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Comparing the ice nucleation efficiencies of ice nucleating substrates to natural mineral dusts

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Mineral dust particles in the atmosphere may act as efficient ice nuclei over a wide range of temperature and relative humidity conditions. The ice nucleation capability of dust particles mostly depends on the particle surface area and the associated physico-chemical surface properties. It has been observed that the surface-related ice nucleation efficiency of different dust particles and mineral species can vary by several orders of magnitude. However, the relation between aerosol surface properties and observed ice nucleation efficiency is still not completely understood due to the large variability of chemical compositions and morphological features.

In order to gain a better understanding of small scale freezing processes, we investigated the freezing of several hundreds of small droplets (V=0.4 nl) deposited on materials with reasonably well defined surfaces such as crystalline silicon wafers, graphite and freshly cleaved mica sheets under atmospherically relevant conditions. These substrates are intended to serve as simple model structures compared to the surface of natural aerosol particles. To learn more about the impact of particle morphology on ice nucleation processes, we also investigated micro-structured silicon wafers with prescribed trenches.

The ice nucleation efficiencies deduced from these experiments are expressed as ice nucleation active surface site density values. With this approach, the freezing properties of the above-described substrates could be compared to those of natural mineral dusts such as agricultural soil dusts, volcanic ash and fossil diatoms, which have been investigated in AIDA cloud chamber experiments.

All tested ice nucleating substrates were consistently less efficient at nucleating ice than the natural mineral dusts. Crystalline silicon only had a negligible influence on the freezing of small droplets, leading to freezing near the homogeneous freezing temperature threshold. Applying surface structures to silicon led to a shift towards heterogeneous freezing. However, the measured ice nucleation active surface site densities were still smaller than those of mineral dusts.