CZECH
HYDROMETEOROLOGICAL
INSTITUTE

SAMIRA

Combined use of In-situ, Earth Observation and Modelling Data in Air Quality Mapping

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SAMIRA

esa

1. Introduction of SAMIRA project for AQ mapping

2. Data fusion methodology

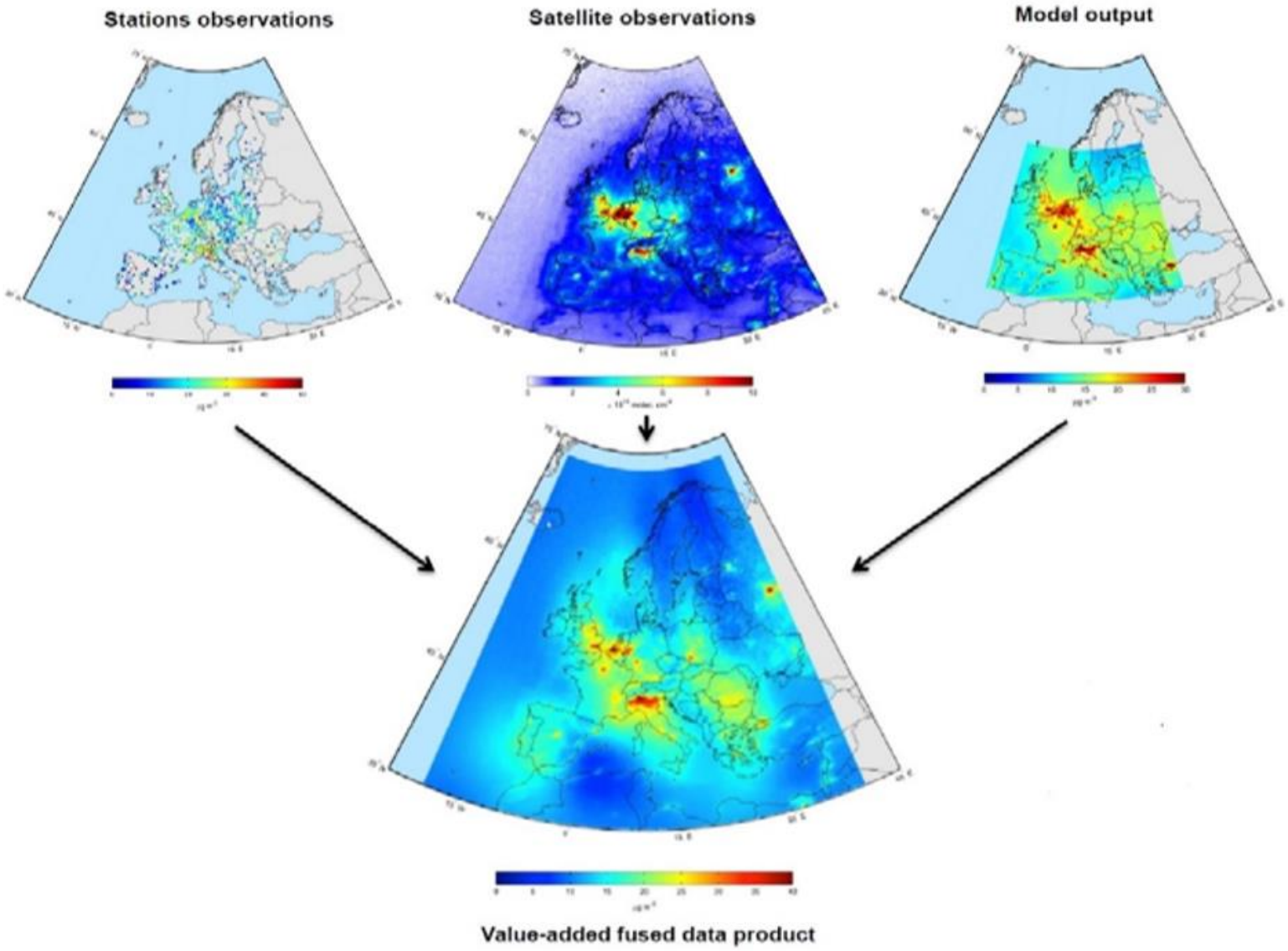
3. Data sources for AQ mapping

4. Earth observation data treatment

5. Data fusion results

Introduction of SAMIRA project

- Project of European Space Agency (ESA)
- SAMIRA – Satellite based Monitoring Initiative for Regional Air quality (CZ, PL, RO, NO)
- Improving of regional air quality assessment through synergetic use of data from 3 sources:
  - In-situ measurements
  - Earth observations
  - Chemical transport modelling
- One of the goals: development of more accurate air quality mapping for PM, NO_2, SO_2 using data fusions methods (residual kriging)



Source: Schneider et al. (2012). ETC/ACM Technical Paper 2012/9.

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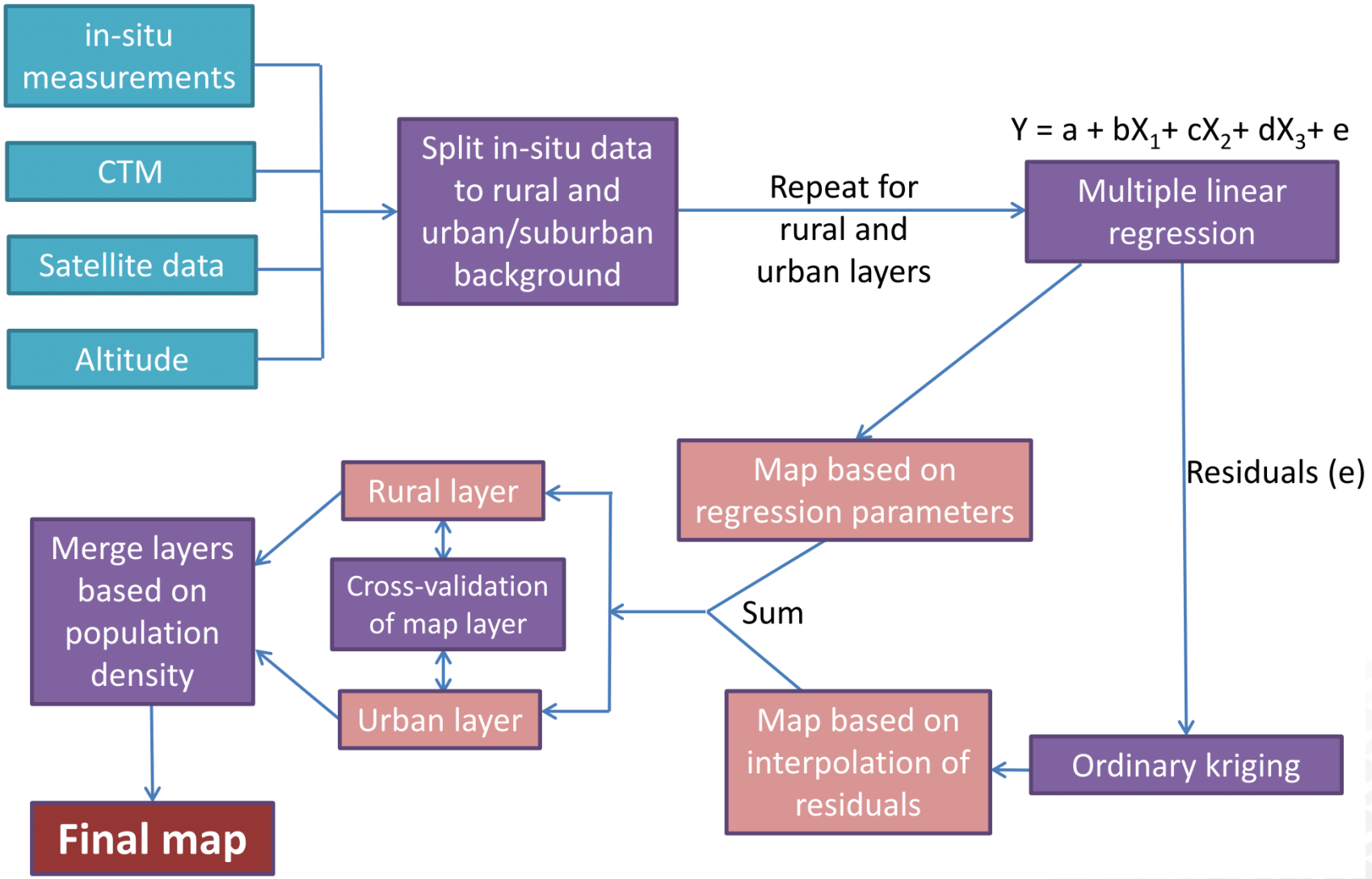
Regression – Interpolation – Merging Mapping



Implementation

- R code
- Usage of existing packages and functions for linear model and variogram model fitting etc.
- Temporal resolution:
  - Annual
  - Daily
  - Hourly
- Spatial resolution:
  - Czech domain: **1 x 1 km** computational and final
  - European domain: **5 x 5 km** computational, **1 x 1 km** final

