

Himalayan cryosphere*

The National Conference on Himalayan Cryosphere (NCHC) provided a platform for various researchers working in the field of glaciology to showcase the outcomes of their research and also to plan the way forward. It focused on topics related to the climate change, hydrology and natural hazards of the Himalayan cryosphere.

The conference was inaugurated by Sanjeeva Rao (SERB, New Delhi), J. Srinivasan (IISc, Bengaluru), Akhilesh Gupta (DST, New Delhi), Ravi S. Nandjundiah (IISc) and Anil V. Kulkarni (IISc). In their inaugural talk, they jointly enumerated the importance of the Himalayan glacier studies, and stressed upon the need and directions for research on changing climate and glacier scenario of the Himalaya.

The keynote lecture in the first technical session was delivered by D. P. Dobhal (WIHG, Dehradun), who put forth several scientific concerns related to the Himalayan glaciers. He addressed questions related to climate change and glacier fluctuations in the Himalaya. Babu Govindha Raj (National Remote Sensing Centre (ISRO), Hyderabad) introduced a recent GIS-based technique in assessing the glacier volume even in non-accessible glaciers. This model developed by James and Carrivick¹ uses the central flow line and digital elevation model (DEM) to calculate the glacier ice thickness. Aparna Shukla (WIHG, Dehradun) in her poster, well correlated the mass balance data of the Chota Shigri glacier obtained from the ground measurements and remote sensing for the period from 2002 to 2013. According to her study, the data obtained from both the sources are highly positively correlated ($r^2 > 0.75$). Hence the remote sensing data can be considered in the cases where ground

data are not available either for equilibrium-line attitude (ELA) or mass balance. Sujata Dash (Defence Terrain Research Laboratory, New Delhi) in her poster presented a study to highlight the stable or advancing behaviour of the terminus of the glaciers of the Karakoram Range. The multi-temporal remote sensing data of optical and microwave range can be used for studying the flow dynamics and surging behaviour of the Karakoram glaciers. In yet another poster, Yogesh Karyakarte (Sikkim University, Gangtok) presented the fact that 12% of the glaciated area of the North Sikkim Himalaya has been lost in the years between 1962 and 2015 at the rate of $\sim 0.22\%$ per annum.

The second technical session themed on Himalayan cryosphere modelling had an introductory talk by Argha Banerjee (IISER, Pune). He explained the concept that the debris-covered glacier exhibits a thinning behaviour prior to its retreat. The debris layer imparts an insulating effect on the glacier, which lowers the specific melt-rate. M. R. Bhutiyani (Defence Terrain Research Laboratory, New Delhi) delivered the second keynote lecture discussing the fact that certain altitudes in the Karakoram Range show glacial advance rather than retreat. R. Srinivasan (IISc, Bengaluru) presented a talk on evidence for glaciation in the geological records. Sourav Laha (IISER, Pune) spoke about the relevance of studying the thermal properties of the debris layer. According to his study on the Hamtah glacier, the thermal conductance at different depths of the supraglacial debris can be calculated to estimate the heat available for glacial melt. Aditya Mishra (HNB Garhwal University, Srinagar, Uttarakhand) presented a poster on the estimation of the ice thickness of the Satopanth glacier using ground-penetrating radar (GPR). According to his study, the ice thickness near the snout ranges from 40 to 45 m, whereas at the upstream end of the ablation zone the ice thickness is estimated to be 120 m according to the GPR values. S. N. Remya (IISc, Bengaluru) in her poster presented the need to estimate the glacial stored water so as to calculate the extent of its

availability to the major Indian rivers. Reshama Kumari (IISER, Pune) presented her study on the steady-state extents of the glaciers of the Chandra-Bhaga catchment over 150 years using the available albumen prints by noted photographer, Samuel Bourne and the recent remote sensing data, and hence deciphering the corresponding climatic conditions prevailing during those times, especially the Little Ice Age extent.

