National Weather Service
St. Louis, MO

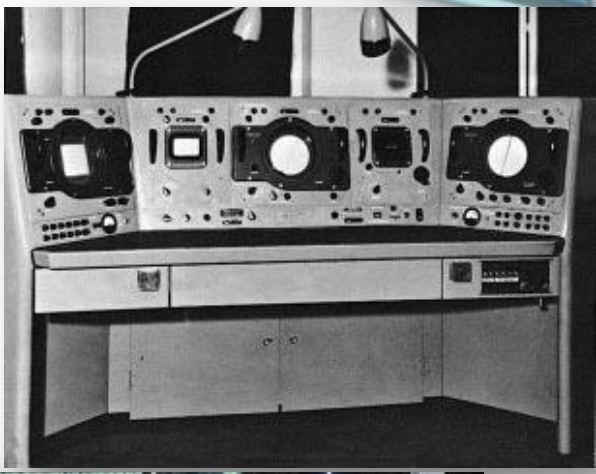
Weather Radar
Do You Really Know What You are Looking At?

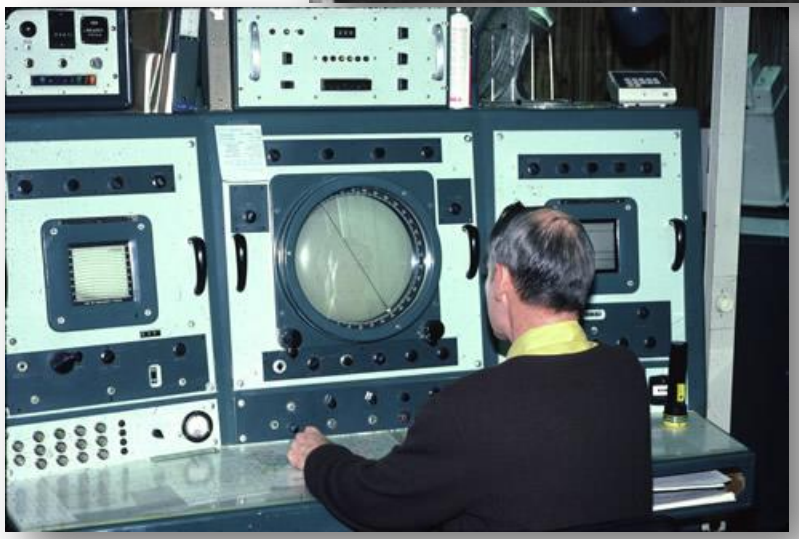
2010 SEMA Conference

April 20 – 23, 2010

Radar History

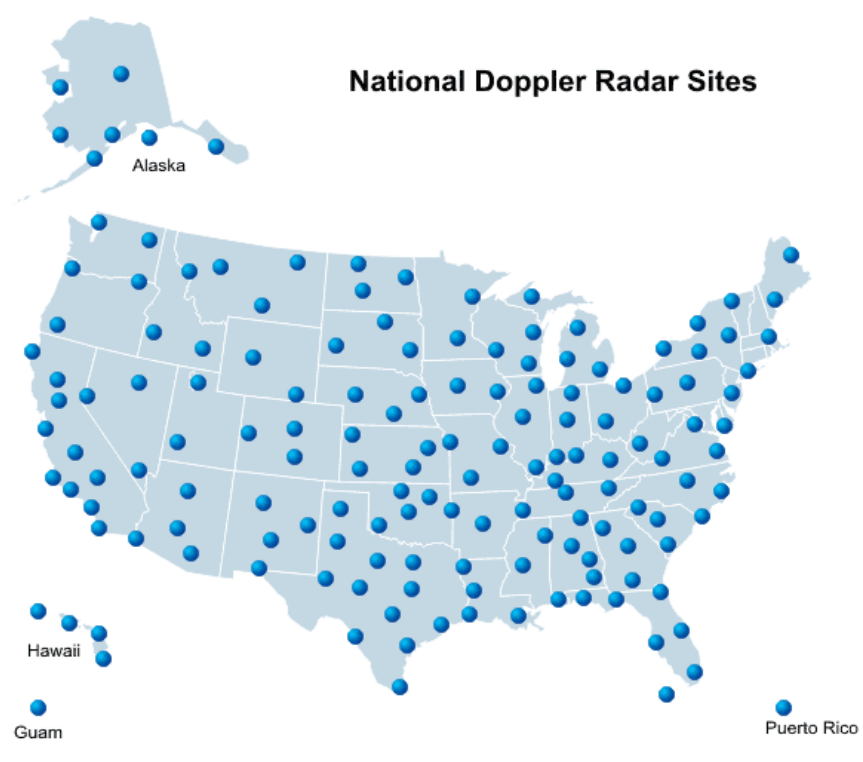
- World War II radar technology
- 1946 – APQ-13s / CPS-9s
- 1959 – WSR-57s
  - Network/53
  - Hurricane / Tornado emphasis
  - Camera added
- 1976 – WSR-74s
  - Local Warning





WSR-88D (NEXRAD)

- Development 1960-1980
- First – Twin Lakes, OK
  - Fall 1990
- Color imagery
- Doppler data
- Higher resolution
- Scanning strategies



