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Characterization of ice nucleation on different natural dust samples

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The impact of aerosols on Earth's climate is still uncertain. Therefore a better understanding of direct and indirect effects of aerosols is essential to improve models and the ability to predict future climate change. A natural source of aerosols is desert dust. Laboratory measurements investigating the influence of dust on heterogeneous freezing of water droplets are presented. We performed measurements with seven dust samples collected in the Etosha pan in Namibia, in the Makgadikgadi pan in Botswana (from three different locations), on the Altiplano in Bolivia, in Qatar and in the Hoggar mountains in Algeria. After sieving, the particle diameters of these dusts were < 32 μm. The mineralogical composition of the dusts was determined by X-ray diffraction.

For the investigation of the ice nucleation ability of these dusts, emulsion as well as bulk freezing measurements were performed with a differential scanning calorimeter (DSC). For the emulsion measurements a suspension of a dust was mixed with water. Mixed with a mineral oil/lanolin mixture, the water droplets in the emulsion had mean diameters of around 2 μm. Heterogeneous freezing of dusts was characterized by three temperatures for frozen fractions of 0.1, 0.25, and 0.5, respectively. Heterogeneous freezing temperatures for all 7 samples were quite similar, namely 245 – 246.5 K (for frozen fractions of 0.1), 243 – 244.5 K (for 0.25) and 240 – 241.5 K (for 0.5). Emulsions consisting of pure water suspensions froze with onset temperatures of around 237 K.

Emulsion measurements with Hoggar mountain dust were also performed with an additional solute such as ammonium sulfate, malonic acid, glucose or PEG 300. Immersion freezing was found to be suppressed in the presence of solutes.

For the bulk measurements dusts were suspended in pure water and droplets with radii of about 1 mm were subjected to repeated freezing cycles. Freezing temperatures in the range of 253 - 265 K were found for cooling rates of 10 K/min, depending on the dust and on the specific portion taken from a dust suspension.