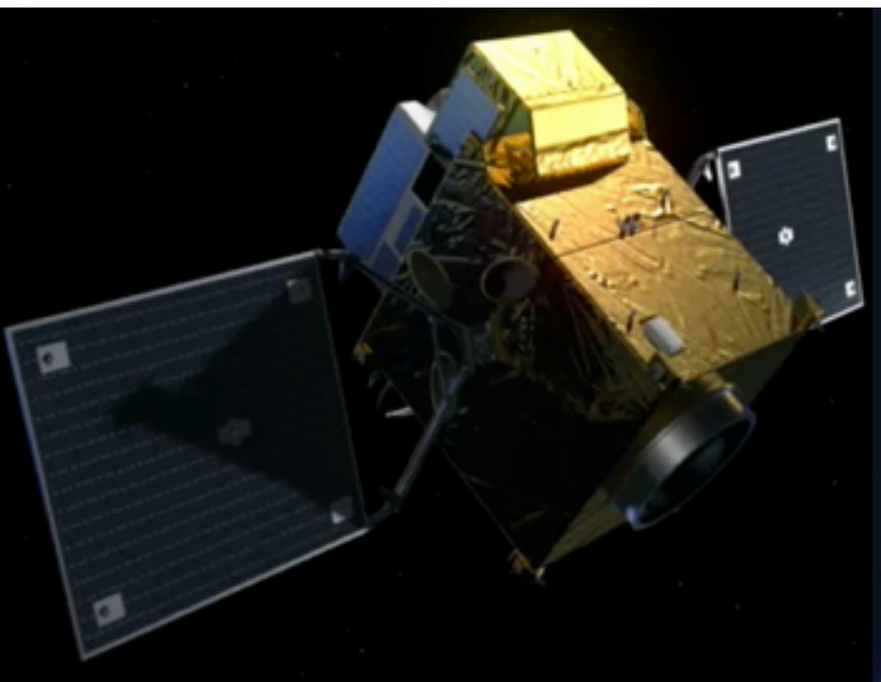
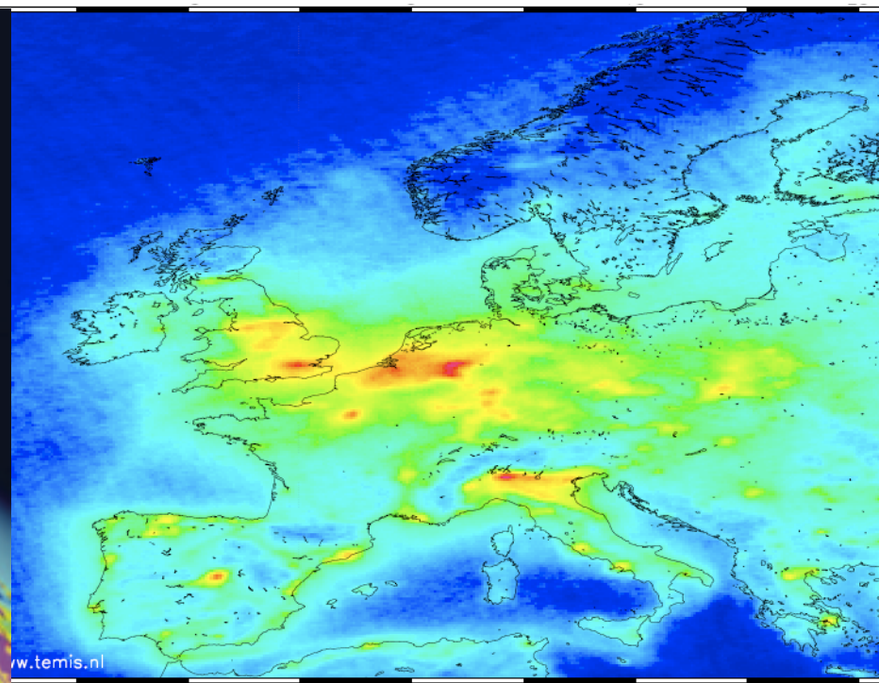
Impact of Spaceborne Observations on Tropospheric Composition Analysis and Forecast (ISOTROP)

An OSSE to study the impact of Sentinel 4 and 5 data on air quality forecasts

Henk Eskes, KNMI, The Netherlands,
ISOTROP partners, ESA

Presented at CEOS-ACC, Frascati, 30 April 2015





The ISOTROP Team

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment

KNMI
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- Jason Williams
- Pepijn Veefkind
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- Johanna Tamminen

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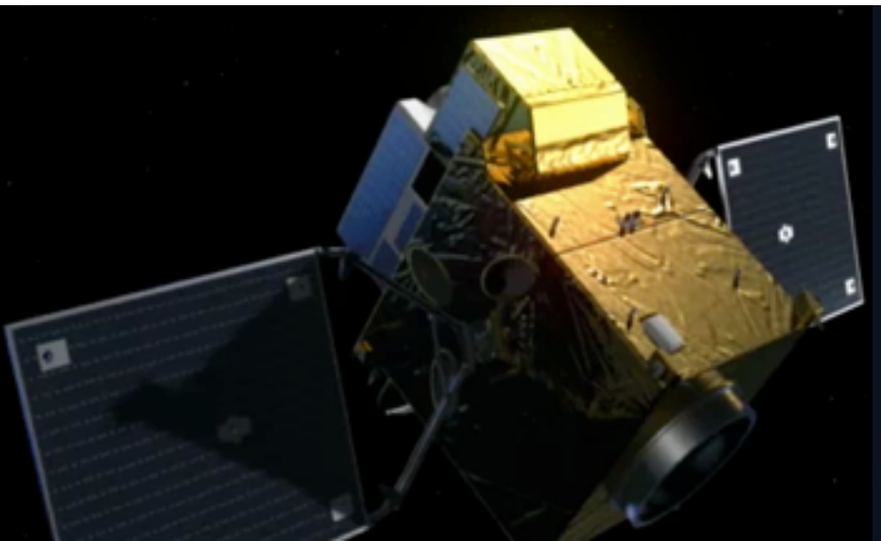

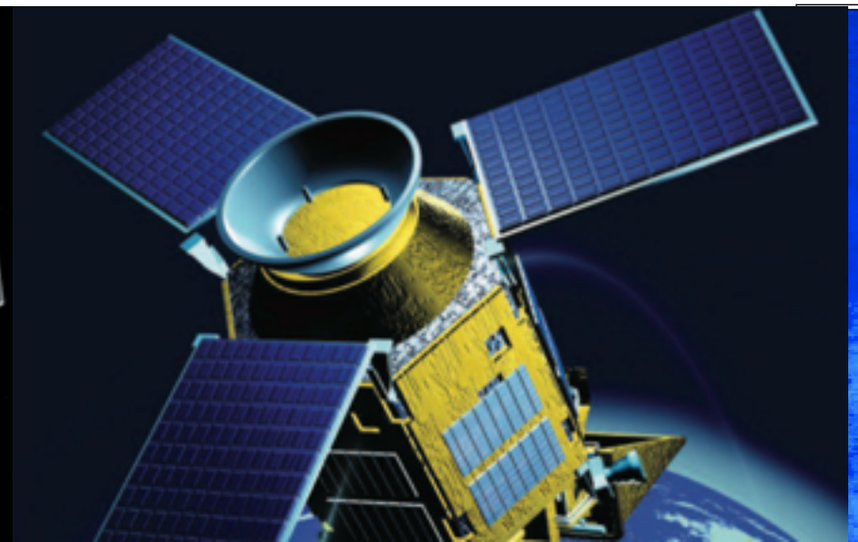

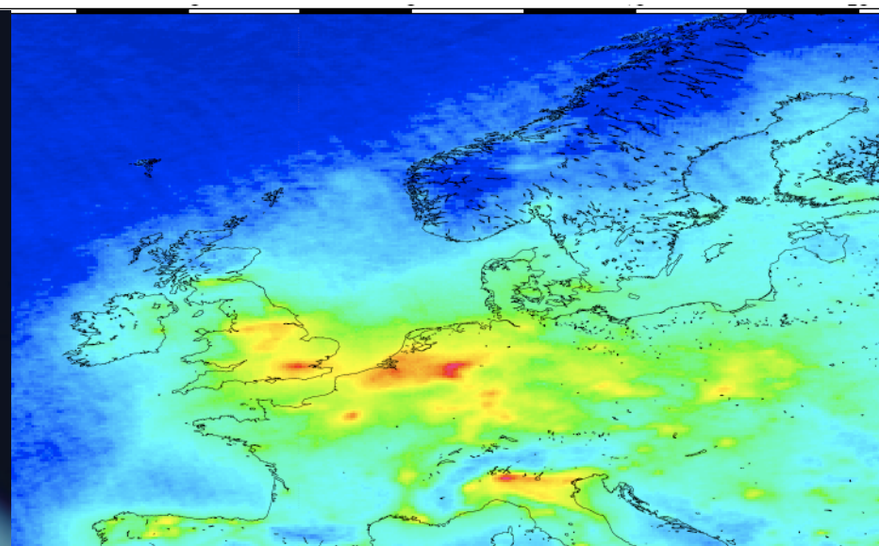

Project objectives

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Objectives of ESA study

1: To assess the value of LEO+GEO satellite observation system measuring in the UV-VIS for tropospheric composition monitoring using data assimilation.
Focus on O_3, CO, NO_2, HCHO

- Gain in model + forecast skill.
- Improvement of boundary layer (BL) concentrations.
- Improvement of impact long-range transport on BL.
- Improvement of continuous and episodal sources.
- Optimisation of surface emission rates.

2: To study the impact of cloudiness, aerosol, surface albedo and uncertainty in the dynamical fields (vertical transport) on model and forecast skill. Optimise the assimilation approach.

Approach and partner roles

KNMI, FMI: synthetic observations
TNO, KNMI: OSSE with LOTOS-EUROS for NO2, HCHO (BL and emissions)
CNRM-GAME, NILU: OSSE with MOCAGE for CO and O3 (transport)

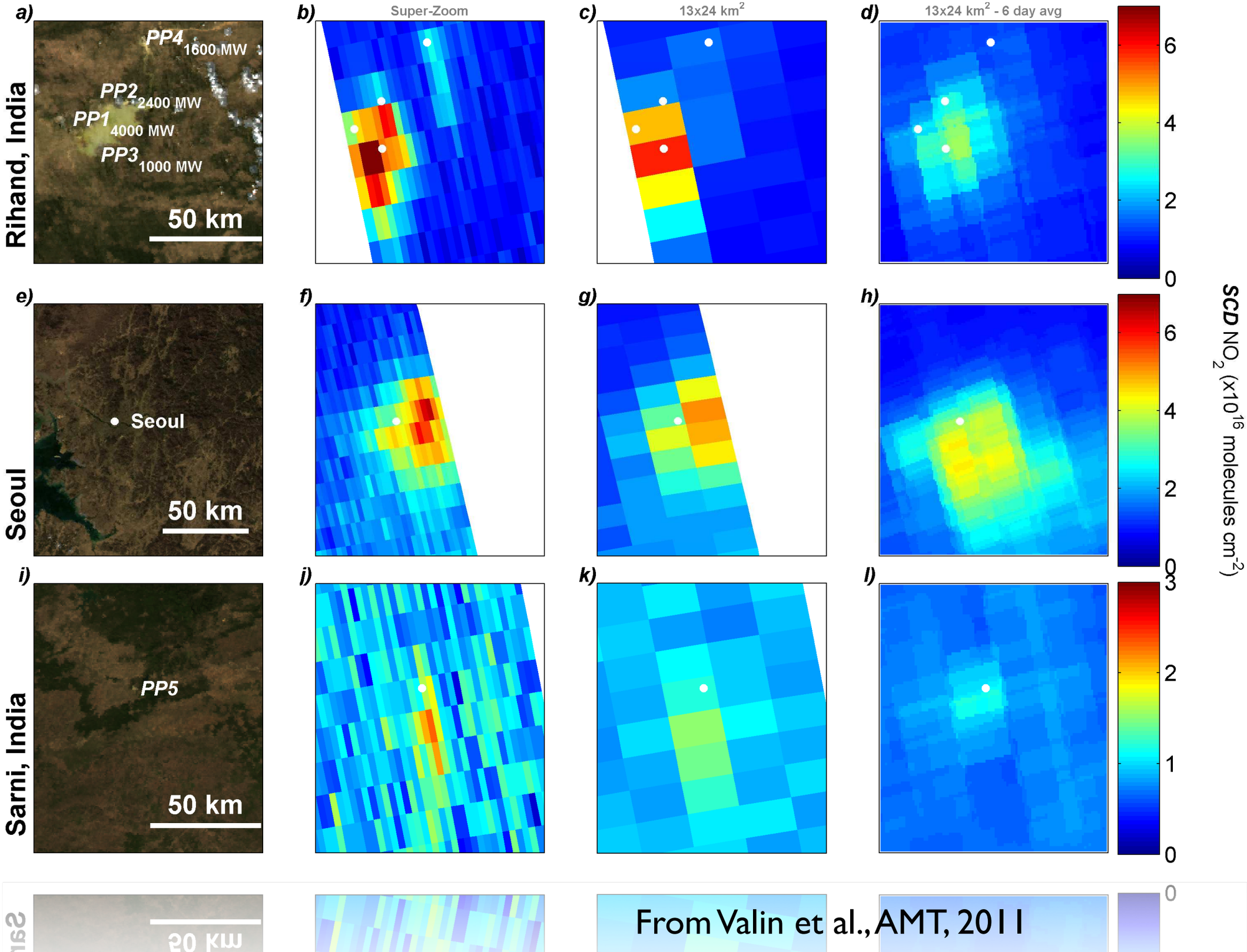
OSSE = Observing System Simulation Experiment

