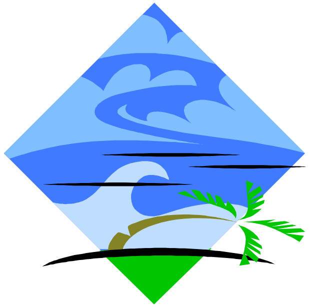


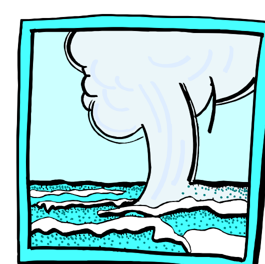
Extreme Weather Events
ERC (TropiNet – UPRM Testbed)

Program: NSF ERC
Deadline: Dec 17, 2002

UPRM Team: José G. Colom Ustáriz, Sandra Cruz Pol, Rafael Rodríguez Solís, Walter Díaz, Havidán Rodríguez, Lionel Orama

University of Puerto Rico – Mayaguez

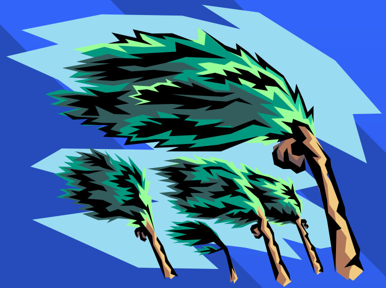
August 30, 2002




NASA
N817NA

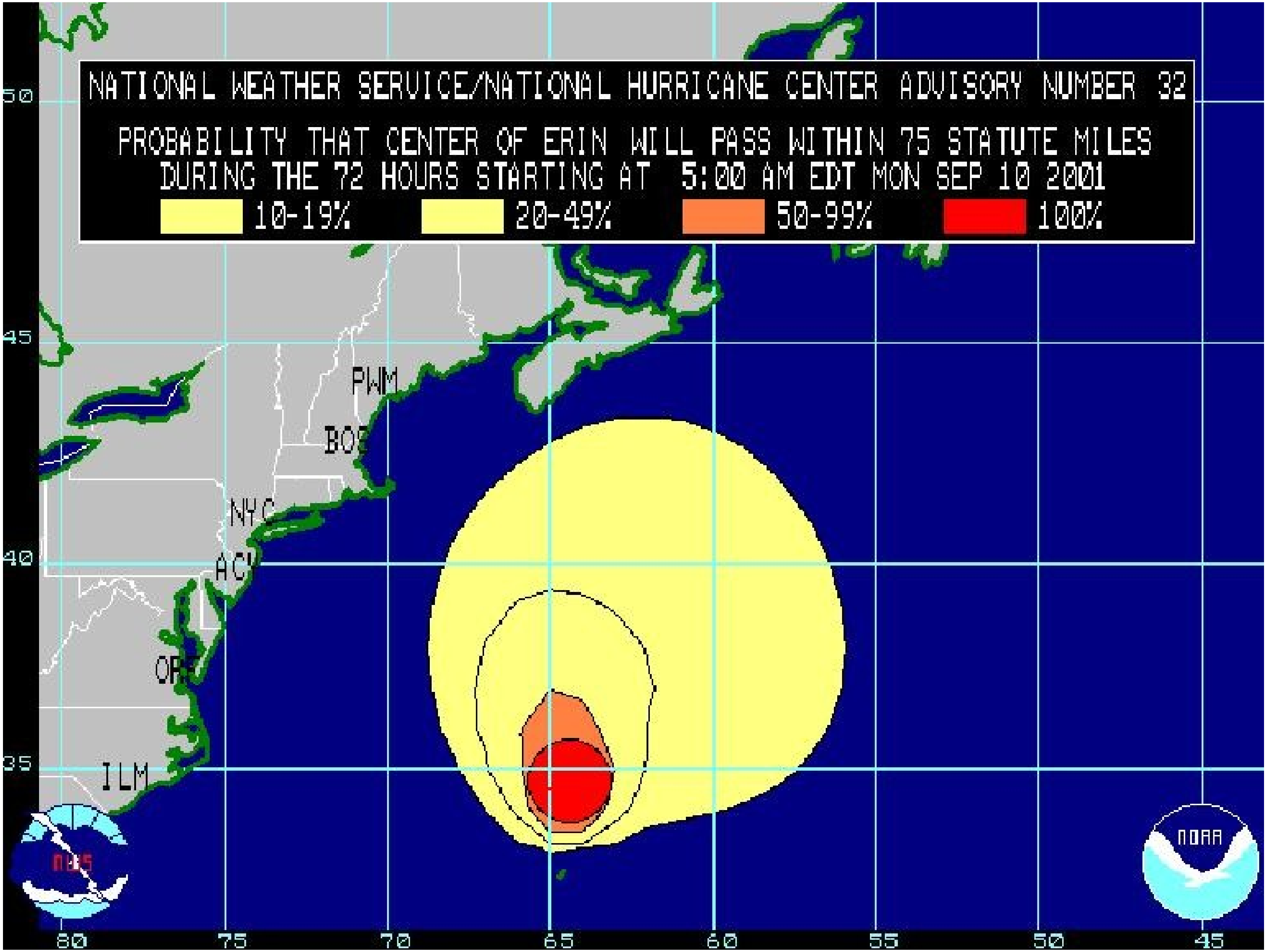
Academic Partners

- University of Massachusetts –Dr. David McLaughlin
- Colorado State University – Dr. Steven A. Rutledge, Dr. V. Chandrasekar
- University of Oklahoma – Kelvin K. Droegemeier
- Mount Holyoke College, MA



