

Interactive comment on “Harmonization of Global Land-Use Change and Management for the Period 850–2100 (LUH2) for CMIP6” by George C. Hurtt et al.

George C. Hurtt et al.

gchurtt@umd.edu

Received and published: 22 July 2020

Anonymous Referee #1 (Received and published: 4 June 2020) General comments: The authors seek to provide fractional land-use patterns, underlying land-use transitions, and key agricultural management information for the time period 850-2100 at 0.25 degree resolution, all while having a smooth transition between methods applied to past and future results and preserving the future changes. Such an effort is of high importance to both the land surface and climate modelling communities, as maps of this type are essential drivers in simulations studying the feedbacks between the land surface and the climate. This work builds on a previous product, LUH1. Some changes

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are an increase in spatial resolution (0.25 degree instead of 0.5 degree); a larger list of 12 subgrid scale land-use types used in the land-use transition matrix; and tracking of key management activities related to agriculture. The authors clearly state assumptions they make in the work at various points in the manuscript, which is fine; I don't require justification for clearly-stated assumptions, although it's always welcome.

Overall the work is high quality, and I believe should be published with only minor revisions.

Specific comments: It was only in section 2.12 that I understood that eight different LUH2 scenarios are available for the future, and (I assume) one for the historical period. I was under the impression that the IAM runs were somehow averaged to create one trajectory from 850-2100. Assuming I am not mistaken, it would be good to clarify that in the abstract and/or introduction, to let users know precisely how many trajectories are available.

> We have now specified the number of scenarios (eight) in the Abstract and the 3rd paragraph of the Introduction.

In section 2, line 125, A and m are solved for. That implies that f and l in Eqs. 1 and 3 are already known. For someone unfamiliar with the process, it's not clear how the inputs listed in lines 127-133 lead to this, before reading all of the detailed description. A short sentence making the explicit link would be welcome here to ease the reader in to the more detailed discussion. For example, when discussing shifting cultivation (line 261), the authors “abandoned the Heinemann et al. (2017) prescribed percentage of total cropland area in the grid cell (e.g. cropland to secondary land), and cleared the same area from natural vegetation”. This sounds like it could be A given in Eq 1. Therefore, it's not clear to me what is being solved for in Eqs. 1 and 3, and how the datasets listed in Section 2 contribute to that. Perhaps even a short paragraph would be useful to clear that up. Section 2.11.1 addresses this, but it's easy for the reader to be lost by then.

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> Thank you for this constructive feedback. We have attempted to clarify this by simplifying the way in which the cropland management vector is described, and adding a line to the paragraph right before Section 2.1 (which is in addition to the details already given in that paragraph).

The wood harvest numbers are detailed in Section 2.5; however, it's not clear how this feeds into Eqs. 1 and 3. Combined with the forest loss map from 2.6? Perhaps this is described a bit more in Sections 2.10.1 and 2.11.2, but it would be good to keep the reader on track earlier, making sure each section is tied to the overall goal of solving Eqs. 1 and 3.

> We have added a sentence at the beginning of Section 2.5 that references Eq. 1 and points the reader to the additional details that are given later in Sections 2.10 and 2.11.

From Section 2.9, I understand that LUH2 does not simply use output from IAM inter-comparison projects or separate runs; significant work was carried out to harmonize the input and create a consistent set of IAM simulations specifically for this project. That deserves more emphasis, in my mind; incorporating a couple words around lines 90 would be good.

> Thank you for this suggestion. We have added several additions to the third paragraph of the Introduction to help emphasize this more, including additional references to IAM publications that describe these scenarios in more detail.

Is the paragraph starting around line 525 part of the "Harmonizing inputs" section? It seems to be part of a section dedicated to smoothing the transition between the historical and future datasets, although I don't see such a dedicated section. I understand "Harmonizing inputs" to be harmonizing the data that goes into the IAM runs. If this paragraph is really discussing that, a sentence to make it more clear would be appreciated. Conversely, if "Harmonizing inputs" is completely dedicated to smoothing the transition between historical and future datasets, I would propose to make that more explicit, as the previous language never connected the idea of "Harmonizing inputs" to

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"Smoothing the transition".

> We have modified the title of this section to be "Harmonization of LUH2 Inputs" to make this clearer.

In line 550, no rationale is given for holding the values between 0 to 500. I propose to either explicitly call this an assumption, or to add a sentence/reference giving the reason for these limits (well, the upper limit...limiting fertilizer application to positive numbers makes perfect sense, and thus the lower limit does not need justification). The following sentence could either apply to this choice of 0 to 500 or to the overall method described in the paragraph, and so a couple words to remove ambiguity would be welcome.

> This is a good point. The upper limit of 500 was a simplifying assumption and this has now been made clear in the paragraph about harmonizing fertilizer data inputs.

Figure 1 does a nice job of showing the inputs, model, and outputs. Perhaps a similar chart separated into historical maps, future maps, and the transition would also help the reader?

