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

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The Amu Darya is one of the most important rivers in the lowlands of Central Asia, ensuring the supply of irrigation water for agriculture in that arid region. Control of the water flow due to hydropower generation in Tajikistan (Norak Dam, planned Rogun Dam) is a highly political issue. The sources of the Amu Darya are located in the glacierized high-mountain areas of Tajikistan, Kyrgyzstan and Afghanistan (Pamir, Alai and Hindukush mountains). These environments are highly dynamic systems particularly sensitive to climate fluctuations and changes. During the previous decades, numerous lakes have developed or enlarged in the forefields of the retreating glaciers. Other lakes in the area are embedded in older glacial landscapes or retained by rocky swells, block or debris dams. The latter two types of dams are usually formed by landslides or moraines, Usoi Dam impounding lake Sarez is the highest landslide dam in the world and goes back to an earthquake in 1911. Whilst the safety situation of Lake Sarez is still discussed controversially, a number of glacial lakes poses a threat to the mountain communities downstream. At least two significant glacial lake outburst floods (GLOFs) were recorded in the study are in the last ten years, one of which caused major destruction. Besides the hazards, lakes may also offer a potential for hydropower generation. Furthermore, they mirror the dynamics of the high-mountain environment and therefore indicate fluctuations and changes.
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. More than 2000 lakes exist in the area, most of them are located between 4200 and 4800 m a.s.l., many of them are directly related to retreating glacier tongues. The detailed analysis was focussed on this type of lakes, most 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.