Hurricanes

- Hurricanes are large, tropical storm systems that form and develop over the warm waters near the equator.
- They are responsible for weather that can devastate entire communities:
  - Heavy rain -- Flooding
  - Strong Winds
  - Very Large Waves and Storm Surge
  - Possibly Tornadoes


NATIONAL WEATHER SERVICE/NATIONAL HURRICANE CENTER ADVISORY NUMBER 32
PROBABILITY THAT CENTER OF ERIN WILL PASS WITHIN 75 STATUTE MILES
DURING THE 72 HOURS STARTING AT 5:00 AM EDT MON SEP 10 2001
10-19%
20-49%
50-99%
100%
PWM
BOS
NYC
AC
ORF
ILM
50
45
40
35
80
75
70
65
60
55
50
45
NWS
NOAA

Flash Floods - #1 Weather Related Killer in US

Rapid City, SD (1972)	
238 fatalities	$164 million damage
Dallas, TX (1995)	
16 fatalities	$1 billion damage
Ft. Collins, CO (1997)	
5 fatalities	$100 million damage
Hurricane Mitch (1998)	
>10,000 fatalities in Central America	

How can we improve the forecast and effectively manage the impact of landfalling hurricanes?

How can we reliably detect and warn against deadly tornadoes?

How can we predict flash floods, damaging hail, and severe thunderstorms several hours in advance?

How can we reduce weather-related air traffic delays?

How do we effectively manage the flow of weather information before, during, and after a natural disaster?

Coverage Floor at R_{max}

Source: Assessment of NEXRAD Coverage and Associated Weather Services, National Research Council, National Academy Press, 1995.

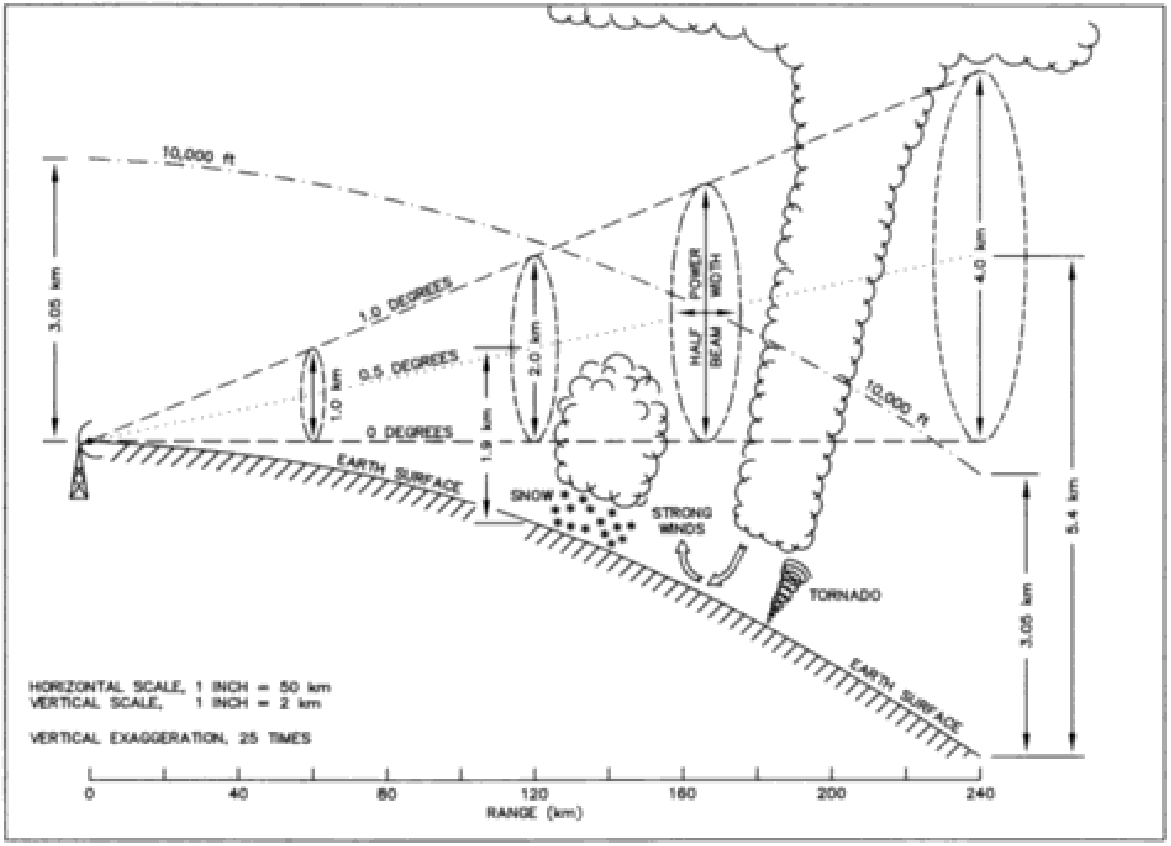


Figure A-3 Diagram illustrating the effect of range and earth curvature (with standard atmospheric refraction) on NEXRAD cross-beam resolution and coverage of low-level weather phenomena. Courtesy of SRI International.

