Revision Notes

Dear Editor and Reviewers:

Thank you for your letter and the reviewers' comments concerning our manuscript entitled "Evaporation, infiltration and storage of soil water in different vegetation zones in the Qilian Mountains: A stable isotope perspective" (Manuscript Number: Hess-2021-376).

According to the reviewers' comments, we have made careful revisionsto the manuscript. In the revised version of the manuscript, the revised portions have been marked in red. The main corrections and the response to the reviewers' comments are as follows.

Responses to the reviewer's comments:

The authors have made considerable efforts in addressing the comments of the reviewers. However, there are still some issues with this paper. The text is still not very clear in places, although the grammar is much better. In part it is due to some complex sentences and specific phrases. This is mostly in the introduction. Overall the results and discussion are much better as they have a reasonable level of detail.

The paper still does not convey a strong reason as to why this work is of interest to the broader international community. For an international journal such as HESS, it is important to show how the work informs studies by groups working on similar problems elsewhere. Some better explanation of this is needed in the section on motivation and in the Conclusions.

I have annotated some of the responses to my original comments below (in green) where I think there are still issues. These are mainly explanations that are not clear or where more context is needed.

Thanks for your comments.

Abstract

Comment: The abstract needs improvement. Abstracts are important as they are what convince the readers to look at the rest of the paper. They should convey not only what has been studied and why, but should also contain enough details so that the main conclusions are evident. This abstract needs improving, specifically:

The abstract was improved but there still are several qualitative statements. For example the sentence below gives a relative order but no values and still uses terms such as “weak” that are not clear.

24-27: Each vegetation zone's soil water storage capacity followed the order of alpine meadow > deciduous forest > coniferous forest > mountain grassland. In addition, the water storage capacity of shallow soils in different types of vegetation areas was weaker than that of deep soils.

Response: According to your suggestion, we have further improved the Abstract section, including quantification and examination of the main conclusions.

L18-20: The results show that the order of soil water evaporation intensities in the four vegetation zones was mountain grassland (SWL_{slop}: 3.4) > deciduous forest (SWL_{slop}: 4.1) > coniferous forest (SWL_{slop}: 4.7) > alpine meadow (SWL_{slop}: 6.4).

L25-30: Each vegetation zone's water storage capacity of the 0-40 cm soil layer followed the order of alpine meadow (46.9 mm) > deciduous forest (33.0 mm) > coniferous forest (32.1 mm) > mountain grassland (20.3 mm). In addition, the 0-10cm soil layer has the smallest soil water storage capacity (alpine meadow:43.0 mm; coniferous forest: 28.0 mm; mountain grassland: 17.5 mm; deciduous forest: 29.1 mm).

Introduction

Comment 1: Comment 3: L50. Do you mean on the ground surface or in the near-surface part of the soils?

Response: We rewrite this sentence.

L58-60: The evaporation of liquid water produces water vapor enriched in ^{1}H and ^{16}O, while the remaining water is enriched in ^{2}H and ^{18}O (Ferretti et al., 2003).

This does not answer the question as to where this is taking place.

Response: We re-answered the question about where this is taking place, showing that evaporation mainly occurred in the near-surface part of the soils.

L54-57: Evaporation mainly occurred in the near-surface part of the soils (0-10 cm), and the light isotope molecules (^{1}H and ^{16}O) evaporated preferentially, resulting in the enrichment of heavy isotopes (^{2}H and ^{18}O) on the soil surface (Ferretti et al., 2003).

Comment 2: Comment 4: L48-75. This would not be readily understandable to many readers who had not worked with these types of data. It is too generally worded and needs details. This paragraph is important as it sets the framework for using the stable isotopes to understand processes. (1) Define that you are discussing ^{18}O and ^{2}H data (there are lots of stable isotopes!). (2) Terms such as "makes soil water isotopes enriched" are vague. Specifically, evaporation enriches the residual water in ^{18}O or ^{2}H (or increases the $\delta^{18}O$ and

δ^2H values) (3) Likewise, "soil moisture fractionation is positively correlated with evapotranspiration but negatively correlated with precipitation". Are you talking about the magnitude or sign? (4) How significant? (5) Define the d-excess (briefly) (6) L63-70. Lacks detail and is unclear.

