Applications of Dual-Pol Radar Data into New England Weather Scenarios

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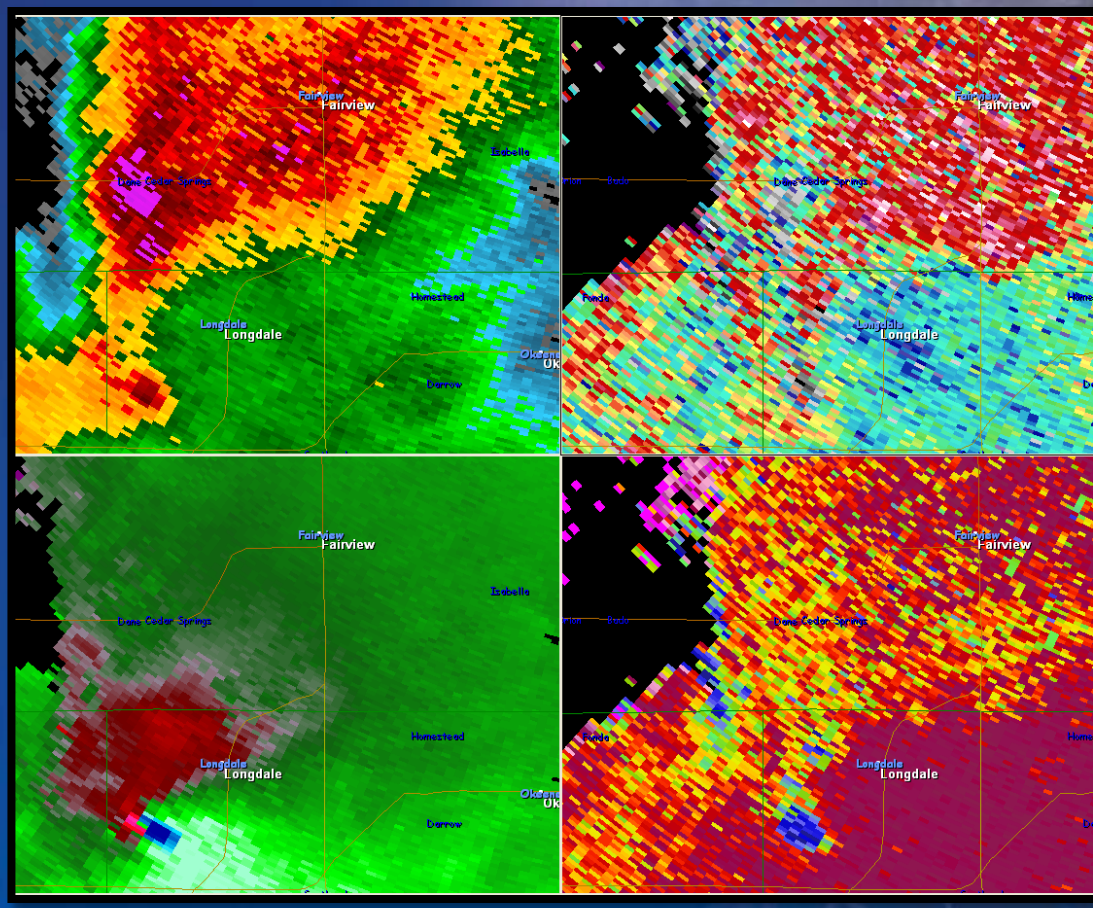
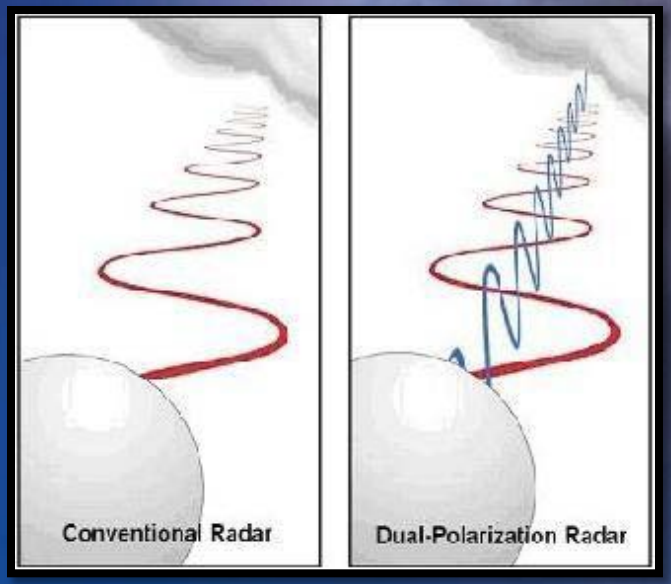
Outline

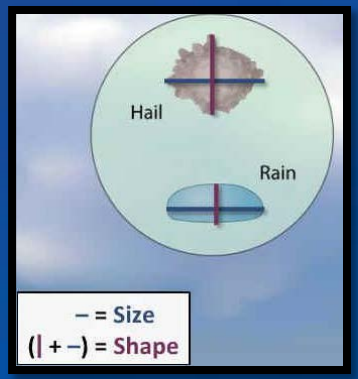
- What is Dual-Pol
- Dual-Pol 101
- Weather Scenarios

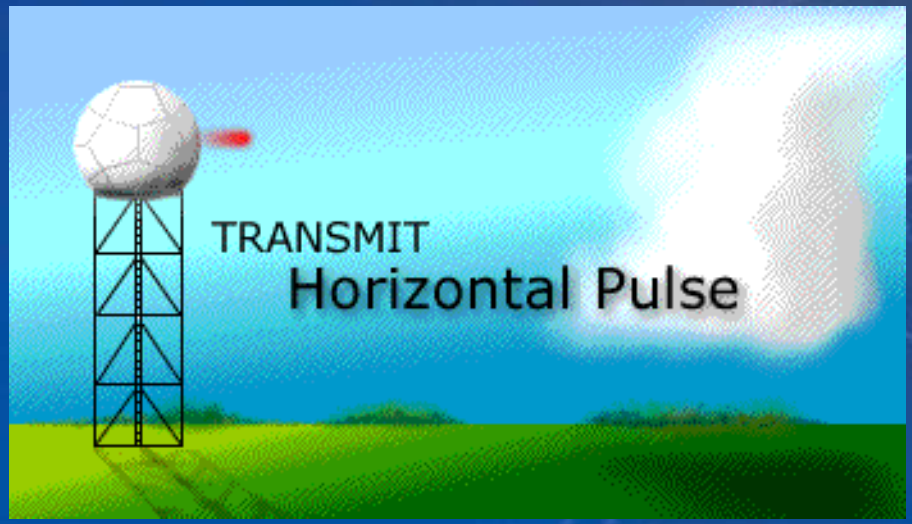


What is Dual-Polarization & How Is It Different from Current Radar??

- Many radars transmit and receive radio waves with a single, horizontal polarization
- Polarimetric radars transmit and receive both horizontal ***and vertical polarizations***
- Can determine:
  - SIZE
  - SHAPE
  - VARIETY

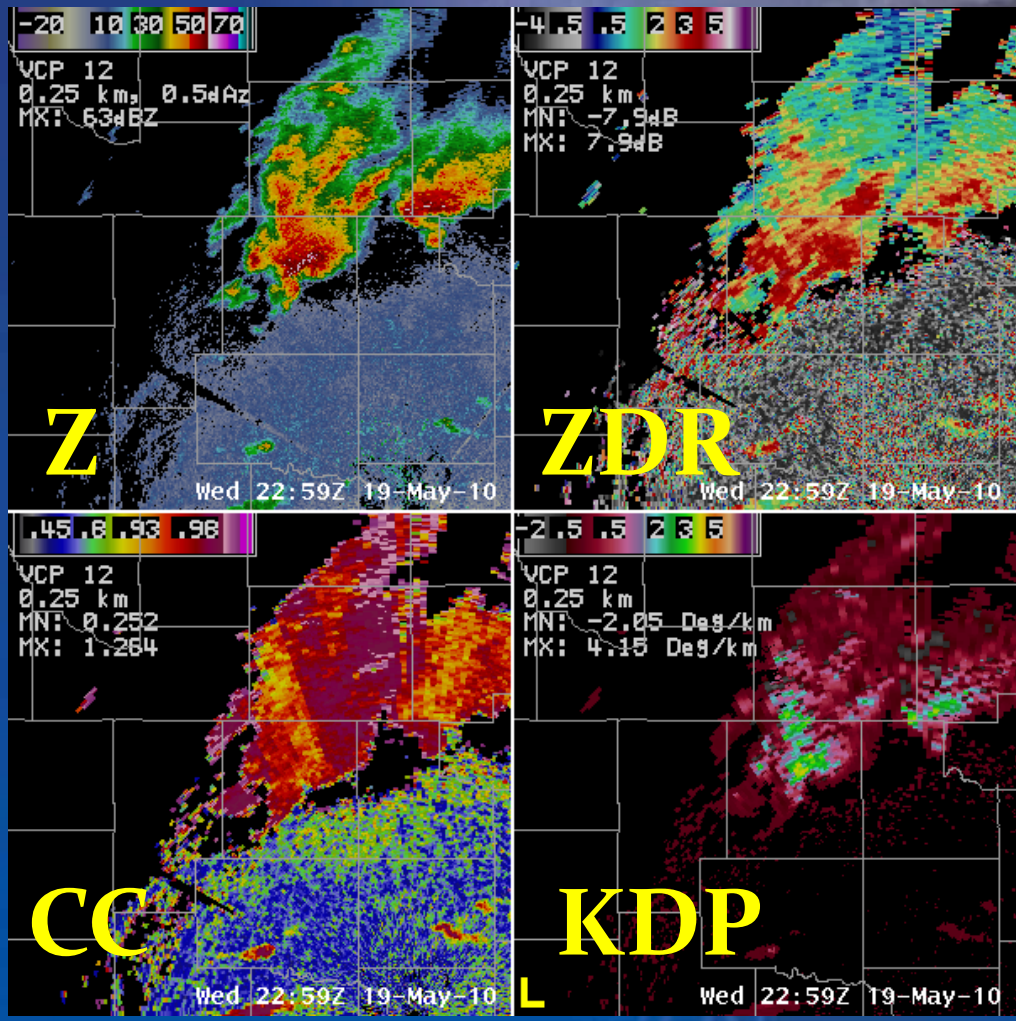






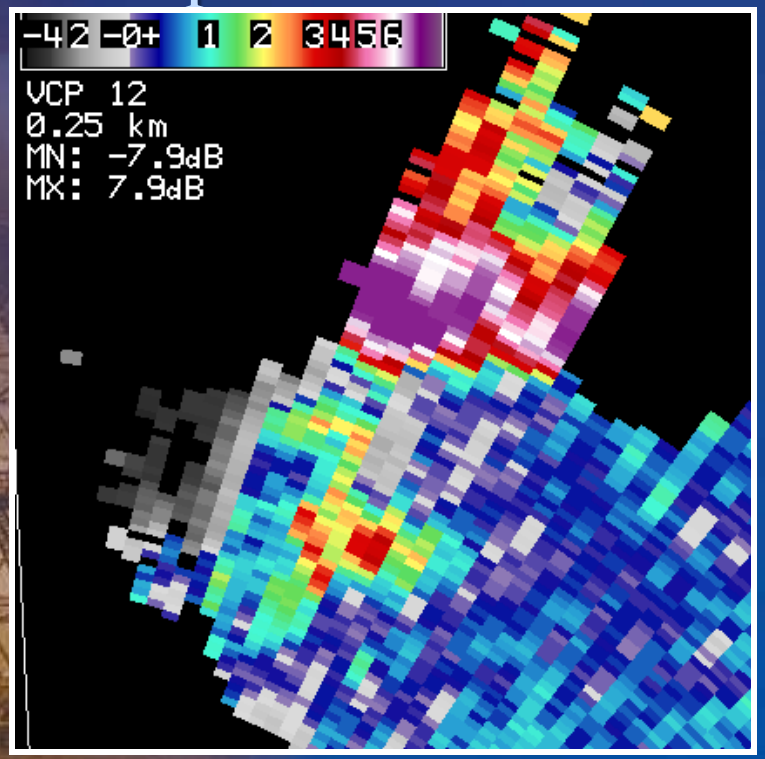
Base Products Available to Dual-Pol

- Still get:
  - Reflectivity (Z)
  - Velocity (V)
  - Spectrum Width (SW)
- Plus:
  - Differential Reflectivity (ZDR)
  - Correlation Coefficient (CC)
  - Specific Differential Phase (KDP)

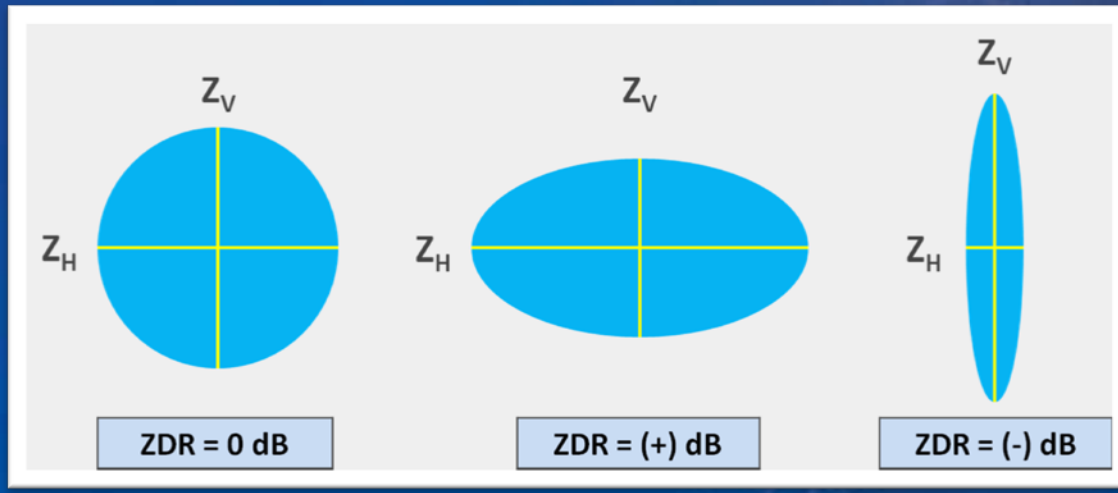


Differential Reflectivity

- Diff between the Horizontal & Vertical reflectivity factor
- Defines the drop size
- Good indicator of mean drop size



- **Used for:**
  - Hail
  - Melting Layer
  - Updraft
  - Tornadic Debris
  - Rain vs Snow
  - Diff Types of Frozen Precip

