1. Introduction about the revision

Based on the suggestions and comments from reviewers, the paper has been substantially improved again. In this revision, a great deal of time has been spent for improving the language and general presentation again. And what's more, we supplemented the uncertainty analysis as suggested by the reviewer, the difference between glacial melt water and snow melt water also was discussed and some minor revisions have been made in order to present the results with more proper styles. In addition, we also revised the abstract, conclusion and other details of the article. The changes have been marked in red.

2. Response to reviewer comments

Response to Reviewer#1

It's my pleasure to review this manuscript. Qilian Mountain is the transition zone between the Tibetan Plateau and the arid region, which is important for regional water resource management. This study conducts a comprehensive and detailed analysis on the hydrological process in this region based on solid and abundant isotope data. The results are helpful for understanding the role of cryosphere on runoff processes, which make this manuscript worth publishing. I recommend to accept this manuscript after moderate revisions to address following general and specific comments.

General comments:

English writing: The English writing of this manuscript should be improved thoroughly. The issues include the choice of word, grammar issue and the structure of sentence. I suggest the authors to ask some native English speaker to edit the language, or use some English editing software (e.g., Grammarly).

Thank you very much for your comments. We have spent a great deal of time for improving the language and general presentation again to make the full text accurate and fluent.

Definition of water sources: The author considers the glacier and snow meltwater as one water source in experiment and analysis. However, I think it is better to distinguish glacier and snow melt. Glacier melt water comes from glacier, which can be regarded as the solid water storage. Snowmelt comes from snowpack, which is formed by the seasonal snowfall (a part of precipitation). If snow and glacier is not distinguished when designing the sampling work, I suggest the authors to make some discussion on this issue.

Thank you very much for your comments. Glacier and snow meltwater are the runoff formed by glacier ice and snowmelt water on the surface of glaciers flowing into river channels. Samples for this study were collected from May to October at the end of the glacier, the snow covering the glacier begins to melt in March and April as the weather warms, and by May there is very little left. By June, the snow has melted and the water flowing into the channel is glacial meltwater. Snow cover at the end of the glacier had little effect on runoff segmentation, so we didn't analyze the snow melt water and glacier melt water separately. At the same time, we have discussed this phenomenon in the paper. Thanks again for your valuable advice.

Uncertainty issue: The contribution of water sources is calculated by end-member mixing analysis. The average isotope composition is used to represent each end member. However, considering the isotope composition has strong spatial and temporal variation (especially for precipitation), the uncertainty of the EMMA result must be addressed. Please use some common method to quantify the uncertainty.

Thank you very much for your comments. We have supplemented the method of uncertainty analysis and analyzed the uncertainty in hydrograph separation of runoff sources and in the result section, the uncertainty analysis is added.

Specific methods are as follows: The uncertainty of tracer-based hydrograph separations can be calculated using the error propagation technique (Genereux, 1998; Klaus & McDonnell, 2013). This approach considers errors of all separation equation variables. Assuming that the contribution of a specific streamflow component to streamflow is a function of several variables c1, c2, …, cn and the uncertainty in each variable is independent of the uncertainty in the others, the uncertainty in the target variable (e.g.,the contribution of a specific streamflow component) is estimated using the following equation (Uhlenbrook & Hoeg,2003):

$$W_{f_x} = \sqrt{\left(\frac{\partial z}{\partial c_1} W_{c_1}\right)^2 + \left(\frac{\partial z}{\partial c_2} W_{c_2}\right)^2 + \cdots + \left(\frac{\partial z}{\partial c_n} W_{c_n}\right)^2}, \quad (5)$$

where W represents the uncertainty in the variable specified in the ubscript. fx is the contribution of a specific streamflow component x to streamflow. The software package MATLAB is used to apply equation 5 to the different hydrograph separations in this study.

The results are as follows: Using the approach shown in Eq. (5), the uncertainty originating from the variation in the tracers of components and measurement methods can be calculated separately (Pu et al., 2013). The uncertainty was estimated to be 0.04 for the three-component mixing model in the study region. The uncertainty terms for the supra-permafrost water accounted for more than 47% of the total uncertainty, indicating that the δ18O variations in the supra-permafrost water accounted for majority of the uncertainty. Although there is some uncertainty in hydrograph separation, isotope-based hydrograph separations are still valuable tools for evaluating the contribution of meltwater to water resources and particularly helpful for improving the understanding of hydrological processes in cold regions, where there is a lack of observational data.

