Improving Fields Of Radar Variable Estimates at Low-to-moderate SNRs

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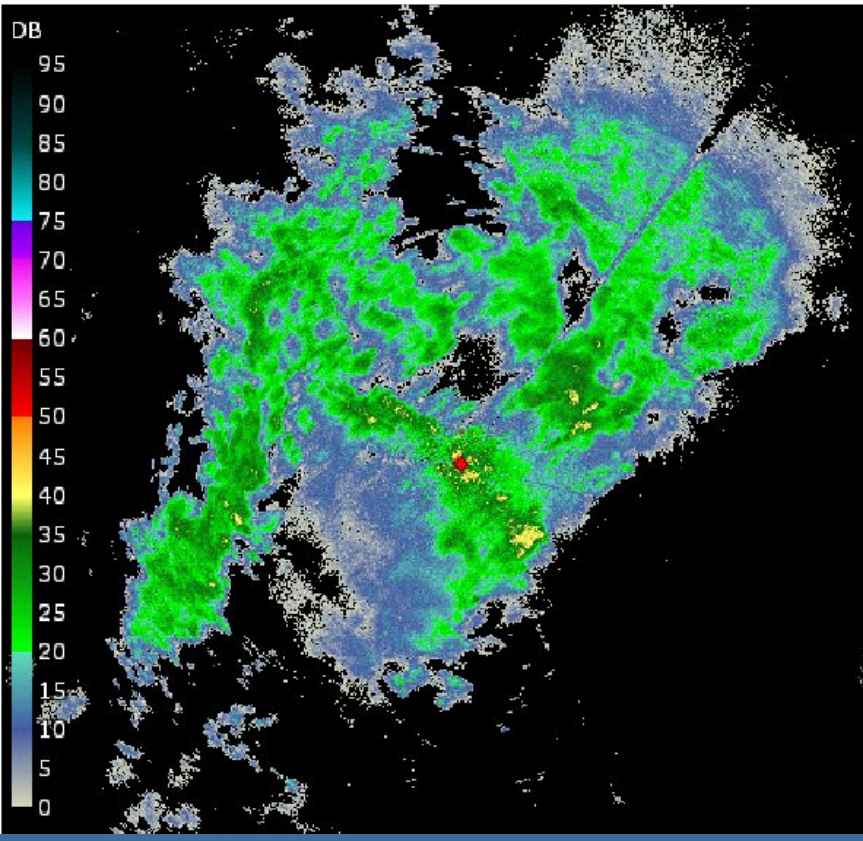
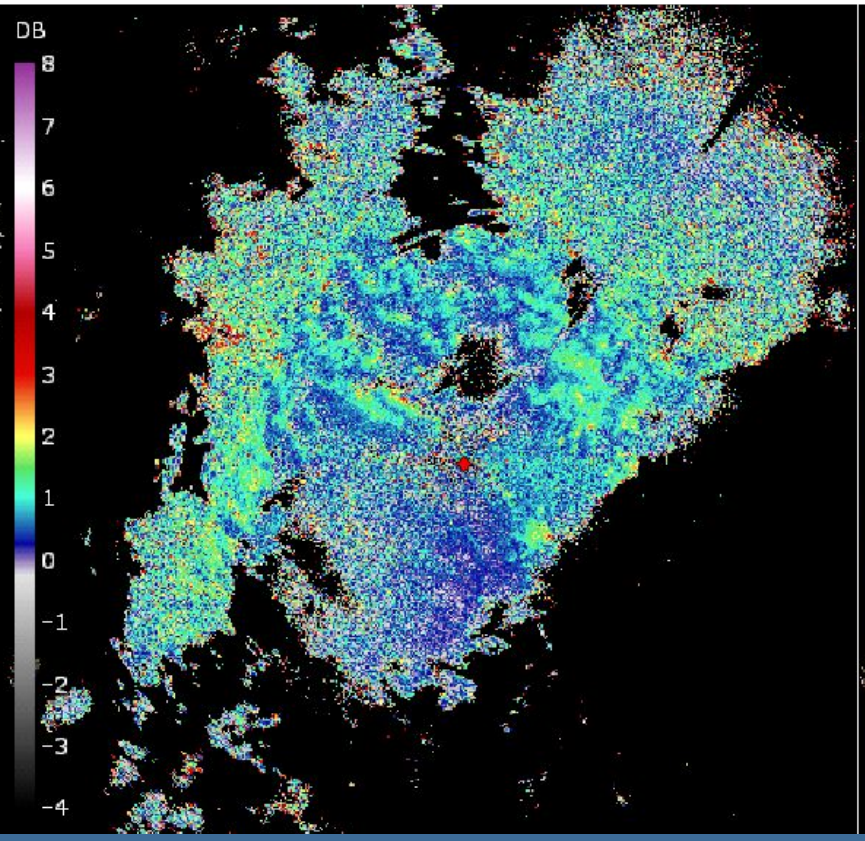
Motivation

- Fields of polarimetric variables tend to appear noisy in the areas where
  - SNR is low-to-moderate (e.g., < 20 dB).
  - Correlation coefficient is low (e.g., < 0.95)

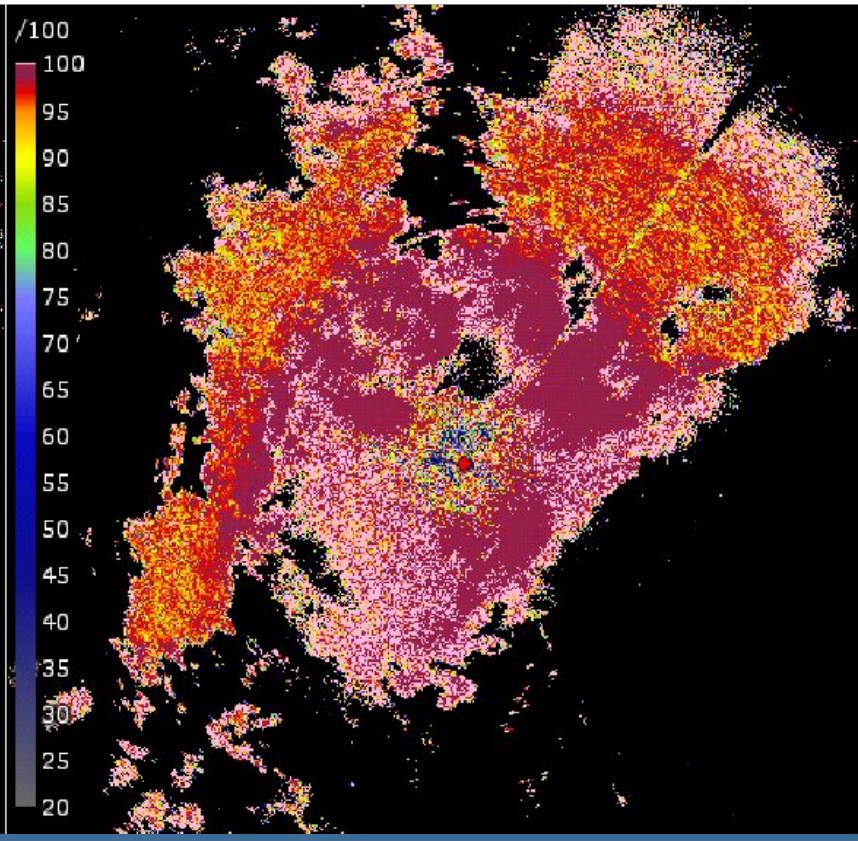
SNR



ZDR



Conventional CC

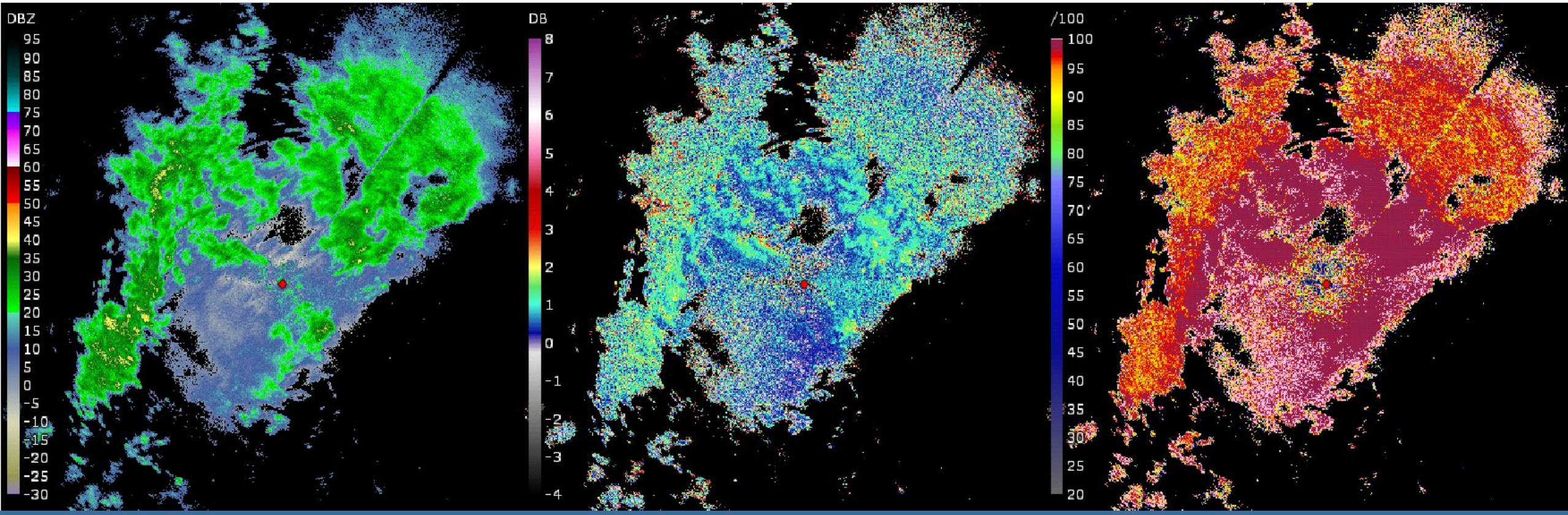


Data collected with KOUN on 27 October 2020 at the 0.5° elevation angle with VCP 215.

Motivation

- Fields of polarimetric variables tend to appear noisy in the areas where
  - SNR is low-to-moderate (e.g., < 20 dB).
  - Correlation coefficient is low (e.g., < 0.95)

Z | ZDR | Hybrid CC (HCC)

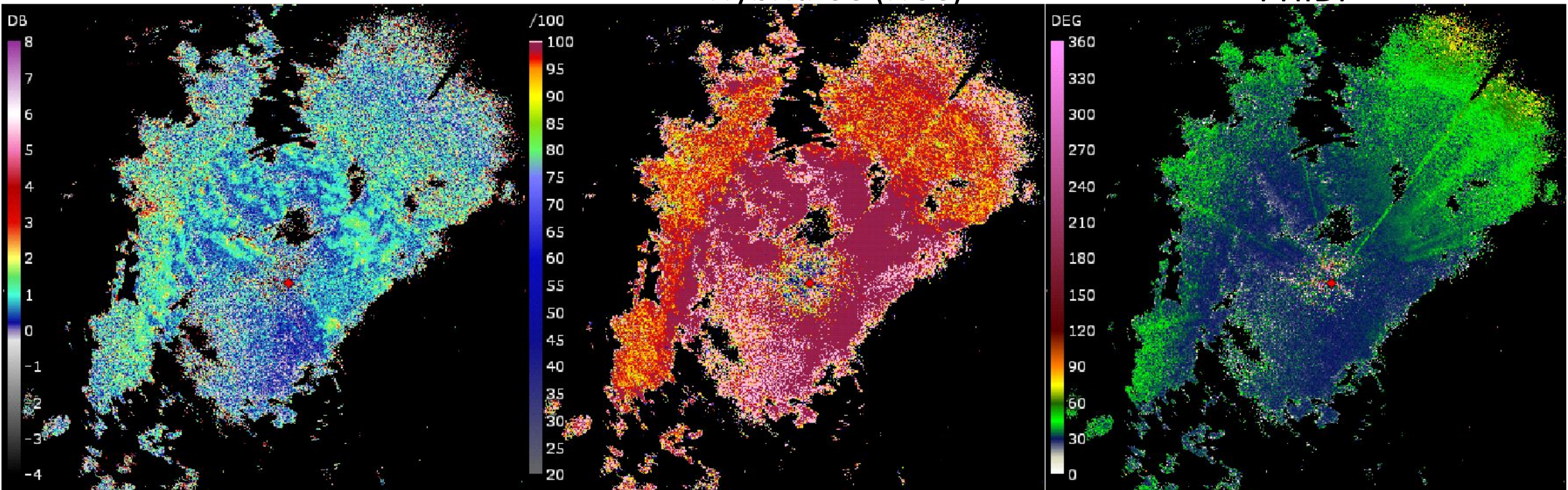


Data collected with KOUN on 27 October 2020 at the 0.5° elevation angle with VCP 215.

Options for improvement in Level II data

- Range Oversampling & Whitening Processing
  - Will improve standard deviations (SDs) across the board for the existing VCPs.
  - New VCPs that improve update times and retain existing SDs are likely to appear.
- Hybrid-Scan Estimators (HSE)
  - Use estimates from Doppler scan non-overlaid bins to improve DQ.

