Snow microstructure on sea ice- first results from the MOSAiC expedition

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November 22, 2022

Abstract

We measured during the MOSAiC field experiment the snow microstructure on sea-ice from early winter to the melt season, and continued measurements with the surface scattering layer. We could measure every week 1-2 full snow profiles between 0.1-0.3 m. We extracted, mostly in-situ, cores of 48-78 mm diameter and of about 0.1 m length, and scanned with 18-28 µm resolution. The goal of these measurements is to understand the formation and metamorphism of the snowpack in detail, and to derive detailed geometrical and physical properties from the samples. We will present first examples and and overview of characteristic snow profiles from leg 1 - 4, spanning the winter, spring and melt season.

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Background

Snow on sea ice governs much of the heat exchange during winter, and its melting during summer. The microstructure plays a key role in the thermal heat resistance and in the albedo. During the MOSAiC expedition, we installed a micro-computer tomograph (micro-CT) on board the research icebreaker Polarstern which drifted for a full year in the Arctic Ocean. We measured 1-2 full snow profiles every week between 0.1-0.3 m deep. We extracted, in-situ, cores of 48-78 mm diameter and 0.1 m length, and scanned with 18-28 µm resolution. The goal of these measurements is to understand the formation and metamorphism of the snowpack in detail and derive detailed geometrical and physical properties from the samples.

Conclusion

Atmospheric conditions have a large influence on snow's microstructure. This includes precipitation, steep temperature **gradients**, windy conditions and warm air intrusions as the key drivers of ice melt in summer.

In winter we observed, for the first time, the inclusion of brine in snow samples on first year ice. Until now it was not known how brine is included in the snow structure.

In summer, the surface scattering layer (SSL) greatly affects light transmission through the ice and determines the albedo. We were able to document, for the first time, the microstructure of the SSL on multiple ice types and its development under different atmospheric conditions.

Precipitation

Figure 2 *3D reconstruction of dendrites on sea ice in low-wind conditions.*

Temperature gradients producing surface hoar and depth hoar

Figure 3 *Surface hoar produced when there are high temperature gradients between a cold atmosphere and warmer ice surface.*

