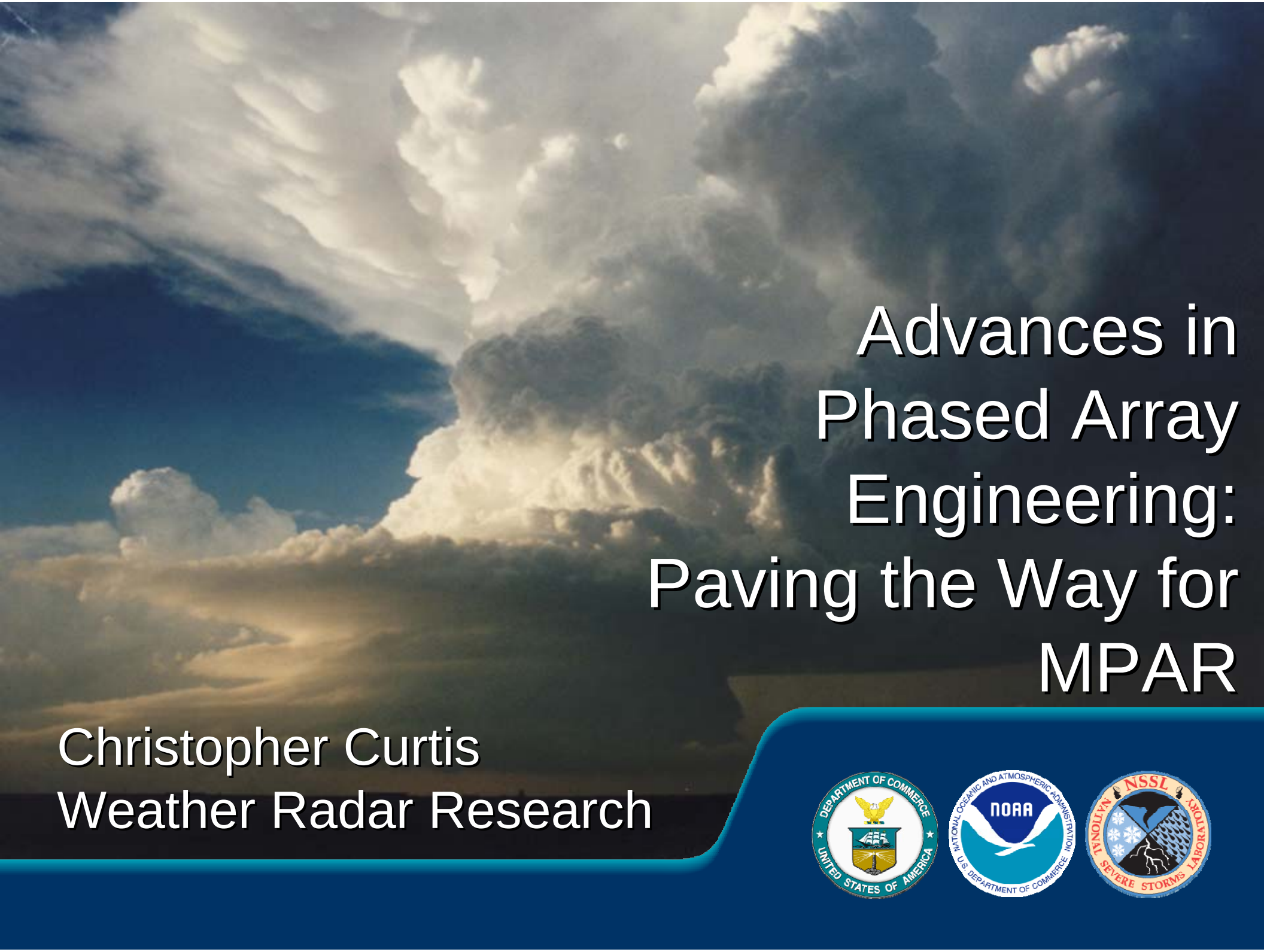


Advances in Phased Array Engineering: Paving the Way for MPAR

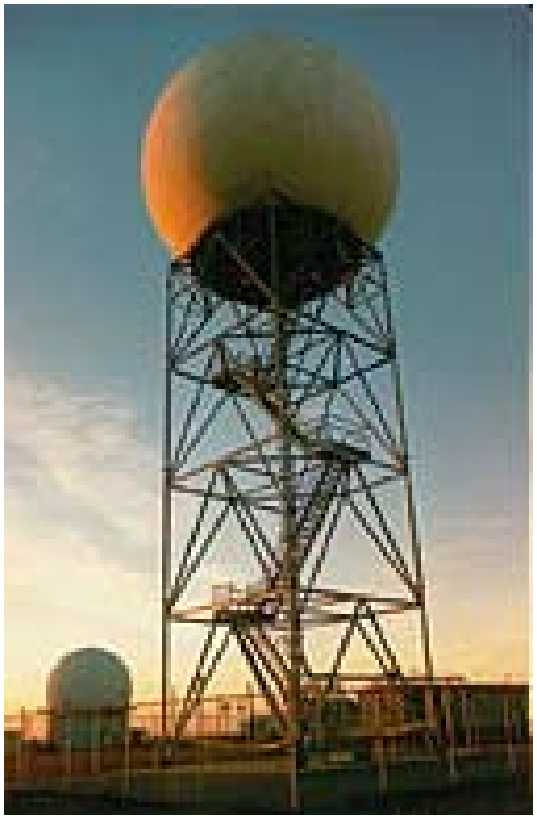
Christopher Curtis
Weather Radar Research

