Dear Referee #2:

First of all, thank you very much for the helpful comments and your kind feedback, your comments are listed below, along with our responses to each one.

- Some works, e.g., the systematically literature review of propagation probability model, need to be added into the Introduction or Discussion sections.

RESPONSE: Thanks for your advice. The purpose of this section is to introduce the use of Bayesian model to explore probabilistic relationships among different types. We have rewritten this section based on your advice.

MODIFICATION: A number of studies have attempted to assess the propagation relationships between two drought types based on probabilistic method. This is due to that the probability information of one type of successive drought events is contained in another type of drought associated with it (Wu et al., 2021). Bayesian networks is a probabilistic model that acquires probabilistic inferences over interacting variables of interest based on a graphical structure. Therefore, this method has been proved to be a better way to quantify the probability relationship between different drought types (Ayantobo et al., 2018; Chang et al., 2016; Das et al., 2020). For example, Guo et al (2020) calculated occurrence probability of hydrological drought based on different intervals of duration and severity of meteorological drought. Sattar et al (2019) identified the occurrence probability of different classes and lag time of hydrological drought according to intensity of meteorological drought. Xu et al., (2021) found that the probability of agricultural drought severity increased synchronously with meteorological drought in different regions of China. Jehanzaib et al., (2020) concluded that the probability of meteorological drought in the Korean Peninsula propagating into hydrological drought increased significantly under climate change. In general, these studies primarily focus on the relationship between duration and severity between two drought types but ignore their affected area relationships. Xu et al. (2015a) found that drought occurrence probability would be underestimated if drought affected area were not considered. Therefore, the traditional

drought probabilistic model of drought propagation can be improved by introducing the three-dimensional drought identification method, which provides more drought information (Liu et al., 2019).

- Line 214 (i.e., Eq. (10)), the “n – 1” is shown in the inner product should be revised as “n – i”. Moreover, please define or explain the symbols that appeared in this and some other equations, e.g., the term c is not defined. Please carefully check them.

RESPONSE: Thanks for your hint. We indeed made a mistake when typing the Eq.(10). We have corrected it and added the explanation of the symbols. Furthermore, all equations have been carefully checked to ensure no errors would occur.

MODIFICATION:

$$f(x_1,\ldots,x_n)=\prod_{i=1}^{n} f_i(x_i)\times\prod_{i=1}^{n-1}\prod_{j=1}^{n-i} c_{i,i+j|1:(i-1)}\left\{F(x_i\mid x_1,\ldots,x_{i-1}),F(x_{i+j}\mid x_1,\ldots,x_{i-1})\right\} \quad (10)$$

where $f(x_1,...,x_n)$ represents the joint density function. c represents bivariate Copula densities, which includes Gumbel, Gaussian, Frank, and Clayton Copula function; F represents cumulative distribution function of marginal distribution. i and j represent root nodes.

- For Section 4.2, please provide specific information about paired drought events so that we can identify the characteristics of four paired categories. At the same time, I found the statement “Among them, the peaks of the meteorological drought event appeared two months ahead (December 2007) that of ecological drought (February 2007)” may be wrong in Lines 250-251. As you know, the duration between December 2007 and February 2007 is far more than two months. Please revise it.

RESPONSE: This is a good suggestion. We have provided specific information about paired drought events to show the characteristics of four paired categories. Relevant description will be added in Section 3.3 in the next version.

MODIFICATION: In type OTM, meteorological drought showed a longer duration, a larger affected area, and a greater severity than ecological drought. However, this is contrary to

the type of MTO. Simultaneously, ecological drought in type MTO showed a longer duration, a larger affected area, and a greater severity than those in type OTM.

