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Assessing hydrologic components of a glaciated catchment in the central Himalaya

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The Hindu-Kush Karakoram and Himalaya (HKKH) mountains are the water towers of Asia, as they deliver water to nearly half of the world's population. Despite so, it is mostly unclear what is the relative contribution of rainfall, snow and ice-melt to hydrological fluxes in this area. Here, we study the Dudh Kosi River catchment (450 to 8848 m asl, ca. 4000 km2) in central Nepal, including the Khumbu glacier at Mt. Everest's toe. Two critical components for predicting hydrologic fluxes in steep mountain ranges are: (1) accurate information of energy and mass fluxes, especially at high altitudes, and (2) depiction of rainfall and snowfall amount and dynamics. In this study, we use a combination of unique ground-control data and remote-sensing data to provide realistic hydrologic modeling boundary conditions. We primarily relied on and validated (1) Moderate Resolution Imaging Spectroradiometer (MODIS) product MOD11/MYD11, to calculate day/night land surface temperatures and monthly lapse rates; (2) Tropical Rainfall Measurement Mission (TRMM) 3-hourly rainfall data from TRMM product 3B42 with 0.25° x 0.25° spatial resolution; and (3) MODIS product MOD10/MYD10 to derive daily snow covered areas. Ground-control data are derived from high altitude stations provided by the Ev-K2-CNR Committee of Italy, as well as from data of the Department of Hydrology and Meteorology (DHM) at lower elevations. We model hydrological run-off processes with a semi-distributed, altitude-belt based model. While the validated remote-sensing data generally provide good agreement with station data, snowfall component is not well depicted. We rely upon a correlation of precipitation with altitude combined with snow depth measurements at the EV-K2-CNR Pyramid (5050 m asl) to evaluate snowfall contribution. We use a degree-day approach and explicitly treat debris coverage on ice and snow. Our preliminary results indicate that approximately 20% of annual discharge is derived from snow and ice melt. Ice melting is highest during the late summer season, when air temperature and solar radiation exert a strong forcing upon snow free ice. Our combined approach of remote-sensing and ground-control stations provide realistic hydrologic-modeling parameters that can used for predicting water resources in this sparsely-monitored region.

Keywords: Himalaya; hydrological models; water resources; remote sensing.