

RESPONSES TO EDITOR’S COMMENTS

We are grateful to Editor for his/her insightful review. The provided comments have contributed substantially to improving the paper. According to them, we have made significant efforts to revise the manuscript, with the details explained as follows.

Point #1

COMMENT: While working on the revisions, please also reconsider the choice of color scheme used in multiple figures that is divergent, while the variable you are displaying is actually continuous.

RESPONSE: We sincerely appreciate the editor’s valuable comment. In the revised manuscript, we have replaced the color schemes in the relevant figures with sequential colormaps. In detail, the revised figures are provided as follows:

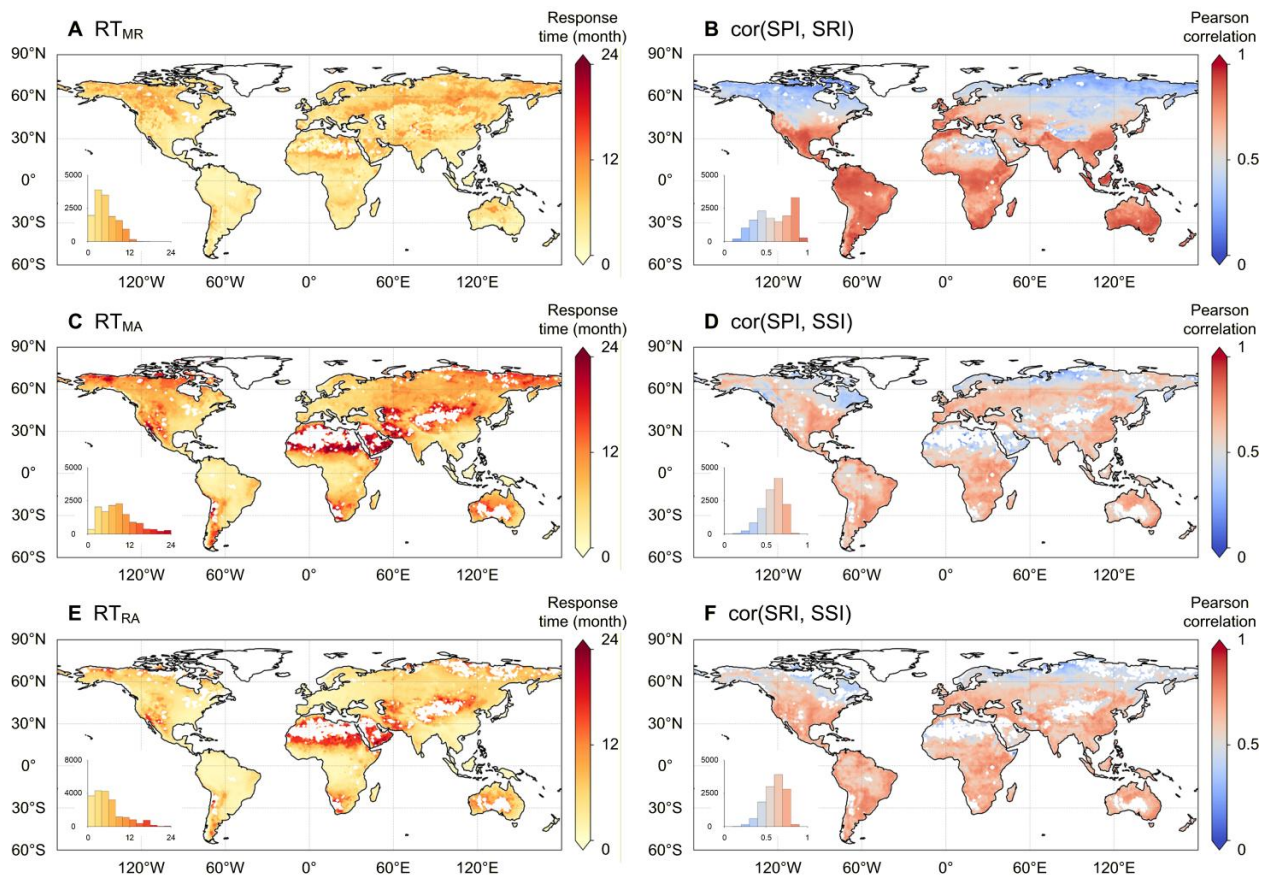


Figure 1. Spatial patterns of average response time from meteorological to runoff droughts (RT_{MR}), from meteorological to agricultural droughts (RT_{MA}), and from runoff to agricultural droughts (RT_{RA}), and the corresponding Pearson correlation

