OPERATIONAL AIR QUALITY FORECAST FOR CENTRAL EUROPE

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HARMO22

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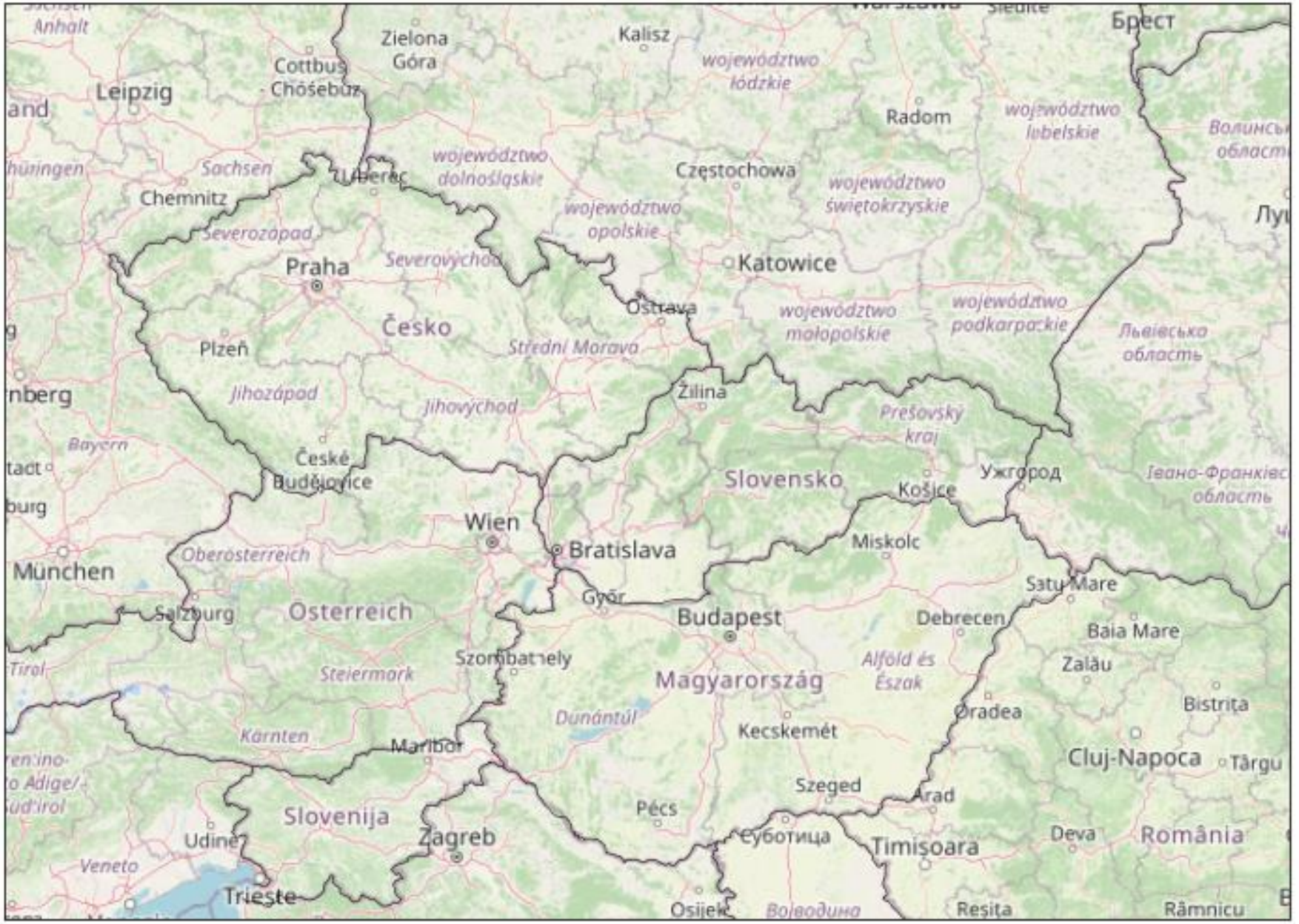
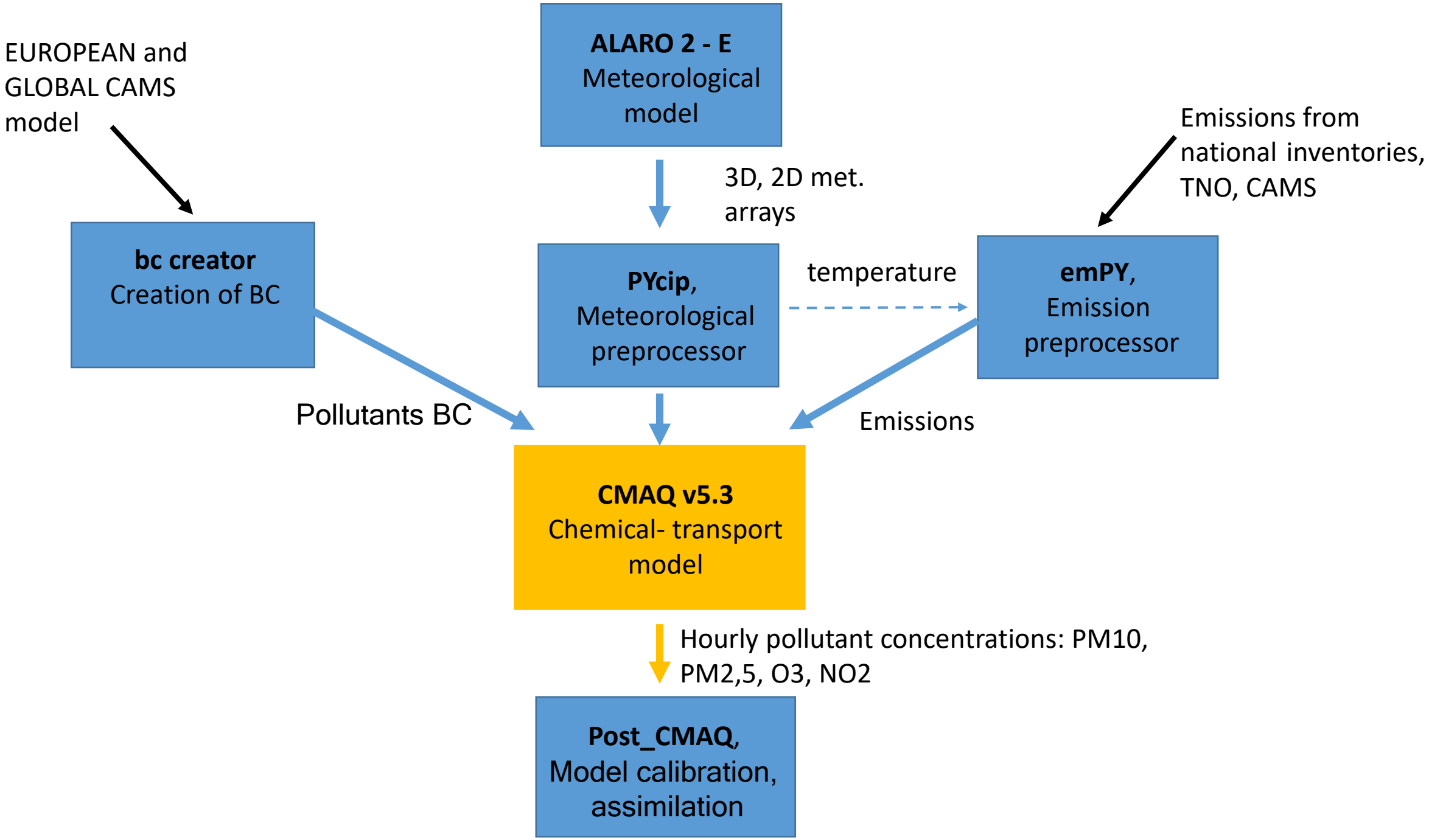
Introduction

- In September 2023, the operational air quality forecast was launched at Slovak Hydrometeorological Institute
- The core of the air quality forecast is the chemical-transport model CMAQv5.3.3 (EPA, USA), which uses meteorological forecasts from the ALADIN NWP model (ALARO 2-e).
- Operational air quality forecast is running in two terms: 00 and 12 UTC for +48 hours.
- The boundary conditions are taken from the CAMS GLOBAL and CAMS EUROPE air quality forecasts.
- Horizontal resolution of the model is 2 × 2 km.
- For Slovakia bottom-up fine resolution emission, outside CAMS, TNO emissions are used
- Map products can be viewed at the address available on the SHMÚ intranet, but it is planned to place the forecasts the public web site in this year (CAMS NCP - Slovakia).
- It can be an important source for informing about possible coming smog and predicting their duration.
- Automatic validation is made for PM, NO_2, and O_3