Uncertainty estimation

- Using leave-one-out cross-validation
- Data fusion estimate calculated for each in-situ measurement point from all available information except from the point in question
- Procedure repeated for all measurement points in the available set
- Statistical indicators: bias, RMSE

$$bias = \frac{1}{N}\sum(Z_i - \widehat{Z}_i)$$

$$RMSE = \sqrt{\frac{1}{N}\sum(Z_i - \widehat{Z}_i)^2}$$

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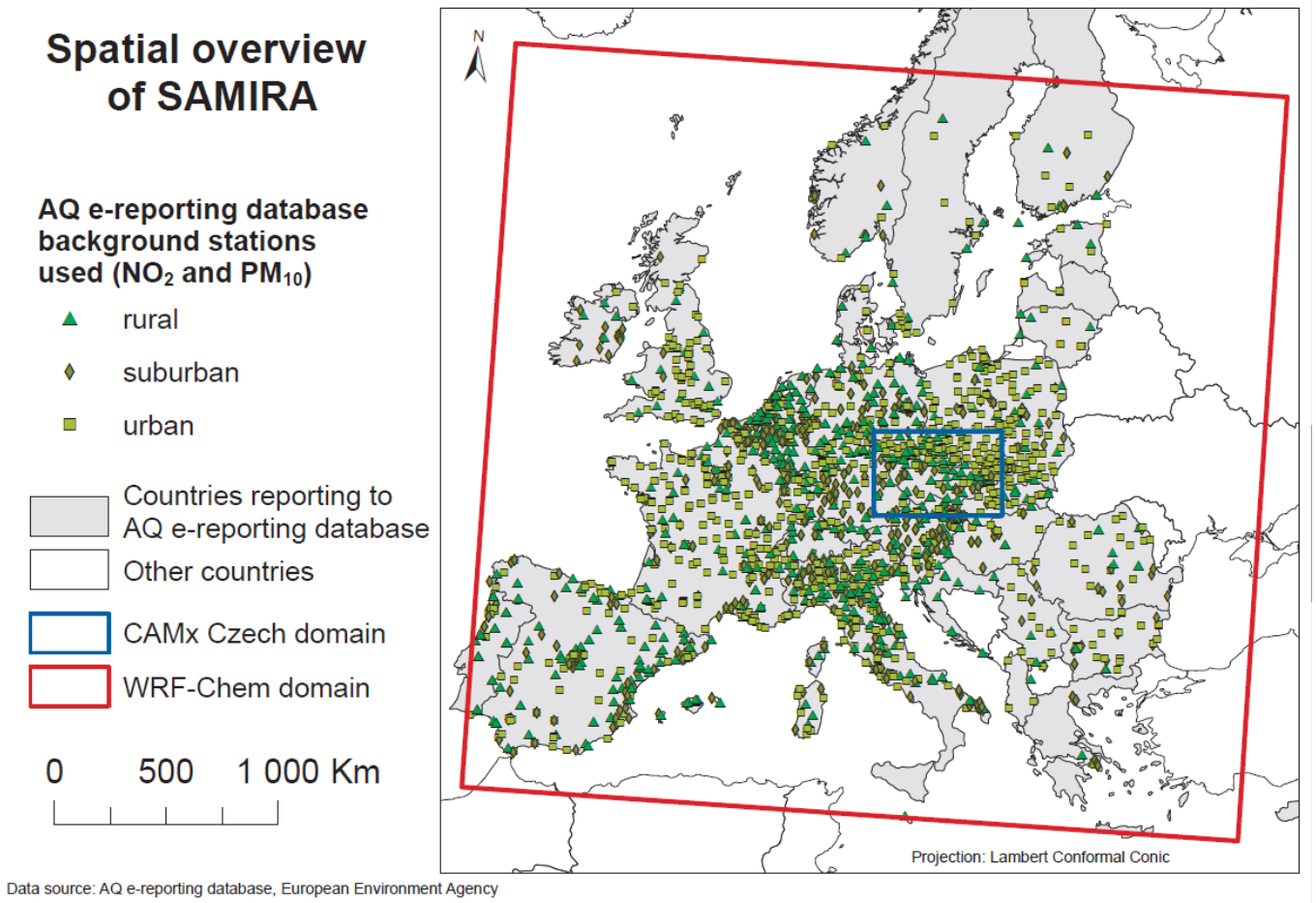
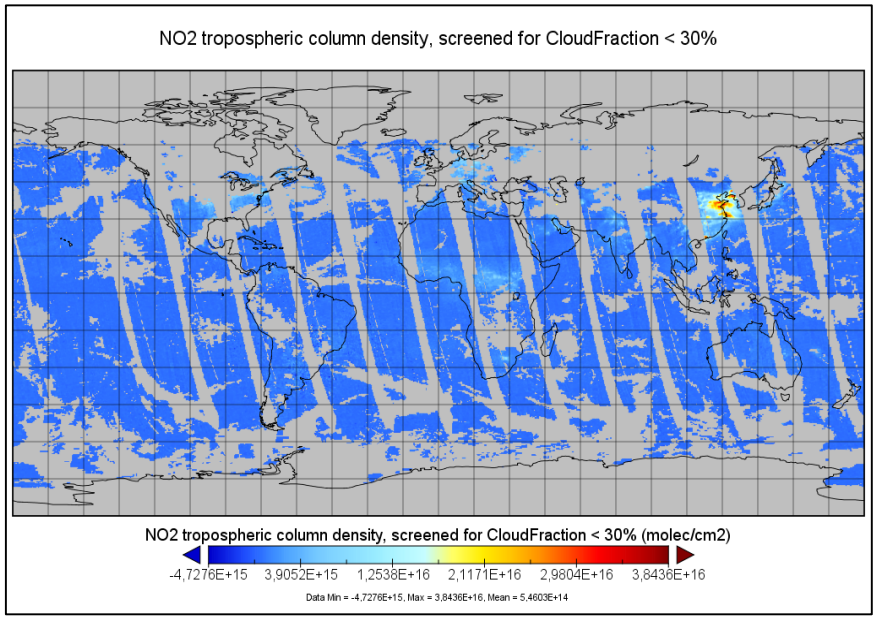
Input data

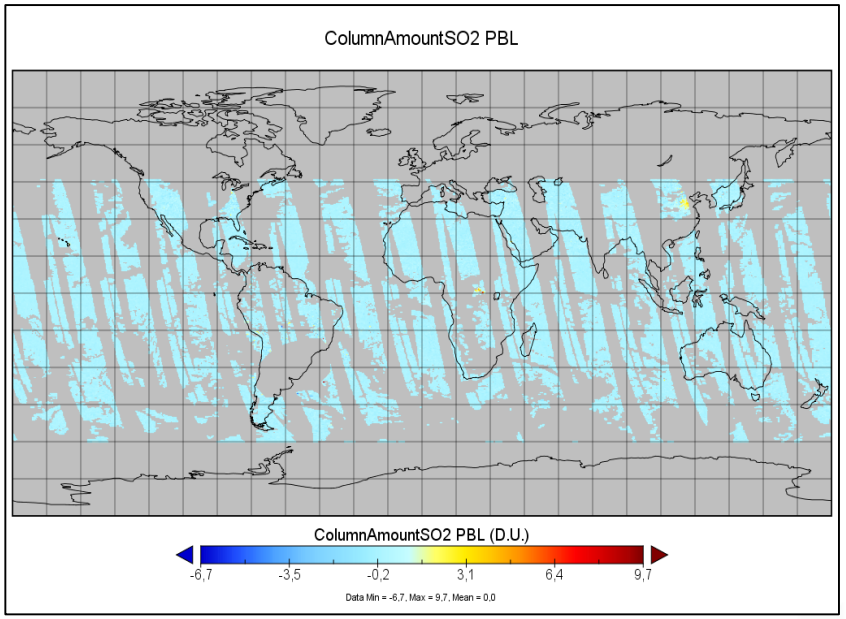
- Czech domain
  - Czech Air Quality Information System database (in-situ data)
  - Satellite data (OMI, GOME, SEVIRI)
  - CAMx model
  - Altitude
- European domain
  - EEA's AQ e-reporting database (in-situ data)
  - Satellite data (OMI, GOME, SEVIRI, MODIS)
  - WRF-Chem model
  - Altitude
- Pollutants: NO_2, SO_2, PM_{10}, $PM_{2.5}$

In-situ and modelling data



Satellite data





OMNO (NO_2)

OMSO (SO_2)

