NEXRAD

Technical Advisory Committee Meeting

Mitigation of Range Velocity Ambiguities

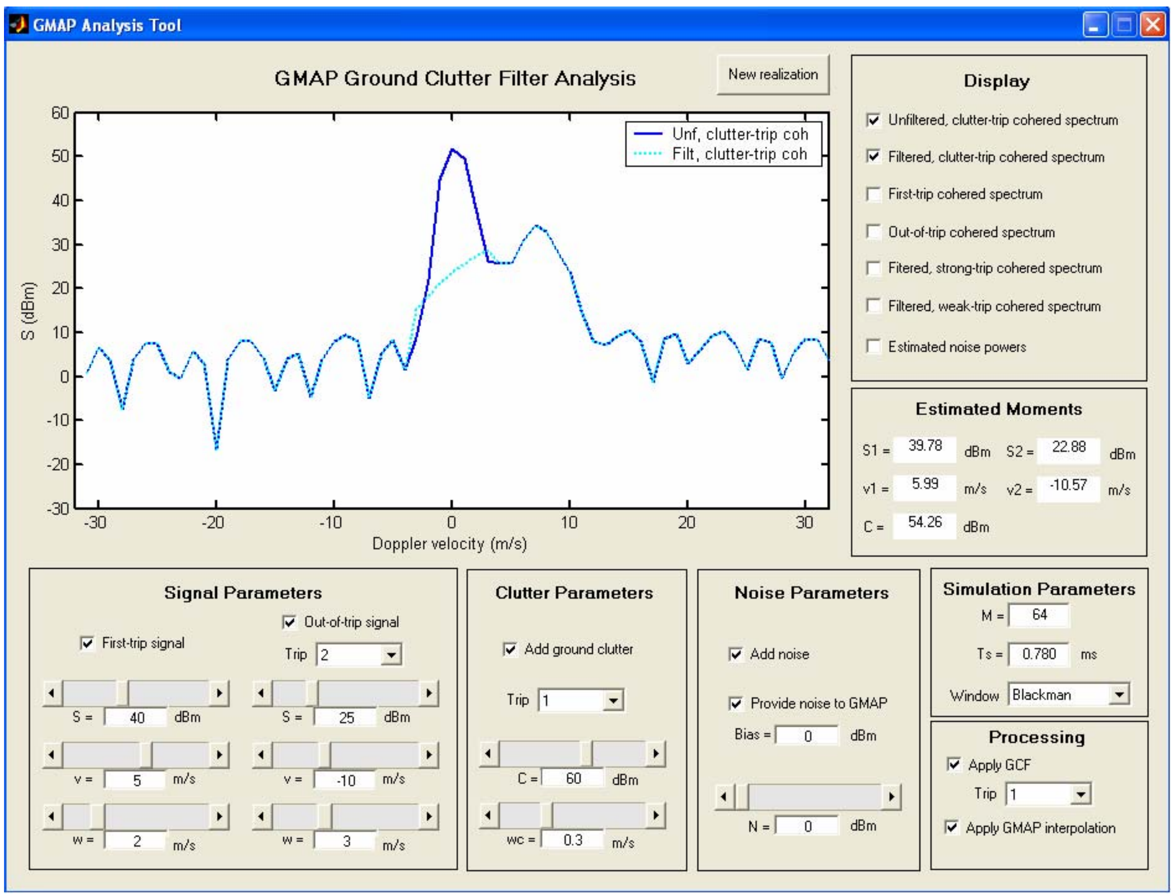
Analysis and Evaluation

Sebastian Torres

Simulation Studies

Simulation studies using synthetic data

- Statistical performance
- Sub-function tests (e.g., study of GMAP)



Studies using time-series data (I)

- Real-time
  - Phase coding
    - Uses WSR-88D phase shifter
    - 1st trip decoding
  - Staggered PRT
    - Complete processing except for GCF
  - Implemented on the RRDA for
    - General quality assessment
    - Aid in data collection
    - Immediate comparison

Studies using time-series data (II)

- Off-line
  - Playback through RRDA
  - Playback through SimSPS: Simulator of the Signal Processing Subsystem
    - Exact replica of RRDA's SPS implemented in MATLAB
    - Functionality matches legacy WSR-88D
    - Easy implementation of evolutionary requirements
    - Allows for both qualitative and quantitative analyses

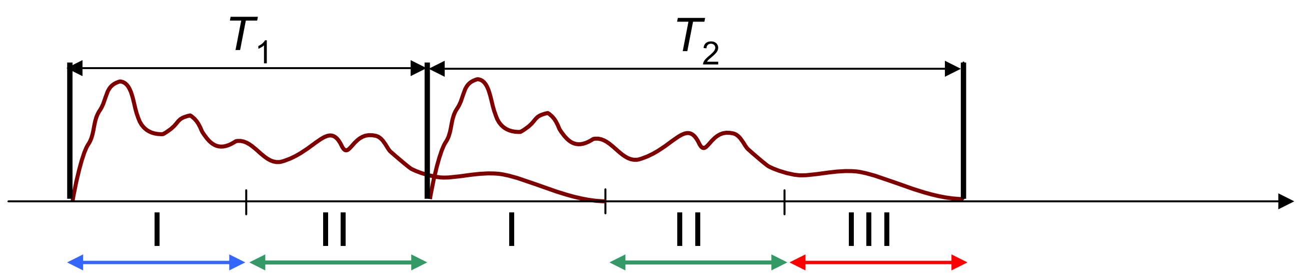
R/V Ambiguity Mitigation Algorithms

Staggered PRT

Phase Coding

The Staggered PRT Algorithm

- Transmitter alternates two PRTs
  - PRT ratio: $\kappa = T_1/T_2 = m/n$



- Maximum unambiguous range
  - r_{a2} for reflectivity
  - r_{a1} for Doppler velocity and spectrum width
- Maximum unambiguous velocity
  - $v_a = m\ v_{a1} = n\ v_{a2}$ (Velocity dealiasing algorithm)

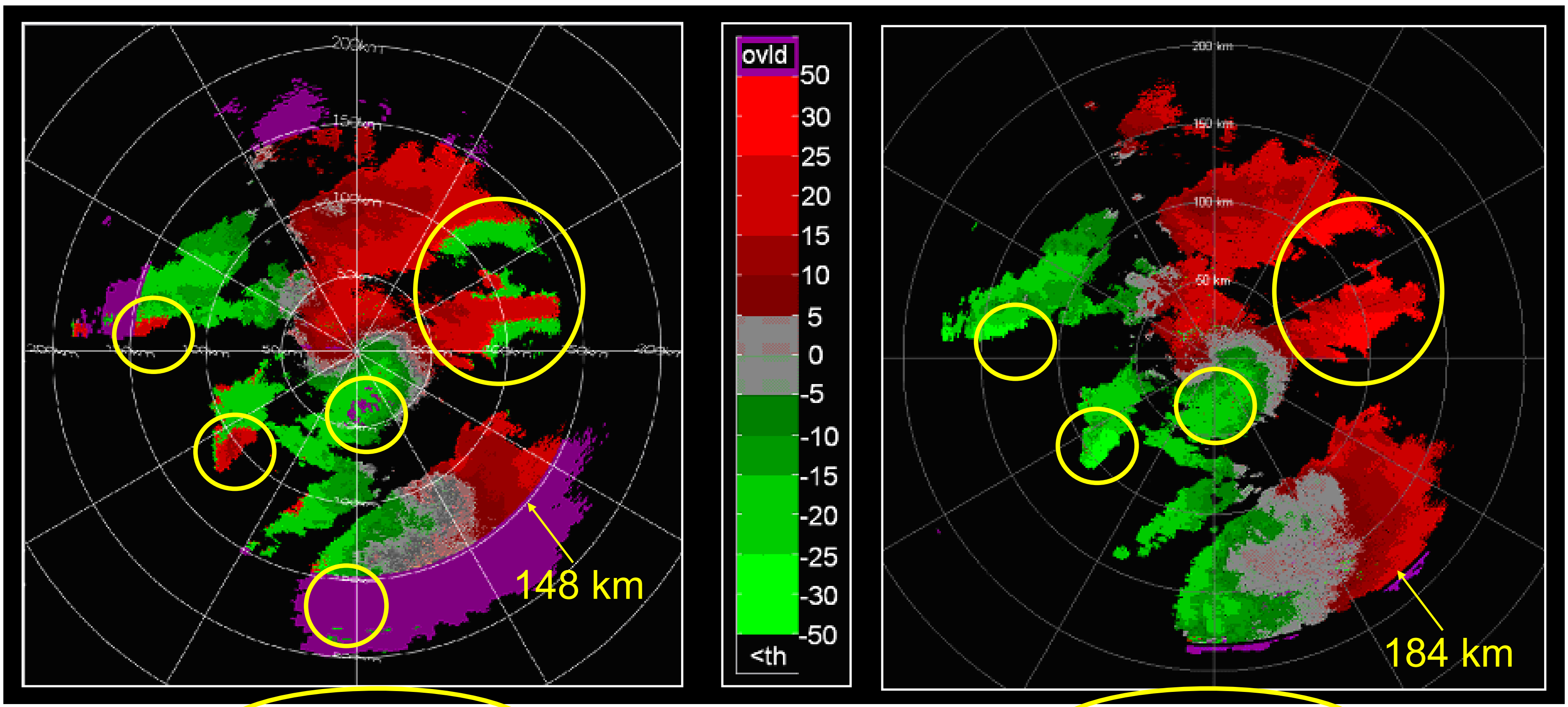
The Staggered PRT Algorithm

04/06/03 4:42 GMT

EL = 2.5 deg

KTLX
VCP 11 – Batch Mode

KOUN
Staggered PRT (184 km/276 km)



v_a = 25.4 m s^{-1}

v_a = 45.2 m s^{-1}

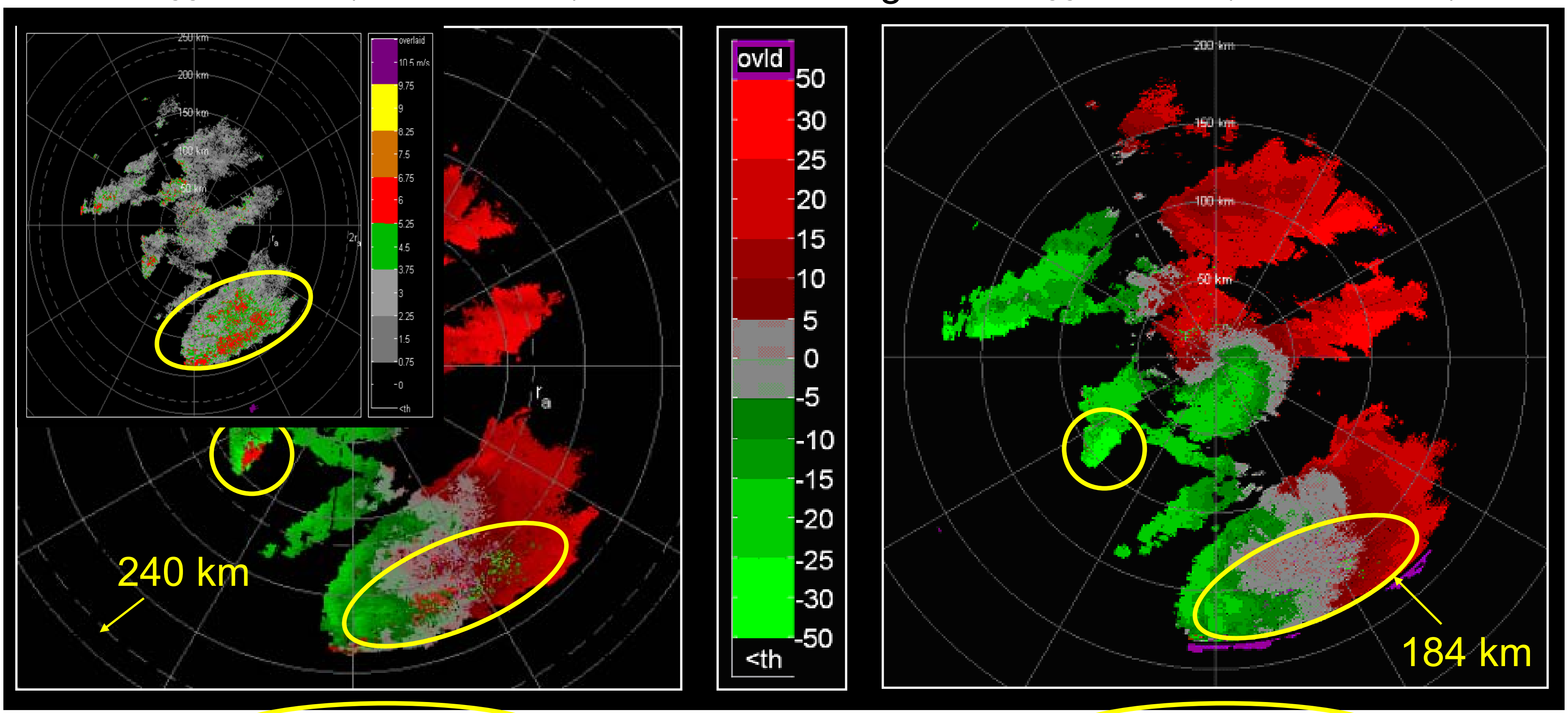
Velocity Computation
Algorithm Performance

