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Synoptic conditions favouring the occurrence of strong aerosol episodes over the broader Mediterranean basin

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The present work aims at determining the synoptic conditions that favour the occurrence of strong aerosol episodes over the broader Mediterranean basin. In a first step, an objective and dynamic algorithm was set up to identify the strong aerosol episodes, based on daily aerosol optical depth values at 550nm (AOD550nm) from MODIS-Terra satellite database over the period 2000-2007. According to the algorithm, strong aerosol episodes occurred in each geographical cell (1o x 1o spatial resolution) of the study area whenever AODmean+2STDV$\leq$AOD550nm<AODmean+4STDV, where the mean and standard deviation values were calculated on the basis of total daily AOD550nm values for the grid cell in term. Subsequently, they were selected only those cases (days), for which at least 50% of the total number of cells of the entire region ($\sim$600 pixels) were available, and at least 30 strong aerosol episodes occurred at the pixel-level over the study region. Finally, the total number of selected days with strong aerosol episodes was equal to 219.

In order to study the synoptic conditions, prevailing during the days of strong aerosol episodes, the fields of geopotential height at 500mb and mean sea level pressure (SLP) taken from the NCEP/NCAR reanalysis project, were used. At first, Factor analysis (S-mode) has been applied, in order to decrease the dimensionality of the raw atmospheric field data (500hPa and SLP). In a further step, Cluster Analysis was also applied to identify/classify the prevailing atmospheric circulation types during the aerosol episodes, into 7 representative clusters. The intra-annual variation of the frequency of occurrence, for each cluster, reveals that strong aerosol episodes mostly occur during spring and summer (89%). This can be attributed either to the stable atmospheric conditions and to the small precipitation amounts (especially in summer) that lead to the accumulation of aerosol particles in the atmosphere or to the prevailing synoptic conditions enabling transport of large amounts of aerosol (dust) from Africa.

The atmospheric circulation of type (Cluster) 1 is the least frequent (3.2% of the 219 days) of all 7 types, and indicates that when it occurs, mainly in March, aerosol episodes take place in the Atlantic coast of the Iberian peninsula and in NW Africa (most likely desert dust). Cluster 2 (8.7%) can be characterized as a 'desert dust cluster' since the associated synoptic conditions favour the transport of Saharan desert dust particles to the central and eastern Mediterranean, primarily during spring and secondarily in autumn. The atmospheric circulation for the days of Cluster 3 (24.6%, observed mostly between June and August) can be related to strong aerosol episodes (most probably desert dust) occurring in the western parts of the Mediterranean. Nevertheless, it can also induce episodes over the Balkan and Anatolian peninsulas, arising from intense fires along the western parts of Black Sea and subsequent transport of fine particles to the south. This transport is done through a strong air flow generated by the combination of the extension of Azores Anticyclone over Europe and a low pressure system in the Middle East (extension of Pakistan thermal low). The synoptic conditions associated with Cluster 4 (18.3%), reflect the passage of low pressure systems that move across the Mediterranean Sea, inducing strong desert dust episodes over the western and central parts of the study region. The synoptic patterns related to Cluster 5 (6.8%) consist in a strong trough with its axis over the central Mediterranean, and a moderate low pressure system in the Levantine Sea, which cause a generally southern airflow carrying large amounts of mineral dust particles from Sahara (and Arabian peninsula) towards the eastern Mediterranean basin during spring (April and May). According to our analysis, the most frequent synoptic situation is that of Cluster 6 (28.3% or 62 days) and is observed in late summer (July and August); under such conditions, strong transport of mineral aerosols from the northern African coasts takes place in the Iberian peninsula, while at the same time the prevailing atmospheric conditions lead to the accumulation of large amounts of fine particles (biomass burning, urban pollution) over the Balkan peninsula. Finally, the mid-tropospheric geopotential height field and the mean SLP for Cluster 7 (10% during spring) seems to be related to the eastward shifting of Sharav cyclones along the northern African coasts, which transport desert particles towards the Mediterranean basin. This can be proved from an extended zone of occurring strong aerosol episodes across the Mediterranean Sea. The type of atmospheric circulation of Cluster 7 is observed during spring (maximum frequency in April) that is when the Sharav cyclones originate over NW Africa and shift eastward

across the Mediterranean basin. Our analysis can conditionally serve as a tool to forecast strong aerosol episodes in the Mediterranean basin. Improvements to the method are planned by increasing the number of studied cases and also by characterizing the nature (type) of aerosol episodes.