Aviation Weather Hazards Observed with Phased Array Radar

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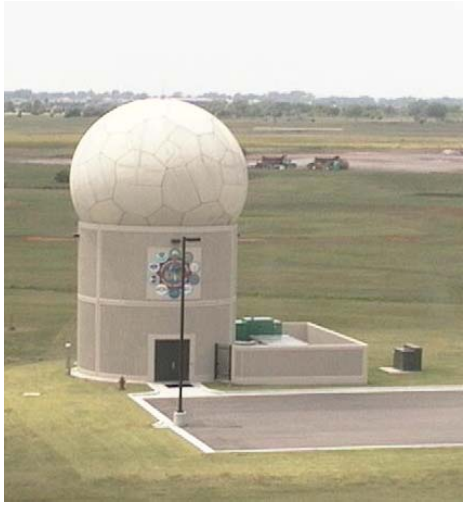
National Weather Radar Testbed

The NWRT is a research and development facility designed to prototype and evaluate the use of phased array radar for weather surveillance and target tracking applications.



Developed by 3 sector partnership: government, academia, and industry

- NOAA/National Severe Storms Lab
- National Weather Service
- Office of Naval Research
- Federal Aviation Administration
- Dept. of the Navy
- University of Oklahoma
- OK State Regents
- Lockheed Martin
- Basic Commerce & Industries, Inc.

Why Phased Array Radar?

Faster update times

- **Stationary antenna allows 4 co-located faces**
- **Electronic beam steering allows advanced sampling strategies**

Adaptable scan capability

- **Freedom to create scanning strategies suitable for variety of weather phenomena**
- **Ability to change scanning strategies through the radar control interface in real time.**

Benefits of NWRT PAR to Aviation

Faster scan rates + Adaptable scan capability =

Increased safety and capacity in severe weather conditions via hazardous weather monitoring

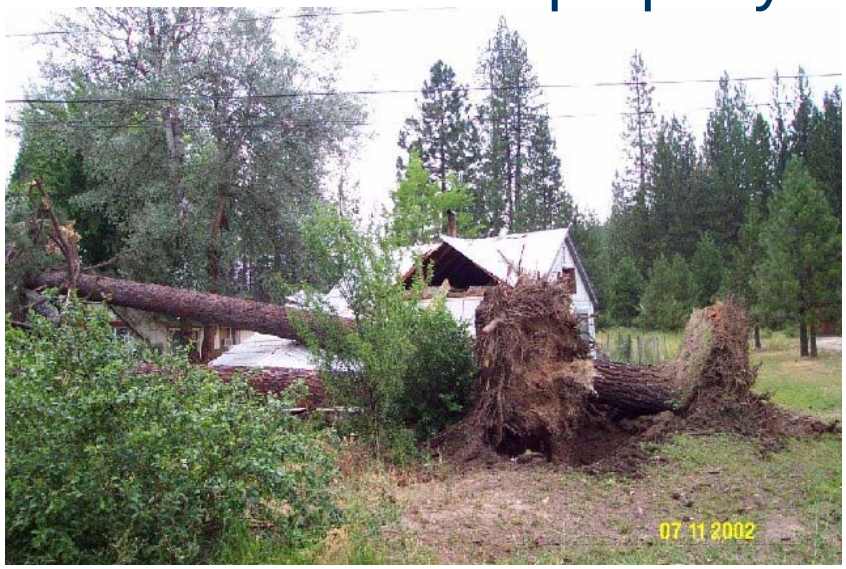
- Microburst wind shear
- Gust front/wind shift
- Convective storms
- Hydrometeor discrimination

Microbursts

Small-scale downdrafts (< 4 km) that produce strong winds

Hazardous to aviation

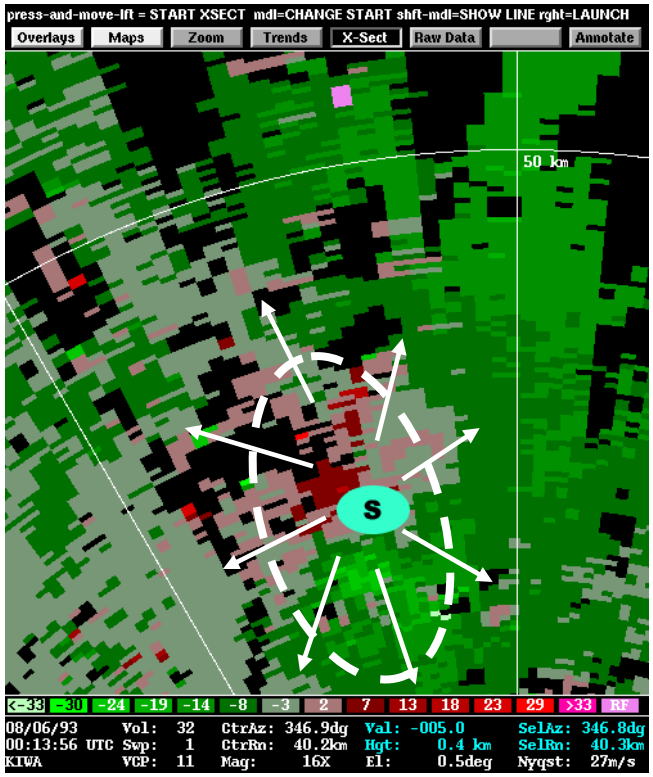
Hazardous to lives/property



Microburst Detection

Radial divergence signature at low elevations

Shallow outflow – must be well sampled near the surface



Microburst short-term prediction

Temporal scale: 15-20 minutes

- ≥ 20 PAR VCP 12 volume scans
- 3 to 5 WSR-88D VCP 12 volume scans
- 4 to 6 TDWR hazardous mode volume scans

