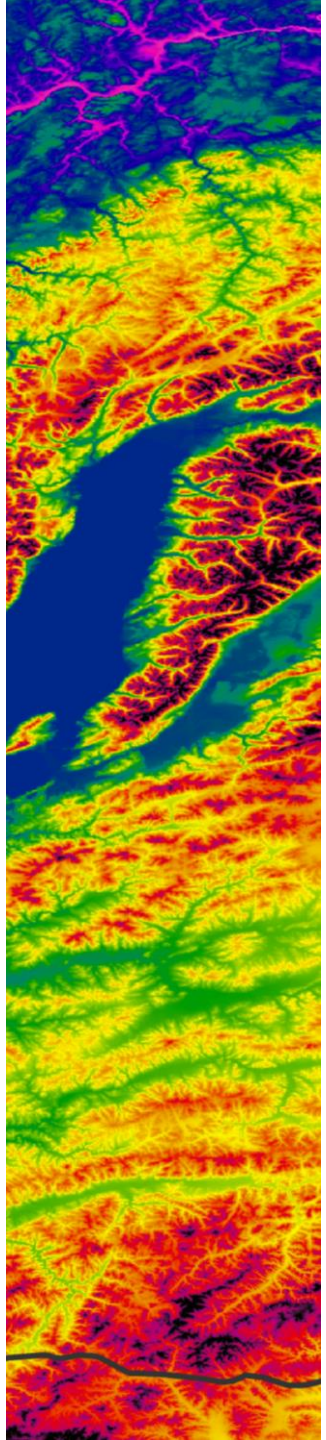




Radar Interferometry

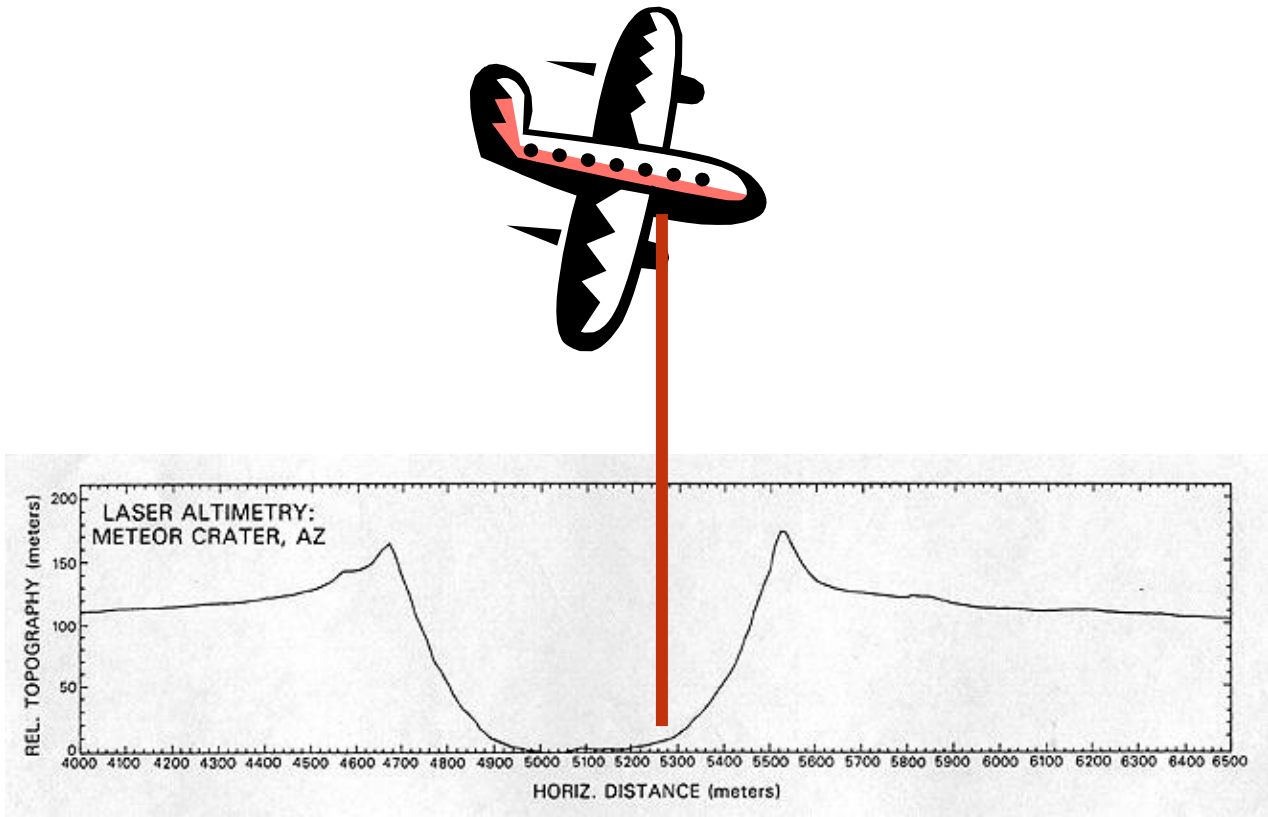
- Use phase difference in two radar signals to measure elevation differences
- Signals are from two receivers so called “synthetic aperture radar” or SAR.

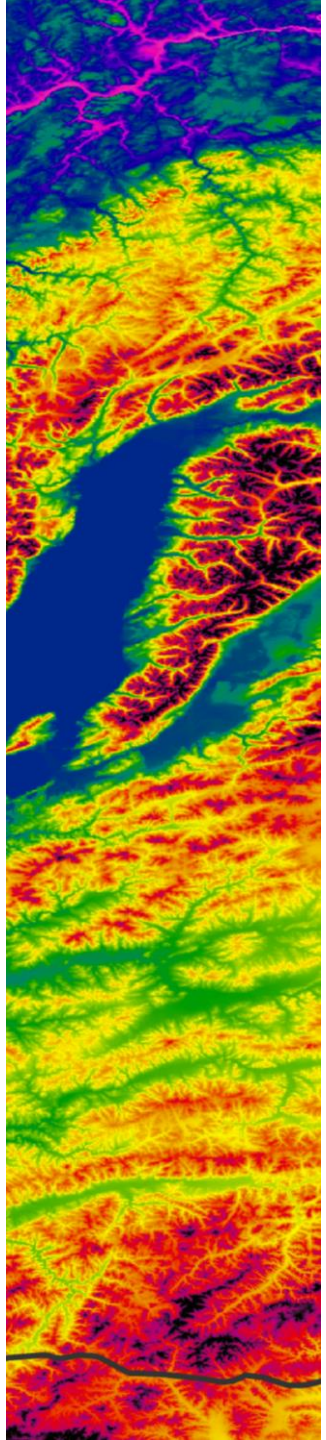




Laser Altimetry

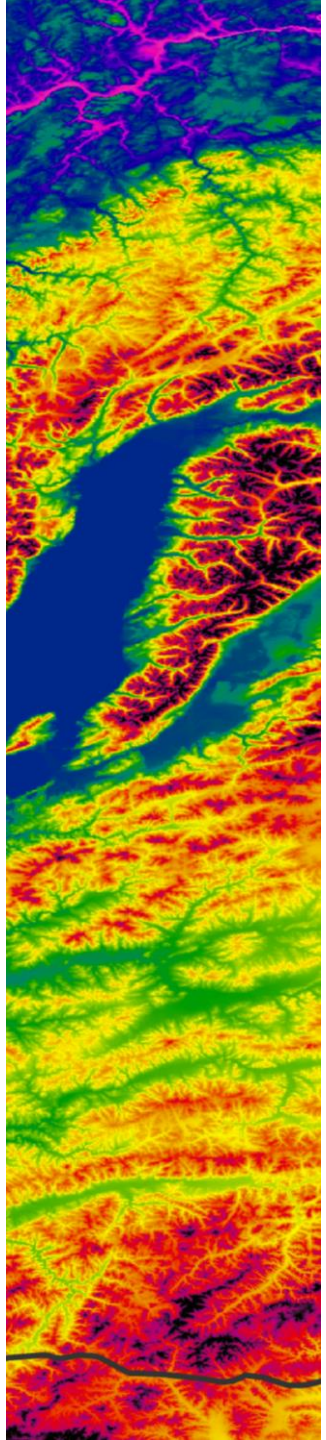
- Fly laser over area, and time reflection of laser.





