This paper presents an innovative hybrid model combining VMD, Informer, and LSTM for daily drought prediction in the Huaihe River Basin. The methodological approach is innovative, integrating signal decomposition with advanced deep learning architectures for drought prediction. However, the manuscript has several critical issues related to experiment design, methodological justification, and interpretation of results, which must be addressed before it can be considered for publication.

1.The study is fundamentally built on the DEDI index, derived from ERA5 reanalysis-based actual evapotranspiration (AET). This choice introduces a significant, and largely unacknowledged, source of bias and uncertainty. The ERA5 model, like most land surface models, does not explicitly represent irrigation, a dominant human activity in the agriculturally intensive Huaihe River Basin. This omission likely leads to a systematic overestimation of drought severity during growing seasons.

Reply: Thank you for your valuable comments. Regarding the issue you raised about the ERA5 data not explicitly considering irrigation, we understand the limitations of this data, particularly in agricultural regions like the Huaihe River Basin, where the impact of irrigation on soil moisture and drought conditions is crucial. However, we chose to use ERA5 data primarily due to its high spatio-temporal resolution and the availability of long-term time series data, which makes it highly suitable for climate-driven drought analysis.

In fact, several studies have demonstrated the effectiveness of the ERA5 and ERA5-Land datasets in regions such as the Huaihe River Basin. For example, (Gao et al., 2023) studied the distribution characteristics of cloud water resources (CWRs) using ERA5 data in the Huaihe River Basin and effectively assessed the relationship between water vapor distribution and climate change in the region using this high-resolution reanalysis data. Their research shows that ERA5 data provides an effective description of the hydrometeorological processes in the region, which has been validated and proven to be applicable to regional drought and water resources studies. (Liu et al., 2025) analyzed the recovery characteristics of agricultural drought in the Huaihe River Basin using ERA5-Land data, evaluating drought recovery time and water demand using soil moisture index (SWDI) and precipitation index (WAPI). They noted that ERA5-Land soil moisture data showed significant accuracy in agricultural drought assessment, further proving the effectiveness of ERA5-Land data in spatial and temporal distribution and prediction during the drought recovery phase. Even without irrigation data, ERA5-Land was able to capture the dynamic changes in regional drought. (Zhang et al., 2021)utilized ERA5-Land data and the standardized soil moisture index (SWDI) to assess agricultural drought in four provinces of southern China. The results showed that the dataset efficiently evaluated soil moisture deficits and accurately reflected drought intensity and extent. These studies collectively demonstrate that ERA5 data has high accuracy and reliability in analyzing regionally climate-driven droughts.

Gao, J., Feng, J., Cao, Y., & Zheng, X. (2023). Evaluation of Cloud Water Resources in the Huaihe River Basin Based on ERA5 Data. *ATMOSPHERE*, *14*(8), 1253. https://doi.org/10.3390/atmos14081253

Liu, J., Zhu, Y., Horton, R., Lü, H., Ahmed, N., Fu, Y., Xu, Y., Chen, T., & Yao, Y. (2025). Agricultural drought recovery characteristics and water requirement for rapid drought recovery in the Huai River Basin, China. *Journal of Hydrology: Regional Studies*, *59*, 102396. https://doi.org/10.1016/j.ejrh.2025.102396

Zhang, R., Lu, L., Ye, Z., Huang, F., Li, J., Wei, L., Mao, T., Xiong, Z., & Wei, S. (2021). Assessment of Agricultural Drought Using Soil Water Deficit Index Based on ERA5-Land Soil Moisture Data in Four Southern Provinces of China. *AGRICULTURE-BASEL*, *11*(5), 411. https://doi.org/10.3390/agriculture11050411

Zhang, X., Duan, Y., Duan, J., Chen, L., Jian, D., Lv, M., Yang, Q., & Ma, Z. (2022). A daily drought index-based regional drought forecasting using the Global Forecast System model outputs over China. *ATMOSPHERIC RESEARCH*, *273*, 106166. https://doi.org/10.1016/j.atmosres.2022.106166

2.The most severe shortcoming is the complete absence of validation against independent observational data.The entire modeling pipeline—from DEDI calculation to model training and evaluation—operates within the only ERA5 reanalysis. There is no validation against independent observational data (e.g., in-situ soil moisture, streamflow, reservoir levels, or satellite-based drought indices like SMAP soil moisture or GRACE terrestrial water storage). Consequently, the reported high performance may indicate skillful fitting to the internal structures of the reanalysis product rather than a predictive capability for real-world drought events.

