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

Carlos R. Wah Gonzalez
Graduate Student
Electrical and Computer Engineering
Advisors: Dr. Jose Colom,
Dr. Rafael Rodríguez
Dr. Leyda V. León

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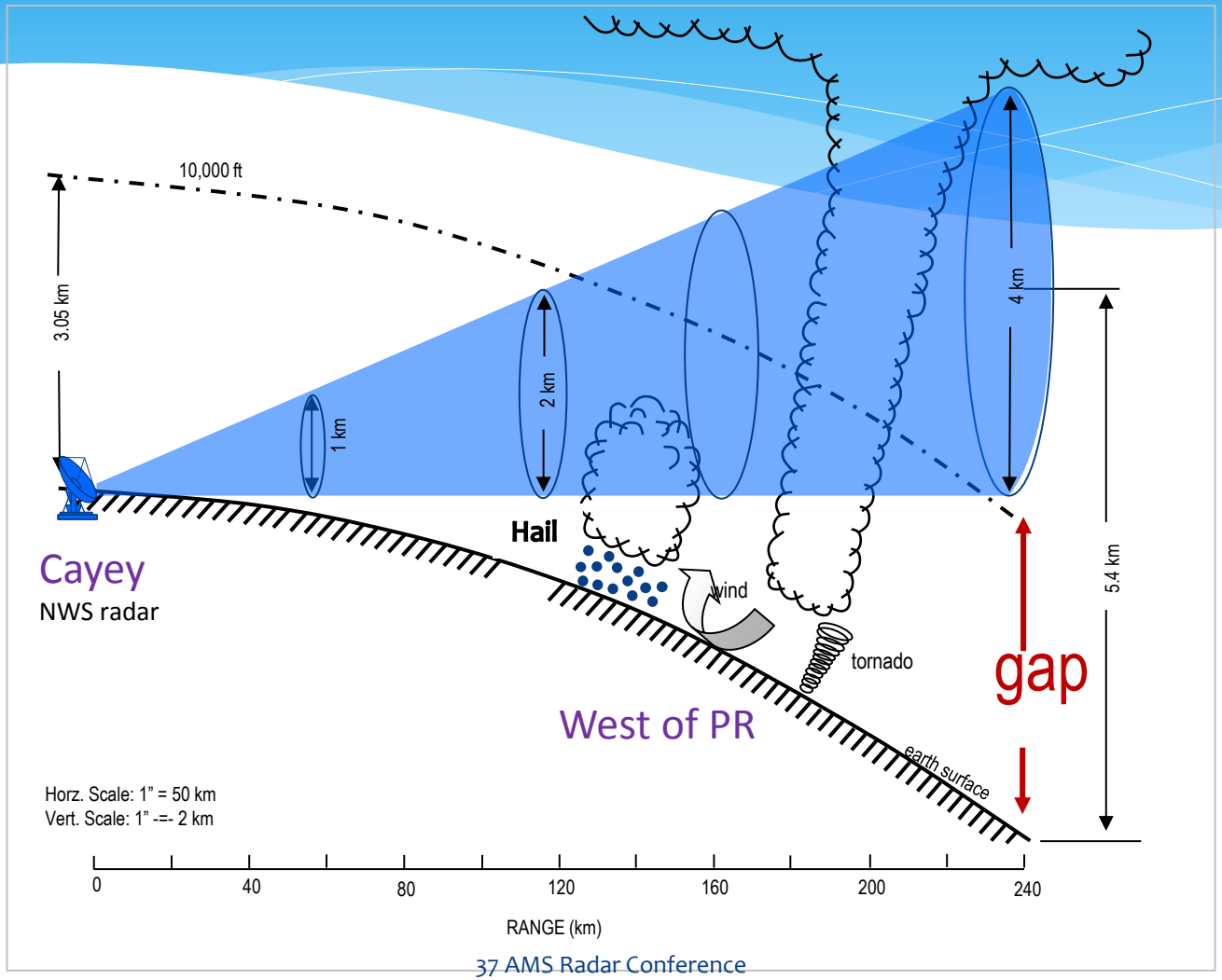
Outline

* 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



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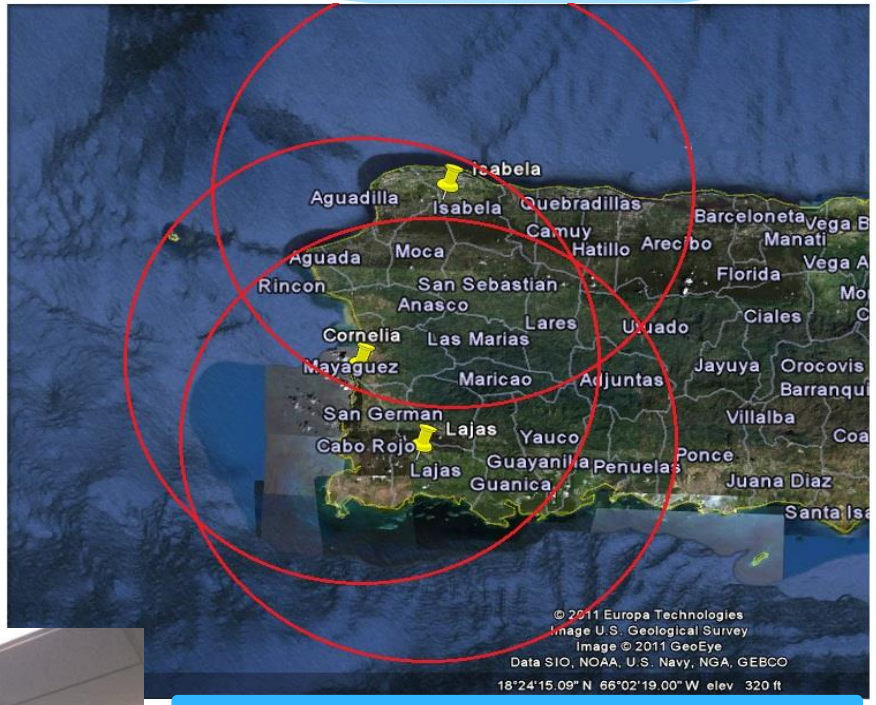
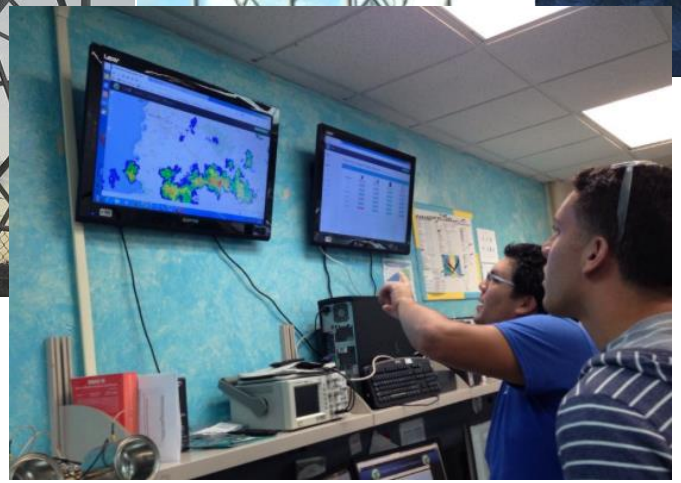
TropiNet Weather Radar Network

Mayor Research Instrument (MRI)





