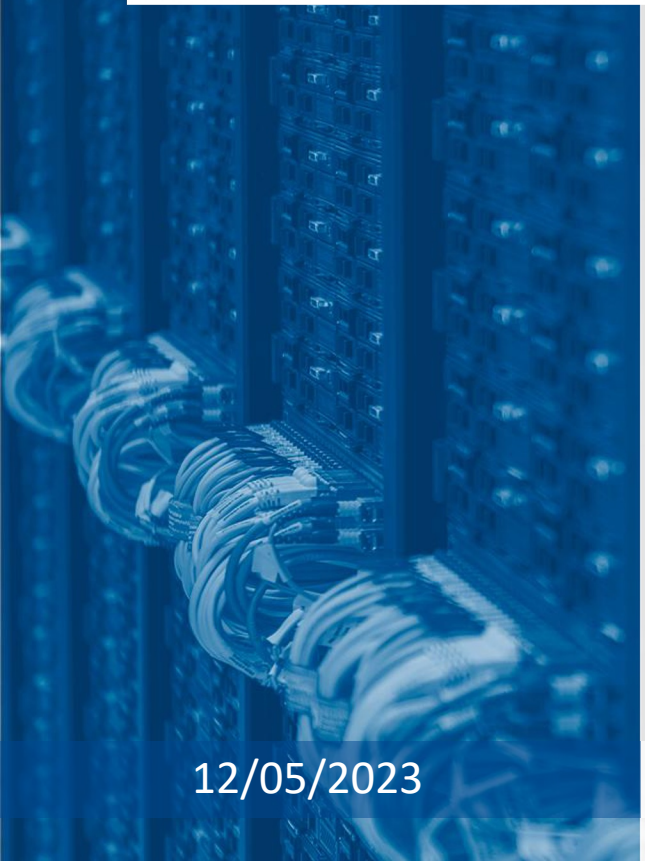


Assessing ozone abatement scenarios in the framework of the Spanish Ozone Mitigation Plan

Hervé Petetin[1], Marc Guevara[1], Roger Garatachea[1], Franco López[1], Kevin Oliveira[1], Santiago Enciso[1], ***Oriol Jorba***[1], Xavier Querol[2], Jordi Massagué[2], Andrés Alastuey[2] and Carlos Pérez García-Pando[1]

[1]*Barcelona Supercomputing Center, Earth Sciences department, Atmospheric Composition group*
[2]*Institute of Environmental Assessment and Water Research*

12/05/2023

24th EMEP Task Force on Measurement and Modelling Meeting

Objectives

- **To assess the impact of abatement emission measures defined by the *official national plan of energy and climate* (PNIEC) and the *national air pollution control program* (PNCCA) on ozone levels in Spain**

- **To explore additional abatement measures in key emission sectors (e.g. road transport, emissions from use of solvents, industry, aviation, shipping) to further mitigate ozone levels in Spain**

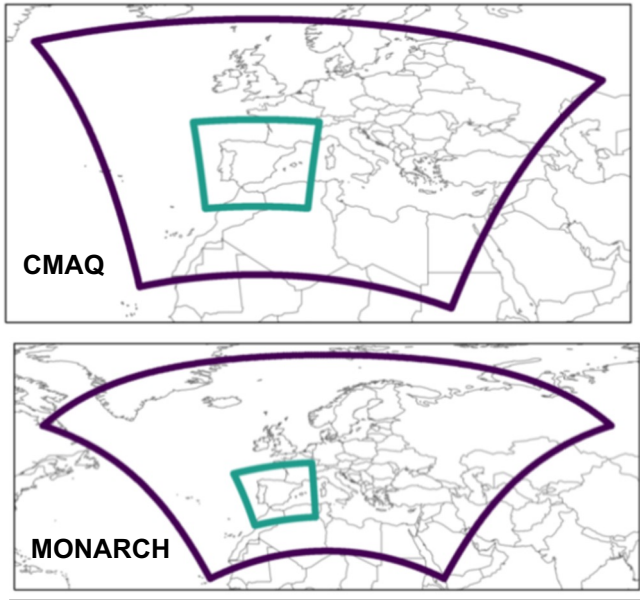
Petetin et al. 2023 (submitted)

Methodology

Air quality Models and setup

- 2 models (robustness in sensitivities and model uncertainty): **WRF-CMAQ**, **MONARCH**
- Same anthropogenic emissions: CAMS-REG-ANT-v4.2 (Europe), HERMESv3 bottom-up (Spain)
- Period of study July 2019