LIght Detection And Ranging

Horizontal resolution: 2m
Vertical accuracy: ± 2cm



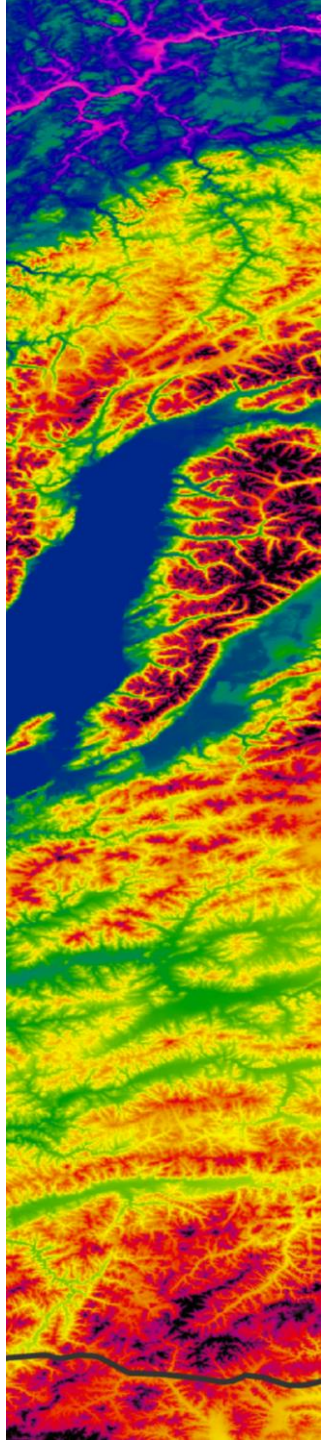
DTM Data Sources

Primary Data Sources:

- Shuttle Radar Topography Mission (SRTM) or other airborne sensors

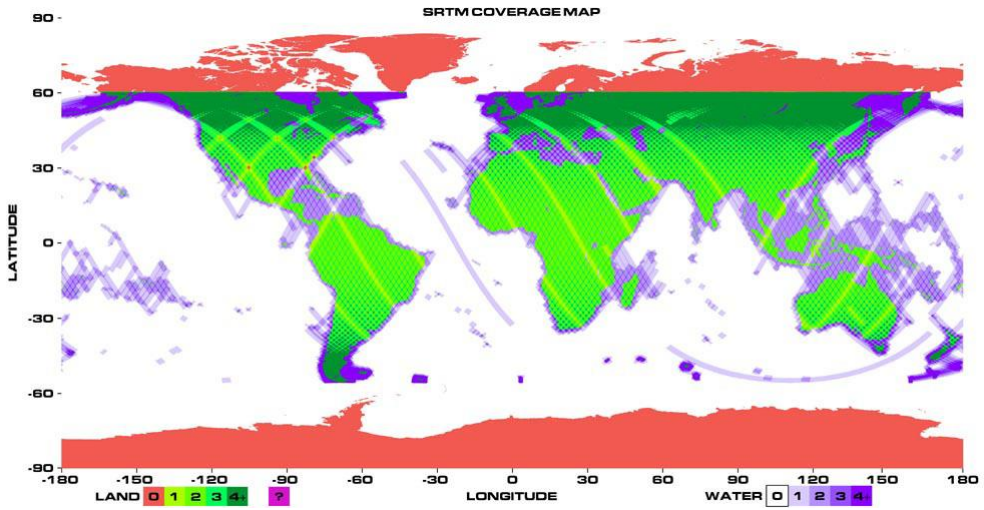
Secondary Sources from existing maps:

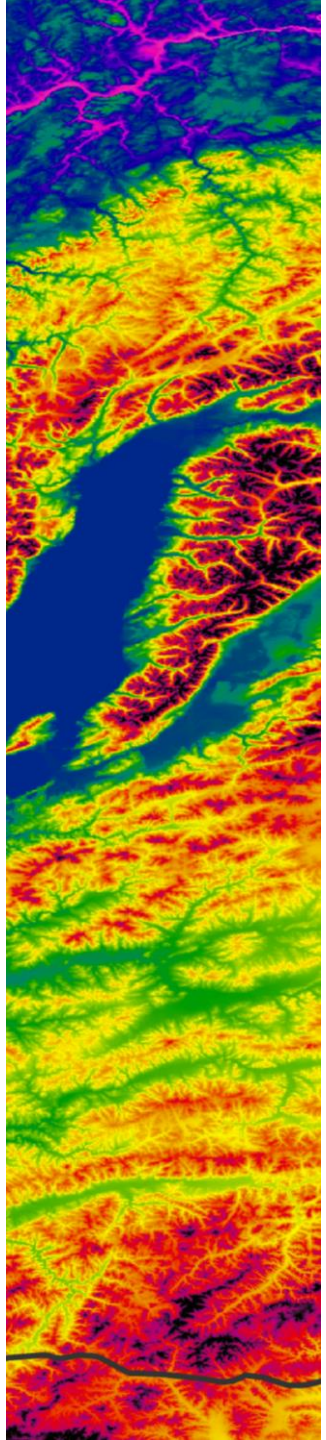
- 30m DEMs from 1:24,000 scale map
- 1” National Elevation Dataset
- 3" (100m) DEMs from 1:250,000 scale maps
- 30" DEM of the earth (GTOPO30)



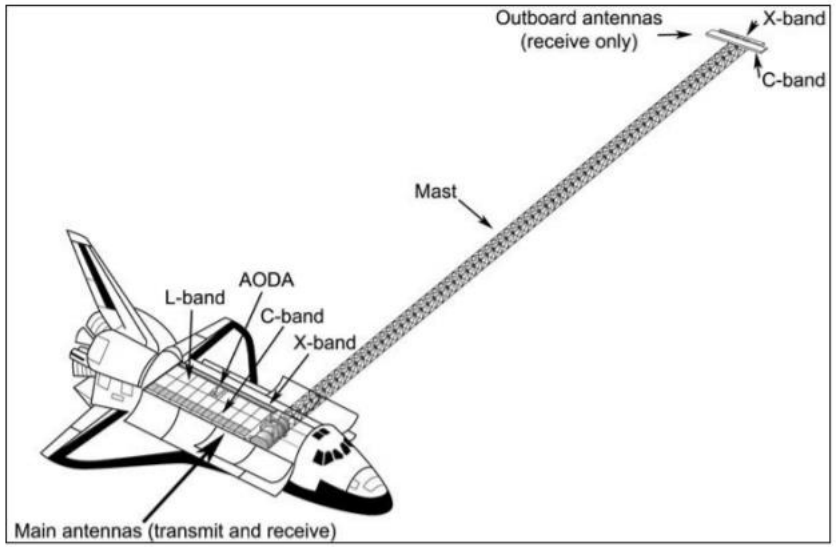
Shuttle Radar Topography Mission (SRTM)

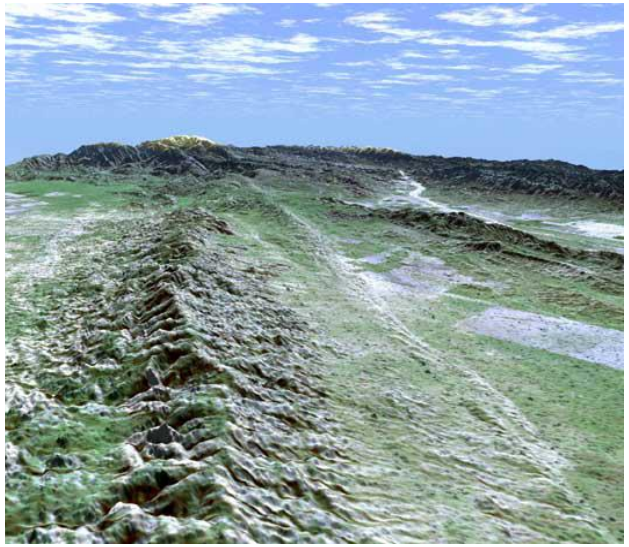
- 1 arc-second elevation data for the United States, 3 arc-second data for the globe
- Produced by radar measurements from a Shuttle mission, Feb 11-22, 2000

