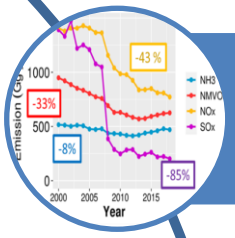
22nd Task Force on Measurement and Modelling Meeting
Online Meeting, 10-12 May 2021

Concentration changes in Spain -with special focus on NOx and O3-

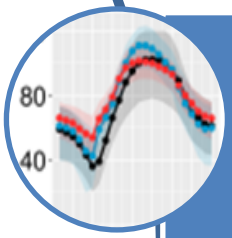
Marta G. Vivanco , Mark R. Theobald , Juan Luis Garrido, Alejandro Rodríguez , Victoria Gil, Fernando Martín

Group of Atmospheric Pollution Modelling. CIEMAT

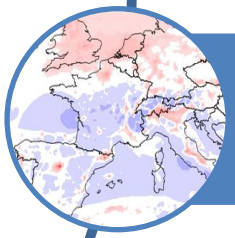
Outline



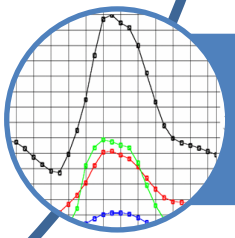
Concentration changes in Spain (5 slides)



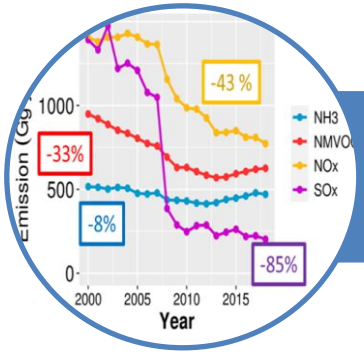
NOx and O3 (considering past, *1st Spanish National Air Pollution Control Programme* (NAPCP) and COVID (3 slides)



COVID simulations (5 slides)

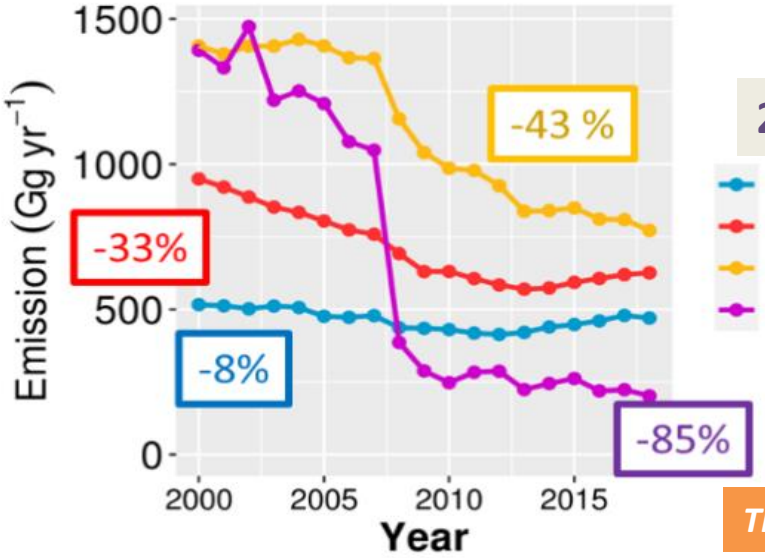


Model answers depending on chemical mechanism (2slides)



Concentration changes in Spain

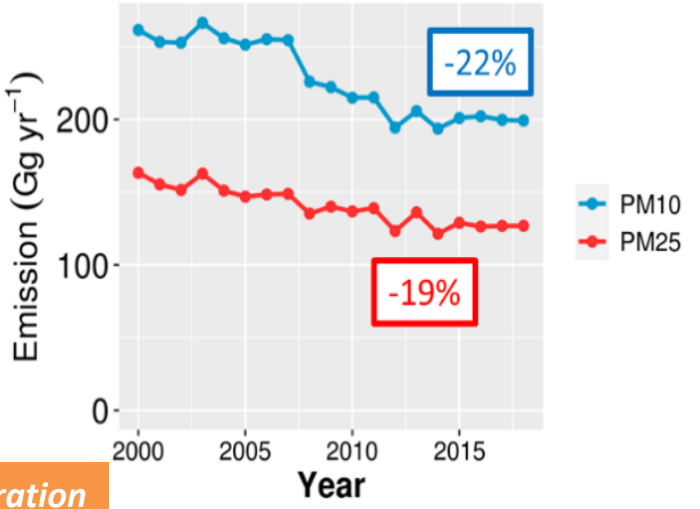
Emissions



2000-2018

NH3
NMVOC
NOx
SOx

National Emission Inventory, 2020 ed



Theobald et al. In preparation

Observed concentrations

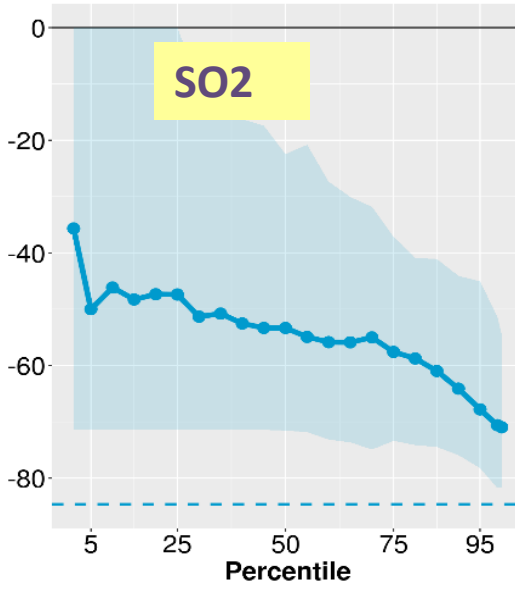
Changes in concentration percentiles : 2000-2002 to 2016-2018

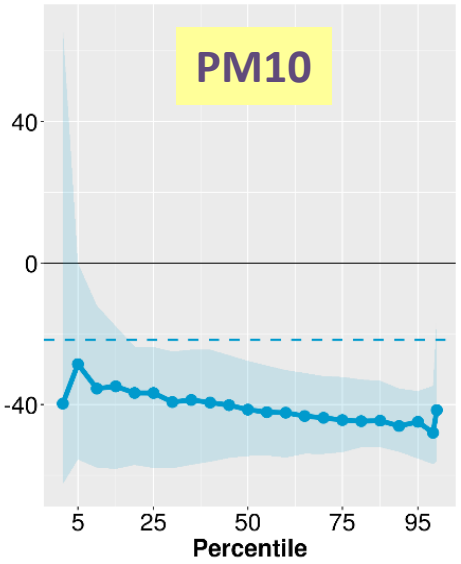
(All sites with data for the two periods)

SO2 and PM10: **Significant reductions of air concentration.**
More pronounced for the highest values (*higher values moving to lower values, and thus less decrease of lower values?*)

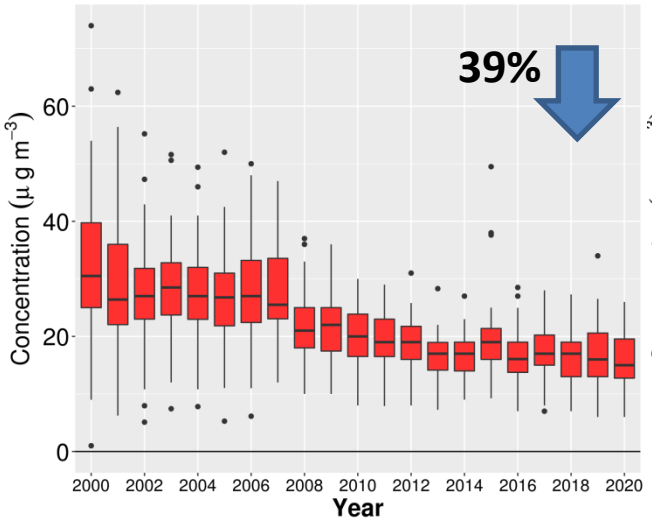
SO2: lower decrease of air concentration **comparing with emission reduction**. *Changes in SO2 oxidation?*

PM10: **Higher decrease** of air concentration **comparing with emission recuction**. *Also reduction of secondary PM10 (less sulphates, nitrates)?*

