

Capacity building in glaciology*

The Himalaya is the youngest and loftiest mountain chain on Earth. It is a huge reservoir of water being a source to many important rivers in South Asia. Outside the polar region, it is the largest glacier system with maximum deposit of snow and ice. Therefore, the study of mountain glaciers of the Himalaya has significant implications to understand climate change and the future of water resources in India. There are about 9575 glaciers in the Indian part of the Himalaya, of which only a few have been monitored on a long-term basis. Glaciers are one of the most important recorders of climate change as they are extremely sensitive to even small climatic perturbations. The Greenland and Antarctic ice sheets have been losing mass over the last few decades. Glaciers have continued to shrink and it is expected that global ice volume will decrease further. This necessitates studying the climate change impact on glaciers and its consequences. Glaciologists have developed many sophisticated techniques to monitor the glaciers, of which remote sensing is one of the most important components for assessment of climate change on snow and ice. However, the lack of expertise in this domain needs training programmes, workshops and seminars to be conducted for young people in this thrust domain by experts in the field. Divecha Centre for Climate Change (DCCC), Indian Institute of Science (IISc), Bengaluru has been conducting training programmes in glaciology. Since 2011, five training programmes have been successfully conducted. The first training programme was conducted in collaboration with the University of Sherbrooke, Canada and the remaining four in collaboration with the University of Iceland, Reykjavik, Iceland. In continuation of these series, the fifth training programme was conducted to educate the trainees on various facets of glaciology, climate change and remote sensing. An

overwhelming response was received and 40 trainees from different universities, academic and research institutions, having diverse backgrounds, from all over India and Bhutan participated in the training programme.

The training programme was inaugurated on 8 June 2015 by A. S. Kiran Kumar (ISRO). Helgi Bjornsson (University of Iceland), Anil V. Kulkarni (DCCC), J. Srinivasan (DCCC) and some faculty members of IISc were also present. The main objective of this training programme was to enthuse young researchers for initiating systematic studies of glaciated regions of the Himalaya. It was stressed that a multidisciplinary approach is needed for glaciological studies in order to understand the complete glacial environment, including the physical and chemical changes.

Overall 30 lectures and 9 practical sessions, including discussions were conducted. The training started with an effective talk by Kiran Kumar throwing light on the vision and mission of ISRO with the implication of space technology in day-to-day activities. The other lectures covered almost all the aspects of glaciology, basics of remote sensing and climate change. Helgi Bjornsson covered several topics in his lectures, which included an overview of the cryosphere and its morphology; global distribution of snow and ice with distribution of temperature change; thermal classification of glaciers; methods to evaluate the mass balance; the energy budget; movement of glaciers; ice-core studies and glacial lake outburst flood (GLOF). As glaciers are important from the hydrological point of view, he also covered glacier hydrology in his talks. J. Srinivasan explained an overview of climate change along with the basics of remote sensing. Anil V. Kulkarni delivered informative talks on the utilization of quantitative remote sensing in glaciology; the algorithms to extract snow and glacier-covered regions; identification of various snow and ice features that could be mapped; use of remote sensing to analyse the mass balancing, depth estimation and hydrology of glaciers. He also emphasized on the research gaps in the Third Pole. G. Bala (Centre for Atmospheric and Oceanic Sciences (CAOS), IISc) gave an overview of the general circulation of the

atmosphere and oceans; concepts of geo-engineering; heat transportation process through ocean and atmosphere; climate feedback and carbon cycle. Thora Ellen (University of Iceland) talked on permafrost and colonization of deglaciated area with various ecological changes. G. S. Bhat (CAOS, IISc) talked about the techniques to observe meteorological changes with errors and accuracies in the observational data. S. K. Satheesh (CAOS, IISc) explained the effect of aerosols and climate change on glacier systems. Ashwagosh Ganju (Snow and Avalanche Study Establishment, Chandigarh) delivered a comprehensive lecture on snow studies with respect to avalanche investigations in India. All these talks were compiled with numerical problems on the topics covered during the lectures with interactive sessions. Besides, the trainees also got an opportunity to attend a special lecture by Maj. Gen. S. S. Sharma regarding the first Indian wintering Antarctica expedition. The training lecture series concluded with a talk on glaciological research opportunities in India by P. Sanjeeva Rao (DST, New Delhi).

The training course aimed at imparting multidisciplinary ideas in different fields which could be useful for youngsters working in different organizations. The training provided an opportunity to interact with renowned workers, having an exchange of opinions/suggestions and enthused discussions which helped the participants develop a broad outline on glacier studies with regard to remote sensing and climate change in India and across the world. The training programme also provides an opportunity for young researchers and scholars to get trained and educated in glaciology at the University of Iceland, Reykjavik for the period of six months. The course would be sponsored by Climate Research Foundation (Iceland), which aims to promote and encourage youngsters in the field of glaciology.

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