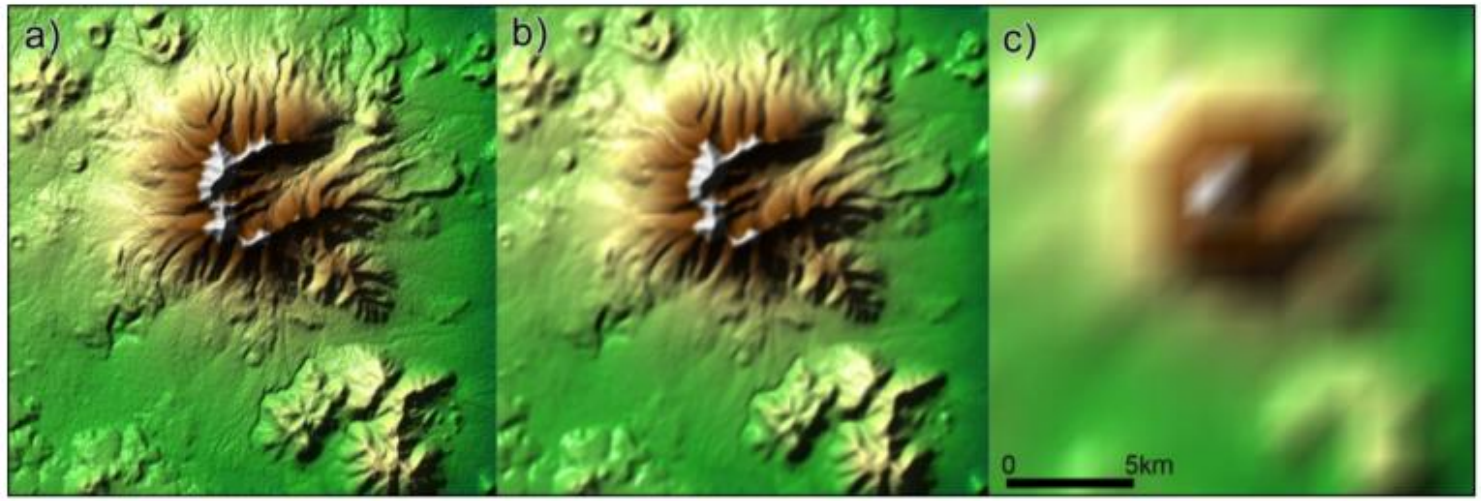


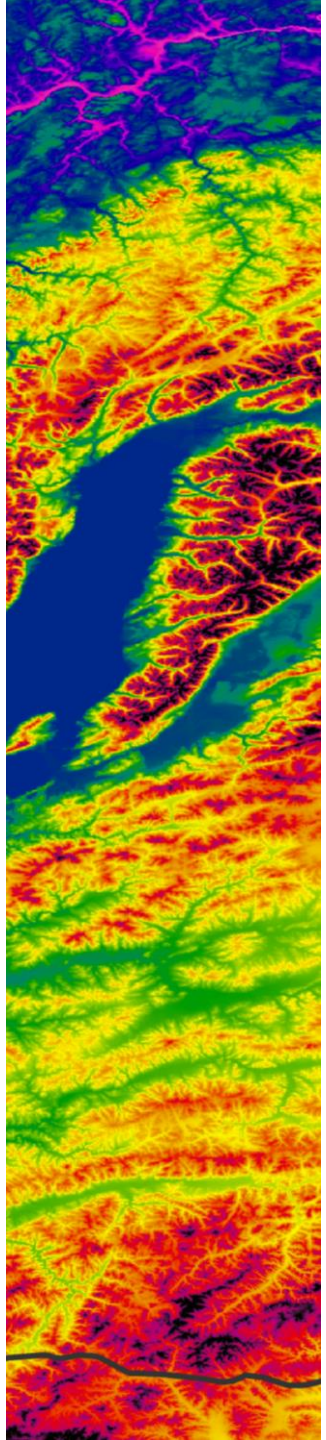


Shuttle Radar Topography Mission (SRTM)