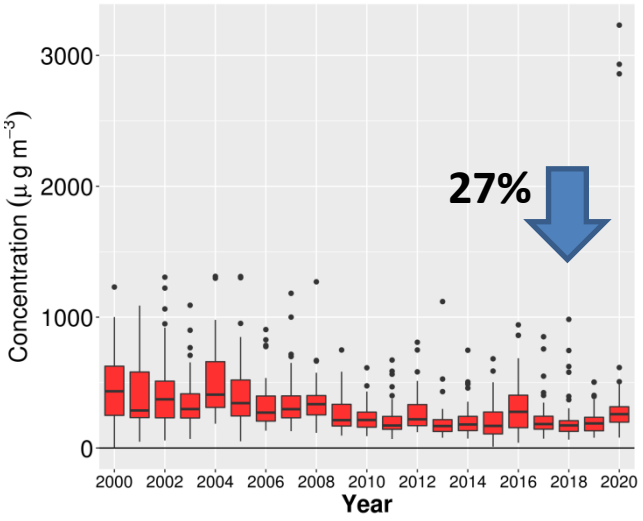




PM10 Annual Mean

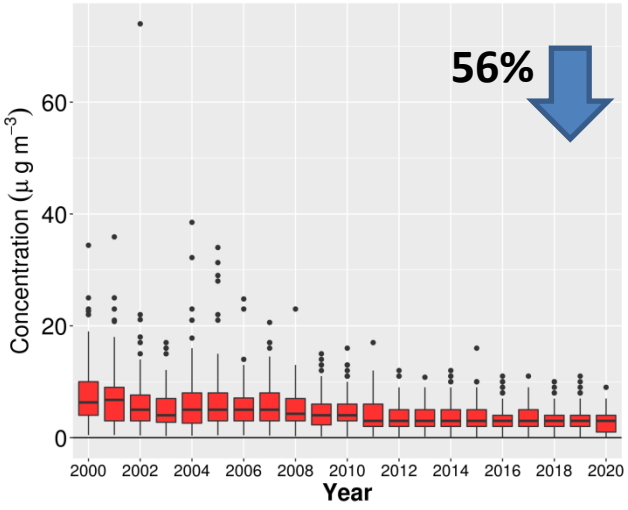


PM10 Maximum hourly

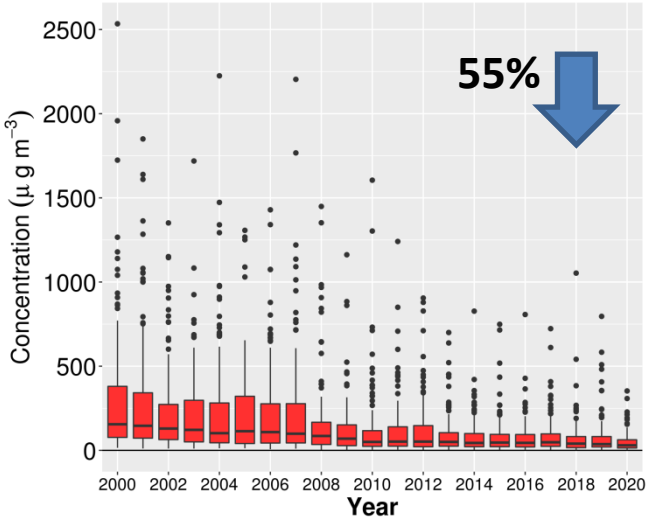


PM10: Decrease of **Annual mean** and **maximum hourly concentration**

SO2 Annual Mean



SO2 Maximum hourly



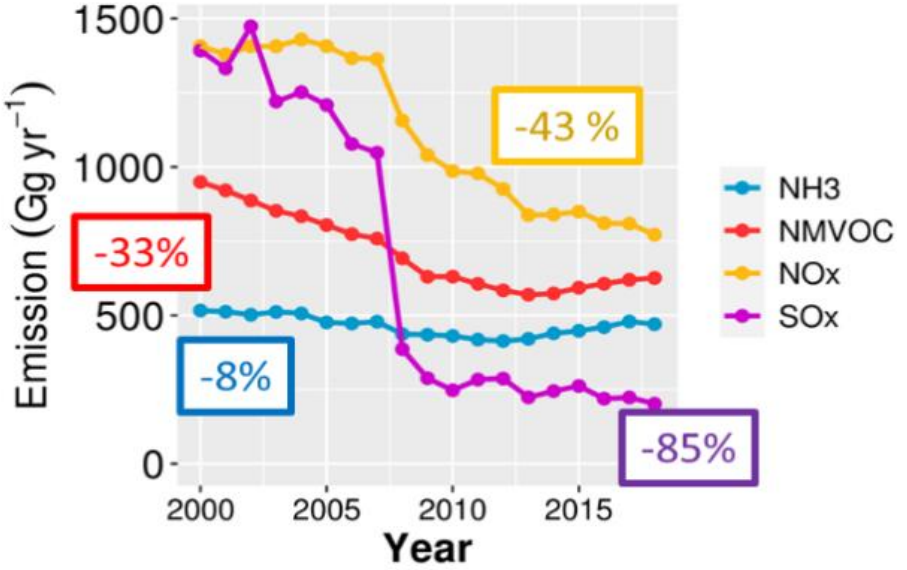
SO2: Decrease of **annual mean** and **maximum hourly concentration**

Changes in concentration percentiles (2000-2002 to 2016-2018): **2000-2002 to 2016-2018**

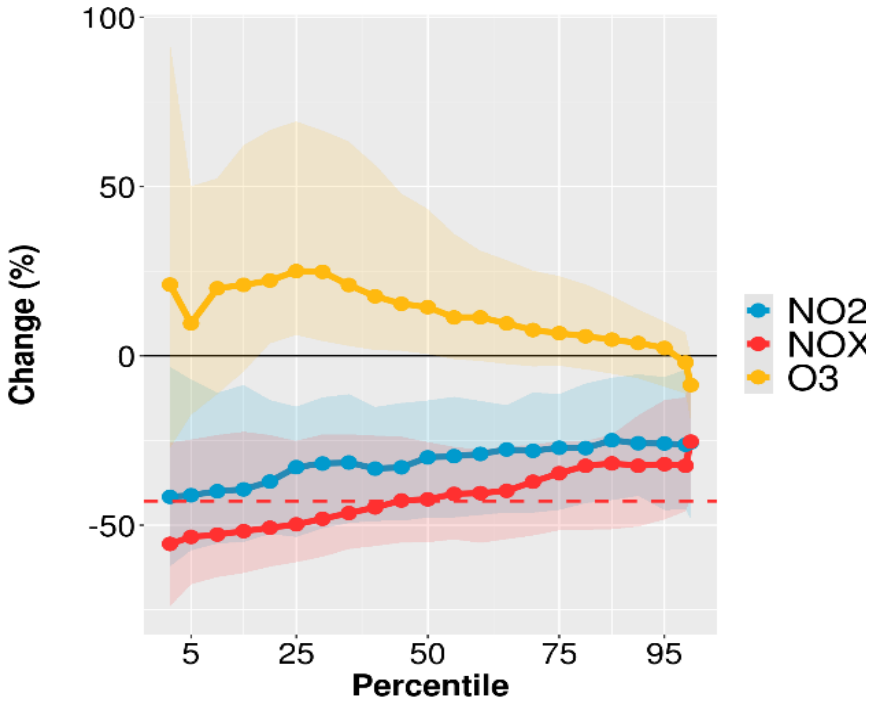
All sites with data for the two periods . Percentiles calculated from observation data for the two periods

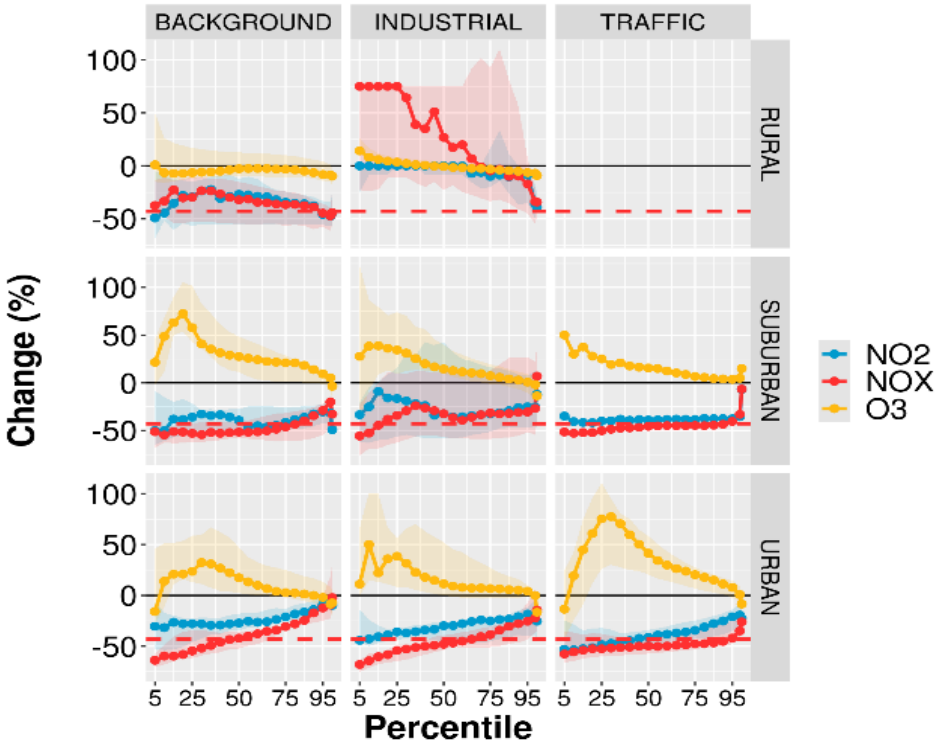
NO2: **Significant reductions of air concentration.** More pronounced for the lowest values. NOx concentration decreases similar to **emission reduction**.

