Atmos. Chem. Phys. Discuss., 8, S10434–S10438, 2009
www.atmos-chem-phys-discuss.net/8/S10434/2009/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "The CO_2 inhibition of terrestrial isoprene emission significantly affects future ozone projections" *by* P. J. Young et al.

Anonymous Referee #2

Received and published: 14 January 2009

===== General comments:

This manuscript describes the impacts of CO2 inhibition of isoprene emissions on tropospheric ozone chemistry in the UM_CAM future simulations. The authors interpret and discuss their model results very carefully well mentioning both chemical and physical aspects.

The experimental scenario and setup are basically straightforward. Their simulation of CO2 impacts on isoprene emissions and underlying key mechanisms seem to be described in the manuscript. However, their simulation of isoprene emission response associated with CO2 changes does not seem to be clearly shown in the manuscript. The authors could better present it, I think.

At present, actual response of plants to atmospheric CO2 and associated isoprene emission change appear to be very uncertain and dependency of such processes on vegetation type has not been clarified yet as well. In this sense, CO2 effects on isoprene emissions can not be treated properly in a global model at the present knowledge level. So, the results from this study should be regarded just as a potential. I feel the authors should be more careful with this point, and should emphasize it more in their discussions and conclusions.

The overall text is competently written, and reference to related previous studies is appropriate and adequate, several sentences seem to be tediously written, though.

The subject of this paper appears to be appropriate to the ACP. Changing process of tropospheric ozone is complex, and there are only a limited number of studies on future ozone projection including climate change impacts. And, given the large importance of ozone for understanding climate change, this study can be regarded as a significant addition to the current knowledge. However, I would like the authors to consider my questions and revise the manuscript before I recommend the publication of this paper. Details of my comments will be found in the following.

===== Major comments:

Block-19892:

*** L20: "lifetime by ˜7 months" :

Is it possible to describe this using percentage change instead of absolute lifetime (or adding it in parentheses) ?

*** L21-: "and emphasize the problems of using globally averaged climate metrics..."

The meaning of this part appears to be unclear to those who reads this paper from the first. The authors should explain more.

Block-19894-19895:

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"LPJ-GUESS and isoprene emission" :

This section discusses the mechanism of isoprene emission response to atmospheric CO2 changes with showing the previous experimental studies, briefly mentioning their used vegetation models. However, their adopted methodology of isoprene emission simulation was not so clear to me. Please clarify in the text if you use the parameterization like Arneth et al (2007a), or simulate explicitly isoprene emission response with a process-based calculation.

Block-19895:

*** L16: "successfully reproduced the leaf isoprene response observed in most experimental studies in which plants were grown in a range of CO2 environments (Possell et al., 2005)."

What kind of plants are considered in those experimental studies ? I presume that most important plant type for global isoprene emission is the tropical rain (evergreen) forest. Such is included in those studies ?

*** L26: "Clearly, a larger number of studies are needed to establish the CO2-response more firmly, but when included based on our current knowledge the CO2-inhibition of isoprene emission has the potential to counter the stimulating effects of higher temperature and vegetation CO2 fertilization in a range..."

Does your model include temperature and CO2 fertilization effects on isoprene emissions ? If so, you should mention the simulated sensitivities to temperature and CO2 fertilization, apart from CO2 inhibition effect. At least, the authors should describe their treatment of these two effects in the model.

Block-19896:

"2.2 UM_CAM chemistry-climate model"

Could you add description of your adopted lightning NOx emissions with its global

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amount (TgN/yr)? This appears important for interpretation of your results especially for the tropics.

Does CO2 inhibition cause any impacts on dry deposition process in your model ?

Block-19897-19898:

"3 Experimental description"

Are meteorological fields in noCO2 and wCO2 runs identical completely ? If your model includes feedback from chemistry to climate, meteorology should differ between these two runs. In that case, it might be difficult to extract the impacts of CO2 inhibition only.

I'm bit concerned about (year) ensemble number of your three runs (baseline, noCO2, & wCO2). Presumably, the authors used ten years simulation for their analysis. Please describe it in the text.

*** Fig. 2.:

Does this result (wCO2) include CO2 fertilization as well as inhibition ?

Block-19899:

*** Fig. 3(a).:

The picture displays large reduction (5-10 ppbv) over the Indian ocean in January. Please describe this and the reasons.

*** Fig. 3(a,b,&c).:

These pictures depict differences between two distinct model runs. Did the authors check the statistical significance of this results ? I recommend for the authors to check it with the t-test or other valid metrics for the individual model grids and highlight the statistically significant grids only in the pictures.

*** L17-: "The ozone increase resulted from reduced sequestration of NOx by isoprene oxidation products (isoprene nitrates and PAN) (e.g. Roelofs and Leliveld, 2000), lead-

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ing to increased NOx levels (10?30%) and increased ozone production in 20 these regions, as well as reduced isoprene ozonolysis (as noted by Fiore et al., 2005; Wiedinmyer et al., 2006)."

I think reduced ozonolysis is the dominant factor for the ozone increases rather than reduced NOx sequestration, since the NOx levels in Amazon Africa are not so high.

Block-19902:

*** L23-:

"As well as emission perturbations, climate change also contributes to the impact on ozone. In UM CAM, the effect of climate change alone on the tropospheric ozone burden is a 3.5% reduction (Zeng 25 et al., 2008), mainly attributable to an increased loss rate with the higher humidity in a warmer climate."

How about the impacts of temperature increase (or decrease) on isoprene emissions and associated ozone distribution changes in your model ? If your model includes temperature impacts on isoprene emissions, you should contrast them with impacts of CO2 inhibition.

Block-19904:

"conclusions"

The authors should mention the model diversity of the response of ozone distribution to isoprene change as discussed in section 4 with suggesting the potential reasons for it.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 19891, 2008.

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