



EMS Annual Meeting Abstracts

Vol. 18, EMS2021-169, 2021

EMS Annual Meeting 2021

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Characterization of dynamic and thermodynamic features of African dust outbreaks over the western Mediterranean basin: trend analysis for the 1948-2020 period

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All African dust outbreaks (ADO) that increased the regional-background levels of PM at the SE, SW, E, Central, NW, N and NE regions of the Iberian Peninsula and the Balearic Islands have been identified from 2001 to 2020 using a well-known procedure (https://www.miteco.gob.es/images/es/metodologiaparaepisodiosnaturales-revabril2013_tcm30-186522.pdf). However, the meteorological tools (air mass back-trajectories, satellite imagery and numerical models for prediction of dust levels) and data bases (time series of PM levels registered at air quality monitoring stations) needed to perform the identification procedure are scarce before the year 2000. For this reason the occurrence of ADO in the western Mediterranean basin during the former decades has not been well addressed so far.

In this study we have used the NCEP/NCAR global reanalysis dataset fields of meteorological parameters to characterize the main distinctive synoptic dynamic and thermodynamic features that were associated to the development of ADO and analyze their time evolution in the 1948-2020 period.

First, the main synoptic circulation types that favored the occurrence of the ADO identified in 2001-2020 were obtained. With this aim, a circulation classification methodology was applied for classifying the daily fields of geopotential height at the 850 hPa level at 12 UTC into prevalent atmospheric circulation types for SW Europe and NW Africa.

Next, the daily mean values of the 1000-500 hPa layer geopotential thickness (GT), the mean 925-700 layer potential temperature (TPOT) and the anomalies of temperature at 850 hPa (TANOM) were computed over all the regions of study. High values of these thermodynamic variables are associated with the presence of warm, stable and dry air masses. In fact, significantly higher values of GT, TPOT and TANOM were obtained in all regions during days under ADO circulation types than during other days in 2001-2020.

Finally, we analyzed the time evolution of all the days under ADO circulation types and their associated daily mean values of GT, TPOT and TANOM over the regions of study using the Theil-Sen method from 1948 to 2020.

Our results show that the monthly number of days under ADO circulation types display an upward trend of 0.06 monthly days per year at the 99.9% confidence level. Statistically significant upward

trends for the monthly mean values of GT, TPOT and TANOM were also obtained over all the regions during days under prevailing ADO circulation types in summer, spring and winter.

In summary, the frequency of the dynamic and thermodynamic synoptic conditions favouring the development of ADO over the western Mediterranean basin 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.

Acknowledgements:

This study was funded by research project POSAHPI (Agencia Estatal de Investigación, PID2019-108101RB-I00).