Title: The role of rock fractures on tree water use of water stored in bedrock: Mixing and residence times

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5   **MS type: Research article**

Reviewer 1:

Comments on egusphere-2025-3937

This study employs a combination of stable isotope tracing, the MixSIAR Bayesian mixing model, and
10   hydrometric observations to quantitatively analyze the spatiotemporal variations in tree water sources within karst regions, and to explore the role of rock fractures in tree utilization of bedrock-stored water. The research topic is of considerable scientific significance and shows a reasonable degree of originality, providing valuable insights into plant water-use strategies and ecohydrological coupling mechanisms under complex lithological conditions. Overall, the study presents a clear research framework and is
15   supported by adequate data; however, improvements are needed in the description of experimental details, the clarity of figure presentation, and the logical interpretation of results. I recommend a major revision before the manuscript can be considered for publication.

Response: We sincerely thank the reviewer for the careful and constructive evaluation of our manuscript. We appreciate the positive assessment of the scientific significance and originality of this work. We fully
20   agree that improvements are needed in the description of experimental details, figure clarity, and interpretation of results. Below, we respond point-by-point to all comments and clearly indicate how each issue will be addressed in the revised manuscript.

1. L130-133: It is recommended to present the sampling information in a table, including details such as
25   the number of samples and sampling frequency. In addition, the current description of different depths is rather vague.

Response: We thank the reviewer for this important suggestion. In the revised manuscript, detailed sampling information is now summarized in a series of tables. Specifically, Table A1 provides an overview of soil moisture monitoring and soil water sampling design, including site-specific sampling
30   depths, sampling frequency, and sampling periods for bulk soil water and mobile soil water. Additional tables (Tables A2 and A3) summarize the corresponding sampling design for rock water and tree xylem

water, respectively. The number of collected samples for each water compartment is reported in Tables B1–B4. In addition, the Methods section has been revised to replace the previous depth range description with explicit reference to predefined discrete sampling depths, thereby removing ambiguity in the description of soil depth.

Revised manuscript text: The method for collecting mobile soil water and bulk soil water samples at different depths involved two preparatory steps: (1) soil boreholes were manually drilled using a soil auger to predefined discrete depths at each study site.; (2) at selected depths, soil material was removed and ceramic tensiometer tips connected to suction lysimeters were installed for the collection of mobile soil water. The boreholes were then backfilled with the original soil to ensure proper contact and minimize disturbance. Bulk soil samples were collected at all predefined depths and bulk soil water was subsequently extracted from the collected soil samples using laboratory extraction methods. The site-specific sampling depths, sampling frequency, and sampling periods for bulk soil water and mobile soil water are summarized in Table A1.

Table A1. Summary of soil moisture monitoring and soil water sampling design across study sites.

Category		Soil moisture monitoring	Bulk soil water sampled	Mobile soil water sampled
Dates		Sep 2022–Jun 2025	Apr 2024–Mar 2025	Sep 2022–Nov 2024
Frequency		30 min	Dry season: once per month; rainy season: 1–2 times per month	Dry season: once per month; rainy season: 1–4 times per month
Depths at defferent sites (cm)	A	5, 20, 50, 100, 150	5, 20, 50, 70, 100, 150	50, 100
	B	5, 20, 50, 100, 180	5, 20, 50, 70, 100, 180	20, 50, 100, 180
	C & D	5, 20, 40, 50	5, 20, 30, 40, 50	20, 40, 50
	E	5, 30, 50, 100	5, 30, 50, 70, 100	30, 100

Table B1. Statistics of MRT and MTT (day) for mobile and bulk water in different soil layers.

Site	Depth (cm)	K_h (cm·h^{-1})	Average moisture content	Mobile soil water					Bulk soil water				
				MRT	MTT	Number of samples	R^2	Standard error	MRT	MTT	Number of samples	R^2	Standard error
A	5	3.83	0.153	-	-	-	-	-	36	6	16	0.75	19.08
	20	3.33	0.223	-	-	-	-	-	65	16	16	0.89	11.20
	50	2.33	0.264	72	15	68	0.56	18.15	139	26	16	0.67	8.48
	70	2.18	-	-	-	-	-	-	155	28	16	0.54	8.46
	100	1.96	0.133	74	31	36	0.83	11.77	138	32	16	0.64	9.96
B	5	0.58	0.212	-	-	-	-	-	49	10	16	0.80	11.74
	20	0.44	0.245	63	23	23	0.61	9.35	177	31	16	0.55	9.01
	50	0.16	0.241	459	34	38	0.52	2.09	471	73	16	0.50	9.00
	70	0.17	-	-	-	-	-	-	638	82	16	0.54	6.82
	100	0.18	0.125	244	43	40	0.54	5.34	685	47	16	0.50	5.41
	180	0.10	0.182	77	24	25	0.64	10.59	708	63	16	0.53	4.84
C&D	5	4.96	0.191	-	-	-	-	-	40	6	16	0.78	17.07
	20	1.04	0.261	85	25	51	0.68	12.28	60	12	16	0.81	11.02
	30	1.04	-	-	-	-	-	-	66	9	16	0.83	13.13
	40	1.04	0.209	85	33	45	0.74	11.04	63	12	16	0.87	10.71
	50	1.04	0.209	63	20	49	0.83	11.77	95	17	16	0.93	7.18
E	5	1.42	0.309	-	-	-	-	-	47	8	16	0.83	13.63
	30	0.75	0.227	122	38	33	0.57	9.77	108	19	16	0.68	12.30
	50	0.75	0.298	-	-	-	-	-	131	27	16	0.85	8.95
	70	0.83	-	-	-	-	-	-	118	24	16	0.88	7.79
	100	0.96	0.204	144	32	48	0.50	9.84	121	17	16	0.74	9.41
Mean	51	1.39	0.217	135	29	41	0.64	10.18	196	27	16	0.72	10.25

Table A2. Summary of rock moisture monitoring and rock water sampling design across study sites.

Category		Rock moisture monitoring	Rock water sampled
Dates		Sep 2022–Jun 2025	Sep 2022–Mar 2025
Frequency		30 min	Dry season: once per month; rainy season: 1–4 times per month
Depths at defferent sites (cm)	A	20, 62, 105, 147, 220, 270	62, 147, 270, 600
	B	45, 50, 60, 80, 100, 150, 180	45, 50, 60, 80, 100, 150, 180
	C & D	20, 40, 79, 94, 165, 176, 200, 244, 306	79, 94, 165, 176, 200, 244, 306
	E	170, 207	170, 207, 248
Fracture apertures at defferent sites (mm)	A	0.54, 0.8, 0.92, 1.89, 3.06, 6.45	1.89, 3.06, 5, 6.45
	B	0.47, 0.5, 0.55, 1.43, 10, 15, 21	0.47, 0.5, 0.55, 1.43, 10, 15, 21
	C & D	0.16, 0.2, 0.26, 2, 20, 30, 35, 38	0.16, 0.26, 2, 20, 30, 35, 38
	E	2.4, 2.6	1.84, 2.4, 2.6

