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Application of model output statistics to the GEM-AQ high resolution air quality forecast

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ABSTRACT

The aim of the presented work was to analyse the impact of data stratification on the efficiency of the Model Output Statistics (MOS) methodology as applied to a high-resolution deterministic air quality forecast carried out with the GEM-AQ model. The following parameters forecasted by the GEM-AQ model were selected as predictors for the MOS equation: pollutant concentration, air temperature in the lowest model layer, wind speed in the lowest model layer, temperature inversion and the precipitation rate. A representative 2-year series were used to construct regression functions. Data series were divided into two subsets. Approximately 75% of the data (first 3 weeks of each month) were used to estimate the regression function parameters. Remaining 25% (last week of each month) were used to test the method (control period). The subsequent 12 months were used for method verification (verification period). A linear model fitted the function based on forecasted parameters to the observations. We have assumed four different temperature-based data stratification methods (for each method, separate equations were constructed). For PM_{10} and $PM_{2.5}$, SO_2 and NO_2 the best correction results were obtained with the application of temperature thresholds in the cold season and seasonal distribution combined with temperature thresholds in the warm season. For the PM_{10}, $PM_{2.5}$ and SO_2 the best results were obtained using a combination of two stratification methods separately for cold and warm seasons. For CO, the systematic bias of the forecasted concentrations was partly corrected. For ozone more sophisticated methods of data stratification did not bring a significant improvement.

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1. Introduction

The aim of the presented work was to assess the impact of the Model Output Statistics (MOS) methodology (Wilby and Wigley, 1997) as applied to a deterministic air quality forecast over Malopolska Voivodship. An operational air quality forecast for Malopolska was initiated in November 2010. A 3-day forecast of four gaseous pollutants (O_3, SO_2, NO_2, CO) and aerosols represented as PM_{10} and $PM_{2.5}$ was calculated using the GEM-AQ model (Kaminski et al., 2008).

The skill score of the air quality deterministic forecast depends, to a large extent, on the sub-grid variability of the input parameters describing surface properties. In urban areas, at a given resolution one cannot sufficiently describe the sub-grid spatial variability of emission fluxes and urban structures. In the case of a complex terrain there is also a problem with representation of orography, surface fluxes and wind direction. Statistical techniques do not consider individual physical and chemical processes and use historical pollution concentrations and meteorological data in order to establish statistical relationships. Even though local influences might be better represented, the spatial representativeness of such forecast is limited to the vicinity of a particular monitoring station.

A combination of a deterministic approach and statistical post-processing may lead to an improvement of forecast accuracy. MOS is a standard technique used in meteorology for forecast post-processing. A specified series of model output and observational data are used to calculate the best-fit coefficients that are further applied to model forecasts. This technique improves the forecast accuracy for selected locations, as it accounts for local influences which are not completely resolved by the deterministic forecast at a given grid scale (Wilson and Vallée, 2003; Taylor and Leslie, 2005).

The MOS approach was used for the maximum daily ozone concentration forecast in France (Honoré et al., 2008). The authors combined modelled temperature and modelled ozone concentrations using a linear regression. This methodology improved the prediction of ozone episodes characterized by concentration higher than 180 μg/m^3 (information threshold as defined in the CAFÉ directive). Thus, it was incorporated into the French PREV'AIR air quality forecasting system. A

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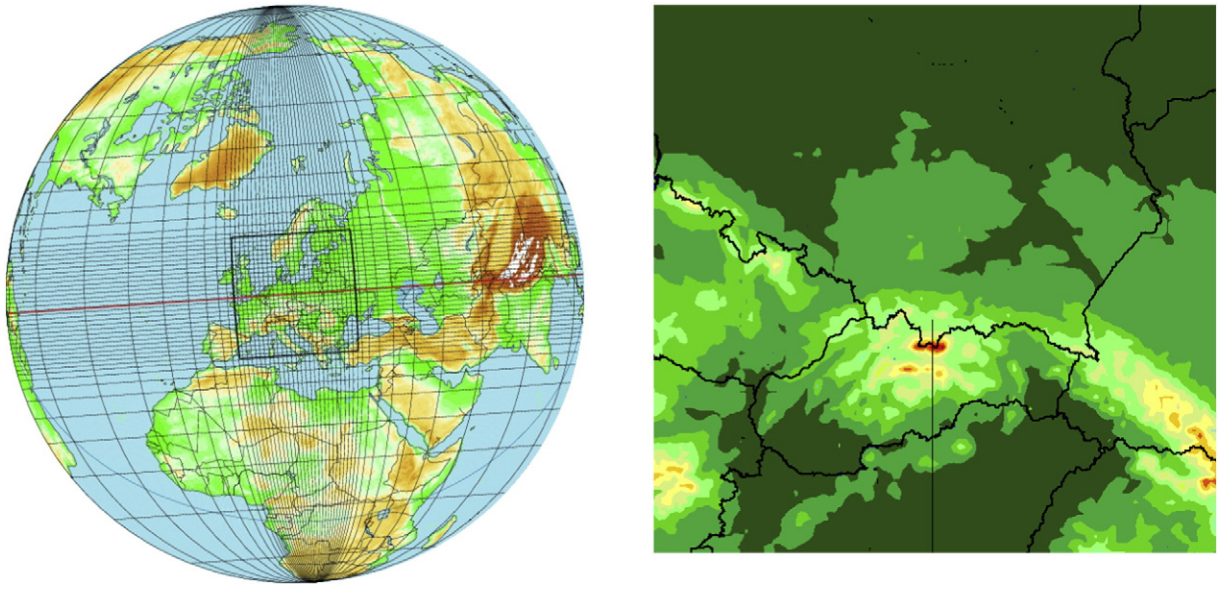

