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Simulating aerosol microphysics with the ECHAM/MADE GCM – Part I: Model description and comparison with observations

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Abstract. The aerosol dynamics module MADE has been coupled to the general circulation model ECHAM4 to simulate the chemical composition, number concentration, and size distribution of the global submicrometer aerosol. The present publication describes the new model system ECHAM4/MADE and presents model results in comparison with observations. The new model is able to simulate the full life cycle of particulate matter and various gaseous particle precursors including emissions of primary particles and trace gases, advection, convection, diffusion, coagulation, condensation, nucleation of sulfuric acid vapor, aerosol chemistry, cloud processing, and size-dependent dry and wet deposition. Aerosol components considered are sulfate (SO_4), ammonium (NH_4), nitrate (NO_3), black carbon (BC), particulate organic matter (POM), sea salt, mineral dust, and aerosol liquid water. The model is numerically efficient enough to allow long term simulations, which is an essential requirement for application in general circulation models. Since the current study is focusing on the submicrometer aerosol, a coarse mode is not being simulated. The model is run in a passive mode, i.e. no feedbacks between the MADE aerosols and clouds or radiation are considered yet. This allows the investigation of the effect of aerosol dynamics, not interfered by feedbacks of the altered aerosols on clouds, radiation, and on the model dynamics.
In order to evaluate the results obtained with this new model system, calculated mass concentrations, particle number concentrations, and size distributions are compared to observations. The intercomparison shows, that ECHAM4/MADE is able to reproduce the major features of the geographical patterns, seasonal cycle, and vertical distributions of the basic aerosol parameters. In particular, the model performs well under polluted continental conditions in the northern hemispheric lower and middle troposphere. However, in comparatively clean remote areas, e.g. in the upper troposphere or in the southern hemispheric marine boundary layer, the current model version tends to underestimate particle number concentrations.

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