
**XIII giornata sulla modellistica in ARIA(NET)
Milano, 24-25 marzo 2026**

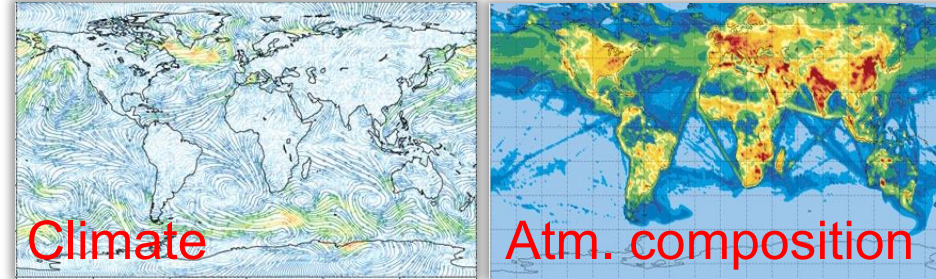
Ricostruzione di composizione atmosferica e clima sull'Europa per il periodo 2005-2019 con il sistema WRF+FARM

Sandro Finardi, Nicola Pepe, Paola Radice, Camillo Silibello

The overall aim of **FOCI** is to improve our knowledge of individual and cumulative contribution to climate change of non-CO₂ radiative forcers and their precursors

- **Assessment of Regional Climate Models** during the last part of the historical period
 - Multimodel approach experimented for RegCM5-Chem, WRF-Chem, WRF-CMAQ, **WRF-FARM** driven by EC-Earth and ready for EMAC

Global climate predictions



Forcings

Anthropogenic emissions

Wildfires emissions

Land cover

Coherent with Climate CMIP6/CMIP7

Integration needed for downscaling:

- CEDS -> PM2.5, PM10
- GFED -> daily wildfire emissions
- LUH2 -> LUCAS

BCs from driving ESM

Inline forcings computation

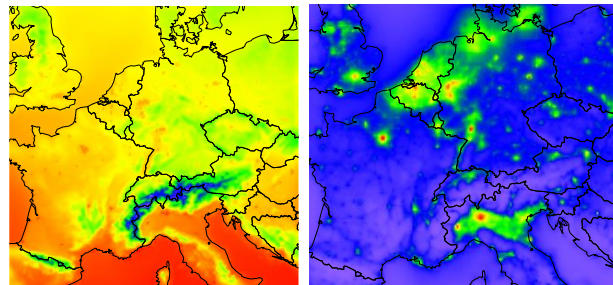
Biogenic emissions

Dust

Sea Salt

Driven by downscaled climate and related inputs (land cover)

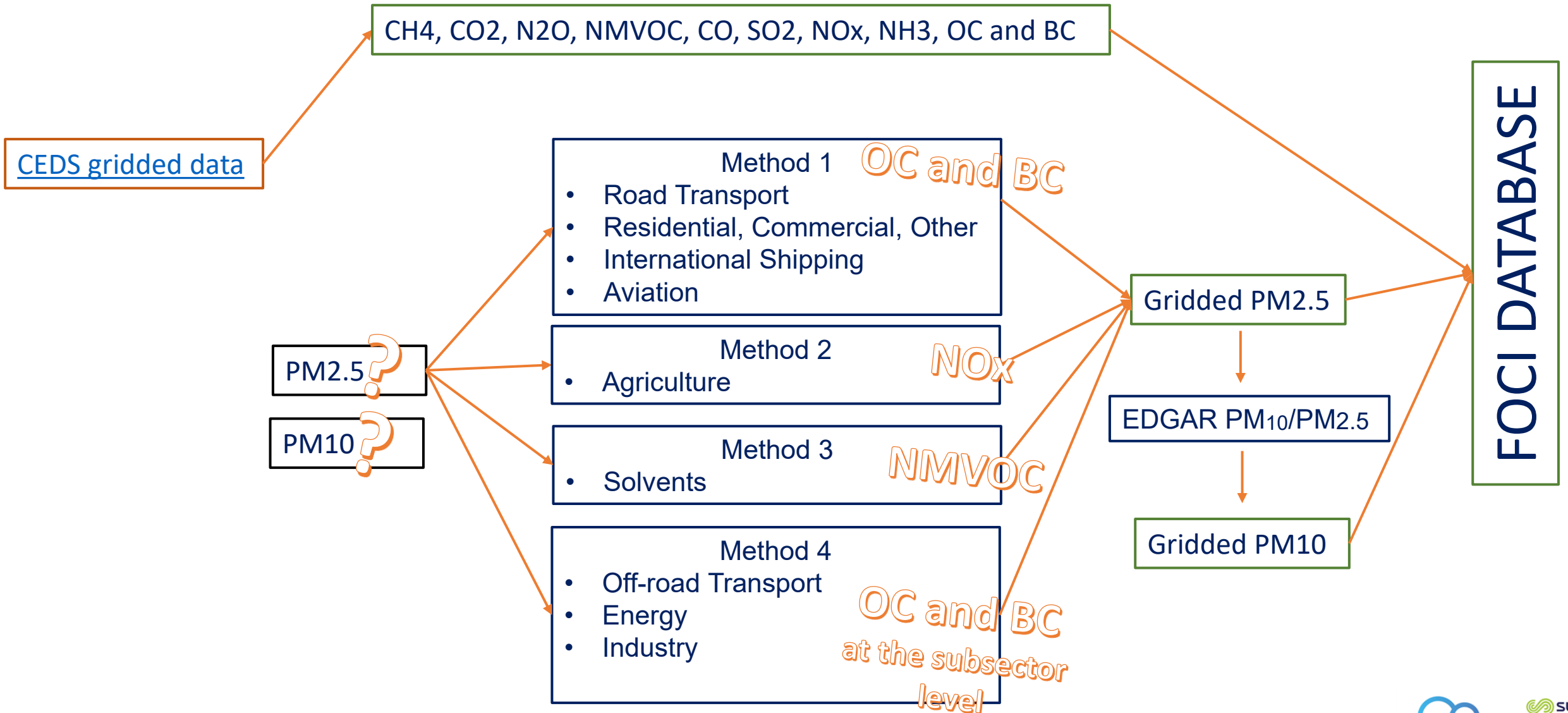
RCMs



Regional climate & atm. Comp predictions

Scenario	Models	Time window	Met. driver	Atmospheric composition driver	Emissions	Land Cover
Historical driven by reanalyses (2004-2019)	WRF+FARM	2004-2019	ERA5	CAMS global Reanalyses	CEDS	LUCAS (LH2 compatible)
Historical driven by EC-Earth3 (historical 2004-2014 and SSP3.7.0 2015-2019)	WRF+FARM	2004-2019	EC-Earth3	EC-Earth3	CEDS	LUCAS (LH2 compatible)
CMIP6 SSP3.7.0 scenario (2045-2055)	WRF+FARM	2045-2055	EC-Earth3	EC-Earth3	ScenarioMIP	LUCAS (LH2 compatible)
CMIP6 SSP3.7.0-low NTCF scenario (2045-2055)	WRF+FARM	2045-2055	EC-Earth3	EC-Earth3	AerChemMIP	LUCAS (LH2 compatible)

SSP3-7.0 scenario is a medium-high reference scenario within the “regional rivalry” socio-economic family
 SSP3-7.0-LowNTCF variant of the SSP3-7.0 scenario with reduced near-term climate forcer (NTCF) emissions





FARM domains and configuration

External domain (nearly coincident with CORDEX Europe),
grid spacing 27km, $n_x=191$, $n_y=190$, $n_z=18$

Internal domain, grid spacing 9km, $n_x=187$, $n_y=184$,
 $n_z=18$

Simulation length: 15 years (2005-2019), 2004/12=spin-up

LandCover: LUCAS

Forcing at BC: CAMS global reanalyses (EAC4)