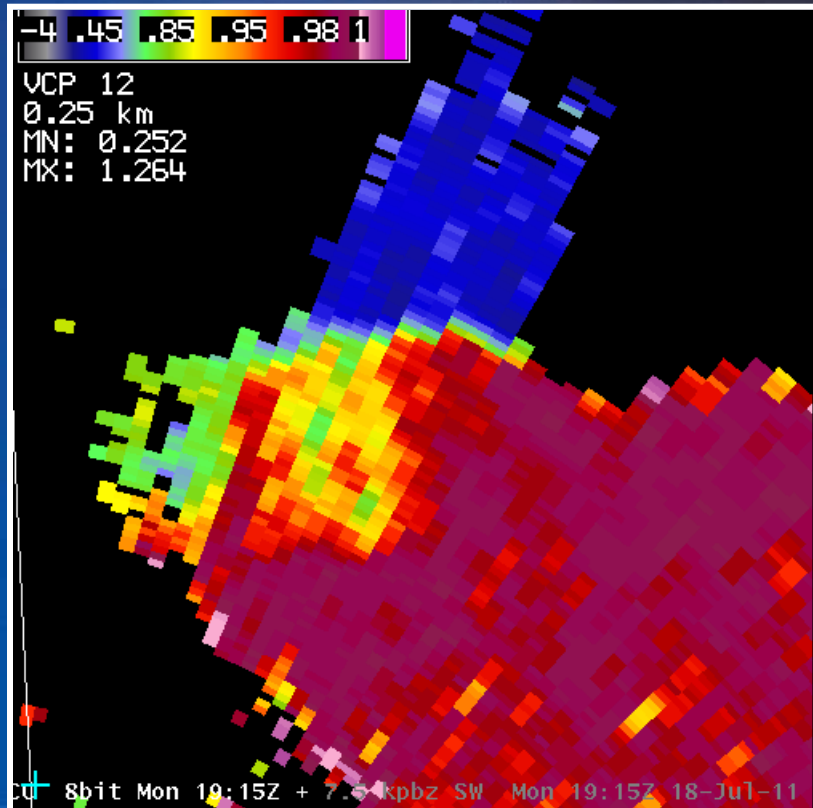


Correlation Coefficent

- **Used for:**
  - Large Hail
  - Tornadic Debris
  - Rain vs Snow
  - Melting Layer
  - Irregular hydro shapes

Hydrometeors	CC	Values
Non-meteorological	Low CC	< 0.8
Meteorological – non uniform	Mod CC	0.8-0.97
Meteorological - uniform	High CC	> 0.97

- Measure of how similarly the horizontally and vertically polarized pulses are behaving in a pulse volume
- Great at discriminating non vs met echoes



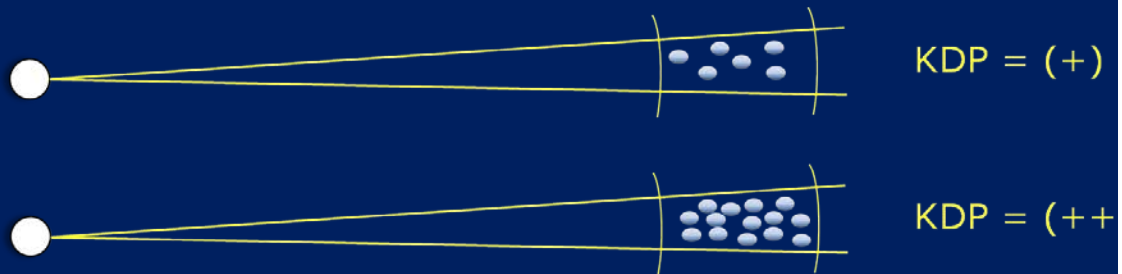
Specific Differential Phase

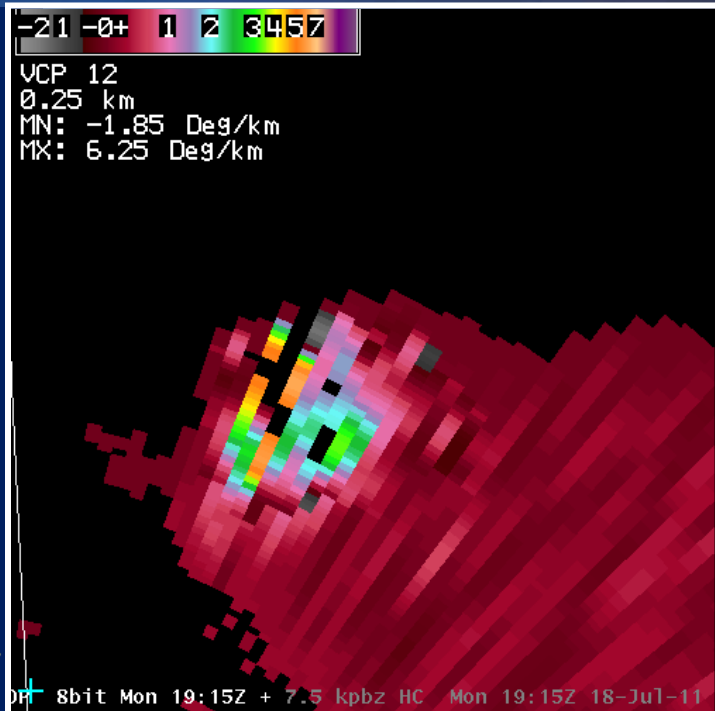
- Range derivative of the differential phase shift along a radial
- Non meteorological echoes aren't shown

- **Used for:**
  - Heavy Rain
    - Heavy Rain mixed with hail
    - Cold vs. Warm Rain Process

- Similar to ZDR

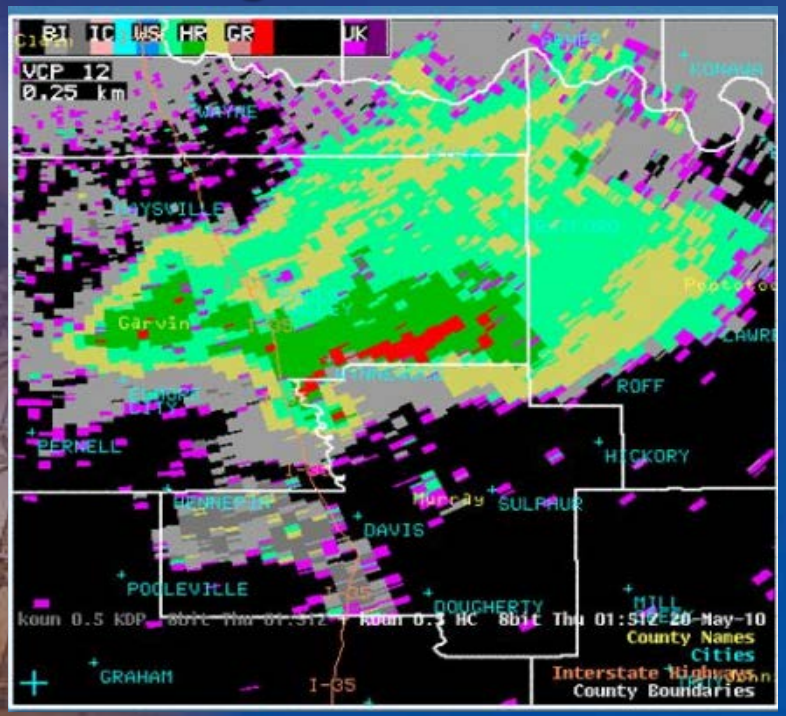
- Particle Concentration

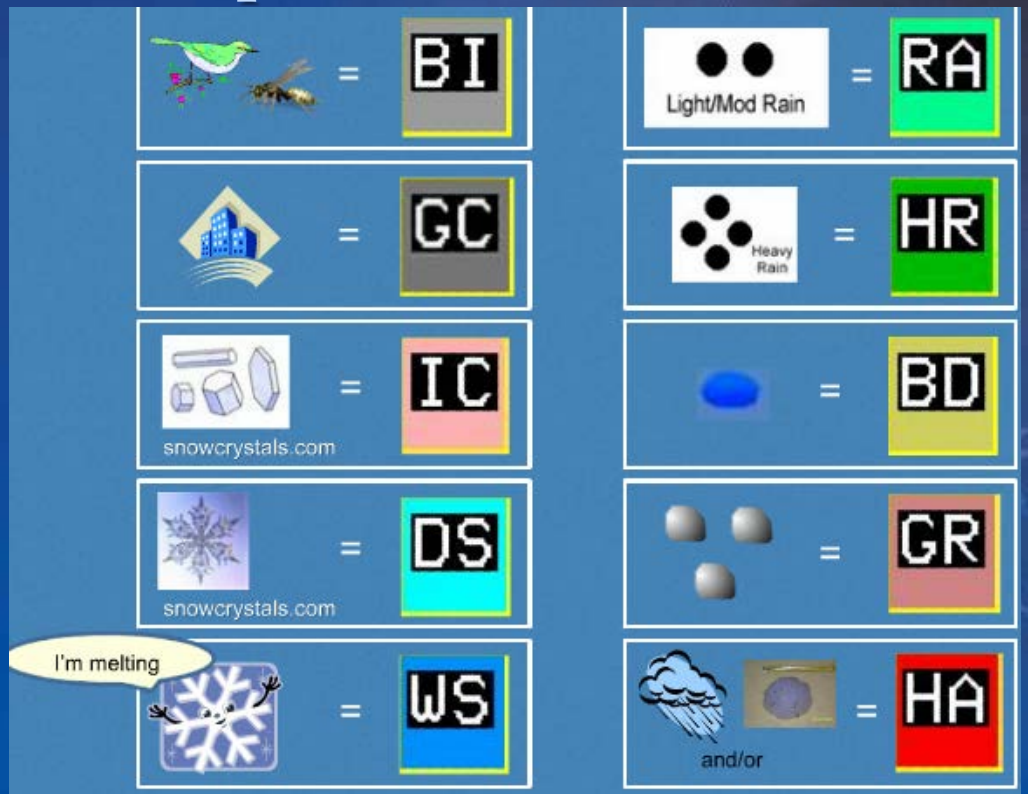




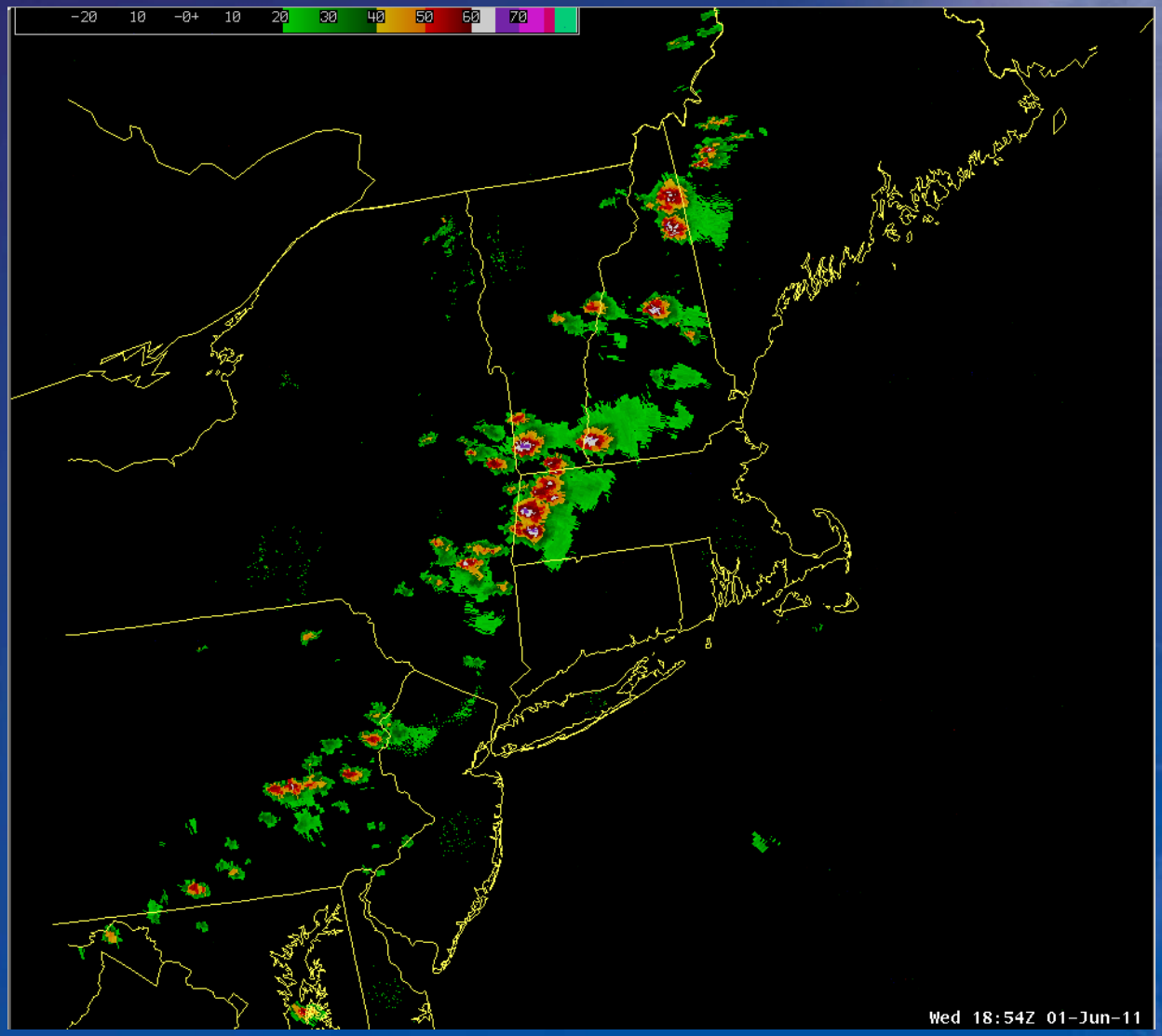
Hydrometeor Classification Algorithm

- HCA uses polarimetric base data to make a *guess* at precip type
- Quick look at regions of interest
- Used as input for improved QPE
- Limitations = subjectivity & overlaps
- Its an *algorithm*



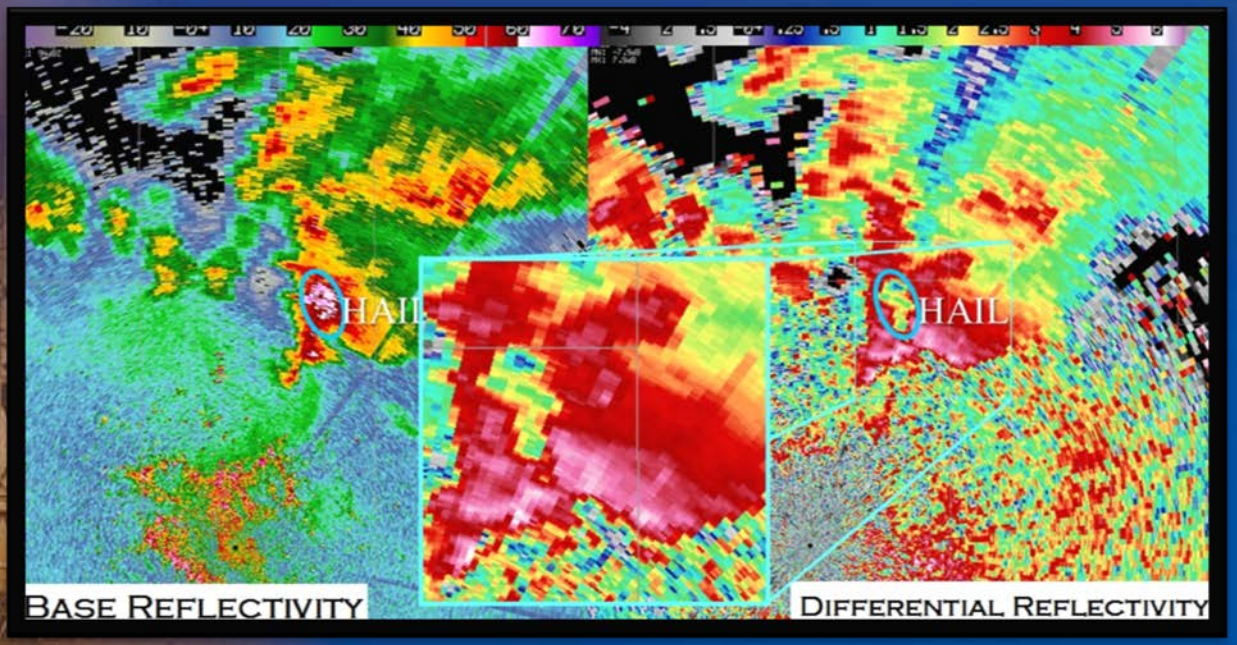


Severe Weather



Dual-Pol Base – Hail Detection

- Very high Z (> 55 dBZ)
- Variable ZDR:
  - Usually low (-0.5 - +1.5dB)
  - Positive when mixed with rain!
- Low CC (0.70-0.95)
- If melting hail, high KDP (>1.5 deg/km)