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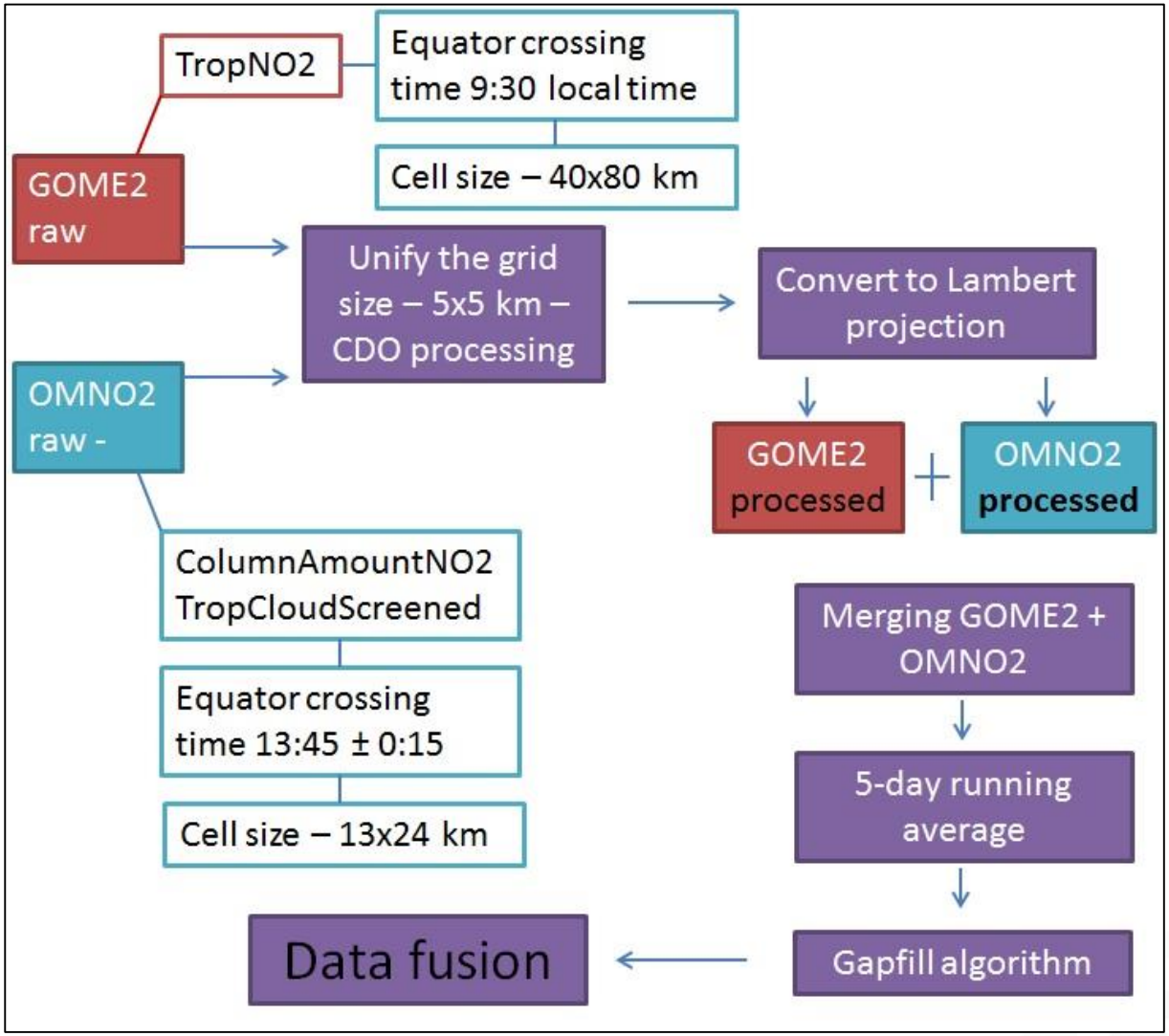
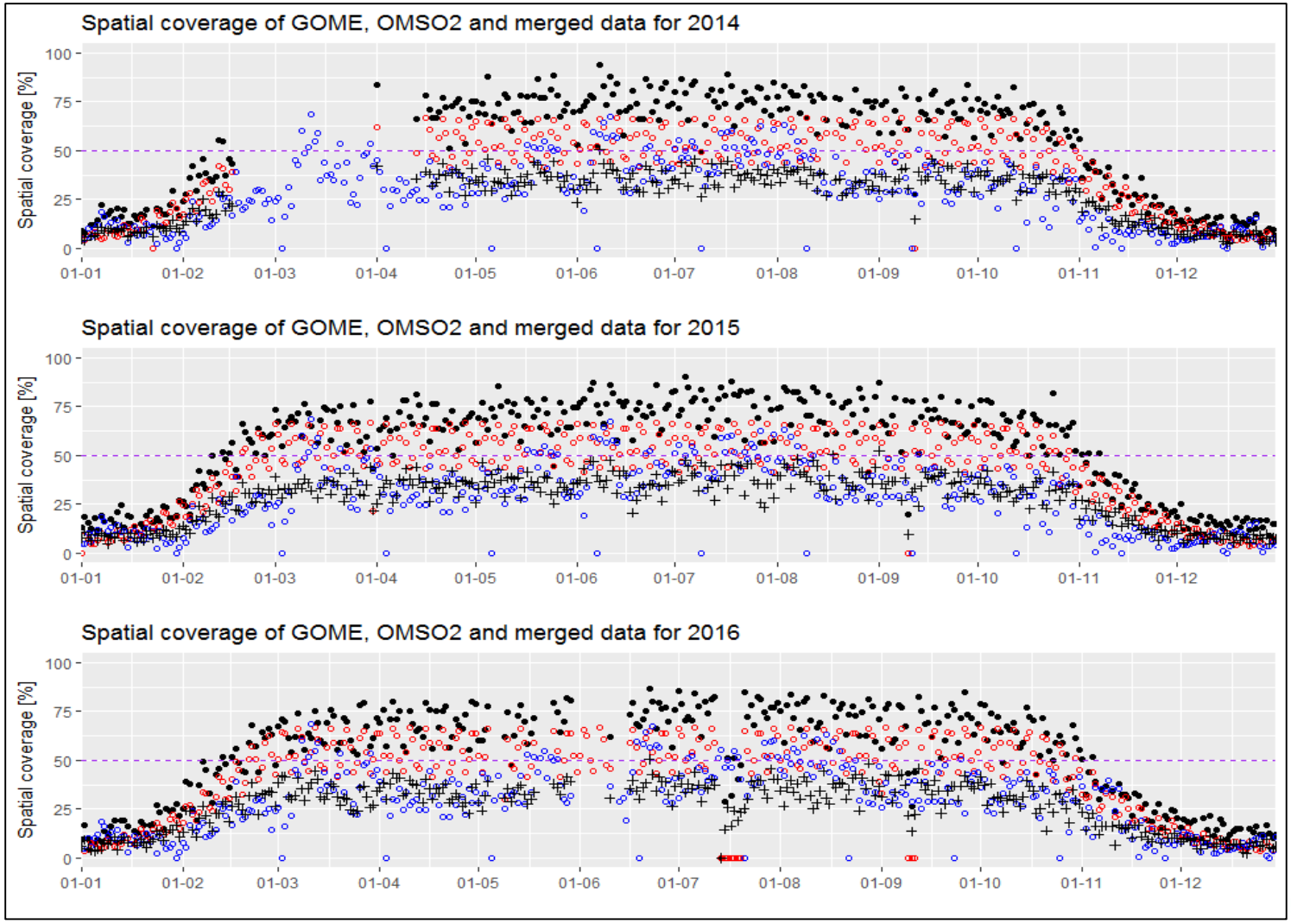
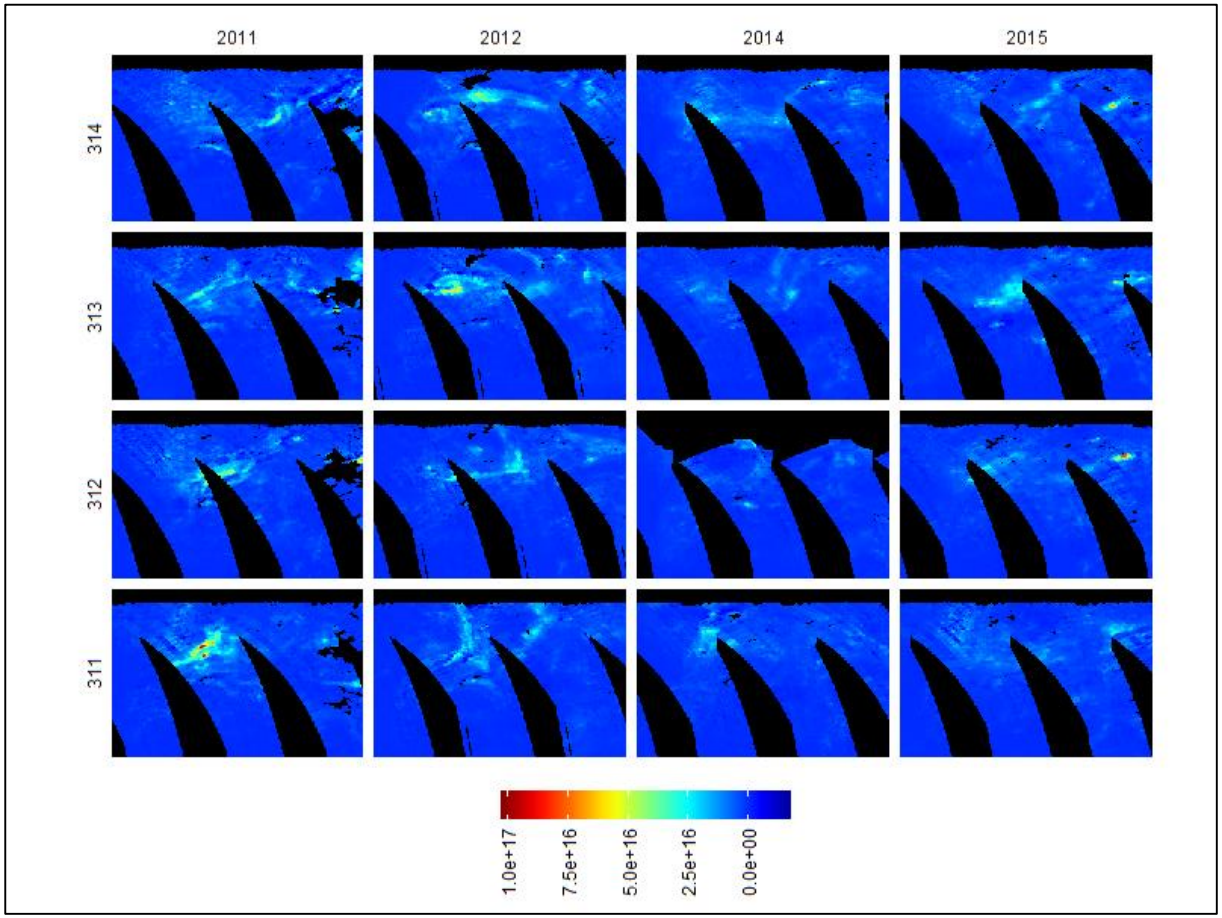
Data processing of two NO_2 satellite data products