Reply: Thank you for your valuable comments. We acknowledge that modeling and evaluation based solely on a single reanalysis data source (ERA5) indeed limits the model's direct validation ability for real drought processes. This limitation has been clearly identified as one of the important constraints of this study in the discussion section of the revised manuscript.

In this study, ERA5 reanalysis data was chosen primarily for its comprehensive advantages in temporal continuity, spatial consistency, and multi-meteorological variable synergy. ERA5 has been widely used in global and regional hydrometeorological studies and has demonstrated good stability and reliability for key variables such as evapotranspiration, precipitation, and soil moisture. As a result, it is often used as the data foundation for constructing regional drought indices and methodological studies. In global-scale studies, Xu et al. (2024) used ERA5 data for global-scale drought prediction, demonstrating that ERA5 data can effectively predict drought events worldwide. Filipović et al. (2021) constructed a regional soil moisture prediction system using ERA5 data and drought predictions through the LSTM model, proving ERA5's independent application capability in local drought forecasting. Gupta et al. (2024) proposed a deep learning model based on ERA5 data for global drought prediction, highlighting the potential and value of ERA5 data in global drought forecasting.

In a regional study, Gao et al. (2023) conducted a spatiotemporal analysis of cloud water resources in the Huaihe River Basin using ERA5 data, showing that ERA5 can effectively capture variations in cloud water resources, providing reliable data support for water resource management and drought prediction in the region. Zhang et al. (2021) used ERA5-Land data to construct a Soil Moisture Deficit Index (SWDI) for evaluating agricultural drought in the Huaihe River Basin, and through comparison with other data sources, validated the applicability of ERA5-Land data to drought analysis for the region. Additionally, Li et al. (2025) modelled hydrological drought in the Huaihe River Basin using ERA5 data, and the study demonstrated that ERA5 data can effectively predict drought events in the region, proving its applicability.

Therefore, we will clearly state in the discussion section of the revised manuscript that future research will combine ground observational data and multi-source remote sensing/reanalysis products to further systematically test the model's practical applicability, uncertainty, and cross-dataset generalization capabilities.

Xu, L., Zhang, X., Wu, T., Yu, H., Du, W., & Chen, N. (2024). Global prediction of flash drought using machine learning. Geophysical Research Letters, 51(21). https://doi.org/10.1029/2024GL111134.

Filipović, N., Brdar, S., Mimić, G., Marko, O., & Crnojević, V. (2021). Regional soil moisture prediction system based on Long Short-Term Memory network. Biosystems Engineering. https://doi.org/10.1016/j.biosystemseng.2021.11.019

Gupta, B. B., Gaurav, A., Attar, R. W., Arya, V., Bansal, S., Alhomoud, A., & Chui, K. T. (2024). Advance drought prediction through rainfall forecasting with hybrid deep learning model. SCIENTIFIC REPORTS, 14(1), 30459. https://doi.org/10.1038/s41598-024-80099-6

Zhang, R., Lu, L., Ye, Z., Huang, F., Li, J., Wei, L., Mao, T., Xiong, Z., & Wei, S. (2021). Assessment of Agricultural Drought Using Soil Water Deficit Index Based on ERA5-

Land Soil Moisture Data in Four Southern Provinces of China. AGRICULTURE-BASEL, 11(5), 411. https://doi.org/10.3390/agriculture11050411

Li, M., Yao, Y., Feng, Z., and Ou, M.: Hydrological drought prediction and its influencing features analysis based on a machine learning model, Nat. Hazards Earth Syst. Sci., 25, 4299–4316, https://doi.org/10.5194/nhess-25-4299-2025, 2025.

