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Atmospheric Nucleation and its relationships to Biosphere - Atmosphere Interactions

Markku Kulmala

Department of Physical Sciences, University of Helsinki, Finland
((markku.kulmala@helsinki.fi / Fax: +358919150860 / Phone: 358919150756)

The main coupling mechanism between biosphere - atmosphere interactions and atmospheric nucleation is via photosynthesis. In practice, photosynthesis drives plant gross primary production (GPP), the difference between net ecosystem exchange of CO_2 (NEE) and total ecosystem respiration (TER). Forest ecosystems are usually sinks of CO_2, and a direct negative feedback (the higher the CO_2 concentration, the higher the rate of photosynthesis) exists between increasing atmospheric CO_2 concentrations and photosynthesis. On the other hand, forest ecosystems also act as significant sources of atmospheric aerosols. Terrestrial vegetation contributes substantially to emissions of a variety of Biogenic Volatile Organic Compounds (BVOCs) also as side products of photosynthesis, and newly formed particles in forested areas have been found to contain large amounts of organic material. The ratio of BVOC emission to carbon assimilation is generally a few percent, and if increased CO_2 concentrations enhance photosynthesis, formation and emissions of several BVOCs may increase and possibly modify the aerosol particle formation routes.

Although observed all over the world, the understanding of atmospheric new particle formation is still far from complete. Altogether, most observations made so far support the idea that nucleation and subsequent particle growth are uncoupled under atmospheric conditions. The associations between formation rate and H_2SO_4 vapour concentration are suggestive of the involvement of H_2SO_4 in atmospheric nucleation, yet the actual nucleation mechanism remains to be definitively identified. We have seen that ion-induced nucleation is taking place all the time, but its contribution is usually limited at least in the continental boundary layer. Observed growth rates of nucleated particles cannot usually be explained by the condensation of sulfuric and associated inorganic compounds (water and ammonia) alone. Organic compounds having a very low saturation vapor pressure would appear to be the most likely candidates for assisting the growth of nucleated particles, yet identity of these compounds remains to be revealed. Depending on the location, atmospheric aerosol formation is capable of increasing the concentrations of cloud condensation nuclei (CCN) by a factor more than two over the course of one day. Also we have seen that the contribution of BVOCs is significant in CCN production.

In future, the relative contribution of biogenic and anthropogenic emissions to atmospheric aerosol should be investigated. While biogenic aerosol formation mechanisms are known for the most part because of the research carried out during the recent years, there is an urge for applying them in the global scale in the future. This calls for understanding and ability to observe how the biogenic formation mechanisms are linked to underlying ecosystem processes. At the same time it is important to make an integrated attempt to understand various, but inter-linked, biosphere-atmosphere interactions by using inter- and multi-disciplinary approaches in a coherent manner.