NEXRAD Installation

8.5 meter antenna
10 meter radome
500 kW transmitter

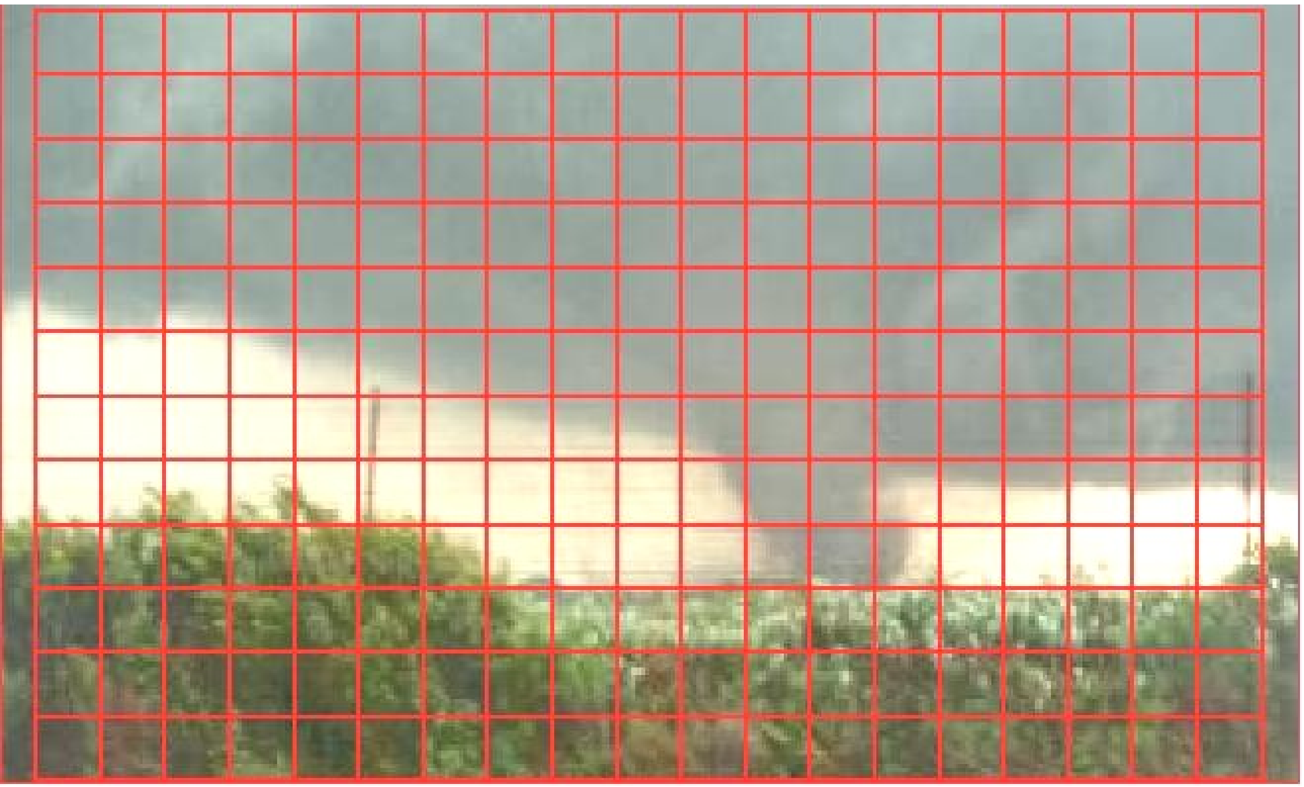
165 installations across US including one (1) in Cayey, PR.

WSR-88D Facility Damage in Northern Taiwan 1996

Source: NCAR Web Site
http://www.scd.ucar.edu/vg/Herb/herb.html

Improved Prediction of Extreme Weather events

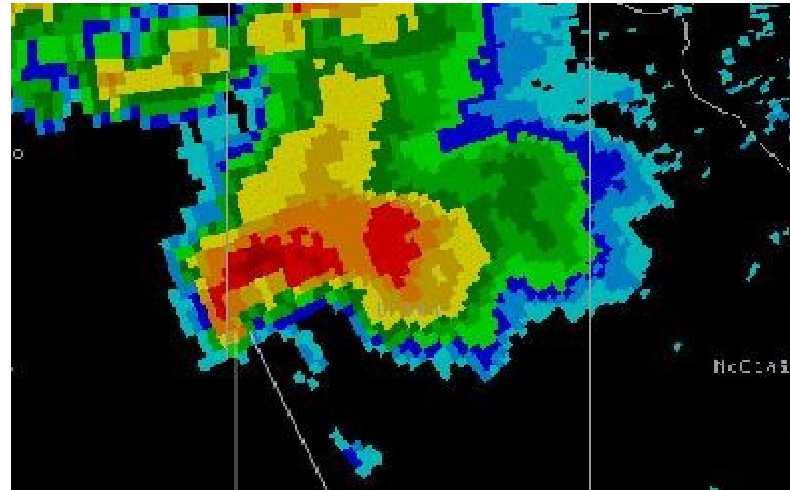
Improved Detection and Prediction of Extreme and High-Impact Weather events



