We thank the reviewer for taking the time to review our manuscript and provide constructive comments.

In revising our manuscript, we noted that our model simulations had used a fixed pre-industrial nitrogen deposition rate. In our resubmission, we reflected that it would make more sense to show results from LPJ-GUESS with the nitrogen cycle switched off. This was because the principal aim of our paper was to explore the sensitivity of the carbon cycle to 'expressions' of El Nino and we might expect that this sensitivity would be greatest using the C-only version of LPJ-GUESS as carbon uptake is not limited by nutrient availability (which may decline with water availability in dry years, when nitrogen immobilisation rates increase). Nevertheless, as one of our main regions of interest was the tropics, we would not expect a strong limitation by nitrogen (Vitousek et al. 1984) and as a result, we do not anticipate a strong sensitivity in our results to our choice of biogeochemical cycle. To assure the Editor/Reviewer of this insensitivity we have shown the results of both cycles (N-cycle on/off) below (Fig 1). We also used this opportunity to update the model comparison against the more recent TRENDY v7 runs.

Overall, we found that LPJ-GUESS is close to the TRENDY v7 ensemble mean and simulations are mostly within the model range (i.e. across TRENDY models) when we switch the nitrogen cycle off. The spatial distribution of the summed composite GPP anomalies (see fig. 2) shows that LPJ-GUESS picks up the main anomalies associated with EP El Nino events and remains within the TRENDY models' range. Finally, LPJ-GUESS has a strong negative bias in Australia. As our results show, Australia does not make a large contribution to long-term changes in any of the carbon fluxes and pools.

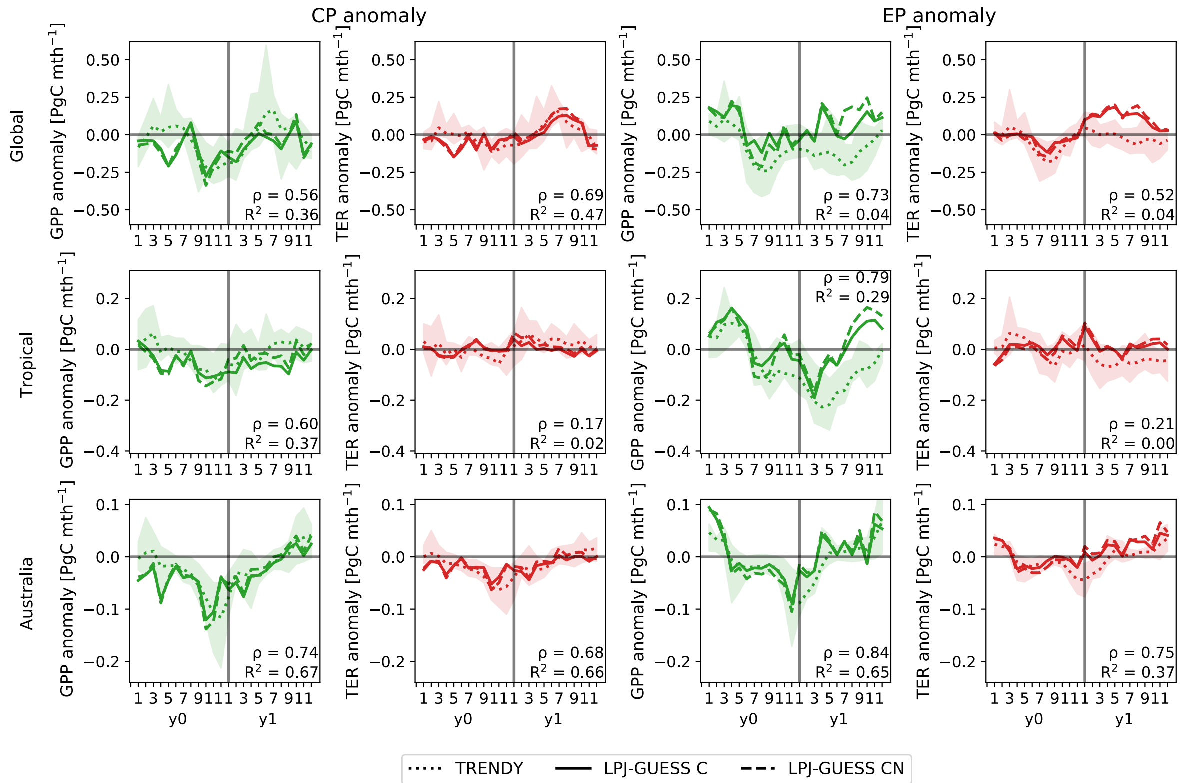

Fig. 1. Monthly composite anomalies during the El Nino developing (y0) and decaying (y1) year in gross primary production (GPP; green lines) and terrestrial ecosystem