Response: According to the suggestions of three reviewers, this part was rewritten to solve the above problems: (1) We identified stable isotopes of hydrogen and oxygen; (2) According to your suggestion, the expression has been changed; (3) and (4) According to the reviewer's suggestion, we introduced the evaporation process more and deleted the influencing factors of evaporation; (5) We defined "d-excess"; (6) I gave a detailed description of this part to make it more expressive of the status quo of the research.

This is still not very clear in places (see comments on the modified text below). This is an important section and there is more explanation than was in the original paper. However, some of the issues (definition of lc-index and explanation of the memory effect) are still not there.

Response: At the appropriate place in the text, we added the definition of lc-index (L61-64) and the explanation of the "memory effect" (L47-53).

L62-65: Landwehr and Coplen (2006) defined line conditioned excess as the difference between the δ^2H value of the water sample and the $\delta^{18}O$ linear transform value of the same sample, where the linear transformation reflects the relevant referenced meteoric water relationship.

L48-54: The dynamic water process reflected by the displacement of the isotope signal on the soil profile is called the "memory effect". Understanding the "memory effect" will help us to trace the dynamic changes in climate and soil hydrology (Kleine et al., 2020). The change of stable isotopes in near-surface soil water may reflect the precipitation variation, but these variations decrease with depth unless there is preferential flow (Peralta-Tapia et al., 2015; Sprenger et al., 2016; Sprenger et al., 2017).

Comment 3: L44-92: Water seepage in the unsaturated soil zone and the water evaporation at the air-soil interface are the main forms of soil water transport. Seasonal variations in precipitation isotopes are often used to track the process of soil water leakage (Stumpp et al., 2012).

During the piston infiltration process, precipitation with different δ2H and δ18O peaks are retained in the soil profile and gradually disappears as the infiltration depth increases (Sprenger et al., 2016a), while the preferential flow will keep these peaks until reaching the deep soil layer (Peralta-Tapia et al., 2015). During a precipitation event, the response of the water isotopes in the surface soil to precipitation is more obvious, changing to nearly that of the stable isotopes of the precipitation. With the deepening of the soil layer, the seasonal variation in precipitation isotope signals rapidly attenuates, and the influence of precipitation on soil water gradually weakens (Sprenger et al., 2017).

This says the same thing twice and could be clearer (all that it says is that the variation of stable isotopes in near-surface soil water are likely to reflect the rainfall variation but that these variations are attenuated with depth unless preferential flow occurs)

Response: Based on your suggestion, we have revised this section.

L48-54: The dynamic water process reflected by the displacement of the isotope signal on the soil profile is called the "memory effect". Understanding the "memory effect" will help us to trace the dynamic changes in climate and soil hydrology (Kleine et al., 2020). The change of stable isotopes in near-surface soil water may reflect the precipitation variation, but these variations decrease with depth unless there is preferential flow (Peralta-Tapia et al., 2015; Sprenger et al., 2016; Sprenger et al., 2017).

Comment 4: Evapotranspiration is the main form of soil water dissipation. Because the mass of hydrogen and oxygen atoms that make up water molecules are related to their thermodynamic properties, isotope fractionation of water will occur in the process of the water cycle. The evaporation of liquid water produces water vapor enriched in ^{1}H and ^{16}O, while the remaining water is enriched in ^{2}H and ^{18}O (Ferretti et al., 2003).

Confusing as written and you probably only need the last sentence.

Response: We have edited this section to make it more concise.

L54-57: Evaporation mainly occurred in the near-surface part of the soils (0-10 cm), and the light isotope molecules (^{1}H and ^{16}O) evaporated preferentially, resulting in the enrichment of heavy isotopes (^{2}H and ^{18}O) on the soil surface (Ferretti et al., 2003).

Comment 5: Dansgaard (1964) proposed the concept of d-excess (d-excess=$\delta^{2}H-8\delta^{18}O$) to illustrate the intensity of evaporative fractionation. In the state of isotopic equilibrium, the d-excess is 10.

Not strictly true, d is related to humidity and the value of 10 relates to average global humidity

Response: By further reviewing the literature, we have revised our interpretation of d-excess.

L57-62: Dansgaard (1964) proposed the concept of d-excess (d-excess=δ^2H-8δ^{18}O) to illustrate the intensity of evaporation fractionation. Assuming that evaporation occurs in the atmosphere with a humidity of 75%, it shows that the d-excess value of atmospheric moisture accounts for the d-excess value of 10‰ in the atmospheric moisture, which conforms to the worldwide average isotopic labelling of meteoric waters.