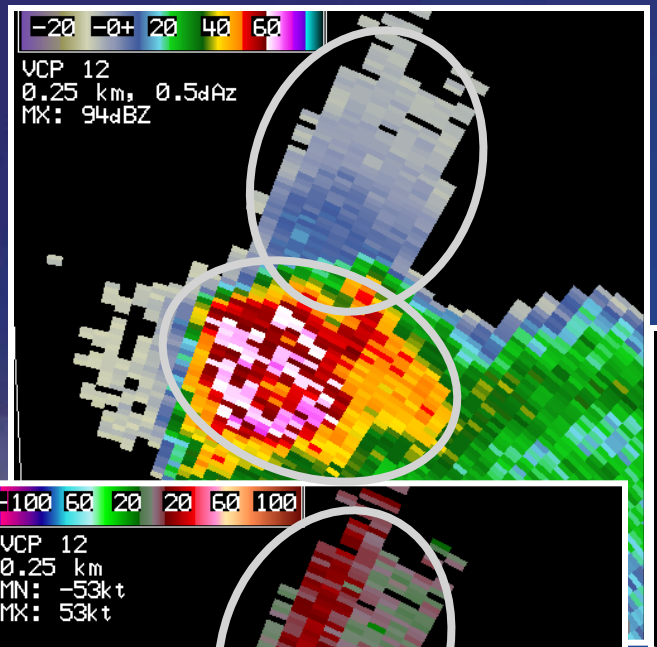


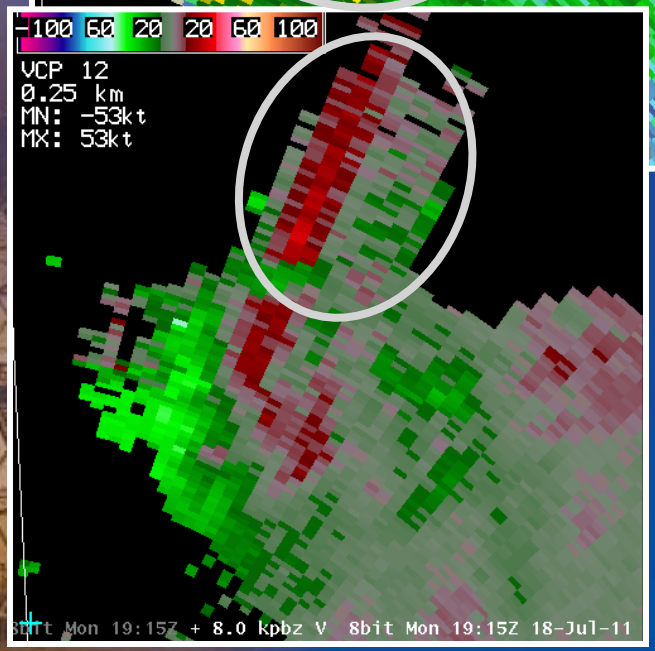
TBSS Example from Pittsburgh, PA.

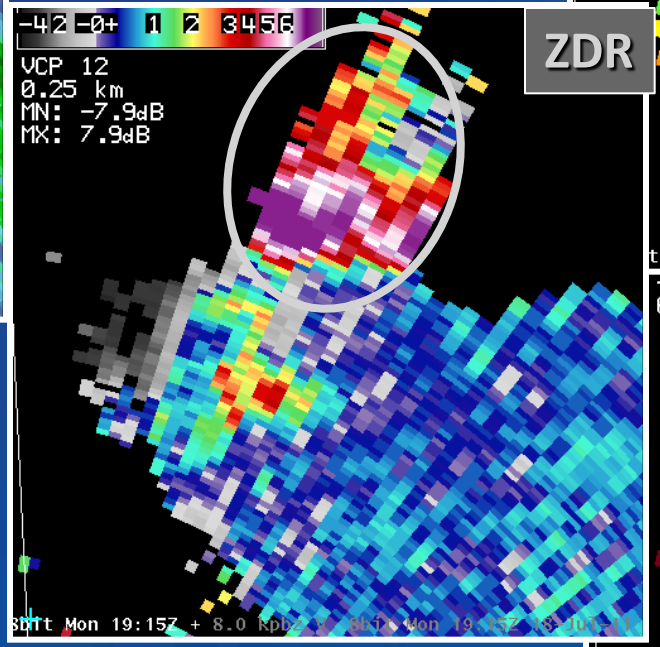
7/18/11

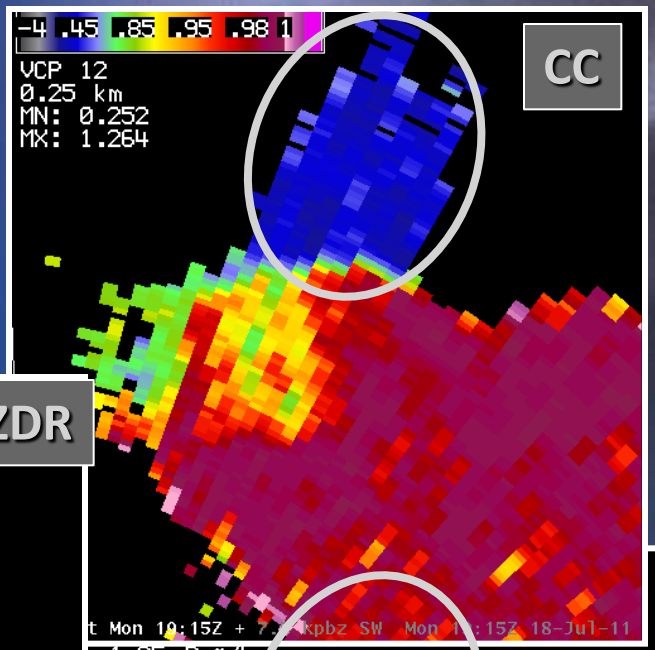
19:15Z

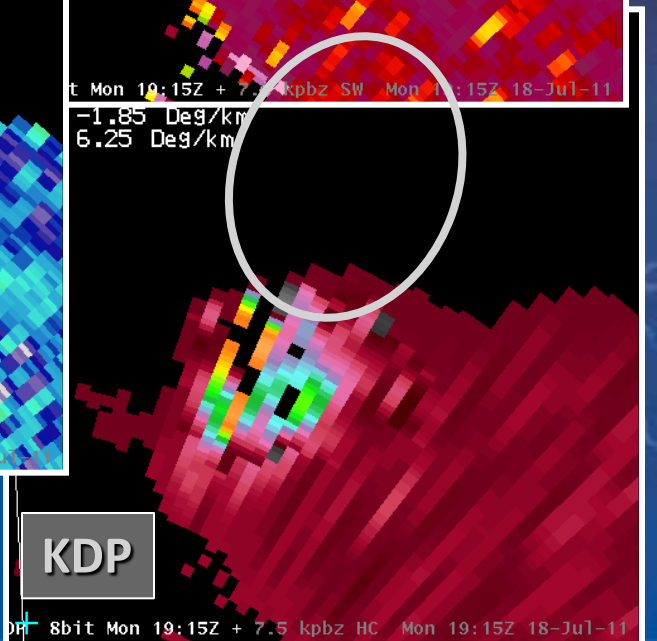
8.0 °





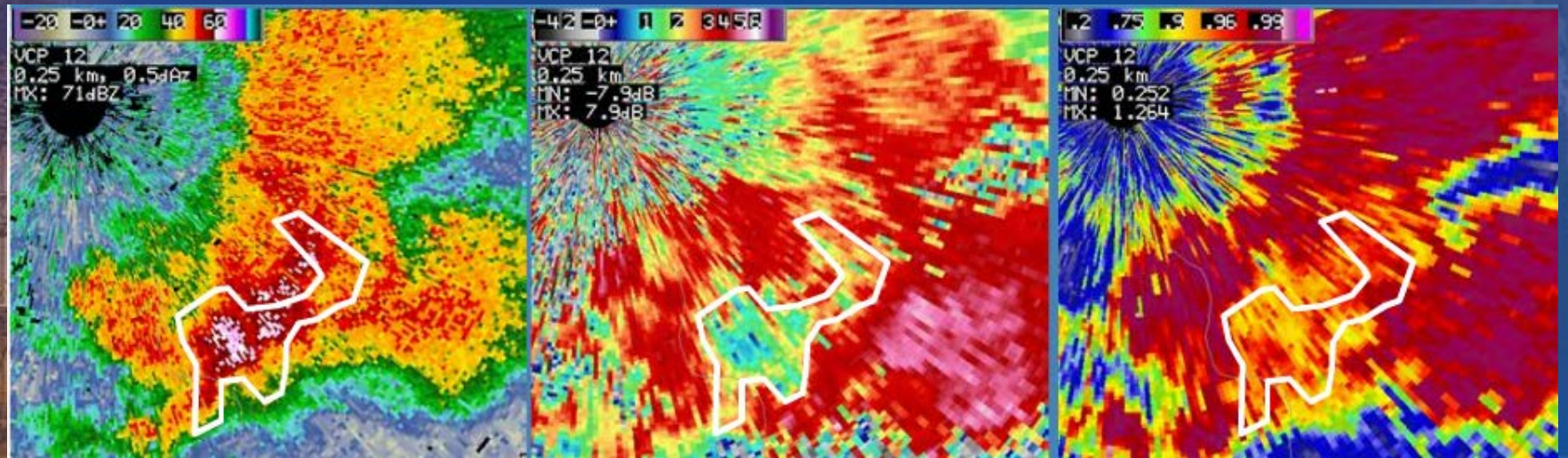






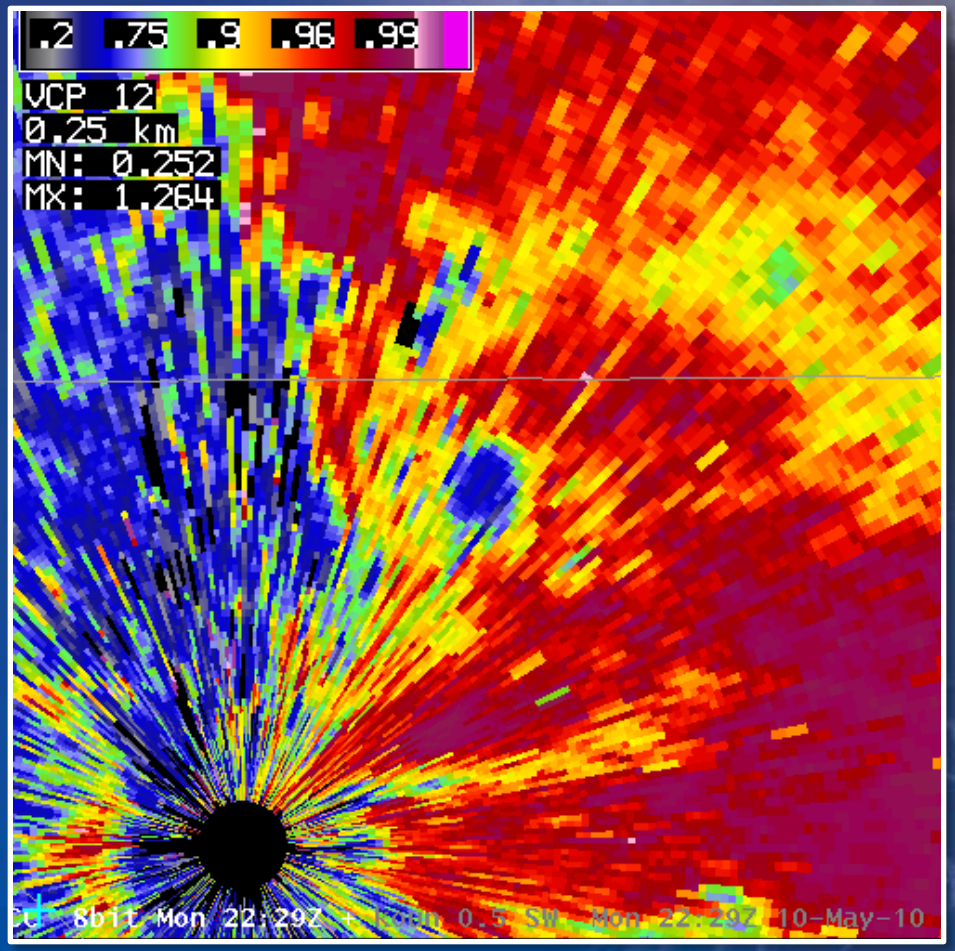
Strengths and Limitations of Dual-Pol Hail Detection

- **Strengths**
  - More robust than using Z alone
    - Can see hail signature in ZDR and/or CC even when Z is questionable
  - Can detect significant hail (> 2 inches diameter)
  - TBSS easier to detect
- **Limitations**
  - No explicit size estimation
    - Differentiation between marginally svr and non-svr hail
  - If hail is detected, sometimes still not possible to tell if it is reaching the ground



