Geophysical Research Abstracts
Vol. 18, EGU2016-13922, 2016
EGU General Assembly 2016

Life and death of ice cliffs and lakes on debris covered glaciers – insights from a new dataset from the Nepalese Himalaya

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Numerous studies suggest that supraglacial ice cliffs and lakes could be one contributing factor to relatively high overall ablation rates on debris covered glaciers. While some studies have quantified backwasting rates, developments over the larger scale have not yet been assessed. Field work and earlier studies during three seasons in the Langtang catchment in the Nepalese Himalaya has given some insights into how these landforms develop, from initial emergence to persistence and disappearance.

From 6 sets of concurrent high-resolution satellite imagery and DEMs between 2006 and 2015 and an additional image from 1974, we assembled an extensive dataset of these landforms on all glaciers in the catchment, including nearly 4000 individual lakes and cliffs. We show that ice cliffs appear in combination with lakes or without and there are lakes that are not bordered by a cliff. Numbers vary strongly between seasons, especially as lakes show strong seasonal variability. There are furthermore different types of cliff forms – circular, lateral and longitudinal – that give an indication of their formation process. Circular cliffs form with either collapsing subglacial channels or overdeepenings caused by water accumulating on the surface, while lateral cliffs are likely associated with underlying crevasses. Some of the cliff and lake systems remain at the same location on-glacier over a number of years, while most move with the whole glacier body down valley.

From the DEMs determine preferential slopes and expositions of the cliffs in the catchment which have been shown to be essential aspects in explaining the backwasting process.

In combination with field observations from one glacier, where most of these types were present, we can infer development processes of a number of systems over the whole catchment. It is also apparent that densities of these landforms vary greatly over the glacier surface, which can be explained with velocities or underlying bed topography in different cases.

The event of the Gorkha earthquake of April 2015, that resulted in massive avalanches mixed with debris covering many of the landforms provides another case of investigation. In the subsequent imagery the emergence of new and old cliffs under the initially flat debris cover point to the initial formation process of these landforms.