Outline

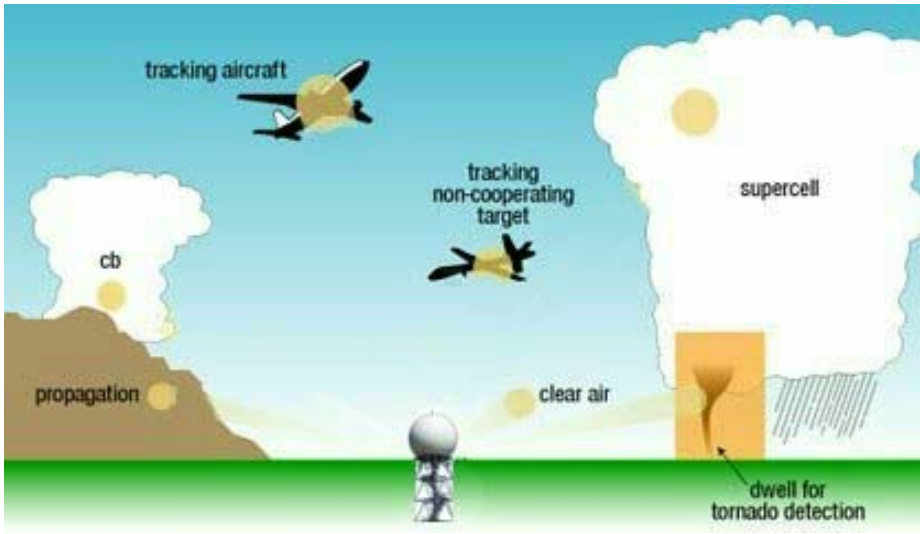
- Why phased array?
- What is MPAR?
- Accomplishments
- Current Research
- Future Directions

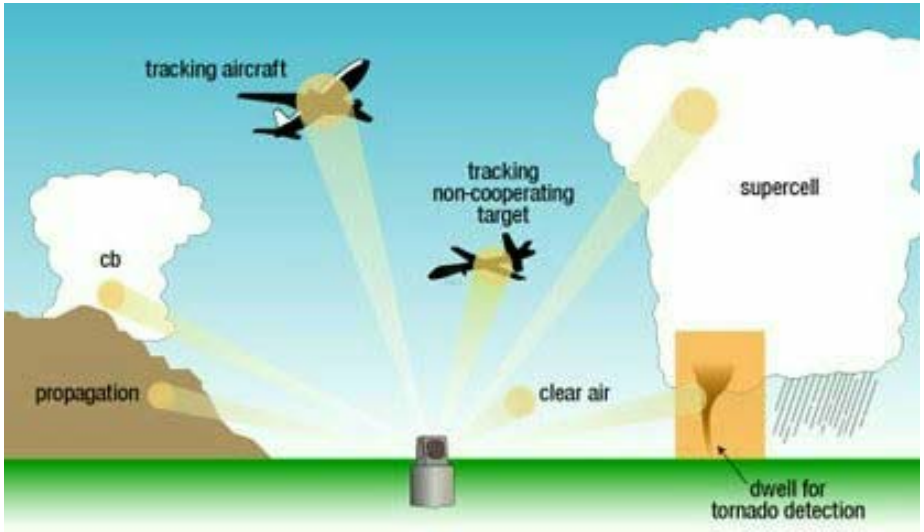
Motivation

- WSR-88D is about 20 years old
- What should replace it?
- Reduce total number of radars?
- Combine weather and aircraft surveillance?



Weather Radar Antennas: Conventional and Phased Array





Conventional Antennas:

- Rotating Antenna (Smearing)
- Mechanical Inertia
- Limited Scanning Capabilities
- Fixed Beam Shape
- Dual Polarization with Feed

Phased Array Antennas:

- Fixed Antenna (No Smearing)
- No Mechanical Inertia
- Adaptive Scanning Capabilities
- Changing Beam Shape
- Issues with Dual Polarization

What is MPAR?

MPAR – Multifunction (Multimission) Phased Array Radar

- Possible WSR-88D replacement
- Four fixed faces
- May use multiple frequencies

Potential Missions

- Long-range Weather
- Terminal Surveillance (including non-cooperative targets)
- En Route Surveillance
- Terminal Area Weather

"The value of MPAR can only be improved by conducting applied research and testing of phased array radar technology and improving airport tracking of aircraft and weather information for civilian use."
—NOAA Five Year Research Plan, 2008-2012

adapted from Zrnić, D. S., J. F. Kimpel, D. E. Forsyth, A. Shapiro, G. Crain, R. Ferek, J. Heimmer, W. Benner, T.J. McNellis, R.J. Vogt, 2007: Agile beam phased array radar for weather observations. *Bull. Amer. Meteor. Soc.*, **88**, 1753-1766.

