Snow Cover Impacts on Antarctic Sea Ice

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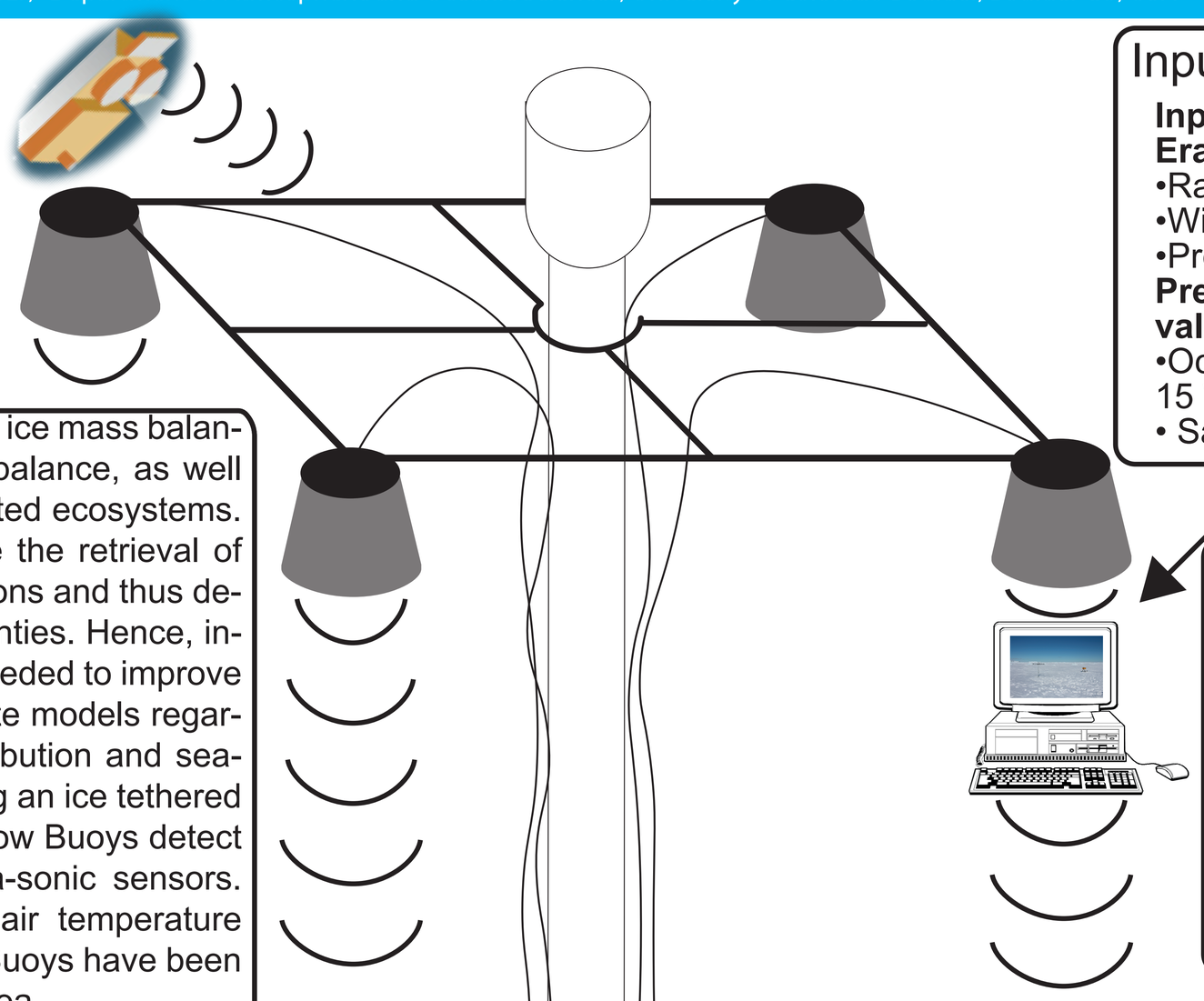
Background:

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.This impacts the surface energy balance, as well as the global climate and ice-associated ecosystems. The snow cover properties dominate the retrieval of many airborne and satellite observations and thus determine to a major factor the 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. This we achieve by deploying an ice tethered autonomous platform. The so call Snow Buoys detect snow height changes with four ultra-sonic sensors. Furthermore, it measures position, air temperature and pressure. Since 2013, 27 Snow Buoys have been deployed on sea ice in the Weddell Sea.



