On the qualification of available sea ice freeboard data for the validation of remote sensing observations

Sandra Schwegmann[1], Stefan Hendricks[1], Robert Ricker[1], Christian Haas[2,3], Andreas Herber[1]

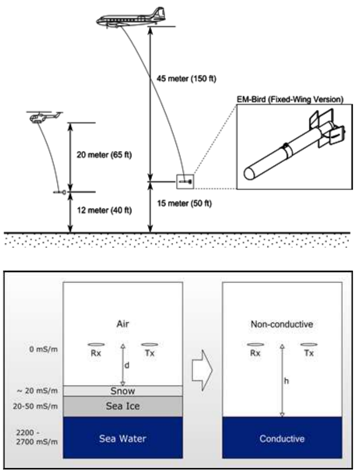
[1] Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
[2] University of Alberta, Edmonton, Canada
[3] York University, Toronto, Canada

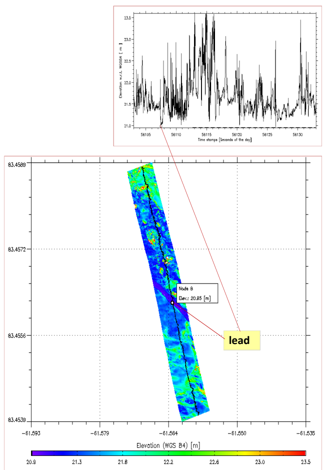
Introduction

The significant loss of Arctic sea ice during the last decades shows the sensitivity of the sea ice system to changes in the global climate. To distinguish between natural variability and the impact of global warming, an understanding of processes and feedbacks is necessary and for that, consistent and comprehensive measurements of the most important sea ice properties are required. Strategies to investigate the sea ice thickness distribution, crucially needed for an investigation of ice mass changes, has only recently been developed. To contribute to the interpretation of the remotely sensed sea ice thickness products, which are mainly based on freeboard determination from altimeter measurements, available airborne sea ice thickness and freeboard data have been collected within the Sea Ice Downstream Services for Arctic and Antarctic Users and Stakeholders (SIDARUS) EU-Project, and have been analyzed with respect to their usability for validation of the large scale satellite products.

Data collection and processing

Airborne total (ice + snow) freeboard and thickness data presented here were collected during the PAMARCMIP campaign in 2011 with Polar 5. Freeboard was measured with a laser scanner system and sea ice thicknesses with an electromagnetic induction sounding system (EM-Bird, Haas et al. , 2009).

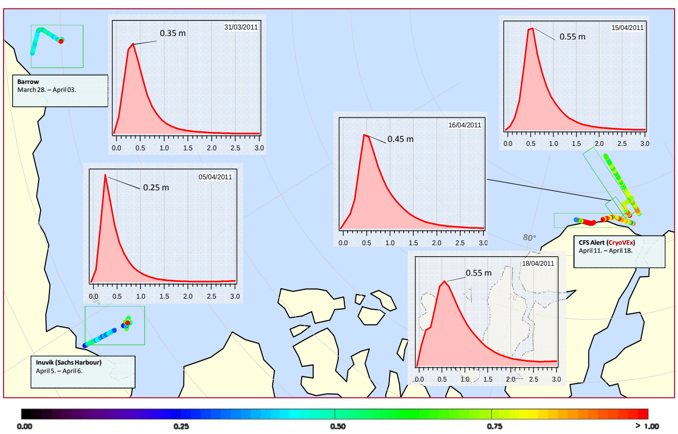




Left: Sketch of airborne sea ice thickness measurements with electromagnetic induction sounding based on 1D assumption: Electrical conductivity of sea ice negligible and level sea ice within footprint. Sea ice thickness is derived from the difference between sea ice/snow surface (detected by laser altimeter measurements) and the sea ice-ocean interface (derived from EM data).

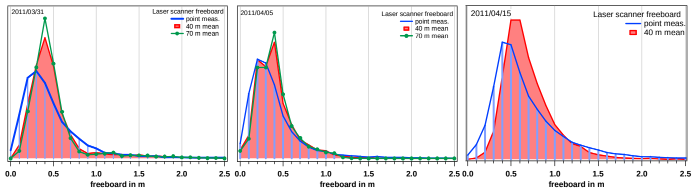
Right: 10 seconds frame of laser scanner measurements. Determination of sea surface height by detection of leads in the profiles.

