Staggered PRT Update
(Last Update Nov 2013)

David Warde and Sebastián Torres
CIMMS/The University of Oklahoma
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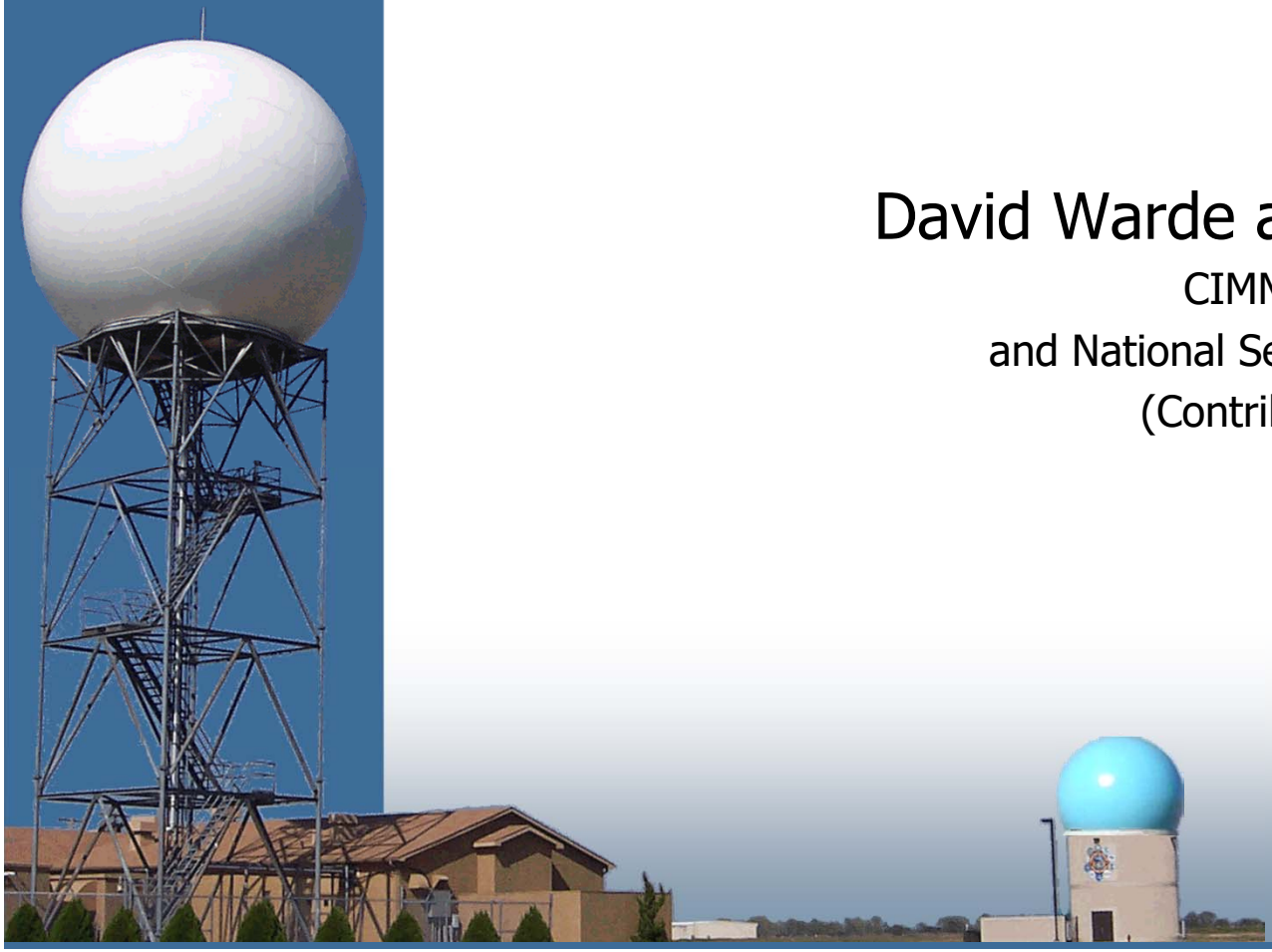
(Contributions from ROC/NWS/NOAA)



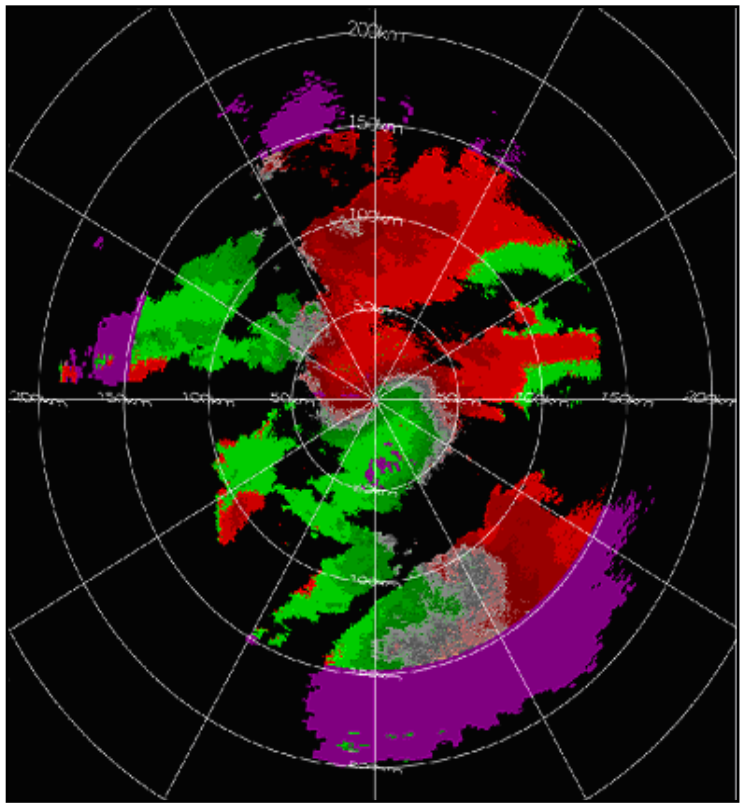
NEXRAD TAC
Norman, OK
29 April 2019

Why Staggered PRT?

- Less "Purple haze": **larger r_a**
- Less Velocity aliasing: **larger v_a**

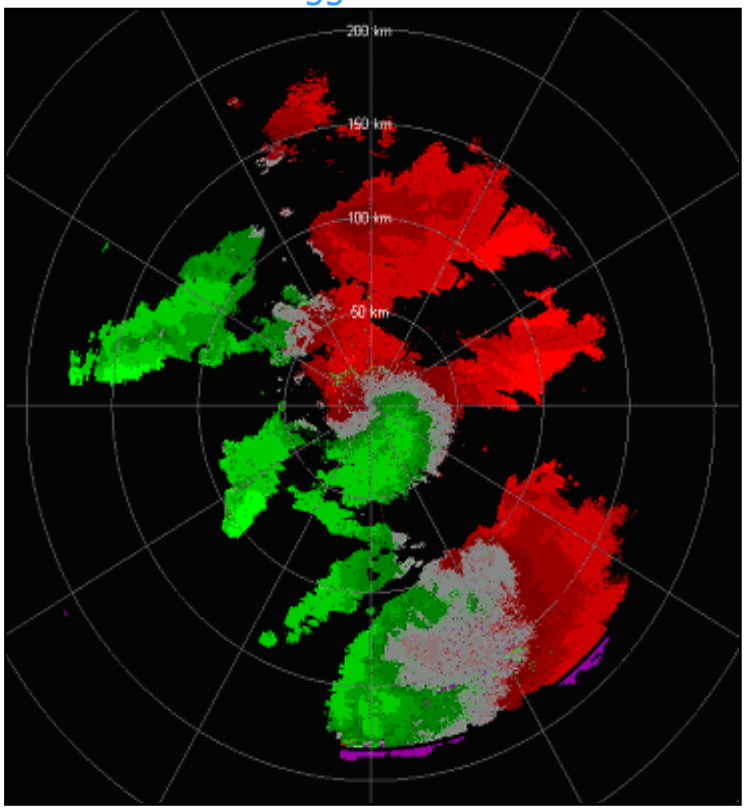
Doppler Velocity from KTLX

Batch Mode



Doppler Velocity from KOUN

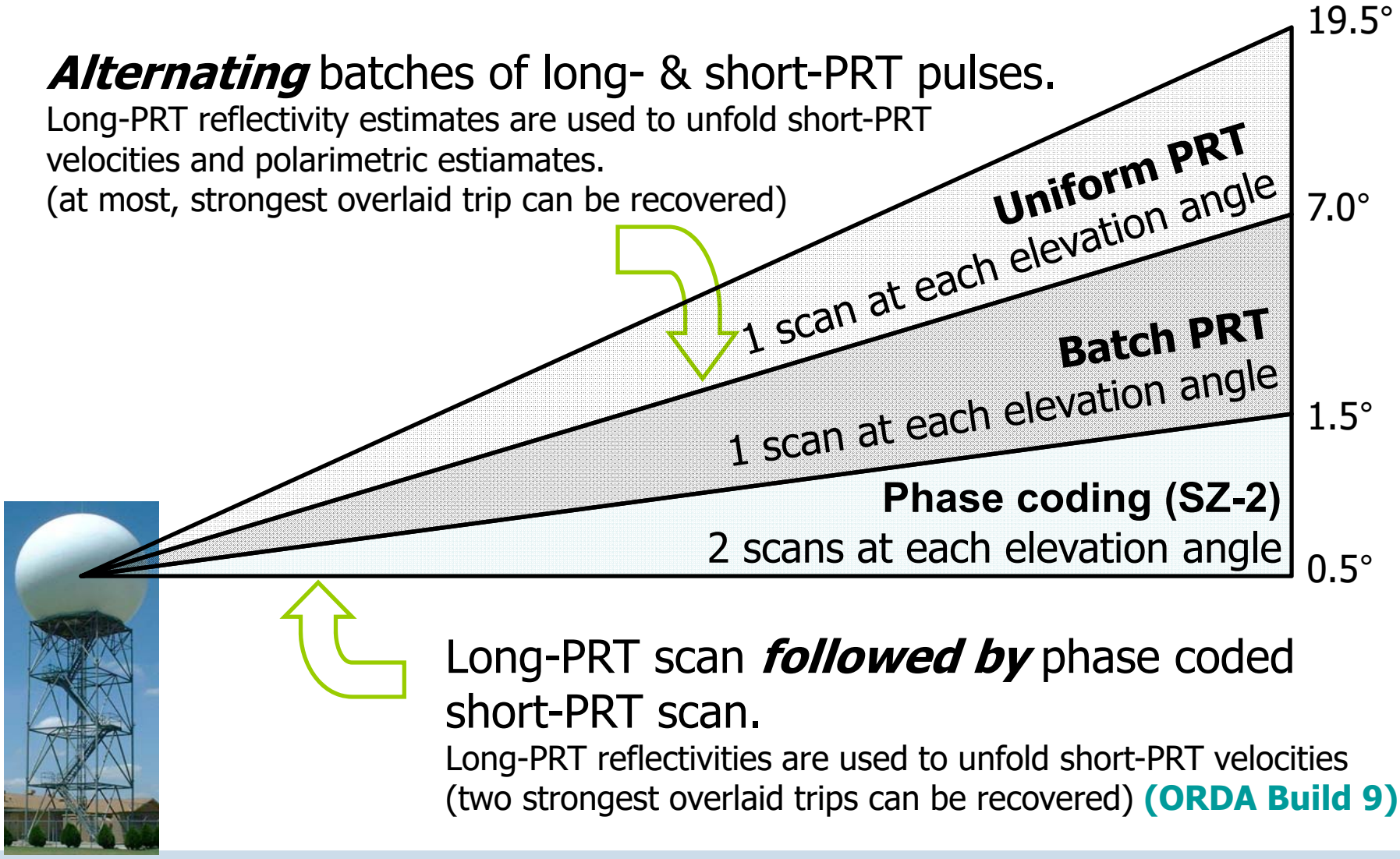
Staggered PRT



Current Mitigation Strategy

Alternating batches of long- & short-PRT pulses.

