Dear Reviewer:

Thank you for your letter and for the reviewer's comments concerning our manuscript entitled “Difference of SPAC composition and control factors of different vegetation zones in north slope of Qilian Mountains” (Manuscript Number: bg-2021-127).

According to the comments of the reviewer, we have revised our manuscript carefully. The primary corrections and the response to the reviewers’ comments are as follows.

Responses to the reviewer’s comments:

This manuscript (bg-2021-127), entitled "Difference of SPAC composition and control factors of different vegetation zones in north slope of Qilian Mountains", investigated the differences in SPAC composition of three different vegetation zones of the period of April 2018 to October 2019, and attempled to find the controlling factors. This paper is the one that I have seen so far in the research on SPAC water cycle with relatively rich data and very reasonable argumentation. This manuscript provides a lot of valuable isotope data for understanding the water cycle in arid and semi-arid regions. In this paper, the micro-SPAC water cycle is well correlated with the basin water cycle, and the case studies are compared and discussed at the regional and global scales. It is a writing style that I admire a great deal. So I support the publication of the article. However, there exist some problems, including English language, basic format, and the description of the research samples is not enough. In addition, many explanations in the text are not clear enough. A good article must be very scientific and well expressed. Therefore, I think the article can only be published after having solve the following problems.

Response: We have gradually improved it by carefully revising every recommendation you mentioned.

Specific comments:

1. **Why choose these three sampling points as the research area of this manuscript? How long is the sampling interval? The author has made a lot of**

descriptions on sample collection and experimental analysis, but if the author can more clearly describe how to select samples, it will be more reasonable, for example, in Section 2.2: We have collected samples of precipitation, groundwater, soil, and plant at Lenglong (alpine meadow), Hulin (forest), and Xiying (arid foothills) in the Shiyang River Basin from April 2018 to October 2019.

Response: We consider the sea surface, topography, the distance between sampling points, and the consistency of sampling time. We finally chose the Lenglong sampling point to represent the alpine meadow, the Hulin sampling point represents the forest, and the Xiying sampling point represents the arid foothills. Our sample collection interval is one month. From April 2018 to October 2019, we collected a total of 1281 samples in the Shiyang River Basin, including 472 precipitation samples, 570 soil samples, 119 plant samples, and 120 groundwater samples. Soil and plant samples need to be vacuum extracted. The extraction instrument used is the LI-2100 automatic vacuum condensation extraction system. The analysis instrument is the LWIA-24d liquid water isotope analyzer. For precipitation and groundwater samples, they are directly analyzed with a fluid water isotope analyzer. After the test of each batch of samples is completed, we will use the LIMA software to select the wrong pieces and re-analyze the experiment until the tested value passes the LIMA software inspection.

2. **Section 3.2: With the continuous progress of vegetation restoration, the vegetation coverage of alpine meadows will continue to increase. How do you know that the vegetation coverage of alpine meadows has increased? Is the conclusion drawn from the relevant literature or based on actual data?**

Response: The increase of vegetation coverage rate of the alpine meadow is calculated according to the rise in grassland area, with data from the comprehensive natural survey report of Shiyang River Basin. According to the complete survey report on the natural resources of the Shiyang River Basin, the natural grassland area of the Shiyang River Basin was 12,452.72 hectares in 2017 and 13,071.94 hectares in 2019. We can see that from 2017 to 2019, the grassland area of the Shiyang River Basin increased by 619.22 hectares, which shows the increase in vegetation coverage in the

Shiyang River Basin.

3. **Section 3.2: "Along the three vegetation zones of alpine meadow-forest-arid foothills, soil water isotope gradually enriched.The coefficient of variation of the arid foothills is the largest". Why is the coefficient of variation of the isotope of soil water in the dry mountain foothills the largest?**

Response: On the one hand, the stable isotope variation coefficients of different water bodies in the three vegetation areas calculated through mathematical statistics are shown in Table 2. In Table 2, the coefficient of variation of soil water isotope of the alpine meadow is -0.16, the coefficient of variation of soil water isotope of the forest is -0.25, and the coefficient of variation of soil water isotope of the arid foothills is -0.15. It can be known from the numerical value that from forest to arid foothills, the more inclined to arid regions, the larger the coefficient of variation of soil water isotope, and the more unstable the soil water isotope. On the other hand, there is little precipitation in the arid foothills, and the soil water is mainly recharged by groundwater. Precipitation events mainly occur in summer when the temperature is higher. The isotope distillation of soil water is significant, and the isotope of soil water is very different when there is precipitation and when there is no precipitation so that the isotope of soil water in the arid foothills varies greatly, and the coefficient of variation is large.