04/06/03 4:50 GMT

EL = 2.5 deg

KOUN
Staggered PRT (240 km/360 km)

KOUN
Staggered PRT (184 km/276 km)



v_a = 34.6 m s^{-1}

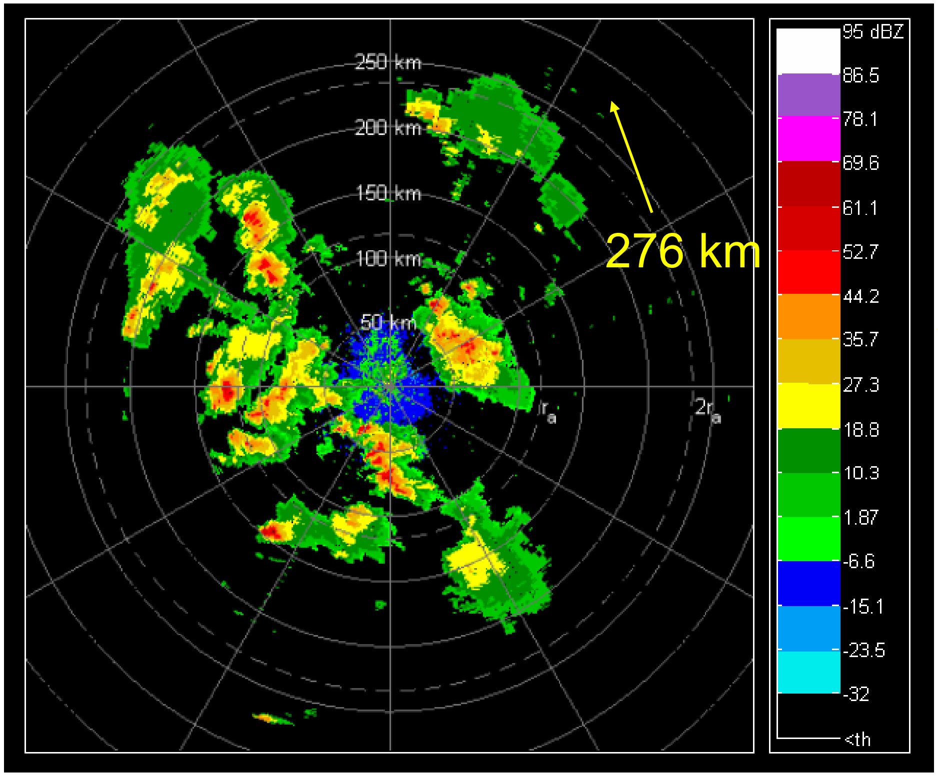
v_a = 45.2 m s^{-1}

Censoring

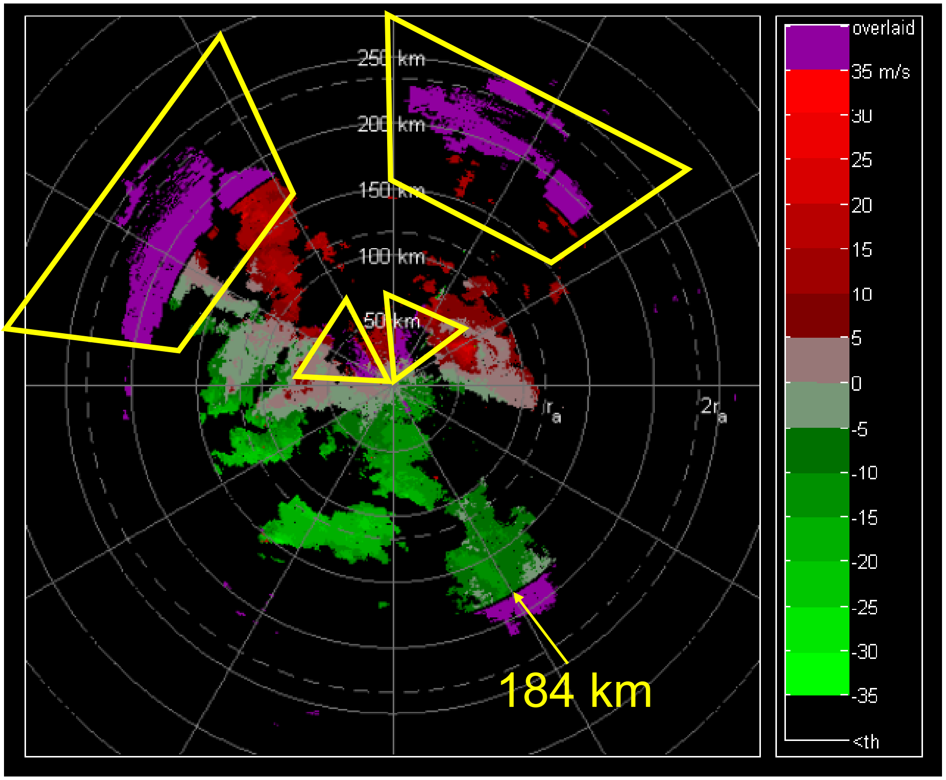
03/18/03 3:28 GMT

EL = 1.5 deg

Reflectivity
Staggered PRT (184 km/276 km)



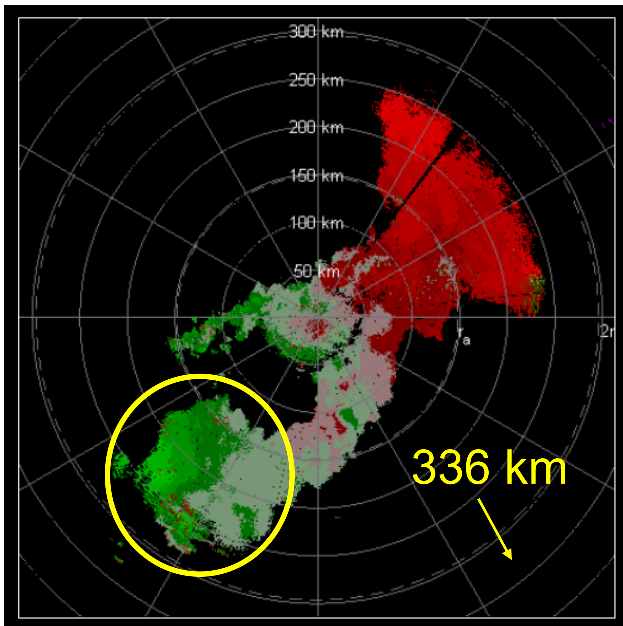
Velocity
Staggered PRT (184 km/276 km)



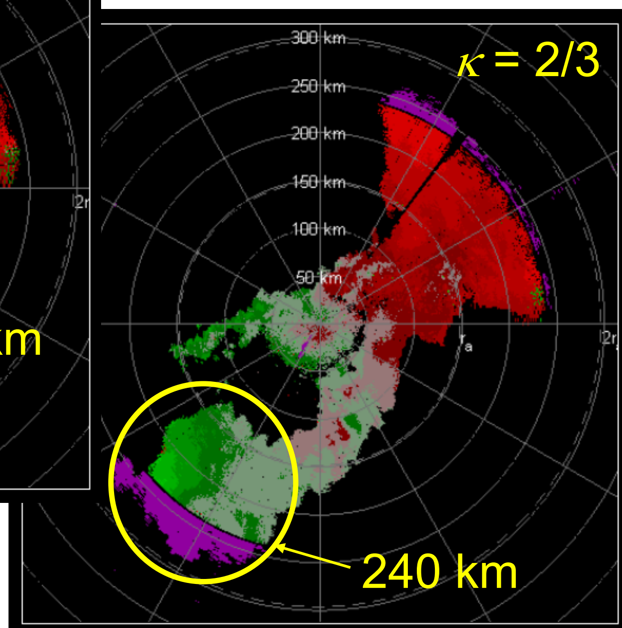
v_a = 45.2 m s^{-1}

PRT Trade-Off

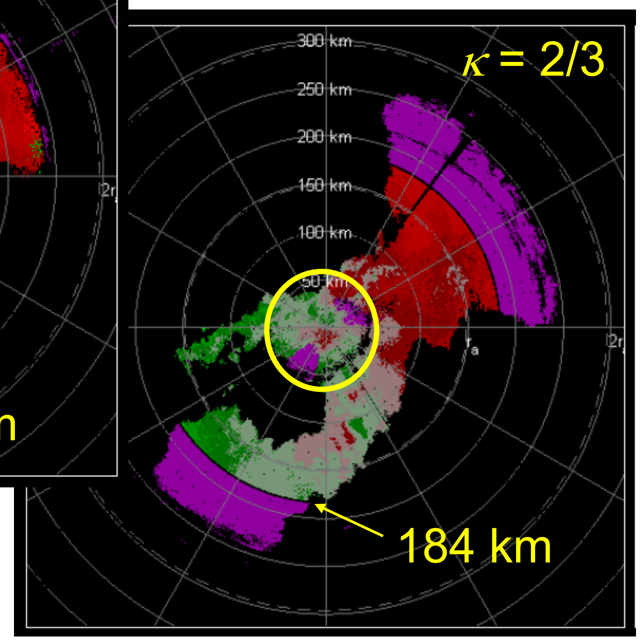
04/06/03 3:14 GMT
EL = 1.5 deg



Long PRTs
Staggered 336/466
v_a = 26.8 m s^{-1}



Medium PRTs
Staggered 240/360
v_a = 34.6 m s^{-1}



Short PRTs
Staggered 184/276
v_a = 45.2 m s^{-1}

The SZ-2 Algorithm

- Transmitted pulses are phase-modulated with SZ(8/64) switching code
- Phase-coded scan is preceded by long-PRT surveillance scan
  - Surveillance scan is not phase coded
  - Powers from the surveillance scan are used to determine overlaid trips in the phase-coded scan
  - Spectrum widths from the surveillance scan are used for censoring