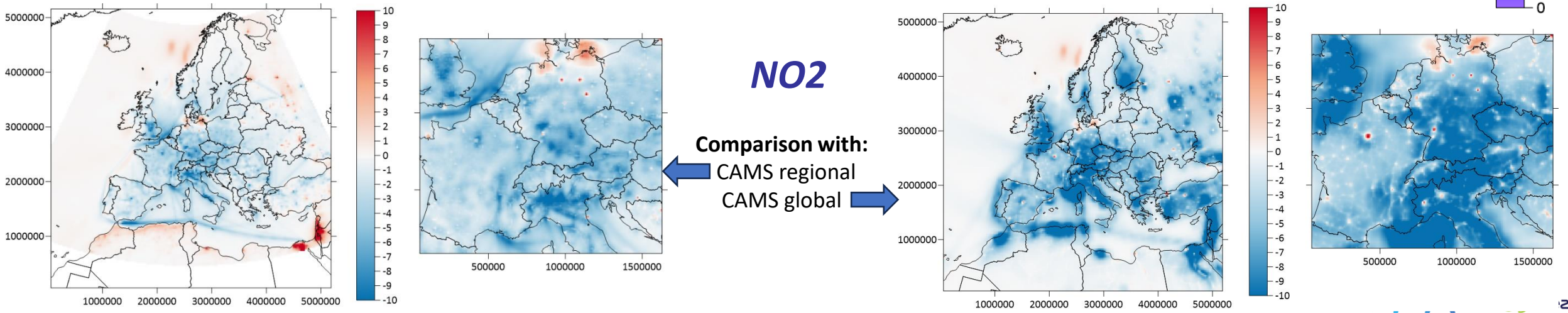
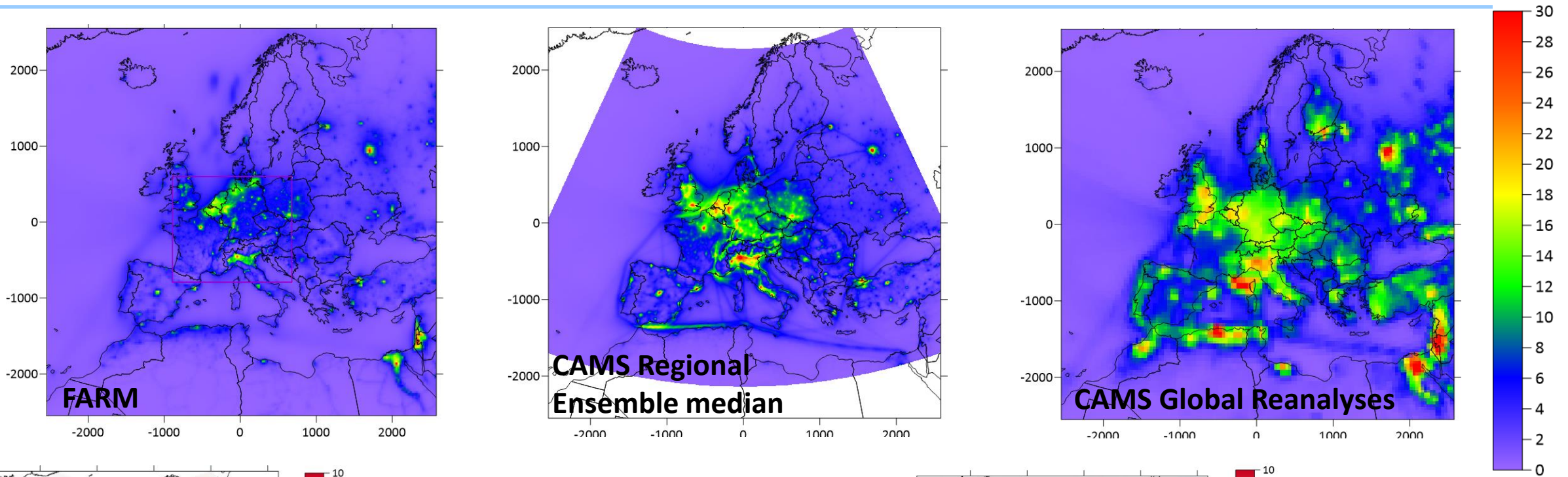
Emission inventory: CEDS + GFED5

Biogenic emissions: PSEM

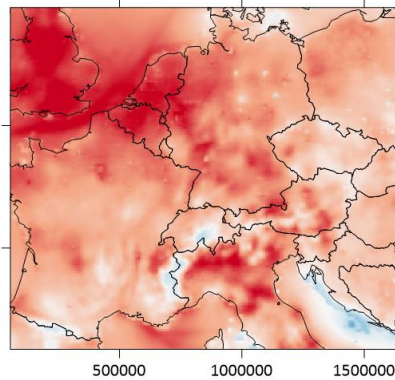
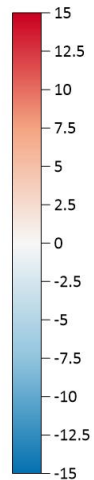
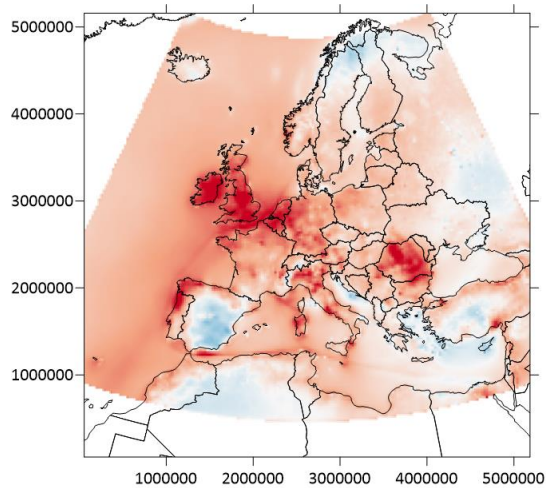
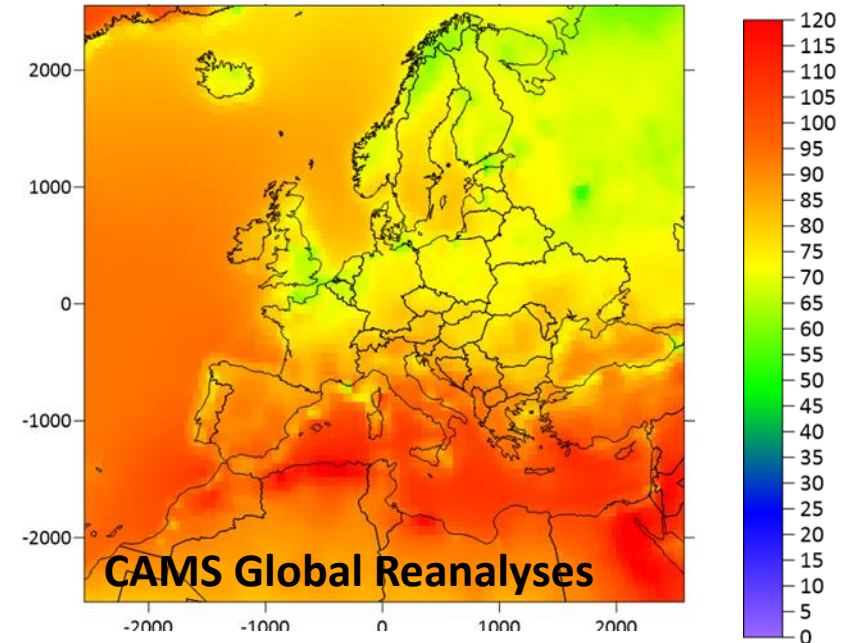
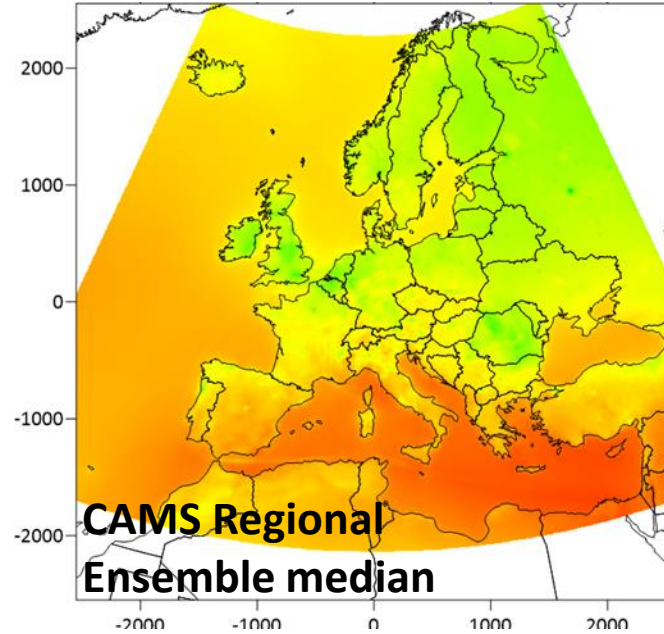
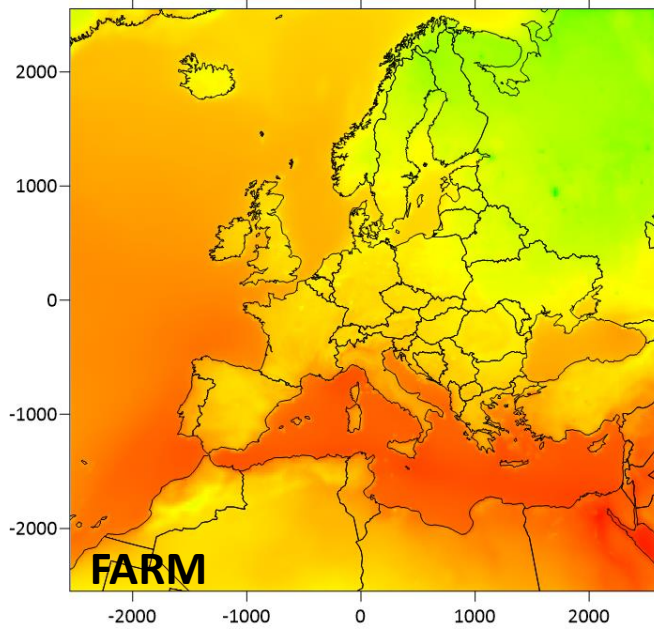
Chemical scheme: SAPRC99

Aerosol scheme: modal, AERO3

FARM evaluation with reanalyses for historical simulation (2013 to 2019)



FARM evaluation with reanalyses for historical simulation (2013 to 2019)

