Effects of a less tapered window on data quality in super-res mode

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MOTIVATION

- Polarimetric variables are **mor**
  decrease in SNR than the sp

From SNR of 20 dB to SNR of 2 dB
SD(Z) goes up by ~1.3x (RECT WIN)
SD(Z) goes up by ~1.3x (VON HANN WIN)

  – Application of von Hann window i
  exacerbates this effect

But for DP variables

RECT WIN

SD(Z_{DR}) by ~6.7x
SD(CC) by ~104x
SD(ϕ_{DP}) by ~6x

VON HANN

SD(Z_{DR}) by ~6.7x
SD(CC) by ~135x
SD(ϕ_{DP}) by ~6.8x

- If M = 16, $v_a \approx 9$ m s^{-1} (VCP12) at 20 dB SNR
  – Rect. → Von Hann ⇒ SD(Z) ↑ 32%

USING VON HANN WINDOW SIGNIFICANTLY DEGRADES THE QUALITY OF DP ESTIMATES!

⇒ SD(ϕ_{DP}) ↑ 45%
⇒ SD(CC) ↑ 55%

RECT. VS. VON HANN WIN.

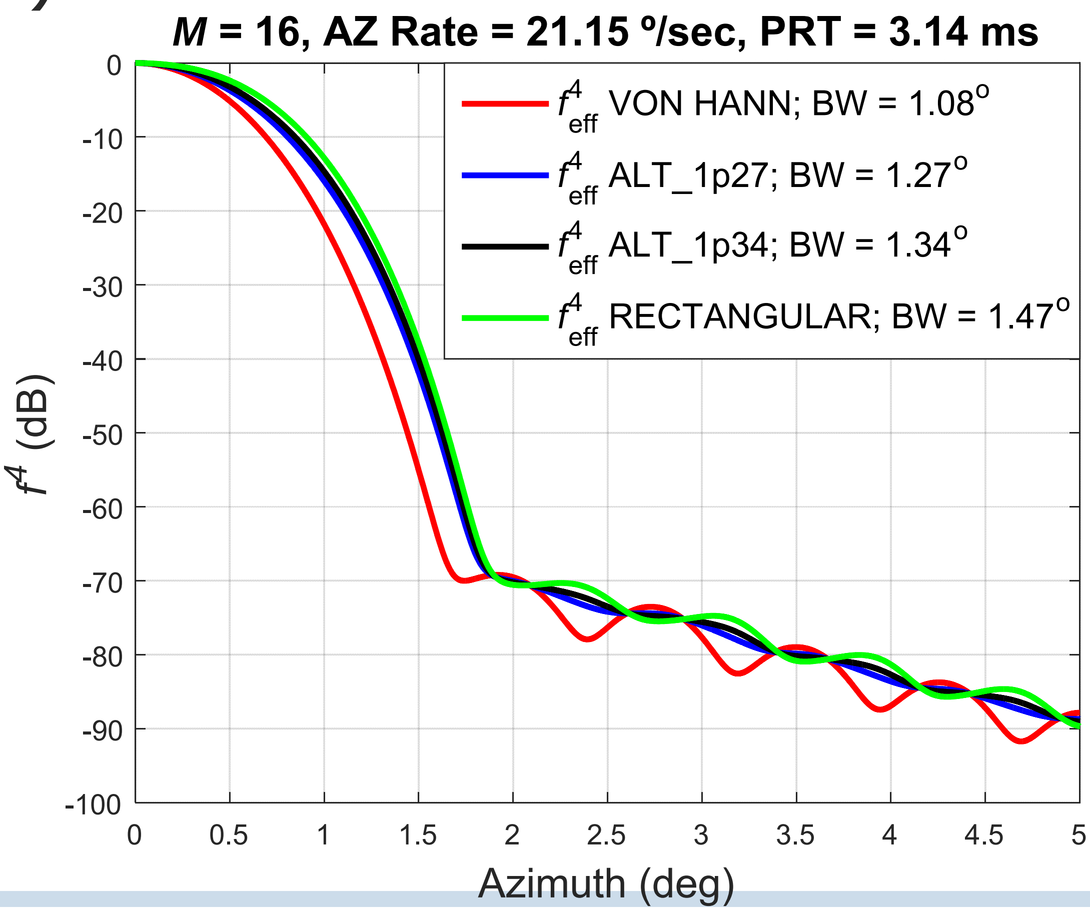
- Rectangular window produces higher quality data than von Hann in terms of SD but the effective beamwidth increases from about 1.08° to 1.47°
  - This raises concerns that some weather features might be obscured (e.g., tornado debris signatures).
- To mitigate such possibility replacing von Hann with alternative window which yields effective beamwidth between 1.1° and 1.47° has been proposed

$$ALT(n) = A - B\cos\left(2\pi \frac{n+0.5}{M}\right)$$

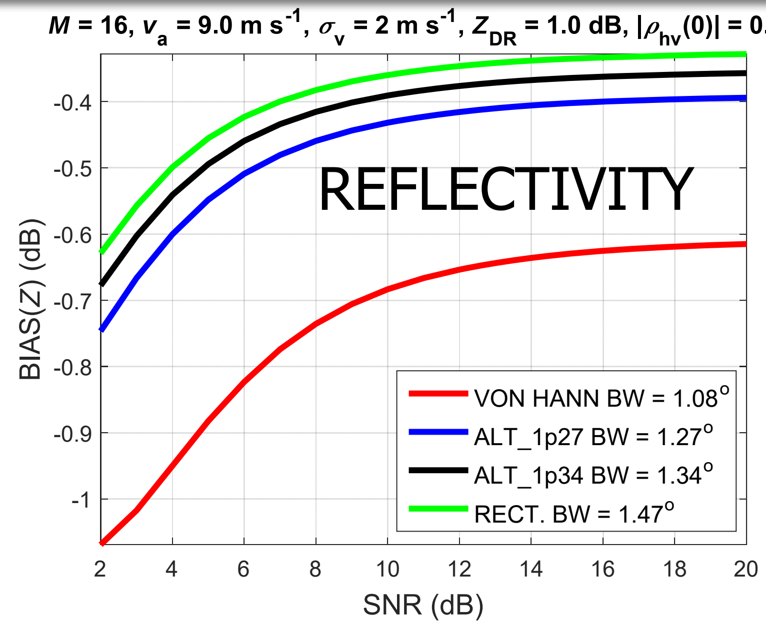
  - A = 0.75 & B = 0.25 $\Rightarrow$ effective beamwidth is 1.27°
  - A = 0.75 & B = 0.15 $\Rightarrow$ effective beamwidth is 1.34°

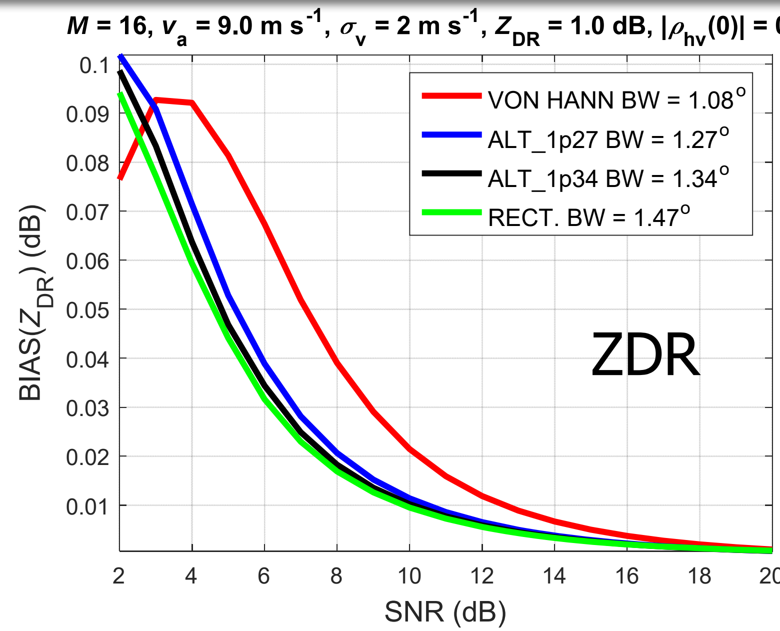
EFFECTIVE ANTENNA PATTERNS

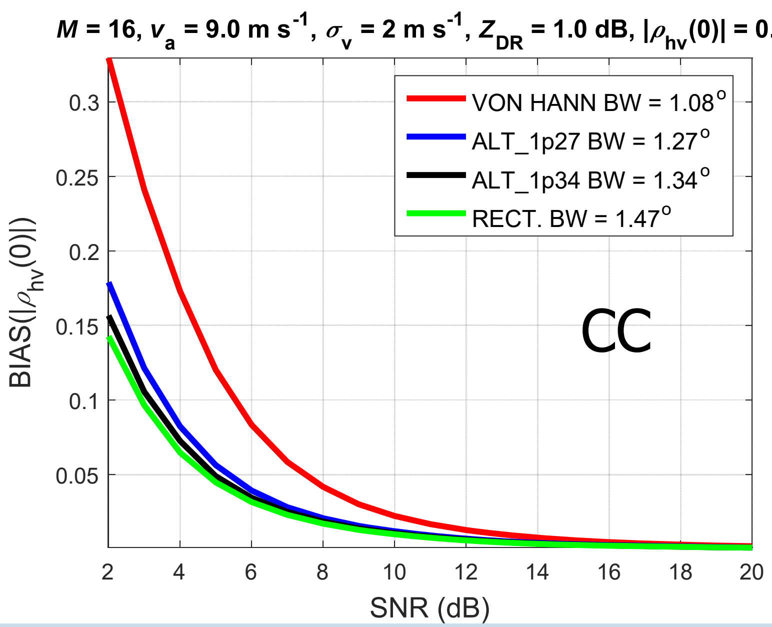
- Less tapered windows increase the width of main lobe but DO NOT INCREASE THE SIDELOBE LEVEL (i.e., no increase of contamination from targets outside the main beam)

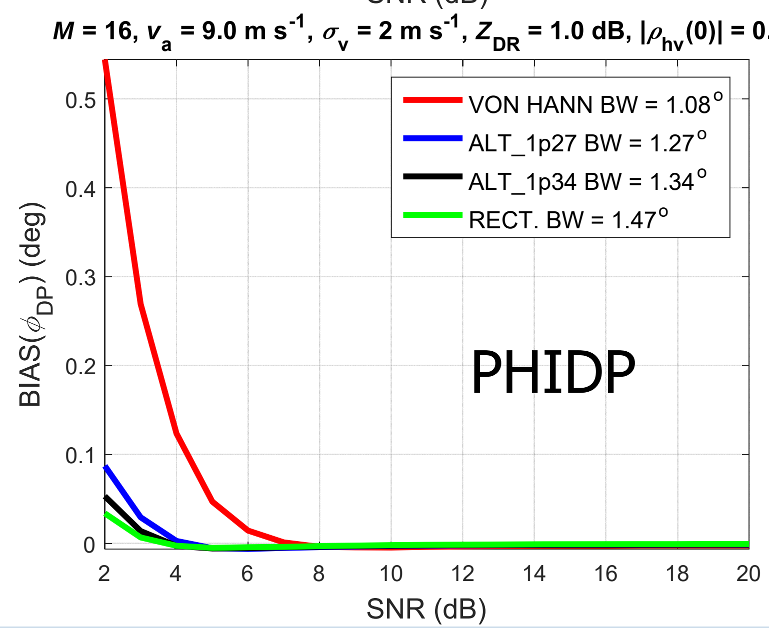


BIAS

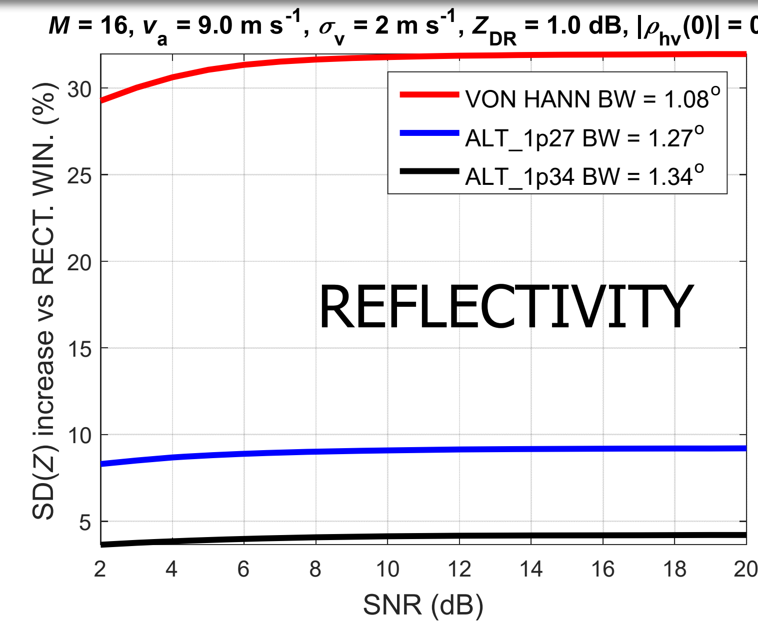

M = 16, v_a = 9.0 m s^-1, σ_v = 2 m s^-1, Z_DR = 1.0 dB, |ρ_hv(0)| = 0.99
REFLECTIVITY
BIAS(Z) (dB)
SNR (dB)
VON HANN BW = 1.08°
ALT_1p27 BW = 1.27°
ALT_1p34 BW = 1.34°
RECT. BW = 1.47°

