

**Improving Air-Pollution Dispersion Forecasts with a Hybrid
Physical-Machine Learning Approach**

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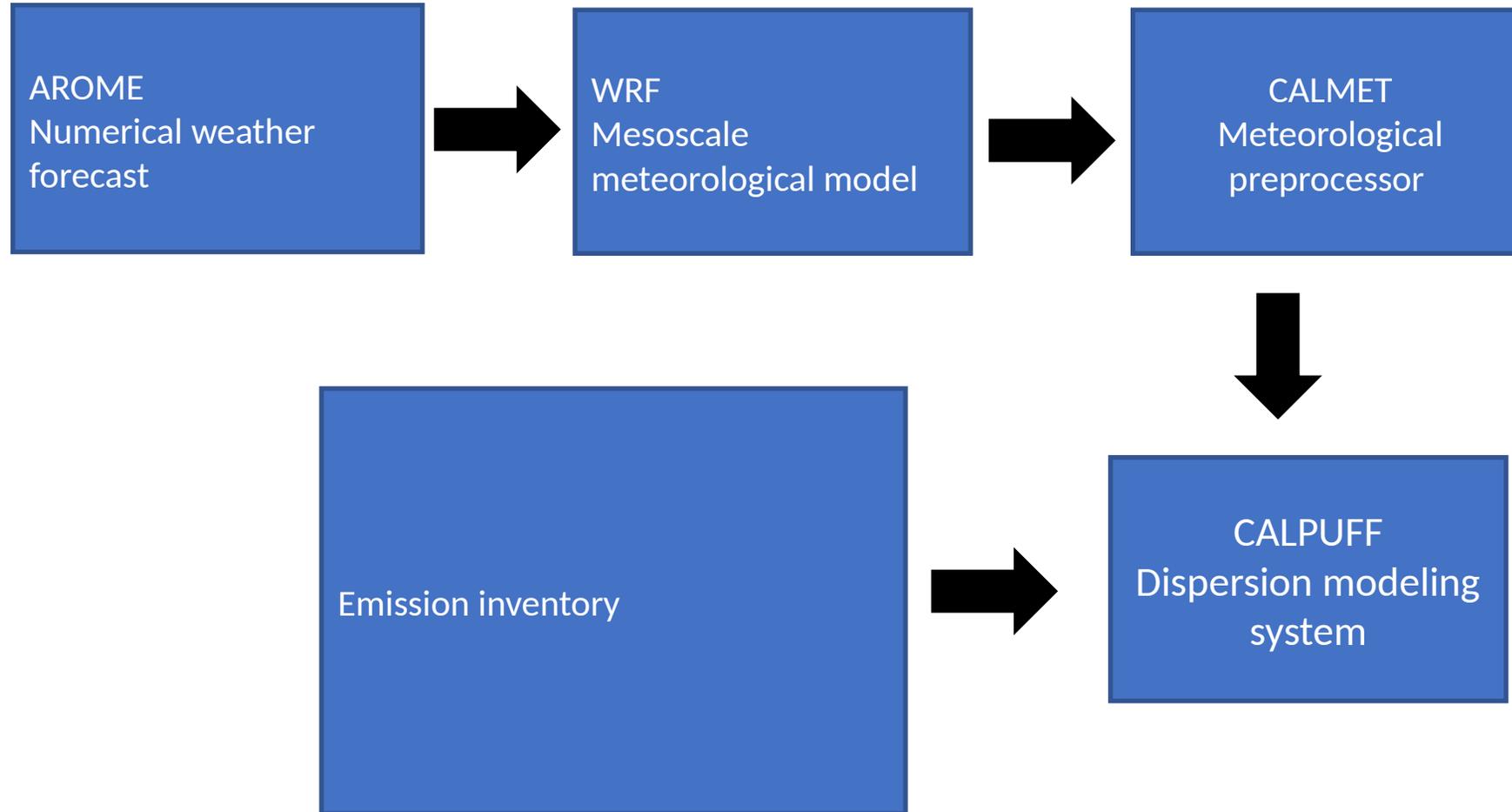


