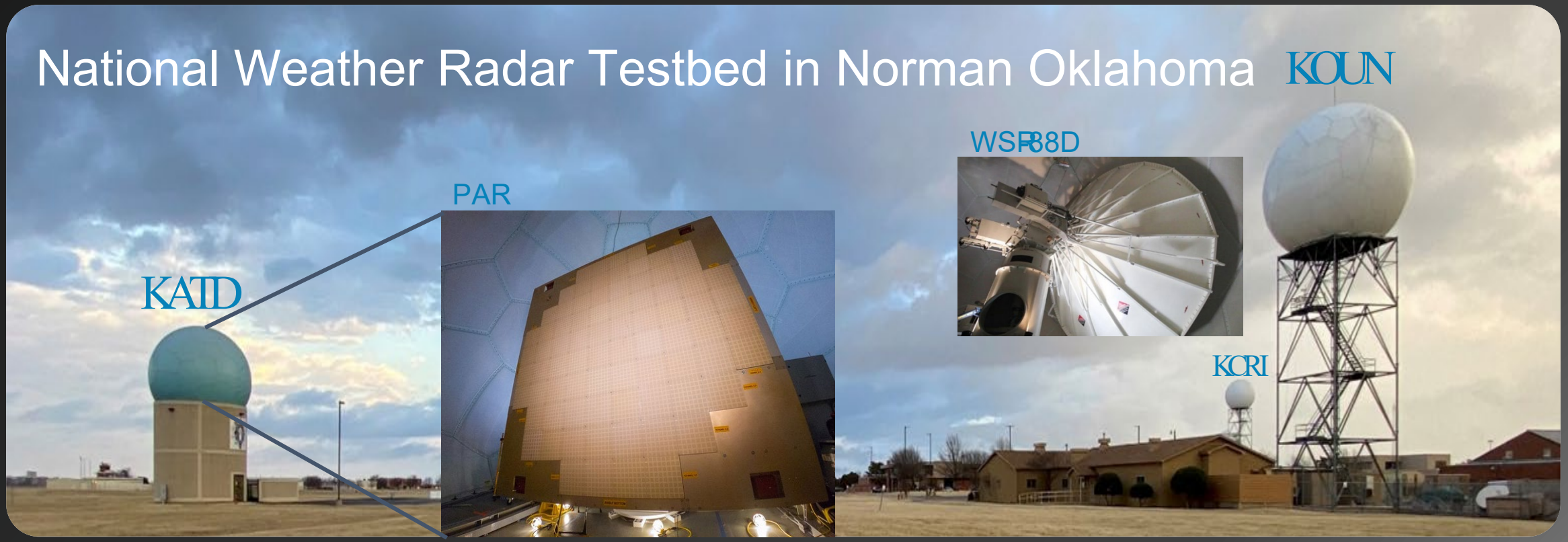
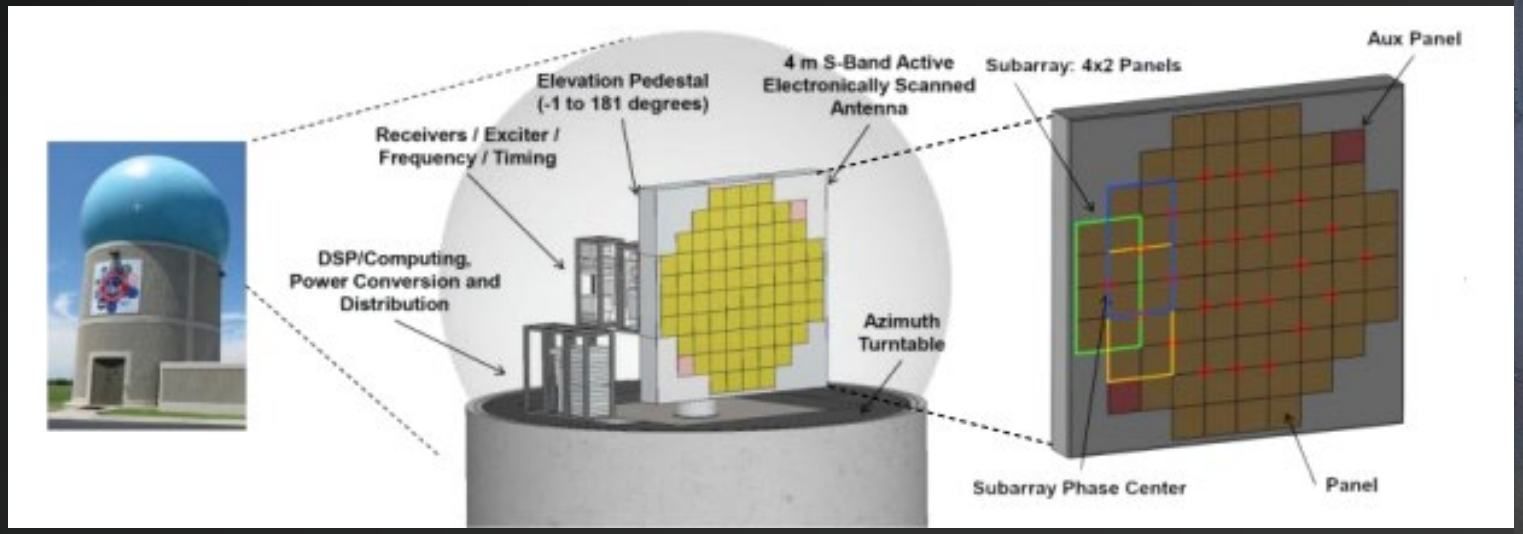
NOAA NSSL Phased Array Research & Development Program Update

