We would like to express our sincere gratitude to the reviewer. Your rigorous review and valuable suggestions have played a crucial role in enhancing the academic quality of this manuscript. Each of your suggestions has prompted us to re-examine the logic, methodology and presentation of our conclusions, resulting in a more rigorous argument and clearer exposition. We would like to express our sincere gratitude for the time and effort you have devoted to this paper, and for your recognition of and encouragement regarding the value of this research.

Major Concerns

(1) The Introduction states that plant access to bedrock fissure water is influenced by bedrock weathering degree, fissure density, and fissure depth. The author also repeatedly emphasizes the regulation effect of the interactions between root distribution and rock fissure on root-zone water recharge and transpiration water age. However, the manuscript provides neither root distribution data for the studied species nor structural parameters of the weathered bedrock. More importantly, there is no statistical analysis testing interaction or regulation effects, making the claimed "interaction" unsupported. Consequently, the results are seriously disconnected from the Introduction. In addition, the two stated scientific hypotheses appear problematic: for hypothesis (i), plant root water uptake is a consumption term of the root zone water, and should not be framed as a key process controlling root-zone recharge; for hypothesis (ii), testing this hypothesis is unnecessary because the root-zone recharge ratio (β) is a key parameter used to calculate transpiration water age, and therefore is inherently expected to be a dominant driver.

Reply: Thank you very much for your thorough review and valuable suggestions. These comments hit the mark and helped us recognize the significant shortcomings of the original manuscript in terms of data support, statistical validation, and logical framework. We have reflected deeply on these issues and developed a comprehensive revision plan.

First, we fully agree that demonstrating the "root–fissure interaction" requires direct observational data on root distribution and structural parameters of the fissure network. The original manuscript did indeed present these critical pieces of information inadequately, reducing "interaction" to a verbal statement. To address this, we have supplemented the following content in the revised manuscript. In the revision, we will add data on the vertical distribution depth of roots within rock fissures, as well as structural parameters of the rock fissures. Currently, we have carried out corresponding work by conducting vertical drilling near the target plants in the study area until no more roots were visible. Simultaneously, we investigated the distribution and aperture of fissures in the vertical boreholes using minirhizotron equipment, thereby enhancing the data support of the manuscript.

Second, prompted by your reminder, we also realized that the "interaction" was not reflected in the text, and the existing data could not adequately substantiate it. Therefore, we have uniformly revised the "scientific hypotheses" throughout the manuscript to "research objectives" and modified the specific statement of these objectives accordingly. They are as follows: (i) How does rock fissure water regulate the dynamics of root-zone water replenishment in plants with different rooting depths within the epikarst? (ii) How does the seasonal variation in root-zone water replenishment further influence plant transpiration water age? If this is still inappropriate, we will make further corrections.

Figure S1: Vertical drilling and installation of micro-root tubes near target plants in the study area.

(2) The study treats bedrock fissure water as a plant water source. However, based on the sampling distribution shown in Fig. 2b, plant sampling sites and fissure-water sampling sites are far apart. From the map scale, the farthest fissure-water site appears to be more than 1 km from the plant sampling locations. Given the likely horizontal spatial heterogeneity in fissure-water isotopes, this design can lead to a serious mismatch between plant water and fissure water, making the inferred plant water source contributions unreliable.

Reply: Thank you very much for raising this critical methodological concern. This issue directly pertains to the reliability of the core conclusions of our study, and we have made revisions accordingly.

In the karst critical zone, we consider that fissure water does not exist as "static water" isolated within individual fissures, but rather as a continuous water body with certain mixing characteristics, interconnected through the fissure network. Particularly in areas such as our study site, where vertical fissures are densely developed, the fissure network constitutes a relatively connected subsurface water storage system. After precipitation infiltrates, it moves downward along vertical fissures under gravity and mixes at fissure intersections, resulting in a certain degree of spatial homogeneity in the isotopic composition of fissure water within the same hydrological unit.

At the same time, the direct collection of rock fissure water presents significant technical challenges. In this study, we collected a total of 36 fissure water samples (Fig. 2b), with their spatial distribution mainly concentrated within the study plot area. Only two rock fissure water sampling points were relatively far from the plots (approximately 1.2 km), but they were located on the same hillslope as the plots. Our primary objective was to capture the overall isotopic characteristics of rock fissure water by using as many sampling points as possible to avoid the spatial heterogeneity inherent in karst regions.