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

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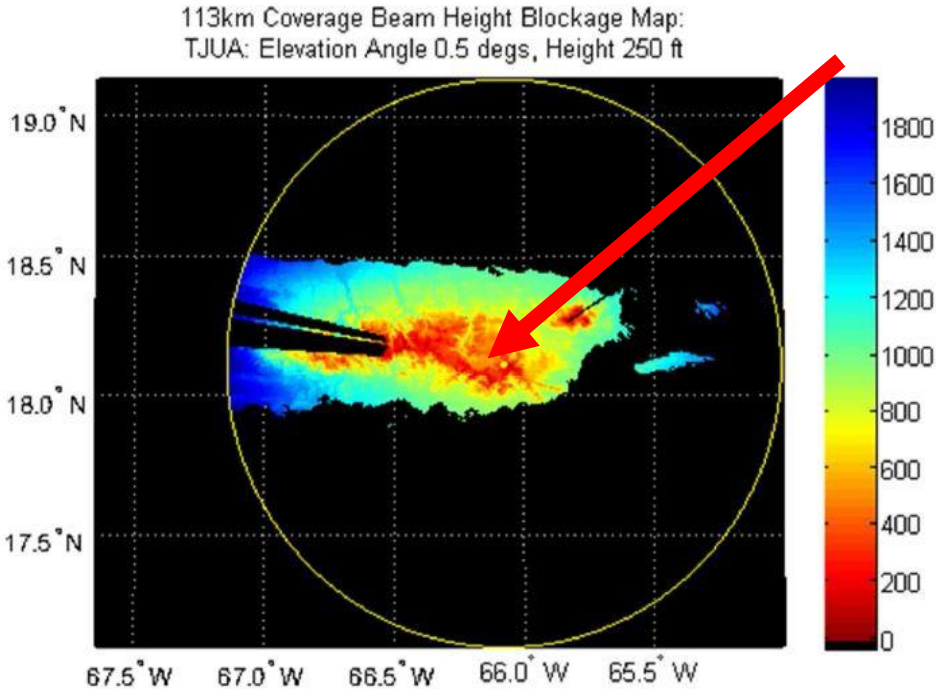
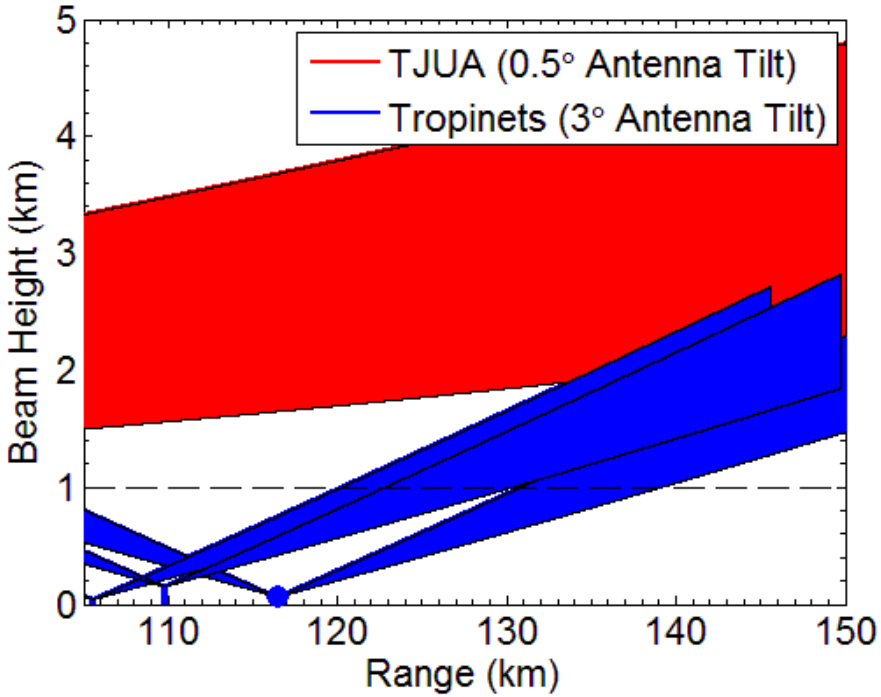
TropiNet will complement NWS radar



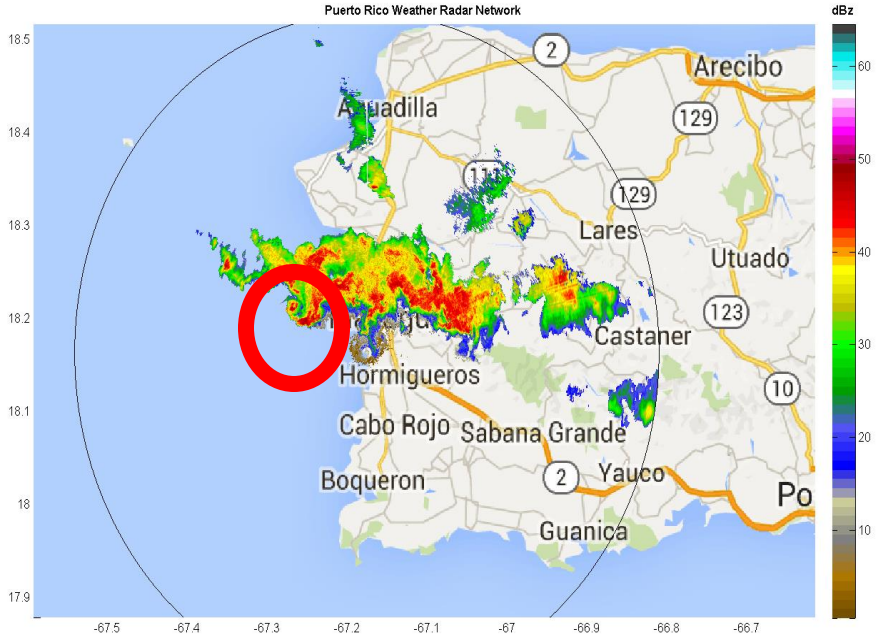
Blockage due to Central Mountain Range---NEXRAD 0.5 Elevation



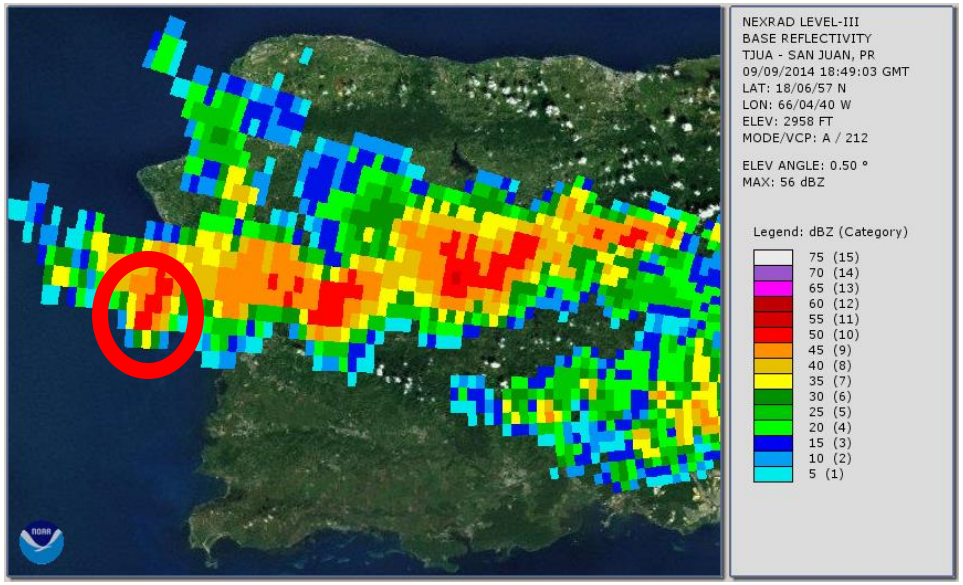
Beam Height at west coast--- NEXRAD vs TropiNet

