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The seasonal cycle of an ice-shelf influenced fast-ice cover, derived from thermistor-chain temperature profiles

Summary

The overall goal of this study is to characterize the seasonal evolution of an Antarctic coastal, ice-shelf influenced fast-ice regime with an autonomous thermistor chain.

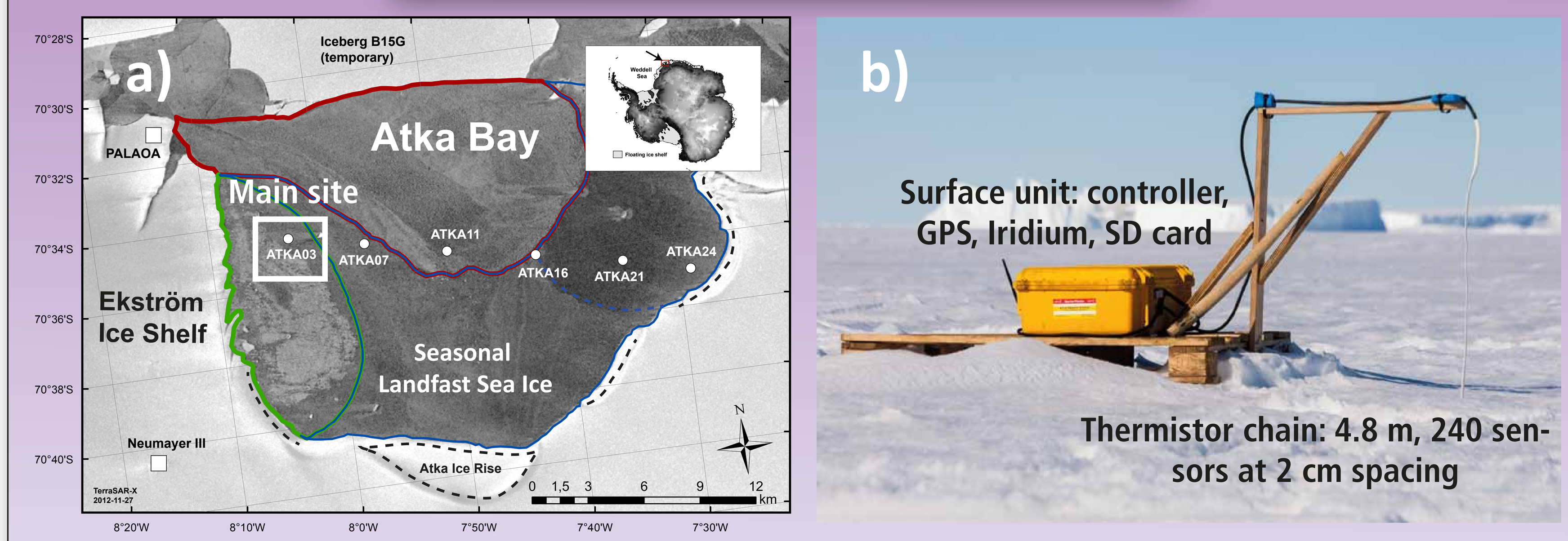
Background: The formation of ice platelets in supercooled water is a manifestation of basal melt processes in the cavity. These crystals accumulate in large amounts below the fast ice to form a porous layer. Despite its importance for sea ice and ecosystems in coastal Antarctica, information about its formation and spatio-temporal variability is sparse. This is at least partly attributed to the lack of suitable methodology.

Method: We obtained a 15 month long time-series of sea-ice temperature profiles on the fast ice of Atka Bay, a coastal sea-ice regime in the eastern Weddell Sea. We used a thermistor chain with the additional capability of actively heating its thermistor elements, taking advantage of the different thermal characteristics of the surrounding medium. Despite the rising interest in this kind of instrument, its full potential has not been assessed yet.

