Meteorology 3110

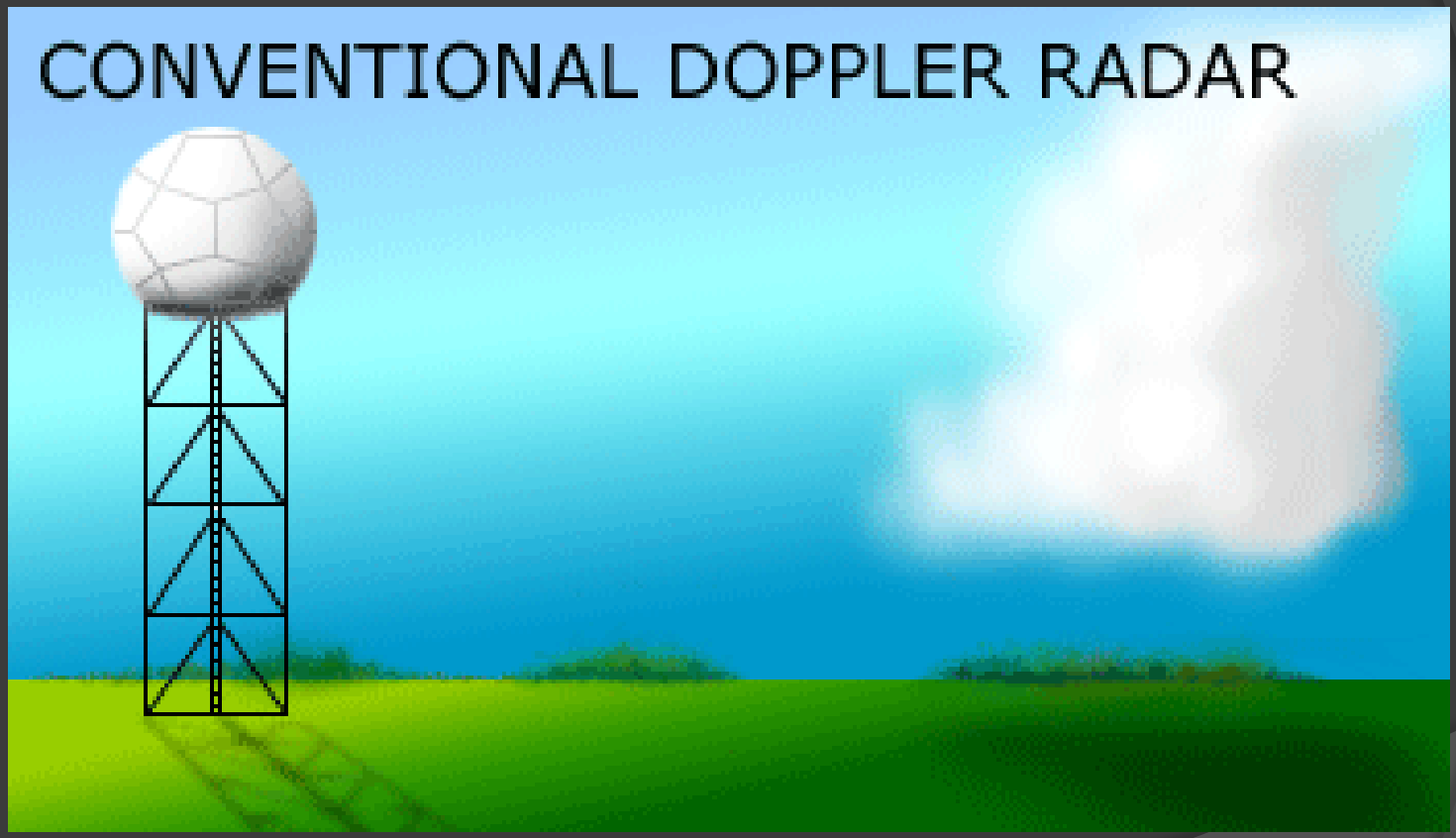
RADAR

What is it?

- RADAR
  - RAdio Detection And Ranging
- Transmits electromagnetic pulses toward target.
  - Tranmission rate is around 100's pulses per second (318-1304 Hz).
  - Short silent period between pulses.
  - Pulse repetition frequency (PRF)
- Measures the amount of beam that returns to the receiver.
  - Called reflectivity.
  - Energy is scattered back to antenna by precipitation size particles.
  - Back-scattered energy.
- Amount of energy return is primarily dependent on three factors:

1. Size of target.
2. Distance from the target.
3. Wavelength of pulse.

CONVENTIONAL DOPPLER RADAR

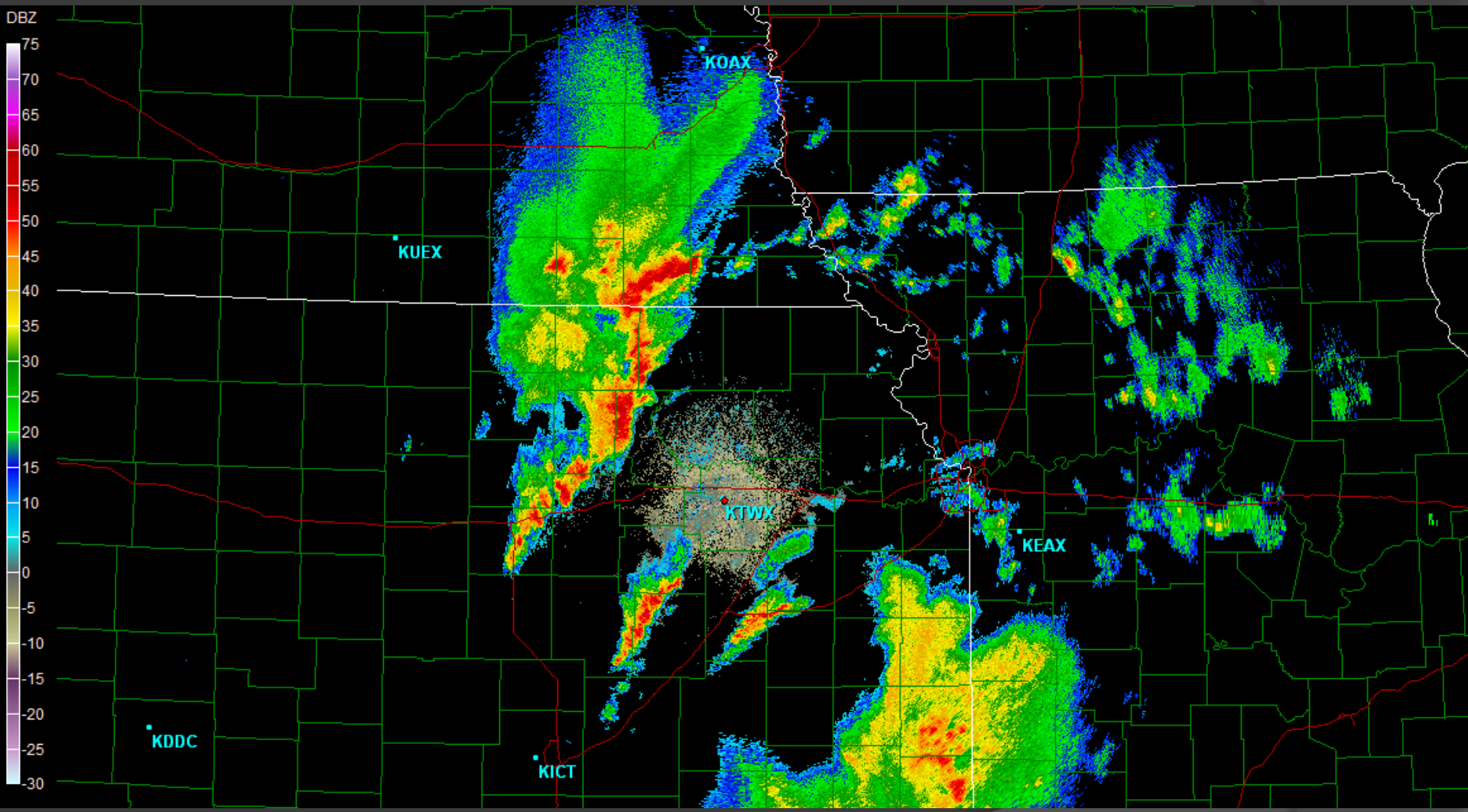


Essentials

- Rayleigh Scattering law
- Back-scattered radiation ~ $D^{6.}$
- For collection of equal-size drops ~ $1/\lambda^{4.}$
  - Returned energy increases rapidly with decreased wavelength.
- The wavelength you use depends on what you want to look at or resolve.
  - Recall what you learned in Mteor 301.
  - Weather radar: Typically 1 to 20cm.
  - 3 cm for cloud detection, 10 cm for precipitation.