Long-PRT reflectivity estimates are used to unfold short-PRT velocities and polarimetric estiamates.
(at most, strongest overlaid trip can be recovered)



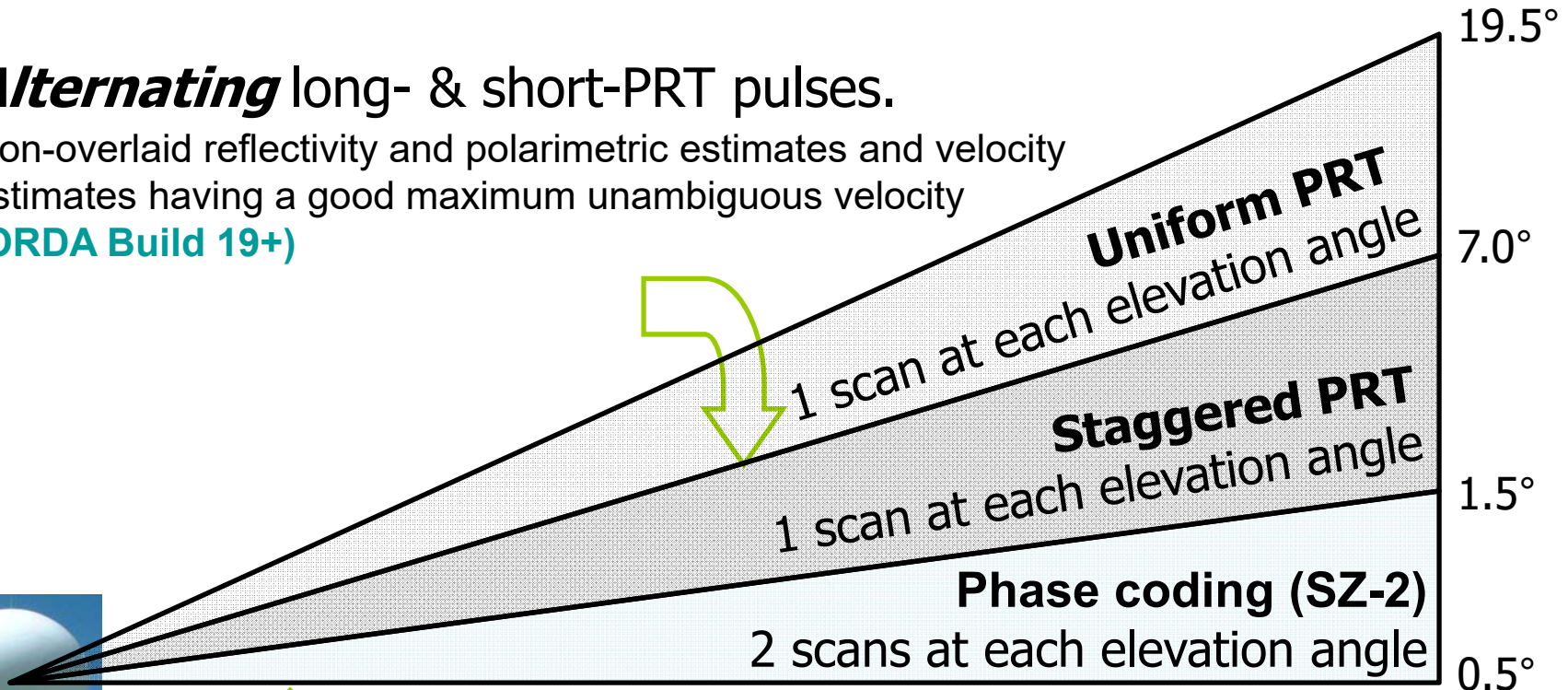
Long-PRT scan ***followed by*** phase coded short-PRT scan.

Long-PRT reflectivities are used to unfold short-PRT velocities (two strongest overlaid trips can be recovered) **(ORDA Build 9)**

Proposed Mitigation Strategy

Alternating long- & short-PRT pulses.

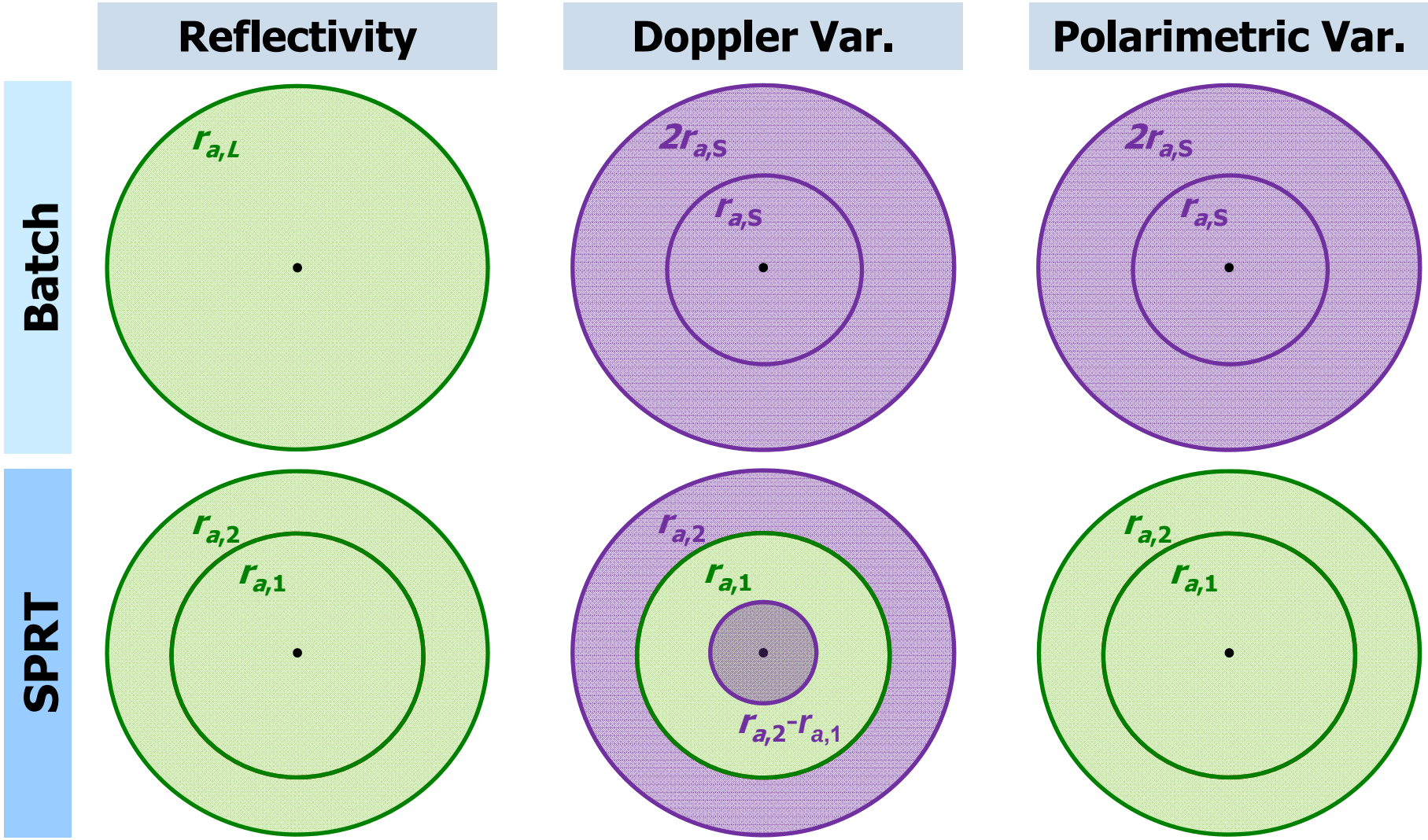
Non-overlaid reflectivity and polarimetric estimates and velocity estimates having a good maximum unambiguous velocity **(ORDA Build 19+)**



Long-PRT scan ***followed by*** phase coded short-PRT scan.

Long-PRT reflectivities are used to unfold short-PRT velocities (two strongest overlaid trips can be recovered) **(ORDA Build 9)**

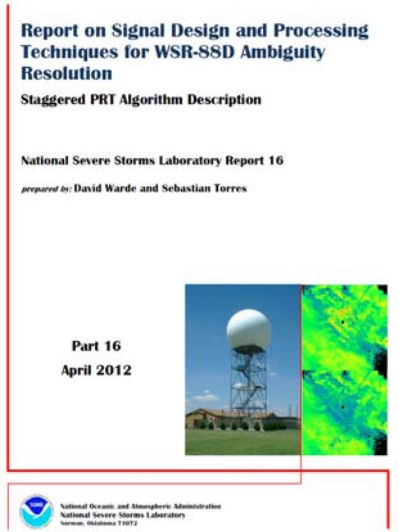
SPRT Range Coverage



key: No "purple haze" possible vs. Some "purple haze" possible

Milestones

- **2003**: 2/3 PRT ratio with DC filter
  - NSSL Report 7
- **2005**: SACHI filter (standalone)
  - NSSL Report 9
- **2007**: Informal presentation to ROC DQ Team
- **2008**: Any PRT ratio with DC filter
  - NSSL Report 12
- **2009**: 2/3 PRT ratio with SACHI filter
  - Stand-alone algorithm description delivered on 03/09
- **2009**: 2/3 PRT ratio with SACHI filter and overlaid echo recovery
  - Stand-alone algorithm description delivered on 07/09
  - NSSL Report 13
- **2010**: Extension to dual polarization
  - NSSL Report 14
- **2012**: CLEAN-AP
  - NSSL Report 16
- **2015**: CLEAN-AP/WET
  - NSSL Report 17
- **2017**: CLEAN-AP/WET and "Matched Autocorrelation" spectrum width estimators
  - Stand-alone algorithm description delivered on 07/17
  - NCAR Hybrid spectrum width estimator
- **2018**: Enhancement to velocity dealiasing
  - Mitigate "catastrophic" dealising errors
    - Meteorological – Low signal-to-noise or High spectrum width
    - System – Transmitter or Receiver loss of coherency
  - Stand-alone algorithm description delivered on 11/18


Report on Signal Design and Processing Techniques for WSR-88D Ambiguity Resolution

Staggered PRT Algorithm Description

National Severe Storms Laboratory Report 16

prepared by: David Warde and Sebastian Torres

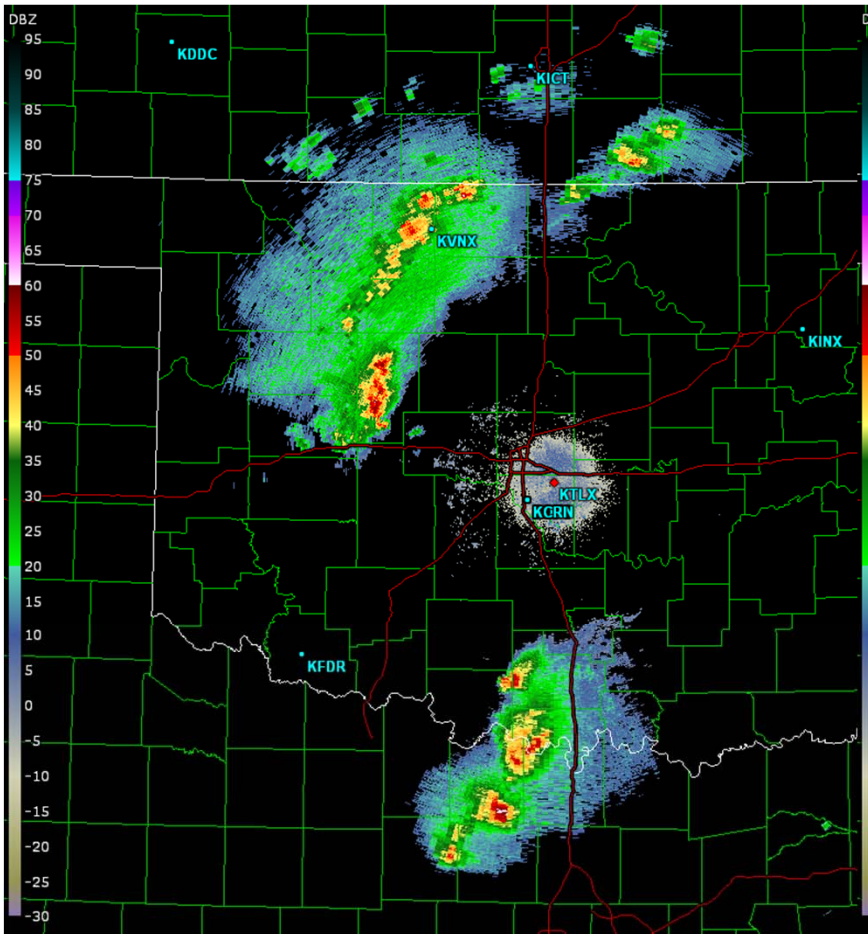
Part 16

April 2012

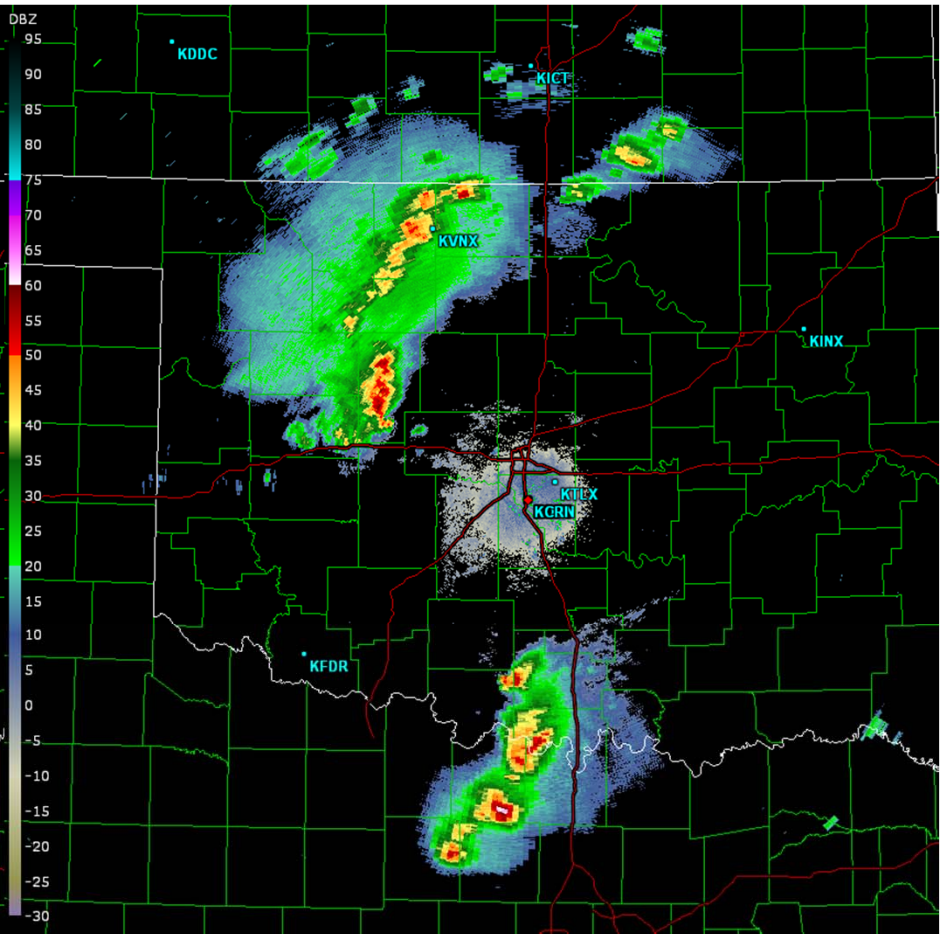
KTLX/KOUN, April 18, 2019

Reflectivity

KTLX (Batch)



