

Multispectral satellite observation of O₃ pollution over Europe during the COVID-19 lockdown of springtime 2020

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(1)



(2)



(3)



(4)



(5)

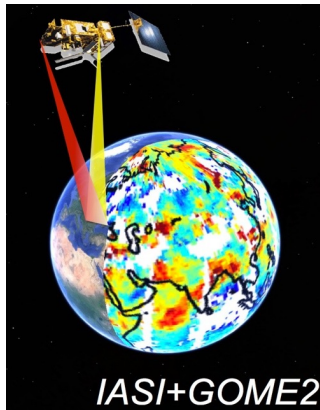


Scientific objectives

- ❑ Quantify the impact of the COV-19 lockdown on ozone pollution over Europe
- ❑ Analyze the link with photochemical regimes : NO_x-limited & VOC-limited

Which approach ?

→ Synergism of **satellite observations**, in-situ data and a **chemistry-transport model**



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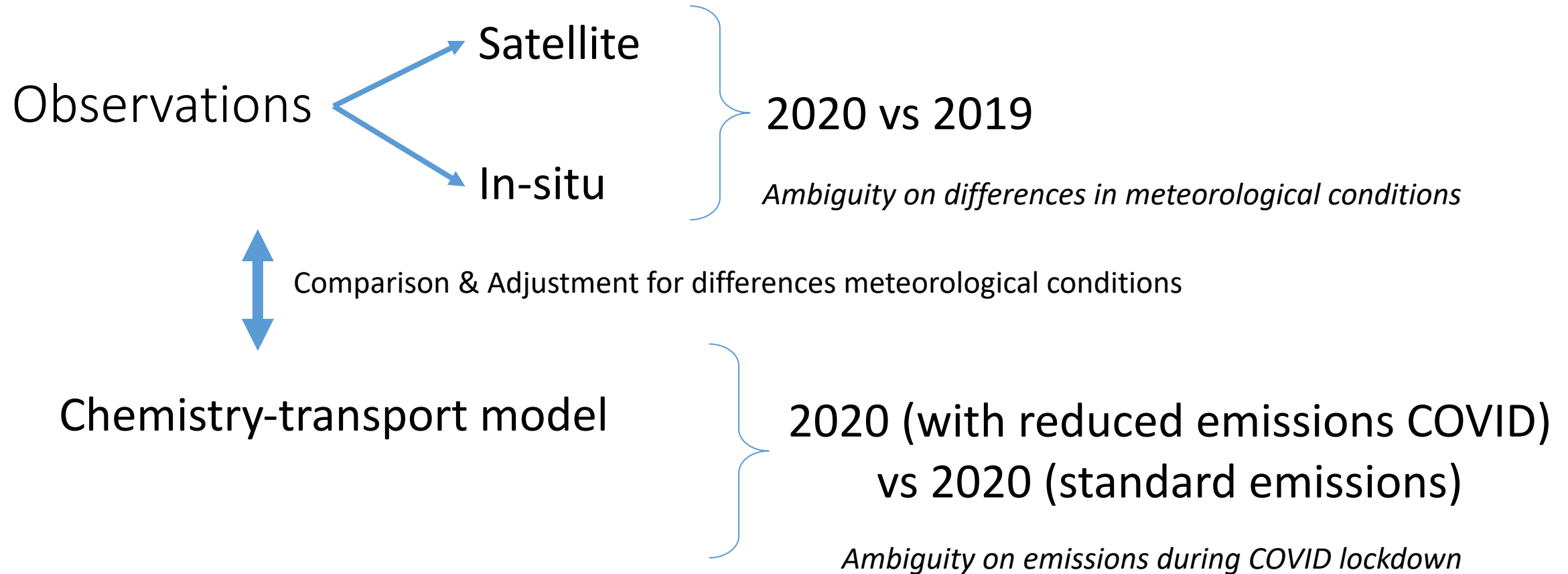
The new multispectral satellite data
“IASI+GOME2”

→ Enhanced sensitivity to near-surface O₃

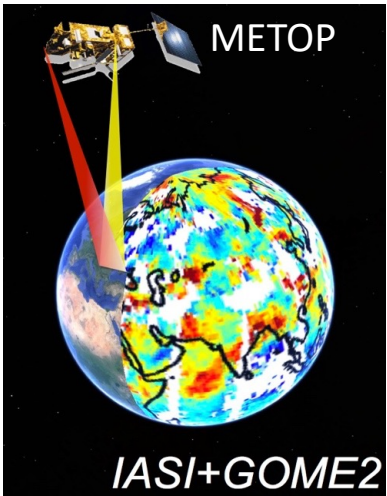
Approach to study the impact of COVID19 lockdown on ozone pollution (1/3)

Complexity

➔ *Secondary pollutant with non-linear effects according to NO_x-limited and VOC-limited regimes*

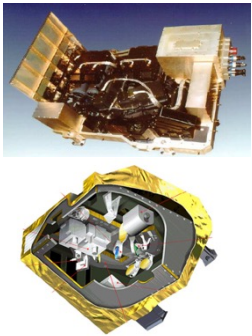


Satellite observations: **The IASI+GOME2 multispectral approach**



Synergism of co-localized IR and UV measurements

Global daily coverage
(morning ~ 9:30 LT)
since 2008



Observed spectra



[Cuesta et al., 2013, ACP]

