

Interactive
Comment

Interactive comment on “GEM-AQ, an on-line global multiscale chemical weather system: model description and evaluation of gas phase chemistry processes” by J. W. Kaminski et al.

J. W. Kaminski et al.

Received and published: 15 January 2008

Response to Referee #2

We would like to thank Referee #2 for the review and comments. In general we agree with the presented suggestions and will incorporate these in the final submission.

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Comment:

This review was submitted on the heels of the thoughtful reviews by Referees 3, 1, and 4. I agree with my colleagues that this manuscript makes a sufficient contribution to be publishable once revisions have been made to address a number of concerns

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expressed in those three other reviews and in this one. Since many of my concerns with this manuscript have already been mentioned by one or more of the other Referees, I will try to restrict myself to points not already raised.

I very much agree with the other Referees, though, about the apparent arbitrariness and lack of explanation about the choice of comparison periods. For the satellite instruments [..].

Reply:

In our paper we were faced with a decision to focus on events or a general comparison, otherwise it would be much too long in detail in order to be useful in science. We choose to follow the more general route and show that the model does a "good"; (or better) job by comparing with the measurements that have become available and of course bearing in mind that even at 1.5° horizontal resolution it is not a air quality (AQ) regional model. (We should mention that the current version of GEM, mesoglobal GEM is running at 0.33° , which would, with AQ modules represent a regional AQ model with a global domain.) For example, for our comparison of the ozone sondes we, of course, compared many more that we showed in the paper and at the end showed both good and poor cases. For the "Logan"-sondes there was no case that was poor for all seasons, but there was not much tropical data. A comparison with SHADOZ was more revealing in that pointed to potential limitations with the means by which the current version of the model handles convection and that of course is related to lightning but we felt no need to show lots of plots. For NO₂ we did a general comparison focusing on general regions knowing that China's emissions were far from correct and that biomass burning (and Boreal forest burning) has a large annual variability. But it was important to see if we could capture the general behaviour. We consider that our analysis showed that. Our comparison with the aircraft data was mean only to address the issue of other species not generally covered by satellite data such as ethane. However, the meteorology was not that for the various expeditions. However, we feel that the analysis was sufficient to evaluate the model. Ideally, we could have

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focussed on a single experiment but this has already been done in all (or most) cases. And we do plan to analyse the data from INTEx expeditions.

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Comment:

Would "GEM-AQ, an on-line global multiscale chemical weather modelling system: model description and evaluation of gas-phase chemistry predictions" be a more accurate title?

Reply:

Thank you for the suggestion. We will change the title to: "GEM-AQ, an on-line global multiscale chemical weather modelling system: model description and evaluation of gas-phase chemistry processes";

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Comment:

p. 14899, l. 8-14. How are grid-scale clouds represented?

Reply:

Grid scale clouds are produced by the shallow and deep convection parameterizations as well as the condensation scheme (based on Sundqvist scheme) for stratiform clouds. We will add a sentence in the text.

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Comment:

p. 14899, l. 24. There are some inconsistencies between the text in this section and the tables.

Reply:

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We will correct the table and make sure the text is consistent.

=====

Comment:

p. 14900, l. 20. NO_y is not a model variable (Table A1). How is this field used to constrain NO, NO₂, HONO, HNO₃, PAN, and so on?

Reply:

We will change the text to explicitly state which fields are replaced. (i.e. NO, NO₂, HNO₃, HNO₄, N₂O₅) to avoid any confusion.

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Comment:

p. 14900, l. 21. Roughly how many model levels lie between 100 and 10 hPa?

Reply:

There are 6 model levels above 100 hPa.

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Comment:

p. 14901. Just as for Referee 4, it was not clear to me that the aerosol package was activated in the five-year simulation described in this manuscript. Nothing is said in the description of the model configuration at the beginning of Section 3 about the aerosol package being turned off for the simulation, but modelling an extra 60 tracer [..].

Reply:

We will modify Section 2.2.2 to explicitly state that the aerosol package is activated in the GEM-AQ model simulation. However, since the focus of the paper is "gas phase" we feel that enough information is provided. We are continuing with model scenarios

and evaluations. The impact of the aerosol package will be evaluated in the next stage. Aerosols are important in providing surface area for the heterogeneous hydrolysis of N_2O_5 . Likewise, HOx and O_3 are important in the in-cloud oxidation of SO_2 to H_2SO_4 .

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Comment:

p. 14901. How many gas-phase species are dry deposited and how many are wet deposited?

