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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.

Anonymous Referee #2

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The manuscript by Telford et al. discusses the main features of atmospheric composition changes resulting from the use of an interactive photolysis scheme in a global chemistry-climate model, as opposed to using an offline photolysis scheme. The analysis confirms results from previous studies, and adds new dimensions to such evaluation efforts by performing comparisons against satellite observations, and by analysing the effect of using the interactive treatment on individual important photolysis reactions. The manuscript is well-structured and useful to the community, as it explores important interactions in the composition-climate system and explores thoroughly aspects of the behaviour of a widely used chemistry-climate model. It should be published following the minor revisions listed below.

Page 3218, Lines 4-5: Please change “chemistry climate” to “chemistry-climate”.

Page 3218, Lines 17-18: Arguably photolysis is important pretty much everywhere. Perhaps rephrase to “especially in regions with large variability in cloud and constituent optical depths”.

Page 3218, Lines 19-end of paragraph: This information seems a bit out of place here. It would fit better in the model description section. The introduction section should include a bit more information on the effect of different components of the climate system (clouds, aerosols, overhead ozone, surface reflections) on photolysis, with some further references provided.

Page 3219, Lines 3-4: It should be made clearer what an “idealised atmosphere” is in this case.

Page 3219, Lines 9-12: Wouldn’t it be reasonable to use a whole-atmosphere version of the model for this analysis? Please comment.

Page 3219, Line 11-12: This sentence kind of raises the expectations that a short evaluation on how photolysis treatment improves stratospheric performance may follow in the manuscript. It should be made clear from here that the influence of photolysis on stratospheric performance is not analysed in this study.

Page 3220, Line 1: Please change “These” to “ERA-Interim”.

Page 3220, Line 4: Please remove the first “and”.

Page 3221, Line 2: Is the number given for lightning emissions in Tg(N) or Tg(NOx)?

Page 3222, Line 1: Please change “two stream” to “two-stream”.

Page 3222, Line 8: Why “Apart from the stratospheric ozone”? Was stratospheric ozone influencing photolysis in the old scheme? And if yes, how?

Page 3222, Lines 15-16: Suggested rephrasing: “Recently, interactive photolysis

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schemes have been developed that are fast enough to be incorporated into global models." Fast-J is also mentioned in the next sentence.

Page 3222, Line 21: Please put a "," after "code".

Page 3222, Line 25: Fast-JX does not exactly combine Fast-J and Fast-J2. Fast-J2 is an improved version of Fast-J (that is more suitable for whole-atmosphere models).

Page 3223, Line 4: Please change "this will now be" to "thereafter".

Page 3223, Lines 15-24: What quantum yields have been used?

Page 3225, Lines 1-3: What are the sulphate fields that have been used? Do they vary seasonally/interannually?

Table A1: Suggested change in caption: "Photolysis reactions employed in MetUM Fast-JX and the source of their corresponding absorption cross sections."

Page 3225, Line 19: Please change "the photolysis code" to "the standalone photolysis code".

Page 3225, Line 25: Please change "TES satellite" to "TES satellite instrument" (also in other places in the text).

Page 3226, Line 10: I would suggest renaming the standard scheme to "offline" or "standard" rather than "climatological". I see "climatological" as a better name for an interactive photolysis scheme using climatological fields of clouds, aerosols etc.

Page 3227, Line 3: Both this paragraph and the next more or less start with "First", which makes the flow a bit confusing.

Fig. 1: Presumably the photolysis rates are on a logarithmic scale. This should be clear on the axis.

Page 3227, Line 17-19: What are the possible implications of the NO photolysis discrepancy?

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Page 3227, Line 24: Please change “schemes” to “scheme” and add “standalone” before “photolysis”.

Page 3228, Lines 5-9: This is not clear: Why is the better θ agreement reflecting improvements in the ERA-Interim reanalysis? If I understand correctly, the improvement is in comparison to the results of nudging with ERA-40 versus the ERA-40 reanalysis itself.

