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 systematic 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. You can find it in **Line 55-Line 69**.

MODIFICATION: The probability information of one type of successive drought events is contained in another type of associated drought (Wu et al., 2021). Therefore, a number of studies have attempted to assess the propagation relationships between the two drought types based on the probabilistic method. A Bayesian network is a probabilistic model that acquires probabilistic inferences over interacting variables of interest based on a graphical structure. Therefore, this method has been proven to be suitable for quantifying 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 the occurrence probability of hydrological drought based on different intervals of duration and severities of meteorological drought. Sattar et al (2019) identified the occurrence probability of different classes and lag times of hydrological drought according to the 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 in the Korean Peninsula, the probability of meteorological drought propagating into hydrological drought increased significantly under climate change. In general, these studies primarily focused on the relationship between duration and severity between the two drought types but ignored the relationships among affected areas. Xu et al. (2015a) found that the probability of drought occurrence would be underestimated if drought affected areas are not considered. Therefore, the traditional probabilistic model of

drought propagation can be improved by introducing the three-dimensional clustering method, which would provide 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 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. The modification is located in **Line 227-Line 230**.

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. The relevant description will be added in Section 3.3 in **Line 276-Line 279**.

MODIFICATION: Meteorological drought of OMT type showed a longer duration, a larger affected area, and a greater severity than ecological drought. However, this is contrary to

type MTO. Simultaneously, ecological drought of type MTO showed a longer duration, a larger affected area, and a greater severity than those of type OTM (Figure 5).

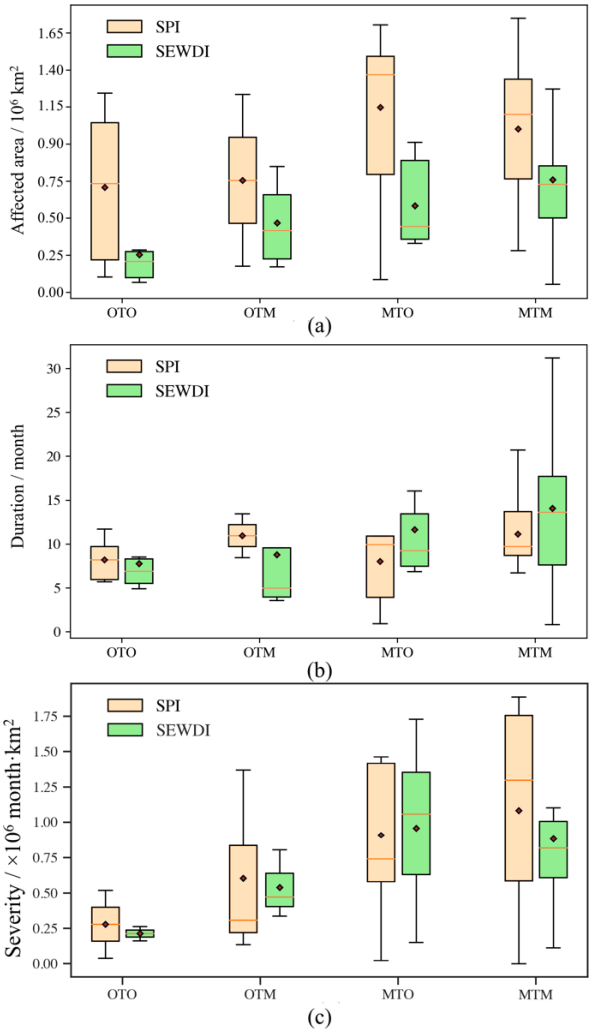

Figure 5. A box plot showing the intensity, duration, and affected area of paired meteorological-ecological drought among different types

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)." in **Line 285-Line 286**.

- 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 9 and related descriptions in Section 3.4 with reference to the advice of Referee#1.

