High-resolution Airborne Laser Swath Mapping DEM's for ICESat Calibration/Validation

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Selection Criteria of Cal/Val. Sites

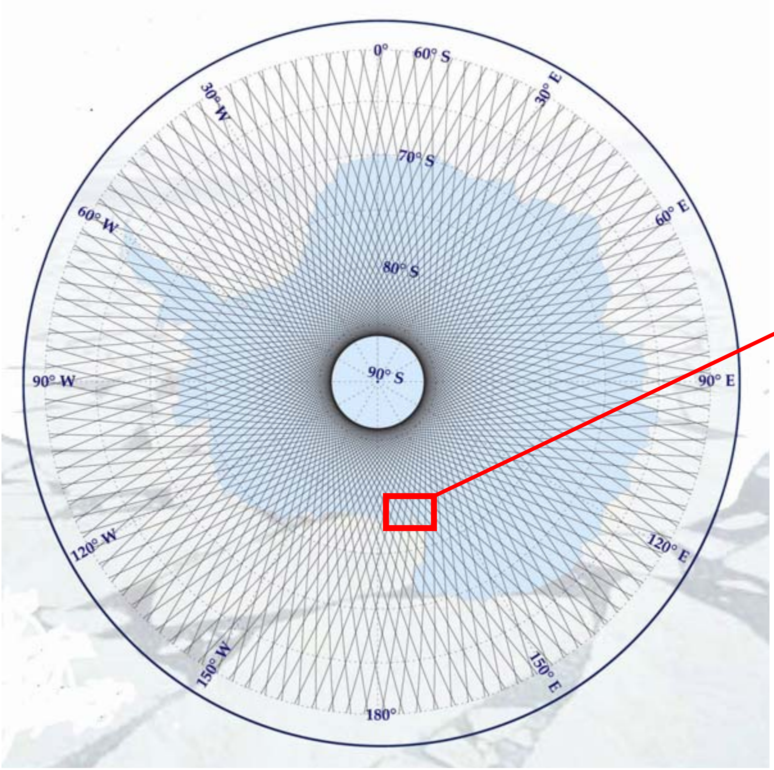
- Stable surface during ICESat lifetime
- Minimal interannual variability (preferably no vegetation or snow/ice cover)
- Minimal cloud cover
- Smooth surface at the scale of the ICESat footprint
- Diverse topography (flat, sloping, undulating and rough)
- Surface slope with different magnitude and aspects to decorrelate attitude and range biases
- High track density of ICESat orbits to ensure frequent revisits
- Sites are needed at areas with different ICESat orbital altitude to resolve range scaling errors
- Sites in polar regions are close to science targets

