Snow and ice thickness derived from sea ice mass balance buoys in the Transpolar Drift system

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10 different work packages in total
WP1: "Establishing an adaptive and more complete Arctic observing system" (Lead: NPI / LUND)

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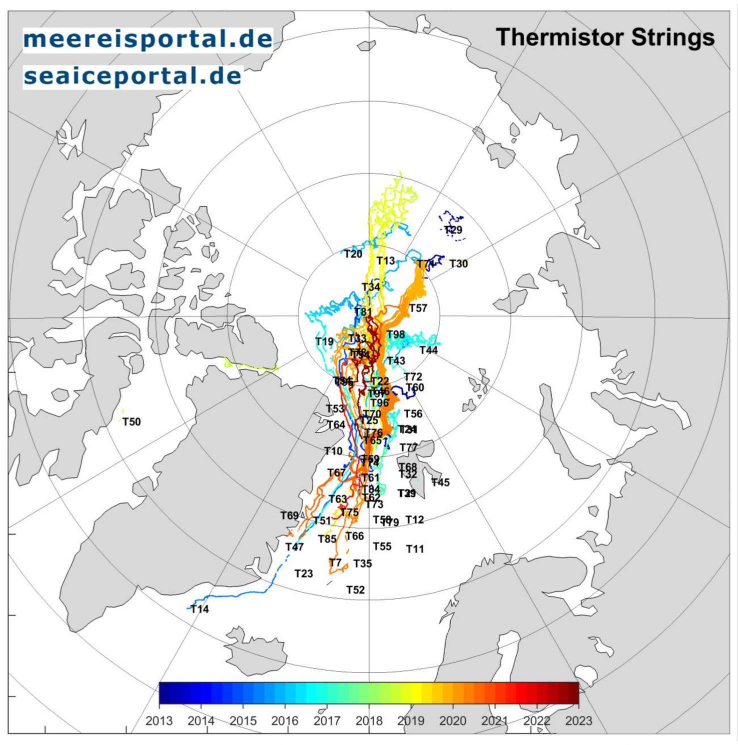

Figure 1 Overview of thermistor buoy drift tracks in the Arctic between 2012 and 2023 (data.seaiceportal.de).