Model	CMAQ	MONARCH
Domains	Europe (12km)/Spain (4km) Lambert Conformal Conic	Europe (20km)/Spain (5km) Rotated latitude-longitude
	37 vertical layers (top 50 hPa)	24 vertical layers (top 50 hPa)
Meteorology (BC)	WRFv3.5 (FNL)	NMMB (ERA5)
Chemistry (BC)	CMAQv5.0.2 CB05 + AERO6 (CAMS)	Online CB05 + BSC aerosols (CAMS)
Natural emissions	MEGAN (biogenic)	MEGAN (biogenic) + GFAS



Emission scenarios

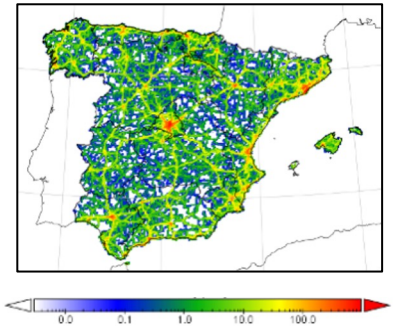
Scenario	Description
Base case (**BE**)	Reference year 2019, combine HERMESv3 (BSC bottom-up emissions for Spain) + MITERD (LPS, PRTR-Spain, fleet composition and official use of solvents) + CAMS-REG (shipping emissions)
Planned emissions (**PE**)	BE + emission changes projected for 2030 according to measures proposed in PNIEC and PNCCA plans of Spain (consistent with projected data 2030 CLRTAP)
Specific scenario 1 (**SE_T50**)	BE + PE with the assumption that only 50% of emission reductions projected for road transport in PE will be achieved
Specific scenario 2 (**SE_S25**)	BE + PE + with -25% additional reduction of emissions from use of solvents
Specific scenario 3 (**SE_I25**)	BE + PE + with -25% additional reduction of the industrial emissions from refineries and manufacturing plants of other non-metallic mineral products except for cement plants
Specific scenario 4 (**SE_A25_M20**)	BE + PE + with -25% and -20%* additional reduction of emissions from aviation and shipping, respectively. *In line with expected reduction in case of the implementation of a nitrogen emission control area (NECA) zone in the Mediterranean Sea.
Specific scenario 5 (**SE_A25_M60**)	BE + PE + with -25% and -60%* additional reduction of emissions from aviation and shipping, respectively. *More ambitious than a NECA.

Base case (BE) anthropogenic emissions

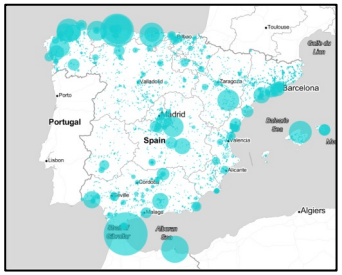
Processing emission scenarios using HERMESv3 system

- **BE** **Base case scenario**

Reference year 2019, combine HERMESv3 (BSC bottom-up emissions for Spain)
+
Spanish Emission Inventory MITECO (energy and manufacturing industry - *Large Point Sources*, *Pollutant Release and Transfer Register*-Spain -, fleet composition and official use of solvents)
+
CAMS-REG (rest Europe, shipping emissions)



NOx emissions (t/yr)



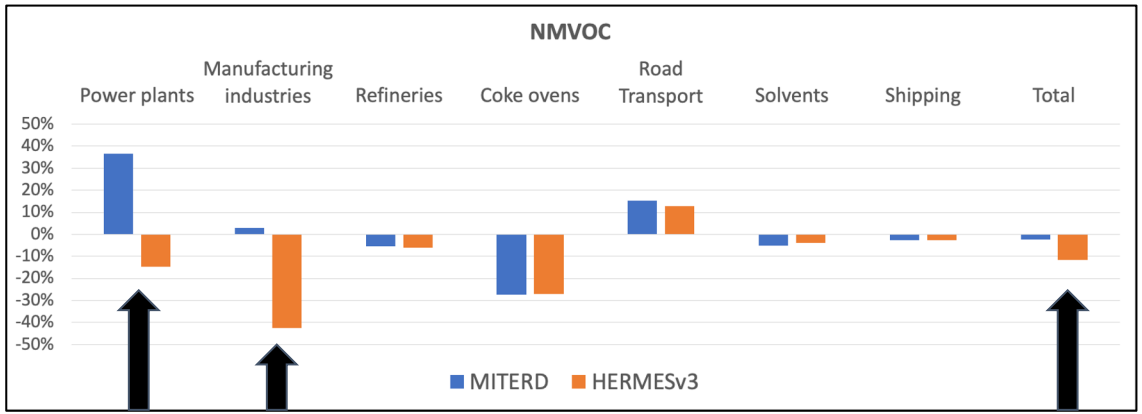
NOx emissions of large point sources

Planned emission scenario (PE)

