Changes in glaciation of the Shelek River basin from 1955 to 2014

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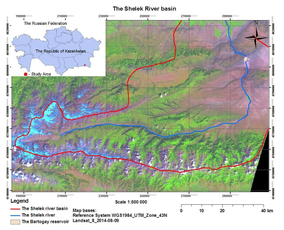
Introduction

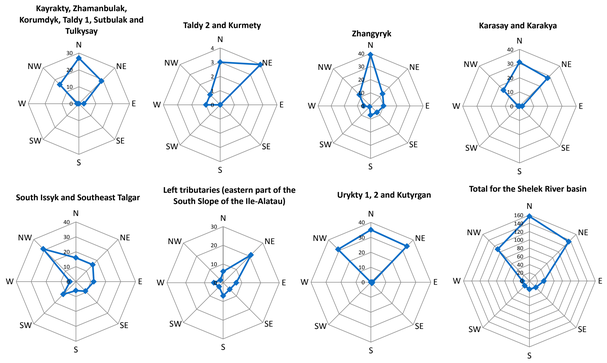
The Shelek River is a left tributary of the Ile River and it flows in the southern part of Almaty province, between two ridges of north Tien-Shan: Ile-Alatau and Kungey Alatau. This river is one of the biggest rivers in the southeast Kazakhstan. Since 1960's glaciation of this basin was observed by many researchers in different years. Available catalogues of glaciation were created by Vilesov E.N., Cherkasov P.A. and Uvarov V.N. There is a difference in results of calculations and methods of assessment by the materials of aerial photography. Nevertheless it was shows that this difference is not big. In our research we have considered changes only for visible part of glaciers. Analysis and creation of new catalog of glaciation by processing and interpretation of satellite images (Landsat 8) for this basin let us to compare our results with previous catalogs and to give an assessment of changes. (E. N. Vilesov, 1968)



Distribution of glaciers in the river basin

As a basis was taken the same method of dividing, which was taken in the old catalogue and division of the entire Shelek River consist of next parts:
1) Glaciers of the Zhangyryk river basin;
2) Glaciers of the Taldy 2 and Kurmety river basins;
3) Glaciers of the Urykty 1 and 2 and Kutyrgan river basins;
4) Glacier of the South Issyk and Southeast Talgar river basins;
5) Glaciers of the left tributaries (eastern part of the South Slope of the Ile-Alatau);
6) Glaciers of the Karasay and Karakya river basins;
7) Glaciers of the Kayrakty, Zhamanbulak, Korumdyk, Taldy 1 Sutbulak and Tulkysay river basins.
Contouring of glaciers and mountain ridges was done manually.
All glaciers were divided into 12 morphological types. For dividing as a basis were used the "Glossary of glacier mass balance and related terms" and the "Guidance for creation of catalogs of glaciations of the USSR". For calculations of the glaciers volume, were used formulas developed by J. Macheret, P. Cherkasov and L. Bobrova (Macheret et al., 1988)

Distribution by Exposition as of year 2014



Changes

Name of the basins	Number of glaciers as it is given in the catalogue as of year 1968	Number of glaciers as of year 2014	Number of decayed glaciers	Area of glaciation, km²	Share in the total area of glaciation of the Shelek River basin, as of year 2014 %	Share in the total area of glaciation of the Shelek River basin, from the old catalog, %
Zhangyryk	53	94	20	55.6±2.00	28.8	29.2
Taldy 2 and Kurmety	7	9	2	0.9±0.03	0.5	0.5
Urykty 1 and 2 and Kutyrgan	43	102	16	6.9±0.25	3.6	5.1
South Issyk and Southeast Talgar	45	106	22	76.8±2.76	39.7	34.8
Left tributaries (eastern part of the South Slope of the Ile-Alatau)	28	57	15	14.9±0.54	7.7	8.2
Karasay and Karakya	34	78	18	14.7±0.53	7.6	9.1
Kayrakty, Zhamanbulak, Korumdyk, Taldy 1 Sutbulak and Tulkysay	39	66	18	23.4±0.84	12.1	13.1

Total area of visible part of glaciers as of year 2014 is about 193.2±6.96 km², it means that reduction of glaciation compare to old catalog is about 28-33%. These figures also confirm the fact that reduction of glaciation in the Shelek river basin has significantly lower rate compare to for example the North Slope of Ile-Alatau, where reduction of glaciation from 1955 to 2008 is about 40%. Only one part of the basin (South Issyk and South-East Talgar), showed an increasing of its share in the total area of glaciation of the Shelek River basin, but very significantly, from 34.8% to 39.7%. As it was mentioned before this is mainly due to orography, microclimate features and presence of big glaciers like Korzhenevskyi and Bogatyr, as we remember big glaciers are more stable than small ones.

The Korzhenevky glacier (left) and the Bogatyr glacier (right), (photos by Blagoveshensky V.P.)

