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Interactive comment on “Carbon density and anthropogenic land use influences on net land-use change emissions” by S. J. Smith and A. Rothwell

Anonymous Referee #1

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Smith and Rothwell have used a conceptually simple model of the terrestrial carbon cycle to estimate the size of carbon emissions due to land-use change, and the sensitivity of this estimate to its underlying assumptions. The method allows to clearly and consistently differentiate the potential magnitude of key uncertainties in the assessment of land-use change emissions, both under the deforestation dominated historical period and a future afforestation scenario. Given the difficulty of comparing published studies of land-use change emissions due to the different assumptions and definitions used in those studies, a carefully constrained analysis such as presented here presents a useful step forward in understanding.

The article is well written and generally easy to follow although there are some areas that require or would benefit from further discussion/explanation, as detailed below.

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The model conceptualisation and reasoning appears robust, and I have few quibbles with the science so long as the points below can be adequately addressed. The authors should, however, double check all values in the tables, main text, and SI, as there are several places where there appear to be inconsistencies. For instance, the total 1700–2000 LUC emission for the VEGAS and CESM sensitivity studies are +16.4 and +20.4 Gt C respectively in the SI, but -20, and +32 Gt C in Table 5. Line 24 on pg. 4170 then goes on to describe decreases of 6 and 18% for these sensitivities relative to the central scenario, which is consistent with neither set of results.

Overall I would recommend the paper for publication subject to minor revisions.

Main comments

The results are clearly dependent on the values selected in Table 1 and 2 of the supplementary information (SI). There need to be some justification of why the numbers used were chosen.

The analysis is restricted to emissions from land-use change, and the effects of changing climate and atmospheric CO₂ concentration are not considered. This usefully simplifies the interpretation of the results. Possibly it does not add a substantial bias to the historical emissions calculation (although it most likely does to the future scenario calculations), however there should be more discussion of how changing climate and [CO₂] are likely to influence the results. If the study was just restricted to a sensitivity analysis of land-use change assumptions in the absence of a changing environment then this discussion would not be required, and could be left to a separate paper (as the authors indicate that they plan to do). However, as the results are also presented as an estimate for the historical period, and directly compared (in section 4.2) to studies that do take a changing environment into account, such discussion is necessary, perhaps also with a couple of additional sensitivity studies to back it up.

It took me quite a long time to work out why cropland should become a carbon sink in the 21st century, and for pastureland it still isn't clear to me. The particularly confusing

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line is on pg. 4168, line 24, “Cropland also becomes a net sink, and both cropland and pastureland take up carbon as the total areas of each decrease.” This implies that the sink behaviour of the crop and pasture lines on Fig. 1 in the 21st century is due to the total areas of each decreasing. Following the authors’ method, a reduction in cropland area would cause cropland to be a carbon source (as LU emissions are allocated to the ecosystem type that loses area). I think the authors perhaps meant something like “both cropland and pastureland take up carbon due to productivity increases and XXXX respectively, despite the total areas of each decreasing”? In any case, it would be helpful if the authors could clarify this, and make the reasoning for this behaviour more explicit at its first mention.

On pg. 4170, line 7, the authors state that the results from their work are similar to those of Hayes et al. However, I would say that one really needs the eye-of-the-believer to agree with that at first glance. Many of the results displayed in the SI actually appear very different. This statement should be removed or further justified.

The land-use types in Table 6 appear to encompass the major global land uses. Why then are the total land areas so different between G-Carbon (9831 MHa) and GCAM (11390 MHa)?

Minor/typographical comments

It would be helpful to number and properly caption the tables and figures in the SI, e.g. Table S1, S2, etc. It would also help the reader if the main text referred to specific section/figures/tables in the SI.

Pg. 4162, line 12. Please define harvest index to assist the reader.

Pg. 4166, l. 11. I believe the reference to Figure 3 should actually be to Figure 2. Also Table 3 should be referenced here.

Pg. 4168, l. 21. ‘Significant’ is mistyped.

Pg. 4168, footnote. “. . .to a regime in which global policies. . .”

Pg. 4169, l. 8. I believe the reference to Table 5 should in fact be to Table 4?

Pg. 4169, l. 19. "...for the lower estimate of DeFries..."

Pg. 4170, l. 4. I believe the reference to Table 5 should in fact be to Table 4?

Pg. 4170, l. 4. "...values here are within..."

Pg. 4170, l. 23. Please give references for these models.

Pg. 4171, l. 17. Please add "in our simulations" after "21st century".

Pg. 4171, l. 20. "Densities" is mistyped. Also please rephrase this whole sentence without the use of the brackets. This type of sentence is difficult to read, and, as space is not an issue, would be much better as two separate sentences.

Pg. 4172, l. 17. The second clause of the first sentence does not make sense. The text in section 5.3 of the main text and section 3.3 of the SI are very similar and repeat each other. I suggest taking the salient bits out of the SI, adding them to the main text, and then deleting this SI section, in order to tell the story more smoothly.

Pg. 4173, l. 18. "LUC results are most sensitive". To what does "most" refer? Bigger sensitivities than these have already been described in the previous sections.

Pg. 4171, l. 22. Replace "areas as" with "the areas".

Pg. 4175, l. 4. Missing full stop after "scenario"

Pg. 4175, l. 10. "GCM" or "GCAM"?

Pg. 4175, l. 14. "...we find net land-use..."

Pg. 4176, l. 7. "emissions" should be "emission".

Pg. 4176, l. 8. This statement is true for a non-spatially explicit model such as G-CARBON, but a spatially explicit ecosystem model should (in theory) capture the productivity variation. Therefore please caveat this statement.

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Pg. 4176, l. 27. “While the substantial uncertainty in LUC emissions were about 10% lower than in our central case,” doesn’t make sense in the context of the sentence. Please rephrase.

Table 1. Add a line break between “Western Europe” and “Japan”. “Former Soviet Union” has been split across the two columns. “Australia and New Zealand”, rather than “Australia_{NZ}”.

Table 2. Stating that uptake is negative in the caption would assist the reader.

Table 4. I think the third column should be labelled “1850-2000”. Also the totals for G-CARBON are in correctly rounded to 250 and 210, instead of 253 and 211. If the intention was to round to two significant figures, then this appears neither necessary, nor consistent throughout the table.

Table 5. As mention above, significant inconsistencies with the main text and SI.

Table 6. I presume that the lower row in each section corresponds to GCAM? The labelling is incorrect.

Fig. 1. Shrubland and pasture lines are difficult to differentiate.

Fig.2 There is no grey line on the key.

The comments below apply to the supplementary information.

Section 2.1. Units missing for table.

First table in Section 3.1. What are the Feedbacks? They are not described in the main text or the SI. Please either add sufficient description and interpretation, or remove these value from the table.

Section 3.2 VEGAS and CESM have not been previously defined in the SI.

Pg. 11, l. 15. Do you mean “separated into 10% increments of forest cover”?

Pg. 13, l. 4. “Because peat does not build-up, . . .”

Pg. 14, l. 31. “historical time period”.

Pg. 15., l. 37. “is increased from 15% to 40%”.

Pg. 16, l. 7. Do you have boreal forests in tropical regions?

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