Evaluation of Satellite-based Rainfall Estimates for the Upper Blue Nile Basin

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Abstract Water resources planning and management are generally based on precipitation data. In the Nile Basin, conventional rain gauges are normally sparse, and hence, satellite-based rainfall estimates have become vital for hydrometeorological studies in the basin. However, estimates from satellite rainfall products are prone to bias and need to be validated in this region. In this study, four widely used high-resolution products (TRMM-3B42-RT, PERSIANN-CCS, GSMAP, and CHIRPS-V2) were evaluated against monthly ground observations from 44 stations over the Upper Blue Nile Basin during the period (2003-2013). The evaluation process is based on several standard statistical criteria to assess the ability of both satellite products and bias correction methods to capture the rainfall characteristics of this area. The results show that rainfall estimates from CHIRPS have a more reliable agreement with ground measurements than other products, especially in the wet season. The findings demonstrate the importance of assessing and correcting the outputs of different satellite rainfall products to be used for various hydrological applications in the Nile Basin.

Keywords: Satellite precipitation products, CHIRPS, GSMAP, PERSIANN, TRMM, Upper Blue Nile Basin.

1. Introduction

Precipitation information is crucial in water resources management, especially flood and drought mitigation. Ground stations networks are considered reliable sources of precipitation data if the stations are well distributed in the study area, which is not always the case in many regions especially in developing countries and mountainous areas. For such regions, satellite products can provide important sources of precipitation measurement for use in various hydrological models (Yang et al. 2016). Recently, numerous satellite products have been developed to provide accurate estimates of precipitation.

Many studies evaluated the accuracy of satellite products in different regions. In the United States of America, the performances of CMORPH, PERSIANN, and TRMM 3B42 V6 were evaluated by Tian et al. (2007) and Nesbitt et al. (2008), who concluded that TRMM 3B42 V6 was the best. Liu et al. (2015) evaluated three satellite precipitation products (TRMM 3B42, CMORPH, and PERSIANN) over a subtropical watershed in China. They indicated that TRMM 3B42 was the best product at monthly and annual scales, while CMORPH was the best at the daily scale. In Iran, Boroujerdy et al. (2013) evaluated the performances of four satellite rainfall estimates (CMORPH, PERSIANN, adjusted PERSIANN, and TRMM-3B42 V6) and concluded that both the adjusted PERSIANN and TRMM 3B42 V6 performed better than the other two products. In Africa, some recent studies have been conducted to evaluate the performance of different satellite products. For example, Tote et al. (2015) evaluated the performances of three products: TARCAT v2, FEWS NET, RFE v2, and CHIRPS for the period (2001–2012) in Mozambique, Southeast Africa. They indicated that all satellite products overestimated low rainfall and underestimated high rainfall values, and both RFE v2 and CHIRPS performed the best. Dinku et al. (2011) evaluated the performances of TRMM and PERSIANN over the Upper Blue Nile (UBN) and indicated that both products performed better during wet seasons than dry seasons.

The main objective of this study is to assess the performances of four commonly used satellite precipitation data (TRMM 3B42 RT, PERSIANN CCS, GSMAP, and CHIRPS V2) regarding 44 stations over the Upper Blue Nile Basin, for the period (2003-2013).

2. Methodology

2.1. Data

Two types of precipitation data were used: point gauged and gridded satellite. The point gauged data consists of monthly precipitation data at 44 stations for the period (2003-2013), obtained from the Environment and Climate Research Institute, National Water Research Centre, Egypt. The monthly satellite precipitation data were obtained from four products (TRMM 3B42 RT, PERSIANN CCS, GSMAP, and CHIRPS V2).

2.2. Evaluation

The performance of satellite data was evaluated against gauged data using statistical and categorical indices. Statistical indices are used to measure the performance of satellite products in estimating the amount of precipitation only, but the categorical indices evaluate the performance of the satellite data regarding its compatibility with the observed data. The statistical indices include frequency-based indices (mean, STD, the 90th percentile) and time-series-based indices (root mean square error RMSE, correlation coefficient CC, relative bias RB, and mean error ME). Four categorical indices (probability of detection POD, false alarm ratio FAR, critical success index CSI, and BIAS) were used.

3. Results

The aim of the study is to choose the best satellite product that can represent the observed rainfall data in the Blue Nile Basin. The satellite data was compared with the observed data using several evaluation indices. CHIRPS V2 is the best product according to most indices, while GSMAP is the worst (Figure 1). Both TRMM 3B42 RT and PERSIANN CCS performed reasonably well in the case study. While CHIRS is the best product for heavy precipitation, PERSIANN is the best for medium precipitation. All products perform poorly in the dry season.