Requires -

- dense observations
- information management
- accurate numerical forecasting

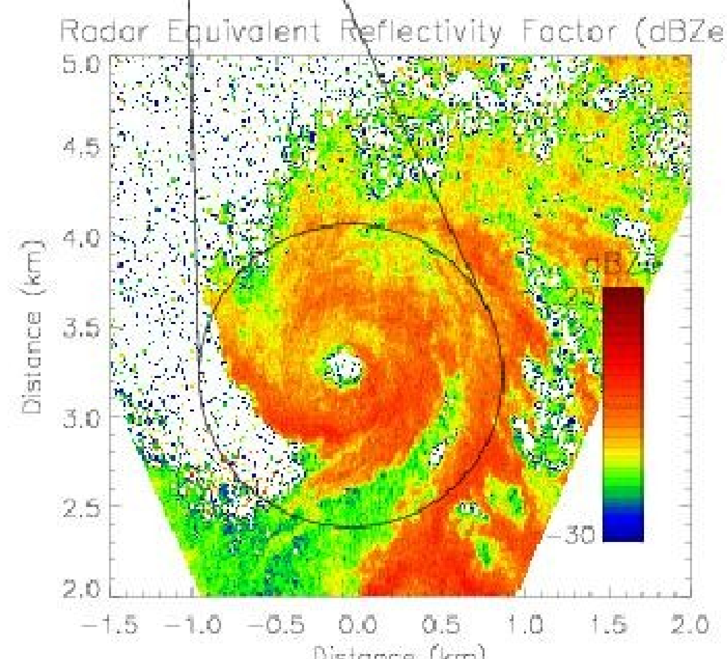
May 3, 1999 Tornado Outbreak in Oklahoma



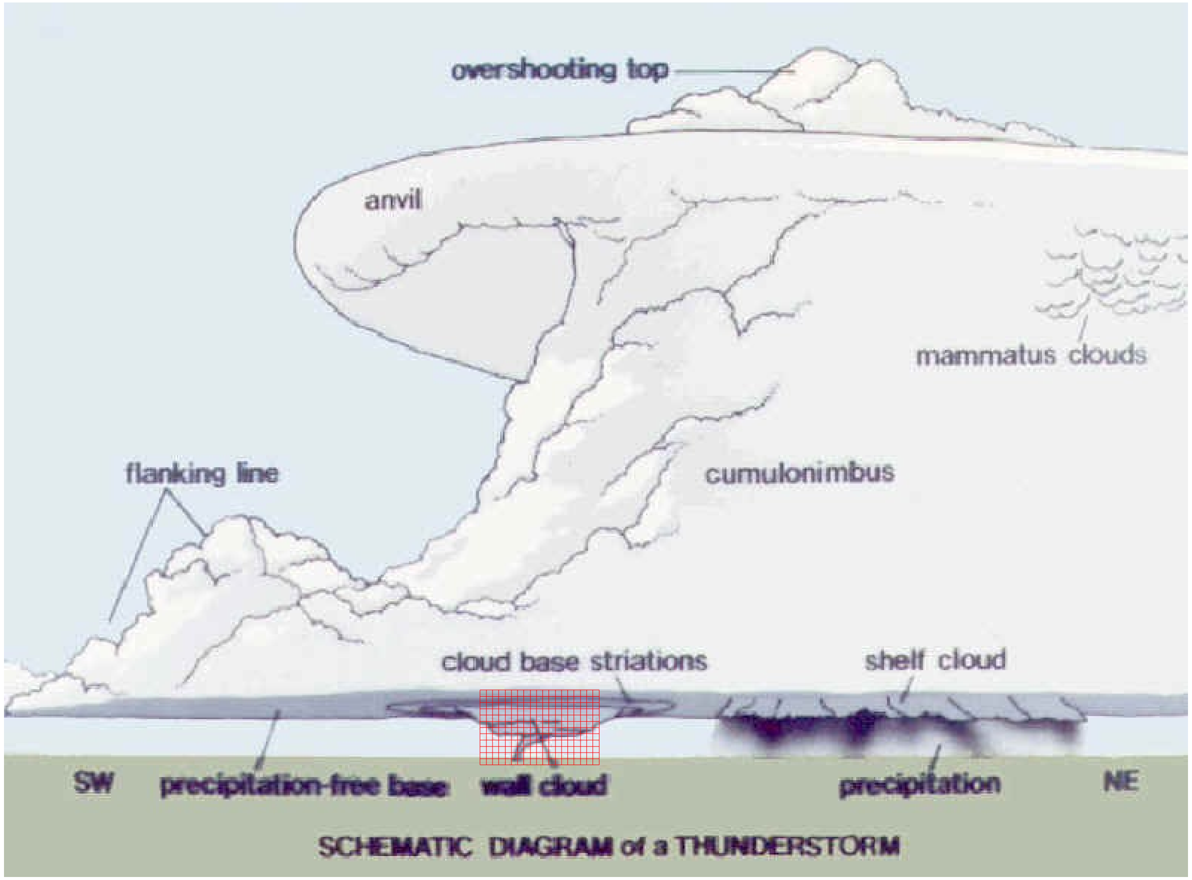
• 38 dead, 748 injured, $1 Billion damage

• NWS warning based on NEXRAD detection of a tropospheric mesocyclone saved est. 600 lives

• UMASS/UOklahoma radar captures the *tornado* on the ground, yielding highest Spatial resolution images ever with W-band radar



