

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.

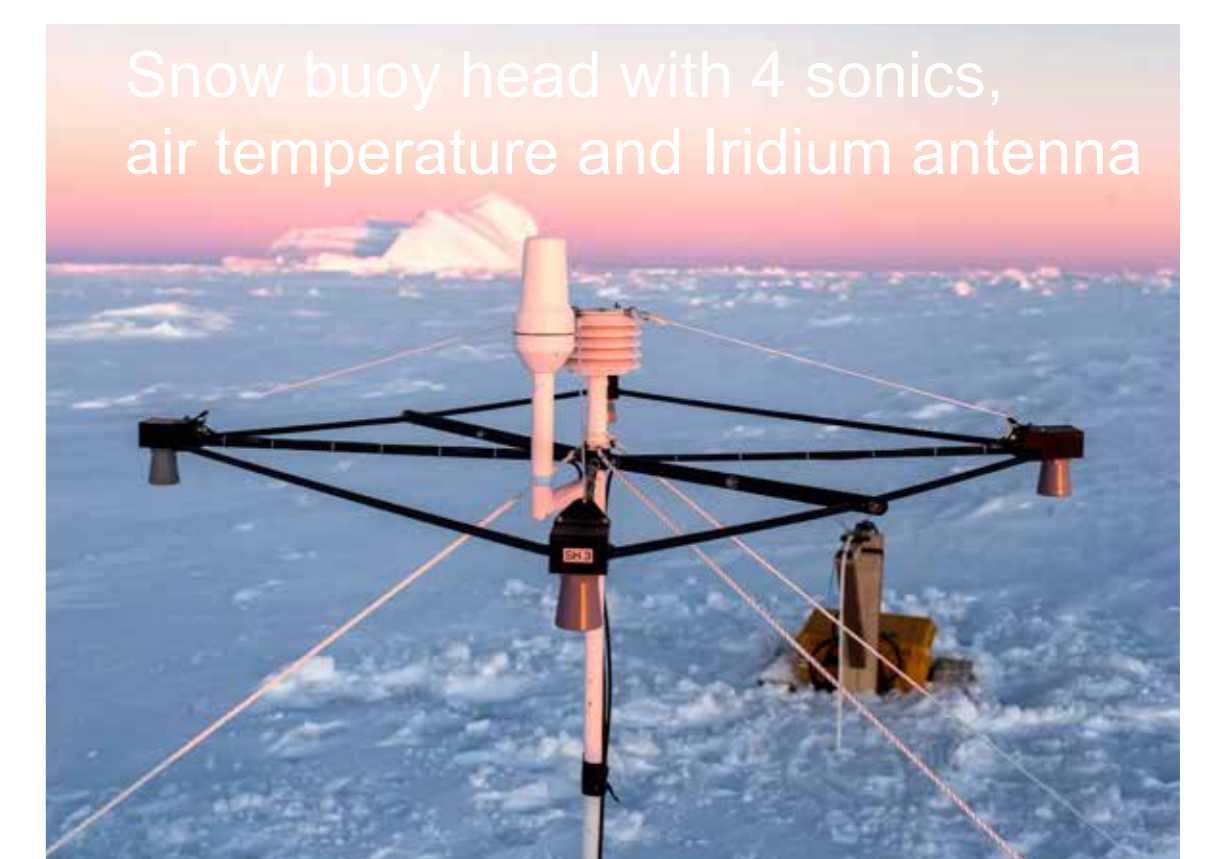
Near real time data sharing into international networks for a large user community: GTS, buoy programs

