Innovative Techniques to Improve Weather Observations

David Warde (CIMMS/OU)

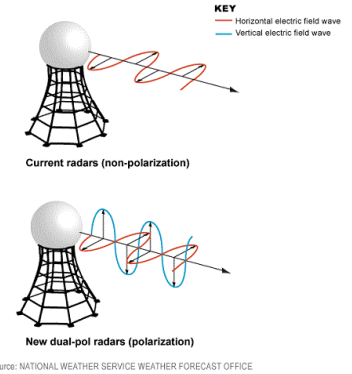
February 25–27, 2015

National Weather Center

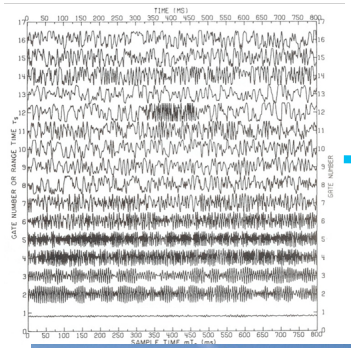
Norman, Oklahoma

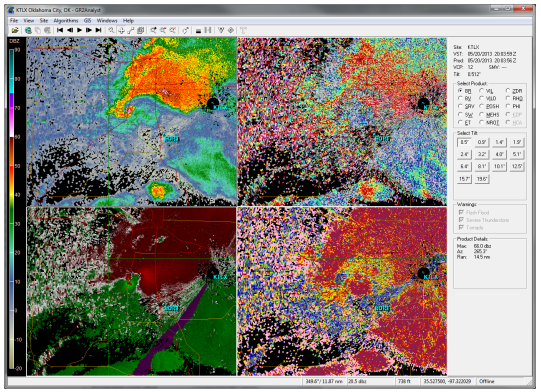
Signal Processing

Waveform Generation → Detection → Sampling → Clutter Filtering → Parameter Extraction



Time series data





Hardware Functions

Software Functions

Adapted from Rich Ice (ROC) presentation at Baron Weather Radar Summit, 7-8 Jan. 2015

Signal Processing – Pre-Doppler (1960s – 1980s)

Waveform Generation → **Detection** → **Sampling** → **Clutter Filtering** → **Parameter Extraction**

Waveform Generation	Detection	Sampling	Clutter Filtering	Parameter Extraction
Uniformly Spaced Pulses	Analog Receiver	Fixed Pulse	Mostly Non-existent	Intensity Display
	Envelope Detection	Antenna Rotation Speed	MTI Radar?	DVIP Levels
			Manual Censoring	Electronically Generated Countours
				Experiments With R-Meters

All Hardware!
Usually with Vacuum Tubes!

Hardware Functions

Software Functions

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Signal Processing – Doppler (1990s)

Waveform Generation → **Detection** → **Sampling** → **Clutter Filtering** → **Parameter Extraction**

- Uniformly Spaced Pulses
- Stable/Coherent Transmit Phase
- Analog Receiver
- Quadrature Phase Detection
- Multiple Pulse Widths
- Selectable Number of Samples
- IIR Notch Filters
- Two-Pulse Canceler
- Clutter Maps
- Covariance Estimators (Velocity, Spectrum Width)
- RV Mitigation: Dual Scans Dual PRFs
- Noise Measurement
- SNR and Strong Point Censoring

Hardware Functions

Software Functions

Adapted from Rich Ice (ROC) presentation at Baron Weather Radar Summit, 7-8 Jan. 2015

Signal Processing – Dual Polarization (2000s)

Waveform Generation → **Detection** → **Sampling** → **Clutter Filtering** → **Parameter Extraction**

