APPLICATION OF WRF-CHEM TO FORECAST PM_{10} CONCENTRATIONS OVER POLAND

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INTRODUCTION

In this study we apply the on-line model WRF-Chem version 3.5 (Grell et al. 2005; Skamarock & Klemp 2008) to forecast PM_{10} concentration over Poland, with a focus on the south-west part of the country called the Lower Silesia region. The PM_{10} forecasts are tested during the winter 2014 from 1st January to 28th February, as winters in general are favourable in Poland to high particulate matter concentrations due to both high coal consumption, which is commonly used fuel e.g. for heating houses, and meteorological conditions. The forecasts are evaluated by comparison with observations gathered by the Voivodeship Inspectorate of Environmental Protection in Poland.

DATA AND METHODS

The WRF-Chem model setup

WRF-Chem is used in nested mode with a summary of the model configuration in Table 1 and Fig. 1. The simulations are driven by the GFS meteorological data, available every 3h, with 0.5° x 0.5° spatial resolution. Emissions are the TNO MACC II data set with 1/8° x 1/16° spatial resolution (Pouliot et al. 2012). The first 48-h forecasting cycle on the 01 January 2014 uses a 2-week spin-up, with the model simulations started the 15th of December using the GFS-FNL meteorology for initial and boundary conditions. From the 2nd of January, the model uses chemistry cycling, and the WRF-Chem run for the previous day is used to initialize the next day's forecasting simulation. Temporal variations in emissions are restricted to emissions from nature, while the TNO MACC II emissions are assumed constant during the entire simulation.

Model evaluation

The PM_{10} concentrations forecasts were compared with daily mean observations gathered by the Voivodeship Inspectorate of Environmental Protection, from sites in Lower Silesia region in SW Poland (Table 2), separately for 24h and 48h lead time (Table 2). Time series and scatter plots for the two stations with the lowest MB and one station with the highest MB are given as examples (Fig. 3).

Table 1. Model configuration

Category	Model setup
Forecasts period	01st January – 28th February 2014
Domains	Europe (36 km) – Poland (12 km) – SW Poland (4 km)
Vertical resolution	35 layers
PBL process	YSU
Land-surface process	NOAH
Cumulus	Kain-Fritch for d1 and d2
Shortwave & Longwave radiation	RRTMG
Microphysics	Lin
Gas-phase mechanism	RADM2
Aerosol model	MADE/SORGAM
Photolysis scheme	Fast-J
Wet deposition	Simplified parameterisation for wet scavenging

Table 2. Model performance for the 24h and 48h lead time

Forecast range	N	FAC2	MB	NMB	RMSE
24h	977	0.67	-16.17	-0.38	29.17
48h	977	0.67	-16.38	-0.38	29.51

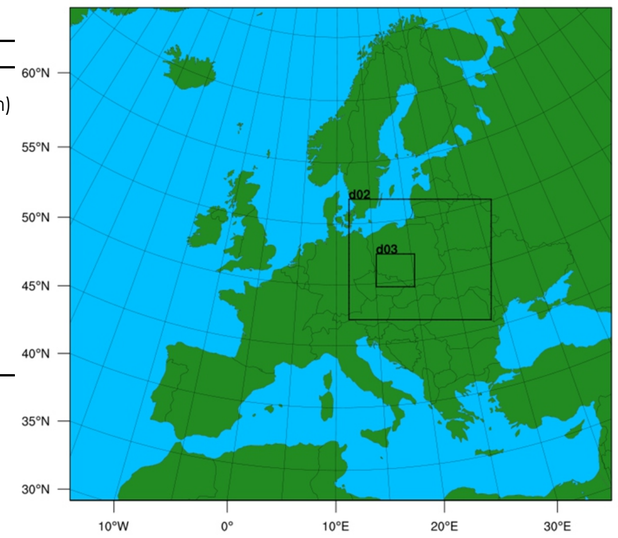

Figure 1. WRF-Chem model domains.

