ICESat-2 and ATLAS: Next Steps in Ice Sheet Laser Altimetry

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Recent Evolution of Ice Sheet Laser Altimetry

ICESat (2003-2009)
Geoscience Laser Altimeter System (GLAS)

Airborne LiDARs

eoPortal Directory (2016)
ICESat-2 (2017-?)
Advanced Topographic Laser Altimeter System (ATLAS)
Two Generations: GLAS and ATLAS

NASA (2015)

Debora McCallum, NASA (2015)
How does ATLAS stack up?

Table 1. Specifications for current satellite and airborne laser altimetry systems compared with those proposed for the ICESat-2 system. Estimated precision (1σ) is based on system performance over ice sheets, with the exception of GLAS where precision refers to performance over sea ice.

<table>
<thead>
<tr>
<th>System</th>
<th>Footprint size</th>
<th>Along-track sampling</th>
<th>Wavelength</th>
<th>Altitude</th>
<th>Swath width</th>
<th>Scanning/profiling</th>
<th>Estimated precision (1σ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airborne Topographic Mapper (ATM)</td>
<td>~1–2 m</td>
<td>~5 m</td>
<td>532 nm</td>
<td>~500 m</td>
<td>150–300 m</td>
<td>Scanning</td>
<td>~10 cm*</td>
</tr>
<tr>
<td>Land, Vegetation and Ice Sensor (LVIS)</td>
<td>10–25 m</td>
<td>Contiguous</td>
<td>1064 nm</td>
<td>10 km</td>
<td>2 km (~80 beams)</td>
<td>Scanning</td>
<td>~6 cm†</td>
</tr>
<tr>
<td>Geoscience Laser Altimeter System (GLAS) on ICESat</td>
<td>~50 m</td>
<td>172 m</td>
<td>1064 nm</td>
<td>600 km</td>
<td>50 m (single beam)</td>
<td>Profiling</td>
<td>~2 cm†</td>
</tr>
<tr>
<td>Advanced Topographic Laser Altimeter System (ATLAS) on ICESat-2</td>
<td>10 m</td>
<td>50 cm</td>
<td>532 nm</td>
<td>600 km</td>
<td>6 km (3 sets of beam triplets, with 3 km separation)</td>
<td>Profiling</td>
<td>~10 cm†</td>
</tr>
</tbody>
</table>

ATLAS Measurement Concept

NASA (2016)

NASA (2016)
Simulated Data

● Why use them?
  ○ Establishment of familiarity with micropulse LiDAR (MPL) data
  ○ Differences between simulated and measured heights → calibration and validation of ICESat-2 data products

● Airborne MPL datasets comparable to ICESat-2 products
  ○ Sigma Space MPL → land ice and vegetation data over MD, NJ, and Greenland
  ○ Multiple Altimeter Beam Experimental Lidar (MABEL) → designed specifically as an airborne simulator for ICESat-2
  ○ MATLAS → reproduces expected performance of ATLAS, generated from MABEL granules
  ○ Slope Imaging Multi-polarization Photon-counting LiDAR (SIMPL) → flies lower than MABEL with four collocated beams; vegetation data over the East Coast and water and snow data over Lake Erie
Simulated Data Products ATL03 and ATL06

| Product Number | Name                     | Short Description                                                                                                                                                                                                 | Latency*
|----------------|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------
| ATL03          | Global Geolocated Photon Data | Precise lat, long and height above ellipsoid for all received photons determined using POD and PPD. Along-track data, per shot per beam. Geophysical corrections applied. Classification of each photon (signal vs. background) and into surface types (land ice, sea ice, ocean, etc...). | 21 days |
| ATL06          | Land Ice Height          | Surface height for each beam, along and across-track slopes calculated for beam pairs. All parameters are calculated at fixed along-track increments for each beam and repeat.                                             | 45 days |

Latency: the approximate elapsed time between data acquisition on a satellite and its meaningful delivery to the user

The ATL06 data product is of a higher “level” than the ATL03 data product

NASA (2015)
Sample Processing: Ground Track 462, Pair 3
Sample Processing: Ground Track 462, Pair 3
Sample Processing: Ground Track 462, Pair 3
Sample Processing: Ground Track 904, Pair 1