SCIENCE

New method better estimates melting of debris-covered Himalayan glaciers

Shubashree Desikan

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A study of the Satopanth glacier in order to model the melting of debris-covered glaciers has been carried out by a group of Indian researchers. Their new method gives a better estimate of the glacier's melting than existing ones. Studying debris-laden Himalayan glaciers is important from the point of view of how climate change affects them. About 20% of Himalayan glaciers are debris-laden, and their dynamics are very different from the ones without debris cover. The study was published in *Journal of Glaciology.*

Effect of debris

In glaciers without a debris cover, the rate of melting increases as the elevation decreases. However, in glaciers covered with debris, the thick cover partially insulates the glacier from the warm exterior and thereby slows down the melting. The thickness of the debris cover, by and large, increases as the glacier flows down. This works against the general trend that the lower the elevation, the higher the rate of melting. Matters are further complicated because the thickness of the debris cover is not uniform but fluctuates randomly.

This line of research was initiated by H.C. Nainwal of the Geology Department, Hemwati Nandan Bahuguna Garhwal University, in 2004. Initially it constituted studies of paleoglaciation and monitoring the fronts of Satopanth and Bhagirath Kharak glaciers. “Full scale glaciological observations began in 2013,” says R Shankar of The Institute of Mathematical Sciences, Chennai, and an author of the paper.

Prof. Shankar and Argha Banerjee, now with IISER Pune, are interested in developing a model to describe the dynamics of debris-laden glaciers like the Satopanth. The collaboration happened almost by chance: “I was planning a motorcycling trip in Garhwal, including a visit to Gangotri in 2007. I came across a paper by [Harish Chandra] Nainwal in *Current Science* on the geomorphology of Gangotri valley and took a copy along to see what it was like on the field,” says Prof. Shankar. This brought them, and Dr Banerjee, together to discuss Satopanth. Along the way, they realised that it was an important problem to model the dynamics of debris-covered glaciers.

Studying Satopanth

Satopanth glacier is located in Garhwal in Central Himalaya, in Uttarakhand. It is the origin of the river Alaknanda, one of the two main tributaries of the Ganga. The other tributary is Bhagirathi, which originates from the Gangotri glacier. These two rivers join at Devprayag, around 70 km upstream of Rishikesh. Downstream of Devprayag, the river is called Ganga.

To study the melting, the team planted nearly 60 bamboo stakes in the Satopanth glacier, most of which were placed in ten transverse lines below 4,600 metres elevation. The initial depth of the bamboo stakes was noted down, and periodic measurements were made over the course of three years to assess how much ice had melted. Nearly 1,000 measurements were made, mainly by Sunil Singh Shah, the first author of the paper.

Better estimate

They computed the sub-debris melting of the glacier by interpolating the collected data as a function of thickness of the debris and averaging over debris thickness distribution over different parts of the glacier. This is to be contrasted with the conventional method where the collected data is interpolated as a function of elevation. The new method introduced by the group worked better at estimating the dynamics of the glacier than the conventional method.

They also repeated the estimation after leaving out several of the data points and restricting the data to about 25 stakes. They could still get better results than the conventional method. “This established a clear advantage of the new method. The estimates were seen to be more robust when a reduction in the number of stakes was applied,” says Prof. Shankar. Using a more detailed measurement of the debris thickness variation would make the estimate more accurate, the authors write in the paper.

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