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A new high-resolution chemical ice core record over the last glacial period from NGRIP

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Recently a new record of northern hemisphere climate has been presented based on stable isotope data from the North Greenland Ice Core Project (NGRIP). The results show a pattern of cold stadials and Dansgaard-Oeschger (DO) events (warm interstadials) more distinct than for the Summit ice cores (GRIP and GISP2). These large and abrupt climatic changes are as well reflected in the records of various chemical species though their amplitude and temporal evolution are not uniform.

During the NGRIP field season in summer 2000 continuous high-resolution measurements of ionic species have been performed covering the last glacial period from approximately 110 ka to 10 ka before present. We used a Continuous Flow Analysis (CFA) system to measure the mass concentrations of water-soluble ions including sodium (Na^+), calcium (Ca^{2+}), ammonium ($NH_4{}^+$), sulphate ($SO_4{}^{2-}$), and nitrate ($NO_3{}^-$), the electrolytical melt-water conductivity and the number concentration of insoluble microparticles. The effective depth resolution of approximately 1 to 2 cm led to a temporal resolution, which is sub-annual to annual over the transition and the DO events, but approximately annual to biennial during the stadials.

Because most of the ion species represent a temporally changing mixture of several sources, interpretation of their ice core records is not straight forward, especially during the strongly variable glacial conditions. Based on ion mass ratios within extraordinary high peaks we separated the different source contributions to the total Na^+, Ca^{2+}, and $SO_4{}^{2-}$ inputs, generally into a sea-salt (ss) and a non-sea-salt (nss) part. The resulting time series of ss-Na^+, nss-Ca^{2+}, nss-$SO_4{}^{2-}$ and excess-$SO_4{}^{2-}$ (originating from biogenic or volcanic sources) are examined with respect to DO events. For example, the marine ss-Na^+ signal shows much less pronounced DO events compared to total Na^+ pointing to a significant influence of continental aerosol on total Na^+. The same feature is observed for $SO_4{}^{2-}$, where we found the continental background contribution to be much higher than expected based on the crustal sulphur abundance. However, for $SO_4{}^{2-}$ the assessment is more complicated, due to additional $SO_4{}^{2-}$ sources involved and a relatively higher analytical error.

The presented data overview revealed a promising potential for further examinations of the CFA records regarding their short-term variability, the exact timing and phasing of DO transitions and the counting of annual layers to back up and refine the NGRIP ice core chronology. Furthermore it will be possible to infer occurrence rate records of volcanic eruptions and biomass burning events during the last glacial period to asses their possible influence to the northern hemisphere climate.