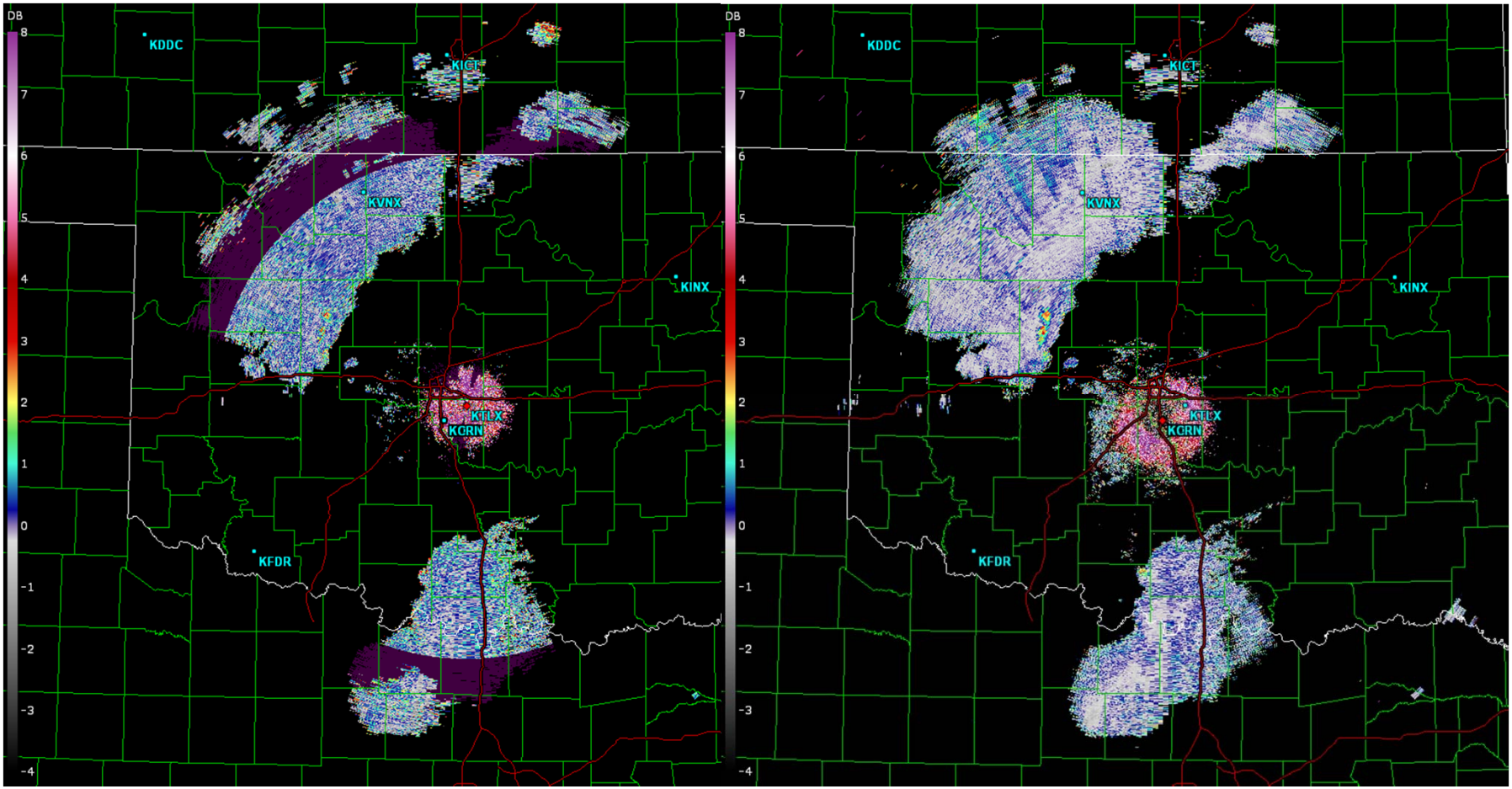
KOUN (SPRT)



KTLX/KOUN, April 18, 2019

Differential Reflectivity

KTLX (Batch) KOUN (SPRT)

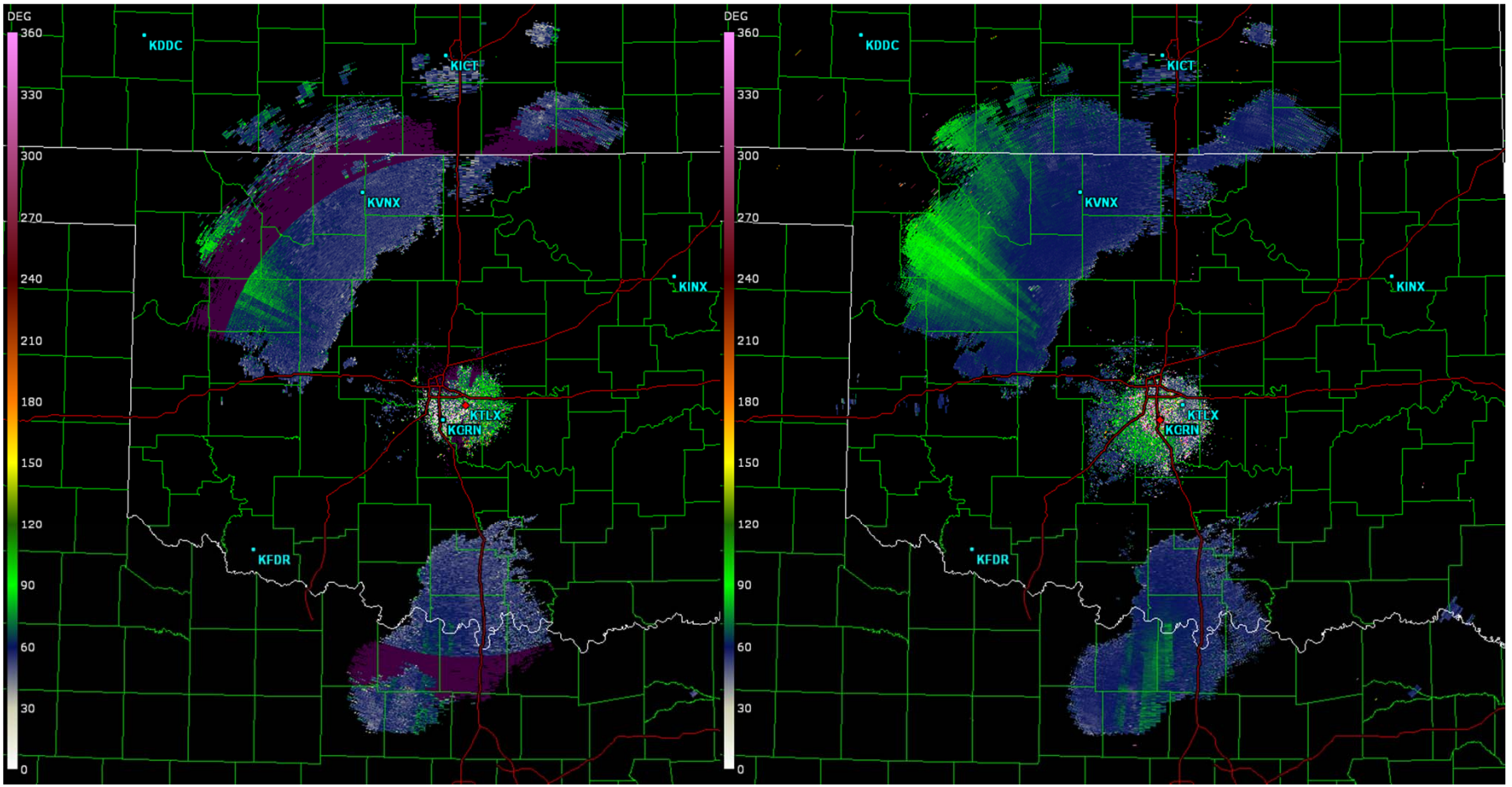


KTLX/KOUN, April 18, 2019

Differential Phase

KTLX (Batch)

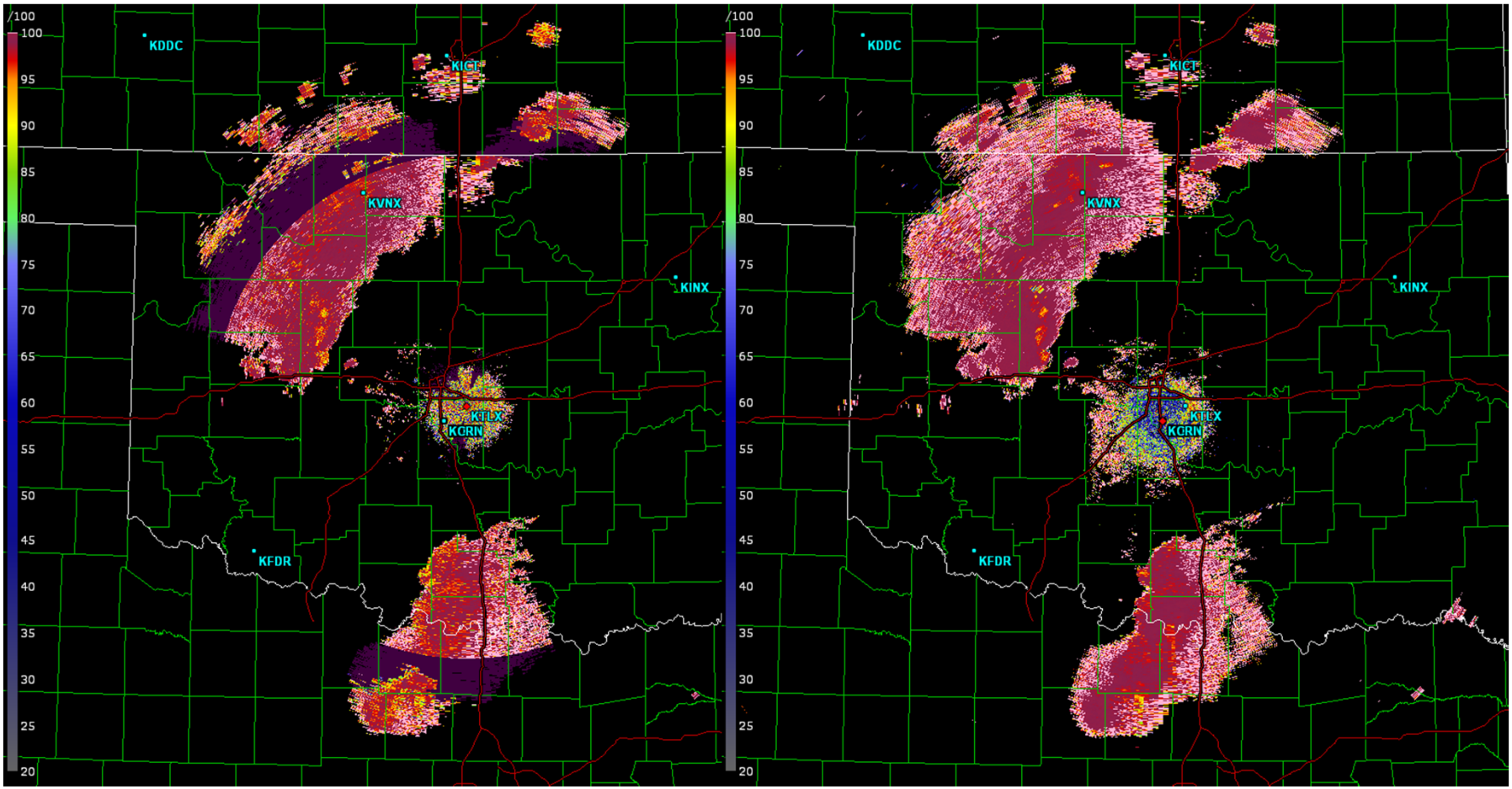
KOUN (SPRT)