Precursor signals occur aloft prior to outflow at surface

- Strong / deep mid-altitude radial convergence
- Elevated reflectivity core that rapidly elongates / descends
- Roberts and Wilson (1989), Eilts et al. (1997)

Example: July 10, 2006 (PAR)

Central Oklahoma environmental conditions:

- Moderate CAPE
- Weak vertical environmental wind shear
- Favorable for “wet” microbursts

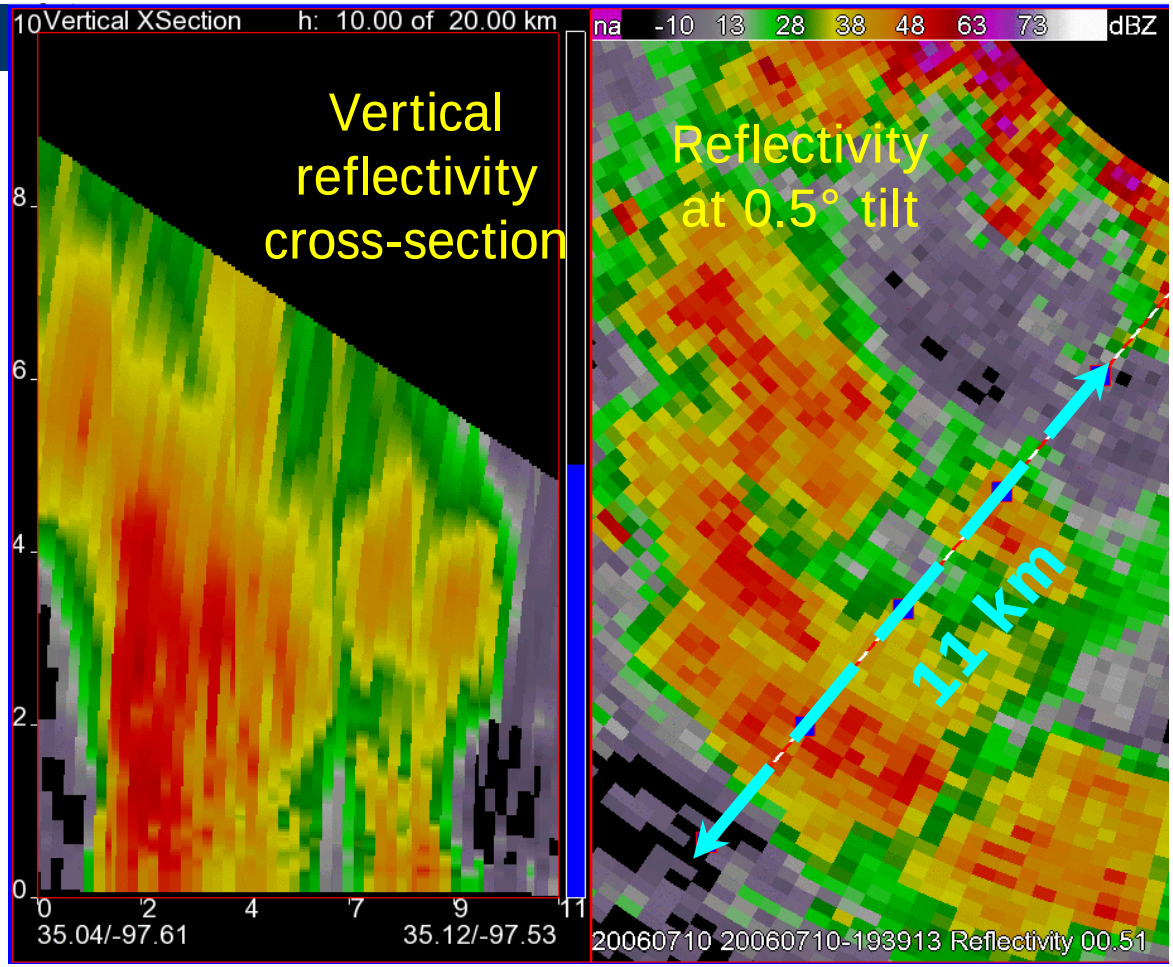
Radar sampling resolution

	NWRT PAR	TDWR (OKC)
Complete volume scan	34 seconds	180 seconds (60 s at 0.5º)
Beam width	1.5º – 2.1º	0.5º
Azimuthal Sampling	1.0º	1.0º
Gate spacing	240 m	150 m
Elevation angles	14	9