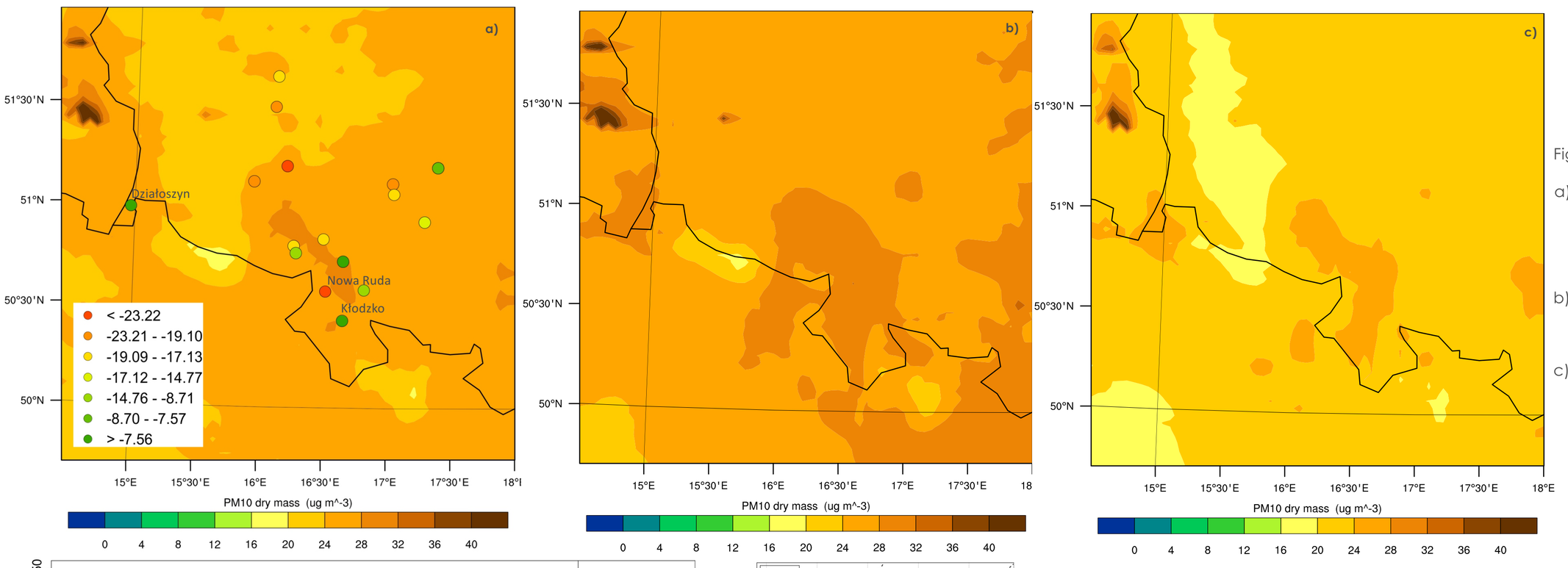

Figure 2.

a) Period average (Jan-Feb 2014) PM_{10} concentrations and mean bias statistic marked by dots (MB=model-observation), 48h lead time

