Investigation of physical properties of particles in the EastGRIP ice core gives new insights into climatic changes during the Last Glacial Termination

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Characterising insoluble particles in ice cores provides information needed to reconstruct past climatic changes, for example, in circulation patterns and radiative transfer. Concentration, size distribution, and mineralogy of particles are influenced by how the particles are deposited on the ice sheet, transported, and mobilised in their respective source regions.

To quantify the past changes in concentration and properties of insoluble particles, the Classizer One instrument, which is based on the novel single particle extinction and scattering (SPES) method, has been incorporated into the continuous flow analysis set-up in Bern. This allows for the first time high-resolution, continuous, and simultaneous measurements of particle number concentration, diameter, and refractive index in the size range of 0.2 to 2 µm. Thus, covering the full size range of the main mode in the particle number size distribution, which is crucial for the radiative effect of dust in the atmosphere.

Here we present the first study of continuous concentration and size distribution measurements of water insoluble particles in ice cores smaller than 1 µm. The SPES method was used to characterise particles in the EastGRIP ice core from 8000 to 16000 years BP, i.e., including the Bolling Allerød/Younger Dryas climate oscillation. On the one hand, results of previous studies on supramicron dust particles can be confirmed, including the observation that particle concentration is higher, and particles are larger during colder times. On the other hand, the high-resolution measurement in a smaller size range reveals features that were previously hidden.

Over the course of the Younger Dryas (GS-1) the concentration decreases by a factor of 3.5, while the geometric mean of the number size distribution increases by approximately 9%. This is also the case towards the end of the Oldest Dryas (GS-2.1), albeit to a lesser extent. In both instances, the concentration and the modal particle diameter are anti-correlated before they both rapidly decrease at the onset of the following warm phase. While the changes at the transition from the cold to the warm phase may be explained, at least to some degree, for supramicron aerosol by changes in transport efficiency, the opposing trends during the cold phases cannot. This is because a faster transport would lead to an increase in both concentration and particle size for
particles larger than approximately 1 µm, where size fractionation by dry deposition occurs.

Additional information can be gained looking at the geometric standard deviation and the effective refractive index. The latter stays relatively constant over the investigated period, which indicates that there were probably no major changes in the mix of potential source regions. The geometric standard deviation does not change abruptly at the onset of a warm phase contrary to the concentration and geometric mean. Instead, it gradually increases already starting in the cold phase. This suggests that climatic changes, probably in the source regions or en route, start taking place prior to the rapid transition to the warm phase.