EGUsphere, author comment AC2
https://doi.org/10.5194/egusphere-2022-321-AC2, 2022

Reply on RC2

Fulden Batibeniz et al.

Author comment on "Countries most exposed to individual and concurrent extremes and near-permanent extreme conditions at different global warming levels" by Fulden Batibeniz et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-321-AC2, 2022

We would like to thank the reviewers for their valuable comments. We have addressed all major and minor comments of the reviewers through appropriate changes and hope that the revised manuscript satisfies the reviewers' concerns.

The Response to the Reviewers file provides complete documentation of the changes made in response to each comment. The document is designed so that the changes that have been made in response to each comment can be immediately read and understood, independent of the other comments and responses. While this comprehensive comment-by-comment explanation requires some duplication of material throughout the document, our intention is that it helps to evaluate precisely how each comment has been addressed.

Reviewers' comments are shown in **bold**. The authors' response is shown in plain text.

Summary of edits

Here we would like to summarize the changes we made in the manuscript. We did considerable updates in the used methodology. For extreme wind event calculation, we now use daily maximum wind instead of daily wind and for drought events' calculation we now use daily data instead of monthly soil moisture data. We also changed our definition of concurrent events, and only marked the months where the extreme pairs occurred on the same day, whereas before it was on the month level.

We would like to also note that we changed the methodology of extreme indices and percentile calculation. It is mentioned previously in literature that percentile based indices for climate change detection may create artificial jumps at the beginning and end of the reference period (Zhang et al., 2005). These discontinuities can lead to an artificial frequency increase outside the reference period (e.g., at warming levels). We used the bootstrap resampling procedure proposed by Zhang et al. (2005) to overcome this problem. Indeed, this procedure improved our results in terms of inhomogeneities occurring outside the reference period.

Some of the above-mentioned calculations and text editing are still ongoing. We are also revisiting the text for every section to address all the questions/concerns of the reviewers.

Reviewer #2

This is an interesting and important study focussing on changes in four individual and two concurrent extremes at different warming levels (GWLs) with reference to the pre-industrial level (1850-1900) based on multiple CMIP6 models. These findings are important to understand the changes in frequency of extremes at present and probable warming levels in the future. However, I have two major concerns: 1) the study involves statistical analysis but offers very little on physical linkages in model processes and extreme weather events, and 2) the manuscript lacks clarity in description of the adopted methods. On a broader context, there are several studies that are coming out in the recent times that are merely the outcome of the CMIP6 models represented in terms of charts and maps, offering very little on science and understanding. I hope the authors will add discussions and usability beyond that.

We would like to thank the reviewer for their overall positive evaluation of our manuscript. We have made substantial changes in the manuscript to eliminate the concerns of the reviewers. We now explained our methodology with more details and illustrations. We will improve our discussion in a way to include more physical linkages.

Further, the study starts discussing high vulnerability of tropical countries to climate extremes. Yet, it limits itself to exposure of extremes to the population, ignoring other indicators relevant to the individual extremes. While this may be beyond the scope of the study, I would suggest rewriting the introduction part for better communication.

Thank you for your insight. We are editing the text for better communication.

Other points:

1- There has been discussion on population data from different sources and interpolating data from 2000-2100; however, later on, the population of 2015 is employed for the determining exposure. Hence, the significance of lines 116-118 is difficult to understand.

Thanks for pointing this out. We revisited and clarified the text for the population counts section. Indeed, we only use 2015 Gridded Population of the World version 4 (GPWv4) data to calculate the population exposure in section 3.4. Therefore, we decided to remove information related with population projections of shared socioeconomic pathways (SSP5) to avoid confusion.

2- In addition to the reference provided for the methodology to select data for different warming levels, some details in addition to Line 135-137 would clarify the audience.

We thank the reviewer for this suggestion. In response to the reviewer's concern about the warming levels, we now explained the global warming levels extensively with a figure and text in the methodology section, which we believe will help readers to understand global warming levels better. Warming levels are 20-years periods unique to each model due to different climate sensitivity and internal variability and thus timing of the global warming levels. We first calculate the annual average global temperature. Then, we subtract the average global temperature of the reference period 1850-1900 (pre-industrial period) from every year between 1850-2100 and take the 20-years running mean. The first year a certain anomaly such as 1ºC, 1.5ºC, 2ºC, and 3ºC is exceeded is the central year of the warming level period and the warming level period is obtained by subtracting 10 and adding 9 to the central year. For example, IPSL-CM6A-LR reaches 2ºC warming in

2036 so the period selected for this model is 2026-2045. On the other hand, MRI-ESM2-0 reaches 2ºC warming in 2040 and the period selected is 2030-2049. In previous analysis warming levels included 30-years but now we changed it into 20-years consistent with the chapter on weather and climate extremes of the IPCC AR6 (Chapter 11; Seneviratne et al., 2021).

3- I also have some reservations on the monthly temporal scale, based on which concurrent extremes are determined here. I hope the authors have considered the timing of the events in a month, particularly for Rx1day and extreme wind, to declare the two events as concurrent. More details related to Line 163-167 are required to clarify concurrent extremes.

We understand the reviewer's concern. In principle you could have an extreme precipitation event at the beginning of the month and extreme wind event at the end of the month both occurring in the same location. Even though two of those hazards don't interact with each other, they contribute to the overall exposure of that grid cell/location. However, to overcome this concern we also changed our definition of concurrent events, and we only marked the months where there is daily concurrency of extreme pairs.

4- I am unclear on the method adopted for the event fraction and frequency (Line 176-177) of extremes—an explanation of how to reach the particular fraction need to be added.

Thanks for the comment. We revised the text to avoid this confusion. The frequency and fraction have the same meaning in the text. The pre-industrial period has 612 timesteps (51-years * 12 months) and global warming level periods have 240 timesteps (20-years * 12 months). Each timestep is either 1 or 0. We average these values over time and the resulting value is between 0 and 1 indicating a fraction of that period exposed to specific extremes. To ease understanding we multiply it with 100 and give it as a percentage.

5- In Figure 5b(top row), the number of concurrent extremes for the Indian region changes from 2 at present GWL to 1 at 1.5°C and then changes further. How does the number of concurrent extremes change at 2°C and 3°C for that region? Also, the possible reason behind this need to be explained in the corresponding section.

Thanks for pointing the problem out. We repeated all the analysis so the values for India changed and fixed. The previous values were caused due to plotting mistakes, and they are now fixed.

Reference:

Zhang, X., Hegerl, G., Zwiers, F. W., and Kenyon, J.: Avoiding Inhomogeneity in Percentile-Based Indices of Temperature Extremes, Journal of Climate, 18, 1641–1651, https://doi.org/10.1175/JCLI3366.1, 2005.

Seneviratne, S.I., X. Zhang, M. Adnan, W. Badi, C. Dereczynski, A. Di Luca, S. Ghosh, I. Iskandar, J. Kossin, S. Lewis, F. Otto, I. Pinto, M. Satoh, S.M. Vicente-Serrano, M. Wehner, and B. Zhou, 2021: Weather and Climate Extreme Events in a Changing Climate. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press,

Cambridge, United Kingdom and New York, NY, USA, pp. 1513–1766, doi:10.1017/9781009157896.013.