coefficients derived from the ensemble of ERA5, GLDAS, and TerraClimate datasets. The blank grids indicate that the correlation between different drought indices is not statistically significant (p -value < 0.05). The inner plots show the histograms of response time and maximum correlation across global land areas.

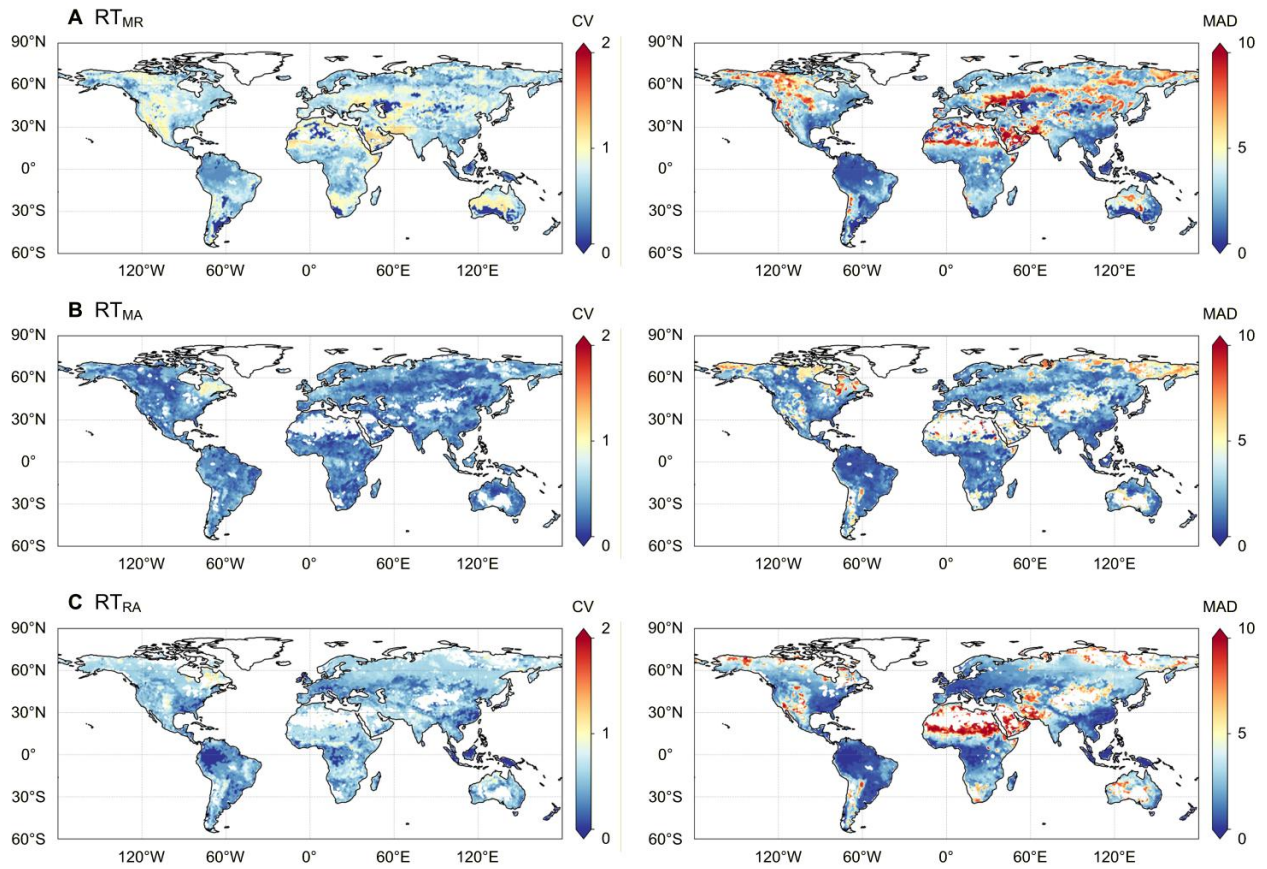


Figure 2. Spatial patterns of CV and MAD across the ERA5, GLDAS, and TerraClimate datasets for the response time from meteorological to runoff droughts (RT_{MR}), from meteorological to agricultural droughts (RT_{MA}), and from runoff to agricultural droughts (RT_{RA}). Larger values of the CV and MAD signify a more substantial disparity among distinct datasets.