Processing emission scenarios using HERMESv3 system

- **BE** **Base case scenario**
- **PE** **Planned emission scenario**

BE + emission changes projected for 2030 according to measures proposed in PNIEC and PNCCA plans of Spain (consistent with projected data 2030 CLRTAP)



NMVOCs emission difference (%) between MITERD and HERMESv3

Lack of information to distribute expected increase of NMVOC emissions from future biomass power plants

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Specific scenarios

Processing emission scenarios using HERMESv3 system

		Emission reduction (reference EB) E(NOx)	E(VOCs)
● **BE**	**Base case scenario**		
● **PE**	**Planned emission scenario**	-37.0%	-4.9%

Specific scenarios:

● **EE_T50**	**PE with lower reductions in road transport (-30% instead -60%)**	-23.1%	-5.1%
● **EE_S25**	**PE with higher reductions in use of solvents (-25%)**	-37.0%	-18.1%
● **EE_I25**	**PE with higher reductions in industry (-25%)**	-38.8%	-5.0%
● **EE_A25_M20**	**PE with higher reductions in aviation (-25%) and shipping (-20%)**	-38.3%*	-5.0%*
● **EE_A25_M60**	**PE with higher reductions in aviation (-25%) and shipping (-60%)**	-40.4%*	-5.2%*

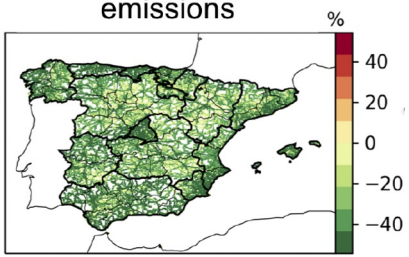
(less ambitious than PE)
(more ambitious than PE)

**excluding international shipping*

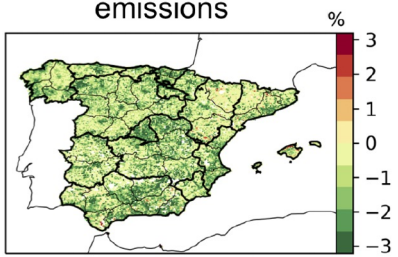
Results

Planned scenario vs Base case scenario

Planned change NOx anthropogenic emissions

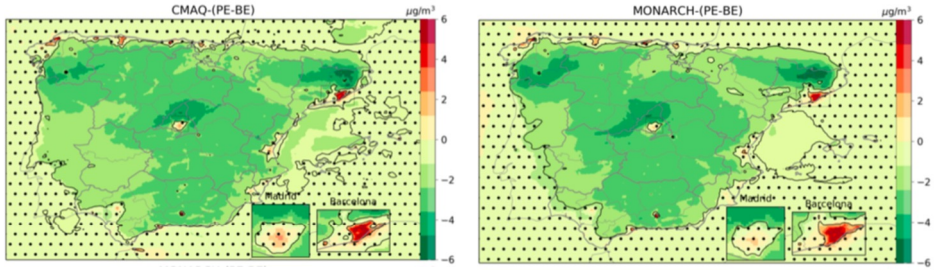


and NMVOC anthropogenic emissions

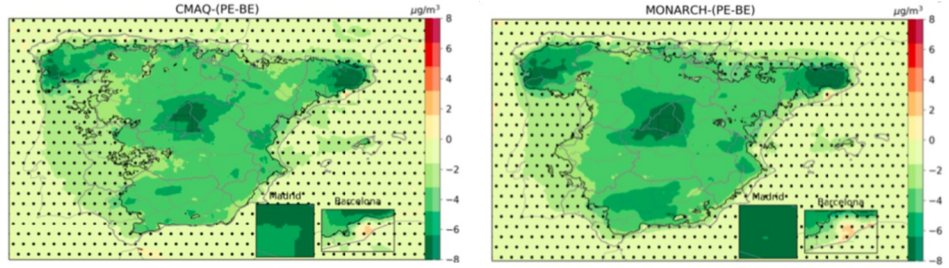


(2030 abatement plan)