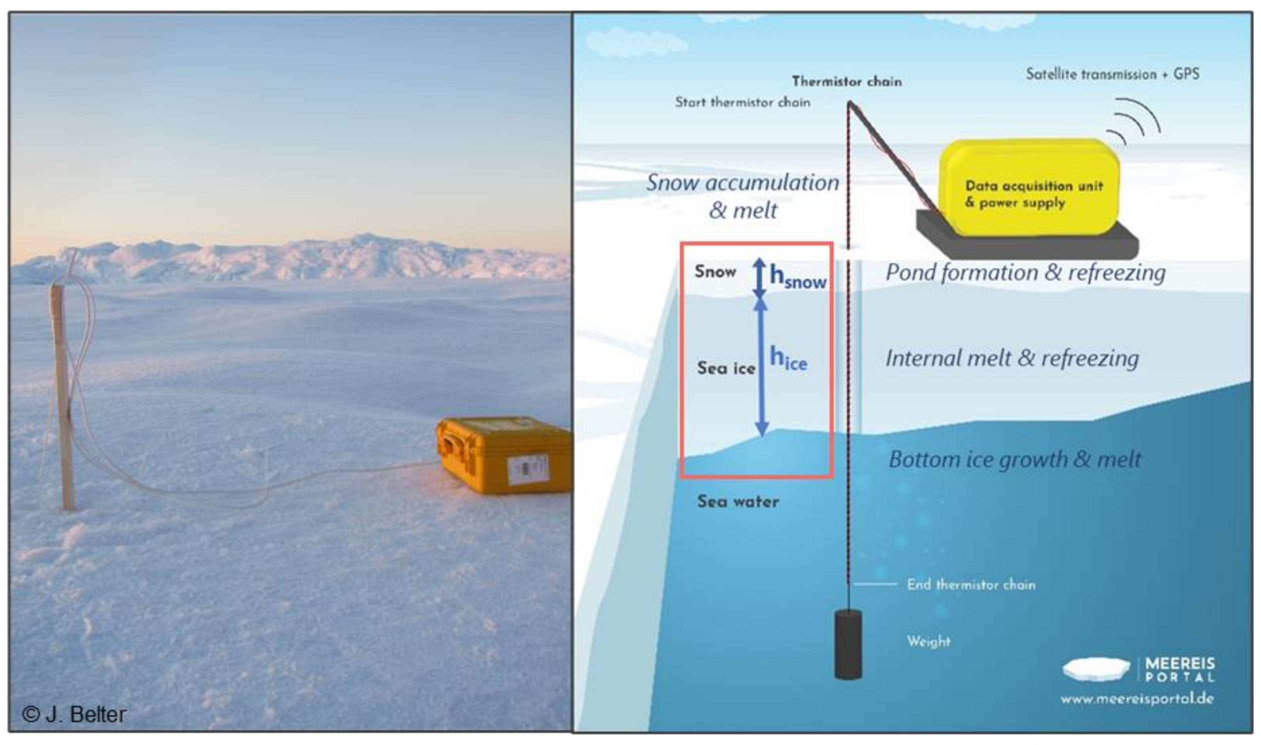

Figure 2 (left side) Photograph of buoy "2018T55" right after deployment in the East Siberian Sea. **(right side)** Schematic of a thermistor buoy (SIMBA) and its surrounding interfaces & processes (© seaiceportal.de; Grosfeld et al. (2016)).

Thermistor buoys (SIMBA) on data.seaiceportal.de

- **More than 90 SIMBA buoys** (e.g., Jackson et al. (2013)) deployed & archived
- All years between **2012 – 2023**
- **Both hemispheres covered** (roughly two thirds Arctic ("MOSAiC boom"), one third Antarctic)
- Mainly **drift and temperature** data

→ No thickness data included yet – now consistent processing for Arctic PASSION

Aims

- Achieve a **better understanding of the interannual variability** of SIMBA measurements through **analyzing decadal changes & linkages** to large-scale observations
- Develop a **uniform processing scheme for SIMBA** in order to minimize methodological ambiguities in the derivation of **snow-ice-ocean interfaces**
- Create a **data set with added value** in terms of **characterizing the sea ice mass balance** & related **external parameters** in close proximity
- Make data set available in a way that **maximizes its usability/compatibility** within an **Arctic observing system**

SIMBA processing: From temperatures to geophysical parameters

Snow & sea ice interfaces mainly through manual classification in a consistent & guided processing framework

