## Response to Interactive comment to anonymous referee #2

Thank you for the positive assessment and suggestions to improve the manuscript. Below are the questions and suggestions followed by answers including the changes that were made in the manuscript.
In addition to addressing the reviewers comments we extended the analysis to including the newly available LUH2 net dataset in the analysis. Since this dataset will be used e.g. in CMIP6 simulations, we expect this dataset to emerge as one that will frequently be used for modeling studies in the future. As this we included it in the analysis. The inclusion of LUH2 in averages and uncertainties in C stocks and fluxes did not change the outcomes of this study. We also include a section on the inclusion of LUH2 as a model that is indeed not completely independent from LUH1 and HYDE in the discussion.

*1. Including in the discussion a critique of how wood harvest can be included in the future, and what sorts of feedbacks would be expected on the component flux emissions*

We included in the discussion section a paragraph on wood harvest and why we did not include it in our analysis.

discussion, §4.3, lines 600-607: *We did not account for wood harvest in this study as the uncertainty in the actual spatial pattern of wood harvest in combination with the ways wood harvest is done in practice over the globe (clear cut, selective harvesting of specific age classes or a mixture of both) introduces many possibilities as to how this process can be implemented in DGVMs. In a model such as LPJ-GUESS, where forest ecosystem and wood parameters vary significantly over tree age classes, this would result in a wide span of possible solutions depending on the parameters used for implementation of wood harvest that would be better addressed in a thorough sensitivity study investigating a variety of possible implementations, rather than with a single representation.*

In the same sense, emissions from various pools and the types of process feedbacks are dependent on the selected implementation and should be investigated in a separate study. As other studies showed, the consideration of wood harvest increases the annual land use flux (Houghton et al., 2012; Shevliakova et al., 2009). Emissions from transitions of forest to non-forest LU types would then be smaller (as average forest biomass would be lower when wood harvest is considered). Therefore especially the timing when fluxes from wood harvest are emitted to the atmosphere is affected by the ex-/inclusion of wood harvest. Likewise we would expect the distribution of soil legacy effects to differ. As our study does not address the issue of wood harvest, and because of the many uncertainties and technicalities involved in its implementation, we do not feel it appropriate for us to speculate here on the best way to include wood harvest. This should instead be the topic of a separate analysis that fully investigates the consequences of the various assumptions.

*2. Is forest age structure included in the model? The authors mention that 'young stands are harvested before old stands'. This implies there is age structure. Also, what is the logic for harvesting the young stands first rather than the old stands? What would be the implications of doing this in reverse?*

The LPJ-GUESS model is characterized through the representation of gap dynamics and age classes in cohorts of 5 years (Smith et al., 2001). This includes an explicit representation of vegetation structure, dynamics and competition between the individual cohorts of a PFT population. Replicate patches are simulated to take account of stochastic processes of individuals (establishment and mortality).

In the first version of the manuscript we have not mentioned the explicit representation of vegetation dynamics and age structure in the text. We corrected for this and added the following text:

§2.2, lines 212-2213: *Vegetation structure, dynamics and competition between age cohorts of a PFT population are explicitly represented in the LPJ-GUESS model.*

The assumption that, upon conversion of natural to agricultural lands, young stands are harvested before old stands, follows the idea that younger and not-yet-mature stands in practice would be cut down before old-growth forest would be touched. This assumption is not based on solid evidence, however, follows logical considerations that land managers might take and was applied in previous modeling studies e.g. (Hurtt et al., 2011; Stocker et al., 2014). It also reflects the likely accessibility of land where the forest has already been cut, versus land with old-growth forest. Doing the reverse, i.e. cutting down oldest stands first, would result in a probably unrealistically high immediate and long-term loss of above and below-ground C stocks, and therefore higher total emissions from land-use change.

*3. Fire is not discussed in the manuscript – how would the authors plan to include fire feedbacks and the reorganization of forest structure in their sub-grid cell based transitions?*

Fire is represented explicitly in the LPJ-GUESS model, with a full description of the algorithm given by Thonicke et al. (2001). Thus the forest structure simulated is an emergent result of a number of processes, including fire. For any full details on the model's structure and implementation (with fire among this) the reader is referred to the given references (Lindeskog et al., 2013; Sitch et al., 2003; Smith et al., 2014, 2001). As such, and because fire is not a focus of the manuscript, fire is not mentioned explicitly.
The status of global fire modeling is discussed in a recent publication by Hantson et al. (2016). It shows that there are advances in representing fires in global models but also a number of challenges attached to the process of finding reliable representations and predictions. Fire dynamics will be influenced under land rotations such as shifting cultivation, and are certainly one aspect that could be the focus of a dedicated study. Since this is not within the scope of the manuscript, we do not treat this issue in any detail but added a statement to the discussion that relates to different vegetation and ecosystem dynamics under repeated land changes.