4. **Section 3.2: "The soil water content of alpine meadows is higher than that of forests and arid foothills, and the soil water content of alpine meadows increases with the soil depth". Why does the soil water content of alpine meadows increase with the increase of soil depth? The author did not give an explanation in the manuscript. Does this characteristic of change appear in different soil depths?**

Response: There is a lot of precipitation in the alpine meadow area, even in the winter, when the temperature is below zero, there is solid precipitation in Lenglong. Alpine meadow vegetation has a shallow root system, small tree crown, low transpiration and low water consumption. The low temperature throughout the year and high air humidity make it difficult for the soil water in alpine meadows to evaporate. As the soil depth increases, there is a frozen soil layer. The lower temperature makes the firm soil layer almost always exist, making the soil water content of the alpine meadow increase with the soil depth. The characteristics of this change are different in different soil layers of alpine meadows. The following describes the changes of soil water content in different soil layers of alpine meadows:

In April, the soil water content of alpine meadows decreased at 10-40 cm, gradually increased at 40-70 cm, and progressively reduced at 80-100 cm. In May, the soil water content of the alpine meadow increases at 10-20 cm, decreases at 20-30 cm, increases at 30-40 cm, decreases at 40-60 cm, and gradually increases at 60-100 cm. In June and July, the soil water content of alpine meadows decreased by 10-60 cm and increased by 70-100 cm. In August, the soil water content of the alpine meadow increased by 10-40cm, decreased by 40-60cm, and increased by 60-100cm. In September, the soil water content of alpine meadows decreased by 10-30cm, increased by 30-50cm, and decreased by 60-100cm. So the soil water content of alpine meadows at the same depth varies significantly in different months, and the changes in soil water content of alpine meadows to varying depths at the same time are more complicated. But in general, the soil moisture content of alpine meadows increases with the increase of soil depth, and the forest soil moisture content decreases with the growth of soil depth.

5. **Section 3.3, line 228-229: "High temperature is related to groundwater level exposure". What does this sentence mean?**

Response: The original meaning of this sentence is that the soil water and groundwater in the arid mountain foothills intersect, which is related to the exposure of the groundwater level caused by high temperature. We have rewritten the relevant part:

In Fig. 4, in the rainy season, the surface layer of soil water in the arid foothills intersects with plant water, and the surface and deep layers of groundwater intersect with soil water, and precipitation is the most abundant. It shows that the plant water in the dry mountain foothills in the rainy season preferentially uses the surface water of the soil and does not directly use the precipitation. The soil water mainly supplies the groundwater. In the dry season, plant water is most abundant, and the isotopic values of groundwater and soil water are close. It shows that the soil water in the dry mountain foothills is mainly recharged by groundwater in the dry season. According to the natural resources survey report of the Shiyang River Basin, the buried groundwater level in the arid piedmont area is 2.5-15 meters, and the groundwater burial is relatively shallow, making the soil water in the arid foothills mainly recharged by groundwater in the dry season.

6. **In the discussion section, why only discuss the impact of temperature and altitude on SPAC? Why are other factors not discussed?**

Response: Dai et al. (2020) pointed out that local factors, especially local temperature, mainly control the change of stable isotope precipitation in mid-latitudes. In this study, the Shiyang River Basin is located in the arid area of the northwest inland. The isotope precipitation effect is not significant, and the temperature effect is substantial. And because the Shiyang River Basin is mainly affected by advection water vapor, the elevation effect of isotopes is obvious. Therefore, only the influence of temperature and altitude on SPAC will be discussed in the Discussion. In order to compare temperature and altitude with other factors, we added the influence of other control factors on the isotope composition of SPAC in the discussion. To compare temperature and altitude with other factors, we added the influence of other control factors on the isotope composition of SPAC in the Discussion.

7. **Line 240-241: This phenomenon shows that precipitation plays a major control role in the water cycle of precipitation-soil-plants. What does this phenomenon mean**?

Response: This phenomenon means that along with the change of precipitation-soil water-plant water, forest $\delta^{18}O$ is gradually enriched. In contrast, soil water isotopes in arid foothills and alpine meadows are most depleted in summer. In other seasons, $\delta^{18}O$ is enriched along precipitation-soil water-plant water. In summer, the alpine meadow has a lot of precipitation and the soil has a lot of water. However, due to the low temperature (average summer temperature of 9.80℃), water is not easy to evaporate, and soil water isotopes of alpine meadows are relatively depleted in summer. In summer in the arid foothills, especially in August, although the temperature is relatively high (the average summer temperature is 23.92℃), the precipitation is low, the soil water content is low, and the soil water isotope is somewhat depleted. So soil water isotope and plant water isotope are affected by precipitation isotope, and precipitation isotope plays a significant control role in precipitation-soil water-plant water.