O3: **Increase of concentration, except for the highest values (p99)** More pronunced in urban trafic sites. (NO-titration effect). **Slight decreases in Rural backgound** .

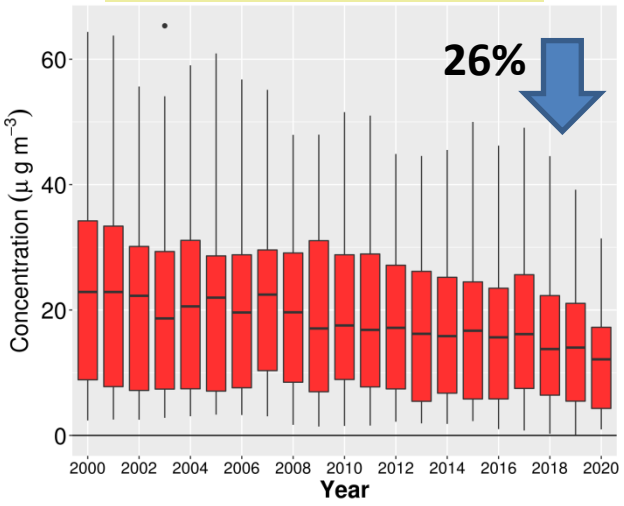


Theobald et al. In preparation

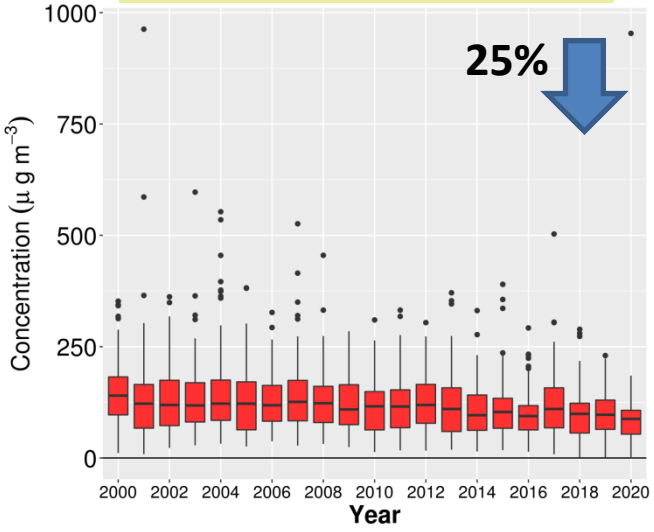




NO2 Annual Mean

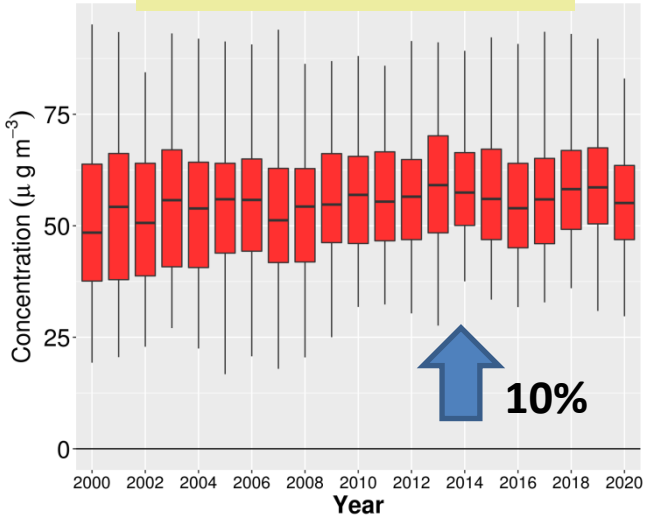


NO2 Maximum Hourly

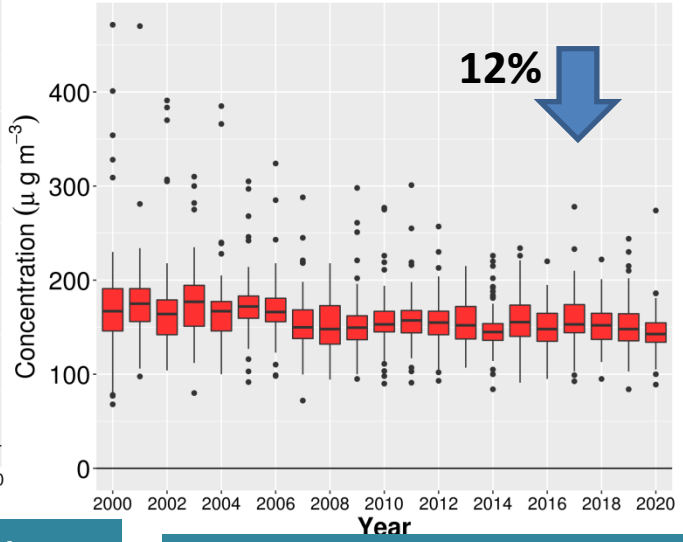


NO2: Decrease of Annual Mean and Maximum Hourly concentration

O3 Annual Mean



O3 Maximum Hourly



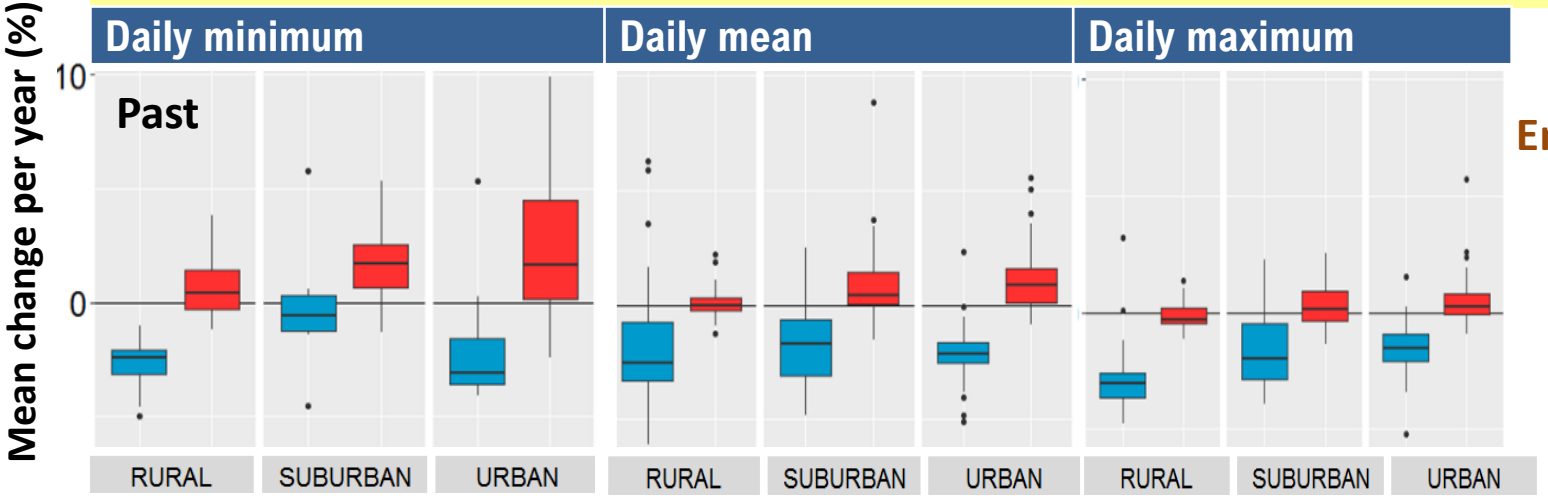
O3: Increase of Annual Mean and decrease of maximum hourly concentration

More contribution of low values (winter, night time)

