2. Казьмин С.П. Геолого-геоморфологическая основа ландшафтов. Климатические условия эволюции (на примере Западной Сибири). Германия, Саарбрюккен: Междунар. изд-во LAP LAMBERT Academic Publishing, 2011. 176 с.
3. Соколов Б.С. Древняя жизнь и геологическое время // Эволюция жизни на Земле: Материалы IV Международного симпозиума, 10-12 ноября 2010 г. Томск: ТМЛ-Пресс. 2010. С. 5-8.
4. Добровольский В.В. География почв с основами почвоведения. М.: Просвещение, 1976. 288 с.

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БЫСТРЫЕ СОКРАЩЕНИЕ ЛЕДНИКОВ И ИХ ВЛИЯНИЕ НА ВОДНЫЕ РЕСУРСЫ В ЗАПАДНОЙ ЧАСТИ ЖЕТЫСУСКОГО (ДЖУНГАРСКОГО) АЛАТАУ

Калдыбаев А.[1] *, Чен Я.* [2]
[1] *Институт ионосферы*
Республика Казахстан, г. Алматы, Каменское плато,
e-mail: azamatkaldybayev@gmail.com
[2]*Синьцзянский институт экологии и географии*
Китай, Урумчи, e-mail: chenyn@ms.xjb.ac.cn

SUSTAINED RAPID SHRINKAGE OF GLACIERS AND THEIR IMPACT ON WATER RESOURCES IN WESTERN PART OF ZHETYSU (DZHUNGAR) ALATAU

Kaldybayev A. [1], *Chen Y.* [2]
[1] *Institute of IonosphereRepublic of Kazakhstan, Almaty*
, e-mail: azamatkaldybayev@gmail.com
[2] *Xinjiang Institute of Ecology and Geography*
China, Urumqi, South Beijing Road 818, e-mail: chenyn@ms.xjb.ac.cn

Key words: Glacier shrinkage, glacier mapping, river runoff, Karatal river basin

Abstract

Our glaciological studies were conducted for the periods of 1956-1989, 1989-2001 and 2001-2012 based on Landsat TM/ETM+ data analysis. Well-established semi-automated band ratio technique was applied for glacier mapping. Result showed comparatively highest shrinkage rate (-1.02%) than in other glacierized areas of Central Asian mountains, including Altai, Tien Shan and Pamir. We also analyzed long-term climatic and runoff fluctuation for the different sub-basins of the Karatal River with various size of glacierized area. Positive trend in annual discharge was detected in almost all glacierized tributaries of Karatal River during last half century.

Mountain glaciers are a sensitive indicator for climate change [IPCC, 2007] as well as essential water storage areas on a seasonal, mid-term, and long-term time scale [5]. Various researches based on remote sensing methods founded that Central Asian glaciers has accelerated their shrinkage at the last several decades [1, 4, 8], mainly those that are located on the peripheral regions of the Tien Shan [5, 10].

In spite of the glaciers' importance to the economy, regular glacier mass balance and other ground-based glaciological measurements were discontinued in the Karatal River basin, as well as in the entire Zhetysu Alatau mountains, after the collapse of the USSR during the 1990s. The first detailed glacier inventory, the 'Catalogue of Glaciers' ('GI' USSR 1980), was published in 1980, and was based on airborne imagery from 1956. Cherkasov [2] compiled the second glacier inventory, using topographic maps on a 1:25000 scale, based on aerial photographs taken in 1972, and two more limited glacier studies were conducted for the 1990s and 2000s. These inventories, however, remained as unpublished reports [11]. Nevertheless, analyses of the glacier changes for basins located in the entire Zhetysu Alatau were reported by several authors, who estimated that the total decrease of the glacier area in Karatal River was 34.8% during 1956-2000 [7, 8, 11]. However, glacier changes in the Zhetysu Alatau, including Karatal River basin for last one and half decade has not been published. Thus, glacier changes in surface area in Zhetysu Alatau, including Karatal basin glaciers, are still poorly understood.

