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The direct effect of aerosols on solar radiation based on satellite observations, reanalysis datasets, and spectral aerosol optical properties from Global Aerosol Data Set (GADS)

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Abstract. A global estimate of the seasonal direct radiative effect (DRE) of natural plus anthropogenic aerosols on solar radiation under all-sky conditions is obtained by combining satellite measurements and reanalysis data with a spectral radiative transfer model and spectral aerosol optical properties taken from the Global Aerosol Data Set (GADS). The estimates are obtained with detailed spectral model computations separating the ultraviolet (UV), visible and near-infrared wavelengths. The global distribution of spectral aerosol optical properties was taken from GADS whereas data for clouds, water vapour, ozone, carbon dioxide, methane and surface albedo were taken from various satellite and reanalysis datasets. Using these aerosol properties and other related variables, we generate climatological (for the 12-year period 1984–1995) monthly mean aerosol DREs. The global annual mean DRE on the outgoing SW radiation at the top of atmosphere (TOA, ΔF_{TOA}) is −1.62 W m^{-2} (with a range of −15 to 10 W m^{-2}, negative values corresponding to planetary cooling), the effect on the atmospheric absorption of SW radiation (ΔF_{atmab}) is 1.6 W m^{-2} (values up to 35 W m^{-2}, corresponding to atmospheric warming), and the effect on the surface downward and absorbed SW radiation (ΔF_{surf}, and $\Delta F_{surfnet}$, respectively) is −3.93 and −3.22 W m^{-2} (values up to −45 and −35 W m^{-2}, respectively, corresponding to surface cooling). According to our results, aerosols decrease/increase the planetary albedo by −3 to 13% at the local scale, whereas on planetary scale the result is an increase of 1.5%. Aerosols can warm locally the atmosphere by up to 0.98 K day^{-1}, whereas they can cool the Earth's surface by up to −2.9 K day^{-1}. Both these effects, which can significantly modify atmospheric dynamics and the hydrological cycle, can produce significant planetary cooling on a regional scale, although planetary warming can arise over highly reflecting surfaces. The aerosol DRE at the Earth's surface compared to TOA can be

up to 15 times larger at the local scale. The largest aerosol DRE takes place in the northern hemisphere both at the surface and the atmosphere, arising mainly at ultraviolet and visible wavelengths.

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