NICHOLAS SCHOOL OF THE ENVIRONMENT

Project Based GIS: Geospatial data (II)

ENVIRON 761

Geospatial Applications for Conservation & Land Management

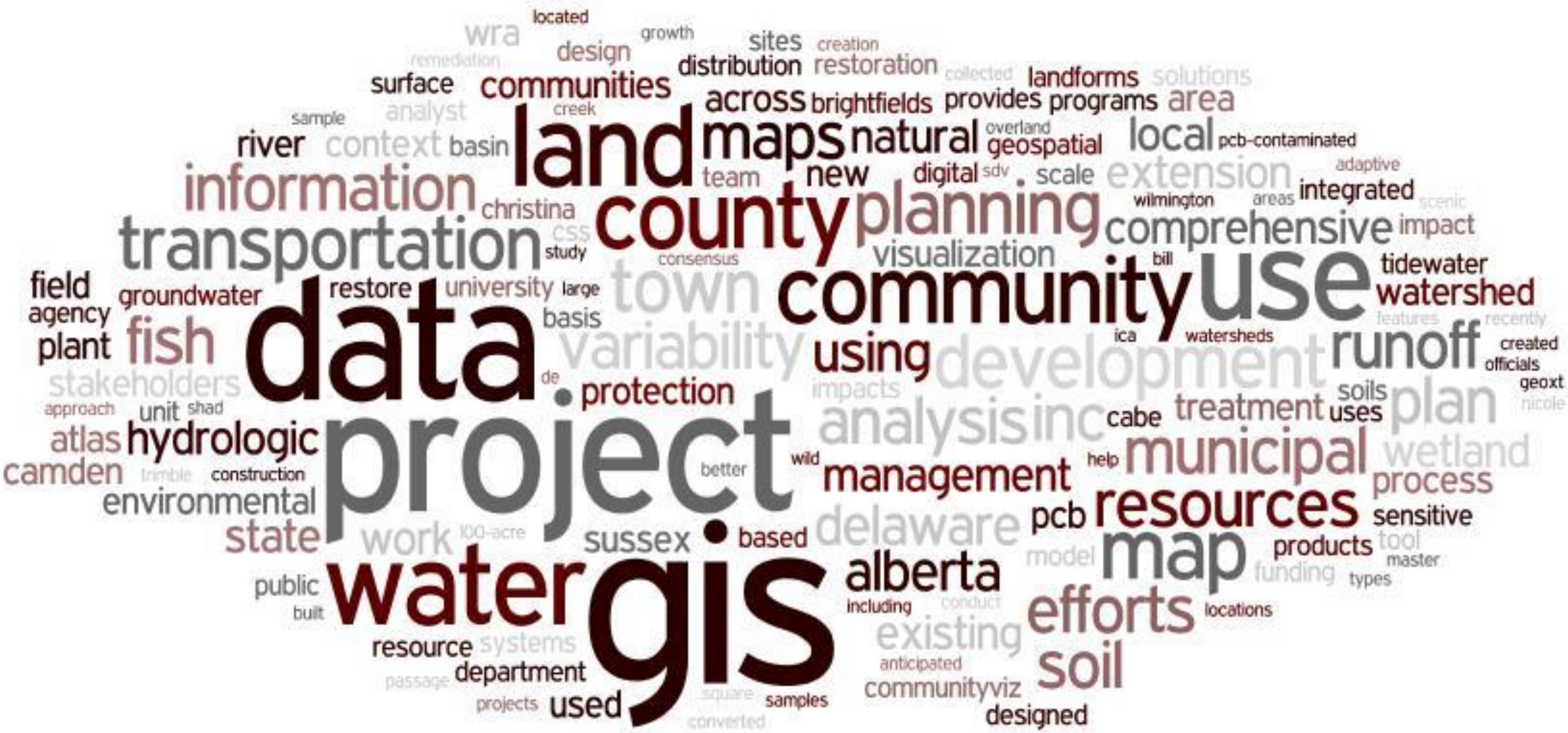
Part 1 - recap

- Data is a central component in GIS analyses
- Finding data, while getting easier, remains a time consuming step
  - Familiarity with public domain sources helps
- Even after finding data, you need to understand the data and its limitations

Today…

- Data portals and clearinghouses
- Searching for specialized data
- An in-depth look at digital elevation data

Finding Data: Portals & Clearinghouses



http://free-gis-data.blogspot.com/

Data as infrastructure

Federal Register
Vol. 59, No. 71
Wednesday, April 13, 1994

Presidential Documents

Title 3—
The President

Executive Order 12906 of April 11, 1994

Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure

National Spatial Data Infrastructure (NSDI)

http://www.fgdc.gov/nsdi/nsdi.html

- National Geospatial Data Clearinghouse
- Spatial data standards
- National Digital Geospatial Data Framework &
- Partnerships for data acquisition

Other National SDI's

- "Geoconnections in **Canada**"
  http://geoconnections.nrcan.gc.ca/
- **Australian** Spatial Data Infrastructure (ASDI)
  http://www.icsm.gov.au
- **United Kingdom** Location Programme (UKLP)
  http://data.gov.uk/location/uk-location-programme

- Spain: http://www.idee.es
- Netherlands: https://www.pdok.nl/
- Brazil: http://www.ibge.gov.br/english/
- India: https://nsdiindia.gov.in/nsdi/nsdiportal/index.jsp

Portals: Geospatial "One-Stops"

- Provides users an organized, often searchable venue for locating and downloading data…

- Very useful, but often unsuccessful…

National Geospatial Data Clearinghouse (NGDC)
- 1994

Geospatial One-Stop (GOS)
- 2003

(Geo)Data.gov/ Geospatial Platform
- 2011

Conservation Geo-Portal

Metadata standards

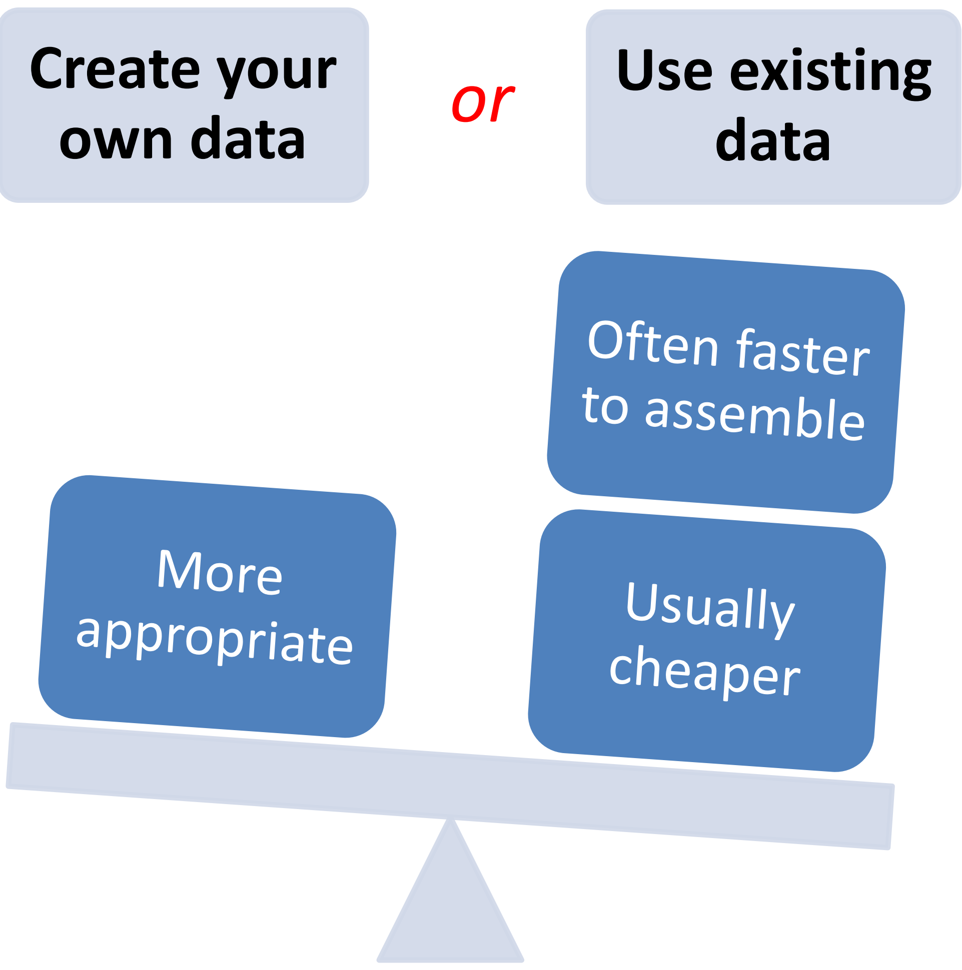
1. Identification of the dataset
   - Originator/creator; how the data set is maintained
   - Publication title & date
   - Purpose & time period
2. Quality of the dataset
   - Consistent? Complete? How created…
   - Assessment statistics
3. Organization of the dataset
4. Spatial Reference
5. Attribute information
6. Distribution information/restrictions
7. Contact information

Useful Portals

Geospatial Portals

- * http://datagateway.nrcs.usda.gov/
- * http://landcover.usgs.gov/index.php
- * http://worldwildlife.org/pages/conservation-science-data-and-tools
- * http://www.sage.wisc.edu/atlas/maps.php
- http://daac.ornl.gov/VEGETATION/vegetation_collections.shtml
- http://data.geocomm.com/
- http://datadownload.unep-wcmc.org/datasets
- http://datadownload.unep-wcmc.org/datasets
- http://daymet.org/
- http://gisinventory.net/
- http://nationalmap.gov/viewer.html
- http://serppas.org/Maps.aspx
- http://water.usgs.gov/lookup/getgislist
- http://www.census.gov/geo/www/cob/bdy_files.html
- http://www.cgiar-csi.org/data
- http://www.csc.noaa.gov/digitalcoast/data/index.html
- http://www.databasin.org/
- http://www.gap.uidaho.edu/
- http://www.nass.usda.gov/Research_and_Science/index.asp

Obtaining data: Considerations



Creating your own data

GIS Data Sources

Drew Decker

p. 37

Proper planning, though not too much—and I'll discuss this—is the key to building GIS databases. Building GIS databases is best described by breaking the process down into stages (we are assuming here that the data do not already exist, or if similar data do exist, that they do not meet our requirements):

1. Coordinate
2. Specify
3. Plan
4. Fund
5. Build
6. Distribute
7. Maintain

Volunteered Data

- USGS VGI resources
  http://cegis.usgs.gov/vgi/results.html
- Presentations from a workshop at UC Santa Barbara in 2007
  http://ncgia.ucsb.edu/projects/vgi/products.html
- Penn State Geography Department
  https://www.e-education.psu.edu/geog583/node/43

http://ebird.org

http://wiki.openstreetmap.org/wiki/Main_Page

http://www.inaturalist.org/

http://www.youtube.com/watch?v=8hhXZwLFfao

Searching for data

> **GIS Data Law 3** Almost all GIS data have some value. Some data may require more manipulation but they can still make your GIS work better.

Decker, p. 35

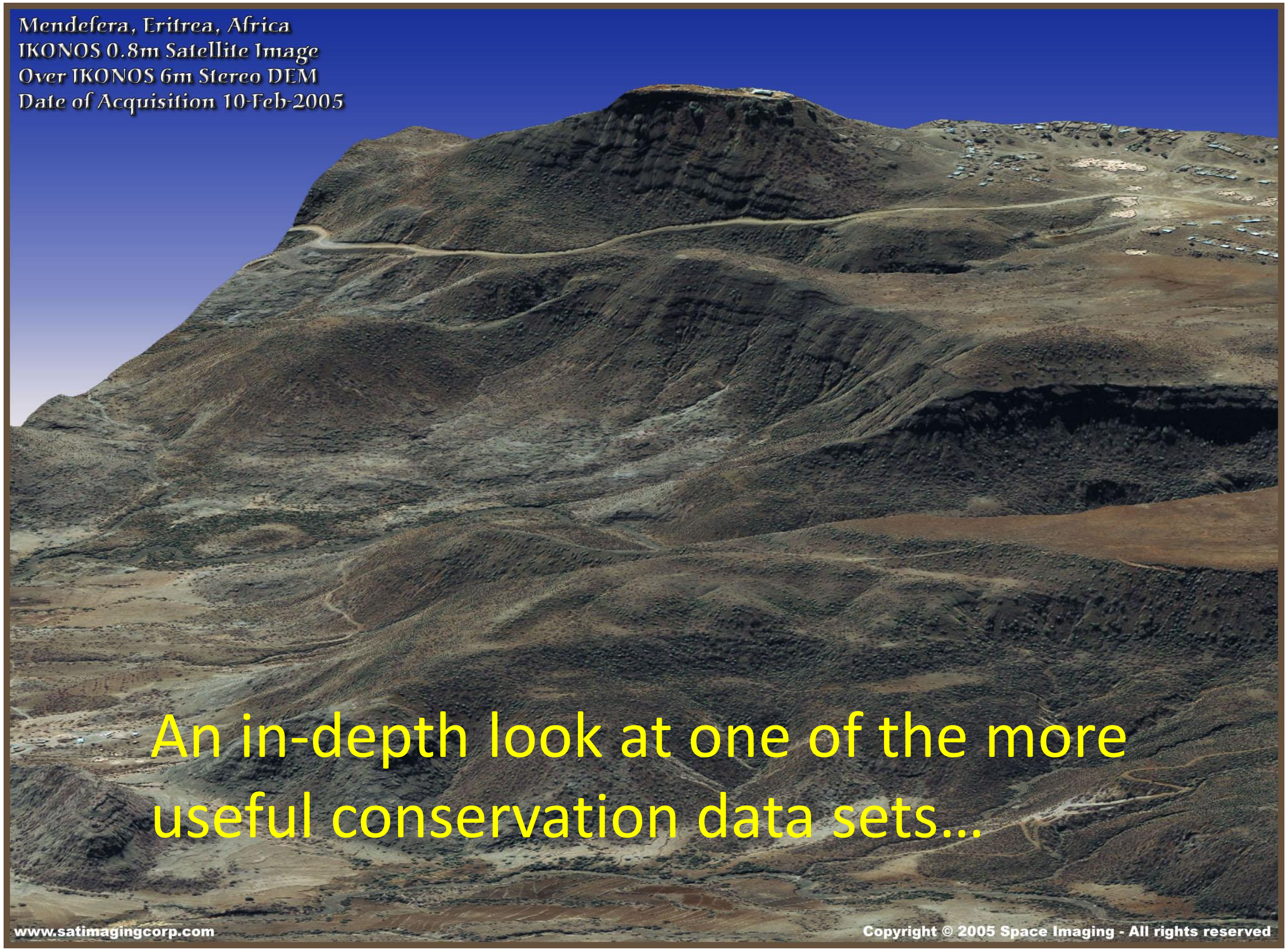
Techniques for finding good spatial data:

- Knowing **where** to look…
  - Useful public domain datasets
  - Useful data portals/clearing houses
  - Web services
- Knowing **how** to look…
  - Web Search techniques

Web Searches

- Use keywords & search tricks:
  - “.shp|.e00|.zip” “shapefile” “ftp”
- Skim Metadata XML files
  - Search for “http://” or ftp://
- Dissect URLs to navigate to parent folders
- Use the Wayback machine… http://archive.org/

Elevation Data



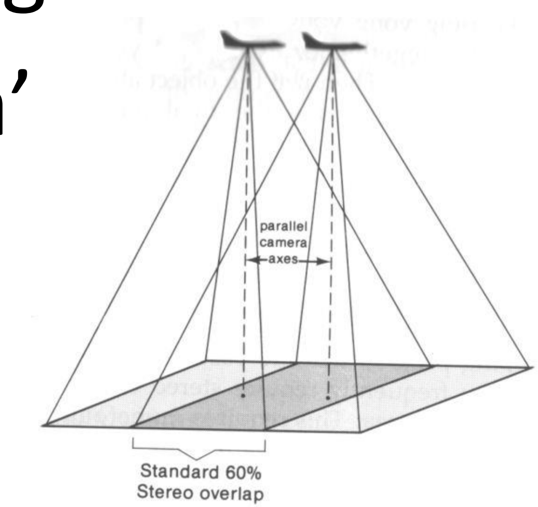
Where do elevation data come from?

Historical evolution

Increasing resolution

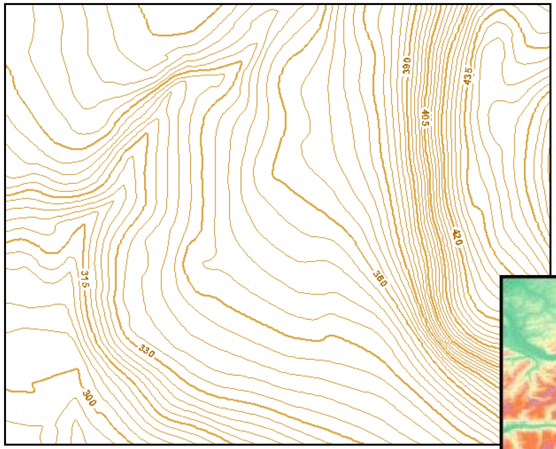
- Ground surveys:
  Geodetic surveying: small number of points with high precision

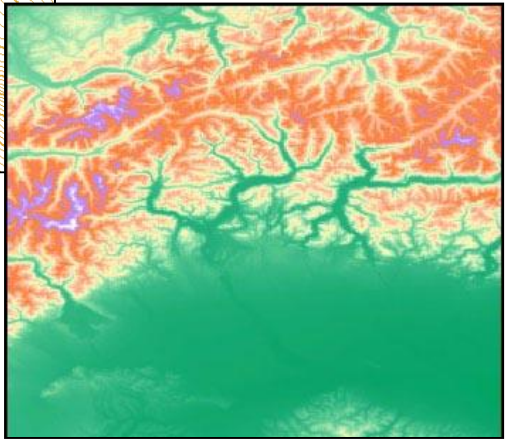
- Overlapping air photos
- Overlapping satellite images
- Radar with 'dual antenna'
- LIDAR



Photogrammetric processing

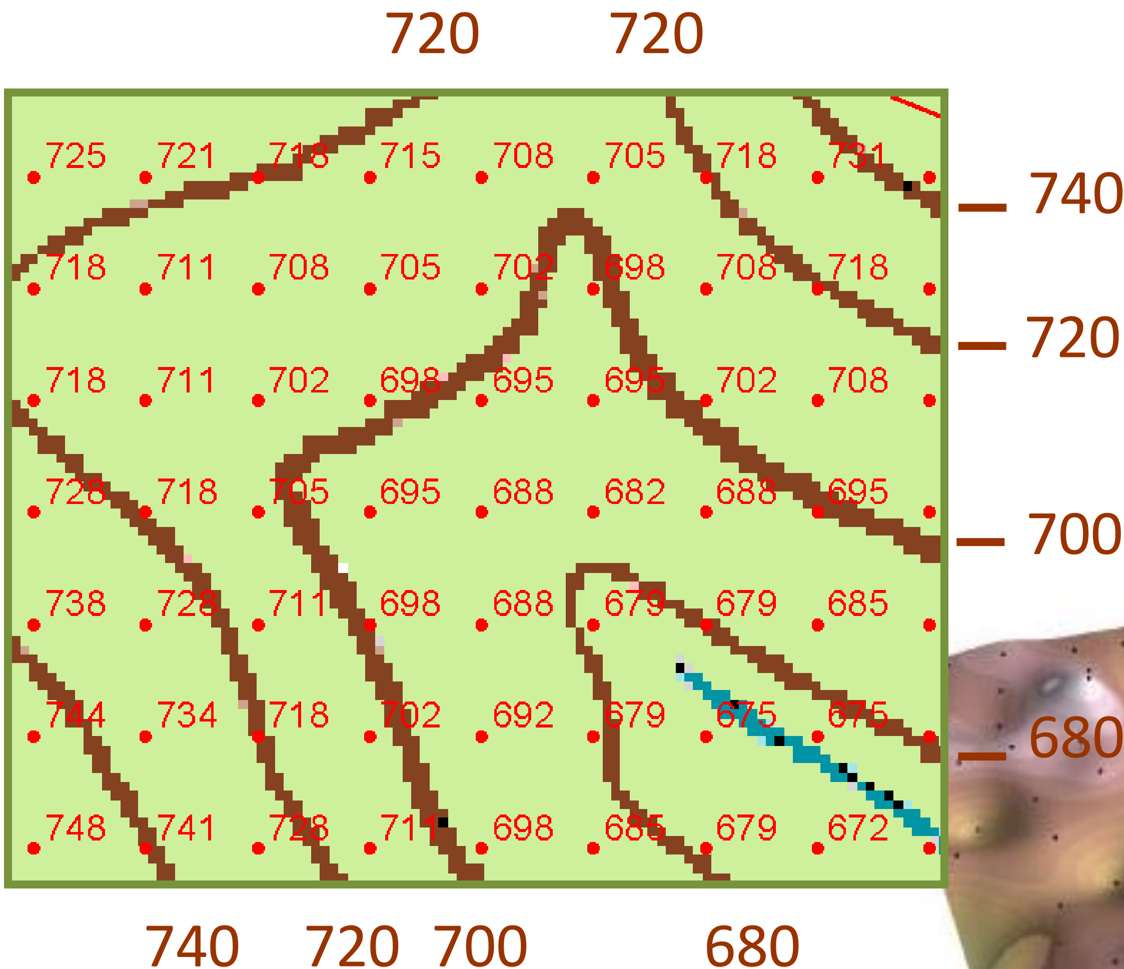
Parallax!

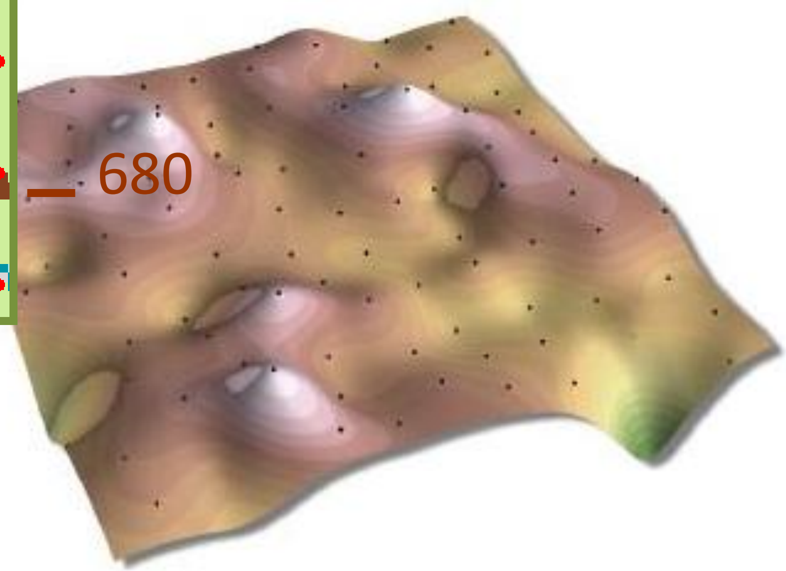




http://egsc.usgs.gov/isb/pubs/booklets/topo/topo.html

From contours to raster surfaces

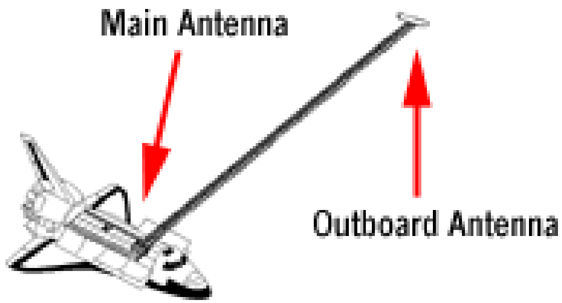




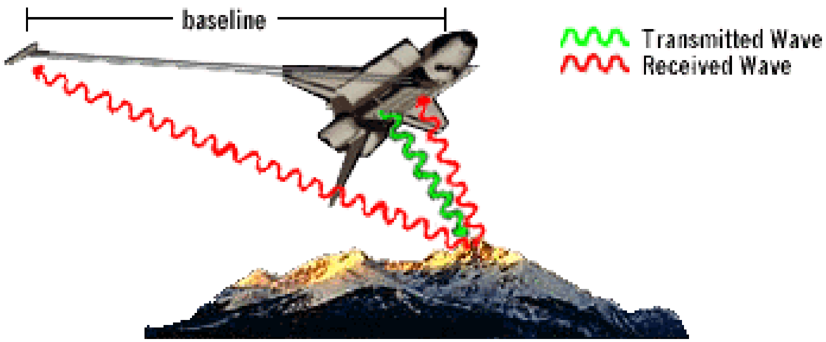
Arc/Info:
topogrid

Shuttle Radar Topographic Mission (SRTM)

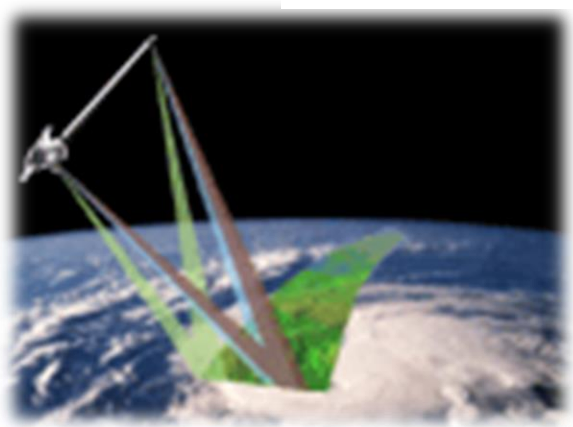
- US data = 1'' resolution (approximately 30 m)
- Rest of the world = 3" or ~90m
- "Radar interferometry"



Reflected radar signals collected at two antennas, providing two sets of radar signals separated by a distance.



Radar signals being transmitted and recieved in the SRTM mission (image not to scale).



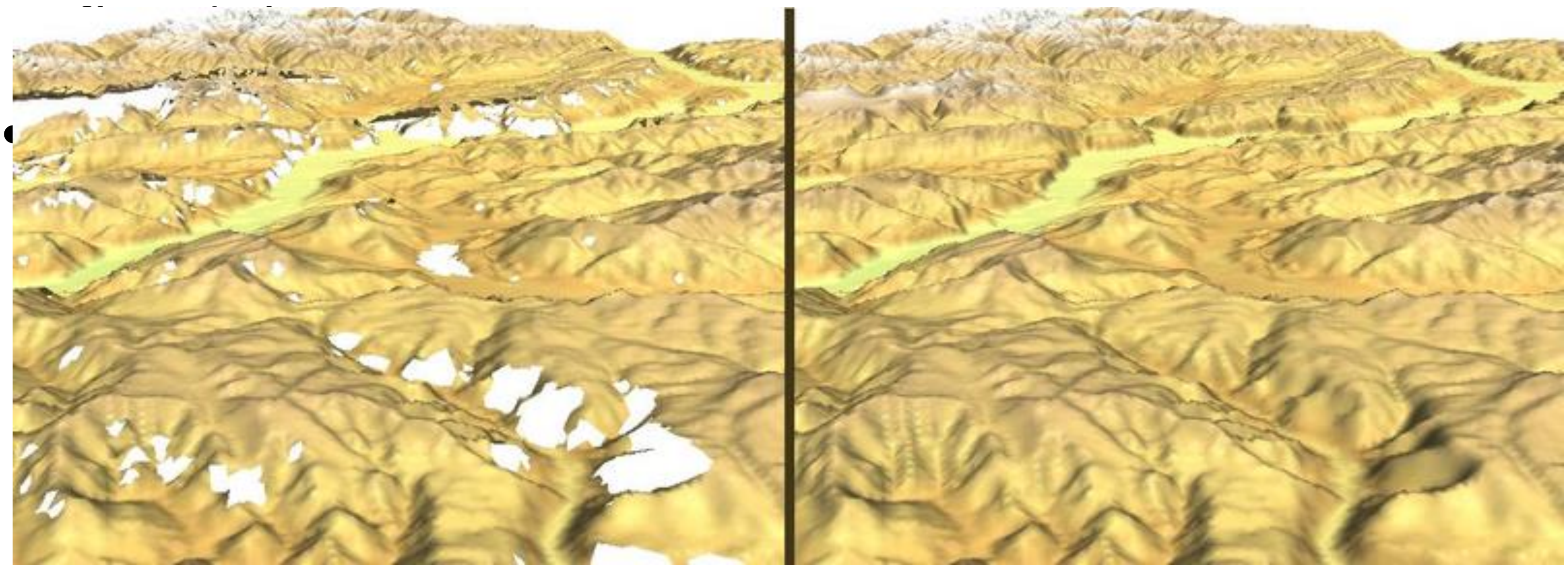
http://srtm.csi.cgiar.org/

STRM data

- Collected from Space Shuttle Endeavor (Feb. 2000)
- 99.97% land mass covered at least once
  - 94.59% twice; 49.25% three x; 24.10% four x
- Geographic coordinate system used
  - WGS 84 horizontal datum; EGM96 vertical datum
- Errors from mast motion & phase noise errors
- Error tolerances:
  - 30 m ground sample distance
  - 16 m vertical height