8. **Line 241-242: "Previous studies have shown that local factors, especially local temperature mainly control the stable isotope changes of precipitation in mid-latitudes". The author does not mention any information about the previous research in the manuscript, such as the source of the research.**

Response: We have added the publication information of the reference.

Hans, P. P. 2009. Data Transformation in Statistical Analysis of Field Trials with Changing Treatment Variance. *Agronomy Journal*(4), doi:10.2134/agronj2008.0226x.

9. **Line 248-250: "From alpine meadow to arid foothills, the correlations between temperature and soil are 0.41, 0.30, and 0.19, respectively, and the correlations with plants are 0.24, 0.27, and 0.25, respectively". How are these correlation coefficients obtained?**

Response: These correlation coefficients are obtained by analyzing the correlation between temperature and soil and plants in alpine meadows, forests, and arid foothills. Because the temperature effects of soil water isotope and plant water isotope are not as significant as precipitation isotope, and precipitation isotope plays an important control role in SPAC, the description of soil water isotope and plant water isotope temperature effect is less important in this article.

10. **Section 4.2: In this part, the author mainly discusses altitude and precipitation isotope, but the description of the relationship between soil water isotope and plant water isotope and altitude is too little.**

Response: We have added a description of the relationship between plant water isotope and altitude and the relationship between soil water isotope and altitude.

The study area is divided into the rainy season (May-September) and dry season

(10-April of the following year), and the relationship between altitude and isotope is analyzed (Fig. 7). The altitude effect of precipitation isotope is stronger than the relationship between soil water isotope and altitude and the relationship between plant water isotope and altitude, but the relationship between plant water δD and altitude in the rainy season is stronger than the relationship between soil water δD and altitude. It shows that in SPAC, precipitation isotope is most affected by altitude, and plant water isotope is least affected by altitude. As the quality of water vapor rises along the hillside, the temperature continues to decrease, and the isotopic values of precipitation continue to be consumed. From the arid foothills to alpine meadows, the elevation rises from 2097m to 3647m. The average values of precipitation isotopes $\delta^{18}O$ and δD changed from -7.33‰ to -9.10‰, and from -48.62‰ to -54.93‰, respectively. The rate of change was -0.11‰$(100m)^{-1}$, -0.41‰$(100m)^{-1}$, In the globally recognized precipitation δ18O altitude gradient range, this rate of change is -0.28‰ $(100m)^{-1}$ (Porch and Chamberlain, 2001). The squares of correlation coefficients between $\delta^{18}O$ and δD of rainy season precipitation and altitude are 0.79 and 0.98. The rate of change is -0.12‰$(100m)^{-1}$ and -1.05‰$(100m)^{-1}$, respectively. In the dry season, the correlation coefficient squares of $\delta^{18}O$ and δD with altitude are 0.88 and 0.90, respectively, and the rate of change is -0.18‰$(100m)^{-1}$ and -0.79‰$(100m)^{-1}$, respectively. It can be seen that the altitude effect of precipitation $\delta^{18}O$ is stronger in the dry season (R^2=0.88) than in the rainy season (R^2=0.79), and the altitude effect of precipitation δD is stronger in the rainy season (R^2=0.98) than in the dry season (R^2=0.90). The relationship between soil water isotope and altitude is stronger in the rainy season (R^2=0.26, R^2=0.73) than in the dry season (R^2=0.28, R^2=0.26). The relationship between plant water $\delta^{18}O$ and altitude is stronger in the dry season (R^2=0.11) than in the rainy season (R^2=0.11), and the relationship between plant water δD and altitude in the rainy season (R^2=0.62) is stronger than that in the dry season (R^2=0.56). It can also be seen from the figure that there are anti-elevation shows in some areas, mainly from forests to dry foothills. This may be related to the existence of reservoirs in the arid foothills. Reservoirs may cause the reversal of the local water vapor cycle-the anti-elevation effect. Generally speaking, there is a negative correlation between altitude and SPAC isotope composition. The altitude effect of precipitation isotope is stronger than the relationship between soil water isotope and altitude, and stronger than the relationship between plant water isotope and altitude.