Results: Calculating the basal energy budget, we find a negative oceanic heat flux which accounts for 18 % of sea-ice growth. This corresponds to a platelet layer ice-volume fraction of 18 %, which is also confirmed by model simulations and agrees well with a previous study at the same location. In addition, this study confirmed the seasonal evolution of the platelet layer found in the previous year. Ice platelets dominated the overall sea-ice thickness gain by effectively contributing 1.28 m, or 61 %, of the total sea ice growth.

Finally we use this unique dataset to assess the potential of this relatively new instrument design (Jackson 2013), highlighting its advantages and pointing out its caveats.

Study area and method

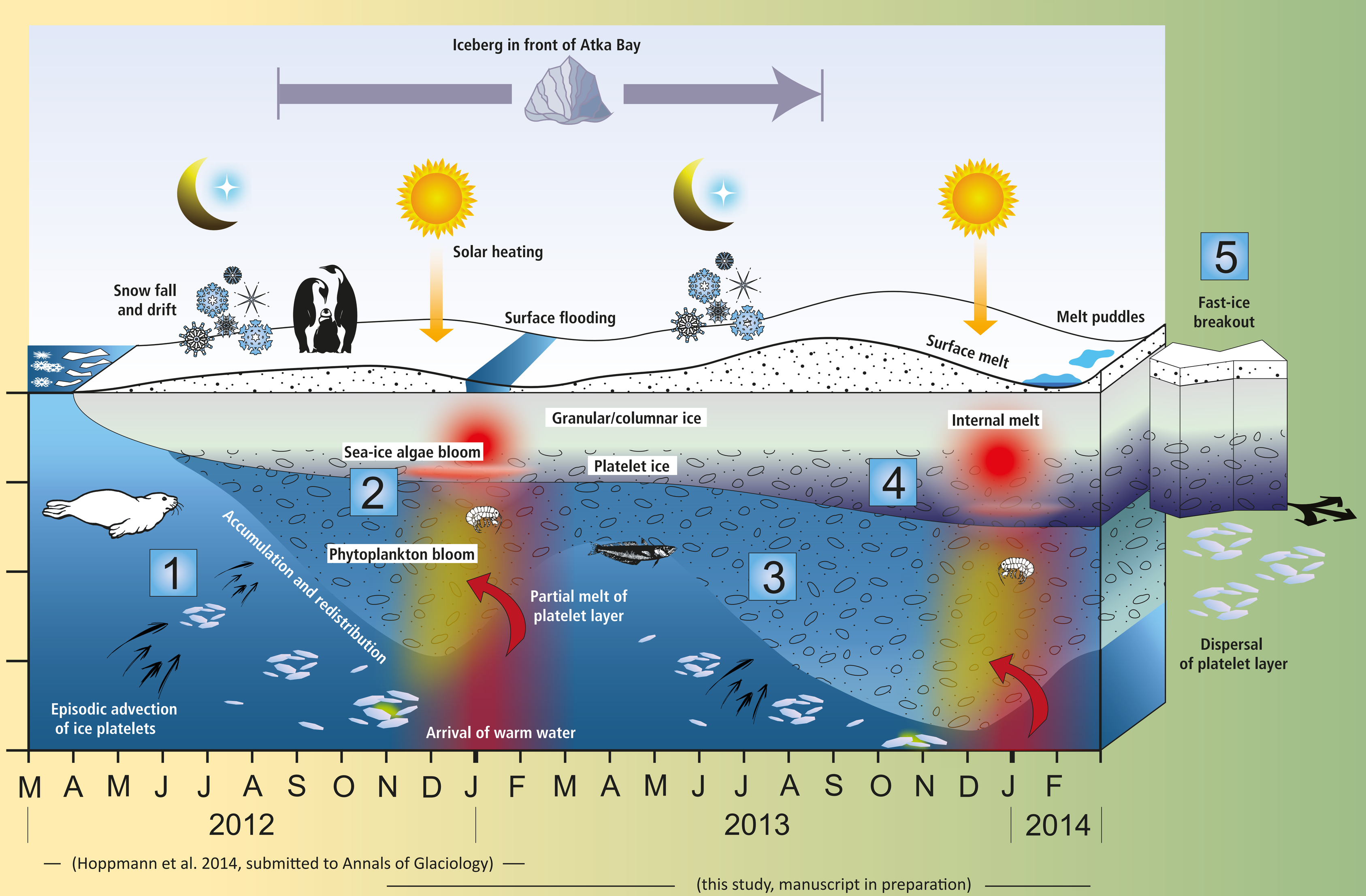


a) TerraSAR-X image of the study area, a few days after deployment of the thermistor chain. The presence of second-year ice during in 2013 is attributed to the temporary grounding of a large iceberg in front of Atka Bay.

