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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Impacts of future land use and land cover change on mid-21st-century surface ozone air quality: Distinguishing between the biogeophysical and biogeochemical effects" *by* Lang Wang et al.

Anonymous Referee #2

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This paper advances a new framework for quantifying the influence of land use and land cover (LULC) on surface ozone. The authors separately consider feedbacks labeled biogeochemical, defined as the responses of sources and sinks of ozone through vegetation, and labeled biogeophysical, defined as physical climate feedbacks in response to changing albedo and the responses of surface energy budgets and hydrologic cycling, and thus atmospheric circulation. Two scenarios for LULC out to mid-century are considered, RCP4.5 and RCP8.5. The authors conclude that the impact from biogeophysical pathways is important and can be larger than that from biogeo-

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chemical pathways.

General points:

1. It would be useful to add some discussion regarding the potential for low frequency climate variability to influence the findings given that SSTs and sea ice are prescribed, and only a single ensemble member is used. See for example Deser et al., 2012: Deser, C., Knutti, R., Solomon, S. et al. Communication of the role of natural variability in future North American climate. Nature Clim Change 2, 775–779 (2012) doi:10.1038/nclimate1562

2. The treatment of vegetation, specifically what is prescribed versus calculated in the model should be clarified in the text. For example, LAI is described in Line 192 as being prescribed from observations, yet Figure 2 shows changes under the LULC scenario. Are these future changes prescribed as part of the LULC scenario or is the vegetation changing dynamically?

3. What are the assumptions underlying the number or fraction of isoprene emitters in the forest in the land model? Is it assumed that the emissions of isoprene from a forest are constant over time and globally in the model? Similarly, what assumptions underlie the treatment of dry deposition in the model?

4. Is anything else besides LULC changing albedo in the model? This seems to be the case in Figure 5b (and 8b?), where there is no corresponding change in Figure 2. Is snow cover changing dynamically in the model? Some discussion is needed. It could be useful to show the change in cloud cover too.

5. It first appears in Figure 4 that LULC is larger in RCP4.5 than in RCP8.5, which becomes more apparent later, and is briefly mentioned in the text (Lines 523-524). It would be clearer to include some discussion of this when these results are first displayed. Furthermore, are LULC changes in these two RCP scenarios consistent with the assumptions for greenhouse gases and other emission changes? Or is LULC de-

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coupled from choices about other emissions?

6. The conclusion and discussion section is somewhat redundant with earlier text. I suggest shortening to focus on the most important messages of the paper and their implications.

7. The figures are small and hard to read.

Detailed points:

8, Lines 72-74. What about direct reaction of O3 + HOx and non-stomatal pathways for deposition?

9. Lines 102-104, and Figure 4, and elsewhere: Are these annual mean values or summertime?

10. Line 238. What are the time periods considered for present and future?

11. Line 405. Doesn't NOx decline sharply in the RCP scenarios in this region? Emissions are held constant in the model to isolate LULC changes, but some acknowledgment that the full scenario would have large ozone changes due to precursor emission changes seems warranted. Do the LULC changes amplify or dampen the emission driven changes?

12. Line 408. Does this chemistry require updating in light of newer work indicating sufficient OH recycling at low NOx levels? At minimum, some discussion is needed.

13. Line 441-443. This discussion is qualitative when it should be possible to quantify the findings. For example, why not report a spatial correlation to strengthen this point? Also, are the dry deposition and isoprene emission patterns the same in the offline and online versions? From Table 2, I expected more damping of the responses in the offline version but it's really hard to compare Figures 3 and 4 beyond looking at patterns. Improving the figures to enable the reader to extract more meaningful and detailed information would be helpful.

14. Line 519. Where do we see that soil is drier?

15. Line 544. Why not show the same evidence as for Figure 6, perhaps in the supplement?

16. Line 550. Should this be RCP4.5 here? Otherwise this sentence does not make sense.

17. Line 555-556. This discussion is unnecessarily speculative as it should be possible to demonstrate whether this mechanism is operating in the model or not.

18. Line 560-562. Would be helpful to refer to Figure 2 here.

19. Line 572. How have local responses been separated out here? Wasn't LULC changed everywhere in the model at the same time?

20. Line 586. Could refer back to Table 2 here.

21. Line 622-623. Briefly explain how this conclusion was reached. Are these the only mechanisms by which the model can respond to changes in LULC?

22. Figure 1. Some additional detail could be added here. For example, in the green box, won't the sign of the change depend on the location dependent to how the westerlies are displaced? Similarly, in the yellow box, should the sign of the change depend on local chemistry and emissions in the case of isoprene, and also on location with respect to the anomalous high and changes in moisture divergence or net surface radiation?

23. Table 2. Why not add columns for the changes in surface ozone here?

24. Figure 4. How has significance been assessed? This should be explained in the methods section.

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