Author's response to comments from Anonymous Referee #1 (second round):

"Changes in BVOC emissions in response to the El Niño-Southern Oscillation"

by Ryan Vella et al.

Once again, we thank editor and referees for taking the time to review our revised manuscript. Here, the comments from Anonymous Referee #1 (from August 07, 2023) are reproduced in black, while our comments are presented in blue.

From Anonymous Referee #1's response:

First I want to apologise for the delay in my responses, I know it's frustrating to wait for feedback. But on to the review: It is quite obvious how much effort went into the revision of the paper which is great and in my opinion really improved the manuscript compared to the version before! However, I still have some (very minor) comments, which I listed below.

Thank you for your positive comments. We also understand that many people are on holiday in the summer time and responses could take a bit longer. We truly think that our study benefited a lot from your review! Detailed response below.

L. 1: You have a typo there: BOVCs instead of BVOC

Corrected.

L. 37: At the end of the paragraph I think you could add a sentence stating that BVOC emissions vary between years (with a reference), and this might then link better to the next paragraph where you talk about climate variability associated withuncertainties persist due to the influence of climate change on climate variability and ENSO

The following sentence was added: "BVOC emissions exhibit year-to-year variations attributed to the vegetation's sensitivity to climatic conditions. Our prior investigations have revealed that isoprene fluxes, spanning a decade, display a standard deviation of 8 Tg yr^{-1} (Vella et al., 2023). "

L. 64: Similar to my suggestion above, make you could highlight the knowledge gap you address in your paper here? I.e. you could talk about uncertainty in ENSO associated BVOC emissions in a future climate.

This sentence was added a the end of the paragraph: "However, uncertainties persist due to the influence of climate change on ENSO variability."

L. 79-80: Can you rephrase this sentence 'Although global changes in these variables can indicate broad global trends, anomalies associated with the ENSO are often observed at regional scales' . I find the first half of the sentence a bit confusing

Sentence modified to: "While changes in these parameters on a global scale can indicate overarching trends, anomalies connected to the ENSO are often identified at a regional level. "

L. 83: I know you say this later on in your manuscript, but I think to motivate your introduction you can include here also '[...] North East Australia (NEAus), and these regions are commonly thought to be hotspots for ENSO-associated climate anomalies' or something similar

Text included.

L. 84 – 94: I think this paragraph would fit better as the second last paragraph? And then after this one you can give an overview about what you do in your study (which you currently do in L. 65 – 84). But of course this is your decision to make, and I'm also happy if you leave it the way it is.

Agreed. Updated accordingly

L. 108: Can you define the acronym LPJ-GUESS?

Yes, updated.

L. 124 – 130: Do I understand correctly that with 'fully-coupled' you mean here that there isn't a feedback from the vegetation to climate variables (temperature, precip, incoming SW radiation?)

Correct. We use EMAC states to determine the vegetation in LPJ-GUESS but the only feedback going back to EMAC are the interactive BVOC fluxes. Updated as follows: "While efforts towards a fully coupled configuration are ongoing, in this work, we use the standard EMAC-LPJ-GUESS coupled configuration, where the vegetation in LPJ-GUESS is entirely determined by the EMAC atmospheric state, soil, N deposition, and fluxes (Forrest et al., 2020), but there is no feedback from the vegetation to climate variables (e.g., changes in albedo and roughness length)."

L. 144: If soil moisture is such a strong influence on the BVOC emissions, why didn't you use the soil moisture output from LPJ-GUESS but the aridity index instead? To be clear, I'm not asking you to change it, I'm just wondering why.

Initially we used the precipitation, but then we went for the AI as it gives a better representation of the water stresses. Indeed, the soil moisture from LPJ-GUESS could have also been used.

L. 148 – 155: I think this is great but to me it sounds like it belongs in the discussion. Up to you though!

Agreed. Moved to the discussion.

L. 161: 'greater or equal 0.5° for five' – you're missing a C here

Corrected.

L. 171: Maybe I misunderstood the methods but I thought before you said that the CO2 concentration for 348ppmv is representative of 1983 (here you say 2000)

For our study we use 348ppmv representative of 2000. In the introduction I cited a study that have used prescribed CO_2 representative of 1983, This study was also mentioned in the discussion and the sentence was reformulated to be clear that this was not our work: "Lathiere et al. (2006) showed that, with CO_2 concentrations fixed to 1983, isoprene emissions are higher (1.92%) during El Niño years and lower (-0.63%) during La Niña years compared to the 1983–1995 average".

