

Dear Editor,

We are pleased to send you all replies and text changes we got by two anonymous reviews and A. Giannini.

Please find in the following the point to point answers to our manuscript.

Best regards,
Tim Brücher

Referee #1:

We thank referee #1 for his/her constructive comments which help to improve our manuscript.

General:

... This should be pointed out in the abstract and it can also benefit from more emphasis/clarification in the introduction and method parts.

We agree and we will add some clarifications in the abstract.

*“In comparison with these changes, any variation of the type of land use in the study area leads to very small, mostly insignificantly small, additional differences in mean temperature and annual precipitation change in this region. **These findings are only based on the specific setup of our experiments, which only focuses on variations in the kind of land use, and not the increase in land use over the 21st century nor if land use is considered at all.**”*

Specific comments:

Page 1103, Line 7-8: This sentence about coupling immediately following the sentence on Koster et al. study is not appropriate. The Koster et al. approach indicates the strength of coupling regardless whether the feedback is positive or negative, so the coupling strength index has no sign (it is theoretically positive. Any negative values are considered noise. If the author made this statement based on other studies, a reference is then needed.

We agree and delete the ‘Koster-sentence’.

Page 1109, Lines 13-15: How might the sharing of moisture between crops and natural vegetation have an impact on the main finding of the study? In reality, this would not happen because the crops and natural vegetation are physically located apart. This was touched upon later in the discussion, but this feature of the model should be clearly pointed out in the methodology part as well.

We agree. We will add text to the methodology to explain the sharing of moisture between all tiles within one grid box.

*“... Within JSBACH, grid boxes over land are divided in a non vegetated part (e.g. desert) and a vegetated one, the latter one is seperated in managed land (shrubs and pasture) and natural vegetation (woody types plus grasses). **This partitioning is not given for the underlying hydrological, as this version includes a single bucket approach. Therefore, all PFTs in one grid box can access the same soil water bucket at the same time, even these tiles are physically located apart in the real world.**”*

Page 1112, Lines 7-10: The authors think that other models would turn out similar results. How does the dynamic vegetation changes from this model differ from or are similar to results from Yu et al. based on a dynamic vegetation model driven with a large number of 19 GCMs? (Yu M, Wang GL, Parr D, Ahmed KF, Climatic Change, 2014)

We think that the link to this publication is most appropriate in the introduction part, as the study of Yu et al. belongs to a different topic. Although the experiments described in Yu et al. are based on the same forcing (RCP 8.5), Yu et al. does not account for feedbacks from biosphere to atmosphere, as in these experiments the climate is prescribed as an external forcing for the offline simulations of the DGVM. Also the focus is set on potential vegetation and not on changes in land use.

“In contrast to other studies dealing e.g. with changes in the landscape by climate change (Yu et al., 2014) we explicitly focus on impacts of anthropogenic changes in land use on climate in an comprehensive earth system modelling approach. To study possible feedback of conflict-induced land-cover changes on climate without knowing the effect of climate change on conflict nor the effect of conflict on land-cover change, we consider a simplified set up of numerical climate simulations.”

Technical corrections:

Page 1102, lines 10-12: “. . . replace the entire area . . . WITH either pasture or agriculture

We will correct accordingly.

“In subsequent simulations, we replace the entire area affected by anthropogenic land cover change in the region between the Sahara in the North and the Guinean Coast in the South (4 to 20° N) with either pasture or agriculture, respectively.”

Line 13, what does “mean agriculture” mean?

We will be more precise.

“The RCP8.5 base line simulation reveals strong changes in the area mean agricultural land use and monsoon rainfall.”

Page 1106, lines 2-4: This sentence is very confusing. Does not seem like a complete sentence.

We will check and improve the sentence.

“The desert fraction increases, if not at least once a year the green pools are filled at maximum level.”

Line 11: “properties of grazing . . .” should be “parameters of grazing”?

The sentence is changed to:

“Grazing is two times higher for pasture than for crops, which is parameterized by a higher herbivory and a higher leaf shedding over pasture land.”

P1105 Line 14: “sawing” is a typo.

We will correct this typo.

“Leaf regrowth is limited by NPP (Net Primary Productivity) for grass and pasture, while it is

assumed that crops have a constant leaf regrowth after sowing. “

P1105 Line 19: “both” should be changed to “the two”

We will correct accordingly.

“... and pasture, because (i) **the two** differ in their phenology, (ii) the maximum leaf area index ...”

Page 1110, Lines 10-13: This sentence is confusing – not sure what the emphasis of this sentence is. The part about temperature leaves me the impression that is opposite of what I think it meant to be. Should rephrase.

We will rephrase the sentence.

“The maximum difference between RCP8.5 and LUC or LUP in annual mean values are up to 0.5 K for temperature or 100 mmyr^{-1} for precipitation, which is about 5 % of the annual precipitation sum in AOI.”

Page 1112, Line 23: “what shouldn’t be the case” “what” should be changed to “which”

We will change accordingly.