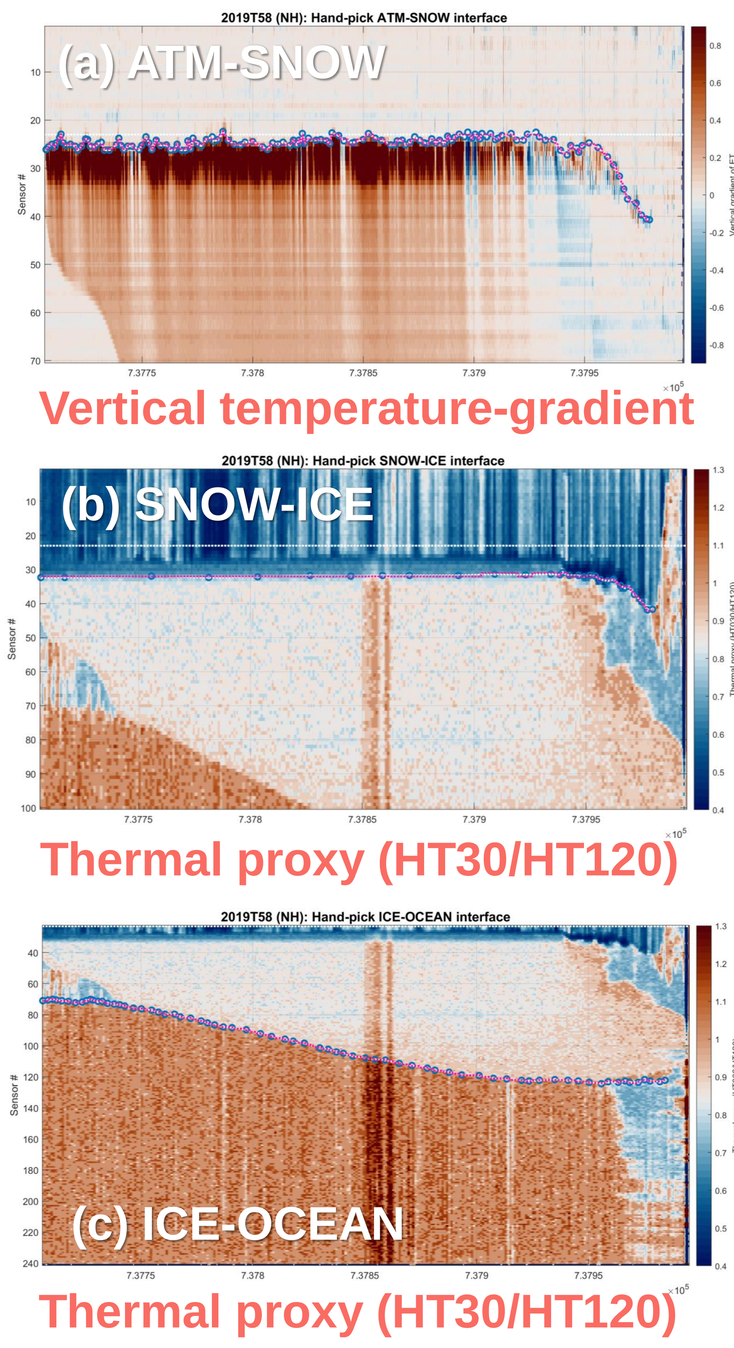

Figure 3 Example for picked locations of the **(a)** atmosphere-snow, **(b)** snow-ice and **(c)** ice-ocean interface for buoy "2019T58", based on the vertical gradient of recorded temperatures and the thermal proxy as the ratio of heating temperatures (HT) after 30s and 120s. The purple line indicates interpolated interface positions between manually classified points (blue circles) .