SRTM issues

- Voids: "no-data" spaces (white below) where the water or the shadows obstructed the determination of the altitude.
- Canyons, mountain “shadows”, lakes and large



Post-processed SRTM data

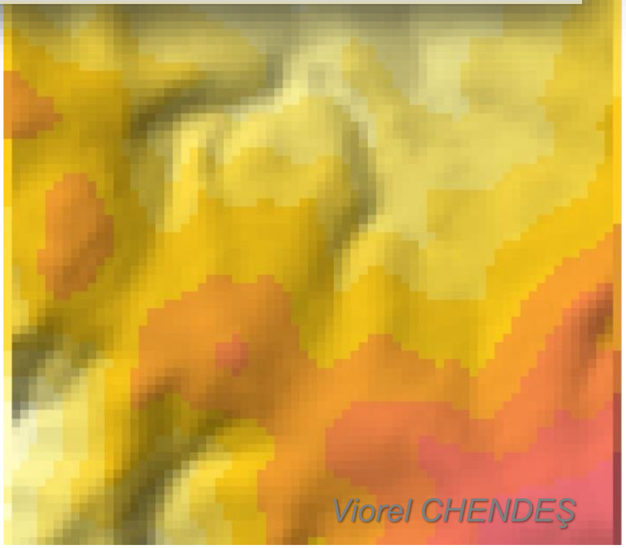
http://dds.cr.usgs.gov/srtm/SRTM_image_sample/docs/SRTM_Image.pdf

SRTM *vs* Photogrammetric derived DEMs

	NED	SRTM
Resolution	1 Arc Second (~ 30m resolution)	1 Arc Second (~30m resolution)
Source Data	Maps / Aerial Photos	Radar Images
Source Resolution	10m & 30m DEMs	30m
Source Dates	1925-1999	February, 2000 Space Shuttle Endeavor
Surface Type	"Bare Earth"	"First Return"
Accuracy Specifications	7m RMSE	10m RMSE

SRTM at 3'' res.
(about 90 m)
Hm = 1275.3

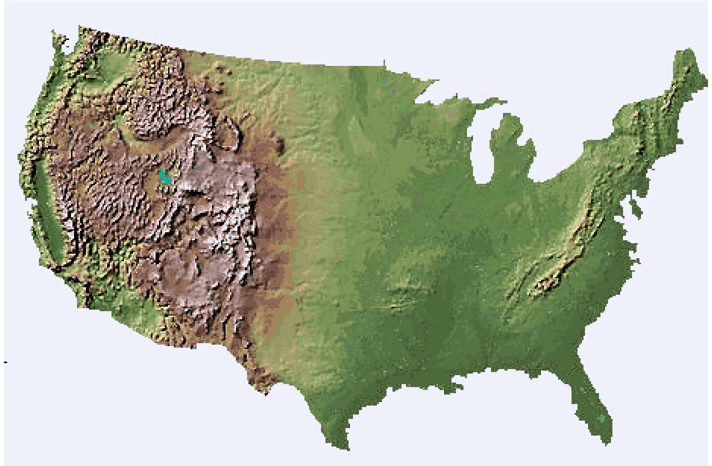
SRTM at 30 m
from 3'' SRTM
Hm = 1279.7

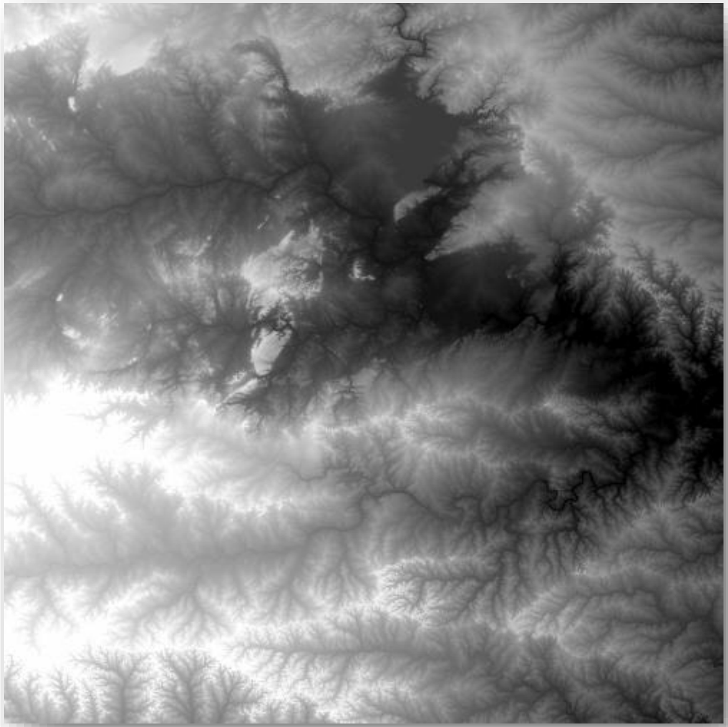


DTM from topo maps
at 1:25.000 scale
Hm = 1267.3

National Elevation Dataset (originally)

- 1 arc-second (~30m) resolution
- Seamless in 1° blocks for the United States
- 10 billion data
- Derived from USGS 1:24,000 quadrangle sheets





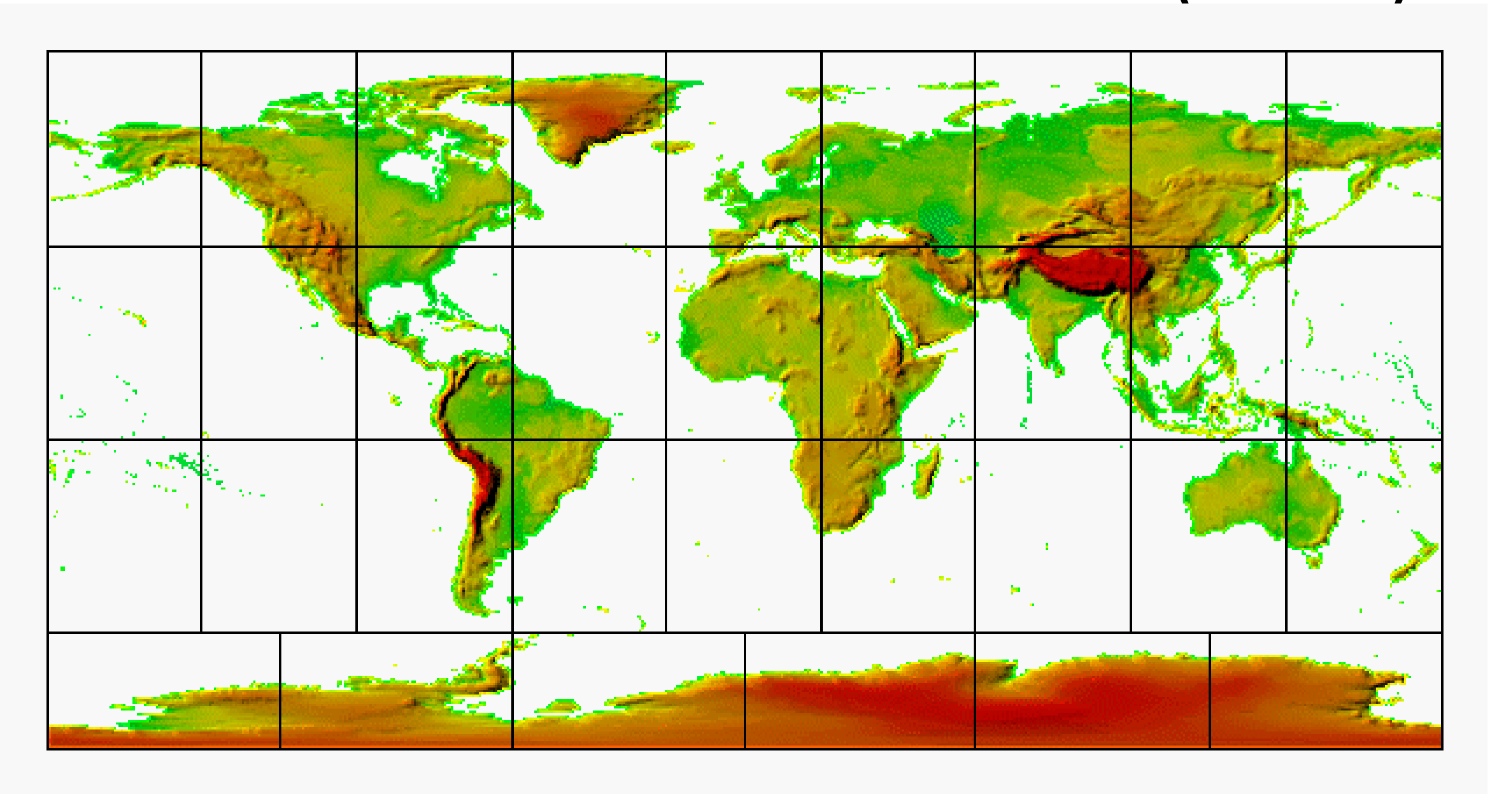
http://seamless.usgs.gov/

National Elevation Dataset (now)

- "Living dataset"
  Best available raster elevation data of the conterminous United States, Alaska, Hawaii, and territorial islands
- Available nationally at resolutions of :
  - 1 arc-second (about 30 meters)
  - 1/3 arc-second (about 10 meters)
  - 1/9 arc-second (about 3 meters, in limited areas)
- Data provided in geographic coordinate system
  - NAD 83 horizontal datum; NAD 88 vertical datum
- Accuracy varies spatially b/c variable sources

Other DEM sources: GTOPO

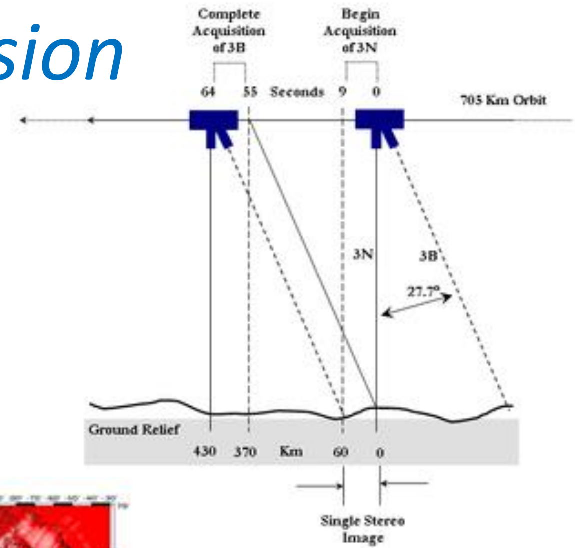
- GTOPO – Global 30 arc-second (~1km)



http://eros.usgs.gov/products/elevation/gtopo30.php

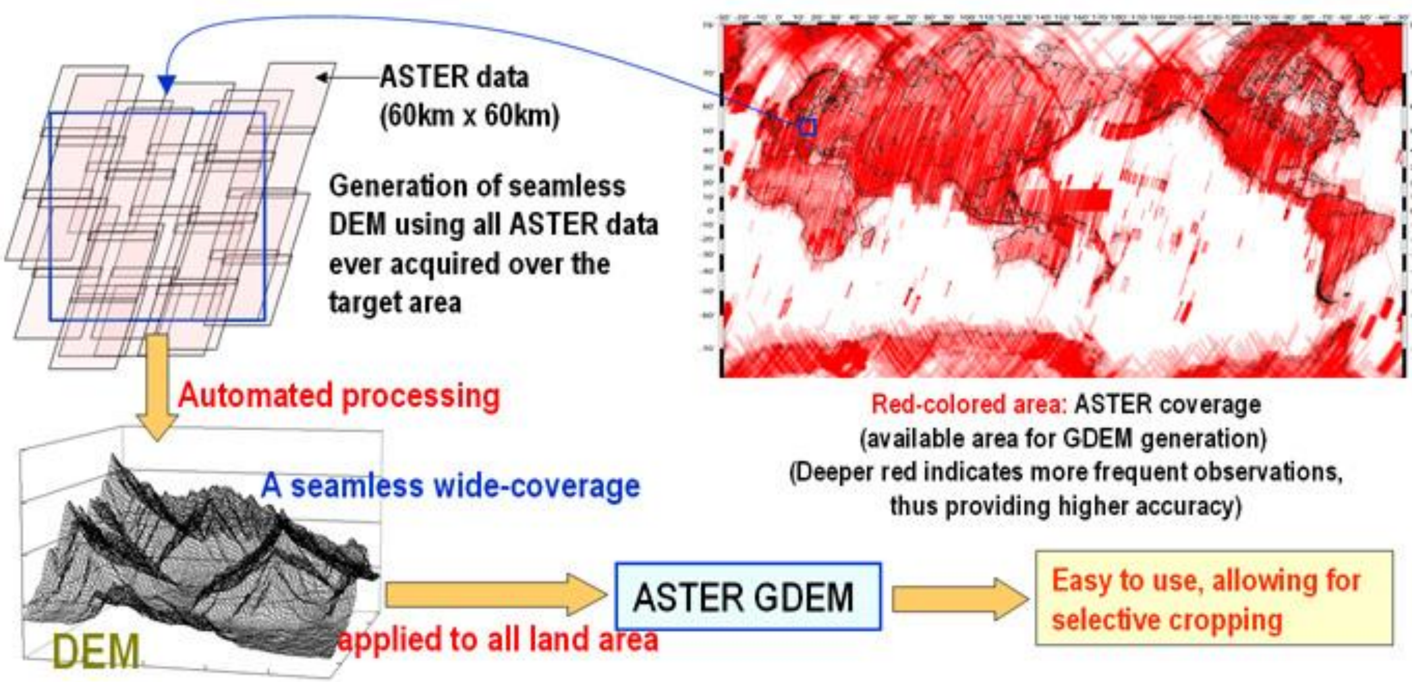
Other DEM data sources: **ASTER**

Advanced Spaceborne Thermal Emission & Reflection Radiometer



-Track Imaging Geometry of the ASTER
R Nadir and Backward-Viewing Sensors

- 30 m resolution
- Seamless coverage : 83°N←→ 83°S



ASTER data

- Multispectral imager launched by NASA in 1999
- Backward-looking near-IR band provides stereo coverage (i.e. ability to collect elevation data)
- Seamless coverage extending from 83°N to 83°S
  - 1.3 million scenes
- Data provided in 1x1° GeoTIFF tiles w/ 30m cells
  - GCS: WGS84 horiz. datum; EGM96 vert. datum
- 7 – 14m accuracy (varies by tile)
- *Version 1* of data release
  - Self described as "experimental" or "research grade"