ZDR | Hybrid CC (HCC) | PHIDP



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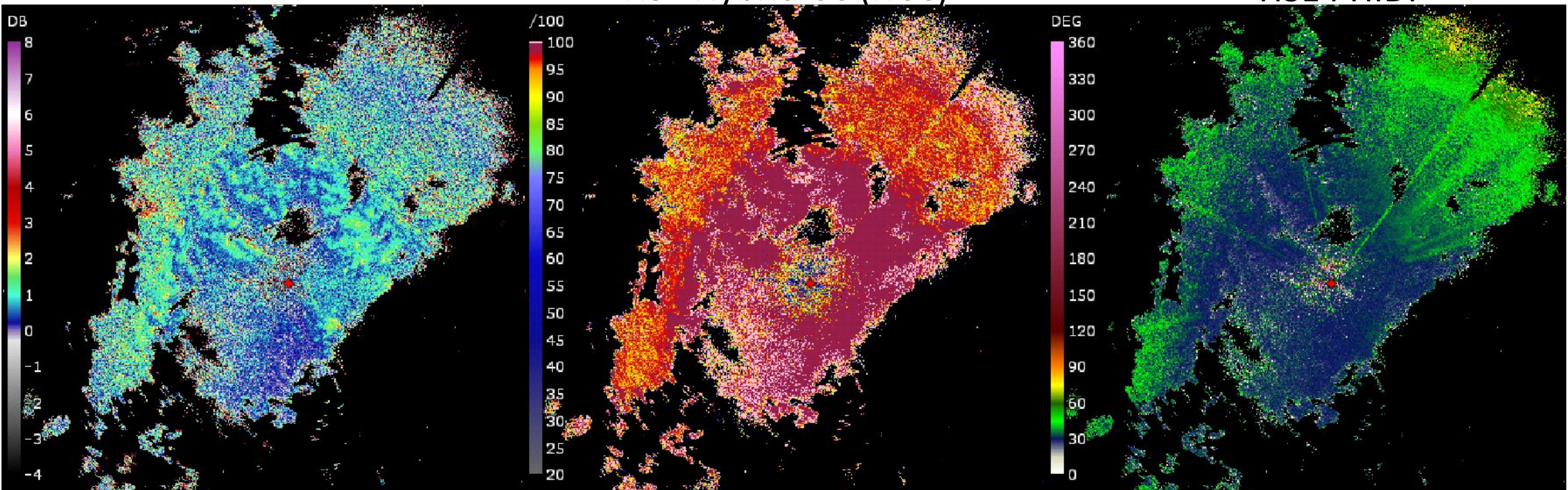
HSE ZDR

HSE Hybrid CC (HCC)

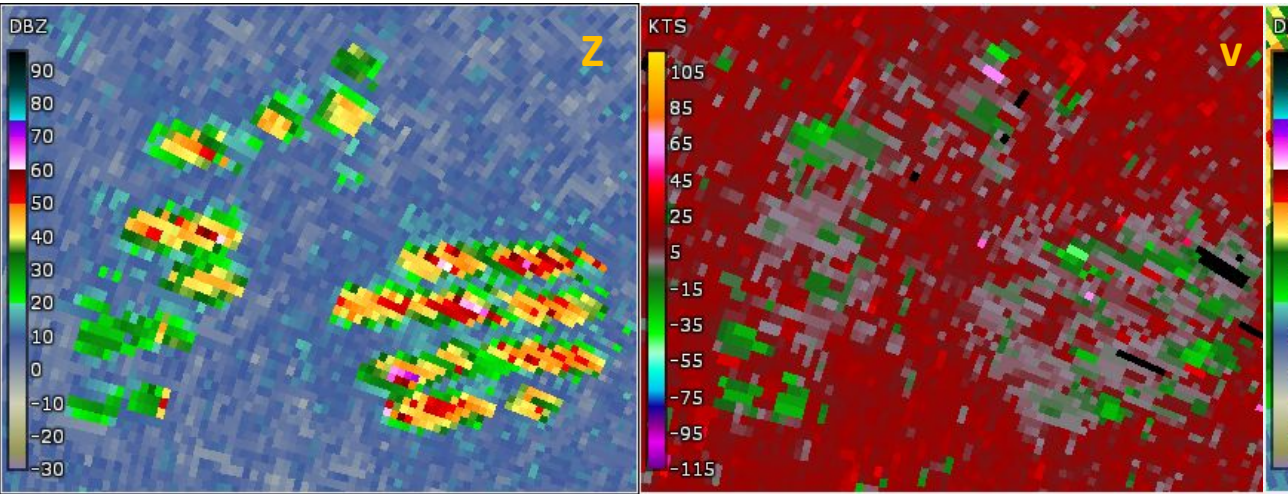
HSE PHIDP



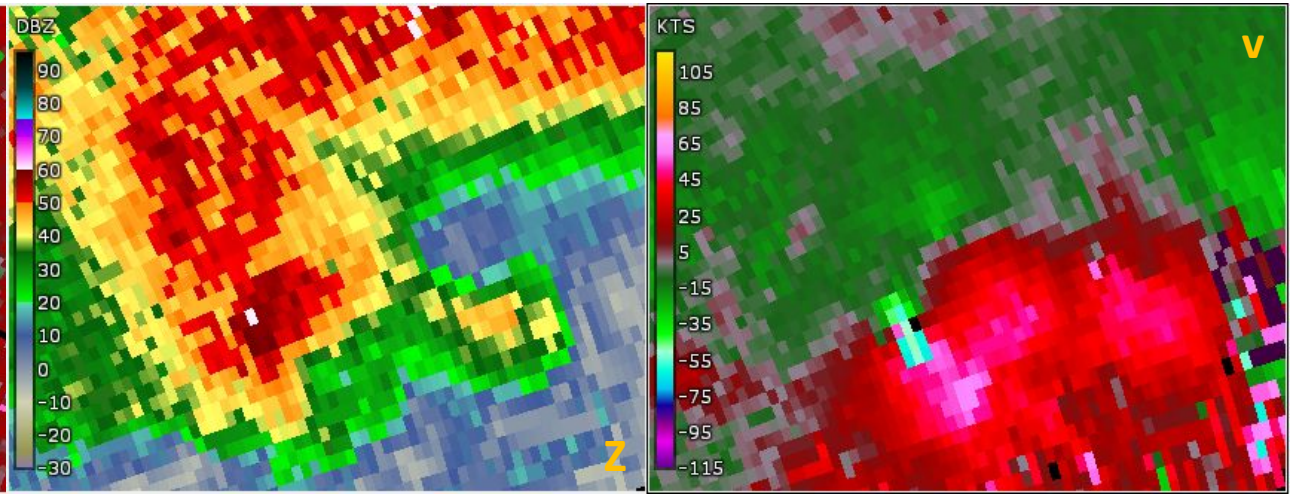
Data quality improvements in ORPG

- The ORPG preprocessor smooths the fields by applying
  - the 3-point moving average in range on Z.
  - the 5-point moving average in range on v (used for HCA only), ZDR, and CC.
  - 9-gate filtering ("lightly filtered,") or 25-gate filtering ("heavily filtered") on PHIDP.
- This reduces the noisiness of data fields at the cost of degraded range resolution (even though the sampling spacing remains 250 m)
  - Retains the uneven standard deviations across data fields.
  - High-gradient features are smeared into surrounding gates.

L2: WIND FARM



L2: TVS



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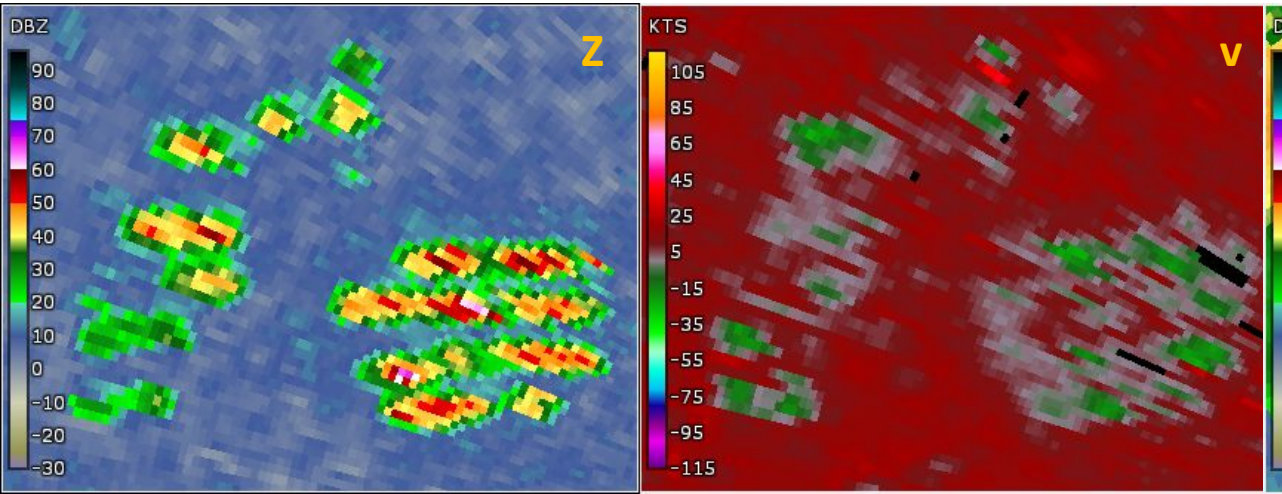
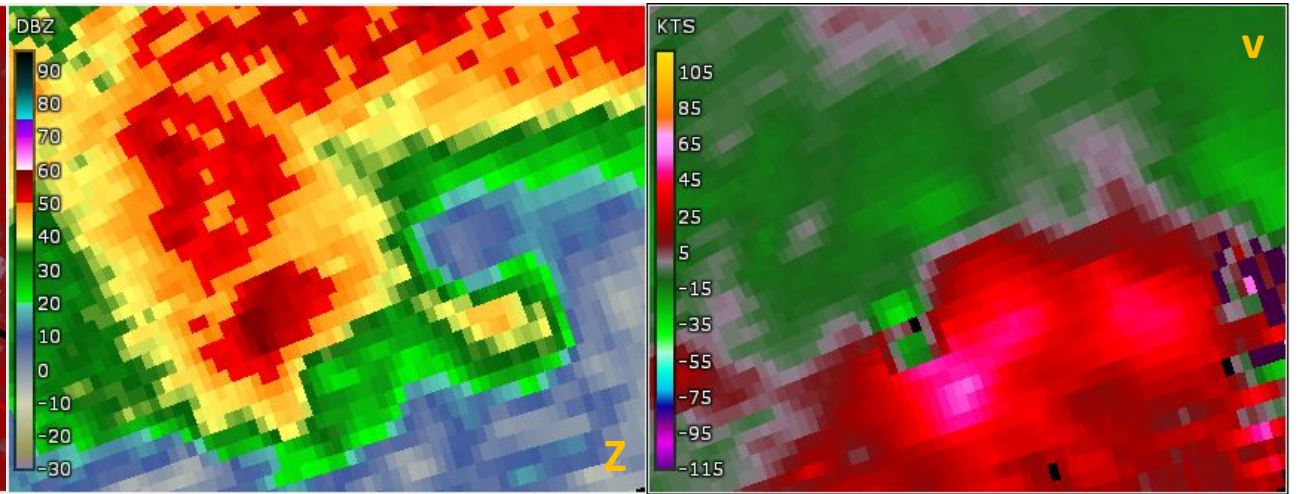
ORPG preprocessor: WIND FARM



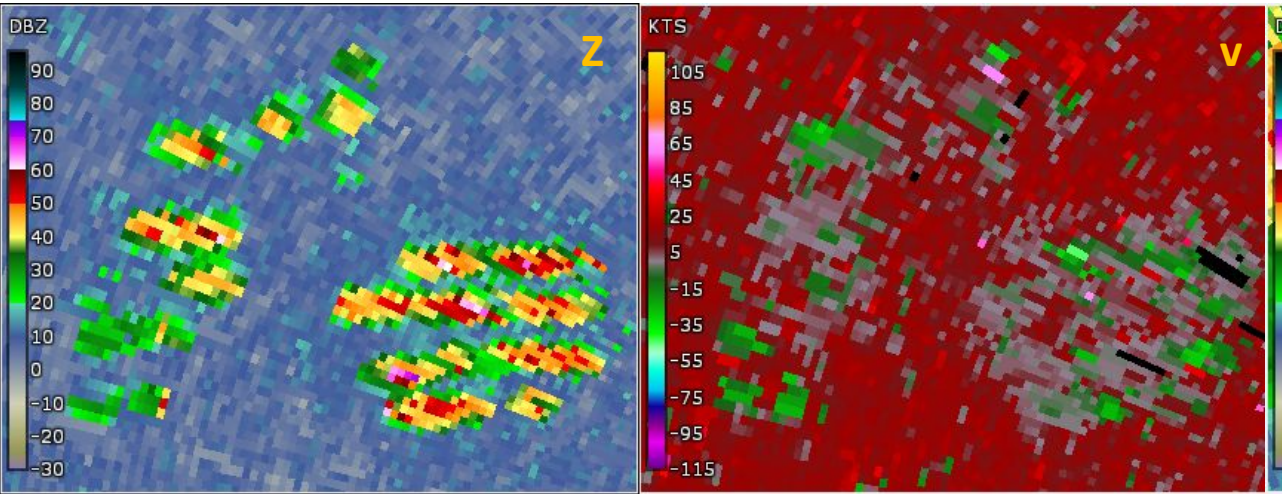
ORPG preprocessor: TVS



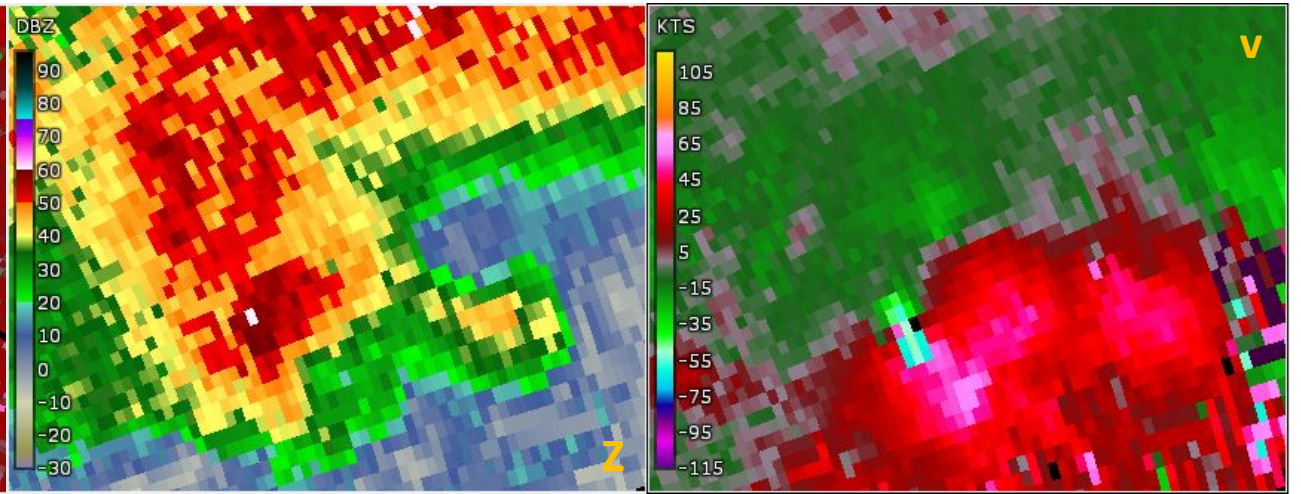
Improved DQ in ORPG (WARA)

- Trade range resolution to improve DQ so that the resolution degradation is larger in the areas of noisy data but smaller in regions where DQ is satisfactory via Weighted Adaptive Range Averaging (WARA)
  - Estimate variance at each range bin using estimates of SNRh and CC via precomputed lookup tables.
  - Find the variable filter length *L* and weights *w* to maintain the variance at the chosen reference level for Z, v, ZDR, and CC variables.
  - Applies variable filter along with Chebyshev's inequality test. The latter prevents high-gradient features from being smeared to surrounding gates.