NWRT Accomplishments (National Weather Radar Testbed)

Early Upgrades

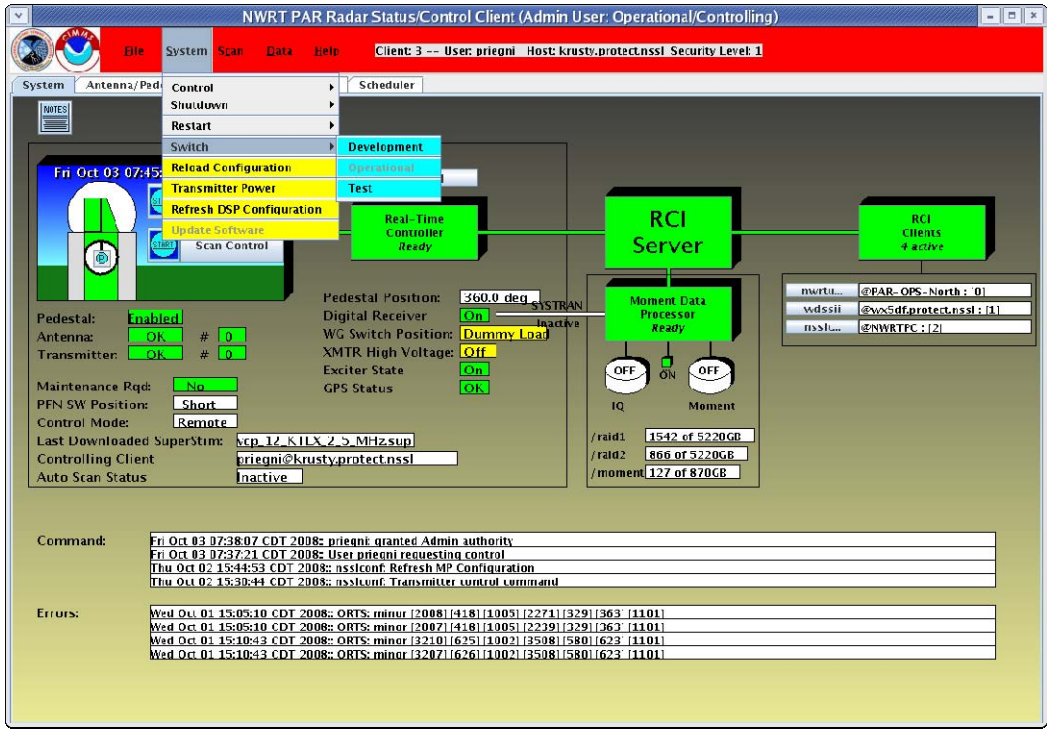
- Data Recording
- Real-Time Display
- Radar Control Interface (RCI)

Hardware/Infrastructure Upgrades

- Parallel Processing w/Linux Nodes
- Reuse of established infrastructure from ORPG (Open Systems Radar Product Generator)

Software/DSP Upgrades

- Data Quality (including calibration)
- Range Unfolding
- Clutter Filtering



Current Research

Beam Multiplexing

- Research showing feasibility
- Continued research on new strategies
- Applicability to fast weather detection strategies

Relevance:

Improve timeliness of warnings and accuracy of numerical models with faster updates, uses unique capabilities of phased array antenna

Quality:

Yu, T.-Y., M. B. Orescanin, C. D. Curtis, D. S. Zrnic, D. E. Forsyth, 2007: Beam Multiplexing Using the Phased-Array Weather Radar. *J. Atmos. Oceanic Technol.*, **24**, 616-626.

Current Research

CLEAN-AP
(Clutter Environment Analysis using Adaptive Processing)

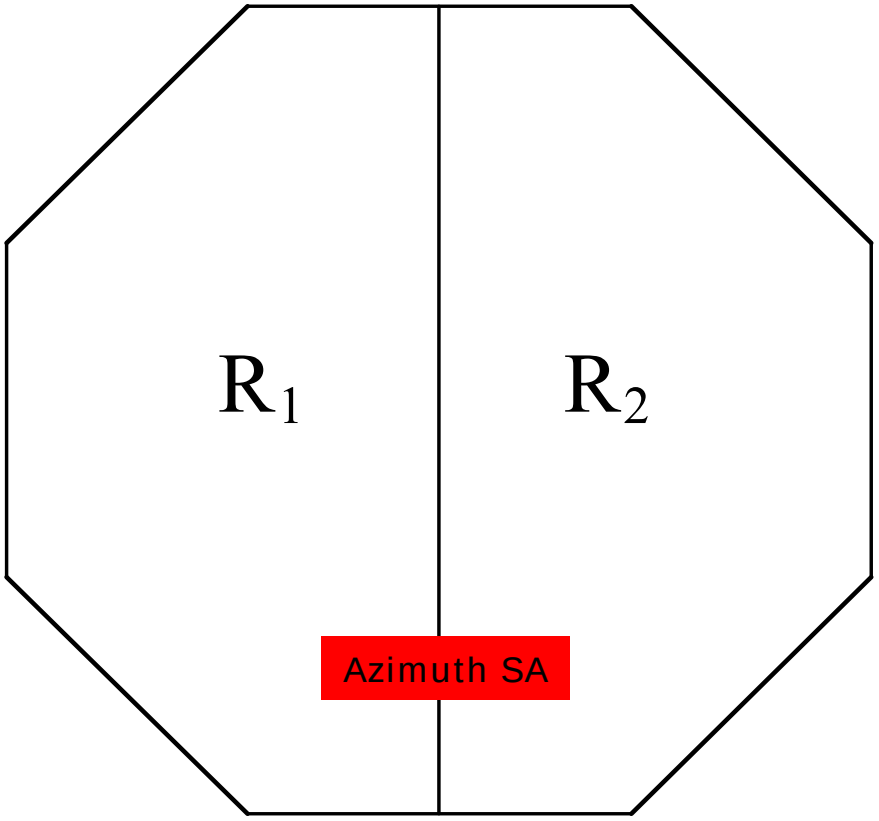
- Identifies ground clutter and AP (anomalous propagation) clutter and filters the clutter