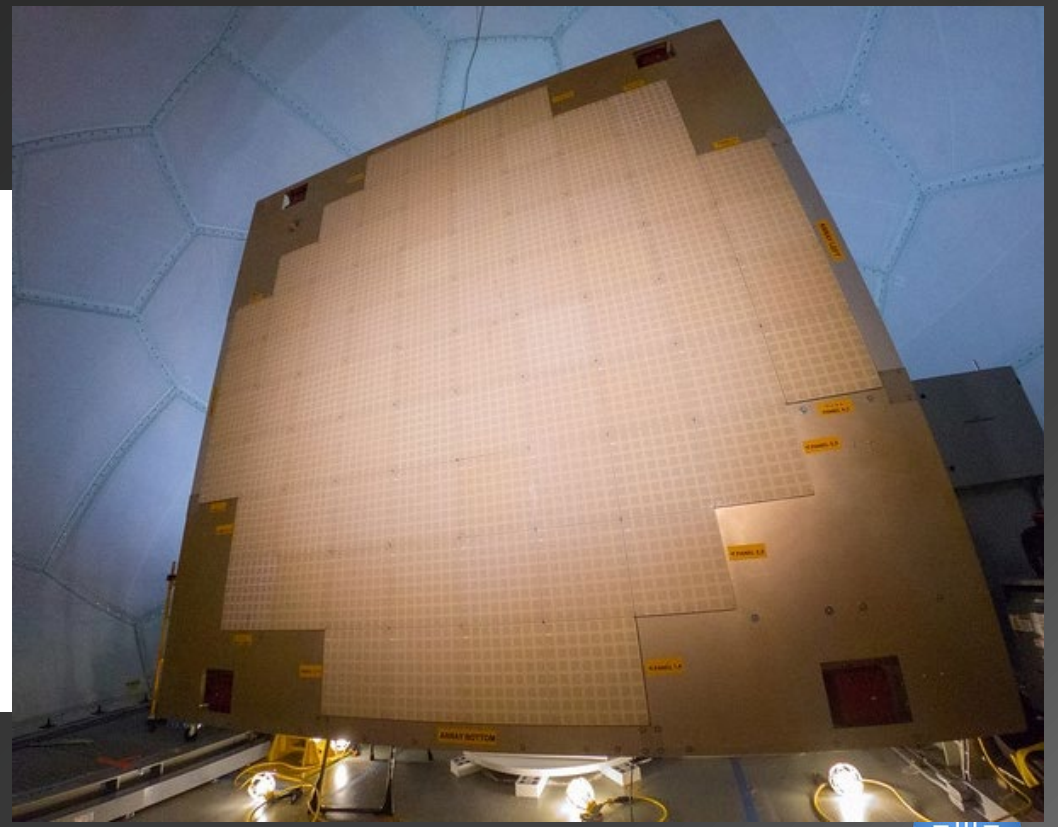
Anthony Reinhart NOAA/OAR/NSSL

National Weather Radar Testbed in Norman Oklahoma



Phased Array Radar (PAR)

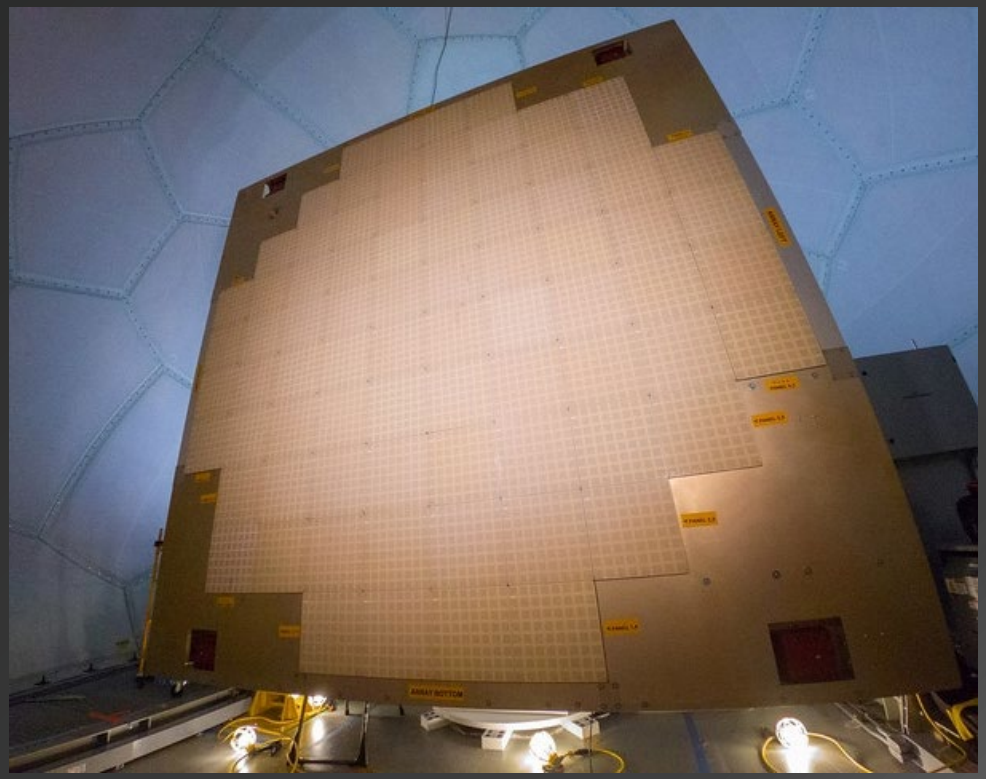




Above: The Advanced Technology Demonstrator (ATD), dual polarization PAR at NSSL.

