Responses to comments from RC2
Manuscript: "Influence of plant traits on water cycle processes in the Amazon Basin"

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Dear editor,

This letter serves to reply to to the comments provided by RC2 to our submitted manuscript. We appreciate the time to review our work, and have seriously considered and appreciated all the comments by the reviewer. We detail below on how we plan to address them in a revised version.

RC2.1. *In this work the authors analyze different remotely sensed plant traits on water fluxes, VPD and surface temperature. The plant traits analyzed are Specific Leaf Area (SLA), Leaf Dry Matter Content (LDMC), Leaf Phosphorous Content (LPC), Leaf Nitrogen Content (LNC) NDVI and LAI. The authors find that SLA, NDVI and LAI are strongly associated with water fluxes and surface temperature. The associations are exacerbated at extreme values.*

I found the objectives of the article interesting, but think there are serious problems with the work and unfortunately cannot recommend publication.

Response: Thank you for your assessment of our work.

RC2.2. *The physical relationships between NDVI/LAI, evapotranspiration, land surface temperature have been developed for decades and are a standard in land surface models. Earth system models also incorporate phosphorous and nitrogen. It was not clear to me that the authors were familiar with current ways to model these relationships, or what specific problem they were addressing. Are the authors are implying that the current parameterization of land surface traits is incorrect or insufficient? I would agree, there are likely severe problems with our current parameterizations, but without an overview of current methods and clear identification of the problems, I don't understand how multivariate linear regression models will help us better understand these highly nonlinear relationships. I think that the work needs to clearly articulate how our current representation of the relationship between plant traits and water cycle variables is problematic, and how their remote sensing analysis will help.*

Response: Thank you for the helpful comments and feedback. We subdivide the comment into three parts:

1. What is the advance in relation to the current way Earth System models (ESM) are implemented and parameterized

Indeed, as mentioned very nicely by the reviewer, current versions of ESMs already include many of these relationships and in many ways well established while in other cases (like phosphorous) less well developed or coupled with the other biogeochemical cycles. As such, we acknowledge that it might not have been clear what our purpose was. This consists of three aspects: (i) many ESMs represent plant functional types, yet there is a wide funtional space that is yet to be represented, i.e. a forest is composed of different species and its canopy has a spatial variation in the functional traits within the forest (Sakschewski et al., 2016). While some attempts already exist in literature including this aspects of functional diversity in dynamic vegetation models like LPJ-GUESS (Smith et al., 2001; Wu et al., 2015; Sakschewski et al., 2015), this is not widespread and often these rely on parameterisation based on biased in situ trait measurements (Jetz et al., 2016), which fortunately are improving on a regular basis (Kattge et al., 2020). The new developments in trait ecology and remote sensing of biodiversity and traits (Ustin & Gamon, 2010; Homolová et al., 2013) can help complete this gap in knowledge as well as becoming well recognized at the intersection between ecologists, remote sensing scientists and modelers (Zhang et al., 2021).

2. Why does multivariate linear regression models help

We agree that this might be a oversimplification given that there is growing understanding and agreement that these relationships are highly non linear. We acknowledge that nonlinear relationships are inherent in modeling the interactions between plant functional traits and environmental parameters ((Levis, 2010; Fisher & Koven, 2020)). Despite this complexity, we have chosen to initially employ multivariate linear regression to investigate the associations between plant traits and water cycle parameters, utilizing the R2 value to represent the explained power and slope to explain the direction. Understanding the potential limitations of linear regression in capturing nonlinear relationships, we have also explored the use of quantile regression. This approach has been successfully applied in ecological research to assess relationships existing at extreme quantiles of variables ((ter Steege et al., 2023; Wittmann et al., 2017; Cade, 2017; Sun, Gao, & Li, 2017)). By employing both multivariate linear regression and quantile regression, we aim to provide a comprehensive understanding of these relationships, acknowledging their potential nonlinearity and spatial diversity. Additionally, in the manuscript, we have also conduct the analysis at the sub-basin level to further explore spatial variations in these relationships. This sub-basin scale analysis allow better capture of localised characteristics and variations in plant trait-water cycle parameter associations. In the updated manuscript, we will also include results using generalized linear mixed models (GLMMs) to enhance our understanding further. GLMMs offer a flexible framework for modeling nonlinear relationships and can provide valuable insights into the complex interactions between plant traits and water cycle parameters. Given this feedback, in the revision we will explore non-linear models to capture these relationships.

3. What is the contribution of the remote sensing analysis

We chose to use a remote sensing based approach because we believe that it can contribute by providing a continuous surface of plant functional traits, which has been identified as a constraint due to the limited availability of field measurements spatiotemporally. Therefore, our study aims to augment the current understanding of this process and examine alternative ways to provide data to paramaterise land surface models with information on traits.

RC2.3. *I am assuming that the regressions are done using time-averaged quantities, and you do the regressions with different in space... correct? Could you please clearly explain how you are doing this?*

Response:

The water cycle parameters were collected for the period 2001-2010 with varying spatial and temporal resolutions. For the spatial dimension, all parameters were upscaled or downscaled to 0.05-degree pixels. In the temporal dimension, we calculated the average and standard deviation at each pixel over the span of 10 years.

We will ensure to provide this information in the updated version to make it clearer.

RC2.4. *There is insufficient background on the remote sensing estimates. Can you please specify the satellite used for each estimate? What satellite estimates are you using for soil moisture? VPD? LST? What are the uncertainties associated with each of these variables?*

Response:

We apologize for the insufficiency of the background on the remote sensing estimates. Here is a brief summary of satellite products used in our analyses. We will update the manuscript to add these details:

- Soil Moisture (Guevara et al., 2021): The dataset used data from the ESA-CCI (European Space Agency Climate Change Initiative v4.5) dataset as the starting points and use terrain parameters, bioclimatic features, and soil type classes to fill gaps in the ESA-CCI dataset. Hence the satellite sensors used are the ones in the ESA-CCI, i.e. Envisat, ERS Satellites, AVHRR sensors.

- VPD (Abatzoglou et al., 2018): VPD was extracted from the TerraClimate dataset. There were five main sources used for the production of the TerraClimate dataset, which are WorldClim v2, WorldClim v1.4, CRU Ts4.0, JRA-55, Root zone storage capacity (shown in Table 1 in (Abatzoglou et al., 2018))

- LST (Wan et al., 2015): LST was acquired from the MODIS instrument on the Terra satellite, part of the NASA's Earth Observing System (EOS) program.

RC2.5. *Critically, variables such as ET (which I believe are MODIS?) are derived quantities that use NDVI/LAI. As such, it is not surprising that you would find a relationship. This makes the entire analysis very problematic.*

Response:

We greatly appreciate the comments from the reviewer and acknowledge the oversight on our part. We fully agree and have removed the analyses related to NDVI/LAI.

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