Snow Cover Impacts on Antarctic Sea Ice

Leonard Rossmann[1], Marcel Nicolaus[1], Michael Lehning[3,4], Nander Wever[3,4], Margaux Couttet[3], Lars Kaleschke[2], Nina Maaß[2]
[1]Alfred-Wegner-Institut Helmholltz-Zentrum für Polar- und Meeresforschung, [2]Universität Hamburg
[3] School of Architecture, Civil and Enviromental Engineering, École polytechnique fédérale de Lausanne,
[4]WSL-Institut für Schnee- und Lawinenforschung SLF

DFG Fördernummer: NI 1096/5-1
KA2694/7-1
SNF Fördernummer: 20002E-160667

Background:

The slight increase of Antarctic sea ice extent over the last years is in contrast to the observations in the Arctic, and the causes are not well understood yet. Besides atmospheric and oceanic processes, the heterogeneous and year-round thick snow cover on Antarctic sea ice is a major factor governing the sea ice mass balance. The impacts on the surface energy balance have important feedbacks on global climate and ice-associated ecosystems. The snow cover dominates many airborne and satellite observations and thus determines methodologies and uncertainties. Hence, information about snow on sea ice is needed to improve remote sensing algorithms and climate models regarding Antarctic-wide snow depth distribution and seasonality.

The overall goal of this **Swiss-German co-funded** project is to quantify the amount and distribution of snow on Antarctic sea ice, its physical properties and their evolution over time. We are developing a new and consistent snow data product for Antarctic sea ice. This project will help to shed light on Antarctic sea ice mass and energy balance and dynamics.

We achieved:
- Deployment of autonomous snow measuring stations (Snow Buoys)
- Comparison of in-situ measurements to different other snow products
- Implementation of a sea ice domain into numerical snow model SNOWPACK
- Improvement of the microwave emission model MEMLS

WP2: Regional differences of snow cover on Antarctic sea ice

Snow depth data analysis from passive microwave satellite observations is used to determine the spatial variability of snow depth on sea ice around Antarctica. The Advanced Microwave Scanning Radiometer 2 (AMSR-2) and the SMOS (Soil Moisture and Ocean Salinity) satellites in combination will reveal the different snow depths with the help of the in-situ measurements (WP1) and the numerical upscaling approach from WP3.
Here, the work currently focuses on the improvement of the numerical microwave emission models. Fig. 4 illustrates the internal dependencies.

