Dual-Pol Radar Data: A Brief Primer
and
A Few Brief Pseudo-Operational Exercises

(Courtesy of)

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What Will Be New with Dual-Pol?

Same VCPs

10 cm Wavelength

1.2 degree effective beam width

Reflectivity/ Velocity/ Spectrum Width unchanged

New Products:

Differential Reflectivity (ZDR)

Correlation Coefficient (CC)

Specific Differential Phase (KDP)

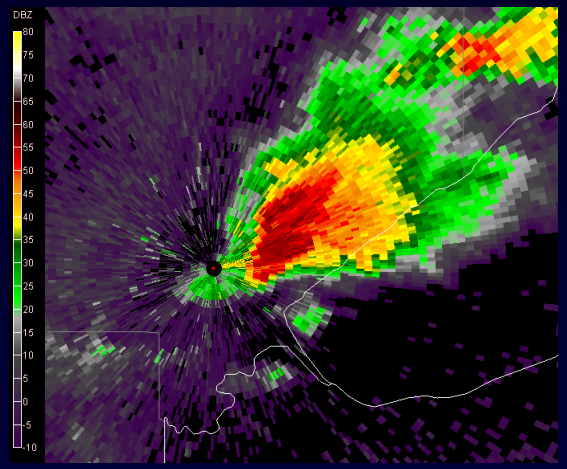
Melting Layer (ML)

Hydrometeor Classification (HC)

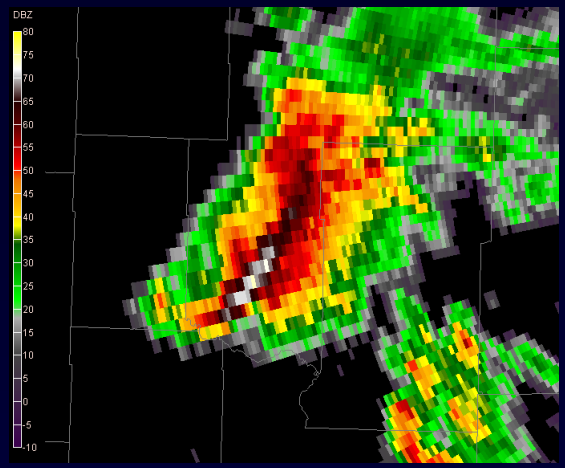
Quantitative Precipitation Estimation (QPE) (9 Products)

Why Upgrade to Dual-Pol?

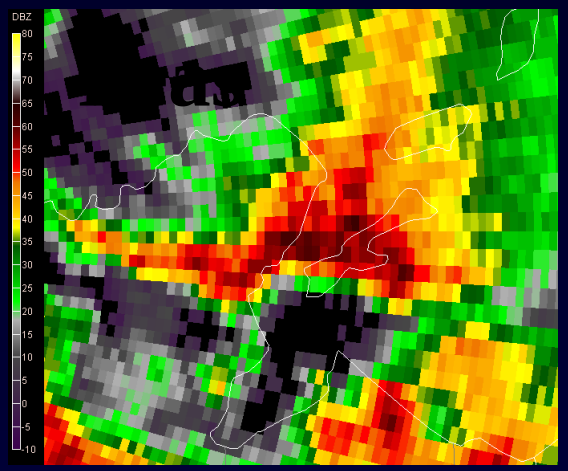
Thunderstorm examples



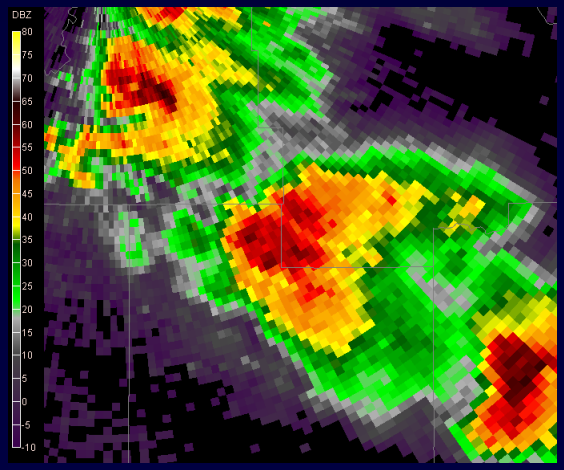
Softballs



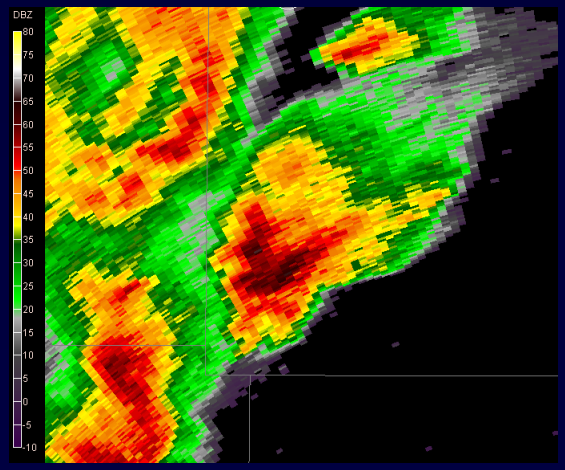
Quarters/Golf Balls



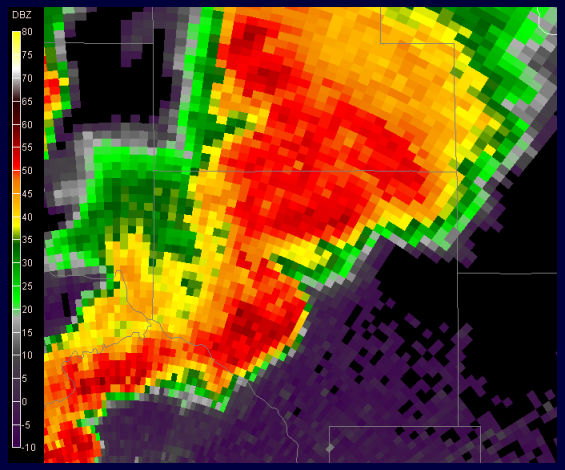
Peas/Torrential Rain



Grapefruit



Quarters 4 inches deep

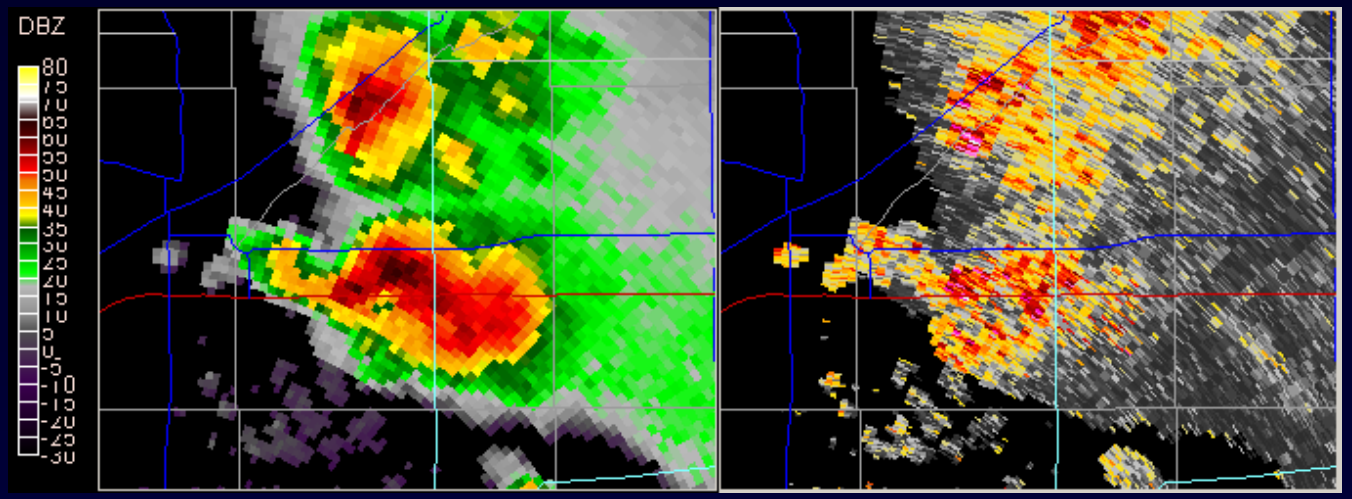


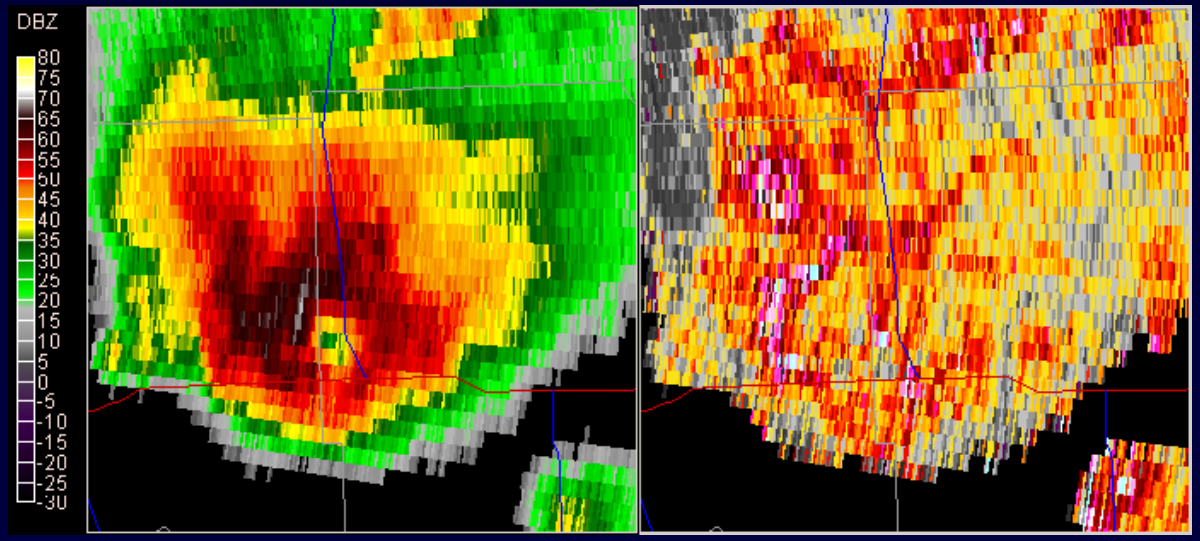
Pennies

Why Upgrade to Dual-Pol?

Giant Hail examples

Aurora, NE
Supercell
6/22/2003

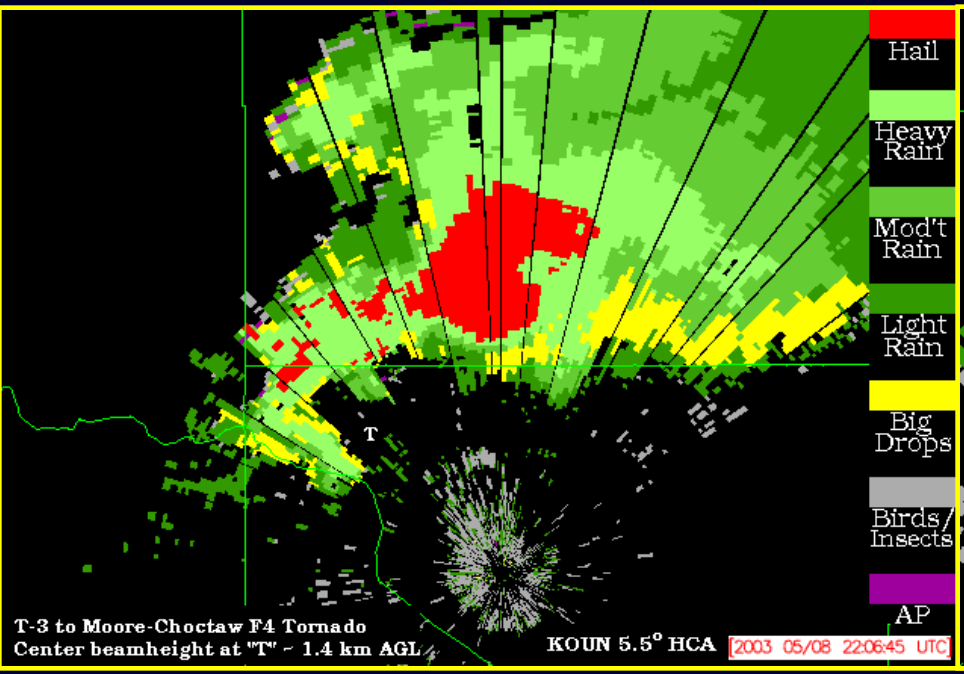




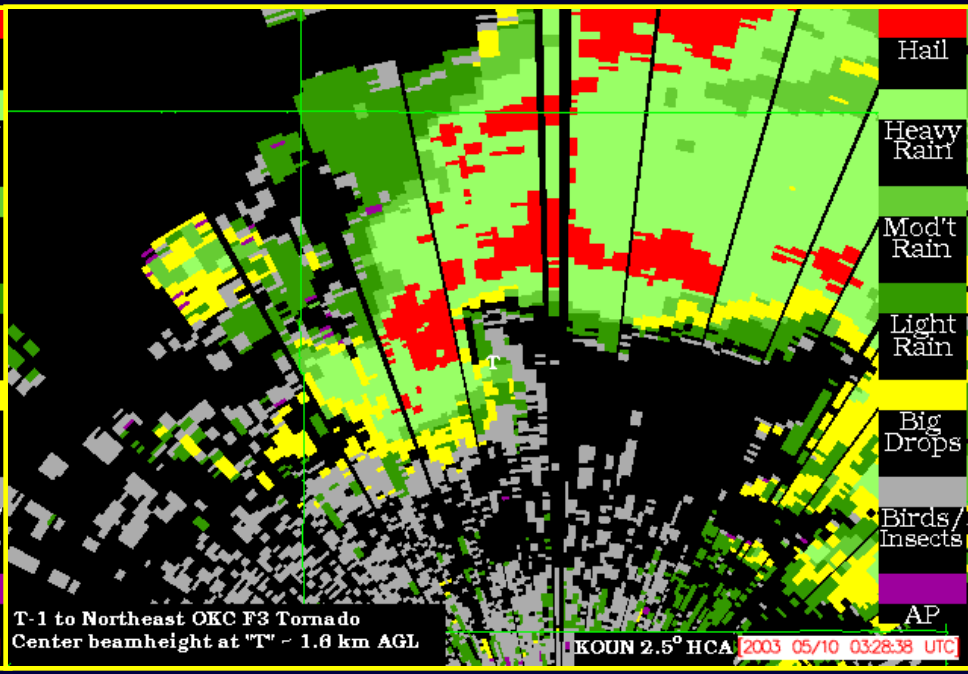
Vivian, SD
Supercell
7/23/2010

Why Upgrade to Dual-Pol?

