

# Multispectral satellite observation of $O_3$ pollution over Europe during the COVID-19 lockdown of springtime 2020

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(1)



(2)



(3)



(4)



(5)

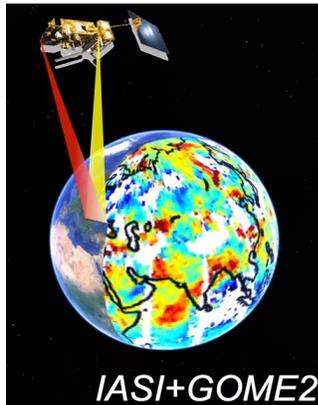


# Scientific objectives

- ❑ Quantify the impact of the COV-19 lockdown on ozone pollution over Europe
- ❑ Analyze the link with photochemical regimes : NO<sub>x</sub>-limited & VOC-limited

Which approach ?

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



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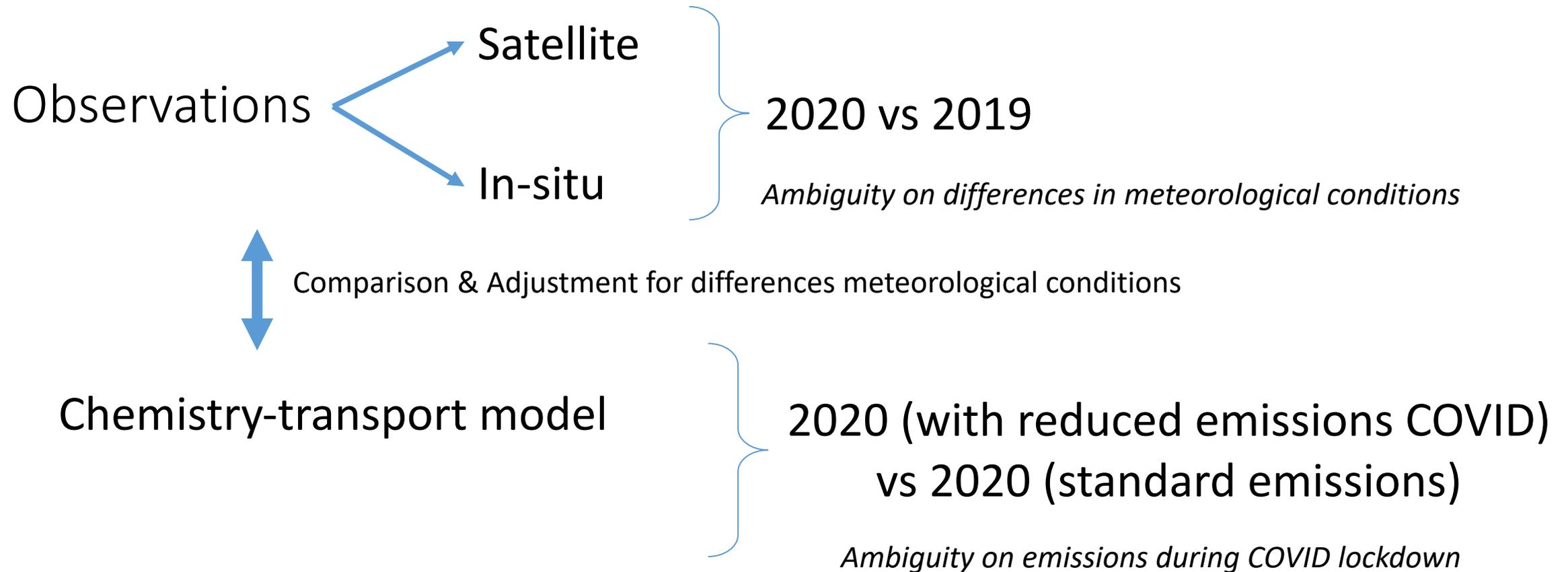
The new multispectral satellite data  
“IASI+GOME2”

→ Enhanced sensitivity to near-surface O<sub>3</sub>

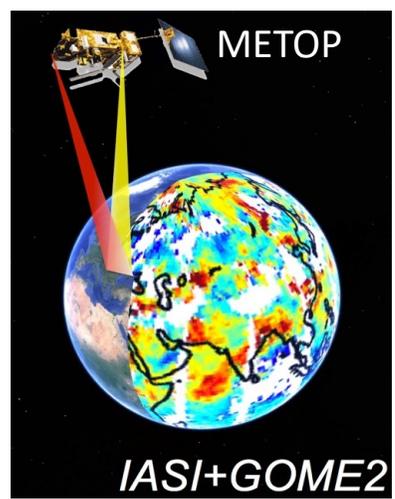
# Approach to study the impact of COVID19 lockdown on ozone pollution (1/3)

*Complexity*

→ *Secondary pollutant with non-linear effects according to NO<sub>x</sub>-limited and VOC-limited regimes*

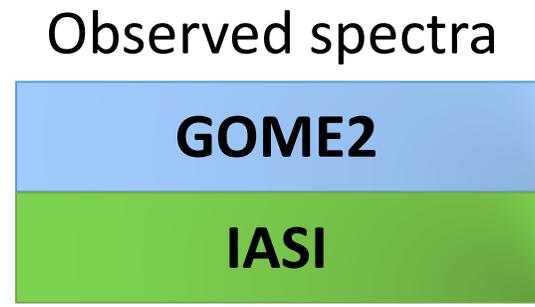
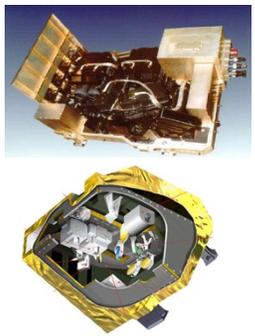