The Data Problem -



Spatial Domain –
200 km x 200 km x 10 km

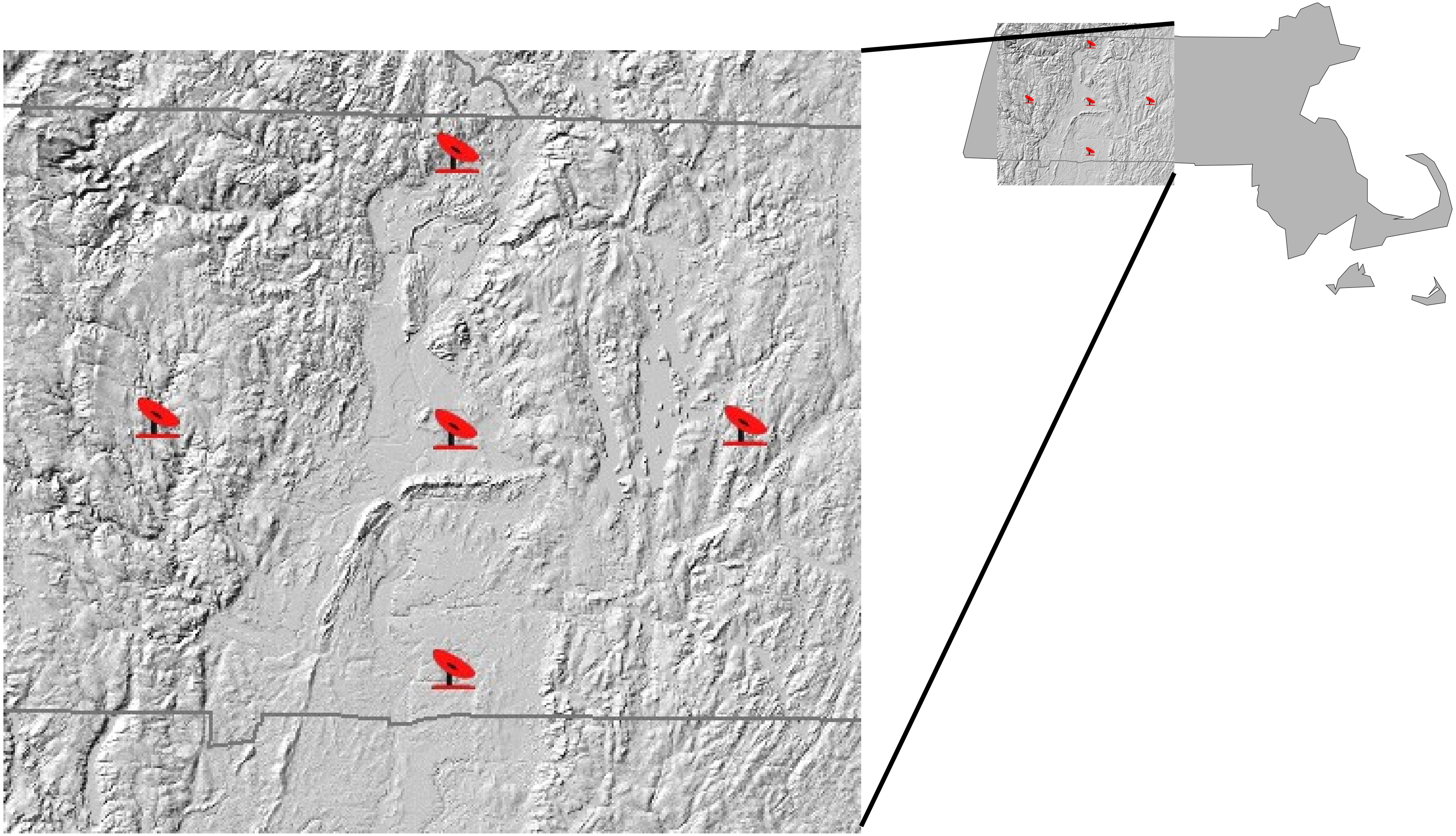
Voxel Resolution -
100 m x 100 m x 100 m

Storm Data Volume –
200 M voxels
4 bytes per voxel
800 Mbyte or
6.4 Gbit *per update*

