Assessment of relative contribution of various components of the cryosphere in the Tien Shan and Gissar-Alay Mountains using isotopic analysis

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Introduction

The biggest future challenge of climate and glacier change to Central Asia (CA) is impact of glacier retreat on water recourses. The rivers of CA start in the mountains and supply up to 90% of water for domestic, industrial and agricultural use on the plain. Changes in streamflow in response to changes in glacierization have been modelled for a number of catchments in CA suggesting that an initial growth in discharge will occur followed by a decline after the 2040s. The uncertainty about the extent and timing of the projected changes remains high because they depend on relative contributions of different sources of water to total runoff such as seasonal snow pack, glacier ice, rock glaciers and permafrost. These vary between catchments and have not been reliably quantified.

This study presents an assessment of the observed and future streamflow in the glacierized catchments of CA and aims to constrain uncertainty in modelling of the future water availability and quality using data on isotopic composition of streamflow and different sources of water.

Study area

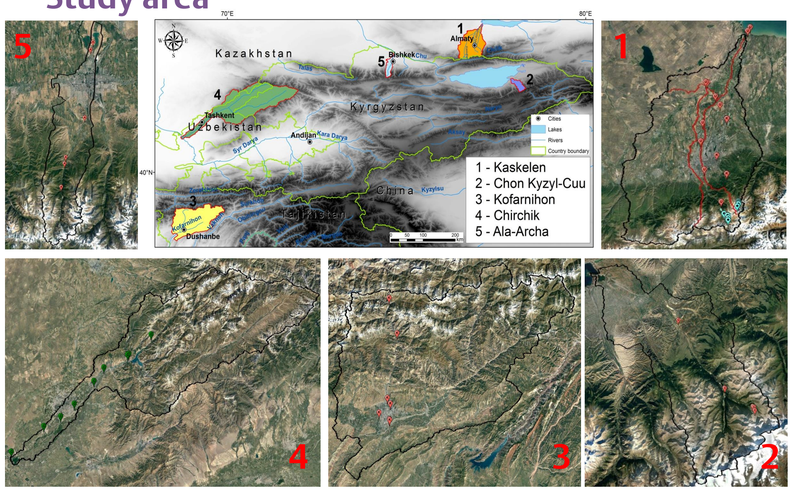

Figure 1. Location of study catchments

Table 1. Catchment characteristics and sampling information

№	Country	Catchment	Area, km²	Number of sampling points	Responsible organization
1	Kazakhstan	Kaskelen	3792	3 + 1 Kapshagay reservoir	Kazakhstan Institute of Geography (KIG), Almaty
		Ulken Almaty	485	6 + 9 from upper zone	
		Kishi Almaty	1048	3 + 11 from upper zone	
2	Kyrgyzstan	Chon Kyzyl-Cuu	605	5	Tien Shan Mountain Research Centre (TSMRC), Bishkek
3	Tajikistan	Kofarnihon	7536	6	Institute of Water Problems, Hydropower and Environment (IWP), Dushanbe
4	Uzbekistan	Chirchik	13464	8	Department of Glaciology and Geology, Institute of Geology and Geophysics (IGG), Tashkent
5	Kyrgyzstan	Ala-Archa	701	6	Central-Asian Institute for Applied Geosciences (CAIAG), Bishkek

The data are supplied by the newly developed Central Asian Research and Adaptation Water Network (CARAWAN)

Background

This study assesses changes in seasonal and monthly flow in seven catchments draining the northern Tien Shan Mountains, Central Asia over a period from the 1950s to the present day.

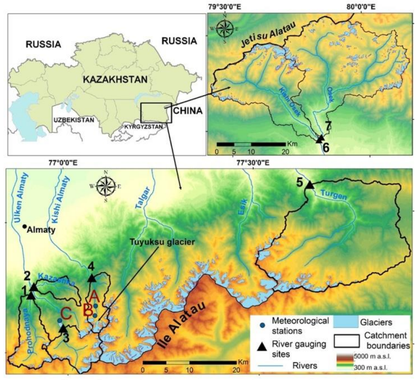

Figure 2. Location of catchments with streamflow analysis
Numbers show locations of the gauging sites: 1 – Prohodnaya, 2 – Teresbutak, 3 – Ulken Almaty, 4 – Kishi Almaty, 5 – Turgen, 6 – Osek, 7 – Kishi Osek.
Letters show locations of meteorological stations: A – Mynzhilki, B – Tuyuksu, C – Bolshoe Almatinskoe Lake (BAL)

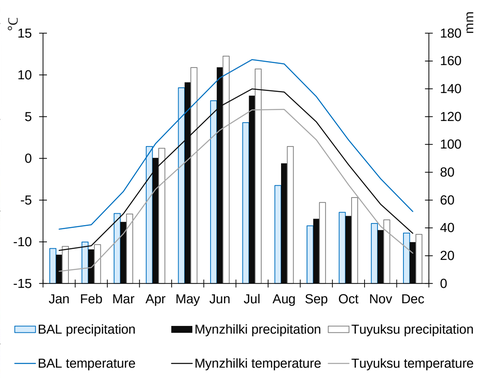

Figure 3. Temperature and precipitation climatology for 1974-2013 for BAL (2500 m a.s.l.), Mynzhilki (3010 m a.s.l.) and Tyuksu (3438 m a.s.l.) meteorological stations. Locations of the stations are shown in Fig. 2.