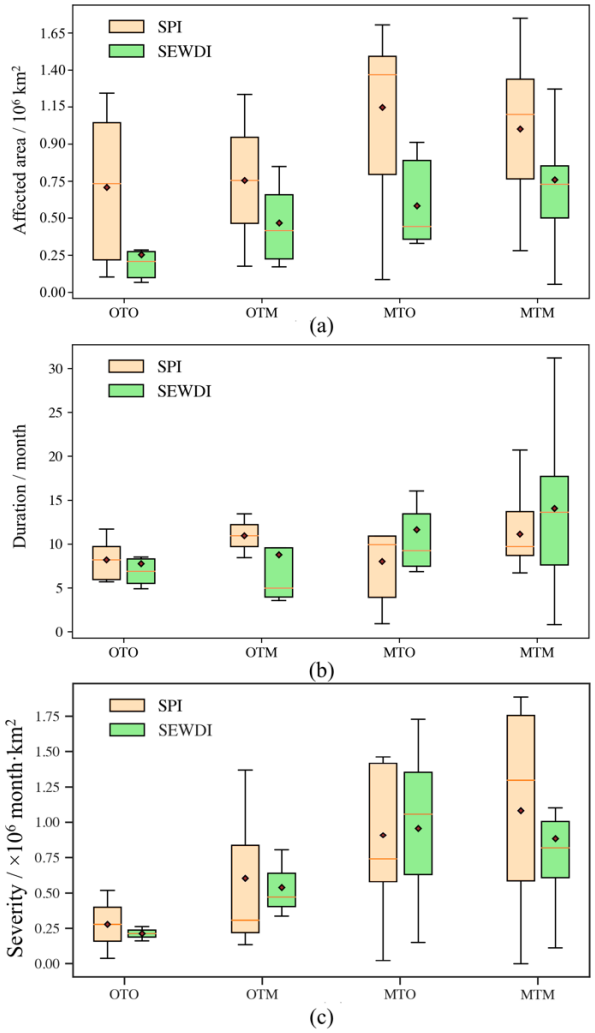

Figure 5. A box plot showing the intensity, duration, and affected area of paired meteorological-ecological drought among different types

MODIFICATION: The statement “Among them, the peaks of the meteorological drought event appeared two months ahead (December 2007) that of ecological drought (February 2007)” was corrected to " Among them, the peaks of the meteorological drought event appeared two months ahead (December 2007) that of ecological drought (February 2008)."

- An essential part of this article is the use of machine learning to solve a binary

classification problem. In this context, I suggest adding a plot that shows the severity, duration, and affected area of meteorological droughts propagated and didn't propagate.

RESPONSE: That is an excellent suggestion. Thank you very much for that as well! In this study, machine learning models were used to determine whether a meteorological drought event has propagating potential. We have added Figure 7 and related description in Section 4.3 with reference to the advice of Referee#1.

MODIFICATION:

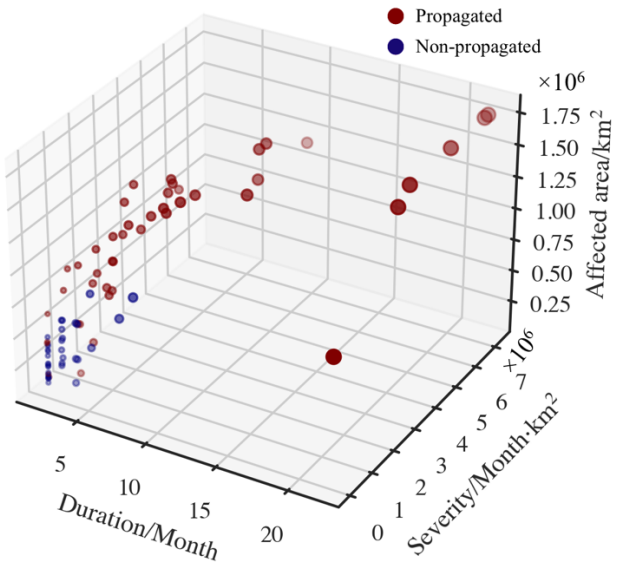

Figure 9 Three-dimensional diagram showing characteristics of meteorological drought events. Larger circles indicate greater severity.

As can be seen in Figure 9, propagated meteorological droughts have greater severity, larger affected area, and longer duration than non-propagated droughts.