Project limitations

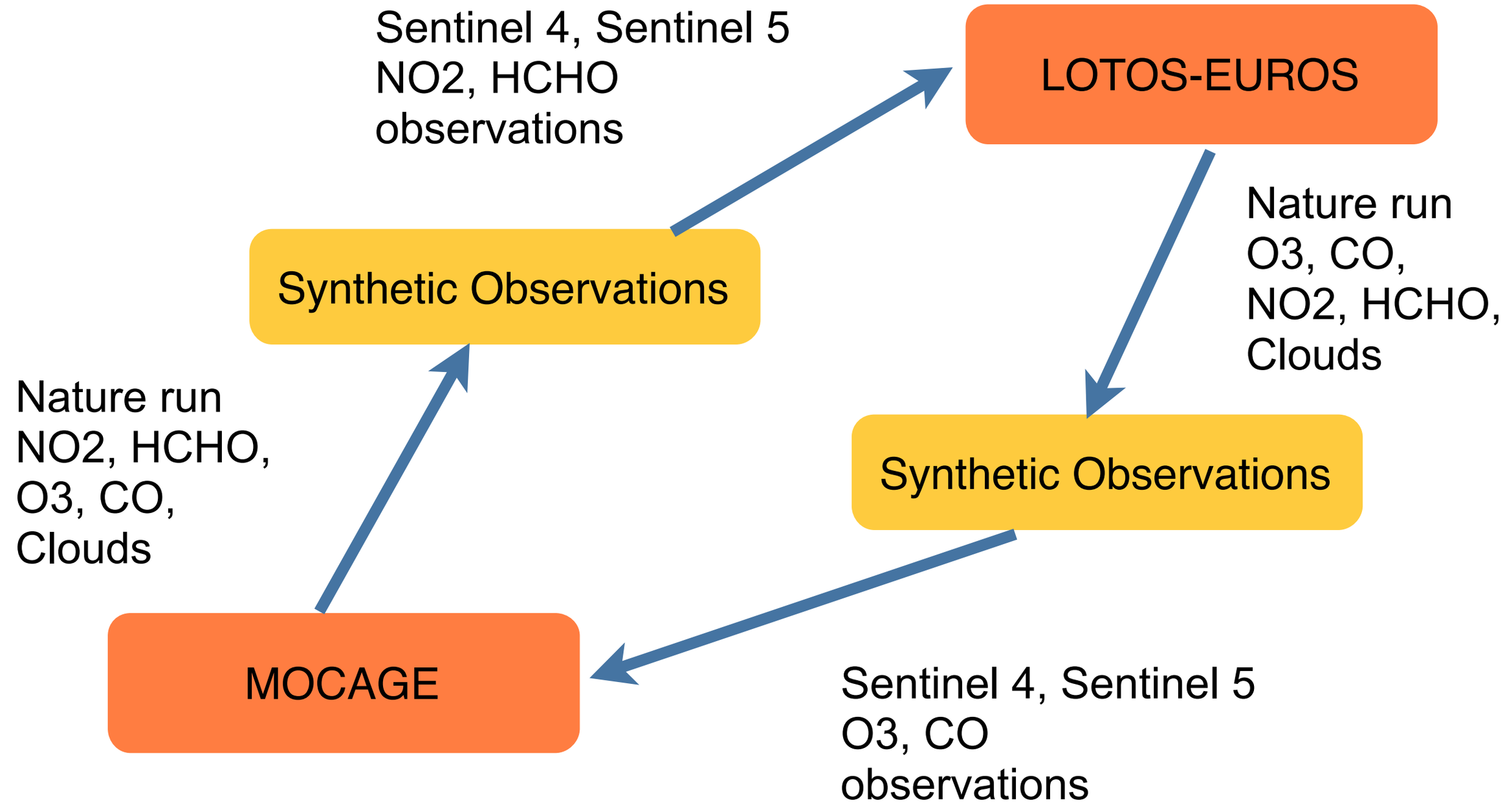
Focus on four species: O_3, CO, NO_2, HCHO

- Project is “univariate” in nature:
  species will be studied individually
- Synergy with other available (satellite) data not studied
  In particular the combined use of UV-Vis-NIR-SWIR and TIR is a powerful approach to obtain better vertical information on CO and O_3

High Spatial Resolution



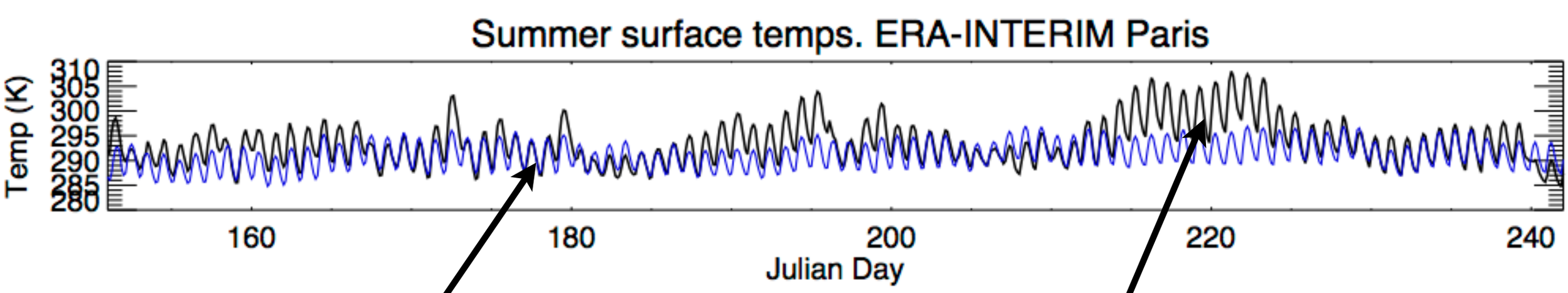
Cross-OSSE


Sentinel 4, Sentinel 5
NO2, HCHO
observations
LOTOS-EUROS
Nature run
O3, CO,
NO2, HCHO,
Clouds
Synthetic Observations
Nature run
NO2, HCHO,
O3, CO,
Clouds
Synthetic Observations
MOCAGE
Sentinel 4, Sentinel 5
O3, CO
observations

Time periods

Summer 2003: June-July-August
Winter 2003/4: November-December-January

Fire events (2003 Portugal)



Periods where 2003 is representative of a normal year

Very hot periods in Summer 2003

Study domains

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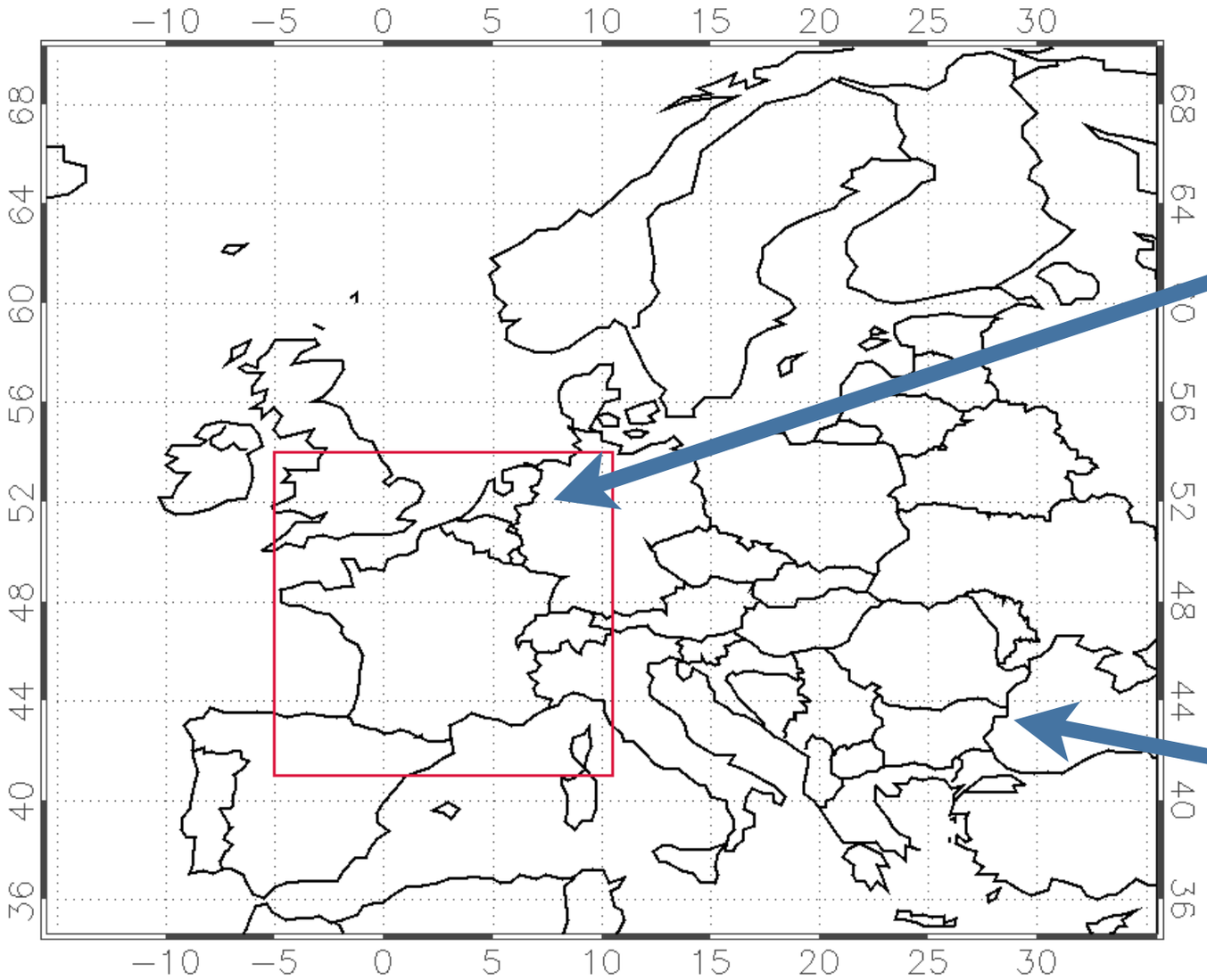

OSSE domain for
NO2, HCHO
LOTOS-EUROS
resolution 0.0625 x 0.125

OSSE domain for
CO,O3
MOCAGE
resolution 0.2 degree

Nature run comparisons

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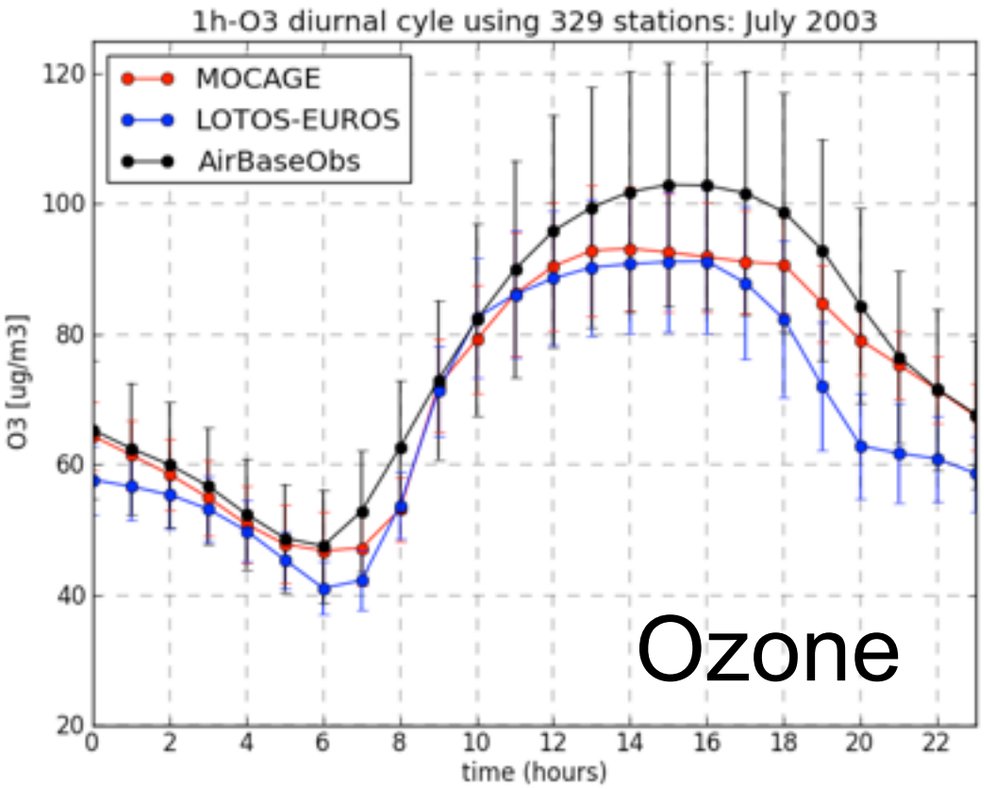

