Impacts of Wildfires: Analysis of 2022 & 2024 Campaigns. Preliminary results

Marta G. Vivanco, Victoria Gil, Coralina Hernández, Mark Theobald, Juan Luis Garrido

27th EMEP Task Force on Measurements and Modelling Meeting
Bled, 28-29 April 2026

And some some results of the participants in the modelling of O_3/VOC/SOA EMEP Intensive Measurement Period of 2022

FMI	**INERIS**	**ENEA**	**CIEMAT**
Risto Hänninen, Rostislav Kouznetsov, Andreas Uppstu, Mikhail Sofiev	Florian Couvidat, Victor Lannuque, Antoine Guion, A.Colette	Mihaela Mircea, Andrea Bolignano Felicita Russo Gino Briganti	Marta G. Vivanco, Coralina Hernández, Mark Theobald, Victoria Gil

Outline

1. **July 2022 and September 2024 Campaigns: Particulate Matter**
   - Based on CHIMERE (CIEMAT) analysis

2. **July 2022 Campaign: VOCs & O_3 Intensive Measurement Period**
   - Gaseous Species: Multi-model assessment (CHIMERE, SILAM, MINNI)

3. **September 2024 Campaign: VOCs & O_3 Intensive Measurement Period**
   - Gaseous Species: Based on CHIMERE (CIEMAT)

1 July 2022 and September 2024 Campaigns: Particulate Matter

- Based on CHIMERE analysis (CHIMERE 2023r3)

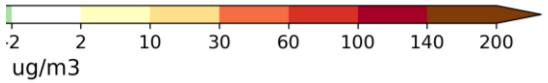
- Meteorology: IFS, 2022
- **Fire Emissions:** CAMS Global Fire Assimilation System (**GFAS**), 0.1 0.1 degrees, hourly
- Boundary conditions EAC4 (ECMWF Atmospheric Composition Reanalysis 4)

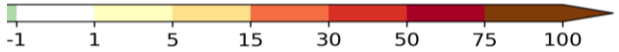
Differences between simulations with and without fires.

Campaign 2022: 0.1º, approx. 10km Anthropogenic emissions CAMS-REG_8-0, 2022

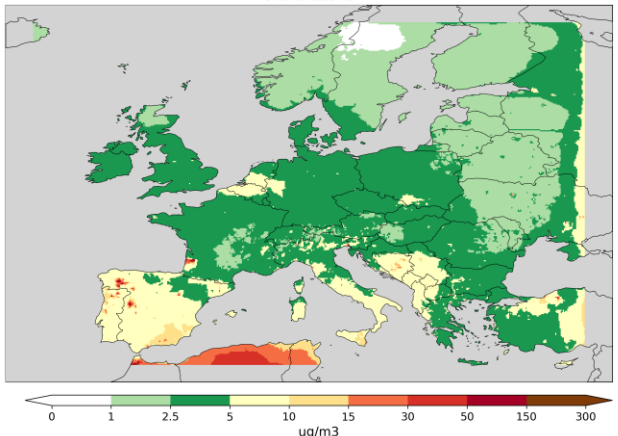
Campaign 2024: 0.15º (EU) + 0.05º(SP), Anthropogenic emissions EMEP, 2022

PM2.5

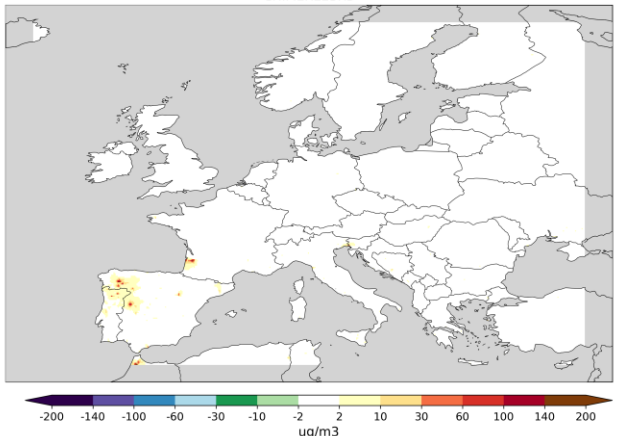




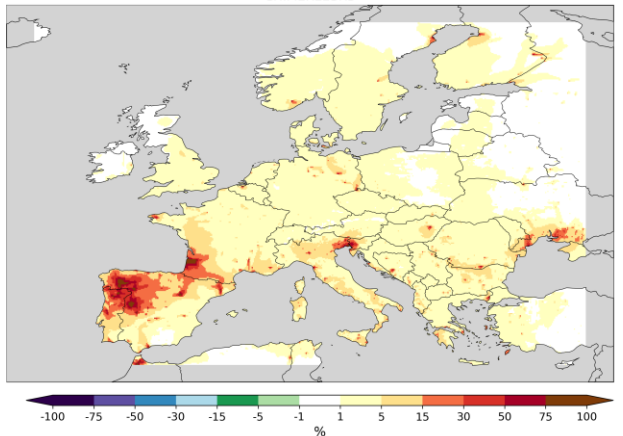
2022 — July



BASE

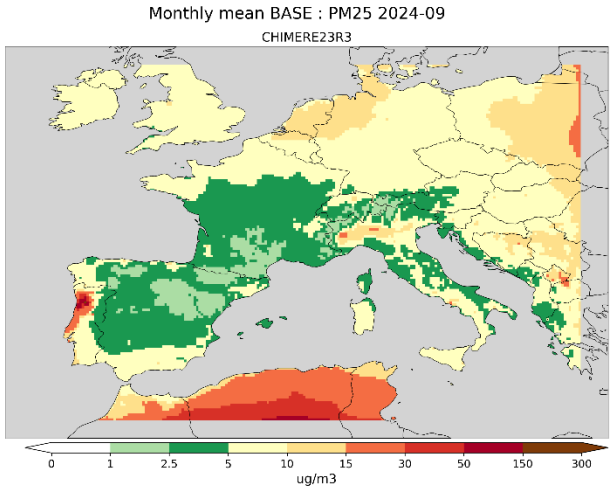


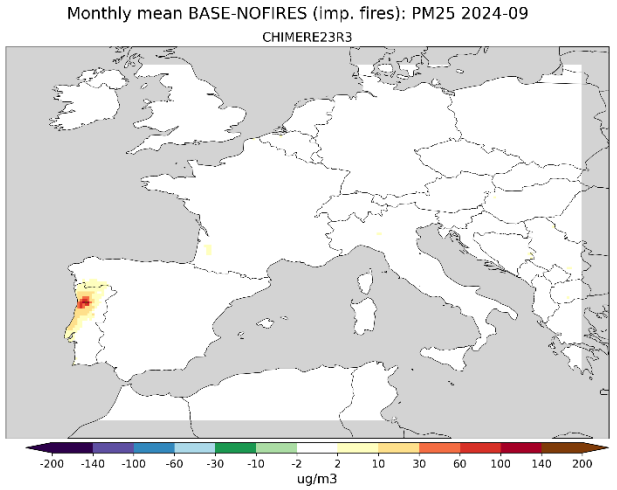
Abs .D

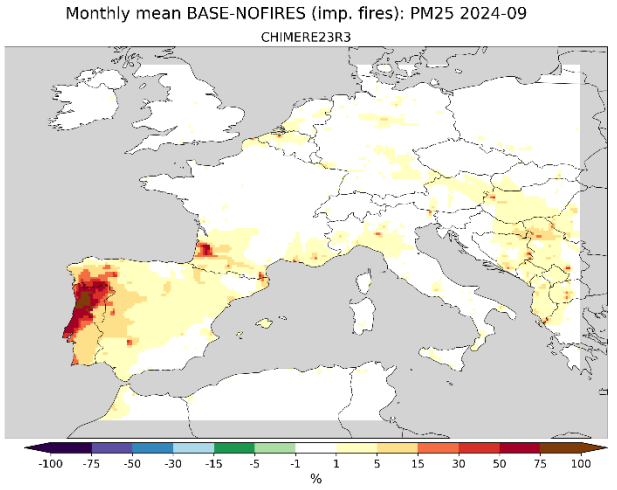


Rel D.

2024 — September





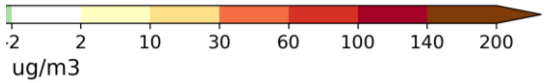


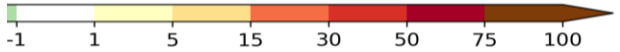
2022 Campaign: Impact was most severe across Northwestern (NW) Spain.

2024 Campaign: Significant anomalies centered over Northern Portugal

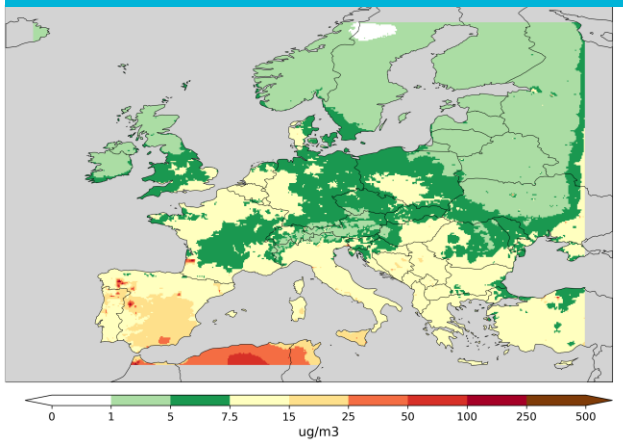
Model estimates significant increases in PM2.5 levels, reaching more than 75% . Increments can range between of 30–140 µg/m³) in the most affected areas.

PM10

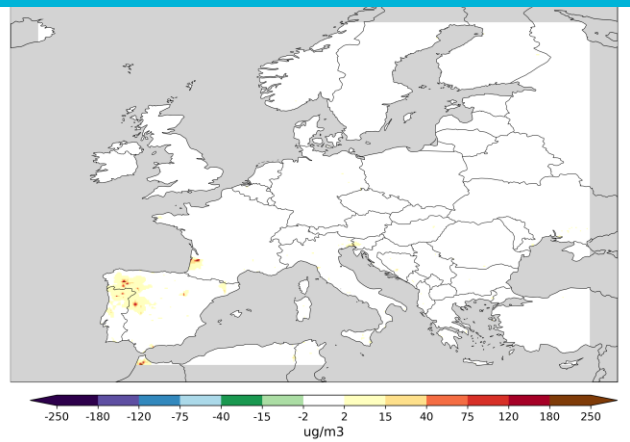




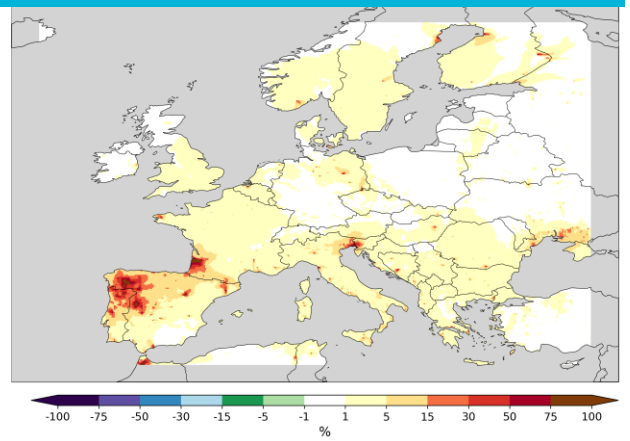
2022 — July



BASE

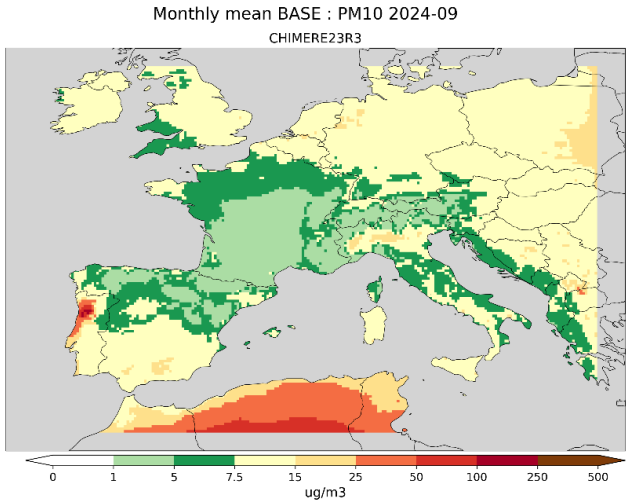


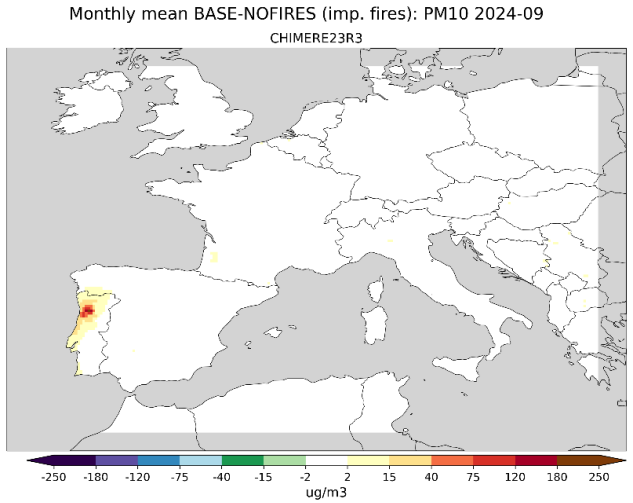
Abs .D

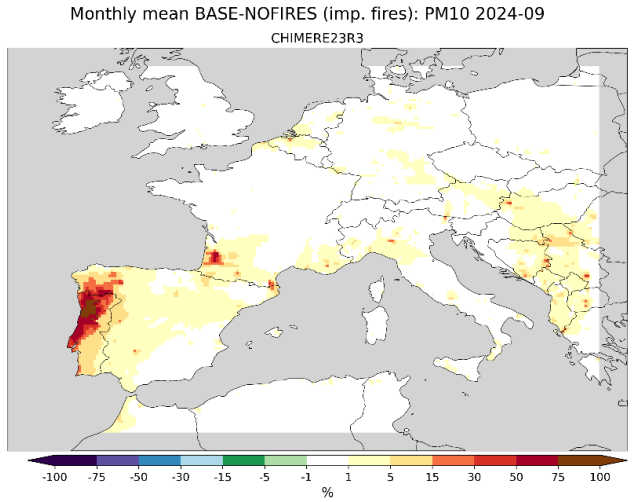


Rel D.