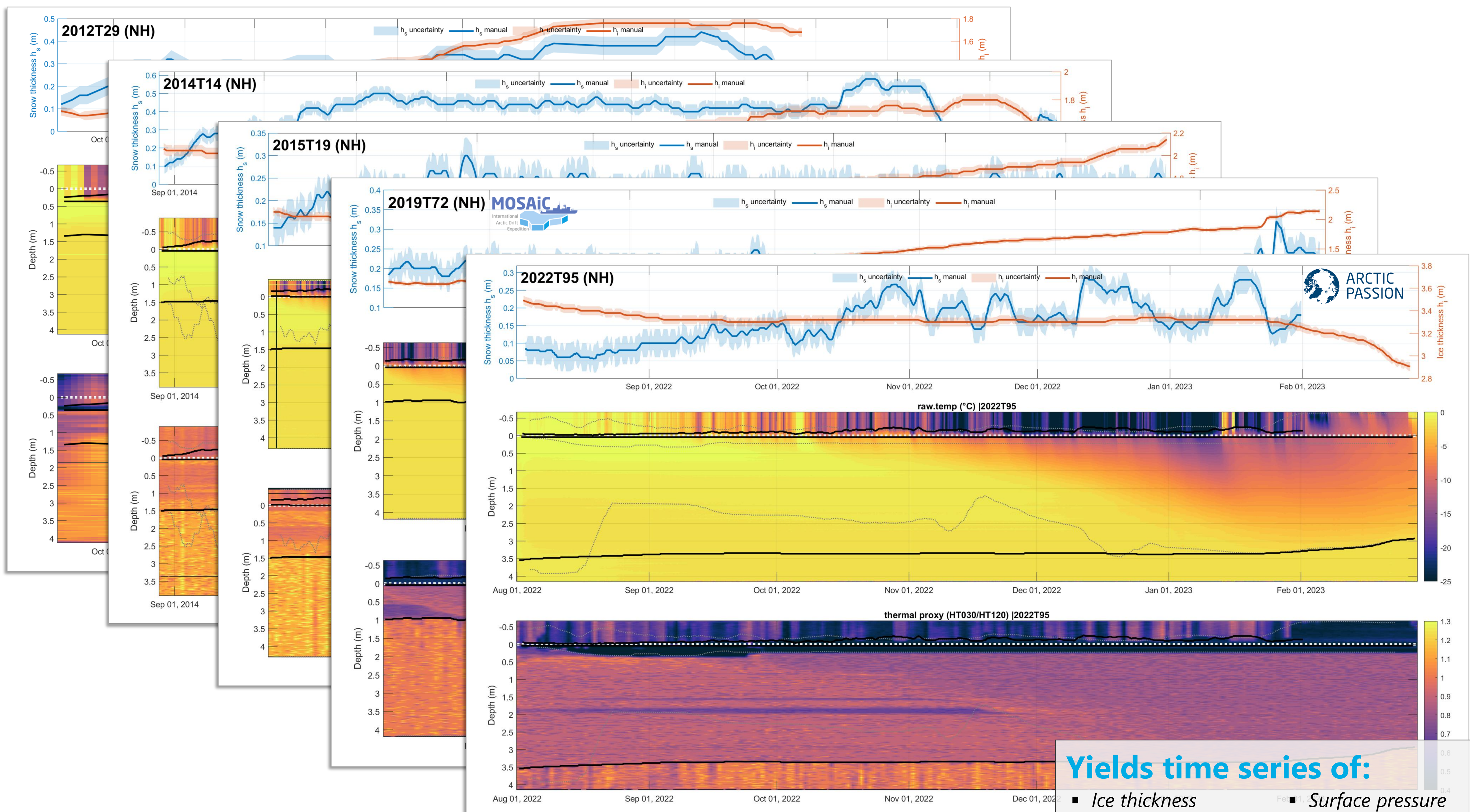

Figure 4 Examples for derived snow- and ice thicknesses (top panels; blue and red lines respectively) for buoys "2012T29", "2014T14", "2015T19", "2019T72" and "2022T95", together with respective profile time series of recorded environmental temperatures in °C (mid panels) and the thermal proxy as the ratio of heating temperatures after 30s and 120s (lower panels). Manually classified interfaces are marked as black solid lines, while other alternative automatic retrievals are marked with light grey dotted lines.

Yields time series of:

- *Ice thickness*
- *Snow thickness*
- *Interface temperatures*
- *Air temperature*
- *Surface pressure*
- *Ice growth*
- *Surface & bottom melt*

Application: SATELLITE comparisons

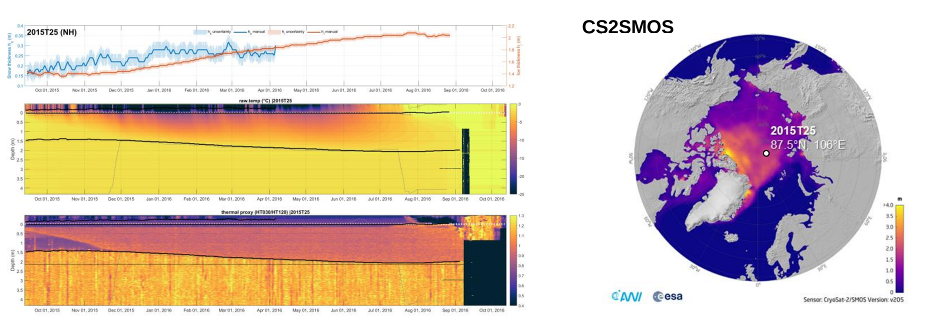

Figure 5 (left side) Derived snow- and ice thicknesses (top panel; blue and red lines respectively) for buoy "2015T25" (OCT 2015 to JUL/AUG 2016), together with respective profile time series of recorded environmental temperatures in °C (mid panel) and the thermal proxy as the ratio of heating temperatures after 30s and 120s (lower panel). **(right side)** Pan-Arctic map of satellite-derived ice thicknesses (CS2SMOS – Ricker et al. (2017)) for the first week of 2016 (Jan 01 to 07).

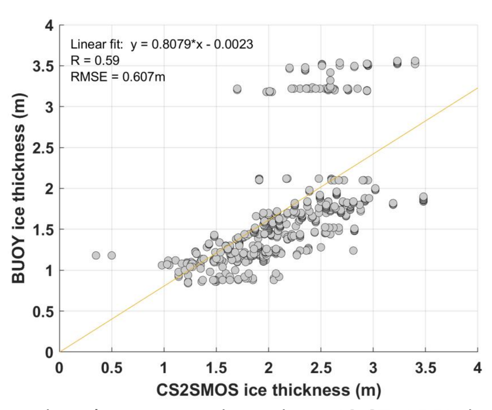

Figure 6 Linear regression between wintertime (OCT-APR) ice thicknesses of a subset of 10 SIMBA buoys, deployed between 2012 and 2016 in the Transpolar Drift, and their corresponding satellite-derived ice thickness counterpart (CS2SMOS - Ricker et al. (2017)).

