Geophysical Research Abstracts
Vol. 16, EGU2014-10315, 2014
EGU General Assembly 2014

The challenges of catchment hydrological modelling in the Himalayan region: a case study from the Dudh Kosi River basin of Eastern Nepal

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Catchment-scale hydrological modelling in the Himalayan region suffers from multiple issues that affect our ability to represent the hydrological dynamics of a river system. Due to a lack of monitoring infrastructure, especially in the high-altitude areas, the spatial distribution of precipitation is essentially unknown. Therefore, the regionalization of precipitation in river basins is a challenging task that has implications in the modelling approach at different levels. This paper explores the uncertainty in modelled discharge using different precipitation input datasets in the glaciated catchment of the Dudh Kosi River basin in Eastern Nepal (3712 km2). The basin hosts some of the world's highest mountain peaks, including Mt Everest. Six precipitation stations, which cover mostly the lowland area of the basin, give a station density of one station per 618 km2. First, we examine precipitation dynamics in the study area based on the observed data. Second, the process-oriented distributed J2000 hydrological model is applied in the Dudh Kosi River basin. Third, the model is run with APHRODITE-(V1003R1), CPC-RFE-(2.0) and TRMM-(V7) precipitation products to compare observed and modelled discharge.

Nearly 82% of the precipitation occurs during the monsoon season (June - September), and the limited station observations suggest that there is non-uniform distribution of precipitation in which the underlying topography has a great influence. The maximum precipitation occurred at the station which is located on the middle hills region, followed by the station located at the foothills of the Higher Himalaya. Compared to the observed precipitation, the TRMM product is found to be 7% less than the observed data, whereas the other two products were up to 35% less. The model was applied with the six stations data and the regionalization was carried out using Inverse Distance Weighting (IDW) method to simulate the hydrograph. The model was first applied between 1985-1997 in which the model simulates the hydrograph with a Nash–Sutcliffe efficiency of 0.85, a logarithm Nash–Sutcliffe of 0.93, and a coefficient of determination of 0.85. To apply the model during the recent period (2002-2007) when the rainfall products are available, the model was run with the same parameter sets. With observational inputs, high flows are underestimated for some years between 2002 and 2007. Out of the three products, the TRMM generates a better hydrograph, but Percentage BIAS (PBIAS) is -26%, compared to –17% with observed station data between 2002 and 2007. The APHRODITE and CPC-RFE datasets result in discharges that are underestimated by 47% and 51% respectively. The model results based on the three precipitation products suggest that discharge underestimation is due primarily to precipitation input. The lack of precipitation information brings additional challenges to hydrological modelling in the Himalayan region and future research should focus on precipitation observations and dynamics in high-altitude areas.

Key words: Catchment hydrology, Himalayan region, J2000 hydrological model, Precipitation pattern