2024 — September



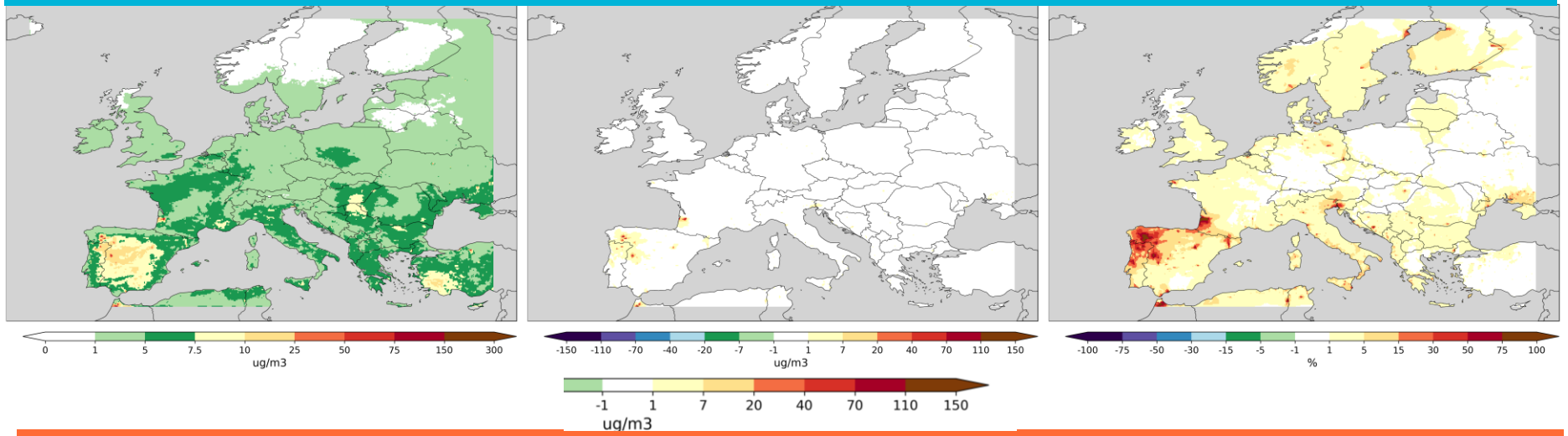




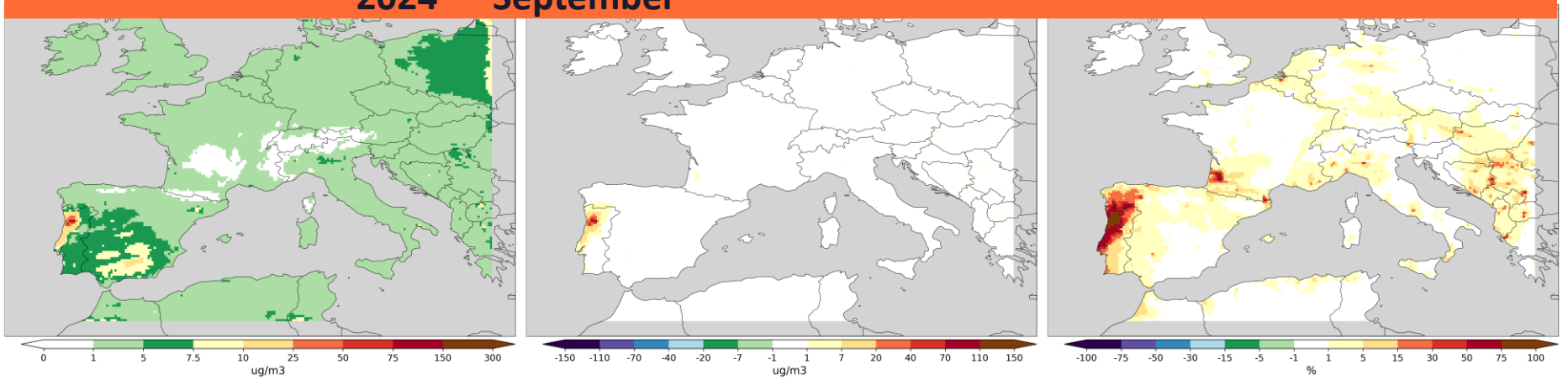
PM10 displays spatial patterns similar to PM2.5, though it is slightly more localised near the emission sources.

pPPM — Primary Particulate Matter:

2022 — July



2024 — September



BASE

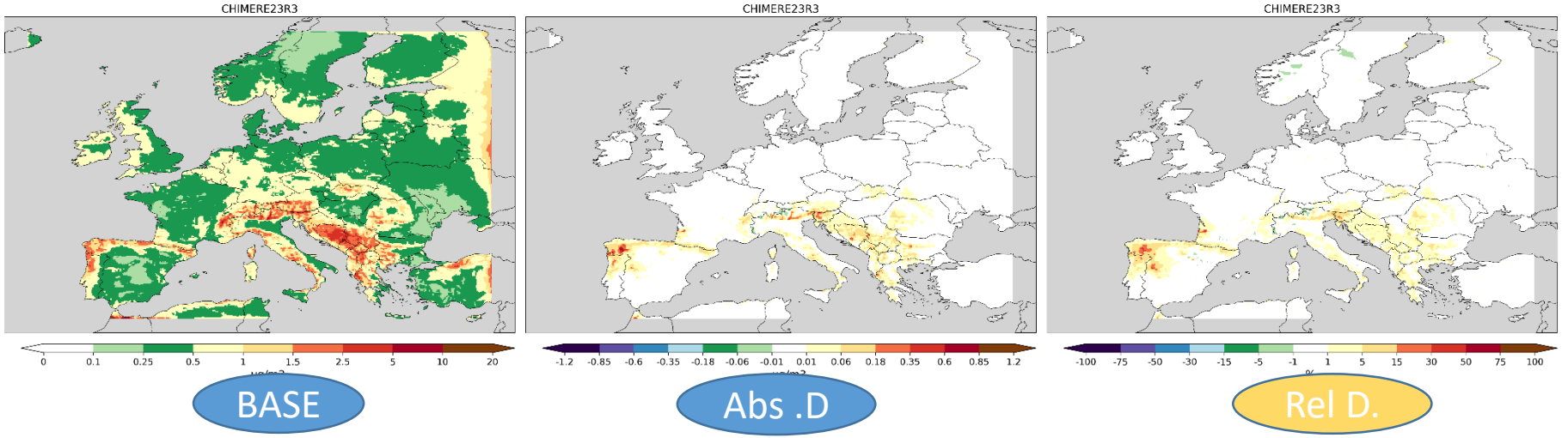
Abs .D

Rel D.

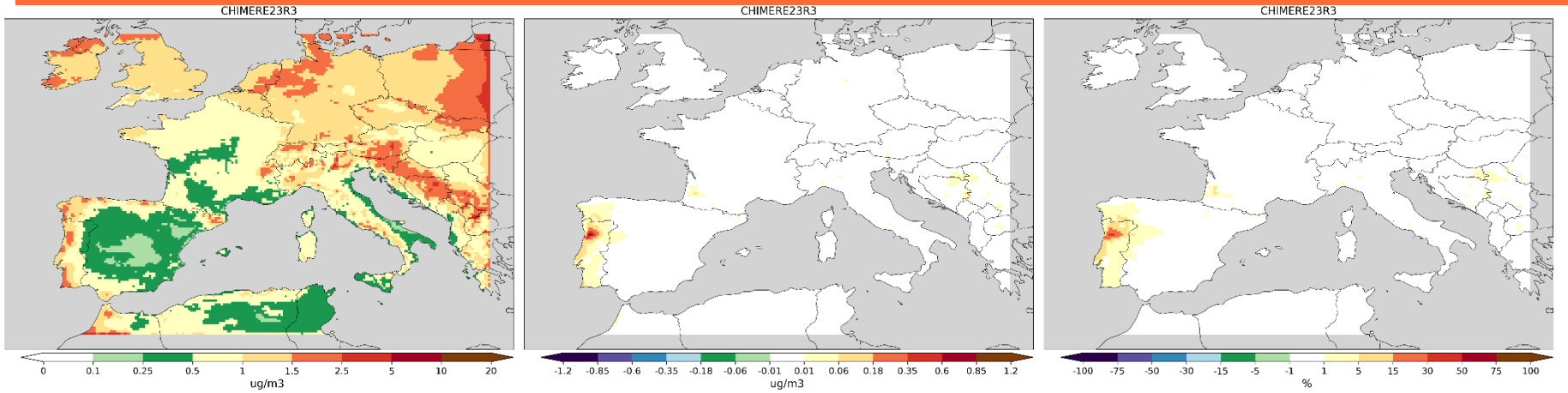
- Relative increases: Over 75–100%+ in fire-affected areas.
- Absolute increments: 20–110 µg/m³ at the fire core.
- Major contributor to PM2.5 in those areas.

SOA — Secondary Particulate Matter:

2022 — July



2024 — September



The fire impact is dominated by PPM, according to the models, with a much lower SOA contribution.

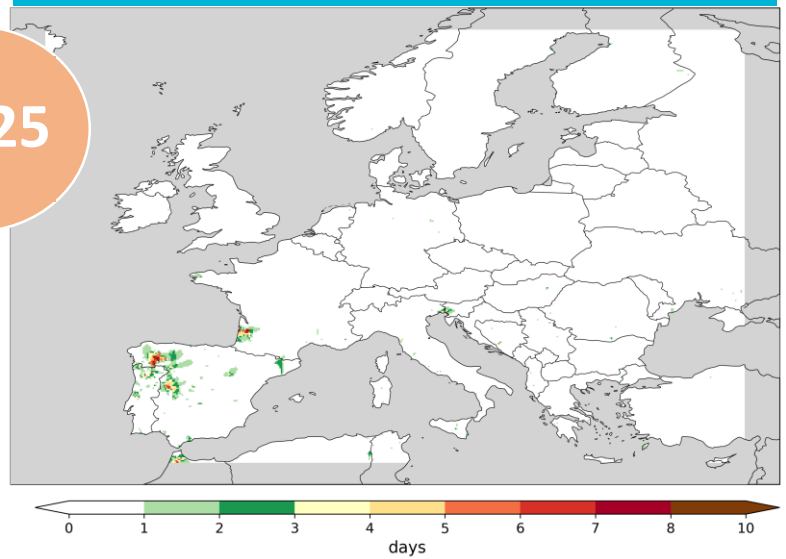
It would be good to revise the secondary organic aerosol formation mechanisms