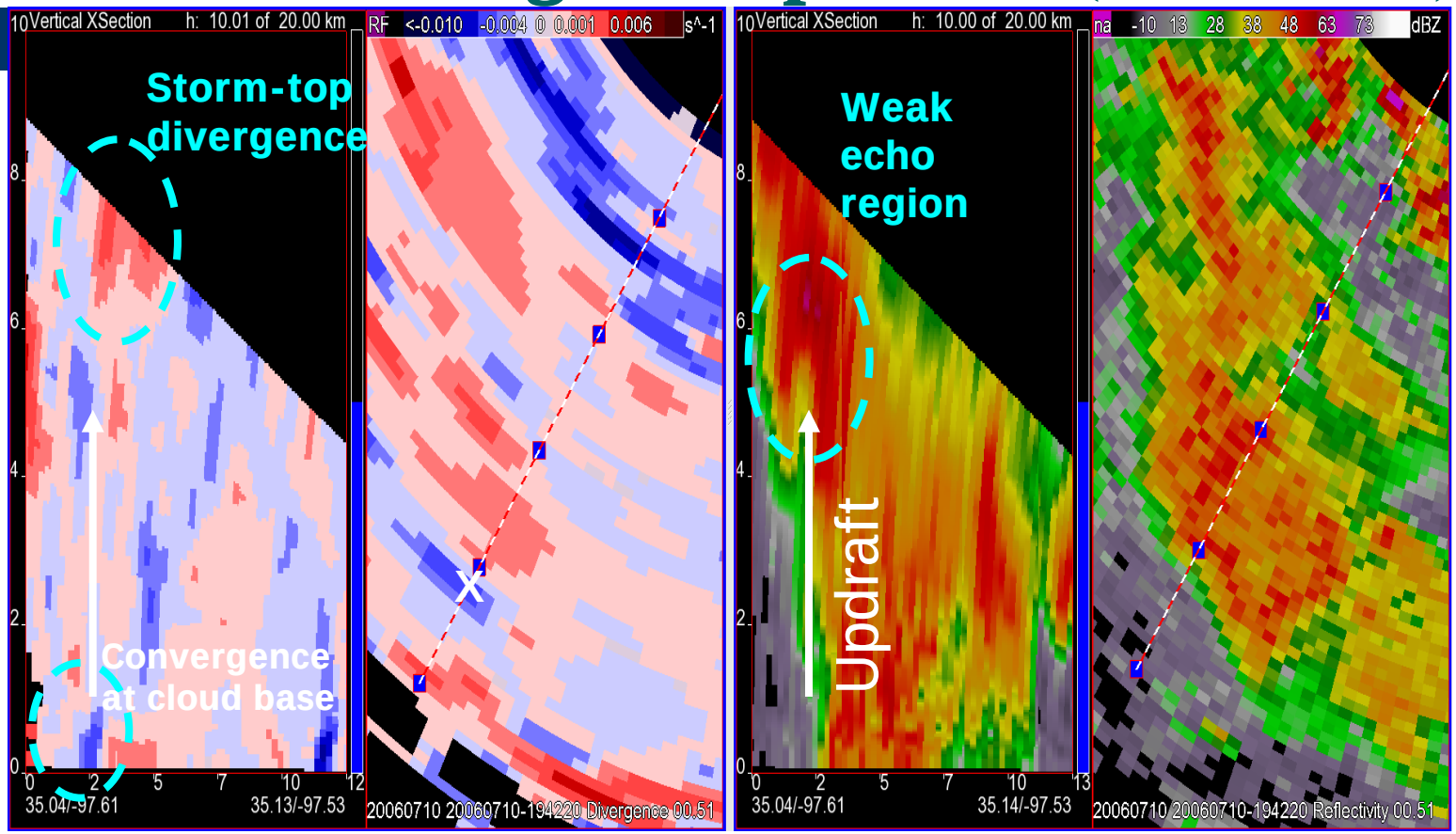
Example: July 10, 2006 (PAR)

