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Biosphere-aerosol-cloud-climate interactions

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Atmospheric aerosol particles and trace gases affect the quality of our life in many different ways. In polluted urban environments, they influence human health and deteriorate visibility. In regional and global scales, aerosol particles and trace gases have a potential to change climate patterns and hydrological cycle. Aerosol particles also influence the radiation intensity distribution that reaches the earth surface having a direct influence on the terrestrial carbon sink. Better understanding of the various effects in the atmosphere requires detailed information on how different sources (including those of biosphere) and transformation processes modify properties of aerosol particles and trace gases. Trace gases and atmospheric aerosols are tightly connected with each other via physical, chemical, meteorological and biological processes occurring in the atmosphere and at the atmosphere-biosphere interface. An important phenomenon as an example is atmospheric aerosol formation, which involves the production of nanometer-size particles by nucleation and their growth to detectable sizes. Human actions, such as emission policy, forest management and land use change and various natural feedback mechanisms involving the biosphere and atmosphere have an impact on the coupling between the aerosols and trace gases.

In 2001 and also in 2007, the Intergovernmental Panel on Climate Change (IPCC) estimated the global and annual radiative forcing due to greenhouse gases and aerosols, along with natural changes associated with solar radiation. Emphasis was placed on the complexity of the combined direct and indirect forcing from both aerosols and gases as well as on the importance of improving our understanding of the role that each of these three individual components plays in radiative forcing in an integrated system. Such knowledge would reduce the uncertainty in current estimates of radiative forcing and enable a better prediction of the effects of anthropogenic activity on global change. The most important issue to resolve is how the different components affecting radiative forcing interact with one another. We have recently proposed a mechanism that couples the effect of CO_2 and aerosol particles on climate. This suggestion is based on connections between photosynthesis, emissions of non-methane biogenic volatile organic compounds (BVOCs), and their ability to form aerosol particles.

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. 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 load 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.

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