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Identifying the most hazardous synoptic meteorological conditions for Winter UK PM10 exceedences

Chris Webber, Helen Dacre, Bill Collins, and Giacomo Masato
United Kingdom (c.p.webber@pgr.reading.ac.uk)

Summary
We investigate the relationship between synoptic scale meteorological variability and local scale pollution concentrations within the UK. Synoptic conditions representative of atmospheric blocking highlighted significant increases in UK PM10 concentration ([PM10]), with the probability of exceeding harmful [PM10] limits also increased. Once relationships had been diagnosed, The Met Office Unified Model (UM) was used to replicate these relationships, using idealised source regions of PM10. This helped to determine the PM10 source regions most influential throughout UK PM10 exceedance events and to test whether the model was capable of capturing the relationships between UK PM10 and atmospheric blocking. Finally, a time slice simulation for 2050-2060 helped to answer the question whether PM10 exceedance events are more likely to occur within a changing climate.

Introduction
Atmospheric blocking events are well understood to lead to conditions, conducive to pollution events within the UK. Literature shows that synoptic conditions with the ability to deflect the Northwest Atlantic storm track from the UK, often lead to the highest UK pollution concentrations. Rossby wave breaking (RWB) has been identified as a mechanism, which results in atmospheric blocking and its relationship with UK [PM10] is explored using metrics designed in Masato, et al., 2013. Climate simulations facilitated by the Met Office UM, enable these relationships between RWB and PM10 to be found within the model. Subsequently the frequency of events that lead to hazardous PM10 concentrations ([PM10]) in a future climate, can be determined, within a climate simulation. An understanding of the impact, meteorology has on UK [PM10] within a changing climate, will help inform policy makers, regarding the importance of limiting PM10 emissions, ensuring safe air quality in the future.
Methodology and Results
Three Blocking metrics were used to subset RWB into four categories. These RWB categories were all shown to increase UK [PM10] and to increase the probability of exceeding a UK [PM10] threshold, when they occurred within constrained regions. Further analysis highlighted that Omega Block events lead to the greatest probability of exceeding hazardous UK [PM10] limits. These events facilitated the advection of European PM10, while also providing stagnant conditions over the UK, facilitating PM10 accumulation. The Met Office UM was used and nudged to ERA-Interim Reanalysis wind and temperature fields, to replicate the relationships found using observed UK [PM10]. Inert tracers were implemented into the model to replicate UK PM10 source regions throughout Europe. The modelled tracers were seen to correlate well with observed [PM10] and Figure 1 highlights the correlations between a RWB metric and observed (a) and modelled (b) [PM10]. A further free running model simulation highlighted the deficiency of the Met Office UM in capturing RWB frequency, with a reduction over the Northwest Atlantic/ European region. A final time slice simulation was undertaken for the period 2050-2060, using Representative Concentration Pathway 8.5, which attempted to determine the change in frequency of UK PM10 exceedance events, due to changing meteorology, in a future climate.

Conclusions
RWB has been shown to increase UK [PM10] and to lead to greater probabilities of exceeding a harmful [PM10] threshold. Omega block events have been determined the most hazardous RWB subset and this is due to a combination of European advection and UK stagnation. Simulations within the Met Office UM were undertaken and the relationships seen between observed UK [PM10] and RWB were replicated within the model, using inert tracers. Finally, time slice simulations were undertaken, determining the change in frequency of UK [PM10] exceedance events within a changing climate.

References

Masato, G., Hoskins, B. J., Woolings, T., 2013; Wave-breaking Characteristics of Northern Hemisphere Winter Blocking: A Two-Dimensional Approach. J. Climate, 26, 4535-4549.