Early Detection of Severe Storms


Photo by Adam Smith


Photo by M. Bennet

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Acknowledgements

NSSL

- NWRT PAR hardware and software engineering teams
- Experimental Warning Program Leaders

NOAA

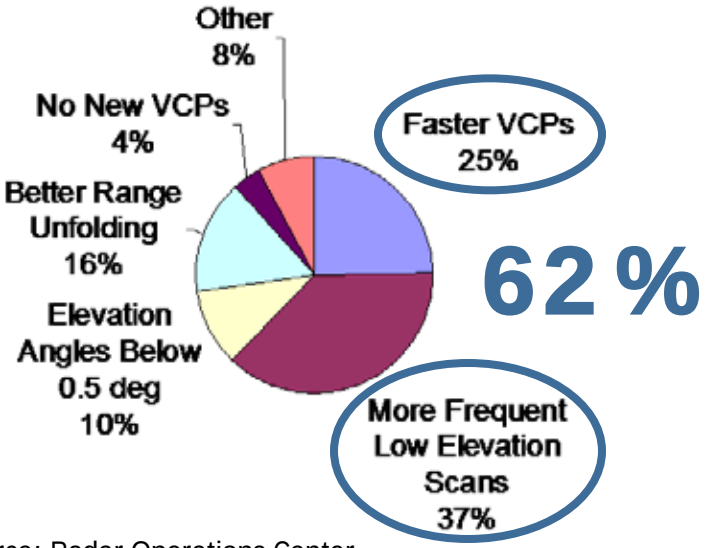
- Hazardous Weather Testbed Directors
- National Weather Service

OU School of Meteorology and Atmospheric Radar Research Center

Private Industry Partners

Purpose of the NWRT PAR

Stakeholders' needs: **Faster Updates**



Source: Radar Operations Center

Strengths and limitations of current radar systems: **To maintain and/or provide**

1) Reliable, clean, accurate, volumetric data, without intervention
2) Higher-temporal and higher-spatial resolution data
3) Consistent and low-altitude information throughout CWA
4) Precipitation type, size, distribution, and intensity information

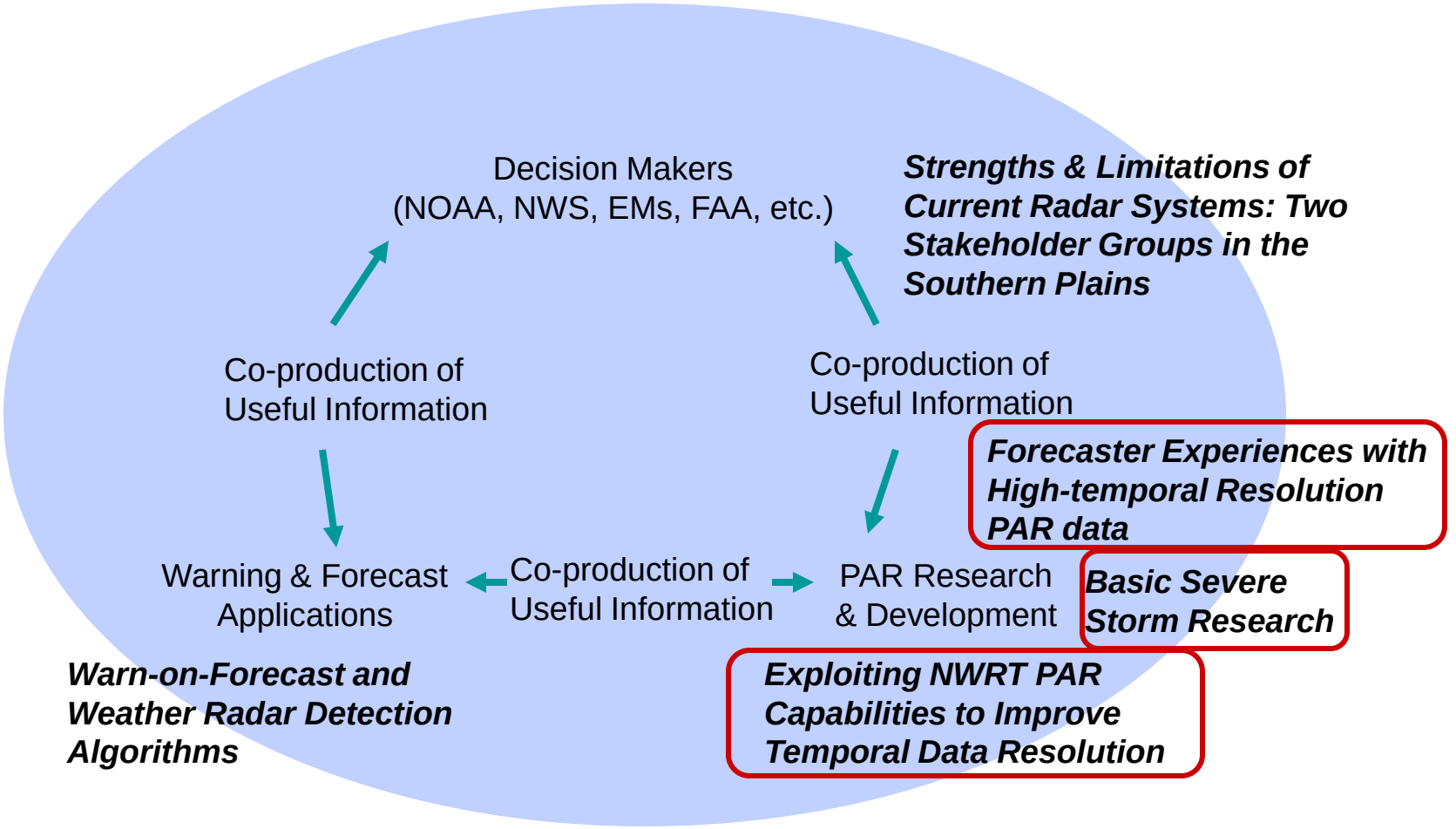
Source: Newman et al. (2009)

