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mit vergleichenden Untersuchungen in arktischen Eisgebieten

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Seasonal evolution of an ice-shelf influenced fast-ice regime, derived from an autonomous thermistor chain

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Summary

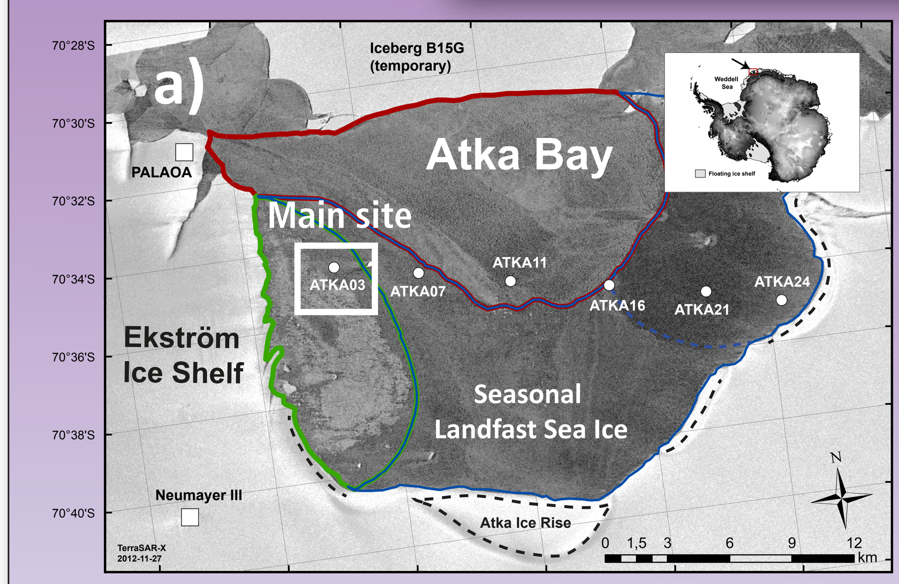
The overall goal of this study is to characterize the seasonal evolution of an Antarctic coastal, ice-shelf influenced fast-ice regime with an autonomous thermistor chain.

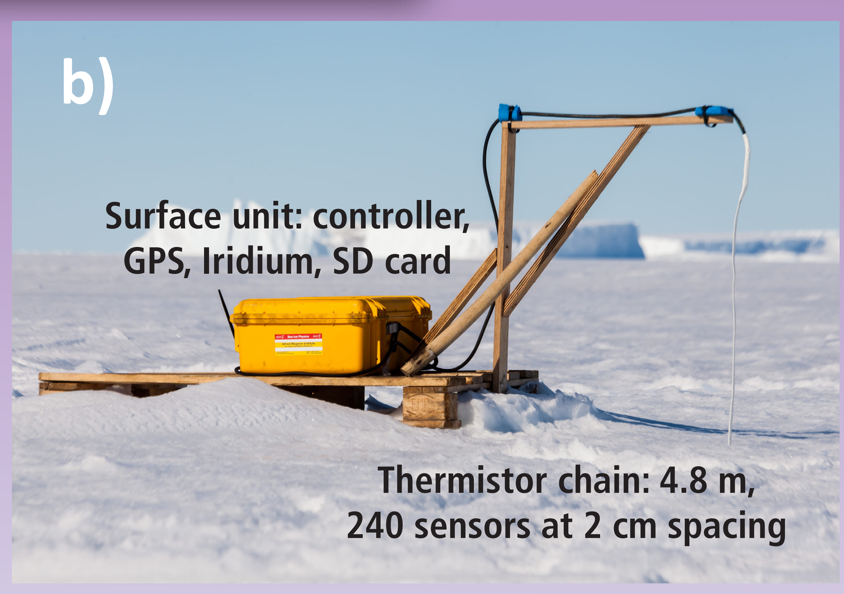
Background: The formation of ice crystals in supercooled water at depth is a manifestation of **basal melt processes in the ice-shelf cavity**. These ice platelets accumulate in large amounts below sea ice to form a **porous layer**. This phenomenon is of crucial importance for fast-ice properties and ecosystems in coastal Antarctica, but information about its formation and spatio-temporal variability is still 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 meda. 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 **heat flux into the ocean** which accounts for 18 % of solid 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 (Hoppmann et al. 2014). **Ocean/ice-shelf interaction dominated the overall (solid+loose) 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



