COMBINATION OF SATELLITE PRECIPITATION ESTIMATES AND RAIN GAUGE FOR HIGH SPATIAL AND TEMPORAL RESOLUTIONS

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ABSTRACT

The satellite rainfall estimate is widely used due to its spatial coverage, obtaining estimates even to remote areas and difficult to access. In addition, there are many products that combine satellite precipitation estimates and rain gauges. However, most of these products are combined for a period of 24-hour, because the rain gauge data are obtained for a 24-hour accumulation period. However, with the use of telemetric stations it is possible to get the accumulated precipitation in periods from 15 minutes. This work describes a new product with high temporal-spatial resolution using gauge-satellite-based analysis of 3-hour precipitation over South America making use of telemetric station of Parana state. This technique can be used to validate the precipitation in the early hours of the models and for nowcasting. The new product, called CoSch-3 has the great advantage of identifying the precipitation related to mesoscale convective systems and other systems that generate large cumulative rainfall in short periods. This product is based on about 100 telemetric stations and the Tropical Rainfall Measuring Mission (TRMM). The results show the remarkable improvement in the quality of the final product used for tracking systems with large accumulated precipitation in a few hours.

INTRODUCTION

The use of satellite rainfall estimates is widely used in hydrology, for application of water resources and monitoring of natural disasters. The satellite rainfall estimate data is generally applied in large basins (with areas bigger than 2000 km²) as used in the simulations of streamflow by Falck et al. (2015) The larger basins have response times in the range of days, filled slowly, and can be monitored by satellite products due to temporal and spatial resolution of the data. In addition to greater spatial coverage, satellites have less data interruptions when compared to rain gauges and radar, as an alternative to the continuous real-time monitoring even smaller basins.

Mesoscale Convective System (MCS) are responsible for intense precipitation events over short periods. The MCS affect southern Brazil and Paraguay throughout the year, specially in the summer months. The systems are associated with large accumulated rainfall in a few hours and occur frequently in the region associated with landslides, destruction of plantations, falling trees, among other negative social and economic impacts.

The region of Paraguay and southern Brazil is inserted in the La Plata basin, where there is great number of telemetric surface stations, allowing it to generate precipitation fields observed in accumulated time scale less than daily. However, there is no rain gauges coverage in all areas and to estimate precipitation via remote sensing becomes essential.

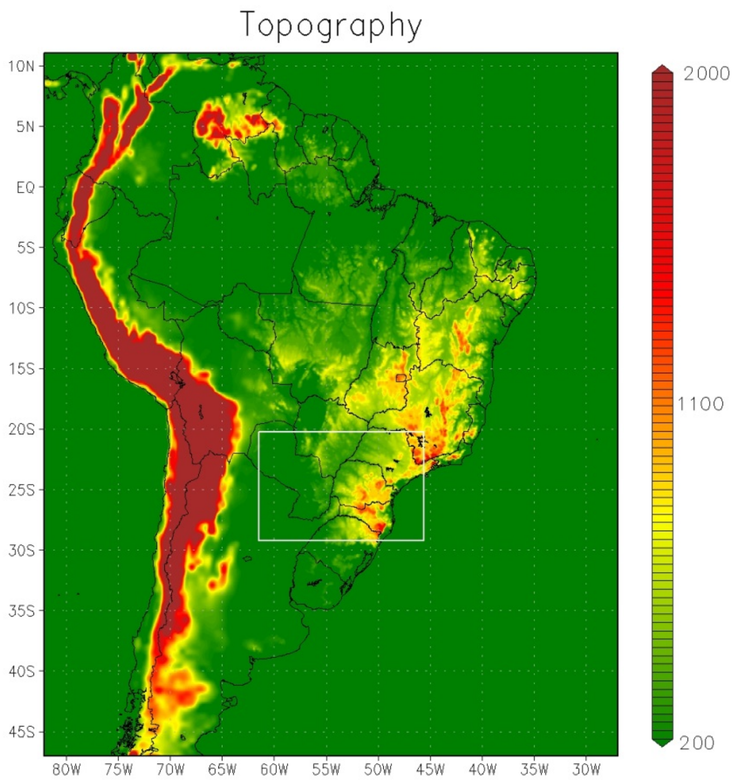

Figure 1. Topography of South America and the highlighted area of study.

