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▼ Sections

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< Previous Article   Next Article >

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# Empirical Formulation for Multiple Groups of Primary Biological Ice Nucleating Particles from Field Observations over Amazonia

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## Abstract

To resolve the various types of biological ice nuclei (IN) with atmospheric models, an extension of the empirical parameterization (EP) is proposed to predict the active IN from multiple groups of primary biological aerosol particles (PBAPs). Our approach is to utilize coincident observations of PBAP sizes, concentrations, biological composition, and ice nucleating ability. The parameterization organizes PBAPs into five basic groups: 1) fungal spores, 2) bacteria, 3) pollen, 4) viral particles, plant/animal detritus, 5) algae, and their respective fragments. This new biological component of the EP was constructed by fitting predicted concentrations of PBAP IN to those observed at the Amazon Tall Tower Observatory (ATTO) site located in the central Amazon. The fitting parameters for pollen and viral particles and plant/animal detritus, which are much less active as IN than fungal and bacterial groups, are constrained based on their ice nucleation activity from the literature. The parameterization has empirically derived dependencies on the surface area of each group (except algae), and the effects of variability in their mean sizes and number concentrations are represented via their influences on surface area. The concentration of active algal IN is estimated from literature-based measurements. Predictions of this new biological component of the EP are consistent with previous laboratory and field observations not used in its construction. The EP scheme was implemented in a 0D parcel model. It confirms that biological IN account for most of the total IN activation at temperatures warmer than  $-20^{\circ}\text{C}$  and at colder temperatures dust and soot become increasingly more important to ice nucleation.

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