MEETING REPORT

Snow and glacier melt runoff modelling in the Himalayas*

It is now well accepted that the changes in the snow cover and glacial mass resulting from climate change can have a negative impact on the hydrological regime of the river basins having their headwaters in the Hindu Kush–Himalayas (HKH), which supports 10 major perennial rivers of this region. The changes in the snow and glacier cover can enhance the inter-annual variability, seasonality and/or water availability. This can have a profound impact on the lives and livelihood of 1.3 billion people living in those river basins unless proper adaptation and mitigation strategies are adopted. Adaptation and mitigation activities, however require good qualitative understanding on the role of snow and glacier melt processes and the likely changes that can happen in the future. The lack of baseline data in Himalayan region attracted attention of the IPCC in the 4th assessment report and brought a call from policy and decision makers to gradually improve the monitoring schemes of snow, ice and water resources. Also in the recent years, the awareness among scientists and political leaders regarding the severe lack of data and comprehensive knowledge on reduction in snow and ice mass and its implications for water resources in the HKH region has increased significantly.

Hydrological models with strong snow and glacier melt simulation capacities are essential tools to understand these processes, although the capacity among the professionals is limited in this region. With the objective of strengthening the capacity among key stakeholders in the region, International Centre for Integrated Mountain Development (ICIMOD) organized the week-long training workshop entitled 'Regional Training Workshop on Snow and Glacier Melt Runoff Modelling in the Himalayas' during 24–28 August 2009. The workshop was financially supported by Division of Early Warning and Assessment (DEWA) Regional Office, Asia-Pacific of United Nations' Environmental Program (UNEP). Technical support to the workshop was provided by Swiss Federal Institute of Technology, Zurich (ETH Zurich) and Tribhuvan University, Nepal.

There were 23 participants from 6 countries of the HKH region. The workshop session dealt elaborately on two hydrological models: HBV (Hydrologiska Byråns Vattenbalansavdelning)[1], a semi-distributed conceptual model and TAC-D a fully distributed conceptual model. HBV is the improved version of SMHI (Swedish Meteorological and Hydrological Institute) model in Sweden. The HBV model consists of several fundamental hydrological routines, including a snow and glacier routine based on a degree-day relation, and a soil moisture routine that accounts for soil field capacity and changes in soil moisture storage due to rainfall/snow melt and evapotranspiration. The runoff generation routine transforms water from the soil moisture zone to runoff. The model TAC-D (tracer aided catchment model, distributed)[2] is a fully distributed version of the HBV model with a more process-based runoff generation routine. It is a grid based, conceptual rainfall runoff model with a modular structure; it has been designed to simulate runoff, different runoff components and solute concentrations in a more process oriented way. Processes incorporated into the model include snow and glacier melt, interception, evapotranspiration, surface storage, overland flow, different interflow processes, groundwater flow and channel routing. TAC-D is coded in an environmental modelling language which is part of the GIS PC-Raster[2]. We found that TAC-D has better control within the sub-catchment area and provides more accurate runoff simulation.

A brief overview of a physically based model 'TOPKAPI', still under development by ETH Zurich, was also provided. The sessions included both lectures and hands-on exercises on HBV and TAC-D models. Further, the participants were appraised on the regional climate model (RCM) outputs available in the region. The participants were acquainted with techniques to extract climate change scenarios from RCM outputs and their use in the hydrological models for impact studies. Participants observed that both models can be used in applications such as real-time forecasting, control of data quality, design floods, synoptic water balance mapping, water balance studies, simulations of the effects of a changing climate and simulations of groundwater response.

The organization of the training workshop was highly appreciated by the participants. A need to follow up on the proceedings of the workshop was emphasized. The participants agreed to form an informal network to communicate their experience in use of the models. The participants also requested ICIMOD and the relevant institutes in the HKH region to formulate a pilot project, in which the knowledge and skill gained during the workshop could be implemented.

*A report on a training–workshop on 'Snow and Glacier Melt Runoff Modelling in the Himalayas' during 24–28 August 2009 organized by International Centre for Integrated Mountain Development (ICIMOD).

1. Bergström, S., The HBV Model – Its Structure and Applications, SMHI, RH, 4, Norrköping, Sweden, 1992.
2. Karssenberg, D., Burrough, P. A., Sluiter, R. and de Jong, K., *Trans. GIS*, 2001, **5**, 99–110.

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