Snow Buoy

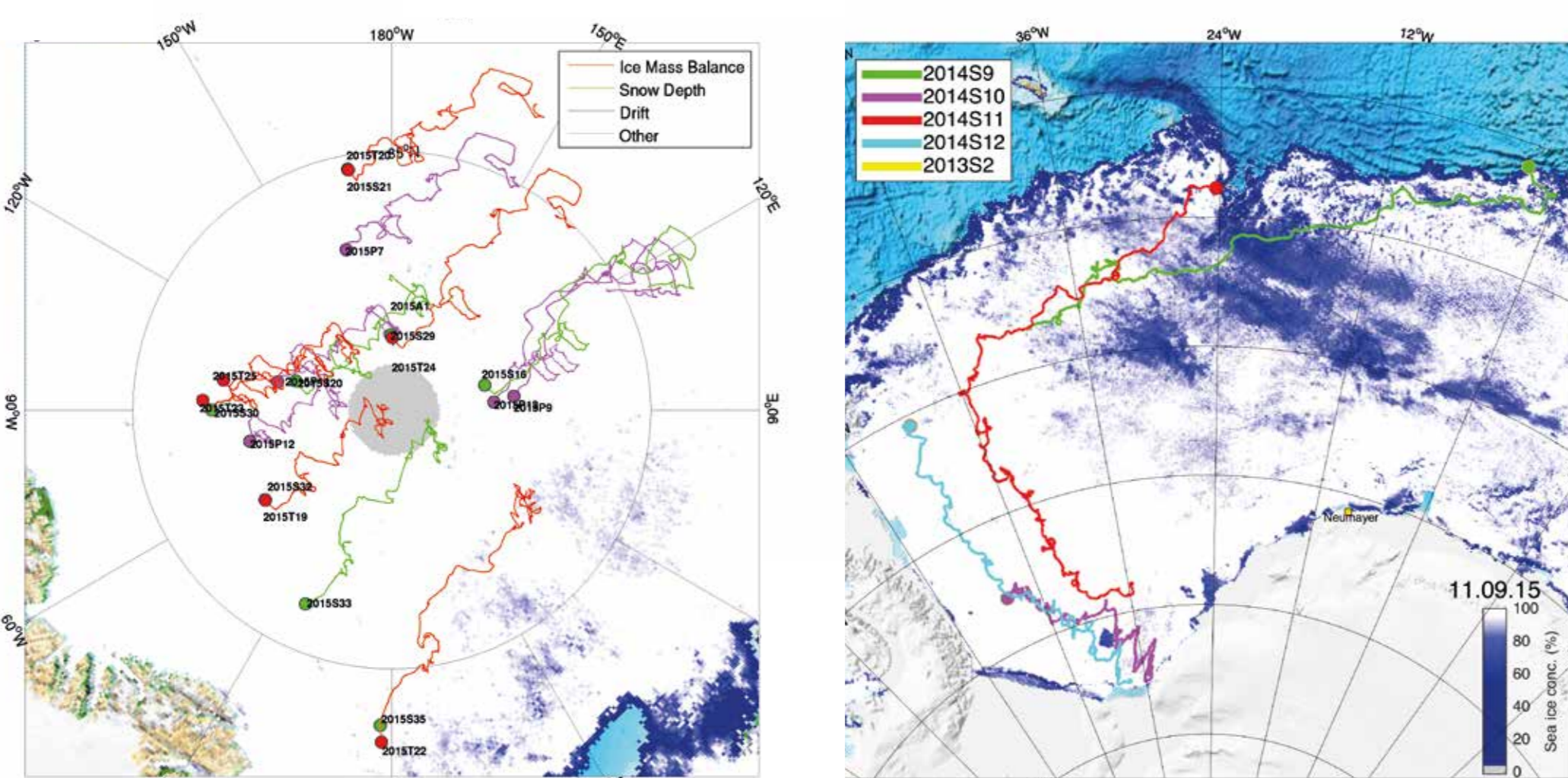
- Commercial (Met Ocean, Canada) product in close collaboration between research and engineering
- First deployments on Arctic and Antarctic sea ice in 2013
- 2 product updates (total: 42 units deployed, status May 2016)
- **Measured parameters: 4x snow depth, air temperature, body temperature, barometric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

