What is Dual-Polarization Radar and What Can It Do for Me?

Part 1

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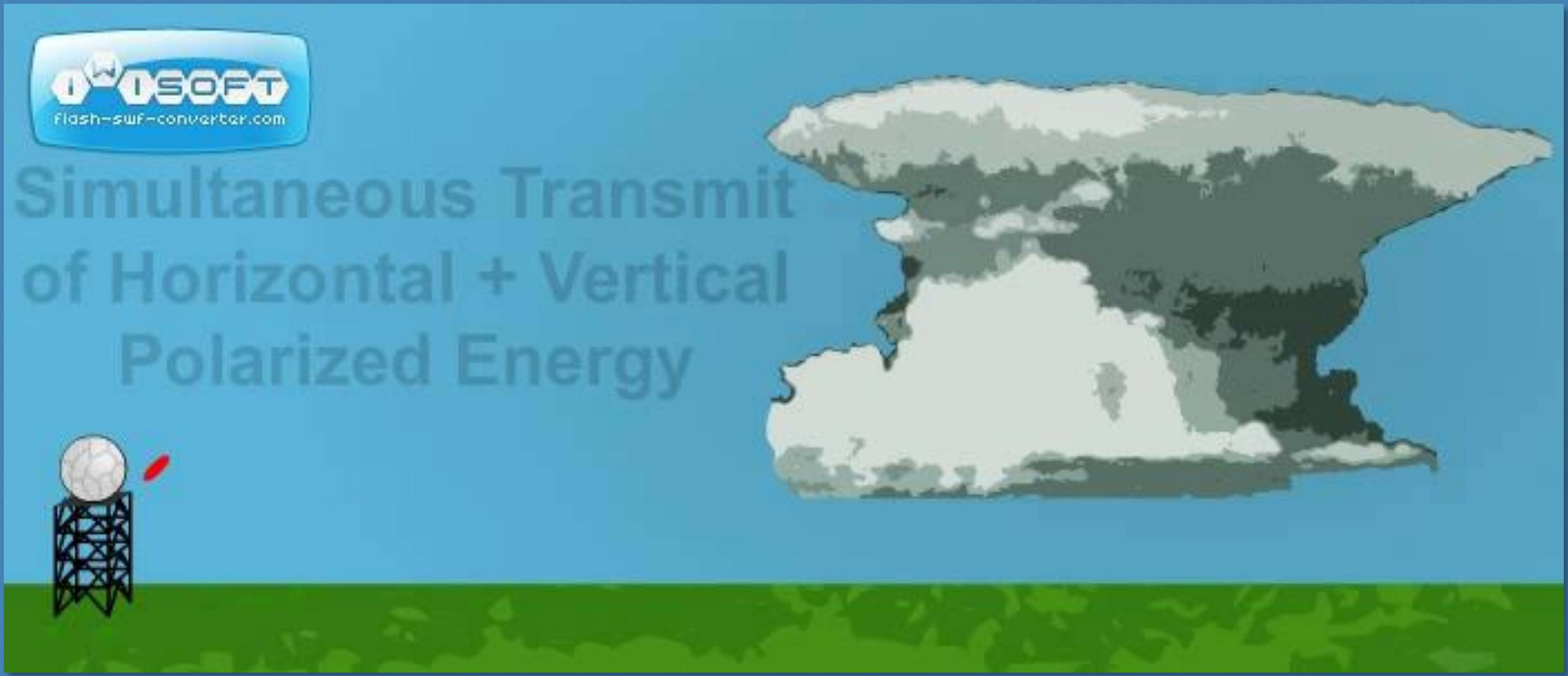
Objectives

1. Describe how dual-polarization radar (dual-pol) works compared to current WSR-88D
2. Identify the base and derived products that will be available with dual-pol
3. Describe the concept behind each new base product
4. Identify the typical values of each base product for rain, hail, snow/ice crystals, and clutter/biological scatterers

