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Aerosol absorption and radiative forcing

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Abstract. We present a comprehensive examination of aerosol absorption with a focus on evaluating the sensitivity of the global distribution of aerosol absorption to key uncertainties in the process representation. For this purpose we extended the comprehensive aerosol-climate model ECHAM5-HAM by effective medium approximations for the calculation of aerosol effective refractive indices, updated black carbon refractive indices, new cloud radiative properties considering the effect of aerosol inclusions, as well as by modules for the calculation of long-wave aerosol radiative properties and instantaneous aerosol forcing. The evaluation of the simulated aerosol absorption optical depth with the AERONET sun-photometer network shows a good agreement in the large scale global patterns. On a regional basis it becomes evident that the update of the BC refractive indices to Bond and Bergstrom (2006) significantly improves the previous underestimation of the aerosol absorption optical depth. In the global annual-mean, absorption acts to reduce the short-wave anthropogenic aerosol top-of-atmosphere (TOA) radiative forcing clear-sky from −0.79 to −0.53 W m^{-2} (33%) and all-sky from −0.47 to −0.13 W m^{-2} (72%). Our results confirm that basic assumptions about the BC refractive index play a key role for aerosol absorption and radiative forcing. The effect of the usage of more accurate effective medium approximations is comparably small. We demonstrate that the diversity in the AeroCom land-surface albedo fields contributes to the uncertainty in the simulated anthropogenic aerosol radiative forcings: the usage of an upper versus lower bound of the AeroCom land albedos introduces a global annual-mean TOA forcing range of 0.19 W m^{-2} (36%) clear-sky and of 0.12 W m^{-2} (92%) all-sky. The consideration of black carbon inclusions on cloud radiative properties results in a small global annual-mean all-sky absorption of 0.05 W m^{-2} and a positive TOA forcing perturbation of 0.02 W m^{-2}. The long-wave aerosol radiative effects are small for anthropogenic aerosols but become of relevance for the larger natural dust and sea-salt aerosols.

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