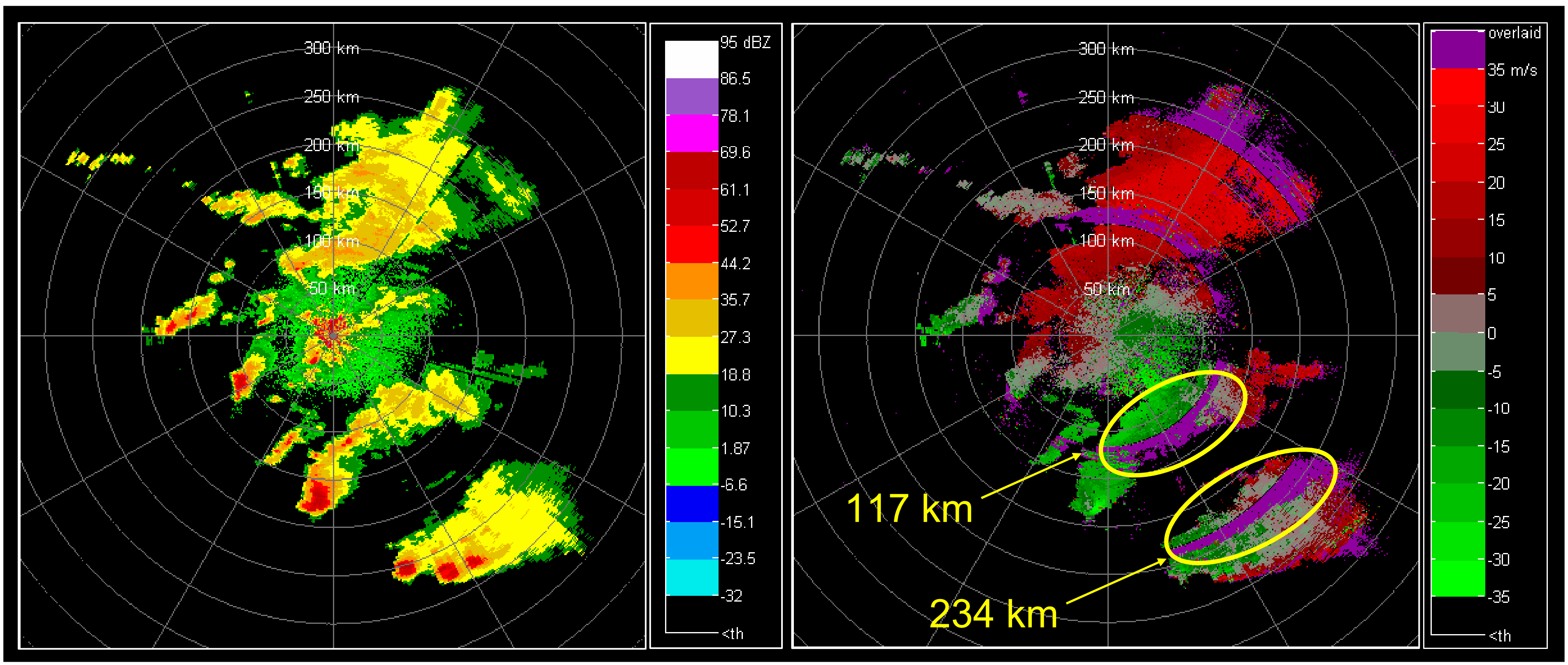
SZ-2 Algorithm Performance

04/06/03 4:26 GMT

Reflectivity
Long PRT

EL = 0.5 deg

Velocity
SZ-2 with short PRT

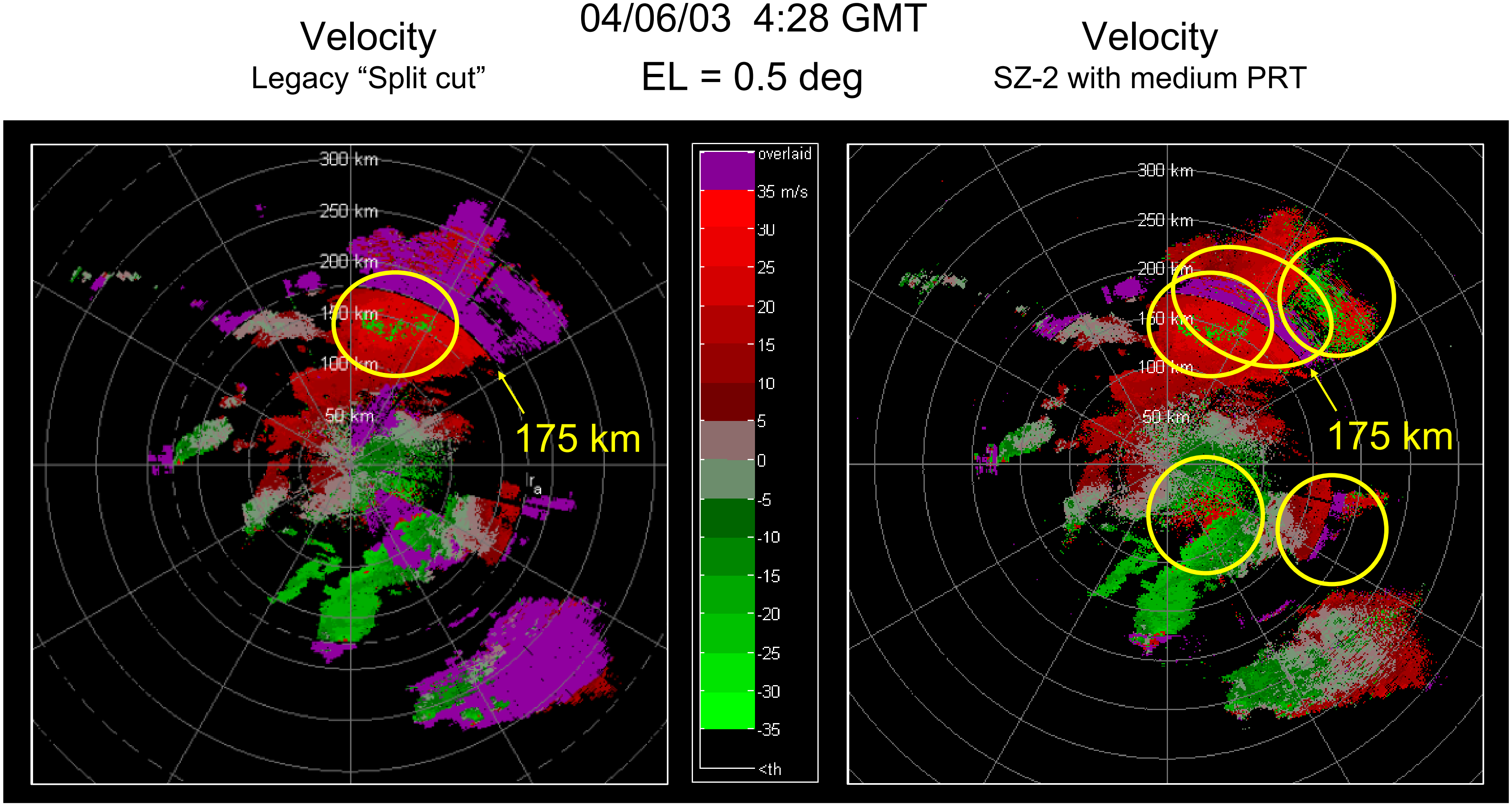


$v_a = 35.5 \text{ m s}^{-1}$

SZ-2 Algorithm Performance

04/06/03 4:28 GMT

EL = 0.5 deg



v_a = 23.7 m s^{-1}

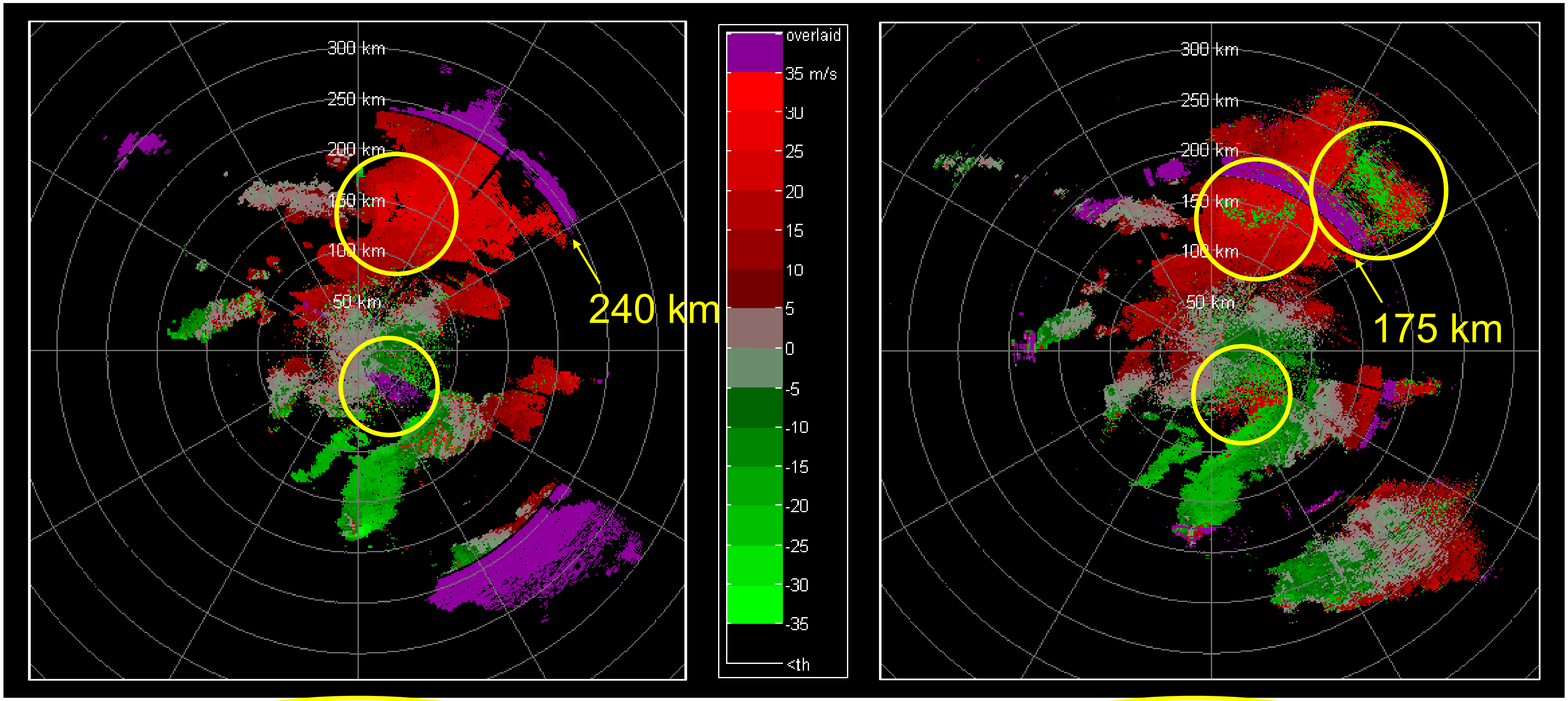
Staggered PRT vs. SZ-2

04/06/03 4:30 GMT

EL = 0.5 deg

Velocity
Staggered 240/360

Velocity
SZ-2 with medium PRT



v_a = 34.6 m s^{-1}

v_a = 23.7 m s^{-1}

Performance of R/V Ambiguity Mitigation Algorithms

KOUN Cases

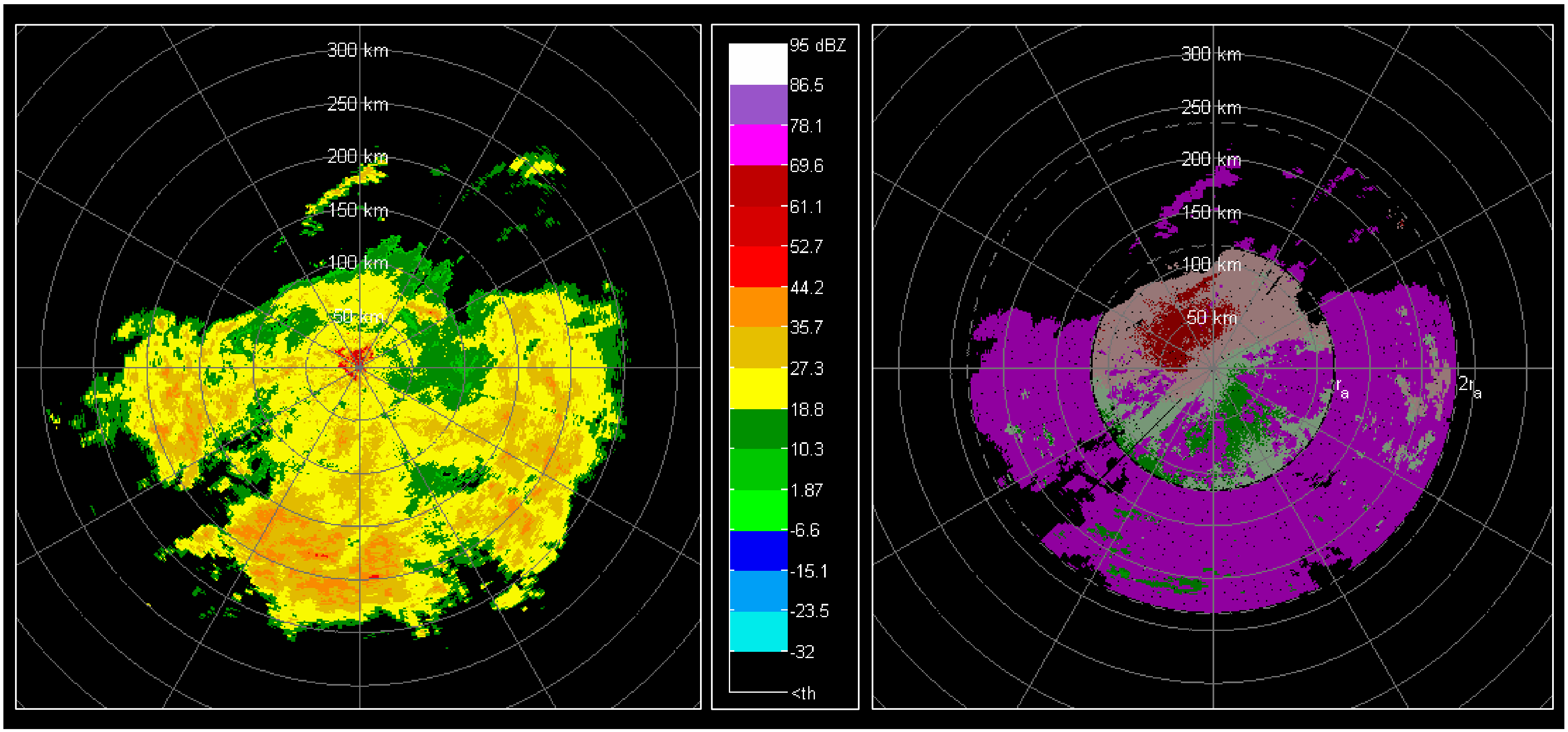