Supercell Hydrometeor Distribution



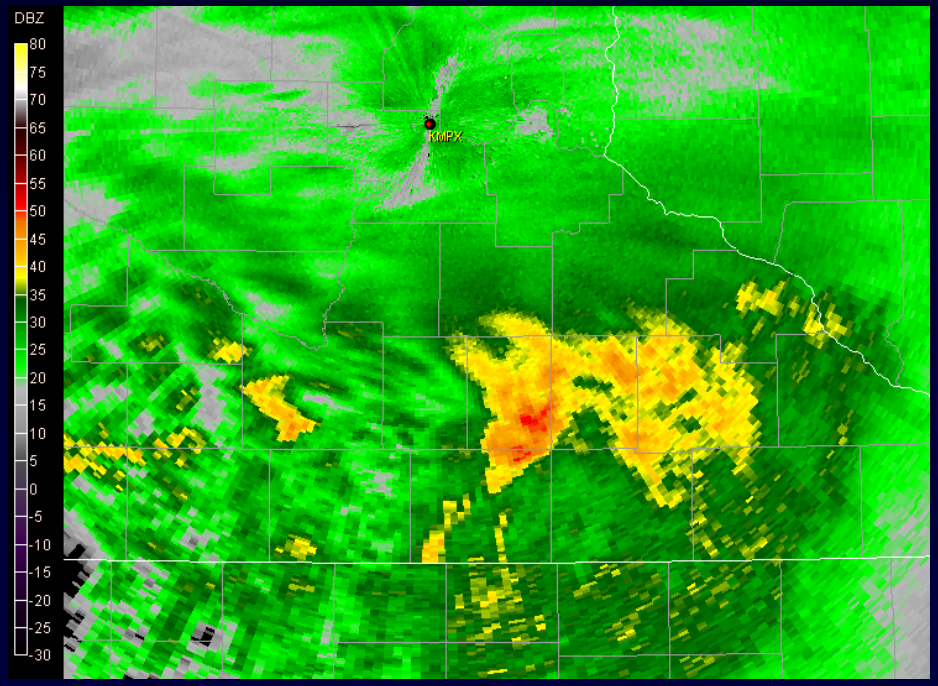
8 May 2003



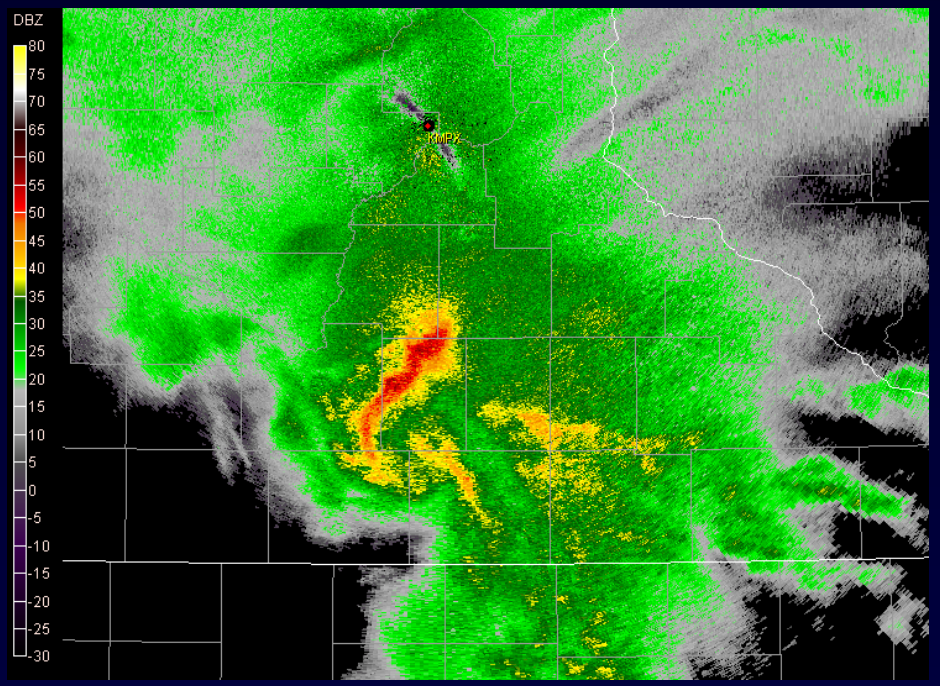
9 May 2003

Why Upgrade to Dual-Pol?

Winter Storm Examples



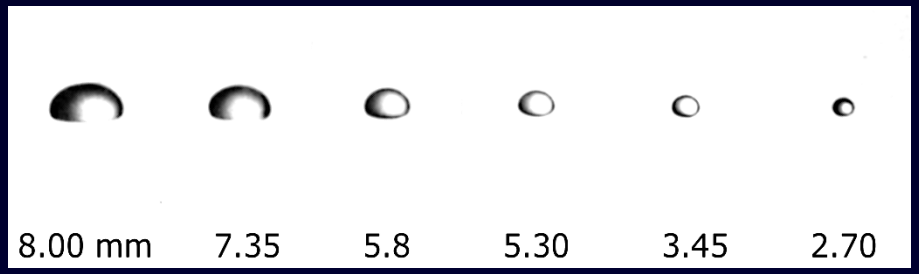
Melting Layer: Mixed precip



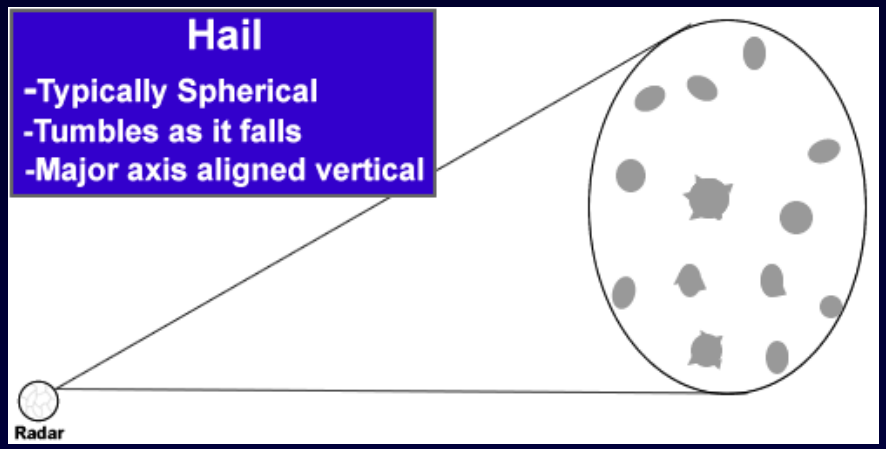
Wet Aggregates:

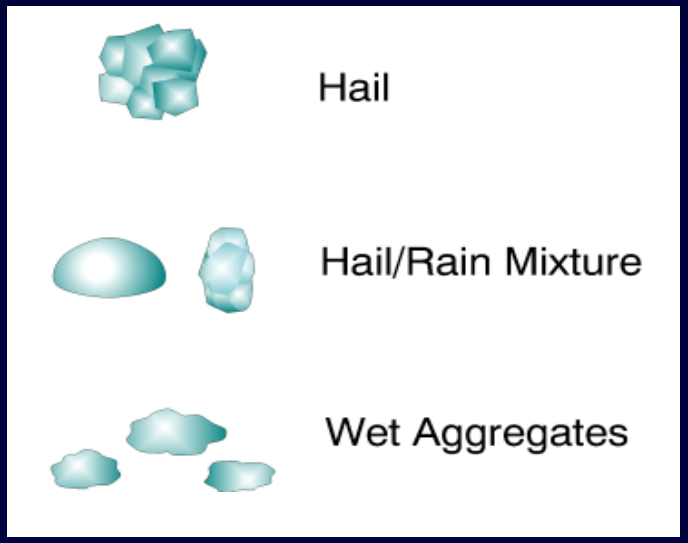
3 Inch/hour Snowfall Rates

Radar Sampling: The Dirty Details



Raindrops fall as oblate spheriods





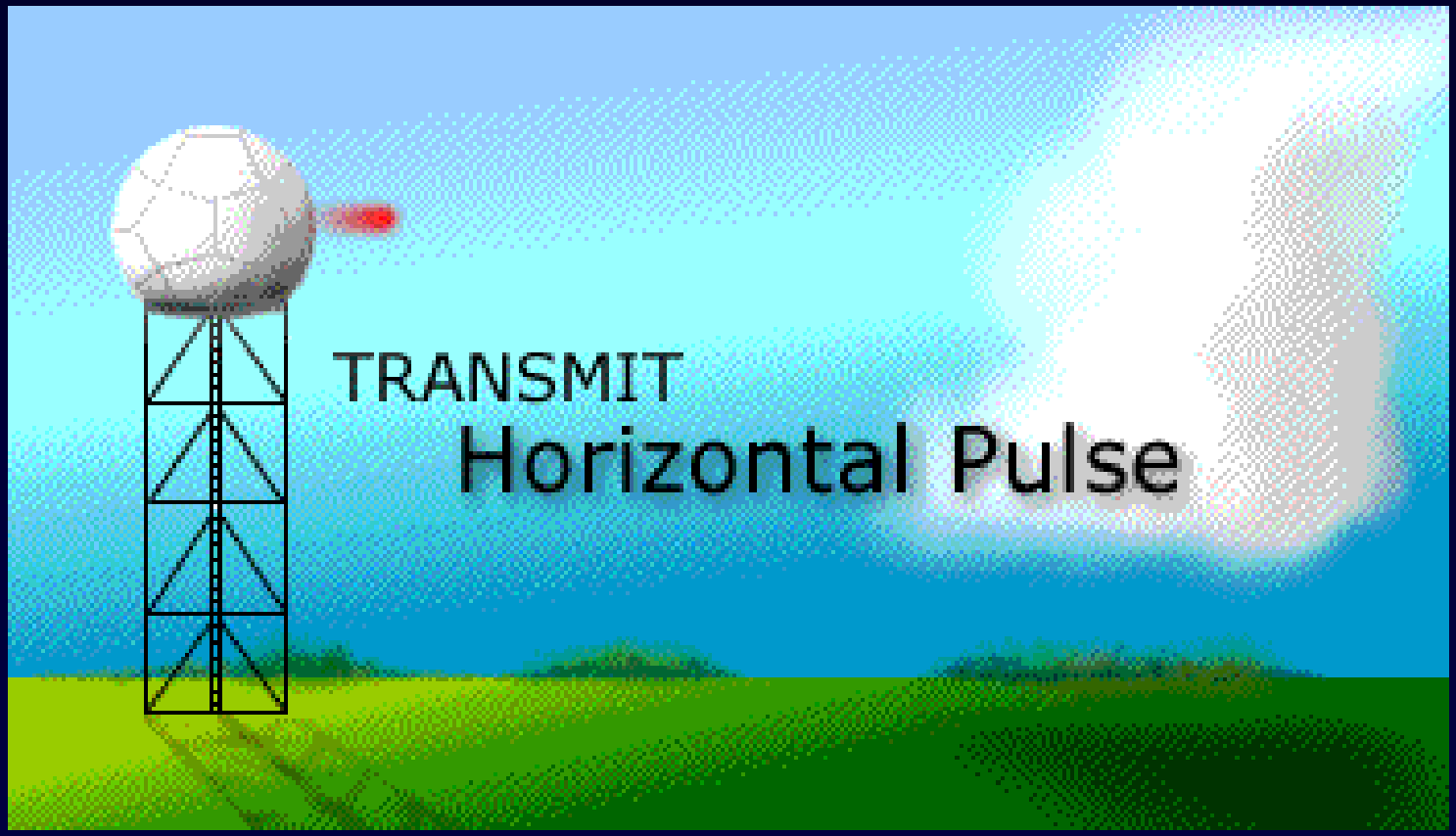
Power Return is proportional to

$$\sum n^6$$

Hydrometeor size/phase and fall speed diverstiy

Dual-Pol Radar Basics

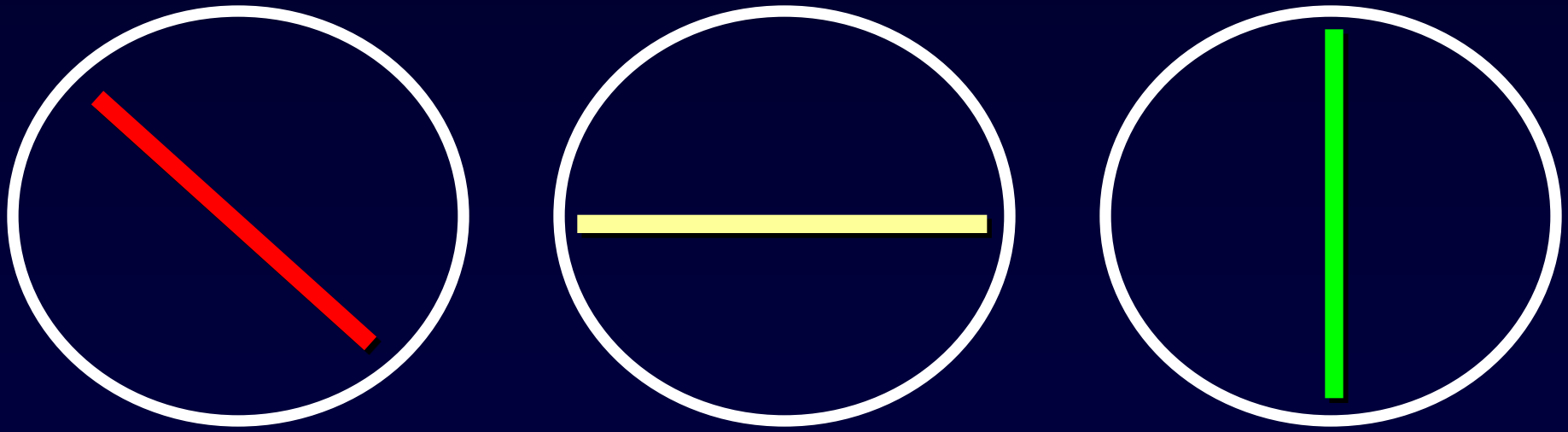
Pulse Transmit/Receive Schematic



Dual-Pol Radar Basics

WSR-88DPulse Transmit/Receive Schematic

Looking "Down Beam"