L2: WIND FARM



L2: TVS



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  - Estimate variance at each range bin using estimates of SNR_h and CC via precomputed lookup tables.
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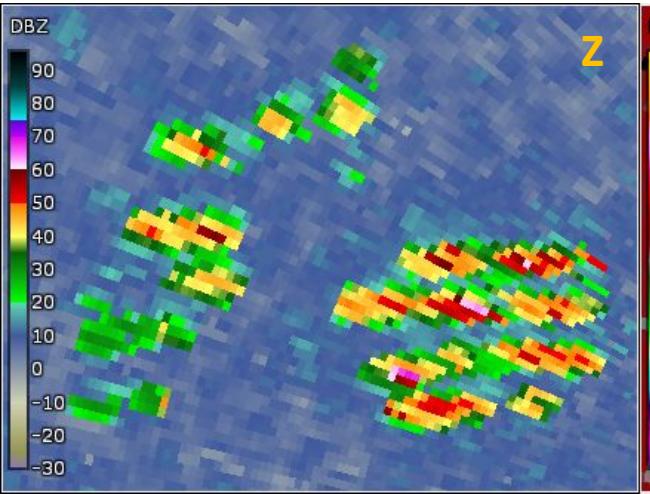
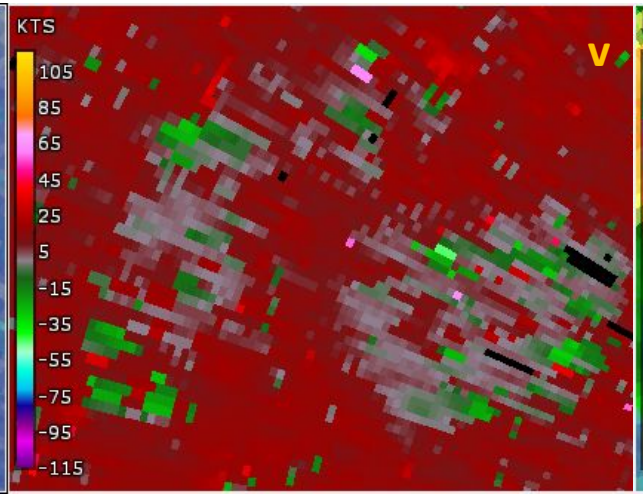
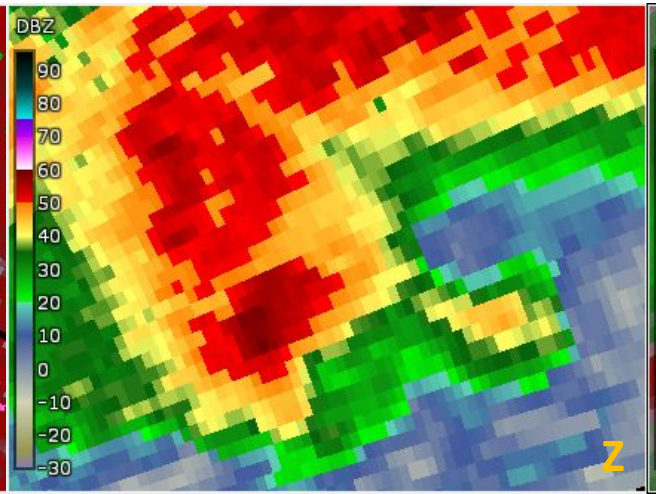
  - Applies variable filter along with Chebyshev's inequality test. The latter prevents high-gradient features from being smeared to surrounding gates.

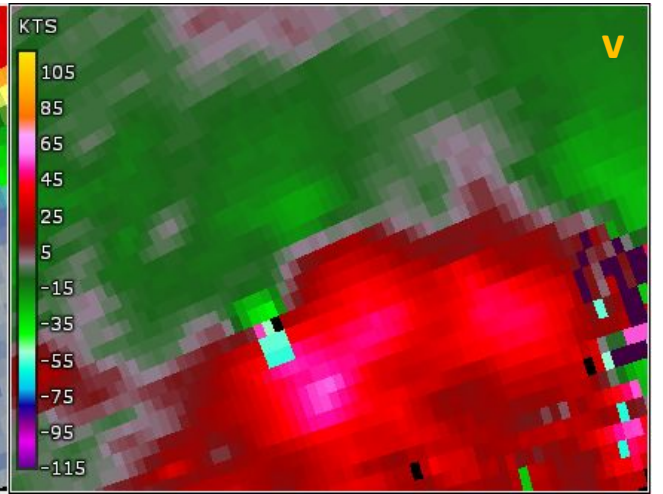
WARA: WIND FARM





WARA: TVS

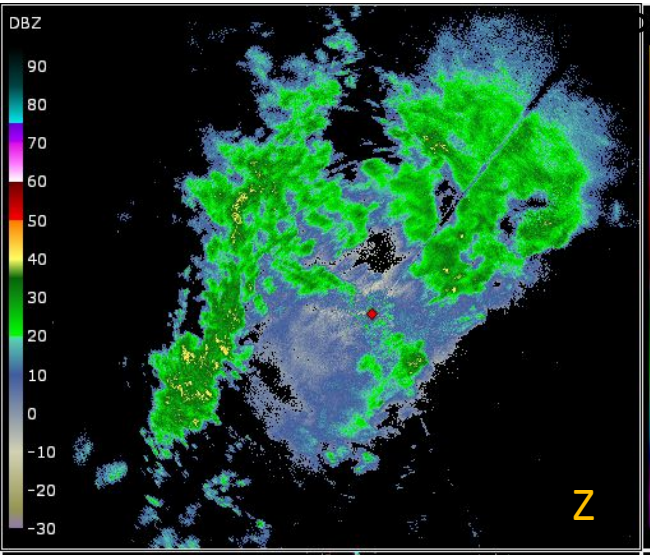


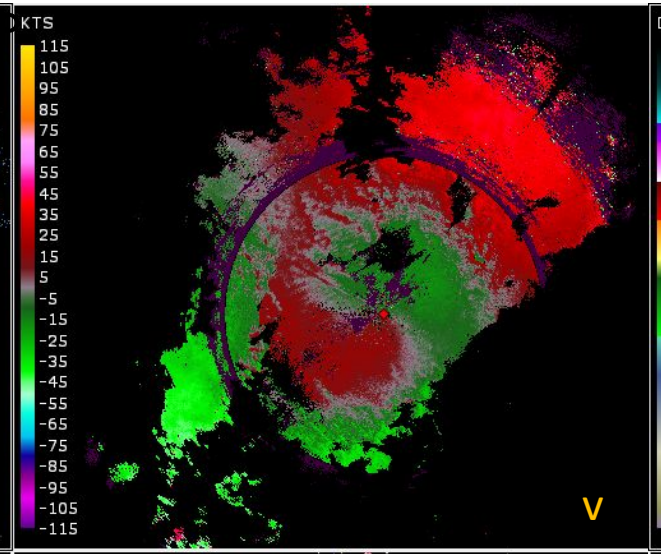


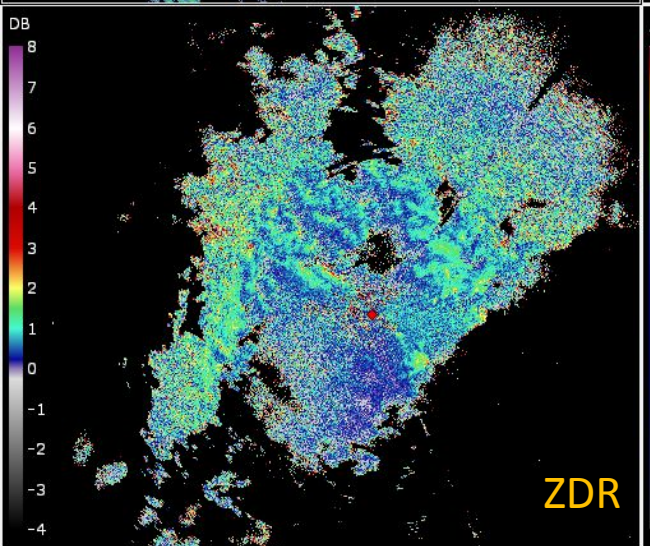
Example 1: Level II

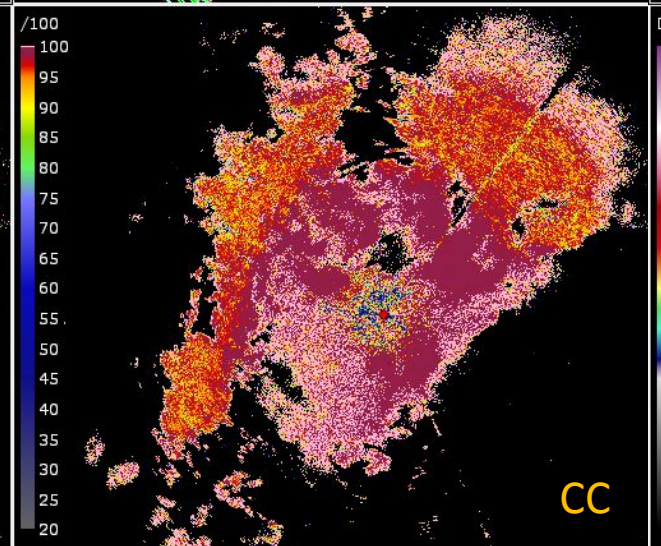
Data collected with KOUN on 27 October 2020 with VCP 215.

