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# Ice nucleation by surrogates for atmospheric mineral dust and mineral dust/sulfate particles at cirrus temperatures

C. M. Archuleta, P. J. DeMott, and S. M. Kreidenweis
Department of Atmospheric Science, Colorado State University, Fort Collins, 80523-1371 Colorado, USA

Abstract. This study examines the potential role of some types of mineral dust and mineral dust with sulfuric acid coatings as heterogeneous ice nuclei at cirrus temperatures. Commercially-available nanoscale powder samples of aluminum oxide, alumina-silicate and iron oxide were used as surrogates for atmospheric mineral dust particles, with and without multilayer coverage of sulfuric acid. A sample of Asian dust aerosol particles was also studied. Measurements of ice nucleation were made using a continuous-flow ice-thermal diffusion chamber (CFDC) operated to expose size-selected aerosol particles to temperatures between -45 and -60°C and a range of relative humidity above ice-saturated conditions. Pure metal oxide particles supported heterogeneous ice nucleation at lower relative humidities than those required to homogeneously freeze sulfuric acid solution particles at sizes larger than about 50 nm. The ice nucleation behavior of the same metal oxides coated with sulfuric acid indicate heterogeneous freezing at lower relative humidities than those calculated for homogeneous freezing of the diluted particle coatings. The effect of soluble coatings on the ice activation relative humidity varied with the respective uncoated core particle types, but for all types the heterogeneous freezing rates increased with particle size for the same thermodynamic conditions. For a selected size of 200 nm, the natural mineral dust particles were the most effective ice nuclei tested, supporting heterogeneous ice formation at an ice relative humidity of approximately 135%, irrespective of temperature. Modified homogeneous freezing parameterizations and theoretical formulations are shown to have application to the description of heterogeneous freezing of mineral dust-like particles with soluble coatings.

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