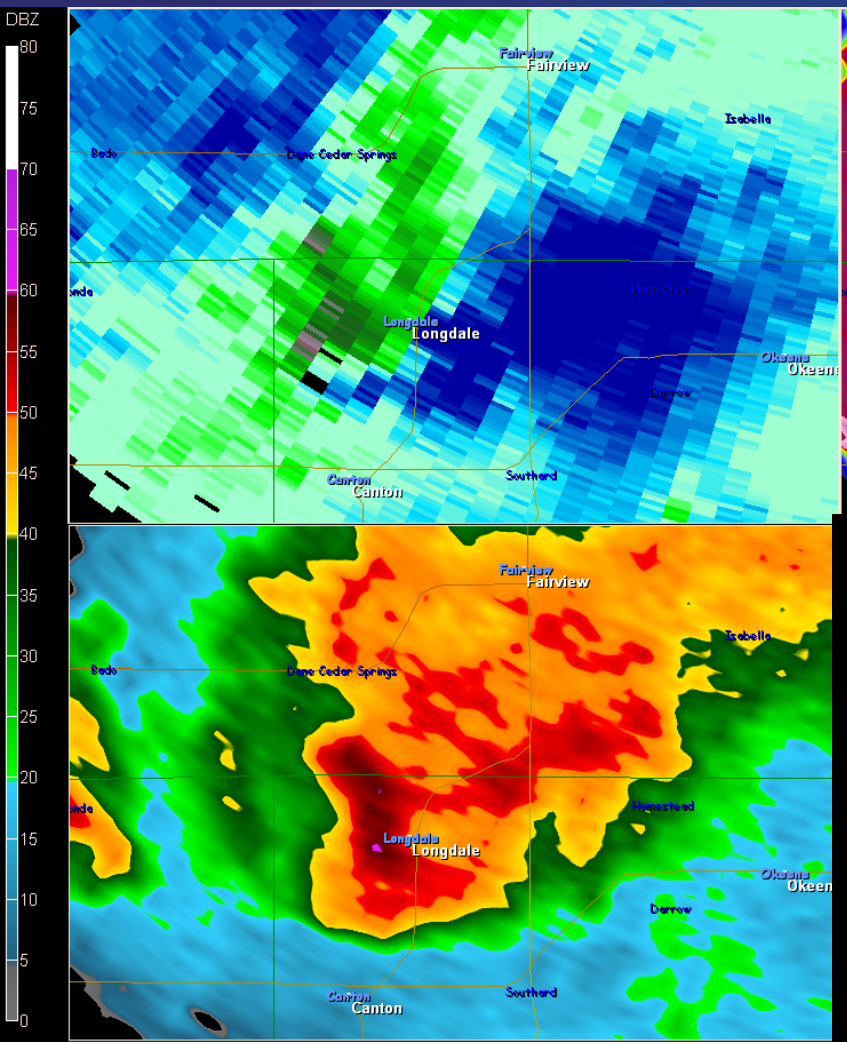
Dual-Pol – Tornadic Debris Signature

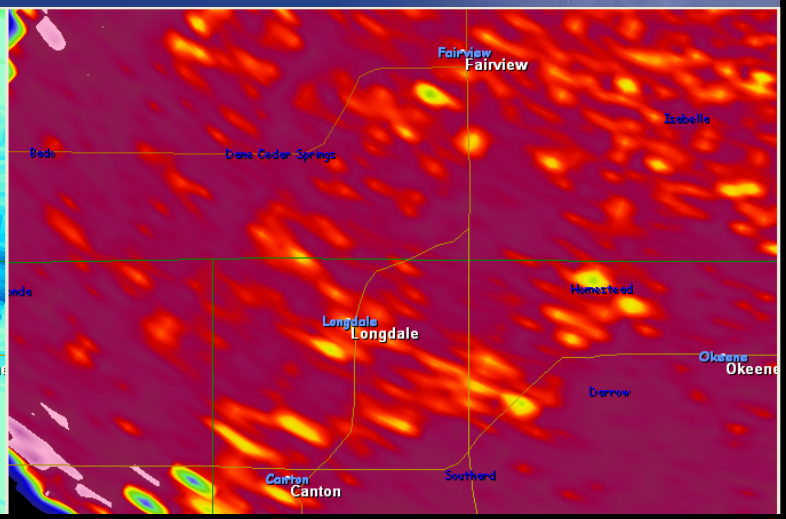
- Must have: Strong rotational signature in SRM
- High Reflectivity
- CC typically less than ~0.80



Tornadic Debris Aloft from Vance AFB, OK.

5/24/11





30,000ft

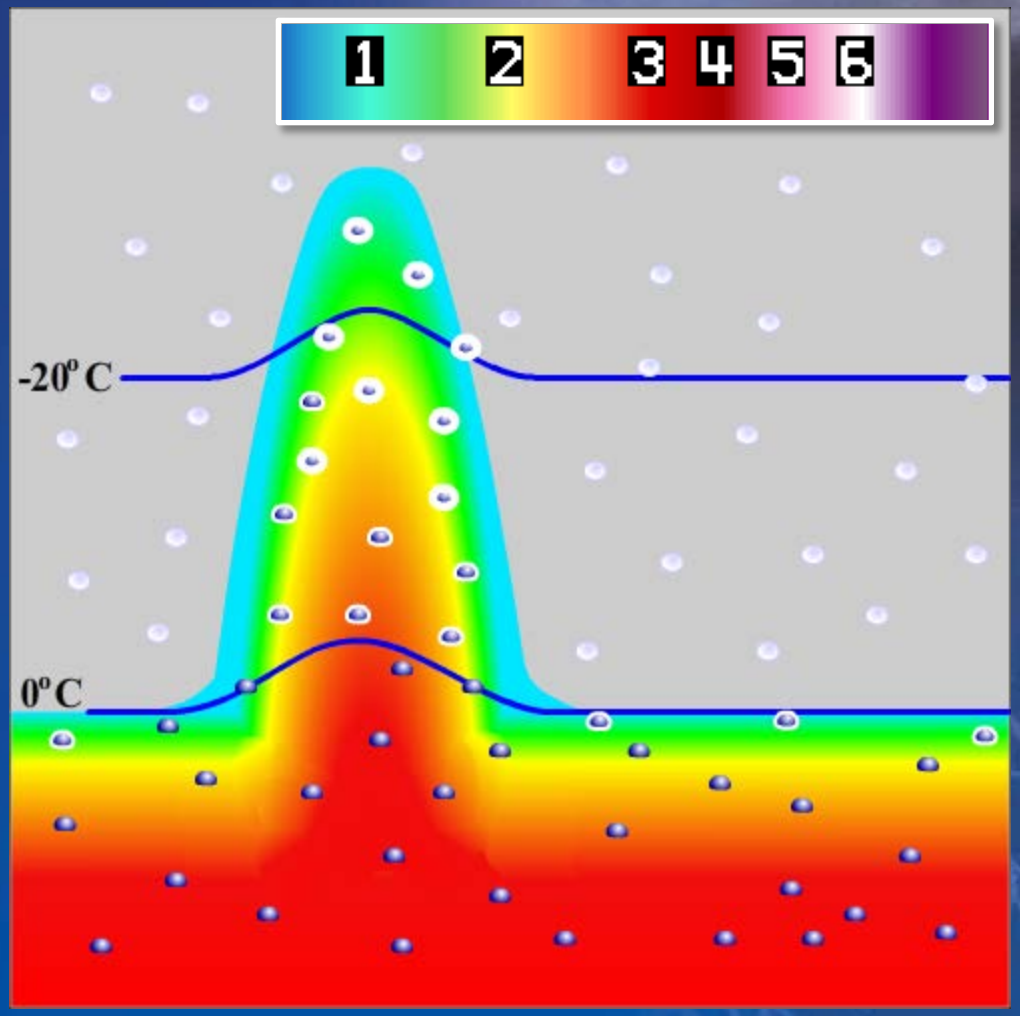
- CC at 6.4°
- Debris signature hardly noticeable, however there is an area of low CC where there is rotation and higher level of reflectivity aloft
- low CC values – less than 0.92

Strengths and Limitations of Dual-Pol Tornadic Debris Detection

- **Strengths**
  - Indicates a tornado [illegible] hat it is doing damage
  - Allows for specific[illegible] ess of the location of the tornado and tor[illegible] suant to standard radar location errors)
- **Limitations**
  - Not a predictor of a tornado!!!
  - Must be close range
  - Tornado must hit something to produce a signature
  - Maximum Dependable Range 60km (strong tornadoes further)

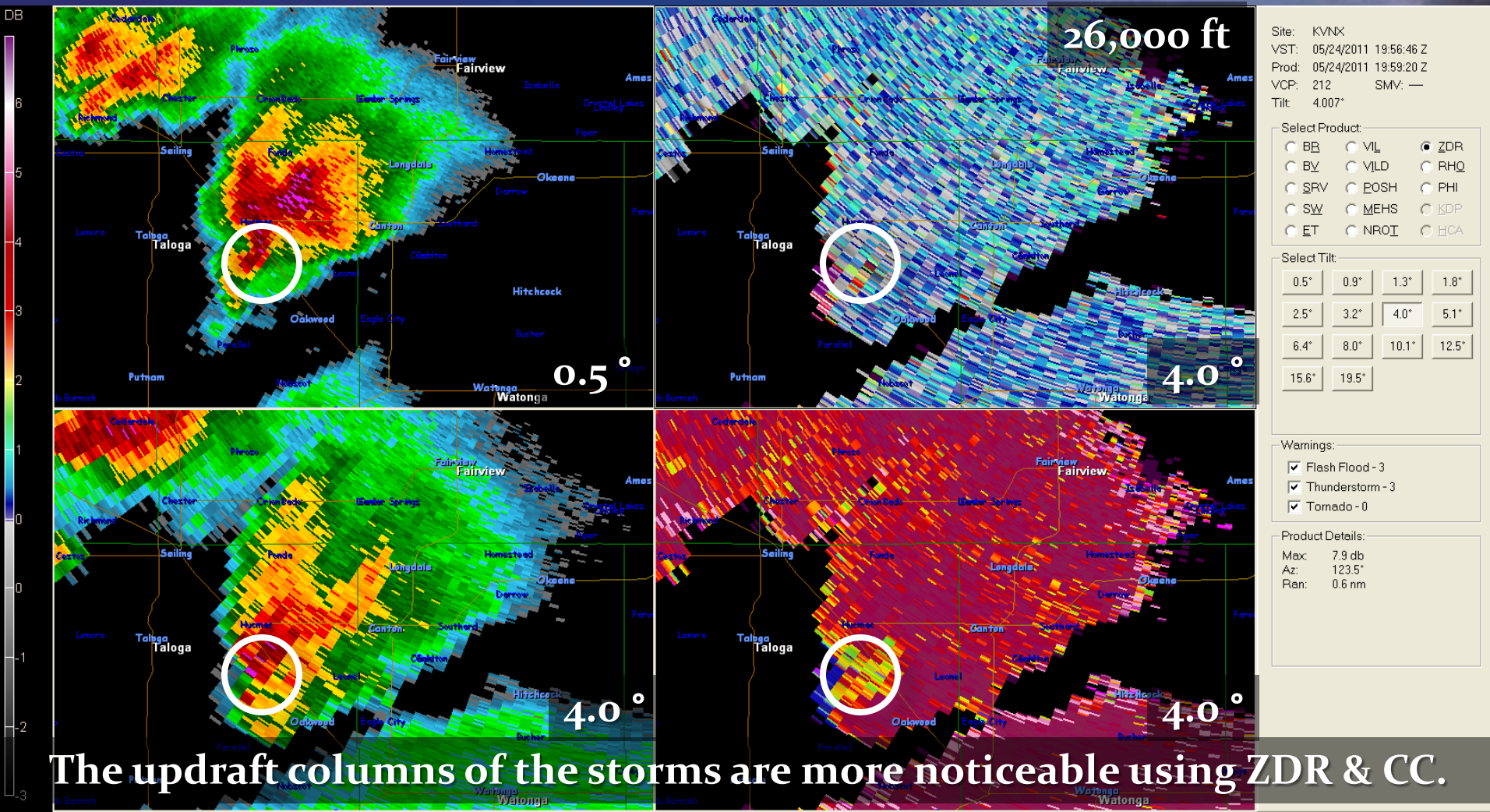
Dual Pol – Updraft Detection

- "ZDR columns": regions of liquid water (strongly positive ZDR) found above the environmental 0°C height



Updraft Detection

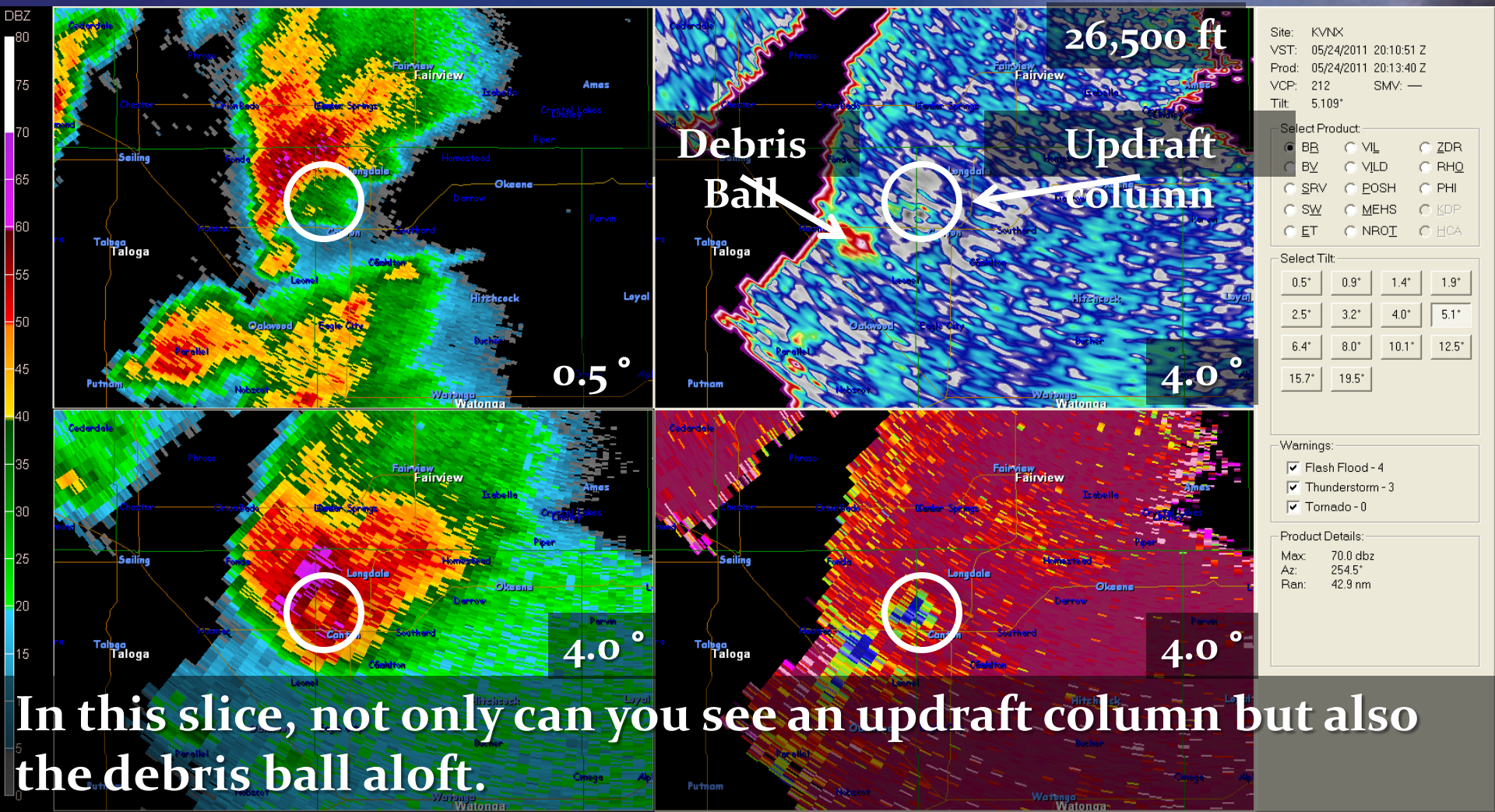
ZDR Column off of KVNX 05/24/11



The updraft columns of the storms are more noticeable using ZDR & CC.

