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The role of meteorology in the near-surface ozone enhancements over Europe during the COVID-19 lockdown of early spring 2020

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Over the last two years non-pharmaceutical intervention measures in the form of social distancing and lockdowns have been applied to reduce the transmission of SARS-CoV-2. While the exact nature and duration of these measures have varied substantially over the European continent, most countries were under strict lockdowns at the beginning of the pandemic, from mid-March to late April 2020. This caused unprecedented falls in industrial activity and vehicle use, two of the main sources of air pollution.

Here we investigate the effects of that lockdown on the near-surface ozone concentrations. For that purpose, we use 1-h daily maximum nitrogen dioxide (NO_2) and maximum daily 8-h running average ozone (MDA8 O_3) observations at ~1300 background sites of the European Environment Agency's air quality database (AirBase) as well as a meteorological reanalysis.

We find that the lockdown caused a substantial reduction in NO_2 concentrations across Europe, while O_3 increased over northwestern and central Europe compared to the same period in 2015-2019. In some countries like Germany, O_3 concentrations were typical of the summer season. Atmospheric conditions were also anomalously stable, dry and warm over large parts of the continent, which could potentially rise the O_3 concentrations. Consequently, to separate the effect of meteorology and emissions, we have built statistical models fed by reanalysis meteorological data and estimated the expected O_3 concentrations during that period in the absence of a lockdown. The results indicate that a considerable fraction of the observed O_3 changes can be explained by elevated temperatures, low atmospheric humidity and high solar radiation.

While this analysis shows a dominant role of the meteorology during the early-spring lockdown, we will discuss other factors such as changes in chemical regimes (caused mainly by sharper decreases in emissions of nitrogen oxides than those of volatile organic compounds) that may have yielded regional ozone enhancements during the pandemic.