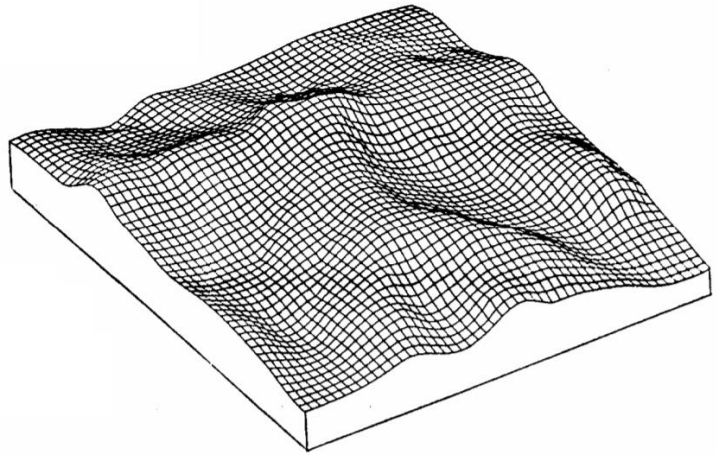




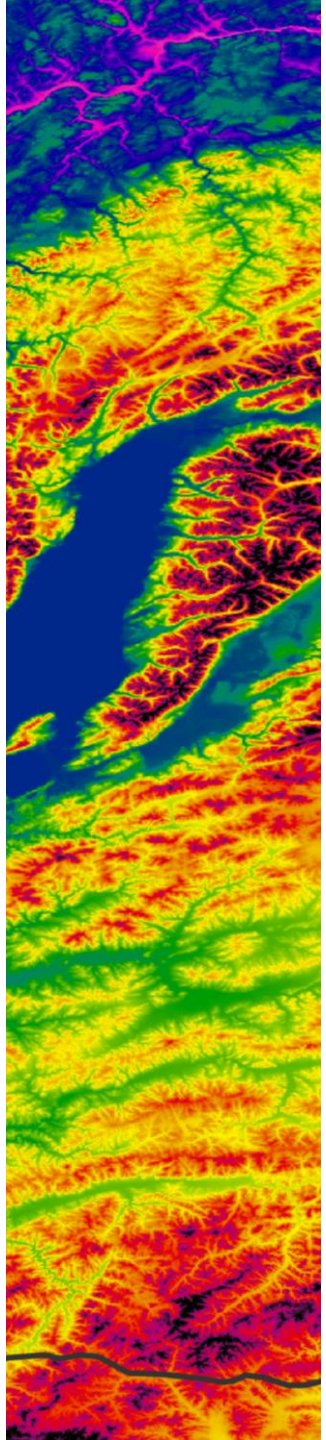




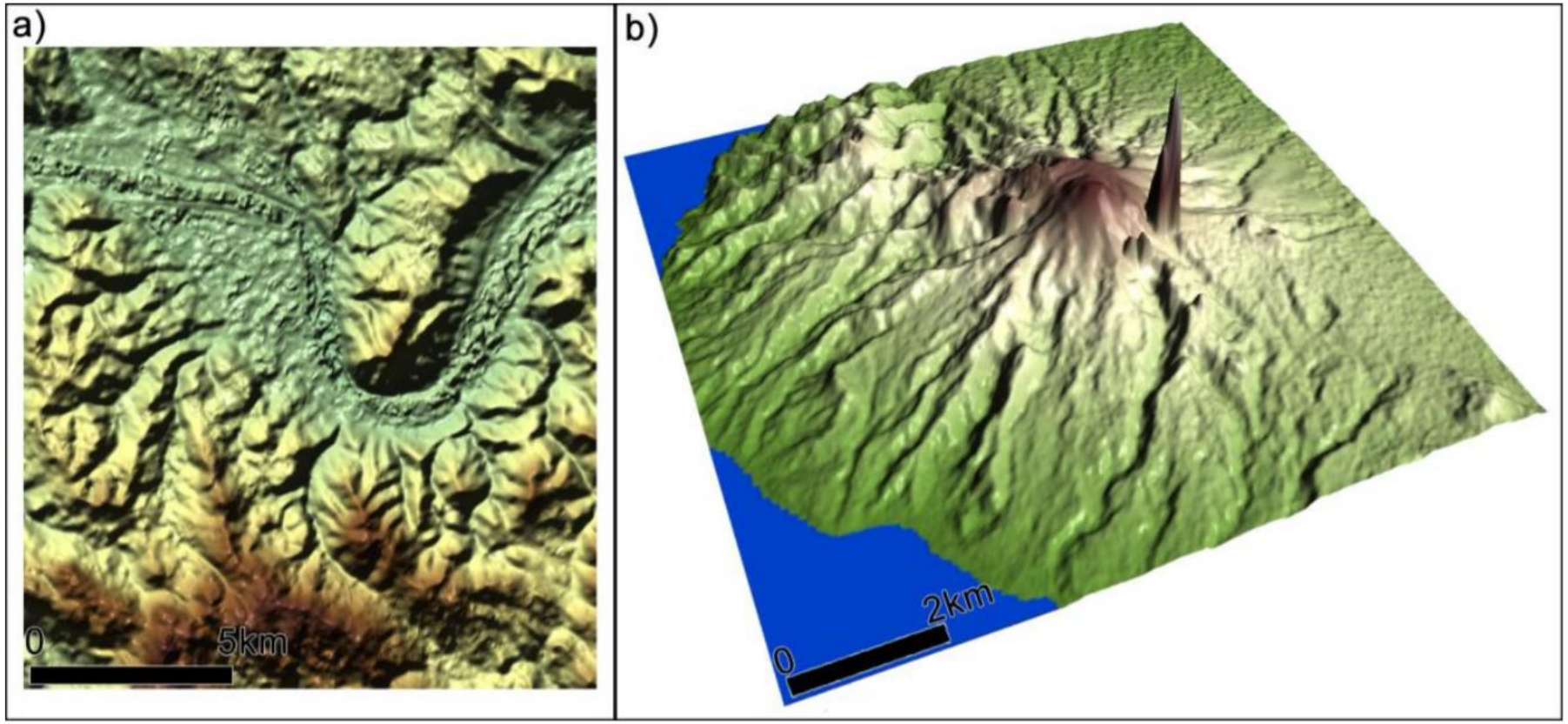
ASTER DEM

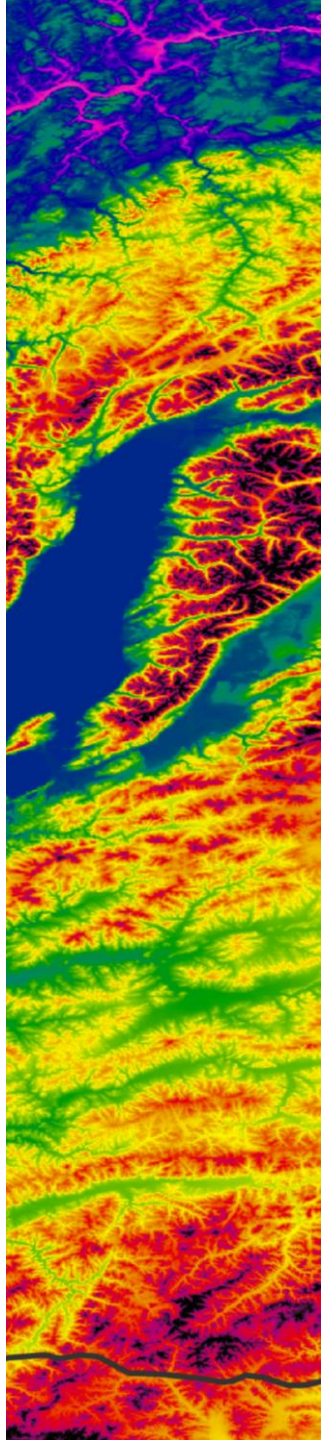


- Advanced Spaceborne Thermal Emission and Reflection Radiometer
- Off-Nadir pointing allows DEM
- First international DEM of decent quality available.
- Must request generation of DEM (slow turnaround) but FREE!



ASTER DEM - BUG

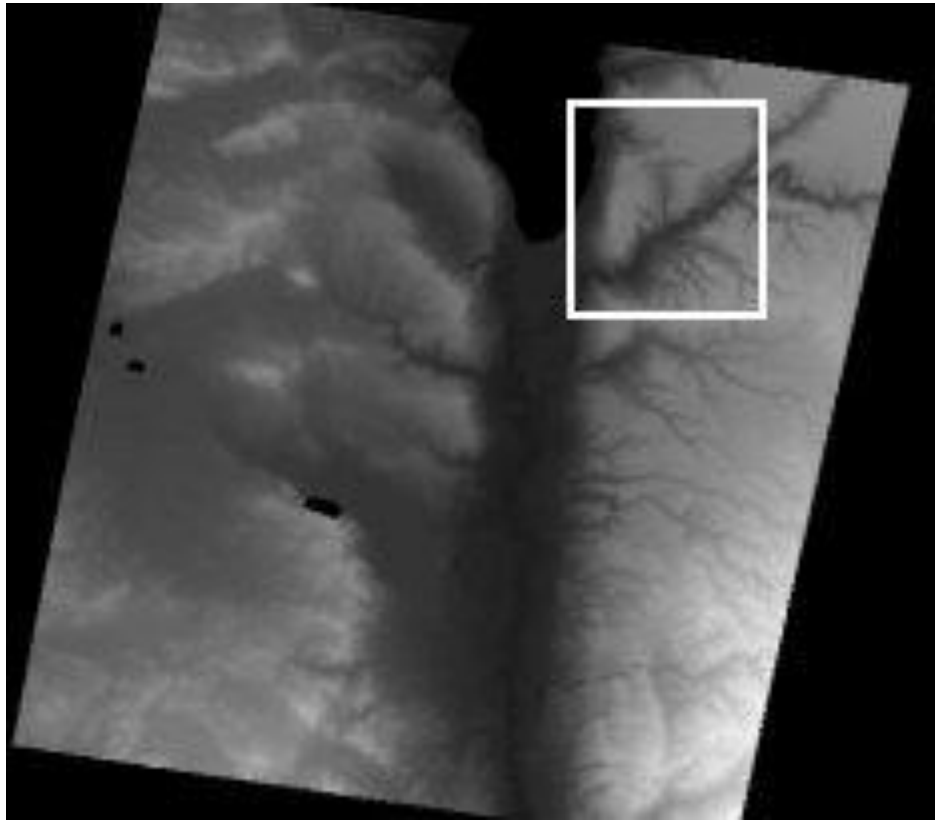


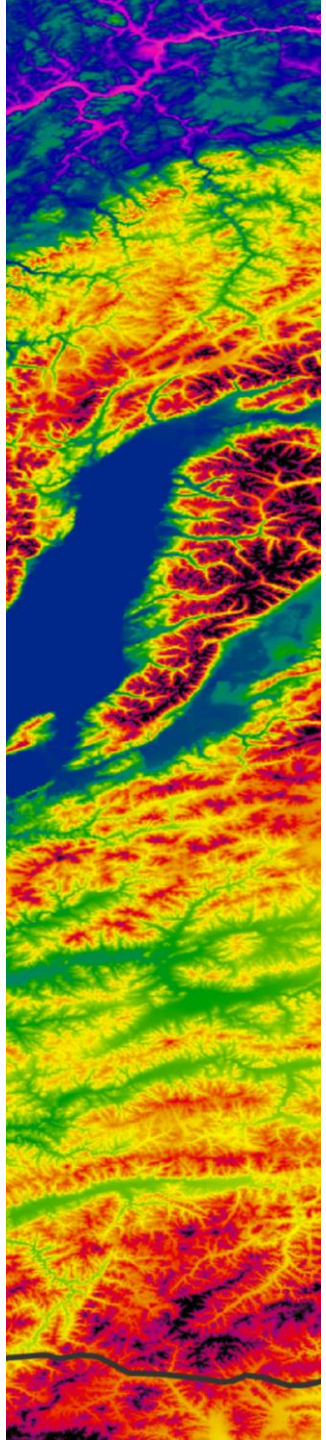


DTMs

- GTOPO30
  (1 km^2/pixel)

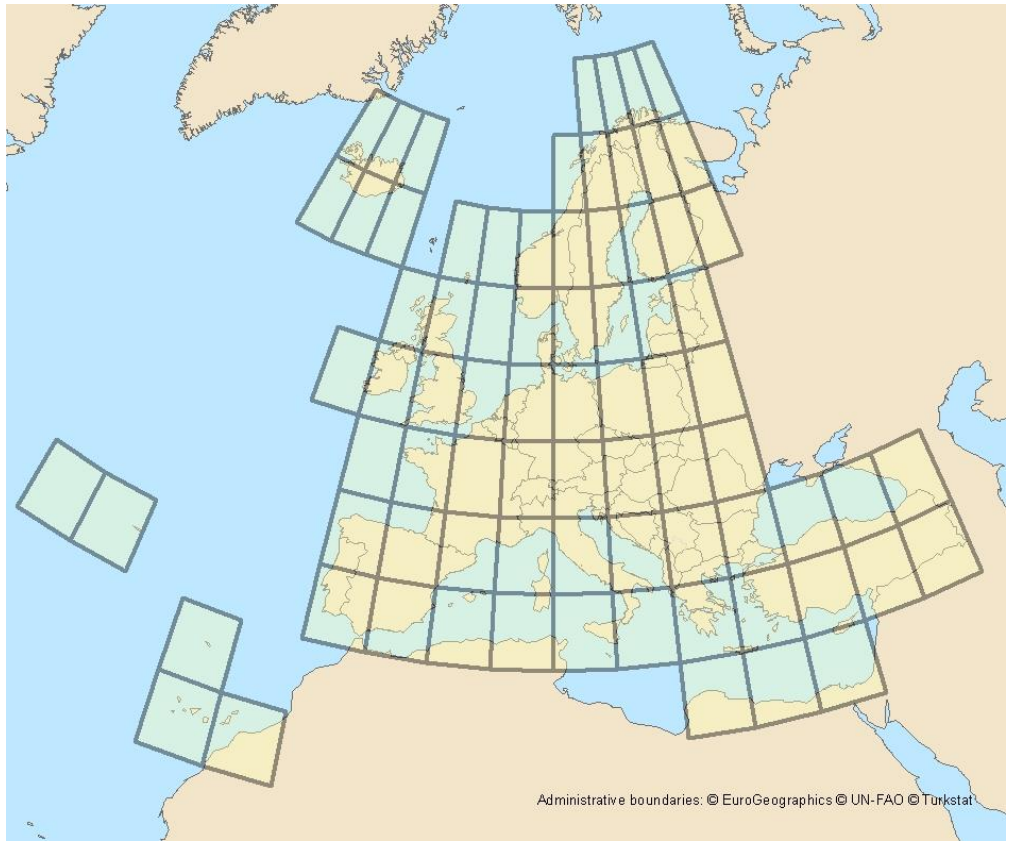
- ASTER
  (30 m^2/pixel)