# Satellite observations: **The IASI+GOME2 multispectral approach**



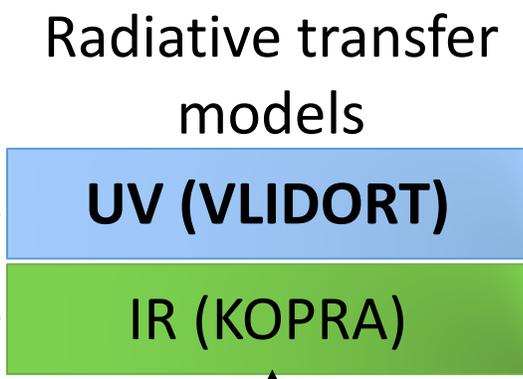
## Synergism of co-localized IR and UV measurements

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



[Cuesta et al., 2013, ACP]

Atmospheric and surface conditions

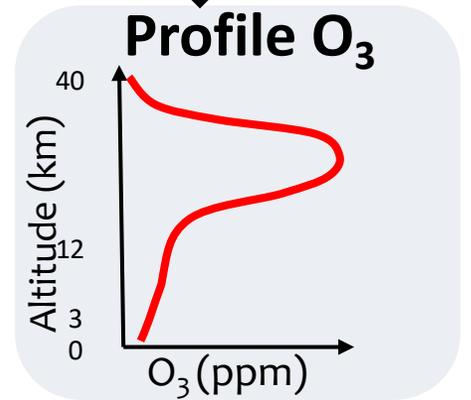


Simultaneous minimisation of IR and UV residuals

Adjusting a unique O<sub>3</sub> profile

Iterations

**Increased sensitivity in the lowermost troposphere**



# The chemistry-transport transport model **CHIMERE**

CHIMERE v2017 (Menut et al., 2020)

20 x 20 km<sup>2</sup> - 9 vertical levels

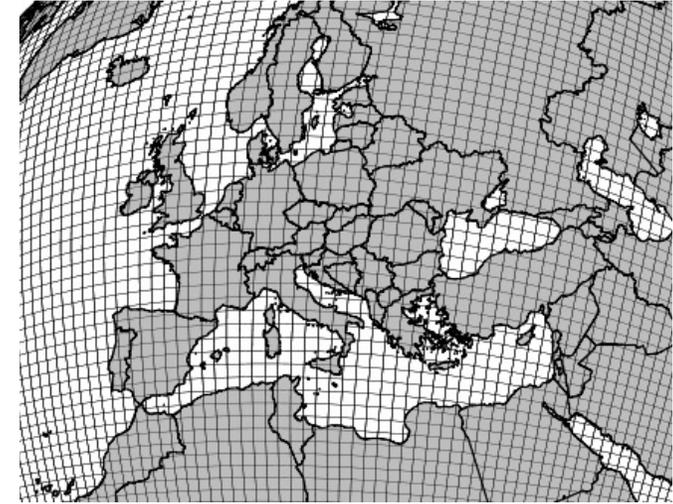
Anthropogenic emissions from HTAP v2.2

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

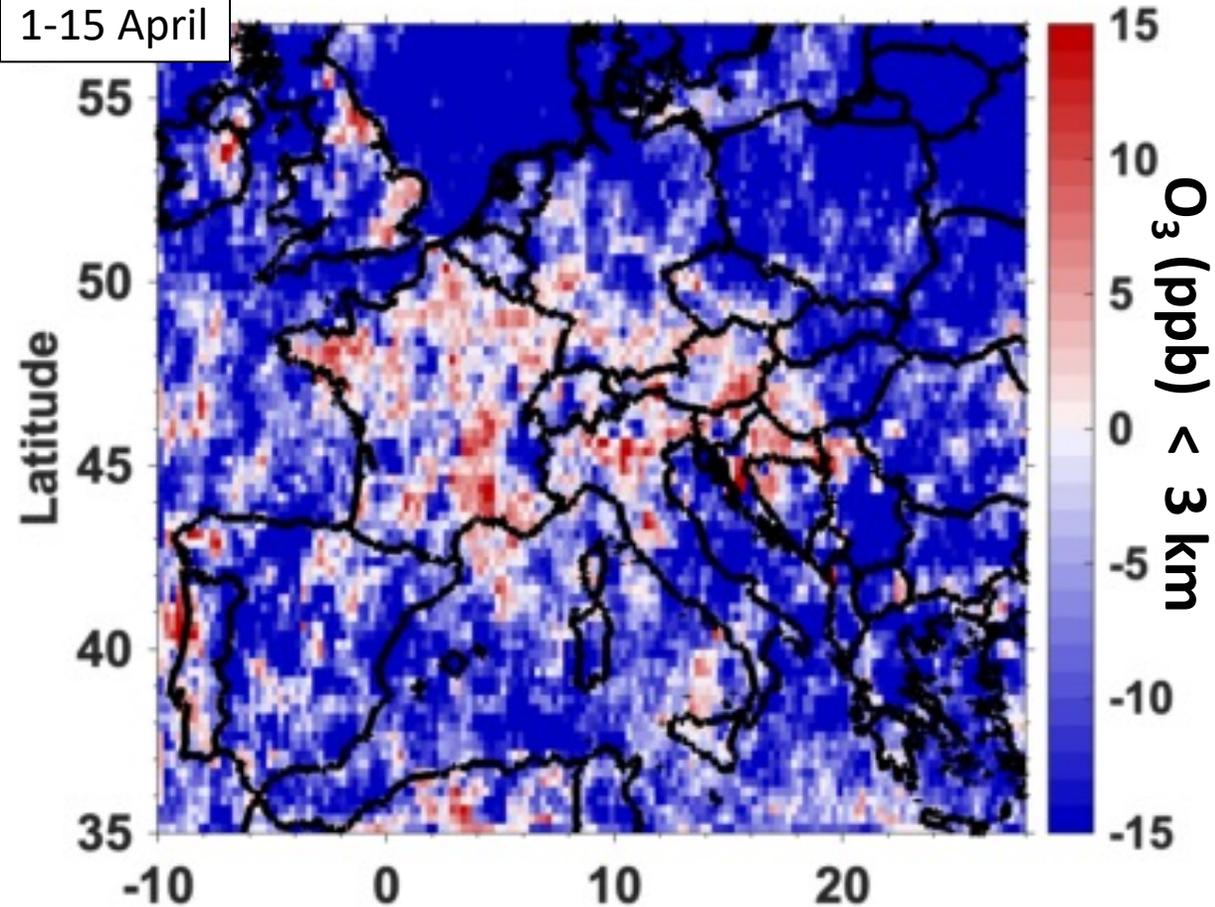
Δ Meteorology correction for observations

