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Interactive comment on "Historical CO_2 emissions from land-use and land-cover change and their uncertainty" *by* Thomas Gasser et al.

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Comment 1.1

General points

In this study, the authors investigated the historical carbon emissions caused by land-use change using a reduced-form Earth system model, OSCAR. They conducted a series of ensemble simulations to obtain the best guess and its associated uncertainty of the land-use-induced emission. The estimated historical cumulative emission, 206±57 Pg C, is substantial and looks consistent with those obtained by previous global carbon budget studies. Land-use change is an important anthropogenic CO2 source and related to various human activities such as agriculture and urbanization. Therefore,

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clearly, this study falls within the journal scope and will carry implications on the global carbon budget.

Response 1.1

We thank the referee their comments and for recognizing the potential impact of our work.

Comment 1.2

On the other hand, the methodology they adopted is slightly complicated. They proposed a unifying approach for the bookkeeping model and dynamic global vegetation models, but I could not understand how these approaches were integrated into the OSCAR model. It was impressive for me that the model allowed a large number (10,000) of ensemble simulations, but how biogeochemical parameterizations were perturbed was not adequately described. Although the authors provided long appendix, the methodology should be clarified in the main text (section 2.).

Response 1.2

Done. The following text was added to section 2.

These parameterizations are drawn randomly and with equiprobability from a pool of potential sets of parameters. This main pool is obtained by combining smaller pools of available parameterizations for separate processes (or group of processes), as described by (Gasser et al., 2017). For instance, recalibration of the preindustrial steady-state led to 11 possible parameterizations for preindustrial net primary productivity and turnover times, 4 for preindustrial wildfire rates, 5 for preindustrial export fractions from crop harvesting, and 2 for those from animal grazing. This is already a total of 11 $\times$ 4 $\times$ 5 $\times$ 2 = 440 parameterizations. These are further combined with available parameterizations for other elements such as the transient response of the land carbon cycle to atmospheric CO2 and climate change, or the handling of harvested wood products, which leads to a main pool of $\sim$1.5 million sets of parameters.

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Comment 1.3

The evaluation of the loss of additional sink capacity (LASC) is the remarkable feature of this study, although it looks to depend heavily on previous studies such as GCP2019 and FRA2015. Overall, the manuscript is well written and I recommend a few amendments as seen below.

Response 1.3

Thank you for the support. We note that our study uses GCB2019 and FRA2015 data as input, and so it does depend on that data as much as any other modelling study depends on their own input data. We do not see that as a weakness.

Comment 1.4

Specific points

Line 79: Please provide more specifications of the OSCAR model, such as spatial resolution, spin-up method, time step, etc.

Response 1.4

The first paragraph of section 2 has been extended with this information: OSCAR is not spatially explicit, but the global land C cycle is divided into 10 broad world regions; it does not require spin-up because the preindustrial steady-state is directly calibrated on TRENDY models; it works with a yearly time-step.

Further information is available in Appendix, and ultimately in the description paper of the model (Gasser et al., 2017).

Comment 1.5

Line 83: Can you explain more about the “10,000 different biogeochemical parameterizations”?

Response 1.5

Done. See response 1.2.

Comment 1.6

Line 92: In general, Results section should present exclusively the outcomes obtained in the present study and so should not include citations to other studies. The present "3. Results" section looks more like a "Results and Discussion" section. Please consider restructuring of the manuscript.

Response 1.6

We fully understand the referee's point of view, and acknowledge that our structure somewhat differs from that of a typical paper. However, we are reluctant to change the structure for one main reason. The way we wrote the "Results" section is meant to take the reader progressively through several aspects of our simulations, each time comparing our results with reference studies to give confidence as to the performance of the model and the robustness of the subsection's results and those of the next sub-sections. Separating results and comparison would somehow suspend the reader's validation of our results until the discussion section, or force a tedious back-and-forth between both sections. Additionally, it seems a stand-alone section for comparing our results to existing ones would imply having a significant amount of repeat in the text.

Therefore, we stick to the initial structure. Nevertheless, to make it clear from the start, we renamed section 3 "Results and comparison to existing estimates".

Comment 1.7

Line 107: Can you specify what is "the change in empirical constraint" responsible for the larger LASC?

Response 1.7

This is specified in the following sentence (and already was in the previous version of the manuscript).

Comment 1.8

Line 223: Please explain what are the “seven categories of LUCCC activities”, in a consistent manner with those in the “2. Overview of the methodology” section (only three activities in Line 69-70).

Response 1.8

Done. We have added the following text at the beginning of section 3.5.

These categories are essentially a subdivision of the main three LULCC activities mentioned previously in the short description of OSCAR. Category 1 corresponds to land-cover change (LCC) where forest is replaced by cropland. Category 2 is LCC where forest is replaced by anything else (but forest). Category 3 is the opposite of 1 and 2: LCC where any type of land but forest is replaced by forest. Category 4 is LCC where non-forested natural land is replaced by any anthropogenic land. Category 5 is the opposite of 4. Category 6 is any LCC happening among anthropogenic land (e.g. pasture to cropland). Category 7 is the sum of wood harvest and LCC happening from any type of natural land to the same type of natural land (e.g. forest to forest). Note that because of the model’s structure, the effects of shifting cultivation are included in their corresponding LCC categories.

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