

## ***Interactive comment on “Historical CO<sub>2</sub> emissions from land-use and land-cover change and their uncertainty” by Thomas Gasser et al.***

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CO<sub>2</sub> emissions from land use and land cover change (LULCC) are uncertain as they are not directly observable. In the annually updated Global Carbon Budget, two methods are used to estimate the emissions: a book-keeping approach based on LULCC data and empirical response functions, and results from process-based dynamic global vegetation models. T. Gasser and co-authors present results from a model (OSCAR) which combines book-keeping approaches with process-based modelling. There are several benefits to this approach, including an additional, constrained estimate of annual CO<sub>2</sub> emissions from the land and a method for evaluating sources of uncertainty. This manuscript describes some of these results. Overall I think this is a very strong manuscript, it is well written and forms an important contribution to the Global Carbon

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Project. I appreciated having an explanation of the model in the Appendix (although I have noted a few questions about this below). My primary concern is about the choice of constraint and sensitivity of model results to the choice, which I explain below. There a couple of other 'substantial' comments, and a few minor comments.

The constraint:

First, what is the constraint used in reducing the ensemble of simulations (as in, what is the value)? I see it is given at Line 112, but I think this is an important piece of information to include in the Methods and in Section A.5.

The choice of constraint seems very important. It's not clear how robust the results are to the choice of constraint (which is important given how uncertain the constraint is). Although this is not discussed in the manuscript, some information about sensitivity of results to the constraint is provided within the figures and tables. From examining Table 2 – in general there is overlap between the annual and cumulative emissions when comparing the two methods of constraining OSCAR. The biggest differences are for cumulative land carbon sink (which I think makes sense given that the original constraint mostly impacted the land carbon sink in Figure 1c, indicating this is a large source of potential uncertainty), and for LASC (which has a strong dependence on the land carbon sink, so that makes sense as well). I think the manuscript should include discussion of this sensitivity; and justification for choosing the constraint in this study.

A related question I have (although maybe not for this paper): The uncertainty analysis revealed that biogeochemical parameters contribute to large proportion of the model uncertainty. This is attributed to the carbon densities (Lines 175-176), so it makes me think an additional constraint could be carbon stored in soils and vegetation. Have the authors considered using present-day carbon stocks as an additional constraint?

Other comments:

Lines 435-438: The pre-industrial steady state carbon pools are determined using

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average climate variables from 1901-1930. I'm not sure how much IAV occurred during this time period, but using average climate, rather than looping through years (as in GCB), will neglect the impact of IAV on the pools. Is it possible this has an impact on the steady state pool values, and would cause spurious transient responses when switching to the historical transient simulations?

Lines 284-286: Annual emissions would be less without changes in environmental conditions (according to the model): in terms of what the model is simulating, why is this? (e.g. is it increasing fire emissions? More land carbon without the changes resulting in higher emissions? Etc)

Minor comments

OSCAR calculates carbon stocks and fluxes for average biomes within 5 regions – what are the biomes? I think these should be stated up front in Section 2 and in A.1. Also state number of regions.

Line 181: Typo; I think you mean Table 3.

Lines 358-359: Could you clarify what “definition 3” and “definition B” are?

Line 383: Recommend replacing ‘a fortiori’, I had to look it up

Line 439: The word “past” here is a little vague; in my mind it can mean either ‘beyond 1950’ or ‘further in the past than 1950’; perhaps just change to ‘after’ (I think that’s what is meant here).

Lines 435-455: Perhaps reference Figure 1 and related discussion here to note that there is further discussion of the effect of the constraint in the main text.

Lines 451-453: It would be helpful if you state here the number of model parameters, and refer to section A.7 where they are introduced.

Section A.7: Which CMIP5 experiments were used for calibrating the sensitivity functions?

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Eq 19: How is tau\_shift determined? Also it's not clear how Eq. 13 is used to derive Eq. 19. Is this a typo?

I can't see where Fslash comes into the overall equations, other than the initialization step in Eq. 31.

Sorry if I have missed it, but I also don't see an explanation of how the LASC is calculated. I assume it's related to Eq. 42 but without transient LULCC?

Table A2: What are the units (Mha)?

Figure A1: Is the brown line in panel (e) mislabelled?

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