International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 4
April 2017

Event and Continuous Hydrological Modeling with HEC-HMS: A Review Study

Sonu Duhan*, Mohit Kumar#
**M.E (Water Resources Engineering) Civil Engineering Student,*
PEC University Of Technology, Chandigarh, India
#Assistant Professor, Civil Engineering Department,
PEC University Of Technology, Chandigarh, India

ABSTRACT
Hydrological modeling system represents a part of hydrologic cycle in a simplified and conceptual way. Hydrological cycle represents the circulation, occurrence, distribution and conservation of earth water and it is never-ending process. Hydrological models are primarily used for hydrologic prediction and helps in understanding the hydrologic response of a particular catchment area. Hydrological modeling and its operations requires a larger set of temporal and spatial data. Indeed, the accessibility and accuracy of this data usually becomes a concern to cope with and this puts a more considerable effect on the precision of model. Due to lack of data accuracy, efficiency of the model is compromised for hydrological model simulation and its operations like calibration and validation. The current technical note describes the literature study on the event and continuous hydrological modeling with Hydrologic Engineering Centre's Hydrologic Modeling System (HEC-HMS). This literature review represents the development approach of hydrologic modeling by combining the finer-scale event and coarse-scale continuous hydrological modeling by using HEC-HMS.
Keywords: hydrological modeling, HEC-HMS, loss method, base flow

INTRODUCTION

Water is a rare commodity and an important factor for socio-economic development and food security particularly in arid and semi-arid regions. Water shortages and poor water management have appeared to be limitations to the economic development and overall growth of a particular region.

Flash floods are also very common phenomenon along with erosion and land slide which is triggered by heavy rainfall intensity and high runoff velocity. High volume of sediment delivered to river channels causes modification on the river flow path, silting up of reservoirs and eventual failure of hydraulic structures.

For sustainable enlargement and better management of water resources, a complete understanding of hydrologic response of a particular watershed should be known. This leads to a trustworthy representation of the rainfall-runoff relation at various spatial and temporal scales. Effective estimation of runoff values and groundwater recharges from a rainfall event helps in development of all water resources projects i.e. storage reservoirs of surface water, design of hydraulic structures and flood protection structures, hydropower and irrigation projects.

Hydrology deals with the conservation of earth's water and their association with the environment within each phase of hydrologic cycle. Now-a-days, hydrologic response of catchment systems are changing due to rapid increase in urbanization and industrial growth including deforestation, land cover and land use pattern changes. Along with climate change, soil heterogeneity has also put great emphasis on the flow of many rivers all around the world. Therefore to evaluate the impact of these changes, Hydrological models have been developed across the world to study the hydrologic behaviour of a catchment system. The input variables used by hydrological models are precipitation characteristics, relative humidity, wind speed, soil type and their properties, topography, watershed properties, hydrogeology and other parameters.

This paper represents the literature study on event and continuous hydrologic modeling with HEC-HMS software (Hydrologic Engineering Centre – Hydrologic Modeling System).

INTRODUCTION TO MODEL

A model is a simplified illustration of reality. In a simple way it is a process in which a set of input like physical, chemical and biological properties is

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 4
April 2017

converted to a set of output. The model which gives results approximately same as real one by using less number of parameters is called effective model. In hydrology studies, models are generally used for prediction or estimation of the system performance and combining various hydrological operations.

Hydrological modeling is a widely used technique to define the hydrological response of a watershed due to precipitation and other hydrological parameters. It permits to predict the changes in hydrologic response due to various improved watershed practices and to have a complete understanding of hydrological parameters which affect the watershed hydrological response. Based on the availability of monitoring data, hydrological models may be event or continuous process model.

(a) Event Process Models

These models are designed for the simulation of individual event and its emphasis on infiltration, evaporation and surface run-off. Event hydrological modeling of a basin represents finer-scale hydrologic process and defined the basin response to a selected precipitation event. Event hydrologic simulation calculates total runoff volume, runoff depth, peak discharges and time of peak discharges on the basis of event storm. The selection of a fine-scale step and the selection of storm events for developing the effective model are extremely important factors for event modeling (De Silva et al., 2014).

