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Geoscientific
Model Development
Discussions

Interactive comment on “Implementation of the Fast-JX Photolysis scheme into the UKCA component of the MetUM chemistry climate model” *by* P. J. Telford et al.

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We thank the anonymous reviewer for their comments. We provide more detailed responses below.

An excellent model development paper that transcends mere development and teaches us, giving us a new scientific understanding of atmospheric chemistry. For the most part this paper is clearly written. It contains no extraneous material, and it accurately describes the new MetUM chemistry-climate model. There are some minor revisions that I recommend below, but otherwise this manuscript should proceed

almost directly to GMD. 3218/8 Indeed the ‘new methods of validating’ are excellent and make important scientific contributions to our understanding of atmospheric chemistry. 3218-3219 Introductory section is clear and cleanly written.

3219/24 This shift from ERA-40 to ERA-Interim is very important, as we all remember the troubles with ERA-40. If possible it would be good to have a very short section on what improved or worsened with this change.

We believe the reviewer is referring to the problems with the overly rapid Brewer Dobson Circulation in ERA-40 analyses(Uppala et al., 2005), especially when employed in CTMs (see e.g.Monge-Sanz et al. (2007)). However we never encountered such large problems in the nudged model, with, for instance, the latitudinal gradient of total ozone being well reproduced (see Telford et al. (2009)) and age of air being slightly too old compared to observations, rather than too young as has been observed in CTMs driven by the ERA-40 reanalyses. We believe that this arose from the GCM dynamics reducing our sensitivity to the problems in the reanalysis. Indeed many of the dynamical features, including stratosphere to troposphere exchange (STE) are determined by the underlying model set-up and are little changed by the nudging. Therefore the switch from ERA-40 to ERA-Interim analyses is less important than in CTMs.

3220/11 Perhaps begin this sentence with clarification that we are not looking at radical change in the overall rate of HO2 + NO, but its small quantum yield to HNO3: “ In terms of reactions that transform NOx to HNO3, we also: : :” Yes thats true. We clarify that this is an additional reaction.

3220/17 Is methane fixed at 1.76 ppm (NOT ‘v’) throughout the stratosphere also? Note if a fall-off similar to observed is used. Also, the ‘v’ is incorrect and we all need to expunge it. Measurements are made as mole fraction relative to dry air. The ‘volume’ is incorrect as the Virial corrections are not applied. And thus ‘by volume’ has *some potentially large and undefined errors.*

Methane is set to 1.76 ppm throughout the stratosphere. However we note that, in the tropospheric version of the model at least, there is no attempt to realistically model stratospheric chemistry, with no Cl-Br chemistry and O3 and NOy overwritten above 30hPa. Whole atmosphere chemistry versions of the model have been prepared (Archibald et al. (2012); Morgenstern et al. (2012)) where methane is treated more realistically. ppmv has been changed to ppm.

3221/2-4 For the VOCs, the Tg yr-1 is correct, but for the lightning and soil NOx the units should be Tg-N yr-1.

Corrected.

3223/1 ' of this code (v64) into: : :" - if possible insert version that you took, it is used later also.

We have added this information as a footnote.

The only significant changes post v64 in fast-JX are noted in the later versions, you may or may not want to note these insofar as it impacts your analysis later. V66: JPL-2010 updated (not VOC) gives very small changes; NO X-sections multiplied by 0.6 based on CCMVal analysis. V67: All VOCs updated to JPL-2010, some large changes.

We note that much of the cross sections have been updated by ourselves (albeit to JPL-2006 rather than JPL-2010), and compare reasonably well to the latest Fast-JX standard cross sections in the PHOTOCOMP2 model intercomparison (in preparation), though we have yet to include the more sophisticated pressure dependence of the VOC cross sections from the latest version. When discussing the NO photolysis we mention the correction in later versions of Fast-JX.

3223/16 'cross section (including quantum yields): : :' /17 For all species but O(1D) the quantum yields are included with the X-sections. Not sure how you want to say this.

We have modified the text to try and make this clear.

/24 Somewhere in Bian's fast-J2 paper it notes that these J's were designed to be good to about 64 km (0.1 hPa), but not much above because the larger S-R cross sections were ignored and Lyman-alpha is not included.

We chose 20hPa to be conservative. This height can be easily raised if the user desires. Given the preponderance of model layers in the lower atmosphere from a speed point of view curtailing at 20 or 0.1 hPa makes only a small difference.

3224/7-10 Give units of LWP, also the units of the parameters make no sense to this reviewer: e.g., the 'b' unit is 1670 m/kg, when I divide by the cloud R-eff (m), I get 1/kg, which is then added to the 'a' parameter with units of m2/kg (this unit makes sense). Am I missing something?

This is a typo, of course the units should be m^3/kg.

3227/19 (as above) – you can note that the more recent fast-JX versions recommend scaling the NO X-section by 0.6 to deal with this.

This has been noted in the text (see above).

3228/1-12 This is very useful knowledge for the community and could be expanded as much as the authors wish.

As we noted above the results were rather uninteresting, without the dramatic improvements of performance seen in CTMs. Differences with the previous more detailed study described in Telford et al. (2009) seem to be as much a result of changes in the underlying model as changes in the analyses.

3230/16 Use of "frequencies" to described the photolysis rates is odd, I keep thinking maybe you mean different wavelengths?

This is an interesting question as to what to label what has traditionally been called photolysis cross sections. By dimensional analyses these are in fact frequencies (/s), which is what we label them. However to avoid confusion we adopt the approach of e.g. Wild et al. (2000) and relabel them photolysis rates.

3231/4 "much attrib: : :ozone column" – Is this compatible with the fact that J-O1D is probably the most sensitive J-value to ozone column? Most of the others are in the blue region which is less sensitive. /14 Lower => shorter wavelength bins

Yes, that is compatible.

3234/15-18 Good point. /19-27 Interesting analysis, this is clearly an area where almost all of us are puzzled.

The authors are glad we are not the only ones. However we do believe that the issue in this model is probably due to the upper boundary condition, the use of fixed methane or some combination of the two. We tried emitting methane in the same manner as the VOCs, but this produced high biases in CH4, and we tried changing the upper boundary condition to model output from a whole atmosphere chemistry runArchibald et al. (2012) which also did not fix the problem. However a more sophisticated approach (e.g. fixing methane lower boundary conditions as in Morgenstern et al. (2009), latitudinal dependence of choice of upper BC) may yield benefits.

3237/14-20 This section missed a proofreading. "Even with resolution of the biases in ozone there are still potential ways: : :.One obvious opinion regards: : :." Also

use of "import" in line 20 reads awkwardly.

These phrases have been removed.

Figure 9 is difficult to read and get a message from – is there any easier way to show the data?

We add an annual average profile to highlight the agreement between the model and observations, and clarify the text to improve the message for the reader.

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