# Satellite IASI+GOME2 vs Surface In situ

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

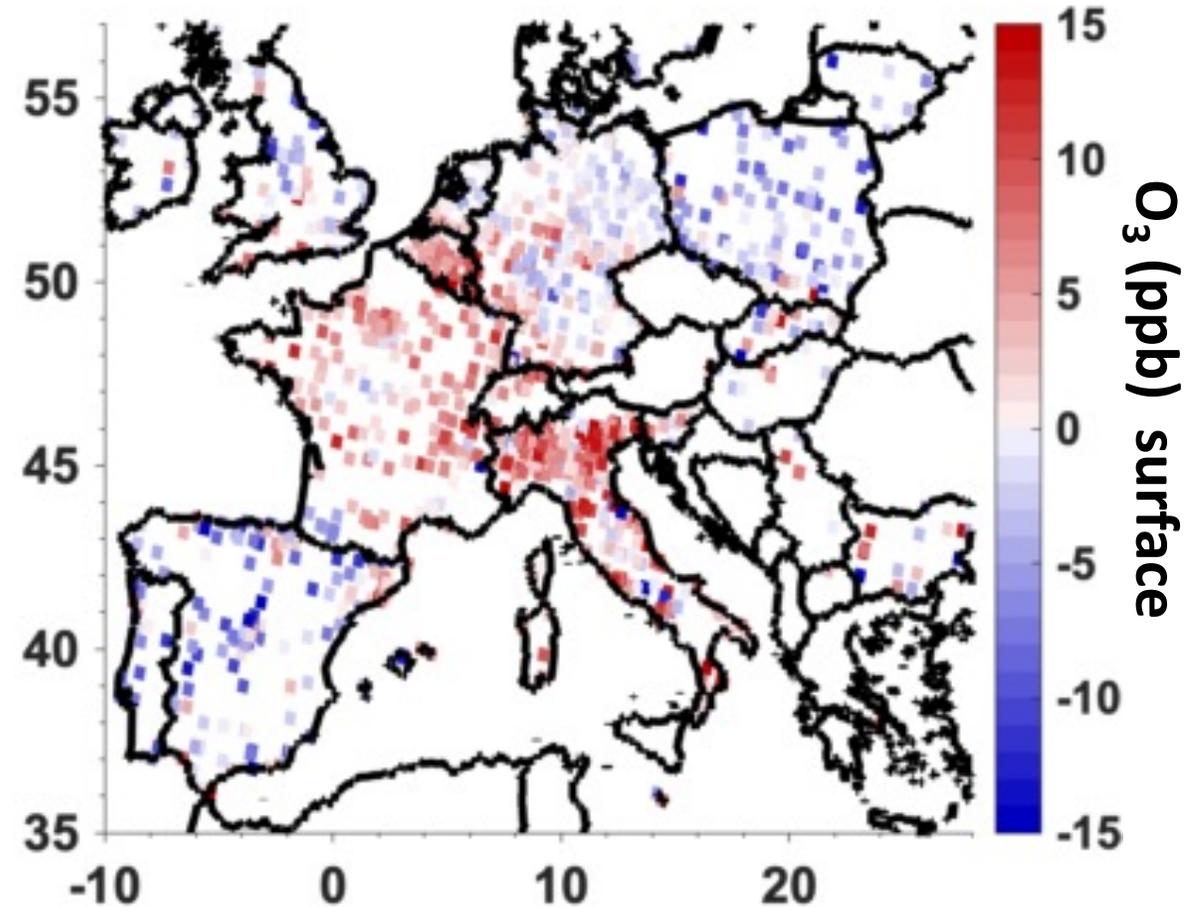
**IASI+GOME2 satellite observation**

1-15 April



Agreement with regimes from Beekmann and Vautard, 2010

**In situ measurements at the surface**



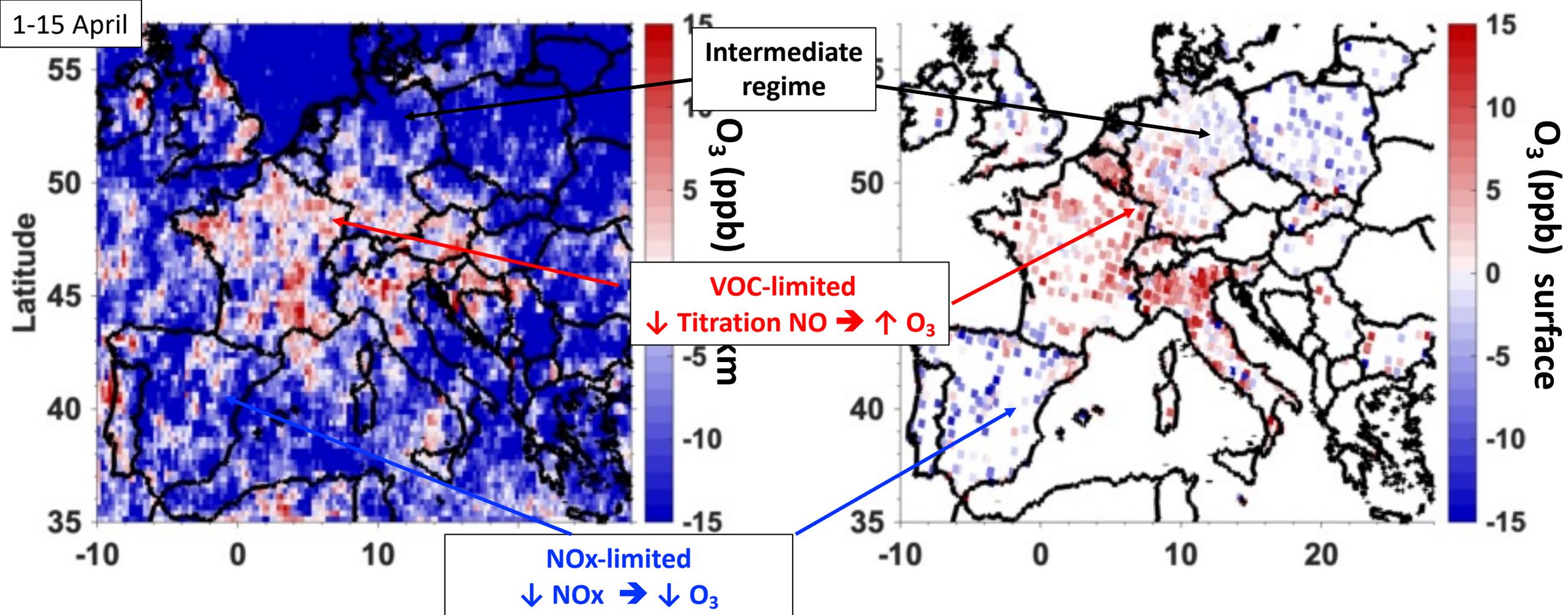
Good satellite/in situ agreement on spatial distribution and concentrations in absolute value!

