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Identification and monitoring of potentially dangerous glacial lakes in northern Tien Shan (Kazakhstan/Kyrgyzstan) using geoinformation techniques

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Like in many other parts of the world, the glaciers in northern Tien Shan are receding and the permafrost is thawing and concomitant glacial lakes are developing. Outbursts of these glacial lakes pose severe hazards for the society. Over the last decade, several outbursts in this seismically active region are documented. Multi-temporal space imageries are an ideal means to study and monitor glaciers and glacial lakes over larger areas. Morphometric analyses and modelling approaches allow the estimation of the potential danger of glacial lake outburst floods (GLOFs). In this paper, we present a comprehensive approach to identify glaciers and the potentially dangerous glacial lakes based on multi-temporal space imagery from 1972 (Corona KH-4B), 1973 (Landsat MSS), 1991 (Landsat TM), 1999 (Landsat ETM+), 2000/2001/ (ASTER) 2005, and 2008 (Landsat TM) as well as morphometric analysis and modelling. The identification and monitoring of glacial lakes were carried out automatically using image ratioing and the Normalized Difference Water Index (except for the panchromatic Corona images). The results were evaluated and, if necessary, manually edited. The probability of the growth of a glacial lake was estimated by analysing glacier changes, glacier motion, and slope analysis. A permafrost model based on morphometric parameters, solar radiation and regionalised temperature conditions aided us to asses the effect of probable permafrost thawing. A GIS-based model was applied in order to simulate the possible downstream impact of a lake outburst. The findings of our studies indicate a continuous glacier recession with an increasing number and area of glacial lakes. This possibly leads into a higher risk of a glacial lake outburst. Finally, the lakes are classified according to their outburst probability and their downstream impact.