Reviewers #1 comments:

First of all, I would like to thank for inviting me to review the manuscript entitled "Model Comparisons between Canonical Vine Copulas and Meta-Gaussian for Agricultural Drought Forecasting over China" for possible publication in HESS. I return comments on the above-referenced manuscript. This manuscript has organized pretty well and can be accepted for publication in this journal if the authors carefully revised the following issues. The topic falls into the scope of HESS.

The authors shall do more work to present the topic well so that it is easy for the readers to follow. For example, it is mentioned in lines 95-97, "The objective of this study therefore was to compare the forecast ability of agricultural drought in August of every year in the period 1961–2018 between canonical vine copulas (i.e., 3C-vine model) and MG model under three-dimensional scenario." Why did you just choose August? Why does the study examine the performance of these models? What are the problems, and how these models addresses the problems?

Data are not described, for example what are the data characteristics, what are the data that are used for the estimations and validations.

To better understand, it is better to provide a flow chart of proposed method at the end of the materials and methods section.

The internal copulas of the C-vine not discussed in the first tree. Also, evaluation statistics on tree structure selection are not clear.

Last but not least, in Figure 4, the NSE values are between -0.2 to 0.2, is this acceptable?

Responses to the comments from Reviewer #1

We thank the reviewer for the critical review. The thoughtful comments have helped improve the manuscript. The reviewer's comments are italicized and our responses immediately follow.

First of all, I would like to thank for inviting me to review the manuscript entitled "Model Comparisons between Canonical Vine Copulas and Meta-Gaussian for Agricultural Drought Forecasting over China" for possible publication in HESS. I *return comments on the above-referenced manuscript. This manuscript has organized pretty well and can be accepted for publication in this journal if the authors carefully revised the following issues. The topic falls into the scope of HESS.*

Response: Thank you for this comment, we appreciate your interest in our manuscript. Modifications will be done according to the reviewers' comments in order to improve the quality of the current manuscript.

(1) *The authors shall do more work to present the topic well so that it is easy for the readers to follow. For example, it is mentioned in lines 95-97, "The objective of this study therefore was to compare the forecast ability of agricultural drought in August of every year in the period 1961–2018 between canonical vine copulas (i.e., 3C-vine model) and MG model under three-dimensional scenario." Why did you just choose August? Why does the study examine the performance of these models? What are the problems, and how these models addresses the problems?*

Response: We would like to thank the reviewer for the positive and constructive comments.

***a*) Why did you just choose August?**

We will add details about choosing August as the interested month in the next revised manuscript.

We used 6-month timescale SPI and SSI to depict meteorological drought and agricultural drought, respectively. Therefore, the SPI (SSI) in August, which is calculated by the cumulative precipitation (soil moisture) from March to August, can indirectly reflect the surplus and deficit situations of water in spring (March-April-May) and summer (June-July-August) seasons. This is a key growth period for crops (e.g., anthesis, fruiting, and seed filling) and vegetation and is also the period with frequent droughts. As such, the agricultural drought forecast in August is of primary interested in this study. Undoubtedly, agricultural drought forecast can be implemented in any interested months based on 3C-vine model and MG model.

***b)* Why does the study examine the performance of these models?**

It will be further clarified in the next revised manuscript. Meta-Gaussian (MG) model, as a usually statistical method, has been extensively employed in drought forecast and risk assessment. However, MG model only depicts the linear relationship among explanatory variables (predictors) and predictand variable via covariate matrix, it cannot characterize the nonlinear or tail dependence existed in variables (Hao et al., 2016). Fortunately, vine copulas (also known as pair copula constructions; here, canonical vine (C-vine) copulas, a sub-classes of vine copulas, is of primary interest) are capable of bridging this gap. C-vine copulas can flexibly combine multiple variables via bivariate copula to characterize numerous or complex dependencies. However, only few have applied vine copulas for drought forecasts (Wu et al., 2021). Therefore, investigations on drought forecasting skills between C-vine copulas and MG models are an implication to obtain reliable drought forecasts.

