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Stable water isotope monitoring network of different water bodies in Shiyang River Basin, a typical arid river in China

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Abstract: We have established a stable water isotope monitoring network in the Shiyang River Basin in China'arid northwest. The basin is characterized by low precipitation, high evaporation and dense population. It is the basin with the most significant ecological pressure and the greatest water resources shortage in China. The monitoring station covers the upper, middle and lower reaches of the river basin, with six observation systems: river source area, oasis area, reservoir canal system area, oasis farmland area, ecological restoration area, and salinized area. All data in the data set are differentiated by water body types (precipitation, river water, lake water, groundwater, soil water, plant water). The data set is updated annually to gradually improve each observation system and increase data from observation points. So far, the data have been obtained for five consecutive years. The data set includes stable isotope data, meteorological data and hydrological data in the Shiyang River Basin. The data set can analyze the relationship between different water bodies and water circulation in the Shiyang River Basin. This observation network's construction provides us with stable water isotopes data and hydrometeorological data, and we can use theae data for hydrological and meteorological related scientific research. It can also provide a scientific basis for water resources utilization, water conservancy project construction, and ecological environment restoration decision-making in China's arid areas. The data that support the findings of this study are openly available in Zhu (2021) at "Data sets of Stable water isotope monitoring network of different water bodies in Shiyang River Basin, a typical arid river in China (Supplemental Edition)", Mendeley Data, V1, doi: 10.17632/w5rpxwf99g.1.

Keywords: Stable isotopes; Arid river; Monitoring network

1 Introduction

Hydrogen and oxygen isotopes are useful tracers in the water cycle (Zannoni et al., 2019). While the proportion of stable isotopes such as δ^2H and $\delta^{18}O$ in natural water bodies is small, δ^2H and $\delta^{18}O$ respond very quickly to environmental changes and historical record information on the

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water cycle evolution. Simultaneously, the fractionation of isotopes also runs through every link of the water cycle (Song et al.， 2007; Dansgaard W, 1953； Dansgaard W, 1964). Stable isotopes of hydrogen and oxygen in water have been widely used in the water cycle (Edwards et al., 2010; Penna et al., 2013; Timsic et al., 2014; Evaristo et al., 2015; Negrel et al., 2016), paleoclimate and paleoenvironmental evolution (Wei et al., 1994; Speelman et al., 2010; Steinman et al., 2010; Hepp et al. 2015), reconstruction of pale plateau height (Thompson et al., 2000; Yao et al., 2008; Xu et al., 2015; Li et al., 2017) and other fields. Stable isotopes provide an effective method for studying of regional and global water cycles (Craig, 1961; Tian et al., 2001; Vallet-Coulomb et al., 2008; Bowen et al., 2012; Gibson et al., 2017). In the water cycle, the composition of hydrogen and oxygen isotopes in different water bodies is affected by isotope fractionation. The isotopes are widely distributed in time and space, and different water bodies have different isotope characteristics (Zhang et al., 2015; Christophe et al., 1998;). Precipitation stable isotopes are affected by climate change caused by large scale weather events and local meteorological elements, and geographical conditions. With the change of precipitation isotopes, the isotopes of surface water and groundwater will also change in time and space sensitively (Yin et al., 2010). Many researchers have studied stable isotopes of hydrogen and oxygen in different regions of the world and have achieved fruitful results (Matthew et al., 2010). There are about 1400 precipitation

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stable isotopes monitoring stations worldwide (IAEA/WMO, 2014). In addition to GNIP, some national scale isotope monitoring networks have been built successively, such as Canada (Birks et al., 2009), The United States (Vachon et al., 2007), Austria (Kralik et al., 2004), France (Chery et al., 2004), and India (Kumar et al., 2010). Since the beginning of the 21st century, international collaborative research programs on isotopes have been carried out with the auspices of international organizations such as the International Atomic Energy Agency (IAWA), UNESCO and WMO. For example, the Global Network of Isotopes in Rivers, GNIR (for short), The Isotope Global Observation Network of Water and Carbon cycle Dynamics (LEAFLET), and the National Coordinated Research Project (CRP) for determining farmland water cycle fluxes by applying environmental isotope technology. Compared with traditional hydrology methods, hydrogen-oxygen stable isotope technology has significant advantages in solving the problems such as the recharge relationship between different water bodies, soil, and plant water sources, and the calculation of lake surface evaporation (Liu et al., 2009; Tian et al., 2009; Pu et al., 2013; Wang et al., 2014; Wang, 2016; Ding et al., 2018). In particular, meteoric water - surface water - soil water - groundwater can be regarded as a unified "system" to quantitatively study the hydraulic connections between different water bodies (Burns, 2002). With the continuous improvement of stable isotope theory and analysis and determination technology, isotope

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hydrology has gradually become one of the crucial branches of hydrology. Its scope and depth of research have also been expanded constantly. However, due to the limitations of sampling time and space and the limitations of experimental analysis, there has always been a lack of comprehensive research on different water bodies in the same area or basin over a long period time, which makes it challenging to use stable isotope comparison to study the water cycle in a specific area.

This paper compiles the stable water isotope data of the Shiyang River Basin from 2015 to 2019 and its corresponding meteorological and hydrological data into a data set. The stable isotope data are all obtained by field sample collection and laboratory test and analysis. Meteorological and hydrological data are obtained by weather and hydrological stations in the Shiyang River Basin. We can ues these data to analyze the relationship between different water bodies, understand the Shiyang River Basin water cycle process, and provide a scientific basis for water resources utilization, water conservancy project construction, and ecological environment decision in the arid region of China. Thus, the present study underlines the effective use of stable isotopes in studying the hydrologic cycle, which is not yet been utilized in many parts of the world. The Shiyang River Basin study should reference for subsequent research in arid regions within China and other regions of the world.

2 Study area

The Shiyang River Basin is located in the eastern section of Qilian Mountain and Hexi Corridor, and it is the third-largest river in the flowing water system in the Hexi Corridor of Gansu Province. The topography of the Shiyang River Basin slopes sharply from southwest to northeast, with Qilian Mountains in the south, alluvial plains and Gobi in the middle, and flood plains and deserts in the north (Zhu et al., 2020). The river is about 250 km long, and the basin area is $4.16\times 10^4 km^2$ (101°41'-104°16'E and 36°29'-39°27'N). The average annual runoff is about $15.75\times 10^8 km^3$. From south to north, the Shiyang River Basin covers three different climatic regions: the southern Qilian Mountain area has an alpine and semi-arid climate (2000-5000m above sea level), with an annual average temperature below 6℃ and rainfall of 300-600mm; the central corridor plain has a dry climate (1500-2000m above sea level), the annual average temperature is between 6-8℃, and the rainfall is 150-300mm. In the north, there is an arid climate (1300-1500m above sea level), with an annual average temperature higher than 8℃ and rainfall less than 150mm (Wen et al., 2013). The precipitation in Shiyang River Basin is mainly from July to September, and the average relative humidity in summer and autumn is higher than that in winter and spring. Because the evaporation is far more than the precipitation, the farmland irrigation water in Shiyang River

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Basin is mainly surface and groundwater. The Shiyang River Basin has complete surface water and groundwater irrigation system, irrigating 4.6 million mu of cultivated land in the basin.