Only highest values…

Concentration changes

Past observations 2000-2002 to 2016-2018

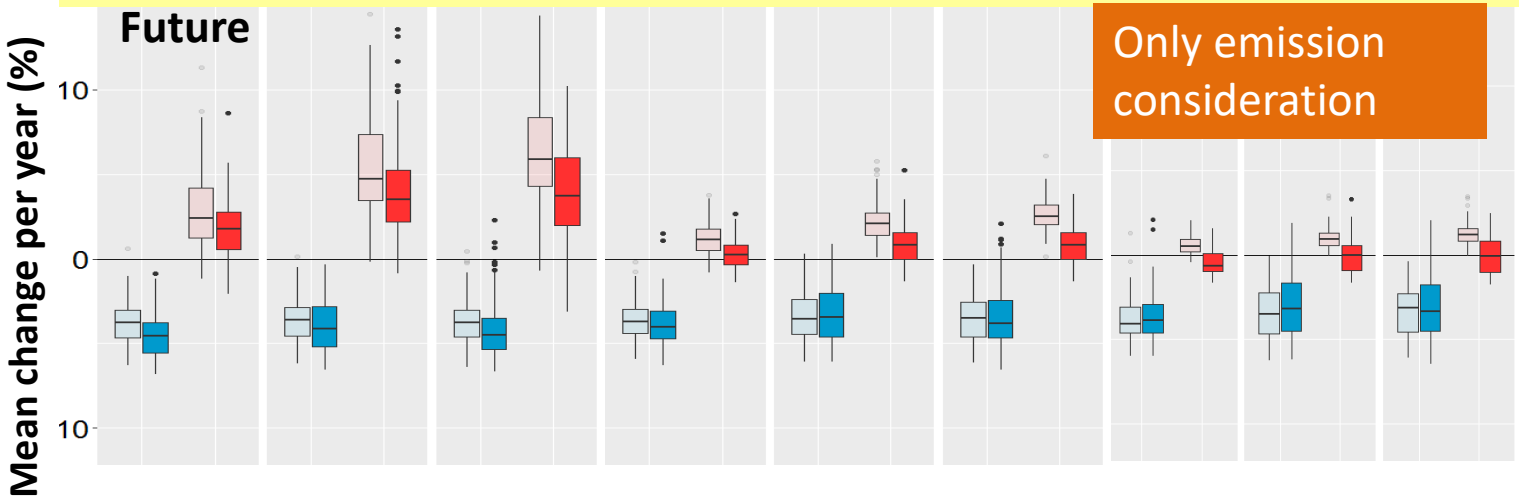


Emission changes

NOx: -43%

NMVOCs: -33%

Model estimates: measures in the *1st Spanish National Air Pollution Control Programme* ,(NAPCP) **WAM 2030 scenario. Concentration change (%) (WAM2030 – 2016)**



Only emission consideration

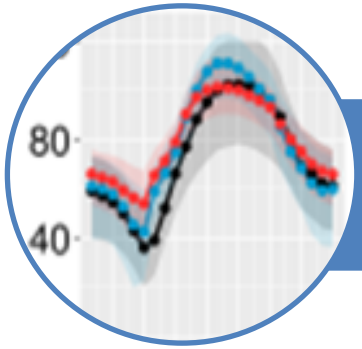
CHIMERE MODEL; METEOROLOGY: 2016.
Vivanco et al. 2021, Atmosphere

Emission changes

NOx: 33%

NMVOCS: 0.4%

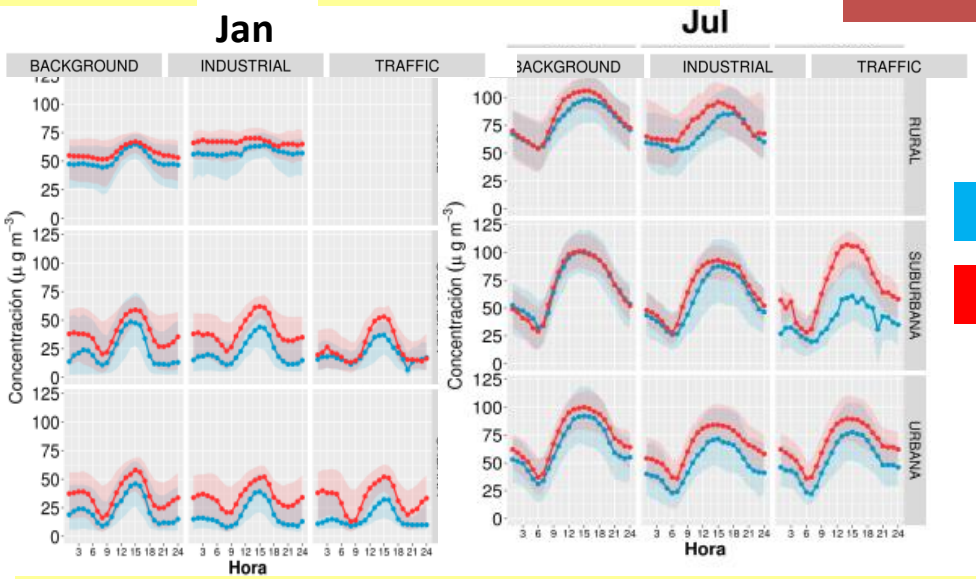
NO2: Decrease of concentration **O3**: Increase of concentration, specially for minimum values. No change or slight reduction of maximum values, specially in rural areas.



NOx and O3 (from observations, NAPCP and COVID)

Past observations

Diurnal Ozone Cycle



2000-2002

2016-2018

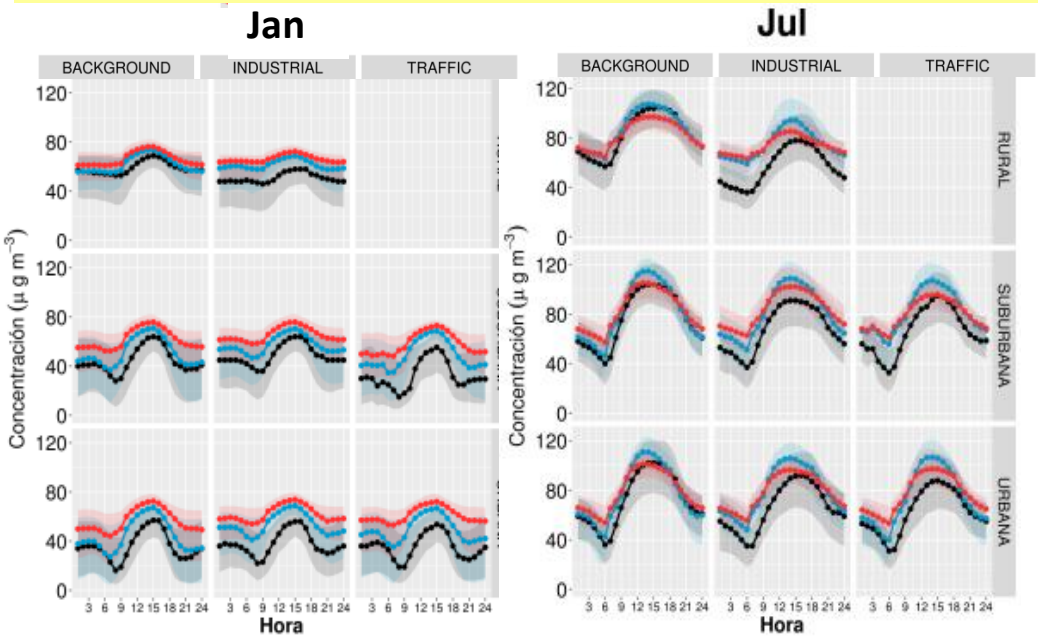
Less NOx and ant. NMVOCs emissions

OBS 2015, 2016, 2017, 2018, 2019

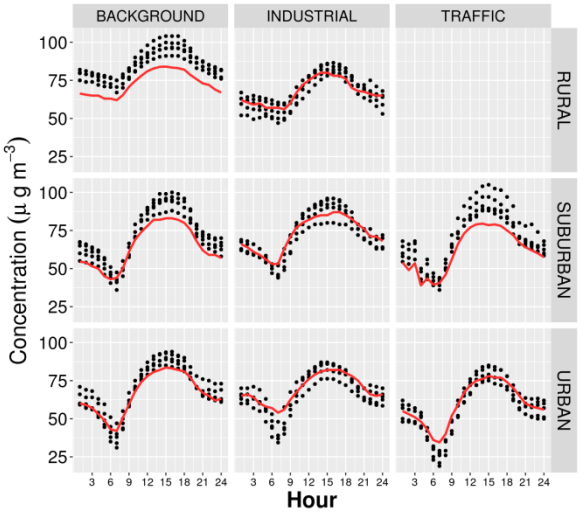
OBS 2020

Less NOx and ant. NMVOCs emissions

National Air Pollution Control Programme ,(NAPCP) **WAM 2030 , model estimates)**



