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RADAR PROPERTIES OF TROPICAL RAIN FOUND FROM DISTROMETER DATA AT COSTA RICA

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1. INTRODUCTION

An analysis of drop size distributions (DSDs) for tropical rain is presented in this paper. The DSD observations are the first measurements of its kind at Central America, and they were used to obtain empirical relations between radar measurables and rainfall integral parameters (Z-R relations).

The paper also describes some microphysical characteristics found in each category when partitioning rain events into Convective, Transition and Stratiform (according with the method of Atlas et al. 1999) .

In addition, comparisons are made with similar studies obtained from GATE, TOGA COARE, and the Arecibo Campaign in Puerto Rico (Ulbrich et al., 1999).

2. METHODS & RESULTS

Measurements of DSDs (one-minute averages) were taken at San José, Costa Rica, from October to December 2000. The sensor used was the Optical Spectro Pluviometer (OSP), which was designed and built by the *Centre de Recherches en Physique de l´Environnement Terrestre et Planétaire* (CETP) and is described in Hauser et al. (1984). For this study, the OSP was re-calibrated by the method described in Campos and Zawadzki (2000).

For the analysis, it was selected a thunderstorm event on October 12, 2000, which lasted from 12:45 LT (UTC – 6h) to near 15:15 LT (146 observations in total). It was then computed the time variation of the rain rate (R, in mm/h), reflectivity (dBz), and mean volume diameter (D_0, in mm, as defined by Ulbrich, 1983), by using

$$R = \frac{\pi}{6} \int_0^{\infty} D^3 \; v_D \;\; N(D)\, dD \quad ; \qquad (1)$$

$$Z = \int_0^{\infty} D^6 \; N(D)\, dD \quad ; \qquad (2)$$

$$2\int_0^{D_0} D^3 \; N(D)\, dD = \int_0^{D_{\max}} D^3 \; N(D)\, dD \quad . \qquad (3)$$

The results are presented in Figure 1. In addition, Figure 2 presents the average DSD for the whole thunderstorm event (and the corresponding Marshall-Palmer DSD is plotted in dashed lines).

When analyzing the variation of D_0 with R, it is possible to identify three distinct regimes, as noticed by Atlas et al. (1999): Convective, Transition, and Stratiform (see these regimes in Figure 1). In fact, we have observed these regimes in most of the cases with our database. However, our initial stage (Convective), shows an irregular coupling between R and D_0 . Some times one increase with the other (as in Figure 1), but some others D_0 seems decorrelated with R (as in Atlas et al., 1999). At the Transition stage, D_0 decreases sharply with R. The stratiform stage, at the end of the events, shows the smallest D_0 and very light R. Within the Stratiform stage, however, we have seen in several events (not shown) the same dependence between D_0 and R as in the Transition, with the only difference of the R intensity.

Interestingly enough is the well-formed plateau found in the average DSD for the Convective regime on October 12 (Figure 3). Atlas and Ulbrich (2000) associate these kind of shapes in the DSD as an effect of the drop sorting due to updrafts.

3. DISCUSSION

From the microphysics point of view, it is very important to identify the Convective, Transition, and Stratiform regimes in the tropical rain (Atlas and Ulbrich, 2000). Is it also that important from the radar hydrology point of view (i.e., for the rain quantification from Z-R relations)?

In order to address this question, we computed Z-R relations by linear regressions of 10logZ as a function of logR. If we exclude from the analysis the instrumental dependence of the Z-R relations (Campos and Zawadzki, 2000), it is then possible to isolate the variations in Z-R relations due to the microphysics (natural variations in DSD from Convective, Transition and Stratiform regimes). Table 1 presents the Z-R relation for the whole event on October 12, as well as the Z-R relations for each regime.

It is clear that the coefficients are significantly different for each regime (note that one standard deviation corresponds with the 32% level of significance in a standard normal probability distribution), and that the average of the same coefficient in the three regimes is different from the same coefficient for the whole event. We should expect a similar behavior when averaging the coefficients A and B from different rain events in order to obtain a "seasonal" Z-R relation. This seasonal Z-R

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relation will then be different from the one (and perhaps more corrected relation) obtained by using one single data set with all the DSDs from all the rain events. Furthermore, what seems to be a natural variation in the Z-R relation is very often a systematic error introduced by the analysis method (Campos and Zawadzki, 2000).