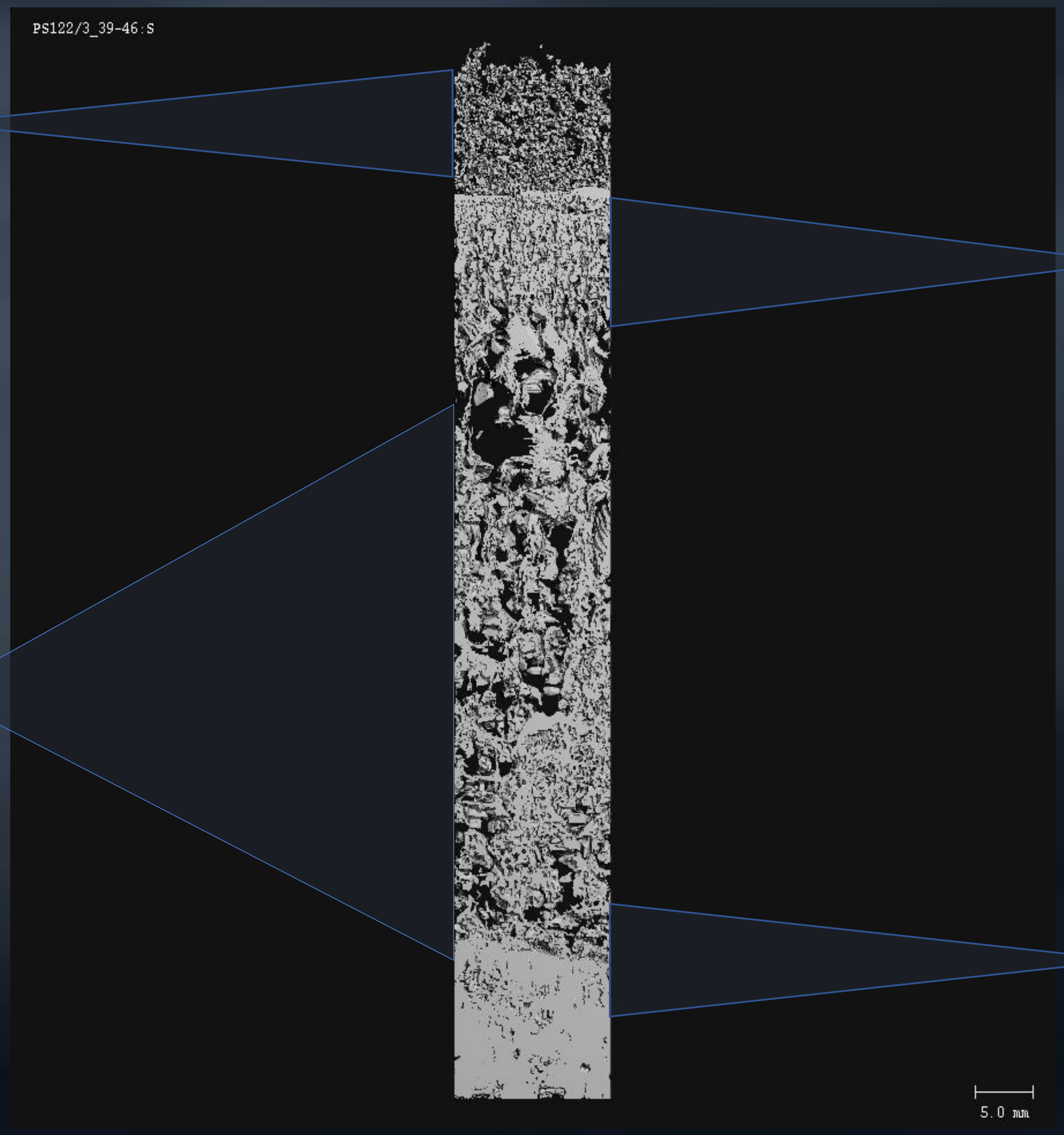

Figure 1 *A micro-CT image showing a typical stratigraphy profile in the winter season.*

Wind crusts

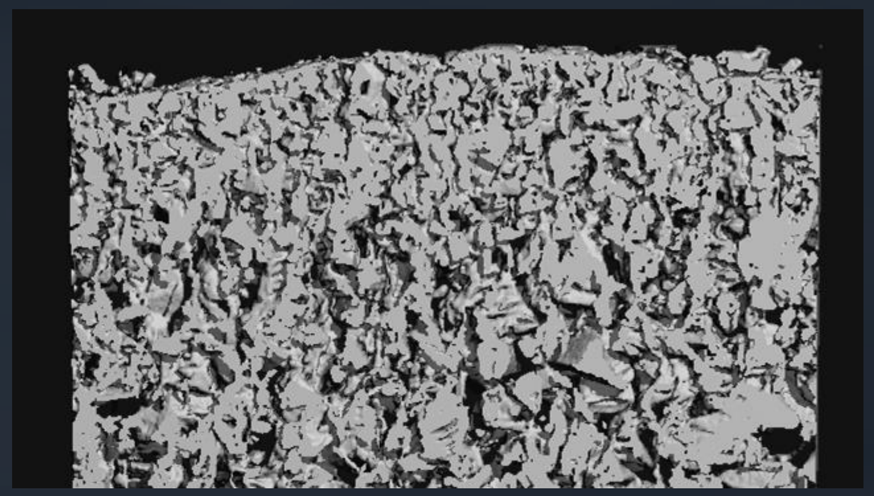

Figure 4 *Metamorphosed wind crust showing typical depth hoar crystals.*

Brine inclusion

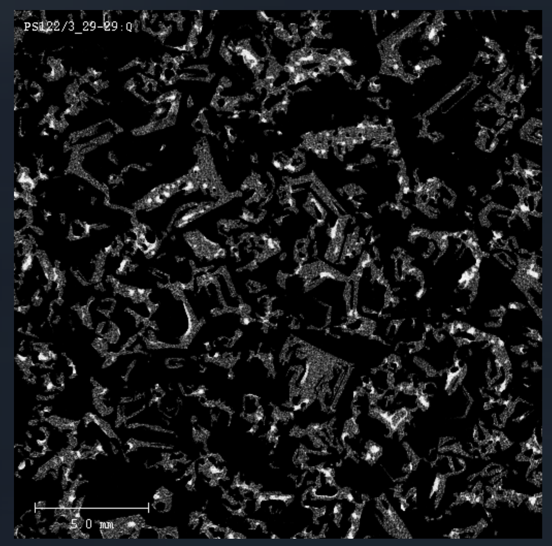

Figure 5 *A cross-section slice of depth hoar (grey) showing brine inclusion (white).*