- Uniformly Spaced Pulses
- Phase Coded Pulses
- Dual Polarization

Hardware Functions

Software Functions

- Digital IF Receiver (14 bits)
- Digital Matched Filter

- "Indexed" Radials
- Selectable Volume Resolution

- Adaptive Spectral Filter
- Two-Pulse Canceler
- Clutter Identification

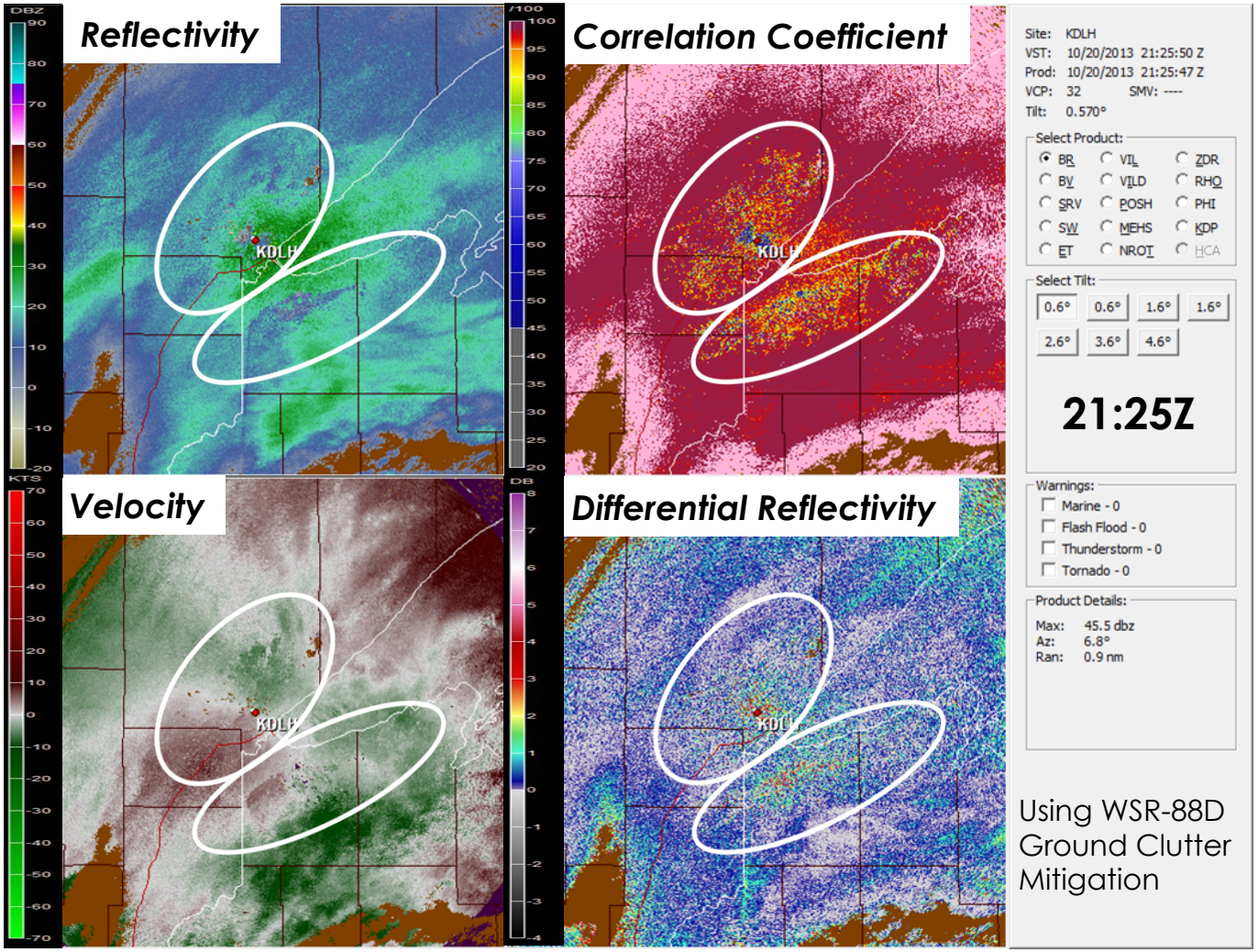
Adapted from Rich Ice (ROC) presentation at Baron Weather Radar Summit, 7-8 Jan. 2015

