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Past local temperatures obtained from the EDML ice core using differential diffusion

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Since the 1960-s the stable water isotope signal in ice core records has been used as a proxy for palaeotemperatures. However, this direct interpretation of the isotope signal has limitations, as the relationship between the isotope ratio and atmospheric temperature is known to fluctuate both spatially and temporally. One way to circumvent these limitations is the use of diffusion thermometry as pioneered by Johnsen et al (2000). In the firn stage the isotope signal is subject to a smoothing caused by the random movement of water vapour in the pores of the snow. The total amount of diffusion a layer has suffered is measured in terms of the diffusion length. This length is sensitive to changes in firn temperature and the accumulation rate at the site. The diffusion length for Oxygen-18 is higher than that for Deuterium due to a difference in ice-vapour fractionation factors. As these fractionation factors are dependent on the temperature of the firn, the difference in diffusion length can be used to estimate past local temperatures.

To apply this differential diffusion method successfully, it is necessary to have high resolution measurements for both Oxygen-18 and Deuterium. We present such measurements for the EDML ice core. In total 400 m of ice was measured with a 5 cm resolution from periods in the mid and early Holocene, the last glacial-interglacial transition and the last glacial period. Application of the differential diffusion method to this dataset shows a decreasing temperature trend during the Holocene and a surface temperature of approximately -55 °C in the interval representing the LGM in the ice (∼10 °C colder than present day temperature (not corrected for changes in altitude)). This is, within the error limits, in line with the temperature reconstructed from the stable water isotope proxy itself using the spatial isotope/temperature gradient (EPICA community members, 2006).

References:

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