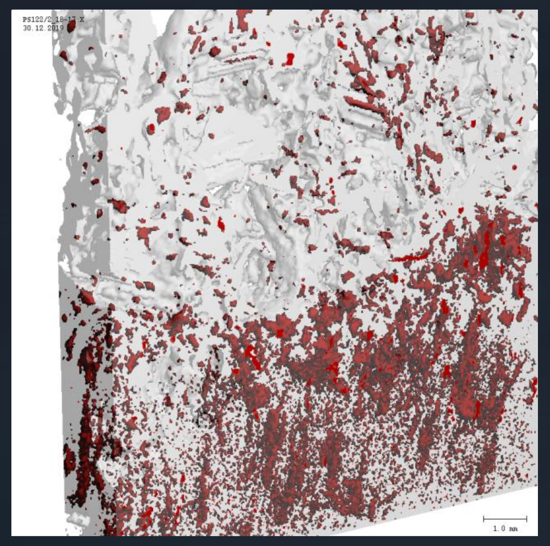

Figure 6 *Snow-ice interface with the brine pockets (red).*

Surface melt

During the melt season the snow underwent extreme coarsening due to the consistent temperatures around 0°C. This produced rounded grains which quickly melted away to reveal the porous surface on the ice, known as the SSL.

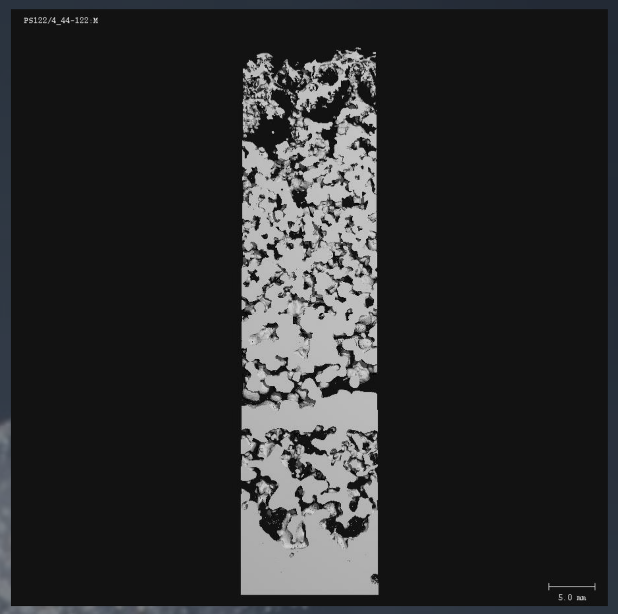

Figure 7 *Rounded grains during the melt season.*

The surface snow melted away to reveal the ice surface.

At the same time brine channels interconnected in the ice to produce extremely porous ice

Figure 8 *Interconnected brine channels.*

After further melting of the surface large porous pillars appeared on the surface of the ice known as the surface scattering layer (SSL).

This has a large effect on albedo and light transmission through the ice during summer

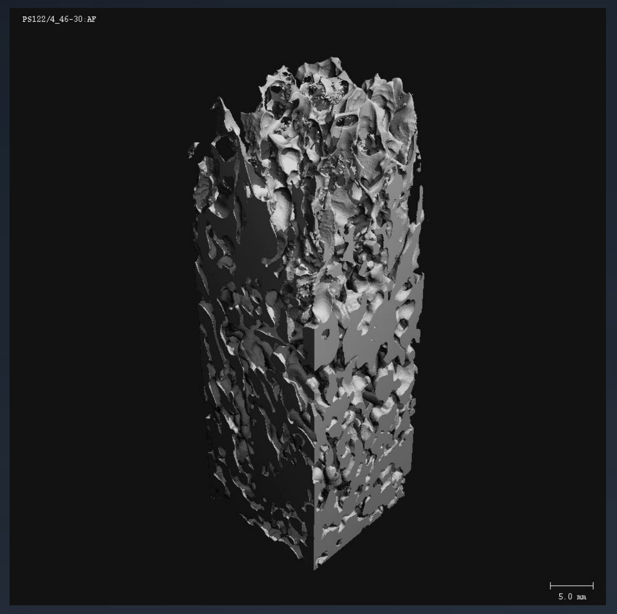

Figure 9 *The surface scattering layer*

A precipitation event covers the SSL with fresh snowfall at the start of winter and the cycle begins again

Figure 9 *The surface scattering layer covered with fresh snowfall*