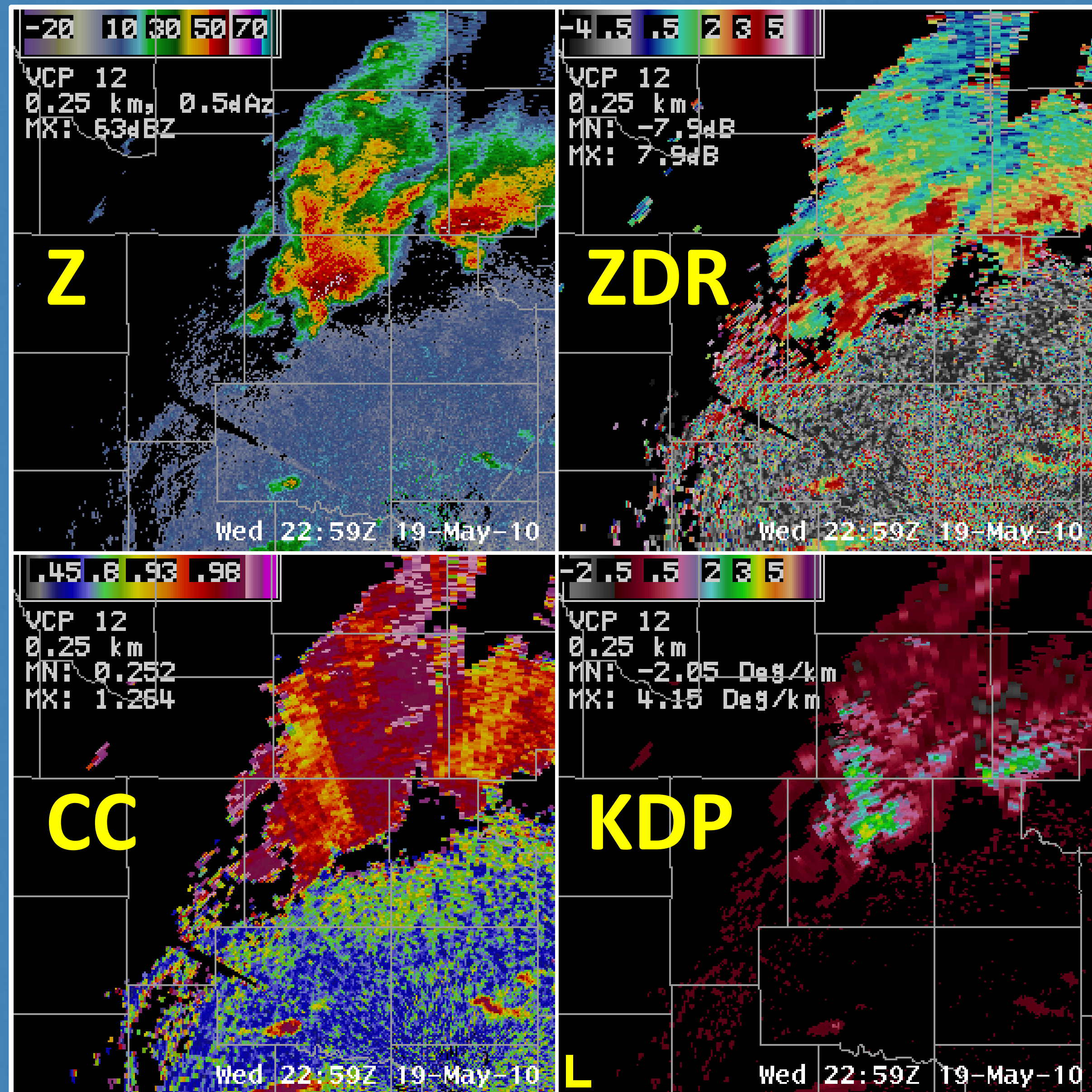
1. How Dual-Pol Works



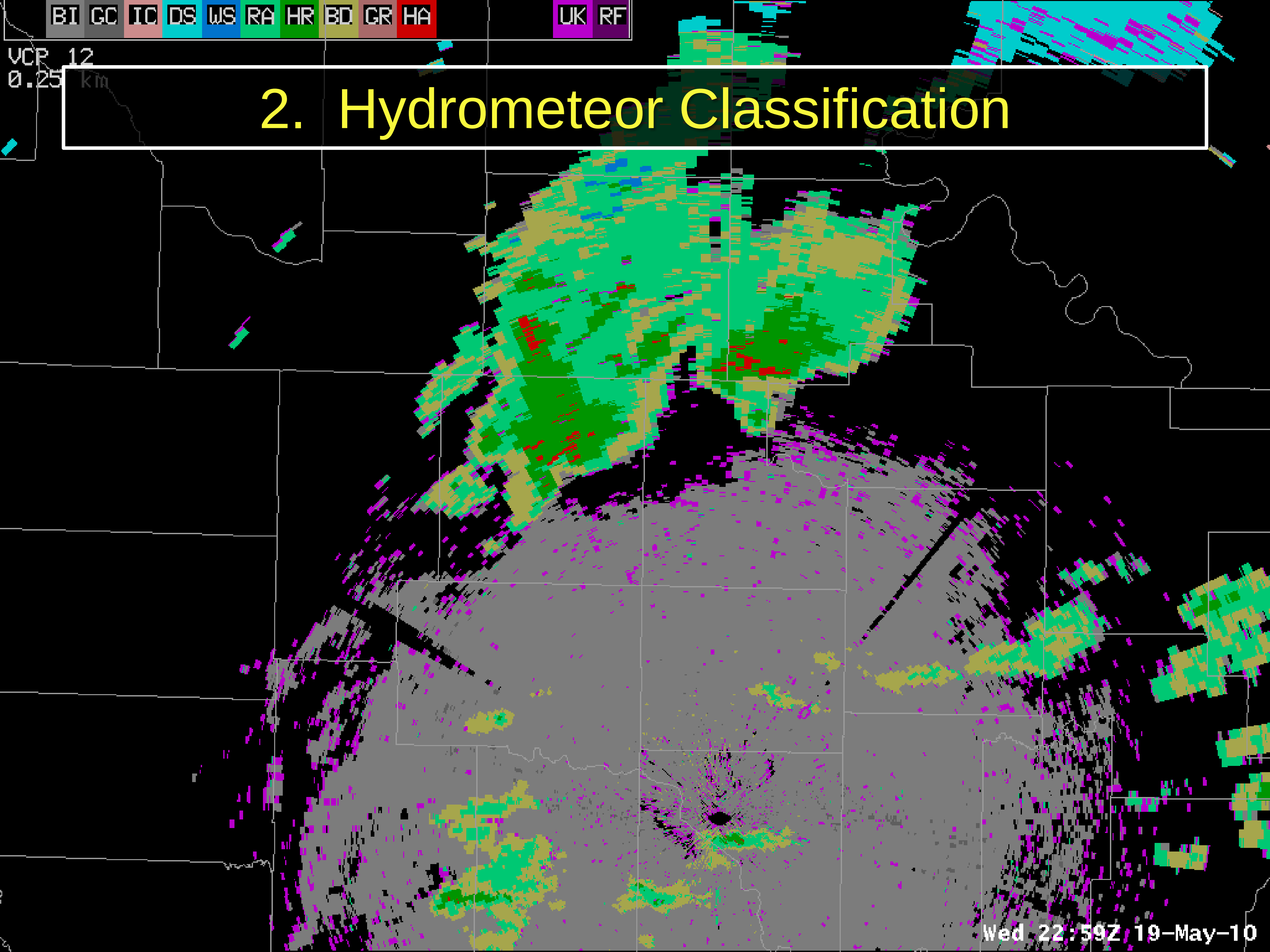
- ***CONVENTIONAL***
  - Send/receive horizontal polarization (size only)
- ***DUAL-POL***
  - Send/receive both horizontal & vertical polarization (size, shape, variety)

2. Base Products Available with Dual-Pol

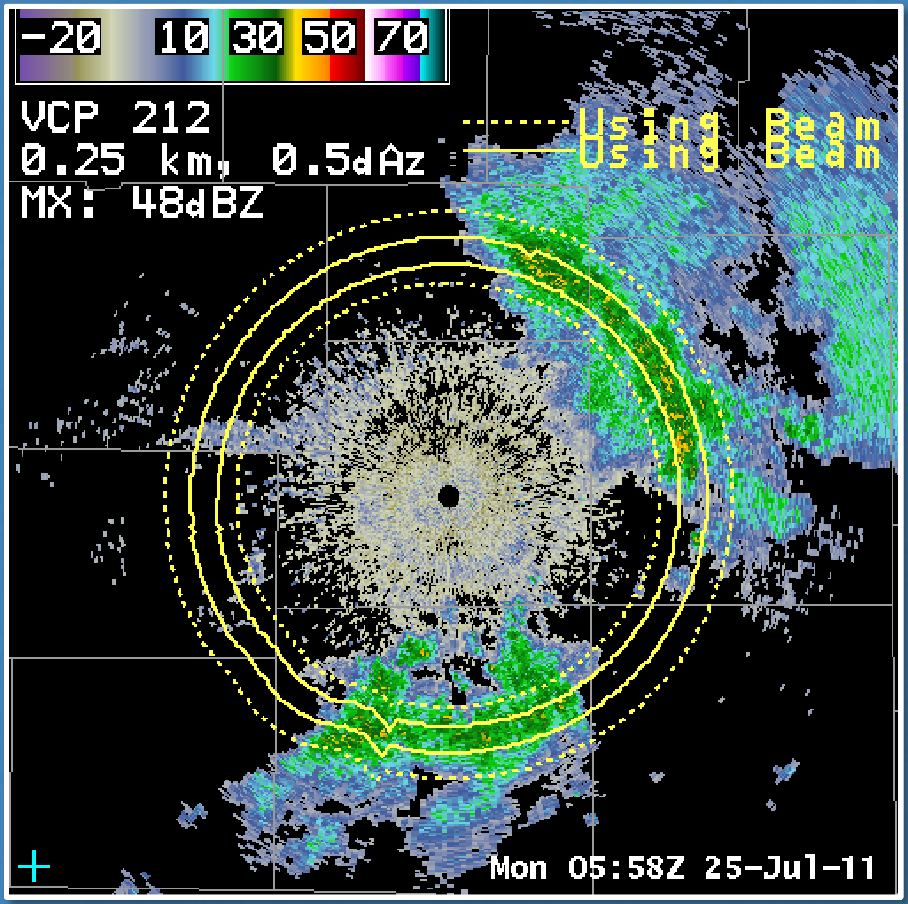
- Still get:
  - **Reflectivity (Z)**
  - **Velocity (V)**
  - **Spectrum Width (SW)**
- Plus
  - **Differential Reflectivity (ZDR)**
  - **Correlation Coefficient (CC)**
  - **Specific Differential Phase (KDP)**

