

We again thank all reviewers for their comments, constructive suggestions and appreciate the time taken to review this work for a second time. We have again carefully considered all comments and have provided our response and stated any changes to the manuscript below.

In the following, reviewer comments start with a **R:** and are set in grey italics, while our responses and corrections start with a **A:** and are in red.

Response and revisions to comments from 'Anonymous Referee #1' are presented first, followed by comments from Junichi Tsutsui.

Anonymous Referee #1

We thank the reviewer for carefully identifying the following issues. These have all been addressed in the revised manuscript, and we appreciate the reviewer for picking up on them.

R: Equation 4a, I suggest swapping w and $w-1$ out for w_m and w_{m-1} (i.e. subscripts). The way it stands now it seems a bit confusing.

R: Page 21 line 388: "Further assessment our" -> "Further assessment of our"

R: Page 23 line 449: "Our frameworks" -> "Our framework's"

R: Page 23 line 459: Are you sure about the last access data for the esgf website? That seems a long time ago for a 2025 article to have checked that..

A: We thank the reviewer for picking up on this error, this was a typo on our part and is intended to be read as 'Jan 2024'

R: Page 4, Figure 1 caption: "Refer to sections 4.2.1 and 4.2.1", I suspect one of these duplicate numbers should be something else... 4.2 and 4.2.1?

Junichi Tsutsui:

R: To clarify, my concern was primarily about the validity of the cumulative CO2 emissions data. While the temperature data can be directly related to the CMIP6 model output used in this study, the CO2 emissions data are not, which raises questions about the validity and relevance of the results from the sensitivity analysis regarding the remaining carbon budget. Besides, the current manuscript describes the CO2 emissions data from fossil fuels and industrial processes, but not from land use and land-use change. Although some of the CMIP6 models have a carbon-cycle component, evaluating emissions associated with land use are not straightforward.

A: We thank the reviewer for clarifying their comment and apologise for the confusion on our end.

Firstly, we understand that our analysis of SIA against CO2 emissions, the way currently described, may seem a little out of place. While the primary focus of framework development is based in the relation to temperature, we include a sensitivity analysis of the remaining carbon budget to showcase the flexibility of our framework, showing it can be used for analysis on more than just temperature, and also to contextualise our results within broader climate mitigation benchmarks. This addition is intended to show an example of application, rather than extend the scope, while aligning with methods used in prior assessments such as those in the IPCC. We have added a sentence to Section 5.3, pg.19 to clarify this.

Secondly, in terms of the CO₂ emissions data used, we realise we did not update this correctly in the manuscript. Originally, we used only fossil and industrial CO₂ emission data however in the submitted iteration of the manuscript, we use fossil, industrial and LULUCF CO₂ emission data. We have corrected this in the revised manuscript under the 'Data' description in Section 3, pg. 5.

Thirdly, given the reasons/ discussion above we are eager to keep the carbon budget analysis in the manuscript if possible. We acknowledge that there are differences in the LULUCF (land use, land use change and forestry) emissions between ESMs. However, here we chose a common approach that has also been utilised by the IPCC WG3, where a harmonised LULUCF emissions time series based on historical bookkeeping estimates of anthropogenic emissions are used. We therefore use the same approach to infer cumulative emissions as in IPCC WG3, however we acknowledge that ESMs that infer LULUCF emissions from land-use patterns face uncertainty due to varying model assumptions and the inherent complexity of LULUCF processes, which can lead to differences in the effective LULUCF emissions estimated by different ESMs. We have added another few sentences to Section 3, pg. 5 to hopefully justify our approach and explain the thinking behind the data.

We thank the reviewer for carefully identifying the following minor issues. These have all been addressed in the revised manuscript, and we appreciate the reviewer for picking up on them.

R: *Acronym SSP should be defined at its first appearance L68 instead of L75.*

R: *The font size used for labels and annotations in Figure 1 appears to be still too small. I recommend increasing the font size to improve the overall clarity and accessibility of the figure.*

R: *I agree with the authors' response for equation (3a), not (2a) I believe, but further I have noticed redundant parentheses in the denominator of equation (2).*

R: *I understand 'm' represents a reference point for each month. Although I am not confident, 'reference point' may be better wording than 'average point'.*

R: *Area units should be km², not Km², in Table S3.*

R: *I have also noticed that the minus sign is represented using a hyphen (-) throughout the text. For clarity and correctness, I recommend using the proper minus sign character (Unicode U+2212) instead.*