Table 1. Z-R relations for the event on 12 Oct 2000. $Z = (A \pm A_{ERR})\ R^{(B \pm Berr)}$. The coefficients A_{ERR} and B_{err} are the corresponding standard deviations of A and B.

12 Oct 2000	A	A_{ERR}	B	B_{err}
Convective (6 obs.)	702.2	172	1.61	0.182
Transition (53 obs.)	104.7	22.6	1.63	0.099
Stratiform (86 obs.)	227.4	12.8	1.49	0.048
Whole (146 obs.)	275.3	17.1	1.27	0.038

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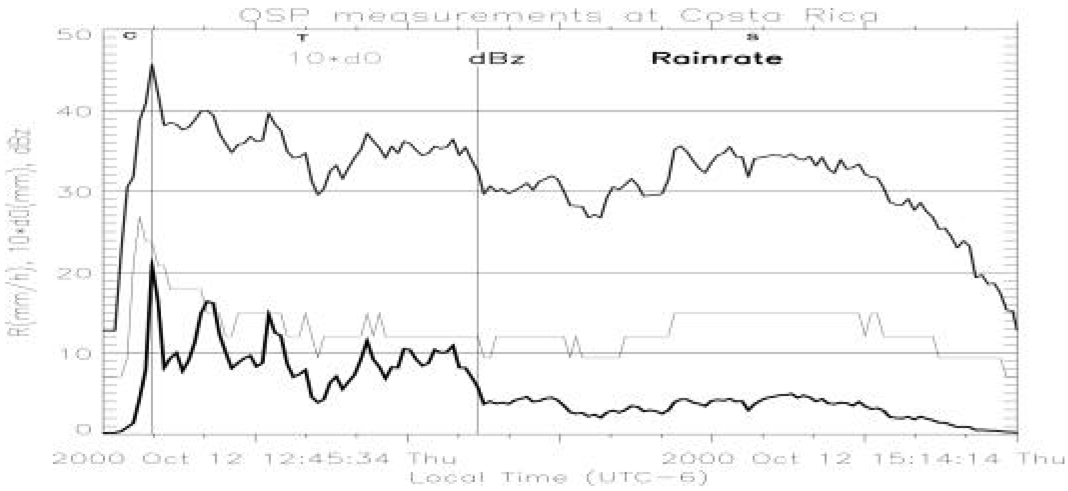

Fig. 1. Time variation of R. Z. and D_0.

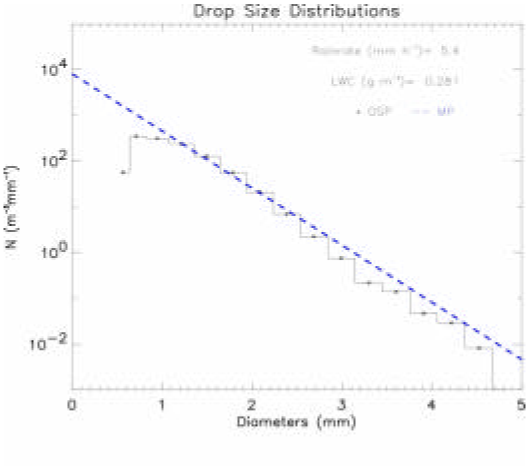

Fig. 2. Average DSD for the whole event.

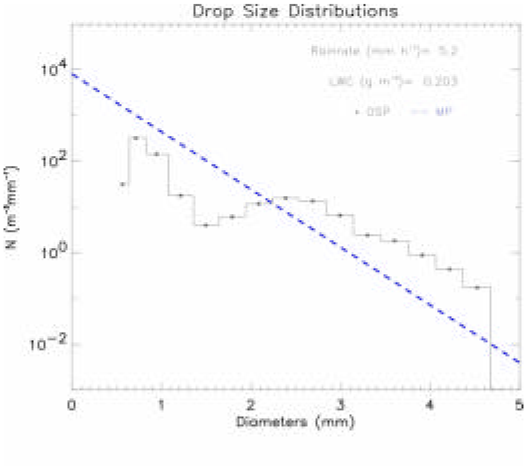

Fig. 3. Average DSD for the Convective stage.