Specific comments:

L25: change 90 years to 1990s

Thank you very much for your comments. We have changed "90 years" to "1990s"

L47: Immerzeel et, al. 2010

Thank you very much for your comments. We have changed "Immerzeel et al,.2010" to "Immerzeel et al., 2010"

L139-142: The permafrost area is also according to glacier inventory?

Thank you very much for your comments. permafrost area is calculated from the permafrost dataset of the Qinghai-Tibet Plateau. We have changed "According to the second glacier inventory of China, there are 2859 glaciers in the Qilian Mountains, with a total area of 1597 km^2, and the total areas of glacier reserve and permafrost are 84.48×10^8 m^3 (Sun et al., 2015a), and 9.39×10^4 km^2 (Zhou et al., 2000), respectively." to "According to the second glacier inventory of China and permafrost dataset of the Qinghai-Tibet Plateau, there are 2859 glaciers in the Qilian Mountains, with a total area of 1597 km^2, and the total areas of glacier reserve and permafrost are 84.48×10^8 m^3 (Sun et al., 2015a), and 9.39×10^4 km^2 (Zhou et al., 2000), respectively."

L161: Better to provide some basic information of the precipitation samples, such as the number of station, and sampling frequency.

Thank you very much for your comments. We have updated the details of precipitation in sample collection sample collection and analysis, specific as follows: An observation network of precipitation stable isotope including 19 sampling stations in the Qilian Mountains was established (Fig. 1), and 1310 groups of precipitation samples were collected during 2012–2018 in Menyuan, Huangyuan, Gulang, Qilian, Yeniugou, Tuole, Minle, Gangcha, Tianjun, Jiayuguan ,Jiutiaoling, Xidahe, Changma, Daiqian, Anyuan, Suli, Ebao ,Hulugou and Binggou . All the precipitation events were collected according to the definition of precipitation event stipulated by meteorological observation, that is, all the precipitation from 20:00 of the same day to 20:00 of the next day was defined as a precipitation event, and a sample was collected.

L183: change the title to "Meteorological and hydrological data"

Thank you very much for your comments. We have changed "Hydrological data" to "Meteorological and hydrological data"

L262: rewrite the sentence "and the weak time variation first increased and then decreased"

Thank you very much for your comments. We have changed "In general, from May to October, fluctuations in $\delta^{18}O$ were small, and the weak time variation first increased and then decreased" to "In general, from May to October, fluctuations in $\delta^{18}O$ were small, and the overall trend is increasing first and then decreasing"

L297-300: rewrite this sentence.

Thank you very much for your comments. We have changed this sentence to "This phenomenon can be explained by the following reasons: First, supra-permafrost water is mainly stored in the active layer of the permafrost, and under the strong evaporation, the stable isotope concentration would be unbalanced through the influence of dynamic fractionation. Second, the supra-permafrost water is replenished by a mixture of precipitation, glacier and snow meltwater, resulting in random fluctuations in stable isotope concentrations."

L322: change 'less' to 'more depleted', 'more' to 'more enriched'

Thank you very much for your comments. We have changed "less" to "more depleted", changed "more than" to "more enriched" and changed this sentence to "For example, in the Danghe River, in May and October, $\delta^{18}O$ was more depleted -11‰, while in February, it was more enriched -9‰"

L326: The paragraph (L326-336) is not a 'conclusion' of above paragraph (L317-325). Consider to combine them and simplify.