KTLX/KOUN, April 18, 2019

Cross-Correlation

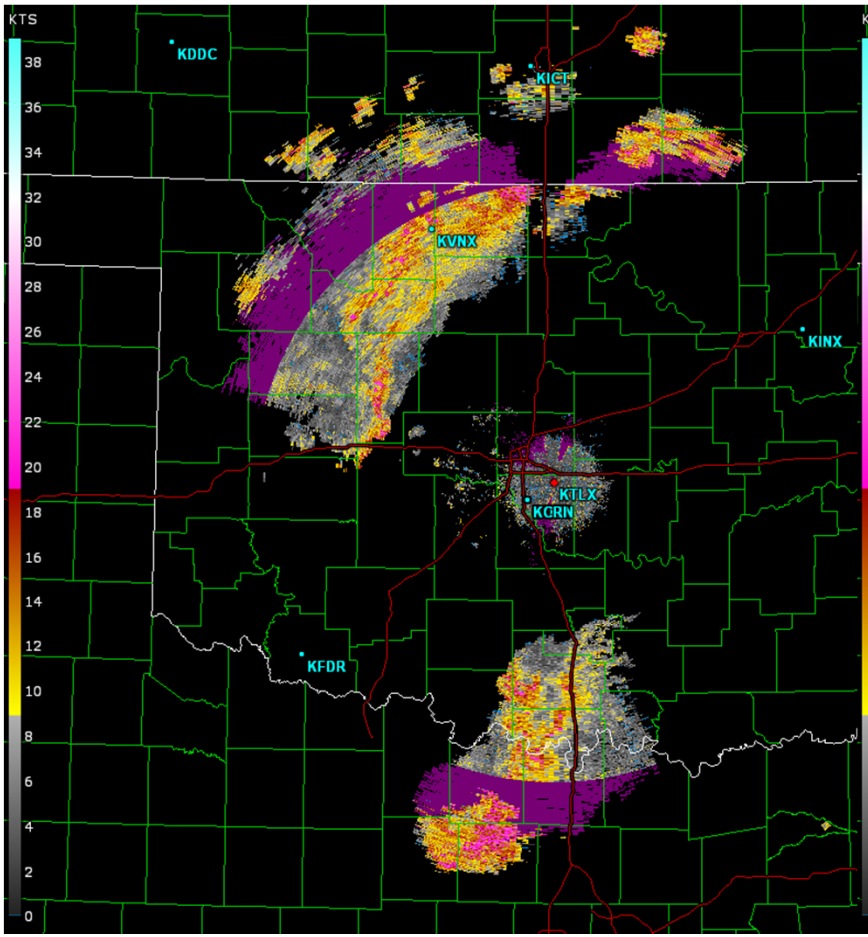
KTLX (Batch) KOUN (SPRT)



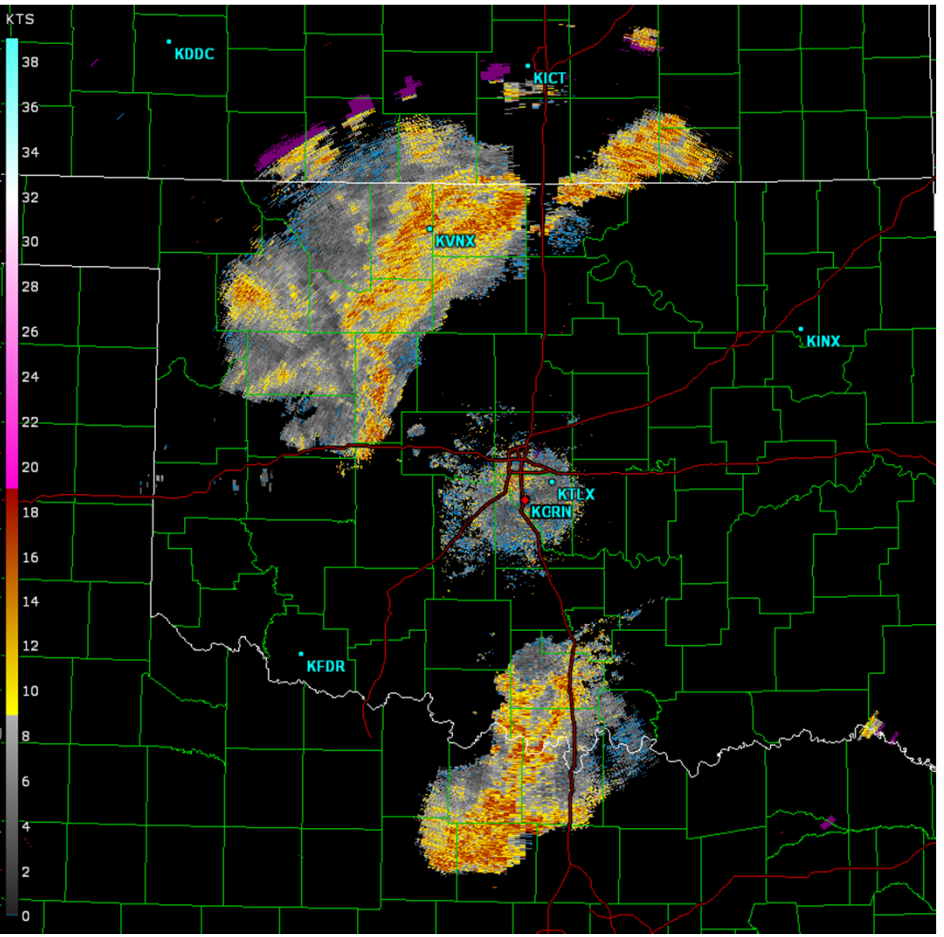
KTLX/KOUN, April 18, 2019

Spectrum Width

KTLX (Batch)



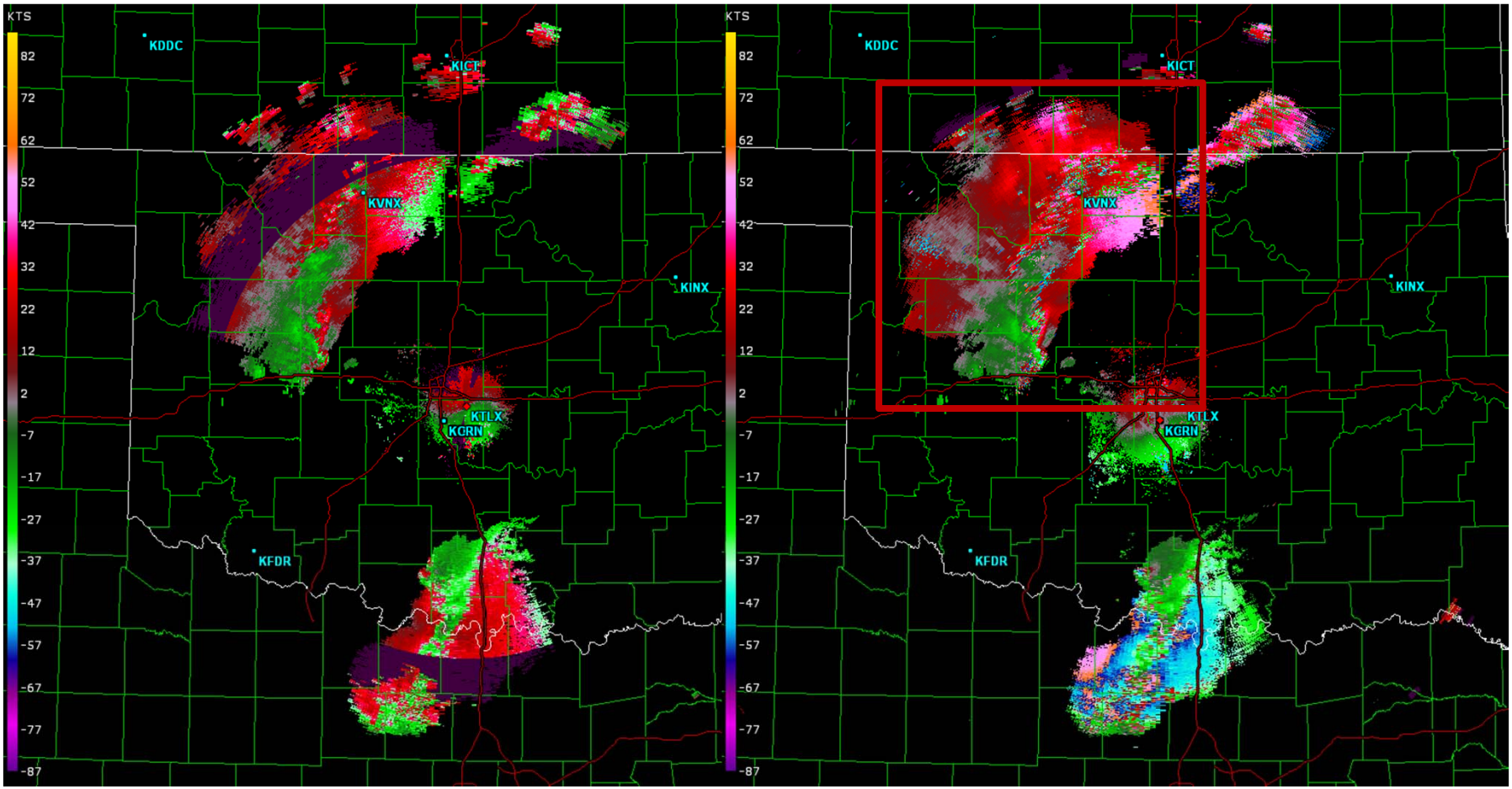
KOUN (SPRT)



KTLX/KOUN, April 18, 2019

Velocity

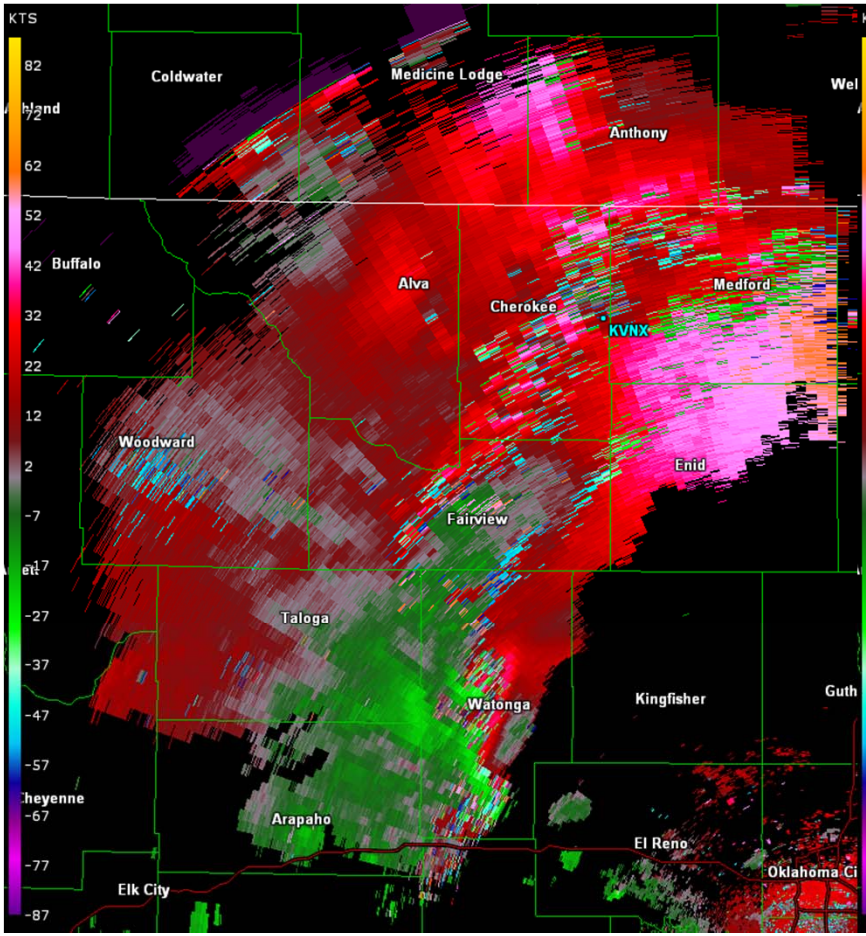
KTLX (Batch) KOUN (SPRT)