VCP 12

34 second volumetric updates



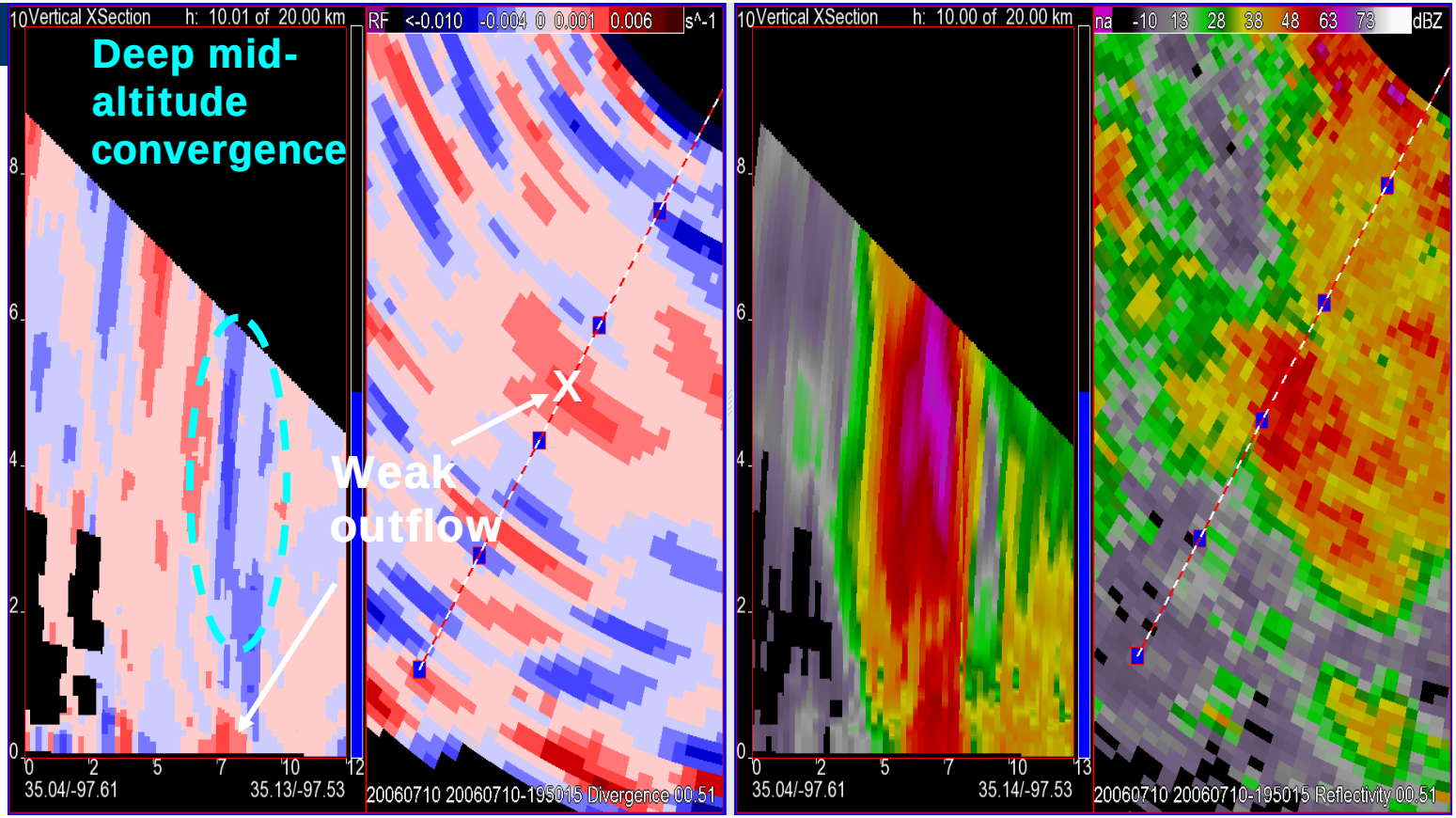
Radial Divergence profile (T= -13 min)



Vertical 0.5° tilt
PAR Divergence

Vertical 0.5° tilt
PAR Reflectivity

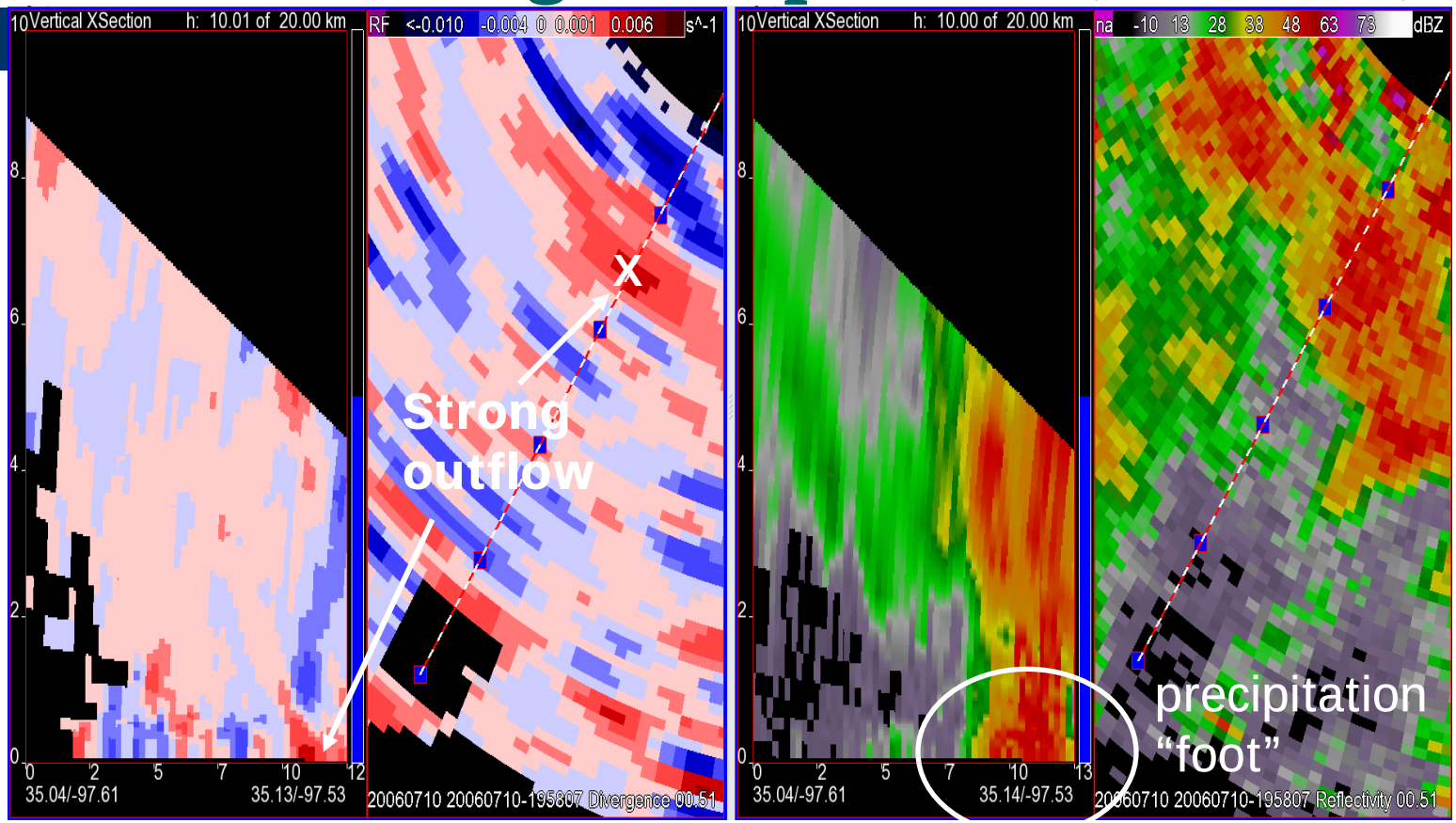
Radial Divergence profile (T= -6 min)