Thank you very much for your comments. We have revised this paragraph and combined them into above section. Specific as follows: The maximum monthly mean values of $\delta^{18}O$ in the HIRS, USYR, and QIRS were in September, February, and October, respectively, while the minimum monthly mean values were in May, July, and June, respectively. because of the long distance from west to east in the HIRS, the $\delta^{18}O$ values of different rivers varied greatly. For example, in the Danghe River, in May and October, $\delta^{18}O$ was more depleted -11‰, while in February, it was more enriched -9‰. the δ18O of river water in the Shule River in the western segment fluctuated greatly compared with the three rivers in the Shiyang River Basin in the eastern segment. In terms of average values, the Heihe River Basin in the middle reaches was the greatest, followed by the Shiyang River Basin in the eastern part, while the Shule River Basin in the western part was significantly negative. with an average value of -9.97‰, which was generally negative. The $\delta^{18}O$ in the river water of the Heihe River, located in the middle Qilian Mountains, was positive, with an annual average of -7.75‰ and -6.79‰ in April.

In the USYR system, except for the Jinqiang River, the river water $\delta^{18}O$ values of the Huangshui and Datong Rivers were relatively positive, with mean values of -7.76‰ and -7.58‰, respectively. The $\delta^{18}O$ values of river water in the Jinqiang River were relatively negative, with large fluctuations. In the QIRS, because of the large extent of uninhabited areas, sampling was conducted only in the Buha River, where the $\delta^{18}O$ ranged from -9.47‰ to -7.96‰, with a mean of -8.59‰. In terms of its weak seasonal variation, the maximum occurred in October and the minimum occurred in June.

L346-348: The isotopic difference between river and precipitation should indicate that the recharge source is not precipitation. Please check.

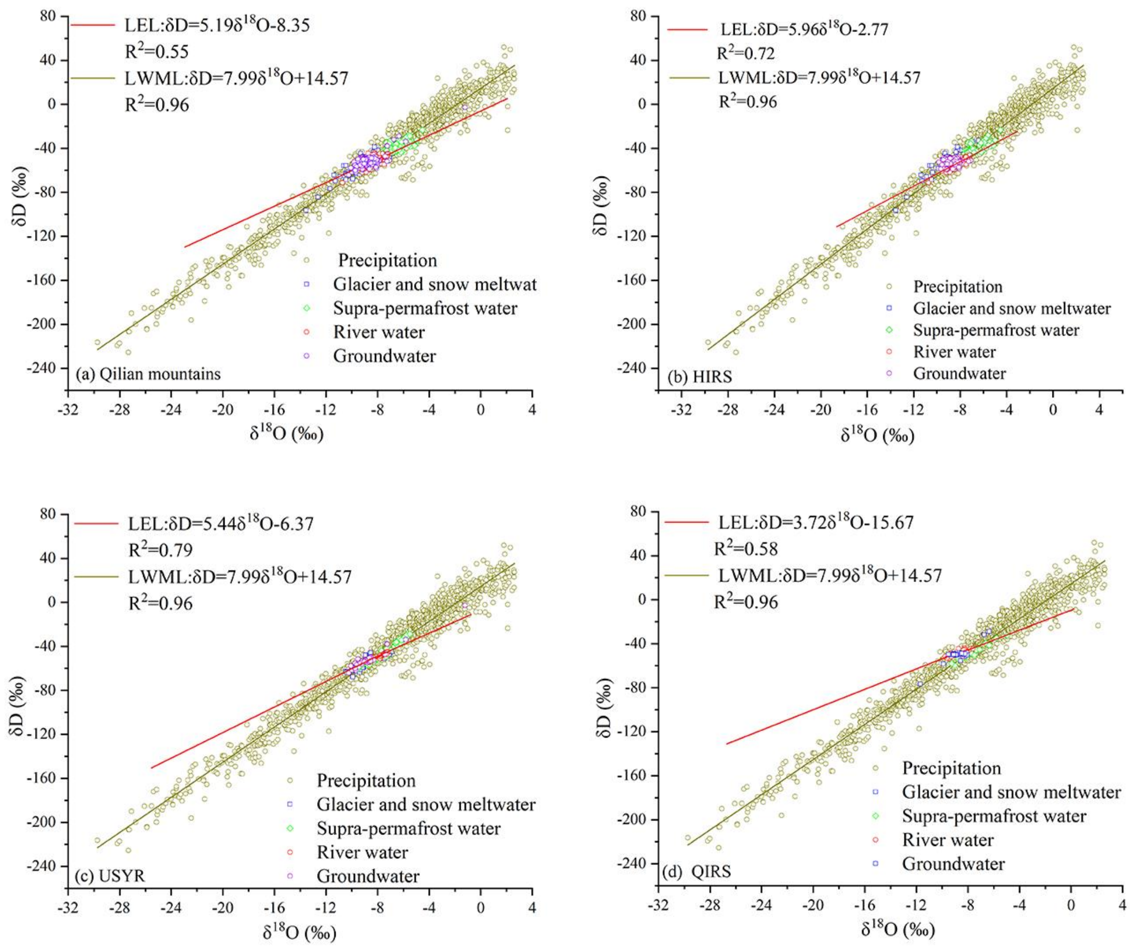
Thank you very much for your comments. We have checked and changed it to "However, there is a significant difference between $\delta^{18}O$ in river water and precipitation, which indicates that the potential recharge source of these three river systems is not only precipitation." At the same time, the isotopic relationship between river water and various water sources is shown in Fig.8. The stable isotopic compositions of river water and groundwater were close to the LMWL, and their values were between those of precipitation, glacier and snow meltwater, and supra-permafrost water, indicating that river water was fed by all of these. isotopic difference between river and precipitation should indicate that the recharge source is not precipitation

