Error Analysis of Global Satellite Precipitation Products Using Daily Gauged Observations over the Upper Central Blue Nile Basin

By

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Abstract

The main purpose of this research is to examine the error characteristics of satellite based precipitation estimation with the view to improve the reliability of wet season (June to September) rainfall dataset over the Blue Nile Basin (Ethiopia). The study utilized the historical rainfall datasets and six satellite derived precipitation datasets (3B42_V7, 3B42_RT, gauge adjusted and un-adjusted products of CMORPH, and PERSIANN over the period of 2000 to 2013. The error analysis utilized statistical techniques of missed rainfall volume fraction (MRV), falsely detected rainfall volume fraction (FRV), mean relative error (MRE), bias ratio (Bias), coefficient of variation of error (CVE) and the trends of the error metrics with respect to elevation. The three error metrics, MRE, Bias and CVE are further examined for five rainfall thresholds associated with different percentile categories (2^{nd}, 20^{th}, 50^{th}, 80^{th} and 98^{th}). Results show that CMORPH has relatively lower MRV (~1.5 %) than the TRMM and PERSIANN products (10 -13 %.). Non-gauge adjusted PERSIANN gave slightly higher percentage of FRV (13%) than the other satellite rainfall products (10 to 11 %). Non-gauge adjusted PERSIANN gave slightly higher percentage of FRV (13%) than the other satellite rainfall products (10 to 11 %). Among the six satellite rainfall products only adjusted PERSIANN overestimated gauge precipitation whereas, adjusted CMORPH exhibited relatively better bias estimation. Among the six satellite rainfall products the adjusted CMORPH has relatively better potential to improve rainfall estimate over the region. However, for higher rainfall amounts, particularly above the 50^{th} percentile threshold non-adjusted PERSIANN performed better than the others.

Introduction

Water resource assessment, planning and management in Africa are often constrained due to lack of reliable spatio-temporal rainfall data. Satellite and global reanalysis products are steadily growing and offering useful alternative datasets of rainfall globally. The study area of this research is focuses on the upper central Blue Nile Basin in Ethiopia which is located in the mountain chain of the Great Horn of Africa between 10°N to 12.5°N and 36°E to 38.25°E. The study domain contains three sub-basins from the upper Blue Nile Basin of complex terrain of about 46,200 km^2 catchment area. The aim of this research is to examine the error characteristics of the main available global satellite precipitation products (3B42_V7, 3B42_RT, gauge adjusted and un-adjusted products of CMORPH and PERSIANN over the period of 2000 to 2013) with the view to improve the reliability of wet season (June to September) rainfall datasets over the upper Blue Nile Basin in Ethiopia.

Methods

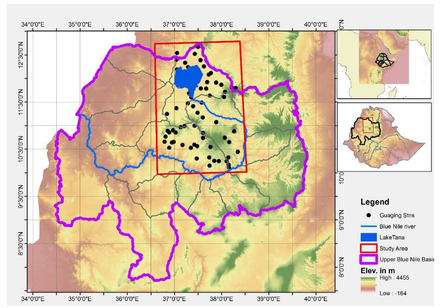

Fig1: *Topography of the upper central Blue Nile and the spatial distribution of historical rainfall gauging stations.*

The error analysis utilized statistical techniques of missed rainfall volume fraction (MRV), falsely detected rainfall volume fraction (FRV), mean relative error (MRE), bias ratio (Bias), coefficient of variation of error (CVE) and the trends of the error metrics with respect to elevation. The three error metrics, MRE, Bias and CVE are further examined for five rainfall thresholds associated with different percentile categories (2^{nd}, 20^{th}, 50^{th}, 80^{th} and 98^{th}).