Reflectivity values

- Reflectivity is measured in decibels (dBZ)
- 20 dBZ → Precipitation reaches the ground.
  - Important to realize for chasing.
- Rainfall
  - 20-45 dBZ : light to moderate.
  - 40-50 dBZ : Pretty good rainfall.
  - 60-70 dBZ : More than likely hail.
- Snowfall
  - 25-30 dBZ : Light to moderate snowfall.
  - 30-35 dBZ : Moderate to heavy snowfall.
  - 35-40 dBZ : Very heavy snowfall (rare) or rimed flakes.
- Ice
  - Ice itself doesn't have a very high reflectivity.
  - Why is hail so reflective?
  - Bright-banding


DBZ
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-25
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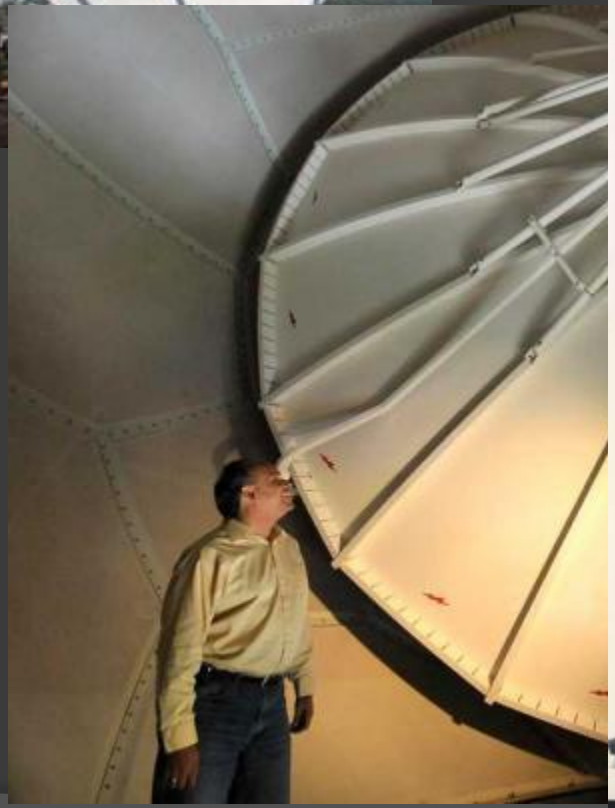
KOAX
KUEX
KTWX
KEAX
KDDC
KICT

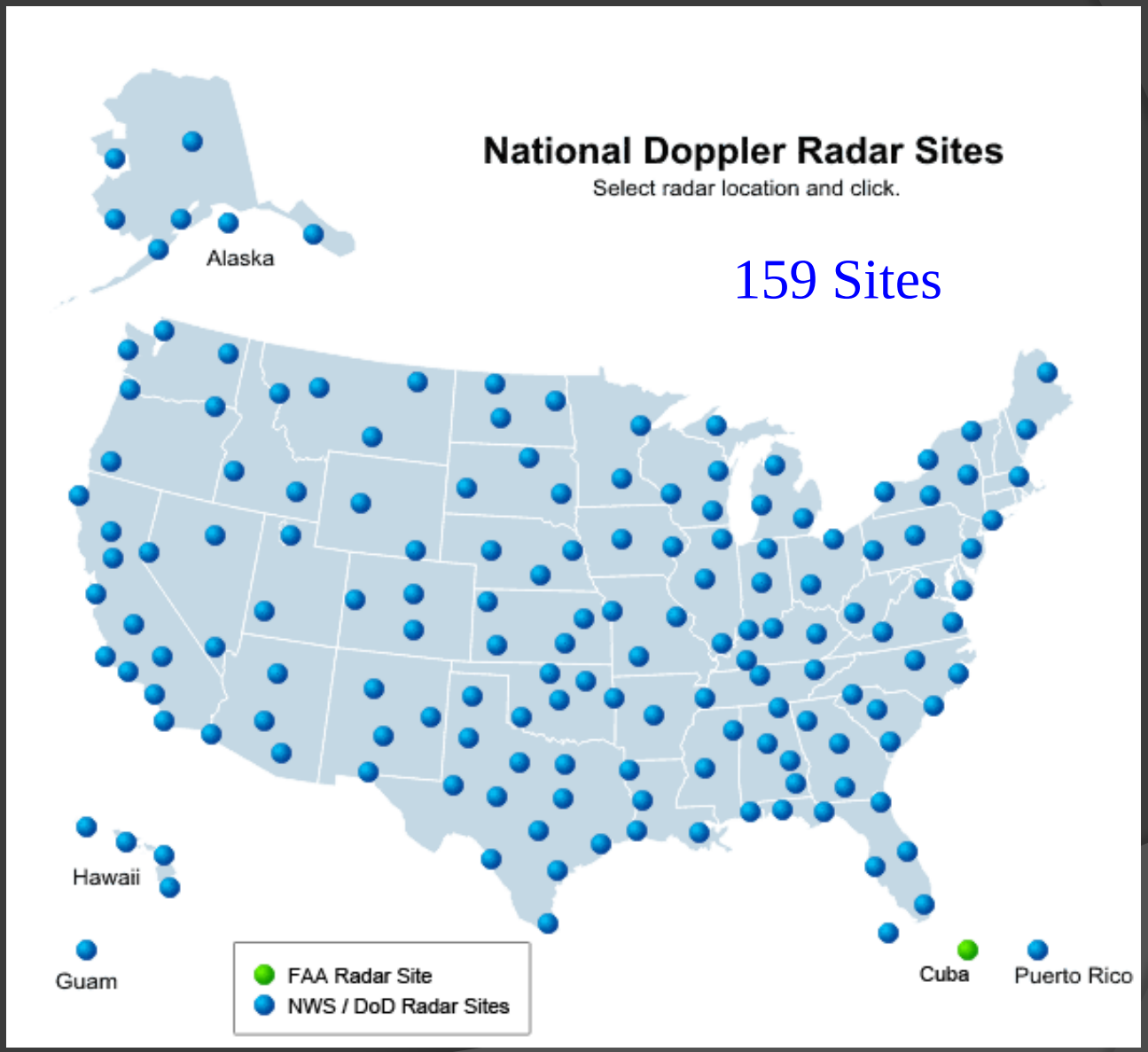
Operational Radar

- A.k.a., the things you see on Gibson Ridge software.
- Current radars: WSR-88D's (NEXRAD)
  - Weather Surveillance Radar made operational in 1988 and are of the doppler variety.
  - Previous radars were WSR-57's and WSR-74's.
  - 28 ft diameter dish that rotates at 360º at several tilts.
  - Dual polarization completed in 2013.
  - Phased-array upgrade possible at some point in the future.
- Course notes pictures/MetEd modules.




NOAA

Sites


National Doppler Radar Sites
Select radar location and click.
159 Sites
Alaska
Hawaii
Guam
Cuba
Puerto Rico
FAA Radar Site
NWS / DoD Radar Sites