L369-372: Please rewrite.

Thank you very much for your comments. We have changed this sentence to "For glacier and snow meltwaters, it distributed in the center of the LMWL, while the supra-permafrost water is mainly distributed below the LMWL."

L372: groundwater is not shown in the legend.

Thank you very much for your comments. We have replenished the legends of the groundwater in Fig. 1. The details are as follows:



L405: What does ‘as the third end-member’ mean?

Thank you very much for your comments. In this study, End-member mixing analysis (EMMA) was used to determine the contribution ratio of different water sources to runoff. Through the analysis of relationships of stable isotopes between river water and various water sources. We determined that rivers are fed by precipitation, meltwater, and supra-permafrost water. The precipitation, supra-permafrost water, and glacier and snow meltwater were taken as three end-members to calculate the contribution of each endmember to the river.

L413: Change clearly to significantly

Thank you very much for your comments. We have changed “clearly” to “significantly”

L470-472: Please rewrite

Thank you very much for your comments. We have changed this sentence to “The temperature and precipitation in July and August reached the highest value in the year with the melting depth of the active layer for permafrost further increases and the water absorption is enhanced”

L474: ‘directly’ or ‘slowly’? On my understanding, here it should be a word opposite to ‘rapidly’.

Thank you very much for your comments. We have changed “‘directly” to “slowly”

L483-484: When temperature decreases, the soil begins to freeze. Why can permafrost layer release water?

Thank you very much for your comments. As temperatures rise, permafrost regions begin to melt, thickening the active layer of permafrost and storing large amounts of rainwater in it. When the temperature starts to drop and the permafrost area starts to freeze, the active layer of permafrost releases the stored water and feeds the river.

L502-505: Please rewrite

Thank you very much for your comments. We have changed this sentence to “In the western section of the Qilian Mountains, the contribution of precipitation to Shule River was between 50% and 65%, for the Heihe River, located in the middle of the Qilian Mountains, the contribution was approximately 60%-70%, and at the Shiyang River in the eastern part of the Qilian Mountains, the contribution of precipitation was approximately 75%-80%.”

4.1.1: Try to make some discussion on the pattern of meltwater's contribution, rather than simply list the results.

Thank you very much for your comments. We have made some discussion on the pattern of meltwater's contribution as “Different types and sizes of glaciers have different sensitivities to climate change that lead to significant differences in their processes of runoff yield and concentration. The contribution of glacier meltwater to mountain runoff showed significant spatial differences. Glacial meltwater and its contribution to runoff in cold basins is controlled by the number, size, area ratio, and storage capacity of glaciers in the basin. In general, the larger the scale of the glacier, the higher the ice reserves, more glacier and snow melting water can be provided. Secondly, climate conditions, especially temperature changes, have a great influence on the amount of glacier and snow melting water. As a result, the contribution of meltwater to runoff varies from river to river because of differences in the glaciers themselves and differences in climate conditions and sampling times.”

