CHARACTERIZATION OF DYNAMIC AND THERMODYNAMIC FEATURES OF AFRICAN DUST OUTBREAKS OVER THE IBERIAN PENINSULA AND THE BALEARIC ISLANDS: TREND ANALYSIS FOR THE 1948-2020 PERIOD

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In this study we have investigated the main distinctive synoptic dynamic and thermodynamic features associated to the occurrence of African dust outbreaks (ADO) over regions of the of the Iberian Peninsula (IP) and the Balearic Islands (BI), with the aim to evaluate their time evolution and seek for time trends in the last 70 years. This information will be useful to detect increasing trends in the occurrence of African dust outbreaks that could exacerbate harmful effects on human health and ecosystems in this region.

First, we calculated from NCEP/NCAR global reanalysis dataset fields, daily values of geopotential thickness in the 1000 – 500 hPa layer (GT), mean potential temperature between 925 and 700 hPa (TPOT) and temperature anomalies at 850 hPa for the climatological period 1981-2010 (TANOM) for the BI and the SE, SW, E, Central, NW, N and NE regions of the IP in the period 2001-2020. This period was selected due to the availability of the dates when ADO happened on each of the 8 sub-domains and also of the data sets of daily net dust load contributions to the regional background levels of PM10. Our results bring out that the occurrence of ADO was accompanied by a significant increase in levels of TPOT, TANOM and GT throughout all the year and in all regions in any season. Moreover, we have observed that higher values of TPOT, TANOM and GT resulted in events with higher contributions of dust load to the regional background levels of PM10 in all regions. That is, the higher the levels of the thermodynamic variables, the higher the intensity of the ADO.

Next, the main synoptic circulation patterns related to the occurrence of ADO in the period 2001-2020 over each sub-domain were obtained, and their associated mean values of thermodynamic parameters were evaluated. For this purpose a non-hierarchical k-means cluster analysis was applied for classifying the geopotential height fields at the 850 hPa level at 12 UTC, into similar groups, each one representing a prevalent circulation type (CT) over this region. As a result, 11 different synoptic CT were identified. ADO scenarios were produced under 6 specific CT, whereas the other 5 CT did not favour the transport of air masses from desert regions. In all cases, ADO CT were associated with above-average levels of the thermodynamic variables TPOT, TANOM and GT registered over different areas of the IP-BI region in 2001-2020. Moreover, depending on the period of the year, the type of ADO circulation pattern changed.

Finally, we investigated the time evolution of all the days under ADO CT that happened from 1948 to 2020 and the associated daily mean values of thermodynamic parameters using the Theil-Sen method, to check the occurrence of time trends. Our results showed that the monthly number of days under ADO CT displayed a statistically significant upward trend in 1948-2020. Statistically significant positive trends were again obtained for the summer, spring and winter periods and for the occurrence of individual ADO CT. Besides, positive trends of TPOT, TANOM and GH, averaged over the IP-BI domain, were also obtained in summer, spring and winter during specific ADO CT in the period 1948-2020.

In summary, the frequency of the dynamic (0.06 monthly days/year) and the levels of the thermodynamic (0.38 m/year for GH and 0.02 ºC/year for TPOT and TANOM) synoptic conditions favouring the development of ADO over the IP-BI domain has increased over the last 70 years. These results are in line with the exacerbation of warm conditions registered in southern Europe during the last decades.

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