

## Response to RC1:

This manuscript proposes a new method based on drought-period data for characterizing drought propagation in karst regions. This method avoids the interference of data from non-drought periods, especially addressing the applicability issue in karst regions, and contrasts it with the limitations of traditional methods affected by non-drought period data. The research findings have practical significance for drought early warning and water resources management, particularly in karst regions where it is difficult to accurately simulate using hydrological models. However, due to the following issues, the manuscript currently does not meet the publication requirements of the HESS journal.

**Response:** Thank you for your constructive feedback and comprehensive evaluation of our manuscript. We fully acknowledge the research strengths highlighted in the review—specifically, the proposed new method’s ability to avoid interference from non-drought period data, address applicability challenges in karst regions, and provide a comparative analysis of the limitations of traditional methods affected by non-drought period data. We also appreciate the recognition of our findings’ practical significance for drought early warning and water resources management, particularly in karst regions where accurate hydrological modeling remains challenging.

We sincerely accept the assessment that the manuscript currently does not meet the publication requirements of HESS. We have carefully reviewed all the identified issues and are committed to conducting thorough and systematic revisions to address each concern. Key revisions will include: quantifying karst hydrological characteristics; supplementing discussions on climate change impacts; standardizing terminology consistency; improving the clarity of statistical analyses and figure descriptions; exploring the mechanism underlying  $T_P$  and  $T_L$  differences with quantitative hydrogeological support; and clarifying variable definitions in equations.

The specific comments are as follows:

1. The groundwater hydrological characteristics in karst regions have not been

specifically quantified. Only a general description of "karstification degree" is used, which weakens the depth of the mechanism explanation. It is recommended to supplement karst development parameters (such as karst porosity, groundwater level dynamic data) or cite existing geological survey results, and clarify the classification criteria for karstification degree (such as based on the proportion of karst area or hydrogeological zoning).

**Response:** Thank you for your comment on quantifying karst groundwater hydrological characteristics. We agree that the general description of "karstification degree" weakened the mechanism explanation—this was an oversight in the original manuscript. To address this, we will revise as follows:

We will incorporate the study area's lithological data and define karst coverage rate (the proportion of carbonate rock area to the total watershed area) as a quantitative indicator to characterize karst development degree. We will further clarify classification criteria based on this rate (e.g., dividing into high/medium/low development levels by specific thresholds), making the description concrete and standardized.

2. The data time range (1957–2008) is relatively early. Why not use more recent data? The impact of climate change in the past decade or so has been more significant. It is recommended to discuss the potential impact of climate change (such as the increased frequency of extreme precipitation) on drought propagation characteristics.

**Response:** Thank you for your comment on the data time range and climate change impacts. Our study focuses on watersheds with different karst development levels. The 1957–2008 period was selected because it is the only common time span with available hydrological data—access to such data in China is limited, and this ensures sample representativeness.

Notably, this study primarily investigates the impact of the underlying surface on drought propagation characteristics. Following your suggestion, we will supplement a discussion on the potential impacts of climate change (e.g., increased frequency of extreme precipitation) by integrating relevant literature in the Discussion section. We

also plan to explore this topic further in future research.

3. In Figure 3, "meteorological drought inde" is used for all indices, while "index" is used in the text. Is this a spelling error or does it have a specific meaning?

**Response:** Besides the meteorological drought index, Figure 3 also includes hydrological drought indices. The "index" mentioned in the text refers specifically to the meteorological drought index when the ordinate of the coordinate axis in Figure 3 is labeled as such.

4. The new method has obvious limitations as it is only compared between karst and non-karst basins. It is recommended to increase case verifications in different climate zones (such as arid and humid zones), or cite existing studies to illustrate the transfer potential of the method. In the "Discussion" section, supplement the analysis of the applicability to other types of droughts (such as agricultural drought) to clarify the boundaries of the method.

**Response:** Thank you for your comment on the limitations and applicability of the new method. We acknowledge this inherent limitation—this study focuses primarily on verifying the method's applicability and improvement effects in karst basins compared to non-karst basins. As suggested, we will supplement the Discussion section with an analysis of the method's applicability to other types of droughts (e.g., agricultural drought) to clarify its boundaries. Additionally, we plan to explore the advantages and disadvantages of this method relative to traditional ones across different climate zones (e.g., arid and humid zones) in future research.

