Earth Syst. Dynam. Discuss.,
doi:10.5194/esd-2015-88-AC2, 2016

Earth System Dynamics Discussions
Open Access
EGU

Interactive comment on "Vegetation-climate feedbacks modulate rainfall patterns in Africa under future climate change" *by* M. Wu et al.

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Received and published: 21 April 2016

Comments from reviewer #2:

This paper presents a future prediction study on climate-vegetation interactions in Africa. While the concept is not new, it does add to an emerging body of literature on interactive vegetation-climate predictions and will be of interest to many readers of ESD. The paper potentially merits publication, but quite a few major issues need to be addressed:

(1) Introduction: The flow of thought is very hard to follow. Part of the reason has to do with a rather liberal use of terminology. Probably a more strict use of the words "change" "variability" "pattern" "feedback" will help. The way it is now, many sentences are either vague or not accurate, which does not serve the readers well. Needs a better

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Discussion paper

organization.

Response: We will revise the introduction and will attempt to use a more strict terminology throughout the article.

(2) Introduction: An important body of literature (e.g., Claussen 1997 climate dynamics, Claussen 1998 global change biology; Zeng et al., 1999 science; Alo & Wang, 2010 climate dyamics; Yu et al., 2015 climate dynamics) on vegetation-climate interactions is missing, although some of them are later mentioned in the Discussion section. The introduction part of a paper should be the place where the status of science is conveyed and gaps identified. Otherwise it will be misleading for readers who are new to the topic.

Response: We will add a new paragraph to the introduction where we will cite most of these highly relevant papers and highlight the specific gaps that our paper is attempting to address.

(3) Partly related to (2), the statement in lines 111-112 is misleading. The first several sentences in section 4.1 should be moved here to provide readers an accurate description of the status of science, and the authors need to further elaborate to explain why this study adds values to existing literature.

Response: This will be addressed, see response to previous comment. The revised statement will be : “Recent studies have used a regional climate model to investigate the impact of climate-vegetation interaction for West Africa, identifying significant vegetation feedback in modulating local hydrological cycling (e.g. Wang and Alo, 2012;Yu et al., 2015;Alo and Wang, 2010). Additionally, a number of GCM-based studies have investigated the climate effects of anthropogenic perturbations, such as deforestation or afforestation (e.g. Lawrence and Vandecar, 2015). Such studies point to potentially significant forcing of regional climate dynamics, particularly rainfall patterns, as a result of changes in land cover. No study to date has, however, characterised the coupled dynamics of vegetation and climate under future radiative forcing for the entire African domain at a grid resolution high enough to capture regional features and forcings.”

(4) Fig.1: The color scale is very difficult to read if one were to try to figure out the actual magnitude of the model biases. Should use more distinguishable color scales/ use stronger contrast between the colors.

Response: This will be addressed, thanks for the suggestion.

(5) Fig.1 and 2 showed severe bias of the model in capturing the spatial pattern of precipitation distribution and vegetation distribution. Essentially, LAI has negligible difference between the Sahelian savannan and the central Africa forest. The discussion and statement about model performance in Section 3.1 significantly downplayed the severity of this model biases.

Response: We agree that these biases are significant. We will add a substantial discussion of the bias in precipitation pattern and LAI in Section 3.1, such as acknowledgement for the LAI bias "A systematic overestimation is apparent for savannahs, and a significant underestimation for the central Africa rainforest area" and more explanation for the precipitation bias"The simulated daily precipitation for central Africa tends to be underestimated during the late afternoon and night (Nikulin et al., 2012), resulting in dry bias. The wet bias over the northern savannah is mainly caused by a too early onset of the rainy season (b1, Fig. 2) which is possibly caused by the interactions between the simulated deep convection and the Africa Easterly Waves (Sylla et al., 2011)" Additionally, in response to Comment (7) from Reviewer #1 which is also relevant to this comments, we will add a new figure (Fig A1) and related discussion evaluating low-level circulation and humidity. We found that the dry bias over central Africa and wet bias over Sahelian savannah are not primarily related to the biases in the circulation, but are more likely to be related to problems with the convection scheme in the regional model (Nikulin et al. 2012). In contrast, the model has done a relatively good job in reproducing overall circulation patterns, including the southern and northern trade wind over Atlantic oceans (Fig. A1), Walker circulation (Fig. 6), which are important for this study. This will be included in section 3.1 also.

(6) The model biases in precipitation and more importantly in vegetation could significantly influence the location and magnitude of the difference between FB and NFB, and need to be discussed explicitly.

Response: For the vegetation dynamics, the bias in simulated present-day vegetation is largely related to a bias in precipitation. We agree that this potentially influences the simulated difference between FB and NFB, as the latter uses the resultant, biased vegetation as forcing. This may lead to an offset in the locations of the strongest impact of vegetation feedbacks in the model, but we assume that this bias does not critically affect qualitative aspects of the feedbacks that we find. One reason for such confidence is that the bias is small in magnitude compared to the size of the simulated future changes in LAI and precipitation. We will add more discussion in section 4.2. The influence of the bias on model's dynamics is explained in point (8) further below.

(7) Lines 315-320: The albedo difference is negligible? One would think that albedo changes can be significant in areas with increase of vegetation cover.

Response: We agree that albedo changes play a role for surface temperature changes, this was ill-phrased in the original manuscript. We have identified warming effects from albedo change, which gives an overall warming effect in northern hemisphere winter on the edge of the area of forest expansion in the northern savannah region (Fig. A2). An increase in vegetation (forest) cover gives both an albedo (warming) effect and an evaporative (cooling) effect, with the combined effect depending on their seasonal balance. In general, modelling studies tend to show that evaporative cooling effects are more dominant in the tropics while albedo warming effects are more dominant over high-latitude regions (e.g. Bala et al., 2007;Claussen et al., 2001). The missing explanation for the albedo effect will be added to section 3.3 as "Overall, the turbulent heat fluxes increase, which tends to cool the surface and the lower atmosphere, exceeding the opposing (warming) effects of increased vegetation cover on albedo, thus resulting in an overall cooling effect.".

(8) Lines 448-453: This is not true. The state of the vegetation is very important in determining the interannual variability of vegetation and the vegetation feedback effects. This is why the issue of severe model bias needs to be acknowledged and its implication explicitly discussed, as suggested in comment 6).

Response: We agree with the reviewer on this point, we did not express our point well in the original manuscript. We intended to point out that bias in LAI within a given land cover type (forest, savannah or grassland) is likely to have a smaller impact on the simulated climate than an inaccurate distribution of land cover types. Although our simulations have evident bias in LAI and precipitation, overall patterns of vegetation distribution across Africa are comparable to observations. This will be further explained in section 4.2 as "Despite biases in the initial precipitation and vegetation state (LAI) for some regions, our model was able to reproduce the present-day land cover type (Fig. 4a). Vegetation-induced changes in circulation, thus a substantial change in moisture transport and precipitation, are mainly triggered by changes in land cover type (Fig. 4A), therefore, we argue that the influences from biases in initial conditions on such mechanism found in this study should be limited."

Minor comments: Lines 92-94: "... are important to . . . " is rather awkward. You mean ". . . are important determining factors for . . ." ? Fig. A4: "temperature gradient" should be changed to "temperature contrast" as y-label.

Response: Will change as suggested, thank you for the suggestions.

Please also note the supplement to this comment:
http://www.earth-syst-dynam-discuss.net/esd-2015-88/esd-2015-88-AC2-supplement.pdf

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