Gao, J., Feng, J., Cao, Y., & Zheng, X. (2023). Evaluation of Cloud Water Resources in the Huaihe River Basin Based on ERA5 Data. ATMOSPHERE, 14(8), 1253. https://doi.org/10.3390/atmos14081253

3.The paper reports predictive skill at lead times (up to 180 days) that far exceed the theoretical limit of deterministic weather prediction (~2 weeks), yet fails to provide a coherent physical rationale. It is unclear what physical memory mechanisms the model is leveraging for predictions at 30-180 days. Is it capturing real hydrological memory (e.g., from deep soil moisture, groundwater) or merely fitting to statistical autocorrelation and the annual cycle?

Reply: Thank you for your valuable comments. Regarding the issue of 180-day forecasting capability, we believe that the model's forecasting ability does not fall under deterministic weather forecasting. The model's predictive power arises from the time accumulation characteristics of the drought process itself and the extraction of multi-time-scale information. Existing studies (such as the VMD-CNNBiLSTM framework) have shown that drought index sequences can be decomposed into different frequency components using variational mode decomposition, where the low-frequency components represent slow changes and the drought background state has strong temporal memory. Based on this, deep learning models mainly learn the continuity and evolution trends of drought states rather than specific meteorological events. Therefore, the model's forecasting ability on medium- to long-term scales is more akin to "drought state prediction" rather than traditional weather forecasting.

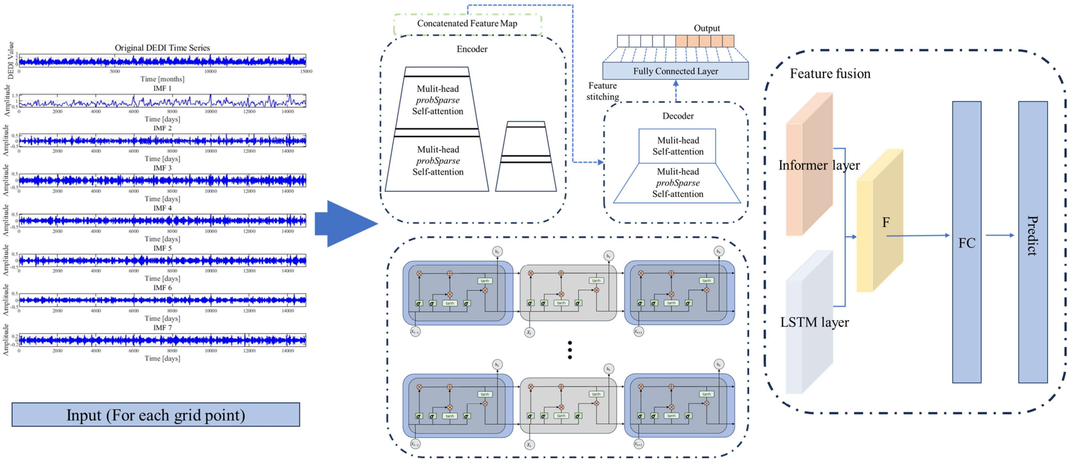
Su, T., Liu, D., Cui, X., Dou, X., Lei, B., Cheng, X., Yuan, M., & Chen, R. (2024). Prediction of DEDI index for meteorological drought with the VMD-CBiLSTM hybrid model. JOURNAL OF HYDROLOGY, 641, 131805. https://doi.org/10.1016/j.jhydrol.2024.131805

4.The critical parameters for VMD—the number of modes (K) and the penalty factor (α)—are not justified. How were they determined (e.g., using center frequency observations, energy loss ratio)? Their arbitrary selection affects all subsequent analysis. The architecture of the "dual-branch parallel" Informer-LSTM fusion is described only at a high level. How exactly are the outputs from the Informer (global trends) and LSTM (local dynamics) combined (e.g., concatenation, weighted averaging)? A detailed diagram or formula is needed.

Reply: Thank you for your valuable comments. We appreciate the reviewer's attention to the choice of VMD parameters. Regarding the selection of key parameters in variational mode decomposition (VMD), the penalty coefficient α and the number of modes K were not arbitrarily set, but rather determined by referring to existing mature studies and considering the characteristics of the data in this study.

