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A global view on aerosol micro- and macrophysical processes

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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.

Although budgets for aerosol emission and deposition (macrophysical fluxes) have been studied before, much less is known about the budgets of e.g. nucleation, coagulation and condensation (microphysical fluxes). A better understanding of their relative importance would help understand aerosol model structural errors and imply simplifications for faster, leaner aerosol models that allow climate simulations with interactive aerosol at reduced cost.

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: 1) coagulation only matters when nucleation or Aitken mode particles are involved; 2) coagulation is important for the formation of accumulation mode particles; 3) microphysics particularly affects number densities and hence aerosol sizes; 4) aging due to sulfate collection is an important process but hydrophilic number densities typically dwarf hydrophobic number densities; 5) lifetime of the nucleation mode is very short (0.4d); 6) these conclusions are robust for pre-industrial and modern emission scenarios.

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.