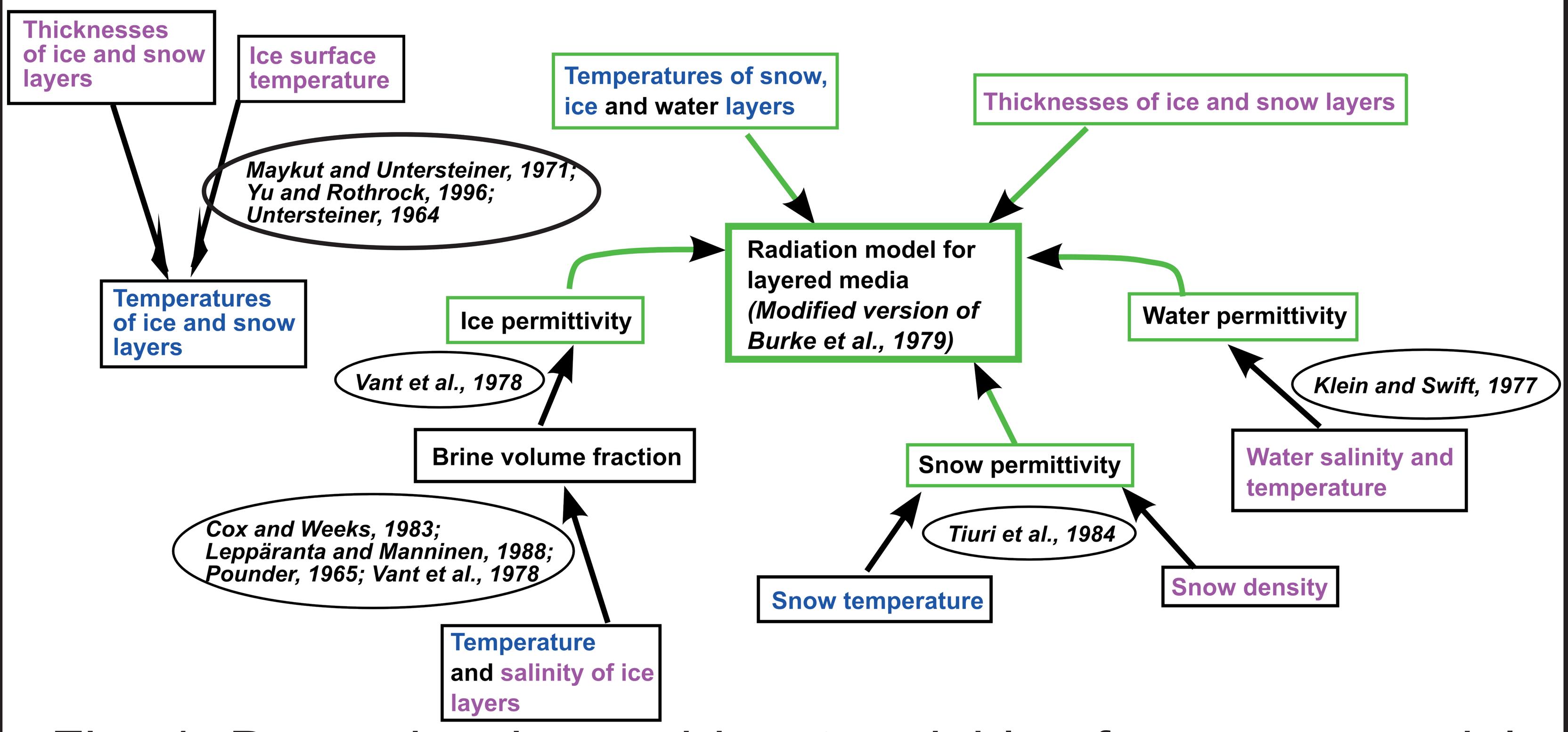

Fig. 4: Dependencies and input variables for our numercial microwave emission model after [3] .

WP4: international cooperation, education and outreach

Fostering the German-Swiss collaboration on Antarctic sea ice research and outreach projects in schools.

Achieved goals:
- Planned reseach stay from the AWI PhD student in Switzerland at the SLF starting on 19. Sep. 2016
- Successful mentoring of the „Adopt a buoy“ program (Fig. 6)

Fig. 6: The„Adopted Buoy“ from the school class of the HIGHSEA Program, which was deployed in the Weddell Sea on the 21/01/16. Photo: Stefanie Arndt, AWI

WP1: Mass balance and properties of snow on Antartic sea ice during different seasons

This work package includes analysis of in-situ measurements and autonomous drifting observations from 15 Snow Buoys (Fig.1). These Snow Buoys measure snow accumlation, temperature, pressure and position. **First results** show a good correlation with the new snow product ORAS5 [1,2] from the ECMWF (Fig. 2). The major snow accumulation events are visible and even the increased melting of the snowpack when the buoy reached the marginal sea ice zone are dominat in both data sets. Further work will include coupling of Snow Buoy data with the MEMLS and SNOWPACK model.