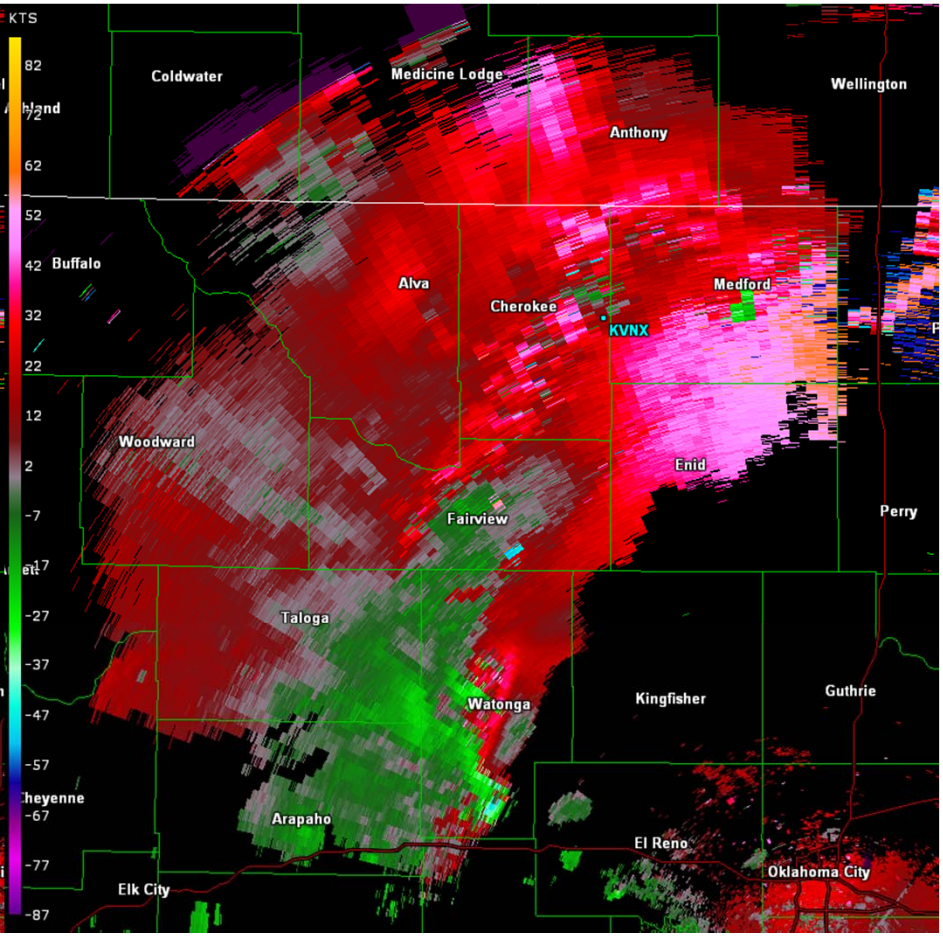
KTLX/KOUN, April 18, 2019

Velocity

KOUN (VDTF)



KOUN (1DVDA)

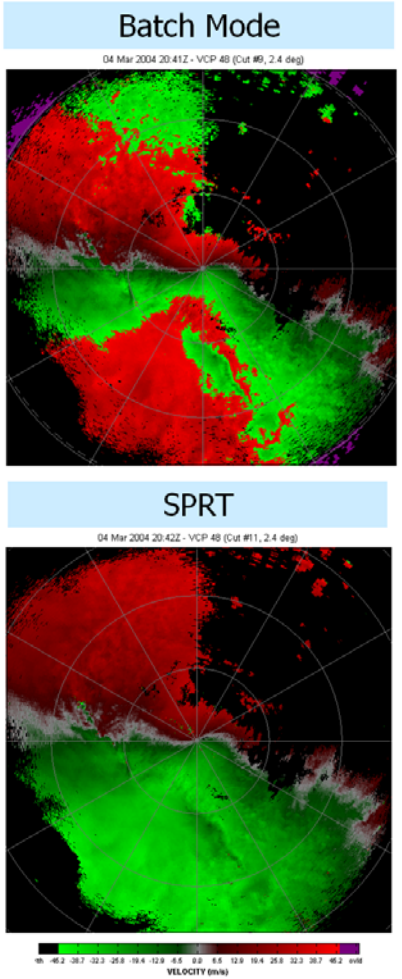


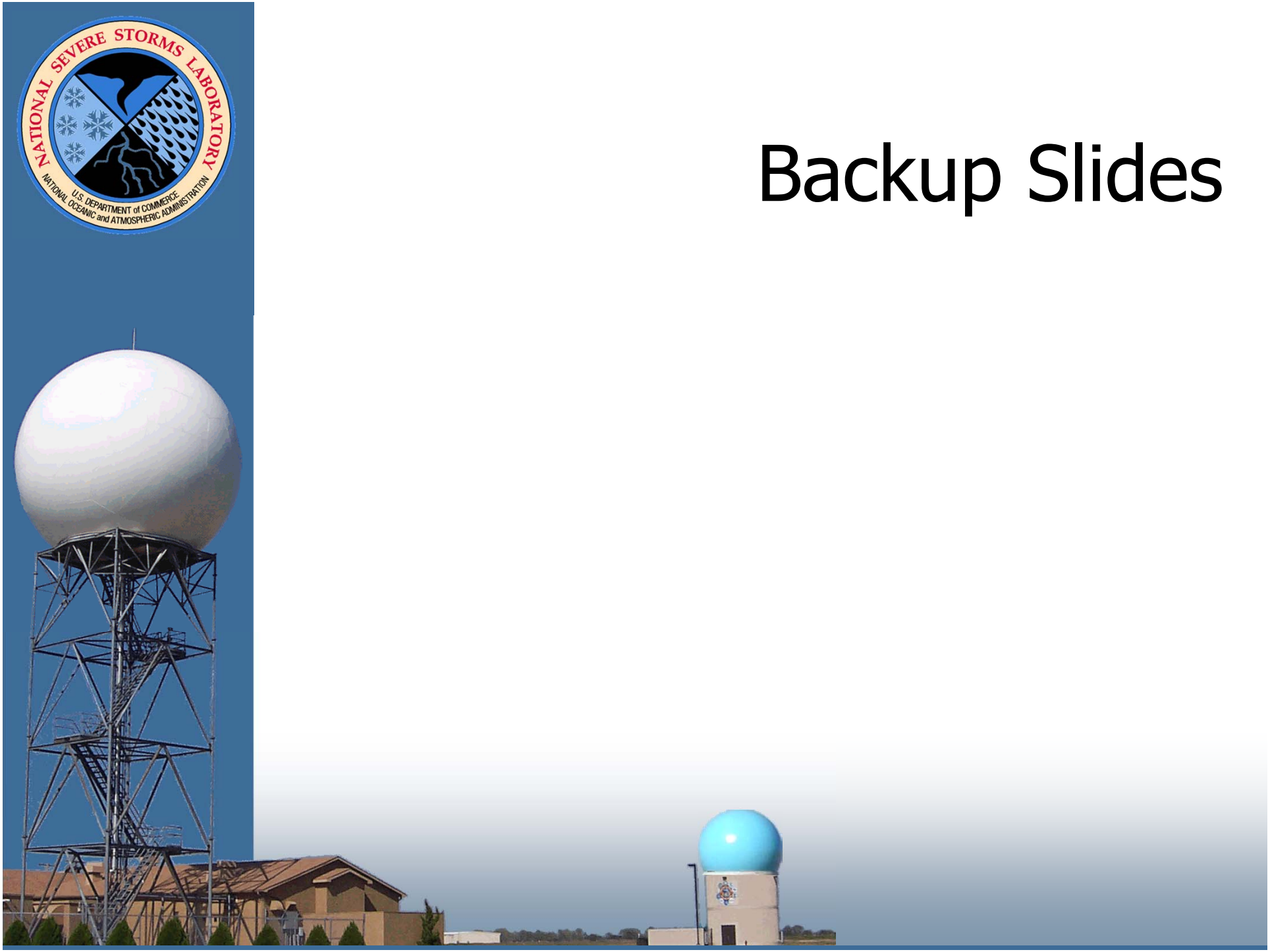
Future Work

- Support implementation of SPRT on the ORDA
- Support engineering evaluation of SPRT
- Support ORPG 2D-VDA modifications for SPRT
- Support VCP design for SPRT

Summary

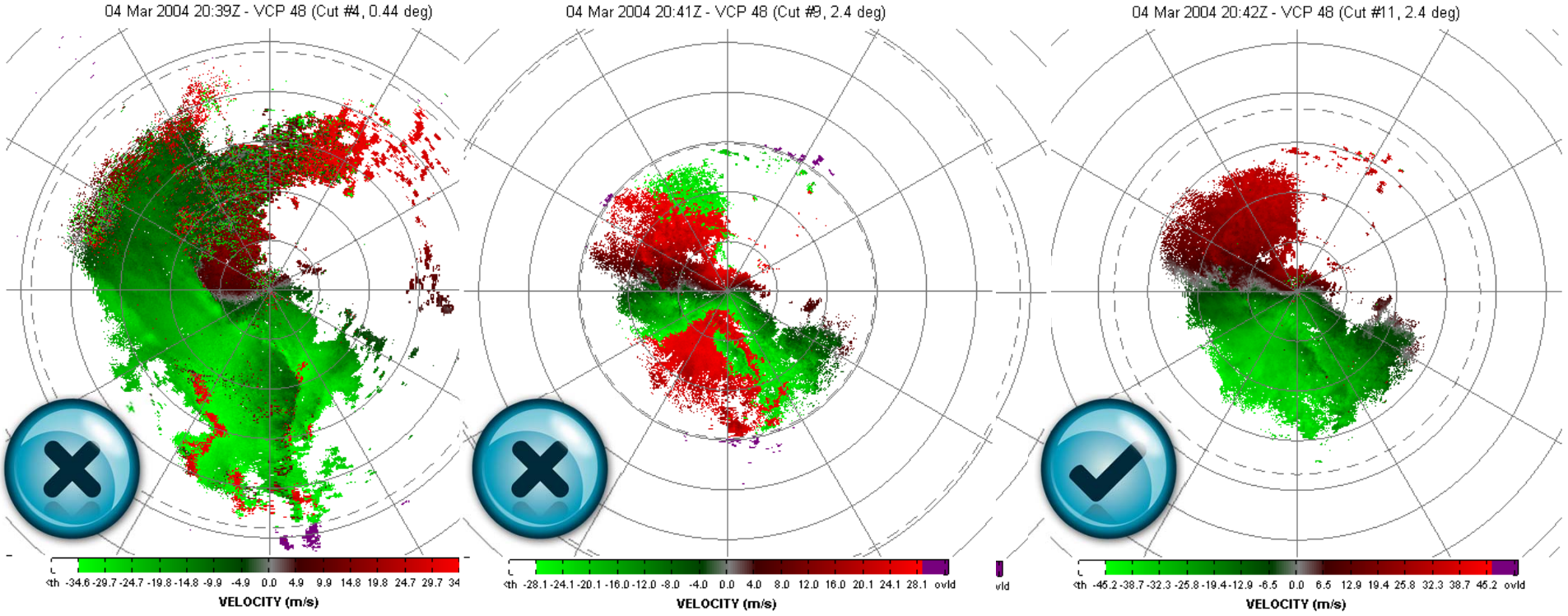
- SPRT is a **mature technique**
  - dual-pol extension
  - CLEAN-AP/WET
  - "Matched Autocorrelation" spectrum width
  - 1DVDA (improved velocity dealiasing)
    - November 2018 algorithm delivered
- SPRT **improves**
  - **range coverage**
    - less purple haze for v and σ_v, no purple haze for the polarimetric variables
  - **velocity measurements**
    - significantly less velocity aliasing
  - **data quality**
    - reflectivity and polarimetric variables with lower variance
- SPRT is expected to replace Batch in all VCPs





Backup Slides

What does a good VCP look like?



