(Reviewer comments in *italics;* Responses in **bold**)

Response to Anonymous Referee #1 Received and published: 11 July 2017

General Comments:
Reviewer summary:
The manuscript presents results from the DGVM INLAND evaluating the effect of climate variability, fire and phosphorus limitation on vegetation structure and dynamics in the transitional zone between the forested Amazon and grassland savanna of the Cerrado. Changes in net primary production, aboveground biomass, and leaf area index are assessed between simulations, and simulated aboveground biomass is compared to observations. Transects along the Amazon-Cerrado transition zone are analyzed in subsets, as well as the region as a whole. Inclusion of climate variability, fire and maps phosphorus limitation improves simulation of vegetation structure across the region and for four of five transects. The cerrado transect has the lowest correlation to observations. Fire has the strongest impact on vegetation characteristics, followed by phosphorous limitation. Overall, INLAND with these included factors appears effective at simulating vegetation across the region, but regional deficiencies show that more improvements can be made.

Article contribution and overall impact:

This study highlights the need for improved simulation of vegetation in a key forest-savanna transition zone. A shift in vegetation in this region has the capacity to impact the cycling of water and nutrients as well as energy fluxes beyond the area of forest-savanna transition. Uncertainty in future climate and fire behavior as well as the feedback between these factors make the vegetation state of this region difficult to predict. The manuscript does a good job of presenting the challenges of simulating vegetation in this transitional zone where climate, nutrients and fire are essential contributors to vegetation state. The inclusion of phosphorous limitation in the simulations for the region is an important addition to the evaluation of vegetation state. The discussion would benefit from a more detailed description of the fire model and fire activity during simulation. The concluding recommendations for future work also need to be clarified. Discussion of the importance of vegetation size structure and how this is or is not represented in INLAND should also be added. A key component of the mortality of woody vegetation to fire is its size at the time of fire and the ability to accumulate size between fires. This is central to the work of many of W. Hoffman's papers in the region (Hoffman et al 2003, Hoffman et al 2009, Hoffman et al 2012). Please add discussion of size structure to the manuscript.

Response: We are grateful to the reviewers for their insightful comments and helpful suggestions. We can include a better fire model description and describe how it works throughout the discussion of its impact on the vegetation structure. We will include a more complete discussion about the influence of fire on size structure along the transition. Details about recommendations for future work also may be clarified.

Detailed comments:

1. *Page 6 line 101-107: Add the 1x1 degree grid size to this section.*

Response: This information was added. See below:
"The present study focuses on the Amazon-Cerrado transition (Figure 1). We use the official delimitation of the Brazilian biomes proposed by IBGE (2004), and define five transects along the transition border with 1° × 1° grid size (the terms "transition", "Amazon-Cerrado transition" and "Forest-Savanna transition" are used interchangeably with the same meaning throughout this manuscript)."

2. *Page 9 line 159-164: Provide more detail concerning fire model. Is the fire ignition probability the same in every pixel, or is there spatial variability? If there is spatial variability what drives this parameterization? Does flammability vary by PFT?*

Response: The fire ignition probability is spatially varied in INLAND. INLAND incorporates all fire components of the CTEM (Canadian Terrestrial Ecosystem Model) model (Arora and Boer, 2005). These components simulate fire at the daily timescale (instead of the yearly timescale of earlier models) by computing the probability of fire occurrence, which is based on biomass availability, flammability and ignition source for each pixel (using observed lighting frequency). Burned area is modeled as an ellipse of dimensions determined by wind and fuel conditions. The fire model of CTEM uses an arbitrary anthropogenic fire probability which is summed to the natural ignition probability. In summary, the natural ignition probability is represented by a lightning scalar, which varies from 0 to 1 as cloud-to-ground lightning frequency varies from a specified lower value of essentially no lightning to an upper value close to the maximum observed. The probability of fire ignition due to human causes may be selected depending on location and human activity and determines the lower limit of ignition constraint. In INLAND, we use 0.50 for the probability of fire ignition due to human cause. Additionally, we suggest the reviewer to verify the arbitrary ignition scheme in Figure 3c in Arora and Boer (2005), which we do not have permission to reproduce. Moreover, in INLAND the vegetation structure is represented by two layers. The fire occurrence reduces the upper canopy decreasing the trees LAI (LAI upper), and opening the canopy. The opening canopy implicates in more luminosity penetration and consequently increase of photosynthesis rates by grasses (increasing of LAI lower) initializing a competition between PFTs for light resource. We will include these details concerning fire model in the Methods section.

3. *Page 16 line 316: define "transition" here and throughout manuscript. The reference is not always clear. Most often it appears to be Amazon-Cerrado transition or forest-savanna transition, if that is correct please add the extra detail here and throughout manuscript (Pg 20 line 403, pg 21 line 419, pg 22 line 426,428,443, pg 23 line 451)*

Response: We agree with the reviewer that this term was not always clear and may generate doubts. To clarify, we included in Page 6 line 105-106 a brief reference: "The terms Amazon-Cerrado transition, forest savanna transition or transition are used interchangeably with the same meaning throughout this manuscript".

4. *Page 17 line 323-325: Update sentence to "responsible for altering the simulated AGB to approach the observed AGB" or some variant. Current sentence structure is unclear.*

Response: The sentence has been changed. See below:
"In T2, T3 and T4, however, fire is responsible for altering the simulated AGB to the observed AGB in the eastern pixels of the Cerrado domain (Figure 5)".

5. *Page 18 line 345-349: What observational data set is this being compared to for current vegetation state? Is this a by pixel comparison of the same grid size?*

Response: We use the official delimitation of the Brazilian biomes proposed by IBGE (2004), which reconstructs in more detail the probable location of the vegetation before the anthropogenic interference. This database is a vector database and is available in http://downloads.ibge.gov.br/downloads_geociencias.htm.