L515: Change the word ‘production and confluence’

Thank you very much for your comments. We have changed these words and changed this sentence to “Different types and sizes of glaciers have different sensitivities to climate change that lead to significant differences in their processes of runoff yield and concentration.”

Table 1. Providing drainage area and glacier cover area of each river. Add horizontal lines between different Drainage areas. Otherwise, reader may think Datong River is belong to HIRS.

Thank you very much for your comments. We have supplemented drainage area and glacier cover area of each river in Table 1.

Data type			glacier data		Hydrological data	
Drainage	River	River basin	Glacier area/km^2	Source	Period	Source
HIRS	Danghe River	Shule river	203.77	Sun et al.,2015	1990-2020	HWRBGS
	Changma River		509.87	Sun et al.,2015	1990-2020	HWRBGS
	Taolai River	Heihe river basin	78.33	Sun et al.,2015	1990-2020	HWRBGS
	Heihe River				1990-2020	HWRBGS
	Xiying River	Shiyang River Basin	39.94	Sun et al.,2015	1990-2020	HWRBGS
	Nanying River				1990-2020	HWRBGS
	Zamu River				1990-2020	HWRBGS
USYR	Datong River	Datong River Basin	20.83	Sun et al.,2015	1990-2020	HWRBGS

	Jinqiang River	Jinqiang River basin	---	---	1990-2020	HWRBGS
	Huangshui River	Huangshui Rive basin r	----	------	1990-2010	Zhang et al,.2014
QIRS	Buha River	Buha River basin	10.27	Sun et al.,2015	1990-2016	Liu et al,.2020

Figure 8: This figure should be the relationship between 2H and 18O in different water bodies, rather than the relationship of isotope between river water and various water sources. The figure title is misleading.

Thank you very much for your comments. We have changed the title of this graph to "Relationships of $\delta^{18}O$ and δD between river water and various water in (a) Qilian mountains, (b) HIRS, (c) USYR, (d) QIRS"

Response to Reviewer#2

In this work, Gui et al. has e quantified the runoff components of 11 major rivers in the Qilian Mountains and investigated the influence of cryosphere changes on mountain runoff based on 2164 environmental isotope samples in the transition zone between the Tibetan Plateau and the arid region. The data of this paper is very comprehensive and the method is reasonable. The analysis of this article is in a good logic. In general, this study is interesting. However, there are still some places that need to be revised, and I will mention it and suggest that the author supplement it. I suggested that this manuscript should be published after minor modifications.

1. The abstract lacks the improvement of the research height, and the practical application and scientific significance of this research should be summarized concisely.

Thank you very much for your comments. The abstract has been revised as: "As the transition zone between the Tibetan Plateau and the arid region, the Qilian Mountains are important ecological barriers and source regions of inland rivers in northwest China. In recent decades, drastic changes in the cryosphere have had a significant impact on the formation process of water resources in the Qilian Mountains. In this study, 2164 environmental isotope samples were used to quantify the runoff components of 11 major rivers in the Qilian Mountains and to investigate the influence of cryosphere changes on mountain runoff. The results showed that the mountain runoff mainly comes from the cryosphere belt, which contributes to approximately 82%、71%, and 80%, respectively, in the Hexi inland water system, upper stream of the Yellow River system, and Qinghai inland river system. The maximum contribution ratio of glacier and snow meltwater to runoff occurred in May, but not in July and August, when the temperature was the highest. The important contribution of supra-permafrost water to runoff gradually increased from May to October and reached approximately 40% in some rivers in October. Cryosphere degradation in the Qilian Mountains after 1990s has caused a rapid increase in runoff, a change in the peak runoff time, and an increase in runoff in winter. These changes in hydrological processes bring opportunities and challenges to managing inland river water resources, and various adaptive measures to seek advantages and avoid disadvantages have been proposed. The findings from environmental isotope analysis provide insights into understanding water resources and realizing harmony of life, agriculture, industry, and ecological water use."

2. Line 19 please change “in the Hexi inland water system” to “in the Hexi inland River system”

   Thank you very much for your comments. It has been revised as: “in the Hexi inland River system"

3. I respectfully suggest that brief subsections on laboratory analysis, using what instruments and where, and data analysis in Sample collection and analysis.

