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Dust radiative effect over Europe, Mediterranean, Sahara and Middle East from a radiative transfer model using BSC-DREAM8b aerosol optical data

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The arid regions of Saharan desert and Middle East are the world's major dust sources. However, dust particles from these areas are transported to nearby regions, through favourable synoptic conditions, even reaching remote locations in Europe or in the Arctic. This transport is very important in numerous aspects. One of its most important effects is on the radiation budget, and more specifically on solar radiation, through the aerosol direct radiative effect (DRE). Previous studies have shown that this effect is great under dust load conditions. Therefore, it is very important to simulate dust transport processes and associated radiative effects. The simulation of dust production, transport and removal is done by numerical models, which however have their own limitations as to the consideration of physical and dynamical processes as well as their initial conditions. On the other hand, the computation of dust DRE is ideally done with radiative transfer models (RTMs), which however imply uncertainties associated with the input aerosol optical properties. The most important aerosol optical properties used in RTMs and climate models are aerosol optical depth (AOD), single scattering albedo (SSA) and asymmetry parameter (AP).

The main target of the present study is to reduce the uncertainties of dust DRE by using a detailed spectral RTM and an acknowledged regional and meso-scale model describing the distribution of dust. The combined use of these tools is applied to the region covering the deserts of Sahara, Arabian Peninsula and Middle East, and the neighbouring Mediterranean basin and European continent (extending from 15ºN to 60ºN and from 21ºW to 54ºE). The computations are performed on a monthly mean basis, refer to the 11-year period 2000-2010, and quantify the effects of dust on the reflected solar radiation at the top of atmosphere (DRETOA), on the absorbed solar radiation within the atmosphere (DREatmab), and on the downwelling and absorbed solar radiation at the surface (DREsurf and DREsurfnet, respectively). The RTM takes into account all physical parameters of the Earth-Atmosphere system that interact with solar radiation, namely ozone, carbon dioxide, methane, water vapour, clouds (low, middle, high), aerosol and atmospheric molecules (Rayleigh scattering) as well as surface reflection. Emphasis is given to aerosol optical properties (AOD, SSA and AP) which are all obtained from the dust regional BSC-DREAM8b model. Detailed analysis is undertaken of the modelled aerosol properties, and the spatial and temporal (seasonal and year by year) variation of these properties and of the model DREs are thoroughly investigated. In addition, the computed DREs are inter-compared with corresponding ones obtained with the same RTM using aerosol data from satellites (e.g. MODIS) or other datasets (e.g. Global Aerosol DataSet, GADS and Hamburg Aerosol Climatology, HAC).