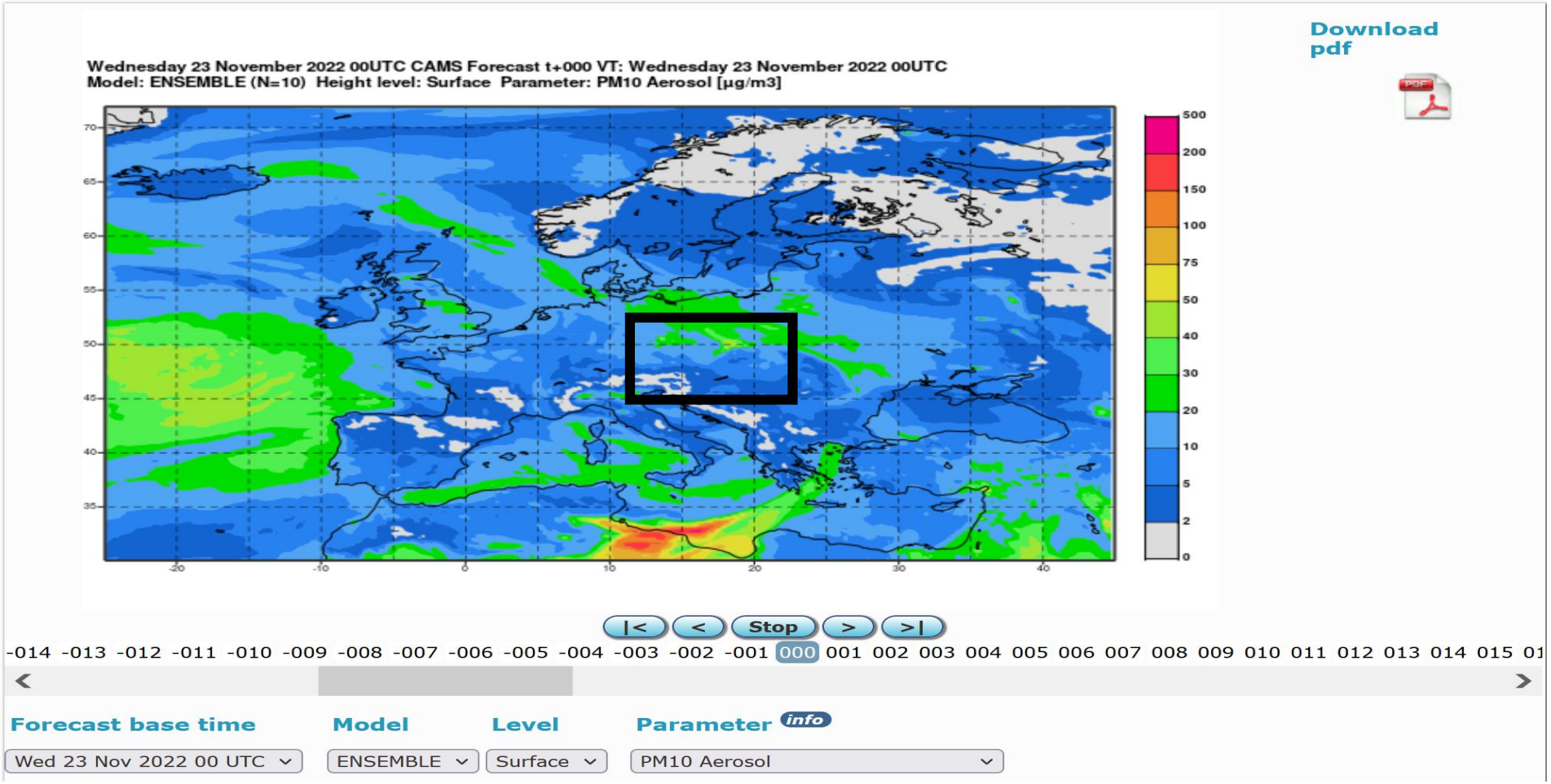
Model domain



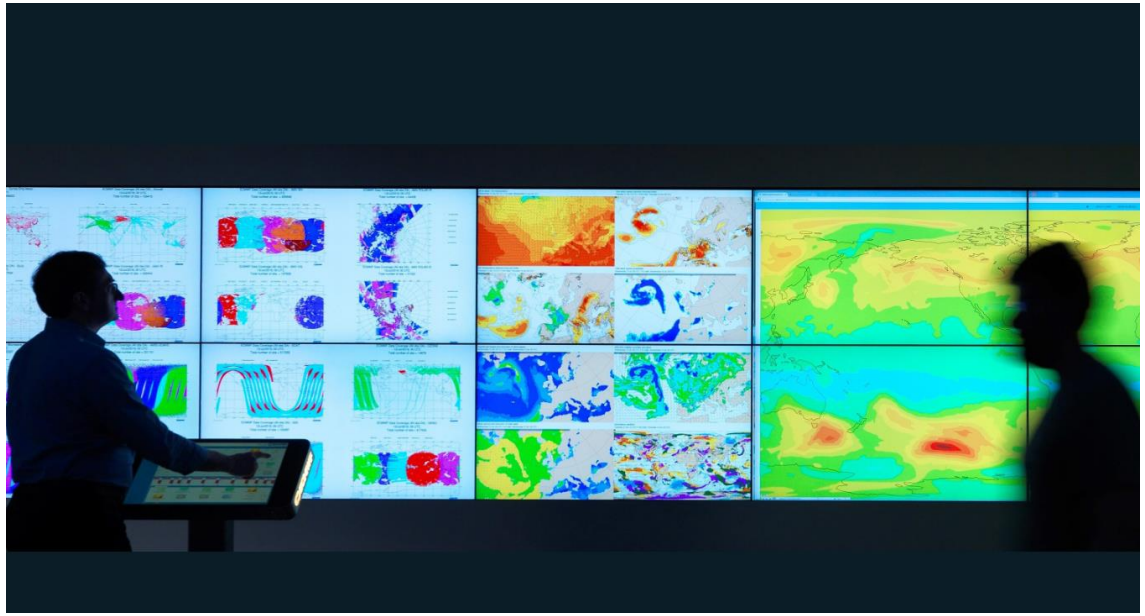

EUROPEAN and GLOBAL CAMS model
ALARO 2 - E Meteorological model
Emissions from national inventories, TNO, CAMS
3D, 2D met. arrays
bc creator Creation of BC
PYcip, Meteorological preprocessor
temperature
emPY, Emission preprocessor
Pollutants BC
Emissions
CMAQ v5.3 Chemical- transport model
Hourly pollutant concentrations: PM10, PM2,5, O3, NO2
Post_CMAQ, Model calibration, assimilation

Boundary conditions from CAMS EUROPE

EUROPEAN AIR QUALITY - ENSEMBLE HOURLY FORECASTS AND ANALYSES

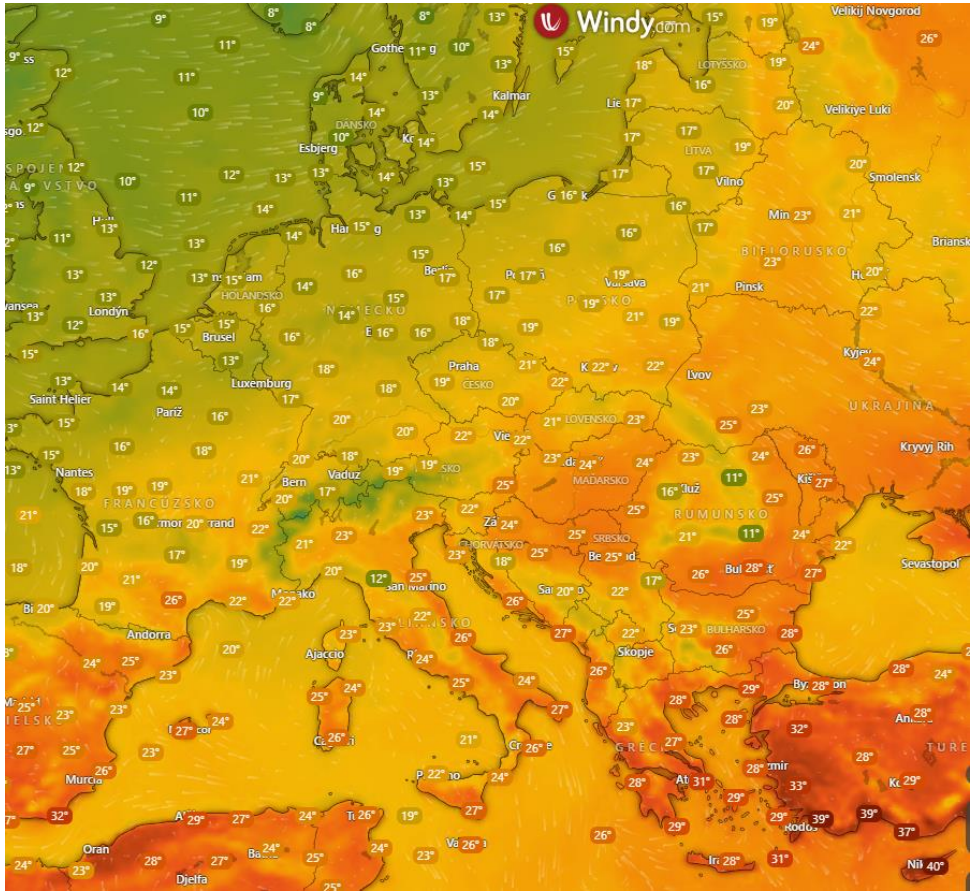


Numerical meteorologists get expertise also from graphical model comparison with measurements



Weather room at ECMWF

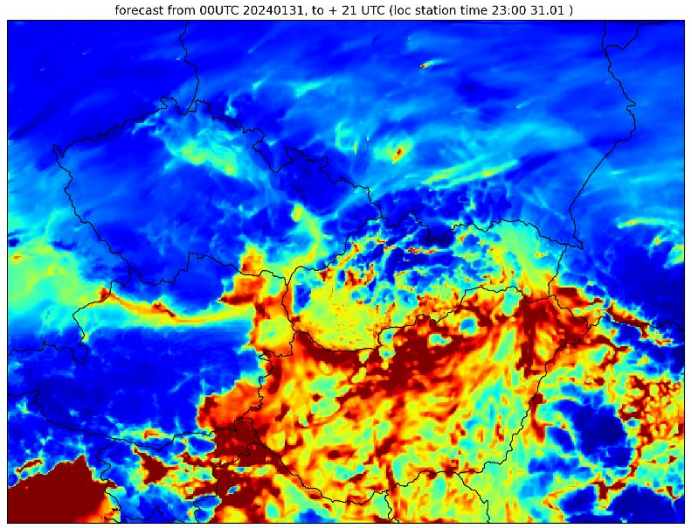
https://www.esa.int/ESA_Multimedia/Images/2020/01/Weather_room_at_ECMWF



