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Partitioning of microbial cells between clouds and precipitation

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It is known that microorganisms are present in the outdoor atmosphere, in clouds and precipitation. These microorganisms originate from various local and distant sources and consist of very diverse and ephemeral communities. The most abundant bacterial taxa typically include Alpha-, Beta- and Gamma-Proteobacteria, with notably *Pseudomonas* and *Sphingomonas* among the dominant genera observed. Still, very little is known about their sources, metabolic activity, distribution, and their dynamics during their atmospheric life cycle. It was proposed in the past that bacteria with high ice nucleation activity are likely more efficiently precipitated than others [1]. Here, we extend this hypothesis and suggest more generally that different bacteria taxa could exhibit different phase partitioning between aerosol particles, cloud and rainwater, which may affect their atmospheric residence times. This implies that microorganisms are not equally distributed among the different atmospheric compartments (clouds, aerosols and precipitation).

To investigate this hypothesis, cloud and rain samples were collected simultaneously from single precipitation events, from two meteorological stations located at different altitudes: the summit of puy de Dôme Mountain (1465 m above sea level; France), embedded in clouds, using cloud impactors and high-flow-rate impingers [2], and below the summit, at Opme Station (680 a.s.l.) where precipitation occurred, using automated precipitation collector. The bacterial biodiversity was examined by 16s rRNA gene amplicon MiSeq sequencing. Samples were also characterized for their chemical contents. We show that clouds and precipitation host distinct microbial communities. Clouds host communities from high altitude likely to be of distant origin, while precipitation also includes material originating from the air column underneath and from local origin. So, comparing the biodiversity hosted in clouds and precipitation within single air masses provides information on the relative contribution of local and distant sources to the microorganisms deposited at the surface with rainfalls, and provides very new information concerning the processing and fate of bacteria in the atmosphere.

[1] M. Joly, P. Amato, L. Deguillaume, M. Monier, C. Hoose, and A. M. Delort, "Quantification of ice nuclei active at near 0 °C temperatures in low-altitude clouds at the Puy de Dôme atmospheric

station," *Atmos. Chem. Phys.*, vol. 14, no. 15, pp. 8185–8195, 2014.

[2] T. Šantl-Temkiv et al., "High-Flow-Rate Impinger for the Study of Concentration, Viability, Metabolic Activity, and Ice-Nucleation Activity of Airborne Bacteria," *Environ. Sci. Technol.*, vol. 51, no. 19, pp. 11224–11234, 2017.