Expected change in **hourly mean O_3** in July 2019



BE-PE (µg/m³)
mean -2.4/-2.4
min -68.4/-51.0
max 89.2/42.5



BE-PE (µg/m³)
mean -3.8/-4.0
min -26.9/-44.5
max 29.4/13.7

Expected change in **daily 8-hour max O_3** in July 2019

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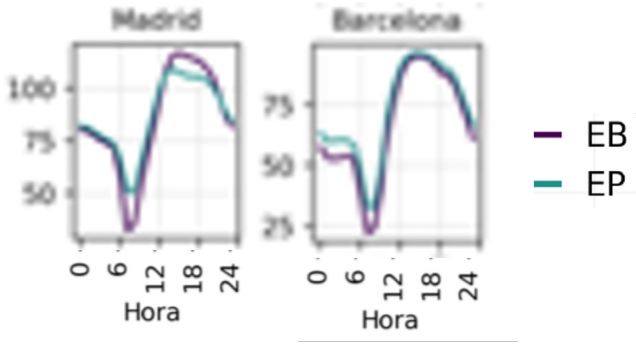
Statistically significant? YES NO

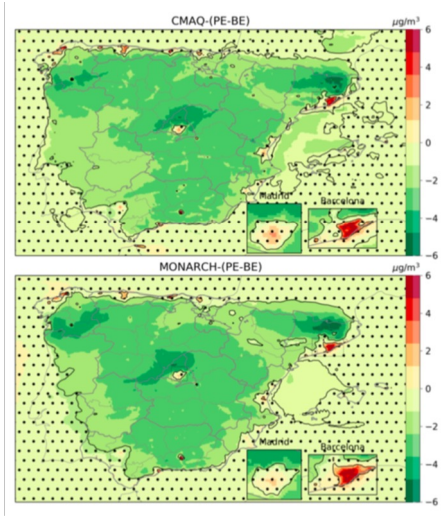
Consistent results between the two models, more robust conclusions

Planned scenario vs Base case scenario

Titration effect more relevant in some coastal cities

Mean daily profile: **O_3 increase during the early morning compensated by a decrease in the afternoon in Madrid city but not in Barcelona city**

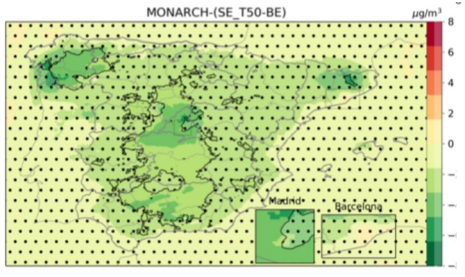


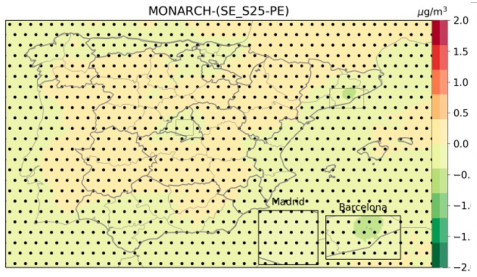


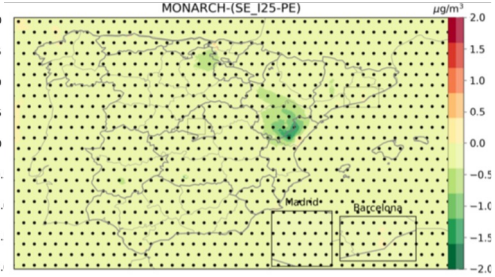
Mean difference O_3 (MD8h) July 2019

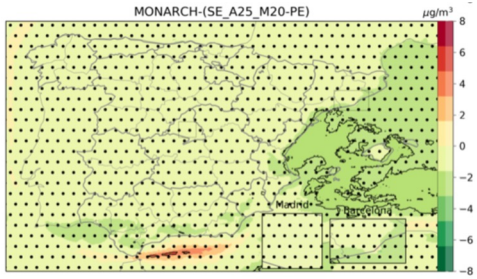
Specific scenarios

Statistically significant? **YES** **NO**









SE_T50 : -30% instead of -60% reduction of **road transport PE**

Achieving only half the objective of reduction of road transport emissions implies achieving **only 50-60% of the O_3 reductions** expected with PE.

Road transport is the key sector for achieving generalized reduction of O_3 in Spain.

