

Evaluation of HEC-HMS & WMS Rainfall-Runoff Model for Part of Baitarani Sub-Basin

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Abstract: Conceptual rainfall-runoff model using HEC-HMS and WSM representing catchment hydrological response to rainfall as a series of mathematical relationships for Baitarani sub-basin has been modelled in source software. The observed data of several rainfall stations inside the river basin are input in the model system along with potential evapotranspiration and the results are calibrated with the observed data of daily discharge at Anandapur gauge and discharge site (G&D) for a period of about 17 years. The warm up and validation periods is taken as 1 year for 2008 which shows the highest observed peak flow. The optimum value of HMS model parameters are observed within the maximum and minimum limits. Drainage network and sub-basin delineation for the watershed Anandapur has been used as an objective function to describe the agreement between the modelled stream flow and observed stream flow time series. The calibration and validation are fairly overlapping modelled and observed discharge (flow) graph which is an indication of good model performance.

Keywords: HEC-HMS, WMS, Rainfall- runoff modelling, SMA, DEM, Hydrological alteration, Simulated flow

1. Introduction

As we are advancing in technologies, economic growth, urbanization, the complexity in climate is increasing in a converse manner. And its effect has been seen very much on the monsoon expectancy as well as on the record rainfall. Also, during the last six decades the growth in population is explosive, accordingly the necessities for the resources for living have been increased rapidly. One of the most vital of these resources is water which includes irrigation supply, industries use other than drinking purpose. Thereby, the load of this particular resource has been increasing for many years. Requisite, managing these water competent is crucial. Hence it puts a challenge to the water managers and planners to make future policies and execute it in a way to eradicate it. Various simulations and modelling are done to study these scenarios. Rainfall runoff modelling is very much technique to do the calculations and studies. A rainfall runoff model is used to derive runoff for a particular area from inputs of rainfall and potential evapotranspiration (or aerial potential evapotranspiration). Conceptually, all rainfall runoff models represent catchment hydrological response to rainfall as a series of mathematical relationships. They provide runoff output from each functional unit as total discharge. In this study HMS (Hydrological Modelling Software) along with WMS (Watershed Modelling Software) is used to get the results of runoff discharge.

The HEC model is designed to simulate the response of a surface runoff of a basin against the precipitation using hydrological data. The model was carefully calibrated and verified in basin using historical observed data and runoff is calculate (Asadi and Boustani, 2013) [1]. For the efficient management of water resources in the target basin, this study proposed a method by applying the hydrological simulation model.

2. Study Area

The Baitarani sub basin is situated approximately between east longitudes of 85° 10' to 87° 03' and between north latitudes of 20° 35' to 22° 15'. The Baitarani river originating from Keonjhar District of Orissa is one of the important rivers of the State flowing eastward and joining the Bay of Bengal. The beginning portion of the river acts as the boundary between the Orissa and Jharkhand states of India. The major tributaries of Baitarani are rivers like Deo, Kanjhari, Kusei, Salandi and Matai. The River enters in plains at Anandapur. Maximum temperature rises to 40.5°C during summer while the minimum during winter may be as low as 8-9°C. The rainfall is received from the south-west monsoon from June to October. The study area is shown below figure

