TIME EVOLUTION OF A STORM FROM X-POL IN SÃO PAULO: A ZH-ZDR AND TITAN METRICS COMPARISON

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1. Introduction

By exploring dual polarization radar measurements it was possible to identify different types of hydrometeors in storms and estimate their amount. The distribution and type of hydrometeor within a severe convective storm impact, to a certain degree, its dynamics. The identification and estimate of amount of the hydrometeors are important for many applications in research and operations. The identification of hydrometeor types, for instance, precedes the estimation of water content throughout the spatio-temporal evolution of precipitation. That estimation is highly relevant for outstanding applications such as in hydrology and NWP. While the operational frequency is a key parameter in the choice of the equipment to be used for hydrometeorological applications, there has been an ever growing interest in the shorter X-band. At this frequency radars are relatively smaller, allow that high resolution observations are made with moderate size antennas and are suitable for mobility. Such assets are to be balanced against the heavy attenuation suffered by X-band, a traditional major disadvantage. However, this disadvantage can be mitigated by using polarimetic based methods which provide correction for the incurred attenuation.

This paper builds upon data obtained with the polarimetric X-band mobile radar system of the research project GLM-CHUVA. Data are from observations performed while the radar was sited at approximately 45.9°W, 23°S, at São José dos Campos, near São Paulo, during operations related to the project campaign of the 2011/2012 summer in the Paraiba Valley, one of several campaigns of the GLM-CHUVA. The same set of data was used in a previous work (Calheiros et al, 2012) to generate a ZH-ZDR scatter plot which was comparable with those presented in studies developed abroad (e.g. Marzano et al, 2010). In this paper, a cell as defined with the TITAN System (Dixon and Wiener, 1993) was selected from a complex of storms which developed on the 8th of January, 2012 for a verification of the temporal evolution of the ZH-ZDR scatter plot. Data from PPI's at 1° and 6.2° elevation were used for the plots.

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The study covered the period of about one hour, during which the cell kept identified by TITAN, essentially along its rapid development and mature stages. Hydrometeors were counted in successive scans along the tracking period, focusing on rain. Identification of rain areas in the scatter plots was based on previous works developed elsewhere, in particular on the simulations of Marzano et al. (2010) using the X-band.

The time evolution of the hydrometeor counts was compared to the corresponding TITAN metrics. A comparison of the rain evolution to that documented from a storm observed in central Europe during the field phase of the Convective and Orographically-induced Precipitation Study (COPS) (Schmidt et al, 2012), was also performed. In section 2 data characteristics and processing are detailed. Section 3 presents the results and analyses. Conclusions are drawn in the section 4.

2. Data and Processing

Data used in this study are from the X-band polarimetric radar operated by the GLM-Chuva project during the 2011/2012 summer campaign in the Paraiba Valley. Radar position is shown in Figure 1. The available data file covered the period from November, 2011 to March, 2012. The radar antenna features a 1.3º beam width performing volume scans at 13 elevations angles from 1.0º to 24.0º; range resolution was 150m and data were recorded at a 1º nominal resolution in azimuth. PRF was 1500 Hz/ 1200 Hz (5/4 staggering) and volume scans were completed every 6 minutes.

Together with a volume scan an azimuth scan at 89º elevation was performed for ZDR bias correction purposes (Sakuragi, in this conference). In this study PPIs at elevations of 1º and 6.2º were explored with the TITAN system (Dixon, 1993) for storms with cells keeping their identity for about an hour, within a range of about 60 km from the radar. A cell from January 8th, 2012, which was identified and tracked by TITAN using a threshold of 40 dBZ during the interval from 14:48 UT to 15:48 UT, was selected. Figure 2 exemplifies the cell at 15:42 UT as shown in the composite product from the TITAN menu.