# Satellite IASI+GOME2 vs Surface In situ

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

**IASI+GOME2 satellite observation**

**In situ measurements at the surface**

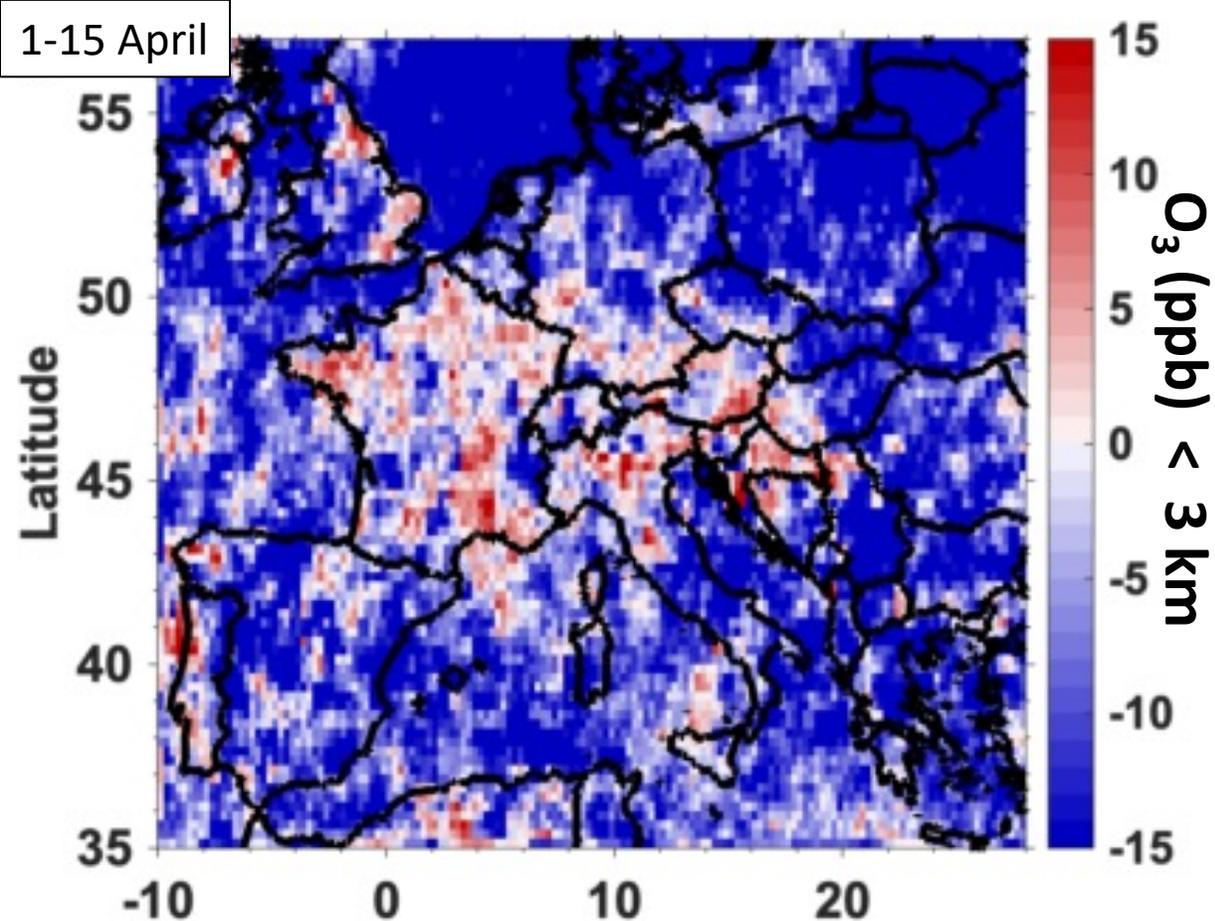


Clear signatures from VOC-limited & NOx-limited regimes from Beekmann and Vautard, 2010

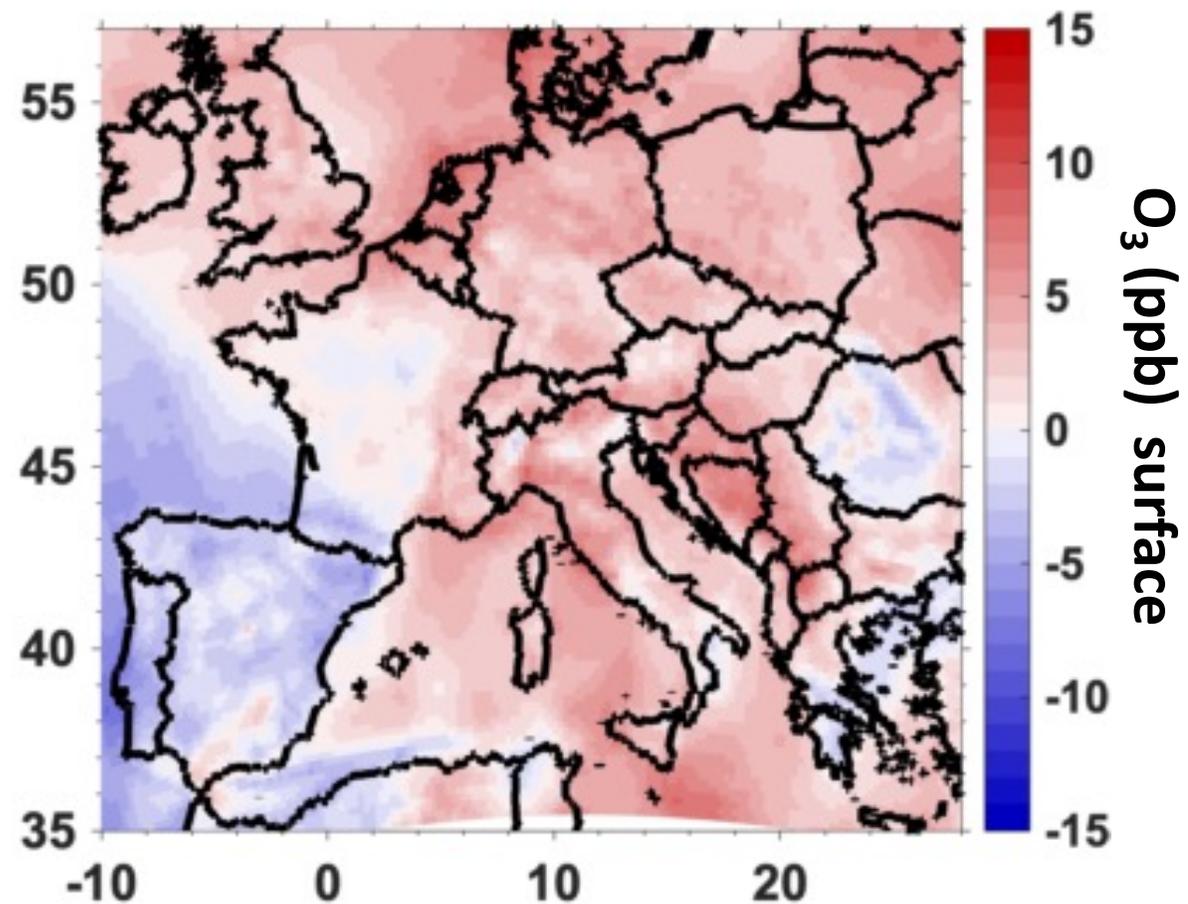