More importantly, the δ^2H of rock fissure water ranged from –75.5‰ to –56.4‰, a range far narrower than that of soil water. This indicates that, despite the wide spatial distribution of sampling points, the isotopic composition of rock fissure water exhibits good statistical stability. The xylem water isotopic values of plants (δ^2H of deep-rooted plants in the dry season: –59.7‰ to –52.9‰) fell exactly within this range, suggesting that plants depend on rock fissure water.

Finally, we acknowledge that the current sampling design is not optimal and has certain limitations. In future work, we will further optimize the sampling scheme to minimize these shortcomings.

(3) The appendix provides sap flow data, yet the Methods lack any description of sap-flow measurement and processing. Moreover, the study includes four plant species, but sap flow is reported for only one species. The appendix also includes MixSIAR-based source contribution results, but the manuscript does not describe model settings, nor does it explain how isotopic data from different sources were aggregated for model input. In addition, Fig. 2c shows the eddy-covariance tower and the caption mentions evapotranspiration measurements, but the manuscript does not present corresponding results. Finally, Fig. 9 uses ERT inversion to characterize soil and bedrock water storage; however, the Methods do not specify which of the four survey line correspond to which locations on the sampling map, nor how the two survey lines per plot were selected (what criteria or principle guided the survey line layout).

Reply: Thank you for your suggestion. This was indeed a significant omission in the methodological description of the original manuscript. We will systematically supplement these experimental protocol gaps. Once again, we appreciate your reminder, and we believe that the revised manuscript will show significant improvements in both the completeness of methodological descriptions and the consistency of data presentation.

For example: To investigate the subsurface moisture distribution in plant root zones, this study employed Electrical Resistivity Tomography (ERT) to conduct two-dimensional profile imaging of typical sample plots. ERT measurements were performed using the ABEM Terrameter LS2 system (ABEM, Sweden), with 32 electrodes deployed along each survey line at an electrode spacing of 1.0 m, achieving an exploration depth of approximately 8 m. The acquired ERT data were processed using the open-source resistivity inversion software ResIPy, developed by Professor Andrew Binley's team at Lancaster University (Blanchy et al., 2020). ResIPy enables accurate inversion and interpretation of resistivity data, revealing moisture distribution within the rhizosphere zone. In two typical sample plots within the study area, two survey lines were established in each plot, traversing the root zones of deep-rooted tree species (*Ailanthus altissima*, *Juglans regia*, *Koelreuteria paniculata*) and shallow-rooted tree species (*Zanthoxylum bungeanum*, *Eriobotrya japonica*, *Broussonetia papyrifera*), respectively (detailed information on the relevant plants can be found in Table A1). The survey lines were oriented perpendicular to the topographic contours to ensure they traversed the plant root zones and extended to both sides to cover the potential water uptake range.

(4) There is no dedicated "Statistical analysis" subsection in the Methods, and the Results largely read as a compilation of observations. For both root-zone recharge ratio and transpiration water age, the manuscript does not conduct significance tests among species, nor does it analyze how these parameters respond to environmental drivers—therefore the subsequent Discussion is not well supported. Additionally, the current PIB modeling framework considers only precipitation and plant xylem water as end-members, while treating soil as a "black box." This creates a key logical gap: parameters with strong vertical heterogeneity (e.g., root distribution, soil water storage, and fissure-water occurrence) may be spatially mismatched with the estimated root-zone recharge ratio and transpiration water age. The authors must clarify and justify this issue explicitly in the Methods.

Reply: Thank you very much for raising this critical issue. We fully agree that the original manuscript lacked a systematic statistical analysis framework, which limited the presentation of results to a descriptive level and failed to provide statistical support for the mechanistic interpretations in the discussion section. To address this, we have supplemented the revised manuscript accordingly. At the same time, we will conduct significance tests for root-zone replenishment among different species, as well as analyses of the effects of root-zone replenishment and transpiration water age on environmental driving factors.