Data Comparison

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



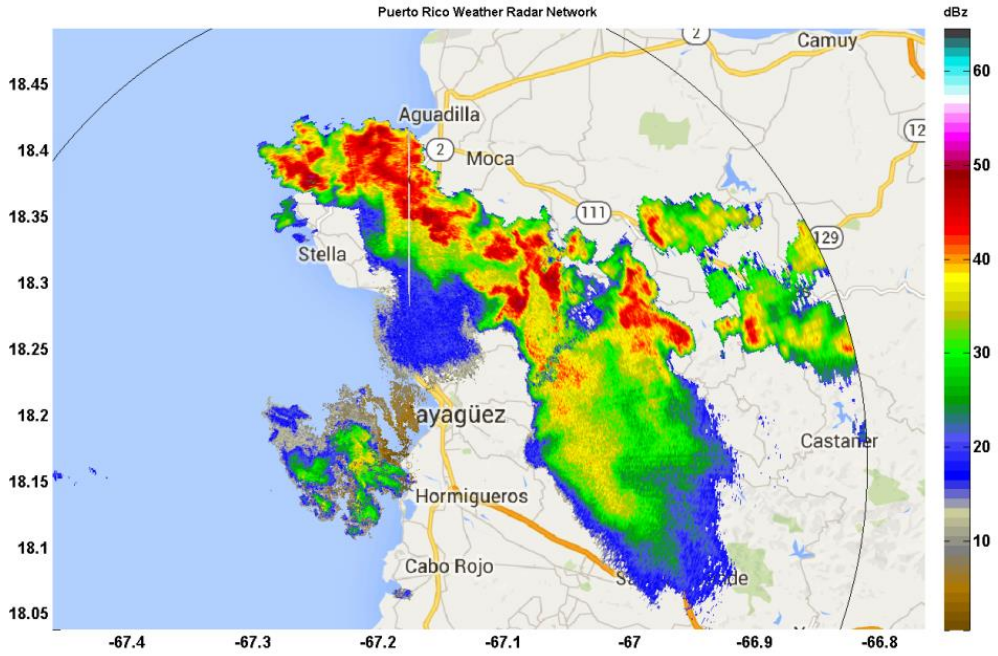
TropiNet Cabo Rojo



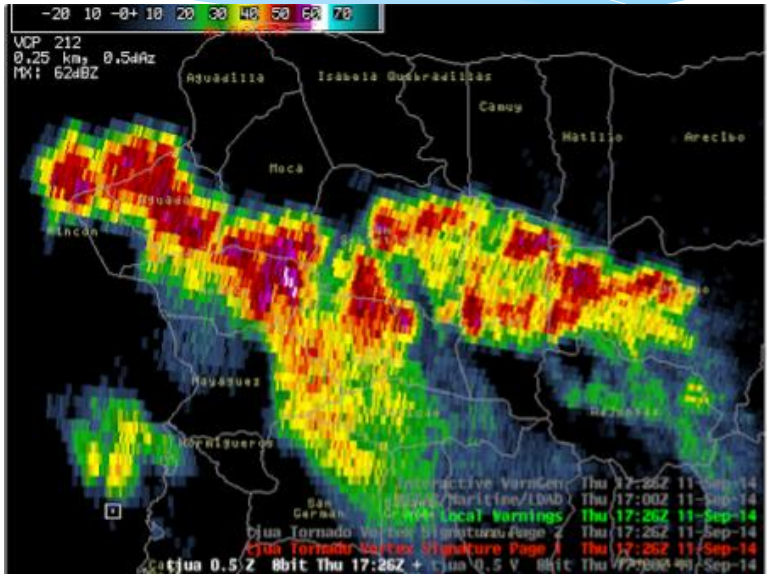
NWS NEXRAD

Hail Storm over Añasco

Date: Sept 11, 2014 Time:17:26:06 UTC



TropiNet – Cabo Rojo



NWS NEXRAD

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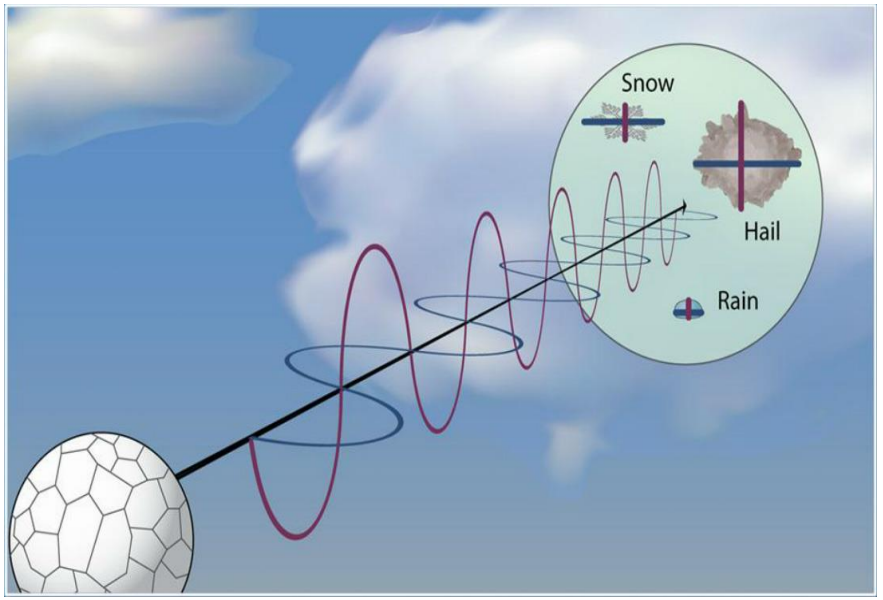
What is a Dual-Polarized Radar?

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



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Polarimetric Products

* Reflectivity (Zv, Zh)
* Differential Reflectivity (Zdr)
* Specific Differential Phase (KDP)
* Differential Phase Shift (ΦDP)
* Correlation Coefficient (CC)

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Reflectivity (Z)

* Radar Reflectivity depends on:
  * Number of drops per volume;
  * Diameters of the Hydrometers

* $Z = \underbrace{\frac{1024 \ln(2)}{c\pi^3}}_{\text{Radar Constants}} \underbrace{\left(\frac{\lambda^2}{G^2 P_t \tau \theta \phi}\right)}_{\text{Radar Characteristics}} \underbrace{\left(\frac{P_r r^2}{|K_w|^2}\right)}_{\text{Target}}$

* $dBZ = 10 \log\left(\frac{Z}{1\frac{mm^6}{m^3}}\right)$

dBz Value	Interpretation
< 15	clouds
15-20	light steady rain
30-40	showers or heavier rain
> 50	thunderstorms

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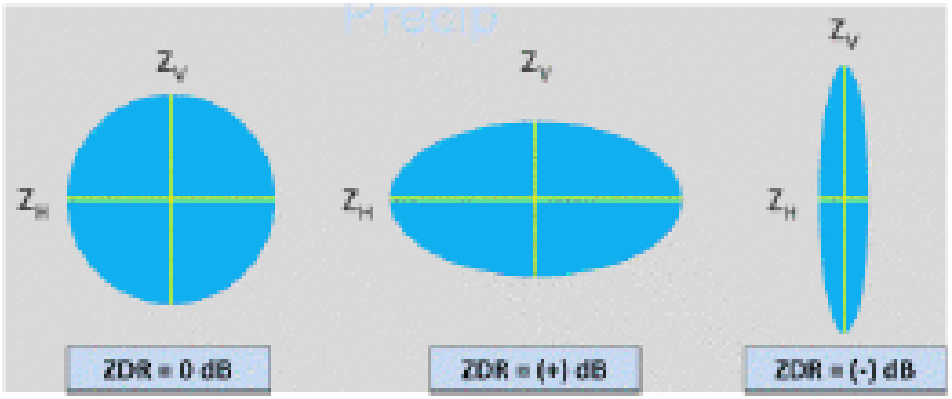
Differential Reflectivity (ZDR)