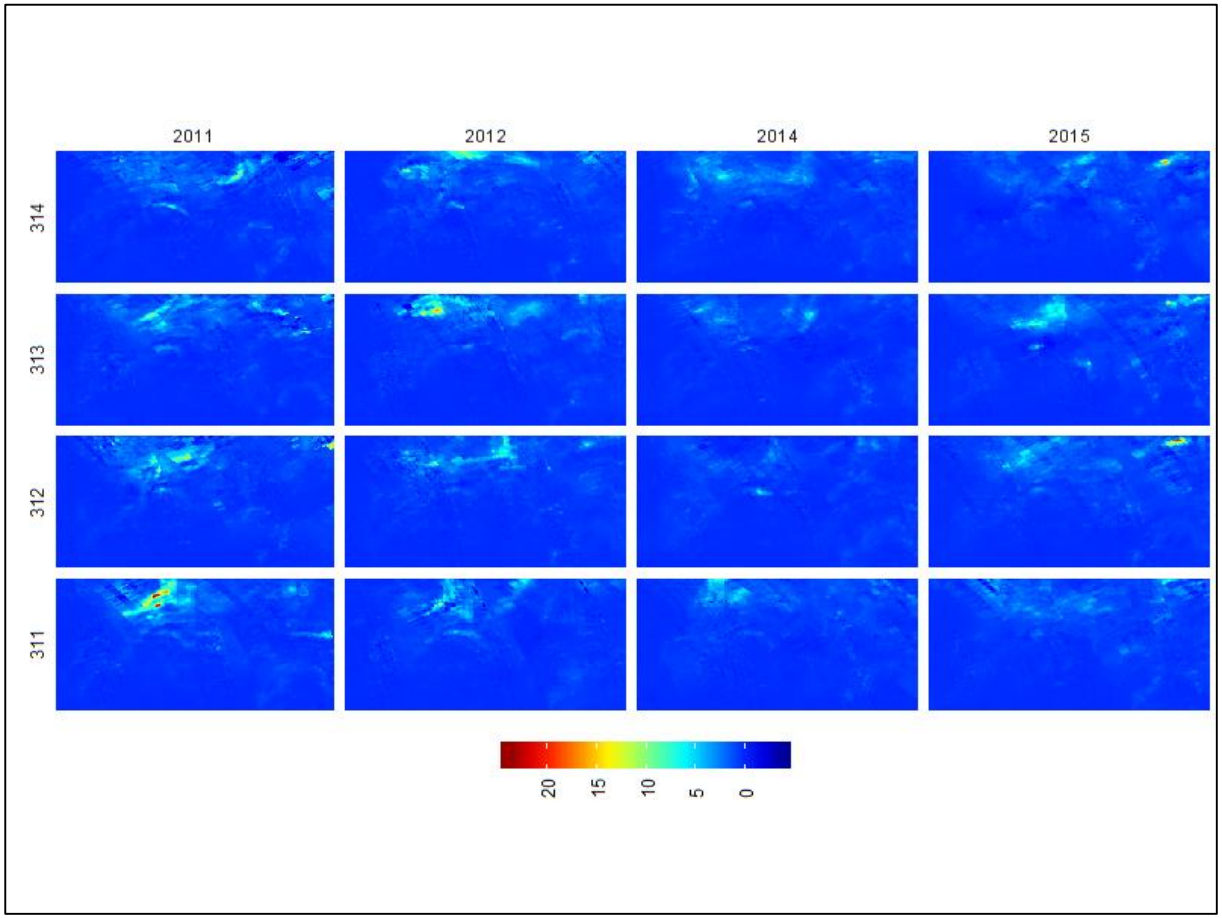
Red circles represent **GOME2**, blue circles represent **OMI** – OMSO2 data, black dots represent **merged data** and black crosses represent merged data considering only positive values.

Gap filling procedure for NO_2: Input (OMNO2)



For gap filling of each day, data for 4 days in 4 years needed.

Gap filling procedure for NO_2 : Output



Daily data processed by „gapfill“ procedure, Europe

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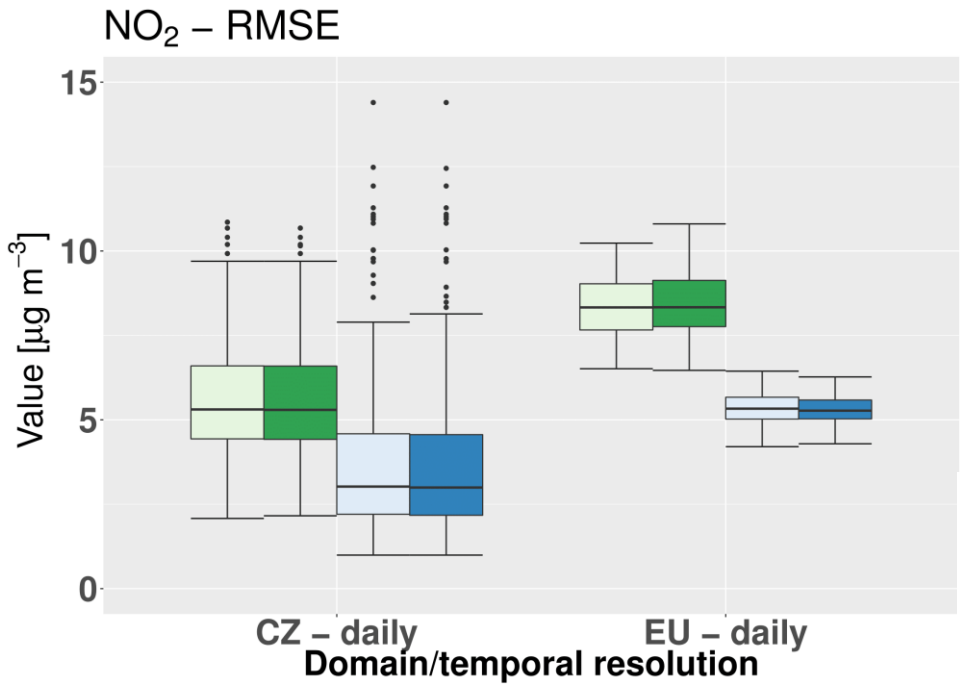
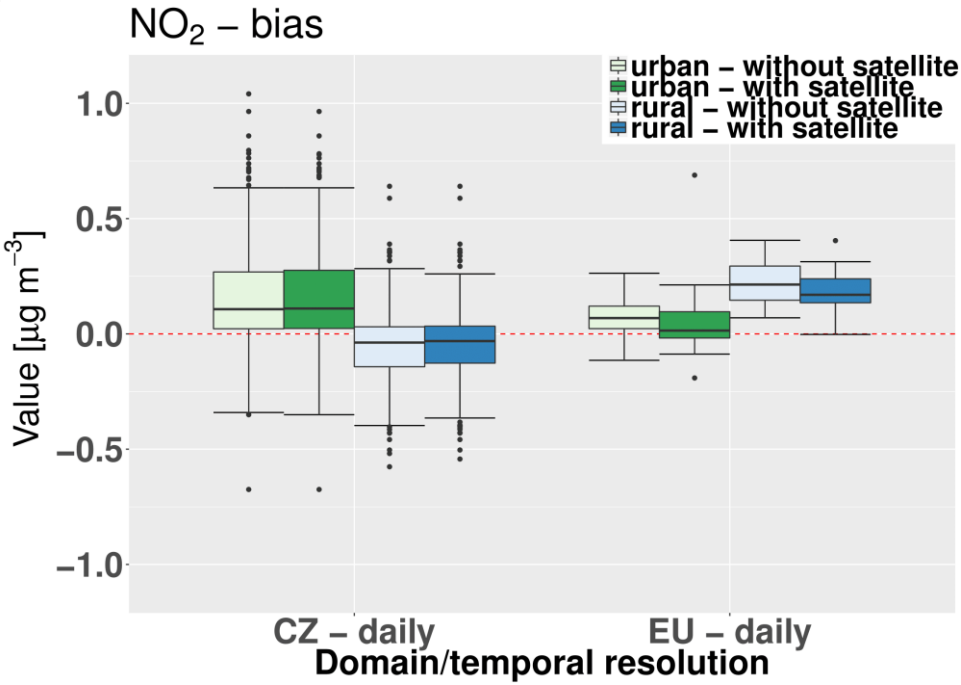
Current results

- Czech domain
  - Daily NO_2 (year 2014)
  - Daily SO_2 (year 2014)
  - Daily/hourly PM_{10} (several days/hours in 09/2014)
  - Daily/hourly $PM_{2.5}$ (several days/hours in 09/2014)
- European domain
  - Daily NO_2 (09/2014)
  - Annual NO_2 (2014)
  - Daily/hourly PM_{10} (several days/hours in 09/2014) – SEVIRI AOD
  - Daily/hourly $PM_{2.5}$ (several days/hours in 09/2014) – SEVIRI AOD
  - Daily PM_{10} – MODIS AOD (09/2014)