- I suggest replacing "Three-dimensional drought identification method" with "Three-dimensional clustering method".

RESPONSE: We agree and can see your point. We will replace "Three-dimensional drought identification method" with "Three-dimensional clustering method" in the next version.

Details:

- Lines 24-25, for specification, the drought classification should be changed as the "drought types". Please revise it.

RESPONSE: Thanks for the hint. We have corrected "drought classification" to "drought types".

- Lines 66-68, “Taking a typically ecological fragile region … to meteorological drought”, I suggest revising it as “Taking a typically ecological fragile region, Northwestern China (NWC), as an example, the motivation of this study, from a three-dimensional perspective, is proposed a novel hybrid machine learning-Copula method to investigate the response probability of ecological drought to meteorological drought” to highlight the novelty of this paper.

RESPONSE: Thanks. We have followed your advice, and changed it.

- Line 94-99, authors should refine their explanation of why SPI-3 is used to represent meteorological drought.

RESPONSE: Thanks for the hint. Line 94-99 has been changed to " Previous studies found that the standardized precipitation evaporation index (SPEI) overestimated the meteorological drought in NWC where actual atmospheric water demand is determined by precipitation variation (Ayantobo and Wei, 2019; Zhang et al., 2019a; Zhang et al., 2021b). Additionally, precipitation is the main water resources for vegetation growth in most regions of NWC due to the great depth to groundwater (Cao et al., 2021). Standardized precipitation index (SPI) was thus used in the current study to represent meteorological drought. SPI at different time scales was calculated by aggregating *n*-month moving sums, allowing the identification of various drought types (McKee et al., 1993). At short time scales, drought events have a high frequency and a short duration, while at the longest time scales, they have a longer duration and a lower frequency. SPI–3 has been reported to be highly representative of the impacts of meteorological conditions on vegetation as the vegetation variation is sensitive to three months accumulated precipitation (McKee et

al., 1993; Vicente-Serrano et al., 2012; Vicente-Serrano et al., 2010; Vicenteserrano et al., 2010). Therefore, SPI-3 was used to characterize meteorological drought in this study."

- Section 3.3.2, the number of steps regarding the Spatiotemporal connection of two drought types may be disordered, e.g., the statements of steps were listed as Firstly and Secondly in Lines 154-155, but that remained as the Secondly in Line 163. Please check it.

  RESPONSE: Thanks for the hint. We will revise "Secondly" in line 163 in original manuscript to "Thirdly" in next version.

- Lines 206-207, please revised the “Cramer-von Mises (CM) test” as the “Cramer-von Mises (CvM) test” based on common sense.

  RESPONSE: Thanks for the hint. We have corrected it to " Cramer-von Mises (CvM) test".

- Line 224, I recommended the authors revised the caption of this section as “Top ten meteorological and ecological drought events according to drought severity”.

  RESPONSE: We agree and can see your suggestion. The caption of this section has been revised to "Top ten meteorological and ecological drought events according to drought severity".

- For Figure 5, as the double y axes are used, I suggest the authors display them with different colors, e.g., the red and blue y-axes are used to display the extent of area and severity. Similarly, please revise Figure 8.

  RESPONSE: Thanks for the hint. We have revised Figure 5 and Figure 8 according to your suggestion.

