Comparisons of Daily Thailand Rain Gauge with GPCC and TRMM Satellite Precipitation Measurements

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Abstract—**Daily rainfall data collected by the Thailand Meteorological Service over Thailand for the period 1993-2002 have been used to examine the characteristics of rainfall at different time and space scales. The daily gauge data consists of more than a hundred rain gauges located in five main divisions in Thailand. The gauge data are binned at 1^0 by 1^0 grids and compared with the Global Precipitation Climatology Centre (GPCC) gauge analyses and the Tropical Rainfall Measuring Mission (TRMM) and other –GPI calibration (3B42) and the TRMM merged and satellite analysis (3B43). Preliminary comparison of the gridded monthly averages shows that the gauge data are very close to the GPCC estimates, with a bias of 1.4 mm/month. The bias between 3B43 and gauge is 4.0 mm/month and between 3B42 and gauge is 27.8 mm/month, respectively. The bias and RMSD for the daily data are –0.88 and 9.71 mm/day, respectively. While the gauges tends to be lower than 3B42 overall, there are substantial regional and seasonal differences.**

I. INTRODUCTION

Precipitation is one of the major components of the global hydrological cycle that maintains the terrestrial, atmospheric and oceanic water balance. Variations in precipitation may have serious effects on global water cycle, climate changes and societal activities.

In Thailand, rainfall variations have a major impact on the local agriculture and fresh water supply for human consumption. Excess rainfall causes severe flooding, property and lives loss. For example, in October 2003, the waters inundated the Southern Thai city of Phetchubari, causing the worst flooding the region has seen in the last thirty years. Three people died and 2460 homes were damaged (The Earth Observatory & Natural Hazards http://earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3),

A better understanding of the spatial and temporal rainfall distributions would be essential in estimating crop water uses, the water available for direct human consumption and water resource management, assessing efficient irrigation and understanding the ecosystem. Also, accurate monitoring and prediction of rainfall would help reduce property damages and lives loss that may occur from flooding.

The basic rain measuring instruments have been the rain gauges. However, Rain gauges provide only point measurements in limited areas. Remote sensing techniques, such as those using radar or satellites are great complements for monitoring rainfall over large areas.

NASA and the Japan Aerospace Exploration Agency (JAXA) collaborated in launching the Tropical Rainfall Measuring Mission (TRMM) satellite in November 1997 to study global rainfall. The major rain sensors for the rainfall measurement onboard TRMM are Precipitation Radar (PR), TRMM Microwave Imager (TMI) and Visible Infrared Scanner (VIRS). Kummerow et al. (2000) provided a good description of the TRMM project and instrument performance.

There are a number of efforts to compare and validate TRMM rainfall products with other rainfall measurements. In this study, we compare a high density rain gauge dataset over Thailand (only land part) with two TRMM Level 3 rainfall products: 3B42 which is a calibrated geosynchronous IR rain rate using TRMM estimates and 3B43 which merges satellite data from TRMM, geosynchronous IR, SSM/I, and rain gauges. Because of the high spatial and temporal resolution, 3B42 is the most used TRMM product for operational users. It is necessary to quantify the biases of the TRMM products relative to gauge measurements that have been used historically to calibrate hydrologic models. In addition, the comparison of Thailand rain gauges and the global precipitation climate centre (GPCC) analysis is also being presented.

II. DATA

A. Thailand Rain Gauge dataset

Ten years (1993-2002) of monthly and daily rainfall data collected from more than a hundred rain gauges over the country are obtained from the Thai Meteorological Department (TMD). The data are binned into 1x1 degree boxes. Thailand covers about 40 1x1 degree grid boxes. There are at least two gauges per grid box. The dataset is separated into five main geographic regions: north, central, northeast, east and south. Figure 1 shows the five regions and the gauge locations.

B. GPCC

The gauged based gridded precipitation product is obtained from the Global Precipitation Climatology Centre (GPCC), which is available via the internet (URL: http://gpcc.dwd.de). The GPCC dataset is a near real-time monthly analysis. The data product is combined with the Monitoring Product based on internationally exchanged meteorological data and monthly precipitation data delivered by national agencies or other institutes from 173 countries. The temporal coverage of gauges is roughly 30,000 gauges worldwide. The average gauge-density is about 2 gauges per 1x1 degree grid box. The data are combined with precipitation estimates based on various satellite estimates to produce the Global Precipitation Climatology Project (GPCP) satellite-gauge combined datasets (Rudolf et al., 1994). In this project, we explore only 10 years of data from 1993 to 2002.

