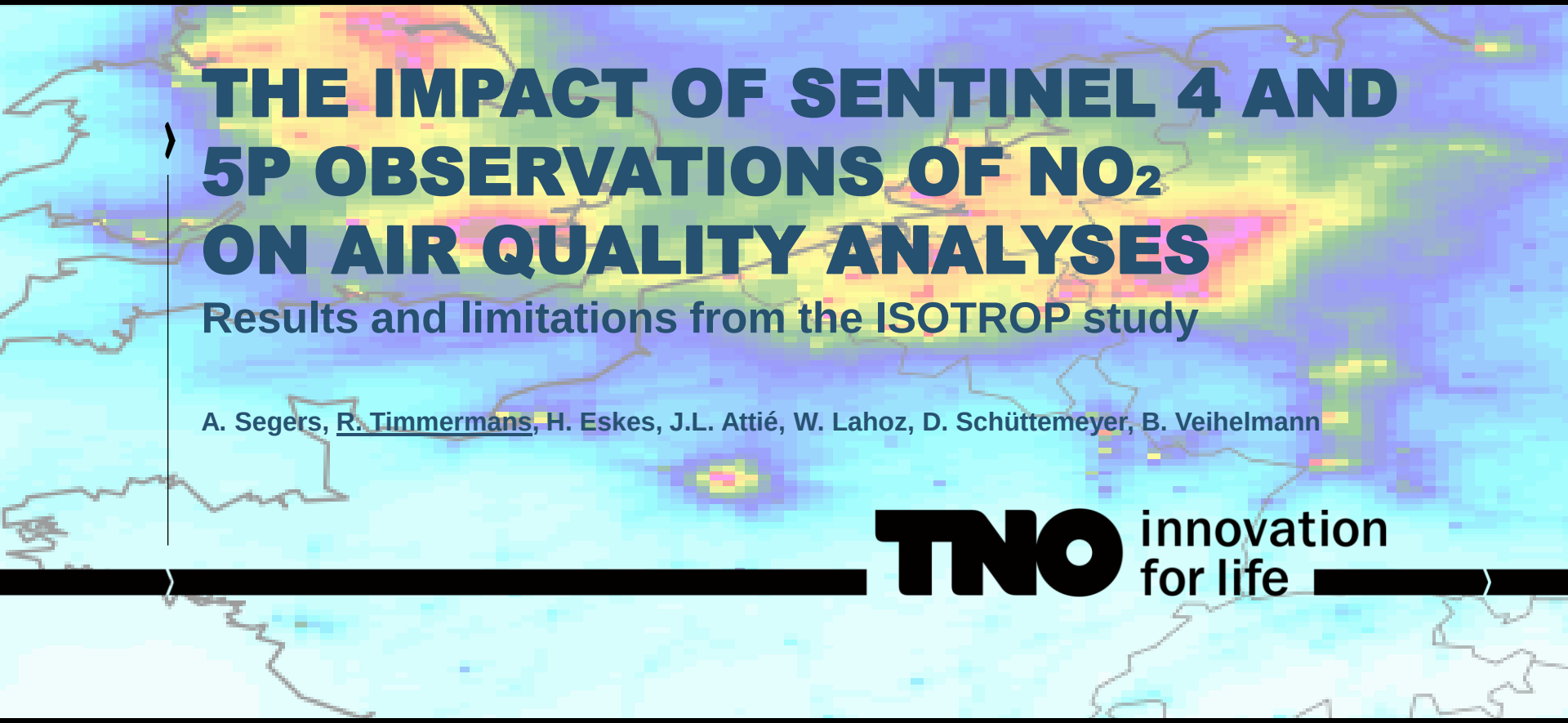


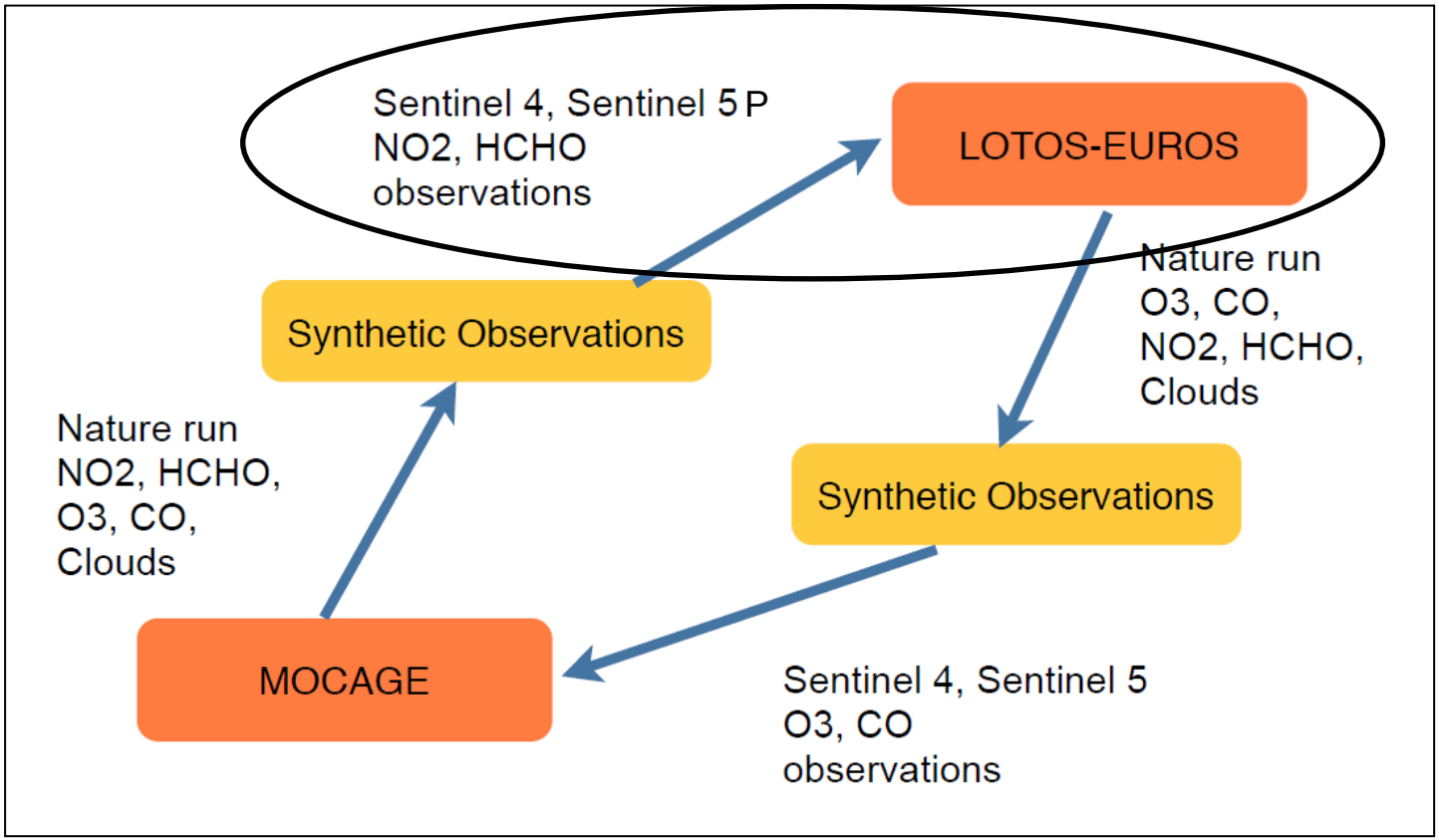
THE IMPACT OF SENTINEL 4 AND 5P OBSERVATIONS OF NO_2 ON AIR QUALITY ANALYSES

Results and limitations from the ISOTROP study

A. Segers, R. Timmermans, H. Eskes, J.L. Attié, W. Lahoz, D. Schüttemeyer, B. Veihelmann

