Sea Ice Thickness Variability in the Fram Strait

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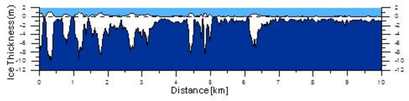
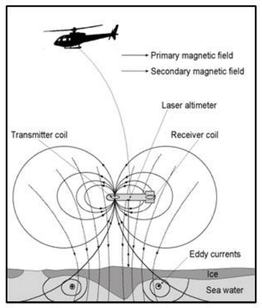
Measurement Techniques

- Total ice thickness (ice plus snow) is measured with helicopter borne electromagnetics. (EM-Bird, EMB; Haas et al. 2009); the sensor responds to the distance to the seawater (high electrical conductivity); a laser altimeter determines the height; see photo (left), setup sketch (right) and data example (below)
- Ice thickness on local scale is measured with drillings and/or ground electromagnetics (Haas et al. 1997) - also used for calibration of helicopter surveys





Background and Motification

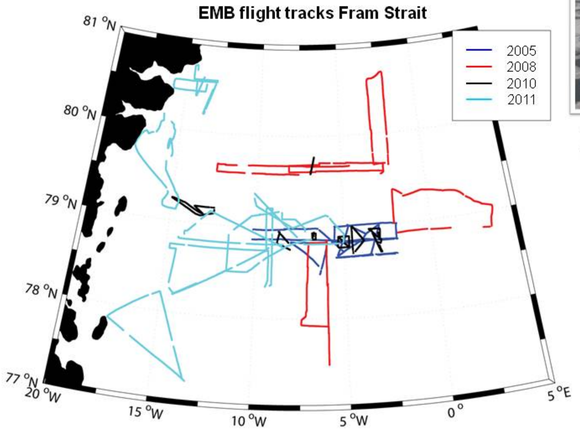
- Arctic sea ice thickness is a crucial parameter when quantifying and assessing the status of the ice cover in connection with climate research
- Ice thickness changes affect the mechanical properties in dynamic ice processes, energy fluxes between atmosphere and ocean, the ocean freshwater budget and the ecosystem
- Knowledge on the regional distribution of ice thickness is important for improving coupled climate models and for calibration and validation of satellite remote sensing products (e.g. the new ESA CryoSat-2 satellite)
- While ice extent is studied daily from satellites with partly high resolution, the knowledge about sea ice thickness distributions in the Arctic is in general still quite limited

Observation Region: Fram Strait

- The Fram Strait (see map, western part marked by red box) is the only deepwater connection between the Arctic Basin and other oceans, and the main export route for sea ice leaving the Arctic
- Fram Strait sea ice has been studied over several decades (Vinje et al. 1998, Vinje 2001, Spreen et al. 2009), but EMB surveys started not earlier than 2005; Upward looking sonar data are currently reprocessed and will be integrated with EMB results
- By assessing the sea ice status in the Fram Strait, the understanding about conditions in the source regions of ice drifting through the Fram Strait is improved

Regional Sea Ice Thickness in Fram Strait

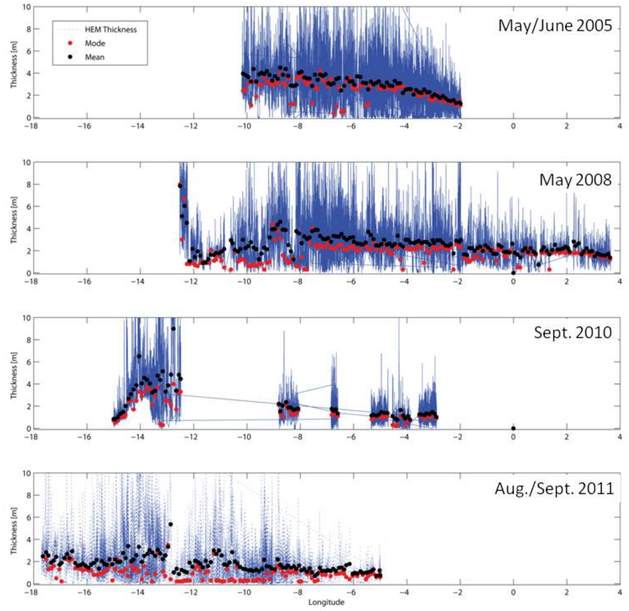
- During four expeditions, the total ice thickness in Fram Strait was investigated with EMB flights in spring (May/June 2005, 2008; Pedersen et al. 2009) and late summer (August/September 2010, 2011); Amount and regional distribution of flight tracks for the four expeditions varied corresponding to ice and weather conditions (see map below)
- Typical ice conditions in Fram Strait have changed during the last decade: The portion of thick multiyear ice became less, replaced by first- and second year ice; recent measurements from late summer 2011 show hardly any thicker (often multiyear) ice left (see photos to the right)
- Modal ice thickness in Fram Strait drops from spring to late summer by more than 1 m