Refractivity Measurement

- Measure moisture in the air using ground clutter targets

Transverse Winds

- Measure winds perpendicular to winds normally measured by Doppler weather radar



from presentation by Guifu Zhang

Collaboration & Partnerships

Dual polarization active array:

- BCI (Basic Commerce & Industries)/Lockheed Martin/OU
- Lincoln Lab
- FAA

OU Collaborations:

- Refractivity
- Transverse Winds
- Ensemble Kalman Filtering
- DARE/PASSE – Mobile Radars

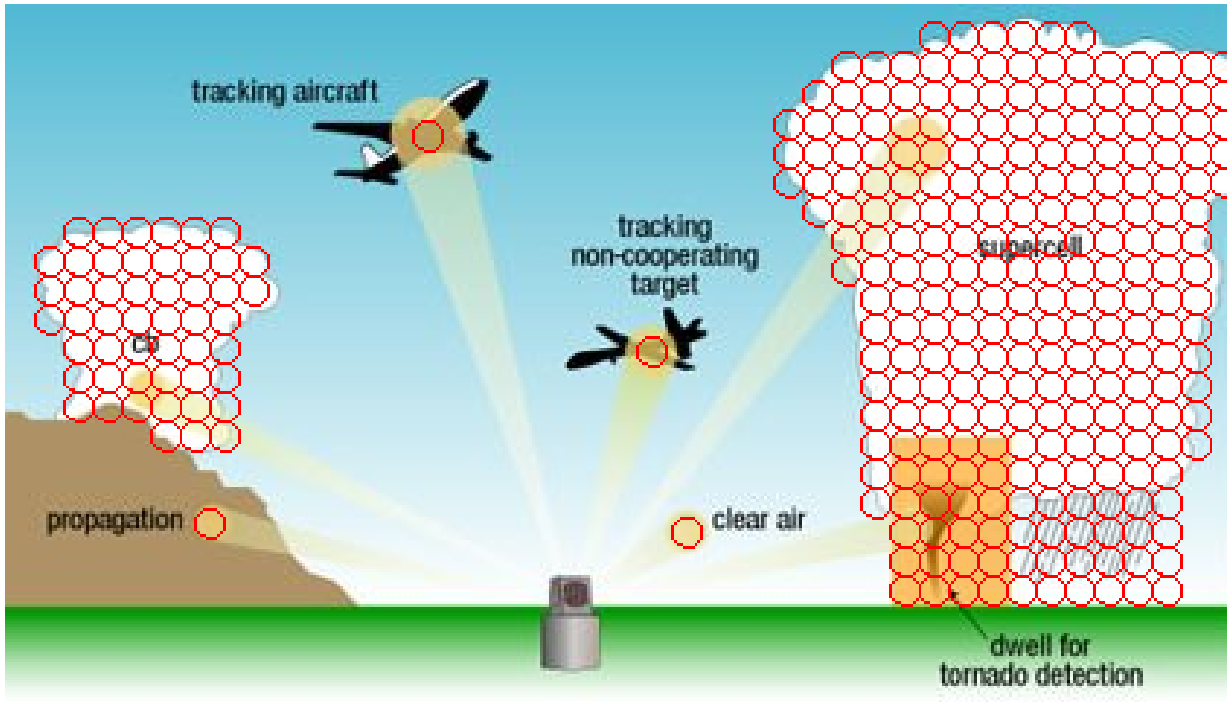
Internal collaboration:

- NWRT Demonstration – fast updates
- Hazardous Weather Testbed

Future Directions

Adaptive Scanning

- Initial work on separating data based on mission
- Simple adaptive weather scheme currently being tested
- Possible future multi-mission tests