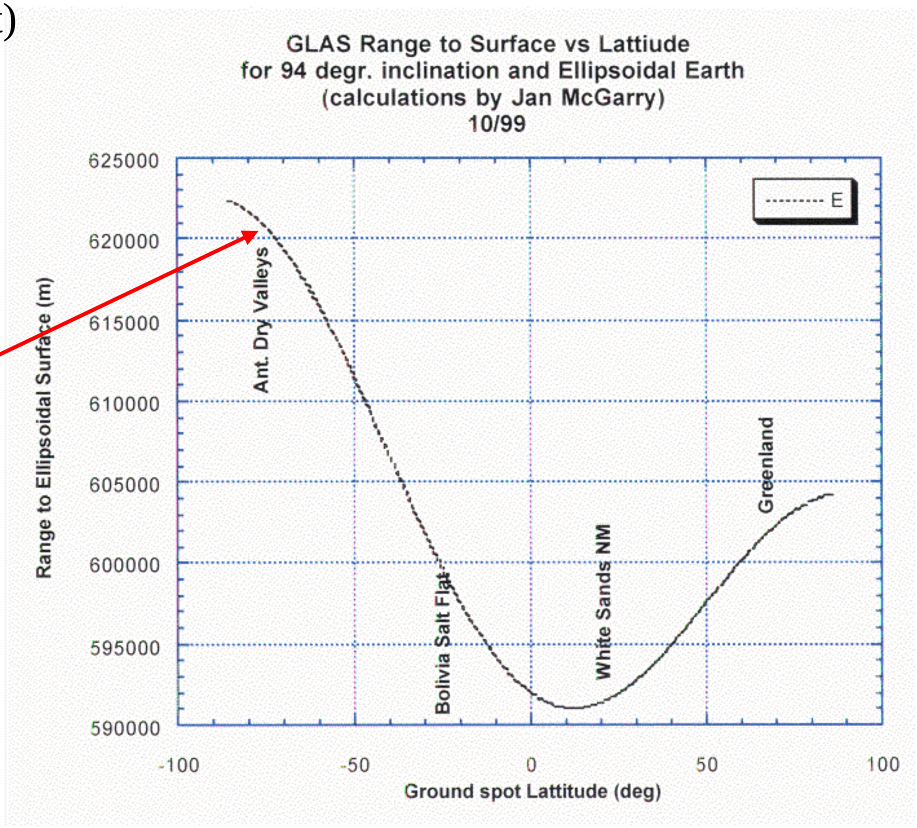
ICESAT calibration/validation site

Dry Valleys, Antarctica (77-79°N, 158-168°E)

Dry Valleys fulfill most of the site selection criteria:

- High track density (left)
- Maximum range part of ICESat orbit (right)

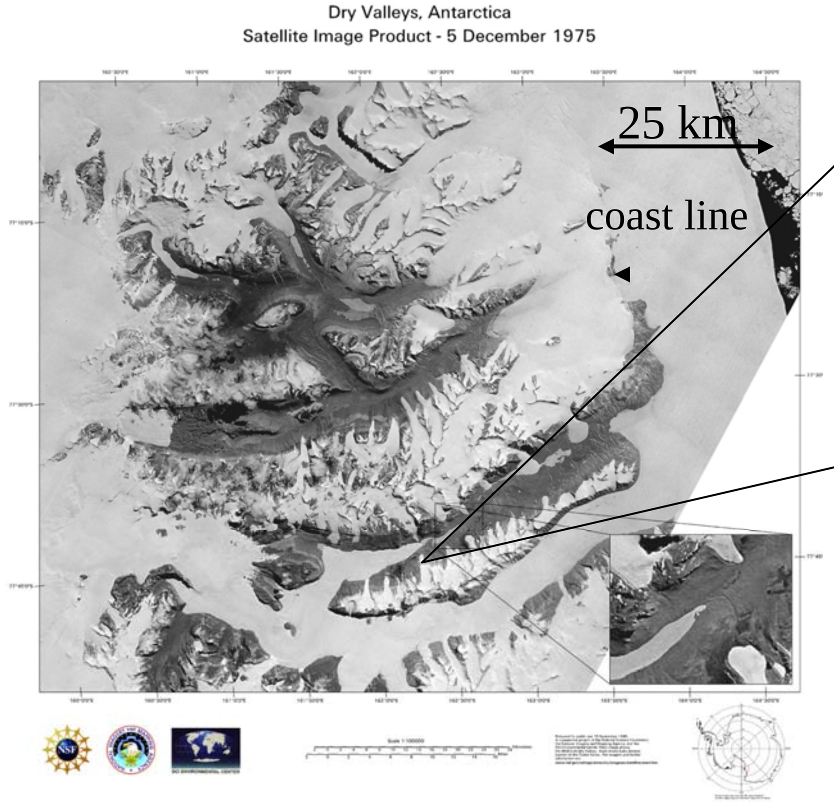


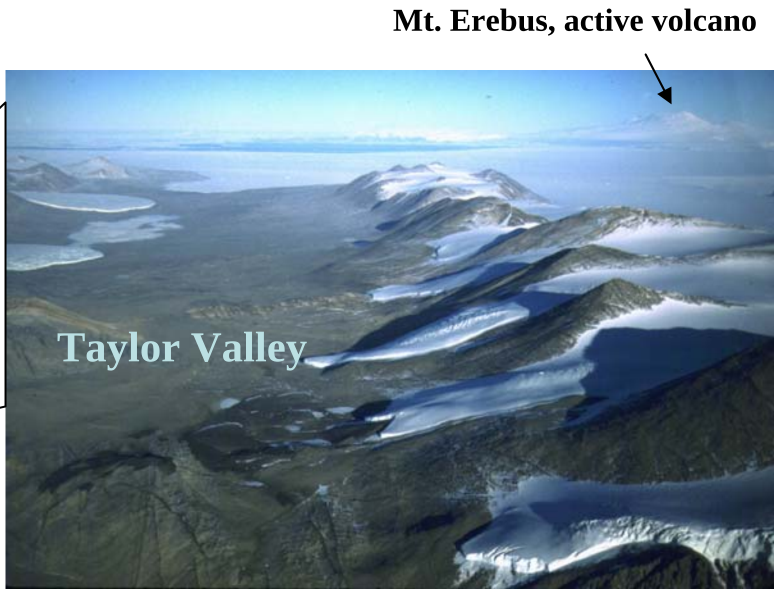


ICESAT calibration/validation site

Dry Valleys, Antarctica (77-79^{o}N, 158-168^{o}E)