respiration (TER; sum of autotrophic and heterotrophic respiration; red lines) for all CP and EP El Nino events listed in appendix table A1 averaged over the globe, the tropics (23°S–23°N) and Australia. The dotted lines show the TRENDY v7 composite, the solid lines are the individual LPJ-GUESS run where we switch off the nitrogen cycle, the dashed lines show the model runs with dynamic nitrogen cycling (compare Wang et al., 2018). ρ and R^2 show the correlation coefficients and R^2 values between the LPJ-GUESS and the TRENDY ensemble mean. The shaded area shows the model spread of the individual TRENDY models.

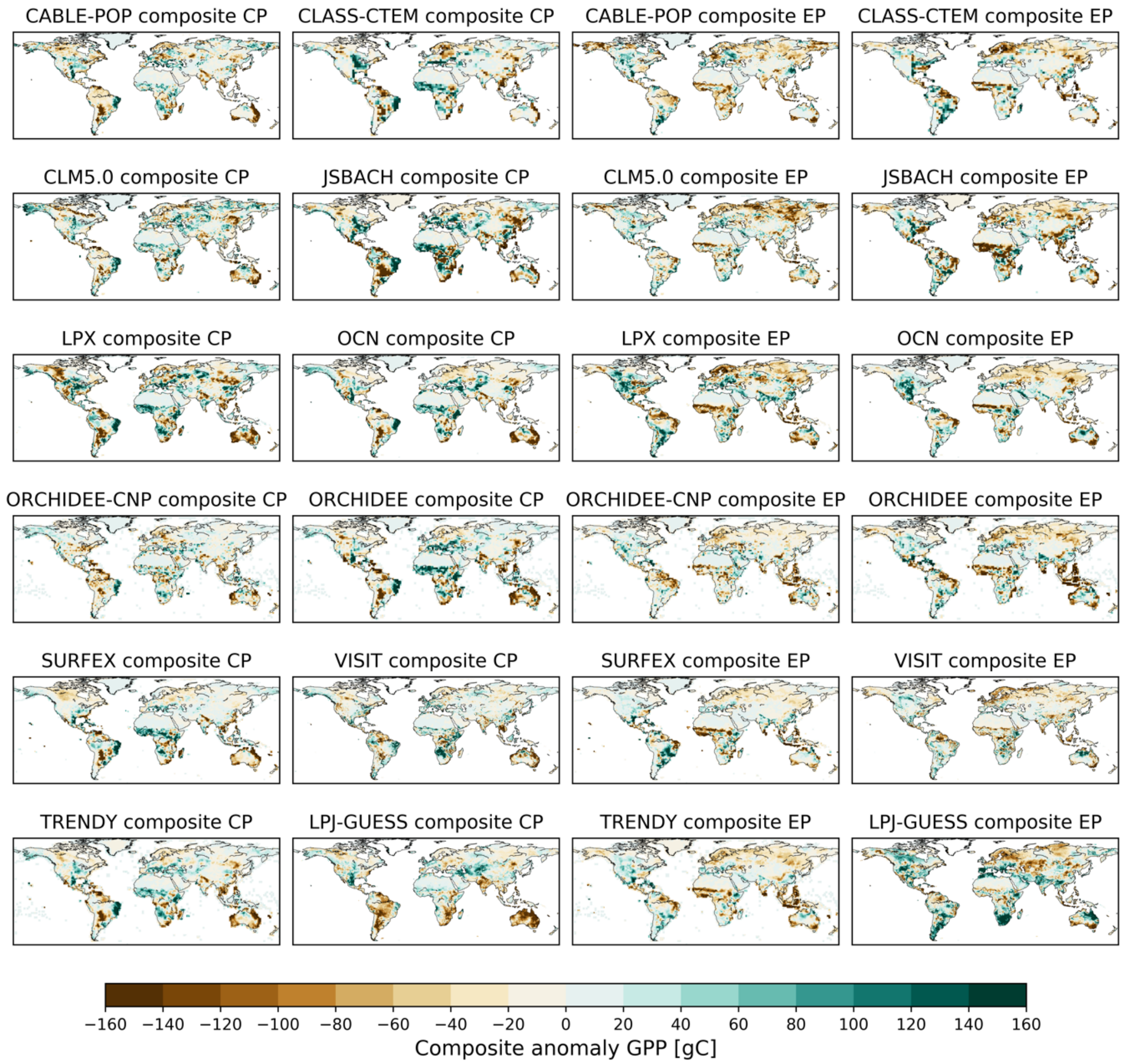

Fig. 2: Composite anomalies in gross primary production (GPP) summed over the the El Nino developing and decaying year for all CP and EP El Niño events listed in tab. B1 for the individual TRENDY models, the TRENDY composite and the individual LPJ–GUESS run (compare Wang et al., 2018).

Below we address the reviewer's comments point by point. We add our replies in italics and highlight suggested modifications in the manuscript in red.

Referee #1

This manuscript investigates the impacts of different expressions of El Nino on the long-term terrestrial carbon storages, using a DGVM LPJ-GUESS with the manipulated climate forcing. They pointed out that CP and EP events can significantly influence the interannual variability of terrestrial carbon cycle, but cannot lead to NBP trend. Therefore, they suggest that future simulations of carbon cycle may not need to well simulate the expressions of El Ninos in Earth System model. The method is well described and writing is clear with concise and clear conclusions.

We thank the reviewer for their assessment and the acknowledgement of our contributions.

1. L120: "associated with El Nino events according to the best fit in duration and amplitude in ONI...". Because there are actually 6 CP, 7 EP, and 2 Mix, you can clearly show the replacement relationships in the table for the manipulations (like in Table A1). It can be more straightforward for us to understand it.

   We added two more columns in table A1 where we specify the replacement relationships.

2. The units in spatial patterns in Figure B1–B4 are not correct. For example, flux is gC=>gC/m2/yr?, carbon pool is gC yr-1?=>gC?

   Thank you for pointing this out, we changed it accordingly and updated the figures.

3. In Discussion: Some aspects can be mentioned further.
