Sea Ice CCI project Phase 2
2015-2017
## Improvements in Phase 2 with regards to GCOS Requirements

<table>
<thead>
<tr>
<th>Sea Ice Concentration</th>
<th>GCOS requirements (2011 update)</th>
<th>CCI Phase 1</th>
<th>CCI Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial Resolution</td>
<td>10-15 km</td>
<td>25 km</td>
<td>25 km</td>
</tr>
<tr>
<td>Temporal Resolution</td>
<td>Weekly</td>
<td>Daily</td>
<td>Daily</td>
</tr>
<tr>
<td>Accuracy</td>
<td>5% ice area fraction</td>
<td>3-4 % (interior)</td>
<td>improved</td>
</tr>
<tr>
<td>Stability</td>
<td>5% per decade</td>
<td>assessed: stable</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sea Ice Thickness</th>
<th>GCOS requirements (2011 update)</th>
<th>CCI Phase 1</th>
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</tr>
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<tbody>
<tr>
<td>Spatial Resolution</td>
<td>25 km</td>
<td>100 km</td>
<td>100 km</td>
</tr>
<tr>
<td>Temporal Resolution</td>
<td>Monthly</td>
<td>Monthly (winter)</td>
<td>Monthly (winter)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>0.1 m</td>
<td>0.5 m (target)</td>
<td>?</td>
</tr>
<tr>
<td>Stability</td>
<td>unspecified</td>
<td>not assessed</td>
<td>To be assessed</td>
</tr>
</tbody>
</table>
Arctic ice extent decreases, Antarctic ice extent increases

IPCC AR5, 2013
Arctic and Antarctic ice concentration

Ice concentration in %

Uncertainty in %

Uncertainty = tiepoint + smearing + daily variability with a grid cell
Ice thickness product from ENVISAT radar altimeter

Monthly maps of FB and SIT (winter months)
100 km grid
Arctic coverage (< 82N due to satellite orbit)
Ice thickness from ENVISAT RA 2002-2012
Ice thickness validation using in situ data from North Pole drifting stations

- Collocated in situ and Envisat data
- Every 10 days measurements
- 100 m × 100 m polygon
Seasonal ice thickness evolution from collocated NP-37 and Envisat RA-2 (100-km grids) data (1)

\[ \rho_{\text{ice}} = 915.1 \text{ kg/m}^3 \]

Snow: Warren climatology

Mean (S.D.) diff: 0.69 (0.21) m
(Mean (S.D.) diff: 0.46 (0.25) m)
ρ_{ice} = 882 \text{ kg/m}^3
Snow : Warren climatology

Mean (S.D.) diff: 0.08 (0.14) m
(Mean (S.D.) diff: -0.13 (0.18) m)

Seasonal ice thickness evolution from collocated NP-37 and Envisat RA-2 (100-km grids) data (2)
Seasonal evolution of **snow depth** from NP-37 and Warren climatology over RA-2 100-km grids

Mean (S.D.) diff: -12.9 (6.7) cm
(Mean (S.D.) diff: -7.1 (4.6) cm)
Winter month ice draft from mean ULS and Envisat RA-2 data in the Beaufort Sea (2004-2012)

\[ \rho_{\text{ice}} = 900 \text{ kg/m}^3 \]

Snow: Warren climatology (12 by 30 deg. lat/lon sector)

Mean (S.D.) diff: 0.67 (0.33) m
Sea ice freeboard from airborne data

Available data from Operation Ice Bridge

- March 2010
- April 2010
- March 2011
- March 2012

Contains:
- snow-ice freeboard (laser)
- snow depth (snow radar)

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OIB RA

Freeboard [m] 2012 2011 2010/3 2010/4

MD(OIB-RA) = 0.005 m (0.09)

grid number
Extending the ECV timeseries in phase 2

Sea ice concentration

Sea ice thickness

Satellite sensors for Sea Ice Concentration in CCI Phase 2

Satellite sensors for Sea Ice Thickness in CCI Phase 2
Ice concentration tasks

- reduction of uncertainties
- improved quantization of uncertainties
- improvements to the spatial resolution
- extension of the time series (1978-2015)

Specific issues:
- melt season
- thin ice
- snow cover
Ice thickness tasks

- extension of the Envisat RA-2 SIT time series by ERS-1/2 and CryoSat-2
- development of a consistent multi-mission sea-ice freeboard processor
- optimization of freeboard-to-thickness conversion
- development of an Antarctic SIT product
- development of an operational system for SIT ECV production

Issues: bridging different altimeters, penetration depth, snow cover, melt season,
Sea ice drift as ECV

- obtain analyze user requirements
- intercompare algorithms in a Round-Robin exercise, and document the best of these for future ice drift ECV
- estimate uncertainties for the selected algorithm;
- to prepare for upcoming satellite and sensors;

Ref. IPCC AR5, 2013
Scientific climate topics in the Polar regions

• Changing sea ice (reduced extent and thickness) has impact on climate at lower latitudes
• Why is the Antarctic sea ice extent increasing?
• Interaction between marine terminating glaciers and sea ice: less sea ice leads to more calving?
• Dynamic topography in the Arctic Ocean- > effect on ocean circulation and sea ice motion
• Radiation (cloud cover) effect on melting/freezing
• Marine ecosystems dependency on sea ice
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