Stratiform Precipitation

Phase Coding

Reflectivity
Long PRT

10/08/02 15:11 GMT
EL = 0.5 deg

Velocity
Legacy short PRT



v_a = 8.9 m s^{-1}, r_a = 466 km

v_a = 35.5 m s^{-1}, r_a = 117 km

Stratiform Precipitation

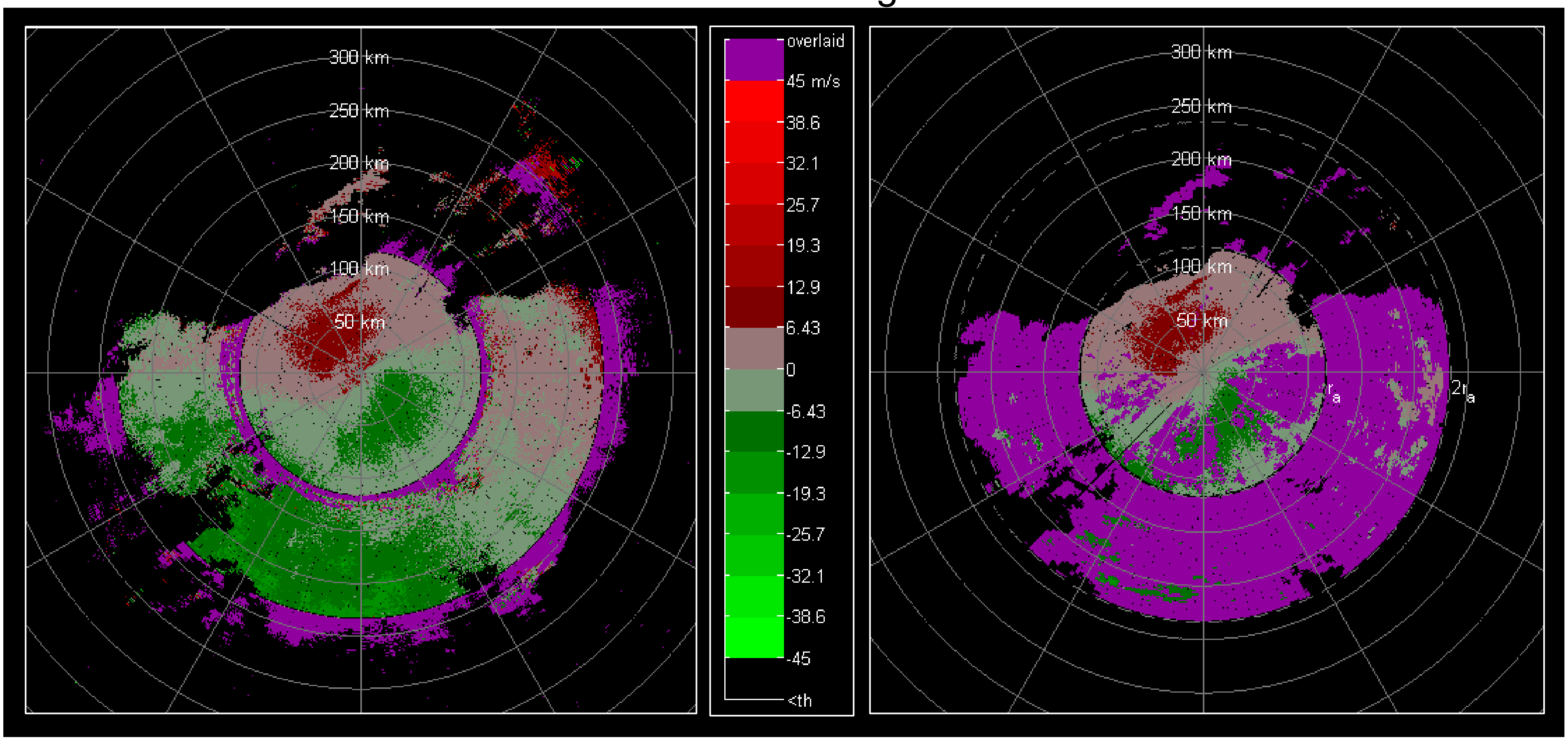
Phase Coding

10/08/02 15:11 GMT

EL = 0.5 deg

Velocity
SZ-2 with short PRT

Velocity
Legacy short PRT



v_a = 35.5 m s^{-1}, r_a = 117 km

v_a = 35.5 m s^{-1}, r_a = 117 km

Stratiform Precipitation

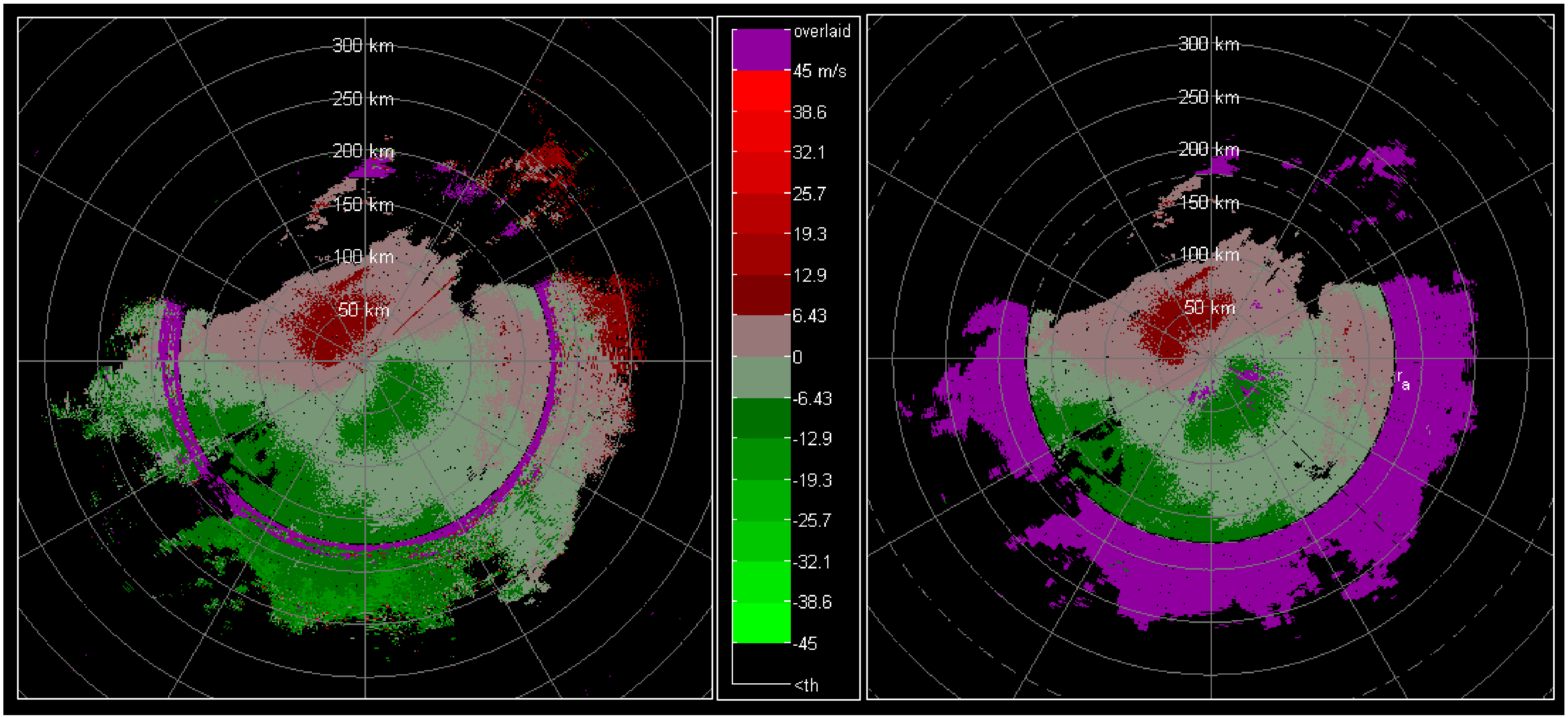
Phase Coding

10/08/02 15:11 GMT

EL = 0.5 deg

Velocity
SZ-2 with medium PRT

Velocity