   a) ENSO diversity (Capotondi et al., 2015): Although replace the CP and EP events based on their durations and amplitudes, every ENSO event is unique with different spatial impacts.

      We agree that every El Nino or La Nina event is unique. We did mention this as a limitation in the future directions:

      'Individual El Nino events vary in location, timing and magnitude and teleconnections are influenced by the background climate and climate variability'.

      We now cite the Capotondi et al., 2015 paper. However, given we are undertaking a sensitivity study we are not sure expanding this point is adding much value. Unless we have misunderstood the reviewer's suggestion, we are happy to accept further comment.

   b) Changes in frequency of ENSO occurrence in future: Though it maybe doesn't influence your conclusions, you can discuss that frequency change may have some influences.

We agree that work that revisits this question for the perspective of a future climate may well be warranted. However, there is little evidence suggesting that the frequency of El Nino – La Nina cycles might change in the future. Some studies indicate changes in the properties of El Nino events, i.e. magnitude (e.g. Wang et al., 2019) as well as spatial features (e.g. Yeh et al., 2009). However, the representation of ENSO diversity in CMIP5 and CMIP6 models is associated with high uncertainty due to model biases especially in the equatorial Pacific, resulting in low model agreement (e.g. Freund et al., 2020). A future experiment set-up would need an ensemble of climate forcing datasets and probably multiple DGVMs since the results may be very sensitive to assumptions related to vegetation responses to [CO_2] and interactions with nutrients (Zaehle et al., 2014).

These are important issues and therefore we added the following into the future directions section:

Moreover, exploring the impact of different expressions of El Nino in a future climate would be worthwhile. However, we note that this would probably require multiple DGVMs to account for the uncertainty associated with the vegetation responses to [CO_2] and interactions with nutrients (Zaehle et al., 2014). In addition, the representation of ENSO diversity in CMIP5 and CMIP6 models is highly uncertain due to model biases, especially in the equatorial Pacific, resulting in low model agreement (e.g. Freund et al., 2020). Therefore, to obtain robust results, a future experiment design would need multiple climate forcing input datasets as well.

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