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ATMOSPHERIC ICE NUCLEI CONCENTRATIONS AND CHARACTERISTICS: CONSTRAINING THE ROLE OF BIOLOGICAL ICE NUCLEI.

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Ice initiation in clouds warmer than -35C is presently known to occur only through the action of special particles acting as ice nuclei. Atmospheric measurements of ice nuclei concentrations, physical and chemical characteristics made over the past 15 years demonstrate the apparent nature of this special population and provide some apparent constraints on the contributions of ice nuclei from biological sources. Measured concentrations of ice nuclei are usually below 0.1 cm-3 at any temperature below 0C except in special circumstances, including strong dust transport events. Ice nuclei concentrations measured in the free troposphere with a continuous flow diffusion chamber instrument do not follow an exponential increase with decreasing temperature, but rather increase only modestly at lower temperatures. The strongest decrease in ice nuclei concentrations occurs for aerosols processed warmer than about -15C. This result and the known nature of biological ice nuclei to express activity in the temperature regime between 0 and -10C indicates the potential special realm of biological ice nuclei.Investigations of the compositions of the residual particles from freshly nucleated ice crystals by transmission electron microscopy and more recently using single particle mass spectrometry support that the largest source type of ice nuclei are mineral dust particles. Contributions to ice nuclei from carbonaceous aerosol particles vary from just a few percent to as much as 33% at temperatures below -10C. The source of these carbon-containing particles is not known. Few are recognizable morphologically as bacterial cells, although this could be influenced by present sampling procedures that have restricted measurements to aerosols below 1 micron. Nevertheless, the typical larger ice crystal residual nuclei are predominately mineral dust particles. It is possible that the smaller carbon particles detected as apparent ice nuclei have a source from biological aerosol fragments, but this remains to be confirmed. It is particularly important to advance investigations of the types of particles that are active at the warmest sub-cooled temperatures where the influence of the nuclei on the subsequent ice phase evolution of clouds may be strongest.