

The retreat of Tien Shan glaciers (Central Asia) since the Little Ice Age obtained from the moraine positions, aerial photographs and satellite images

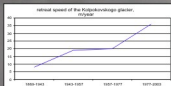
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The retreat of the terminus of glaciers and loss of glacier's area from their maximum extent during the "Little Ice Age" maximum (LIA) (XVIIIth-XIXth centuries) have been estimated using aerial photographs (from 1956 to 1987) and the latest satellite images (from 2001 to 2004) in the central Tien Shan mountains (Kyrgyz Republic).

In order to increase the accuracy in the identification of the moraines at the satellite and aerial images, all kind of published information about the front positions of glaciers in the end of XIX century was used. The glaciers under investigation are located on Teskey-Atatau, Ak-Shyrak, Adir-Tor Ranges.

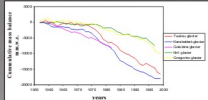
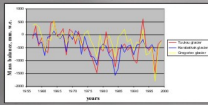
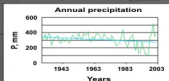
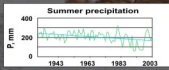
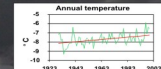
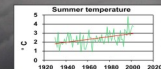
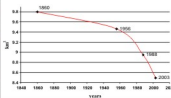
There is a great diversity of types, exposure and size of glaciers in the area. On the average the glaciers in these areas have retreated by 900-600 m since the LIA maximum. Thus in the second part of XXth century, glaciers area has changed by about 25-30% comparing with 5-8% between 1880 and 1970s.

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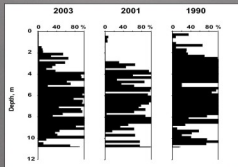


The comparison of aerial photographs from 1956 and 1988 and satellite images from 2003 show considerable retreat of glacier terminus from 1956. The rate of retreat is compared to that determined from LIA moraine positions.

Gregoriev glacier area has been changed since 1860 from 9.8 km² to 9.46 in 1956, 8.9 km² in 1988 and 8.3 km² in 2003.



Glacier mass-balance measurements and reconstructions (Gregoriev glacier) shows that, the glaciers were stable from the end of 1950th to the mid of 1970th. Negative mass balance is prevailing since 1970th.



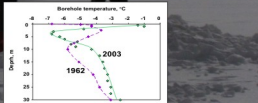
Present warming is also the reason of structural changes of glaciers in addition to retreat of glacier terminus.

Five shallow ice cores have been recovered from the summit of the Gregoriev Ice Cap (41.98°N; 77.92°E; 4609 m a.s.l.) in Tien Shan, Central Asia, between 1990 and 2003.

The detailed stratigraphic records for the top sections of the 1990 and 2001 cores indicate that 3.8 m of snow/ice accumulated in the 11 years. The mean annual net accumulation derived from this comparison is 0.35 m in ice equivalent (i.e. (260 mm w.e.) for the period from 1990 to 2001. The net accumulation from 1963 to 1990 was 0.42 m i.e. (320 mm w.e.). Moreover decrease of firn pack depth from 9 to 6 m has been observed at 4450 m site between 196 and 2003.

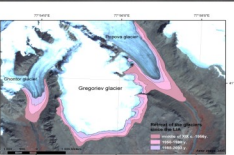
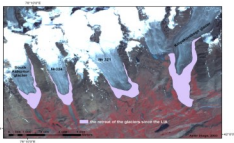
Over the same period infiltration ice concentration has been increased as a result of more intensive melt water percolation.

Temperature measurements in the boreholes on the top of the Gregoriev glacier in 1962 (Dikikh, 1965) and 2003 shows that the temperature rise is -2.5 C at 10 m and 0.5 C at 30 m depth.



Unprecedented wastage and structural changes of glaciers in the Tien Shan from the mid-1970s till the beginning of the XXI century most likely resulted from the increase of summer air temperature and decrease of summer precipitation which have been recorded at the meteorological stations (the Tien-Shan station etc).

The change in atmospheric pressure over the central North Atlantic Ocean during the mid-1970s can be one of the possible reasons for these processes.



number	number of	length	number of
of	glaciers	of	glaciers
1860	10	100	20
1956	30	1.1, 2	30
1988	2	7.5, 1	30
2003	3	3.1, 4	30
2003	3	1.5, 1.7	30
2003	30	5.1, 6	30
2003	30	6.1, 7	30
2003	30	7.1, 9	30

number	number of	length	number of
of	glaciers	of	glaciers
1860	2	50	20
1956	2	70	20
1988	2	80	20
2003	2	90	20
2003	2	100	20
2003	2	110	20
2003	2	120	20
2003	2	130	20
2003	2	140	20
2003	2	150	20
2003	2	160	20
2003	2	170	20
2003	2	180	20
2003	2	190	20
2003	2	200	20