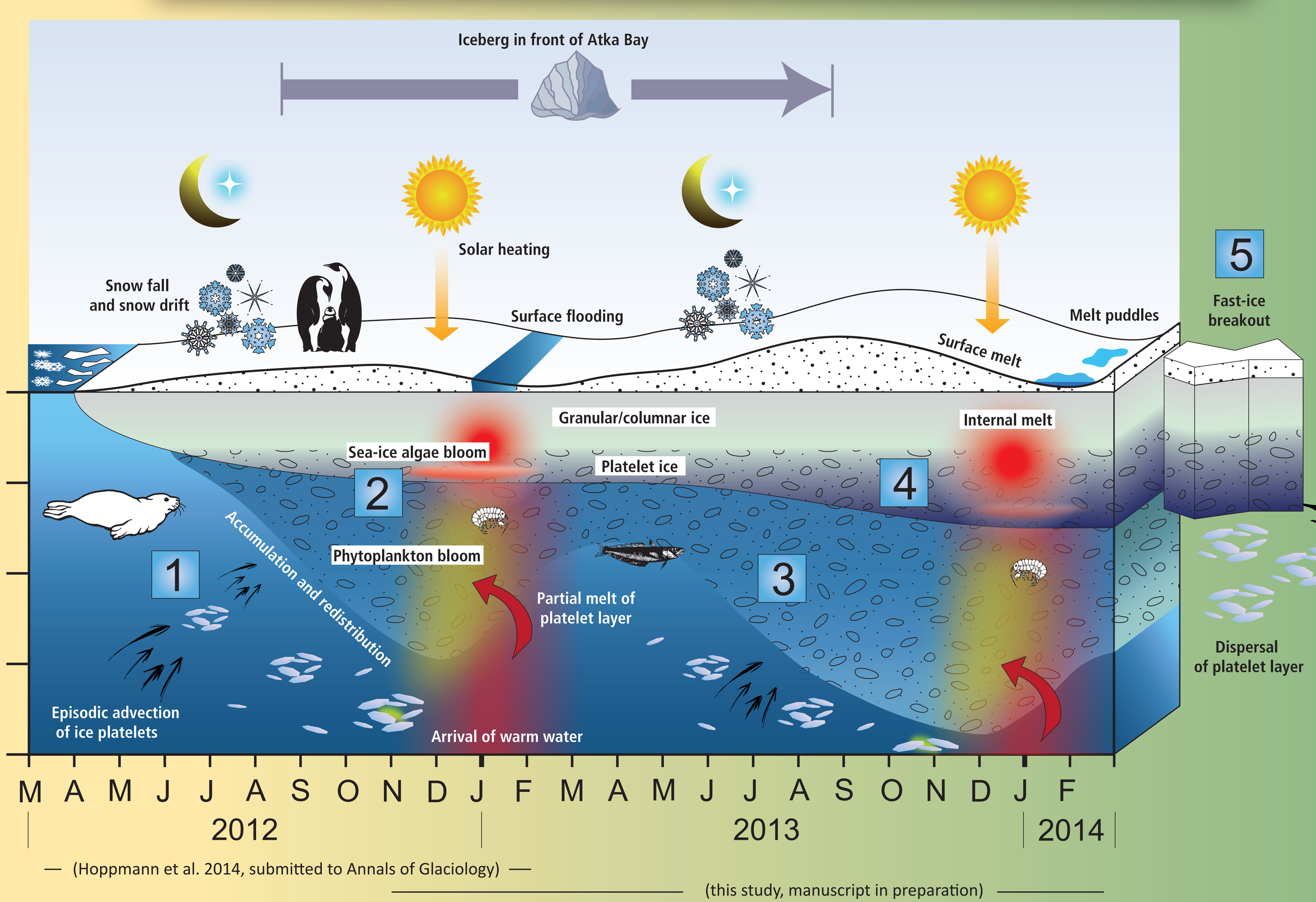


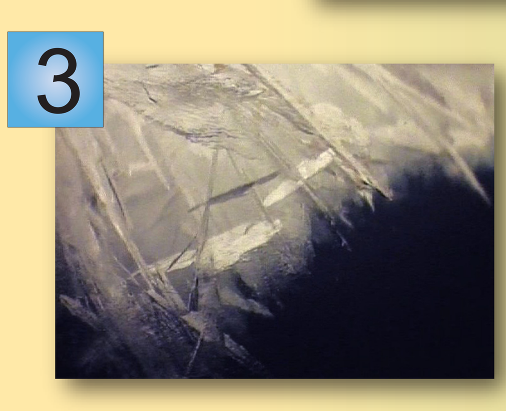
a) TerraSAR-X image of the study area, a few days after deployment of the thermistor chain. The presence of second-year ice during in 2013 is attributed to the temporary grounding of a large iceberg in front of Atka Bay.