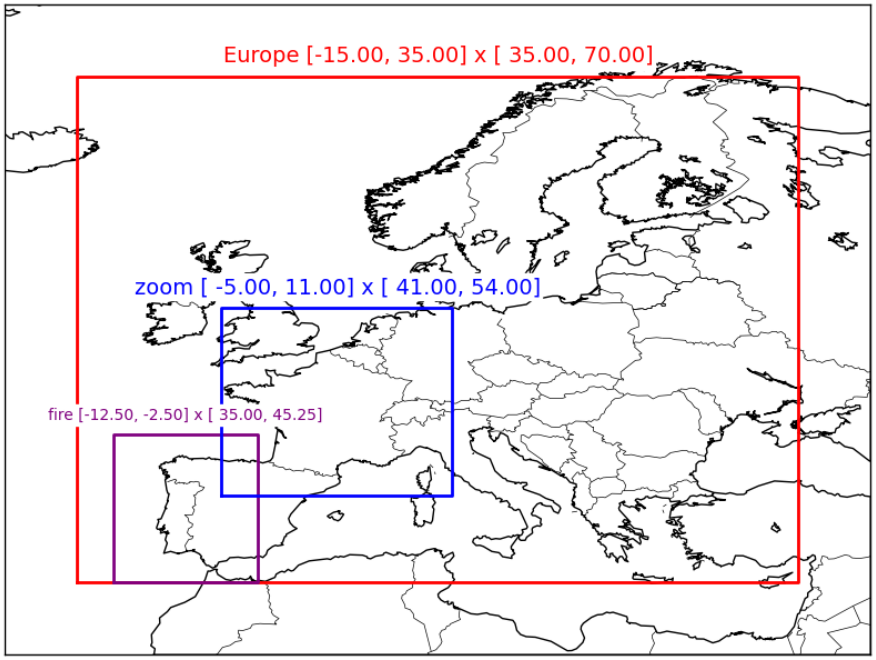
TNO innovation for life

FOCUS OF THIS PRESENTATION



Determine added value of S5P & S4 observations NO2 and HCHO columns

STUDY DOMAIN AND PERIODS



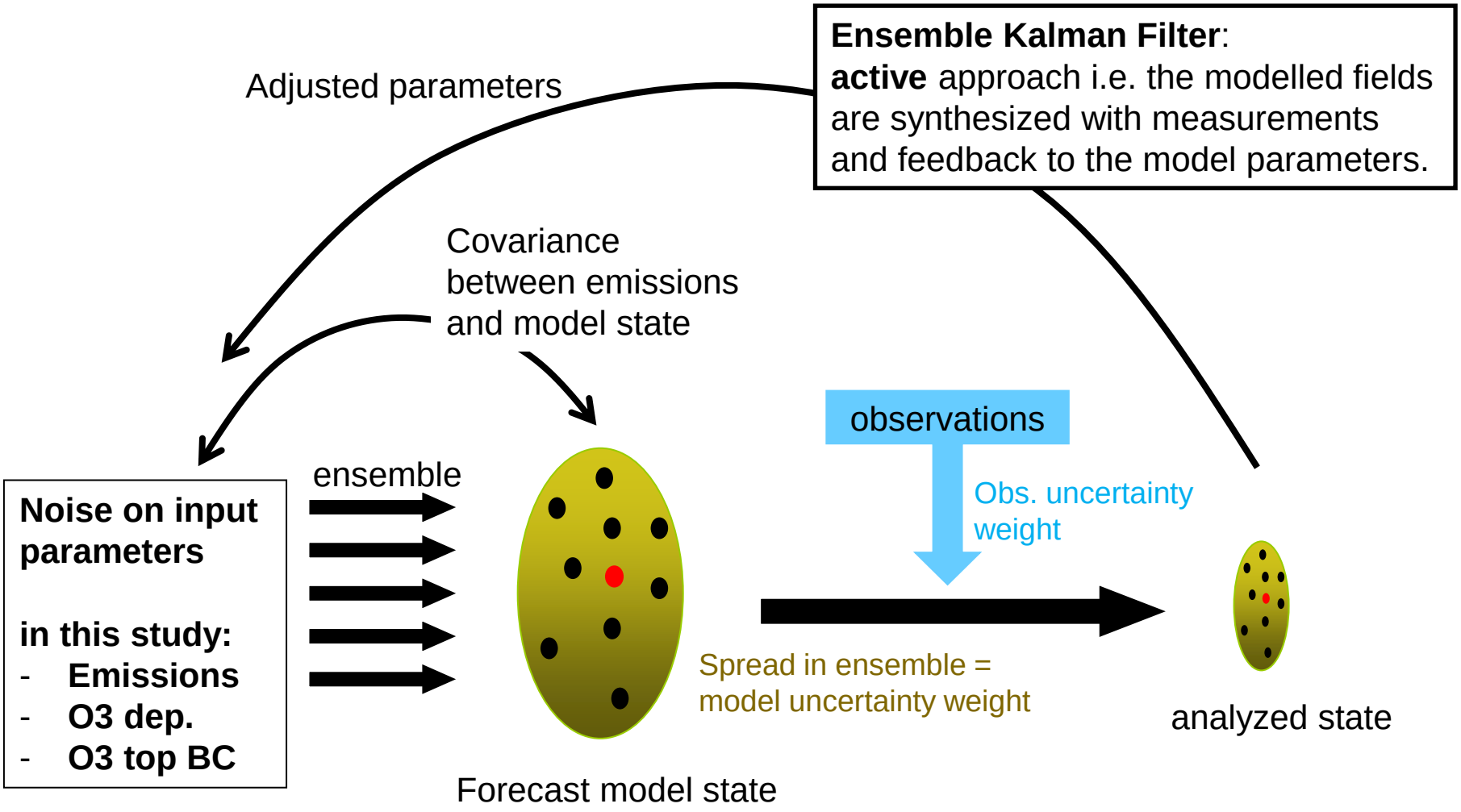
Summer 2003: June-July-Aug.
Fire episode : 2 weeks in summer ‘03

Winter 2003/4: Nov-Dec.-Jan.