* 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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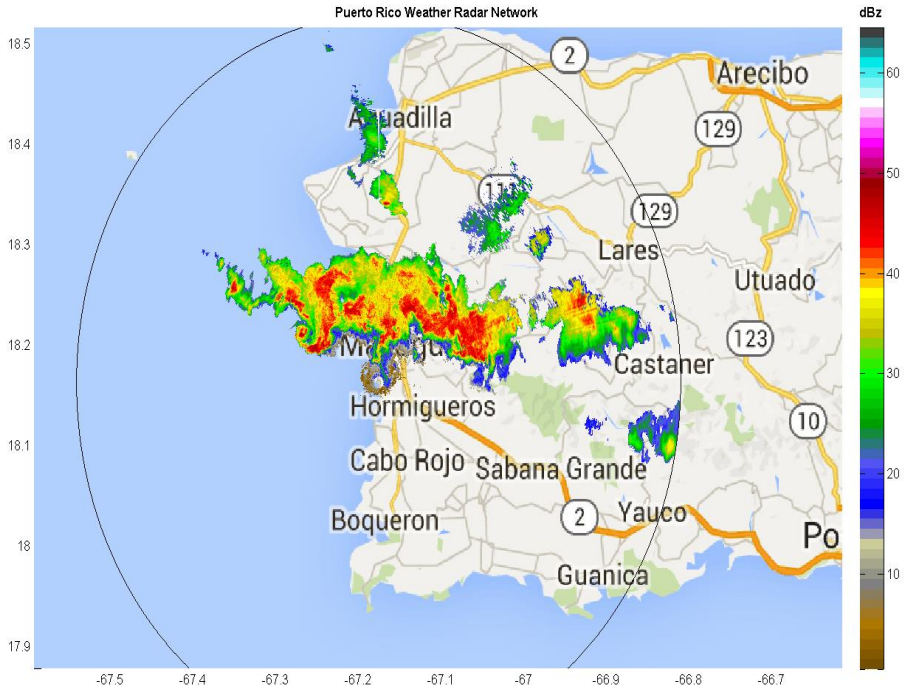
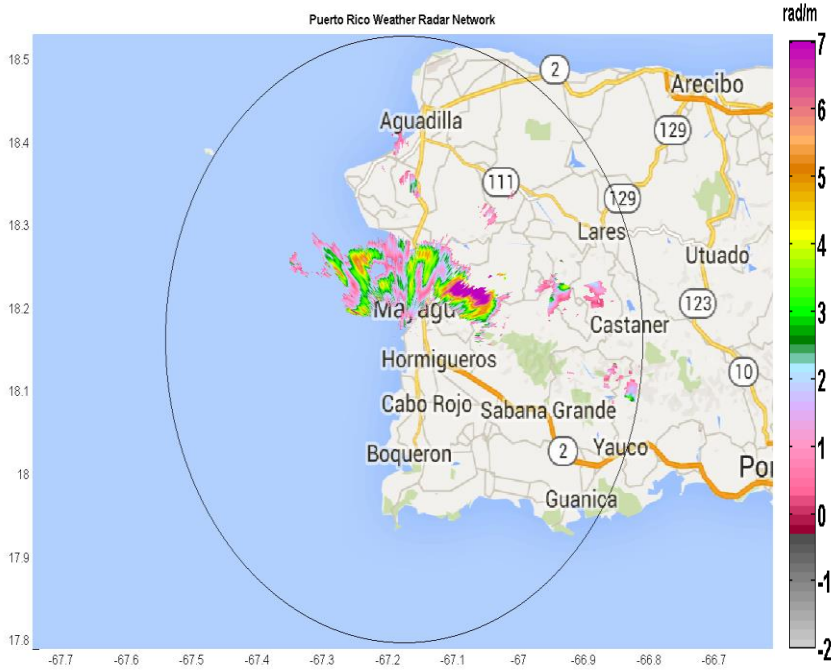
Specific Differential Phase (KDP)

* 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





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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

$$Z = 10 \log \frac{1}{A*t} \sum_{i}^{\infty} \left(\frac{|Ki|^2}{|Kw|^2} \right) \left(\frac{Di^6}{Vi} \right)$$

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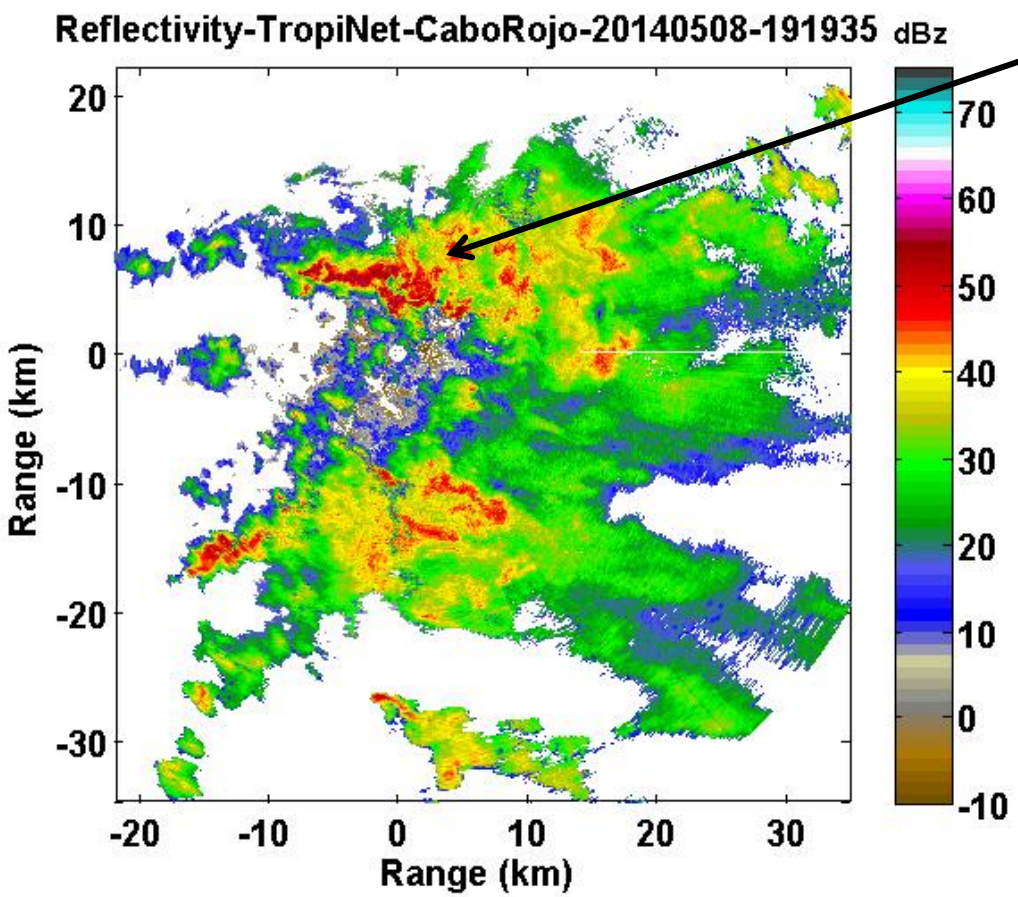
Rainfall Rate

* The estimation and prediction of the rainfall rate is important to safe home, properties, and most important lives.
* Algorithms to estimate Rainfall Rate:
  * $Z_h = aR^b$
  * $R = c1\ K_{DP}^{b1}$
  * $R\ (Z_h, Z_{DR}) = a\ Z_h^b\ Z_{DR}^c$
  * $R\ (K_{DP}, Z_{DR}) = a\ K_{DP}^b\ Z_{DR}^c$
  * $R\ (Z_h, K_{DP}, Z_{DR}) = 1.0624\ Z_h^{0.3}\ K_{DP}^{0.5}\ Z_{DR}^{-0.84}$

