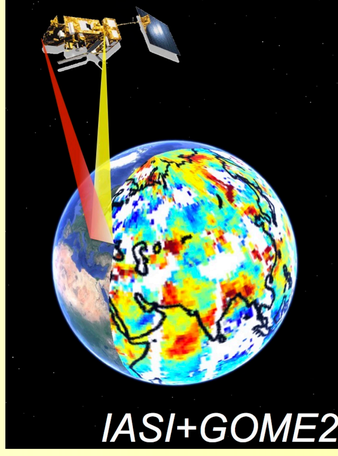
Global distribution of lowermost tropospheric ozone pollution from multispectral synergism of IASI and GOME-2 satellite measurements



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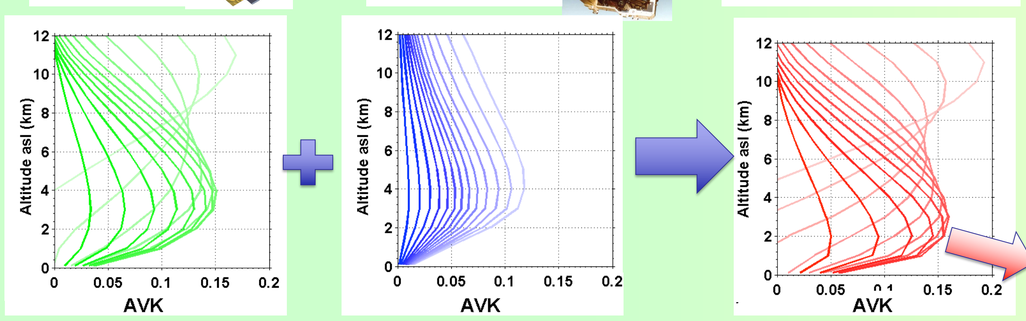
1. Rational

We present a comprehensive study integrating satellite observations of ozone pollution, in situ measurements and chemistry transport model simulations for quantifying the role of anthropogenic emission reductions during the COVID-19 lockdown in spring 2020 over Europe. Satellite observations are derived from the IASI+GOME2 multispectral synergism, which provides particularly enhanced sensitivity to near-surface ozone pollution. These observations are first analysed in terms of differences between the average on 1-15 April 2020, when the strictest lockdown restrictions took place, and the same period in 2019. They show clear enhancements of near-surface ozone in Central Europe and Northern Italy, and some other hotspots, which are typically characterized by VOC-limited chemical regimes. An overall reduction of ozone is observed elsewhere, where ozone chemistry is limited by the abundance of NOx. Satellite and in situ surface observations are compared to model-derive estimates of the impact of the COVID-19 lockdown on ozone pollution.

2. Lowermost troposphere ozone by IASI+GOME2

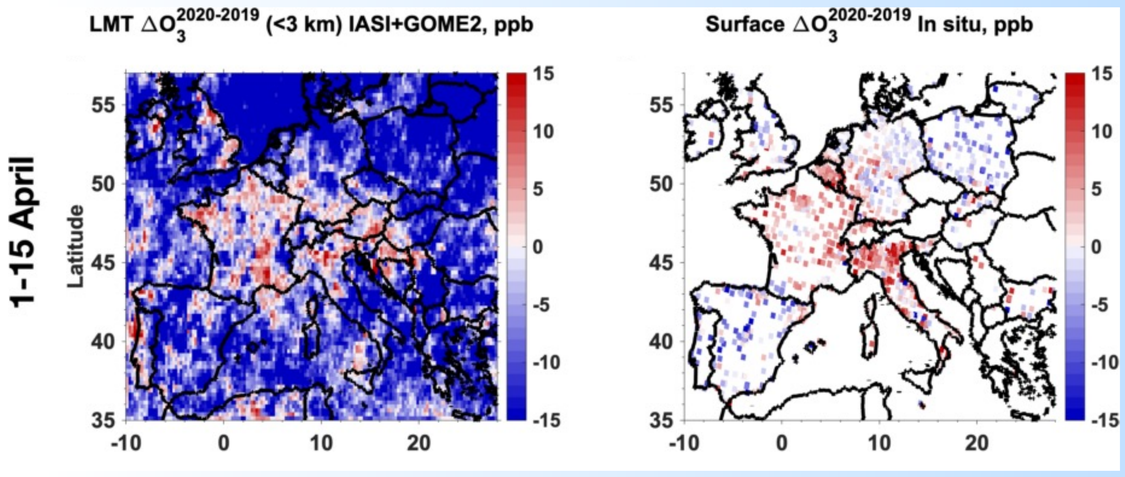
IASI+GOME2 synergism technique: simultaneous fit of co-located spectra from IASI (IR) and GOME-2 (UV) using a Tikhonov-Phillips regularisation (Cuesta et al., 2013)

IASI **GOME-2** **IASI+GOME2**



Sensitivity enhancement towards the surface: AVK at the lowermost troposphere (<3km) peaks down to **2 to 2,5 km** over land during summer

3. IASI+GOME2 satellite data vs Surface in situ



Good agreement : ✓ **Mean bias of 8%** ✓ **Good correlation (0.55) and variability** ✓ **Precision of 11 ppb**