Legacy medium PRT



v_a = 23.7 m s^{-1}, r_a = 175 km

v_a = 23.7 m s^{-1}, r_a = 175 km

Stratiform Precipitation

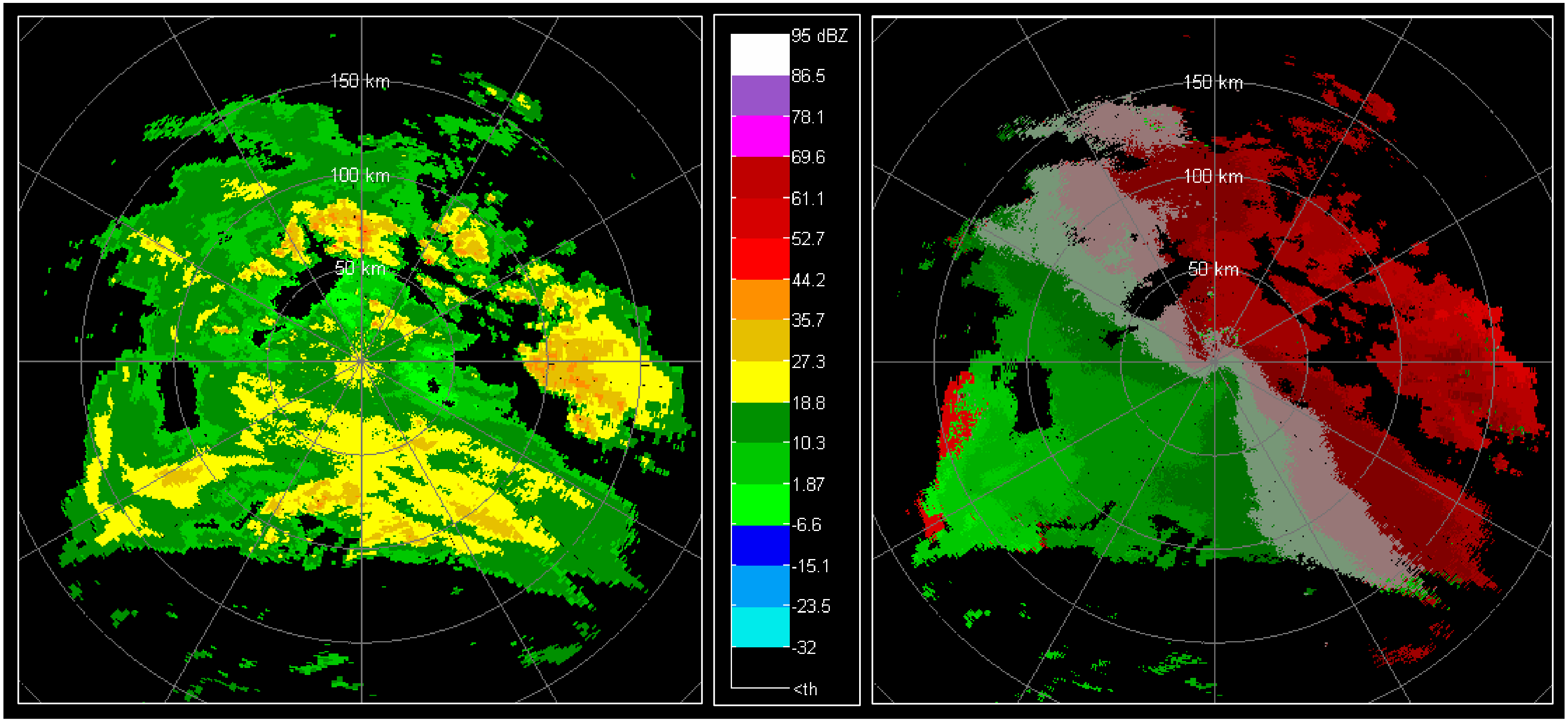
Staggered PRT

02/13/03 20:57 GMT

EL = 1.5 deg

Reflectivity
Long Staggered PRT

Velocity
Long Staggered PRT



v_a = 26.8 m s^{-1}, r_{a1} = 336 km , r_{a2} = 466 km

Stratiform Precipitation

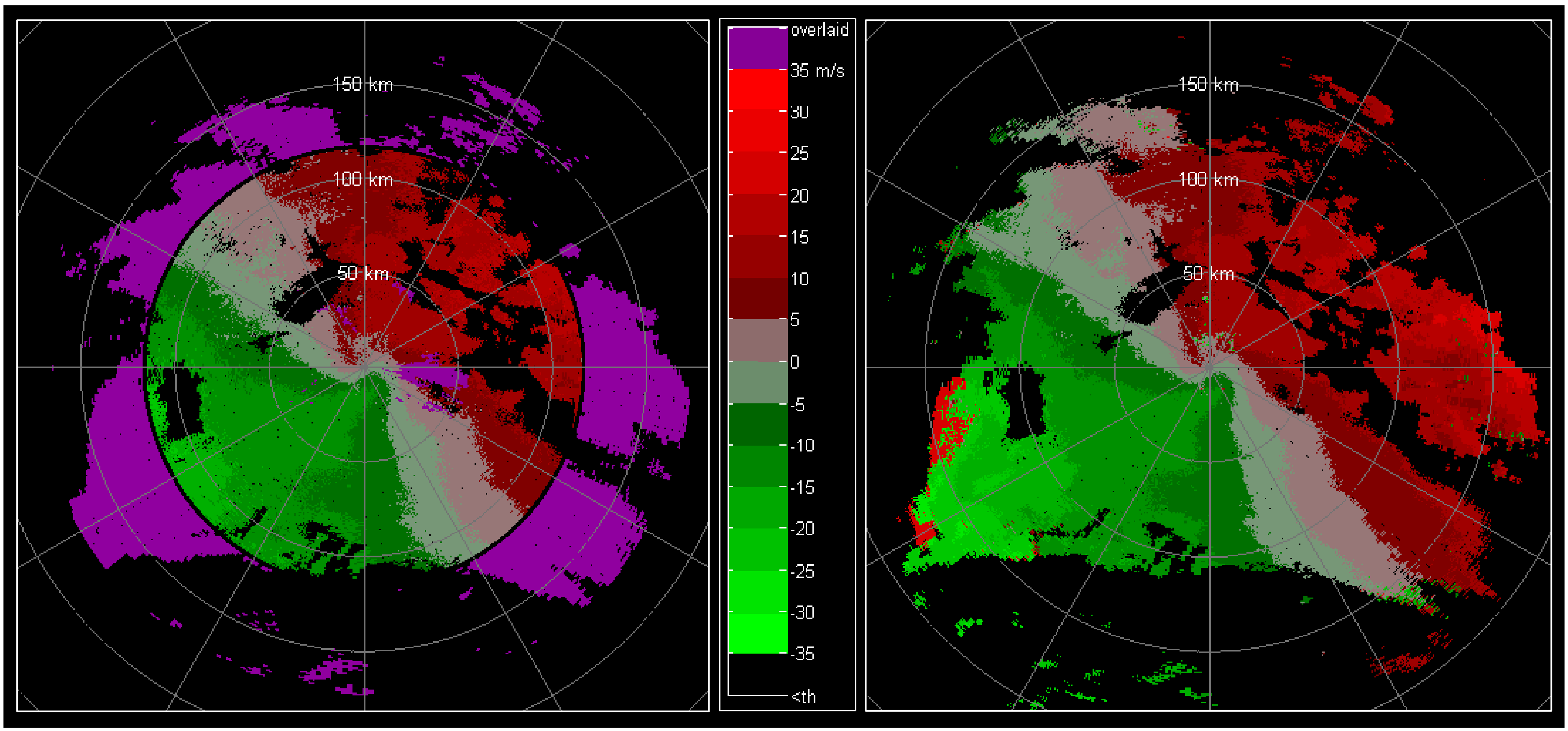
Staggered PRT

Velocity
Short Staggered PRT

02/13/03 20:57 GMT

EL = 1.5 deg

Velocity
Long Staggered PRT



v_a = 71.2 m s^{-1}, r_{a1} = 117 km , r_{a2} = 175 km v_a = 26.8 m s^{-1}, r_{a1} = 336 km , r_{a2} = 466 km