3 Observation network design

3.1 Site Selection

To form a stable isotope monitoring network for different water bodies, we have set up 53 monitoring points in the Shiyang River Basin from 2015 to 2019, among which 34 were upstream, 16 in the midstream, and 3 in the downstream. Systematic sampling is carried out once a month, and 6,760 samples have been obtained, including 1,210 precipitation samples, 1,101 surface water samples, 161 groundwater samples, 3,779 soil water samples, and 509 plant water samples. Fig. 1 shows the distribution of stable water isotopes monitoring points in the Shiyang River Basin. These monitoring points are located in different positions (upstream, middle and downstream) within the basin, including six observation systems (Fig. 1): river source area, oasis area, reservoir system area, oasis farmland area, ecological restoration area, and salinized area, which is convenient to comprehensively analyze the microscopic water circulation process in the arid area.

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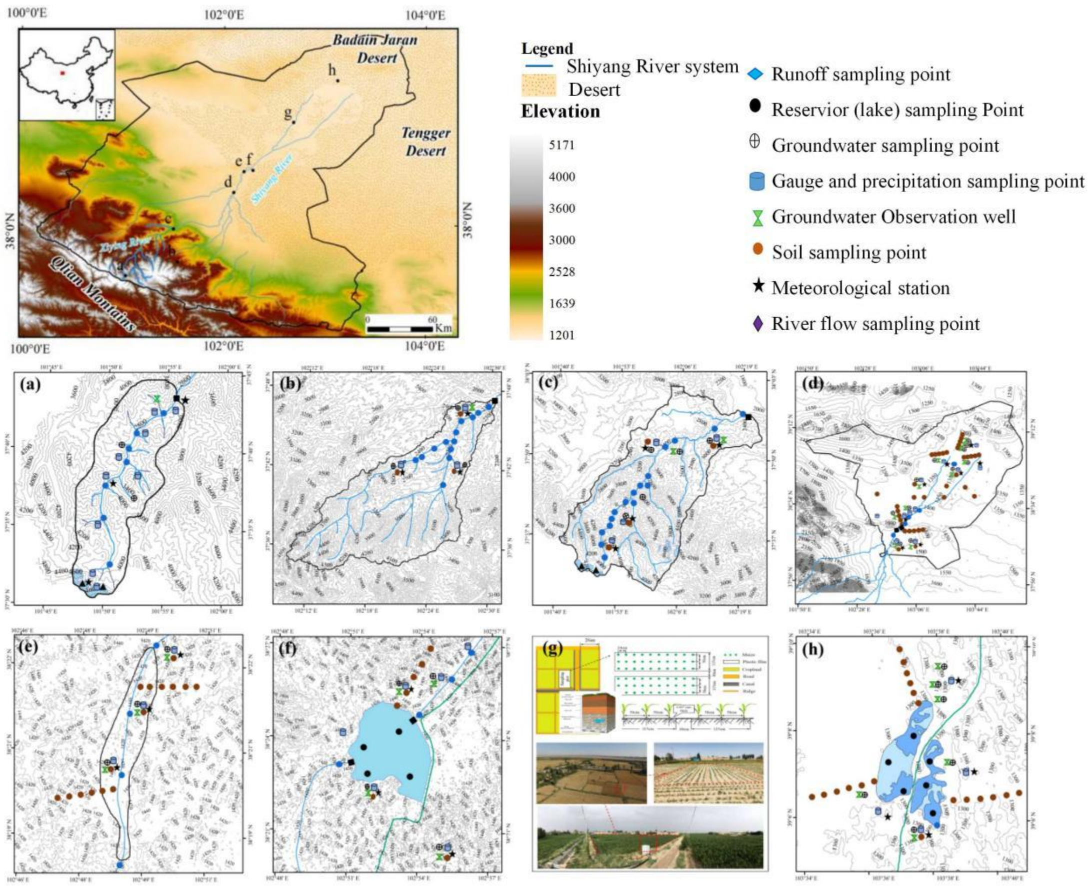

Figure. 1 Shiyang River Basin Monitoring Network (a: Ningchang River observation system, river source area; b: Ice trench observation system, river source area; c: Xiying River Basin, source observation system; d: Minqin soil system, ecological restoration; e: Dongtan Wetland Observation System in the middle reaches of Shiyang River, ecological restoration; f: Hongyashan reservoir canal observation system, ecological restoration; g: Datan Farmland Observation System, ecological restoration; h: Qingtu Lake observation system,

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ecological restoration)

4 Instrument and data acquisition

4.1 Collection of precipitation

In order to collect precipitation, 16 weather stations were set up in Shiyang River Basin, which included rainfall barrels for precipitation observation and sampling. The rainfall barrels are placed in an open place outside and composed of rain carriers, funnel, water storage bottles, and rain cups. The diameter of the rain carrier is 20 cm, and the port of the device is horizontal. The height of the rain-bearing mouth of the instrument is set as 70 cm from the ground plane. The rain gauge is used to observe precipitation and collect precipitation samples. The collected liquid precipitation is transferred to a 100 ml high-density sample bottle immediately after each precipitation event. Measuring cylinder for solid-state precipitation, with rain collection back to indoor at room temperature (23℃), then transferred to the high density in the sample bottle. The sample bottles were sealed with parafilm until the end of cryopreservation, at the same time, in samples of the polyethene bottle label, label date, type of precipitation (rain, snow, hail) and rainfall. For the occurrence of multiple precipitation events within a day, multiple sampling is required.

4.2 Collection and storage of surface water and groundwater

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Polyethene bottles are used to collect surface water (rivers, lakes, reservoirs) and groundwater samples. When collecting water samples, stratified sampling is carried out at different depths (surface layer, middle layer, bottom layer). The bottle of the sample is sealed with parafilm film and then frozen until the experiment. Meanwhile, a label is pasted on the polyethene sample bottle, telling the date, sampling point, sampling depth of the sample and the stream and tributary stream. The collected water samples should be placed in places where the sunlight is not direct so as to avoid evaporation of water, which would affect the validity of the data.The samples were taken back to the refrigerator in the laboratory within 10 hours.

4.3 Collection and storage of soil and plant water

The soil sample is collected at a depth of 100cm, and samples are taken sequentially at 10cm intervals. The soil samples collected were divided into two parts, one part of which was put into a 50 ml glass bottle. The bottle mouth was sealed with parafilm membrane and transported to the observation station within 10 hours after the sampling date was marked for cryopreservation to test stable isotope data. The other part of the sample was placed in a 50 ml aluminium box and by using the drying method to test the soil moisture content. Plants sample collection: sampling scissors collected the xylem stem of vegetation, the bark was stripped and put into a 50 ml glass bottle, sealed, and frozen until the experimental analysis.

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5 Data set

The stable isotope data is obtained through experimental analysis, and the meteorological data is obtained from the weather station in the Shiyang River Basin.

