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Study of the Mediterranean desert dust outbreaks' vertical structure based on a synergistic use of satellite and ground retrievals

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The Mediterranean basin is frequently affected by dust outbreaks originating from the north African and Middle East deserts. These outbreaks reveal strong spatial and temporal variability which is mainly determined by the prevailing synoptic conditions. Aiming to their description, a synergistic use of various measurements can be the optimal approach.

The scope of the present study is to describe the 3D structure of Mediterranean dust outbreaks through a synergistic use of various satellite observations. For this purpose, daily retrievals of aerosol optical depth (AOD550nm), Ångström exponent (α), effective radius (reff), aerosol index (AI) and fine fraction (FF) were taken by the MODIS-Terra/Aqua (Collection 051), EP-TOMS and OMI-Aura databases. These data are used as inputs to an objective and dynamic algorithm which identifies and classifies desert dust (DD) episodes into strong and extreme ones, in each 1° x 1° grid cell, over the periods 2000-2013 and 2003-2012. However, the specific satellite retrievals refer to the whole atmospheric column and thus are not able to provide information at different heights. In order to address this issue, coincident CALIOP-CALIPSO observations have been aggregated and averaged for 16 layers up to 8km, equally spaced in vertical terms.

During the period 2000-2013, strong and extreme DD episodes occurred more frequently over the western (9.9 episodes/year) and central parts (3.3 episodes/year) of the Mediterranean. Although the episodes taking place in the eastern Mediterranean are less frequent, they appear to be the most intense, with maximum intensities up to 1.3 and 3.0 (in terms of AOD) for strong and extreme ones, respectively. Based on the CALIPSO retrievals, dust aerosol layers extend from 0.5 to 4.5km above sea level (a.s.l.) near to the northern African coasts, gradually getting narrower up to the 40o N parallel. Dust particles can be uplifted even higher, up to 8km, between the parallels of 33o N and 37o N. In longitudinal terms, the dust aerosol layers extend from 1 to 6km in the eastern and central parts of the study region, while their base altitude is at 2km a.s.l. in the western parts. On a seasonal basis, the geometrical characteristics of dust outbreaks reveal higher variability in latitudinal than longitudinal directions. Similar results are found from the corresponding analysis for the period 2003-2012.

The performance of the algorithm is evaluated against ground measurements from 109 AERONET and 22 PM10 stations. During DD events, the AERONET AODs increase significantly at longer wavelengths reducing thus the spectral variability of their median values (0.5-0.75). Due to this spectral behavior, the peak of the size distribution is found around at 1.7μm-2.2μm increased by a factor of 10 compared to the climatological values. In association with this, the α values are lower than 0.5 and the reff values are higher than 0.6. A typical spectral variability, indicative of dust particles, is also found for the single scattering albedo and the asymmetry parameter. The comparison with the surface measurements of PM10 concentrations, revealed high success scores, ranging from 68% to 97%, highlighting the appropriateness of the selected methodology.