Transmit Pulse polarized at 45 degree angle

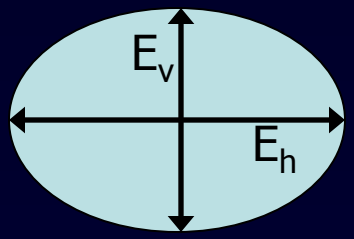
Receive and Process the returned vertically and horizontally returned power separately

Differential Reflectivity (ZDR)

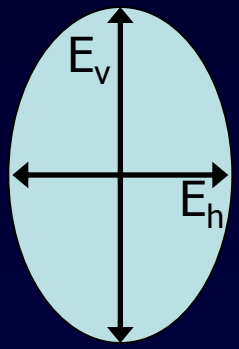
Simply a ratio of returned horizontal to vertical power

$$Z_{DR} = 10 \log_{10} \left(\frac{Z_{hh}}{Z_{vv}} \right)$$

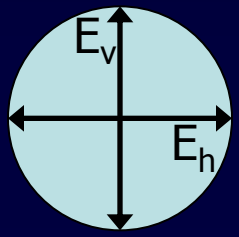
Differential Reflectivity (ZDR)



- **ZDR > 0 → Horizontally-oriented mean profile**

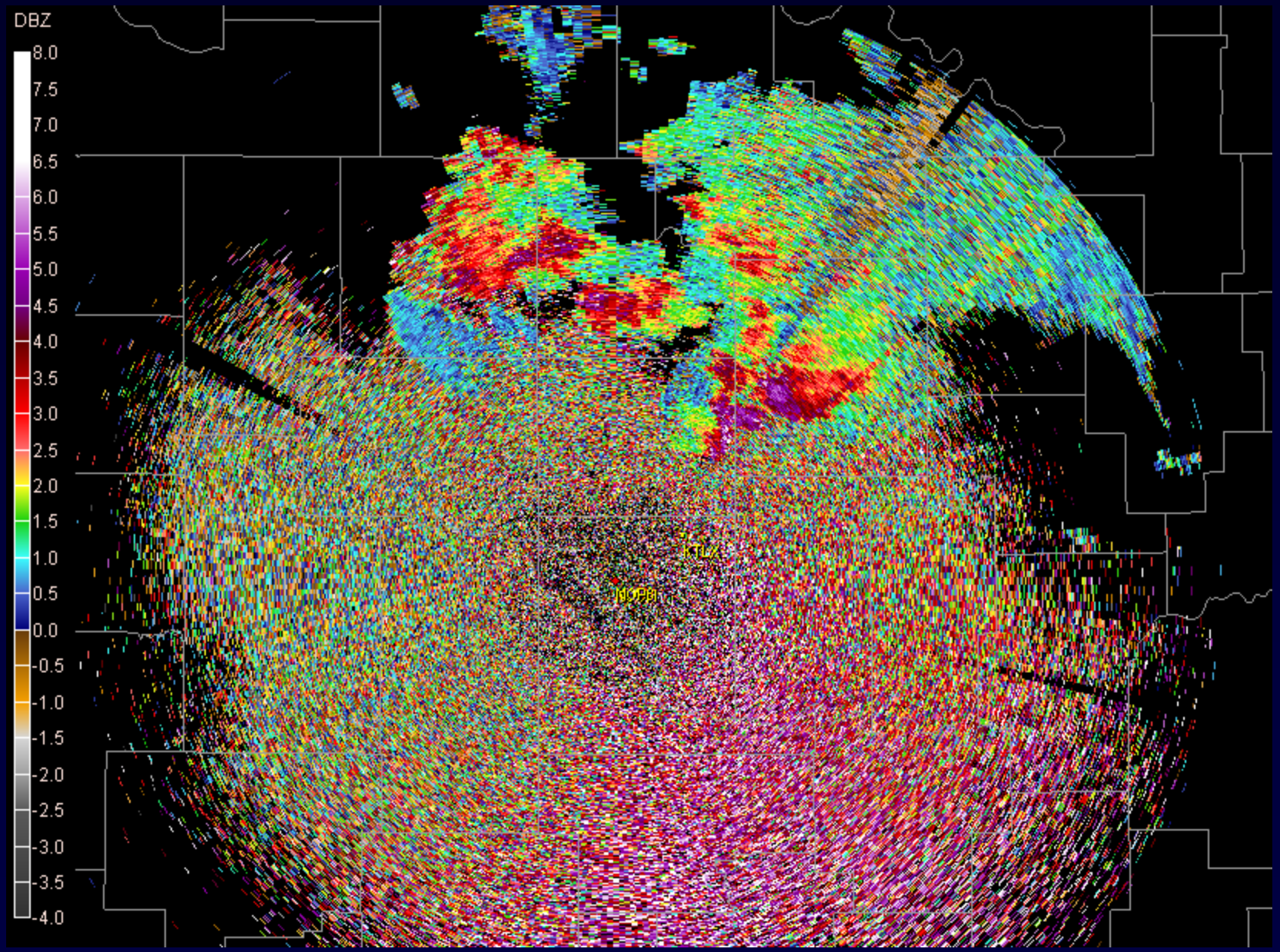


- **ZDR < 0 → Vertically-oriented mean profile**



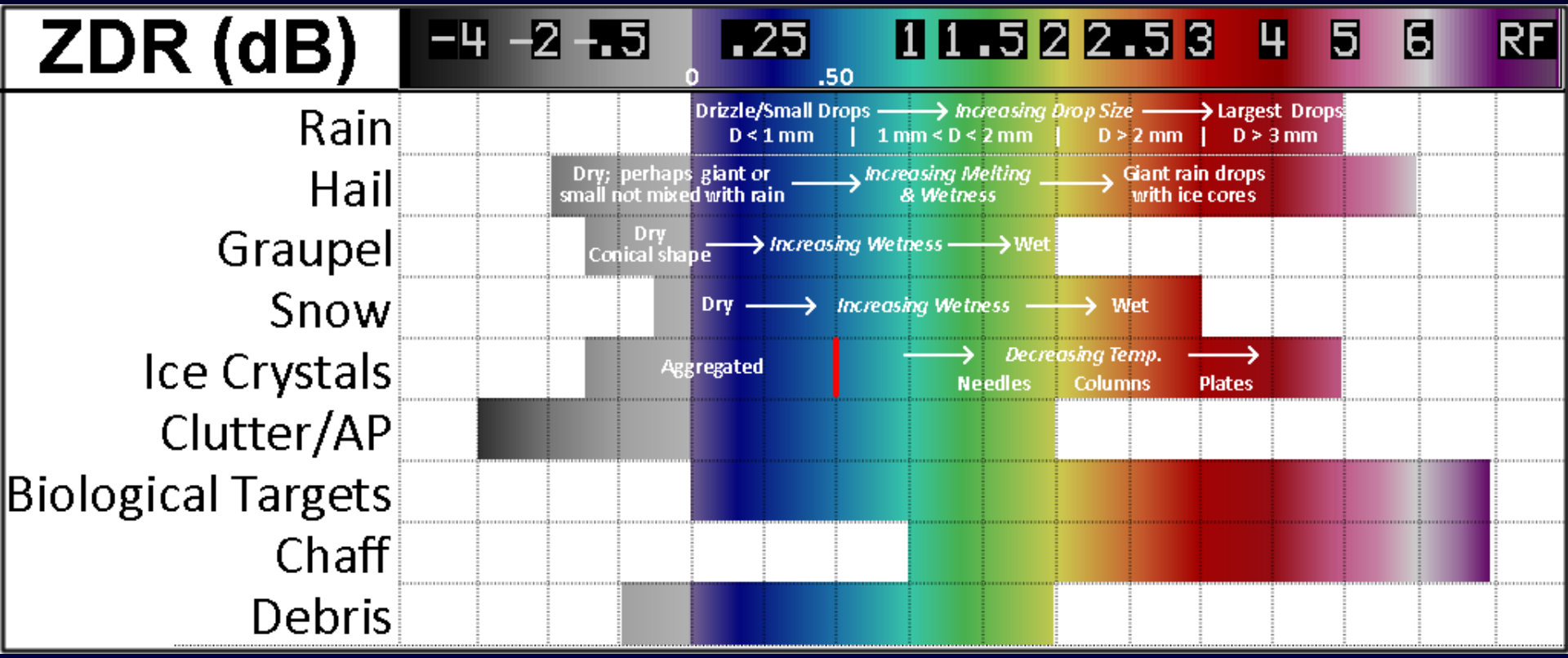
- **ZDR ~ 0 → Near-spherical mean profile**

Differential Reflectivity (ZDR)



Differential Reflectivity (ZDR)

Typical Data Ranges for ZDR



Correlation Coefficient (CC)

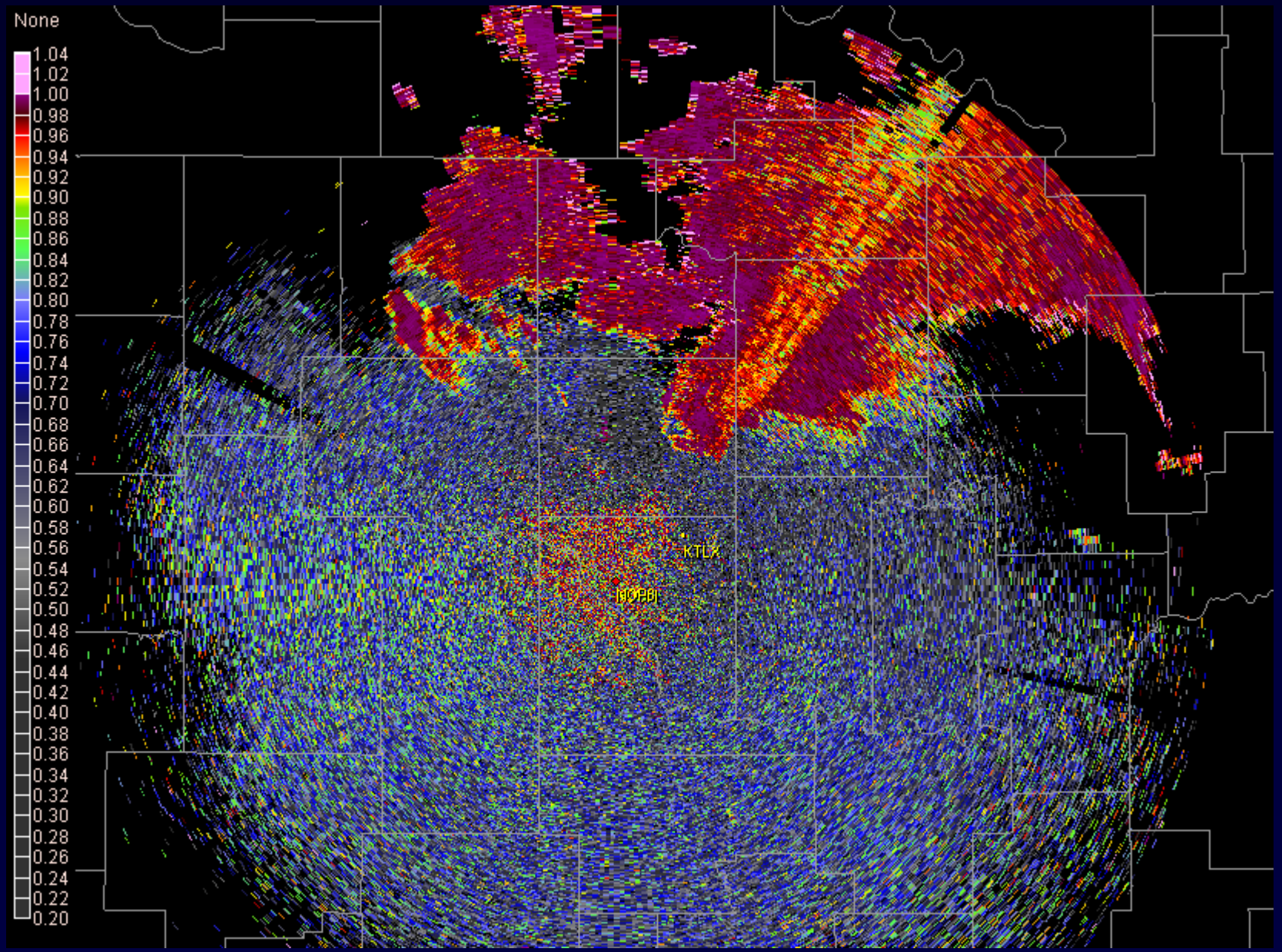
How similarly the horizontally and vertically polarized backscattered energy are behaving within a resolution volume for Rayleigh scattering

$$\left|\rho_{HV}(0)\right| = \frac{\left\langle S_{vv} S_{hh}^{*} \right\rangle}{\left(\left\langle S_{hh}^{2} \right\rangle^{1/2} \left\langle S_{vv}^{2} \right\rangle^{1/2} \right)}$$