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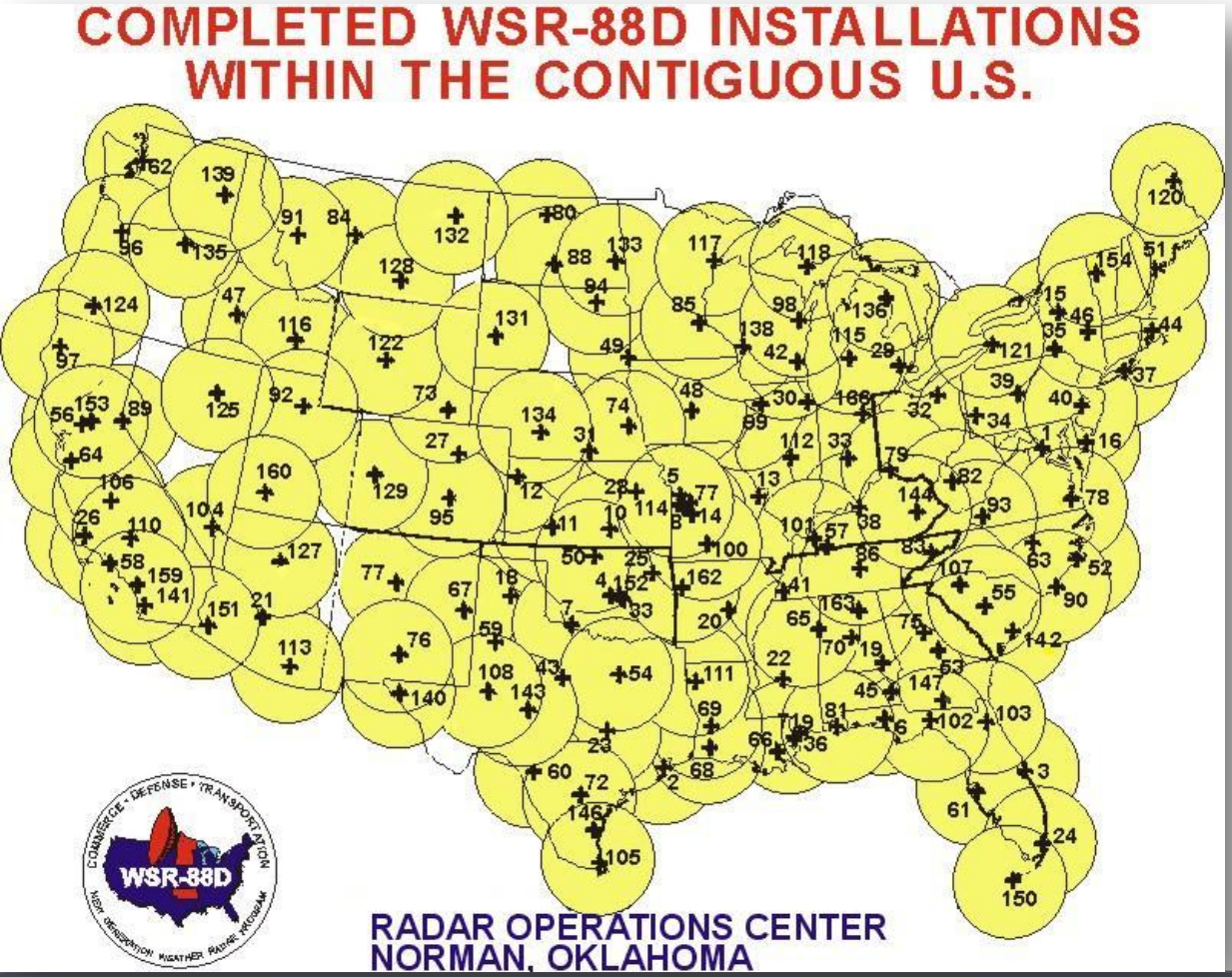
WSR-88D

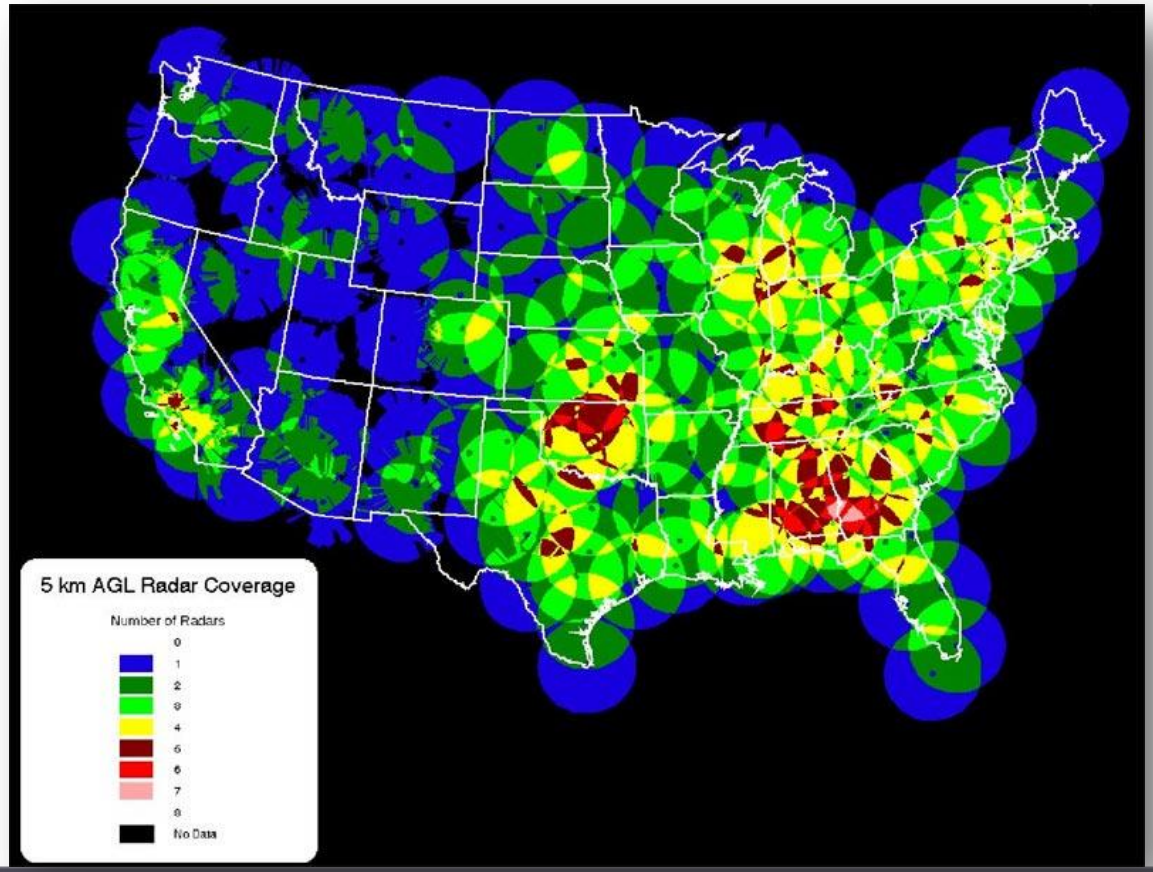


WSR-88D - Specs

- Dish – 28 feet/Dome 39 feet
- Radar Wavelength: S-Band, 10 cm
- Radar Frequency: 2880 MHz
- Beam width: 1 Degree (0.88 – 0.96)
- Peak Power: 750 kW
- Tower Height: 40 ft – 100 feet