Vertical 0.5° tilt
PAR Divergence

Vertical 0.5° tilt
PAR Reflectivity

Radial Divergence profile (T = 0 min)



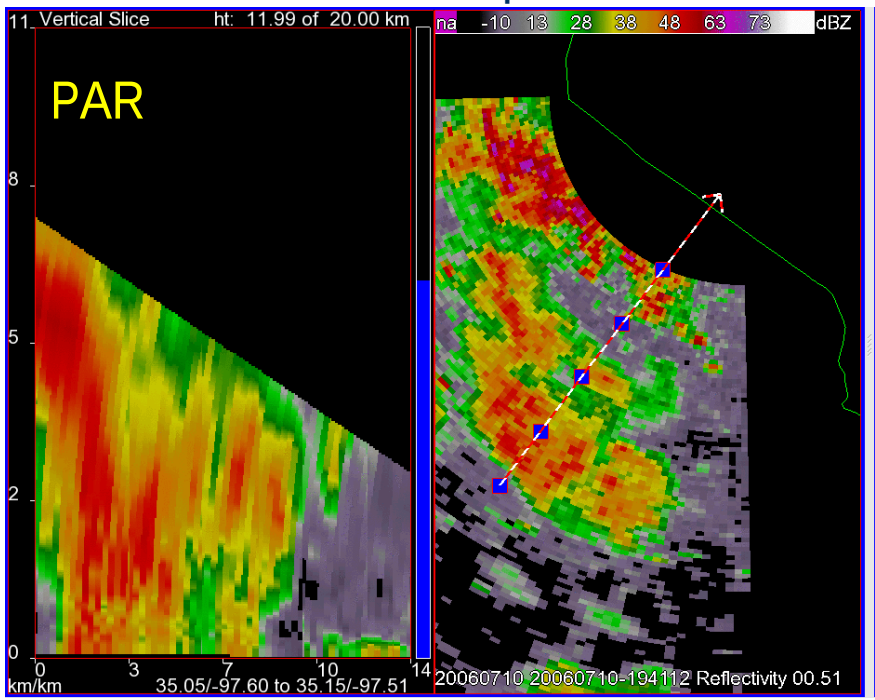
Vertical 0.5° tilt
PAR Divergence

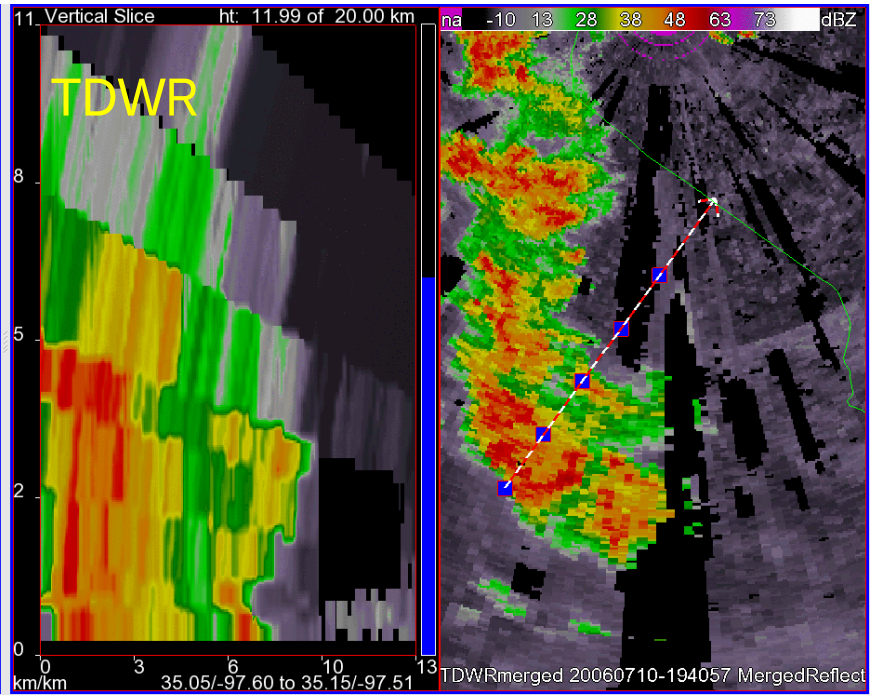
Vertical 0.5° tilt
PAR Reflectivity

PAR / TDWR comparison

34 second volumetric updates

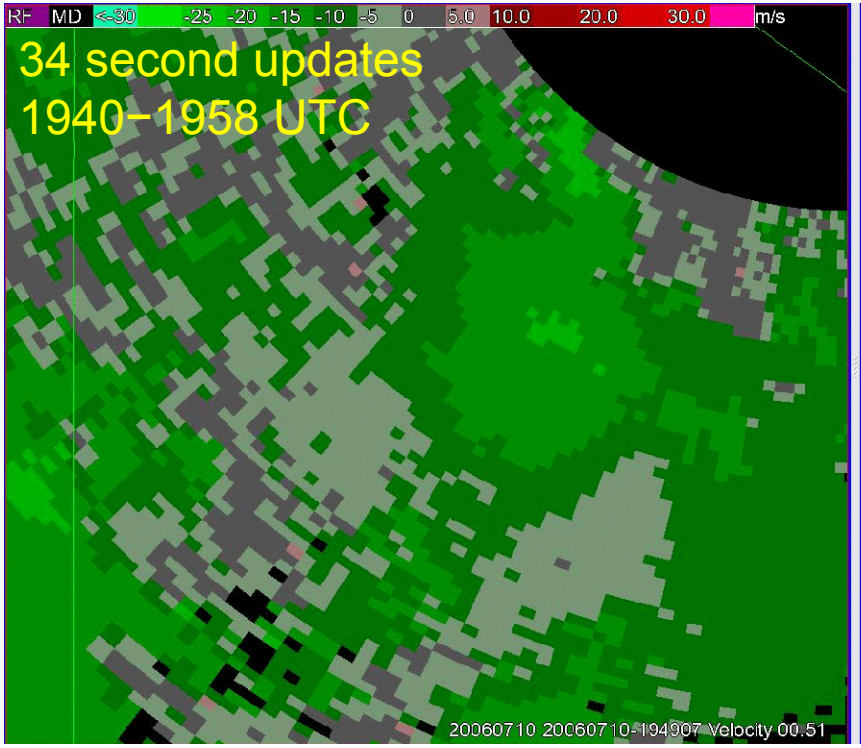
60 second updates



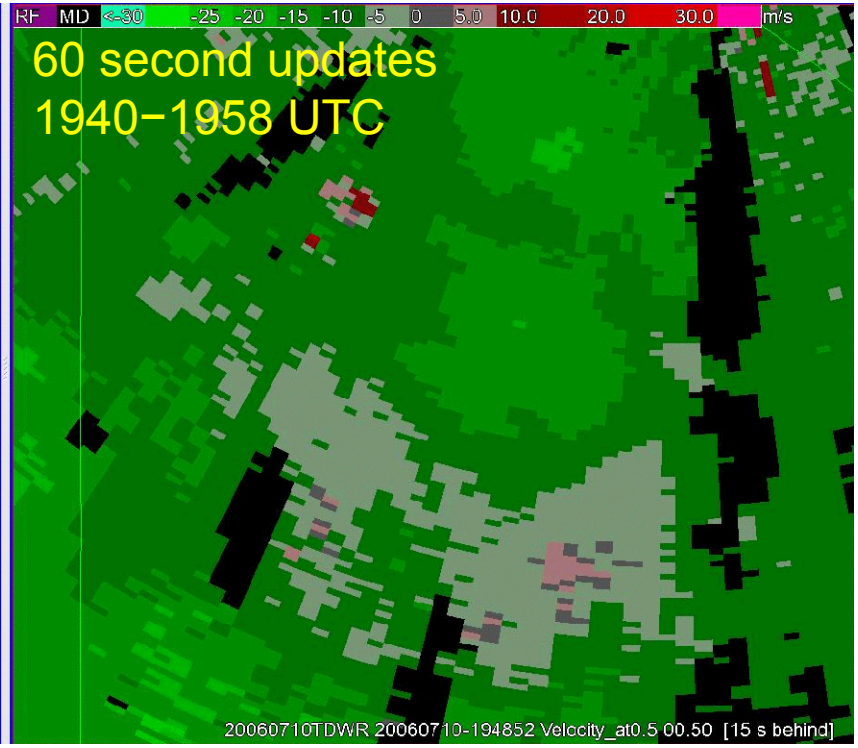


Vertical 0.5° tilt Vertical 1-km CAPPI

PAR / TDWR velocity data

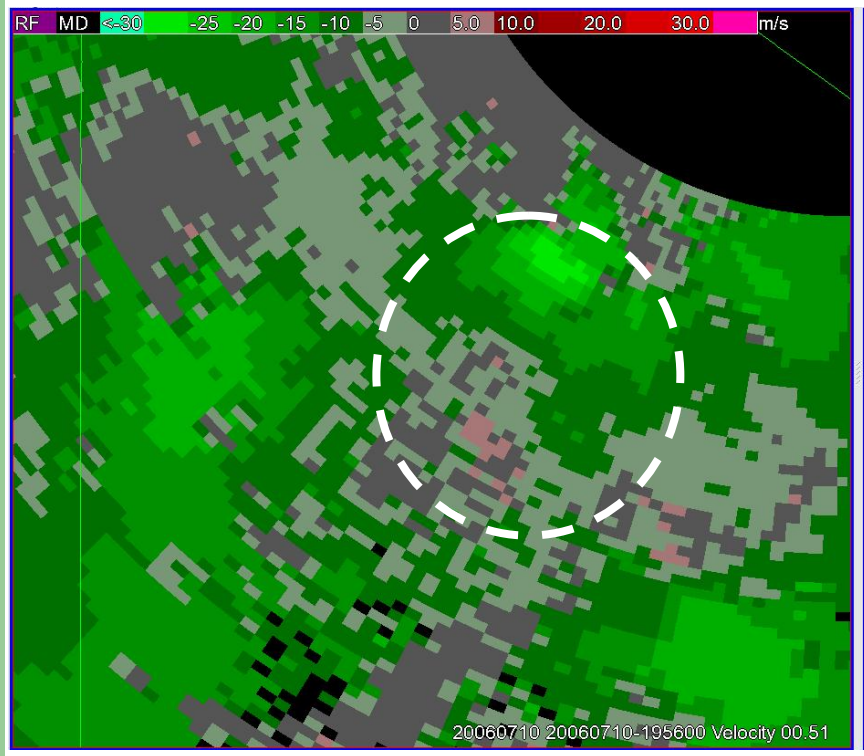


PAR Radial Velocity

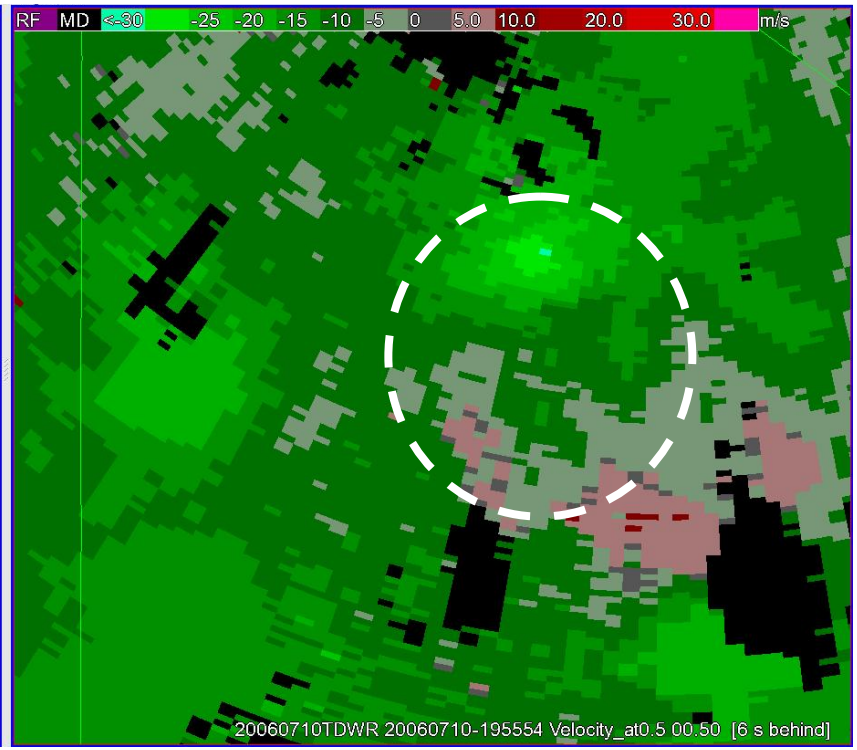


