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Comment on gmd-2022-154

Anonymous Referee #2

Referee comment on "Isoprene and monoterpene simulations using the chemistry–climate model EMAC (v2.55) with interactive vegetation from LPJ-GUESS (v4.0)" by Ryan Vella et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-154-RC2, 2022

"Isoprene and monoterpene simulations using the chemistry-climate model EMAC (v2.55) with interactive vegetation from LPJ-GUESS (v4.0)", by Ryan Vella et al.

The manuscript by Vella et al. documents the coupling between EMAC and two terpenoid emission schemes driven by dynamic vegetation from LPJ-GUESS. The results from the two schemes are compared against each other, as well as to emissions computed directly inside LPJ-GUESS. In addition, a series of doubled CO2 concentration simulations was performed to illustrate the sensitivities of the simulated terpenoid emissions to these.

Overall, the paper presents an important linkage between ecosystems and atmospheric chemistry, and it is good to see this linkage represented in the EMAC system. While the simulations themselves and their analysis may not be very novel, the implementation serves a clear purpose, and a manuscript like this documenting model development is well suited for GMD.

The description of the coupling may need some clarifications (see below) but is overall fine, and analysis and its description are understandable, but the manuscript would benefit from a better explanation of the simulation setup in the Methods section, to provide the information on the simulations on beforehand. In particular, it would be good to describe whether these simulations are run as bi-directional interactions (L. 336) including changes in the climate caused by the changes in atmospheric chemistry, or whether the setup simply tests the emission response, but not the EMAC response to these (which I guess is the case). Also, it would help to understand the role of the results from the BVOC emission routine in LPJ-GUESS (Fig. 9), which are presented separately from those of the two other schemes – are these available for use in EMAC as well, or are they only presented here for comparison?

Apart from that, it would be good to clarify more clearly in the Methods section which elements of the coupling come from LPJ-GUESS, and which are assumptions that are used to "interpret" the LPJ-GUESS results inside ONEMIS or MEGAN in the model description. I have indicated the places that are unclear below.

I expect that the manuscript will be suited for publication in GMD once these comments have been accounted for.

Major remarks:

- L. 23: Oxidative stress is one possible reason for BVOC emissions, but they can also be triggered by other chemical, physical or biological stresses and processes (e.g. herbivory, signaling between organisms, or also oxidative stress originating from the atmosphere, e.g. under elevated ozone concentrations)
- L. 25: I think that all plants emit BVOC, but they can emit very different compounds, and not all emit isoprene.
- L. 91: It would be interesting to summarize the difference between ONEMIS and MEGAN a bit further. E.g., in the later text, it appears that the two treat canopy structure in a different way. It would be good if the authors could give a brief description of the two schemes, as they are so fundamental for the rest of the paper.
- L. 107: I think that LPJ-GUESS v4.0 contains a functional land use scheme, see Lindeskog et al. 2013. In general, I think that the fact that land use is not represented should receive more attention in the discussion, in particular because the original emission schemes appear to represent crops. How important is this omission for the outcomes generated by the LPJ-GUESS-informed emissions schemes (ONEMIS and MEGAN)?
- Section 2.3.2: The authors have chosen to use LPJ-GUESS to provide information on LAI and PFT distribution, but other characteristics that are required for ONEMIS or MEGAN are not taken from LPJ-GUESS, but rather computed with the help of database numbers. Foliar density (L. 135) is computed from simulated LAI, rather than from the foliar C simulated by LPJ-GUESS. Why is this done? And how similar or different are the applied specific leaf weights from those used in LPJ-GUESS itself? The same applies to the LAD distribution, which is taken from some standardized profiles, rather than using LPJ-GUESS' vertical distribution of LAI. It would be nice to hear more about this, and mention explicitly which information comes from LPJ-GUESS, and which from other (literature) sources. E.g., I guess that the canopy height (h) in Eq. 2 comes from LPJ-GUESS and does not use the fixed height of 25 m (L. 160), given the simulated variations in canopy height (Fig. 5), but I cannot find this in the description.
- Results: At several places, seasonal variations are displayed as global mean (Fig. 4 bottom panel; Fig. 7 and 8 third row, Fig. 9 second row). However, the opposite seasons in the Northern and Southern hemisphere make it hard to interpret these; it would be nice to see them separated for the two hemispheres, or have them shifted by 6 months before adding, to represent the true seasonal cycle.

- L. 225: I agree that the representation of LAI has improved, but for the isoprene emissions, it is also important that the vegetation distribution has improved. Is this the case? See also my earlier remark on the representation of crops.
- L. 267: Why is the BVOC emission routine from LPJ-GUESS presented separately here? Is it available for use in EMAC, or is it just for comparison here? It would be interesting to see the results compared to Fig. 7 and 8 (again, please ensure that colour scales are the same). The description of the BVOC emission routine in LPJ-GUESS should be part of the methods section – this would also help to clarify what the status of this is relative to the other two emission schemes.
- Section 3.3: The description of the setup of the sensitivity simulations should be part of the methods section.

Minor remarks:

- Figures: It would help to add labels (a, b, etc.) to the panels in the figures, to make the references to the figures more accurate.
- L. 37: Check spelling of "monoterpene"
- L. 48: Not all stress effects are represented (properly) in our current process-based models.
- L. 90: "this schemes" – does this refer to the two emission modules?
- L. 132: "number of leaves": Do you mean "amount of leaves"?
- L. 202: Clarify that "broadleaf" and "needleleaf" are trees.
- Fig. 7 and following figures: Please ensure that the colour scales for the ONEMIS and MEGAN panels are the same, so that the patterns can be easily compared. Also, please clarify the use of the "climatological input": Is this a climatological input to ONEMIS and MEGAN (and how do the two schemes compare when running these climatological results), or is this one set of climatological input of emissions to EMAC?
- L. 213: "Elevated" isoprene emissions. Elevated relative to the climatological inputs? Please specify what the reference level is here.
- L. 236: "cross-annual": do you mean interannual?
- Fig. 11: Please check the figure quality/resolution for the final publication, it is a bit blurred in the discussion paper.
- L. 331: The first sentence could be removed.
- L. 342: Check spelling of "climatology"
- L. 349: "when the difference in the prescribed monthly LAI": Do you mean the year-to-year difference here?

References:

Lindeskog, M., Arneth, A., Bondeau, A., Waha, K., Seaquist, J., Olin, S., & Smith, B. (2013). Implications of accounting for land use in simulations of ecosystem carbon cycling in Africa. Earth System Dynamics, 4 (2), 385–407.
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