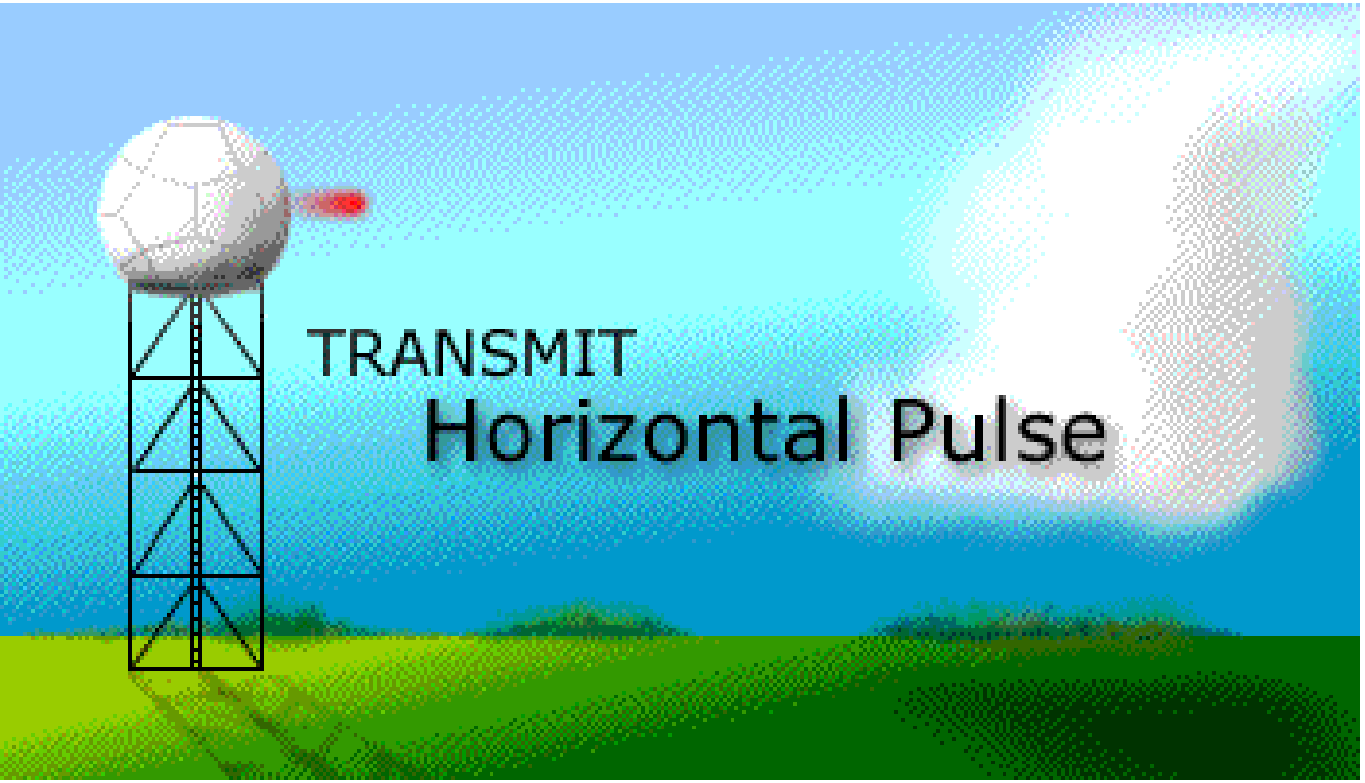
WSR-88D

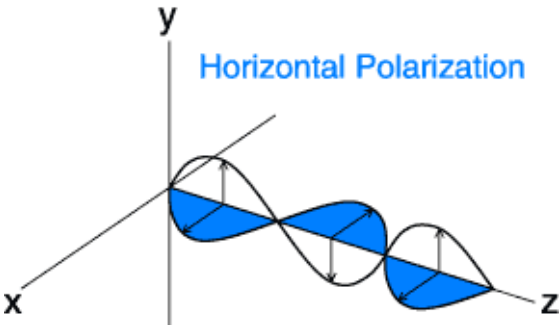
- **Can see 248 nm – Warning: 124 nm**



WSR-88D

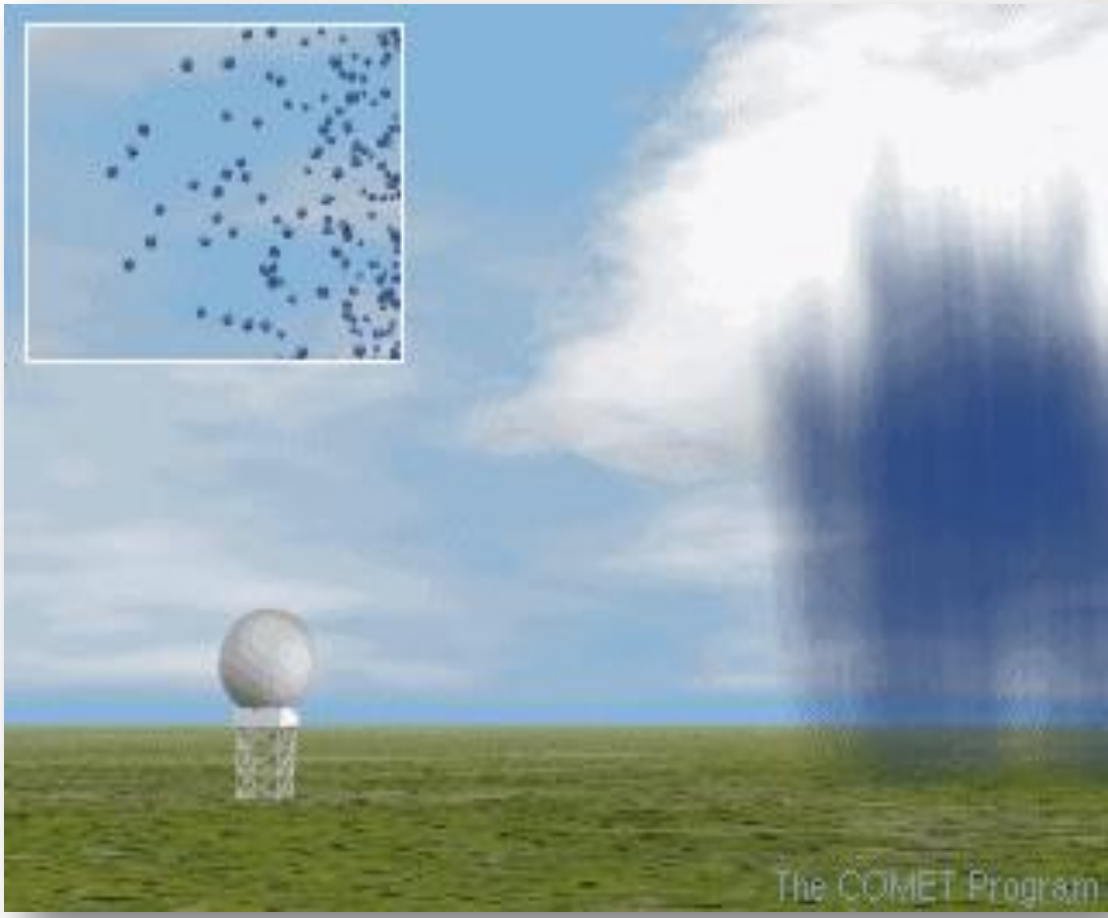
- **Pulse of energy**





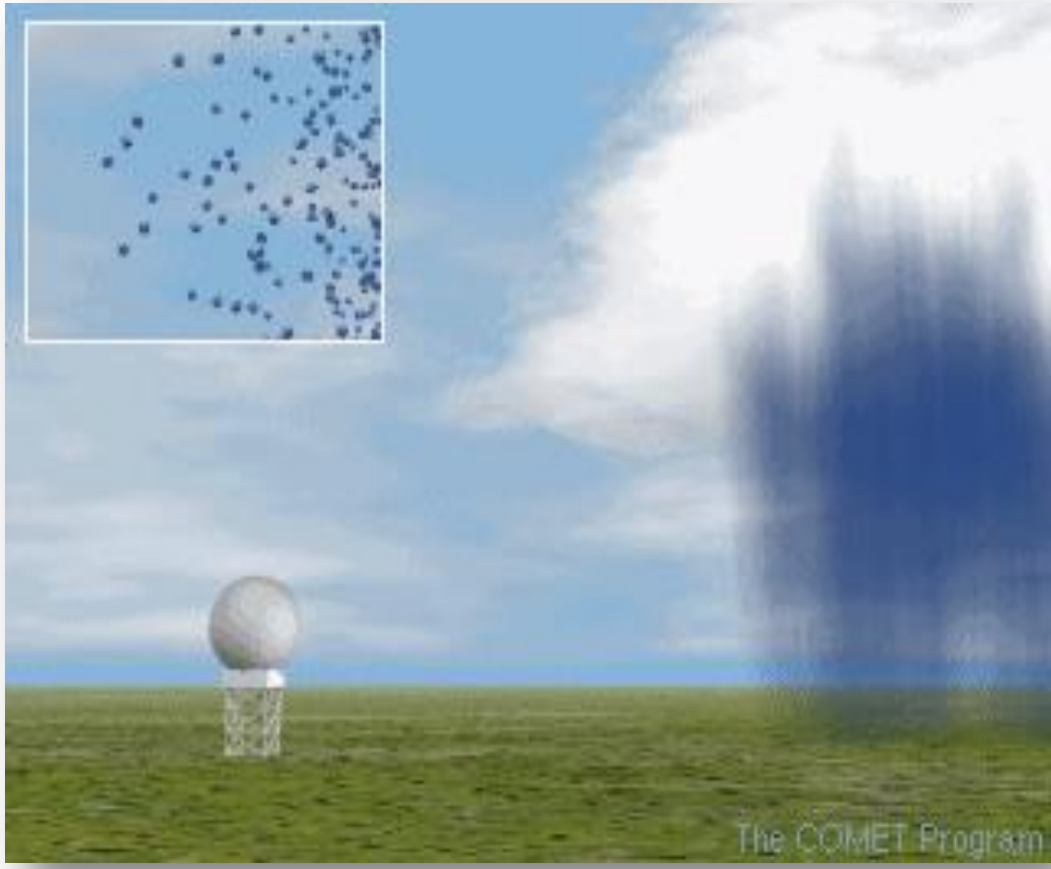
WSR-88D