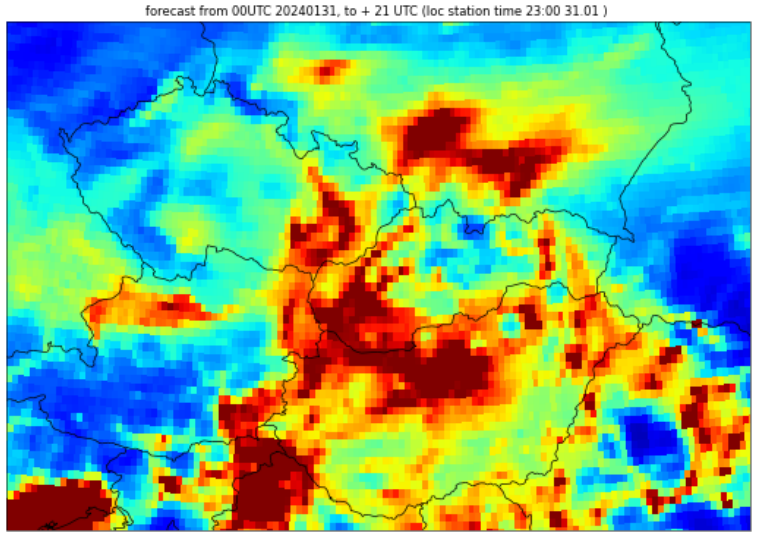
Temperature from ECMWF model and measured temperature

www.windy.com

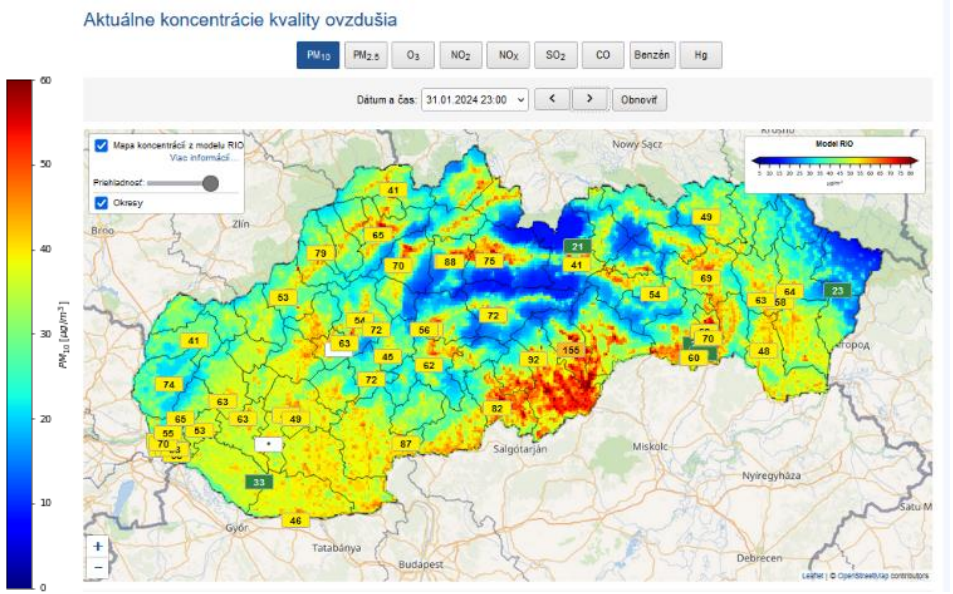
At SHMÚ we graphically compare CMAQ model with measurements and NRT maps from RIO model



CMAQ forecast for PM_{10}



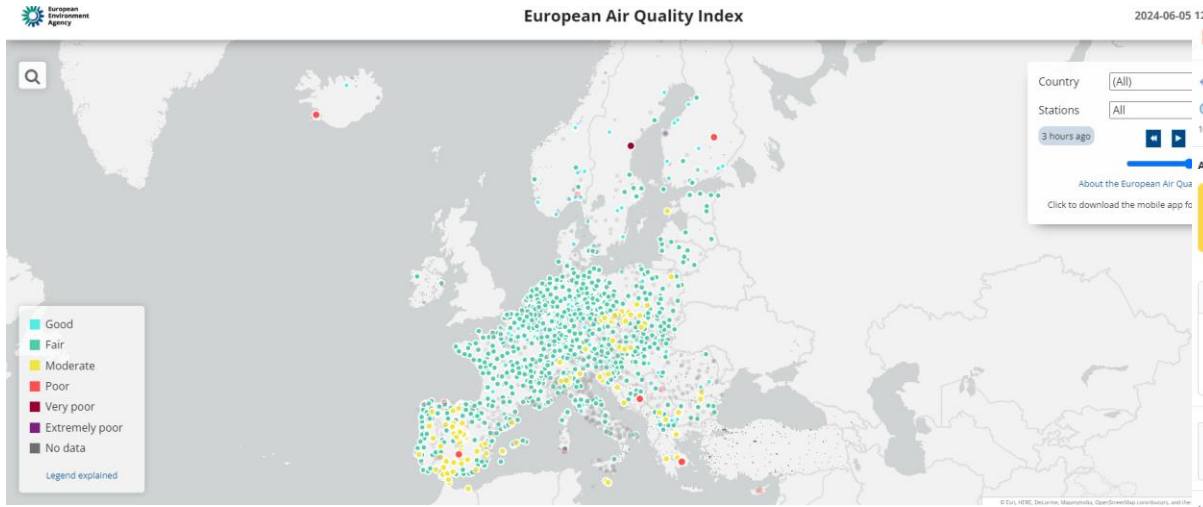
CAMS forecast for PM_{10}

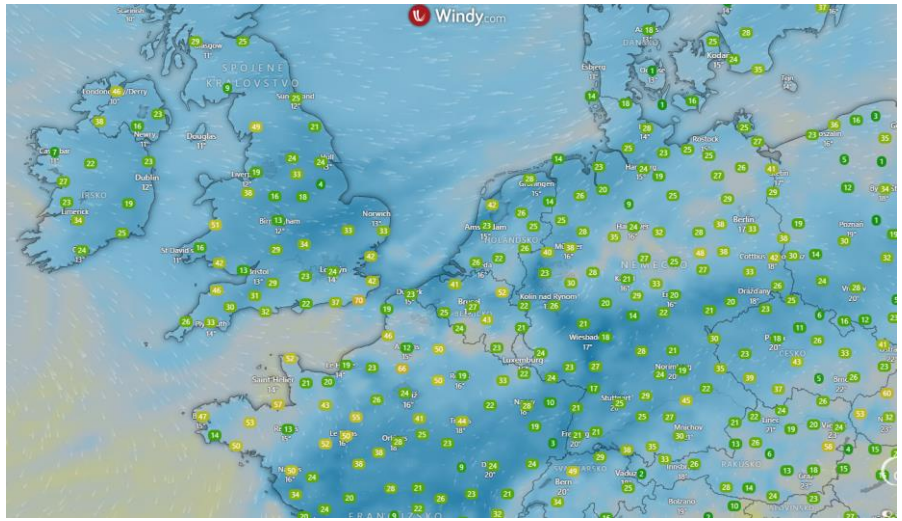


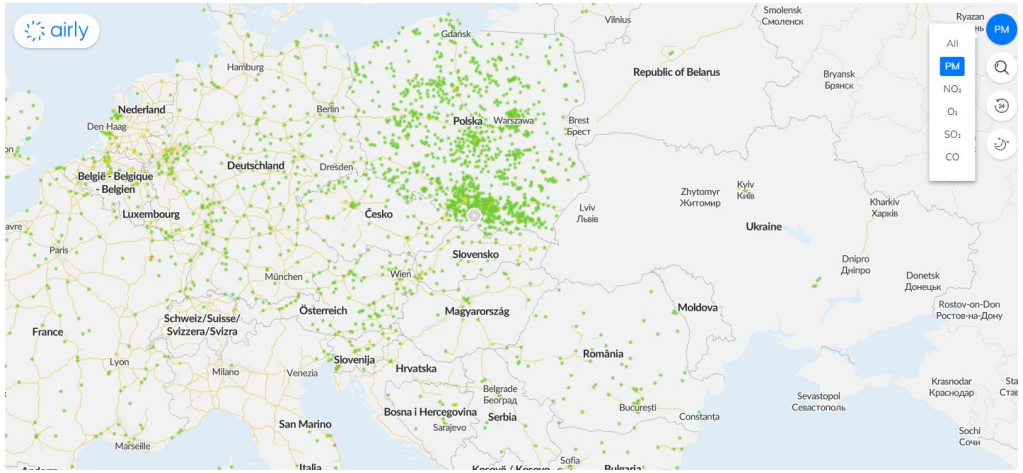
near-real time measured and interpolated concentrations by model RIO (developed by VITO) aviable at www.shmu.sk

Graphically comparison – step by step can sometimes gives us more insight to the model performance than the pure statistic validations