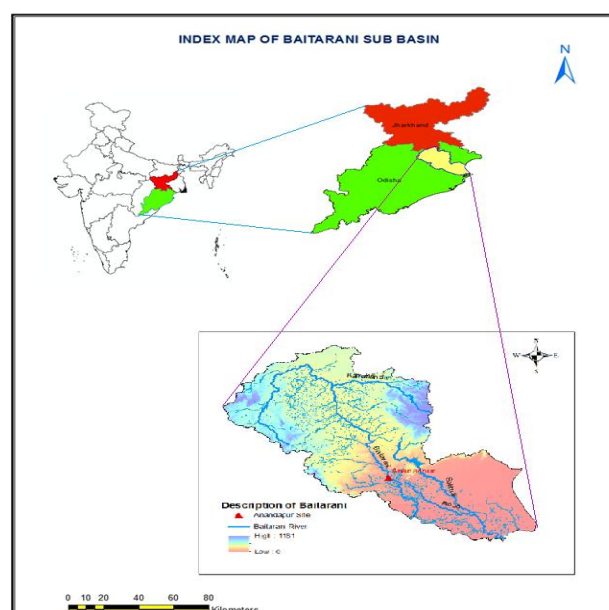


Figure 1: Description of study area

3. Methodology

The study includes various input materials in datasets e.g. Digital Elevation Model (DEM), Rainfall, Soil, Land Use Land Cover (LULC). The rainfall for this project was collected from (Global Ensemble Forecast System) GEFS. The present study followed the hydrological methodology using SMA method.

In WMS (WMS 10.1 Tutorial Manual, 2016) [5],[6], first a DEM of the study area was used for delineation purpose of the area of study with outlet point taken at Anandapur location. The DEM was first made in .hdr format from .TIFF format by ArcGIS to use it as input in WMS. The area was delineated by taking the outlet point at Anandapur. The Rainfall data along with Evaporation, Soil, Land Use Land Cover was used, the runoff was calculated in HEC-HMS software (HEC-HMS 4.1 User Manual, 2015) [4], using (Soil Moisture Accounting) SMA. It is achieved by the simulation of the movement of precipitation through the storage volumes that represent Canopy interception, Surface depressions, the Soil profile and Groundwater layers. The soil moisture accounting loss method uses five layers to represent the dynamics of water movement above and in the soil. The figure 3. Shown below shows the particular layers in SMA method. The calculations of surface runoff are performed by the transform method contained within the sub-basin, Clark Unit Hydrograph method was used in the methodology. It's a synthetic hydrograph method (it's not required to develop a unit hydrograph by the previous observed hydrographs). Base flow method is used for the subsurface calculation contained within the sub-basin. The flow chart for the methodology followed is shown in below figure 2.

