VALIDATION OF DAILY SATELLITE RAINFALL PRODUCTS OVER SOUTH AMERICA

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Abstract

A station network of about 300 gauges over the mountainous region of Colombia is used to evaluate five different satellite rainfall estimates at daily time scale and 0.25^o spatial resolution. This region of South America has a very complex topography and associated high spatial variability of rainfall. Thus, validation of satellite rainfall estimates over this region is of great interest. The evaluated satellite rainfall products are TRMM-3B42, TRMM-3B42RT, CMORPH, PERSIANN, and the Naval Research Laboratory's blended product. The validation results are reasonably good. The correlation coefficients are between gauge measurements and the satellite estimates between 0.42 and 0.48, the average probability of detection and false alarm rates are 0.70 and 0.20, respectively. The HSS statistic is relatively high, particularly for CMORPH (0.52) and TRMM-3B42 (0.49). These results are very encouraging considering the complexity of the terrain and associated high spatial variability of rainfall.

1. Introduction

It is important to evaluate the different satellite rainfall estimates over different climatic and geographic regions. This will help in identifying specific weakness and strengths of the different products. Here a station network of about 300 gauges is used to evaluate fife different satellite rainfall products over a complex terrain over Colombia in South America. The validation region has a very complex topography and associated high spatial variability of rainfall. The topography varies from sea level to over 3000 meter (Figure 1), while the mean annual rainfall varies under 500 mm over the northeastern part of the country to over 11000 mm over parts of the southwest. The evaluated satellite rainfall products include the "TRMM and Other Satellites (TRMM-3B42, Huffman et al. 2003) and its real-time version(TRMM-3B42RT), NOAA-CPC morphing technique (CMORPH, Joyce et al. 2004), Precipitation Estimation from Remotely Sensed Information using Artificial Neural Network (PERSIANN, Hsu et al. 1997), and the Naval Research Laboratory's blended product(NRLB, http://www.nrlmry.navy.mil/sat-bin/rain.cgi). These products are evaluated at daily time scale and spatial resolution of 0.25°. The station data used for this validation was obtained from Colombia Meteorological Office (IDEAM). The gauge data are gridded and then averaged at the appropriate spatial scales. The next sections describe the data used and present the results.

2. Validation region and data

The validation region is over Colombia, which is located over northwestern part of South America (Figure 1). Daily data from 2000 to 2005 for about 800 stations were obtained from the IDEAM. After a laborious quality check, only about 300 stations were retained and used for the validation. The distribution of the stations used is given in the Figure 1 below. Only daily data from 2003-2005 were used to accommodate CMORPH which started at the end of 2002. Data from all the months is used for each year. The quality controlled gauge measurements were then interpolated into regular grids of 0.05°, and then avenged at 0.25° spatial resolution. All available stations were used for interpolation. However, only 0.25° grid boxes with at least one gauge were used for comparison with the satellite products.

