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Interactive comment on "CO_2 fertilization effect can cause rainfall decrease as strong as large-scale deforestation in the Amazon" *by* Gilvan Sampaio et al.

Anonymous Referee #2

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In this study the authors assess the impacts of higher CO2 and deforestation on precipitation over the Amazon. They compare two simulations from the CPTEC-Brazilian Atmospheric Model, one with a 50% increase in the atmospheric CO2 concentration and another with all forest converted to grassland. The main results suggest that both scenarios lead to similar reductions in annual precipitation of 12% (higher CO2) and 13% (deforestation) due to equivalent reductions (20%) in transpiration. Though changes in precipitation and transpiration are similar, the causes (e.g., reduced stomatal conductance vs. reduced leaf area) and impacts on circulation differ.

Overall, this research addresses an important scientific question, with relevance to so-

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ciety. The focus on smaller increases in CO2, 1.5x vs 4x as in other work, is particularly relevant for the near future. The well referenced discussion section is also very useful for understanding how this work fits into previous literature. And the fact that precipitation changes are similar in the two simulations, but with very different circulation anomalies, is especially interesting. However, some claims are made without direct evidence/analysis to support them, and additional figures are need to clarify the mechanisms discussed. For example, a major conclusion is a strengthening of the Walker circulation in both scenarios, but only the 850mb wind field is shown. It would help to provide a much more robust analysis of circulation and moisture transport changes over the region. There are also some inconsistencies between the results in the figures and descriptions in the text. After addressing the comments below, this work would be a good fit with this journal.

Major Comments:

1. Is it a coincidence that 1.5xCO2 and 100% substitution to grassland give similar results? Why were these values chosen to compare? Why not 2xCO2 or 50% substitution to grassland? Some motivation for this specific comparison is needed. For example, when in the future would we expect to reach 1.5xCO2 based on the current trajectory of emissions, and how does that compare to the timescale of deforestation based on current deforestation rates?

2. The meridional mean changes in Figure 4c show increases in column specific humidity along the western side of the Amazon due to physiology, but the moisture transport in Figure 5a and discussion in the text indicate a reduction in the flux to the Andes (2.1 kg/m/s reduction). Likewise, in the deforestation case for the same region, there is a large reduction in low level humidity (Figure 4d), but Figure 5b shows an increase of 10.8 kg/m/s. In order to understand these results, it would be helpful to see what the horizontal wind anomalies look like at different levels? It might also help to decompose the moisture transport changes in order to understand the contribution from changes in humidity vs. changes in circulation.

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3. Comparing Figures 6c and 6d, it seems that the evaporation from the soil and canopy are compensating the reduction from transpiration in the deforestation simulation during the wet season. It would be helpful to see what the seasonal cycle of these other evaporation terms look like? What would cause them to increase, despite a decrease in precipitation, in the deforestation simulation? It would also be helpful to see the seasonal cycle of LAI in this figure to better understand the mechanisms described. Likewise, adding annual mean net radiation to Figure 3c (and perhaps the season cycle of net radiation to Figure 6) would help clarify the mechanisms driving changes in the energy budget and surface temperature.

4. The fact that the two scenarios give similar results is really interesting. It is likely there would be some compensating effects on transpiration if they were simulated together (transpiration would decline by less than the two added together), but it is less clear what the impact on circulation would be. It would be very interesting to add a third scenario in which both elevated CO2 and deforestation occur together. There are several places in the manuscript that refer to a “Full” simulation which is not shown in the figures, is that referencing this combined scenario?

Minor Comments:

Line 26: What specifically is "its dry-season lower surface vegetation coverage" referring to aside from the "decreased leaf area index" that is already mentioned?

Line 80: Suggest changing "majorly in" to "mostly on".

Line 108: Does the vegetation component of CPTEC-BAM allow for increases in LAI, without a change vegetation type, due only to higher CO2? Or is it only the impact on stomatal conductance?

Line 110: Suggest changing to: "Control run with an atmospheric CO2 concentration of 388 ppmv."

Line 116: Should this be "climatological mean" or "climatological mean annual cycle"?

Often the seasonal cycle is retained in prescribed SST simulations, is that the case here?

Line 117: What does it mean that "vegetation distribution could vary"? Does this mean that a forest can become a grassland interactively? Does the model represent disturbances like drought and fires that are needed to drive this transition?

Line 135: What is the region averaged over in Figure 3? Is it the entire region shown in Figure 2 or just the Amazon? You could add a box to figure 1 or 2 showing the region. This should be stated in the figure caption as well.

Line 138: How do you know the "reduction in precipitation leads to an increase in regional temperature" and not the other way around? From the experiment, it seems more likely reduced ET leads to higher temperature and lower precipitation, and the temperature and precipitation changes likely feedback on each other. I suggest using language such as "is associated with" rather than "leads to". I suggest being careful about causal relationships throughout the manuscript.

Line 140: What is the 3rd scenario?

Line 143: It would be helpful to include the net surface radiation term as part of Figure 3c. Or even the up and down terms for short and longwave radiation. In the deforestation simulation, latent heat goes down, but sensible is mostly unchanged, which implies net radiation also goes down. Do you know why? Is it just due to the surface albedo change or are there changes that might impact other terms as well, such as cloud cover?

Line 147: Again, I don't think "yields" is a good word choice because it implies a causal relationship, which is not shown. I would think the "reduction of moisture convergence" yields "decreased precipitation" and not the other way around.

Line 153: What is the change in "gross primary productivity" in these simulations?

Line 157: What is the "Full" run mentioned here? "Full" is not a simulation mentioned

earlier or in Table 1.

Line 162: Figure 4 is not referred to in the text. It should be referenced somewhere before Figure 5.

Line 167: Could you show the impact of "decreased roughness length of surface" quantitatively? How does the boundary layer height change overall? What is the influence of roughness length vs. higher temperatures and heating on vertical mixing?

Line 171: Again, there is reference to a third scenario.

Line 173: What do the horizontal wind anomalies look like at different levels? It might help to decompose the moisture tranport changes in order to understand the contribution from changes in humidity vs. changes in wind.

Line 182: This section also references a third "Full" simulation not shown in the figures or described in the text/table.

Line 188: To understand the seasonality of the precipitation changes, and differences between wet and dry seasons, it would be useful to assess the circulation changes and moisture transport at a seasonal timescale as well. For instances, are the circulation changes due to eCO2 larger than deforestation during the rainy season, leading to a larger decrease in precipitation from Oct to Dec?

Line 189: I'm not sure the ET changes explain the moderate increase in temperature due to deforestation because it is more moderate throughout the year, including the dry season when ET decreases more than in the physiology simulation.

Line 198: Figure 6c shows a decrease in ET, but this sentence states that evaporation increases. I think the decrease in soil water in the physiology simulation is probably due to the decrease in precipitation, since ET decreases all year round.

Line 200: It would help to show the seasonal cycle of LAI or vegetation coverage in these simulations. That would help explain the seasonal pattern of ET and soil wetness

better, particularly for the deforestation run. This could be added as a panel to Figure 6.

Line 212: The "strengthening of the Walker cell over the Amazon" is not shown in the results. I suggest adding a figure that shows the full vertical-zonal wind anomalies.

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