RAINFALL ESTIMATION OVER SOUTH AMERICA USING THE PRECIPITATION RADAR PRODUCT OF THE TRMM SATELLITE, IR-VIS CLOUD CLASSIFICATION AND PROPERTIES OF CONVECTIVE SYSTEMS

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INTRODUCTION

Due to the low spatial sampling of the ground-based radars, an accurate rainfall estimation using geosynchronous satellite data becomes an important tool in meteorology and hydrology applications. Vicente et al. (1998), Adler and Negri (1988) and Scofield (1987) focus on this topics using the GOES infrared (IR) window (11µm). In this work the GOES visible channel (VIS) (0.65 µm) is also used in order to obtain a cloud classification, allowing us a specific rainfall rate estimation for each cloud type. TRMM precipitation radar data is used in the analysis (November of 2004) and validation (December of 2004) phases. The model classifies first the pixels associated with rain and then estimates a value of rainfall rate for these pixels. The final rainfall estimation uses some radiative and evolution parameters (Machado et al. (1998) of the convective systems, the brightness temperature of the GOES IR channel and IR-VIS cloud classification.

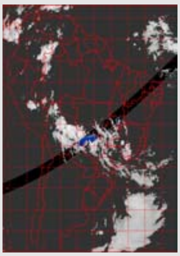

Fig. 1. Area selected for this study. In black the TRMM swath andin dark grey the precipitation area.

DATA

- Tropical Rainfall Measuring Mission (TRMM) precipitation radar satellite data.
- IR-VIS cloud classification, carried out using a cluster analysis.
- Cloud top temperature (Tb), 11µm brightness temperature.
- Parameters derived from the convective systems described in Machado et al. (1998)

RAIN / NO-RAIN DISCRIMATION

More than 90% of the raining pixels were classified as convectives and cold stratiform in the cloud classification; therefore, only clusters (pixels colder than 250 K) classified as convectives or cold stratiform were flagged as rainfall clouds. Only pixels embedded in flagged rain clusters belonging to these classes were considered to produce rain. A final condition was imposed: only pixels with a brightness temperature colder than the mean temperature were finally classified as rain pixels.

RAINFALL RATE ESTIMATION

The following parameters associated with the structure and evolution of each convective systems are computed for five different thresholds (250 K, 240 K, 230 K, 220 K and 210 K): Mean and Minimum Temperature, Mean Temperature difference between two consecutive images, Minimum temperature difference between two consecutive images and the expansion computed as the normalized difference between areas divided by time (30 min.) in two consecutive images.
The rainfall rate estimation of the pixels classified as rain pixels consist of three steps:

1. In the first step the mean rainfall rates from the radar data are computed for each cluster and each threshold. This value is compared with the parameters of the cluster in the same threshold. A multiple linear regression is computed between these variables and the mean rainfall rate and a value of rain (Rm) is associated to each cluster for every threshold (figure 1).

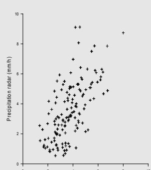

Fig. 2. Scatter plot between the mean radar rainfall rate versus Rm for each cluster, for a 230 K threshold.

2. In the second step a pixel correction is added to Rm using a non linear relation between Tb less the mean temperature of the cluster and the radar data for each pixel of the cluster in a given threshold .

3. In the third step the distribution of the estimated rainfall rate obtained in the second step (r) is fitted to the radar distribution to obtain the final value of the estimated rainfall rate (figure 3).

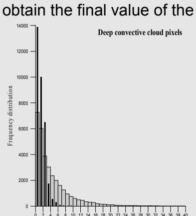

Fig. 3. Frequency distribution of r (in black) and the radar data (in grey) for deep convective clouds.

RESULTS AND CONCLUSIONS

Fig. 4. Rainfall rate on November 17 of 2004 (1045 UTC). Radar (left) Estimated (right).

POD (probability of detection), FAR (fals alarm ratio), ERR (error) and FBI (frequency bias index) was used to validate the rain/no-rain discrimination comparing the radar data with the estimated rainfall rate. Table 1 shows the results.

Table 1. Rain / no-rain discrimination statistical parameters

	Analyzed period	*Validation period*	*Whole period*
POD	**0,61**	**0,55**	**0,57**
FAR	**0,43**	**0,32**	**0,37**
ERR	**0,26**	**0,27**	**0,26**
FBI	**1,06**	**0,81**	**0,91**

The statistical variables used to validate the rainfall rate estimation has been computed for different grid sizes: 5x5 pixels (20x20 km), 9x9 pixels (36x36 km), 15x15 pixels (60x60 km) and 25x25 km (100x100 km). Table 2 shows the results for both the analysed and validation period.

Table 2. Statistics of the algorithm for 4 different grid sizes.

Period	**Analysing**				**Validation**			
Grid size, Km	**20X20**	**36x36**	**60x60**	**100x100**	**20x20**	**36x36**	**60x60**	**100x100**
Sample size	4460	1781	704	244	1488	524	205	75
Correlation	0,32	0,45	0,54	0,64	0,26	0,39	0,53	0,64
Sat. std dev	2,61	2,26	1,87	1,37	3,42	3,01	2,44	1,90
Radar std dev	2,35	1,86	1,38	0,92	2,76	2,22	1,68	1,24
Rmse	4,45	4,15	3,95	3,99	5,92	5,63	5,23	5
Bias	1,1	1,01	1	1,11	1,63	1,55	1,38	1,42
POD	0,81	0,88	0,94	0,98	0,73	0,81	0,87	0,93
FAR	0,16	0,11	0,07	0,03	0,17	0,13	0,08	0,04
ERR	0,23	0,17	0,11	0,03	0,25	0,2	0,13	0,07
FBI	0,97	1	1,02	1,01	0,89	0,94	0,95	0,97

- The parameters score slightly better during the analysed period, but not with a great difference.
- The algorithm tends to overestimate the value of rainfall.
- The algorithm starts to performs reasonably well from a 60x60 km grid size.

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