> Thank you for your appreciation of the model diagram in Figure 1 and for your suggestion to further illustrate the model features by separating this figure into historical maps, future maps, and transitions. However, we intentionally did not provide this separation because an essential feature of our model and dataset is that it harmonizes the historical and future time periods together, while providing a consistent set of states, transitions, and management data. If we were to separate these time periods and data types in the figure, it would imply that they could be considered separately, which is counter to the intended use of this product.

The paragraph beginning in line 707 is quite interesting. As I understand that the eight future trajectories were run specifically for this project, it would be nice to develop this further and see if some of the observations can be explained. For example, the

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idea that global cropland area and wood harvesting increased did not surprise me (increased population, increased food supply, wood/bioenergy products increasingly viewed as favorable for the environment). Six scenarios projecting decreased grazing land did surprise me, though, as I would have expected increased meat consumption as more societies shift to the "Western" meat-heavy diet. If the IAM scenarios had been taken from another source, it would not be necessary to explore them further here; however, as it seems that much work went into creating these trajectories for this project, I would appreciate another paragraph dedicated to this. I note that further observations are mentioned in later sections (Sec 3.3, for example), but I don't see any driving factors for the differences.

> Thank you for your interest in these future scenarios. The 8 scenarios were developed as part of ScenarioMIP and are documented in the related publications that we have referenced. We have now added a reference to Popp et al. 2017 and Stehfest et al. 2019 at the beginning of Results section to help clarify this. The beginning of Section 2.8 (future land-use inputs) was also expanded to clarify where these future scenarios come from, and where they are already documented, including a new citation to Riahi et al. 2017.

The badge plots in Figure 8 are great to depict the transition information. I do struggle with the font, though. Could the text indicating the land use (e.g., pasture) be instead put in a legend across the bottom, with the text in the same color as the sector and made larger, at least for the eight trajectories where the font is the smallest (it appears they share the same sectors)?

> Thank you for your appreciation of these figures. We have updated these figures so that they are larger and no longer have the labels for the various land-use types. The colors representing each land-use type are now described in the figure caption.

The authors claim the new LUH2 products contain fifty times the information as the previous LUH1 product on two separate occasions in prominent places (abstract and

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conclusion), but do not support this anywhere in the text. It would be best to either add supporting evidence for this claim or remove it.

> We have added additional information to the first paragraph of the Conclusion section that describes the ways in which the data in the LUH2 products contains 50 times more detail.

The evaluation of the LUH2 dataset against diagnostics is most welcome, and it's particularly interesting to see the comparison also against LUH1 for these same diagnostics (Table 3). The diagnostics are not discussed in any detail, though, which makes me wonder how they are "new", as mentioned in the abstract. I would modify the abstract to remove the word "new" or add more discussion on the diagnostics themselves demonstrating that they are, in fact, new, why they were selected, and how tables 3 and 5 compare in their selected diagnostics (they are not identical, for some reason). Additionally, I would be much more interested to read in the abstract what the result of the assessment was rather than just reading that the assessment was done.

> Thank you for your appreciation of our diagnostic assessment. The diagnostics were "new" for LUH2 in the sense that they were significantly expanded from the simple diagnostic assessment reported as part of LUH1. The numerical values reported in the diagnostic tables (Table 3 and Table 5 – which are not identical due to differing time periods) are already cited and discussed in numerous places throughout the manuscript, particularly throughout Section 3.1, so we don't think there is a need to add any additional discussion of them.

Some technical comments: Line 81: "Le Quéré et al. ,2016" should be "Le Quéré et al., 2016"

> Done

Line 771: There is an open paranthesis, but no close in the next line. "reference value of $0.3 \times 10^6 \text{ km}^2$."

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> Fixed

Line 780: Sometimes petagrams of carbon is written "Pg C" in this paragraph; other-times "PgC". I prefer "Pg C".

> Done. Standardized to "Pg C" through-out manuscript.

Line 791: Four significant figures in these numbers seems pretty optimistic, as that implies an uncertainty of less than 0.1%. I would stick to three at the most (e.g., 13.3%), since this paragraph is reporting differences in the created datasets and not a real uncertainty compared to observations (I'm sure the uncertainty compared to real historical values would be fairly high). Some consistency should be applied to the number of significant digits reported in this paragraph (and likely the whole paper...I see anywhere from two to five for various numbers, with no clear reason).

> Thank you for this suggestion. We have modified the paragraph in question so that the cited values have only 3 significant figures (which is also consistent with the values in the table they are referring to). We have also gone through the whole manuscript and adjusted all numerical values to have no more than 3 significant figures. There are a few exceptions that have 4 significant figures but those are values that we are citing from other publications and datasets, so we have not modified the number of significant figures used in those sources. In some cases we have used fewer than 3 significant figures – this was done when we wanted to improve readability of the data in the tables (for example, by providing all values in a column to the nearest integer), or when the values reported had a much higher known uncertainty.

Line 793: There is a stray "." after 58.

> Fixed

Line 812: The "yr -1" has been split over two lines.

> Fixed

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Line 910: Uses "bookkeeping". Next line using "bookkeeping". Line 596 uses "book-keeping".

> We have now standardized the manuscript to consistently use the word "bookkeeping", which is consistent with the term used on the Global Carbon Budget annual publications.

Interactive comment on Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2019-360>, 2020.

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