Aster data – version 2

Released October 17th, 2011

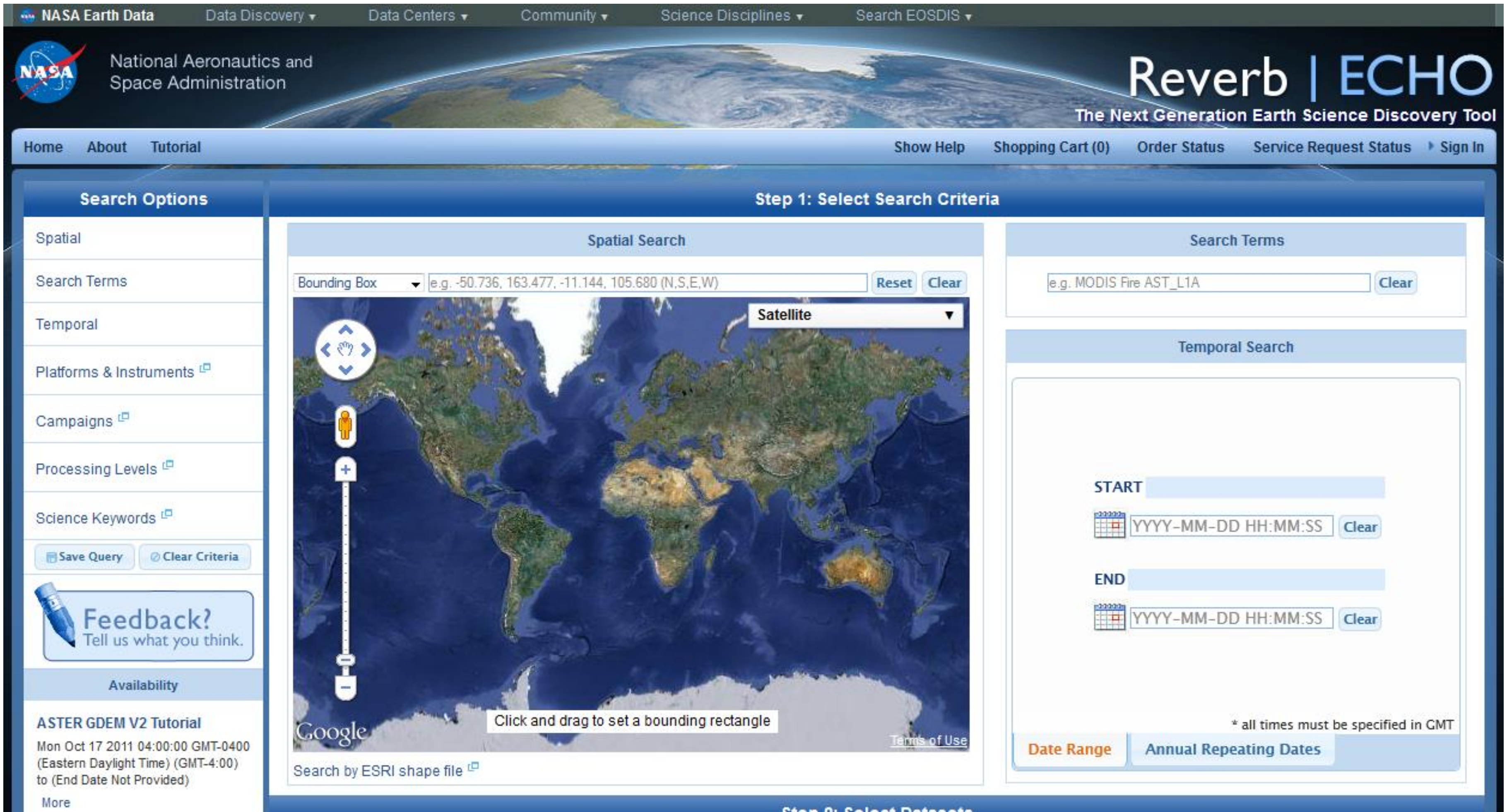
Improvements in product quality due specifically to:

- the increased number of acquired ASTER stereo pairs
- refinements to the production algorithm (water masking, smaller correlation kernel size, bias removal).

These improvements include increased horizontal and vertical accuracy, better horizontal resolution, reduced presence of artifacts, and more realistic values over water bodies

Obtaining ASTER data

- http://reverb.echo.nasa.gov



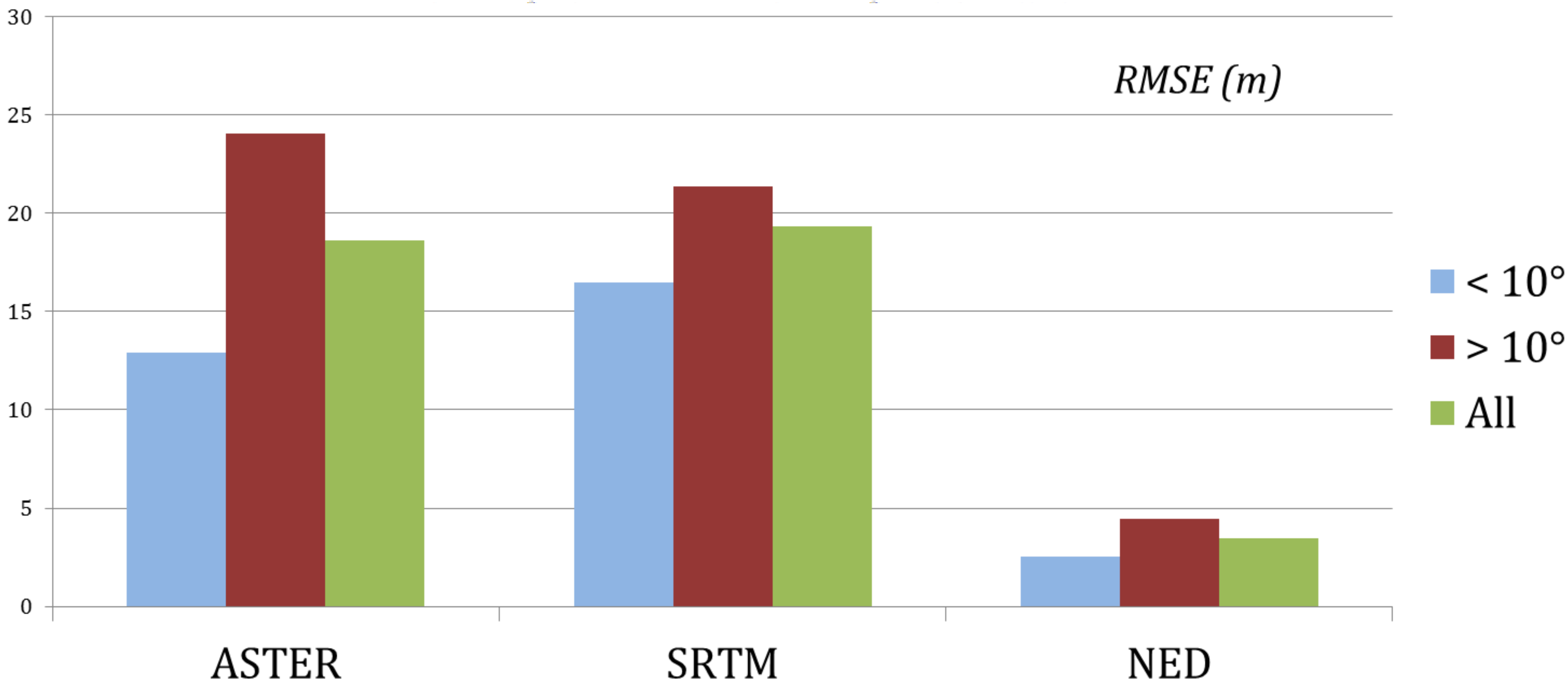
Comparing global digital elevation sources

	ASTER GDEM	***SRTM3***	***GTOPO30***
Data source	ASTER	Space shuttle radar	From organizations around the world that have DEM data
Generation and distribution	METI/NASA	NASA/USGS	USGS
Release year	2009 ~	2003 ~	1996 ~
Data acquisition period	2000 ~ ongoing	11 days (in 2000)	
Posting interval	30m	90m	1000m
DEM accuracy (stdev.)	7~14m	10m	30m
DEM coverage	83 degrees north ~ 83 degrees south	60 degrees north ~ 56 degrees south	Global
Area of missing data	Areas with no ASTER data due to constant cloud cover (supplied by other DEM)	Topographically steep area (due to radar characteristics)	None

http://www.ersdac.or.jp/GDEM/E/2.html

Comparing NED, STRM, ASTER

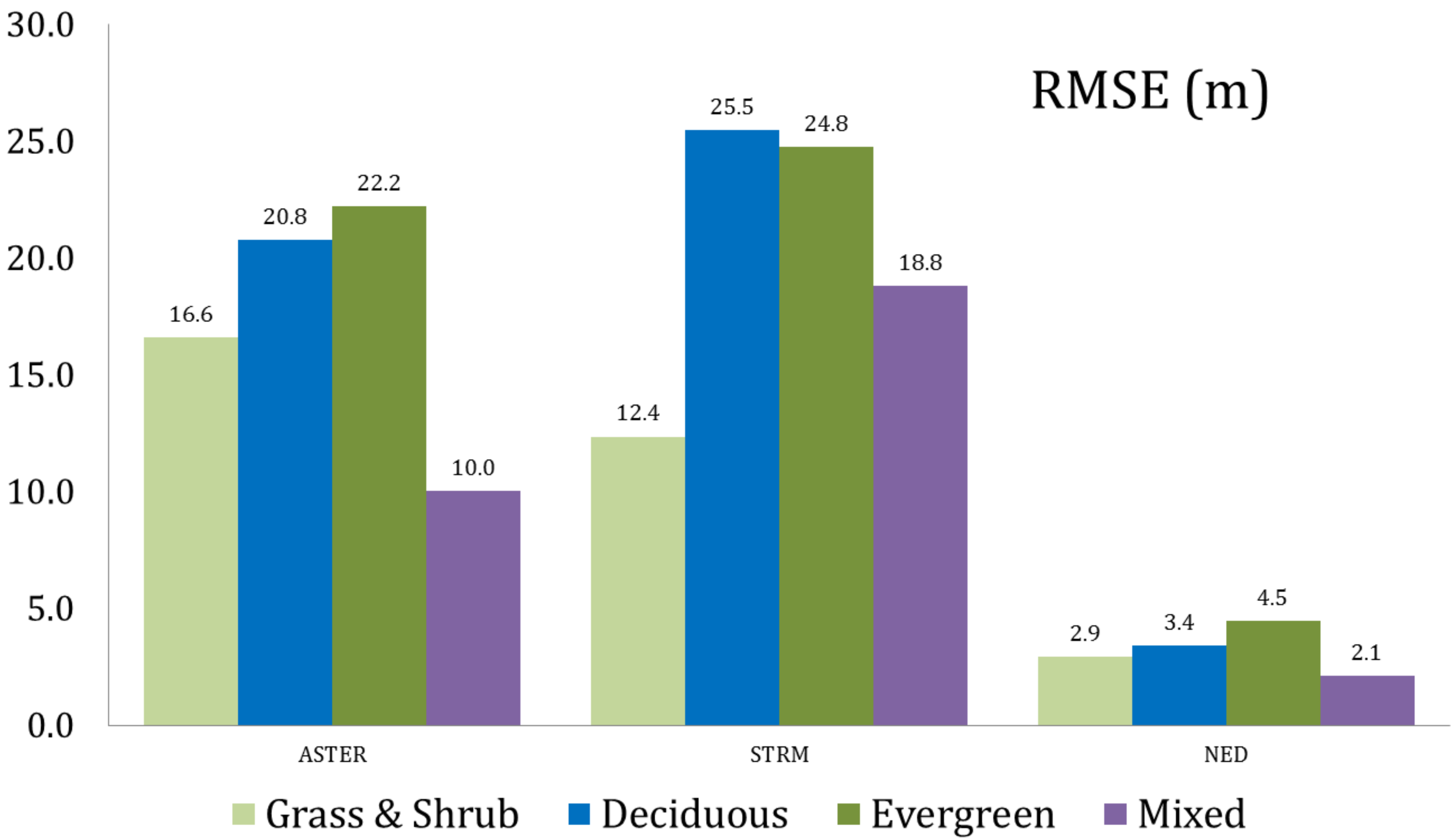
Table 3. Results of accuracy assessment of the remotely sensed DTMs versus the reference data for slopes less



Tighe and Chamberlain (2009)

