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Sea Ice Mass Balance influenced by Ice Shelves

- Investigations on snow cover and platelet ice formation at Atka Bay -

Abstract

The formation and growth of platelet ice close to Antarctic Ice Shelves contributes significantly to the total mass of the land-fast sea ice. Platelet ice are crystals forming and growing in a layer of supercooled water masses which are modified through interaction with ice shelves. These platelets float upwards, either underlying a sea-ice sheet or attaching to the base of the sea ice, being incorporated into the structure of the ice.

Another characteristic feature of Antarctic sea ice is a thick, partly multi-year snow cover, which leads to snow-ice formation, surface flooding and the formation of superimposed ice from snow melt water.

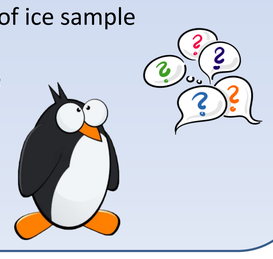
My object is to investigate the role of platelet ice and snow cover for the mass balance of the fast ice in the Atka Bay near Neumayer III station. Continuous measurements of ice and snow thicknesses at several locations on the fast ice serve as a basis for my investigation. In addition, I will take ice cores during field campaigns, and establish an autonomous mass-balance station. Finally, I will compare the results with data from other fast-ice regions of Antarctica, collected in the framework of the Antarctic Fast Ice Network (AFIN).

My analysis of the seasonality, spatial variability of platelet ice and snow will lead to a better understanding of sea-ice properties and formation processes in Antarctica. The field studies described above will be complemented by satellite observations and numerical simulations in order to estimate the results on a larger scale.

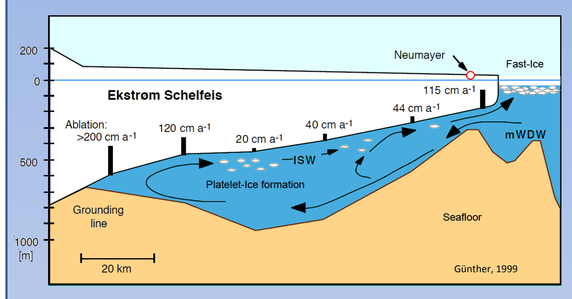
Fast ice? Platelets? Ice Shelves?

Some explanations…

- **land-fast sea ice:** regions of stationary sea ice frozen along the coast (“fastened”)
- **platelet ice:** crystals of ice forming in the water column
- **supercooled water:** liquid water below the freezing point; crystallizes in presence of a seed crystal
- **mass-balance:** difference of sea-ice growth and melt/ablation
- **freeboard:** distance from sea-ice surface to water surface;
- **snow cover:** just kidding!
- **ice-shelf:** part of a glacier or ice-sheet flowing onto the ocean surface
- **Atka Bay:** part of the Weddell Sea, seasonally covered with fast ice
- **Neumayer III:** AWI´s famous Antarctic research station, located at 70°40´S, 008°16´W on the Ekström ice shelf
- **Ekström ice shelf:** ice shelf on Princess Martha Coast of Queen Maud Land; thickness of 160 meters, rises 15 meters above the sea level
- **thin section:** laboratory preparation of ice sample with thickness <1mm
- **Skidoo:** small motorized snowmobile



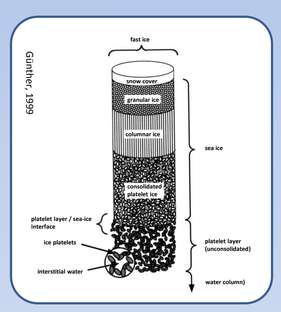
A platelet pu²zle in Antarctica



Left: Simplified process of platelet ice formation in supercooled ice shelf water masses (ISW)

Right: Sample ice core from Atka Bay:

- Platelet ice accounts for more than 60 % of total sea ice mass
- Two different layers: consolidated platelet ice (frozen into the structure) and unconsolidated platelet layer below the solid sea ice

