8-1-2014

Bayesian Parameter Estimation Of Modified Bartlett-Lewis Rectangular Pulse (MBLRP) Poisson Cluster Model

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BAYESIAN PARAMETER ESTIMATION OF MODIFIED BARTLETT-LEWIS RECTANGULAR PULSE (MBLRP) POISSON CLUSTER STOCHASTIC RAINFALL GENERATOR

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Stochastic rainfall generators or stochastic simulation have been widely employed to generate synthetic rainfall sequences which can be used in hydrologic models as inputs. The calibration of Poisson cluster stochastic rainfall generator (e.g. Modified Bartlett-Lewis Rectangular Pulse, MBLRP) is seriously affected by local minima that is usually estimated from the local optimization algorithm. In this regard, global optimization techniques such as particle swarm optimization and shuffled complex evolution algorithm have been proposed to better estimate the parameters. Although the global search algorithm is designed to avoid the local minima, reliable parameter estimation of MBLRP model is not always feasible especially in a limited parameter space. In addition, uncertainty associated with parameters in the MBLRP rainfall generator has not been properly addressed yet. In this sense, this study aims to develop and test a Hierarchical Bayesian Model (HBM) based parameter estimation method for the MBLRP rainfall generator that allow us to derive the posterior distribution of the model parameters. The proposed models are tested to ensure model performance throughout Jeonju-si weather station in South Korea. It was found that the HBM based MBLRP model showed better performance in terms of reproducing rainfall statistic and underlying distribution of hourly rainfall series.

Model Background & Results

Poisson cluster stochastic rainfall generators have been used to provide sub-daily rainfall scenarios to hydrologic models in a watershed which data is not available or relatively short. It is extremely important to ensure the simulated rainfall scenarios reasonably reflect underlying characteristics of the observed rainfall. There are several approaches to simulate sub-daily rainfall sequences and various studies along this line have been conducted in hydrologic community. Among these, the Bartlett Lewis Rectangular Pulse (BLRP) model based on the Poisson cluster rainfall models is the most proven approach [1, 2]. The BLRP model is designed to simulate rainfall as a sequence of storms composed of rain cell clusters [3, 4, 5].

To calibrate Poisson cluster stochastic rainfall generator, optimization techniques are generally involved with the local optimization algorithm by which the MBLRP model is seriously affected by the presence of multiple local minima, so that the calibration associated with the MBLRP models has been acknowledged as a difficult task [6, 7].

In this regard, the global search algorithm (e.g. particle swarm optimization and shuffled complex evolution) were adopted to avoid the local minima. But it is not always feasible to estimate reliable parameter estimation of MBLRP model in a limited parameter space. In addition, uncertainty associated with parameters in the MBLRP rainfall generator has not been properly addressed yet.

In this sense, a main objective of this study is to develop and test a Hierarchical Bayesian Model (HBM) based parameter estimation method for the MBLRP rainfall generator that allow us to derive the posterior distribution of the model parameters. Furthermore, this study investigates the choice of the object function in the calibration process within the Hierarchical Bayesian framework. The proposed models are tested to ensure model performance throughout Jeonju-si weather station in South Korea. A comparison of rainfall statistics between Bayesian MBLRP and SCE-UA in July in Jeonju-si is presented in Table 1. It was found that the HBM based MBLRP model showed better performance in terms of reproducing rainfall statistics and underlying distribution of hourly rainfall series. Especially, the HBM model is much better than SCE-UA method to reproduce variance that is generally related to reproduction of the extreme precipitation events.

Table 1. Comparison of rainfall statistics between observation, Bayesian model and SCE-UA algorithm over different aggregation time in July

Month	Statistics	Aggregation Time	Observation	Bayesian Simulation	SCE-UA Simulation
July	Mean	1hour	0.39	0.39	0.32
		3hour	1.18	1.16	0.96
		12hour	4.71	4.62	3.84
		24hour	9.42	9.24	7.68
	Variance	1hour	4.80	4.15	3.17
		3hour	25.54	22.67	16.52
		12hour	181.83	164.92	104.51
		24hour	432.85	426.85	250.23
	Autocorrelation	1hour	0.45	0.46	0.43
		3hour	0.38	0.37	0.28
		12hour	0.21	0.28	0.19
		24hour	0.19	0.26	0.17
	Zero Depth probability	1hour	0.87	0.91	0.92
		3hour	0.80	0.82	0.83
		12hour	0.64	0.63	0.62
		24hour	0.49	0.50	0.48

Acknowledgments

This research was supported by a grant(11CTIPC02) from Construction Technology Innovation Program (CTIP) funded by Ministry of Land, Transport and Maritime Affairs of Korean government.

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