   Thank you very much for your comments. In 2.3.1 sample testing, these details have been introduced. The details are as follows: All kinds of water were carried out in the Key Laboratory of Eco-hydrology of Inland River Basin, Chinese Academy of Sciences to analysis of the hydrogen and oxygen stable isotopes. For the analysis stable isotopes of soil water, water was extracted from soil using a cryogenic freezing vacuum extraction system (LI-2000, Beijing Liga United Technology Co., Ltd., China), which can achieve complete extraction with high precision. Then the stable isotopes in the all kinds of water were measured using a liquid water stable isotope analyser (Model DLT-100, Los Gatos Research, Inc., Mountain View, CA, USA). The accuracies of 18O/16O and D/H were 0.2‰ and 0.5‰, respectively, which conform to the rule of valid digits for stable isotope analysis.

4. L296-301: rewrite this sentence. This sentence is not clear. Please rewrite

   Thank you very much for your comments. We have revised this sentence as: “This phenomenon can be explained by the following reasons: First, supra-permafrost water is mainly stored in the active layer of the permafrost, and under the strong evaporation, the stable isotope concentration would be unbalanced through the influence of dynamic fractionation. Second, the supra-permafrost water is replenished by a mixture of precipitation, glacier and snow meltwater, resulting in random fluctuations in stable isotope concentrations.”

5. Please explain the term of d-excess.

Thank you very much for your comments. We have explained d-excess in Section 2.3.1 as “The d-excess can be defined as:

$$\text{d-excess}=\delta D-8\delta^{18}O \qquad (2)$$

The value of d-excess is equivalent to the intercept when the slope of local meteoric water is 8, which is used to represent the imbalance degree of the evaporation process."

6. L322: change ‘less’ to ‘more depleted’, ‘more’ to ‘more enriched’

Thank you very much for your comments. We have changed ‘less’ to ‘more depleted’, changed ‘more’ to “more enriched”.

7. Please make sure the citation appeared in the article are consistent with those listed in the Reference part.

Thank you very much for your comments. We have checked the full text carefully to make sure the citation appeared in the article are consistent with those listed in the Reference part.

8. L403-405: change “The contribution of supra-permafrost water to Danghe, Changma, Taolai, Heihe, Xiying, Nanying, and Zamu Rivers was…” to “Danghe River, Changma River, Taolai River, Heihe River, Xiying River, Nanying River, and Zamu River”.

Thank you very much for your comments. We have changed “The contribution of supra-permafrost water to Danghe, Changma, Taolai, Heihe, Xiying, Nanying, and Zamu Rivers was…” to “Danghe River, Changma River, Taolai River, Heihe River, Xiying River, Nanying River, and Zamu River”.

9. L470-472: This sentence is not clear. Please rewrite

Thank you very much for your comments. We have changed this sentence to “In June, the contribution of precipitation to runoff from mountains in the HIRS, USYR system, and QIRS was 73%, 64%, and 72%, respectively.”

10. Different styles have been used when citing figures in the text. Such as 'Figure(s)' and 'Fig(s)'. Please unify them.

Thank you very much for your comments. We have checked the full text carefully and unify the format of figures.

11. The conclusion part is too long. I recommend rephrase this paragraph and state the importance of the findings.

Thank you very much for your comments. We have reorganized the conclusion to make clear the main findings of the study. The new conclusions are as follows: Based on the isotopic data of 1310 precipitation, 338 river water, 96 glacier and snow meltwater, 108 supra-permafrost water, and 312 groundwater samples, the study quantified the runoff components of 11 major rivers in the Qilian Mountains and investigated the influence of cryosphere changes on runoff from mountains. It was found that the stable isotopes of river water and groundwater in the study area were relatively invariable, unlike that of precipitation, which showed significant seasonal variation. The annual mean values of δ18O of river and groundwater in the Qilian Mountains were -8.49‰ and -8.76‰, respectively.

