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Immersion freezing of biological particles at LACIS

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Biological particles, especially bacteria being ubiquitous in the atmosphere, belong to the most efficient ice nuclei (IN) (Möhler, 2008) and hence might have a large impact on weather and climate. In this study, the immersion freezing behavior of different size segregated biological particles is investigated at the laminar flow tube LACIS (Leipzig Aerosol Cloud Interaction Simulator, Hartmann et al., 2011). For these experiments, SNOMAX and outer membrane vesicles (OMV) are used as IN. SNOMAX industrially produced from Pseudomonas-syringae bacteria, which are very ice nucleation active, can be seen as a proxy for ice nucleating bacteria in general. On the surface of these bacteria, ice nucleating proteins that initiate the freezing are situated (Maki et al., 1974). Additionally, it has been found that some ice nucleating bacteria strains have the ability to produce OMV, i.e. strangulated parts of the bacterial cell consisting of the same membrane material (Phelps et al., 1986). These OMV might contain the same ice nucleating proteins on their surface and thus might be able to nucleate ice as well. The OMV used in our experiments were extracted from bacteria cultivated from rain samples collected in Denmark from 30 m height. In our experiments, the biological particles are suspended in air via atomization, size selected by means of a Differential Mobility Particle Sizer, and then fed into LACIS. In LACIS, well defined droplets are produced by activating the biological particles to cloud droplets, so that each droplet contains only one biological particle. By decreasing the temperature in LACIS, these droplets are frozen. To determine the ice fraction, i.e. the fraction of frozen droplets to all particles, the liquid and frozen droplets are distinguished by means of a newly self-built optical device, which is positioned under LACIS, using the depolarization of light scattered by a single particle. The ice fractions are measured as a function of temperature and then used to determine nucleation rates. For 650 nm and 800 nm SNOMAX particles, the ice fraction versus temperature is a very steep function and almost linear within the temperature range between -3°C and -10°C. The ice fraction observed for the OMV is close to the detection limit, in a range of about 1 %, implying that only a small fraction of the OMV are ice nucleating active.

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