The differing impact of air stagnation on near-surface ozone across Europe

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1. Introduction

Daily maximum temperature is known to be the meteorological variable that mostly controls the afternoon near-surface ozone concentrations during summer. Air stagnation situations, characterised by stable weather conditions and poor ventilation, also lead to the accumulation of pollutants and regional ozone production close to the surface. This work evaluates the joint effect of daily maximum temperature and a simplified air stagnation index on surface ozone observations in eight regions of Europe during summer 1998-2015.

2. Meteorological and ozone data

1. Meteorological fields provided by the ERA-Interim reanalysis at 0.75° x 0.75° horizontal resolution.
2. Interpolated datasets of MDA8 and hourly $O_3$ over Europe at 1.0° x 1.0° resolution during summer 1998-2015. The regionalization of these datasets provided by Carro-Calvo et al. (2017) is used:

3. Air stagnation

We have used the simplified air stagnation index defined by Horton et al. (2012). A reanalysis grid cell is considered as stagnant if three conditions are simultaneously met on a given day: wind speed at 10m < 3.2 m/s, wind speed at 500hPa < 13.0 m/s and precipitation < 1 mm. This index has recently been used to characterize the spatiotemporal variability of air stagnation in Europe (Garrido-Perez et al., 2018):

4. Relationship between MDA8 $O_3$, temperature and stagnation

Pearson correlation coefficients (R) between the daily time series of average $T_{\text{max}}$, MDA8 $O_3$ and the percentage of the area under stagnant conditions (AS) for each region in summer:

<table>
<thead>
<tr>
<th>Region</th>
<th>R</th>
<th>BRIT</th>
<th>NCE</th>
<th>NSC</th>
<th>BALT</th>
<th>IBE</th>
<th>WE</th>
<th>SCE</th>
<th>EE</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{\text{max}} - \text{MDA8 } O_3$</td>
<td>0.18</td>
<td>0.32</td>
<td>0.35</td>
<td>0.48</td>
<td>0.42</td>
<td>0.30</td>
<td>0.62</td>
<td>0.50</td>
<td>0.73</td>
</tr>
<tr>
<td>$\text{AS} - \text{MDA8 } O_3$</td>
<td>0.24</td>
<td>0.39</td>
<td>0.06</td>
<td>0.27</td>
<td>0.36</td>
<td>0.62</td>
<td>0.70</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>$T_{\text{max}} - \text{AS}$</td>
<td>0.23</td>
<td>0.47</td>
<td>0.21</td>
<td>0.33</td>
<td>0.41</td>
<td>0.35</td>
<td>0.58</td>
<td>0.44</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Correlation table

- Considerable spatial heterogeneity across Europe
- The correlations of MDA8 $O_3$ with temperature are higher than with stagnation for most regions
- Stagnation is also a good predictor of $O_3$, especially in central/southern Europe (IBE, WE, SCE, EE) and NCE.
- Unclear if the high AS - $O_3$ correlations in the central/southern regions reflect the $O_3 - T$ relationship

$O_3$ distributions

- MDA8 $O_3$ consistently increases over central/southern Europe and NCE under stagnant conditions
- Stagnation exerts a minor control on MDA8 $O_3$ over most of northern Europe (BRIT, NSC, BALT)
- Under non-stagnant situations, northern Europe is affected by southerly advection that often brings more polluted air masses. This mechanism has been related to $O_3$ extremes there (Carro-Calvo et al., 2017).

5. Impact of stagnation on the $O_3$ diurnal cycle

- Larger amplitudes of the $O_3$ diurnal cycle in the central/southern regions and NCE when stagnation occurs
- Low nighttime $O_3$: stable shallow boundary layer and, presumably, enhanced dry deposition and chemical destruction of $O_3$
- High daytime $O_3$: mix with air from the residual layer, accumulation of $O_3$ / precursors and photochemical production

6. Conclusions

We have been able to identify regions with different responses of summer $O_3$ to the occurrence of air stagnation. Stagnation has a clear impact on $O_3$ in central/southern Europe, but this is not always the case for the northern regions. This regional dependency of the $O_3$ - stagnation relationship across Europe indicates that climate model projections of increases in stagnation should not directly be translated into degraded air quality without a proper assessment of the regional impacts. For further details see Garrido-Perez et al. (2019).

References