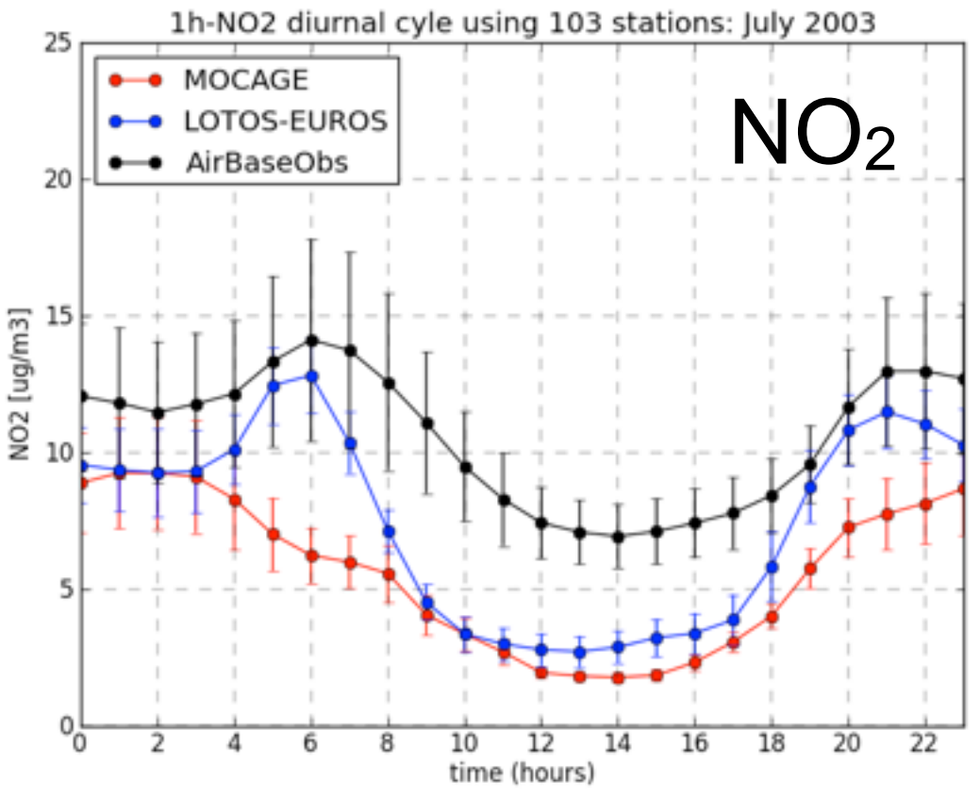

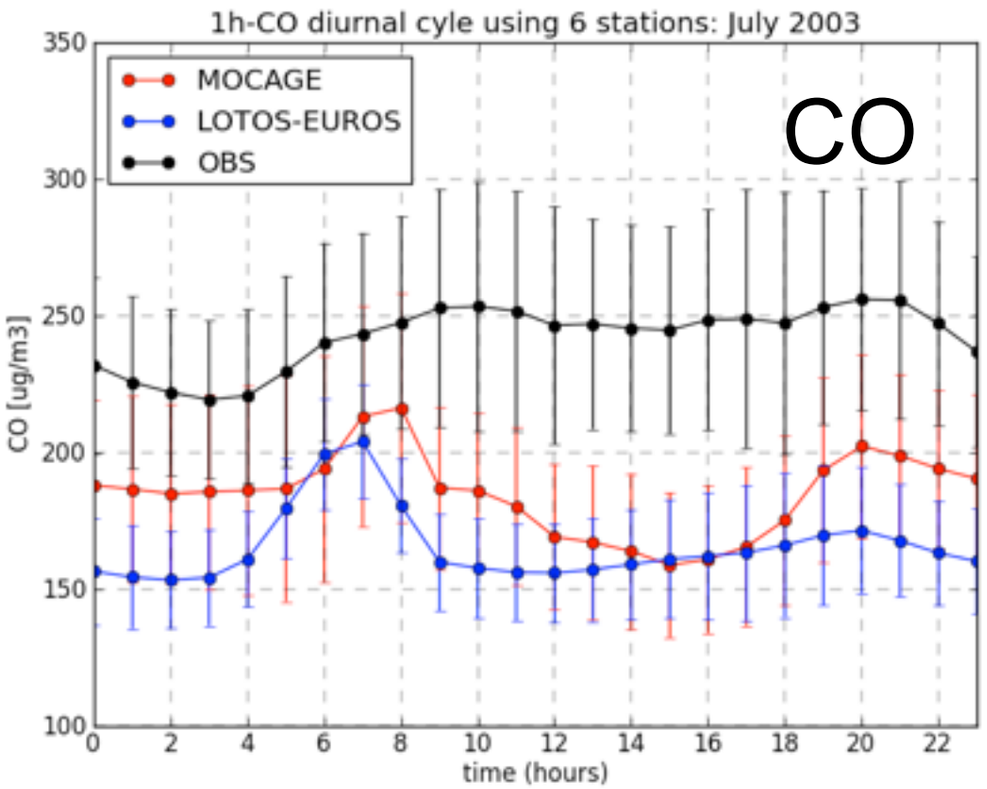

Synthetic observations

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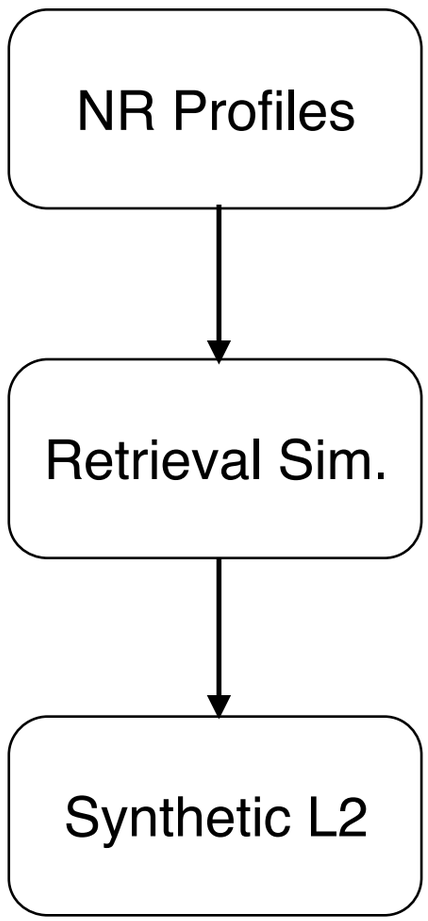
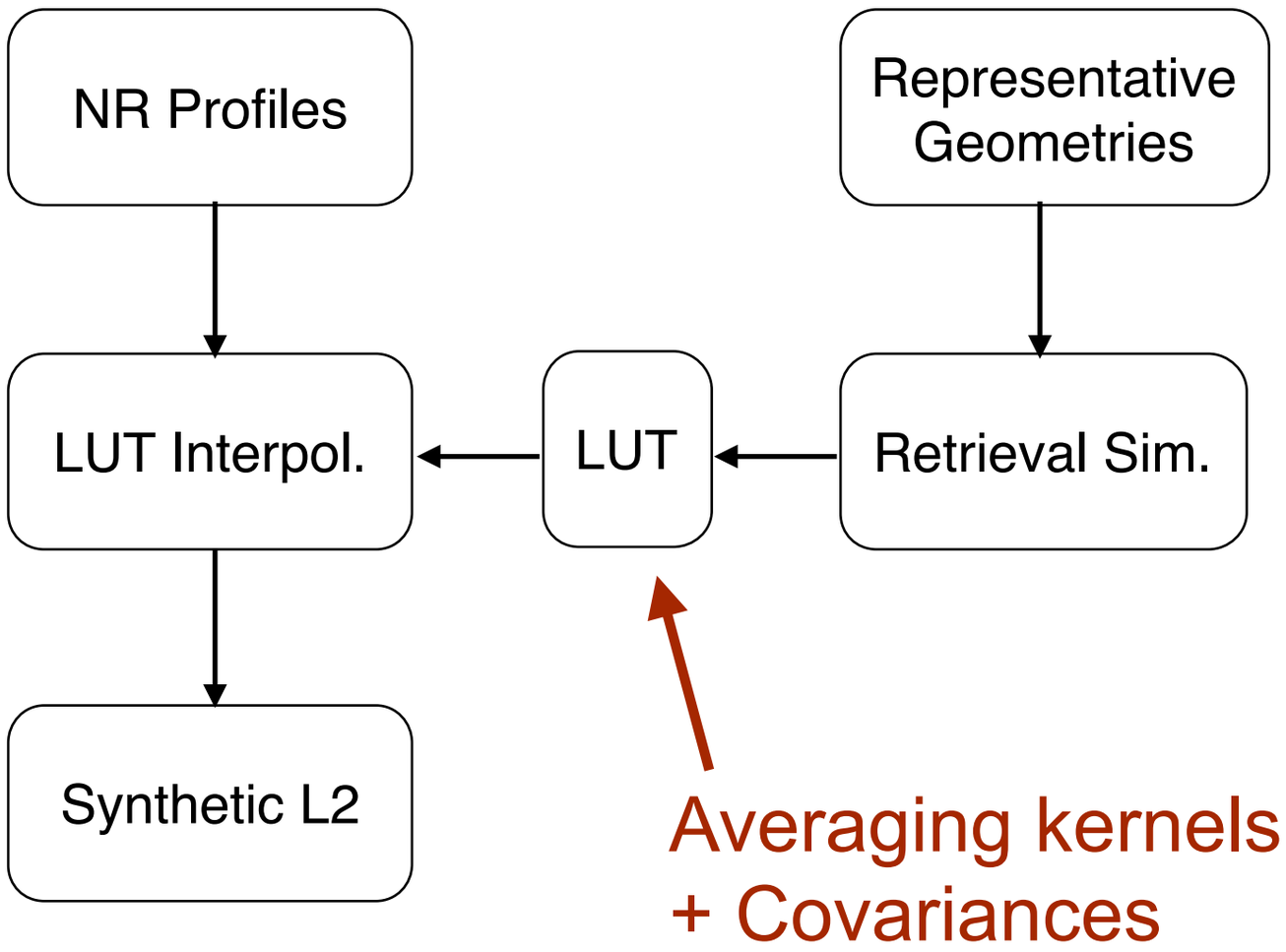
"Brute-force" method



LUT-based method



Based on optimal Estimation (Rodgers) and DOAS
Observation error covariance matrices, kernels
Orbit simulator

Observations - CO

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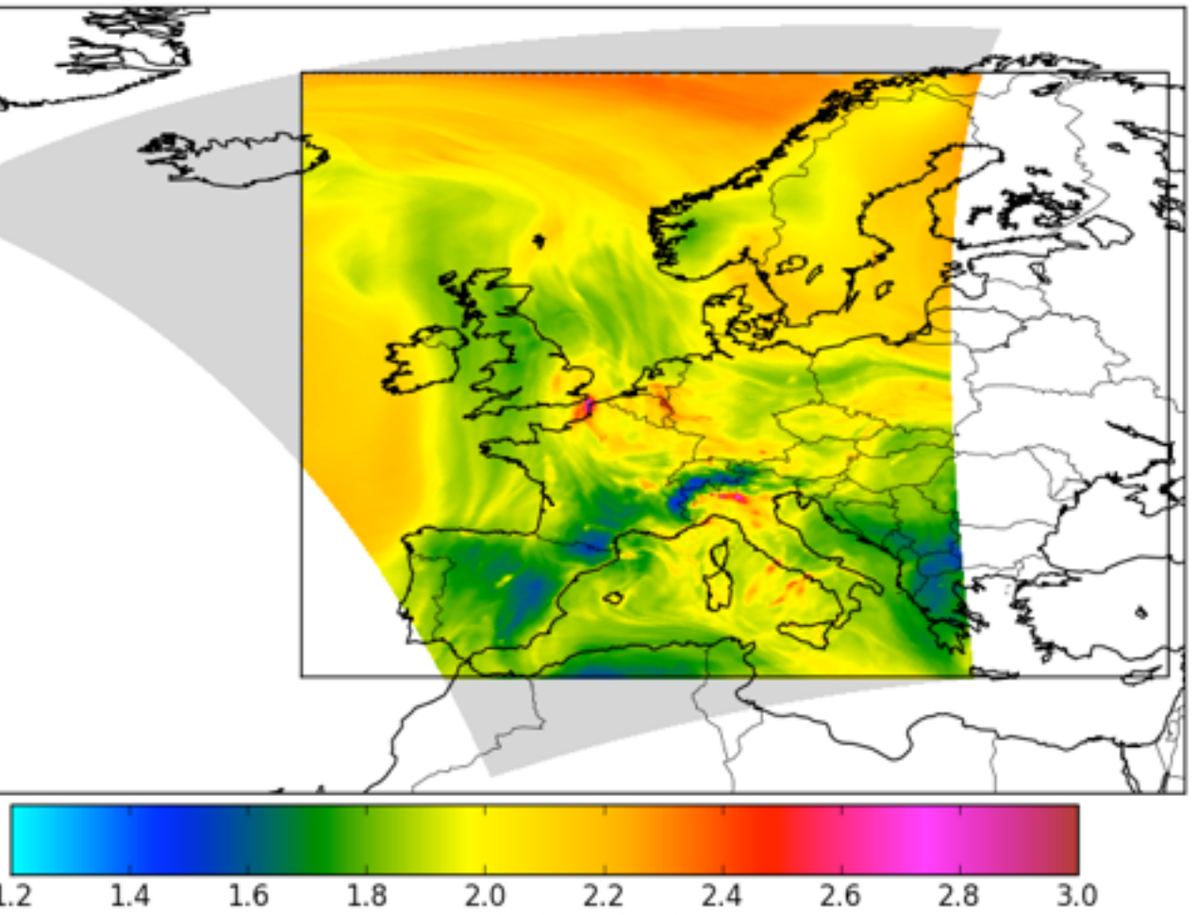
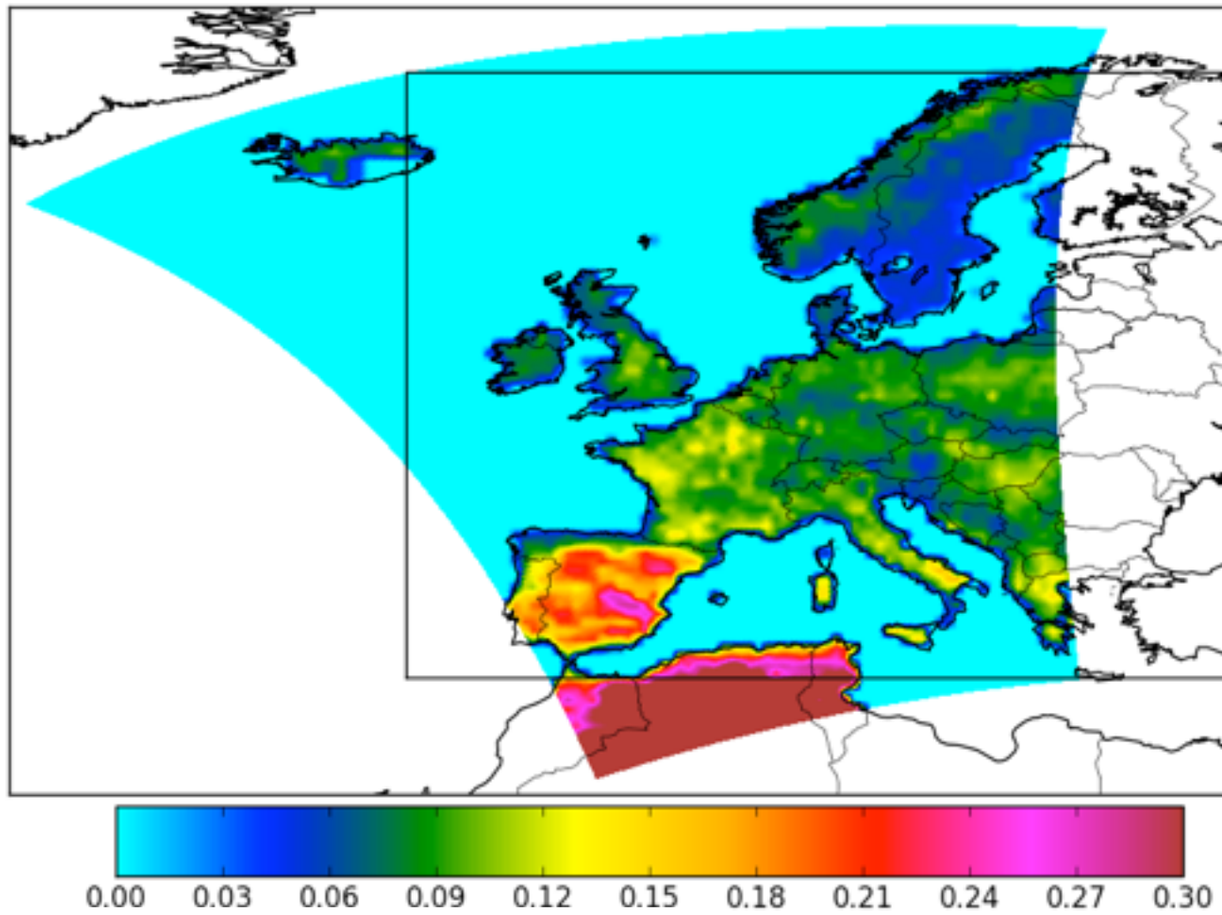
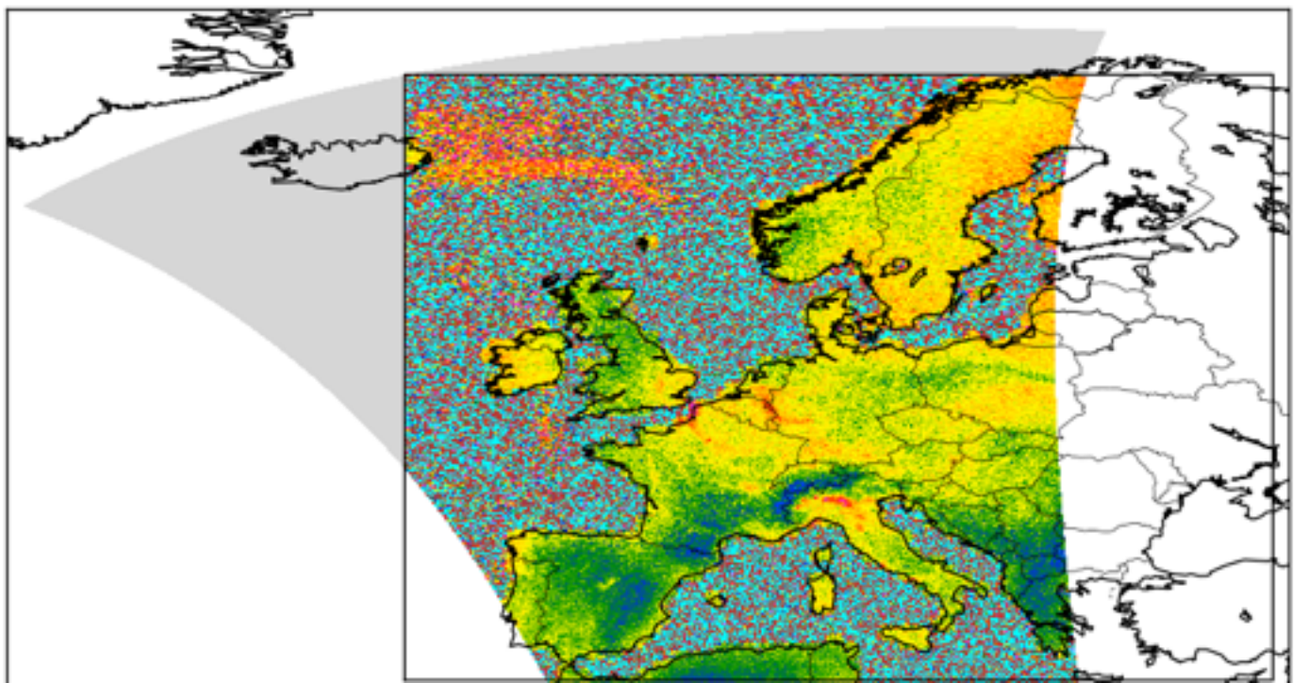