# Satellite IASI+GOME2 vs CHIMERE model

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

**IASI+GOME2 satellite observation**



**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**

“business as usual” inventory


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

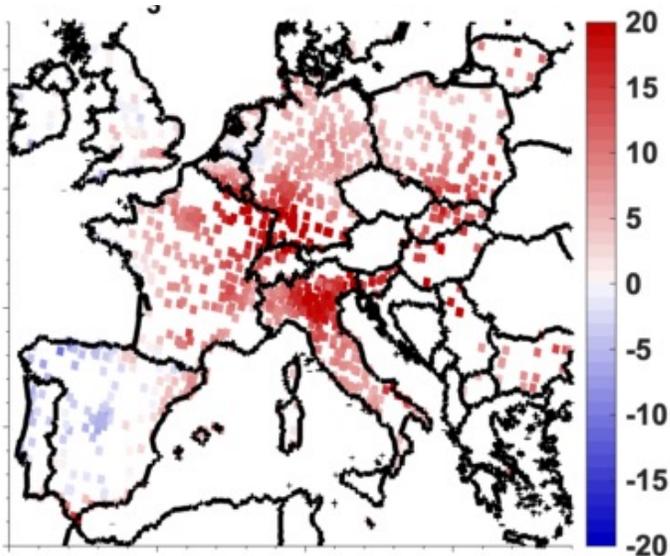
→ Adjustment for changes in meteorological conditions between 2020 and 2019 using model simulations

