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Current State and Dynamics of the Aktru Glaciers Over the Period of Instrumental Observations

Geographical Station Aktru

Valerii Zemtsov, Yuriy Narozhniy
Department of Hydrology, Laboratory of Glaciology and Climatology

1 Research history

Friedrich-August von Gebler
(1781–1850)

The investigation of the Altai glaciers began in the first half of the XIX century when

F. Gebler in 1835 studied the Altai Mountains and introduced them to the community of geographers as a glacial area

The systematic study of glaciers was started
by V. V. Sapozhnikov in the end of the XIX century

The first Tronovs' expedition was organized in 1912. In 1925, B. V. Tronov made the first catalogue of the Altai glaciers (Tronov 1925) in which data on 408 glaciers covering a total area of 590 km^2 were systematically presented.

M. V. Tronov continued the investigations and described 724 glaciers with an area of 600 km^2 (Tronov 1949). He organized the TSU Aktru research station in 1957.

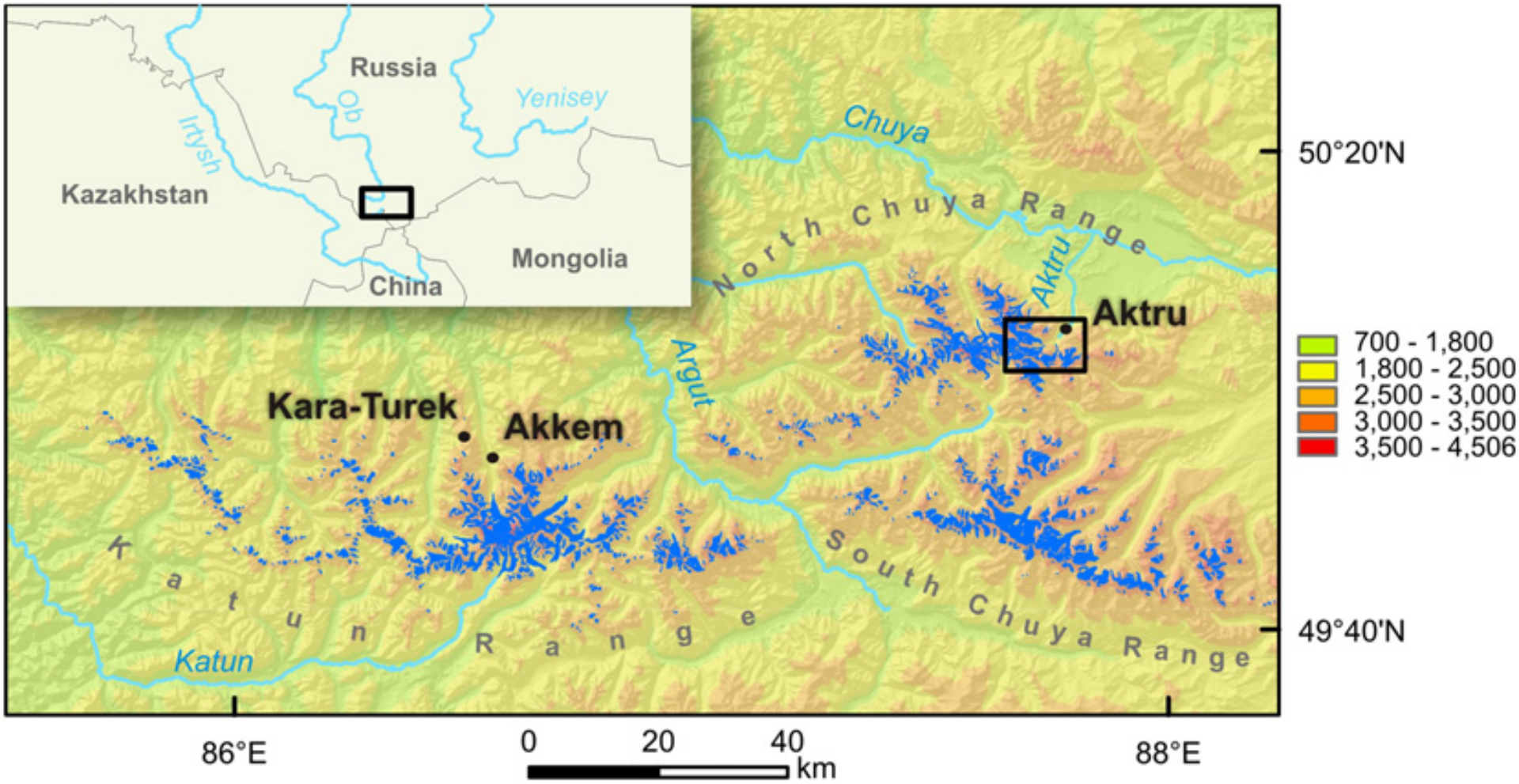
During the **International Geophysical Year (1957–1959)** and the **International Hydrological Decade (1965–1974)**, the main focus was on investigations of the main glaciers from permanent research stations that were established in the basins of the Aktru, Multa, and Akkem rivers.

Repeated cataloguing of the Altai glaciers was then carried out (Catalogue of glaciers of the USSR 1978).

Currently, such observations continued only at the Aktru Station.

A huge amount of material on the Altai glaciers was contributed to the study of regional glaciation in the Atlas of snow and ice resources of the World (World Atlas 1997).

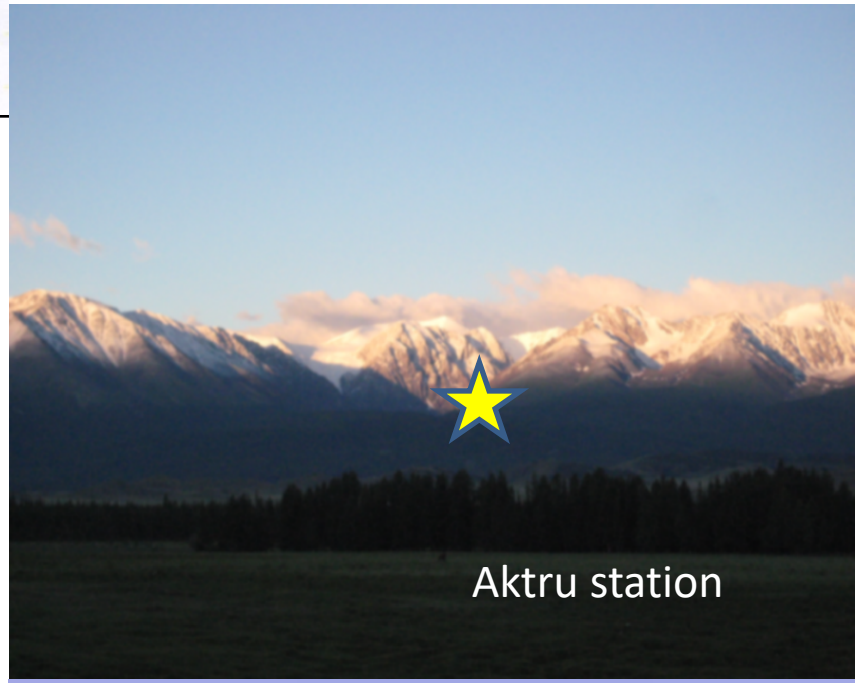
The period since 1980 until the present time is characterized by the most detailed and comprehensive data on the characteristics of the Altai glaciers reflecting recent trends of glacier regimes and mass balance.