L. 178: You write here SW USA but in other places it's without a space (i.e. SWUSA)

Corrected.

L. 184: I think you can drop 'with respect to time' here as you state later on you're looking at temporal simulations

'with respect to time' removed.

L. 183-188: I'm really sorry, I should have thought about this earlier, but I wonder whether you could add a third panel in your methods figure (i.e. Fig. 1) with a schematic that shows the approach you describe in L. 183-188?

The lower panel in Fig.1 actually shows the SST used for both isolated and sustained simulations. In the isolated simulations we use SST/SIC shown as "base years", then we use the corresponding SST/SIC from event year 1 2 and switch back to base conditions (exactly as shown in the figure). For the sustained simulations we take 12-month SST/SIC from event year 1 & 2 (corresponding to the particular scenario) and we prescribe these data perpetually in our simulations.

L. 196: Instead of 'These simulations' you could also write 'The simulations conducted in this study'

Corrected.

L. 201 – 206: Could also go into the discussion

Moved to discussion.

L. 217 – 220: It is not clear to me what you mean with 'the monthly order of months may be disrupted, meaning that month 1 in the simulation could be March'?

Text was updated as follows and is hopefully more clear: "The baseline simulation employs SST/SIC spanning from January to December, whereas the ENSO simulations adopt distinct 12-month sequences spanning the event years 1 and 2 (see Fig. 1). In these subsequent simulations, there could be a disruption in the sequential order of months given that the ENSO event occurs over two years and could start in March, April, or May of the first event year. Nevertheless, the annual ENSO cycle remains consistent given that these 12 monthly SST/SIC data are used perpetually. ".

L. 221: Better than what?

Text updated: "Compared to the isolated simulations, the sustained simulations better constrain the correlations between BVOC flux emissions, meteorology, and vegetation changes, and they provide statistical confidence that the characterised perturbations are caused by ENSO rather than other variability attributed to the climate system.".

Fig. 2 caption: Typo (resposne)

Corrected.

Fig. 3 (and 8) caption: I don't think you're describing everything you show in this figure? You say it's the Pearson correlations but to me it looks like a scatter with a linear regression fitted through the points AND the pearson correlations printed in the figure. Sorry I should have seen this earlier on but only noticed it in this revision!

Agreed. Captions for Fig. 3, 8, and for relevant figures in the supplementary material were updated: "Scatter plots with a linear regression fit including the Pearson's correlation (r)..."

Table 2: I'm sorry I'm only picking up on this now but two questions: 1. Why did you not include any estimates for significance in this table (which you did for the figures)? 2. Why did you analyse the correlation coefficient between standardised anomalies in Table 2 but in Figure 3 they are not standardised?

1. Correlations with $p < 0.01$ in Table 2 are now in bold.

2 . We used the standard anomalies in both instances as described in the figure captions. We found a typo in the x-axis label for the AI panel. Now it reads "Aridity Index Std anomaly (-)" - also for Fig. 8 and supplementary figures.

L. 259/260: I also wonder about interactions. Again, I'm not asking you to redo this but would you expect different results if you accounted for interactions in your statistical approach (i.e. if you applied partial correlation which allows you to control the effect of other related variables)?

While considering interactions in the analysis could provide valuable insights into complex relationships, we think that our results without interactions remain valid. While interactions could introduce additional nuances, our current findings are robust enough to highlight the relationships between the driving variables and BVOC fluxes.

L. 283: Typo: NWAus instead of NEAus

I found some inconsistencies between NW and NE Australia. I checked a map for Australia and our domain actually falls mostly in the "Northern Territory". This domain was renamed to "North Australia (NAus)" throughout the manuscript.

L. 290-292: Do you have any references that support your claim of a potential for either sustained El Nino (or La Nina? It's not clear from your text) in a changing climate?