(b) Continuous Process Models

These models are used for long-term simulation. Continuous simulation synthesizes the hydrologic process and numbers of precipitation events and their cumulative effects by using effective soil properties to analyze soil moisture conditions over a long-lasting time period. Both dry and wet conditions of the watershed within that long-lasting time period are used in the continuous simulation process to develop hydrological models.

HISTORY OF HEC-HMS

The U.S. Army Corps of Engineers (USACE) developed Hydrologic Engineering Centre (HEC) software in 1964 to establish the technical expertise that subsequently known as hydrologic engineering. CEIWR-HEC was setup to present training courses and these courses later became to be known as HEC software programs. Many algorithms like HEC-1 (1998), HEC-1F (1989) and HEC-IFH (HEC, 1992) have been modified and merged with new algorithms to develop a comprehensive program for simulation purposes. Many research programs have been designed to develop new algorithms and analysis techniques for developing more effective system.

The first program release which performed event-simulation processes was HEC-1 program and called Version 1.0. It introduced many valuable improvements over the program which includes a vast number of hydrograph ordinates and gridded surface runoff representation. The estimation of parameters with optimization tools is very effective in this version as compared to former programs. The second release was called Version 2.0 which greatly emphasize on continuous-based simulation capabilities. In this version, Soil moisture accounting (SMA) method was added which improved the program from an event-based simulation program to continuous simulation program. The storage reservoir elements were improved to include physical varieties for a spillway, overflow and this version also facilitates with option of overtopping failure of hydraulic structure.

With advanced calculation features and improved graphics interface, the third major release was introduced which called Version 3.0. The new graphics interface was designed to increase user efficiency and make it easy to create and manage every type of data which needed for hydrological modeling simulation.

The fourth and last major program released was called Version 4.0 with advanced computation practices and amplified with many more methods for representing physical process, especially in the meteorological modeling. This advanced version also facilitates with surface erosion, sediment transport and water quality simulation capabilities and is also added with real-time forecasting processes. Enhancement of the system is still ongoing by USACE to facilitate advanced technology in the advanced hydrology.

LITERATURE REVIEW

A) M. M. G. T. De Silva et al

This study represented by M. M. G. T. De Silva et al describes the use of HEC-HMS software

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 4
April 2017

applications in flood control measure, disaster mitigation strategies and water management practices in the studied area by performing event and continuous modeling. This study is carried out in Kelani river basin of area 2,230 km^2. In this study an extremely heavy precipitation event of November 2005 is used for calibration purposes and precipitation events of April-May 2008, May-June 2008, and May 2010 are used for validation purposes. The calibrated parameters of event modeling were used in the continuous hydrological modeling.

Methodology used in this study is shown in the following tables as:

Serial no.	Calculation type	Method used
1	Loss parameters	Green and Ampt
2	Runoff Transform Parameters	Clark Unit Hydrograph
3	Base Flow Parameters	Recession Base flow

Table 1: Event Modeling Methodology

Serial no.	Calculation type	Method used
1	Loss parameters	Soil Moisture Accounting
2	Runoff Transform Parameters	Clark Unit Hydrograph
3	Base Flow Parameters	Recession Base flow

Table 2: Continuous Modeling Methodology

The result of this study shows HEC-HMS software produce stream runoff in the basin with a higher precision of average computed Nash-Sutcliffe efficiencies of 0.91 for event-based simulation and 0.88 for continuous simulations. The HEC-HMS is effectively useful to analyze the future extreme conditions by using the characteristic of modeling approach and a variety of data.

B) Xuefeng Chu et al

The study represented by Xuefeng Chu et al describes generation of hydrological model by combining event and continuous modeling with HEC-HMS software on Mona Lake Watershed in west Michigan. Four heavy rainstorm events are used for calibration and validation of event modeling. Then these calibrated event model parameters are used for continuous hydrological modeling.

