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Photochemistry versus biological activity towards organics in cloud water

Amina Khaled, Minghui Zhang, Pierre Amato, Anne-Marie Delort, and Barbara Ervens
Institut de chimie de Clermont Ferrand, Chemistry, Aubière, France (amina.khaled@uca.fr)

The aqueous phase of clouds is a complex atmospheric medium containing a multitude of organic and inorganic species with different reactivities. The main oxidant towards organics in the aqueous phase is the OH radical. Many studies have identified biological material as a major fraction of ambient aerosol loading with bacteria being a small fraction. Laboratory experiments in our and other research groups have shown that microbial degradation of small organics (e.g., formic and acetic acids) can efficiently occur in artificial and real cloud water in competition to chemical radical reactions. However, in current models, it is usually assumed that bacteria are not metabolically active in the atmosphere. The aim of our study is to identify conditions, under which biological activity is significant in the multiphase system for specific organic compounds. Using a cloud multiphase process model, we compare the predicted fractions of organics consumed by radicals in the gas and aqueous phases to that by microbial processes of bacteria in the aqueous phase over large ranges of microphysical (e.g., cloud liquid water content, drop number), biological (cell concentration and activity) and chemical parameters (reaction rate constants and Henry's law constants). We identify the organic properties and cloud parameters under which metabolic processes represent major atmospheric sinks for organics. In our cloud model, we consider the fact that only a small number fraction of droplets contain active bacteria cells. As many other models might not be able to describe such microphysical details, we also suggest simplified model approaches to represent microbial activity in clouds.