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Aerosol direct radiative effect on solar radiation over the Mediterranean Basin based on spectral aerosol optical properties from MODIS

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The mean monthly direct radiative effect (DRE) of aerosols on solar radiation is estimated, by using a deterministic atmospheric spectral radiation transfer model. The model uses climatological data from the International Satellite Cloud Climatology Project (ISCCP-D2), National Centers for Environmental Prediction – National Center for Atmospheric Research (NCEP-NCAR) Global Reanalysis project, and other global data bases. The aerosol DRE computations are performed in the ultraviolet, visible and near-infrared, spanning the total shortwave (SW) spectral range 0.2–10 μm. The model estimates the aerosol effect on the SW radiation budget of the Earth-atmosphere system, namely on the solar radiation at the top of atmosphere (TOA), within the atmosphere, and at the surface. The spectral aerosol optical properties, which are of primary importance for the aerosol DREs, are taken from the MODerate resolution Imaging Spectroradiometer (MODIS) of NASA (National Aeronautics and Space Administration).

In the present study, the temporal and spatial variability of DRE, over the broader area of the Mediterranean basin, on a gridded 2.5ºx2.5º latitude-longitude and mean monthly resolution basis, is investigated for the period from 2000 to 2004. The Mediterranean basin is a climatically sensitive region, with sub-regions that are threat-

ened by desertification processes according to the Intergovernmental Panel on Climate Change (IPCC). In addition, the Mediterranean Sea is subject to exceptionally high aerosol optical depths, whereas some of its surrounding land areas (e.g. west Sahara) have even larger aerosol optical depths, similar to those in downwind regions of Asia (India, China). These particularities together with the large solar radiation that reaches the Mediterranean atmosphere push forward the importance of the study of aerosol DRE in this region.

According to the model results, the annual mean aerosol DRE on the outgoing (reflected) SW radiation at TOA (ΔF_{TOA}) equals -3.2 W/m^2, and ranges between -7.5 and 1 W/m^2, with positive/negative values corresponding to "planetary" warming/cooling over the study region. The aerosols also increase the atmospheric absorption of SW radiation (ΔF_{atmab}) by 6.5 W/m^2 (values up to 14 W/m^2, indicating an atmospheric warming due to aerosols). In addition, aerosols are found to decrease the downwelling and absorbed SW radiation at surface (ΔF_{surf} and $\Delta F_{surfnet}$) by -11.3 and -5.2 W/m^2 (with values locally as large as -22.5 and -7.2 W/m^2, respectively), inducing thus a very important surface radiative cooling.

The model results at the geographical cell level reveal that aerosols cause in general "planetary" cooling over the broader Mediterranean region, apart from the region of Northern Africa where the presence of desert dust aerosols results in planetary warming. On the other hand, the presence of aerosols causes a uniform atmospheric warming and surface cooling over the entire Mediterranean basin.

Furthermore, our investigation shows an important decreasing trend of aerosol optical depth over the study region from 2000 to 2004, equal to -15%. This decreasing AOD trend results in a decreased "planetary" cooling (decrease of ΔF_{TOA} by 0.69 W/m^2), i.e. a planetary warming over this climatically sensitive area. This warming arises from an atmospheric cooling (decreased atmospheric warming by 1.25 W/m^2), and a warming of the region's surface (decreased surface cooling by 2.17 W/m^2) due to decreasing aerosol loads.

The use of qualitative aerosol data, such as those from MODIS, combined with detailed radiation transfer models, is an important tool for investigating the radiation budget of climatically sensitive areas like the Mediterranean basin, especially in view of possible climatic changes, and determine the role of aerosols to those changes.