Determine how to best capitalize on PAR capabilities to address 21st century forecast and warning needs

Integrated Scientific Research

Goal: Produce the most usable technology

End-to-End-to-End Research Process

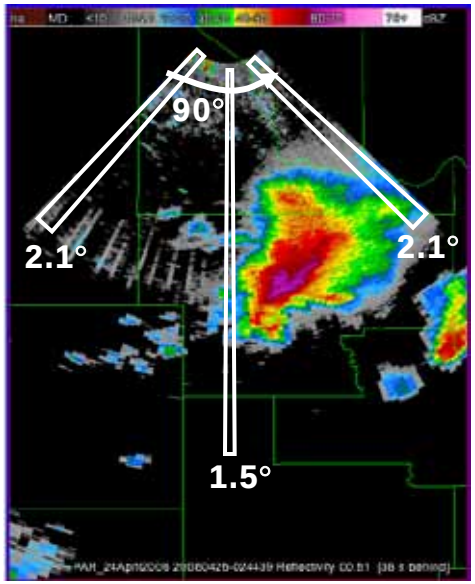


Adapted from Morss et al. 2005

Characteristics of NWRT PAR

Current Setup

High-Temporal Resolution Data



90° Sector Scan

Ultimate Goal

Specs [3] Current Requirements

Characteristics Similar to WSR-88D

Wavelength: PAR = 9.4 cm / WSR-88D = ~10 cm (S-band)

Range Resolution: PAR = 240 km / WSR-88D = 250 km

Signal Processing Upgrades

- **Data Quality**: brings performance closer to that of operational radars
  - Artifact removal
    - Ground clutter, interference, DC bias, point targets
  - Range and velocity ambiguity mitigation
  - Calibration
- **Evolutionary**: demonstrates PAR technology for weather applications
  - Adaptive scanning
  - Range oversampling
  - Beam multiplexing
  - Spectral analysis
  - Multi-function


Photo by M. Benner

Courtesy of Sebastian Torres

PARISE

Phased-**A**rray **R**adar **I**nnovative **S**ensing **E**xperiments

To develop:

High-temporal resolution, phenomenon-based scanning strategies

To evaluate:

Strengths and limitations of PAR data in the warning decision process

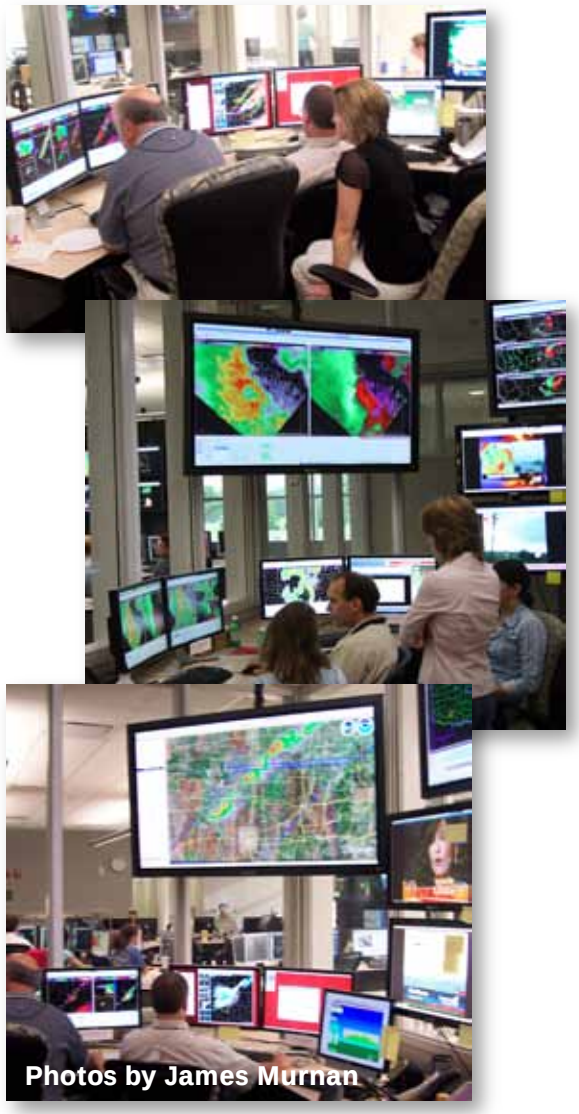
Challenges of using PAR data in a pseudo-operational environment

Impact of scanning strategies on depiction of severe storms

To improve:

