Government of Nepal
Ministry of Energy, Water Resources and Irrigation
Water Resources Research and Development Centre
Pulchowk, Lalitpur

WRRDC RESEARCH LETTER

Issue: 12
September 2021

Water and energy budget based distributed hydrologic modeling in Budhiganga River Basin of Nepal

Introduction

Hydrologic modeling of a poorly gauged river basin is critically important for water resources management, especially if some infrastructure is going to be built in the river basin. Budhiganga river basin is one of the poorly gauged mountainous river basin of Nepal Himalaya, a sub-basin of large river basin system, called Karnali. Figure 1a shows the location and drainage basin of the Budhiganga River at Chitreghat having basin area of 1646 sq. km. Figure 1b shows the Digital Elevation Model (DEM) of study area. About 70-75% of the precipitation falls in July-September, owing from summer monsoon precipitation. This research aims in development of a base model in distributed hydrologic modeling framework at Budhiganga River Basin considering the validation of river flow at basin outlet - Chitreghat station and model simulated snow cover area with Moderate Resolution Imaging Spectroradiometer (MODIS) derived snow cover.

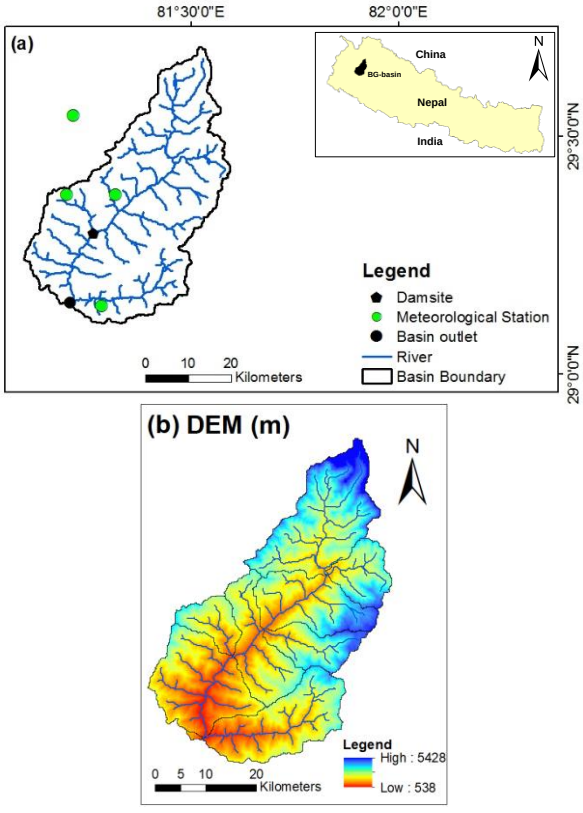

Fig. 1a – Drainage basin, 1b -DEM

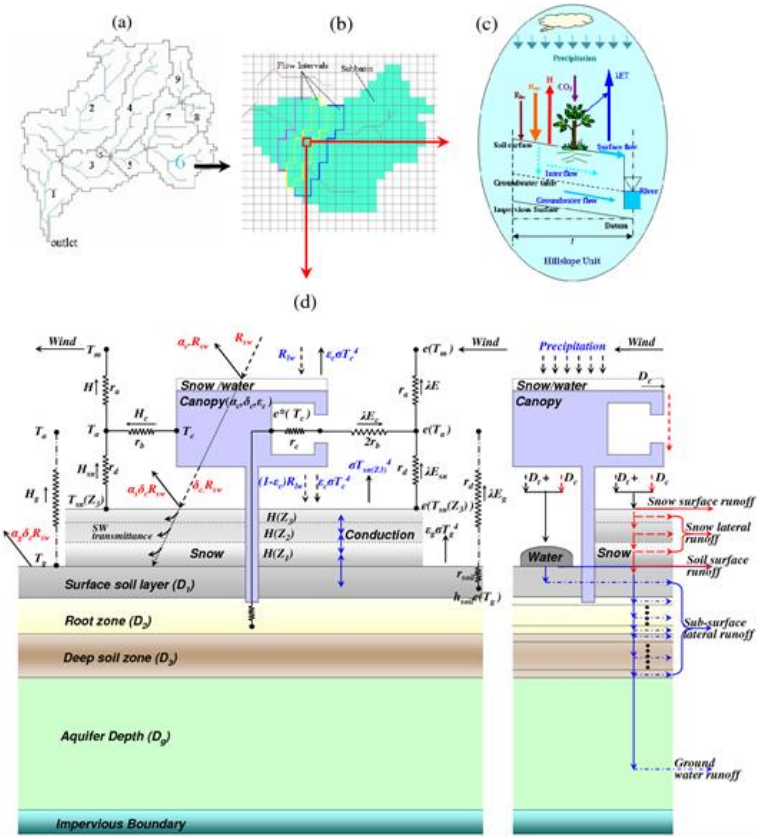

Fig. 2 Overall structure of WEB-DHM-S (after Shrestha et al, 2015)

Materials and Methods

The Water and Energy Budget based Distributed Hydrologic Model with improved snow physics (WEB-DHM-S) model (Shrestha et al., 2012, 2015) has been used in this study. Overall structure of the model is shown in Figure 2. All time-variant, static input data and gridded evaluation data were prepared on a 200m grid resolution. Time-variant input data include downward longwave and shortwave radiation, wind speed, air temperature, relative humidity, precipitation, Leaf Area Index (LAI) and Fraction of Photosynthetic Active Radiation (FPAR). Static data include DEM, soil type and land use. Evaluation data include MODIS derived snow cover (MOD10A2) and observed daily discharge. Precipitation and temperature data are obtained from Department of Hydrology and Meteorology, Nepal. Other meteorological input data are from NASA Global Land Data Assimilation System Version 2 (GLDAS2). LAI/FPAR input are from MODIS (MOD15AH2). Altitudinal gradient of precipitation is employed in angular distance weight method following Shrestha et al. (2015). Based on observed precipitation gradient between the stations, the average value of $0.00045 m^{-1}$ is used for the model grids having elevation above 1400 masl.