El =



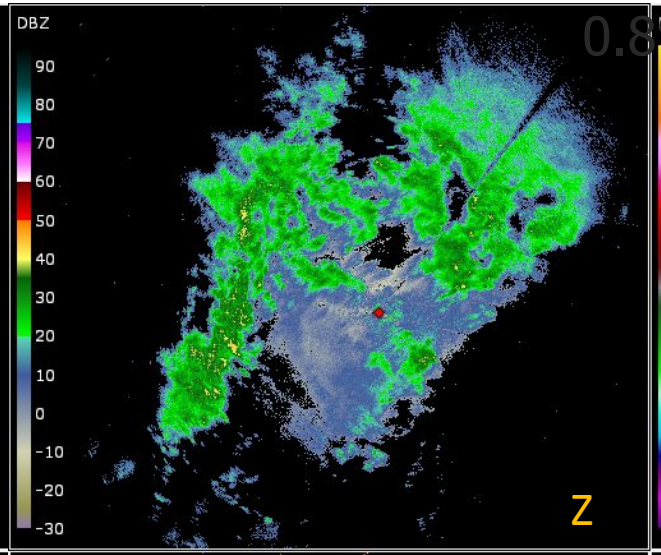


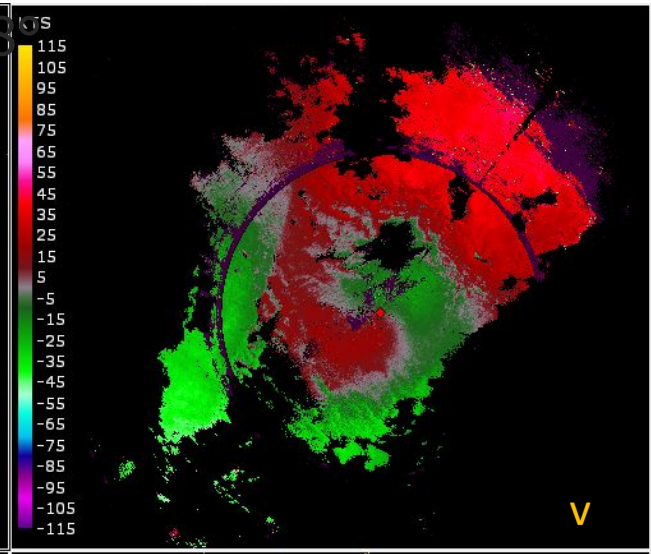


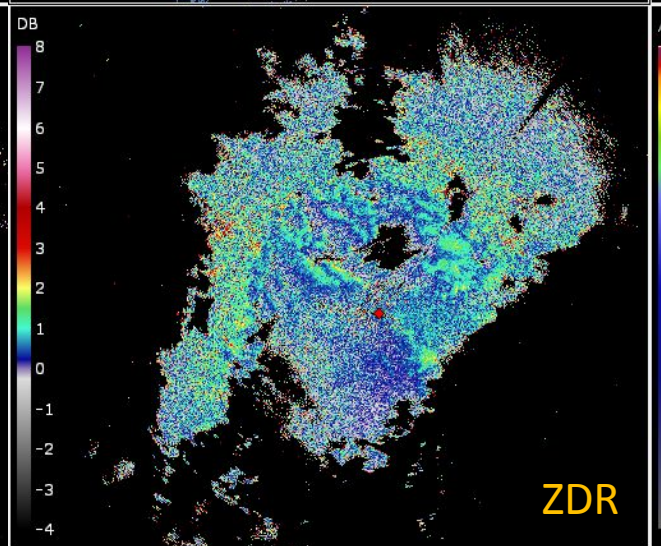


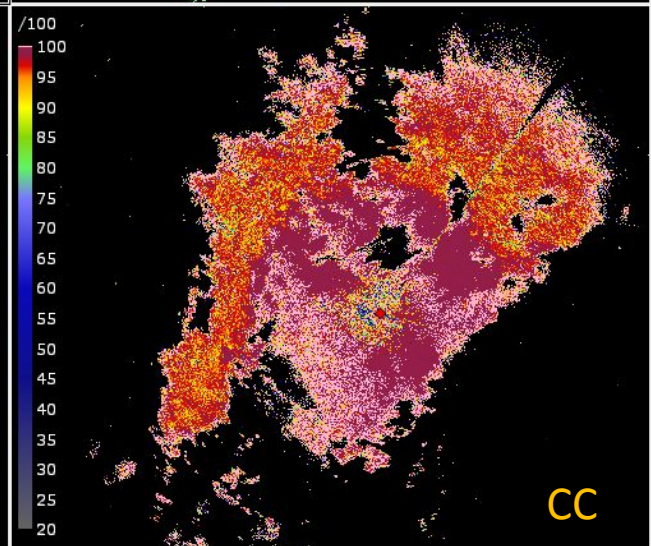
El =

0.8°





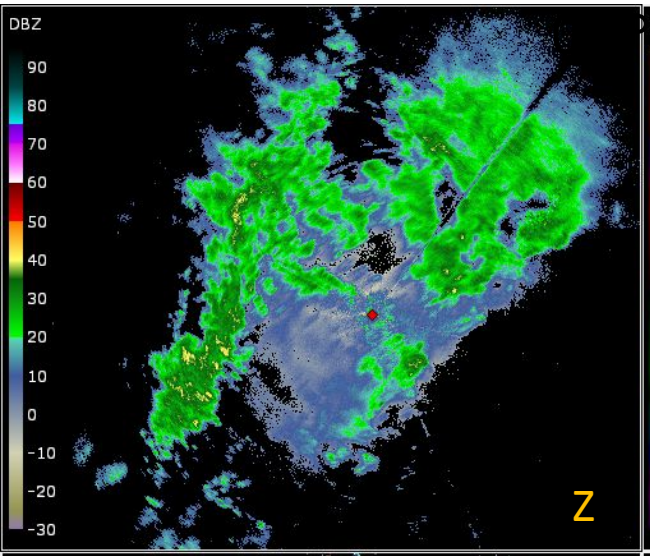


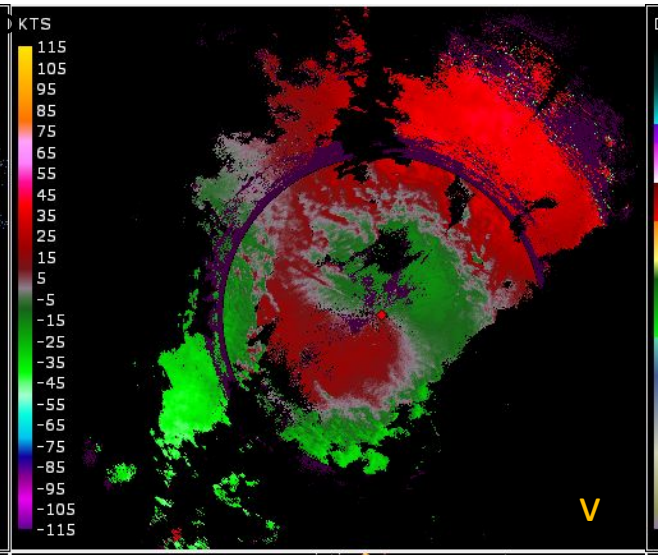


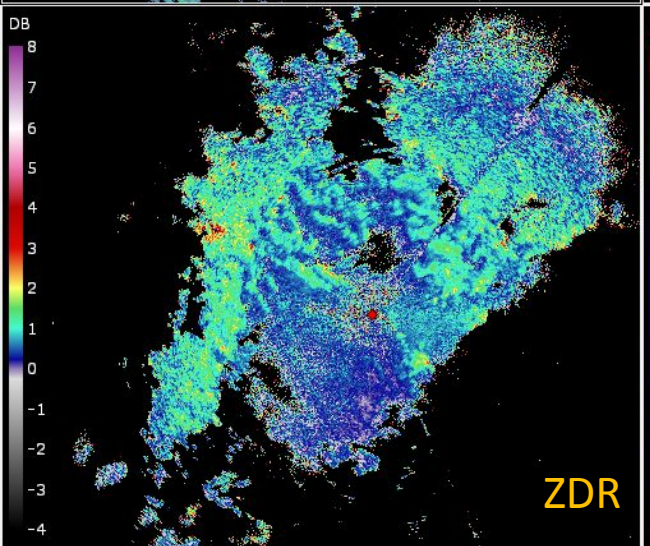
Example 1: ORPG preprocessor

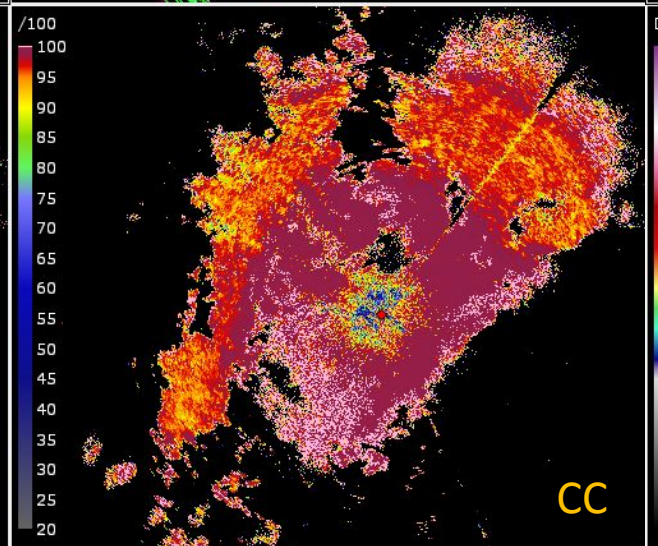
Data collected with KOUN on 27 October 2020 with VCP 215.

El =









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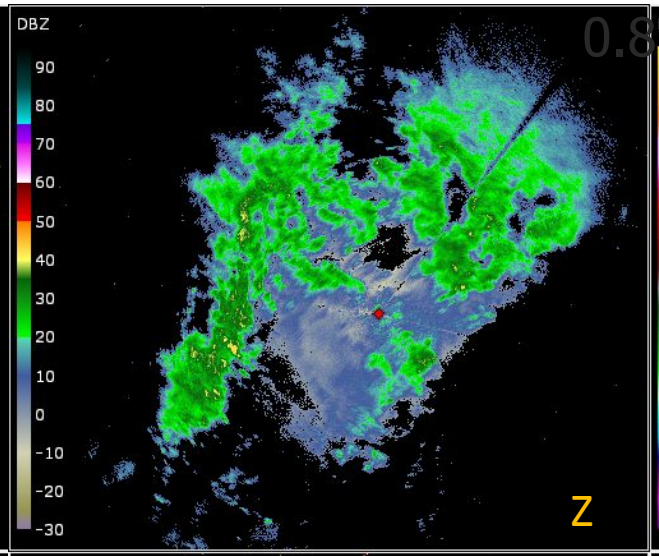
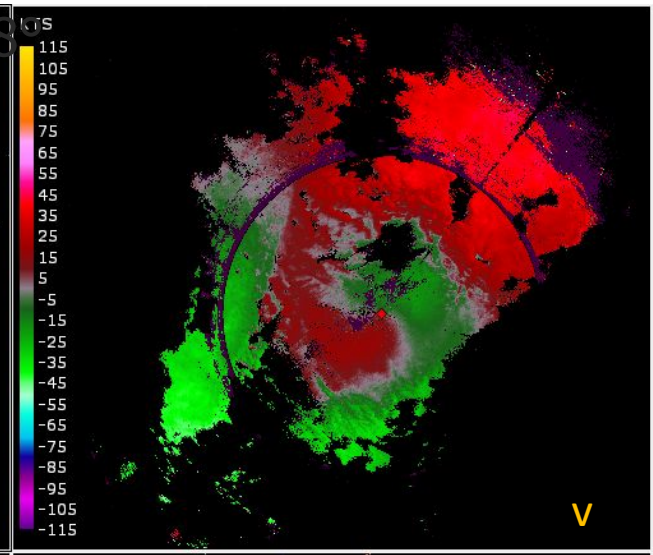
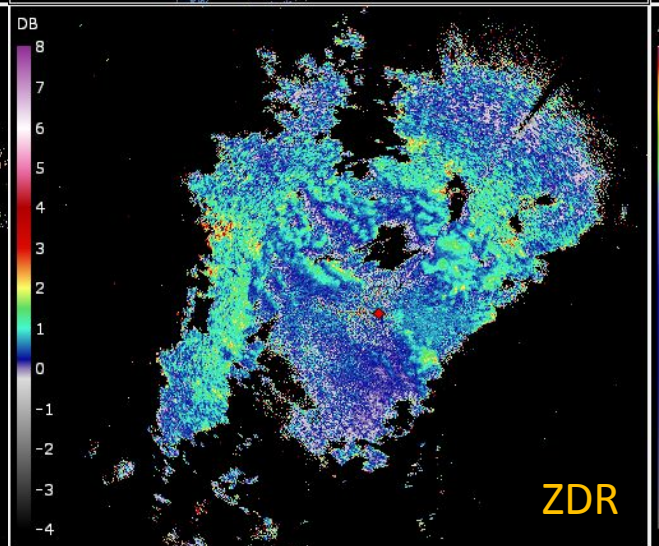
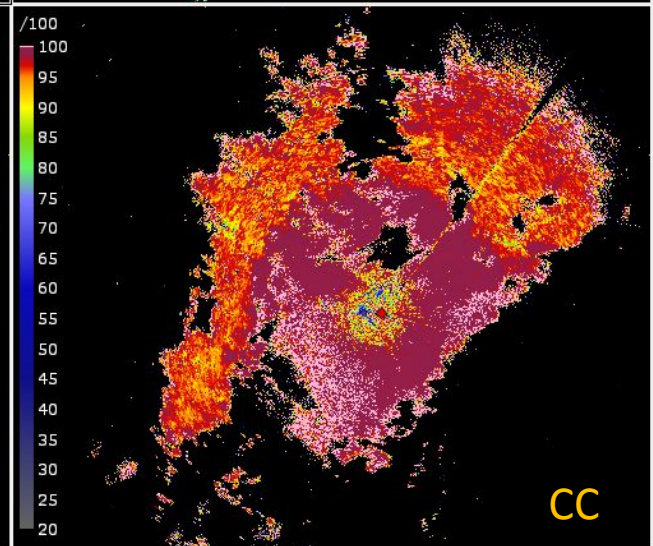






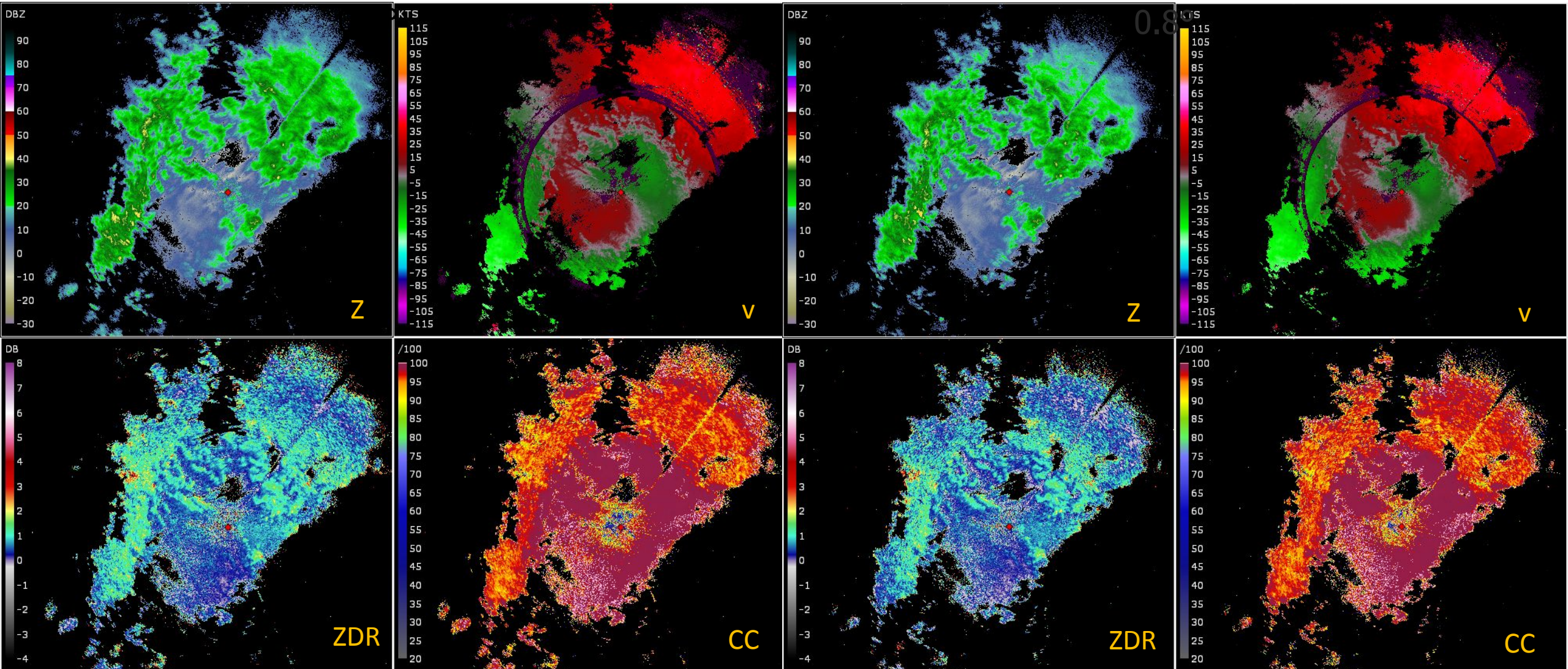


Example 1: WARA

Data collected with KOUN on 27 October 2020 with VCP 215.