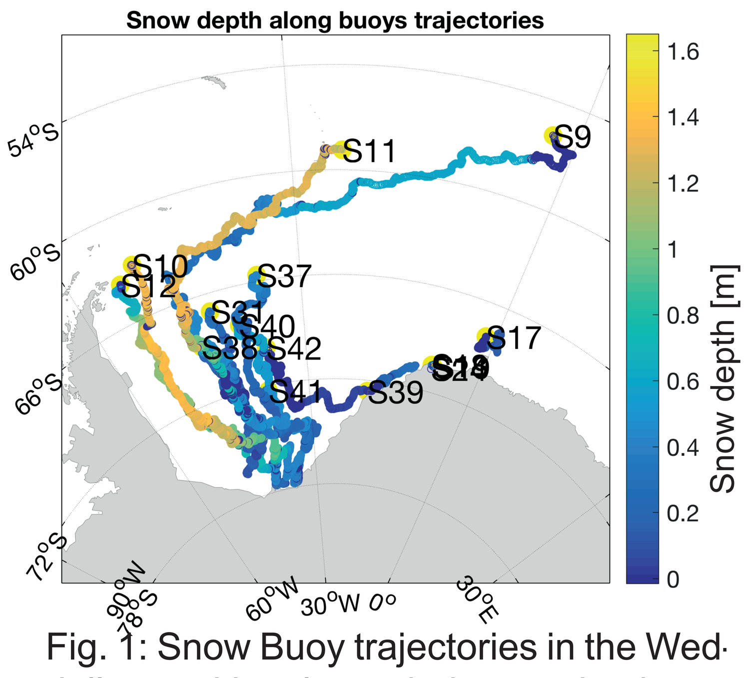

Fig. 1: Snow Buoy trajectories in the Weddell sea with color coded snow depth

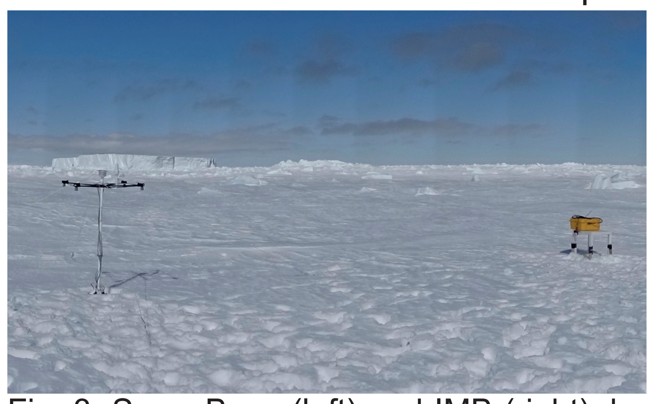

Fig. 3: Snow Buoy (left) and IMB (right),deployed on a sea ice floe in the Weddell Sea,

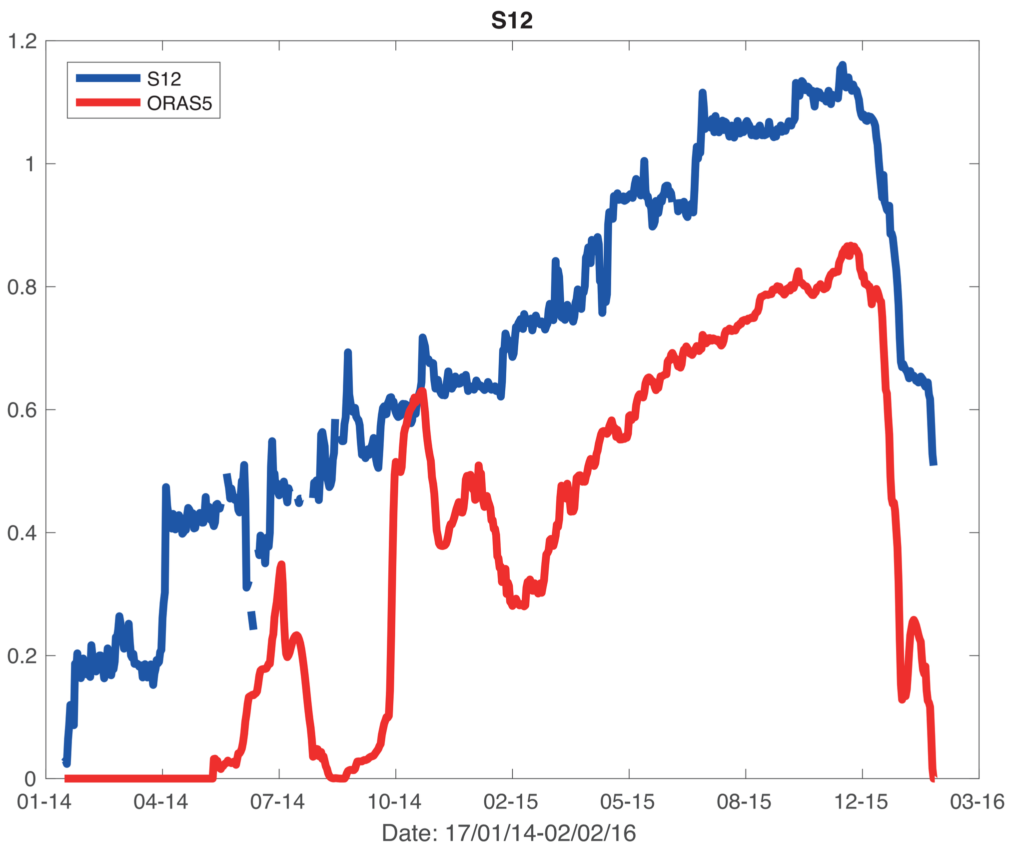

Fig. 2: The new snow on sea ice product ORAS5 from the ECMWF combined with the the snow depth from the Snow Buoy 2014S12. The data shows good correlation with major accumulation events and futher both data sets show the increased melting of snow when the buoy reached the marginal sea ice zone.

