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A satellite view of the direct effect of aerosols on solar radiation at global scale

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Aerosols are a key parameter for better understanding and predicting current and future climate change. They are determining, apart from clouds, patterns of solar radiation through scattering and absorption processes. Especially, under cloud-free skies, aerosols are the major modulator of the solar radiation budget of the Earth-atmosphere system. Although significant improvement has been made as to better understanding the direct radiative effect (DRE) of aerosols, there is still a need for further improvement in our knowledge of the DRE spatial and temporal patterns, in particular with respect to extended spatial and temporal coverage of relevant information. In an ongoing rapidly evolving era of great satellite-based achievements, concerning the knowledge of solar radiation budget and its modulators, and with the great progress in obtaining significant information on key aerosol optical properties needed for modeling DRE, it is a great challenge to use all this new aerosol information and to see what is the new acquired scientific knowledge.
The objective of this study is to obtain an improved view of global aerosol DRE effects using contemporary accurate data for the important atmospheric and surface parameters determining the solar radiation budget, with emphasis to state of the art aerosol data. Thus, a synergy is made of different datasets providing the necessary input data and of a detailed spectral radiative transfer model (RTM) to compute spectral globally distributed aerosol DREs. Emphasis is given on using highly accurate and well-tested aerosol optical properties. Spectral information on aerosol optical depth (AOD) is taken from retrieved products of the MODerate resolution Imaging Spectroradiometer (MODIS) instrument, while similar information is taken from MODIS for the aerosol asymmetry parameter (AP) over ocean. Information from MODIS is also taken for the aerosol single scattering albedo (SSA). All this information comes from the latest Collection 006 (C006) MODIS-Aqua monthly dataset and covers world desert areas that were not covered previously. The missing aerosol information is completed by the Global Aerosol Data Set (GADS). The RTM required input data are supplemented by other than aerosol data in which cloud optical data are key ones. For this information, namely cloud optical depth, as well as for other cloud properties like cloud cover we rely on the well established International Satellite Cloud Climatology Project (ISCCP) dataset, which ensures information for different cloud types, low, middle and high, all over the globe. The RTM runs under aerosol present and absent conditions enable the computation of aerosol DREs at the Earth's surface, as well as at the top of the atmosphere (TOA) and within the atmosphere. The spatial and temporal coverage and resolution of the study is constrained by the availability of all model input data, and the DREs are obtained on a monthly mean basis and at 2.5 by 2.5 degrees latitude-longitude resolution for the period 2000-2009. The DRE spatial and temporal, seasonal and inter-annual, variation is examined over the globe, with emphasis on specific world regions of aerosol interest, like deserts or areas of anthropogenic or biomass burning activity. The contribution of aerosols to the regional and global solar radiation budget and its spatio-temporal distribution and associated tendencies are also assessed.