2024 vs 2022 — Key Differences

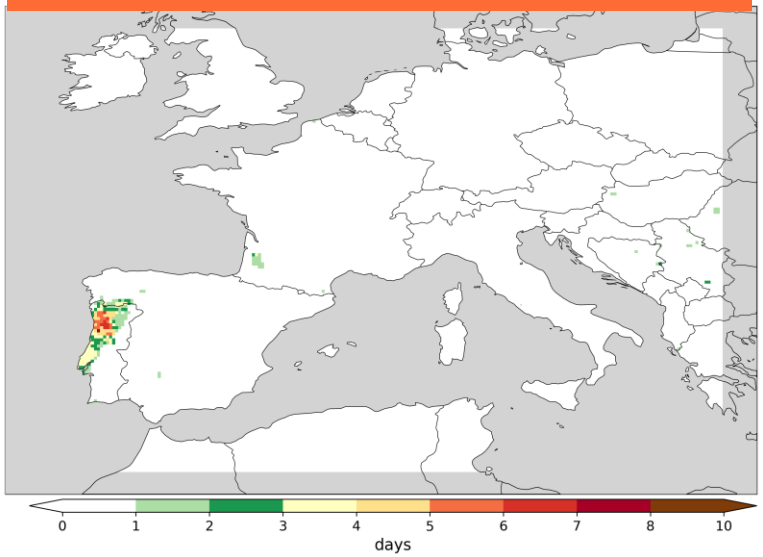
Exceedance Days: Fire Attribution

PM25

PM2.5 fire days — 2022-07

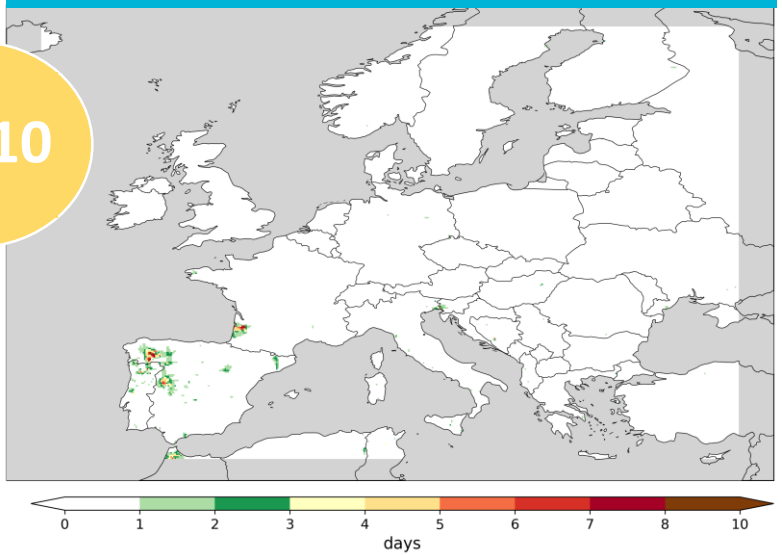


PM2.5 fire days — 2024-09

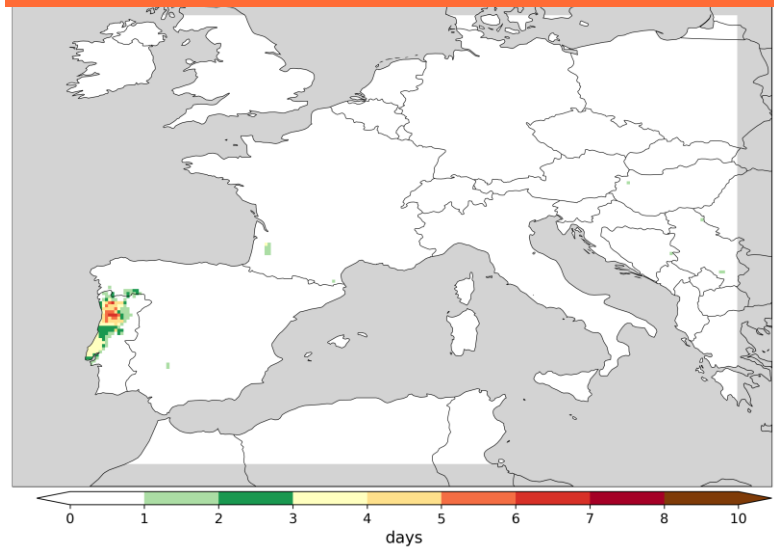


PM10

PM10 fire days — 2022-07



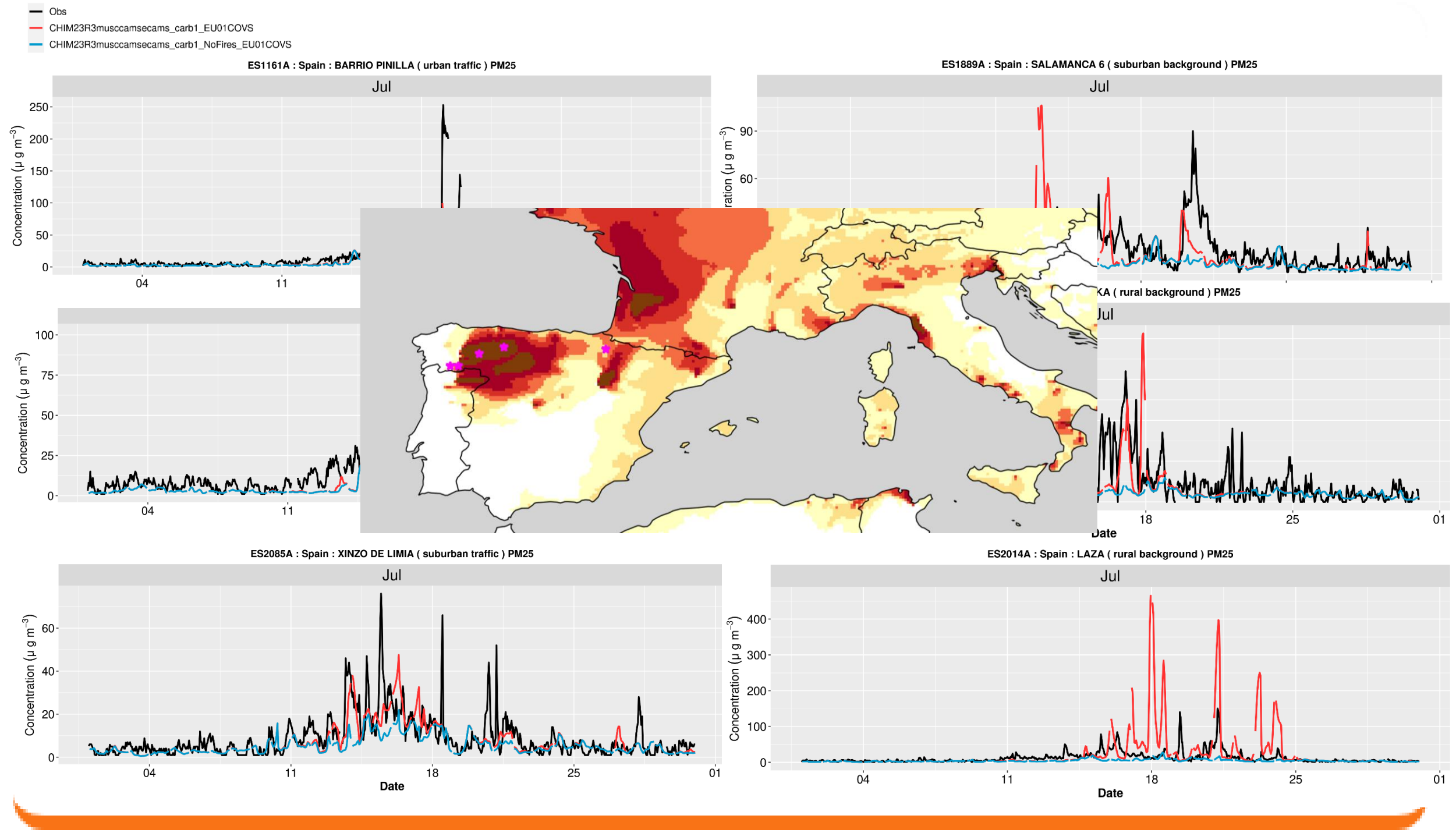
PM10 fire days — 2024-09



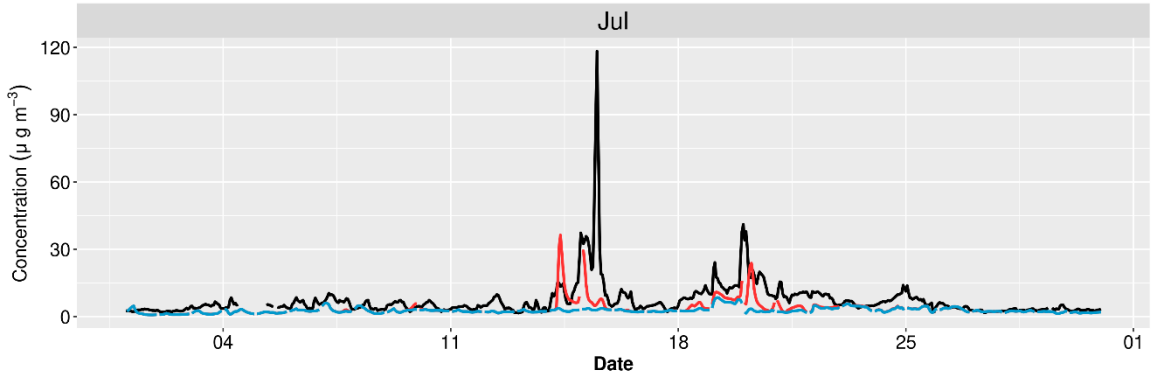
PM2.5 daily limit
25 µg/m³

- In 2022: fire-driven exceedances affect NW Iberia zone (parts of Galicia, northern Portugal, and Extremadura). In 2024: the signal almost entirely within Portugal, with minor spillover into Galicia.
- Wildfire-attributable exceedances reached up to 8 days in the most impacted areas, particularly during the 2022 campaign.

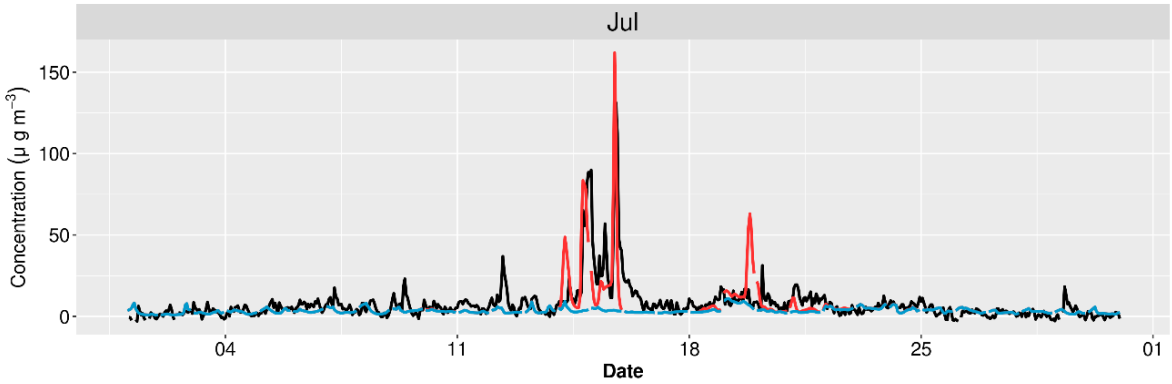
PM10 daily limit
45 µg/m³


Obs
CHIM23R3musccamsecams_carb1_EU01COVS
CHIM23R3musccamsecams_carb1_NoFires_EU01COVS
ES1161A : Spain : BARRIO PINILLA (urban traffic) PM25
ES1889A : Spain : SALAMANCA 6 (suburban background) PM25
KA (rural background) PM25
ES2085A : Spain : XINZO DE LIMIA (suburban traffic) PM25
ES2014A : Spain : LAZA (rural background) PM25
Jul
Concentration (µ g m−3)
Date
04
11
18
25
01

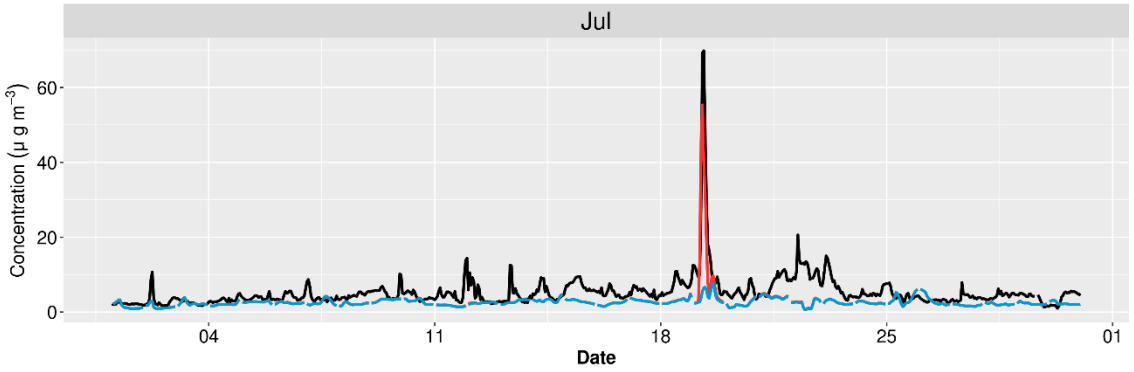
FR12020 : France : PEYRUSSE (rural-remote background) PM25



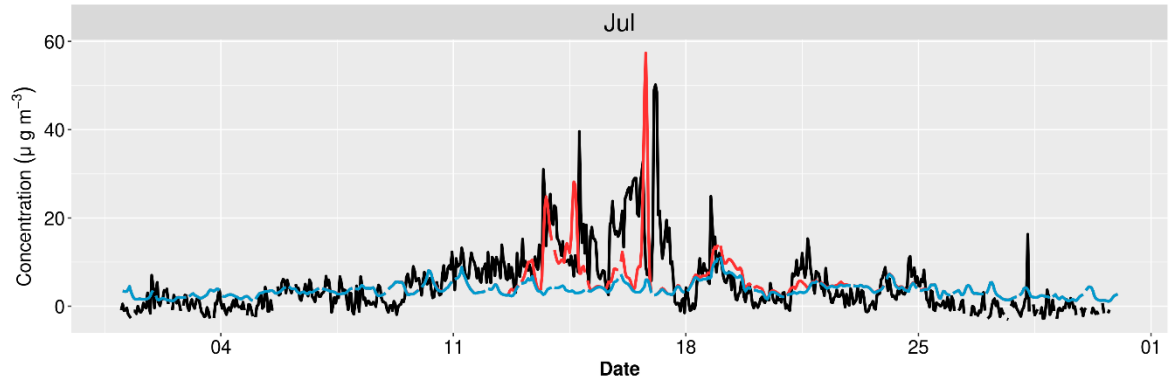
FR31041 : France : MONT DE MARSAN (urban traffic) PM25



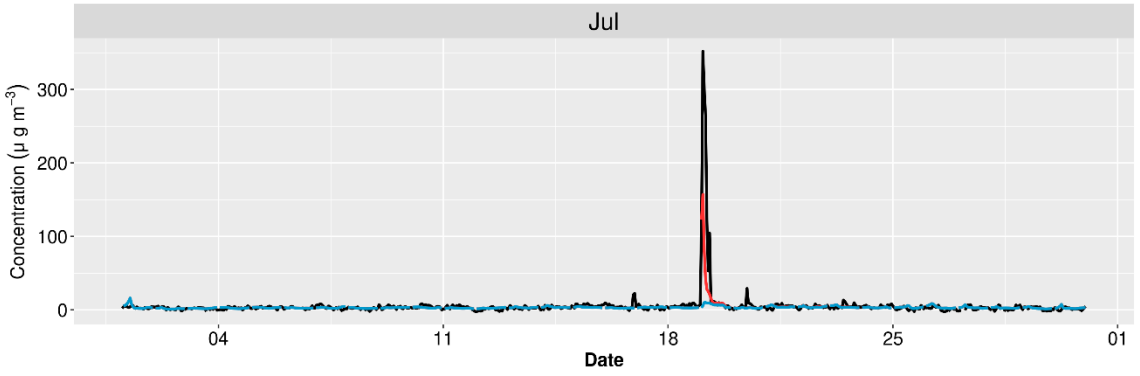
FR09302 : France : Zoodyssée Chizé (rural-regional background) PM25



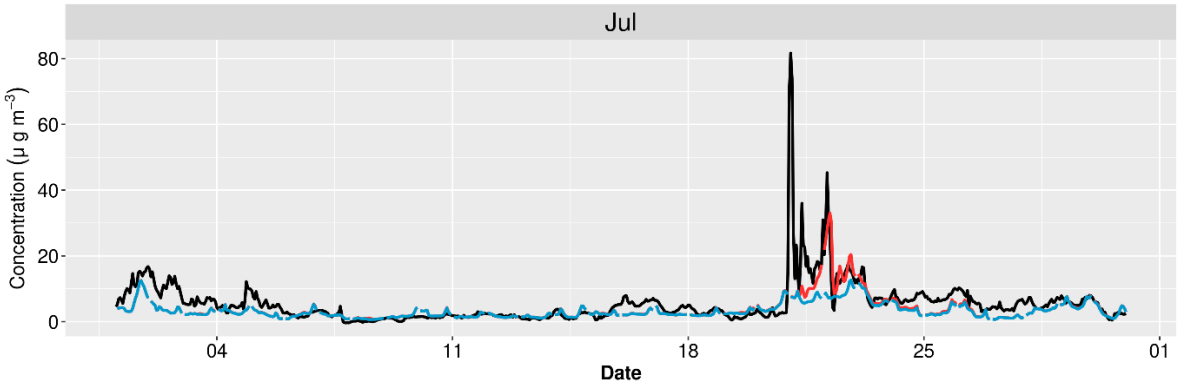
FR31043 : France : Biarritz-hippodrome (suburban background) PM25



FR31007 : France : BASSENS (urban industrial) PM25



HR0015A : Croatia : VIŠNJAN (rural background) PM25



2 July 2022 Campaign: VOCs & O_3 Intensive Measurement Period

- Gaseous Species: Multi-model assessment (CHIMERE, SILAM, MINNI)

