Author's response to comments from Anonymous Referee #2

"BVOC emission flux response to the El Niño-Southern Oscillation "

by Ryan Vella et al.

We thank editor and referees for taking the time to review our manuscript and for the valuable feedback. Here, the comments from Anonymous Referee #2 (from June 05, 2023) are reproduced in black, while our comments are presented in blue.

From Anonymous Referee #2's response:

In this article the authors explore the impacts of ENSO on modelled emissions of biogenic volatile organic compounds (BVOCs). The article is well written and this is an interesting study, which is certainly within the scope of the journal, but should only be published after the following comments have been addressed.

My major concern is with regards to Section 3 (Results and Discussion). In the absence of a dedicated "Discussion" section I would have expected to see more analysis and comparison to the wider literature alongside the presentation of the results. In the Introduction, several studies are cited that have used observations to explore the links between ENSO and the biosphere – how do your model results compare to what they found? This is an interesting study and should be published but without some more context the reader is left to do a lot of work themselves to understand the implications of these results.

Thank you for considering this study for potential publication in BG. We acknowledge the lack of discussion in the submitted version. We now included a dedicated Discussion Section that compares our results with several studies, including those cited in the Introduction. Below is some text from the new Discussion section. We invite the reviewer to check out the updated version of the manuscript for further details.

"The BVOC emission anomalies from our isolated simulations agree with previous work linking high BVOC emissions with El Niño years (e.g., 1983, 1987, 1990–1991 and 1994–1995), and lower emissions with La Niña years (e.g 1984–1985, 1988–1989) (Lathiere et al., 2006; Naik et al., 2004). With CO_2 concentrations fixed to 1983, it was shown that isoprene emissions are higher (1.92%) during El Niño years and lower (−0.63%) during La Niña years compared to the 1983–1995 average (Lathiere et al., 2006). Our simulations, based on 1997/98 (Very Strong El Niño) and 1988/89 (Very Strong La Niña), suggest an increase (2.9%) and a decrease (−0.1%) for El Niño and La Niña, respectively. The variances could arise from differences in the model configurations and the fact that the time frames for "base conditions" differ."

Minor Comments:

Section 1 (Introduction):

Could you expand slightly on the statement you make about future changes in ENSO: “several studies have suggested the possibility of more persistent ENSO conditions in the future (e.g. Bacer et al., 2016; Cai et al., 2015)” - does this mean more frequent, longer lasting, more extreme etc? You can then come back to this in your later Discussion to help the reader understand the implications of your results.

This statement in the Introduction was updated as follows: "some studies have suggested the possibility of increased frequency of extreme ENSO events under greenhouse warming (e.g, Cai et al., 2015, 2021)." This means that ENSO evens are expected to occur more often with bigger intensities, but not necessarily longer lasting.

Section 2.2:

Can you justify the use of BVOC fluxes from ONEMIS (rather than MEGAN) if they are the only emissions used here.

Both ONEMIS and MEGAN could have been used for this study. We decided to use ONEMIS here as this module is the standard and more established emission model in EMAC. ONEMIS has been integrated in EMAC and used for a long time and thus BVOC emissions from ONEMIS could be compared with previous studies. Additionally, the current MEGAN version in EMAC uses the parameterised canopy environment emission activity (PCEEA) algorithm (only considering above-canopy photosynthetic photon flux density) rather than the alternative detailed canopy environment model that calculates light and temperature at each canopy depth. On the other hand, in ONEMIS, emissions are calculated within four distinguished layers of the canopy. In Vella et al. (2023), we found some artifacts in the BVOC emissions from MEGAN resulting from the PCEEA. For example, in dense forests, higher LAI (e.g. from increased temperature) at the top of the canopy could result in more shade in the lower parts of the canopy, resulting in a net decrease in BVOC emssions.