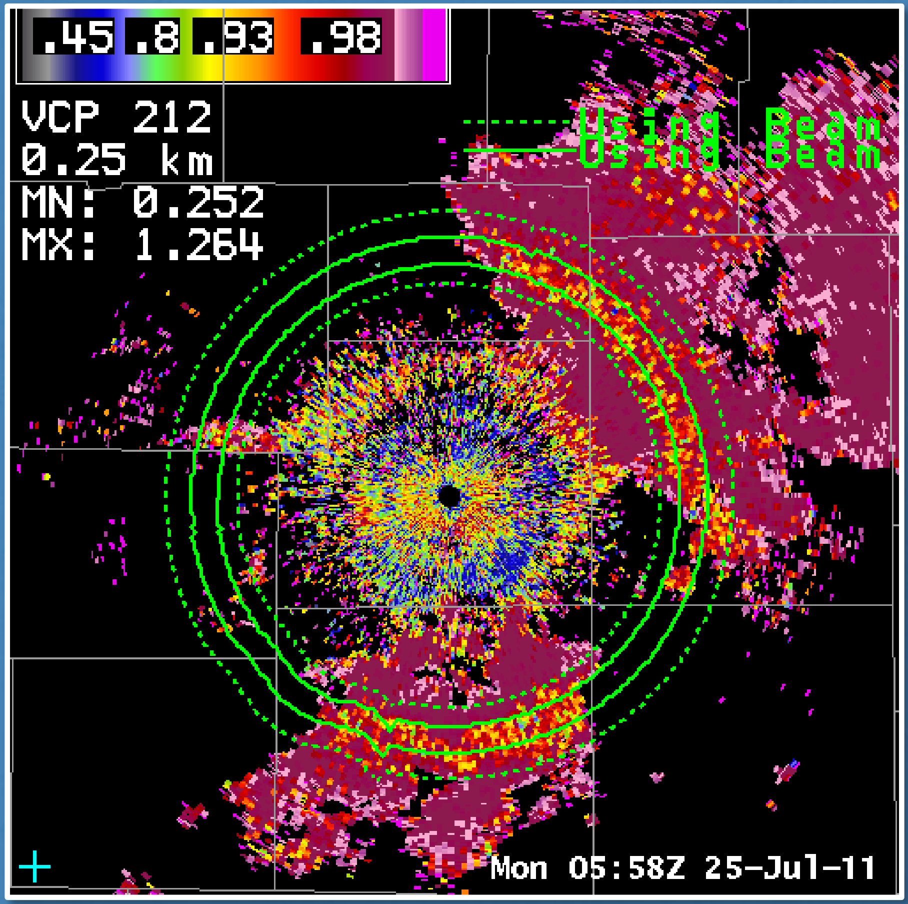


2. Hydrometeor Classification



2. Melting Layer

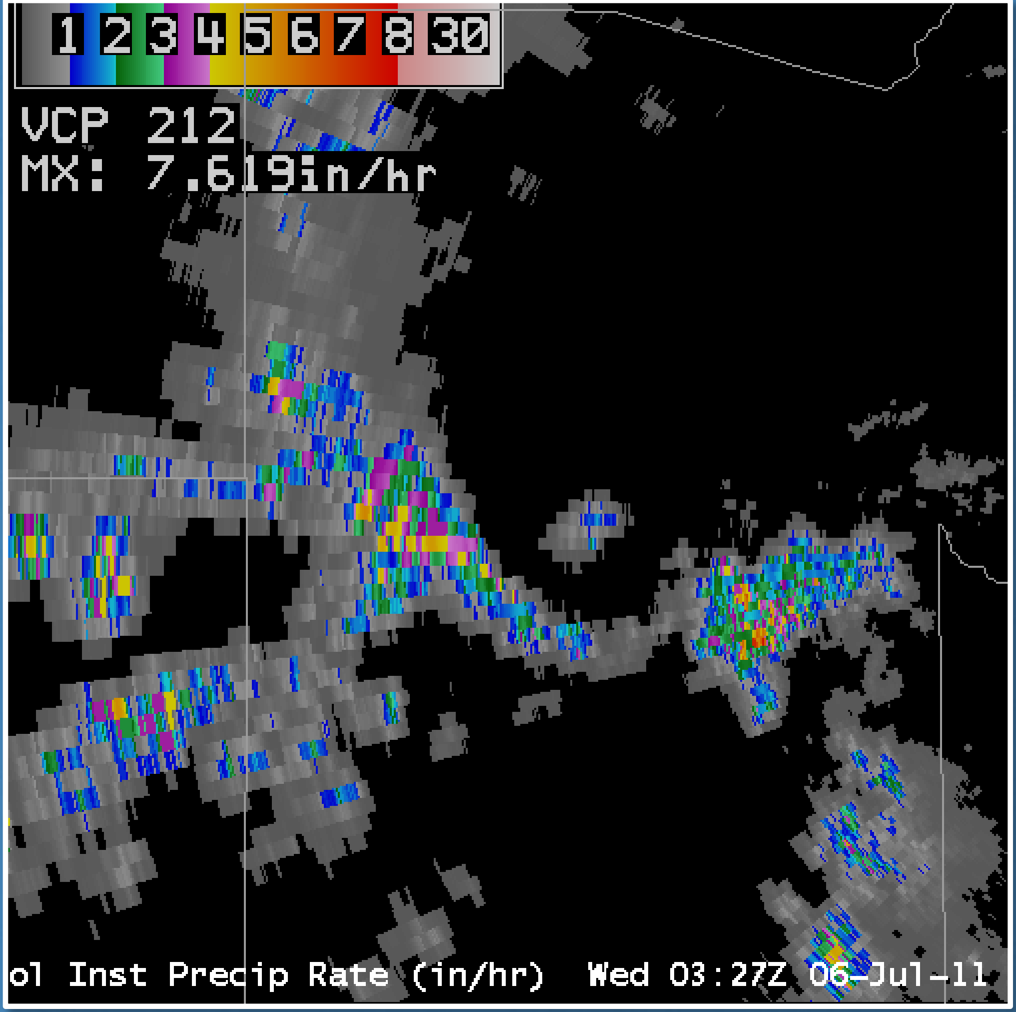




Stands out like a sore thumb in CC

2. Precipitation (QPE) Products

- 9 new products
  - Instantaneous
    - HHC
    - DPR
  - Accumulation
    - STA (i.e. STP)
    - DSA (i.e. STP)
    - OHA (i.e. OHP)
    - DAA (i.e. OHP)
    - DUA (i.e. USP)
  - Diff (DP – Legacy)
    - DSD
    - DOD



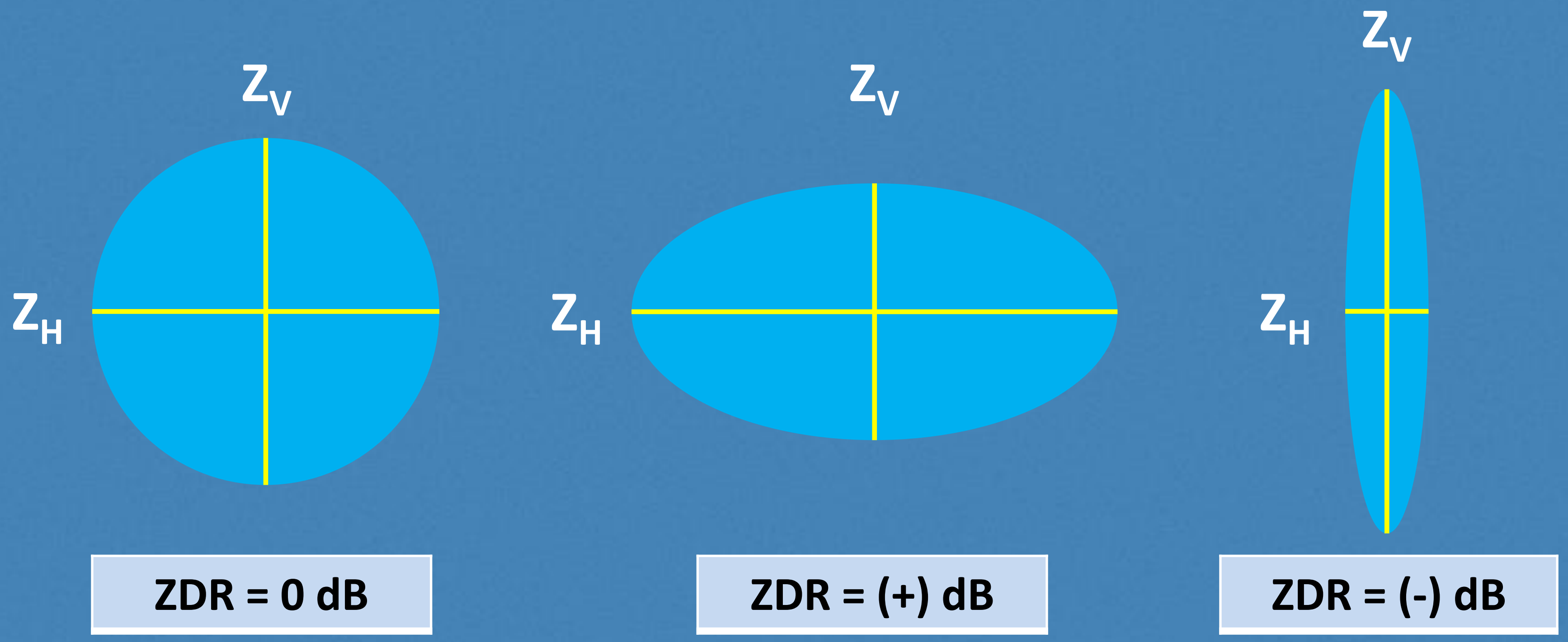
3. What is Differential Reflectivity?