COVID, observations



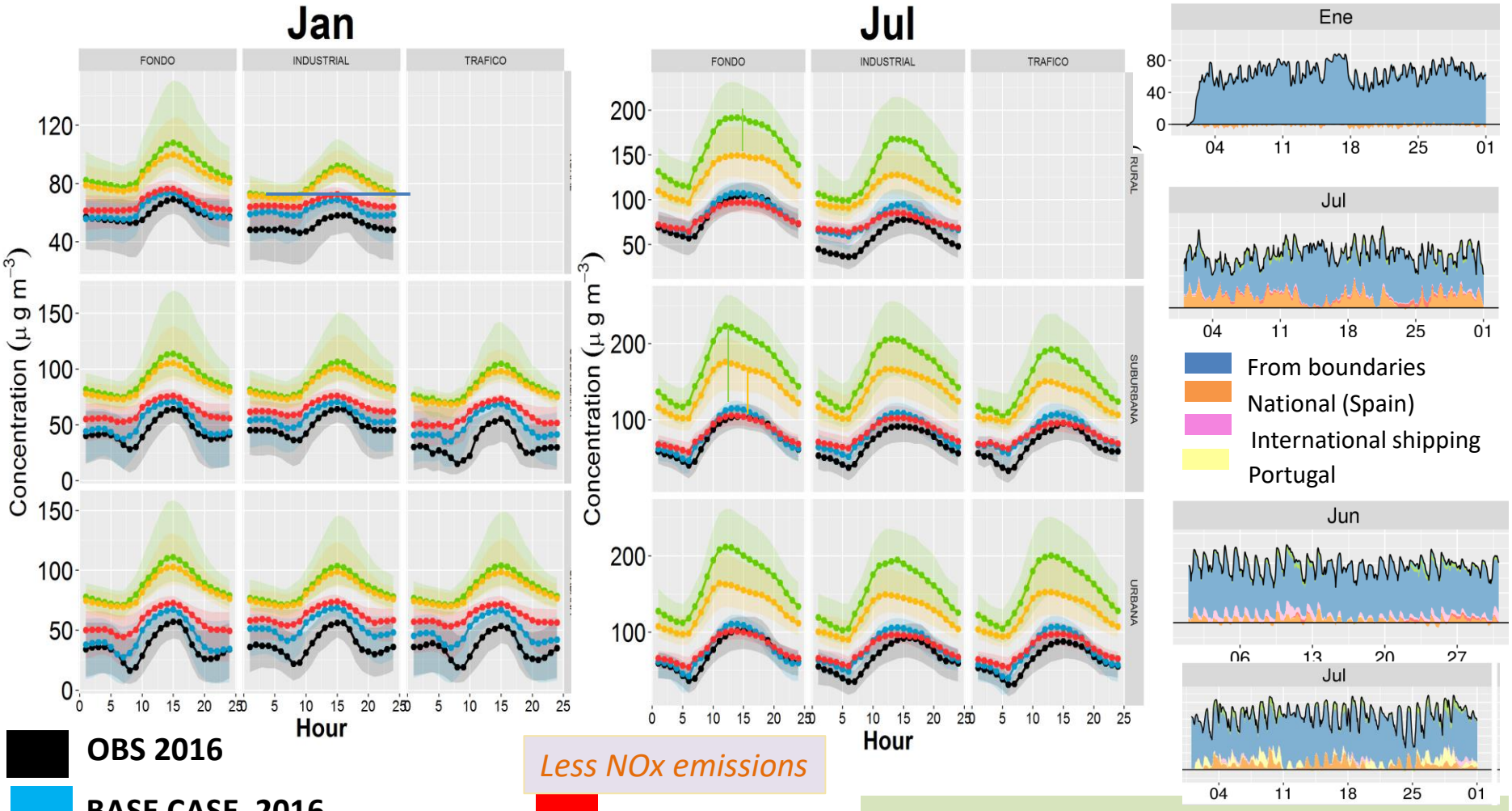
OBS

BASE CASE 2016

WAM 2030

Less NOx emissions

National Air Pollution Control Programme (NAPCP, **WAM 2030), model estimates**



OBS 2016

BASE CASE 2016

BASE CASE 2016 ~~NO+O3~~

Less NOx emissions

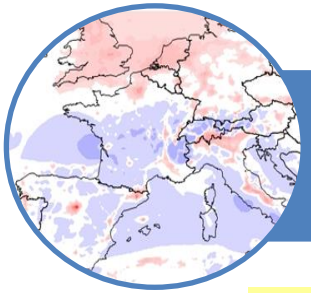
WAM 2030

WAM ~~NO+O3~~

$$O_3 + NO \rightarrow NO_2 + O_2$$

- Low impact of local emission reduction in winter
- Winter: Titrating background ozone? And titrating O3 produced by other non-national sources ?
- Annual mean increasing because of increasing lower values: does this have an impact?

On-going studies: Impact of other reactions involving VOCs, radicals; In combination with contributions; emission reductions

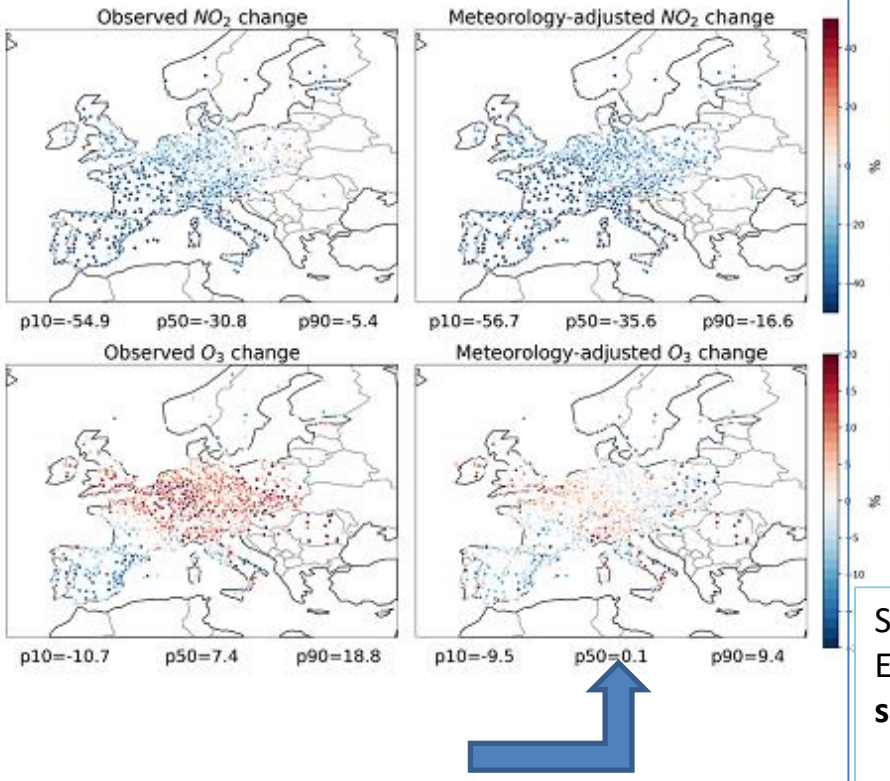


COVID simulations

O3 and NOx

From Ordoñez et al. 2020

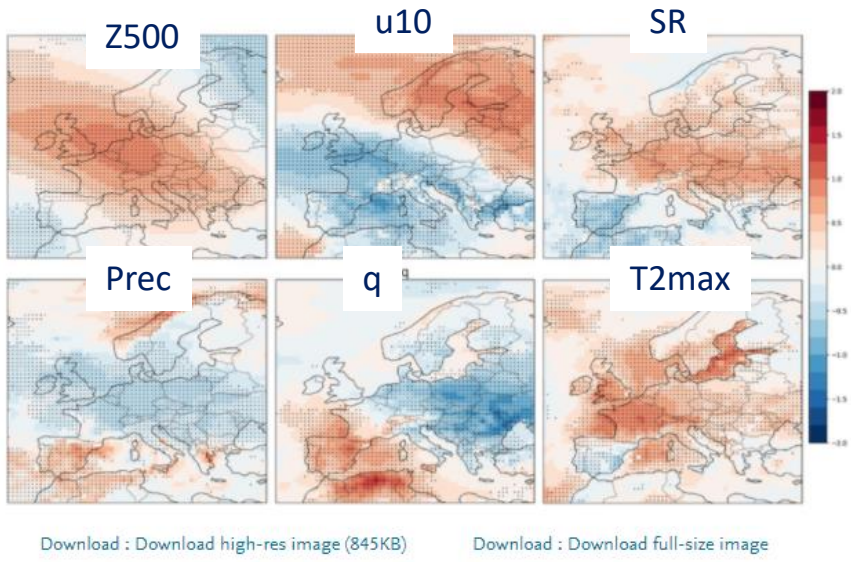
Average anomalies (%) of the observed **1-h daily maximum NO2** (top) and max 8-hourly O3 (bottom) (**background sites**) **in 2020 related to 2015–2019**. (**15 March-30 April)**



Average meteorologically-adjusted changes (%) (difference between the observed concentrations and the concentrations estimated by a generalised additive model (GAM))

Figure from Ordoñez et al. 2020

Analysis of **anomalies of some meteorological fields** : **15 March – 30 April 2020** compared to the same period in **1981–2010**



Significantly positive Z500 anomalies over large parts of Europe (apart from the SW and NE of the domain)→ **supressed zonal winds in the lower levels**

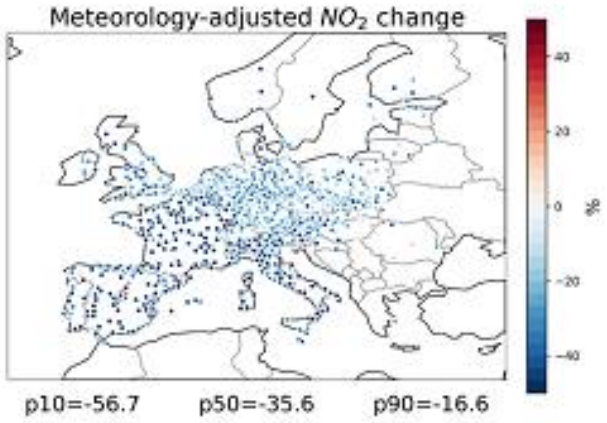
A **strong contrast between the Iberian Peninsula and the rest of Europe**:

