ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

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Snow depth and air temperature on sea ice derived from autonomous Snow Buoy measurements

Background

More observations of snow depth on sea ice are **urgently needed** for various applications in polar and climate research. Large-scale and seasonal snow depth products are required for many in-situ, remote sensing, and numerical modelling applications.

We developed a new buoy type to obtain **time series of snow depth** and **air temperature** on Arctic and Antarctic sea ice. The buoy is based on four sonic ranging sensors, and transmits the data via Iridium satellites.

The buoy concept and design are based on **low unit costs and easy deployment**. Snow buoys proved to be most valuable when co-deployed with other buoy types.

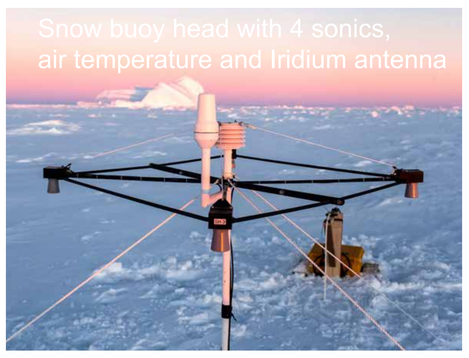
Near real time data sharing into international networks for a large user community: GTS, buoy programs

Snow Buoy

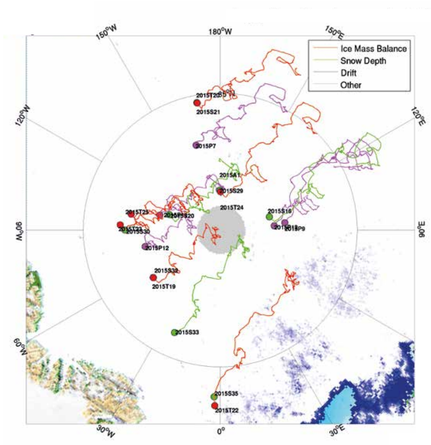
- Commercial (Met Ocean, Canada) product in close collaboration between research and engineering
- First deployments on Arctic and Antarctic sea ice in 2013
- 2 product updates (total: 42 units deployed, status May 2016)
- **Measured parameters: 4x snow depth, air temperature, body temperature, barometric pressure, and GPS position**
- Data transmission of hourly means through Iridium SBD
- Deployment with 2 persons in approx. 30 min
- Power supply by Alkaline or Lithium batteries, lifetime > 1 year
- Data access in near real time:
  http://data.seaiceportal.de

Parameter	Sensor	Accuracy	Interval
Distance to Surface	Max Botix, Sonar MB7092	1 cm	7 / hour
Air Temparature	YSI, 44032	0.5°C	7 / hour
Surface Temperature	YSI, 44032	0.5°C	20 / hour
Barometric Pressure	Vaisala, PTB 110	1 mbar	20 / hour
Data transfer	Iridium 9602 SBD		every 3 hours
GPS Position	Jupiter 32xLP module & antenna	10 m	1 / hour

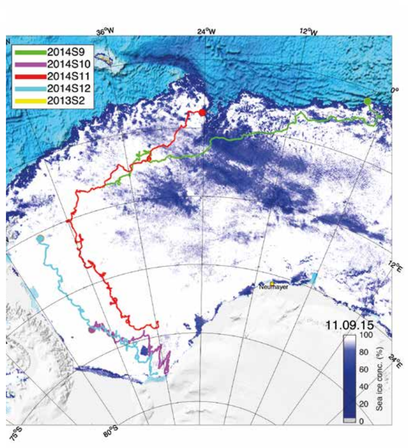

Snow buoy (2013S2) at Neumayer


Snow buoy head with 4 sonics, air temperature and Iridium antenna

Deployments & Data



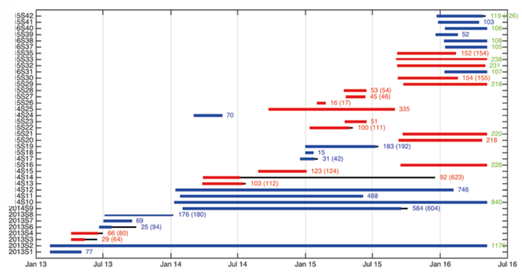
Snow buoys (green lines) contribute to a network of autonomous platforms in the Arctic (deployed in autumn 2015). (Figure: www.seaiceportal.de)