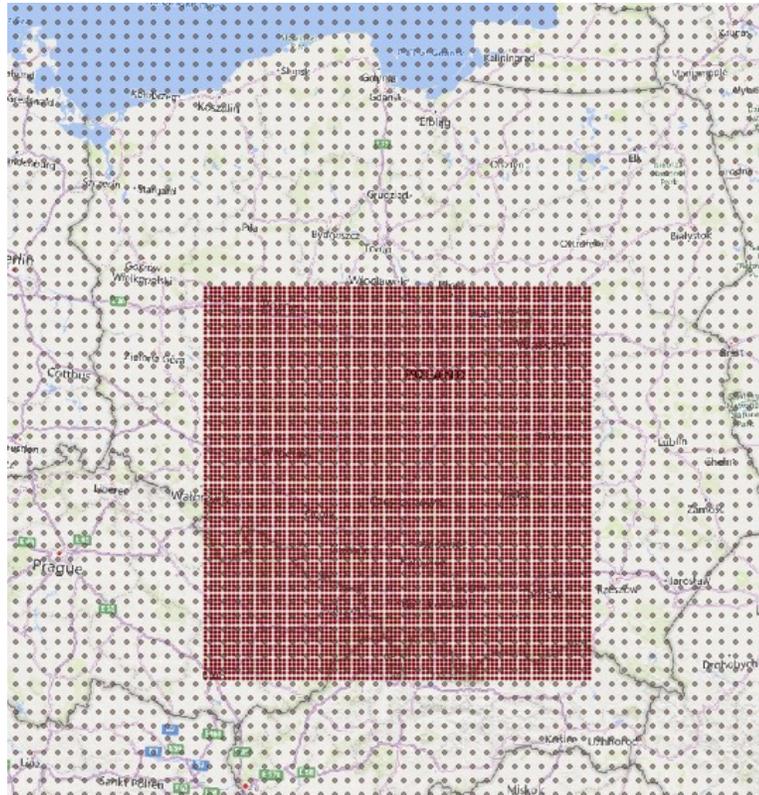
1. FAPPS description

2. Modelling domains

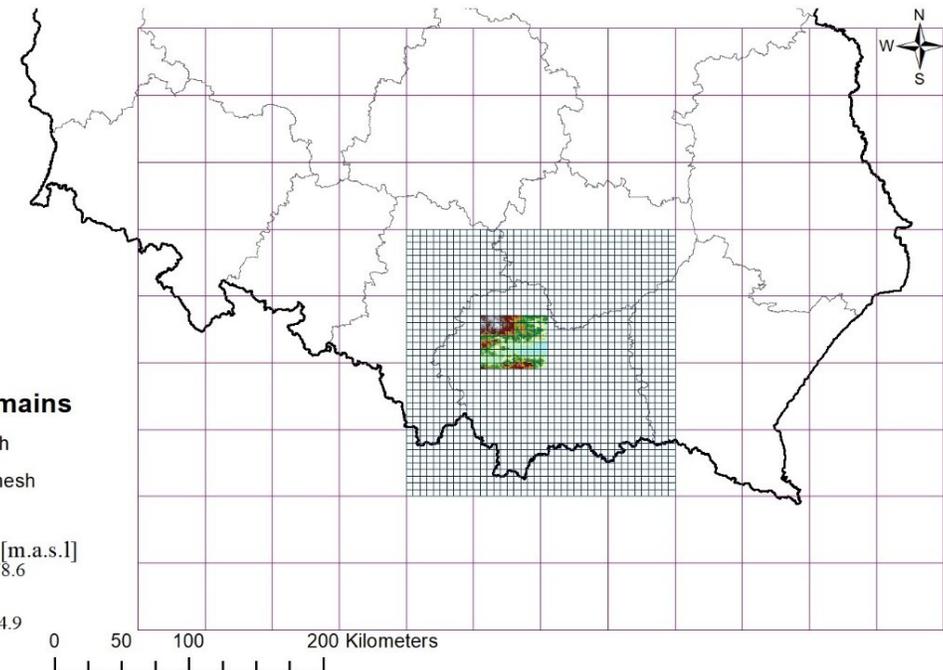
3. Machine Learning techniques

4. Comparison of numerical modelling with modeling+machine learning



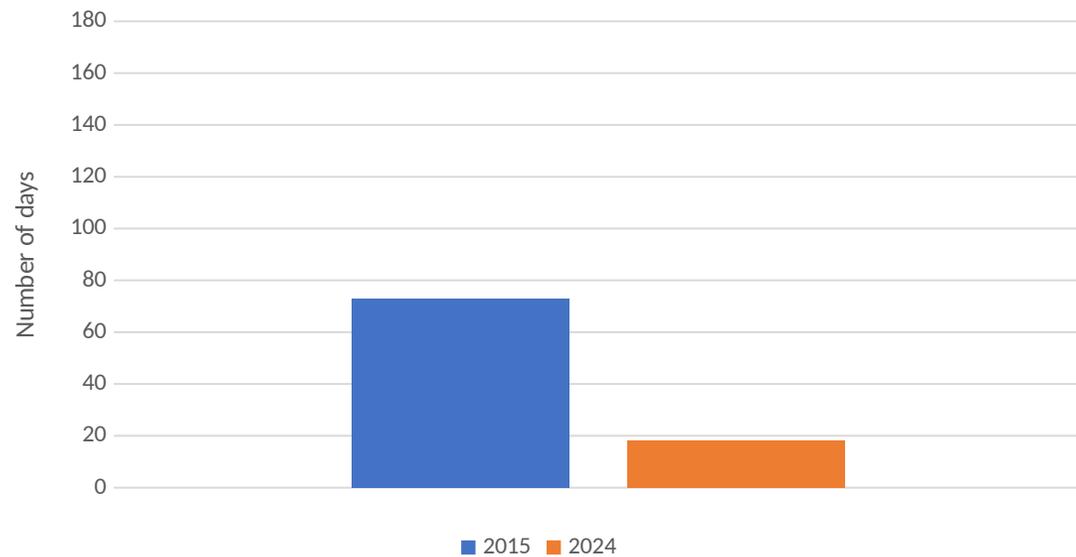


Meteorological domains

