

Geosci. Model Dev. Discuss., referee comment RC2  
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## Comment on gmd-2021-173

Anonymous Referee #2

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Referee comment on "An improved carbon greenhouse gas simulation in GEOS-Chem version 12.1.1" by Beata Bukosa et al., Geosci. Model Dev. Discuss.,  
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Review of "An improved carbon greenhouse gas simulation in GEOS-Chem version 12.1.1"  
by Beata Bukosa et al.

This paper simulated CO<sub>2</sub>, and CO<sub>2</sub> production by oxidation of CH<sub>4</sub> and CO using 3 different types of OH fields. The topic of research is important for better estimation of CO<sub>2</sub> sources and sinks on the Earth's surface. The distribution of OH is heavily concentrated over the tropical region, where CO<sub>2</sub> would be added to the atmospheric CO<sub>2</sub> due to oxidation of CO and CH<sub>4</sub>. If ignored this CO<sub>2</sub> chemical production, biased source of CO<sub>2</sub> is needed from the tropical land and ocean regions by inverse modelling. I very much liked the idea of this research, but unfortunately wasn't able to read through the whole manuscript due to poor execution of the research idea, in my opinion. Thus I cannot recommend publication of this work in Geoscientific Model Development in the present form or anything close to this. It is better to rerun the model and submit a newly prepared manuscript.

Here are some of my major concerns:

Table 1: For example, "Coupled only" : I do not understand - are all CO are produced from CH<sub>4</sub> oxidation ? If so you are going to underestimate CO. If not, is CO in L(CO) and P(CO)ch<sub>4</sub> are different entities, then there is a good chance of double counting

Formulation of Eq. 1 & 2 (also for CO): Not correct !!, I think Eq. 1 and Eq. 2 are not separable in a chemistry-transport model, except for "tagging". Please clarify or rectify errors

Figure 2: Quite large differences in OH. Acceptable? May be you should run CH<sub>3</sub>CCl<sub>3</sub> tracer of checking your OH.

Figure 5 (left column): the P(CO)ch<sub>4</sub> and P(CO<sub>2</sub>) are apparently not consistent with the OH fields in Figure 2.

This where I had to stop going forward or read the text carefully. I am extremely sorry, but this has to be solved first before interpreting the results. You have about 20% higher OH for the red and purple lines, compared to blue, both at the surface and at 500 mb when averaged over a year (Fig. 2). But here in Fig. 5, we find the blue line is close to purple than the red line for P(CO<sub>2</sub>), and also I cannot explain the relative values of P(CO)ch<sub>4</sub> as expected from the OH fields. I understand that the OH level is affecting the concentrations of CO and CH<sub>4</sub> and then you get very mixed pictures for P(CO) or P(CO<sub>2</sub>). But these are not realistic, because we only have one state of CO and CH<sub>4</sub> concentration distributions (strictly). If you are checking the effect of OH then design experiments accordingly, and so on. Please consider.