OMG: Oceans Melting Greenland

- How much are the Oceans Melting Greenland?
  Warm water is melting glaciers that flow into the oceans, but it lies hundreds of meters below the surface, making remote sensing difficult.

- Need ocean obs. to track spread of warm water

- Need Ice obs. to quantify ocean impact on glacier loss

Proposed Observations:
Yearly aircraft campaigns to deploy expendable temperature/salinity profilers, measure ice loss at the continental margin & map shape and depth of the sea floor on the shelf and in fjords.

Goals: Understand and characterize interactions between the oceans and ice loss on Greenland, pave the way for improved sea level predictions, and relate subsurface conditions to remotely sensed observables.
**OMG Mission Concept**

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<tr>
<th>Ocean</th>
<th>Ice</th>
<th>Sea Floor</th>
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<td>AXCTD Survey</td>
<td>GLISTIN Survey</td>
<td>AirGRAV survey</td>
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<tr>
<td>Deploy expendable temp. &amp; salinity profilers every 50 km in key self regions</td>
<td>Elevation changes in 10km swath of marine terminating glaciers near ocean</td>
<td>Ship-based</td>
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- **Once per year surveys**
  - Airborne gravity measurements (AirGRAV)
- **One time surveys**
  - Ship-based acoustic campaign to sample key fjords & ground truth AirGRAV
AXCTD probes

Aircraft eXpendable Conductivity Temperature Depth Probe (AXCTD)

- Air-launched expendable probes
- Off-the shelf (decades-long heritage)
- 1000 m depth range
- FM radio transmission of data to aircraft
- Approx. 5 kb per profile
- Cost: ~$2k per probe.

### PROBE SPECIFICATIONS

<table>
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<tr>
<th>PROBE</th>
<th>PARAMETER</th>
<th>DEPTH</th>
<th>ACCURACY</th>
<th>ACQUISITION SYSTEM</th>
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<tr>
<td>AXCTD</td>
<td>conductivity, temperature</td>
<td>1000 m</td>
<td>-0.035 mS/cm, -0.035°C</td>
<td>MK 12</td>
</tr>
</tbody>
</table>

![AXCTD probe image](image1.png)

![Temperature, Conductivity, and Salinity profile](image2.png)

An AXCTD profile
**Ocean – AXCTD Survey**

**Scientific need**
- Yearly T, S profiles with 50km spacing on shelf with 5m vert. res., 0.1°C, 0.05 psu accuracy

**Implementation**
- Once per year AXCTD survey in summer near min. sea ice extent
- P-3, Alt 10,000 ft., 500 km/hr
- 4 flights (airports: Thule, Nuuk, Kulusuk, Constable)
- ~30 hours: $166 k,
- 200 AXCTD deployments: $340k
- 5 year program: $2.5 M
- Resulting measurements: 50 km spacing, 0.1m vertical resolution 0.02 °C, 0.02 psu accuracy
GLISTIN-A
GLacier and Ice Surface Topography Interferometer – Airborne

- Glacier and Ice Surface Topography Interferometer (GLISTIN) will provide all-weather, high-resolution swath ice surface topography, not available through existing lidar (i.e. ICESAT-2) or radar (CryoSat) sensors
- GLISTIN-A (airborne) engineering upgrades completed 2012
- Fully operational and campaign/science ready on GIII with no instrument development required (see data at right)

Results from GLISTIN-A engineering flight (ping-pong acquisition mode) for Rosamond area collected 8/6/12. The color represents height and one color cycle corresponds to 100m). Results posted at 10m.

Example GLISTIN-A topography mosaic collected as a proof-of concept during NASA International Polar Year activities on 5/5 and 5/6 2009. The height precision is 10cm-1m for a 10m horizontal resolution and 6km swath-width. The upgraded GLISTIN-A system has similar precision with swath in excess of 10km. Recent campaign to Alaska (4/13) validated performance over ice in an OMG-like scenario (processing in progress).
Science Implementation – Ice Loss

Ice – GLISTIN Survey

Scientific need
- Yearly elevation within 10km of terminus, for marine term. glaciers with 5-10m vert., 100 m, horiz. res.

Implementation
- Once per year GLISTIN survey
  - Gulfstream-III, Alt 10,000 ft., 795 km/hr
  - 6 flights double coverage (airports: Thule, Kangerlussuaq)
  - Flight cost: $3k/hr
  - Data processing: $5k/hr
  - ~ 36 hours ($8k/hr): $288 k,
  - Including transit costs: $400k/year
  - 5 year program: $ 2.0 M
  - Provides 0.4m vertical accuracy, 5-10m horizontal resolution,
AirGrav – Airborne Gravity

Contractor – SGL
- Provides instrument and data processing
- Will lease, equip and operate aircraft as part of contract

Instrument accuracy vs line density
Science Implementation – AIRGrav

**Bathymetry – AIRGrav**

**Scientific need**
- Bathymetry survey in key regions on shelf with 0.5mGal (100 m vert.) res. 1km horiz. res.

**Implementation**
- Once time AIRGrav survey
- Contract to SGL (TBD)
- Twin Otter, Alt 1,000 ft., 260 km/hr
- 39 flights (airports: Ilulissat, Kangerlussuaq, Nuuk, Thule, Upernavik, Uummannaq, Ittoqqortoorm (snow), Kulousuk, Narsarsuaq, Nerelerit)
- Flight cost: $2.8k/hr
- ~ 324 hours ($8k/hr): $900 k,
- Including transit/rental costs: $1.1 M
Contractor – Ship Survey

- Terrasond will lease, equip and operate ship
- Data processing services included
- Swath width depends on depth ~few hundred meters
- Vertical accuracy & resolution of a few meters
**Science Implementation – Ship Bathymetry**

**Bathymetry – Ship-based**

**Scientific need**
- Bathymetry in key fjords for geometry & sill depth – 10 m vert., 10 m horiz res., 300 m beam swath

**Implementation**
- Once time ship-based multibeam sonar survey
- Contract to Terrasond (TBD)