- Radar is only transmitting six seconds of every hour (about 0.17%)
- The radar “listens” the other 99.83%.



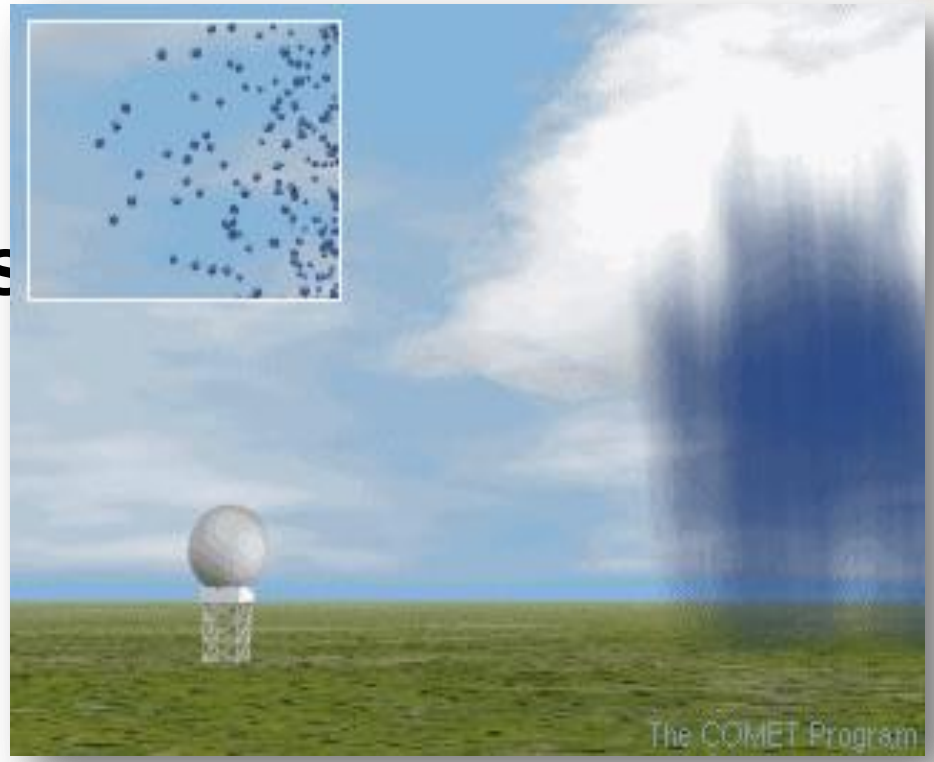
WSR-88D

- **Radar targets include:**
- **Rain**
- **Hail**
- **Snow**
- **Drizzle**
- **Dirt/dust**
- **Smoke**
- **Insects**
- **Birds**
- **Air density changes**