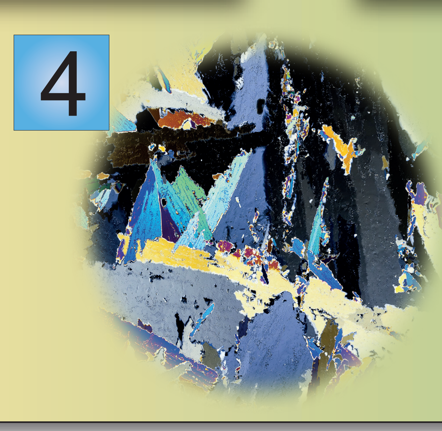
b) Air, snow, sea-ice and seawater temperatures were recorded daily between 21 November 2012 and 09 February 2014 (temperature profiles).

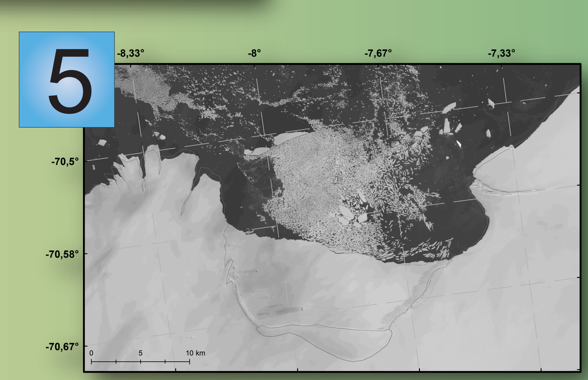
Additionally, thermistor elements were heated and the temperature rise after 30 s and 120 s was recorded (heating profiles).