5.1 Observation point

From 2015 to 2019, a total of 53 monitoring points have been set up in the Shiyang River Basin. For the convenience of data recording, each monitoring point is recorded in short form. Table 1 lists each station's complete names and corresponding meteorological parameters, easy to understand and use.

Table 1 List of site parameters

Abbreviation	Full name	Longitude	Latitude	Elevation (m)	Temperature (℃)	Precipitation (mm)	Sampling type	Location
QHLYXM	Qinghai Forestry Project	101°51'	37°32'	3899	-	-	river water	a
MK	Colliery	101°51'	37°33'	3647	-0.23	1039.17	precipitation	a
LXWL	Winding Road	101°50'	37°34'	3305	-	-	river water	a
SDHHC	Tunnel Junction	101°50'	37°34'	3448	-	-	river water	a
BDZ	Transformer Substation	101°51'	37°33'	3637	-	-	soil, plant, river water	a
NQ	Ningqian	101°49	37°37'	3235	-	-	river water	a
SCG	Ningtanhe Middle East branch mixed	101°50'	37°38'	3068	-	-	river water, precipitation, soil	a

	water							
MTQ	Wood Bridge	101°53'	37°41'	2741	-	-	river water	a
SCLK	Three-way Intersection	101°55'	37°43'	2590	-	-	river water	a
JTL	Nine Ridge	102°02'	37°51'	2267	-	-	groundwater	a
WGQ	The Bridge of the Cultural Revolution	102°07'	37°53'	2174	-	-	river water	a
XYSK	Xiying Reservoir	102°12'	37°54'	2058	-	-	river water	c
XYZ	Xiying Town	102°26'	37°58'	1748	10.44	491.35	precipitation	c
GGKFQ	Reform and Opening Bridge	101°58'	37°46'	2590	-	-	river water	c
HJX	Huajian Township	102°00'	37°50'	2390	7.65	262.64	river water, groundwater, precipitation, soil	c
WW	Wuwei	102°37'	37°53'	1581	5.23	300.14	river water	c
HLZ	Ranger Stations	101°53'	37°41'	2721	3.25	469.44	river water, precipitation, soil, plant, groundwater	a
LLL	Lenglong Ridge	101°28'	37°41'	3500	5.78	350.34	precipitation	a
ZZXL	Zhuaxi Xiulong	103°20'	37°18'	3556	-2.37	500.17	precipitation	d
JDT	Jiudun Beach	102°45'	38°07'	1464	10.54	-	precipitation	d
SCG	Shangchigou	102°25'	38°03'	2400	7.28	377.13	precipitation, river water, groundwater	d
WWPD	Wuwei Basin	102°42'	38°06'	1467	-	-	precipitation, groundwater, soil, plant	d

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DT	Dongtan	102°47'	38°16'	1434	8.90	240.05	river water, soil, plant	e
HYSSK	Hongyashan Reservior	102°53'	38°24'	1416	7.81	100.17	river water, groundwater, soil	f
CQQ	Caiqi Bridge	102°45'	38°13'	1443	5.63	300.26	groundwater, river water, soil, plant	d
XJG	Xiajiangou	102°42'	38°07'	1200	9.36	110.18	groundwater	d
HGG	Hongqi Valley	102°50'	38°21'	1421	8.34	113.16	precipitation, groundwater	d
BHZ	Protection Station	102°29'	38°09'	2787	-	-	groundwater	d
BDC	Beidong Township	103°02'	38°32'	1367	9.52	155.45	groundwater	g
XXWGZ	Xiyin Wugou Township	102°58'	38°29'	1393	-	-	groundwater	d
MQBQ	Minqin Dam	103°08'	39°02'	1400	8.33	113.19	soil	d
QTH	Qingtu Lake	103°36'	39°03'	1313	7.86	110.79	precipitation, groundwater, lake water, soil	h
SWX	Suwu Township	103°05'	38°36'	1372	9.82	155.84	groundwater, soil, plant, river water	d
DTX	Datan Township	103°14'	38°46'	1349	11.49	-	precipitation, groundwater, soi, plant, river water	g
YXB	Yangxia Dam	102°41'	38°01'	1489	10.76	-	precipitation, groundwater, soil, plant	d
XBZ	Xuebai Toen	103°01	38°32'	1387	10.77	-	precipitation	b
SYQ	Laboratory	102°22'	37°42'	2438	-	-	river water,	b

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	Area						soil	
XCL	Small Valley	102°24'	37°43'	2267	-	-	river water	b
JCLK	Intersection	102°20'	37°41'	2544	-	-	river water, soil	b
QSHSY	Spring River	102°22'	37°38'	2747	-	-	spring water	b
HLD	Confluence	102°26'	37°44	2146	-	-	river water, soil, plant	b
QXZ	Meteorological Station	102°20'	37°42	2543	3.34	510.56	precipitation, groundwater	b
BGH	Binggou River	102°17'	37°40'	2872	5.28	-	river water, soil water,	b
NCHHLH	South Nancha River	102°26'	37°43'	2163	-	-	river water	b
LKS	Two Pine	102°17'	37°40'	2832	5.69	-	river water, soil	b
NYSKRK	Nanying Reservoir	102°29'	37°47'	1955	7.82	330.16	river water	b
SGZZ	Sigou stckade	102°23'	37°40'	2492	10.34	675.54	river water	b
JZGD	Construction Site	102°25'	37°41'	2303	-	-	river water	b
QLX	Qilian Township	102°42'	38°08'	3394	5.13	300.15	precipitation, spring water	d
XYWG	Xiying Wugou	102°10'	37°53'	2097	7.99	197.67	river water, precipitation, soil, plant	c
HSH	Hongshui River	102°45'	38°13'	1454'	-	-	river water	d
XCL	Small village	102°24'	37°43'	2267	-	-	river water	b
YHRJ	A family	102°20'	37°42'	2543	-	-	river water	b

5.2 Meteorological and hydrological data set

We obtained the meteorological data, including temperature, precipitation, atmospheric

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pressure, relative humidity, wind speed, sunshine duration. Store the obtained weather data in the corresponding weather station file. Through the classification and sorting of meteorological data, the daily meteorological data, monthly meteorological data, seasonal meteorological data, and annual meteorological data are formed. Finally, the meteorological data set is formed. The obtained hydrological data includes the precipitation and flow data of each hydrological observation point. Through the classification and arrangement of hydrological data, daily hydrological data, monthly hydrological data, seasonal hydrological data, and annual hydrological data are formed. Finally, the hydrological data set is formed.

5.3 Stable water isotope data set

The stable water isotope data set is compiled from Fig. 2. Firstly, field sampling is conducted to obtain samples of different water bodies. The sampling interval is one month, and the data set is updated once a year. According to the types of samples, the samples can be divided into two categories: precipitation, river water, lake water, and groundwater can be directly tested after filtration, while soil water and vegetation water need to be vacuum condensed and extracted to separate the water in soil and vegetation for testing and analysis. The assembly of the data set relies mainly on the monitoring data and instrument test data. The extraction apparatus's use is BJJL - 2200 fully automatic vacuum condensate extraction system. Analysis instrument is LWIA -

24 d liquid water isotope analyzer. Therefore, higher requirements are put forward for the quality and feasibility of the data. We use manner-Kendall software to test the data obtained from meteorological and hydrological stations. The inspection of data is an important step to judge the validity of data. The stable isotope data set and the meteorological and hydrological data set are combined into one data set.