WSR-88D

- **Size of particles**
- **Shape of particles**
- **Number of particles**
- **State of particles (liquid, ice, snow)**
- ***Reflectivity***

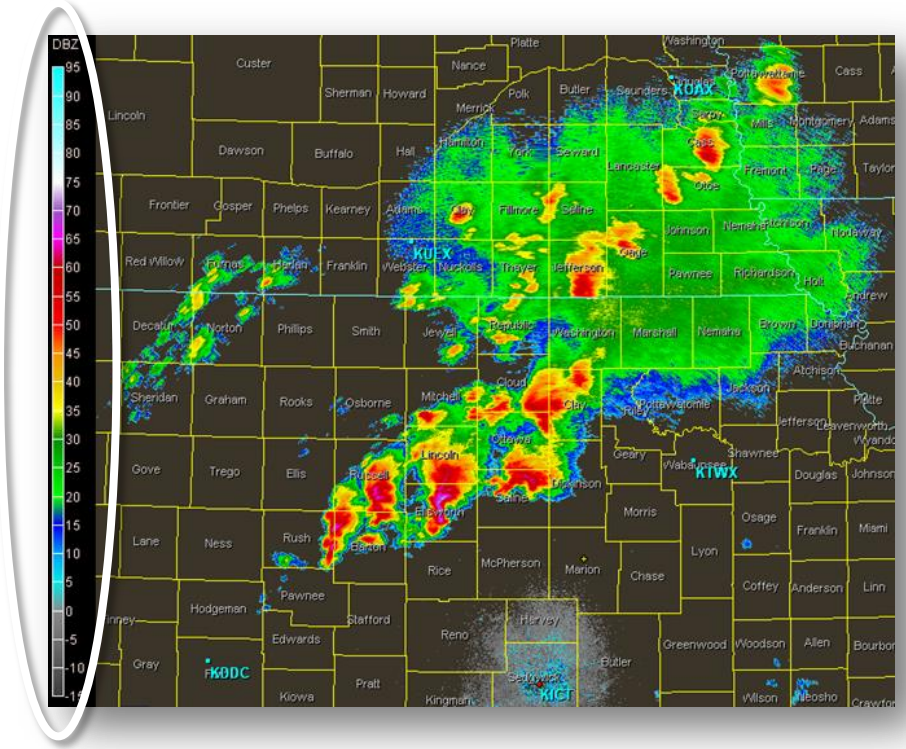


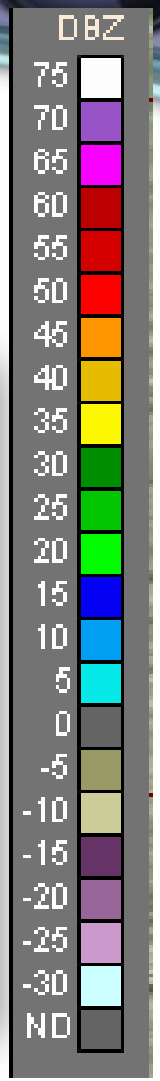
WSR-88D

- **Large more numerous particles, such as big raindrops and water coated hail** ***Return more energy/power***
- **Small raindrops, ice, snow, drizzle** ***Return less power energy/power***

WSR-88D

- **Color scale on reflectivity displays is a representation of the power return**
- **But – Scales change**