THE ADVANCED TECHNOLOGY DEMONSTRATOR

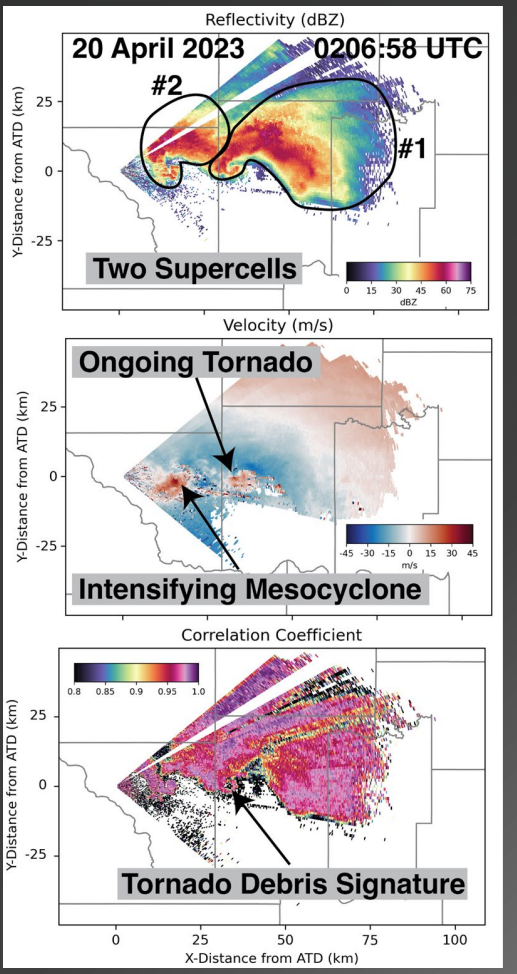
- S-band, dual-polarization weather radar with a 1.6° beamwidth at broadside.
- Built as a proof-of-concept for demonstrating robust dual-polarization calibration on a PAR system.
- Replicates one side of a 4-face panel concept. Has a 90° field of view and can be repositioned to scan any sector of interest.
- Working through upgrades to infrastructure including new servers, new radome, and potential gpu beamforming



The Advanced Technology Demonstrator (ATD), dual-polarization PAR at NSSL

ATD DATA COLLECTION (2021-PRESENT)

- ATD has collected over 500 hours of weather data across 100+ events.
- Enables scientists and engineers to continue to drive innovative science and advance NOAA's understanding of PAR technology and meteorology
- Provides NWS Norman WFO with real-time access to ATD data for use during severe weather events
- Near real-time figures and all past figures: https://apps.nssl.noaa.gov/par/
- 2023 and future years of data are located: data.nssl.noaa.gov/



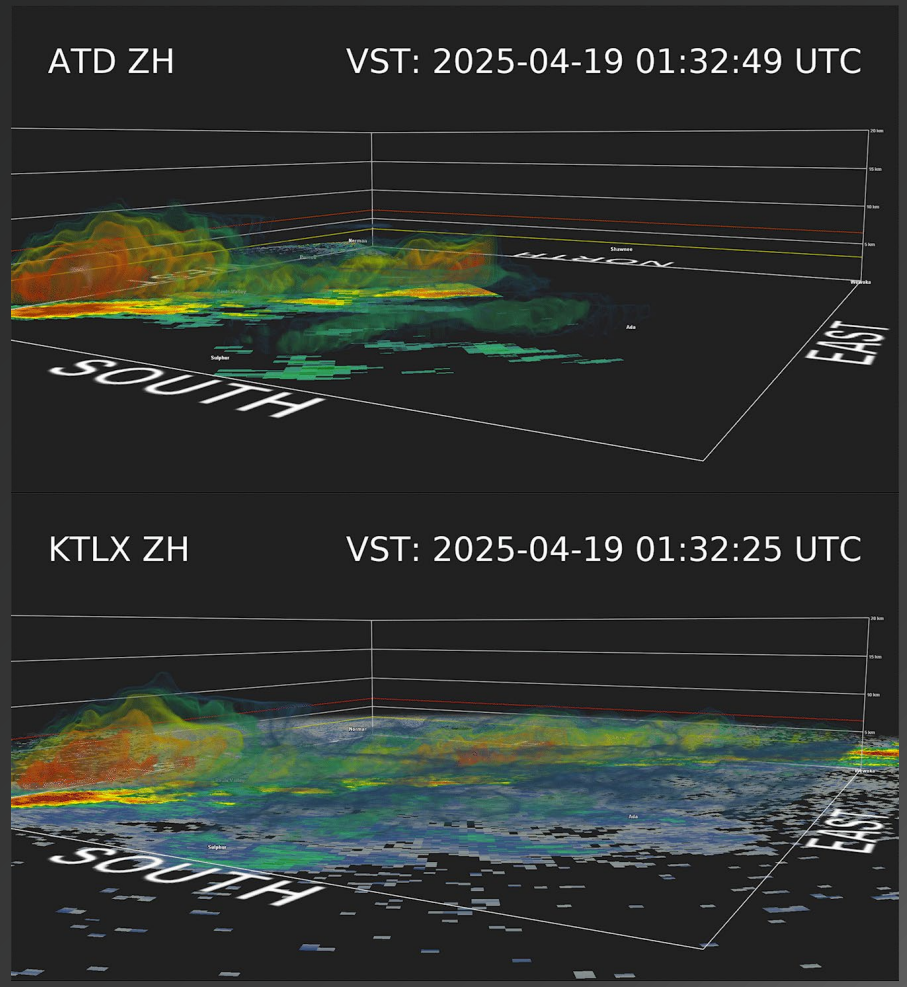
2021 – Present Data Collection Event Type

Tornadic Supercells	Severe and Non-severe MCS	Severe Multicell Convection	Non-severe Multicell Convection	Downburst	Winter Weather	Clear Air & Engineering Tests
20	25	25	20	10	10	18

ATD DATA COLLECTION

Data collection priorities:

- Scan strategies that leverage the flexibility of the ATD, including adaptive scanning and beam spoiling, to provide optimal balance in the aforementioned scan attributes.
- Utilize the new and maturing advanced scanning capabilities of the ATD to more completely demonstrate the full concepts of stationary PAR operations, particularly those related to adaptive scanning and (if possible) beam spoiling.
- Study the operational and research benefits of flexible scanning that PAR affords (e.g., adaptive scanning).