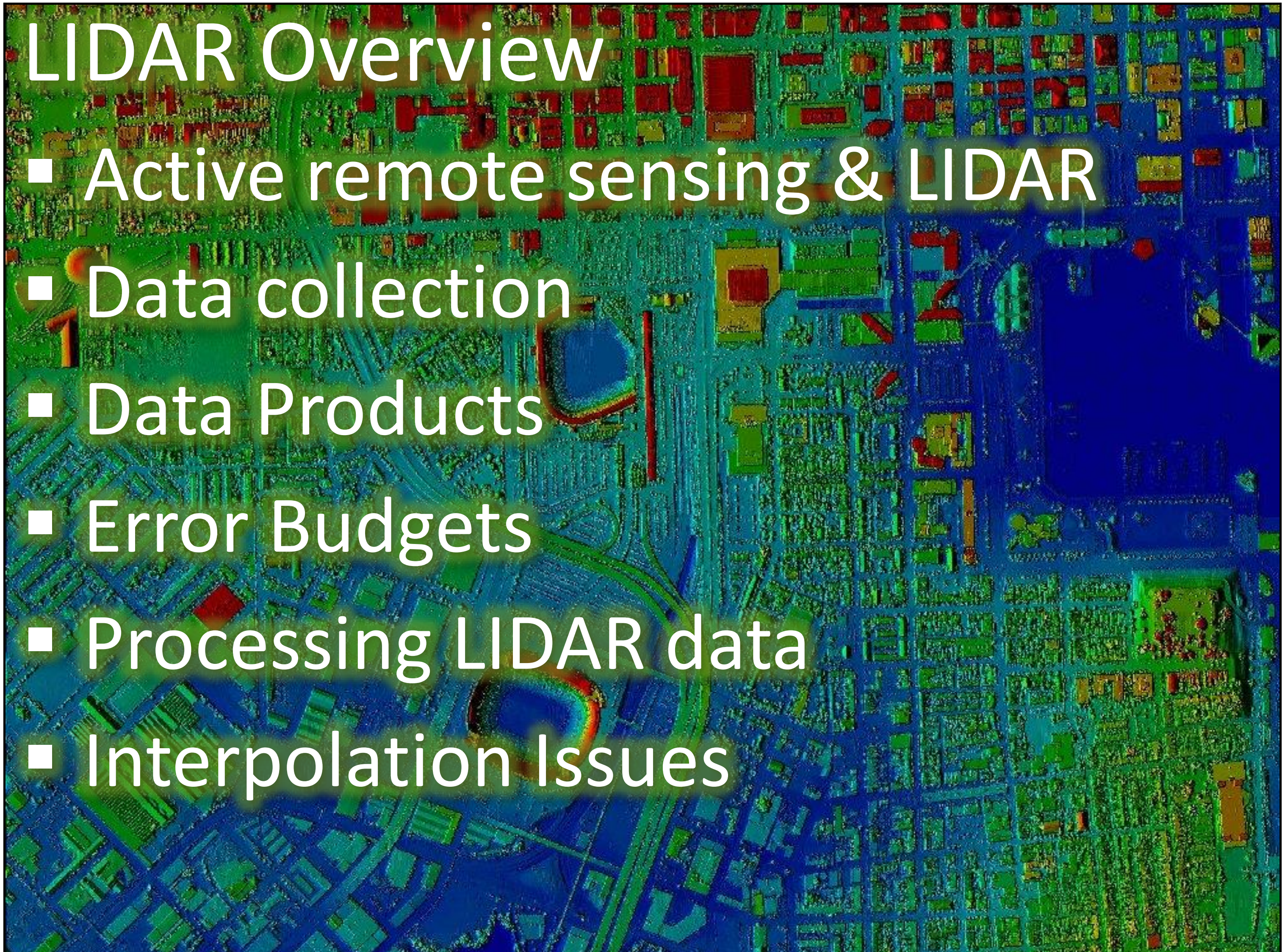
Comparing NED, STRM, ASTER

Table 4. Accuracy Assessment of DTMs with field collected GPS GCPs over the three land cover types.

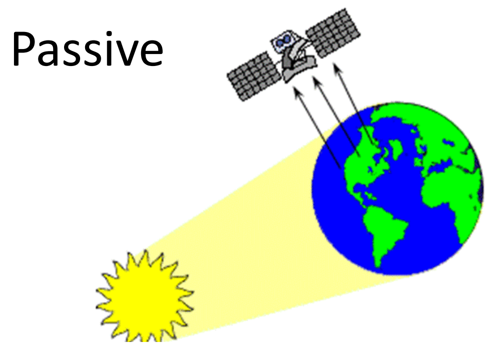


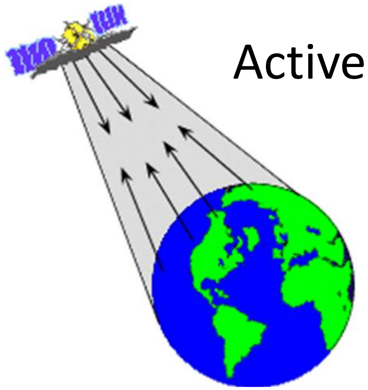
Tighe and Chamberlain (2009)

Light Detection and Ranging (LIDAR)



Active vs. Passive Remote Sensing





Active Remote Sensing

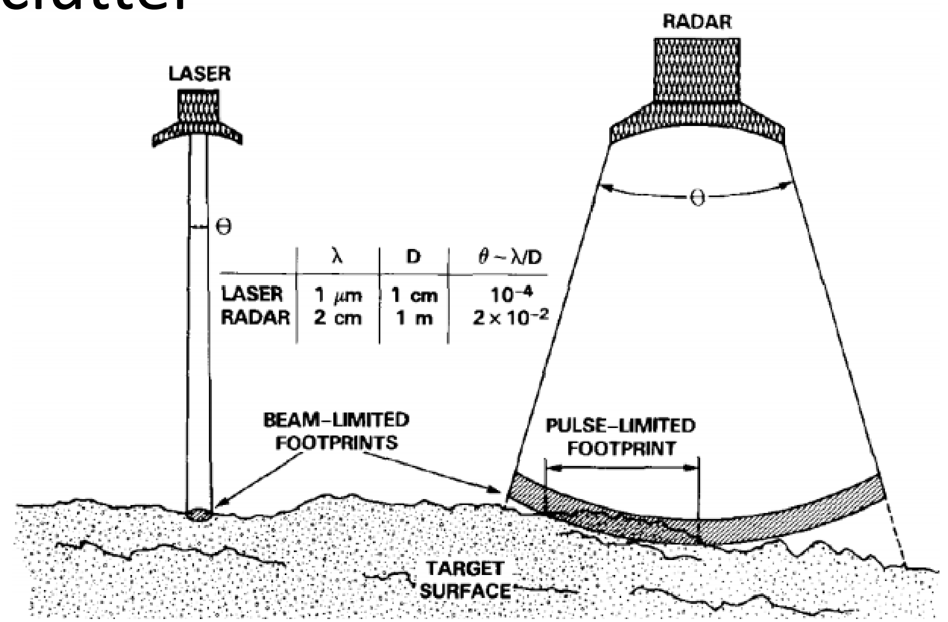
- Provides own source of energy for illumination
- Independent of natural light sources and time of day
- Reduced sensitivity to background light
- High intensity stimulating signal; less interference
- Control of stimulating signal
- Knowledge of stimulating signal

Images: Canada Centre for Remote Sensing

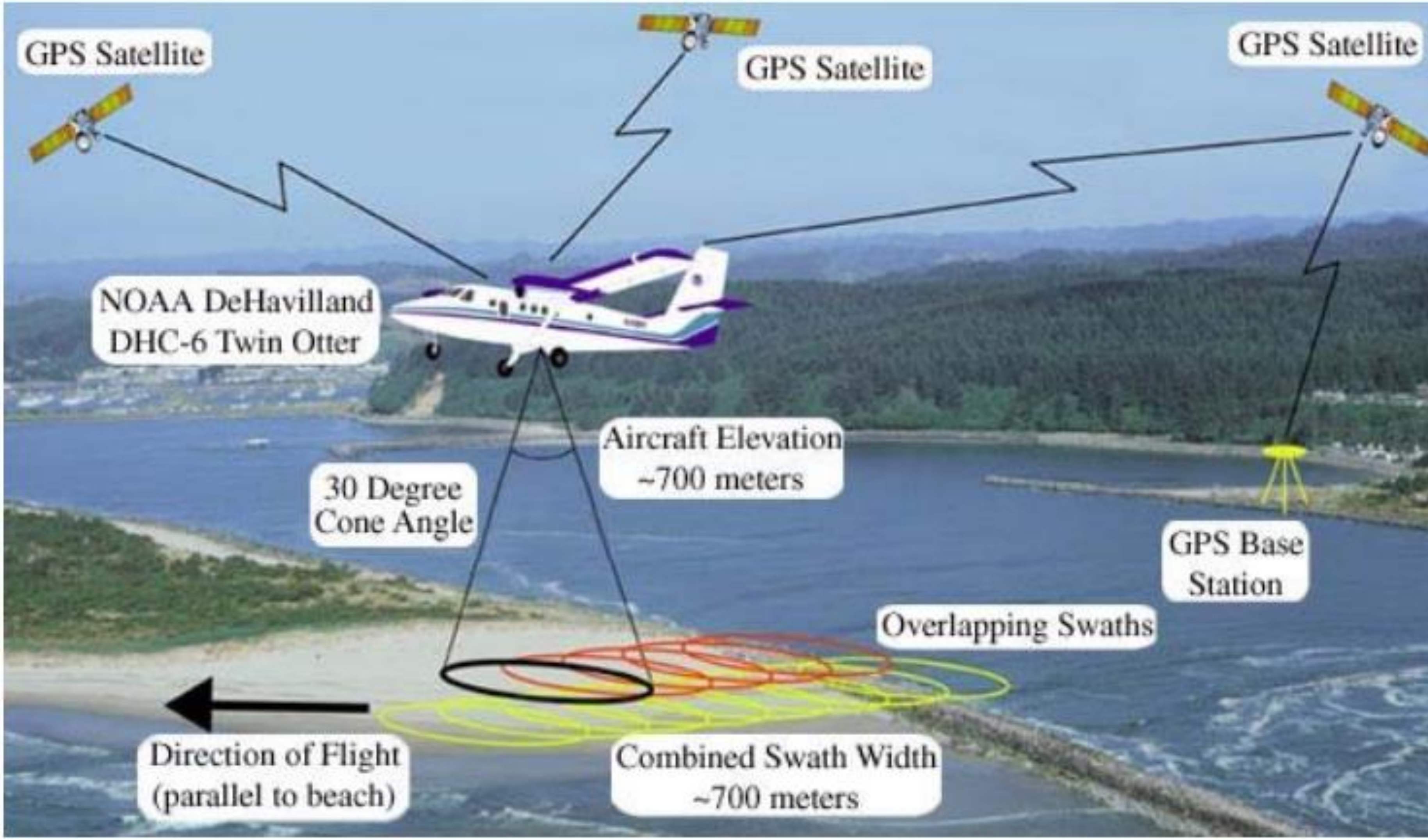
LIDAR *vs.* other active remote sensors

Lasers *vs.* microwaves (e.g. RADAR) or sound (SONAR)

- Easier aiming → better imaging
- Less diffraction → better spatial resolution
- Better angular range and Doppler resolution
- No sidelobes, no ground clutter
- Narrow spectrum → high coherence
- Tunable wavelength
- Polarization control
- No electromagnetic interference (EMI)

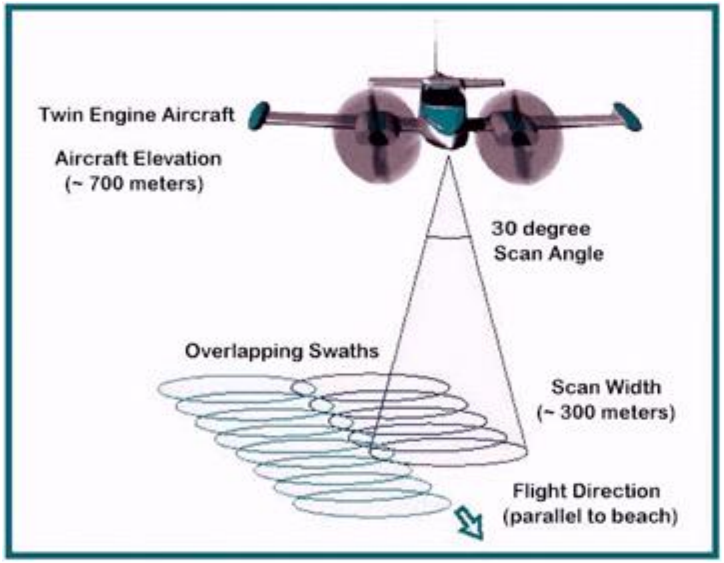


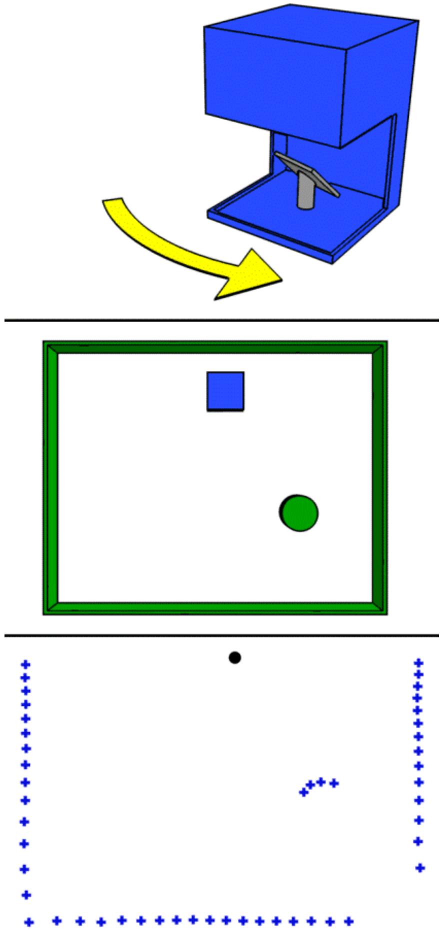
LIDAR: data collection



LIDAR: data collection

- System emits 5,000 – 50,000 pulses per second in a scanning array.
- Scanning angle, flying height, & airspeed determine point spacing .
- Pulses form a cylinder of light as rotating mirror deflects laser beam to ground



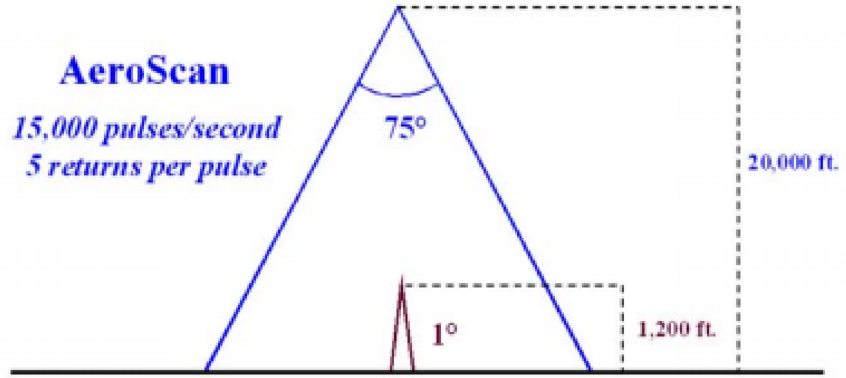


http://www.ncfloodmaps.com/pubdocs/lidar_final_jan03.pdf

LIDAR: Altitude, posting, and accuracy

Flight Altitude	Post Spacing	Vertical/Horizontal Accuracy
20,000 feet	12 meters	±0.6/1.5 meters
12,000 feet	8 meters	±0.30/1.0 meters
8,000 feet	5 meters	±0.25/0.50 meters
4,000 feet	2 meters	±0.20/0.30 meters

Depending on the coverage and point density required, a scan rate and field of view setting can be set to obtain the optimal result. The LIDAR instrument's field of view can vary from 5 to 75 degrees.



