Response to comments

Paper #: *bg-2017-291*
Title: *Gross changes in forest area shape the future carbon balance of tropical forests*
Journal: *Biogeosciences*

Reviewer #2:

General Comments:

Comment #1

I read this manuscript with much interest, and found it to have novel elements which provide new and useful information. However, it could benefit from some revisions.

Response #1

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

Comment #2

The first part of the paper is about land use changes, from forest to agriculture. However changes from primary and secondary forest to plantations are also discussed (and the abbreviation LUC is used). Harvesting in rotation is not generally considered land use change (but a land cover change), so this abbreviation might be better changed to Land cover change (LCC) which would encompass both the forest gain scenario and land use change (loss of forest to agriculture). The paper uses land cover data (Hansen), which further confuses the reader, when land use is mainly used. The authors could check the consistency of these terms (land use and land cover) in the paper.

Response #2

We agree that the satellite data from Hansen et al. (*2013*) we used in the case study is land cover change rather than land use change, and the idealized scenarios are more land use change although also a land cover change, as described on **P3L12** "The land-use changes considered in this study are forest loss (tropical moist forest transformed to cropland) and forest gain (cropland abandonment to secondary tropical moist forest) in Latin America.". We will change the term into "land-use and land-cover change (LULCC)" throughout in the text to be consistent.

Comment #3

One of the concerns in the paper is the methods, which could be expanded to clarify some points. The analysis of the Hansen data, for example is not included. For example, what forest cover threshold did you use in the analysis? Did you for example mask out those pixels with loss or gain but with <10%, or another appropriate canopy cover threshold for the region? Or is it exactly following the Poorters map? How was the change of grid cell to 0.5o done? For example, pixels only partially within the area of interest are included or not? I wonder if the choice of grid cell size would impact the results? Was 0.5o chosen for a specific reason?

Response #3

We will add some sentences to clarify the forest cover change data from Hansen et al. (*2013*) in the revised manuscript: "Forest cover data from Hansen et al. (2013) comprise three layers at 30 m resolution: tree cover fraction (0-100% in each pixel) in year 2000, forest area loss (each pixel labeled with a loss year) during 2000-2012, and forest gain during 2000-2012 (not specifying the gain year). Attributing the forest gain to a specific year is challenging because of the difficulty in detecting young forests from satellite reflectance measurements (Hansen et al., 2013).In this study, we used the forest loss and forest gain layers to calculate the ratios of gross-to-net area changes (γ_{Anet}^{Agross}) at a $0.5° \times 0.5°$ resolution, and the average values of γ_{Anet}^{Agross} from the dataset of Hansen et al. (2013) during 2000-2012

rather than for a single year since the year of forest gain is not reported. The gross changes at the 0.5 ° level were calculated by summing the absolute areas of forest loss and gain at the 30 m level during 2000-2012 in each 0.5 ° grid cell, while the net changes were the sum of gross forest loss (negative) and gross forest gain (positive)." Thus, we didn't use the tree cover fraction threshold because we didn't use the tree fraction data.

It is not necessary to be <u>exactly</u> the same region of the Poorter et al.'s map because the biomass recovery estimates from Poorter et al. (*2016*) are based on forest sites and forest plots and thus represent a rough (not precise) Latin America region. Thus there is no such issue of partially overlapped pixels. We gave the latitudes and longitudes of the region we used from the map of Hansen et al. (2013) in **Figure 5**.

The gross changes compared to net changes essentially is a matter of resolution. For example, if the source data is at 30 m spatial resolution and all the models are run at 30 m resolution, there would be no difference between gross and net changes. The differences between gross and net changes only emerge when aggregating high-resolution data into a coarser resolution. The reason for choosing the 0.5 ° resolution was described on **P7L18**: "The spatial resolution of 0.5 ° is a typical resolution of DGVMs when they simulate global E_{LULCC}." Because the 30 m spatial resolution from Hansen et al.'s data is relatively high, using other grid cell size like 0.1 ° or 1 ° would be expected to give similar patterns as using 0.5 ° in **Figure 5**.

Comment #4

Figure 5 is also not clear to me, for example (if I understand correctly), those pixels in blue reached the threshold for the secondary forest clearing (and also the primary forest clearing) and those in green reached the threshold for the primary forest clearing only? This would be useful information to include in the caption.

Response #4

Yes, that is correct. We will add it in the caption as suggested: "The blue grid cells represent a cumulative carbon emission in 20 years no matter whether the lost forest is primary or secondary. The green ones represent a cumulative carbon emission only if the cleared forests are primary forests."

Comment #5

The results for the soil carbon change are also interesting and useful to include, but I find the discussion about this lacking. Indeed, there is a huge amount of uncertainty related to changes in soil carbon (see for example Don et al. 2011 Impact of tropical land-use change on soil organic carbon stocks – a meta-analysis). Incorporating some aspect of uncertainties related to this could have been helpful, and indeed, uncertainties are missing in all findings of the paper.

