Tropical Rainfall Rate Relation Assessments from Dual Polarized X-band Weather Radars

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Introduction

Improving today's weather monitoring and forecasting, requires an increase in both the resolution and volume coverage of observations in the lowest kilometers of the troposphere. This is especially true in Puerto Rico, where complex topography limits the use of traditional long-range radar systems, making the deployment of a network of short range radars an attractive alternative to observe the weather. Due the topography and the wet season of the island, the formation of convective storms cause mayor flooding in the west side of Puerto Rico. It is important for the Puerto Rico Weather Radar Network (PRWRN) to develop an algorithm, which will help us to warn the residents of the flash floods. Thanks to the Dual Polarized Weather Radars, new variables are introduced, which gave us more information of the storms.

We usually convert the radar data into rainfall rate with the relation $Z=aR^b$ (Fig. 1b), which takes the reflectivity value and calculates the precipitation intensity. But with the polarimetric variables, such as the Differential Reflectivity (Z_{DR}) and the Specific Differential Phase (K_{DP}), we get more information of the hydrometeors in the storm. Like the rainfall rate relation, we can find rainfall rate relations with the polarimetric varibles:

$$R=aZ_{DR}^{b}Z^{c} \quad (1)$$
$$R=aZ_{DR}^{b}K_{DP}^{c} \quad (2)$$
$$R=aZ_{DR}^{b}Z^{c}K_{DP}^{d} \quad (3)$$

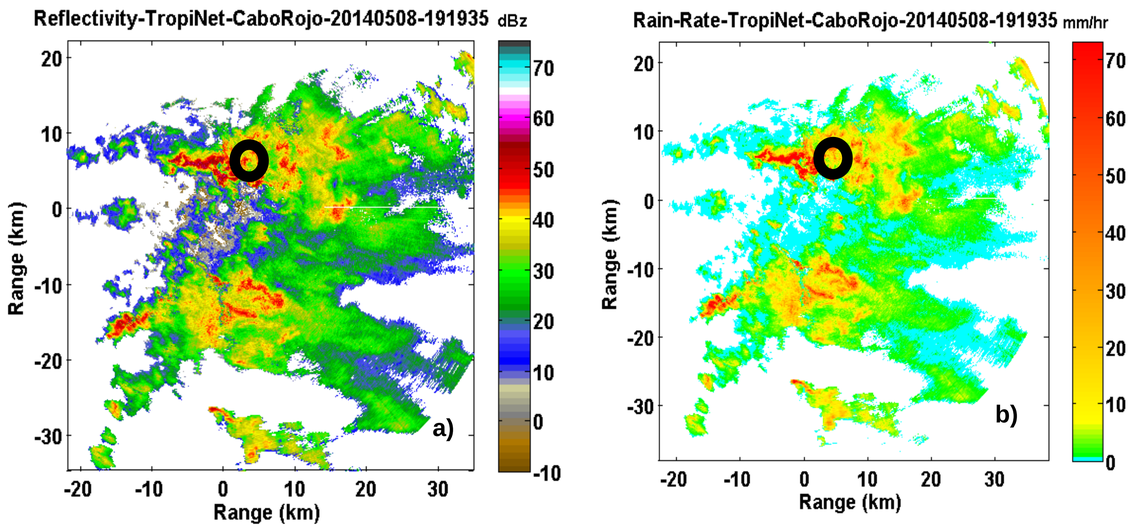

Figure 1: TropiNet Cabo Rojo Data: a) Reflectivity and b) Rainfall Rate; circle shows the disdrometer location

To compare the data, UPRM has installed two Thies Clima Disdrometers (Fig. 3), one in the UPRM campus and the other one in UPRAg campus, which will help us to observe the precipitation intensity on the ground. This type of disdrometer gives us variables like the type of the hydrometeors, it calculates the equivalent radar reflectivity, the visibility, the particles fall speed and diameters, among other valuable information. If we look at Figure 1b, over the disdrometer is a rainfall intensity around the 40-45 $mm \cdot hr^{-1}$, if we compare it with Figure 2, we can observe that over the disdrometer is a radar reflectivity of 47.6 dBZ and a rain intensity of 42.49 $mm \cdot hr^{-1}$