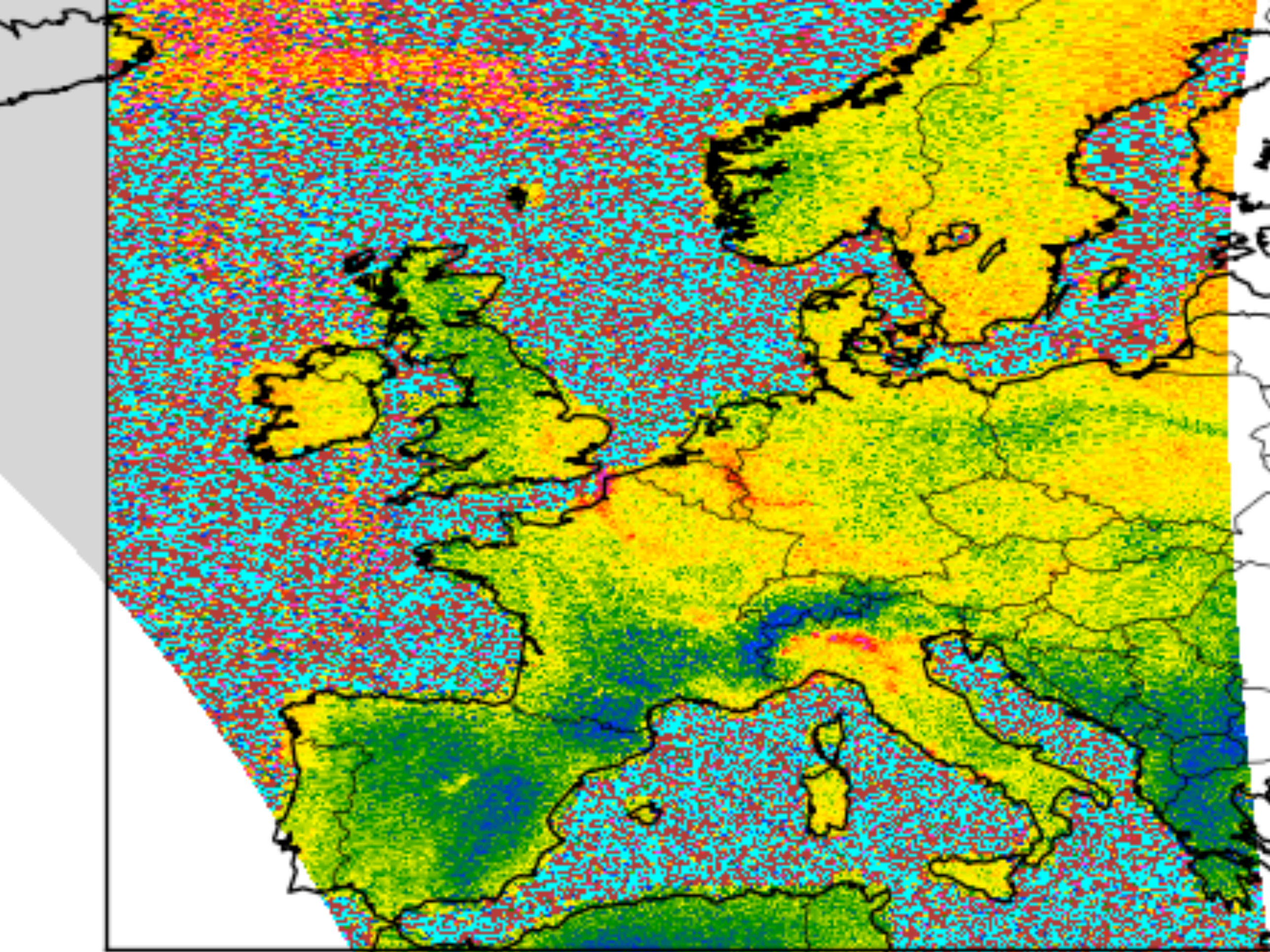
Nature Run



Albedo

Retrievals





CO OSSE
analysis increments

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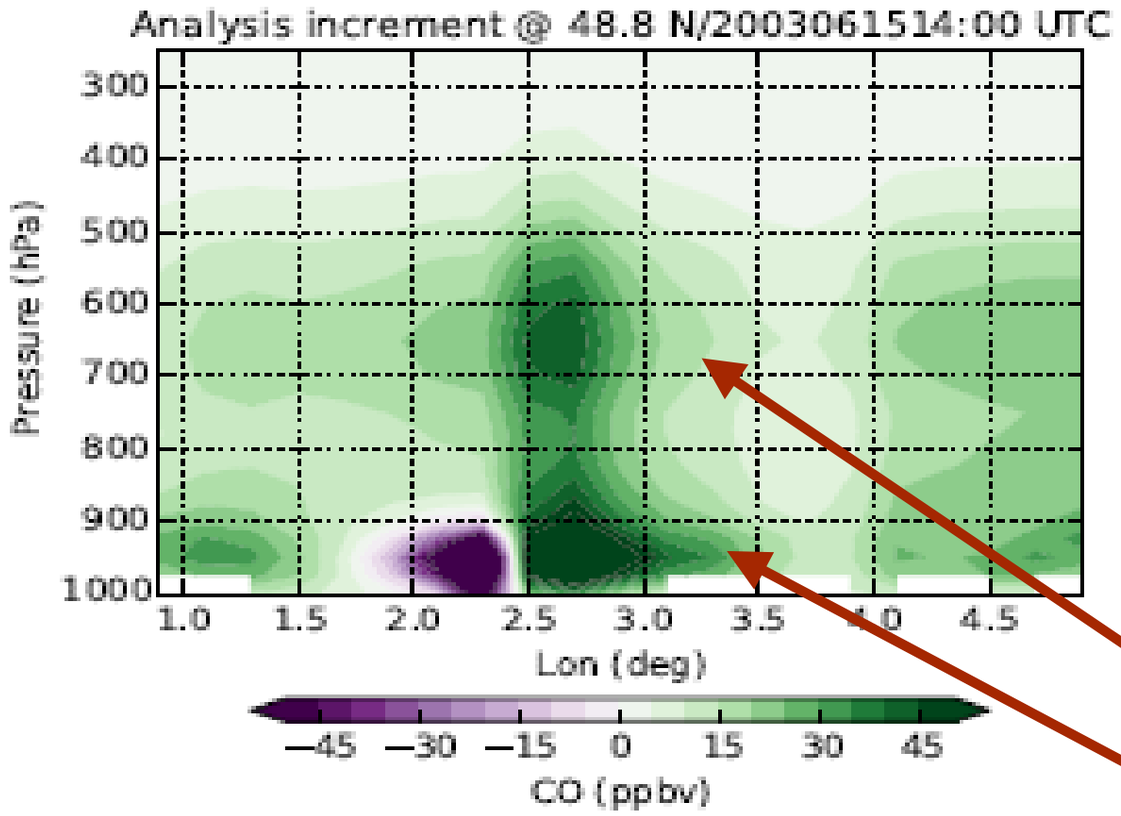