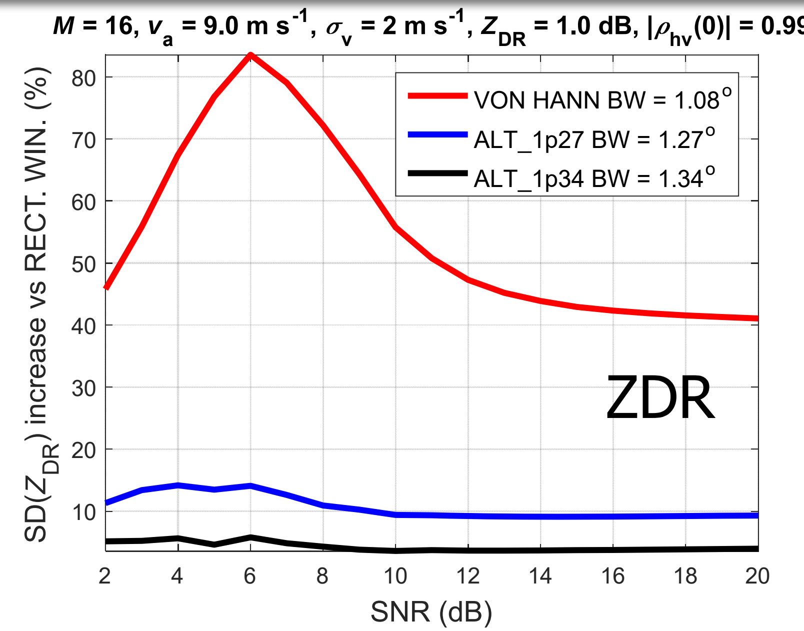

M = 16, v_a = 9.0 m s^-1, σ_v = 2 m s^-1, Z_DR = 1.0 dB, |ρ_hv(0)| = 0.99
ZDR
BIAS(Z_DR) (dB)
SNR (dB)
VON HANN BW = 1.08°
ALT_1p27 BW = 1.27°
ALT_1p34 BW = 1.34°
RECT. BW = 1.47°

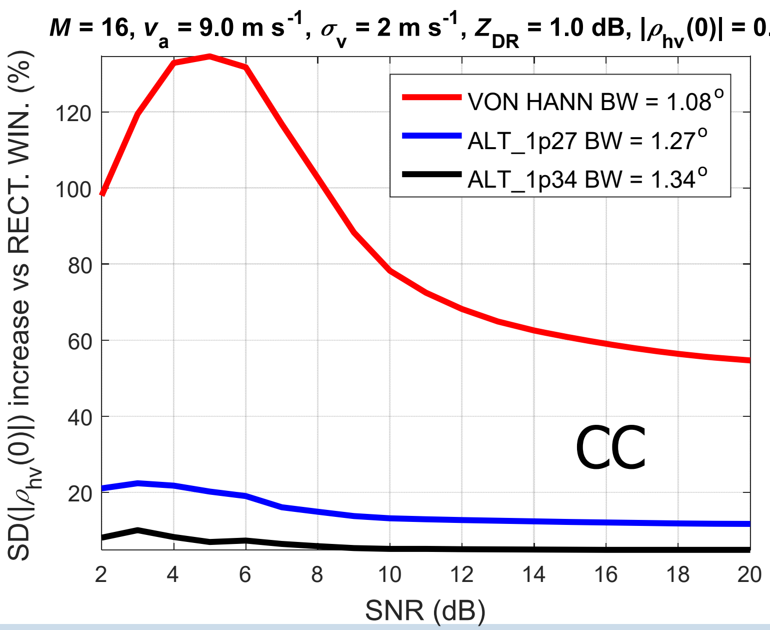

M = 16, v_a = 9.0 m s^-1, σ_v = 2 m s^-1, Z_DR = 1.0 dB, |ρ_hv(0)| = 0.99
CC
BIAS(|ρ_hv(0)|)
SNR (dB)
VON HANN BW = 1.08°
ALT_1p27 BW = 1.27°
ALT_1p34 BW = 1.34°
RECT. BW = 1.47°

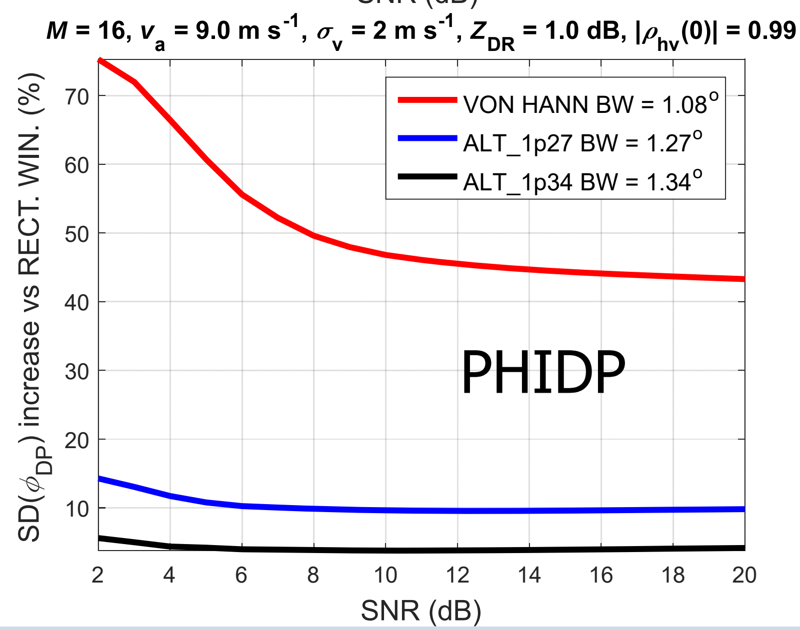

M = 16, v_a = 9.0 m s^-1, σ_v = 2 m s^-1, Z_DR = 1.0 dB, |ρ_hv(0)| = 0.99
PHIDP
BIAS(φ_DP) (deg)
SNR (dB)
VON HANN BW = 1.08°
ALT_1p27 BW = 1.27°
ALT_1p34 BW = 1.34°
RECT. BW = 1.47°

STANDARD DEVIATION





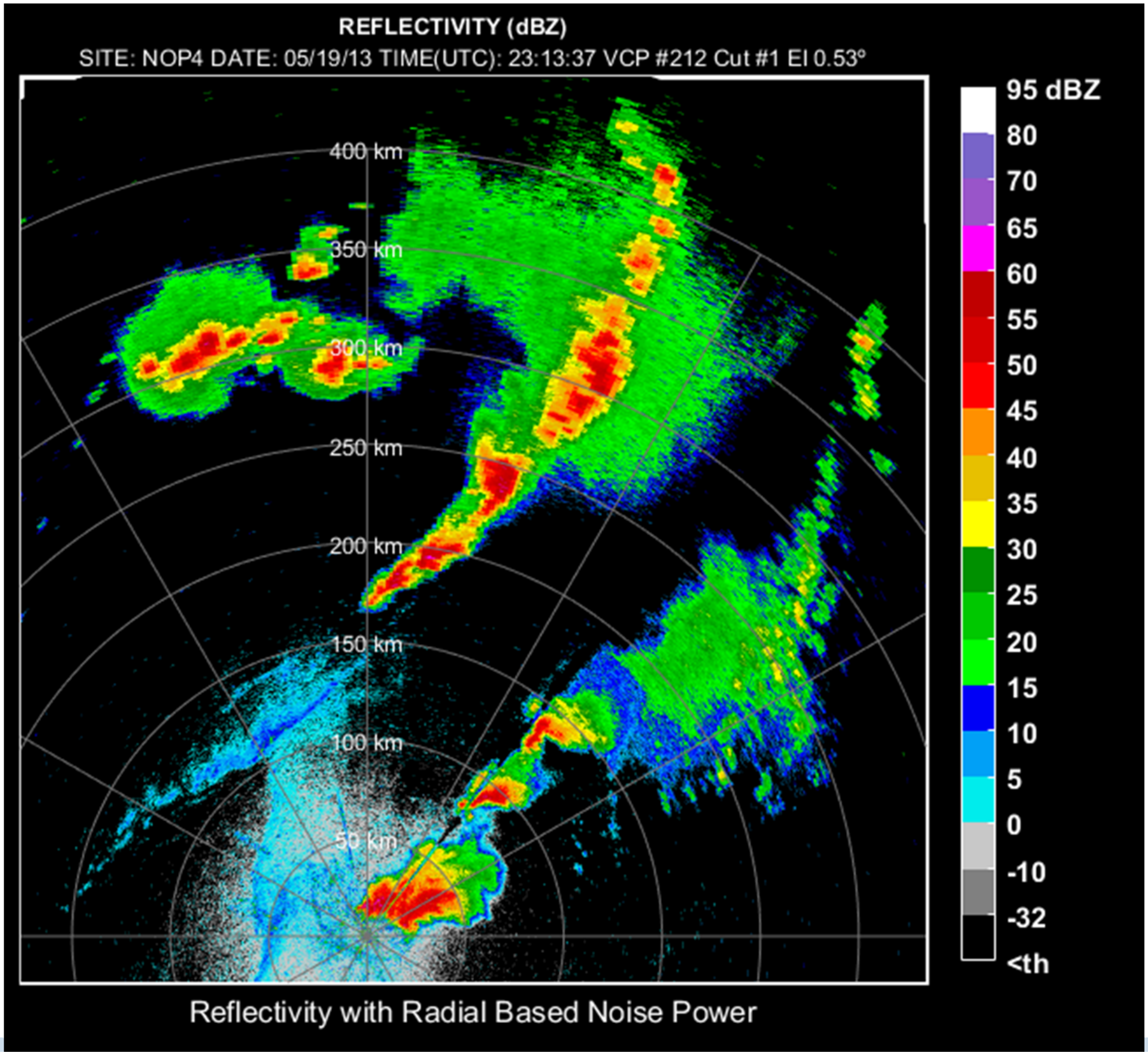




PERFORMANCE vs. DATA WIN.