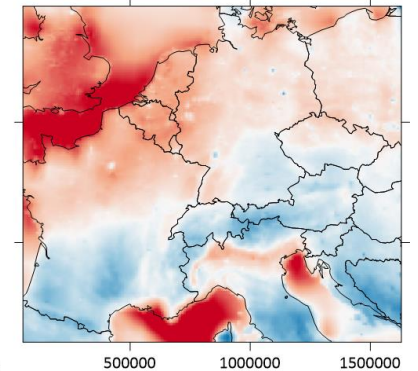
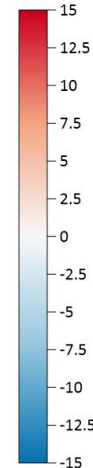
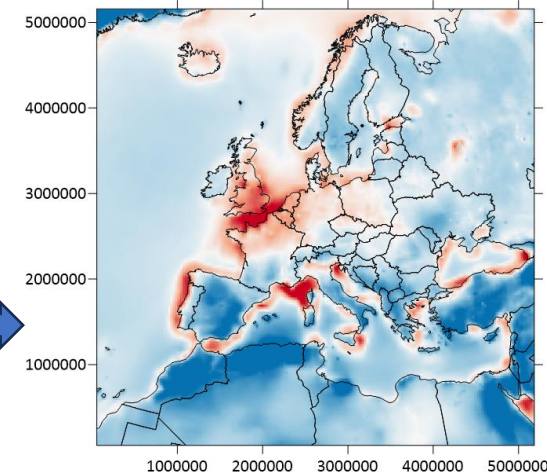


O3 mda8h

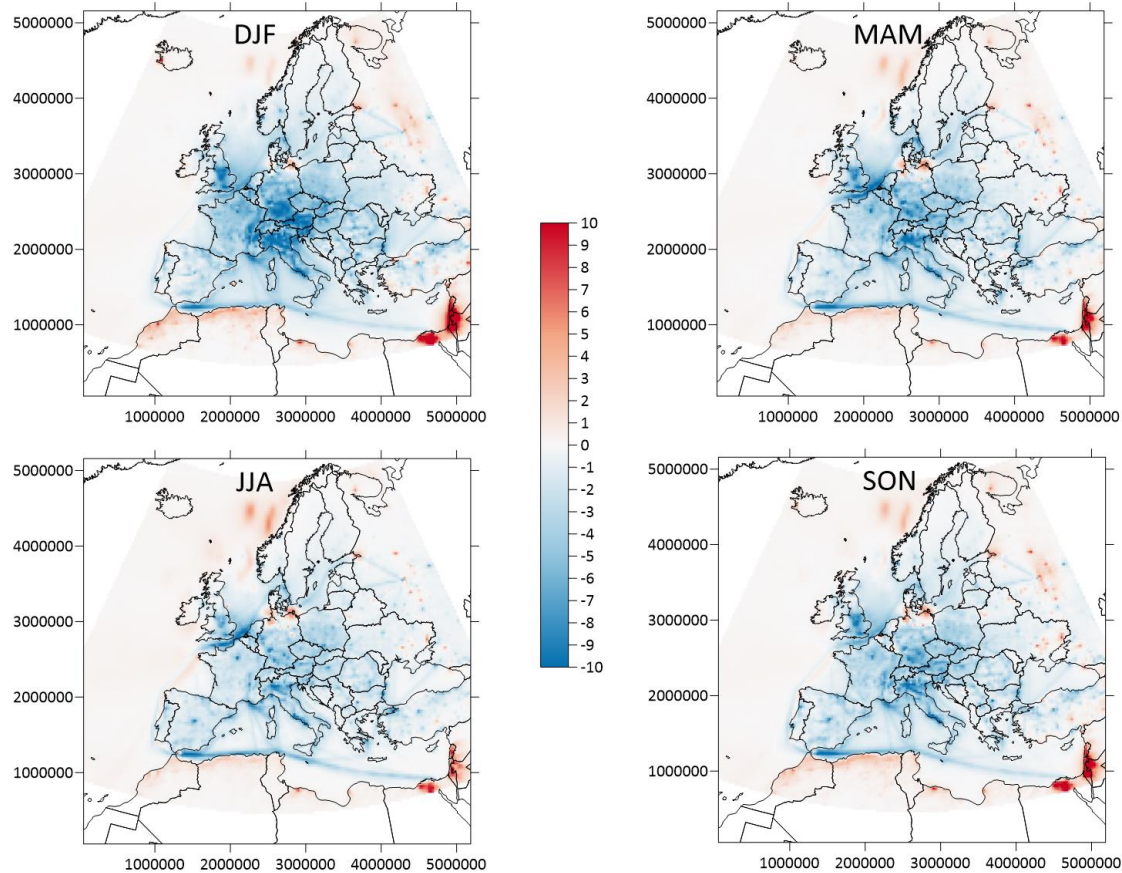
Comparison with:

← CAMS regional

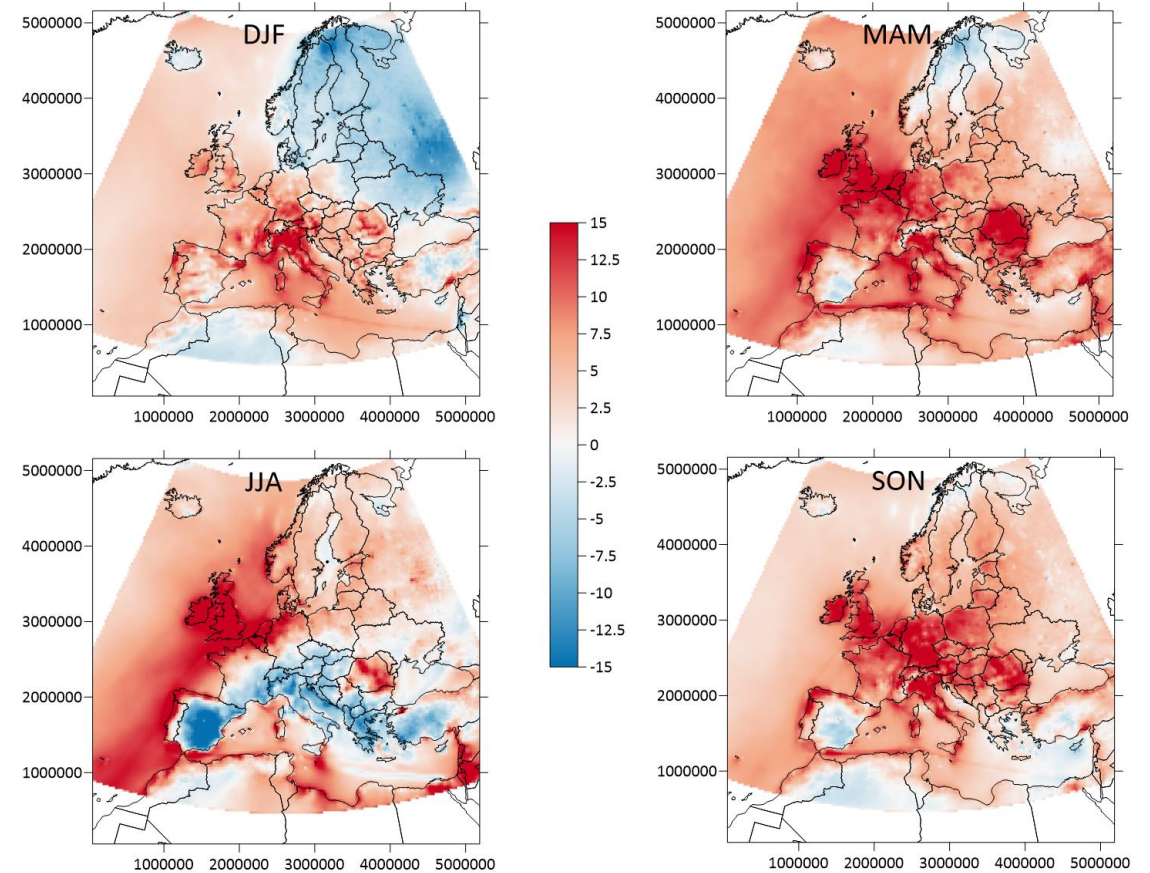
CAMS global →

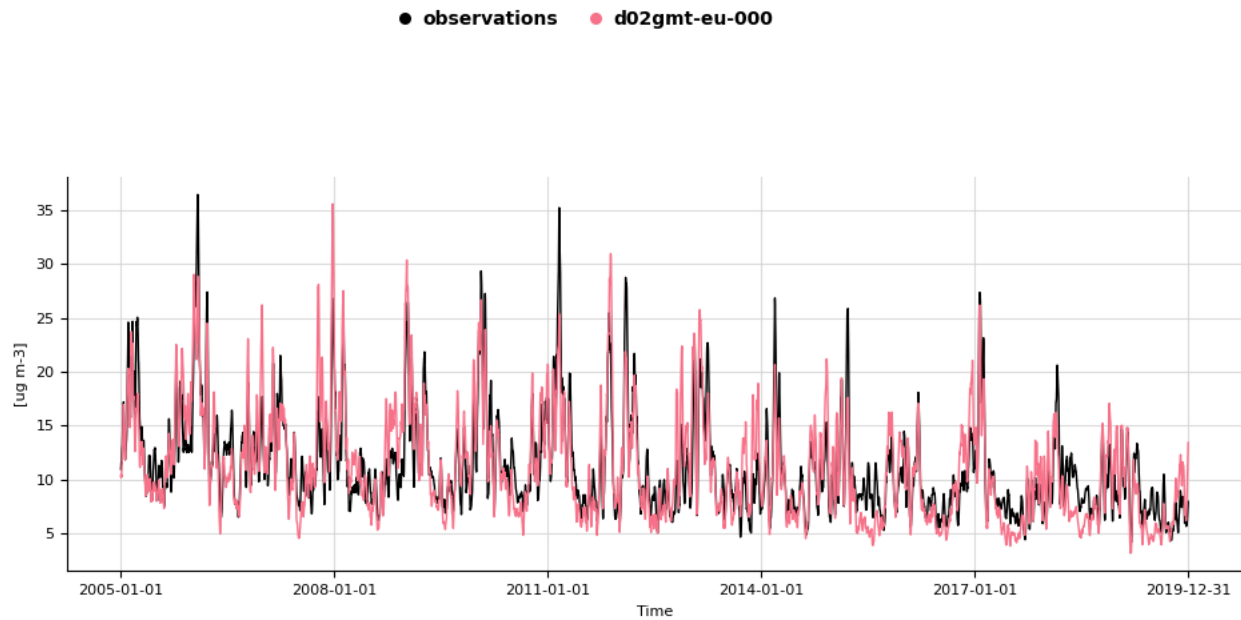
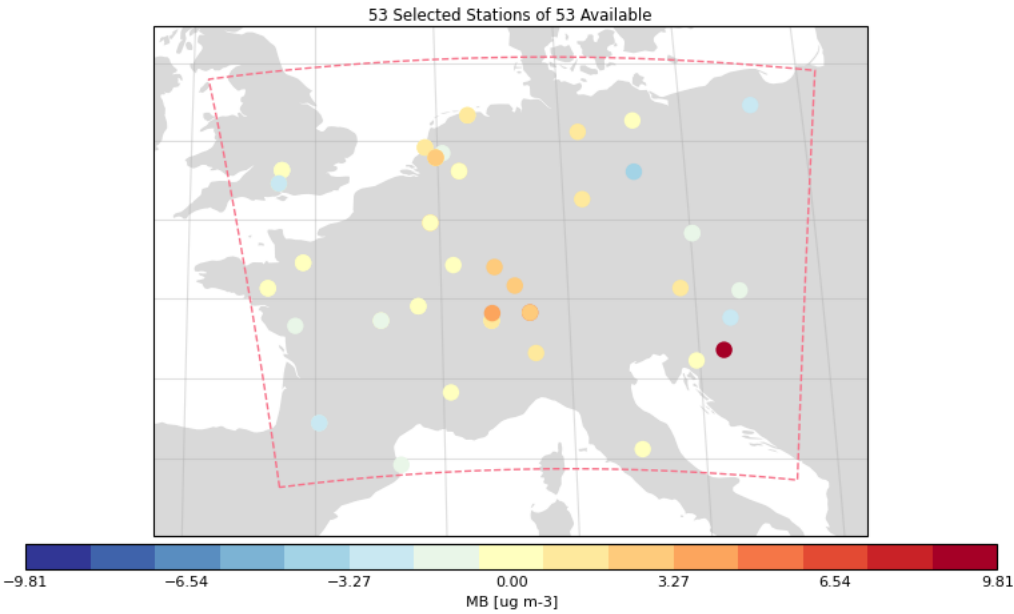


2005-2019 season mean NO₂ diff
FARM – CAMS regional ens. median

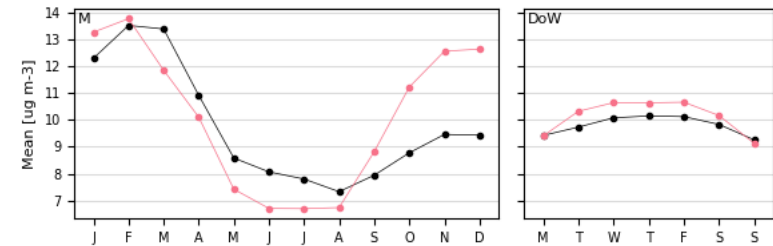
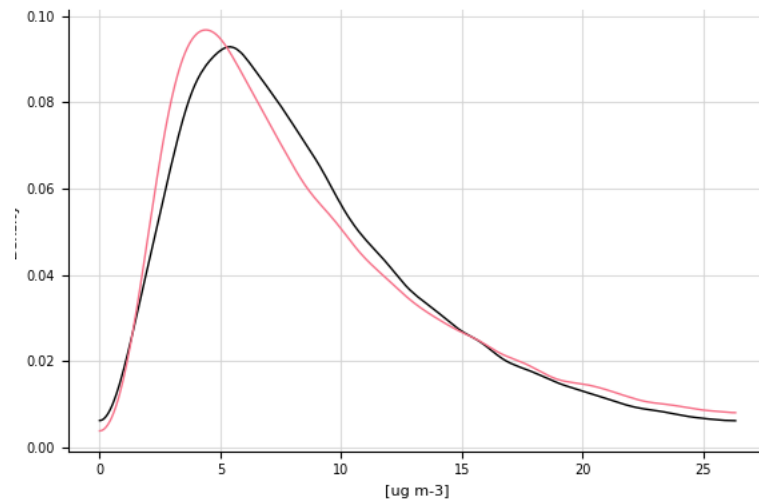


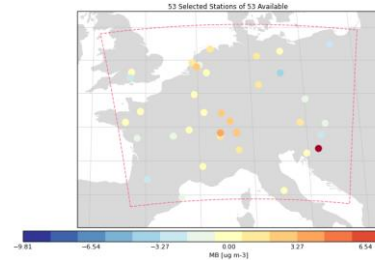
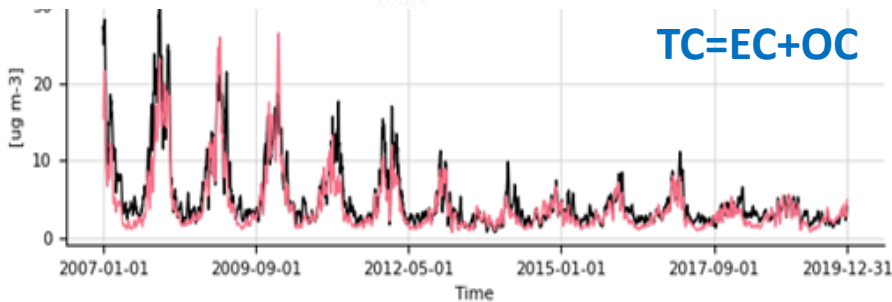
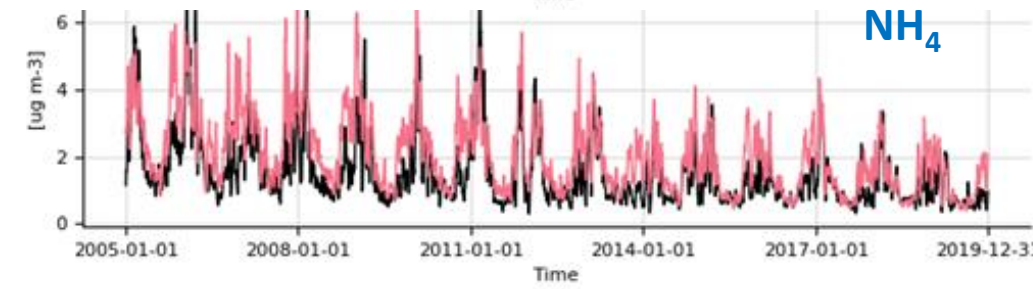
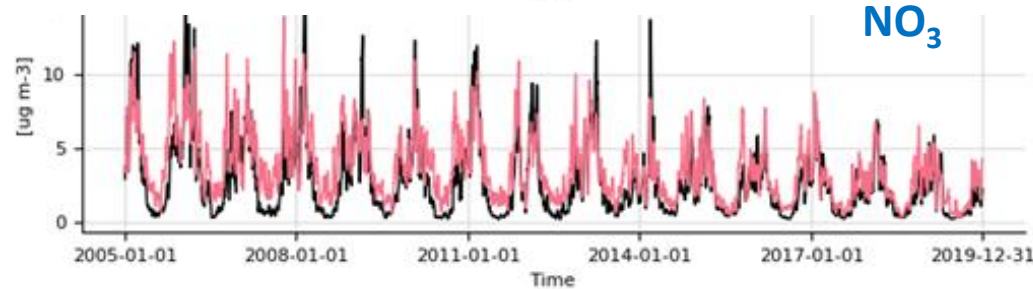
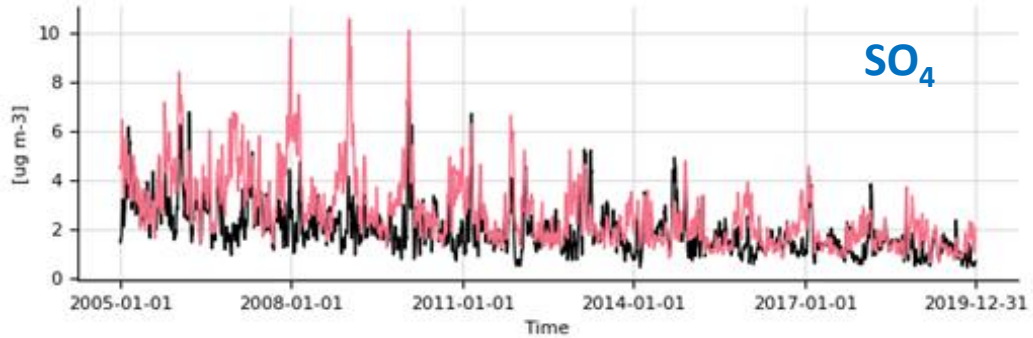
2005-2019 season mean O₃ MDA8H diff
FARM – CAMS regional ens. median



