

Author's response to the Anonymous Referee for the manuscript titled "**Historical Trends and Controlling Factors of Isoprene Emissions in CMIP6 Earth System Models**" by Thi Nhu Ngoc Do and co-authors.

We would like to thank the referees for the helpful comments. We have revised the manuscript in response to his comments and hope it is now suitable for publication. Below, the referee's comments are presented in *blue italics*, with our responses in regular font. The revisions made to the manuscript are highlighted in **red**, and the corresponding line numbers show where each change has been made in the revised version.

Reply to Referee #1

This paper by Do et al. examines the differences in historical trends and controlling factors of isoprene emissions across six modelling approaches and highlights the importance of better parameterizing the CO₂ effect, as well as the global/regional PFT distribution and LULCC effects, on isoprene emissions. The study indicates that the influence of CO₂ and LULCC effects on long-term isoprene emissions surpasses climate factors, which is currently not well understood. As the increase of CO₂, LULCC and temperature are happening together, I feel this work comparing these controlling factors is quite important.

Overall, I found the quality of the work strong, with appropriate and justified methods. Hence, the conclusions are strongly supported by the evidence provided. The suggestions I make below are primarily to increase clarity and conciseness but in themselves are minor things that don't significantly question the findings of this work.

Thank you for the encouraging comments. We have made every effort to address your helpful comments to improve clarity and conciseness in the revised manuscript. Please find detailed responses to your comments below.

Lines 17-18: The influence of isoprene on the Earth's radiative balance, as you very nicely described in the introduction (lines 51-56). Therefore, I suggest you rewrite this sentence by clarifying the indirect effect of isoprene on the radiative balance.

Thank you for your helpful comments. We have revised the sentence to better clarify the indirect effect of isoprene on the Earth's radiative balance. The revised sentences (Lines 17–18) are as follows:

“Terrestrial isoprene, a biogenic volatile organic compound emitted by many plants, **indirectly influences the Earth's radiative balance through its interactions with atmospheric oxidants, affecting ozone formation, methane lifetime, and secondary aerosol production.**”

Lines 375-376: From a visual analysis, I would say that VISIT-S3(G1997) and UKESM1-0-LL(P2011) show higher emissions in the northwestern Amazon, which is interesting and in line with satellite retrievals of isoprene concentrations over this region (doi:10.1029/2021JD036181). I suggest mentioning/citing this here.

Thank you for your helpful comment. We have revised the text to mention the higher emissions in the northwestern Amazon as simulated by VISIT-S3(G1997) and UKESM1-0-LL(P2011), which align with satellite retrievals of isoprene concentrations in this region. The revised sentences (Lines 377–380) are as follows:

“VISIT-S3(G1997) and UKESM1-0-LL(P2011) also identify the Central Amazon as the emission hotspot but show relatively higher emissions in the northwestern Amazon. This pattern aligns with satellite retrievals of isoprene concentrations over this region (Wells et al., 2022), though the emissions are of a smaller magnitude compared to those simulated by CESM2-WACCM(G2012) and NorESM2-LM(G2012).”

Lines 376-377: I do not see a hot spot of isoprene emission in the northern Amazon for the simulations with GFDL-ESM4(G2006). It seems there is a hot spot in the central and western Amazon, but it is a weak sign compared to other simulations. Was it just a visual analysis?

Thank you for your helpful comment. We have revised the text to correct the identification of the western Amazon as an emission hotspot in the GFDL-ESM4 (G2006) model and have incorporated your clarification regarding the weaker signals in the revised sentences (Lines 380–382) below:

“However, GFDL-ESM4(G2006) and GISS-E2.1-G(G1995) models respectively recognize the western Amazon and northern Amazon as emission hot spots, respectively, although this signal is weaker compared to other models”.

This result was based on a visual analysis of the overall hotspot identification for emissions. However, the figures showing emissions across the entire Amazon can be found in Table S4. This table shows that emissions are highest in the CESM2-WACCM(G2012) and NorESM2-LM(G2012) models, moderate in VISIT-S3(G1995) and UKESM1-0-LL(P2011), and lowest in GFDL-ESM4(G2006) and GISS-E2.1-G(G1995). This distribution aligns with the spatial emission patterns observed across the models.

Lines 537-540: I found this confusing. Wasn't the precipitation dataset the same for both models? Can you please explain why you have increased precipitation and reduced precipitation in the same Amazon region? Maybe I missed this point, but I think it is worth explaining it here.

Thank you for your helpful comment. We apologize for the confusion. In response, we have clarified in the manuscript that the climate datasets (including precipitation) differ between the models. The

input datasets for VISIT(G1997) and the Random Forest emulator applied to each CMIP6 model are described in Sections 2.1.2 (Lines 202–203) and 2.2.2 (e.g., Lines 264–270), respectively. We hope this revision addresses your concern. The revised sentences (Lines 549–553) are as follows:

“Precipitation-driven changes remain highly uncertain, both in magnitude and sign of the trends. For example, VISIT(G1997) shows marked increases in Amazonia emissions because of increased precipitation, whereas UKESM1-0-LL(P2011) projects a decrease in the same region because of reduced precipitation. **This discrepancy results from the different climate datasets: VISIT(G1997) relies on reanalysis data, while UKESM1-0-LL(P2011), like other CMIP6 models, uses its own modelled climate data (Fig. S7).**”

Line 678: it is not usual to present a new figure/result in the discussion section. I suggest moving figure 14 to the results.

Thank you very much for your comment. In the revised manuscript, we have moved Figure 14 to the Results section and revised the text accordingly. For your reference, please see lines 583–599.

Lines 619-691: In general, this whole section seems more like results (some repetition from the results) than discussion. I suggest integrating it to the results or reducing it.

Thank you very much for your suggestion. We have integrated the results of the inter-model spreads of each factor’s contribution to isoprene emission trends (Fig. 14) into the Results section. The revised manuscript now focuses on discussing the variability in the attribution of isoprene emission trends among the models. As a result, we have adjusted the content in Lines 619–691 (now Lines 663–730) to better align with the Discussion section, ensuring that it complements the Results without redundancy.

Line 714: Do you mean “both sets of modelling studies”? You have cited a few studies in the previous sentence. I suggest you rewrite this sentence for clarification.

Thank you for your helpful comment. We have revised the sentence for clarity. In the revised manuscript, we now refer to “both sets of modelling studies” as your suggestion to better distinguish the different study groups. The revised sentences (Lines 751–752) are as follows:

“**Both sets of modelling studies** entail uncertainties; yet, in the absence of measurements or proxies, modelling serves as our sole resort for estimating preindustrial isoprene emission rates.”

Thank you once again for your time and consideration.

Kind regards,

Ngoc Do

(On behalf of the co-authors)