Re: Manuscript #hess-2024-118 entitled “Exploring the Potential Processes Controls for Changes of Precipitation-Runoff Relationships in Non-stationary Environments”.
RC1: 'Comment on hess-2024-118', Anonymous Referee #1

The topic “Exploring the Potential Processes Controls for Changes of Precipitation-Runoff Relationships in Non-stationary Environments” is valuable for hydrology. But this paper reads like a case study. The impacts of the study for the general hydrology and its novelty are not clear. The three main objectives of this study are developing an integrated framework, proposing a novel driving index for changes in DPRR, and establishing a holistic conceptual model. But developed the framework, driving index and conceptual model are also not clear and seem not innovative enough.

Reply: Thank you once again for affirming the value of this research in the field of hydrology. Regarding the **applicability** of this study, although we used the Wei River Basin, which is experiencing intensive anthropogenic activities and climate change as an example to demonstrate the proposed general framework, the general applicability of this study will emphasize in the *Discussion* and *Conclusion*.

Regarding the **innovation** of the main objectives of this study, the **first innovative point** is the proposal of a novel Driving Index for Changes in Precipitation-Runoff Relationships (DPRR) to quantify the driving levels and directions of factors influencing precipitation-runoff links. This index primarily addresses the limitations of traditional indices or models that assume stationary conditions for assessing precipitation-runoff relationships in catchments exhibiting non-stationary behaviors. The **second innovative point** is the development of an integrated framework based on the proposed index, designed to explore the potential process controls on changes in precipitation-runoff relationships in non-stationary environments. The framework systematically includes detecting non-stationary processes, quantifying changes in PRR, assessing the driving levels and directions of potential influencing factors, analyzing hydrological responses to the temporal dynamics of driving factors, quantifying the nonlinear and intricate interplay among driving factors, and considering other anthropogenic influences such as large-scale surface water withdrawals from reservoirs and total water usage in the basin, including agricultural, industrial, and domestic sectors. The **third innovative point**, based on the aforementioned assessment results, is establishing a holistic conceptual model of catchment response to infer the potential processes controlling changes in precipitation-runoff relationships, which guides regional water use and resource allocation.

Detail comments:

1) To the best of my knowledge, the response of runoff to rainfall is non-linear, especially in the semi-arid regions, where infiltration excess runoff is dominant and the amount of runoff is sensitive to rainfall intensity. Rainfall as a major factor influencing the runoff coefficient should be considered, besides potential evapotranspiration.

Reply: We agree with the reviewer that the response of runoff to rainfall is non-linear and that precipitation is the most crucial factor in runoff generation. Given the importance of precipitation, we have used it as the input variable for our proposed Driving Index for Changes in Precipitation-Runoff Relationships (DPRR). Other factors are primarily used to explore their driving effects on the precipitation-runoff relationship.

2) In terms of anthropogenic activities, the constructions of check dams and reservoirs may be the more dominant factor influencing the runoff generation and the precipitation-runoff relationships in the region compared to ISR, NTL and POP.

Reply: We agree with the reviewer's viewpoint that the construction of check dams and reservoirs may be the dominant factor influencing precipitation-runoff relationships. This study quantitatively investigated the impacts of reservoirs and various types of water usage (agricultural, industrial, and domestic) on precipitation-runoff relationships in *Section 4.5.2*. However, the collection of data for reservoirs and different types of water use in some catchments presented challenges, and some regions may not be influenced by reservoirs or dams. Additionally, acquiring long-term, continuous data on anthropogenic activities presents significant challenges. Remote sensing has proven to be an essential tool for identifying and assessing the temporal and spatial distributions of anthropogenic activities (An et al., 2024). Considering the study's applicability across various types of catchments, this study also uses various types of remote sensing data, including Impervious Surface Ratio (ISR) data, Night-Time Light (NTL) data, and Population (POP) data to comprehensively collect data on anthropogenic activities.

3) Vegetation dynamics are affected by both climate and afforestation, and how to distinguish them or consider their relationship with other factors?

Reply: We selected vegetation dynamics as a distinct control factor to explore its impact on PRR, primarily referencing the study by Fowler et al. (2022). In addition, the influence of climate change and human activities on vegetation dynamics, and consequently on the PRR, is highly complex. Therefore, we explore the impacts of climate forcing, anthropogenic influences, and vegetation dynamics on PRR, respectively.

4) Lines 96-97. What does the driving level and direction refer to?

Reply: Within a specified period, the driving level of DPRR signifies the influence level exerted by a particular factor on the correlation between precipitation and runoff during the period, and the driving direction of DPRR signifies whether a particular factor has positive or negative effects on the PRR during the period.

5) Figure 1-2. These sub-figures for each basin in Fig 1 and Fig 2(b) can be removed.

Reply: The sub-figures for each basin in Figure 1 have been removed to simplify the presentation of the study area. However, we have better explained the content of Figure 2b, which is "Visual synthesis of selected process explanations for potential driving mechanisms of the changes in PRR under non-stationary processes depicting a general catchment affected by anthropogenic interference," and there are no "sub-figures for each basin".

6) Figure 3. It is inappropriate to put tables and graphs together in a figure.

Reply: The table highlights the significant variation characteristics shown in Figure 3. The table and graphs will be separated.

7) 302-315. The heat map in Fig 4b is hard to understand and more detail is needed to explain. What's the relationship among these sub-figures. It seems inappropriate to put these in a figure.

Reply: The five sub-figures in Figure 4b correspond to the PRR results of the five basins. The content of the figures shows the PRR at various periods and time scales in each basin, that is, the DCCA values at various periods and time scales in each basin. The relevant content will be supplemented in the explanation of Figure 4b.

References

Fowler, K., Peel, M., Saft, M., Peterson, T. J., Western, A., Band, L., Petheram, C., Dharmadi, S., Tan, K. S., Zhang, L., Lane, P., Kiem, A., Marshall, L., Griebel, A., Medlyn, B. E., Ryu, D., Bonotto, G., Wasko, C., Ukkola, A., Stephens, C., Frost, A., Gardiya Weligamage, H., Saco, P., Zheng, H., Chiew, F., Daly, E., Walker, G., Vervoort, R. W., Hughes, J., Trotter, L., Neal, B., Cartwright, I., and Nathan, R.: Explaining changes in rainfall-runoff relationships during and after Australia's Millennium Drought: a community perspective, Hydrol. Earth Syst. Sci., 26, 6073-6120, 10.5194/hess-26-6073-2022, 2022.