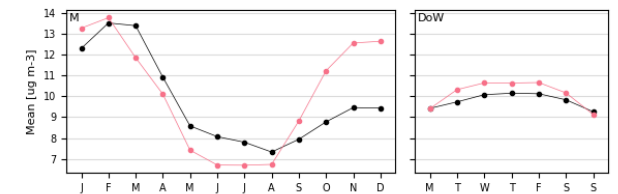
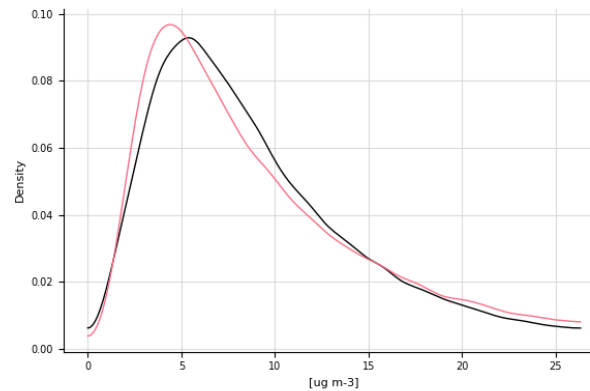
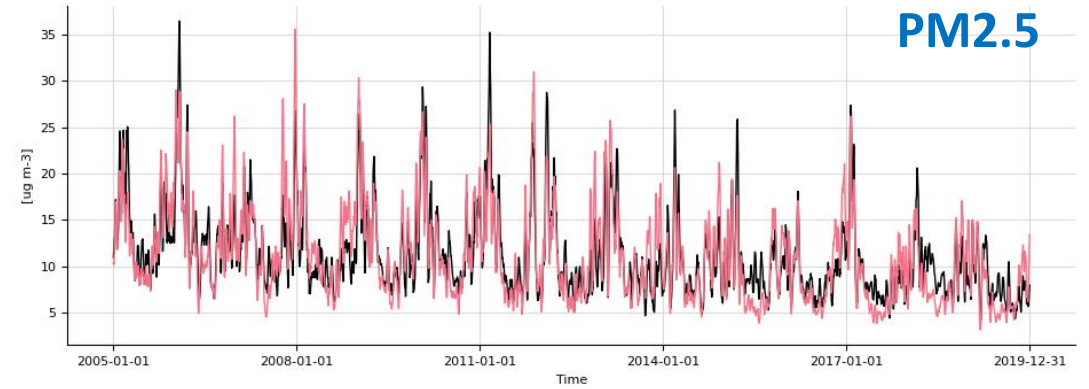


	Mean	StdDev	p5	Median	p95	NStations	Min	Max
observations	9.80	7.50	2.77	7.63	24.14	20.00	0.80	69.34
d02gmt-eu-000	10.14	7.41	2.59	7.88	25.31	20.00	0.98	52.17





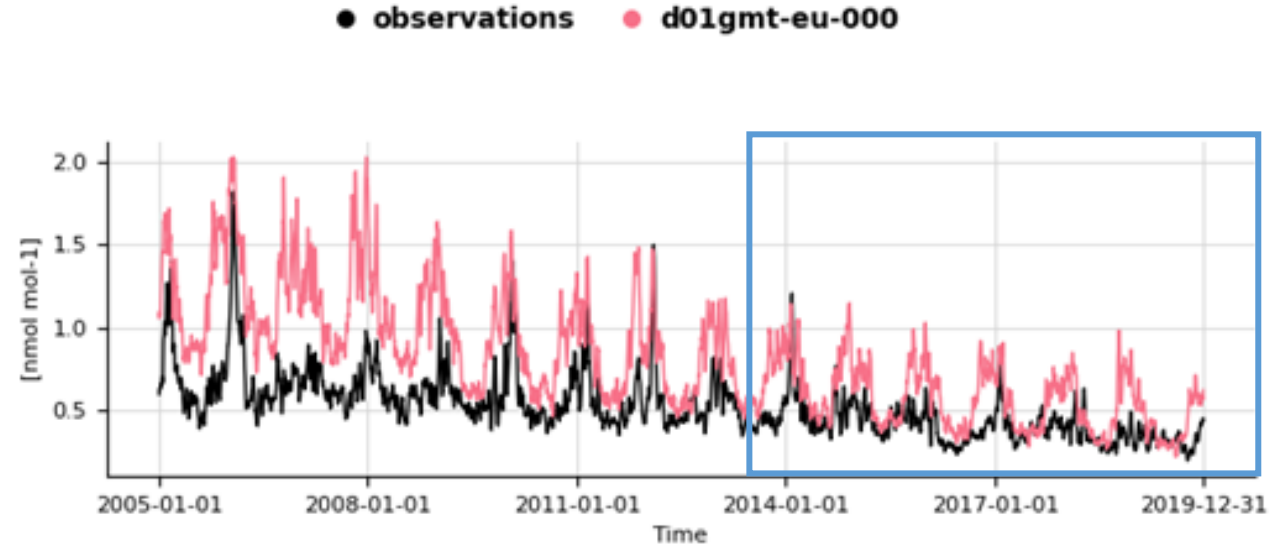
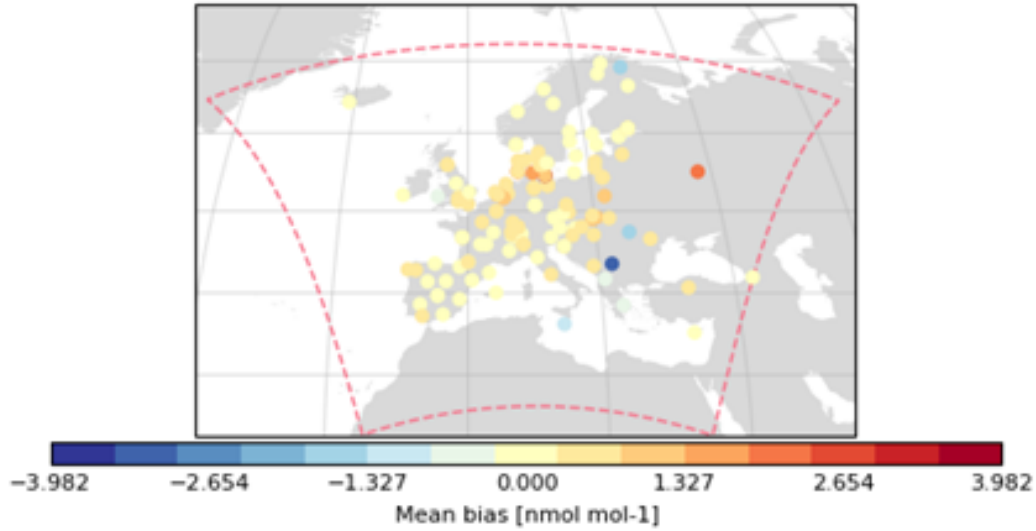
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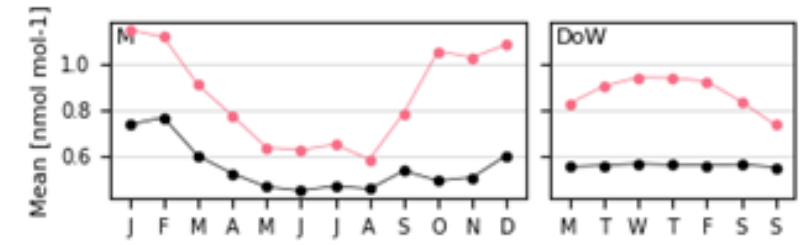
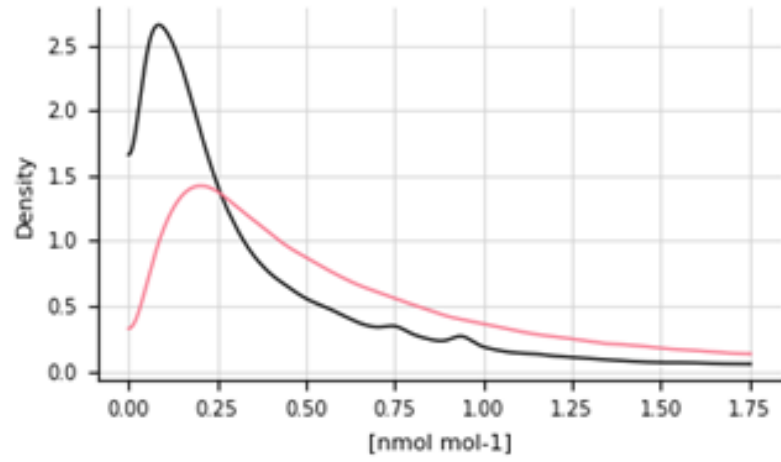
● observations ● d02gmt-eu-000

