We thank the anonymous referee #2 for the helpful comments which helped to improve our manuscript further. We revised the manuscript by accommodating the referee's suggestions as much as possible. In the following, we provide our responses (written in red, *added text to the manuscript italic*) to the referee's comments (written in black).

The manuscript quantifies potential carbon mitigation using land cover and land use change scenarios related to a BECCS, an afforestation, and combined scenario using the LPJ-GUESS dynamic global vegetation model. In addition to quantifying carbon mitigation, they also quantify changes in a variety of ecosystem services that LPJ-GUESS variables can roughly be related to, including albedo, N losses, biodiversity, run off, etc. Given the importance of carbon management in mitigating climate change, this manuscript is very useful to have in the literature to provide a context for evaluating trade-offs.

We are happy the reviewer acknowledges the significance of our study.

My main comments are:

1. The work is all modeling based and so the performance of the model under present day conditions and the uncertainties moving into the future are quite important but are neglected. It would be helpful to investigate these uncertainties more formally, or to add a section in the Discussion on 'Uncertainties', what the authors consider to be of highest importance and what should be done to reduce the uncertainties.

We agree with the reviewer that uncertainties should be investigated. LPJ-GUESS has been confronted against a wide range of local to global scale observations, and model performance has been reported extensively in many of the previously published studies. We therefore added a brief re-cap on these to the paper but refer the reader mainly to these other papers. We also provide two additional figures:

"4.1 Modelling uncertainties under present-day and future climate

The ES indicators analysed in this study are subject to uncertainties arising from knowledge gaps, simplified modelling assumptions, and the need to use parameterisations suited for global simulations. LPJ-GUESS has been extensively evaluated against present-day C fluxes and stocks, both for natural and agricultural systems, at site scale and against global estimates (e.g. Fleischer et al., 2015;Piao et al., 2013;Pugh et al., 2015;Smith et al., 2014). The use of forcing climate data from only one climate models can be a major source of uncertainty as shown by the large variability in future terrestrial C stocks introduced by different climate change realisations even for the same emissions pathway (Ahlstrom et al., 2012). As we use here the low emission scenario RCP2.6 we expect this effect to be relatively small. The albedo calculation in this study was not used previously but patterns simulated by LPJ-GUESS under present-day conditions (Fig. S5) broadly agree with Fig. 3 in Boisier et al. (2013). Evapotranspiration and runoff in LPJ were evaluated by Gerten et al. (2004). Global total runoff calculated in this study for the 1961-1990 period is 26% higher than their results. Simulation biases against global estimates and observations from large river basins in the Gerten study were mainly attributed to uncertainties in climate input data and to human activities such as LUC (which is now accounted for) and human water withdrawal. Spatial runoff patterns as simulated by the current LPJ-GUESS version (Fig. S6.) seem to reveal some improvements compared to the biases reported in Gerten et al. (2004) in mid and high latitudes, but the model still overestimates runoff in parts of the tropics. With respect to crop production, simulated crop yields in LPJ-GUESS are constrained by N and water limitation, but not by local management decisions, crop varieties/breeds, diseases and weeds (Lindeskog et al., 2013;Olin et al., 2015b). While we accounted for these additional restrictions by scaling simulated present-day yields to observations, adopting the original LPJ-GUESS yield variations into the future might create substantial biases in simulated changes in crop production. Global N-leaching rates are highly uncertain but the annual rate simulated with LPJ-GUESS (if all N losses are assumed to be via leaching) is within the range of published studies (Olin et al., 2015a).

For BVOCs, global data sets for evaluation are not available (Arneth et al., 2007;Schurgers et al., 2009). Spatial emission patterns are in good agreement to other simulations (Hantson et al., 2017). While LPJ-GUESS has thus been evaluated as comprehensively as possible a further next step for multi-process evaluation would be adopting a formalised benchmarking system that allows also to score model performance (Kelley et al., 2013). Likewise, large uncertainties reside in the actual LUMs, which differ to a large degree in their estimates of main land cover classes for the present day (Alexander et al., 2017;Prestele et al., 2016), and for which evaluation against observations has been identified as a challenge (van Vliet et al., 2016)."

2. I agree with the second reviewer that it is somewhat confusing to have the IMAGE and MAGPIE models run with LPJml, and then for this publication to use LPJ-GUESS. I understand that the IAM models needed a terrestrial biosphere model to generate the land-use change scenarios, but its not clear whether you want to compare with the LPJml results, or whether to simply use the land cover/land use change scenarios as driver data for LPJ-GUESS.

Most of the analysed ecosystem service indicators were not simulated/reported by the LUMs so we used LPJ-GUESS to analyse impacts on a wide range of ecosystem services within a consistent modelling framework. In cases where the output was also available from the LUMs we made a comparison to the LPJ-GUESS results. We made this clearer by including the following statement in section 2.4:

"With the exception of C removal and crop production these variables were not available from both LUMs."

We also made it clearer that our results are LPJ-GUESS output by using the terms $LPJG_{IMAGE}$ and $LPJG_{MAgPIE}$ instead of IMAGE/MAgPIE when referring to results from LPJ-GUESS simulations driven by IMAGE and MAgPIE land-use patterns.

3. The implementation of land cover and land use change in LPJ-GUESS is a bit vague. Please specify i) if gross or net land cover change transitions are used, ii) if wood harvest is considered, and iii) whether product pools are included.

While it is now technically possible to simulate gross transitions in LPJ-GUESS (Bayer et al., 2017), the LUMs in this study used only net transitions. Wood harvest was not reported by the LUMs. We made this clear in the scenario description section 2.2:

"LUC was provided by the LUMs as net land cover transitions. Wood harvest was not accounted for in the data provided by the LUMs."

LPJ-GUESS represents a product pool. We added the following sentence to the LPJ-GUESS description section 2.1:

"When forests are cleared for agriculture, 20% of the woody biomass enters a product pool (turnover time of 25 years), with the rest being oxidized (74%) or transferred to the litter (6%)."

References

Bayer, A. D., Lindeskog, M., Pugh, T. A. M., Anthoni, P. M., Fuchs, R., and Arneth, A.: Uncertainties in the land-use flux resulting from land-use change reconstructions and gross land transitions, Earth Syst Dynam, 8, 91-111, doi:10.5194/esd-8-91-2017, 2017.