



## How rare are Himalayan Glacial Lake Outburst Floods?

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Increased glacial runoff in the Hindu Kush-Karakoram-Himalaya (HKKH) has spawned several thousand moraine-dammed and supraglacial lakes, many of which have been rapidly expanding in the past decades. These lakes can release large amounts of water and sediment during Glacial Lake Outburst Floods (GLOFs), potentially impacting population, livestock and infrastructure downstream. Whether contemporary atmospheric warming and glacier recession increases the likelihood of GLOFs in the next few decades remains debated. Despite plausible mechanistic links between climate changes and GLOF occurrence, rigorous predictions of changes in GLOF hazard suffer from the low frequency at which we observe GLOFs in this region. We surmise that a censoring bias affects our current knowledge of GLOF occurrences, favoring the reporting of mostly larger floods with commensurate larger impact.

To reduce this bias, we present the first consistent GLOF inventory for the HKKH compiled from time series of optical satellite images between the late 1980s and 2017. We developed a machine-learning approach to predict land cover on 8200 Landsat images and to automatically detect areas where shrinking water bodies left traces of fresh sediments or eroded flood tracks downstream. Our mapping approach reveals 19 previously unreported GLOFs in an area covering 57% of the HKKH, raising the total count of known GLOFs by 172%, based on inventories featuring eleven GLOFs in the region since 1989. Our data suggest higher GLOF frequencies in the central Himalayas and the Nyingtanglha mountains, while vast parts of the Hindu Kush and Karakoram may not have had GLOFs large enough to be detected with our method. Our inventory prompts a rethinking of prevailing concepts on the spatial pattern, temporal trends and associated hazard from Himalayan outburst floods.