SO₂ (ppb) FARM vs EMEP network 2005-2019

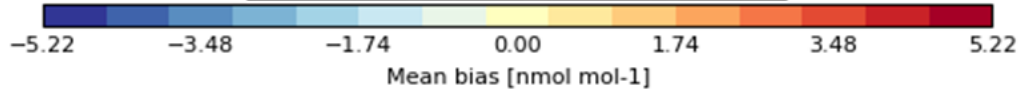
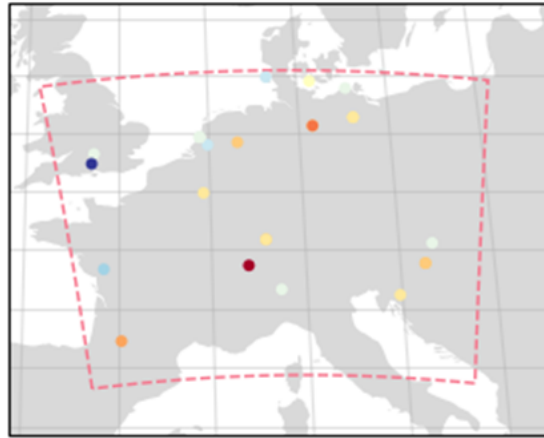
135 Selected Stations of 135 Available



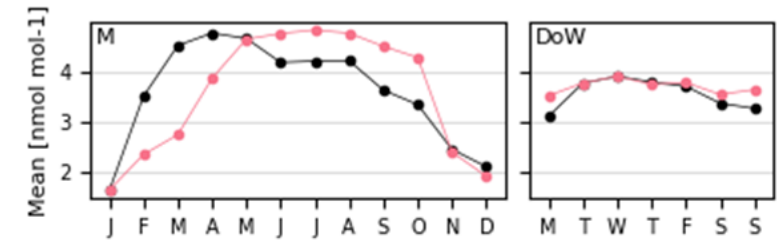
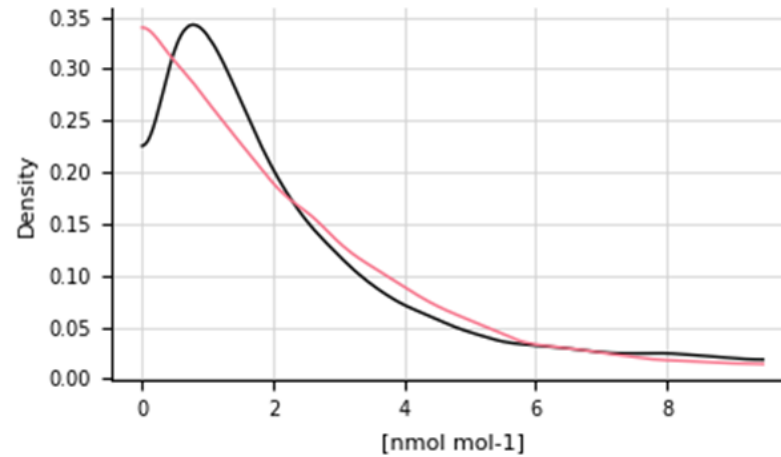
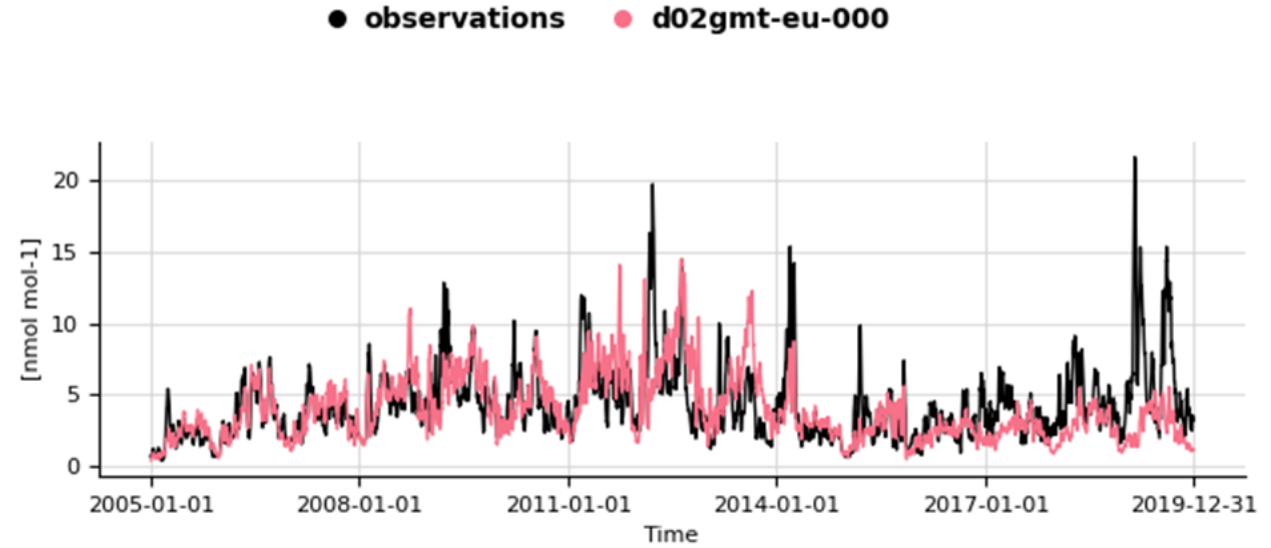
	Mean	StdDev	p5	Median	p95	Min	Max	NStations
observations	0.55	0.57	0.14	0.39	1.47	0.08	7.65	60.40
d01gmt-eu-000	0.87	0.62	0.24	0.71	2.06	0.10	5.20	60.40



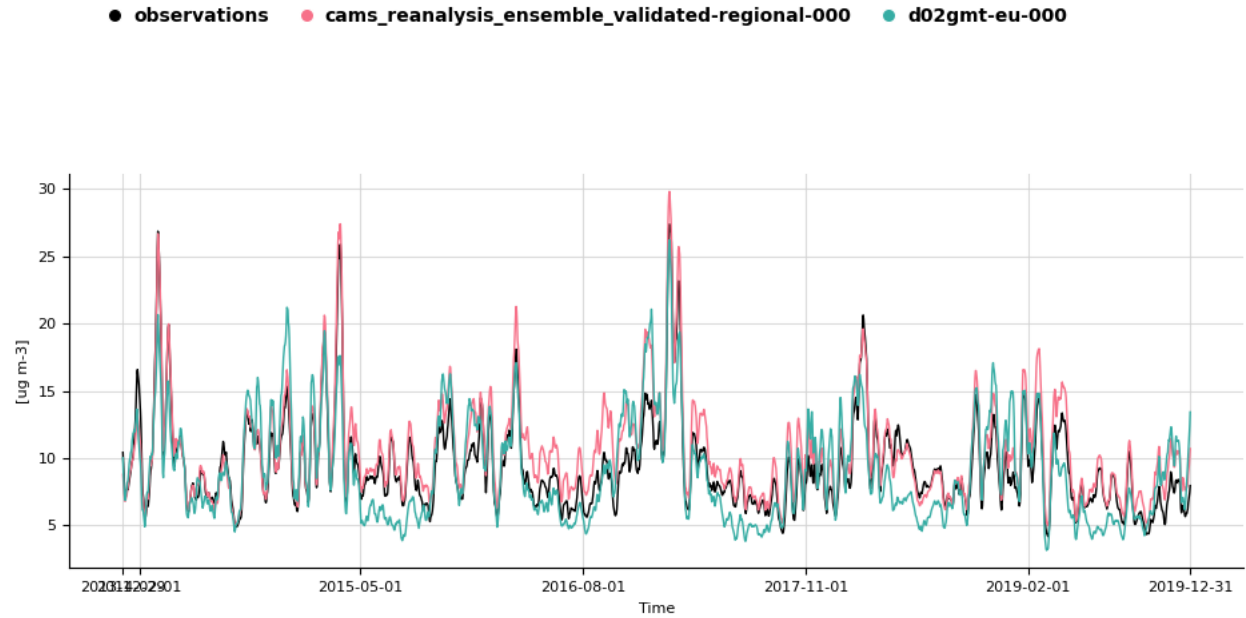
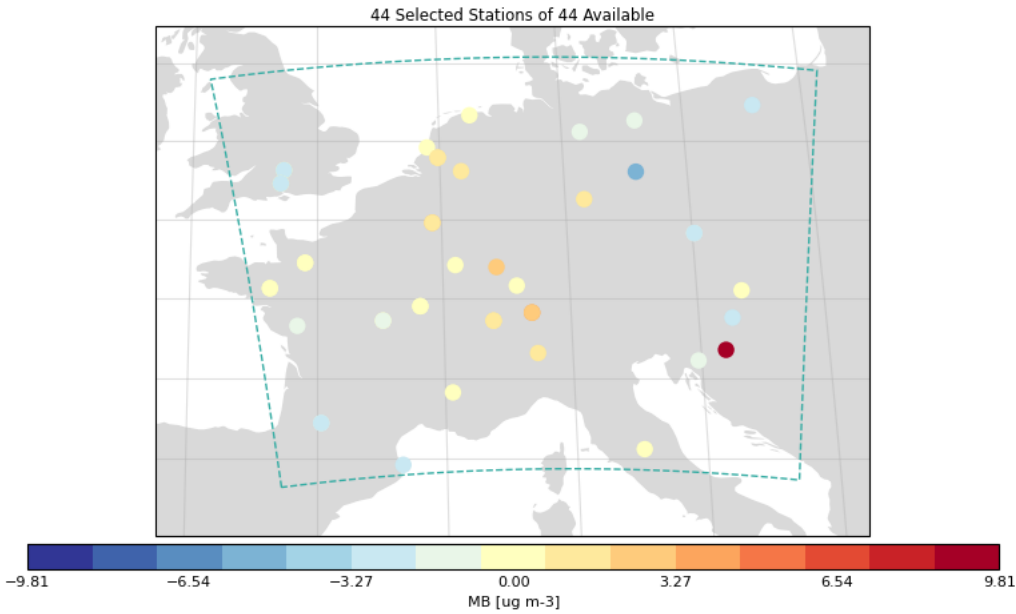
25 Selected Stations of 25 Available