Input: SNOWPACK

Input from Era-Interim:
- Radiation
- Wind
- Precipitation

Prescribed values:
- Ocean heat flux: 15 Wm^2
- Salinity: 1-4 PSU

Input from Snow Buoy
- Air temperature
- Inital snow depth
- Snow accumulation

Input from IMB
- Initial Temperature profil

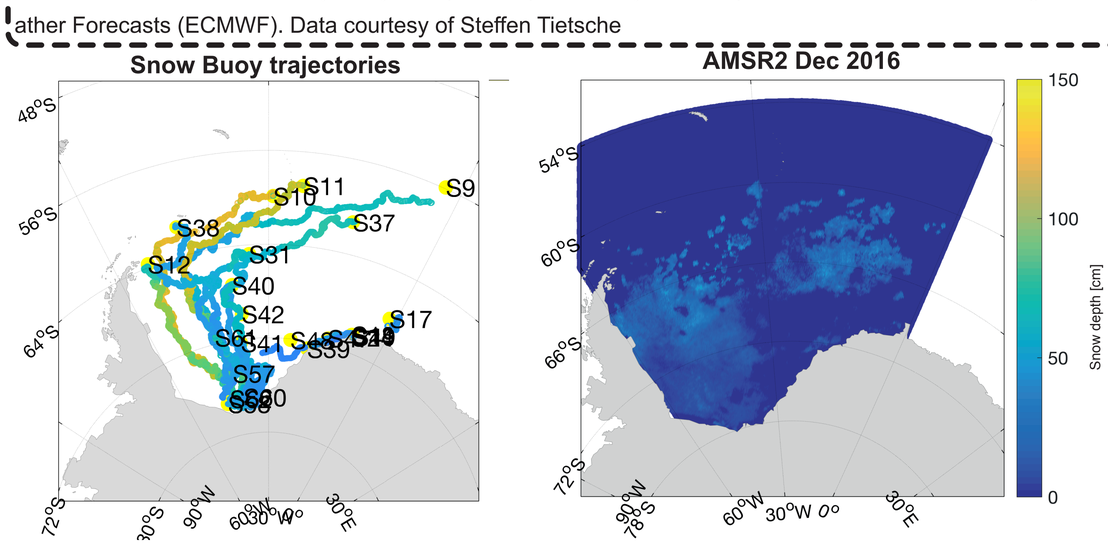
Method: SNOWPACK

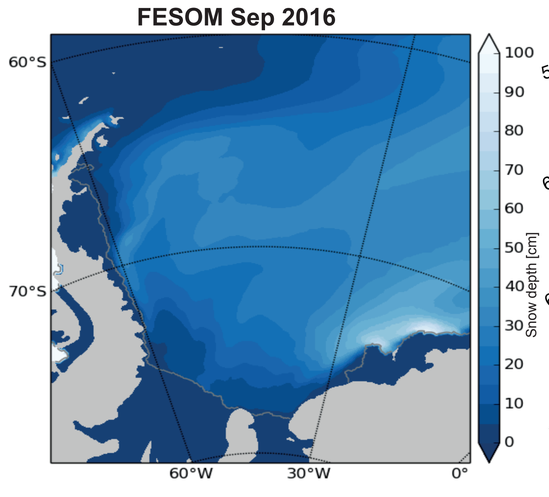
- 1D thermodynamic sea ice model including snow cover processes
- Well established numerical snow model (Lehning et al., 2002b)
- New implemented sea ice branch

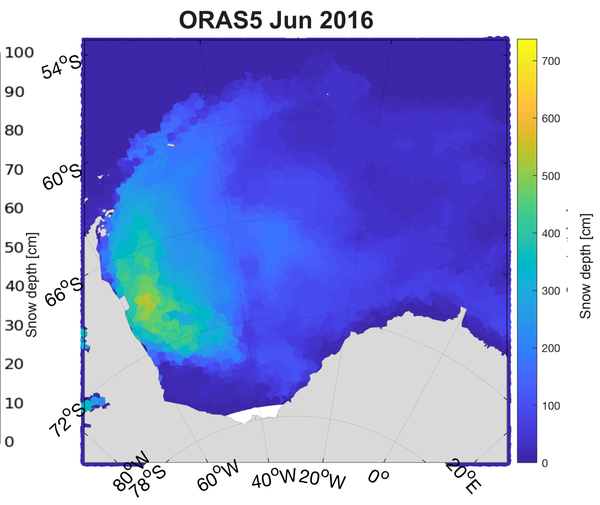
RESULTS 1:

Comparison between different data types

- **AMSR2** is the space borne snow depth retrieval from the Advanced Microwave Scanning Radiometer 2 satellite provided by the University of Bremen.
- **FESOM** is the Finite-Element Sea ice-Ocean Model product, provided by the AWI (data courtesy of Lukrecia Stulic).
- **ORAS5** is the Ocean Re-Analysis System product provided by the European Centre for Medium-Range Weather Forecasts (ECMWF). Data courtesy of Steffen Tietsche





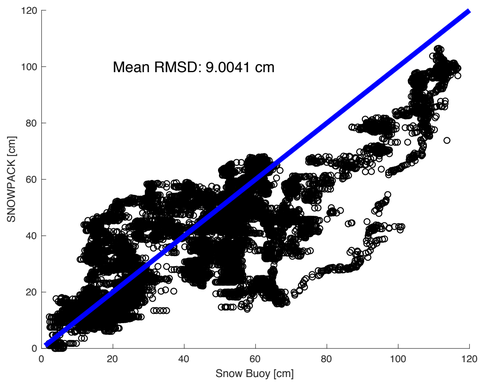


The plots show snow depth distribution in the Weddell Sea from four products during different timings of the year. AMSR2, FESOM and ORAS5 over and underestimate the snow depth seen by Snow Buoys.