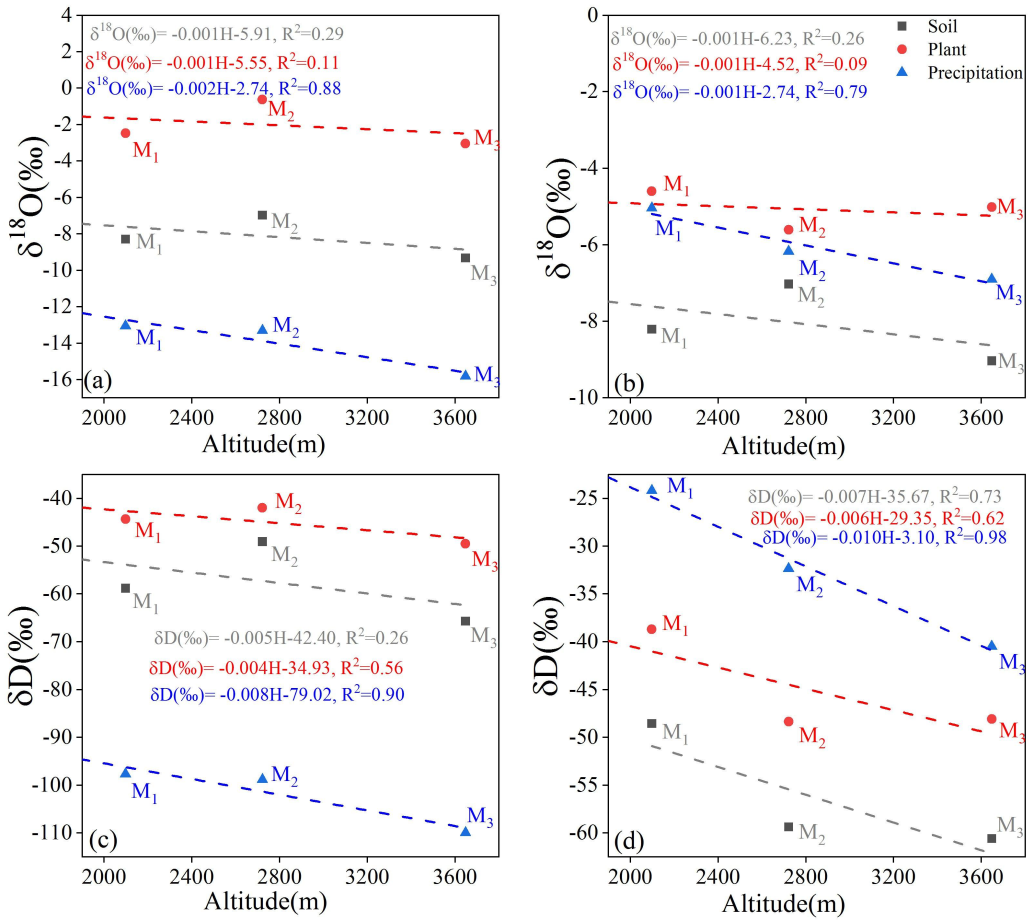

Fig.7 Relationship between different isotope and altitude in the dry season (a, c) and in the rain season (b, d), M_1 stands for alpine meadows, M_2 stands for forests, and M_3 stands for arid foothills

11. **Line 255-256: "...the correlation between the isotope of precipitation in the arid mountain foothills and the temperature fails the significance test." Why fails the significance test?**

Response: When the temperature is lower than 0 degrees celsius, there may be solid precipitation in the alpine meadows in the upper reaches of the Shiyang River Basin. At the same time, there is almost no precipitation in the middle and lower reaches. As the precipitation samples in the arid foothills are few and mainly concentrated in summer, when the temperature is lower than 0 degrees celsius, the correlation between precipitation isotope and temperature failed the significance test. In future research, it is necessary to strengthen the long-term systematic observation of the middle and lower reaches of the Shiyang River Basin, especially the arid piedmont area, and obtain more precipitation samples below 0°C, to more accurately analyze the impact on precipitation isotope.

Minor comments:

1. In the abstract, the author directly proposed SPAC, the author did not give any explanation about wahst is SPAC.

Response: We have added a description of SPAC in the abstract.

2. Line 28: the reference is incorrectly cited.

Response: The order of reference has been modified.

Song et al. 2002; Gao et al., 2009; Coplen, 2013; Shou et al. 2013

3. Part 2.3, the font size of the formula (1-1) , (2-1) to (2-4) are different.

Response: We have unified the font and size of all formulas in this article.

4. Line 47: change "The content of the SPAC hydrological cycle research are dramatically enriches and expands" to "The content of SPAC hydrological cycle research has been greatly enriched and expanded".

Response: We have adjusted this sentence according to your suggestion.

5. In the manuscript, some formats are not standardized, and some letters

should be superscripts, such as in line 34, 18O ; line 57, δ18O; line 88, 15.75×108.

Response: We have standardized all the formats in the text.

6. The scientific counting method of temperature in this manuscript is inconsistent, as in section 4.1: 9.8℃, 23.92℃.

Response: We have unified the scientific counting method of all the numbers in the article.

7. Line 88: change 15.75×108 km3 to 1.58×10^8 km^3.

Response: We have changed 15.75×10^8 km3 to 1.58×10^8 km3.