55 Table B3. Statistics of MRT and MTT (day) for fractures of different apertures and depths.

Site	Aperture (mm)	Depth (cm)	Porosity (ε_p)	K_h (cm·h^{-1})	Average moisture content	MRT	MTT	Number of samples	R^2	Standard error
C&D	0.16	306	1	0.09	0.354	124	31	54	0.56	11.30
C&D	0.26	244	1	1.13	0.256	118	34	43	0.63	10.80
B	0.47	60	1	3.04	0.217	57	24	44	0.72	14.04
B	0.50	45	1	3.42	0.310	23	-2	30	0.70	17.44
B	0.55	50	1	3.71	0.217	91	25	59	0.50	17.77
B	1.43	80	0.98	17	0.260	76	22	34	0.64	14.03
E	1.8	248	0.75	13	-	73	20	34	0.72	14.84
A	1.89	270	0.98	673	0.217	108	30	61	0.61	14.62

Site	Aperture (mm)	Depth (cm)	Porosity (ε_p)	K_h (cm·h^{-1})	Average moisture content	MRT	MTT	Number of samples	R^2	Standard error
C&D	2	79	0.74	76	0.256	35	2	60	0.73	15.13
E	2.4	170	0.6	34	0.413	103	29	23	0.55	12.06
E	2.6	207	0.54	47	0.413	97	33	70	0.75	10.23
A	3.06	62	0.80	40	0.203	60	22	44	0.69	13.90
A	5	600	0.66	3496	-	182	29	47	0.50	6.21
A	6.45	147	0.55	6208	0.317	100	24	38	0.69	9.75
B	10	100	0.41	6	0.206	136	27	38	0.55	12.20
B	15	180	0.45	33	0.158	84	21	44	0.57	12.85
C&D	20	200	0.47	315	0.311	176	25	53	0.60	8.63
B	21	150	0.74	1042	0.188	198	38	25	0.55	12.20
C&D	30	165	0.49	87	0.311	303	20	25	0.54	6.90
C&D	35	176	0.74	2232	0.311	169	38	43	0.50	9.22
C&D	38	94	0.70	2746	0.256	200	24	50	0.61	6.23
Mean	9.41	173	0.74	813	0.272	120	25	44	0.61	11.92

Table A3. Summary of tree-based sampling design and root-zone characteristics across study sites.

Site	Tree number	Species	Characteristics of root zone			Characteristics of trees			
			Soil depth (cm)	Soil volume (m^3)	Fracture volume (m^3)	Height (m)	DBH (cm)	Canopy area (m^2)	Sapwood area (cm^2)
A	bp$_1$	*Broussonetia papyrifera* (L.) L'Hér. ex Vent.	200	1.68	1.30	7.00	29.60	62.83	499
	bp$_2$		200	0.67	0.52	7.00	12.80	25.04	82.60
	bp$_3$		200	1.26	0.98	7.00	22.00	47.12	219
B	ts$_1$	*Toona sinensis* (A.Juss.) M.Roem.	43	1.12	0.04	5.50	5.40	1.30	18.36
	ts$_2$		22	0.42	0.05	5.80	5.80	1.51	19.23

Site	Tree number	Species	Soil depth (cm)	Soil volume (m^3)	Fracture volume (m^3)	Height (m)	DBH (cm)	Canopy area (m^2)	Sapwood area (cm^2)
	ts5	*Toona sinensis*	16	0.12	0.61	11.50	10.77	14.00	34.19
	ts6	(A.Juss.) M.Roem.	60	6.88	2.19	12.35	36.00	50.46	593
C	cc3	*Cinnamomum camphora* (L.) J.Presl.	52	0.71	0.95	7.00	11.73	21.90	59.24
	yd1	*Yulania denudate*	53	0.37	0.44	6.00	9.63	10.07	38.45
	yd2	(Desr.) D.L.Fu	52	1.42	0.33	7.00	12.75	7.52	16.34
	ts3	*Toona sinensis*	24	0.22	1.01	10.50	10.00	10.40	31.27
D	ts4	(A.Juss.) M.Roem.	60	0.32	1.33	10.50	9.50	13.70	29.52
	cc1	*Cinnamomum camphora*	24	0.22	1.65	10.00	13.40	17.01	96.54
	cc2	(L.) J.Presl.	30	0.68	1.50	8.00	14.39	15.47	128
	bp4	*Broussonetia papyrifera*	100	2.40	0.38	6.70	16.00	28.04	116.50
E	bp5	(L.) L'Hér. ex Vent.	15	0.15	0.41	6.50	13.30	30.68	87.26
	kp1	*Koelreuteria paniculate*	20	0.19	0.06	7.00	8.00	4.24	30.44
	kp2	Laxm.	20	0.18	0.04	5.80	6.80	2.83	23.12

60   Table B4. Statistics of MRT and MTT (day) for different trees at typical sites in the study area.

Site	Tree number	From mobile soil water to tree		From bulk soil water to tree		From rock water to tree		Number of samples	R^2	Standard error
		MRT_1	MTT_1	MRT_2	MTT_2	MRT_3	MTT_3			
	bp1	53	-1	58	5	47	-4	45	0.55	13.40
A	bp2	59	5	64	10	53	1	45	0.52	14.70
	bp3	39	-8	44	-3	31	-12	45	0.57	14.41
B	ts1	14	0	38	-13	79	3	44	0.52	13.96
	ts2	40	-7	94	-3	101	-3	44	0.60	10.72

Site	Tree number	From mobile soil water to tree		From bulk soil water to tree		From rock water to tree		Number of samples	R^2	Standard error
		MRT_1	MTT_1	MRT_2	MTT_2	MRT_3	MTT_3			
C&D	ts_3	18	-9	60	8	54	7	44	0.63	10.29
	ts_4	22	-10	48	6	51	7	44	0.68	9.07
	ts_5	8	-9	32	7	25	7	44	0.60	10.13
	ts_6	96	2	124	18	128	19	44	0.67	7.78
	cc_1	42	-4	79	13	73	12	44	0.72	11.13
	cc_2	43	-1	80	15	74	14	44	0.72	11.18
	cc_3	45	2	68	19	71	19	44	0.77	11.91
	yd_1	37	-15	60	1	63	2	44	0.54	9.83
	yd_2	29	-12	54	4	57	5	44	0.55	14.51
E	bp_4	13	-21	72	-1	61	-13	44	0.61	12.87
	bp_5	26	-21	83	5	52	-11	44	0.68	10.70
	kp_1	25	-33	83	-6	51	-23	44	0.52	15.78
	kp_2	32	-22	88	5	56	-12	44	0.68	12.09
Mean		36	-9	68	5	63	1	44	0.62	11.91

2. L243-245: After heavy rainfall events, precipitation isotopes may become depleted, and in addition to the contribution of high-altitude water vapor, potential mechanisms may include enhanced convective processes leading to increased water vapor mixing, reduced evaporation of raindrops during their descent, and changes in air mass trajectories and water vapor sources. The relative contributions and magnitudes of these mechanisms still require further analysis.

Response: We agree with the reviewer that multiple processes may contribute to isotopic depletion following heavy rainfall events. In the revised manuscript, we have expanded our explanation to explicitly include enhanced convective processes, reduced sub-cloud evaporation (evaporation of raindrops during descent), and changes in air mass trajectories. Furthermore, as suggested, we have acknowledged that while identifying these mechanisms is important, quantifying their relative contributions requires further analysis beyond the scope of this study.

Revised manuscript text: This depletion is likely driven by multiple mechanisms beyond only the input of high-altitude water vapor. These include enhanced convective processes leading to increased water vapor mixing, reduced evaporation of raindrops during their descent, and changes in air mass trajectories and water vapor sources. Collectively, these factors drive the distinct isotopic depletion observed, they collectively reflect the significant impact of intense rainfall on the local hydrological cycle.