RESULTS 2:

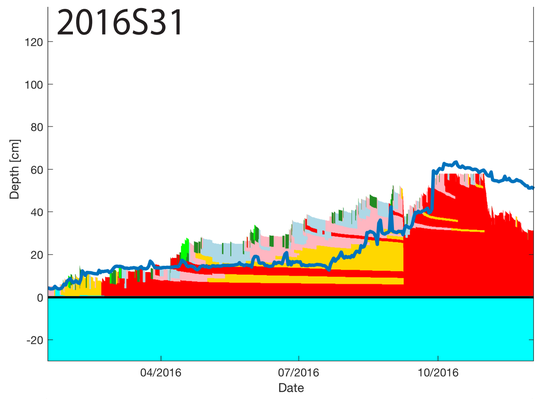
SNOWPACK simulations and grain type

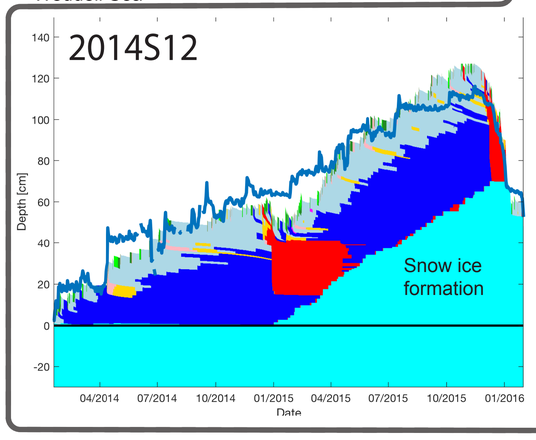
difference Plot
Snow Buoy vs SNOWPACK

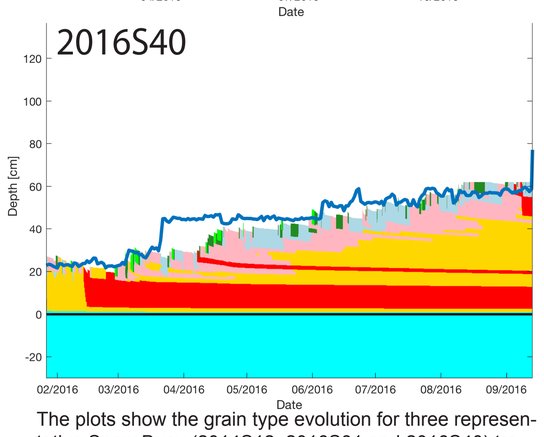


Scatter plot of snow depth of Snow Buoy vs Snowpack for several Snow Buoys deployed in the Weddell Sea

Example simulations

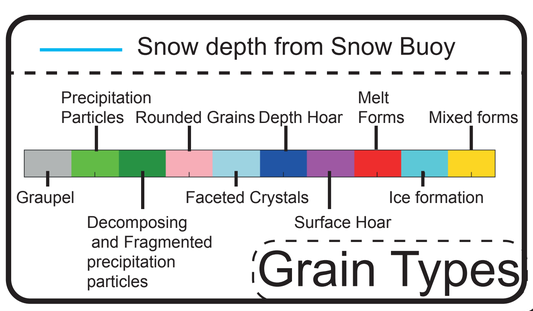






The plots show the grain type evolution for three representative Snow Buoy (2014S12, 2016S31 and 2016S40) trajectories.

- Snowmelt occurs when Snow Buoy reaches the marginal ice zone
- Layering, grain metamorthisim, melt freeze cycles and snow ice formations are representive in the model

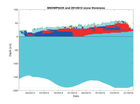


Conclusions

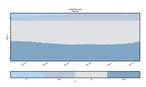
- The products of AMSR2, FESOM and ORAS5 show a clear mismatch to the snow depth of the autonomous Snow Buoys.
- SNOWPACK with input from ECMWF reproduces the snow depth with a root mean square error of 9 cm.
- SNOWPACK reproduces the snow metamorphism and snow ice formation, which influences space borne retrieval algorithms and the mass and energy balance.

Outlook

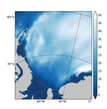
- We will derive snow stratigraphies along buoy trajectories to support remote sensing data interpretation.



- Grain type/size evolution and snow ice formation will a major part of future studies in order to link to remote sensing operations.



- The co-deployed IMBs will act for further validation of the SNOWPACK sea ice model.



- A direct link between SNOWPACK and FESOM will improve the snow depth in FESOM tremendously. This will enable us to generate a Weddell Sea wide snow depth product.

Citations:
Lehning et al., 2002a Lehning, M., Bartelt, P., Brown, R.L., Fierz, C., and Satyawali, P.K. 2002. A physical SNOWPACK model for the Swiss avalanche warning, Part II. Snow microstructure, Cold Regions Science and Technology 35, 2002, 147–167.

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, ORAS5 data courtesy of Steffen Tietsche (ECMWF)

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