We agree the this sentence was not clear and could lead to confusion. The text was updated as follows: "While the current climatic conditions do not align with this scenario, it has been suggested that under the influence of climate change, both El Niño and La Niña could become more intense and prolonged (Cai et al., 2015, 2021). The main objective of the presented simulations is to statistically analyse the response of the driving variables to ENSO, enabling us to examine potential lasting impacts on the biosphere and BVOC emissions. "

L. 325: 'indicating a small boost in primary productivity' – here it might be worth noting that this is not statistically significant. In general the NPP changes seem to be not significant in most cases except for the La Nina anomaly for SWUSA? Might be worth mentioning

Agreed. Text updated: "On a global scale during El Niño occurrences, a slight rise (0.20%) in NPP is noted, although this change lacks statistical significance."

Fig. 6: Why did you choose these four regions?

This sentence was added: "PFT fractional coverage in CEAfr, SEAfr, and NAus exhibited minimal variations and are therefore excluded from Fig. 6."

L. 383 and 384: Again typo: NWAus instead of NEAus

Updated as mentioned above.

L. 385: Can you explain your PCA method in the methods section?

Yes. We added a new section in the Methods section: "Principal Component Analysis (PCA) was used on climate variables to assess their correlation with isoprene emissions during El Niño events (Section 3.2.3). PCA is a statistical method used to simplify and understand complex datasets by transforming the original variables into a new set of orthogonal (uncorrelated) variables called principal components. These components are linear combinations of the original variables that capture the maximum variance in the data. For each pixel of the model output, we perform PCA to extract the first principal component for each driving variable (temperature, radiation, aridity index, NPP, and LAI). The correlation between the first principal component of each driving variable and isoprene/monoterpene emission fluxes is computed for each pixel. These correlation values are then used to rank the variables' importance in driving isoprene/monoterpene emissions during El Niño events for each pixel."

L. 404: 'mostly resemble a potentially natural vegetation' – isn't switching LUC off the definition of potential natural vegetation?

Correct. Sentence updated to: "...does not include anthropogenic deforestation (and land-use changes), so the simulated vegetation patterns represent potential natural vegetation."

L. 405: Do you have a reference for your statement about the dry/ moist biases?

Citations added.

L. 414: I was quite curious about the asymmetry in the response as well when I reread your manuscript. Do I understand it correctly that you suggest that the anomaly magnitude in the climate forcing differs between El Nino and La Nina and that might cause the asymmetric response? Then why is the asymmetry not the same for all regions? Could it be linked to different vegetation types, and/ or does LPJ-GUESS simulate different sensitivities to water stress/ water pulses depending on the underlying vegetation?

Yes we think that this asymmetry also arises from the response of different vegetation types. We added this paragraph in the discussion: "Our results suggest that this asymmetry in BVOC emission during El Niño and La Niña arise from regional anomalies within the corresponding ENSO occurrences. However, the observed dissimilarity in asymmetry among various regions implies that this phenomenon is influenced by the distinctive responses of varied vegetation types. While LPJ-GUESS simulates consistent responses in terms of water uptake and water limitation on photosynthesis across all PFTs, the phenological response varies among them. Notably, raingreen trees and grasses, common in savanna ecosystems, tend to "switch off" their leaves at low soil moisture levels to better handle reduced precipitation. This can lead to reduced GPP/NPP, subsequently affecting emissions of BVOCs."

L. 470: temperature bias = temperature anomaly?

Yes, we now use "anomaly" for consistency.

L. 553 – 560: Great discussion! One thing I wonder: You highlight LAI as a dominant driver for BVOC emissions. Maybe it is different in your model set-up, but if I remember correctly in the 'standard' LPJ-GUESS, LAI does not vary throughout the year for evergreen species (which are dominant in Amazonia and SE Asia) and the carbon allocation happens on an annual timesteps. Do you think this could influence your results?

You are correct in noting that the 'standard' LPJ-GUESS model assumes a fixed LAI throughout the year for evergreen species and employs an annual carbon allocation time step. These assumptions could indeed impact the accuracy of our findings regarding BVOC emissions in regions dominated by evergreen vegetation such as Amazonia and Southeast Asia. The lack of temporal variation in LAI and the use of an annual time step may limit the model's ability to capture the dynamic responses of evergreen species to changing environmental conditions, however, in this study, we focus on the statistical relations using the sustained simulations an therefore the sub-yearly variably is not critical for our analysis.

L. 561: 'can be found in the supplementary'

Corrected.

References

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