Updraft Detection

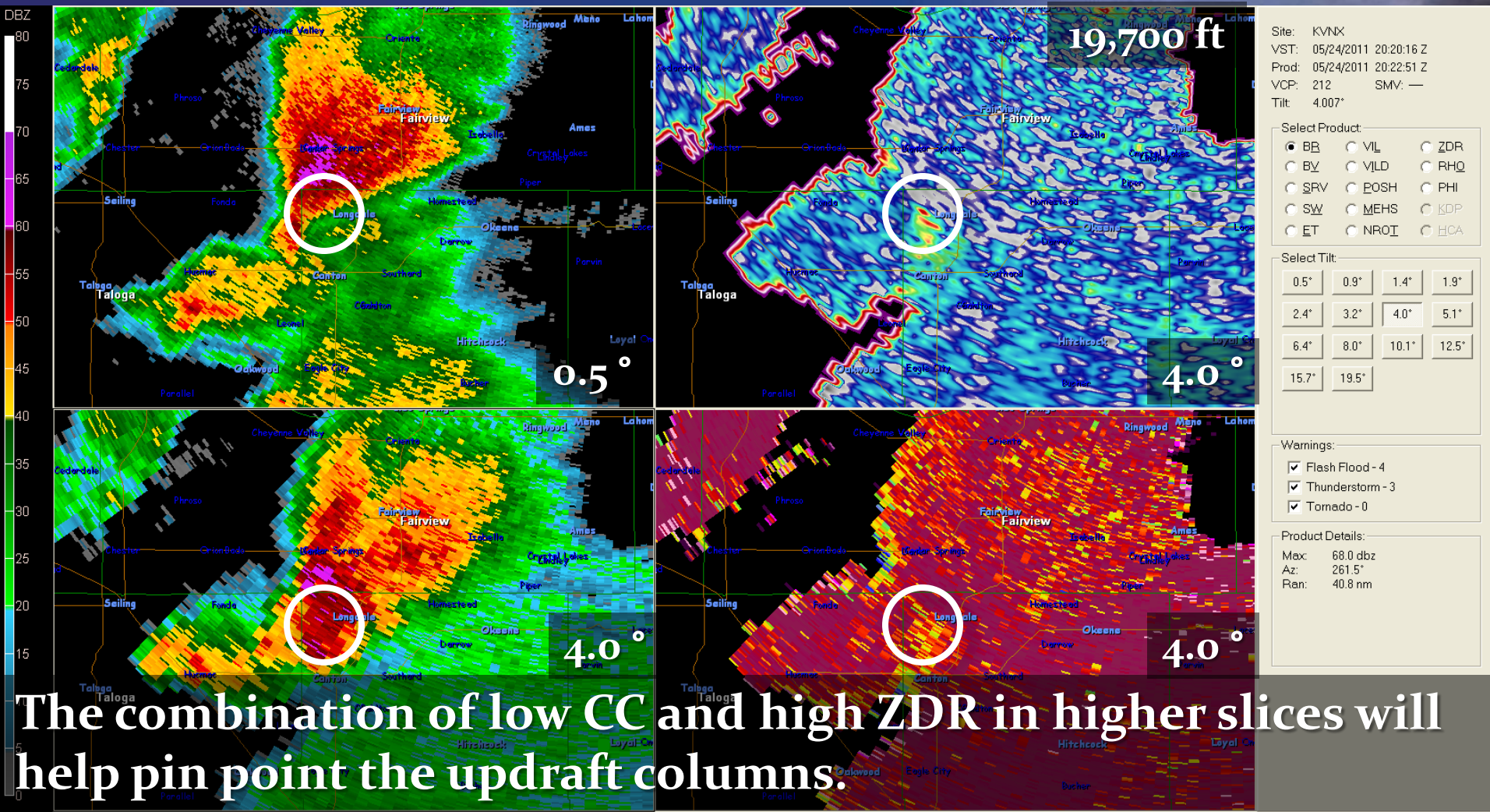
ZDR Column off of KVNX 05/24/11



In this slice, not only can you see an updraft column but also the debris ball aloft.

Updraft Detection

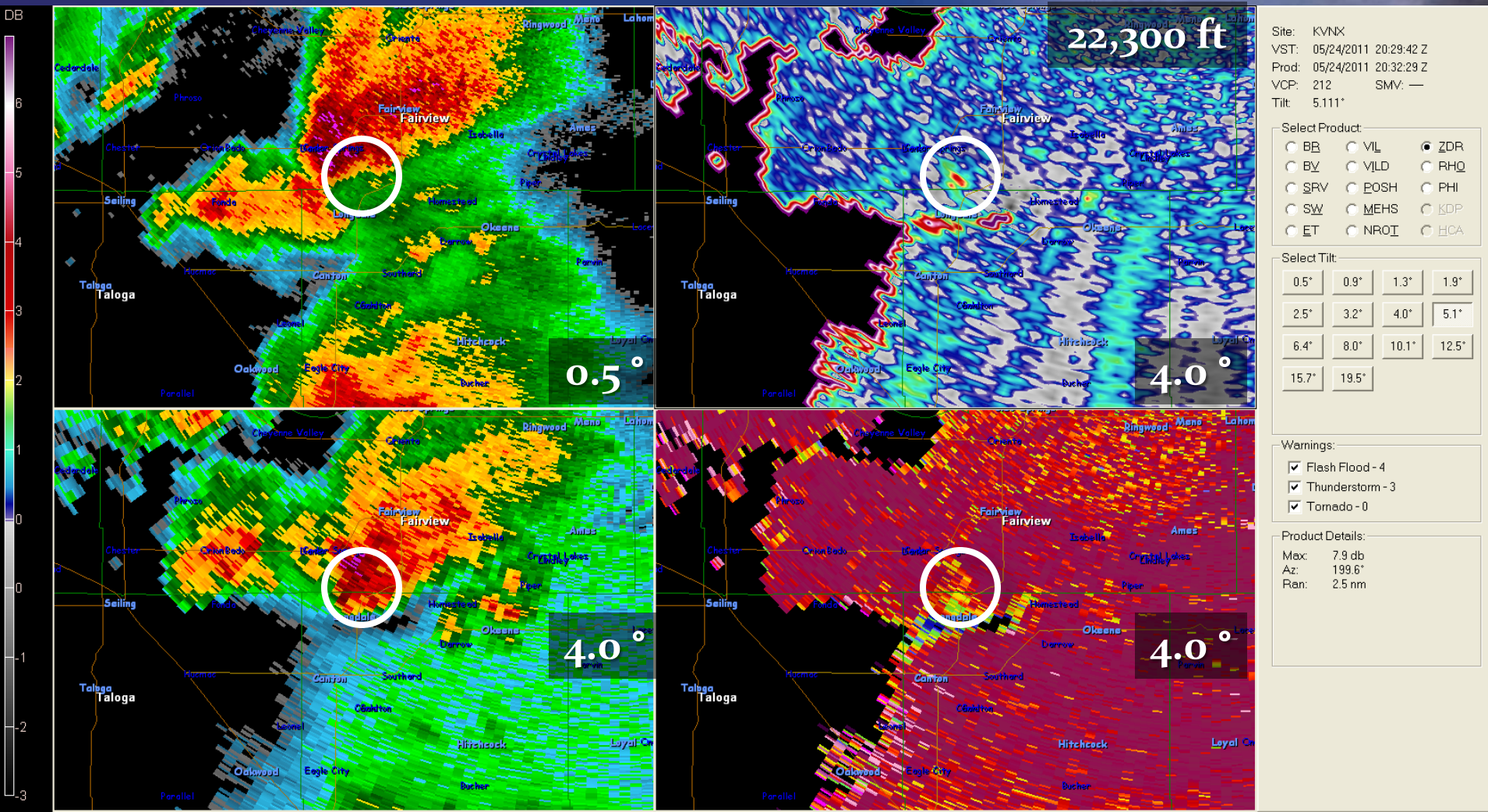
ZDR Column off of KVNX 05/24/11



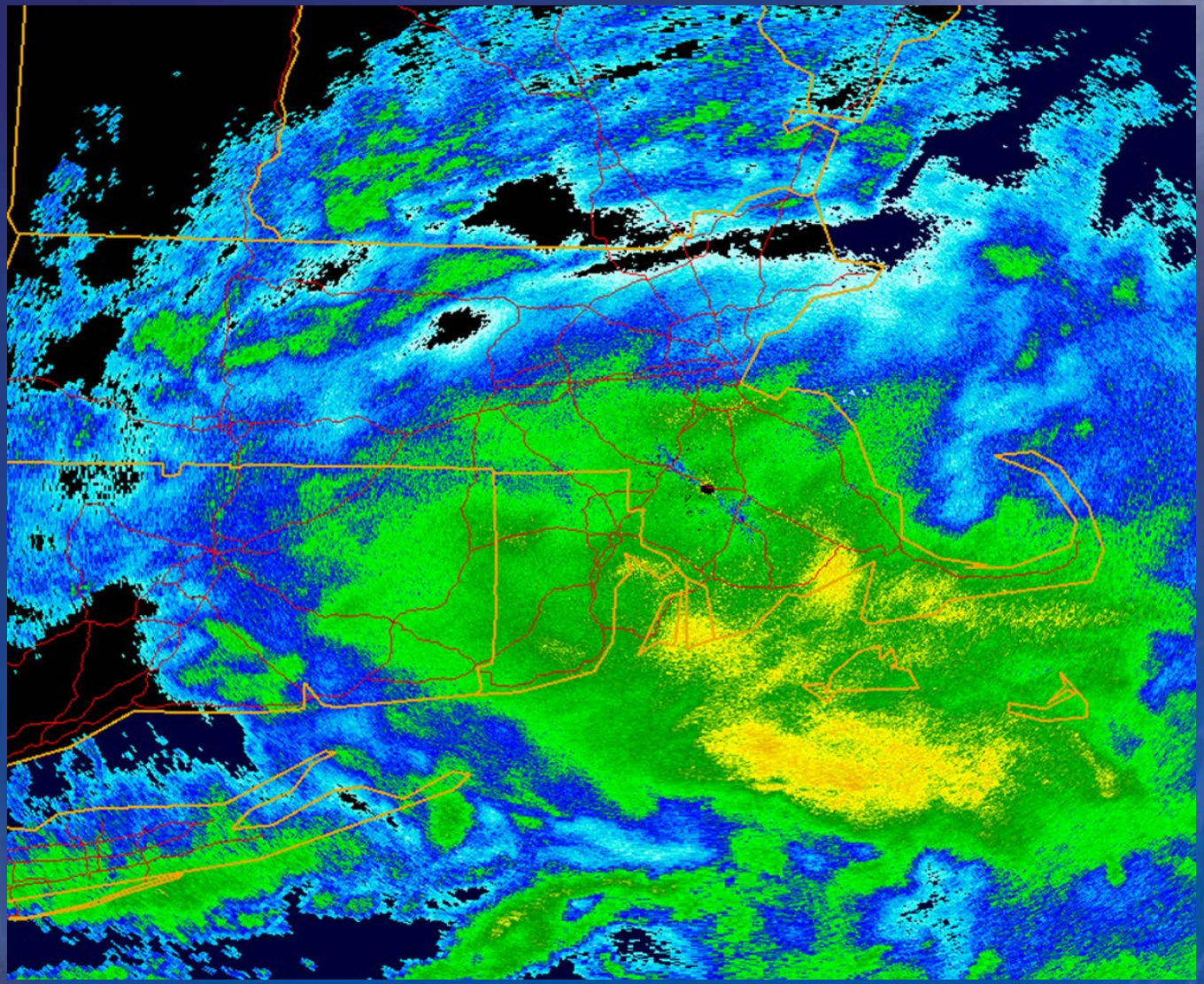
The combination of low CC and high ZDR in higher slices will help pin point the updraft columns.