4. Adjustment of observations (satellite and in situ) for differences in meteorological conditions between 2020 and 2019

For assessing the impact of the reduction of anthropogenic emissions during the lockdown, we adjust the satellite and in situ surface observations for withdrawing the influence of meteorological conditions in 2020 and 2019. This adjustment is derived from the chemistry transport model simulations using the meteorological fields of each year and identical emission inventories.

$$\Delta O_{3\,obs\&mod}^{\,covid} \approx O_{3\,obs}^{\,2020} - O_{3\,obs}^{\,2019} - \left(O_{3\,mod_{STD}}^{\,2020} - O_{3\,mod_{STD}}^{\,2019}\right)$$

where “modSTD” corresponds to simulated ozone with the standard or “business as usual” inventory. This adjustment does not rely on any estimation of the variations in anthropogenic emissions during the lockdown. For simulations, the superscripts 2020 or 2019 refer to the year of meteorological conditions that have been used.

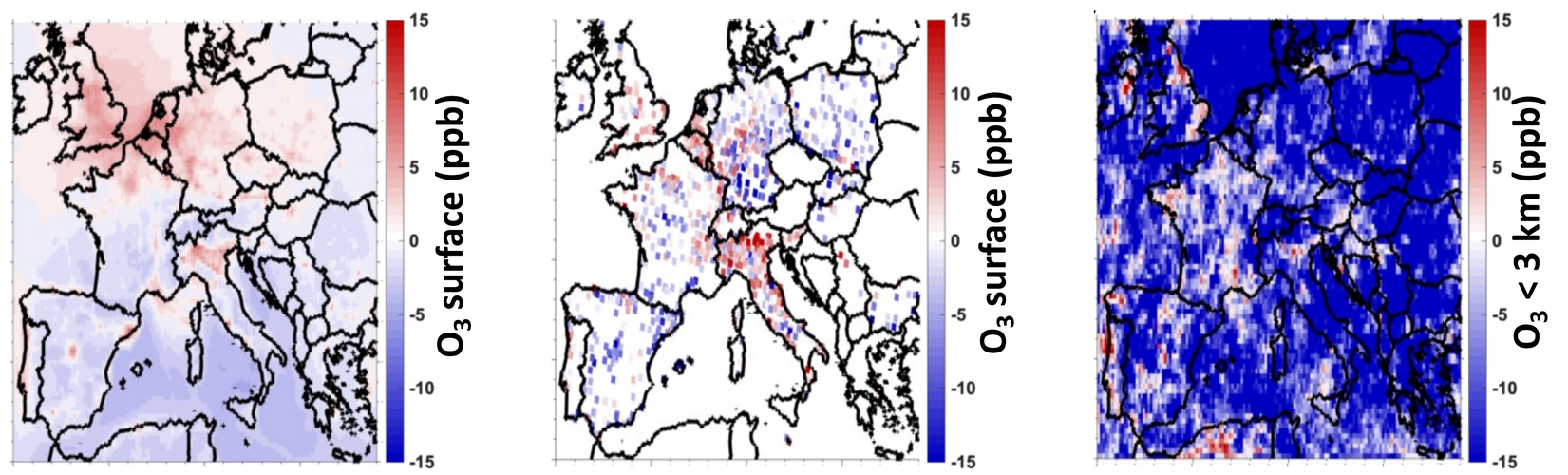
5. COVID-19 lockdown impact on O_3 pollution : IASI+GOME2 vs In situ at the surface vs CHIMERE model

Satellite and surface in situ observational assessments are compared with model-only estimations, using the CHIMERE chemistry transport model. For analysing the uncertainty of the model estimates, we perform two sets of simulations with different setups, differing in the emission inventories, their modifications to account for changes in anthropogenic activities during the lockdown and the meteorological fields. Whereas a general qualitative consistency of positive and negative ozone anomalies is remarked between all model and observational estimates, significant changes are seen in their amplitudes. The model underestimate the range of variability of the ozone changes by at least a factor 2 with respect to the two observational data sets, both for enhancements and decreases of ozone, while the large-scale ozone decrease is not simulated.

CHIMERE model
2020 (COVID-Reference)

In situ surface
2020 – Meteo-corrected 2019

Satellite IASI+GOME2
2020 – Meteo-corrected 2019



See more details in
Cuesta, J., L. Costantino, M. Beekmann, G. Siour, L. Menut, B. Bessagnet, T. C. Landi, G. Dufour and M. Eremenko
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6. Summary

1. The full “Satellite + In situ + Model” approach provides a comprehensive characterization of the impact of Covid19 lockdown on O_3 pollution
2. It shows Covid-19 lockdown impact on ozone:
   ➔O_3 reduction in most NOx-limited regions
   ➔O_3 accumulation over Northern Europe due to inhibition of nighttime titration associated with NO availability
3. The new IASI-GOME2 satellite approach shows good agreement with photochemical regimes and with in situ measurements at the surface
4. Meteorological conditions in 2020 : particularly sunny conditions also enhanced O_3 over northern Europe. We derive a correction for this effect for observation-assessment of COVID-19 lockdown impact using CHIMERE simulations.
5. IASI-GOME2 / In-situ vs. CHIMERE : Fair relative agreement on regimes over France/Italy/Spain, but differences in sign over Germany/Poland and the significant background large-scale decrease associated with the lockdown is missing in the model

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