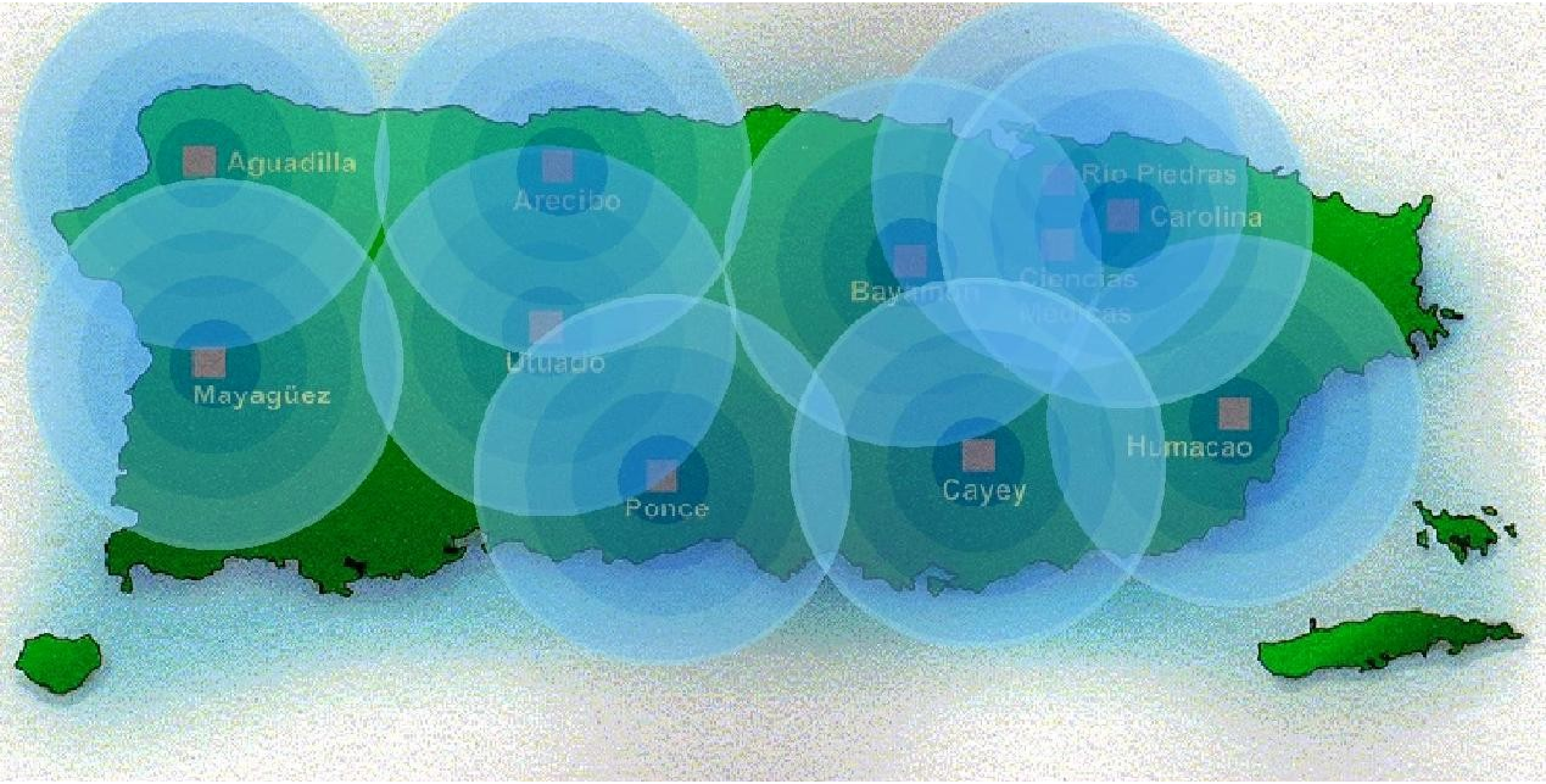
Update Every Minute –
100 Mbit/sec

Demonstration Network

5 Nodes in Western Massachusetts



TropiNet - 11 Nodes in Puerto Rico



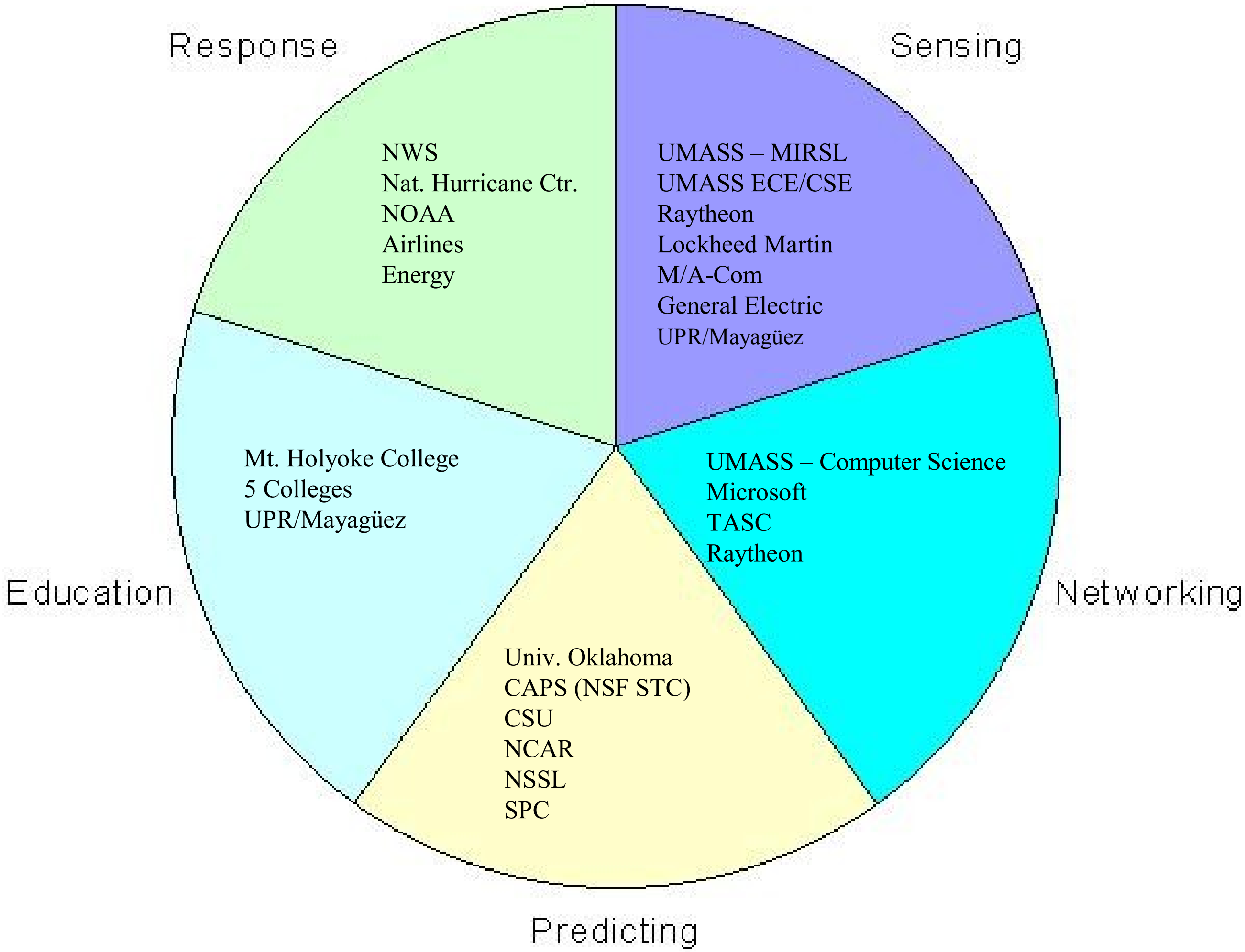
Key Technology Areas

- Sensors
- Wired & wireless access
- Networks & computation
- Small-scale modeling & numerical prediction
- Visualization, dissemination
- Social/Political Science

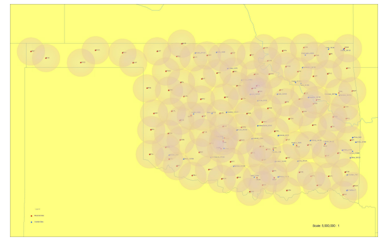
Research Challenges

- Sensing – high resolution views of the lower troposphere; quantitative information extraction; low-cost sensors that can be built onto the national infrastructure (telecom towers, Internet access).
- Networking – sensor network management, distributed computing, reliable, affordable access to selective data; open Internet-based delivery.
- Predicting – storm tracking; high resolution data assimilation; accurate NWP.

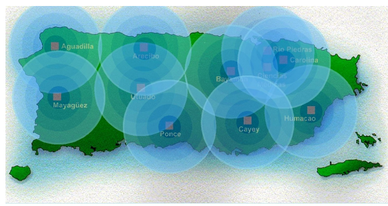
Engineering Research Center For Extreme Weather Events



