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Aerosol-Cloud-Precipitation Interactions in the Climate System

Meinrat O. Andreae
Max Planck Institute for Chemistry, Mainz, Germany (m.andreae@mpic.de)

Aerosols serve as cloud condensation nuclei (CCN) and ice nuclei (IN) and thus have a powerful effect on cloud properties. Increased aerosol concentrations resulting from pollution lead to higher cloud droplet concentrations, but smaller droplet sizes. This in turn affects the physical processes inside clouds that lead to the initiation of precipitation. Depending on a number of factors, including aerosol composition, atmospheric stability, and cloud water content, increasing CCN concentrations may either decrease or increase rainfall. In convective clouds, early rain formation is suppressed, which makes more water and energy available to rise higher in the atmosphere and form ice particles. This may invigorate the dynamics of convection, encourage the formation of hail and lightning, and enhance the transport of materials to the upper troposphere. In turn, cloud processing also affects the concentrations, composition, and distribution of atmospheric aerosols. In order to understand and quantify the effects of air pollution on climate, and precipitation in particular, knowledge of natural abundance and characteristics of aerosols is as essential as the observation of perturbed conditions. I will present recent advances in the conceptual understanding of aerosol-cloud-precipitation interactions, with emphasis on the role of convective clouds on the aerosol life cycle.