Influence of the modelling methodology on the assessment of impacts and air quality compliance. Spanish National Air Pollution Control Programme – 2023 (NAPCP-2023) case study.

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CIEMAT. Madrid, Spain

TFMM, Warsaw, May 6-7 2024

Updated National Air Pollution Control Programme – 2023 (NAPCP-2023)

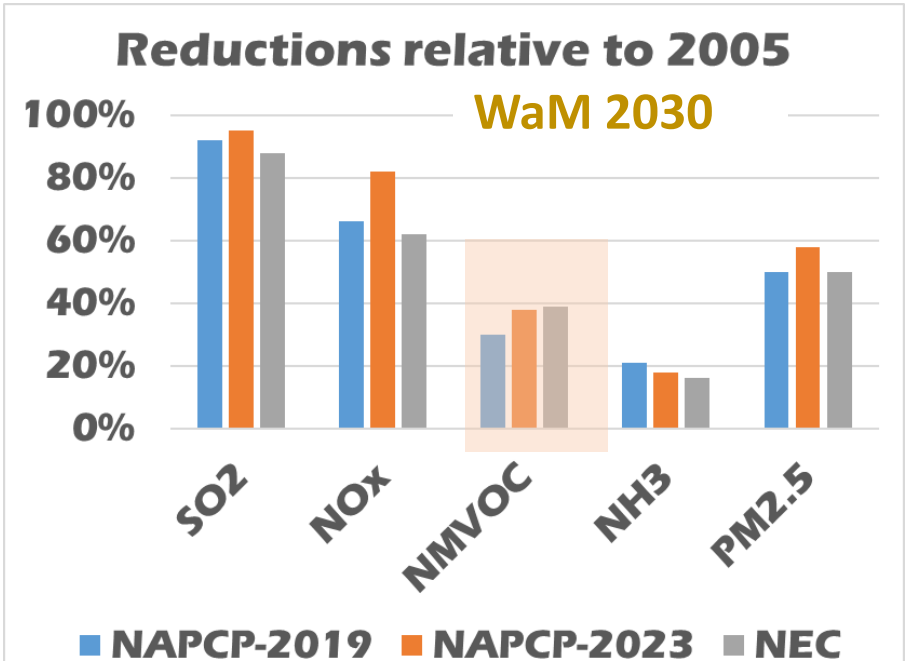
Developed by the Ministry for the Ecological Transition and Demographic Challenge (MITECO)

NAPCP-2023 contains emission reduction measures to meet the objectives for 2030 in the National Emission Ceilings Directive for Spain

NEC Objetives for Spain:

SO_x	88%
NO_x	62%
NMVOC	39%
NH_3	16%
PM2.5	50%

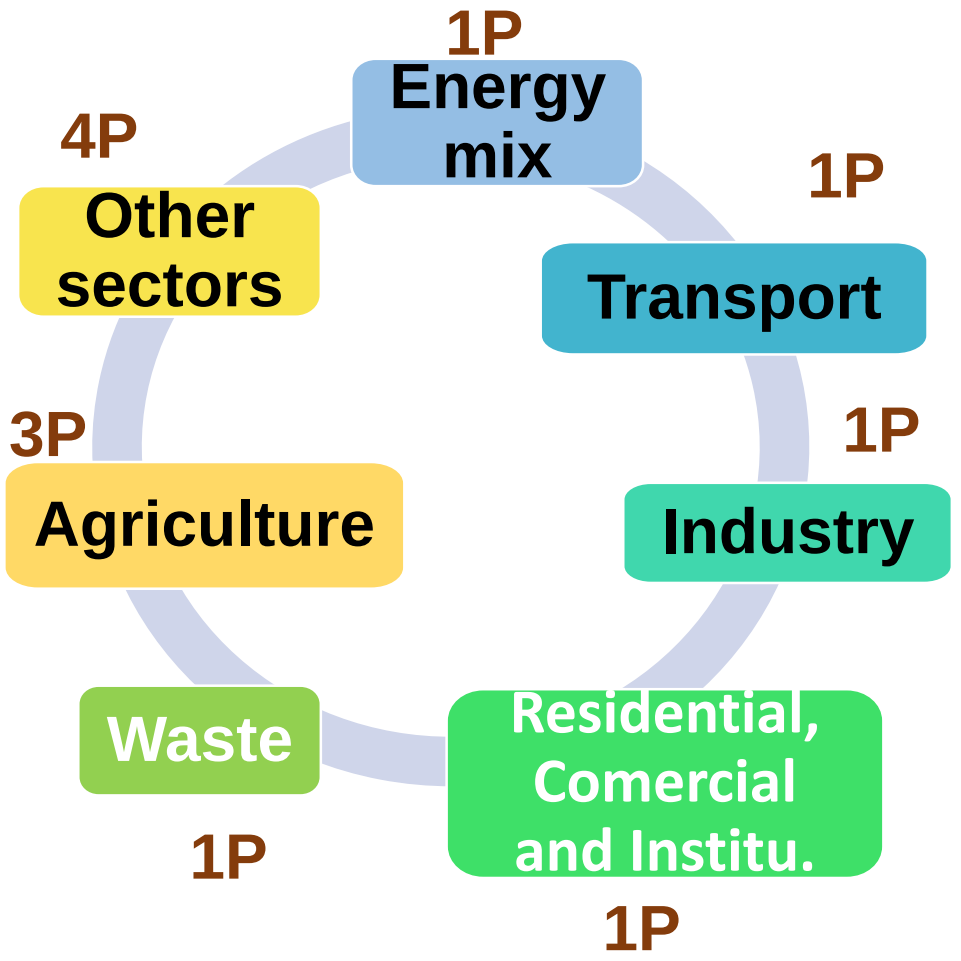
Relative to 2005



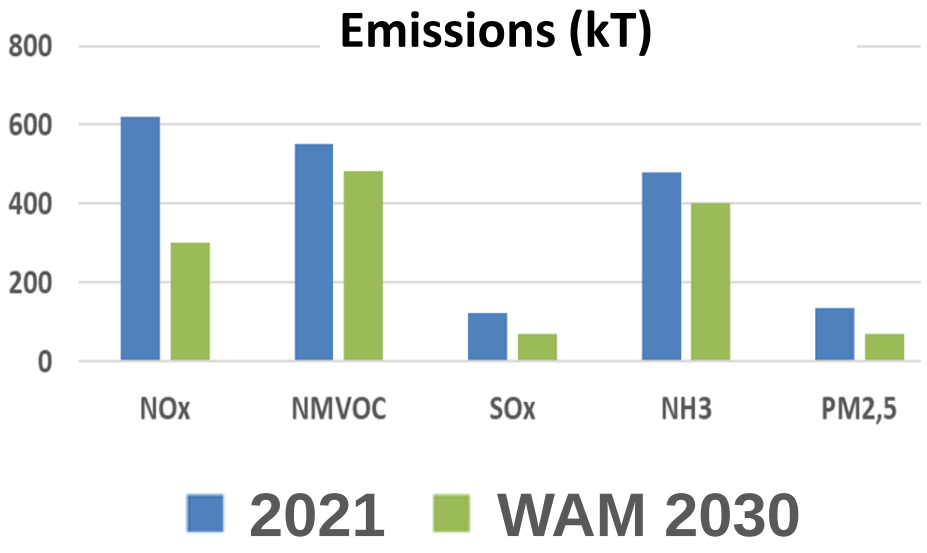
https://www.miteco.gob.es/content/dam/miteco/es/calidad-y-evaluacion-ambiental/sgalsi/atm%C3%B3sfera-y-calidad-del-aire/emisiones/pol-med/actualizacion_pncca2023_240115.pdf

E.1	Energy mix
T.1	Emission reductions for road transport, rail, aviation and shipping
I.1	Industrial Sector
EE.1	Improved energy efficiency in the residential, comercial, institutional and other sectors
RS.1	Waste
A.1	Use of fertiliser plans
A.2	Reduction of emissions form burning prunings
A.3	Manure and housing management for cattle, pigs and poultry
O.1	Reduction of emissions from residential wood burning
O.2	Reduction of emissions from the domestic use of solvents and paints
O.3	Public awareness campaigns
O.4	Reduction of tropospheric ozone precursors

