

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

L. M. Frohn et al.

Received and published: 9 October 2003

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

General comments:

Reviewer: The manuscript does not contribute much to the scientific progress within the scope of ACP. There are no substantial new concepts, ideas, methods or data included.

Answer: The authors disagree with the reviewer that there are not any substantially new concepts, ideas, methods or data contributed by the manuscript. We also disagree that the paper is not within the scope of the ACP. In the recent years the trend in air pollution modelling has been towards long-term calculations of one year or more and high-resolution modelling, including the different issues affecting model performance. Furthermore, the modelling community has more or less been divided in sepa-

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rate groups - one concerning global to regional modelling and one concerning regional to local modelling. In the work presented in this paper, an attempt is carried out in order to combine these areas of research in one model capable of doing long-term and high-resolution modelling covering the Northern Hemisphere and with focus on local effects. Nesting is a relatively new and evolving topic within the research field of air pollution. Several nested air pollution models exist, however none of them cover a hemispheric domain, thereby including intercontinental transport. The authors are however aware of the fact that at least two European research groups are in the process of developing hemispheric air pollution model systems. To conclude, we therefore believe that the results from the REGINA model are interesting to the community of the researchers addressed by ACP in terms of scientific progress within the field of hemispheric and nested air pollution modelling.

Reviewer: Potentially the study could give information about the usefulness (or perhaps uselessness) of nesting hemispheric coarse scale models with finer scale continental models.

Answer: The process of nesting hemispheric coarse scale models to obtain finer scale resolution over smaller areas is indeed useful in the assessment of air pollution levels. An EMEP workshop on hemispheric air pollution was held in Germany in October 2002 and one of the main conclusions was that air quality, apart from being controlled by local and regional emissions, is also influenced by emissions, transport and transformation processes at the intercontinental and hemispheric scale. However, we will try to provide a more thorough argumentation for this point of view in the manuscript.

Specific comments:

Reviewer: The model description is insufficient. There is almost no description of the modifications to the Strand and Hov (1994) chemistry. The ammonium chemistry is not described sufficiently; There is no description of the biogenic VOC chemistry in the model.

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Answer: The full description of the chemical scheme was originally not included in order not to make the manuscript too lengthy. Also the scope of the paper is not the description of the details of the chemical scheme. The scheme is thoroughly documented in a PhD-thesis (Frohn, 2003), however since this thesis is currently in print and therefore not yet available, a more comprehensive description of the chemical scheme has now been included in the paper.

Reviewer: The dry deposition scheme is not discussed at all; What wet deposition parameters are used?

Answer: The deposition is handled differently for dry deposition of 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.

Reviewer: What boundary conditions are used for the large-scale domain?; The spin-up times and the handling of initial and boundary conditions should be specified for the scenarios.

Answer: The spin-up time and boundary conditions are the same for all scenarios. A description of the spin-up time as well as the initial and boundary conditions for the mother domain and the first nest is now included in the paper.

Reviewer: The description of the eight model scenarios is confusing.

Answer: We have tried to clarify the motivation for, as well as the description of the conditions for the eight scenarios.

Reviewer: Discussions and explanations of results are lacking, e.g. why is there such a big difference in the bias between model scenario 4 and 5 (in February)? And why does the bias increase for SO₂ and decrease for SO₄ when going from model 4 to 5?

Answer: Section 4 including the discussions and explanations of results has now been rewritten and the treatment of the results is more comprehensive.

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Reviewer: The ranking method used by the authors is not very interesting in itself.

Answer: The ranking method applied in the present study is the method widely recommended by the ETEX modelling community as the preferred way of differentiating between models with different set up and similar results, see Mosca et al. (1998).

Reviewer: If possible there should also be some comparisons with other published studies, using similar models.

Answer: There are many published studies concerning the application of nested grid models with a large domain (e.g. Europe or US) and a high resolution target, see e.g. Kessler et al. (2001), Jakobs et al. (1995) or Kim and Cho (1999). Many of these studies focus on air pollution episodes concerning ground-level ozone or acid rain. The focus of the present study is the validation of the model and the sensitivity of the model results to the resolution in the input data. To the author's knowledge no similar studies have been published. Furthermore a model comparison is out of scope of the present paper.

Reviewer: Can the authors show any case where the inclusion of the non-European part of the Northern Hemisphere gives an improvement in modelled concentrations/depositions in Europe, compared to using only the "European" domain?

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). As mentioned the focus of the current paper is not the importance of intercontinental transport for the European pollution levels but rather the sensitivity of model results to input data resolution. Another reason for applying a hemispheric nested model is to calculate improved boundary conditions for the European domain. If the domain is limited to Europe the applied boundary conditions must

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be constant values or obtained from another large-scale model. Improved boundary conditions are especially important for ozone, which again is vital for the photochemistry involving many other chemical compounds. For a long-lived chemical compound like ozone the boundary conditions and spin up times are extremely important in order to achieve the right level of concentrations in the model.

Reviewer: If the authors believe that their results are better represented by the high-altitude EMEP stations why not compare to these stations too?

Answer: The problem is that the model height is not representative of the surface for high-altitude stations due to the relatively coarse resolution of the model. It is therefore not necessarily the calculated surface concentrations which represent a high-altitude station, but rather the calculated concentrations from one of the elevated model layers which should be compared to the measurements. Due to limited disc space, however, 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: Have the authors checked the quality of the measurement stations in the EMEP/CCC reports and the site descriptions on the EMEP web pages? Poor quality stations should be excluded from the validations

Answer: Yes, the quality of the measurement stations has been checked in the EMEP/CCC reports, however it is not possible to sort out stations based on the quality classification carried out in these reports. Many measurements of NO₂ and SO₂ are classified as having an expected accuracy in the annual average worse than +/-20% or unknown corresponding to the two categories with the lowest accuracy. This includes data from e.g. the German stations Westerland and Langenbrügge, which are normally considered very good background stations. Furthermore these low accuracy measurements are not detectable by inspection of the time series and therefore only stations with obvious problems (e.g. large gaps in time series or unrealistic values etc.) have been excluded from the validations.

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Reviewer: Could the authors motivate the choice of the two stations Langenbrügge and Oulanka for showing time series of different compounds? Maybe it would be more interesting to show time series for some Irish, British and/or Norwegian stations where the influences of North American emissions may be expected to be larger than in Germany and Finland.

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.

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