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Close-range photogrammetric reconstruction of moraine dam failures

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Glacial Lake Outburst Floods (GLOFs) from moraine-dammed lakes represent a high magnitude, low frequency catastrophic glacio-fluvial phenomena, with the potential to cause significant damage to property and infrastructure in high-mountain regions. Detailed accounts of GLOF dynamics, in particular the initiation and propagation of dam breaching are extremely rare, owing to their occurrence in often remote, inaccessible areas, as well as the impracticalities associated with attempting to directly instrument such high magnitude, turbulent flows. In addition to the dearth of detailed, first-hand observations of dam failures, reconstruction of breaches and failure mechanisms derived from morphological evidence is hampered by the lack of high-quality, high-resolution DTMs of remote alpine areas. Previous studies have therefore resorted to the use of coarse resolution data products (SRTM, ASTER GDEM) to quantify characteristics of failure events, e.g. pre-flood lake volume, dam height/width, which may give rise to considerable uncertainty in related numerical simulations and assessments of downstream flood hazards.

In this paper we employ a novel low-cost, close-range photogrammetric technique, termed 'Structure-from-Motion' (SfM) to provide detailed in-situ reconstructions of dam and valley topography for two moraine dam complexes which have produced historical GLOFs in the Khumbu Himal, Nepal. Requiring little more than a consumer-grade digital camera and suitable ground control for implementation, the resolution of the final data products are comparable to that obtained using ground-based or airborne LiDAR. These data facilitate the extraction of precise estimates of dam (and breach) geometry, volumes of water and sediment removed during the outburst events, and the downstream channel topography. We conclude by directly comparing such key metrics derived from low-resolution topographic datasets, with those acquired in situ using the SfM technique, and discuss the implications for the reconstruction of flood dynamics.