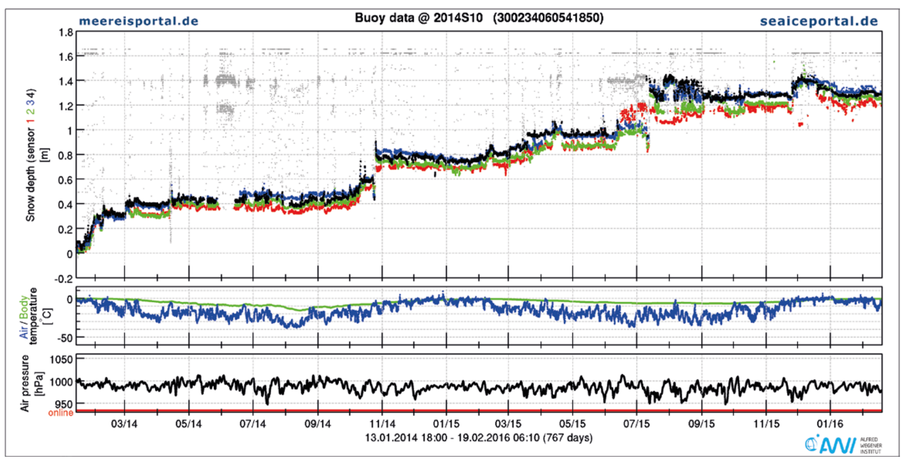


Four snow buoys drifting through the Weddell Sea. See also results section. (Figure: www.seaiceportal.de)

In total, 40 snow buoys were deployed on Arctic (20) and Antarctic (20) from icebreakers, by snow mobile from land, or by helicopter since 2013.

2 snow buoy prototypes were deployed at the Neumayer base, allowing comparisons to other snow depth and meteorological measurements.

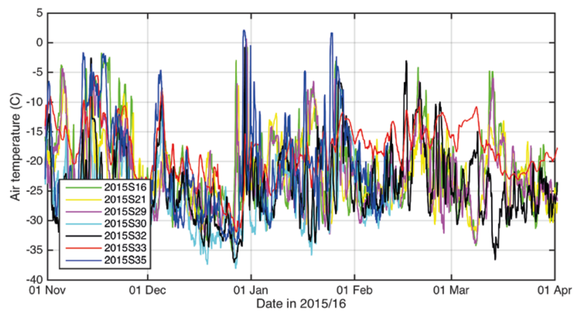

Life time (days) of all snow buoys: Arctic (red), Antarctic (blue), Green numbers: buoy still active



Results from snow buoy 2014S10, drifting through the Weddell Sea and reporting data for more than 2 years. Total snow accumulation is >1.2 m.
Top: Snow depth measured from the four sonics. Grey dots represent discarded measurements after standard quality control.
Middle: Air and body temperature with annual cyle
Bottom: Barometric air pressure
(Figure: www.seaiceportal.de)

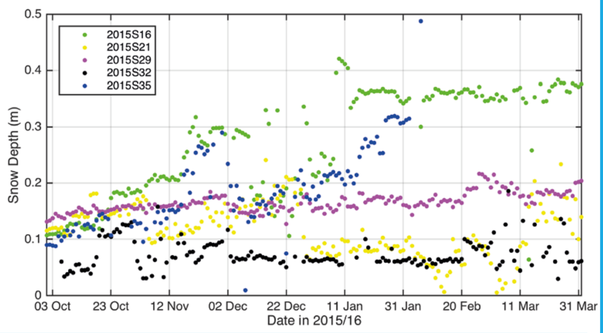
Results & Highlights

- Third-generation snow buoys advance seasonal monitoring of snow depth on sea ice.
- Snow buoys are reliable (up to >2 years) instruments for snow depth and air temperature measurements on sea ice.
- A standard data processing has been developed and gives mostly good and consistent data sets.
- Near real time data allow immediate analysis, e.g. during Arctic warming event (winter 2015/16).