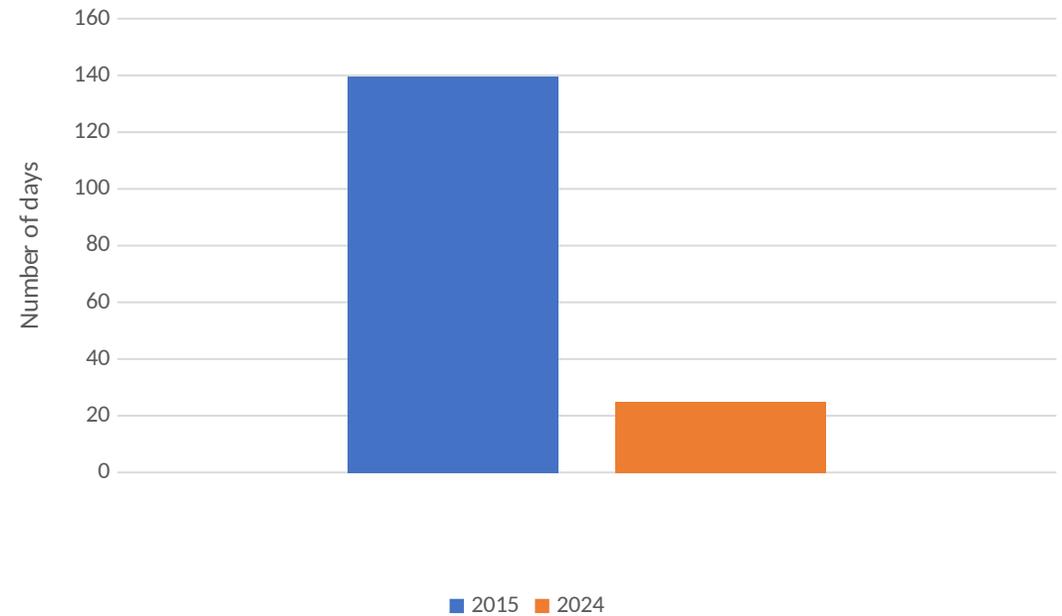


Dispersion modelling domains

Annual average number of exceedances of the 24-hour PM10 limit value in Lesser Poland



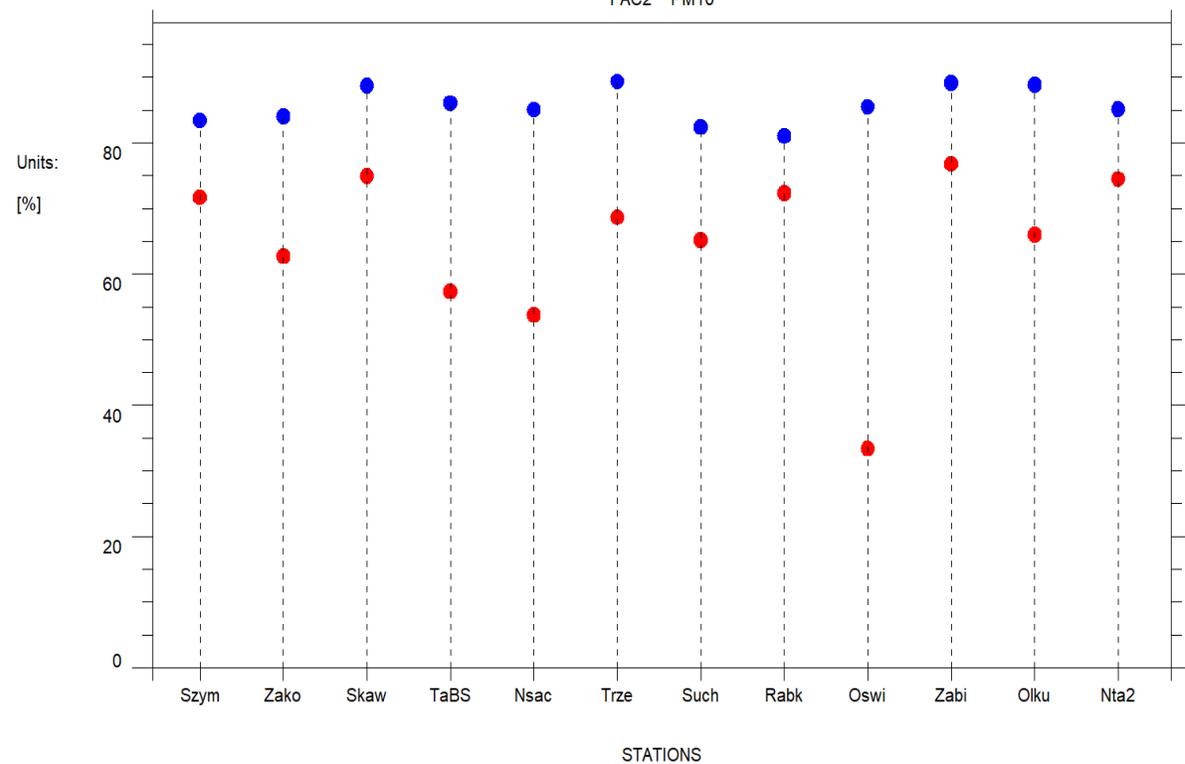
Annual average number of exceedances of the 24-hour PM10 limit value in Krakow



