A31G-1827 Parameterizing the Impact of Phase State on the Ice Nucleation Abilities of Organic Aerosols

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Abstract

Organic aerosol (OA) particles have long been viewed as poor heterogeneous ice-nucleating particles (INPs) because they were assumed to be in a liquid phase state. However, recent studies demonstrate that OAs can vary their phase state from liquid to semi-solid or glassy depending on temperature, relative humidity, and composition. Emerging research suggests that such changes in phase state can strongly impact the ice nucleation abilities of certain OAs. However, direct parameterizations linking aerosol viscosity to ice nucleation capability are still lacking.

In this study, we experimentally measured the ice nucleation rate of 2-methyltetrol (2-MT) aerosols—a key component of isoprene-derived secondary organic aerosols (SOAs)—at various viscosities by pre-cooling the aerosol particles at different temperatures. Results show that as the viscosity of the 2-MT particles increased, their ice nucleation ability was strongly enhanced. Using classical nucleation theory, we developed a semi-empirical parametric model to represent how viscosity affects the heterogeneous nucleation rate, bridging experimental results with direct modeling inputs.

Our findings highlight the substantial impact of viscosity on the ice nucleation potential of OAs under typical cirrus cloud conditions, showing that the ice nucleation rate can increase by 2 to 3 orders of magnitude as the phase state transitions from liquid to semi-solid. Based on data from a previous field study, our model predicts that INP concentrations from SOA could reach approximately ~1 to 40 L^{-1} in the cirrus cloud region of the upper troposphere above the Amazon rainforest, in agreement with recent field observations and previous estimates. Our new parameterization framework can be incorporated into regional and global climate models to enhance the representation of cirrus cloud formation and predictions of future climate.

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