Radiative transfer
models



Simulated Spectra

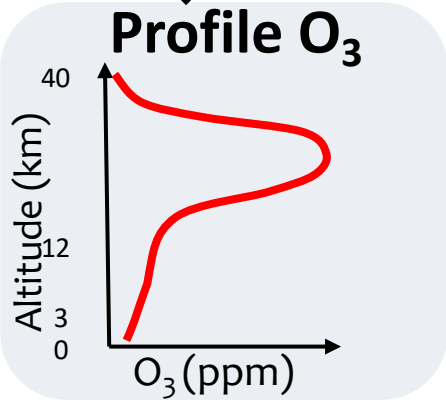


**Simultaneous
minimisation of IR
and UV residuals**

Adjusting a
unique O₃
profile

Iterations

**Increased sensitivity in
the lowermost
troposphere**



The chemistry-transport transport model CHIMERE

CHIMERE v2017 (Menut et al., 2020)

20 x 20 km² - 9 vertical levels

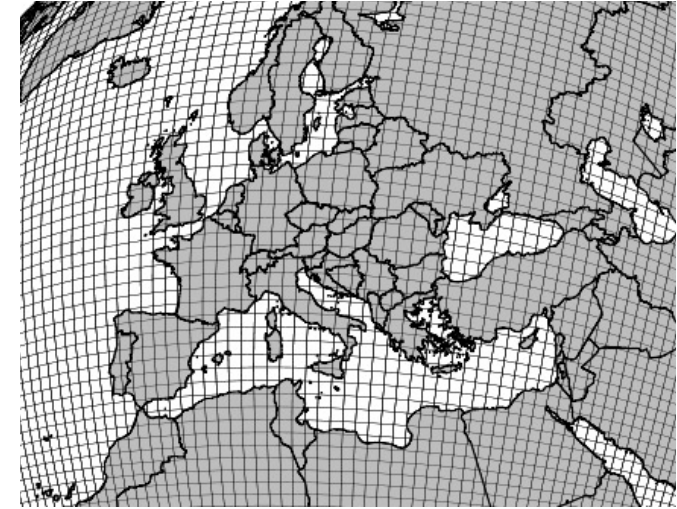
Anthropogenic emissions from HTAP v2.2

Meteorological fields from the BOLAM model

MEGAN biological emissions

COVID run :

↓ road traffic, ↓ industry, ↓ airplane & ship traffic (% from CAMS covid inventory)



April 2020 (COVID emissions), April 2020 (reference emissions) & April 2019

Model-derived COVID lockdown effect

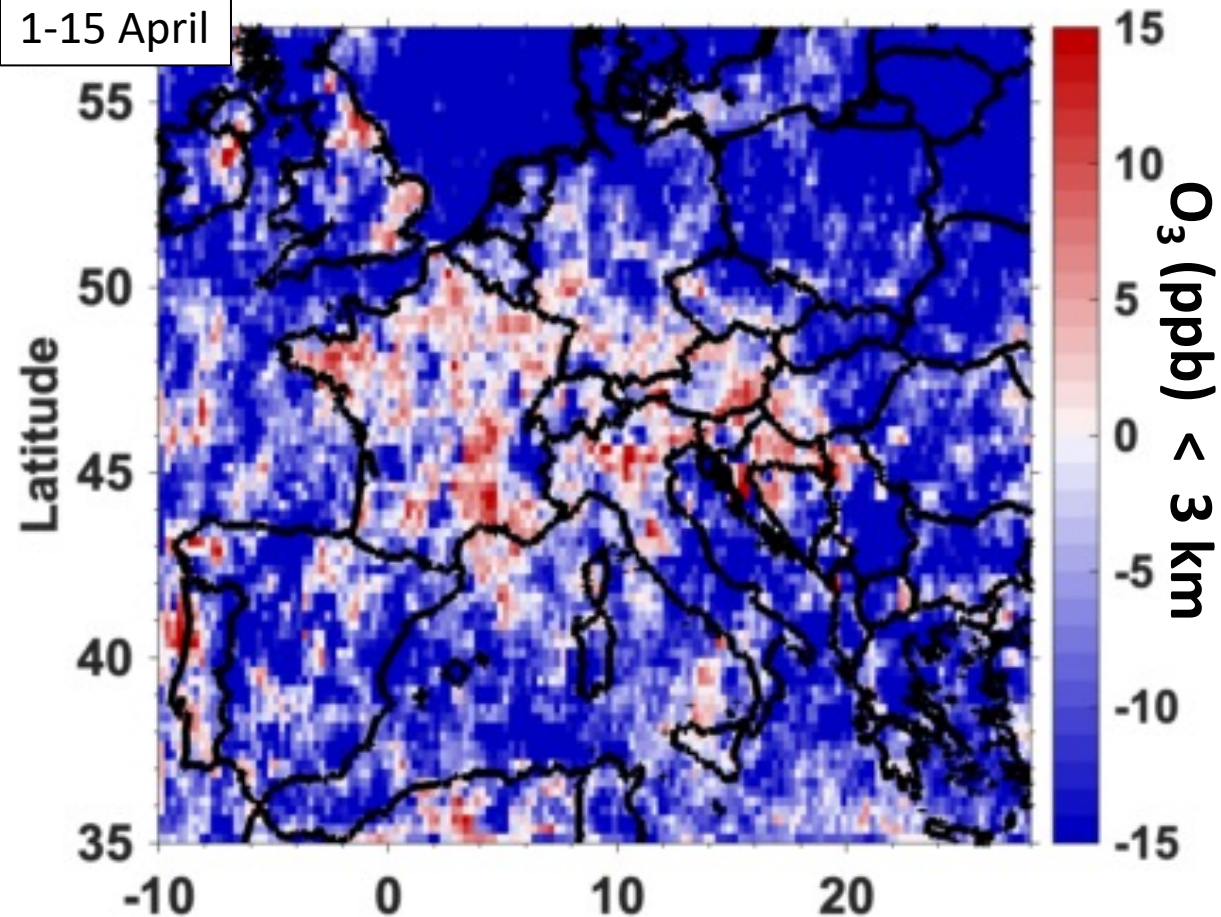
Δ Meteorology correction for observations