Results and Discussion

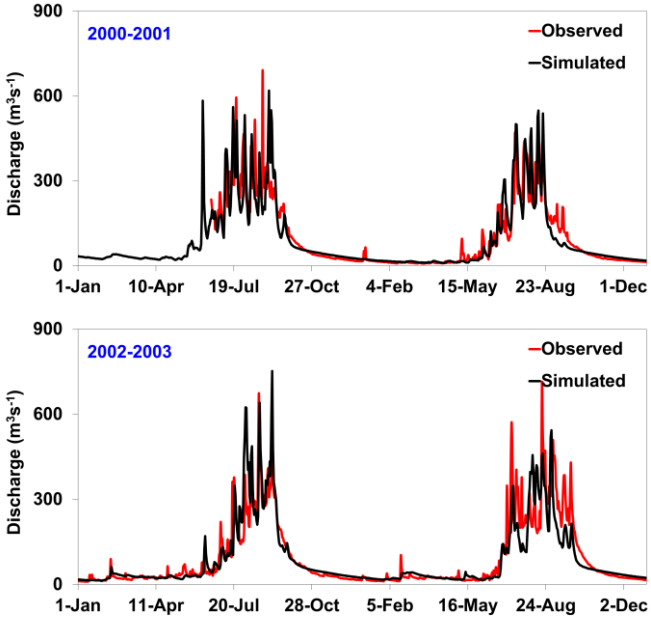

Fig. 3. Observed and Simulated Discharge in 2000-2001 (Calibration) and 2002-2003 (Validation)

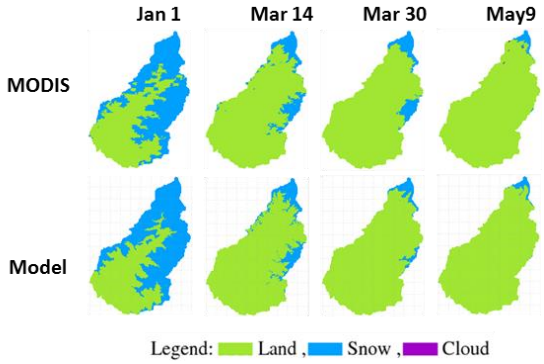

Fig. 4. MODIS Vs. Model Snow cover area (SCA) in 2003

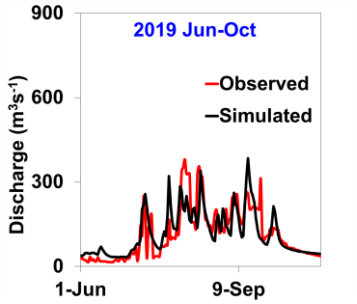

Fig. 5. Observed and Simulated Discharge in 2019 (June-October)

Model is calibrated in year 2000-2001 and is validated in year 2002-2003. Observed and simulated discharge at Chitreghat station is presented in Figure 3. Results show that the discharge is well simulated having Nash Efficiency (NSE) at 0.74 to 0.81 and Relative Error (RE) at -2.1 to 1.64% in calibration period. NSE and RE are at 0.71 to 0.73 and +8 to -13% respectively in validation period. Snow melt contribution to annual runoff is estimated at about 3%. Snow cover is remarkably well simulated by the model in comparison to MODIS derived snow cover. Model simulated and MODIS derived snow cover for selected dates in 2003 is presented in Figure 4. Further, model performance is validated in summer season of 2019 (Figure 5).

Remarks

WEB-DHM-S model has been developed for Budhiganga River Basin of Nepal. Model was found to be capable of well simulating the observed discharge during 2001-2003 (Calibration) and during 2006-2008 and 2019 (Validation). Lack of precipitation stations is the major limitation of the model simulation as it has the highest influence over calibration of model parameters. In future, model will be further tuned and long term hydrology will be generated to be applicable for hydrological analysis of water resources projects within the study region.

Acknowledgment

Department of Hydrology and Meteorology is acknowledged for providing hydro-meteorological dataset.

Reference

Shrestha, M., Wang, L., Koike, T., Xue, Y., and Hirabayashi, Y. (2012) Modeling the spatial distribution of snow cover in the Dudhkoshi region of Nepal Himalaya, J. Hydrometeor., 13, 204-222,doi: 10.1175/JHM-D-10-05027.1.

Shrestha, M., Koike, T., Hirabayashi, Y., Xue, Y., Wang, L., Rasul, G. and Ahmad, B. (2015) Integrated simulation of snow and glacier melt in water and energy balance-based, distributed hydrological modeling framework at Hunza River Basin of Pakistan Karakoram region. J. Geophys. Res. Atmos. 120, 4889–4919.

FOR FURTHER INFORMATION:
Government of Nepal
Ministry of Energy, Water Resources and Irrigation
Water Resources Research and Development Centre
Dr. Maheswor Shrestha, Executive Director, maheswor.shrestha@nepal.gov.np
Mahesh Khanal, Information Officer, mahesh.khanal@nepal.gov.np
Website: www.wrrdc.gov.np

Citation: Shrestha, M., 2021. Water and energy budget based distributed hydrologic modeling in Budhiganga River Basin of Nepal Himalaya, WRRDC Research Letter, Issue no: 12, September 2021, pp. 1-2.