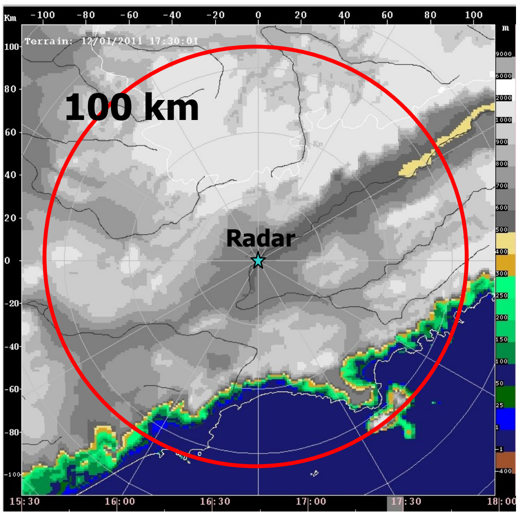


Fig. 1. GLM-Chuva Project X-band polarimetric radar, operated in the Paraiba Valley to a range of 100 km during the 2011/2012 summer campaign.

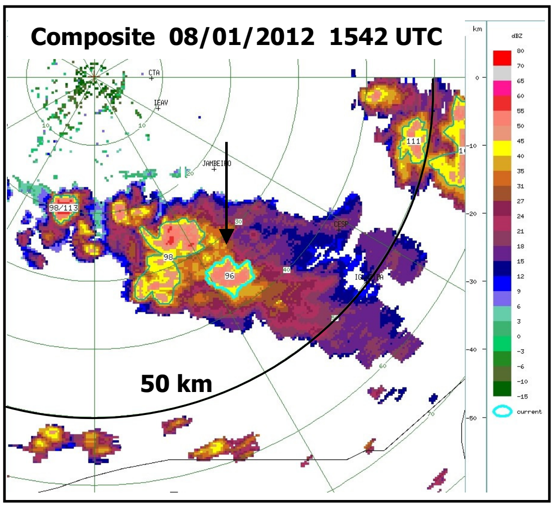


Fig. 2. Composite PPI from 08/01/2012. The black arrow indicates the cell selected for the study.

The cell was depicted in the PPI's at the two elevations chosen and within range ring sectors at the defined 9 dBZ threshold. Ranges covered by the cell were approximately within the ring 30-57 km for PPIS at both elevations.

At those distances the beam will be around 590-1220 m AGL for 1º elevation, and 3300-6500 m AGL for 6.2º elevation. The 0º isotherm from the São Paulo radiosonde station at 12 UT was at about 4200 m, a height that is reached by the beam at approximately 39 km from the radar.

The pairs ZH-ZDR from the range ring sectors defined in the PPIs at the two elevations, for every 6 minutes along the tracking period, constituted the data base for the study. A scatter plot ZH-ZDR was generated for each time step and hydrometeor counts were generated for the classifying boxes as defined in Table 1.

Table 1 – Classifying boxes for rain in the ZH-ZDR scatter plot, 1º PPI.

Box	ZH (dBZ)	ZDR (dB)
1	9<ZH<20	0<ZDR<0.5
2	20<ZH<30	0<ZDR<4
3	30<ZH<43	0.3<ZDR<5
4	43<ZH<53	0.8<ZDR<5.2
5	53<ZH<63	1.5<ZDR<5.5

Figure 3 depicts the boxes defined in Table 1 overlaid on the simulated X-band classes in Figure 1 of Marzano et al (2010).

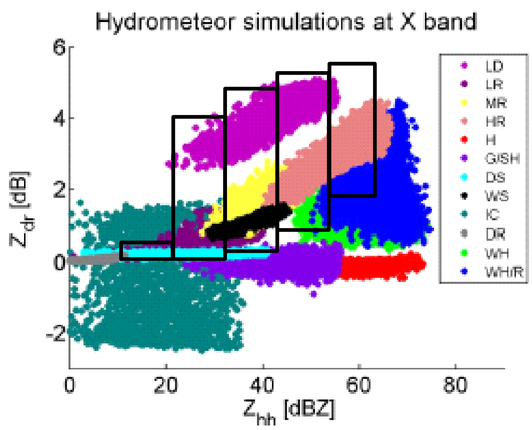


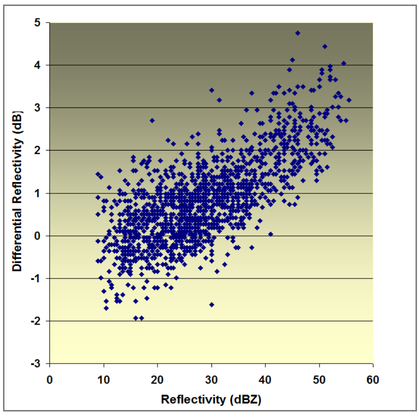
Fig.3. Boxes defined in Table 1, overlaid on the simulated X-band classes in Figure 1 of Marzano et al (2010).

