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Aerosol size-dependent below-cloud scavenging by rain and snow in the ECHAM5-HAM

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Abstract. Wet deposition processes are highly efficient in the removal of aerosols from the atmosphere, and thus strongly influence global aerosol concentrations, and clouds, and their respective radiative forcings. In this study, physically detailed size-dependent below-cloud scavenging parameterizations for rain and snow are implemented in the ECHAM5-HAM global aerosol-climate model. Previously, below-cloud scavenging by rain in the ECHAM5-HAM was simply a function of the aerosol mode, and then scaled by the rainfall rate. The below-cloud scavenging by snow was a function of the snowfall rate alone. The global mean aerosol optical depth, and sea salt burden are sensitive to the below-cloud scavenging coefficients, with reductions near to 15% when the more vigorous size-dependent below-cloud scavenging by rain and snow is implemented. The inclusion of a prognostic rain scheme significantly reduces the fractional importance of below-cloud scavenging since there is higher evaporation in the lower troposphere, increasing the global mean sea salt burden by almost 15%. Thermophoretic effects are shown to produce increases in the global and annual mean number removal of Aitken size particles of near to 10%, but very small increases (near 1%) in the global mean below-cloud mass scavenging of carbonaceous and sulfate aerosols. Changes in the assumptions about the below-cloud scavenging by rain of particles with radius smaller than 10 nm do not cause any significant changes to the global and annual mean aerosol mass or number burdens, despite a change in the below-cloud number removal rate for nucleation mode particles by near to five-fold. Annual and zonal mean nucleation mode number concentrations are enhanced by up to 30% in the lower troposphere with the more vigourous size-dependent below-cloud scavenging. Closer agreement with different observations is found when the more physically detailed below-cloud scavenging parameterization is employed in the ECHAM5-HAM model.

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