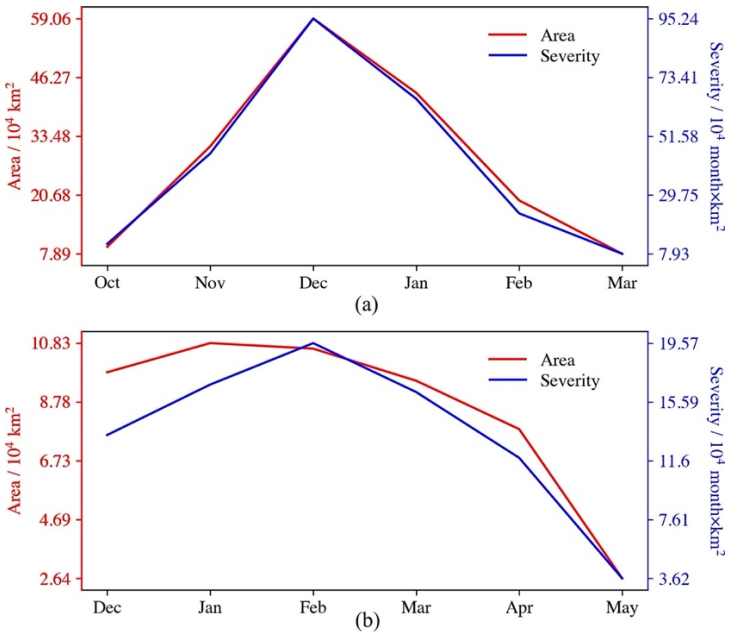

Figure 5: Temporal evolution of DS and DA of (a) meteorological drought event No. 87 and (b) ecological drought event No. 127.

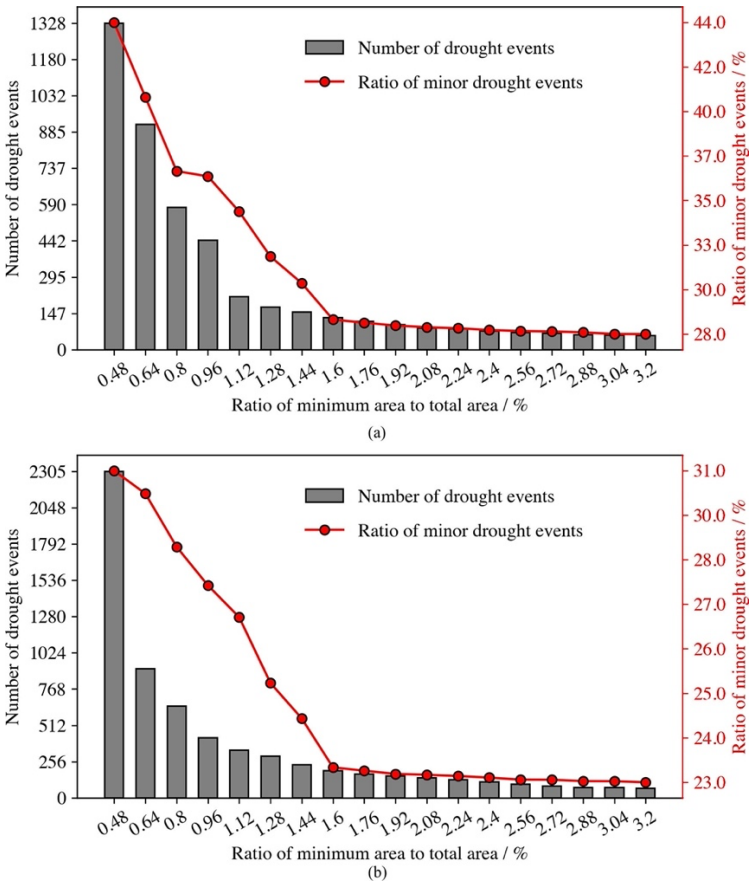

Figure 8: Sensitivity test of overlapping areas of drought patches between two adjacent months.

- Line 255-256, the “of five-fold cross-validations” should be removed from the latter part of this sentence as the relevant statement has been presented in the former.

  RESPONSE: Thanks for the hint. We have deleted the “of five-fold cross-validations” in the latter part of this sentence.

- Line 257-258, the GP and MP should be listed as full names when they appear for the first time.

  RESPONSE: Thanks for the hint. We have corrected it to " Most models showed good performance except for Gaussian Process and Multi-layer Perceptron."

- In Figures 2 and 7, based on the terms commonly used, the drought levels regarding the “serious” should be revised as “severe”. Of course, the same statement about this need to be changed throughout the manuscript.

  RESPONSE: Thanks for your advice, we have revised "serious" to "severe" in Figure 2, Figure 7, and related content throughout the manuscript.