VCP 212
El. 0.53°
M = 16
r_a = 470 km
v_a = 8 m s^{-1}
VON HANN WIN.
EFF. BW = 1.08°

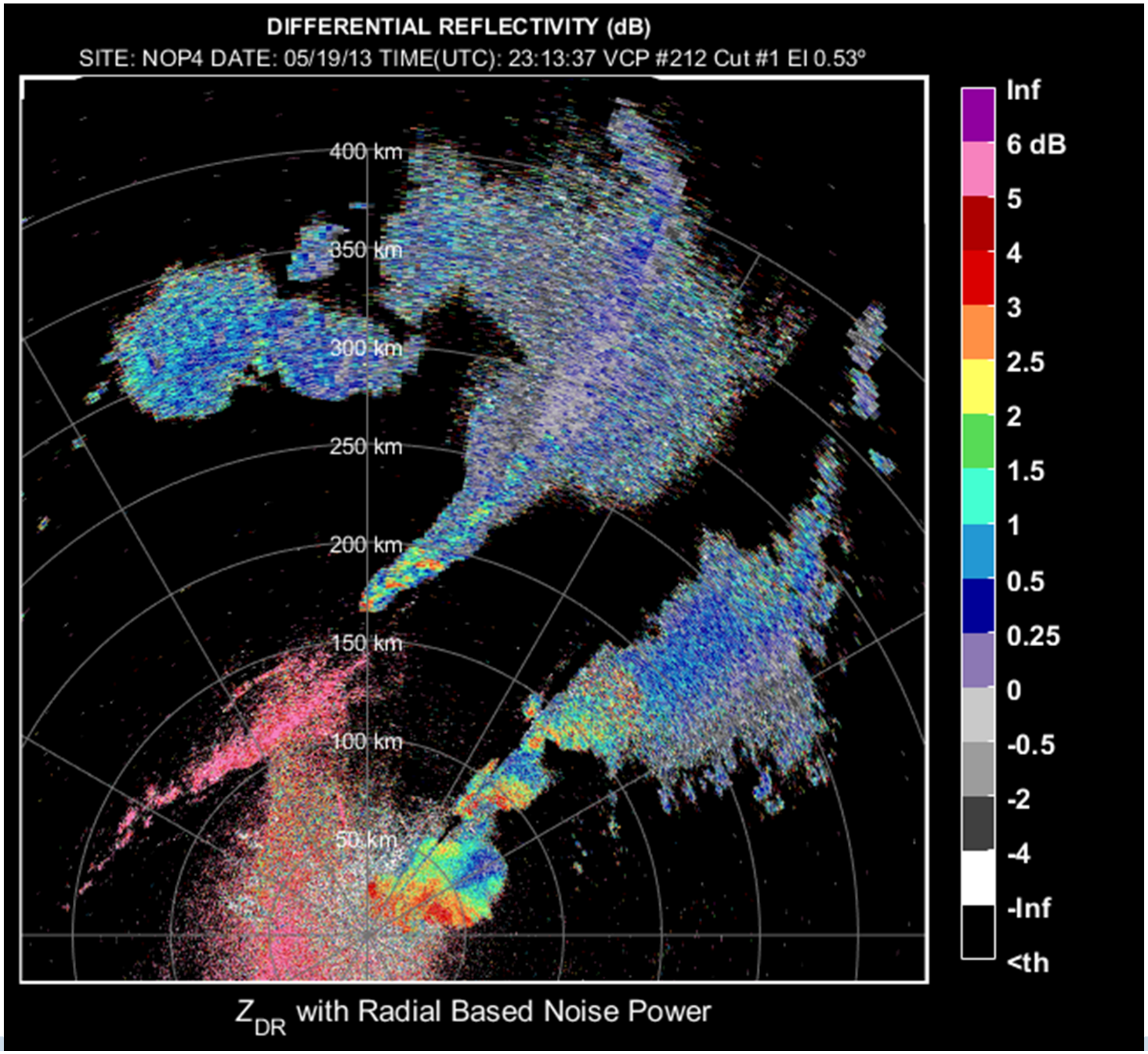
Super-Res Reflectivity



PERFORMANCE vs. DATA WIN.

VCP 212
El. 0.53°
$M = 16$
$r_a = 470$ km
$v_a = 8$ m s^{-1}
VON HANN WIN.
EFF. BW = 1.08°

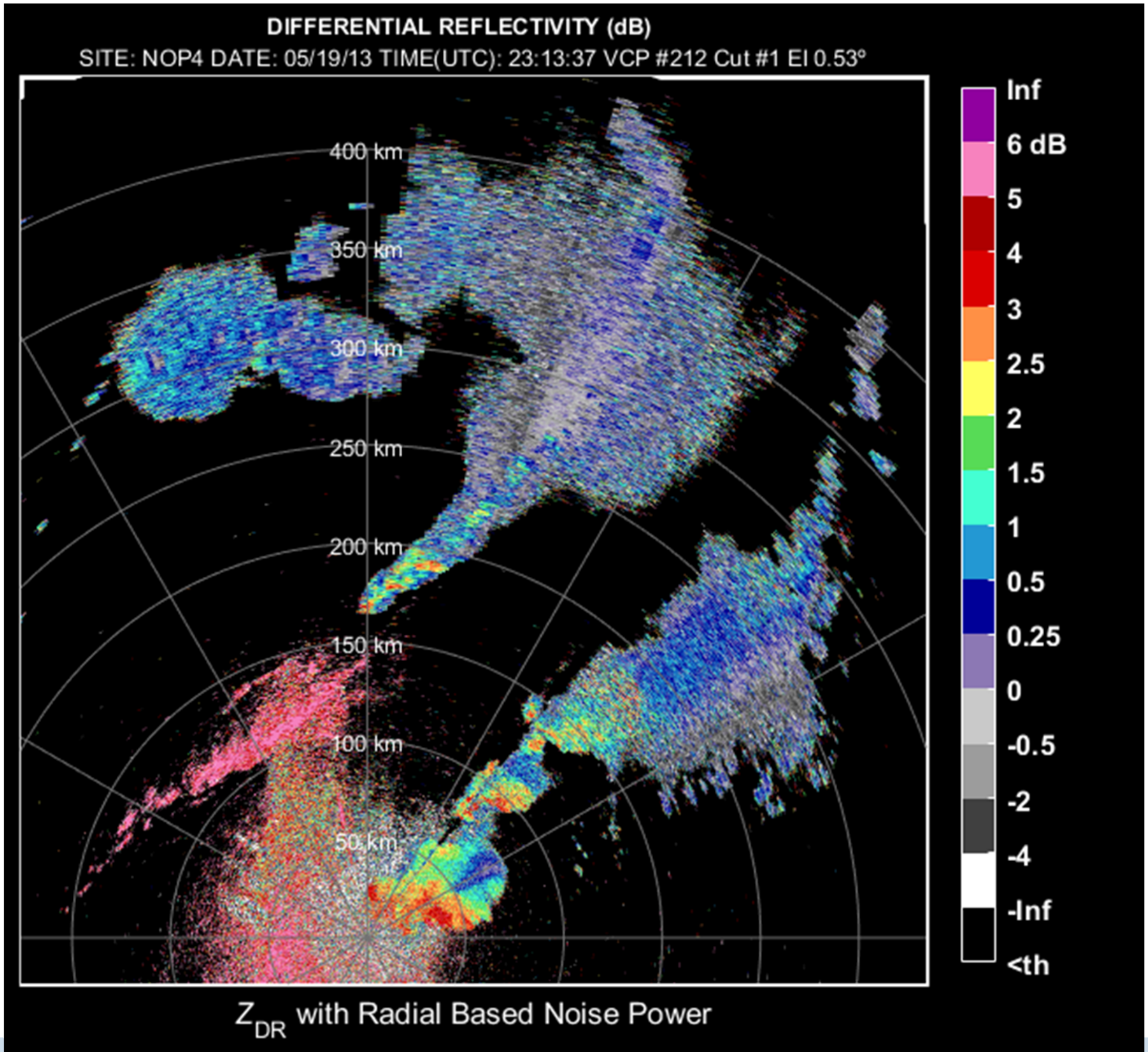
Super-Res ZDR



PERFORMANCE vs. DATA WIN.

VCP 212
El. 0.53°
$M = 16$
$r_a = 470$ km
$v_a = 8$ m s^{-1}
ALT_1p27 WIN.
EFF. BW = 1.27°

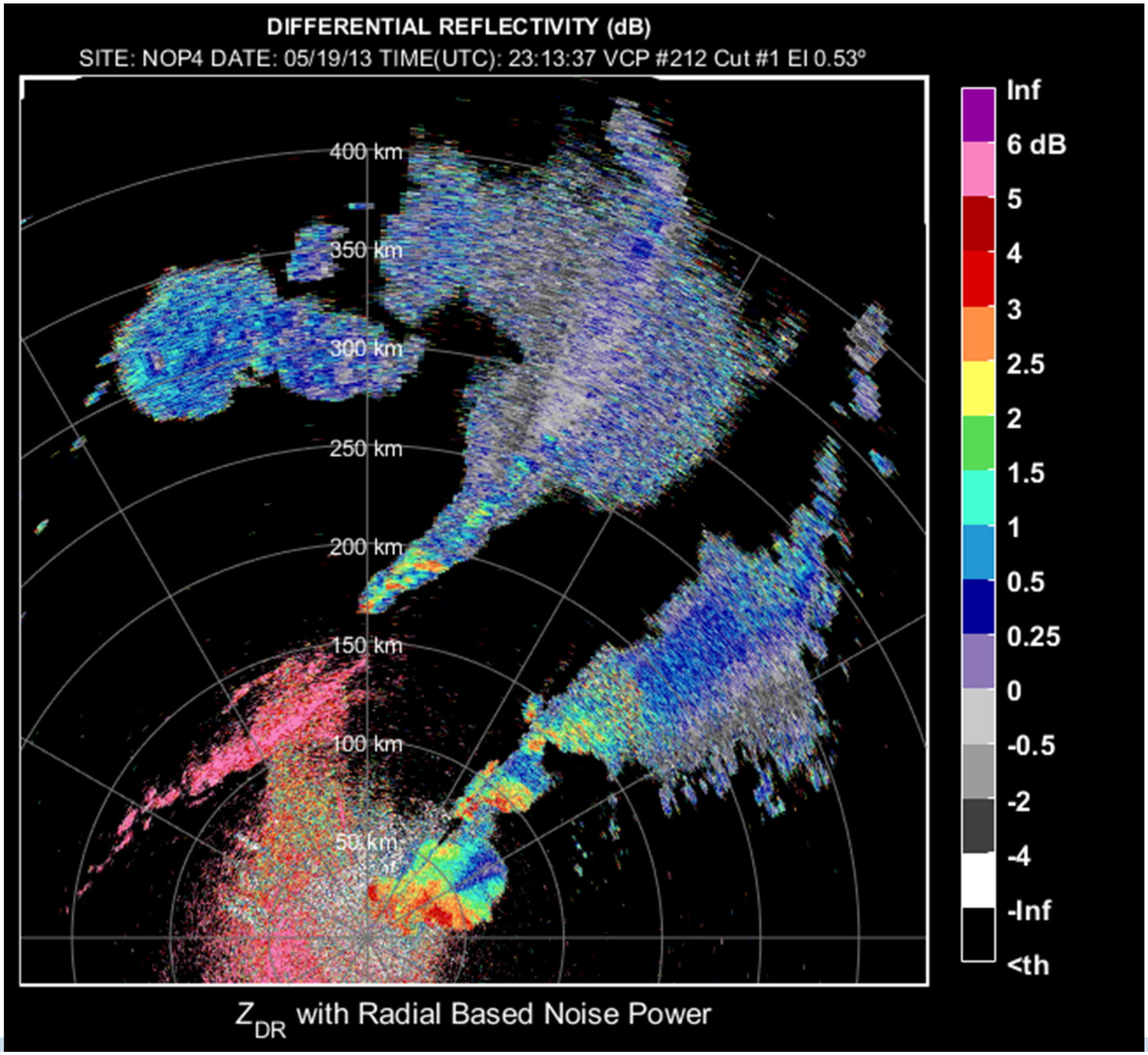
Super-Res ZDR



PERFORMANCE vs. DATA WIN.

