Interactive comment on “Evaluation of the GEM-AQ model in the context of the AQMEII Phase 1 project” by J. Struzewska et al.

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The authors would like to thank Referee #3 for comments and suggestions.

Specific comments

Referee #3 comment:
The measurement stations used are grouped as rural, suburban or urban stations. However, the horizontal resolution of 0.2 deg. is somewhat coarse and unable to resolve most urban features, and therefore the urban stations should probably not have been included in the data set used for verification. I encourage that either these stations be left out of the presented evaluation results, or in case the authors can argue that the urban stations selected are not influenced much by unresolved urban features this should be explained in the paper.

Authors’ reply:
The general concept of the AQMEII-P1 project was to assess the performance of different air quality models on a continental scale at the resolution of 0.2 deg. The number of rural stations is significantly smaller than the number of urban stations. Thus, the suggested comparison would not give a sufficient spatial representation of the model performance. Moreover, the use of “urban stations” allows for the analysis of the sub-grid variability of the concentration fields.

We will add more explanation concerning the use of urban station measurements in the revised version of the manuscript.

Referee #3 comment:
In section 1 Introduction, it is described that air-quality results from the previous day are used as initial conditions for the air-quality module. Since there is no air-quality data assimilation in the model system, this procedure implies a risk of bias. The authors are encouraged to comment on this.

Authors’ reply:
The aim of the AQMEII-P1 project was to analyse model uncertainties based on a comparison with measurements (“operational evaluation” – which is the aim of this manuscript) as well as the models’ responses to different perturbations (i.e. parameterizations, emissions).

The model intercomparison rules adopted in the AQMEII Phase 1 assumed no chemical data assimilation, to better expose capabilities of individual models in maintaining a proper chemical regime.

Referee #3 comment:
The air-quality model is implemented on-line with the meteorological model used, which is indeed admirable. However, I find that only little description is devoted to the meteorological part of the model, e.g. procedures for meteorological data assimilation and initialization, and I would recommend including additional information on these matters

Authors' reply:
The GEM meteorological model is documented in many scientific publications. GEM is used as the operation weather forecast model at the Canadian Meteorological Centre, Environment Canada. All primary model references were provided. In addition, all 'vital' model setup information is provided in Section 2.1.

A procedure for 'meteorological data assimilation and initialization' is provided on page 1473 line 20, i.e. Gauthier et al. (1999). We will explicitly state that the global objective analysis was done using the 3D-Var assimilation method.

Referee #3 comment:
An integration time step of 600 s is used. It would be nice with a discussion of this value which I find somewhat large.

Authors' reply:
Description of the numerical scheme used in the GEM model is given on page 1474 line 12.

GEM uses a semi-Lagrangian, semi-implicit (SISL) scheme where terms giving rise to fast modes such as gravity wave are approximated by implicit differencing. Therefore, SISL models are capable of maintaining stability at relatively large time steps. This feature has been extensively documented in the literature (i.e. Robert, 1981, Robert et al., 1985). Kalnay (2003), in her textbook on NWP, calls this class 'the ultimate models'. Thus, a time step of 600 seconds, at the spatial resolution used, is sufficiently short to guarantee solver stability.

Properties of the chemical solver are given in Kaminski et al. (2008). Time evolution of all chemical species is solved using a mass-conserving implicit time stepping discretization, with the solution obtained using Newton's method.

Referee #3 comment:
The verification is limited to 8-hour running average ozone concentration and 24-hour PM10 concentration. However, in order to represent the diurnal cycle, and especially the afternoon ozone peak on warm summer days, the authors are encouraged to show also verification results at higher temporal resolution, e.g. hourly average concentrations, or at least include a discussion on this issue in the paper. This applies also to other local air-pollution episodes.

Authors' reply:
Results presented in the manuscript were selected based on wider analyses. The afternoon ozone concentration peak was analysed based on the daily maximum and results were very similar to the 8-h running average of ozone concentrations (example on Fig.1). Such analyses were undertaken for stations in Poland,

Germany, Czech and Slovakia in respect to O_3 and PM_{10} episodes in the context of the trans-boundary transport events.

To facilitate the intercomparison, we decided to follow the extent of other papers already published (e.g. Appel et al, 2012; Brandt et al, 2012) in the present paper. GEM-AQ performance in extreme situations in the summer of 2006 is already documented (Struzewska and Kaminski. 2008). In fact, this paper contributed to the decision of selecting 2006 as a test year for AQMEII-P1). We will consider a separate article on a series of specific air quality episodes in Central Europe.