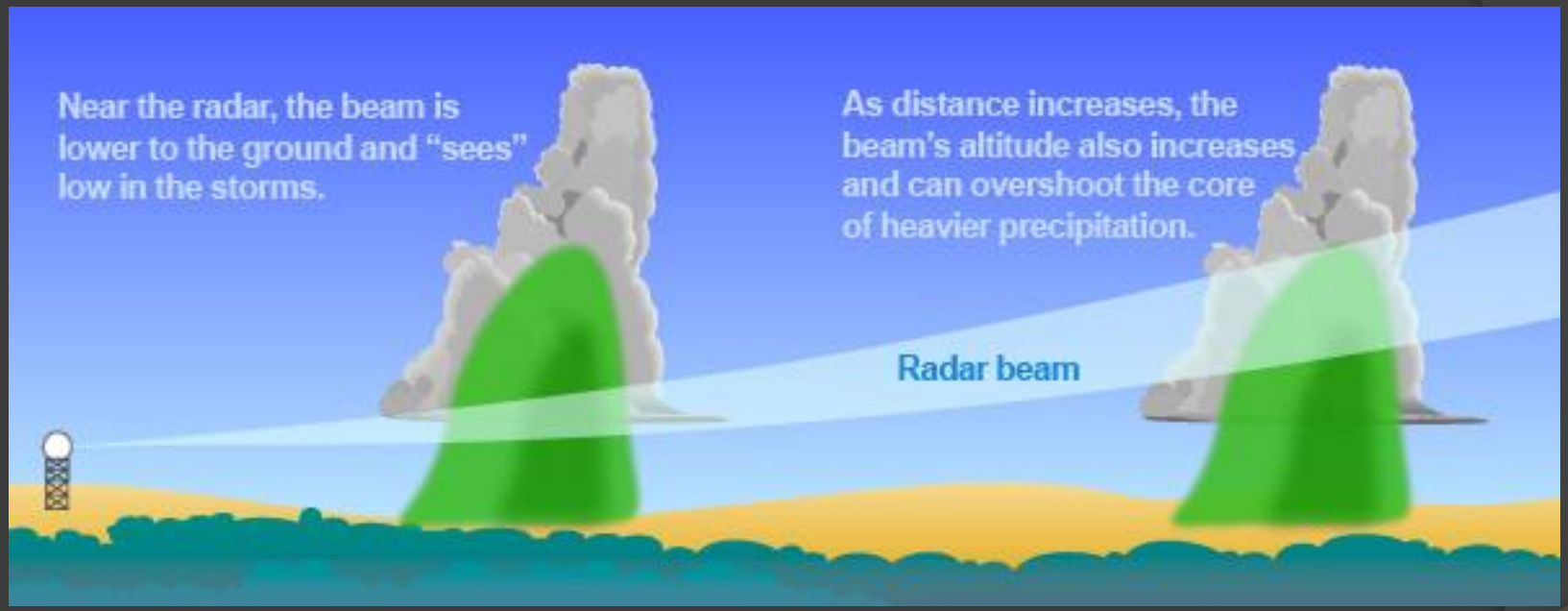


Image provided by Rich Kinney, NWS, Des Moines

Images provided by Rich Kinney, NWS, Des Moines

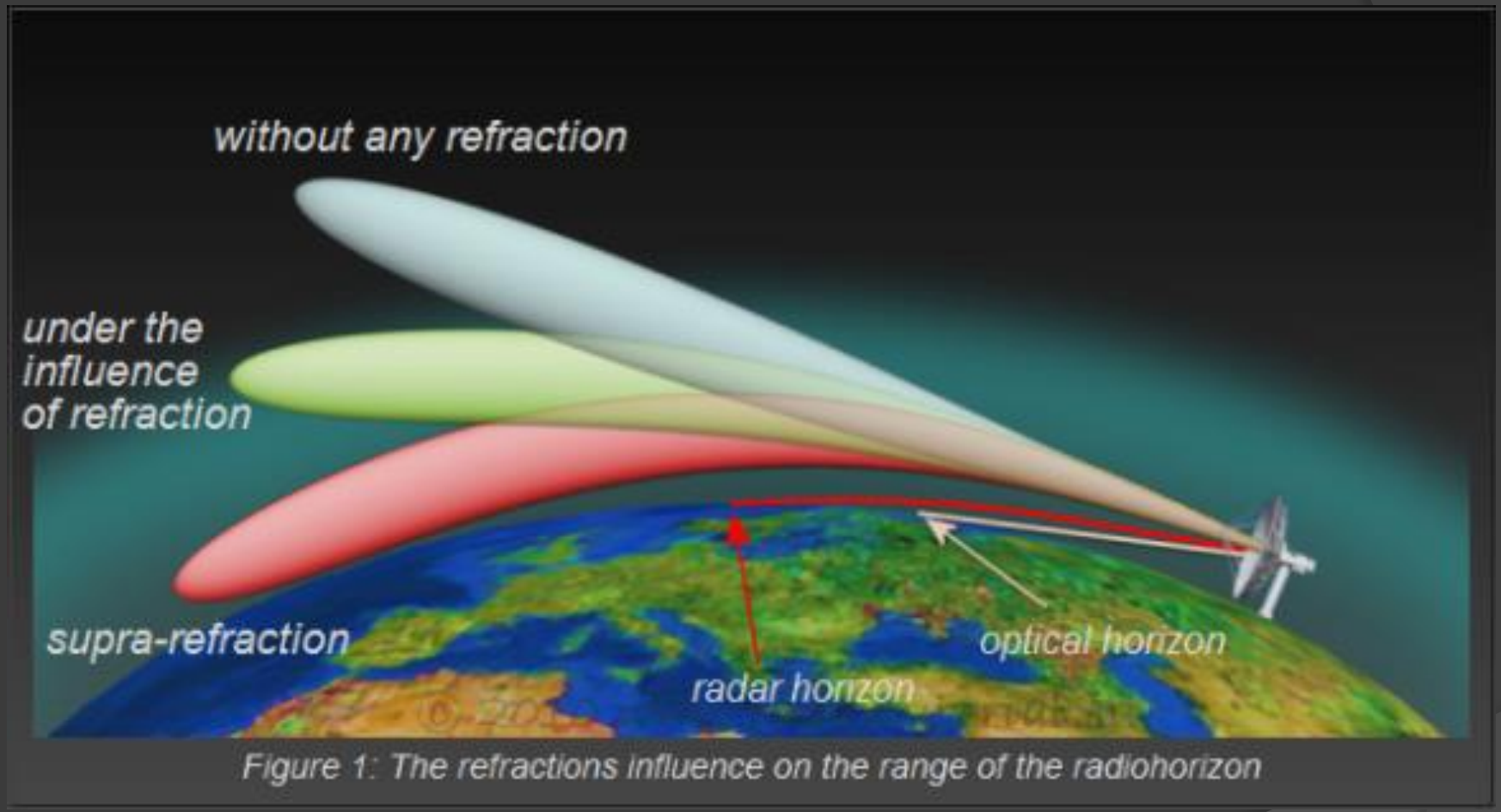


Figure 1: The refractions influence on the range of the radiohorizon

VCP

- Volume coverage pattern
- Modes: Convection, shallow precipitation, clear air.
- Clear Air: Two digits starting with a 3
- Convection: Two digits starting with a 1.
- Shallow precipitation: Two digits starting with a 2.

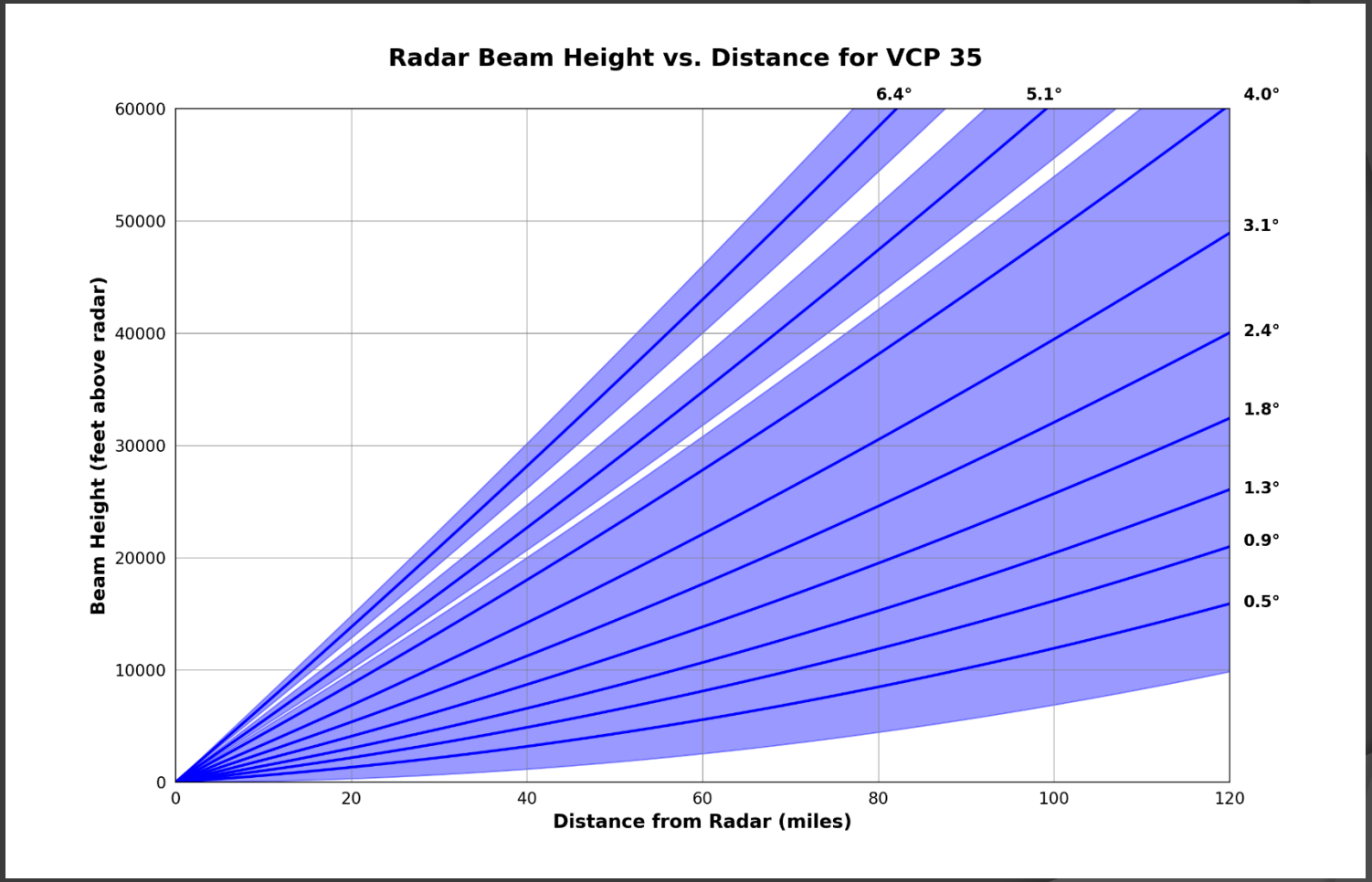
Clear Air Modes

- VCP 35 - 9 Elevation angles in 7 minutes
  - Default mode
  - Radar slows down and scans fewer angles to reduce wear and tear
  - If radar detects precipitation, it will automatically switch out of clear air mode.
  - Sometimes used when there is very light rain or drizzle and no thunderstorms.

- VCP 31 - 5 Elevation angles in 10 minutes
  - Long pulse mode – increases power and the sensitivity of the radar
  - Often used in snow and freezing drizzle to show where precipitation is occurring.
  - Slow VCP.