Comment 6: Compared with d-excess, lc-excess can better explain the evaporative fractionation process. The main reason is that lc-excess of precipitation and soil water changes smoothly and has relatively small seasonal changes (Landwehr et al., 2014).

This is not a good explanation of the lc-excess (there is an explanation below, but something is needed here-at least define the term)

Response: We added the definition of lc-excess.

L62-65: Landwehr and Coplen (2006) defined line conditioned excess as the difference between the δ^2H value of the water sample and the δ^{18}O linear transform value of the same sample, where the linear transformation reflected the relevant referenced meteoric water relationship.

Comment 7: The dynamic changes in isotopes record the signal of soil water evaporation. This enrichment from dynamic fractionation exists in soil water isotopes in different climatic regions. Compared with temperate regions, the signals of evaporation in arid and Mediterranean environments penetrate deeper into the soil (Sprenger et al., 2016b). Some water is stored in the soil after evaporation and seepage. The water storage capacity of humid areas is higher than that of arid areas, the water storage capacity of forests is higher than that of grasslands, and the water storage capacity of the surface soil layer is lower than that of deeper soil layers with higher clay content (Heinrich et al., 2019; Sprenger et al., 2019; Kleine et al., 2020; Snelgrove et al., 2021).

In alpine mountains, climate warming accelerates the melting of glaciers and frozen soil, and the dynamic interaction between water bodies stored in different media becomes the main influence on the water cycle (Penna et al., 2018).

Not clear-what are "dynamic interactions between water bodies stored in different media" and how do they influence the water cycle.

Response: We briefly described the dynamic interactions between water bodies and its influence on the water cycle.

L80-87: Interactions between precipitation and the soil-plant-atmosphere system determine the distribution of water in various storage reservoirs and the subsequent release of water vapor to the atmosphere. These interactions include mainly interception, throughfall, canopy drip, snow accumulation and ablation, infiltration, surface and subsurface runoff, soil moisture, and the partitioning of evapotranspiration between canopy evaporation, transpiration, and soil evaporation. As the main links of the hydrological cycle, these processes have a profound impact on regional water balance and flux distribution.

Comment 8: Previous studies on the evaporation, infiltration, and storage of soil water have mostly focused on different climatic regions or vegetation types in the same climatic region. Understanding the climatic and hydrological conditions of different vertical vegetation zones and clarifying the regulating role ofvegetation in the water cycle can help better adapt to climate change's influences on the hydrological cycle in source areas. This study monitored the stable isotope composition of precipitation and soil water and the spatiotemporal dynamics of soil water storage in four vegetation zones (alpine meadow, coniferous forest, mountain grassland, and deciduous forest) with different hydrothermal conditions in the Xiying River Basin. To explore the differences in soil water evaporation, infiltration, and storage processes in these four different climates, vegetation types, and terrain types, the following research objectives were proposed: (1) to explore the evolution of isotope evaporation signals and the "memory effects" of precipitation input, mixing and rewetting; and (2) to understand the soil water storage capacity and influencing factors of four vegetation areas in mountain areas.

What the “memory effects” are and why they are important is still not explained.

Response: At the appropriate place in the text, we added the explanation of the “memory effect”.

L48-54: The dynamic water process reflected by the displacement of the isotope signal on the soil profile is called the "memory effect". Understanding the "memory effect" will help us to trace the dynamic changes in climate and soil hydrology (Kleine et al., 2020). The change of stable isotopes in near-surface soil water may reflecs the precipitation variation, but these variations decrease with depth unless there is preferential flow (Peralta-Tapia et al., 2015; Sprenger et al., 2016; Sprenger et al., 2017).

Comment 9: Comment 6: L84. "Heat conditions" do you mean temperatures?

Response: We want to express the vegetation zone under different moisture and temperature conditions. Based on this, I re-narrate this sentence.

L83-86: This study monitored the stable isotope composition of precipitation and soil water and the spatiotemporal dynamics of soil water storage in four vegetation zones (alpine meadow, coniferous forest, mountain grassland, and deciduous forest) with different hydrothermal conditions in the Xiying River Basin.

"Hydrothermal conditions" no clearer than "heat conditions" – do you mean temperatures?

