4.047 Introducing biological processes in cloud chemistry models.

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Abstract:

Models have been developed to study the multiphase cloud chemistry. But, only abiotic processes have been considered in these models to represent the transformations of organic and inorganic species. Recently, microorganisms (bacteria, yeasts and fungi) have been discovered as new potential actors of cloud chemistry. The presence of metabolic activity in clouds leads to an uptake of molecular compounds by cells as nutrients but also to a production of larger molecules. Microorganisms are therefore considered as biological catalysts and they potentially compete with chemical reactions in cloud aqueous phase.
Microorganisms can degrade carbon compounds such as formaldehyde, methanol and organic acids thanks to their carbon metabolism. They also interact with oxidants: they consume H_2O_2 that is a major source of $HO^\bullet$ radicals due to their oxidative stress metabolisms. Recently, comparisons between the rates of biotic and abiotic transformations in microcosms mimicking cloud environments have clearly demonstrated that biodegradation can be competitive with radical chemistry. However, such laboratory experiments have been performed under “bulk” conditions that reflect only aqueous phase reactivity. But the cloud system is a multiphase (gas/liquid/solid) medium where chemical processes take place and are modified by microphysical and dynamical processes. The next step is thus to integrate biological reactions within cloud chemistry models.
For this, biodegradation rates were experimentally determined for 4 chemical compounds (formic and acetic acids, formaldehyde and H_2O_2). Three bacteria strains isolated from the cloud water sampled at the puy de Dôme (France) were selected for their capacity to efficiently degrade these compounds. These biodegradation rates are introduced for the first time in a multiphase cloud chemistry model using the CLEPS aqueous mechanism (Cloud Explicit Physico-chemical Scheme). The objective of this work is to compare radical vs. microbiology efficiency looking at the effect of selected “key” environmental parameters such as temperature and solar irradiation intensity.