Source: noaa.gov/jetstream/vcp_max

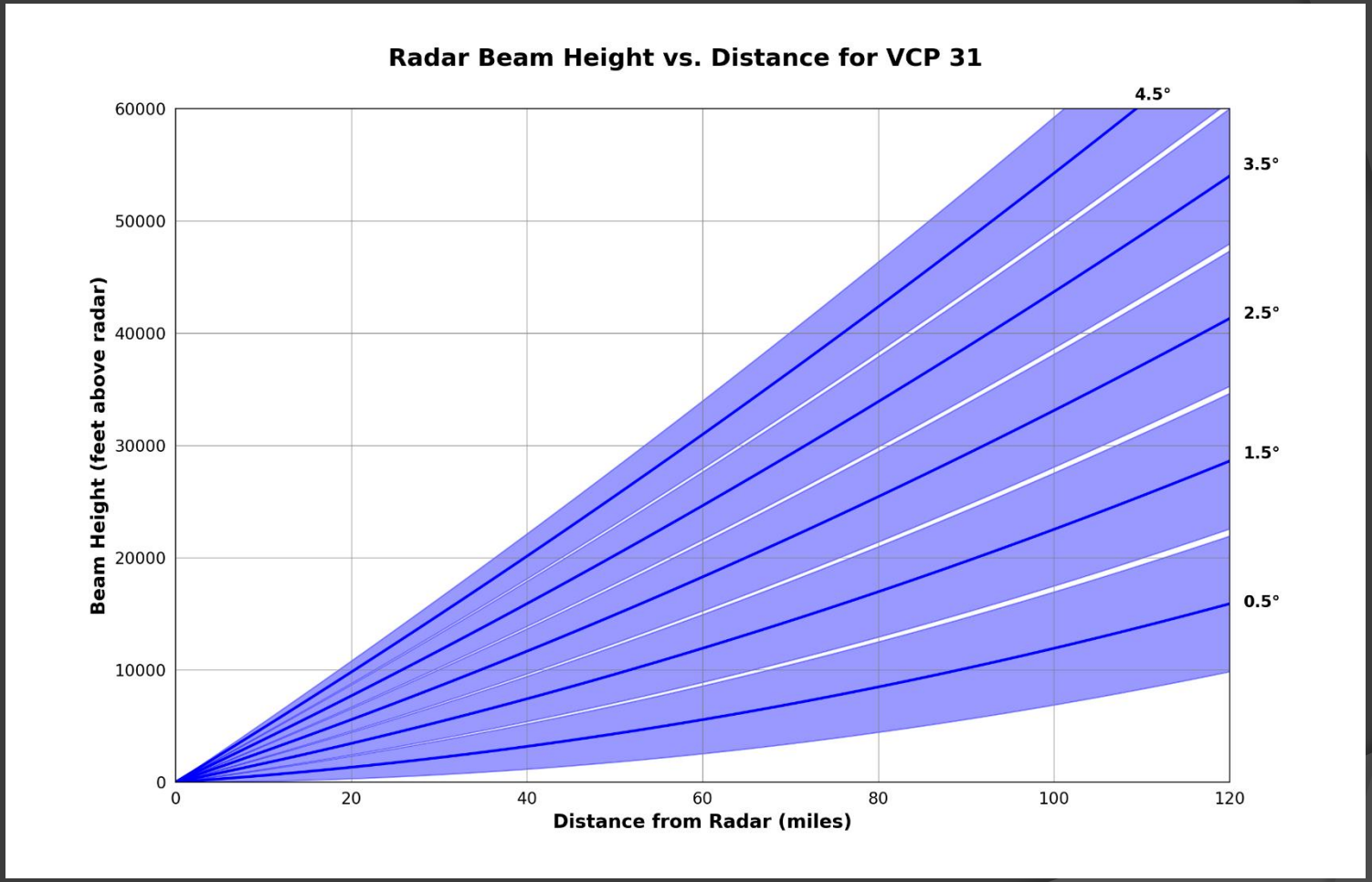
VCP 35



9 Elevation angles in 7 minutes

Source: noaa.gov/jetstream/vcp_max

VCP 31



5 Elevation angles in 10 minutes

Source: noaa.gov/jetstream/vcp_max

Precipitation Modes

- VCP 12 or 212 – 14 elevation angles in 4 ½ minutes
  - Default precipitation mode
  - Best of rapidly developing thunderstorms and severe weather

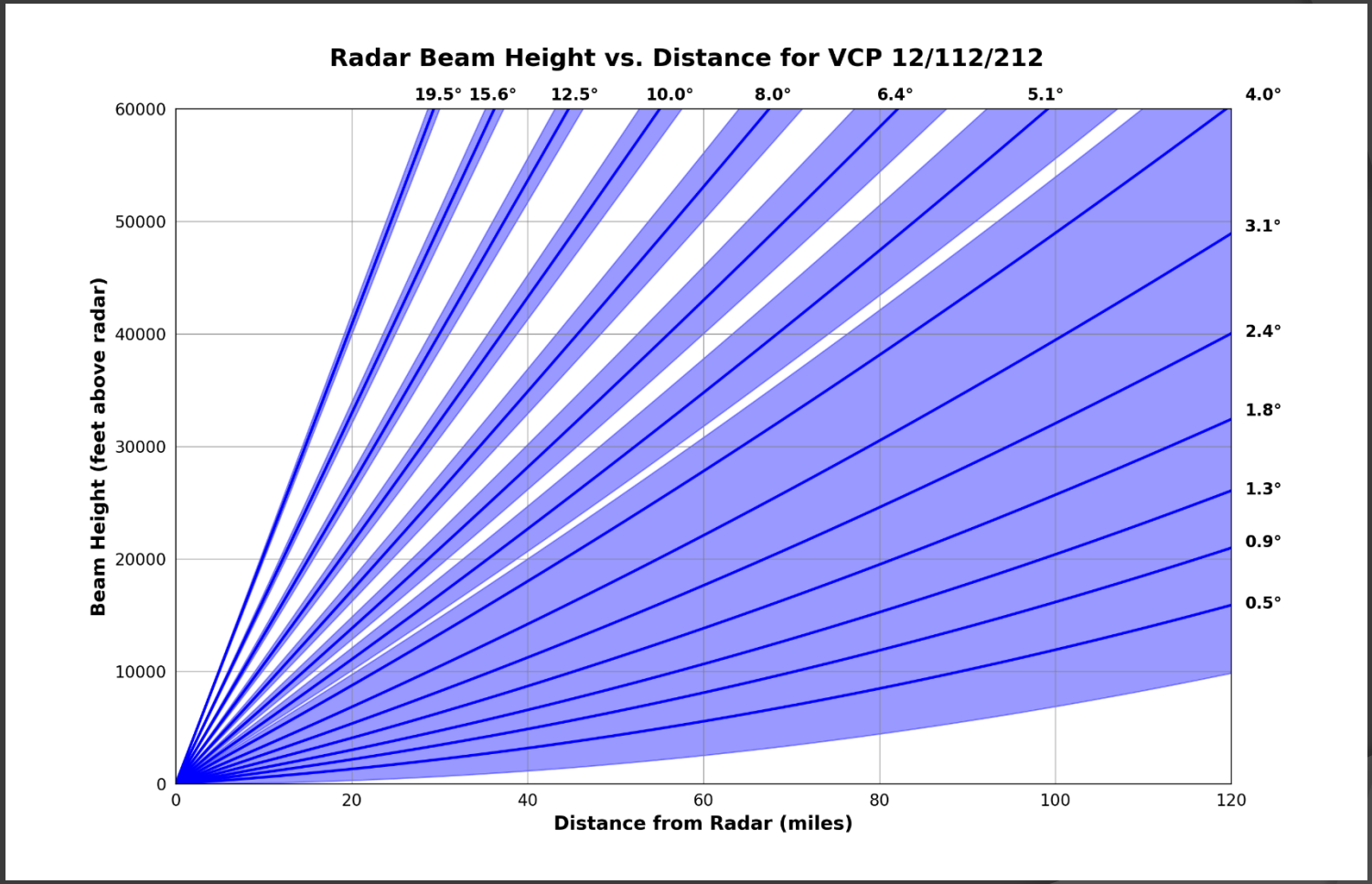
- VCP 215 – 15 elevation angles in 6 minutes
  - Provides best vertical resolution of all VCPs
  - Slower rotating antenna allows for higher quality data
  - Best used for surveillance (wide spread rain or snow without thunderstorms)

- VCP 112 – 14 elevation angles in 5 ½ minutes
  - Uses a unique velocity algorithm to maximize velocity data quality
  - Often used in the vicinity of tropical cyclones where precise velocity data is hard to obtain.