6. *Page 18 line 359-364: Do the climate datasets used in simulation include reduced rainfall and ENSO effects? Explain this further.*

Response: The CRU climate database, which is used in our study, included reduced rainfall and ENSO effects. The CRU gridded climate dataset is a database developed from monthly observations at meteorological stations across the world's land areas (Harris et al., 2014). These dataset includes six mostly independent climate variables (mean temperature, diurnal temperature range, precipitation, wet-day frequency, vapor pressure, and cloud cover). Maximum and minimum temperatures have been arithmetically derived from these. This gridded product will be publicly available, including the input station series (http://www.cru.uea.ac.uk/ and http://badc.nerc.ac.uk/data/cru/).

7. *Page 21 line 409: Update to "for the most part Dynamic Vegetation Models"*

Response: That has been changed.

8. *Page 22 line 435-437: Add more detail clarifying how the INLAND model differs from reality. Is it able to simulate rapid restoration following fire? If not, what would need to be added to the model's fire or vegetation characteristics?*

Response: In our model, the restoration of vegetation after fire occurrence is exclusively due to the canopy opening and consequently more luminosity penetration into lower canopy. Two layers in the INLAND represent the vegetation structure. The fire occurrence reduces de upper canopy decreasing the trees LAI (LAI upper), and opening the canopy. Thus, we have more luminosity penetration and consequently increase of photosynthesis rates by grasses (increase of LAI lower) initializing a

competition for light resource. The dynamic vegetation module computes for each PFT: gross and net primary productivity, changes in biomass pools, simple mortality disturbance processes and resultant LAI, with the same manner before the fire occurrence, thus allowing vegetation type and cover to change with time.
The partitioning of the NPP for each PFT resolves carbon in three AGB pools: leaves, stems and fine roots. The LAI of each PFT is obtained by simply dividing leaf carbon by specific leaf area, which in INLAND is considered fixed (one value) for each PFT.

INLAND has eight soil layers to simulate the diurnal and seasonal variations of heat and moisture. Each layer is described in terms of soil temperature, volumetric water content and ice content (Foley et al., 1996; Thompson and Pollard, 1995). Furthermore, all of these processes are influenced by soil texture and amount of organic matter within the soil profile.

Considering these aspects of vegetation dynamics and soil physical properties the model can simulate plant competition for light and water between trees, shrubs and grasses through shading and differences in water uptake (Foley et al., 1996). We included more details about restoration following fire.

9. *Page 22 line 444: Update to "but the inclusion of these effects"*

Response: That has been changed.

10. *Page 22 line 442-445: This needs more explanation. Is the vegetation simulation insufficient because of the presence of transitional and robust pixels in the cerrado in fig 5? Or is this because of comparisons to observed data of vegetation in the cerrado?*

Response: The sentence was re-written. See below:
"**From Figure 5, it is clear that CV, F and P limitation in the transition zone reduce the AGB, approaching the simulated to the observed data. However, the inclusion of these effects is still insufficient to represent the actual vegetation structure in the Amazon-Cerrado border (Figure 6L).**"

11. *Page 23 line 449: what is meant by residence time?*

Response: Residence time is the average time a particle resides (passes) in a pool or system. In INLAND, the residence time is a parameter of the vegetation used by the PFTs to allocate carbon in the different compartments of biomass (leaves, roots and stems). The residence time of carbon in a biomass compartment is intended to represent the loss of biomass through mortality and tissue turnover.

12. *Page 24 line 477-479: Explain this in more detail: "It does not dynamically change the allocation"*

Response: Parameters can be fixed or dynamically allocated, which means that they can change over time. Fixed parameters for a given PFT are assumed during the carbon allocation in INLAND. For tropical evergreens trees, for example, we have

50% of carbon allocation in stems, 25% in leaves and 25% in roots. Even though there is evidence that in the Amazonia-Cerrado transition the carbon allocation rates may vary in some situations of water stress, the INLAND model do not represent this strategy.

13. *Page 25 line 495-496: Reword this sentence. The meaning is not clear.*

Response: We agree to the reviewer. This sentence was changed. See below: "Obtaining ecophysiological parameters is a challenge to the scientific community once the field measurements depend on fieldwork conducted throughout all the transition area."

14. *Page 26 line 522-525: Inclusion of spatially explicit parameters may or may not improve DGVM simulation. This assumes that the existing processes are accurate, and that it is merely parameters. Provide more discussion of this possibility, or re-word this section.*

Response: There are evidences that the inclusion of spatially explicit parameters may improve DGVM simulation. Castanho et al. (2013) showed that the simulated aboveground biomass in Amazonia improved with spatially biophysical parameters such as woody biomass residence clearer time, maximum, carboxylation capacity (Vmax), and NPP allocation to wood. They found that using single values for key ecological parameters in the tropical forest biome severely limits simulation accuracy. We believe that the same limitation occurs along the transition. The use of spatial parameters allows represent the spatial heterogeneity along the Amazon-Cerrado border and may lead to simulated spatial variability of biomass. However, the lack of data observed in this region limits the representation and understanding of how biophysical parameters vary throughout the transition. Thus, it is necessary obtain physiological and structural parameters to establish numerical relationships between the environment and the vegetation dynamic models.

Page 26 line 525-527: What is meant by temporal variability? Size structure?

Response: Currently the physiological parameters of vegetation are fixed, each PFT uses a fixed carbon allocation parameter, mortality, carboxylation capacity and others from start to finish of the simulation. We suggest that these parameters should be dynamically allocated, i.e. temporal variability in physiological parameters of vegetation, as a function of other simulated variables should be included, to improve the simulation results.