El =

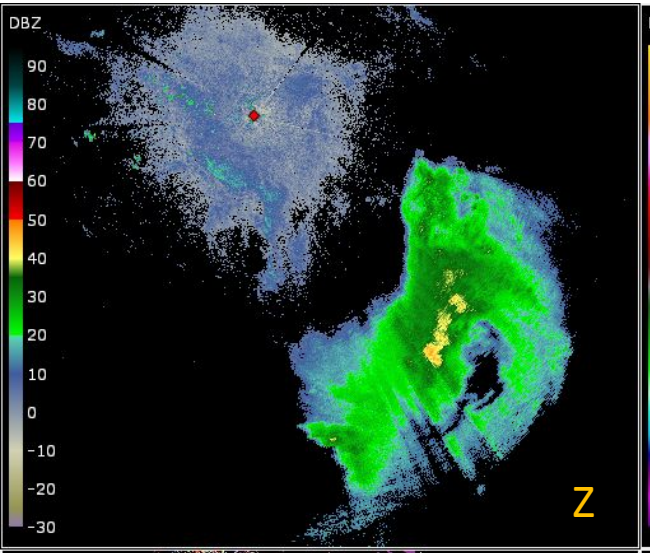
El = 0.8°

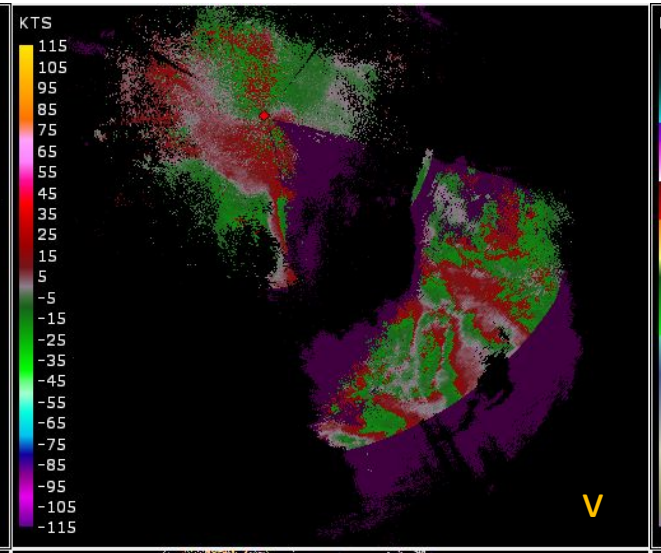


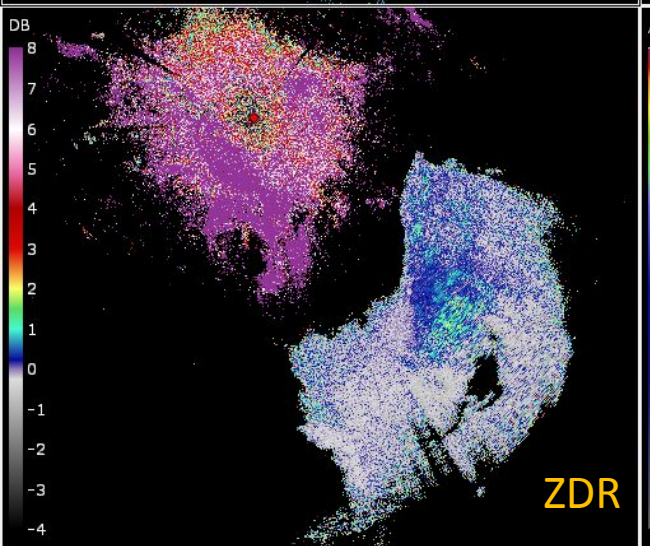
Example 2: Level II

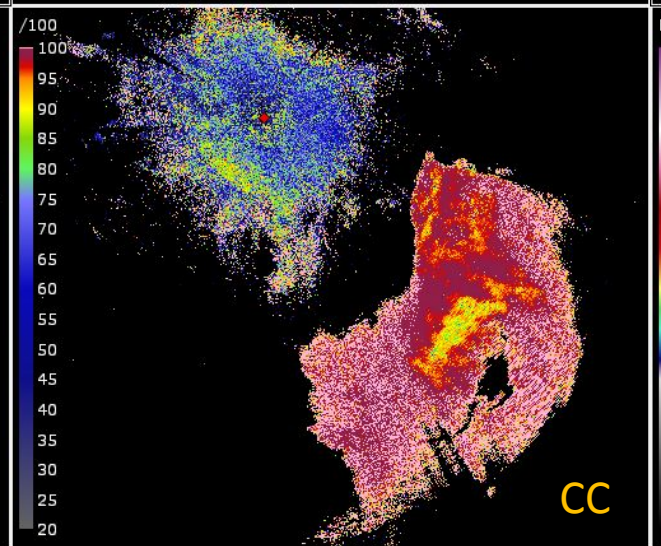
Data collected with KOUN on 12 June 2021 with VCP 32.

El = 0.5°

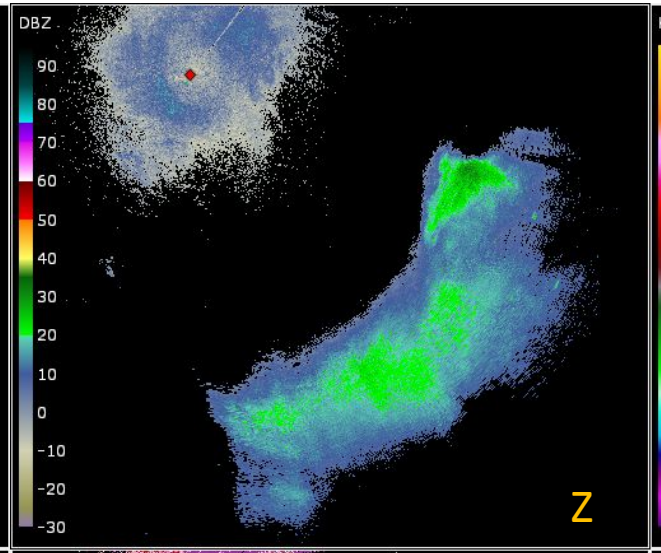


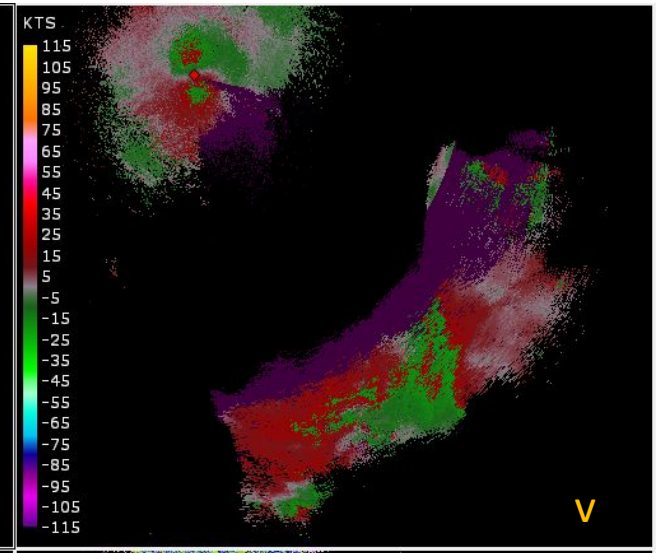


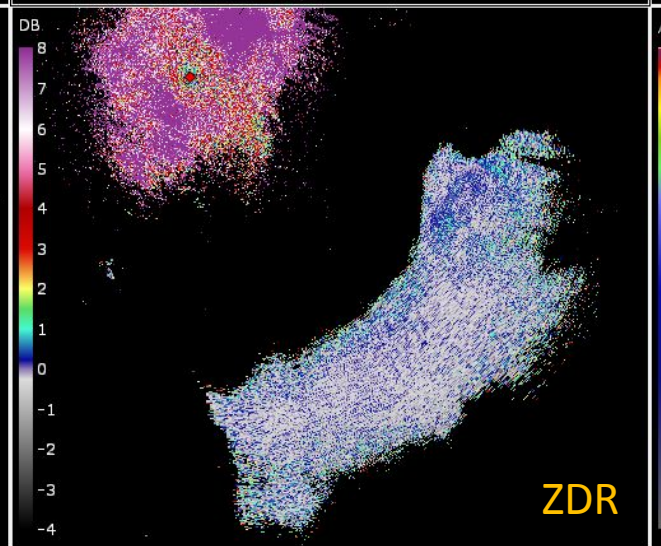


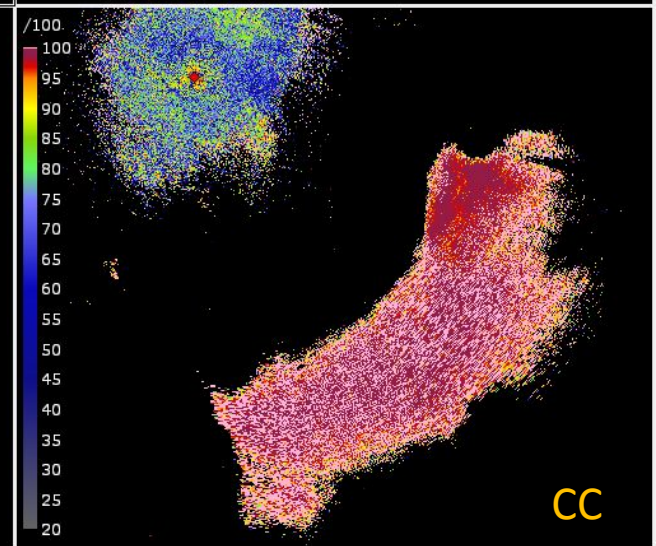


El = 1.5°





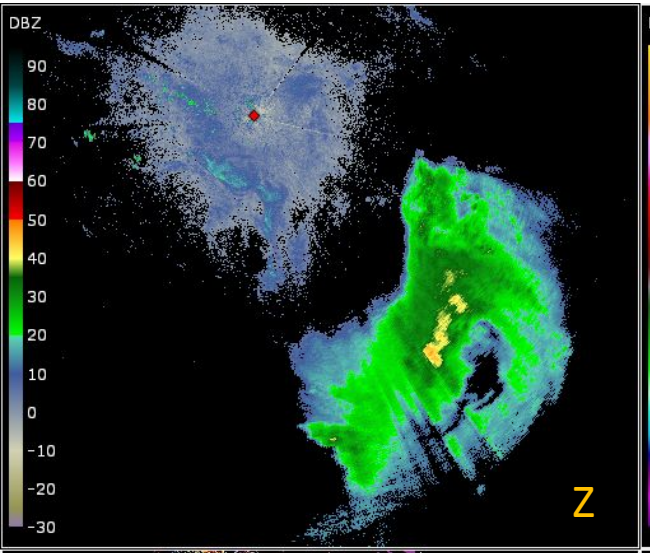


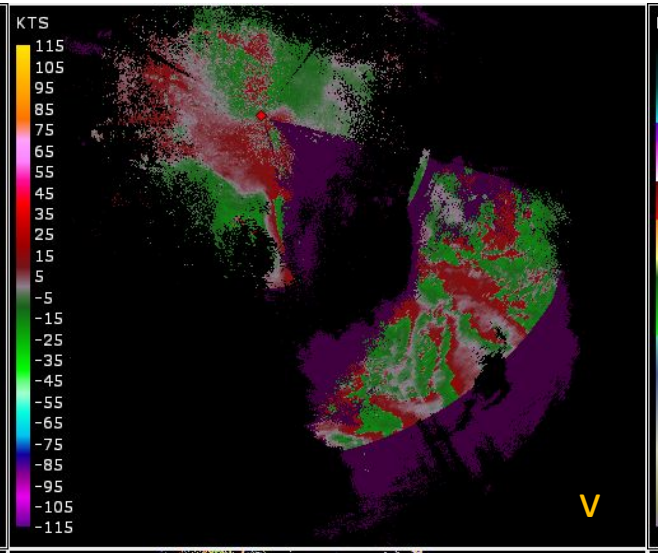


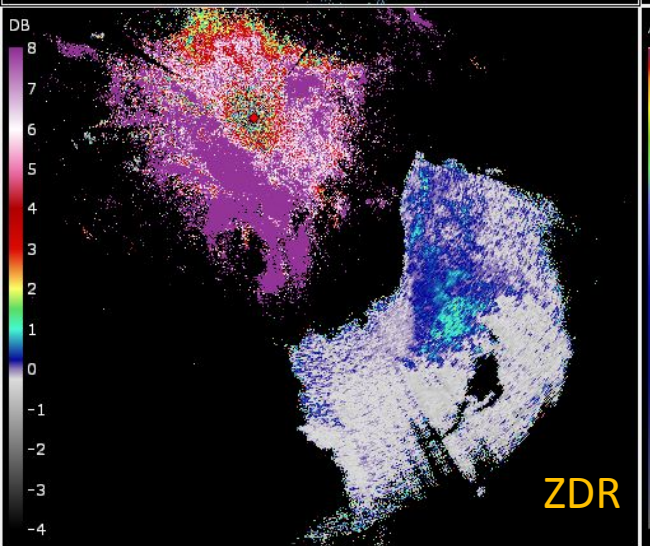
Example 2: ORPG preprocessor

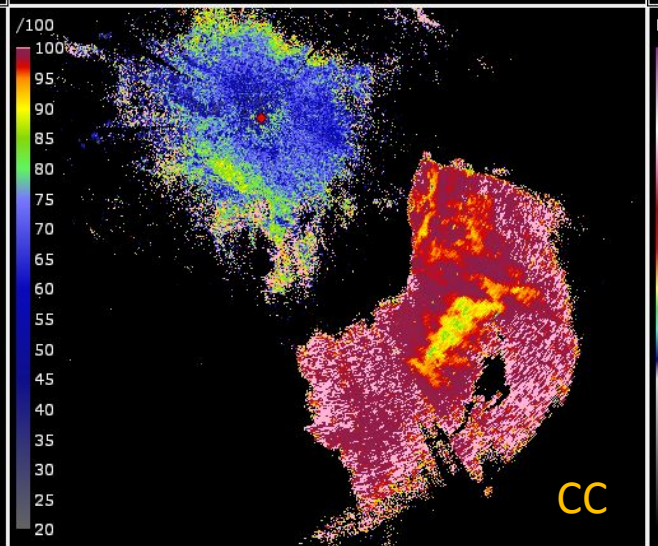
Data collected with KOUN on 12 June 2021 with VCP 32.