Fig. 2: The fonts of the text in this figure are a bit too small. This is true for several of the figures.

Page 3228, Paragraph starting at Line 23: Other weaknesses should be mentioned as well, such as the poor comparison over the US/north Atlantic in DJF. Also, are there any known issues associated with the ERA-Interim data that can drive some of the main model discrepancies in clouds? Are there any features of the TES comparison shown later that can be explained by the cloud discrepancies seen here?

Page 3229, Line 4: Please change “is” to “likely is”, as you have not demonstrated this.

Table 2 is very useful and informative, but you should provide more information on how many flights were used. Perhaps all? If yes, provide date range or something equivalent.

Page 3230, Line 24 and onwards (till end of paragraph): The difference in the HONO performance is interesting, and attributing it to using more up-to-date cross sections in the model (i.e. implying that the measurements are not very trustworthy) sounds valid. However, the explanation given for the fact that the offline model also performed poorly is not very clear or conclusive. What does “old photolysis measurements” mean and how do we know that “much can be attributed to an overestimation of the stratospheric ozone column”?

Page 3231, Line 11: Suggested rephrasing: “This is as expected as” to “This is explained by the fact that”.

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Page 3231, Line 19: Does “average bias” refer to global?

Page 3231, Line 20-23: You can change “However” to “Although” and remove “though” from later in the sentence. Also, the separation of “that of using all 18 wavelength bins” from the rest of the sentence using commas is not ideal, as it lengthens the sentence too much. Maybe use parentheses?

Page 3232, Line 11: Please change “those” to “that used”.

Page 3232, Line 12: “six hourly” -> “3-hourly”.

Page 3232, Line 14: Please remove one “we”.

Page 3232, Lines 15-16: Please briefly mention what this method involves and what it achieves.

Page 3232, Lines 27-28: Please explicitly mention the model versions (past and present) that you are referring to, for the sake of accurate documentation.

Page 3233, Line 1: Have the authors tried to make comparison maps for the upper and lower edges of the vertical region that they analyse (400hPa and 800hPa)? As these regions often (though not always) lie above and below clouds, correspondingly, the differences may be larger. Although the weighting of the datasets towards the TES averaging kernel may be smoothing out differences even in this case.

Table 3: Please state what tropopause has been used.

Page 3233, Lines 16-17: I would not agree on this. The comparison between the offline and the interactive scheme results is a clear demonstration of how interactive photolysis affects methane lifetime, since everything else is kept the same. Possibly in the model version used in Morgenstern et al. (2012) photolysis rates would be dramatically high had they used an offline photolysis scheme.

Fig. 6: What does the standard deviation indicate?

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Fig. 7: What is the frequency of the ozone CO data that have been used to calculate correlations? Please state in the caption.

Page 3236, Line 2: Please add comma after “troposphere”.

Page 3236, Section starting at Line 24: In this section, or anywhere in the text, there is not much discussion/description of the overhead ozone column that was used for interactive photolysis calculations in the tropospheric chemistry model. What has been used, and how much do the authors trust it? Could stratospheric ozone features be driving tropospheric OH or ozone discrepancies?

Fig. 8: Please remove “of O3 column”.

Page 3237, Lines 1-4: Please clarify that the ozone biases are not caused by the use of interactive photolysis.

Page 3237, Lines 15: Please remove “a”.

Page 3237, Lines 19: You could perhaps suggest that for e.g. comparisons to aircraft data, aerosol layers and their effect on photolysis can be important (since temporal and spatial scales are relatively small).

Page 3237, Lines 23-25: Please state what you mean by “new techniques”.

Page 3238, Lines 9: Please change the second “photolysis” to “scheme” or something equivalent, in order to avoid repetition. A comma before “the interactive” would also help.

Interactive comment on Geosci. Model Dev. Discuss., 5, 3217, 2012.