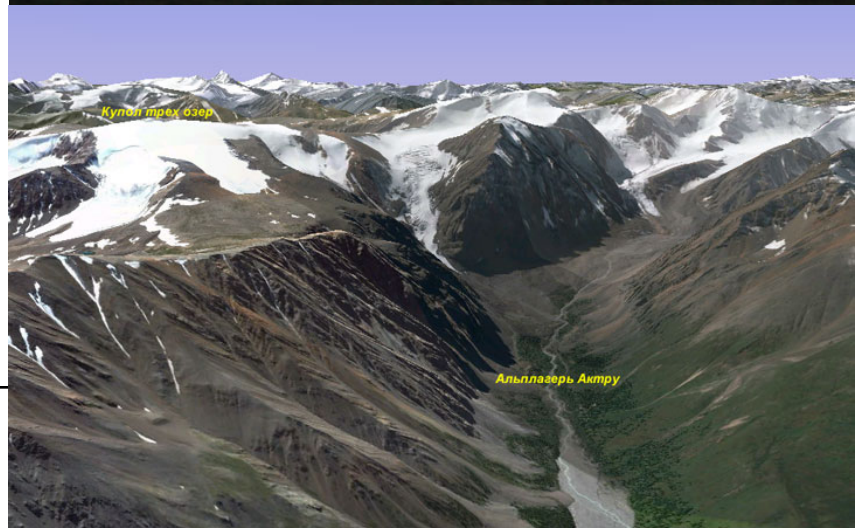


Source: Surazakov et al 2007

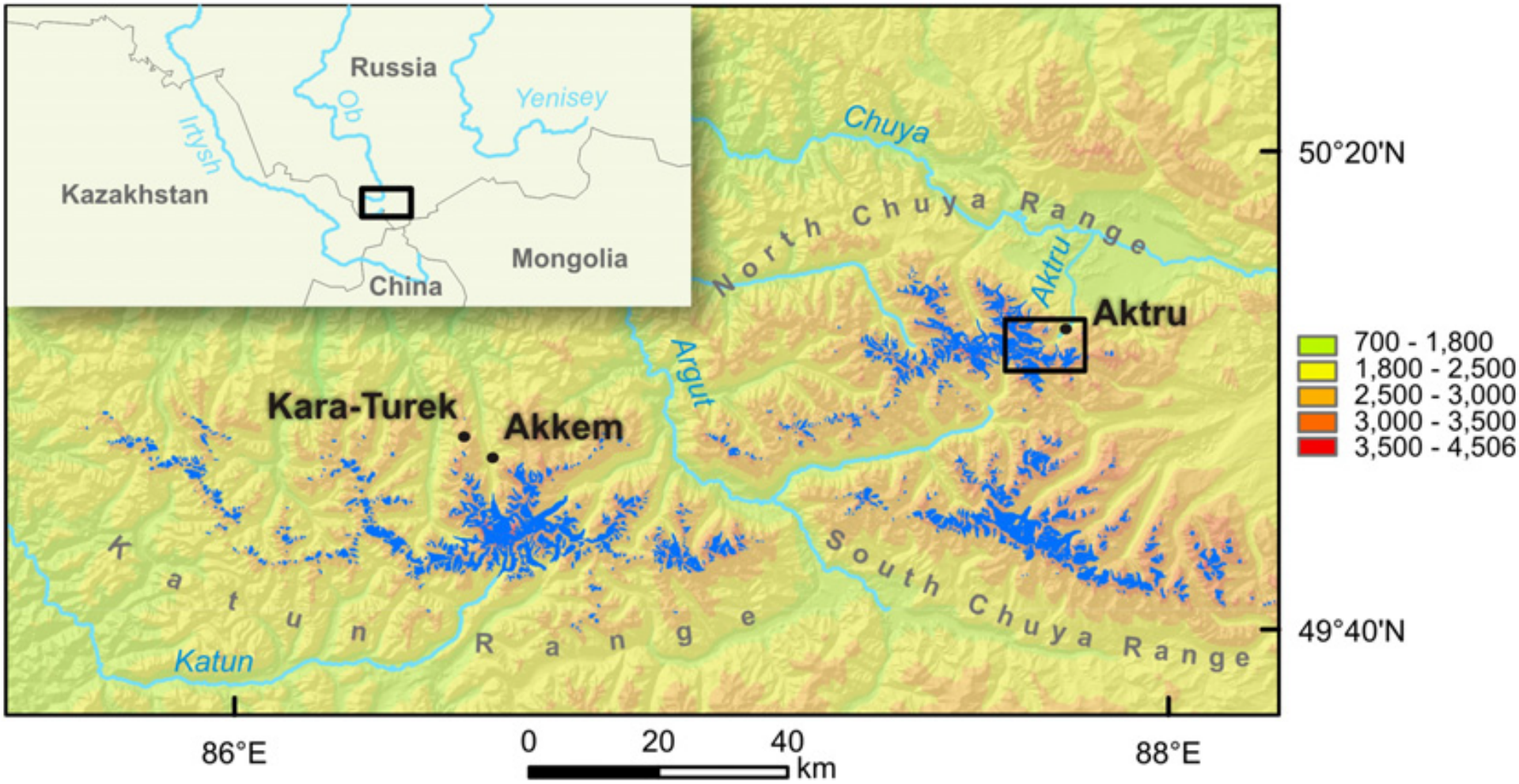
2 The Aktru research station

INTER ⇄ ACT
International Network for Terrestrial Research and Monitoring in the Arctic