The aim of this study was to conduct a detailed study of rainfall in the short term, combining data from precipitation of telemetric stations the state of Paraná and satellite rainfall estimates.

The Cosch-3 product was developed in order to generate a precipitation field in the short term as close to reality as possible, which is extremely important for validation of comparisons and calibration of numerical weather prediction models and hydrological models.

METHODOLOGY

The new product uses the methodology of Vila et al. (2009) for including telemetry stations surface data accumulated in periods of 3 hours equivalent to the product precipitation estimated Real Time 3B42 TRMM multisatellite Precipitation Analysis

(TMPA). However, differs from the accumulated rainfall period analyzed and from it becomes feasible to generate rainfall estimation fields combined for shorter periods.

Combination of the Data and Validation

The correction technique proposal is based on schemes of additive bias correction (ADD ou rr^{+}) , ratio bias correction (RAT ou rr^{*}) combined, so that a weight is applied to them, and the best result is used.

$$rr^{+} = rr_{sat} + (rr^{i}_{obs} - rr^{i}_{sat}) \quad (1)$$

$$rr^{*} = rr_{sat} \times \left(\frac{rr^{i}_{obs}}{rr^{i}_{sat}}\right) \quad (2)$$

$$rrcorr = \alpha \times rr^{+} + \beta \times rr^{*} \quad (3)$$

The surface data is interpolated to the same grid equal to the satellite (0.25 x 0.25 °) using the method of nearest neighbor and masquerades regions to five pixels further from the area of influence of telemetric. For each non-masked point one of the two methods is selected (ADD or RAT) according to the one with the least difference when compared to the observed data. Where the data were not masked, the 3B42RT remains as it was, ie unchanged.

To validate were removed 10% of the stations randomly, and the remainder is used to remove the bias. And that was conducted 10 times, ensuring that all stations were ever removed. The obtained statistical part is detailed in the results.

RESULTS

The results were divided in the statistical part and comparing the estimated precipitation fields by TRMM and modified for the case study. Areas and instability lines acted in the study region during 6th to November 9th, 2014.

Figure 2 shows the rainfall fields for November 9th , 2014 for 3B42 Real Time (Fig.2a,b), and after applying the CoSch3 (Fig.2c,d) and the rainfall gauge (Fig.2e,f). The precipitation accumulated between 13:30 - 16:30 Z is equivalent to 15Z (Fig.2a,c,e); the same to 18 Z, accumulated between 16:30 - 19:30 Z (Fig.2b,d,f). The

3B42RT underestimated the rainfall that occurred at 15Z. On the second time (18z) the opposite happened, there was an overestimation compared to rainfall gauge data. Figure 2 indicate for more intense rainfall there is an underestimation and more intense rainfall there overestimate the precipitation field.

These two schedules were selected in order to analyze MCS heavy rainfall and show that the CoSch3 can either enter rainfall compared to 3B42RT and remove, indicating an underestimation and overestimates of the 3B42RT respectively.

Table 1 shows the mean of BIAS (in millimeters), root-mean-square error (RMSE in millimeters), and correlation coefficient (r) for the proposed models for 6th to November 9th, 2014 . Bold values are the best result obtained for this MCS and for each statistical parameter. In this case, it can be shown that the CoSch3 has a better performance than ADD and RAT separately, and has a better performance than 3B42 Real Time.