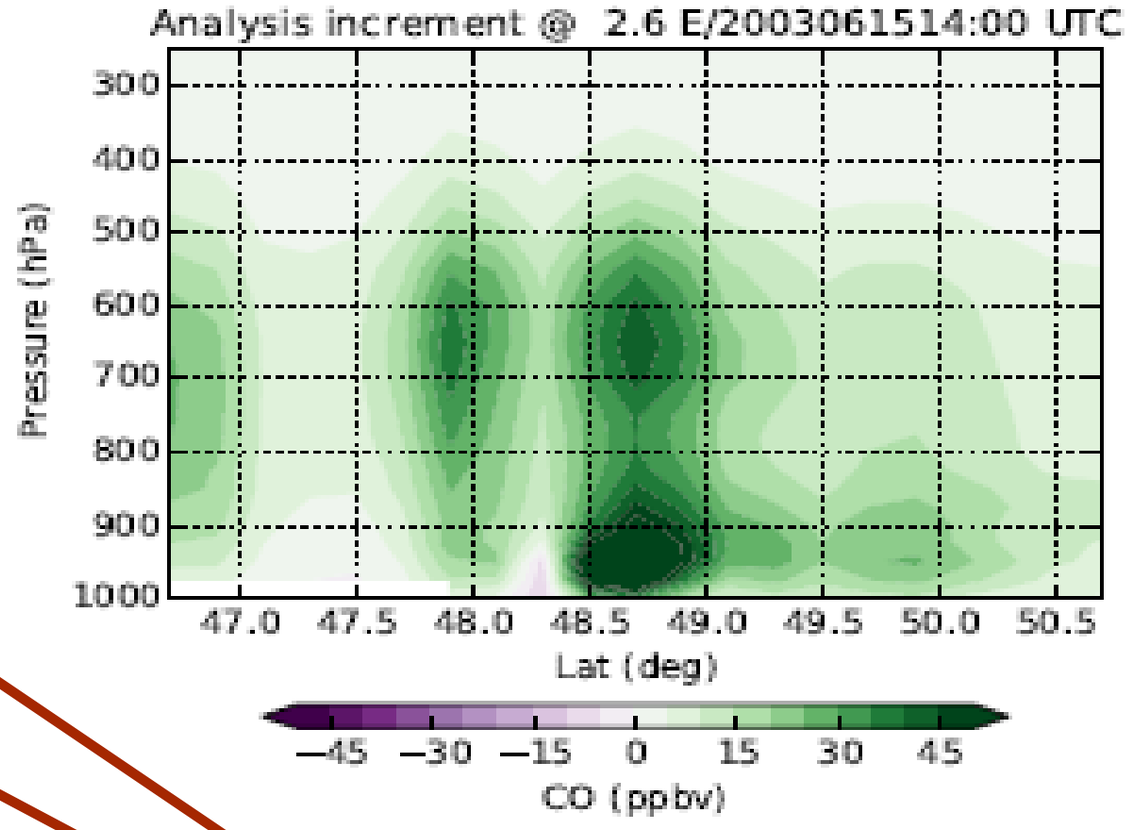

Clear impact in both PBL and free trop

CO OSSE
analysis increments

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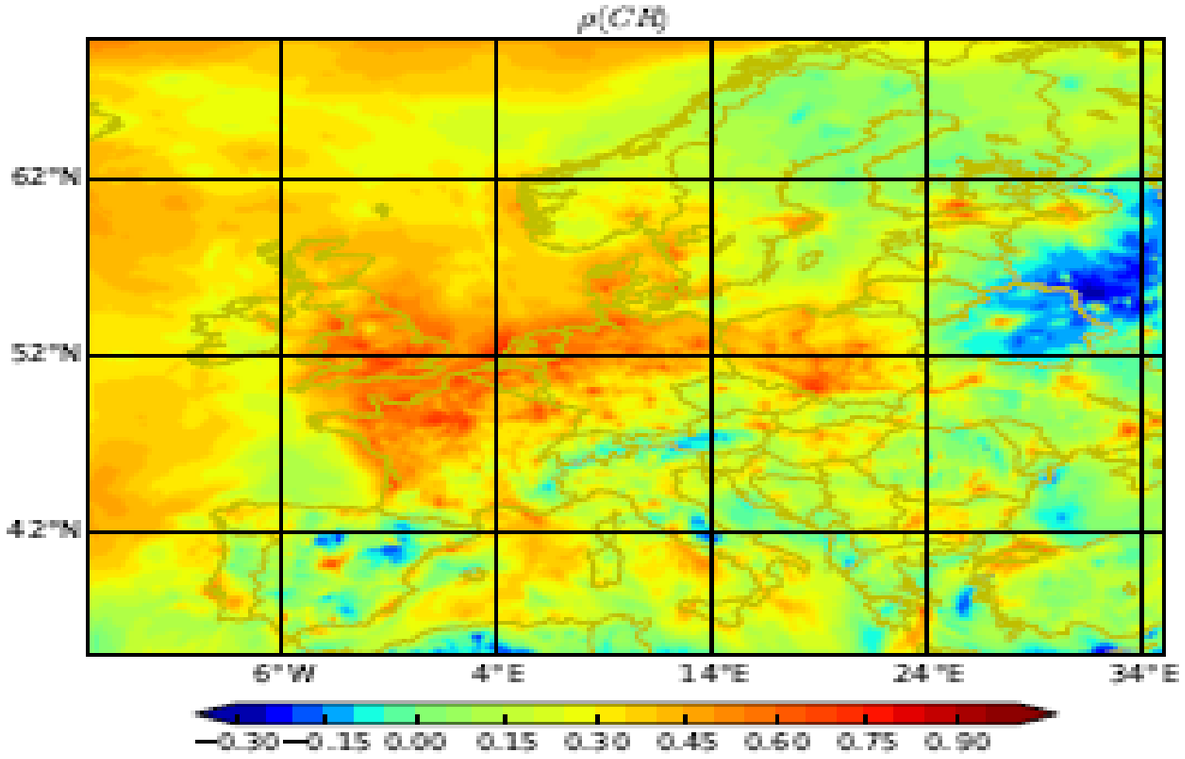
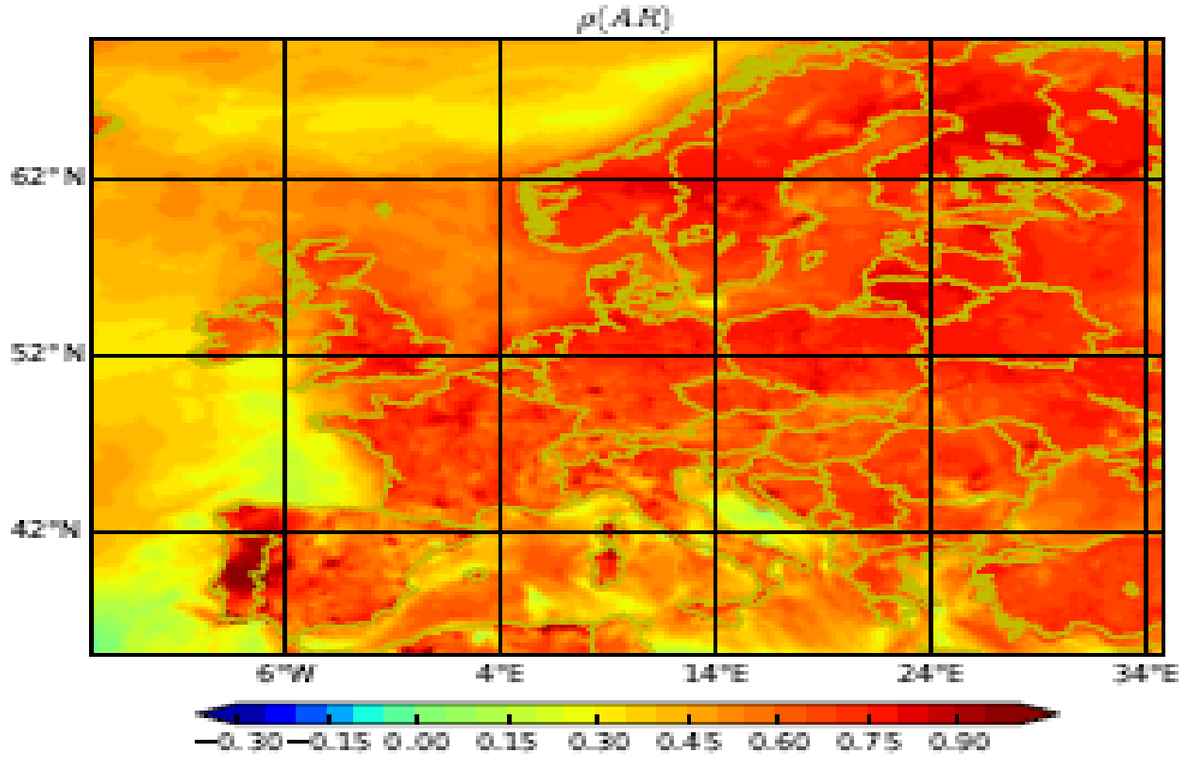


Correlation (CR-NR)



Correlation (AR-NR)

CO OSSE
Time series surface

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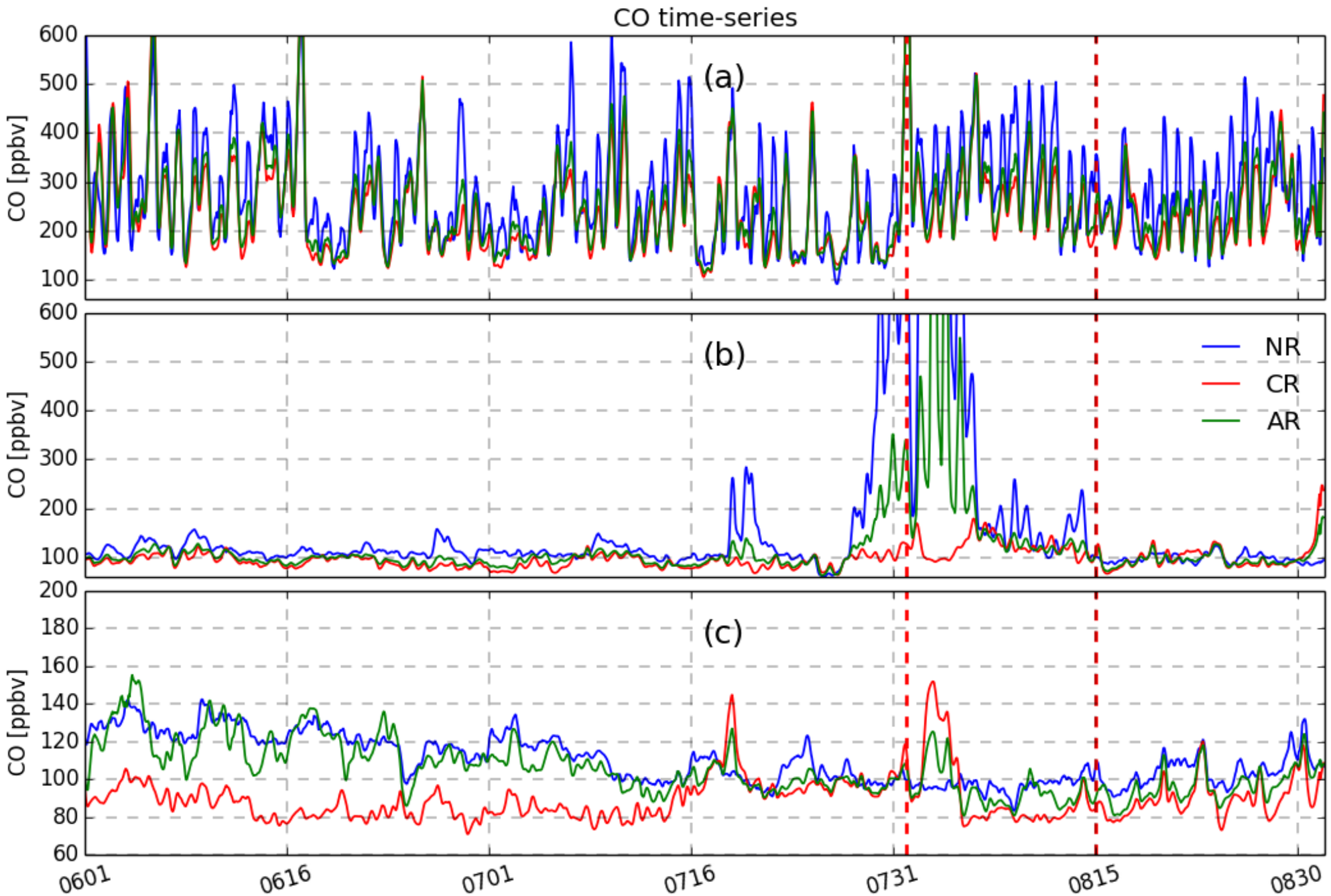

Paris

Fires in Portugal

East Europe

Observations - NO2, S5

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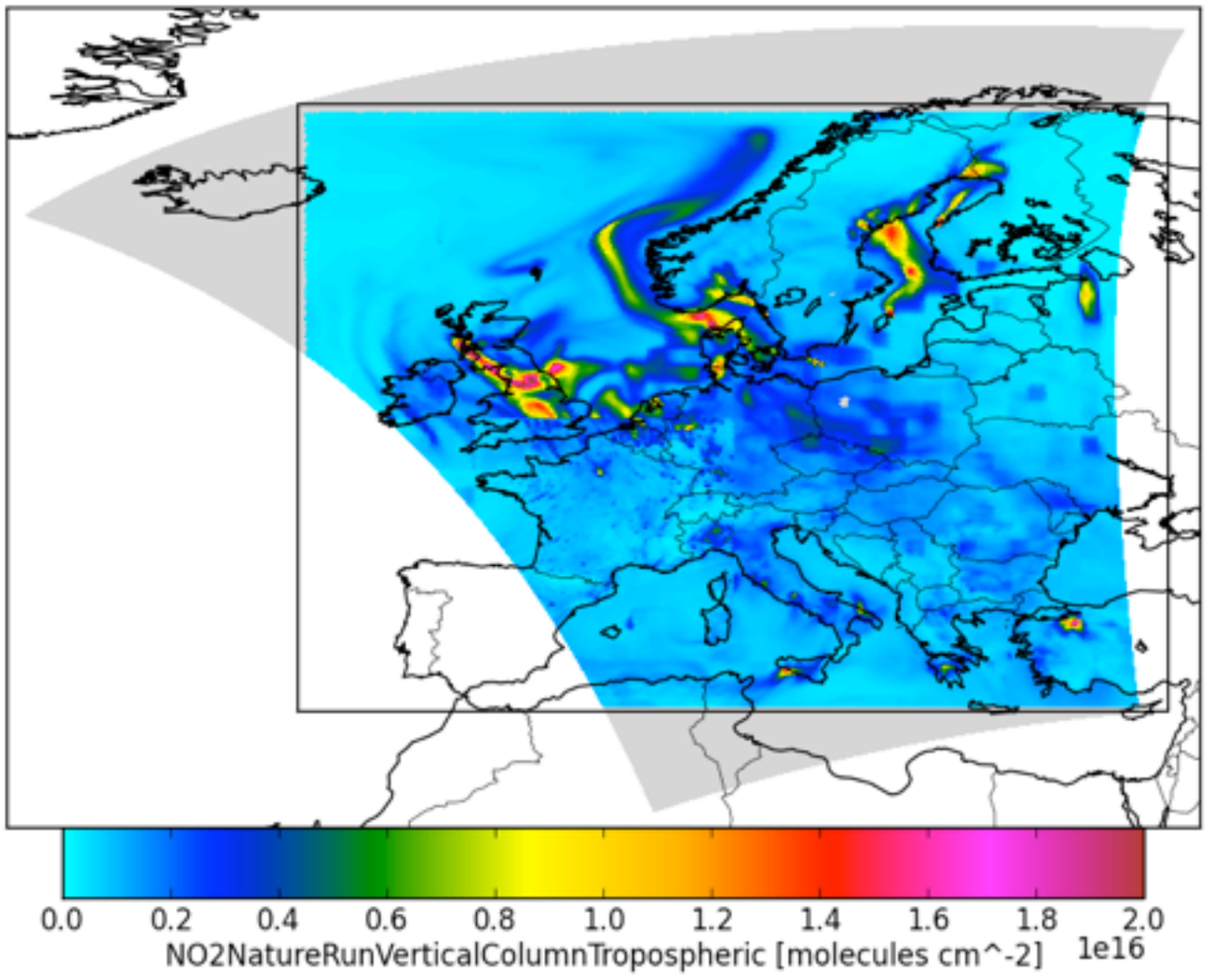
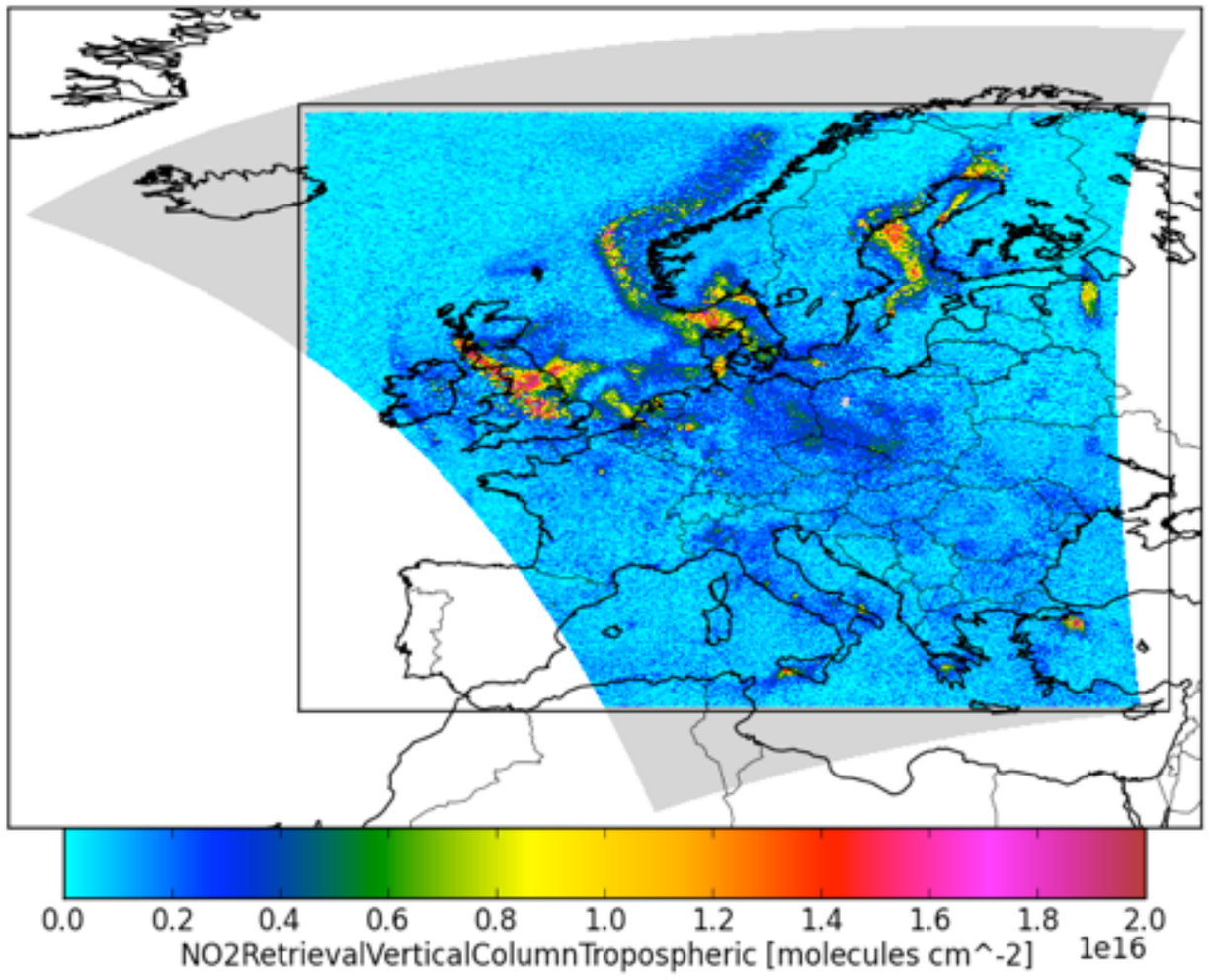