For the EUROPE just index maps exists not concentrations

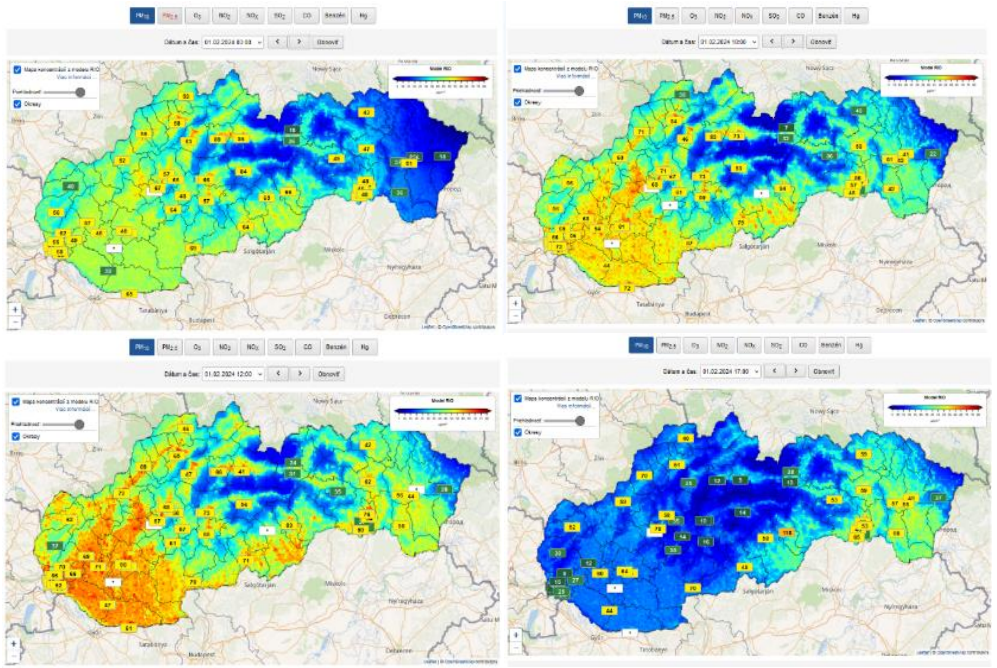


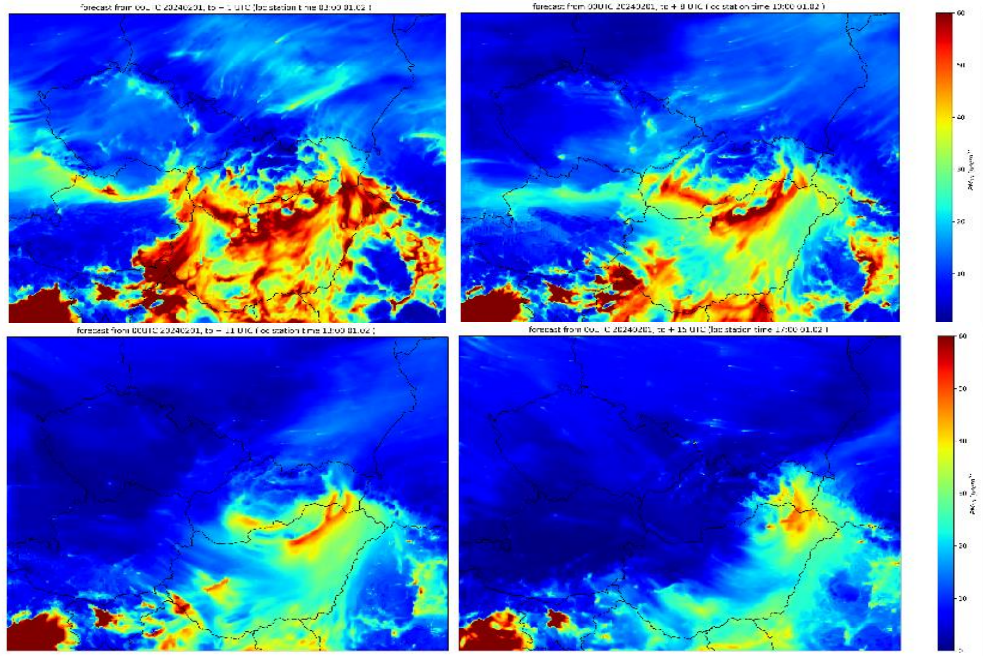


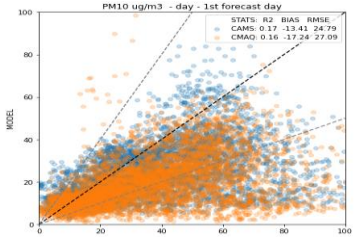


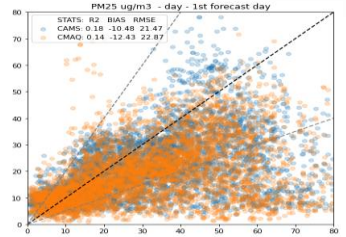
Index maps are not suitable for air-quality modelers, **it would be great to have European NRT air-quality concentrations map**

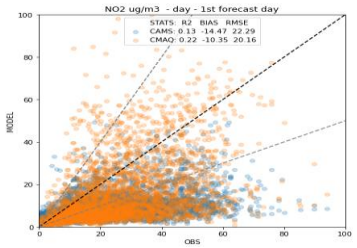
Winter adverse dispersion situation from 29/01/2024 to 02/02/2024 affected by the local heating

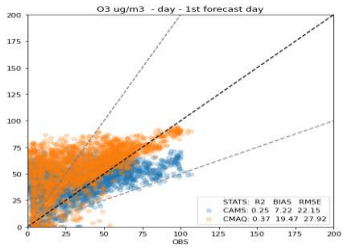




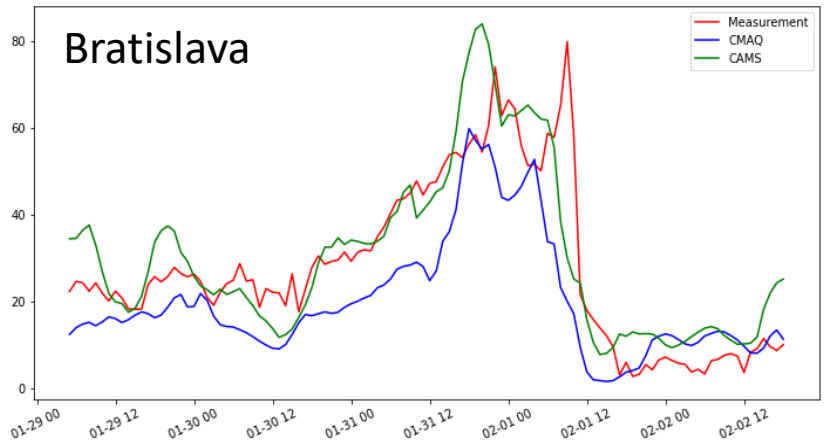




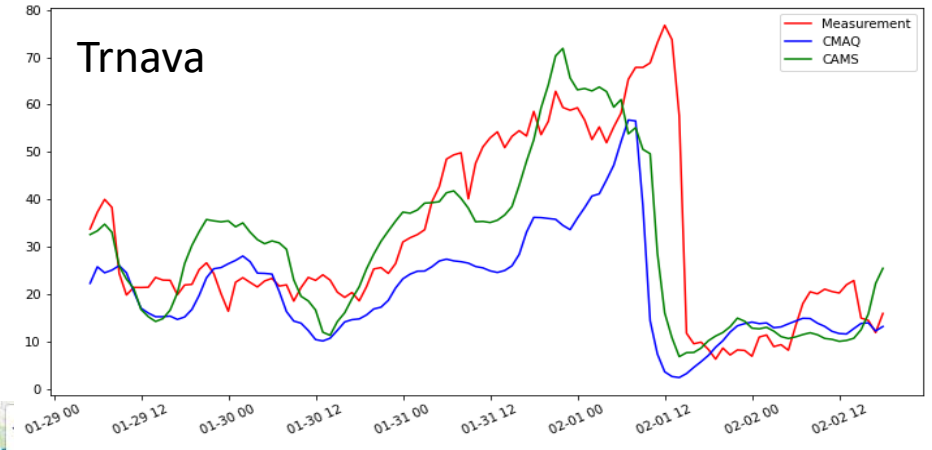


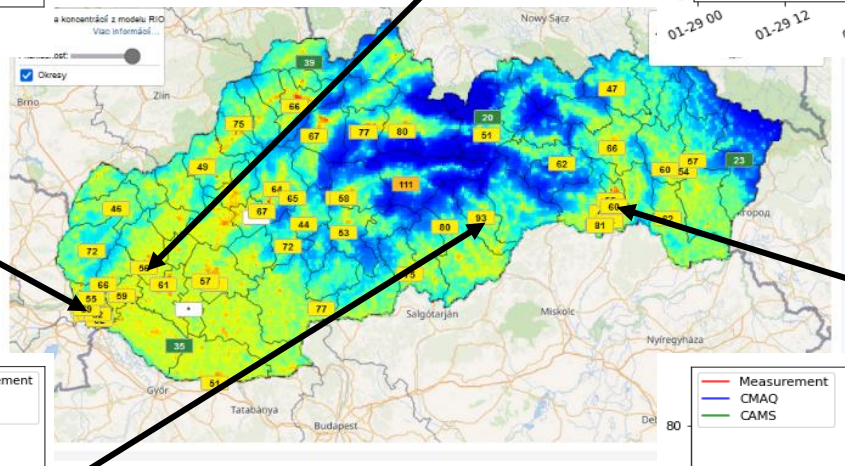


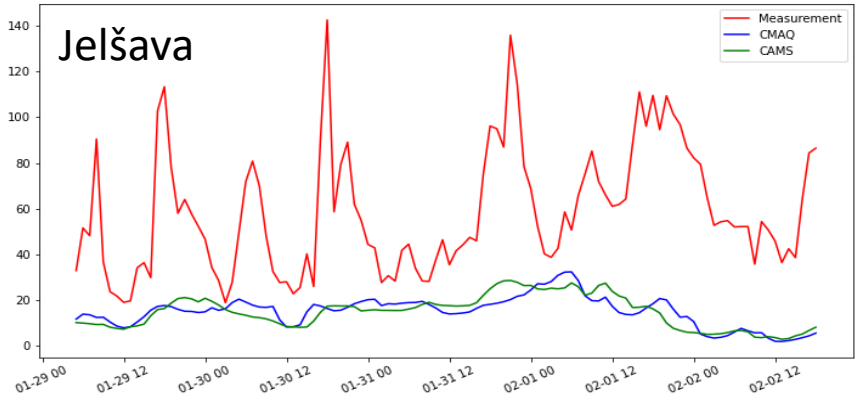
Winter adverse dispersion situation from 29/01/2024 to 02/02/2024 afected by the local heating