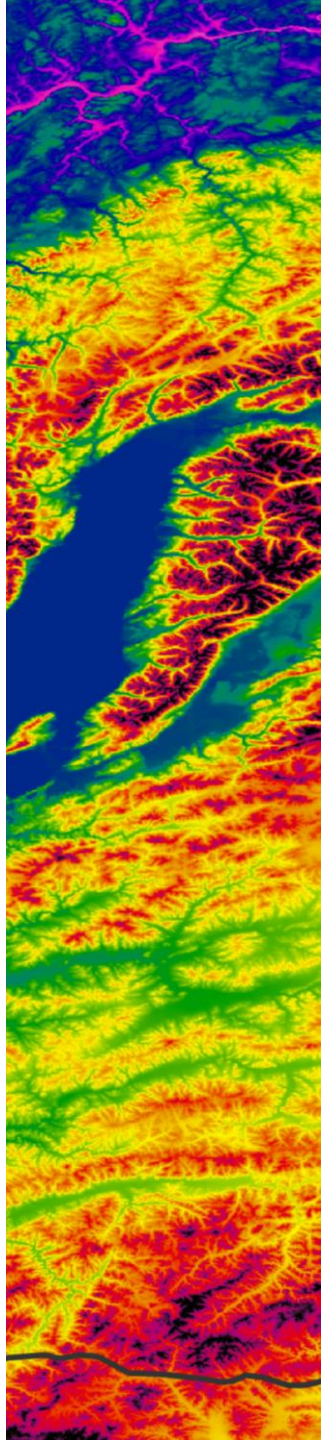




EUDEM (25 m)

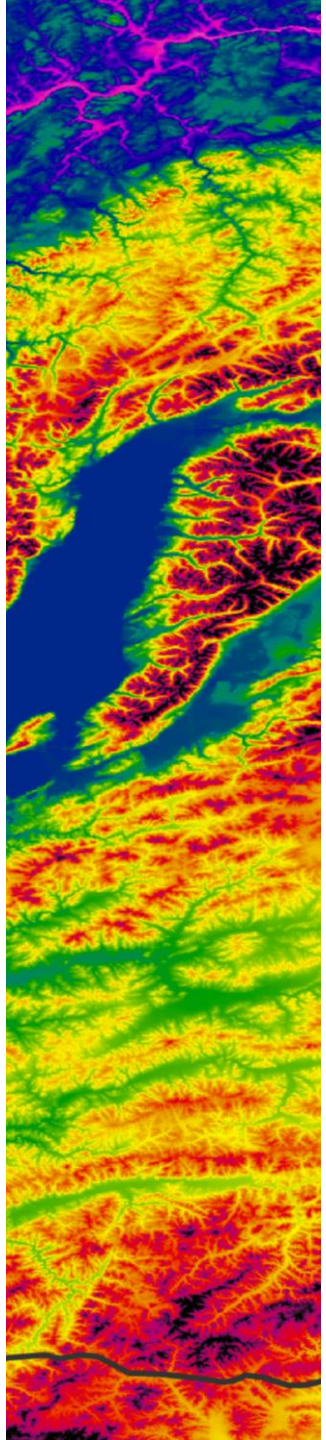
- The Digital Elevation Model over Europe from the GMES RDA project (EU-DEM) is a Digital Surface Model (DSM) representing the first surface as illuminated by the sensors.
- The EU-DEM dataset is a realisation of the Copernicus programme, managed by the European Commission, DG Enterprise and Industry.





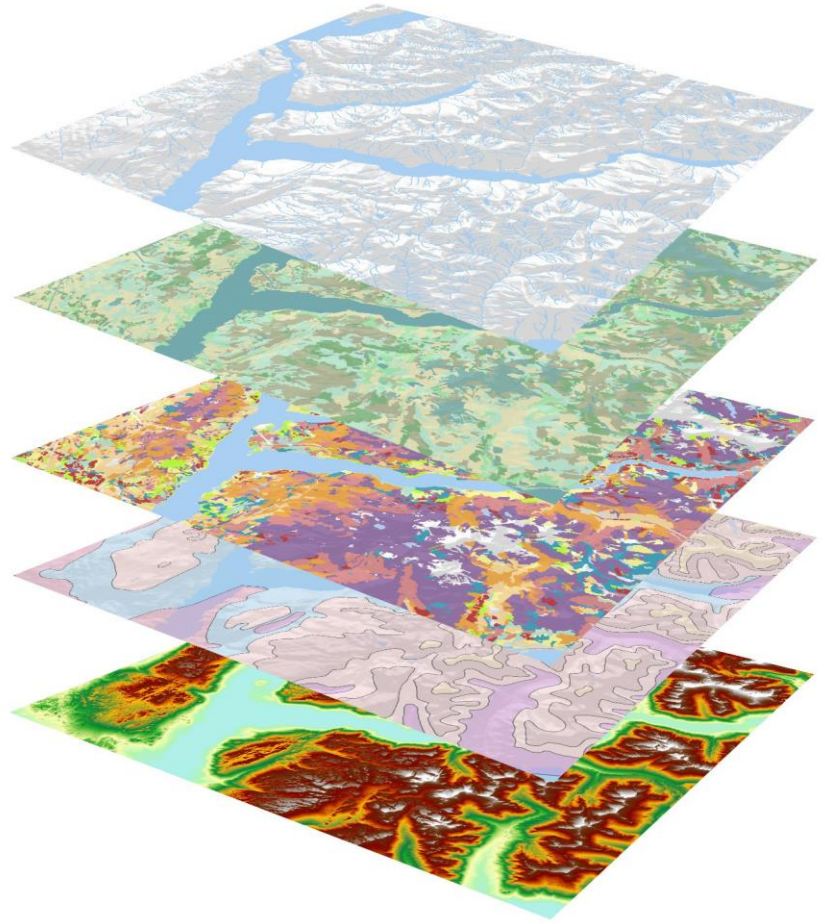
Problems with DEMs

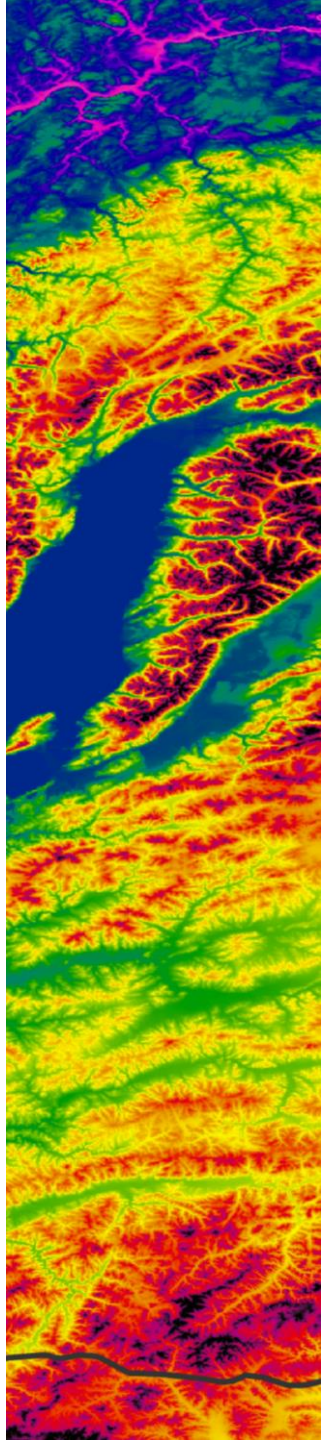
- Issues worth considering when creating/using DTMs
  - quality of data used to generate DEM
  - interpolation technique
  - give rise to errors in surface such as:
    - sloping lakes and rivers flowing uphill
    - local minima
    - stepped appearance
    - etc.



