Global Journal of Science Frontier Research: H
Environment & Earth Science
Volume 16 Issue 4 Version 1.0 Year 2016
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Regional Estimation of Flood Quantile at Ungauged Sites

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GJSFR-H Classification: *FOR Code: 300105*

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I. Introduction

Flood quantile estimation is an vital concern in hydrology, especially in ungauged catchments. According to Sivapalan et al. (2003), ungauged catchments are catchments that had insufficient data histories (in terms of both data quantity and quality) [1]. The majority of rivers and stream reaches and tributaries in the Peninsular Malaysia are ungauged or poorly gauged [2]. Trustworthy estimation of flood quantile is a vital aspect in watershed development, as it is influential in gaining a deeper sense of flow variability in ungauged basins. Regionalization refers to the method of relocating the information (hydrological information) from one catchment (location) to another. Agreeing to this explanation, the ungauged catchments should be located in a region homogeneous with the gauged basins. The hypothesis behind the homogeneous is that identical geology, climate, topography and soils in the homogeneous area would generally yield identical responses, but not essentially in geographically neighboring catchments [3]. Regionalization technique is to decide and clarify hydrological variables of interests. In flood quantile regionalization, the recorded stream flow data of neighboring or similar gauged catchments will be used to create hydrological model parameters or relationships with catchment characteristics. Then relationship between stream flow and catchment characteristics are then develop to obtain hydrological models. This relationship is known as regionalization method. For the latter, model performance are evaluated using simulated ungauged catchments, before the model can be used in real ungauged catchments. After a relationship between catchment characteristics and hydrological variables is generally acceptable, it is important to authenticate the model before it can be applied in ungauged basins. The leave-one-out cross-validation procedure is generally used to measure the validity of the model proposed [4].

II. Data and Methodology

a) Data

The data were acquired from Department of Irrigation and Drainage, Ministry of Natural Resources and Environment, Malaysia. There are 70 station chosen whereas all the stations are located in Peninsular Malaysia. They are located within latitude 1° N-5° N and longitudes of 100° N-104° N.

b) Regionalization for Linear Regression

The variation in streamflow characteristics such as flood quantiles are very related to the variations of physiographic and climatic factors. Using this fact emperical equations develop to relate streamflow chrateristics with the meteorogical and physiographic variables. There are many models whereby the relationship between catchment streamflow and catcthment charateristics can be expressed. However, in practice the most commonly used relationship between the flood quantiles (Q_T) and catchment characteristics is the power form function. The power function has the following form:

$$Q_T = \alpha_0 A_1^{\alpha_1} A_1^{\alpha_2} \cdots A_2^{\alpha_n} \varepsilon_0 \quad (1)$$

where $\alpha_1, \alpha_2, \ldots, \alpha_n$ are the model parameters, $A_1, A_2, ..., A_n$ are the site characteristics, ε_o is the multiplicative error term, n is the number of sites characteristics and Q_T is the flood quantile of T-year return period. The power form model can be linearized by a logarithimic transformation whereas the parameters of the linearized model can be estimated by a linear regression model. In other word, taking logs on both sides,

$$\log(Q_t) = \log(\alpha_0) + \alpha_1 \log(A_1) \ldots + \alpha_n \log(A_n) + \log(\varepsilon_0)$$

or

$$Y = X\beta + e \quad (2)$$

where

$Y = \log(Q_T)$ for $i = 1, 2, \ldots, m$: vector of flood qunatiles from m sites.

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$\beta = [\log(\alpha_0), \alpha_1, \ldots, \alpha_n]$: vector of coefficients;

$X = [(1, \quad \log A_i)]$: matrix of the logarithm of the physiographic and meteorological charateristics with the first column being equal to one.

$e = [\log(\varepsilon_0)]$: matrix of the logarithm of the error terms ε_0, which are assumed to be independent, identically distributed with 0 mean and constant variance.

m = total number sites

n = number of independent variables excluding the constant term

c) *Topological Kriging (TK)*

TK applies kriging methods over a geographical space and combines two groups of forcing for hydrological variability (Archfield et al., 2013). TK is then applied to build region on Peninsular Malaysia based on rainfall data.

III. Results

Table 1: Leave-One-Out validation result in term of prediction accuracy

	Hydrological Variables	LR	R-LR
NASH	q10	0.6831	0.7012
	q50	0.6722	0.6836
	q100	0.6324	0.6539
RMSE	q10	825.9714	796.5721
	q50	874.1341	858.6972
	q100	912.2361	895.9628

Tab. 1 show the comparison between linear regression without regionalization (LR) and linear regression with regionalization (R-LR). Both of model performance are measure using NASH and RMSE. R-LR is a procedure where the region of Peninsular Malaysia is divided according it hydrology similarities and then LR is applied between each region obtain form TK. From Tab. 1, the result indicated R-LR is perform better than LR. The used of regionalization is important because it will group the catchments with similar hydrology attributes and make the model easier to build a suitable relationship between input and output. Thus Regionalization Linear Regression is better than benchmark model linear regression.

IV. Conclusion

The used of Topological Kriging (TK) for flood quantile estimation at ungauged basin is presented in this study. Each of the region obtain from TK are then applied LR. Three various return period in this study were used to see the capability of the model to estimate for short term and long term. R-LR are then compare with LR witohot the implementation of TK. The result LR with implementation of TK produce more reliable estimation of flood quantile at ungauged basin.

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