Convective Precipitation

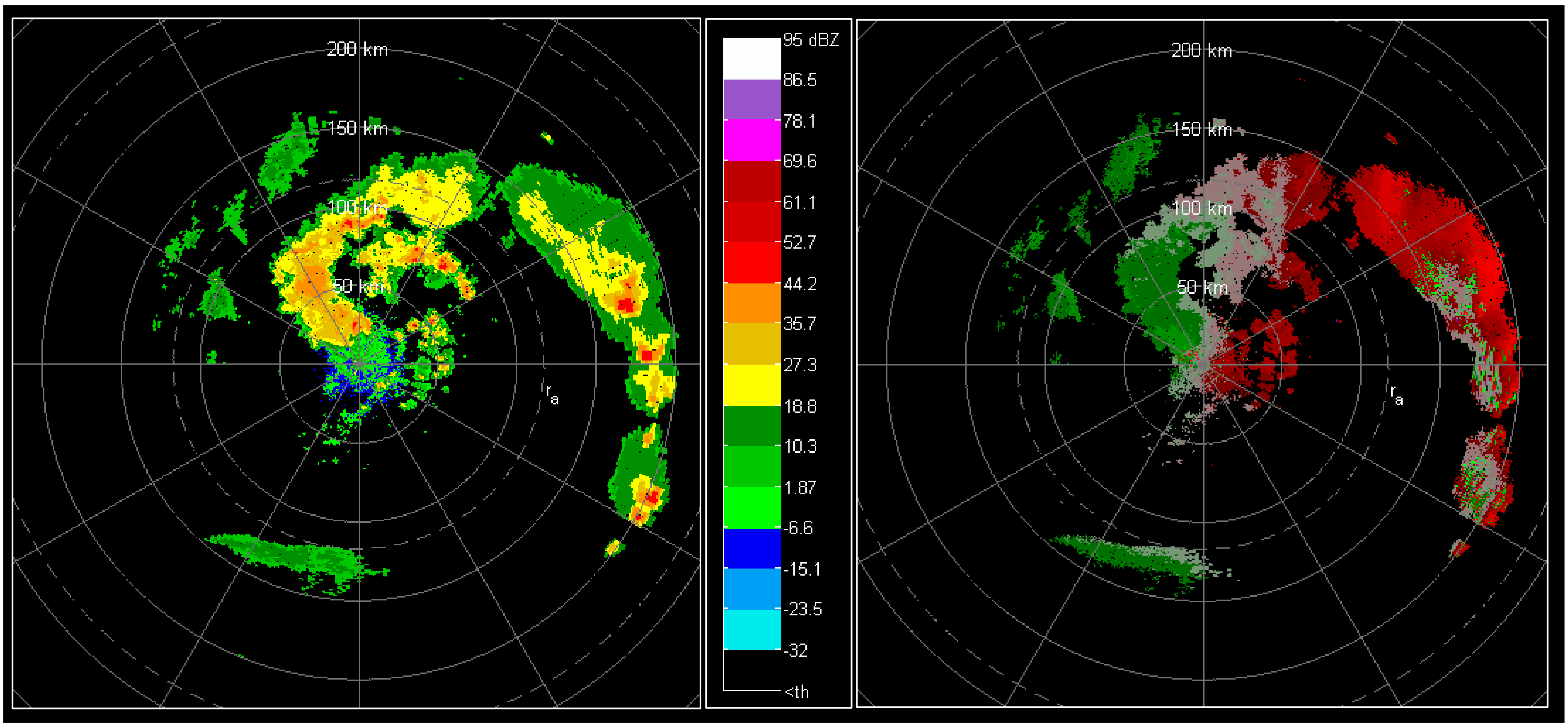
Staggered PRT

05/17/03 0:39 GMT

EL = 2.5 deg

Reflectivity
Staggered PRT

Velocity
Staggered PRT



v_a = 34.6 m s^{-1}, r_{a1} = 240 km , r_{a2} = 360 km

Convective Precipitation

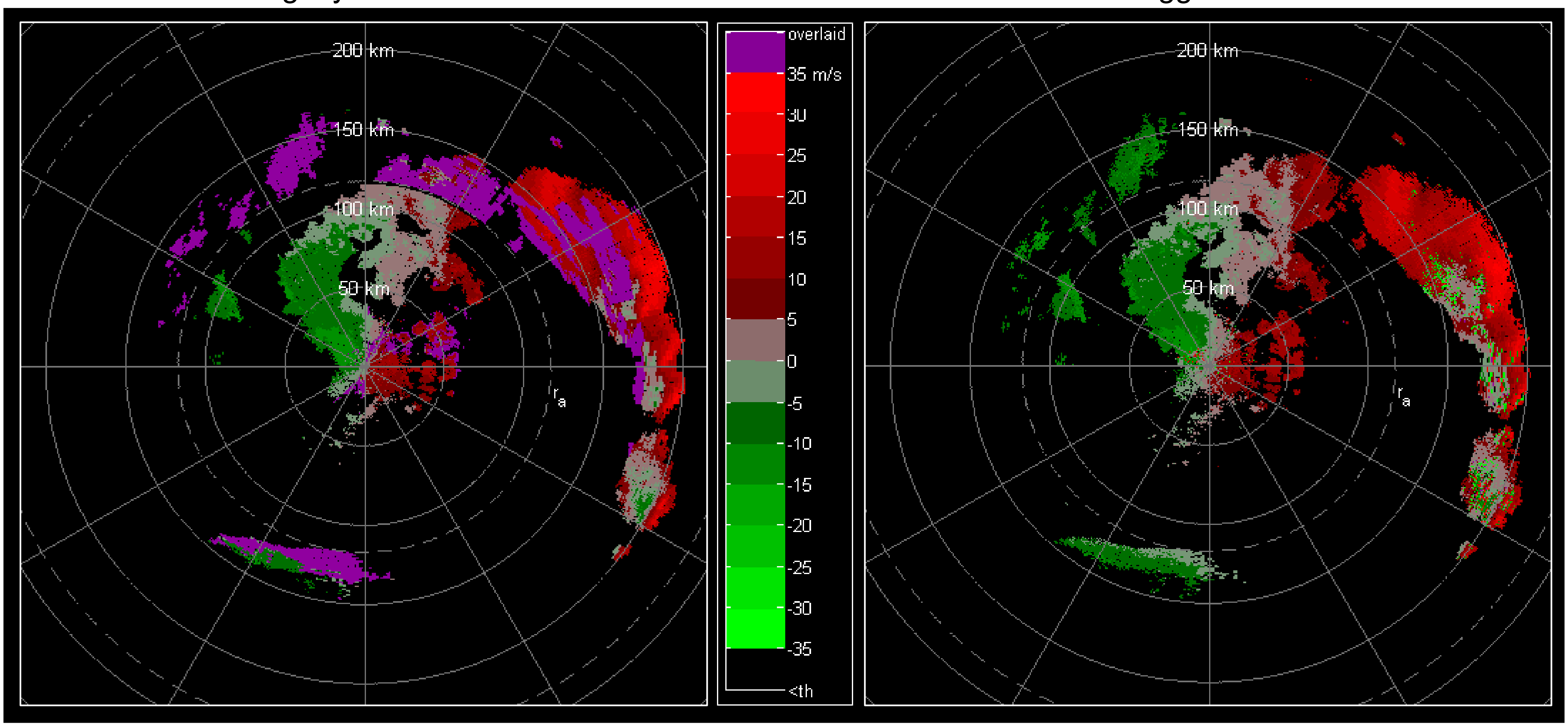
Staggered PRT

05/17/03 0:39 GMT

EL = 2.5 deg

Velocity
Legacy short PRT

Velocity
Staggered PRT



v_a = 35.5 m s^{-1}, r_a = 117 km

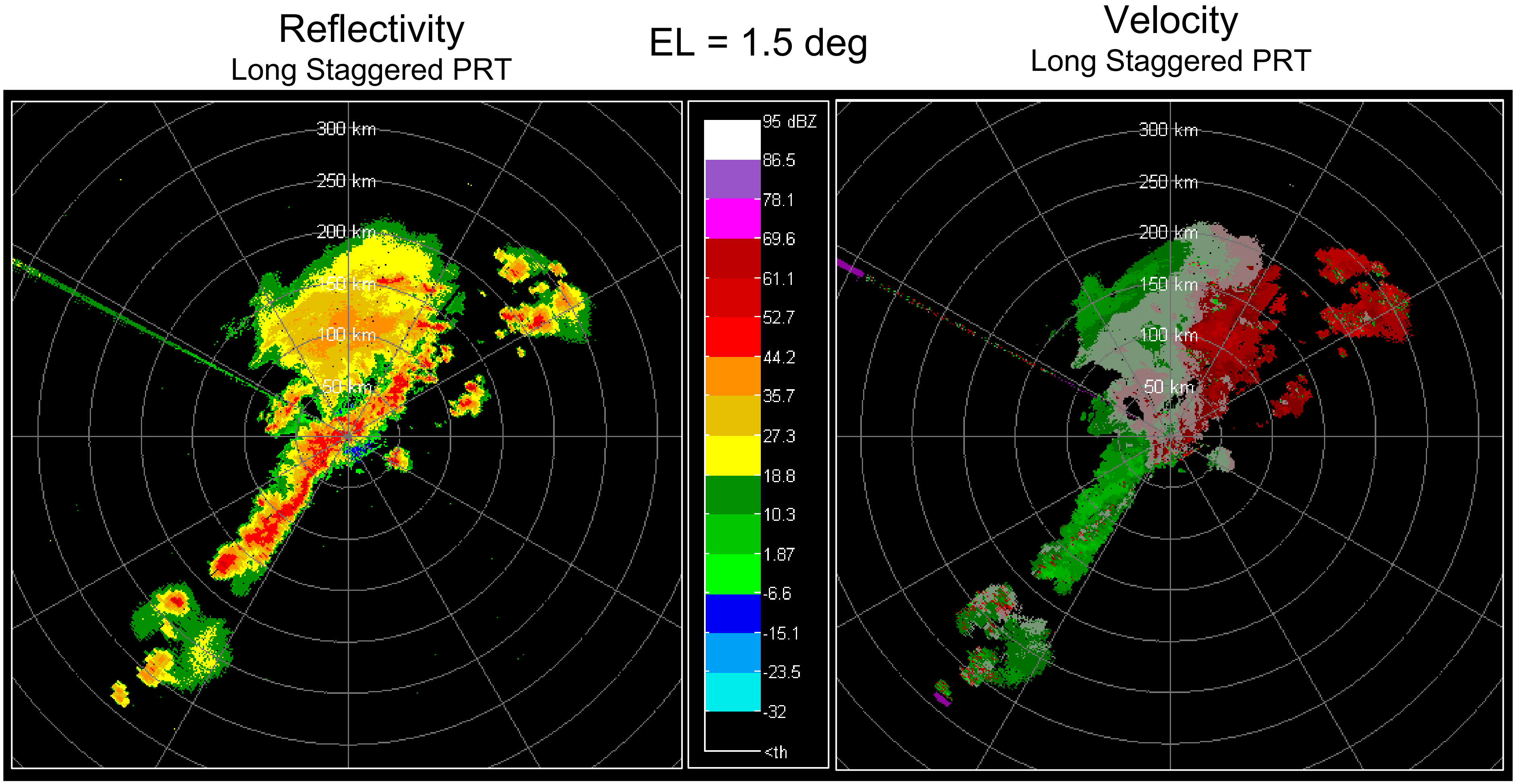
v_a = 34.6 m s^{-1}, r_{a1} = 240 km , r_{a2} = 360 km