Table 1: Comparative statistics between 3B42RT, CoSch3, ADD and RAT

	REAL TIME			CoSch 3			CorrADD			CorrRAT		
	BIAS	RMSE	r	BIAS	RMSE	r	BIAS	RMSE	r	BIAS	RMSE	r
6 - 9 Nov	0,5402	2,7079	0,2461	**0,0702**	**1,6727**	**0,3421**	0,10393	1,8513	0,31941	0,0796	1,8564	0,2537

Some statistics such as bias score (BIAS), probability of detection (POD), false alarm ratio (FAR), and equitable threat score (ETS or CSI) were computed for different rainfall thresholds as follows: 1, 2, 5, 10 and 20 mm, like Vila et al (2009). Figure 3 shows the mean of the statistics for 3B42RT and CoSch3 for all cited rainfall thresholds

In this MCS, Cosch3 has improvement for all rainfall thresholds when compared with 3B42RT.POD (Fig.3a) is higher for most thresholds, suggesting that CoSch3 can get more correct estimates in each category. The FAR (Fig.3b) is smaller for all thresholds, indicating that the false alarms estimated by CoSch3 are smaller than 3B42RT. Critical Success Index (CSI, Fig. 3c) is sensitive to hits because it penalizes both misses and false alarms in the same way, and it is higher for all thresholds. The BIAS (Fig. 3d) of CoSch3 is closer to one for all thresholds - which is the ideal value.

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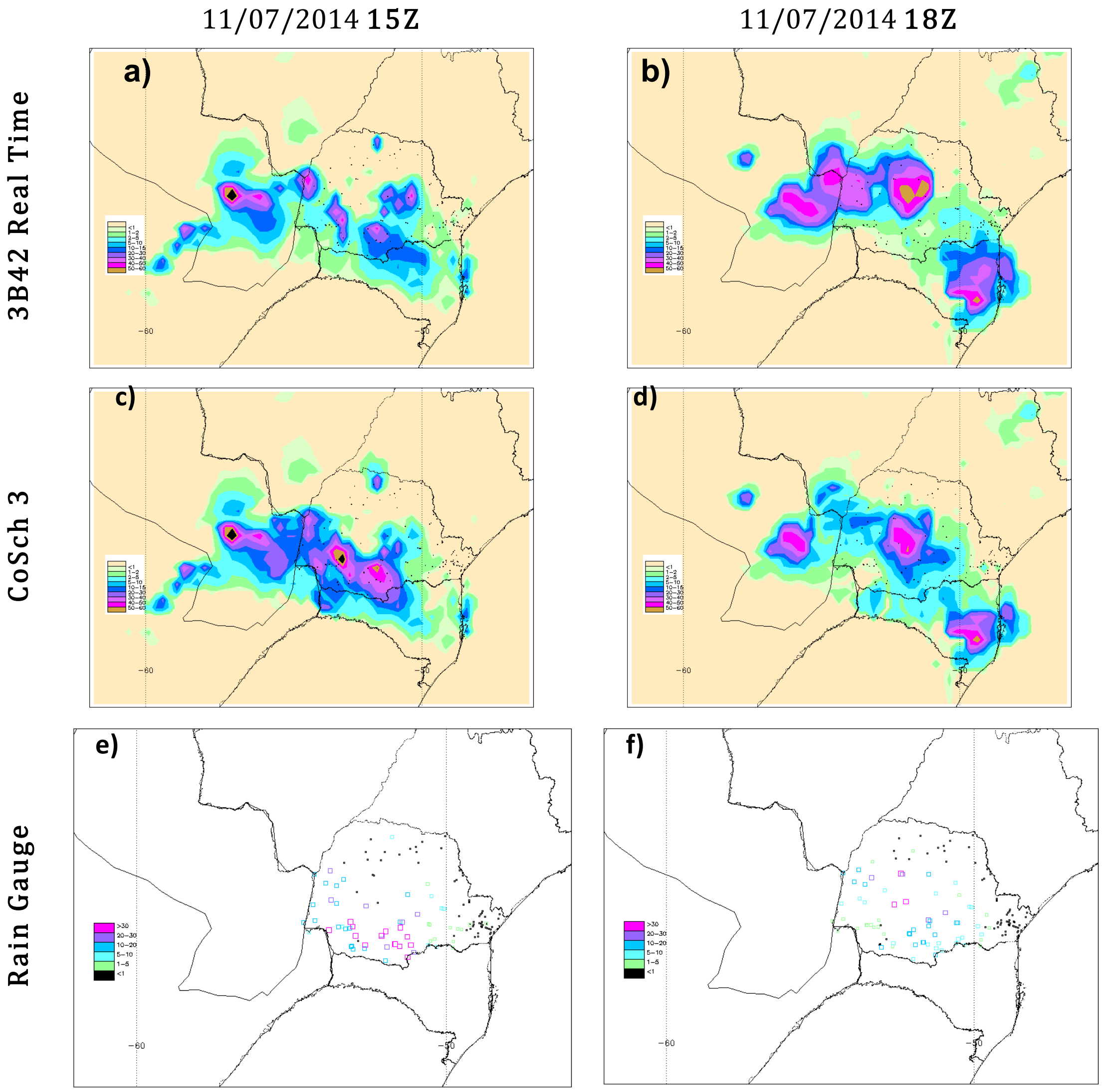