El = 0.5°

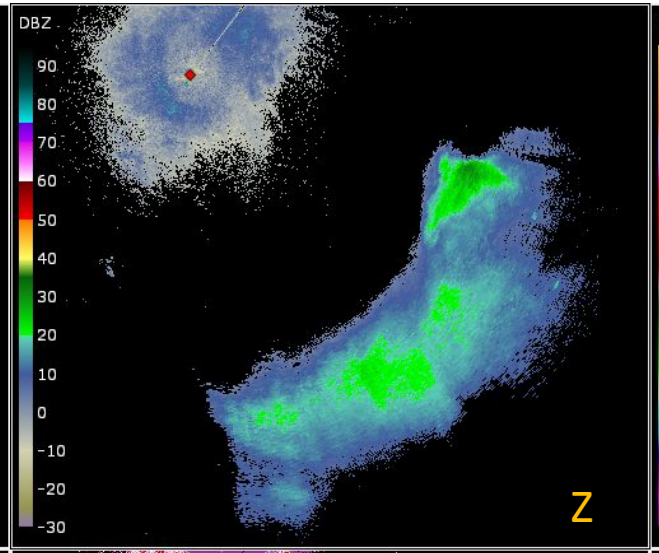


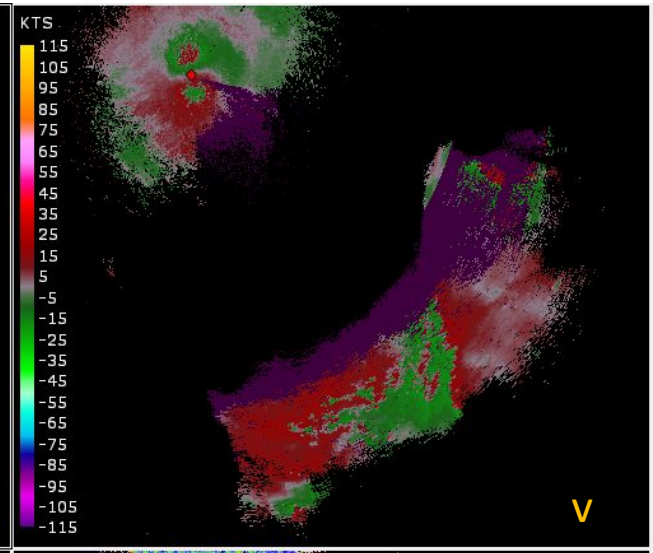


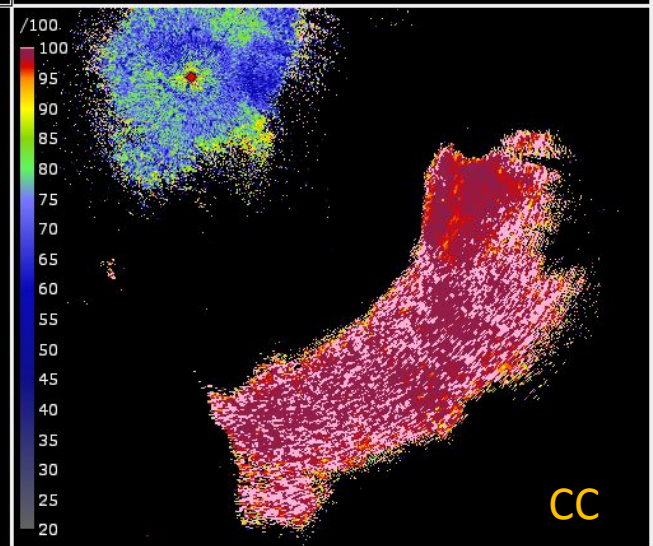




El = 1.5°



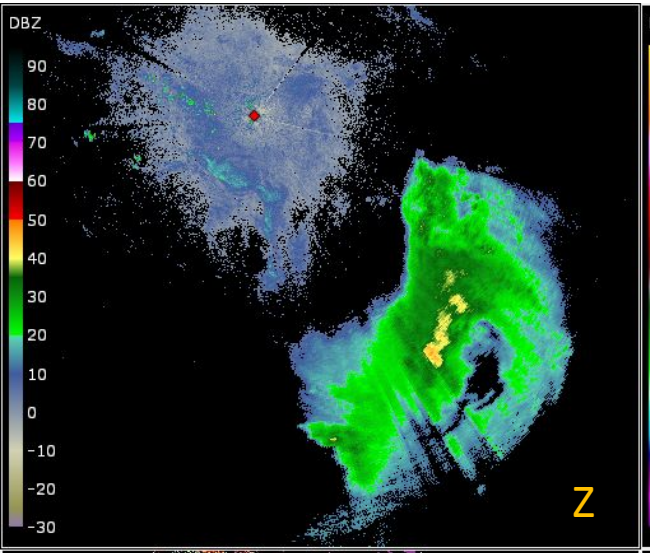


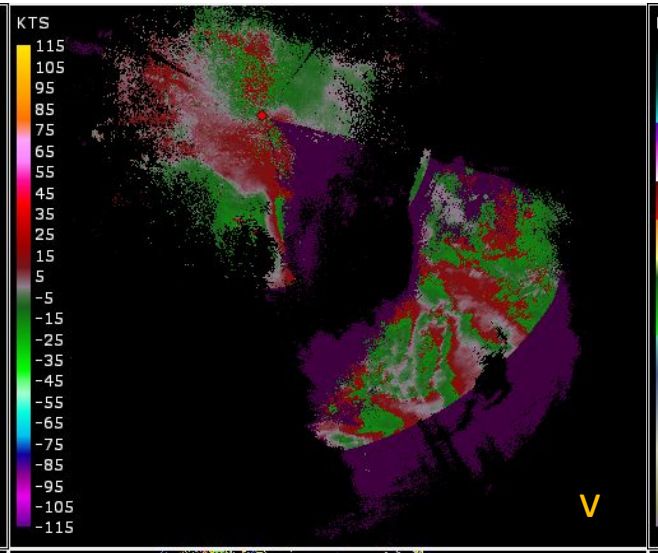


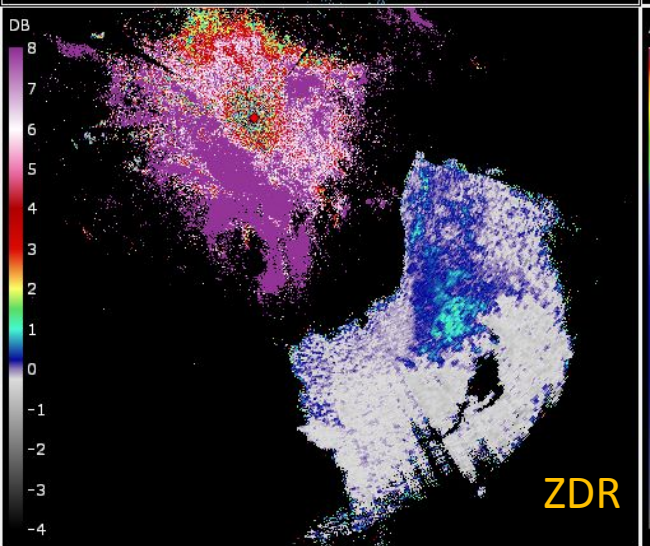
Example 2: WARA

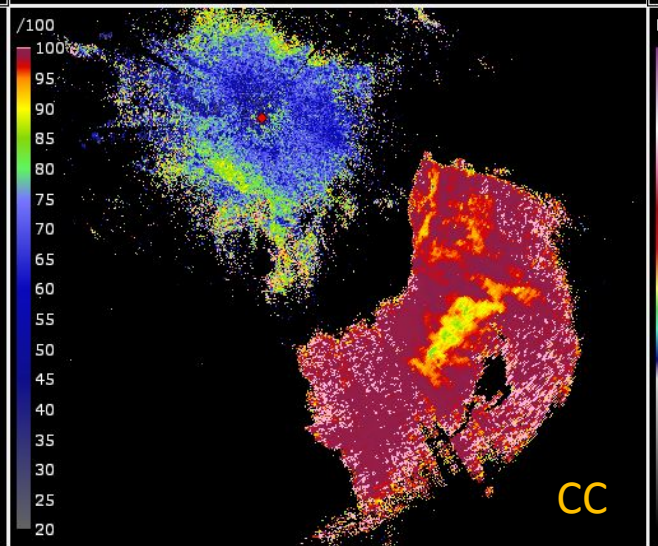
Data collected with KOUN on 12 June 2021 with VCP 32.