- Definition:
  - Difference between horizontal and vertical reflectivity factors

Range of Values	Units	Abbreviations
-7.9 to 7.9	decibels (dB)	ZDR or Z_{DR}

$$ZDR = Z_H - Z_V$$

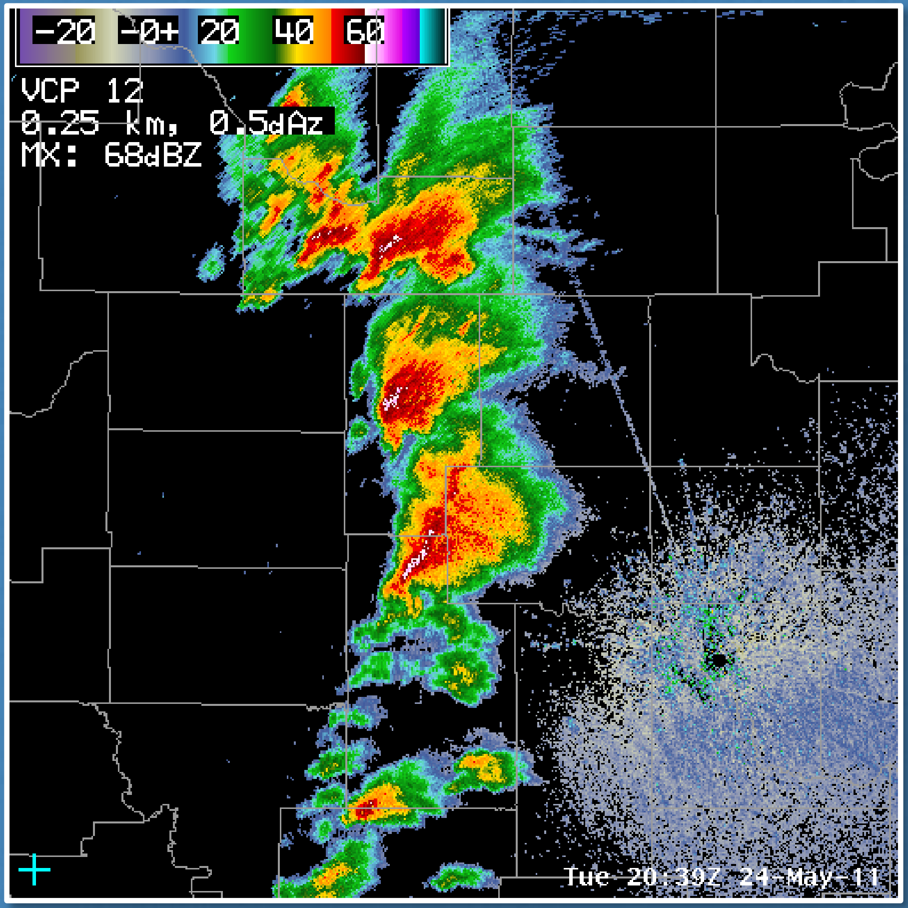
3. How Do I Interpret ZDR?



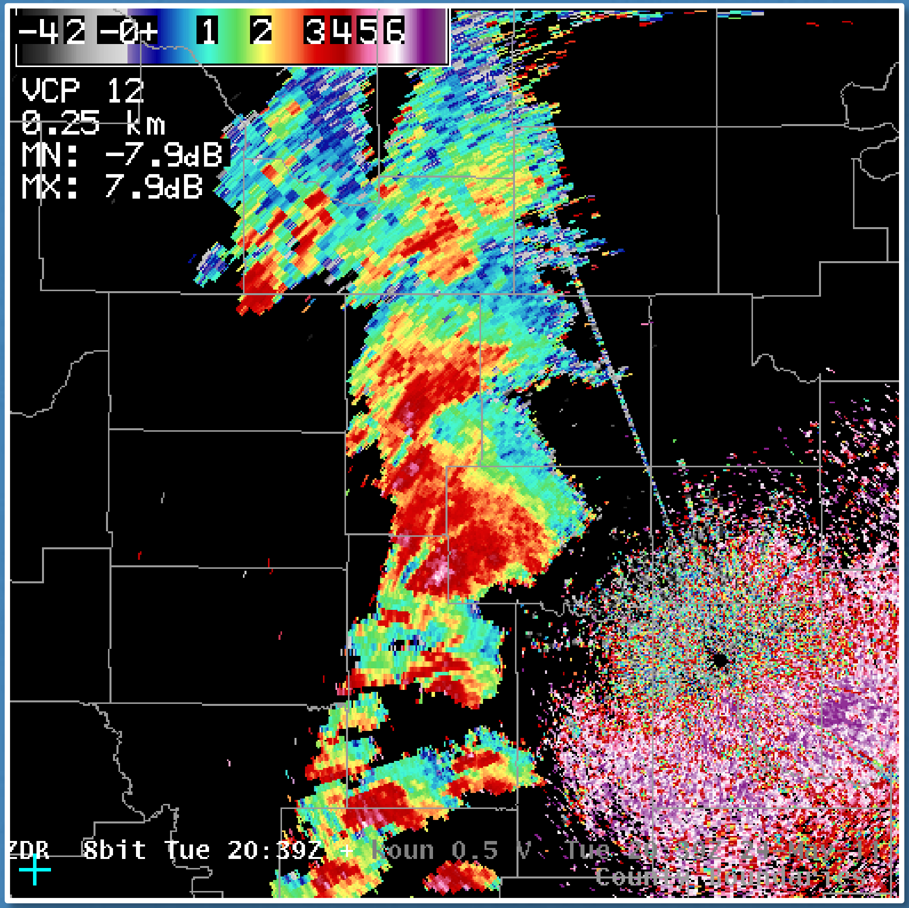
- Caveat:
  - Biased toward dominant scatterer!