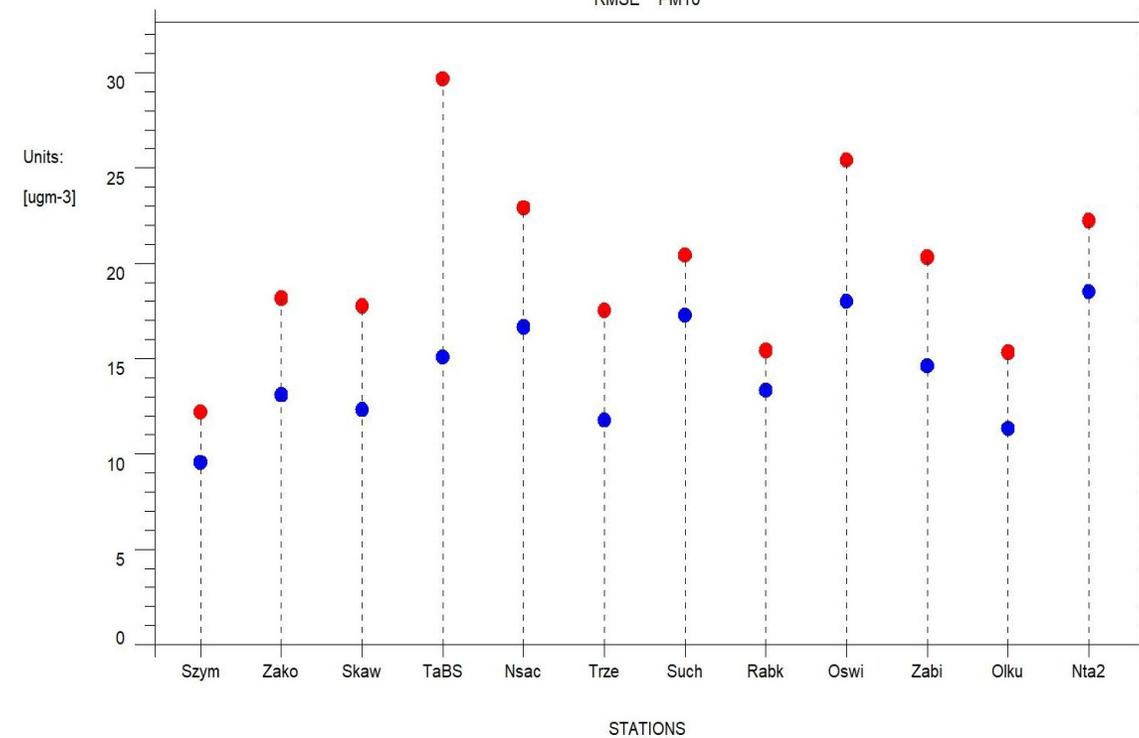


1. Hourly concentrations predicted with CALPUFF
2. Models trained on 2022 and 2023 data from official measurement stations
3. ML learns the residual = measured – CALPUFF
4. Techniques used: Gradient-boosted/bagged trees (LightGBM, XGBoost, CatBoost, HGB, ExtraTrees), robust linear (Huber), and a RNN
5. Models are blended (non-negative weights learned on the validation year; station-balanced).
6. Output: Corrected forecast = CALPUFF + predicted residual
7. Results verified by predicting values for 2024