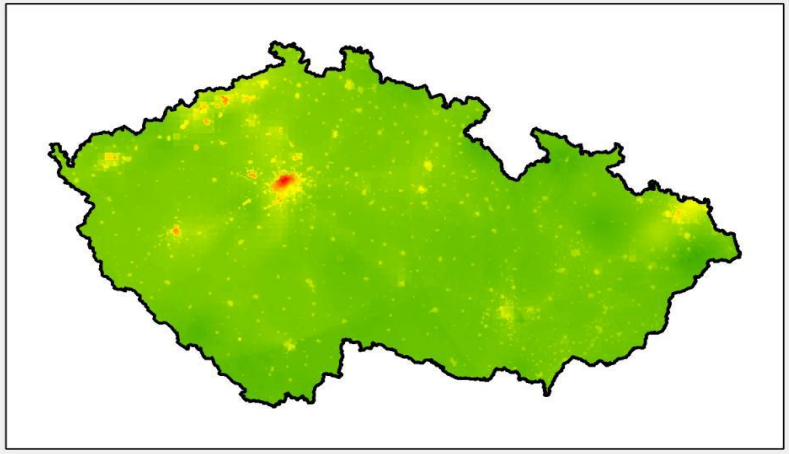
Results: NO_2 daily – RMSE and bias



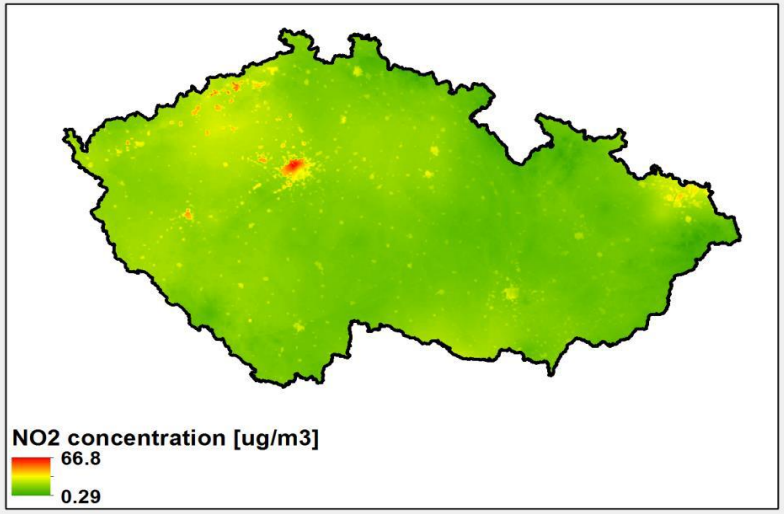


Resulting maps – CZ NO_2 daily

Daily NO2 map 25. 2. 2014 - without satellite data



Daily NO2 map 25. 2. 2014 - with satellite data



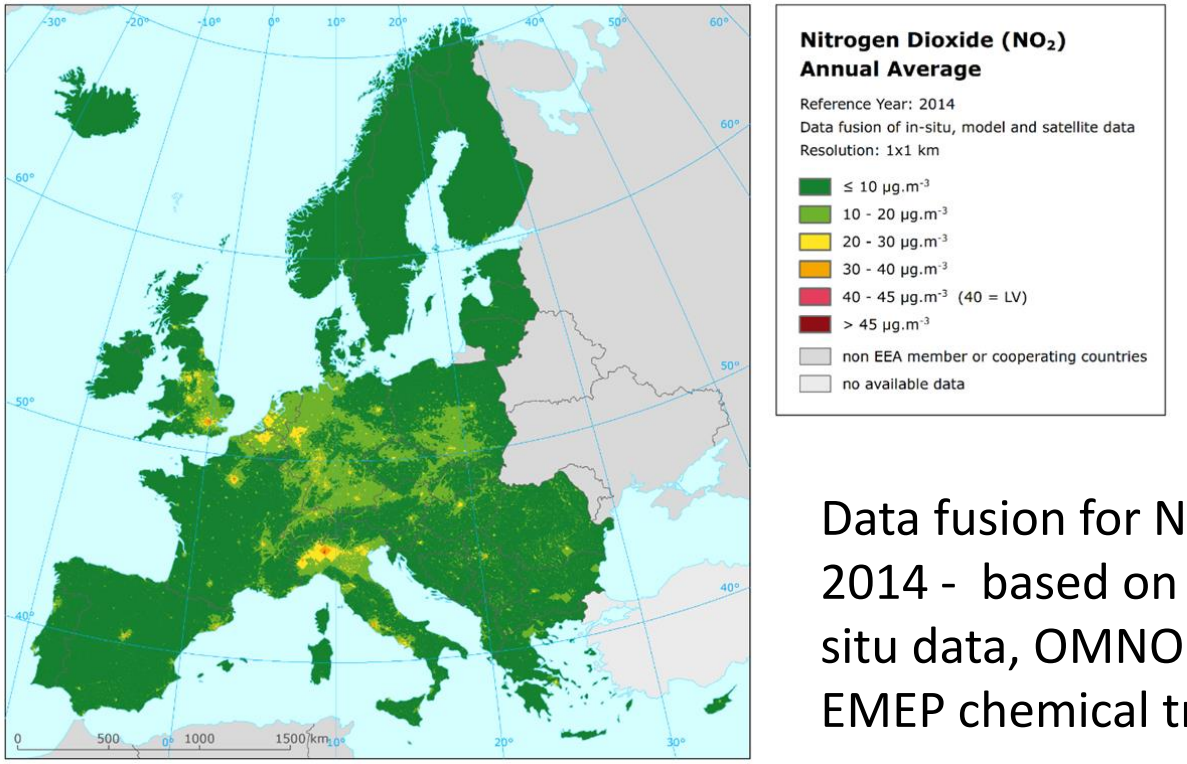
Results: NO_2 annual – RMSE and bias

spatial interpolation variant		rural areas				
		RMSE	nRMSE	bias	R^2	lin. regr. equation
(i)	No ln transf., Mat., without satellite	3.89	0.428	0.12	0.555	y = 0.569x + 4.04
(ii)	No ln transf., Mat., with satellite	3.80	0.418	0.10	0.576	y = 0.564x + 4.05
(iii)	No ln transf., Sph., without satellite	3.89	0.428	0.12	0.555	y = 0.569x + 4.04
(iv)	No ln transf., Sph., with satellite	3.80	0.418	0.10	0.576	y = 0.564x + 4.05
(a)	No ln transf., Sph., additional suppl. data, without satellite	3.31	0.365	0.06	0.678	y = 0.696x + 2.82
(b)	No ln transf., Sph., additional suppl. data, with satellite	3.23	0.356	0.03	0.692	y = 0.690x + 2.84

spatial interpolation variant		urban background areas				
		RMSE	nRMSE	bias	R^2	lin. regr. equation
(i)	No ln transf., Mat., without satellite	5.67	0.281	0.08	0.445	y = 0.456x + 11.07
(ii)	No ln transf., Mat., with satellite	5.55	0.275	0.10	0.468	y = 0.467x + 10.86
(iii)	No ln transf., Sph., without satellite	5.73	0.284	0.09	0.433	y = 0.459x + 11.02
(iv)	No ln transf., Sph., with satellite	5.62	0.278	0.12	0.455	y = 0.466x + 10.90
(a)	No ln transf., Sph., additional suppl. data, without satellite	4.77	0.236	0.01	0.608	y = 0.640x + 7.27
(b)	No ln transf., Sph., additional suppl. data, with satellite	4.58	0.227	-0.01	0.637	y = 0.652x + 7.01

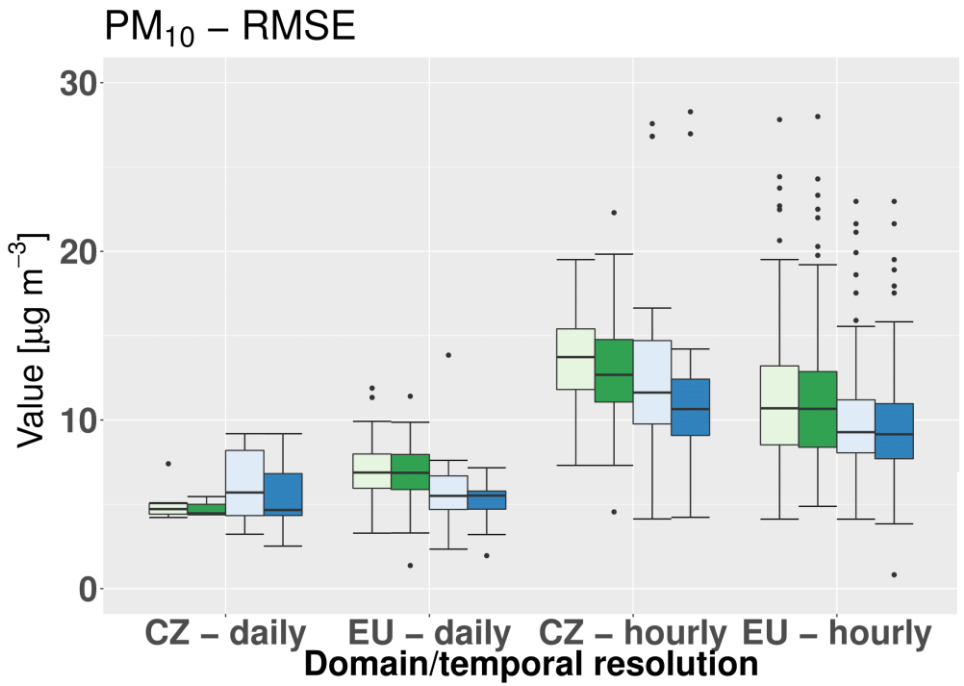
Data fusion for NO_2 annual average 2014 – comparison of different variants

Resulting maps EU NO_2 – annual

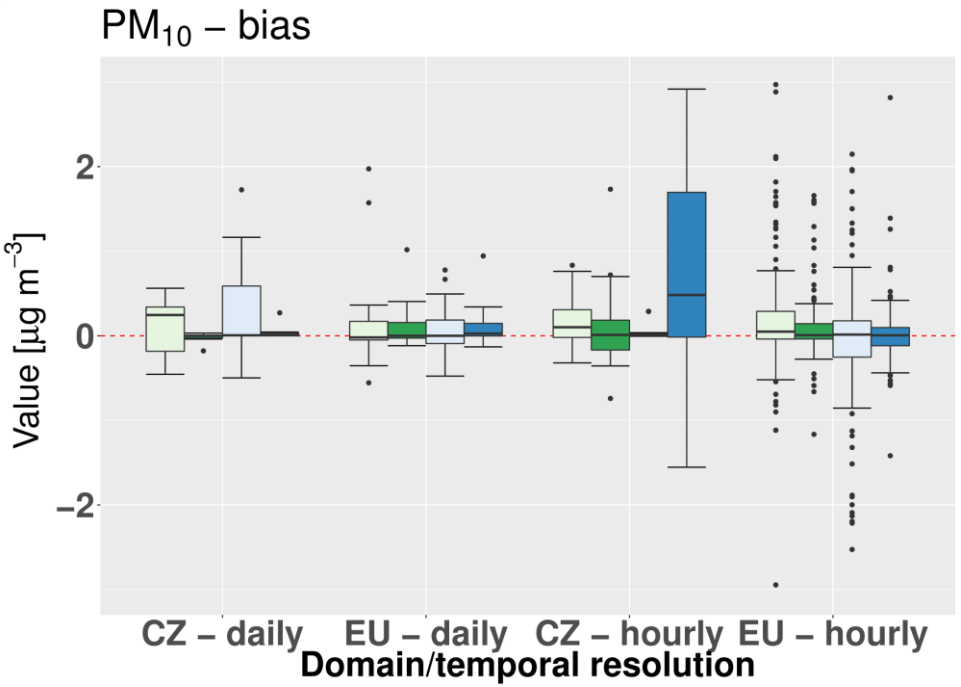


Data fusion for NO_2 annual average 2014 - based on AQ e-reporting in-situ data, OMNO satellite data and EMEP chemical transport model