MODIFICATION:

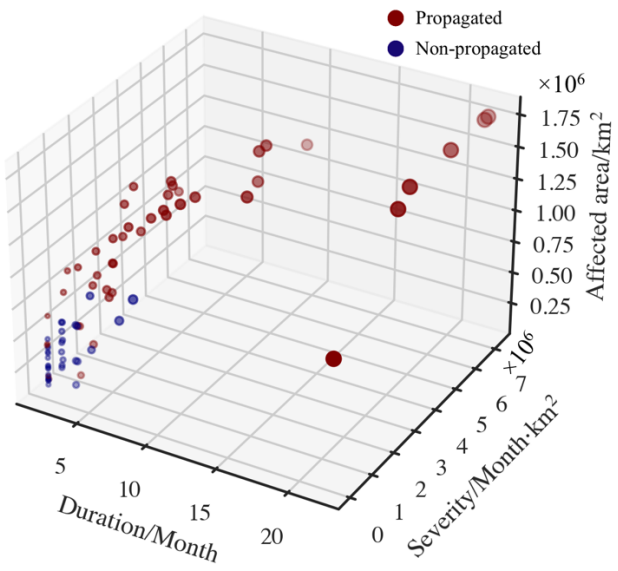

Figure 9 Three-dimensional diagram showing characteristics of meteorological drought events. Larger circles indicate greater severity.

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 text.

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" in **Line 26**.

- 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 are characterized by high frequency and short duration, while at long time scales, they have longer duration and lower frequency. SPI–3 has been reported to be highly representative of the impacts of meteorological conditions on vegetation as vegetation variation is sensitive to precipitation accumulated over three months (McKee et

al., 1993; Vicente-Serrano et al., 2012; Vicente-Serrano et al., 2010). Therefore, SPI-3 was used to characterize meteorological drought in this study." **in Line 102-Line 107.**

- 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 **Line 170** in the revision 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" in **Line 220.**

- 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" **in Line 256.**

- 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. Now, they have been changed to Figure 7 and Figure 3 in the revision version.

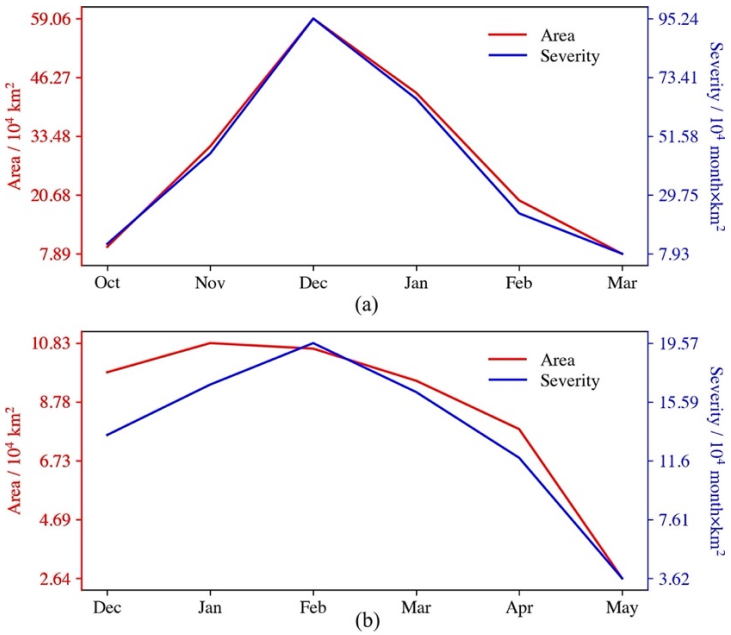

Figure 7: Temporal evolution of DS and DA of (a) meteorological drought event No. 87 and (b) ecological drought event No. 127.