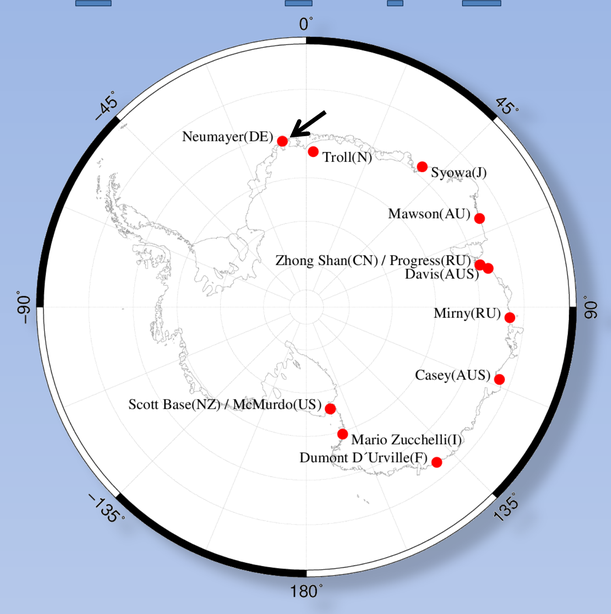


Single crystal of platelet ice
diameter: up to 15cm, thickness: 2-3mm

Thin section of consolidated platelet ice between crossed polarizing filters

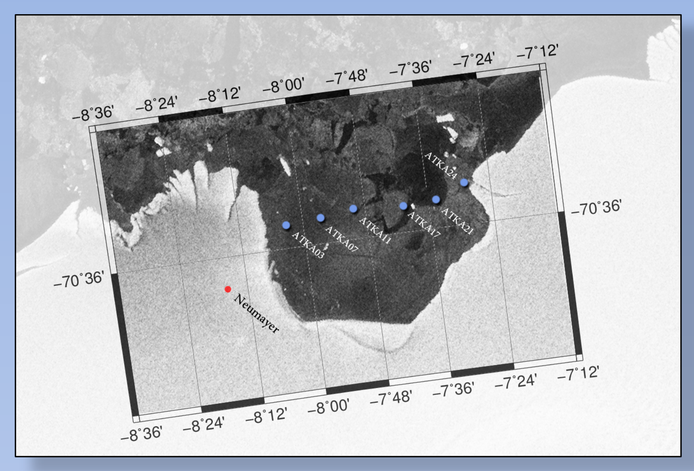
Two major studies of Atka Bay platelet ice to date:
1. Kipfstuhl 1982: platelet ice
2. Günther 1995: sea-ice biology

The Antarctic Fast Ice Network



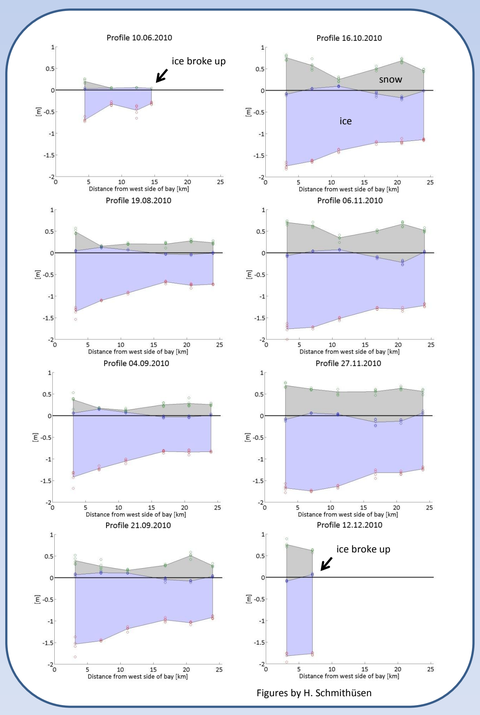
- International network of fast ice monitoring stations around the Antarctic coastline
- Measurements include ice and snow thicknesses, freeboard, dates of fast ice formation and (intermittent and final) breakout, as well as meteorological and oceanic parameters
- Provides online data access

Sampling sites on Atka Bay fast ice



- Fast ice is safe to travel typically from May to December
- In June 2010, the fast ice broke up, possibly due to an iceberg which calved off the coast near Atka Bay in 2009

Preliminary results (2010 measurements)



Figures by H. Schmithüsen

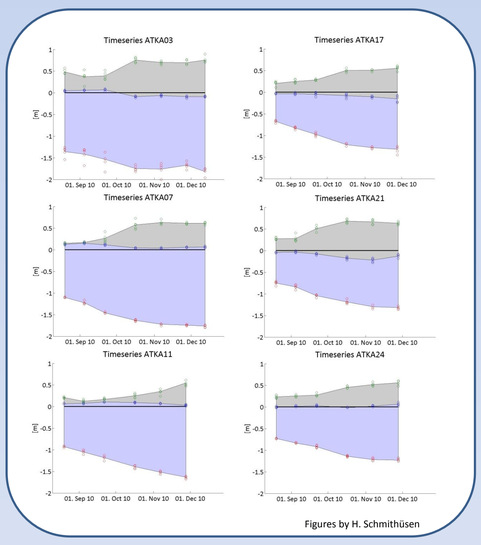
Methods:

- Snow, ice & freeboard measurements, photos
- Every 2 - 3 weeks, dependant on weather conditions
- Five measurements at each sampling site (local variability)

First results:

- Ice thickness increases from June to December, then ice starts breaking up in the West
- Ice is thicker in the western part of the Bay
- Snow cover is variable over the Bay
- Surface flooding / negative freeboard increases over time and is higher in the East (thinner ice / thick snow)
- Local variability highest in the West
- Platelet ice was observed occasionally at different sites (more systematic investigations needed)

Left: profiles along Atka Bay
Below: timeseries at different sampling sites (see above)



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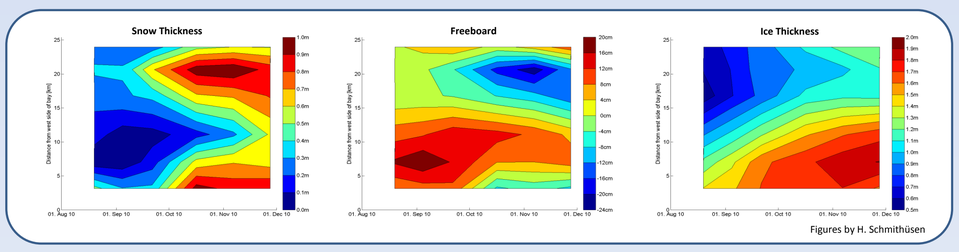

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Left: contour plots of snow thickness, freeboard and ice thickness across Atka Bay between mid-August and December.

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Outlook

2011/12

- Automatic weather station
- Autonomous sea ice mass balance site
- EM31 transects
- Thickness of platelet ice layer
- Online data access (Atka Bay Sea ice Observatory)

2012/13

- Field Campaign: analyse ice cores, thin sections, CTD under fast ice
- Improvements of platelet layer measurements
- Comparison with other regions: Polarstern cruise into Weddell Sea
- Optical properties of snow & ice