***c)* What are the problems, and how these models addresses the problems?**

The problem is that under using the same explanatory variables (i.e., antecedent meteorological drought and agricultural drought persistence) situations, C-vine copulas model whether improving the forecasting performance of agricultural drought by comparing with that MG model. To address this problem, we compared the forecasting ability between 3C-vine copulas and MG models for the spatial patterns of selected typical agricultural drought (i.e., August in 2018) under 1–3-month lead times. Moreover, the performance metrics, e.g., NSE, R^2, and RMSE, are used to evaluate the forecast skill between 3C-vine copulas and MG models for agricultural drought.

(2) *Data are not described, for example what are the data characteristics, what are the data that are used for the estimations and validations.*

Response: We thank the reviewer for this comment. It will be further clarified in the next revised manuscript. The leave-one-out cross validation (LOOCV) (Wilks, 2014) is applied to forecast agricultural drought for each grid cell in August of every year during 1961–2018 based on the 3C-vine model or MG model, namely, each time one sample (or observation) was left for validation, and the rest were used to establish 3C-vine model or MG model and obtain the corresponding parameters of these models. In other words, this process was repeated 58 times (the length of years used in this study) for a specific grid cell.

(3) *To better understand, it is better to provide a flow chart of proposed method at the end of the materials and methods section.*

Response: We appreciate the reviewer's comment. As the reviewer points out, we will provide a flow chart (Figure R1) for the proposed method as follows.