Warning operations

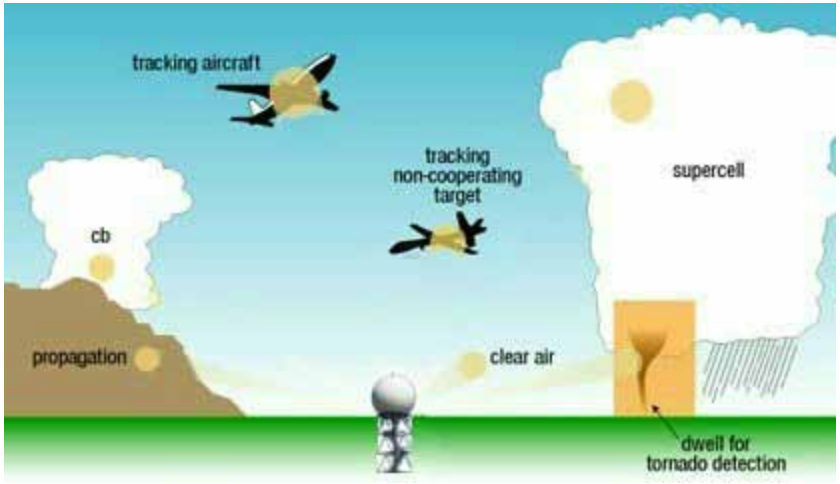
Understanding of severe storm processes



Electronic Adaptive Scanning

Conventional scanning

Everywhere
Sequential



Adaptive scanning

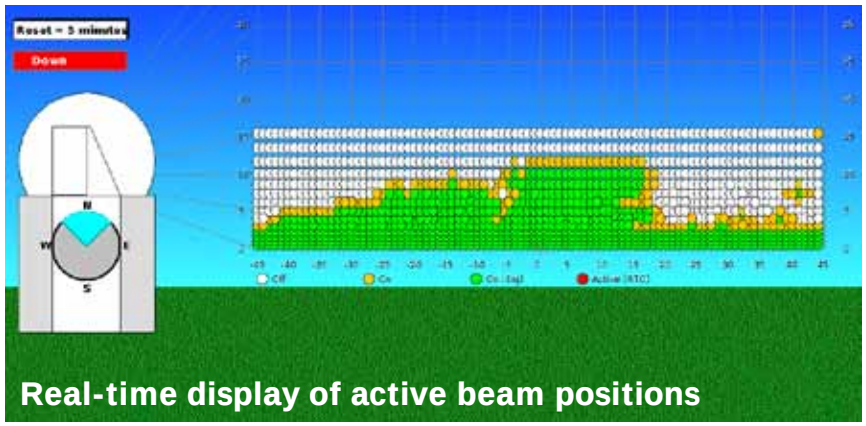
Areas of interest only
Arbitrary

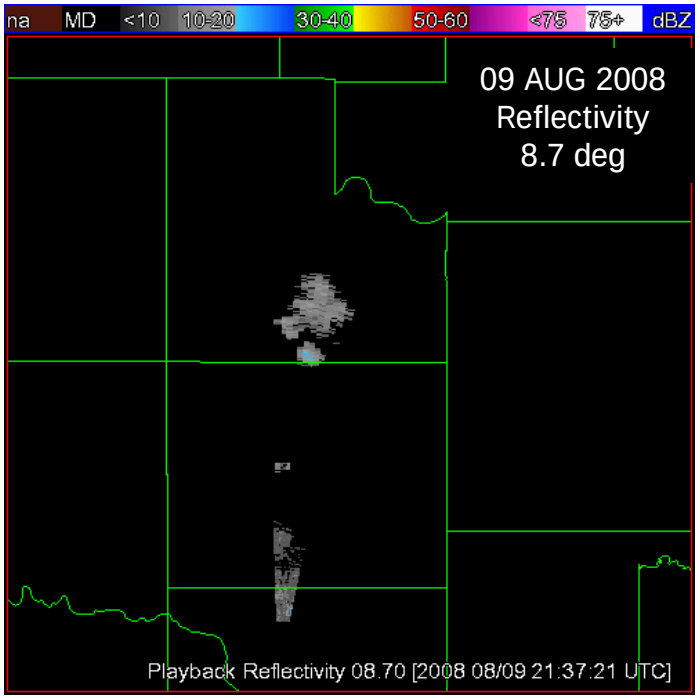
Courtesy of Chris Curtis

Goal: Faster Updates

ADAPTS

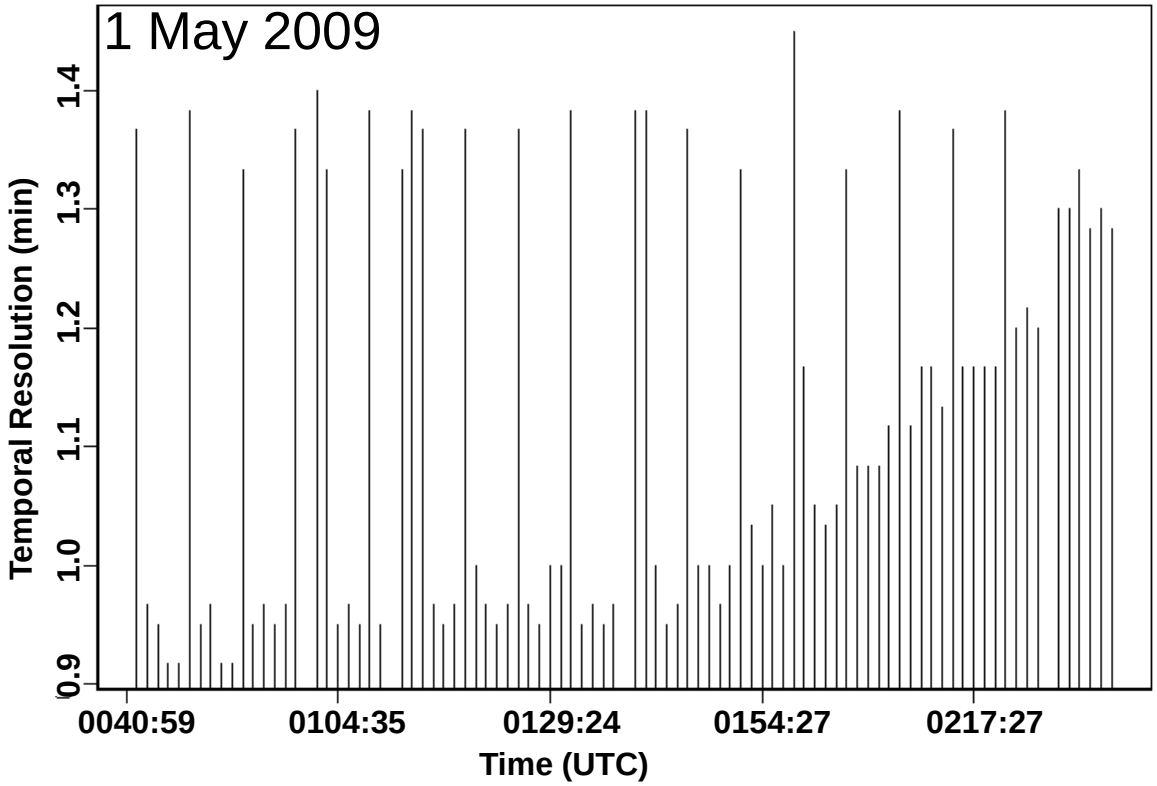
- Adaptive DSP Algorithm for PAR Timely Scans
  - Beam positions are classified as **active** or **inactive**
    - Only **active** beam positions are scanned
    - Full volume scans are scheduled periodically
  - Active beam positions meet one or more criteria
    - Elevation angle
    - Continuity and coverage
    - Neighborhood