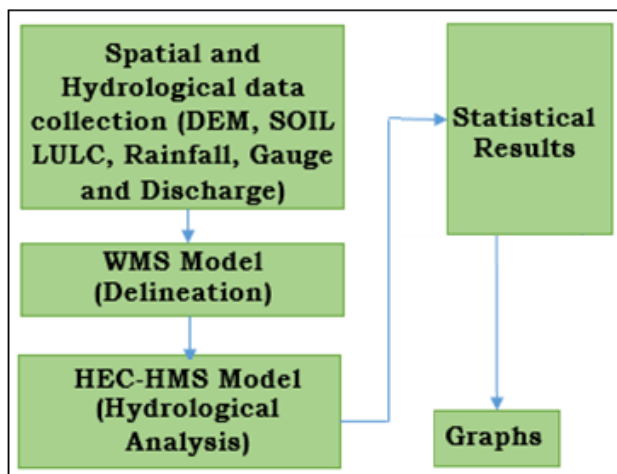


Figure 2: Infiltrations among layers in SMA method

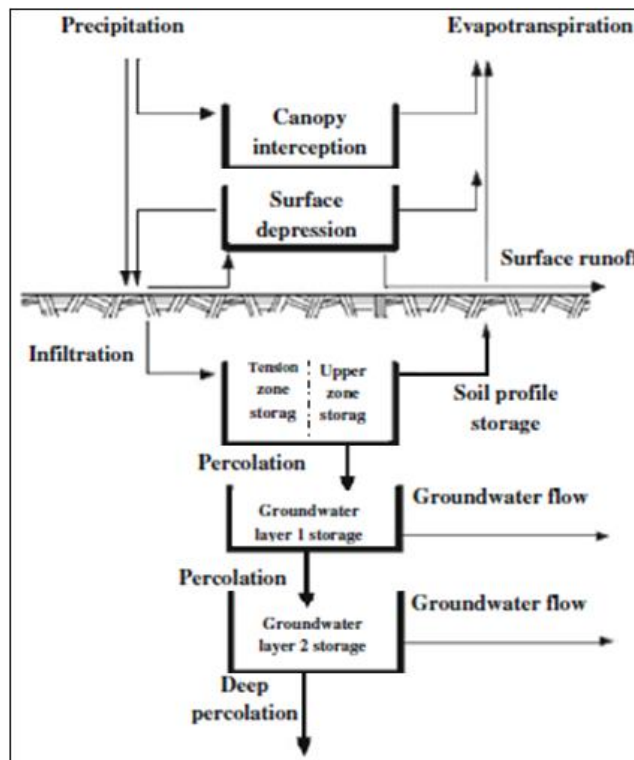


Figure 3: Infiltrations among layers in SMA method

4. Calibration and Validation

The simulated runoff was calibrated against the observed discharge data from CWC's [3] Anandapur site for the seventeen years data viz. 2000 to 2016. The objective of the model calibration is to determine the gap between observed flow data and the flow data obtained by simulation. HEC-HMS model is calibrated for the continuous simulation. Runoff the Baitarani river basin for seventeen years i.e. 2000 to 2016 were used for simulation of HEC-HMS model. During calibration following parameters were adjusted manually. The following parameters were initially taken arbitrarily and optimized in the trial run: (a) Storage Coefficient, (b) Time of concentration, (c) Max Infiltration, (d) Soil Percolation, (e) Soil Storage, (f) Tension storage.

5. Results and Discussion

The HMS was run for the rainfall data uniformly distributed over the study area for seventeen years to get the simulation runoff for the period from 2000 to 2016 depicted in figure 4. Average rainfall in the study area varies from 1876 mm to 390 mm (Central Water Commission, 2016-2017) [2].

The peak flow in observed flow is seen in the year 2008 of magnitude 5357.756 cumecs. The calibration of model was carried out for year 2008 between 1 January to 31 December. The model was optimized for the simulation by optimization trials. The optimization trial optimizes the values of parameters entered in the starting of setting up of model in HMS. The parameter after optimization is shown in the table 1 below. The figure 5 also shows the complete optimization trial obtained after the successful completion of optimization run.