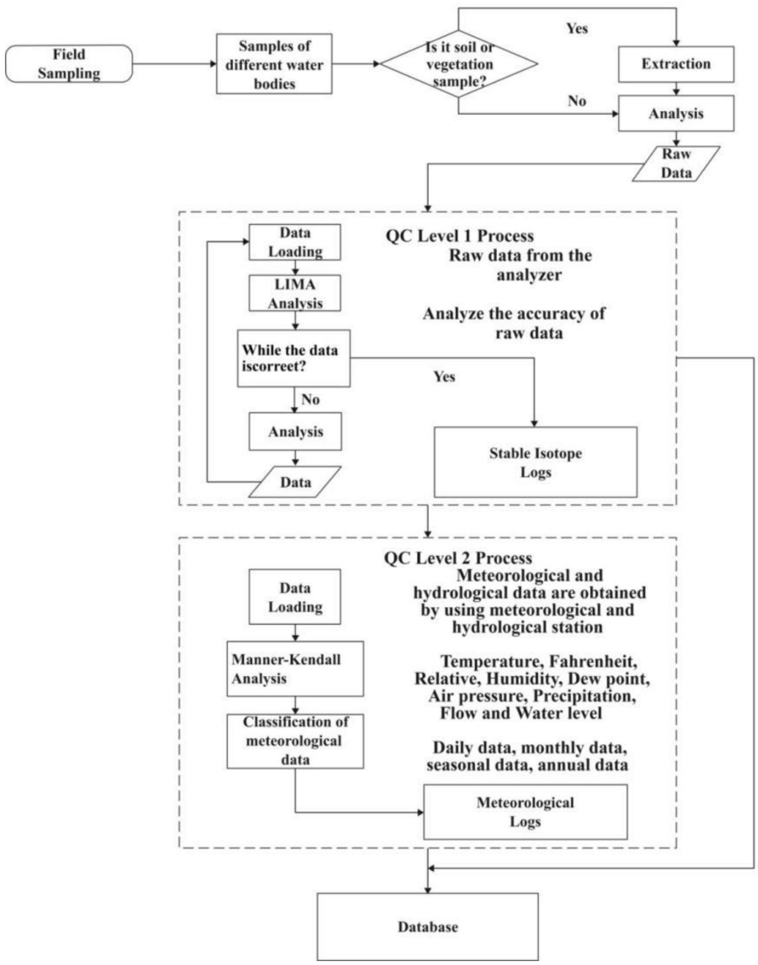

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Figure. 2 Extraction, analysis of the instrument and data set production process

6 Data quality

This monitoring network aims to provide data for the Shiyang River Basin, and there can be no great lag. In practice, some quality problems have little impact on data users, because we will test the quality data before opening data, on the one hand, for meteorological and hydrological data, we will use manner-Kendall software to test the isotopes data. For isotopic data, we will use LIMA post-analysis software to select the wrong samples and reanalyze them. On the other hand, we will screen the experimental data again and let the data's users get the quality data. At present, the leading cause of data error is instrument error. Here are some common problems.

6.1 Sample collection and storage

After sample collection, extraction and analysis are needed. The extraction work is aimed at soil and vegetation samples, which need to be stored in the freezer until the experimental analysis. From the point of view of the collection, vegetation samples should be collected quickly. Otherwise, resulting in a small amount of water in the vegetation, which will affect the quality of the data. From the sample storage perspective, when too many vegetation samples are collected, the time from sampling to extraction to analysis will be too long, and the isotope fraction caused by evaporation will affect the test results.

6.2 Experiments

The experimental equipment has impurities in the pipeline, methanol, ethanol pollution and other problems, leading to errors in the experimental data. Therefore, the instrument should be checked and cleaned on time during sample analysis. After completing the experiment, we should test the the data promptly manner, and select the wrong samples.

6.3 Modification of plant water isotope data

Suppose the water sample contains compounds with the same absorption characteristics of the same wavelength. In that case, it will lead to errors in the measurement of the laser liquid water analyzer, and the most likely pollutants to cause errors are methanol and ethanol. So using deionized water with different concentrations of pure methanol and ethanol, the combination of Los Gatos company LWIA - Spectral Contamination Identifier v1.0 Spectral analysis software (NB) to determine methanol and ethanol (BB) pollution degree of spectrum measurement, establishing the δ^2H and $\delta^{18}O$ correction method for the spectra of pollution (Meng et al., 2012; Liu et al., 2013). In the correction process, the configuration of methanol and ethanol solution concentration was similar to Meng's experiment (2012). Correction results for methanol its broadband measurements of NB metric logarithmic respectively with $\Delta\delta^2H$ and $\Delta\delta^{18}O$ are significantly quadratic curve relationship, respectively is:

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$$\Delta\delta^2\mathrm{H} = 0.018(\ln NB)^3 + 0.092(\ln NB)^2 + 0.388\ln NB + 0.785(R^2 = 0.991, \ p > 0.0001) \quad (2\text{-}1)$$

$$\Delta\delta^2\mathrm{O} = 0.017(\ln NB)^3 - 0.017(\ln NB)^2 + 0.545\ln NB + 1.356(R^2 = 0.998, \ p < 0.0001) \quad (2\text{-}2)$$

Its broadband measurements for ethanol correction results in BB metric and $\Delta\delta^2$H and $\Delta\delta^{18}$O, a quadratic curve and linear relationship respectively, are:

$$\Delta\delta^2\mathrm{H} = -85.67BB + 93.664(R^2 = 0.747, p = 0.026)(BB < 1.2) \quad (2\text{-}3)$$

$$\Delta\delta^2\mathrm{O} = -21.421BB^2 + 39.935BB - 19.089(R^2 = 0.769, \ p < 0.012) \quad (2\text{-}4)$$

7 Results and discussion

7.1 Stable isotopes characteristics of different water bodies

In the catchment dominated by precipitation, the seasonal difference between δ^{18}O and δD values is large (Dansgaard W, 1964). In Fig. 3, we can be found that (1) δ^{18}O and δD are periodic with time, that is, they are depleted in winter and spring, enriched in summer and autumn, and the value of stable isotopes reaches a high value in summer and a second high value in autumn. The former is related to precipitation dilution, while the latter is related to high temperature and intense

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evaporation. (2) $\delta^{18}O$ and δD of lake water fluctuate more than river water, groundwater, soil water, and plant water, because the lake's evaporation is much more robust in summer than in other seasons. (3) The change trend of $\delta^{18}O$ and δD in surface water is the same, the change of groundwater lags behind that of surface water, and its change range is smaller. (4) The variation of $\delta^{18}O$ and δD in different water bodies are generally consistent, showing good consistency.

