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Error analysis of global satellite precipitation products using daily gauged observations over the upper central Blue Nile Basin

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Abstract

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. Aim of this paper is to examine the error characteristics of the main available global satellite precipitation products with the view to improve the reliability of wet season (June to September) rainfall datasets over the upper Blue Nile Basin in Ethiopia. The study utilized six satellite derived precipitation datasets at 0.25-deg spatial grid size and daily temporal resolution:1) the near real-time (3B42_RT) and gauge adjusted (3B42_V7) products of Tropical Rainfall Measuring Mission (TRMM) Multi-satellite Precipitation Analysis (TMPA), 2) gauge adjusted and unadjusted Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN) products and 3) the gauge adjusted and un-adjusted product of the National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center Morphing technique (CMORPH) over the period of 2000 to 2013. The historical daily rainfall data sets are chosen for the same period from 64 gauging stations which are within a mountainous area of about 45,000 km2. The elevation of gauges used in this error study ranged from 1800 to 3000 meters above sea level. 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 (2nd, 20th, 50th, 80th and 98th) . Results show that CMORPH has relatively lower MRV ($\sim$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). Bias showed increase underestimation with increase in rainfall threshold for all rainfall products. 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. Generally, no significant relationship is observed between gauge rainfall elevation and the error metrics. We have observed that 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 50th percentile threshold non-adjusted PERSIANN performed better than the others.