Geophysical Research Abstracts
Vol. 19, EGU2017-8471, 2017
EGU General Assembly 2017

Impact of high-latitude blocks and subtropical ridges on air quality in Europe

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We present an analysis of the impact that high-latitude blocks and subtropical ridges exert on European air quality. For this purpose, a catalogue of blocks and ridges over the Euro-Atlantic region is used together with a gridded dataset of maximum daily 8-hour running average ozone (MDA8 O_3) covering the 1998-2012 period as well as daily average near-surface PM10 observations from the European Environment Agency's air quality database (AirBase) during 2000-2009. The response of the pollutant concentrations to the location of blocks and ridges with centres in two main longitudinal sectors (Atlantic, ATL, 30°-0° W; European, EUR, 0°-30° E) is examined, with a focus on summer-spring ozone and winter PM10.

The impact of blocks and ridges on ozone is regionally and seasonally dependent. In particular, blocks within the EUR sector yield positive ozone anomalies of ∼5-10 ppb over large parts of central Europe in spring and northern Europe in summer. More than 20 % and 30 % of the days with blocks in that sector register exceedances of the 90th percentile of the seasonal ozone distribution over large regions during spring and summer, respectively. The impacts of ridges are subtle and more sensitive to their specific location, although they can trigger ozone anomalies of ∼5-10 ppb in Italy and the surrounding countries in summer, eventually exceeding the EU target value for maximum daily 8-hour mean ozone (120 μg m-3, approximately 60 ppb).

During winter, PM10 over large regions of Europe presents completely opposite responses to blocks and ridges. The anticyclonic circulation associated with EUR blocking implies a collapse of the boundary layer as well as reduced wind speeds and precipitation occurrence, yielding large positive anomalies which on average exceed ∼10 μg m-3 over the whole continent, reaching ∼50 μg m-3 at some locations. Conversely, the enhanced zonal flow around 50°-60° N and the increased occurrence of precipitation over northern-central Europe on days with ATL ridges favour the ventilation of the boundary layer and the impact of washout processes, reducing PM10 concentrations on average by around 7 μg m-3 and up to 45 μg m-3 for some locations. Finally, we have found that both patterns can partly control the interannual variability of winter mean PM10 in southern Germany, where this pollutant presents a correlation of 0.83 with EUR blocks and -0.65 with ATL ridges.

The findings reported here can be exploited in the future to evaluate the modelled responses of air quality to circulation changes within chemical transport models (CTMs) and chemistry-climate models (CCMs).