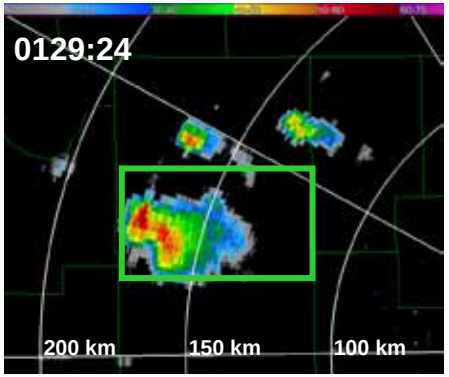


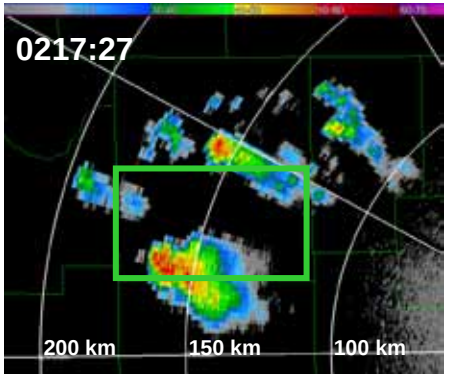


Courtesy of Sebastian Torres

ADAPTS: Faster Updates

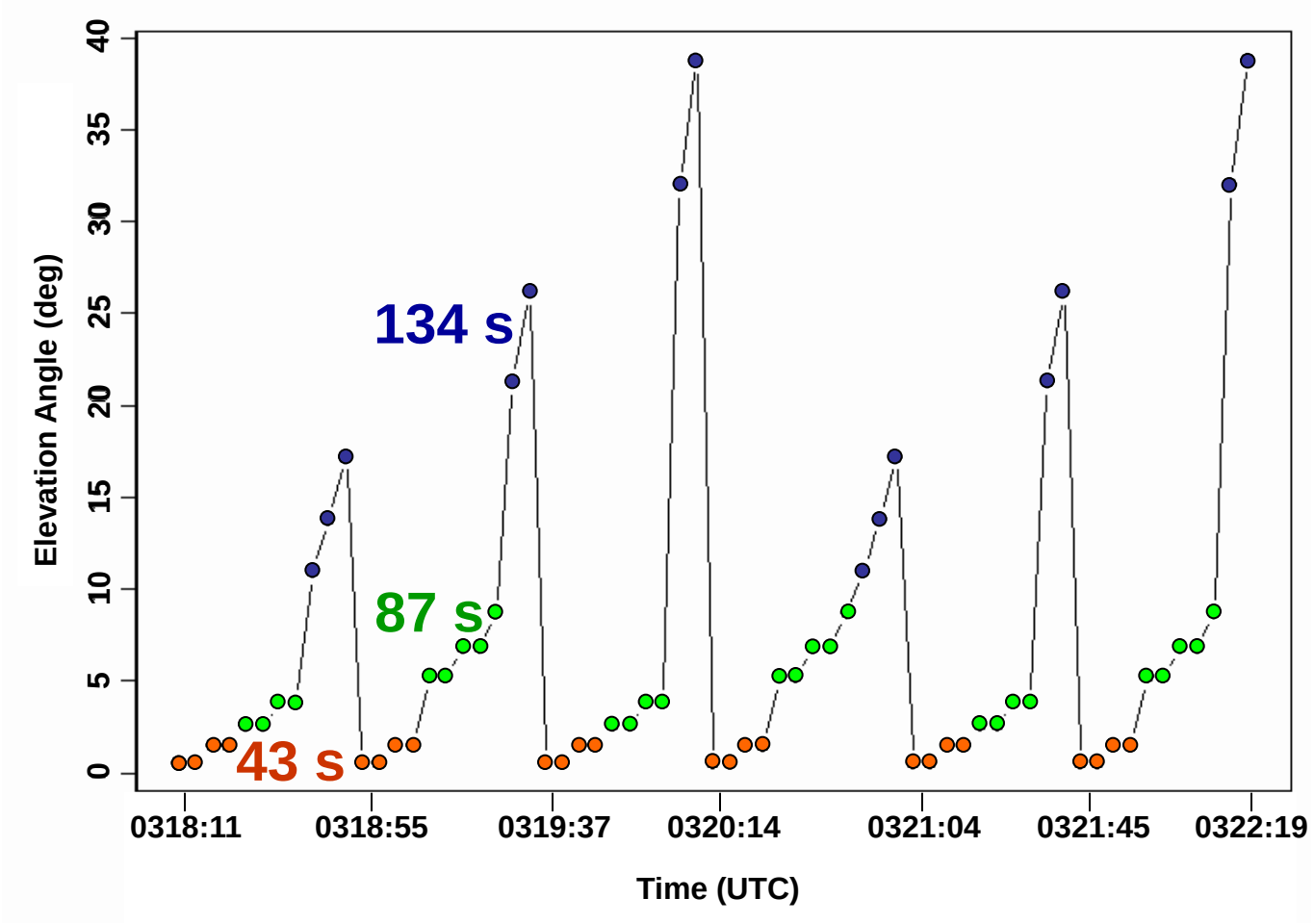






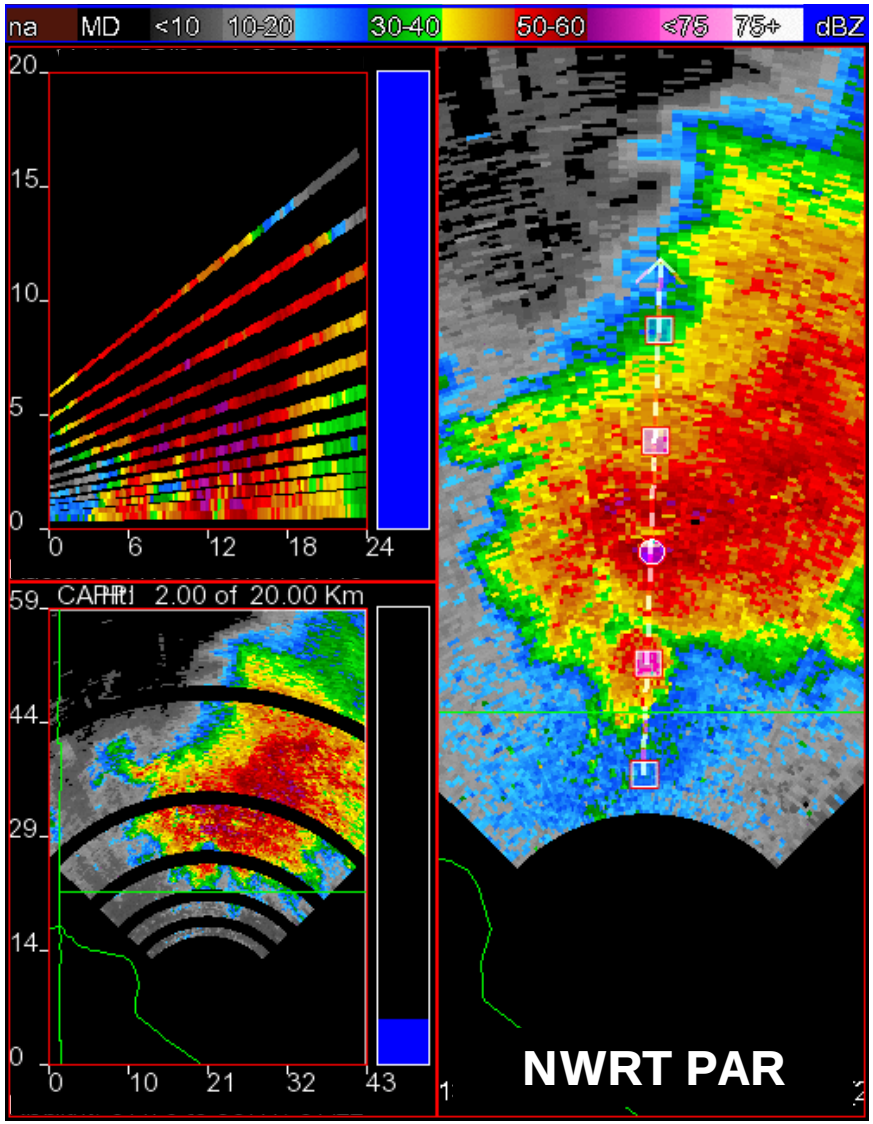
Elevation-Prioritized Scanning

Strategy yields different update times at different elevations by scheduling 14 tilts in a non-sequential manner



Elevation-Prioritized Scanning

- Strategy yields different update times at different elevations by scheduling 14 tilts in a non-sequential manner
  - **Low-levels: 43 s updates**
  - **Midlevels: 87 s updates**
  - **Upper-levels: 134 s updates**