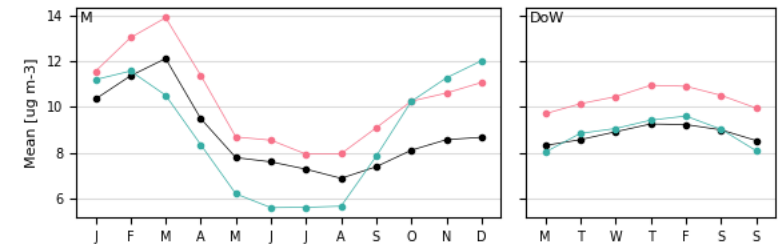
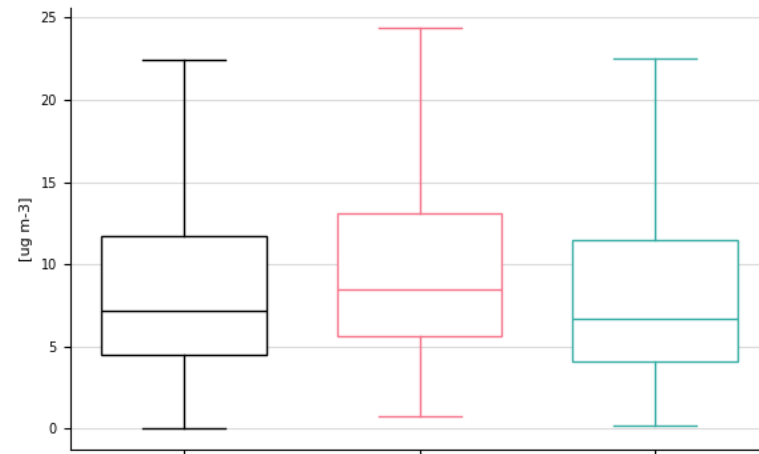
	Mean	StdDev	p5	Median	p95	Min	Max	NStations
observations	3.38	2.48	0.81	2.76	8.07	0.26	20.23	4.55
d02gmt-eu-000	3.56	2.21	0.84	3.15	7.68	0.37	12.11	4.55



PM2.5 - FARM vs CAMS vs EMEP observations 2014-2019

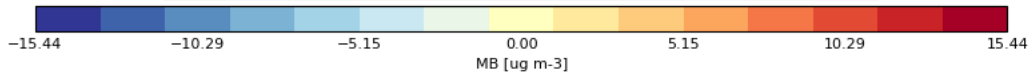
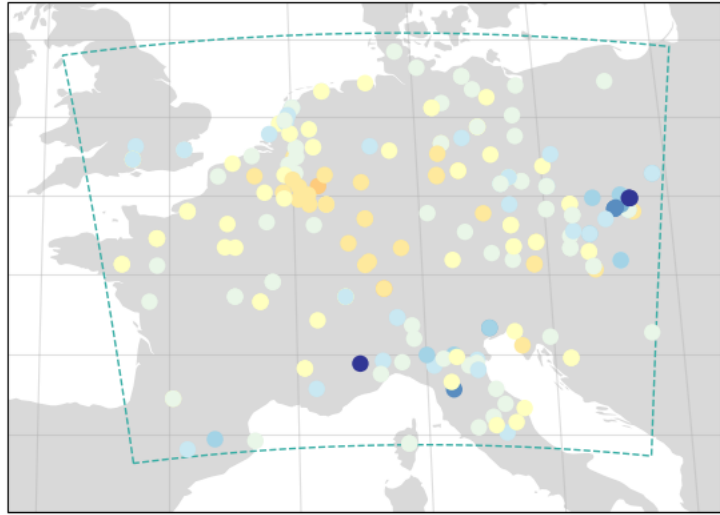


	Mean	StdDev	NMB	NME	RMSE	r
cams_reanalysis_ensemble_validated-regional-000	1.54	0.04	23.88	36.38	3.92	0.85
d02gmt-eu-000	0.03	-0.01	4.61	47.85	5.81	0.63

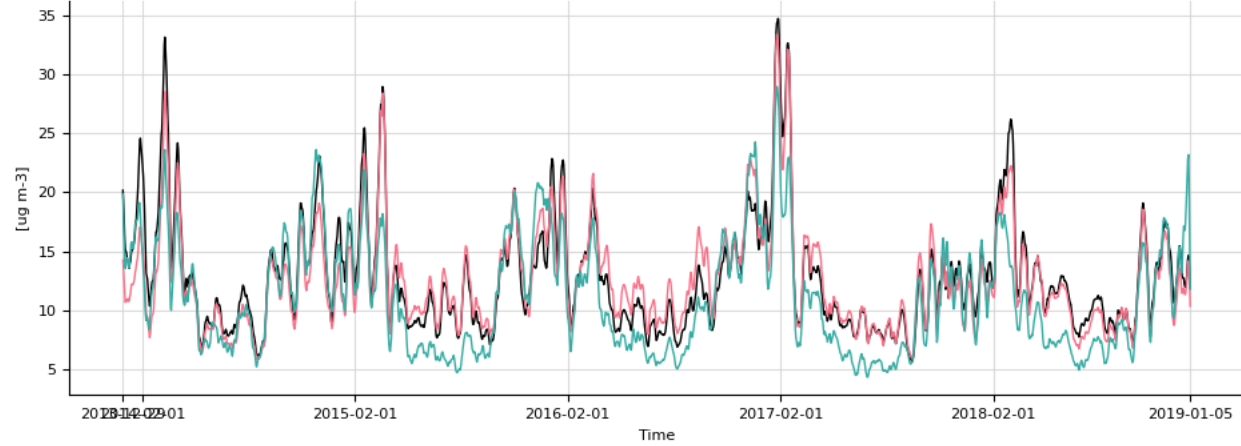


PM2.5 - FARM vs CAMS vs EEA observations 2014-2019

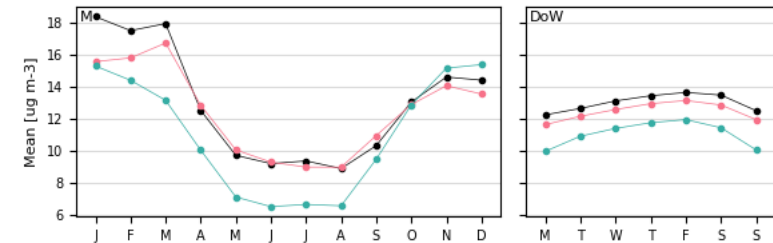
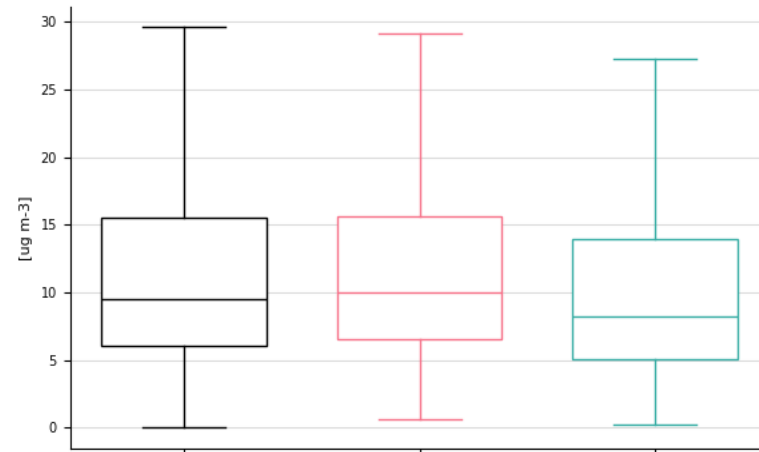
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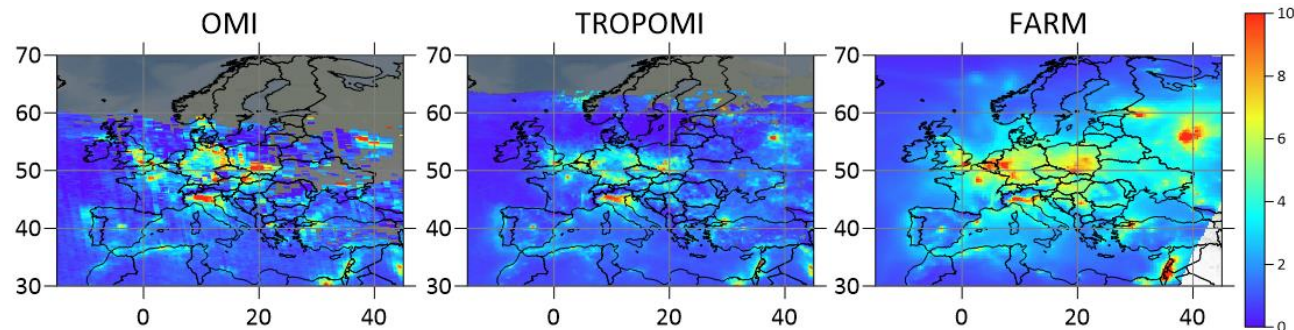
● observations ● cams_reanalysis_ensemble_validated-regional-000 ● d02gmt-eu-000