Model	Institution
SILAM v6.0 (r605788)	FMI
MINNI-PSEM	ENEA
MINNI-MEGAN	ENEA
CHIMERE 2023r2	INERIS
CHIMERE 2023r3	CIEMAT

And some some results of the participants in the modelling of O_3/VOC/SOA EMEP Intensive Measurement Period of 2022

FMI

Risto Hänninen, Rostislav Kouznetsov, Andreas Uppstu, Mikhail Sofiev

INERIS

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ENEA

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2 July 2022 Campaign: VOCs & O_3 Intensive Measurement Period

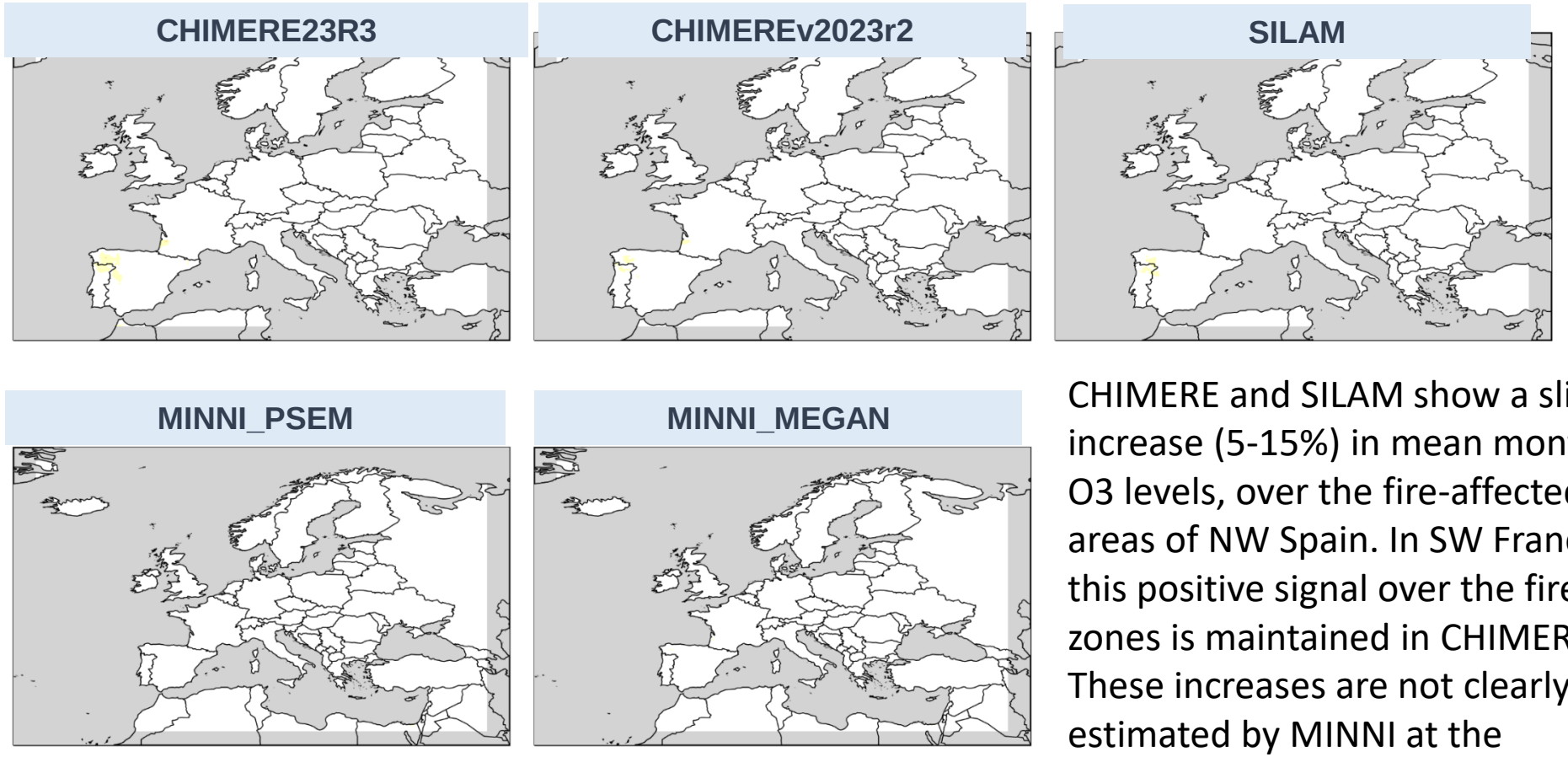
- Gaseous Species: Multi-model assessment (CHIMERE, SILAM, MINNI)

O3

Rel D.

Impacts on Monthly Mean Value

2022-07



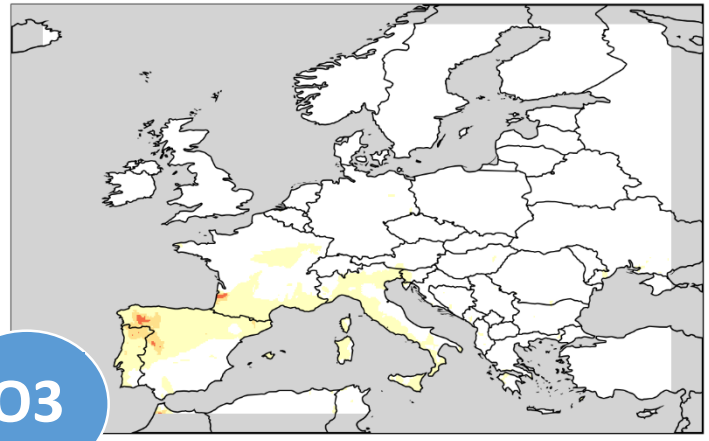
CHIMERE and SILAM show a slight increase (5-15%) in mean monthly O3 levels, over the fire-affected areas of NW Spain. In SW France, this positive signal over the fire zones is maintained in CHIMERE. These increases are not clearly estimated by MINNI at the monthly mean level.

Impacts on Monthly Mean Value

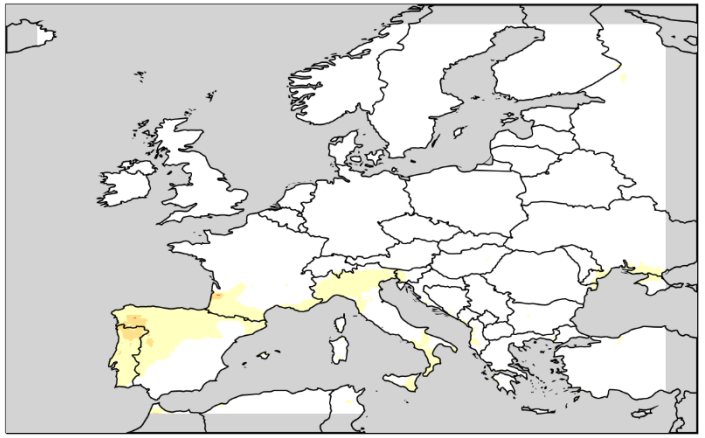
Abs .D

O3

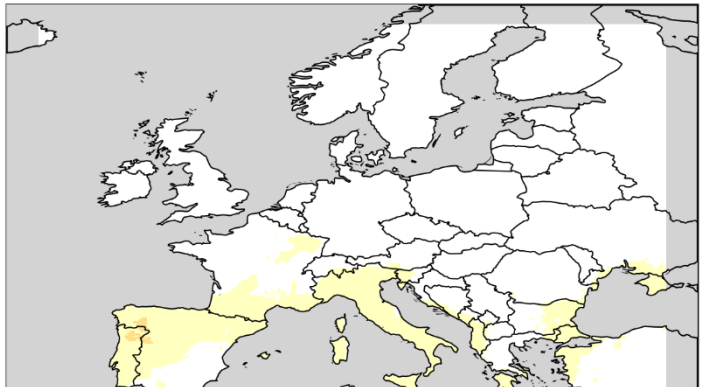
CHIMERE23R3



CHIMEREv2023r2

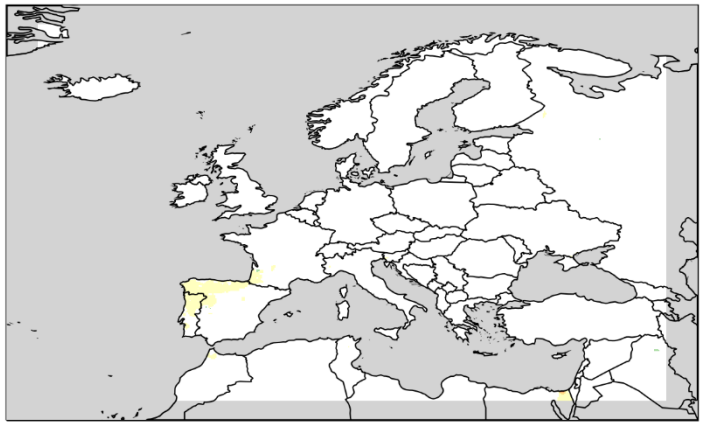


SILAM

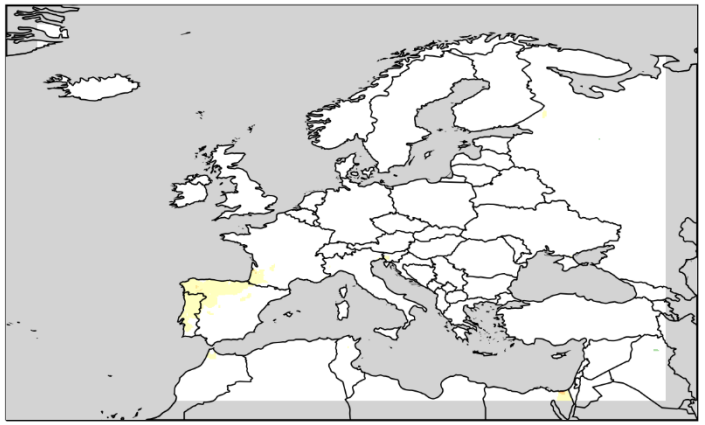


Daily mean BIOwFIRES-BIO (imp. fires): O3 2022-07-16

MINNI_PSEM



MINNI_MEGAN

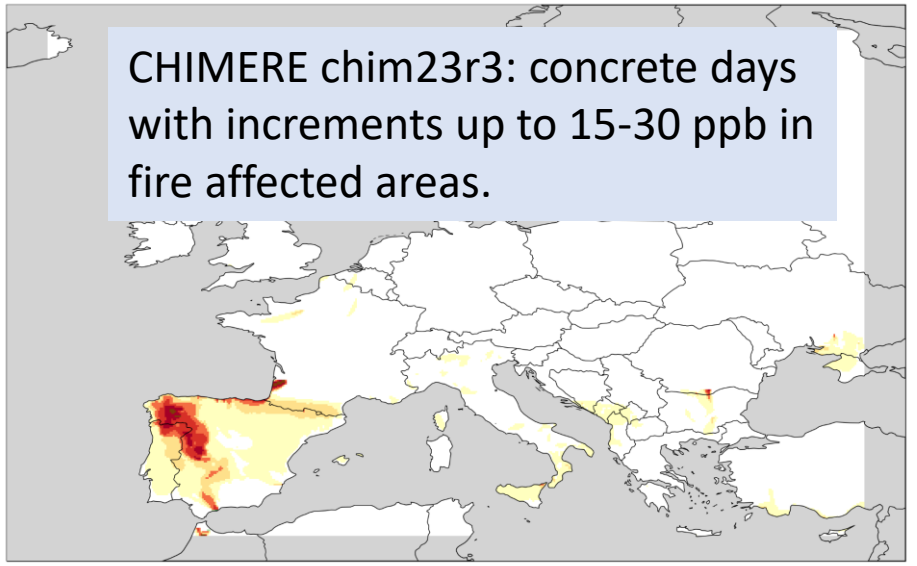


−50.0 −30.0 −15.0 −8.0 −4.0 −2.0 −0.5 0.5 2.0 4.0 8.0 15.0 30.0 50.0

Monthly Mean (ppbv)

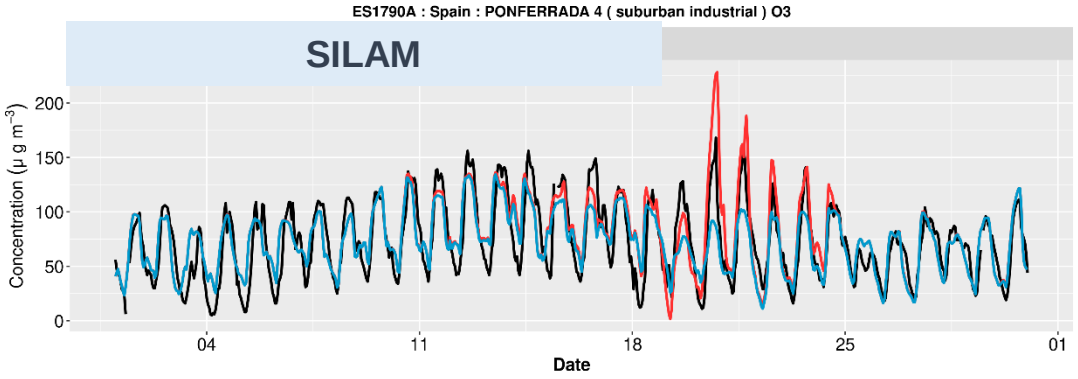
CHIMERE23R3

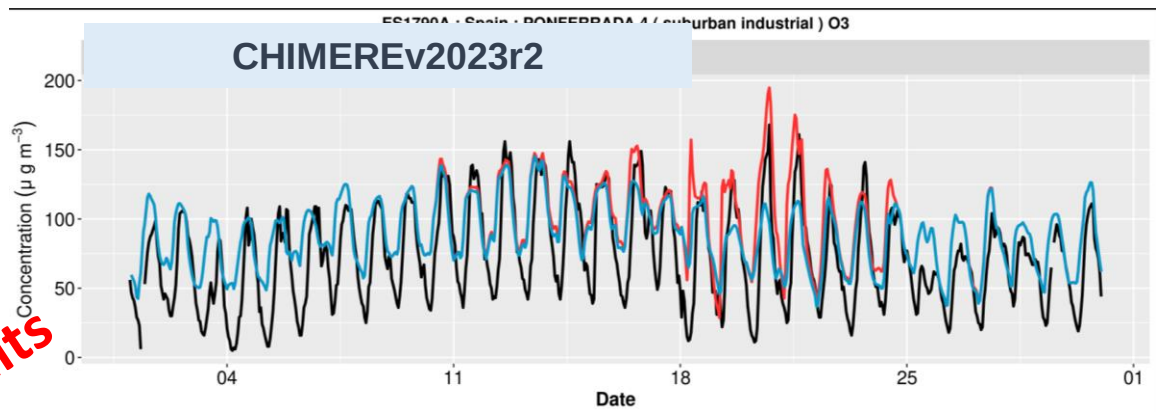
CHIMERE chim23r3: concrete days with increments up to 15-30 ppb in fire affected areas.