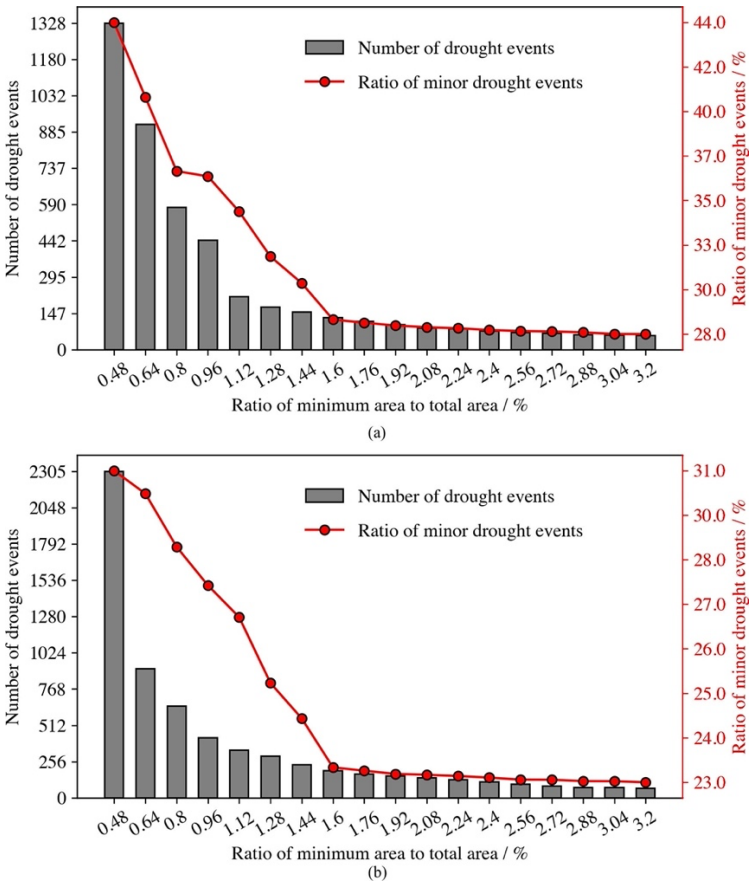

Figure 3: Sensitivity test of overlapping areas of drought patches between two adjacent months.

- 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 **Line 294**.

- 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 (it has been changed to Figure 10 in the revision version), and related content throughout the manuscript.

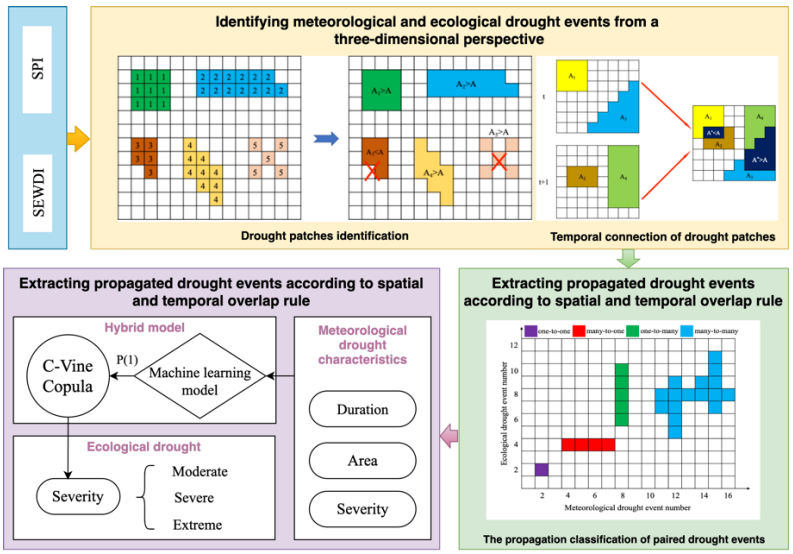

Figure 2: A schematic diagram illustrating the procedure of the drought propagation identification method.

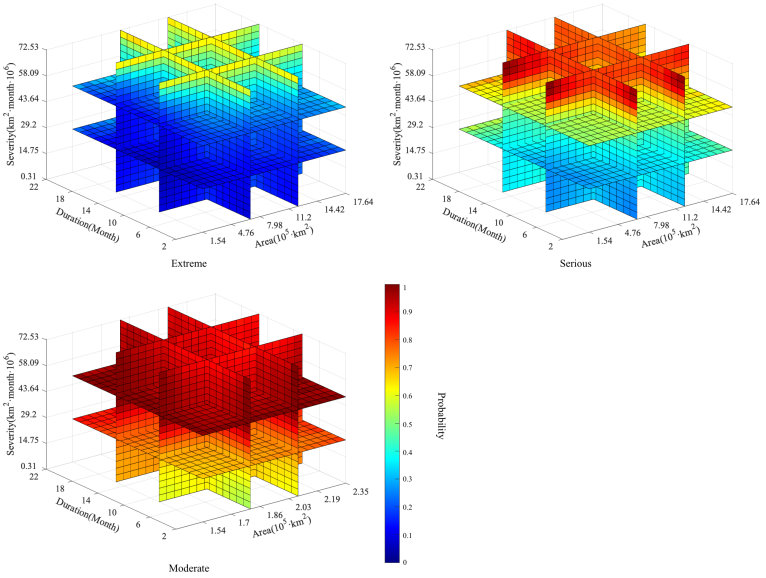

Figure 10: Conditional probability of ecological drought at (a) extreme, (b) severe, and (c) moderate levels, given that characteristics of meteorological drought exceed a certain value.