Example applications

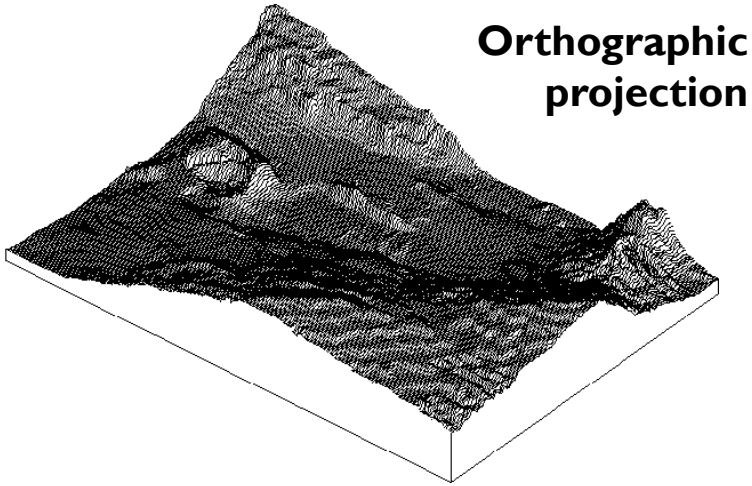
- Visualisation
  - terrain and other 3D surfaces
- Visibility analysis
  - intervisibility matrices and viewsheds
- Hydrological modelling
  - catchment modelling and flow models
- Engineering
  - cut & fill, profiles, etc.

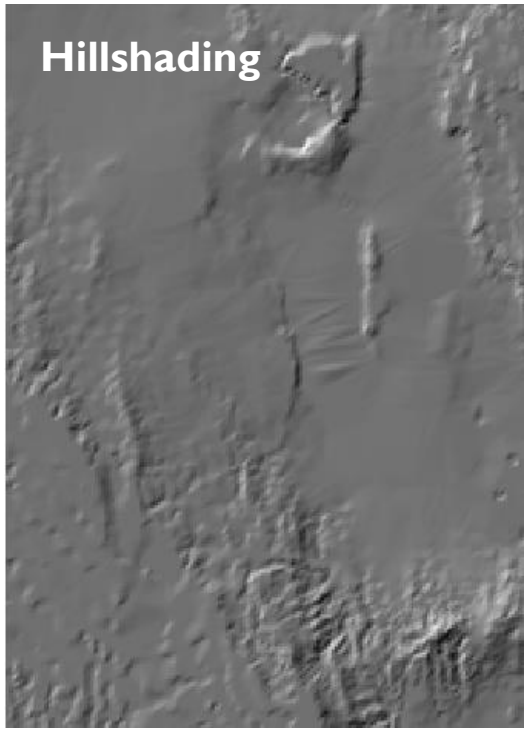


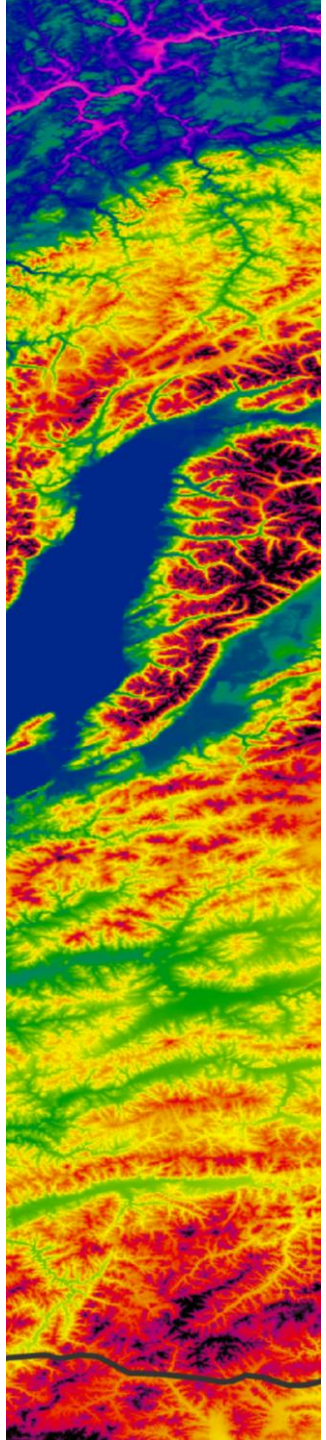


Terrain visualisation

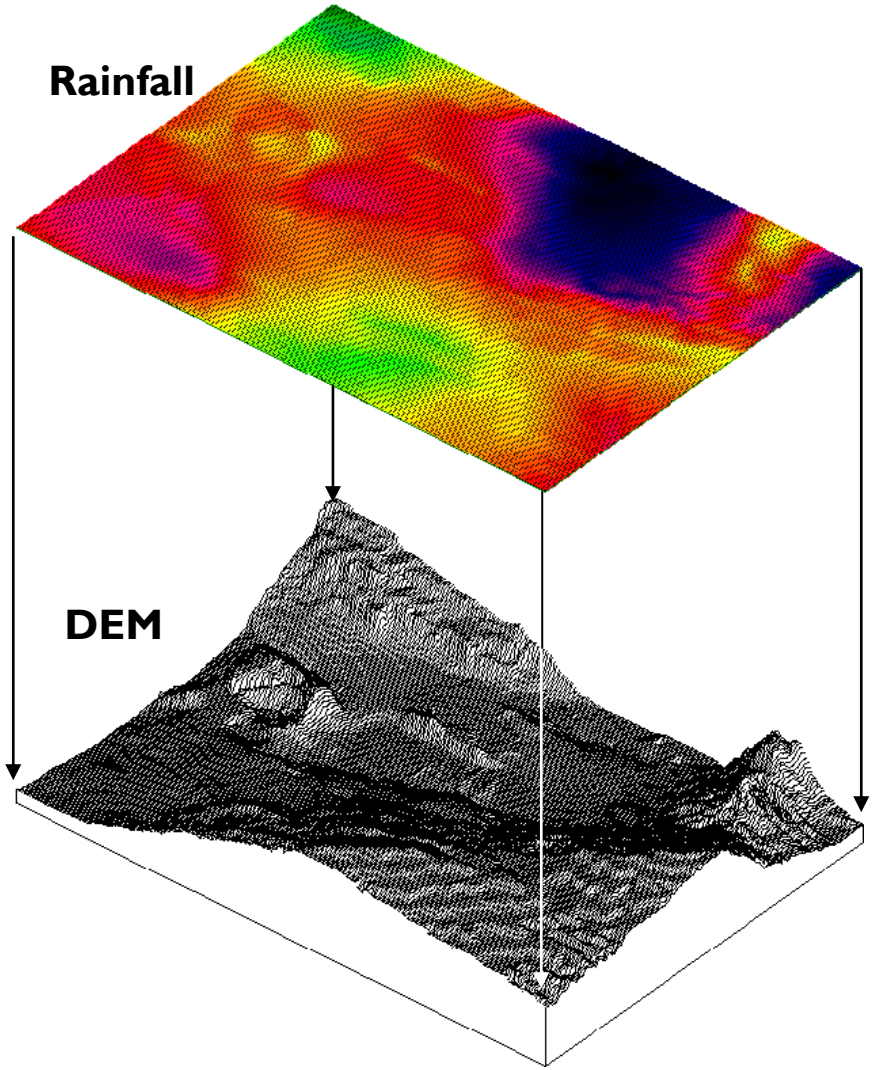
- Analytical hillshading
- Orthographic views
  - any azimuth, altitude, view distance/point
  - surface drapes (point, line and area data)
- Animated ‘fly-through’
- What if? modelling
  - photorealism
  - photomontage
  - CAD