Aktru Valley



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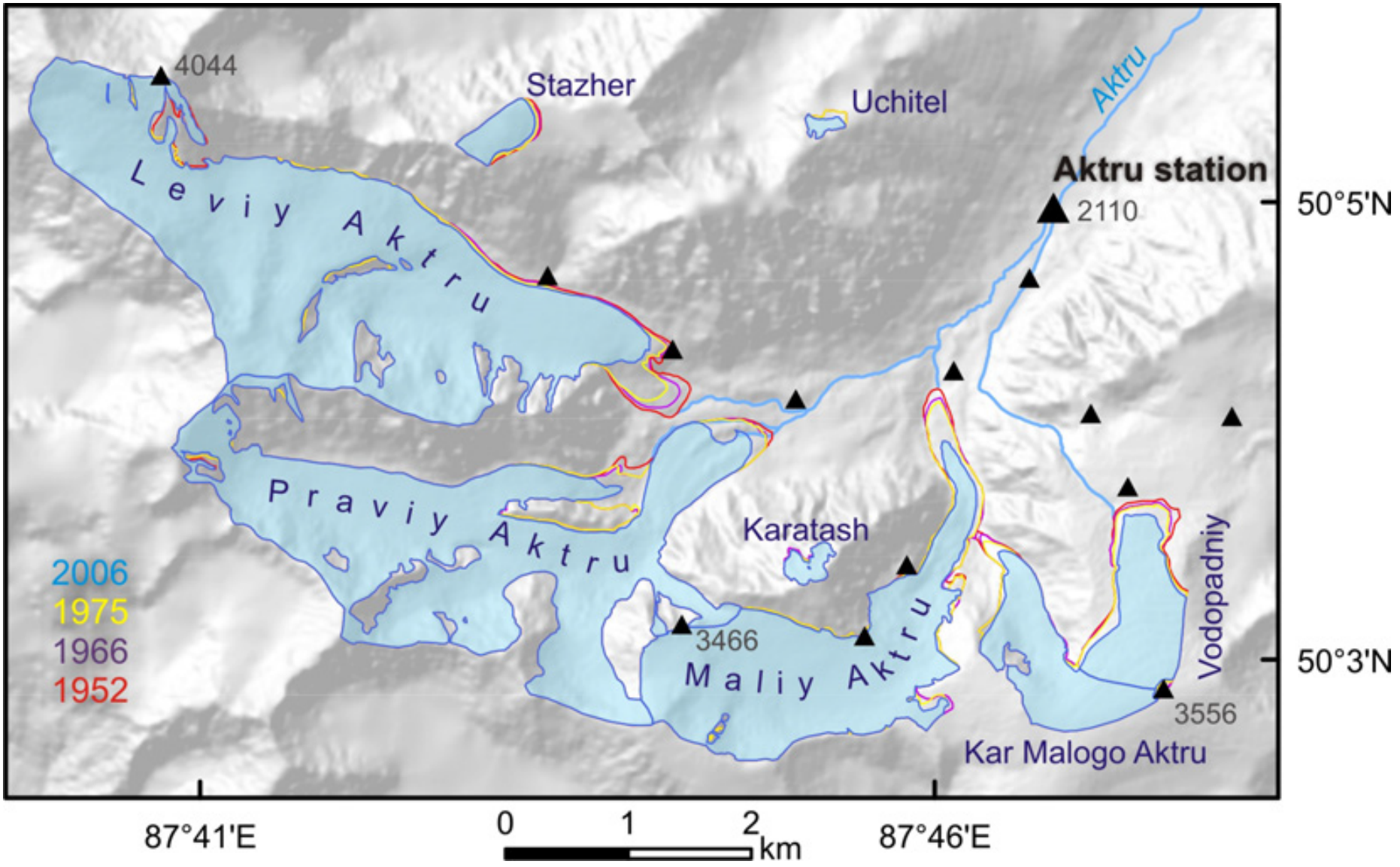
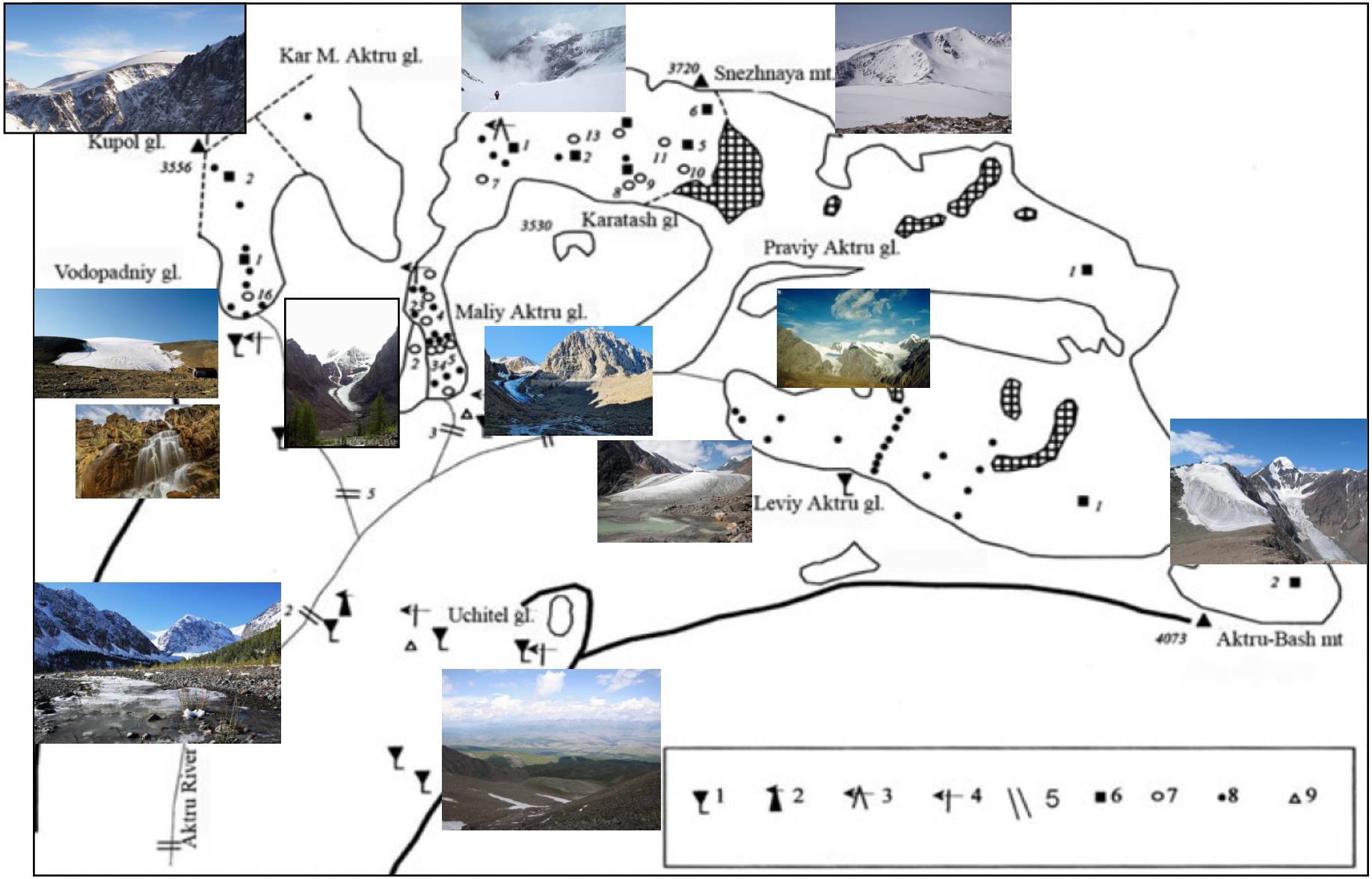