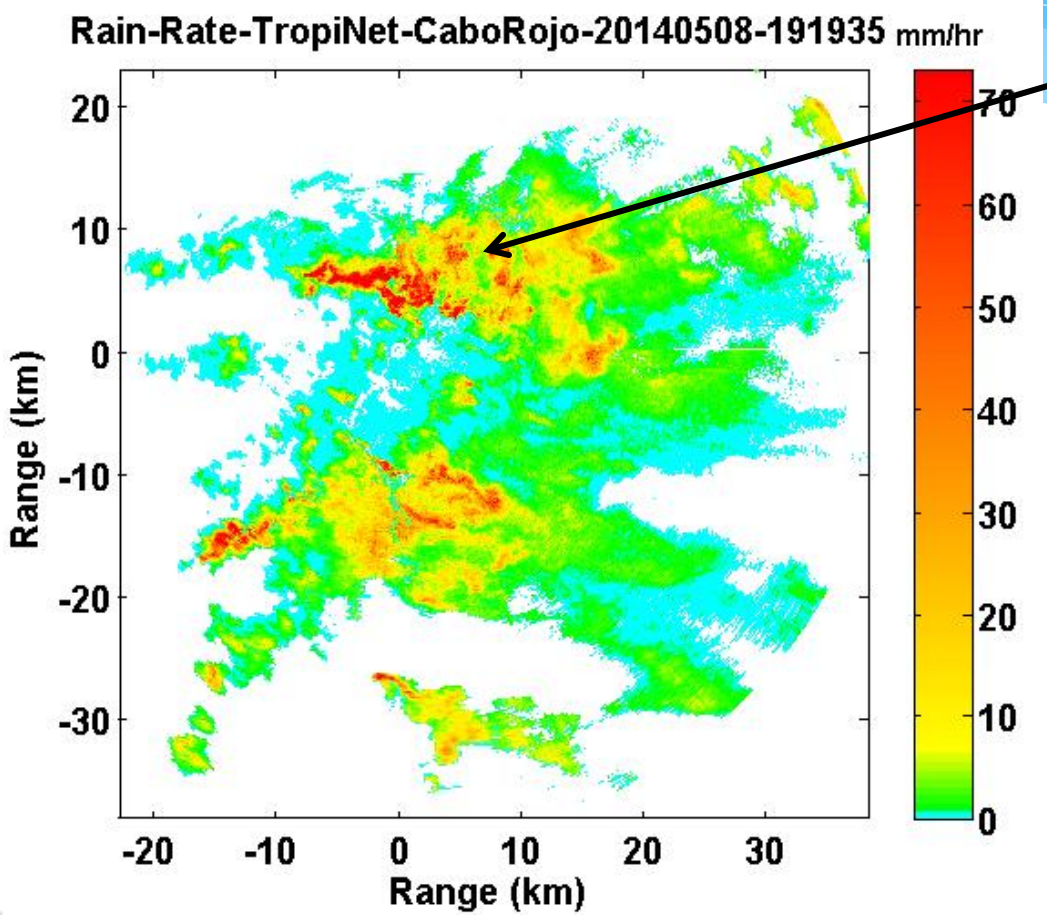
Case of Study: May 8,2014



Location of Disdrometer UPRM

Z=45-50dBZ

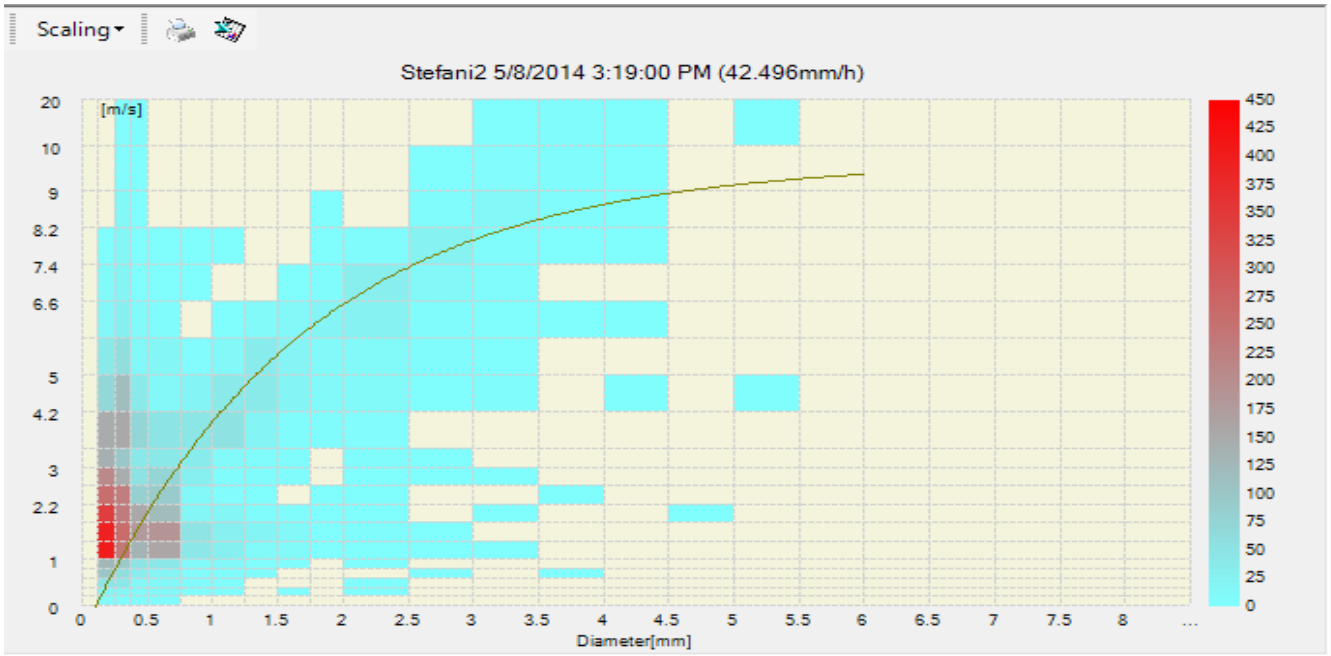
Rainfall Rate: Disdrometer Parameters

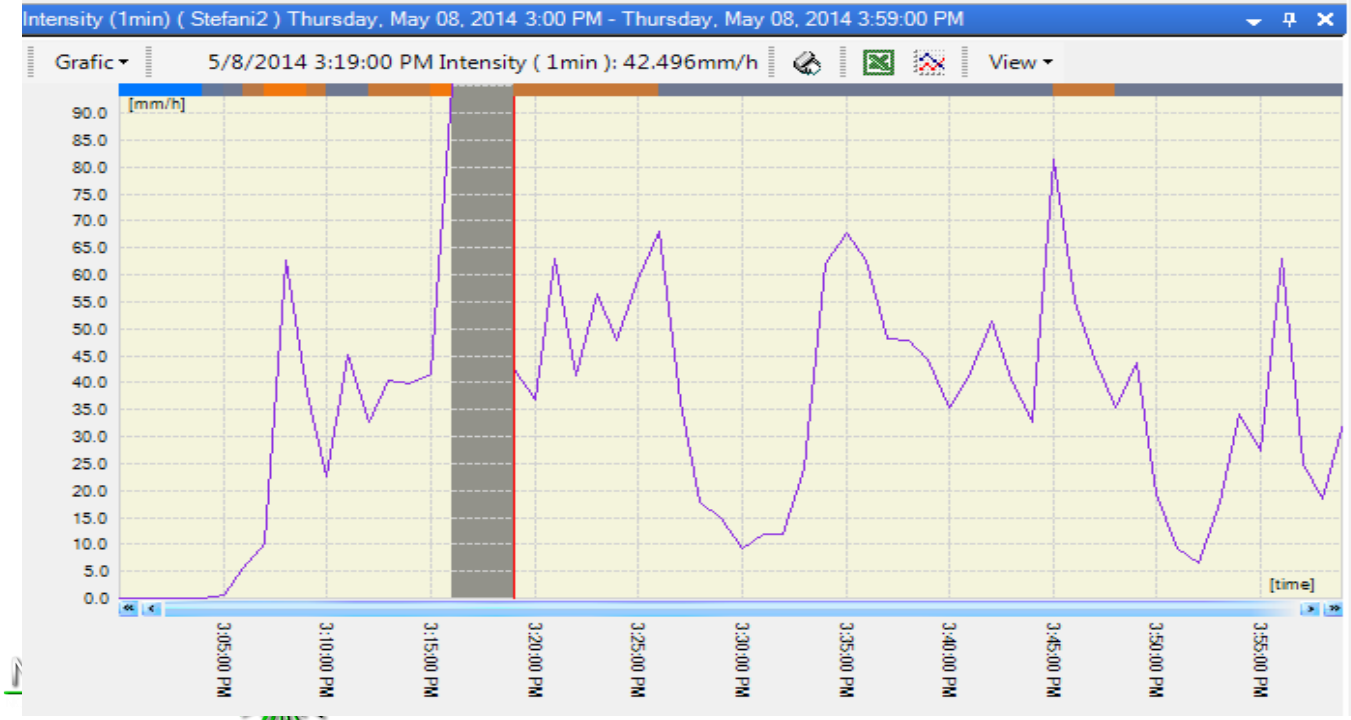


Location of Disdrometer: UPRM

Disdrometer Parameters
Z=a(RR)^b a=236.3695857
b=1.33856652
RR=((Z/a).^(1/b));
Rain Rate Calculation for TropiNet.