Squall Line

Staggered PRT

06/11/03 6:27 GMT

EL = 1.5 deg

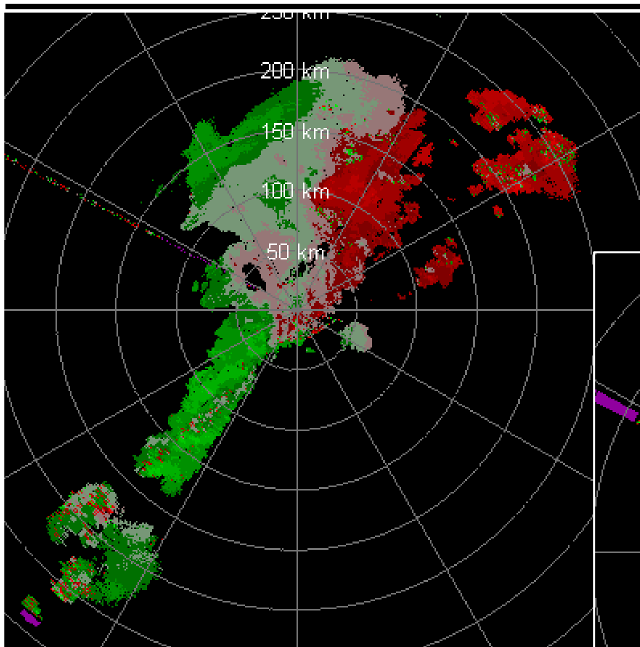


v_a = 26.7 m s^{-1}, r_{a1} = 336 km , r_{a2} = 466 km

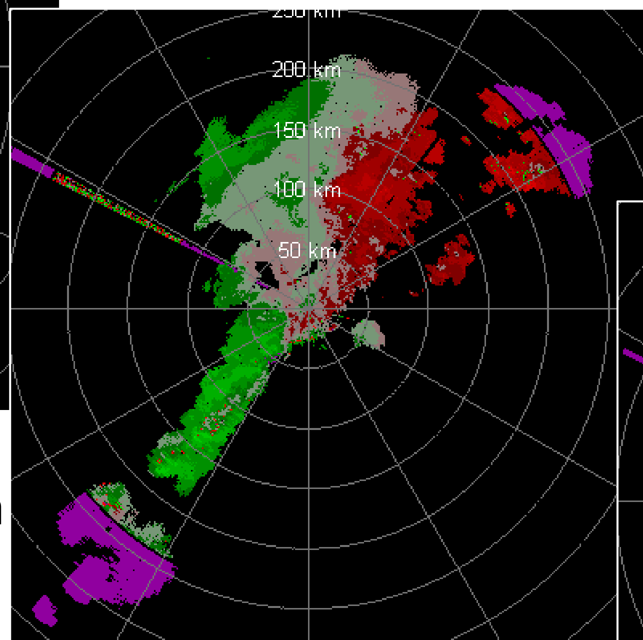
Squall Line
Staggered PRT

06/11/03 6:27 GMT

EL = 1.5 deg

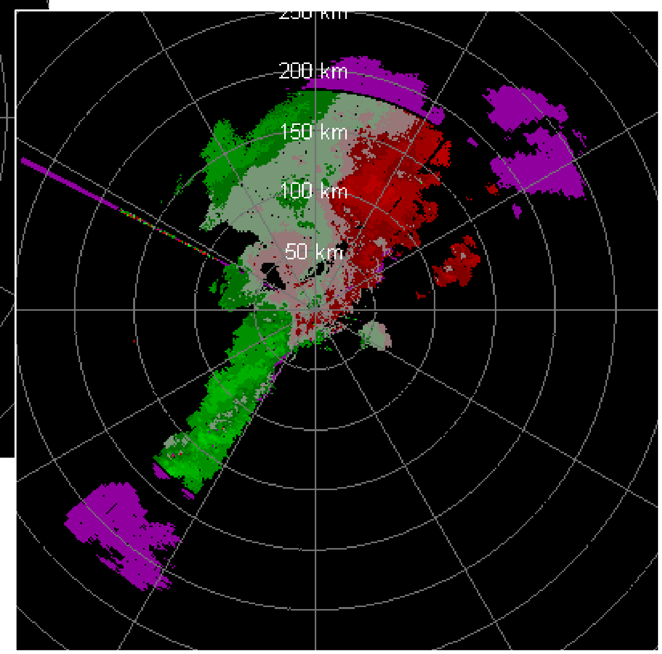


Long PRTs
Staggered 336 km/466 km
v_a = 26.8 m s^{-1}



Medium PRTs
Staggered 240 km/360 km
v_a = 34.6 m s^{-1}

Short PRTs
Staggered 184 km/276 km
v_a = 45.2 m s^{-1}



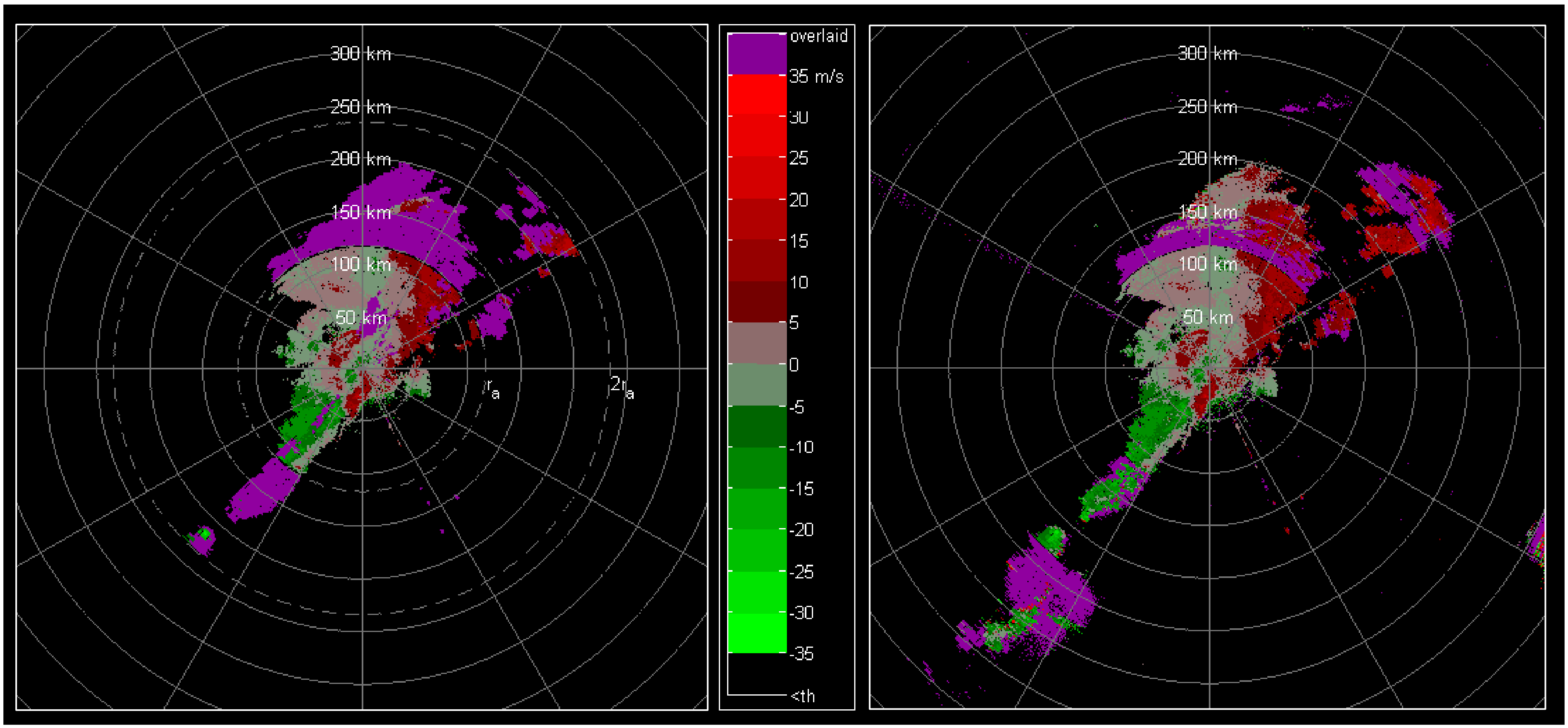
Squall Line
Phase Coding

06/11/03 6:44 GMT

EL = 0.5 deg

Velocity
Legacy short PRT

Velocity
SZ-2 with short PRT



v_a = 35.5 m s^{-1}, r_a = 117 km

v_a = 35.5 m s^{-1}, r_a = 117 km

Squall Line

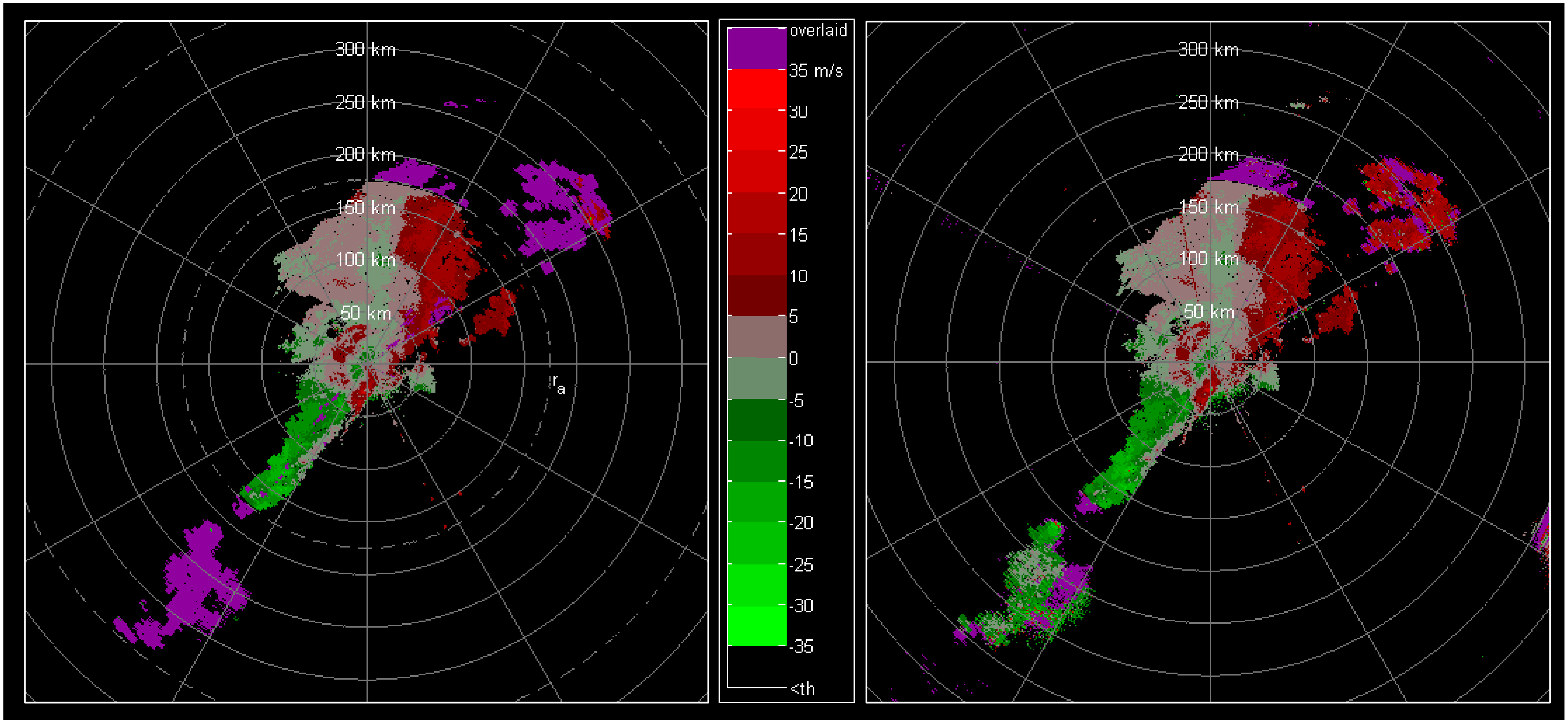
Phase Coding

06/11/02 6:44 GMT

EL = 0.5 deg

Velocity
Legacy medium PRT

Velocity
SZ-2 with medium PRT



v_a = 23.7 m s^{-1}, r_a = 175 km

v_a = 23.7 m s^{-1}, r_a = 175 km

MCS-Squall Line

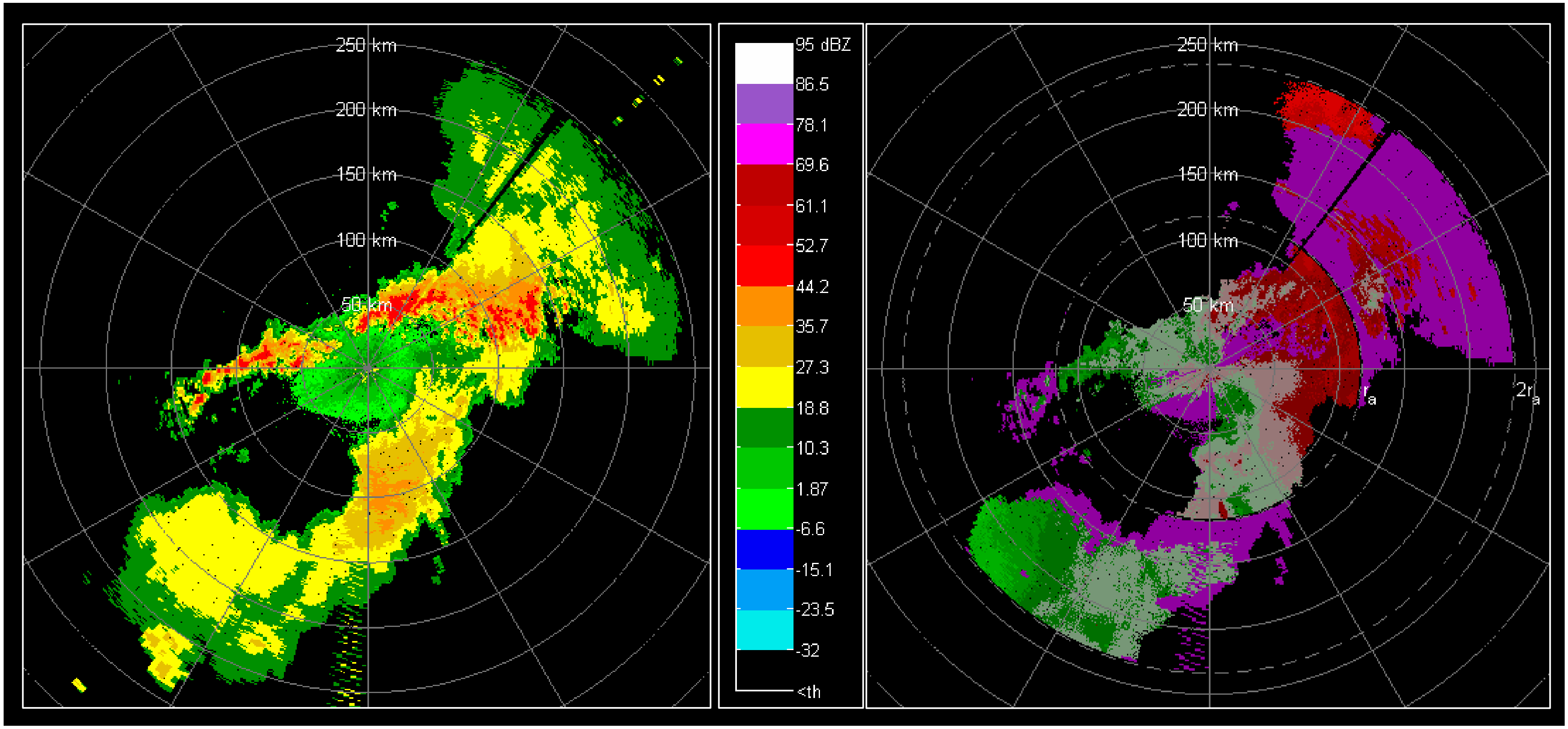
Phase Coding

06/26/03 3:14 GMT

EL = 1.5 deg

Reflectivity
Long PRT

Velocity
Legacy short PRT



v_a = 8.9 m s^{-1}, r_a = 466 km

v_a = 35.5 m s^{-1}, r_a = 117 km

MCS-Squall Line

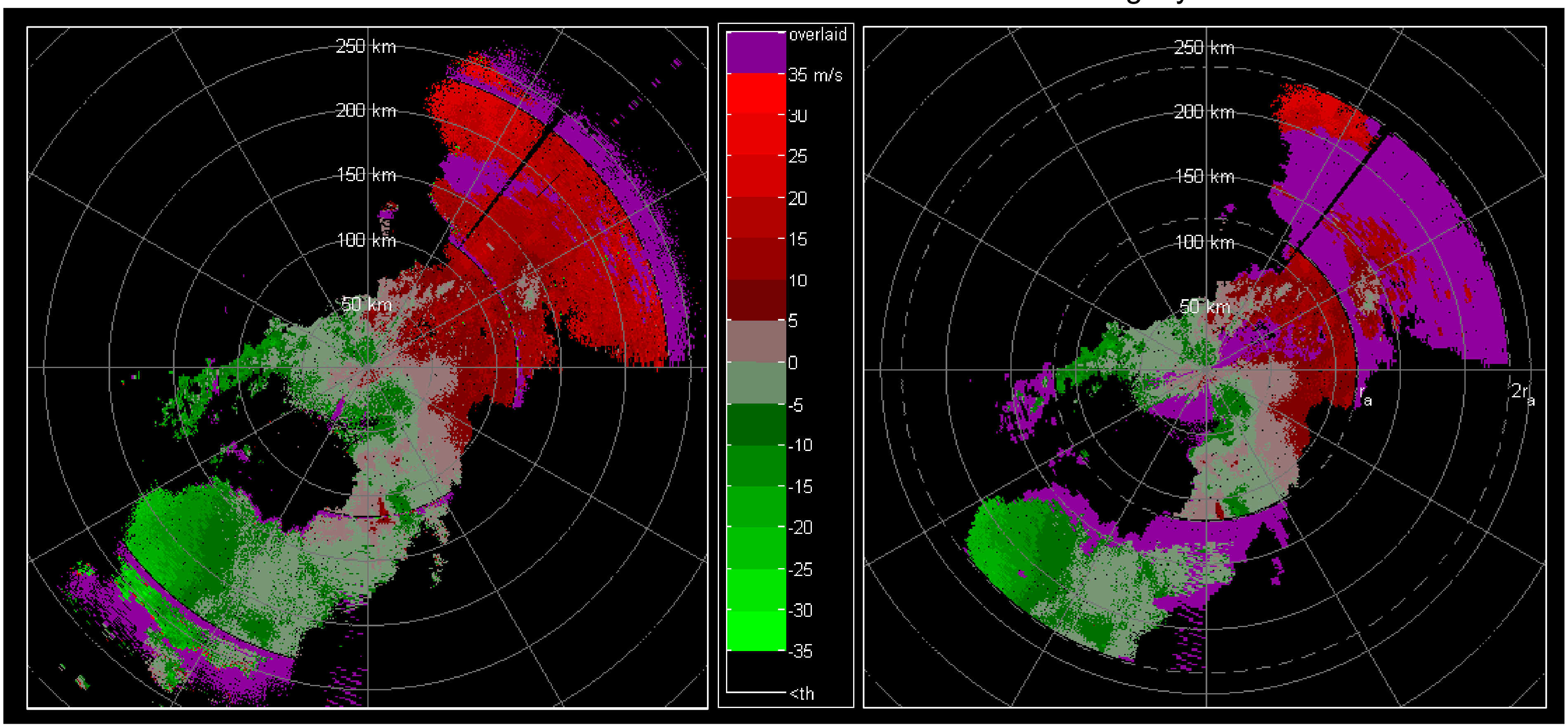
Phase Coding

06/26/03 3:14 GMT

EL = 1.5 deg

Velocity
SZ-2 with short PRT

Velocity
Legacy short PRT



v_a = 35.5 m s^{-1}, r_a = 117 km