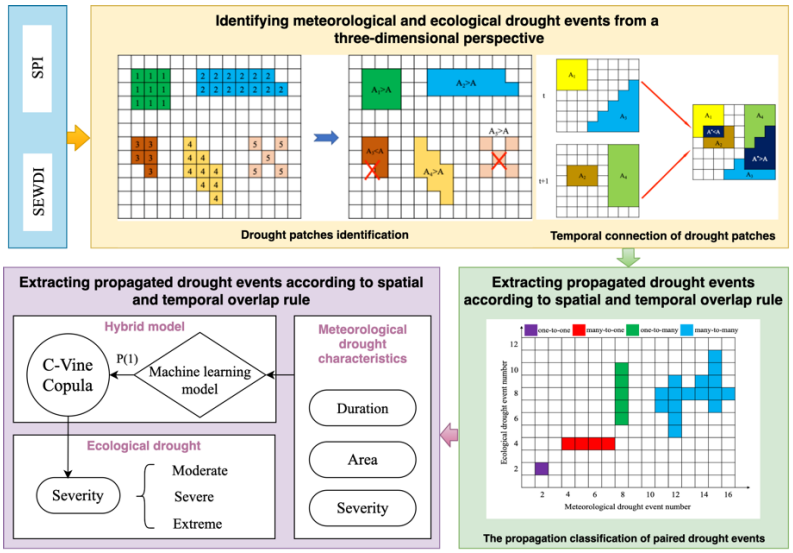

Figure 2: A schematic diagram illustrating the procedure of the drought propagation identification method.

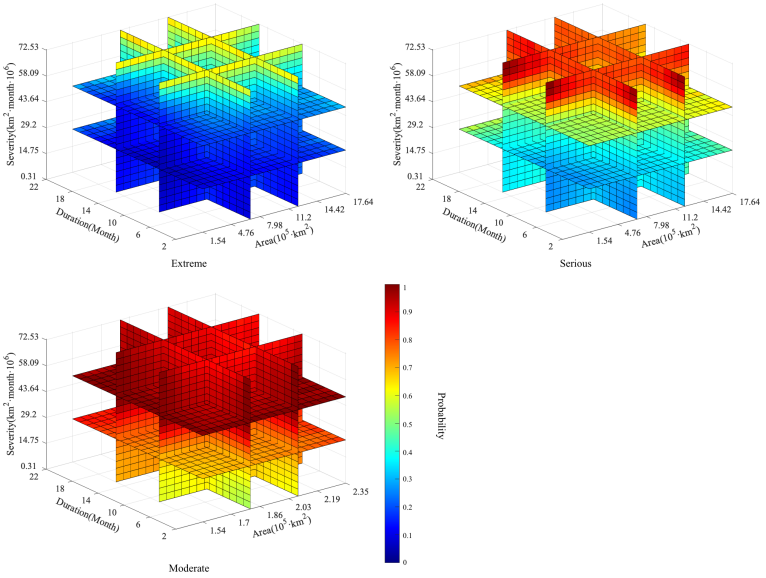

Figure 7: Conditional probability of ecological drought at (a) extreme, (b) severe, and (c) moderate levels, given that characteristics of meteorological drought exceed a certain value.

- In Figure 2, I think the title in purple color should be changed to "Constructing response model of ecological drought to meteorological drought".

RESPONSE: Thanks, we have changed it according to your suggestion.