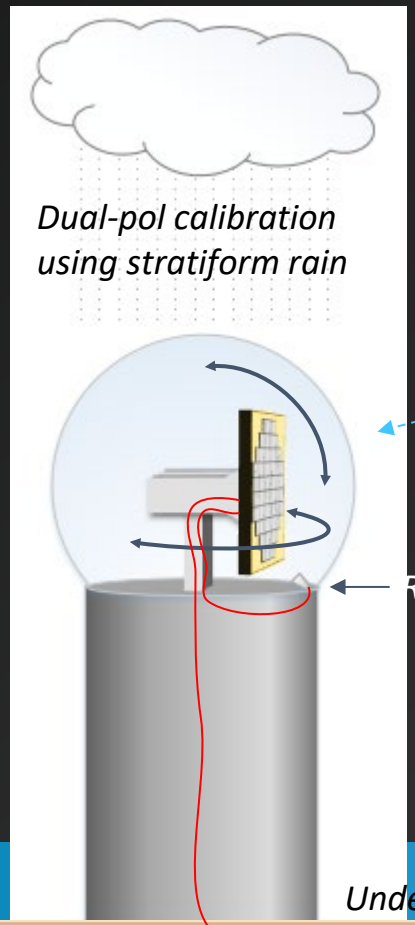


Volumetric PAR (top) and WSR-88D (bottom) data. The first half of the animation shows radar reflectivity (ZH) and the second half shows normalized rotation (NROT). Brighter reds (blues) in NROT depict increasingly intense cyclonic (anti-cyclonic) rotation. VST is the volume start time.

ATD Calibration Infrastructure

Challenge: The most significant risk for dual-pol phased array radar is calibration tolerances.

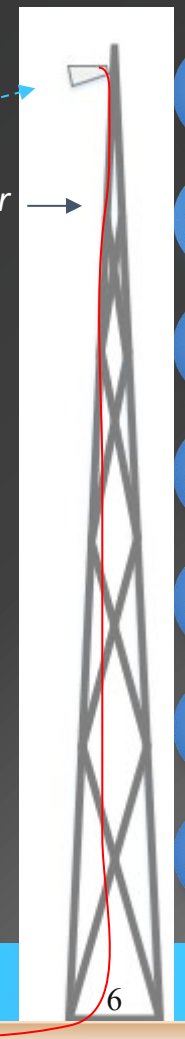
Strategy: Build in as many tools as possible to take measurements. Our main tool is the **calibration tower.**