ASSIMILATION RUNS

	Domain	Ground ozone	GEO S4 NO_2	LEO S5P NO_2	GEO S4 HCHO	LEO S5P HCHO
Reference run	All	X				
AR GEO NO_2	All	X	X			
AR LEO NO_2	All	X		X		
AR GEO+LEO NO_2	Zoom	X	X	X		
AR GEO HCHO	All	X			X	
AR LEO HCHO	All	X				X

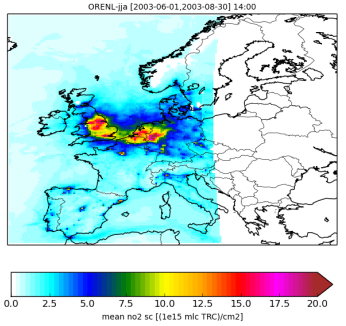
DATA ASSIMILATION IN LOTOS-EUROS

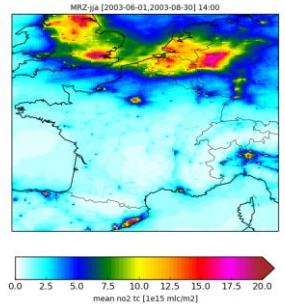


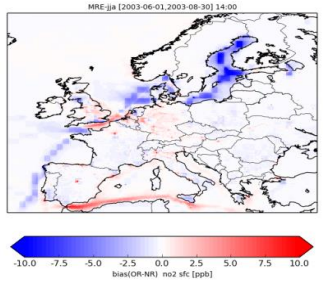
ISOTROP RESULTS AND CONCLUSIONS

The evaluations are focusing on three types of variables:

- **Satellite columns**, where we directly compare the synthetic satellite observations with the collocated (in space and time) values from the model that are convolved with the provided averaging kernels to produce a column value representing the satellite product.
- **Total columns**, where we compare the gridded LOTOS-EUROS NO_2 columns (without applying averaging kernels) to the gridded NO_2 columns from the nature run. It is unclear if these columnar values are representing the same altitude range and should therefore be considered with care.
- **Surface concentrations**, where we compare gridded LOTOS-EUROS surface concentrations with the surface concentrations from the nature run.



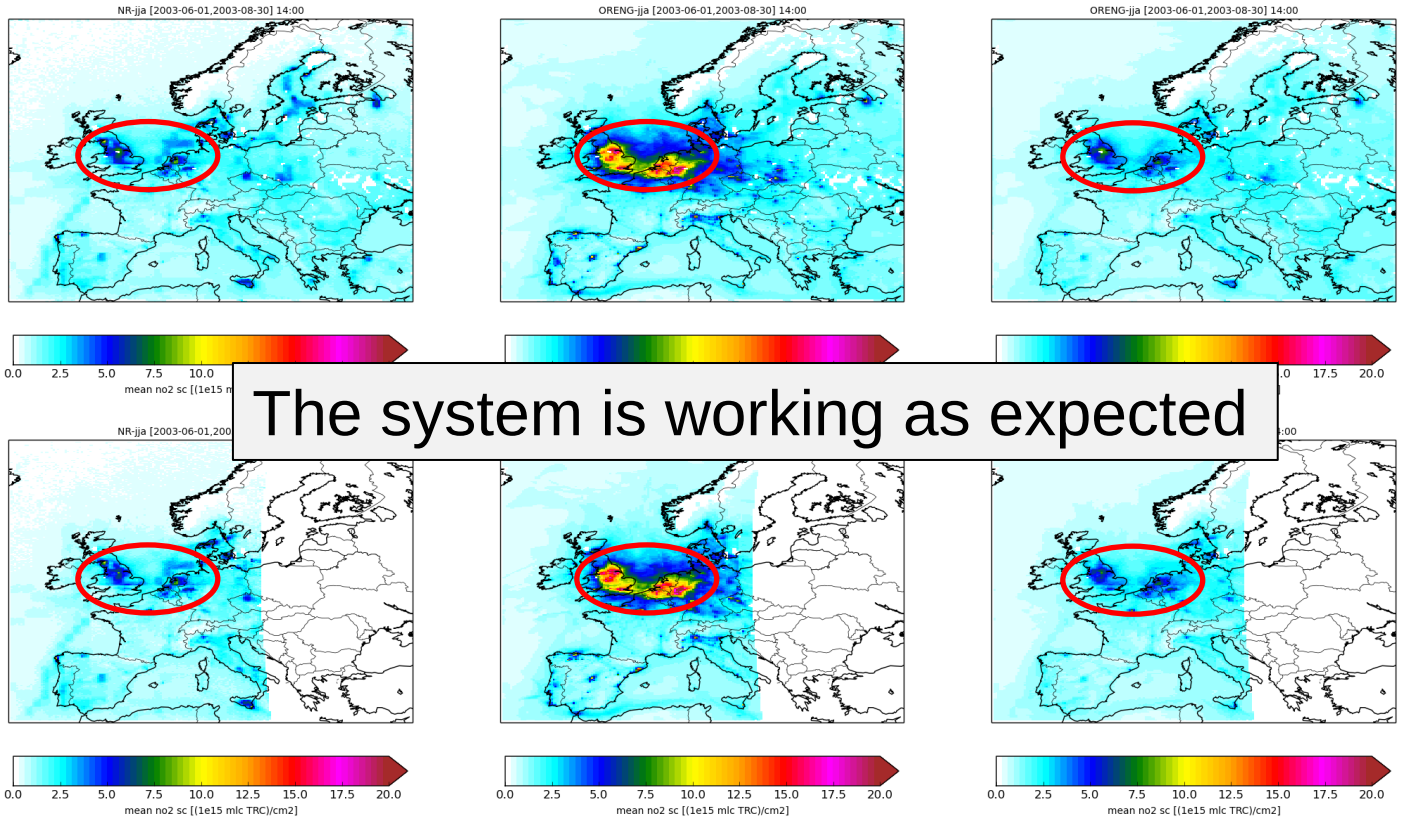




ISOTROP RESULTS AND CONCLUSIONS

Summer Satellite columns NO_2, 14h

Synthetic NO_2 columns | Model run | Assimilation run



The system is working as expected

S4

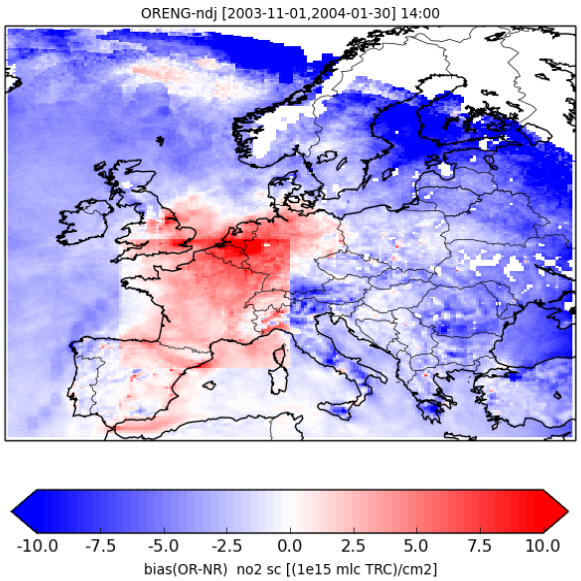
S5P

Figure 1 Europe-summer period averaged synthetic NO_2 columns at 14h (left) and collocated convolved NO_2 columns from Model Run (middle) and Assimilation run (right) for O_3 gb + S4 NO_2 (top) and O_3 gb+ S5P NO_2 (bottom).