Unlike other relatively homogeneous ecosystems, karst regions possess a unique surface-subsurface dual hydrological structure. Due to shallow soils (with an average thickness of only 26 cm) and a rock outcrop rate as high as 70%, the water supply capacity of soil to plants is limited. Moreover, precipitation rapidly infiltrates through the densely developed fissure network, making it difficult for water to remain on the surface for extended periods. The bedrock in the study area is predominantly dolomitic limestone, with strong dissolution and extensively developed fissure systems. Vertical drilling observations indicate that the subsurface space for plant growth is highly fragmented, and the fissure network not only provides physical pathways for root extension but also serves as a critical water source sustaining plant survival during the dry season.

However, while highlighting the important role of rock fissure water, we should not overlook the function of soil water in karst ecosystems. Although the soil layer is thin, it plays an irreplaceable role in temporarily retaining moisture during the initial stages of precipitation and in supplying water to shallow-rooted plants (such as *Zanthoxylum bungeanum* and *Eriobotrya japonica*). The methodological approach of this study (the PIB model), which primarily defines root-zone water storage as rock fissure water, represents an adaptive adjustment based on the analysis of plant water source contributions in the study area (Liu et al., 2025) and observations of root distribution. Therefore, we will systematically address the role of soil in the discussion section and explicitly point out the limitations of this methodology in Section 4.3.

Namely: To test the differences in root-zone water replenishment and transpiration water age among plants with different rooting depths and across seasons, a one-way analysis of variance (ANOVA) was used for significance testing. This analysis was performed using IBM SPSS Statistics 26 (IBM Inc., Armonk, NY, USA) at a significance level of $p > 0.05$. In the text, "SD" stands for Standard Deviation, which is used to measure the dispersion of data relative to the mean. All charts and visualizations were generated using Origin 2021 (Origin Software Inc., Fairview, TX, USA).

Reference: Liu, X., Chen, X., Zhang, Z., Liu, W., Gao, F., Cheng, Q., Peng, T.: The role of rock fractures as a water source for trees growing in karst, Water Resour. Res, 61(11), e2024WR039588, 2025.

Other concerns

(1) Line 45: “However” is used as a transition, but there is no logical contrast between the two sentences.

Reply: We are very grateful for the reviewers’ suggestions and have made the necessary revisions.

Namely: As a crucial link connecting soil and the atmosphere, plant transpiration accounts for more than 60% of terrestrial evapotranspiration (Schlesinger and Jasechko, 2014), a substantial flux that primarily relies on the replenishment of root-zone soil water (Luo et al., 2023). The transport and residence time of root-zone water not only determine whether plants can utilize current precipitation or rely on stored "old water" in response to environmental changes, but also serve as a key to understanding the temporal dimension of plant water use.

(2) Fig. 5: Scatter points for different plant water sources and plant water overlap heavily, and no clear pattern is visible.

Reply: We are very grateful to the reviewer for this important comment. We have redrawn the figure to present it to readers as clearly as possible.