Satellite IASI+GOME2 vs Surface In situ

$O_3(2020) - O_3(2019) \rightarrow$ Lockdown effect + Δ Meteorology

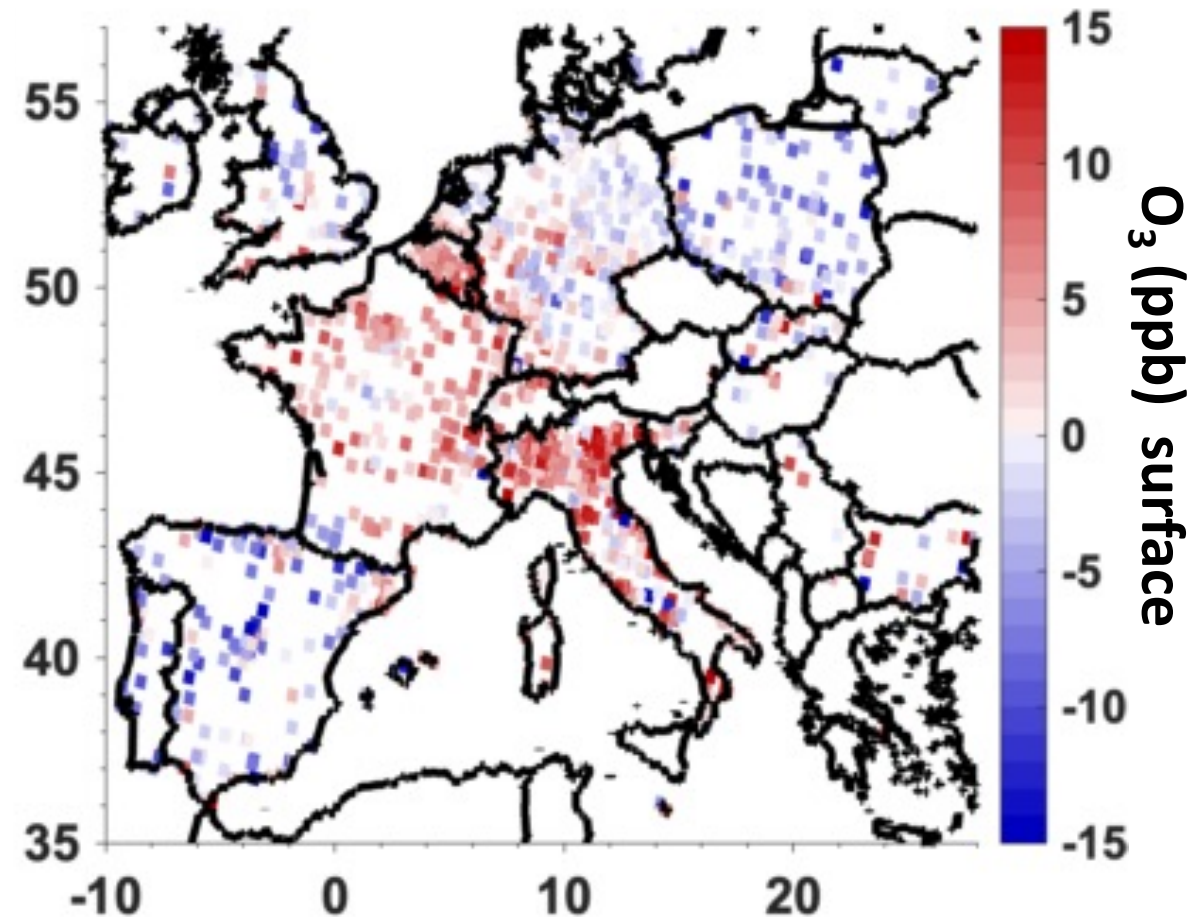
IASI+GOME2 satellite observation

1-15 April



Agreement with regimes from
Beekmann and Vautard, 2010

In situ measurements at the surface



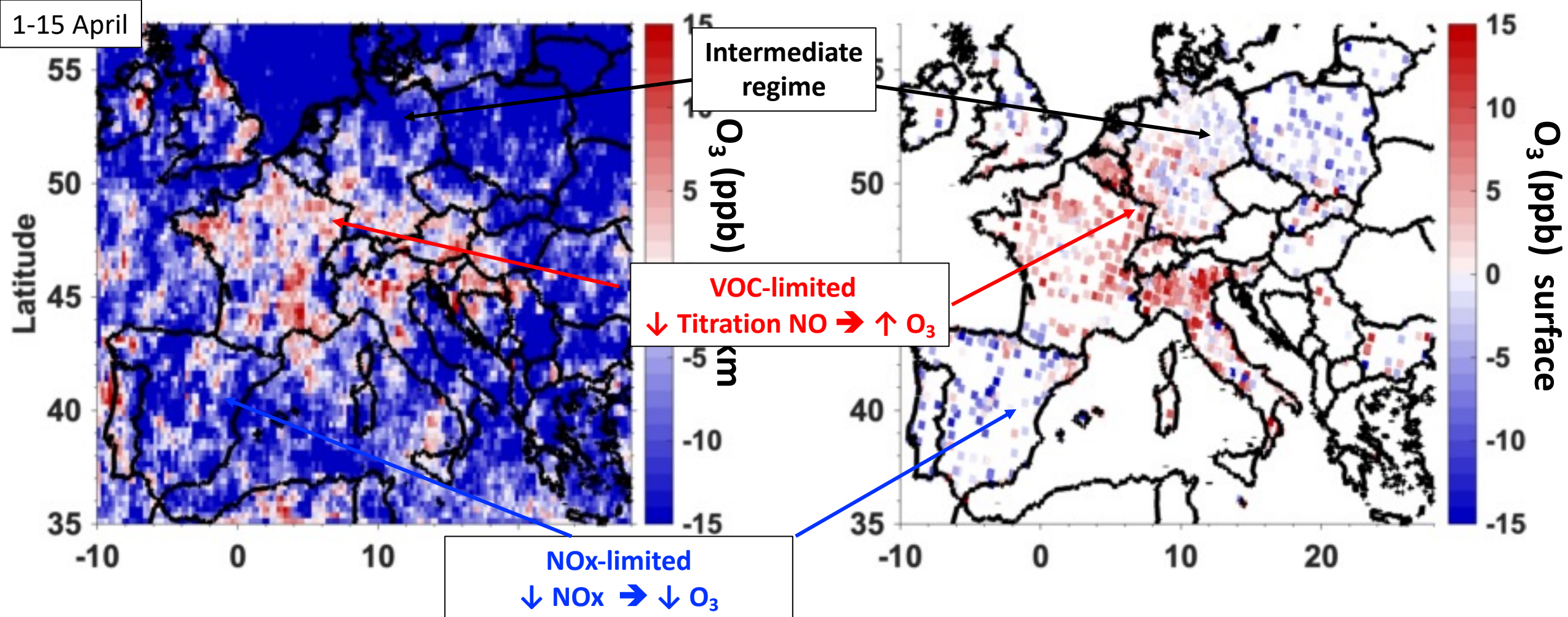
Good satellite/in situ agreement on spatial