12 packages of 61 measures



Methodology



- Chemistry and Transport Model: CHIMERE
- 0.08º x 0.08º (within a european simulation at 0.15º x 0.15º)
- 2021 emissions: Spain: MITECO. Rest of Europe: EMEP
- Emission reductions in WAM 2030: MITECO. Relative to 2021
- Meteorology: ECMWF-IFS 2021 (Thanks to AEMET for access to the MARS archive of ECMWF)
- Correction based on 2021 observations

CM(2021) = M(2021) + R(2021)

CM(WAM2030) = M(WAM2030) + R(2021) M(WAM2030)/M(2021)

CM: CORRECTED MODEL
M: MODEL
R: RESIDUAL (O-M)

NO2 **ANNUAL MEAN**

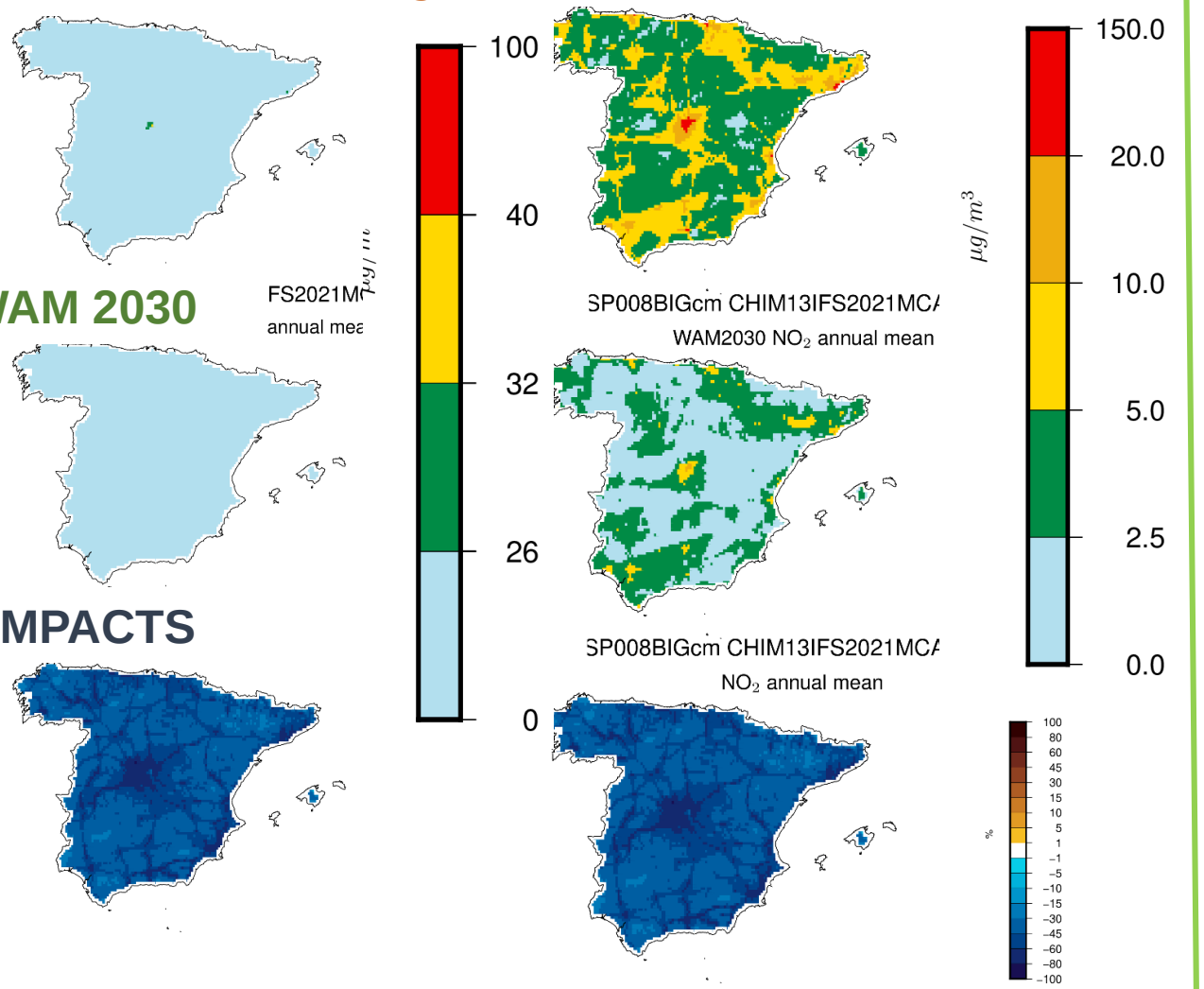
2021

WAM 2030

IMPACTS

CD

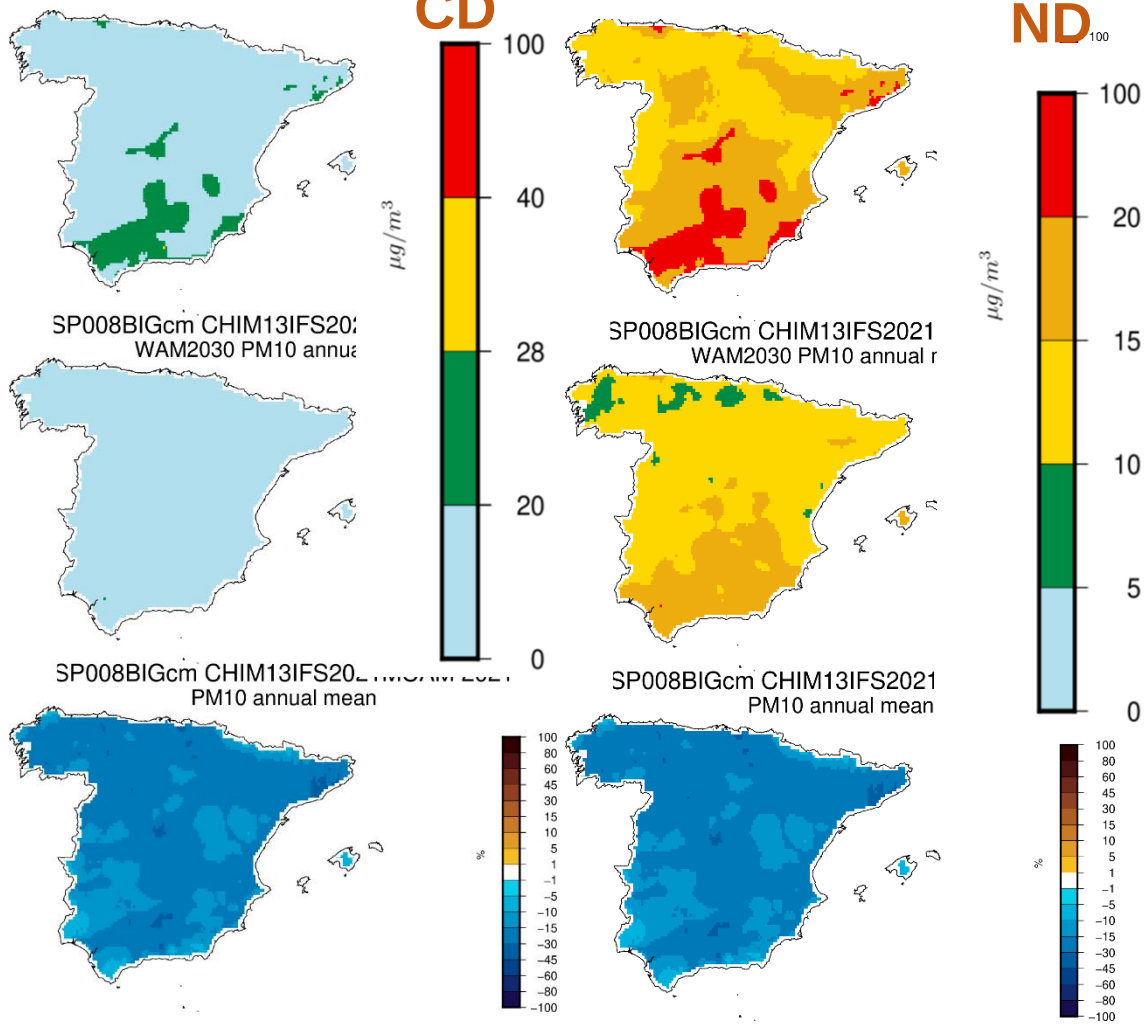
ND



PM10 **ANNUAL MEAN**

CD

ND

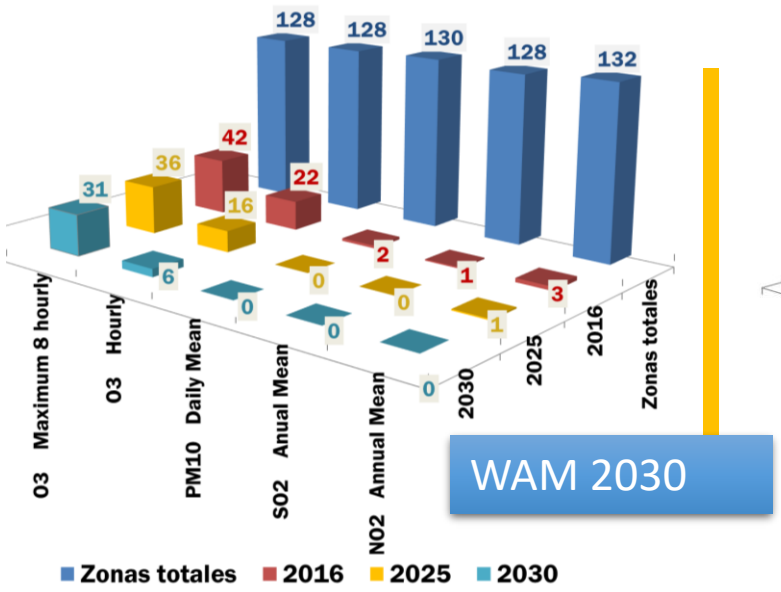


CD: Current Directive; ND: New Directive

Evaluation of the compliance with European legislation (AAQD)

Number of non-compliant air-quality zones

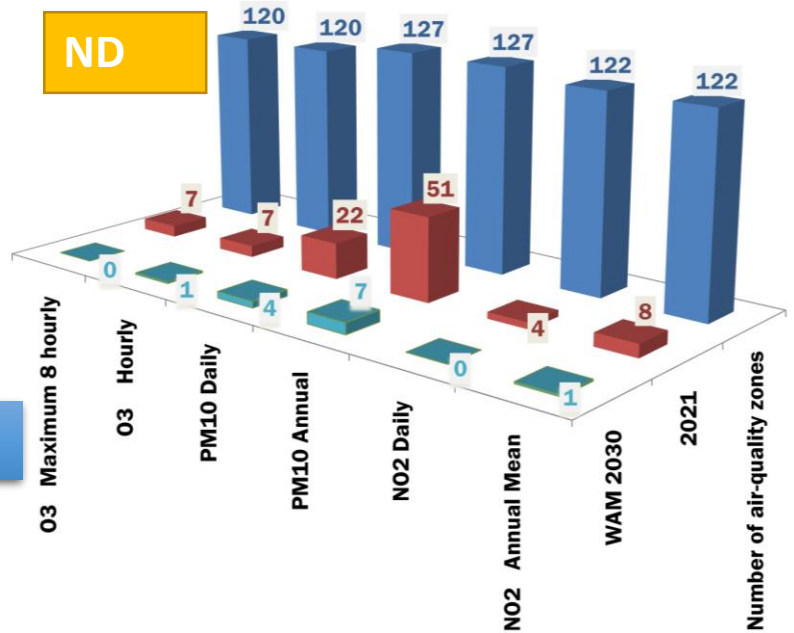
PNCCA-2019



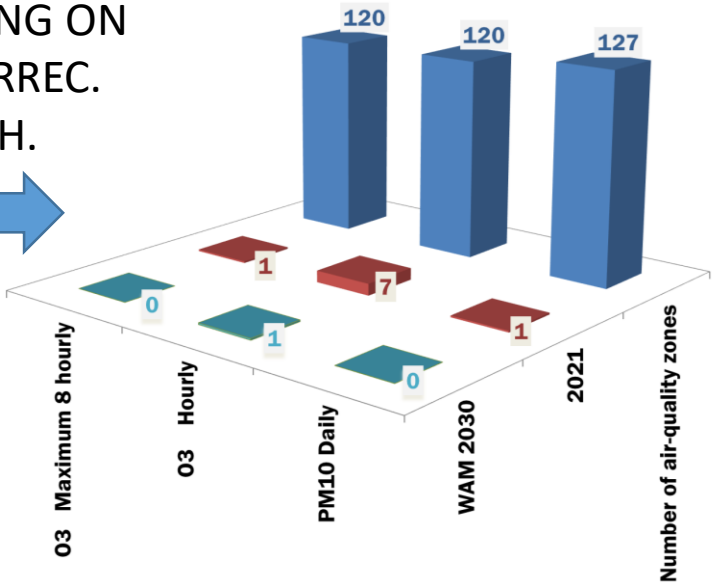
WAM 2030

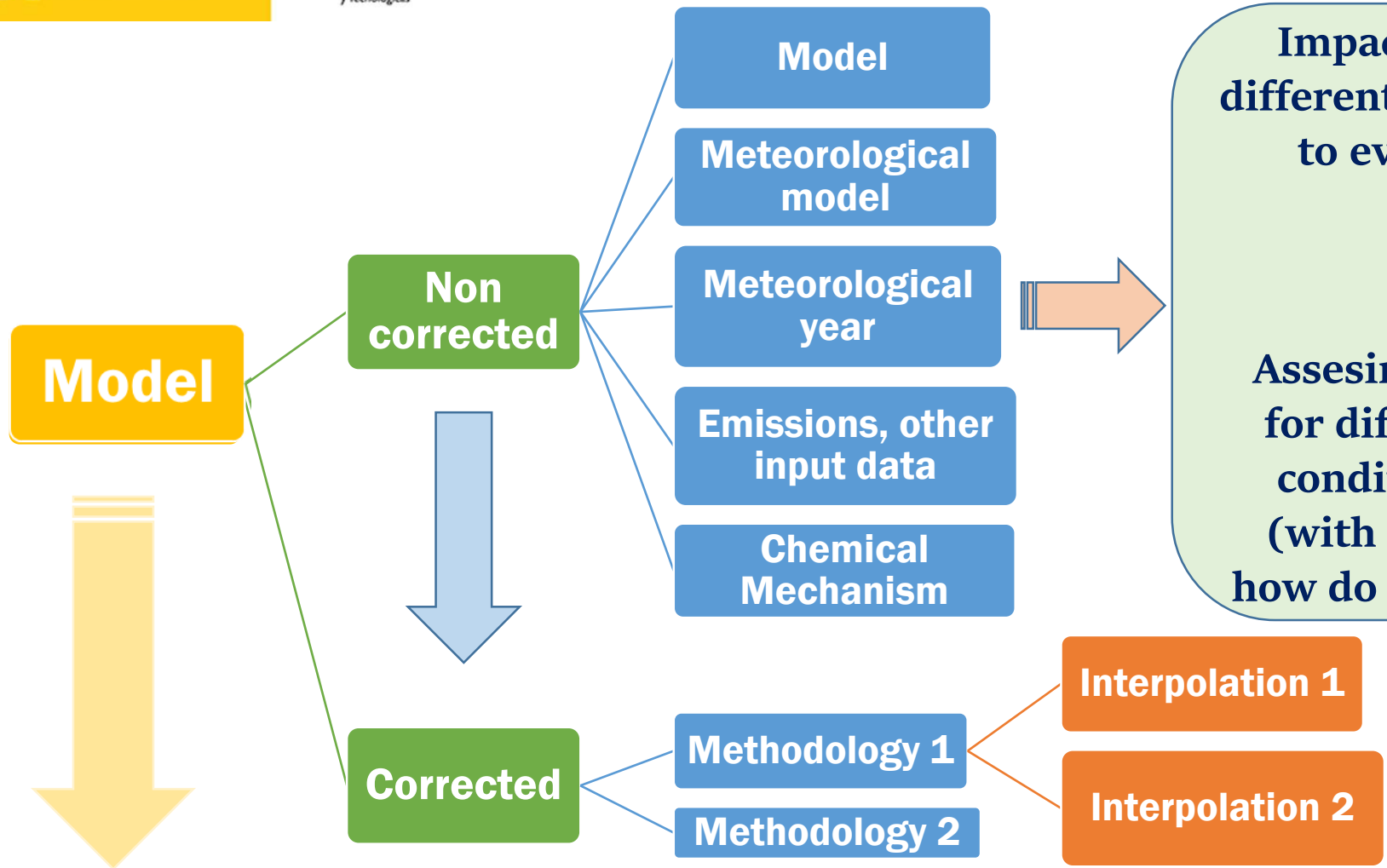
PNCCA-2023

ND



DEPENDING ON THE CORREC. METH.