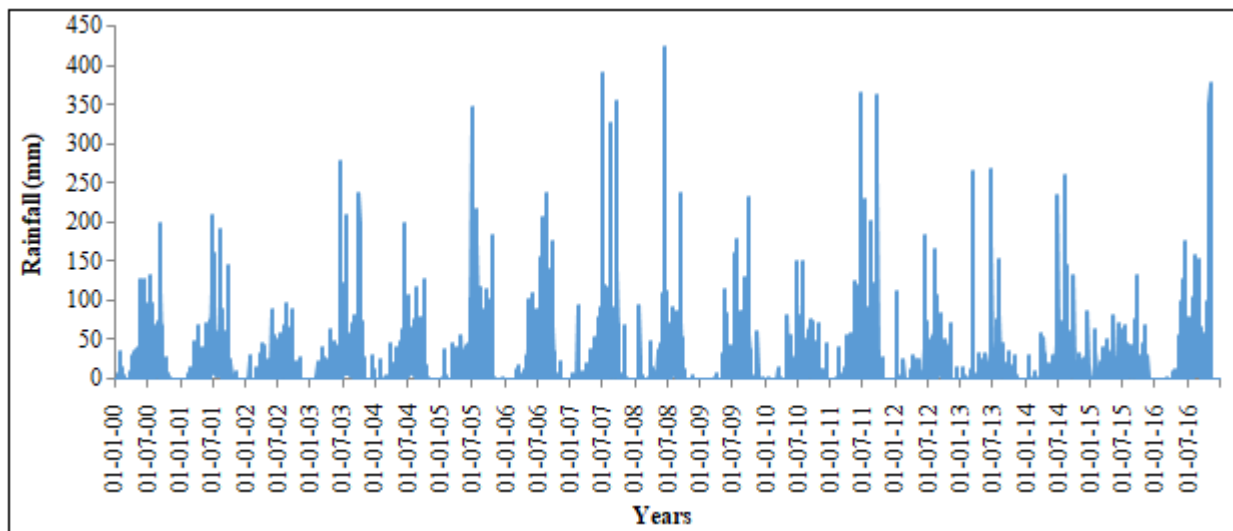


Figure 4: Daily rainfall graph of 17 years

Table 1: Optimized parameter

Parameter	Optimized Value	Units	Minimum Limit	Maximum Limit
Storage Coefficient	930.71	HR	0.01	10000
Time of concentration	8.000	HR	0	1000
Max Infiltration	0.0105953	MM/HR	0.01	500
Soil Percolation	0.0265273	MM/HR	0.01	500
Soil Storage	3.5337	MM	0.01	1500
Tension storage	1.0200	MM	0.01	1500

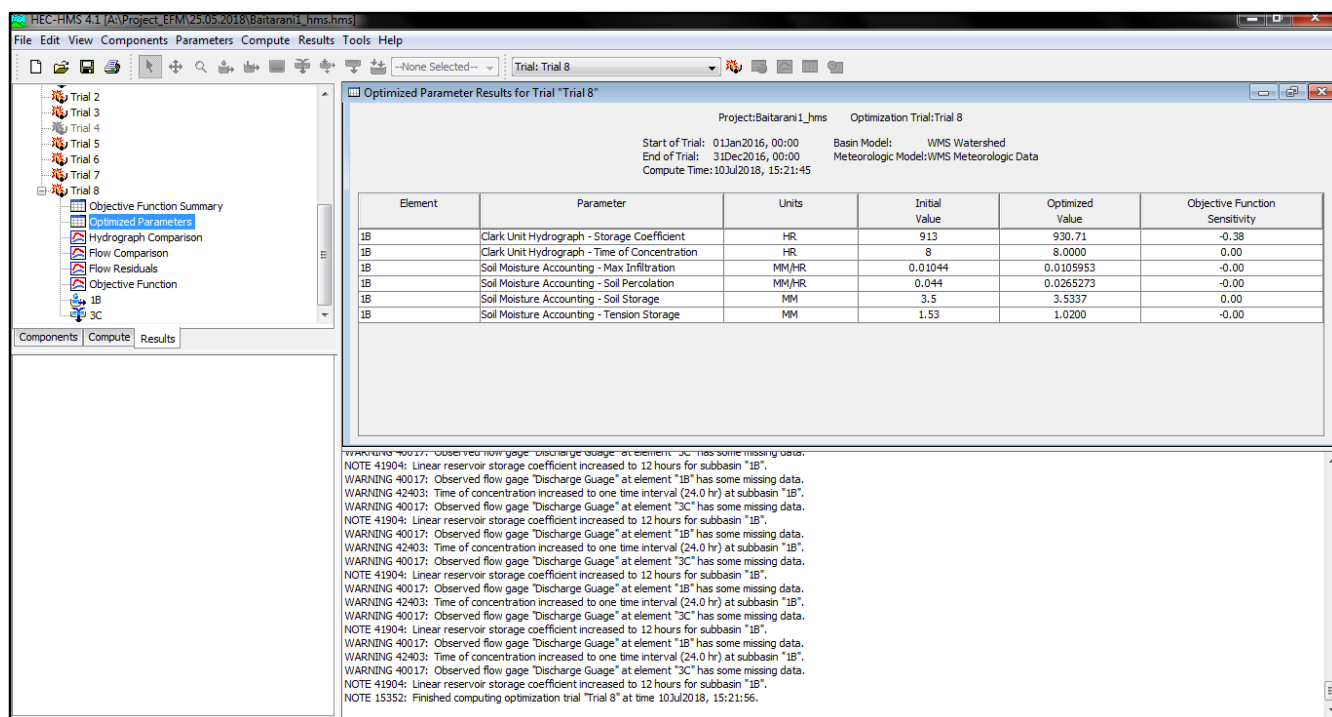


Figure 5: Optimized Parameters

The temporal variation in the observed and simulated runoff at Anandapur, which is the outlet point of basin over calibration period of 1 January to 31 December 2008, depicted in figure 6. The figures depicts clearly that the observed and simulated runoff flow are overlapping closely with a few sway at some points on time line.