Nature Run



Noisy observations

Observations - NO2, S4

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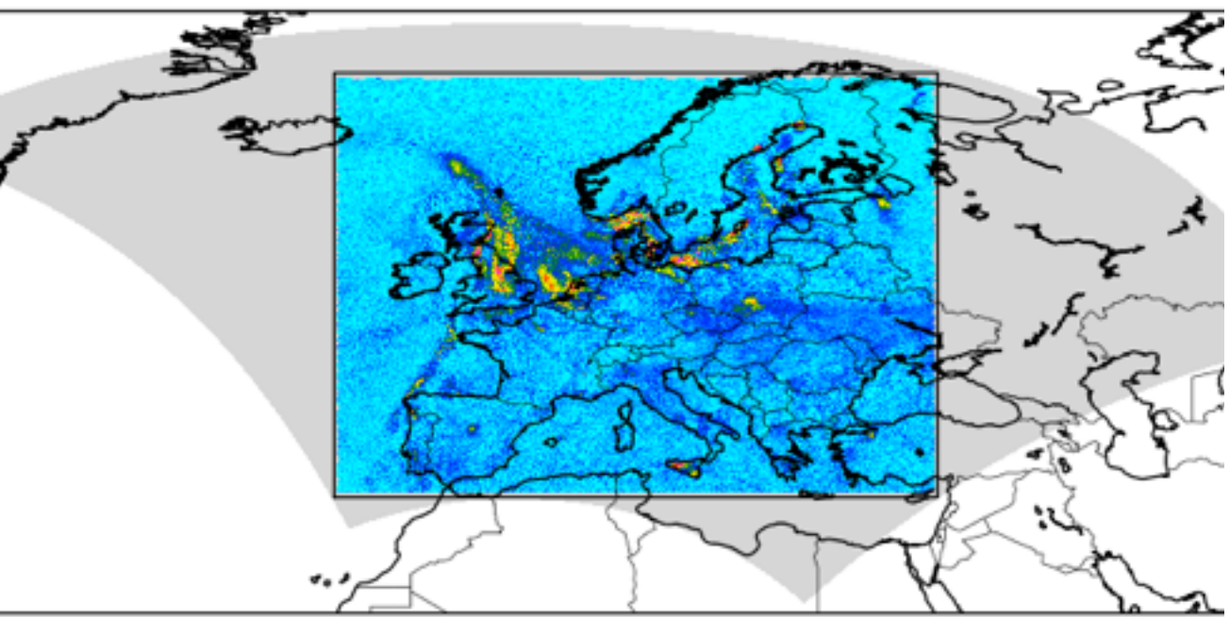
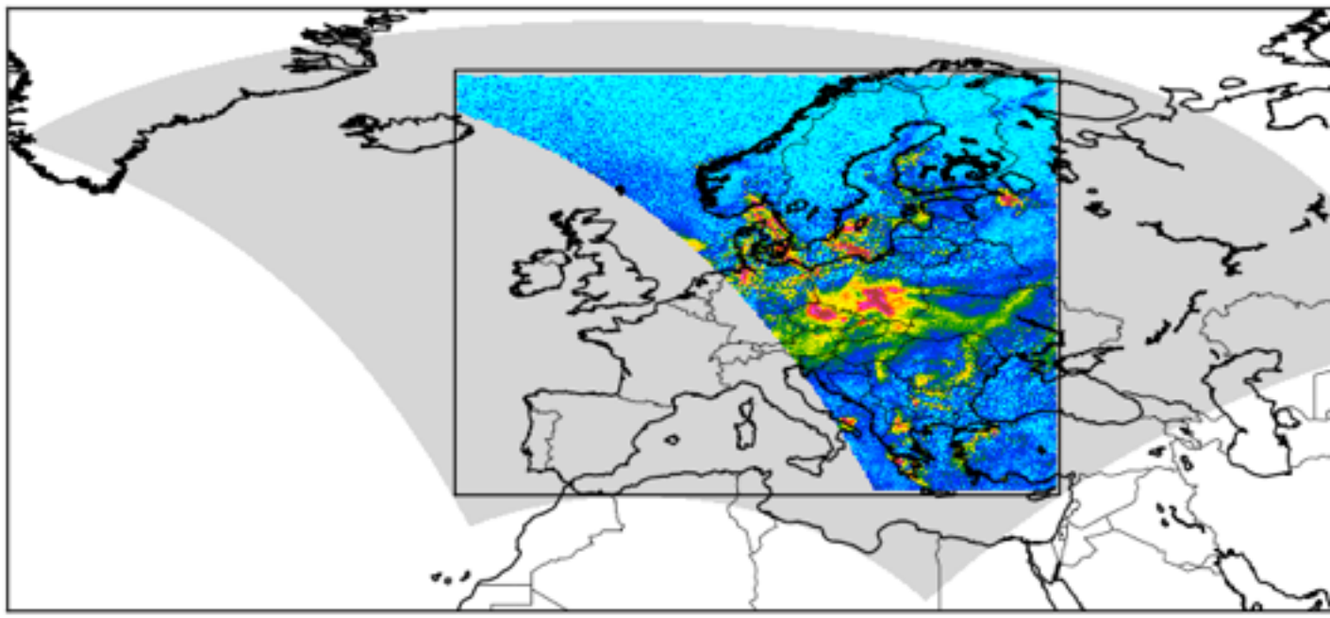


Local noon



Early morning

NO2 OSSE

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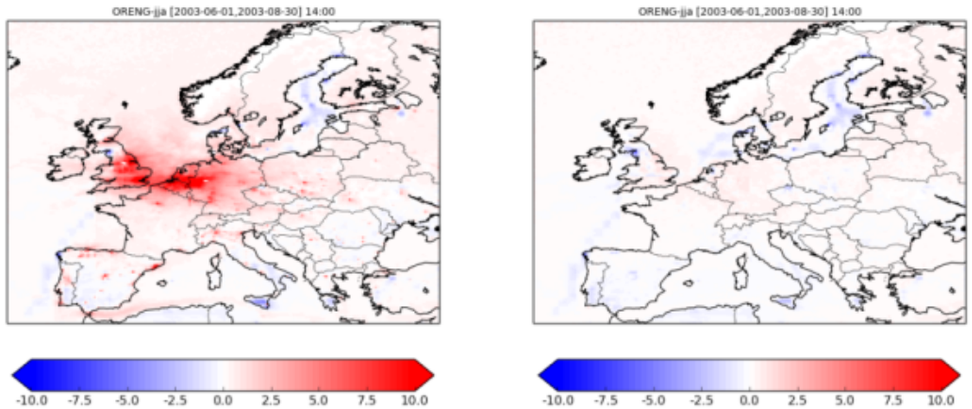
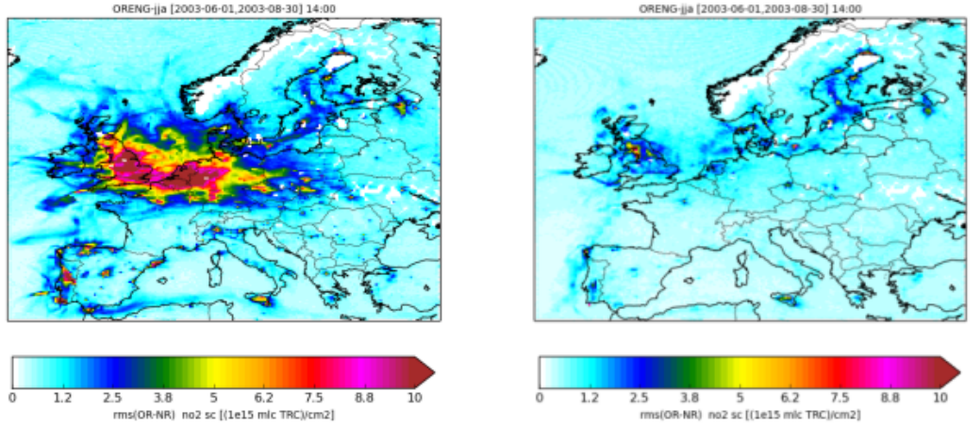
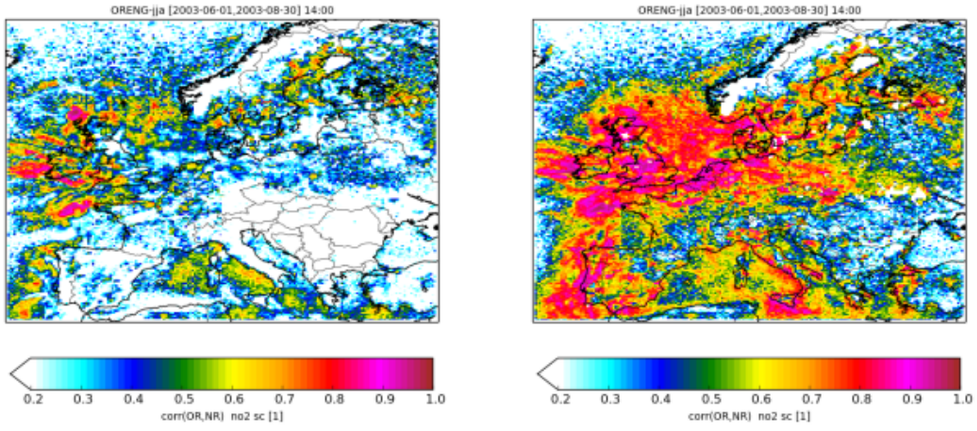
	S4		S5	
	CR	AR	CR	AR
Bias				
RMS				
Corr				

NO2 OSSE: Diurnal cycle

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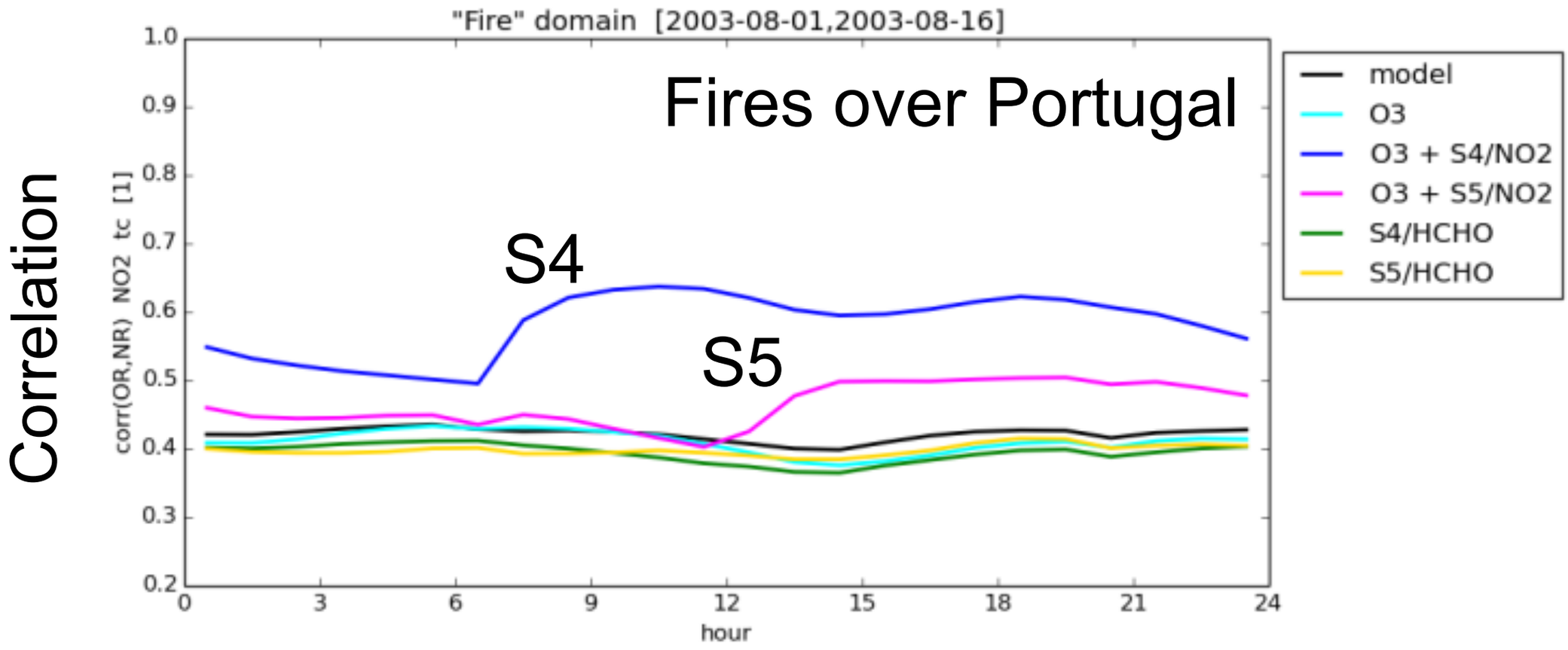