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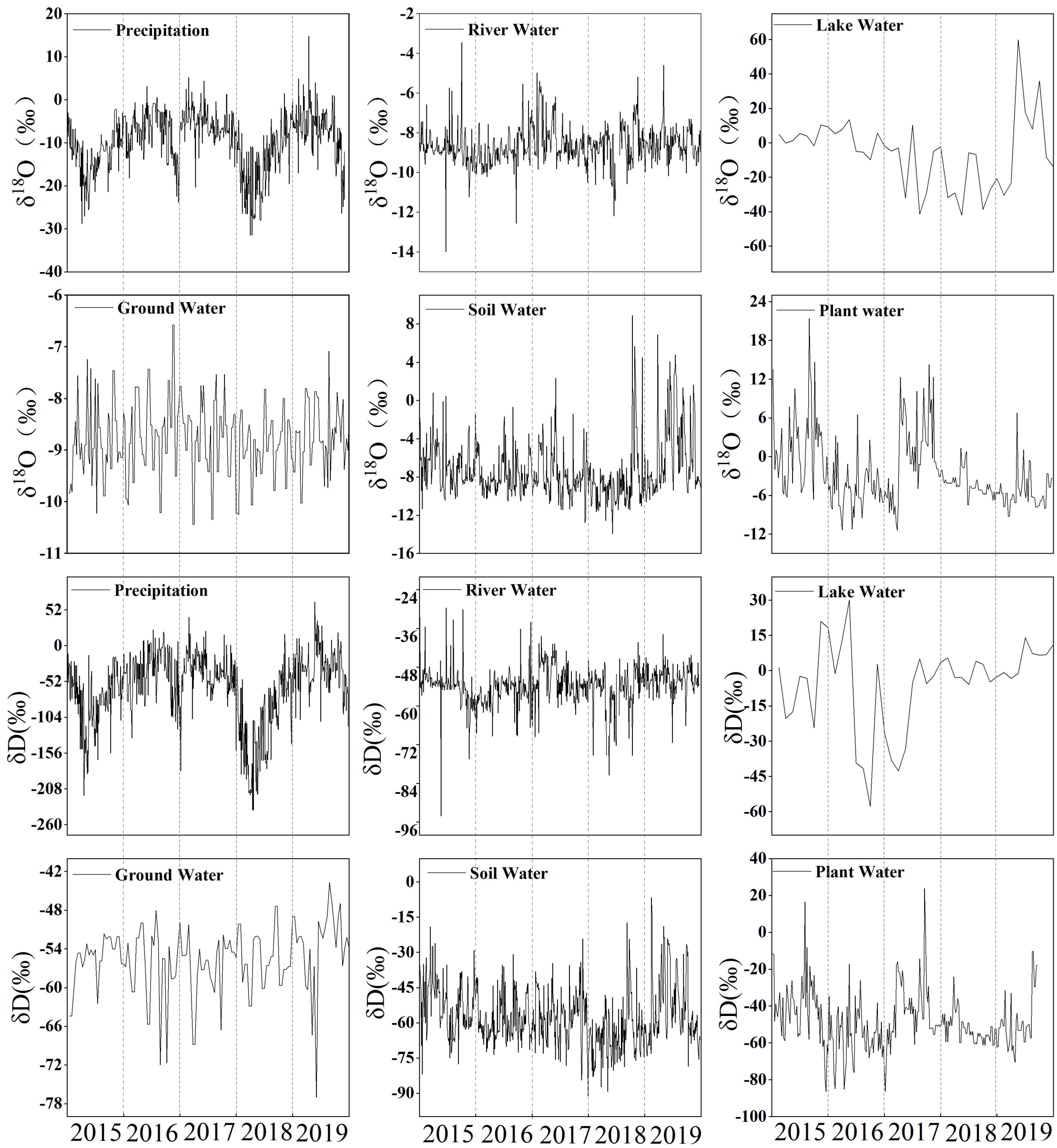

Figure. 3 Distribution of different water bodies' $\delta^{18}O$ and δD in the Shiyang River Basin from 2015 to 2019

7.2 Changes in runoff

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According to the four hydrological observation stations in the Shiyang River Basin, the multi-year average water level in the Shiyang River Basin from 2015 to 2019 was 9.71m. among which the average annual water level of 2015, 2016, 2017, 2018, and 2019 are 9.56m, 10.67m, 10.11m, 7.18m, and 11.06m, respectively. In 2018, Shiyang River Basin had the lowest water level of 7.18m. The water level in this basin peaks in summer and reaches a second peak in spring, and the water level in Shiyang River Basin is in the rainy season in summer with more precipitation. Spring mountain snow and ice melt supply Shiyang River related.

The annual flow of the Shiyang River Basin from 2015 to the 2019 year is 1436.04m^3/s, among which the annual flow in 2015, 2016, 2017, 2018, and 2019 are 1435.9m^3/s, 1435.81m^3/s, 1436.05m^3/s, 1436.14m^3/s, and 1436.29m^3/s, respectively. The flow in spring and summer is larger than that in winter and autumn. Take the year 2015 as an example, the maximum flow of the Shiyang River Basin was 57.0m^3/s, which appeared on July 5. The annual runoff was 3.016 × 10^{8}m/s, the runoff modulus was 0.936 × 10^{-3}m^3/(S.km^2), and the runoff depth was 29.5mm. The largest flood volume1day, 3days, 7days, 15days, 30days, and 60days occurred on July 5, July 4, July 4, July 2, July 2, and June 22.

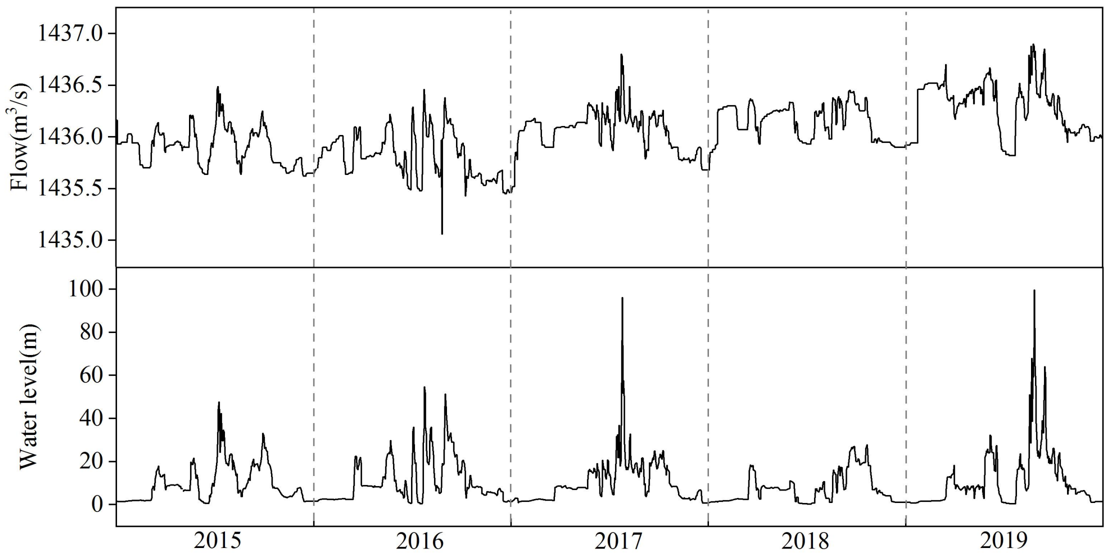

Figure. 4 Changes of hydrological data of the Shiyang River Basin from 2015 to 2019

7.3 Connections between different bodies of water

Based on the precipitation isotope data of the Shiyang River Basin from January 2016 to December 2019 (Fig. 5), using the least squares of the LMWL of the Shiyang River Basin, the local waterline equation (LMWL) is obtained: $\delta D = 7.65\delta^{18}O + 9.75$, compared to the global atmosphere waterline equation (GMWL), slope and intercept are small, but δD and $\delta^{18}O$ maintain a good linear relationship ($R^2 = 0.96$), which is related to the geographical location of the study area. The Shiyang River Basin is located in the northwest inland of China, and the climate environment is dry. It is subject to intense secondary evaporation during the precipitation, making the slope and intercepts relatively small. It also reflects the existence of stable isotope unbalanced fractionation effect under the arid climate background.

