Puerto Rico Student Test Bed

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Overview

• What is CASA?
  – Student Test Bed (STB)

• Magnetron Radar
  – Quantitative Precipitation Estimation (QPE) Study
  – Data Validation
  – Radar Specifications

• Off-the-Grid Radar
  – Antenna
What is CASA?

• **Collaborative Adaptive Sensing of the Atmosphere**
• NSF Engineering Research Center Program
  – Established in 2003
• Objective
  – To create a new engineering paradigm in observing, detecting and predicting weather and other atmospheric phenomena.
• Partner Universities
  – University of Massachusetts
  – Colorado State University
  – University of Oklahoma
  – University of Puerto Rico at Mayaguez
Student Test Bed

• Objective
  – To establish a QPE sensing network starting in the western end of the island taking into consideration coverage gaps from NEXRAD.

• Radar Sites
  – Three sites were selected based on geographical data and sociological impact. These are located in Mayagüez, Aguadilla and Lajas.
Student Test Bed

SLT Area
Flooding Areas in Western Puerto Rico

SLT Area
Weighted Total Population

Legend
- puntos_estación lejas_Layer
- pr_northwest_100FEMAPoly
- Counties
- pr_northwest_100FEMAPoly_INT
- bloques SLT

Legend
- Radar/Sifiers_Eventa_2_inter vals
SLT Block Demographics include computed area IMPOP
- 5.00 - 10.12
- 10.13 - 14.46
- 14.47 - 16.43
- 16.44 - 20.49
- 20.50 - 24.90
- 24.91 - 30.25
- 30.26 - 40.25
- puntos_estación lejas_Layer
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QPE Study

- Quantitative Precipitation Estimation
  - One of main efforts of CASA
  - Studies using 2-D video disdrometer performed
  - QPE using attenuating wavelength
    - X-Band Radar
QPE Study

- Path-Integrated Attenuation (PIA)
  - Study performed by Delrieu et al. [1]
    - Grenoble, France
  - Surface Reference Technique
  - Ratio of mountain returns
    - Presence and absence of rain
  - Later used for rain rate calculations
    - Rain rate retrieval algorithm not yet selected
QPE Study

• Methodology
  – Low elevation angle
  – Identify mountain cluttered radar bins using apparent reflectivity
    • Calculate average $Z_a$ over cluttered bins during dry period
    • Compare to average $Z_a$ during rain event
  – Perform rain rate retrieval
Data Validation

• Several Tipping-Bucket Rain Gauges
  – Located along propagation path

• Joss Waldvogel Impact Disdrometer
  – Rain Drop Size Distribution (DSD)
  – Expected Reflectivity Calculations
Radar Specifications

- Raytheon Marine X-Band Radar
- Single Polarization
  - Magnetron
    - $F = 9.41 \text{ GHz}$
    - $P_{\text{peak}} = 25 \text{ kW}$
    - Duty Cycle$_{\text{max}} = 0.001$
Radar Specifications

• Modifications
  – Antenna
    • 1.22m Parabolic Dish
    • $G = 38$ dB
    • $2.0^\circ$ HPBeamwidth
  – Spinner
    • Originally 25 RPM
    • Lowered to 3 RPM
Radar Specifications

• Modifications
  – Data System
    • Linux based Mini-ITX embedded system
    • 12 Bit ADC for sampling video signal
    • 802.11b data transport to data archive server
  – Control
    • FPGA on PCI bus for timing signals and antenna position encoder data
Radar Specifications

• Location
  – Roof of electrical engineering building at UPRM
  – Tower already installed
Radar Specifications

Raytheon X-Band Radar
Modified Front End Diagram

- Magnetron
  - 9.41 GHz
  - P = 25 kW = 74 dBm

- Isolator
  - IL = 0.4 dB

- Power Sampler
  - IL = 50 dB

- Attenuator
  - IL = 35 dB

- Power Combiner

- Circulator
  - IL = 0.5 dB
  - Isolation = 25 dB

- Limiter
  - Pmax = 26 dBm
  - IL = 2 dB

- PIN Switch (Reflective)
  - IL = 0.85 dB
  - Isolation ≥ 67 dB

- LNA
  - Gain = 7.0 dB
  - P1dB = -8 dBm
  - F = 3.5 dB

- VCO
  - 9.470 GHz

- IR Mixer
- 60 MHz

- To Data System

Receiver Noise Figure = 8.00 dB
Receiver Dynamic Range = 91.74 dB
OTG Antenna

- Physical size: 17” by 17”
- Material: TLY-3 from Taconic
  - Er = 2.2, h = 0.787mm
- Resonant Frequency = 9.38GHz[*]
- Antenna tested in RadLab.
- The antenna did not perform as expected.

[*] result given by Designer
OTG Antenna

- BW of single-pol antenna: 9.25 - 9.6 GHz [VSWR < 2].
- Higher side-lobes in left side of the pattern due to undesired radiation in the corporate feed.

[measured in Radiation Lab.]
OTG Antenna

• A multi-layer antenna is under design for dual polarization.

• Both polarizations are fed by aperture coupling.

• The array antenna will have rows of these patches connected in series.

• Resonant Frequency: 9.5 GHz [*]

• Cross-polarization: Around 29 dB for a single patch for each polarization is expected.

• This patch exhibits linear polarization and/or circular polarization if desired.
Latest Achievements

• Radar antenna moved to Stefani building rooftop.
Questions