Note: LOTOS-EUROS assimilation is adjusting emissions:
longer memory than e.g. 3D-Var

NO2 OSSE: Zoom domain

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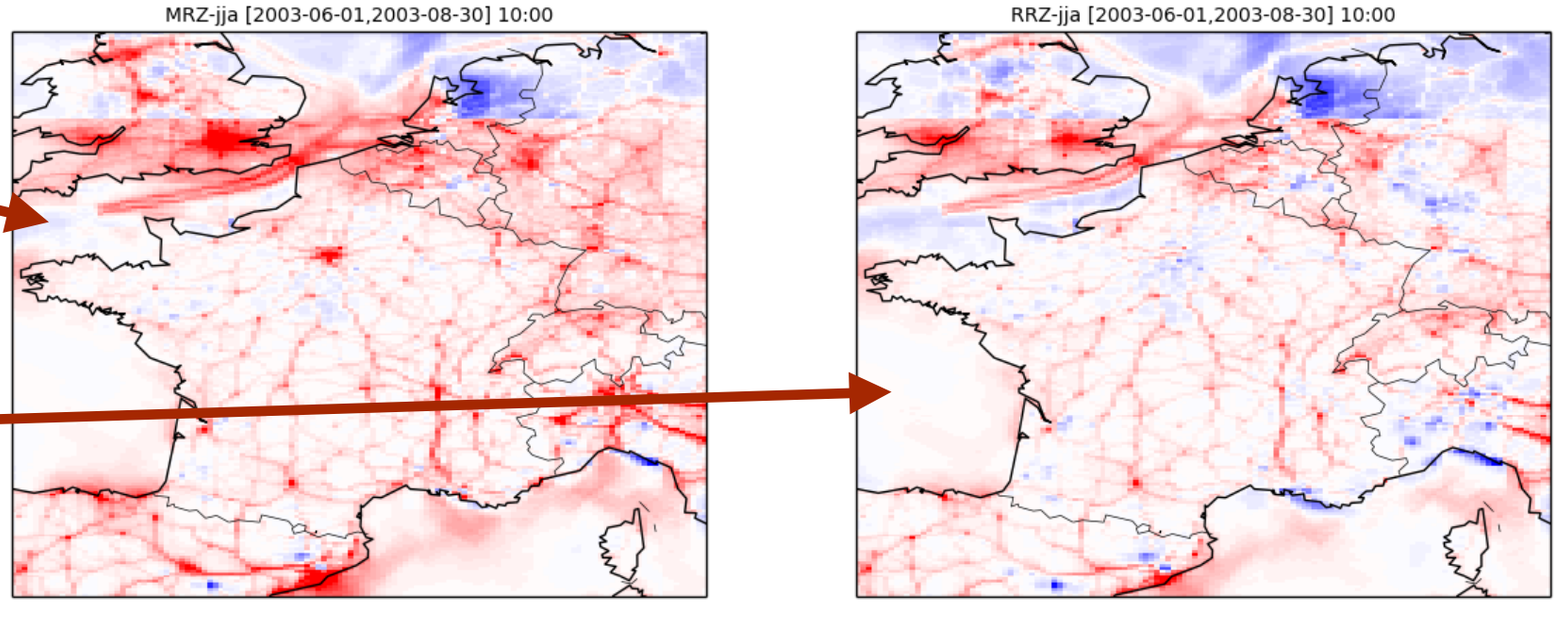
Free

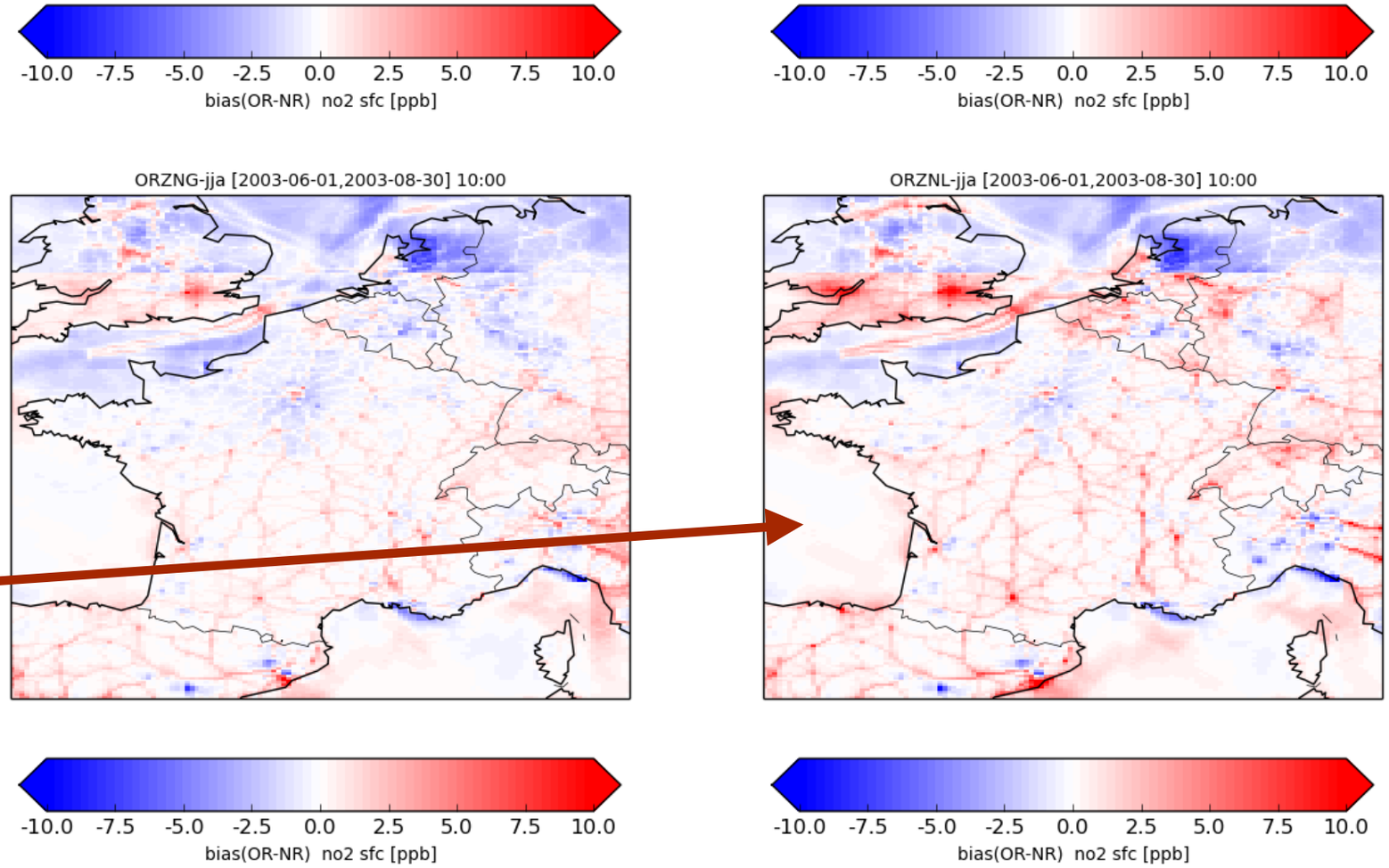
Control:
O3 surface assimilation



Surface NO2, 14:00

S4

S5



Observations - HCHO

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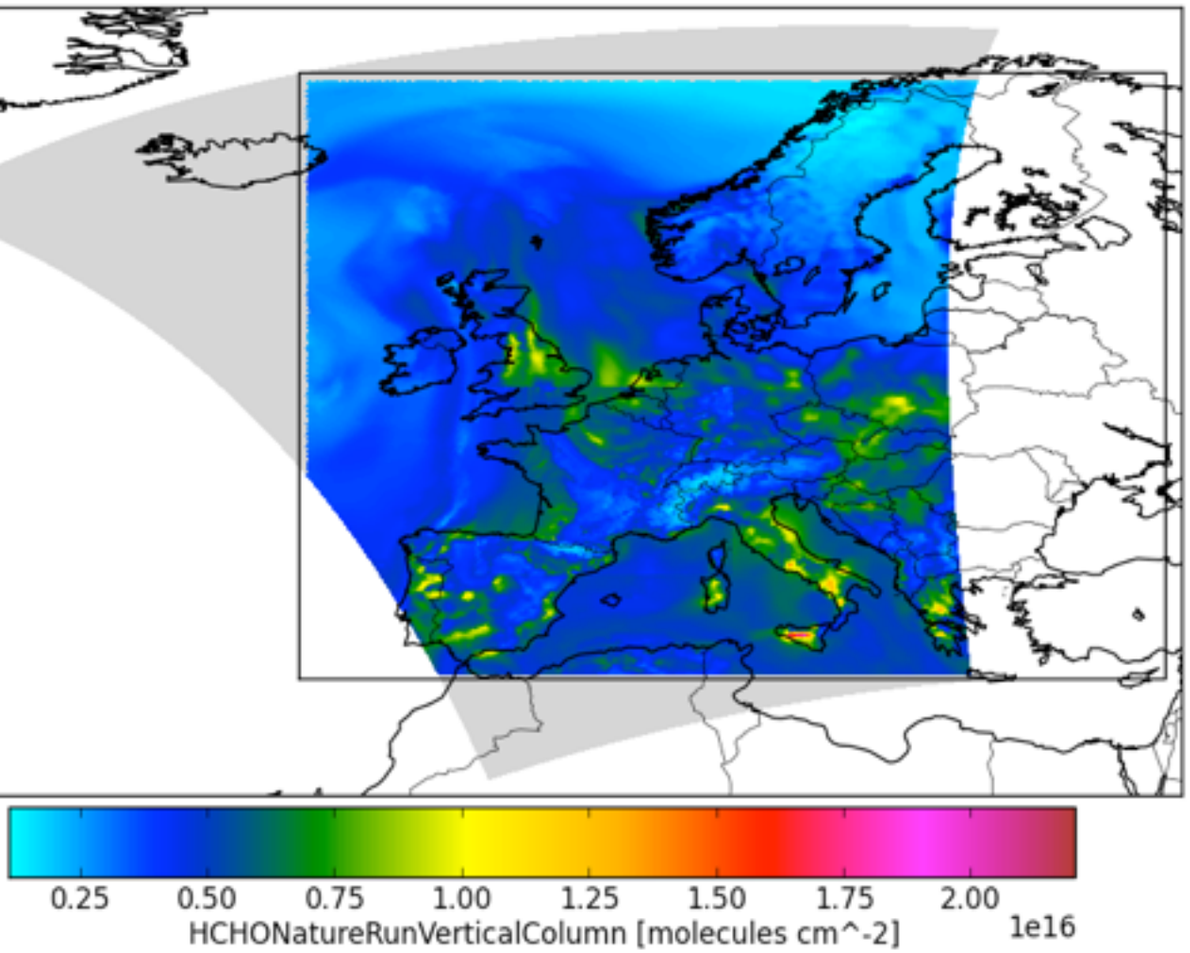
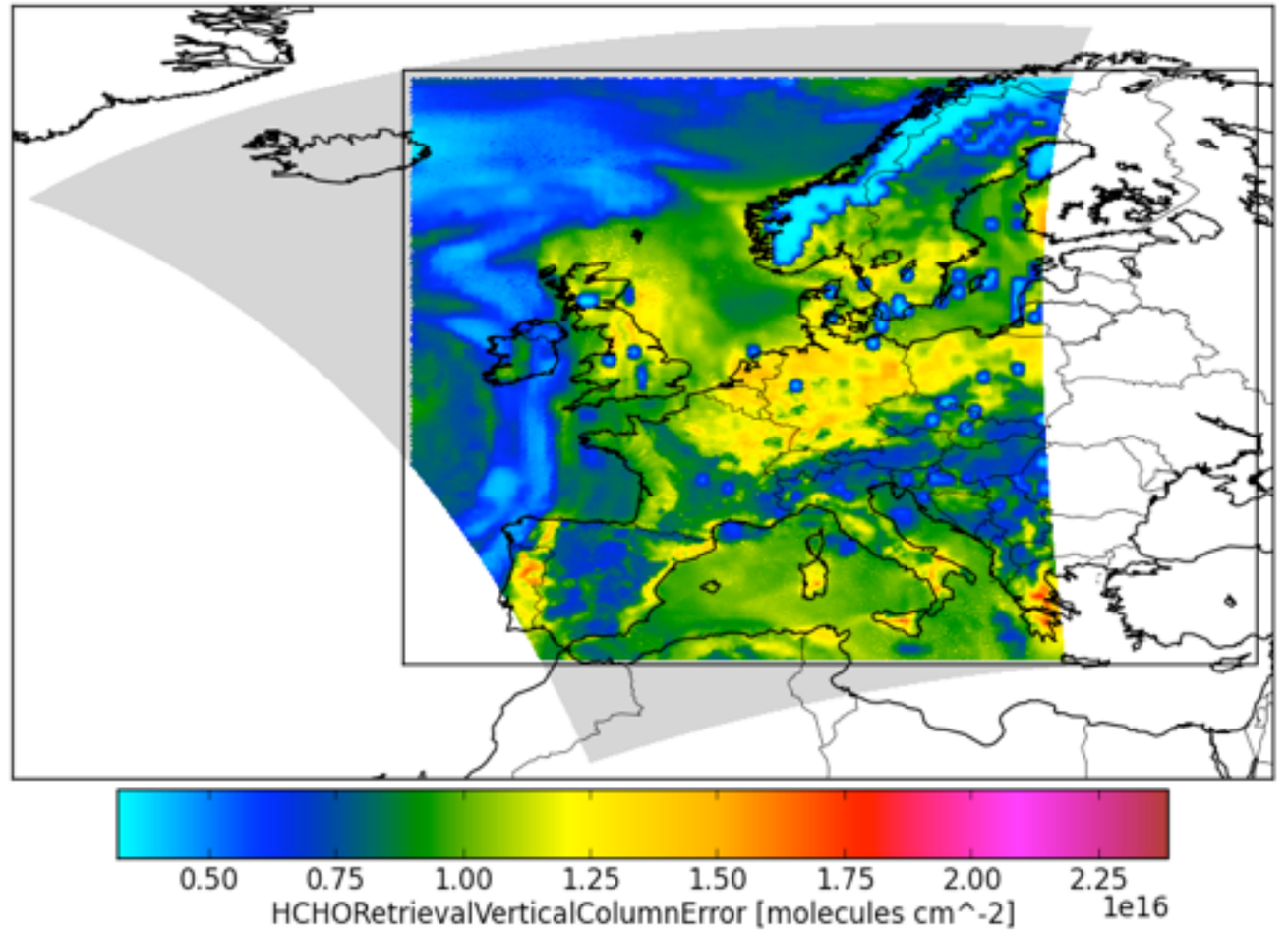
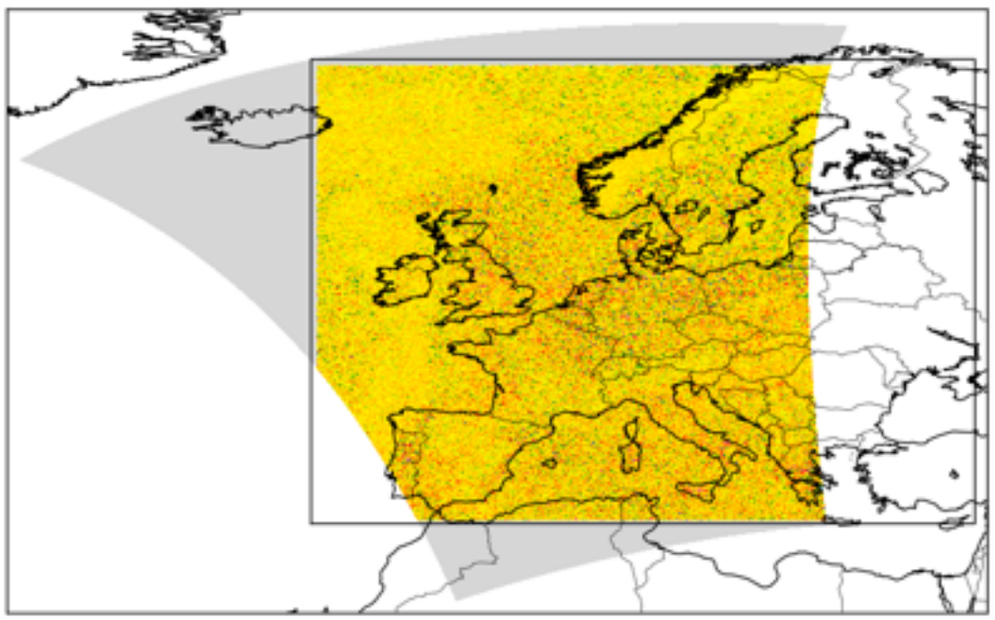