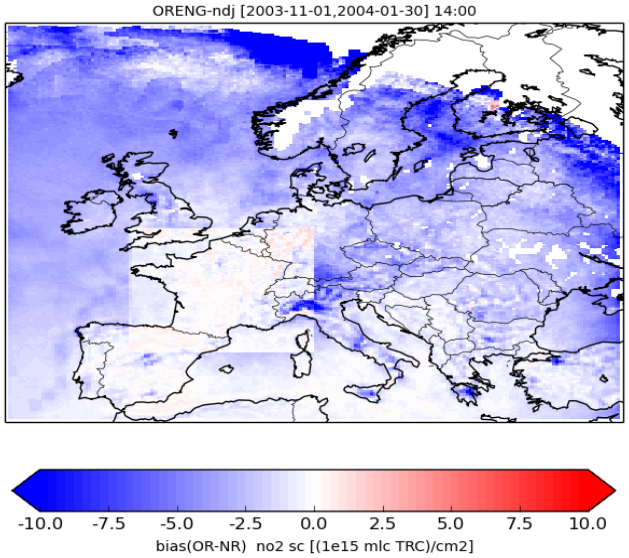
ASSIMILATION SKILL

Winter, bias in
Satellite columns NO_2
14h

Model run



Assimilation run - S4

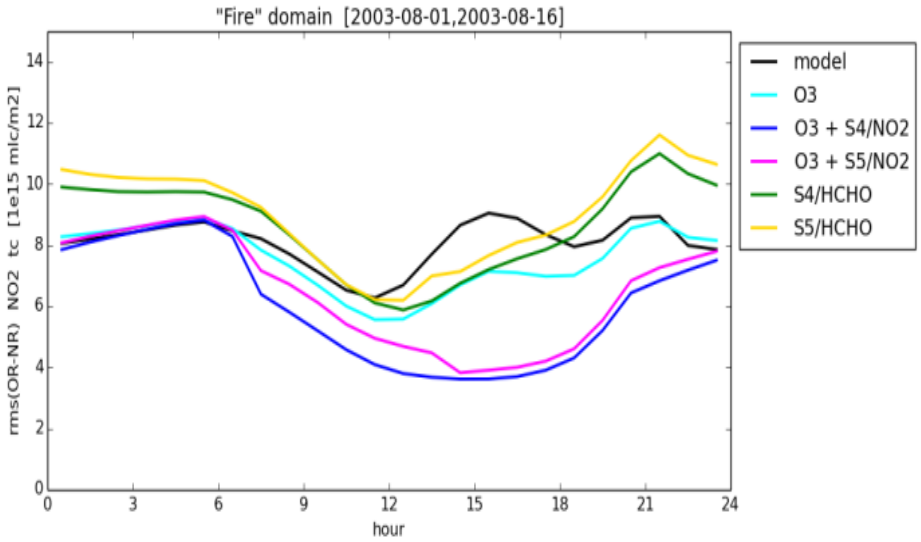


Assimilation improvement for negative biases < for positive biases
Model has harder time pulling NO_2 up than down →
Eastern Europe observations and large values and thus large relative errors.
Over Atlantic no sources to adjust

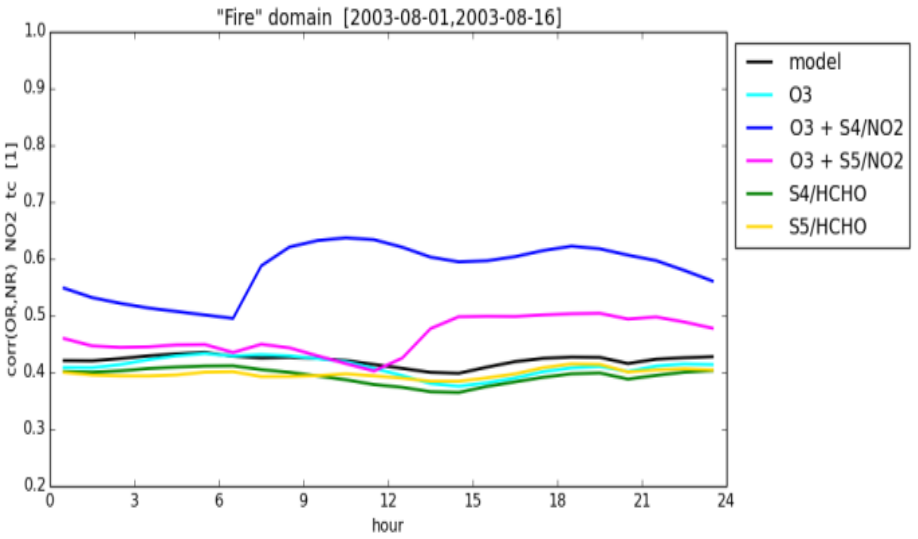
ADDITIONAL BENEFIT S4 OVER S5P

Fire episode
total columns NO2

RMSE



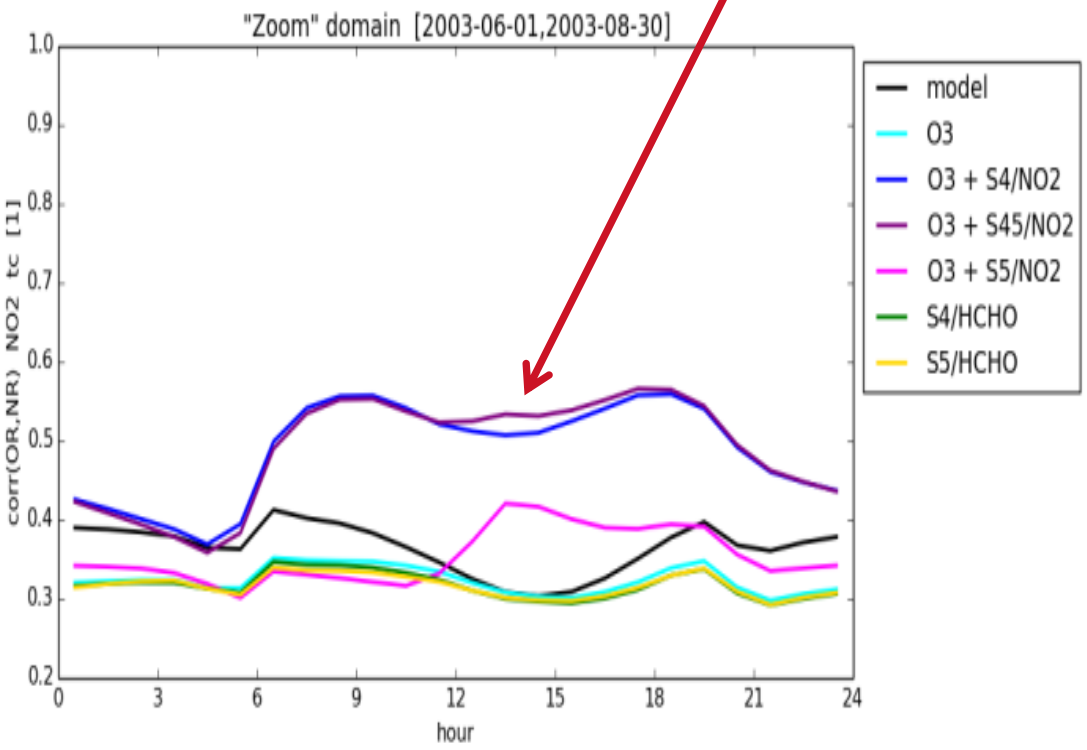
temporal correlation (over 3 months)
for each hour of the day