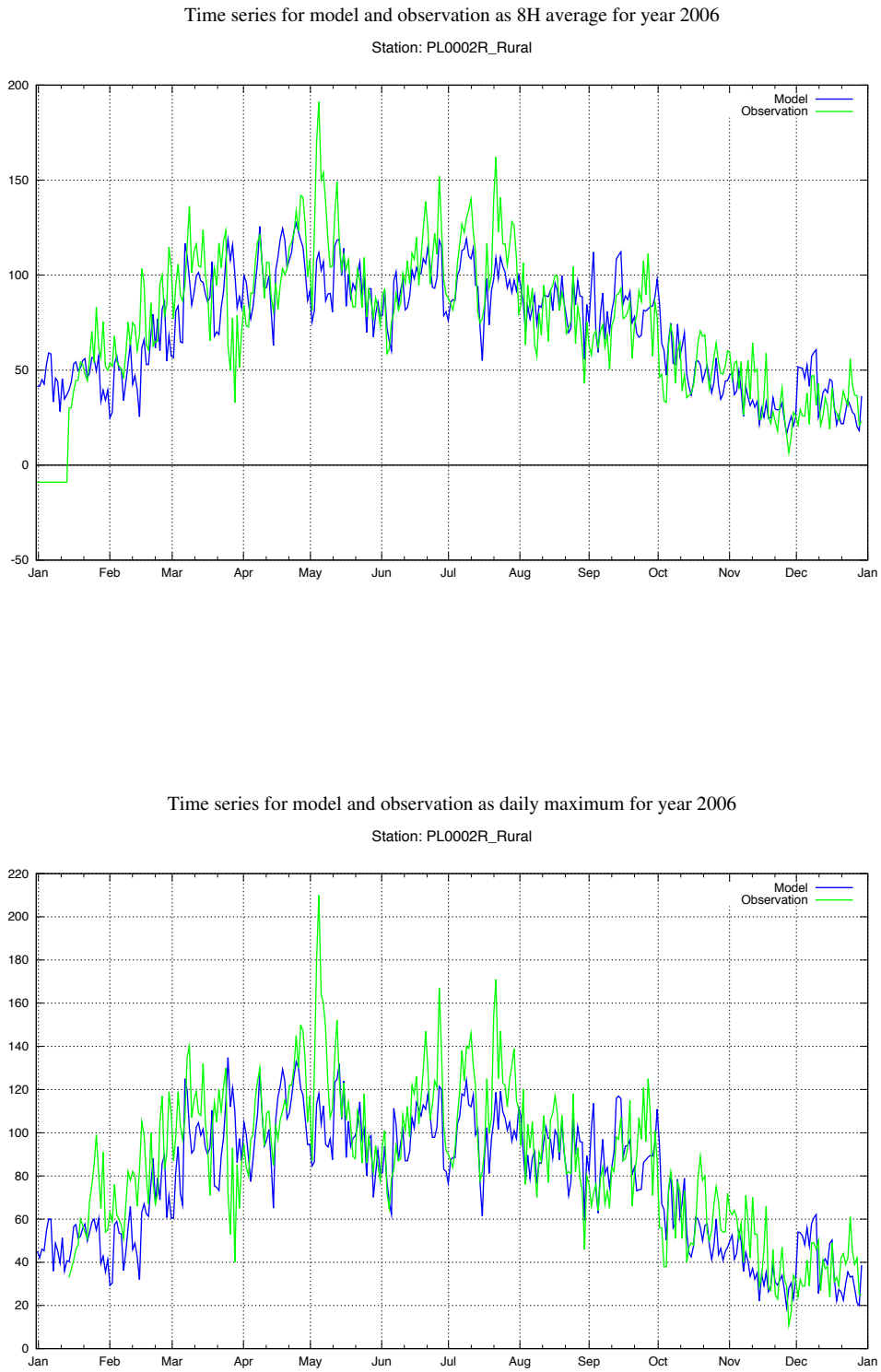

Figure.1

Also, the 1-h maximum displayed on Taylor Diagram showed good performance of the GEM-AQ model (coded as PL1) as compared to other models participating in AQEMII-1 (Fig.2).

