Response to comments

Paper #: *bg-2017-186*
Title: *Land-use and land-cover change carbon emissions between 1901 and 2012 constrained by biomass observations*
Journal: *Biogeosciences*

Reviewer #1:

General Comments:

Comment:

Li et al add to the growing number of manuscripts on emergent constraints. Here they arrive at constrained LULCC emissions estimates by combining TRENDYv2 output, observationally-inspired biomass datasets, and regressions. This paper is well written. I have only a few very very minor issues (a 30 minute time burden at most to fix). Otherwise, publish as is.

Response:

We thank the reviewer for the comments and suggestions. Please see the detailed point-by-point responses below.

Specific Comments:

Comment:

P4L1: Help the reader who is not steeped in the minutiae of LULCC terminology here by adding more detail on "lost sink capacity" and "the loss of additional sink capacity"

Response:

The sentence on **P4L1** was revised as "This calculation of LULCC emissions by DGVMs includes the "lost sink capacity" (called "altered sink capacity" in Gasser and Ciais, (2013) and "loss of additional sink capacity" in Pongratz et al., (2014)), because simulated NBP in the S2 simulation without LULCC is a net sink over areas affected by LULCC in S3. For example, forests have larger carbon storage and slower turnover time than croplands and thus are expected to be carbon sinks when atmospheric CO_2 level increases. After deforestation to croplands, this sink capacity due to CO_2 fertilization is lost."

Comment:

P5L23: Incomplete sentence starting with Liu et al. (2015) ...?

Response:

This sentence was revised as: "Note that the uncertainties in the corresponding constrained results using these three alternative datasets do not include 1) the uncertainties of converting aboveground biomass to the total of aboveground and belowground biomass for datasets from Liu et al. (2015) and GEOCARBON (Avitabile et al., 2016; Santoro et al., 2015) and 2) the uncertainties of ignoring non-woody biomass in datasets from GEOCARBON (Avitabile et al., 2016; Santoro et al., 2015) and Pan et al. (2011)."

Comment:

P9L8: I appreciate the understatement but unless I misread Table 3 all the estimates are (by row) indistinguishable in a statistical sense. So you might want to focus on that and relative error to paint a slightly more optimistic picture of robustness.

Response:

As suggested, we added a sentence on **P9L8**: "The estimates of E^c_{LUC} constrained by the biomass datasets from Liu et al. (2015) and GEOCARBON (Avitabile et al., 2016; Santoro et al., 2015) are rather consistent with E^c_{LUC} constrained by biomass data from Carvalhais et al. (2014), implying the robustness of our estimates."

We didn't expand this point because the three alternative observation-based biomass datasets from Liu et al. (*2015*), GEOCARBON (*Avitabile et al., 2016; Santoro et al., 2015*) and Pan et al. (*2011*) are not fully consistent (in terms of the inclusion of herbaceous biomass, the underlying forest cover map, the measurement date, ...) (see **Section 2.2**) and are not entirely independent from the biomass dataset of Carvalhais et al. (*2014*) (e.g. In the NH, the basis of Carvalhais et al. (*2014*) should be very similar to Santoro et al. (*2015*). And Carvalhais et al. (*2014*) and Avitabile et al. (*2016*) uses Saatchi et al. (*2011*) for the tropics).

Comment:

P10L13: Remove "the" before "CO2 fertilization"

Response:

Revised accordingly.

Comment:

P10L15: The "Methods of defining" sentence. Not sure how to read the "to be associated". There is no future tense here? Just rewrite this to highlight the robustness of your findings.

Response:

This sentence was revised as: "For a given biomass dataset, the choice of a method for defining deforestation grid cells (Method-A, Method-B and Method-C) has very small influence on our results (Table 3)."

Comment:

P10L27: Your "that" clause is off. Perhaps start a new sentence with "This may..."? You use 1/3 of mean biomass later on (same para) and use the word large here. Can you quantify large so we have some sense of scale regarding the 1/3 number?

Response:

This sentence was revised as: "Currently, the uncertainties in the satellite-based biomass datasets are relatively large (e.g. 38% on average in tropics, Saatchi et al., 2011) at the pixel level (< 1 km). This introduces uncertainties in the constrained cumulative LULCC emissions, depending on the forest types and biomass range. For example, on average at the global scale, the relative uncertainty at the resolution of DGVM grid cells ($0.5° \times 0.5°$) is about one-third of the mean biomass (Carvalhais et al., 2014) and the relative uncertainty is smaller for high biomass areas in tropics (Avitabile et al., 2016; Saatchi et al., 2011)."

Comment:

P16: Not sure what to make of the nonsense words here...

Response:

We are sorry about this editing error, and this page was deleted accordingly.

Comment:

My final point (take it or leave it, it's more of a meta-point, as it were) is more of a "so what" question. Looking at Figure 6 (and excluding the Pan et al. bars) what has the gain in all this been? To put it another way, the "best estimate" from TRENDYv2 would be the 150 value. That was your "new and improved" value? I am not trying to belittle this effort or mindset. This is simply a question I've had whenever I read an emergent constraint paper. I'm also not sure there are enough papers out to form a critical mass to inspire a "best practices" or "lessons learned" paper. But it's thought to keep in mind.

Response:

We thank the reviewer for this thought. We acknowledge that the constrained cumulative LULCC emissions are close to the unconstrained ones from models. This is what the results turned out to be. Our work offers at least an evaluation of the modeling results using the observation-based biomass. More importantly, we combined the uncertainties in the regressions from state-of-the-art models with uncertainties in multiple observation-based biomass and gave a constraint with a 1-σ Gaussian

uncertainty. The idea of an emergent constraint paper is to give a more accurate estimate and / or a reduced uncertainty on an unknown variable by combining a heuristic relationship between two modeled variables (an observable and an unknown one) with actual observations of the observable variable. "Lessons learned" in our study are 1) that there is a heuristic relationship between biomass and cumulative land use emissions among different models, 2) that available biomass data confirm independently the median of modeled emission estimates, and 3) that more accurate biomass data in the future would allow to falsify some of the modelled estimates of emissions. We will elaborate on these points at the end of the conclusion section in the revised manuscript.