Boundaries are compatible with the works of Al-Sakka (2011) and Dolan and Rutledge (2009), for rain. Scatter plots were generated also for the 6.2º elevation where the beam is predominantly above the 0º isotherm. TITAN was run for the 9 dBZ threshold within the range ring sectors, for the full volume scans, to generate the cell metrics.

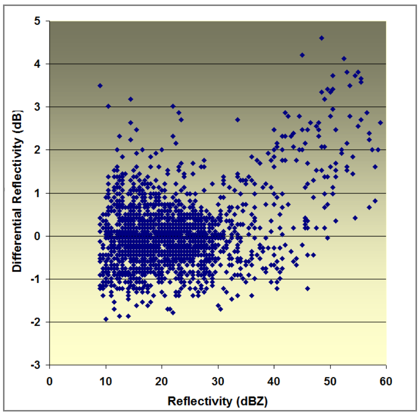
3. Results and Analysis

There were, for each elevation, 11 scatter plots for each 6 minutes along the tracking period and 2 additional plots towards dissipation. Here are shown only selected plots from the mature phase, in Figure 4(a) to (d).

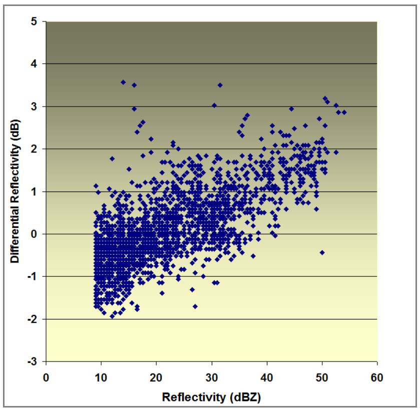
(a)



(b)



(c)



(d)

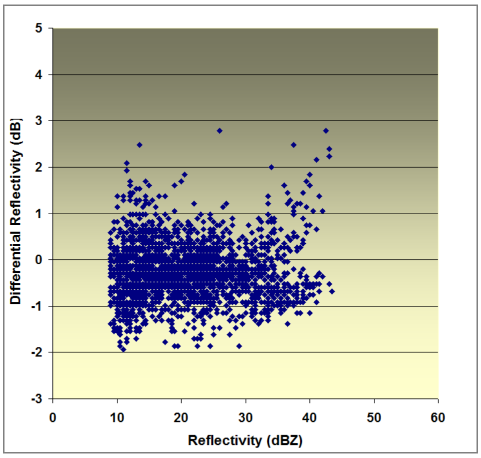


Fig. 4. Scatter plots (a-d) for selected times along the tracking period from 15:24UT and 15:48 UT, taken at 1° and 6.2° elevations, respectively.

The hydrometeor counts provided the results registered in Table 2 below. Only scatter plots of the identified cell tracking period were considered.

Table 2. Rain classified hydrometeor counts from 14:48 UT to 15:58 UT, 1º PPI.

Box / Time (UT)	1	2	3	4	5	Sum over all boxes
14:48	6	42	64	31	0	143
14:54	15	83	83	37	8	226
15:00	7	61	101	38	0	207
15:06	11	117	166	68	2	364
15:12	37	134	190	85	0	446
15:18	67	226	269	128	2	692
15:24	69	424	365	159	9	1024
15:30	27	349	252	168	3	799
15:36	40	352	175	99	0	666
15:46	287	443	528	212	0	1470
15:48	136	338	257	116	1	848

The following characterization of the hydrometeors was considered:

Box 1: Light Rain/Drizzle
Boxes 2 and 3: Moderate Rain
Boxes 4 and 5: Heavy Rain

The sum of counts over all boxes (last column to the right in Table 2), designated SUM_Precip, together with the TITAN metrics for the area of precipitation (Preciparea(km^2) and the flux of precipitation (Precipflux(m^3/s) is shown in Figure 5, in the sequence.