Future Directions

Range Oversampling Techniques

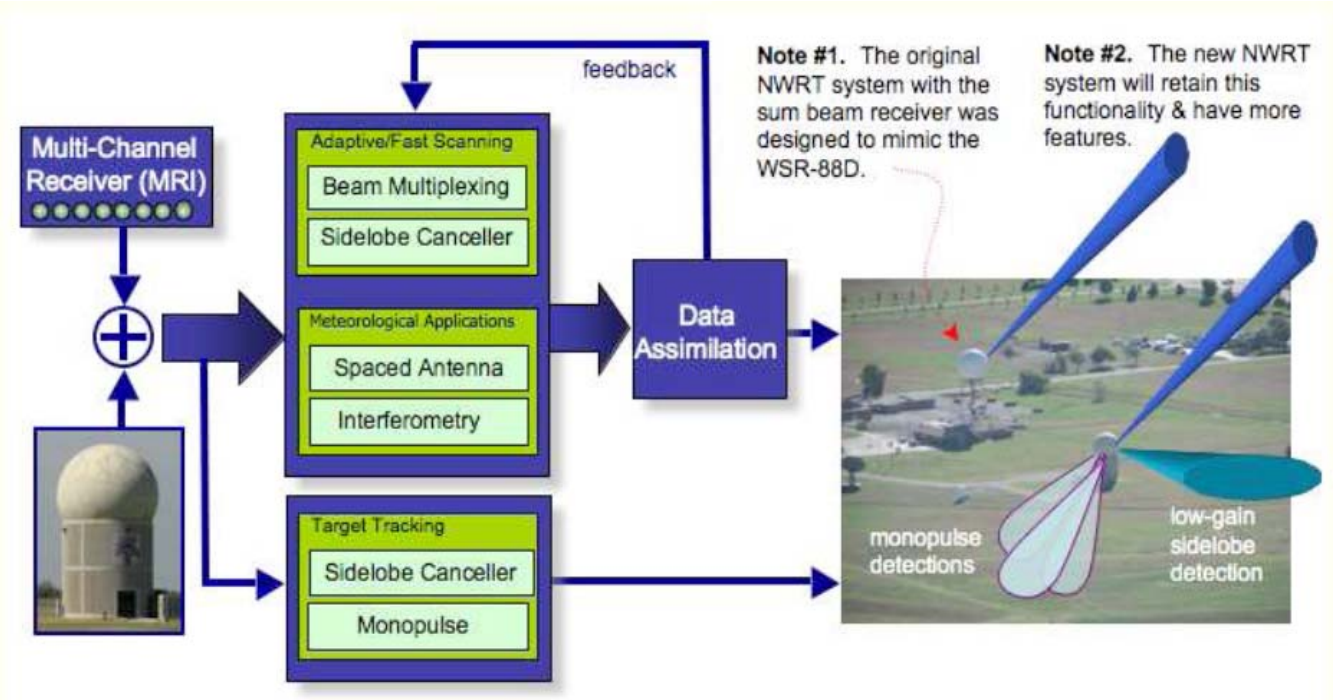
- Increase data quality or faster updates

Coherency Based Detection

- Improve detection of weather by using additional parameters, being implemented on NEXRAD

Multi-Channel Receiver

- Enables research on use of multiple channels for transverse winds and cancelling techniques, NSF funded collaborative project



from Yeary, M., R. Palmer, G. E. Crain, M. Xue, Y. Zhang, P. Chilson, X. Qin, R. J. Doviak, and A. Zahrai, An Update on Multi-Channel Receiver Development for the Realization Multi-Mission Capabilities at the National Weather Radar Testbed, *25th Conference on IIPS,* 8B.5.

Summary

- ✓ MPAR and future funding profile drive our phased array research
- ✓ NWRT platform allows both phased array research and research for transfer of new technology to NEXRAD

"The warnings themselves will see dramatic improvements. For example, tornado warning lead times will be on the order of one hour, rather than minutes. Technology like phased array radar, significant improvements in our under-standing of mesoscale weather processes, and the development of models that embody this understanding will enable this accomplishment." – NOAA 20 Year Research Vision

Questions:

Backup Slides

Current Research

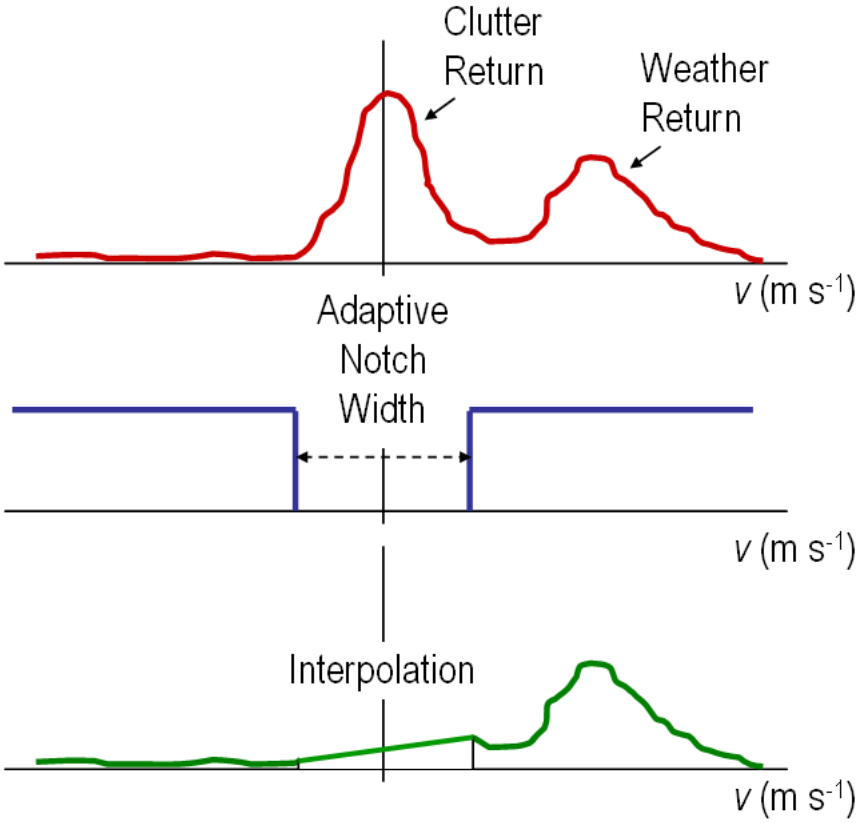
CLEAN-AP
(Clutter Environment Analysis using Adaptive Processing)