(From: EarthData)

LIDAR: data collection

LIDAR Echo Time To Measurement Range Conversion

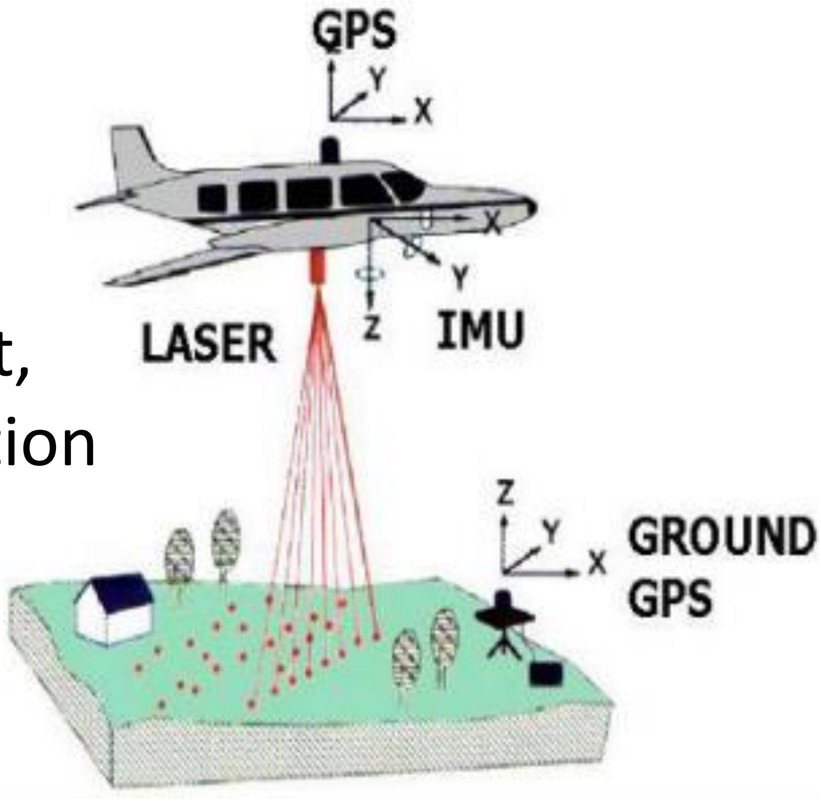
assume the speed of light, $c = 3.0 \times 10^8$ m/s

- 1 ns = 0.3 m = 11.8 inches
- 1 microsecond = 300 m = 984 feet
- 10 microseconds = 3 km = 1.86 statute miles = 1.61 nautical miles
- 100 microseconds = 30 km = 18.6 statute miles = 16.1 nautical miles
- 1 ms = 300 km = 186 statute miles = 161 nautical miles

LIDAR: data collection

- Onboard GPS determines the x, y, and z coordinates of the moving LIDAR sensor in the air, surveyed relative to one or more GPS base stations to increase precision.

- An Inertial Measuring Unit (IMU) directly measures the roll, pitch, and heading of the aircraft, establishing the angular orientation of the LIDAR sensor about the x, y, and z axes in flight.

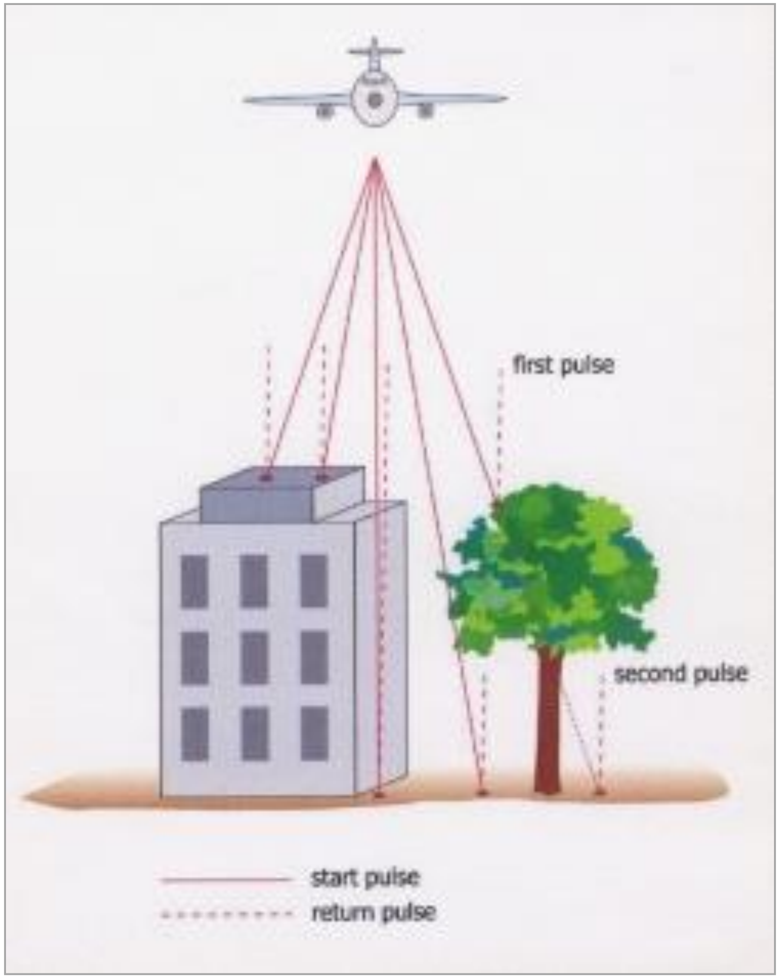


LIDAR: data collection

- The LIDAR sensor measures the scan angle of the laser pulses. Combined with the IMU data, this establishes the angular orientation of each laser pulse.
- The LIDAR sensor measures the time needed for each emitted pulse to reflect off the ground (or features thereon) and return to the sensor.

LIDAR data products: pulse returns

- Sensors can pick up multiple returns per pulse – up to 5.
- The first return is the first thing hit by the pulse (e.g. tree top, roof, bird in flight)
- If the target is soft, (e.g. forest canopy), some of the beam will penetrate giving a second return.
- The last return represents bare earth – *usually, but not always.*



Multiple LIDAR returns

Highest point (first return)

Mid-level LIDAR

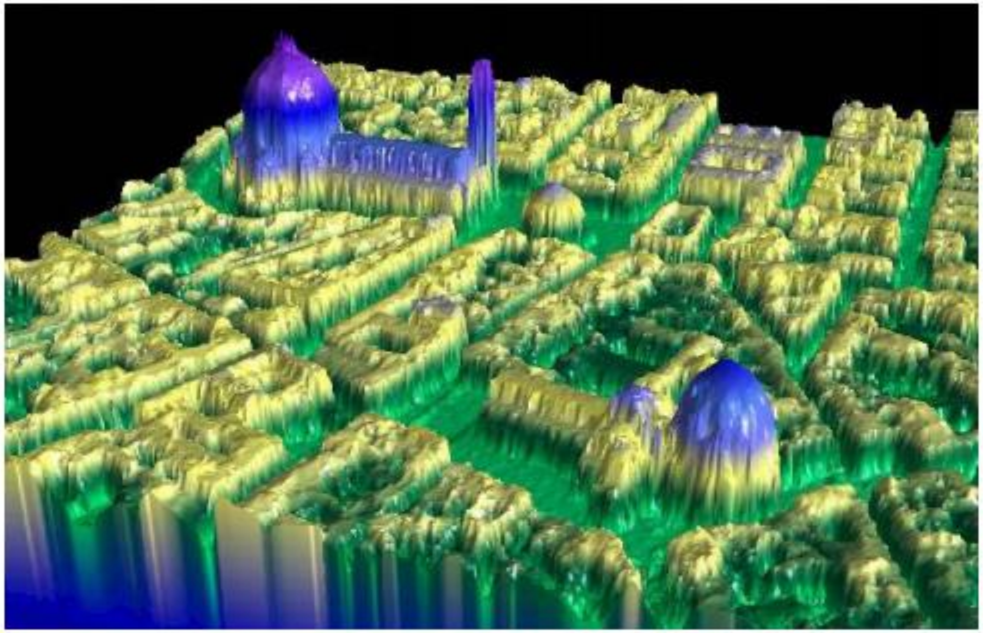
Bare Earth LIDAR

Images courtesy Great Britian Foresty Commission
http://www.forestry.gov.uk/forestry/INFD-6RVC9J

LIDAR: Post processing

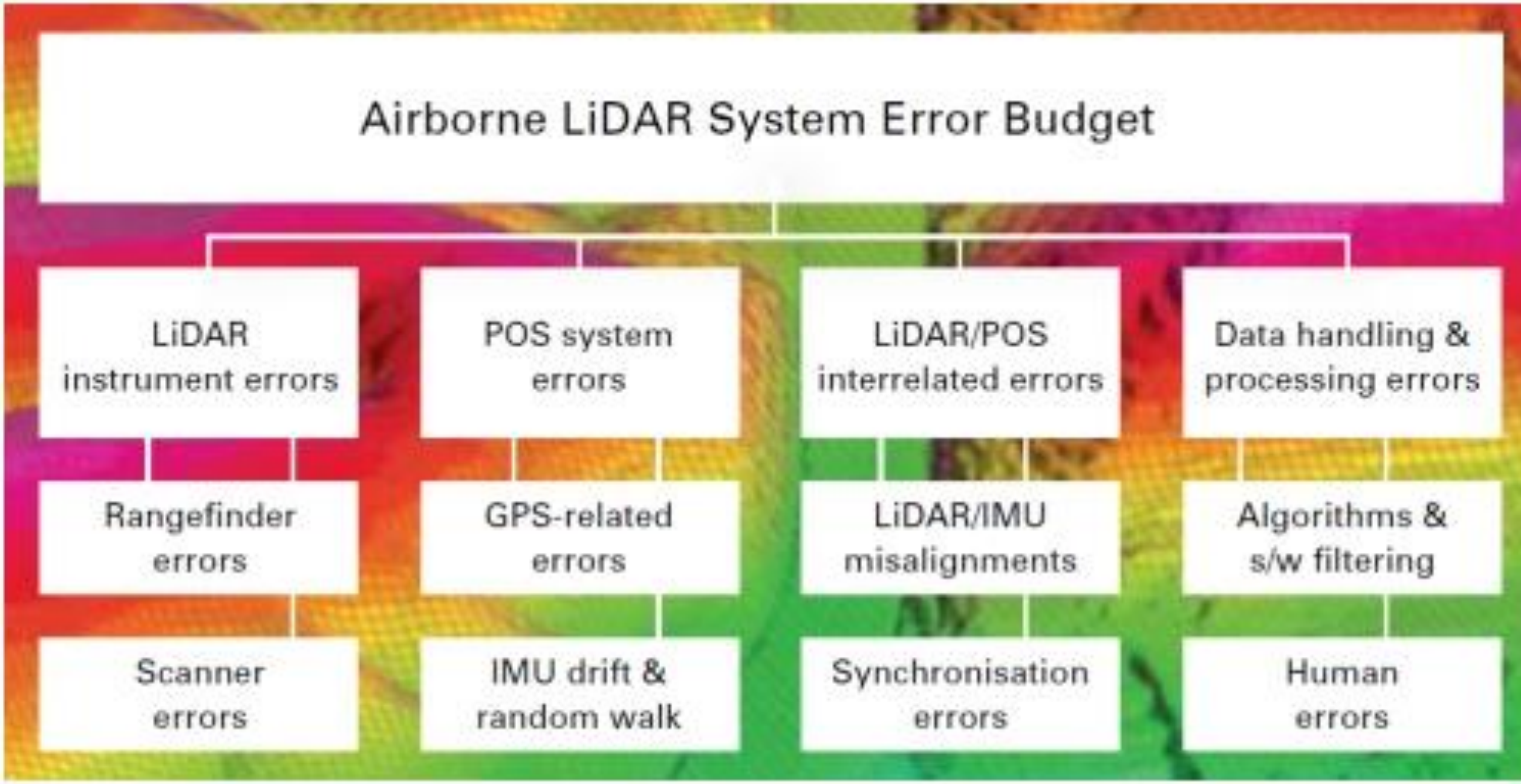
Need to filter out features you don't want to map:

Pre-Processed LIDAR Data in an Urban Area



- Automated post-processing to detect unnatural elevation changes (e.g. rooftops).
- Manual checking (against imagery) for more challenging circumstances (e.g. vegetation). $$