VCP 212
El. 0.53°
$M = 16$
r_a = 470 km
$v_a = 8\ m\ s^{-1}$
RECT. WIN.
EFF. BW = 1.47°

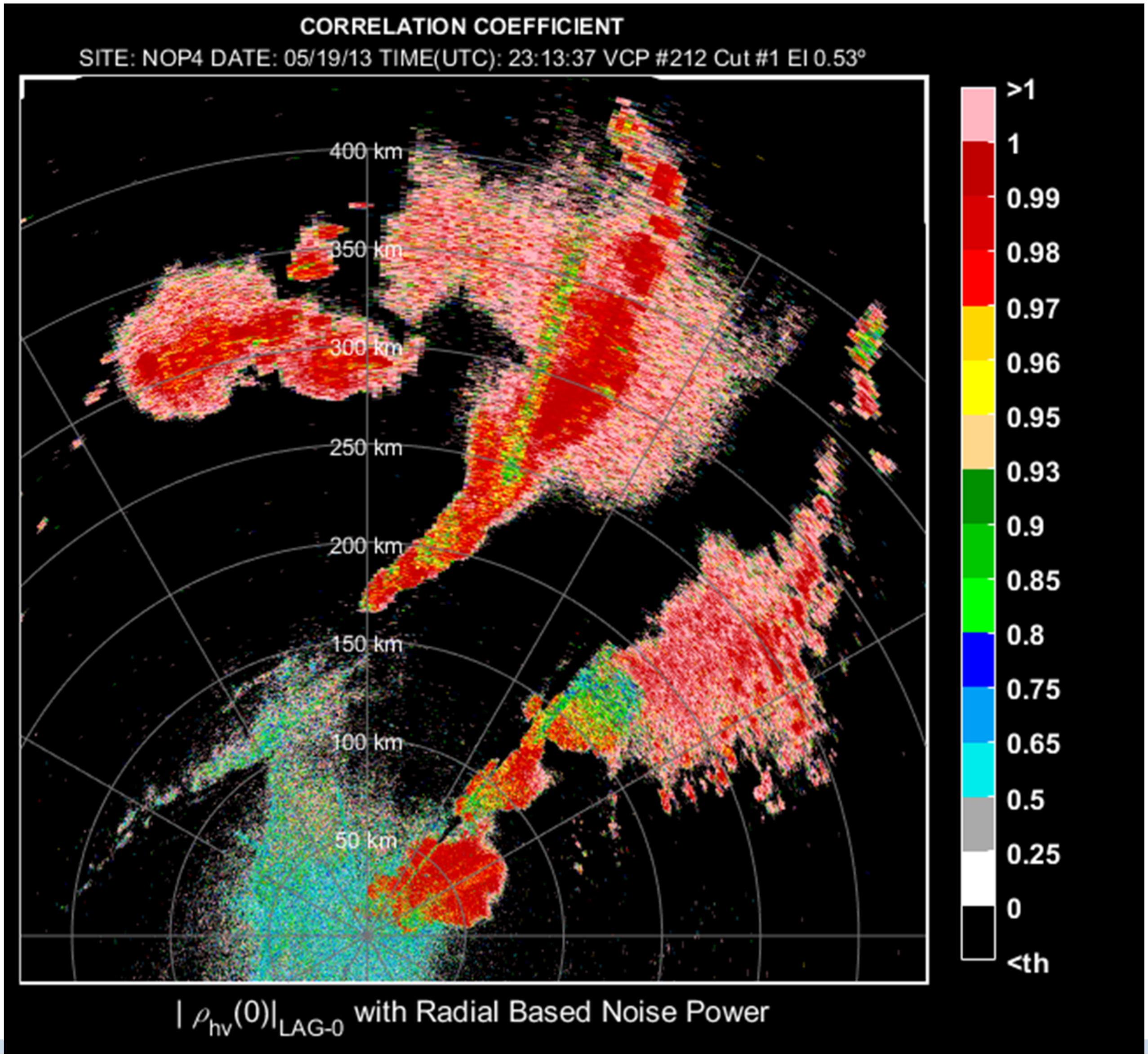
Super-Res ZDR



PERFORMANCE vs. DATA WIN.

VCP 212
El. 0.53°
$\boldsymbol{M = 16}$
$\boldsymbol{r_a = 470}$ **km**
$\boldsymbol{v_a = 8}$ **m s^{-1}**
VON HANN WIN.
EFF. BW = 1.08°

Super-Res Legacy Correlation Coefficient



PERFORMANCE vs. DATA WIN.

VCP 212
El. 0.53°
M = 16
r_a = 470 km
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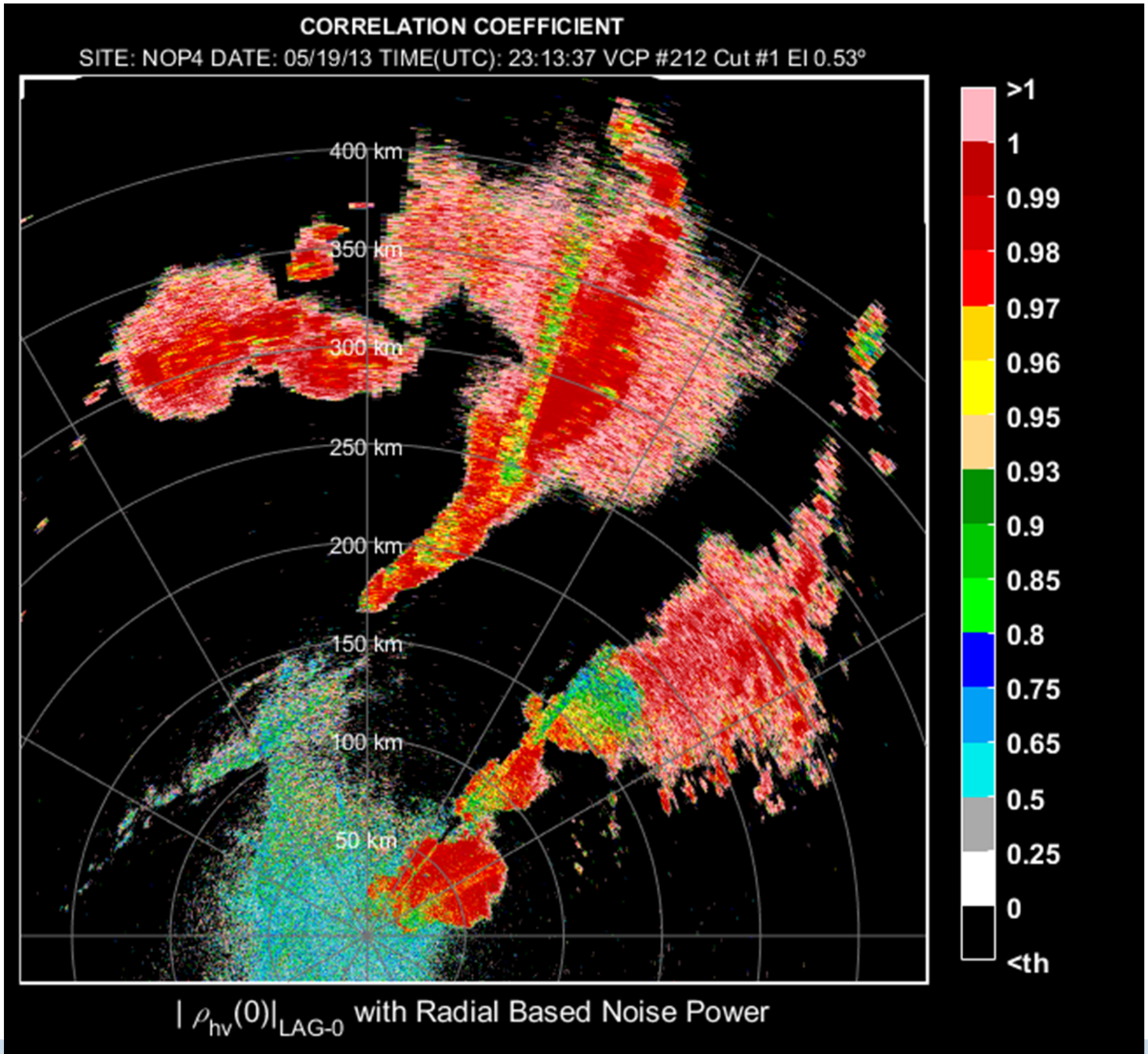
ALT_1p27 WIN.
EFF. BW = 1.27°

Super-Res Legacy Correlation Coefficient



PERFORMANCE vs. DATA WIN.

VCP 212
El. 0.53°
***M* = 16**
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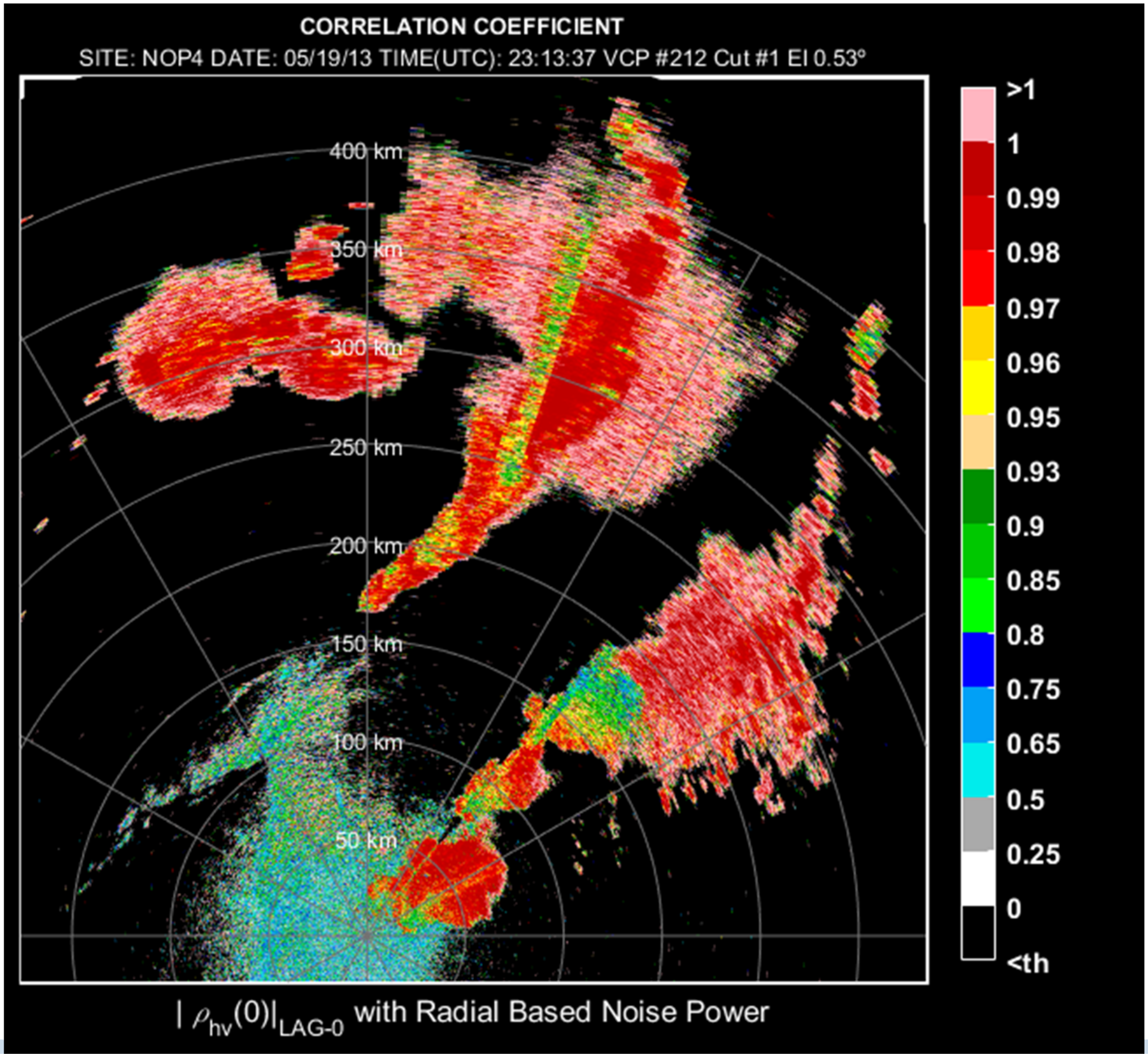
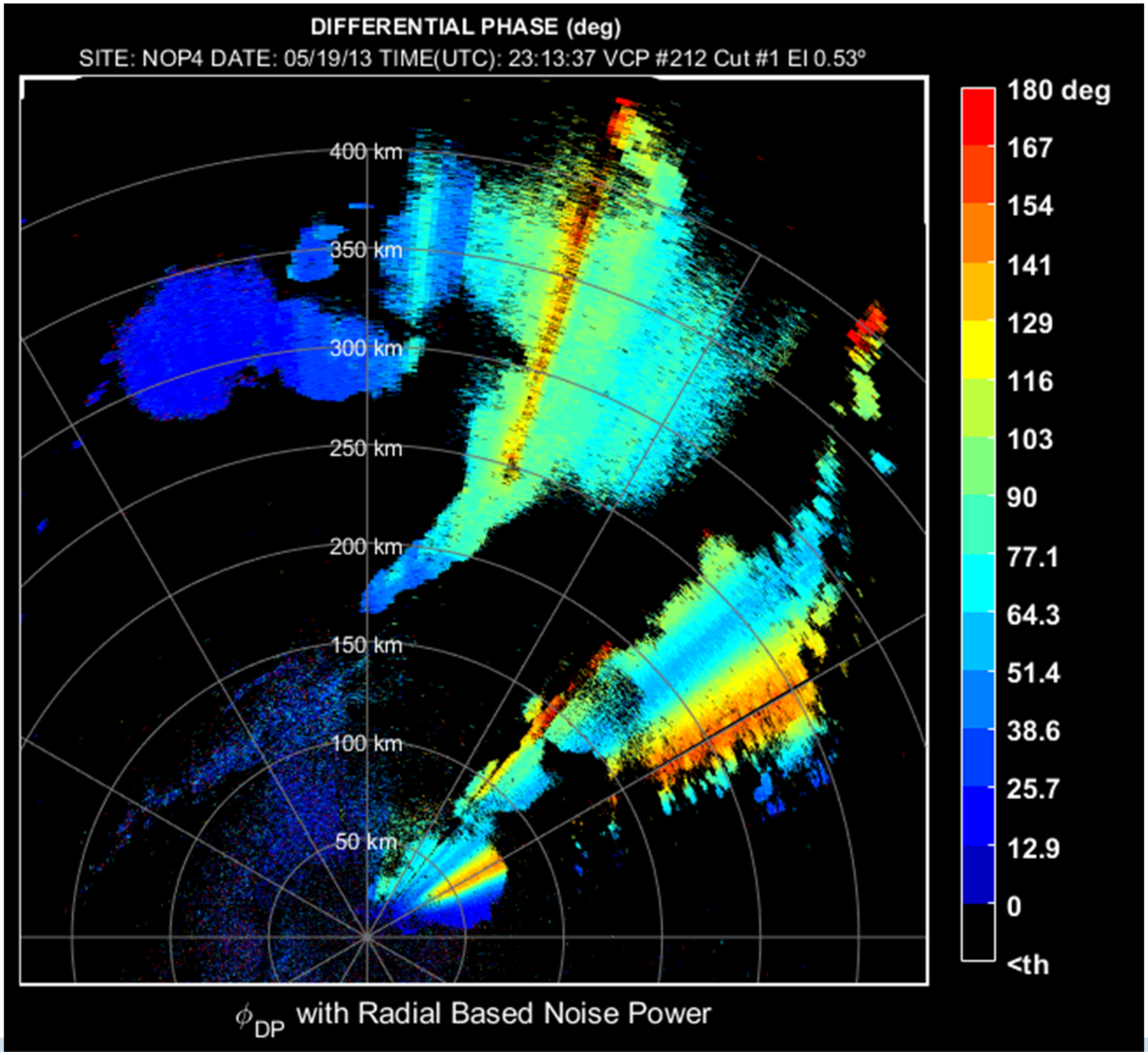
v_a = 8 m s^{-1}
RECT. WIN.
EFF. BW = 1.47°