- **positive anomalies of precipitation and specific humidity**
- **negative anomalies of solar radiation and temperature**

Carlos Ordóñez a,∗, Jose M. Garrido-Perez a,b, Ricardo García-Herrera (2020) , Early spring near-surface ozone in Europe during the COVID-19 shutdown: Meteorological effects outweigh emission changes Science of the Total Environment 747 (2020) 141322

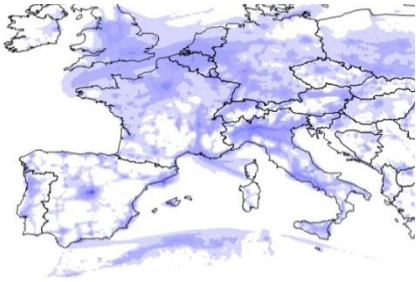
OBS (Ordóñez et al. 2020)

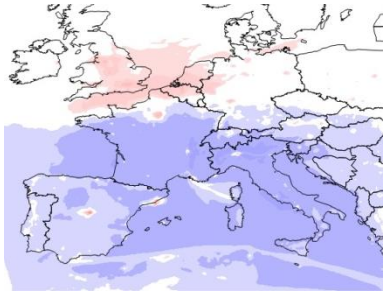
Average meteorologically-adjusted changes (%)



MODEL RESULTS

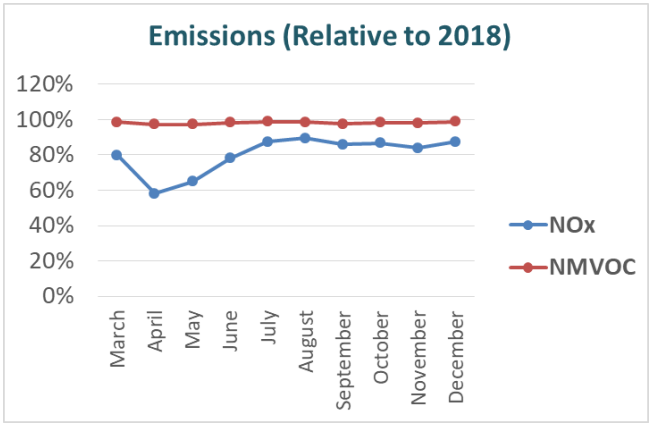
CHIMERE model; Meteo 2020; emissions 1) 2018 and 2) COVID emissions





Emissions:

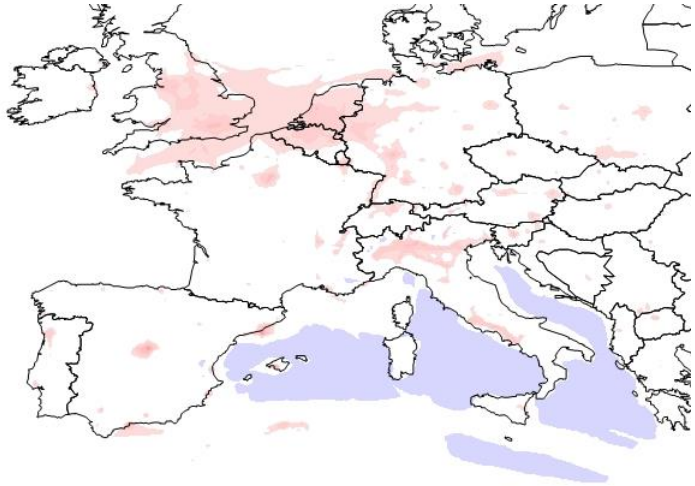
- Guevara et al. 2021 (**until 31/07/2021**)
- **1/08/→31/12**, ellaborated in CIEMAT (Rodriguez et al. In preparation)



- **Carlos Ordóñez** a,∗, Jose M. Garrido-Perez a,b, Ricardo García-Herrera (2020) , Early spring near-surface ozone in Europe during the COVID-19 shutdown: Meteorological effects outweigh emission changes Science of the Total Environment 747 (2020) 141322
- **Guevara, M.,** Jorba, O., Soret, A., Petetin, H., Bowdalo, D., Serradell, K., Tena, C., Denier van der Gon, H., Kuenen, J., Peuch, V.-H., and Pérez García-Pando, C.: Time-resolved emission reductions for atmospheric chemistry modelling in Europe during the COVID-19 lockdowns, Atmos. Chem. Phys., 21, 773–797, https://doi.org/10.5194/acp-21-773-2021, 2021

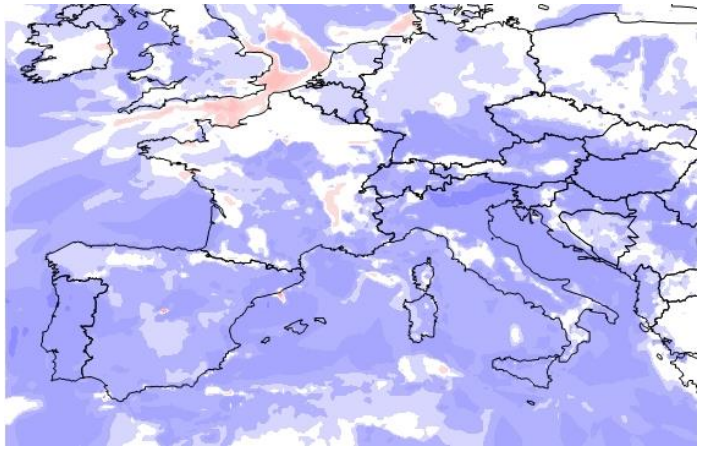
CHIMERE model Meteo 2020; Differences of O3 concentration considering 1) 2018 emissions and 2) COVID emissions

