

Glacial lakes and their recent expansion in the Bhutan Himalayas

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Current conditions and secular changes in ice-contact lakes in the Bhutan-China border region were investigated using satellite imagery. More than 50 ice-contact or ice-proximal lakes were identified, of which 14 were evidently growing. Glacial lake expansions in the research area are characterised as follows:

(1) appearance of some supraglacial lakes as the initial water area and the subsequent expansion of the merged lake

(2) directly begins from a single lake at the initial stage and the consequent expansion. The lake expansion in the debris-covered area in the lower part of glacier shows the former pattern. Intricate lower shorelines may be considered as the evidence of such an expansion history. The latter pattern is recognised from small debris-free or partially debris-covered glacier.

The growth period in most valley glaciers has been 40 to 70 years. At the same time, glacial lakes in the debris-free or partially debris-covered cirque glaciers grow in about half the duration of this period because the ablation area is small and its gradient is steep. The growth rate on both the sides of the Bhutan Himalayan mountain are from 35 to 70 m/year and less-than 0.04 km²/year (southern side) and from 10 to 40 m/year and less-than 0.03 km²/year (northern side).

The emergence year of most of the lakes in the southern side of the range varies from the 1950s to the 1970s, whereas in the northern side, the lakes appeared two or three decades before that in the southern side. Such regional characteristics are mostly caused by the difference of development process of lake basins by horizontal retreat in the northern side and vertical thinning in the southern side. Debris-rich glaciers which show vertical thinning may be resulted from glacier accumulation mostly due to snow avalanche with occasional rock fall at exposed steep slopes in the southern side of the main range. Although further research is required to confirm, it can be considered that such accumulation process cause lag of glacial lake development.