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Simulating aerosol microphysics with the ECHAM4 / MADE GCM – Part II: Results from a first multiannual simulation of the submicrometer aerosol

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Abstract. First results of a multiannual integration with the new global aerosol model system ECHAM4/MADE are presented. This model system enables simulations of the particle number concentration and size-distribution, which is a fundamental innovation compared to previous global model studies considering aerosol mass cycles only. The data calculated by the model provide detailed insights into the properties of the global submicrometer aerosol regarding global burden, chemical composition, atmospheric residence time, particle number concentration and size-distribution. The aerosol components considered by the model are sulfate (SO_4), nitrate (NO_3), ammonium (NH_4), black carbon (BC), organic matter (OM), mineral dust, sea salt and aerosol water. The simulated climatological annual mean global atmospheric burdens (residence times) of the dominant submicrometer aerosol components are 2.25 Tg (4.5 d) for SO_4, 0.46 Tg (4.5 d) for NH_4, 0.26 Tg (6.6 d) for BC, and 1.77 Tg (6.5 d) for OM. The contributions of individual processes such as emission, nucleation, condensation or dry and wet deposition to the global sources and sinks of specific aerosol components and particle number concentration are quantified. Based on this analysis, the significance of aerosol microphysical processes (nucleation, condensation, coagulation) is evaluated by comparison to the importance of other processes relevant for the submicrometer aerosol on the global scale. The results reveal that aerosol microphysics are essential for the simulation of the particle number concentration and important but not vital for the simulation of particle mass concentration. Hence aerosol microphysics should be taken into account in simulations of atmospheric processes showing a significant dependence on aerosol particle number concentration. The analysis of the vertical variation of the microphysical net production and net depletion rates performed for particle number concentration, sulfate mass and black carbon mass concentration unveils the dominant source and sink regions. Prominent features can be attributed to dominant microphysical processes such as nucleation in the upper troposphere or wet deposition in the lower troposphere. Regions of efficient coagulation can be identified.

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