Super-Res Legacy Correlation Coefficient



PERFORMANCE vs. DATA WIN.

Super-Res Differential Phase



VCP 212
El. 0.53°
***M* = 16**
r_a = 470 km
v_a = 8 m s^{-1}
VON HANN WIN.
EFF. BW = 1.08°

PERFORMANCE vs. DATA WIN.

VCP 212
El. 0.53°
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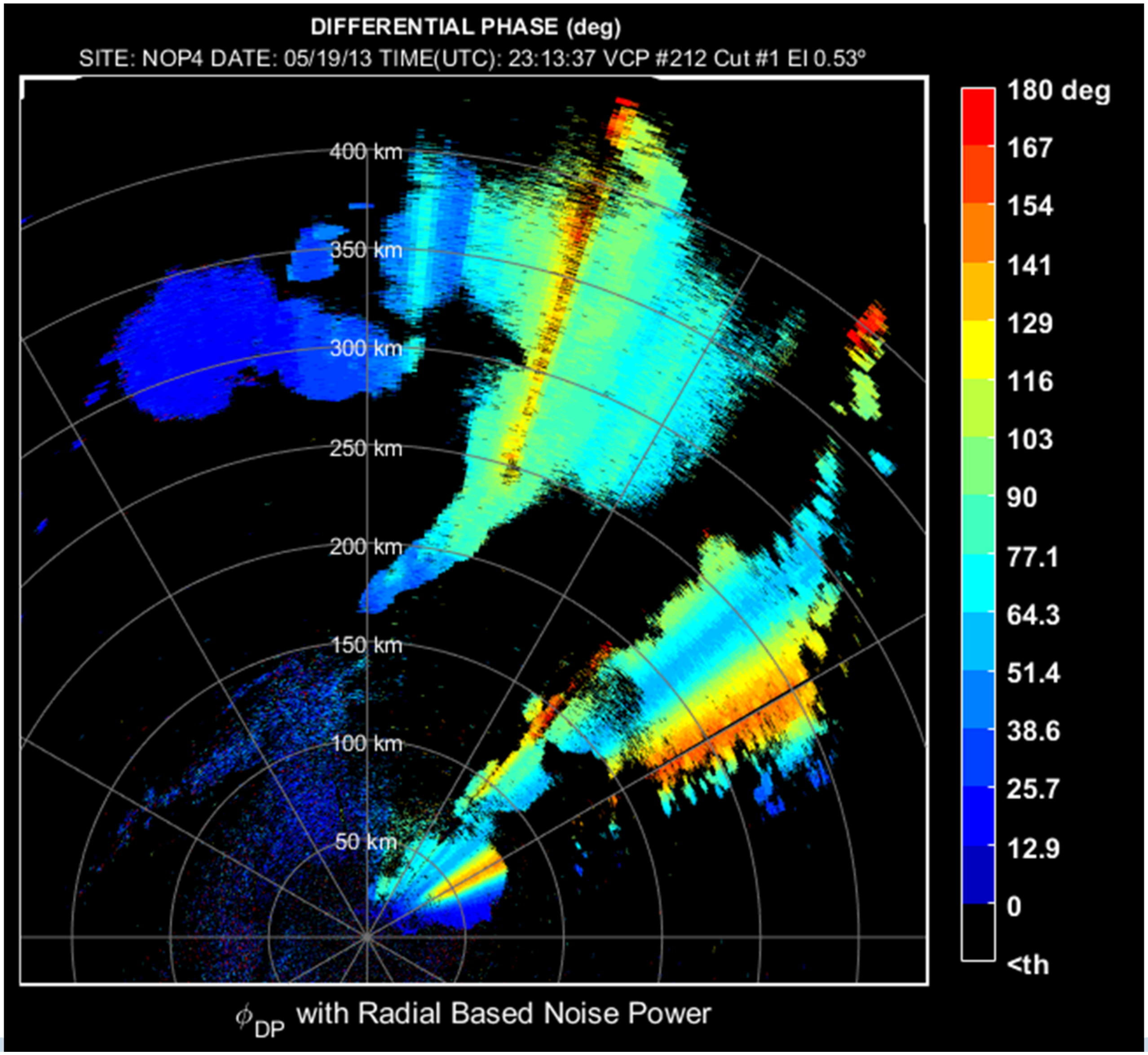
r_a = 470 km
v_a = 8 m s^{-1}
ALT_1p27 WIN.
EFF. BW = 1.27°

Super-Res Differential Phase



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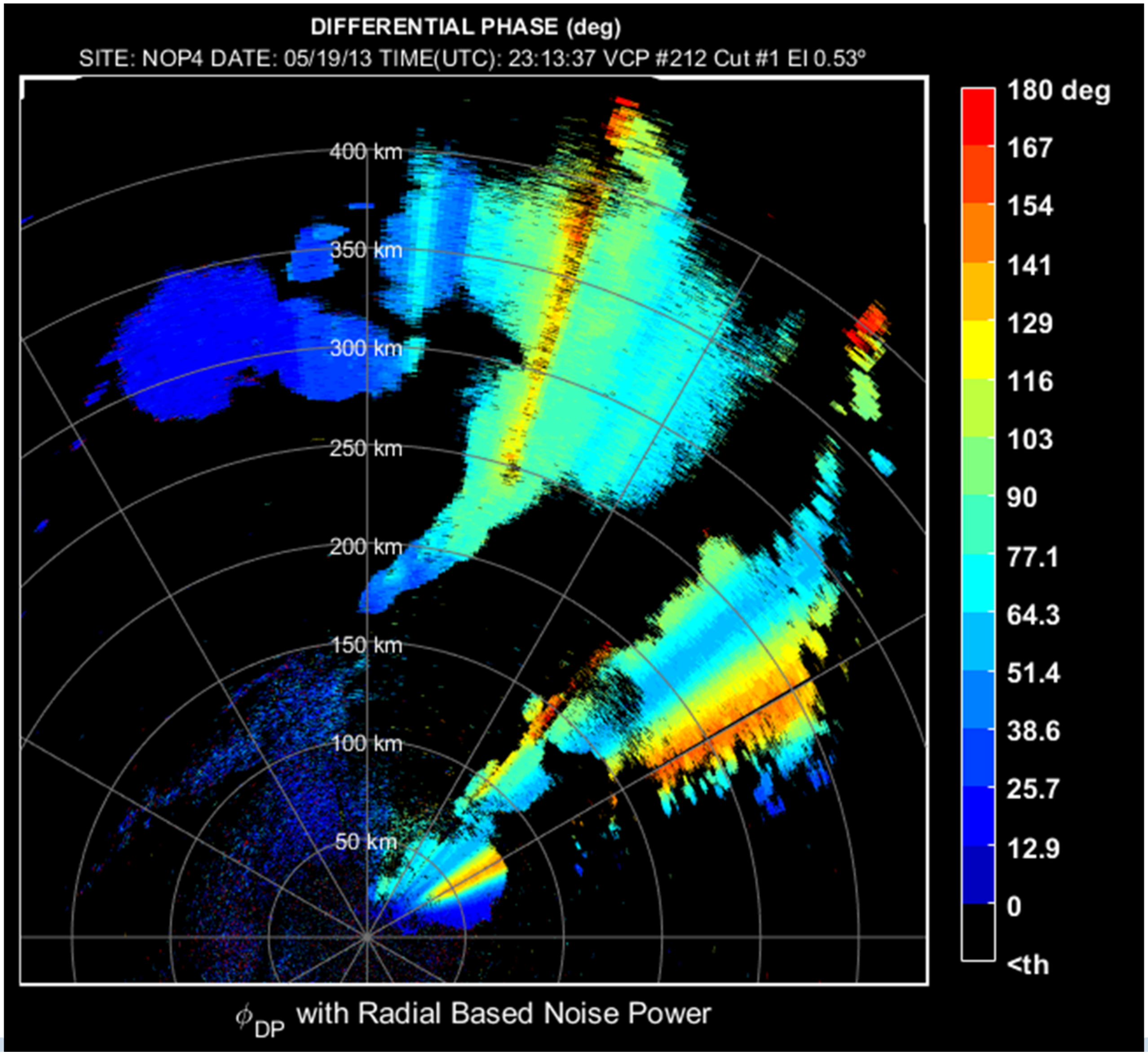
Super-Res Differential Phase



PERFORMANCE vs. DATA WIN.