8. Lin 89-91: please add the corresponding references.

Response: We have added the publication information of the reference.

Zhou, J. J.,Zhao, Y. R., Huang, P., and Liu. C. F. 2020. Impacts of ecological restoration projects on the ecosystem carbon storage of inland river basin in arid area, China. Ecological Indicators. doi:10.1016/j.ecolind.2020.106803.

9. Improve the clarity of Figure 1 to Figure 4 to make it easier to obtain relevant information from the diagram.

Response: We have adjusted the clarity of the pictures, and re-drawn some pictures to facilitate readers to obtain relevant information from the pictures more intuitively.The revised figure is shown below:

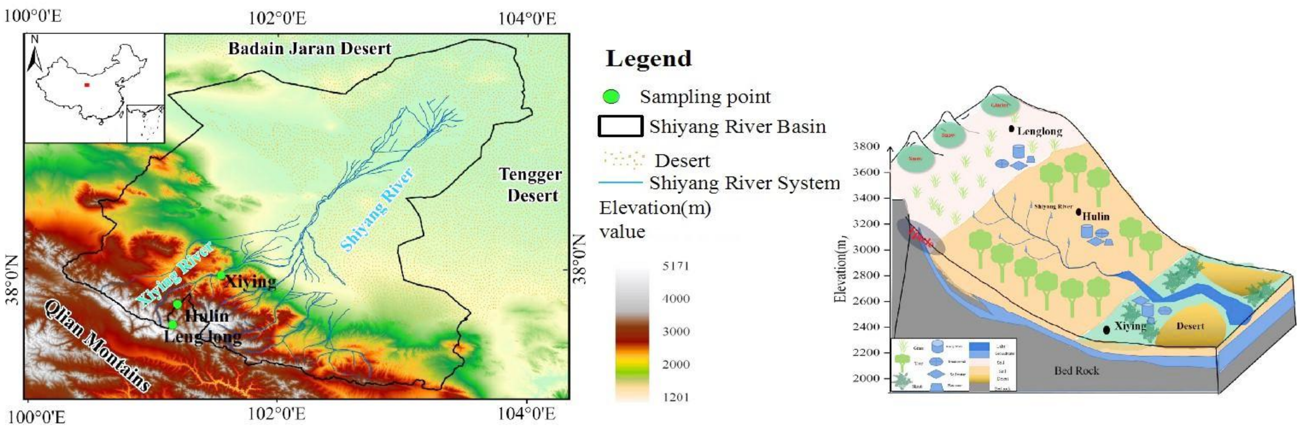

Fig. 1 Study area and observation system

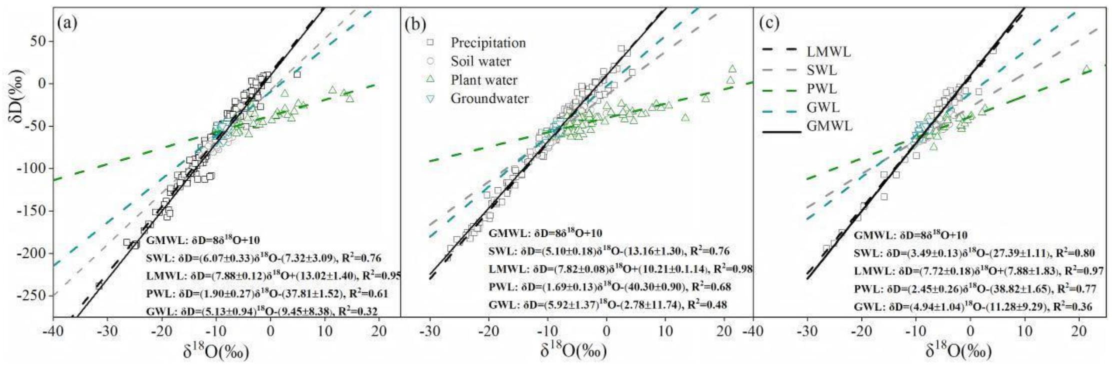

Fig.3 Relationship of stable isotopes in different water bodies in alpine meadow (a), forest (b) and arid foothills (c)