Updraft Detection

ZDR Column off of KVNX 05/24/11

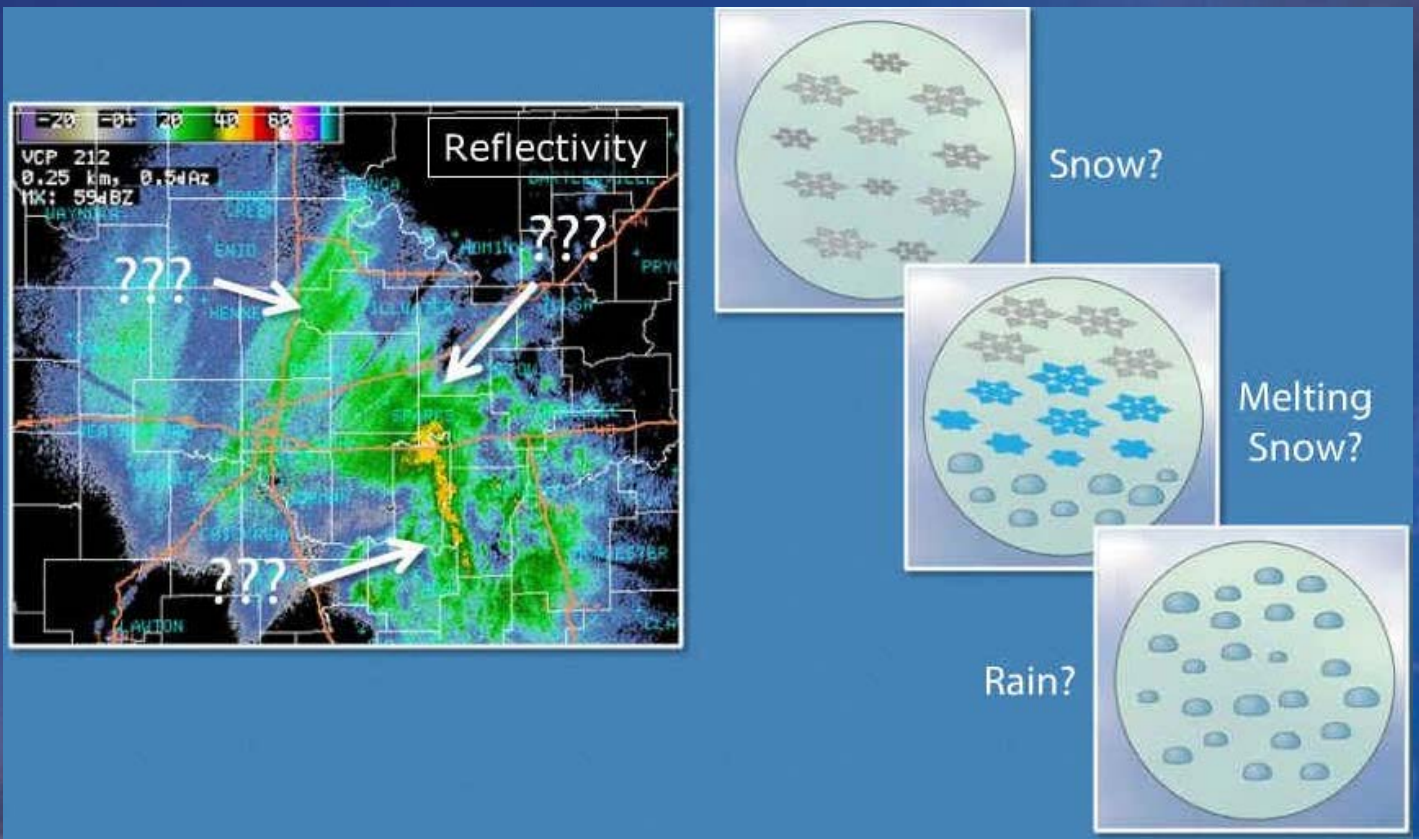


Winter Weather



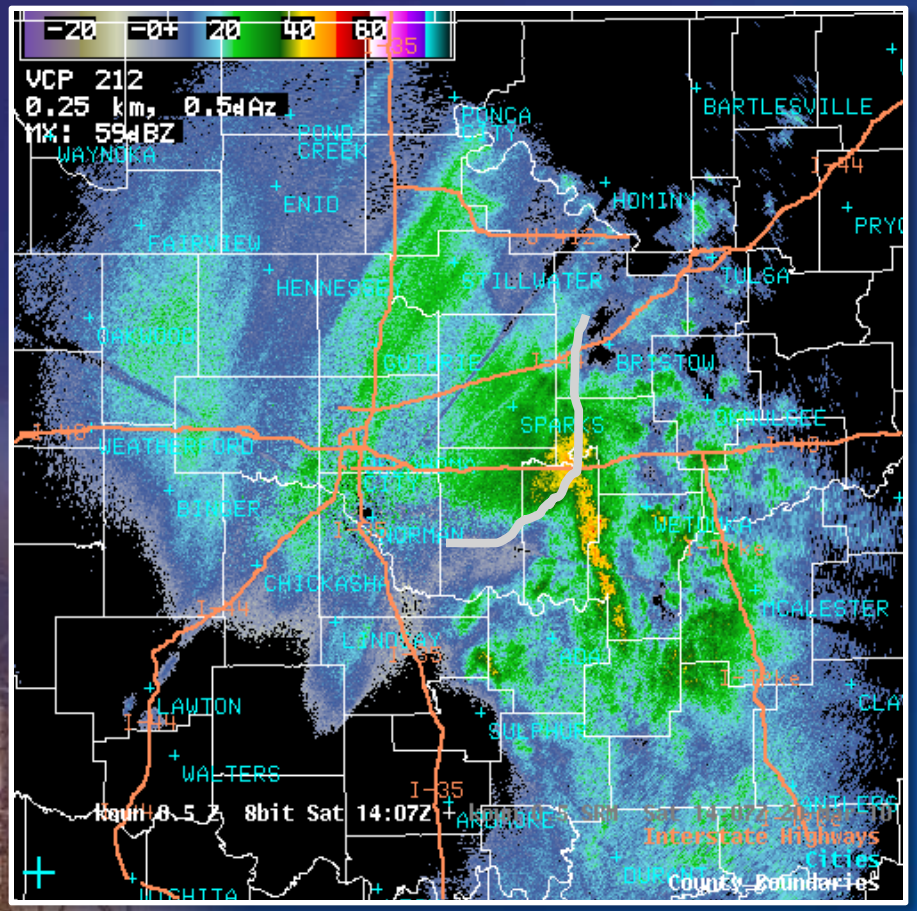
Dual Pol – Winter Weather

- The use of the new dual-pol variables will help identify between frozen and liquid hydrometeors. They will also help identify areas of homogeneous and non-homogeneous hydrometeors.

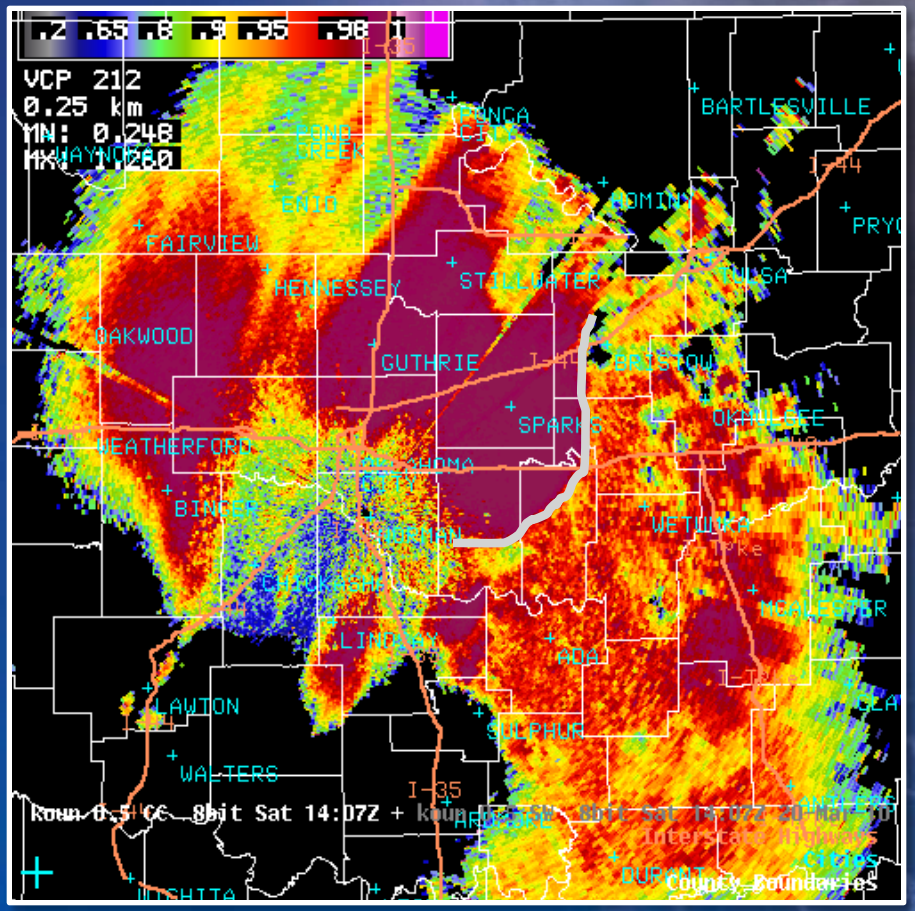


Rain vs. Snow

Reflectivity



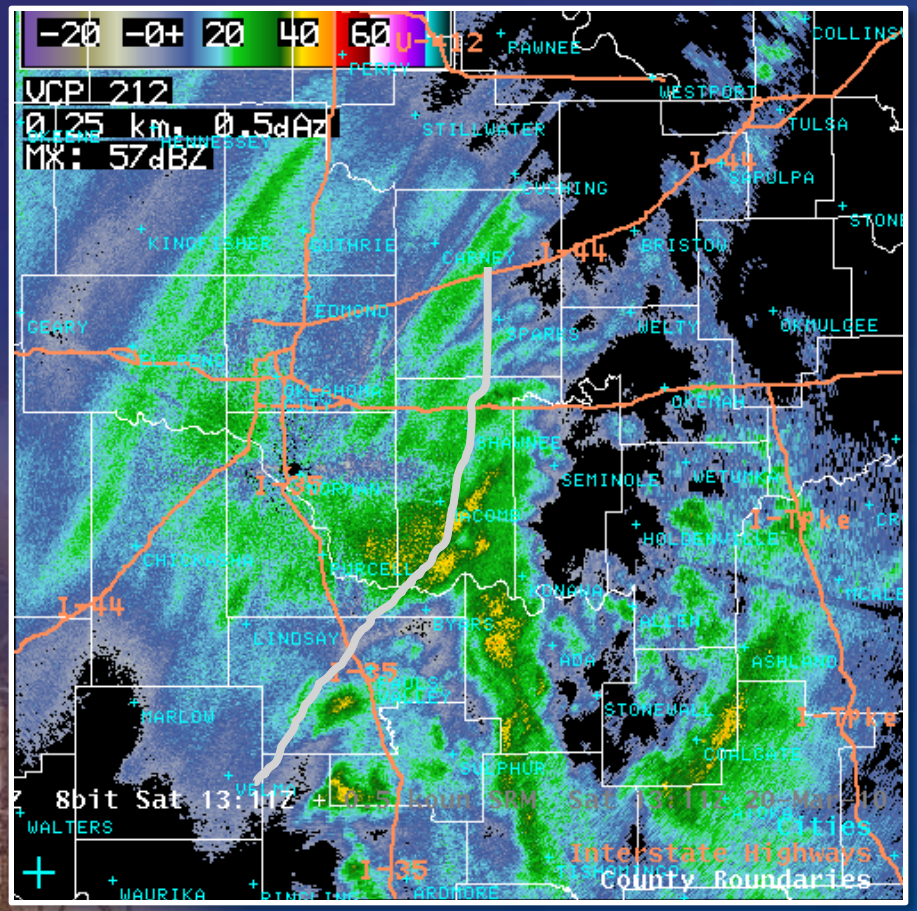
Correlation Coefficient



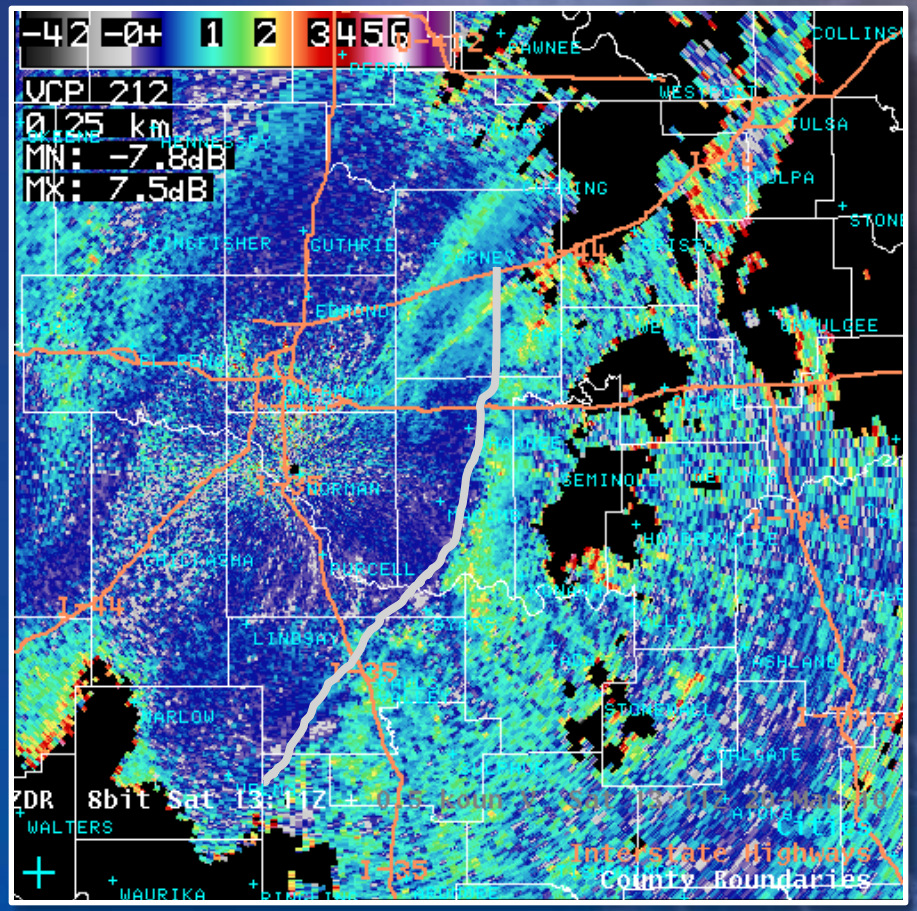
Transition from high to low CC marks the rain/snow transition line