In this study, the penalty coefficient α (bandwidth constraint parameter) was empirically chosen based on the length of the time series. Its value range was set to 1.5–2.0 times the sample length, and the final value of 1.75 times the sample length was selected as the consistent parameter for this study. This setting aims to balance frequency band separation ability and mode stability. The penalty coefficient α controls the bandwidth of each mode: when α is small, the bandwidth of each IMF component is large, which may cause spectral overlap between different modes, leading to some IMF components containing signals from other components and weakening the physical interpretability of mode decomposition. On the other hand, when α is too large, the bandwidth is overly compressed, making the decomposition results more sensitive to noise. Additionally, the number of modes K (i.e., the number of IMF components) was determined based on the frequency distribution characteristics of the decomposed signals. In this study, K was uniformly set to 7 to ensure that the main frequency information of the original DEDI sequence could be fully decomposed and retained, while avoiding the redundancy caused by excessive decomposition. This parameter combination demonstrated stable decomposition effects and predictive performance in preliminary experiments with multiple representative grid points.

We also used a parallel approach with Informer and LSTM. By using two parallel branches, the model is able to perform information extraction and processing: the Informer branch handles global temporal patterns and is effective at processing long time-series data, while the LSTM branch handles local temporal patterns, capturing short-term dependencies and dynamic changes in sequence data. The feature vectors from both the Informer and LSTM branches are then concatenated along the feature dimension and input into a fully connected layer for nonlinear mapping and fusion. This fusion method allows the model to leverage both the global information extraction capability of Informer and the local temporal relationship modeling ability of LSTM.



The figure above shows the parallel operation of the Informer and LSTM branches, without any formulas.

Su, T., Liu, D., Cui, X., Dou, X., Lei, B., Cheng, X., Yuan, M., & Chen, R. (2024). Prediction of DEDI index for meteorological drought with the VMD-CBiLSTM h ybrid model. JOURNAL OF HYDROLOGY, 641, 131805. https://doi.org/10.1016/j.jhydrol.2024.131805

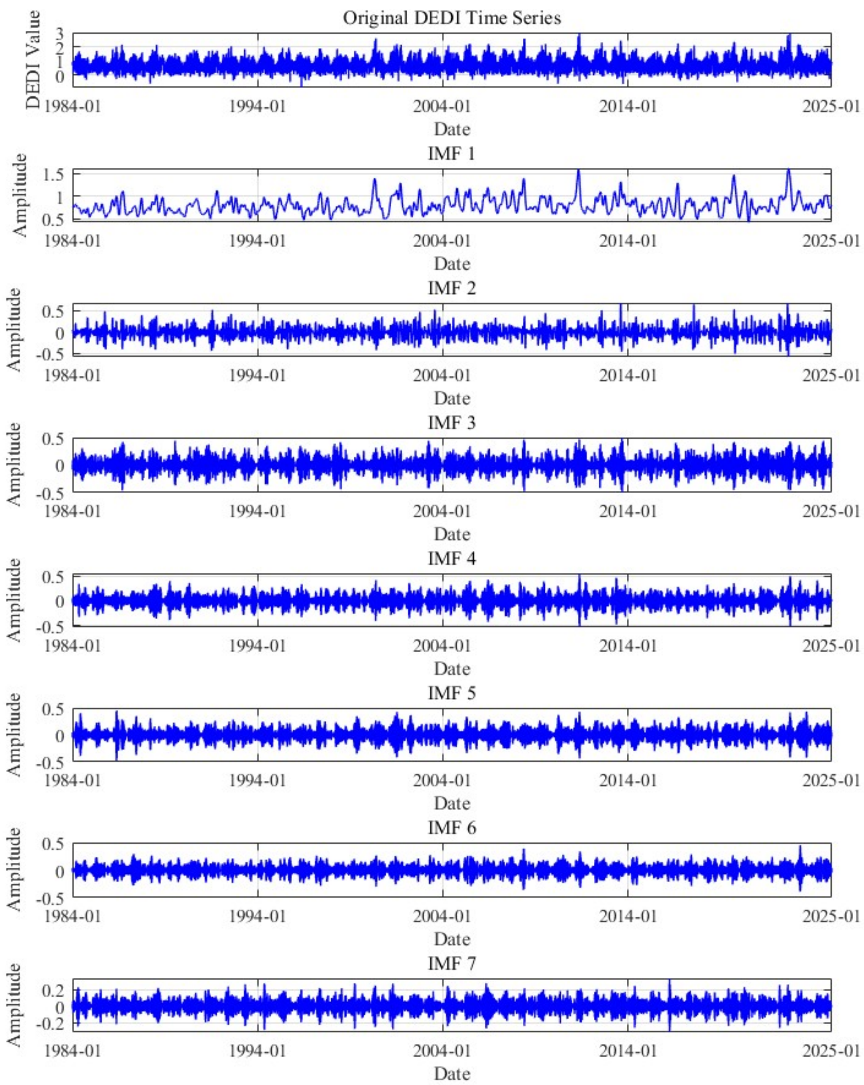
5. The current discussion is primarily a restatement of results.It must be expanded to include:Strengths of the proposed approach,Limitations and Weaknesses and A clearer illustration of the forecast value and potential applications.