Fig. 1. GEM-AQ grid configuration: (a) – global variable resolution grid with 0.22 deg. spacing in the core over central Europe; (b) – LAM grid with 0.0625 deg. grid spacing.

similar technique was applied by Denby et al. (2008) to improve the spatial representation of PM_{10} predicted concentration with respect to exceedances of a 50 μg/m^3 threshold. Konovalov et al. (2009) proposed regression functions for daily averaged PM_{10} concentrations for 2003–2006. The warm (April–September) and cold (October–March) seasons were treated separately. For the operational LOTOS-EUROS model, regression functions for daily average PM_{10} concentrations and daily maximum ozone concentrations were based on forecast results from 2003 to 2005 and validated for 2006 (Pijnappel, 2011).

The novelty of the proposed approach is in the application of different data stratification strategies for the regression coefficients estimation. The results may have practical applications as MOS post processing is used to improve the forecast accuracy in terms of thresholds exceedances.

2. Materials and methods

Analyses were undertaken based on results from an operational air quality forecast for Malopolska Voivodship. Air quality in southern Poland is often below the standards defined by the CAFÉ Directive (2008/50/EC). Most of the poor air quality episodes are due to extremely high PM_{10} concentrations. Also, this geographical area is treated as a potential source region of particulate matter for neighbouring countries.

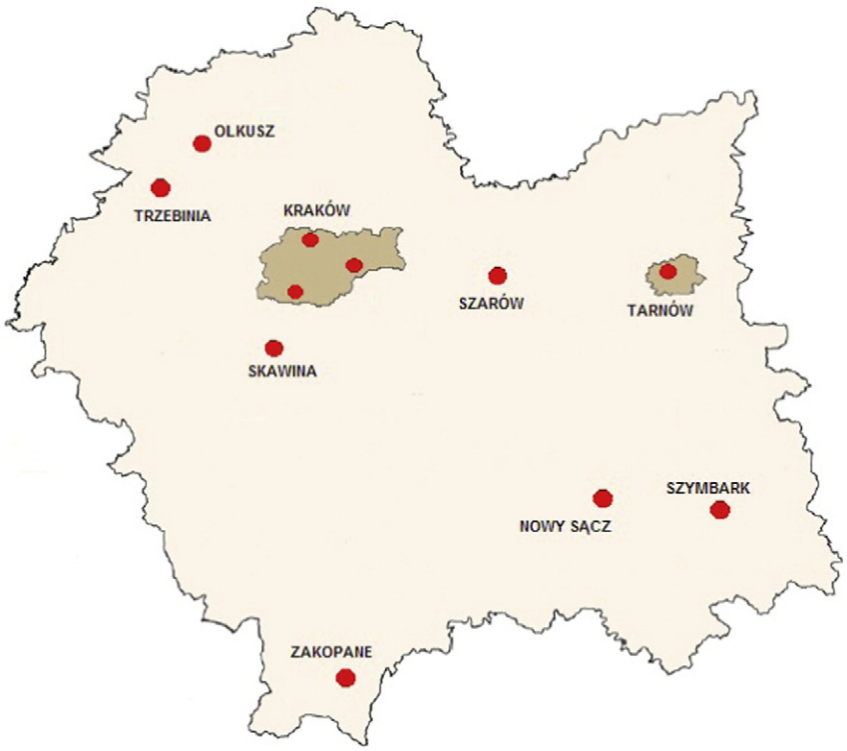

Fig. 2. Air quality monitoring stations in Malopolska Voivodship.

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