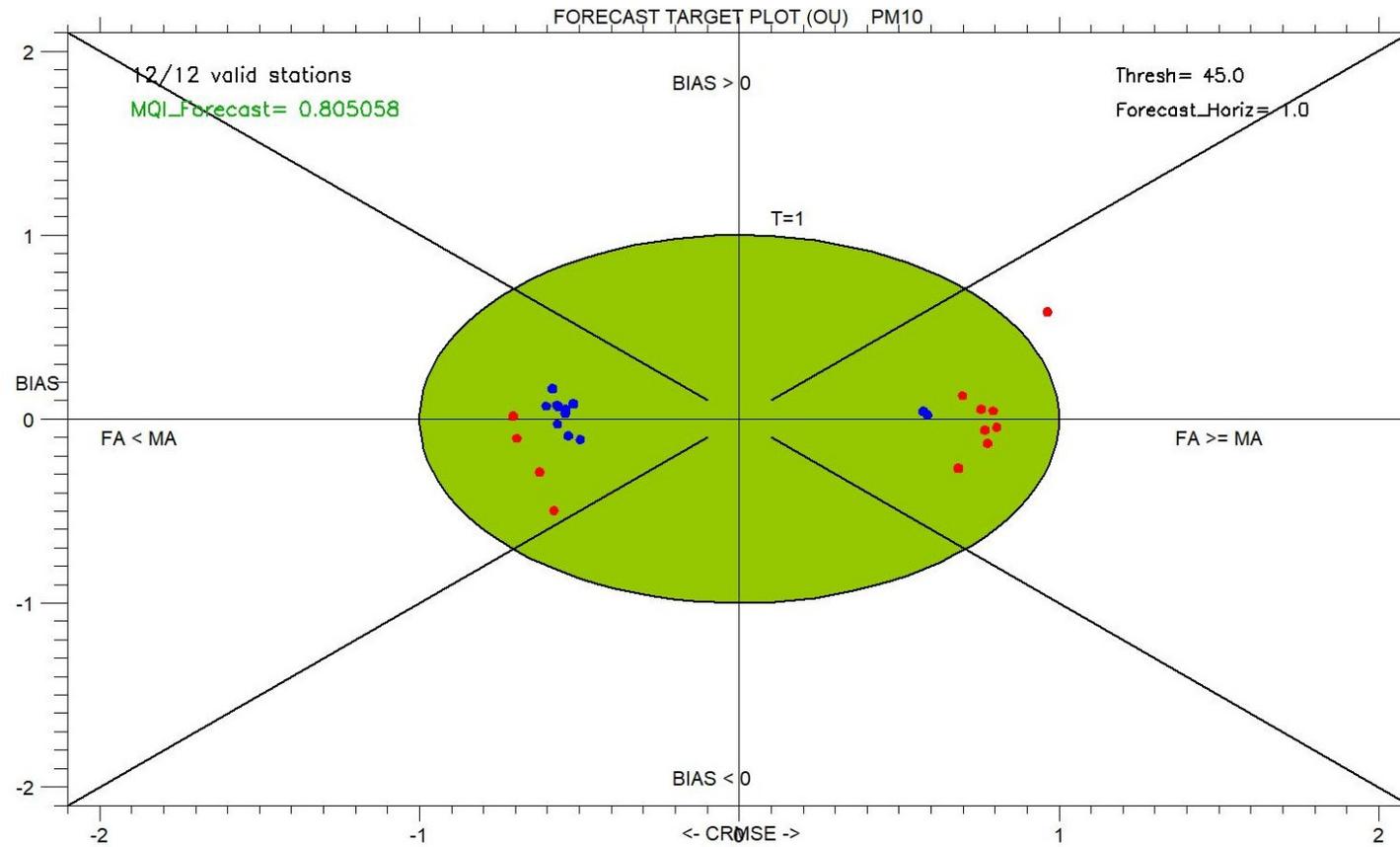
FAC2 PM10



RMSE PM10

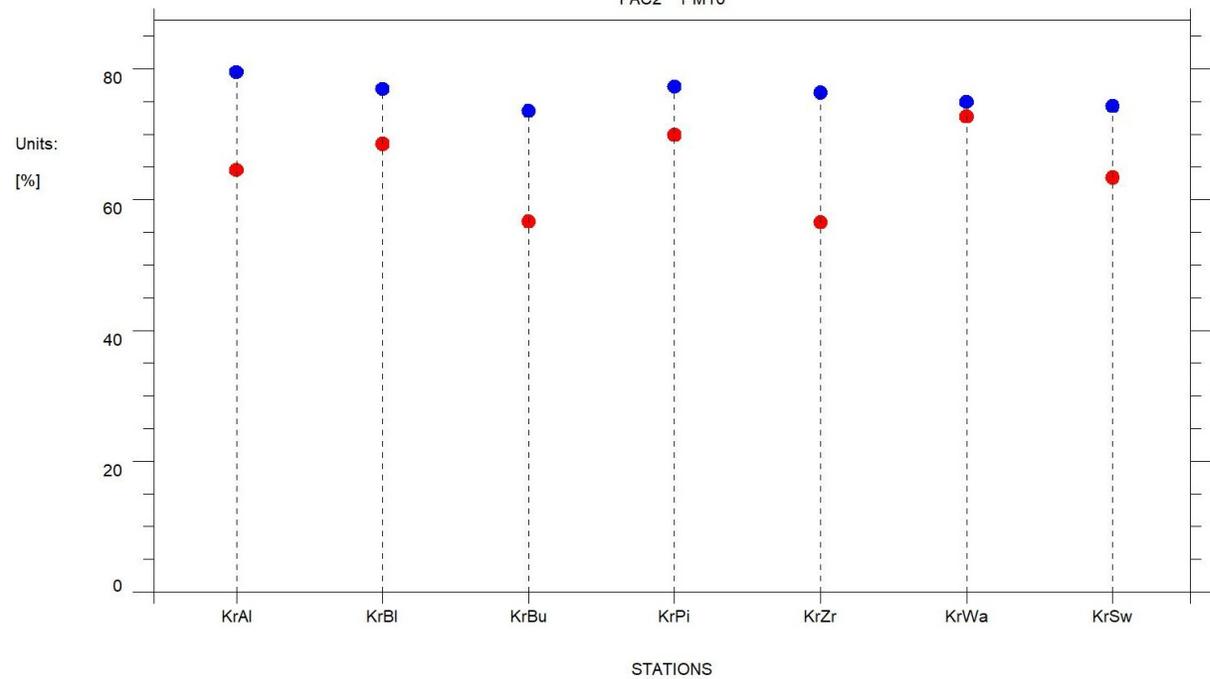


red – CALPUFF, blue – CALPUFF+ML

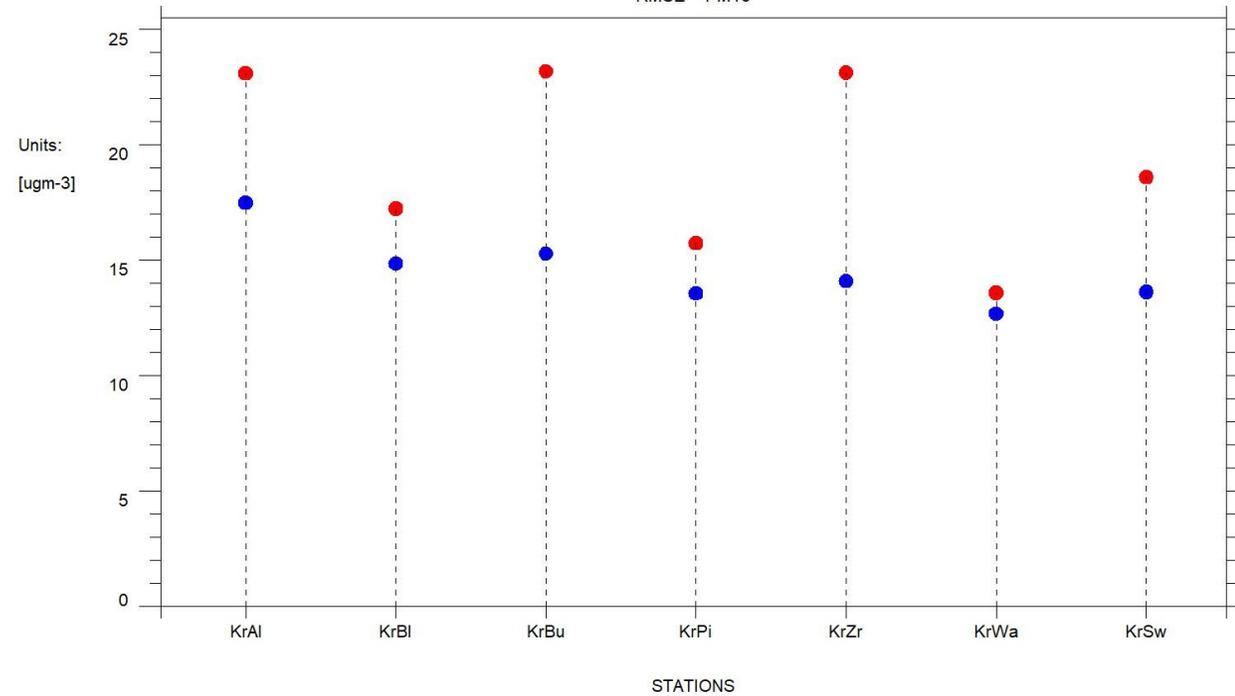


red - CALPUFF, blue - CALPUFF+ML