Ice conditions during PAMARCMIP 2011

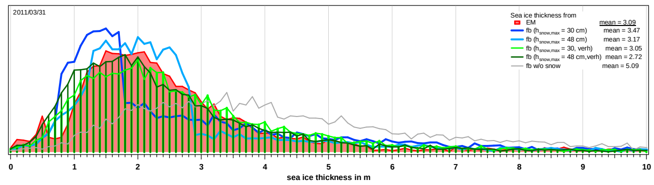


Flight tracks of laser scanner measurements in the Beaufort and Lincoln Sea. Colored dots indicate mean sea ice freeboard, histograms show freeboard distribution of the respective regions.

Results



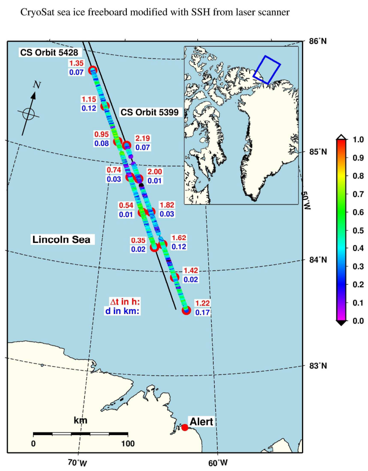
Laser scanner freeboard data are averaged over the footprint-areas of the EM-Bird thickness measurements (40 m, red) and the ICESat footprint (70 m, green).

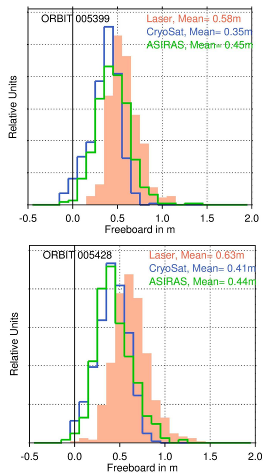


Sea ice thicknesses derived from freeboard measurements by

$$h = fb \cdot \frac{\rho_{water}}{\rho_{water} - \rho_{ice}} + h_{snow} \frac{\rho_{snow} - \rho_{water}}{\rho_{water} - \rho_{ice}}$$

with ρ_{ice} = 910 kg/m^3, ρ_{water} = 1020 kg/m^3 and ρ_{snow} = 300 kg/m^3. Maximal snow thicknesses are set to 30 cm and 48 cm, respectively, where freeboard is larger than the maximal snow thickness ($h_{s,max}$). Otherwise, snow thickness is half of the freeboard in one case, or a percentage of the freeboard defined by the snow-freeboard relation in the other case.





Left: Map of CryoSat orbits performed in conjunction with airborne freeboard measurements from Polar 5.

Right: Comparison between laser scanner, ASIRAS and CryoSat freeboard measurements.

Conclusions

- The footprint-area has to taken into account when comparing different datasets
- Description of sea ice thickness with freeboard difficult w/o proper snow information
- CryoSat and ASIRAS data well comparable, offset to laser scanner data due to snow penetration of radar signal. BUT: radar does not penetrate entire snow cover.

Literature:
Haas, C., J. Lobach, S. Hendricks, L. Rabenstein, and A. Pfaffling (2009). Helicopter-borne measurements of sea ice thickness, using a small and lightweight, digital EM system, Journal of Applied Geophysics, v. 67, iss. 3, p. 234-241.
Polar Airborne Measurements and Arctic Regional Climate Model Simulation Project (PAMARCMIP), http://www.awi.de/en/research/research_divisions/climate_science/sea_ice_physics/expeditions/aircraft_campaigns/arctic_spring_pamarcmip/
Sea Ice Downstream Services for Arctic and Antarctic Users and Stakeholders (SIDARUS), http://sidarus.nersc.no/

Sandra Schwegmann
Sandra.Schwegmann@awi.de
Bussestr. 24
27570 Bremerhaven

MyOcean Science Days 2012
19 - 21 November 2012
Geesthacht, Germany