Project report for Montanaview fellowship

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Title: Estimating the snowmelt derived runoff in Upper Missouri River Basin with snowmelt runoff modelling

Thank you for awarding me the Montanaview fellowship. Here follows the project report, as required.

1. Introduction

Mountain watersheds are an important source of freshwater and hydrological cycle in the mountainous regions (He et al., 2014). In the mountain watersheds of high latitudes (Higher than 40°N and lower than 40°S), snow is an important factor to consider during the estimation of streamflow, since snow precipitation, accumulation, and melt have significant impact on the streams. The goal of snowmelt runoff modelling is to estimate the streamflow due to snowmelt. The Snowmelt Runoff Model (SRM) developed by (Martinec, 1975) is one of the models developed to estimate the snowmelt-derived streamflow. SRM has been used successfully in many

watersheds in various climatic conditions worldwide. Data required for SRM are temperature, snow cover, and precipitation. Historically, in-situ data were used to calculate the streamflow from SRM. Now-a-days, advances in remote sensing instruments and techniques allow the researchers to determine these data remotely. In this study, we used the Land Surface Temperature (LST) and snow-cover data from spaceborne Moderate Resolution Imaging Spectroradiometer (MODIS), and precipitation data from Tropical Rainfall Measurement Mission (TRMM) satellites to estimate the snowmelt-derived streamflow in the Upper Missouri River Basin using the SRM.

2. Study area

Site selected for this study was the Upper Missouri River Basin (UMRB). The UMRB is named over the upper part of the Missouri river basin comprising of the headwater in the Rocky Mountains in Montana, Idaho and Wyoming. The UMRB has an approximate watershed area of 59,400 km^2. Topographic elevation in UMRB ranges from ~860m to ~3445m with elevation gradient ranging from higher at South West to Lower at North East. The watershed outlet is located at the Morony dam approximately 20km North East of Great Falls, Montana. A stream gauge is installed on the Morony dam to measure the daily streamflow.

3. Progress

We are using the LST and snow-cover data from MODIS, and precipitation data from TRMM satellites. TRMM provides daily precipitation data, and MODIS provides daily and 8-day LST and snow-cover data. Recently MODIS daily snow-cover cloud free product is released, and it is said to provide better snow-cover area. We developed some basic batch processing codes to

process the MODIS and TRMM data automatically. MODIS 8-day data is done processing. TRMM daily data is processed for 4 years and rest is under processing. MODIS daily data is yet to process. Since the TRMM data is under processing, we used the pre-processed MODIS 8-day LST and snow-cover data, and the precipitation data collected at the National Weather Service's (NWS) Great Falls weather station to demonstrate the working of SRM model. We performed the forced calibration of the SRM model and estimated the snowmelt-derived streamflow for 7 years. Figure 1 shows the comparison between measured and computed streamflow values. The combined Nash-Sutcliffe coefficient (R^2) value was 0.73, indicating successful calibration.

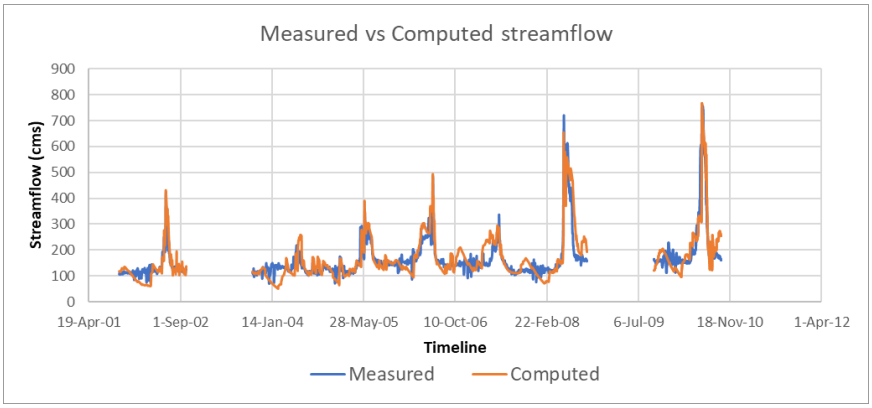

Figure 1. Measured vs computed streamflows for 7 years

Recently, we were also able to estimate the streamflow using MODIS 8-day LST and snow-cover, TRMM daily precipitation data, and the optimized parameters suggested in (Martinec and Rango, 1986) for water year 2003. The optimized R^2 value for one year was 0.5977 (~0.6), which indicates that estimating the streamflow from SRM model solely based on spaceborne remote sensing products seems effective. Figure 2 shows the estimated streamflow solely using remotely sensed products.

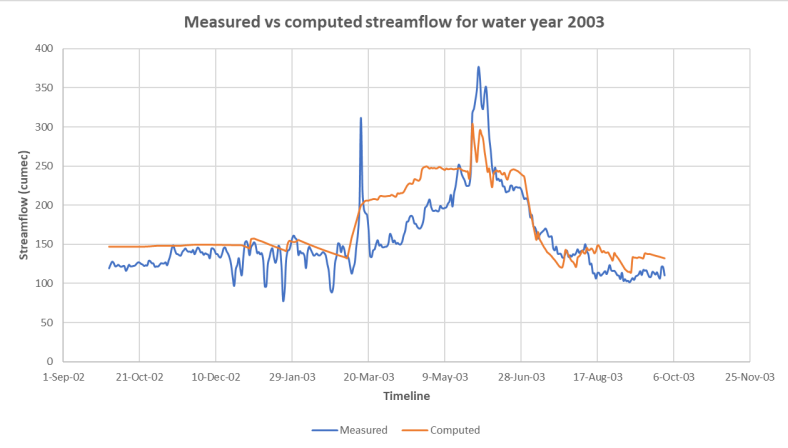

Figure 2. Measured vs computed streamflow solely using remotely sensed data

4. Future work

Future work includes completing the pre-processing of remaining MODIS and TRMM datasets, calibrating the SRM model using MODIS and TRMM data, and predicting the streamflows upon successful calibration. Other part of the future work is to develop and test the Hydroelectric Generation (Hydro-gen) model which is under development, and determine the hydroelectric energy production from the Morony dam.

5. References

He Z., Parajka J., Tian F., Blöschl G. 2014. Estimating degree-day factors from MODIS for snowmelt runoff modeling. Hydrology and Earth System Sciences. 18(12). 4773-4789.

Martinec J. 1975. Snowmelt-runoff model for stream flow forecasts. *Hydrology Research*. 6(3), 145-154. DOI: 10.2166/nh.1975.0010.

Martinec J., Rango A. 1986. Parameter values for snowmelt runoff modelling. *Journal of Hydrology*, 84(3-4), 197-219. DOI: 10.1016/0022-1694(86)90123-X.