Approach to Achieving the Vision

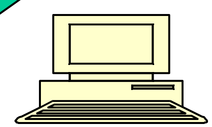


Scalable network architectures



Distributed sensor testbeds

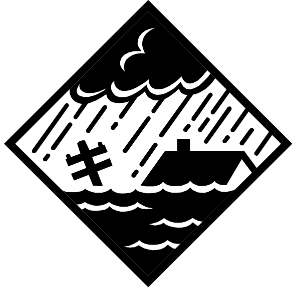
Field experiments



Prediction Algorithms

Multi-platform experiments

Sensor development



UPRM Progress towards ERC

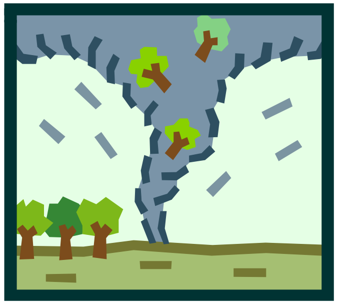
- Pre-proposal was approved – Formal Invitation from NSF
- MOU for Collaborative UMass/UPRM Ph.D
  - Adjunct professors: J. Colom, S. Cruz, S. Sekelsky & R.Rodríguez
- UPRM and UPR-CA provided $11,880 for pre-proposal meetings.
  - First meeting was in April, 2002
  - Second meeting schedule for early September, 2002.
- Already have one graduate student working with
  - Raytheon modifications to X-band radar (this summer at UMass)
  - Survey analysis of PR island network of weather radar
- Acquisition of laboratory space-Stefani 201
- UMass-PI, visited UPR in February, 2002 and met with
  - Drs. M.Gómez, Pablo Rodríguez, L. Morell and R. Vázquez.