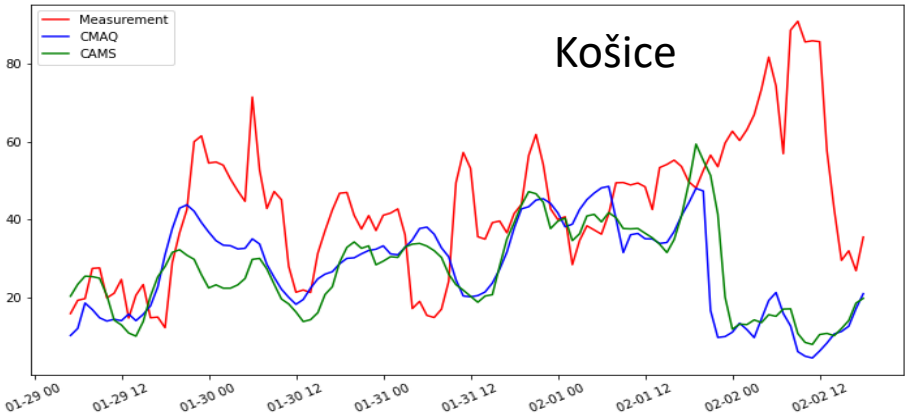


PM_{10}









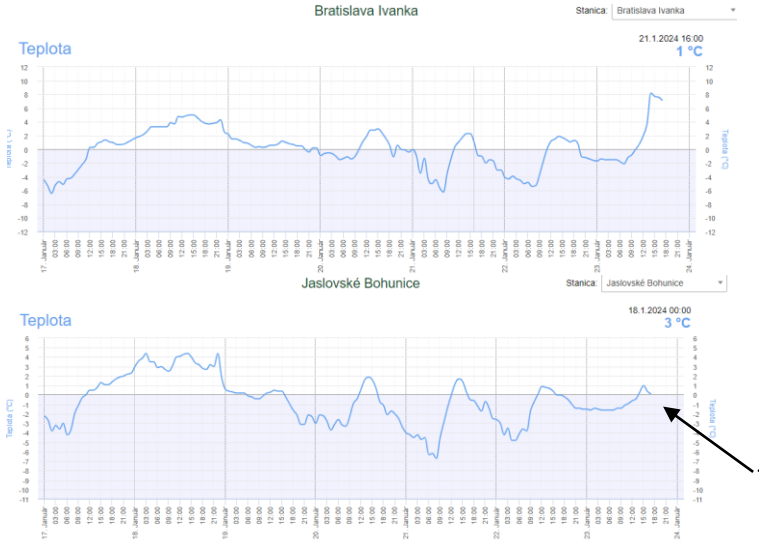
Winter adverse dispersion situation from 29/01/2024 to 02/02/2024 afected by the local heating

What we learned

-> the models do not capture the poor air quality in settlements located in narrow deep valleys which are polluted by local heating systems

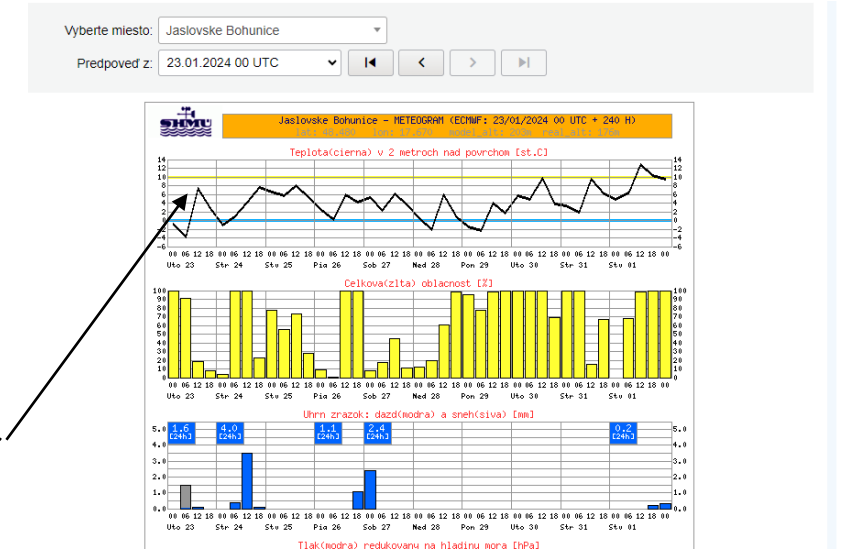
-> during the fronts in winter, the model tend to mix the ground layer significantly and quickly, although in reality, the older air mass likely remains in the ground layer for several hours longer than predicted

-> the similar problems has also NWP “meteorological” models



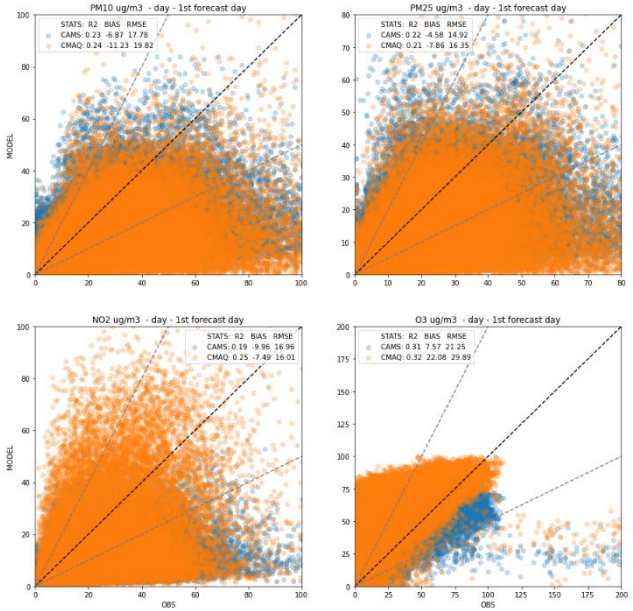
Measured temperature

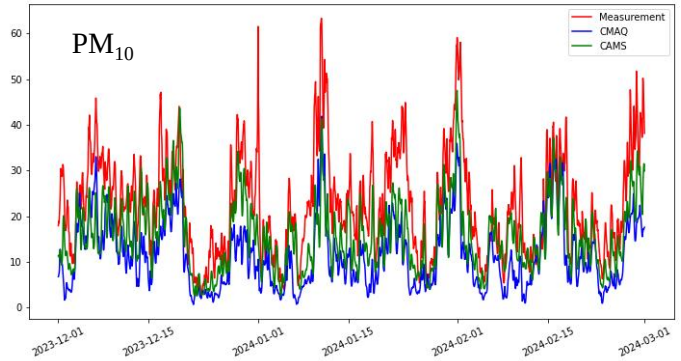
Large discrepancy between temperature



ECMWF forecast

2023/2024 winter statistics

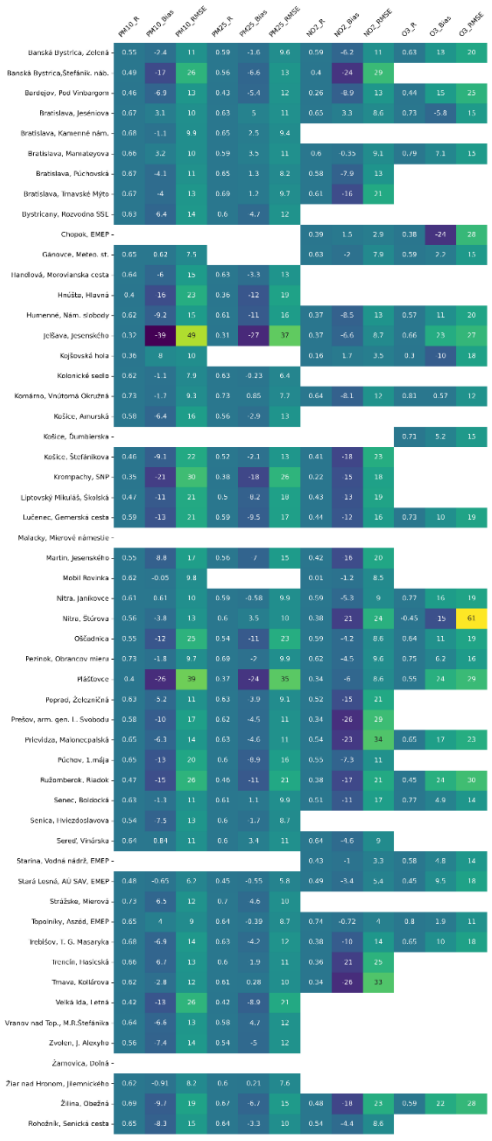




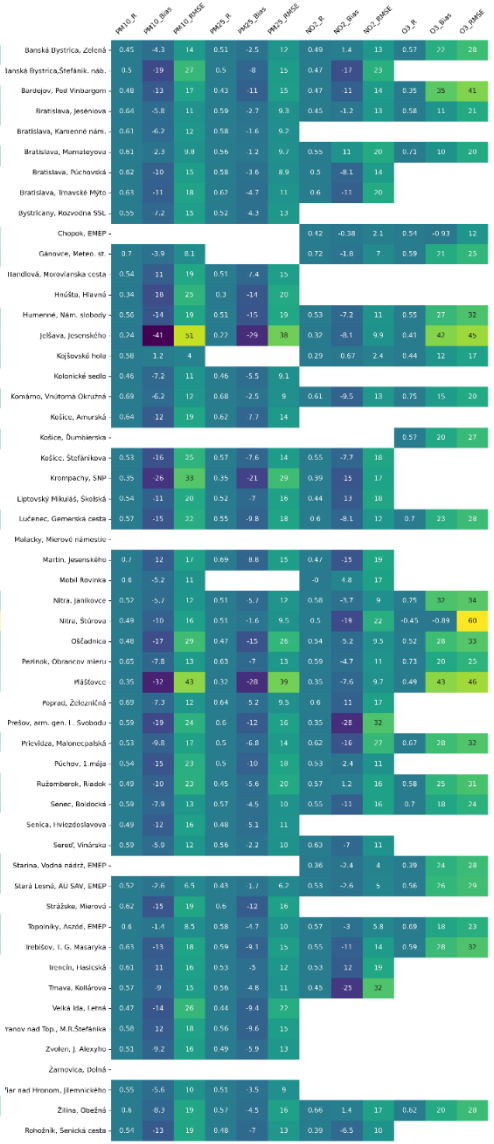
In case of PM, CMAQ model performs slightly worse than CAMS. This could be caused by the following factors: 1) CAMS model is assimilated using observations while CMAQ is not, 2) coupling CMAQ with CAMS as boundary conditions is insufficient, 3) operational CMAQ uses boundary conditions from -1d CAMS model forecast in order to enable the model running operationally at 2:30 UTC. 4) CAMS is an ensemble model, in which possible systematic errors of individual models can be cancelled out in the averaging process.