T_1 = 1.6 ms
T_2 = 2.4 ms
M = 28

SPRT

T_L = 1.6 ms
T_S = 2.4 ms
M_L = 41

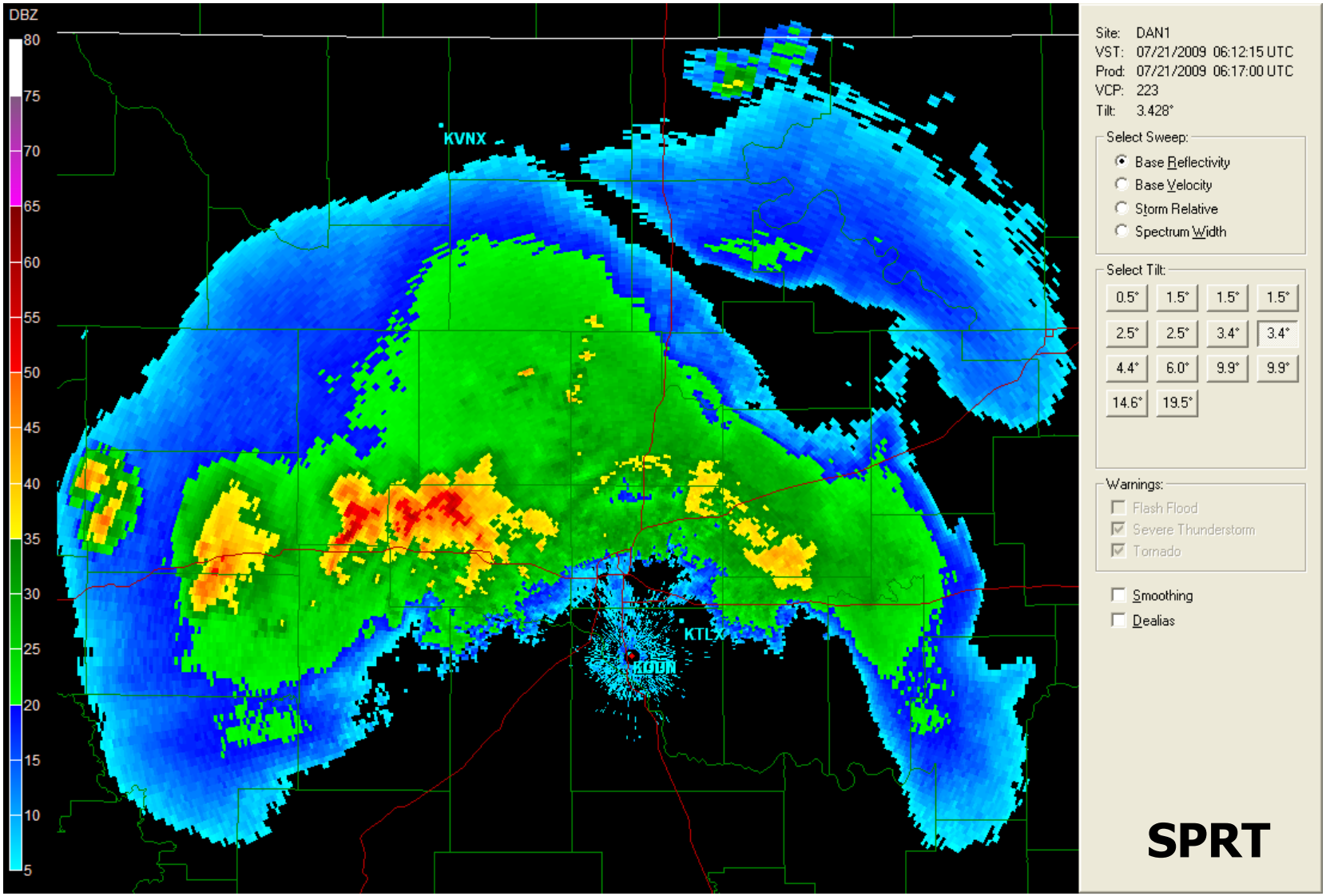
Batch
(~ same dwell times)

T_1 = 1.23 ms
T_2 = 1.84 ms
M = 40

SPRT

Batch PRT vs. Staggered PRT

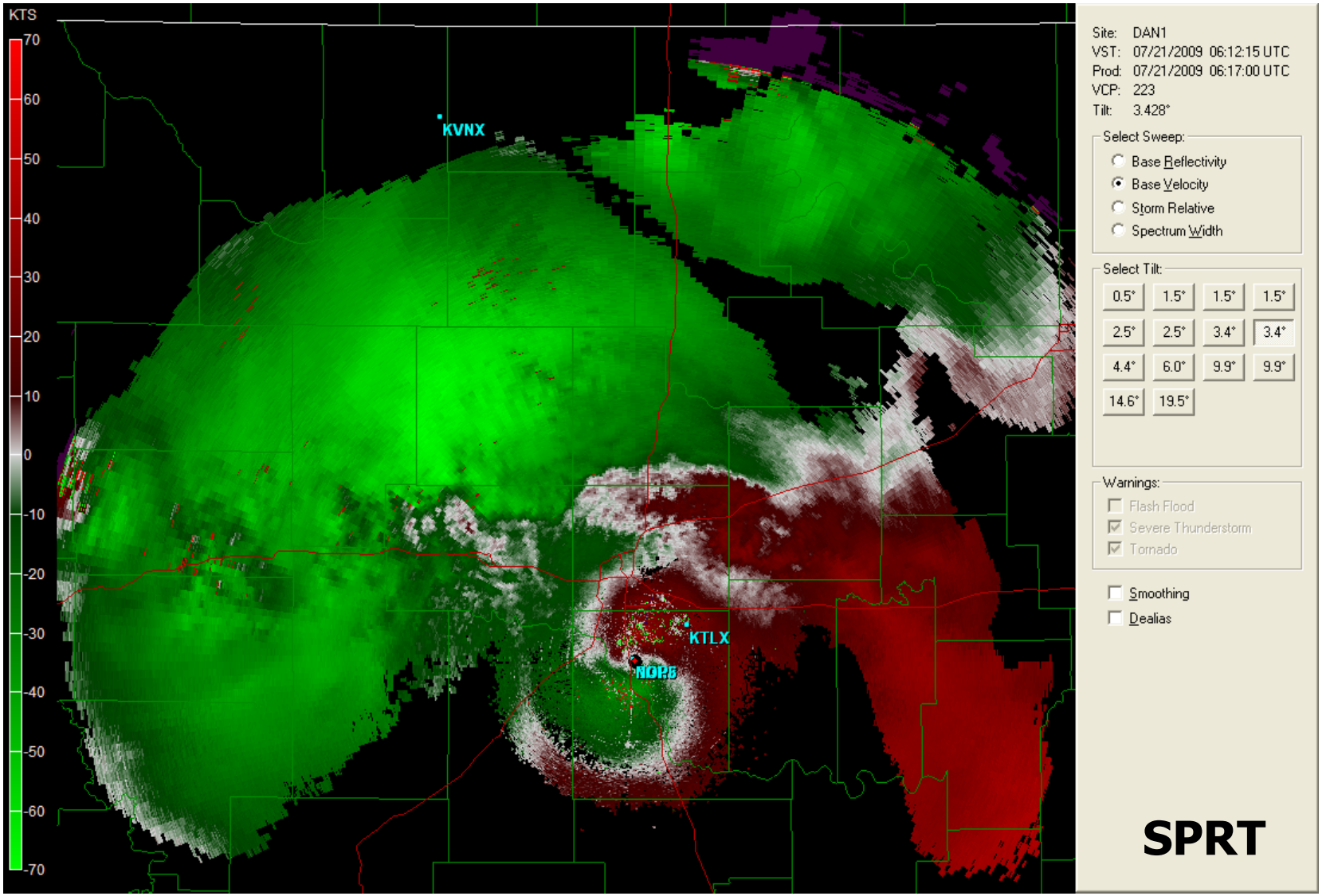
Reflectivity



(courtesy of D. Saxion, ROC)

Batch PRT vs. Staggered PRT

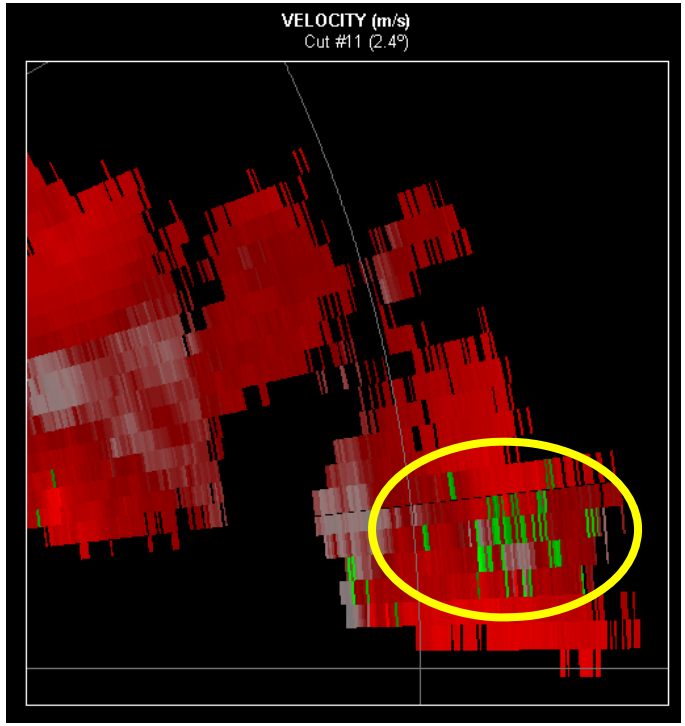
Doppler Velocity



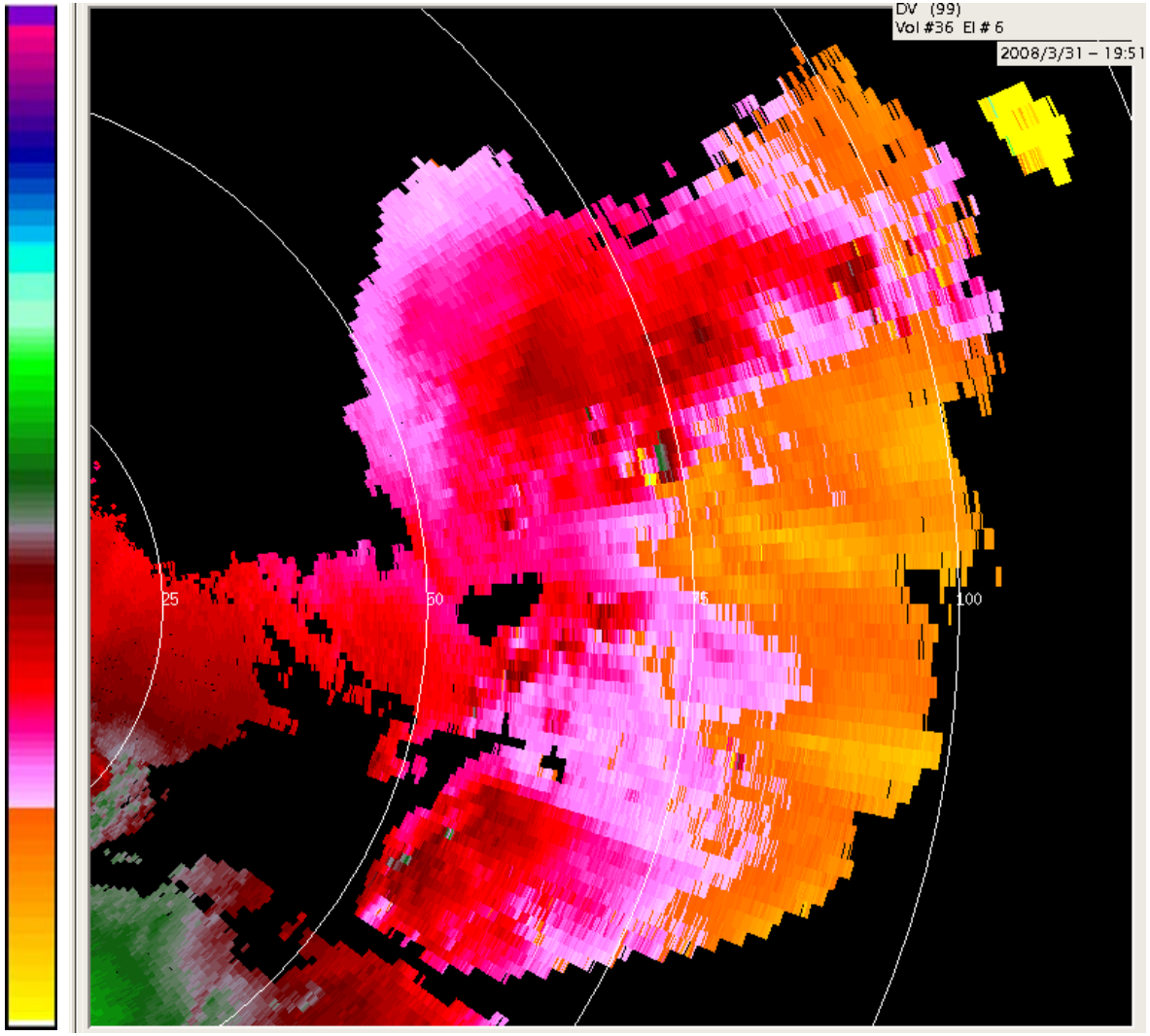
(courtesy of D. Saxion, ROC)

"Catastrophic" Velocity Errors

- A "**catastrophic error**" occurs if errors of estimates are so large that v_1 and v_2 cannot be properly dealiased
  - These appear as speckles in the velocity fields
  - Catastrophic errors are more likely for wider normalized spectrum widths
  - The ORPG velocity dealiasing algorithm has been modified to mitigate these



