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Signal vs. Noise: Obtaining a representative $\delta^{18}O$ record in a low-accumulation region

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Single ice cores have been proven to be a key archive to reconstruct climate changes on glacial to interglacial time scales in temperature as well as in greenhouse gases and many other climate parameters. In contrast, for the Holocene climate evolution single ice cores are likely less reliable recorders. The small amplitude of Holocene climate changes, together with the goal to reconstruct high-temporal resolution records down to subannual timescales, poses a significant challenge to the interpretation of ice core signals, especially in low-accumulation regions as the Antarctic plateau.

In order to learn about the representativity of single firn cores and to optimize future ice-core based climate reconstructions, we undertook an extensive study of replicate firn coring and surface snow sampling at Kohnen station on Dronning Maud Land, Antarctica. For the first time – to our knowledge – two-dimensional images of the water isotope and density structure of the upper firn have been obtained from two 45 m long and 1.2 m deep firn trenches separated at a distance of 500 m, yielding a climate proxy archive spanning roughly the last five years.

In this contribution, we present the results of the stable water isotope compositions obtained from the two firn trenches.

Seasonal layering of the isotopes is following an absolute depth scale likely caused by an annual reorganization of the snow surface directly related to the local dune scale. Local surface winds cause highly variable isotopic signals of the surface snow, featuring a similar range as the seasonal cycle. However, even in deeper layers, strong perturbations of the isotopic stratigraphy are found, resulting in a low representativity of single firn cores. On the contrary, the mean trench profiles are highly correlated, giving a representative climate signal over a spatial scale of at least 500 m. The decorrelation length of the stratigraphic noise is $\sim$10 m, yielding an estimate of an optimal sampling strategy for firn cores taken at low-accumulation sites. Supplemented by independent snow surface samples, the trench results show a strong increase of isotopic values of the surface snow layer in early austral summer. Tentatively, this is unlikely to be related to summer accumulation and is part of the ongoing research at Kohnen station.