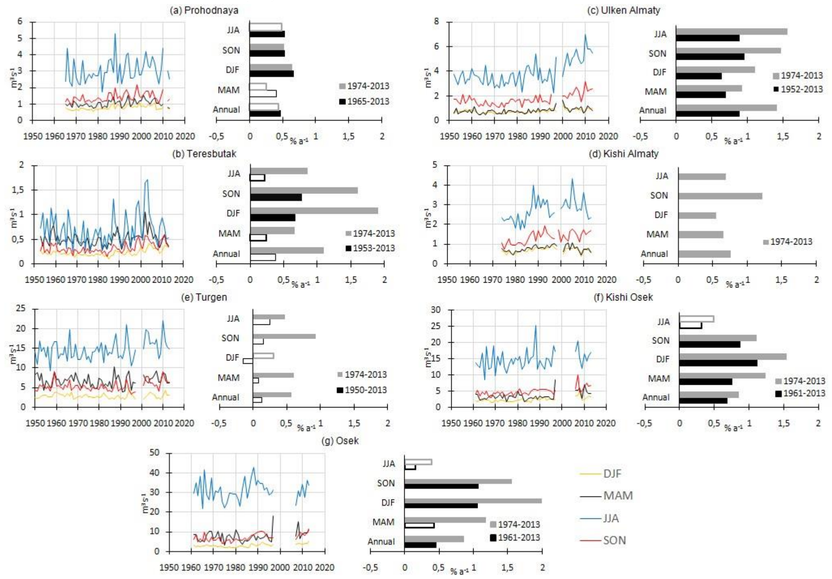

Figure 4. Trends in seasonal and monthly streamflow (% a^{-1}) over the 1974-2013 period and full duration of individual records calculated using Mann-Kendall test. Solid bars represent trends significant at 0.05 confidence level. Trends in seasonal streamflow (% a^{-1}) over the 1974-2013 period calculated using Mann-Kendall test for a range of thresholds. Solid bars represent trends significant at 0.05 confidence level[1].

Assessment of changes in streamflow since the 1950s

- To date, there was no consensus about trends in river discharge in Central Asia
- decline in monitoring after 1990
- rivers are heavily managed
- Continuous streamflow monitoring at 16 mountain rivers
- 7 natural catchments with long-term (>40 years), homogeneous records

Seasonal Mann-Kendall trends (% a^{-1}) in streamflow

- No statistically significant negative trends in any catchment or season in the consistent (1974-2013) and the extended periods
- Increase in autumn and winter streamflow
- Increase in summer streamflow in catchments with glacierization > 10 %
- Consistent trends in 1974-2013 and extended periods. Stronger trends were observed since the 1970s

Preliminary results

The sampling is carried out according to the agreed plan in each country (Table 2).

Table 2. Plan of sampling

№	Sources	Frequency
1	Streamflow headwaters	daily
2	Streamflow downstream (sample collection points together with water quality samples)	biweekly
3	***Sources***:	
	Spatial distribution: Several glaciers/rock glaciers/wells ect contributing to the flow	several times
	Precipitation	each time it rains/snow
4	***Additional data:***	
	Discharge/level, temperature, precipitation	daily
	Glaciers: Ice: at 20-30 cm: cut out block of ice: melt in a plastic bag	once
	Permafrost: water from the bottom of the active layer	once
	Groundwater	several times
	Moraine and rock glaciers: melt water	several times
	Lakes	several times

At the moment, we have data set for two years 2017, 2018 for Kazakhstan catchment and continue collection of samples. This year was started sampling collection in 4 countries of Central Asia.

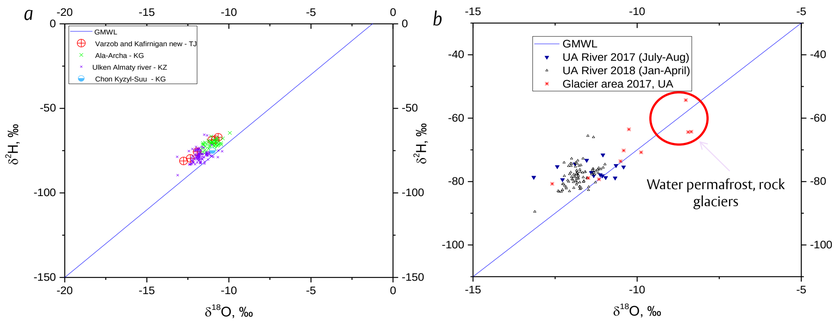

Figure 5. Stable water isotopes composition: (*a*) historical data for Central Asia and (*b*) recent data set for Kazakhstan catchments for 2017, 2018[2-5]

Stable water isotope composition in streamwater in different study catchments show :

- All studied rivers have similar isotopic signatures indicating similarity in sources of water (Fig. 5)
- The main sources are groundwater , melt water and precipitation

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