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Interactive comment on "Current challenges of implementing land-use and land-cover change in climate assessments" *by* R. Prestele et al.

Anonymous Referee #3

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The manuscript by Prestele et al., "Current challenges of implementing land-use and land-cover change in climate assessments", provides an overview of recent publications on interactions among land-use, carbon cycling, and different aspects of climate. First, the manuscript aims "...to identify existing shortcomings of the current LULCC representation within DGVMs and ESMs, reveal the underlying mechanisms and constraints that have hampered improved representations until now, and propose pathways to improve current representations" (page 3, lines 5-7). Second, based on the literature review, the manuscript attributes the lack of progress in including LULCC into climate assessments, to 1) the failure to account for uncertainty in reconstruction and future scenarios of gridded LULCC; 2) resolving sib-grid changes in land-use activities (e.g. gross transitions); 3) allocation of primary lands to managed lands in DGVMs and ESMs. Manuscript reviews a number of studies and discusses a wide range of

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limitations, specifically in CMIP5 historical reconstruction and future scenario. It has interesting discussion of how to use remote sensing data in improving treatment of LULCC processes in scenario development and its implementation into DGVMs and ESMs. However, the title is not appropriate because climate assessments such as IPCC do not implement LULCC – IPCC assessments review literature. CMIPs are not part of the IPCC, although their model simulations provide input to IPCC.

The manuscript has four major shortcomings: 1) While the manuscript reviews and synthesizes a number of recent studies on the development of scenarios of LULCC and of LULCC for climate and carbon cycling, it does not actually provide new insights or synthesis of LULCC implementation in ESMs and DGVMs. The manuscript provides a discussion of how the CMIP5 scenario was constructed and its limitations, but does not discuss differences in land use components of different ESMs or DGVMs. Or how they implemented the CMIP5 LULCC scenario. Table 1 gives 4 examples: 3 DGVMs (2 of which are variants of LPJ model) and a new HadGEM2-Jules ESM. There is no comprehensive analysis of CMIP5 ESMs or TRENDY DGVMs used in the AR5 in respect to LULCC. Thus, the manuscript's first goal is not supported by new insights beyond those previously published in the literature. 2) The manuscript claims that the limited characterization of uncertainty in CMIP5 and CMIP6 LU reconstructions and scenarios is responsible for the lack of progress on LULCC in climate assessments. There is no reason to believe that's true. CMIP is designed to compare climate models and ESMs under a common set of forcings and capture model structural uncertainty. CMIPs never claimed to capture all uncertainty due to input forcing. It's a well-established practice in climate MIPs to provide a standard scenario for all forcings – greenhouse gases, short-lived species, solar, constants, volcanoes and LULCC, particularly over historical periods. Such GCM or ESM simulations are extremely computationally expensive. Permutation of alternative forcings datasets is not likely something that many climate centers will be able to engage and afford. The idea of multiple LULCC reconstructions advocated by the paper for CMIPs is not practical.

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If some modeling group/center wants to explore uncertainty due to LULCC, there is more than one scenario that is available even from the GLM model: Hurtt et al. (2006) included both scenarios based on SAGE and HYDE datasets. Hurtt et al. 2011 examines different assumptions in the GLM model. The main bottleneck for improving LULCC characterization in the CMIP is poor representation of LULCC processes in GCMs and ESMs. Most CMIP5 ESMs or TRENDY DGVMs can't use the information available in CMIP5 or CMIP6 historical reconstructions or future scenarios. For example, most of the CMIP5 models use only information about land use fractions, and not gross transitions provided by the Hurtt et al. (2011) data set. With the exception of very few models, ESMs do not represent shifting cultivation or wood harvesting. Another unsupported assumption in the manuscript is that, by making additional ESMs or GCMs with alternative representations of LULCC history, one would get a better handle on the uncertainty in climate feedback of LULCC. It's not necessarily true: most studies with and without LULCC typically find a small difference in global climate and small regions with statically distinguishable differences in climate characteristics. One would need a large ensemble of such simulations to find differences between the biogeophysical effects of alternative LULCC reconstructions and scenarios, unless they are really different as in future scenarios. Biogeophysical differences should be more pronounced, but the problem is that CMIP5 or even CMIP6 ESMs are incapable of representing major LU processes such as shifting cultivation, wood or crop harvesting..

3) The manuscript questions assumptions in CMIP5 Hurtt et al. 2011 reconstruction and future scenario. The Hurtt et al. (2011) effort, for the first time, harmonized historical reconstruction with the 4 Representative Concentration pathways (RCP) scenario and took into account gross transitions between different LU types in both tropics and extra-tropics. The authors are mistaken in their assumption that no-shifting cultivation in the extra-tropics implies no gross-transitions in the extra-tropics; for example, non-zero transitions between pastures to crops and crops to pastures. Furthermore, for CMIP6 (Lawrence et al. 2016), there will be a focus and additional LUH reconstructions available, as well as more details about the relationship between land cover

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and land use categories. I think a lot of criticism of the CMIP5 LULCC reconstruction and scenario is valid but the authors are overlooking improvements in the new reconstruction for CMIP6, which is publicly available now on the CMIP6 website. While it's possible to construct more detailed scenarios for recent periods with satellite coverage or for specific countries (e.g., Table 2 in the manuscript), particularly in the Northern Hemisphere, it is difficult if not impossible to develop multi-century reconstructions on a global scale with consistent sets of assumptions. Making simple assumptions in ESM is not an unreasonable approach for global, multi-century analyses. Assuming transitions based on the satellite era for the entire CMIP-style experiments may be problematic, as well, for pre-industrial or future periods

4) The rationale for including analysis from the CLUMondo model is not clear – it demonstrates how spatio-temporal variations could be different within the grid. It does not show that such patterns will affect climate or carbon cycling. Besides the CLUMondo analysis, there is no new analysis in this manuscript. So, there are no new insights/analysis, just a synthesis of other studies, which are already partially covered by the authors in related publications (e.g., Alexander et al. 2016, Bayer et al, 2016, Prestele et al. 2016).

I think the most interesting part of the paper is the section on remotely sensed data (high and low resolution) in development of new diagnostics for evaluation of global LULCC reconstructions or models. Perhaps the authors can re-frame their analysis and demonstrate how such data can be used to improve or evaluate reconstructions (e.g. the one in CMIP6) or to create new diagnostics to evaluate ESMs and DGVMS.

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