Annual Mean



No change or some increases over some areas

Maximum 8-hourly

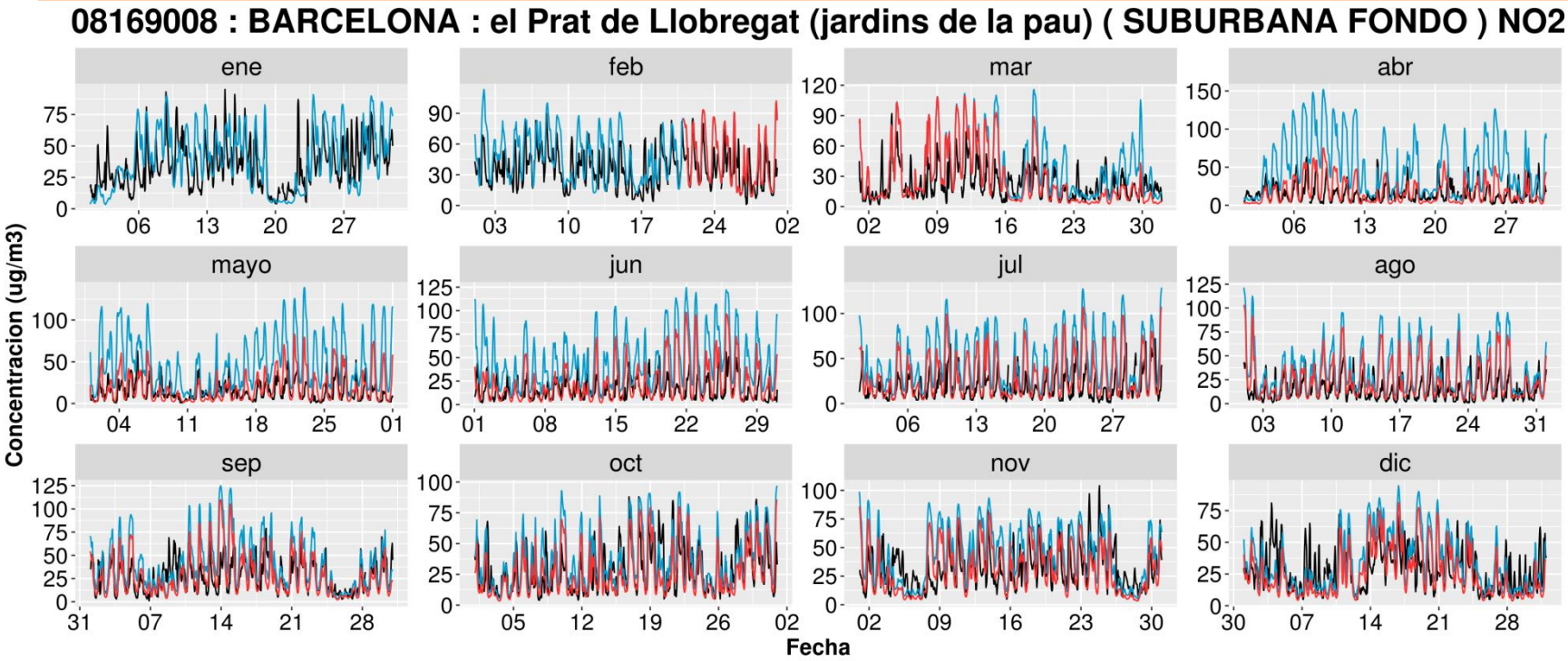


Mainly: a general decrease of maximum 8-hourly. No changes over some parts

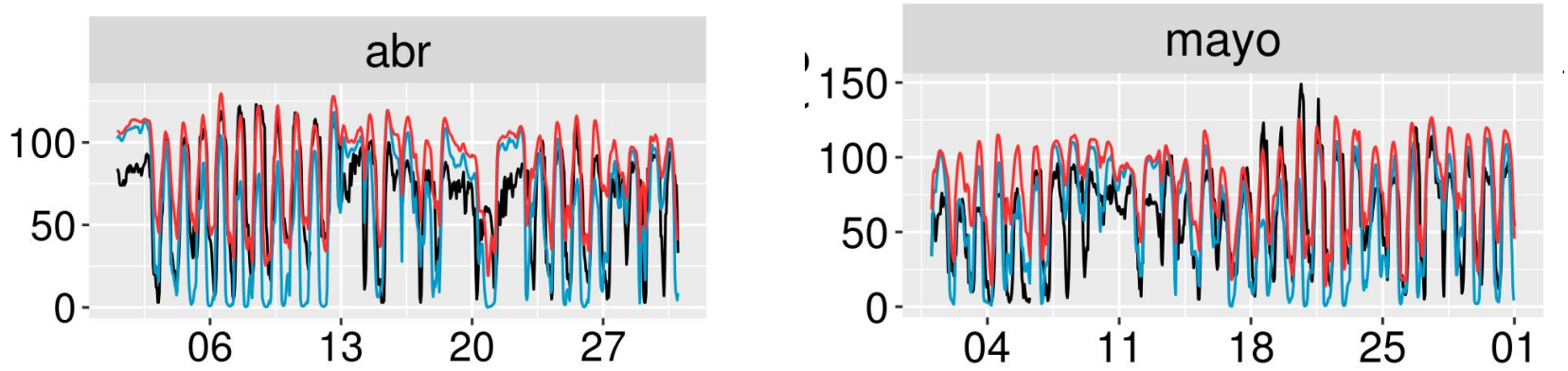
PRELIMINARY

NO2

2018 emissions
COVID emissions

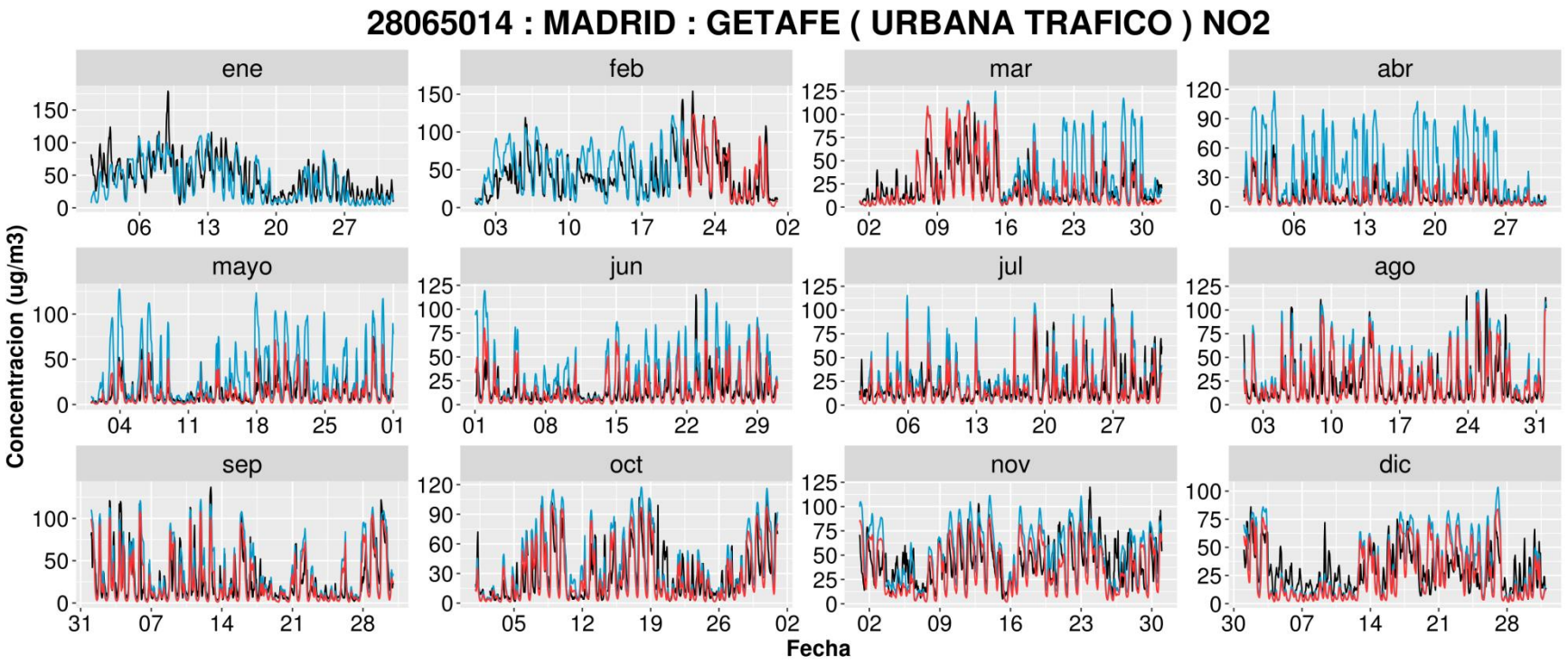


OZONE

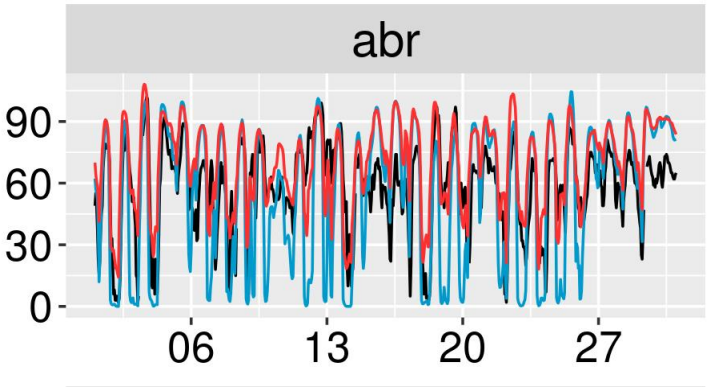


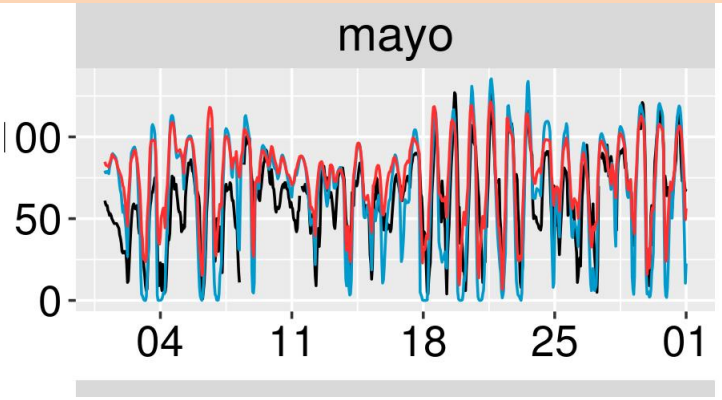
NO2

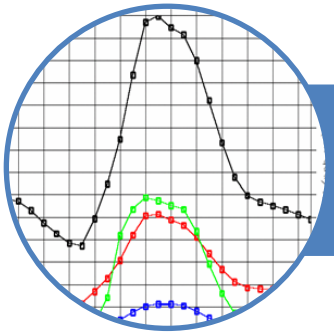
2018 emissions
COVID emissions



OZONE



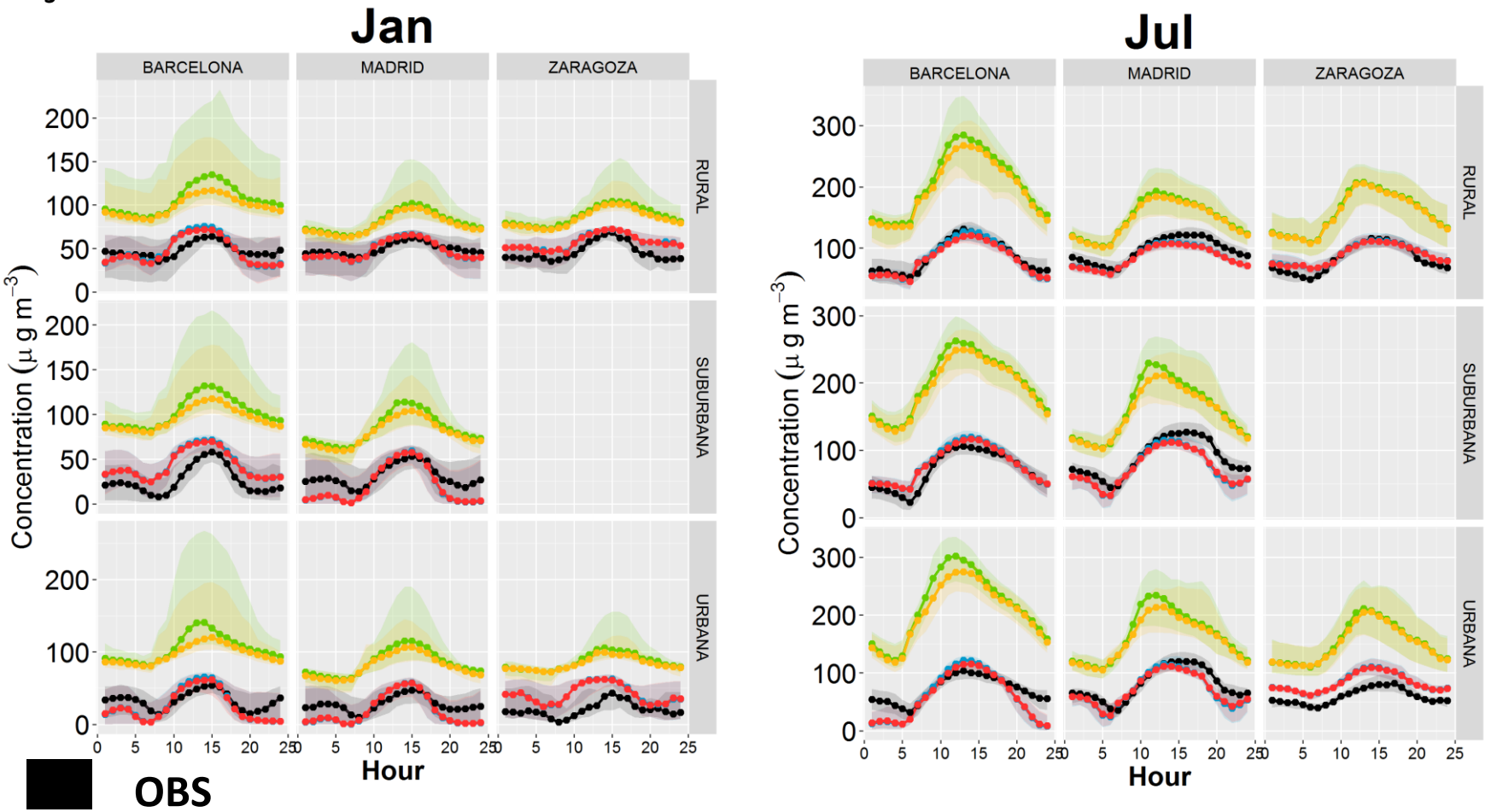




Model answers depending on chemical mechanism

Comparison between MELHIOR2 and SAPRC07

O_3 – Background stations in Barcelona, Madrid and Zaragoza



$$O_3 + NO \rightarrow NO_2 + O_2$$

On-going studies: Impact of other reactions involving VOCs, radicals

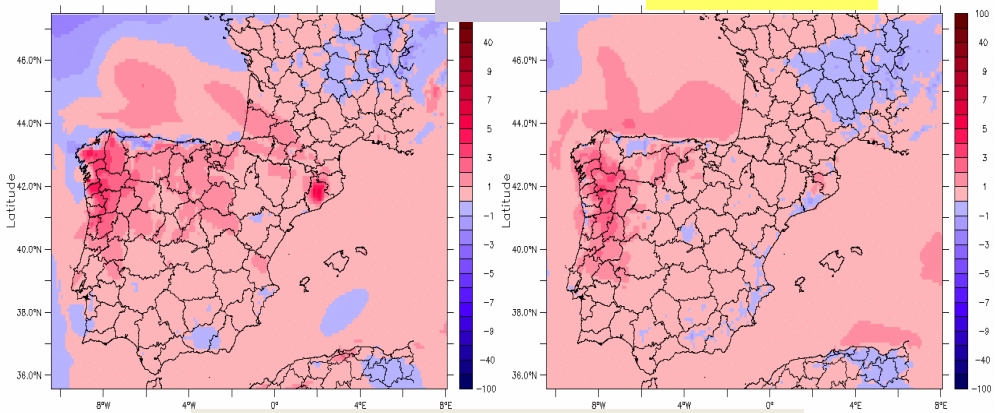
Differences for some compounds (large for PAN)