b) Average PM_{10} concentrations for January 2014, 48h lead time

c) Average PM_{10} concentrations for February 2014, 48h lead time

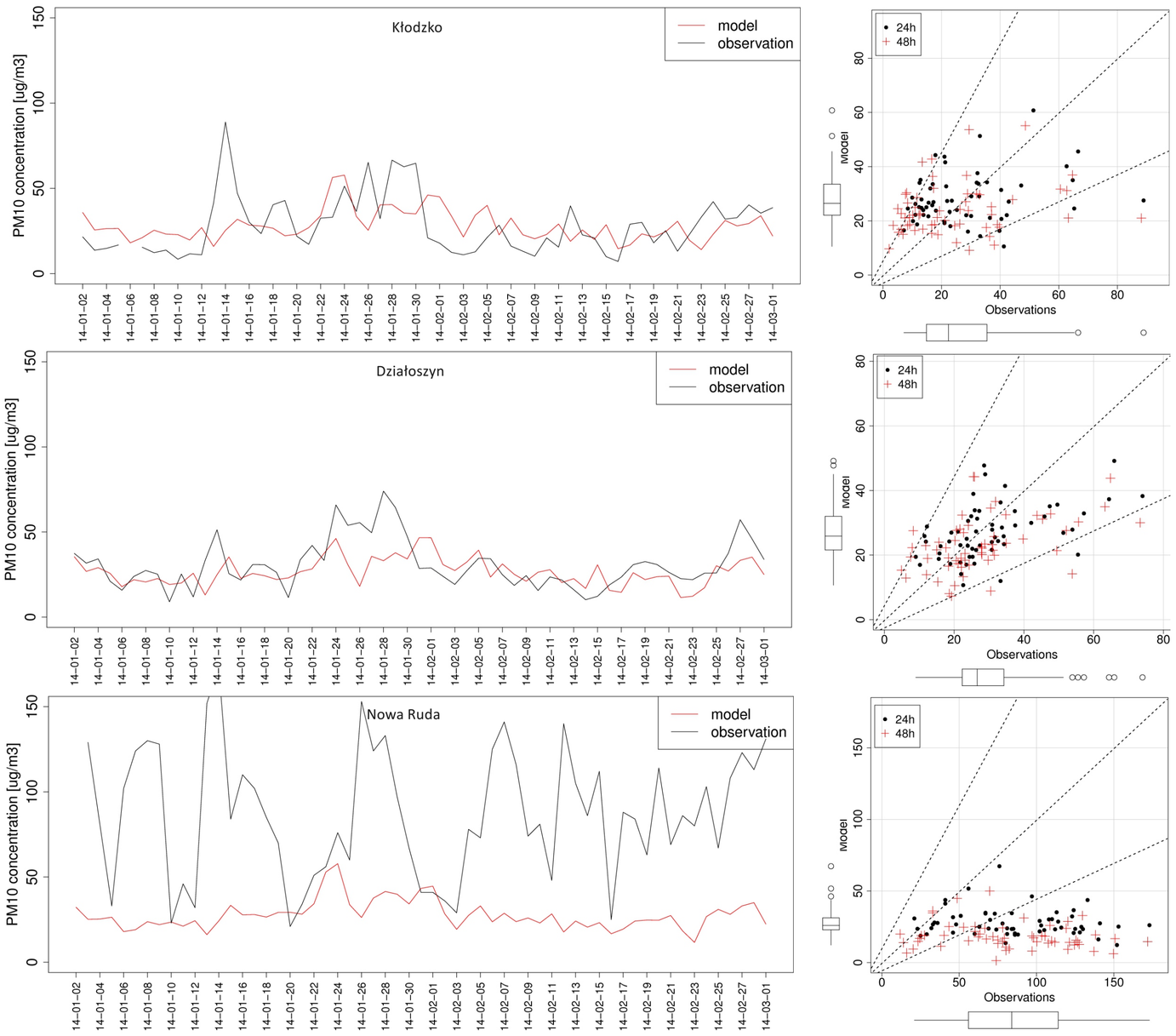

Figure 3. Time series of PM10 concentration for the 48h lead time of the forecasts for Kłodzko, Działoszyn and Nowa Ruda. Scatter plots for these stations, presenting both 24h and 48h lead time; bosplots for 48h lead time.

RESULTS

The mean PM_{10} concentration is observed to be 42 μg m^{-3} for the entire period. MB calculated from all stations is about -16 μg m^{-3} and FAC2 statistic equals to 0.67 (Table 2). The simulated forecast performance is slightly better for the 24h lead time compared to the 48h lead time (Table 2). The lowest MB, among all stations, is for Kłodzko whereas the highest is for Nowa Ruda (Fig. 2).

The model generally captures the observations at Kłodzko and Działoszyn, whereas in the case of Nowa Ruda, the model is not able to reproduce the observations during a series of episodes with very high PM_{10} concentrations (Fig. 3).

CONCLUSION

We have found that WRF-Chem in general captures the variability in observed PM_{10} concentrations for most of the stations. However the highest observed peaks are underestimated by the model. In fact, the lowest performance was obtained for the Nowa Ruda station, which is located in a deep valley. This area has a high contribution of the emissions from coal fired residential heating. Such circumstances could cause high PM_{10} observed concentrations peak during certain weather types such as winter time inversions. We argue that a higher resolution sector based emission data and temporal emission profile will be helpful for this analysis in connection with a focus on PBL processes in WRF-Chem and their impact on the initial distribution of emissions.

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