

***Interactive comment on* “Cloud impacts on photochemistry: a new climatology of photolysis rates from the Atmospheric Tomography mission” by Samuel R. Hall et al.**

W.J. Collins (Referee)

w.collins@reading.ac.uk

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Review of Hall et al. 2018

This paper nicely describes J-value measurements as part of the Atom-1 campaign. These measurements and those from further Atom campaigns will provide an excellent resource for assessing chemistry models.

The overall conclusion seems to be that “A primary uncertainty remains in the role of clouds in chemistry. . .”. There should be enough information available to the authors to make some more conclusive statements. The authors need to think more about what

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are the key messages they want people to take away from reading this paper.

The paper does not appear very clear as to its main purpose. Model-measurement comparisons can be used to assess whether models are fit for purpose (which doesn't seem the aim here) or to investigate where the models can be improved. This paper touches on the latter, suggesting that there are deficiencies in the treatment of clouds, but not what. It could be that models have too much or too little cloud, or that the frequency pdf of cloud amount is wrong, or that the radiation codes don't treat overlaps correctly or the parameterisation of cloud scattering is wrong. From this paper we still have no idea where to start looking to improve the models. Given the very different results between the observations and (some of) the models it must be possible to give some more concrete statements.

A very serious deficiency of the paper is the lack of coincident cloud observations. Cloudy/clear ratios are presented but with no data on what amounts of cloud caused these, it is therefore impossible to know whether the model-measurement differences are caused purely by different clouds. Measurements over 4 days in one particular August cannot be considered a representative climatology. Were these 4 days more or less cloudy than the climatological average? Where would the observed clouds for these 4 days lie on figure S6? Even if clouds weren't specifically measured by the Atom-1, cloud data will be available from satellite measurements or re-analysis data. This will require a significant amount of work by the authors, but I don't see the value of the paper without this.

A significant improvement to the paper would come from plotting the cloudy/clear ratios as a function of cloud fraction (at different levels) for both the models and observations (or reanalysis) – or the authors may come up with a better way of controlling for cloud amount. This would overcome a lot of the issue of likely very different clouds amounts in the 4 particular observed August days with 1 random modelled August day. It would identify whether for the same cloud amount, models and measurements were calculating very different J-values.

Abstract: This needs to contain the key messages from the study.

Page 1: This page seems mostly trying to justify why it is not sensible to do point comparisons. While the real world is 3D, the model radiation codes are typically 1D and so comparing the 1D models with 3D observations would actually seem a sensible test of whether 1D models can represent the real world. More importantly, the claim that 4 days of measurements can be considered a climatology representative even of August 2016 let alone Augusts in general is never questioned. No evidence is presented as to how representative the observed statistics of clear/cloudy might be.

Page 2, line 8: "... net probabilistic distribution of observed J-values". Again this glosses over the issue that the pdfs might be specific to those particular 4 days in August 2016, rather than being a more general climatological probabilistic distribution.

Page 5, line 16: Just as 4 days of observations can't be considered a climatology, a single day in August can't be representative. It should be possible to get much more than a single day's data from these models. Most of the models seem either to use re-analysis or were nudged; did they use meteorological fields from the days of the campaign or a random August?

Page 7, line 19: Are the narrow peaks due to the frequency of clouds? It could be that some models have an average cloud fraction of 0.1 by having a fraction of 0.1 everywhere, but others have the same mean fraction with a large variety of cloud amounts. PDFs of CF and/or COD are needed (along the lines of fig 6).

Section 3.2: Given the large differences between the models it is essential to use more than the averaged cloud properties to understand the correlations between CF, COD and J-values, and how these differ between the models. How is COD calculated – does it use the same radiation scheme as for J-values or is from the climate radiation scheme?

Section 4.3: It would be useful to use UCI to replicate figure 4 for the ICAs and QCAs

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to determine how much the averaging contributes to the different distributions in observations and models.

Conclusions: This paper needs a conclusion section. As it stands it is not at all obvious what the overall conclusion of the study is, other than clouds are difficult and more work is needed.

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