CMAQ model has better horizontal resolution, allowing it to predict smaller and local hotspots. This is the reason why CMAQ model outperforms CAMS model in NO_2 predictions (NO_2 concentrations decrease rapidly with the distance from the source, so the space resolution is crucial). In case of O_3, CMAQ model correlates with the observations quite well but it has rather large systematic BIAS. The origin of this BIAS will be subject to further study.

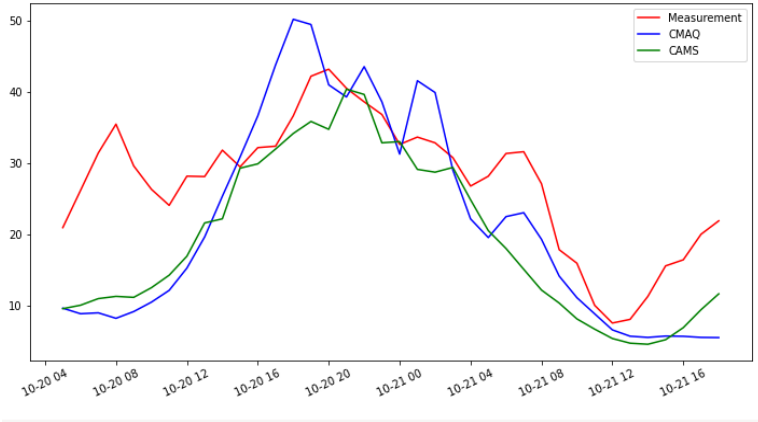
CAMS



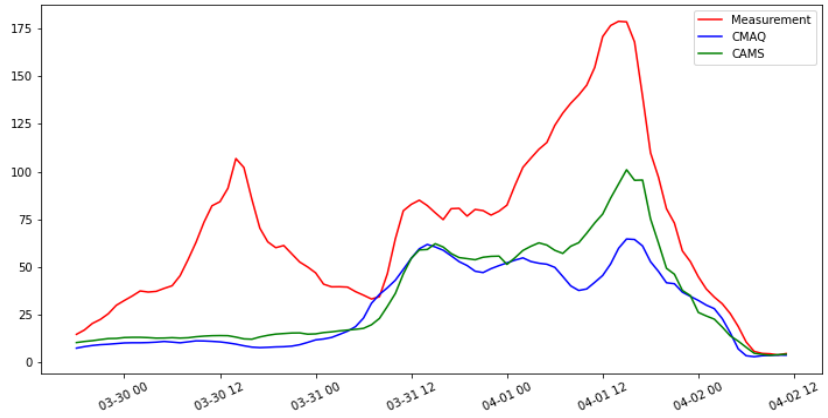
CMAQ



Saharan dust episodes

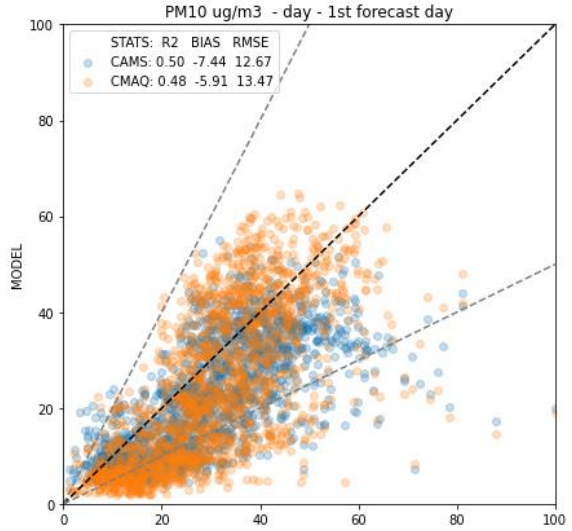


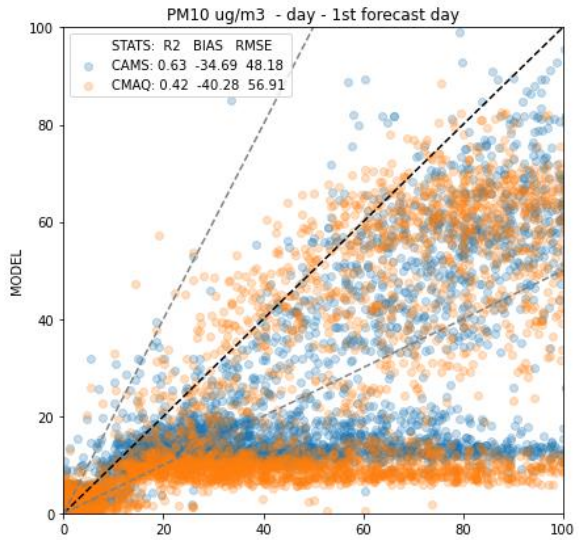
PM_{10}



Episode from 20. to 21. October 2023

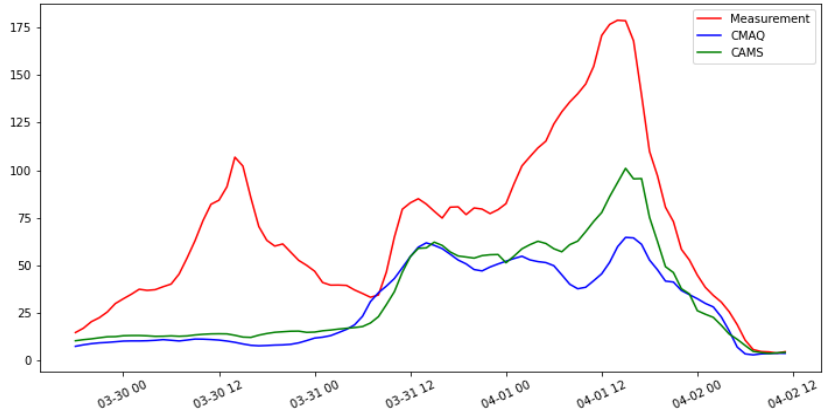
Episode from 30. March to 02. April 2024



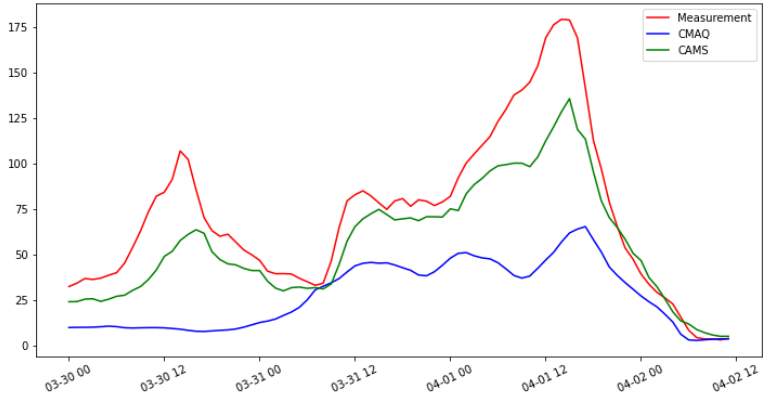


Saharan dust episodes using analysis products

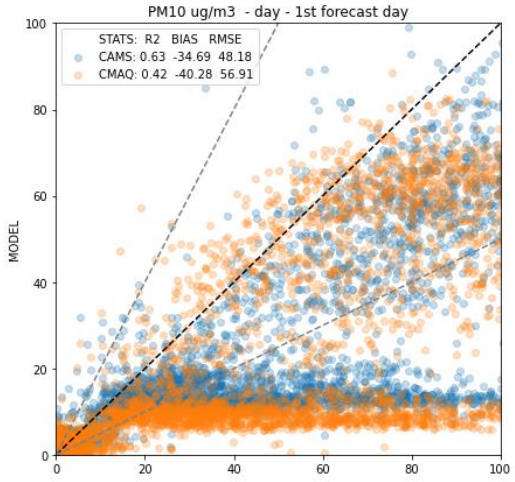
Episode from 30. March to 02. April 2024



