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The Role of Organic Aerosols in Homogeneous Ice Formation

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Recent field observations suggest that the fraction of organic-containing aerosol particles in ice cloud particles is diminished when compared to the background aerosol prior to freezing. In this work, we use model calculations to investigate possible causes for the observed behavior. In particular, homogeneous freezing processes in cooling air parcels containing aqueous inorganic particles (represented by sulfuric acid) and organic particles (represented by pure malonic acid and mixed malonic / sulfuric acid solutions) are studied with a detailed microphysical model. A disparate water uptake and resulting size differences that occur between organic and inorganic particles prior to freezing are identified as the most likely reason for the poor partitioning of organic aerosols into the ice phase. The differences in water uptake can be caused by changes in the relationship between solute mass fraction and water activity of the supercooled liquid phase, by modifications of the accommodation coefficient for water molecules, or by a combination thereof. The behavior of peak ice saturation ratios and total ice crystal number concentrations is examined, and the dependence of the results on cooling rate is investigated. Finally, processes are discussed that could possibly modify the homogeneous freezing behavior of organic particles.