The third technical session on climate change in the Himalayan cryosphere had an invited talk by H. S. Negi (SASE, Chandigarh). He discussed the IPCC-2013 report about the loss of mass of the Greenland and Antarctic ice sheets. He also stated the role of black carbon in the melting of Himalayan glaciers². Pankaj Kumar (IISER, Bhopal) presented a scheme for the glacier mass balance and areal extent of glaciers of the South Asian Himalaya. According to the findings, the glacier area shows remarkable decrease, but a certain area in the Karakoram shows a considerable spatial increase. Shruti Singh (Sharda University, Greater Noida) presented her work on the impact of climate change on the Naradu glacier. Her study using multiple regression methods shows the increase in snow-line over the last 34 years. Ipsita Roy (BSIP, Lucknow) presented her work on the palaeoclimatic records from the Dokriani Glacier valley using a multi-proxy approach. She demarcated the climatic episodes of the Holocene based on pollen records along with the $\delta^{13}\text{C}$ values and the magnetic susceptibility data of the subsurface sedimentary profile.

The fourth technical session was based on the hydrology of the Himalayan cryosphere. Farooq Azam (NIH, Roorkee) delivered a keynote lecture. He expressed his view on the fact that glaciological data are still sparse on a global scale. Ajit Singh (NCAOR, Goa) presented his work on stable oxygen and hydrogen isotope composition of precipitation, ice and melt water from Sutri Dhaka Glacier. His study suggests that almost 40% of the water in the Indus River comes from ice melt. Shiv Mohan Singh (NCAOR, Goa) presented a poster

*A report on the 'National Conference on Himalayan Cryosphere' held at the Indian Institute of Science, Bengaluru, during 23 and 24 January 2017. The conference was organized at the Divecha Centre for Climate Change, Indian Institute of Science, Bengaluru and supported by the Department of Science and Technology and Science and Engineering Research Board.

on the various microbes obtained in the Chota Shigri Glacier. The enzymes obtained from these microbes can be purified and utilized in the food and beverage industries. Mayank Shekhar (BSIP, Lucknow) presented a poster entitled 'A tree-ring based January–April discharge reconstruction of Zemu Chuu, North Sikkim Eastern Himalaya'. He observed that the growth rings of trees in the river catchment areas of the Sikkim Himalaya were a valuable tool to reconstruct the stream flow.

The next technical session consisted of lectures and posters themed on the disasters of the Himalayan cryosphere. Ashwagosh Ganjoo (SASE, Chandigarh) presented a keynote lecture in this session. He focused on natural disasters in the glaciated terrains. During his talk, he specified that 477 glacial lakes and water bodies have been monitored during 2016

using cloud-free satellite data. It has been observed that several lakes have shown an increase in water spread area; several show decrease while a considerable number has exhibited no change. Sanjay Deswal (Department of Geography, Govt College Dujana, Haryana) delivered a talk on 'Glacial retreat, formation of glacial lakes and GLOF risk assessment in Lahaul Himalaya, North-west India'. According to the study, a total of $0.65 \pm 0.21 \text{ km}^2$ area of the valley glaciers in the Lahaul Himalaya has been vacated during 1989–2013. All glaciers have been observed to recede at a rate of 5–10 m/yr during 1965–2015. However, interestingly, between 2002 and 2013, these glaciers have shown a slower retreat rate (1.69 m/yr).

In the concluding valedictory-cum-brainstorming session, several loopholes and emerging challenges in the cryo-

spheric studies were discussed. It was suggested that various parametric studies be undertaken at least on one glacier so as to ascertain its future. Besides observation and modelling studies, more data on the palaeo aspect of glaciers should also be considered with collaborative effort.

-
1. James, W. H. and Carrivick, J. L., *Comp. Geosci.*, 2016, **92**, 90–103.
 2. Menon, S., Koch, D., Beig, G., Sahu, S., Fasullo, J. and Orlikowski, D., *Atmos. Chem. Phys.*, 2010, **10**(10), 4559–4571.

Ipsita Roy* and **Mayank Shekhar**, Birbal Sahni Institute of Palaeosciences, 53, University Road, Lucknow 226 007, India.

*e-mail: ipsita.roy@bsip.res.in