18 JULY, 2016

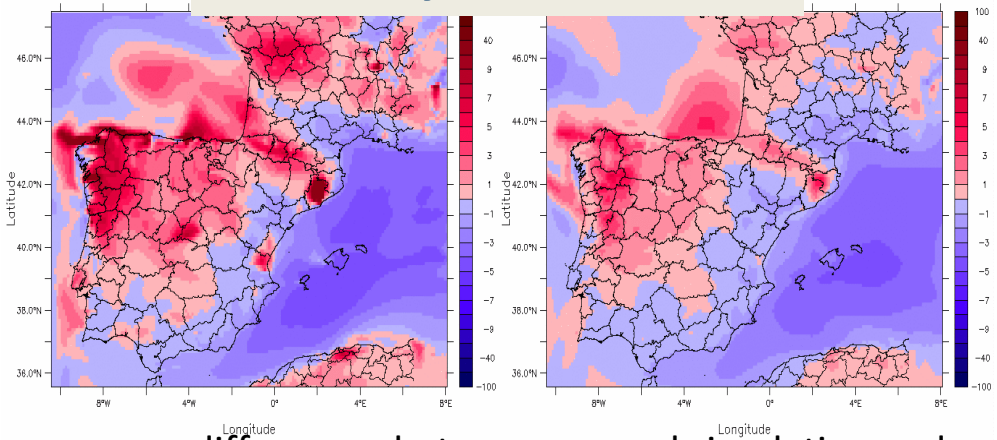
DIFFERENCES BETWEEN CHEMICAL MECHANSIMS

MELCHIOR – SAPRC07

daytime O3 **night**



Sensitivity to NO-titration

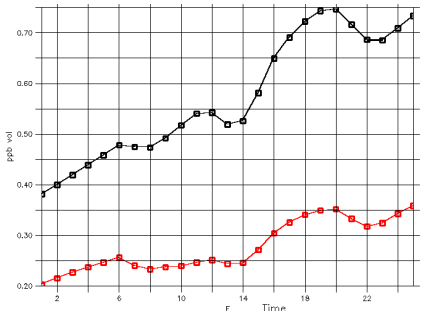


differences between normal simulation and simulation without nitration .

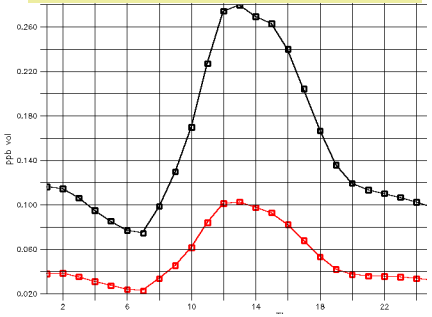
July, 18, 2016

PAN

Site in Cataluña



Site in Barcelona

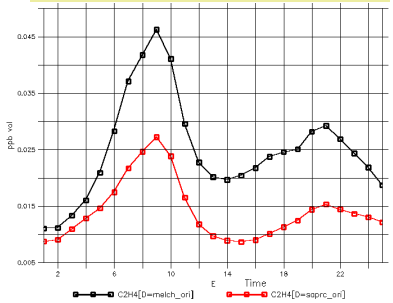


MELCH - ORI

SAPRC - ORI

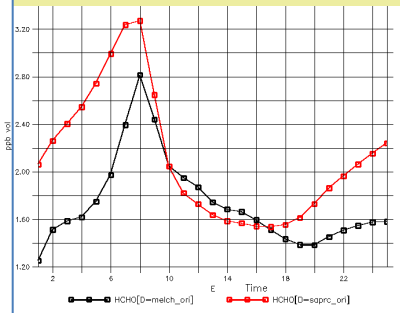
C2H4

Site in Andalucía



HCHO

Site in Barcelona



Very important to have measurements of VOCs!

Thank you

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*Retos-AIRE: Ai**R** pollution mitigation actions for **E**nvironmen**T**al p**O**licy **S**upport. **AIR** quality multiscale modelling and evaluation of h**E**alth and vegetation impacts* ***RTI2018-099138-B-100 Plan Nacional I+D+i***