# Impact of COVID-19 lockdown for Surface MDA8 O<sub>3</sub>

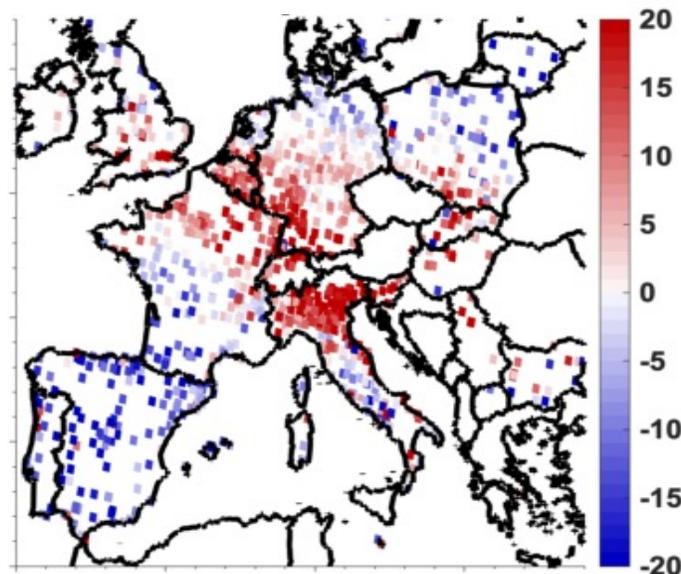
1-30 April

Our approach

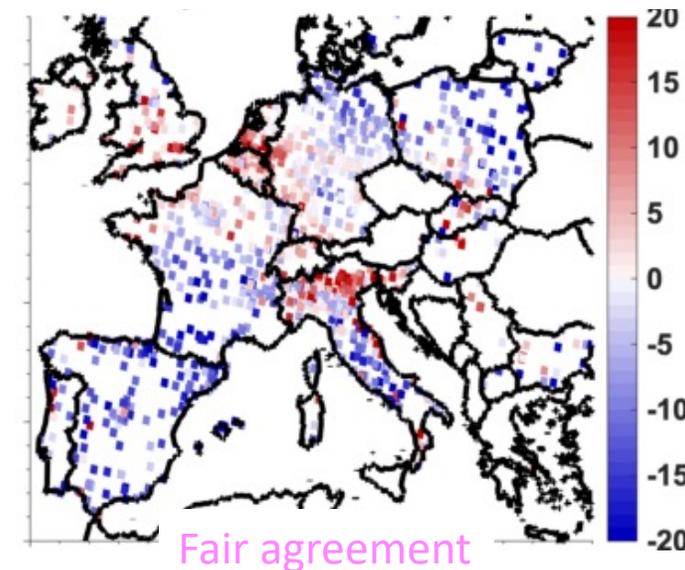
CHIMERE STD  $\Delta O_3^{2020-2019}$



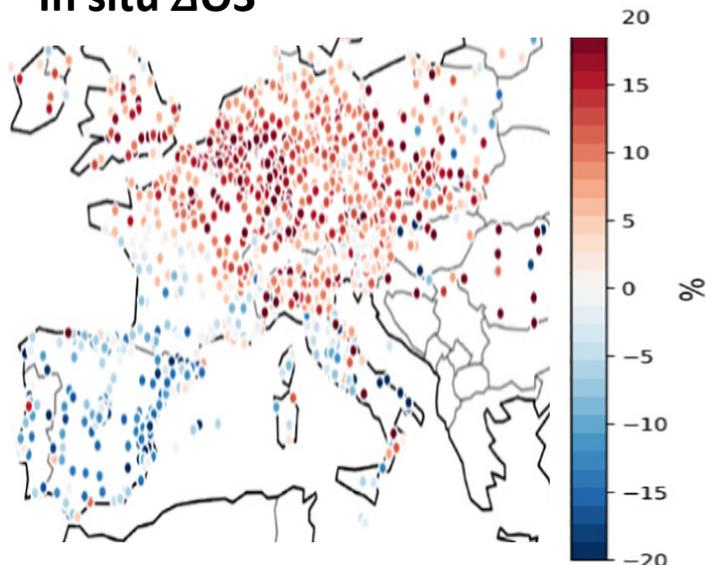
In situ  $\Delta O_3^{2020-2019}$



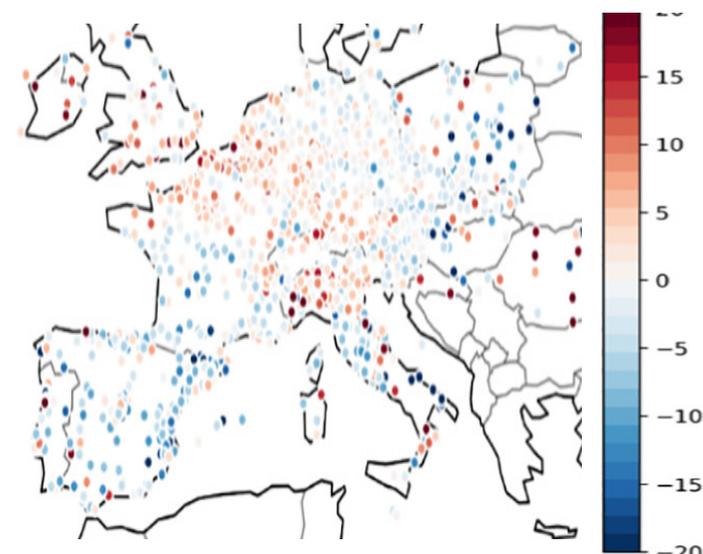