WP3: Large-scale properties of snow on Antarctic sea ice

By applying the MEMLS and SNOWPACK (Fig. 5a/b) models we will aim to generalise the findings from the in-situ observations (WP1) in terms of temporal and spatial variability and integration. Therefore, a sea ice domain has been introduced into the numerical model SNOWPACK. The new model simulates thermodynamic sea ice growth including flooding processes (Fig. 5b). The unique SNOWPACK advantage of having a detailed snow microstructure representation is maintained and used for MEMLS input. Ice is coloured in cyan and the different grain types correspondingly. In Fig. 5b the liquid water content shows the areas of flooding and the creation of snow ice. This model is well suited for further snow on sea ice analysis linked to in-situ measurements from the Snow Buoys (WP1) and gives the opportunity for upscaling to satellite footprint (WP2).

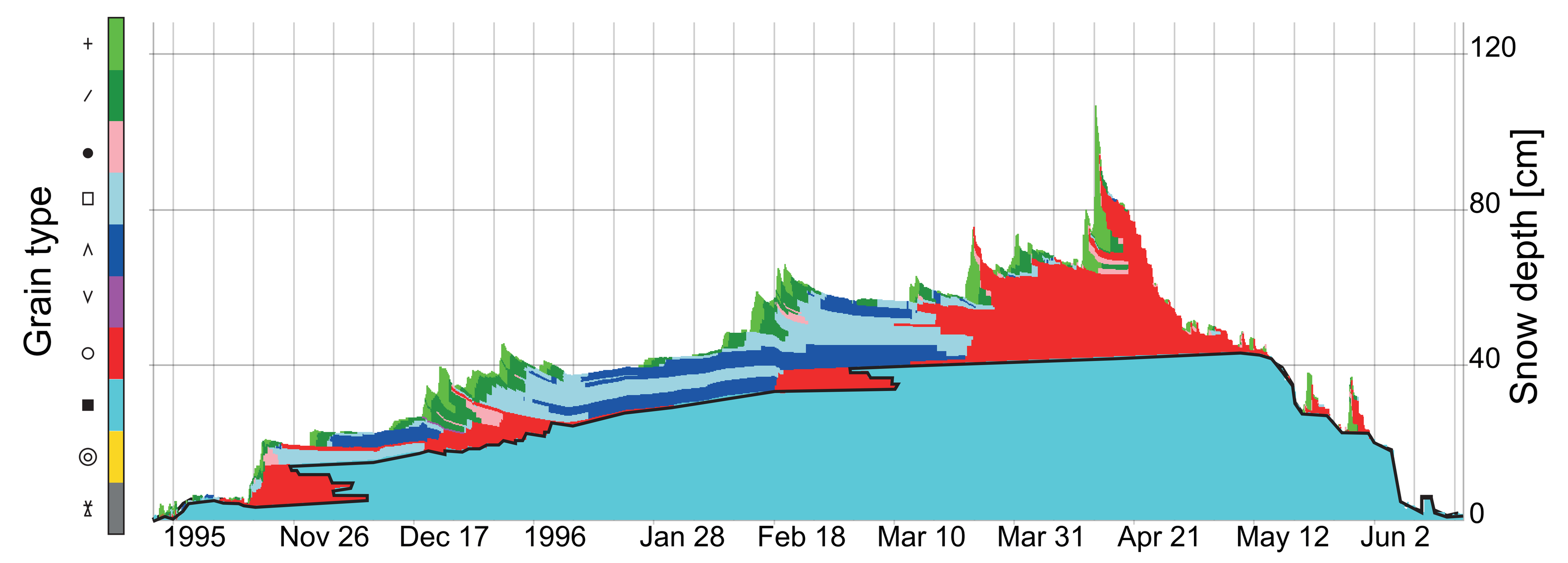

Fig. 5a: SNOWPACK simulations with sea ice domain using Weissfluhjoch meteorological forcing data. Sea ice is represented in cyan, the other colors indicate snowpack microstructure.