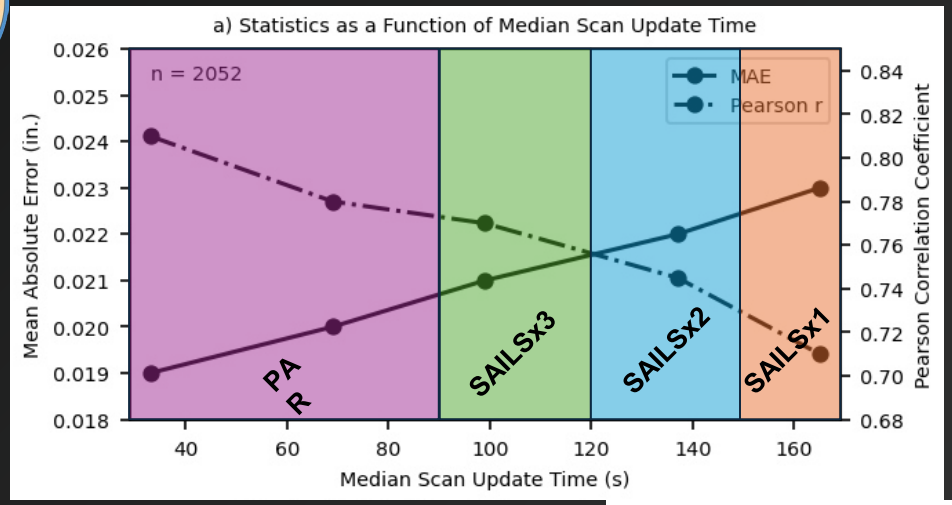
Drone

Calibration tower can receive, transmit, or even simulate a far-away target

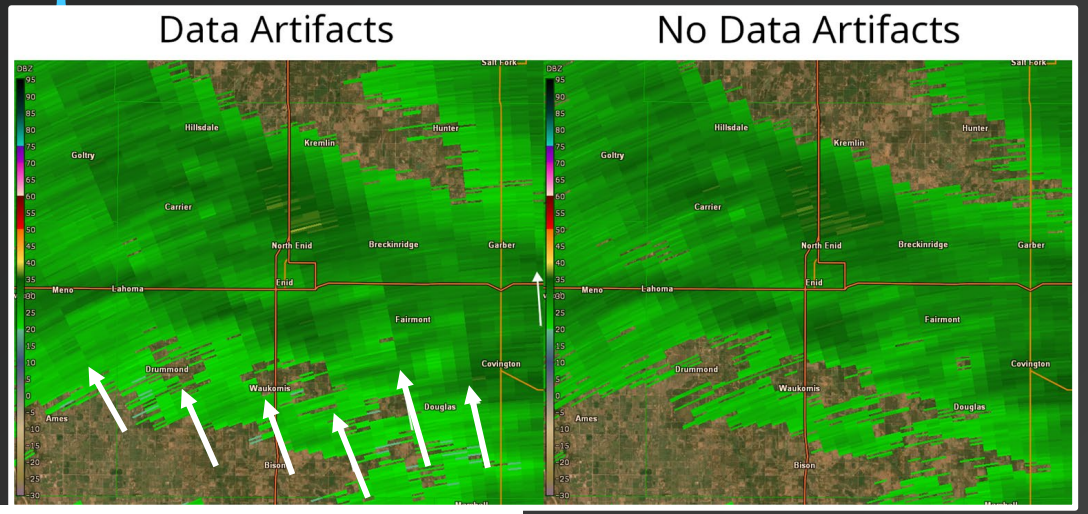
Cal tower



Advancing meteorological and engineering rese towards operations

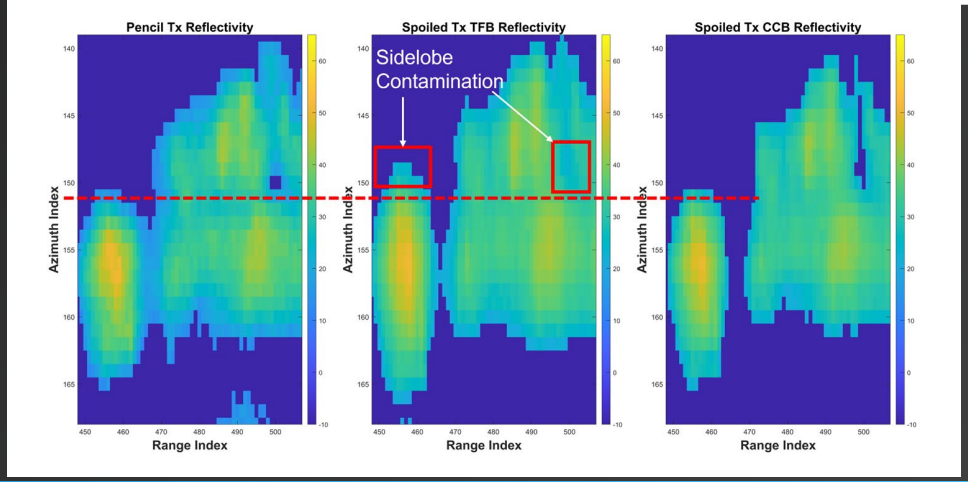


Rainfall Estimation with PAR

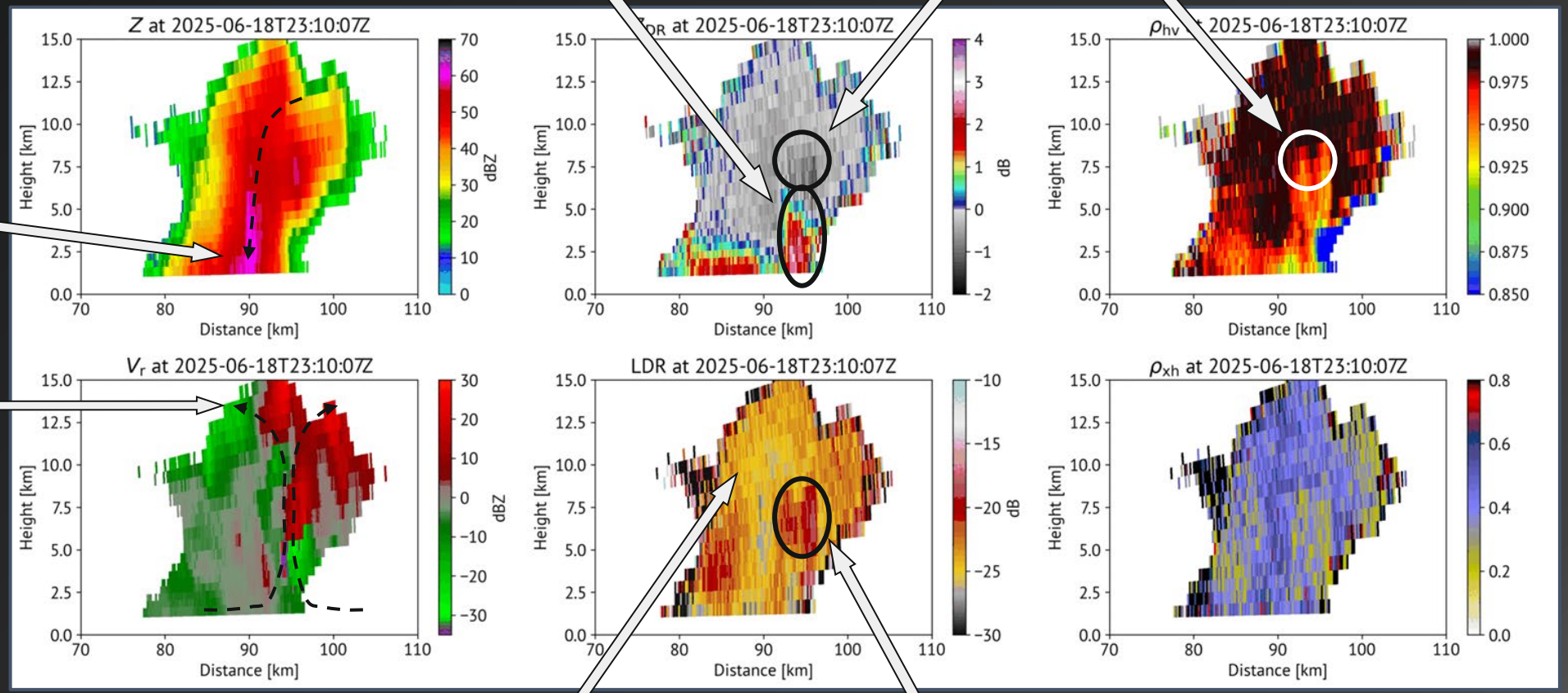


Improved Imaging quality

New beamforming techniques



