Atmospheric Chemistry and Physics Discussions

Interactive Comment

Interactive comment on **"Validation of a 3-D hemispheric nested air pollution model"** *by* **L. M. Frohn et al.**

L. M. Frohn et al.

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The authors would like to thank the reviewer for the very useful and constructive comments to the paper.

General comments:

Reviewer: The presentation of the physical concepts and parameterisations used in the model and the comparison between measured and calculated concentrations could be considerably improved.

Answer: The model description section has been rewritten in order to improve the description of the physics and parameterisations. Furthermore the results section also covering the comparison between measured and calculated concentrations has been rewritten. The Figures presenting time series for Oulanka and Langenbrügge have been replaced by time series comparing the measured and calculated concentrations

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averaged for all stations.

Reviewer: Explanations why the work is done and a detailed scientific discussion of the results is missing sometimes. I would like to encourage the authors not to restrict themselves to much to technical descriptions of the model (which are detailed and important) but also to add more scientific discussions on the results.

Answer: The introduction has been rewritten to provide a better description of the motivation for the study. Furthermore section 4 has been rewritten in order to make the scientific discussion of the results more complete.

Specific comments:

Reviewer (concerning the abstract): To focus also on scientific questions and to describe the scientific goals of the contribution clearer.; The abstract can provide some arguments why it is interesting and important to extend a limited area air pollution model for Europe to the Northern hemisphere (e.g.: impact of intercontinental transport on ozone or other air pollutants to Europe and vice versa, (two way nesting); import and export of air pollutants; contribution of global pollution to European pollution levels and vice versa).; Why are only EMEP stations selected for the comparison?; Why is the focus of the study Europe?; Are there similar studies for other continents or Europe?; Do measurements show the importance of intercontinental transport to Europe?; What are the main results of the sensitivity studies of the model performance with respect to resolution in emission and meteorology?; Which scientific questions have been solved?; What has been improved (or not improved)?; What can be improved in the future?; What can be concluded for different species?; In general I suggest to shorten the technical part in the abstract and to focus on the scientific goals of the study, the scientific questions to be answered and the reasons for doing this study.

Answer: The abstract has been rewritten. It now includes a description of the scientific goals, motivation and questions as well as a summary of the conclusions and findings. A short discussion of similar model studies has been included in the introduction to-

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gether with examples of studies showing the importance of intercontinental transport. The EMEP measurement data were selected because they were the only presently available data set at the National Environmental Research Institute covering a relatively large domain. The reason for choosing the European area as the model domain is that one of the original aims of developing the model is to quantify the amount of pollution entering and leaving the area around Denmark. Furthermore detailed emission data are available for Europe through EMEP. It is equally possible to focus REGINA model studies at any other location in the Northern Hemisphere provided that the input data (emissions) as well as measurement data are available at a sufficient resolution.

Reviewer: More arguments should be given why a specific improvement or development has been done.

Answer: The argumentation has been extended in the model description section.

Reviewer: I suggest to refer also to other model chains from global to regional/local scale and to some results of the EMEP modelling work in the discussion of the results.

Answer: A short discussion of similar model studies (EMEP and EURAD) has been included in the introduction.

Reviewer: The authors should try not to mix up the terms horizontal grid size and scales.

Answer: Ok

Reviewer: What are the lateral boundary conditions of REGINA, what are the initial conditions?; What are the upper boundary conditions/values e.g. for ozone?

Answer: The lateral and upper boundary values during conditions of inflow are taken from results from a global model. A detailed description of the procedure of extracting these global model data has been included in the paper. The initial concentration fields are also taken from this global model, however additionally REGINA is run with a spin-up time of one month after reading the initial conditions, in order for the concentration

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levels of particularly ozone to adjust. A more detailed description of the boundary conditions has been included in the paper.

Reviewer: How is ozone treated in the free atmosphere?

Answer: A description of the chemical scheme is now included in the paper.

Reviewer: The sentence "Episodes like this will not be included in the results if the domain is limited" is not correct: the episodes are included also in regional models, but the impact of intercontinental transport can not be included in a consistent way.

Answer: The sentence has been removed and the introduction has been rewritten.

Reviewer: At least for one episode the impact of intercontinental transport could be illustrated by comparing limited area results for Europe (nest 1 domain without the hemispheric domain) with the results obtained with REGINA.

Answer: The REGINA model is currently being set up for the European area without the hemispheric input, however calculations have not yet been performed and direct results are therefore not yet available. An example of an important episode of intercontinental air pollution transport is reported in a paper by Stohl et al. published in 2003. A reference for this paper has now been included in the present manuscript. Other examples are given in Langmann et al. (2003).

Reviewer: The meaning of sigma is not explained.

Answer: An explanation of the sigma-coordinate has been included in the model description.

Reviewer: How is dry deposition calculated?

Answer: The dry deposition is handled differently for gaseous and particulate material as well as for deposition to water and land surfaces. A short description of the dry (and wet) deposition parameterisations is now included in the paper.