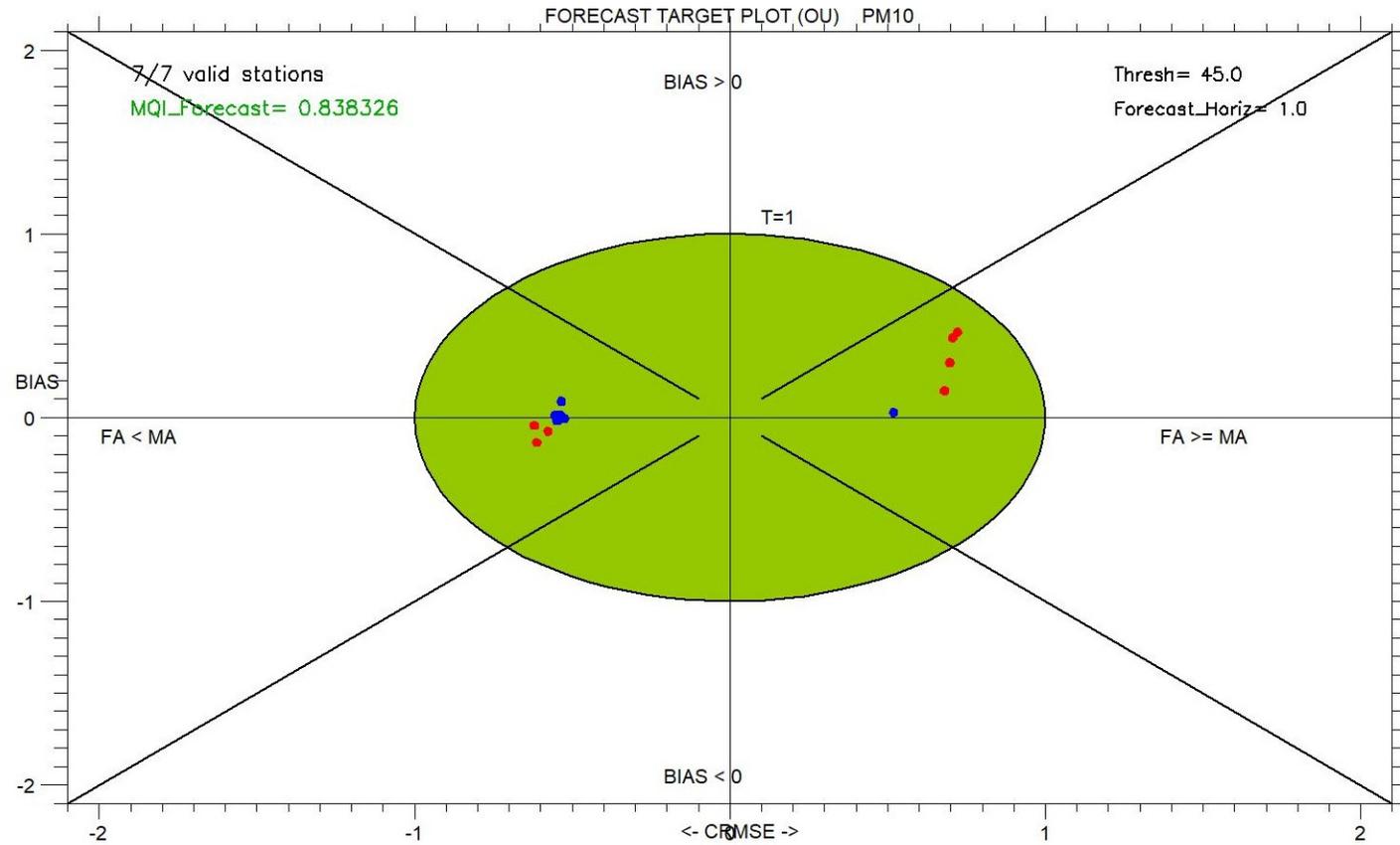
FAC2 PM10



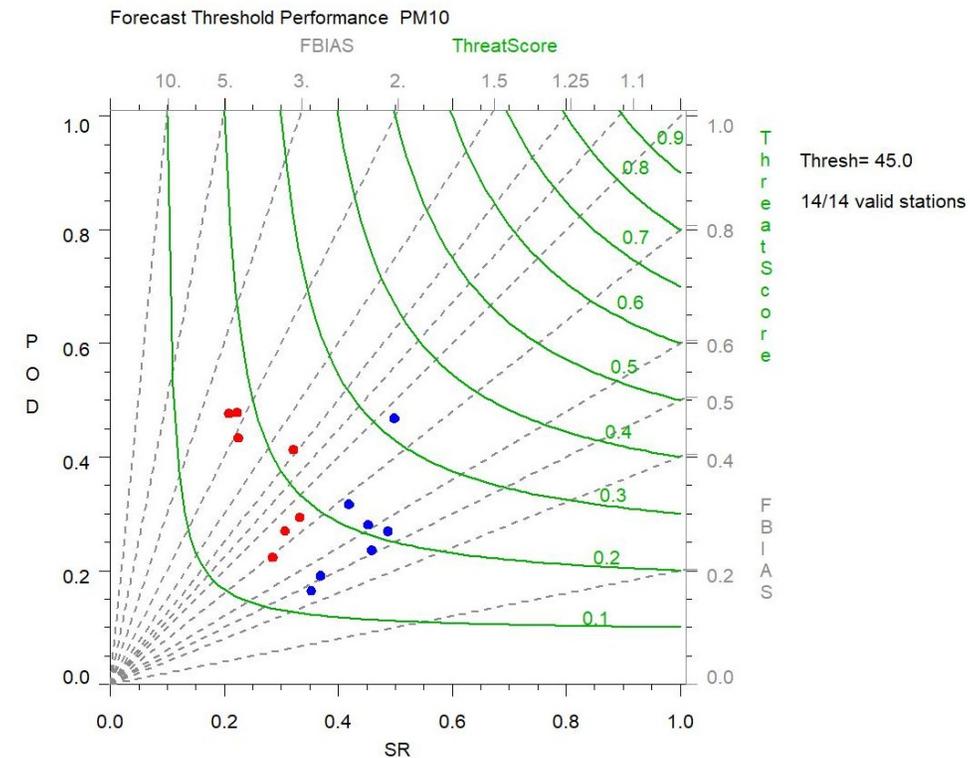
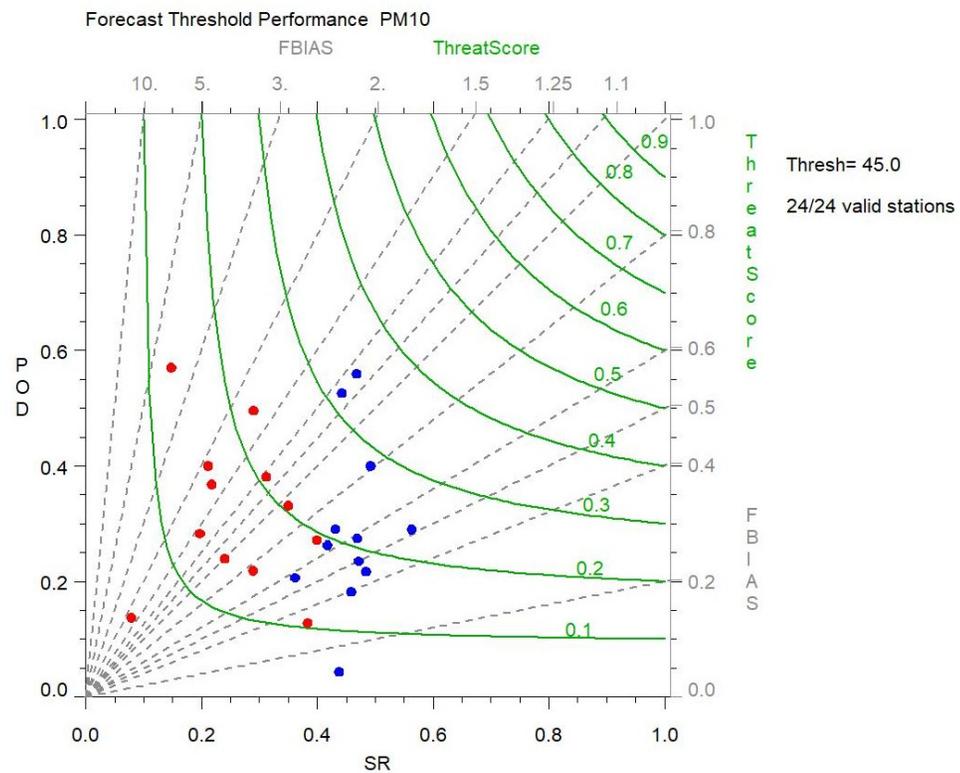
RMSE PM10



red - CALPUFF, blue - CALPUFF+ML



red - CALPUFF, blue - CALPUFF+ML



red - CALPUFF, blue - CALPUFF+ML

left - Lesser Poland, right - Krakow

1. ML methods allow to significantly improve forecasts of PM10 concentrations and correct numerical model's biases
2. There is work to be done to improve detection of threshold exceedances (new emission inventory, higher resolution of meteorological model)
3. Measurements are taken at specific points, and the model works in the whole domain at a given resolution

Thank you

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