Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2017-425-RC2, 2018

Biogeosciences Discussions
Open Access
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Interactive comment on "Plant functional diversity affects climate–vegetation interaction" *by* Vivienne P. Groner et al.

Anonymous Referee #2

Received and published: 26 January 2018

This manuscript aims to assess the sensitivity of the simulated extent of green Sahara during the African Humid Period (AHP), and the manner in which the land cover from this green Sahara transitions to current desert conditions , to the representation of plant functional types (PFTs) in the MPI-ESM (i.e. the PFT diversity). The subject of the manuscript is of broad interest and many past studies have addressed the question of the extent of green Sahara. Authors claim that differences in past studies are due to representation of different PFTs in different models (this appears to be a valid argument based on results presented in this manuscript) but the general strength of the land-atmosphere feedbacks (which depends on a particular land surface model) likely also plays a role. That is, the extent of green Sahara will be different amongst models despite same PFTs because different land surface models have different strengths of

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land atmosphere coupling. In addition, different land surface models will likely represent same PFTs with different parameterizations and parameter values. This aspect is not discussed in the manuscript.

This study can be assessed in the context of paleo vegetation as the first reviewer appears to have done but also in the context of land-atmosphere interactions which is where my expertise lies. In my opinion, the manuscript needs clarification of several items before it may be considered for publication in BG.

The competition between PFTs is an important aspect of this study but I felt that the description on page 4 (lines 5 – 25) wasn't sufficient for me as a reader to understand how competition actually works. Since this is a modelling study, I feel it is important to lay it out for the reader. The text on page 5 attempts to do this but it seems it doesn't go all the way.

Other comments

Having read the authors' response to Reviewer #1 I now realize out of 21 PFTs only 8 PFTs can grow in the region considered. However, when I read the manuscript the first time I had similar confusion. So perhaps this point needs to be clarified.

Section 2.2 needs more info about model setup and discussion of implications of how this set up is done.

1) How does use of present day SSTs affects the overall results? Does an interactive ocean generally amplify or dampen the effect of land-atmosphere feedbacks?

2) Other atmospheric boundary conditions correspond to what time period?

3) What do soil properties mean – do you mean soil texture and permeable soil depth.

4) Since land-atmosphere feedbacks are key to understanding the results presented in this manuscript it would be useful to put albedo, typical LAI, rooting depth and vegetation height of different PFTs in a table for reader to understand how the different

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physical characteristics of a PFT can potentially affect land-atmosphere interactions.

On Page 6, around line 24, it is mentioned albedo in the C4 grass simulation is lower than that in the EXP_ALL simulation. Is this an error? Grasses are generally brighter than trees. But then on page 7, lines 11 and 12, the manuscript correctly notes that albedo is higher in EXP_C4 than in EXP_ALL. Please correct the sentences on page 6 so that they are consistent with the text on page 7.

On Page 7, line 2, the phrase "slows down water and energy fluxes" is unclear. What does slowing down means does it mean decrease in fluxes. If yes, which fluxes – I suppose evapotranspiration (i.e. latent heat). Please be explicit.

Page 7, line 16-20. Yes, C4 grasses are more productive than C3 grasses. But productivity is different than specific leaf area (SLA, m2/kg C) which is a measure of how many m2 of leaves can be constructed with a Kg of carbon of leaf biomass. The discussion in lines 16-20 appears to be mixing productivity with SLA.

Page 7, line 21. "Grass cover is not directly reduces by disturbances". This seems contradictory to what happens in nature. Grasses are more flammable than trees so fires affect grass cover more drastically – although, of course, grasses spring back faster too.

Page 7, line 33. ". . . SRG outcompetes C4 due to the implicit assumption of light competition". So are shrubs assumed to be taller than trees. This is where a more complete description of how competition works can help. A model can simulate the actual physical processes or it can assume that certain hierarchy in vegetation superiority exists. It seems in this case, the model assumes that shrubs are always superior to grasses and if they can exist then they will take over grasses. Is this correct? Is this a reasonable assumption. The purpose of additional description of the competition module is to highlight all primary assumptions and structure of the competition module while acknowledging its limitations. Yes, models aren't perfect but if their features and limitations are well highlighted then it's easier for readers to put the results in the context of

the model.

Page8, Section 3.2, lines 15-16. " . . . we subtract 100-year averages of consecutive time slices . . ." only becomes clear once a reader looks at Figure 5. Please reword this sentence to make it more clear.

In Figure 5 the units of precipitation change make sense. The units of precipitation are mm/year and then the change is mm/year per 2k year. This can be simplified and referred to change in annual precipitation and then the units would just be mm/2k years. However, the units of change in fractional vegetation cover seem incorrect. What does fraction/year (i.e. yearˆ(-1)) means? Why is there a year in the denominator? If change in fractional cover over 2k years is being referred to then units should just be fraction/2k years. I am unclear why there's an additional yearˆ(-1) term needed.

Page 9, line 4. It took me a while to realize that delta_P and delta_veg_max do not refer to zonal averages but instead Figure 6 shows zonal averages of these quantities. Please consider rewording this sentence.

Page 9, lines 14-16. I wasn't able to follow this sentence.

Page 9, line 21. What is a "dominant branch"?

Page 10, towards the end of section 3.2, it is discussed how disappearance of SRG leads C4 grasses to establish and an increase in fractional vegetation cover for same precipitation. 1) Why does SRG disappears, and 2) isn't this behaviour (of higher fractional vegetation cover for same precipitation) unrealistic.

Page 10, line 9. " . . . with a strong feedback between single plant types and climate". This sentence is unclear.

On page 10, and earlier on, does "realized PFTs" means the PFT that can potentially exist in a grid cell.

Page 10, last two sentences. Please explain "trait flexibility" and "evolutionary optimality

hypothesis" in one or two sentences.

In context of issue raised by Reviewer #1 also consider showing absolute annual temperatures for 8k years ago and temperature change relative to 0k to justify the need for tropical tree PFT that can survive 10 degree Celsius coldest month temperature.

Figure 4 is an important figure. Figure 5 is also an important figure which illustrates whether the change in precipitation and fractional vegetation cover is gradual or immediate. However, overall as a reader I felt that this discussion wasn't enough or complete to convey the primary message around how the system operates. Perhaps, a simple cartoon of Figure 4 can be used to help understand a reader the discussion around Figure 4 e.g. using horizontal and vertical lines touching the Y and the X axes, respectively.

I am also attaching an annotated version of the manuscript with my hand written comments a lot of which I have already summarized here. But please see this version for other minor comments.

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2017-425/bg-2017-425-RC2-supplement.pdf

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