2015 AMS the 37th Conference on Radar Meteorology, Norman, OK, 14-18 September 2015

P.83 SEVERE WEATHER EVENTS DETECTED BY PUERTO RICO'S TROPINET DUAL-POLARIZED DOPPLER X-BAND RADARS NETWORK

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1. Introduction

In order to improve nowcasting (warning) operations, new technologies that provide products to conduct research activities on precipitation and land surface processes of potentially hazardous weather are necessary. The need for improving weather radar coverage of the lower atmosphere is necessary to allow monitoring of precipitation and at low altitudes to positively impact forecast of flooding. This is especially true for regions with complex terrains, as well as urban and coastal areas. The Puerto Rico's west coast is a combination of all these conditions, where the coast and a range of mountains meet along with urban, making the warning for these areas very challenging and difficult. In addition, the TJUA NEXRAD located at Cayey is approximately 100 km from the west coast, has limitations observing the lower atmosphere in this area due to the complex topography and earth curvature. For this, University of Puerto Rico at Mayaguez sponsored by NSF-MRI developed network of X-band dual-polarized Doppler radars that focus in the observation of the lower atmosphere. The network consists of 3 radars that are strategically located along the west coast and can monitor the lower atmosphere of the west coast with high spatial (150m) and temporal resolution (1 minute), making the west region of Puerto Rico the most densely sampled lower atmosphere in the tropics. These radars have a 40 km maximum range, and their footprints overlap over urban, coastal and mountainous regions.

The UPRM radar infrastructure is already in place, and is currently run by faculty and graduate students. Recently several case studies where funnel clouds, waterspouts, and hail were reported in the west coast. The UPRM radars were able to observe these funnel clouds and waterspouts using it's Doppler capabilities. Moreover, hail detection was possible using polarimetric products (such as Z_{DR} for HDR calculations) at low altitudes; very important for hail detection and algorithm development/improvements in the Tropics. These observations were invisible to the NEXRAD, as the comparison data depicted, and the higher resolution provided more detail in their structural development. These preliminary cases were a strong proof that improvement in Puerto Rico's West coast's nowcasting (warning) operation of NWS can be achieved using the short-range high-resolution radars from the UPRM.

Figure 1: TropiNet X-band Weather Radar Network located in western Puerto Rico's coast.

2. Background and Methods

Hail events are fairly rare in the Tropics *compared* to higher altitudes. But with the deployment of the TropiNet Dual-polarized Doppler weather radar, now is easier to detect, especially in western Puerto Rico where it is located. Frisby (1964 and 1966) and Frisby and Sansom (1967) made the most complete survey of hail in the tropics by dividing it into zones. They gathered data for many years from the literature and through extensive correspondence with individuals and meteorological services. She found that in Zone 1, where Puerto Rico was located, hail principally falls in Spring, when there was the transition right before Summer; but specifically February through May. This was consistent with correspondence with the NWS, who provided a list of 5 likely hail events in the west in a period of 4 months during 2012, but in 2013 four events were clearly identified in a period of 3 days in just the month of September. The advantage of now having dual polarization data in high resolution and given the events frequency in western Puerto Rico we expect enough events to conduct an experiment analyzing the vertical structure of the storm using radar volume scans additional to the ones available.

To examine hail development, reflectivity values higher than 55dBZ will be monitored and the '*hail signal*', known as HDR in dB as defined by Aydin et al.1986, will be calculated using the following relation:

$$HDR = Z_h - f(Z_{DR})$$

The $f(Z_{DR})$ depicts the rain-hail boundary line as shown in Figure 2. This relation is a function of frequency and region.

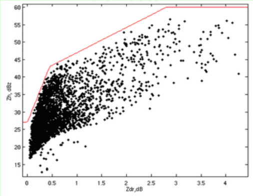

Figure 2: Rain-Hail boundary line simulated by (Tolstoy et al. 2011).

Several relations have been found (Bringi and Chandrasekar 2001) for $f(Z_{dr})$ but none have been found for the tropics at X-band. Sue et al. 2010 described $f(Z_{dr})$ for X-band in a temperate zone (also in Ma 2010, Ma et al. 2010). Another relation using X-band radar data and/or disdrometer data, have been found for sub-tropical coastal environment (Tolstoy et al. 2011).

$$f(Z_{DR}) = \begin{cases} 27 & Z_{DR} \le 0dB \\ 27 + 35.56 Z_{DR} & 0 < Z_{DR} \le 0.45dB \\ 39.74 + 7.23 Z_{DR} & 0.45 < Z_{DR} \le 2.8dB \\ 60 & Z_{DR} > 2.8dB \end{cases}$$

This latter relationship was used to calculate HDR. The intention is to identify hail regions using the dual-polarized data form the TropiNet further on than using Zdr in an inspecting way. This relation in equation 2 was selected as it was found for the closest region to the tropical zone. Because of this, for the purpose of this research, only HDR≥10dB will be considered a '*hail signal*'.

