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Impacts of atmospheric stagnation events on Madrid′s metropolitan area air quality and urban heat island

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Prolonged atmospheric stagnation episodes have drawn attention recently to the scientific community because of their adverse effect upon different urban environment aspects. This contribution examines the main features of such events and focuses on their impacts on air quality and thermal comfort in the metropolitan area of Madrid. This is the main conurbation of the Iberian Peninsula, with more than 6 million inhabitants; in addition, the climatic conditions of the area of study (climate Csa) seem to be conducive to this type of extreme atmospheric events.

Air stagnation days are identified by applying the NCDC methodology (Wang and Angell, 1999) to meteorological records from the WMO 08221 (Madrid-Adolfo Suárez Airport) station. Such method considers a given day as stagnant when daily total precipitation is < 1 mm (i.e. a dry day), daily-mean surface wind speed is < 3.2 m s-1 and upper-air wind speed is < 13 m s-1. Furthermore, if there are 4 or more consecutive days of air stagnation conditions at a given station, those days are considered as one air stagnation event. Besides, air quality levels were analyzed from records supplied by Madrid′s Municipality and Madrid Regional Government air quality surveillance networks. Daily air temperature records were also provided by Spanish Meteorological Agency (Aemet), while surface temperature records were obtained from MODIS MYD11A2 database.

The results or our study confirm the high frequency of stagnation days (more than 40% by year), resulting in most cases from anticyclonic ridges close to the Iberian Peninsula.

The impact of the atmospheric stagnation differs according to the season, given that the predominant local radiative atmospheric processes vary considerably from season to season: nocturnal cooling in winter, diurnal warming in summer. In winter, air quality clearly worsens during stagnation events, recording remarkable increases in particulate matter levels (especially those of smaller diameter, such as PM2.5) and NO_2. Stagnation events tend to be accompanied by more frequent and stronger low-level temperature inversions, which prevents the renewal of old air masses. In summer, stagnant situations cause an increase in heat stress levels, due to a more frequent number of warm days and tropical nights, especially inside the urban areas, allowing the development of an urban heat island that usually exceeds 3 ° C.

Overall, this study may help to understand how atmospheric circulation at different temporal scales affect the human wellness on urban environments, thus providing useful information for the formulation of effective public health management and planning strategies in response to future climate variability and change.