3. L245-248: Under the influence of continental air masses, precipitation isotope values may indeed be relatively high, but "evaporation" may not be the primary cause. More critical factors likely include low precipitation amounts, short air mass transport paths, and low temperatures, which reduce the effectiveness of isotope fractionation.

Response: We appreciate this clarification. We have revised the text to accurately reflect these mechanisms.

Revised manuscript text: In contrast, during the winter and spring months (December to April), precipitation is controlled mainly by continental air masses, with relatively higher δ^{18}O and δD values. This isotopic enrichment is attributed primarily to limited precipitation amounts and shorter water vapor transport paths, which limit the degree of isotopic depletion.

4. L253-254: Regarding the average values of precipitation isotopes, please clarify whether a simple arithmetic mean or a weighted mean was used, and note that the same applies to soil water isotopes.

Response: We clarify that arithmetic means were used for the precipitation isotope values reported in the text and shown in Figure 3. As illustrated in Figure 3, we presented the data using box plots to highlight the statistical distribution and seasonal amplitude of the isotopic signals. Consequently, we calculated the arithmetic mean to represent the central tendency of these seasonal fluctuations (as detailed in the time-series analysis in Fig. 2), providing a baseline for the background isotopic environment that the vegetation experiences throughout the year. We have updated the manuscript (Section 3.1) to explicitly state that these values are arithmetic means. Soil water samples were collected at regular temporal intervals to monitor seasonal dynamics. Therefore, the arithmetic mean accurately reflects the average isotopic condition of the soil moisture that vegetation roots are exposed to over the study period. Using arithmetic means prevents bias towards specific wet periods and allows for an unbiased representation of the temporal variability shown in the box plots.

Revised manuscript text: Fig. 3 indicates that the arithmetic average δ^{18}O value of rainfall in the study area is -6‰, and the average δD value is -35.66‰, with a wide range of variations. We utilized arithmetic means to characterize the central tendency of the seasonal isotopic fluctuations and the background isotopic signature of the study area.

5. L260-263: What is the underlying mechanism for these variations? Possible factors include isotope enrichment caused by evapotranspiration, isotope depletion resulting from precipitation input, and potentially the effects of soil water storage and mixing.

Response: We thank the reviewer for this helpful comment. We agree that the observed seasonal isotope variations in mobile soil water likely reflect a combination of evapotranspiration-driven enrichment during dry periods, dilution by precipitation inputs during wet periods, and soil water storage and mixing processes. In the revised manuscript, we have added brief clarification acknowledging these potential mechanisms. However, we note that a detailed process-based attribution of these mechanisms is beyond the scope of this study. Here, the seasonal isotopic fluctuations are primarily used as a diagnostic signal for sinusoidal fitting to estimate mean residence time (MRT) and mean transit time (MTT), rather than as a basis for mechanistic interpretation.

Revised manuscript text: These seasonal dynamics are primarily driven by the combined effects of isotopically depleted precipitation inputs (amount effect) during the wet season, evaporative enrichment during the dry season, and mixing processes within the soil profile.

6. L265: Here, it would be more appropriate to use the term "soil water line" rather than "evaporation line".

Response: We agree with the reviewer. In the revised manuscript, the term "soil water line" were used instead of "evaporation line.

7. L268-269: The manuscript mentions "relatively stronger evaporative enrichment," but when δD is depleted, it typically reflects source water influence or evaporation-induced depletion rather than enrichment; the authors should rephrase this statement and clarify the mechanisms driving the variations in $\delta^{18}O$ and δD.

Response: We thank the reviewer for this comment. The phrase "relatively stronger evaporative enrichment" does not occur at Lines 268–269, which describe soil moisture dynamics (Appendix Fig. A1c) rather than isotope behavior. Nevertheless, we conducted a full-text review and revised all relevant statements to ensure that depleted δD values are attributed to source water influence, mixing processes, or evaporation-induced depletion rather than enrichment. For example, the interpretation in Lines 286–287 has been revised accordingly to correct the description of $\delta^{18}O$–δD relationships.

Revised manuscript text: The mean $\delta^{18}O$ and δD values of xylem water were -5.99‰ and -51.12‰, respectively. The relatively depleted δD and the overall evaporation line slope of 6 suggest a deviation below the LMWL, reflecting non-equilibrium isotope effects associated with source water mixing and subsurface transport processes.

8. L293-294: It is recommended to mention here that plant water uptake may also be influenced by factors such as preferential uptake, root depth distribution, and soil water availability.

Response: We agree that simply attributing the differences to "hydrological conditions" was too broad. As suggested, we have revised the sentence to explicitly acknowledge the physiological and structural factors influencing water uptake.

Revised manuscript text: This difference indicates that the water use by vegetation is directly controlled by the hydrological conditions at different sites. Specifically, the observed spatial variability is likely driven by the interplay of soil water availability, distinct root depth distributions, and preferential uptake strategies, which collectively determine the accessible water pools at each site.

9. L355–357: MRT is typically derived from isotope-based modeling as the "mean residence time." Can it be directly used to distinguish between "root uptake delay" and "within-tree storage"? Is the author actually referring to MTT (mean transit time) here?

Response: We agree that mean residence time (MRT) and mean transit time (MTT) represent distinct hydrological processes and should be strictly distinguished. MRT, derived from isotopic amplitude damping, typically reflects the time spent in storage—i.e. linked to the storage capacity and mixing turnover time within a storage reservoir (within-tree storage). MTT is the time spent transit storage— derived from isotopic phase shifts, characterizes the advective transport time or delay from the source to the sampling point (root uptake delay). We have rewritten the relevant sentence in Section 3.2 to explicitly distinguish between the two metrics.

Revised manuscript text: Table B4 details both the MRT and MTT for different water sources utilized by trees. Here, MRT (derived from amplitude damping) characterizes the time spent in storage linked to the mixing volume and turnover time of water within the tree-source system (storage), while MTT (derived from phase shift) quantifies the time spent transiting storage; that is the lag time for water to be transported from the soil/rock source to the tree xylem (uptake delay).

10. L375-384: The MixSIAR model inherently involves uncertainty, and does the 30–54% mentioned here represent the uncertainty interval?

Response: We verify that the range "30–54%" reported in this context refers to the range of mean contribution values observed across different individual trees (i.e., spatial/individual variability), rather than the Bayesian credible interval (uncertainty) of the model for a single estimate. As illustrated in Figure 6, we calculated the source contribution for each tree individual. The values "30%" and "54%" correspond to the minimum and maximum mean contributions of mobile soil water among the sampled trees during

the winter months. To avoid confusion between individual variability and model uncertainty, we have revised the sentence to explicitly state that this range represents the variation across individuals.

Revised manuscript text: As shown in Fig. 6a, however, trees still exhibited relatively high uptake of mobile soil water (30-54%, mean 39%), with mean contributions ranging from 30% to 54% across individual trees (population mean 39%).

11. L400: MRT represents a statistical mean reflecting the average turnover rate of a water pool, and it is debatable whether it can be directly equated to "how much seasonal precipitation a water body can store and release precisely" The concept and applicability of MRT should be clarified in the manuscript to avoid potential misunderstandings.