Rain vs. Snow

Reflectivity



Differential Reflectivity

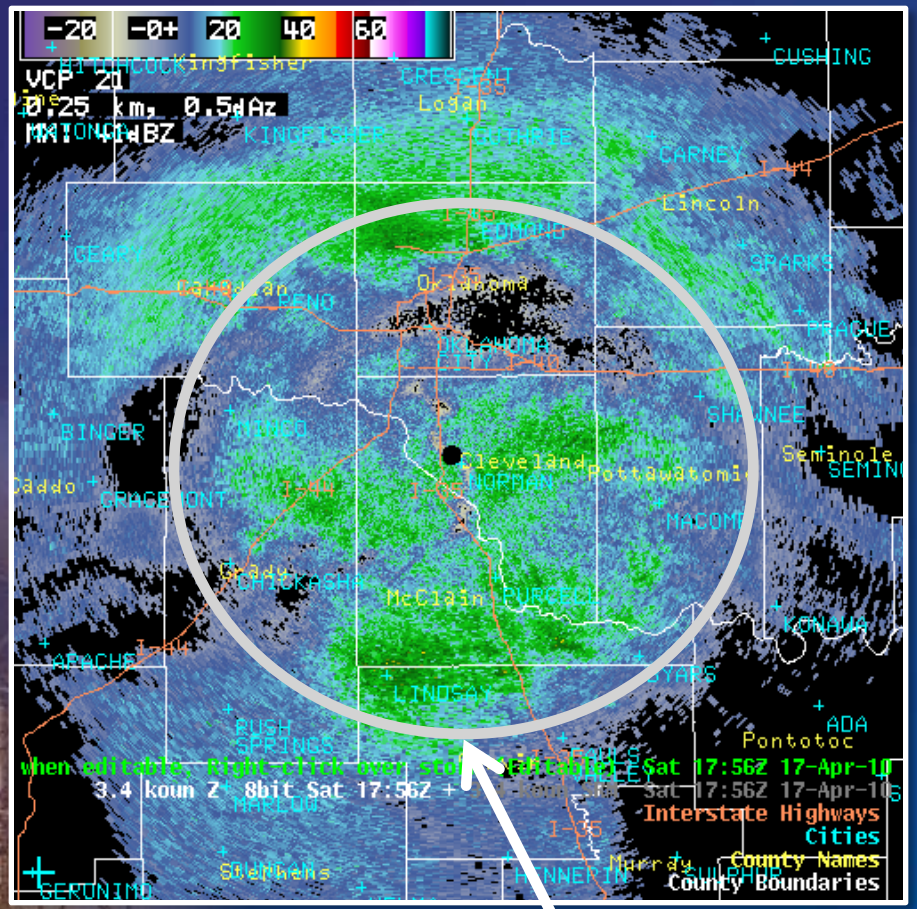


Rain/Melting Layer
ZDR > 1 dB and Generally Noisy

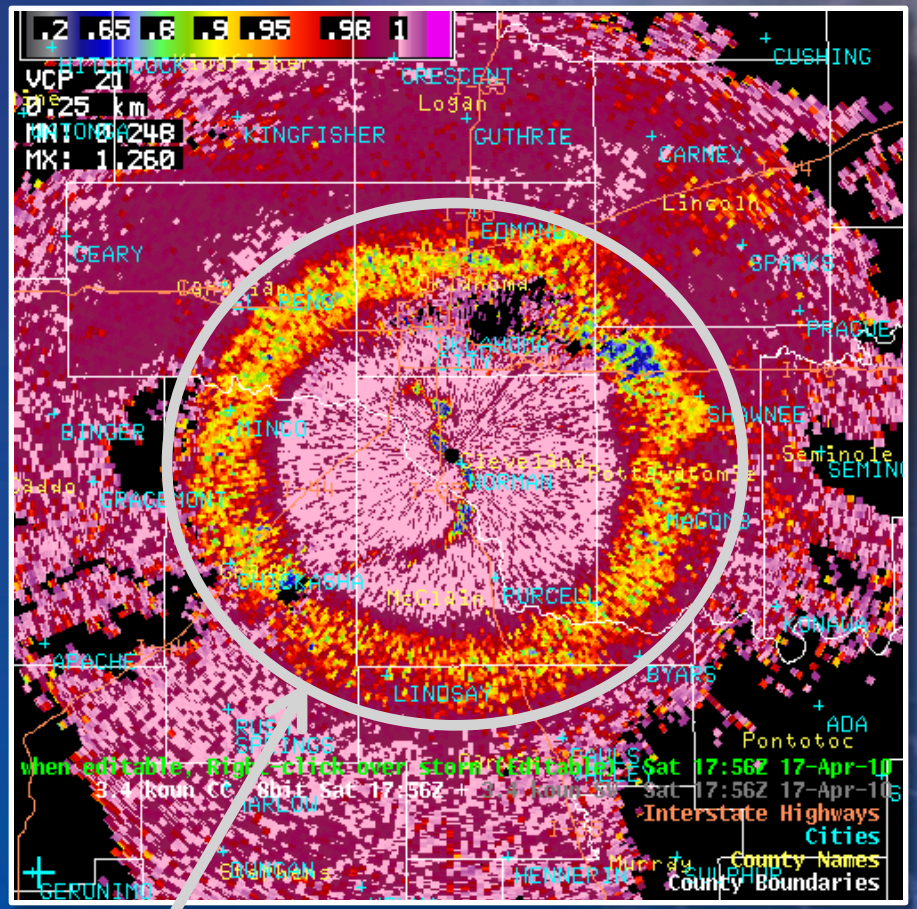
Snow
ZDR < 0.5 dB

Melting Layer

Reflectivity

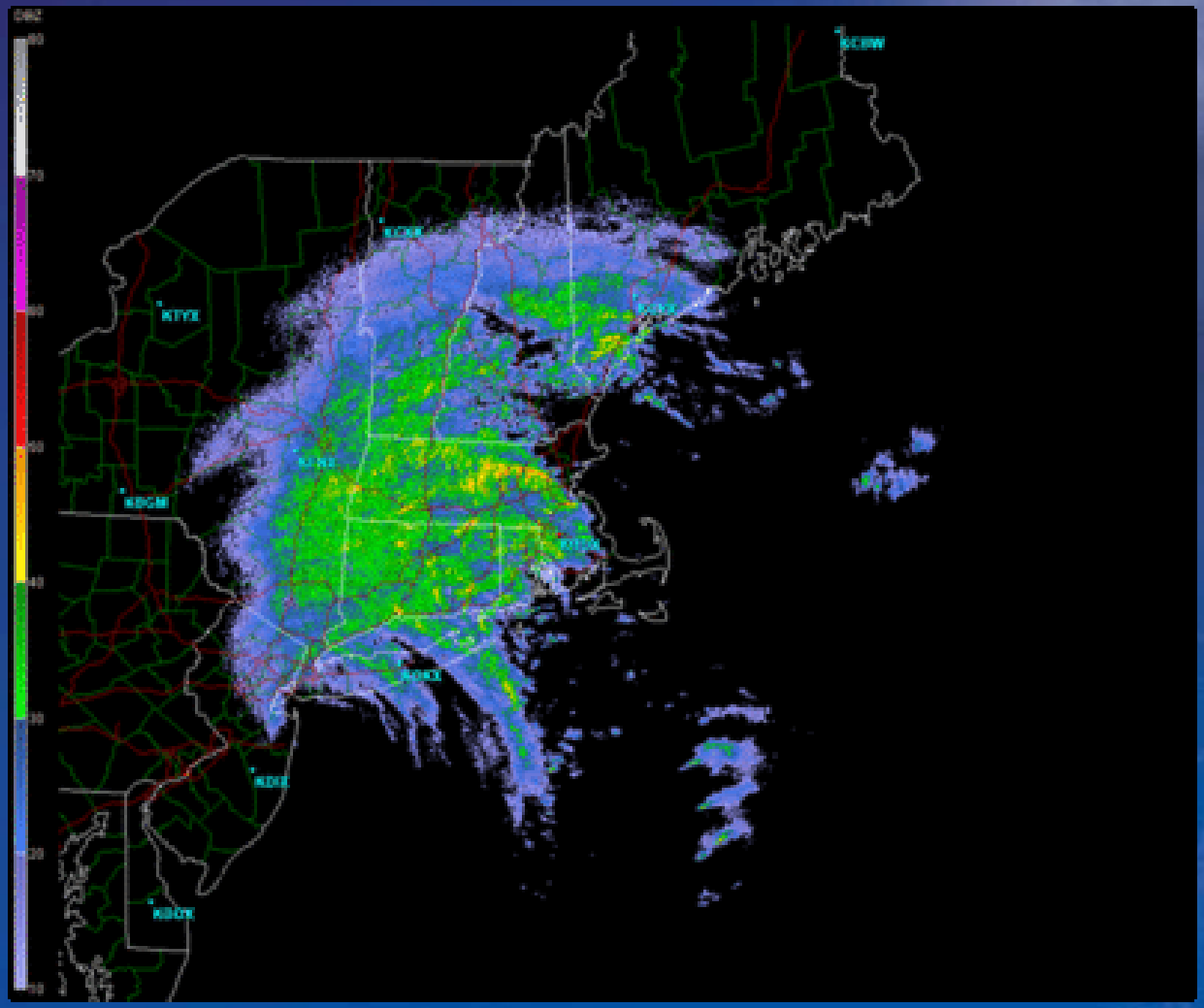


Correlation Coefficient



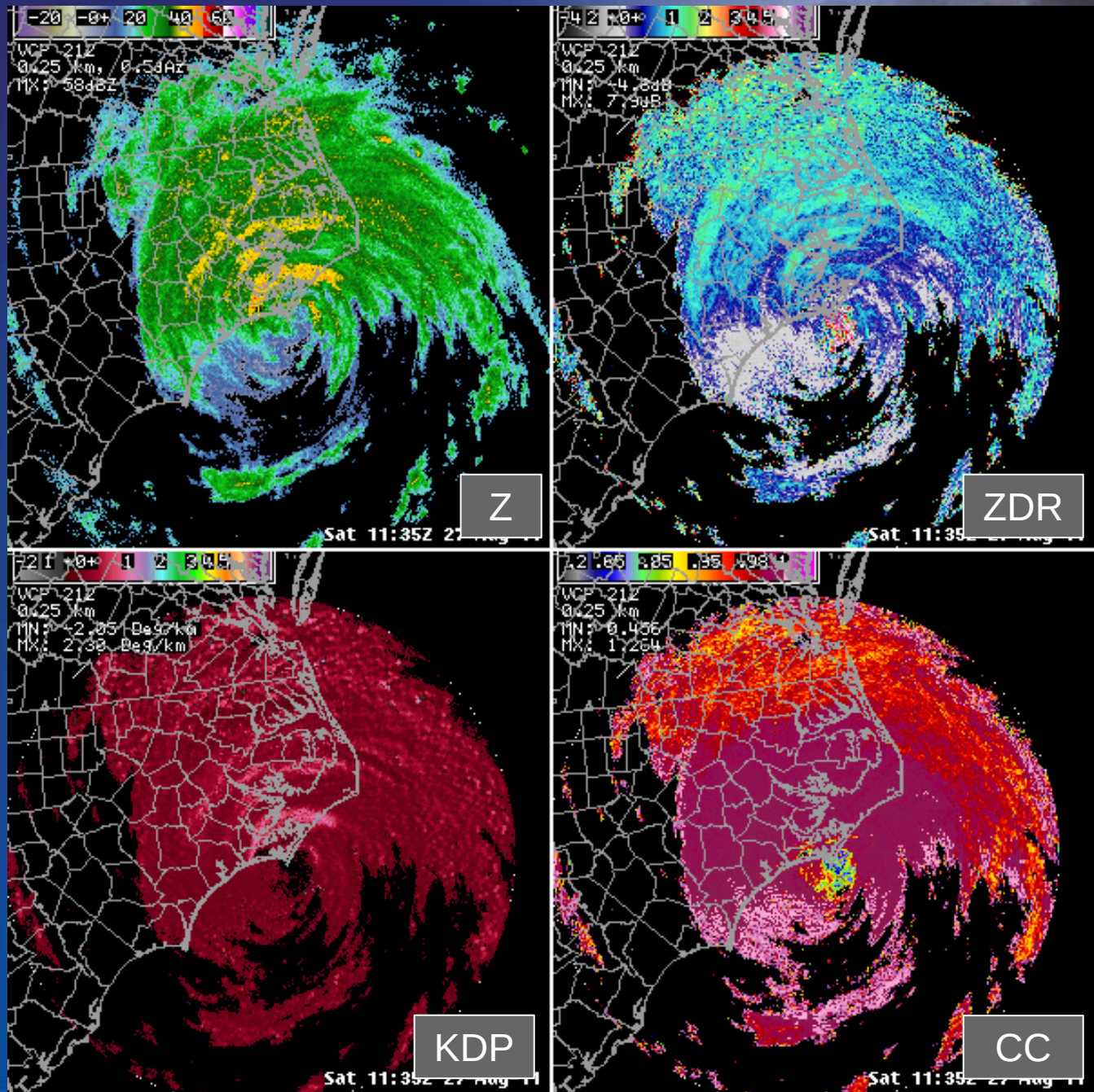
- Bright band not always visible
- Shows up as a ring of low correlation coefficient