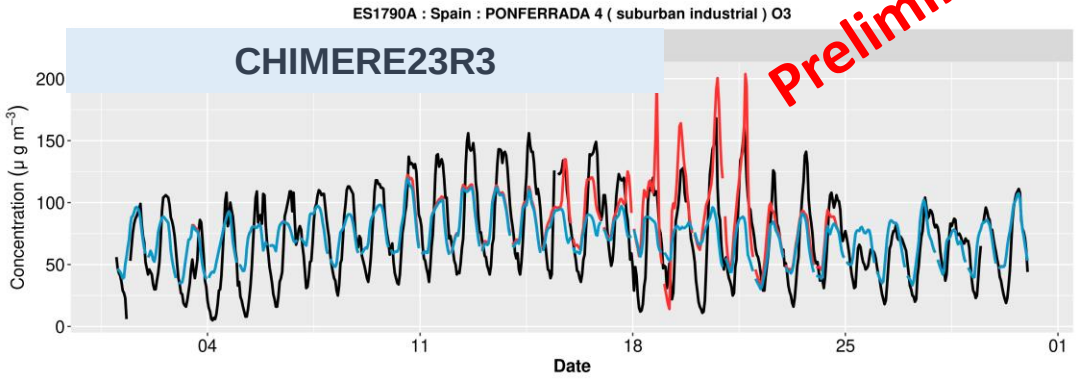
-50 -30 -15 -8 -4 -2 -0.5 0.5 2 4 8 15 30 50

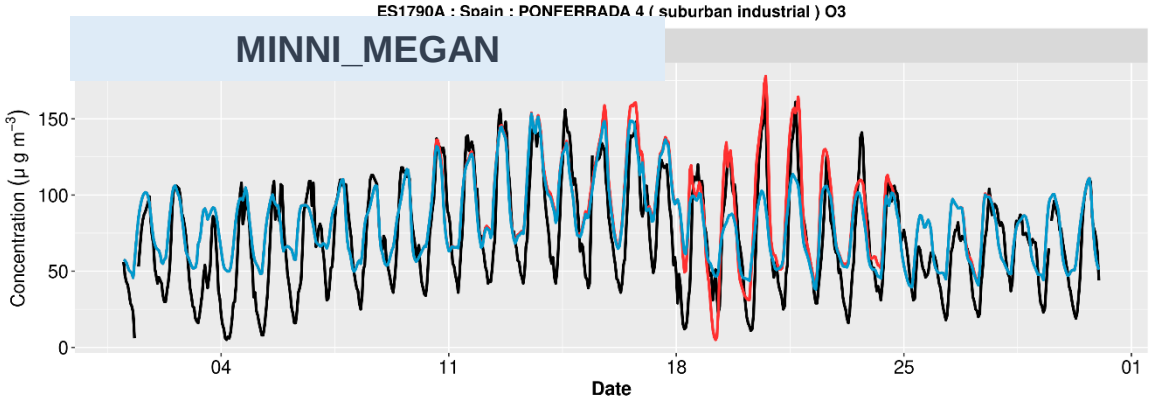
ppbv

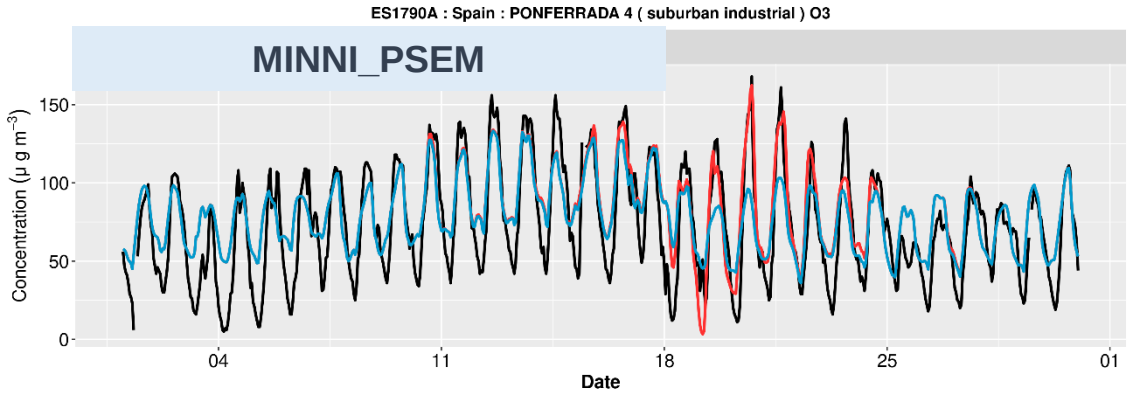




Preliminary Results







Obs

With fires

Without fires

2 July 2022 Campaign: VOCs & O_3 Intensive Measurement Period

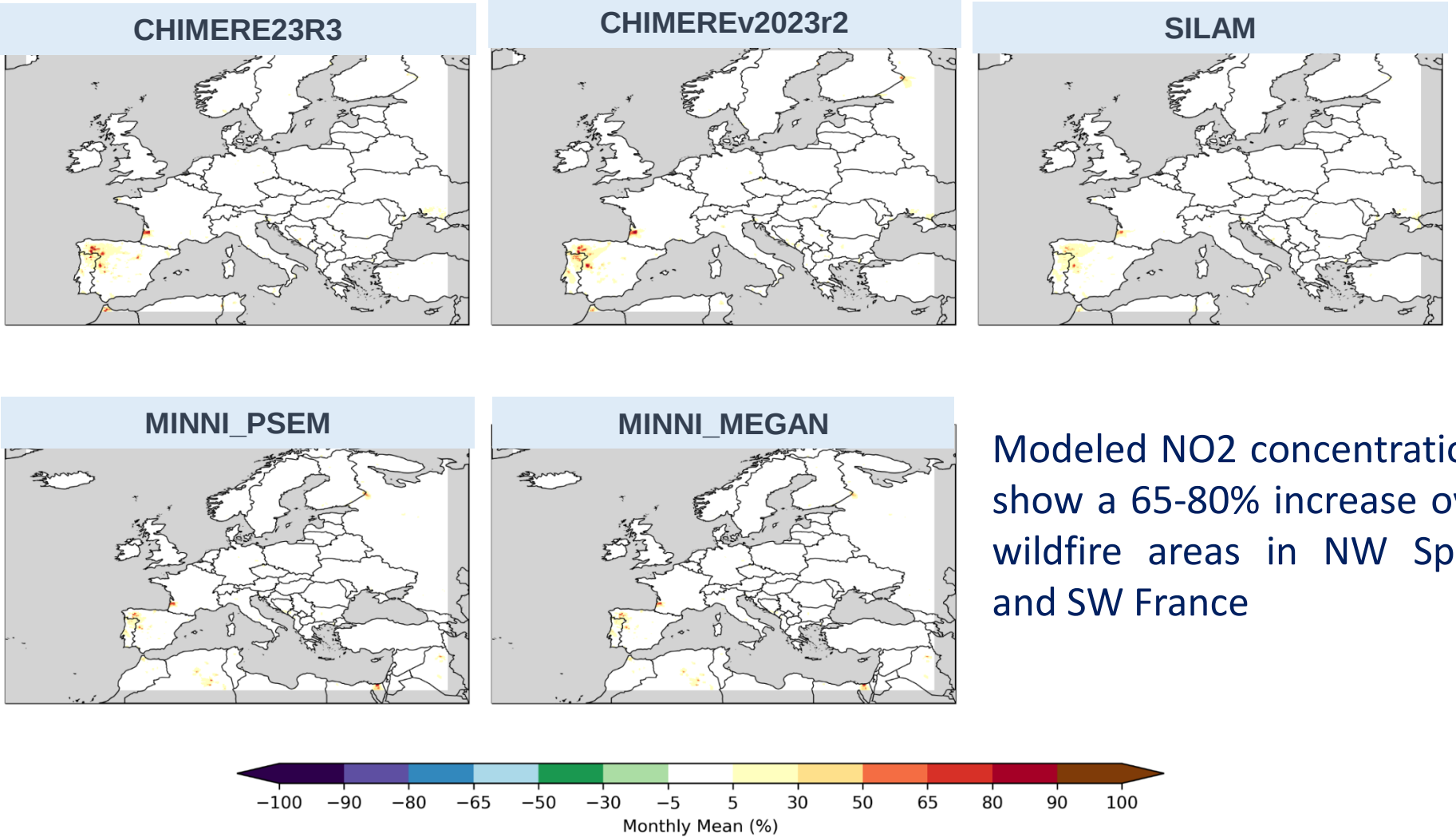
- Gaseous Species: Multi-model assessment (CHIMERE, SILAM, MINNI)

NO2

Monthly Mean Value

2022-07

Rel D.



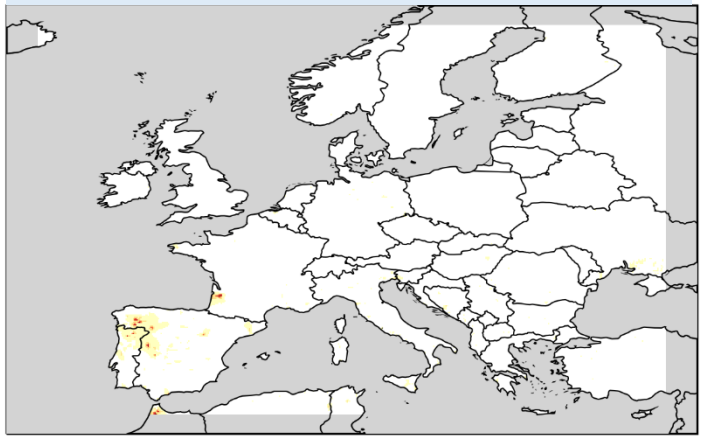
Modeled NO2 concentrations show a 65-80% increase over wildfire areas in NW Spain and SW France