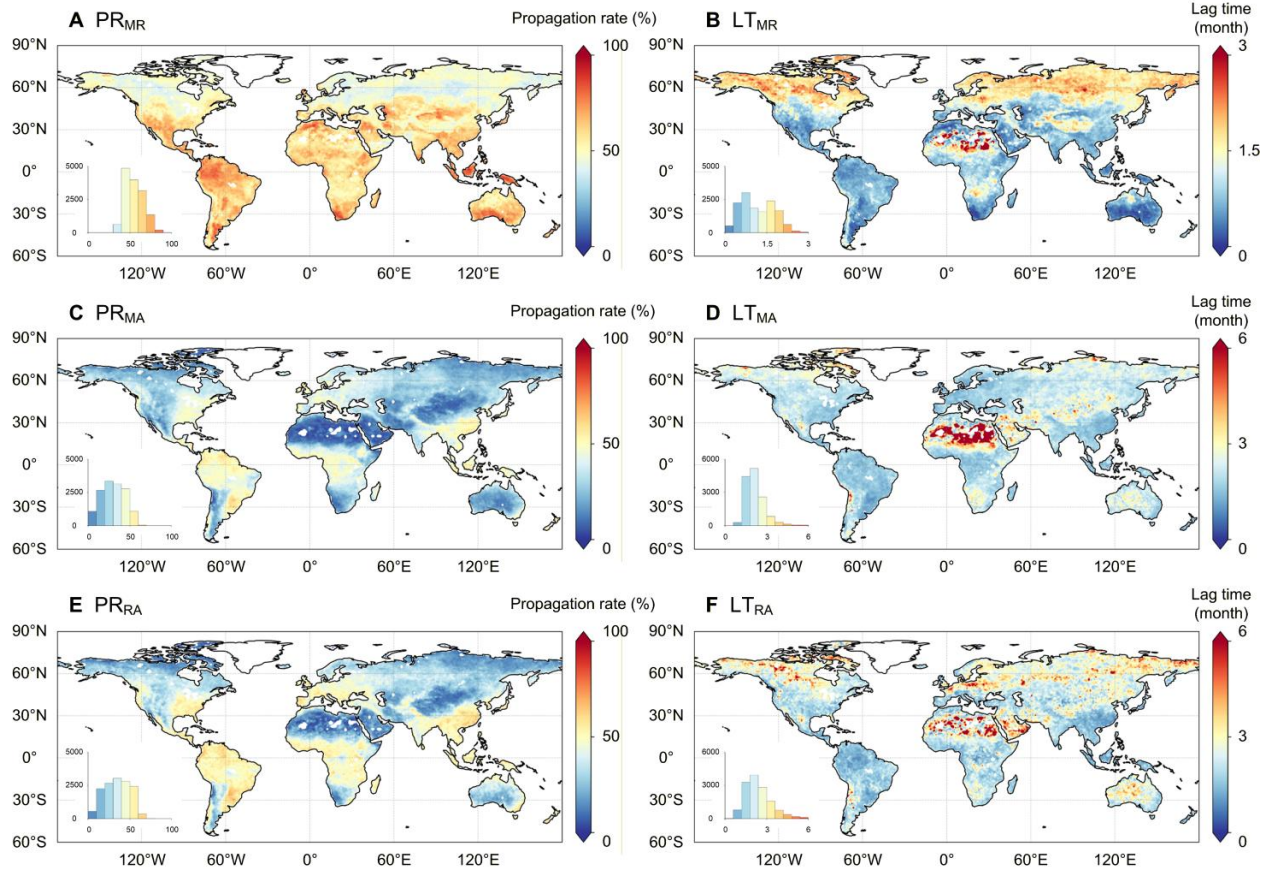


Figure 4. Spatial patterns of propagation rate (PR_{MR} , PR_{MA} and PR_{RA}) and lag time (LT_{MR} , LT_{MA} and LT_{RA}) derived from the ensemble of ERA5, GLDAS, and TerraClimate datasets across global land areas. The inner plots show the histograms of propagation rate and lag time across global land areas. The value of LT_{MR} is lower those that of LT_{MA} and LT_{RA} , so it is assigned a different colour bar.