Figure 2. Precipitation fields for the day 11/07/2014: (a) 3B42RT, (c) CoSch 3, (e) accumulated between 13:30 - 16:30 Z – equivalent to 15Z (a,c,e); the same to 18 Z: (b) 3B42RT, (d) CoSch 3, (f) accumulated between 16:30 - 19:30 Z.

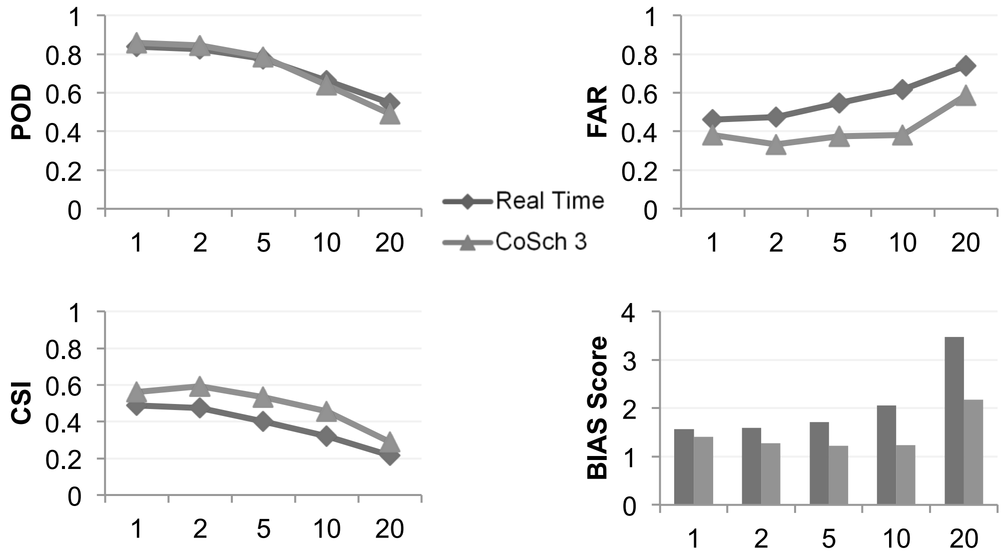

Figure 3. Comparative statistics between the CoSch-3 and 3B42 Real Time: Probability Of Detection (POD), (b) False Alarm Ratio (FAR), (c) Critical Success Index (CSI) and (d) bias score (BIAS).

SUMMARY AND CONCLUSIONS

The estimated precipitation combining IR, MW with precipitation from surface stations for a period of 3 hours showed a statistically superior performance to other methods for the selected case. There were improvements in both the positioning of the systems as well as its intensity and the gain is limited to the area of influence of the surface stations in CoSch-3. For demonstrating the success it is necessary to perform the analysis and validation in a larger case. It also becomes essential greater coverage of measured data at high temporal resolution in the region.

Future studies aim to implement and evaluate the combination for the GPM rainfall estimates and after the necessary adjustments to make it operational at monitoring natural disasters centers in order to analyze the river basins of the region.

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