

## ***Interactive comment on “Evaluating Simplified Chemical Mechanisms within CESM Version 1.2 CAM-chem (CAM4): MOZART-4 vs. Reduced Hydrocarbon vs. Super-Fast Chemistry” by Benjamin Brown-Steiner et al.***

**Anonymous Referee #2**

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Brown-Steiner et al. have performed an evaluation of the performance of a model of atmospheric chemistry run with three different chemical mechanisms to understand how big an impact there is by choosing a different chemical mechanism (network). This is an interesting paper, an important bit of science, and one of only a few examples in the literature to do this sort of work in a 3D sense. Evaluating the performance of these different mechanisms enables sound conclusions to be drawn about their utility. The aim is to see if a very simple mechanism, which would enable much longer (or many more) integrations as solving the coupled ODEs in the chemical network is computa-

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tionally very expensive, is suitable. This is a very well written paper and I could hardly spot any typos or grammatical errors above those spotted by reviewer #1. However, I would like to see further experiments performed before I would recommend that this be published. As it stands, I don't think the suitability of the Super Fast (SF – simple chemistry) scheme to be used beyond a present day set up has been demonstrated. And I think this is key for the argument that the SF scheme is suitable.

The present work focuses on fairly long integrations (25 years or so), where anthropogenic emissions are fixed but interactive biogenic emissions can change as the meteorology in the model changes. Some very nice analysis is then performed against surface observations of O<sub>3</sub> which emphasises that for these conditions, the SF scheme performs well – in accord with the other more complex schemes.

But, to be convinced that the SF scheme is suitable for long simulations of transient forcing, I would like to see simulations that test the response of the chemical schemes to the sorts of changes that have happened over the Anthropocene and for which the SF scheme may well end up being used for within CEMS (i.e. CMIP/AerChemMIP type experiments). For example, I would like to see, as a minimum, a set of simulations using ACCMIP pre-industrial emissions (you could keep the meteorology fixed as it is if that makes things easier) so that we can see what happens between these different schemes when they are perturbed with significant changes in NO<sub>x</sub> and VOC (CH<sub>4</sub>).

I also am a bit concerned with the reproducibility of these experiments outside of the team working on this. There are no mentions of compsets (is that the word used within the CESM model set ups? I'm going from here [http://www.cesm.ucar.edu/models/cesm1.2/casename\\_conventions\\_cesm.html](http://www.cesm.ucar.edu/models/cesm1.2/casename_conventions_cesm.html)) that have been used. Citing some rather old papers as the sources of the rate constants and reactions used, for example in the Reduced Hydrocarbon scheme, makes it difficult for others to test the schemes without large potential for making translational errors (I know, I have made many myself!). I would propose that the mechanism data files be made available (perhaps in a simple scv format?) or at least the compsets for

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these experiments be made available so that others can perform their own tests. GMD is a journal dedicated to holding high standards with code and I think that the mechanisms should be treated as a bit of complex code that should be archived in order to be more easily tested. This would be desirable but I can appreciate that this may not be top priority.

Minor corrections/comments:

Page 8, line 23: A key conclusion of Squire et al. was that sign of the response to changes in emissions of isoprene was different in SF compared to more complex schemes traceable to our best understanding of the chemistry of isoprene (ie. the MCM). I think this needs to be acknowledged here in addition to current acknowledgment that "there are biases in regions of high biogenic chemistry".

I note from Table S2 and from the discussion in Squire et al., that the SF scheme does not include NO<sub>3</sub>. Presumably the bias in isoprene at night (Figure 9) could be solved by simulating NO<sub>3</sub> in the SF scheme? Have the authors considered this? It was not clear from the manuscript if that was tested in addition to the nice tests looking at the impacts of adding in PAN and N<sub>2</sub>O<sub>5</sub>.

Table S2, reaction 14: "idential" should be "identical".

Figure 8: Axis labels are way too small. Please make bigger. As above for Figure 9.

How are the VOC emissions dealt with between the different schemes? I presume that there are different amounts of VOC that go into the simulations? Please can you clarify the magnitude and distribution amongst molecules of the VOC emissions. Emissions are a key part of the chemical mechanism in my opinion.

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