EGU2020-10593
https://doi.org/10.5194/egusphere-egu2020-10593
EGU General Assembly 2020

A comparison of the drainage systems of two High Asian debris-covered glaciers

Catriona Fyffe[1], Evan Miles[2], Marin Kneib[2], Reeju Shrestha[3], Rebecca Stewart[1], Stefan Fugger[2], Matthew Westoby[1], Thomas Shaw[4], Wei Yang[5], and Francesca Pellicciotti[2]

[1]Northumbria University, Newcastle-Upon-Tyne, United Kingdom (catriona.fyffe@northumbria.ac.uk)
[2]Swiss Federal Institute for Forest, Snow and Landscape Research, Zurich, Switzerland
[3]International Centre for Integrated Mountain Development, Kathmandu, Nepal
[4]Advanced Mining Technology Center, Universidad de Chile, Santiago, Chile
[5]Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing, China

Debris-covered glaciers are a crucial source of runoff for downstream communities in High Mountain Asia (HMA), especially in dry periods, and knowledge of runoff patterns is important for irrigation and hydropower. However, very few studies have investigated the hydrology of debris-covered glaciers, especially in HMA. Here, debris-covered ice represents about 30% of the total ice mass and is located in the lower reaches where melt dominates. There is increasing evidence that supraglacial debris influences the structure and efficiency of the hydrological system, but dye-tracing studies are rare (only three in HMA) and only one of those attempted repeat traces at different times in the season. Furthermore, previous studies have not sought to examine each of the hydrological components systematically, which is necessary given the unique components of debris-covered glacier drainage systems (e.g. within-debris flow and interlinked pond systems) which are not present on clean glaciers. Finally, there are differences between debris-covered glaciers which may influence their hydrological systems (such as their climate, debris thickness and surface topography), but a lack of consistency between studies hampers clear comparisons.

This study investigates the hydrological systems of two High Asian debris-covered glaciers with contrasting debris and climate characteristics in both the pre-and post-monsoon. Langtang Glacier in Nepal (visited in May and November 2019) has a very hummocky surface topography covered in metre thick debris, while 24K Glacier, in the SE Tibetan Plateau (visited in June and October 2019) has thinner debris and a particularly wet climate. Our aim was to determine the structure, efficiency and evolution of each part of their hydrological systems. Dye tracing was used to investigate the characteristics of the supraglacial, englacial and subglacial network, and the influence of this drainage network on the resulting runoff was studied using analysis of the proglacial discharge.

The thick debris was an important component of the hydrological system on Langtang Glacier, acting as a source of water in the pre-monsoon and sink of water in the post-monsoon. The

supraglacial hydrology of both glaciers had similar characteristics, with clear evidence of hydrological links between supraglacial ponds, composed of flow paths that could cross surface topographical barriers by following englacial or intra-debris routes. On Langtang Glacier the supraglacial hydrology in the post-monsoon became restricted to isolated ponds and streams emanating from ice-cliffs, whereas on 24K Glacier the linked ponds composing the main supraglacial network evolved into a more coherent stream system. Initial analysis suggests that the englacial/subglacial network of Langtang Glacier was inefficient compared to clean alpine glaciers (mean velocity 0.08 ms^{-1}), whereas fast, peaked breakthrough curves on 24K Glacier (mean velocity of 0.5 ms^{-1} from repeat traces into one moulin) suggest a more efficient system. Debris-covered glaciers therefore share some distinct aspects of their hydrological system (e.g. the occurrence of interlinked ponds), but the englacial/subglacial system efficiency can be altered by the debris thickness, topography and degree of snowcover of the input catchments.