Response: What we want to express here are four vegetation zones with different temperatures and humidity, all of which have been modified.

L93-96: In this study, we monitored the stable isotope composition of precipitation and soil water and the spatio-temporal dynamics of soil water storage in four vegetation zones (alpine meadow, coniferous forest, mountain grassland, and deciduous forest) at different temperatures and humidity in the Xiying River basin.

Comment 10: Comment 7: L82-90. These are fine as general aims, but can you explain (briefly) why this is important (i.e. what are you doing that is new, what are the broader implications?). There is a disconnect here between the broad general themes in the rest of the introduction and your specific study. Also, runoff generation and the memory effect are not explicitly discussed in any depth in the paper (need to make sure that your aims are actually what you discuss).

Response: Previous studies on soil moisture evaporation, infiltration and storage have mostly focused on different climatic regions or vegetation types under the same climatic region, and there are few uses of isotope technology to trace the hydrological processes in the mountain vegetation vertical zone.

This section (L78-88) of the revised manuscript still does not give a sense of importance or broader implications.

Response: We have add the importance of this study and its broader implications.

L102-108: It is hoped that this study can further improve the understanding of the water cycle process and provide a scientific theoretical reference for water resource utilization and ecological restoration in fragile environments. More importantly, it can provide paradigms for research at different spatial scales (latitude zone, longitude zone, watershed, etc.) based on the knowledge of soil moisture evaporation, infiltration, and water storage in typical vertical vegetation zones.

Comment 11: Comment 8: L88. If it is important, define the memory effect and explain why we need tounderstand it.

Response: The "memory effect" means that the temporal and spatial changes of the stable isotope profile of soil water can reflect and characterize the input, mixing, and rewetting process of precipitation. Understanding the "memory effect" helps us trace the dynamic changes of climate and soil hydrology.

Still not explained in the paper (L89-90 just states “to explore the evolution of isotope evaporation signals and the "memory effects" of precipitation input, mixing and rewetting”).

Response: At the appropriate place in the text, we added the explanation of the “memory effect” (L47-53).

L48-54: The dynamic water process reflected by the displacement of the isotope signal on the soil profile is called the "memory effect". Understanding the "memory effect" will help us to trace the dynamic changes in climate and soil hydrology (Kleine et al., 2020). The change of stable isotopes in near-surface soil water may reflect the precipitation variation, but these variations decrease with depth unless there is preferential flow (Peralta-Tapia et al., 2015; Sprenger et al., 2016; Sprenger et al., 2017).

Study area

Comment: Comment 4: Fig. 1. What is the inset on the left-hand map?

Response: The complete nine-dotted line is shown here.

Not clear what the figure shows or what the response means. The caption is uninformative

Response: To make the diagram more clearly express our research area, we have removed the inset on the left-hand map and added relevant information in the caption.

L126-128:

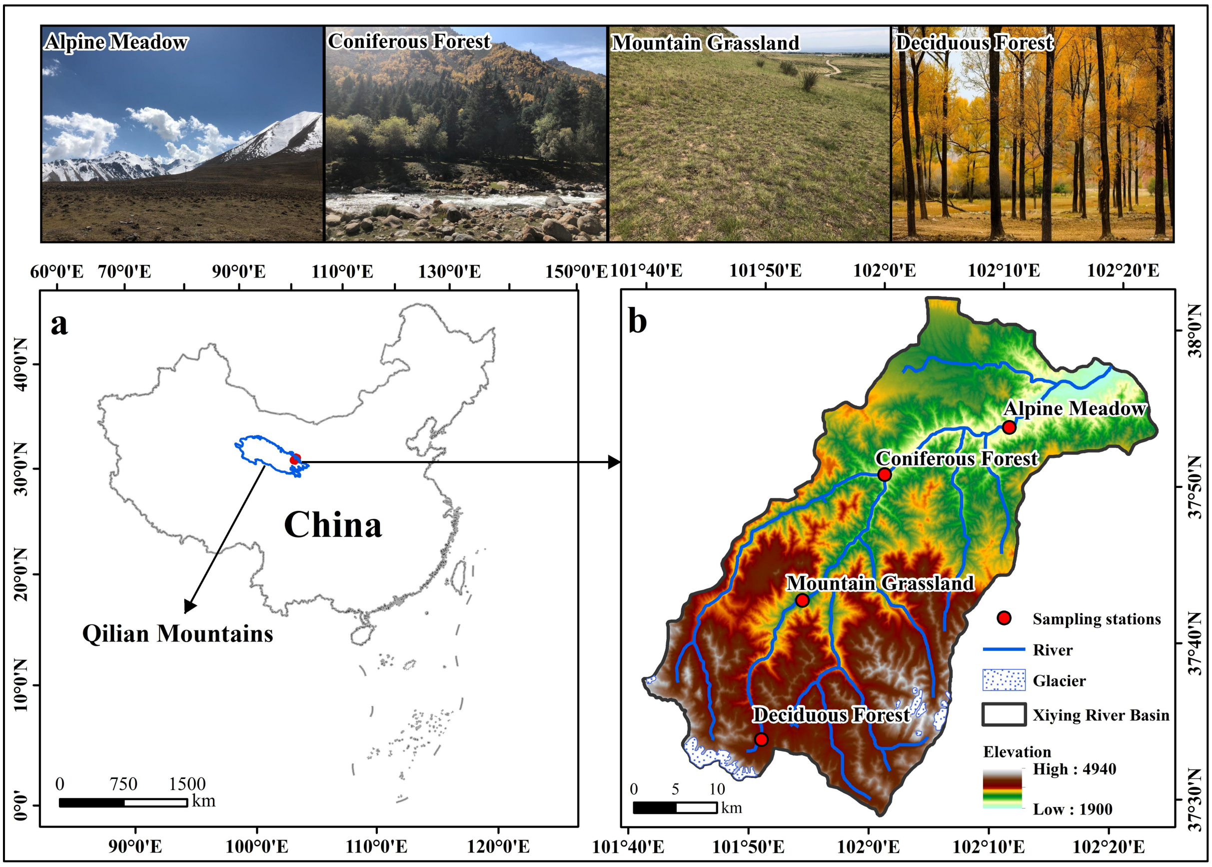

Fig. 1 Study area and location of sampling points（a. The location of the Xiying River Basin in China; b. The terrain and sampling points of the Xiying River Basin）

Methods

Comment: Comment 4: Section 3.2. The analysis is only part of the uncertainty. Did you perform multiple extractions on the same sample to test the uncertainty associated with that. This will undoubtedly be higher and needs to be considered.

Response: During the sampling process, we collected duplicate samples to improve the accuracy of the experiment.

That is good but you need to explain this in the text

Response: We have added instructions for duplicate samples in the manuscript.

L140-144: Three duplicate samples were collected for each soil layer. We placed the collected soil sample into a 50 mL glass bottle, sealed the bottle mouth with Parafilm and marked the sampling date. We froze the sample for storage until experimental analysis. Each sample was collected separately in an aluminum box.

Results

Comment: Comment 1: L175-178. How precise are these values (i.e. is the 1dp precision warranted)? What was the rainfall during those times?

Response: We use FAO Penman-Monteith to calculate the potential daily evapotranspiration (possible evapotranspiration) in the study area (the software calculation results are kept to three decimal places, and we keep one decimal place in the study). This illustrates the date when the maximum and minimum values appear, and there may be no rainfall on that day.

Regardless of the calculations, I am still sceptical that the results are that accurate.

Overall, however, the presentation of the Results and Discussion is much better and the added details help get the message across.

Response: We checked the calculation process and accuracy again, and the results show that it is reliable.

Conclusions

Comment: As with the discussion, the links to the study are not well made. In some ways this material is less general than some of the latter parts of the Discussion (Section 5.3) and it would be worth reordering so that you have the more general ideas at the end.

Response: Based on the opinions of the three reviewers, we re-summarized the conclusions of the manuscript.

This section still does not explain the true value of the study and why it is important to a broader readership. What is it that you have done here that informs work elsewhere? This is important for a paper in an international journal.

Response: Based on the findings of the study, we describe its broader value and reference for future research.

L535-543: The research results can be applied to arid and semi-arid alpine regions and have reference significance for latitude and longitude differentiation. This study mainly emphasized the Spatio-temporal heterogeneity of soil water evaporation, infiltration, and water storage in different vegetation zones. These results are of great value for understanding regional hydrological processes and ecological restoration services in environmentally fragile areas. Furthermore, we hope this study can be used as a basic statement because we continue to use stable water isotopes as a data source to understand hydrological processes from the perspective of process mechanisms.