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Determining the Adequacy of CFSR Data for Rainfall-Runoff Modeling Using SWAT

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Abstract

Stream discharge data are the essential information required to plan and design any watershed related project. In most of the cases, these data may not be available/ collected as there is no prior information regarding the commencement of a new project at the particular site. For a concerned watershed, number of stream gauge stations may be limited. But, due to the availability of large number of rain gauge stations, it is better to have rainfall – runoff model. However, land – based rain gauge stations do not always adequately represent the weather status of a watershed because they are point measurements, can be far from the characteristics of watershed of interest and can have gaps in their data series. Hence in the present study, the adequacy of CFSR (Climate Forecast System Reanalysis) data is determined to solve the problems of data deficiency in watersheds. Karuvannur watershed in Thrissur district is taken as the study area and is modeled using SWAT (Soil And Water Assessment Tool). Initially, the model was run for the available number of rain gauge stations. Then the model was executed by using CFSR data to find the accuracy of CFSR data in rainfall runoff modeling.

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Keywords: Climate Forecast System Reanalysis CFSR data, Rainfall-runoff (SWAT) model

1. Introduction

Among the various resources available, water is the most important and essential resource required for human beings as well as for animals and vegetation. India is a country which is blessed with a large number of rivers. But the problem is that some part of the country is frequently affected by flood whereas the other part by

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drought. This problem of water availability and deficiency is experienced within a year also. These problems become severe as the population and water demand increases.

As far as Kerala is concerned, the problem become complicated again because the number of stream gauge stations for estimating the stream discharge is very less. Thus one can conclude that most of the watersheds in Kerala are either ungauged or poorly gauged. Hence, it become essential to have the rainfall – runoff models, as rainfall data is easy to obtain due to the higher number of rain gauge stations than stream gauge stations. Another problem with the land – based rain gauge stations is that they are point measurements, which may poorly represent precipitation across a watershed. Watershed models offer tools to guide decision making on water resources, water quality, and related hazard issues. One of the major components of watershed model is rainfall-runoff model. Based on the mathematical description of the rainfall-runoff relation for the target basin, it computes the surface runoff corresponding to meteorological forcing data.

The ungauged watershed referred here is the watershed with insufficient number of rain gauge and stream gauge stations. For effective water management in all the watersheds, data deficiency is the most important problem [11]. One possibility is to use multiyear global gridded representations known as reanalysis datasets. Among the various reanalysis data available, the best data suited is from National Centers for Environmental Prediction's Climate Forecast System Reanalysis (CFSR) because it is an openly available reanalysis dataset which includes all the parameters required for the study, i.e. precipitation, temperature, solar radiation, humidity and wind speed. The spatial resolution of CFSR dataset which is in the order of 30 km and available from 1979 onwards [3, 4, 6]. Hence in the present study, the adequacy of CFSR data is to be determined for solving the problems of data deficiency in the watersheds when the number of rain gauge stations are limited.

1. Study Area and Data Collection

2.1. Study Area

The Karuvannur river basin lies between 10° 15' to 10° 40' North latitude and 76° 00' to 76° 35' East longitude within Thrissur and Western Boundary of Palakkad districts of Kerala. Karuvannur River has a drainage area of 1054 km^2, stream length 48 km, average monsoon flow of 1275 Mm^3, and total flow 1330 Mm^3. The average rainfall in the low land of the river basin was estimated to be 2858 mm, the midland 3011mm and the highland 2851 mm. About 60 per cent of the rainfall is received during south west monsoon period, 30 per cent from north east monsoon and 10 per cent in the premonsoon period. Manali is one of the important subwatershed systems in the river basin. This is one of the important forest areas of the river basin as well as the district.

2.2. Data Collection

The two essential components needed to set up SWAT models are:

- Any GIS software to support the storage and display of the relevant maps, to perform the terrain analysis, and to identify the stream reaches and associated subbasins
- A component that can generate all the files needed by SWAT, partly from the input maps and analyses, and partly by manual editing

Hence an open source Arc GIS (version 9.3) interface of SWAT, called ArcSWAT (Version 2012) is selected. The data required for SWAT can be broadly classified into two categories:

- Spatial data
- Temporal data

The required spatial data inputs include Digital Elevation Model (DEM), landuse map and soil map, while the temporal data include air temperature (both minimum and maximum), precipitation, relative humidity, wind speed and solar radiation [9,6].