- Covariance Estimators (Dual Pol. Parameters, Hybrid SW)
- RV Mitigation: Dual Scans Dual PRFs Phase Coding
- Noise Measurement
- SNR and Strong Point Censoring

Ground Clutter Mitigation using Dual Polarization

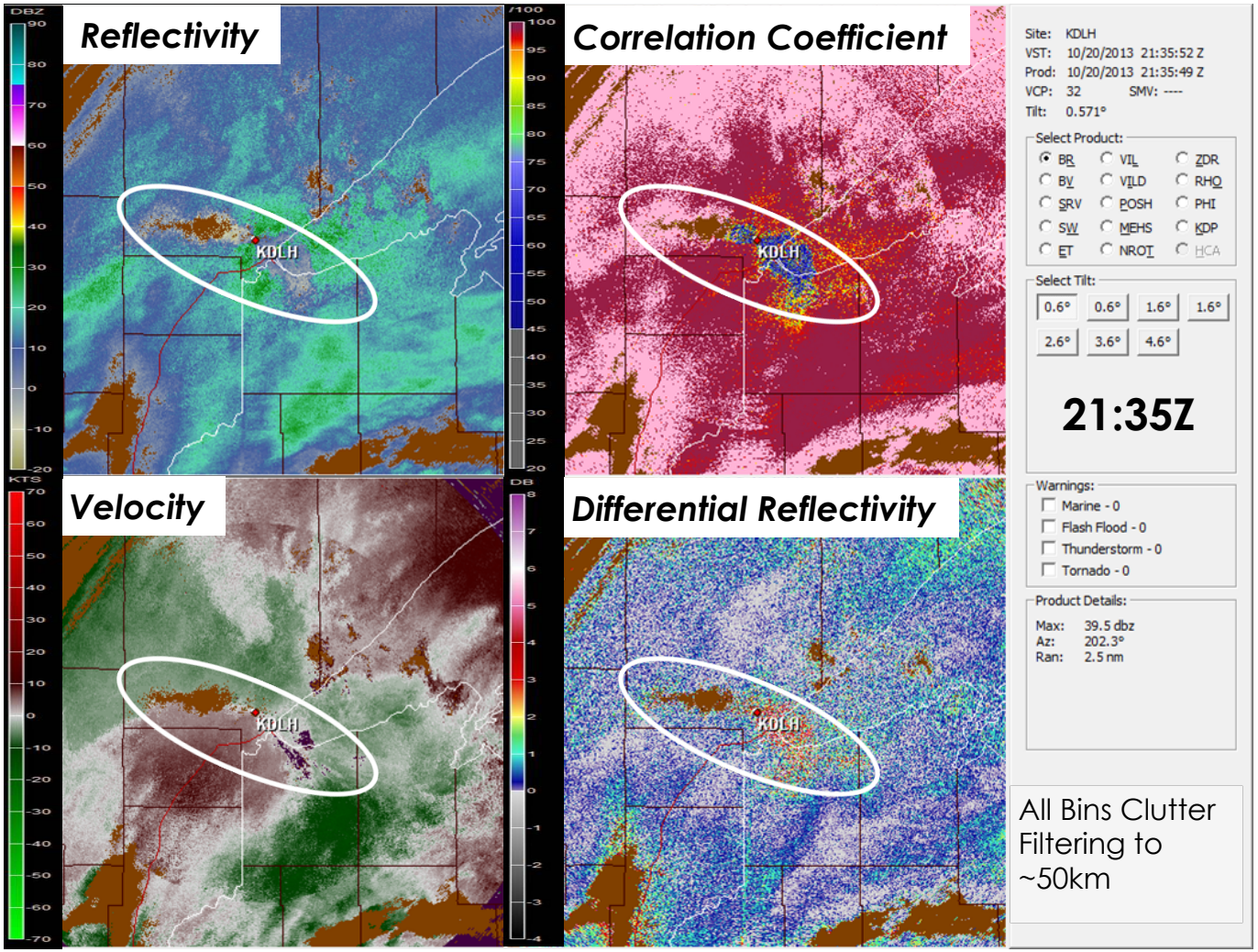
- **Ground Clutter** obscures meteorological data
  - All meteorological variables are affected
  - Contamination characterized by
    - Near zero Doppler velocity
    - Very narrow spectrum width (i.e., small velocity distribution)
- **Ground Clutter Filters** mitigate contamination
  - May not remove all of the contaminant
  - May remove some of the weather signal
    - Near zero Doppler velocity
  - Misapplication degrades data quality!