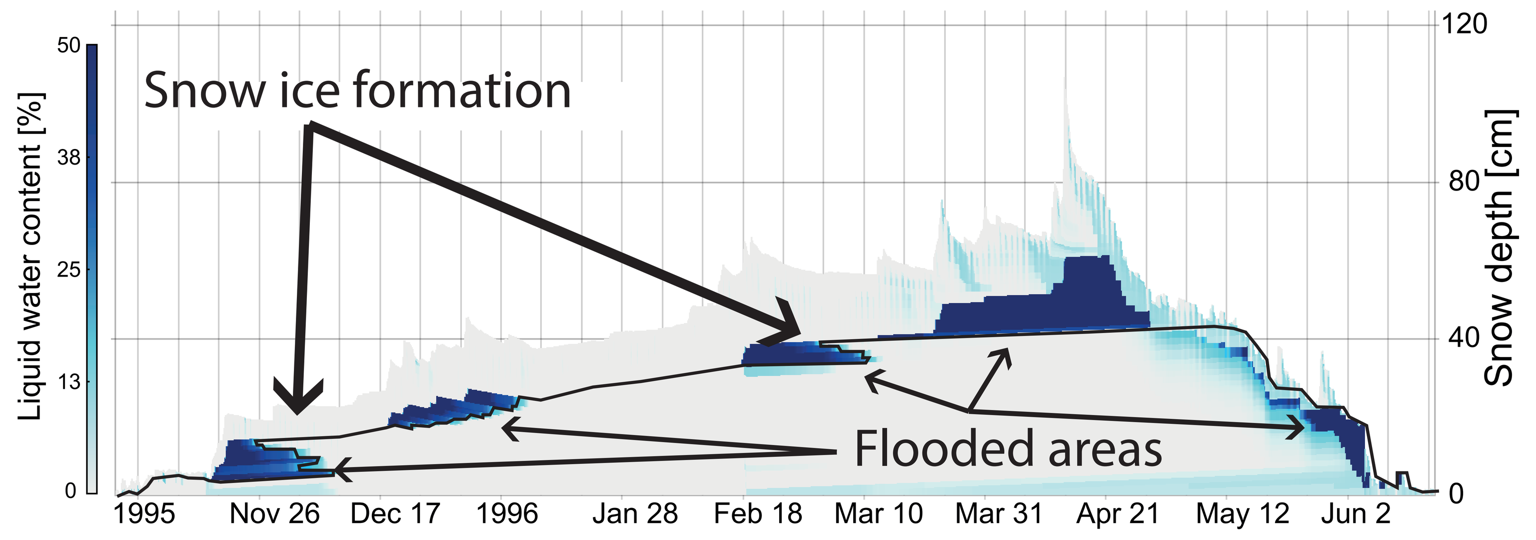

Fig. 5b: Liquid water content (LWC) of the snowpack, the model is able to represent flooding processes with LWC increasing up to 50% after new snow falls.

Reference:
[1] Tietsche, S., Balmaseda, M. a., Zuo, H., & Mogensen, K. (2015). Arctic sea ice in the global eddy-permitting ocean reanalysis ORAP5. Climate Dynamics. http://doi.org/10.1007/s00382-015-2673-3
[2] Zuo, H., Balmaseda, M. A., & Mogensen, K. (2015). The new eddy-permitting ORAP5 ocean reanalysis: description, evaluation and uncertainties in climate signals. Climate Dynamics. http://doi.org/10.1007/s00382-015-2675-1
[3]Maaß, N., Kaleschke, L., Tian-Kunze, X., & Drusch, M. (2013). Snow thickness retrieval over thick Arctic sea ice using SMOS satellite data. Cryosphere, 7(6), 1971–1989. http://doi.org/10.5194/tc-7-1971-2013

Acknowlegements:
Deutsche Forschungs Gemeinschaft (DFG) und Schweizerische Nationalfonds zur Förderung der wissenschaftlichen Forschung (SNF) for co-funding this project.

Meereismessungen der Schnee Bojen 2014S9, 2014S10, 2014S11, 2014S12, 2014S17, 2015S18, 2015S19, 2015S24, 2016S31, 2016S37, 2016S38, 2015S39, 2016S41, 2015S42 von 14.01.2014 bis 31.08.2016 stammen von http://www.meereisportal.de (Förderung: REKLIM-2013-04).

Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
SLF
ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG
HELMHOLTZ GEMEINSCHAFT
BREMERHAVEN
Am Handelshafen 12
27570 Bremerhaven
Telefon 0471 4831-0
www.awi.de