BENEFIT COMBINED ASSIMILATION S4 AND S5P

Summer - zoom
total columns NO2

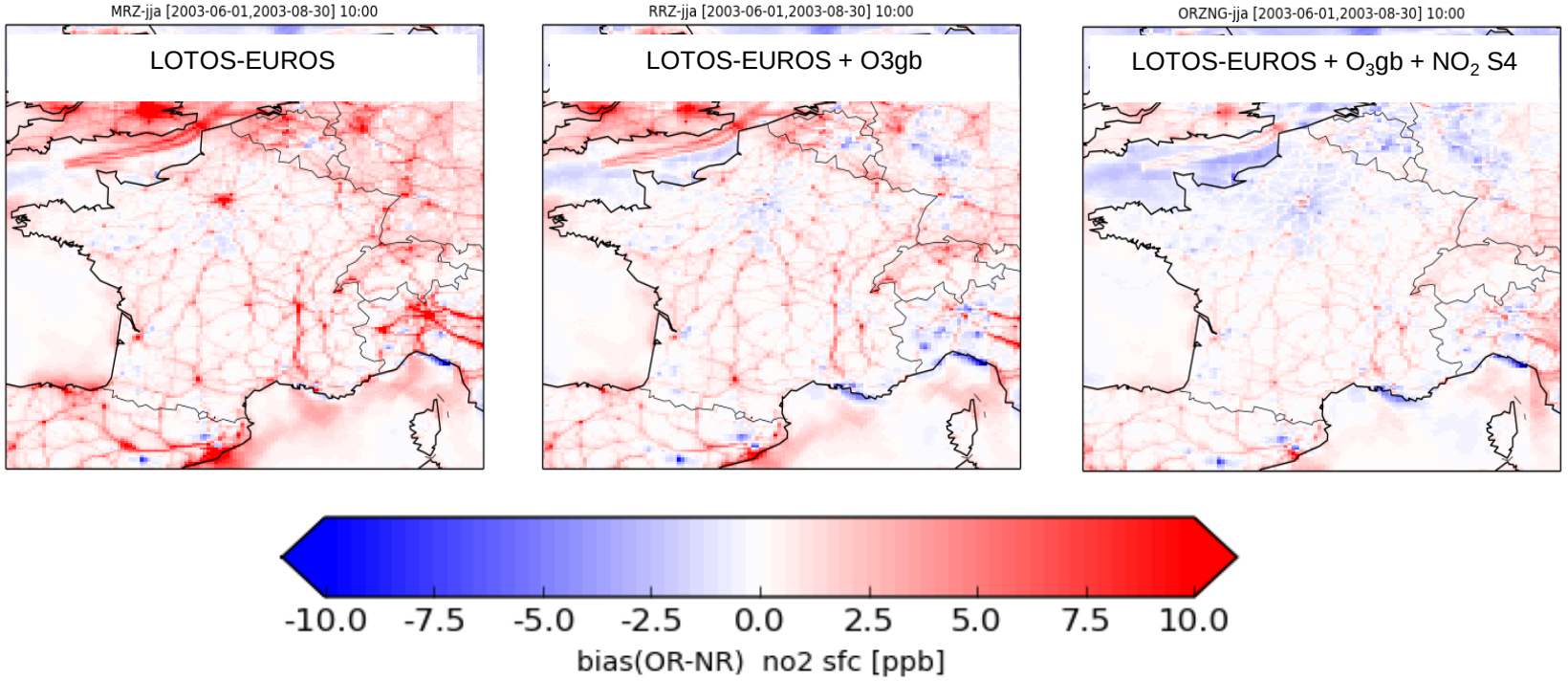
temporal correlation



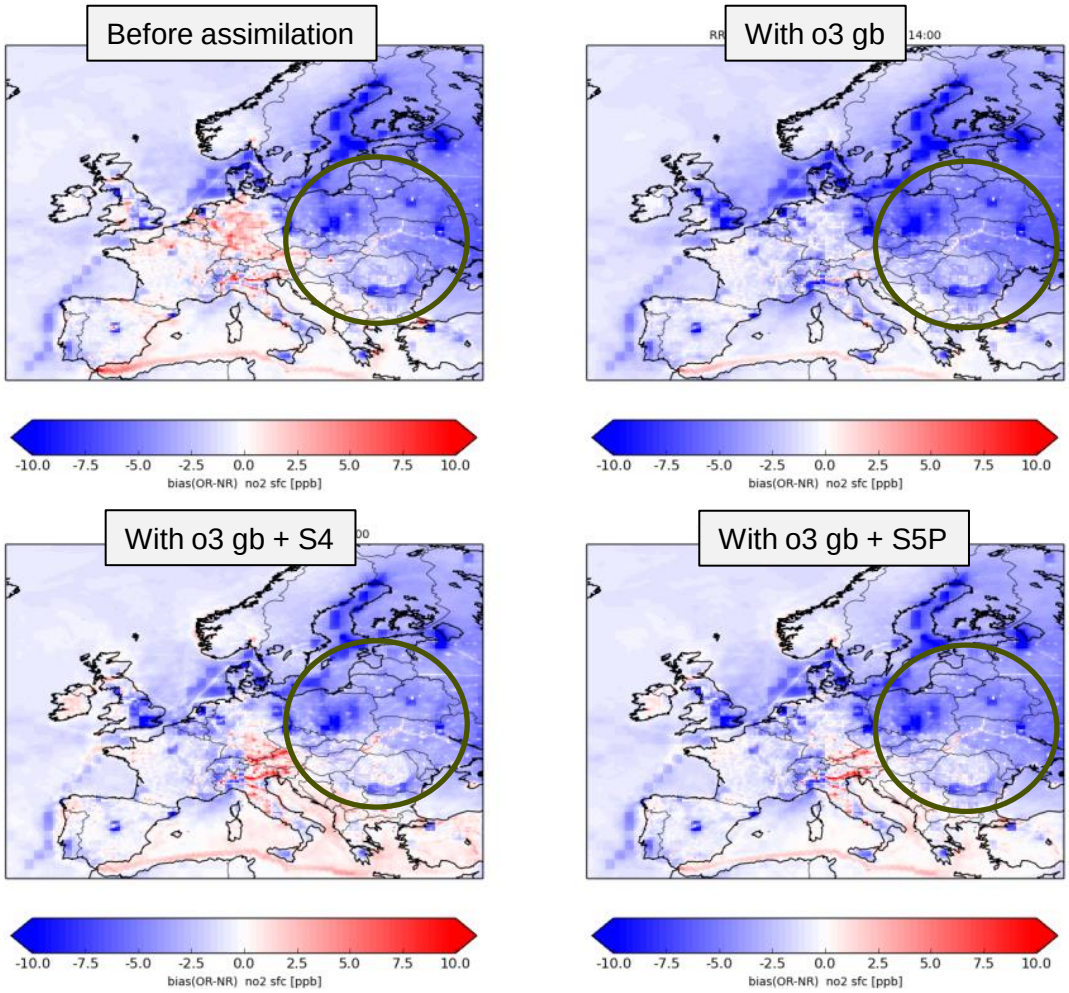
IMPACT ON SURFACE NO2

Example of additional benefit satellite observations

Summer
Bias surface NO2 @10h



IMPACT ON SURFACE NO_2

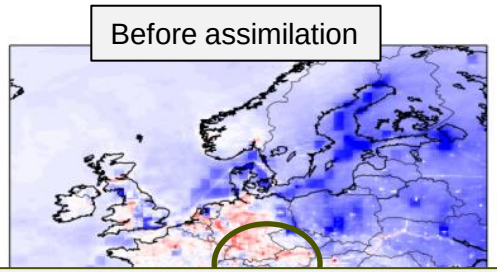


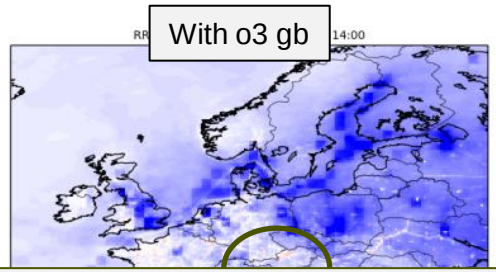
winter
Surface NO2
Bias at 14h

Negative bias decreases through additional assimilation sentinel data

IMPACT ON SURFACE NO2

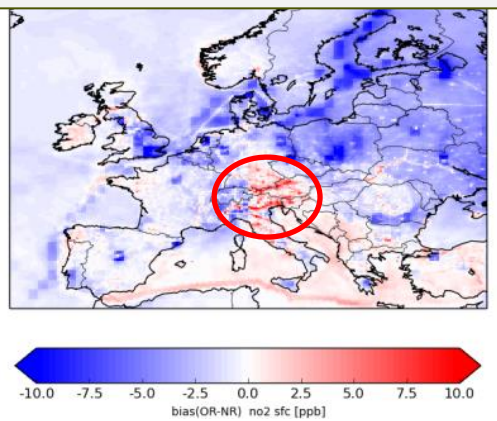
Example where additional assimilation satellite data deteriorates results

