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Hydrology and Earth System Sciences
Discussions

Interactive comment on "The influence of water table depth on evapotranspiration in the Amazon arc of deforestation" *by* John O'Connor et al.

John O'Connor et al.

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Reviewer 2 In this paper, O'Connor et al tackle an interesting and very important question in the field of ecohydrology: how does groundwater affect plant functioning? As a community, it is important that we move from the broad, large-scale influences of climate towards focusing on the regional to local scales, where, as shown by several authors, groundwater might be one of the driving forces of ecosystems. This has important implications for our understanding of the response of natural and agricultural systems to climate change, and this study is a timely contribution to this field. I believe, however, that there are some conceptual and methodological issues with this study that should be addressed before publication. Below I offer some comments on the content of the paper and also pose some questions that might help the authors in

further refining it. Specific comments

1) The ultimate focus or "big question" of this study was somewhat unclear to me as I read the paper. In the introduction, a lot of importance is given to large scale problems such as the impact of land use changes on precipitation recycling and the subsequent negative effect on forest cover through a reduction in ET. However, in the conclusions section, the "key messages" are related to agricultural management and forest conservation. I believe the paper would greatly benefit from a clear, defined question that is posed in the beginning of the paper and that guides the discussion and conclusions. Reply: Thank you for your comment. Our main objective is to study the effect of water table depth (WTD) on evapotranspiration (ET) across the different land covers in the Amazon using remote sensing. Indeed there is a strong emphasis on the role of evapotranspiration and precipitation recycling in the introduction, as this is a highly important ecosystem service in the region. During the course of our analysis we recognised that WTD did not have a major impact on ET when compared to the much larger issue of land cover change. Although we did not find support for an effect on the precipitation recycling system we still felt that it was good to frame our study in the larger context. We agree that the introduction does not currently align with the main take home message. In order to strengthen the findings in this paper we will add information to the introduction regarding the agricultural system and local effects of evapotranspiration.

From the climate system point of view, the small differences in ET between shallow and deep WTD observed in the study might not be significant, while from the perspective of sustainable agricultural management and general crop productivity these changes might suggest a more water efficient practice. Perhaps the authors could group their questions with their hypotheses, which currently are somewhat scattered throughout the introduction and methodology sections.

Reply: Thank you for the comment. We agree and have regrouped the hypotheses into two main themes in the introduction which are then traced back in the results,

discussion and conclusion.

2) Although groundwater is the main environmental factor addressed in this study, very little is discussed about it throughout the paper. What is topography like in the region of study? How does the water table field look like in this area? How deep and how shallow can the water table be? What is the meaning of an “equilibrium water table depth”? What are the benefits and the drawbacks of using an equilibrium water table instead of a dynamic product? Is this an area where the water table responds directly to precipitation or is lateral convergence an important process? These are some key questions that directly impact the hypotheses and conclusion of this study, and therefore should be well addressed in the manuscript.

Reply: Thank you for this comment. We recognise that more information is needed to accurately describe the water table characteristics. We will make sure to include information regarding the maximum water table depth with in our area and add to the description of the modelled used that the “equilibrium” water table depth used is a long term average depth. This model was chosen as it was the best available fit for the spatial and temporal scale. As our goal was not to model evapotranspiration or the water system ourselves we did not want to try and separately simulate a dynamic water table depth. Therefore we choose our distinct shallow (< 2 m) and deep (> 10 m) categories as they are robust for our purposes.

3) I don’t understand the reasoning behind choosing the wet and dry season transitions as periods of stress for vegetation. The use of a climatic index neglects the important time lag displayed by groundwater (and soil moisture in general) that has been shown to support considerable levels of ET well into the dry season for several places in the Amazon basin (Miguez-Macho and Fan, 2012). In fact, seasonal soil moisture storage maps from Miguez-Macho and Fan (2012) show that, in the top 2 m, October is a more critical month in this general area than the dry season transition (June/July) proposed here by the authors. Is there a specific reason for choosing these periods?

Reply: Thank you very much for this question, it was also somewhat raised by reviewer 1. The choice to use the dry season and wet season transition periods was based on the idea that land use change is leading to a lengthening of the dry season and that the high forest evapotranspiration is integral in initiating the wet season. We therefore wanted to examine how access to soil moisture would effect evapotranspiration during these periods. We agree that the time lag between deep and shallow rooted vegetation is an important aspect and will include this in our results / discussion with reference to the seasonality figures in the supplemental information.

4) The authors should include early in the introduction that irrigation is still an uncommon practice in this general area, before proposing that a deep water table is detrimental for crop growth. This is a critical information for understanding why crops in this area would depend on natural soil moisture. As it is now, this is only clarified towards the end of the discussion (line 459). Reply: We agree that more information is needed in the test about the limited use of irrigation. We will add information in the introduction to introduce the reliance on precipitation and the limited application of irrigation.

5) Although a shallow water table can be beneficial for vegetation, as thoughtfully discussed in the manuscript, waterlogging also plays an important role in regulating vegetation function and distribution by causing anoxia in the rooting zone (e.g. Rossato et al (2012) for savannas, among several others). Was this considered when classifying the pixels into the two categories? Does this occur in the study area?

Reply: Thank you for your comment, which is very valid. We are unaware of waterlogging occurring in forest area, waterlogging is an important driver of distribution and function in Brazilian savannas. Nonetheless, because pixels were selected when they were consistently classified as the same land cover type for 12 consecutive years, which we would expect not to be the case if waterlogging had happened as it would lead to changes in land cover. We added the following to the Methods secion 2.3.2 Data analysis to further clarify: “and vegetation distribution as waterlogging of soils can lead to anoxia in the root zone. Due to the selection of only consistently classified

pixels the influence of water logging can be avoided as over time these areas will fall under different classifications"

6) Why were savannas included in the analysis? Very little is discussed about their characteristics, functioning and why they were of interest to this study. In Figure 2 savannas are lumped with croplands as "other vegetation" (line 229) and hypothesized to have shallow roots, while in reality savanna species can grow roots as deep as or even deeper than forests (Canadell et al, 1996). Besides that, waterlogging is an important driver of distribution and function in Brazilian savannas and therefore special attention should be payed to pixels in the "Shallow WTD" category (as said before in item 5), as they might encompass this condition that is highly detrimental for vegetation.

Reply: Thank you for the comment. We have responded to a similar comment by reviewer 1 above. We have added more information of why including cerrado savanna, we also included it in Figure 2 and the explained that savanna species can grow roots as deep as or even deeper than forests by adding references to rooting depths by land cover type. We will also introduce that the deep roots of tree species in savanna's can increase soil moisture available to the shallow rooted grasses via hydraulic redistribution. In the discussion of the "mixed" results seen in the savanna data we will include the possibility that waterlogging may drive vegetation patterns and distribution of different savanna types. We will also discuss the

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