C. TRMM 3B42

The TRMM and Other-GPI Calibration Rainfall Product algorithm (3B42) uses combined rain structure (2B31) and VIRS calibration (1B01) to adjust IR estimates from geosynchronous IR observations. Global estimates are made by adjusting the GOES Precipitation Index (GPI) to the TRMM estimates. The 3B42 algorithm provides the daily tropical precipitation estimates and also the root mean square (RMS) precipitation error estimates. The output is daily rainfall for 1x1 degree grid boxes within the tropical region from latitude 40N to 40S (Huffman et al., 2001).

D. TRMM 3B43

The TRMM and Other-GPI Calibration Rainfall Product algorithm (3B42) produce the gridded precipitation product by combining the four independent precipitation measurements that include the monthly average unclipped TRMM Microwave Imager (TMI) estimate (intermediate product from Algorithm 3B42), the monthly average Special Sensor Microwave/Imager (SSM/I) estimate (3A46), pentad-average adjusted merged-infrared (IR) estimate (3B42), and monthly accumulated Climate Assessment and Monitoring System (CAMS) or Global Precipitation Climatology Centre (GPCC) rain gauge analysis (3A45) (Huffman et al., 1995)

These TRMM data products can be obtained from the GSFC DAAC TRMM data search-and-order system, at http://lake.nascom.nasa.gov/data/dataset/.

III. DATA PROCESSING AND RESULTS

We extract data between latitude 4°N - 22°N and longitude 95°W - 108°E which covers the Thailand region from all data sets. The rain rate at each 1x1 degree grid box is computed by weighting the gauge values at each gauge by its inverse square distance from the grid center. Monthly 3B42 are computed by averaging all daily values of the month. The statistical analyses are based on the time series of daily and monthly area averages (over 40 grid boxes). .

Figure 2 shows the time series of the monthly-accumulated rainfall in millimeters of Thailand Rain Gauges data average over the 40 grid boxes with the GPCC data over the 10-year period (1993 to 2002). Figure 3 shows the TRMM 3B42, the TRMM 3B43 and Thailand Gauge data for the period 1998 to 2002. The bias and the root mean square difference (RMSD) between the monthly gauges data and other data sets are summarized in the table 1. Not surprisingly, the GPCC is close to Thailand gauge estimates. On the other hand, the TRMM 3B42 is much higher than gauges, especially during the raining season (June to September). Since 3B43 is a merged gauge and satellite product, the bias is in between GPCC and 3B42.

The scatter plots between monthly Thailand gauge and GPCC, 3B42 and 3B43 are displayed in Figure 4. Although there is a negative bias (gauge less than 3B42 and 3B43), there is a tendency of the monthly 3B42 to taper around 5-600 mm/month, and hence there is in fact a positive bias (3B42 > gauge) at rain rates higher than around 400 mm/month. The same is true for 3B43, but to a lesser extent.

Figure 5 shows the time series of the daily area average rainfall of gauge and TRMM 3B42. The bias is -0.88 mm/day and the RMSD is 9.7096 mm/day. It is interesting to note that the bias of the area average is smaller than the monthly for 3B42. We also calculate the daily bias for different seasons for all different regions, the results of which are shown in Table 2. TRMM 3B42 is higher than gauges except in the JJA season in the east region of Thailand, which is near the Gulf of Thailand.

Climatologically, Thailand has a dry season during December to April and a rain season starting from May to September. However, the start and end of the rain season is different for the different regions. The northern region (above 10N) rains predominantly during the JJA season and begins to dry afterward. In contrast, the south region shows the largest rainfall during the SON season.

The seasonal distributions of accumulated rainfall from rain gauges and TRMM 3B42 are shown in Figures 6 and 7, respectively. While the patterns of seasonal rainfall are similar, there are seasonal and regional differences. In the North and South region, the gauge estimates are higher than 3B42. 3B42 is much higher during JJA than the gauge, except for the East region. It is not clear the extent to which the discrepancy is due to the coastal stations in the east region.