Formulas which were used for calculations of volume

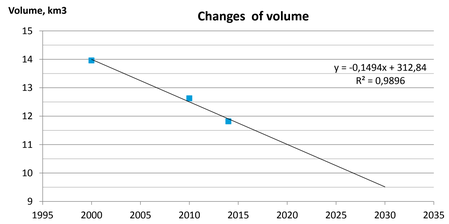
$$V = 29.76 \cdot 10^{-3} S^{1.38} \quad (1)$$

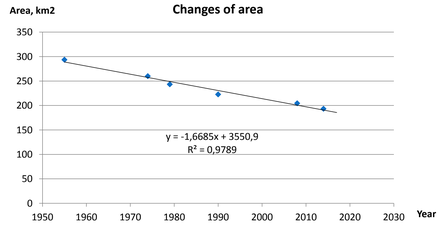
$$V = 29.76 \cdot 10^{-3} S^{1.38} \quad (2)$$

$$V = 0.004 \cdot 10^{-6} S^{1.12} \quad (3)$$

$$V = 4 \cdot 10^{-9} \left(\frac{\sum S_i}{n}\right)^{1.12} \quad (4)$$

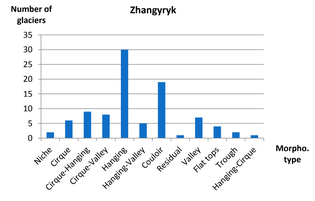
where: V – volume of a glacier;
S – an area of a glacier; formula (1) for main valleys glaciers; formula (2) for cirque glaciers and hanging valleys, with S<3km²; formula (3) for hanging glaciers, with S>0.1 km² and formula (4) for glaciers with S<0.1 km².

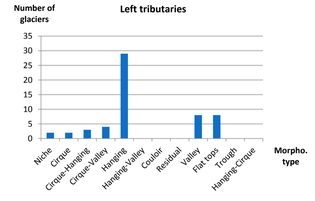


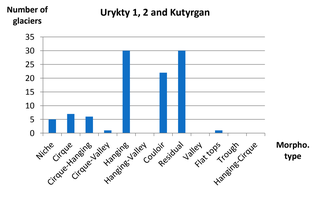


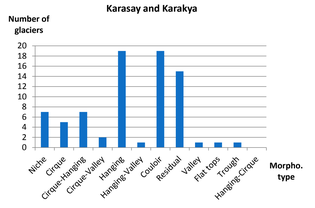
Glaciation of the Shelek River basin as of year 2014

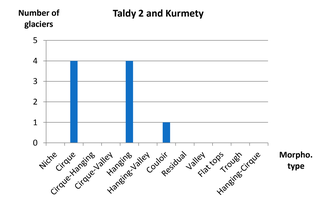
Kayrakty, Zhamanbulak, Korumdyk, Taldy 1, Sutbulak and Tulkysay	Karasay and Karakya	Zhangyryk	Left tributaries	Taldy 2 and Kurmety	Urykty 1, 2 and Kutyrgan	South Issyk and Southeast Talgar	Entire Shelek River basin
Morphological type	Area, km²						
Niche	0.227	0.231	0.427	1.325	0	0.328	5.055	7.596
Cirque	0.357	0.413	1.939	0.479	0.644	1.658	0.235	5.728
Cirque-Hanging	3.207	2.468	3.166	0.325	0	1.584	0.239	10.992
Cirque-Valley	0.669	3.057	4.279	2.394	0	0.798	0	11.199
Hanging	1.871	1.864	0.849	0.497	0.267	2.068	1.536	8.956
Hanging-Valley	1.046	0.268	5.283	0	0	0	2.261	8.860
Couloir	0.098	0.228	0.079	0	0.006	0.228	0.080	0.723
Residual	0.029	0.087	0.004	0	0	0.181	0.263	0.565
Valley	15.916	2.205	19.295	9.515	0	0	38.489	85.422
Flat tops	0	0.107	0.566	0.370	0	0.079	1.151	2.276
Trough	0	3.806	19.714	0	0	0	27.497	51.019
Hanging-Cirque	0	0	0.002	0	0	0	0	0.002

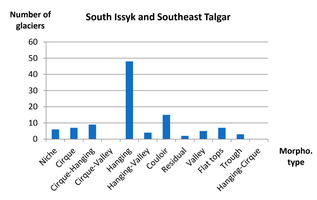












Volume of glaciers as of year 2014

Name of the basins	Volume of glaciers, km³
Zhangyryk	3.160839
Taldy 2 and Kurmety	0.027153
Urykty 1 and 2 and Kutyrgan	0.182340
South Issyk and Southeast Talgar	6.384266
Left tributaries (eastern part of the South Slope of the Ile-Alatau)	0.539038
Karasay and Karakya	0.602786
Kayrakty, Zhamanbulak, Korumdyk, Taldy 1 SutbulakandTulkysay	0.920793
Total	11.817215

Conclusion

Area of visible part of glaciers has reduced by 28-30% from 277.9 km² to 193.3±6.96 km² . This gives us the rate of degradation, about 0.58% per year since 1955.
Also was done calculations of volume of ice, for comparing and building a graph, data available only for years 2000 and 2010. (Final report of the laboratory of glaciology, 2013) In first catalog also was done calculation of the volume, but not for all glaciers. Volume of ice is equal to ≈ 11.8 km3 , which gives us reduction compare at about 15%, since year 2000. Our results also showed how big the difference of changes for sub-basins is. We have revealed 1 sub-basin which share in total glaciation has not changed, 1 which share has increased, and 5 which shares have reduced but with different magnitudes, which in our case mainly due to exposition of glaciers. This shows that analysis of big glacial systems and modeling by using data from one representative glacier like for example Tsentralniy Tuyuksuyskiy from our point of view should be done carefully, because in future can be reached a moment when it cannot be possible anymore apply one model to the entire glacial system, because difference even between small parts of glaciation could be very big.

References

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