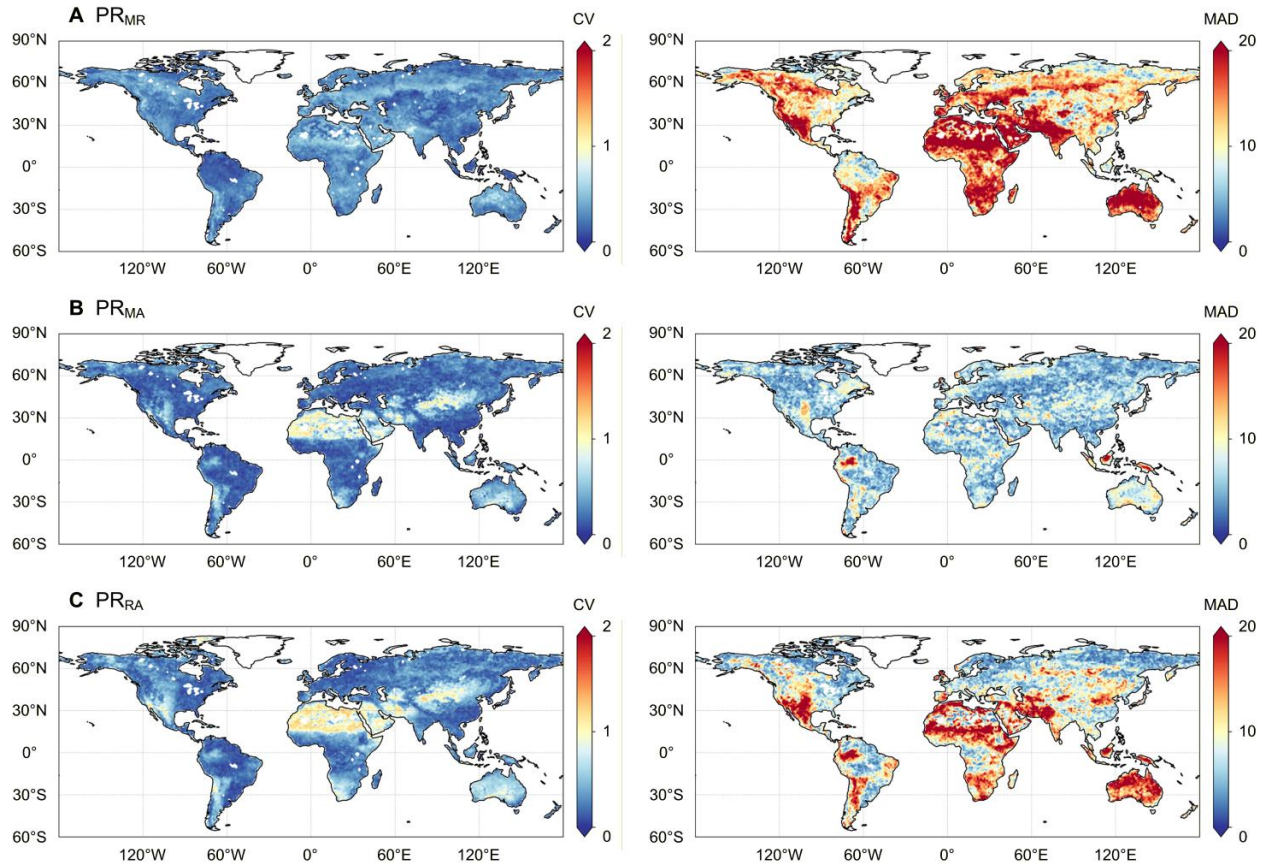


Figure 5. Spatial patterns of CV and MAD across the ERA5, GLDAS, and TerraClimate datasets for the propagation rate from meteorological to runoff droughts (PR_{MR}), from meteorological to agricultural droughts (PR_{MA}), and from runoff to agricultural droughts (PR_{RA}).