distribution and concentrations in absolute value!

Satellite IASI+GOME2 vs Surface In situ

$O_3(2020) - O_3(2019) \rightarrow$ Lockdown effect + Δ Meteorology

IASI+GOME2 satellite observation

In situ measurements at the surface



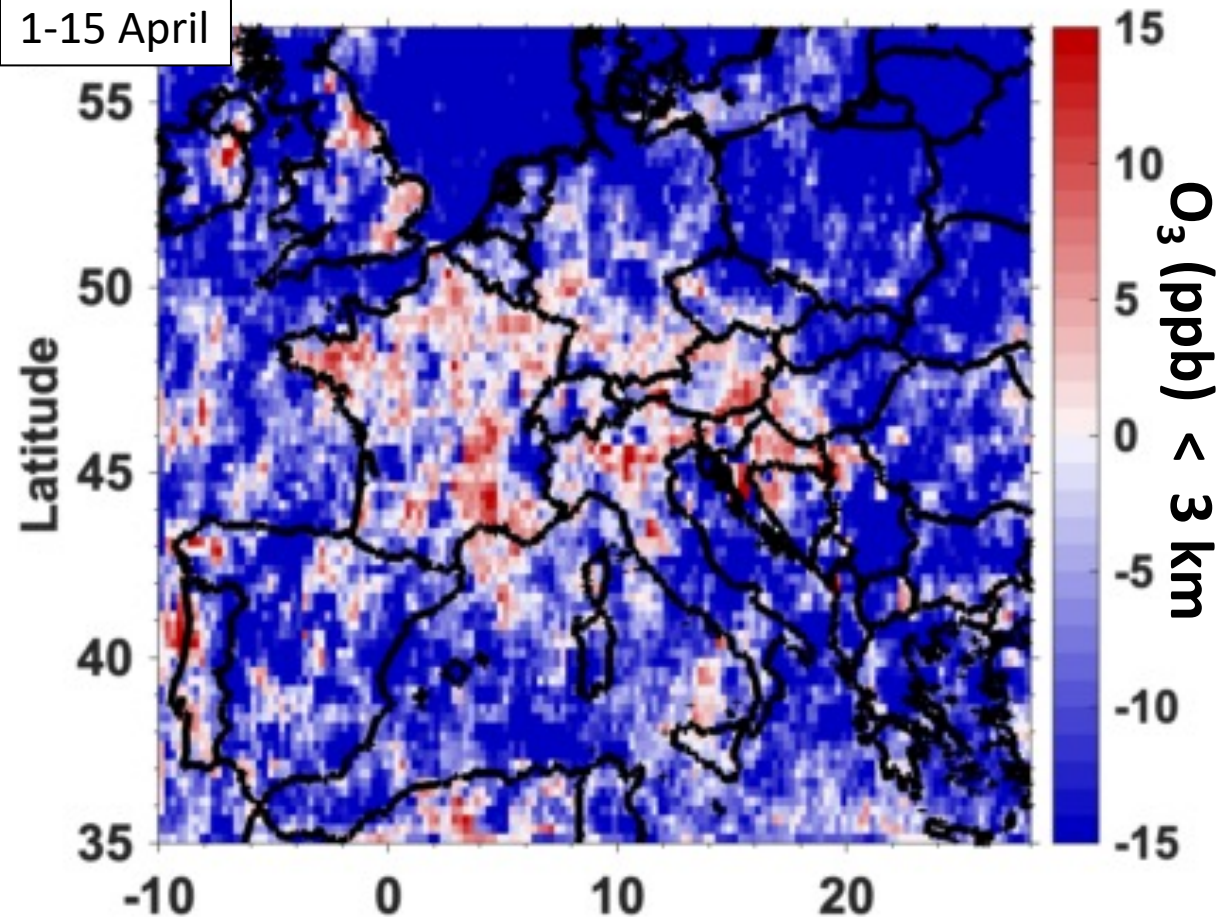
Clear signatures from VOC-limited & NOx-limited regimes from Beekmann and Vautard, 2010