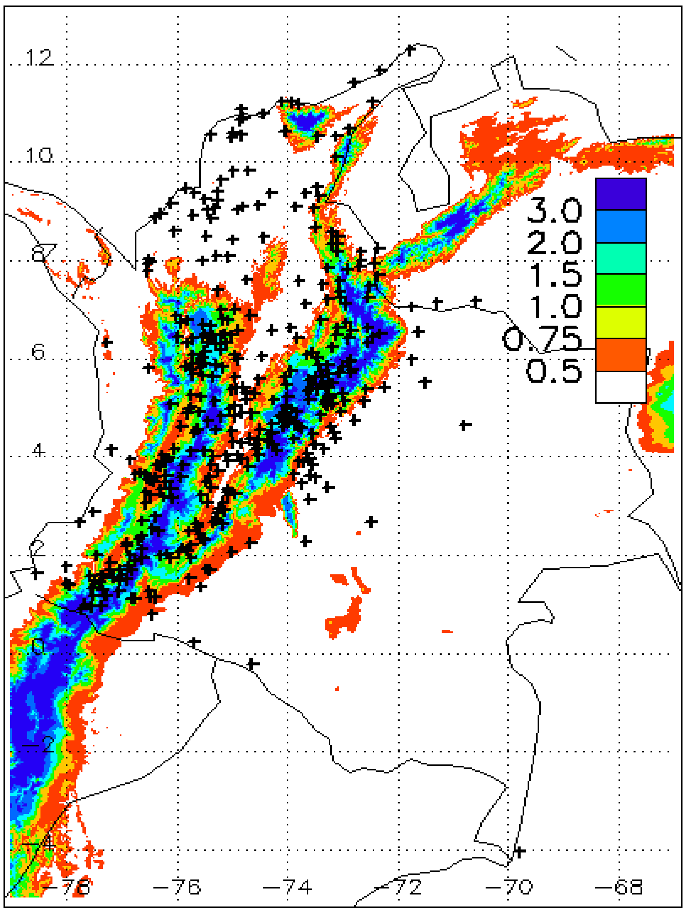

Figure 1: Topography and distribution of raingauge stations (+) used in the validation.

Five different satellite products were evaluated. All the products are available as three-hourly averages at quarter degree spatial resolution. The products are:

- TRMM-3B42 (TRMM and Other Satellites),
- TRMM-3B42RT (Real-time version of 3B42),
- CMORPH (NOAA/CPC morphing technique),
- PERSIANN (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Network), and
- NRLB (Naval Research Laboratory's blended product).

The following table provides summary information of the satellite products.

	Time res.	Space res.	Existence	PM	Gauge
CMORPH	3-hrly	0.25 deg	2002-Pressent	Y	N
NRLB	3-hourly	0.25 deg	2003-2006	Y	N
PERSIANN	3-hourly	0.25 deg	2000-2006	Y	N
TRMM-3B42	3-hourly	0.25 deg	1998-Presesnt	Y	Y
TRMM-3B42RT	3-hourly	0.25 deg	2002-Present	Y	N

Table 1: Summary of the different satellite products evaluated here; the PM and Gauge columns indicate whether the product includes passive microwave (PM) and gauge observations.

3. Validation results

The results of the comparisons of the different satellite rainfall estimates with the gauge data is given in Table 2. The following statistics are presented in Table 2: linear correlation coefficient (CC), Bias, mean error (ME), mean absolute error(MAE), probability of detection(POD), false alarm ratio(FAR), critical success index(CSI), equitable threat score(ETS), Hanssen and Kuipers discriminate(HKS), and Heidke Skill Score(HSS). Correlation coefficient, ME, and MAE represent pixel-by-pixel comparison, while CSI, POD, FAR, ETS, HK and HSS are categorical validation statistics. The pixel-by-pixel comparison statistics are used to evaluate the performance of the satellite products in estimating the amount of the rainfall, while the categorical statistics are used to assess rain detection capabilities. ETS evaluates how well the satellite rain events correspond to the gauge events, HK shows how well the satellite estimates discriminate between rain and no-rain events, and HSS measures the accuracy of the estimates accounting for matches due to random chance.

The overall performance of the satellite products is fairly good, except for PERSIANN. The correlation coefficients are low, but are comparable to results for other geographic regions In fact these results are better than those obtained for a similar mountainous region in Africa (Dinku et al., 2008). The probability of detection is mostly above 70%

while the false alarm rate is between 0.16 and 0.27. The other statistics also show that the satellite products are reasonably good in discriminate between rain and no-rain events. Figure 2 also shows that the cumulative density function (CDF) of the satellite estimates is very close to the raingauge CDF, except for PERSIANN.