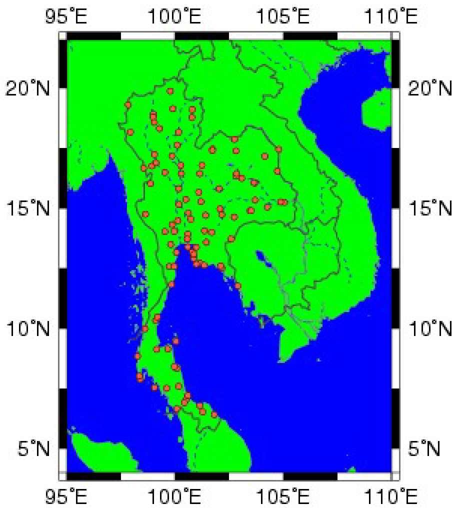

Figure 1: The Distribution of Thailand Rain Gauges

	Bias	RMSD
Gauges - GPCC	1.3939	67.2308
Gauges - 3B42	-27.8909	110.8546
Gauges - 3B43	-4.0240	81.4890

Table 1: Bias and Root Mean Square Difference (RMSD) in mm/month between data sets

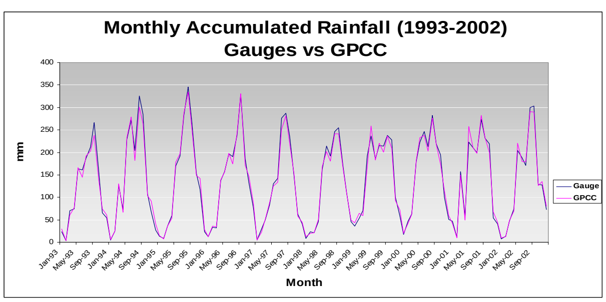

Figure 2: Gauges vs. GPCC

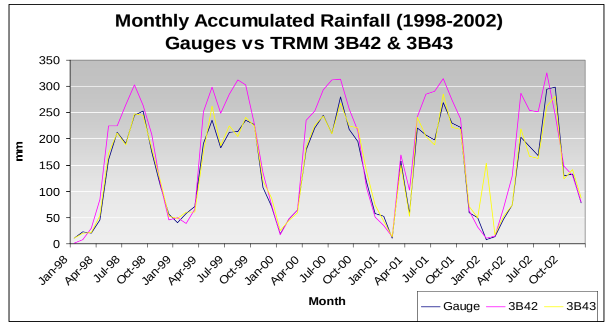

Figure 3: Gauges vs. TRMM 3B42

	Center	East	Northeast	North	South
Annual	-2.455	0.801	-1.293	-1.306	-0.367
DJF	-0.318	-0.063	-0.108	0.068	0.682
MAM	-2.451	-0.132	-1.623	-1.268	-0.232
JJA	-5.556	3.549	-2.427	-3.640	-1.789
SON	-1.437	-0.181	-0.985	-0.342	-0.102

Table 2: Seasonal biases of Gauge – 3B42 (mm/day)

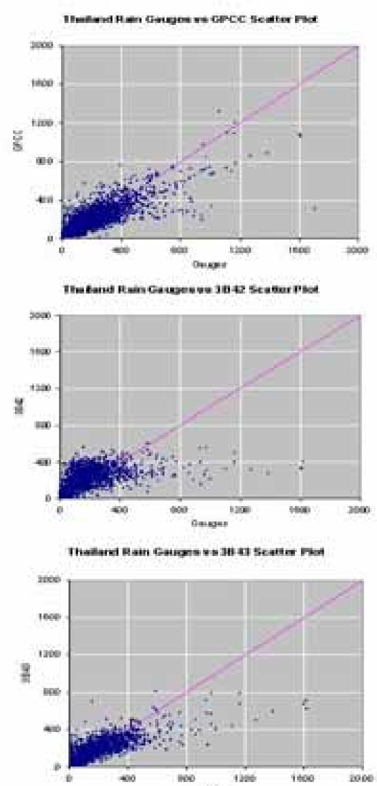

Figure 4: Scatter plots of monthly gauges vs.GPCC, 3B42 and 3B43.