Satellite IASI+GOME2 vs CHIMERE model

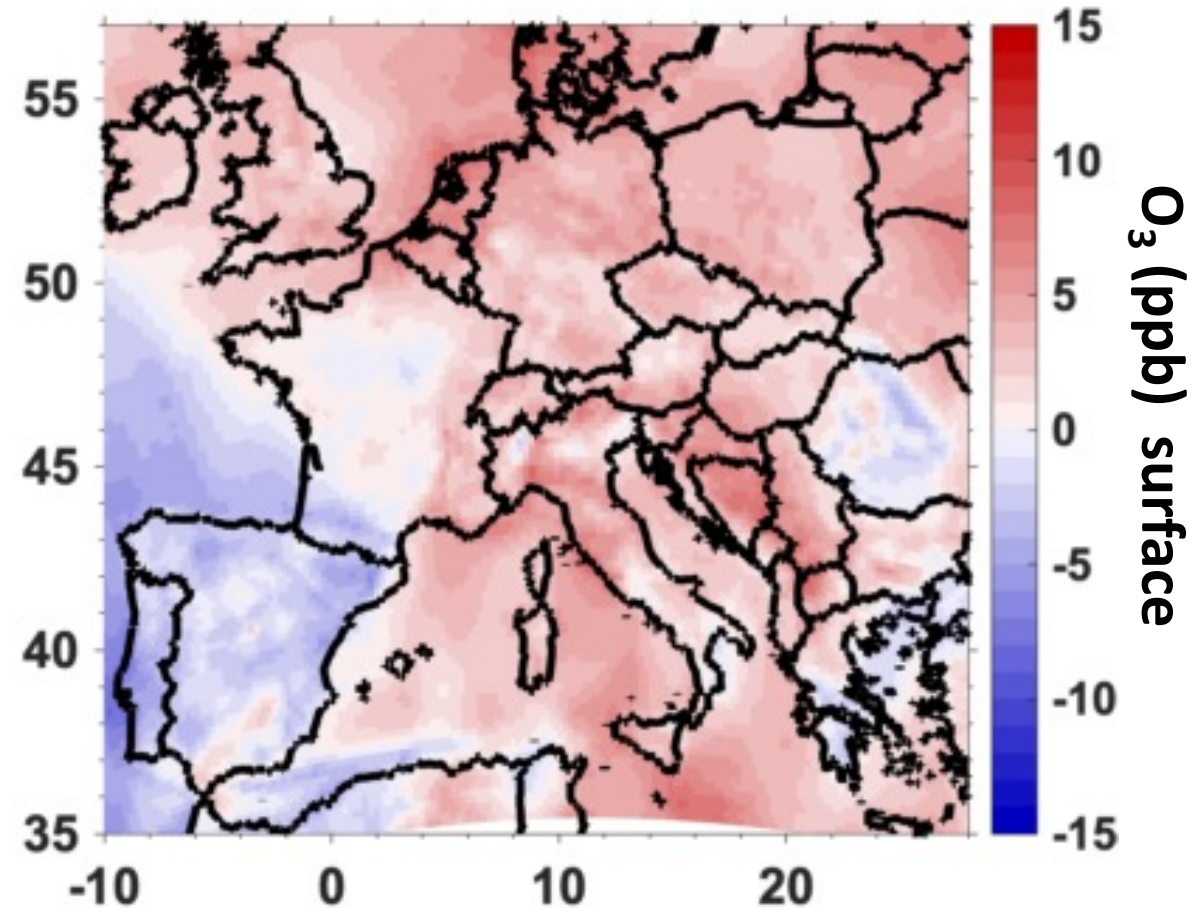
$O_3(2020) - O_3(2019) \rightarrow$ Lockdown effect + Δ Meteorology

IASI+GOME2 satellite observation

1-15 April



CHIMERE simulations



Not very clear signatures from VOC-limited & NO_x-limited regimes


Estimation of the impact of the COVID-19 lockdown from models and observations

From the **CHIMERE model** $\Delta O_{3_{mod}}^{covid} = O_{3_{mod_{COVID}}}^{2020} - O_{3_{mod_{STD}}}^{2020}$

From **surface &
satellite
observations**

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

“business as usual” inventory



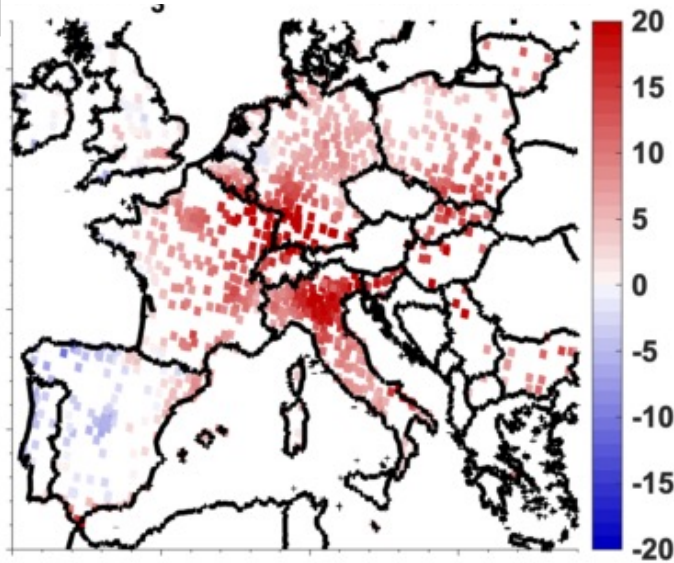
→ Adjustment for changes in meteorological conditions between 2020 and 2019 using model simulations