Using alternate scanning modes to detect storm characteris



Software Drives Capability

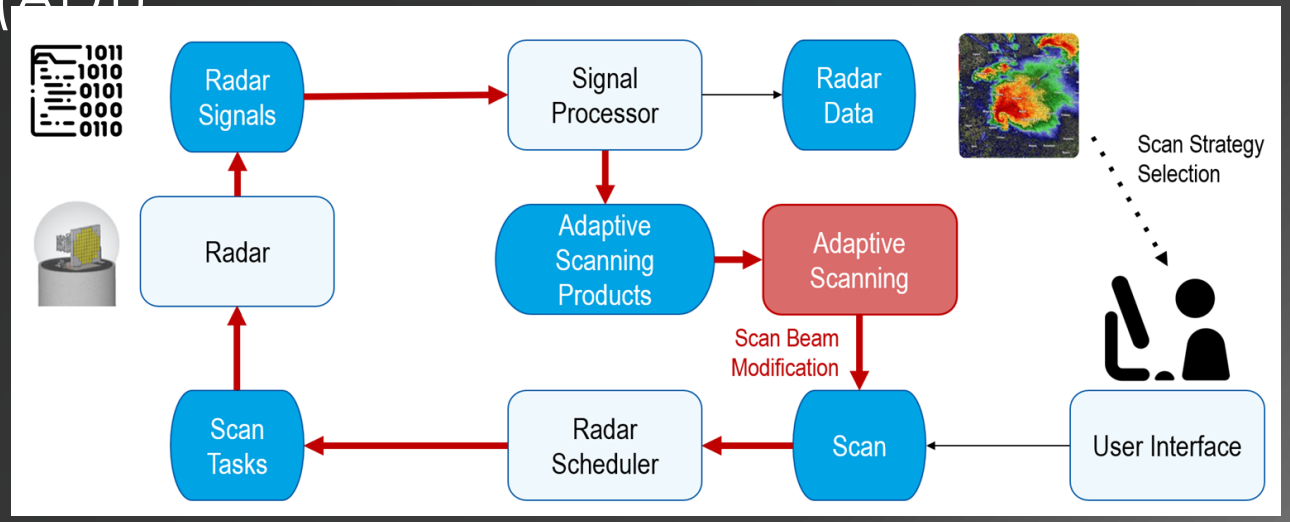
Major software releases twice a year continuously add advanced capabilities in support of program research objectives.

Recent upgrades:

- Adaptive focused observations (ADAPTS)
- Adaptive dwell tailoring (ADT)

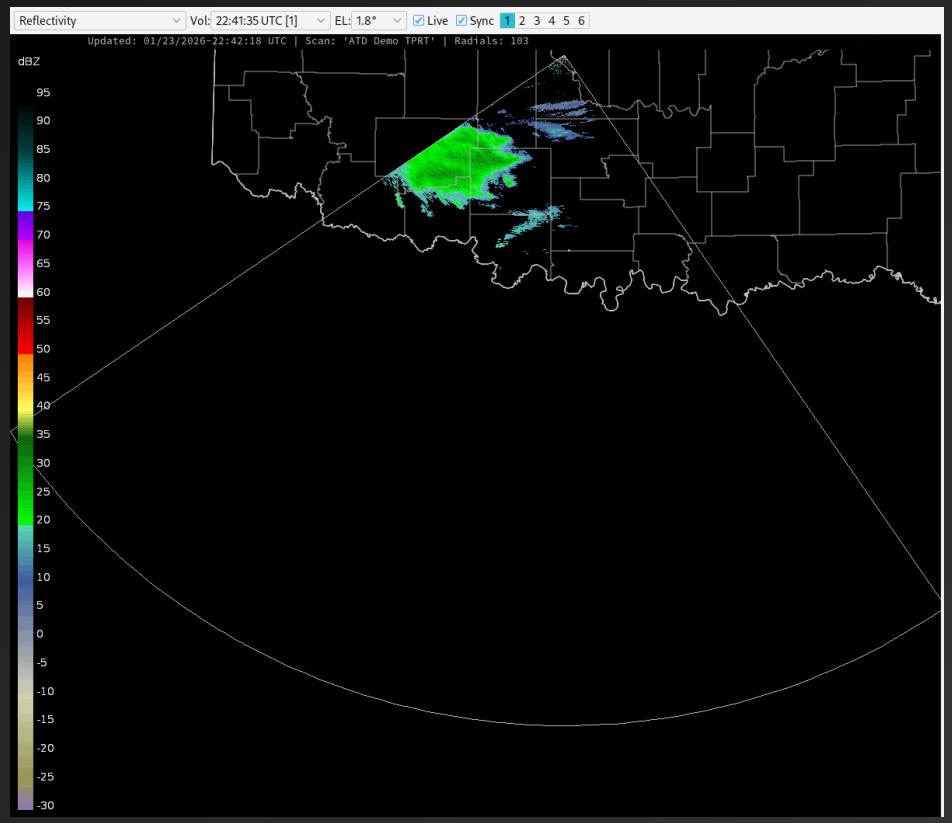
Upcoming upgrades:

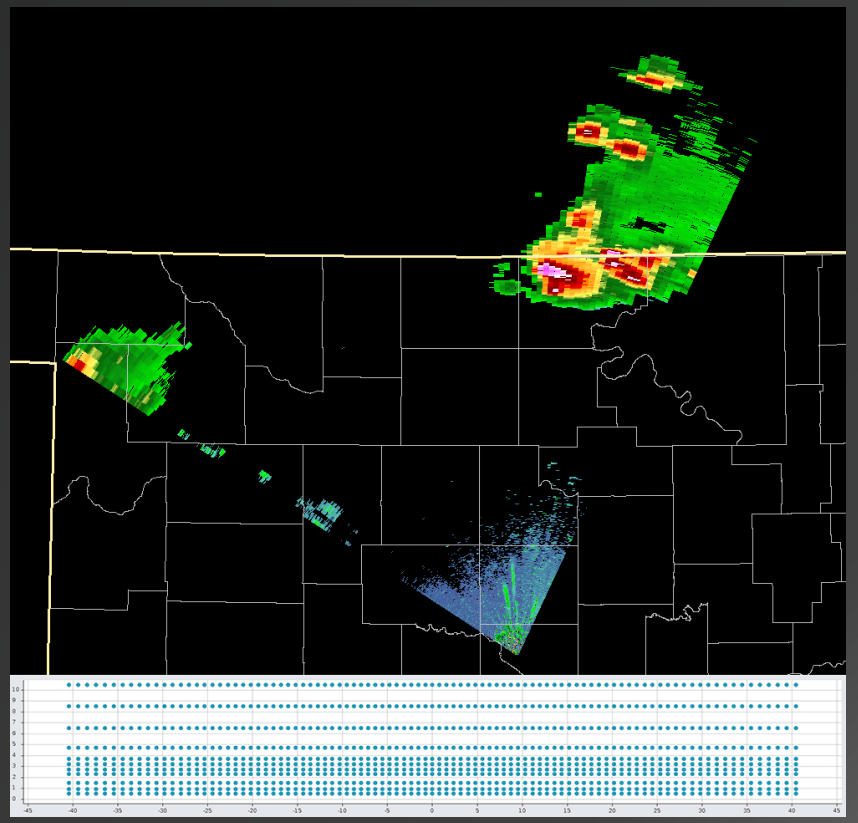
- Radar imaging (transmit beam spoiling)
- Simultaneous measurements of dual-pol variables and LDR



ATD Adaptive Scanning Framework

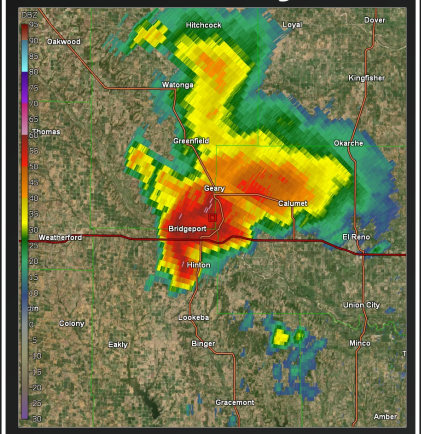
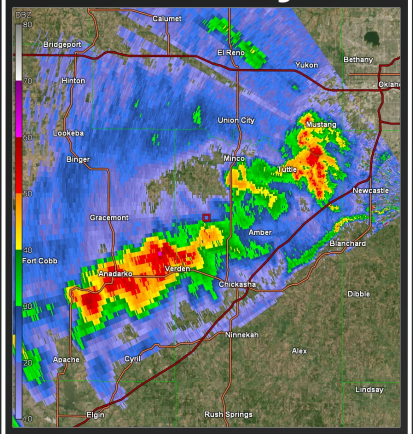
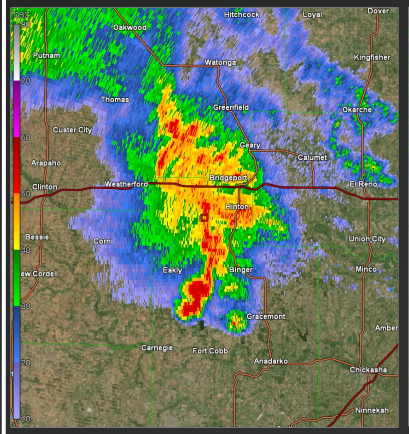
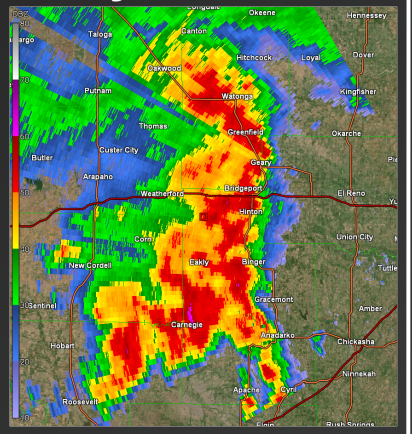
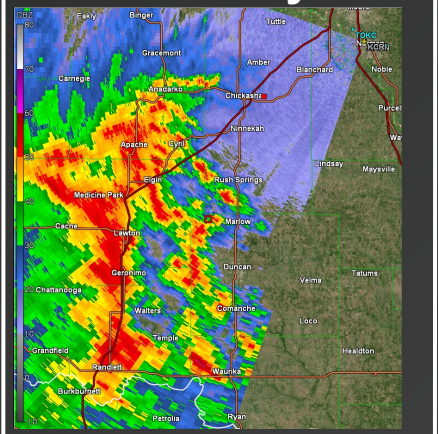
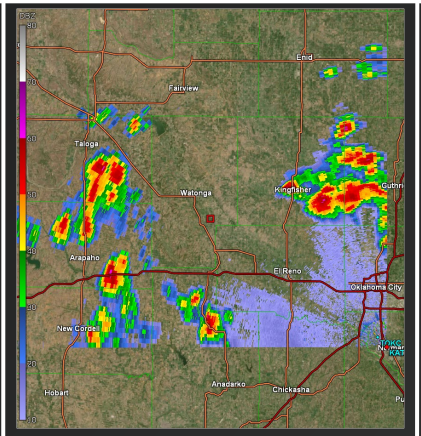
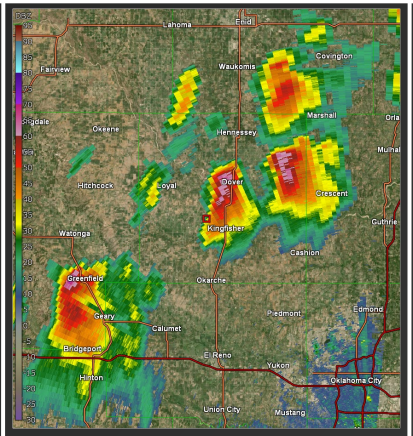
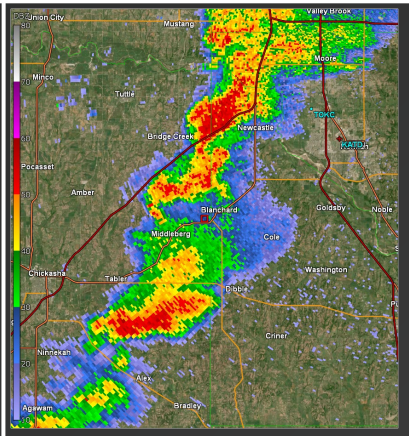
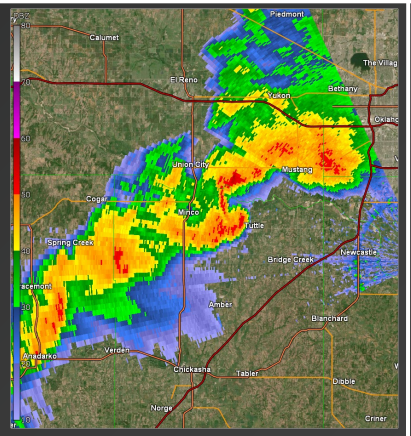
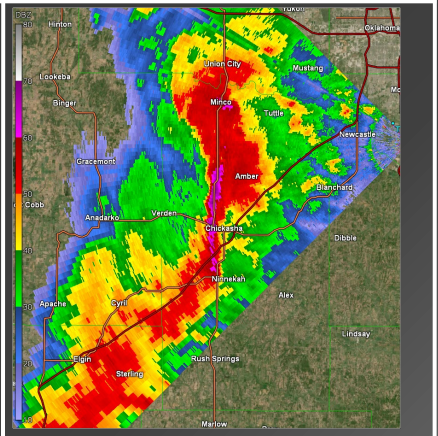
Adaptive Scanning