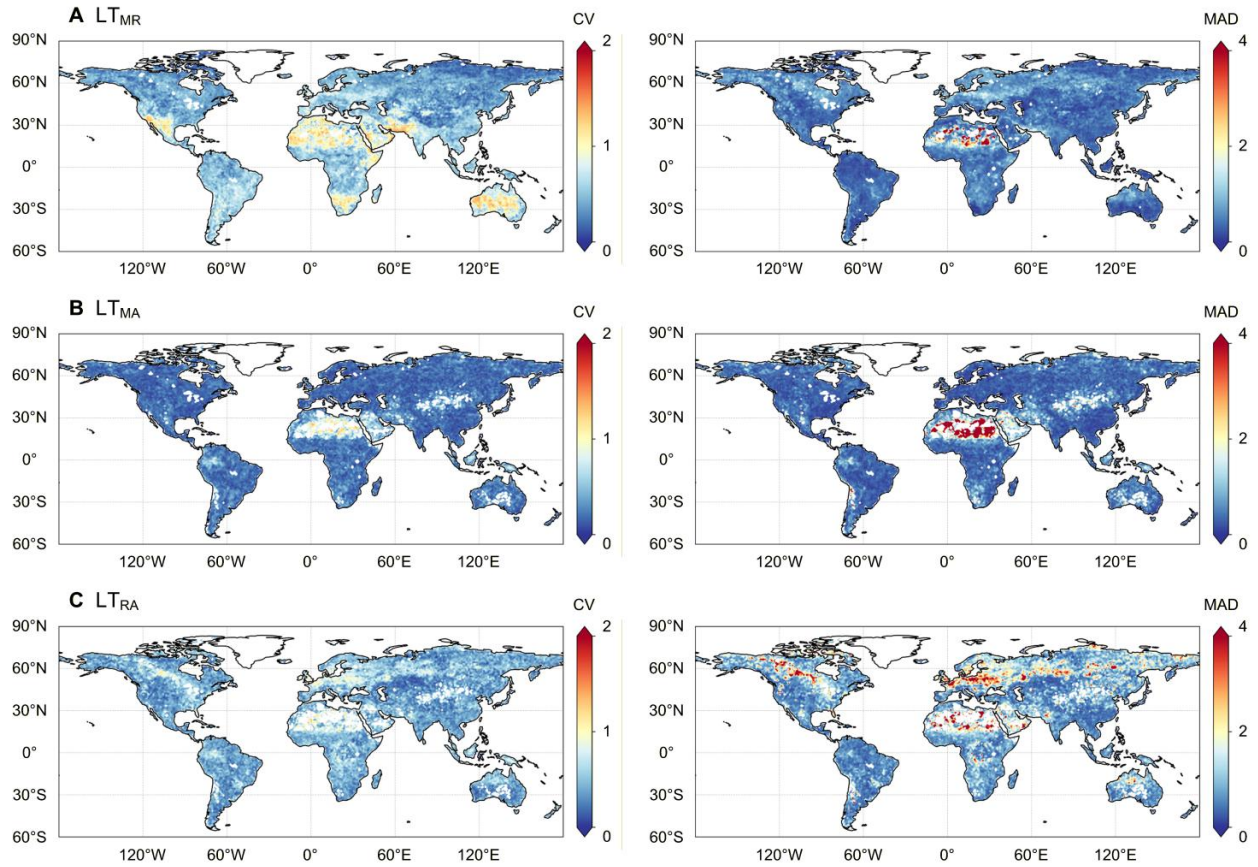


Figure 6. Spatial patterns of CV and MAD across the ERA5, GLDAS, and TerraClimate datasets for the lag time from meteorological to runoff droughts (LT_{MR}), from meteorological to agricultural droughts (LT_{MA}), and from runoff to agricultural droughts (LT_{RA}).

