Cloud modeling with an empirical parametrisation of heterogeneous ice nucleation for multiple aerosol species : role of biogenic particles

Vaughan T. J. Phillips, Constantin Andronache, Paul J. Demott, Cindy E. Morris, David C. Sands

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Cloud Modeling with an Empirical Parametrisation of Heterogeneous Ice Nucleation for Multiple Aerosol Species: Role of Biogenic Particles

Dr. Vaughan Phillips
Meteorology University of Hawaii at Manoa

Constantin Andronache, Paul Demott, Cindy E. Morris, David C. Sands

Analyses of the residual material in ice crystals have revealed that most of them are formed on ice nuclei of dust and carbonaceous aerosol. A significant fraction of these carbonaceous insoluble aerosols appear to have a biogenic source from such things as bacteria, pollen fragments, and decayed vegetative matter. Recent advances in measurement techniques have revealed very high concentrations of bacteria in the free troposphere (e.g. up to 100-1000 L-1). Such bacteria had previously eluded detection because they are mostly rendered non-culturable by atmospheric conditions. Many laboratory studies have shown that a commonly occurring species of bacteria (Pseudomonas syringae) that grows on plant surfaces can have ice-nucleating properties. Its strains have been observed to display a spectrum of varying nucleability. Climate change has the potential to modify the temperature-dependent sources of such biogenic ice nuclei. Consequently, there may be a contribution to the aerosol/ice-cloud interaction in climate change from this temperature-dependence, possibly forming a climate feedback. To address this issue, an empirical parametrisation of heterogeneous ice nucleation is proposed for application in cloud and large-scale atmospheric models. It represents dependences on predicted mass concentrations for multiple chemical species of ice nucleus (IN) aerosols, including biogenic aerosols, in addition to dust and black carbon. The biogenic IN particles are assumed to be ice-nucleation active (INA) bacteria. The scheme includes condensation-, immersion- and contact-freezing modes, in addition to vapour deposition, as mechanisms for heterogeneous nucleation. As an input, it requires prediction by the model of the supersaturation at the convective scale. The scheme is presented and its validation with independent observational data is shown. Sensitivity studies show the impact that such biogenic aerosols can have on cloud properties for a realistic range of scenarios of emission of bacteria.