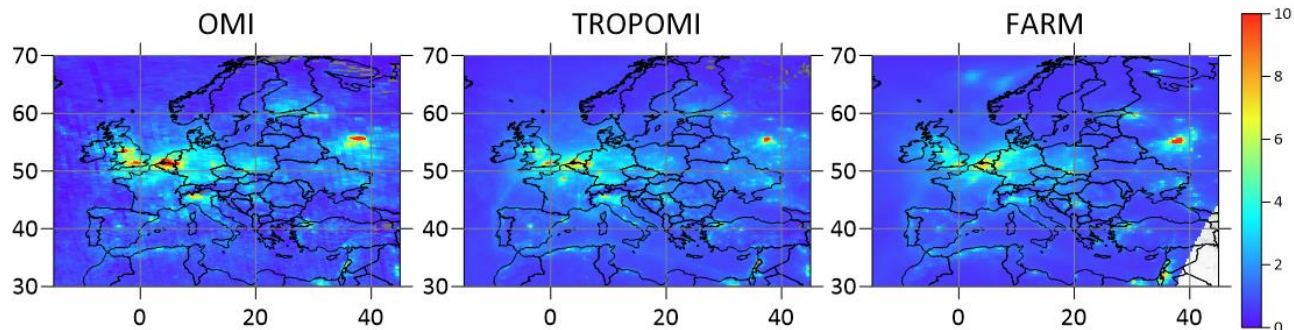
	Mean	StdDev	NMB	NME	RMSE	r
cams_reanalysis_ensemble_validated-regional-000	-0.54	-1.60	1.94	27.10	5.32	0.86
d02gmt-eu-000	-1.94	-1.68	-10.42	41.34	7.93	0.66



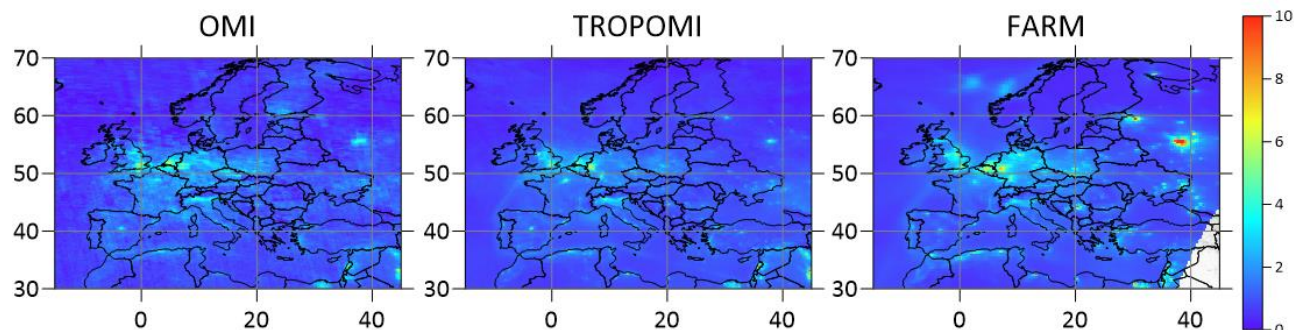
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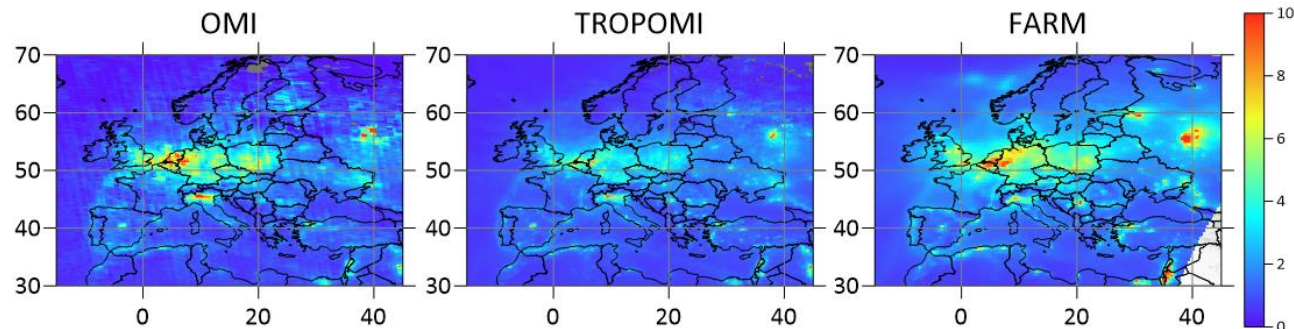
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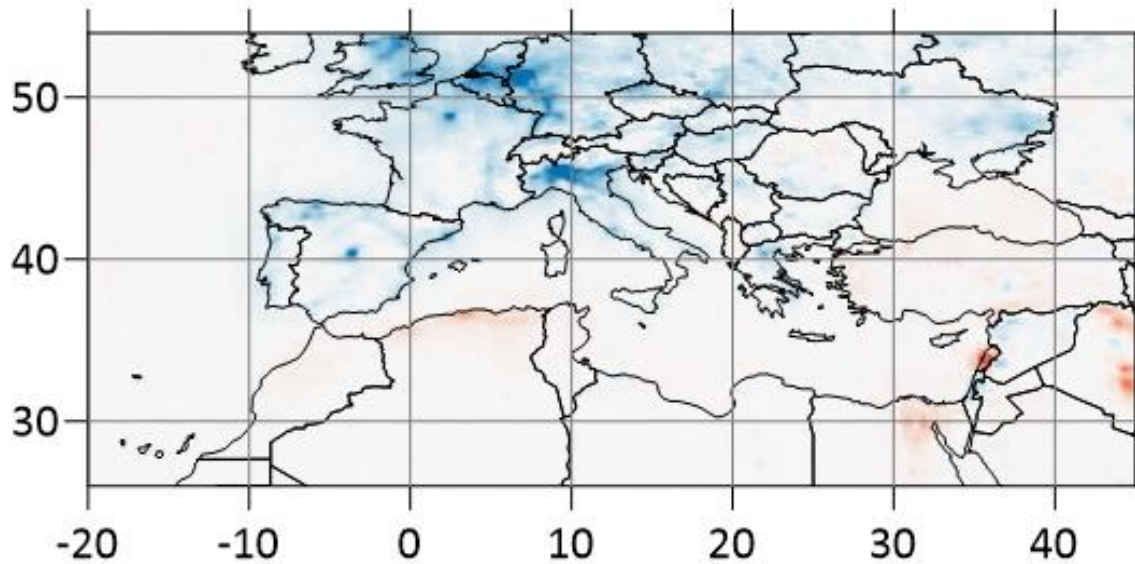


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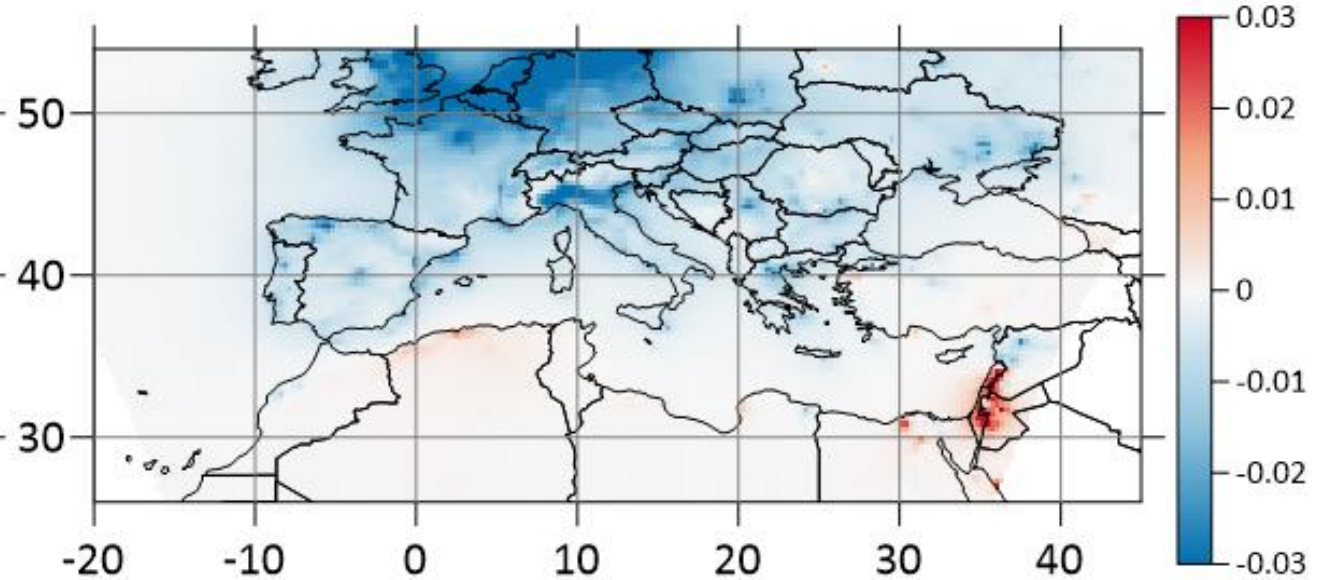


Linear trend of the monthly mean column integrated concentrations 2005-2019

OMI



FARM



(10^{15} molec cm^{-2} month $^{-1}$)

Thank you for your attention!

ACKNOWLEDGEMENTS

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