Source: Surazakov et al 2007



Observational network within the Aktru Basin: 1-cumulative precipitation meters, 2-the Aktru meteorological station, 3-the Upper Aktru seasonal meteorological station, 4- secondary seasonal meteorological sites, 5-water discharge gauging sites, 6-snow pits, 7-boreholes for ice temperature measurements, 8-ablation stakes, 9-permafrost meters (a device measuring a depth at which an ice surface is located in water filled vertical pipe)

Characteristics of the Aktru station (as presented for the INTER-ACT list)

Size of the Aktru drainage basin: 42.9 km^2 incl.16 km^2 of glacier area

Opening year	1956
Operational period	June-August, (May-September)
Institution responsible to run the station	National Research Tomsk State University
Website (institution)	www.tsu.ru
Climate zone	Alpine
Permafrost	Continuous
Geographical Coordinates:	longitude (WGS 84) 87 40'14'' E
Geographical Coordinates:	latitude (WGS 84) 50 06'03'' N
Altitude of station (m asl)	2150
Min Altitude within study area (m asl)	1500
Max Altitude within study area (m asl)	4075
Name of nearest town/settlement	Kurai village
Distance to nearest town/settlement (km)	45
Size of nearest town/settlement (no. of inhabitants)	600
Map	aerial image, satellite image, google earth with low resolution
Mean annual (°C)	-5.2
Minimum annual (°C)	-39.5
Maximum annual (°C)	25,7
Mean temperature in February (°C)	-18.5
Mean temperature in July (°C)	9,5
Total annual precipitation (mm)	542
Precipitation type	snow, rain
Period	June-August
Specific device	Meteostation, Different surveying equipment
Scientific services offered	Free access to extensive ecosystem baseline data, mountaineering

Prof. Michail Tronov
on the Praviy Aktru glacier,
1968

Secondary seasonal meteorological site
Maliy Aktru glacier, 2230 asl

Study of the Maliy Aktru glacier, the 1970s

A secondary seasonal meteorological site

AWS Campbell-2000 on the Leviy Aktru Glacier (source: IG RAN)

Nowadays, different summer schools, research conferences, students' practices are held at the TSU Aktru station.

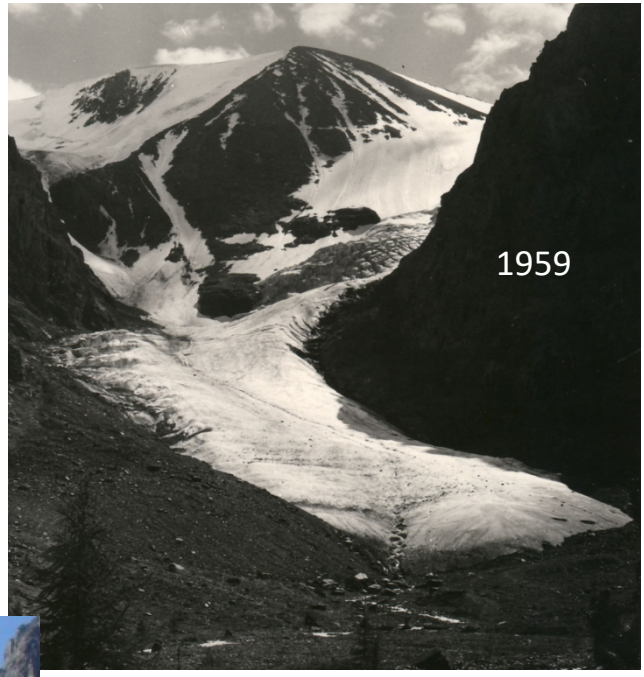
Researchers from Tomsk and different cities and countries in the fields of earth sciences, biology, ecology, archeology conduct their studies at the station and Altai area.

3 Change of Glaciers in the Aktru Basin

The glacier tongue locations in the Aktru basin at that time are well marked in landforms and confirmed by numerous radiocarbon, dendrochronological, and other types of dating

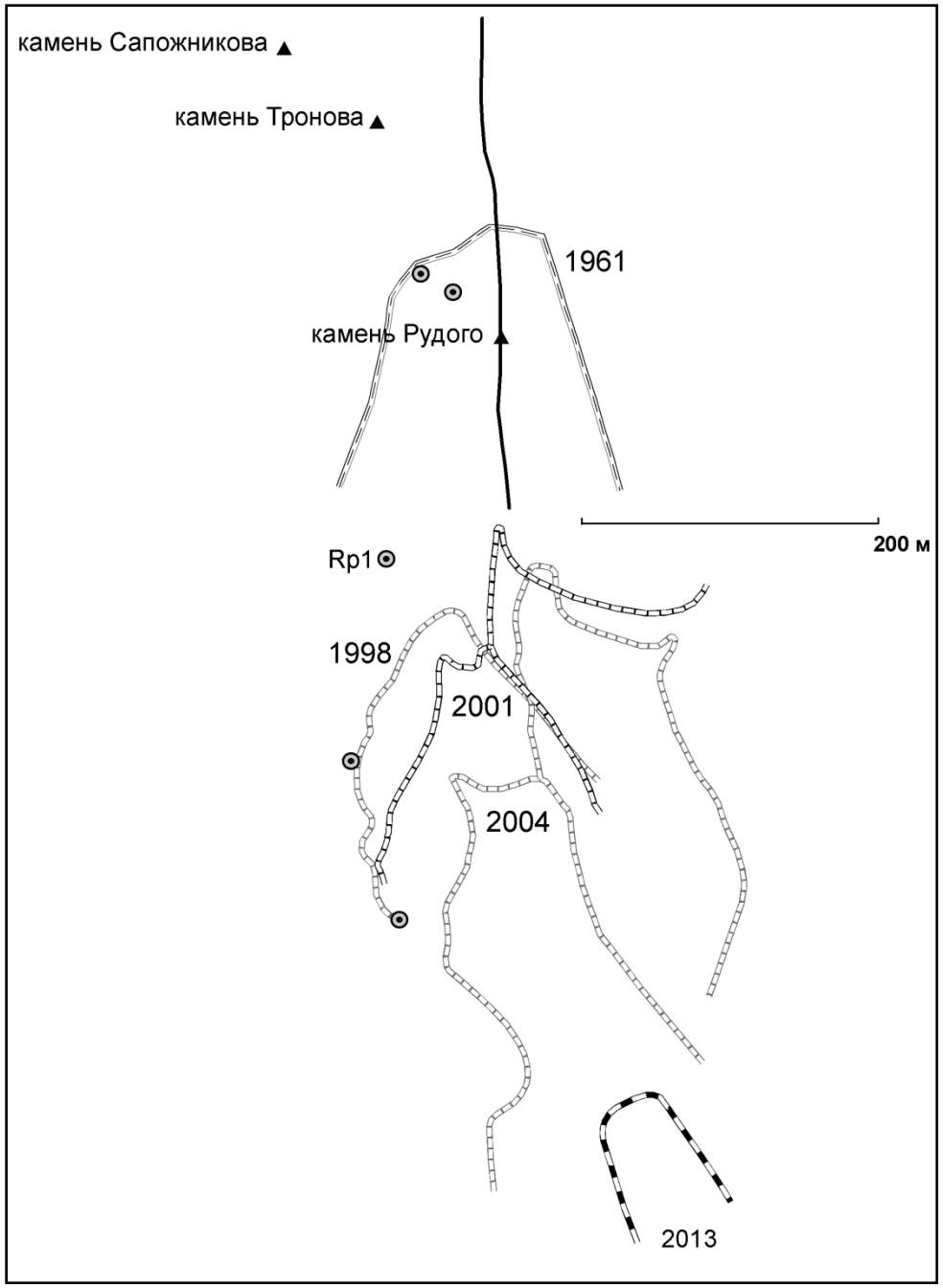
Instrumental measuring glacier front position

Prof. M.Tronov's benchmark



Retreat of the Maliy Aktru glacier

The glacier of Maliy Aktru is a basic glaciological benchmark in the Aktru basin and all over the Altai Region.