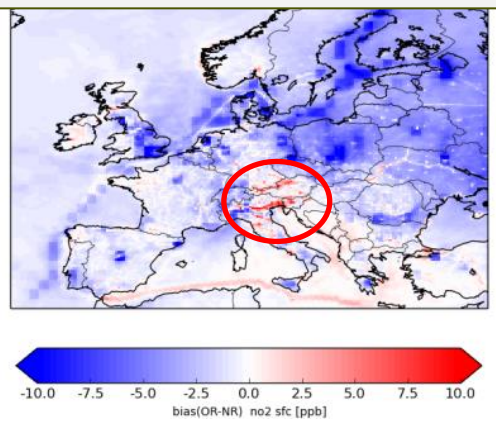


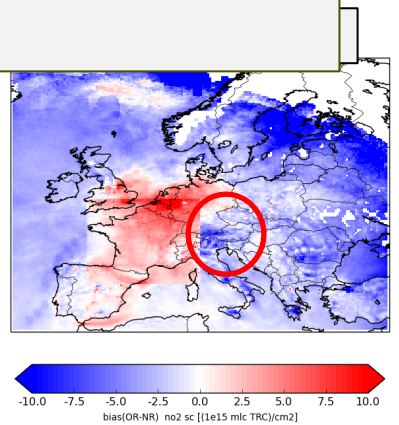


winter
Surface NO2
Bias at 14h

This contradiction between the bias in satellite columns and bias in surface concentrations is due to different NO_2 profiles in the nature run and LOTOS-EUROS. It is thus crucial that NO_2 profiles are correctly modeled and the difference between modelled and nature run profiles should be analysed to correctly assess OSSE results.







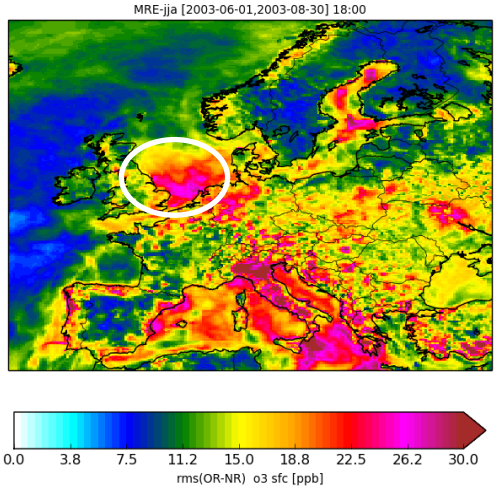
→ Increase NOx emissions

IMPACT ON SURFACE OZONE

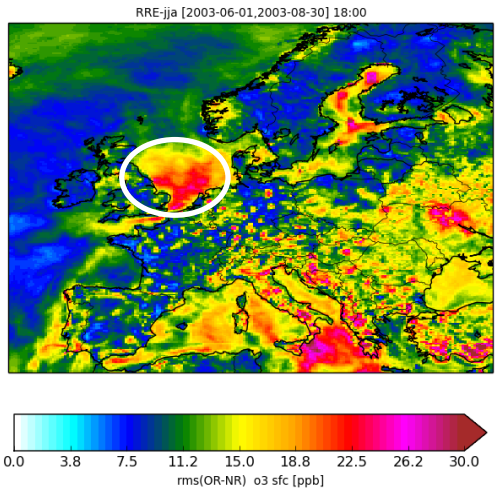
Impact of NO2 satellite data on surface ozone

