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Biological contribution to ice nucleation active particles in clouds at the puy de Dôme atmospheric station, France

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The distribution, abundance and nature of ice nucleation active particles in the atmosphere are major sources of uncertainty in the prediction of cloud coverage, precipitation patterns and climate. Some biological ice nuclei (IN) induce freezing at temperatures at which most other atmospheric particles exhibit no detectable activity ($> -10°C$), but their actual contribution to the pool of IN in clouds remains poorly known. In order to help elucidating this, cloud water was collected aseptically from the summit of Puy de Dôme (1465m a.s.l., France) within contrasted meteorological and physico-chemical situations. Total and biological (i.e. heat-sensitive) IN were quantified by droplet-freezing assay between $-5°C$ and $-14°C$. We observed that freezing was systematically induced by biological material, between $-6°C$ and $-8°C$ in 92% of the samples. Its removal by heat treatment consistently led to a decrease of the onset freezing temperature, by 3°C or more in most samples. At $-10°C$, 0 to 220 biological IN mL^{-1} of cloud water were measured (i.e. 0 to 22 m^{-3} of cloud air), and these represented 65% to 100% of the total IN. Based on back-trajectories and on physico-chemical analyses, the high variability observed resulted probably from a source effect, with IN originating mostly from continental sources. Bacteria concentration in the air at altitude relevant for clouds typically ranges from $\sim$102 to $\sim$105 cells m^{-3}. Assuming that biological IN measured in cloud water samples at $-8°C$ were all bacteria, ice nucleation active bacteria represented at maximum 0.6% of the total bacteria cells present (3.1% at $-12°C$). These results should help elucidating the role of biological and bacterial IN on cloud microphysics and their impact on precipitation at local scale.

References:
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