Status and Recent Results
From the CReSIS Ku-Band and Snow Radars

The National Science Foundation (NSF)
National Aeronautics and Space Administration (NASA)
Kansas Board of Regents (KBOR)

The University of Kansas (KU)
Elizabeth City State University (ECSU)
The Pennsylvania State University (PSU)
Indiana University (IU)
University of Washington (UW)
Association of Computer and Information Sciences and Engineering Departments at Minority Institutions (ADMI)
Los Alamos National Laboratory (LANL)

Centre for Ice and Climate, Niels Bohr Institute, University of Copenhagen (CIC)
Center for Polar Observations & Modeling (CPOM)
Indian Institute of Technology Kanpur (IITK)
University of Magalhães (UM)
Outline

• Data Products
• System Hardware Changes
• Snow Thickness
• Ku-Band Analysis
• Summary
## Data Products

<table>
<thead>
<tr>
<th>Season</th>
<th>Snow</th>
<th>Ku-band</th>
<th>Altimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Radar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009 Greenland P3</td>
<td>Old</td>
<td>No Data</td>
<td></td>
</tr>
<tr>
<td>2010 Greenland DC8</td>
<td>Old</td>
<td>Old</td>
<td>Old</td>
</tr>
<tr>
<td>2010 Greenland P3</td>
<td>Old</td>
<td>Old</td>
<td></td>
</tr>
<tr>
<td>2011 Greenland P3</td>
<td>New</td>
<td>New</td>
<td></td>
</tr>
<tr>
<td>2012 Greenland P3</td>
<td>Raw</td>
<td>Raw</td>
<td></td>
</tr>
<tr>
<td>2009 Antarctica DC8</td>
<td>Old</td>
<td>Raw</td>
<td></td>
</tr>
<tr>
<td>2010 Antarctica DC8</td>
<td>Old</td>
<td>Old</td>
<td></td>
</tr>
<tr>
<td>2011 Antarctica DC8</td>
<td>New</td>
<td>New</td>
<td></td>
</tr>
<tr>
<td>2012 Antarctica DC8</td>
<td>Raw</td>
<td>Raw</td>
<td></td>
</tr>
</tbody>
</table>
Combined Ultra-Wideband Ku-Band Altimeter & Snow Radar

OLD SYSTEMS
Bandwidth
Ku-Band: 6 GHz
Snow: 4 GHz
Independent sweep, timing, GPS, acquisition

NEW SYSTEM
Bandwidth
Dual 6-GHz Bands
Coherent Sweeps.
Synchronized timing, GPS, acquisition.
Combined Instrument.

- Snow Cover over Sea Ice
- Internal Layering
- Fine Resolution
- CryoSat-II Simulator
- Surface Topography
Interface tracker overview

• Works with the new format Snow Radar processed output
• User-defined threshold above the noise power for the air-snow interface
  – Look to further range to make sure the returned pick is not a leading-edge sidelobe
• Range compensation
  – Data beyond the air-snow pick is weighted to remove any attenuation due to the snow cover
  – Snow-ice interface is taken to be the peak with the largest magnitude
• Both interfaces are filtered over a user-defined range line aperture where the filtering weights are taken from the respective scattering magnitudes
Tracker output
Tracker output

• .mat file containing
  – Latitude, Longitude, Air/snow range bin and scattering magnitude, Snow/ice range bin and scattering magnitude, and Range bin size

• After vetting, a comma-delimited file is produced that contains
  – Latitude, Longitude, and Snow depth
  – Currently available for 2010 and 2011 Antarctica

• Snow depth is calculated assuming a constant density
  – Snow depth can be rescaled easily for other densities
Issues to be dealt with

• Data need to be reprocessed with a different coherent noise removal technique
• No means of discriminating between snow cover and open water at the time
  – Scattering magnitude is comparable to the air/snow interface
  – Easy to identify bare ice which can be used for range calibration purposes
10/25/11 – Weddell Sea

<table>
<thead>
<tr>
<th>Segment</th>
<th>AMSR Mean</th>
<th>Radar Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>40.22</td>
<td>31.30</td>
</tr>
<tr>
<td>2-3</td>
<td>41.00</td>
<td>49.28</td>
</tr>
<tr>
<td>3-4</td>
<td>34.85</td>
<td>36.54</td>
</tr>
<tr>
<td>4-5</td>
<td>29.04</td>
<td>22.35</td>
</tr>
<tr>
<td>5-6</td>
<td>21.08</td>
<td>31.19</td>
</tr>
<tr>
<td>6-7</td>
<td>24.43</td>
<td>29.08</td>
</tr>
<tr>
<td>7-8</td>
<td>12.67</td>
<td>33.34</td>
</tr>
<tr>
<td>8-9</td>
<td>8.28</td>
<td>3.61</td>
</tr>
<tr>
<td>9-10</td>
<td>5.94</td>
<td>0.00</td>
</tr>
<tr>
<td>10-11</td>
<td>12.43</td>
<td>8.32</td>
</tr>
<tr>
<td>11-12</td>
<td>13.57</td>
<td>17.16</td>
</tr>
<tr>
<td>12-13</td>
<td>24.97</td>
<td>28.18</td>
</tr>
<tr>
<td>13-14</td>
<td>37.02</td>
<td>45.99</td>
</tr>
<tr>
<td>14-15</td>
<td>30.80</td>
<td>52.29</td>
</tr>
<tr>
<td>15-END</td>
<td>33.39</td>
<td>49.37</td>
</tr>
</tbody>
</table>
Ku-band vs. SIRAL band

- Ku-band data sub-band corresponding to SIRAL band
- Processed data for Ku-band 3.5 GHz and 350 MHz BW
- Results compared for high 3.5GHz BW and low 350 MHz BW resolution
  - over grease ice
  - wet, percolation and dry snow zones
  - sea ice

Over grease ice


3.5 GHz BW
350 MHz BW

depth, $\phi_i = 1.53$ (m)
Wet snow zone

3.5 GHz bandwidth


350 MHz bandwidth


350 MHz Leading edge
3.5 GHz Leading edge

3.5 GHz Surface max
350 MHz Surface max

CReSIS
Center for Remote Sensing of Ice Sheets
Percolation zone

3.5 GHz bandwidth

350 MHz bandwidth

Leading edge
Surface max
Second layer

350 MHz Leading edge
3.5 GHz Leading edge

3.5 GHz Surface max
350 MHz Surface max

3.5 GHz Second layer

kuband 2011 Greenland P3 26-Apr-2011 11:06:15 to 11:06:55

kuband 2011 Greenland P3 26-Apr-2011 11:04:00 to 11:14:00
Dry snow zone

3.5 GHz bandwidth

350 MHz bandwidth


kuband 2011 Greenland P3 26-Apr-2011 11:17:00 to 11:27:00

-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0 100 200 300 400 500 600

3.5 GHz Surface max
3.5 GHz Leading edge
3.5 GHz Second layer
350 MHz Surface max
350 MHz Leading edge

No. of Samples

Leading edge
Surface max
Second layer

depth, e = 1.53 (m)

NSF
NASA
CReGIS
Center for Remote Sensing of Ice Sheets
Summary

• Snow radar interface tracker is providing snow thickness product.
  – Needs interaction
  – 2010/11 Antarctica data available
• Continue to work on other dataset and post results.

• Ku band sub-bandwidth processing indicates primary scattering surface over a variety of snow types.
• Directly applicable to Cryosat-2 data interpretations.
• Investigate results over more areas and sea ice.