Response: We thank the reviewer for this important clarification regarding the interpretation of MRT. We fully agree that MRT represents a statistical, isotope-based indicator of water turnover timescales and should not be equated with a precise quantification of how much seasonal precipitation a water body can store or release. In the revised manuscript, we have revised the interpretation of long MRT values to emphasize their role as indicators of water persistence and renewal timescales, rather than as direct measures of storage volume or release dynamics. For example, we now describe the long MRTs (169–303 days) observed in soil-filled fractures ($\geq$20 mm) at sites C and D as reflecting slowly renewed fracture water pools with long persistence times, which can maintain water availability across seasons and potentially alleviate early-season soil water deficits, rather than explicitly storing and releasing seasonal rainfall. Similarly, the use of fracture water with MRTs up to 128 days by ts_6 is now interpreted as indicating access to relatively stable, long-residence water pools, consistent with its large size and deep rooting system, rather than as a direct measure of within-tree storage or uptake delay. In contrast, smaller individuals at site E are described as relying more strongly on shallow soil water due to limited access to such persistent fracture water pools. Corresponding revisions have been made in the Results and Discussion sections to clarify the conceptual meaning of MRT and to ensure that interpretations focus on effective water availability and turnover timescales, thereby avoiding potential misunderstandings about precise storage and release processes.

Revised manuscript text: Table 3 shows that soil-filled fractures ($\geq$20 mm) at C&D have MRTs as long as 169-303 days (mean 212 days), indicating the presence of slowly renewed fracture water pools with long persistence times, which can maintain water availability across seasons and potentially alleviate early-season soil water deficits. Additionally, Table 4 indicates that ts6 uses fracture water with a residence time of up to 128 days, demonstrating its capacity to access stable, long-residence water for transpiration. As a large tree with an extensive and deep root system, ts_6 efficiently exploits deep fracture water. In contrast, smaller individuals at site E (bp_5, kp_{1-2}) receive lower contributions from rock water (9-12%), relying more on shallow soil water (< 50 cm depth). Collectively, these findings suggest that

long-residence rock fracture water functions as a critical 'transitional reservoir', providing critical water to support tree budding and transpiration at the onset of the growing season.

205 **12.** L461: Lc-excess primarily reflects the intensity of water evaporation and the characteristics of water recharge, nor can it be directly used to indicate water storage time.

Response: We agree with the reviewer. In the revised manuscript, we have corrected our interpretation to align with these physical mechanisms. We have removed the reference to "storage time" and instead explained the isotopic patterns as follows:

210 **Revised manuscript text:** Our study reveals significant isotopic variability in fracture water across different depths and fracture apertures (Figs. A4a and A4b). In the 0-200cm depth range, the Lc-excess values of fracture water are close to 0‰, with many values even falling below 0‰, reflecting the influence of recent rainfall inputs coupled with kinetic fractionation due to near-surface evaporation. Conversely, deep fracture water at depths greater than 200 cm typically has Lc-excess values above 0‰. This distinct

215 isotopic signature suggests that deep fracture water is largely decoupled from surface evaporative processes, likely originating from rapid infiltration events that preserve the initial precipitation signal. Additionally, the aperture of the fractures also significantly affects the isotopic characteristics of the water. Fracture water with apertures between 0.5 and 2 mm exhibits a wide range of δD and $\delta^{18}O$, exceeding the isotopic variation range of xylem water in vegetation, indicating that these small storage volumes are

220 highly sensitive to mixing and variable evaporative fractionation. Meanwhile, fracture water with apertures between 10 and 38 mm has isotopic values within the range of xylem water, and its Lc-excess is less than 0‰—closer to xylem water. This similarity suggests that these larger fractures store water that has undergone evaporative enrichment similar to soil water, thereby serving as a primary and stable water source for vegetation.

225

Minor Comments

1. Fig. 1 requires improvement, with more detailed information on the study area and sampling locations.

Response: We have substantially improved Figure 1 to provide a high-resolution characterization of the sampling locations and their specific environmental contexts.
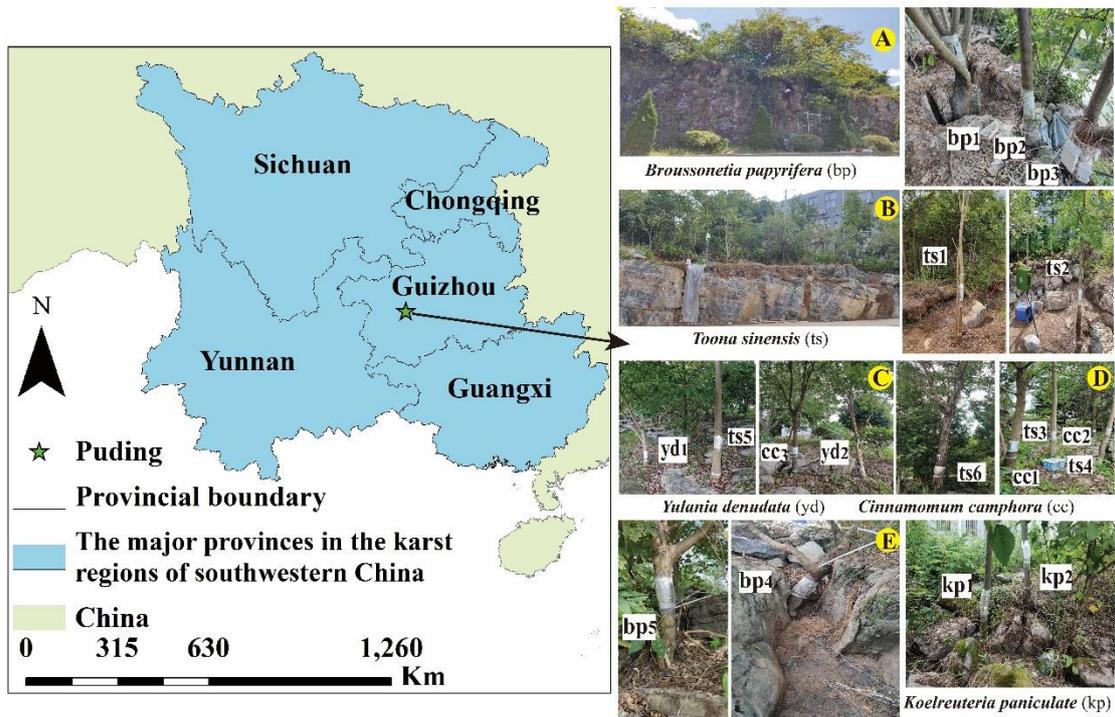
230

Figure 1. The study area and five sampling sites.