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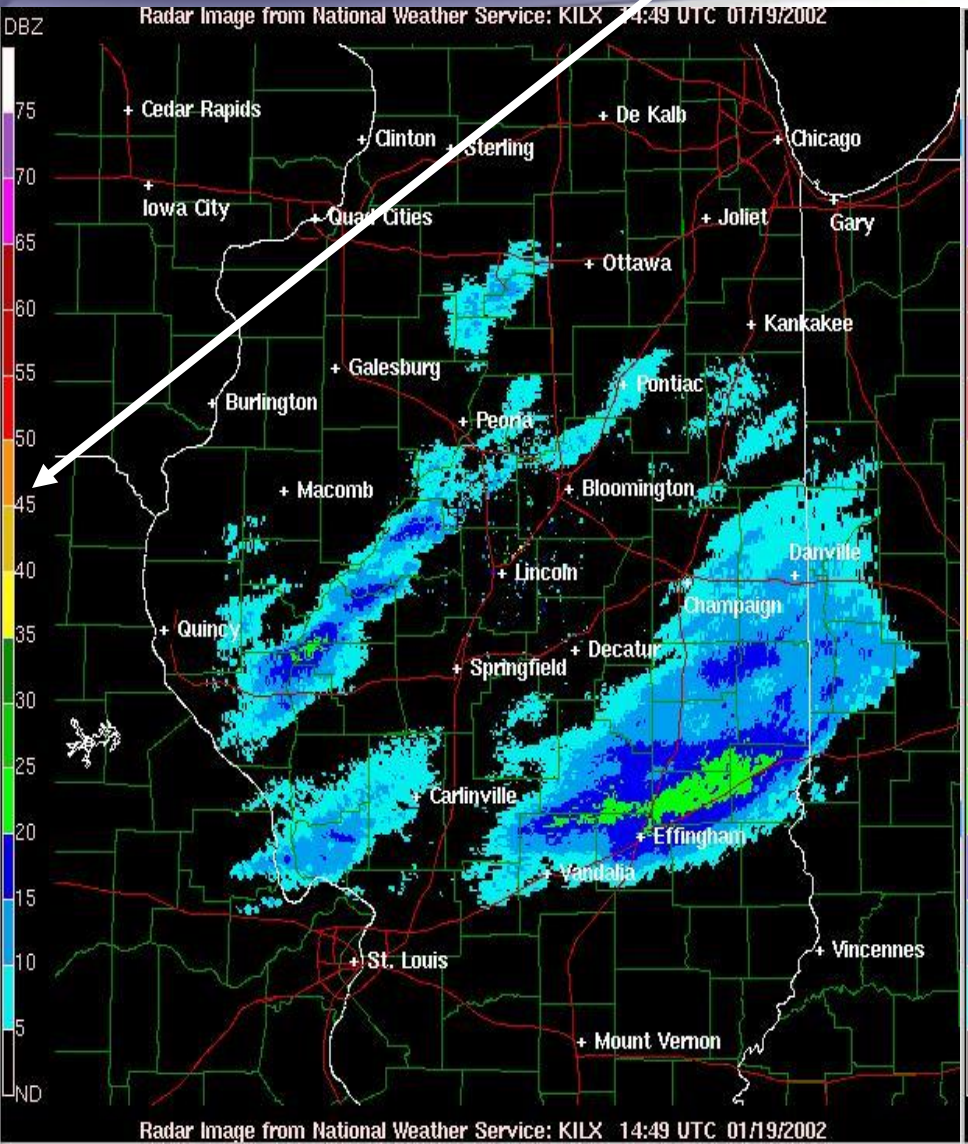
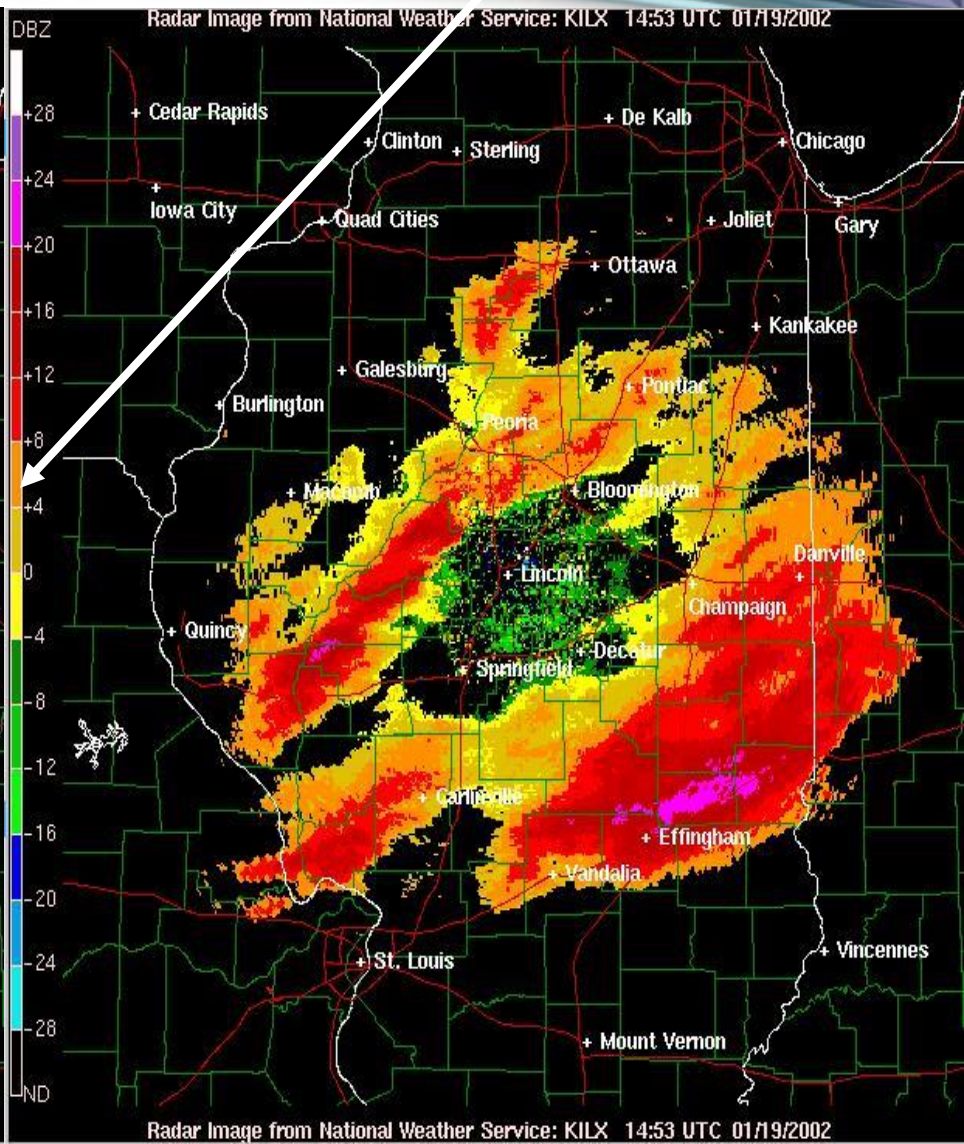
WSR-88D

