Atmos. Chem. Phys., 6, 1777-1813, 2006
www.atmos-chem-phys.net/6/1777/2006/

Analysis and quantification of the diversities of aerosol life cycles within AeroCom

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Abstract. Simulation results of global aerosol models have been assembled in the framework of the AeroCom intercomparison exercise. In this paper, we analyze the life cycles of dust, sea salt, sulfate, black carbon and particulate organic matter as simulated by sixteen global aerosol models. The differences among the results (model diversities) for sources and sinks, burdens, particle sizes, water uptakes, and spatial dispersals have been established. These diversities have large consequences for the calculated radiative forcing and the aerosol concentrations at the surface. Processes and parameters are identified which deserve further research.
The AeroCom all-models-average emissions are dominated by the mass of sea salt (SS), followed by dust (DU), sulfate (SO_4), particulate organic matter (POM), and finally black carbon (BC). Interactive parameterizations of the emissions and contrasting particles sizes of SS and DU lead generally to higher diversities of these species, and for total aerosol. The lower diversity of the emissions of the fine aerosols, BC, POM, and SO_4, is due to the use of similar emission inventories, and does therefore not

necessarily indicate a better understanding of their sources. The diversity of SO_4-sources is mainly caused by the disagreement on depositional loss of precursor gases and on chemical production. The diversities of the emissions are passed on to the burdens, but the latter are also strongly affected by the model-specific treatments of transport and aerosol processes. The burdens of dry masses decrease from largest to smallest: DU, SS, SO_4, POM, and BC.

The all-models-average residence time is shortest for SS with about half a day, followed by SO_4 and DU with four days, and POM and BC with six and seven days, respectively. The wet deposition rate is controlled by the solubility and increases from DU, BC, POM to SO_4 and SS. It is the dominant sink for SO_4, BC, and POM, and contributes about one third to the total removal of SS and DU species. For SS and DU we find high diversities for the removal rate coefficients and deposition pathways. Models do neither agree on the split between wet and dry deposition, nor on that between sedimentation and other dry deposition processes. We diagnose an extremely high diversity for the uptake of ambient water vapor that influences the particle size and thus the sink rate coefficients. Furthermore, we find little agreement among the model results for the partitioning of wet removal into scavenging by convective and stratiform rain.

Large differences exist for aerosol dispersal both in the vertical and in the horizontal direction. In some models, a minimum of total aerosol concentration is simulated at the surface. Aerosol dispersal is most pronounced for SO_4 and BC and lowest for SS. Diversities are higher for meridional than for vertical dispersal, they are similar for the individual species and highest for SS and DU. For these two components we do not find a correlation between vertical and meridional aerosol dispersal. In addition the degree of dispersals of SS and DU is not related to their residence times. SO_4, BC, and POM, however, show increased meridional dispersal in models with larger vertical dispersal, and dispersal is larger for longer simulated residence times.

Final Revised Paper (PDF, 1244 KB)   Discussion Paper (ACPD)

Citation: Textor, C., Schulz, M., Guibert, S., Kinne, S., Balkanski, Y., Bauer, S., Berntsen, T., Berglen, T., Boucher, O., Chin, M., Dentener, F., Diehl, T., Easter, R., Feichter, H., Fillmore, D., Ghan, S., Ginoux, P., Gong, S., Grini, A., Hendricks, J., Horowitz, L., Huang, P., Isaksen, I., Iversen, I., Kloster, S., Koch, D., Kirkevåg, A., Kristjansson, J. E., Krol, M., Lauer, A., Lamarque, J. F., Liu, X., Montanaro, V., Myhre, G., Penner, J., Pitari, G., Reddy, S., Seland, Ø., Stier, P., Takemura, T., and Tie, X.: Analysis and quantification of the diversities of aerosol life cycles within AeroCom, Atmos. Chem. Phys., 6, 1777-1813, 2006.   Bibtex   EndNote   Reference Manager