VCP 212
El. 0.53°
***M* = 16**
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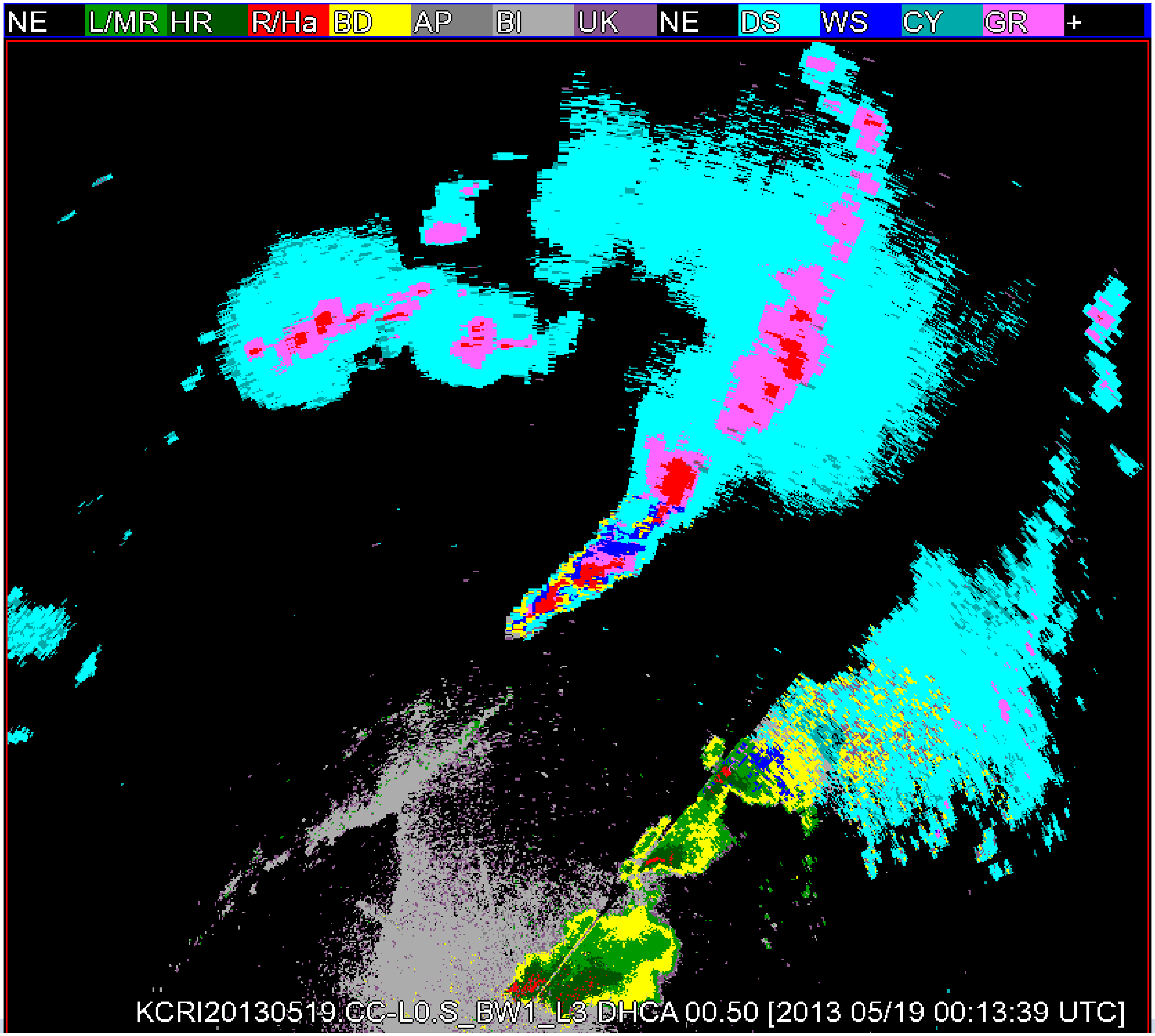
v_a = 8 m s^{-1}
VON HANN WIN.
EFF. BW = 1.08°

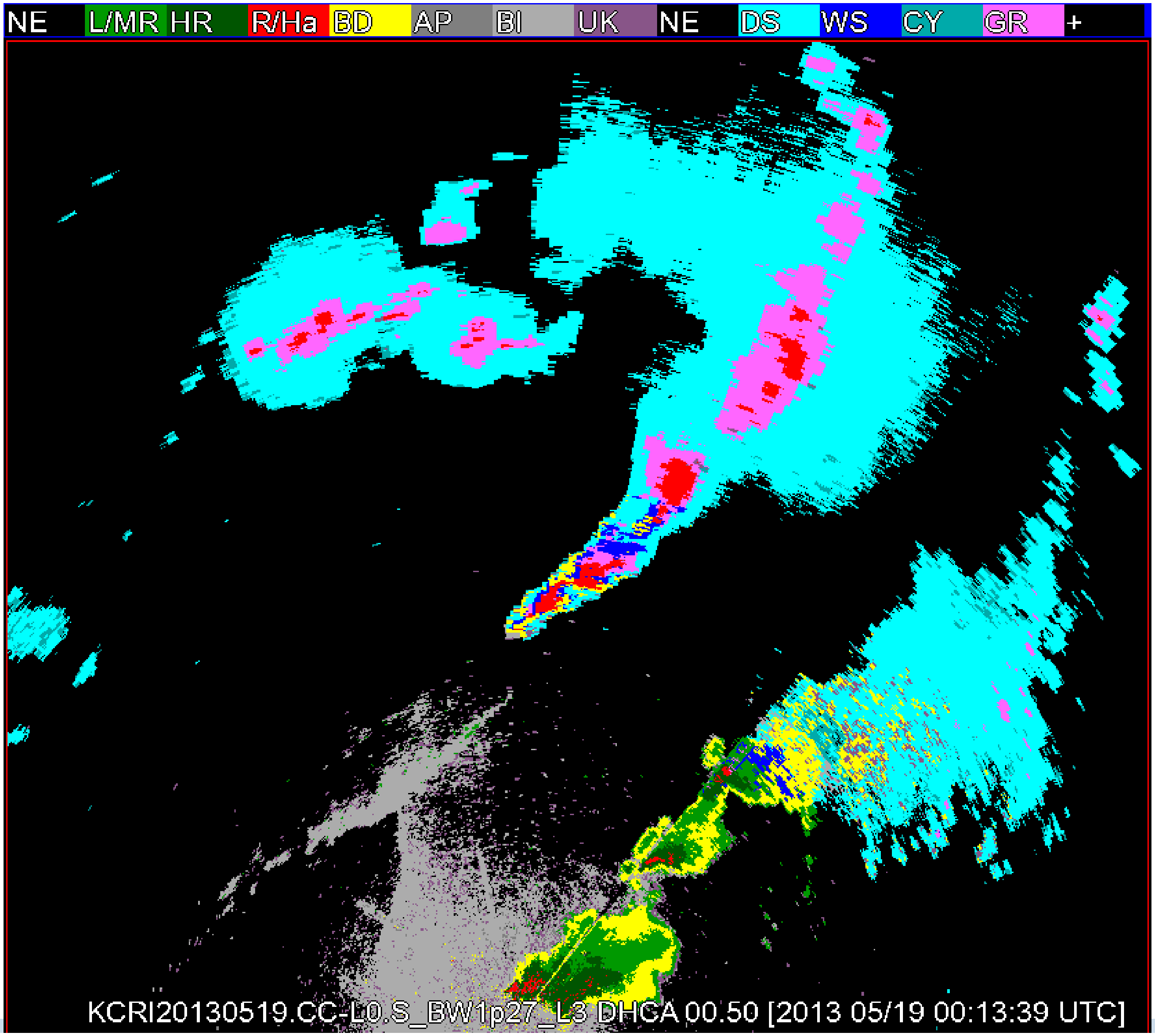
Super-Res HCA



PERFORMANCE vs. DATA WIN.

VCP 212
El. 0.53°
$M = 16$
r_a = 470 km
v_a = 8 m s^{-1}
ALT_1p27 WIN.
EFF. BW = 1.27°

Super-Res HCA



PERFORMANCE vs. DATA WIN.

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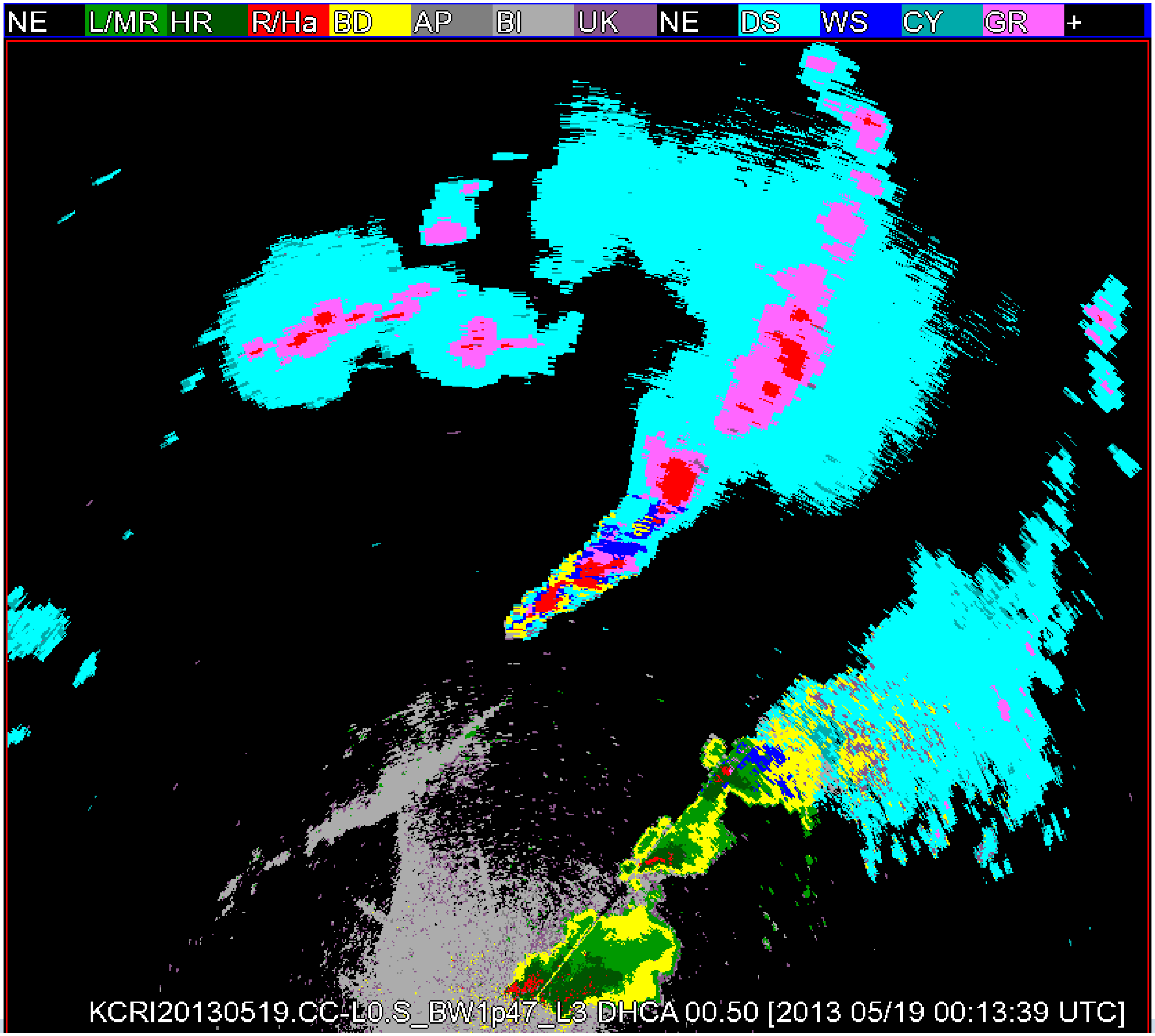
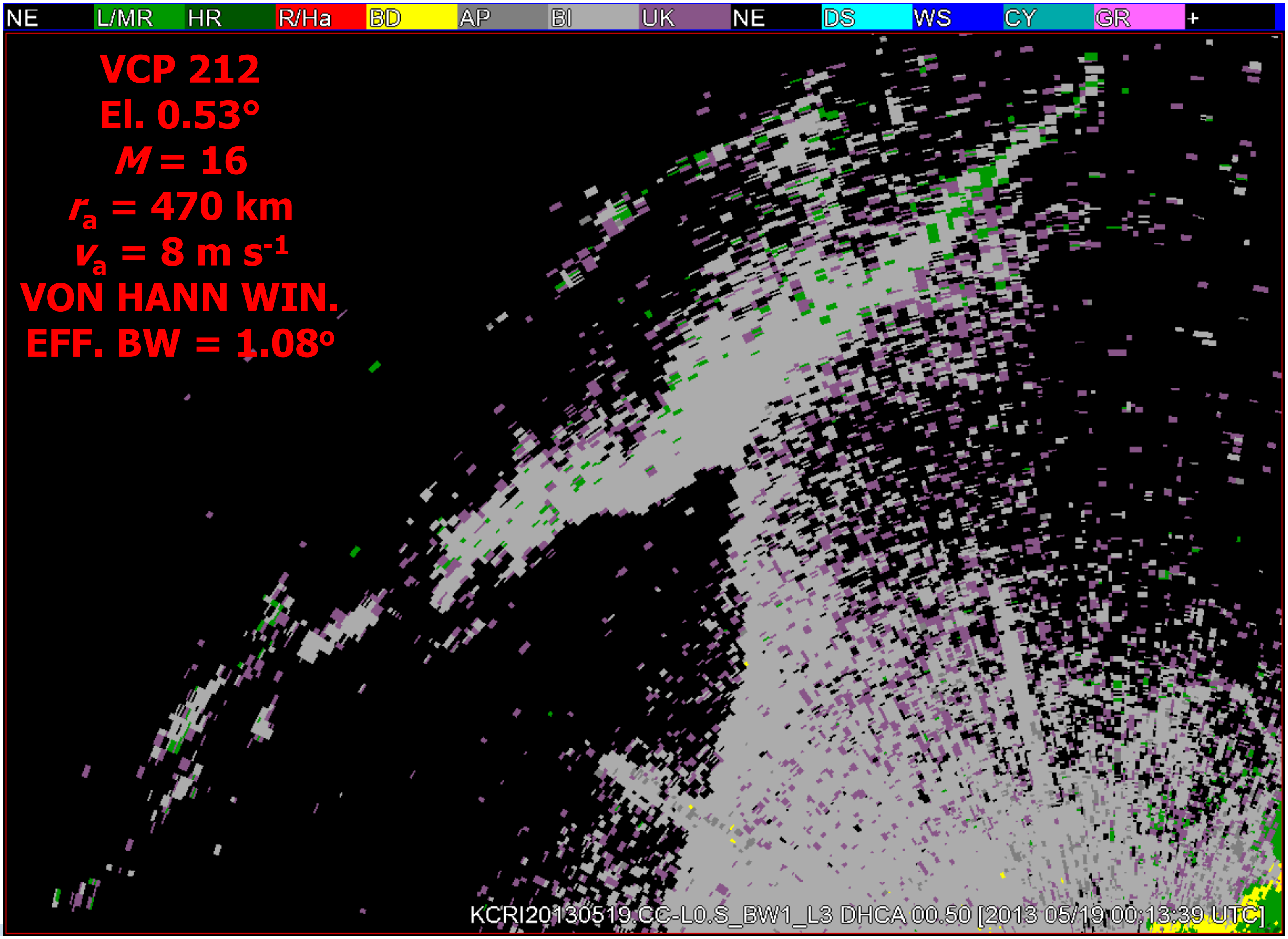
r_a = 470 km
v_a = 8 m s^{-1}
RECT. WIN.
EFF. BW = 1.47°

