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Estimation of aerosol direct radiative effects using global chemistry transport and doubling-adding radiative transfer calculations

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Direct radiative effects of aerosols were estimated based on global aerosol optical fields simulated with the chemistry and transport model TM5. The shortwave radiative transfer was calculated offline with a broadband version of the Doubling-Adding KNMI (DAK) model using 16 streams and 29 wavelength bands. TM5 delivered aerosol extinction, single-scattering albedo and asymmetry factor at these wavelengths, as well as ozone concentration fields. The meteorological input fields were taken from the ERA-Interim reanalysis from the European Centre for Medium-Range Weather Forecasts (ECMWF), which was also used to drive TM5. The monthly radiative fluxes at the top of the atmosphere and at the surface calculated for the reference year 2006 were compared with observation-based data from the NASA/GEWEX Surface Radiation Budget (SRB) project. This indicated that the used surface albedo field retrieved from satellite observations made by the GOME instrument is significantly too low over the oceans. Improved agreement was found using the ocean surface albedo parameterization of Jin et al. (2004). The new modeling system was applied to estimate the global radiative effects of the combined natural and anthropogenic aerosols for the reference year 2006, as well as the direct radiative forcings by aerosol changes between 1850 and 2006. All-sky aerosol effects were estimated by cloud screening using geometric and radiometric cloud cover fields based on satellite observations from MODIS and SCIAMACHY, respectively, as well as by explicit calculations using a simple representation of clouds in the radiative transfer model.