SE_S25: -25% reduction of emissions from **use of solvents**

Limited and localized impact

Main benefit in **slight attenuation of O_3 increase in Barcelona** metropolitan area

Weak impact could be due to **uncertainties in NMVOC emissions** or **limited reduction** compared with -60% NOx in PE

*Different colorbar range

SE_I25: -25% industry emissions

Limited impact downwind areas where industry emission reductions occur (e.g., Castellón, País Vasco) with some reductions in O_3

*Different colorbar range

SE_A25_M20: -25% aviation and **-20%** shipping

Substantial reduction of O_3 in specific coastal areas (up to a few 100 km in-land) on the south-eastern Spain

O_3 increases in the Gibraltar shipping route (reduced titration)

Reducing aviation emissions does not result in any significant impact

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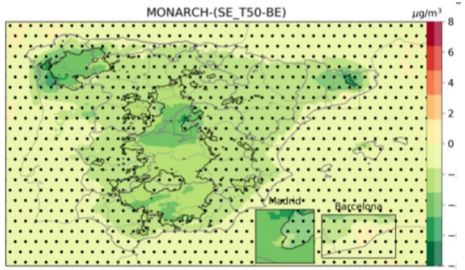
Mean difference O_3 (MD8h) July 2019

Specific scenarios

Statistically significant? **YES** **NO**



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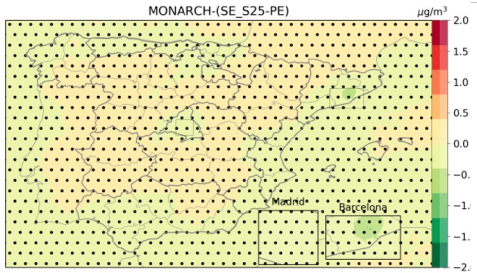

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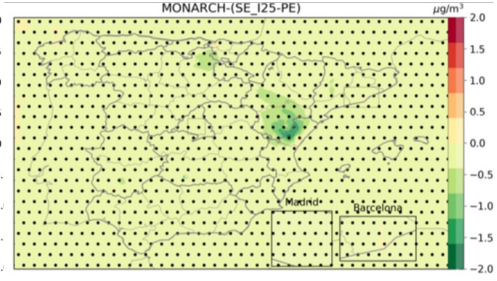

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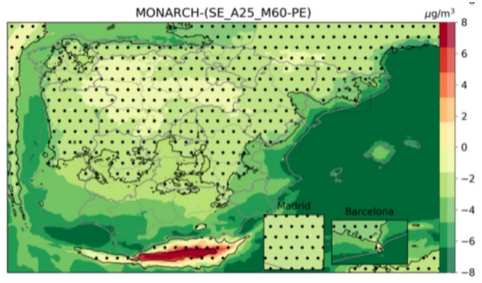
*Different colorbar range



SE_A25_M60: -25% aviation and **-60%** shipping

More ambitious reduction of shipping emissions achieve stronger reductions in O_3 with major changes over the Mediterranean coast up to 300 km in-land

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Impact on the number of daily exceedances

Applying the model-based relative change of O_3 concentrations to the observations:

- **Days with O_3(MD8h) > 120 µg/m3: -37% reduction (-55% with strong abatement of maritime sector)**
- **Days with O_3(h) > 180 µg/m3: -77% reduction (-85% with strong abatement of maritime sector)**

Region	Threshold	N(OBS)	SE_T50	PE	SE_S25	SE_I25	SE_A25_M20	SE_A25_M60
ESP	$120^{(d8max)}$	1217	-22%	-37%	-38%	-38%	-44%	-55%
AND	$120^{(d8max)}$	143	-32%	-50%	-51%	-51%	-58%	-74%
ARA	$120^{(d8max)}$	53	-41%	-53%	-53%	-56%	-61%	-69%
CyL	$120^{(d8max)}$	88	-28%	-38%	-38%	-40%	-44%	-49%
CIM	$120^{(d8max)}$	78	-26%	-51%	-51%	-52%	-55%	-62%
CAT	$120^{(d8max)}$	208	-16%	-28%	-31%	-30%	-39%	-54%
NAV	$120^{(d8max)}$	5	-80%	-90%	-90%	-90%	-90%	-90%
MAD	$120^{(d8max)}$	385	-15%	-33%	-34%	-33%	-37%	-44%
VAL	$120^{(d8max)}$	140	-20%	-31%	-31%	-34%	-43%	-62%
EXT	$120^{(d8max)}$	47	-26%	-49%	-49%	-52%	-53%	-61%
GAL	$120^{(d8max)}$	3	-50%	-67%	-67%	-67%	-67%	-83%
BAL	$120^{(d8max)}$	42	-18%	-25%	-25%	-25%	-44%	-55%
PV	$120^{(d8max)}$	13	-46%	-46%	-46%	-46%	-50%	-62%
AST	$120^{(d8max)}$	2	0%	0%	0%	0%	0%	0%
MUR	$120^{(d8max)}$	10	-20%	-35%	-35%	-35%	-55%	-70%
ESP	$180^{(d1max)}$	44	-44%	-77%	-81%	-78%	-80%	-85%
CyL	$180^{(d1max)}$	1	0%	-100%	-100%	-100%	-100%	-100%
CIM	$180^{(d1max)}$	1	0%	-100%	-100%	-100%	-100%	-100%
CAT	$180^{(d1max)}$	20	-45%	-62%	-68%	-62%	-65%	-78%
EXT	$180^{(d1max)}$	2	0%	0%	0%	0%	0%	0%
MAD	$180^{(d1max)}$	17	-50%	-100%	-100%	-100%	-100%	-100%
VAL	$180^{(d1max)}$	3	-67%	-83%	-100%	-100%	-100%	-100%