Results: PM_{10} daily, hourly – RMSE, bias

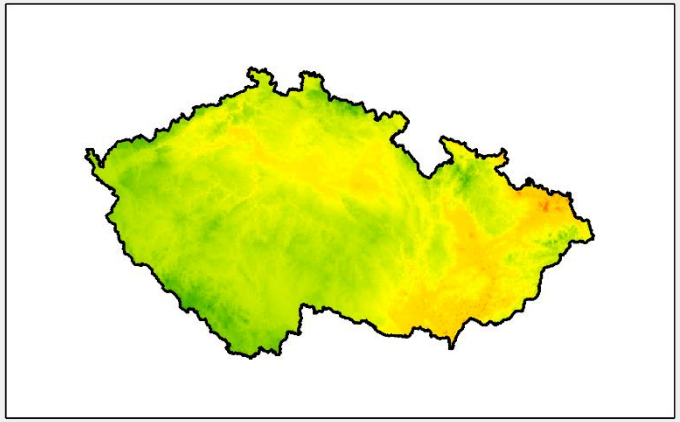


urban – without satellite
urban – with satellite
rural – without satellite
rural – with satellite

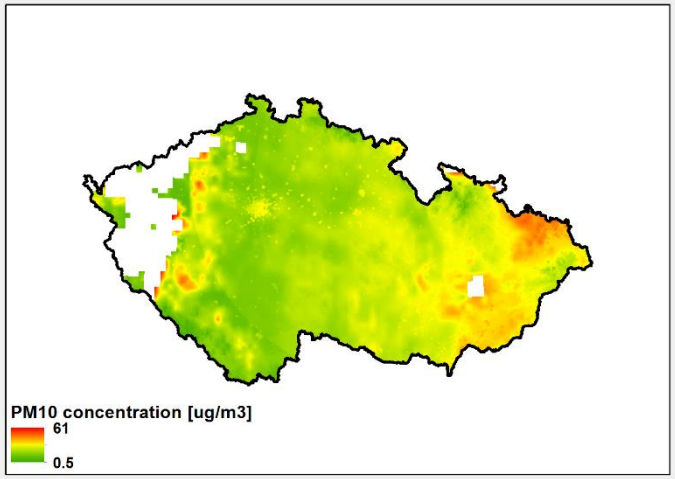


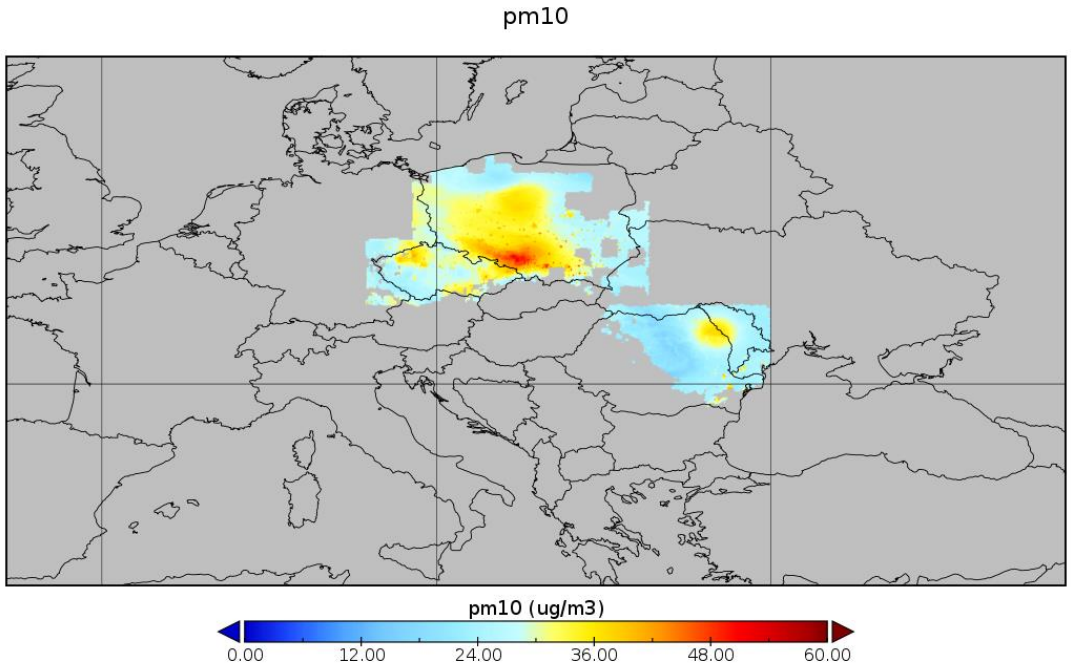
Resulting maps – EU and CZ PM_{10} daily

Daily PM10 map 17. 9. 2014 - without satellite data

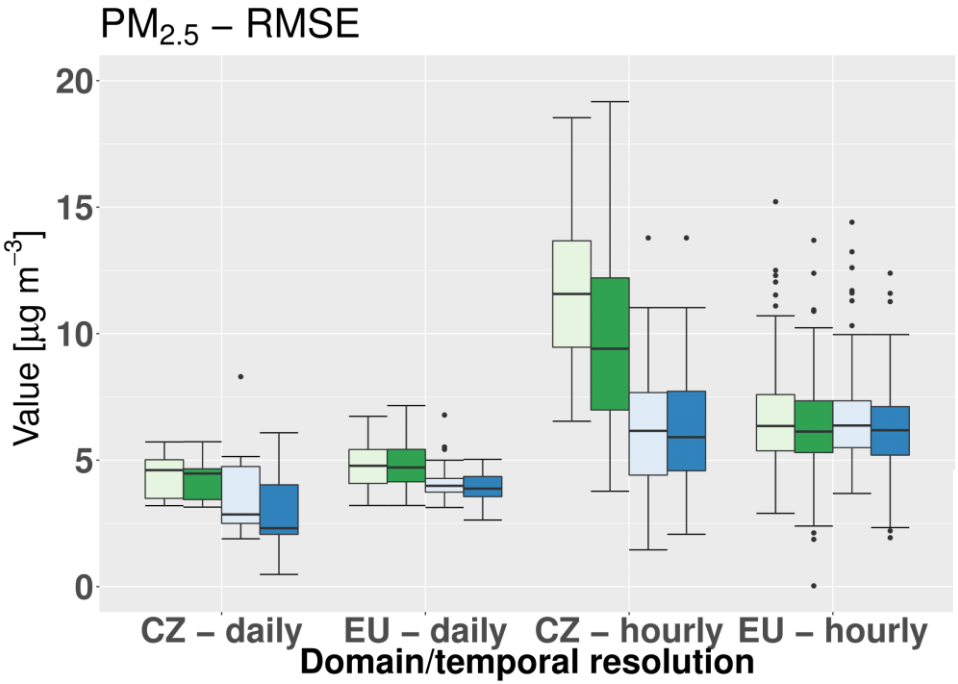


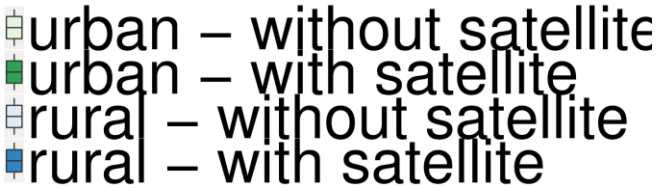
Daily PM10 map 17. 9. 2014 - with satellite data

