Development and characteristics of alpine lakes in the upper catchment of the Amu Darya river, Central Asia

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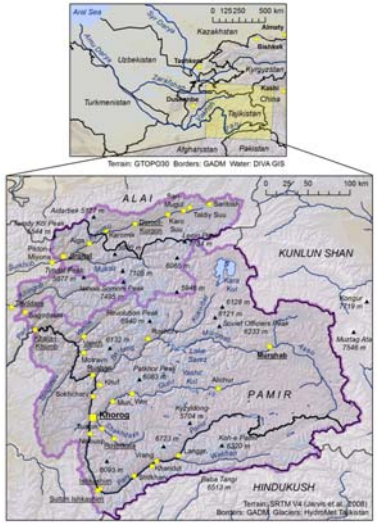
The glacierized high-mountain areas of the Pamir, Alai and Hindukush mountains (Tajikistan, Kyrgyzstan and Afghanistan) are highly dynamic systems particularly sensitive to climate fluctuations. Being the source of the Amu Darya river, they serve as water tower for Central Asia. During the previous decades, numerous lakes have developed or enlarged in the forefields of the retreating glaciers.

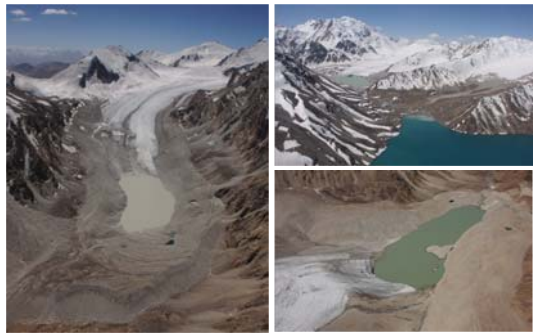
The situation



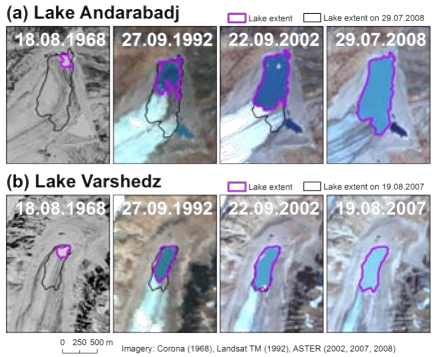
The source areas of the Amu Darya river

Other lakes are embedded in older glacial landscapes or retained by rocky swells, block or debris dams. Some lakes pose a threat to the mountain communities downstream. A glacial lake outburst floods in 2002 caused major destruction. Lakes may also offer a potential for hydropower generation and they mirror the dynamics of the high-mountain environment.
Consequently, up-to date information on the lakes present in the watershed is required.

A comprehensive multi-temporal lake inventory for the upper catchment of the Amu Darya river was prepared and analyzed, based on remotely sensed data. ASTER and Landsat scenes were used as well as Corona images from the late 1960s. The satellite information was complemented by helicopter surveys and in-detail field investigations of selected lakes in 2003, 2009 and 2011. Lake type, size, drainage and development were recorded for all lakes.



Glacial lakes in the southern Pamir



Evolution of two selected lakes over the last 40 years

More than 1800 lakes exist in the area, most of them are located between 4000 and 4900 m a.s.l., many are directly related to retreating glacier tongues. The detailed analysis was focussed on this type of lakes, many of which have experienced a significant growth over the observation period. Whilst there is evidence that the growth of some of the larger glacial lakes has decelerated in the last ten years, others are starting to evolve, illustrating the dynamics of the glacial and periglacial environment. Long-term changes are superimposed – and sometimes blurred – by intra- and inter-annual fluctuations.

Lake statistics, organized by lake type. n = number of lakes, A_{avg} and A_{max} = average and maximum lake area, n_{gr} and n_{sh} = number of growing and shrinking lakes, z_{min} and z_{max} = minimum, average and maximum elevation a.s.l.

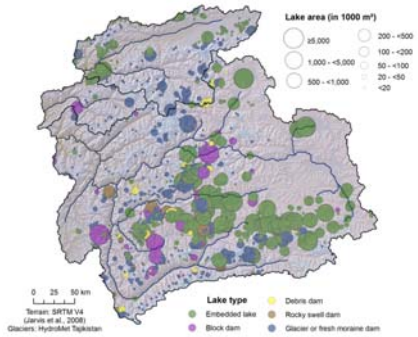
Lake type	n	A_{av} (km²)	A_{max} (km²)	n_{gr}	n_{sh}	z_{min} (m)	z_{max} (m)
Embedded lake	788	0.755	404.553	320	76	1731	5071
Block dam	72	0.307	15.240	22	9	1720	5132
Debris dam	50	1.827	88.514	14	6	2229	4905
Rocky swell dam	29	0.092	0.477	11	2	3179	4875
Glacier or fresh moraine dam	773	0.024	1.892	451	92	2500	5132

Next steps:

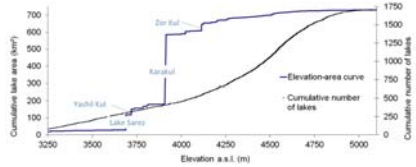
(1) More detailed analysis of temporal lake development

(2) Lake outburst hazard analysis, based on lake characteristics and temporal development

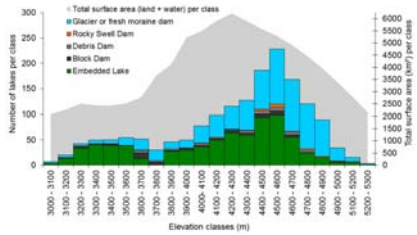
Lake characteristics



Alpine lakes in the study area, differentiated by lake area and lake type



Hypsographic distribution of lakes and lake area



Hypsographic distribution of lakes of different types