Precipitation, river water, lake water, groundwater, soil water, and plant water are distributed near GMWL, indicating that they share the same water source. The deviation of the lake from GMWL indicates that it experienced intense evaporation.

By comparing the slope and intercept of the relation expressions $\delta^{18}O$ and δD of GMWL and different water bodies, it can be seen that, as far as the slope is concerned, precipitation is the highest (7.65), followed by groundwater (5.11), lake water is the lowest (2.14). There is little difference between the slope of precipitation and groundwater, which means there is a mutual recharge relationship. In terms of intercept (d), the precipitation was the highest (9.75), followed by the river (-8.44). When the water body evaporates in the unsaturated atmosphere, the light isotopes evaporate preferentially. The combined effect of the dynamic fractionation effect of the river accelerates the ratio of the δD and $\delta^{18}O$ fractionation effects in the evaporated water vapor, resulting in an increase in d in the water vapor and a decrease in d in the remaining water body. The average value of $\delta^{18}O$ and δD of soil water is between plant water and precipitation, but closer to precipitation (Table 2), indicating that the soil is mainly recharged by precipitation. In the $\delta^{18}O$ and δD equations of precipitation, lake water, soil water, river water, plant water, and groundwater, R^2 decreases in turn, and the linear relationship between $\delta^{18}O$ and δD becomes smaller and smaller.

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These phenomena indicate that different water bodies have different degrees of mutual complementarity. Among them, soil water is the most miscible and is supplied by multiple water sources.

Take $\delta^{18}O$ for example, in terms of the variation coefficient, the absolute value of stable isotopes (4.4) of the lake water is far higher than that of the other five water bodies (groundwater, river water, soil water, precipitation, plant water: 0.08, 0.11, 0.37, 0.71, 2.54), reflecting the high volatility of the lake water.

The correlation coefficient between $\delta^{18}O$ and δD of lake water, groundwater, and plant water is relatively low. The evaporation of lake water in summer is particularly intense, which leads to the great difference in winter and summer. The stable isotopic value of lake water varies significantly in different seasons, leading to a small correlation coefficient between them. The main recharge source of groundwater and plant water is meteoric water. It takes a certain time for meteoric water to converge into surface water and groundwater, leading to isotopic fraction, leading to a small correlation coefficient between $\delta^{18}O$ and δD of the two water bodies.

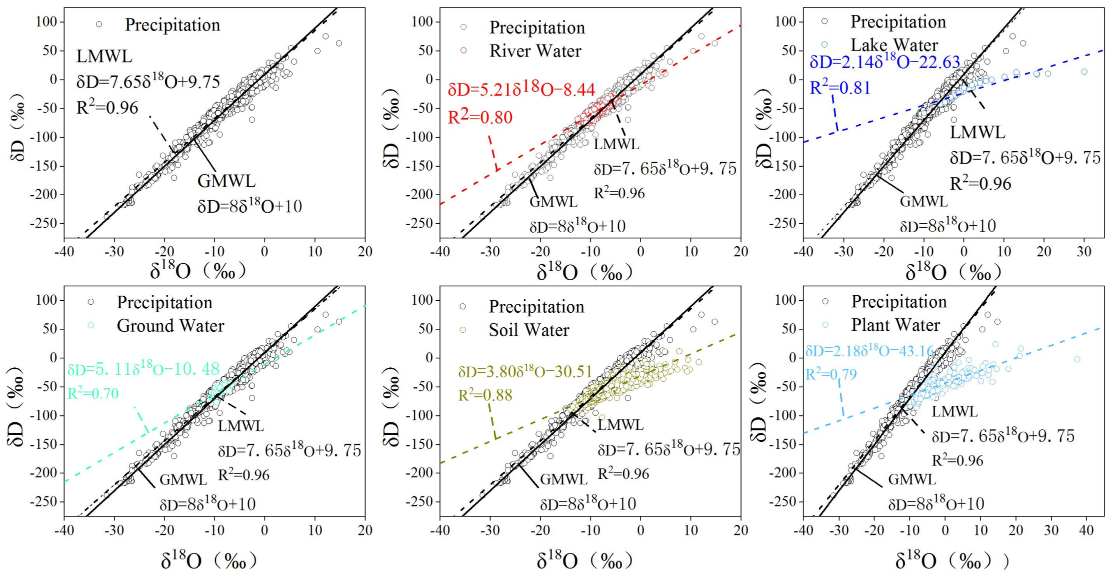

Figure. 5 The change of $\delta^{18}O$ and δD in different water bodies in the Shiyang River Basin

Table 2 Comparison of water bodies $\delta^{18}O$ and δD in the Shiyang River Basin from 2015 to 2019

Water Type	δD(‰)				$\delta^{18}O$(‰)			
	Min	Max	Average	Coefficient of variation	Min	Max	Average	Coefficient of variation
Precipitation	-238.62	75.41	-54.63	-0.85	-31.22	14.79	-8.39	-0.71
River Water	-94.14	-28.89	-53.37	-0.12	-13.98	-3.44	-8.62	-0.11
Lake Water	-57.84	13.56	-18.43	-1.11	-9.86	30.01	1.96	4.4
Underground Water	-76.99	-43.72	-52.42	-0.10	-10.44	-6.57	-8.80	-0.08
Soil Water	-102.95	11.81	-59.39	-0.20	-13.94	11.62	-7.61	-0.37
Plant Water	-86.41	23.87	-48.15	-0.32	-11.43	37.37	-2.27	-2.54

8 Data availability

The data that support the findings of this study are openly available in Zhu (2021) at "Data sets

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of Stable water isotope monitoring network of different water bodies in Shiyang River Basin, a typical arid river in China (Supplemental Edition)", Mendeley Data, V1, doi: 10.17632/w5rpxwf99g.1.

9 Summary and outlook

The data set provides a new observation and data basis for studying stable water isotopes in different water bodies in China's inland river basins. Through these data, we can compare the stable isotopes characteristics of different water bodies and study the correlation between different water bodies, thus providing some guidance for the rational use of water resources in arid regions. The data set will be updated year by year as observations are made. To improve this data set, we encourage data set users to contact the author with suggestions.