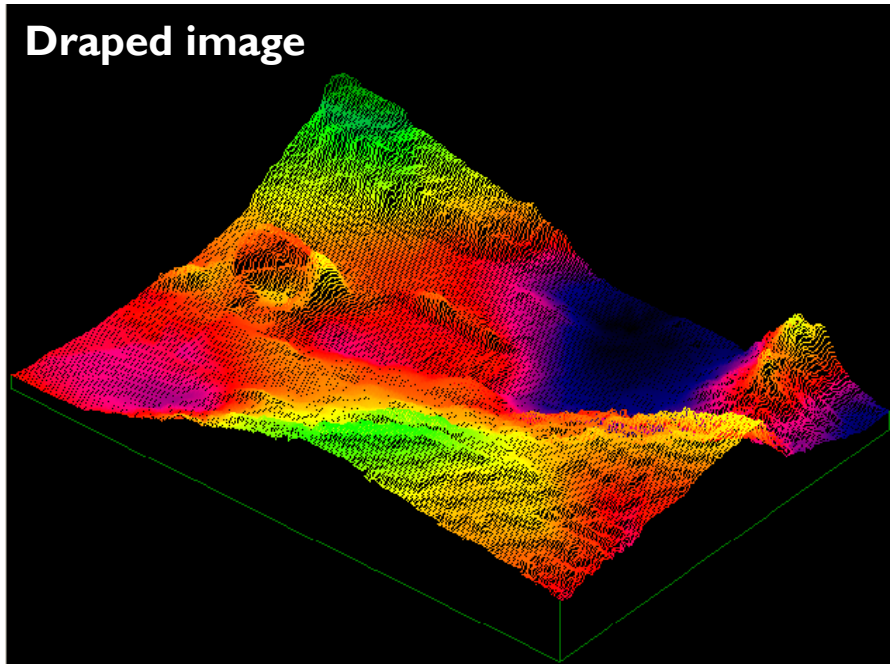


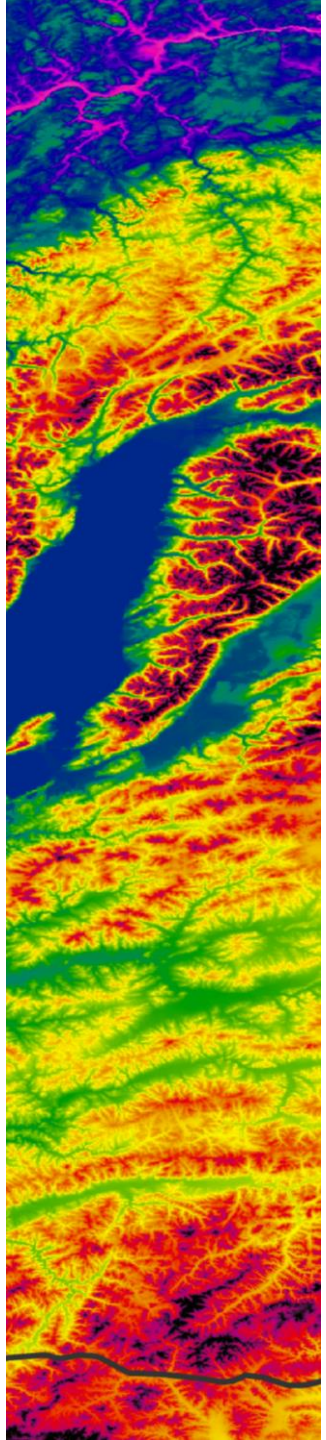




Example surface drape

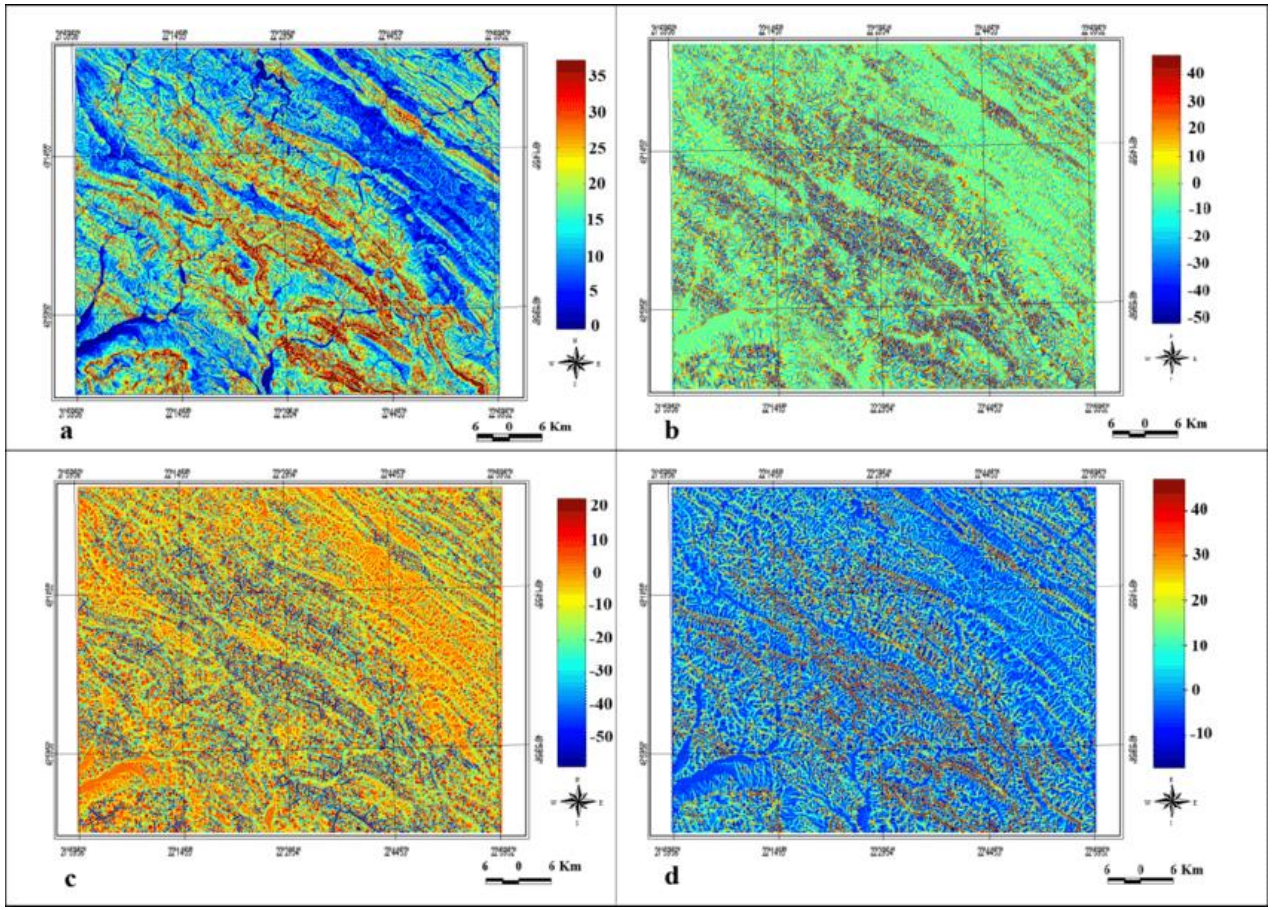


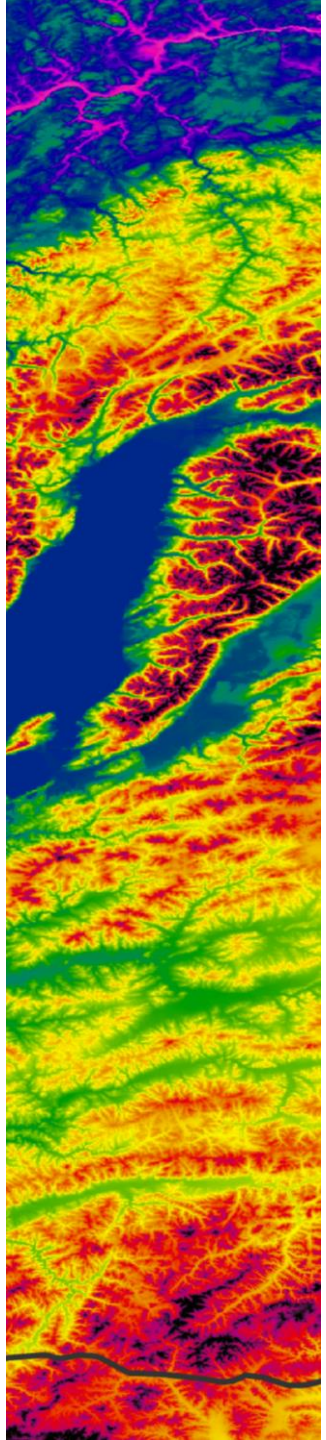




Other derived variables

- Many other variables describing terrain features/characteristics
  - hillshading
  - profile and plan curvature
  - feature extraction
  - etc.



