Postprint: Applicability Assessment of GPM and TRMM Remote Sensing Precipitation Products over the Central Tibetan Plateau

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Date: 2018-11-08T00:00:00+00:00

Abstract

Using precipitation data from five ground observation stations in the Selin Co basin on the Tibetan Plateau from April 2014 to March 2015, the applicability of two remote sensing precipitation observation products—the Tropical Rainfall Measuring Mission (TRMM) precipitation product and the Global Precipitation Measurement (GPM) observation product—was evaluated under high-altitude, cold conditions. Through comparisons using correlation evaluation metrics, error statistical evaluation metrics, and categorical statistical evaluation metrics, the following findings were obtained: At both daily and annual scales, the GPM satellite precipitation product demonstrates higher accuracy compared to the TRMM satellite precipitation product; the TRMM product significantly overestimates precipitation amounts; Both products exhibit substantial deficiencies in detecting heavy precipitation events, while the GPM product shows significantly superior detection capability for light precipitation events compared to the TRMM product; As the statistical temporal scale increases, the accuracy of the GPM precipitation product exhibits a significant increasing trend.

Full Text

Applicability Evaluation of GPM and TRMM Remote Sensing Precipitation Products in the Central Tibetan Plateau

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Abstract: This paper evaluates the uncertainties of satellite precipitation products from the Global Precipitation Measurement (GPM) mission and the widely used Tropical Rainfall Measuring Mission (TRMM) product, based on data from five meteorological stations in the Siling Co Basin of the Tibetan Plateau during the period from April 2014 to March 2015. The accuracies of GPM and TRMM were assessed using the correlation evaluation index (Pearson Correlation Coefficient R), error statistical evaluation index (including root mean square error RMSE and percent bias PB), and classification statistical evaluation index (BIAS, POD, FAR, and HKS score). The results showed that: (1) The accuracy of GPM was higher than that of TRMM at both daily and annual timescales, and precipitation was significantly overestimated when using TRMM products; (2) Although GPM performed better than TRMM in detecting weak precipitation events, both products had significant flaws in detecting heavy precipitation events; (3) The accuracy of GPM was obviously increased with the increase of time scale.

Keywords: ground observation; remote sensing precipitation product; GPM; TRMM; applicability evaluation; Tibetan Plateau

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3.2 Evaluation Results and Analysis

As shown in Figure 3, the cumulative daily precipitation curves for GPM, TRMM, and ground-based observations at different meteorological stations demonstrate that both satellite products exhibit certain deviations from ground observations. Figure 2 presents scatter plots comparing precipitation from GPM and TRMM against meteorological station data, revealing distinct error characteristics between the two products.

Table 3 summarizes the percent bias (PB) and root mean square error (RMSE) values. The results indicate that GPM shows a lower PB and RMSE compared to TRMM, suggesting better overall accuracy. Specifically, for precipitation events in the 2–15 $mm \cdot d^{-1}$ range, GPM demonstrates superior performance with bias values closer to zero, while TRMM tends to overestimate precipitation in this category.

The classification statistical indices (Table 1) were calculated at various precipitation thresholds (0.5, 1, 2, 5, 10, and 20 $mm \cdot d^{-1}$) to evaluate detection capabilities. Figure 4 illustrates the variation of these indices with precipitation intensity. The Probability of Detection (POD) measures the ability to correctly identify precipitation events, while the False Alarm Ratio (FAR) indicates the proportion of false positives. The Hansen and Kuipers Score (HKS) provides a comprehensive assessment of detection skill, ranging from -1 to 1, with higher

values indicating better performance.

At lower precipitation thresholds (< 2 mm $\cdot$ d^{-1}), both GPM and TRMM show relatively high POD values, but GPM maintains a lower FAR, indicating fewer false alarms. However, at higher intensities (> 15 mm $\cdot$ d^{-1}), the performance of both products deteriorates significantly. The BIAS values reveal that TRMM consistently overestimates precipitation frequency across all thresholds, with BIAS > 1, whereas GPM shows better calibration with BIAS values closer to 1.

Figure 5 displays scatter plots of GPM precipitation against ground observations at different timescales (3-day, 5-day, 7-day, and 15-day accumulations). Table 4 presents the corresponding evaluation metrics, demonstrating that GPM' s accuracy improves substantially with increasing temporal aggregation. The correlation coefficient (R) increases from 0.38 at daily scale to 0.95 at 15-day scale, while RMSE decreases proportionally. This timescale dependency indicates that random errors in GPM data tend to cancel out over longer accumulation periods.

The HKS scores further confirm this trend: at the daily scale, GPM' s HKS score is slightly lower than TRMM' s for precipitation intensities above 10 mm $\cdot$ d^{-1}, but at multi-day scales, GPM outperforms TRMM across all intensity categories. For the 15-day accumulation period, GPM achieves an HKS score of 0.90 for precipitation thresholds above 10 mm $\cdot$ d^{-1}, compared to TRMM' s 0.83, representing a relative improvement of approximately 8.4%.

These findings suggest that while GPM represents a significant advancement over TRMM in capturing precipitation patterns over the Tibetan Plateau, users should exercise caution when applying these products for heavy precipitation event detection. The accuracy improvement at longer timescales indicates that GPM data are more reliable for hydrological applications requiring aggregated precipitation inputs, such as drought monitoring and water resource assessment.

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Note: Figure translations are in progress. See original paper for figures.