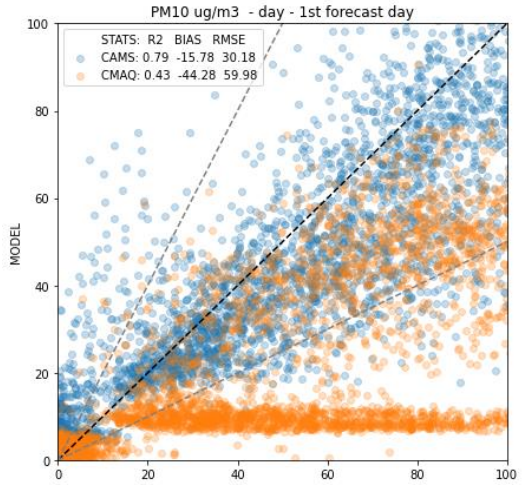
PM_{10}



CAMS forecast



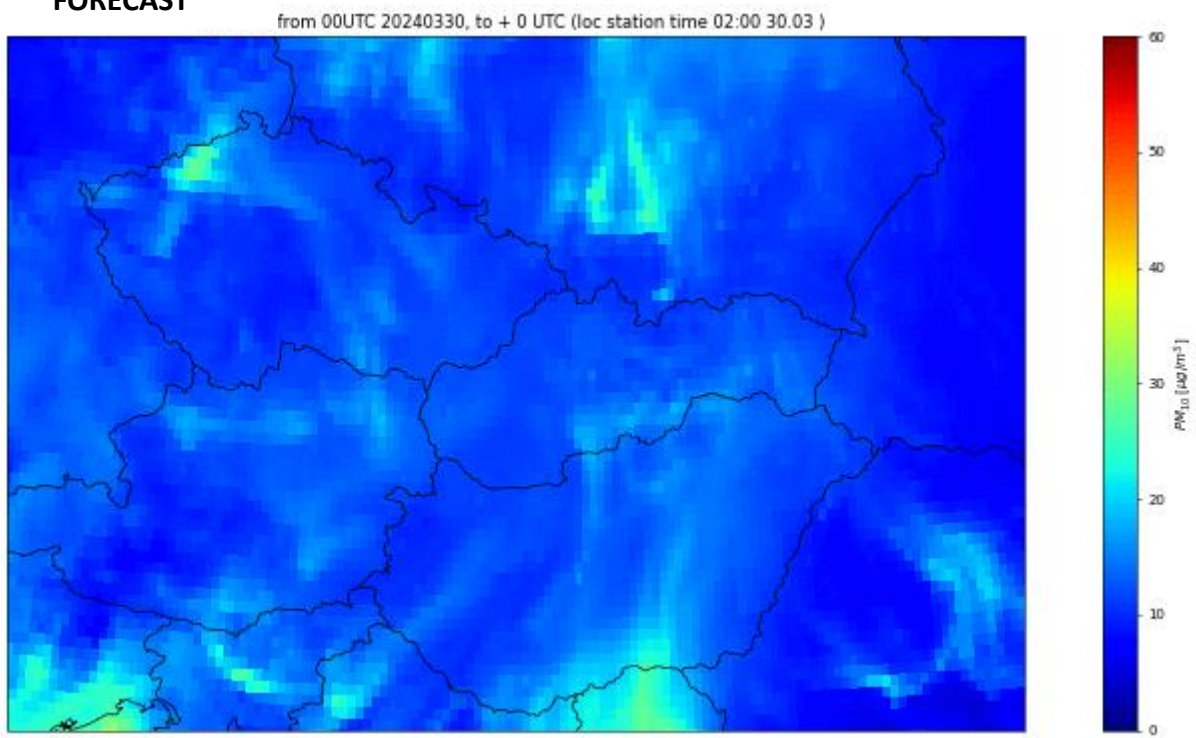
CAMS analysis



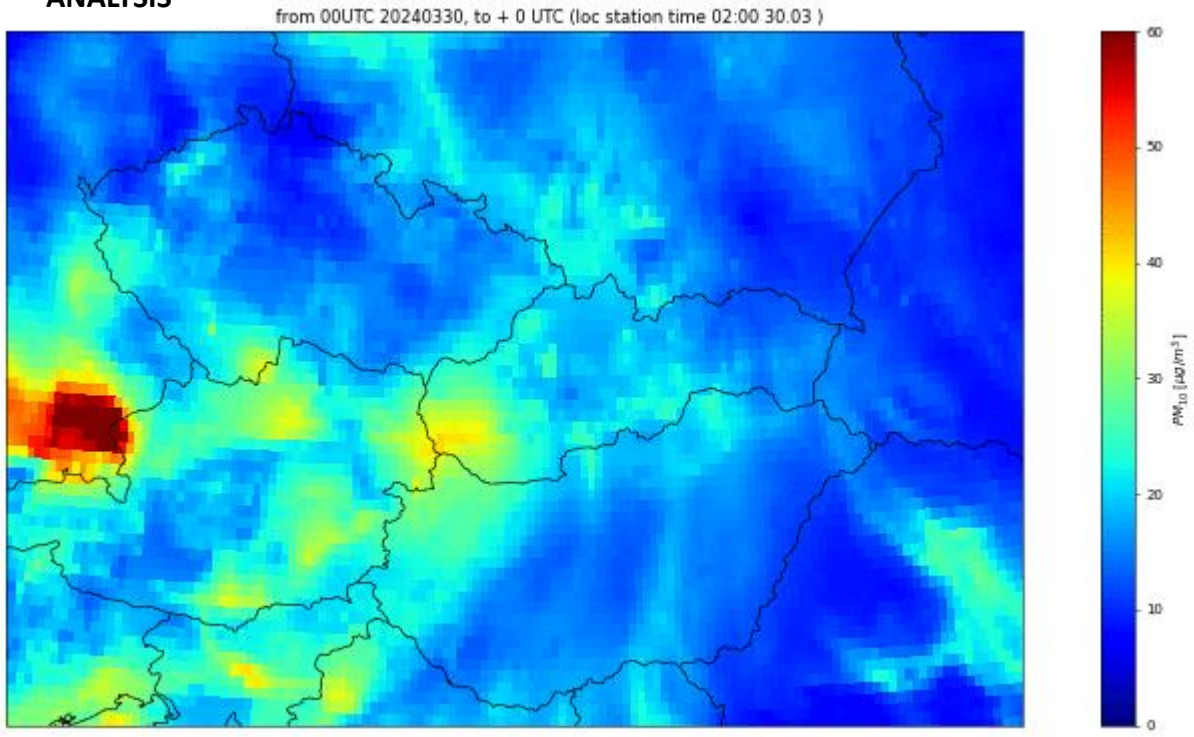
Saharan dust episodes using analysis products