Summer
Surface O3 rmse@ 18h

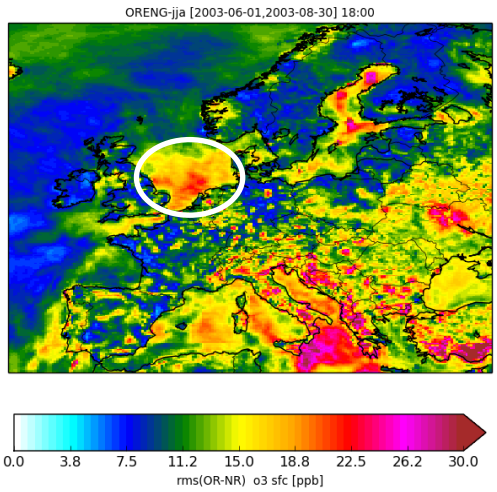
LOTOS-EUROS



LOTOS-EUROS + O3gb



LOTOS-EUROS + O_3gb + NO_2 S4

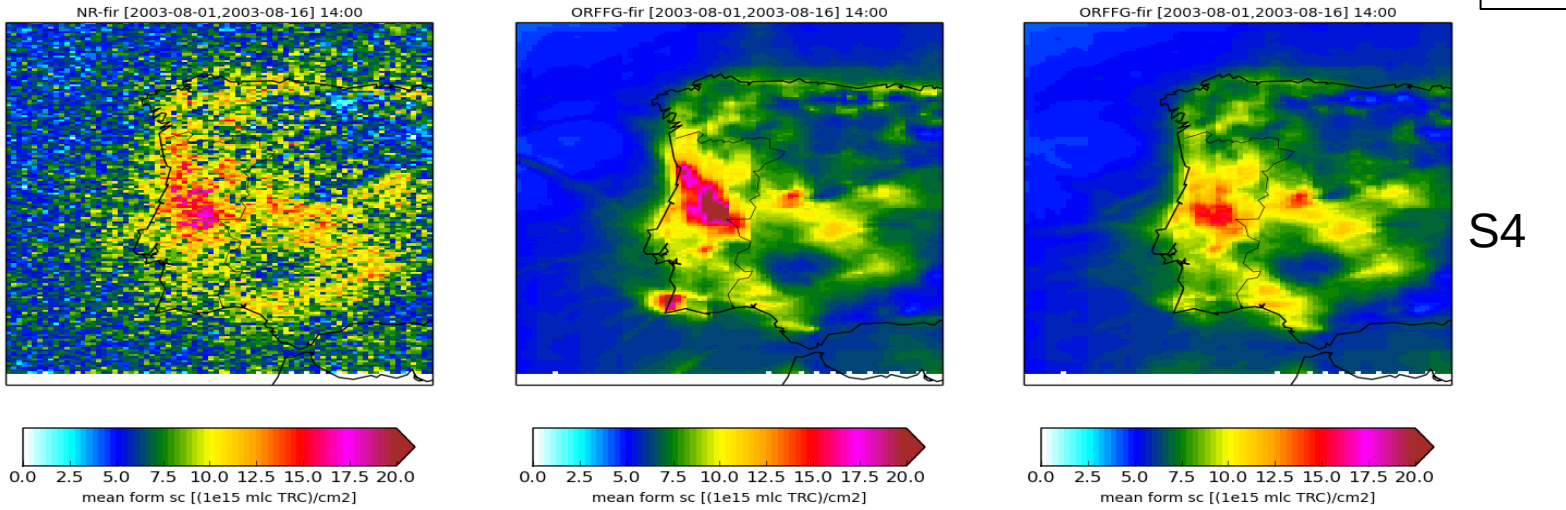


Biases in surface ozone and no2 columns not influenced equally by same (emission) errors → e.g. errors in biogenic emissions or meteorology, limiting factor of data assimilation system