discussion §4.3, lines 596-599: *In the same way, other land-use and land-cover change-related processes (e.g. fate of harvested wood, residue management, occurrence of disturbances, including fire, etc.) might differ under repeated land transitions such as shifting cultivation, and realistic representation of these interactions in process-based models remains a subject for further research.*

## References


Hantson, S., Arneth, A., Harrison, S.P., Kelley, D.I., Prentice, I.C., Rabin, S.S., Archibald, S., Mouillot, F., Arnold, S.R., Artaxo, P., Bachelet, D., Ciais, P., Forrest, M., Friedlingstein, P., Hickler, T., Kaplan, J.O., Kloster, S., Knorr, W., Lasslop, G., Li, F., Mangeon, S., Melton, J.R., Meyn, A., Sitch, S., Spessa, A., van der Werf, G.R., Voulgarakis, A., Yue, C., 2016. The status and challenge of global fire modelling. Biogeosciences Discuss. 1–30. doi:10.5194/bg-2016-17

Houghton, R.A., House, J.I., Pongratz, J., van der Werf, G.R., DeFries, R.S., Hansen, M.C., Le Quéré, C., Ramankutty, N., 2012. Carbon emissions from land use and land-cover change. Biogeosciences 9, 5125–5142. doi:10.5194/bg-9-5125-2012

Hurtt, G.C., Chini, L.P., Frolking, S., Betts, R.A., Feddema, J., Fischer, G., Fisk, J.P., Hibbard, K., Houghton, R.A., Janetos, A., Jones, C.D., Kindermann, G., Kinoshita, T., Klein Goldewijk, K., Riahi, K., Shevliakova, E., Smith, S., Stehfest, E., Thomson, A., Thornton, P., van Vuuren, D.P., Wang, Y.P., 2011. Harmonization of land-use scenarios for the period 1500–2100: 600 years of global gridded annual land-use transitions, wood harvest, and resulting secondary lands. Clim. Change 109, 117–161.

Lindeskog, M., Arneth, A., Bondeau, A., Waha, K., Seaquist, J., Olin, S., Smith, B., 2013. Implications of accounting for land use in simulations of ecosystem carbon cycling in Africa. Earth Syst. Dyn. 4, 385–407. doi:10.5194/esd-4-385-2013

Shevliakova, E., Pacala, S.W., Malyshev, S., Hurtt, G.C., Milly, P.C.D., Caspersen, J.P., Sentman, L.T., Fisk, J.P., Wirth, C., Crevoisier, C., 2009. Carbon cycling under 300 years of land use change: Importance of the secondary vegetation sink. Global Biogeochem. Cycles 23, 1–16. doi:10.1029/2007GB003176

Sitch, S., Smith, B., Prentice, I.C., Arneth, A., Bondeau, A., Cramer, W., Kaplan, J.O., Levis, S., Lucht, W., Sykes, M.T., Thonicke, K., Venevsky, S., 2003. Evaluation of ecosystem dynamics, plant geography and terrestrial carbon cycling in the LPJ dynamic global vegetation model. Glob. Chang. Biol. 9, 161–185.

Smith, B., Prentice, I.C., Sykes, M.T., 2001. Representation of vegetation dynamics in the modelling of terrestrial ecosystems: comparing two contrasting approaches within European climate space. Glob. Ecol. & Biogeogr. 10, 621– 637 10, 621–637.

Smith, B., Wårlind, D., Arneth, A., Hickler, T., Leadley, P., Siltberg, J., Zaehle, S., 2014. Implications of incorporating N cycling and N limitations on primary production in an individual-based dynamic vegetation model. Biogeosciences Discuss. 11, 2017–2054. doi:10.5194/bgd-10-18613-2013

Stocker, B.D., Feissli, F., Strssmann, K.M., Spahni, R., Joos, F., Strassmann, K., 2014. Past and future carbon fluxes from land use change, shifting cultivation and wood harvest. Tellus B 1, 1–15. doi:10.3402/tellusb.v66.23188

Thonicke, K., Venevski, S., Sitch, S., Cramer, W., 2001. The role of fire disturbance for global vegetation dynamics: coupling fire into a Dynamic Global Vegetation Model. Glob. Ecol. Biogeogr. Lett. 10, 661–678.

Wilkenskjeld, S., Kloster, S., Pongratz, J., Raddatz, T., Reick, C., 2014. Comparing the influence of net and gross anthropogenic land use and land cover changes on the carbon cycle in the MPI-ESM. Biogeosciences Discuss. 11, 5443–5469. doi:10.5194/bgd-11-5443-2014