RESPONSES TO REVIEWER ONE'S COMMENTS

We are grateful to Reviewer #1 for his/her insightful review. The provided comments have contributed substantially to improving the paper. According to them, we have made significant efforts to revise the manuscript, with the details explained as follows:

Point #1

COMMENT: *Thank you for clarifying the considered soil layers and your reasoning for investigating the propagation from hydrological to agricultural droughts, this helps. To avoid any confusion around the term hydrological drought though, as you also acknowledge at L517–520, I would recommend using the term ‘runoff drought’ instead of ‘hydrological drought’ throughout the manuscript (including in the title).*

RESPONSE: We sincerely appreciate the reviewer’s valuable comment. We fully agree that adopting the term “runoff drought” enhances clarity and precision, particularly given our specific focus on the propagation of runoff deficits to soil moisture. Accordingly, we have revised the terminology throughout the manuscript, including in the title, abstract, and other sections. In detail, the revised parts are provided as follows:

Title: Understanding meteorological, runoff, and agricultural drought propagation and their influencing factors in an ensemble of multiple datasets

Abstract: Understanding the propagation of diverse drought conditions is essential for effective drought preparedness. This study evaluated the propagation of meteorological, runoff, and agricultural droughts across global land areas from 1958 to 2024 using an ensemble of reanalysis data (ERA5), land surface model simulations (GLDAS), and merged observational datasets (TerraClimate). Two distinct methodological frameworks were employed to characterize drought propagation: time-lag correlation analysis and multi-threshold run theory. Based on standardized drought indices derived from precipitation, runoff and soil moisture, the drought propagation characteristics of response time (RT), propagation rate (PR), and lag time (LT) were examined. Moreover, the climatic and geographical factors influencing drought propagation were quantified using the SHapley Additive exPlanations (SHAP)-based attribution method. The results demonstrate the propagation pathways of meteorological-runoff-agricultural drought at the global scale, with the average RT, PR, and LT from meteorological to runoff drought at 5.0 months, 55.3%, and 1.23 months; from meteorological to agricultural drought at 8.7 months, 30.3%, and 2.60 months; and from runoff to agricultural drought at 5.8 months, 35.0%, and 2.49 months, respectively. Drought propagation exhibits pronounced spatiotemporal heterogeneity, closely related to the regional climatic background. Temperature and potential evapotranspiration are the primary factors influencing the propagation of meteorological drought to runoff drought, whereas precipitation plays a decisive role in the propagation from meteorological or runoff drought to agricultural drought. The findings underscore the importance of taking climatic characteristics into account in the development and implementation of regional drought risk management.

Point #2

COMMENT: L13–15, I see what you mean by the terms ‘meteorological’, ‘hydrological’ and ‘agricultural’ in the brackets, but their placement in the sentence looks rather strange to me, I would suggest some rephrasing.

RESPONSE: We sincerely thank the reviewer's helpful comments. In the revised manuscript, we have rephrased this sentence. In detail, the revised sentence is provided as follows:

“Based on standardized drought indices derived from precipitation, runoff and soil moisture, the drought propagation characteristics of response time (RT), propagation rate (PR), and lag time (LT) were examined.” (lines 13-15 of the revised manuscript)

Point #3

COMMENT: L45–48, what is drought propagation threshold? This is not clear to me from this sentence. I would suggest briefly describing these characteristics here, rather than just listing them.

RESPONSE: We sincerely appreciate the reviewer’s insightful comment. We acknowledge that the term “propagation threshold” was introduced in the introduction without sufficient explanation. We have revised this sentence to provide a brief and clear definition of drought propagation characteristics, rather than merely listing them. Specifically, the drought propagation threshold refers to the critical level of drought conditions required to trigger a detectable response in another drought variable or system. The revised sentence is provided as follows:

“Understanding the characteristics of drought propagation is essential for elucidating drought evolution mechanisms and improving early warning systems. These characteristics include propagation time (the time lag between different drought types), propagation probability (the likelihood of transition between drought types), and propagation threshold (the critical level of drought conditions required to trigger a subsequent drought response).” (lines 44-48 of the revised manuscript)

Point #4

COMMENT: L126, could you please introduce also the spatial resolutions of the raw datasets? I believe this is what comment #8 from the other reviewers referred to as well.