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Conclusions

- The **Planned emission scenario (PE)** allows a strong reduction of O_3(MD8h) of **-4 µg/m³ on average** and we estimate **-37% reduction of daily exceedances**.

- **Road transport** sector is a **key emission sector** for achieving the generalized reduction of O_3 over Spain.

- The **second key sector** appears to be the **maritime emissions** with major impacts in coastal areas (up to 100s km in-land).
  - The implementation of a NECA zone in the Mediterranean Sea should be considered in the future to help controlling shipping NOx emissions in this O_3 hotspot region.

- More **limited and localized response** is found in the other specific scenarios, including the **reduction of solvent, industry and aviation**.

- **Additional ambitious reductions of NMVOC emissions** could compensate the increase of O_3 in urban regions.

Ongoing and future works

Advancing the current knowledge on NMVOC

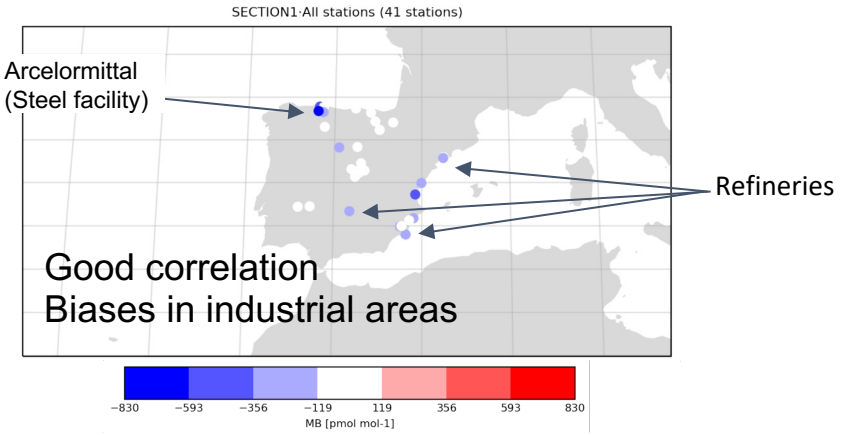
- Updating and improving NMVOC emission speciation profiles (Oliveira et al., 2023)[1]
  - Compilation and comparison of speciation profiles available from databases/literature
  - Speciation of NMVOC anthropogenic emissions (150 activities, more than 900 species)
  - Intercomparison of the NMVOC speciated inventories (HERMESv3 versus CAMS-REG)

- Evaluating MONARCH performance in simulating Benzene, Toluene and Xylene (work in progress)
  - Modelled versus observed concentrations using the national observational network
  - Review of emissions, temporal profiles, spatial proxies,...based on evaluation results
  - Performance of sensitivity tests (e.g., PRTR versus LPS NMVOC emissions in refineries)

