Spatio-temporal variations in vertical snow profiles on sea ice in the Weddell Sea, Antarctica

Introduction SnowCast

Snow on sea ice alters the properties of the underlying ice cover as well as associated exchange processes at the interfaces between atmosphere, sea ice and ocean. As Antarctic snow cover persists during most of the year, it contributes significantly to the sea-ice mass budget due to physical (seasonal) and transient processes within the snowpack. Therefore, several studies have shown the importance of comprehensive understanding of snow properties for large-scale estimates in the ice-covered oceans. However, field studies reveal not only a strong seasonality but also spatial variations from small to large scales in the Antarctic snowpack. It is therefore the overall aim of the proposed project to locate and quantify internal snow melt, snow metamorphism, and snow-ice formation in the Antarctic snowpack on different spatial scales. Results will improve our understanding of processes and interactions in the snowpack as well as at the snow/ice interface associated with seasonal and inter-annual variations in the sea-ice mass budget of the Southern Ocean.

Work package I.a: Vertical snow structures from local to regional scale

Analyzing snow structures in the snowpack and at the snow/ice interface in the Weddell Sea from in situ observations.

I. Snow properties in the western Weddell Sea

Antarctic Winter Ecosystem Climate Study (AWECS)  

Winter Weddell Outflow Study (WWOS)  
25 Aug to 29 Oct 2006

LARSEN 2019 (PS118)  
09 Feb to 10 Apr 2019

Distribution functions of snow depth (left) and snow density (right) separated for AWECS (blue), WWOS (yellow), and PS118 (orange).

II. Snow stratigraphy of different snow regimes

First-year snow  
Multi-year snow

Distribution functions of snow grain types distinguished for seasonal (gray) and perennial snow covers (green).

III. From local and floe-size scales to regional scale

Exemplary snow stratigraphy from 14 July 2013 on first-year ice. Vertical lines in the picture (left) indicate the derived snow layers detected in the plot (right):

- Distinction between seasonal and perennial snow regimes mandatory
- Same magnitude of snow-property variability on regional and floe-size scale
- Snow grain sizes dominate the spatial variability of the Weddell Sea snowpack

Global scale

Snowmelt patterns from passive and active microwave observations

- Analysis of diurnal variations in brightness temperature (passive microwave, 37 GHz, vert. pol.)
- Analysis of scatterometer data (ERS, QSCAT, ASCAT)
- Weddell Sea indicates wide range of surface melt stages

Work package I.a: Temporal evolution of snowpack properties

Analyzing temporal processes in the snowpack and at the snow/ice interface with, e.g., the 1-D snow model SNOWPACK (SPP 1158 project SCASS → L. Rossmann).

Work package I.b: Upscaling of vertical snow processes towards medium- to large-scale estimates ...

Schematic of dominant processes influencing the sea-ice mass and energy budgets in the Southern Ocean during the spring-summer transition.

Work package II.a: Upscaling of vertical snow processes towards medium- to large-scale estimates ...

Work package II.b: ... and large-scale energy and mass budget variations

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Work package II.c: Uncertainty estimate of satellite remote sensing data products

Identifying similarities and differences between the Arctic and Antarctic snowpack with respect to the seasonal cycle of snow properties and processes based on MOSAIC.

Work package III: Hemispherical comparison of snowpack properties

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Arndt et al. (2016)

Arndt et al. (2018)

Arndt & Haas (2019)