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Interactive comment on “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” by A. V. Di Vittorio et al.

Anonymous Referee #2

Received and published: 25 July 2014

GENERAL COMMENTS

The paper argues for a change in the experimental design of RCP scenario simulations made by ESMs. The reasons for the change in experimental design are not thoroughly discussed and are not clearly enough linked to the results section. I think the paper needs to be revised to focus more clearly on linking the results to the subsequent discussion and to make the discussion clear and thorough.

Summary of the Paper

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The authors describes a discrepancy in the amount of afforestation in the GCAM RCP4.5 scenario and a CESM simulation of this scenario. They then modify the way CESM interprets the land-use change scenario, by using an alternative transition-to-cover algorithm which is designed to maximise forest cover. The results show CESM afforestation is substantially increased, but is still lower than the afforestation in the GCAM scenario. The GLM algorithm, that converts GCAM land-use change into a harmonized gridded product, is also modified, but these modifications have only a small affect on CESM afforestation.

The authors do not further investigate the reasons for the discrepancy, although they do suggest it could be caused by differences in the representation of vegetation-climate interactions and forest management by the two models (GCAM and CESM).

It is then suggested that to avoid the discrepancies between IAMs and ESMs future RCP simulations should use a scenario of land-cover change, instead of land-use change.

More Discussion Needed

At a number of points in the paper it is suggested that using a land-cover scenario instead of a land-use scenario will improve ESM simulations, these statements require some defence. The authors need to state their view of the purpose of RCP ESM simulations before they can argue how to best fulfil this purpose. They should also discuss the advantages and disadvantages of each approach.

For example: Is the purpose of the RCP simulations to provide the most accurate prediction of future climate change for a given socio-economic scenario? Or is the purpose of the RCP simulations to allow multi-model inter-comparison of the atmospheric response to prescribed changes in atmospheric composition and land-cover?

I would argue that using a land-cover scenario instead of a land-use scenario will reduce the multi-model spread in ESM simulations, not improve them. Some disadvan-

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tages of the approach are that the uncertainty in the land-cover response to a given land-use change scenario is not sampled, and that the level of coupling between the land and the atmosphere is reduced.

There could also be more discussion about the differences between the representation of forest in GCAM and CESM. Currently the models are shown to produce inconsistent results and a solution is proposed that imposes the GCAM result into CESM. It would also be useful to understand why the models are different, in particular because it might turn out that GCAM has an unrealistic representation of forest and the current proposal of using a land-cover scenario would propagate this error into ESM simulations.

Clarity Needed

The description of the model and the discussion both need to be clearer.

SPECIFIC COMMENTS

Page 7156 Line 14 – “This implies that a more detailed specification of the relationship between land use and land cover may improve earth system simulations.” It wont improve simulations it will increase consistency between simulations.

Page 7158 Line 24 – Does GCAM also make use of CESM soil respiration? That is what figure 2 suggests.

Section 2.3.1 Paragraph 2 – The description of the CLM-to-GCAM link be moved to section 2.1. Perhaps this paragraph should be removed altogether, because the paper does not discuss this coupling and the results do not depend on it. If it is kept adding some equations would make it clearer, e.g. $F_{HR} = HR_{ref} / <HR>$
 $CSOIL_{gcam} = F_{HR} * CSOIL_{gcam}$ It is not clear that this coupling will produce the correct result. For example if increased soil carbon leads to increased soil respiration in CESM, this method would reduce soil carbon in GCAM. Why not just pass soil and vegetation carbon density from CESM to GCAM? It would also be useful to know what role the vegetation and soil carbon densities play in determining the land-use scenario

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produced by GCAM.

Section 2.3.1 - The representation of pasture in CLM should be described. As far as I understand: 1) CLM does not keep track of pasture area. 2) Pasture comprises grass and shrub PFTs. 3) Grass and shrub PFTs are also present in areas that are not pasture. The third point is important for the interpretation of figures 5-7.

Section 3.1 could be made clearer, the first sentence is particularly difficult to understand. Perhaps the number of acronyms used could be reduced. I find it easier to follow if “RCP4.5” is replaced by “GCAM” and if “CLM” is replaced by “CESM”.

Page 7166 Line 1 - “The iESM and RCP4.5 CESM land area discrepancies (Figs. 5–7) result from a gap in the original CMIP5 land coupling design that allows inconsistent forest area and land cover type definitions across models (Fig. 2), along with different underlying carbon cycles.” — This is not a gap! I could argue that CMIP5 was aiming to estimate the impact on climate of anthropogenic emissions and landuse, in which case there is a range of possible land cover, carbon cycle and climate responses. The authors need to state the purpose of the experiments they are proposing.

Page 7166 Line 10 - “Thus, while this is a specific case, the lost iESM afforestation signal is instructive of the shortcomings of the CMIP5 design and the restoration of this signal offers insights into improving land use coupling for model intercomparisons.” — The insights gained need to be clearly explained. The inconsistency between the IAM and ESM forest cover could be due to model errors in the IAM, the harmonization procedure, the translation between land cover type definitions and/or the ESM. This study has shown the afforestation signal is sensitive to the method of translation between land cover type definitions, but that the translation method can not explain the whole discrepancy.

Page 7168 Lines 1-2 – Why is using the upper limit or CLM afforestation reasonable for the RCP4.5 case?

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Page 7168 Paragraph 1 – It would be interesting to compare these estimates to the multi-model range of changes in vegetation carbon and atmospheric CO₂ concentrations in CMIP5.

Page 7168 Line 17 – This sentence needs to be clearer. Isn't NEWLUT forest area also constrained by potential vegetation? By "incomplete" do you mean smaller than GCAM's forest area increase?

Page 7168 Line 17 – Some more details would be interesting... Does CESM include changes to potential vegetation due to climate change? Is afforestation imposed instantaneously in CESM or is there an associated timescale? Could differences in this timescale between CESM and GCAM explain some of the discrepancies?

Page 7169 Lines 21-22 - Land cover is also uncertain and depends on climate, so it would be expected to vary between ESM even if they used the same land surface and carbon cycle components. Why is this uncertainty not of interest?

Page 7169 Line 24-27 – It doesn't make sense to say that the cause of CESM having less forest than GCAM is that CESM doesn't use GCAM forest area. Of course if GCAM forest area is applied in CESM the two areas will be the same! But this doesn't explain why they are different now. The authors have shown that changing the way CESM interprets GLM data can have a large affect on CESM afforestation, they do not test the hypothesis that passing more land cover information increases the consistency of afforestation simulated.

Page 7171 Lines 10-13 – Would this result in each ESM applying land-use change differently for each scenario? For example CESM RCP4.5 would preferentially remove trees when cropland increases, but MPI-ESM RCP4.5 might preferentially remove grassland when cropland increases. And CESM RCP8.5 might remove grasses and trees equally. Does this mean that while each ESM will have similar land-cover they will each be imposing different land-use changes?

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Figure 4 - The caption appears to be the same as figure 3.

Interactive comment on Biogeosciences Discuss., 11, 7151, 2014.

BGD

11, C3782–C3787, 2014

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