Meteorology 311

RADAR
FALL 2015
What is it?

- **RADAR**
  - RAdio Detection And Ranging

- Transmits electromagnetic pulses toward target.
  - Transmission rate is around 100 pulses per second.
  - 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.
Essentials

- Rayleigh Scattering law
- Back-scattered radiation $\sim D^6$.
- For collection of equal-size drops $\sim 1/\lambda^4$.
  - 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 20 cm.
  - 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
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 360° at several tilts.
  - Dual polarization and phased-array are future radar types soon to be implemented.

- Course notes pictures.
Sites

National Doppler Radar Sites
Select radar location and click.

159 Sites
Near the radar, the beam is lower to the ground and “sees” low in the storms.

As distance increases, the beam’s altitude also increases and can overshoot the core of heavier precipitation.
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.
- Convection: Two digits starting with a 1.
- Shallow precipitation: Two digits starting with a 2.
- Clear air: Two digits starting with a 3.
  - Very sensitive, used when there is not precipitation detected in the coverage area.
- Multiple PRF Dealiasing Algorithm Group: Three digits, starting with a 1 and followed by the two digit VCP with similar elevation angles.

VCP 31 and VCP 32
- Clear air mode, 10 minute complete scan, 0.5 (base) - 4.5 degrees with 5 cuts (0.5, 1.5, 2.5, 3.5, 4.5).

VCP 21
- Precipitation mode, 6 minute, 0.5 (base) - 19.5 degrees with 9 cuts.

VCP 11
- Severe Weather (precip mode), 5 minute, 0.5 (base) - 19.5 with 14 cuts
Figure 5.3
Clear Air Scan
Volume Coverage Patterns 31 and 32
VCP 21

Number of Scans: 9  Beam Width: 0.95 degrees

Figure 5-2
Alternative Scan
Volume Coverage Pattern 21
Figure 5-1
Precipitation/Severe Weather Scan
Volume Coverage Pattern 11
Newer VCP’s

- VCP 211, 212, 221
- Same elevation angles as VCP 11, 12, and 21.

- Sachidananda-Zrnic Algorithm (SZ-2)
  - Reduces range ambiguity for Doppler data.
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?
  - $R_{\text{max}} = \text{maximum range which a transmitted pulse wave can travel and return to the radar before the next pulse is emitted.}$
  - $R_{\text{max}} = \frac{C}{2\times\text{PRF}}$
- Huh, again?
  - $V_{\text{max}} = \text{maximum velocity which a Doppler radar can determine unambiguously.}$
  - $V_{\text{max}} = \frac{\lambda\times\text{PRF}}{4}$
- Purple haze: Radar cannot determine which pulse return signal may have come from.
  - Also called “Range folding”.
- Doppler Dilemma.
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 0.5° 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.
Classic Supercell

Images provided by Rich Kinney, NWS, Des Moines
Composite Reflectivity

- Jetstream - An Online School for Weather: RIDGE radar composite reflectivity
Cool Stuff

- Introduction to NEXRAD Anomalies & Artifacts
TBSS
TBSS

- National Weather Service Forecast Office - Midland/Odessa Texas

- Figure #16.
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.
Dual Polarization

- Two beams with different polarization directions: one with horizontal polarization (current polarization) and one with vertical polarization.

- New products useful for:
  - Precipitation type.
  - Rain and snow rate estimates.
  - Identification of aircraft icing conditions.

  - Page produced by Kevin Scharfenberg, who was also an invited speaker at the 2008 Severe Storms and Doppler Radar Conference hosted by the Central Iowa NWA.
Dual Polarization

CONVENTIONAL DOPPLER RADAR