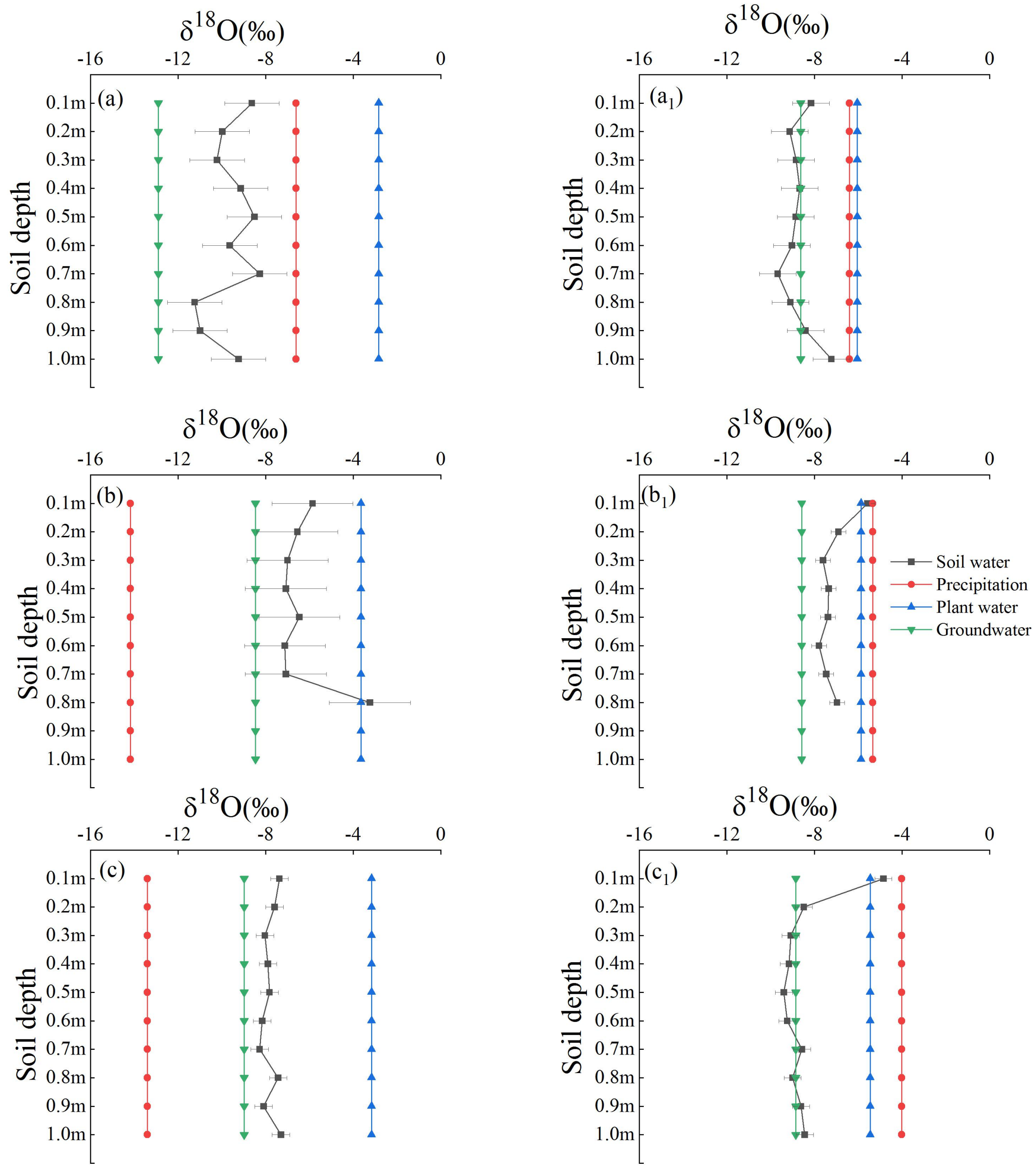

Fig. 4 (a)-(c) represents the variation of $\delta^{18}O$ of soil, plant, precipitation and groundwater with soil depth in the alpine meadow, forests and arid foothills in the dry season, and (a_1)-(d_1) represents the variation of δ18O of soil, plant, precipitation and groundwater in the alpine meadow, forests and arid foothills in the rainy season