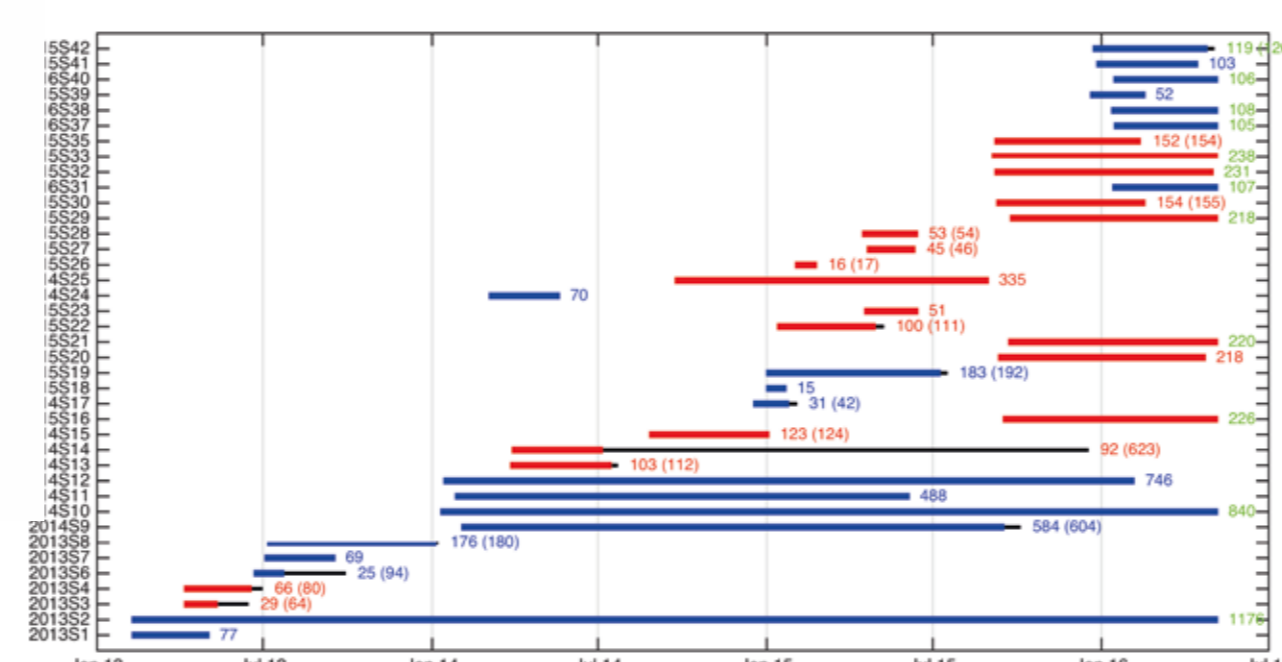


Snow buoys (green lines) contribute to a network of autonomous platforms in the Arctic (deployed in autumn 2015). (Figure: www.seaiceportal.de)

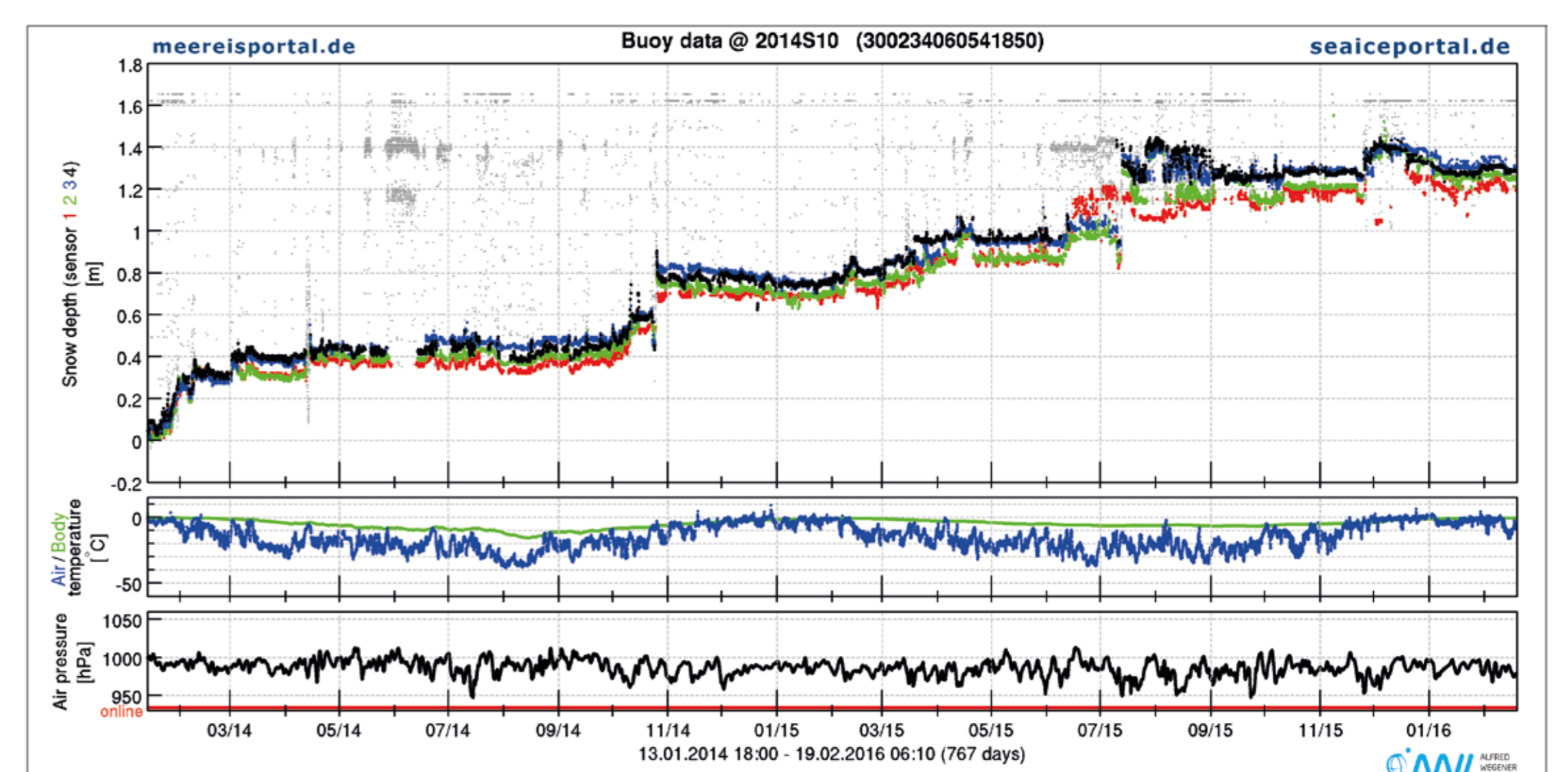
Four snow buoys drifting through the Weddell Sea. See also results section. (Figure: www.seaiceportal.de)