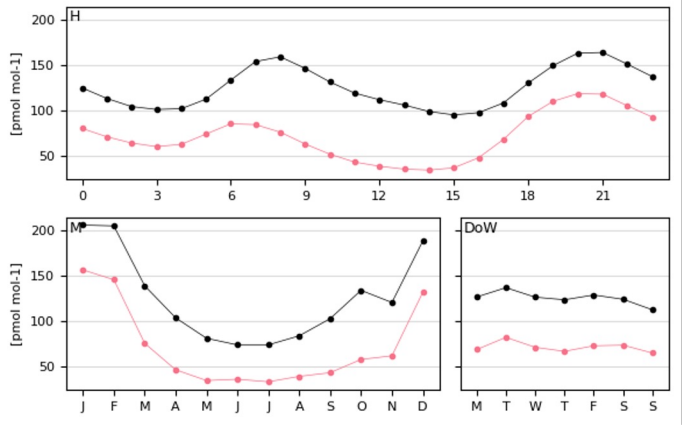
1. K. Oliveira, M. Guevara, O. Jorba, X. Querol, C. P. García-Pando, **A new NMVOC speciated inventory for a reactivity-based approach to support ozone control strategies in Spain**, Science of The Total Environment (2023) 161449.https://doi.org/10.1016/j.scitotenv.2023.161449

VOC evaluation

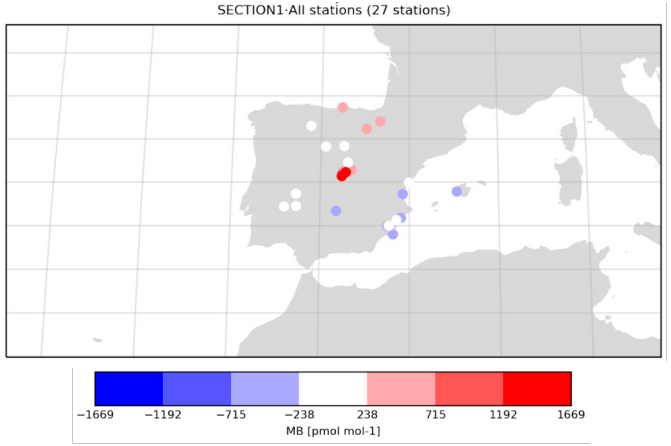
Benzene



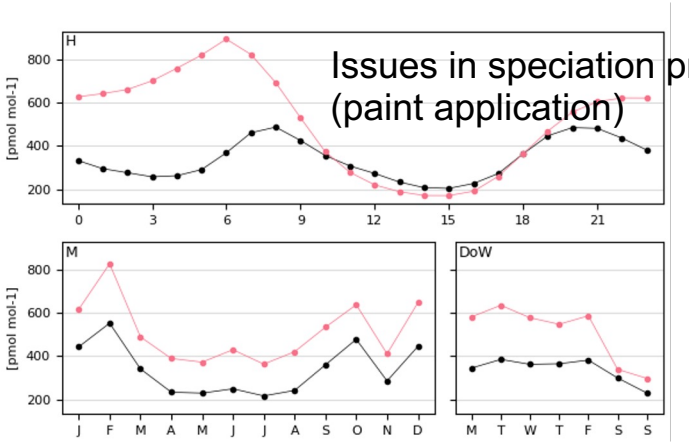
N	NMB	NME	RMSE	r
41	-43.0	47.5	69.58	0.83