El = 0.5°

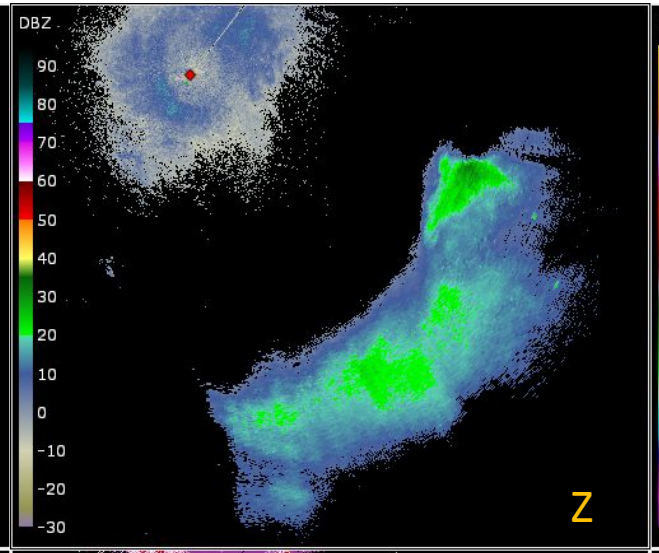


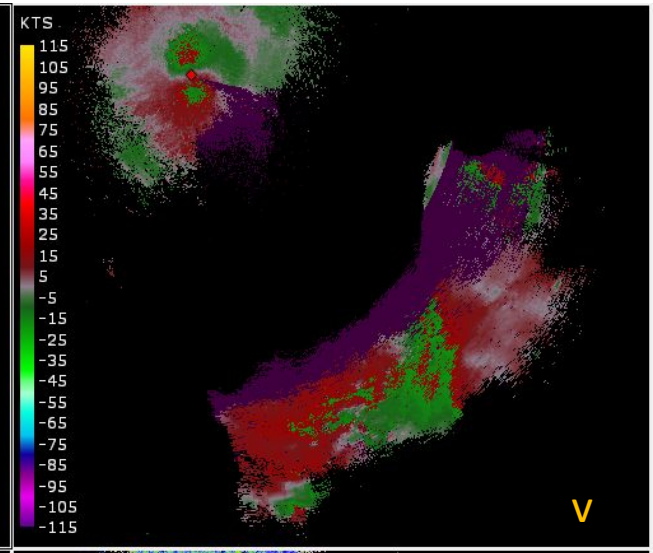


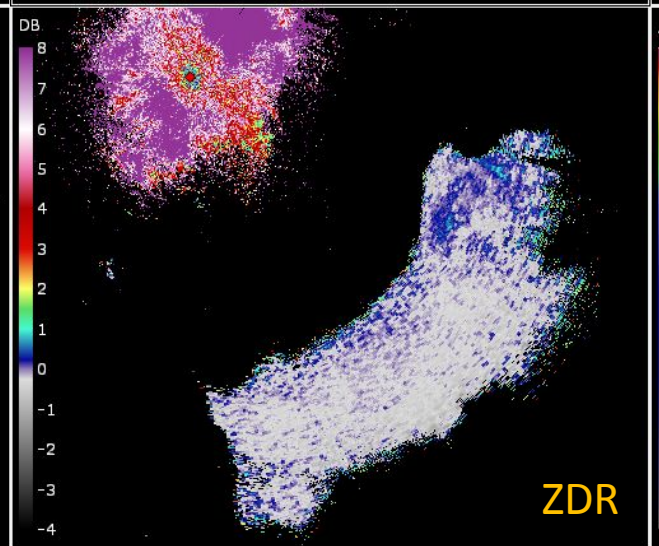


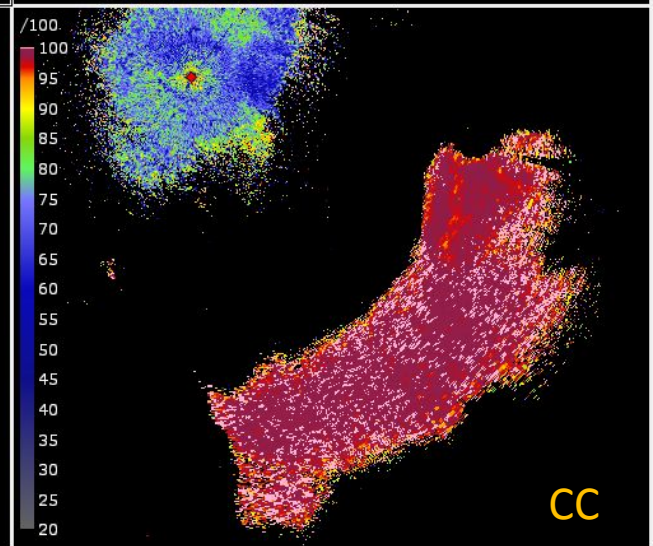


El = 1.5°



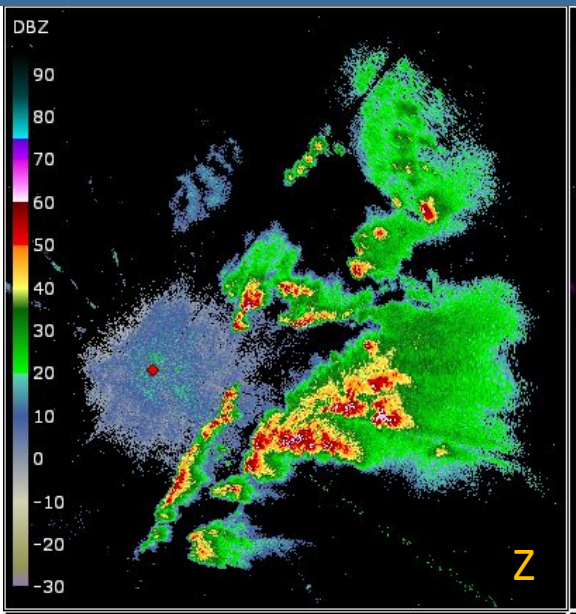


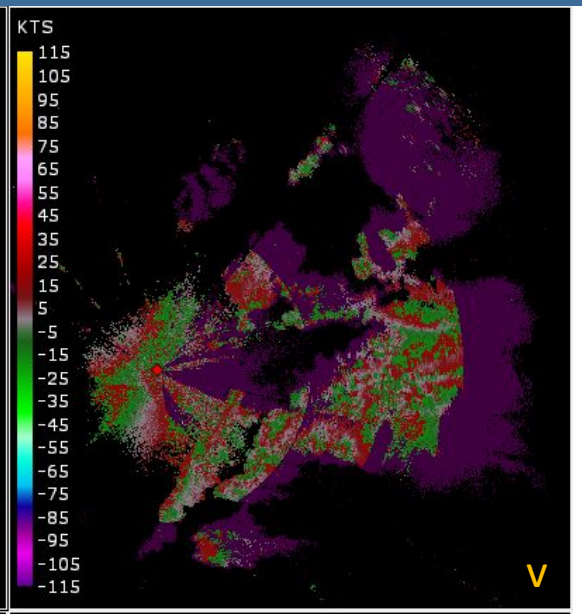


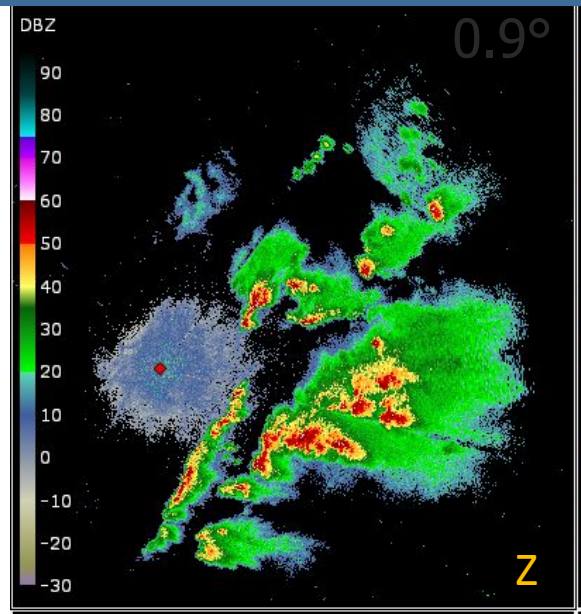


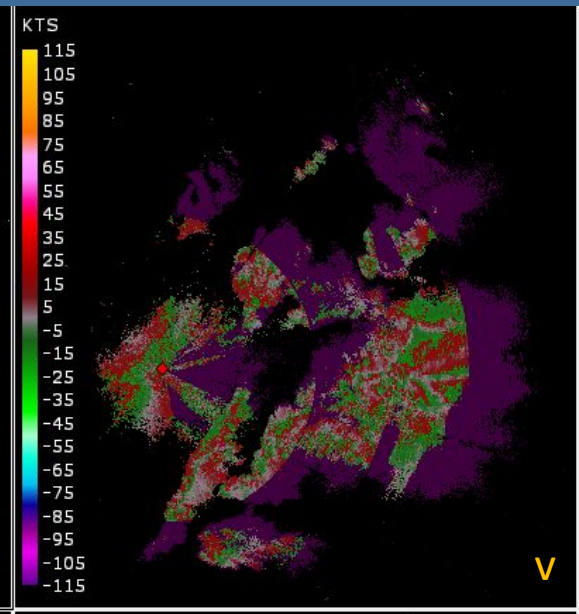
Example 3: Level II

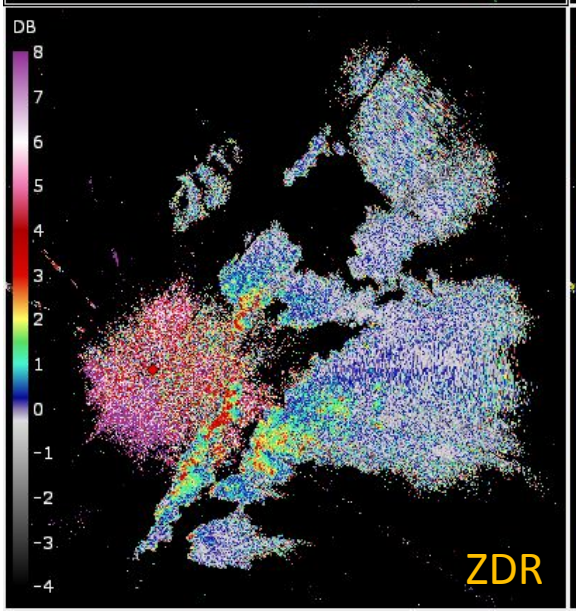
El = Data collected with KOUN on 15 April 2011 with VCP 12. El = 0.9°

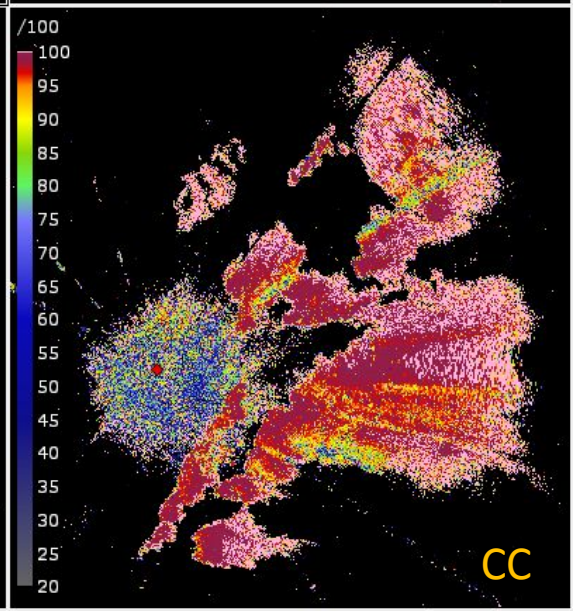


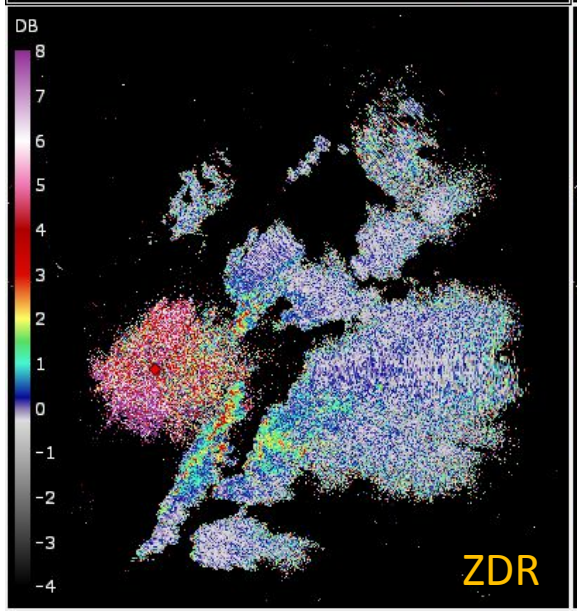


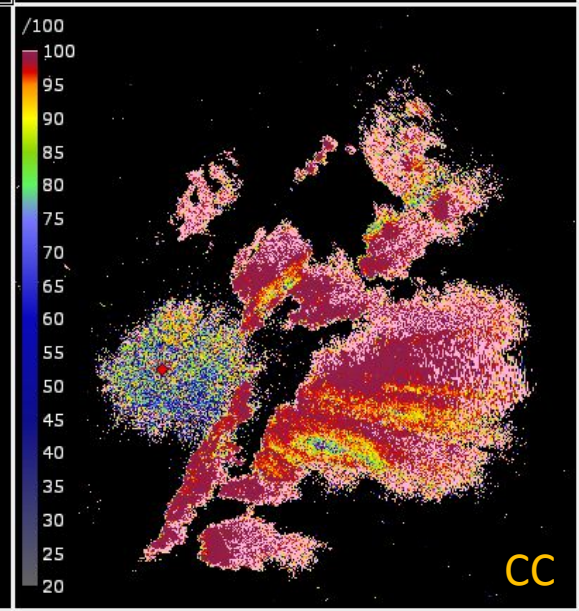










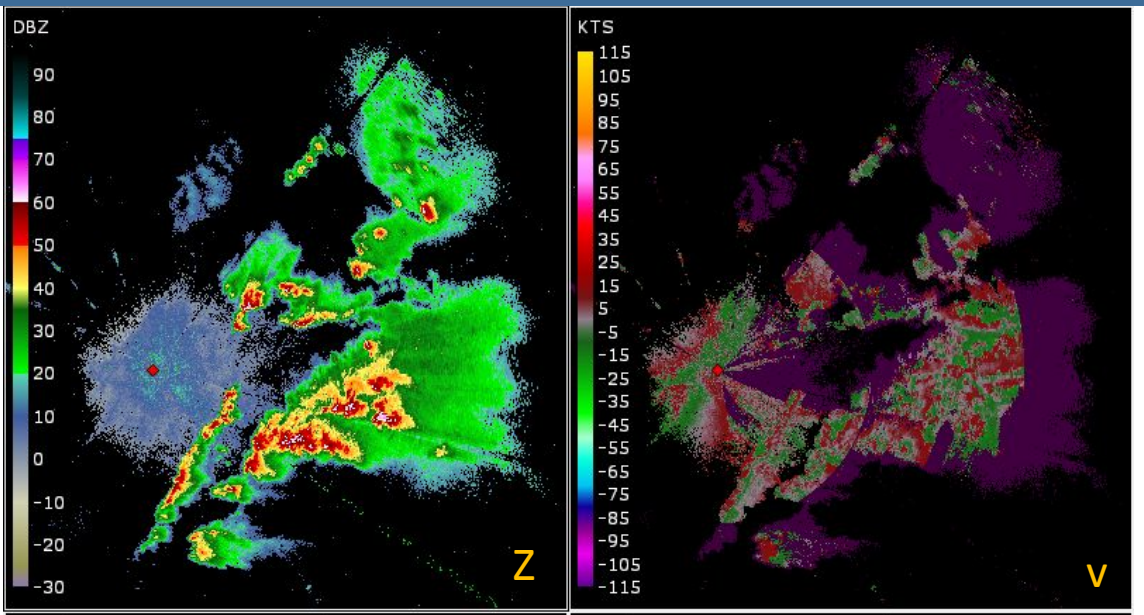


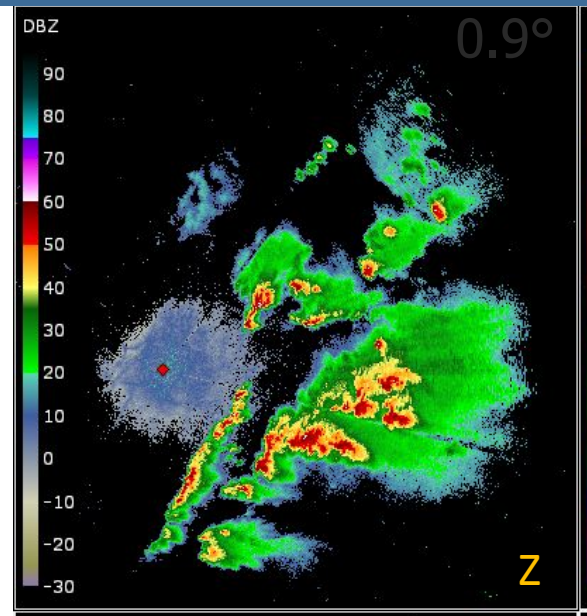
Example 3: ORPG preprocessor

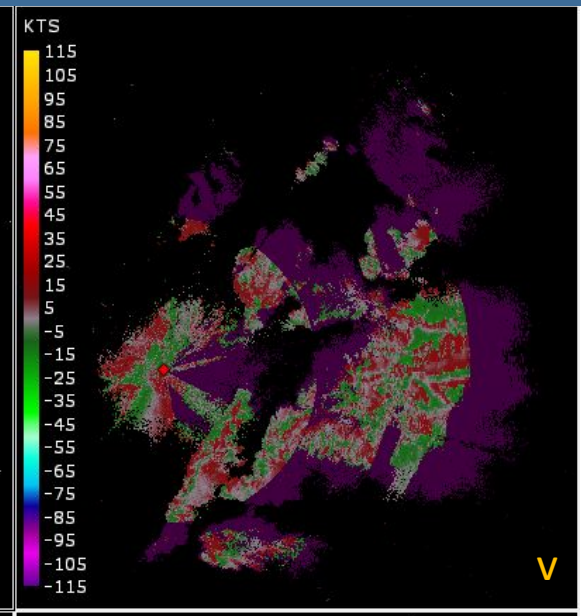
El =

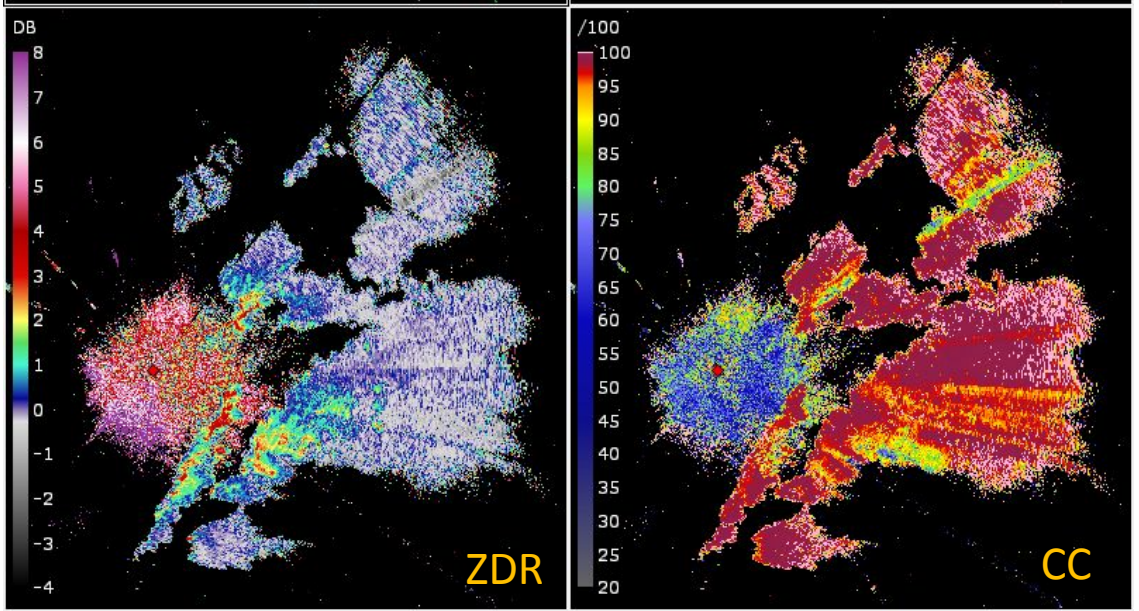
Data collected with KOUN on 15 April 2011 with VCP 12.

