Reply on RC2

István Dunkl et al.

Author comment on "Process-based analysis of terrestrial carbon flux predictability" by István Dunkl et al., Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2021-38-AC2, 2021

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1. The selected variables for NPP and Rh have good references and reasons, and it may need some explanations/discussions why not precipitation and CO2 [1] for NPP, and why not soil moisture, soil clay content [2, 3] (important for soil respiration) for Rh, and the different/related effects in precipitation and soil moisture for NPP and Rh (e.g. the time lag effect of soil moisture with precipitation).

Both NPP and Rh are processes which are highly dependent on water availability. While the vegetation responsible for NPP can access multiple soil layers, most of Rh is taking place in the litter and the topmost soil layer. The moisture dynamics in these layers are more closely related to monthly precipitation then the moisture in the whole soil column (we will add a clarifying sentence on this in the manuscript). Additionally, the soil respiration sub-model is also using precipitation to calculate the rate of Rh.

CO2 fertilization plays a large role in the prediction of the carbon flux trend. However we assumed that the interannual variability of near surface atmospheric CO2, which has an effect on seasonal to decadal predictability, is low.

Clay content is not considered by the Rh model used in MPI-ESM [1]. If the module would include clay content in the calculation of soil respiration, its effect could be measurable through the predictability of SOC, because clay content directly effects SOC dynamics.

2. Are there any conditions for the results of 62% for soil moisture for NPPpred and 52% for SOC for Rhpred (add words that this is for global mean, and discuss with key regions such as Amazon)? And it needs to be more specific for "reveal the crucial regions and ecosystem processes to be considered when initializing a carbon prediction system".

These numbers have been used without sufficient context in the abstract. The needed context is added to the manuscript.

We think that elaborating on the regional patterns and predictability hotspots would be beyond the scope of the abstract. These details are mentioned in the chapters 3.1 and 3.2.

3. The scale mismatch problem between site observed data and model simulated results makes the comparison of NPP and Rh very difficult, and thus result the difficulties in

reducing uncertainty in simulated terrestrial carbon fluxes. And this raises some questions on true meaning of calibrating models with site specific observations with several sets of parameters and their spatial representatives (line 30). Such mismatch may deserve discussions. And I cannot find the o (validation anomalies) descriptions for global gridded NPP and Rh. And some discussions of uncertainties in model structures such as the models involved in TRENDY may be needed.

The reviewer is mentioning the difficulties arising from model parameterization based on site observations. We agree on the mentioned points, however, the validation of the carbon flux patterns is not within the interest of this study. The referred section in the text is included as an example for the efforts being made bring modelled processes closer to observations.

1. Add "and" in line 10 between "soil organic carbon" and "temperature".

Added.

2. Extend implications of this study, for example, can the results here help to constrain the uncertainty in land sink projections?

We acknowledge the limitations of the discussion in this regard and will add further outlook.

3. Can add this ref Zeng et al., (2014) [4] in refine model structure (line 31-32);

The publication is a good example of refined models to improve the simulation of the terrestrial carbon cycle and we can add it to the list.

4. Explain somewhat of "the perfect model framework" in line 36, and why is it called "perfect"?;

Indeed, the description of the term should belong in the introduction and not the methods. We will change the text accordingly.

5. Why Fig.2, 5 and 6 only showed -30~30 instead of -90~90?;

These plots show a subset of the tropics and sub-tropics where the highest potential for (long-term) predictability is located. We will mention the reason for the subsetting in the main text.

6. What are "other factors" in Line 169; And why the Congo basin is not strongly affected by ENSO?

We recognize that "other factors" sounds missleading and will rewrite this sentence.

7. Fig.7 needs legend for black rectangle and yellow triangle and relevance with the following figures and analyses;

A proper description will be added to the figure caption.

8. The long term effects of the initial soil moisture would become very weak for Fig.7? And blue color means lower NPP predictability in wet years in Fig.7 ?

The long lasting effects of these anomalies are because a) they include only the 20% tail end of all extreme years (dry and wet), meaning that these anomalies are of such a strong magnitude that their effect will remain for several months, and b) many of the

extreme years are strong El Niño or La Niña years with sustained precipitation anomalies that will elongate the soil moisture anomalies. The description of blue colors will be added to the figure captions.

9. Are there mechanisms in switch of deepSOIL and midSOIL for La Nina in Fig.8 from March to June?

As the dry season begins with the boreal summer, the topsoil dries out and vegetation growth is increasingly driven by moisture from deeper soil layers.

10. Line 296, the driving factors can be different across key regions (such as discussions in Lines 169), can add some specific summary on key regions.

We will elaborate on the discussion of the regional patterns.

11. Line 413, delete space of "CO 2";

Text will be modified accordingly.

12. Lines 375-426, need to maintain reference formats such as to capitalize journal names (e.g. Functional plant biology; Global change biology; Global biogeochemical cycles).

A uniform format will be applied.

[1] Tuomi, Mikko, et al. "Leaf litter decomposition—Estimates of global variability based on Yasso07 model." *Ecological Modelling* 220.23 (2009): 3362-3371.