Impact of COVID-19 lockdown for Surface MDA8 O₃

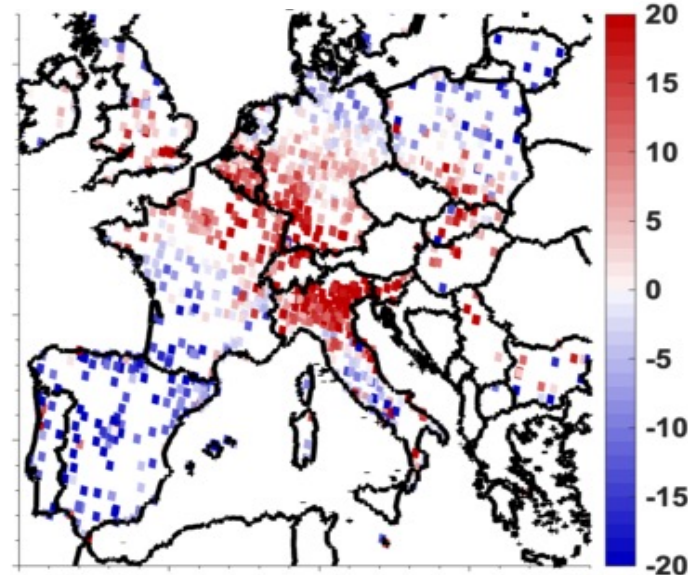
1-30 April

Our approach

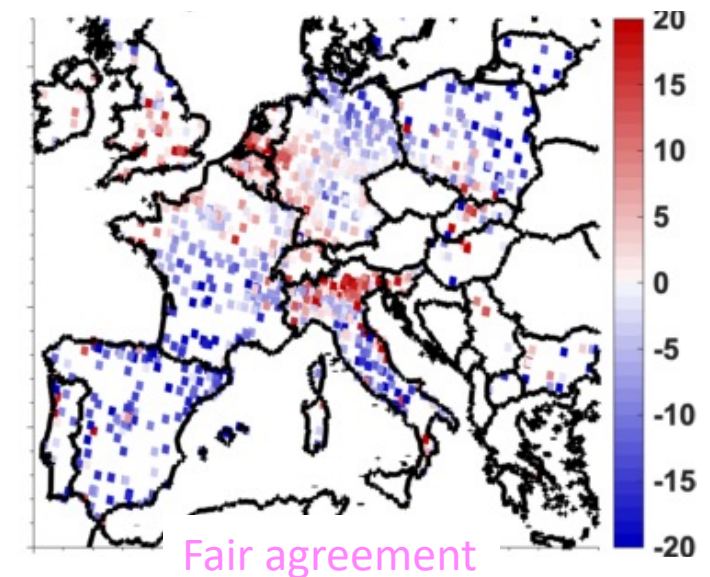
CHIMERE STD $\Delta O_3^{2020-2019}$



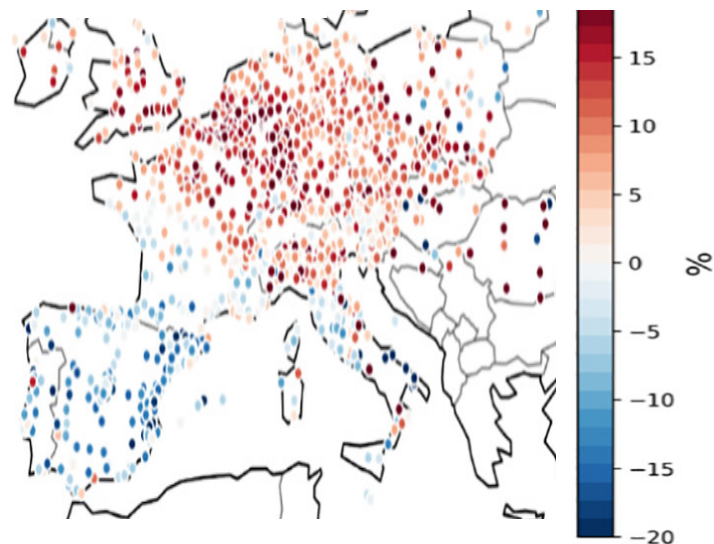
In situ $\Delta O_3^{2020-2019}$



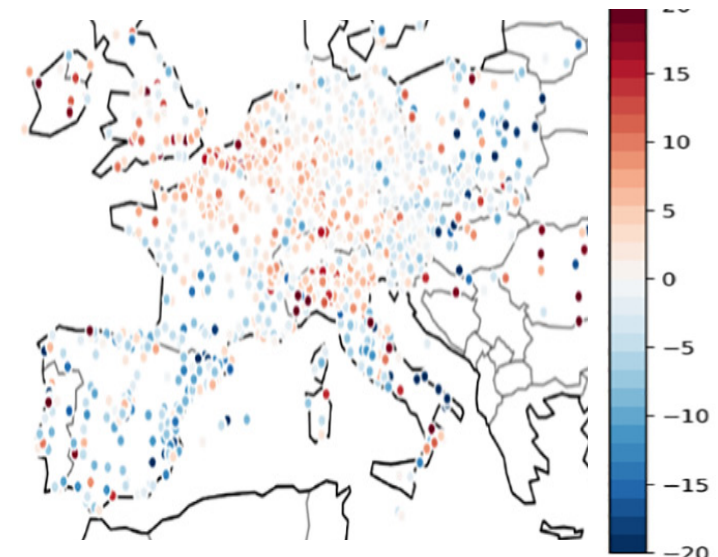
In situ ΔO_3^{COVID} (meteo adjusted)