RR= 40-45mm/hr





Device information

SYNOP

METAR

Meas values

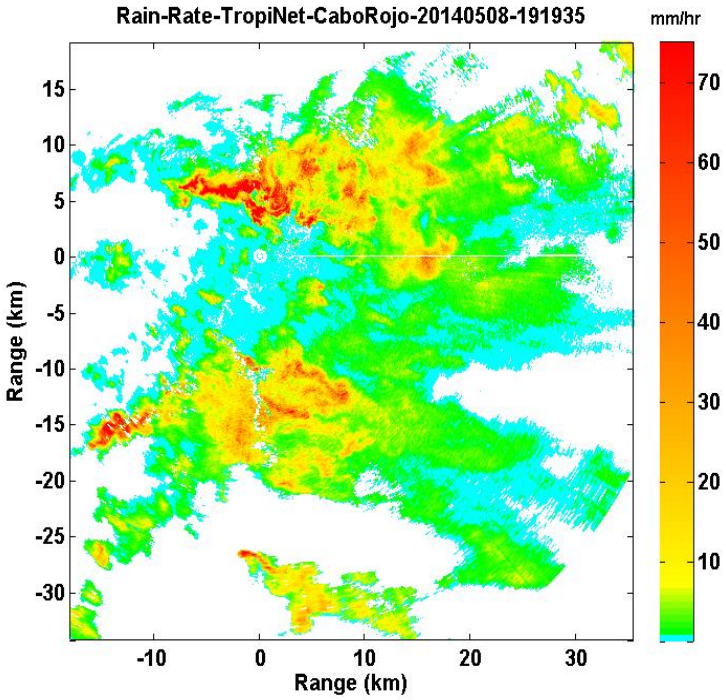
Information	Value
Precipitation amo	144.25mm
Intensity all (aver	53.568mm/h
Intensity all (1min	42.496mm/h
Intensity fix (1min	2.708mm/h
Intensity fluid (1m	39.788mm/h
Max. hail diamete	0mm
Visiblity (1min)	663m
Radarreflectivity (	47.6dBZ
Quality (1min)	50%

Particle information

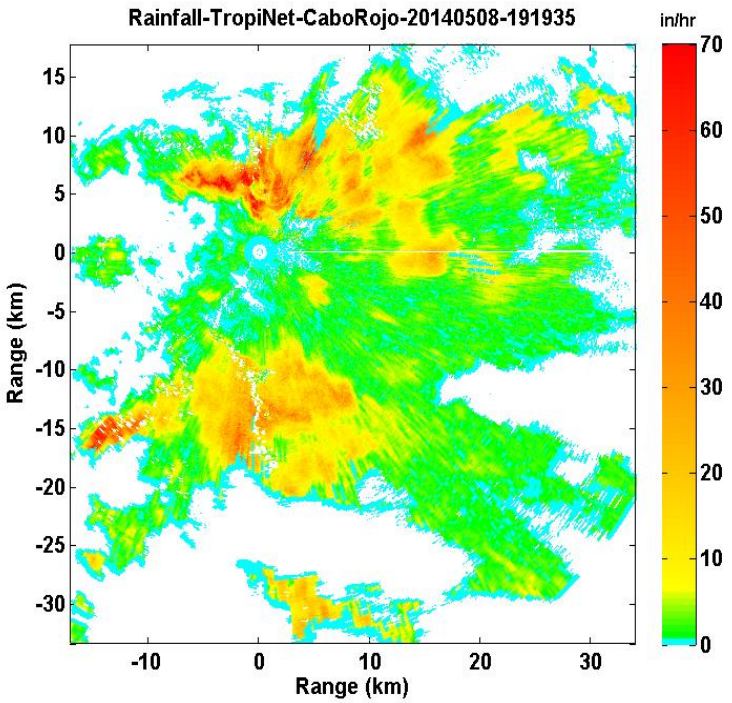
Volume information

Class	Particle Count	Total v
No hydrometer	2214	1
Unknown	465	5
Hail	0	
Solid Precipitatio	0	
Big graupel	28	2
Small graupel	139	1
Snow grains	0	
Rain	440	22
Small rain	399	
Drizzel	3055	

Internal parameters

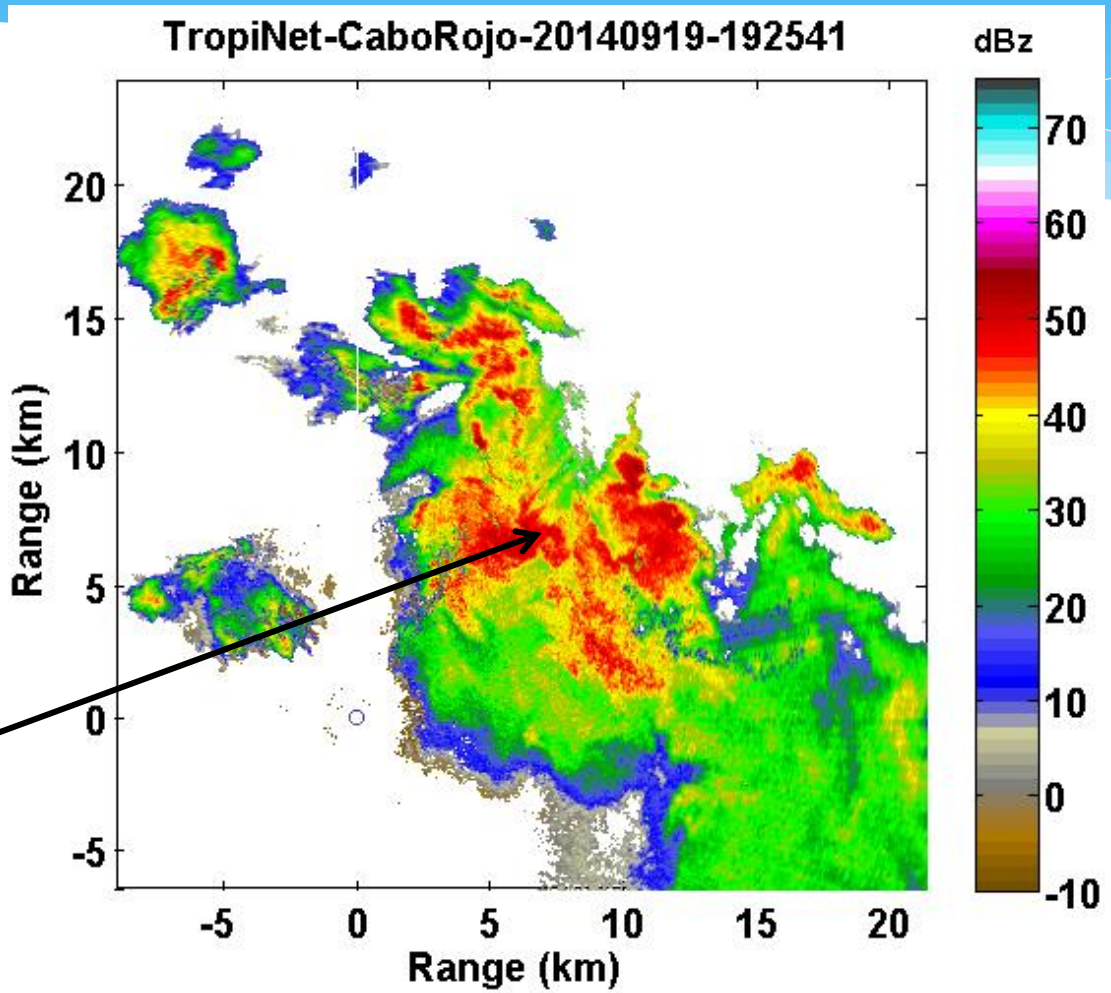


Rainfall Rate algorithm with Reflectivity (Z) and Differential Reflectivity (Z_{DR})