- Identifies ground clutter including AP (anomalous propagation) clutter
- Current NWRT implementation
- Spectral technique, adaptive widowing

Identify Clutter

Filter

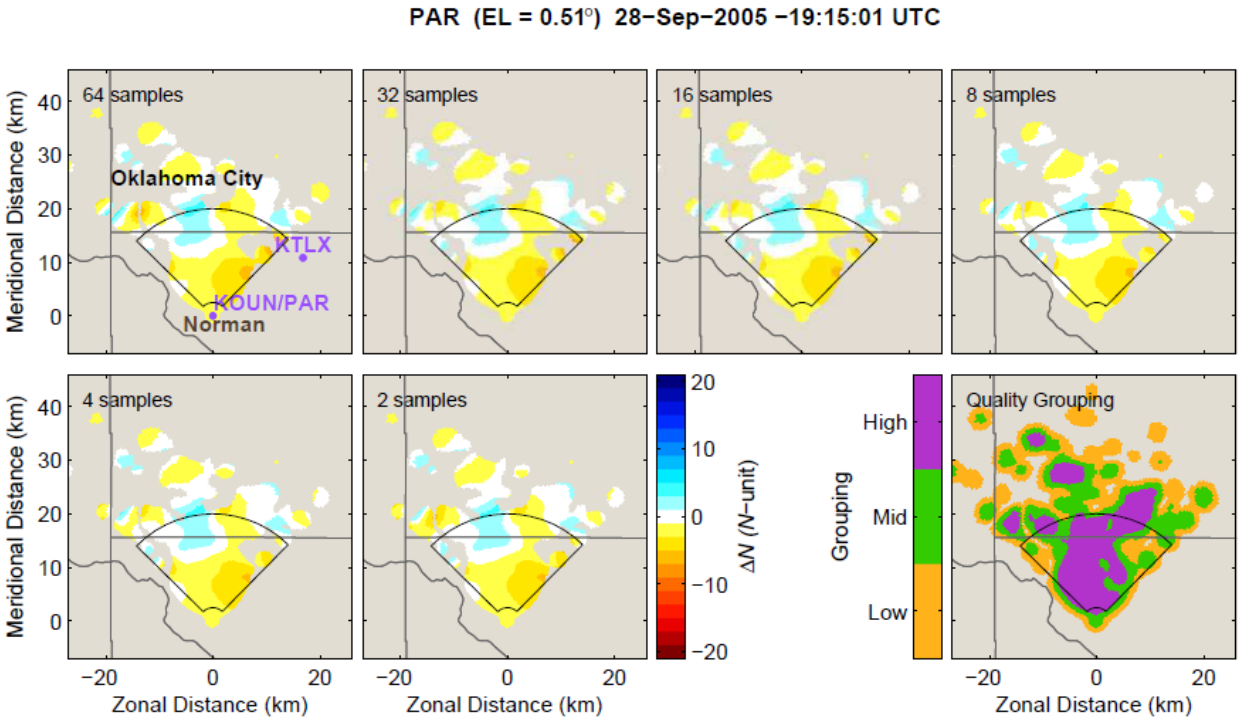
Interpolate



Current Research

Refractivity Measurement

- Uses ground clutter to measure moisture
- Implemented on NWRT
- Additional information for models