LIDAR: error budgets



https://www.e-education.psu.edu/lidar/l3_p9.html

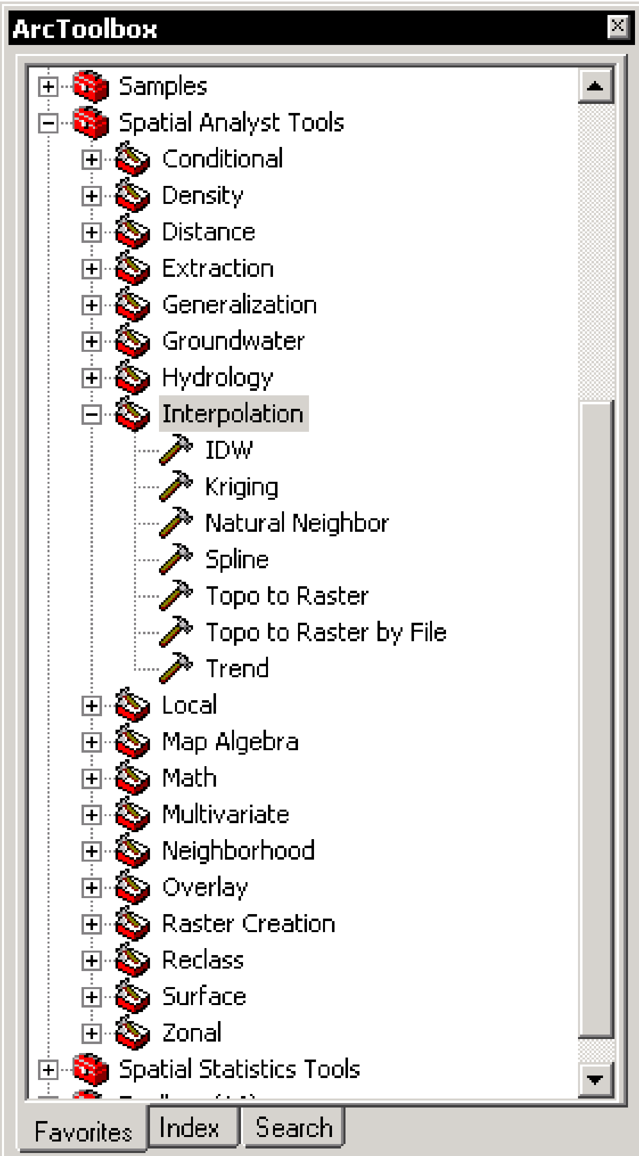
LIDAR: error budgets

- GPS Precision
- INS Precision
- LIDAR System Noise
- Timing Resolution
- Mechanical Tolerances (temperature, atmospheric pressure variations)
- Atmospheric Distortions (extreme ground temperature, haze).

These factors typically add up to an error budget of ± 12 - 15 cm for LIDAR data collection flown at 5,000’ AGL.

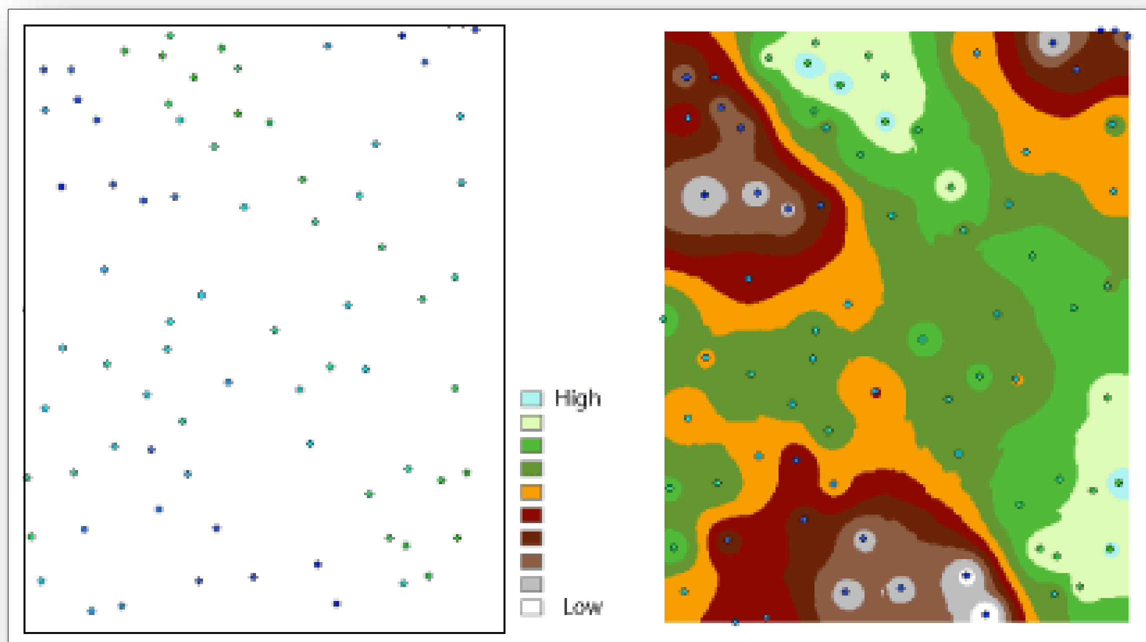
https://www.e-education.psu.edu/lidar/l3_p9.html

LIDAR Processing: Points to Surface

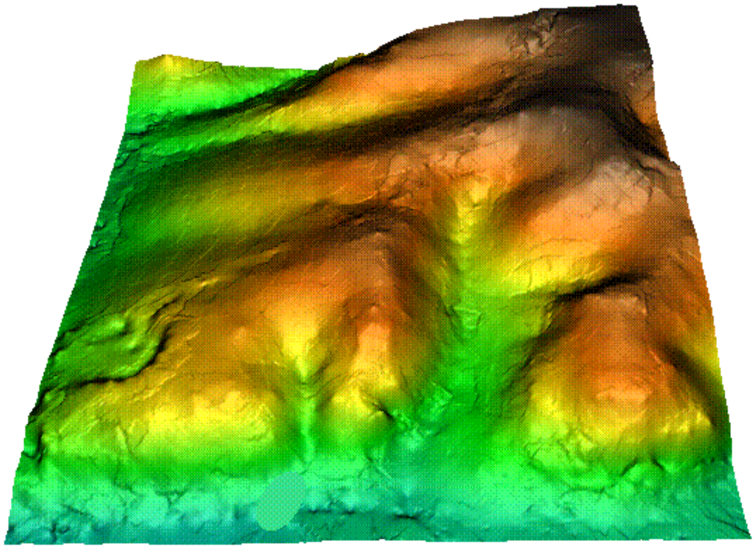


Spatial interpolation methods

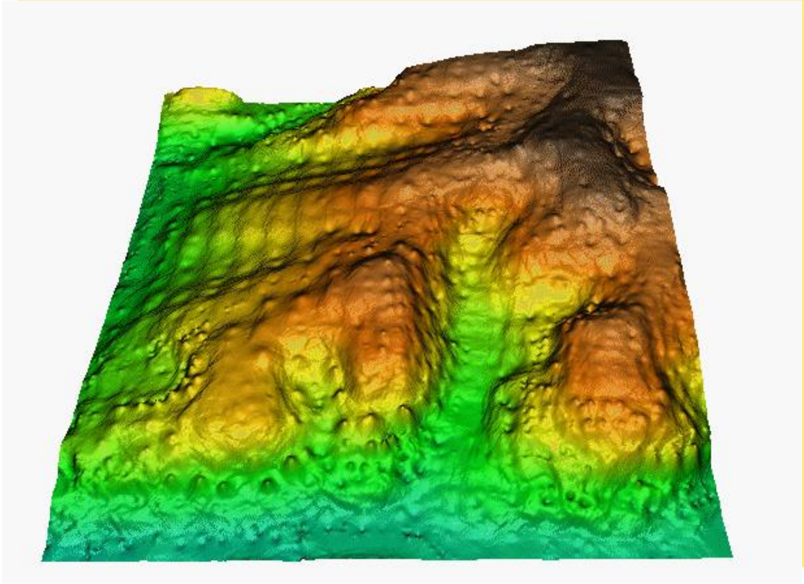
- Inverse Distance Weighting (IDW)
- Kriging
- Natural Neighbors
- Spline



LIDAR Processing: Points to Surface



Spline

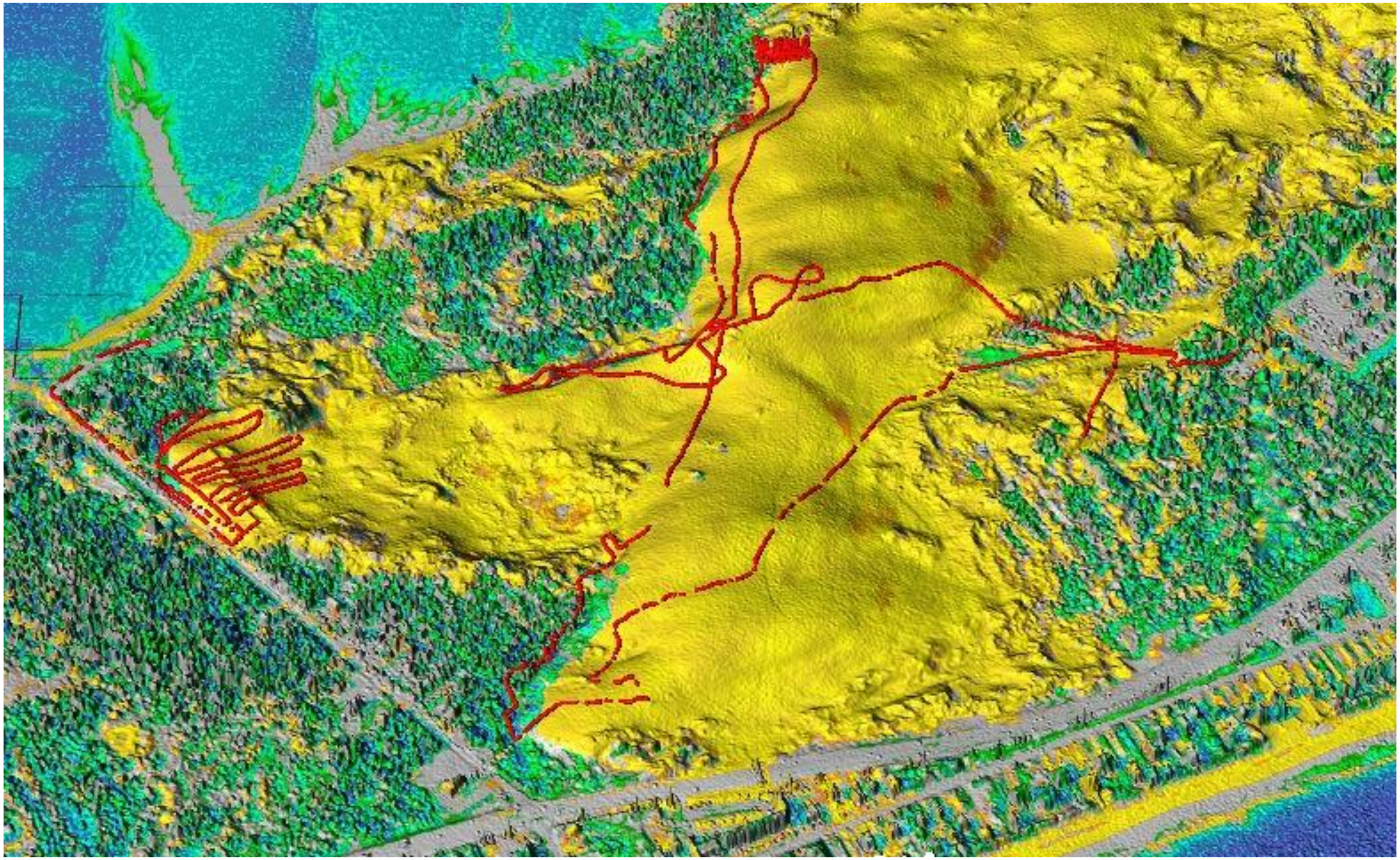


Inverse Distance Weighting (IDW)

Courtesy Graeme Aggett 2001

Interpolation Matters

Combining 98 IR-DOQQ, 99 LIDAR and 02 RTK GPS to assess the change: decreasing elevation, migration



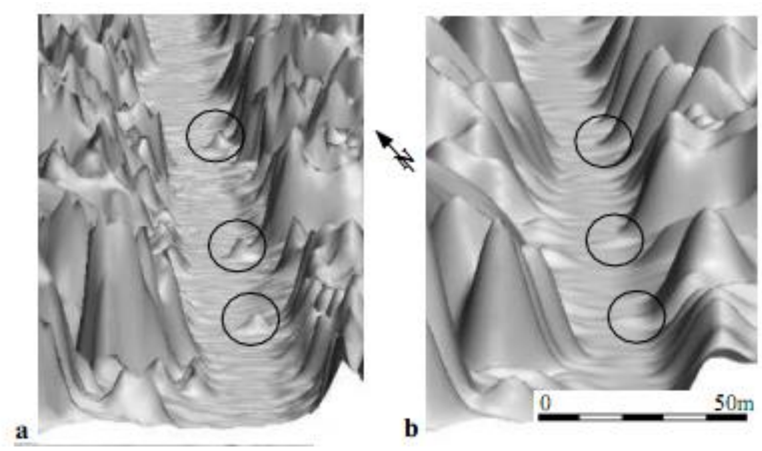
Height Year: m
1950: 43
1974: 34
1995: 27
1999: 26
2002: 24

H. Mitasova http://skagit.meas.ncsu.edu/~helena/publwork/talks2/frf05.ppt

LIDAR: Interpolation

Mitasova, et al 2005

- Importance of smoothing for the surface accuracy and noise reduction.
- Tension parameter is effective for tuning the level of detail in the elevation surface.