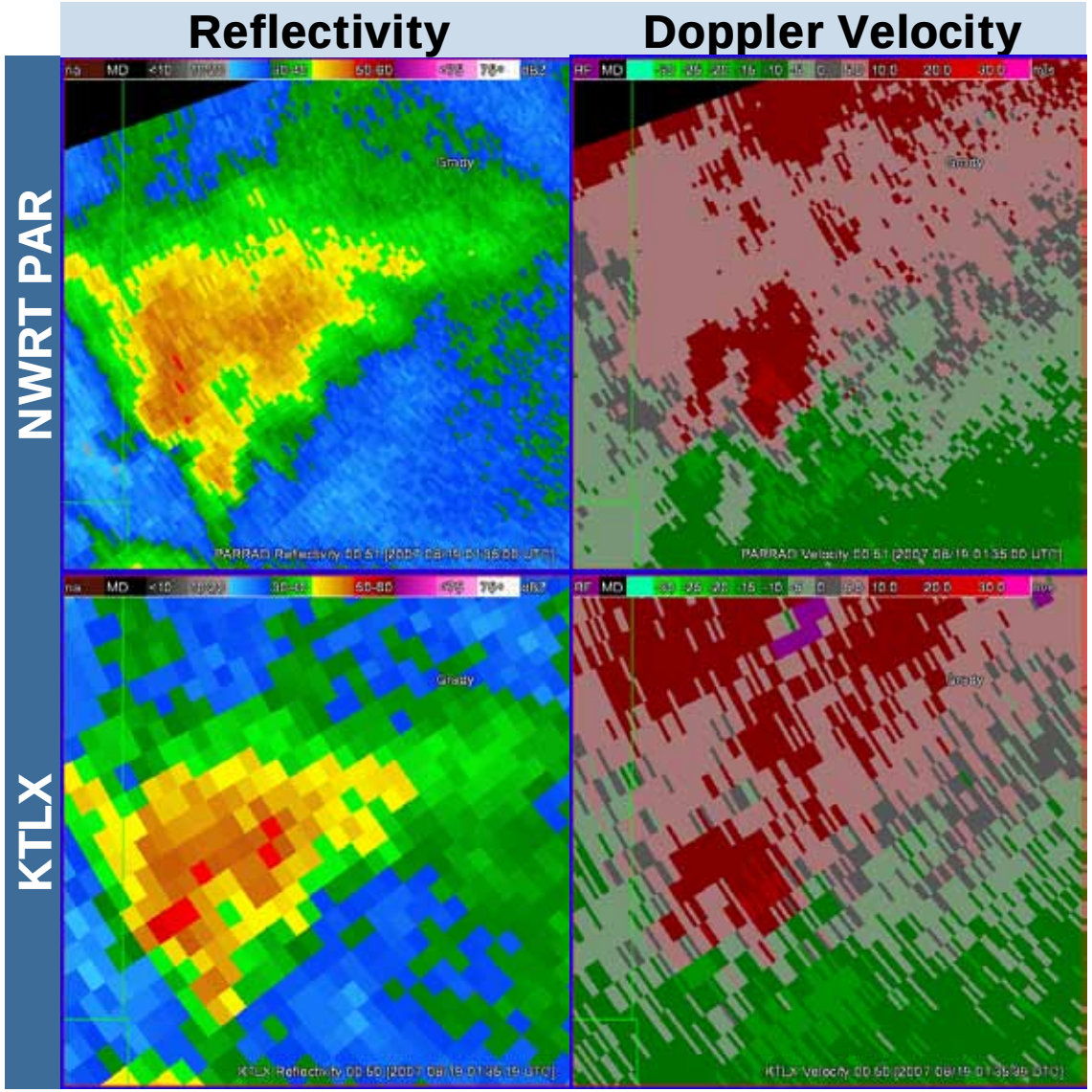


14 May 2009

Radar Locations

Beam Multiplexing: 43 s Updates

- Strategy yields fast update times by concentrating on a sector and using beam multiplexing
  - NWRT PAR
    - 60 deg sector
    - 43 s updates
  - NEXRAD
    - Conventional scan
    - 4.1 min updates



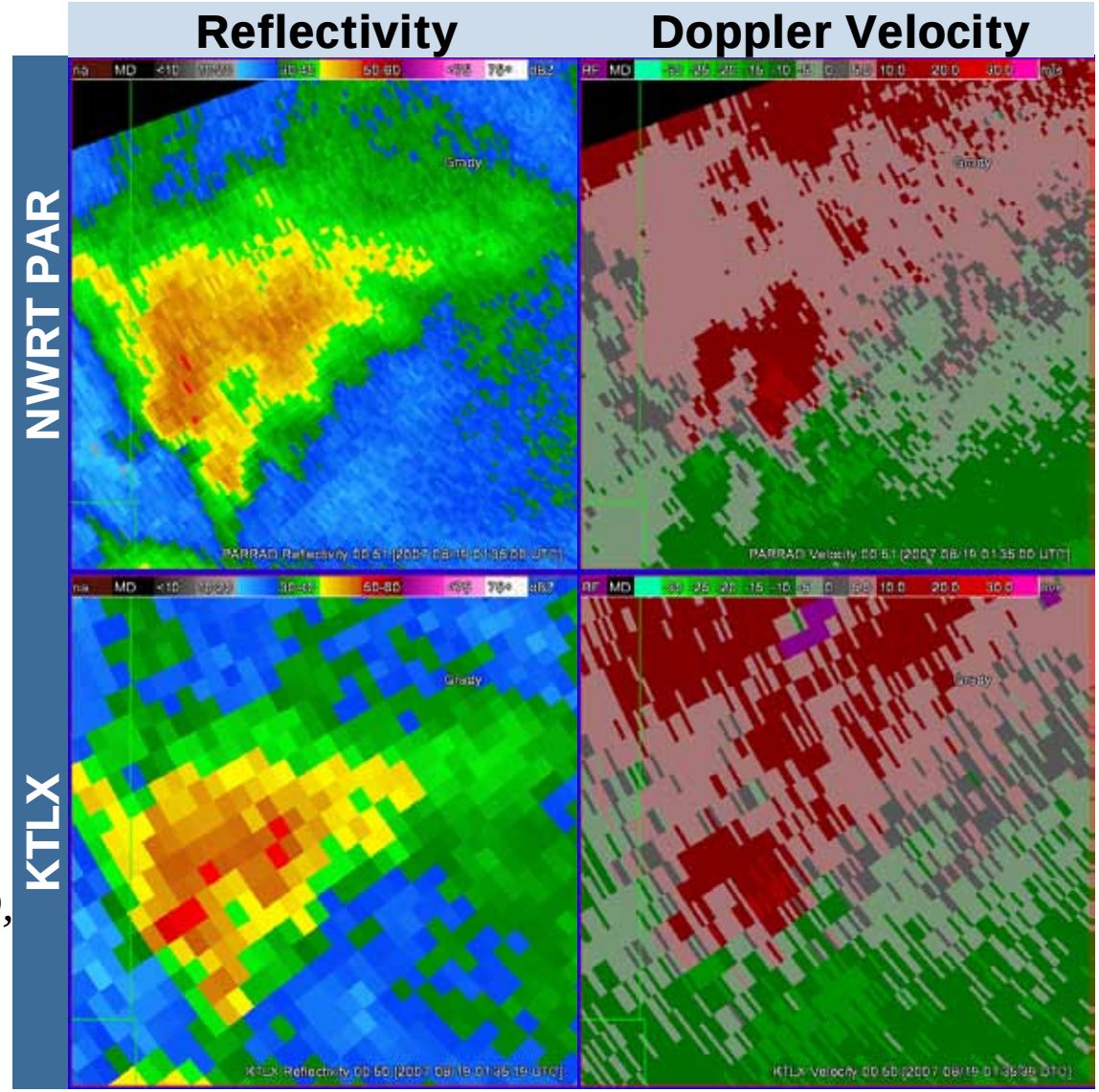
19 Aug 2007

Forecaster Evaluation

"Superior to KTLX for identifying mini-supercell features."