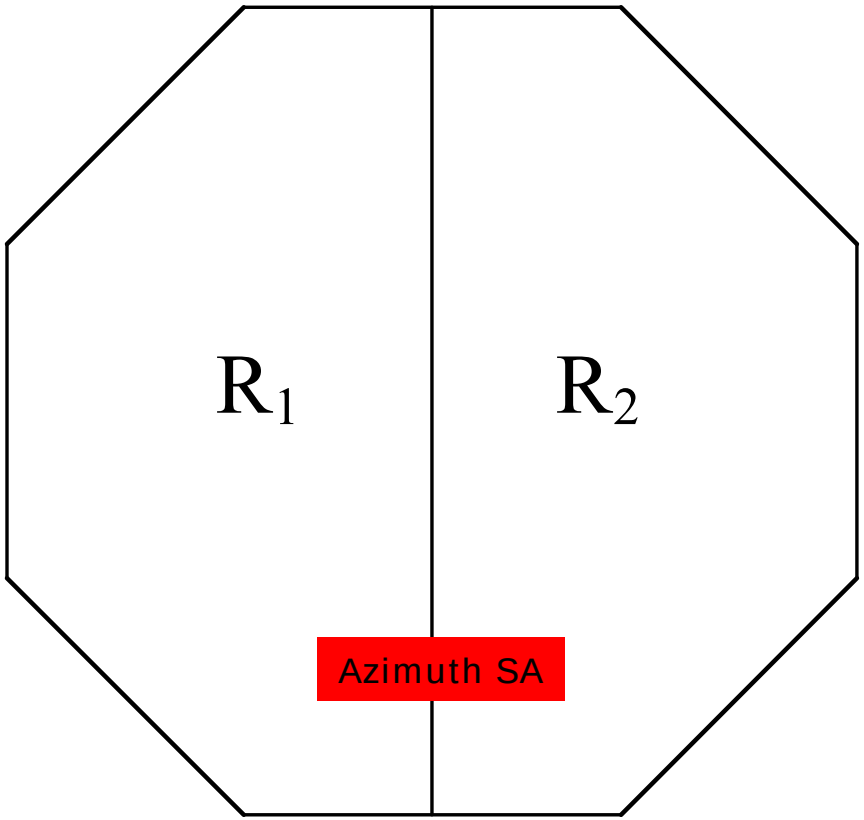


from Cheong, et al., *Refractivity Retrieval Using the Phased-Array Radar: First Results and Potential for Multimission Operation*

Current Research

Transverse Wind Measurement

- Spaced Antenna Interferometry, uses monopulse channels
- Measured antenna patterns, collecting data soon
- Additional information from angular shear



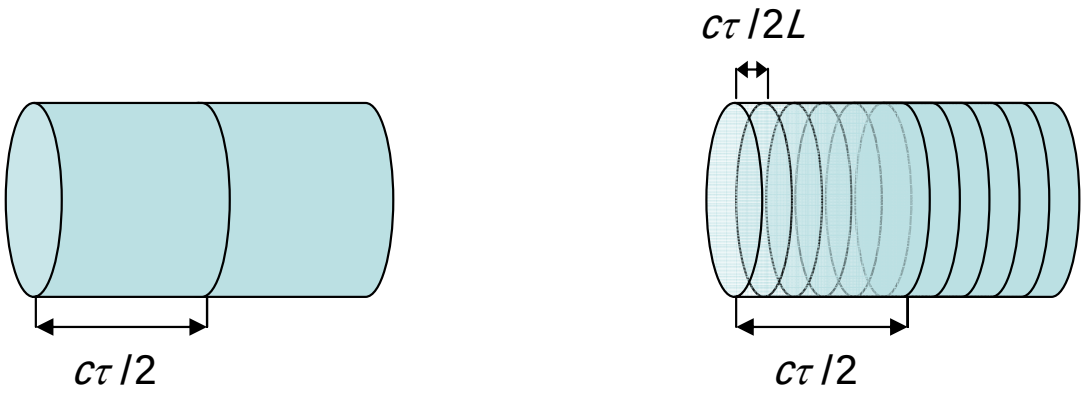
from presentation by Guifu Zhang

Future Directions

Range Oversampling Techniques

- Decrease errors of estimates
- Decrease scan times with same errors
- Future transfer to NEXRAD