RESPONSE: We sincerely thank the reviewer's helpful comments. We agree that specifying the native resolutions provides essential context for the interpolation process. In our study, the original spatial and temporal resolutions of the raw datasets are as follows: ERA5 (1940–present) at $0.25^\circ \times 0.25^\circ$; GLDAS v2.0 at $1^\circ \times 1^\circ$ (1948–2014), GLDAS v2.0 at $0.25^\circ \times 0.25^\circ$ (2015–2024), and TerraClimate (1958–2025) at $1/24^\circ \times 1/24^\circ$. To ensure spatial and temporal

consistency, the period from 1958 to 2024 was selected as the reference period, and all datasets were uniformly interpolated onto a $1^\circ \times 1^\circ$ latitude–longitude grid using bilinear interpolation. In the revised manuscript, we have added a sentence to clarify the original spatial and temporal resolutions of the raw datasets. The added sentence is provided as follows:

“The original spatial and temporal resolutions of the raw datasets are as follows: ERA5 (1940–present) at $0.25^\circ \times 0.25^\circ$; GLDAS v2.0 at $1^\circ \times 1^\circ$ (1948–2014), GLDAS v2.0 at $0.25^\circ \times 0.25^\circ$ (2015–2024), and TerraClimate (1958–2025) at $1/24^\circ \times 1/24^\circ$.” **(lines 125-127 of the revised manuscript)**

Point #5

COMMENT: L194, the header of this subsection is rather cryptic to me, I would suggest some rephrasing.

RESPONSE: We sincerely appreciate the reviewer’s helpful comment. We agree that the phrase “Criterion of variation” does not accurately reflect the methodological content of this section. Accordingly, we have revised the header of Section 2.5 to: “2.5 Assessment of variation across multiple datasets” to make it clearer.

Point #6

COMMENT: L545–547, I would recommend supporting this statement with some references. Disentangling the effects of human activities on drought propagation at a global scale is surely challenging, but we do have some evidence on the effects of human activities for some specific case studies and drought types at least.

RESPONSE: We sincerely appreciate the reviewer’s insightful comment. We have revised the sentence as follows to support the statement with relevant references and acknowledge existing evidence from case studies:

“In addition, human activities—such as water abstraction, reservoir regulation, and land-use change—can profoundly modify natural drought propagation processes by altering catchment storage and flow pathways, thereby influencing drought propagation (Wens et al., 2019; Du et al., 2024). While disentangling the effects of human activities on drought propagation at a global scale remains challenging, existing studies have provided valuable evidence of such influences (Long et al., 2026). Future research could also focus on quantitatively disentangling the effects of human activities on drought propagation, particularly at the global scale.” **(lines 548-554 of the revised manuscript)**

The added references:

Du, M., Huang, S., Singh, V. P., Leng, G., Huang, Q., and Li, Y.: Quantifying the effects of direct human activities and climate change on the spatial propagation of hydrological drought in the Yellow River Basin, China. *J. Hydrol.*, 643, 131931, doi:10.1016/j.jhydrol.2024.131931, 2024.

Long, J., Xu, C., Wang, H., Li, Z., and Xu, F.: Reconstruction of drought propagation pathways: A global analysis of multitype propagation chains and nonlinear mechanisms. *Glob. Planet. Change*, 256, 105144, doi:10.1016/j.gloplacha.2025.105144, 2026.
Wens, M., Johnson, J. M., Zagaria, C., and Veldkamp, T. I.: Integrating human behavior dynamics into drought risk assessment—A sociohydrologic, agent - based approach, *WIREs Water*, 6(4), e1345, doi:10.1002/wat2.1345, 2019.

Point #7

COMMENT: L556, *'finding' should be 'findings'*.

RESPONSE: We sincerely appreciate the reviewer's carefulness. This was a typographical error, and we have corrected this mistake in the revised manuscript.

Generally, we thank the reviewer again for the insightful and careful review. The comments have been very helpful in improving the paper. As also noted in the **Acknowledgments** of the revised manuscript, we greatly appreciate the reviewer's valuable input.