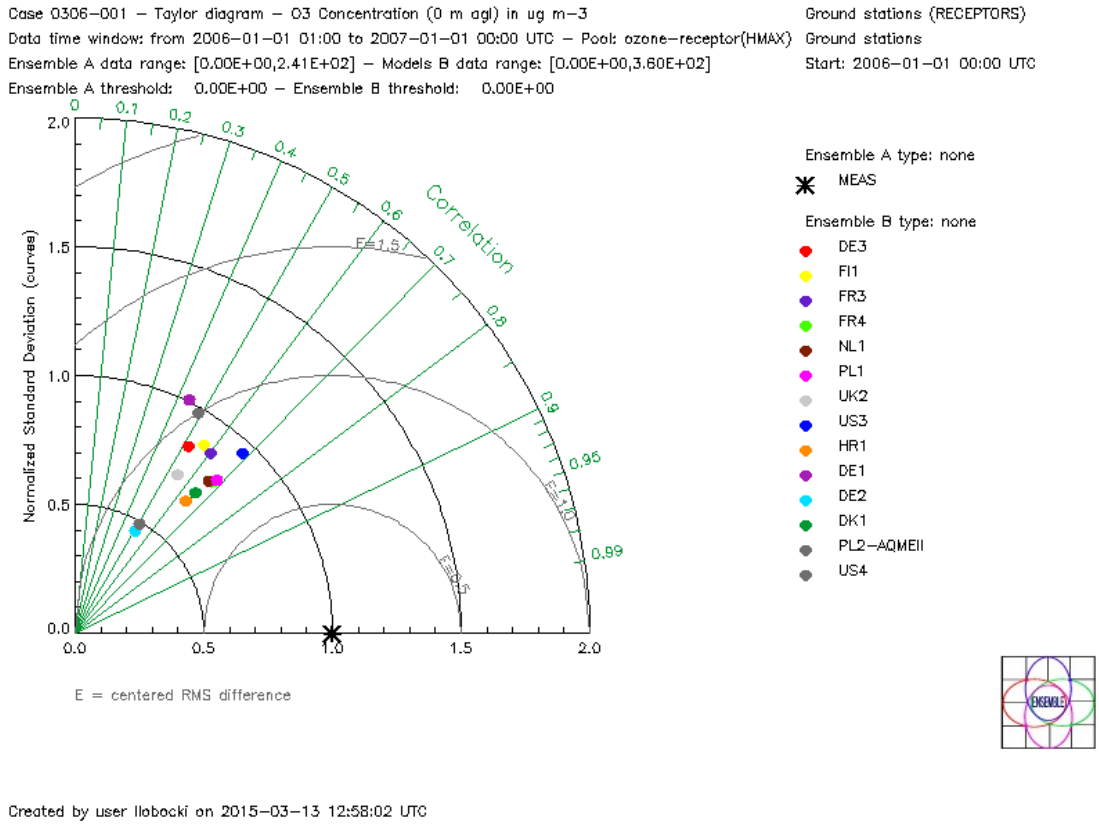

Figure.2

Referee #3 comment:

At many places, verification results are given with four significant digits, e.g. MAGE 16.53 ug/m^3. Considering the inherent model uncertainties, I recommend reducing the accuracy with which such values are given.

Authors' reply:

We will change the error statistics values according to Referee #3 suggestions.

Referee #3 comment:

In section 4.1 Ozone it is speculated that transport of ozone from the upper troposphere might be too weak at high latitudes, but then it is also stated that analysis of effects of the vertical structure is beyond the scope of the study, which focuses on surface concentrations only. I agree that three-dimensional aspects of air-quality modelling can be essential for air-quality modelling, and accordingly I think that this deserves more discussion. I assume that there is a background for the authors' suspicion?

Authors' reply:

A new publication on the seasonal variability of modelled vertical distribution of ozone concentrations and the comparison against ozone soundings over Europe is being prepared.

Referee #3 comment:
In section 5 Summary and Conclusions, it is concluded that the variability of air-pollution species depend on regional climate. Since "climate" is generally understood as long-term averages such as over 30 years, the current study of only one year (2006) is not sufficient for such a deduction. See also last sentence of the abstract.

Authors' reply:
The authors used the term "regional climate" in the context of different features of seasonal variability of temperature and humidity in different regions of Europe (implying also the seasonal variability of emissions) and stratification of the results according to geographical location.

Technical corrections
Referee #3 comment:
Section 3.1.2 Temporal variability of ozone concentrations Define "J-values".
Section 3.2.1 Spatial distribution of PM10 concentrations P. 10, line 9: "() except for of eastern Germany ()" => „() except for eastern Germany
Section 5 Summary and Conclusions MBE values are given without units. Please correct. P. 18, lines 6 and 12: Add comma "," after "Pearson correlation" to enhance readability. P. 18, line 17: I suggest replacing "viable" with e.g. "possible". P. 18, line 20: I suggest replacing "explanation" with e.g. "investigations".

Authors' reply:
The authors will introduce all the technical corrections as suggested.