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Earth System Dynamics Discussions

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

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Review of esd-2016-39: Current challenges of implementing land-use and land-cover change in climate assessments

The authors examine current practices of providing LULCC data and simulating LULCC effects on the earth system in global models and identify 3 main issues related to reliable provision and use of LULCC data. They then move on to the limitations in data for gross land use/cover transitions, and finally discuss land conversion assumptions in modeling as a source of uncertainty. They also make 3 suggestions on how to improve the provision and use of LULCC data.

I appreciate this paper and am pleased that it discusses relatively overlooked, yet very important, issues regarding LULCC and global modeling. I generally agree with the

assessment, but I think that the paper needs some reorganization and some additional discussion to fully and clearly make its case. The main issues requiring attention are summarized here, with specific comments/suggestions following:

1) The paper needs a consistent framing and argument. The three main issues are different between the abstract, text, and conclusion. It appears (see abstract lines 28-34 and page 3 lines 5-10) that the point is to show that the 3 main issues are indeed main issues, based on literature, an example, and discussion of two underlying factors (1) gross transitions and 2) land use change to land cover change translation), and provide suggestions for moving forward. But the main issues are not referred to in the later sections, and these two aspects are not introduced up front so that they can be discussed in the context of the main issues. And the suggestions are not related to the issues.

2) It isn't clear that lack of information on gross transitions is a fundamental factor for the 3 main issues. While there is a lot of uncertainty in estimating gross transitions, and there is a need to improve related data, this seems more like an example of a more fundamental driver. One thing that cuts through the three issues and incorporates gross transitions is data quality. In fact, that is largely what issue 2 in the text describes. And ultimately issue 3 as well (initial, present-day data sets for future projections). Maybe there are only two main issues (single historical product with no uncertainty and uncharacterized/large model uncertainty in future land projections) and two underlying factors (data quality and independent land use and land cover implementation). Then the underlying factors provide guidance for the two communities to work together to address the two issues as they apply to both the human and dgv/es models.

3) The underlying factor of the traditional separation of land use research from land cover research is not addressed until section 4, even though it cuts through the main issues and there is also a main point in the conclusion that land use modeling needs to be integrated with land cover/ecosystem modeling. And one of the suggestions calls for specific land use to land cover conversion information in place of just land use

information. You also use land cover products for figure 5, which are not necessarily consistent with agricultural land use data. Furthermore, this separation is not explicitly discussed, with LULCC being a whole throughout the text, even when discussing how each land model has to make land cover conversion assumptions to accommodate independent land use data. You mainly focus on the land cover conversion uncertainty, but the separation of land use and land cover is the underlying source. There is some additional literature addressing this specific issue that would be useful to the authors. I would also be happy to discuss this further with the authors, as I am trying to finish a manuscript looking at how land cover conversion uncertainty affects carbon and climate projections. Look me up if you are coming to AGU in San Francisco this year.

Specific comments and suggestions:

Abstract

page 1, lines 31-32: this subgrid and gross transition source is not on page 5 as a main source of uncertainty. The second main source in the text is inconsistencies of present day data. You do later discuss gross transitions, and make a statement in the conclusion, however.

page 2, lines 1-2: I think I know who you mean (providers and users), but it is unclear who is included in the "joint development and evaluation" here.

Introduction

page 2, line 12: What do you include as a DGVM here? Some consider any model having vegetation growth in response to environmental conditions as a DGVM. For others a DGVM specifically includes prognostic biogeography (i.e., the extent of vegetation types change according to environmental conditions) and/or successional vegetation processes (e.g., stages of forest stand growth following a forest clearing disturbance).

page 2, line 26: you should also cite: Meiyappan and Jain, 2012. Three distinct global estimates of historical land-cover change an land-use conversions for over 200 years,

Frontiers in Earth Science, 6(2):122-139 (I noticed you cite it later)

page 2, lines 29-30: you should also cite: Di Vittorio et al., 2014. From land use to land cover: restoring the afforestation signal in a coupled integrated assessment-earth system model and the implications for CMIP5 RCP simulations, Biogeosciences, 11, 6435-6450

Provision of LULCC

page 4, lines 11-13: The CMIP5 product harmonizes only land use, and as such the land cover (forest, grass, etc.) and how it is altered by land use is determined independently by the DGVMs/ESMs, and can be dramatically different between models for a given scenario (in fact, prescribed scenarios can be substantially altered in ESMs by this, see Di Vittorio paper listed above). The CMIP6 product is also including forest cover in the harmonization, both for the historical period (with reference to satellite data) and for the IAM scenarios (which actually project all land cover).

page 4, lines 14-15: Only land use is input to and output from GLM for CMIP5, and forest cover is included for CMIP6.

page 5, line 12: It isn't clear here that you have shifted away from the harmonization group of models to a more general group providing present-day lulc data for future projections.