Typical ice conditions in Fram Strait met in September 2004 vs. 2011.

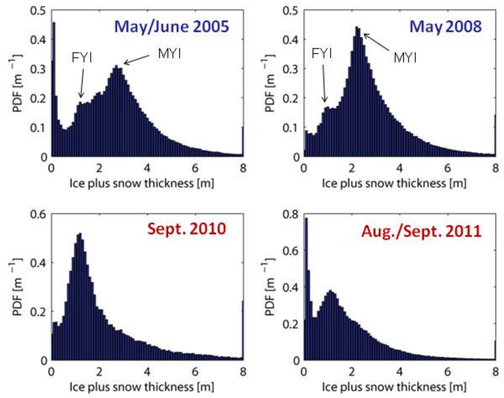
Spatial Variability: West-East Transects

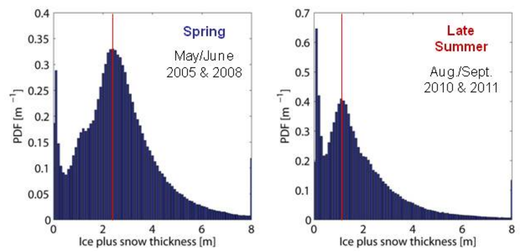
- Total ice thickness gradients from west to east in the Fram Strait (mode and mean in 0.1° bins) appear different between seasons and years; late summer ice has little or no snow cover (snow thicknesses are measured in situ on ice stations (Forström et al. 2011), but they are not explicitly included here)
- Calculating both mean and modal thicknesses reveals different thickness characteristics such as in the centre section of 2008 (gradient in mean, not in mode); westernmost data were measured over landfast sea ice off Greenland (2008, 2010, 2011)
- Differences in mean and modal thicknesses can be related to characteristics of the tail of thickness distributions (related to the amount of different ice types and ridged ice)



Temporal Variability: Seasonal and Interannual

- As one would expect, mean and modal total ice thicknesses are larger in spring (2005 & 2008) than late summer (2010 & 2011)
- Spring distributions (2005 & 2008) have more than one mode, indicating both first- and multiyear ice (see markings)
- Modal thicknesses are less in 2008 vs. 2005, and less in 2011 vs. 2010; differences in characteristics will be closer inspected along with upward looking sonar data from moorings





Fram Strait total ice thickness probability density functions for campaign (upper graphs), and split into seasons (lower graphs): spring (May/June 2005 & 2008) and late summer (August/September 2010 & 2011); modal thicknesses are marked with red lines.

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Conclusions and Outlook

- Fram Strait sea ice mirrors to some extent conditions in the "upstream" area in the Arctic Basin, where the sea ice comes from, and is therefore of high interest in the context of climate research
- Fram Strait sea ice exhibits strong seasonal and regional thickness variations, partly related to different origin of ice and different dynamic and thermodynamic regional conditions
- We are still working on the interpretation of the variability, and with linking up airborne, in situ and mooring-based Upward Looking Sonar ice thickness data
- The results can also help interpreting future datasets on ice thickness from satellite observations

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