Location of the Maliy Aktru glacier front in different years against the main benchmarks in the Aktru Valley [Galakhov et al, 2014]

1961-1995: 160 m lost 4.7 m yr^{-1}

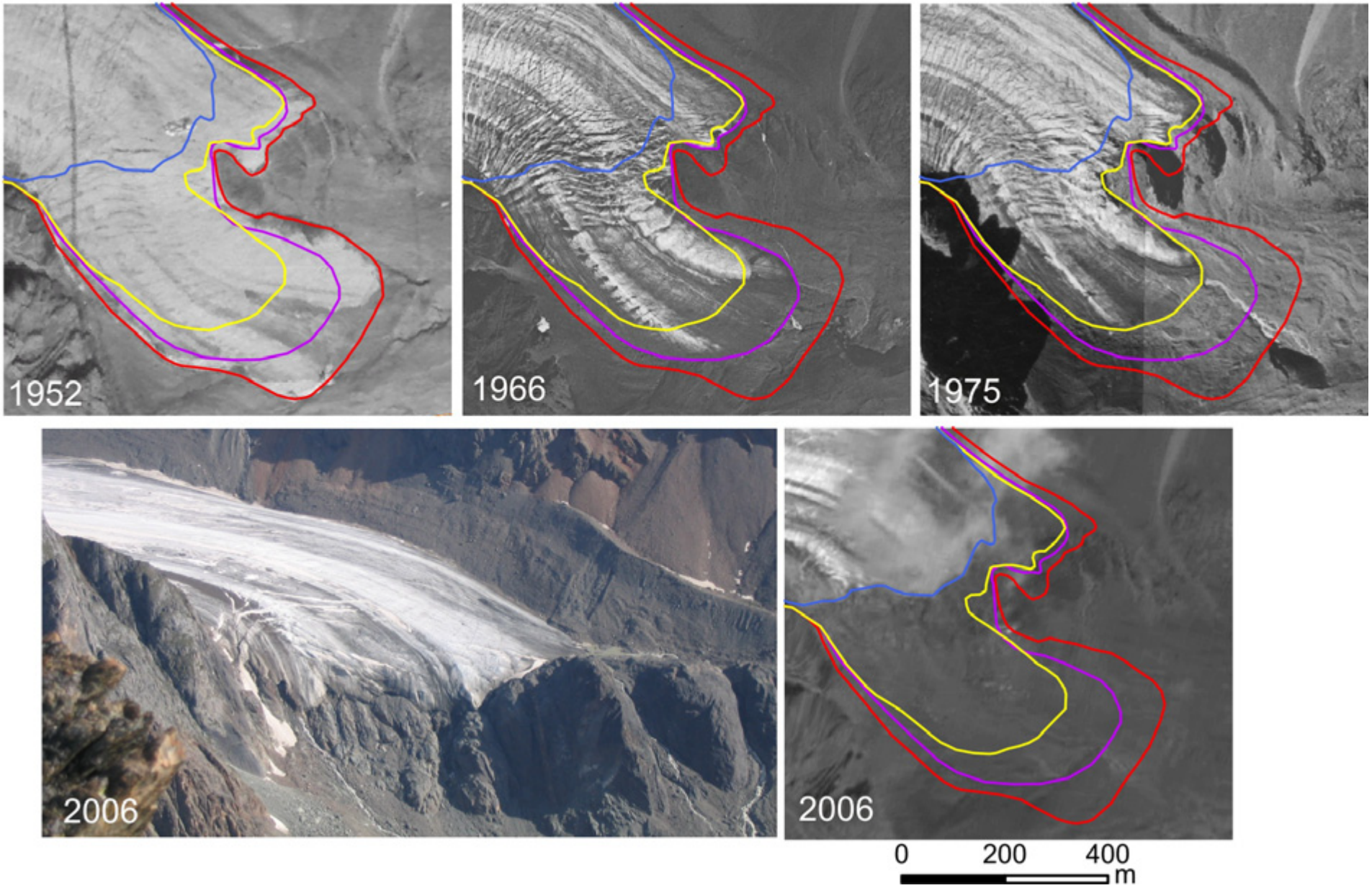
1991-2012: 366 m lost 16.6 m yr^{-1}

▲ main benchmarks

Maliy Aktru glacier

Retreat of
the Bolshoy Aktru glacier

A process of disintegration began
in the end of the 1950s - beginning of the 1960s