ORPG Legacy Velocity Dealiasing



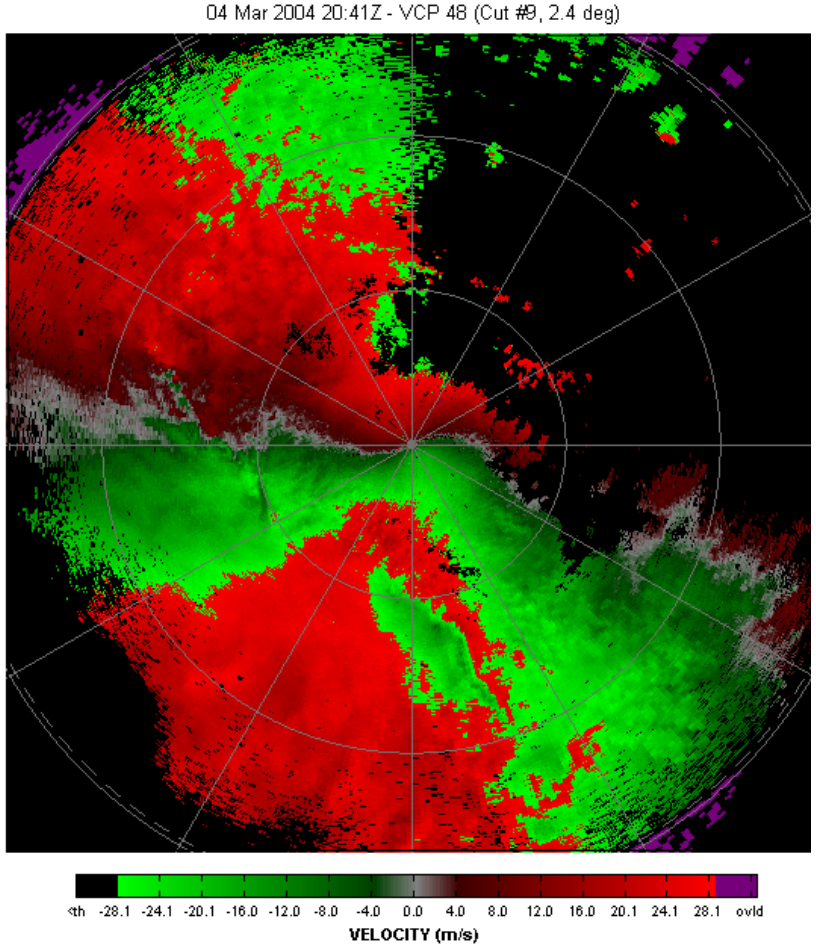
KCRI - 31 March 2008
3.1 deg
Modified Dealiasing

(courtesy of David Zittel, ROC)

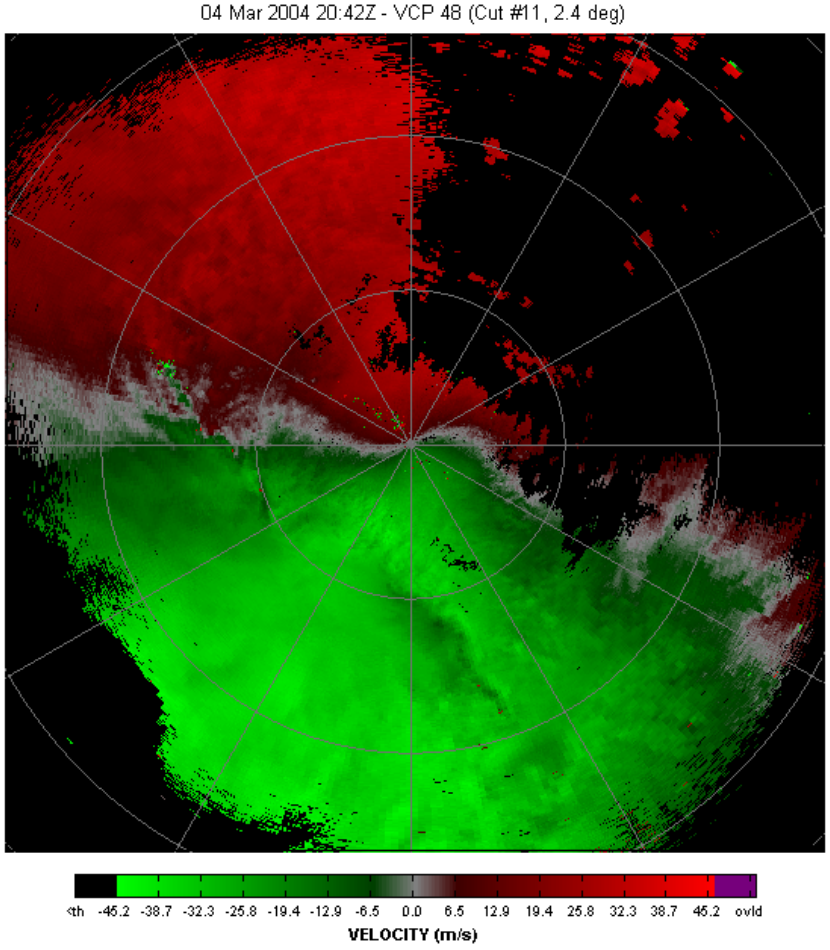
Another great example

Doppler Velocity (04 Mar 2004)

