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Geoscientific Model Development Discussions

Interactive comment on "Implementation and evaluation of online gas-phase chemistry within a regional climate model (RegCM-CHEM4)" *by* A. K. Shalaby et al.

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1) Section 2.3: Since the coupling with chemistry using CBM-Z is the main aspect of the model development, it might be helpful to discuss the CBM-Z mechanism in a little more detail; for example, it is worth pointing out that CBM-Z is using a regime dependent approach to reduce the overall computational time.

We have added additional text about the CBM-Z mechanism on page 5, beginning at line 149.

2) On page 155, Lines 1-3: I suggest that you provide specific model names such as WRF-Chem and CMAQ.

We have added these specific model references where CBM-Z has been implemented to the manuscript text on lines 151-167.

3) Transport from the stratosphere is one of the major sources of ozone in the troposphere. How is the stratospheric ozone treated in the model?

The RegCM-CHEM4 contains 18 vertical levels with the top of the model at 50 hPa. Depending on surface pressure, the top layer of RegCM4 represents the upper troposphere/lower stratosphere. Initial top layer ozone concentrations (as well as horizontal boundary concentrations advected in the top layer during the simulation) are determined by a vertical interpolation of MOZART ozone concentrations. On average, the modeled ozone concentrations in our top layer during the simulation are maintained at lower stratospheric-like concentrations. Currently, we do not include a vertical ozone flux between the top model layer and upper stratosphere across the 50 hPa isobar. So while we do account for stratospheric ozone vertical transport between the high-ozone model top layer and the lower model layers representing the troposphere, we likely underestimate the ozone vertical flux under time periods of intense vertical transport because the top layer could be quickly depleted. We have added a discussion of this treatment to the simulation design (Section 2.7; lines 282-289) and as part of future work in the conclusions section (Section 5; lines 627-631).

4) Sect 3.1: It is not clear why there are temperature biases at those particular areas. I suggest that you at least discuss what temperature biases of 4K really mean for the prediction of ozone in the model. For example, Vieno et al. (2010) concluded that about 5K of temperature biases lead to an about 10ppb increase in ozone prediction in their model during the 2003 heat wave.

We appreciate this suggestion and have revised the temperature analysis in this section to be based on the ECAD station data. We focus on the simulation of the model daily minimum and maximum over the heat wave event and find that this guides the ozone discussion in Section 3.3 in a much more consistent manner, thereby address-

GMDD

5, C144–C148, 2012

ing the reviewer's concern to connect the temperature and ozone biases. Therefore, we have removed the spatial plot of temperature bias averaged over the month of August 2003 (former Figure 3) and replaced this with an analysis of the observed daily minimum and maximum temperature versus the model for the three main regions of the domain (page 11, lines 320-335). Additionally, we have tied these station temperature biases with the ozone bias discussion below (see comment 7, page 13, lines 384-398).

5) In Fig. 4: What are the ozone concentrations that correspond to the black circles?

This was a visualization issue in the original figures and has been corrected in the revised manuscript.

6) Sect 3.2: This part of the discussion is difficult to follow. I suggest that you use less panels (days) in Fig. 4 and clarify the discussion about what happened and what the model captures. Quantify biases whenever possible.

In order to show the evolution of the ozone event and the large synoptic changes that drive the event to a conclusion, we have retained all six panels of this figure. However, we have significantly revised the text in this section section (lines 338-365) to clarify the discussion. We have also added more quantitative text regarding the model bias for this episode.

7) Sect 3.3: Most of the ozone monitoring stations have basic meteorological measurements such as temperature and wind. These data might be helpful for diagnosing some model biases compared with observations. The analysis in this section is not fully convincing in its explanation of what leads to larger biases over central and southern Europe in the model predictions. Mean biases over a one month period do not explain the time series since in the time series there are over-predictions at some periods and under-predictions at others.

We appreciate the reviewer's comment and have revised the event temperature analysis in Section 3.1 (see comment 4, above) and have tied this analysis into the ozone

GMDD

5, C144–C148, 2012

bias discussion in Section 3.3.

8) Page 164: Simulated NO2 concentrations have large biases. Do you have any sense about the NO2 measurement biases? NO2 is source sensitive, and with the coarse model resolution, it is difficult to compare well. I suggest discussing the interpolation of results from NO2 measurement biases/uncertainty (e.g., Lamsal et al., 2008), model spatial resolution, and NO2 source sensitivity rather than stating that 'with monthly emissions, we would not expect to reproduce these daily events with any fidelity'. You probably should consider comparing monthly values according to your statement.

We have revised this sentence and discussion of the NO2 results in accordance with these suggestions (page 16, lines 473-483). We have not included the monthly values due to the fact that in the event analysis is only in a single month.

9) Sect. 3.5: During the extreme heat event, it is likely that VOC and NOx sensitivity will change from its typical scenarios. In addition, VOC and NOx sensitivity could have temporal variations during the extreme events. Please refer to Vieno et al. (2010) for some discussion related to the shifting of VOC and NOx sensitivity in the middle of August 2003 over UK.

While an examination of shifting sensitivities is beyond the scope of this paper, we have added the suggested reference and note that sensitivities may change under extreme heat events (page 18–19, lines 554-555).

Interactive comment on Geosci. Model Dev. Discuss., 5, 149, 2012.

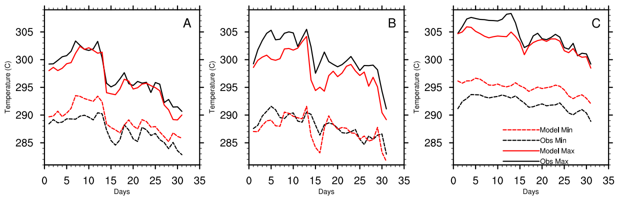

Fig. 1. Revised Figure 3

GMDD
5, C144–C148, 2012

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