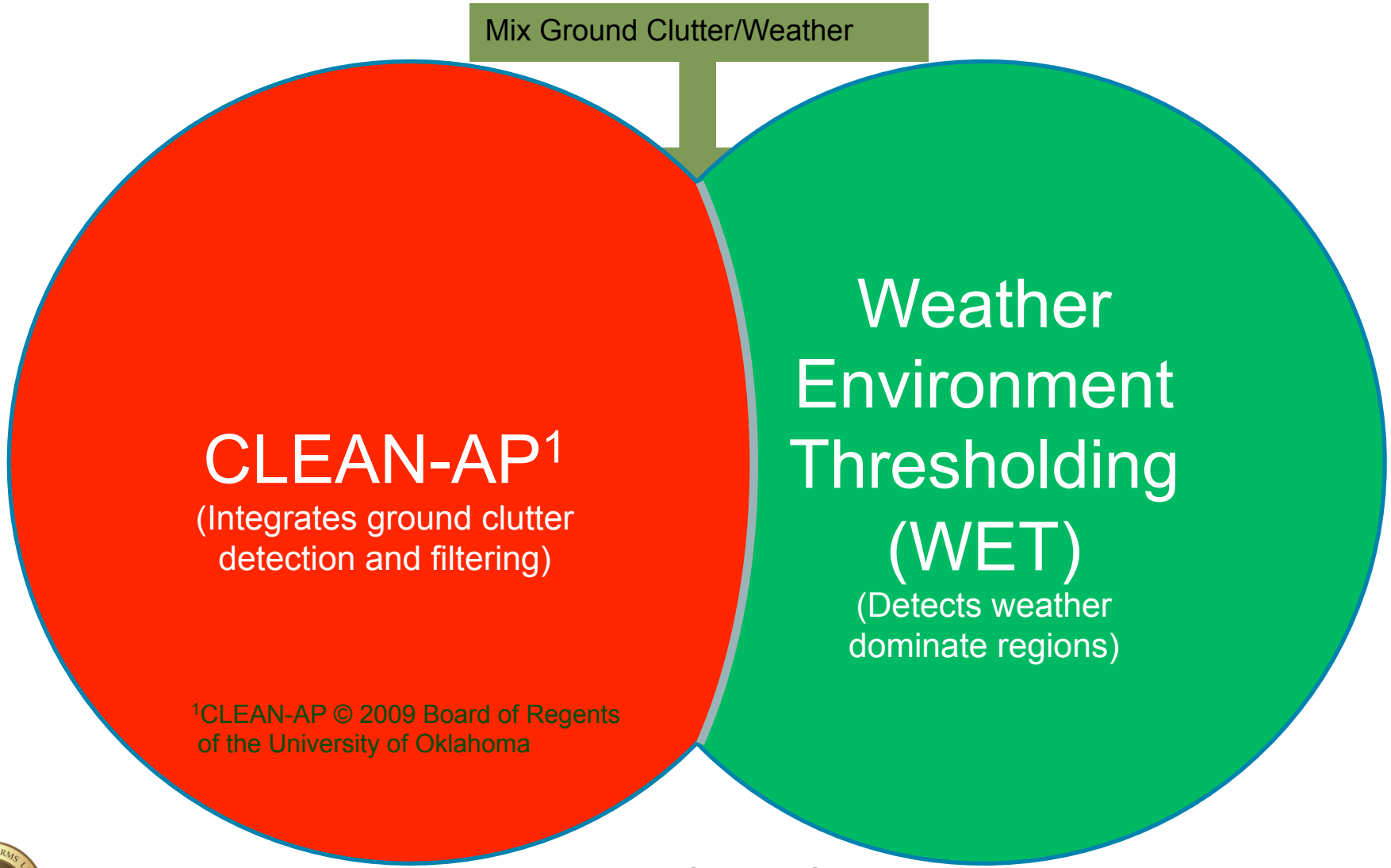
Snowing in Duluth, MN



Using WSR-88D Ground Clutter Mitigation

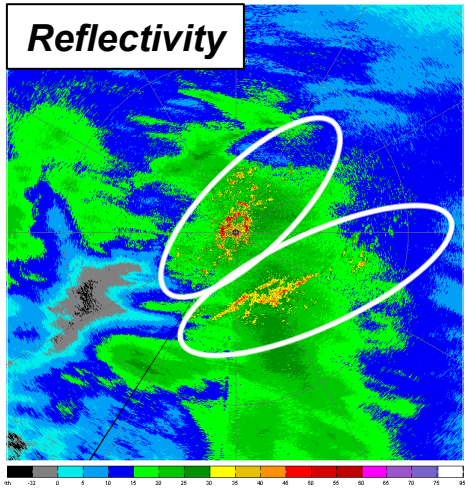
Snowing in Duluth, MN