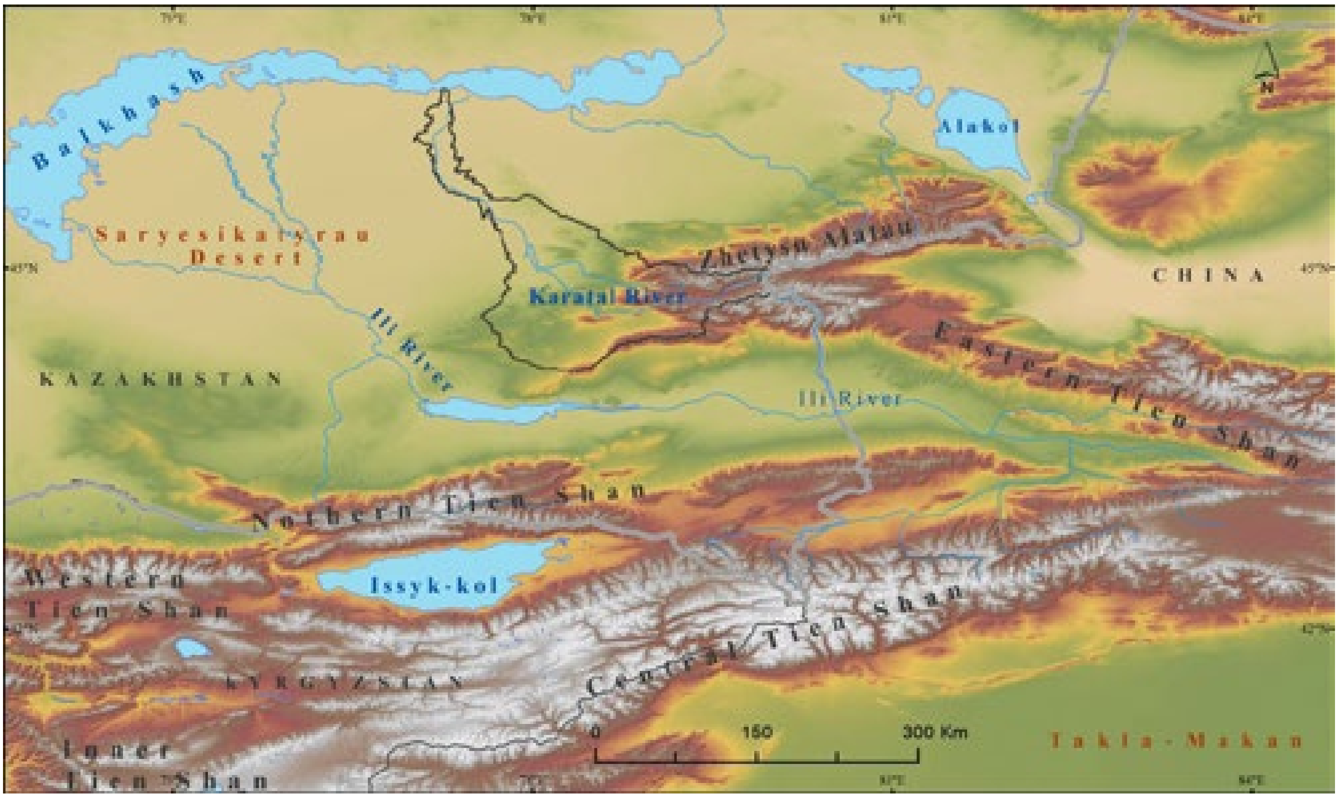

Fig. 1 Geographical location of study area

The Karatal River Basin, which is the largest basin in Zhetysu Alatau, covers an area of 19,100 km2; the total area of the four sub-basins studied here is 4370 km2 (Fig. 1).