NO2

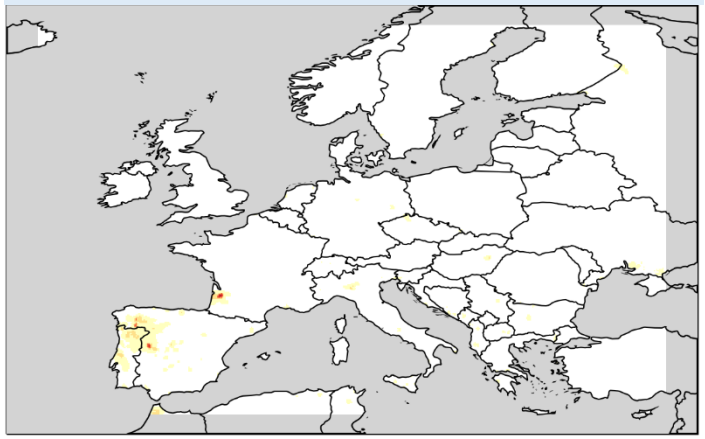
Monthly Mean Value

Abs .D

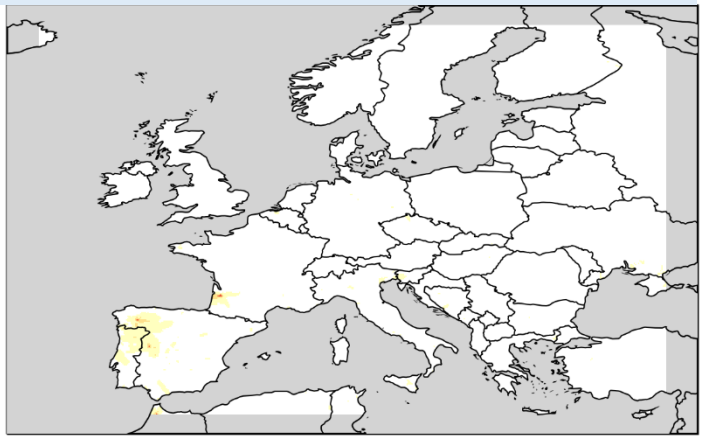
CHIMERE23R3



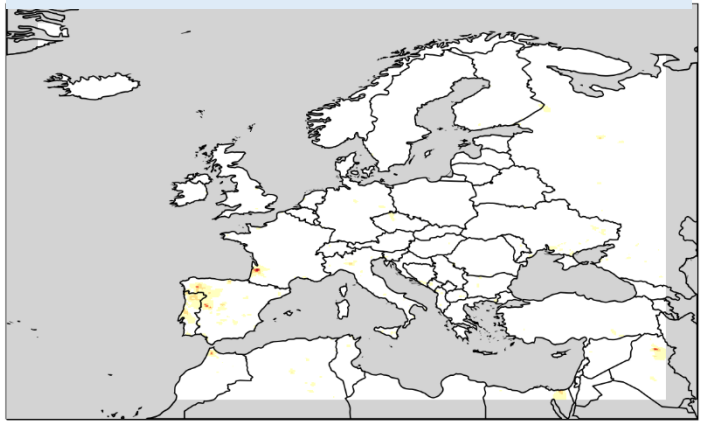
CHIMEREv2023r2



SILAM



MINNI_PSEM



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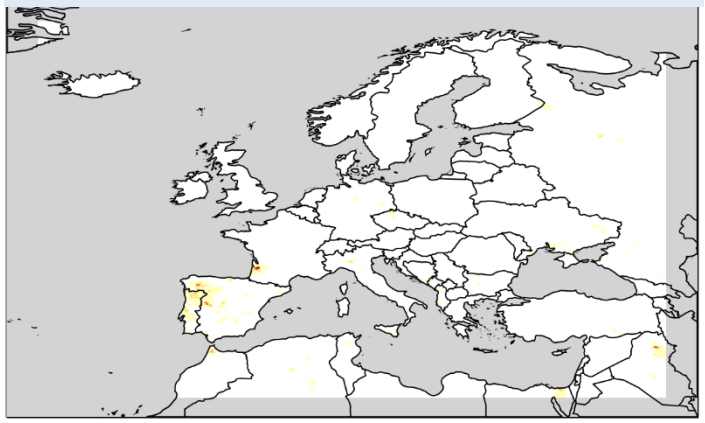
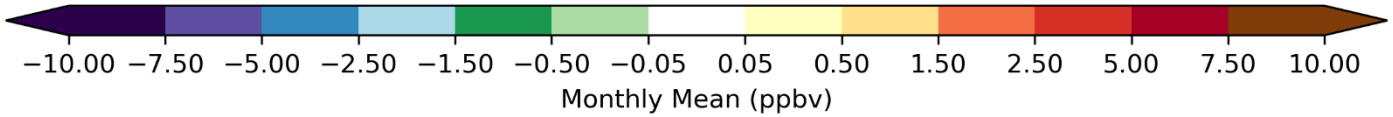
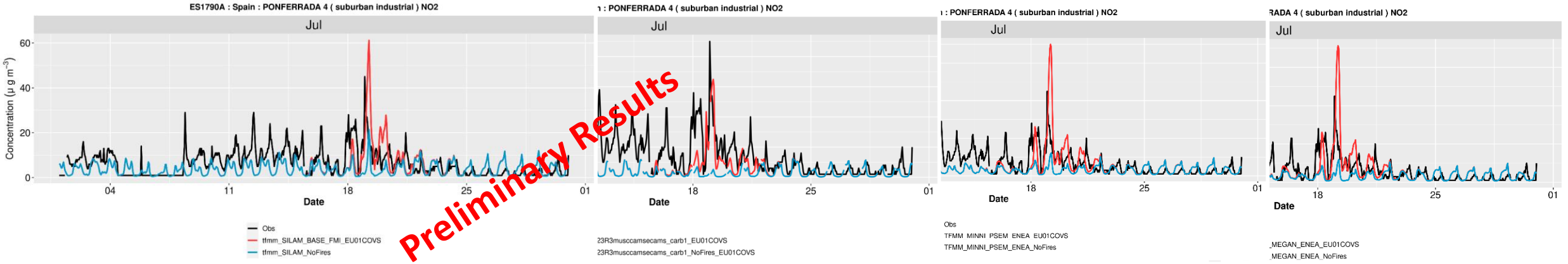
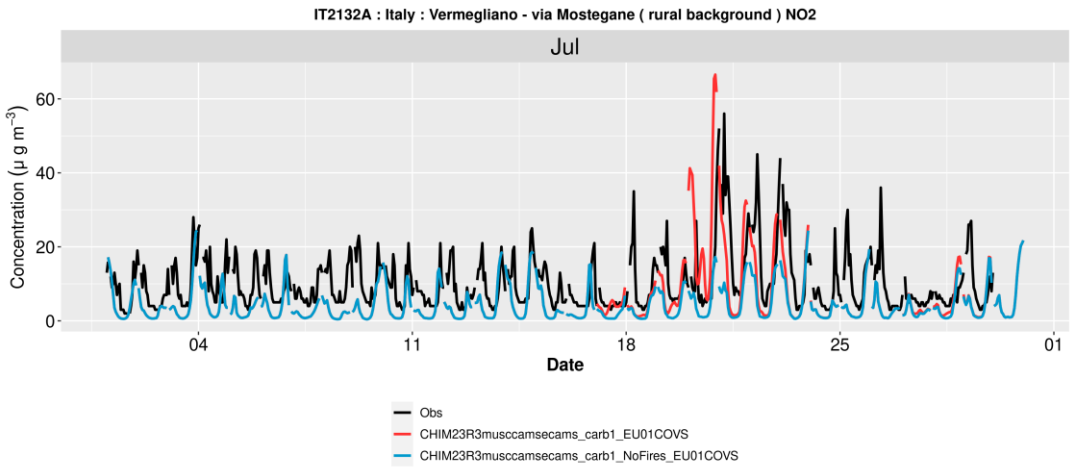








- Models show quite good agreement in identifying the wildfire signal across the domain.
- Although the general trend is well-captured, there is occasional significant overestimation of specific concentration peaks at certain times and locations.

2 July 2022 Campaign: VOCs & O_3 Intensive Measurement Period

- Gaseous Species: Multi-model assessment (CHIMERE, SILAM, MINNI)

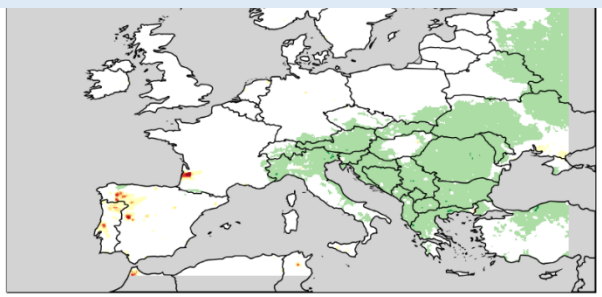
HCHO

Monthly Mean Value

2022-07

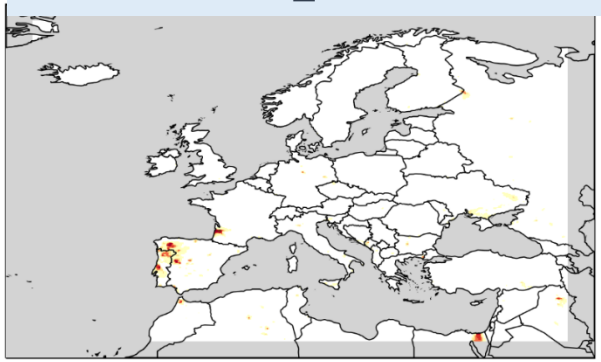
CHIMERE23R3

CHIMEREv2023r2

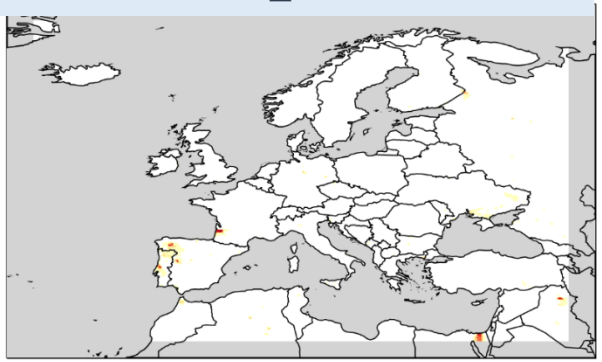


SILAM

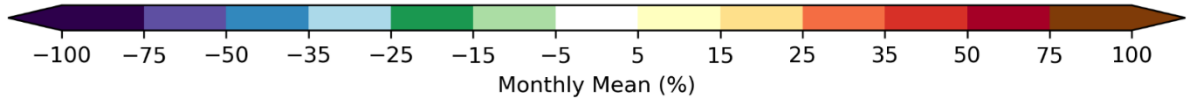
MINNI_PSEM



MINNI_MEGAN



Good model agreement on the general spatial pattern for HCHO increases (decreases for one of the models to be analysed)



2 July 2022 Campaign: VOCs & O_3 Intensive Measurement Period

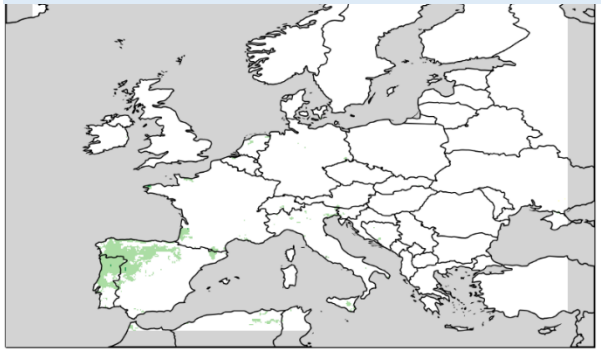
- Gaseous Species: Multi-model assessment (CHIMERE, SILAM, MINNI)

C5H8

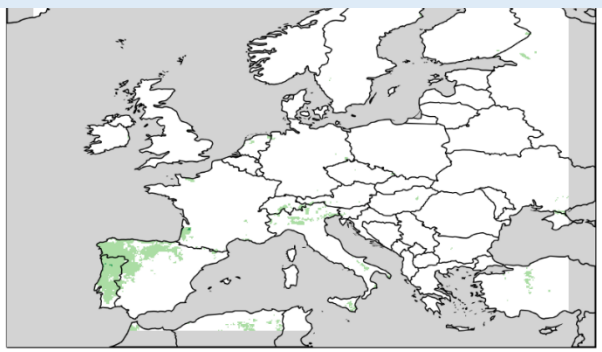
Monthly Mean Value

2022-07

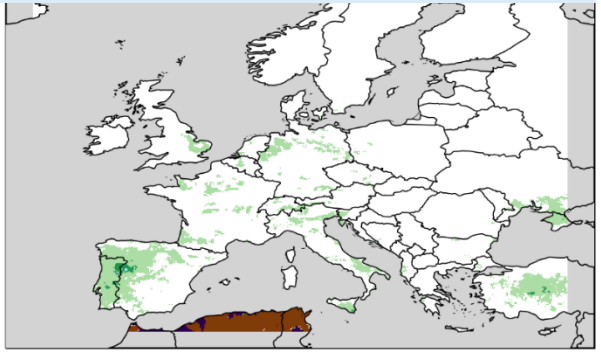
CHIMERE23R3



CHIMEREv2023r2



SILAM



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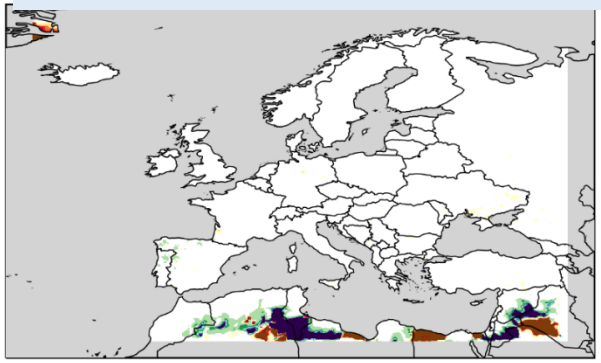

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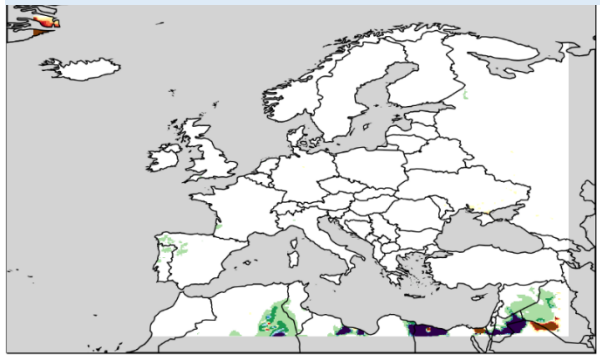
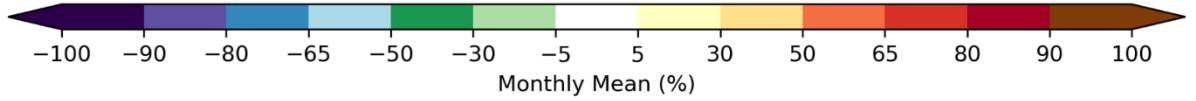
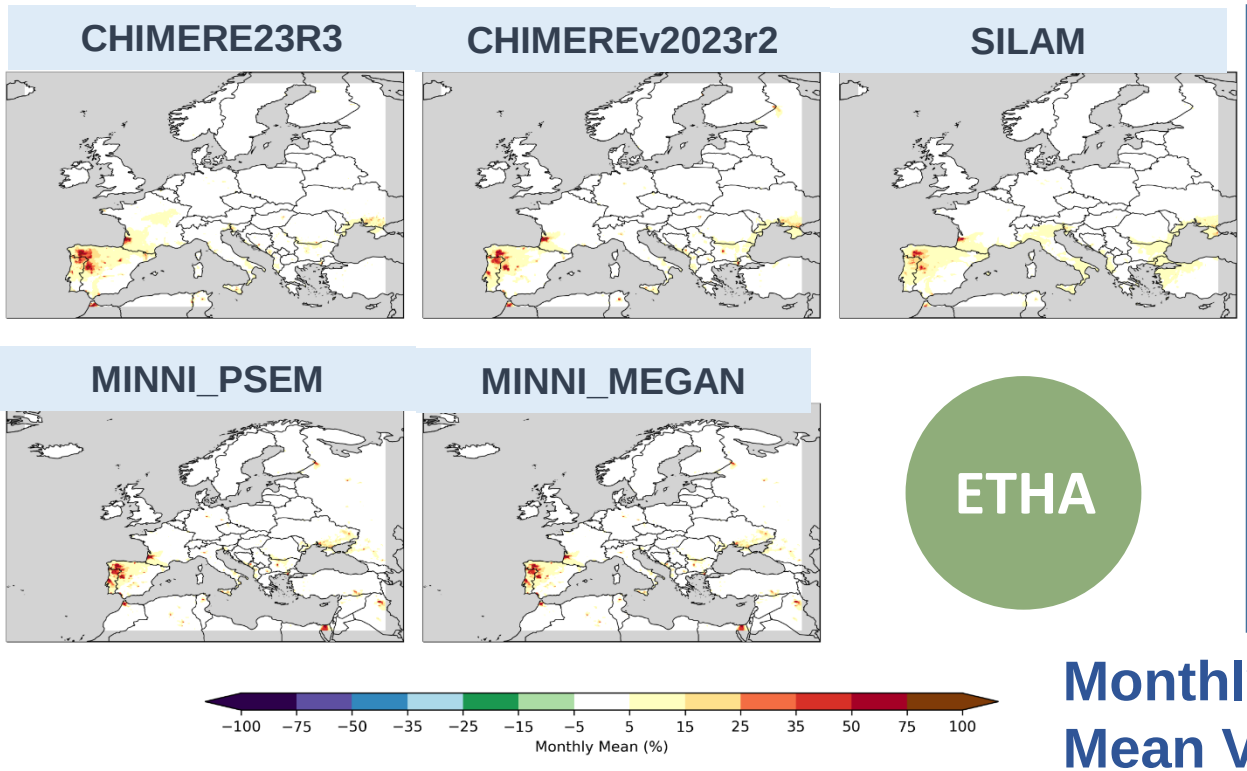


Isoprene: Model agreement on concentration decrease over fire areas, with varying degrees of intensity.