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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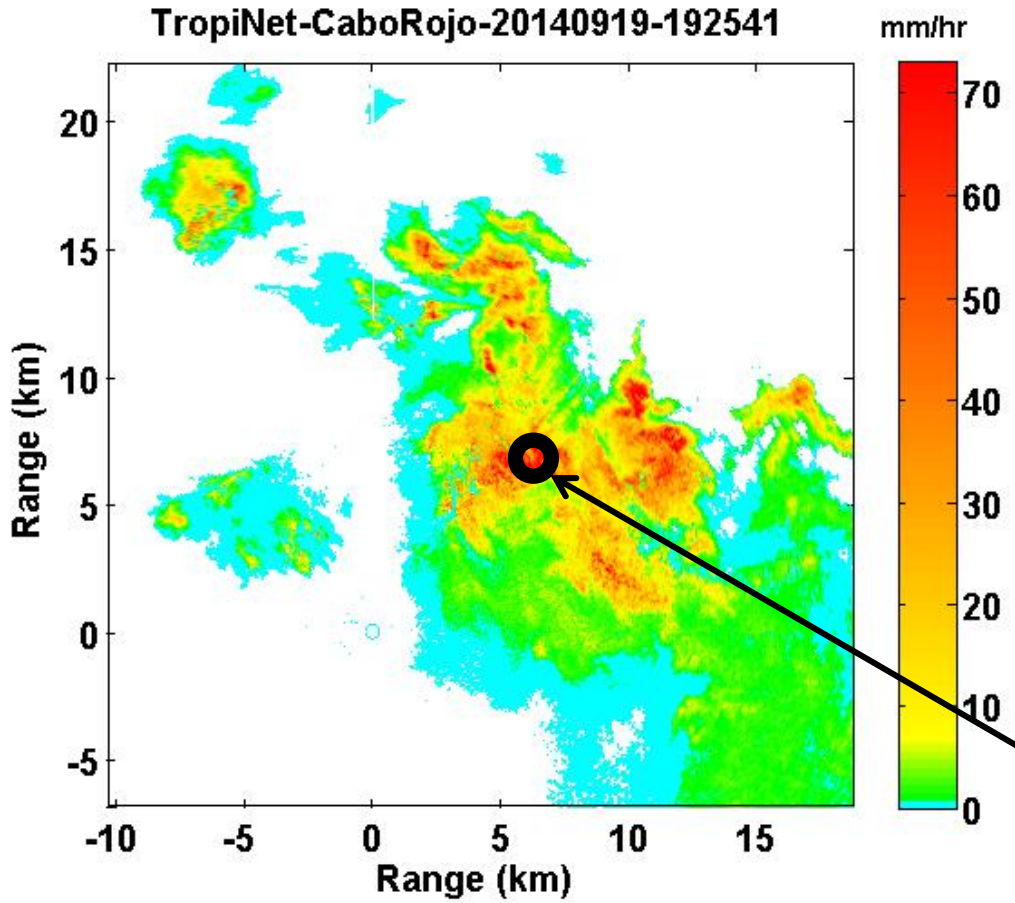
Rainfall Rate: Disdrometer Parameters



Disdrometer Parameters
Z=a(RR)^b a=374.511987
b=1.3535957
RR=((Z/a).^(1/b));
Rain Rate Calculation for TropiNet

Location of Disdrometer: UPRM

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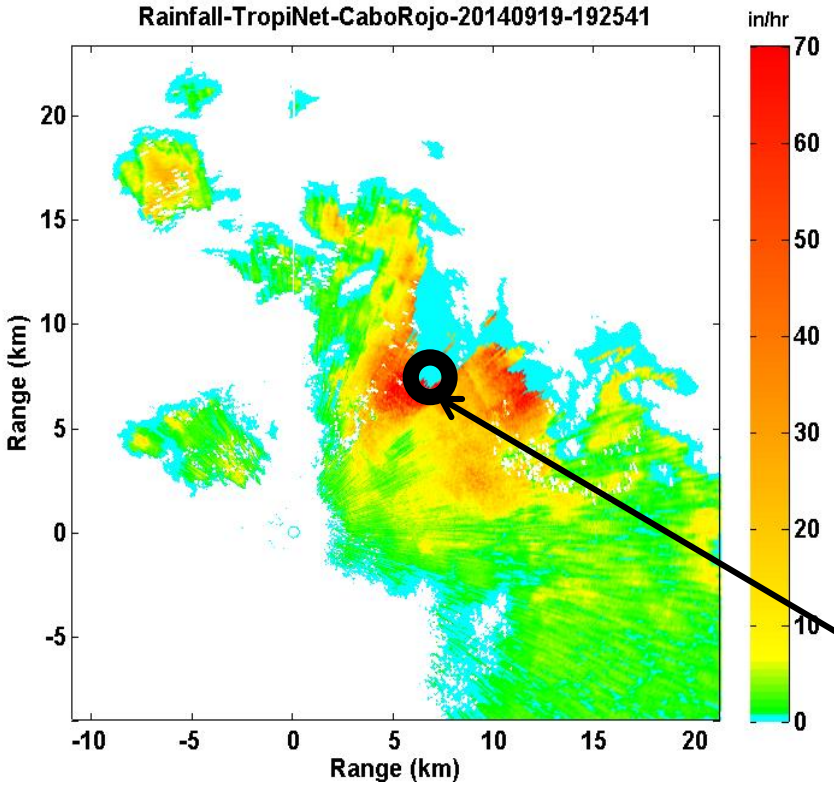
Rainfall Rate with Multidimensional Nonlinear regression