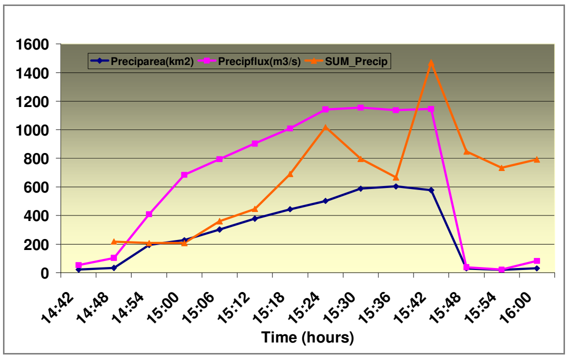


Fig. 5. Titan metrics for the precipitation area and flux of precipitation, as well as for the sum of hydrometeor related to rain.

In general, the evolution of the hydrometeor contents from the ZH-ZDR plots is comparable to the TITAN metrics.

Large drops are identified significantly in the scatter plots only in the early stage of the cell lifecycle. As mature stage develops there is a relative increase of hydrometeors which are classified as ice crystals. From 15:06 UT on, the amounts exceeds that for rain until the end of the lifecycle of the cell. Hydrometeors which classify as wet hail/rain were practically absent.

Regarding the scatter plots from the 6.2º PPI, the beam is mostly above the freezing level and the hydrometeors fit predominantly the ice crystal classification as defined in Figure 2. This condition is, to a certain extent, similar to that found in the study of Marzano et al (2010) in its Figure 5d. The evolution of the hydrometeor counts in the cell selected for this study keep similarities with that in the isolated thunderstorm from the COPS experiment focused in the work of Schmidt et al (2012). The normalized evolution of the fraction of volume of hydrometeors classified as rain at the altitude of 1km was performed with data extracted from Figure 11 of Schmidt et al (2012) and compared in a common time base, i.e. 30 minutes, with the normalized evolution of the number of the rain classified hydrometeors from this study. Figure 6 shows the resulting curves, which are comparable.

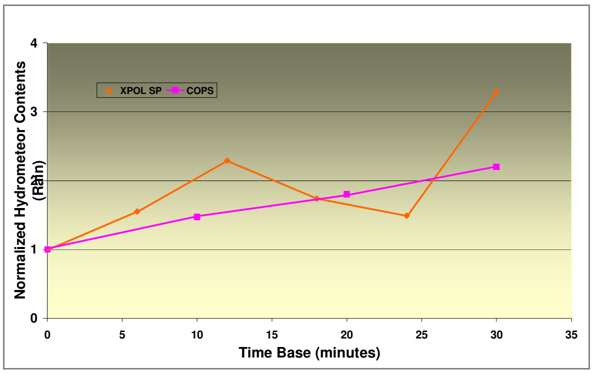


Fig. 6. Normalized evolution of the number of the rain classified hydrometeors.

4. Conclusion

The time evolution of hydrometeors was obtained for the lifecycle of a cell from a thunderstorm complex within the coverage range of the X-band polarimetric radar from the GLM-Chuva project. Focus was on rain. The hydrometeor counts were performed and compared with TITAN metrics from the cell. A comparison was also made with the "golden storm" of the COPS project in central Europe.

Hydrometeor classification schemes developed abroad were applied to the Chuva X-band data operating near São Paulo with satisfactory, though preliminary, results.

Results indicate, also, that the polarimetric ZH and ZDR variables are useful for hydrometeor classification in tropical areas.

Comparison of the evolution of hydrometeor counts with that of TITAN metrics provided favorable results.

Next in this work is the extension of the analysis to the full cell volume and utilization of a substantially larger data set.

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