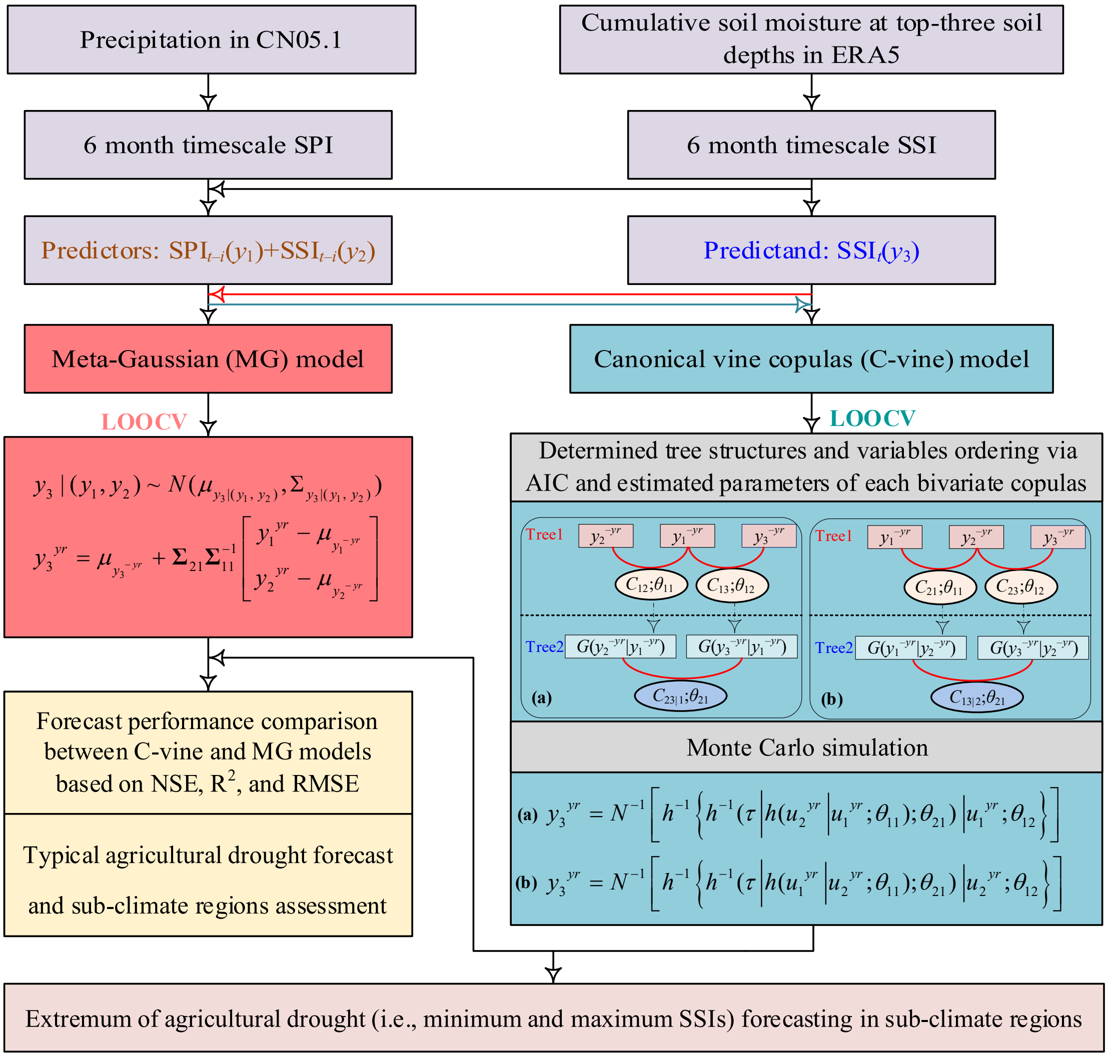

Figure R1 Flowchart of agricultural drought forecasting based on canonical vine copulas (3C-vine) and meta-Gaussian (MG) model under three-dimensional scenarios. Here, t denotes the target month (e.g., August), i signifies the lead times (1–3-months)), LOOCV is the abbreviate of leave-one-out cross validation, y_1^{-yr}(y_2^{-yr}) indicates series after removing a sample (y_1^{yr}(y_2^{yr})) for a specific year, and y_3^{yr} is the agricultural drought forecast value for the target month of a specific year. Note that the optimal tree structure (a or b on the right-hand side of this figure) is selected based on AIC to forecast agricultural drought.

(4) *The internal copulas of the C-vine not discussed in the first tree. Also, evaluation statistics on tree structure selection are not clear.*

Response: We sincerely appreciate the reviewer for these valuable comments. It will be clarified in the methodology section in the next revised manuscript. About the internal copulas used in the C-vine, we selected Gaussian (or Normal), Student-t, Clayton, and Frank, as well as their rotated (survival) forms (Dißmann et al., 2013; Liu et al., 2021) to obtain the optimal bivariate copula for each pairwise variables based on the Akaike information criterion (AIC). With the help of *CDVineCondFit* R function in "*CDVineCopulaConditional*" R package, based on the AIC, we selected the optimal tree structures (i.e., detected the suitable variable ordering; seen in Figure 2).

(5) *Last but not least, in Figure 4, the NSE values are between -0.2 to 0.2, is this acceptable?*

Response: We thank the reviewer for this important comment. We found that the description in Lines 257–259 about NSE, R^2, and RMSE may be unclear. These statements will be further changed as follows:

"***Figures 4a–4i show the difference in NSE, R^2, and RMSE between 3C-vine model and MG model, i.e., $NSE_{3C–MG}$, $R^2_{3C–MG}$, and $RMSE_{3C–MG}$ under 1–3-month lead times for August, respectively***"

In Figure 4a–4c, we calculated the difference in *NSE* between 3C-vine model and MG model, i.e., $NSE_{3C–MG}$. Here, $NSE_{3C–MG}$ greater than 0 indicated the superior agricultural drought prediction ability of 3C-vine model over MG model, and vice versa. Therefore, the NSE values (i.e., $NSE_{3C–MG}$) are acceptable over the interval [–0.2, 0.2].

References

Dißmann, J., Brechmann, E. C., Czado, C., and Kurowicka, D.: Selecting and estimating regular vine copulae and application to financial returns, Comput. Stat. Data Anal., 59, 52–69, https://doi.org/10.1016/j.csda.2012.08.010, 2013.

Hao, Z., Hao, F., Singh, V. P., Sun, A. Y., and Xia, Y.: Probabilistic prediction of hydrologic drought using a conditional probability approach based on the meta-Gaussian model, J. Hydrol., 542, 772–780, https://doi.org/10.1016/j.jhydrol.2016.09.048, 2016.

Liu, Z., Xie, Y., Cheng, L., Lin, K., Tu, X., and Chen, X.: Stability of spatial dependence structure of extreme precipitation and the concurrent risk over a nested basin, J. Hydrol., 602, 126766, https://doi.org/10.1016/j.jhydrol.2021.126766, 2021.

Wilks, D. S.: Statistical methods in the atmospheric sciences, Academic Press, 2014.

Wu, H., Su, X., Singh, V. P., Feng, K., and Niu, J.: Agricultural drought prediction based on conditional distributions of vine copulas, Water Resour. Res., 57, e2021WR029562, https://doi. org/10.1029/2021WR029562, 2021.