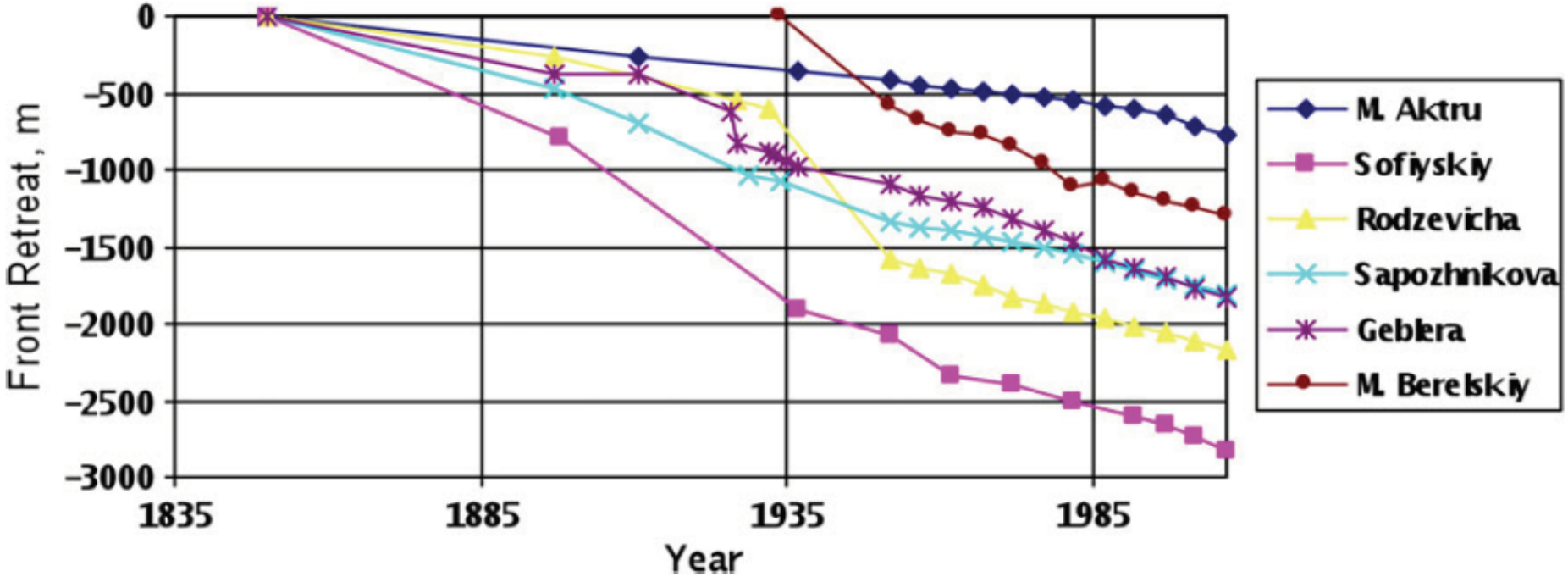


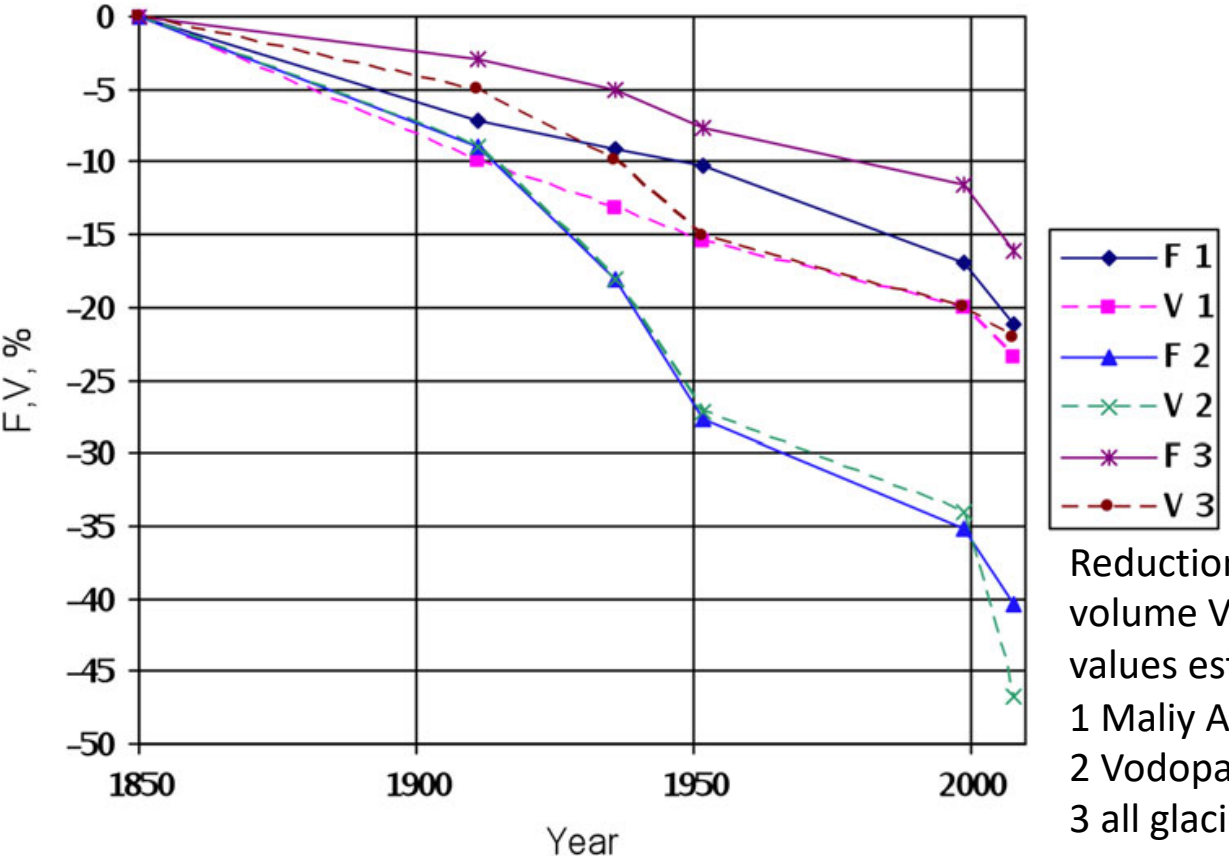
Multitemporal boundaries of the Leviy Aktru glacier terminus overlaid on the orthorectified imagery. On the 2006 PRISM image a light cloud partly obscured the glacier boundary. The lower left image is an oblique photograph taken during the 2006 field work (adapted from Surazakov *et al*. 2007)

Glaciers' front area

(photo A. Rudoy, 2013)

Cumulative curves of glacier front variations during the instrumental observation period have been obtained