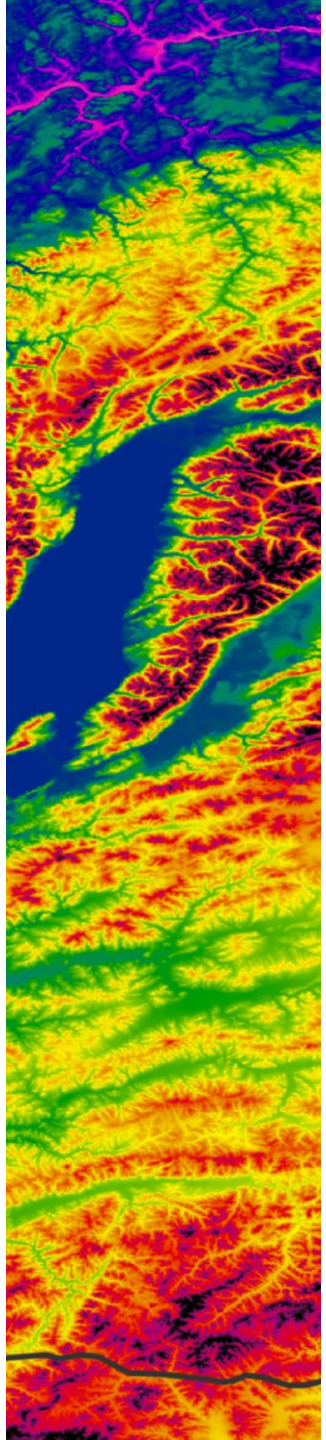


Calculating slope

- Inclination of the land surface measured in degrees or percent
  - 3 x 3 cell filter
  - find best fit tilted plane that minimises squared difference in height for each cell
  - determine slope of centre (target) cell

10	**9**	**8**
8	**8**	**7**
7	**6**	**5**

***Slope* = $b^2 + c^2$**

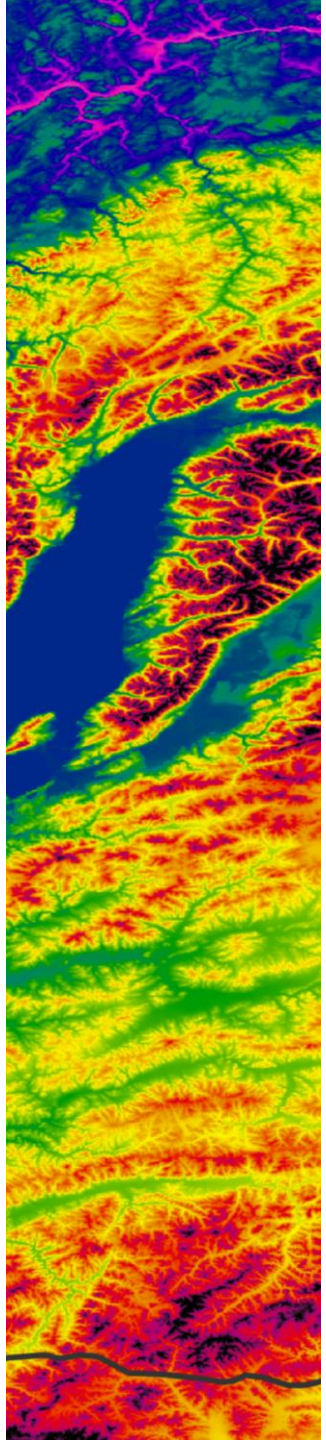


Calculating aspect

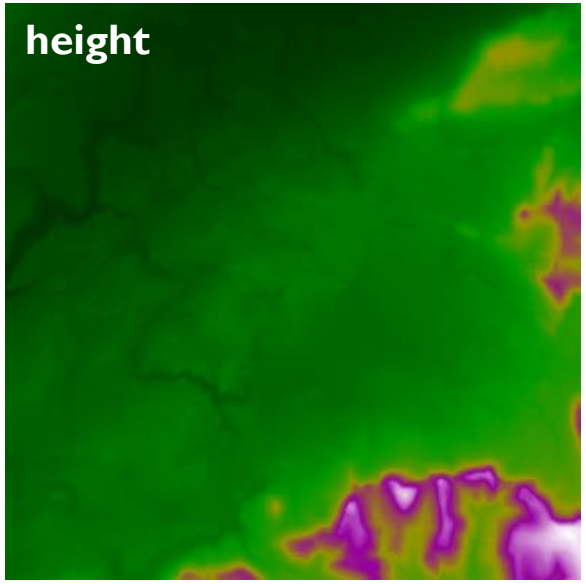
- Direction the land surface is facing measured in degrees or nominal classes (N, S, E, W, NE, SE, NW, SW, etc.)
  - use 3 x 3 filter and best fit tilted plane
  - determine aspect for target cell

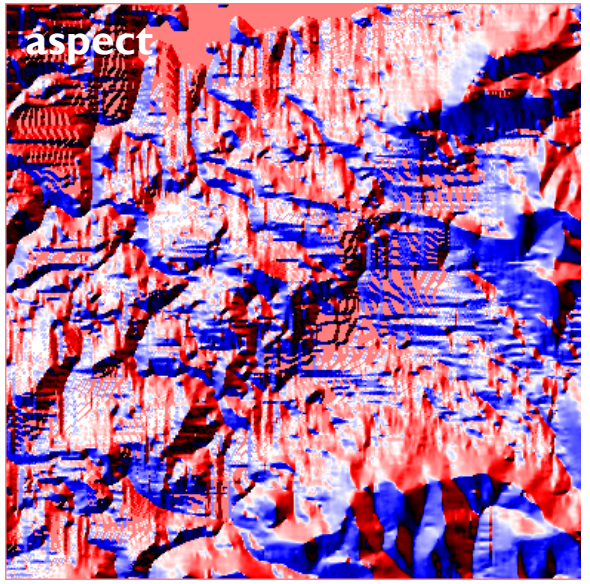
10	**9**	**8**
8	**8**	**7**
7	**6**	**5**

$$Aspect = \tan^{-1} c / b$$

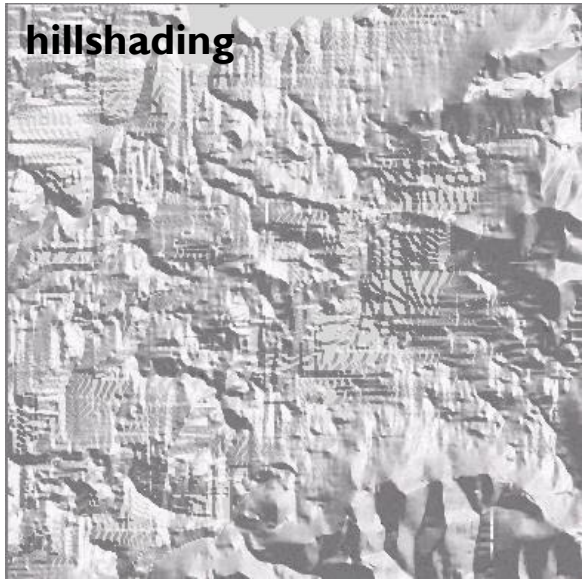


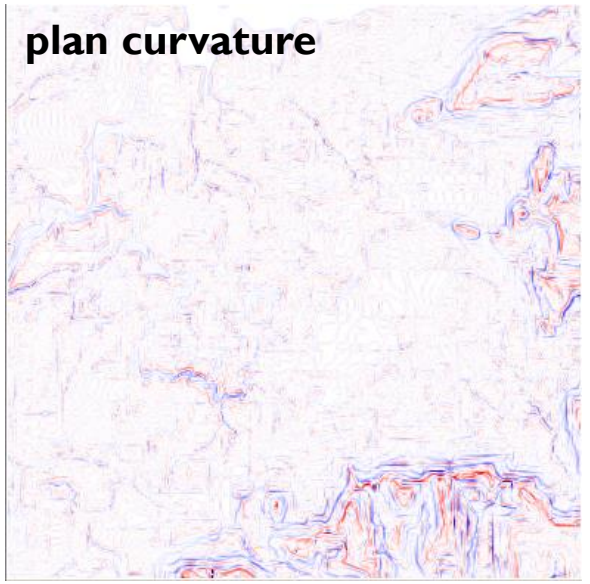
Examples

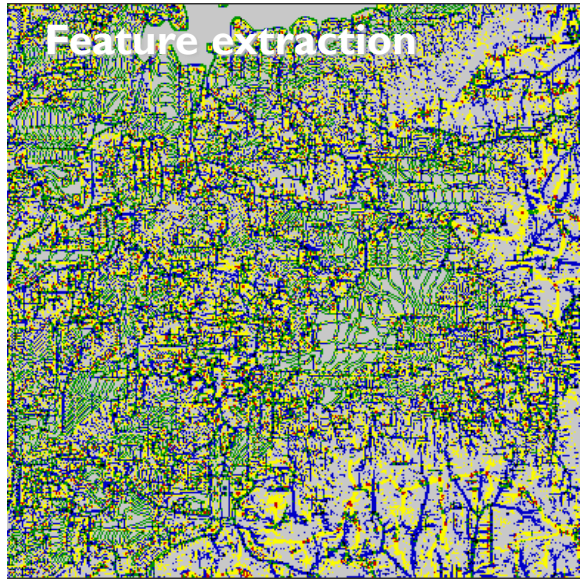

height


aspect


slope


hillshading


plan curvature


Feature extraction