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From Cradle to Grave: Research on Atmospheric Aerosols (Vilhelm Bjerknes Medal Lecture)

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Atmospheric aerosol particles are liquid or solid particles suspended in the atmosphere. Generally, the sizes of aerosol particles are in the range 0.001 - 100 μm. Atmospheric aerosols are of interest mainly because of their effects on health and climate. Concerning health, many epidemiological studies have shown a link between increased mortality/morbidity and increased PM_{10} or $PM2.5$ (particulate matter with an aerodynamic diameter smaller than 10 and 2.5 μm, respectively). Concerning climate, aerosol particles scatter and absorb light (known as the direct effect on climate), and modify cloud properties (with a variety of effects known as indirect effects). These effects are influenced by the chemical and physical properties of the aerosol particles, which makes these properties important to be measured.

Atmospheric aerosol particles are produced by a large variety of sources, and are either emitted as primary particles (i.e., they are directly emitted as particles into the atmosphere) or formed by secondary processes (i.e., by transformation of emitted precursor gases). While the formation pathways of secondary inorganic aerosols such as nitrate and sulfate in general are reasonably well understood, the formation of secondary organic aerosol (SOA) is still an area of active research. A wide variety of gaseous precursors contribute to SOA, and their aerosol yields depend on a wide variety of conditions. In addition, it is still largely unknown to which extent and under which conditions oxidized organic molecules can contribute to nucleation, i.e., the formation of new particles.

Elimination of aerosol particles from the atmosphere mostly occurs by wet deposition, where the ice phase plays an important role. Even though cloud glaciation augments precipitation formation and affects cloud radiative properties little is still known about mixed-phase cloud formation via heterogeneous nucleation. To elucidate some of the involved mechanisms in situ research in such mixed phase clouds has been performed in a series of Cloud Aerosol Characterization Experiments (CLACE) at the high altitude research station Jungfraujoch (3580 m asl).

This presentation will give an overview on recent laboratory experiments and field campaigns. The lab studies relate to SOA formation from a variety of precursors as well as the formation of new particles from gaseous sulfuric acid in combination with other precursor gases where the latter experiments have been performed in the CLOUD experiment at CERN. The field studies relate to the latest developments of source apportionment studies for the organic aerosol, which build on positive matrix factorization of aerosol mass spectrometer data, as well as to aerosol cloud interaction studies on the Jungfraujoch.