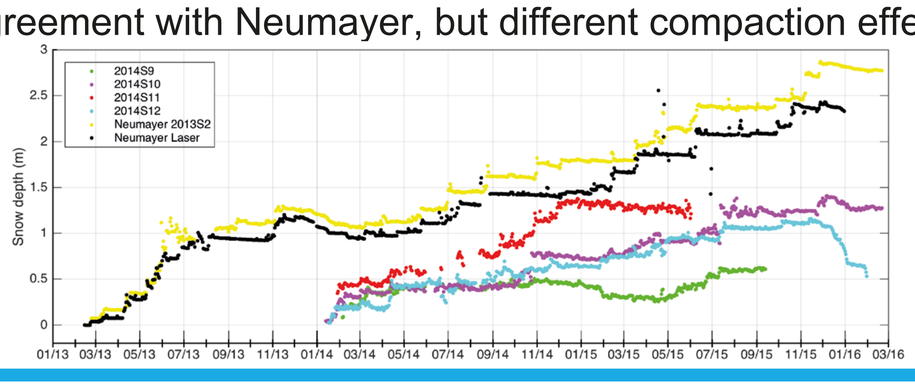


Air temperature (hourly, top) and snow depth (daily mean, right) from snow buoys on Arctic sea ice during winter 2015/16. Drift tracks are shown in the map above.

Arctic winter 2015/16
- Temperatures above melting
- Very warm winter
- No strong surface melting



Seasonality of Weddell Sea snow depth
- No strong summer melt in most parts of the Weddell Sea (except at ice edge)
- No complete melt in any Antarctic time series
- Strong regional differences with net annual accumulation of 20 of 90 cm
- Agreement with Neumayer, but different compaction effects (foundation depth)



Comparison of snow depth from
- 4 Weddell Sea snow buoys on sea ice
- 1 Neumayer snow buoy (on ice shelf) and a reference Laser sensor next to this snow buoy.

Drift tracks and positions are shown in the map above.

Outlook

- Further improvements with respect to data quality and data processing, e.g. effects of air temperature changes on snow depth signals
- Applications of snow buoy data for comparisons with retrievals of snow depth from remote sensing
- Use of the snow buoy as platform for additional sensors, e.g. wind speed/direction, under-ice sonic
- Extending international collaboration on the usage of snow buoys

Acknowlegement
The success of the design and development strongly depended on the good cooperation with the team of MetOcean. We thank Martin Schiller (Alfred-Wegener-Institut, AWI) for his ideas and support when designing the buoy. The prototypes and development were financed through the AWI.
The deployments of the buoys benefited from the logistics and support of many partners and Institutes: AWI, Norwegian Polar Institute, University of Alaska, Universität Hamburg, CH2MHill Polar Services, Barrow Arctic Science Consortium, and UMIAQ. We also thank various cruise leaders, captains, and crews (incl. helicopter teams) for their help and support. The wintering teams at Neumayer III base helped greatly to improve the buoy and to obtain the long time series close to the station.

We highly appreciate the work of the meereisportal.de (www.seaiceportal.de) team for building and maintaining the online platform and data base for all snow buoy data and figures (REKLIM-2012-04). Sea ice concentration, used as background data, is kindly provided by the Universität Bremen (Institut für Umweltphysik).
The snow buoys presented on this poster were funded through the Helmholtz infrastructure programs ACROSS and FRAM. Different authors received funding from external projects: Helmholtz Alliance ‚Remote Sensing and Earth System Dynamics' (HA-310), EU H2020 project SPICES (640161), DFG project SCASI (NI 1096/5-1), ESA Sea Ice CCI phase 2 (AO/1-6772/11/I-AM), and the German Ministry of Economics and Technology (Grant 50EE1008).

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