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Recent changes and fluctuations in the glacial and periglacial environment of Tajikistan

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During the previous decades, the mountain systems of Tajikistan (Central Asia) were the scene of substantial environmental changes. Such have particularly involved glaciers and glacial lakes, whilst permafrost changes remain unclear and hard to quantify.

Changes of glaciers and glacial lakes were quantified using three sets of satellite imagery: declassified Corona scenes (1968) and ASTER images (2001/02 and 2007/08). In each of the investigation areas, most of the glaciers were in a stage of retreat, considering the period from 1968 to 2007/08. This retreat, however, did not occur uniformly, but in a spatially and temporally differentiated way. In the Northern Pamir, most of the retreat seems to have occured in the past decade whilst the glaciers of the Southern Pamir and some of the large glaciers of Northern Tajikistan also decreased substantially in area resp. length from 1968 to 2001/02.

Numerous glacial lakes have formed or enlarged in the forefields of retreating glaciers. Among the total of 428 lakes detected in the Southwestern Pamir, 172 are directly related to existing glaciers. Almost all lakes identified in the 2007/08 imagery were substantially smaller or non-existent in 1968 or even 2001/02. Some of the lakes undergo pronounced intra- or inter-seasonal fluctuations, hampering the quantification of general trends. The lake density is much higher in the South-Western Pamir than in the Northern Pamir or other parts of Tajikistan. Some of those glacial lakes are potentially hazardous in terms of outburst floods (GLOFs).

Surging glaciers exist in the investigation area, particularly in the Northern Pamir. Active resp. recent surges of two glacier tonges were observed and analyzed, comparing a sequence of Landsat and ASTER data. Surging rates up to 2.5 m per day were identified, the total surging distance exceeded 2 km in the case of the Little Saukdara Glacier. Whilst these figures are much lower than those known from glaciers in Alaska or in the Karakorum, the phenomenon still requires attention as surging glaciers may retain lakes prone to sudden drainage.

Permafrost fluctuations are more difficult to detect directly in the field or from satellite imagery than glacier fluctuations. Potential permafrost areas were delineated by adapting empirical approaches developed for the European Alps. The results were evaluated with mapped rock glaciers. Based on IPCC scenarios of temperature increase, projections of future permafrost distribution were worked out. Whilst the absolute retreat of permafrost in terms of square kilometres may come close to 20,000 km^2 in the Pamir until the end of the 21st century, more than half of the potential permafrost areas there will remain. In the less elevated mountains of Northern Tajikistan, most of the permafrost will disappear, however not adding up to comparably large surface areas.

Whilst glacier fluctuations and the evolution of lakes can be well documented using remote sensing techniques, the information on high-altitude climatic conditions is highly insufficient. The few existing meteorological stations partly suffer from lacking maintenance and only provide biased data.

Considering the fact that the livelihood of the local population strongly depends on the water resources from the high-mountain environment and climate change adaptation strategies have to build upon such information, reestablishing those stations and a continuous monitoring of glaciers, glacial lakes and permafrost will be essential in order to keep updated on the high-mountain environment of Tajikistan.