ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

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Effects of different footprint areas on the comparability between measurements of sea ice freeboard

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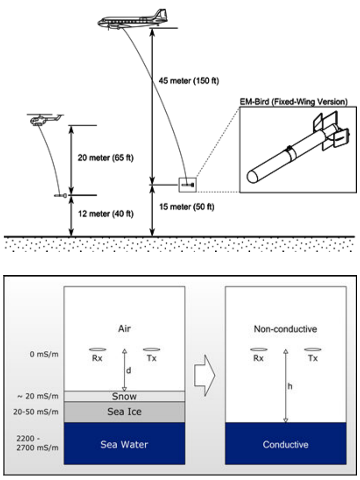
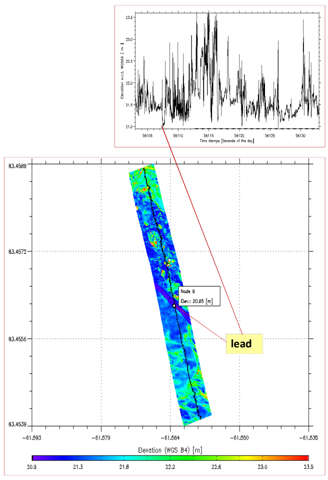
Introduction

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. One major challenge in comparing satellite and airborne measurements is the different footprint area of these methods. Therefore, statistical parameters like the variability of freeboard within the common footprint areas have been analysed from measurements made during the PAMARCMIP 2011 campaign in order to determine the differences between point measurements and areal averages.

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).

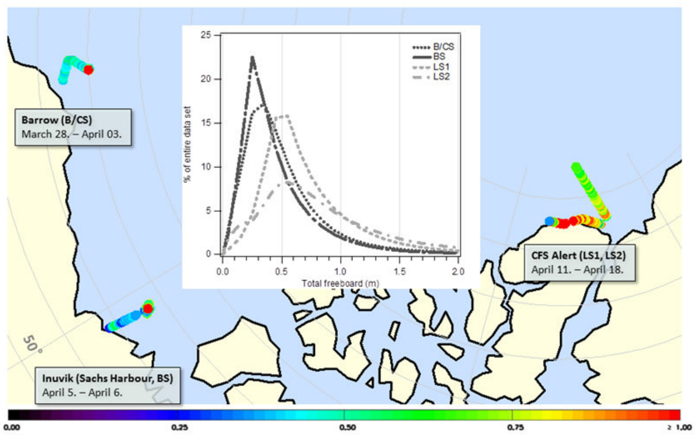




Left: Sketch of airborne sea ice thickness measurements with electromagnetic induction sounding based on 1D assumption: Electrical conductivity of sea ice negligible and level sea ice within footprint. Sea ice thickness is derived from the difference between sea ice/snow surface (detected by laser altimeter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

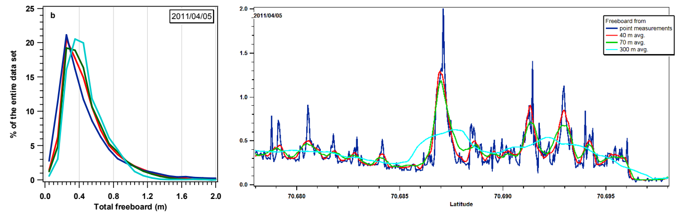
Right: 10 seconds frame of laser scanner measurements. Determination of sea surface height by detection of leads in the profiles.

Ice conditions during PAMARCMIP 2011

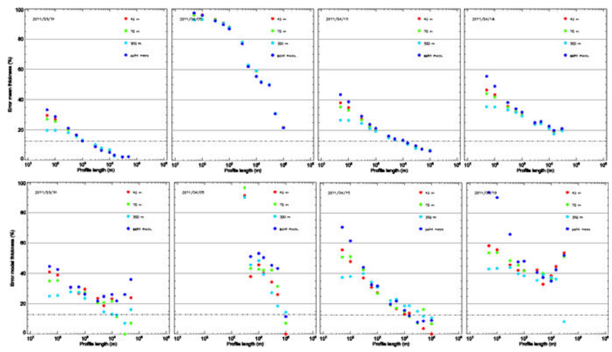


Flight tracks of laser scanner measurements in the Beaufort and Lincoln Sea. Colored dots indicate mean sea ice freeboard averaged over 10 km, the histogram shows the freeboard distribution of the respective regions for the profiles.

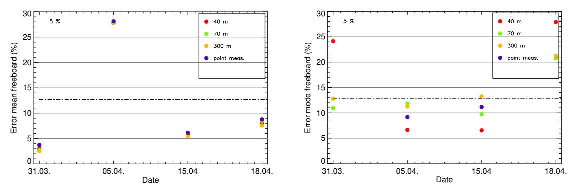
Results



Left: Example for the sea ice thickness distribution as derived from different footprints over the same profile. Right: Comparison between profile data of point measurements and averages over various footprint areas. Profile was taken in the Beaufort Sea. While averages over lower radii (40/ 70 m) represent the variation and distribution in freeboard height well, averages over a higher radius (300 m) smooth the sea ice features strongly.



Standard error ε in percentage of the mean (top) and modal (bottom) freeboard versus profile length in m. Black line shows the 12.75 % threshold which was mentioned by Wadhams (1997) to be a threshold for reliable mean sea ice thickness measurements.



Standard error ε in percentage of mean (left) and modal (right) freeboard using only 5% of the entire data sets. Dates corresponds to the four study areas. Mean values are less sensitive to footprints than modal values are. In addition, for most regions it is enough to have 5 % of the data distributed over the entire region in order to get reliable results.

Conclusions

- Large footprint-areas can smooth sea ice freeboard data significantly
- The length of profile data that is needed to obtain reliable mean and modal freeboard data varies between different regions
- Mean values are more stable and are more suitable for comparisons than modal values
- It is more important to have a large area covered by data in order to get reliable mean or modal freeboards instead of having high resolution data on smaller scales.

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.
Wadhams, P. (1997), Ice thickness in the Arctic Ocean: The statistical reliability of experimental data, *Journal of Geophysical Research-Oceans*, *102*(C13), 27951-27959.
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/

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