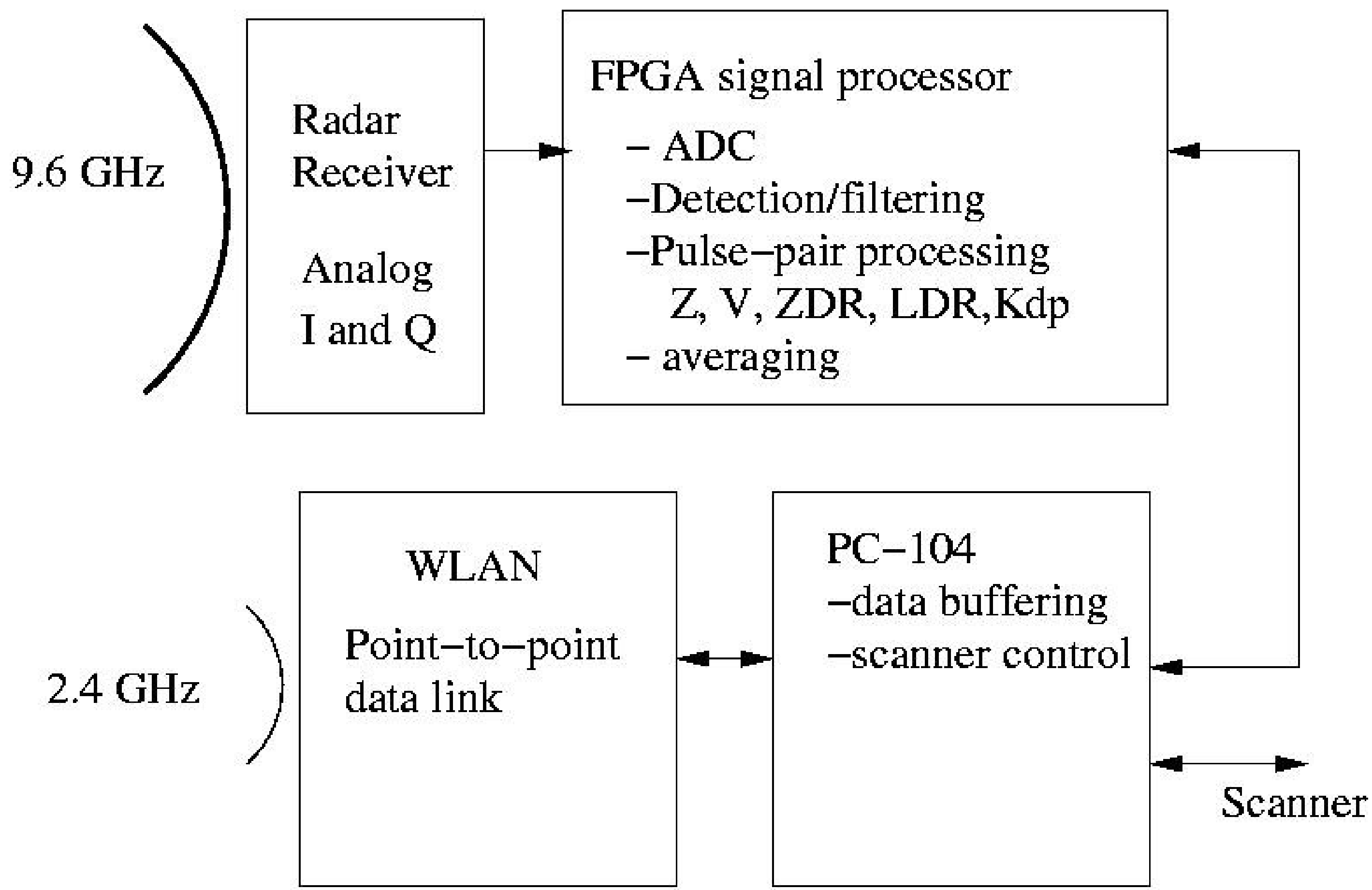
UMASS/UPR Research Opportunities

- UPRM/UMASS Summer Minority Engineering Program
  - 1999 Nelson Vega, Rafael Ramirez
  - 2000 Nivia Colon (**currently MS student at UPR**), Michael Tricoche
  - 2001 Leyda León (**currently MS student at UPR**), Will Padilla, Edna Prado, Harry Figueroa (now **UMASS MS student**), Profs. Cruz-Pol and Colom-Ustáriz (visiting professors at Umass)
  - 2002 Jorge Roman (**current MS student at UMASS, NASA Fellowship**)
  - 2002 Jorge Trabal (summer SPUR program at UMass, current MS student at UPRM)
- Current research collaboration
  - Profs. Colom-Ustáriz and Sekelsky developing a radar sensor node using Raytheon hardware at Mayaguez.
  - Profs. Cruz-Pol, MS students Nivia Colón, Leyda León, and Jorge Villa and Prof. Sekeleky data analysis for next-generation cloud sensing using mmWave radars at Mayaguez.

What’s next?

- Waiting for pre-proposal review from NSF
- Meeting with PR agencies: Aug 23
  - NWS, Meteorologist, government representative
- Meeting with Gómez and McLaughlin Sept 6
- Next meeting: Sept 14, 2002
- Matching funds




9.6 GHz
Radar
Receiver
Analog
I and Q
FPGA signal processor
– ADC
–Detection/filtering
–Pulse–pair processing
Z, V, ZDR, LDR,Kdp
– averaging
2.4 GHz
WLAN
Point–to–point
data link
PC–104
–data buffering
–scanner control
Scanner

Wireless LAN
11 Mbps at 12 miles (18 km)
2 Mbps at 25 miles (40 km)

Seavey Engineering
4’ Dual-polarized parabola

Raytheon High-Seas
Marine Radar
25 kW magnetron

Radar Parameters

- f=9.6 GHz (X-band)
- Dual-polarization - linear V/H
- Pt = 25 kW (magnetron)
- Antenna diameter = 1 m
- Record Doppler moments (pulse-pair)

Mechanical Parameters

- 1 m-diameter antenna
- Elevation-over-azimuth scanner
- 10 m tower to clear vegetation
- Re-deployable towers ?

Marine Radar to Atmospheric Radar Conversion: Technical Issues

- Magnetron frequency drifts with temperature
- Wide bandwidth receiver limits sensitivity to clouds and precipitation
- No Doppler Information
- Single Polarization