Author contributions

Guofeng Zhu, and Yuwei Liu conceived the idea of the study; Peiji Shi, Wenxiong Jia and Junju Zhou set up observation system; Xinggang Ma, Hanxiong Pan,Yu, Zhang, Zhiyuan Zhang and Leilei Yong were responsible for field sampling; Zhigang Sun participated in the experiment; Kailiang Zhao and Yuanfeng Liu participated in the drawing; Yuwei Liu wrote the paper; All authors discussed the results and revised the manuscript.

Competing interests

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The authors declare no competing interests.

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References

Birks, S. J., Edwards, T. W., Biswas, N.C., Gibson, J. J., and McTavish, D.: Isotope climatology of Canada: Insights from the first decade of CNIP operation (1997-2007) , American Geophysical Union, Spring Meeting, 2009.

Bowen, G. J., Kennedy, C. D., Henne, P. D., and Zhang, T. L.: Footprint of recycled water subsidies downwind of Lake Michigan, Ecosph, 3, 1–16, 2012.

Chery , L. , Garnier, J., and Petelet-Giraud, E.: Projet de mise en place d'une banque nationale dedonnées isotopiques. Etat d'avancement année, Orléans, France: BRGM (Bureau de Recherches Géologiques et Minières), 2004.

Craig, H.: Isotopic variation in meteoric waters, 133(3465), 1702-1703, https://doi.org/10.1126/science.133.3465.1702, 1961.

Dansgaard, W: Stable isotopes in pre cipitation , Tellus, 16, 436-468, https://doi.org/10.1111/j.2153-3490.1964.tb00181.x, 1964.

Edwards, T.W.D., Birks, S. J., St Amour, N. A., Buhay, W. M., Mceachern, P., and Wolfe, B.: Progress in isotope tracer hydrology in Canada. Hydrological Processes, 19, 1-1, https://doi.org/10.1002/hyp.5766, 2010.

Evaristo, J., Jasechko, S. and Mcdonnell, J.: Global separation of plant transpiration from groundwater and streamflow, Nature, 525, 91-91, 2015.

Gibson, J. J., Birks, S. J., Jeffries, D., and Yi, Y.: Regional trends in evaporation loss and water yield based on stableisotope mass balance of lakes The Ontario Precambrian Shield surveys, J. Hydrol, 544, 500–510, https://doi.org/10.1016/j.jhydrol.2016.11.016, 2017.

Kong, Y. I., Pang, Z. H., and Froehlich, K.: Quantifying recycled moisture fraction in precipitation of an arid region using D-excess, Tellus B,65,19251, https://doi.org/10.3402/tellusb.v65i0.19251, 2013.

Kralik, M., Papesch,W., and Stichler, W. : Austrian Network of Isotopes in Precipitation (ANIP): Quality assurance and climatological phenomenon in one of the oldest and densest networks in the world, Isotope Hydrology and Integrated Water Resources Management, 146-149, 2004.

https://doi.org/10.5194/essd-2021-79
Preprint. Discussion started: 7 June 2021

Open Access Earth System Science Data Discussions

Kumar, B., Rai, S. P., Saravana, K. U., Verma, S, K., and Pande, N. G.: Isotopic characteristics of Indian precipitation, Water Resources Research, 46, https://doi.org/ 10.1029/2009WR008532, 2010.

Li, J., Shi, P., Zhu, G., He, Y., Liu, Y., Tong, H., and Yang, L.: Characteristics of $\delta^{18}O$ in precipitation and moisture transports in the central hexi corridor, Acta Scientiae Circumstantiae, 35, 947-955, https://doi.org/10.13671/j.hjkxxb.2014.0899, 2015.

Li, L., and Garzione, C. N.: Spatial distribution and controlling factors of stable isotopes in meteoric waters on the tibetan plateau: implications for paleoelevation reconstruction, Earth and Planetary Science Letters, 460, 302-314, https://doi.org/10.1016/j.epsl.2016.11.046, 2017.

Liu, W. R., Peng, X. H., and Chen, X. M.: Determination of hydrogen and oxygen isotopes of liquid water by laser isotope analyzer and correction of spectral pollution, Journal of Ecology, 32, 1181-1186, https://doi.org/CNKI:SUN:STXZ.0.2013-05-015, 2013.

Matthew, J., Currell, I. C., Dean, C., Bradley, D. H.: Recharge history and controls on groundwater quality in the Yuncheng Basin, north China. Journal of Hydrology, 385(1), 2010.

Meng, X. Q., Wen, X. F., Zhang, X. Y., Han, J. Y., Sun, X. M.., Li, X. B.: Influence of organics on

https://doi.org/10.5194/essd-2021-79
Preprint. Discussion started: 7 June 2021

the determination of $\delta^{18}O$ and δD of plant leaves and stalk water by infrared spectroscopy, Chin J Eco-agri, 20, 1359-1365, 2012, https://doi.org/ 10.3724/SP.J.1011.2012.01359, 2012.

Négrel, P., Petelet-Giraud, E., and Millot, R.: Tracing water cycle in regulated basin using stable $\delta^{18}O$-$\delta^{2}H$ isotopes: the ebro river basin (spain), Chemical Geology, 422, 71-81. https://doi.org/10.1016/j.chemgeo.2015.12.009, 2016.

Niu, B., Liu,X ,D., Jing,W ,M ., and Ma, J.: Analysis of temperature, precipitation and runoff characteristics in Dayekou basin of Qilian Mountains, Arid Land Geography, 37, 931–938, 2014.

Penna, D., Oliviero, O., Assendelft, R., Zuecco, G., Meerveld, I. V., and Anfodillo, T.: Tracing the water sources of trees and streams: isotopic analysis in a small pre-alpine catchment, Procedia Environmental Sciences, 19, 106-112, https://doi.org/10.1016/j.proenv.2013.06.012, 2013.

Song, C., Wang, G., Liu, G., Mao, T., Sun, X., and Chen, X.: Stable isotope variations of precipitation and streamflow reveal the young water fraction of a permafrost watershed, Hydrological Processes, 31, 935-947, https://doi.org/10.1002/hyp.11077, 2017.

Speelman, E.N., Sewall, J.O., Noone, D., Huber, M., Heydt, A.V.D., and Damsté, J.S.: Modeling the influence of a reduced equator-to-pole sea surface temperature gradient on the

https://doi.org/10.5194/essd-2021-79
Preprint. Discussion started: 7 June 2021

distribution of water isotopes in the early/middle eocene, Earth and Planetary Science Letters, 298, 57-65, https://doi.org/10.1016/j.epsl.2010.07.026, 2010.

Steinman, B.A., Rosenmeier, M.F., Abbott, M.B., and Bain, D.J.: The isotopic and hydrologic response of small, closed-basin lakes to climate forcing from predictive models: application to paleoclimate studies in the upper columbia river basin, Limnology and Oceanography, 55, 2231-2245, https://doi.org/10.4319/lo.2010.55.6.2231, 2010.

Sun, C. J., Chen, Y. N., Li, W. H., Li, X. G., and Yang, Y. H.: Isotopic time-series partitioning of streamflow components under regional climate change in the Urumqi River, Northwest China, Hydrol, Sci, J, 61, 1443–1459, https://doi.org/10.1080/ 02626667.2015.1031757, 2015a.