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 cycle

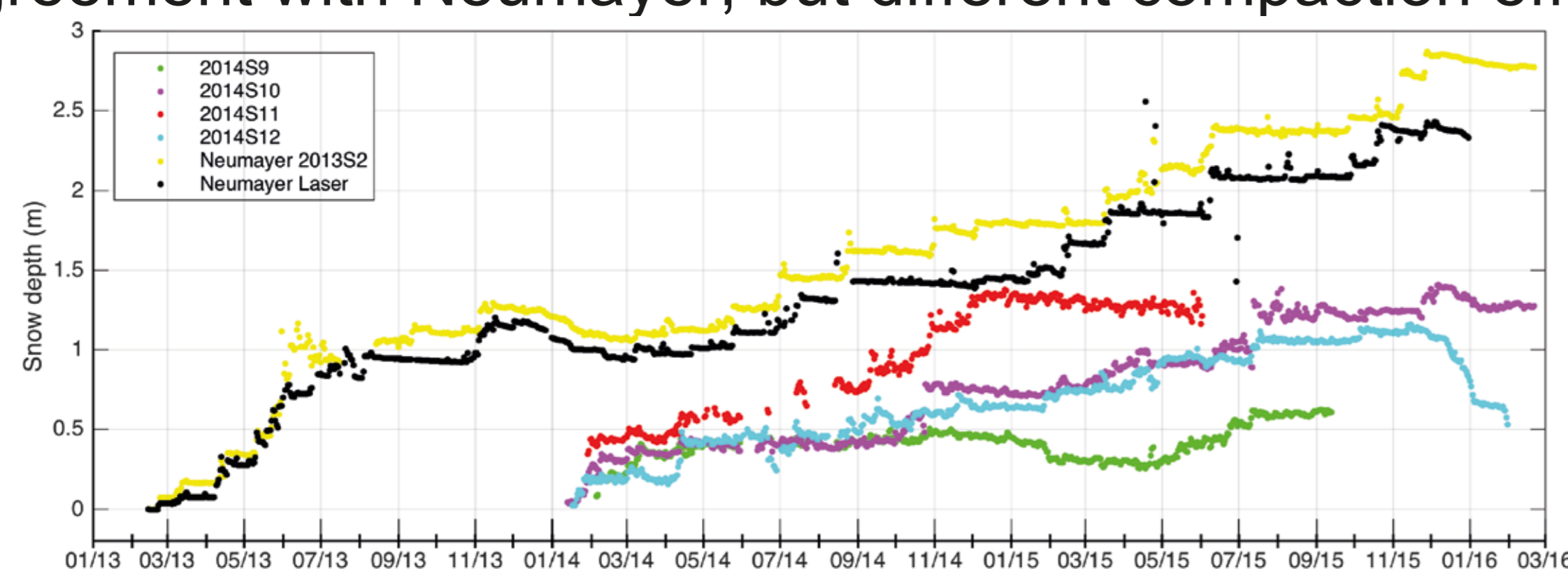
Bottom: Barometric air pressure (Figure: www.seaiceportal.de)