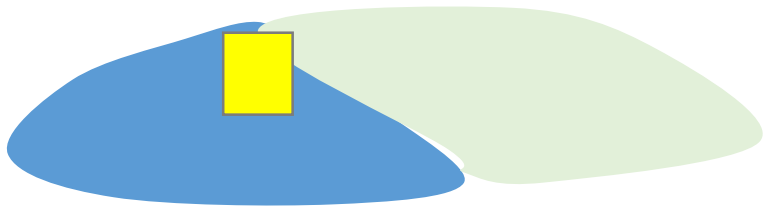
Impacts on air quality with different meteorologies are easy to evaluate with models,

BUT

Assesing the non-compliance for different meteorological conditions is very complex (with a "corrected model" – how do you do the correction?)

CONCENTRATION

In addition, how do we assign an uncompliant model cell to an air quality zone



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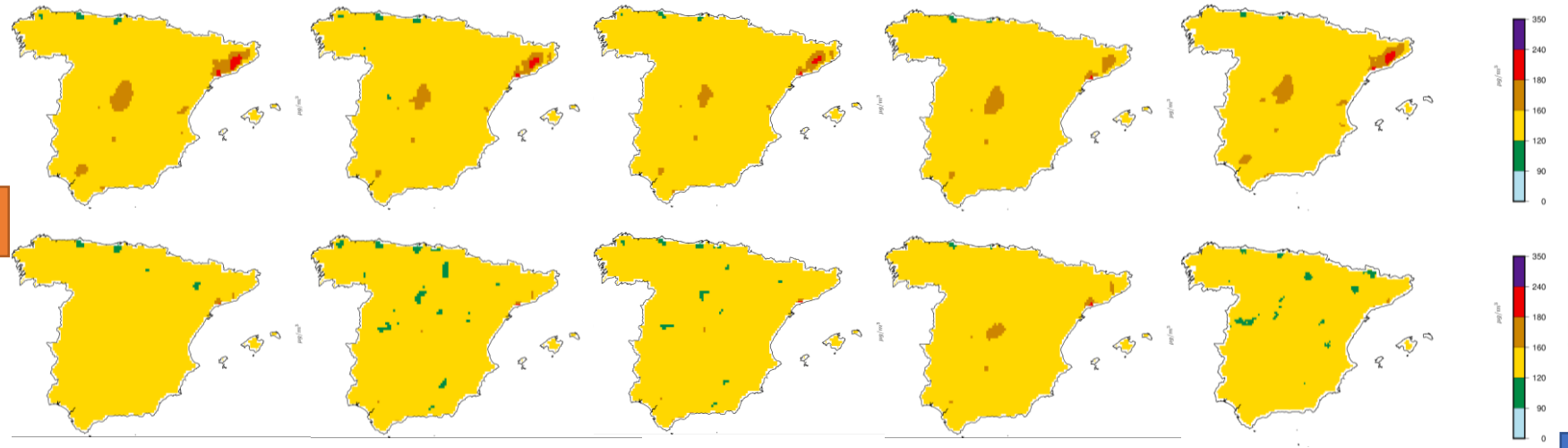
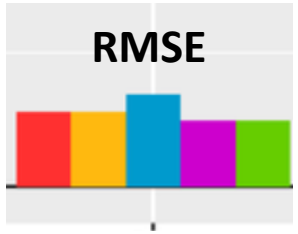
O3 MAX. H.

	CHIM13	CHIM17		
	Met Model: IFS	CHEM. MECH.: MELCHIOR2	CHEM. MECH.: SAPRC07	Met Model: WRF
	Res: 0.1°			Res. 0.08°
2021	7	5	4	1	6
WAM2030	1	1	1	1	0

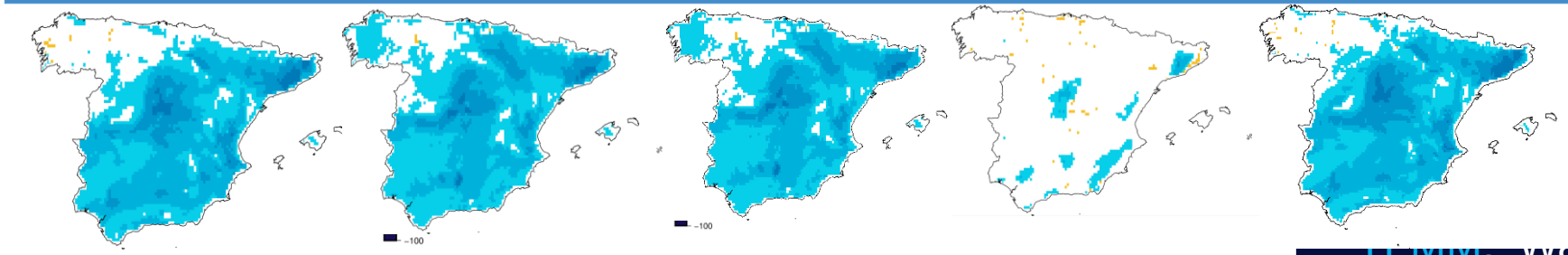
NON-COMPL. AQZ





NON-COMPL. AQZ

IMPACTS



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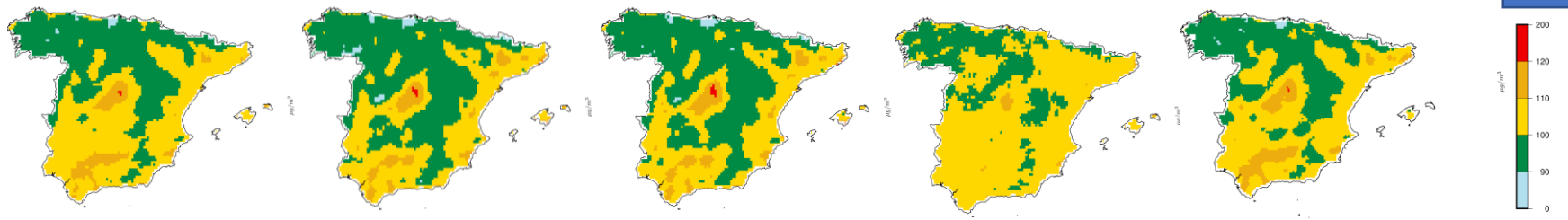
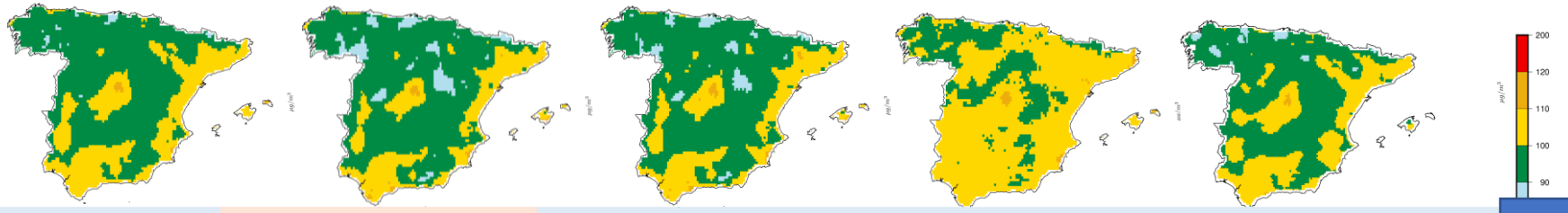
O3

MAX. 8-H (MAX 26º)

	CHIM13	CHIM17			
	Met Model: IFS	CHEM. MECH.: MELCHIOR2	CHEM. MECH.: SAPRC07	Met Model: WRF	
	Res: 0.1°				Res. 0.08°
2021	1	6	5	0	2
WAM2030	0	1	0	0	0

