Mathematical simulation of melting mountain glaciers

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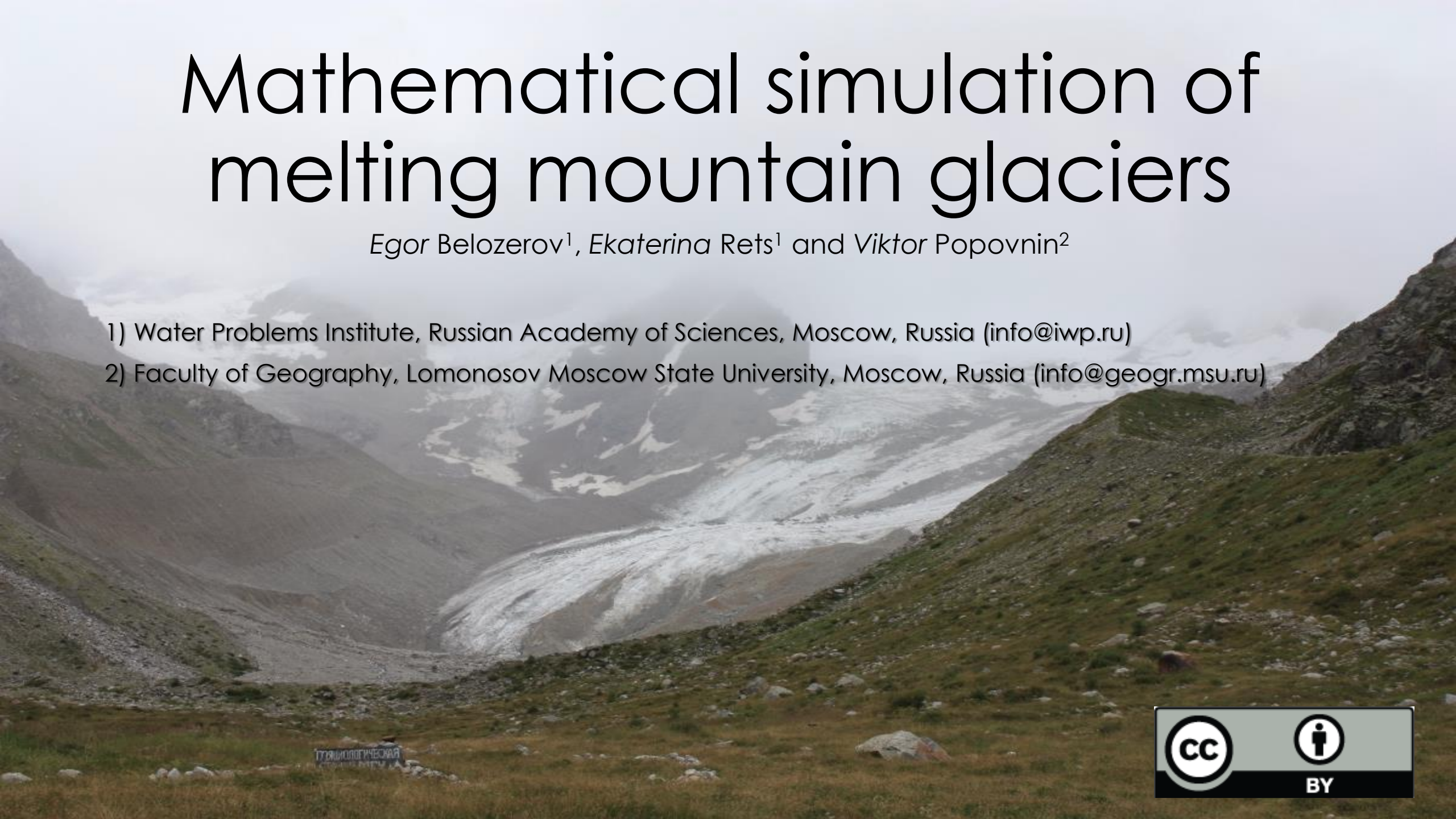
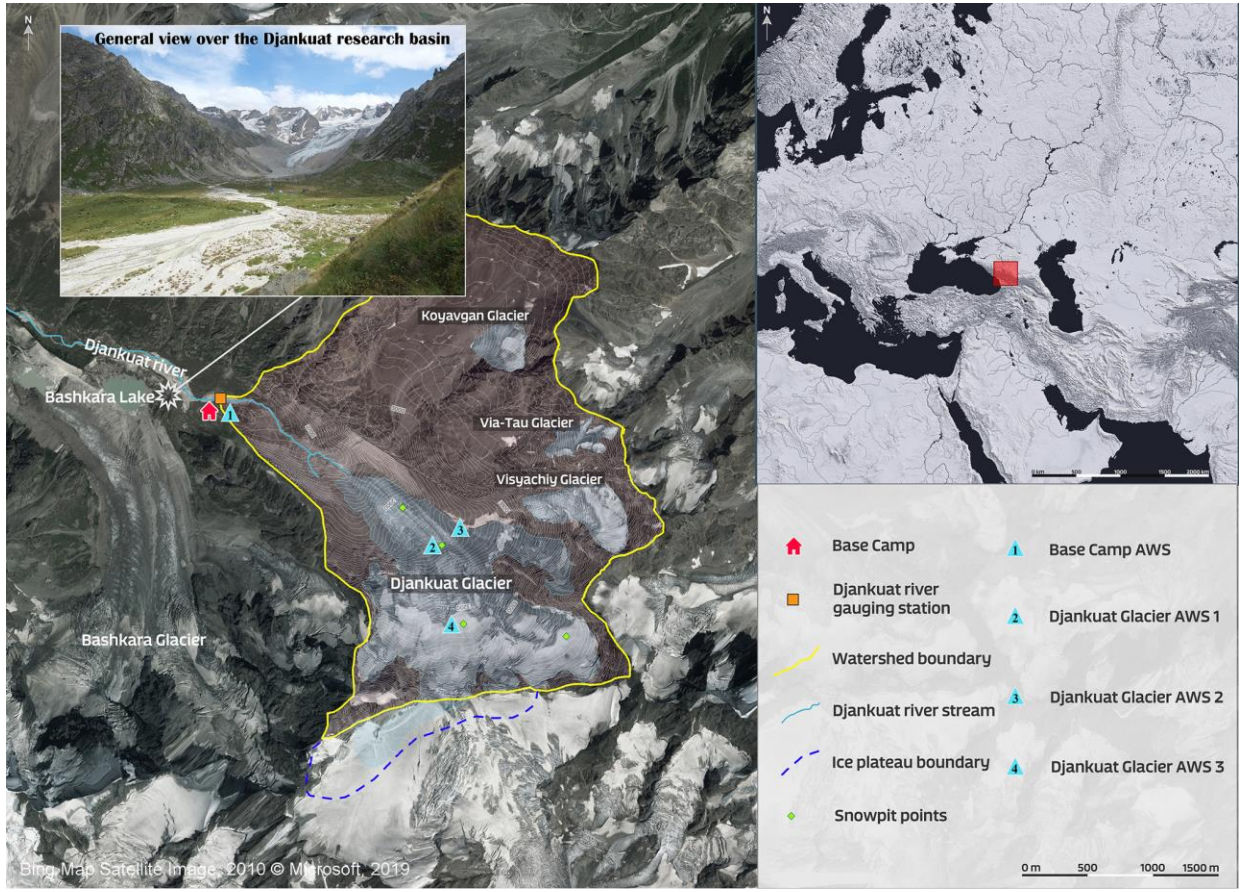


