Journal of Hydrology xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

# Evaluation of TRMM satellite-based precipitation indexes for flood forecasting over Riyadh City, Saudi Arabia

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ARTICLE INFO

*Article history:*
Available online xxxx

*Keywords:*
Flash floods
TRMM
3B42RT
Flood forecasting
Saudi Arabia

SUMMARY

Floods are among the most common disasters harming humanity. In particular, flash floods cause hazards to life, property and any type of structures. Arid and semi-arid regions are equally prone to flash floods like regions with abundant rainfall. Despite rareness of intensive and frequent rainfall events over Kingdom of Saudi Arabia (KSA); an arid/semi-arid region, occasional flash floods occur and result in large amounts of damaging surface runoff. The flooding of 16 November, 2013 in Riyadh; the capital city of KSA, resulted in killing some people and led to much property damage. The Tropical Rainfall Measuring Mission (TRMM) Multi-satellite Precipitation Analysis (TMPA) Real Time (RT) data (3B42RT) are used herein for flash flood forecasting. 3B42RT detected high-intensity rainfall events matching with the distribution of observed floods over KSA. A flood early warning system based on exceedance of threshold limits on 3B42RT data is proposed for Riyadh. Three different indexes: Constant Threshold (CT), Cumulative Distribution Functions (CDF) and Riyadh Flood Precipitation Index (RFPI) are developed using 14-year 3B42RT data from 2000 to 2013. RFPI and CDF with 90% captured the three major flooding events that occurred in February 2005, May 2010 and November 2013 in Riyadh. CT with 3 mm/h intensity indicated the 2013 flooding, but missed those of 2005 and 2010. The methodology implemented herein is a first-step simple and accurate way for flash flood forecasting over Riyadh. The simplicity of the methodology enables its applicability for the TRMM follow-on missions like Global Precipitation Measurement (GPM) mission.



## 1. Introduction

Among various natural disasters, floods have been the most common one (World Disasters Report, 2003). Moreover, flash floods are among the mostly faced and the most deadly (Hapuarachchi et al., 2011; Jonkman and Kelman, 2005) despite their limited affected area (Borga et al., 2014) and being one of the most challenging topics for the research community (Alfieri et al., 2011). Hapuarachchi et al. (2011) tied the driving mechanisms of flash floods either to excessive rainfall or to dam failure; they mentioned the rareness of dam failures and focused on excessive rainfall.

Regions with plentiful rainfall, as well as arid and semi-arid regions, are equally vulnerable to flash floods. Actually, the strongest convective storms are detected in semi-arid regions (Zipser et al., 2006). Recent flood events that occurred in Riyadh, Jeddah and Abha Regions among others in Kingdom of Saudi Arabia (KSA) reflect flash flood risks in arid/semi-arid regions (Fig. 1).

The high fatalities and damages of flash floods arise from the fact that they occur rapidly without enabling time to take mitigation effects. Severity of the damage increases in developing countries where generally warning systems are missing and infrastructures are inadequate (Pombo and de Oliveira, 2015). Developing flood warning systems have been reported in literature as the most effective way to reduce loss of life and property damage (Negri et al., 2005). The advances and criteria in flash flood occurrence methods were reviewed and summarized in Hapuarachchi et al. (2011) and Alfieri and Thielen (2012) in three main categories: Flood Susceptibility Assessment (FSA), Rainfall Comparison (RC) and Flow Comparison (FC). They mentioned that RC indicates a good tradeoff between simplicity and good estimates by requiring just Quantitative Precipitation Estimates (QPE).

As mentioned in Negri et al. (2005), during the flooding events rainfall measurements from ground-based gauging stations can be problematic, since they can be damaged or data transmission may not be possible. These can be minimized by optimal sensor

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http://dx.doi.org/10.1016/j.jhydrol.2016.01.014
0022-1694/