2. Fig. 2 has low readability, and splitting it into two panels for meteorological and isotope data is recommended.

235 **Response:** We thank the reviewer for this suggestion. In the revised manuscript, Fig. 2 has been reorganized by separating meteorological variables and isotope data into two panels to enhance readability.
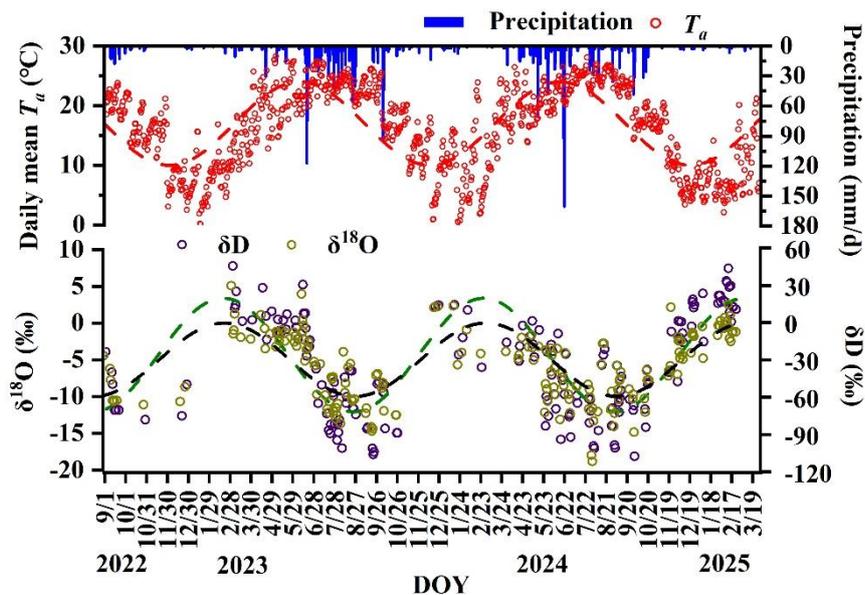
Figure 2. Temporal variations in stable isotopes of precipitation (δD and $\delta^{18}O$), rainfall amount, and daily average temperature.

3. L253: Does the term "precipitation" in the manuscript refer exclusively to rainfall, and if not, please clarify the type of precipitation.

Response: We verify that precipitation in this study refers exclusively to rainfall. The study area is located in a subtropical monsoon climate zone (mean annual temperature of 15.1°C), where solid precipitation (e.g., snow) is negligible. In Section 2.1, we added: "Precipitation in this region occurs exclusively in the form of rainfall."

4. Fig.3 lacks a legend indicating rain water.

Response: We agree and added a clear legend indicating rainwater in Fig. 3 in the revised manuscript.
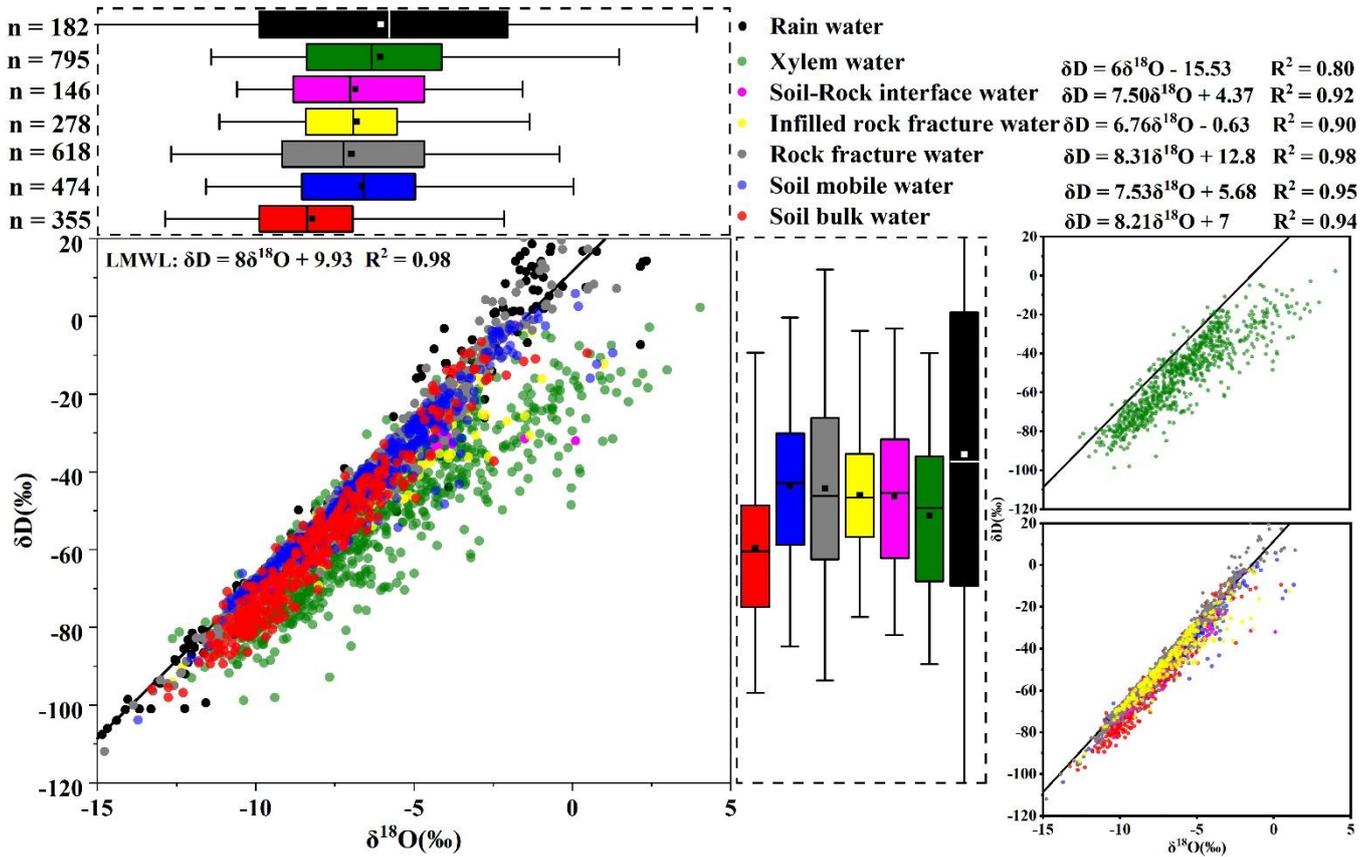
Figure 3. δD-δ¹⁸O relationship diagram for different water bodies during various periods.

250

5. L264-265: The statement "average δD is between 59.61‰" appears to be a error.

Response: We thank the reviewer for identifying this error. The numerical value has been corrected in the revised manuscript.

6. It is recommended to use colors with higher contrast in Fig. 7 for clearer display of the comparison results.

255

Response: Figure 7 has been revised using colors with higher contrast to improve visual clarity.
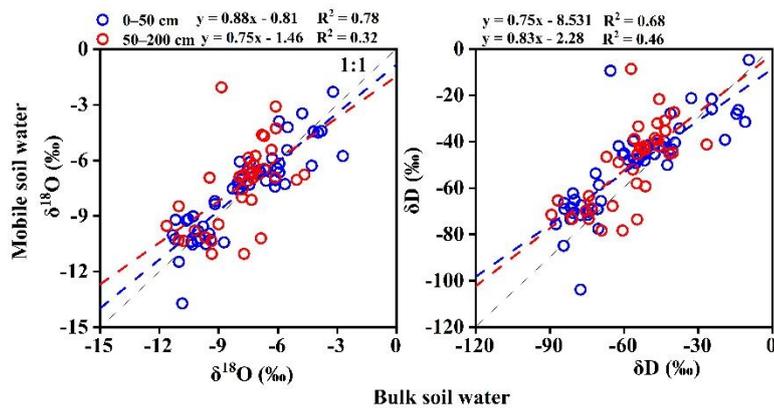
Figure 7. Isotopic comparisons (δD and δ¹⁸O) between bulk soil water and mobile water across soil depths.

7. Check the legends of Fig. A1 and Fig. A2 for accuracy, and ensure the readability of the figures. Adjust the legend and text sizes if necessary.