Location

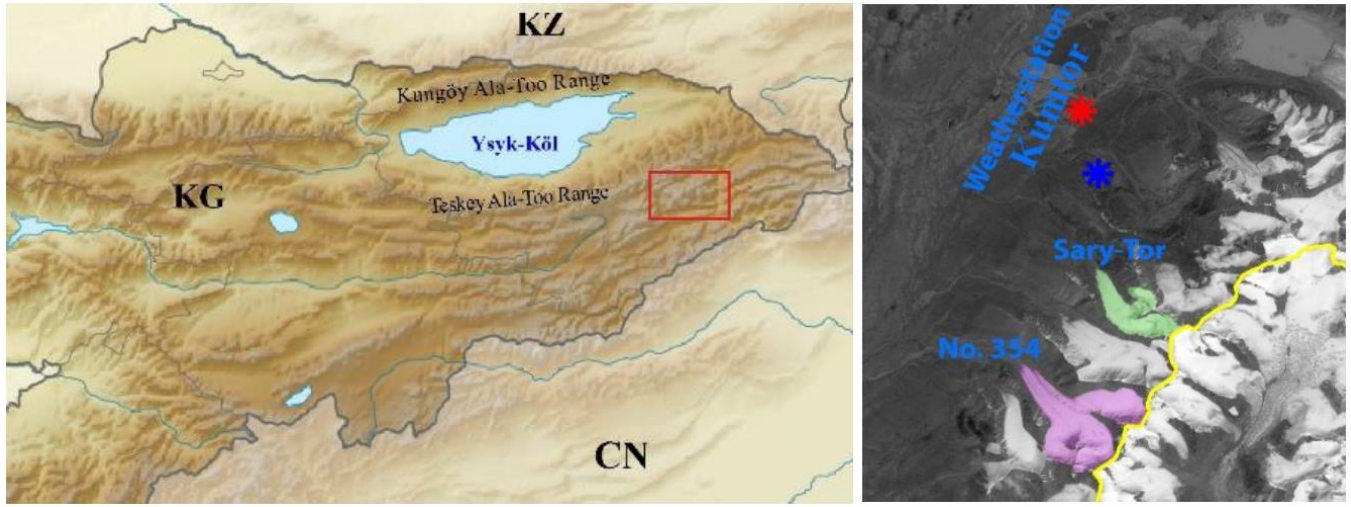
The mountain glacial basin of Djankuat is located in the drive-divide part of the northern slope of the Greater Caucasus Range, in the upper part of the river valley Adyl-Su. The total area of the Djankuat basin is 8.05 km^2, the average height of the glaciers in the basin is about 3250 m, and the surface not covered by glaciers begins from 3200 m to sea level.



The Djankuat River basin with the depicted location of the base camp, main weather stations, snow pits, and the Djankuat River gauging station

Location

Another region of study, the Tien Shan, the Ak-Shiyrak mountain range is located to the south and has a large continental climate. The Kumtor River originates in the central part of the Teskey-Ala Too massif, in the territory of the Ak-Shiyrak massif of the internal Tien Shan. Nearby is Glacier No. 354, which measures mass balance.



Location of the Sary-Tor Glaciers, No. 354 and the Kumtor Weather Station

A-melt model

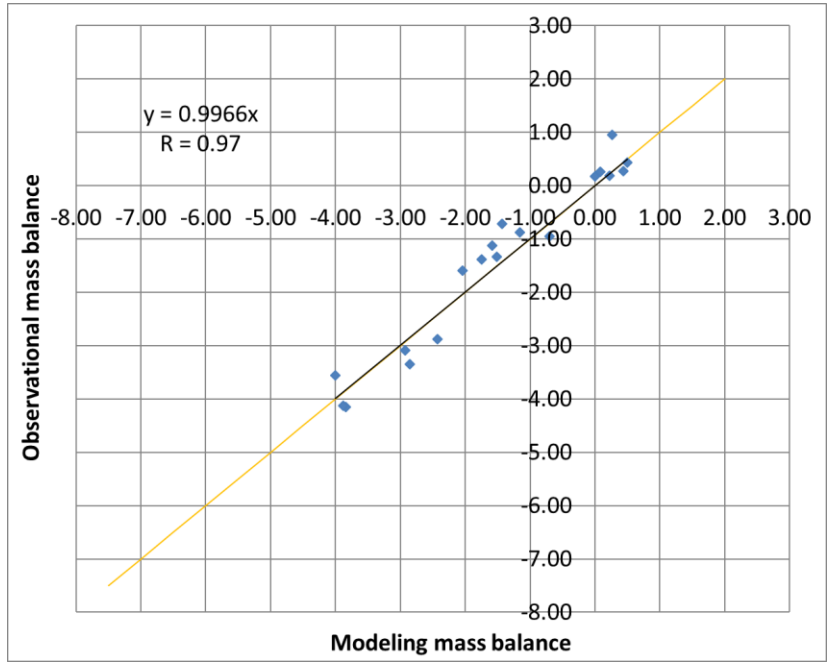
The A-Melt model is based on the heat balance equation (1). Snow and ice melt under the influence of thermal energy coming to the surface of snow or ice. The heat balance of the surface of snow or ice is defined as:

$$\omega = (S_b + S_{df})(1 - A) + E_a - E_z \pm \omega_t \pm Q_m \pm Q_t, \qquad (1)$$

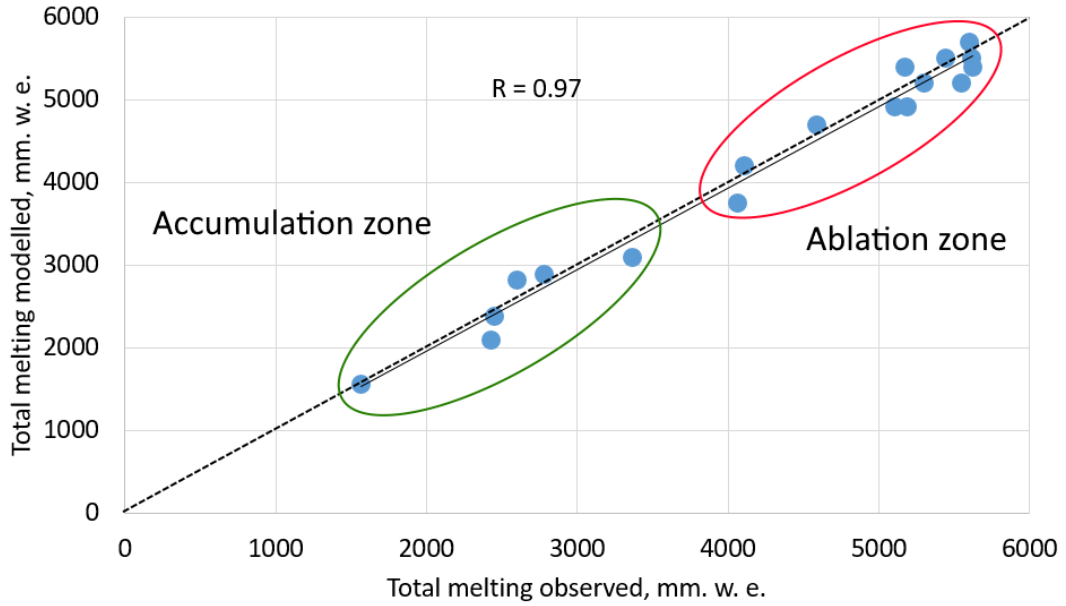
where S_b – incoming direct short-wave radiation; S_{df} – diffused short-wave radiation; A – surface albedo; E_a – long-wave counter radiation of the atmosphere; E_z – long-wave radiation of the Earth's surface; ω_t – turbulent sensible and latent heat fluxes; Q_m – heat flow through the debris cover; Q_t – energy change due to snowpack processes.

Verification of the A-Melt model

The modelling results were verified using the data on the Djankuat and №354 glaciers ablation, the measurements were performed on the ablation stakes net