Source: noaa.gov/jetstream/vcp_max

Source: noaa.gov/jetstream/vcp_max

VCP 12/112/212



VCP 12/212: 14 elevation angles in 4.5 minutes

VCP 112: 14 elevation angles in 5.5 minutes

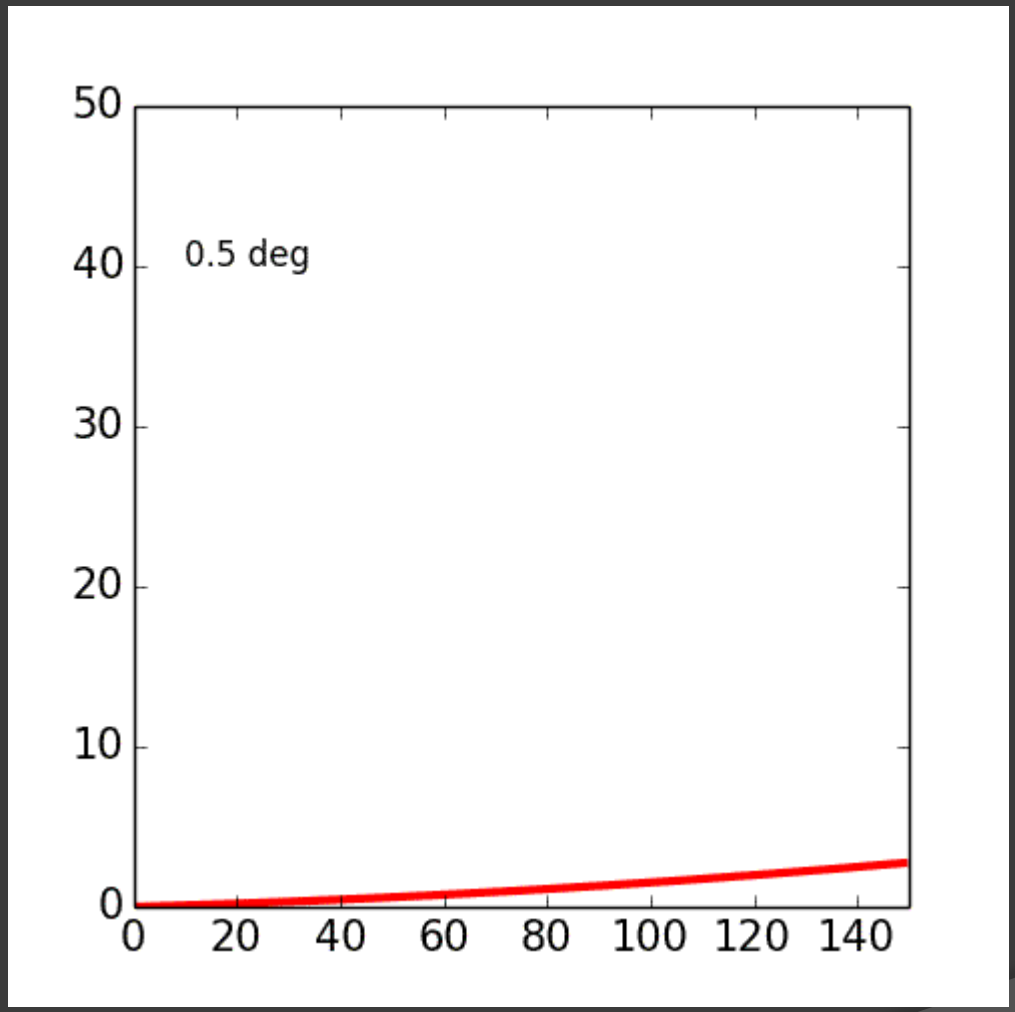
Range Folding

- Occurs when the radar transmits a pulse that hits a target, but cannot get back to the receiver before the next pulse is transmitted
- The returned energy eventually makes it back to the radar, but the radar doesn't know which transmitted pulse it came from.
- The WSR-88D employs a range-unfolding algorithm to try to recover the data, but if it can't figure it out, then the data is lost.
- SZ-2 (Sachdananda-Zrnic) is employed by VCP 212 and tries to reduce range folding.

Source: noaa.gov/jetstream/vcp_max

SAILS/MESO-SAILS/AVSET

- SAILS – Supplemental, Adaptive, intra-volume Low-level Scan
  - Addition of one base scan per volume.
- MESO-SAILS – Multiple Elevation Scan Option for SAILS.
  - Option of doing multiple base scans per volume.
- AVSET – Automated Volume Scan Evaluation and Termination
  - Terminates current volume scan once no meaning full returns are obtained.
  - Doesn’t waste time scanning above storms.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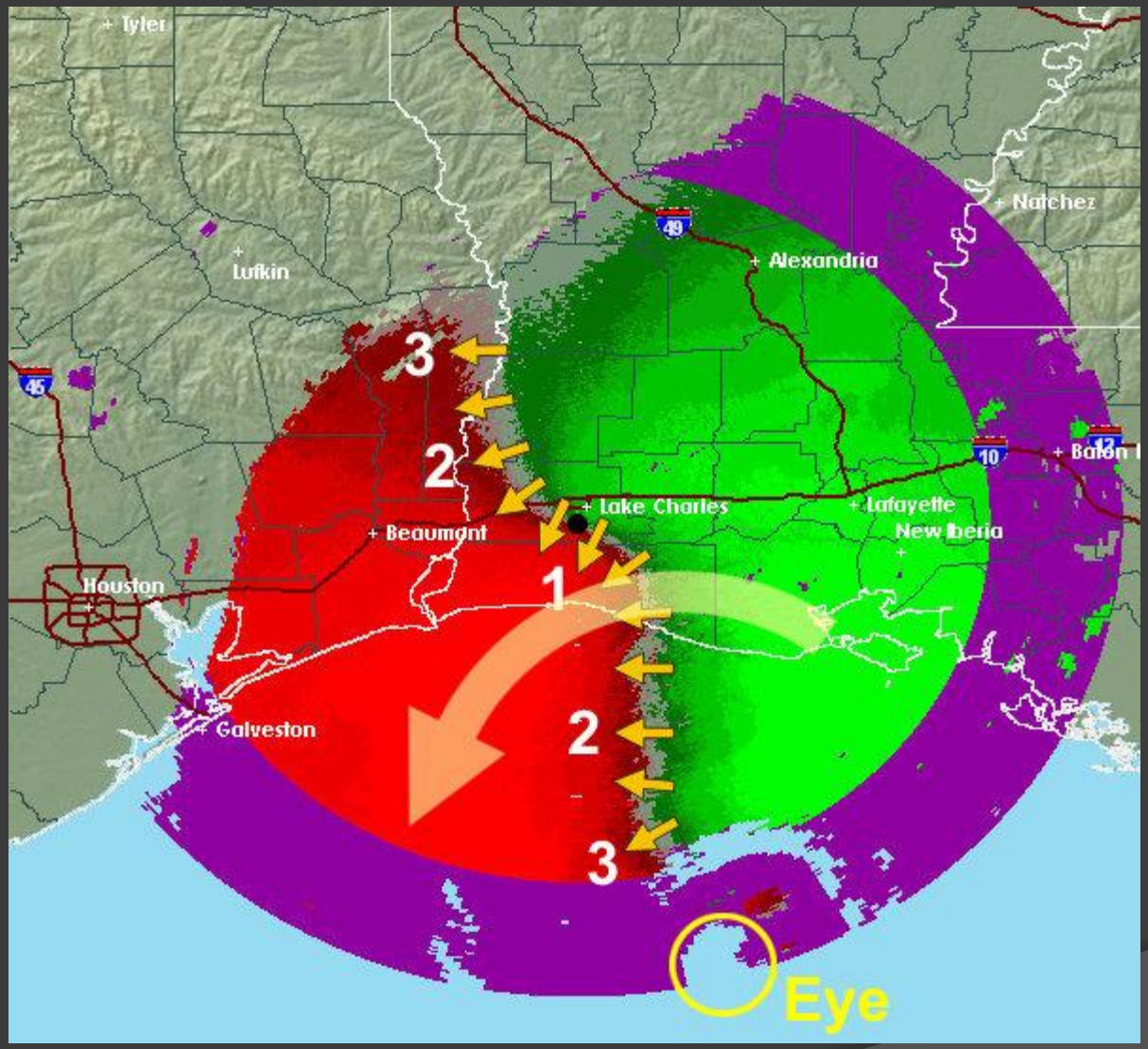
140

PRF

- Pulse repetition frequency
- Frequency at which pulses are emitted (pulses per second).
  - Essentially how long the ‘listening’ stage is (PRT = 1/PRF).
- Determines the maximum unambiguous range and maximum unambiguous velocity
- Huh?
  - R_{max} = maximum range which a transmitted pulse wave can travel and return to the radar before the next pulse is emitted.
  - $R_{max} = C / (2*PRF)$
- Huh, again?
  - V_{max} = maximum velocity which a Doppler radar can determine unambiguously.
  - $V_{max} = (\lambda * PRF) / 4$
- Doppler Dilemma.