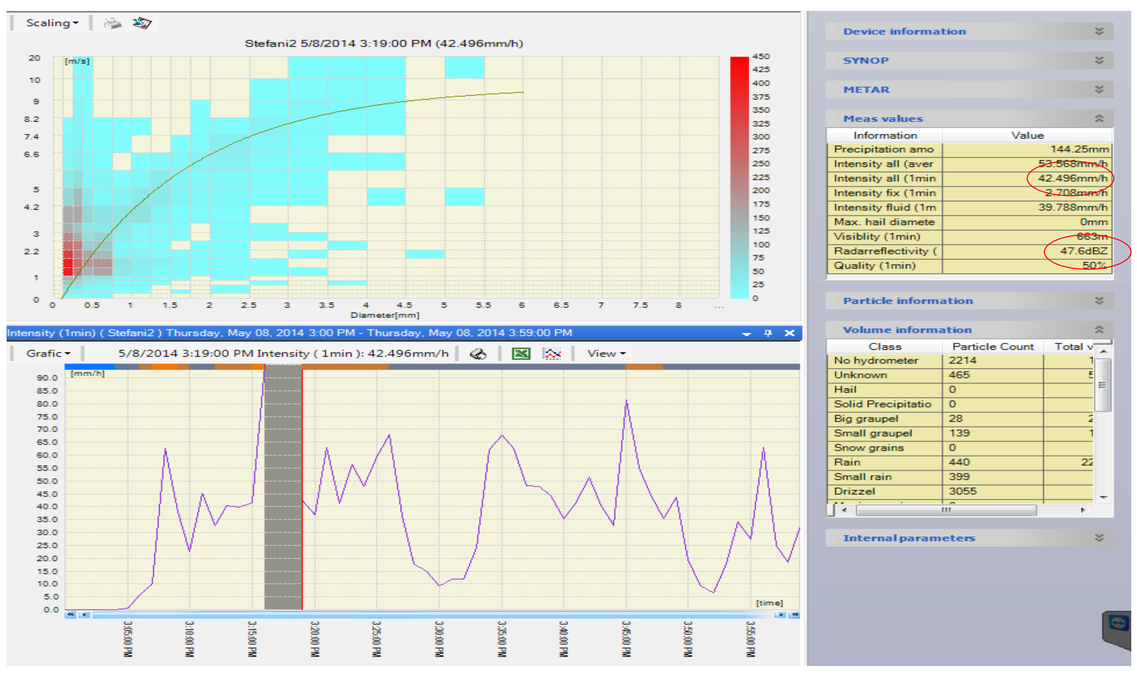

Figure 2: Thies Clima Disdrometer Display; circles shows the radar reflectivity and the precipitation intensity

Figure 3: UPRAg Thies Clima Disdrometer

But we are looking to improve the rainfall rate and study the genesis of the water drops. As we said before, with the introduction of the polarimetric radars we have more information on the hydrometeor, like with the Z_{DR} we know if the water drops are oblate or elongated, and with the K_{DP} we can detect if we have a mixture of ice and rain. We know from the case from the Figure 1, that over the UPRM disdrometer was raining with an intensity of 42.49 $mm \cdot hr^{-1}$. Using equation 2, the rainfall rate is found with polarimetric variables. With this algorithm we can observe that we also have a rainfall intensity around the 40 to 45 $mm \cdot hr^{-1}$, telling us that we have a good algorithm to estimate the precipitation.

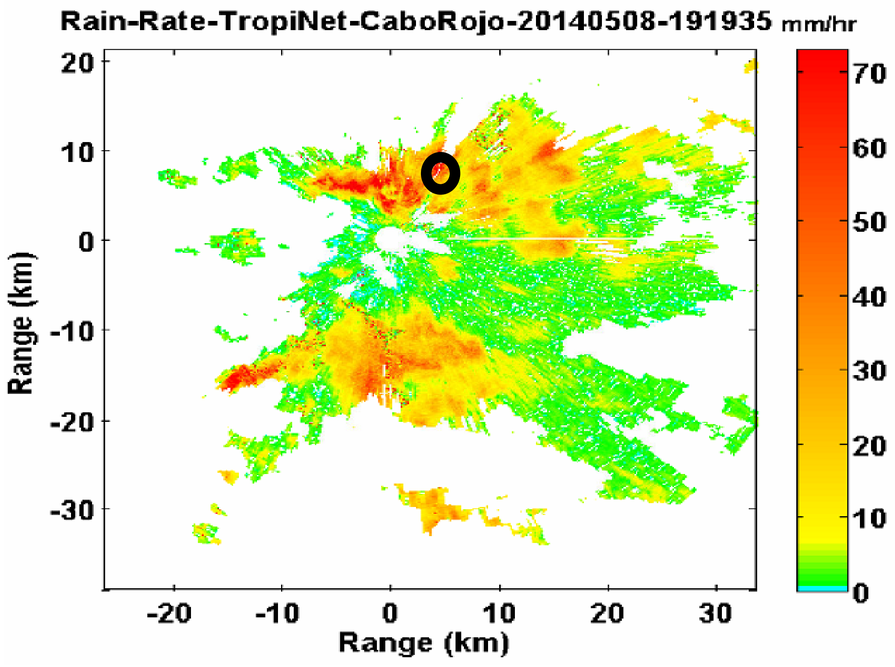

Figure 1: Rainfall Rate for TropiNet Cabo Rojo with polarimetric variables K_{DP} and Z_{DR} , and circle shows the UPRM disdrometer.

Conclusions

The estimation of Rainfall Rate is one reliable algorithm that meteorologist have to alert people of flash floods and save lives. Is of the interest of the PRWRN to provide accurate rainfall data to inform the residents of the west side of Puerto Rico. Since the decades of the 40's, the rainfall rate is estimated only with the radar reflectivity, but with the introduction of the polarimetric variables, new information of the hydrometeors is available. With this new algorithm, we have an improved rainfall rate, which can give us better information and estimation of the rainfall. We cannot only depend on the radar information, but we also need ground instruments such as the rain gauges, to tell us the rainfall intensity and validate the information that is provided by radars. We have been able to develop an algorithm using the 3 polarimetric variables. With this model we have a better estimation of precipitation quantities, and can help prevent major disasters.

Local, Nation and Worldwide Impact

- One radar is already being used by NWS and Emergency Management for the weather monitoring.
- The improved temporal and spatial resolution as well as the proper coverage of the lower atmosphere will help save life and property.
- An immediate impact in the weather forecast of the west coast is expected .
- The network can be expanded and impact the weather forecast in the whole Island
- Countries with mountainous topography can use this technology to cover previously unmonitored areas at relative low-cost

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