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Meteorology-normalized impact of COVID-19 lockdown upon NO2 and O3 in Spain

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The mobility restrictions implemented to slow down the transmission of the new coronavirus disease (COVID-19) drastically altered Spanish anthropogenic emissions in several sectors, leading to substantial impacts on air pollutant concentrations. In order to reliably quantify these changes, the confounding effects of meteorological variability need to be properly taken into account. We thus designed an innovative methodology relying on the use of machine learning (ML) models fed with ERA5 meteorological reanalysis data and other time features, to estimate more accurately the so-called business-as-usual (BAU) pollutant concentrations that would have been observed in the absence of lockdown (Petetin et al., 2020). The difference with concentrations actually observed during the lockdown give meteorology-normalized estimates of the AQ changes due to the altered anthropogenic emission forcing, independently from the meteorological variability. Importantly, our methodology includes a conservative estimation of the uncertainties, which allows to highlight statistically significant changes. This study focuses on NO2 and O3. We applied this analysis for a selection of urban background and traffic stations covering more than 50 Spanish provinces and islands. Validation results indicate that the method usually performs well for estimating BAU concentrations (mean absolute bias below +6%, root mean square error around 25-30% and correlation above 0.80).

The COVID-19-related lockdown has induced a strong reduction (-50% on average) of NO2 concentrations in Spanish urban areas, although with some spatial variability among the provinces. In largest cities, stronger reductions were found at traffic stations compared to urban background ones, reflecting the major impact of the lockdown on traffic emissions. Substantial discrepancies with changes obtained considering a climatological averaged NO2 concentrations were found, highlighting the interest of such ML-based weather-normalization method. Compared to NO2, the impact on O3 is lower and more heterogeneous. In many cities, O3 levels slightly increased (likely due to a reduced titration by NO), but these increments often remain within the (95% confidence level) uncertainties of our methodology. However, during the most stringent phase of the lockdown (beginning of April and the few following days), a clearer O3 increase is found, reaching the statistical significance in several Spanish cities (e.g. Albacete, Barcelona,

Castellón, Mallorca, Murcia, Málaga).

These results are of strong interest for quantifying the corresponding health impacts of these AQ changes, especially for showing the potential trade-offs between health benefits induced by the reduction of NO2 and enhanced mortality due to higher O3.

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