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جلد ۳۰، شماره ۳، مرداد – شهریور ۱۳۹۶، ص. ۷۷۱-۷۵۴

Effect of Weather Station Selection on Parameterization of Modified Bartlett-Lewis Rectangular Pulse (BLRPM) and HSPF Models

E. Dodangeh[1]- K. Shahedi[2*]- K. Solaimani[3]
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Introduction: The proper management of water resources in a watershed requires precise understanding and modelling of the hydrological processes. HSPF model uses an infiltration excess mechanism to simulate streamflow and requires the hourly precipitation data as input. Despite the high accuracy of the HSPF model, the lack of rainfall data at short time scales (hour and less than hour) restricts implementation of the model especially for long time simulations. Some studies have applied simple division for daily rainfall disaggregation into the hourly values to provide data required by the HSPF model. In simple division, each rainfall event is divided into 24 pulse stochastically and the peak flows may not be simulated correctly due to the lower rainfall intensities.

Materials and Methods: In this study, Random Parameter Bartlet-Lewis Rectangular Pluse (BLRPM) model was used for daily rainfall disaggregation into the hourly values to provide data needed by the HSPF model. The model parameters were calibrated using the 1, 24 and 48 hour rainfall data time series of the rain gauge stations inside (Jovestan and Zidasht) and outside (Kalk Chal) the watershed for the period of 2006-2009. To cluster the wet days, the BLRPM model was run several times and a generated sequence which had the best match with the original one in terms of daily totals was selected. Then, the synthetic sequence of hourly rainfall depths was modified based on a proportional adjusting procedure to add up exactly to the given daily depths. The calibrated model was then implemented to disaggregate the daily rainfall data of the watershed for the period of 1995-2005. The resultant hourly rainfall data were then fed into the HSPF hydrologic model to simulate the daily runoff. Parameterization of the BLRPM and HSPF models was also done while keeping the Kalk Chal station out of the calibration.

Results and Discussion: Sum of weighted squared error was calculated to be 1.03 when the data recorded in Kalk Chal station was also considered for parameter estimation of the BLRPM model. Maximum weighted square error was equal to 0.7 for lag-1 auto covariance of daily rainfall data. Keeping the Kalk Chal station out of the BLRPM model parameterization resulted in improved performance of the model. Sum of the weighted error decreased to 0.36 by removing the Kalk Chal station data. The results indicated that the weighted square error values decreased for all of the BLRPM model parameters when Kalk Chal station was not considered for calibration. The lag-1 auto covariance of daily rainfall data had the greatest reduction in weighted square error from 0.7 to 0.07 with and without including the Kalk Chal data set, respectively. The BLRPM model parameters also varied when data of the Kalk Chal station were removed from the calibration process. The k parameter value increased and the values of λ, ϕ and v decreased due to removal of the Kalk chal station data. The highest variation was observed for v decreased from 2.74 to 0.33 by removing the Kalk Chal station. The calibrated BLRPM model, with and without taking into account the Kalk Chal station data set, was employed to disaggregate daily rainfall data into the hourly values. The HSPF model was calibrated using the daily observed streamflow data recorded in Galinak station to simulate daily streamflow in reach 27. The daily streamflow simulations in reach 27 were conducted by implementing the hourly generated rainfall data sets. The results showed that inclusion of the hourly rainfall data recorded in Kalk chal station for parameterization of the BLRPM model caused the reproduction of high-intensity rainfall data in disaggregation process and consequently led to the overestimation of peak flows by HSPF model. Exclusion of the Kalk Chal station for BLRPM model parameterization improved the daily streamflow simulation with Nash-Sutcliff efficiency = 0.76, coefficient of determination = 0.79 and RMSE = 7.11 $m^3.s^{-1}$. These results demonstrated the sensitivity of HSPF model to the weather station selection and rainfall intensities.

Conclusions: The Kalk Chal station located outside of the studied region, with high intensity-short duration

1 , 2, 3- PhD Candidate, Associate Professor and Professor of Department of Watershed Science and Engineering, Faculty of Natural Resources, Sari Agricultural Science and Natural Resources University
(*-Corresponding Author Email: kaka.shahedi@gmail.com)

rainfall pattern caused heterogeneity of the input hourly rainfall data for parameter estimation of BLRPM model. Parameter estimation of the BLRPM model with inclusion of the hourly rainfall data of Kalk Chal station resulted in generation of greater intensities in disaggregation process. Despite the same values of daily rainfall data in streamflow simulations, the high rainfall intensities caused by the data set of Kalk Chal station led to the overestimation of peak flows. The results indicated the high sensitivity of HSPF model to the rainfall intensities.

Keywords: Infiltration, Hourly precipitation, Peak flow, Rainfall disaggregation