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Reviewer: Which land use data set has been used for the calculation of dry deposition?; What is the reason to introduce an additional land use data set?

Answer: The Wilson and Henderson-Sellers data set referred to in the paper is the data set used for the calculation of dry deposition. The data from USGS will be used in the next version of the model.

Reviewer: What is the temporal resolution of the output of the model?

Answer: Hourly model results are saved for the concentration as well as dry and wet deposition of the most important chemical species at specific locations, e.g. the EMEP measurement stations. Mean concentrations are saved for all chemical species with 6-hour resolution.

Reviewer: Why are the seasonal and daily variations of the emissions not included? Is this due to lack of information?

Answer: Yes. Currently the seasonal and daily variations are available at a high resolution for Denmark and we are working on a consistent extrapolation of this data set to cover the surrounding countries. For sulphur and nitrogen oxides the available data sets are obtained from GEIA giving the monthly variation. We have, however, had some problems with these data and they have therefore not been used in the present study. The isoprene emissions include a seasonal variation (monthly values).

Reviewer: How are the biogenic VOC-emissions calculated?

Answer: The only biogenic compound used in the present study is isoprene (terpene and other biogenic VOC's are not included as was erroneously stated in the original paper). The isoprene inventory has been downloaded from the GEIA website.

Reviewer: There seems to be some inconsistency in the land use data set used in the MM5, the deposition fluxes and the biogenic emission fluxes.

Answer: It is true that the land use data used in MM5 is not the same as the data set

used for calculating deposition. According to Guenther et al (1995) the land use data set used to derive the isoprene emissions is compiled by Olson (1992). Even though the ideal solution is that there should be no inconsistencies between the applied data sets, the authors believe that the impact of applying different data sets for meteorology and depositions is small. The largest impact is probably due to the fact that the data set compiled by Wilson and Henderson-Sellers is relatively old.

Reviewer: What are the questions, which will be addressed by the different sets of emission and meteorological scenarios?

Answer: Two different emission inventories are tested for the European domain; the EDGAR and the EMEP database. The question to be addressed is basically just for which database the model is better performing when calculated concentrations are compared to measurements. The final eight model scenarios are designed to determine the sensitivity of the model results to the resolution of the input data as well as to the inclusion of a nest. Some discussion in the scientific community has been aimed at the question whether it is necessary to have input data (meteorology and emissions) at the same resolution as the model is running, or if it suffices to use data with coarser resolution. This is the question, which we try to address with the model scenario set-up in this paper.

Reviewer: What are the "other VOC" in table 2?

Answer: The "other VOC" are not included in the model, and it is a mistake that the text appears in the Table. It is now removed.

Reviewer: If model results for ozone in February are mainly background values (are they?) how are the background values treated in the model?

Answer: Background values are not treated in a separate way in the model. The problem is that with a model resolution of 50 km the calculated concentrations are in better agreement with measurements made at high altitudes far away from influence

from strong NOx sources (in this case denoted background values). When the validation is carried out the stations above 500 meters are excluded and therefore the ozone measurements from the stations where the model is good at calculating ozone concentrations are excluded.

Reviewer: Why are the stations Oulanka and Langenbrügge selected?

Answer: The choice of the German and Finnish stations were more or less made at random. A more appropriate choice for the validation procedure is to show the time series of the mean of all stations, and this is what will be done in the final paper.

Reviewer: Is it really justified to exclude all stations above 500 m only due to the coarse resolution of the model? These stations might represent the background concentrations and can be compared to the results for more elevated layers of the model.

Answer: There are several stations where the model height of the station is much less than the actual height. Examples could be the Swiss station Jungfraujoch, which is located at 3573 m and the Polish station Sniezka located at 1604 m. For these two stations the model height is 2049 m and 462 m respectively. Due to limited disc space only the surface concentrations are saved during the model run and it is therefore currently not possible to carry out the optimal comparison for the high-altitude stations.

Reviewer: Overestimation of SO2 is partially due to the same stations; HU2, PL2, AT2; might this be due to a general overestimation of sulphur emission in parts of Eastern Europe?

Answer: This could be a possibility. The EMEP data are regularly updated, however the sources of these updates are the national reports to EMEP and some countries are known to be behind schedule. REGINA model runs with different emission scenarios are planned for the nearest future and this will provide a possibility for analysing the emission data more carefully.

Reviewer: Is it possible to compare the measured and observed daily maxima for

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ozone (particularly interesting for the summer season)?

Answer: Yes, and a scatter plot showing this comparison has been included for August.

References: Stohl, A., Huntrieser, H., Richter, A., Beirle, S., Cooper, O. R., Eckhardt, S., Forster, C., James, P., Spichtinger, N., Wenig, M., Wagner, T., Burrows, J. P. and Platt, U., "Rapid intercontinental air pollution transport associated with a meteorological bomb." Atmospheric Chemistry and Physics Vol. 3, pp. 969-985, 2003.

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Interactive comment on Atmos. Chem. Phys. Discuss., 3, 3543, 2003.

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