Tyler
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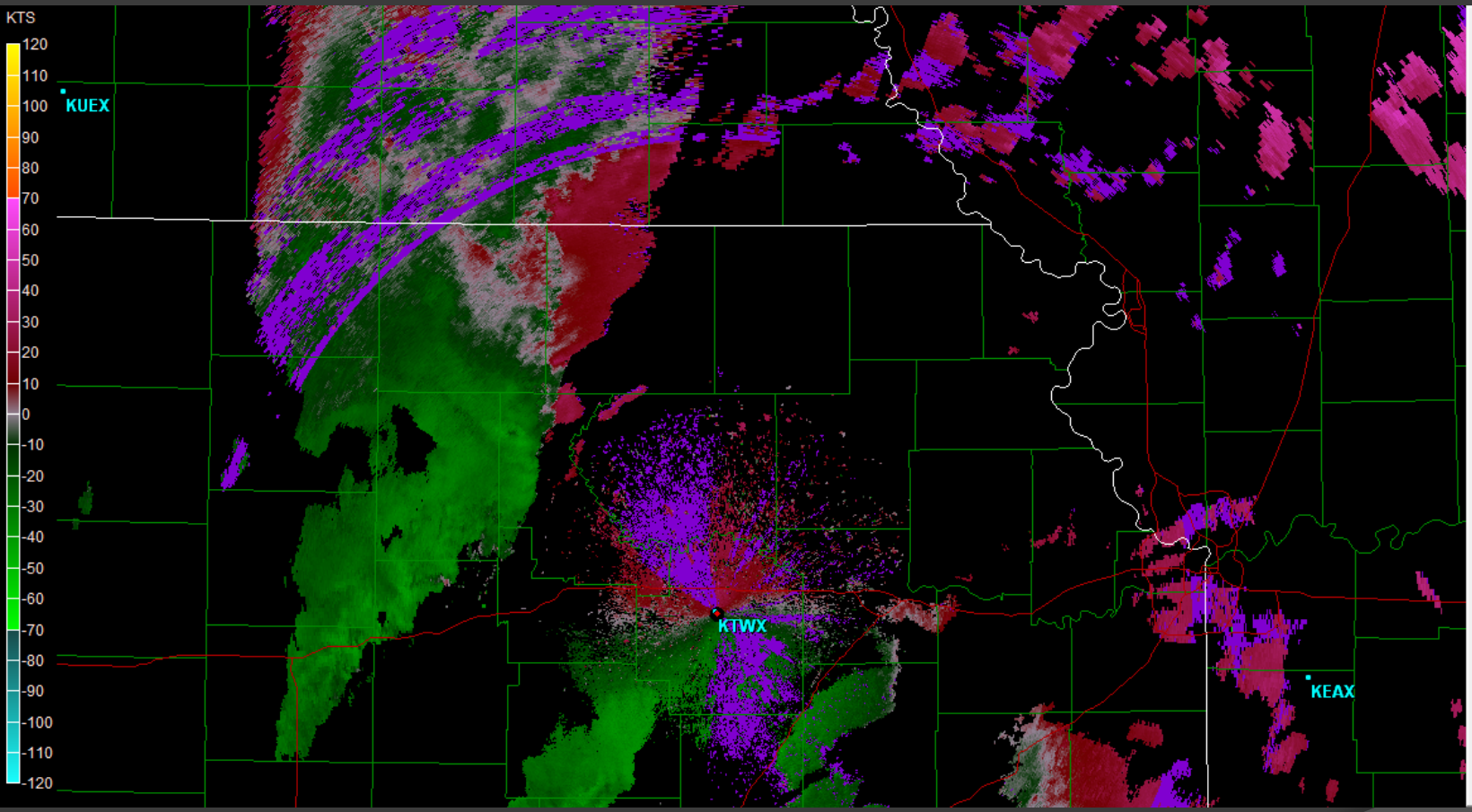
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KUEX
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Site: KTWX
VST: 10/14/2012 00:03:51 Z
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VCP: 212 SMV: ----
Tilt: 0.542°
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BR
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BV
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RHO
SRV
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KDP
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NROT
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Select Tilt:
0.5°
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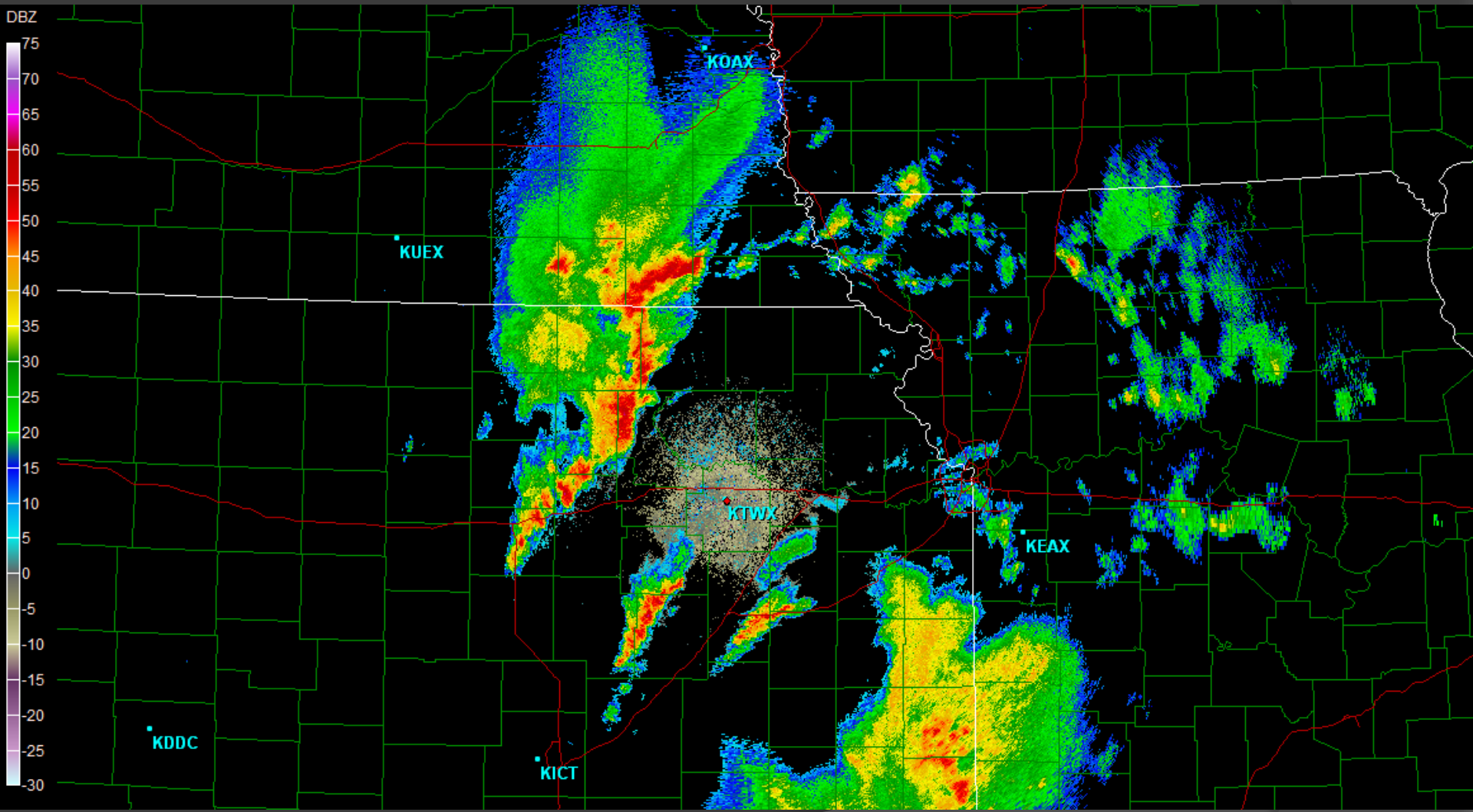
1.8°
2.5°
3.2°
4.0°
5.1°
6.4°
8.1°
10.0°
12.5°
15.7°
19.5°
Warnings:
Marine
Flash Flood
Severe Thunderstorm
Tornado
Product Details:
Min: -59.2 kts
Az: 4.7°
Ran: 109.3 nm
Max: +59.2 kts
Az: 331.2°