- Stable surface during ICESat lifetime
- No vegetation and minimum snow/ice cover in valleys (gray areas: exposed rocks, white: snow and ice)
- Minimal cloud cover
- Diverse topography (flat, sloping, undulating and rough)
- Surface slopes with different magnitude and aspects to decorelate attitude and range biases





Data Acquisition

- To obtain precise elevations the ICESat cal/val sites and other sites of scientific interest were mapped by airborne laser scanning in the McMurdo Dry Valleys and over the Southern Victoria Land Cenozoic volcanoes
  - Joint project of NASA/NSF/USGS
  - Data acquisition with NASA's ATM conical laser scanning system in December 2001
  - Average laser point density is 0.1 – 0.5 point/m^2

DEM Generation Processing Steps

NASA WFF	Data acquisition	GPS/INS/range/intensity/....
	Data processing	t/long/lat/elevation/....
OSU	Database generation	flat file to relational DB
	DEM generation	2m x 2m, 4m x 4m regular grid
	DEM quality control	relative/absolute accuracy
USGS	Data dissemination	DEM/'clean' laser points/....

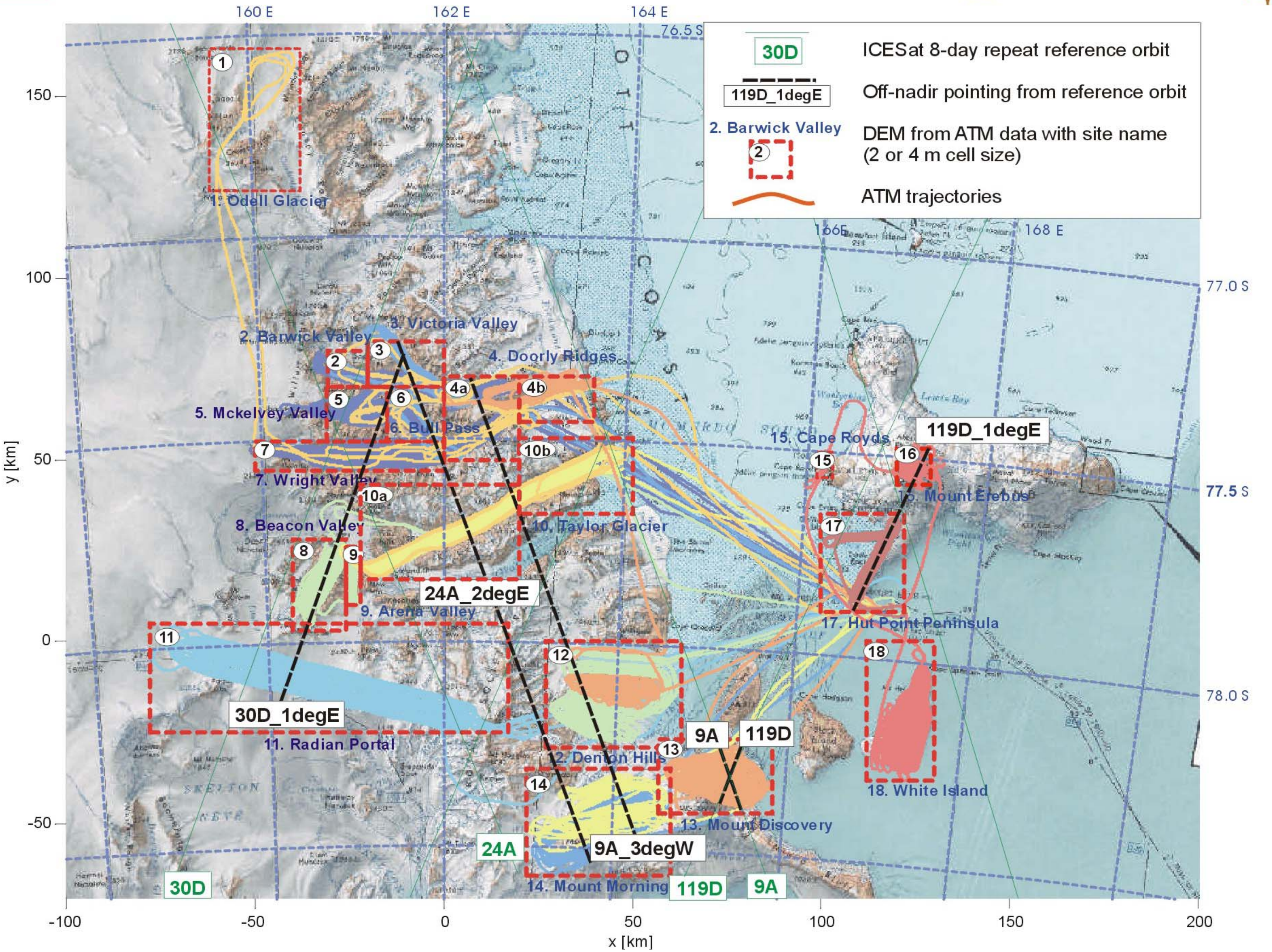
Generating Database