Tropical Weather

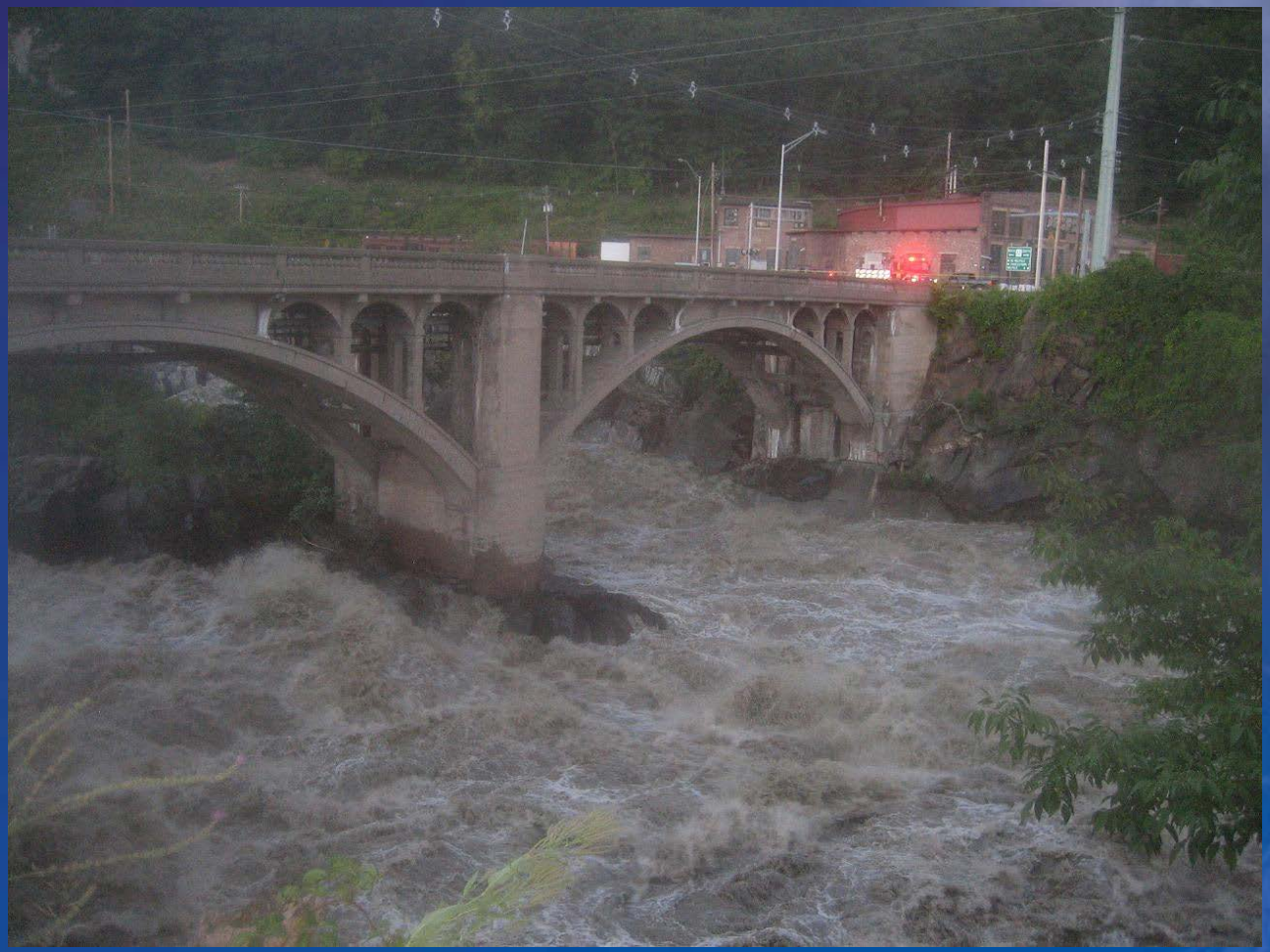


Hurricane Irene

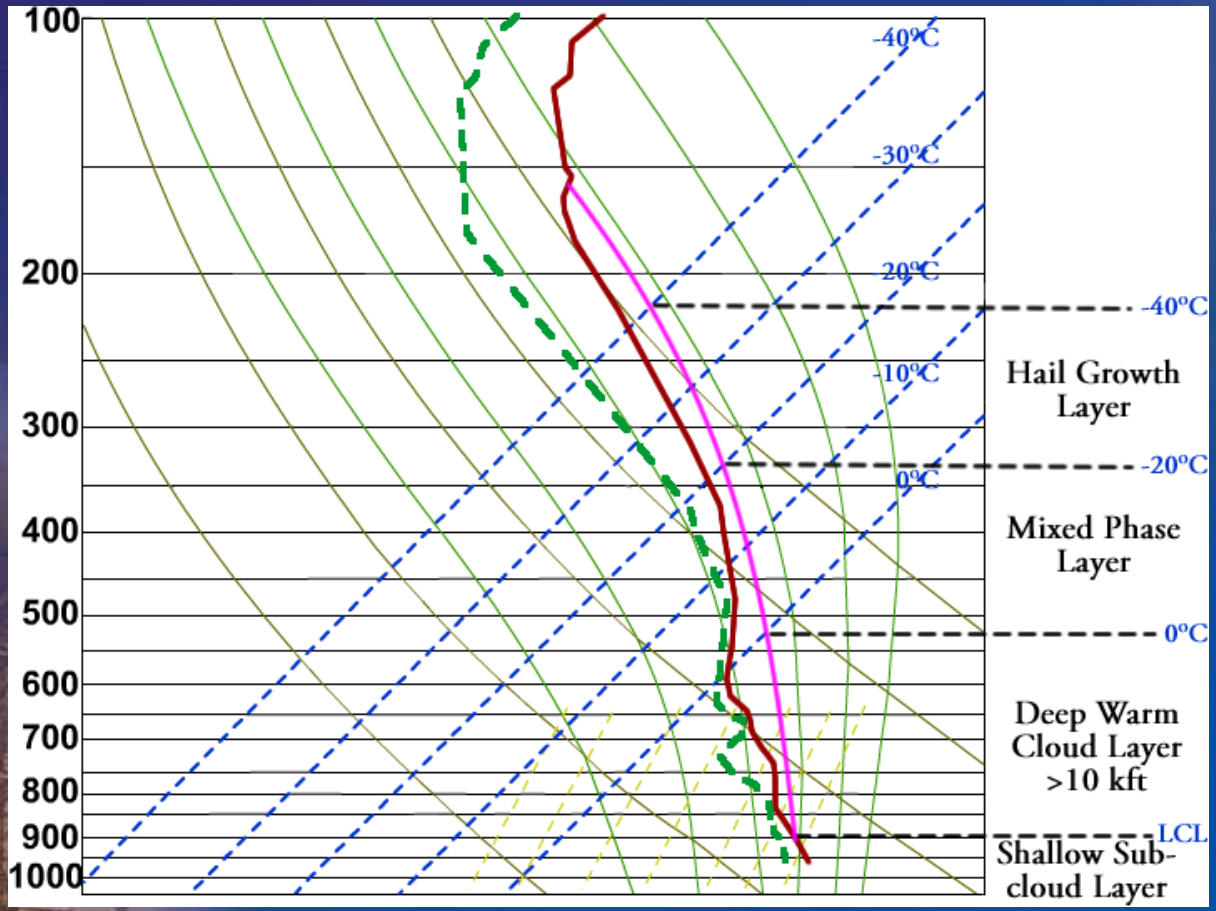
- Mod Z (35-50 dBZ)
- Low ZDR (< 2 dB)
- Mod KDP (up to 2 deg/km)



Precipitation Estimates

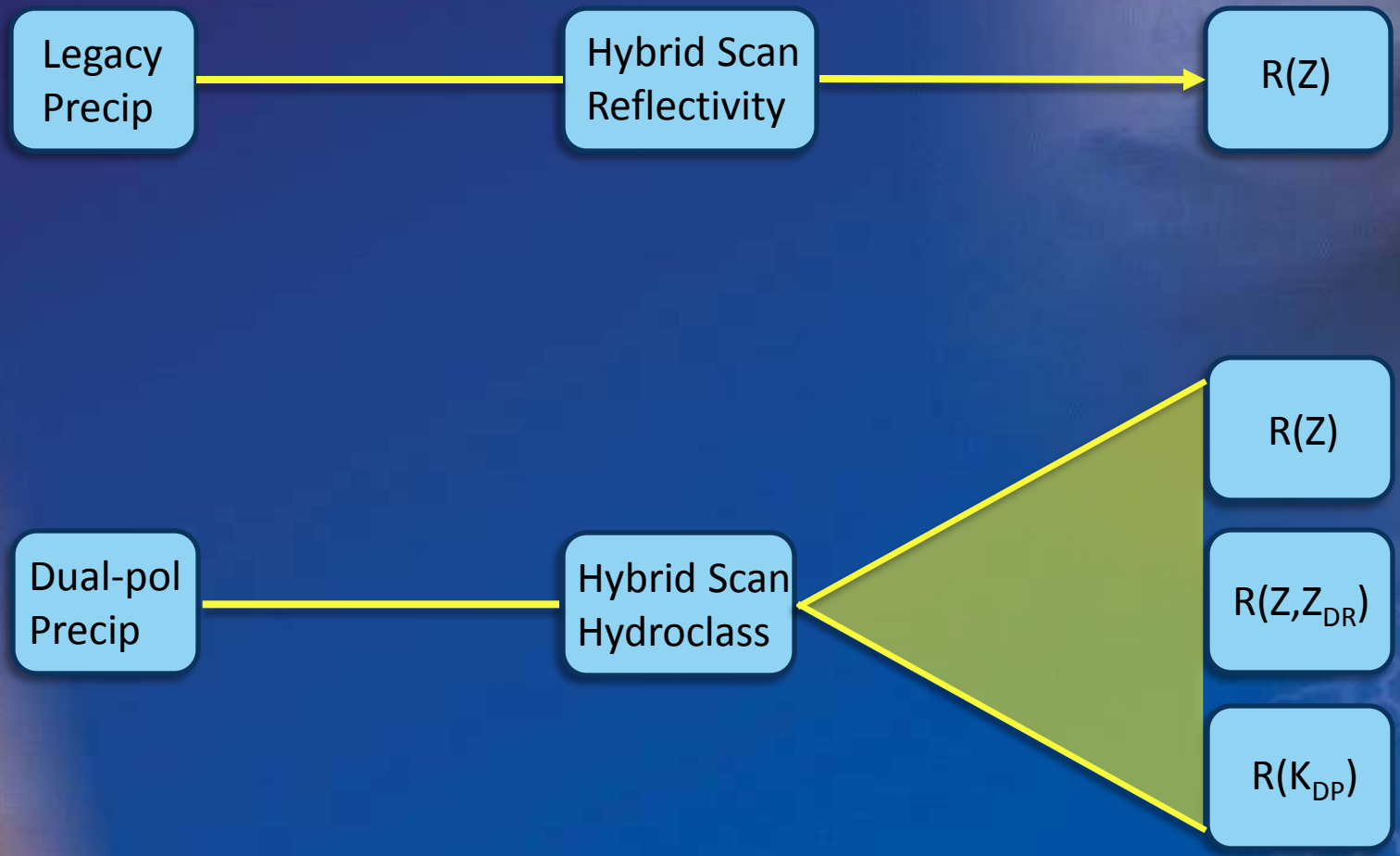


Dual Pol – Precipitation Estimates



- Provides expectations of the rainfall signatures you should expect
  - Tropical
  - Cold rain processes
  - Possibly mixed with hail

Purpose: QPE Specific to Hydrometeor Type!



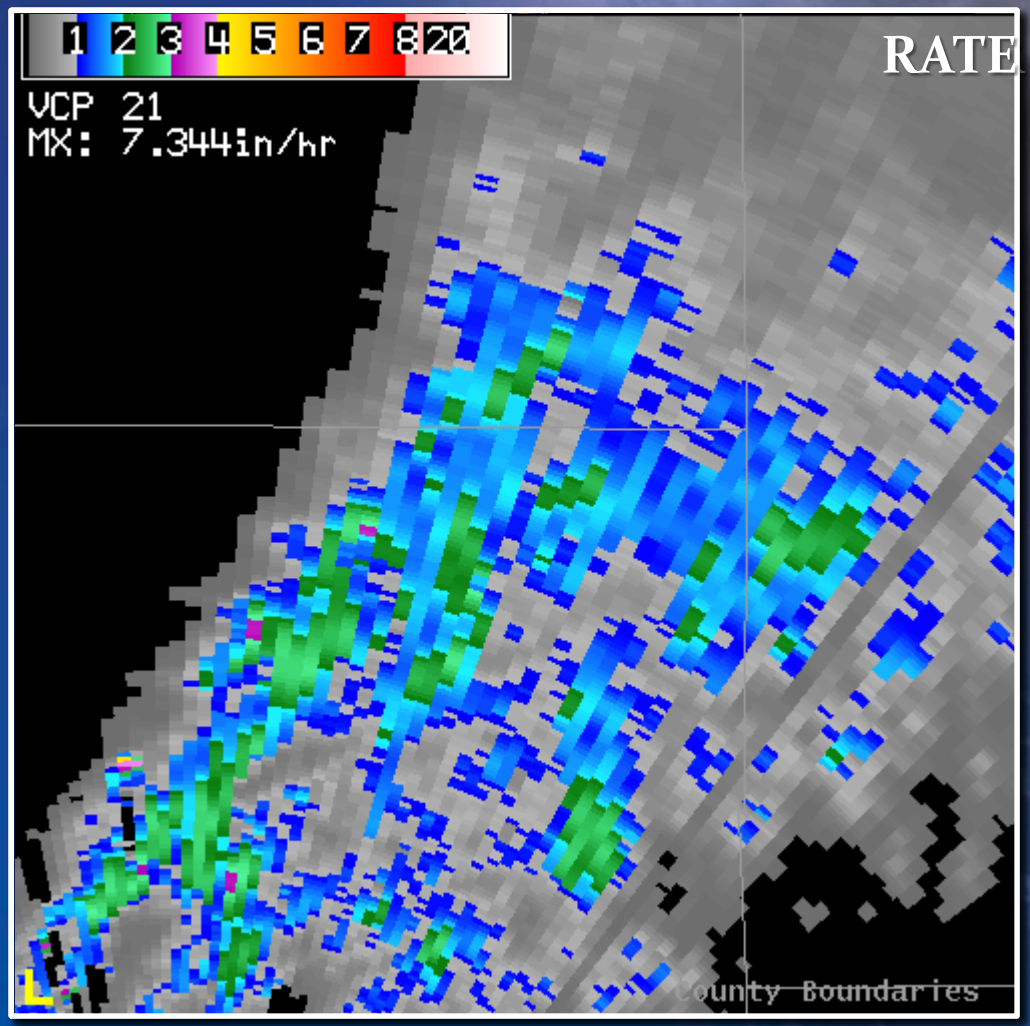
Hydro Met Precip

- Strengths: more accurate
  - Rain rate relations specific to hydromet types
  - Lower sensitivity to hail or bright banding
  - Non-met scat don't contribute to accum
- Limitations
  - Misclassification of hydromet types
  - No bias applied

Product Type	Product Name	Abbreviation
Instantaneous	1. Hybrid Hydroclass	HHC
	2. Digital Precipitation Rate	DPR
Accumulation	3. Digital Accumulation Array	DAA
	4. One Hour Accumulation	OHA
	5. Digital Storm Total Accumulation	DSA
	6. Storm Total Accumulation	STA
Difference	7. Digital One Hour Difference	DOD
	8. Digital Storm-Total Difference	DSD
User-selectable	9. Digital User-Selectable Accumulation	DUA

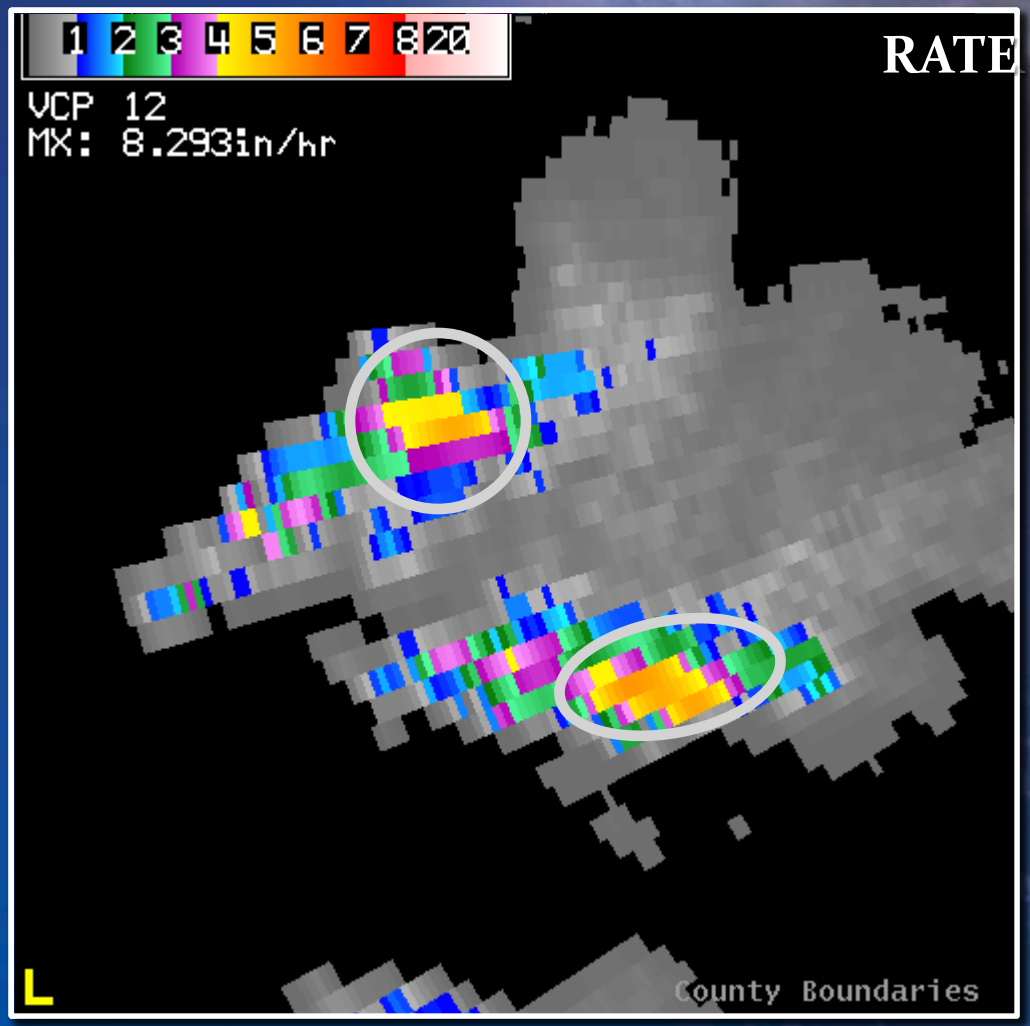
Dual-pol Base Data Characteristics of Heavy Rain: Tropical

- Fairly high 40 > Z > 55 dBZ
- 0.5 > ZDR > 3.0 dB
- CC > 0.98
- KDP > 1.0 deg/km



Dual-pol Base Data Characteristics of Heavy Rain: Continental

- High 50 > Z > 60 dBZ
- 2.0 > ZDR > 5.0 dB
- CC > 0.96
- KDP > 1.0 deg/km



Wrap-Up

- Using the dual-pol products can enhance the warning decision operators confidence in hail size and location, tornadic debris, precipitation estimates, rain/snow line, updraft column etc.

- Forecasters should try to incorporate but not rely solely on the dual-pol products, as there are still errors in some of the data.

- There is still more to learn and discover about dual-pol, as more radars come online.

Questions?

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