Evidence for biological ice nucleating particles in snowfall

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Biological ice nucleating particles (BINPs) have been reported in rain and at altitudes of several kilometers. Due to the relatively warm temperatures at which they can function as freeze catalysts, BINPs in the atmosphere may impact meteorological processes and induce precipitation. We examined 10 snowfall events at four locations in the vicinity of Bozeman, Montana USA during the 2005-06 winter season (from October to April) and seven snowfall events at 5 locations in the French Alpes, Pyrenees and southern France from December 2005 to March 2006. The temperature of detectable ice nuclei activity for the majority (60%) of the samples was greater than or equal to -5 C, based on immersion freezing tests from -2 to -9C. Successive treatment of melted snow with lysozyme (i.e. to lyse bacterial cells) led to reductions in the frequency of nuclei at the warmest temperatures detected, and heat treatment (i.e., to denature proteins) of the samples greatly reduced or completely eliminated all detectable nuclei at -9 C. This ice nucleation activity of apparent biological origin was as prevalent in samples collected during the peak of winter as it was during the early and late portion of the season. Deciduous plants are thought the sources of BINPs (e.g. Pseudomonas syringae); however, ice nucleation activity was also documented in snow samples collected in the Antarctic (McMurdo Station) and Arctic (Wheaton Glacier, Yukon), suggesting long distance air transport of biological ice nuclei to remote sites and maintenance of the ice nucleating activity during transport. Multiple regression analysis of biogeochemical data (major ions, organic carbon, particles, and cell concentrations) collected from the 6 month Montana record provided a model that can predict the total microbial cell concentration in the snowfall based on the NH4+, Ca2+, and total organic carbon concentration. Our results imply that BINPs are ubiquitous in the atmosphere and that for some geographic locations, the concentration of airborne biological particles is related to the snow chemistry.

Keywords: snow, atmosphere, biological ice nucleation