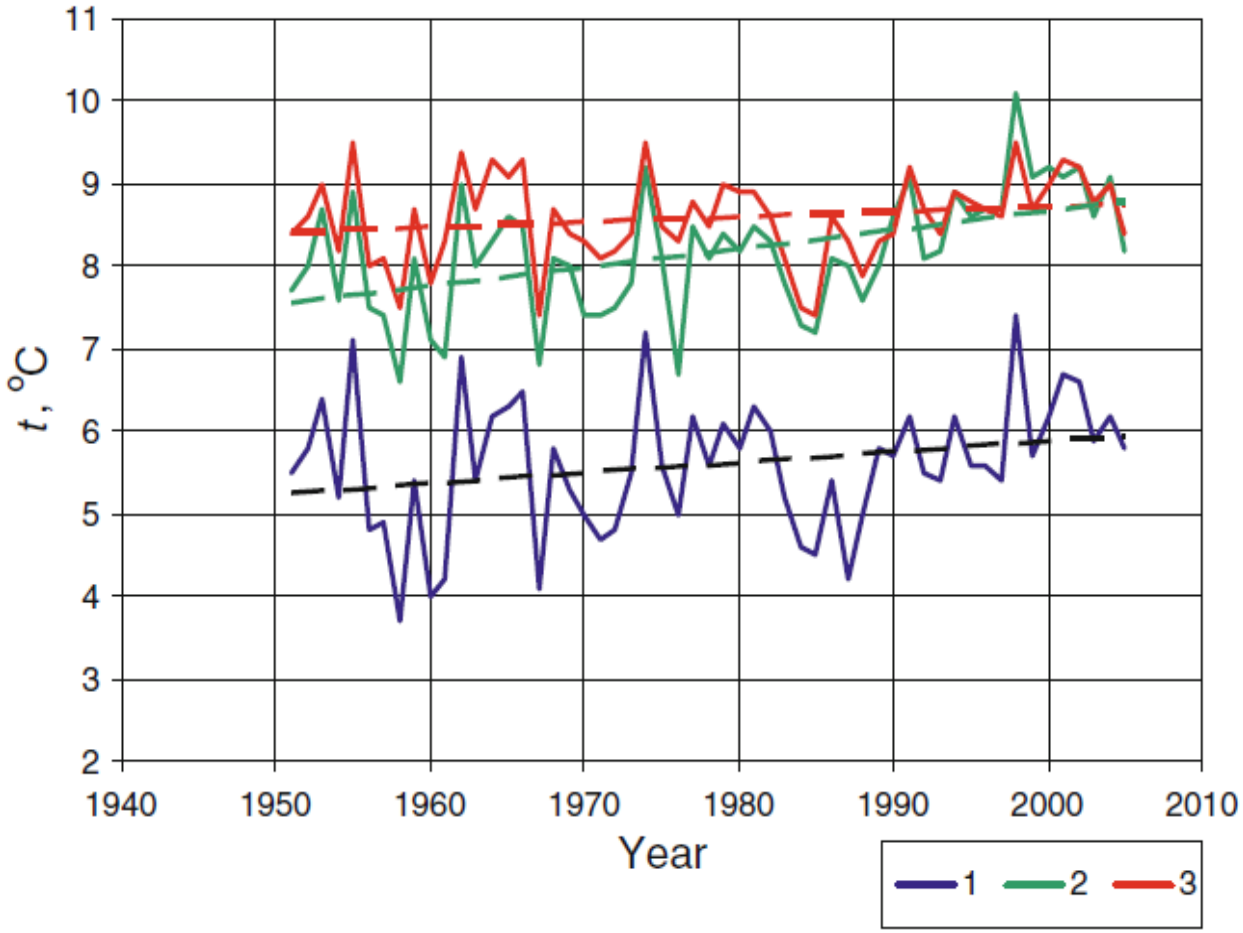
Reduction of glacier areas F (solid lines) and volume V (dashed lines) (in percentage of values estimated for 1850):
1 Maliy Aktru,
2 Vodopadniy,
3 all glaciers

Quantitative estimations made on the basis of both the direct echo-sounding of glaciers and use of the dependencies between V and F for different periods of time show that the volumes of ice are being reduced more intensively than the glacier area, except for the Vodopadniy glacier.

Table 1 Aktru Basin glacier changes between 1850 and 2008

Glacier morphological type and aspect	Year	Glacier front retreat (m)	Annual retreat rate (m/year)	Area (km^2)	Area reduction (km^2)	Volume (km^3)
Maliy Aktru (valley, N)	1850			3.40		0.307
	1911	260	4.3	3.16	0.24	0.276
	1936	90	3.6	3.09	0.07	0.266
	1952	59	3.7	3.05	0.04	0.258
	1999	256	5.4	2.83	0.22	0.245
	2008	146	16.1	2.68	0.15	0.234
Vodopadniy (plateau, N)	1850			1.16		0.062
	1952	245	2.5	0.84	0.32	0.045
	1999	79	1.7	0.75	0.08	0.041
	2008	46	5.1	0.69	0.06	0.033
Maliy Aktru Cirque (cirque, NW)	1850			0.92		0.080
	1952			0.92		0.066
	1999	150	3.1	0.91	0.01	0.062
	2008	47	5.2	0.90	0.01	0.061
Karatash (hanging, N)	2008	–	–	0.09	–	0.003
Bolshoy Aktru (valley, E)	1850			12.04		1.011
	1936	288	3.3	11.50	0.54	0.893
	1952	72	4.5	11.42	0.08	0.870
Leviy Aktru (valley, SE)	1999	463	9.9	5.95	0.20	0.534
	2008	145	16.0	5.87	0.08	0.524
Praviy Aktru (valley, NE)	1999	301	6.4	5.15	0.12	0.288
	2008	123	13.7	4.65	0.50	0.280
Stazhor (cirque-hanging, N)	1850			0.33		0.017
	1952			0.26	0.07	0.014
	1999			0.24	0.02	0.013
	2008			0.22	0.02	0.011
Uchitel (foothill, N)	1850			0.12		0.0043
	1952	160	1.6	0.08	0.04	0.0027
	1999	70	1.5	0.06	0.02	0.0020
	2008	40	4.4	0.04	0.02	0.0014
Basin in total	1850			18.055		1.4842
	1952			16.655	1.40	1.2591
	1999			15.98	0.68	1.1881
	2008			14.88	1.1	1.155

Source: Narozhniy, Zemtsov 2011



Mean summer air temperature time series at the alpine meteorological stations of the Altai:
1 Kara-Tyurek (2600 m asl),
2 Akkem (2050 m asl),
3 Aktru (2150 m asl)

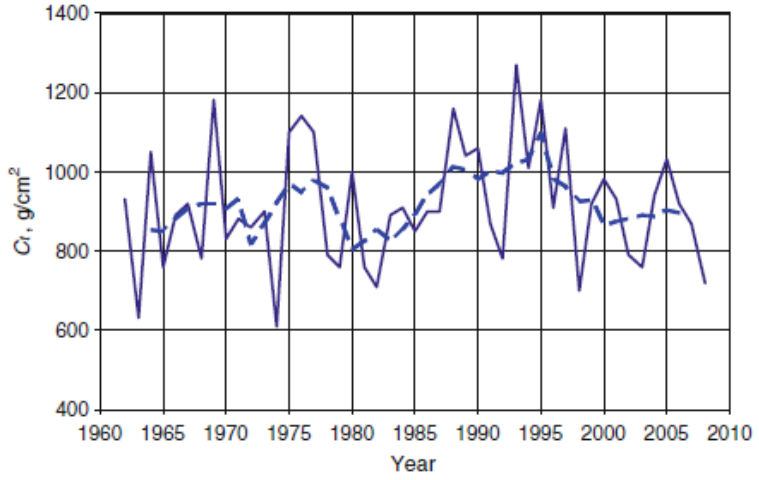
The linear trends of the long-term dynamics of the atmospheric precipitation at the stations are also positive both for the annual period and for the summer and winter seasons, but they are less significant than the increases in air temperature.