v_a = 35.5 m s^{-1}, r_a = 117 km

MCS-Squall Line

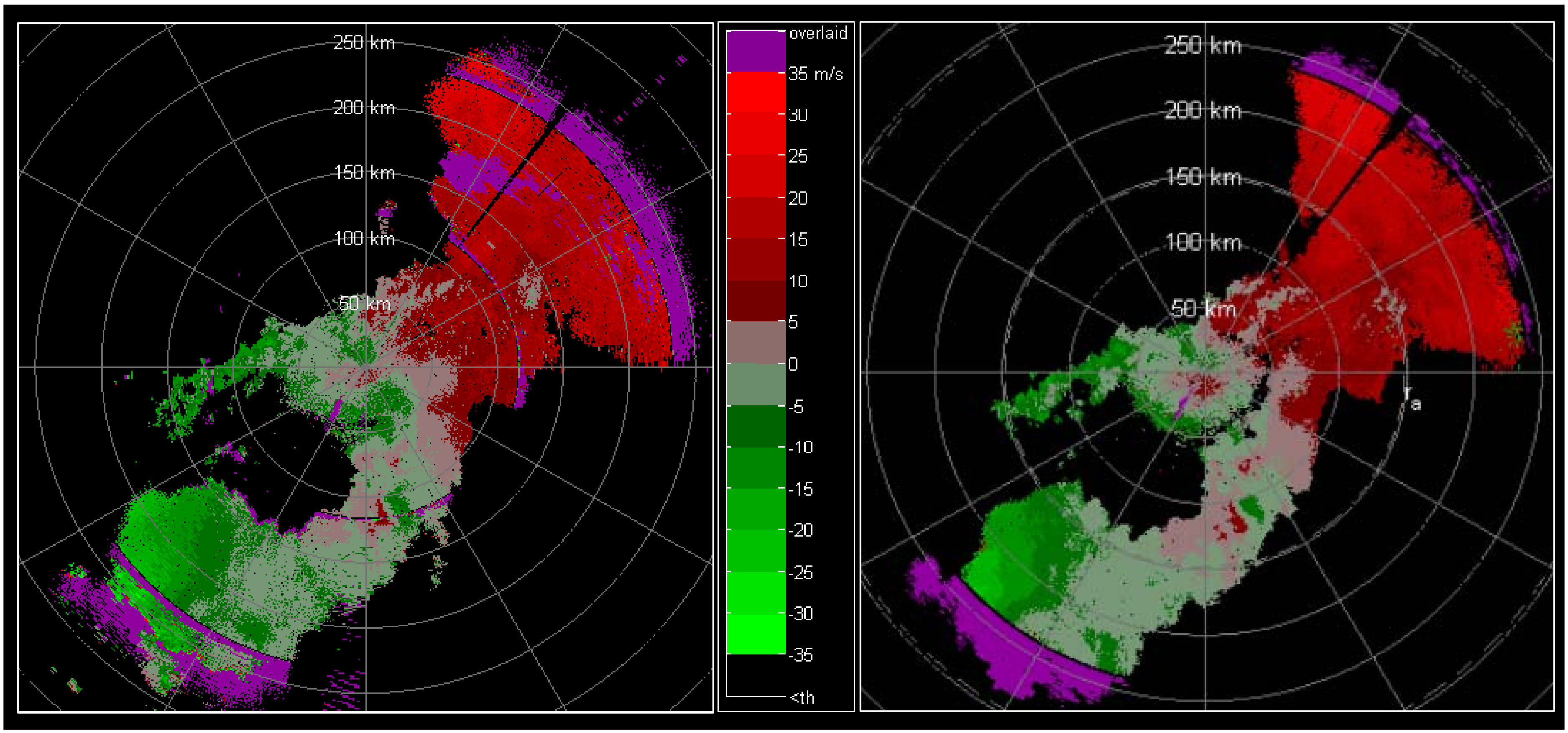
Phase Coding

04/06/03 3:14 GMT

EL = 1.5 deg

Velocity — SZ-2 with short PRT

Velocity — Staggered PRT (240 km/360 km)



v_a = 35.5 m s^{-1}, r_a = 117 km

v_a = 34.6 m s^{-1}, r_{a1} = 240 km , r_{a2} = 360 km

Summary

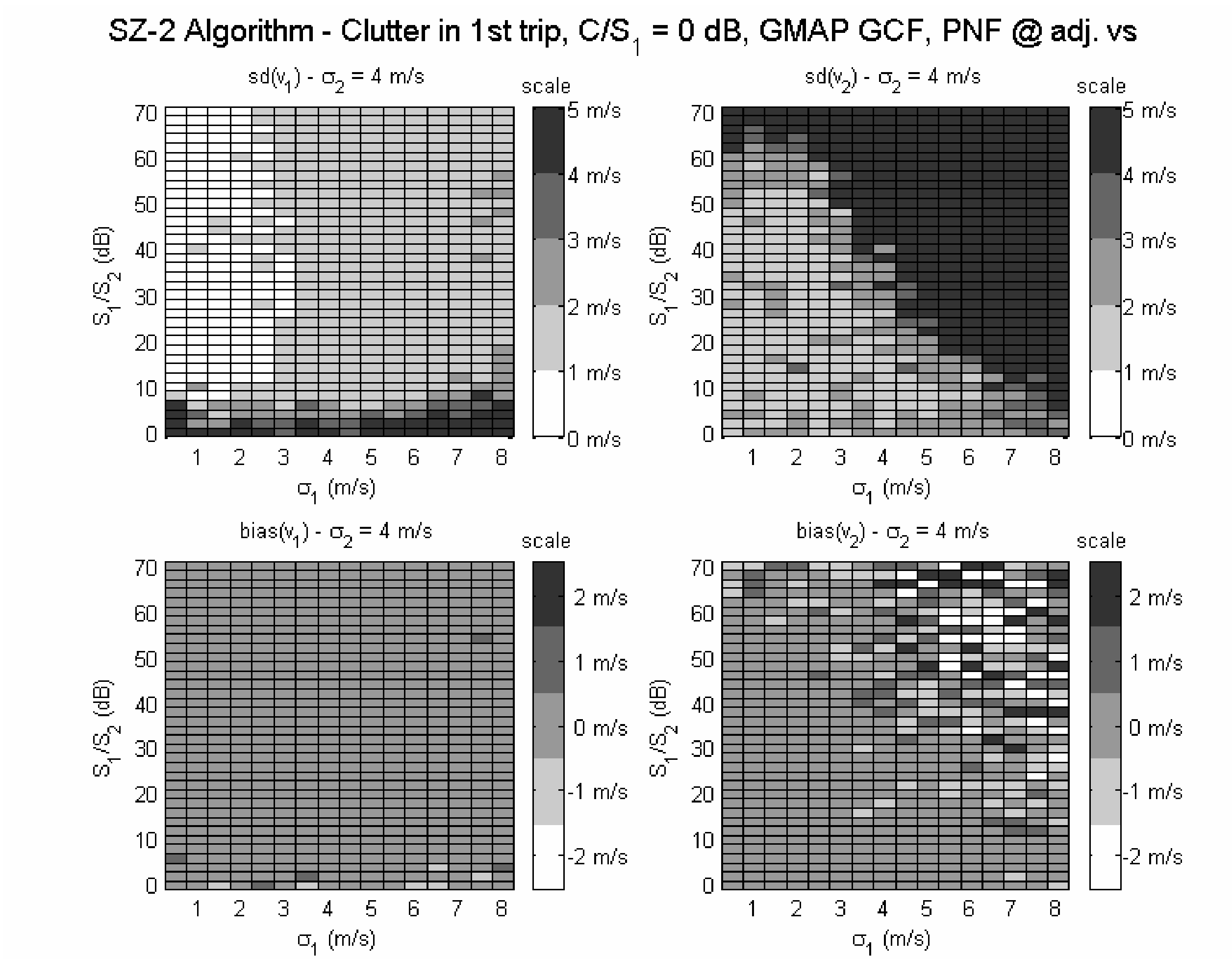
- At lower elevations and in MCS and widespread convective systems, the medium PRT gives best compromise in both techniques
- In shallow stratiform convective systems, the medium Staggered PRT gives good results even at the lowest elevations
- At elevations of 1.5 deg and higher, the staggered PRT has an advantage in clear area coverage
- Both techniques significantly reduce obscuration with respect to legacy processing

The End

Backup Slides

Simulation studies using synthetic data

- Statistical performance



Summary of Staggered PRT Technique

- Range coverage
  - Z to r_{a2} and v to r_{a1}, where $r_{a1}/r_{a2} = m/n = K$
  - Natural “match” for WSR-88D VCPs
- Extension of maximum unambiguous velocity
  - $v_a = m\, v_{a1} = n\, v_{a2}$
- Range-velocity ambiguities
  - Uniform PRT
    - $r_a v_a = c\lambda/8 \rightarrow$ Inadequate for $\lambda = 10$ cm
  - Staggered PRT
    - $r_{a1} v_a = m(c\lambda/8)$
    - r_{a1} vs. v_a trade-off controlled by PRTs

SZ-2 Censoring