Our glaciological studies were conducted for the periods of 1956-1989, 1989-2001 and 2001-2012 based on Landsat TM/ETM+ data analysis. Well-established semi-automated band ratio technique was applied for glacier mapping. All of the selected Landsat TM, ETM+ images were in good condition, and almost free of clouds and snow. Nevertheless, several images for each period were also used because of different snow conditions and ETM+ image gaps. Images provided by the USGS were processed to Standard Terrain Correction (Level 1T), achieving systematic geometric and radiometric accuracy. Geodetic accuracy of the images depended on the accuracy of the ground control points and resolution of the used DEM (30 m).

In 1989, we found 243 glaciers with a total area of 142.8 km^2 that by 2012 had shrunk to 214 glaciers with a total area of 109.3 km^2 –a decrease of 33.5 km^2 over 23 years or -1.02% per year. We also analyzed the shrinkage rate of glaciers based on their differences in size, altitude and aspect of slopes, as well as other topographic parameters in four sub-basins, where glacier shrinkage varied from 18% to 39% (Table 1).

Annual runoff of the almost all sub-basins showed increasing trend for different seasons for entire observed time. Increasing discharge trend was statistically significant in more glacierized catchments (Kora, Koksu and Terisakkan). Trends of runoff for the melting times were close to those in annual period (Table 2).

Table 1
Changes in glacier area

Region	Area change (%) /annual rate (%)					Mean size (km^2) in 1989
	1956-89	1989-01	2001-12	1956-12	1989-12	
Terisakkan	-40/-1.22	-23/-1.96	-20/-1.8	-63/-1.13	-39/-1.68	0.403
Koksu	-31/-0.93	-15/-1.24	-13/-1.14	-48/-0.86	-26/-1.11	0.506
Chizhin	-44/-1.32	-15/-1.24	-9/-0.79	-56/-1.0	-22/-0.97	0.445
Kora	-28/-0.61	-14/-1.03	-7/-0.63	-35/-0.62	-18/-0.80	0.873
Total	-28/-0.86	-14/-1.20	-11/-0.96	-45/-0.81	-23/-1.02	0.588
Glaciers <0.1 km^2 in 1956	-34/-1.04	-68/-5.63	-22/-1.99	-83/-1.49	-75/-3.25	0.031

Table 2
Characteristics of sub-basins and changes in annual runoff

	Glaciation, %	Z of trend in annual runoff	Mean run-off (m3/s)	Basin area(km2)
Kora	14	3.32	14.1	484
Koksu	7	2.38	39.2	1590
Terisakkan	5	2.31	9.3	293
Chyzhyn	2	-0.43	11.6	479
Tekeli	0	0.86	2.2	193

But, streamflow for the cold months showed higher increases in entire observed time for all sub-basins, but the absolute changes remained small. Less glacierized (Chizhin) and non-glacierized sub-basins (Tekeli) show lower increasing trend in the melting season and annual time.

The area changes of the glaciers investigated in the Karatal River basin confirmed an expected and widely published trend of glacier shrinkage [3, 8, 12]. However, with the shrinkage rate of about -0.8% to -1% a-1 for the periods of 1956-1989 and 1989-2012, our results for this study area showed a highest shrinkage rate shrinkage rate compared to other glacierized areas of Central Asian mountains, including Altai, Tien Shan and Pamir [1, 4, 8, 9]. Regionally varying result to climate change implies that glacier decrease is less influenced in the continental inner ridges than in the more moisture outer ridges.

The very high shrinkage rate is likely connected with a general trend of increasing temperature, small size of glaciers and their location on the low altitudes of the outer Zhetysu Alatau ranges. Therefore, we concluded that glacierized areas of the Karatal River basin were located in the most unfavorable conditions for glaciation, and as a result showed comparatively highest shrinkage rate than in other glacierized areas of Central Asian mountains, including Altai, Tien Shan and Pamir.