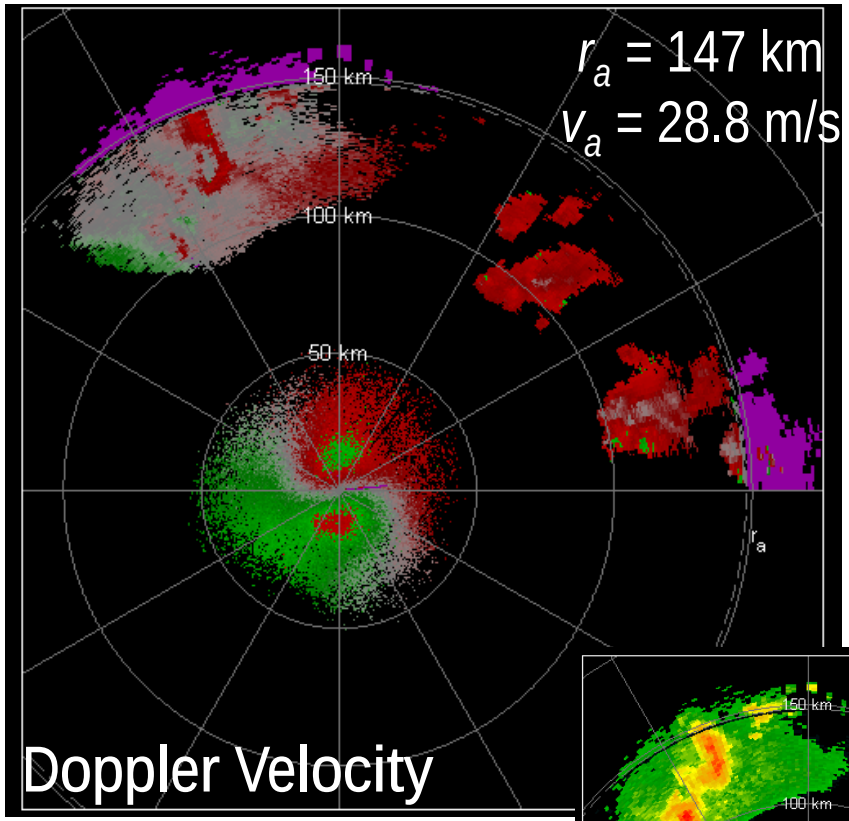
Batch Mode



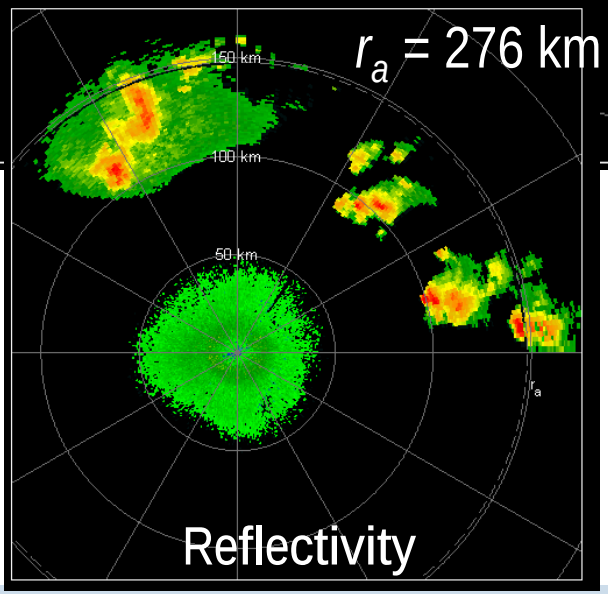
SPRT

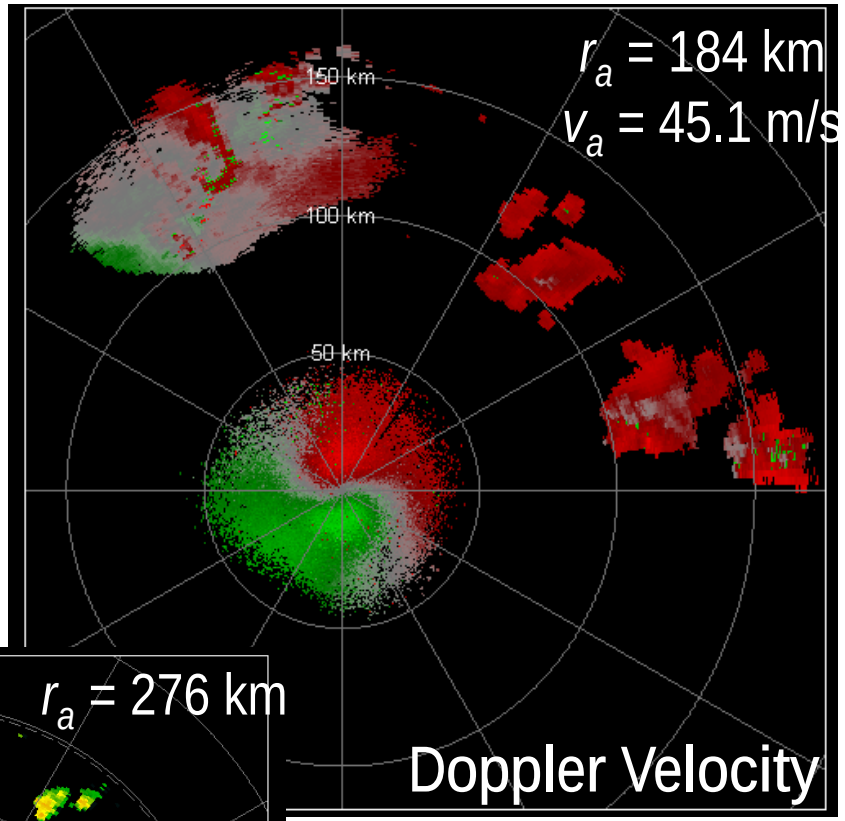


Case I: April 22, 2004 – 2.5 deg



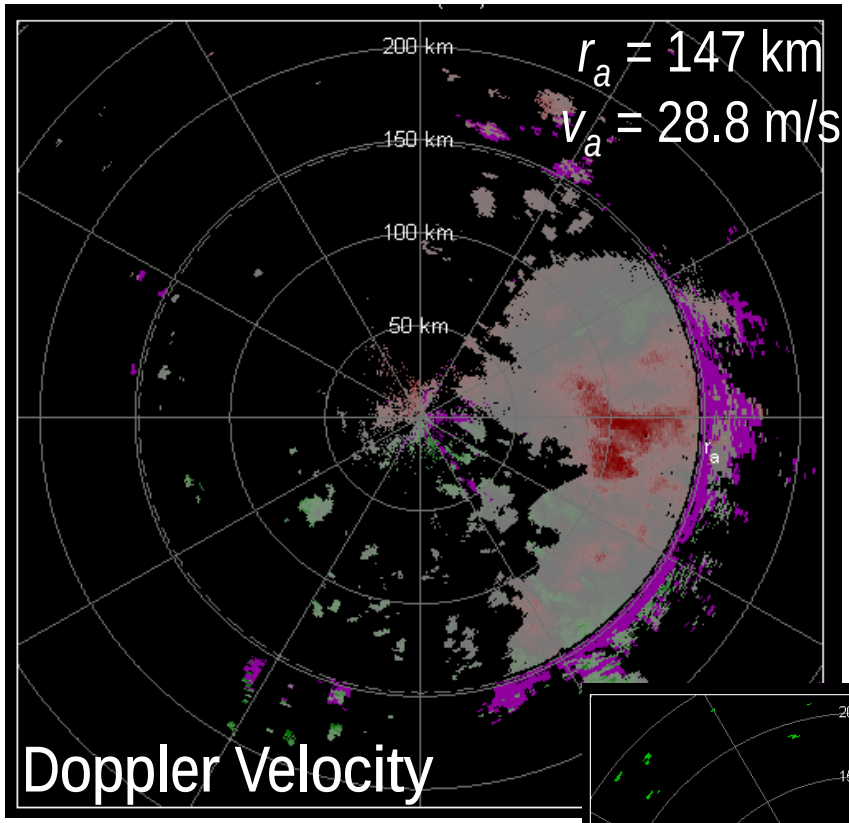
Batch Mode
VCP 11



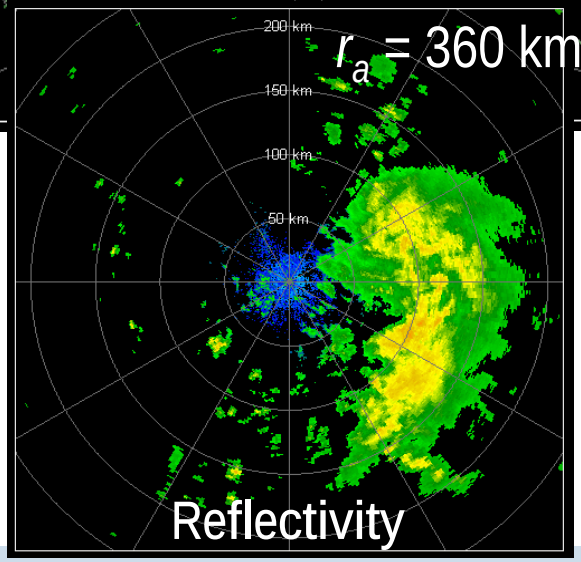


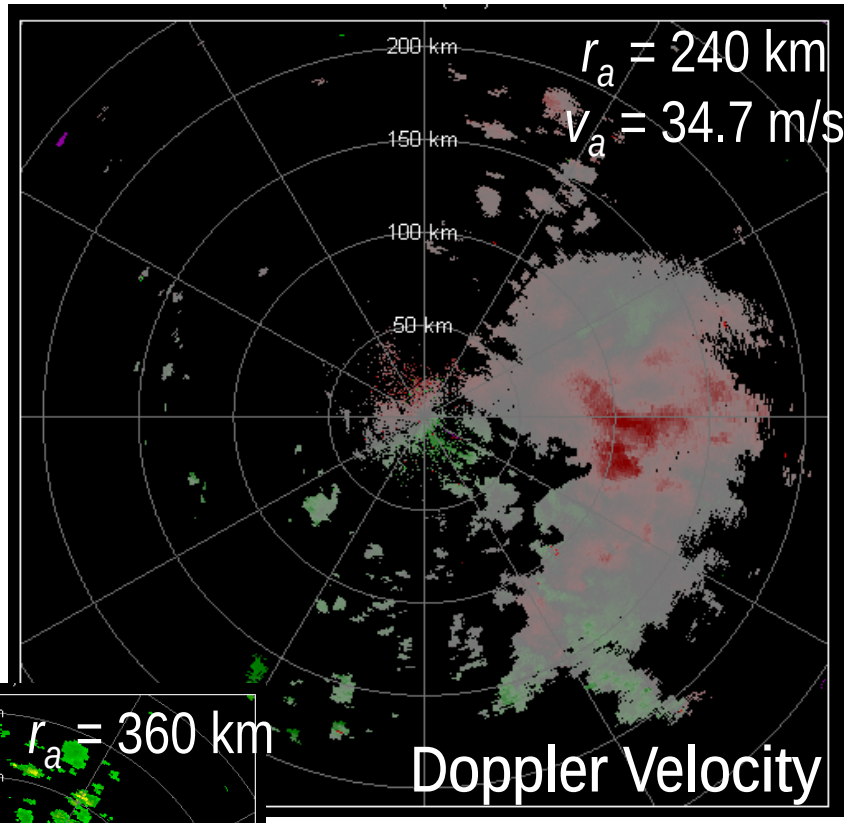
Staggered PRT
(2/3, same DT)

Case II: June 30, 2004 – 1.5 deg



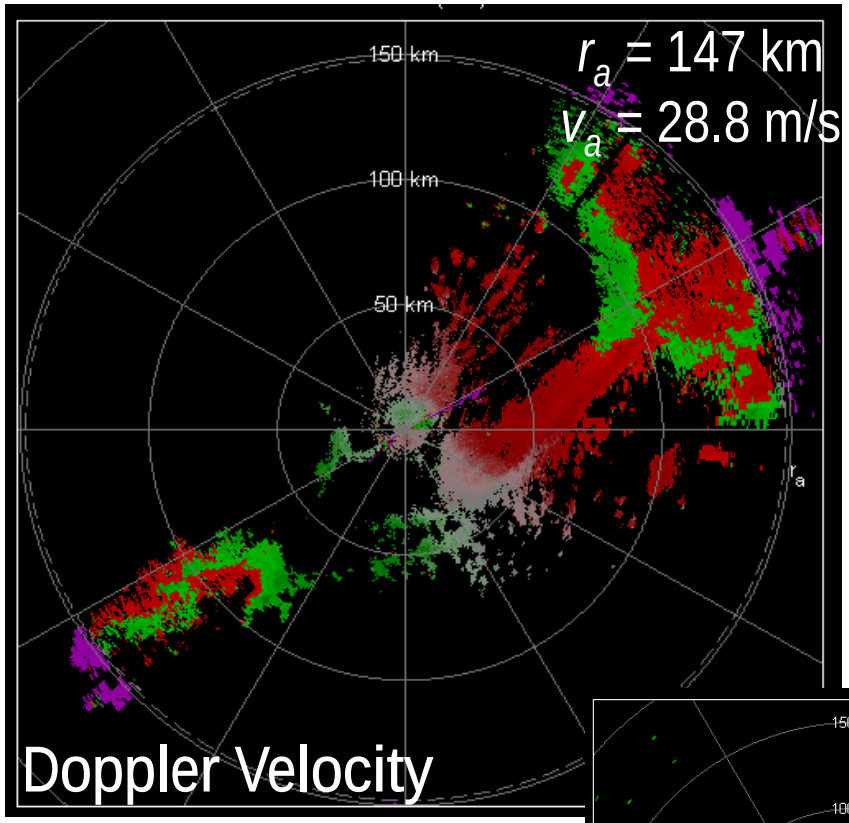
Batch Mode
VCP 11



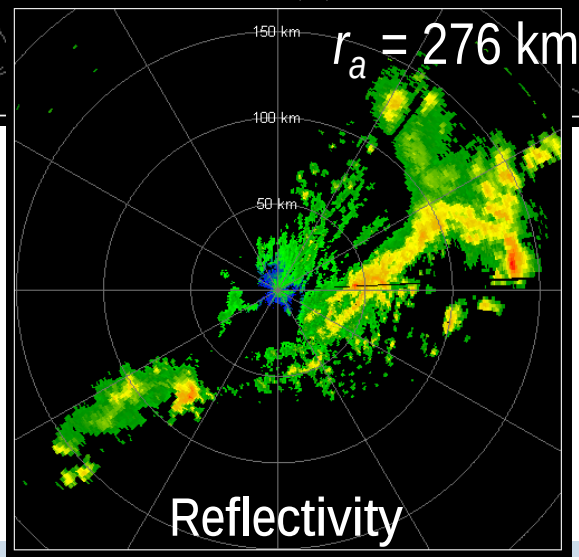


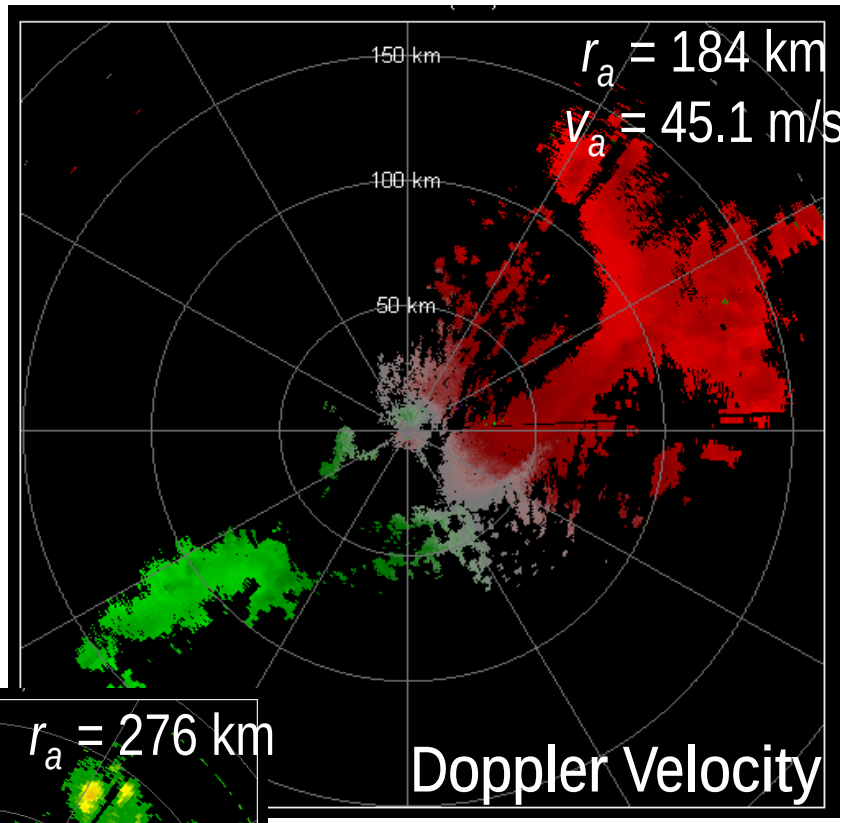
Staggered PRT
(2/3, same DT)

Case III: March 3, 2004 – 2.5 deg



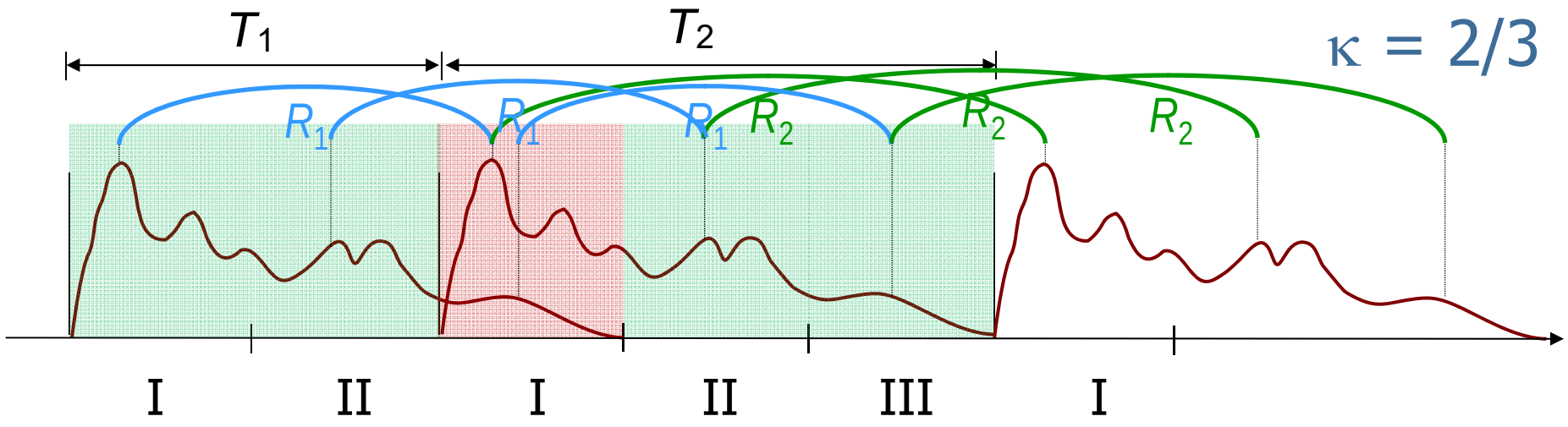
Batch Mode
VCP 11





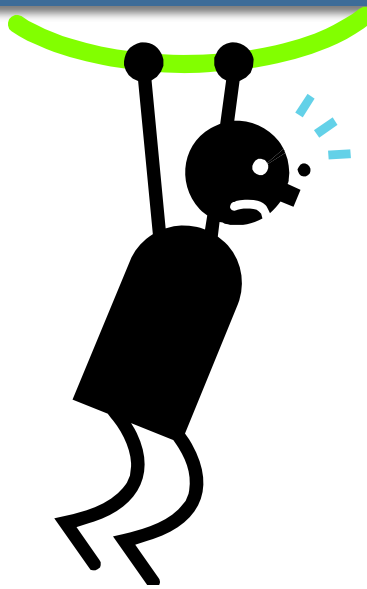
Staggered PRT
(2/3, same DT)

Staggered PRT Processing



- Reflectivity and polarimetric-variable estimation
  - **Segment I**: short PRT samples
  - **Segment II**: short and long PRT samples
  - **Segment III**: long PRT samples
- Velocity and spectrum width estimation
  - **Segment I**: overlaid echoes on one sample of every pair
    - No bias for "dominant" echo
  - **Segment II**: clean pairs
  - **Segment III**: overlaid echoes on one sample of every pair
    - Non-dominant echo must be censored!

Early SPRT Concerns



- Extending the **range** coverage
  - Overlaid echoes
- Extending the Nyquist **velocity**
  - Velocity dealiasing algorithm
  - **Catastrophic** errors
- Defining scanning **strategies**
  - PRT selection
  - Dwell-time selection
- Mitigating **ground-clutter** contamination