



EGUsphere, author comment AC3
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Reply on RC1

Isobel M. Parry et al.

Author comment on "Evidence of localised Amazon rainforest dieback in CMIP6 models" by Isobel M. Parry et al., EGU Sphere, <https://doi.org/10.5194/egusphere-2022-82-AC3>, 2022

We would like to thank the reviewers for their constructive feedback and appreciate their contribution to improving the article. Please see below for answers to the specific points raised in the reviewer comments. Reviewer comments are listed in italics and our responses are shown in bold font.

The current study shows where the abrupt shift likely to happen but less on how. I am looking for some mechanistic explanations on model difference in abrupt shift (AS) identification – some are concentrated, some scattered, some none? One explanation proposed is that the larger internal variability of model led to scattered distribution of AS, perhaps need to present data to show it? In addition, do we expect to see more/less abrupt shift at regions with larger internal variability at all? Any other potential reasons that can explain inter-model variation.

Reply: We would expect detected abrupt shifts to be localised clusters as neighbouring grid points will experience similar climate changes. More abrupt shifts will be detected for models with higher internal variability, but we attempt to remove as many of these as possible through the final abrupt shift criterion. For models with high internal variability (such as EC-Earth3-Veg), the detected abrupt shifts will depend on the threshold much more than models with low internal variability. We will show in a new figure in the Supplementary Material how the results depend on the threshold choice specifically for EC-Earth3-Veg.

We will also add the following text to the Results and Discussion to address the possible mechanisms behind the differences in detected abrupt shifts:

“Differences between modelled vegetation dieback arise for multiple reasons. Although there is a somewhat reduced spread in the CMIP6 model generation, ESMs continue to project different regional climate changes over Amazonia (Parsons, 2020). Even for the same climate change, models produce a range of tropical forest responses, such as different sensitivities to drying (which is affected by assumptions concerning the rootdepth of tropical trees), different responses to warming (controlled through different optimum photosynthesis temperatures), and different representations of climate sensitive disturbance processes (e.g. fires (Table 1)).

The assumed optimum temperature for photosynthesis has been highlighted as a particularly important factor in mediating the response of tropical forests to climate change (Booth et al., 2011). The vegetation components of ESMs often

also have different responses to a given increase in atmospheric CO₂ (Wenzel et al., 2016). The direct physiological effects of CO₂ on the rate of plant photosynthesis and on plant water use efficiency typically counteract the negative impact of climate change on tropical forests (Betts et al., 2004). As a result, the extent of CO₂ fertilization is another important difference across the models (Ramming, 2010).

Abrupt shifts are driven by stochastic variations in each model, which can be either interannually-generated climate variability or the randomness of disturbance events (such as fire), which is assumed in some vegetation models. Where this stochastic forcing is relatively small, the detected abrupt shifts will tend to be spatially coherent and determined by the underlying large-scale patterns of climate change. However, in models where this stochastic forcing is more significant (e.g. EC-Earth3-Veg), detected abrupt shifts tend to be much less spatially coherent. Under these circumstances the detection of an abrupt shift is more dependent on the threshold chosen (see Supplementary Material Figure S1)."

The author demonstrated that diebacks happen at places where there are higher temperature sensitivity of seasonal temperature amplitude – which is further regarded as an early-warning signal (EWS). I am curious that how early could the EWS work, or do we really see higher predictive accuracy of dieback if we use EWS. I am curious whether the ESW is the precursor for the dieback or ESW is caused by the dieback due to climate-vegetation feedback?

Reply: For the purposes of this study, we primarily focus on demonstrating that grid points with higher sensitivities of seasonal temperature amplitude to global warming are more likely to feature a future abrupt dieback, as shown by the tipping risk in Figure 4i. How much forewarning such an indicator could give is a relevant question but is outside the scope of this study. We will therefore tone down our reference to a possible EWS. Climate-vegetation feedbacks will indeed influence the indicator after a dieback event, as can be seen in Figure 3. However, it is important to note that the indicator only uses data up to a doubling of CO₂ and 91% of detected abrupt shifts occur after a doubling of CO₂.

Other comments:

the reason to use 1%. It has been argued it is idealized to use 1% CO₂ simulations, though it is not clear to me how that would be "ideal"

Reply: The 1% CO₂ runs are "idealised" in the sense that they do not take into account socioeconomic factors such as land use changes. For the purposes of our study, this allows us to focus specifically on abrupt changes that are driven by climate change rather than anthropogenic deforestation.

Other than dieback, the authors also present other combinations of AS and trendy changes. Though they are less common, I am wondering if the authors need to provide some mechanistic explanations...or I would suggest removing those as they might be distracting.

Reply: We agree and so for clarity and a more focused view of abrupt dieback shifts we will remove the other combinations of AS and trend changes, represented by blue, orange and green points in Figure 1a-h, from the analysis and figures.

Is it possible the key piece of evidence supporting ESW (Fig. 4i) mostly come from one model - TaiESM1. The model has the largest number of valid samples for the analysis, but

quite few other models – Samu-UNICO, EC-Earth3, does not such the effectiveness of the ESW. How robust it is if we bootstrap model, or normalize result by valid samples. It linked back to my first major concern that why models show different results.

Reply: Thank you for raising this point. While it is true that some of the models do contribute more to the results shown in Figure 4i than others, it is important to note that for four of the seven models analysed in this study there is a clear threshold in the sensitivity to global warming beyond which we only observe dieback shifts (Figure 4b, d, e, f). Meanwhile, the models which do not exhibit dieback shifts in the NSA region (MPI-ESM1-2-LR and UKESM1-0-LL) both show low overall sensitivities of the seasonal temperature cycle to global warming. This is demonstrated in the attached figure, which will be included in the Supplementary Material:

L96. "many abrupt shifts" – perhaps provide a more quantitative statement.

Reply: To provide a more quantitative statement, the sentence on line 96 will be reworded to provide as follows:

"Compared to GFDL-ESM4, EC-Earth3-Veg has approximately 10% fewer abrupt shifts which are more scattered across the Amazon basin."

Figure 3. y axis and caption, what is cVeg? Those are good examples. Is it possible to get a scatter plot of the timings of EWS and dieback for all pixels?

Reply: For clarification we will change the y axis and caption of Figure 3 to read **Vegetation Carbon** instead of **cVeg**. As previously mentioned, we intend to tone down our references to a potential Early Warning Signal.

L115. Regional scale means "region average"?

Reply: Yes, the regional scale refers to the average of the NSA region. For clarity we rewrite the sentence as:

"Interestingly, when inspecting the NSA regional average abrupt changes are not obvious, despite a significant number of local abrupt shifts (see Fig. 2c)."

L175. stufy – study?

Reply: Thanks for spotting this. Correction of 'stufy' to 'study' on line 175

Please also note the supplement to this comment:

<https://egusphere.copernicus.org/preprints/2022/egusphere-2022-82/egusphere-2022-82-AC3-supplement.pdf>