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Characterization of intense aerosol episodes in the Mediterranean basin from satellite observations

Antonis Gkikas (1), Nikos Hatzianastassiou (1), and Nikolaos Mihalopoulos (2)

(1) University of Ioannina, Laboratory of Meteorology, of Physics, Ioannina, Greece (nhatzian@cc.uoi.gr, ++30 26510 08699), (2) Environmental Chemical Processes Laboratory, Department of Chemistry, University of Crete

The properties and distribution of aerosols over the broader Mediterranean region are complex since particles of different nature are either produced within its boundaries or transported from other regions. Thus, coarse dust aerosols are transported primarily from Sahara and secondarily from Middle East, while fine polluted aerosols are either produced locally from anthropogenic activities or they are transported from neighbouring or remote European areas. Also during summer biomass aerosols are transported towards the Mediterranean, originating from massive and extended fires occurring in northern Balkans and Eastern Europe and favoured by the prevailing synoptic conditions. In addition, sea-salt aerosols originate from the Mediterranean Sea or the Atlantic Ocean. Occasionally, aerosols are encountered at very high concentrations (aerosol episodes or events) significantly affecting atmospheric dynamics and climate as well as human health. Given the coexistence of different aerosols as internal and external mixtures characterizing and discriminating between the different types of aerosol episodes is a big challenge.

A characterization and classification of intense aerosol episodes in the Mediterranean basin (March 2000 - February 2007) is attempted in the present study. This is achieved by implementing an objective and dynamic algorithm which uses daily aerosol optical properties derived from satellite measurements, namely MODIS-Terra, Earth Probe (EP)-TOMS and OMI-Aura. The aerosol episodes are first classified into strong and extreme ones, according to their intensity, by means of aerosol optical depth at 550nm (AOD550nm). Subsequently, they are discriminated into the following aerosol types: (i) biomass/urban-industrial (BU), (ii) desert dust (DD), (iii) sea-salt like (SS), (iv) mixed (MX) and (v) undetermined (UN). The classification is based on aerosol optical properties accounting for the particles' size (Ångström exponent, Effective radius), the contribution of fine to total aerosol (Fine fraction) and their UV absorption efficiency (Aerosol index). For each one of these parameters appropriate upper or lower thresholds are set and applied.

According to our results, the most frequent aerosol episodes are DD, being observed in the western and central Mediterranean basin 11 (strong episodes) and 4 (extreme episodes) times/year, respectively, on average. The DD episodes yield 40% of the total number of all strong aerosol episodes, while their contribution rises up to 49% and 71.5% for all extreme episodes over land and sea, respectively. The strong episodes exhibit AOD values as high as 1.6 in the southernmost parts of central and eastern Mediterranean Sea, with values rising up to 5 for extreme episodes, mainly DD and SS. Although more than 90% of aerosol episodes last 1 day, there are few cases, mainly strong DD episodes, which last up to 6 days. Independently of their type, the Mediterranean aerosol episodes occur more frequently in spring and summer and more rarely during winter. The analysis indicates a decreasing tendency of Mediterranean aerosol episodes from 2000 to 2007. 5-days back trajectories for extreme episodes show that air masses inducing BU episodes mostly originate from Europe, those causing DD episodes primarily originate from or travel across North Africa, while SS-like episodes are associated with air masses moving across the northern Atlantic Ocean and the Mediterranean Sea.