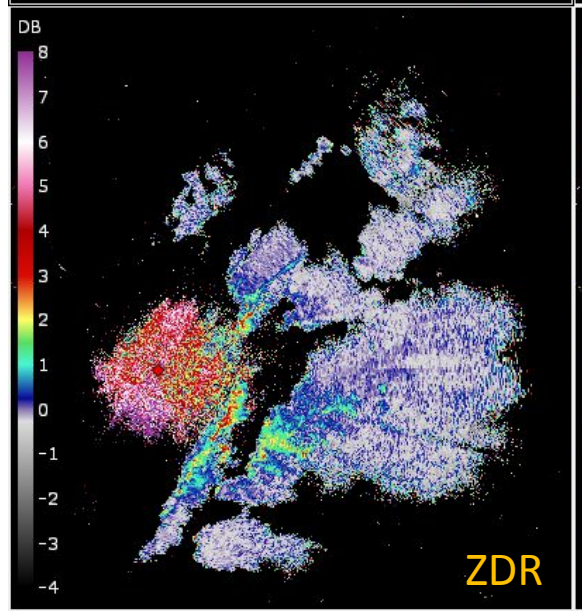
El = 0.9°

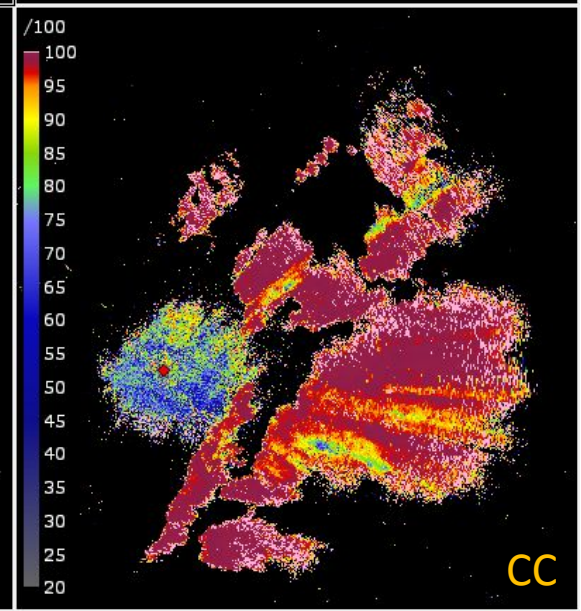








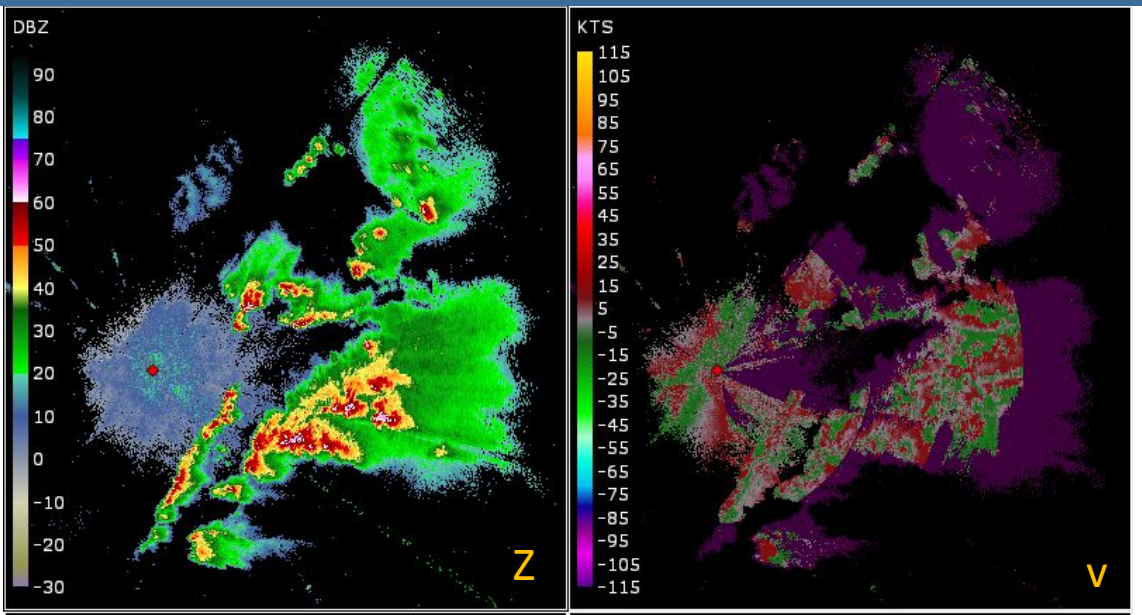


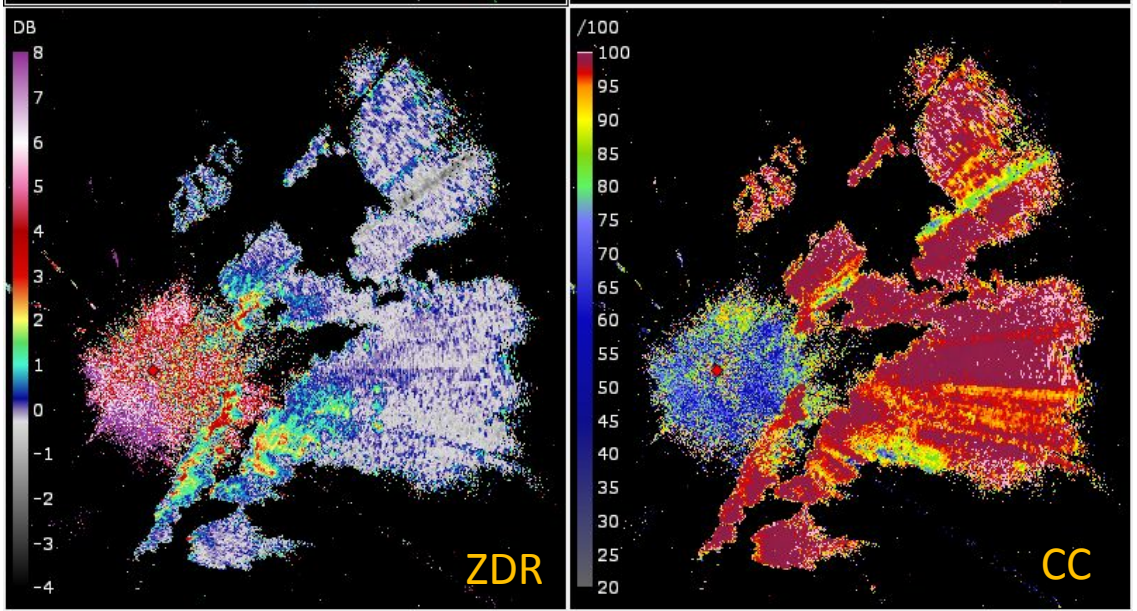


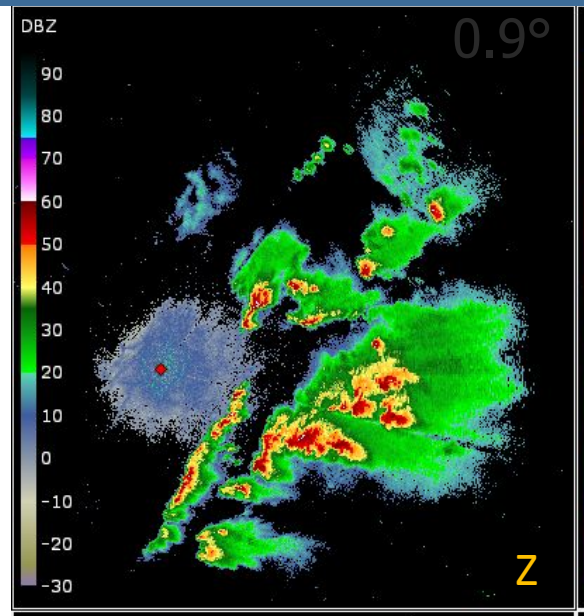
Example 3: WARA

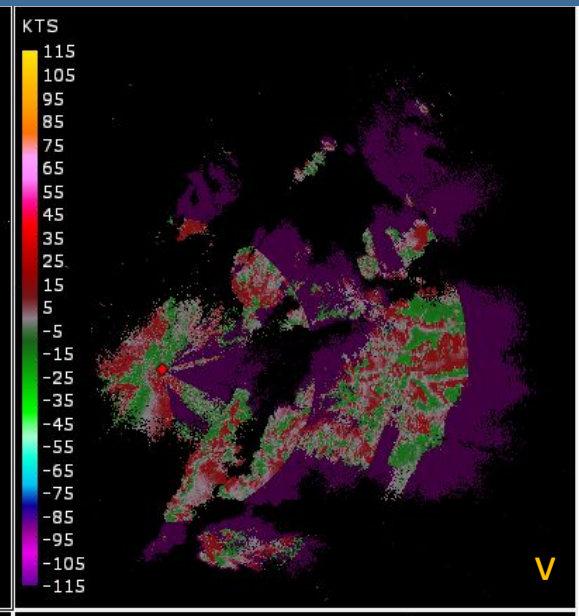
El = 0.9°

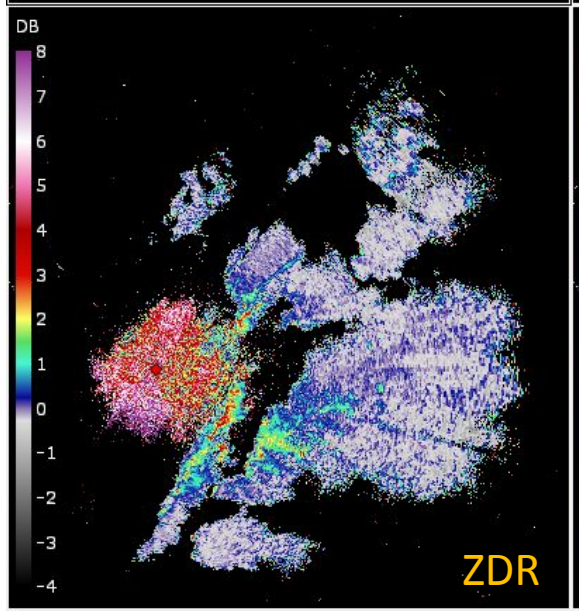
Data collected with KOUN on 15 April 2011 with VCP 12.

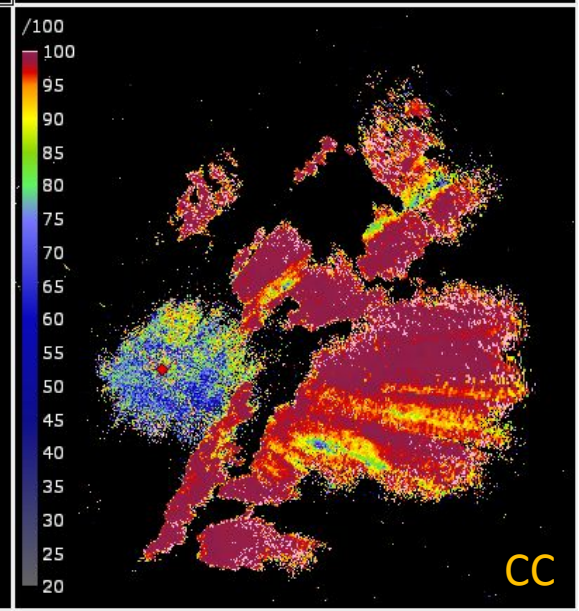












Summary

- Fields of polarimetric variables appear noisy in the areas of low-to-moderate SNRs and/or low correlation coefficient.
- The presented technique improves the appearance of polarimetric variable fields in these areas
  - Applies the weighted adaptive moving average in range that aims to maintain the variance of estimates at the preset reference level.
    - The weights and the number of averaged range bins *L* are variable and depend on the preset reference variance and the estimated SNR as well as CC (from which the estimate variances are assessed via a lookup table).
    - Chebyshev's inequality test is applied to prevent the loss of high-gradient features.
- The presented WARA technique may be used to improve the smoothing process in the ORPG.
  - Possibly enable DP variables to be displayed beyond 300 km.