Excellent discriminator for the presence of mixed hydrometeor phases and/or non-meteorological echoes

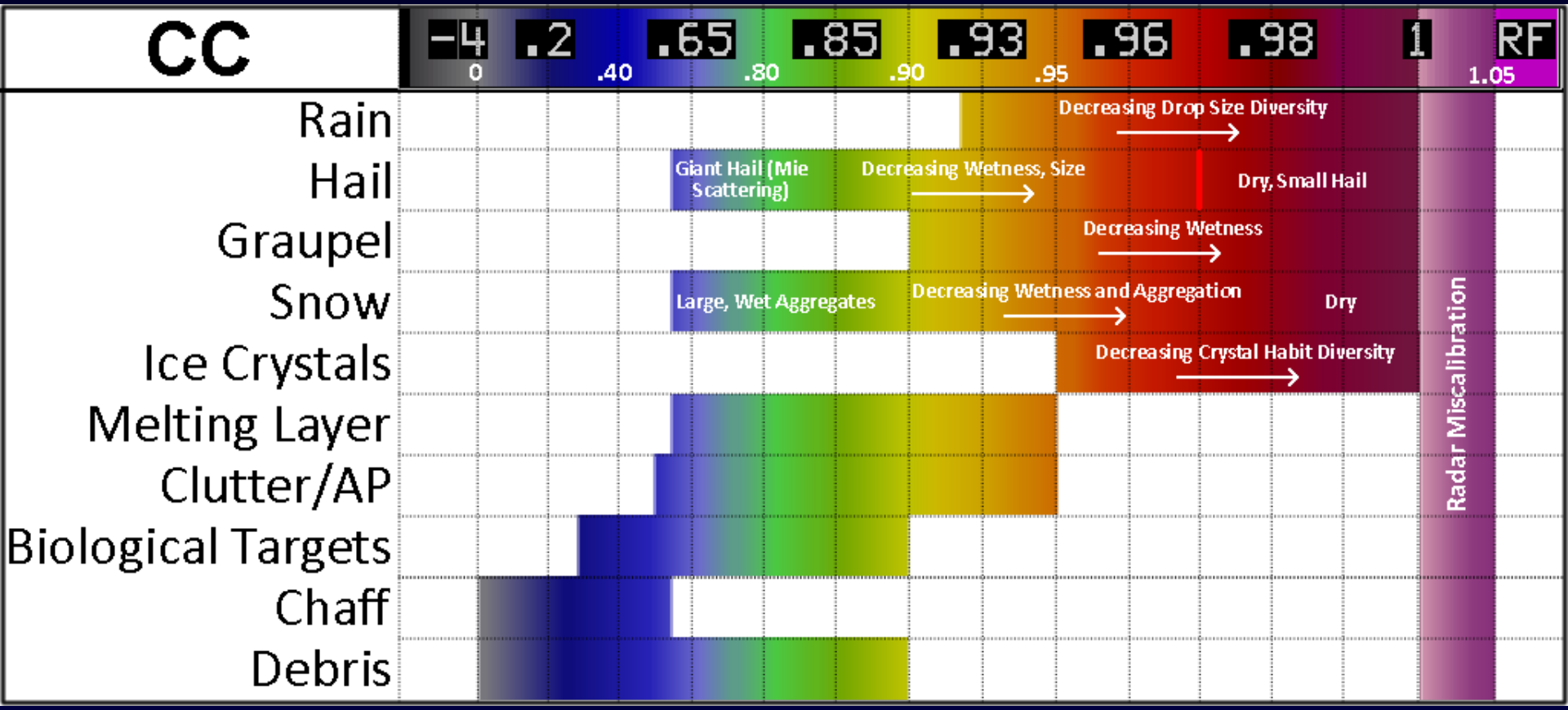
Think Spectrum Width for Hydrometeors™

Correlation Coefficient (CC)



Correlation Coefficient (CC)

Typical Data Ranges for CC - note color table is logarithmic



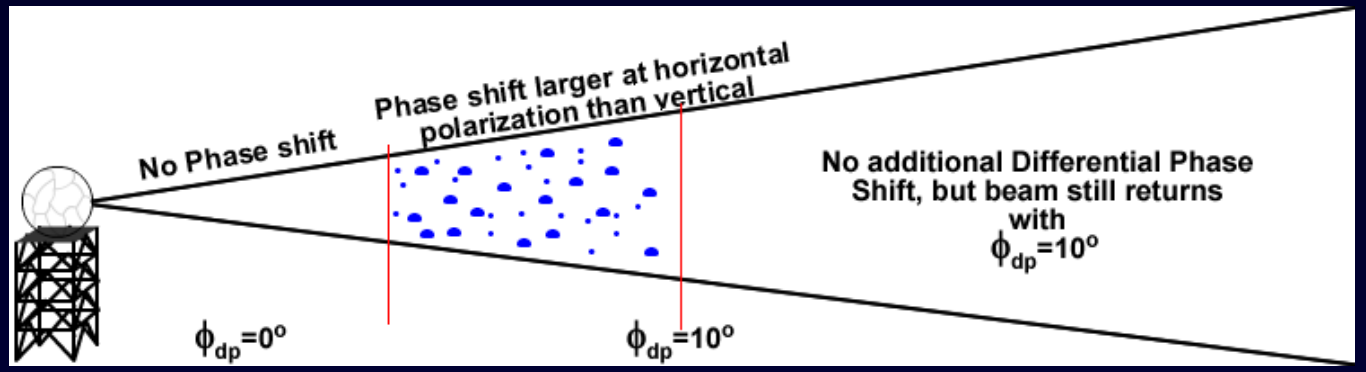
Differential Phase (Φ_{DP})

Measure of the phase difference between horizontal and vertical polarized pulses: ***Propagation Effect***

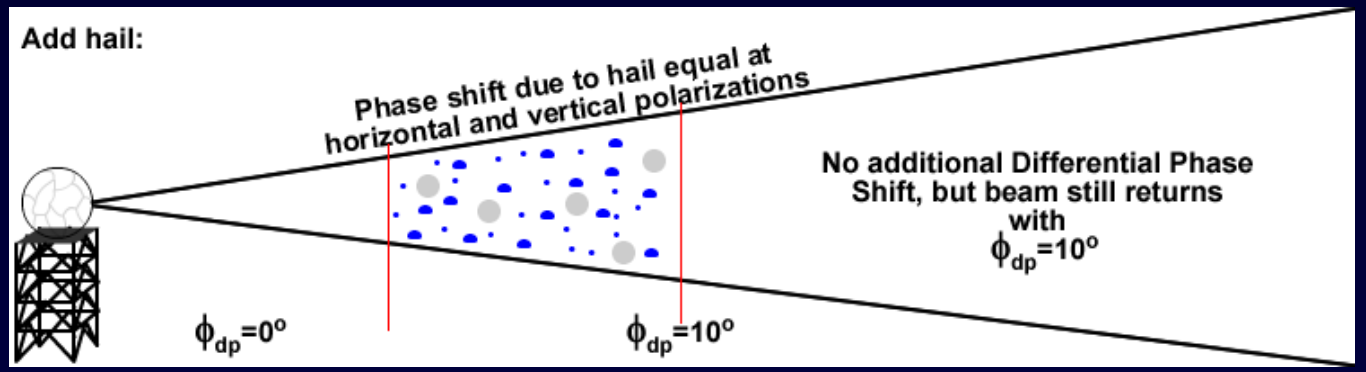
$$\Phi_{DP} = \Phi_{H} - \Phi_{V}$$

Differential Phase (Φ_{DP})

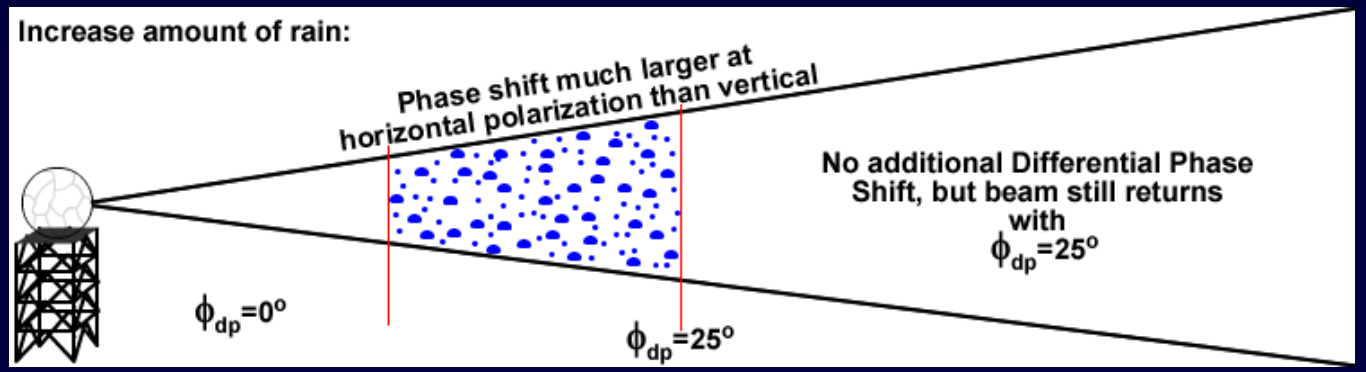
Rain



Rain + Hail



Heavy Rain



Specific Differential Phase (KDP)

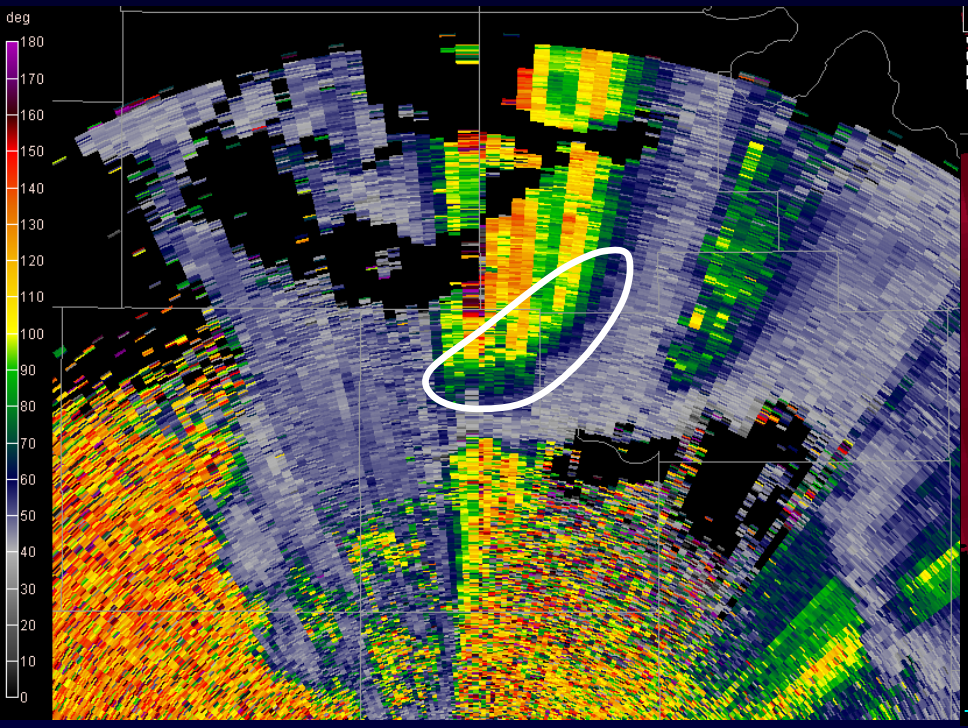
Simply the Range Derivative of Differential Phase

$$K_{DP} = \frac{\phi_{DP}(r_2) - \phi_{DP}(r_1)}{2(r_2 - r_1)}$$

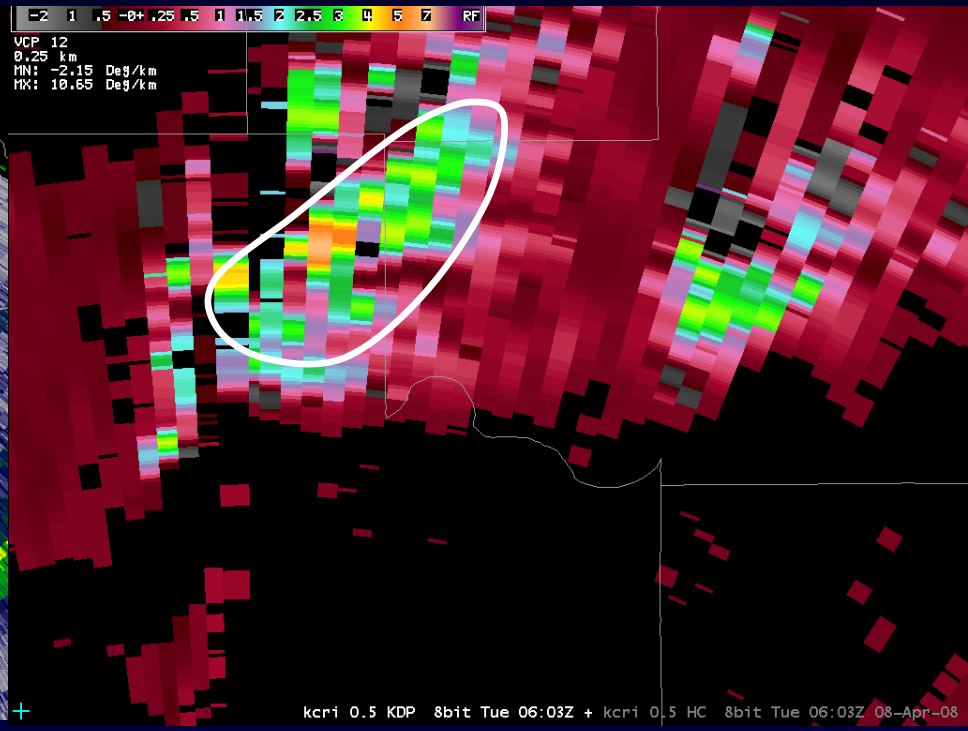
Immune to partial (< 40%) beam blockage, attenuation, calibration, presence of hail