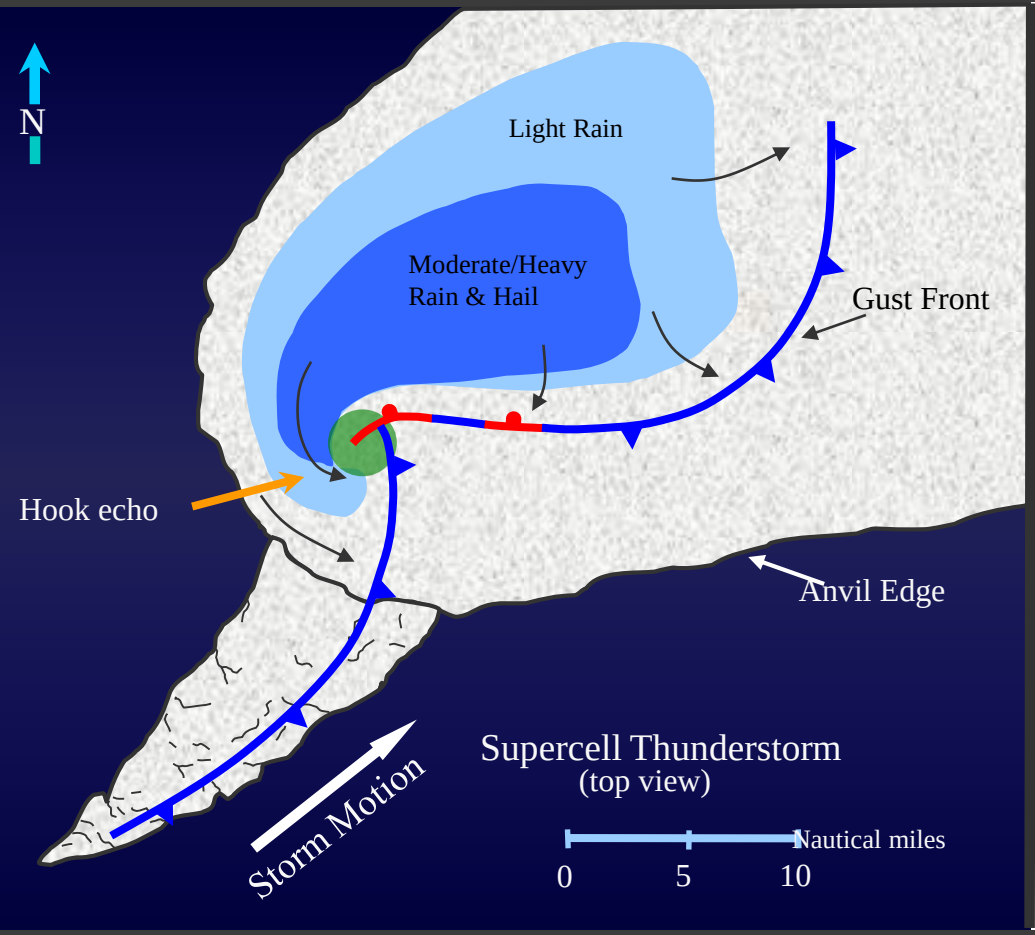
Products or Moments

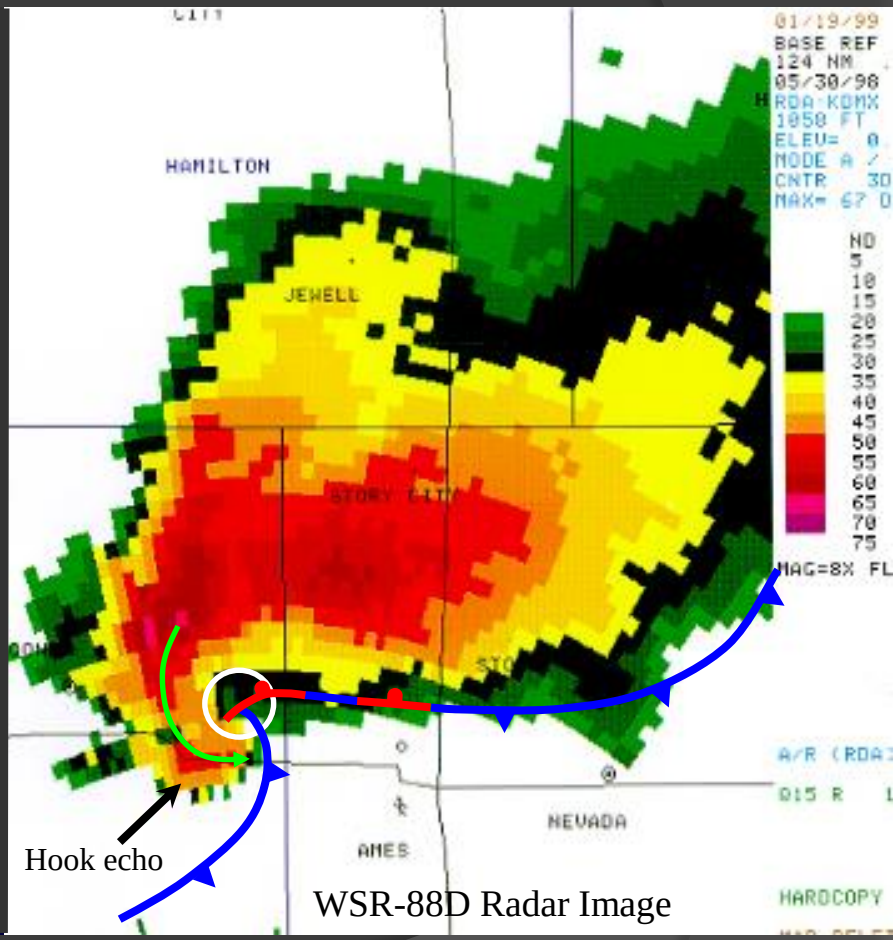
- Base reflectivity: Lowest elevation scan.
  - Basically used to tell what is out there.
- Composite reflectivity:
  - Composed of the greatest reflectivity from any elevation angle seen from the radar.
  - Used to reveal the highest reflectivity in all echoes.
- Base velocity
  - Provides basic wind field from the 0.5º elevation scan via Doppler effect.
  - Radar can only measure motions that have a component along a radial, or essentially toward or away from the radar.
- Spectrum width
  - Spread in the velocity values.
  - Large spectrum width means a lot of turbulence.
- Storm relative motion: Used to detect “mesoscale” circulations.
  - Mean wind field is “subtracted” from base velocity.
- VIL
  - Vertically integrated liquid water.
  - Amount of liquid water that the radar detects in a vertical column of the atmosphere for an area of precipitation.
  - High values are associated with heavy rain or hail.
- Echo Tops
  - Maximum height of precipitation echoes.

Base Reflectivity



Classic Supercell





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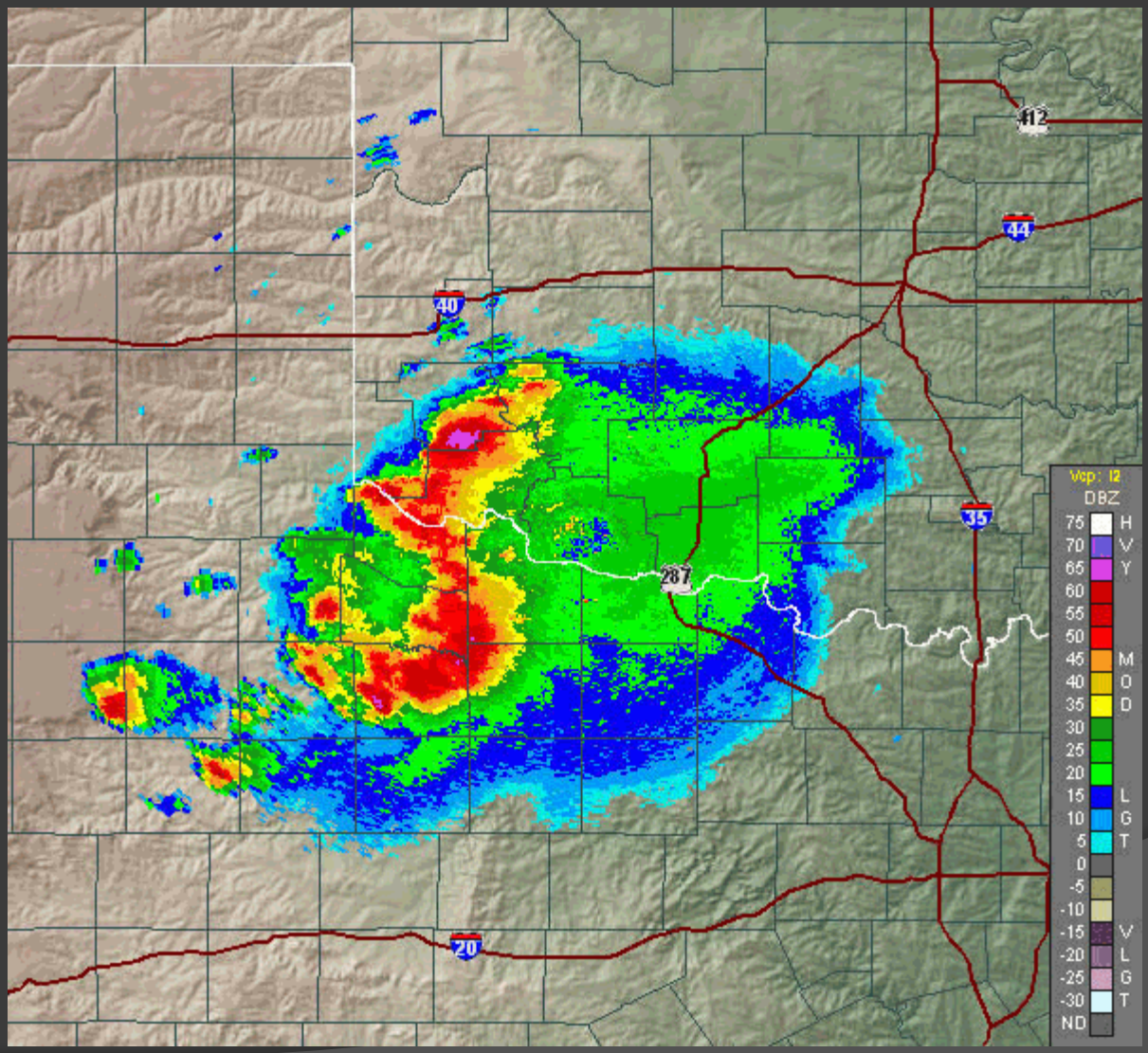
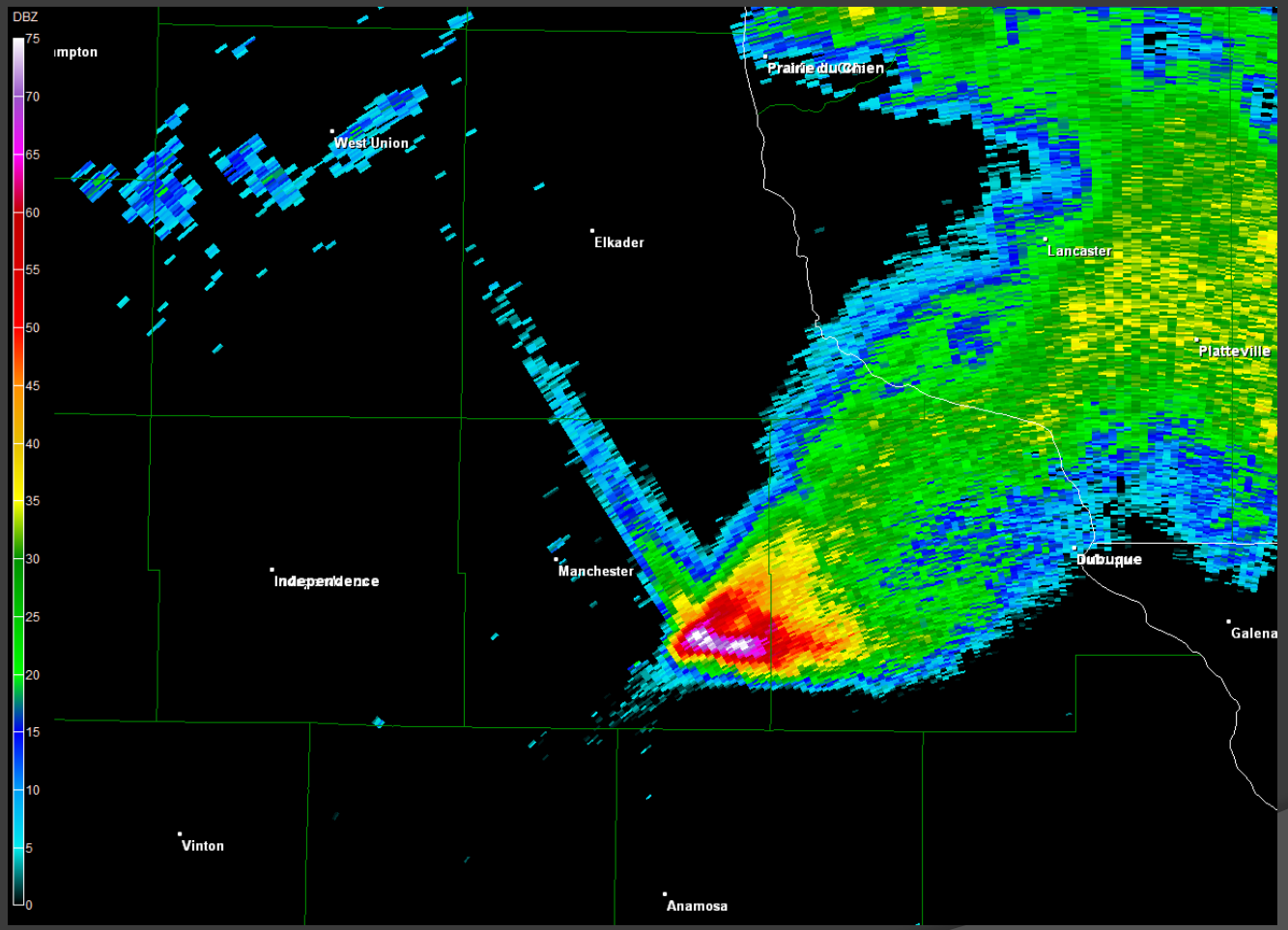
Composite Reflectivity