Response: We have carefully checked and revised Figures A1, A2, and A3 to ensure accuracy and readability. Specifically, we have: (1) Increased font sizes for all axis labels, legends, and text to improve visual clarity, (2) Optimized the figure layout and legends to prevent overlapping and ensure all data points are clearly distinguishable, and (3) Verified the accuracy of the symbols and descriptions in the legends.
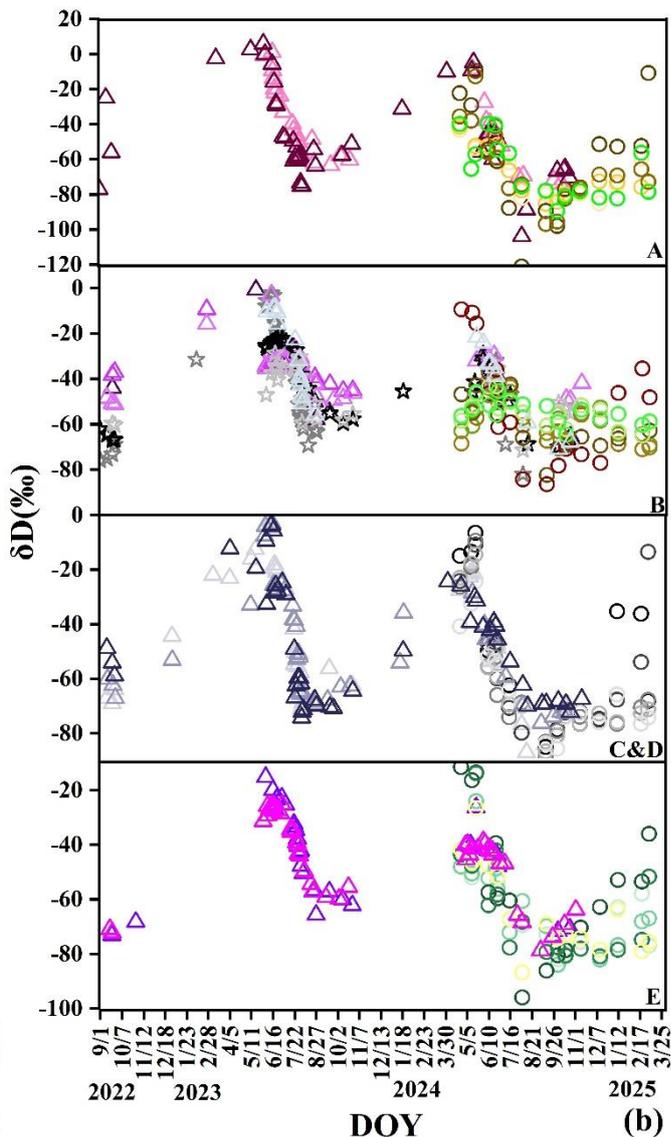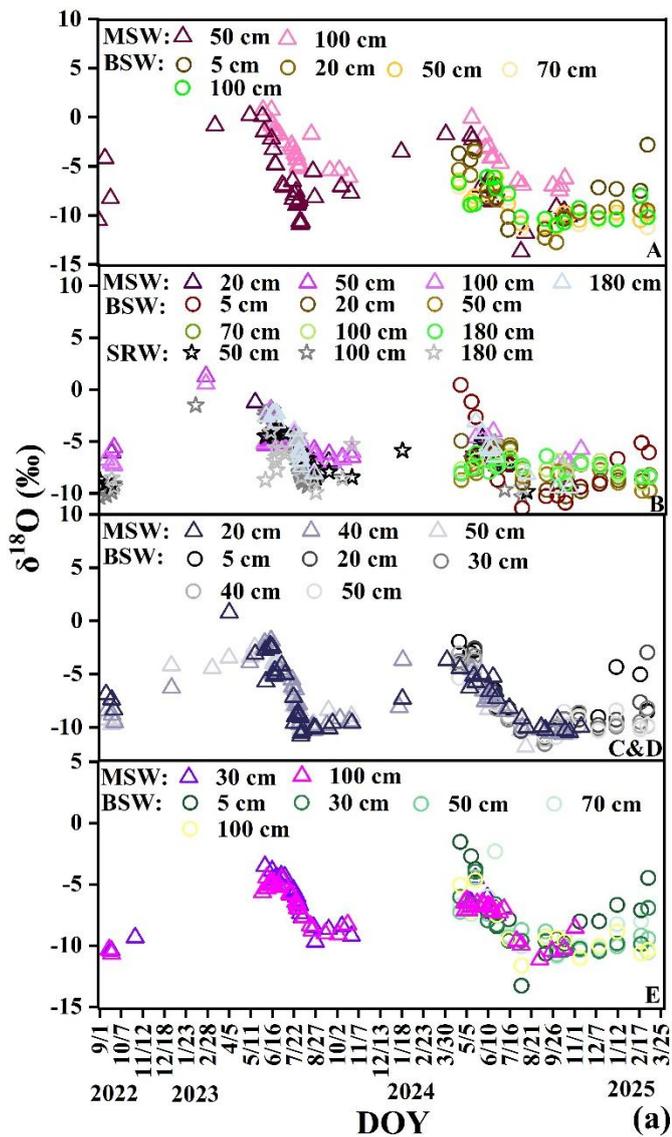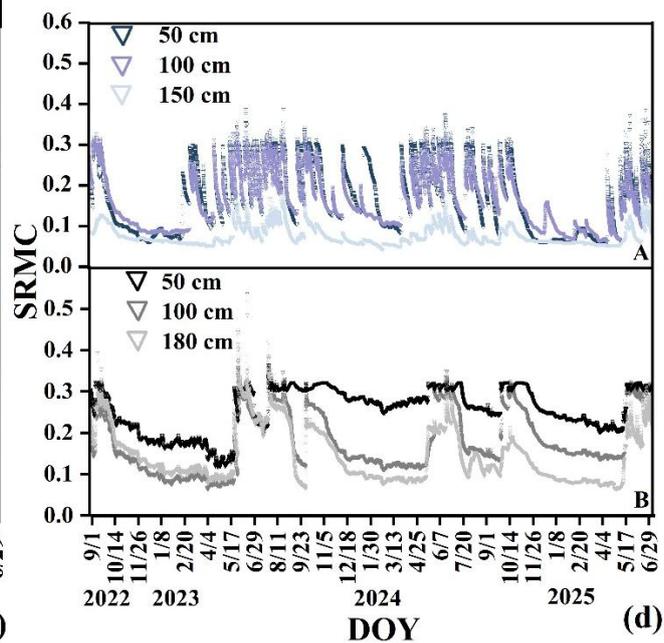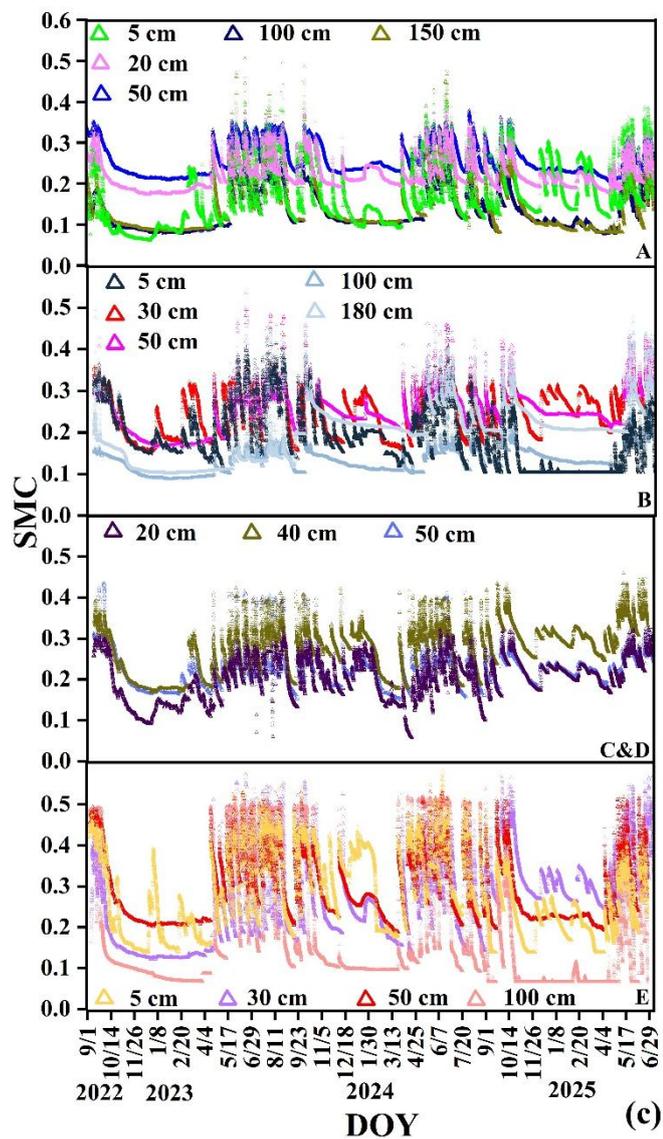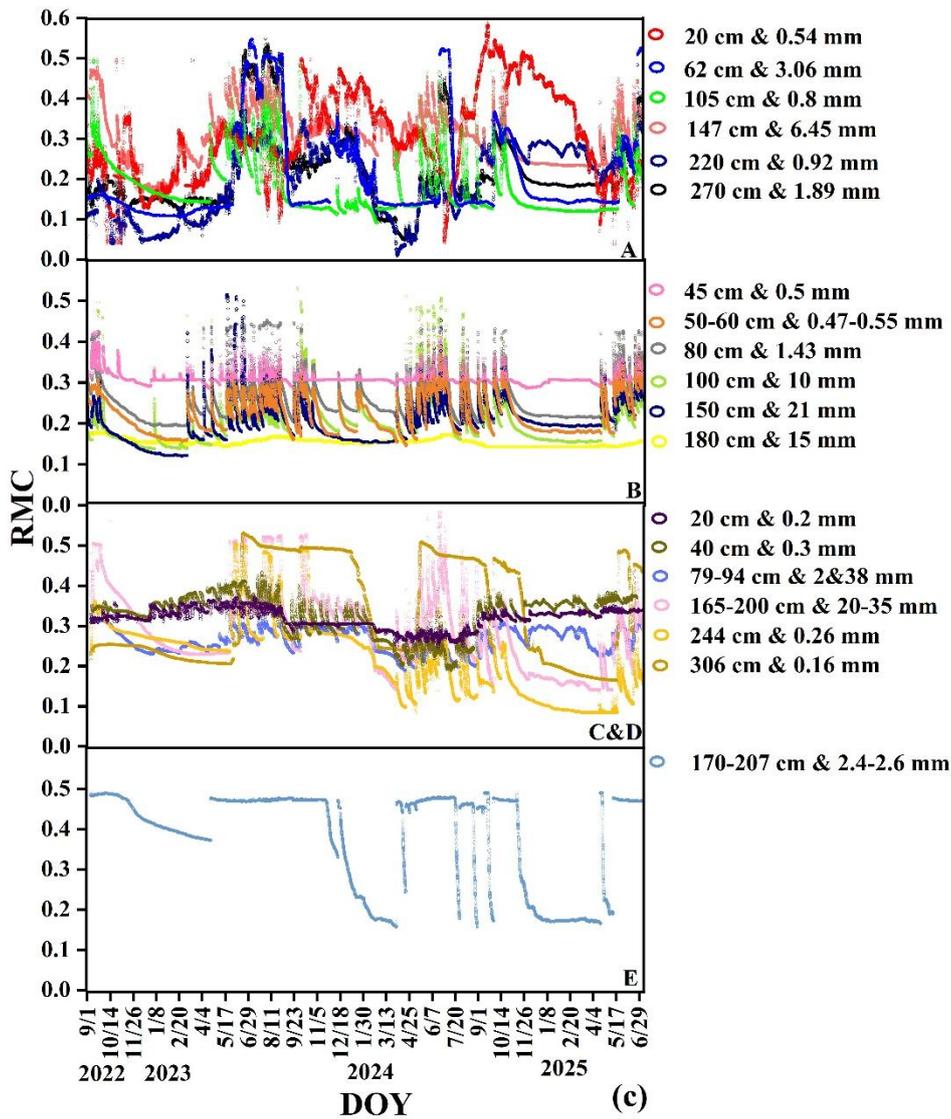