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.
- 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).

Seasonality of Weddell Sea snow depth

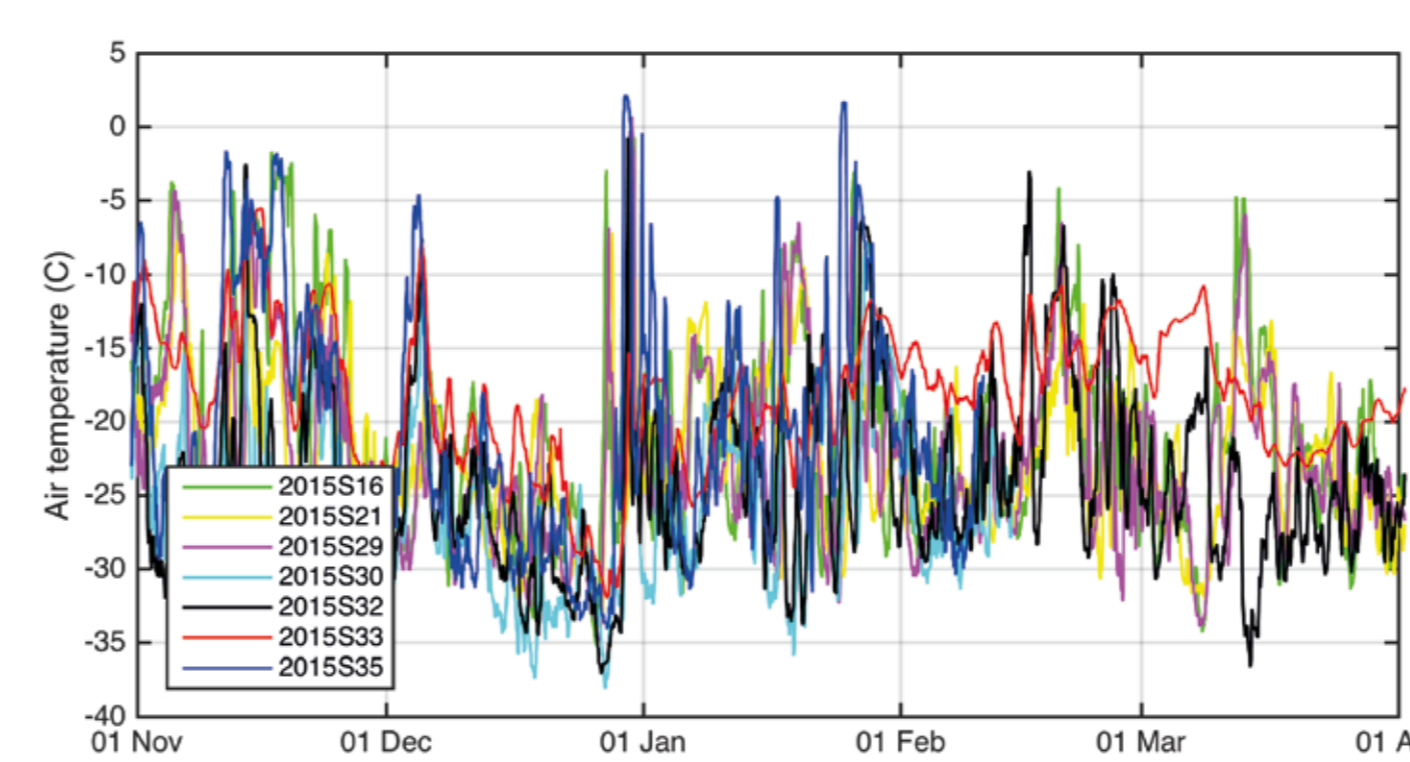
- No strong summer melt in most parts of the Weddell Sea (except at ice edge)
- No complete melt in any Antarctic time series
- Strong regional differences with net annual accumulation of 20 of 90 cm
- Agreement with Neumayer, but different compaction effects (foundation depth)



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.

