Abstract ID : **189**

Characterisation of dielectric and absorbing particles in ice cores from Northeast Greenland with the single particle extinction and scattering method (SPES)

Content

Insoluble particles in ice cores are characterised by their concentration, size, shape, and minerology. Changes in these properties reflect alterations in the source regions, transport, or deposition mechanisms. Particles can be classified as dielectric or absorbing. Mineral dust is mostly non-absorbing or very weakly absorbing. Its main source regions for Northeast Greenland ice cores are the East Asian deserts, whereas absorbing particles originate from combustion processes most likely in North America.

Radiative transfer is strongly dependent on aerosol characteristics, including the refractive index. While dielectric particles scatter light without absorbing it, particles with a complex refractive index absorb part of the radiation. The scattering matrix describes the relation between incident and scattered field and can be used to distinguish between these aerosol species. The single particle extinction and scattering (SPES) method is used to determine the complex scattering amplitude in forward direction. By comparing it to scattering simulations, the refractive index and diameter of particles in a size range from 0.2 to 2 µm can be obtained. This size range covers the maximum of the particle number size distribution expected in polar ice cores. The maximum has been inaccessible by previously available continuous particle sizing methods with typical lower detection limits of around 1 µm. Thus, while most of the mass of mineral dust was observed, the majority of the dust particles was not. By comparing the experimentally retrieved scattering amplitudes to simulations, the distinction between absorbing and dielectric particles is achieved. The SPES method allows for the simultaneous determination of the concentration and particle number size distribution of dielectric and the concentration of absorbing particles. Furthermore, we have incorporated it for the first time into a continuous flow analysis (CFA) set-up, which yields high depth and time resolution while minimizing the risk of contamination.

The Classizer One, which is based on the SPES method, was used to measure part of the main and two shallow cores drilled at the EGRIP site. Here, we will focus on the absorbing particle concentration record obtained with this instrument for the early Holocene up to the year 8000 b2k and for the last millennial. The anthropogenic effect on the absorbing particle concentration and seasonality can be seen in both firn cores. It is characterised by an increase in concentration after the industrial revolution and a decrease to preindustrial levels after reaching its peak shortly after the turn of the century. These results are comparable to studies on black carbon in Greenlandic ice cores. This and the similarity to the wildfire proxy ammonium suggest that the SPES method can be used to determine the absorbing particle concentration accurately and that significant natural and anthropogenic changes in the absorbing particle number can be observed.

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Track Classi ication: Holocene and last 2000 year climate forcings and variability