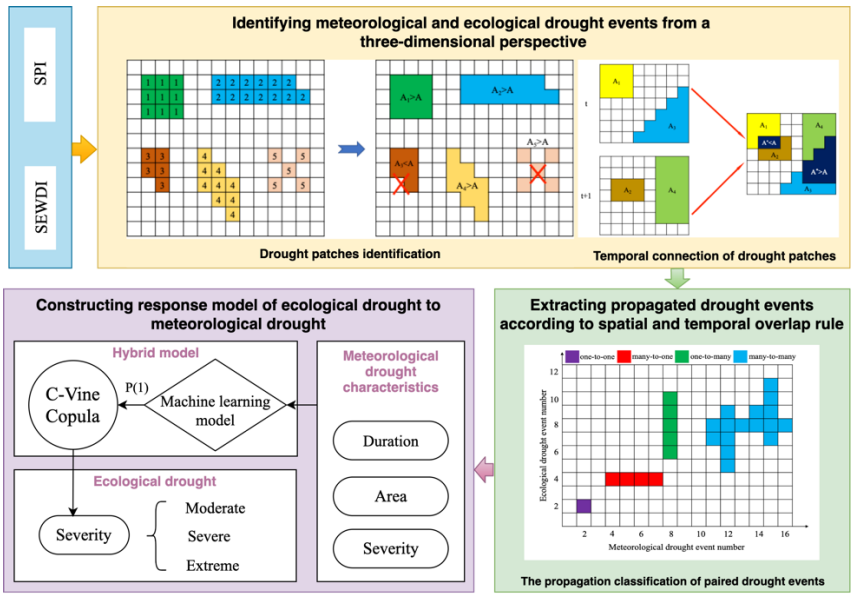

Figure 2: A schematic diagram illustrating the procedure of the drought propagation identification method.

- In the caption of Figure 7, the “different levels” should be pointed out to increase the

readability, e.g., (a) extreme, (b) severe, and (c) moderate. Please check it.

RESPONSE: Thanks, we have changed it according to your suggestion.

MODIFICATION:

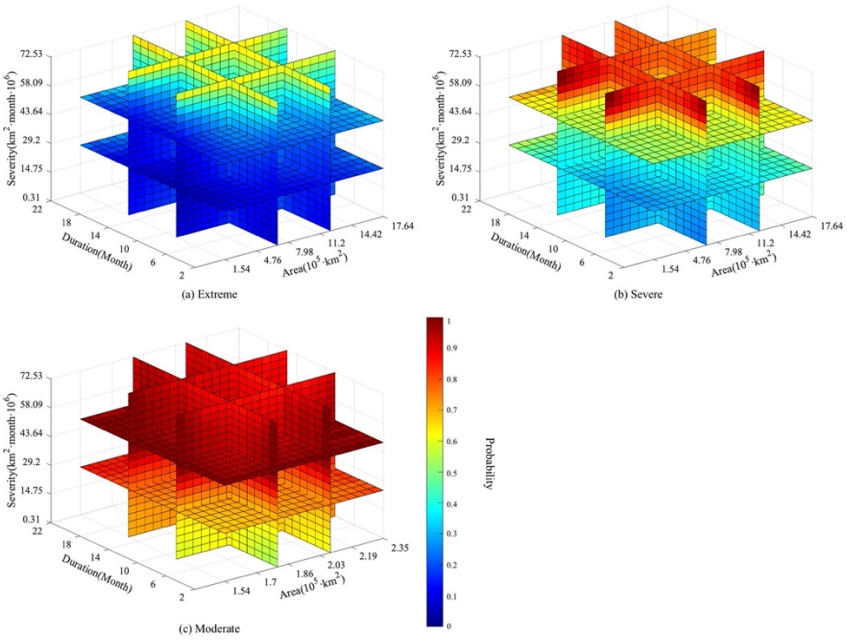

Figure 7: Conditional probability of ecological drought at (a) extreme, (b) severe, and (c) moderate levels, given that characteristics of meteorological drought exceed a certain value.

References:

Jehanzaib, M., Sattar, M. N., Lee, J.-H., and Kim, T.-W.: Investigating effect of climate change on drought propagation from meteorological to hydrological drought using multi-model ensemble projections, STOCHASTIC ENVIRONMENTAL RESEARCH AND RISK ASSESSMENT, 34, 7–21, https://doi.org/10.1007/s00477-019-01760-5, 2020.

Xu, Y., Zhang, X., Hao, Z., Singh, V. P., and Hao, F.: Characterization of agricultural drought propagation over China based on bivariate probabilistic quantification, JOURNAL OF HYDROLOGY, 598, https://doi.org/10.1016/j.jhydrol.2021.126194, 2021.