References

1. Bolch T. Climate change and glacier retreat in northern Tien Shan (Kazakhstan/Kyrgyzstan) using remote sensing data. // Global Planetary Change. 2007. №56. P. 1-12
2. Cherkasov P.A. Calculation of the components of water-ice balance of inland glacier system. // Almaty, 2004. (in Russian)
3. Climate change impacts on glaciers and runoff in Tien Shan (Central Asia). / Sorg A. [et al.] // Nature. Climate. Change. 2012. №2. P. 725-731
4. Glacier changes in the Tien Shan as determined from topographic and remotely sensed data / Aizen V.B. [et al.] //. Global Planetary Change. 2007. №56. P. 328-340
5. Glacier changes in the Big Naryn basin, Central Tian Shan./ Hagg W. [et al.], Global Planetery Change. 2012. №110. P. 40-50

6. Glacier Inventory of the USSR. Central and Southern Kazakhstan, ed. II Balkhash basin, part 5. Karatal river basin // Leningrad: Hydrometeoizdat. 1980. (in Russian)
7. Glaciological system of Balkhash-Alakol basin: state and current changes. / Severskiy I.V. [et al.] // Voprosy geografii I ekologii. №2. P. 31-40 (in Russian)
8. Kaldybayev A., Chen Y., Vilesov E. Glacier change in the Karatal river basin, Zhetysu (Dzhungar) Alatau, Kazakhstan // Annals of glaciology. 2016. №57(71) doi: 10.3189/2016AoG71A005
9. Kutuzov S., Shahgedanova M. Glacier retreat and climatic variability in the eastern Terskey-Alatoo, inner Tien Shan between the middle of the 19th century and beginning of the 21st century // Global Planetary Change. 2009. №69. P. 59-70
10. Spatial variability of recent glacier area changes in the Tien Shan Mountains, Central Asia, using Corona (1970), Landsat (2000), and ALOS (2007) satellite data / Narama C. [et al.] // Global Planetary Change. №71. P. 42-54
11. Vilesov E.N., Morozova V.I., Severskiy I.V. Glaciation Dzhungar (Zhetysu) Alatau: past, present, future. Almaty: Volkova. 2013. 244 p (in Russian)
12. What do we know about past changes in the water cycle of Central Asian headwaters? A review. / Unger-Shayesteh K [et al.] // Global Planetary Change. 2013. №110. P. 4-25

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ВАРИАЦИИ ВЛАЖНОСТИ КЛИМАТА В СРЕДНЕМ И ПОЗДНЕМ ГОЛОЦЕНЕ ПО ДАННЫМ ПАЛЕОЭКОЛОГИЧЕСКИХ ИССЛЕДОВАНИЙ БОЛОТ ЮЖНОЙ ТАЙГИ ЗАПАДНОЙ СИБИРИ

Курьина И.В., Бляхарчук Т.А.
Институт мониторинга климатических и экологических систем СО РАН
г. Томск, пр-т Академический, д. 10/3, e-mail: klimirin@sibmail.com

VARIATIONS IN CLIMATE HUMIDITY IN THE MIDDLE AND LATE HOLOCENE ACCORDING TO PALEOECOLOGICAL STUDIES OF BOGS IN THE SOUTHERN TAIGA OF WESTERN SIBERIA

Kurina Irina V., Blyakharchuk Tatyana A.
Institute of Monitoring of Climatic and Ecological Systems SB RAS, e-mail: klimirin@sibmail.com

Key words: testate amoebae, water table depth, paleoecological reconstruction, Holocene, peatland, southern taiga, Western Siberia, climate changes, paleoclimate

Abstract

The comparative analysis of data on dynamics of water table depth was carried out in three peat cores with different properties and age, collected in the southern taiga of Western Siberia. Obtained unidirectional synchronous changes in water regime of peatlands are most likely the result of climatic change. Increase of water table depth is noted for 450-700, 1300-1360, 1650-1750, 3500-4350 cal. yr. BP, decrease – 300-400, 1400-1500, 4600-5200 cal. yr. BP. Differences in the reconstruction of the water table depth in the peat cores is the result of local endogenous processes.

Палеоэкологические исследования торфяных отложений позволяют реконструировать историю формирования болотных массивов, окружающих их ландшафтов, а также позволяют получать информацию о происходивших за время торфонакопления климатических изменениях. Одним из способов выделения климатических сигналов является сравнение данных о динамике локальных усло-