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Aerosol radiative effects over global arid and semi-arid regions based on MODIS Deep Blue satellite observations

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Aerosols are a key parameter for several atmospheric processes related to weather and climate of our planet. Specifically, the aerosol impact on Earth's climate is exerted and quantified through their radiative effects, which are induced by their direct, indirect and semi-direct interactions with radiation, in particular at short wavelengths (solar). It is acknowledged that the uncertainty of present and future climate assessments is mainly associated with aerosols and that a better understanding of their physico-chemical, optical and radiative effects is needed. The contribution of satellites to this aim is important as a complementary tool to climate and radiative transfer models, as well as to surface measurements, since space observations of aerosol properties offer an extended spatial coverage. However, such satellite based aerosol properties and associated model radiation computations have suffered from unavailability over highly reflecting surfaces, namely polar and desert areas. This is also the case for MODIS which, onboard the Terra and Aqua satellites, has been providing high quality aerosol data since 2000 and 2002, respectively. These data, more specifically the aerosol optical depth (AOD) which is the most important optical property used in radiative and climate models, are considered to be of best quality. In order to address this problem, the MODIS Deep Blue (DB) algorithm has been developed which enables the retrieval of AOD above arid and semi-arid areas of the globe, including the major deserts.

In the present study we make use of the FORTH detailed spectral radiative transfer model (RTM) with MODIS DB AOD data, supplemented with single scattering albedo (SSA) and asymmetry parameter (AP) aerosol data from the Global Aerosol DataSet (GADS) to estimate the aerosol DREs over the arid and semi-arid regions of the globe. The RTM is run using surface and atmospheric data from the ISCCP-D2 dataset and the NCEP global reanalysis project and computes the effect of aerosols at the top of atmosphere (TOA) fluxes (DRETOA), the atmospheric absorption of solar radiation (DREatmab) and the incoming and absorbed surface solar radiative fluxes (DREsurf and (DREnetsurf, respectively). The results are obtained for the period from January 2003 till December 2009, i.e. seven (7) years, on a monthly mean basis.

The RTM results indicate that aerosols significantly enhance the absorbed solar radiation in the atmosphere, especially over the major deserts of Africa and Asia, by amounts ranging from 15 to 55 W/m2 (maximum values in Bodele, Sahara). On the other hand, through scattering and absorption, they decrease the surface absorption of solar radiation, by 10-45 W/m2 over the same areas, thus producing a significant surface radiative cooling. As a result of significant solar atmospheric absorption over the highly reflecting desert surface, aerosols decrease the reflected solar radiation to space, by up to 17 W m-2, producing a decrease of planetary albedo and an important planetary warming. Even larger values are obtained on a seasonal basis, while the average values of DREatmab and DREnetsurf over global land arid and semi-arid regions are equal to 8.9 and -11.3 W/m2, respectively. Significant intra- and inter-annual variations and changes of DREs are also identified.