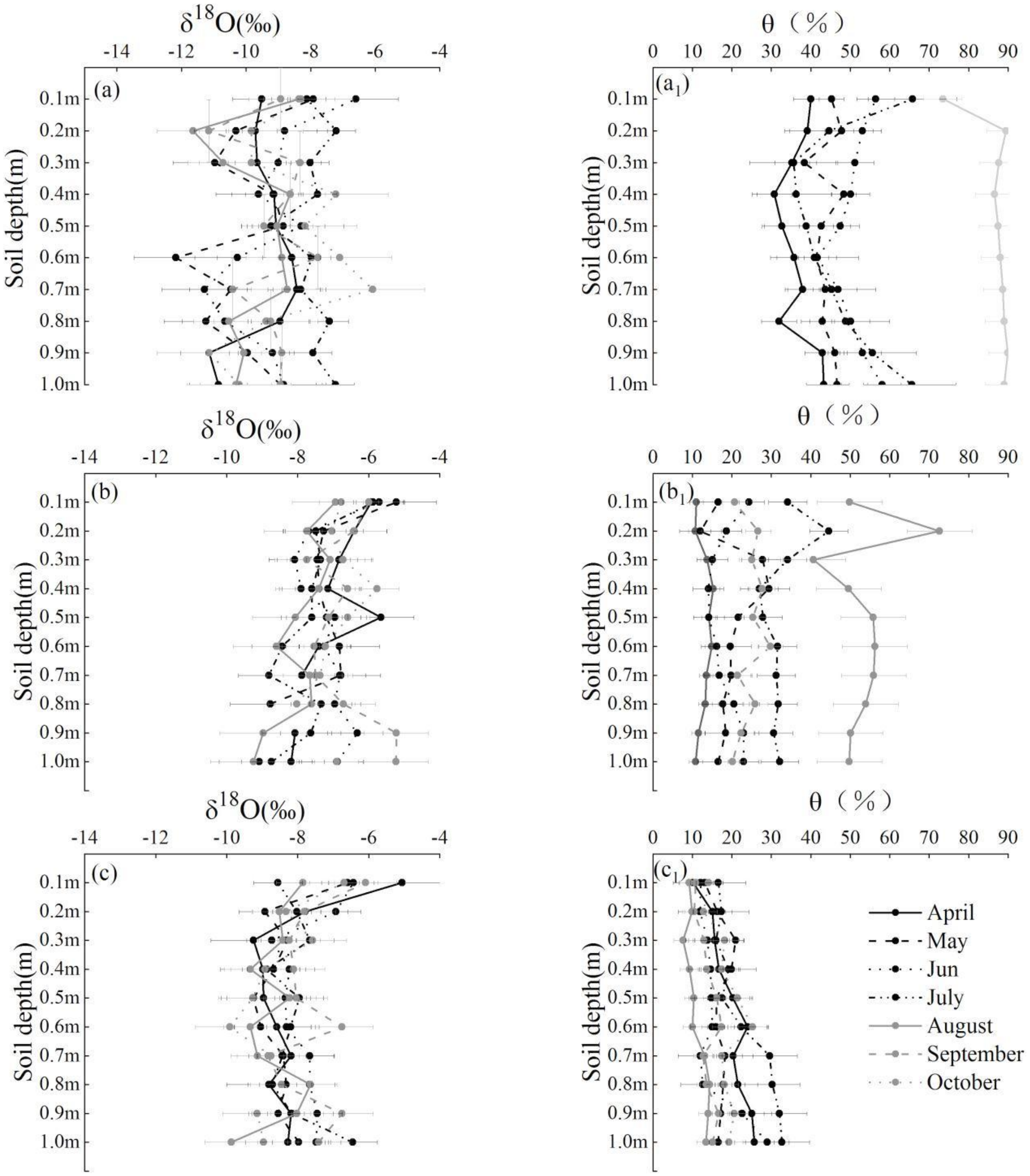

Fig.5 The variation of $\delta^{18}O$ and soil water content (θ, %) with soil depth. (a)-(c) represent alpine meadow, forests and arid foothills, respectively