4. Conclusions

This paper evaluates the performance of four commonly used satellite precipitation data (TRMM 3B42 RT, PERSIANN CCS, GSMAP, and CHIRPS V2) to select the best product that can represent the observed rainfall data in the Blue Nile Basin. The performance of the satellite products was evaluated against gauged data using statistical and categorical indices. The results concluded that CHIRPS V2 is the best product for most cases, especially for heavy precipitation. TRMM 3B42 RT and PERSIANN CCS performed reasonably well in cases of medium and heavy precipitation. In contrast, GSMAP is the worst product in most cases.

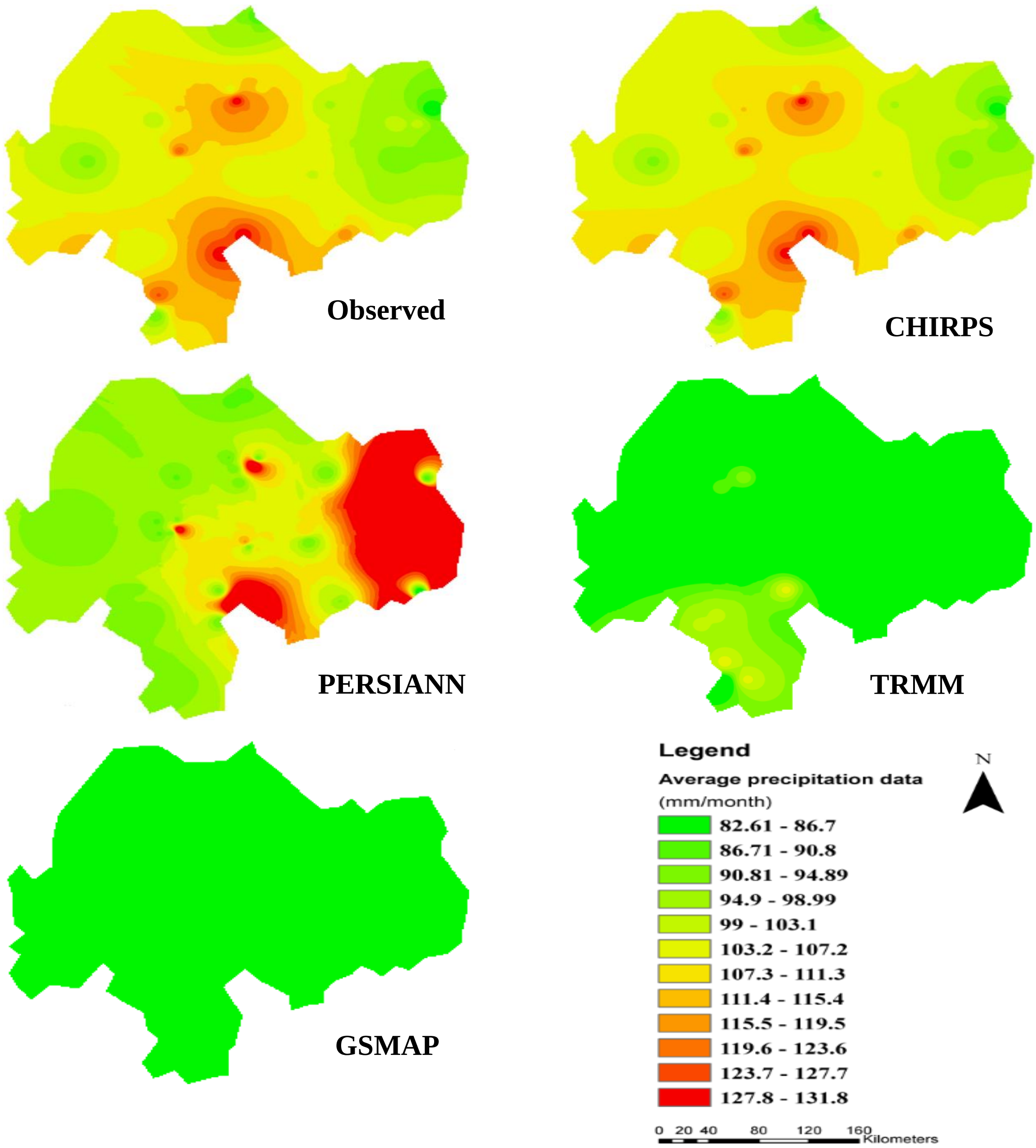

Figure 1. Spatial distribution of average precipitation for observed and satellite precipitation data.

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