Reply:

36 species are dry deposited and 8 wet deposited.

=====

Comment:

p. 14902, l. 11. How were the 1 deg by 1 deg anthropogenic emission fluxes interpolated to the 1.5 deg by 1.5 deg; model grid? How large were the interpolation errors globally? Locally?

Reply:

Emission fields were regridded and mass flux conservation was ensured. Although this method conserves the total flux, it leads to a reduced amplitude and horizontal spread of the emissions field. The global mass is conserved within 1%. We will add a sentence to stress that the fields were regridded and not interpolated.

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Comment:

p. 14903, l. 5. Does the sponge layer truly only act on the top model level?

Reply:

The enhanced vertical diffusion (or sponge layer) affects only the top level of the model.

=====

Comment:

p. 14903, l. 18. Are there any species in Table A1 that CMAM does not consider, and if so, how were these species initialized?

Reply:

The version of CMAM used does not have comprehensive AQ chemistry so that species such as ethane and propane and related degradation products were not available. However, these gradually built up in the system. In the paper we state a 6-month spin-up was used but by the time that we had the model in that state all of the "AQ" species were reasonably well adjusted. And of course the short-time constant species adjust very rapidly.

=====

Comment:

p. 14903, l. 24. Should sea-surface temperature be included in this list? And following Referee #3, which if any of these climatological parameters were specified to vary with time and did the time variation depend on the particular year?

Reply:

Analysed (assimilated) sea surface temperatures are used in the GEM model. Climatological fields are monthly, but they do not vary from year to year.

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Comment:

p. 14904, l. 22-23. What was the sampling frequency of the SHADOZ ozonesondes (i.e., how many profiles per season at a station)?

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Reply:

The number of profiles varies for each station and each season are as follows:

Season: DJF, MAM, JJA, SON

Fiji: 9,4,9,10

KL: 6,7,6,8

Samoa: 5,2,11,9

Watukosek: 10,6,12,13

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Comment:

p. 14905, l. 3-6. What is the approximate pixel size for the GOME measurements?

Reply:

The size of the GOME pixel for the ozone retrievals is normally 960x80 km² (Liu, 2005).
This will be added to the text.

=====

Comment:

p. 14905, l. 10-12. Were the model values matched in time to the GOME observing times for each pixel (see also Referee 3's inquiry re SCIAMACHY)?

Reply:

Yes. The model is sampled within 3 hours of the GOME observing time.

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Comment:

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p. 14906, l. 22. What is the approximate pixel size for the MOPITT measurements?

Reply:

Approximately 22 x 22 km.

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Comment:

p. 14906, l. 22-25. Were the model values matched in time to the MOPITT observing times for each pixel?

Reply:

No, the monthly averaged level 3 data was compared with monthly averaged GEM-AQ results.

=====

Comment:

p. 14910, l. 6-7. What was the GEM-AQ spatial region used to construct the vertical profiles shown in Figure 10?

The TRACE-A data is divided into 5 regions:

East Brazil Coast: 25S to 35S, 40W to 50W

East Brazil: 5S to 15S, 50W to 40W

South Africa: 5S to 25S, 15E to 35E

South Atlantic: 0 to 20S, 10W to 20W

West Africa Coast: 5S to 25S, 0 to 10E

These same regions were used for the GEM-AQ data and then averaged.

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Comment:

p. 14911, l. 23. How can methyl chloroform be used for a diagnostic metric if it is not a GEM-AQ model species? And how useful is CH₄ for this diagnostic calculation if it is not modelled realistically (see comment below re Table A4)?

Reply:

Note that we do not use CH₃CCl₃ per se but rather its lifetime which has proven a useful metric of model <OH> since it is fairly well mixed. The same comments apply to methane.

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Comment:

Table A1. A slight expansion of this table would help to tie the model description

Reply:

We will expand the table as suggested.

=====

Comment:

Table A4. According to this table, no emissions of CH₄ are considered. If true, does this not significantly affect the simulation of background tropospheric chemistry?

Reply:

At the level of global AQ calculations methane is well mixed; only for inversion of sources does one need to be concerned about the deviations from the mean mixing ratio. Thus tropospheric background chemistry will not be affected.

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Comment:

It is also very surprising that industrial emissions of higher alkenes (ALKE) are zero.

