CryoVEx 2011
Airborne Sea Ice Validation Campaign

AWI
University of Alberta

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CryoSat-2 Validation Activities embedded in AWI PAMARCMIP sea ice campaign
CryoSat-2 Underpasses

- Three CryoSat-2 underpasses with Polar-5
  - **14. April 2011:**
    CryoSat-2 Orbit 4400
    Time offset of 1 day (low ice drift)
  - **15. April 2011:**
    CryoSat-2 Orbit 4435
    Coincident with ASIRAS
  - **17. April 2011:**
    CryoSat-2 Orbit 4467
    Coincident with ASIRAS

CryoSat-2 Target Orbits for CryoVEx 2011 for airborne validation activities
Objectives:

- Large scale validation of satellite freeboard (ASIRAS) and thickness (+AEM/LASER) – CryoSat+ aircraft
- Validation of ice freeboard (as measured by Cryosat) to thickness conversion –
  - Ice/snow interface level to thickness conversion aircraft + in situ data.
  - Average radar reflection horizon relationship to ice/snow interface.
- In-situ data for forward modeling of AEM, ASIRAS, CryoSat-2 data

\[ h_i = f \frac{\rho_w}{(\rho_w - \rho_i)} + \frac{h_s \rho_s}{(\rho_w - \rho_i)} \]
- Establish **three** ground validation sites; on fast ice, on thick multiyear ice, on thin multiyear ice or first-year ice; to describe general regional variability

- Perform overflights of ground validation sites with 1. ASIRAS, 2. EM Bird, 3. IceBridge sensors

- Extrapolate results to coincident, simultaneous CryoSat underflights
In-situ measurements at ground validation sites

Line survey
- 10 m: snow depth, ground EM31, snow freeboard measured by rotating laser. Few drill-holes.

Grid survey around corner reflector:
- Snow depth grid 20x20m, every 1 m (ASIRAS across track footprint)
- ~5 Snow pits at selected locations in grid
- Ku-band snow radar (GPR) at snow pits
Example of Polar-5 Nadir-Image

- Two Polar-5 overpasses over southern validation line (April 16.)
- Available
  - EM-Bird thickness
  - High-resolution Laser DEM
  - Aerial Photography
South Site Snow Grids & Pits

Depth

Temperature

-29.8

Soft new snow

45

-25.2

Hard wind blown slab

Density sample taken 11 - 19 cm

33

-22.2

Medium hard wind blown slab

Density sample taken 20 - 26 cm

20

-18.6

Depth hoar

grain size <5 mm

-14.5

Density sample taken 2-8 cm

0

Degrees C

Depth (cm)

0 20 40 60 80 100

snow depth (cm)

0 5 10 15 20

x (m)

0 5 10 15 20

y (m)
<table>
<thead>
<tr>
<th></th>
<th>North Site</th>
<th>South Site</th>
<th>Fast Ice</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean EM thickness</strong></td>
<td>2.37 ± 0.53 (N = 82)</td>
<td>3.18 ± 0.65 (N = 92)</td>
<td>4.25 ± 1.29 (N = 101)</td>
</tr>
<tr>
<td>(snow plus ice; m)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Modal EM thickness</strong></td>
<td>2.1</td>
<td>3.4</td>
<td>3.6</td>
</tr>
<tr>
<td>(m; bin width 0.1 m)</td>
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</tr>
<tr>
<td><strong>Mean snow thickness</strong></td>
<td>0.41 ± 0.13 (N = 82)</td>
<td>0.43 ± 0.22 (N = 99)</td>
<td>0.29 ± 0.16 (N = 101)</td>
</tr>
<tr>
<td>(m)</td>
<td></td>
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</tr>
<tr>
<td><strong>Modal snow thickness</strong></td>
<td>0.30 &amp; 0.40 (bimodal)</td>
<td>0.25 &amp; 0.50 (bimodal)</td>
<td>0.35</td>
</tr>
<tr>
<td>(m; bin width 0.05 m)</td>
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<tr>
<td><strong>Mean freeboard</strong></td>
<td>ND</td>
<td>0.20 ± 0.27 (N = 99)</td>
<td>0.58 ± 0.44 (N = 92)</td>
</tr>
<tr>
<td>(m)</td>
<td></td>
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</tr>
<tr>
<td><strong>Modal freeboard</strong></td>
<td>ND</td>
<td>0.00 &amp; 0.25 (bimodal)</td>
<td>0.60</td>
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<td>(m; bin width 0.05 m)</td>
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CryoVEx & IceBridge snow thickness measurements

- Comparison of in-situ and airborne measurements between corner reflectors
- Good qualitative agreement

Studinger et al. (2011)
All goals achieved
Great luck with weather
Report soon available
Need better methods for snow property measurements
**AWI Airborne Dataset**

- Sea ice thickness data available in first-year and multi-year sea ice regions

**CryoVEx Lincoln Sea:** 3 CryoSat-2 Underpasses, 2 Overflights Validation Line

- High-resolution laser DEM due to low flight altitude (200 ft)

**Aircraft Coordination**

- **Polar-5** and **Twin-Otter:** > 400 km of coincident EM and ASIRAS data

- Very short temporal offset between aircraft, exact match: TBD

**Processing Status**

- EM-Bird Sea Ice Thickness
- Laserscanner DEM
- Nadir Imagery