Nature Run



Retrieval error



Noisy observations

HCHO OSSE

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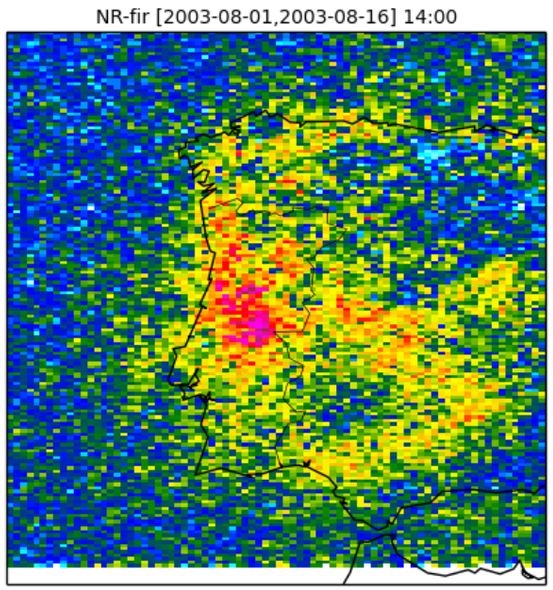

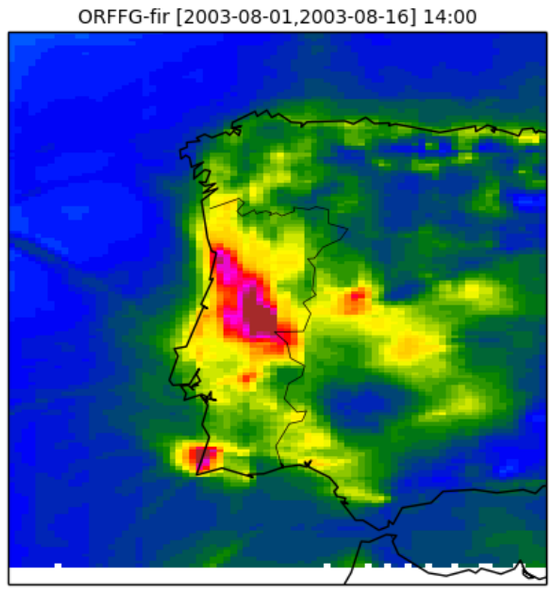

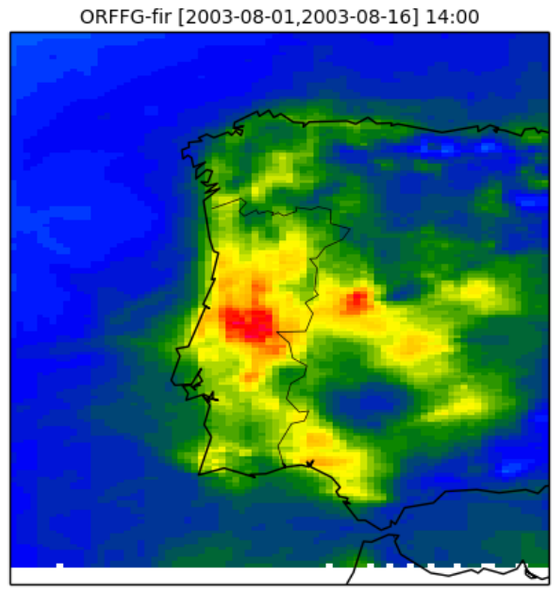

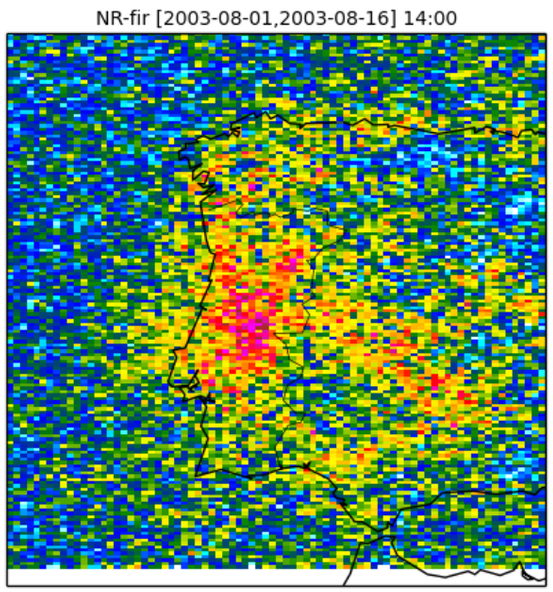

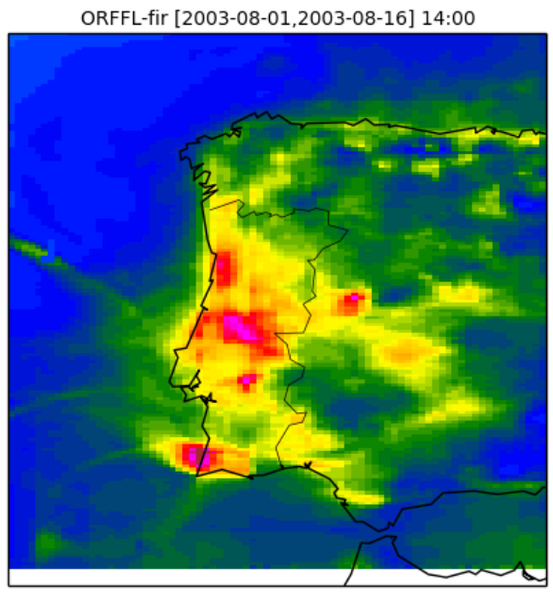

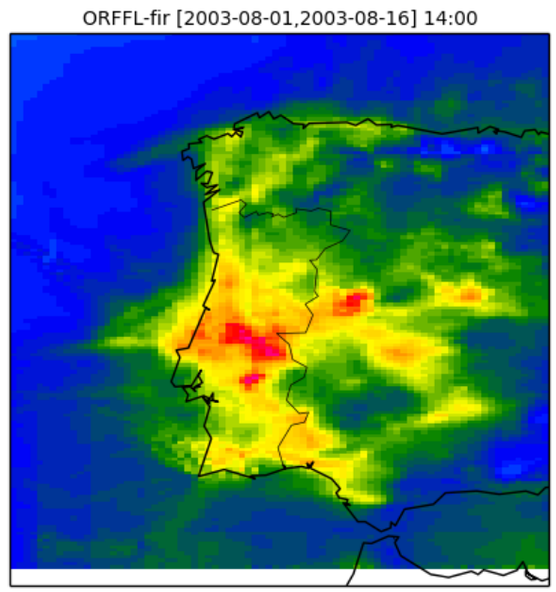

Fires in Portugal

1-16 August 2003

Observations - Ozone

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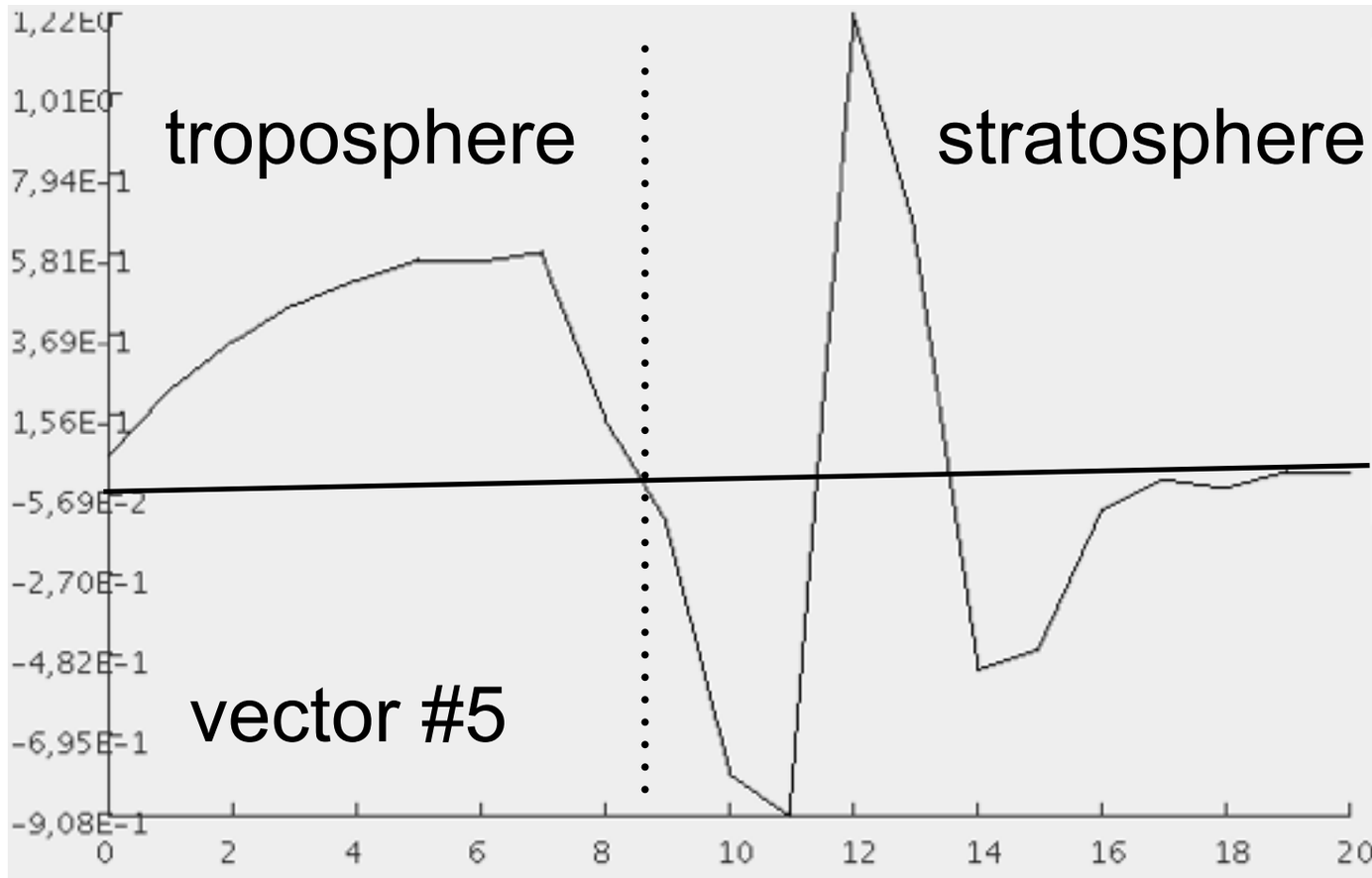
Follow approach of Migliorini, MWR 2008
"Use of Information Content for … efficient interface to DA"

1. Efficient storage: Only kernel vectors and retrieval value for leading eigenvectors
2. Convenient for data assimilation: smaller nr of observations + diagonal obs. covariance

KNMI DISAMAR RTM:
* forward + Optimal Estimation retrieval following Rodgers
* 300-320 nm range @ 7x7 footprint
* 6 leading eigenvectors



Summary ISOTROP project

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment

An OSSE to study the impact of Sentinel 4 and 5 data on air quality forecasts
Target species O3, CO, NO2, HCHO

- Realistic observations with full description of kernels and covariances
- Model differences describe present-day model uncertainty

S4-S5 synthetic observations and lookup-tables available for future OSSE studies

“Atmospheric Composition Observation System Simulation Experiments (OSSE) Workshop”, ECMWF, October 2012
=> Possible collaboration with USA / Asia on OSSE studies for GEO and LEO platforms (CEOS / NASA / MACC)