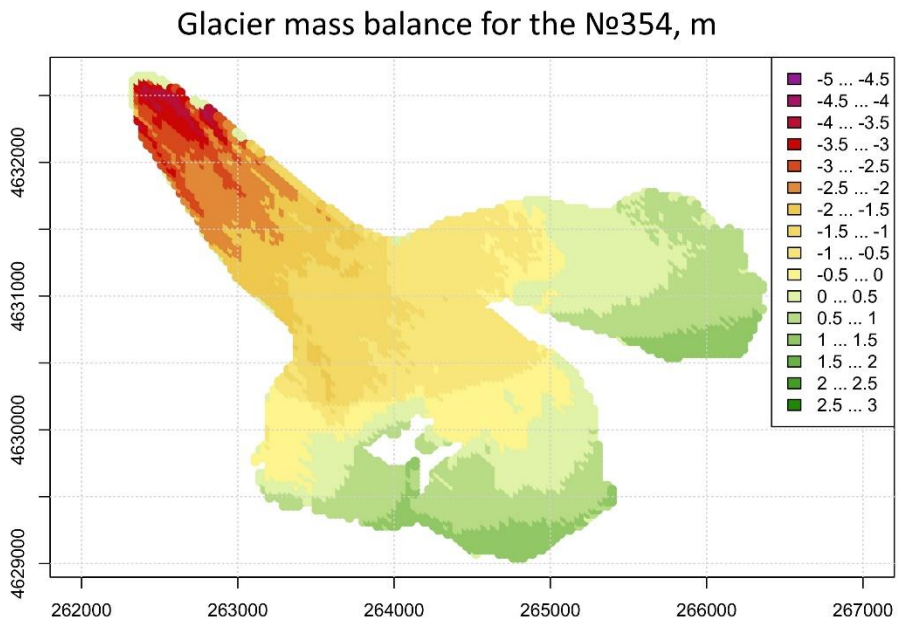


Verification of the A-Melt model for the №354 glacier

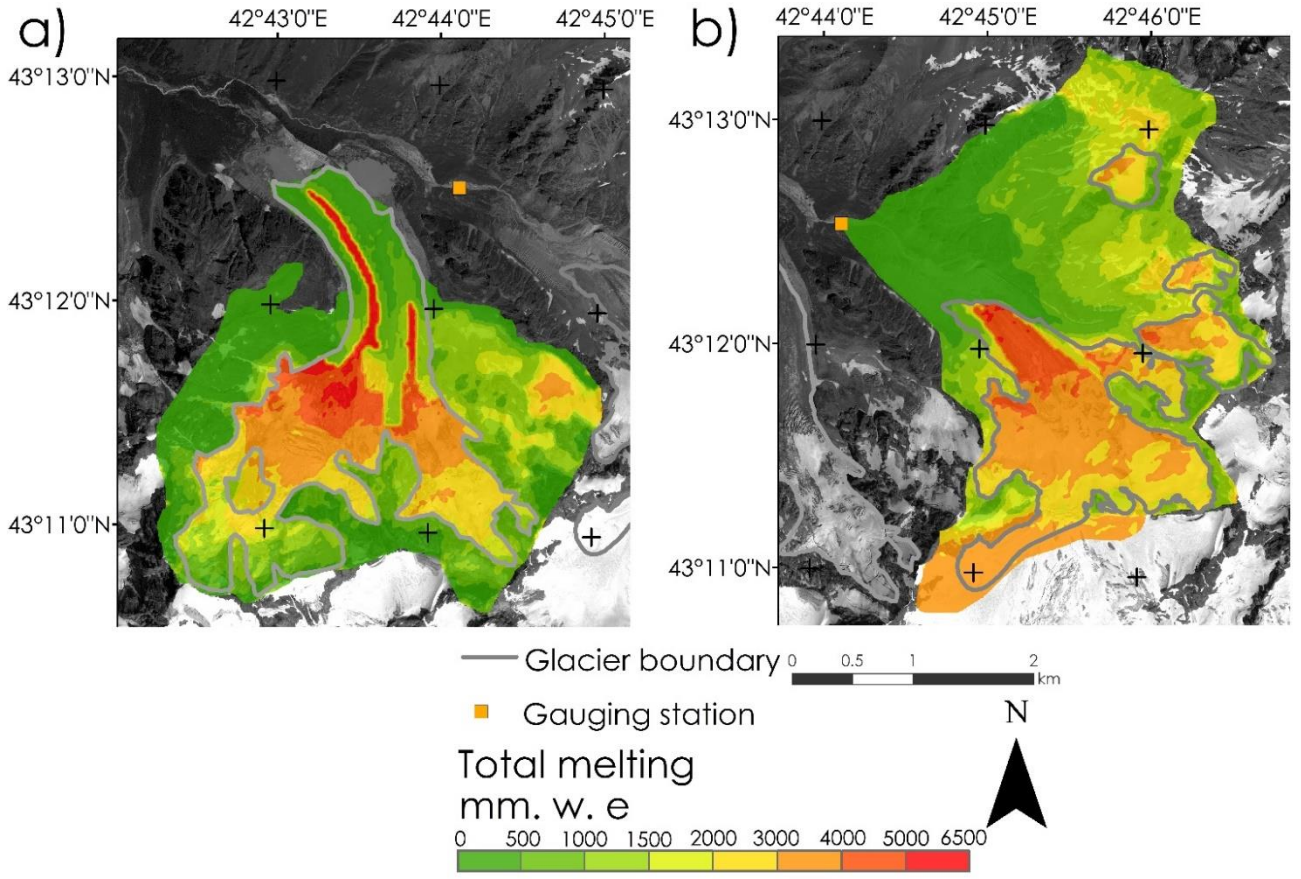


Verification of the A-Melt model for the Djankuat glacier

Modeling of the melting



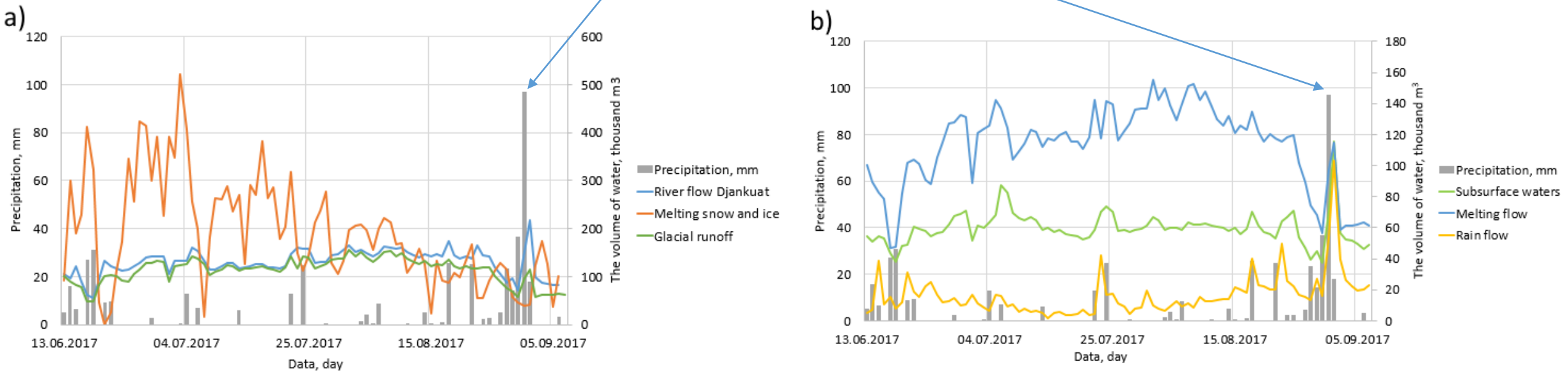
The total melting of snow and ice for the glacier № 354 in m w. e. according to the A-melt model (mean result for 2004 – 2014 yrs.)



The total melting of snow and ice for the Djankuat hydrological basin (a) and glacier Bashkara (b) in mm w. e. according to the A-melt model (gray bar – glacier boundary, orange square – Djankuat hydrological gauge)