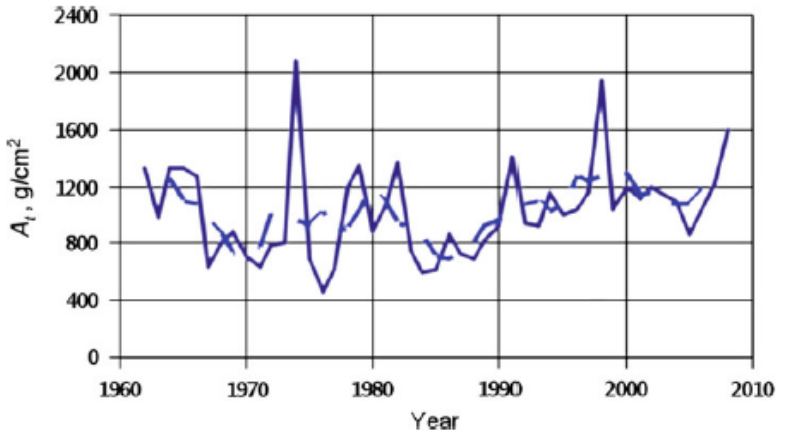
On average, the annual precipitation rates have increased by 8–10%, summer precipitation by 4–5%, and winter precipitation by 10–12%.

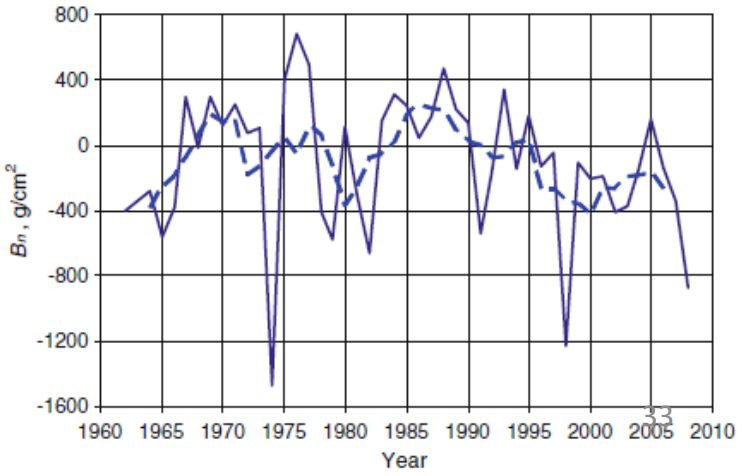
Trends of Glacier Mass Balance in the Altai Mountains

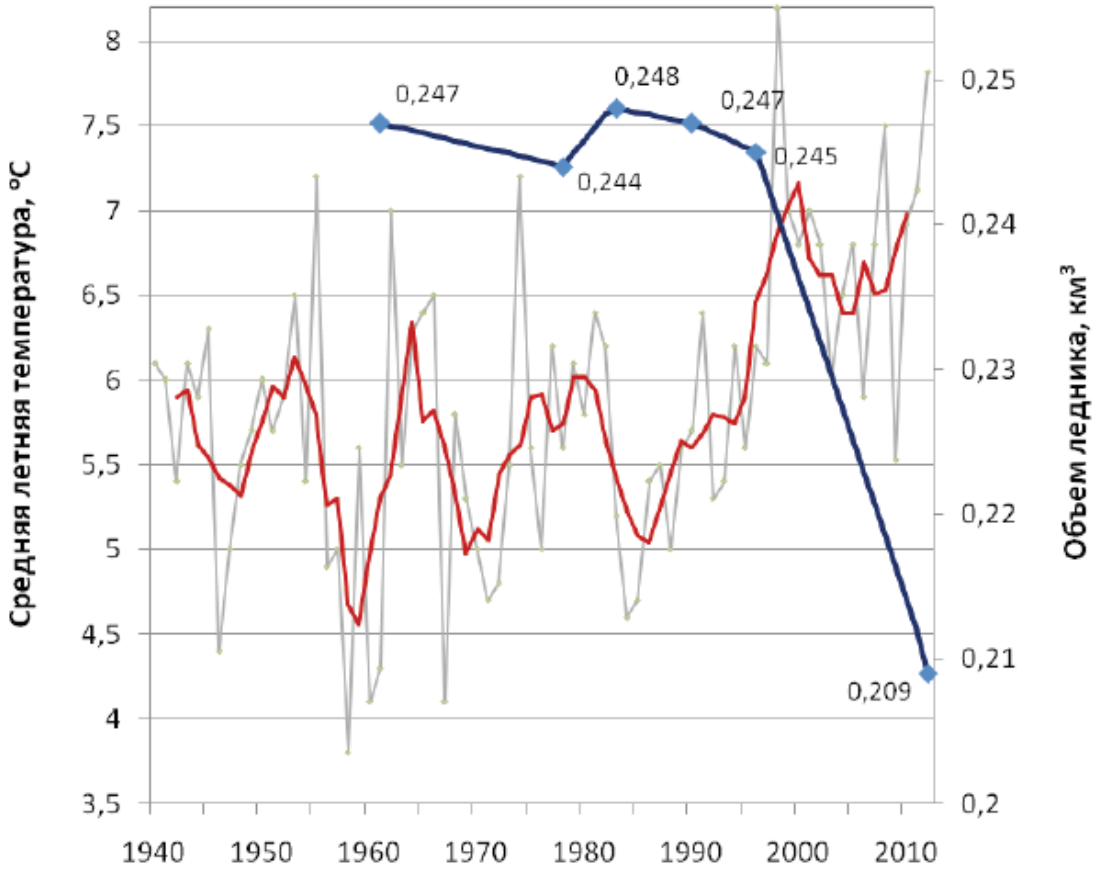
Annual variations of
(1) total annual accumulation C_t,
(2) annual ablation A_t, and
(3) mass balance B_n
of the Maliy Aktru glacier between 1962 and 2008.

Solid line: annual variations;
dashed line: 2–5-years running means









Based on geodetic surveys the ice balance components and the surface of glacier Maly Aktru
(Southeast Altai), the change in its volume **from 1952 to 2012** was estimated.

Most dramatic change of the Maliy Aktru glacier volume (km³) vs the mean summer air temperature at the Kara-Tyurek meteorological station
(2600 m asl) over the period 1961-2012 [Galakhov et al, 2013]:

grey line - mean summer air temperature;
red line – mean summer air temperature moving average;
dark blue line – the glacier volume

4 What is the destiny of Altai glaciers?!

It is necessary to take into account:

- climate change dynamics,

- acceleration of hydrologic cycle,

- likely increase in magnitude and frequency of abnormal hydrometeorological events

- trade-off between the summer temperature (and ablation rate) growth and increasing atmospheric precipitation,

- results of modeling glacier response to certain scenarios of climate change,

The glacial monitoring program continuation is needed.

The project developed in Tomsk State University is aimed at:

- determining the current state of the Aktru glaciers,

- identifying the dependences of mass balance on meteorological conditions

- and testing the mass balance components stability over time.

The project involves:

- re-establishing monitoring network in the Aktru basin,

- conducting glaciological and hydrometeorological observations on glaciers using modern research methods and equipment,

- imitation modeling of glaciers mass balance response to external forcing.

Hydropower station

The Aktru River at the Aktru station during a flood in July 2012
(Source: http://ice.tsu.ru/)

The Aktru River at the Aktru station during a flood in July 2012
(Source: http://ice.tsu.ru/)

Footprints of Altai bear watching researchers (photo: S Nikitin)

Thank you for your attention!