30. March 2024

CAMS EUROPE
FORECAST

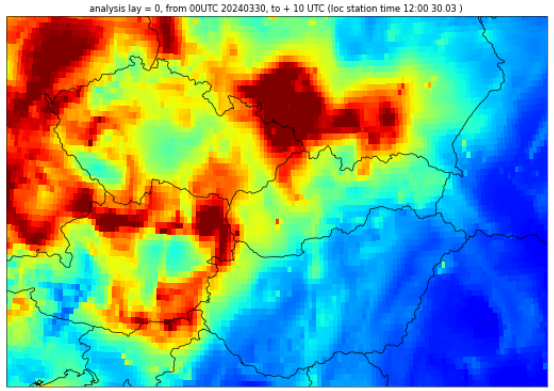


CAMS EUROPE
ANALYSIS

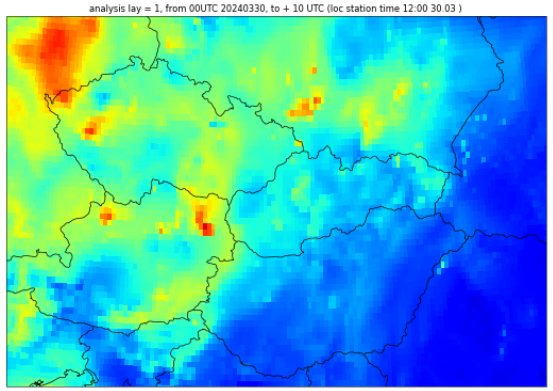


CAMS ANALYSIS, 30. March 2024 00+10 UTC vertical layers

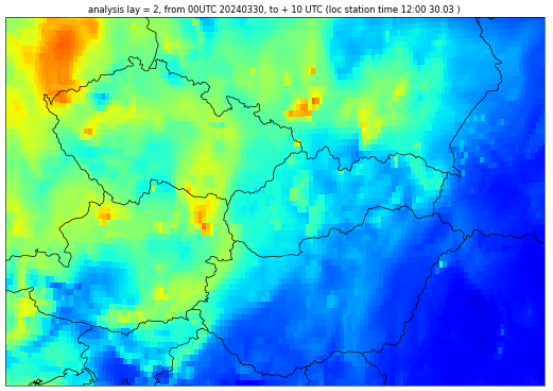
Ground level



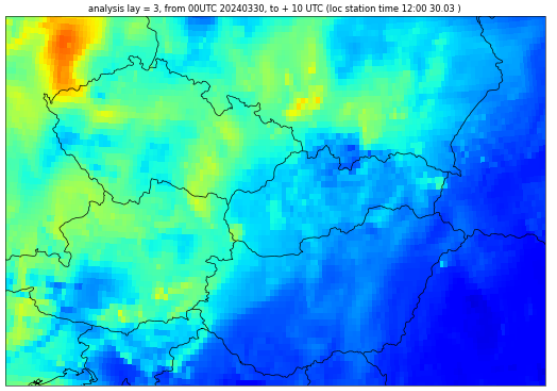
50 m

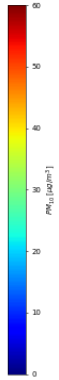


100 m

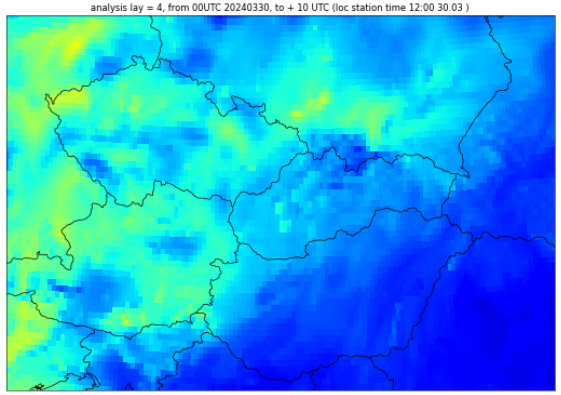


250 m





500 m



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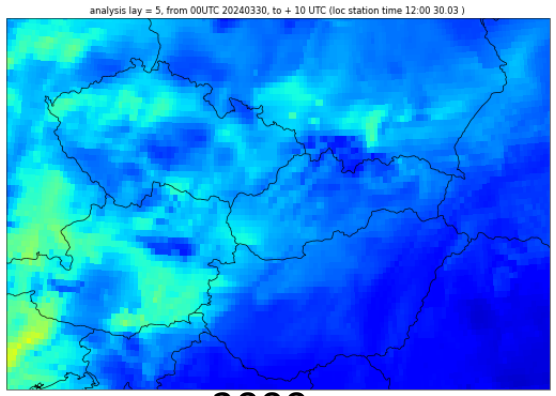
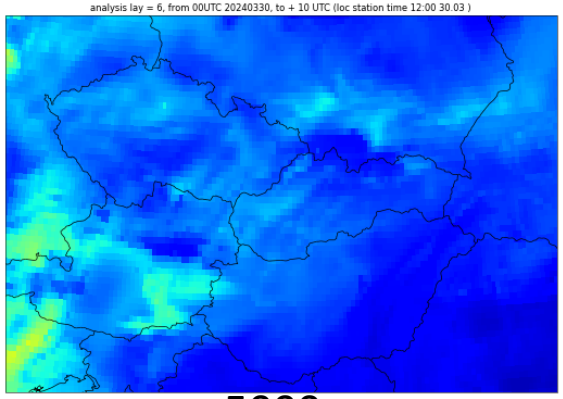
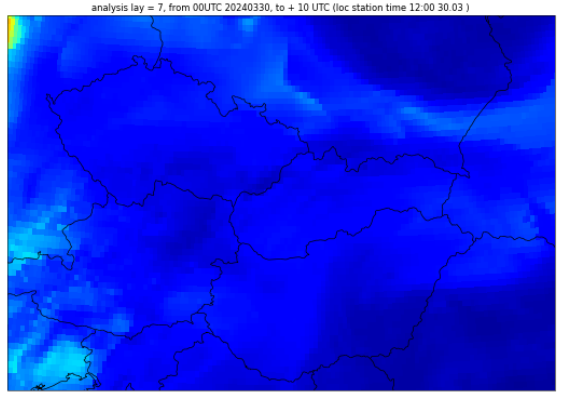
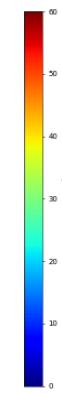


1000 m

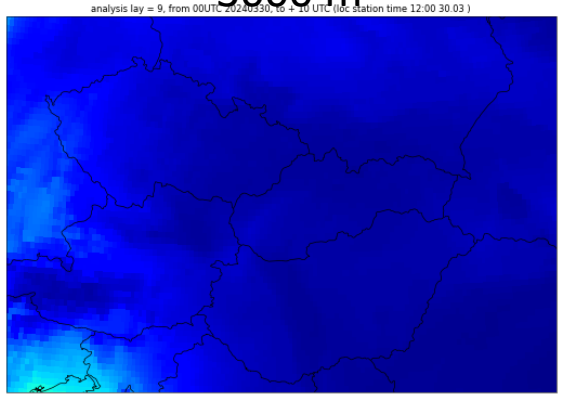


2000 m





3000 m



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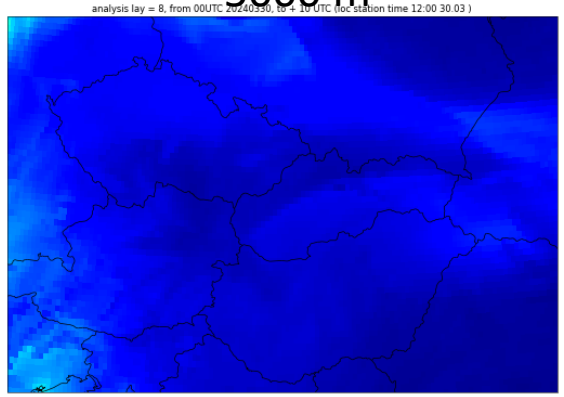
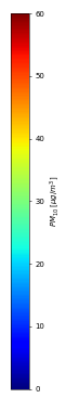


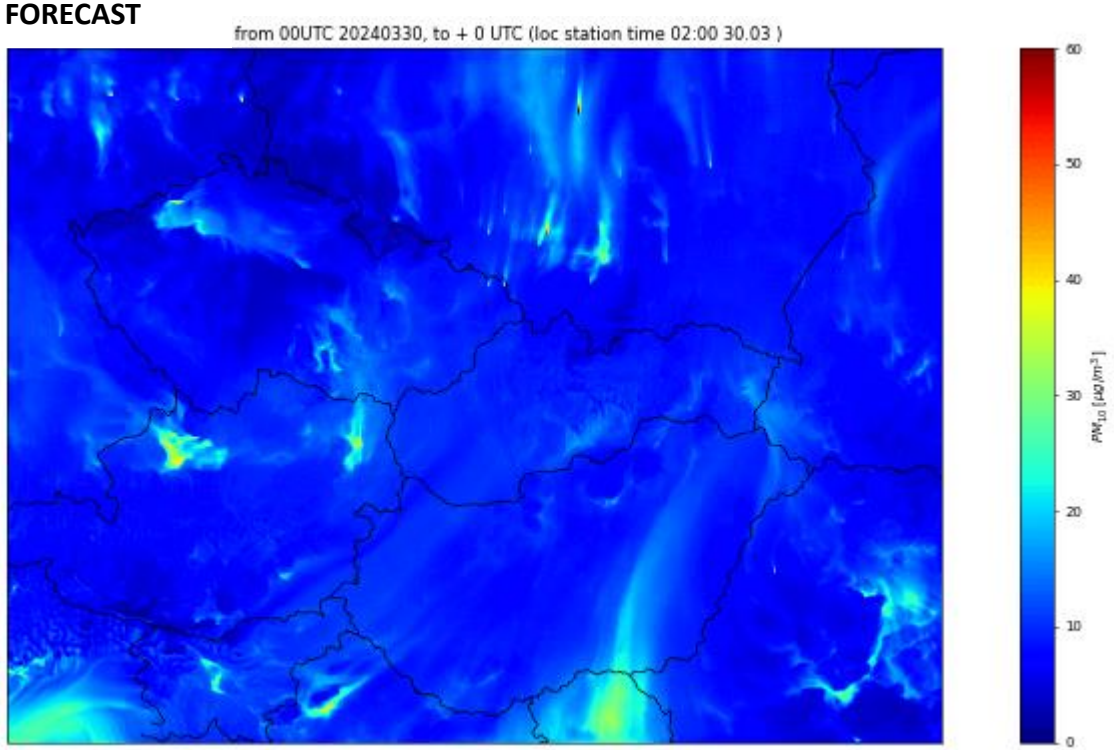


NO SAHARIAN DUST IN UPPER LAYERS.

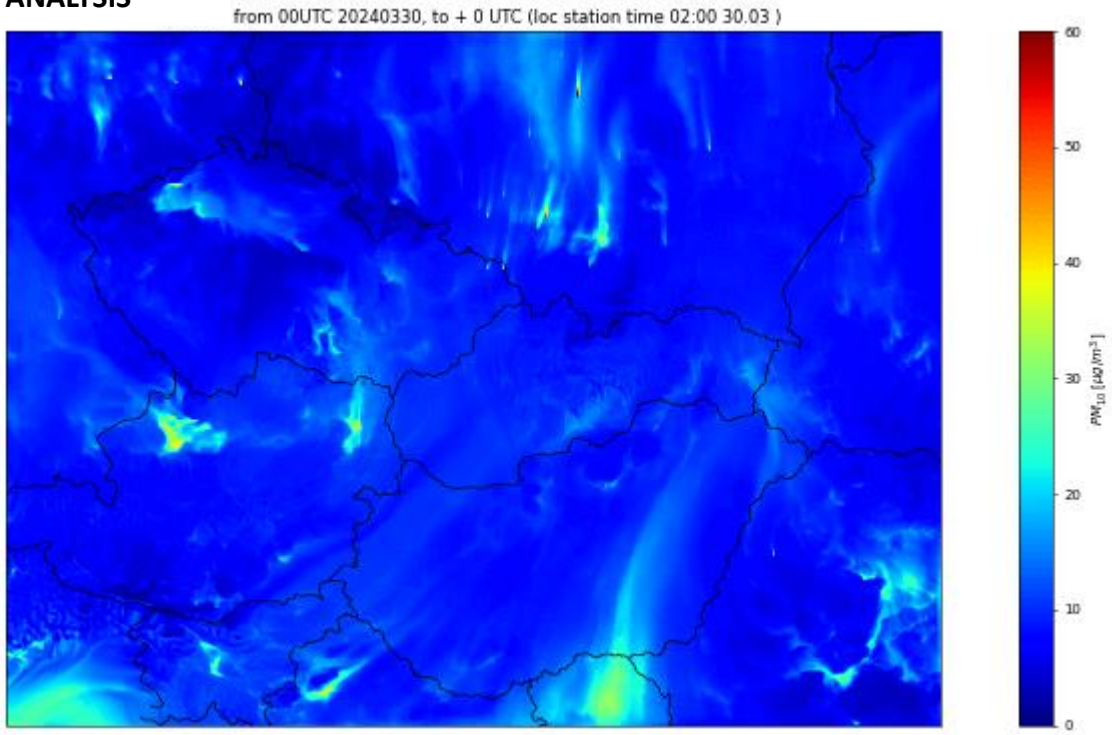
Saharan dust episodes using analysis products

30. March 2024

CMAQ with **BC**
CAMS EUROPE
FORECAST



CMAQ with **BC**
CAMS EUROPE
ANALYSIS



Conclusions

- It was demonstrated that air quality forecasting system at SHMU based on the CMAQ model provides the air quality forecast comparable to CAMS ensemble model. Both models have some common drawbacks – often they are not able properly describe stable conditions in the lower part of boundary layer.

- Especially difficult is the pollution prediction in narrow deep and poor ventilated valleys.

- In winter, during the front passages, the models tend to mix the ground levels of atmosphere too quickly, even when observations such as surface temperature, calm wind, and high pollution indicate the stagnant conditions near the ground.

- It would be helpful to have European NRT air-quality concentrations map for the better understanding of the air-quality models and predictions

- It seems that analysis of CAMS products does not automatically imply better boundary conditions for regional model

- Air quality forecasting system at SHMU is still under the development and further improvements, i.e., updated emission inputs, better coupling to the CAMS model, observation assimilation, are expected to be implemented in the near future.