Discharge

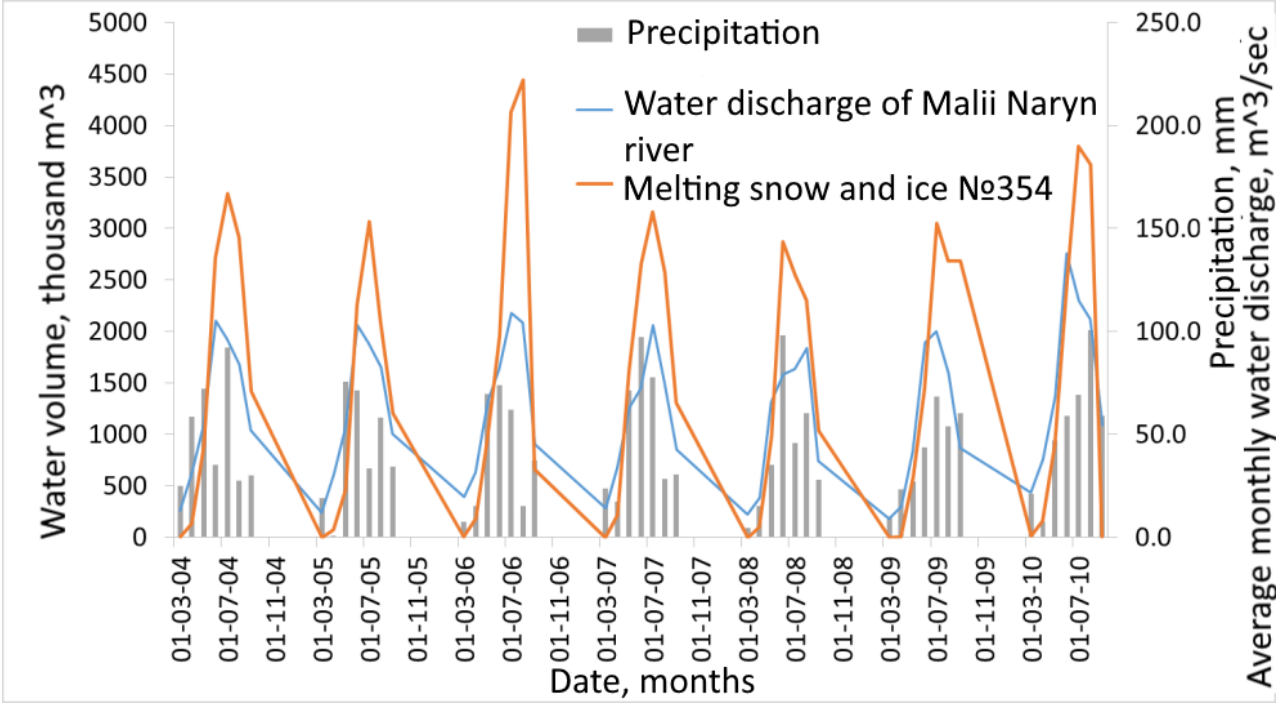
Outburst of Bashkara glacier



Observation data at the Djankuat hydrological gauge: **(a)** flow volume of the Djankuat river (blue line), total volumes of melting snow and ice for the Djankuat glacier (orange line), precipitation (gray columns) and glacial runoff (green line);

(b) melt runoff of the Djankuat River (blue line), subsurface feeding of the Djankuat River (green line), rain flow (green line) and precipitation (gray columns)

Discharge



The average monthly discharge of the Maly Naryn River at the Kichi hydrological station (blue line), the total snow and ice melting for glacier No. 354 * (orange line) for 2004-2010.

Conclusion

The processes of snow and ice melt at the Bashkara and Djankuat glaciers were simulated from 13 June to 7 September, 2017 in the context of glacial runoff assessment task

The average total melting for the Djankuat glacier was 2788 mm w.e. For the glaciers in the Djankuat river basin, the total melting volume was estimated as 0.016 km^3. The runoff of the Djankuat river on average during the study period was 120 thousand m^3 per day, while in June the volumes of melting snow and ice reach 300-400 thousand m^3, which is almost 3 times more than the river runoff

The total melting layer data for glacier No. 354 correlate with the nearby Kichi Sary-Tor River (catchment area 6.98 km^2), r = 0.75, which indicates a direct dependence of the river network on glacier melting. For the hydrological post on the Kichi Maly Naryn River (catchment area of 3470 km^2), the correlation coefficient of water with the simulation reflection is 0.9.