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A new experimental setup to investigate nucleation, dynamic growth and surface properties of single ice crystals

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The nucleation and growth of atmospheric ice particles is of importance for both, weather and climate. However, knowledge is still sparse, e.g. when considering the influences of ice particle surface properties on the radiative properties of clouds. Therefore, based on the experiences with our laminar flow tube chamber LACIS (Leipzig Aerosol Cloud Interaction Simulator, Stratmann et al., 2004), we developed a new device to characterize nucleation, dynamic growth and light scattering properties of a fixed single ice crystal in dependence on the prevailing thermodynamic conditions. Main part of the new setup is a thermodynamically controlled laminar flow tube with a diameter of 15 mm and a length of 1.0 m. Connected to the flow tube is a SID3-type (Small Ice Detector, Kaye et al., 2008) instrument called LISA (Leipzig Ice Scattering Apparatus), equipped with an additional optical microscope. For the investigations, a single ice nucleus (IN) with a dry size of 2-5 micrometer is attached to a thin glass fiber and positioned within the optical measuring volume of LISA. The fixed particle is exposed to the thermodynamically controlled air flow, exiting the flow tube. Two mass flow controllers adjusting a dry and a humidified gas flow are applied to control both, the temperature and the saturation ratio over a wide range. The thermodynamic conditions in the experiments were characterized using a) temperature and dew-point measurements, and b) computational fluid dynamics (CFD) calculations. Dependent on temperature and saturation ratio in the measuring volume, ice nucleation and ice crystal growth/shrinkage can occur. The optical microscope allows a time dependent visualization of the particle/ice crystal, and the LISA instrument is used to obtain 2-D light scattering patterns. Both devices together can be applied to investigate the influence of thermodynamic conditions on ice crystal growth, in particular its shape and surface properties. We successfully performed deposition nucleation experiments considering kaolinite and SnowmaxTM (Johnson Controls Snow, Colorado, USA) particles. Different temperatures and saturation ratios were considered resulting in different growth rates and ice crystal shapes. We have proven the feasibility of the setup for investigating ice particle nucleation and growth. Further investigations and data evaluation concerning the quantification of the ice particle's surface properties are ongoing.

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