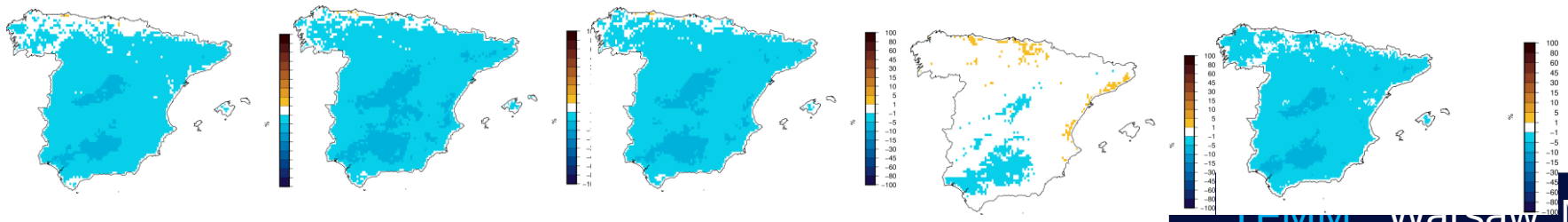
NON-COMPL. AQZ





NON-COMPL. AQZ

IMPACTS



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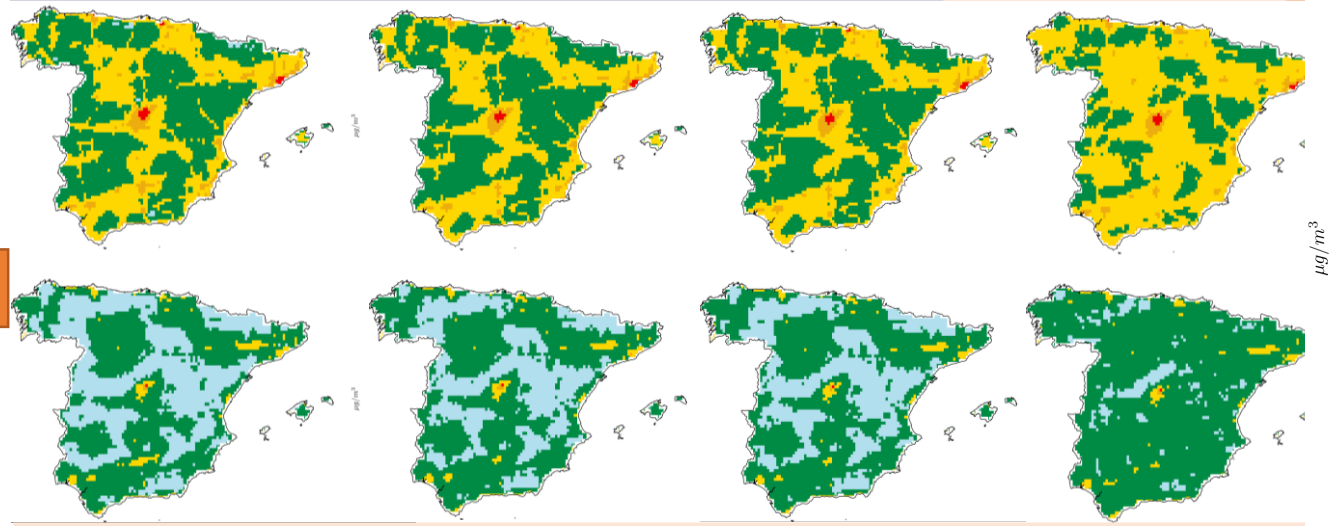
NO2

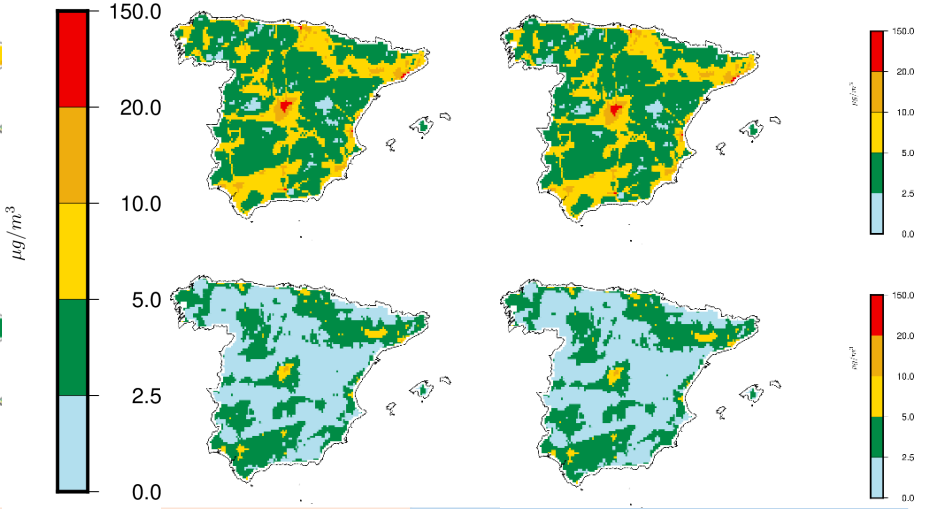
ANNUAL MEAN (ND)

CHIM13	CHIM17				
Met Model: IFS	CHEM. MECH.: MELCHIOR2	CHEM. MECH.: SAPRC07	Met Model: WRF		Other mod.correc.
Res: 0.1°				Res. 0.08°	Res. 0.08°
8	8	8	7	8	13

2021

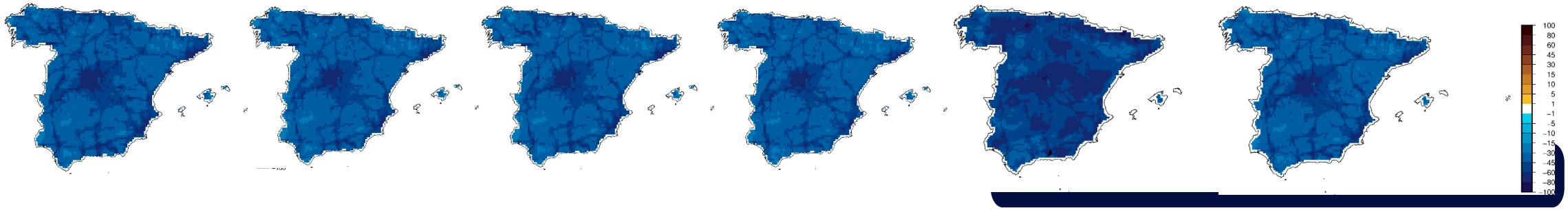


WAM2030



1	1	1	1	1	0

IMPACTS

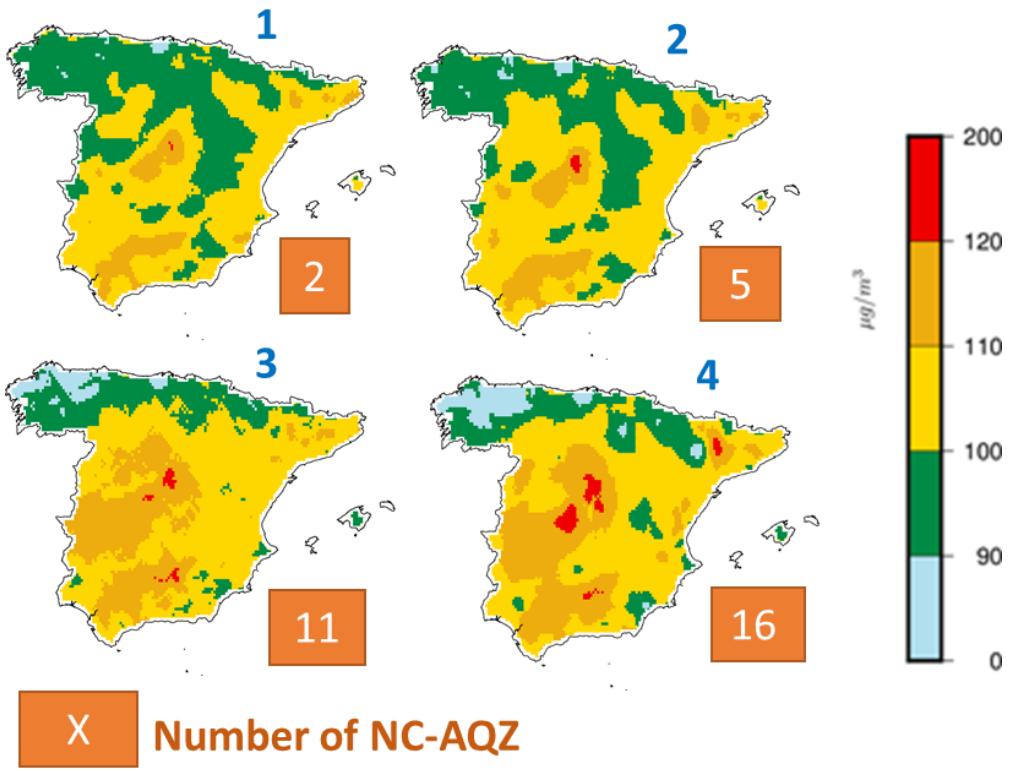


Model correction

O3 26th max8hd

- Model + Bias
- Bias grid obtained from ordinary kriging of bias at sites (Obs. - Model)
- Differences in the method of fitting the theoretical variogram to the empirical one
- 3 of them use a spherical model as a theoretical variogram; they differ on some parameters used in the fitting

