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A pathway analysis of global aerosol processes

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Although budgets for aerosol emission and deposition (macrophysical fluxes) have been studied before, much less is known about the budgets of processes e.g. nucleation, coagulation and condensation. A better understanding of their relative importance would improve our understanding of the aerosol system and help model development and evaluation.

Aerosols are not only emitted from and deposited to the Earth's surface but are modified during their transport. The processes for these modifications include nucleation of H2SO4 gas into new aerosol, coagulation with other aerosol and condensation of H2SO4 unto existing aerosol. As a result of these processes, aerosol grow in size and change their chemical composition, often becoming hydrophilic where they were hydrophobic before. This affects their characteristics for various deposition processes (sedimentation, dry or wet deposition) as well as their radiative properties and hence climate forcing by aerosol.

We present a complete budget of all aerosol processes in the aerosol-climate model ECHAM-HAM including the M7 microphysics. This model treats aerosol as 7 distinct but interacting two-moment modes of mixed species (soot, organic carbons, sulfate, sea salt and dust). We will show both global budgets as well as regional variations in dominant processes. Some of our conclusions are: condensation of H2SO4 gas onto pre-existing particles is an important process, dominating the growth of small particles in the nucleation mode to the Aitken mode and the ageing of hydrophobic matter. Together with in-cloud production of H2SO4, it significantly contributes to (and often dominates) the mass burden (and hence composition) of the hydrophilic Aitken and accumulation mode particles. Particle growth itself is the leading source of number densities in the hydrophilic Aitken and accumulation modes, with their hydrophobic counterparts contributing (even locally) relatively little. However, the coarse mode is mostly decoupled from the smaller modes. Our analysis also suggests that coagulation serves mainly as a loss process for number densities and that it is a relatively unimportant contributor to composition changes of aerosol.

Our results provide an objective way of complexity analysis in a global aerosol model and will be used in future work where we will reduce this complexity in ECHAM-HAM.