Super-Res HCA



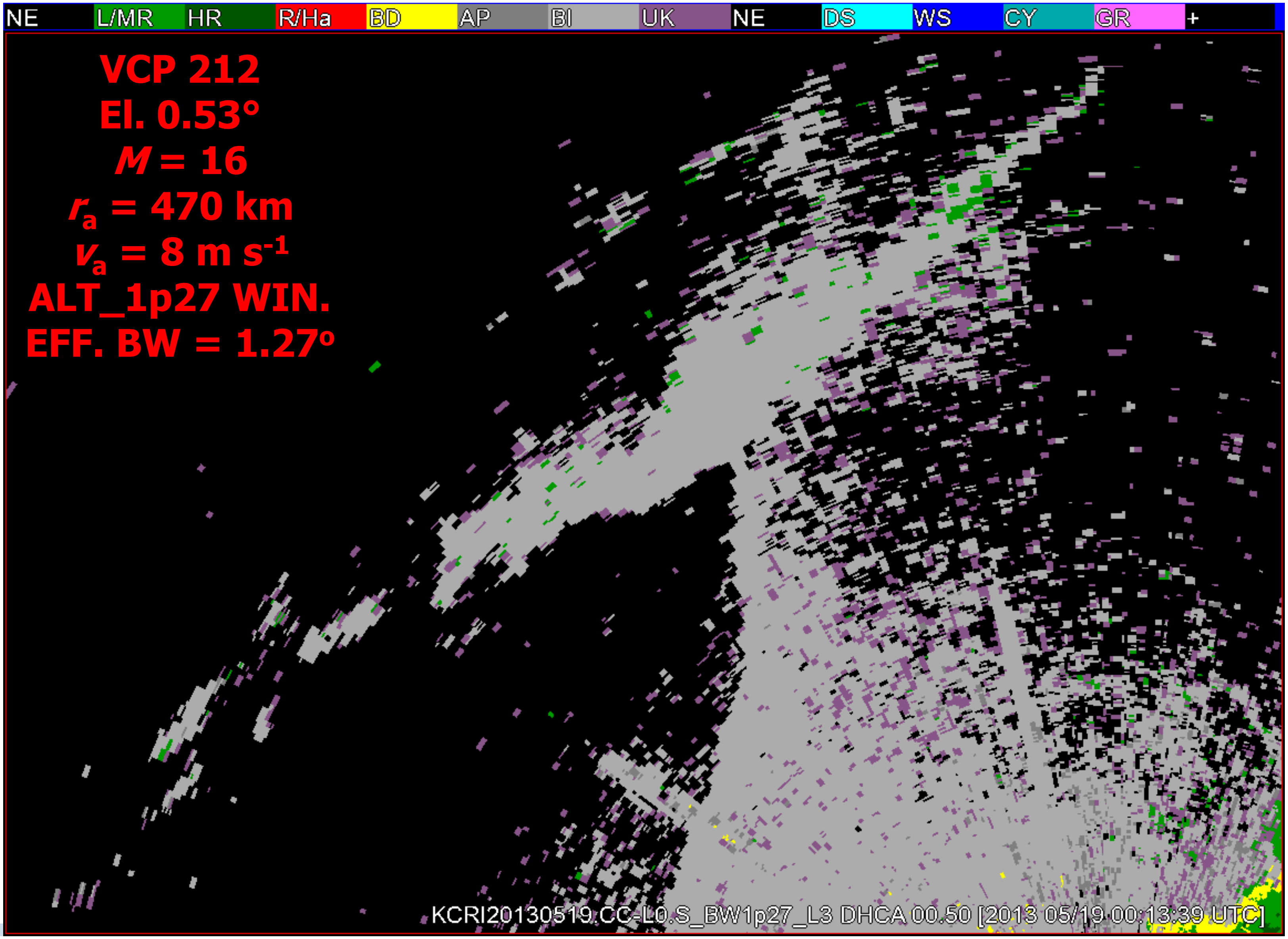
PERFORMANCE vs. DATA WIN.

Super-Res HCA



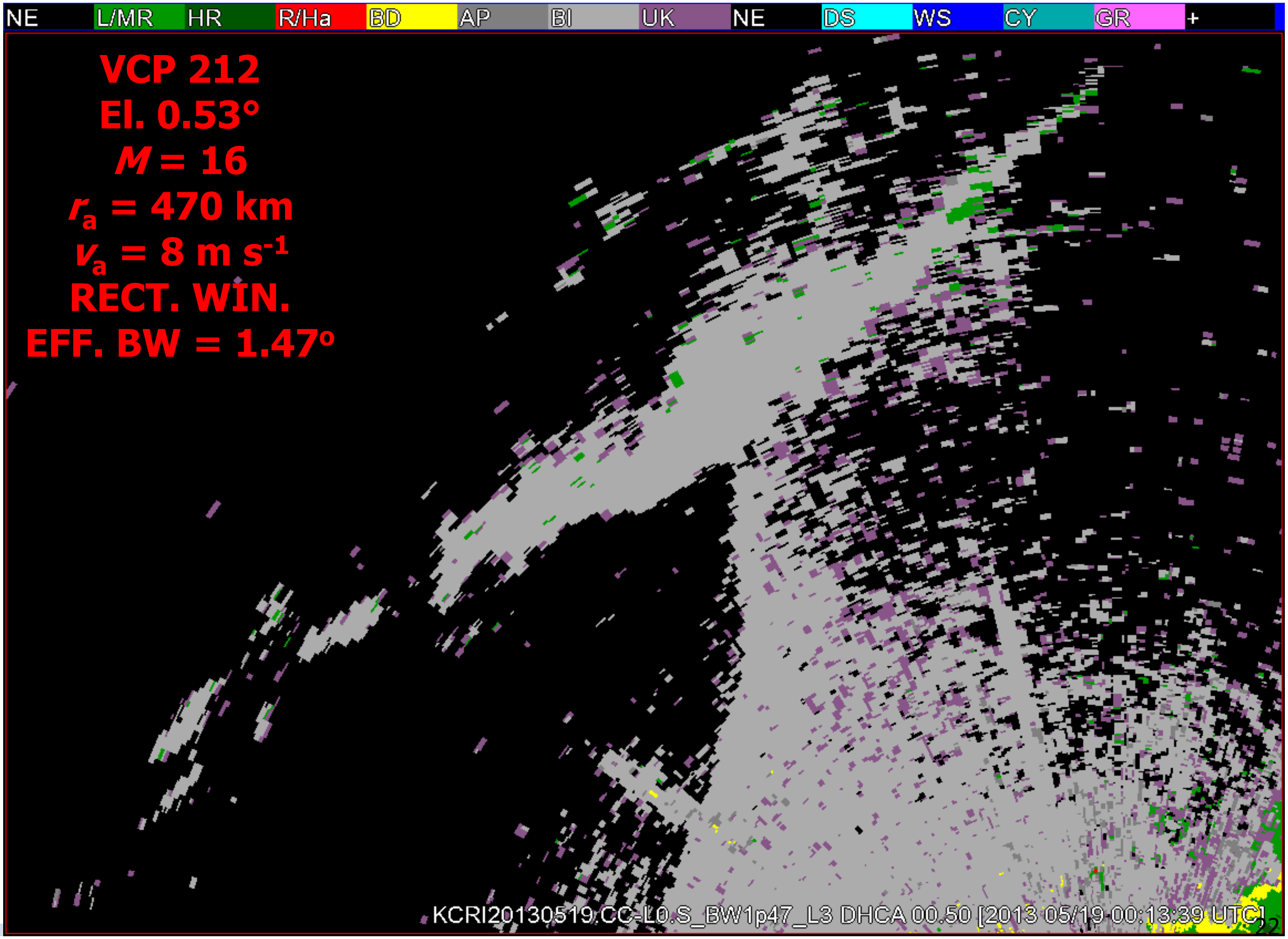
PERFORMANCE vs. DATA WIN.

Super-Res HCA



PERFORMANCE vs. DATA WIN.