Response #5

We will revise the sentences on **P8L9**: "Differences may also exist for soil carbon dynamics after LULCC. There are a great number of meta-analyses or reviews (e.g. Davidson & Ackerman, 1993; Post & Kwon, 2000; Conant et al., 2001; Paul et al., 2002; Davis & Condron, 2002; Guo & Gifford, 2002; Murty et al., 2002; West et al., 2004; Laganière et al., 2010; Poeplau et al., 2011; Powers et al., 2011; Don et al., 2011; Li et al., 2012; Marín-Spiotta & Sharma, 2013; Wei et al., 2014; Kurganova et al., 2014) on the soil carbon change after LULCC based on field measurement data (mostly paired sites and chronosequences). These studies may generally agree with the directions of soil carbon change after LULCC (e.g. soil carbon loss after forest clearing for cropland), but the magnitudes and temporal dynamics of soil carbon changes remain highly uncertain because, among other things, of the limited site number and the diversity of soil properties. Field measurements at site level may be unrepresentative of the whole region because the distribution of biophysical conditions like soil texture, precipitation and temperature may not match the distribution of the whole set of such factors in the LULCC areas in a given region (Powers et al., 2011)."

Specific Comments:

Comment #6

Page 7, line 14-16. There are a number of datasets which you could use, and the data also do not limit the work to small scale analysis, so this sentence seems not to be useful.

Response #6

This sentence will be deleted.

Comment #7

Page 3 line 29/30. I would include here or somewhere appropriate, some numbers related to the total biomass used in the paper from Poorter.

Response #7

The number related to the ratio of aboveground to total biomass is only mentioned in the supporting information in Poorter et al. (*2016*). The ratio Poorter et al. (*2016*) used is from FAO FRA, which is 0.82, basically the same as we used (0.81). We will revise the sentence about on **P3L30**: "For both response curves, a ratio of 0.81 (Liu et al., 2015; Peacock et al., 2007; Saatchi et al., 2011) was used to convert aboveground biomass reported by Poorter et al. (2016) to total biomass, and this ratio is consistent with the one (0.82) that Poorter et al. (2016) used based on FAO FRA (2010)."

Comment #8

Page 9 line 9 – the "new planted forest in rotation practice"- it is not clear what you mean, and do you have a reference for this?

Response #8

We will revise this sentence as: "Forest management practices like wood harvest and thinning extract carbon from the ecosystem and release it to the atmosphere (Houghton et al., 2012), while recovering secondary forest from past deforestation and logging (Pan et al., 2011) and even old-growth forests (Luyssaert et al., 2008) can act as carbon sinks."

Reference

Luyssaert, S., Schulze, E.-D., Börner, A., Knohl, A., Hessenmöller, D., Law, B. E., Ciais, P. and Grace, J.: Old-growth forests as global carbon sinks, Nature, 455(7210), 213–215, doi:10.1038/nature07276, 2008.

Pan, Y., Birdsey, R. A., Fang, J., Houghton, R., Kauppi, P. E., Kurz, W. A., Phillips, O. L., Shvidenko, A., Lewis, S. L., Canadell, J. G., Ciais, P., Jackson, R. B., Pacala, S. W., McGuire, A. D., Piao, S., Rautiainen, A., Sitch, S. and Hayes, D.: A large and persistent carbon sink in the world's forests., Science, 333(6045), 988–993, doi:10.1126/science.1201609, 2011.

Comment #9

You refer to "idealized scenarios". I am not sure about the choice of term here. Ideal for what?

Response #9

We think this is a matter of English here. "idealized" refers to "conceptual" while "ideal" is more like "optimal". Because we want to demonstrate the difference between gross and net changes on E_{LULCC} and determine the critical gross-to-net change ratio, we used these idealized scenarios that are simple and representative, and may not the case in reality.

Page 1 line 28. "compared against" could be changed to "compared to". Landsat is more commonly referred to as medium resolution (rather than high resolution), although the global maps are termed high resolution global maps. I would remove the term or would specify the resolution in m.

Response #10

We will revise it accordingly.

Comment #10

Page 2 line 7. Why "so-called"?

Response #11

We will delete it accordingly.

Comment #11

Page 8 line 5. could be rephrased: "are lower 20 years after the initial LULCC" or in another way.

Response #12

We will revise it accordingly.

Comment #12

Page 7 Line 24. Is it necessary to describe a map as 'spatial'?

Response #13

We will delete it accordingly.

Comment #13

Page 7 line 14. Instead of "real world", "in a case study" or similar?

Response #14

This sentence on **P7L14** will be revised as: "…we further combined such ratios with the land use and land cover change datasets to determine whether a region is a carbon sink or source at a given time horizon."