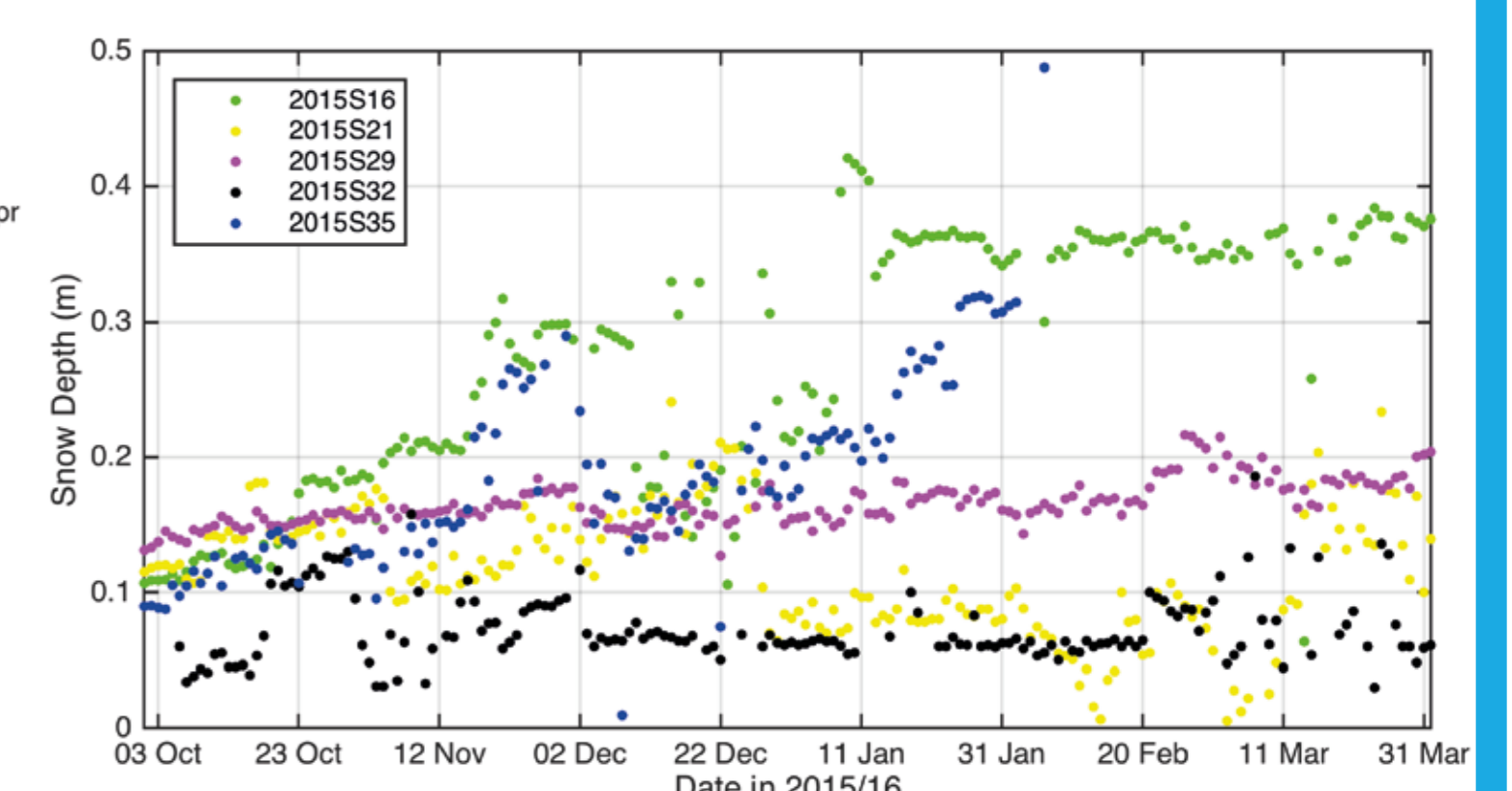
Drift tracks and positions are shown in the map above.



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



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