Excellent indicator of liquid water hydrometeor content within sample volume

Specific Differential Phase (KDP)



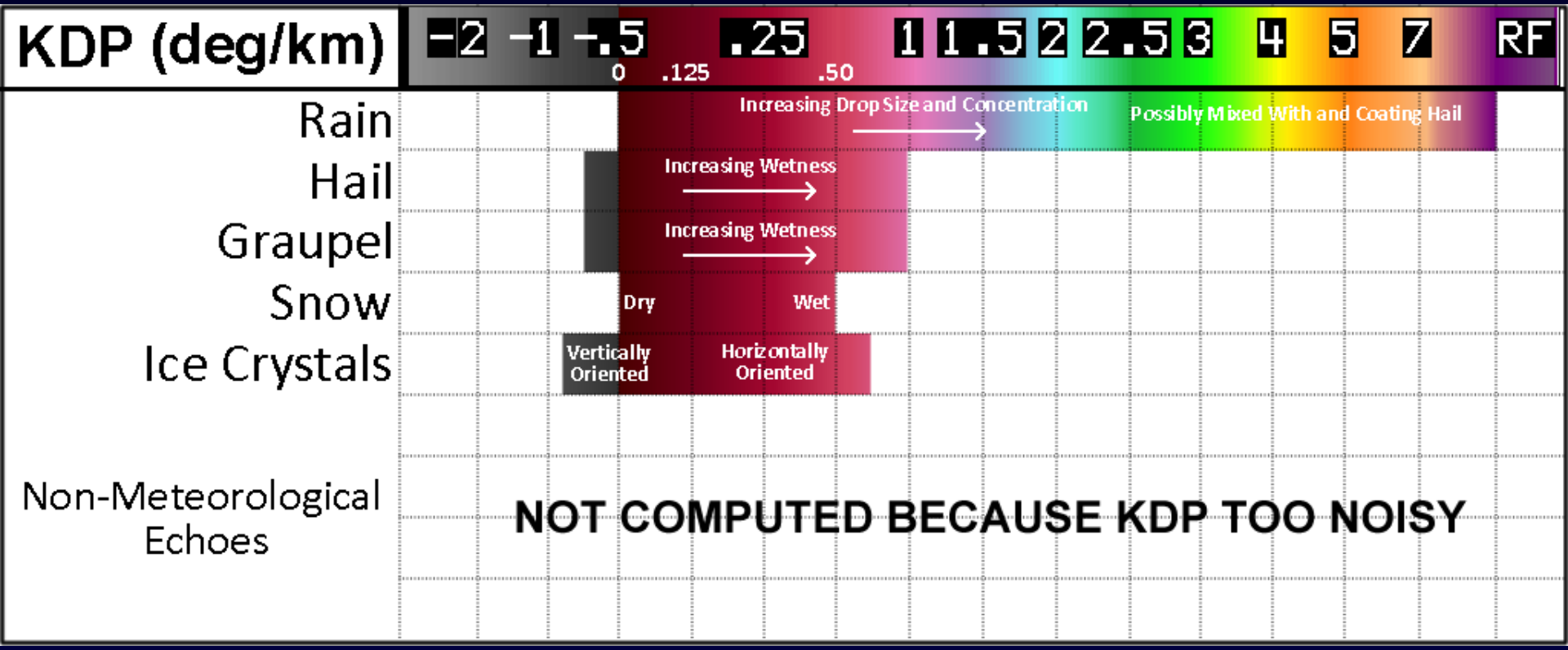
Φ_{DP}



KDP

Specific Differential Phase (KDP)

Typical Data Ranges for KDP



What Will Be New with Dual-Pol?

Biggest fundamental change to our most critical warning decision-making dataset since the advent of the WSR-88D network 15-20 years ago

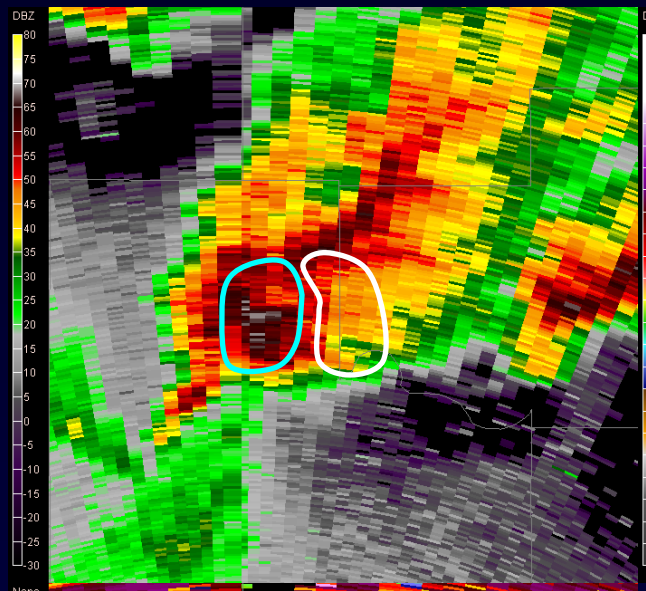
New dual-pol base moment *CANNOT* be used in a vaccum! They MUST be used in complement with each other (similar to spectrum width now)

Pseudo-Operational Case Examples:

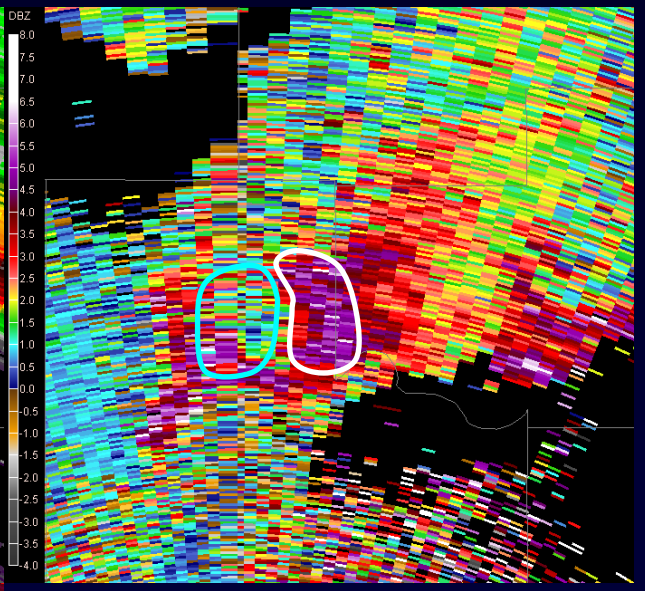
You Determine the Hydrometeor Type

Exercise 1

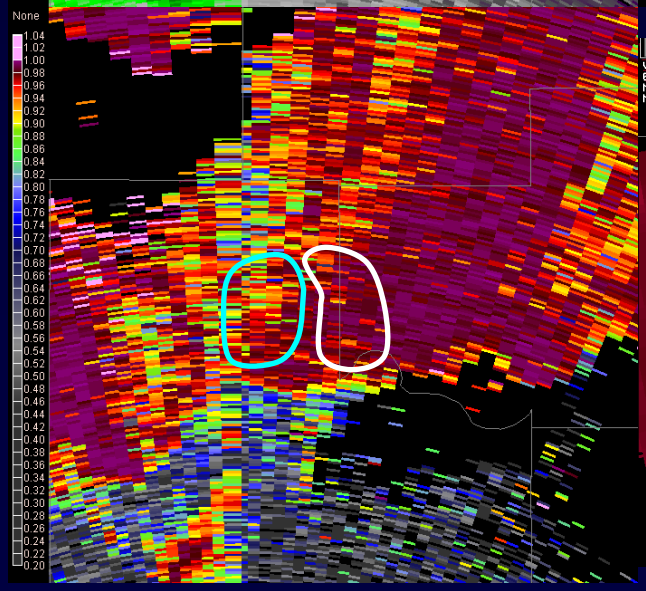
Z:
65-70 dBz
45-50 dBz



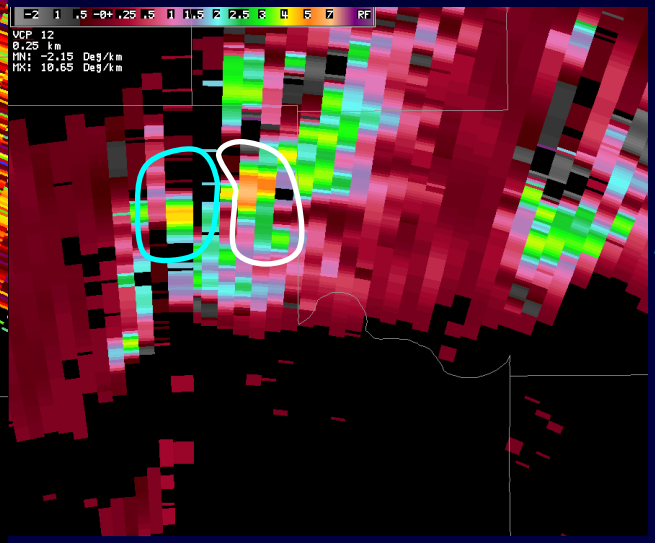
ZDR:
0 to 1 dBz
4 to 7 dBz



CC:
0.92-0.97
0.97-1.00



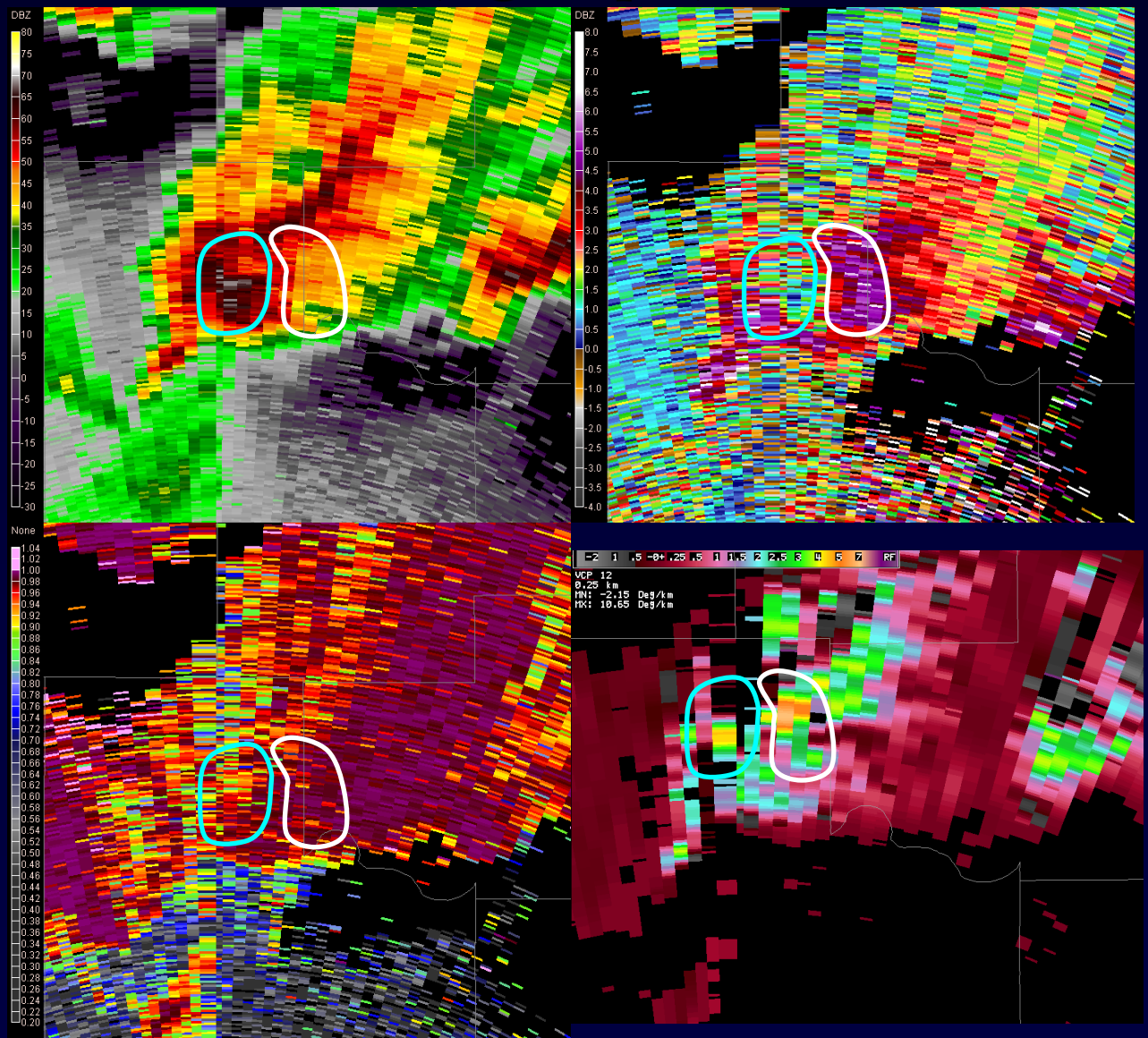
KDP:
3-6 deg/km
5-7 deg/km



Exercise 1: Summary

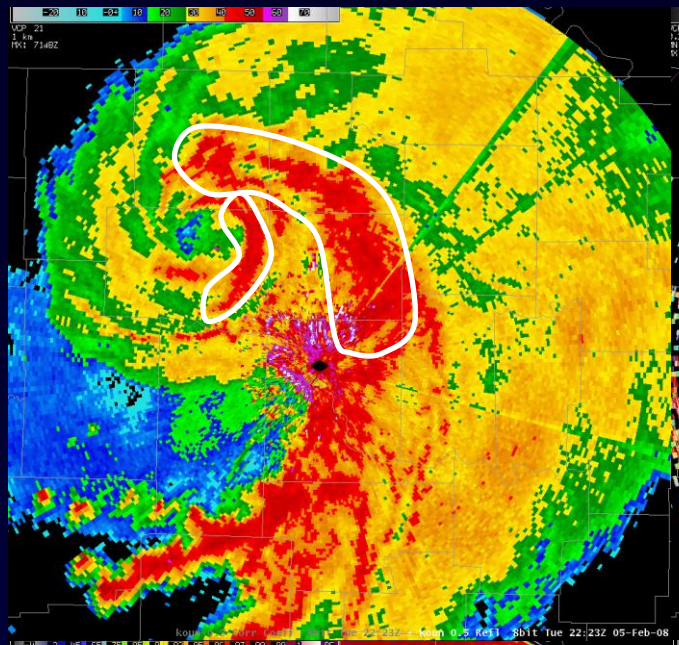
Blue: Heavy Rain and Hail (shedding drops/large hail?)

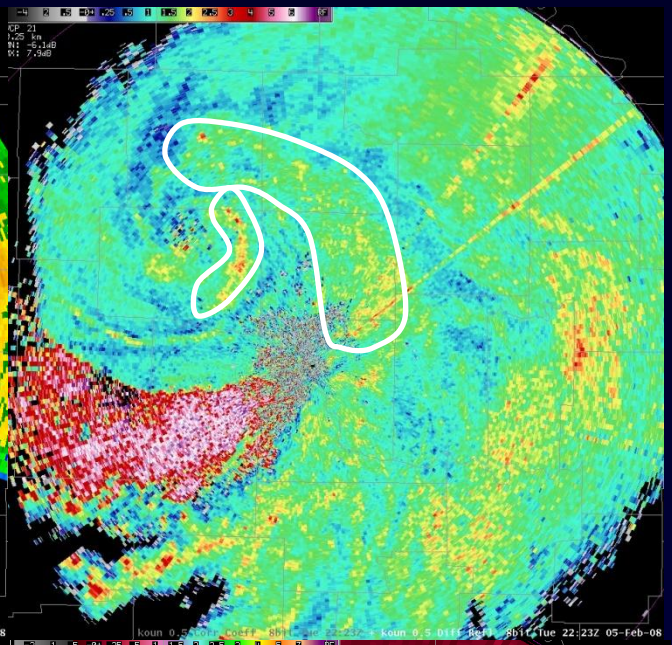
White: Torrential Rain (big drops?)