Non-Overlapping and Overlapping Resolution Volumes



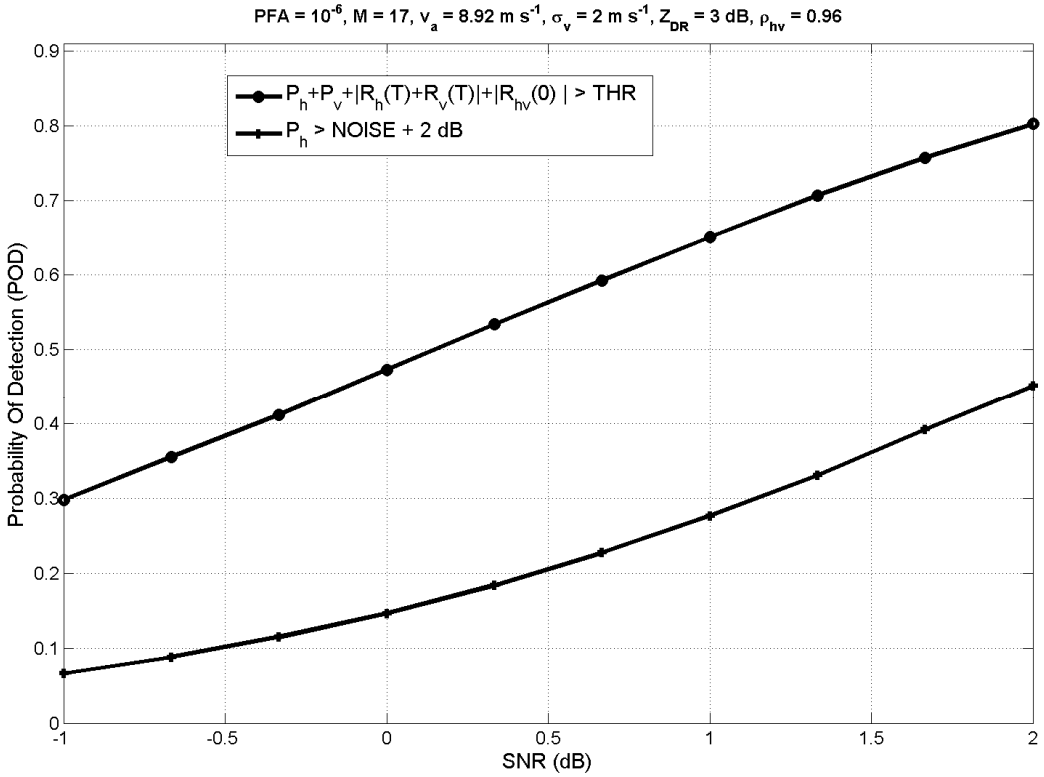
Traditional Sampling

Oversampling

Future Directions

Coherency Based Detection

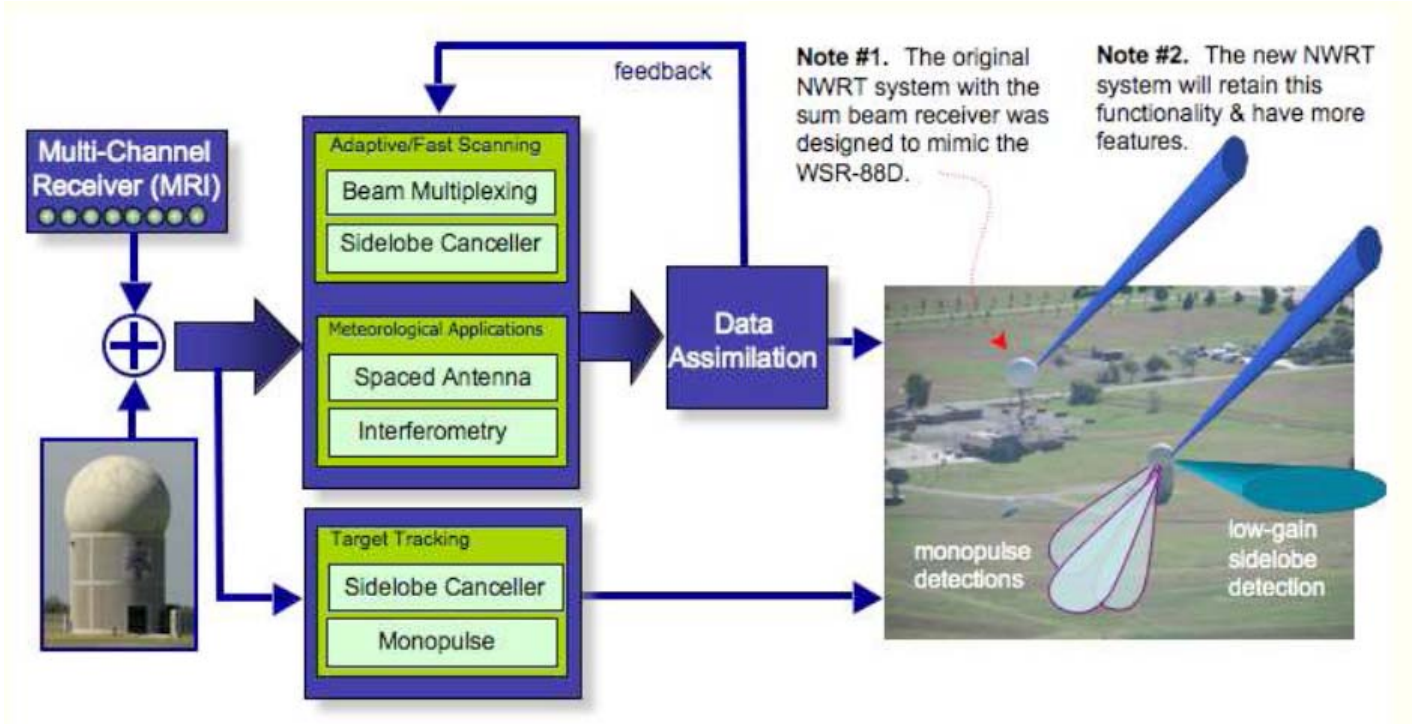
- Immediate application for improving dual-pol weather detection
- Researching feasibility for single-pol radars
- Being transferred to NEXRAD



Future Directions

Multi-Channel Digital Receiver

- Allows research using up to eight channels at once
- Aid in transverse wind and canceller research
- Collaboration with OU



from Yeary, M., R. Palmer, G. E. Crain, M. Xue, Y. Zhang, P. Chilson, X. Qin, R. J. Doviak, and A. Zahrai, An Update on Multi-Channel Receiver Development for the Realization Multi-Mission Capabilities at the National Weather Radar Testbed, *25th Conference on IIPS,* 8B.5.