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Ice nucleation by soil dusts: relative importance of mineral and biological components

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Dusts emitted from agricultural soils may represent a significant source of atmospheric particulates at mid-latitudes. Such dusts, which can be aerosolised by anthropogenic agricultural activities, have previously been estimated to be present in the atmosphere at sufficient number densities that they could potentially compete with other known ice nuclei. In contrast to soils from arid regions, such as the Sahara, fertile soils contain a larger fraction of biological material, which can lead to an enhancement in the ice nucleating ability of their associated dusts. However, considerable uncertainties remain regarding the relative efficacy of soil dust particles from fertile soils as IN. In particular, the relative contribution to the overall ice nucleating activity from both the biological and mineral components present remains unclear.

Using a novel experimental methodology designed to increase sensitivity to a wide range of ice nucleation efficiencies, we have characterised the immersion mode ice nucleating activities of PM_{10} extracted from soils collected in England. By controlling droplet sizes, which ranged in volume from 10^{-12} to 10^{-6}L, we have been able to characterise the ice active site densities in soils (estimated using a time-independent framework) at temperatures ranging from -5˚C down to the homogeneous limit of freezing at $\sim$ -36˚C. To distinguish between biological and mineral IN in the soil dusts, we examined the effects of heat treatment and organic matter digestion with hydrogen peroxide on the ice nucleating activities of the soils. Both heat and H_2O_2 treatment reduced the ice nucleating ability of the soil dust particles at low supercoolings (T >-15˚C) by up to two orders of magnitude, suggesting that the ice nucleating active sites are primarily biological in nature within this regime. However, below -15˚C, we find that the ice active site densities tend towards those expected from the mineral components in the soils, suggesting that the inorganic fraction of soil dusts becomes increasingly important in the initiation of the ice phase at lower temperatures. We conclude that although only being a relatively minor contributor to the global atmospheric dust burden, the enhanced IN activities of dusts generated from agricultural activities may impact upon cloud glaciation, particularly at temperatures above -15˚C.