Exercise 2

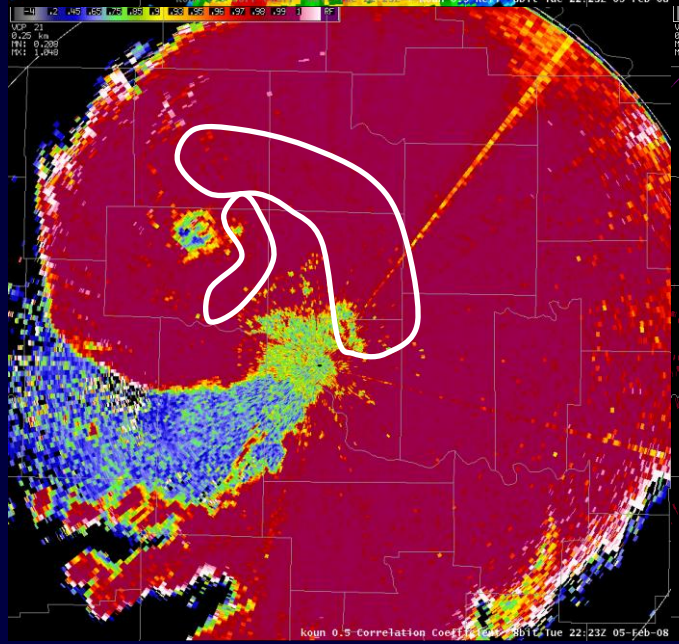
Z:
50-55 dBz

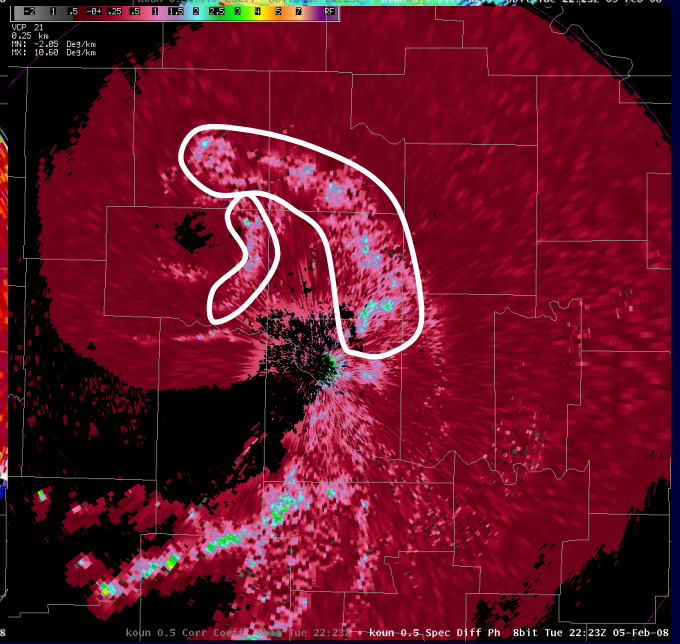




ZDR:
1.5-3 dBz

CC:
> 0.98

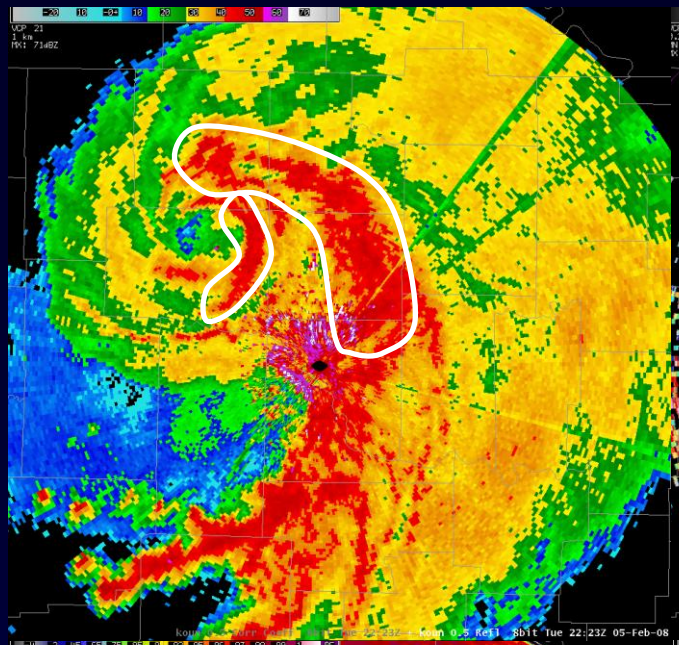




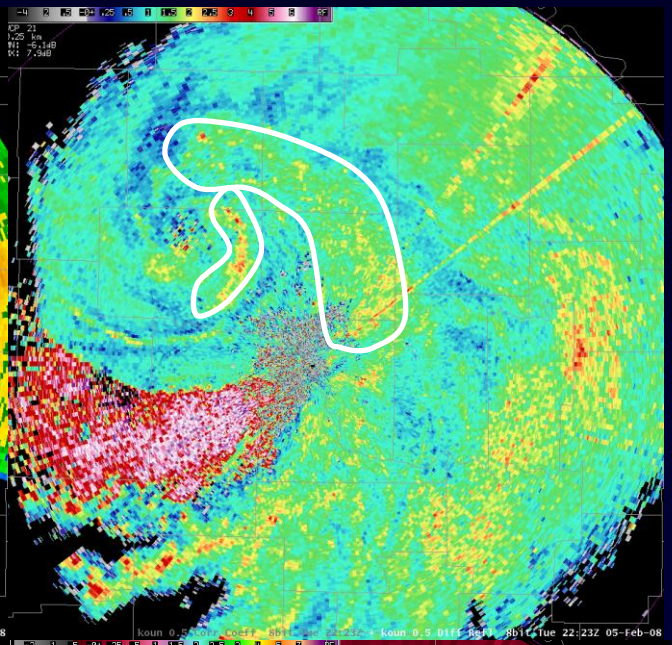
KDP:
2-3 deg/km

Exercise 2: Summary Very Heavy Rain

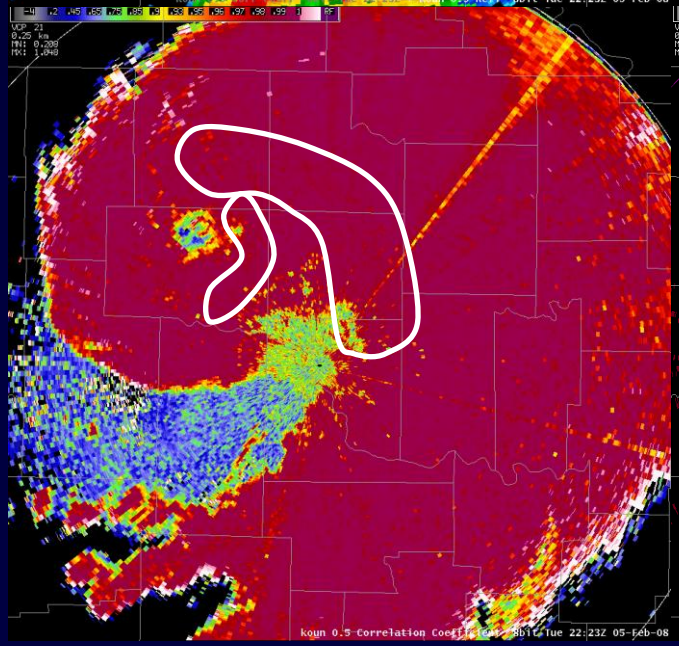
Z:
50-55 dBz



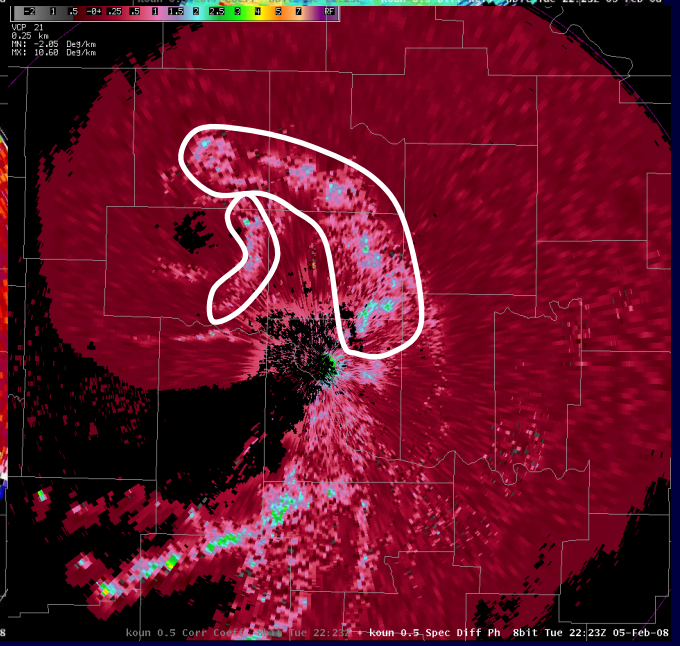
ZDR:
1.5-3 dBz



CC:
> 0.98

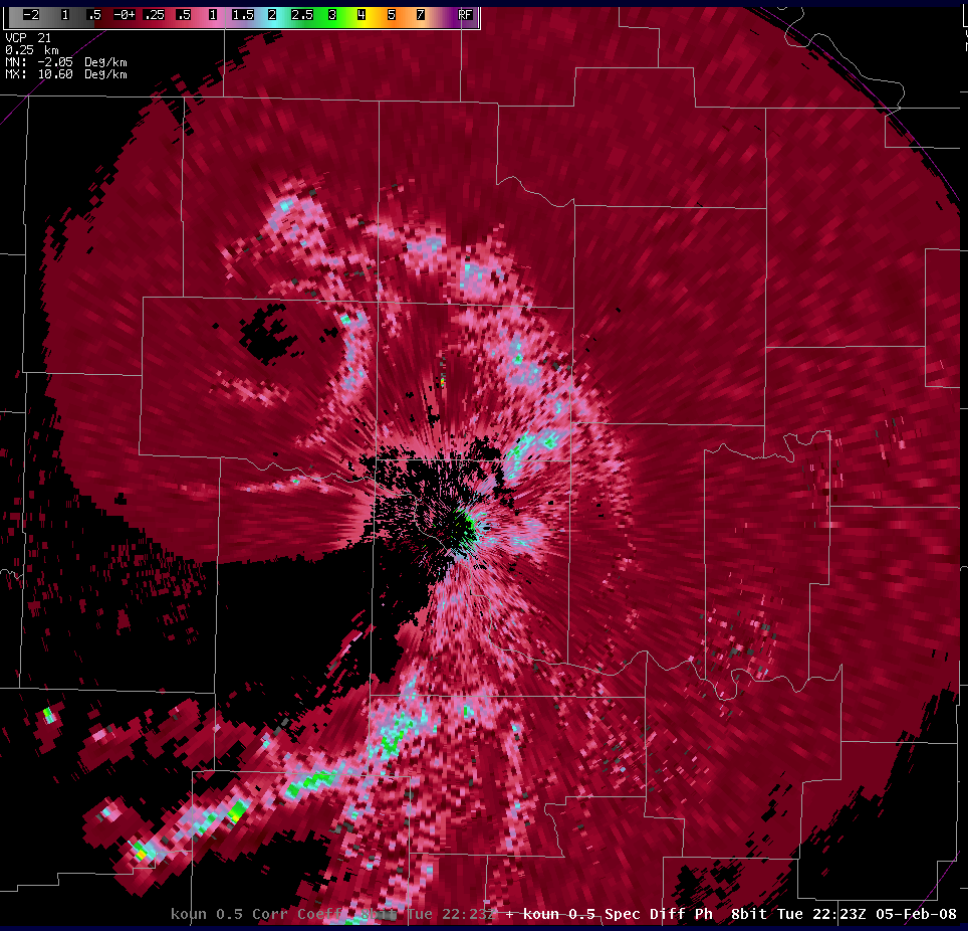


KDP:
2-3 deg/km

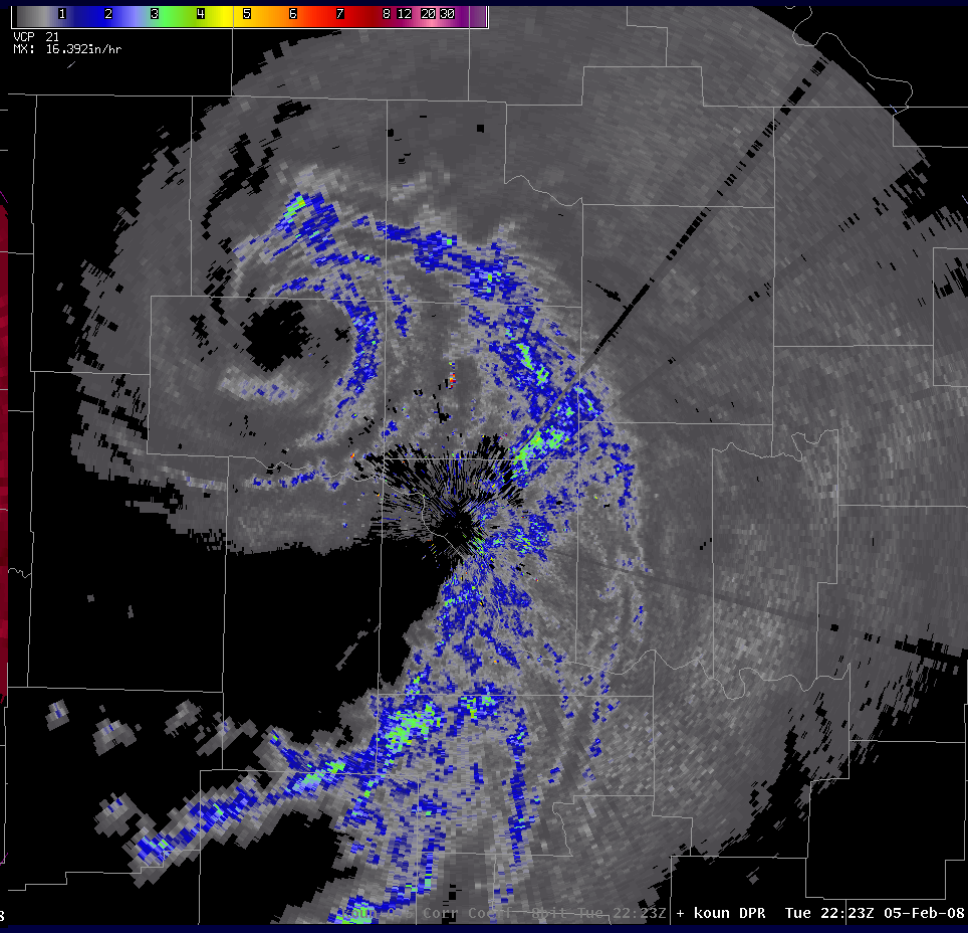


Exercise 2: Summary

KDP



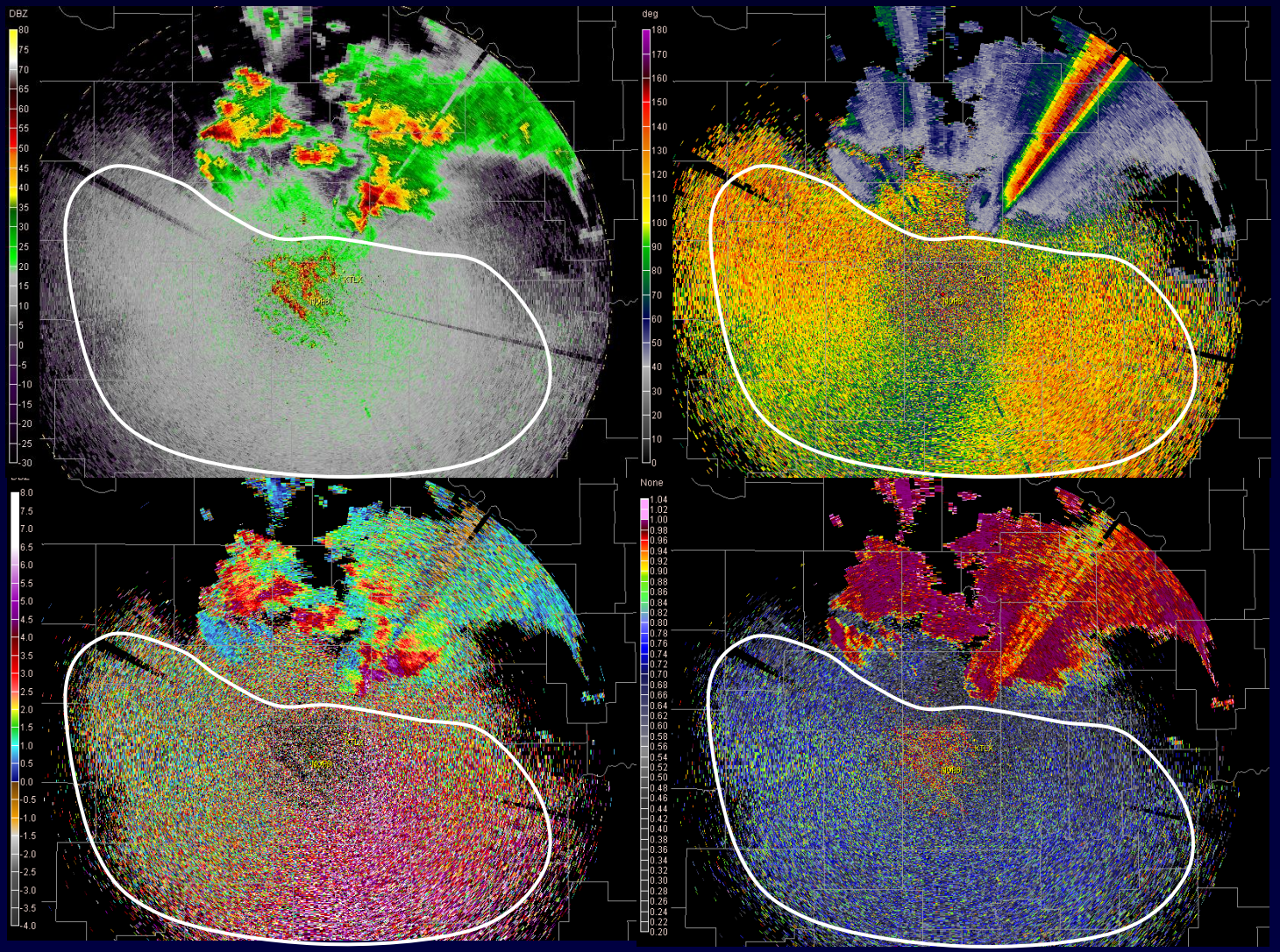
Instantaneous Rainfall Rate



Exercise 3

Z: 8-18 dBz

Φ: slow increase with range

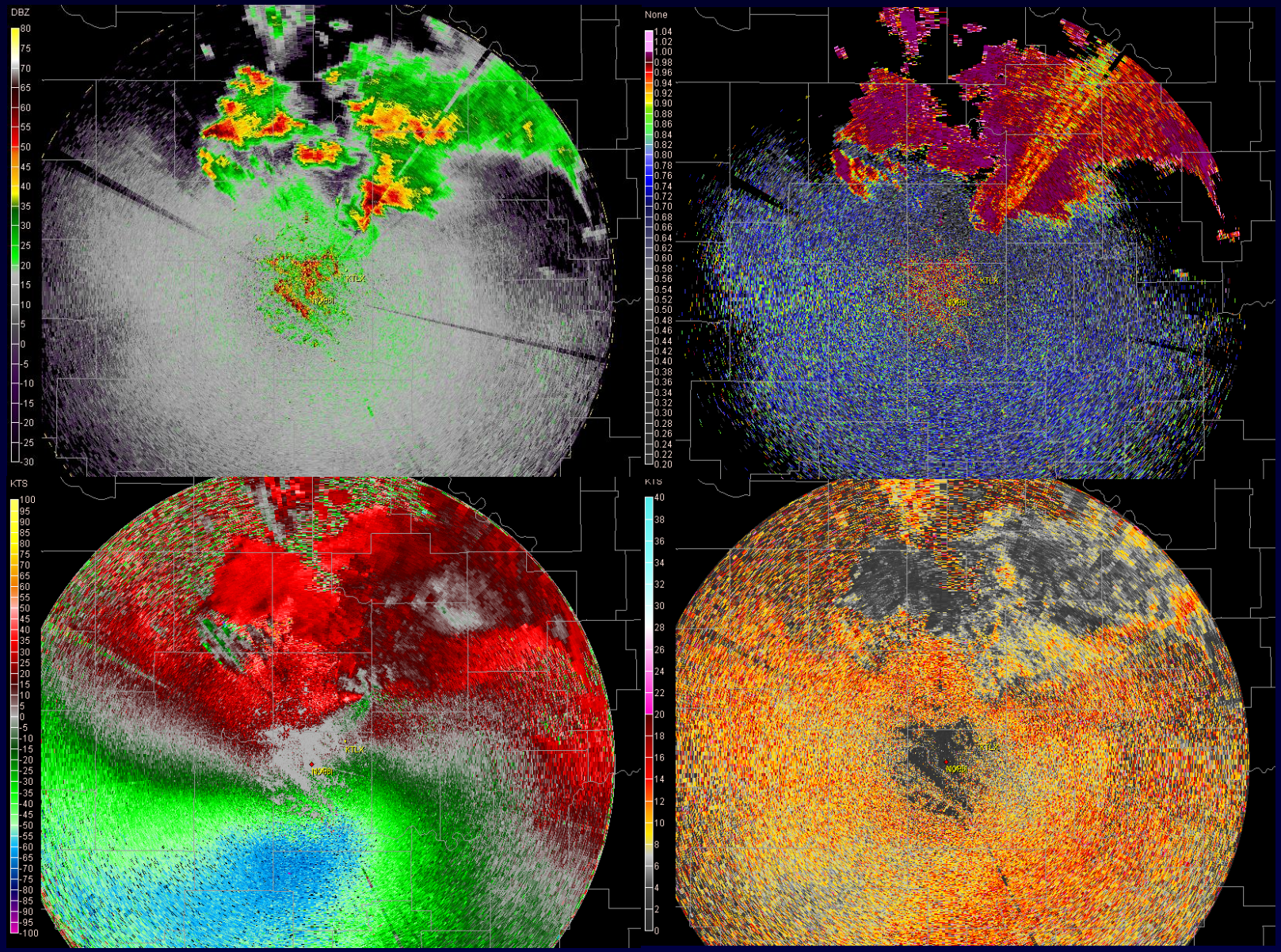


ZDR: Wide Range

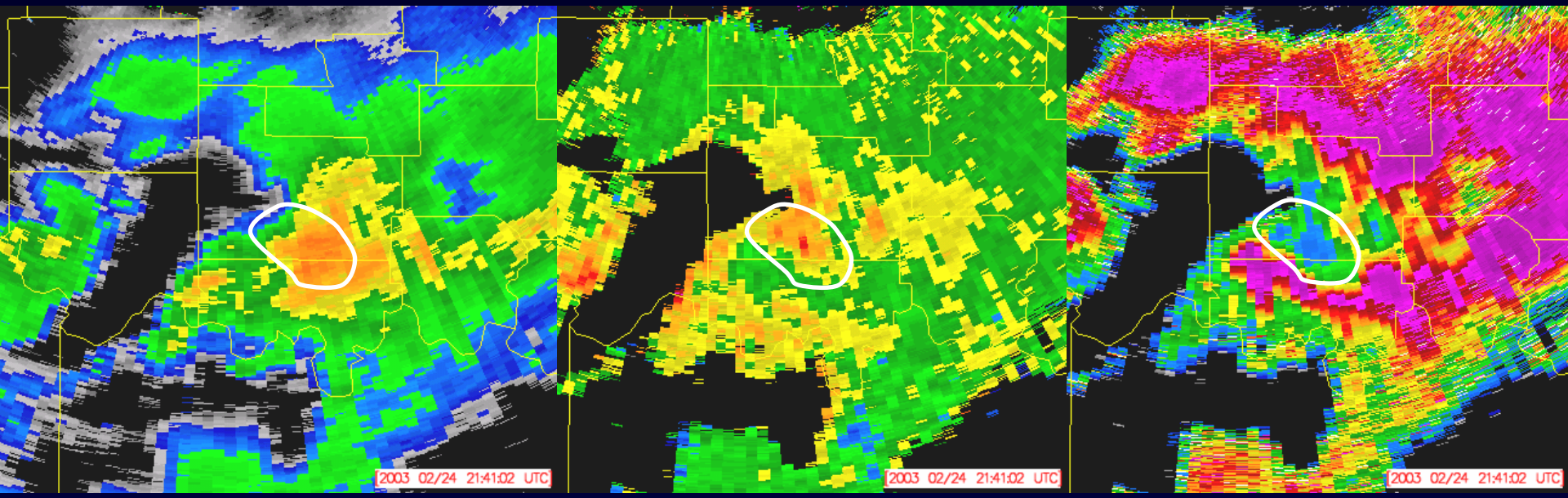
CC: 0.50 to 0.70

Exercise 3: Summary