3. What will ZDR look like?

Z



ZDR



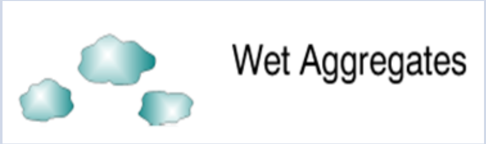
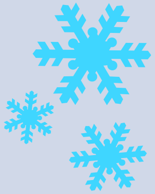
24 May 2011 in West Central Oklahoma

3. What is Correlation Coefficient?

- Definition:
  - Measure of how similarly the horizontally and vertically polarized pulses are behaving in a pulse volume

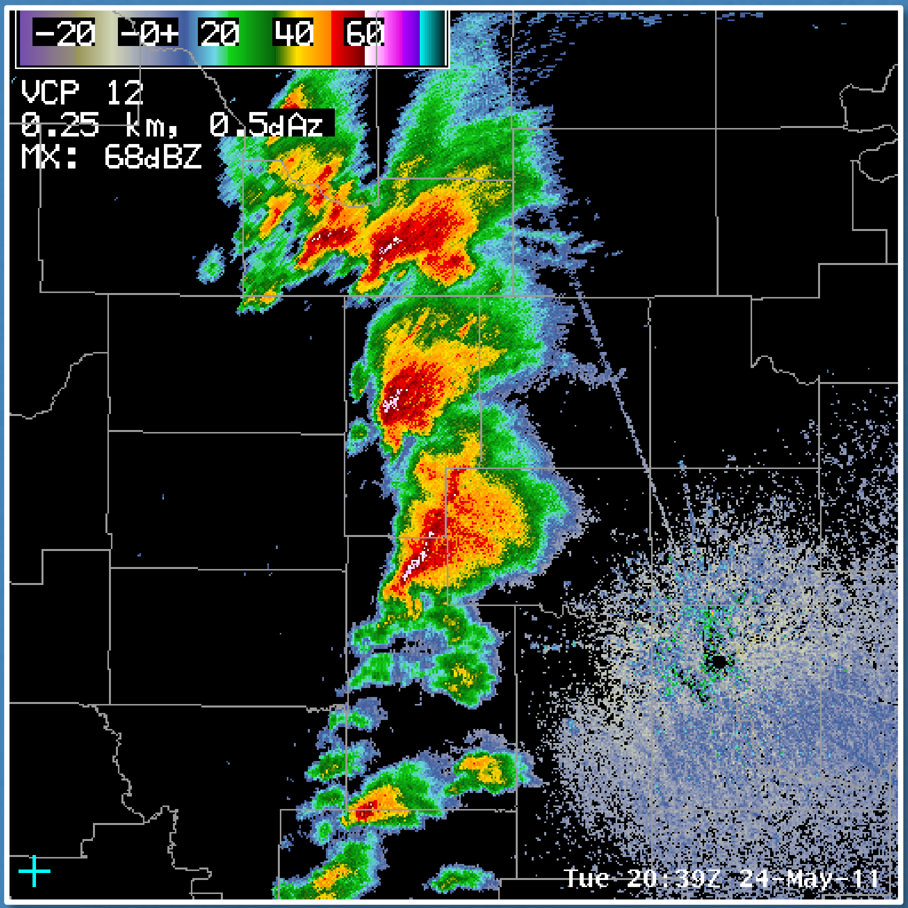
Range of Values	**Units**	**Abbreviations**
0.2 to 1.05	**unitless**	**CC or ρ_{HV}**

3. How Do I Interpret CC?

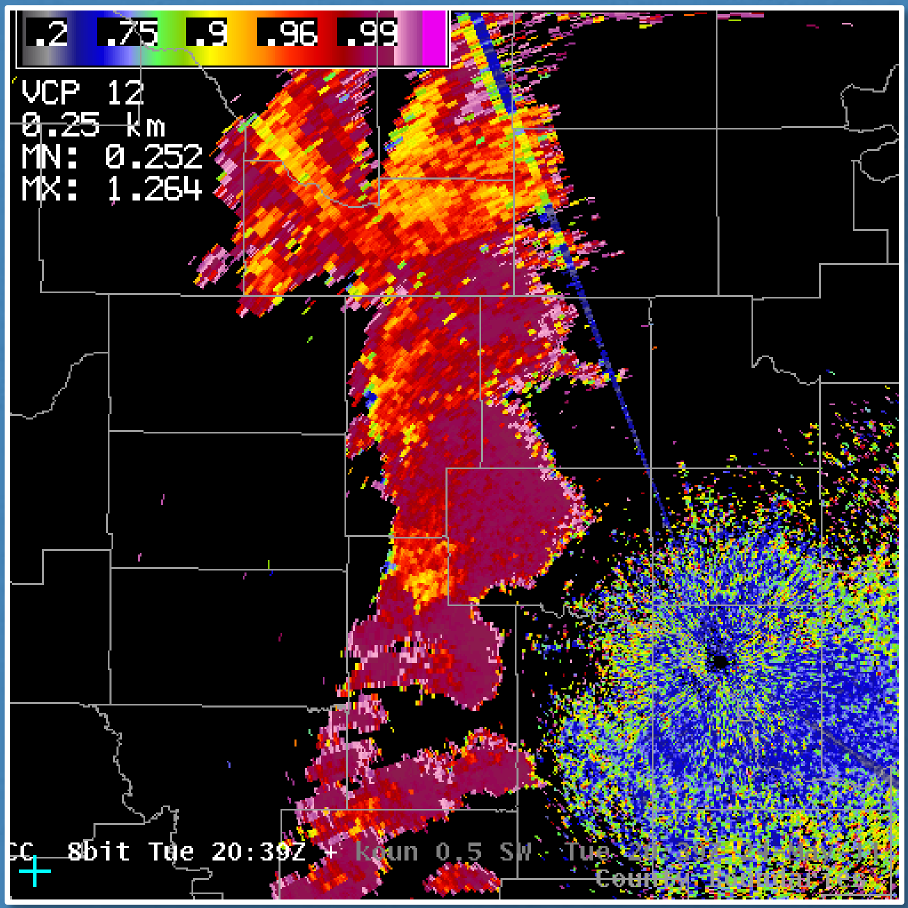
Non-Meteorological (birds, insects, etc.)	**Metr (Non-Uniform)** (hail, melting snow, etc.)	**Metr (Uniform)** (rain, snow, etc.)
	 	 
Complex scattering from pulse-to-pulse. Horizontal and vertical pulses change in different manners from pulse-to-pulse	Somewhat complex scattering from pulse-to-pulse. Moderate differences from pulse-to-pulse for the horizontal and vertical pulses	Well-behaved scattering from pulse-to-pulse. Little differences from pulse-to-pulse for the horizontal and vertical pulses
Low CC (< 0.8)	Moderate CC (0.80 to 0.97)	High CC (> 0.97)

3. What will CC look like?

Z



CC



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3. What is Specific Differential Phase?

