Growth and sublimation of rough ice crystals in a flow diffusion chamber

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It has long been thought that the basic building block for ice crystals in atmospheric clouds is the smooth, hexagonal prism. However, increasing evidence from both *in situ* and remote sensing measurements points to the prevalence of rough or irregular ice crystals [1]. This distinction is important, because the light scattering properties of ice crystals strongly depend on crystal shape, including fine detail such as surface roughness [2]. In turn he scattering properties determine the radiative properties of clouds, which have a strong impact on both weather and climate, since ice-containing clouds such as cirrus cover a large proportion of the Earth's surface at any one time – e.g. as high as 70% in parts of the tropics [3]. Some of the most direct evidence for ice crystal roughness comes from thee *Small Ice Detector* 3 (SID-3) aircraft probe. Unlike other probes, which are limited by their optical resolving power, SID-3 collects two-dimensional scattering patterns, instead of images, to characterize the properties of cloud particles, including surface roughness [1]. While much data collected using SID-3 in various cloud types now exists, it is still not clear which processes lead to the emergence of roughness and complexity in ice particles. This in turn prevents accurate representation of ice-containing clouds in atmospheric models.

To investigate the growth and light scattering properties of ice crystals, a new experimental setup was developed, called *Ice Roughness Investigation System* (IRIS). It is based on a thermally controlled laminar flow tube similar in design to the *Leipzig Aerosol Cloud Interaction Simulator* (LACIS) [4, 5]. Single ice crystals are nucleated on particles attached to fine glass fibres placed at the outflow of the tube, and grown or sublimated by varying the humidity. The setup includes a lab version of SID-3, so that ice crystal roughness and complexity can be quantified in the same manner as during *in situ* atmospheric measurements, and an optical microscope equipped with a camera to provide high-resolution images. The thermodynamic conditions in the measuring volume have been characterized by means of computational fluid dynamics calculations, as well as flow, temperature and dew point measurements. Immersion freezing and deposition nucleation experiments with Arizona Test Dust, kaolinite, illite, soot and Snomax particles have been carried out. Preliminary results of these experiments show that the surface properties of the ice crystals can be modified by varying the humidity, hence growth and sublimation rates. Moreover, repeated growth cycles, with several interspersed growth and sublimation periods, tend to produce increasing crystal roughness.

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