In situ $\Delta O_3^{2020 - \langle 2019-2015 \rangle}$



In situ ΔO_3^{COVID} (meteo adjusted)



From Ordoñez et al., 2020
In situ surface
& statistical predictive model

COVID-19 lockdown impact on O_3 pollution

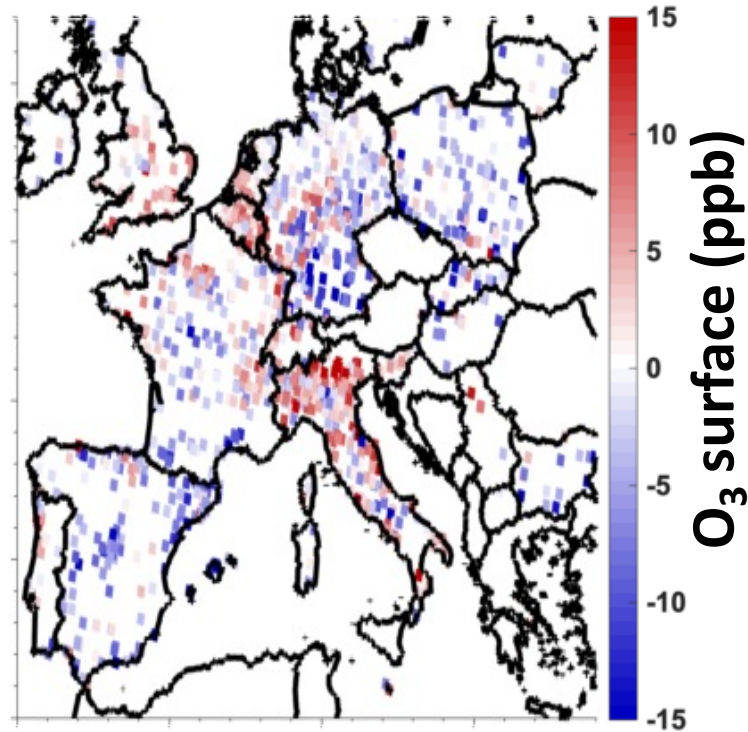
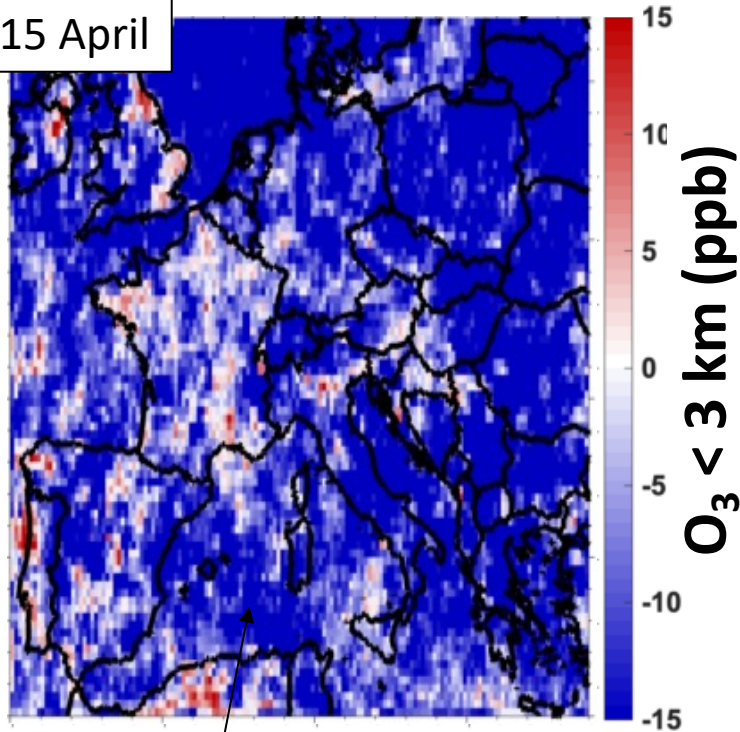
Satellite IASI+GOME2

Meteo-adjusted

In situ surface

Meteo-adjusted

1-15 April



Satellite/in situ fair agreement

NO_x-limited
 $\downarrow \text{NO}_x \rightarrow \downarrow O_3$

VOC-limited
 $\downarrow \text{Titration NO} \rightarrow \uparrow O_3$

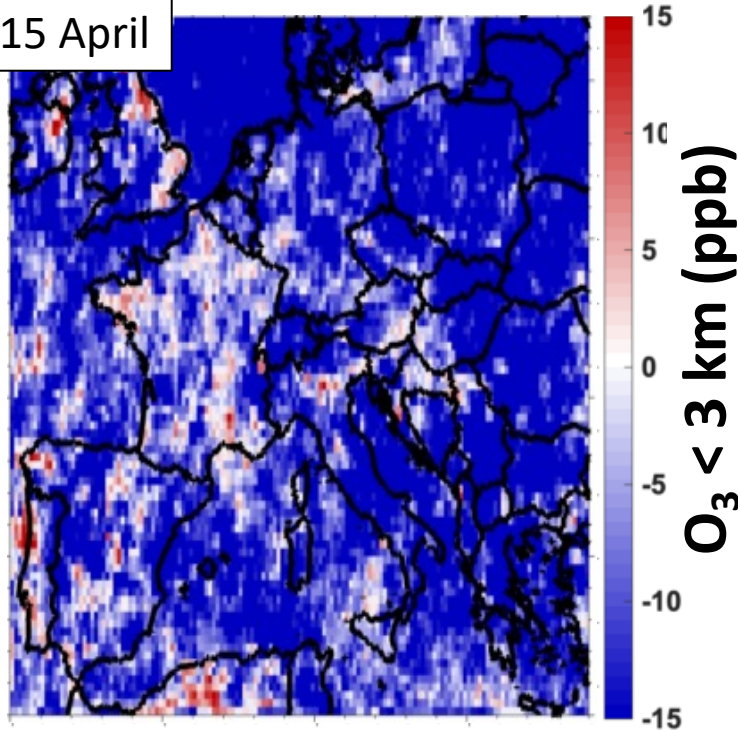
Large-scale reduction seen by ozone sondes & lidars in the free troposphere (Steinbrech et al., 2021)