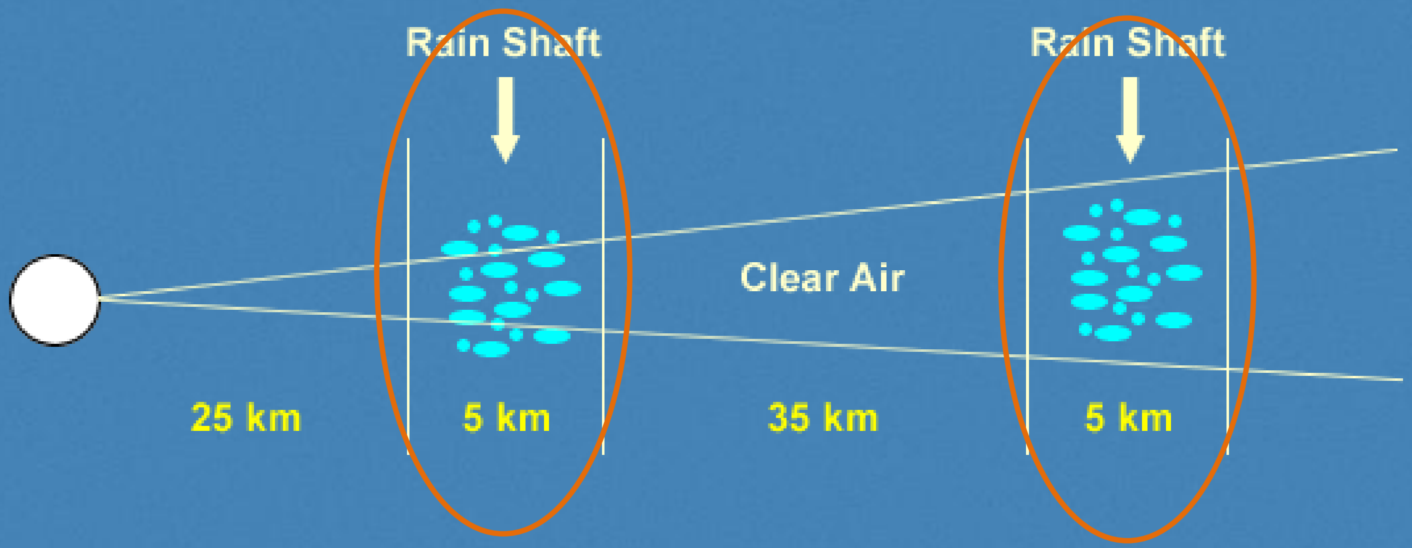
- Definition:
  - Range derivative of the differential phase shift

Range of Values	Units	Abbreviations
-2 to 10	deg/km	KDP or K_{DP}

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

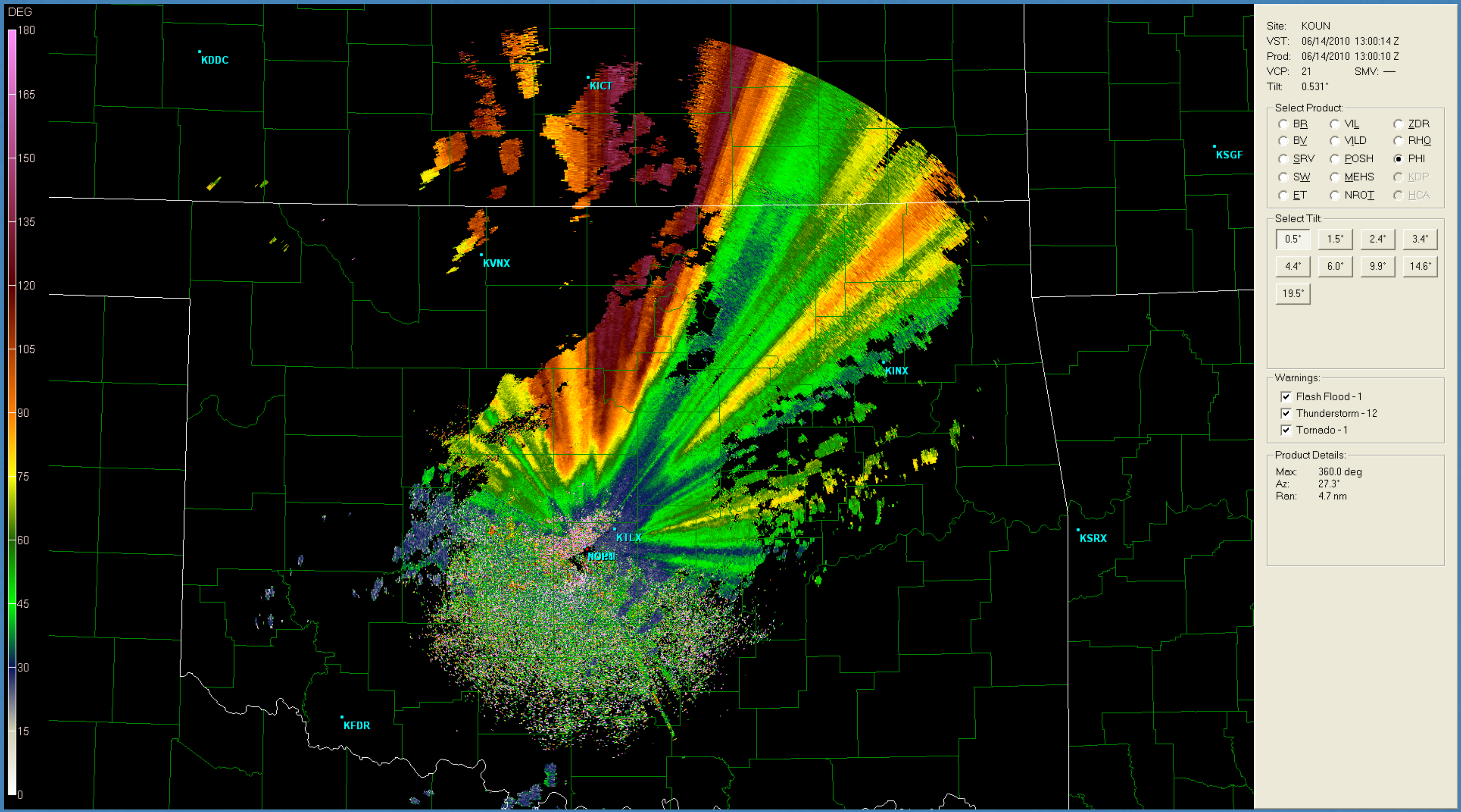
Why KDP?

- Φ_{DP} is cumulative
  – Difficult to interpret



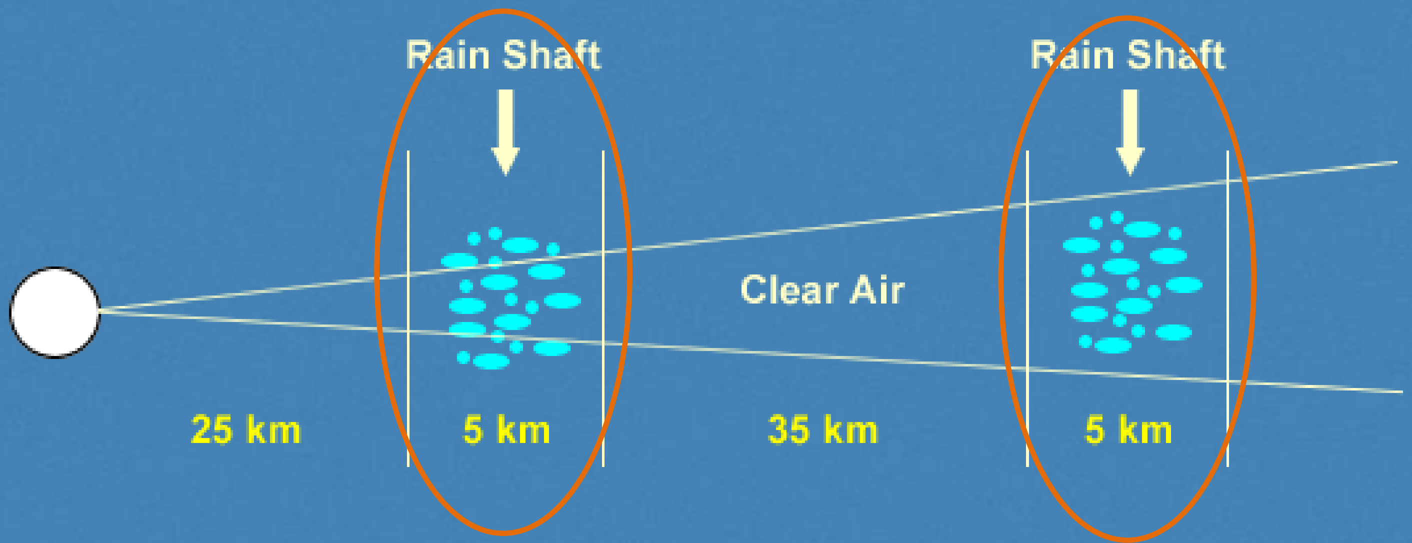
0 deg	Increasing to 20 deg	20 deg	Increasing to 35 deg	35 deg

PhiDP in GR Analyst



Why KDP?