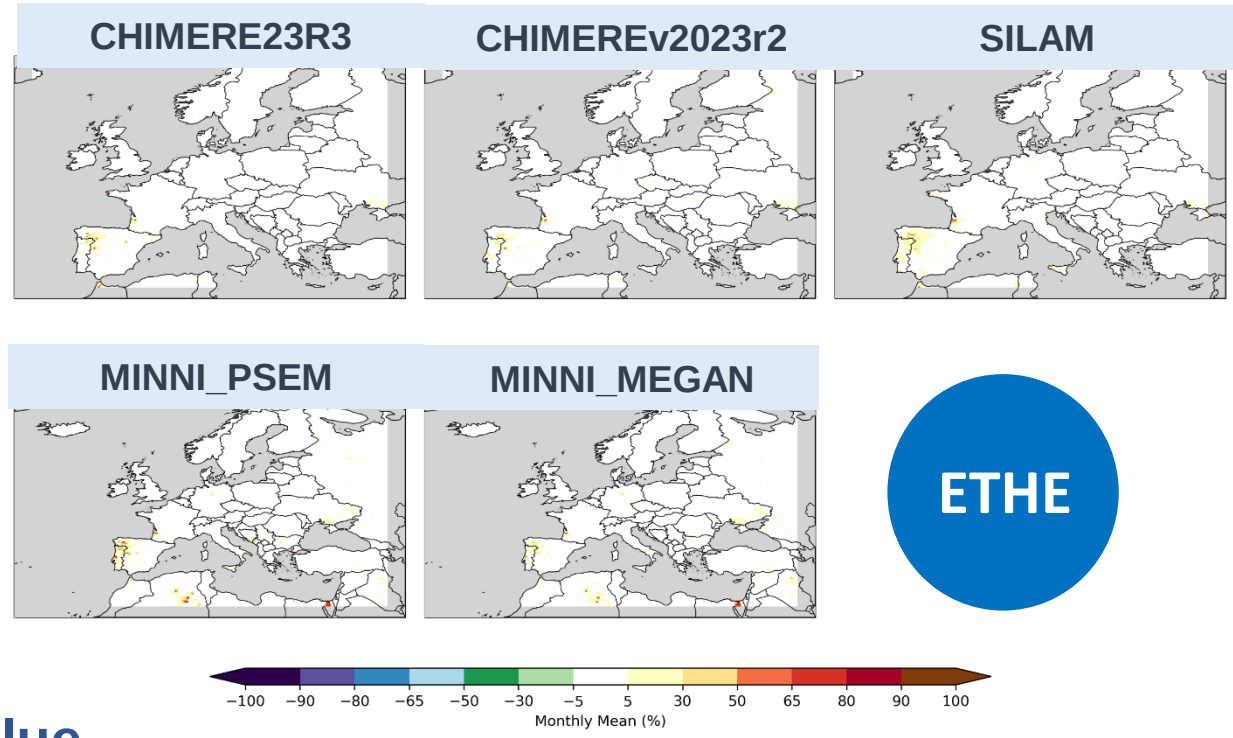


2 July 2022 Campaign: VOCs & O_3 Intensive Measurement Period

- Gaseous Species: Multi-model assessment (CHIMERE, SILAM, MINNI)



Monthly Mean Value



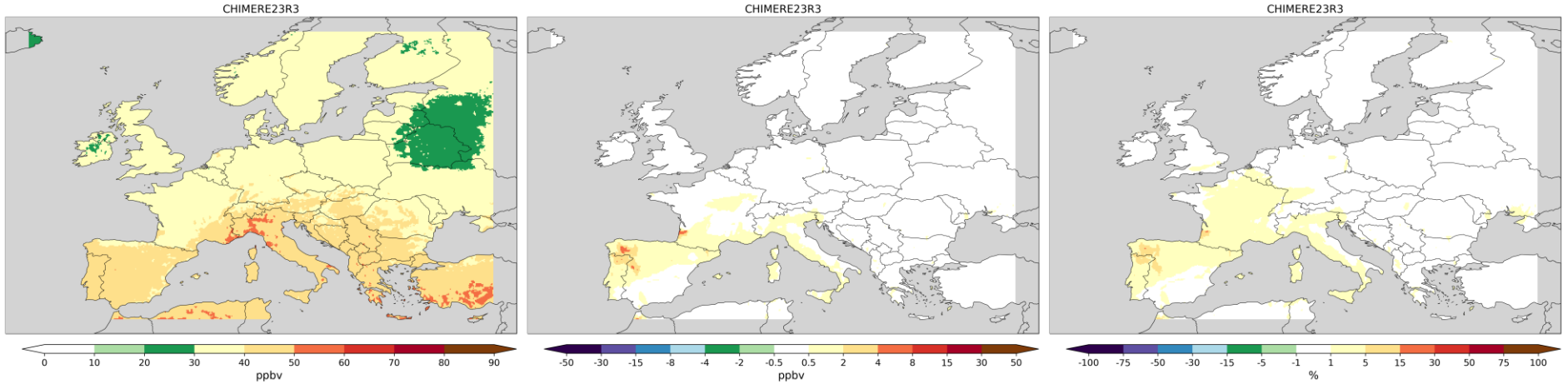
ETHA & ETHE: High model agreement on fire-induced increases.

3 September 2024 Campaign: VOCs & O_3 Intensive Measurement Period

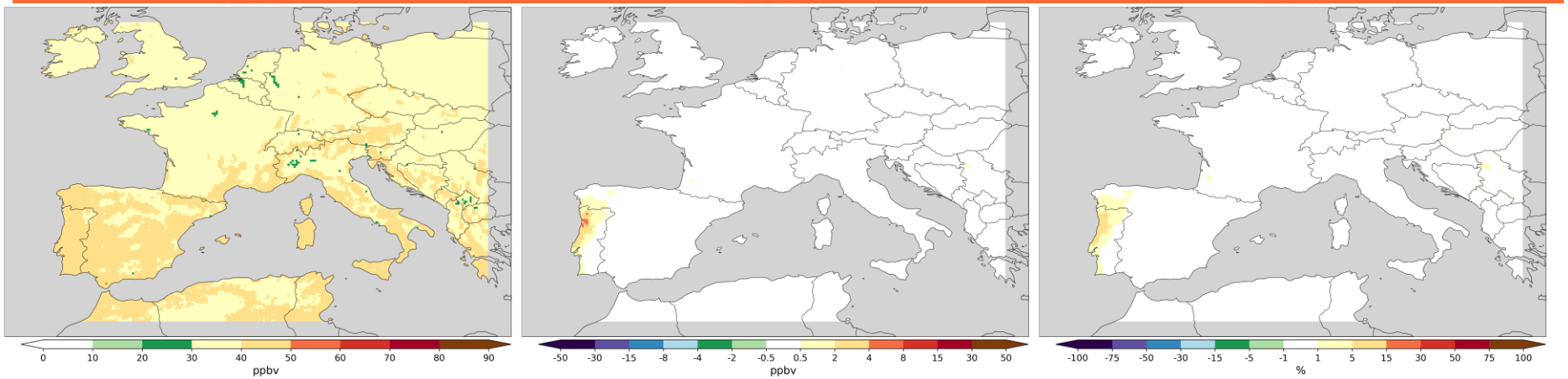
- Gas phase pollutants

O3 — Ozone

2022 — July



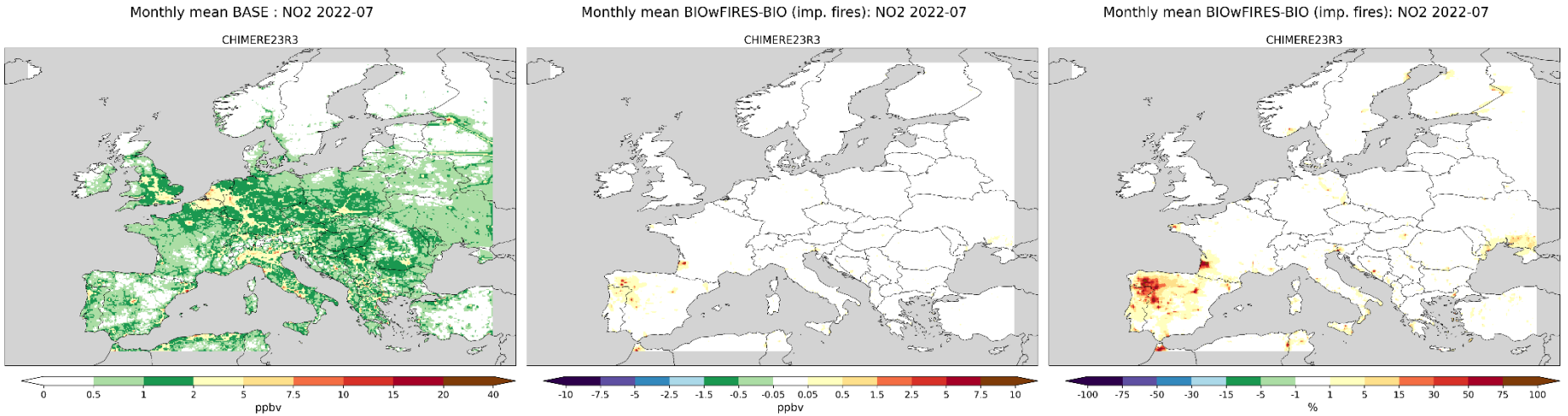
2024 — September



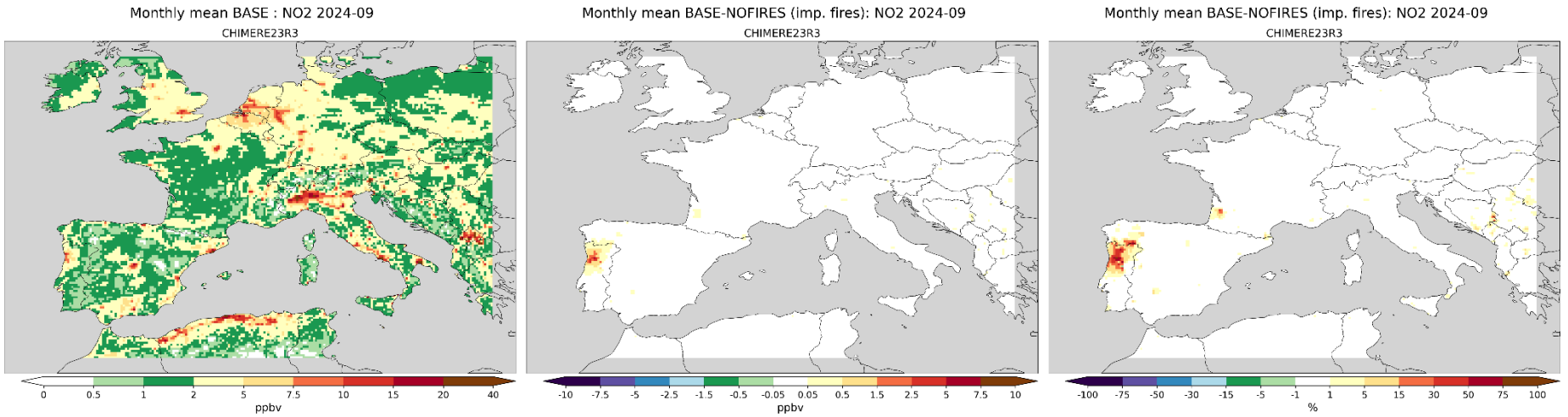
In contrast to the 2022 campaign, the spatial extent of O3 increases in 2024 was much more limited, with fewer areas experiencing significant fire-attributable ozone impacts.

NO2 —

2022 — July



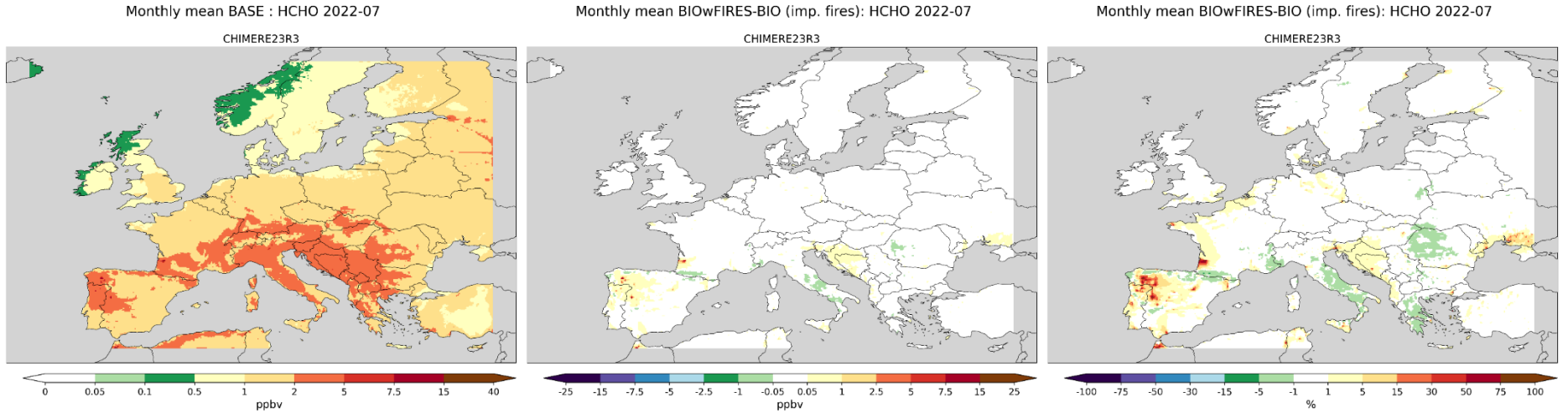
2024 — September



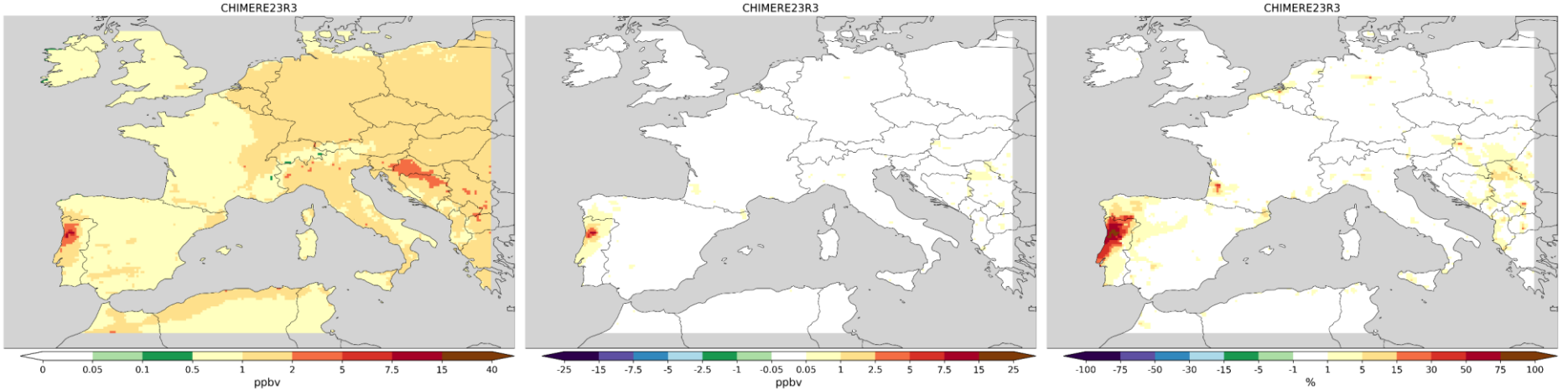
2024 campaign: impacts of fires on NO2 reflect the fact that fires more concentrated in one area in Portugal (in 2022 more emission sources distributed across different areas)