The stable isotope relationships of various waters showed that the river water was fed by precipitation, glacier and snow meltwater, and supra-permafrost water. EMMA was used to determine the contribution ratios of different water bodies to runoff. The calculations showed that precipitation was the main recharge source of seven rivers in the HIRS, the contribution ratios to Danghe, Changma, Qiaolai, Heihe, Xiying, Nanying, and Zamu Rivers being 65%, 51%, 69%, 59%, 75%, 80%, and 79%, respectively. Supra-permafrost water was also an important recharge source for the HIRS. The contribution of supra-permafrost water to Dang, Changma, Taolai, Heihe, Xiying, Nanying, and Zamu Rivers was approximately 21%, 33%, 20%, 33%, 19%, 15%, and 16%, respectively. As the third end-member, the corresponding glacier and snow meltwater contributed approximately 14%, 16%, 11%, 8%, 6%, 5%, and 5% to runoff, respectively. In the USYR system, the contribution of glacier and snow meltwater to the runoff was clearly low, the contribution ratios of precipitation, supra-permafrost, and glacier and snow meltwater to Datong River being 63%, 35%, and 2%, respectively. Jinqiang River was mainly replenished by precipitation and groundwater, which contributed 30% and 70%, respectively, while Huangshui River was mainly replenished by precipitation and supra-permafrost water, which contributed 83% and 17%, respectively. Located in the QIRS, the Buha River was mainly replenished by precipitation, supra-permafrost, and glacier and snow meltwater, with the contributions of these three end-members to the runoff being 58%, 40%, and 2%, respectively.

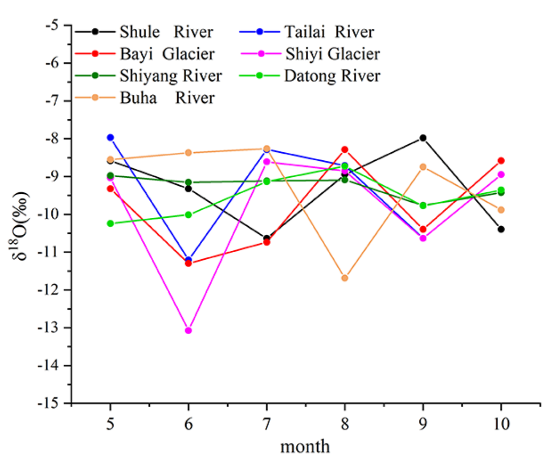
Runoff in the inland rivers of the Qilian Mountains is mainly derived from the cryosphere belt. Calculations using a binary mixed segmentation model showed that the contribution ratios of the cryosphere belt to mountain runoff in the HIRS, USYR system, and QIRS were 82%, 71%, and 80%, respectively. Cryospheric changes have changed the hydrological processes in the Qilian Mountains. After the 1990s, the runoff from the Qilian Mountains generally increased rapidly, the peak time of runoff changed, and runoff showed an increasing trend in winter. These changes in hydrological processes provide both opportunities and challenges, and requires various measures to exploit advantages and avoid disadvantages so as to achieve harmony in ecological, living, and production water use.

12. Please refer to the journal requirements to modify the format of the references

Thank you very much for your comments. We have modified the reference format as required to make it consistent with the journal format

13. Figure 3 is not clear. Please redraw it.

Thank you very much for your comments. We have re-edited Figure 3 to make it clearer



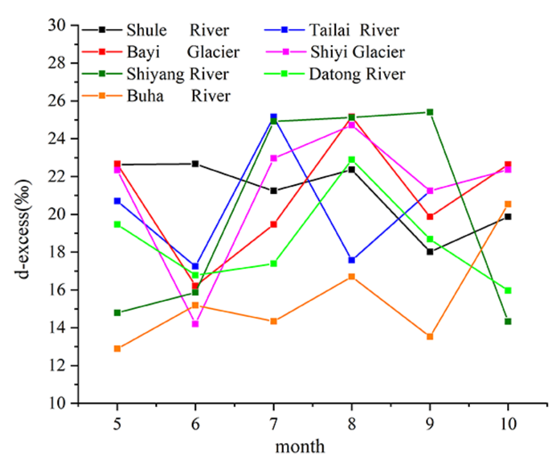


Fig.3

14. English writing: The English writing of this manuscript should be improved thoroughly. The issues include the choice of word, grammar issue and the structure of sentence.

Thank you very much for your comments. We have spent a great deal of time for improving the language and general presentation again.