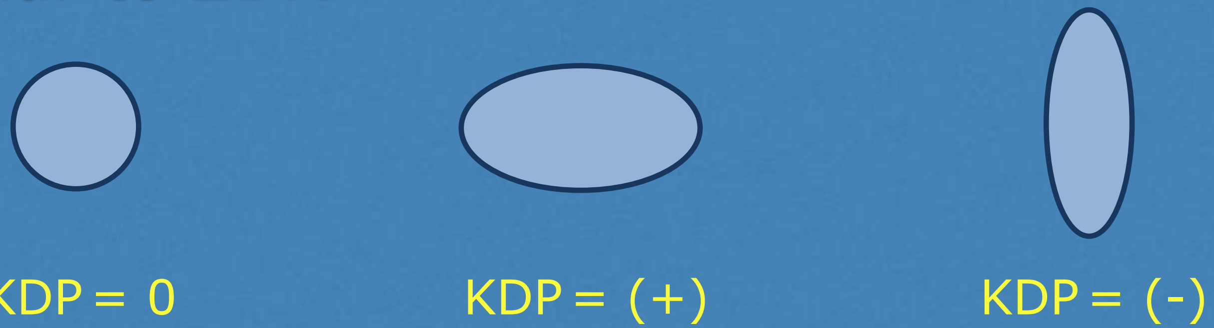
- KDP shows where Φ_{DP} is changing
  - More meteorologically significant



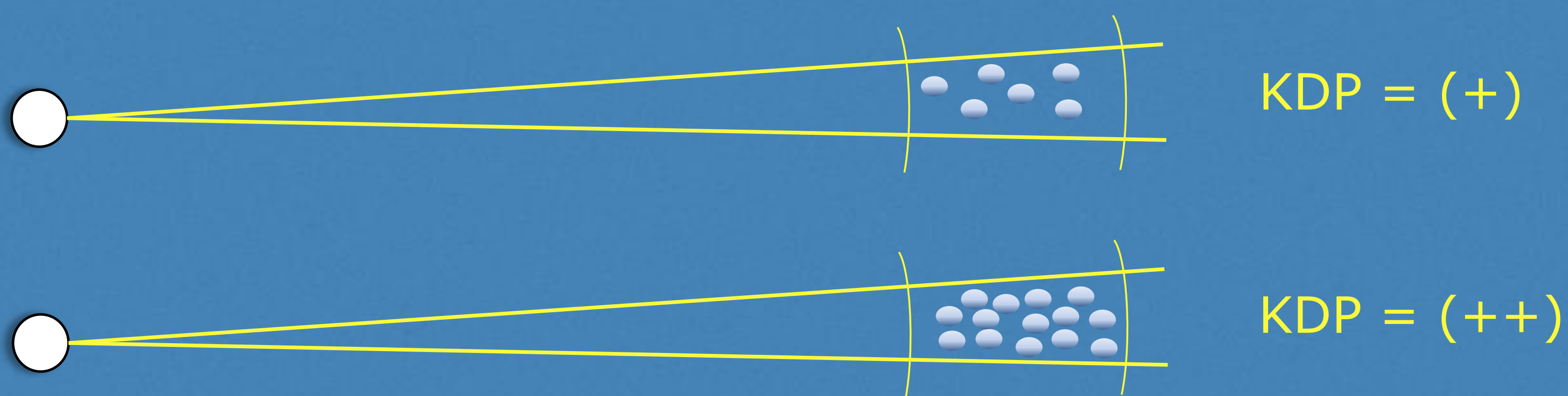
0 deg/km	2 deg/km	0 deg/km	1.5 deg/km	0 deg/km

How Do I Interpret KDP?