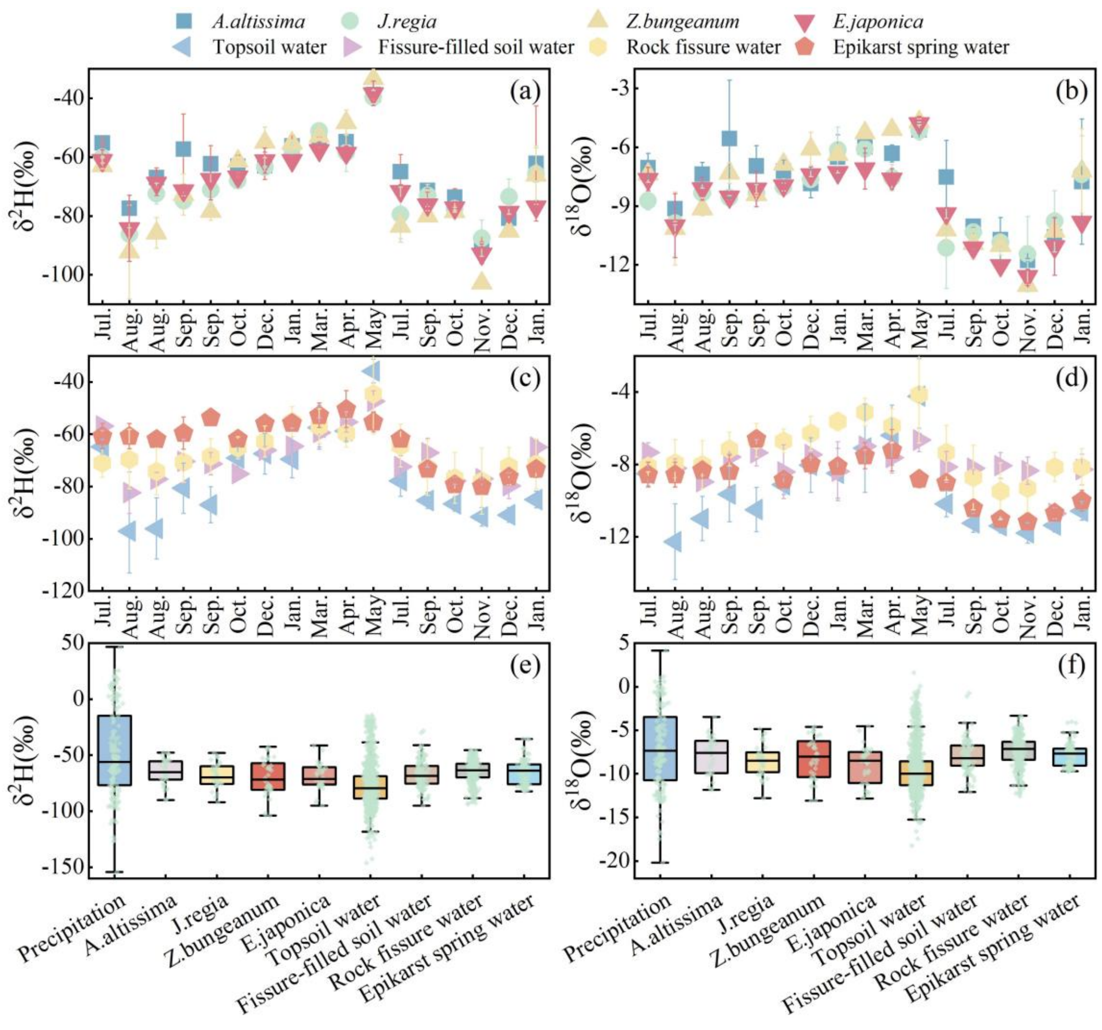

Figure 5. Seasonal variations in hydrogen and oxygen isotopes of different water sources. (a) and (b) show the distribution characteristics of xylem water δ^2H and $\delta^{18}O$

values for *Ailanthus altissima*, *Juglans regia*, *Zanthoxylum bungeanum*, and *Eriobotrya japonica* during the sampling period, respectively. (c) and (d) present the distribution characteristics of δ^2H and $\delta^{18}O$ values for soil water, fissure-filled soil water, rock fissure water, and epikarst spring water, respectively. (e) and (f) display the medians and data distributions of δ^2H and $\delta^{18}O$ for precipitation, plant xylem water, and potential water sources, respectively.

(3) Fig. 6: The soil moisture panel lacks a y-axis. Also, according to the Methods, soil-water data should be discrete, yet the figure shows continuous curves—what statistical basis supports this representation?

Reply: Thank you for bringing this to our attention. We have redrawn the diagram and apologise for any confusion caused by the unclear wording.

