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The role of ice nucleation mode initiated by desert dust on the habit of vapour grown ice crystals

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ABSTRACT The habit or shape of vapour grown ice crystals in clouds have several important consequences. The habit of ice crystals strongly affects the scattering properties of a population of particles which, especially for cirrus clouds may result in great uncertainty in climate predictions. In cumulus clouds the habit of ice crystals affects the production of precipitation (Mason 1994).

Previous studies have shown that ice crystal habit varies as a function of temperature, and the supersaturation at which they are grown. A few recent studies however have also shown that to an extent certain ice nuclei might orientate crystal growth signifcantly (Bailey and Hallett 2002, 2004). In this study we show that the mode of nucleation may control, to an extent ice crystal habit.

Experiments have been performed at the AIDA aerosol-cloud chamber in Germany to investigate ice particle nucleation in the context of cloud particles. The work involves the analysis of ice particle image data taken with an ice particle imaging probe designed for aircraft insitu measurements in clouds. During the experiments, ice nucleation was found to occur via several different modes. An efcient way of investigating the ice nucleus activity was experimented with during the recent experiments. The total pressure inside the AIDA vessel was lowered at varying rates with the total water mixing ratio staying constant and the air temperature corresponding to a quasi-adiabatic expansion. In a typical expansion at -10C, ice would form via deposition of water vapour directly onto the most active ice nuclei, the habits were generally elongated shapes known as spear–heads. With decreasing pressure, further ice nucleation

would occur only following droplet formation. This was classed as immersion freezing as the ice nuclei were immersed inside droplets and only a fraction of the activated droplets would freeze, the habits being more compact plate-like polycrystals. At the end of the expansion, water vapour supersaturation decreased to subsaturated conditions over liquid water and further nucleation occurred. A compositional analysis of the ice nuclei was performed using an Environmental Scanning Electron Microscope (ESEM). The possiblility of deposition nucleation at relative humidities sub–saturated with respect to water saturation was explored. If this is the case, it might go some way to explain the observations of Hobbs and Rangno (1985), who found significant ice production during cloud top mixing/entrainment events in a variety of cumuliform clouds and also of Field et al. (2001), who found that ice nucleation was enhanced in the evaporating regions of orographic clouds. It may also serve as a predictive tool for ice crystal habit.

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