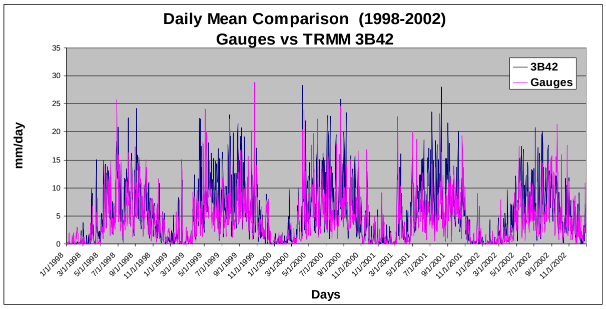

Figure 5: Times series of Daily Mean of Gauges and TRMM 3B42

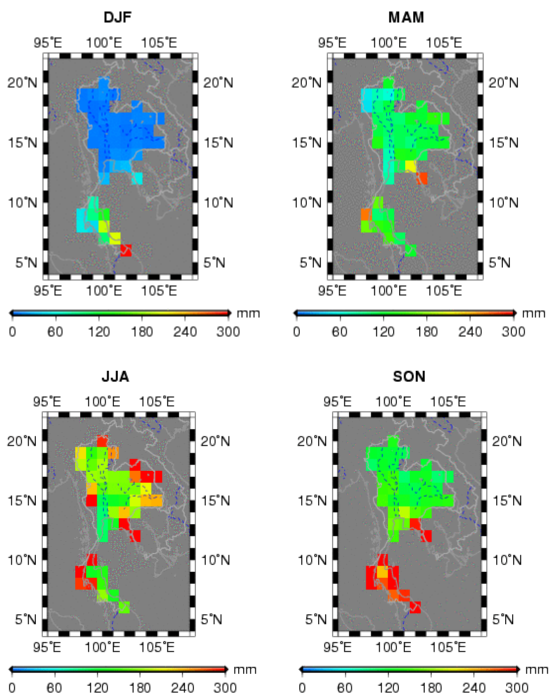

Figure 6: Seasonal distributions of Thailand Gauges Rain rate (1993-2002)

IV. DISCUSSIONS

From the statistical analysis, the GPCC and the TRMM 3B43 are close to gauges estimates. 3B42 is in general higher than the gauge estimates, except for DJF in the North and South regions and JJA in the East region. This is consistent with the results of Chiu and Shin (2004) who found a similar difference between 3B42 and 3B43.

Future work will include examination of the daily differences at the grid and regional scale for different seasons, and other statistics, such as detection probability, false and non-detection rates.

This daily data set will be useful for comparison or validation of the high temporal (daily or 3-hourly) and spatial (1 degree to 0.25 degree) resolution rain products proposed by TRMM and the following-on project, the Global Precipitation Mission (GPM).

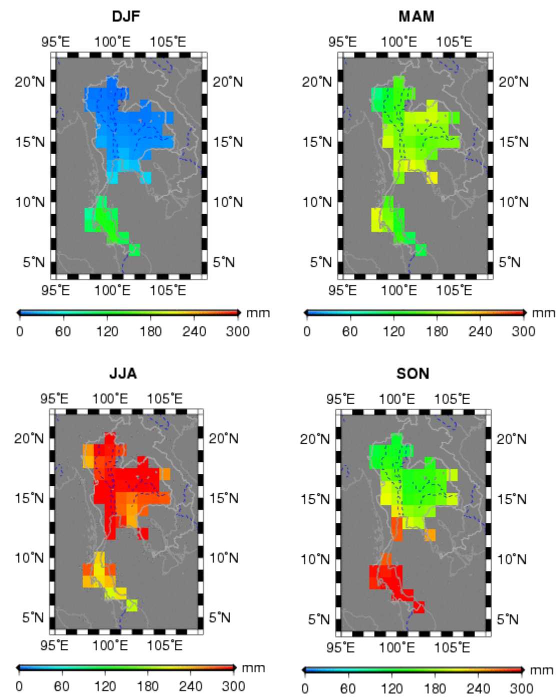

Figure 7: Seasonal distributions of TRMM 3B42 (1998-2002)

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