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Characterizing the origin of extreme air pollution events over the Iberian Peninsula by clustering air quality-climate simulations

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A wide number of studies show that the Iberian Peninsula (IP) exceeds some of the thresholds of air quality established in the legislation. Chemistry transport models (CTMs) play a key role in forecasting the threshold exceedances for human health and ecosystems, and to understand the causes of these extreme air pollution events. Despite improvements due to European legislations, particulate matter and ground-level ozone remain important pollutants affecting human health. However, the short-term forecasts available today (generally less than 48 hours) may hamper the decision-making and the design of abatement strategies to comply with air quality standards in the Iberian Peninsula. In this sense, a characterization of the types extreme air pollution events could help to characterize and understand future exceedances. Moreover, the variation of several circulation types projected under future climate scenarios may increase of the frequency of extreme events related to air pollution over southwestern Europe and the Iberian Peninsula.

In this context, a definition of extreme air pollution events based on a regionalization process has been carried out, applied to a model climatology of air pollution over the Iberian Peninsula. Data from the regional modeling system MM5-CHIMERE-EMEP (driven by ERA40 reanalysis) for the period 1970-2000 is used in this study. The studied pollutants are PM10 and ozone. The domain of study covers the Iberian Peninsula with a horizontal resolution of 25 km and a vertical resolution of 23 layers in the troposphere. The thresholds set for defining the extreme events are characterized from the objective and limit values defined in the Directive 2008/50/EC for ozone (120 μg m-3, 8-hour) and PM10 (50 μg m-3, daily mean).

In order to identify locations with similar patterns in terms of the studied pollutants, a principal component analysis was carried out. This analysis helped us to group areas which usually present the same level of each pollutant concentration over the extreme events. The results of this study could lead to a more efficient design of the measurement locations, reducing their number and/or finding their optimal location.To complete the study, a cluster analysis helped to identify those extreme events which produced similar pollution patterns over the IP. This classification is useful to group similar extreme events and find relationships with e.g., climatology.

The results indicate that all the PM10 winter mean fields follow the same spatial pattern for most of the clustered events. The highest mean values are located in the southwestern Iberian Peninsula. The extreme events are generally associated to anticyclonic situations during wintertime. The histograms are characterized by an important skewness indicating that extreme events of PM10 concentration level are most of time in the very high percentiles. The number of days with exceedances follow the same spatial pattern for most of the groups. Only differences in the frequency appear.

In the case of ozone, the spatial pattern of the ozone concentration in summer is different from the PM10, indicating that the episodes originating exceedances of the ozone threshold are not related to those provoking PM10 episodes. The highest number of days with exceedances is located in the northeastern and eastern Iberian Peninsula, except in the Ebro valley, where the ozone concentration is very low. The Cantabrian and Portuguese coast are always affected by exceedances, although there is a higher frequency when the Iberian thermal low appears at the central part of the IP. This leads to exceedances appearing in southeastern Spain. Another cluster clearly depicts a canalization and run-off along the Rhone Valley into the central-east of the Mediterranean Cost, leading to a transport and canalization along the Jucar Valley (Valencia).