International Max Planck Research School on Earth System Modelling

Towards the Assessment of the Climate Effects of Secondary Organic Aerosols

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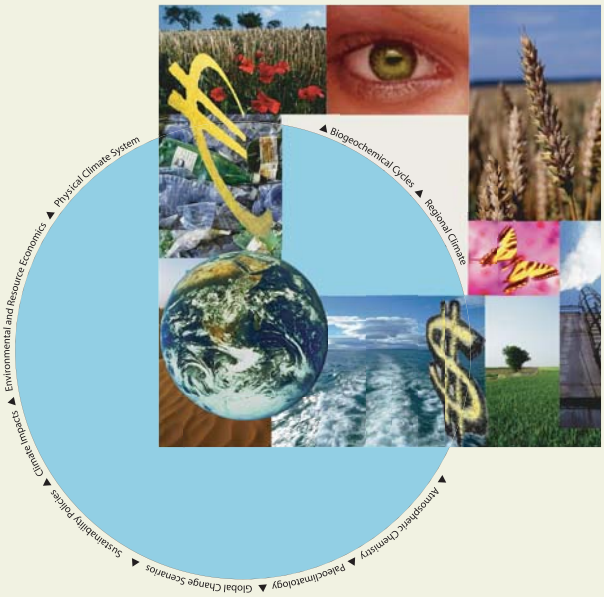

ABSTRACT

Atmospheric aerosols influence the Earth's climate by absorbing and scattering solar radiation and by altering the properties of clouds. Measurements have shown that a substantial fraction of the tropospheric aerosol burden consists of organic compounds. Hundreds of different organic species have been identified in aerosols, yet these are typically able to account for only a minority of the total aerosol organic mass. While progress has been made in the understanding of the roles of certain aerosol types in the climate system, that of organic aerosols remains poorly understood and the climate influences resulting from their presence poorly constrained.

Organic aerosols are emitted directly from the surface (primary organic aerosols, POA), and are also formed in the atmosphere by oxidation reactions of gas-phase precursors (secondary organic aerosols, SOA). The significance of the distinction between primary and secondary organic aerosols lies largely in the fact that SOA condense from the gas phase onto the pre-existing aerosol; so that POA and SOA affect the mass, number and size distributions of an aerosol population in quite different ways.

Both anthropogenic and biogenic SOA precursors are known from laboratory studies and from field measurements. Global inventories of anthropogenic precursor emissions have been constructed, as have canopy models that permit estimation of the production of biogenic precursors from a given biome.

Globally, biogenic emissions of aerosol precursors are estimated to be much the larger source (of the order of several hundred Tg per year) and they form a potentially significant natural source of tropospheric aerosol. A mechanism thus exists whereby vegetation can impact climate through its influence upon the atmospheric aerosol loading, and thereby on the radiative budget and on the properties of clouds. In turn, emission of precursor gases from vegetation is climate-dependent; hence a bi-directional dependency between biosphere and atmosphere is established.

For quantitative study of the climatic influence of these aerosols, and of the biosphere-atmosphere interactions outlined above, a global climate/aerosol model is a suitable tool.

This study builds upon one such model, ECHAM5/HAM, to which techniques to model the formation and behaviour of secondary organic aerosols are added, as well as the necessary global emission inventories, with the following goals:

- Estimation of the direct (radiative) and indirect effects of biogenic organic aerosols
- Estimation of the direct and indirect effects of biogenic plus anthropogenic organic aerosols
- Estimation of the influence of changing climate on the formation of organic aerosols from biogenic precursors
- Progress towards understanding the interactions of secondary organic aerosols with other aerosol species and with clouds

If achieved, these objectives will contribute to improving our understanding of earth system processes, in particular the climate response to anthropogenic and biogenic SOA, the coupling via aerosols of the land biosphere and the climate system and the interactions of natural and anthropogenic aerosols.