TDWR Radial Velocity

PAR / TDWR velocity data



PAR Radial Velocity



TDWR Radial Velocity

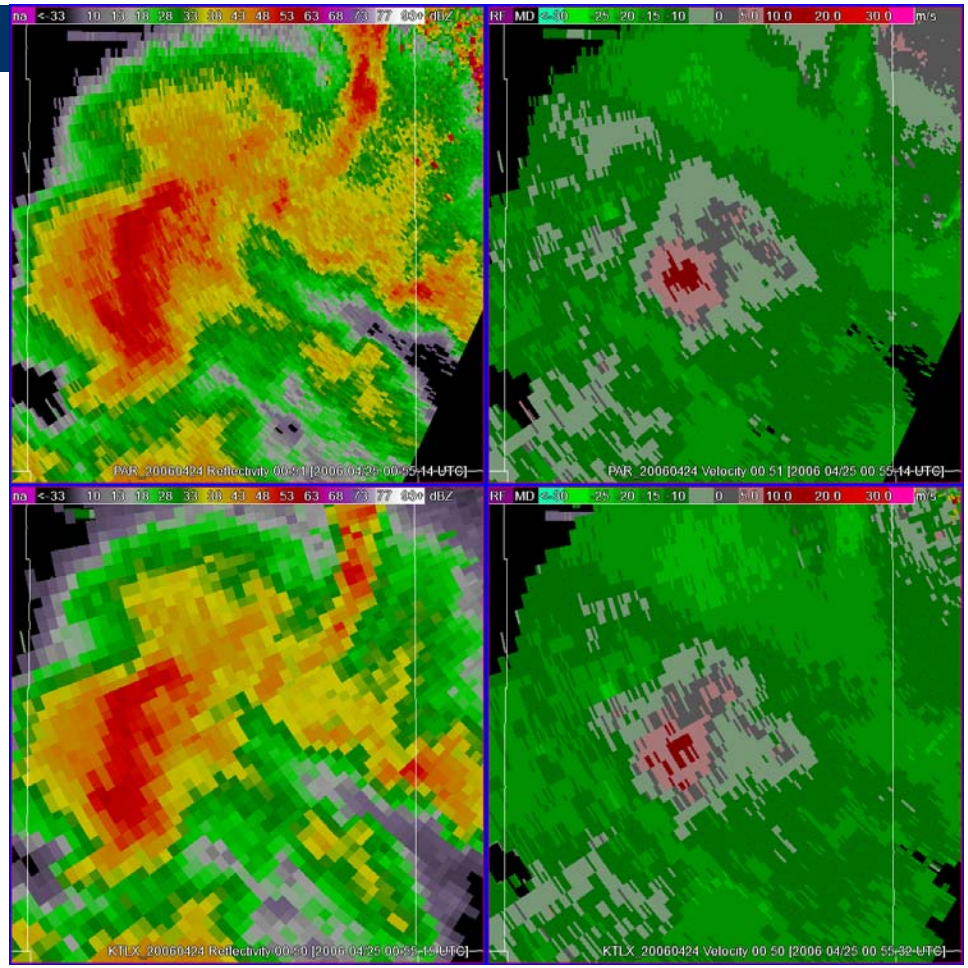
Gust Front: 24 April 2006

PAR Reflectivity & Velocity 0.5° PPI

VCP 12 Clone
90° sector
Images ~ 58 s

KTLX Reflectivity & Velocity 0.5° PPI

VCP 12
Images ~ 4 min



Hail Storm: 15 August 2006

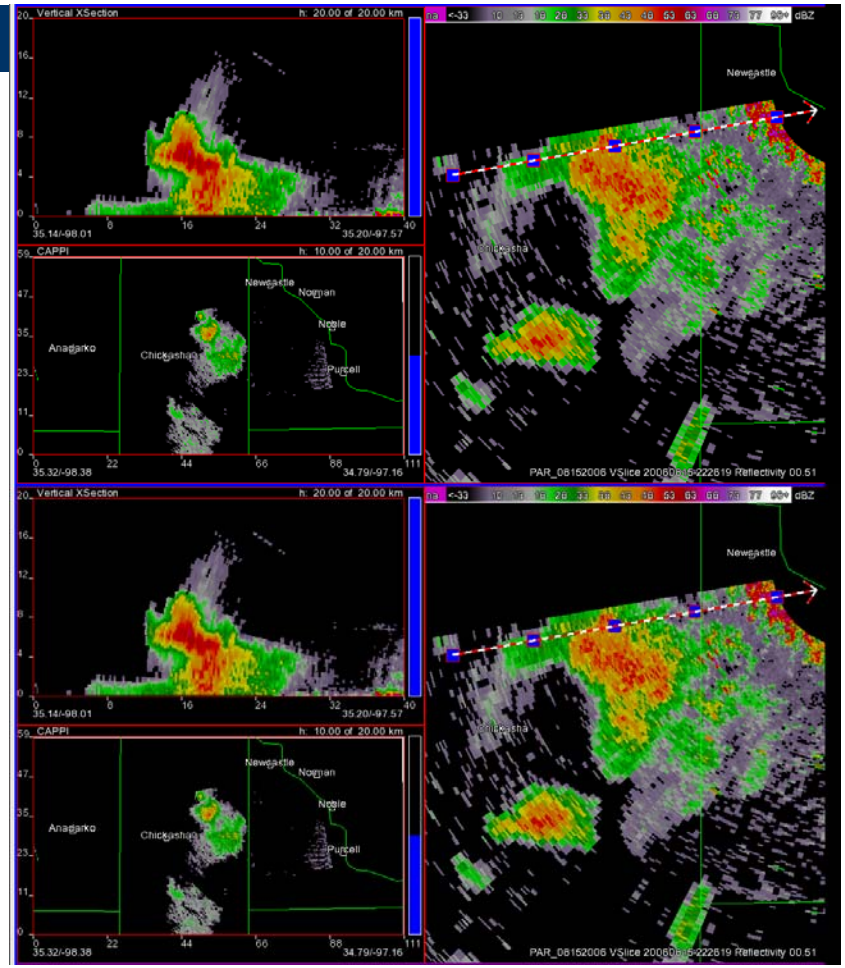
PAR Reflectivity cross-section, cappi (10 km), and 0.5° PPI

31 elevation scans up to 41°, 831 μs PRT

Images ~ 26 s

Simulated WSR-88D Reflectivity cross-section, cappi (10 km), and 0.5° PPI

Images ~ 5 min



Advantages of PAR for Aviation

Full temporal depiction of the evolution of microbursts and other rapidly evolving hazardous weather events

Increases certainty (human confidence + algorithm performance)

Increased safety and capacity in severe weather conditions via hazardous weather monitoring

- Microburst wind shear
- Gust front/wind shift
- Convective storms
- Hydrometeor discrimination

Thanks to:

NSSL Chief of Radar Research & Development: Doug Forsyth

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Chris Curtis

Sebastian Torres

Mike Jain

Dan Suppes

Kurt Hondl

Ric Adams

John Thompson

Contact: Pam.Heinselman@noaa.gov

Back-up Slides

Limitations of current NWRT PAR

Signal processing

No range & velocity ambiguity mitigation

No clutter filtering

Sampling limitations

Data unavailable within 10 km of radar

Data unavailable in cutout regions (53.0°–57.1° az and 68.0°–70.7° az)

Sensitivity

Weak echo and some fine lines may not be detected

Sidelobes

Contamination in regions of strong reflectivity gradients (clutter, hail cores)

Beam broadening

Azimuthal signatures will appear slightly smeared

Polarization

Returns from rain are somewhat diminished