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Influence of synoptic weather on UK surface and tropospheric ozone

R. J. Pope (1,2) and M. P. Chipperfield (1,2)

(1) School of Earth and Environment, University of Leeds, Leeds, LS2 9JT, United Kingdom (earrjpo@leeds.ac.uk), (2) National Centre for Earth Observation (NCEO), University of Leeds, Leeds, LS2 9JT, United Kingdom

Surface ozone is a secondary air pollutant which can significantly impact on human health. These health effects include breathing problems (e.g. asthma), reduced lung function and lung disease. Multiple studies have also shown the link with premature mortality from short and long term exposure to elevated surface ozone. Therefore, understanding the links between atmospheric dynamics and chemistry and emission of precursor gases is vitally important to help policy makes warn the public and mitigate against poor UK air quality.

Here we use a synergy of surface observations, satellite retrievals and a regional air quality model to investigate the importance of synoptic weather on UK surface ozone concentrations. The surface and satellite data come from the Automated Urban and Rural Network (AURN) and Tropospheric Emissions Spectrometer (TES), respectively. Model simulations are from the UK Met Office's regional Air Quality in the Unified Model (AQUM). The Lamb Weather Types (LWTs), an objective classification of midday UK circulation patterns based on surface pressure reanalysis data, are used to sample the observation and model surface ozone data under different atmospheric weather regimes. We focus on summer-time anticyclonic and south-easterly conditions, known to be favourable for enhanced surface ozone concentrations from in-situ production and long range transport.

Under anticyclonic conditions, surface ozone ranges from 50-90 μg/m3 across the UK. Relative to the seasonal average, this results in enhanced concentrations of 0-10 μg/m3 at most sites. South-easterly conditions have more impact with UK concentrations of 60-100 μg/m3, which are larger than the seasonal average by 10-20 μg/m3. Similar patterns are seen in satellite vertical profiles of tropospheric ozone. Though TES does not retrieval surface ozone, it has good sensitivity in the lower atmosphere (e.g. 900-800 hPa). TES shows significantly enhanced ozone concentrations of 0.0-1.0 and 2.0-4.0 ppbv, under anticyclonic and south-easterly conditions, respectively.

We show that AQUM, sub-sampled to AURN, compares well with the observations and can reproduce the elevated surface ozone concentrations under these synoptic conditions. Overall, anticyclonic conditions lead to enhanced surface ozone concentrations which exceed the WHO safe exposure limit (maximum daily 8-hour running average of 100 μg/m3) 20-30% of the time. Under south-easterly conditions, there is a 30-60% chance that UK surface ozone will exceed the WHO limit.