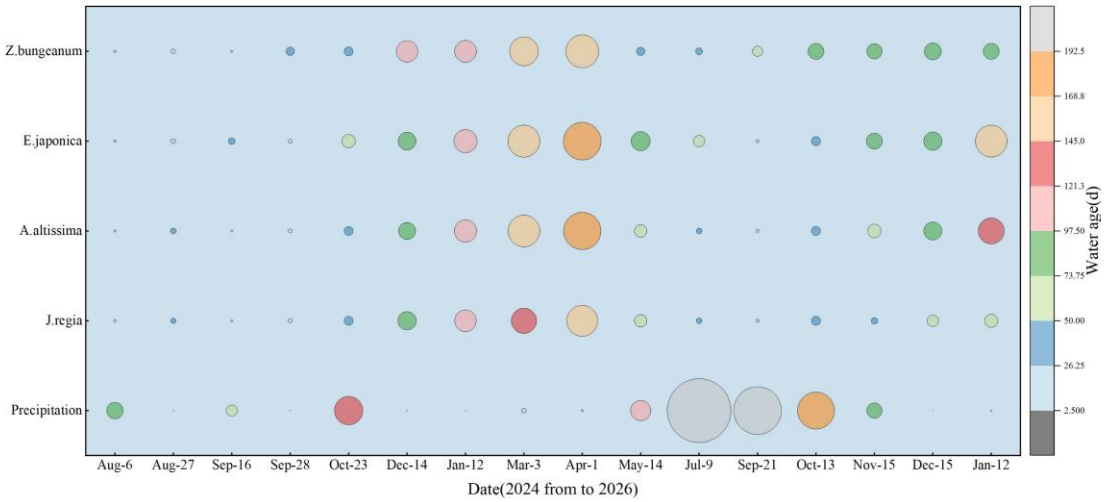

Figure 6. Root-zone water replenishment and cumulative precipitation for four plant species between two consecutive sampling events. Deep-rooted plants include *Ailanthus altissima* and *Juglans regia*; shallow-rooted plants include *Zanthoxylum bungeanum* and *Eriobotrya japonica*. Note: The soil water content line represents the average instantaneous soil water content of the four plant species at each sampling time.

(4) Fig. 8: A significance test is reported, but the specific test method is not stated.

Reply: Thank you for your question. We have added further details regarding the statistical methods below the figure captions.

Namely: Figure 8 Significance analysis of plant transpiration water age in different seasons. Shallow-rooted plants include *Zanthoxylum bungeanum* (Zb) and *Eriobotrya japonica* (Ej), while deep-rooted plants include *Juglans regia* (Jr) and *Ailanthus altissima* (Aa). Note: Different letters indicate significant differences at $p < 0.05$, while the same letter indicates no significant difference (one-way ANOVA).

(5) Line 501–502: Preferential flow is a concept developed for soils; applying "preferential flow" directly to fissure flow is questionable.

Reply: Thank you very much for raising this conceptual question. The concept of "preferential flow" indeed originated in soil physics, initially describing the rapid movement of water through preferential pathways such as macropores, cracks, and burrows, bypassing the soil matrix (Beven and Germann, 1982). Its core connotation is that the water movement velocity exhibits high spatial heterogeneity, with some flow paths transporting water much faster than the matrix flow. However, as research has progressed, the concept of preferential flow has transcended its initial soil context and has been widely applied to various porous and fractured media—including rock fractures, regolith fissures, and even karst conduit systems (Nimmo, 2012; Jarvis et al., 2016). In karst regions, due to the extensive development of fissures, preferential flow is even more common in these areas. At the same time, we will be careful with the wording to avoid ambiguity as much as possible.

Reference: Beven, K., Germann, P.: Macropores and water flow in soils, Water Resour. Res, 18(5), 1311-1325, 1982. Nimmo, J. R.: Preferential flow occurs in unsaturated conditions, Hydrol. Process, 26(5), 786-789, 2012. Jarvis, N., Koestel, J., Larsbo, M. (2016). Understanding preferential flow in the vadose zone: Recent advances and future prospects. Vadose Zone Journal, 15(12), 1-11.

(6) Line 503–504: Attributing $\beta = 0$ to low rainfall and high evapotranspiration lacks supporting evidence.

Reply: We are very grateful to the reviewer for this insightful comment. We will give further consideration to additional evidence regarding $\beta = 0$ during the dry season. We will conduct further literature reviews and data analyses to strengthen the robustness of this finding.

(7) Line 504–506: The manuscript does not quantify water age of water at different depths in the root zone; therefore, the claim that deep-rooted species can utilize “older water” is not supported by the presented analyses.

Reply: Thank you very much for this important comment. We have revised the manuscript, adjusting statements such as "deep-rooted plants utilize old water" that lack direct validation to more appropriate expressions aligned with the current evidence hierarchy. For example, the phrase "confirming that deep-rooted plants rely on old water" has been revised to "the transpiration water age of deep-rooted plants is significantly greater than that of shallow-rooted plants, and their roots are primarily distributed in deep fissure zones, indirectly suggesting that they may utilize water with longer residence times." Meanwhile, we will fully leverage existing data to enhance the reliability of our arguments. For instance, we will analyze the vertical isotopic gradients and seasonal variability of rock fissure water as indirect indicators of water residence time. Additionally, we will statistically quantify plant rooting depth and examine its correlation with transpiration water age to provide statistical support for this inference.