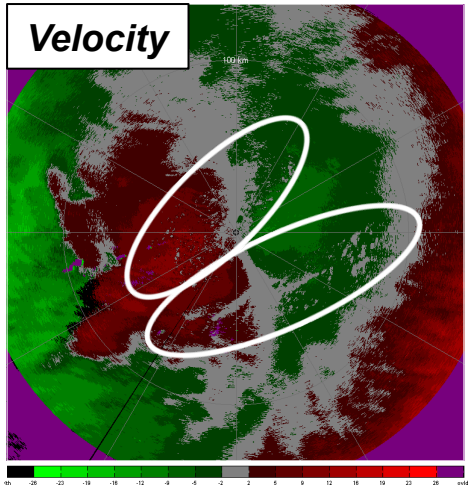


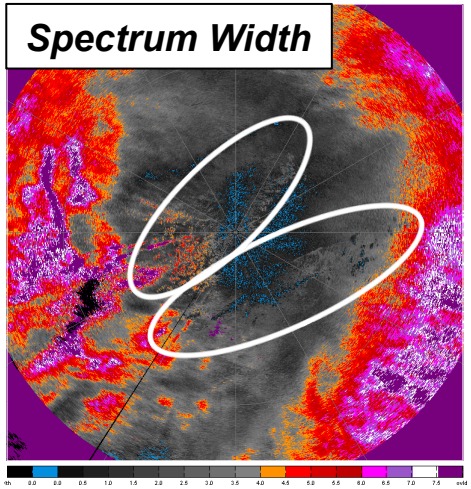


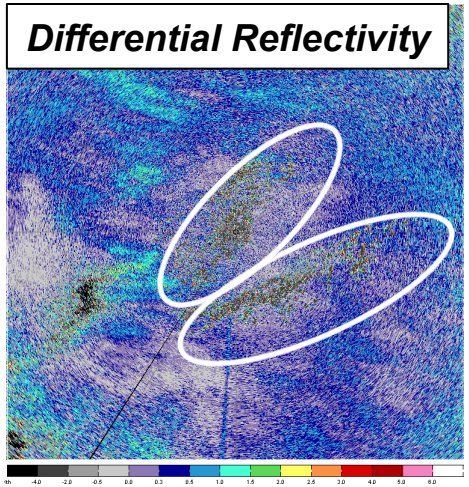
[1]CLEAN-AP © 2009 Board of Regents of the University of Oklahoma