Simplified scheme of fast-ice evolution

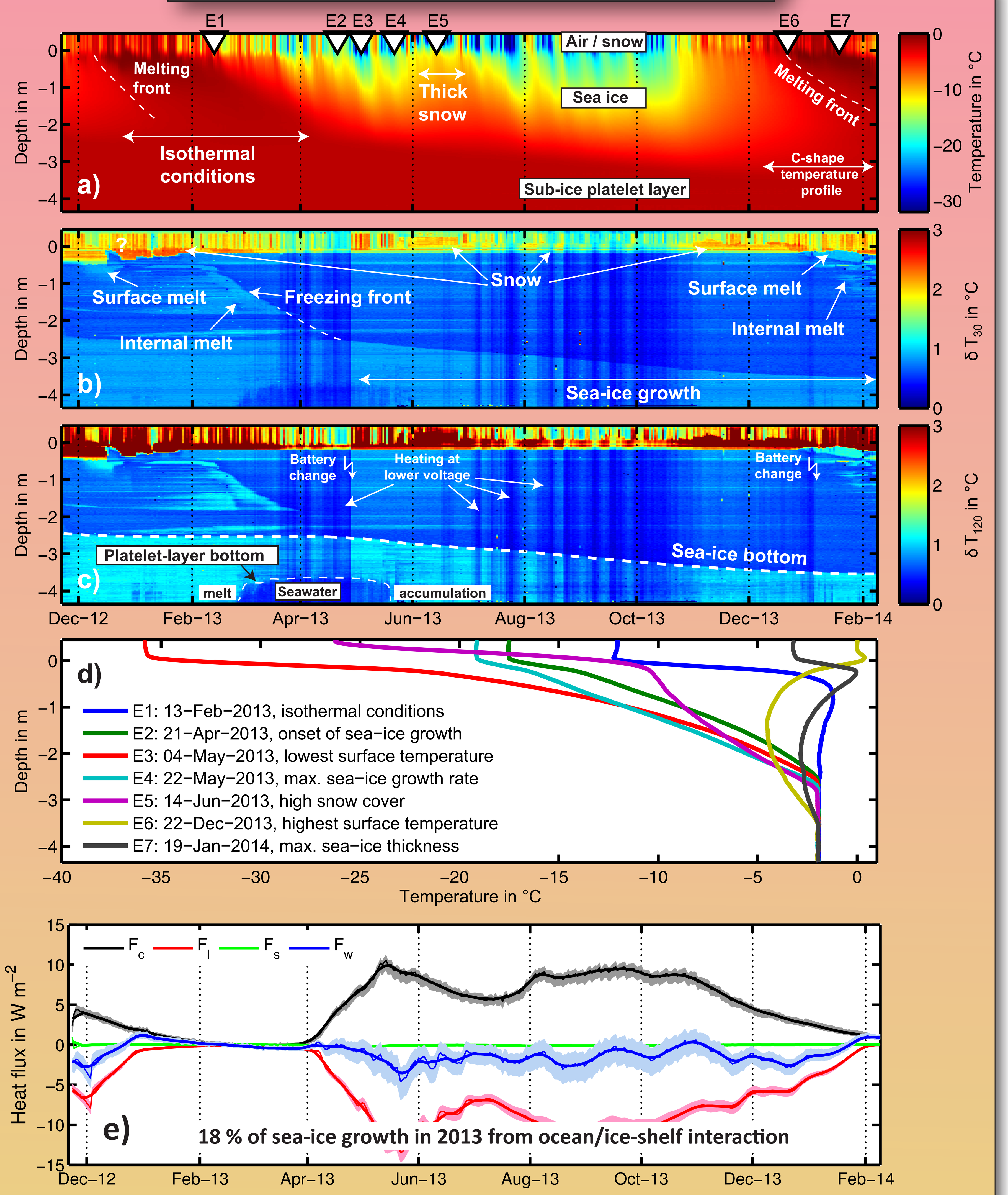








Thermistor chain data



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 for times in a), 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 and warming are positive.)

Temperature profiles

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

Heating profiles

- provide accurate information about evolution of 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 statements are possible due to the complex sensor geometry.
- resolve internal structures
- only method to reveal temporal evolution of platelet-layer thickness

Conclusions

- **Sub-ice platelet layers are a main contributor to sea-ice mass near ice shelves**, especially in slowly growing sea-ice regimes.
- 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** on standard ice mass balance buoys, making the instrument more flexible and easier to deploy.
- The heating mode is potentially able to **determine the thermal conductivity of the medium** the thermistor is embedded in
- The same instrument was recently deployed again on first-year fast ice, complementing the second-year ice dataset shown here.

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