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Impact of heterogeneous ice nuclei on homogeneous freezing events - size does matter

P. Spichtinger (1) and D. J. Cziczo (2)

(1) Institute for Atmospheric and Climate Science, ETH Zurich, Zurich, Switzerland, (2) Atmospheric Science and Global Change Division, Pacific Northwest National Laboratory, Richland, USA (peter.spichtinger@env.ethz.ch)

Different types of aerosols (e.g. mineral dust, soot, ammonium sulfate etc.) can act as ice nuclei (IN) with freezing thresholds much lower than that for homogeneous freezing of supercooled aqueous solution droplets (DeMott et al., 2003; Koop et al., 2000). Ice crystals formed by heterogeneous IN below the homogeneous nucleation threshold can grow by water vapor deposition, thus changing the environmental supersaturations. From earlier studies with models (e.g. Gierens, 2003) or in freezing chambers (e.g. Moehler et al., 2005), we know that heterogeneously formed ice crystals can modulate or even prevent a subsequent homogeneous freezing event. Within these studies usually IN of only one type are used in contrast to the external mixtures often found in the troposphere (Cziczo et al., 2004).

In our study the focus is on the impact of external mixtures of aerosols vs. the impact of single aerosol types on subsequent homogeneous nucleation events during adiabatic cooling events. For this purpose, we use a box model with a recently developed ice microphysics parameterization, i.e. an extended version of the ice microphysics scheme used in Spichtinger and Gierens (2008). In this parameterization the nucleation threshold depends on the size of the IN. Additionally, we implemented a simple but representative parameterization for sedimentation of ice crystals, which is usually not treated in box models. However, from 2D simulations (Spichtinger and Gierens, 2008) it is known that sedimentation is a key process for forming cirrus clouds, which should not be neglected.

Our simulations show that external mixtures can crucially modify subsequent homogeneous nucleation events (i.e. the formed ice crystal number concentrations) and there were large differences between the ice crystal number concentrations for external mixtures of aerosols vs. single type aerosols.

This is important for numerical simulations as well as for future measurements because it is not sufficient to use only one type of IN. For future experiments it is important to know how precise freezing thresholds for different heterogeneous IN need to be measured.

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