Different ways of doing the kriging of residues



1: Python (MC75): Ordinary Kriging; spherical model to fit the experimental semivariogram (automatic fitting, varying bin distance)

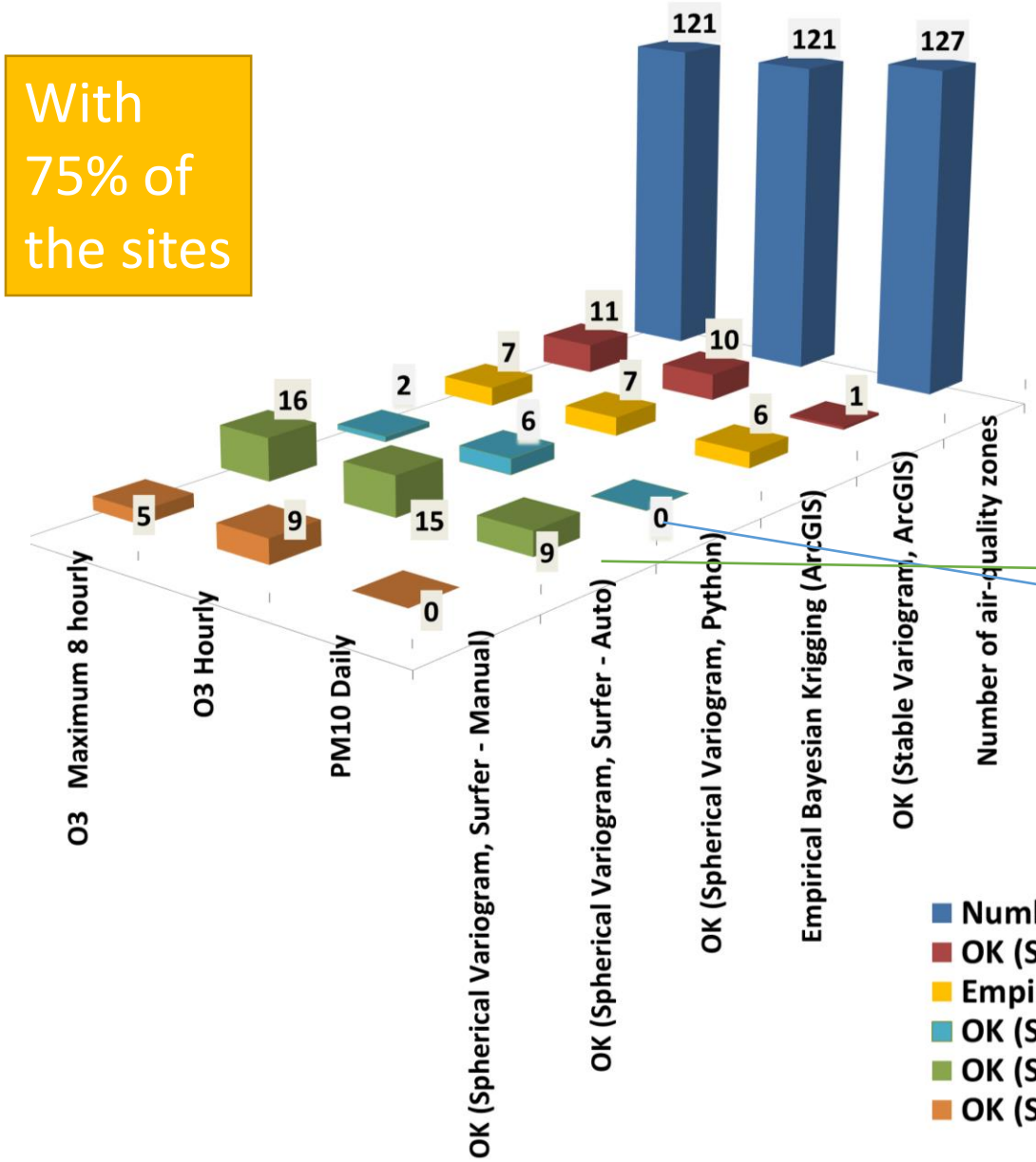
2: Surfer Manual (MCSMA75): Ordinary Kriging; spherical model to fit the experimental semivariogram (manual fitting, varying: range, nugget, sill…)

3: ArcGIS (MCAOK75): Ordinary Kriging; stable model to fit the experimental semivariogram (automatic fitting)

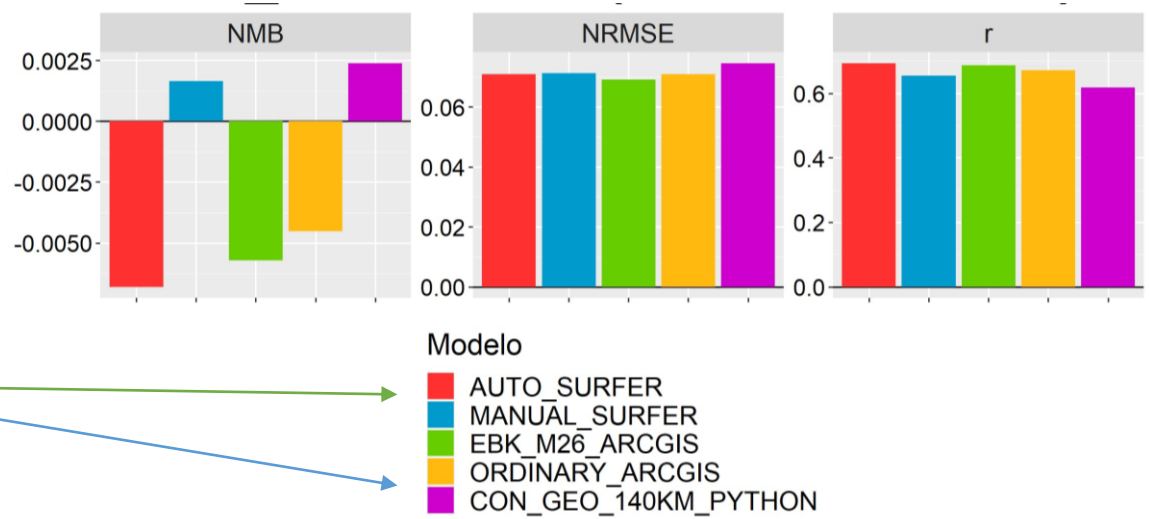
4: Surfer Auto (MCSAU75): Ordinary Kriging; spherical model to fit the experimental semivariogram (automatic fitting)