HCHO — Formaldehide

2022 — July



2024 — September



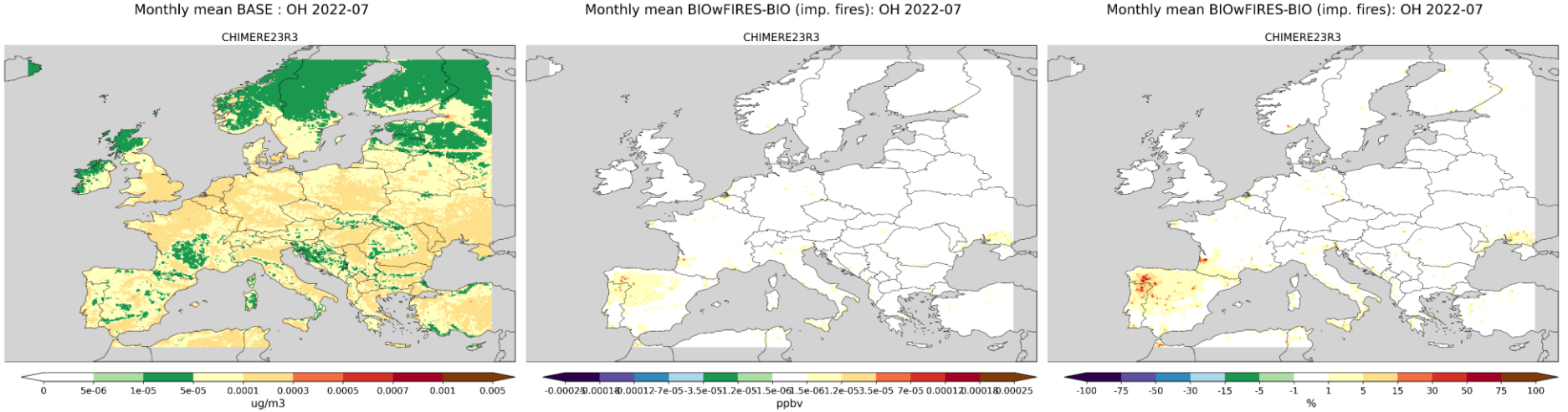
HCHO: positive fire signal in both campaigns.
(15-75%, monthly mean over W Iberia);

Absolute increments of +5-15 ppbv at the affected areas.

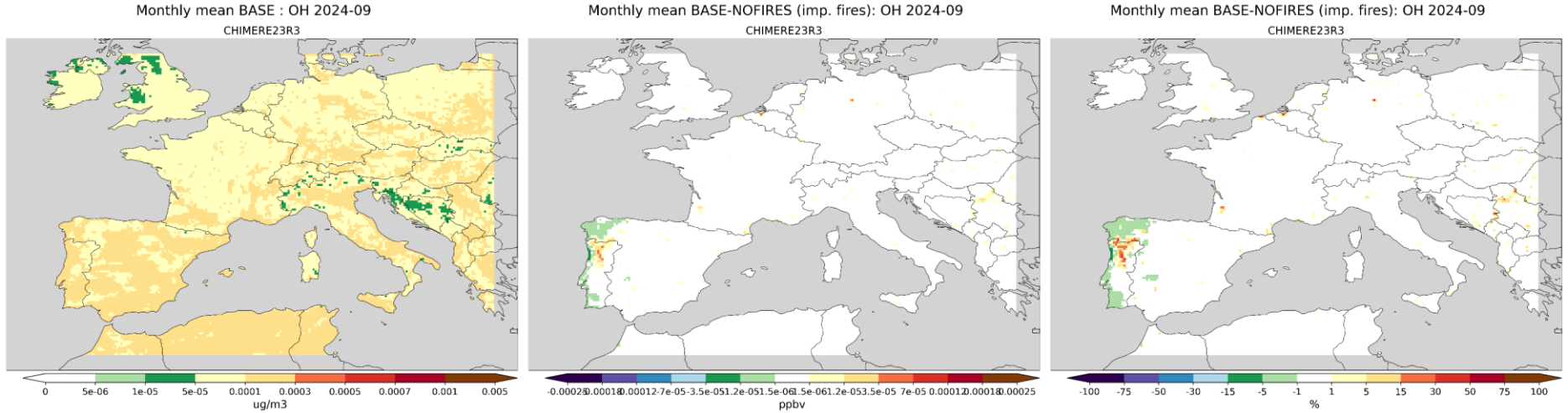
Two drivers: direct GFAS emission of HCHO and secondary formation via OH-oxidation of fire VOCs

OH —

2022 — July



2024 — September

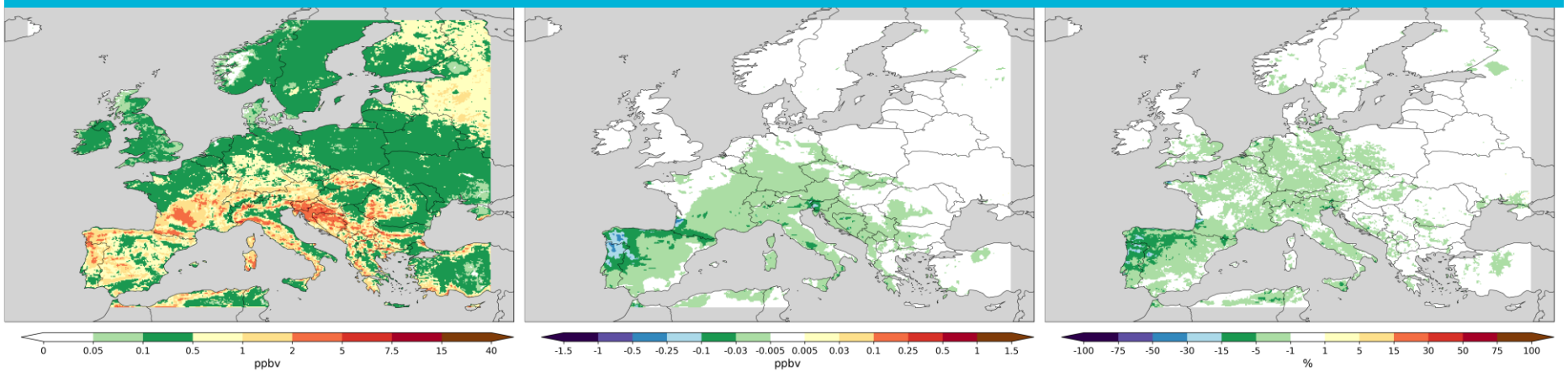


July 2022: predominantly POSITIVE— GFAS emissions → OH formation (HCHO photolysis -> HO2 -> OH;

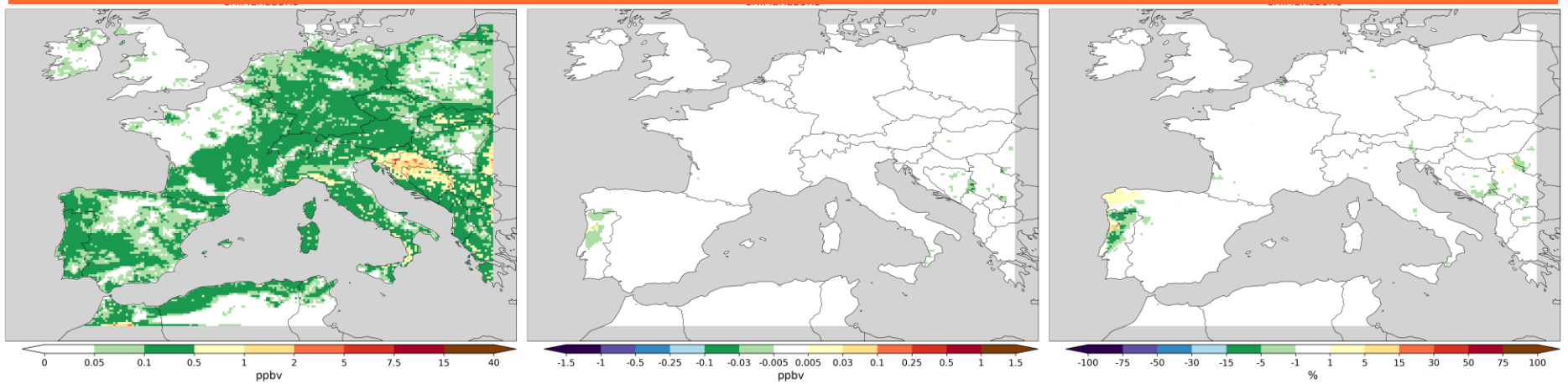
September 2024: Positive signal and negative signal

C5H8 — Isoprene

2022 — July



2024 — September



ISOP at fire source (W Iberia 2022, Portugal 2024): reductions (-0.03 to -0.5 ppbv, monthly mean)

ISOP in distal plume:, slowing biogenic ISOP consumption -> net accumulation

7. Conclusions

Based on the July 2022 and September 2024 wildfire episodes over Europe using CHIMERE23R3 and five models:

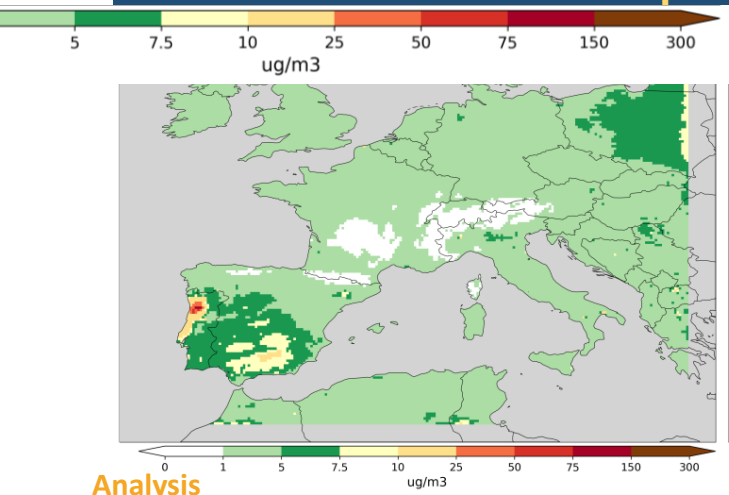
- $PM_{2.5}$ and PM_{10} show the strongest and most spatially robust fire signals. Model estimates significant increases in PM2.5 levels, reaching more than 75% . Increments can range between of 30–140 μg/m³) in the most affected areas. Fire-attributable exceedance days reached 8 ($PM_{2.5}$) in July 2022 and 6 in September 2024.
- PPM is the main contributor in the fire-driven signal of particles. SOA presents much lower fire signal (should model be revised?)
- All five models agree on the sign and broad spatial pattern of fire impacts for gas compounds.
- CHIMERE and SILAM show a slight increase (5-15%) in mean monthly O3 levels, over the fire-affected areas of NW Spain. CHIMERE chim23r3 estimate increments up to 15-30 ppb in fire affected areas for concrete dates.
- HCHO increased robustly and consistently across all models in both campaigns, driven by direct GFAS emission and secondary VOC oxidation.
- Isoprene shows reductions at the fire source (radical overconsumption) and positive anomalies in the distal plume (OH suppression of local biogenic ISOP).
- OH shows a predominantly positive (increment) regional signal over the Iberian plume in July In September Positive signal and negative signal

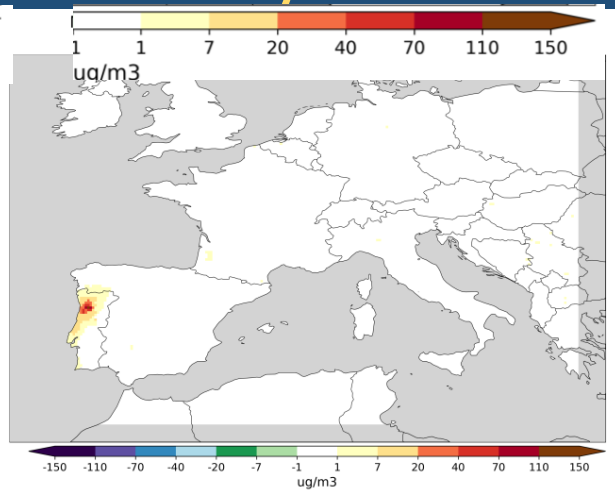
Thanks

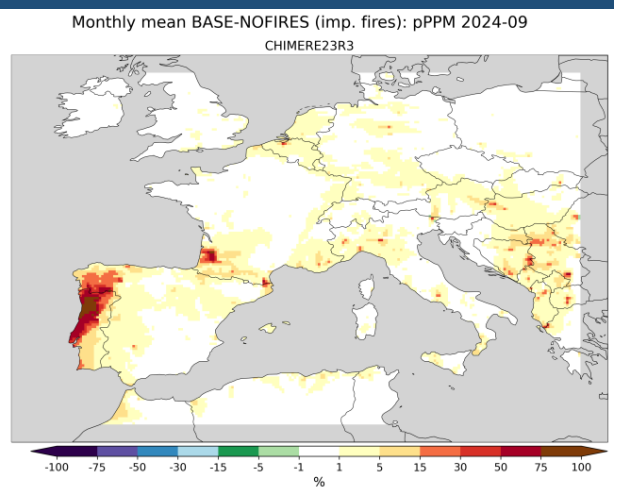
We thank the Ministry for the Ecological Transition and the Demographic Challenge

SOAs & pPPM

pPPM — Primary Particulate Matter







Analysis

SOA — Secondary Organic Aerosol