N = 161348	**PERSIANN**	**NRLB**	**TRMM-3B42**	**TRMM-3B42RT**	**CMORPH**
CC	0.42	0.46	0.54	0.49	0.54
Bias	3.85	1.21	0.80	1.03	1.02
ME	16.47	1.19	-1.13	0.19	0.11
MAE	19.48	6.37	4.67	5.79	5.19
CSI	0.60	0.58	0.60	0.57	0.62
POD	0.77	0.69	0.70	0.64	0.71
FAR	0.27	0.22	0.19	0.17	0.18
ETS	0.27	0.29	0.33	0.31	0.35
HKS	0.42	0.46	0.50	0.48	0.52
HSS	0.42	0.45	0.49	0.47	0.52

Table 2: Comparison of daily satellite rainfall estimates at quarter degree spatial resolution

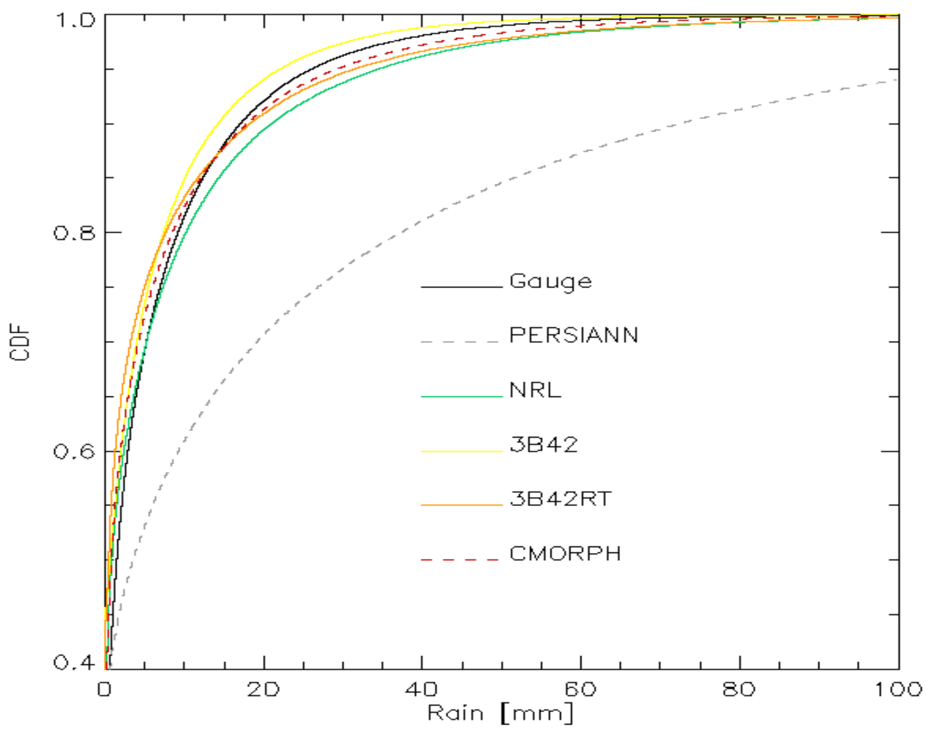

Figure 2: Comparison of raingauge CDF with that of the different satellite rainfall estimates at quarter degree spatial resolution and daily time scale.

Thus, though the satellite products may not give an accurate estimate of the daily rainfall total, they are reasonably good in detecting the occurrence of rainfall and capturing the statistical distribution of the daily rainfall. Comparing the different products, TRMM-3B42 and CMORPH show the best performance, while PERSIANN and NRL show a relatively poor performance. Here it should be noted that TRMM-3B42 is adjusted using gauges available from Colombia through GTS, while the current version of CMORPH does not involve gauge adjustment.

4. Summary

Five different daily satellite rainfall estimates were evaluated over Colombia at a spatial resolution of 0.25^o using a station network of about 300 gauges. The validation region is a complex terrain where elevation varies from sea level to over 3000 meters, and the mean annual rainfall varies from 500 mm to over 11000 mm. The satellites products performed reasonably well, particularly in detecting the occurrence of rainfall and capturing the statistical distribution of the daily rainfall. These results were found to be better than those obtained for another mountainous region in Africa. Among the five satellite products compared here, TRMM-3B42 and CMORPH exhibited better performance, while PERSIANN's performance was very poor.

Reference

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