Model correction

With 75% of the sites



For the 25% not used



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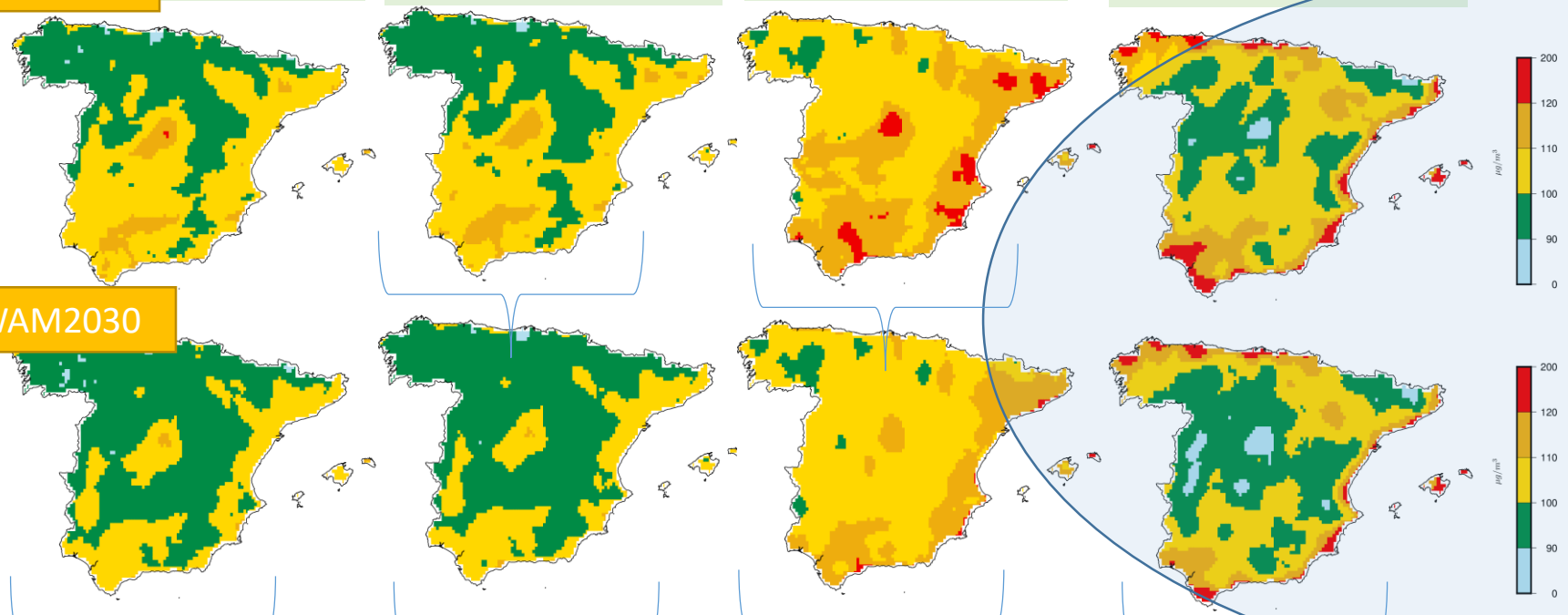
Meteo 2021	Meteo 2016	Meteo 2016	Meteo 2016

REF. CASE

WAM2030



Estimation of fictitious 2021 obs with 2016 meteo-conditions at sites, followed by kriging of bias.

Bias relative to 2021 reference simulation bias.

Bias relative to 2021 reference simulation bias.

Bias relative to 2016 reference simulation bias.

NO SENSE

Year -1
Year -2
Year -3
Year -4

GAM training

GAM Forecast with Yearmet

Year concentration with yearmet

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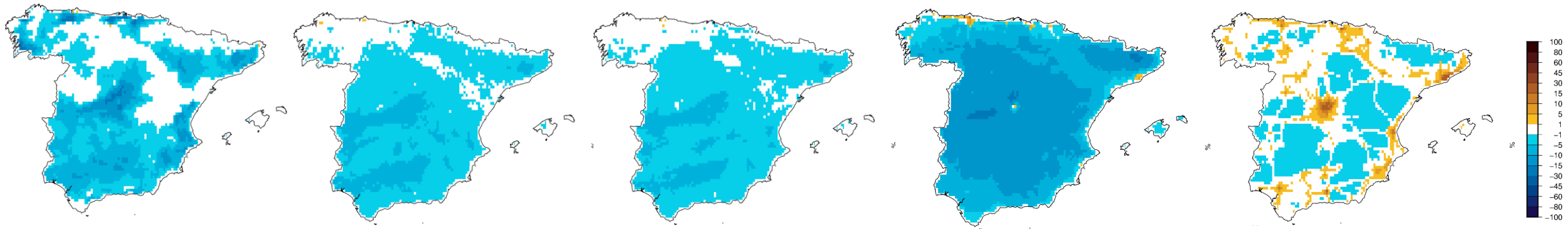
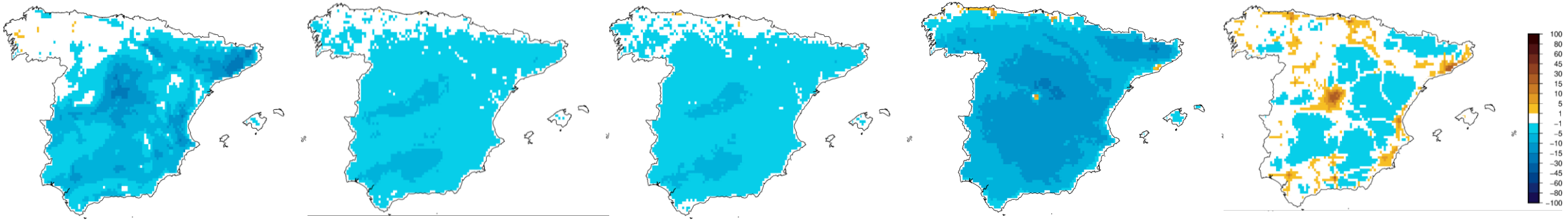
IMPACTS MET 2016

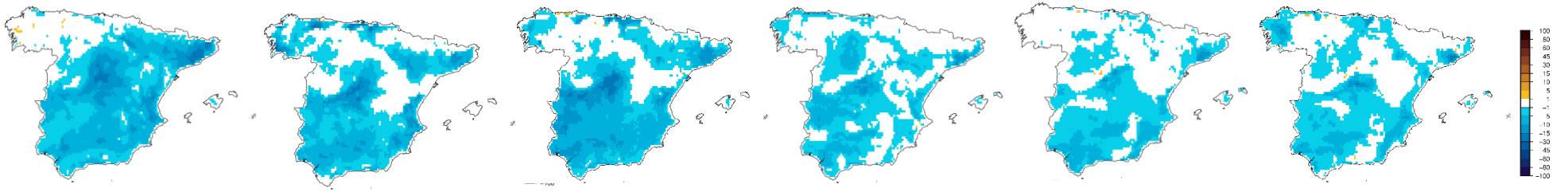
O3 -1st | O3 -19th | O3 -26th | SOMO35 | ANNUAL MEAN