TBSS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West Union
Elkader
Prairie du Chien
Lancaster
Platteville
Dubuque
Galena
Manchester
Independence
Vinton
Anamosa

Bright Banding

Radar beam intersects freezing level and intersects melting precipitation.

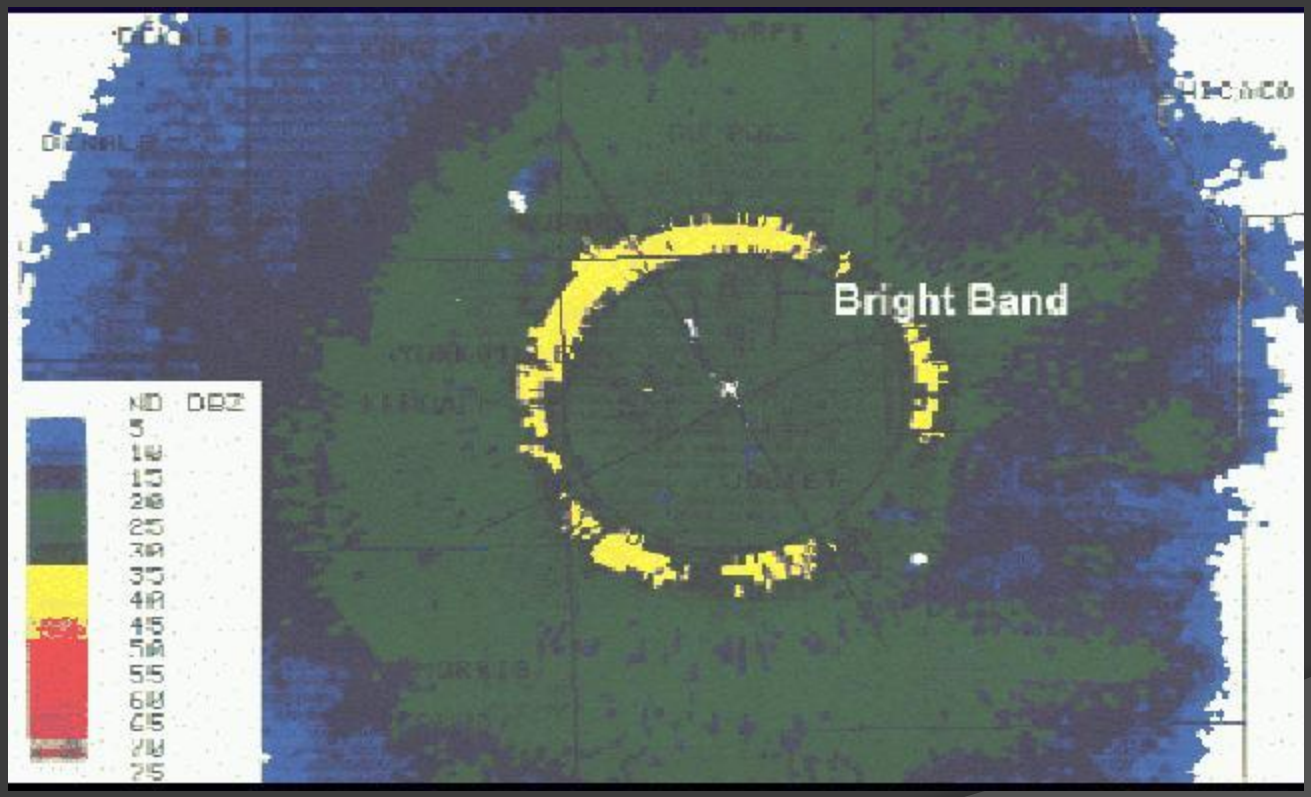

Image provided by Rich Kinney, NWS, Des Moines

Radar fine line

88D can detect subtle differences in humidity and temperature, and the location of boundaries that may be the focus for storm initiation or intensification

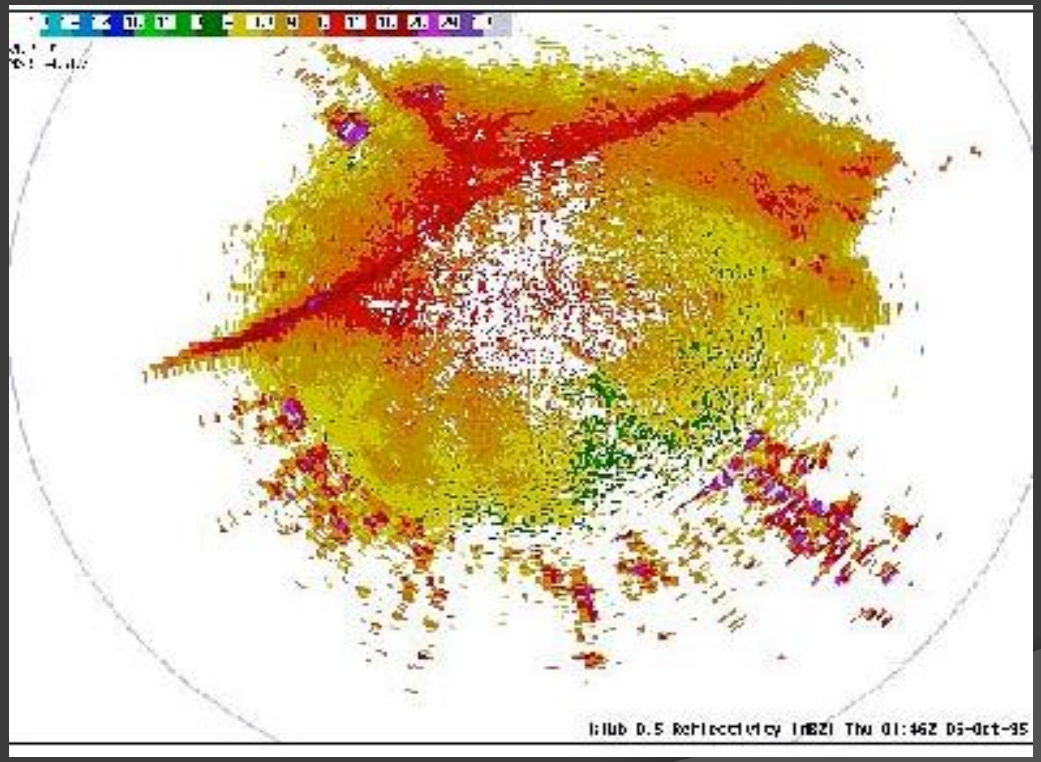

Image provided by Rich Kinney, NWS, Des Moines

AP

- Anomalous propagation.