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Aerosol activation and cloud processing in the global aerosol-climate model ECHAM5-HAM

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Abstract. A parameterization for cloud processing is presented that calculates activation of aerosol particles to cloud drops, cloud drop size, and pH-dependent aqueous phase sulfur chemistry. The parameterization is implemented in the global aerosol-climate model ECHAM5-HAM. The cloud processing parameterization uses updraft speed, temperature, and aerosol size and chemical parameters simulated by ECHAM5-HAM to estimate the maximum supersaturation at the cloud base, and subsequently the cloud drop number concentration (CDNC) due to activation. In-cloud sulfate production occurs through oxidation of dissolved SO_2 by ozone and hydrogen peroxide. The model simulates realistic distributions for annually averaged CDNC although it is underestimated especially in remote marine regions. On average, CDNC is dominated by cloud droplets growing on particles from the accumulation mode, with smaller contributions from the Aitken and coarse modes. The simulations indicate that in-cloud sulfate production is a potentially important source of accumulation mode sized cloud condensation nuclei, due to chemical growth of activated Aitken particles and to enhanced coalescence of processed particles. The strength of this source depends on the distribution of produced sulfate over the activated modes. This distribution is affected by uncertainties in many parameters that play a direct role in particle activation, such as the updraft velocity, the aerosol chemical composition and the organic solubility, and the simulated CDNC is found to be relatively sensitive to these uncertainties.

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