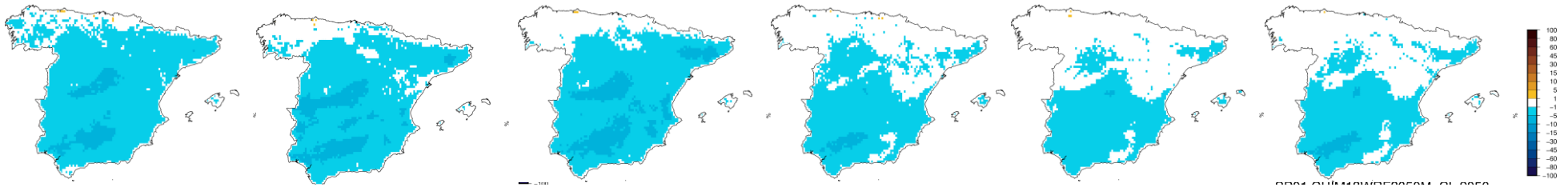
IMPACTS MET 2021



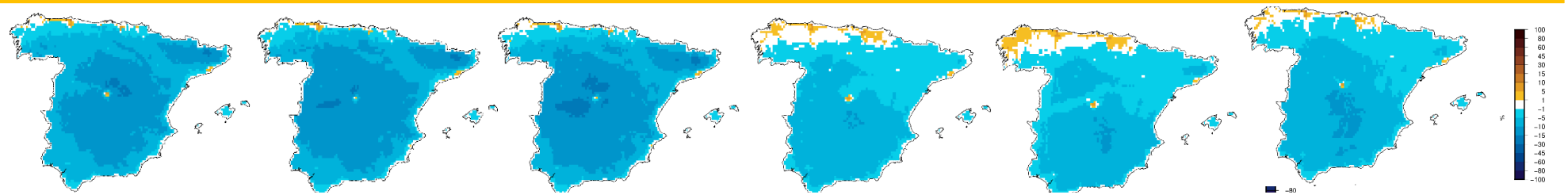
2021	2016	2018	O3 1st	Y-A	Y-B	Y-C



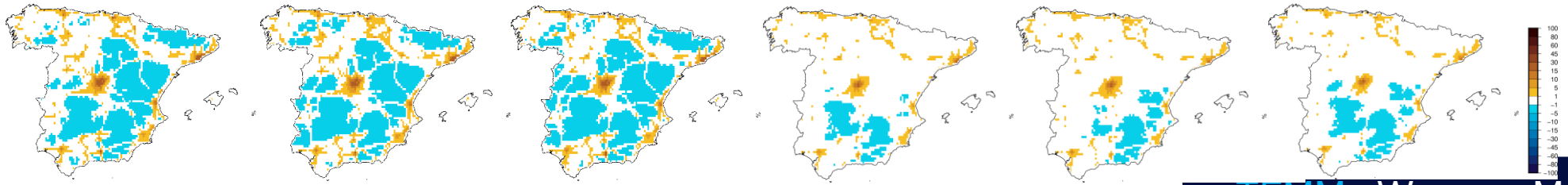
O3 26th daily max8h



SOMO35

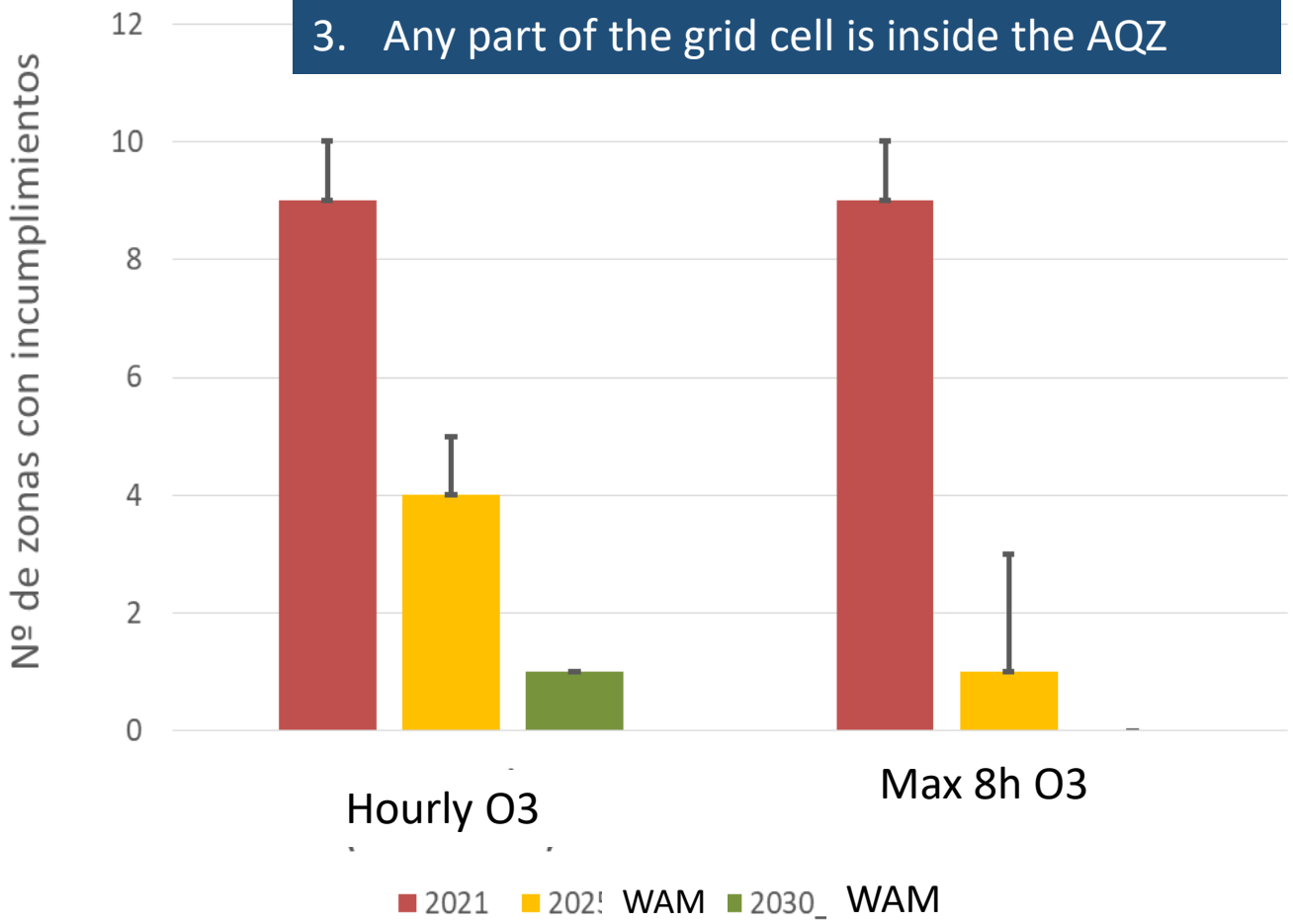


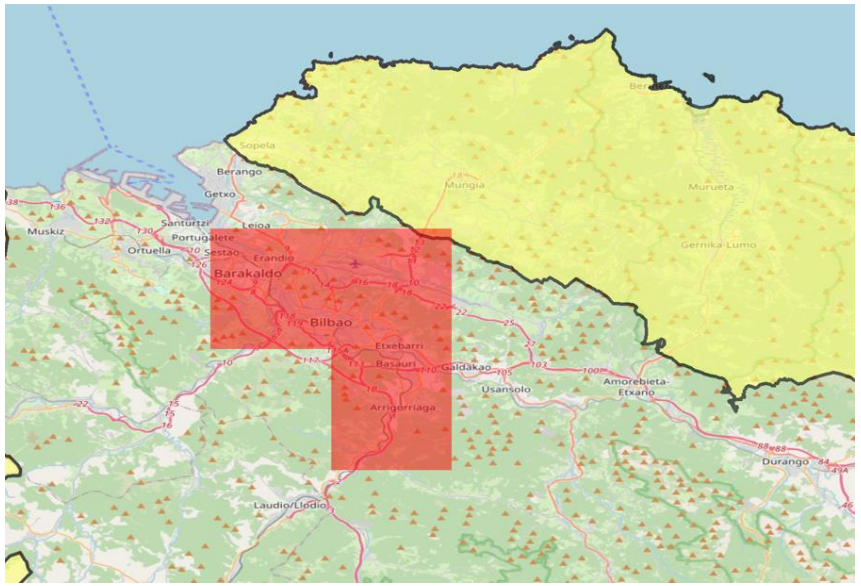
ANNUAL MEAN



Assignment of a non-compliant model cell to an AQZ if

1. The cell centre is in the AQZ
2. More than 50% of the cell area is in the AQZ
3. Any part of the grid cell is inside the AQZ





Another methodology: applying model impacts to observed values at sites in a given scenario

- Non-compliant AQZ only based on an analysis at site locations (not a gridded picture of compliance; needs a good spatial coverage of monitoring sites)

- No need for model corrections

Conclusions

Assessing air quality non-compliance with models (gridded analysis) is a complex task due to:

A. Several factors in model application: resolution, meteorological model, emissions
B. Model correction (multiple methods) For a given method, there are different options (e.g. different interpolation methods)
C. How to assign an uncompliant cell to an air quality zone (affected by the methodology of assignment, model resolution, number/size of zones)
D. More complicated in future/hypothetical scenarios. For instance, considering different meteorological years; while impacts are easy to evaluate with models, assesing the non-compliance for different meteorological conditions is very complex

More discussion needed on this

Thanks!

- Thanks to the European Center for Medium-Range Weather Forecasts (ECMWF) for the provision of meteorological modelling data; with thanks also to AEMET for managing access to this information.

- Project TED2021-132431B-I00 (TRANSAIRE: Transition to cleaner air in Spain) funded by MCIN/AEI/10.13039/501100011033 and by the European Union NextGenerationEU/PRTR

- We thank the Ministry for the Ecological Transition and Demographic Challenge (MITERD) for the provision of the emission inventory and reductions for the measures in the NAPCP. We also acknowledge MITERD for providing data from air quality stations.

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