Birds and Insects: Key is exceptionally low CC values



Exercise 4



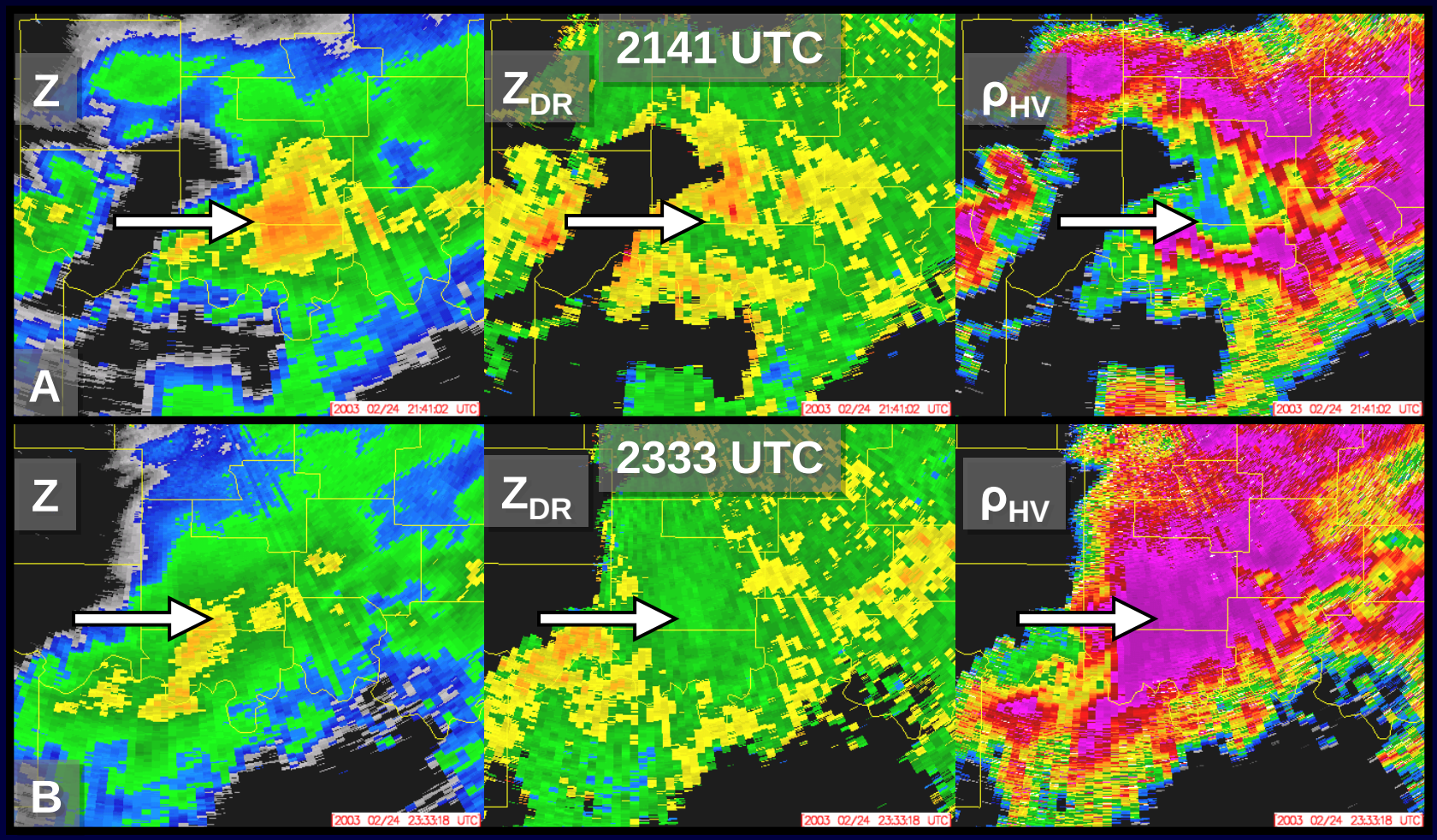
Z: 35-45 dBz

ZDR: +2 to +5 dBz

CC: 0.65 to 0.85

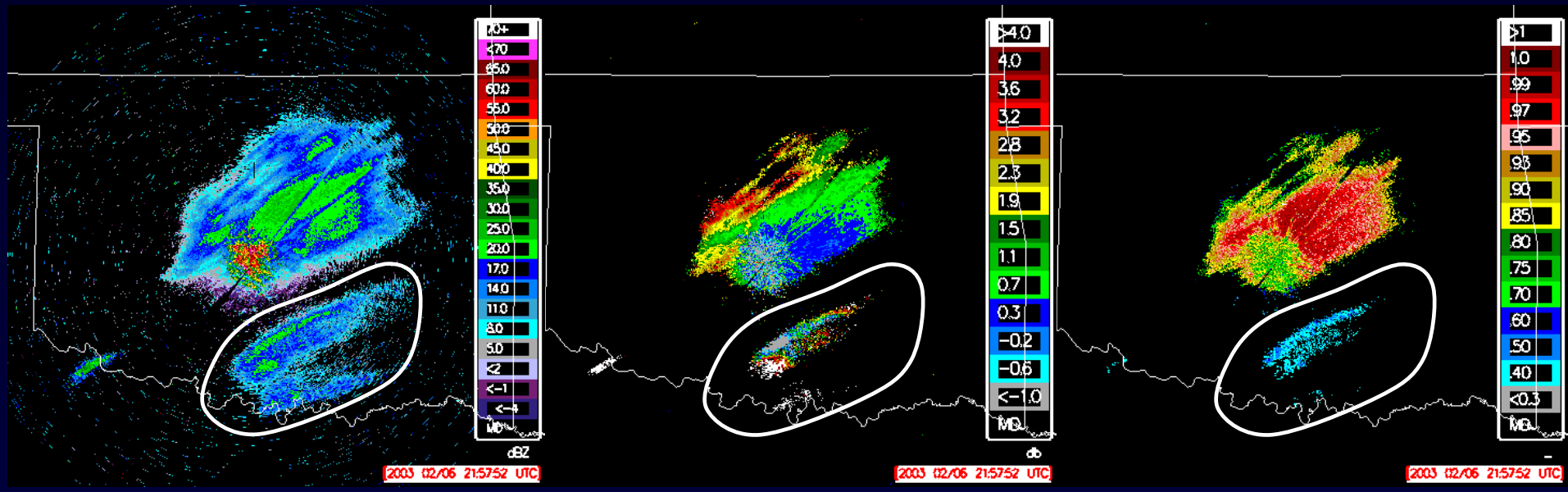
Exercise 4: Summary

Rain/Snow/Sleet Mix



2 hours later: all heavy snow (diabatic cooling effects + FGEN)

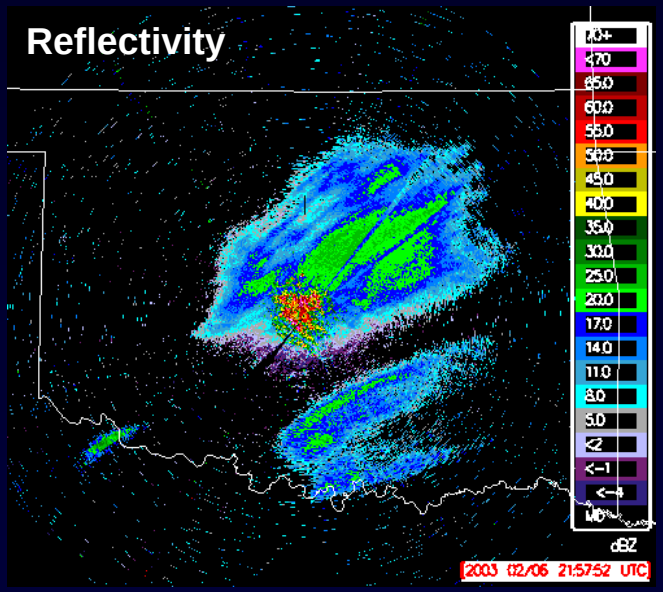
Exercise 5

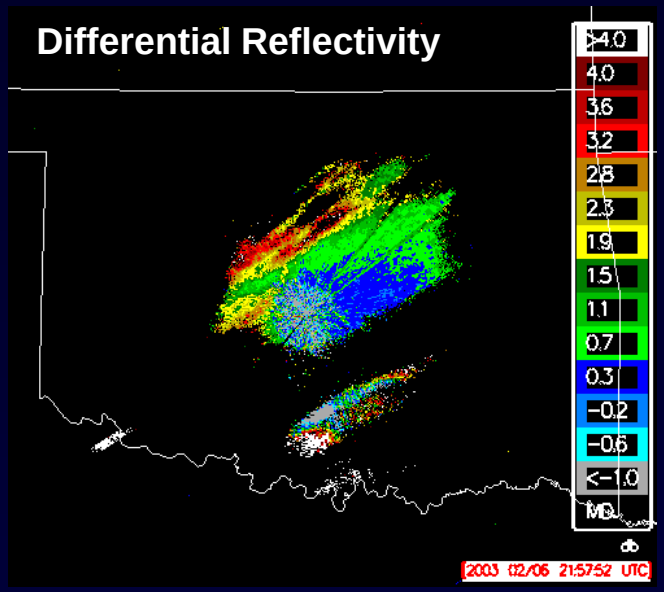


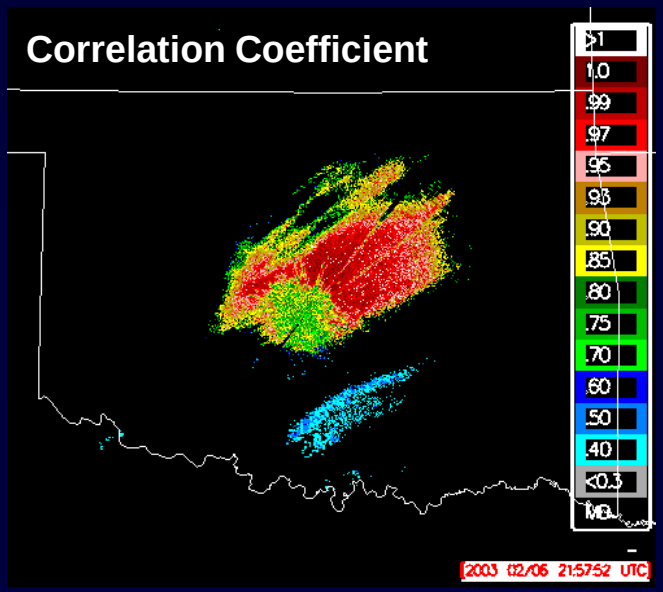
Z: 5-20 dBz **ZDR: Wide Range** **CC: 0.40 to 0.55**

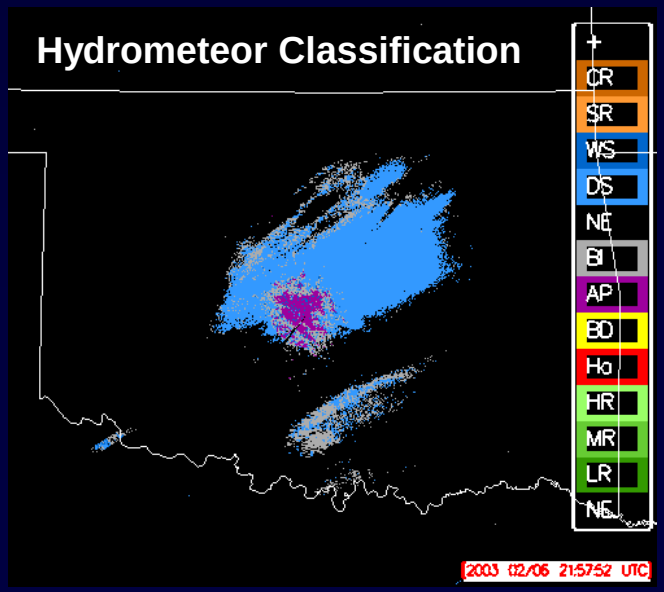
Exercise 5: Summary

Chaff: Key is exceptionally low CC values









Thank You!

References

Dual-Polarization Radar Training for NWS Partners

http://www.wdtb.noaa.gov/courses/dualpol/Outreach/index.html

Dual Polarization Quick Training Aid

http://www.wdtb.noaa.gov/courses/dualpol/trainingaid/index.htm