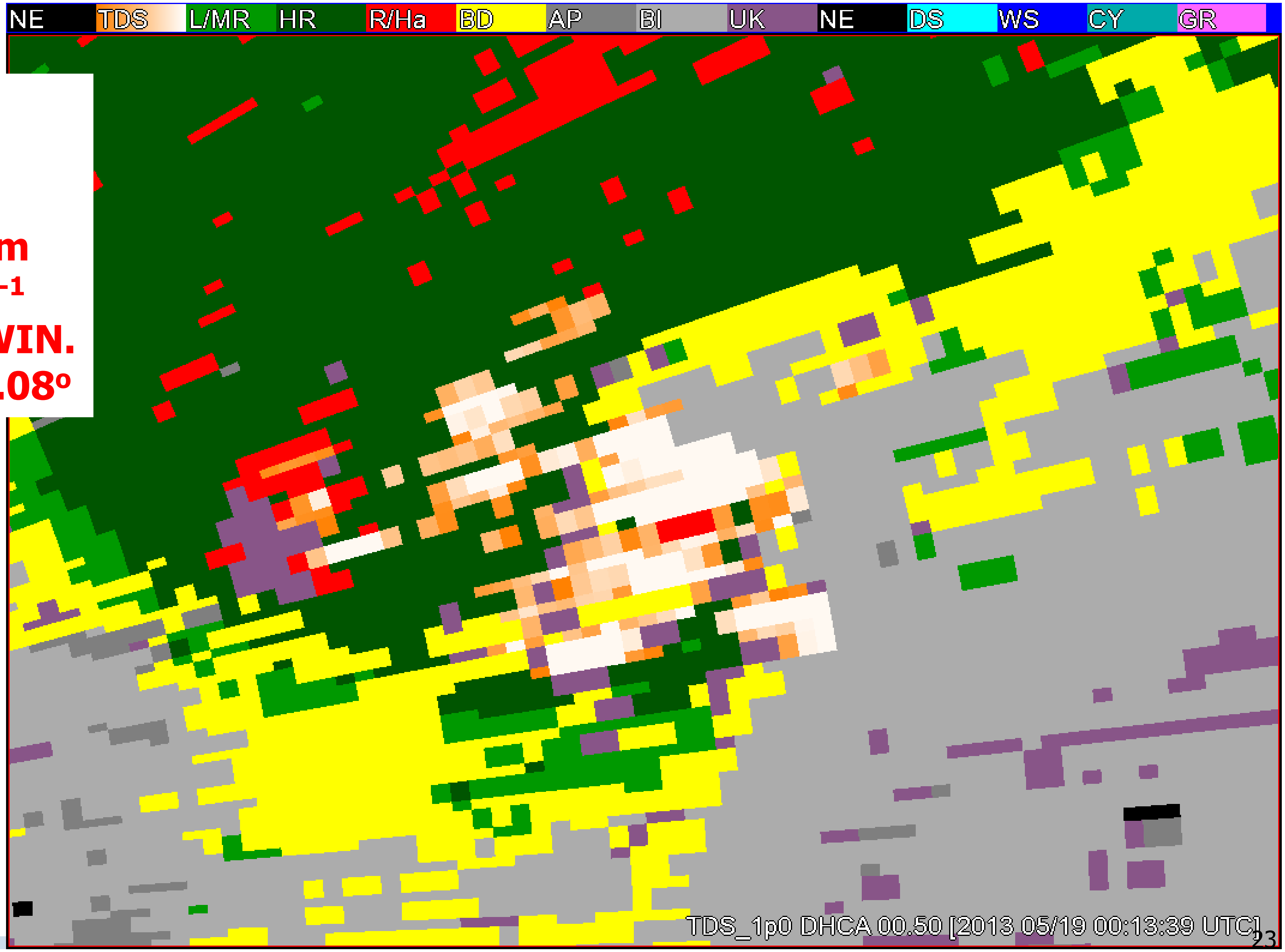
Super-Res HCA



PERFORMANCE vs. DATA WIN.

Super-Res HCA

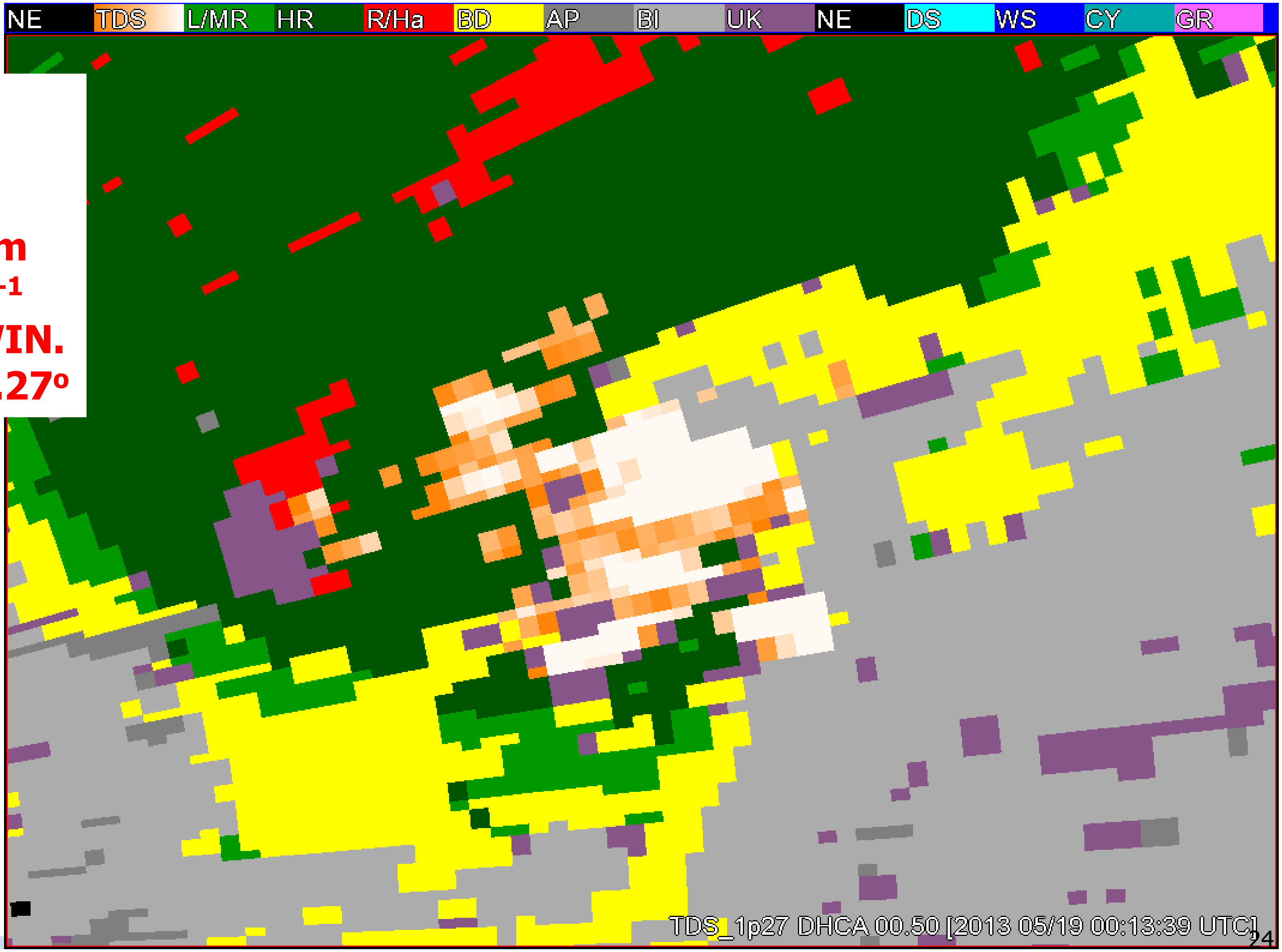
VCP 212
El. 0.53°
***M* = 16**
r_a = 470 km
v_a = 8 m s^{-1}
VON HANN WIN.
EFF. BW = 1.08º



PERFORMANCE vs. DATA WIN.

VCP 212
El. 0.53°
***M* = 16**
r_a = 470 km
v_a = 8 m s^{-1}
ALT_1p27 WIN.
EFF. BW = 1.27°

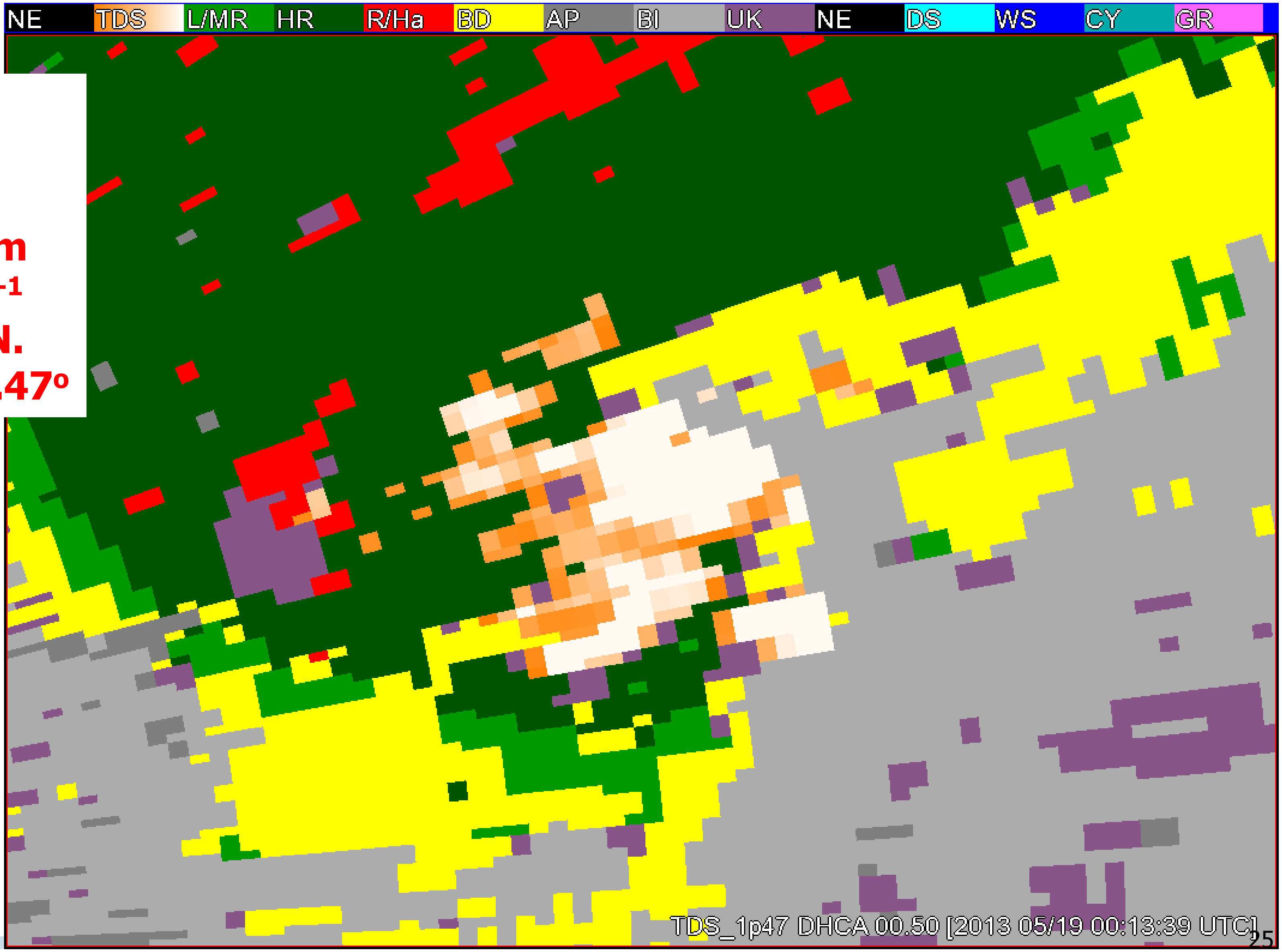
Super-Res HCA



PERFORMANCE vs. DATA WIN.

VCP 212
El. 0.53°
***M* = 16**
r_a = 470 km
v_a = 8 m s^{-1}
RECT. WIN.
EFF. BW = 1.47°

Super-Res HCA



SUMMARY

- As SNR decreases standard deviation of polarimetric variables increases more than in the case of the spectral moments
  - Application of von Hann window in super-res mode exacerbates this effect.
- Replacement of von Hann with the less tapered window has been proposed to mitigate this effect
  - Less tapered window means less noisy data but larger effective BW.
  - But decrease of DP variable azimuthal resolution is not likely to have adverse effects.
  - May improve the function of the hydrometeor classification algorithms (HCA).

SUMMARY contd. …

- Von Hann window can be replaced with
  - rectangular window
    - Effective beamwidth increases from about 1.08° to 1.47°.
  - other less tapered window
    - Effective beamwidth can be controlled (e.g., 1.27° or 1.34° in the cases shown).
- Alternatively effective beamwidth can be varied based …
  - E.g., apply win… NR > 15 dB and rectangula…

ACKNOWLEDGMENTS
John Krause
Jeff Brogden
Eddie Forren
Jeff Snyder