3. RESULTS

CASE 1: HAIL EVENT OVER AGUADA, PR
Sept 12th, 2014 AT 18:48 UTC

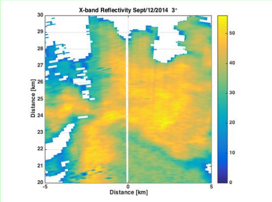

Figure 3: Reflectivity PPI scan 3 at degrees elevation on Sept 12, 2014 at 18:48 UTC.

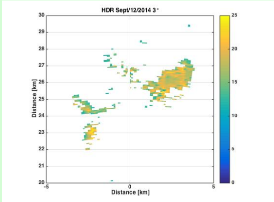

Figure 4: HDR result at 3 degrees elevation on Sept 12, 2014 at 18:48 UTC.

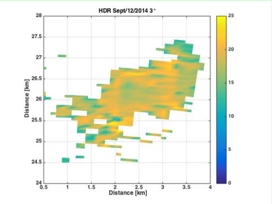

Figure 5: Figure 4 area zoomed in for the same case.

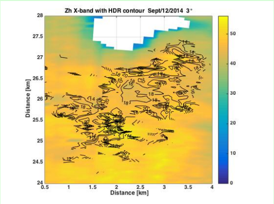

Figure 6: HDR contours over reflectivity Z_H for the case presented.

CASE 2: FUNNEL CLOUD OVER PR-2 ROAD, MAYAGUEZ, PR
Sept 9th, 2014 AT 18:24 UTC

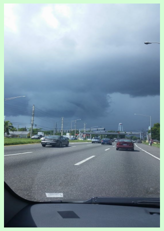

Figure 7: Picture of funnel Cloud over PR-2 road at Mayaguez, PR.

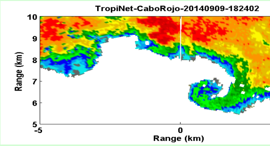

Figure 8: Reflectivity PPI scan at 3 degrees in elevation for the waterspout case on September 9th, 2014 at 18:24 UTC.

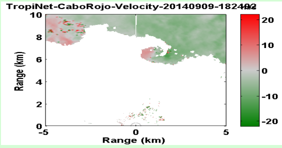

Figure 9: Doppler velocity values for the PPI scan presented in Figure 8. A waterspout was detected.

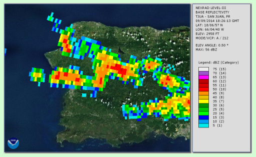

Figure 10: Reflectivity PPI scan from NEXRAD. Waterspout is not detected.

CASE 3: WATERSPOUT IN MAYAGUEZ, PR OFFSHORE
Sept 9th, 2014 AT 18:48 UTC

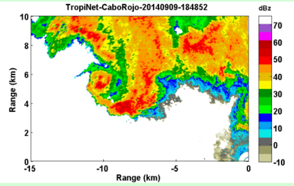

Figure 11: Reflectivity PPI scan at 3 degrees in elevation for the waterspout case on September 9, 2014 at 18:48 UTC.

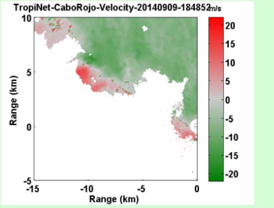

Figure 12: Doppler velocity values for the PPI scan presented in Figure 11. A funnel cloud was detected.

4. Conclusions

Given that for the Puerto Rico tropical zone an HDR relation has not been yet been found, a sub-tropical coastal relation for $f(Z_{DR})$ was used. A threshold of HDR≥10dB was established to identify the '*hail signal*'. With this in place HDR zones up to 25dB were detected. These values coincided with eyewitnesses in the Aguada area.

In the other hand Doppler velocities from the dual–polarized TropiNet radar at the Cornelia Node, provided information to detect two important severe events. One waterspout at the Mayaguez offshore and a funnel cloud over Mayaguez's PR-2 road. Both were witnessed and reported to the NWS.

The detection of these events in the west coast of Puerto Rico represents a milestone, since these events were totally undetected for the NWS's NEXRAD's radar and it was the first time that a dual-polarized weather radar detected severe events like this in Puerto Rico. These results will aid the research community to study this kind of events in the tropics with the use of the new established TropiNet X-band weather radar network.

Acknowledgements; This work was supported by the MRI program of the NSF under award number **0821331**