- 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.

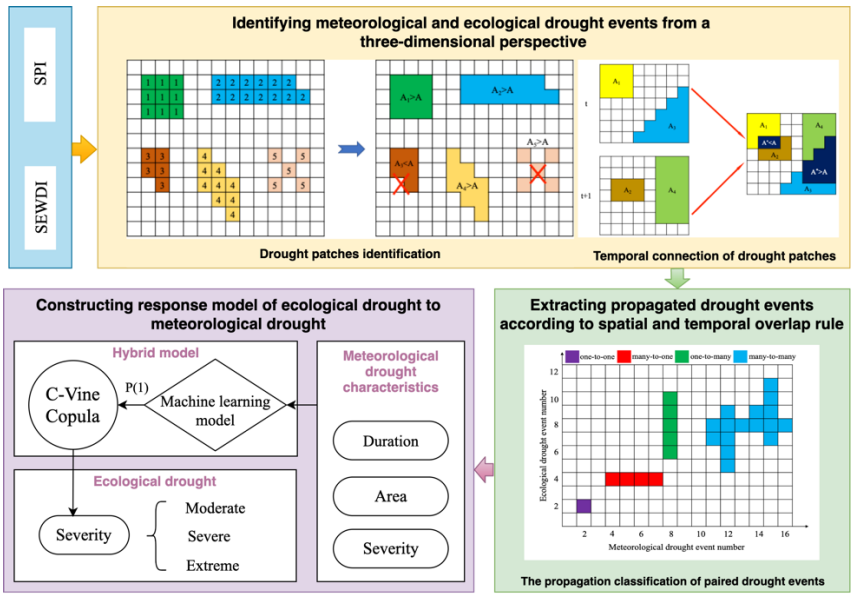

Figure 2: A schematic diagram illustrating the procedure of the drought propagation identification method.

- 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:

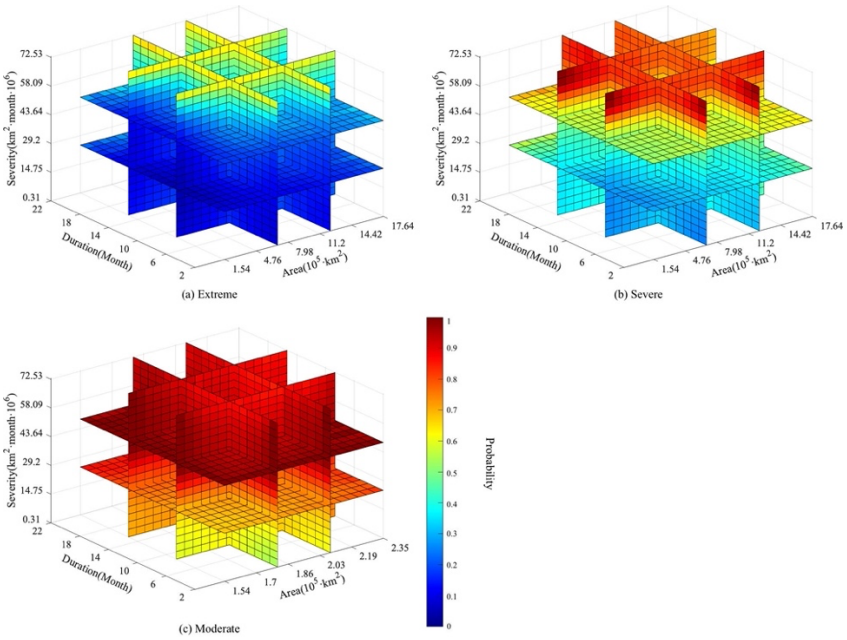

Figure 7: Conditional probability of ecological drought at (a) extreme, (b) severe, and (c) moderate levels, given that characteristics of meteorological drought exceed a certain value.

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.