“But also the grass fraction is increasing dramatically, so a land use change changes the landscape, **which** shouldn’t be the case.”

Lines 4-6: This will potentially lead to “overestimation” or “underestimation”?

The natural vegetation would benefit from more precipitation and the desert fraction would shrink further. How large the effect of the natural vegetation (forest, shrubs, or grass) on climate would be

can not be answered without doing a set of sensitivity studies. Further more, we would mainly see an effect of natural vegetation on climate (which is not the topic of this manuscript) and not of land use change on climate. This is why we would like to leave it open.

Referee #2:

We thank referee #2 for his/her constructive comments which help to improve our manuscript.

General:

Please improve language style by correcting the typos and some inaccuracies in the text (partly see below).

We will correct for typos and inaccuracies by asking a native English speaker to read our manuscript.

Some of the statements are stronger than can be justified from this analysis. E.g. on page 12, line 4, it is concluded as a key message "that there is presumably no impact of land use on climate". The truth is that this study has shown that in the context of climate change it doesn't matter whether land use consists of agriculture or pasture. Whether land use has an impact on African climate change or not could be assessed by model experiments without any land use or without man-made land cover changes during the 21st century.

We agree, and we will change the text. The statement has to be, that there is no impact on the kind of land use, and not land use at all!

*“So, the question arises, if the key message that there is presumably no impact of **changes in the kind of land use on climate**, can be generalised, or if it is model specific. “*

In addit the link of the considered land use scenarios to conflicts is not very obvious. Conflicts in Africa often imply that man-made land cover change is substantially accelerated due to uncontrolled settlement of refugees in one region or by complete abandonment in other regions. This would affect the transformation rates from natural to managed land which are prescribed by the RCP scenarios and not modified in this study. I suggest to make more moderate statements in this respect.

This is a valid comment. Our study is based on the land use rate prescribed by the RCP and we only modify the type of land use. Effects of migration on the land use rate is excluded but certainly an interesting point to mention in the discussion.

“In our study conflict implies changes in the type of managed land, but we neglect possible scenarios including uncontrolled settlement of refugees in one region or complete abandonment in other regions.”

Specific comments:

- 1) Abstract: I do not understand the last sentence of the abstract and how it is concluded from the statements

We change the sentence to make it more clear.

The conclusion is, that the type of land use does not influence climate. By running simulations (transient) to investigate the interplay of conflict, land use, and climate change, there is no need to couple the human component into an ESM. Simulations can be done offline by prescribing the climate (climate change in a transient simulation) as forcing.

“Hence as a good approximation, climate can be considered as an external forcing: models investigating land-use – conflict dynamics can run offline by prescribing seasonal or mean values of climate as a boundary condition for climate.”

- 2) Page 3, lines 20-25: Following the argumentation in this paragraph one would expect that the authors object to underlying assumption of former studies by using e.g. daily extremes. However, they even use annual instead of monthly or seasonal means, assuming that farmers can even cope with climate anomalies over such long time periods. This assumption should be supported by some references or further discussion.

Thank you for pointing at a misunderstanding. The papers we cite use climatological mean values or monthly mean values. Hence we implicitly assumed that in these papers, the assumption of fast adaptation was made. This might be not correct. Therefore we reformulate our statement. We delete the sentence “This implicitly assumes ...” and we continue by “Therefore we focus here on climatological values as well, by considering annual means of temperature and precipitation.”

- 3) Page 14, line 7: at a prescribed ... what?

We will correct the sentence.

“In case of both transitions, if one component is area limited to establish land use, the missing part of natural land would be taken from the other type to ensure that managed land will be established.”

4) Page 6, line 18: Table 1

We will add the number.

5) Page 8, line 4: the spatial distribution of ... what?

We will correct the sentence.

“The spatial distribution of natural and managed land for different plant functional types is shown in Fig. 2.”

6) Fig. 3: Is there a reason why differences are plotted against the period 2006-2035 instead of using a period the 20th century as a reference which is less affected by climate trends?

As the period of the 20th century is also affected by climate trends we proposed to show differences of the period covered by our experiments. The figure plotted against the 20th century would look pretty similar, as the biggest changes are going to happen at the end of 21st century.

7) Fig. 4: The quality is bad and does hardly allow for distinguishing between dashed, dotted and solid lines.

8) Fig. 6: Same quality problem as in Fig. 4 and the labels a-f are missing.

As the curves are color-coded, there is no need to use additional stroke styles, too. Therefore, we changed everything to solid lines and put the letters in.

9) Page 11, line 8-9: (not shown) ... Isn't this shown in Fig. 7f?

Thank you for pointing at this oversight. We change the text to: (shown in Fig. 7f)

“The differences in temperature changes are insignificantly small in the entire region under consideration (Fig. 7f).”

10) Reference list: Please check whether Claussen et al. 2014 is cited in the text.

Citation will be deleted.

