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Comparison of parameterizations for homogeneous and heterogeneous ice nucleation

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The formation of ice particles from liquid aqueous aerosols is of central importance for the physics and chemistry of high altitude clouds. In this paper, we present new laboratory data on ice nucleation and compare them with two different parameterizations for homogeneous as well as heterogeneous ice nucleation. In particular, we discuss and evaluate the effect of solutes and ice nuclei.

One parameterization is the λ-approach which correlates the depression of the freezing temperature of aqueous droplets in comparison to pure water droplets, ΔT_{f}, with the corresponding depression, ΔT_{m}, of the equilibrium ice melting point: $\Delta T_{\mathrm{f}} = \lambda \cdot \Delta T_{\mathrm{m}}$. Here, λ is independent of concentration and a constant that is specific for a particular solute or solute/ice nucleus combination. The other approach is water-activity-based ice nucleation theory which describes the effects of solutes on the freezing temperature T_{f} via their effect on water activity: $a_{\mathrm{w}}(T_{\mathrm{f}}) = a_{\mathrm{w}}^{i}(T_{\mathrm{f}}) + \Delta a_{\mathrm{w}}$. Here, a_{w}^{i} is the water activity of ice and Δa_{w} is a constant that depends on the ice nucleus but is independent of the type of solute.

We present new data on both homogeneous and heterogeneous ice nucleation with varying types of solutes and ice nuclei. We evaluate and discuss the advantages and limitations of the two approaches for the prediction of ice nucleation in laboratory experiments and atmospheric cloud models.