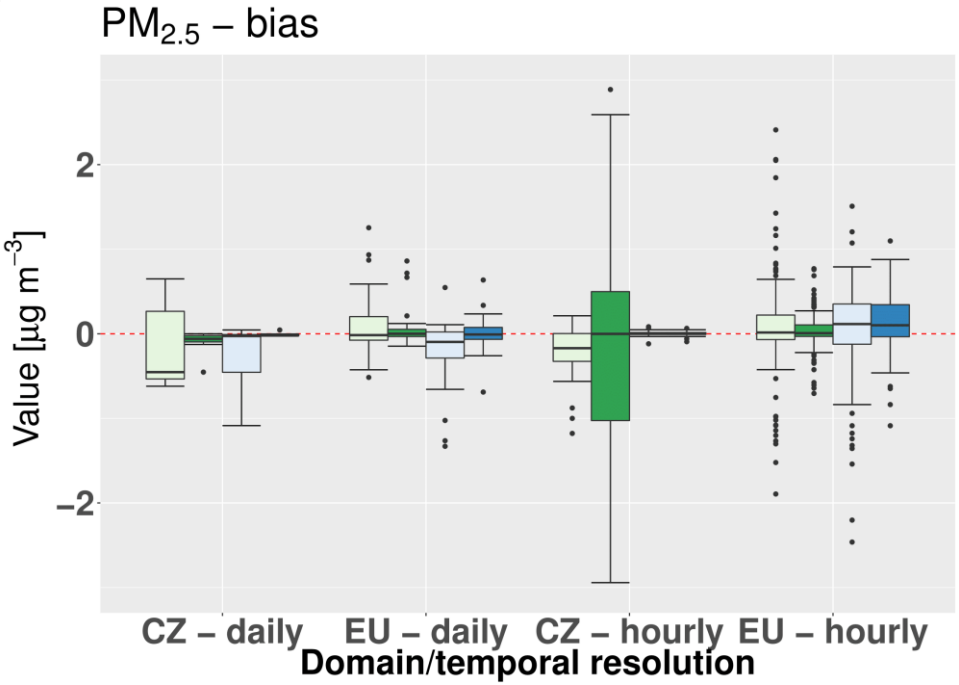




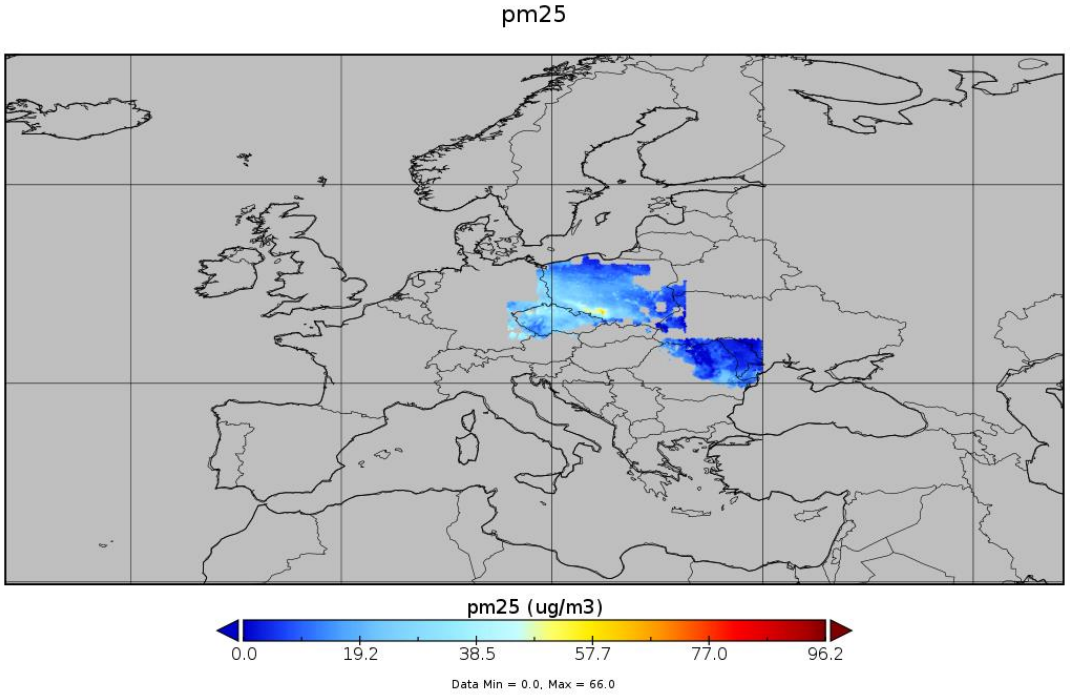
Results: $PM_{2.5}$ RMSE and bias





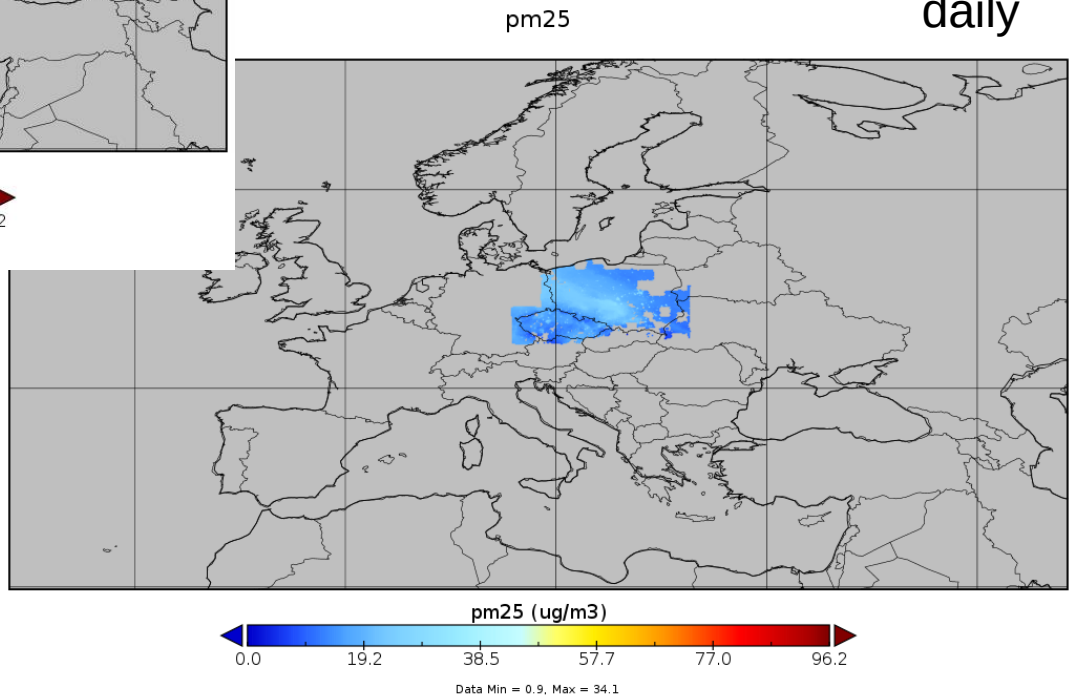


Resulting maps – EU $PM_{2.5}$ hourly, daily

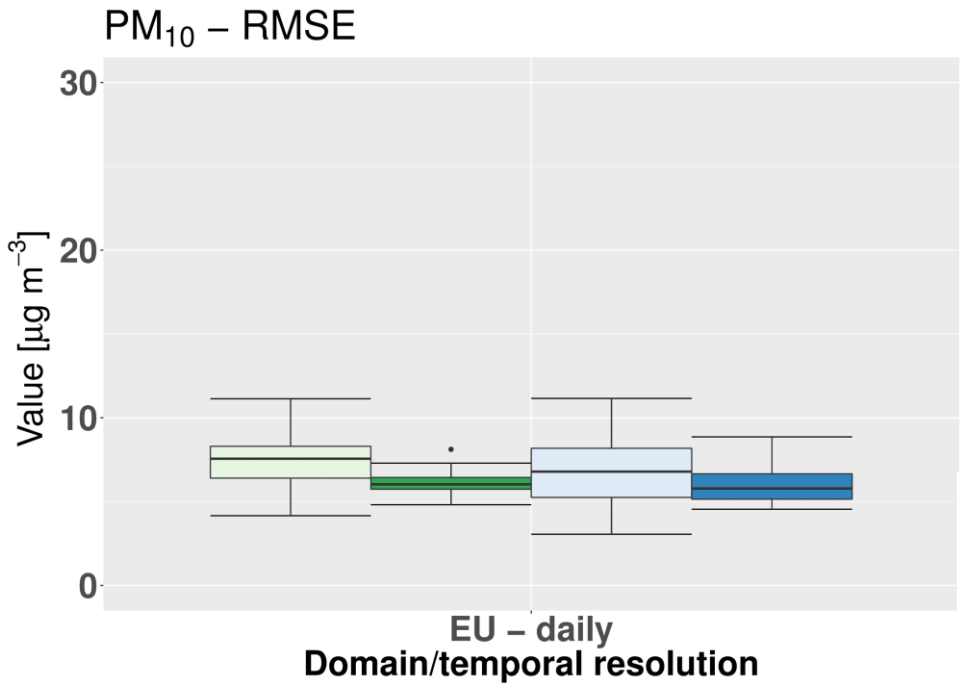


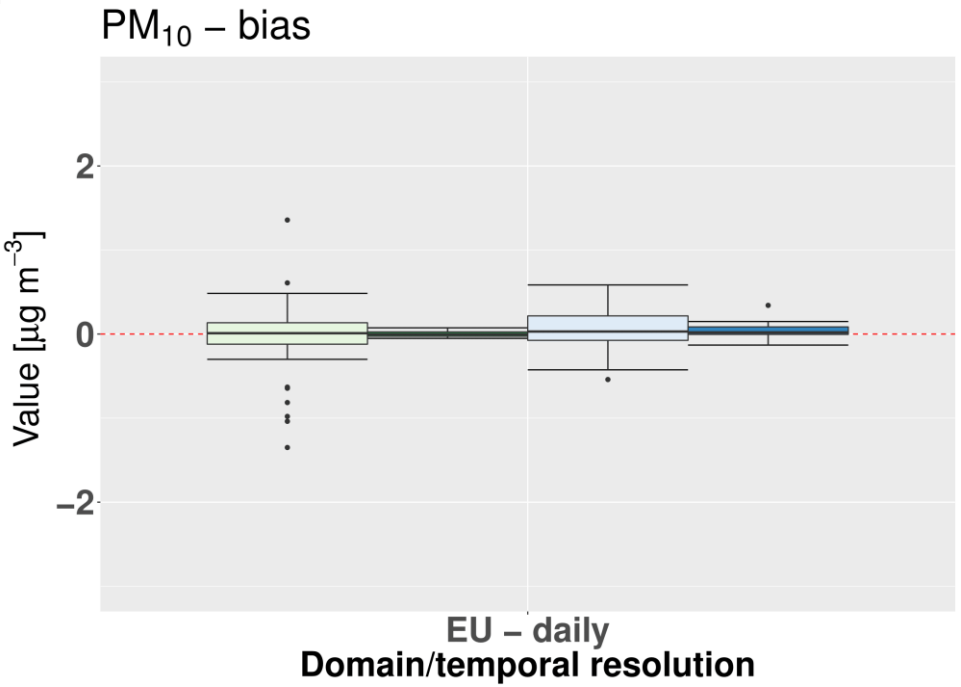
hourly

daily

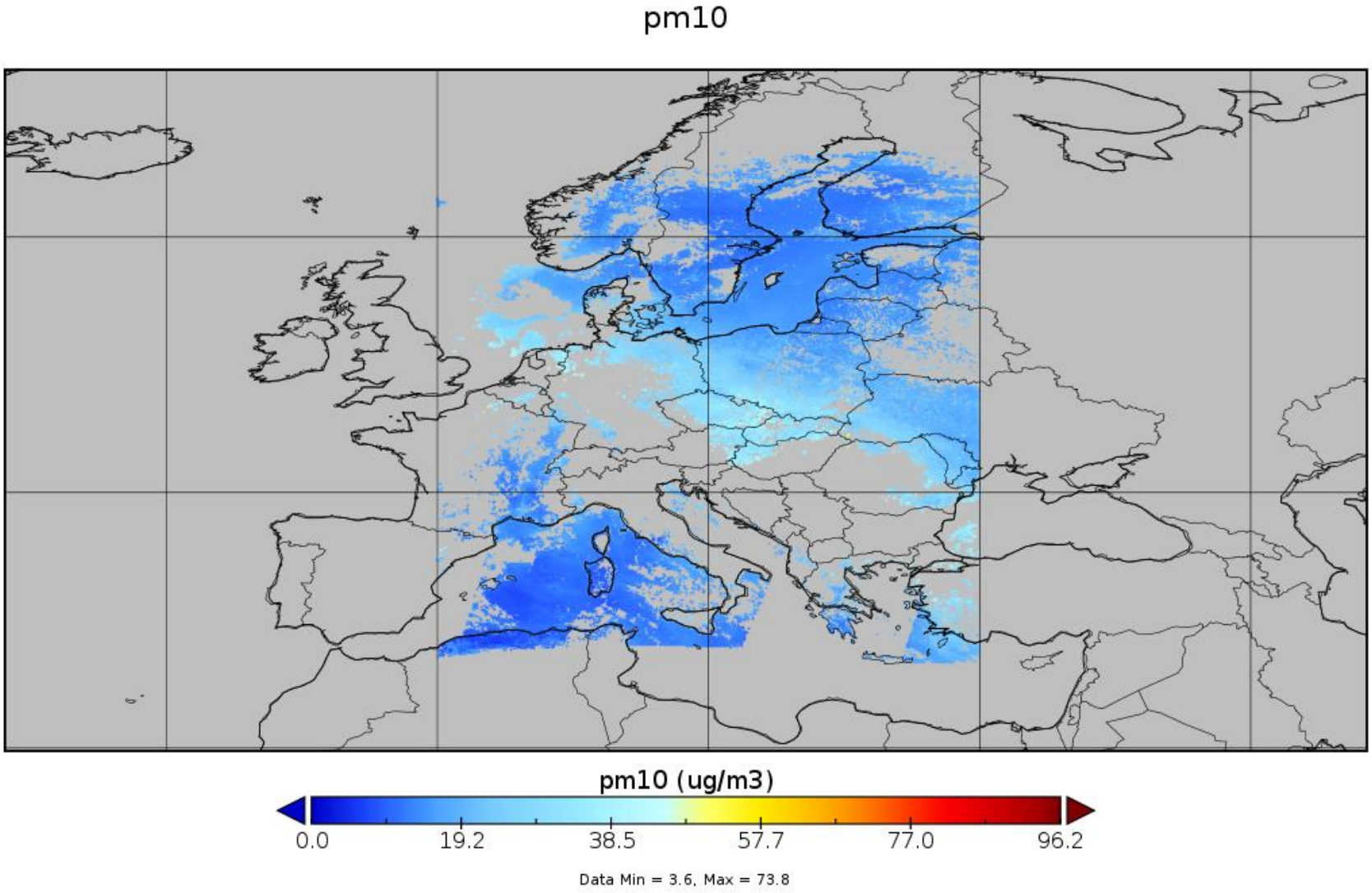


Results: EU PM_{10} daily with MODIS AOD data



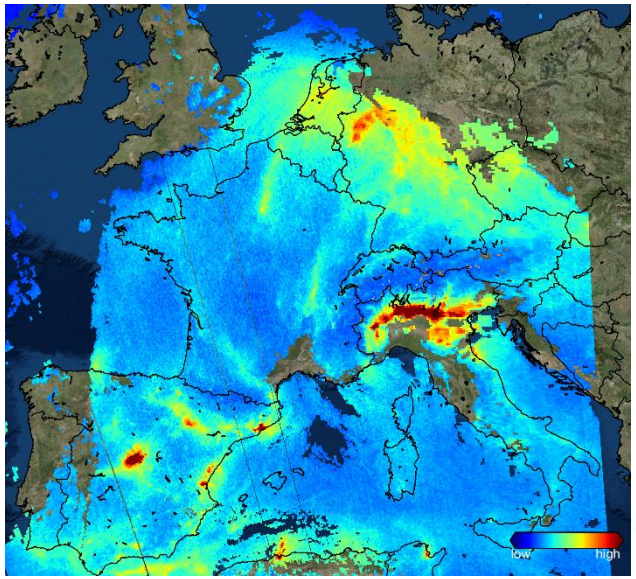


Resulting maps EU PM_{10} – daily with MODIS



Next steps in the project

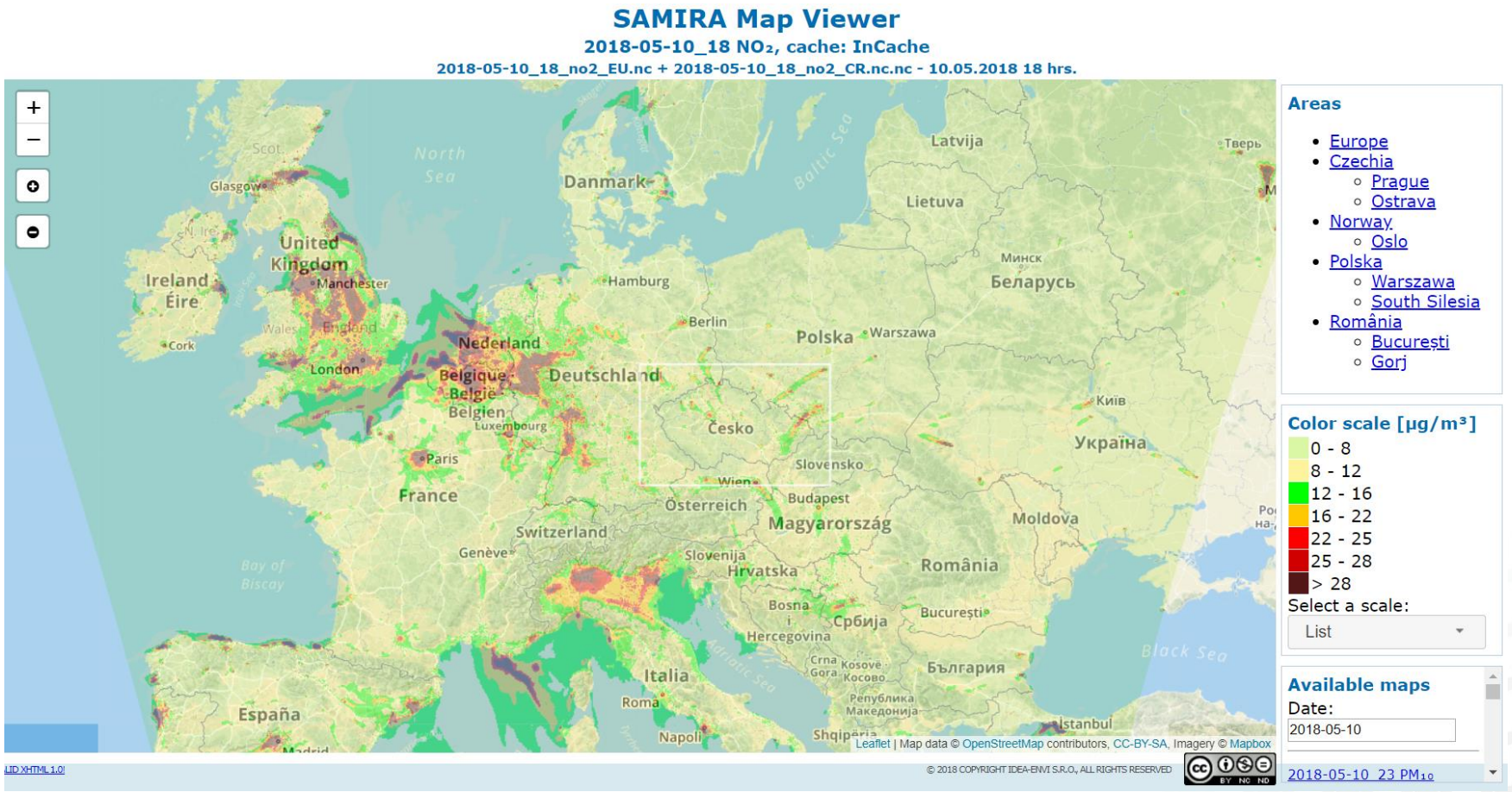
- Fill in the gaps in final maps
- Assess uncertainties
- Include NO_2 and SO_2 EO data from TROPOMI (Sentinel-5P)



(KNMI/ESA)

Next steps in the project

- Provide near real time air quality maps



Conclusion

- Inclusion of the satellite data improves the mapping results of NO_2 for rural areas, both for Czech and European domains, both for daily and annual data.
- For the annual data, this inclusion improves NO_2 mapping results for urban areas as well.
- Inclusion of the satellite AOD data (available in limited days only) improves the PM_{10} mapping results (both for Czech and European domains), both in rural and urban background areas.
- More info about the project: **https://samira.nilu.no**