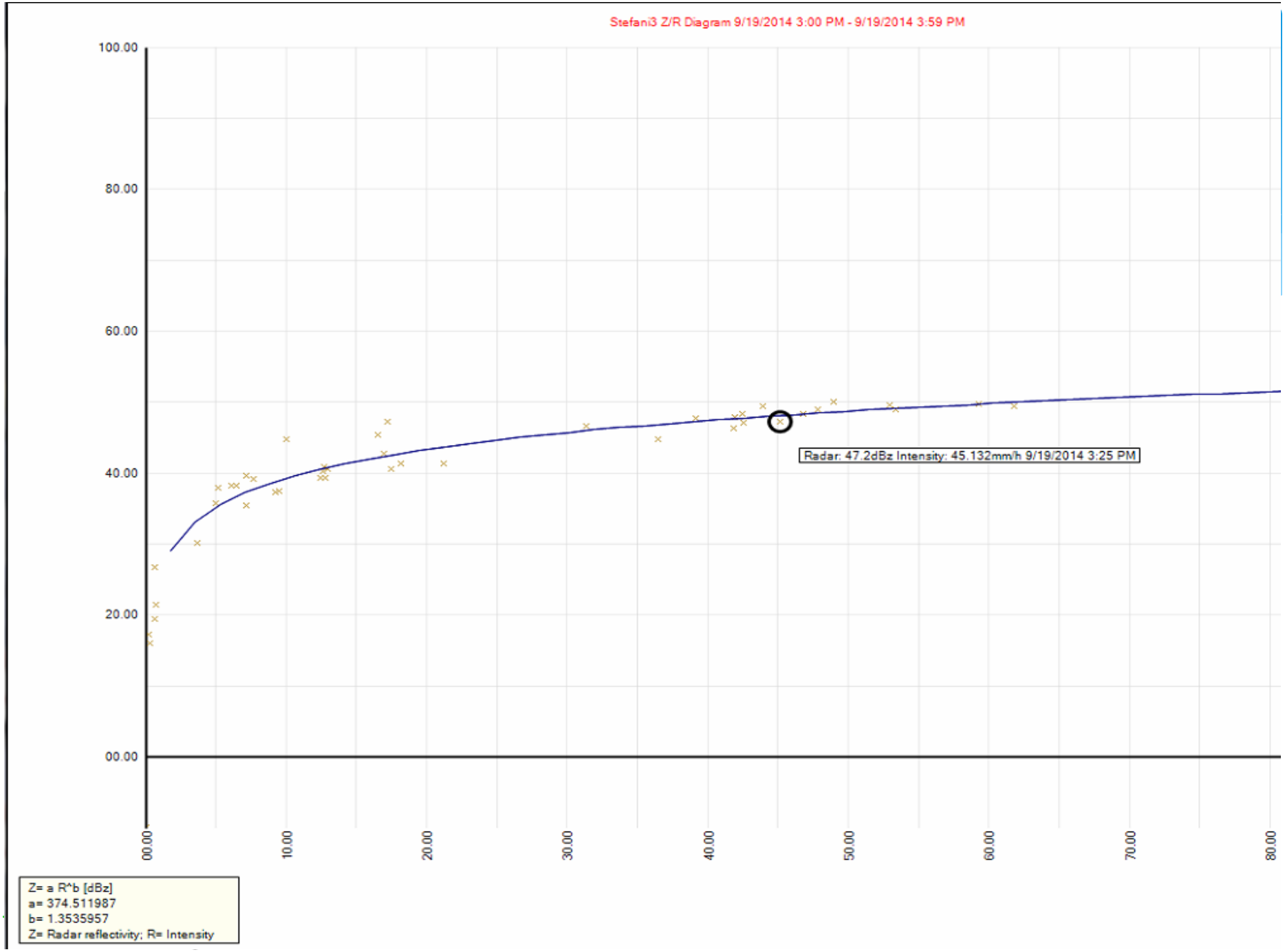


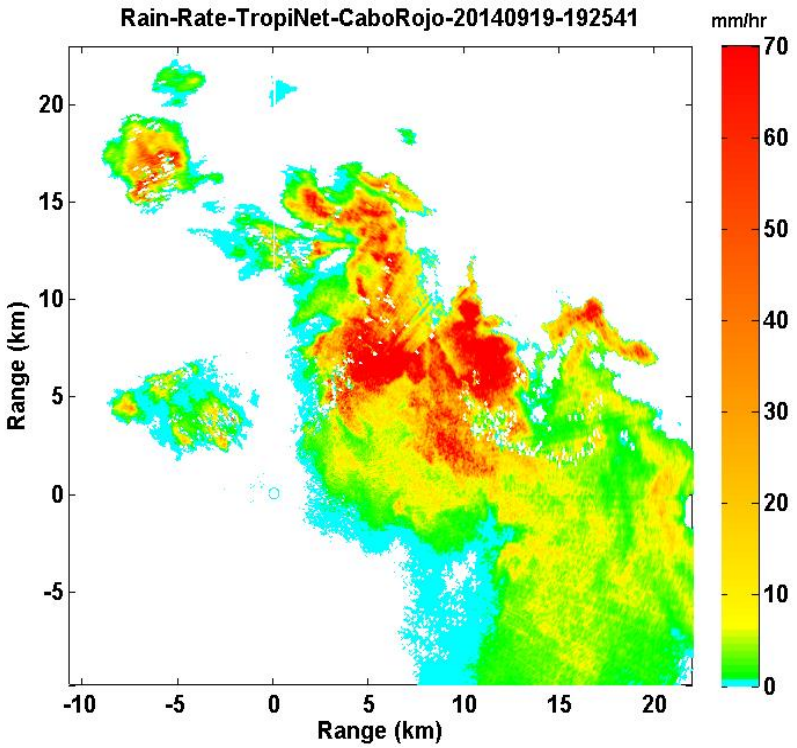
MNR
Parameters Z(mm^6/m^3),
Zdr y KDP (km^-1)

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

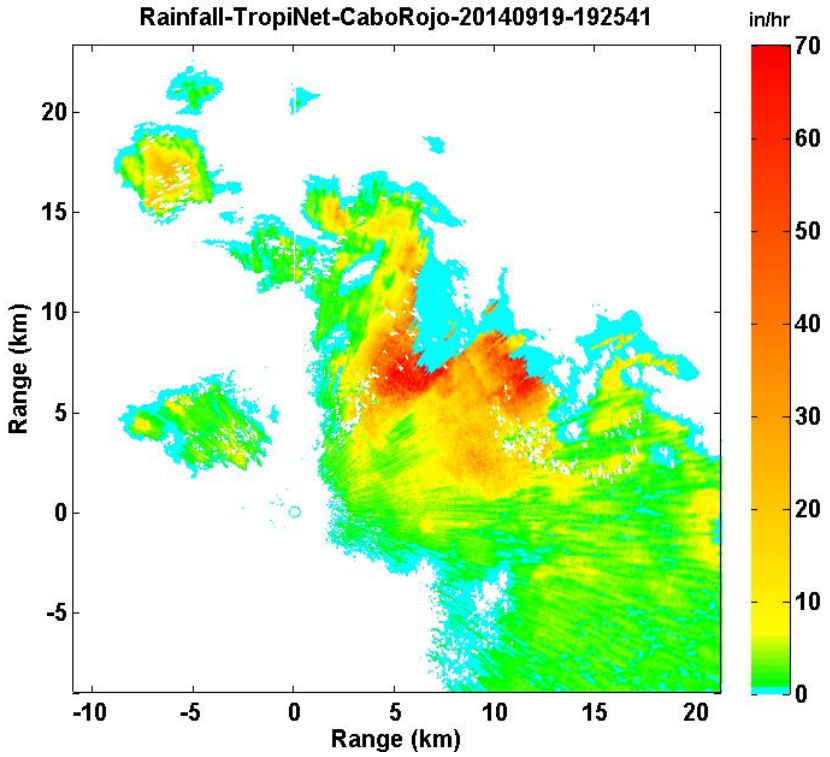
RR=abs(8.2.*b.*KDPX.^0.81);

Location of Disdrometer: UPRM


Stefani3 Z/R Diagram 9/19/2014 3:00 PM - 9/19/2014 3:59 PM
100.00
80.00
60.00
40.00
20.00
00.00
00.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
Radar: 47.2dBz Intensity: 45.132mm/h 9/19/2014 3:25 PM
Z= a R^b [dBz]
a= 374.511987
b= 1.3535957
Z= Radar reflectivity; R= Intensity



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



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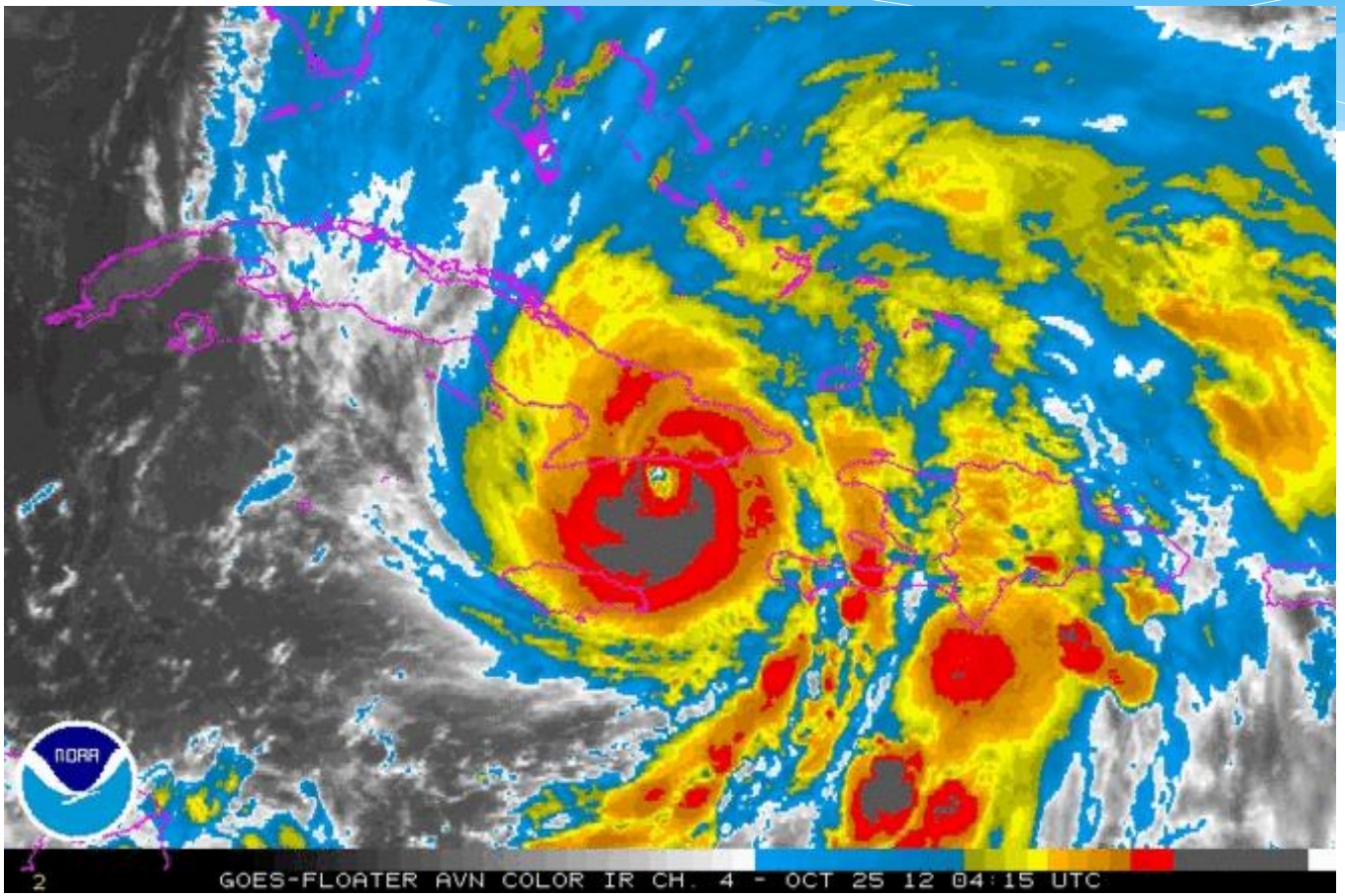
Future Work

* 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?



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