Methodology used in Event and Continuous Hydrological Modeling is shown in the following tables as:

Serial no.	Calculation type	Method used
1	Loss parameters	SCS-CN
2	Runoff Transform Parameters	Clark Unit Hydrograph
3	Base Flow Parameters	Recession Base flow

Table 3: Event Modeling Methodology

Serial no.	Calculation type	Method used
1	Loss parameters	Soil Moisture Accounting
2	Runoff Transform Parameters	Clark Unit Hydrograph
3	Base Flow Parameters	Recession Base flow

Table 4: Continuous Modeling Methodology

This study ascertains that for small size sub-basin, a higher computation time scale restricts in exactly identifying the respond to a event and effectively calculating the hydrologic parameters because their responding time shorter than the hourly time step. Finally high-resolution storm event data enabled to define the model calibration process and identifying the parameters precisely on a finer scale which enhanced the continuous hydrological modeling over a bigger time scale. Therefore, this study recommends that a combination of fine-scale event and coarse-scale continuous modeling could be a precisely technique to facilitate not only to takes benefit of the characteristics of discrete modeling approaches but also enhanced the overall hydrologic modeling efficiency.

C) *Kishor Choudhari et al*

The study represented by Choudheri K. et al describes that HEC-HMS software is effectively used to create rainfall-runoff relation of the Bailjore Nala watershed. Randomly twenty four rainfall storm events selected for rainfall-runoff simulation. Out of these, twelve rainfall events are selected for model calibration and another twelve rainfall events are used for validation purposes.

The loss method and transform method used for this simulation is Soil Conservation Service-Curve Number (SCS- CN) and SCS Unit Hydrograph respectively. The curve number (CN) is an important empirical parameter which plays a significant role for estimating direct surface runoff and infiltration from a rainfall storm. A composite CN and concentration time is calculated as recommended by Panigrahi (2013) and used as input parameters in HEC-HMS for developing model. Channel routing method and base flow method used in the study is Muskingum routing method (K and X) and Exponential recession method respectively. Firstly Muskingum routing K parameter is calculated by the use of inflow and outflow hydrograph and after that X parameter projected by trial and error method.
The initial estimated parameters values are applied in the HEC-HMS and the simulated values like surface runoff volume and runoff depth, peak discharge and time of peak are compared with the observed values to calibrate the model. Initially there are more differences between simulated and observed values therefore optimization is carried out by using optimization tool available in HEC-HMS. After optimization, it is examined that optimized values are very close to the observed ones. After the completion of calibration process, its validation is done and after that it is recommended to use for that particular watershed. For the validation of model, calibrated parameters are used and the forecasted simulated values are compared with the observed values and find out the statistical error functions. Satisfactory performance of model in rainfall-runoff simulation is defined by these error functions. After examined the mathematical error functions it is concluded that the HEC-HMS model can be effectively use for rainfall-runoff simulation in the Baijore Nala Watershed.

D) *W. Boughton* et al

The study represented by W. Boughton et al describes that continuous simulation of stream flow is most growing process in the prediction of design flood. The terminology 'continuous simulation' while used in hydrology represents the evaluation of losses and stream flow from a rainfall storm by considering continuously wet and dry condition of a watershed of different time scale. Almost formerly flood estimation designs are the model of event simulation by considering storm rainfall statistics with assumption of initial losses from beginning of a storm and continuing losses during the storm period. Continuous rainfall-runoff simulation models generate long sequences of stream flow by the use of stochastic rainfall generation technology for a longer period and flood statistics can be extracted directly.
Continuous simulation system are practically use in many countries like Australia, UK, USA and some parts of Africa continents for the Design Flood Estimation. Government agencies of USA (USACE) generate a program of continuous simulation in HEC-HMS software known as Continuous Soil Moisture Accounting method (SMA). There are many aspects of continuous simulation that give significant improvisation over event-based simulation for the estimation of design flood. Continuous simulation programs generate the total flood runoff so that calibration carried out with devoid of any break of surface runoff and base flow.

