بسم الله الرحمن الرحيم

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تم رفع هذه الرسالة بواسطة / حسام الدين محمد مغربي

بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى مسئولية عن محتوى هذه الرسالة.

ملاحظات:
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HYDROLOGIC CALIBRATION OF TRMM-BASED MULTI SATELLITE PRECIPITATION OVER ARID REGIONS

By

Khaled Asaad Ahmed Ahmed

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
In
IRRIGATION AND HYDRAULICS ENGINEERING

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Key Words:

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Summary:

Rainfall depth and distribution is a mandatory input in many fields such as real-life forecasts, hydrological studies, and many engineering applications. Tropical Rainfall Measuring Mission (TRMM) delivered a unique 17-year dataset of global tropical rainfall from 1998 AD to 2014 AD, with 3.0 hours interval. Comparing, assessment, and calibrating TRMM based on the ground stations is very valuable to investigate the use of rainfall estimates from TRMM and moreover, to calculate daily and sub-daily depths and ratios to fill the gaps of sparse rainfall recording gauge networks. Kingdom of Saudi Arabia (KSA) has been selected as the study area representing the arid region. Six statistical performance criteria were carried out to evaluate TRMM on daily basis with respect to corresponding ground stations. Hydrologically, the propose of this work is to know the extent of the possibility of relying on TRMM in generating extreme rainfall values at high return periods specially in ungauged areas.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Khaled Asaad Ahmed Ahmed Date: / / 2021

Signature:

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Table of Contents

List of Tables

List of Figures

Abstract

Tropical Rainfall Measuring Mission (TRMM) delivered a unique 17-year dataset of global tropical rainfall from 1998 AD to 2015 AD, with 3.0 hours interval. Comparing, assessment, and calibrating TRMM based on the ground stations is very valuable to investigate the use of rainfall estimates from TRMM and moreover, to calculate daily and sub-daily depths and ratios to fill the gaps of sparse rainfall recording gauge networks. Arid regions studies were based on monthly and annually precipitation summation. Daily comparison, and extreme events studies are very limited. Most of previous studies were made based on a poor number of ground stations. Kingdom of Saudi Arabia (KSA) has been selected as the study area. The Ministry of Environment Water and Agriculture (MEWA) provides more than 1450 ground rainfall stations. Coordinates of 883 ground stations were determined. The rainfall measurements were made available for of 385 daily rainfall stations for the same TRMM's period, and 152 sub daily ground stations records earlier than TRMM. The dataset thus consists of 6.9 million readings (after eliminating stations with less than three years of record) with their corresponding 14 million readings from TRMM (3 hours interval). Considering this large amount of data that was not available for previous studies for statistical or hydrological assessment of TRMM, the outcomes of such assessment were presented in the form of spatial maps for the whole of KSA. Six statistical performance criteria were carried out to evaluate TRMM on daily basis with respect to corresponding ground stations. These measures are Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), Relative Bias (RB), Correlation Coefficient (CC), Probability of Detection (POD), and Critical Success Index (CSI). Statistical results show very good results as the average of statistical measures are as follow MAE is 3.19, RMSE is 7.19, RB is 0.004, CC% is 8.08%, POD% is 68.55%, and CSI% is 18.04%. This is due to the arid region nature of limited number of rainy days.

Hydrologically, the propose of this work is to know the extent of the possibility of relying on TRMM in generating extreme rainfall values at high return periods specially in ungauged areas. To achieve the purpose, the following methodology was applied. Rainfall ground data were collected from available rainfall gauges for daily and sub-daily records in the study area. TRMM data were also collected for the same ground station's locations. Frequency analyses were undertaken on the rainfall data from ground stations and TRMM sources, using several distributions and the best fitting is selected. Rainfall depths, and rainfall ratios of 3-hr to 24-hr depths at different return periods were derived for ground stations and TRMM, then compared and spatially presented. 24-hr rainfall depths as well as (3-hr to 24-hr) rainfall depths ratio for rainfall depths were compared for TRMM and ground stations. Comparisons were spatially presented for different return periods. Moreover, regression equations were developed to calibrate the TRMM based on the ground stations and predictions were extended to cover the entire study area for locations where ground station data are not available. The results shows that the 24-hr ratios average for (2,5,10,25 years freq. storm) is 1.2 (TRMM/Ground), the average of (3-hr to 24-hr) ratio is 0.75 for ground stations and 0.76 for TRMM, keeping in mind that, the SCS type II ratios were not valid for use in some studied arid regions (e.g. Jeddah –Makkah, KSA) as the SCS type II (3-hr to 24-hr) ratio is 0.6.

Chapter 1: Introduction

1.1 General

Rainfall depths estimate is essential for many applications especially in complex terrain or remote areas. In such areas where rainfall stations are not available or are scattered, satellite precipitation records can be considered helpful as they can give a full spectrum of rain depths instead of one point as the ground stations. In arid regions the rainfall guesstimates have their unique behavior.

Most of Arabian countries are in arid and semi-arid regions. Therefore, rainfall studies are very important. Arid regions are defined as areas where rainfall is insufficient for crop production, while semi-arid regions are defined as areas where rainfall is enough for short production season crop. Figure 1-1 shows arid and semi-arid regions worldwide.

Rainfall depths estimate is considered as the major component of the hydrological and global energy cycle, as well as primary inputs for hydrological, meteorological and climate models. Such models require reliable and accurate precipitation data for successful simulations. Rainfall depths are essential in predicting natural hazards such as floods and droughts. Rainfall intensities, duration and spatial pattern are needed for various applications and simulations.

1.2 Problem Statement

To determine accurate rainfall depths, a ground rainfall station network with very dense coverage is needed, but unfortunately, this is not available everywhere. Moreover, the measured rainfall is a point depth; however, it should be applied on an area and transformation from a point estimate to an aerial one is not reliable or accurate. In the absence of dense coverage of rainfall stations, new approaches to get spatial distribution are needed. One of the major advantages in this line is the use of precipitation estimation from remote sensed information using a satellite such as the TRMM (Tropical Rainfall Measuring Mission). TRMM is a NASA (National Aeronautics and Space Administration) and JAXA (Japan Aerospace Exploration Agency) joint mission.