Reply:

We neglected 'higher alkenes' emission from industrial sources although we could derive it based on the 'other alkadienes and alkynes' hydrocarbon group (v12) in EDGAR2.0. Reported total industrial emission for this group is ~2.4 Tg C / year, which would enhance the total ALKE emission flux in GME-AQ by ~7.6 % (at that moment it is 31.3 Tg C/year). For the future simulations we will complete and update our emission dataset taking into all the reviewers' remarks.

=====

Comment:

Emissions of HONO are not considered either although they are often treated by regional chemical transport models.

Reply:

We based our emissions on the verified global inventories HONO emission was not available in these datasets. However, for regional applications in the global-variable configuration it is possible to combine the global dataset with a more detailed regional one and add new emitted species.

=====

Comment:

And a suggestion: if non-italics were used in this table to indicate emission totals based on the EDGAR inventory and italics were used to indicate emission totals based on the GEIA inventory, it would be possible to provide some additional information about the inventory sources of the emissions that were used by GEM-AQ.

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Reply:

The compilation of the emission dataset for the GEM-AQ chemical mechanism required lumping/regrouping of the original species. Moreover, these two inventories were compiled based on datasets from different sources. Table A4 should be treated as an overview of the emission data used in GEM-AQ simulation. Any changes in the table require additional explanation, which would be rather technical.

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Comment:

Figure 1. What is the meaning of the horizontal bars on each profile?

Reply:

One standard deviation. We will modify the caption.

=====

Comment:

Figure 2. The temperature profile panels are not mentioned in the figure caption.

Reply:

We will modify the caption.

=====

Comment:

p. 14896. For paragraph beginning on line 26, perhaps "In this study GEM-AQ has been exercised ...". And in the last sentence, perhaps "The objectives of this simulation were to ..., to ..., to ..., and to ...".

Reply:

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We will rephrase the paragraph.

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Comment:

p. 14897, l. 12. Perhaps "... Cartography) satellite observations (Burrows et al., ...".

The sentence will be rephrased to include "satellite observations"

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Comment:

p. 14898, l. 25. In previous model formulations of GEM or in other models that used the Arakawa C grid? And for sentence that begins "It is accurate to second order, ...", what does "it" refer to?

Reply:

The sentence will be rephrased to include "The special discretization is accurate to second order,..."

=====

Comment:

p. 14903, l. 20. Perhaps "... 6 months starting from 1 July 2000"?

Reply:

This can be changed.

=====

Comment:

p. 14908, l. 24. 220deg E or W?

Reply:

It refers to 220 degree from the East.

=====

Comment:

p. 14910, l. 13. "Methyl peroxide" here but "methyl hydroperoxide" in Table A1.

Reply:

Both names are correct. We will make the table consistent with the text.

=====

Comment:

p. 14913, l. 22. "chartography"? (cf. p. 14897, l. 12).

Reply:

Interesting point. The title of the paper in Acta Astronautica is spelled as "chartography". Since it is a reference it will stay the way it was published. For the name of the instrument we have followed the KNMI web site and JGR as "cartography". However, the Bremen group "prefers" "chartography". We will use "ch" to follow the Bremen group.

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Comment:

p. 14915, l. 7. Is "peraéetique" correct?

Reply: Spelling will be corrected to "peracétique";

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Comment:

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p. 14916, l. 31. Perhaps "regulatory applications"?

Reply: Spelling will be corrected to "regulatory"

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Comment:

p. 14917, l. 5. Should be "Fehsenfeld".

Reply: Spelling will be corrected.

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Comment:

p. 14917, l. 25. Can this document be obtained from the web?

Reply:

This document is not available from the web, but can be obtained from Environment Canada.

=====

Comment:

Figure 4. Are the ozone time series for hourly ozone measurements? The order of stations in figure and caption does not match the order in which these stations are introduced and discussed in text (p. 14906).

Reply:

The data points are plotted every 6 hours. We will modify the text to match the figure caption.

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Figure 5. Caption should match Figure 6 caption ("GEM-AQ and MOPITT" and explanation for white pixels). As noted by Referee 4, units in panel titles (ppb) do not match colour-bar units.

Reply: We will modify colour-bars in these figures.

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Comment:

Figure 6. Can white pixels also indicate terrain higher than 850 hPa?

Reply: Yes, this is correct. We will add a phrase.

=====

Comment:

Figure 9. The colours used for North America and for South America are similar. Swapping the colours used for South America and Africa, for example, would make it easier to see that five regions have been considered.

Reply: We will remove this figure and will define the five regions in the text.

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Comment:

Figure 10. As noted by Referee 3, a legend or equivalent is needed.

Reply: We will modify the caption.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 14895, 2007.