→Fair to assume a **good representativeness of derived buoy ice thicknesses** for a wider area (here: 25x25 km²)

Application: MOSAiC vs. historic buoys in the Transpolar Drift system

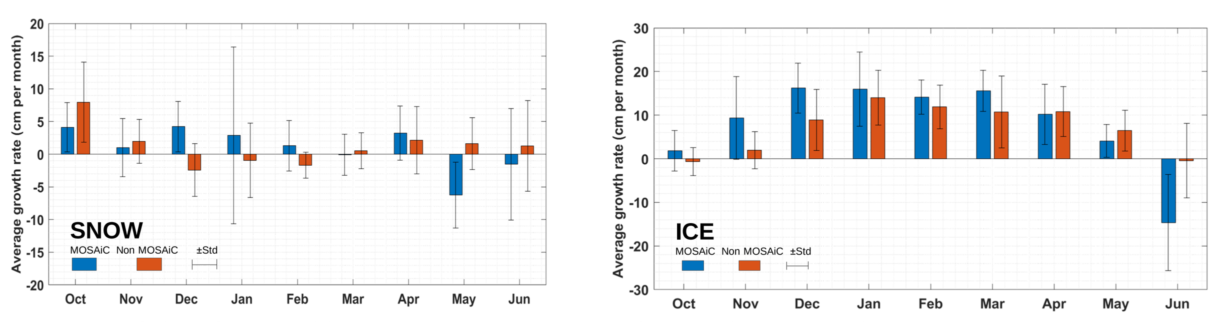

Figure 7 (left side) Monthly average snow growth/melt rates (in cm/month) between October and June together with their standard deviations (black whiskers), compared between MOSAiC (blue bars) and non-MOSAiC (red bars) buoys. (right side) Same as left side, but for ice growth/melt rates.

Winter to spring growth & melt rates (October-June)

- **Snow**: overall high variability
- **Sea ice**: larger growth rates during MOSAiC rather early in Nov/Dec

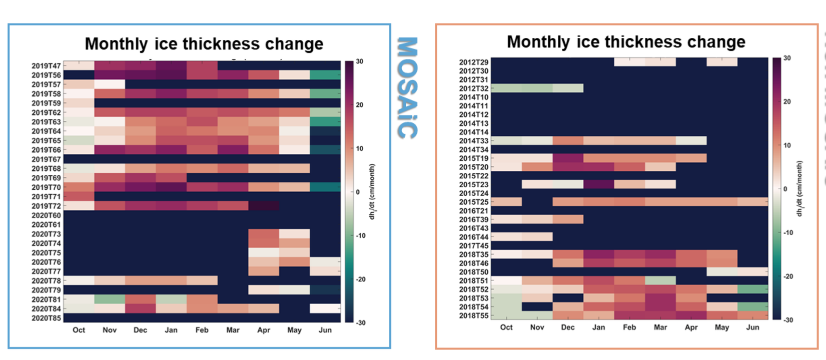

Figure 8 Monthly ice thickness change (in cm/month) for each individual SIMBA buoy deployed during MOSAiC (left side/blue frame; compare Lei et al. (2022) & Nicolaus et al. (2022)) and for non-MOSAiC buoys (right side, red frame).

In short – current status

- More than **10 years** (2012-2023) of **Arctic** & **Antarctic SIMBA data** has been processed in terms of **interface retrieval** and **associated time series**
- **Extendable** to other data sources
- **Snow- & ice thickness data set online soon**
  - Features basic measure for **uncertainty** & derived **mass balance** parameters
  - Easy-to-use & standardized **data formats** (csv & netcdf), to be distributed via Pangaea
- **Analysis of retrieved parameters** & **large-scale context** ongoing

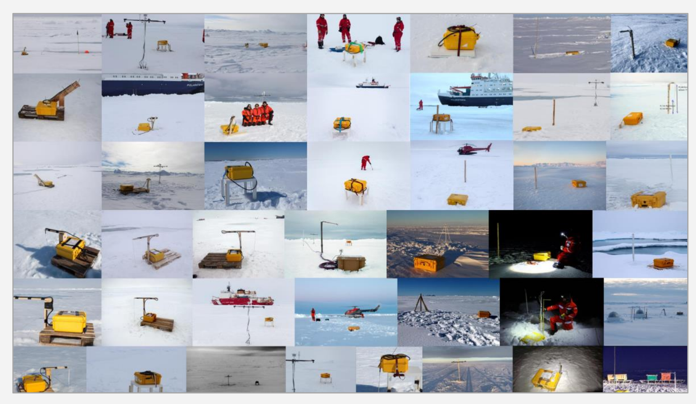

Figure 9 Collection of photographs taken during the deployment of various different SIMBA buoys in the Arctic and Antarctic between 2012 and 2022, as illustrated on individual deployment sheets on data.seaiceportal.de.

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