Reply: Thank you for your valuable comments. We realize that the discussion section currently mainly repeats the results, lacking a clear explanation of the advantages, limitations, forecasting value, and potential applications of the method. During the revision process, we expanded the discussion section to include the following: 1. Elucidation of the advantages of the proposed method, highlighting its innovation and effectiveness in drought forecasting. Specifically, the VMD-Informer-LSTM framework and the "decomposition-parallel modeling-feature fusion" strategy show significant advantages for drought prediction. Specifically, VMD effectively reduces the complexity of the original sequence, allowing the separation and individual modeling of features across different time scales; the parallel structure of Informer and LSTM focuses on modeling long-term background state changes and short-term fluctuations, allowing the model to capture both the continuity of the drought process and its stage-specific fluctuations. 2. Discussion of the limitations and weaknesses of the method. Specifically, (1) The current framework is based solely on the ERA5 reanalysis data and does not incorporate independent ground observation data or multi-source remote sensing data for external validation. (2) The model currently uses one-dimensional time series at each grid point as the modeling object and does not explicitly capture the spatial propagation of drought nor systematically assess prediction uncertainty. 3. Forecasting value, potential applications, and future research directions. Specifically, the framework proposed in this paper has potential application value in analyzing drought evolution trends. This method could provide a reference for medium- and long-term regulation and risk prediction of water resources at the basin scale, especially in predicting medium- and long-term drought states, which has significant theoretical and practical value. Future work will further incorporate multi-source observation data and develop spatiotemporal coupling and uncertainty modeling methods to improve the model's practical applicability and reliability.

Specific Comments

（1）Figure 5: The x-axis label should be changed from "Time" or sample number to a standard calendar date format (e.g., YYYY-MM or YYYY).

Reply: Thank you for your valuable comments. We have made revisions to Figure 5 based on your feedback. The original x-axis, which was labeled with "Time" or sample numbers, has been uniformly replaced with a standard calendar time format (e.g., YYYY-MM) to make the figure more intuitive and standardized. The relevant changes are reflected in the revised manuscript in Figure 5 and in its corresponding description.



（2）Figure 7 and 8: As noted, these figures convey largely redundant information (scatter plots and line charts of the same 180-day predictions). Consider consolidating them into a single, more informative multi-panel figure or moving one to the supplementary material.

Reply: Thank you for your valuable comments. We agree that there is some redundancy in the information presented in Figure 7 and Figure 8. Based on your suggestion, we have made adjustments to the figures. Figure 7 has been moved to the supplementary materials to avoid redundancy in the main text, while retaining the necessary comparative information. In the revised manuscript, the main results figures are kept in the main text, and the corresponding supplementary figures are provided in the supplementary materials.

（3）Ensure all figure captions are descriptive and consistent, following the format of Figs. 1, 5, etc.

Reply: Thank you for your valuable comments. We have systematically reviewed and revised the captions for all figures in the manuscript. The format of the captions has been unified, and necessary explanatory information has been added to ensure consistency in both description and style with Figure 1, Figure 5, and others. These revisions have been completed in the revised manuscript.