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Particle-size dependence of immersion freezing: Investigation of INUIT test aerosol particles with freely suspended water drops.

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One goal of the research group INUIT (Ice Nuclei research UnIT) is to investigate the efficiencies of several test ice nuclei under comparable conditions but with different experimental techniques. In the present studies, two methods are used: the Mainz vertical wind tunnel and an acoustic levitator placed inside a cold chamber. In both cases drops are freely levitated, either at their terminal velocity in the wind tunnel updraft or around the nodes of a standing ultrasonic wave in the acoustic levitator. Thus, heat transfer conditions are well approximated, and wall contact effects on freezing as well as electrical charges of the drops are avoided. Drop radii are 370 μm and 1 mm, respectively. In the wind tunnel, drops are investigated at constant temperatures within a certain time period and the onset of freezing is observed directly. In the acoustic levitator, the drop temperature decreases during the experiments and is measured by an in-situ calibrated Infrared thermometer. The onset of freezing is indicated by a rapid rise of the drop surface temperature because of the release of latent heat.

Investigated test ice nuclei are Snomax® as a proxy of biological particles and illite NX as well as K-feldspar as represents of mineral dust. The particle concentrations are 1×10^{-12} to 3×10^{-6} g Snomax® per drop and 5×10^{-9} to 5×10^{-5} g mineral dust per drop. Freezing temperatures are between -2 and -18°C in case of Snomax® and between -14 and -26°C in case of mineral dust. The lower the particle masses per drop the lower are the freezing temperatures. For similar particle concentrations in the drops, the median freezing temperatures determined by the two techniques agree well within the measurement errors. With the knowledge of the specific particle surface area of the mineral dusts, the results are interpreted also in terms of particle surface area per drop. Results from the wind tunnel experiments which are performed at constant temperatures indicate that the freezing times are shorter the lower the temperatures are.

For evaluation and comparisons of the data, two models of heterogeneous freezing are applied, the stochastic and the time-independent singular description. The nucleation rate coefficients J(T) as well as the surface densities of active sites n_s(T) or the numbers of active sites n_m(T) are determined from the experimental data. It is shown that both models are suited to describe the present heterogeneous freezing results for the range of investigated particle masses or surface areas per drop. The comparison of the results from the two experimental techniques evaluated with the time-independent singular model indicates an excellent agreement within the measurement errors.