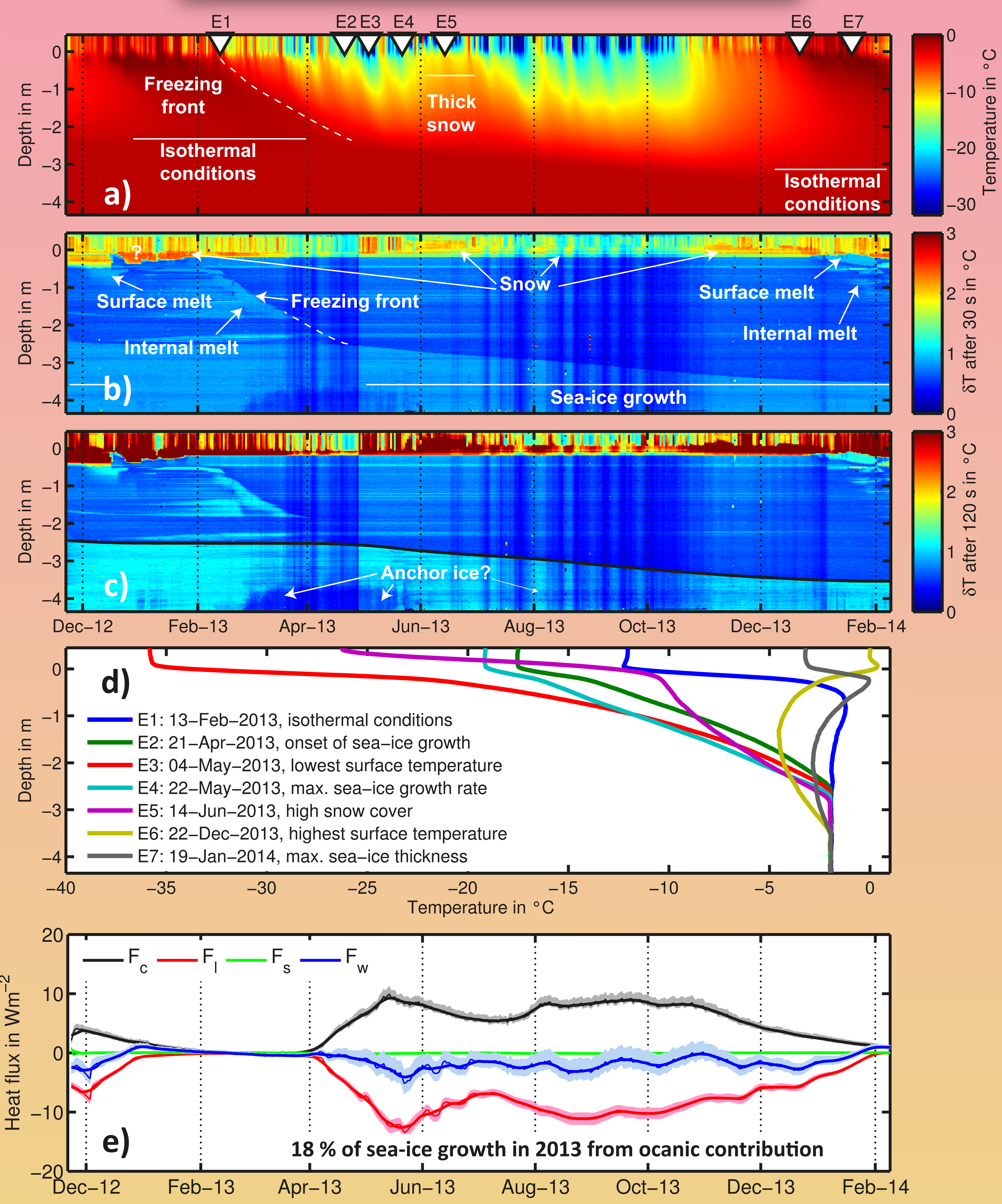
b) Air, snow, sea-ice and seawater temperatures were recorded once each day, between 21 November 2012 and 09 February 2014 (temperature profiles).