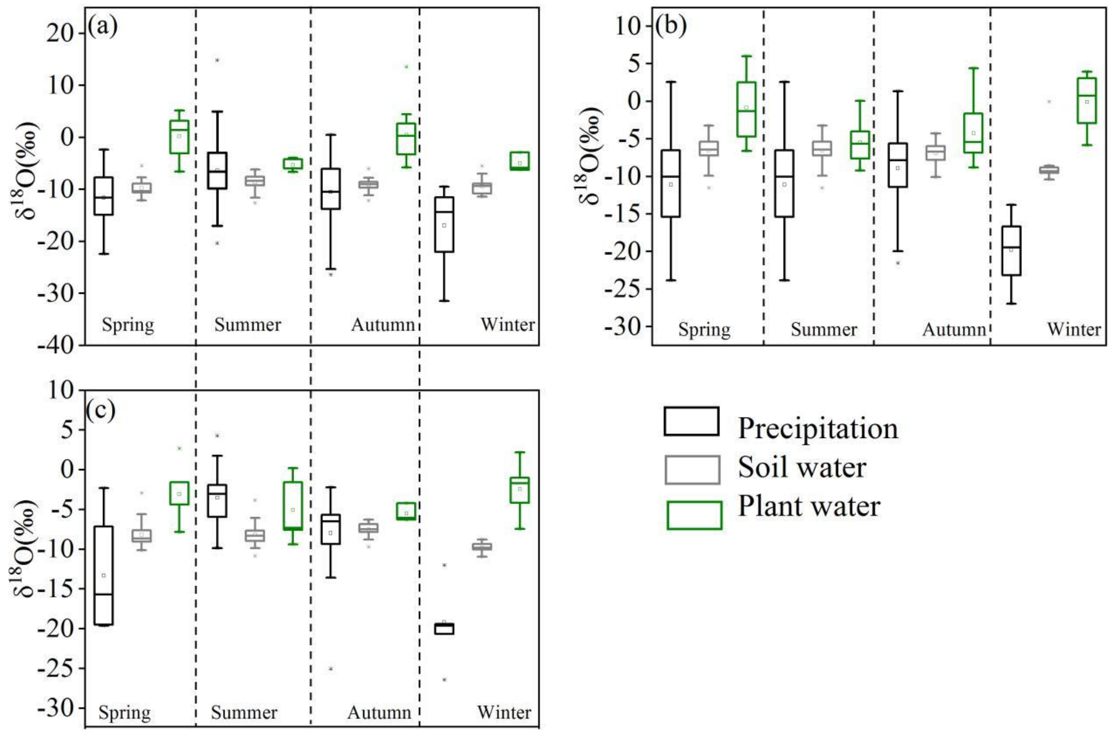

Fig. 6 Seasonal variations of different water isotopes in alpine meadow (a), forests (b) and arid foothills (c)

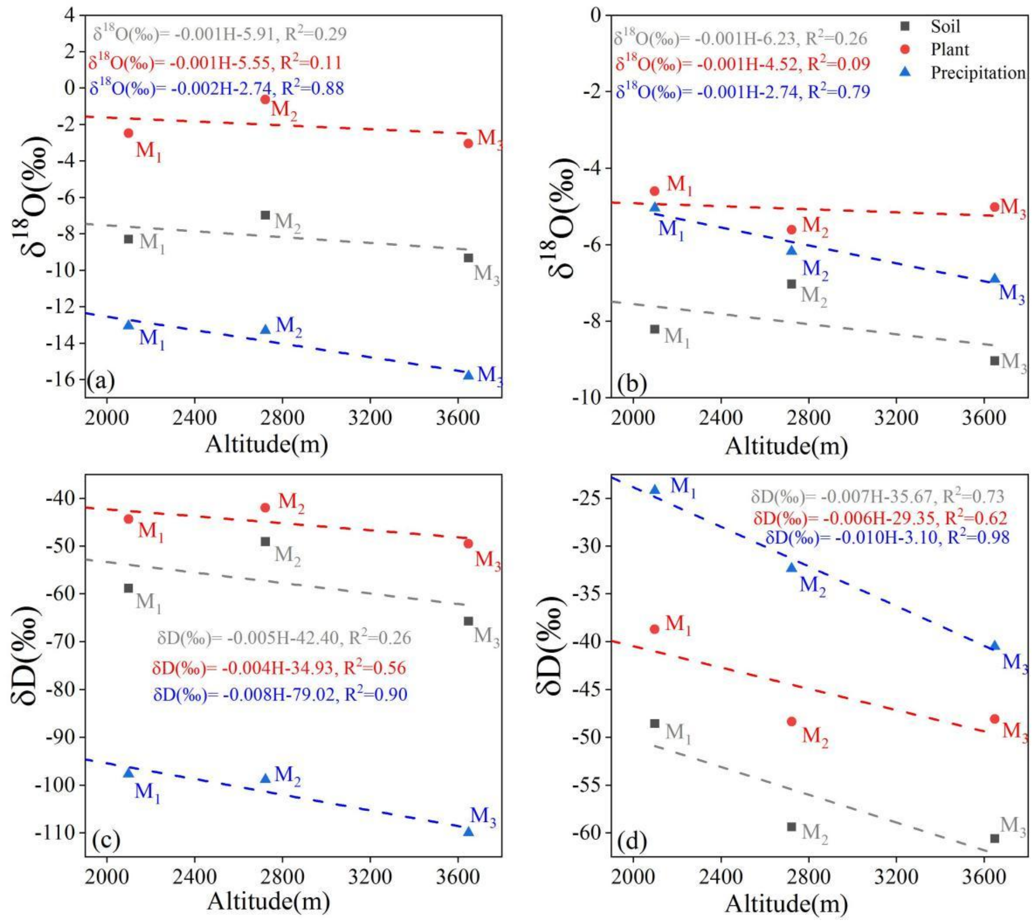

Fig. 7 Relationship between different isotope and altitude in the dry season (a, c) and in the rain

season (b, d), M_1 stands for alpine meadows, M_2 stands for forests, and M_3 stands for arid foothills

10. Line 226 and line 228: In order to maintain consistency, please change "arid piedmont" to "arid foothills".

Response: We have unified the terminology in the text.

11. Line 256: Please pay attention to the spaces between the text , such as change "0°Cand" to "0°C and'.

Response: We have unified all the spaces in the text.