General comments:

This paper presents a study on terrestrial carbon flux predictability using MPI ESM, which shows NPPpred is driven by soil moisture predictability and Rhpred mainly by soil organic carbon (SOC) and explored the effects of climate variables and events (El Nino and La Nina) on Amazon and Australia areas' CFpred. The analyses contents are abundant and the results are convincing. The paper is well-written but needs further careful checks and polish on details.

Specific comments:

I have some questions on the manuscript.

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).
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".
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.

Technical corrections and some minor comments:

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

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

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

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

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

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

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

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 ?

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

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.

11. Line 413, delete space of “CO 2”;

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).

References:

1. Wang, S., et al., *Recent global decline of CO2 fertilization effects on vegetation photosynthesis.* Science, 2020. **370**(6522): p. 1295-1300.
2. Coleman, K., et al., *Simulating trends in soil organic carbon in long-term experiments using RothC-26.3.* Geoderma, 1997. **81**(1-2): p. 29-44.
3. Wang, G., et al., *Modeling soil organic carbon dynamics and their driving factors in the main global cereal cropping systems.* Atmos. Chem. Phys., 2017. **17**(19): p. 11849-11859.
4. Zeng, N., et al., *Agricultural Green Revolution as a driver of increasing atmospheric CO_2 seasonal amplitude.* Nature, 2014. **515**(7527): p. 394-397.