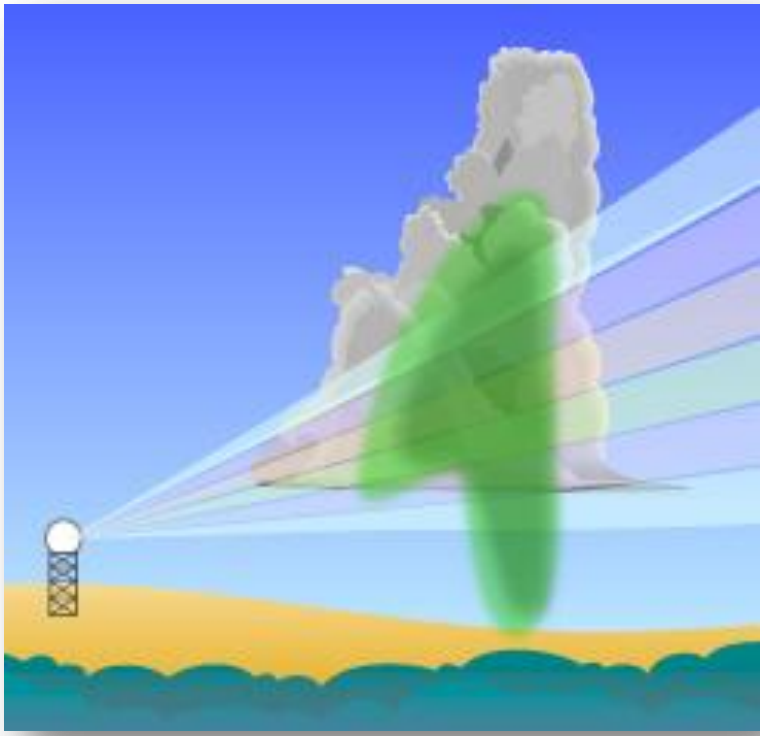
Note the values on each color bar





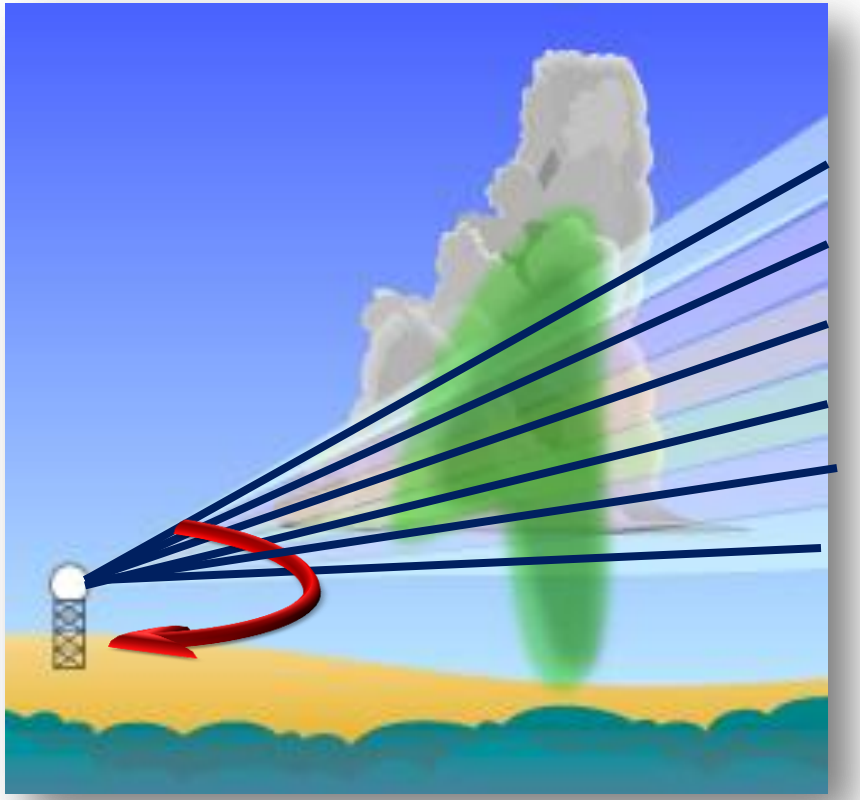
Volume Coverage Pattern (VCP)

- Scanning strategy
- Tell the radar which part of
- the atmosphere to scan
- Allow for 3D views of storms
- Monitor airflow and rotation
- within storms
- Evaluate storm strength and
- trends over time



VCP

- **Radar does a 360 degree sweep**
  Tilts to next elevation



VCP

- **Precipitation Mode (Mode A)**
  - VCP 11: 14 angles in 5 minutes [Severe Weather, Tstorms]
  - VCP 12: 14 angles in 4.5 minutes [Severe Weather, Tstorms]
  - VCP 21: 9 angles in 6 minutes [General Precip, Tstorms]
  - VCP 121, 211, 212, 221: variations of above with additional signal processing

VCP

- **Clear Air Mode (Mode B)**
  - VCP 31: 5 angles in 10 minutes [Very light precip, Clear air]
  - VCP 32: 5 angles in 10 minutes [Very light precip, Clear air]

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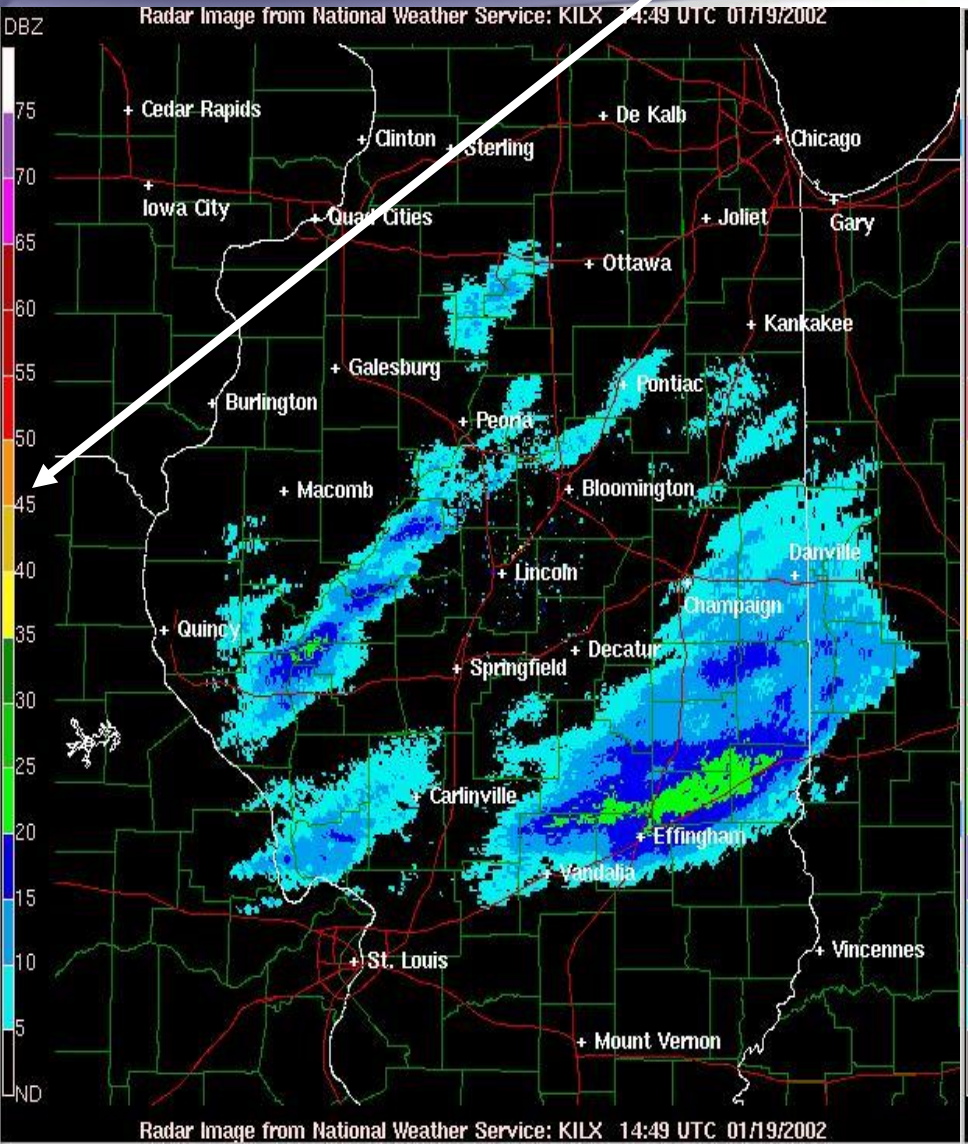
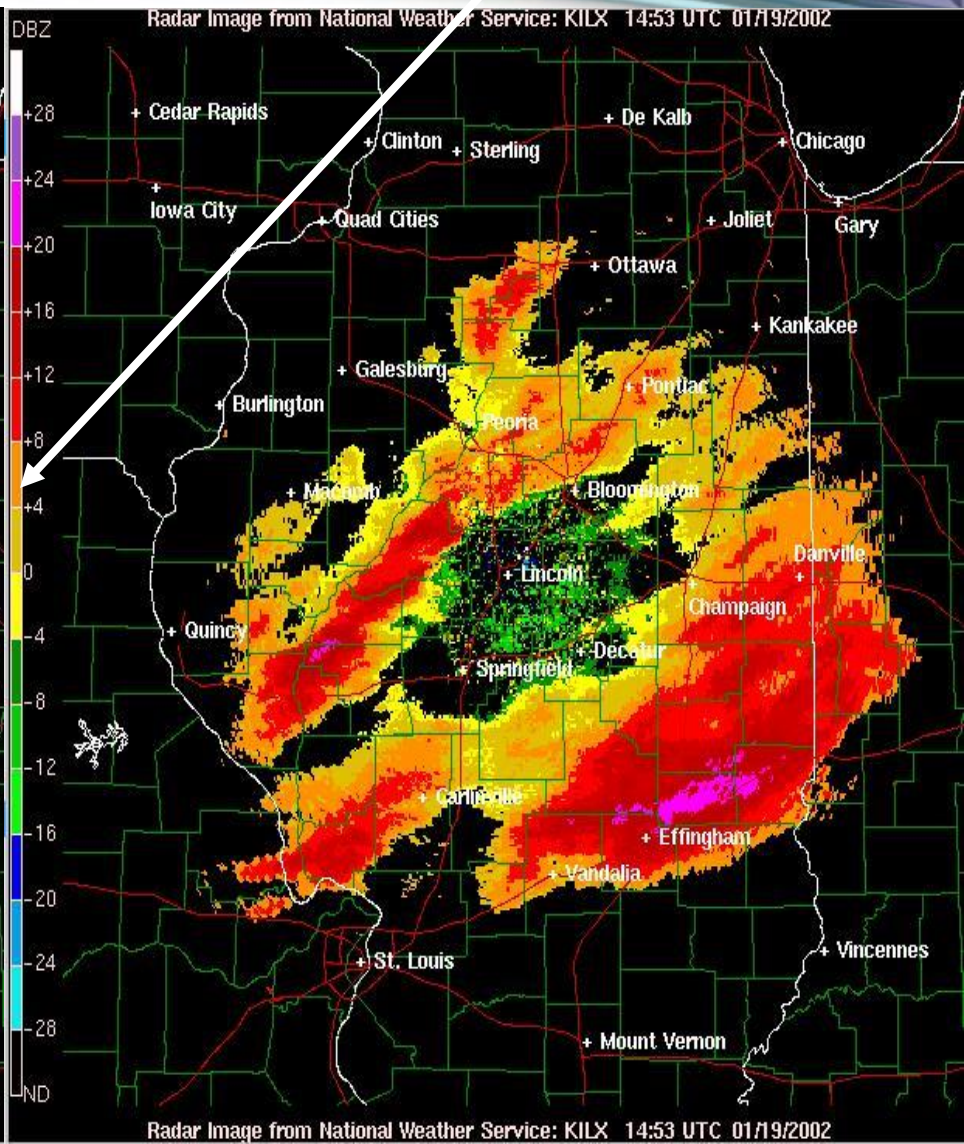
WSR-88D