- Antarctica laser point data set contains over 1.2 billion points, stored on 23 DVDs in over 300 files, sequentially organized by flight lines
- Database required to perform queries with multiple criteria
- Oracle 9i with spatial option was selected
  - data table contains laser points and auxiliary data
  - index tables help to accelerate queries
  - disk capacity needed: approx. 90 GB
  - multiple queries possible, geared towards spatial criteria
    - find points within a specified polygon
    - find points within a search radius of a given point

Generating DEM

- Blunder detection
  - unusual large amount of blunders due to rapid change in albedo and atmospheric conditions
- Boundary definition
  - original laser points are organized by flight lines NOT by project sites (one flight line may cover different sites)
- Grid interpolation
  - surface fitting with robust estimator
  - label grid posts based on fitness error and point distribution
- Quality control
  - internal, e.g. fitness error during interpolation, visualization
  - external, e.g. with GPS control points

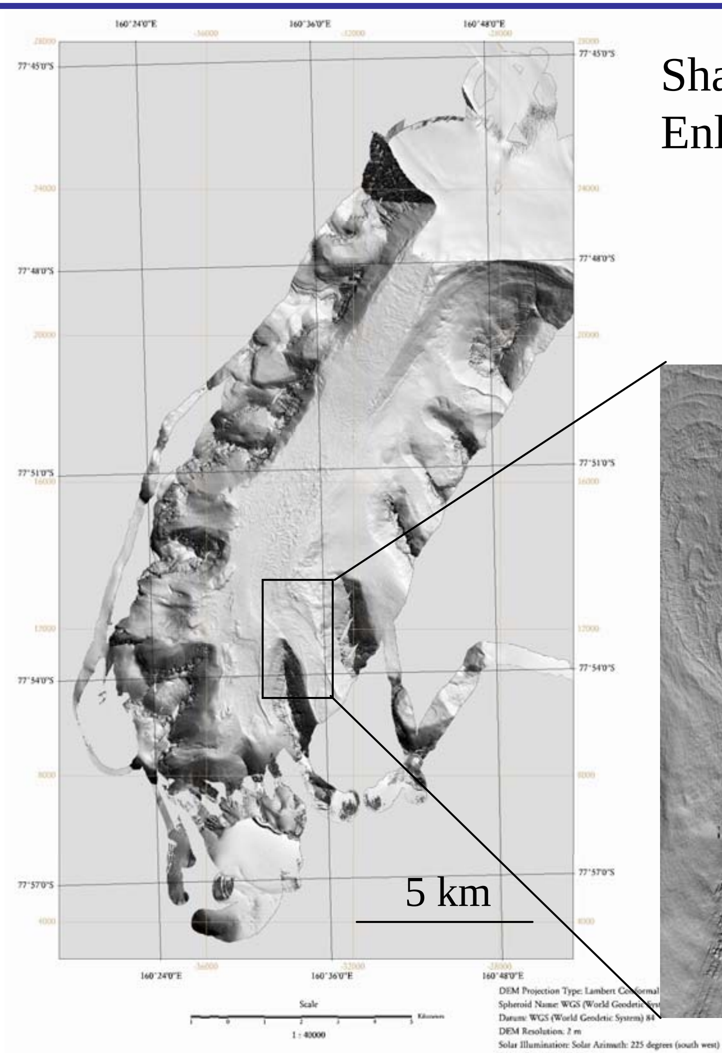
DEMs from ATM scanning laser altimetry data around McMurdo Sound, Antarctica