"Rapid updates at the 0.5° tilt were critical in this case; rotation and TVS features were very fast moving and very fast to evolve."

"Allowed the tornado warning to be issued 3 – 4 min before the signature appeared on 88D, and with higher confidence."

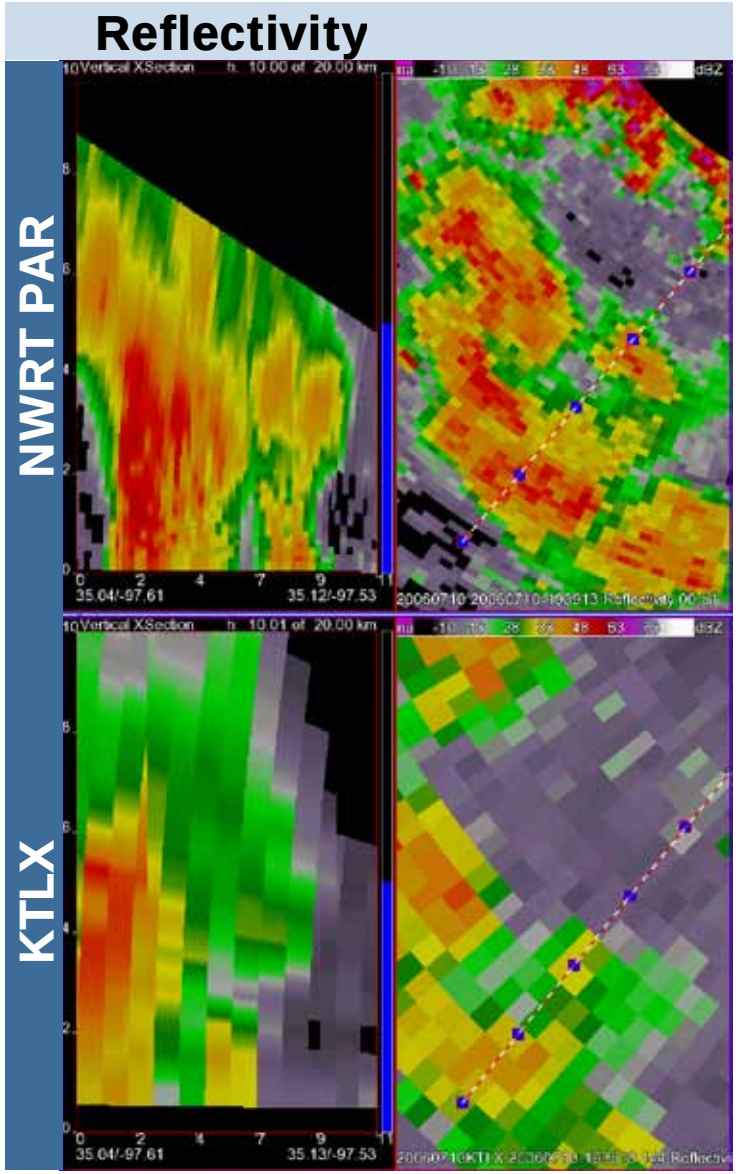


19 Aug 2007

Beam Multiplexing: 34 s Updates

10 July 2006

- Strategy yields fast update times by using beam multiplexing
  - NWRT PAR
    - 90 deg sector
    - 34 s updates
  - NEXRAD
    - Conventional scan
    - 4.1 min updates