COVID-19 lockdown impact on O₃ pollution

Satellite IASI+GOME2

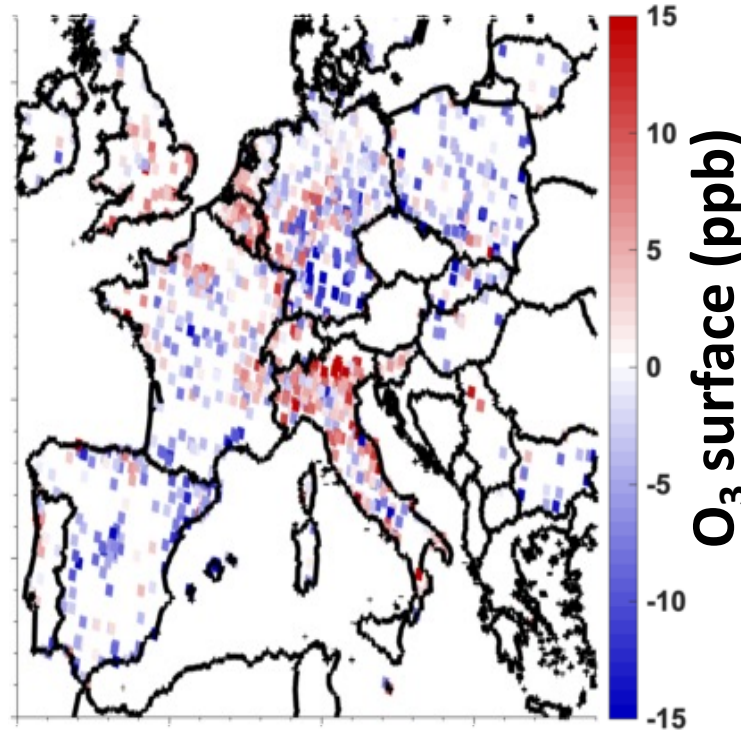
Meteo-adjusted

1-15 April



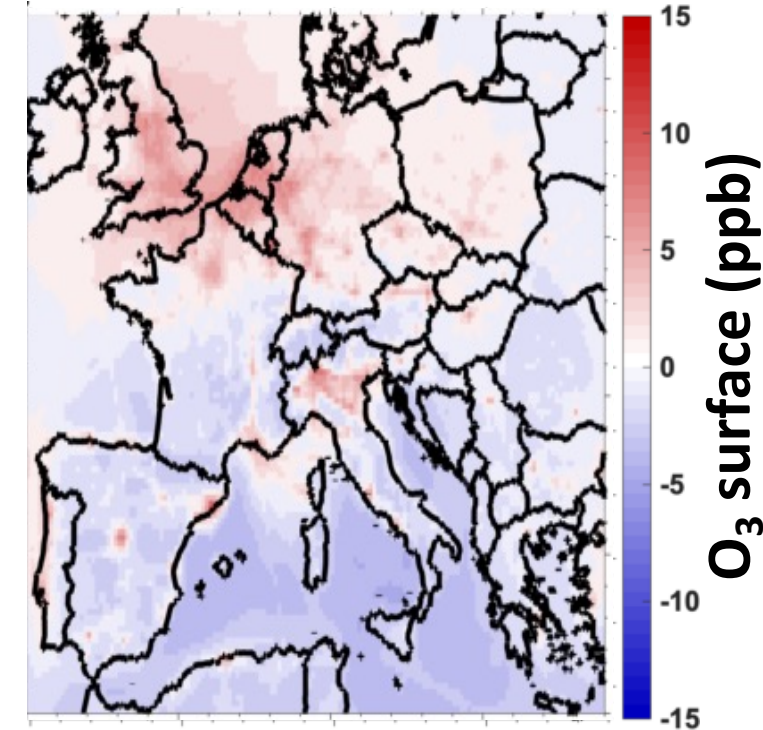
In situ surface

Meteo-adjusted



CHIMERE model

COVID-STD



NO_x-limited
↓ NO_x → ↓ O₃

VOC-limited
↓ Titration NO → ↑ O₃

Agreement over France, Benelux and Italy.

The model : → underestimates the accumulation of O₃ over the Po Valley

→ overestimates that over Germany and Poland

→ Misses the large-scale reduction

Summary

1. This “Satellite + In situ + Model” approach shows the following Covid-19 lockdown impacts on ozone:
 - ➔ O_3 reduction in most NO_x -limited regions and at large scale
 - ➔ O_3 accumulation over Northern Europe
2. The new IASI-GOME2 satellite approach shows good agreement with photochemical regimes and with in situ measurements at the surface
3. We derive an adjustment for the effect of meteorological for observation-assessment of COVID-19 lockdown impact using CHIMERE simulations.
4. 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
 - ➔ See more details in **Cuesta et al., ACPD paper** currently in discussions