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How Does the Error in Satellite-Based Precipitation Estimates Vary with Precipitation, Topography, LULC and Climate?

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Satellite-based Precipitation Estimates (SPEs) are potential precipitation data resource with very high spatio-temporal resolution. However, being indirectly derived from cloud radiances observed by electromagnetic sensors, SPEs are often associated with error. Understanding the characteristics of error in SPEs is important for improving its accuracy and assessing its reliability in climatic and hydrological predictions. The cloud or thermal radiance observations used for retrieving SPEs depends upon the surface emissivity of the region, which in turn significantly varies with the topography, land-use land-cover (LULC) and climate of the region. Therefore, the error in the SPEs over a region is expected to depend upon the topography, LULC and climate of the region. The present study aims to explore and understand the dependence of error in SPEs with rainfall magnitude and the readily available geophysical features such as topography, LULC and climate. The real-time and gauge-corrected versions of Tropical Rainfall Measurement Mission (TRMM) Multi-Satellite Precipitation Analysis and Climate Prediction Center Morphing method (CMORPH) are selected for the analysis over the monsoon-dominated region of India for a duration of 16 years (2001-2016). The daily gauge-based gridded rainfall dataset released by the India Meteorological Department is used as the reference dataset. The error in the SPEs is initially disintegrated into three components - hit bias (H), missed precipitation (M) and false precipitation (F). These components are further evaluated as a function of rainfall magnitude, elevation, LULC and climatic features. Multiple linear regression is also performed to quantify the dependence of error on these features. The results of the study indicate that the rainfall is the most dominating feature affecting the errors, followed by climate, LULC and elevation. Highest magnitude of error is observed over heavy rainfall regions. Built-up LULC zones observe the highest hit bias, while forest regions observe the highest missed precipitation error. Snow regions observe the lowest magnitude of error components. Equatorial monsoon region shows the highest hit and missed precipitation error, while the warm and temperate equatorial regions show the maximum false precipitation alarms. The cold and hot arid regions observe the minimum hit and false error. TRMM precipitation estimates show the least error when compared to CMORPH precipitation. The results of the present study highlight the dependence of error on prominent geophysical features and lead to a better understanding of the characteristics of error. The results of the present study will also provide insights to the data users and producers of satellite precipitation products for their application and further improvement.