Toluene



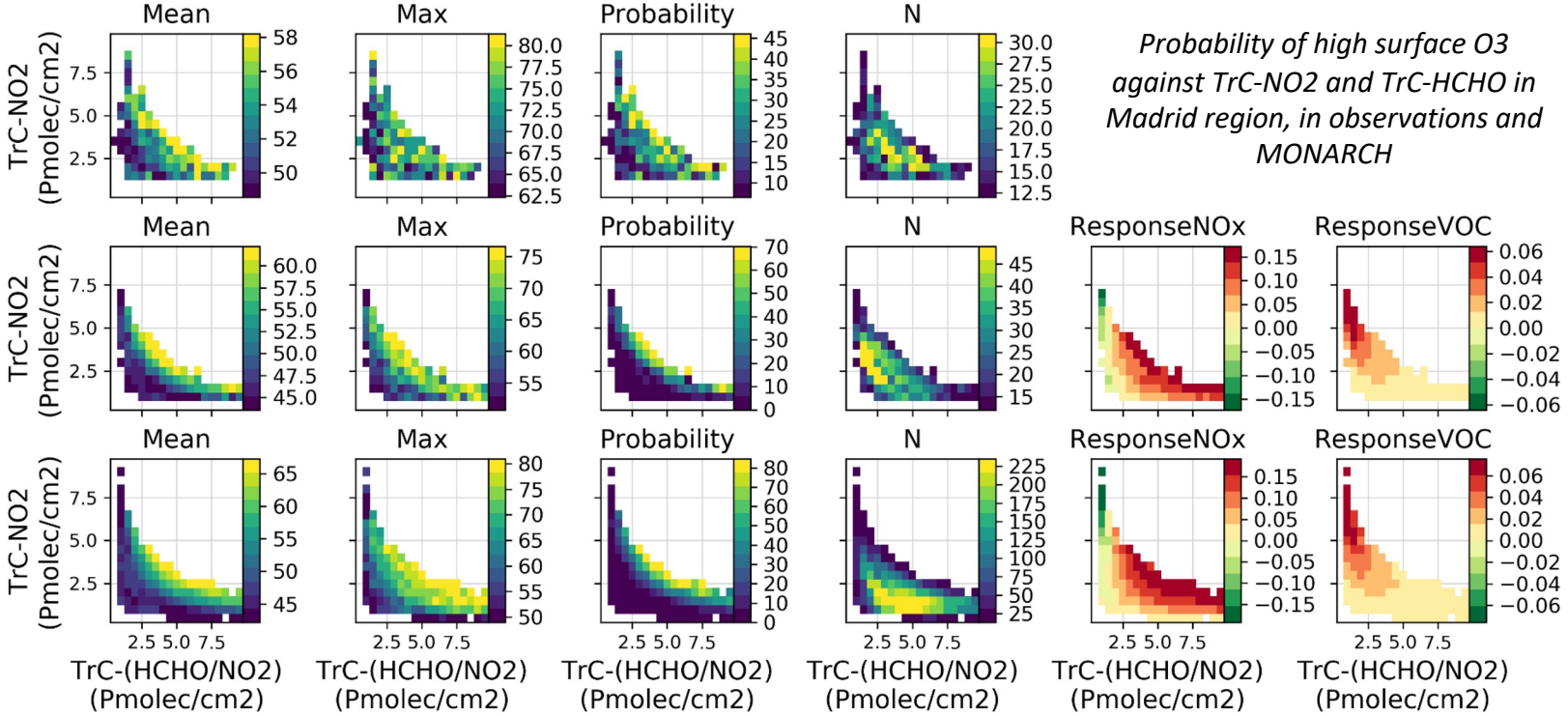
N	NMB	NME	RMSE	r
27	41.9	64.0	311.2	0.67



Issues in speciation profiles
(paint application)

O_3 sensitivity regimes

- Evaluating the O_3 sensitivity regime with TROPOMI HCHO and NO_2 observations (MITIGATE project)

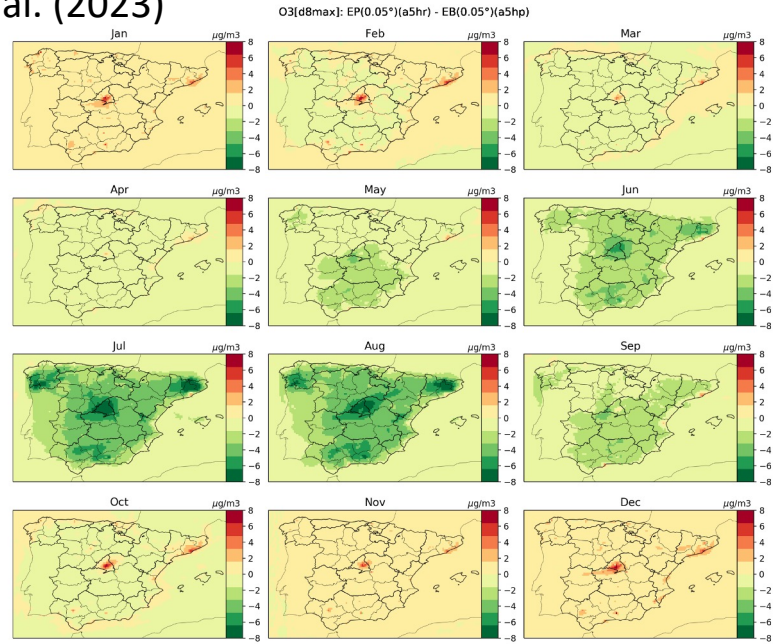


Future works

- Improve Base case emission inventory:
  - Biomass burning sources (e.g. agricultural waste burning, wildfires)
  - Emissions from manufacture of organic chemistry products
  - Production, transportation and storage of fossil fuels and fugitive emissions during vehicle refueling at gas stations
  - Update NMVOCs speciation based on Oliveira et al. (2023)

- Design of new specific scenarios (e.g. combination of previous ones, stronger reduction of NMVOCs)

- Extend the analysis to the full annual cycle.



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Thank you!

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