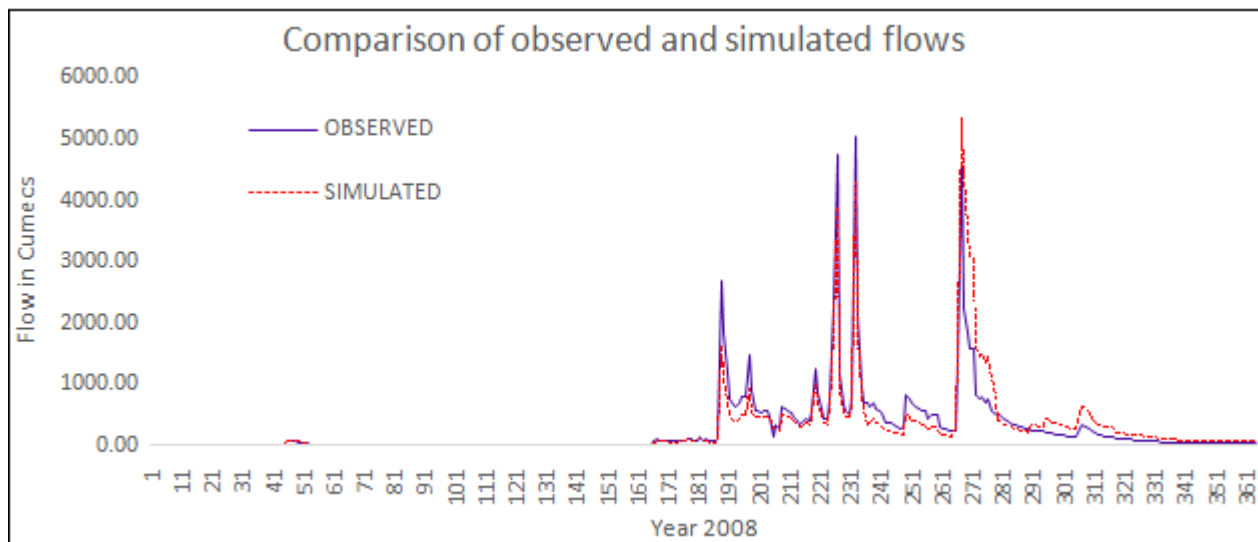


Figure 6: Variation of observed and simulated runoff at the outlet point of basin

6. Conclusion

The rainfall-runoff models are one of the important tools used in hydrology. These are quite useful for planning in water sector being used as one of the first steps towards generating an integrated model at basin/sub-basin level. The model used in the present case study is performing well against the performance criteria. It can be concluded from the obtained values that a strong positive linear relationship appears to exist between simulated and observed flows. There is a scope further for improving the accuracy of the simulated flows and other results by having a data with greater degree of confidence as input and calibration.

References

- [1] AsadiArash, Boustani Fardin, "Performance Evaluation of the HEC-HMS Hydrologic Model for Lumped and Semi-distributed Storm flow Simulation (Study Area: Delibajak Basin)", American Journal of Engineering Research (AJER), 2013.
- [2] CWC Draft Report on "Reassessment of Water Availability in India using Space Inputs (Volume-I)", Central water Commission, Basin Planning and Management Organisation, October 2017.
- [3] CWC Report on "River Basin Planning of Baitarani Sub-Basin", Central water Commission, Basin Planning and Management Organisation, September 2016.
- [4] HEC-HMS 4.1 User Manual on "Hydrologic Modelling System", U. S. Army Corps of Engineers, Institute of Water Resources, Hydraulic Engineering Centre, July 2015.
- [5] WMS 10.1 Tutorial Manual on "Introduction to WMS", Aquaveo 2016.
- [6] WMS 10.1 Tutorial Manual on "Watershed Modelling-DEM Delineation", Aquaveo 2016.