In situ  $\Delta O_3^{COVID}$  (meteo adjusted)



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



In situ  $\Delta O_3^{COVID}$  (meteo adjusted)



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

# COVID-19 lockdown impact on O<sub>3</sub> pollution

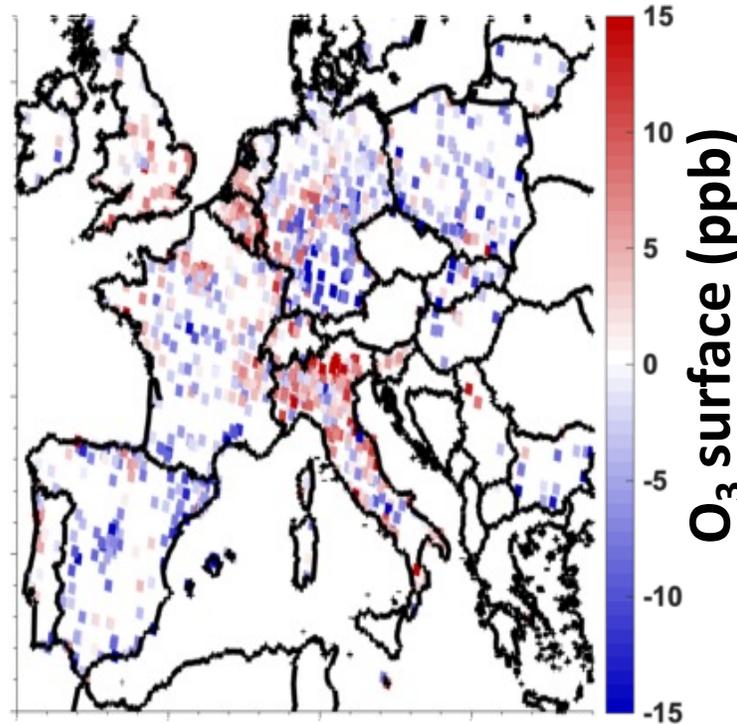
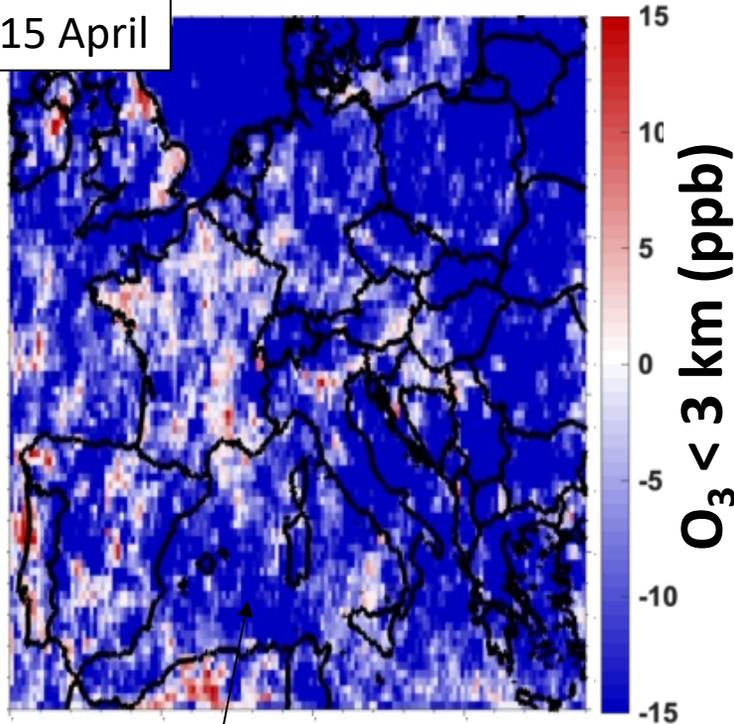
**Satellite IASI+GOME2**