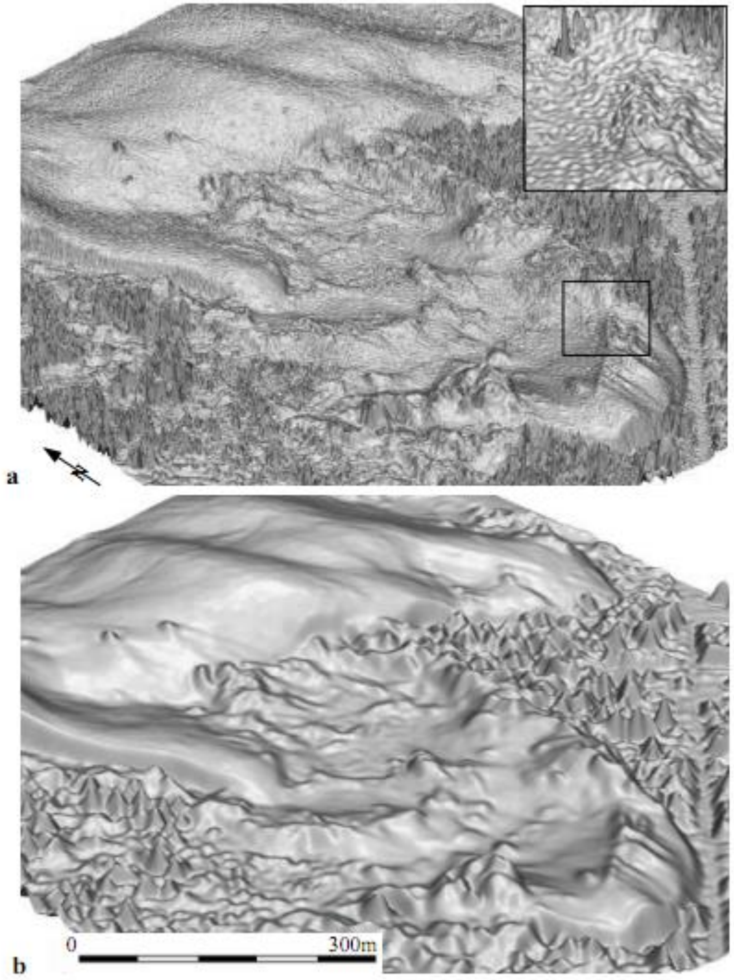
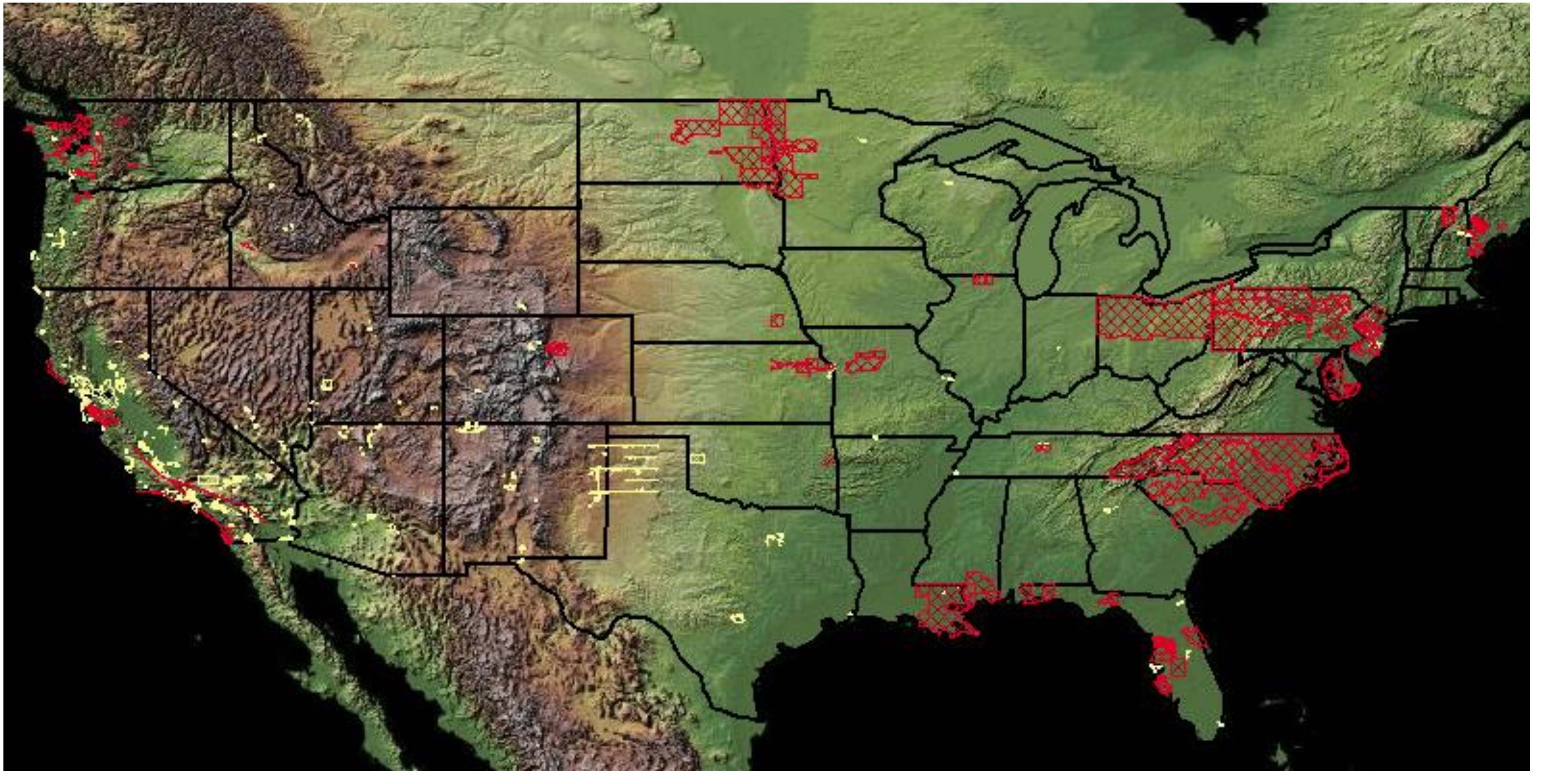


Fig. 2. Impact of tension φ and smoothing w on the 1999 DSM: (a) $\varphi = 400, w = 0.0$; insert shows overshoots for $\varphi = 100, w = 0.0$; (b) $\varphi = 100, w = 0.1$. The w and φ values are given for the RST implementation as *s.surf.rst* module run with the $-t$ flag [16].

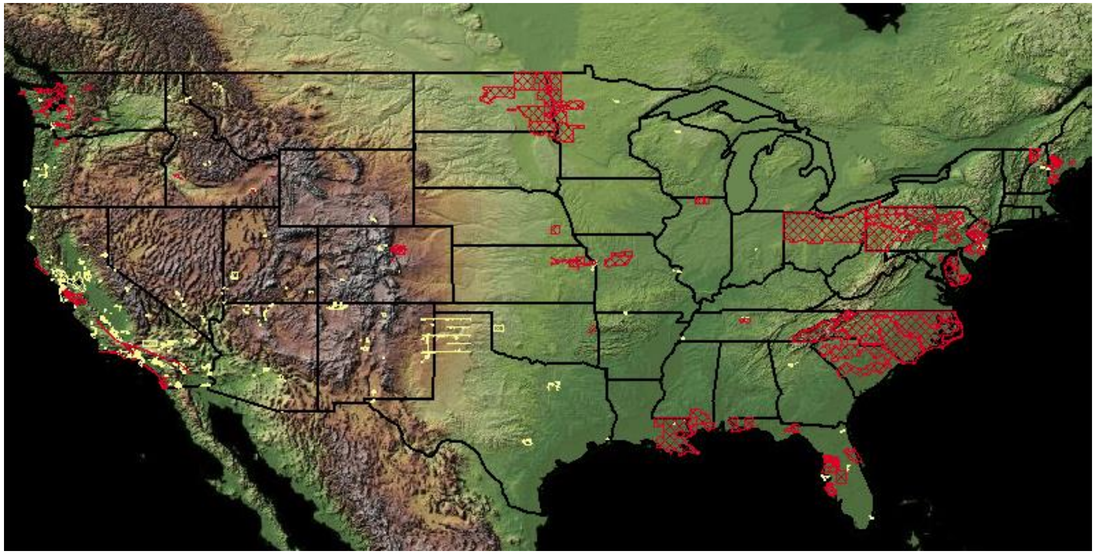
LIDAR: Data availability

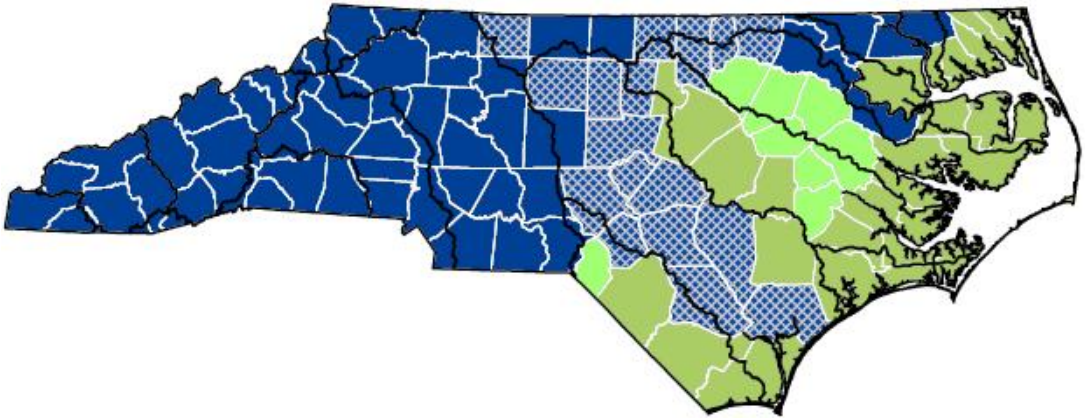
http://lidar.cr.usgs.gov/LIDAR_Viewer/viewer.php



LIDAR: Data availability

http://lidar.cr.usgs.gov/LIDAR_Viewer/viewer.php





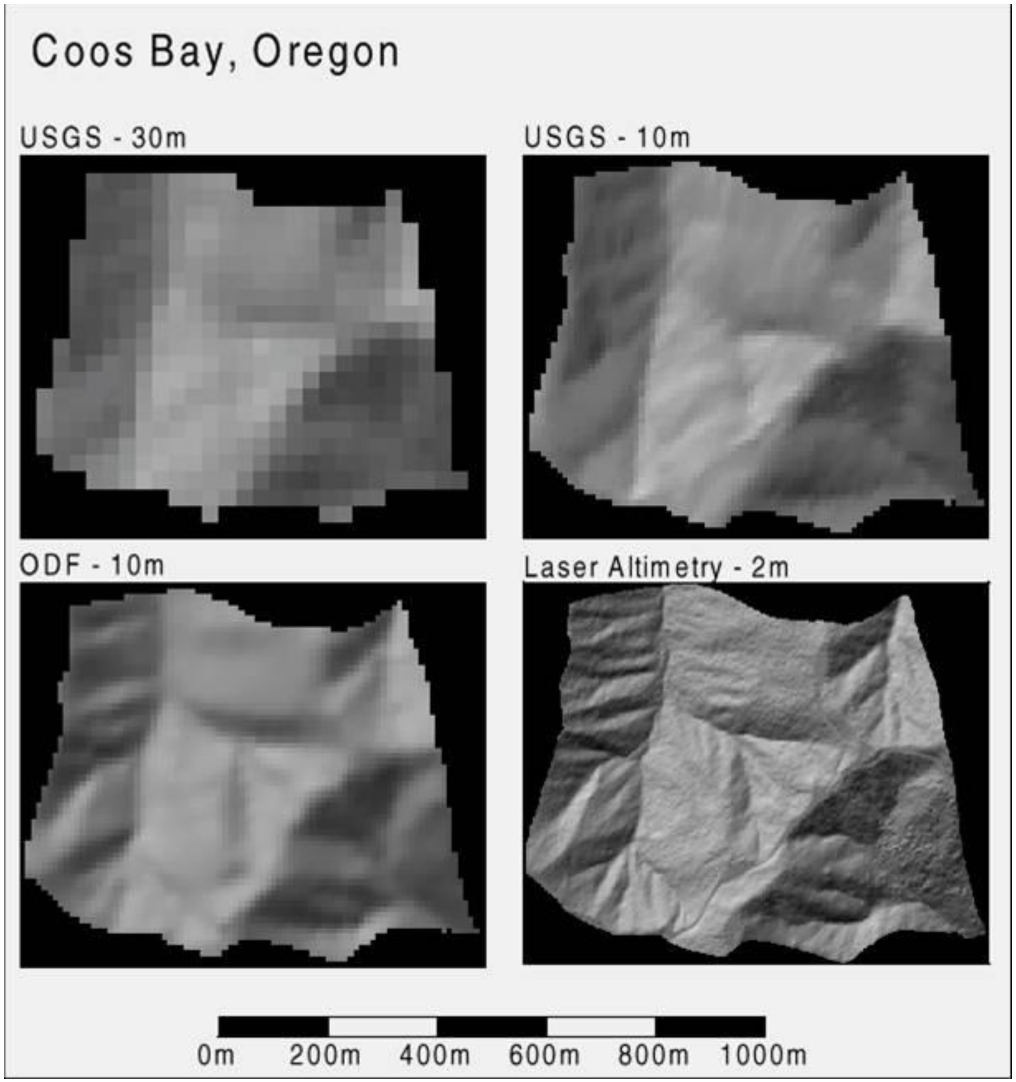
http://www.ncfloodmaps.com/

LIDAR: Advantages/Disadvantages

- – Costly to acquire
- – Costly to post-process
  - – Weed points
  - – Convert points to surface
- – Steep learning curve to use
- – Limited extent of available data

- + Massive amount of data collected fast
- + Superior resolution, detail
- + Multiple returns allows multiple outputs

Comparison of a USGS 30-meter DEM (upper left), a USGS 10-meter DEM (upper right), a 10-meter DEM from the Oregon Department of Forestry (lower left) and a LIDAR-derived 2-meter DEM (lower right).
Courtesy of EarthData International.



Some additional data links:

- NHD+: http://www.horizon-systems.com/nhdplus/
- EDNA: http://edna.usgs.gov/
- HydroSheds: http://hydrosheds.cr.usgs.gov/