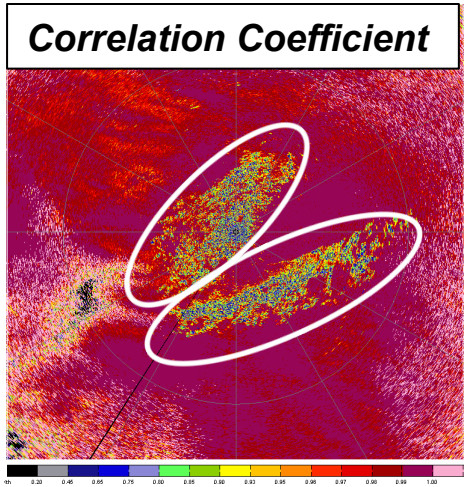
Once Again… Snowing in Duluth, MN

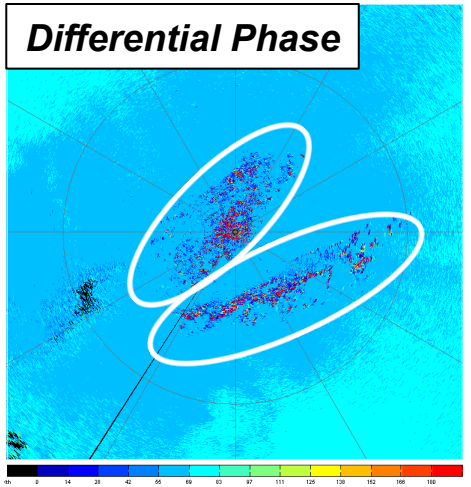






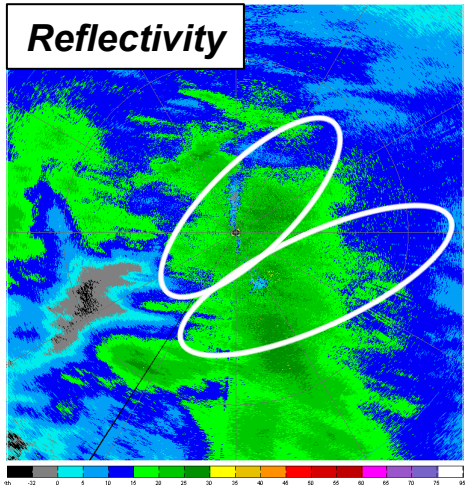


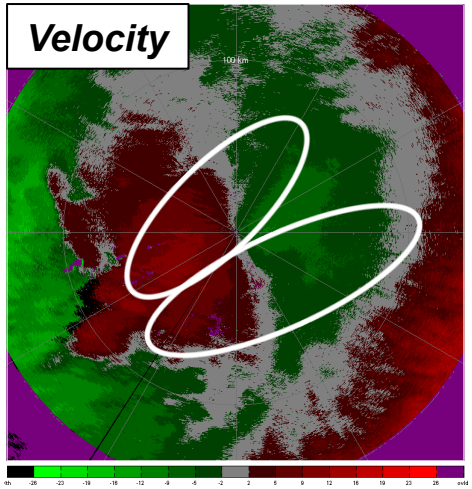


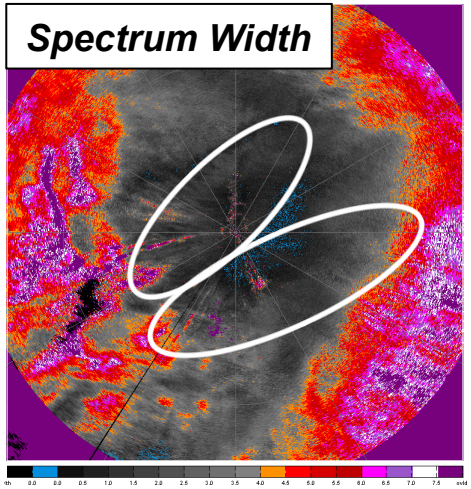


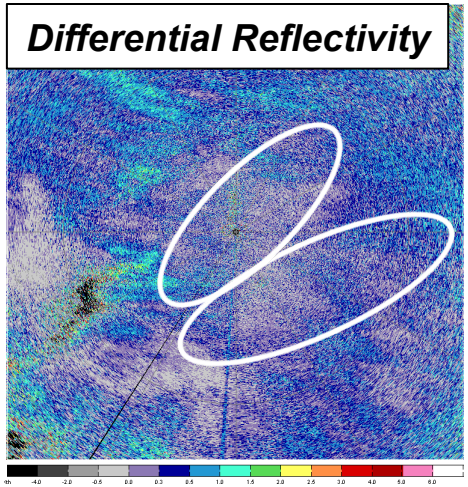
Unfiltered

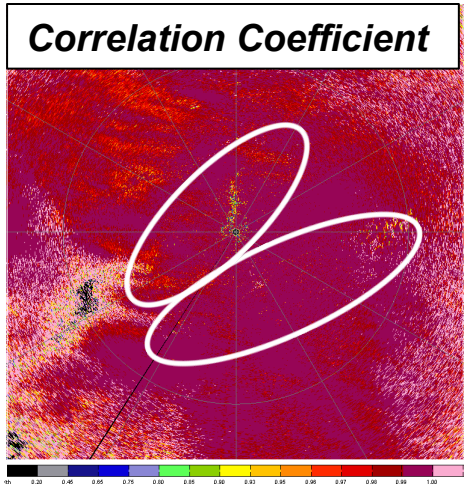
Once Again… Snowing in Duluth, MN

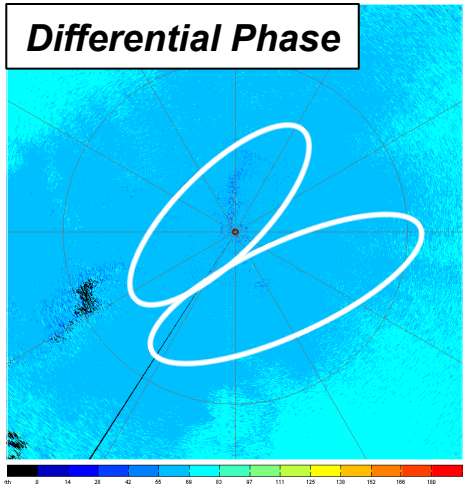












WET/CLEAN-AP

Summary of R2O Activities

Transferring Innovative Techniques to the NEXRAD Network

Recent Transfers

- Staggered pulse repetition time (PRT)
- CLEAN-AP (uniform PRT and staggered PRT)
- SZ-2 censoring
- Polarimetric-variable-specific SNR thresholds
- Less tapered window for super-resolution DP variables
- Coherency-based thresholding
- Noise estimator

Summary of R2O Activities

Transferring Innovative Techniques to the NEXRAD Network

Ready for Transfer

- Improved spectrum width estimator
- Improved correlation coefficient estimator
- Range oversampling processing
- Combining H&V autocovariance estimates for Doppler velocity estimates

Summary of R2O Activities

Transferring Innovative Techniques to the NEXRAD Network

Research in Progress

- Combining autocovariance estimates from different scans for DP variables
- Multi-lag estimators for DP variables
- Using differential-phase information to improve the mitigation of ground clutter (WET)
- Pulsed-interference filter

Summary of R2O Activities

Transferring Innovative Techniques to the NEXRAD Network

Planned Research

- Wind turbine clutter mitigation
- Spatial reconstruction of censored data
- Ground clutter mitigation using spectral decomposition of DP variables
- Artifacts removal and data quality improvement using range-Doppler spectrum