Results

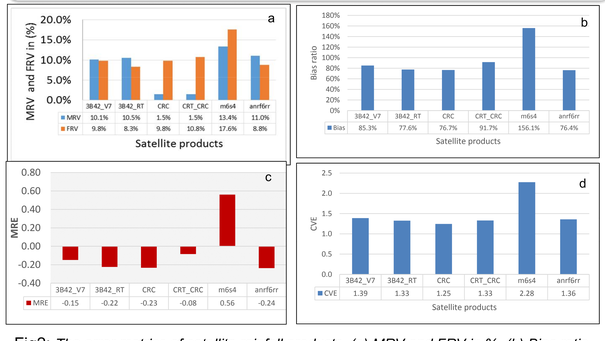

Fig2: *The error metrics of satellite rainfall products (a) MRV and FRV in %, (b) Bias ratio in %, (c) Mean relative error(MRE), (d) Coefficient of variation error(CVE)*

- Results show that CMORPH has relatively lower MRV (~1.5 %) than the TRMM and PERSIANN products (10-13%). Non-gauge adjusted PERSIANN gave slightly higher percentage of FRV (13%) than the other satellite rainfall products (10 to 11 %).
- Among the six satellite rainfall products only adjusted PERSIANN overestimated gauge precipitation whereas, adjusted CMORPH exhibited relatively better estimation bias (0.92) followed by 3B42_V7 (0.85), 3B42_RT (0.78), non-adjusted CMORPH (0.77) and adjusted-PERSIANN (0.76).

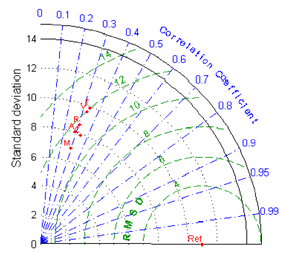

Fig3: Taylor diagram for the six satellite products, V = 3B42V7, R = 3B42RT, C=non-adj.CMORPH, T= adj.CMORPH, M = non-adj. PERSIANN, A = adj.PERSIANN

- The Taylordiagram ((Karl.E Taylor,2001) shows statistical patterns of correlation (~0.3), standard deviation (6 to 8 mm) and RMS difference (11 to 14 mm).
- The results from coefficient of variation of error statistics also showed higher spreads of error for adjusted PERSIANN (CVE=2.2). The other five products gave CVE between1.25 and 1.39 whereas, the non-adjusted CMORPH gave the lowest error spread (CVE=1.25). The spread of the errors is negative correlated to rainfall magnitude.

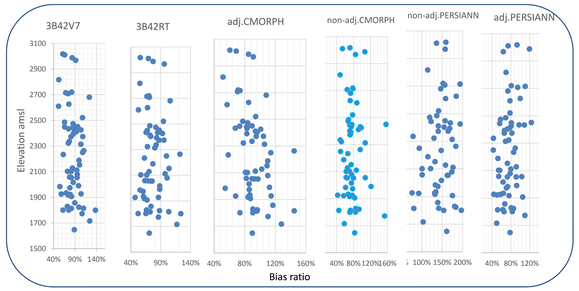

Fig4: scatter plot of elevation vs Bias ratio of the six satellite rainfall products

- The R^2 statistics for the association between elevation and error metrics showed that 3B42V7, 3B42RT and non-adjusted CMORPH (~0.0) and others have a value between 0.12 and 0.22 .
- MRE, Bias and CVE values are in a decreasing trend with an increase the rainfall thresholds associated with different percentile categories.

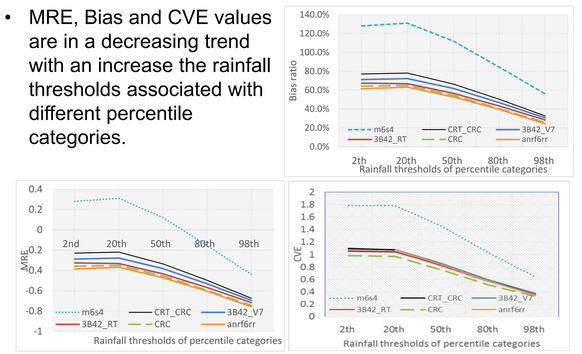

Fig 5: *The three error metrics, MRE, Bias and CVE for five rainfall thresholds associated with different percentile categories (2^{nd}, 20^{th}, 50^{th}, 80^{th} and 98^{th}).*

Conclution

- Among the six satellite rainfall products the adjusted CMORPH has relatively better potential to improve rainfall estimate over the region.
- For higher rainfall amounts, particularly above the 50^{th} percentile threshold non-adjusted PERSIANN performed better than the others.
- We have observed that there is no significant relationship between gauge rainfall elevation and the error metrics.

Ref

1. Karl.E Taylor (2001), Summarizing multiple aspects of model performance in a single diagram, Journal of Geophysical Research Vol.106.

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