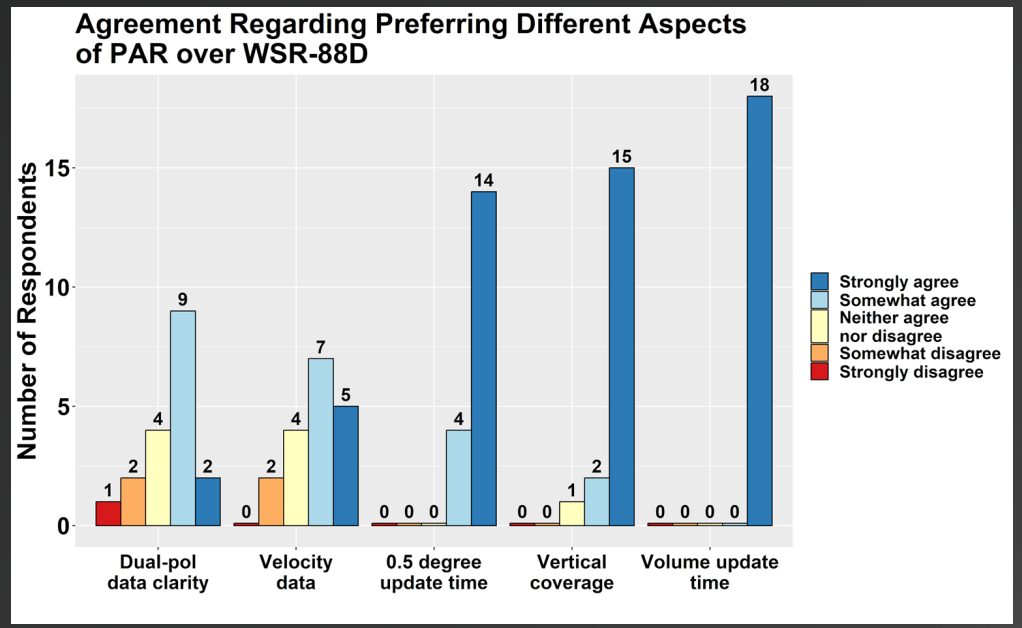
- Two adaptive scanning techniques: ADAPTS and ADT
- PAR electronic scanning provides the flexibility to implement this technology
- Continue expanding AI/ML tools for "smarter" scanning

2024 - 2025 PAR HWT Activity Weekly Structure

	Monday	Tuesday	Wednesday	Thursday
Morning			 	
	Training case	Multicell. Downburst. PAR only Survey & focus group	MCS. Wind and hail Two similar cases, half PAR, half WSR-88D, then switch Survey after each case, focus group after both	QLCS IDSS case PAR only Survey & focus group
Afternoon			 	
	Multicell. Downburst, hail. PAR only Survey and focus group	Supercell. Hail Same case run twice, half PAR, half WSR-88D, then switch Survey & focus group	Tornadic supercell. Two similar cases, half PAR, half WSR-88D, then switch Survey after each case, focus group after both	QLCS Same case run twice, half PAR, half WSR-88D, then switch Survey & focus group

PAR in NOAA Hazardous Weather Testb

- To date, NSSL has conducted two in-person PAR activities and two remote activity focused on exploring how PAR data impact forecaster understanding, confidence, and decision making
  - Results show a high forecaster preference for PAR across all severe hazards shown in the HWT



"[Issuing QLCS tornado warnings] definitely felt more comfortable using the KATD data compared to slower 88D data. The quicker update times/more elevation scans made me more confident to issue tornado warnings and it was easier to identify developing mesovortices." -HWT forecaster

NSSL is providing iterative and continuous feedback to NWS on PAR prior to finalizing next radar network design

- NWS has been charged by Congress to execute the PAR PPA
- Unsure how that changes the program yet

Summary

PAR is a necessary tool that provides increasing operational relevance and is a true next generation technology

NOAA's PAR R&D Program continues to advance our understanding of meteorology and radar engineering

A future PAR smart radar network will be able to leverage AI/ML to 'see' evolution; adjust scans; and maximize data need for end users

We are open to synergistic collaboration and ideas that fit our R&D path

contact: anthony.reinhart@noaa.gov