

# Snow depth on Arctic and Antarctic sea ice derived from new 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.

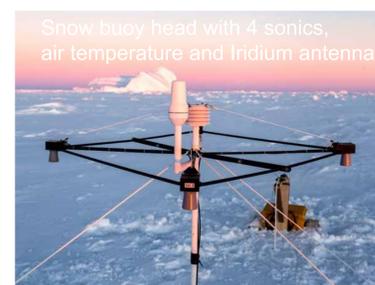
Near real time data sharing into international networks for a large user community: GTS, buoy programs

## Snow Buoy

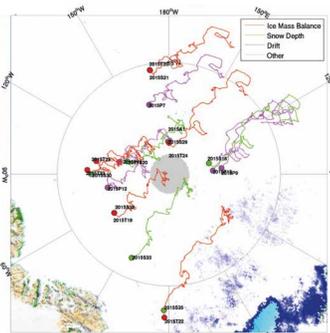
- Commercial (Met Ocean, Canada) product in close collaboration between research and engineering
- First deployments on Arctic and Antarctic sea ice in 2013, 2 product updates (total: 42 units deployed, status Feb. 2016)
- **Measured parameters: 4x snow depth, air temperature, body temperature, barometric 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>

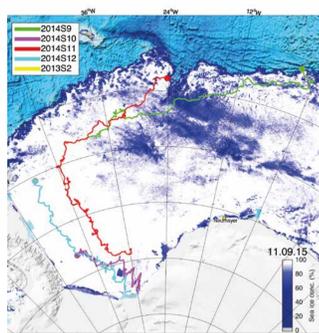
Parameter	Sensor	Accuracy	Interval
Distance to Surface	Max Botix, Sonar MB7092	1 cm	7 / hour
Air Temperature	YSI, 44032	0.5°C	7 / hour
Surface Temperature	YSI, 44032	0.5°C	20 / hour
Barometric Pressure	Vaisala, PTB 110	1 mbar	20 / hour
Data transfer	Iridium 9602 SBD		every 3 hours
GPS Position	Jupiter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



## Deployments & Data



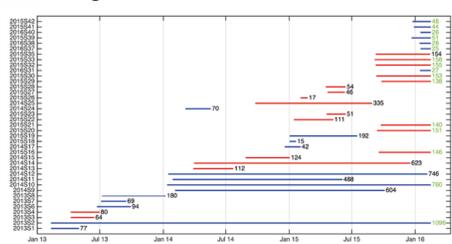
Snow buoys (green lines) contribute to a network of autonomous platforms in the Arctic (deployed in autumn 2016). (Figure: www.seaiceportal.de)



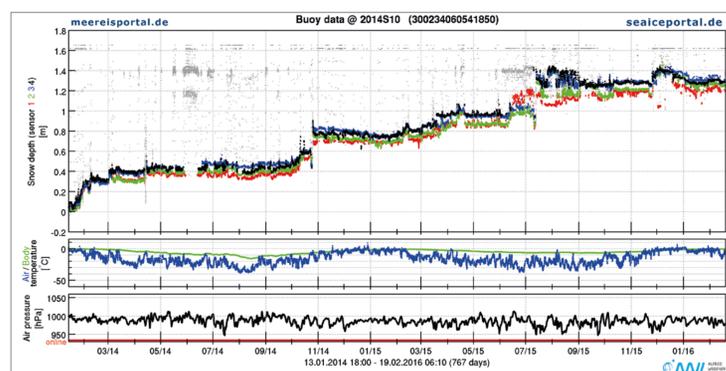
Four snow buoys drifting through the Weddell Sea. See also results section. (Figure: www.seaiceportal.de)

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.

Two prototypes were deployed close to 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.

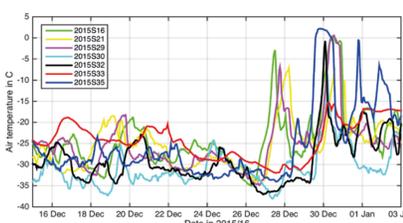
**Top:** Snow depth measured from the four sonics. Grey dots represent discarded measurements after standard quality control.

**Middle:** Air and body temperature with annual cycle

**Bottom:** Barometric air pressure (Figure: www.seaiceportal.de)

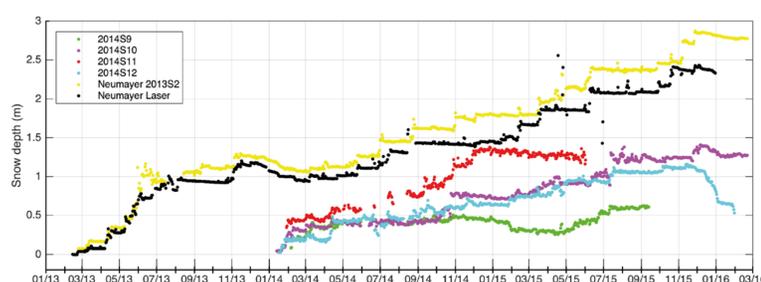
## Results & Highlights

- 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 (longest time series).
- 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 (Dec. 2015).



Air temperature measured by snow buoys in the Central Arctic in December 2015.

### Results from 4 Weddell Sea buoys 1 Neumayer buoy 1 Neumayer reference



- 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)

## 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

**Interested? Feedback wanted!**

Comparison of snow depth from snow buoys and retrievals from AMSR2 brightness temperatures. Time series from the same 4 buoys in the Weddell Sea as shown in Results.