Referee #3 A. Giannini:

We thank A. Giannini for her inspiring comments which help to clarify a misunderstanding.

General:

Realization that (1) to first order sea surface temperatures drive precipitation variability, that (2) land surface contributes a second-order feedback that naturally amplifies the initial ocean-forced variation, and that (3) human influence is varied, and possibly positive, meaning contributing to "re-greening", changes the perspective within which to consider the formulation and evaluation of model simulations such as those discussed in this paper.

The ocean is the main driver for the monsoon system. However changes land-surface conditions affect the African monsoon system as well. The question for us was whether we see any signal from what one might call a second-order feedback. We were surprised to see nothing. This, then, is good news for climate impact modellers who are interested in any feedback of changes in land use on climatological values. They can use climate change as a forcing without bothering with feedbacks from resulting land use changes triggered by climate changes on climate change.

The opportunity to expand this perspective to scenarios of future climate/environmental is missed in this paper. Two aspects to consider would have been the physical effects of climate change, i.e., whether to expect an increase or decrease of seasonal precipitation, as well as lessons learned in societal response to persistent drought of relevance to adaptation. In contrast, the assumptions made here about farmer-herder conflict and land use-conflict relationship strike me as excessively stylized representations of societal interactions in the Sahel. Because they have little counterpart in the real world, the entire study strikes me as little more than an academic exercise.

Our study emerged from our cooperation with colleagues in Hamburg who model farmer-herder conflict. We faced the question of how to combine climate models and conflict models. Should we couple these models interactively or would one-way-coupling be enough? Since the farmer-herder model uses climatological values as input, we focused on climatological values as well. We tend to agree that the farmer-herder model potentially underestimates the total societal response to changing climate.

Only one simulation is run with the standard RCP8.5 configuration, which raises minor concerns about the robustness of the conclusions.

As the figures show, the ensembles from 'default' RCP scenarios are close to each other. For each of our one ensemble member we are close to the RCP results, too. From our point of view these small, insignificant differences do not require more ensemble members.

If I understand correctly, land use is partitioned between natural and anthropogenic, and only the anthropogenic fraction is changed, either according to the standard RCP8.5 scenario or according to the alternative scenarios designed here. An interesting complementary comparison to this set of simulations would have been an RCP8.5 simulation with no ALCC - no anthropogenic land cover change at all - which would have bypassed the complexity of imposing land use/land cover changes in current state-of-the-art models.

The studies you propose by excluding ALCC have already been done within the framework of LUCID. Here we address the issue of changes in land use, but not in the extent of land cover change.

In light of their conclusions, there may be scope to change the title to: "No implications [or impact] of land use change...".

We have to disagree, as this would state, that land use is not affecting the climate. We only show that the type of land use (in our ESM) does not matter. But it is known from many previous studies that land use and land cover change matter. Also, in our study we include the increase in anthropogenic land cover change (analogue to RCP8.5) in all experiments..

I do have one suggestion to make, for future work. In light of the state of our knowledge on land cover/use-climate interactions in the Sahel, in my opinion it would be interesting to begin to use earth system models to understand re-greening, specifically interactions of the physical climate [temperature and precipitation] with hydrology at basin scale, and with greenhouse gases. At the same time, it should be acknowledged that humans may have played and continue to play varied roles, positive and negative, that modify landscapes, and that these will likely escape even the most sophisticated climate modeling effort for quite some time to come.

This is an interesting topic, indeed. We have started working on the topic of greening, or re-greening as a function of climate and CO₂ increase, see: Bathiany, Claussen, Brovkin, Journal of Climate 27 (2014), pp. 7163- 7184. This study focusses on the signal of a strong increase in atmospheric CO₂ over the next two centuries. A larger challenge poses the attribution of present-day re-greening. .

Minor editorial comments:

p.1102, l.6, "baseline" is one word

We will change it accordingly.

*“The **baseline** for these experiments is a ... “*

p.1105, l.9, should read "synthetic"

We will change it accordingly.

*“Pasture and crops use different photos**ynthetic** pathways (Raddatz et al., 2007) and crops have a higher productivity, as ...”*

p.1105, l.11, should read "Additionally". Also, what properties?

We will change it accordingly.

“Grazing is two times higher for pasture than for crops, which is parameterized by a higher herbivory and a higher leaf shedding over pasture land.”

p.1105, l.14, is it "sawing" or "sowing"?

We will change it to “sowing”.

*“Leaf regrowth is limited by NPP (Net Primary Productivity) for grass and pasture, while it is assumed that crops have a constant leaf regrowth after **sowing**. “*

p.1107, l.17, should read "separates", not "seperates"

We will change it accordingly.

*“JSBACH **separates** the vegetated part and the area without soil in a grid cell.”*

Figure A1: what letters stand for should be spelled out in the caption.

Will be added!

*“Diagram to illustrate the legacy effect of long term changes in natural vegetation (**G: grass, W: woody type**) after strong anthropogenic land use transitions (**P: pasture, C: crop**). ...”*