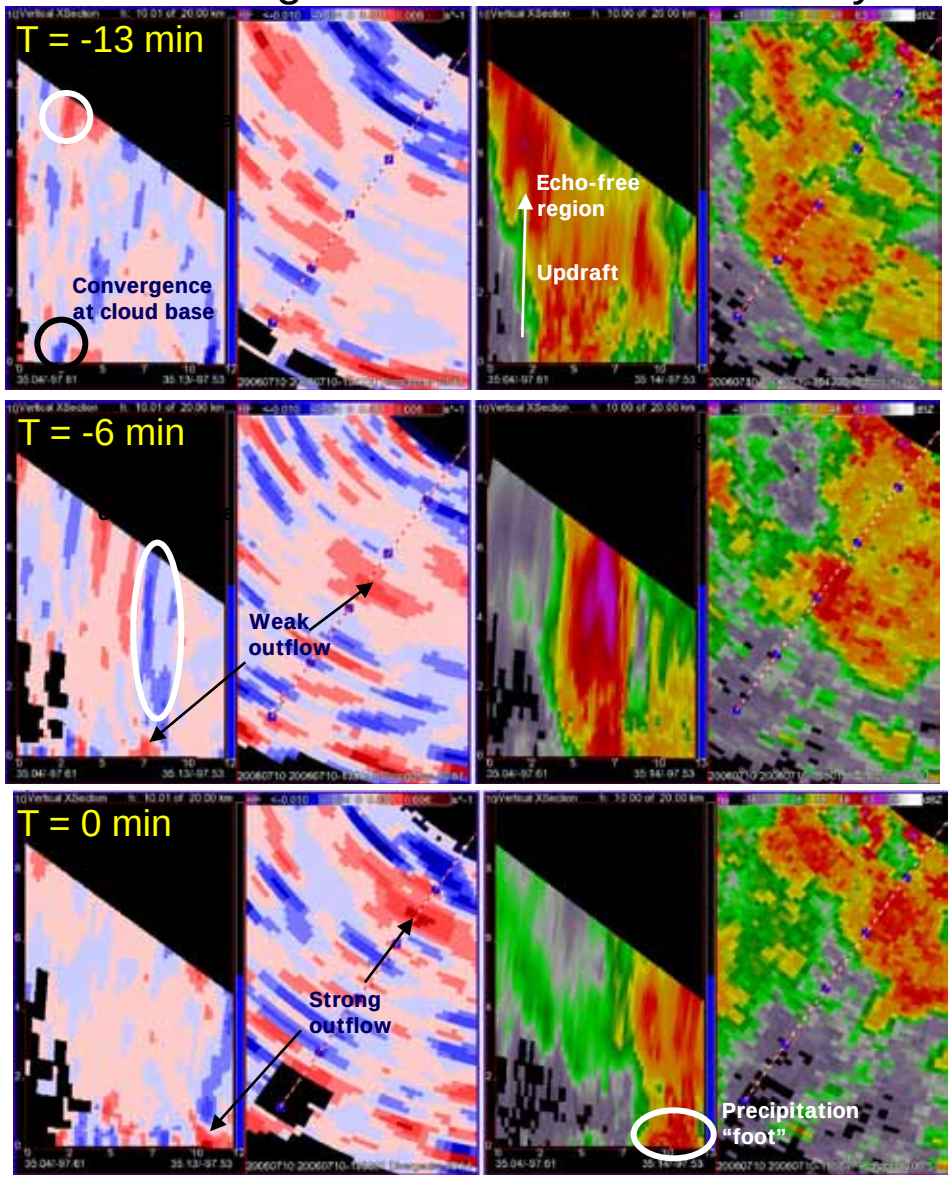
Forecaster Evaluation

"High temporal resolution of PAR allowed me to identify near-ground-level severe winds which were considerably under-played by KTLX (27 kt vs 57 kt)."

"You can diagnose better what's going on so you can have more confidence in issuing or not issuing warnings."

"Rapid updates will help get the warning out period. We have many missed pulse storm hail and wind warnings."

PAR Divergence | PAR Reflectivity



Key Findings

PAR Data Had Major Impact on Warning Decision Process

High-temporal resolution showed continuity of significant, transient features, making them easier to identify

Continuity of features led to greater confidence

Note: No questions asked about confidence

Warnings were issued earlier, increasing lead time over conventional radars

Sampson & LaDue

Wet Microburst Study

- Four days from July and August 2007-2008
- These days qualify as “microburst days” as defined by Atkins and Wakimoto (1991)
- 25 storms were analyzed, 10 were microbursts
  - Reflectivity
  - Divergence

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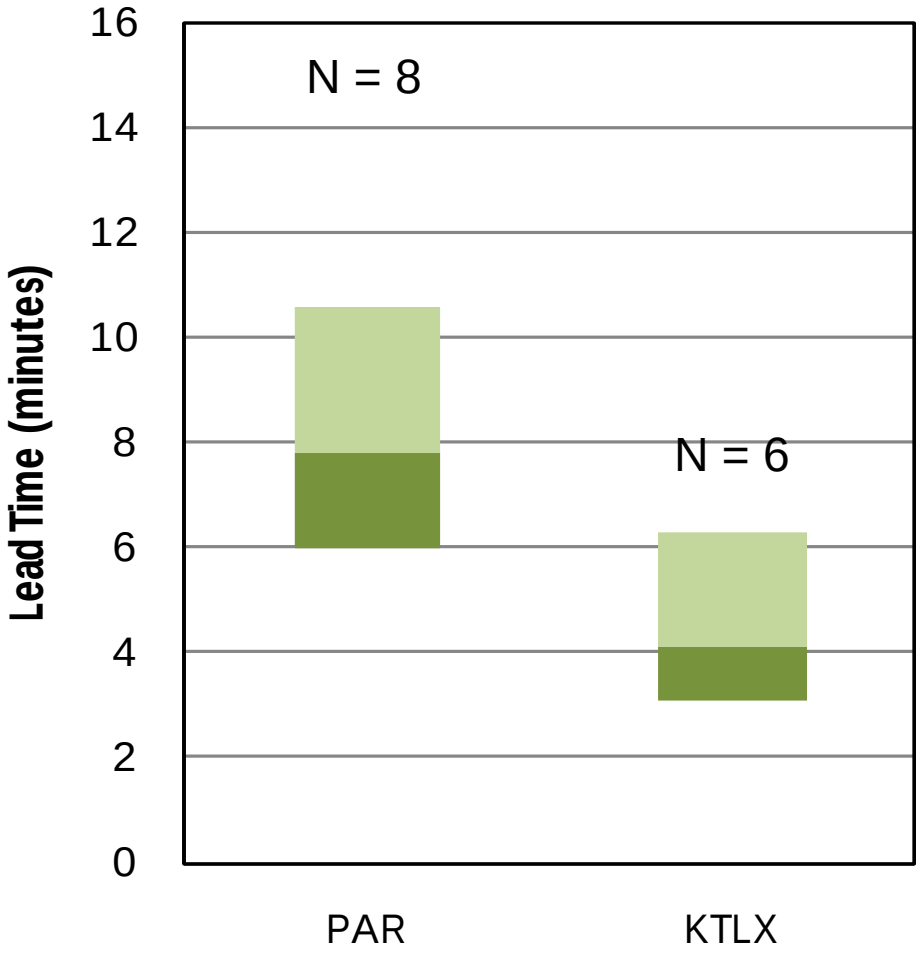
Courtesy Steve Irwin and Travis Smith

Lead time Comparison



Courtesy Steve Irwin and Travis Smith

Summary

NWRT PAR provides the high-temporal resolution data desired by users

- Electronic adaptive scanning *further improves temporal resolution* by activating only beam positions with significant weather; *up to 36% increase in case shown*

Forecaster feedback (N=30) for cases shown indicates 3 key advantages of high-temporal resolution data:

- Identification and continuity of significant features
- Increased confidence in decision-making process
- Few min increased lead-time

Data collected provides opportunity to explore improvements in understanding of storm processes due to high-temporal resolution sampling