Sun, C. J., Chen, Y. N., Li, X. G., and Li, W. H.: Analysis on the stream flow components of the typical inland river, Northwest China, Hydrol. Sci. J, 61, 970-981, https://doi.org/10.1080/02626667.2014.1000914, 2015(b).

Sun, P., Gong, J., Jia, Z.Z., and Xie, Y. C.: Study on the spatiotemporal variation and inflfluence factors of the Jiujin basin based on the size analysis, Geogr. Sci, 36, 902–909, https://doi.org/10.13249/j.cnki.sgs.2016.06.013, 2016.

Sun, Z. G., Zhu, G. F., Zhang, Z. X., Xu, Y. X., Yong, L. L., Wan, Q. Z., Ma, H. Y., Sang, L. Y., and Liu, Y. W.: Identifying surface water evaporation loss of inland river basin based on evaporation enrichment model. Hydrological Processes, 2021.

Thompson, L.G., Yao, T., Mosleythompson, E., Davis, M.E., Henderson, K.A., and Lin, P.: A high-resolution millennial record of the south asian monsoon from himalayan ice cores, Science, 289, 1916-1920, https://doi.org/10.1126/science.289.5486.1916, 2000.

Timsic, S. and Patterson, W. P.: Spatial variability in stable isotope values of surface waters of eastern canada and new england,Journal of Hydrology, 511, 594-604, https://doi.org/10.1016/j.jhydrol.2014.02.017, 2014.

Tian, L. D., Yao, T. D., Numaguti, A., and Keqin, D.: Relation between stable isotope in monsoon precipitationin southern Tibetan Plateau and moisture transport history, Sci. China Series D-Earth Sci, 44, 267–273, https://doi.org/10.1007/BF02911996, 2001.

Vachon, R. W., White, J. W. C., Gutmann, E., Gutmann, E., and Welker, J. M.: Amount-weighted annual isotopic ($\delta^{18}O$) values are affected by the seasonality of precipitation: A sensitivity study, Geophysical Research Letters, 34, https://doi.org/10.1029/2007GL030547, 2007.

Vallet-Coulomb, C., Gasse, F., and Sonzogni, C.: Seasonal evolution of the isotopic composition of atmospheric water vapour above a tropical lake: deuterium excess and implication for water recyling, Geochimica Cosmochimica Acta. 72 (19), 4661–4674, https://doi.org/10.1016/j.gca.2008.06.025, 2008.

Wan, Q. Z., Zhu, G. F., Guo, H. W.,Zhang, Y., Pan, H.X., Yong, L. L., and Ma, H, Y.: Influence of Vegetation Coverage and Climate Environment on Soil Organic Carbon in the Qilian Mountains, Scientific Reports, 9(1): 17623, https://doi.org/10.1038/s41598-019-53837-4, 2019.

Wang, X. Y., Li, Z. Q., Edwards, R., Ruozihan, T., and Zhou, P.: Characteristics of water isotopes and hydrograph separation during the spring flflood period in Yushugou River basin, eastern Tianshans, China, J, Earth Syst, Sci, 124, 115–124, https://doi.org/10.1007/s12040-014-0517-x, 2015.

Wei, K., and Lin, R.: The influence of the monsoon climate on the isotopic composition of precipitation in China, Geochimica, 1, 32-41, https://doi.org/CNKI:SUN:DQHX.0.1994-01-003, 1994.

Wen, X., Wang, T., Xue, X., Duan, H. C., and Liao, J.: Spatial-temporal evolution of the oasis in shiyanghe river basin in 1975-2010, Journal of Desert Research, 249, 2013.

Xu, Q., Hoke, G.D., Liu-Zeng, J., Ding, L., Wang, W., and Yang, Y.: Stable isotopes of surface water across the longmenshan margin of the eastern tibetan plateau, Geochemistry Geophysics Geosystems,15, 3416-3429, https://doi.org/10.1002/2014GC005252, 2015.

https://doi.org/10.5194/essd-2021-79
Preprint. Discussion started: 7 June 2021

Yin, L., Hou, G., Su, X. et al. Isotopes (δD and $\delta^{18}O$) in precipitation, groundwater and surface water in the Ordos Plateau, China: implications with respect to groundwater recharge and circulation. Hydrogeol J 19, 429–443. https://doi.org/10.1007/s10040-010-0671-4, 2011.

Zannoni, D., Steen-Larsen,H. C., Rampazzo, G., Dreossi, G. L.,Stenni, B., Bergamasco, A: The atmospheric water cycle of a coastal lagoon: An isotope study of the interactions between water vapor, precipitation and surface waters, Journal of Hydrology, 572, https://doi.org/ 10.1016/j.jhydrol.2019.03.033, 2019.

Zech, C., Schöne, T., Illigner, J., Stolarczuk, N., Queißer, T., Köppl, M., Thoss, H., Zubovich, A., Sharshebaev, A., Zakhidov, K., Toshpulatov, K., Tillayev, Y., Olimov, S., Paiman, Z., Unger-Shayesteh, K., Gafurov, A., and Moldobekov, B.: Hydrometeorological Data from a Remotely Operated Multi- Parameter Station network in Central Asia, Earth Syst. Sci. Data Discuss, https://doi.org/10.5194/essd-2020-176, in review, 2020.

Zhang ,Y. H., Wu, Y. Q., Wen, X. H., and Su, J. P.: Application of environmental isotopes in water cycle, Adv Water Sci, 5, 738–747, 2006.

Zhou, Y., Wei, W., Che, Q., Xu, Y., Wang, X., Huang, X., and Lai, R.:Bacillus pallidus sp. nov., isolated from forest soil, Int J Syst Evol Microbiol , 58, 2850–2854, https://doi.org/10.1099/ijs.0.014316-0, 2008.

Zhu, G. F., Wan, Q. Z ., Yong, L. L., Li, Q. Q., Zhang, Z. Y., Guo, H. W., Zhang, Y., Sun, Z.G., Zhang, Z. X., and Ma, H. Y.: Dissolved organic carbon transport in the Qilian mountainous areas of China: Hydrological Processes,34, https://doi.org/10.1002/hyp.13918, 2020.

Zhu, G. F.: Data sets of Stable water isotope monitoring network of different water bodies in Shiyang River Basin, a typical arid river in China(Supplemental Edition)", Mendeley Data, V1, doi: 10.10.17632/w5rpxwf99g.1, 2021.

Zhang, L., Qin, X. G., Liu, J. Q., Mu, Y., An, S. K., L,C. H., and Chen, Y. C.: Characters of Hydrogen and Oxygen Stable Isotope of Different Water Bodies in Huainan Coal Mining Area: Journal of Jilin University (Earth Science Edition), 45, 1502-1514,https://doi.org/10.13278/j.cnki.jjuese.201505205, 2015.

Christophe, L., Philippe, L., and François.: The hydrogen isotope composition of seawater and the global water cycle.: Chemica Geology, 145(3), https://doi.org/10.1016/S0009-2541(97)00146-0, 1998.