Accuracy of DEMs
Data Distribution

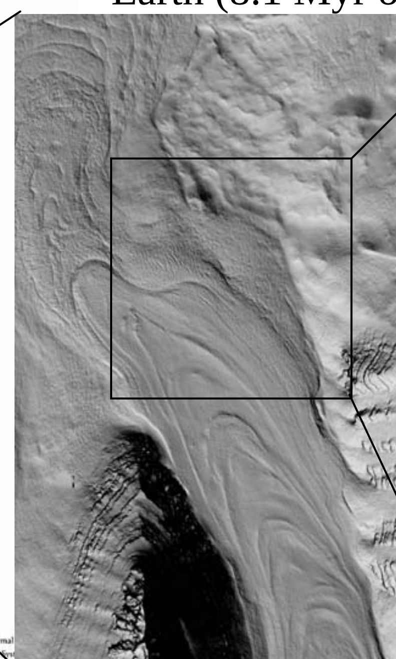
- Accuracy of DEM
  - Internal accuracy is measured by residual of plan fitting within grid cells, and stored in a "label" matrix. For most DEM cell it is better than 10 cm
  - Absolute accuracy of 0.05+-0.5 m is estimated by comparison with 80+ ground GPS points.
    - Most of these GPS positions refer to the antenna phase center and its exact height above the topographic surface is not known. Therefore the RMS error of the DEM might be overestimated → accuracy studies are ongoing
- Data distribution:
  - preliminary data release for NSF PIs and NASA ICESat investigators was in February 2003, final data release is expected in August 2003
  - For information on the data set contact Bea Csatho, OSU, csatho.1@osu.edu or visit http://www-bprc.mps.ohio-state.edu/ohglas/glid_icesat.htm
  - To obtain the data contact Cheryl Hallam, USGS, challam@usgs.gov

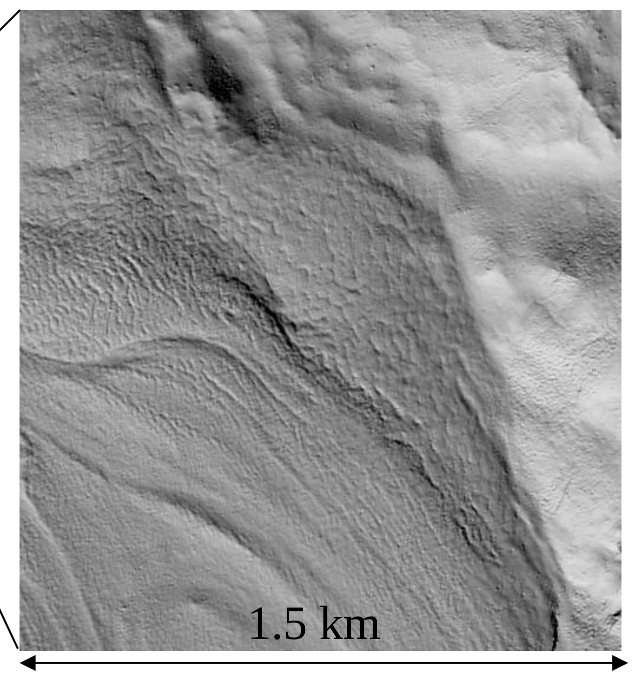
Example 1: Rock glacier and polygons in Beacon Valley



Shaded relief map of Beacon Valley DEM (left)
Enlargements show details of

- Patterned ground, non-sorted polygons (3-20m diameter, troughs: < 2 m deep)
- Surface of rock glacier that might cover the oldest ice on Earth (8.1 Myr older?)





Example 2: Volcanoes and volcanic cones Mt. Erebus (left) and cone alignment on the N slope of Mt. Morning (right)