Section 2.3:

The description of the simulation set up for the isolated scenarios is clear in that base conditions are used throughout the 50 years but with an isolated El Nino / La Nina in years 31-32. It would be useful to add some clarification on what the base conditions are, you mention using the SST/SIC data as forcing data to construct the El Nino / La Nina scenarios but it’s not clear what is used for the non El Nino / La Nina years. It is later mentioned in the description of the sustained simulations but needs articulating sooner and in addition to temperature, what time period do the CO_2 concentrations represent? Could you also add here clarification of what happens in the year following the isolated El Nino / La Nina.

Thanks for pointing this out. Section 2.3 was updated and now clearly states what we mean by "Base conditions" i.e. SST/SIC average from 1980-2009. Is is also mentioned that we keep CO_2 concretions fixed to 348 ppmv, representing the year 2000.

Section 3.1:

It may be beyond the scope of this paper to demonstrate this here but can you be satisfied that your modelling set up captures the observed relationships between e.g., temperature, radiation and BVOC emission fluxes. You can refer to other studies to support this but at the moment the reader is expected to assume that this is the case.

Our results are in good agreement with most studies out there in the ENSO-induced changes for temperature, radiation, NPP, LAI, and BVOC emissions. This is now discussed in the Discussion Section.

"The changes in temperature, surface radiation, and AI during El Niño and La Niña events can have significant impacts on vegetation, as reflected in the changes in NPP and LAI shown in Fig. 5 and Table 4. Our findings are consistent with previous studies linking low global NPP to El Niño years and high global NPP to La Niña years (Zhang et al., 2019; Bastos et al., 2013; Nemani et al., 2003; Behrenfeld et al., 2001). Higher temperatures lead to higher evapotranspiration rates and increased water stress on vegetation, which may result in reduced NPP and decreased LAI. Cooler temperatures can have varying effects on vegetation, depending on the specific ecological conditions of the region. However, increased surface radiation can enhance photosynthesis and potentially lead to higher NPP. The positive anomalies in NPP observed during La Niña in several regions, such as SWUSA, SEAsia, and NEAus, may be attributed to the combined effects of cooler temperatures and increased radiation. "

It would be interesting to understand the difference between the relationships depicted in Figure 3 for the two years during the isolated El Nino / La Nina (green years) and the two years following (yellow years). I.e., which of these variables is driving the change in BVOC emissions once the initial temperature perturbation has gone away, does it change?

We included a new table (Table 2) showing correlations between driving variables and isoprene fluxes: 1) during the event, 2) in the two years following the event, and 3) both time-frames (4 years). This allowed us to discuss in more detail the effect of the driving variables. We found that climatic variables tend to correlate more strongly during the event while the vegetation variables also correlates quite well in the two years following the event, suggesting a longer lasting signal from vegetation.

Section 3.2:

Can you add some clarification to the captions for the Figures and Tables in this section as to the time period that the changes correspond to. From the Methods section I think these must be 30-year means following 20 years of sustained El Nino / La Nina but it would be useful to state that here (especially if my interpretation is not correct!)

Your interpretation is correct. The captions are updated to clarify this point.

In the scenarios that see an increase in total vegetation coverage, do you know which land cover type is being lost? I.e., what is the vegetation expanding into?

After checking the total vegetation coverage in the areas considered, it became clear that there are patches of land missing vegetation (even in areas including dense forest such as the Amazon). As seen in Fig 6. some PFTs expand while others shrink, however it could also be the case that the total vegetated area increases as it expands into these "empty" patches. A sentence was included to explain this.

Editorial Comments:

Page 2, line 30: correct “oxidant”

Page 3, line 70: correct “us” to “use”

Page 6, line 142: correct “Event”

Page 9, line 192, should “start” be “star”?

Page 12, line 237: should “vegetational” be “vegetation”? (I would change this throughout but could leave for Copernicus Copy Editor’s opinion)

Supplement:

Page 1: correct spelling of Table in Fig S1 caption

Manuscript updated accordingly. Thank you.

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