pages 5-6, lines 24-5: Two points here: 1) In the IPCC context, only land use was used, with forest cover coming into play for CMIP6, even though the IAMs project land types for the entire terrestrial surface. This introduces uncertainty beyond just the model structure/assumptions and different input data (see the Di Vittorio paper listed above). 2) The starting point of lulcc determination isn't just about which land-use input data or how processes are implemented. The spatial configuration of these data and the model are key factors in determining model outcomes. And each model has a unique spatial configuration. Gridded models/data do not necessarily resolve this

spatial issue because regional values are often just resampled to the grid. See: Di Vittorio et al, 2016. What are the effects of Agro-Ecological Zones and land use region boundaries on land resource projection using the Global Change Assessment Model, Environmental Modelling and Software, 85:246-265.

page 6, line 2: How were the variables normalized? Could the dominance of initial pasture area be due to it just being the largest difference in relation to the other variables? Also, it would be more clear if you were specific in the text and the caption in describing that the "starting point" and "initial" are the pasture area in relation to fao in 2010, and that "model" is actually model type and presumably the spatial resolution/configuration.

page 6, lines 6-14: I completely agree! While recent feedback on LUMIP has prompted the provision of LU-forest uncertainty along with the CMIP6 LUH product, it still falls short of the comprehensive approach discussed here.

page 6, lines 15-22: The separation of land use and land cover is a critical factor omitted from this discussion. While land use and land cover are often said in the same breath and the LULC(C) acronym is widely used, in nearly all cases people are referring to either land use or land cover. Research is clearly split along these lines, and land use data are remarkably inconsistent with land cover data. Land use and land cover need to be studied together, as an integrated process, in order to reduce LULCC uncertainties and inconsistencies between these two groups of data.

Considering gross land use changes

How does this relate to the three issues in the previous section? Is this really a major driver of the 3 issues, or something along for the ride? It is clearly present in issues 1 and 2 (although the present day isn't discussed, only past and future), while its absence in IAM projection may be the relevant link (as the transitions are determined by a single independent model, which is part of issue 1)

page 7, lines 21-23: Just a note: You are well aware that gross transition information

is highly uncertain, and current work suggests that the CMIP5 LUH data product may actually overestimate gross transitions in the tropical regions.

page 7, line 32: there are no land cover categories in CMIP5 LUH, only primary and secondary land. wood harvest is associated with forest or non-forest, but this land cover designation is based on a threshold of a potential biomass model, rather than more commonly used land cover or potential vegetation data sets.

page 8, line 14: "...increasingly been captured..."

Allocation of managed land in ESMs and DGVMs

Ah, finally! This aspect of separate land use and land cover information/modeling is a factor in all 3 of your main sources of uncertainty, and as such needs to be mentioned up front and related to these uncertainty sources.

page 8, lines 27-28: and scenarios and over relatively short time periods (see Di Vittorio et al 2014)

page 9, lines 26-27: this is consistent with land cover being studied separately from land use, and your examples also relate to your second main source of uncertainty

pages 9-10, lines 30-12: glad you did this! But what determines the source of land use in CLUMondo? It is important to clearly state how this model differs in this selection versus those that use the methods by which you classify the changes. Generally, more info is needed regarding how the different classified algorithms are defined, in relation to how they are implemented in dgvms/esms. The reader should be able to understand what is going on without digging through the supplemental material. Maybe a table of the definitions?

page 10, lines 5-8: what about the undefined category, which is the dominant category according to the figures (not the complex)? what does it stand for? are you grouping this with the complex category?

page 10, line 16: the IAM community has been projecting land use AND land cover for some time, although not necessarily gross transitions.

Conclusion and recommendations

page 11, lines 17-20: this is an important point, but it hasn't been clearly demonstrated in the text, largely because the paper generally refers to LULCC as a whole.

page 11, lines 20-23: while not an individual, agent-based behavioral model, GCAM has been integrated with CESM as the iESM, implementing two-way feedbacks between the human and environmental systems, particularly for terrestrial systems and the effects on land projection. See the oft-noted paper above, which runs the iESM, and: Collins et al, 2015, The integrated Earth system model version 1: formulation and functionality. Geoscientific model development, 8,:2203-2219. There should also be a paper coming out soon on a complete experiment using the iESM to examine the effects of the feedbacks.

page 12, lines 1-19: It isn't clear how these suggestions relate to your three proposed primary issues with LULCC (which should also be restated in this conclusion - 1) uncertainty in lulcc data products is lacking due to not enough different products generated, 2) present-day lulc data are inconsistent and thus contain high uncertainty, and 3) uncertainty in lulcc projections is largely driven by initial data uncertainty over other model-specific sources). Issues 2 and 3 appear to mainly consist of data quality issues. Also note that your second main source on page 5 does not refer to gross or subgrid transitions at all, just to inconsistencies in present day data. Please make your conclusion/suggestions more consistent with the theme of the paper.

Supplemental material

Figure S1 seems a lot more complicated with more steps than described in the text, which makes more sense.

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