E) *Todd H. Bennett et al*

The study represented by Todd H. Bennett et al describes the continuous modeling by the Soil Moisture Accounting method (SMA) in the HEC-HMS for the two hydrological dissimilar watersheds, one is W-1 Watershed, Riesel, Texas and anther is the Little River Watershed, near Tifton, Georgia. Soil moisture accounting (SMA) algorithm is used as a loss method in the HEC-HMS (2000) version which release was called version 2.0 and this technique executes a long-term continuous hydrological simulation that occur and transform by a long time data in a catchment area. SMA simulation accounts the canopy interception, surface storage, soil profile and two ground water layers and calculated the surface runoff, base flow, evapotranspiration losses and percolation losses.
In this study, the model is calibrated using four years data and after that additional seven years data used for validation purposes for the little River watershed. Cumulative observed volumes, peak flows and base flows compared relatively well with the simulated values. For the W-1 watershed, model is calibrated by using three years data and then four years data used for validation purposes. The comparisons of observed flow values and simulated flow values are generally

good and magnitude and timing of peaks also compared relatively well. After applying SMA algorithm to two dissimilar catchments, the ability to simulate rainfall-runoff and base flow continuously over a time period is very effective and very helpful to examine the hydrologic response of the catchments. Comparisons of simulated and observed flow values showed the accuracy of SMA Algorithm. Thus SMA loss method of HEC-HMS precisely used for rainfall-runoff continuous simulation of two dissimilar hydrologically watersheds.

CONCLUSION

This review study demonstrates the application and selection of event-based and continuous hydrological modeling according to the availability of data and other hydrological parameters of the watershed in HEC-HMS. Event-based hydrological modeling is effectively used in small watersheds which do not have long-term monitoring data and continuous data. The study put emphasis on combining the fine-scale event modeling and coarse-scale continuous hydrological modeling with HEC-HMS to develop a effective model. It is concluded that the parameters which are finely calibrated in event models are very helpful to enhance the continuous-based hydrological modeling. At present, continuous hydrological modeling is being used in large scale for getting better outputs and for developing effective models as compared to event-based hydrological modeling. Therefore, it is concluded that continuous hydrological simulation is a rapidly developing practice in hydrology to design flood estimation.

REFERENCES:

1. Bennett, T. H., & Peters, J. C. (2000). Continuous Soil Moisture Accounting in the Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS). In *Building Partnerships* (pp. 1-10).
2. Boughton, W., & Droop, O. (2003). Continuous simulation for design flood estimation—a review. *Environmental Modeling & Software*, *18*(4), 309-318.
3. Choudhari, K., Panigrahi, B., & Paul, J. C. (2014). Simulation of rainfall-runoff process using HEC-HMS model for Balijore Nala watershed, Odisha, India. *International Journal of Geomatics and Geosciences*, *5*(2), 253.
4. Chu, X., & Steinman, A. (2009). Event and continuous hydrologic modeling with HEC-HMS. *Journal of Irrigation and Drainage Engineering*, *135*(1), 119-124.
5. De Silva, M. M. G. T., Weerakoon, S. B., & Herath, S. (2013). Modeling of Event and Continuous Flow Hydrographs with HEC–HMS: Case Study in the Kelani River Basin, Sri Lanka. *Journal of Hydrologic Engineering*, *19*(4), 800-806.
6. Hydrologic Modeling system HEC-HMS, Technical References manual, March 2000, US Army Corps of Engineers Hydrologic Engineering Center.
7. Manual of US Army Corps of Engineers, http://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_385-1-1.pdf.

Panigrahi, B. (2013), A Handbook on Irrigation and Drainage, New Indian Publishing Agency, New Delhi, p. 600.