**Meteo-adjusted**

**In situ surface**

**Meteo-adjusted**

1-15 April



Satellite/in situ fair agreement

*NO<sub>x</sub>-limited*  
↓ NO<sub>x</sub> → ↓ O<sub>3</sub>

*VOC-limited*  
↓ Titration NO → ↑ O<sub>3</sub>

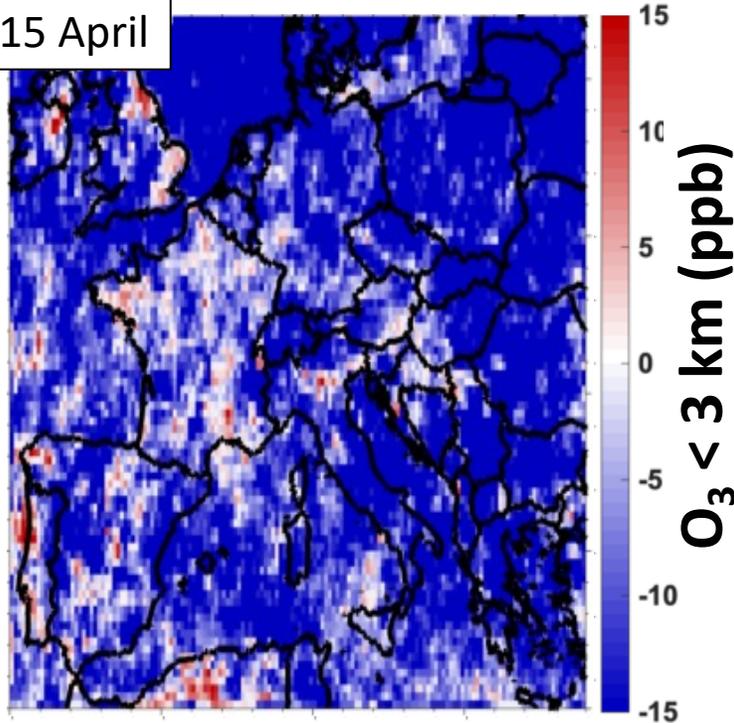
Large-scale reduction seen by ozone sondes & lidars in the free troposphere (Steinbrech et al., 2021)

# COVID-19 lockdown impact on O<sub>3</sub> pollution

## Satellite IASI+GOME2

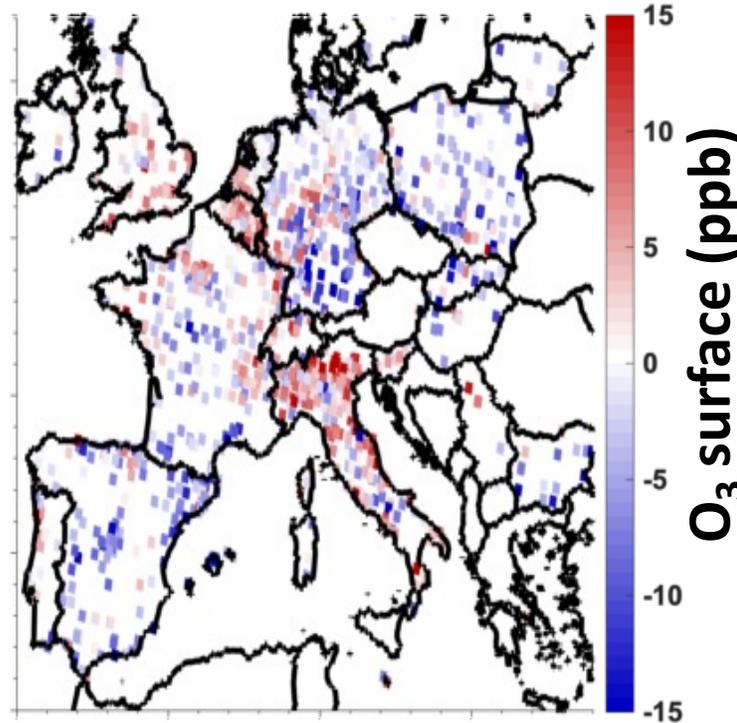
Meteo-adjusted

1-15 April



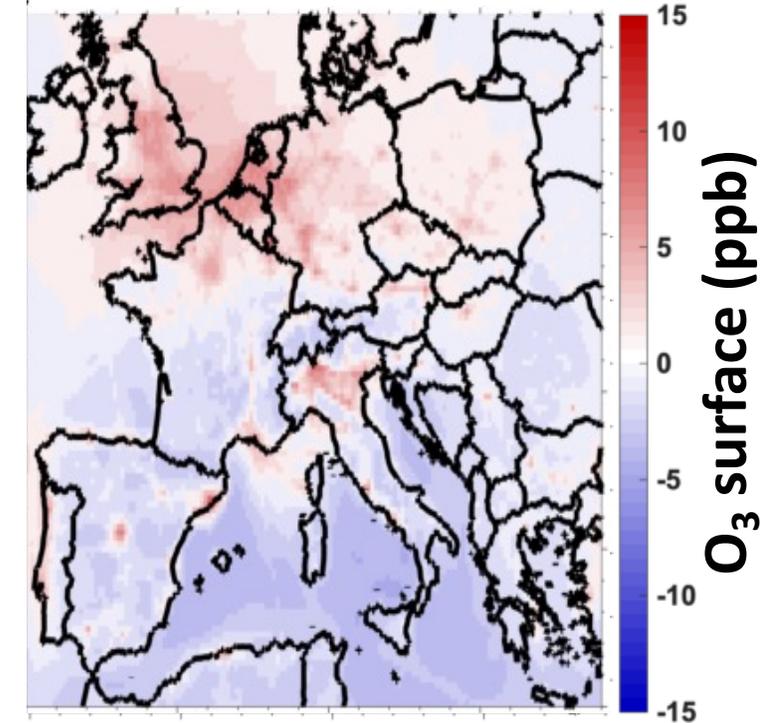
## In situ surface

Meteo-adjusted



## CHIMERE model

COVID-STD



*NO<sub>x</sub>-limited*  
*↓ NO<sub>x</sub> → ↓ O<sub>3</sub>*

*VOC-limited*  
*↓ Titration NO → ↑ O<sub>3</sub>*

*Agreement over France, Benelux and Italy.*

*The model : → underestimates the accumulation of O<sub>3</sub> 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