Additionally, thermistor elements were heated and the temperature rise after 30 s and 120 s was recorded (heating profiles).

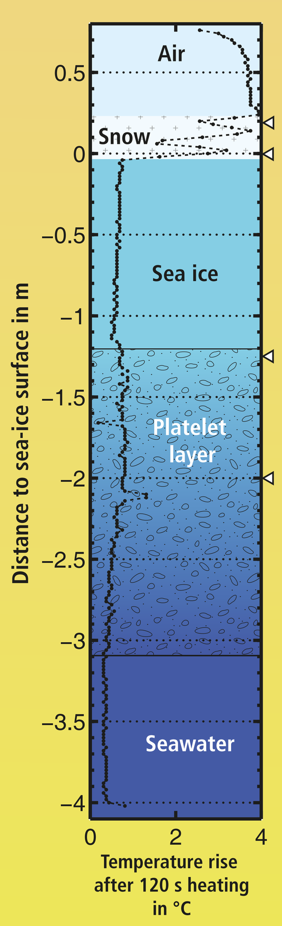
Simplified scheme



Thermistor chain data



a) Thermistor chain daily temperature profiles, b) temperature rise after 30 s of heating, c) temperature rise after 120 s of heating, d) selected characteristic temperature profiles, e) basal energy budget
(F_C: conductive, F_l: latent, F_S: sensible, F_W: residual heat flux. The shaded areas represent the cumulative individual measurement uncertainties. Upward heat fluxes, warming and melting have positive sign.)



Temperature profiles

- suitable to detect snow surface
- fail to detect sea-ice bottom under isothermal conditions
- enable calculation of basal energy budget (conductive, latent, sensi ble, residual heat fluxes)

Heating profiles

- provide accurate information about evolution of interfaces between different media, especially sea-ice surface and bottom, even under isothermal conditions.
- work similar to „needle-probe“ measurement to determine thermal conductivity of a medium, e.g. snow. Currently only qualitative state ments are possible due to the complex sensor geometry.
- resolve internal structures
- only method to reveal temporal evolution of platelet-layer thickness (confirmed by additional data obtained in mid June 2014, left figure)

Conclusions & Outlook

- Sub-ice platelet layers are the main contributor to sea-ice mass near ice shelves, especially in slowly growing sea-ice regimes (such as multi-year sea ice or the presence of a thick snow cover).
- The Instrument used here, a thermistor chain capable of heating its thermistors, is currently the only method to autonomously monitor platelet-layer thickness evolution.
- The heating mode is also able to compensate the lack of acoustic sounders present on standard ice mass balance buoys.
- The heating mode is potentially able to determine the thermal conductivity of the medium the thermistor is embedded in, but more research is necessary.
- The same instrument was recently deployed again on first-year fast ice, complementing the second-year ice dataset shown here.

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References:
Jackson, K., J. Wilkinson, T. Maksym, J. Beckers, C. Haas, D. Meldrum, and D. Mackenzie, A novel and low cost sea ice mass balance buoy, Journal of Atmospheric and Oceanic Technology, 2013.
Hoppmann, M., M. Nicolaus, S. Paul, P. A. Hubkeler, G. Heinemann, S. Willmes, R. Timmermann, and O. Boebel, The role of ice platelets for Weddell Sea land-fast sea ice, Annals of Glaciology Vol. 56 issue 69, 2014.