5. The description of some statistical tests is vague (for example, the  $T_p$  value of the Kruskal-Wallis H test is not fully labeled), and the impact of the sample size (such as the number of drought events) on the results has not been explained.

**Response:** Thank you for your comment on the statistical tests and sample size explanation. We will further improve the clarity of the statistical test descriptions

6. The mechanism of the differences in TP and TL in karst regions has not been fully explored. It is only attributed to "weak regulation and storage capacity", lacking quantitative support from hydrogeological processes. It is recommended to analyze how the interaction between rapid runoff and slow seepage in karst areas prolongs the drought propagation time by combining groundwater flow models or field observation data, to enhance the scientific nature of the conclusion.

**Response:** Thank you for your comment on the mechanism of TP and TL differences in karst regions. We fully agree with your valuable suggestion and appreciate the specific insights, which provide important guidance for our research. The proposed approach—analyzing the interaction between rapid runoff and slow seepage to explain the prolonged drought propagation time via groundwater flow models or field observation data—is scientifically sound. We will strive to conduct in-depth analysis to supplement quantitative support from hydrogeological processes, addressing the current limitation of attributing the differences merely to "weak regulation and storage capacity."

7. Some figure citations are incomplete (for example, the descriptions of Figure 1 and Figure 5 have insufficient correspondence with the text), and the variable definitions in Equation (1) have not been fully explained. It is recommended to ensure that all chart titles and axis labels are complete, and explain key charts one by one in the text.

**Response:** Thank you for your comment on figure citations and variable definitions. We will carefully review all figures and the text to ensure: 1) completeness of figure titles and axis labels; 2) adequate explanation of key figures in the text; 3) full clarification of variable definitions in Equation (1).

8. The text descriptions and explanations of the figures are too simple, making it difficult to understand the specific meaning of the figures, especially for Figure 3 and Figure 4. For example, in Figure 3, there are three sub - figures (upper, middle, and lower), and the upper sub - figure is further divided into left and right parts, but the differences between them are not explained. In Figure 4, the bottom sub - figure lacks

the label (c).

**Response:** We appreciate you pointing out these issues. This was an oversight. We will revise the figures and text as follows: 1) Number all subfigures (e.g., (a), (b), (c)) consistently; 2) Supplement detailed explanations in the text to clarify the differences between subfigures (including the left and right parts of Figure 3's upper subfigure) and their scientific implications.

9. The most crucial factors affecting the propagation from meteorological drought to hydrological drought in karst regions are the heterogeneity and sensitivity of the karst spatial structure. In particular, the drought propagation in different karst compartments has obvious differences. However, this part of the discussion is missing in the paper.

**Response:** Thank you very much for your valuable comments on our manuscript. We fully agree with your insightful observation—the heterogeneity and sensitivity of the karst spatial structure are crucial factors affecting the propagation from meteorological drought to hydrological drought, and the significant differences in drought propagation among different karst compartments are indeed an important discussion point omitted in the original Discussion section. Your comments have helped us improve the logical completeness of our research, and we sincerely appreciate your rigorous review. To address this gap, we will supplement the following core content in the Discussion section of the revised manuscript: Clarify the core characteristics of differences in drought propagation among different karst compartments (e.g., peak-cluster depressions, peak-forest plains, etc.), focus on conducting a comparative analysis around key dimensions such as propagation lag, intensity attenuation law, and duration evolution, and cite relevant literature.

10. It is recommended to use some specific terms. For example, "karsification degree" should preferably be replaced with the more common "karst development intensity" or refer to international karst classification standards (such as Ford & Williams, 2007).

**Response:** Thank you very much for your valuable suggestions regarding the use of specific terms. Your point about "adopting concrete and standardized terminology" is crucial for enhancing the academic rigor and readability of the manuscript, and we fully agree with it. We will strictly revise the manuscript in accordance with your recommendations.

The specific revisions are as follows:

- a. Uniformly replace the original term "degree of karstification" with the more commonly used "karst development intensity" throughout the manuscript to ensure that the terminology aligns with prevalent practices in the field.
- b. Carefully review the international karst classification standards proposed by Ford & Williams (2007), verify the consistency and accuracy of relevant terminology across the entire manuscript, and ensure that the expressions are standardized and consistent with the international research context.

Once again, we appreciate your meticulous guidance. Your suggestions have effectively helped us improve the standardization of details in the manuscript.