- Similar to ZDR

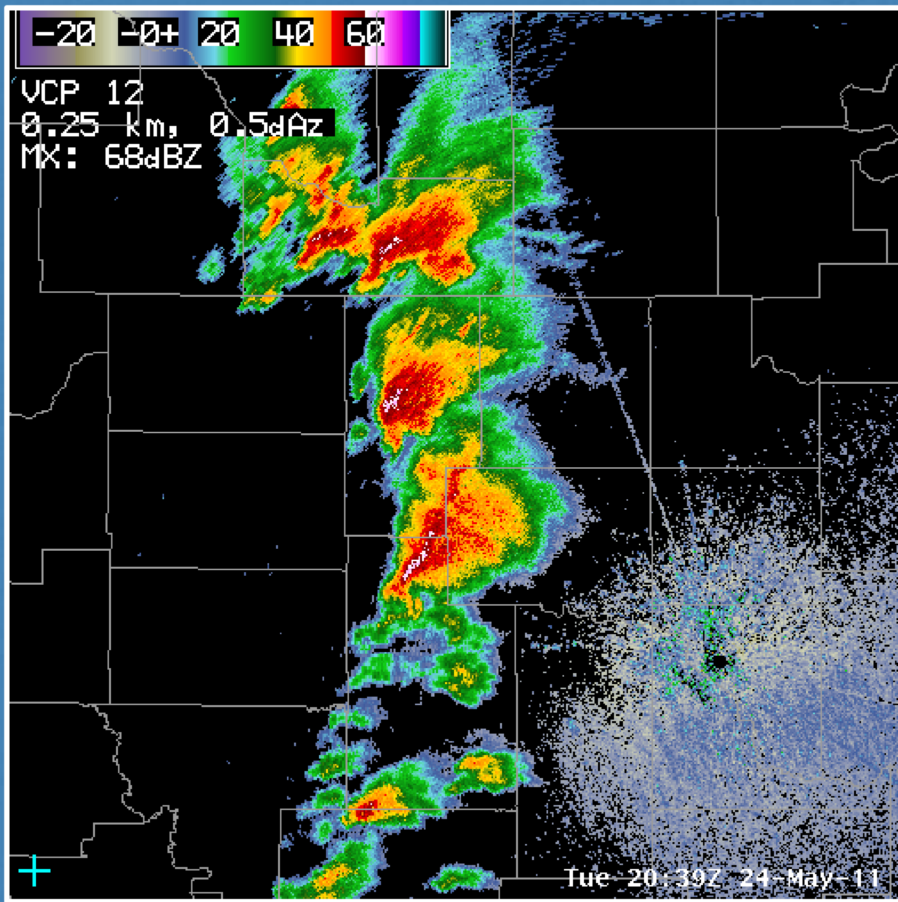


- Particle Concentration

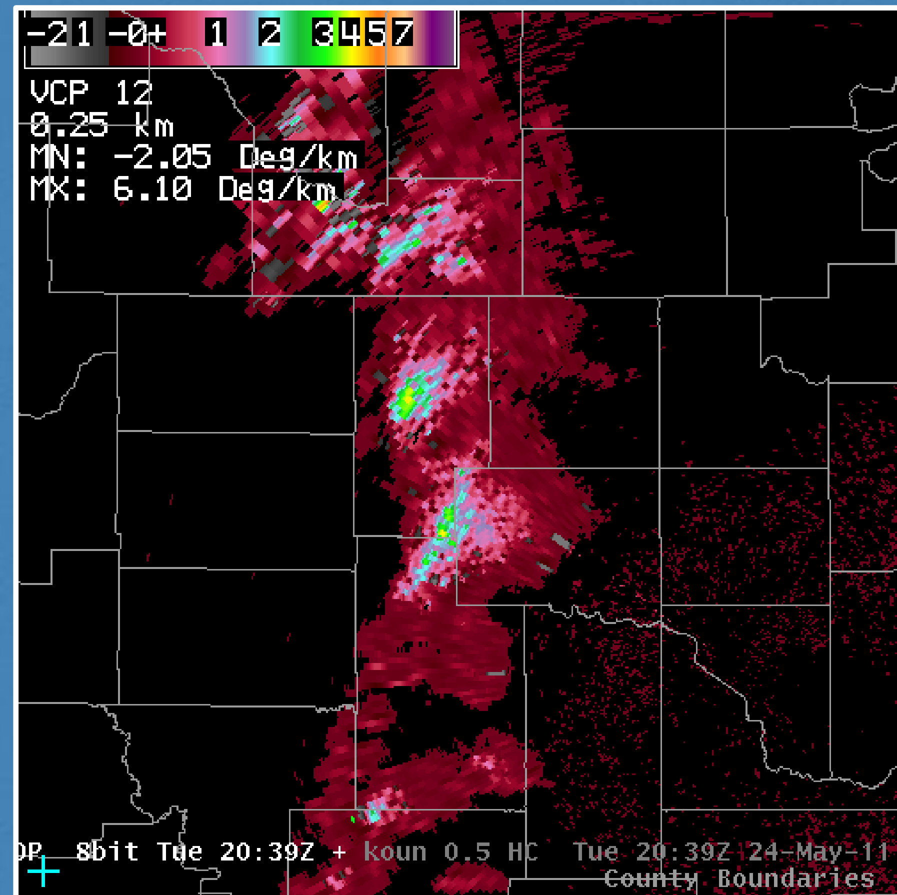


What will KDP look like?

Z



KDP



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Typical Values (Rain)

Z: 10 to 60 dBZ

KDP: 0 to 5 deg/km

Generally increases with increasing size,
But also dependent on number concentration

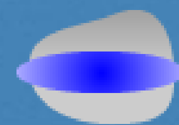
Z

KDP

6 dB ← 0 dB **ZDR**

0.96 → 0.99 **CC**

Typical Values (Hail)

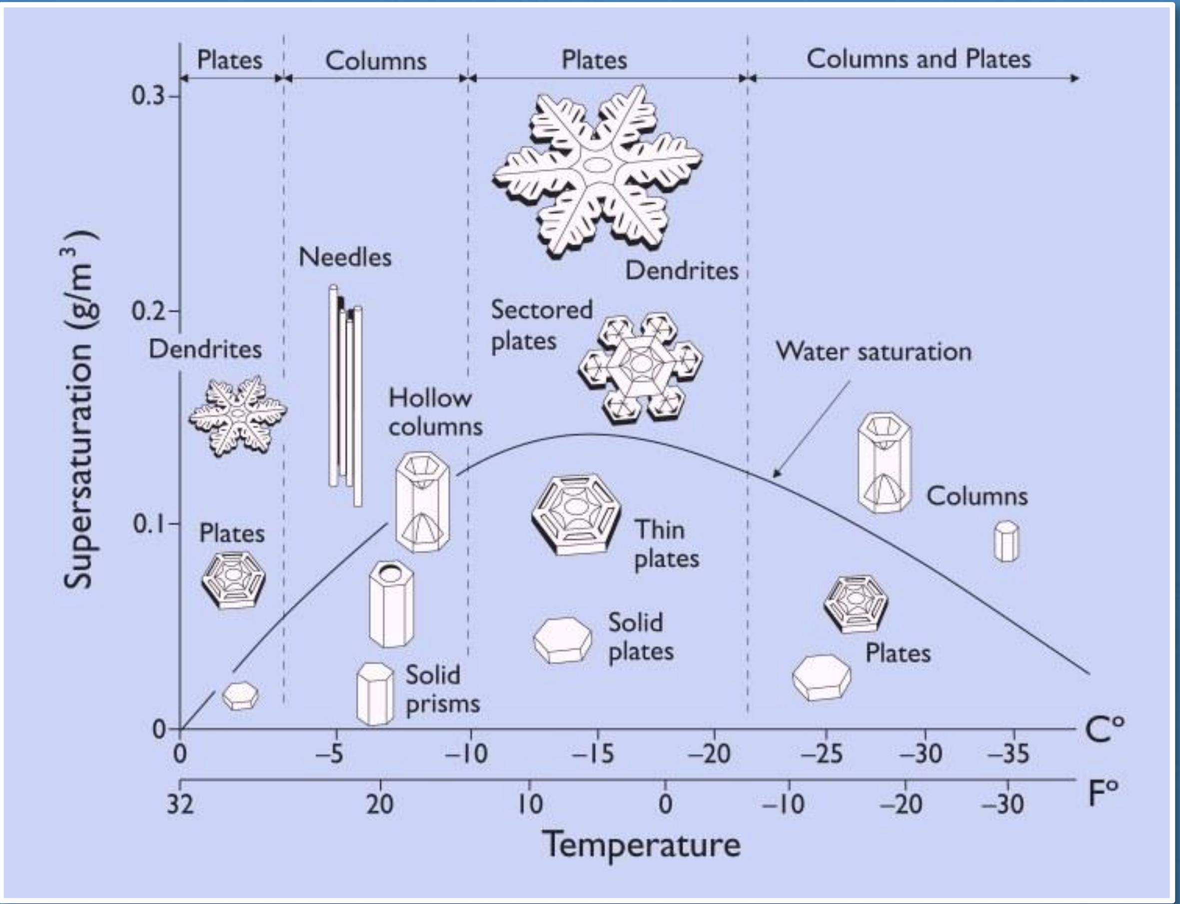


	Classic	*Melting*	*Large (D >= 2”)*
Z	> 55 dBZ	> 60 dBZ	40 – 80 dBZ
ZDR	0 – 1 dB	> 1 dB	-0.5 – 1 dB
CC	0.95 – 0.97	~ 0.95	< 0.9
KDP	~ 0 deg/km	> 3 deg/km	N/A

Typical Values (Snow/Ice)

Z (dBZ)	ZDR (dB)	CC	KDP (deg/km)
< 40	-1 to +5	> 0.95	-1 to +0.5

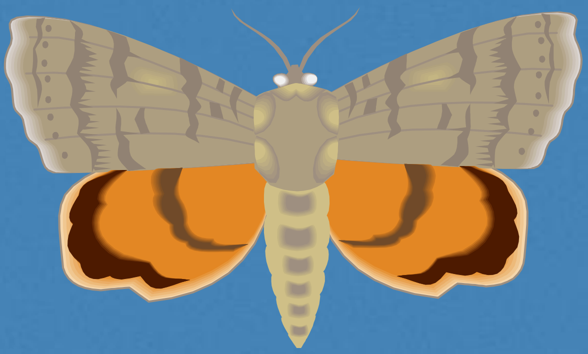
- Density affects ZDR
- Melting snow will have lower CC



Courtesy: SnowCrystals.com

Typical Values (Clutter/Biologicals)

	Clutter	Biologicals
Reflectivity (Z)	Anything	< 40 dBZ
Differential Reflectivity (ZDR)	Noisy	Depends on Orientation
Correlation Coefficient (CC)	< 0.8	< 0.8
Specific Differential Phase (KDP)	N/A	N/A



Summary

- Send/receive H & V polarization
- 3 new base products
  - ZDR, CC, KDP
- Base products help with
  - drop shape (ZDR)
  - variety (CC)
  - liquid water content (KDP)
- Additional information seen in
  - Rain, Hail, Snow/ice and Clutter/Biologicals

Acknowledgements & Questions

- WDTB Dual-Pol Team
  - Jami Boettcher, Andrew Wood, Mark Sessing, Cynthia Van Den Broeke, Paul Schlatter, Darrel Kingfield
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