Figure A1. Dynamic variations in stable isotopes of soil water at different depths at sites (A-E): (a) $\delta^{18}O$ and (b) δD, and moisture content: (c) and (d). Mobile soil water (MSW), bulk soil water (BSW), soil-rock interface water (SRW), soil moisture content (SMC), soil-rock interface moisture content (SRMC).
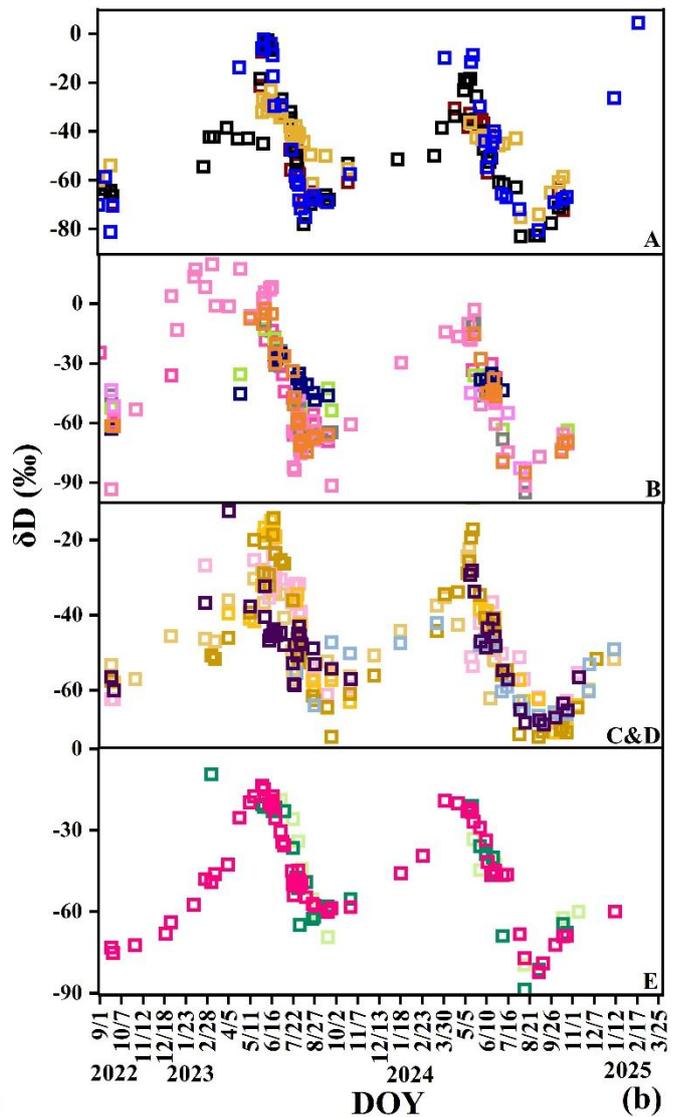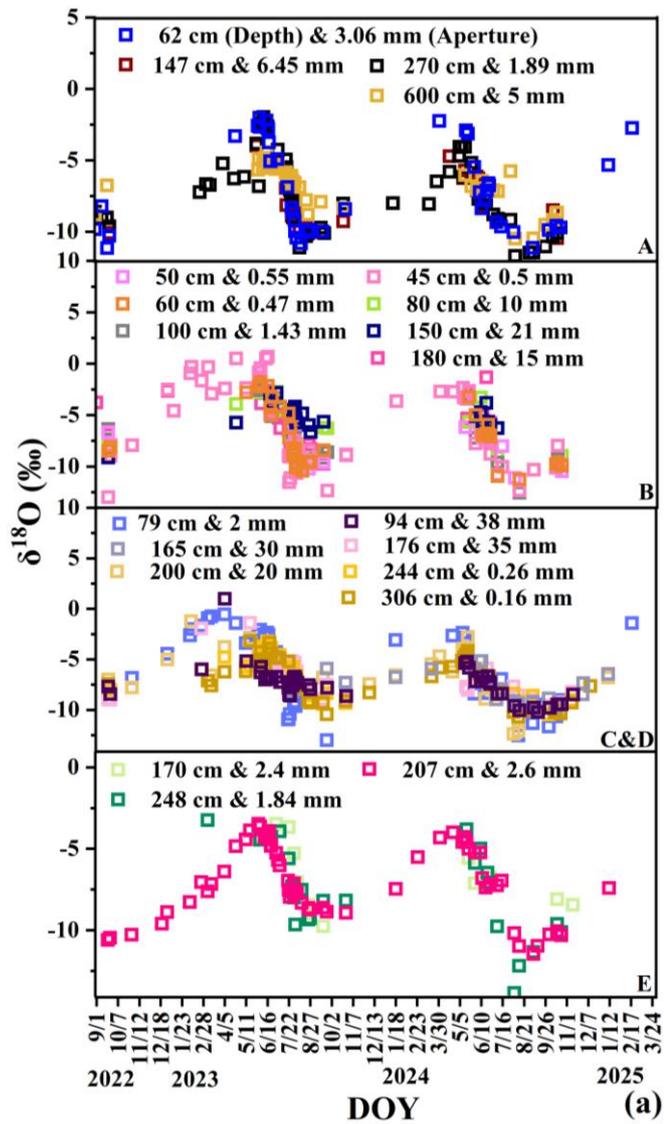
Figure A2. Dynamic variations in stable isotopes of rock fracture water at different depths / apertures at sites (A-E): (a) $\delta^{18}O$ and (b) δD, and moisture content: (c).
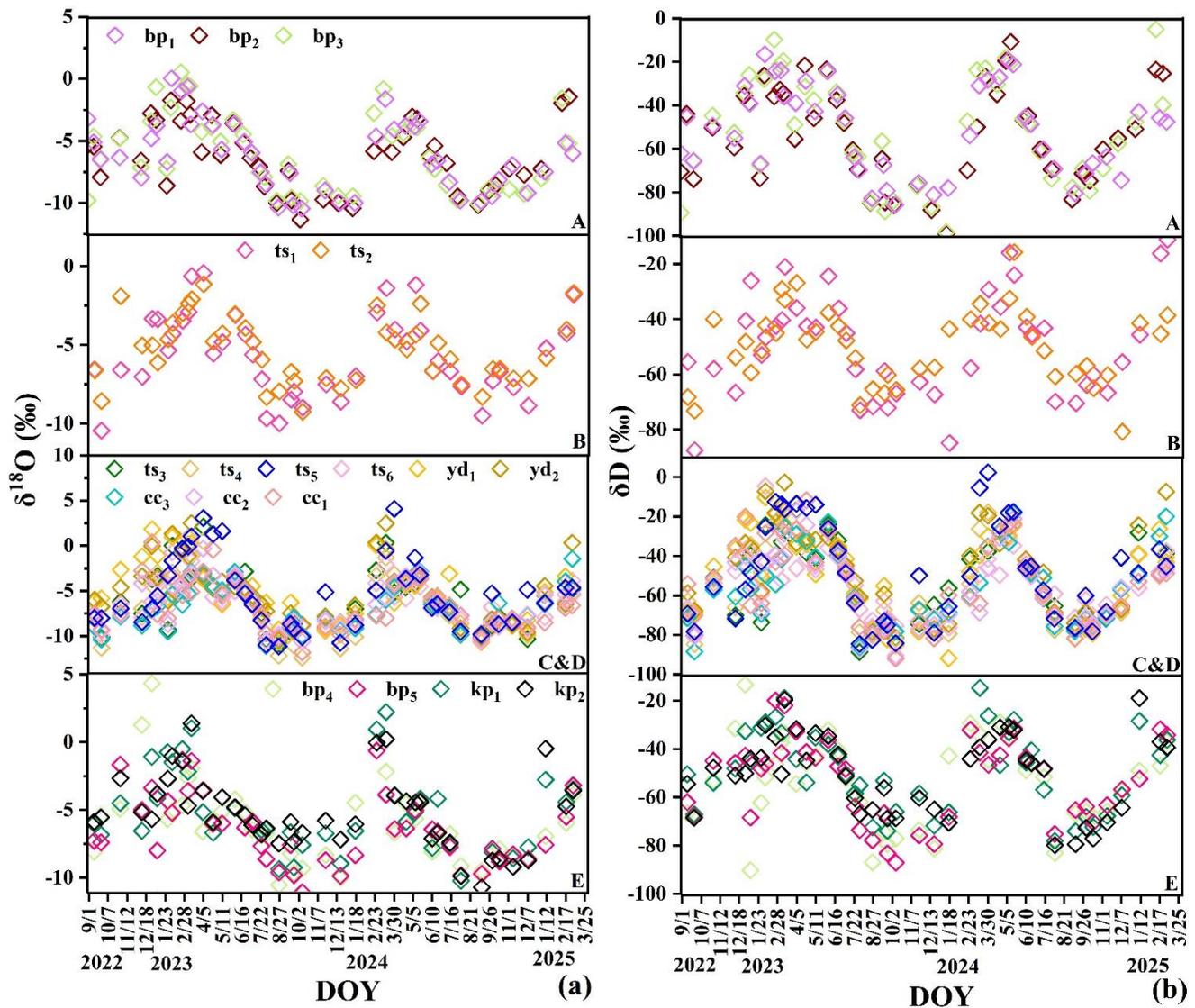
Figure A3. Dynamic variations in stable isotopes of xylem water (δD and $\delta^{18}O$) in different trees at sites (A-E).

8. Some of the parameters in the supplementary tables

Response: We thank the reviewer for noting this issue. We have enriched the supplementary tables to provide a more comprehensive dataset and ensure statistical rigor. Specifically, we added the number of samples, R^2, and standard error to Tables B1–B4. We also incorporated detailed sampling information into Tables A1 and A2. Furthermore, Table A3 now includes detailed soil depth and fracture aperture data for each sampled tree to explicitly support the micro-habitat analysis.