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

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Outline

* Coverage Problem
* TropiNet Overview
  * TropiNet complement NWS radar
* What is a Dual-Polarized Radar?
  * Polarimetric Variables
    * Reflectivity
    * Differential Reflectivity
    * Specific Phase Reflectivity
* Disdrometers
* Rainfall Rate Algorithm
  * Rainfall Cases
* Future Work
* Questions
Coverage Problem

Horz. Scale: 1" = 50 km
Vert. Scale: 1" = 2 km
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TropiNet Weather Radar Network

• X-band
• DUAL Polarized
• 1.4 degrees
• 40 km (150m)
• Doppler

Mayor Research Instrument (MRI)
TropiNet will complement NWS radar

Blockage due to Central Mountain Range---NEXRAD 0.5 Elevation

Beam Height at west coast---NEXRAD vs TropiNet
Data Comparison

Date: Sept 9, 2014 Time: 18:48:52 UTC

TropiNet Cabo Rojo

NWS NEXRAD

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Hail Storm over Añasco
Date: Sept 11, 2014 Time: 17:26:06 UTC

TropiNet – Cabo Rojo

NWS NEXRAD

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What is a Dual-Polarized Radar?

- Transmitting both horizontal and vertical polarized signals.
- Improve the accuracy of the precipitation.
- Shape of the hydrometeors
- Doppler velocity
- Drop size Distribution (DSD)
Polarimetric Products

* Reflectivity (Zv, Zh)
* Differential Reflectivity (Zdr)
* Specific Differential Phase (KDP)
* Differential Phase Shift (ΦDP)
* Correlation Coefficient (CC)
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Radar Reflectivity depends on:
- Number of drops per volume;
- Diameters of the Hydrometers

\[
Z = \frac{1024 \ln(2)}{c\pi^3} \left( \frac{\lambda^2}{G^2 P_t \tau \theta \phi} \right) \left( \frac{P_r r^2}{|K_w|^2} \right)
\]

- Radar Constants
- Radar Target Characteristics

\[
dBZ = 10 \log \left( \frac{Z}{mm^6/m^3} \right)
\]

<table>
<thead>
<tr>
<th>dBz Value</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 15</td>
<td>clouds</td>
</tr>
<tr>
<td>15-20</td>
<td>light steady rain</td>
</tr>
<tr>
<td>30-40</td>
<td>showers or heavier rain</td>
</tr>
<tr>
<td>&gt; 50</td>
<td>thunderstorms</td>
</tr>
</tbody>
</table>
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Differential Reflectivity (ZDR)

- Difference between the horizontal and vertical polarizations.
- Typical values: -4 to 7 dB
- Use to detect:
  - hail
  - Melting layer
  - Tornado Debris
- For ZDR >1 to 5 dB Large Drops
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Specific Differential Phase (KDP)

- Range derivative of the differential phase shift along a radial.
- Non meteorological echoes aren’t shown
- Use to detect:
  - Heavy rain mixed with hail
  - Detect the Drop shape
- Example:
  - For hail KDP near 0 deg/km
  - For rain KDP between 0 and 5 deg/km
KDP vs Reflectivity

Puerto Rico Weather Radar Network

dBz

radiam

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Disdrometers

* Electronic Rain Gauge
* Measures:
  * Drop Diameters
  * Drop fall velocity
  * Drop quantity
  * Classify in different hydrometers
  * Rain Intensity
  * Radar Reflectivity
* Estimates Radar Reflectivity from rain fall data

\[
Z = 10 \log \left( \frac{1}{A*t} \sum_{i}^{\infty} \left( \frac{|K_i|^2}{|K_w|^2} \right) \left( \frac{D_i^6}{V_i} \right) \right)
\]

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Disdrometers

Rainfall Rate Algorithm

- Rainfall Cases

Future Work

Questions
The estimation and prediction of the rainfall rate is important to safe home, properties, and most important lives.

Algorithms to estimate Rainfall Rate:

- \( Z_h = aR^b \)
- \( R = c1 K_{DP}^{b1} \)
- \( R (Z_h, Z_{DR}) = a Z_h^b Z_{DR}^c \)
- \( R (K_{DP}, Z_{DR}) = a K_{DP}^b Z_{DR}^c \)
- \( R (Z_h, K_{DP}, Z_{DR}) = 1.0624 Z_h^{0.3} K_{DP}^{0.5} Z_{DR}^{-0.84} \)
Case of Study: May 8, 2014

Location of Disdrometer
UPRM

Reflectivity-TropiNet-CaboRojo-20140508-191935 dBZ

Z=45-50dBZ
Rainfall Rate: Disdrometer Parameters

Disdrometer Parameters

\[ Z = a(RR)^b \]

\[ a = 236.3695857 \]
\[ b = 1.33856652 \]

\[ RR = \left(\frac{Z}{a}\right)^{\frac{1}{b}} \]

Rain Rate Calculation for TropiNet.

RR = 40-45 mm/hr

Location of Disdrometer:

UPRM

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Rainfall Rate algorithm with Reflectivity ($Z$) and Differential Reflectivity ($Z_{DR}$)

Rainfall Rate algorithm with Specific Differential Phase ($K_{DP}$) and Differential Reflectivity ($Z_{DR}$)
Case of Study #1: September 19, 2014

Location of Disdrometer

UPRM

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Rainfall Rate:
Disdrometer Parameters

Disdrometer Parameters

\[ Z = a(RR)^b \]

\[ a = 374.511987 \]

\[ b = 1.3535957 \]

\[ RR = (\frac{Z}{a})^{(1/b)} \]

Rain Rate Calculation for TropiNet

Location of Disdrometer:
UPRM

TropiNet-CaboRojo-20140919-192541

mm/hr

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Rainfall Rate with Multidimensional Nonlinear regression

MNR Parameters $Z(\text{mm}^6/\text{m}^3)$, $Zdr$ y $KDP (\text{km}^{-1})$

$$b=12*Zeh.^{(0.36)}*Kdp.^{0.4}.*Zdr^{1.02};$$

$$RR=\text{abs}(8.2.*b.*KDPX.^{0.81});$$

Location of Disdrometer: UPRM
Rainfall Rate algorithm with Reflectivity ($Z$) and Differential Reflectivity ($Z_{DR}$)

Rainfall Rate algorithm with Specific Differential Phase ($K_{DP}$) and Differential Reflectivity ($Z_{DR}$)
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Future Work

* Develop the Rainfall Rate Algorithm with the polarimetric variables such as:
  * KDP
  * ZDR
  * Combination of Polarimetric Products
* Implement a rainfall rate algorithm in the Off-the-Grid Single Polarized X-band Radar
Questions?