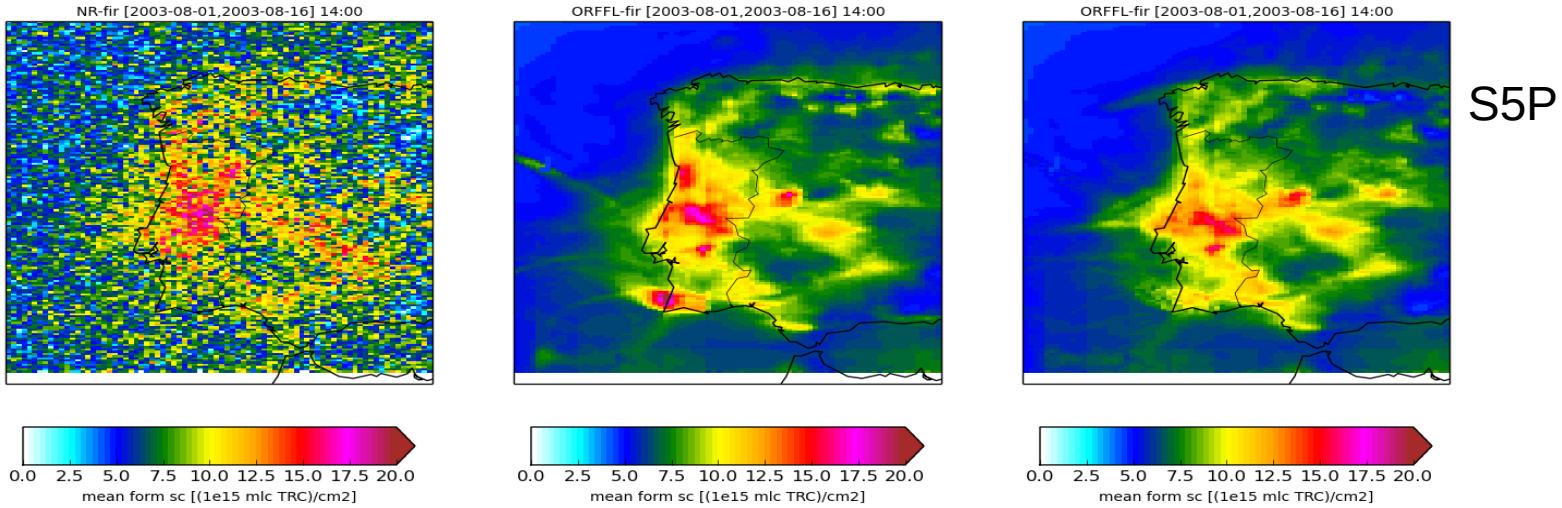
IMPACT HCHO OBSERVATIONS

Fire episode
Sat. columns
HCHO, 14h

Synthetic HCHO columns | Model run | Assimilation run



S4

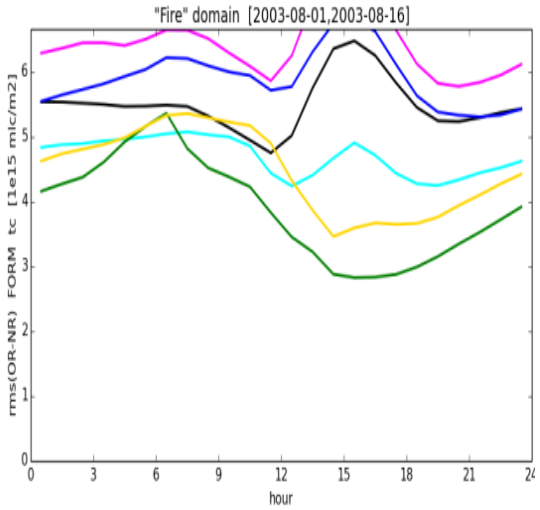


S5P

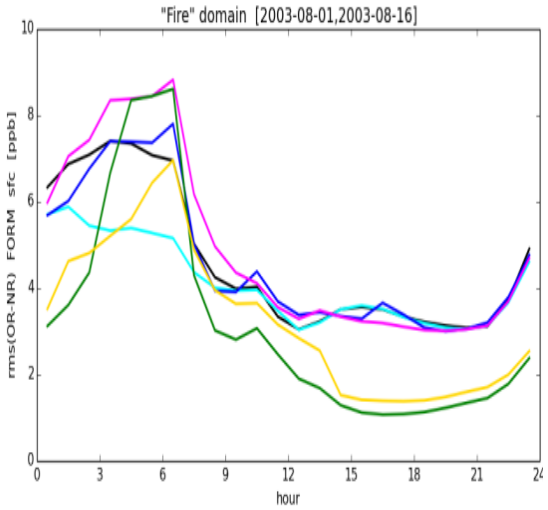
IMPACT HCHO OBSERVATIONS

Only visible in case of elevated HCHO
Largest impact on RMSE

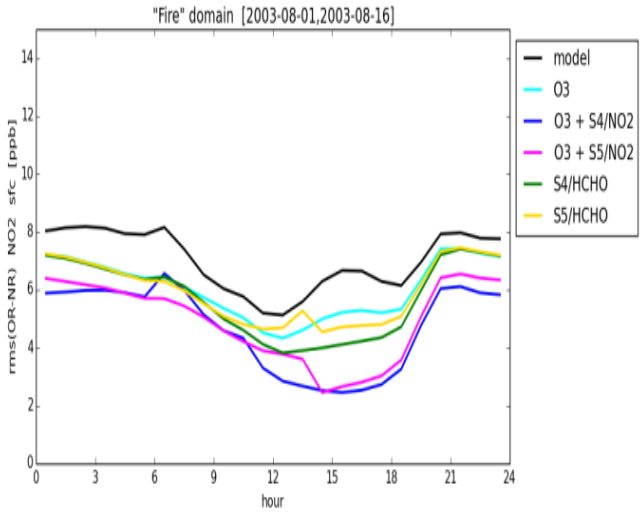
Fire episode and domain RMSE



Total HCHO column



Surface HCHO



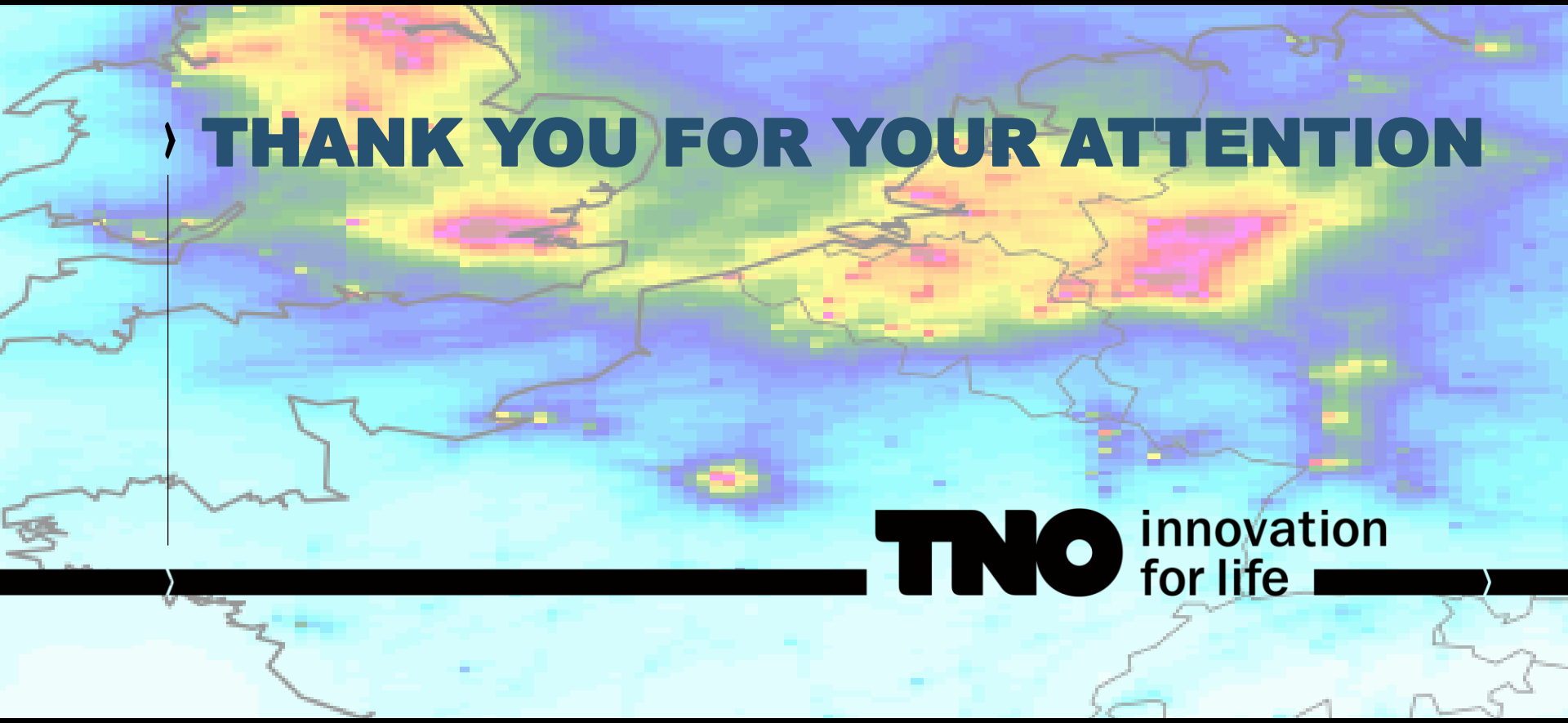
Surface NO2

CONCLUSIONS

- S4 and S5/S5P NO_2 columns positively impact modelled NO_2 values.
- Correct vertical profile in model essential for benefit on surface values.
- The higher temporal resolution of the Sentinel 4 observations has a clear benefit resulting overall in a larger impact especially when the Sentinel 5/5P satellite has no observations (but S5/S5P has global coverage).
- HCHO observations show an added value in case of elevated HCHO values during wildfire event. In other cases the noise in the product unfortunately is too large to provide a benefit to modelled HCHO fields.
- Satellite NO_2 and HCHO do not have a large influence on surface O3.

SOME RECOMMENDATIONS

- Analysis needed of causes for the differences between simulations and observations, these uncertainties can then be taken into account in the production of the ensemble
- Perform investigation of profile differences between model and observations when handling column values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