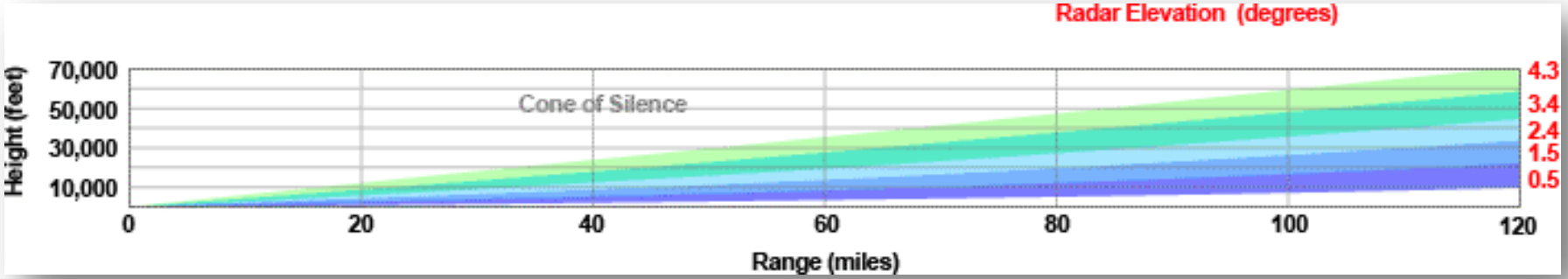
Note the values on each color bar



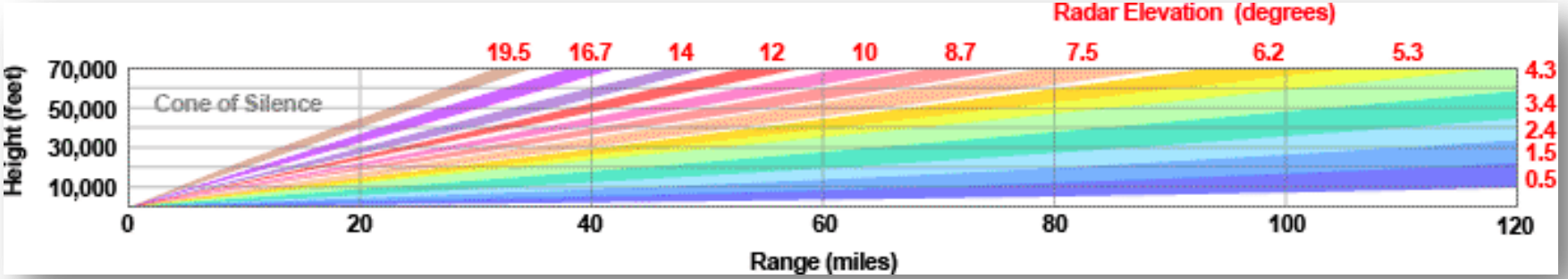


VCP 32 and 11

Clear Air Mode (10 minutes)

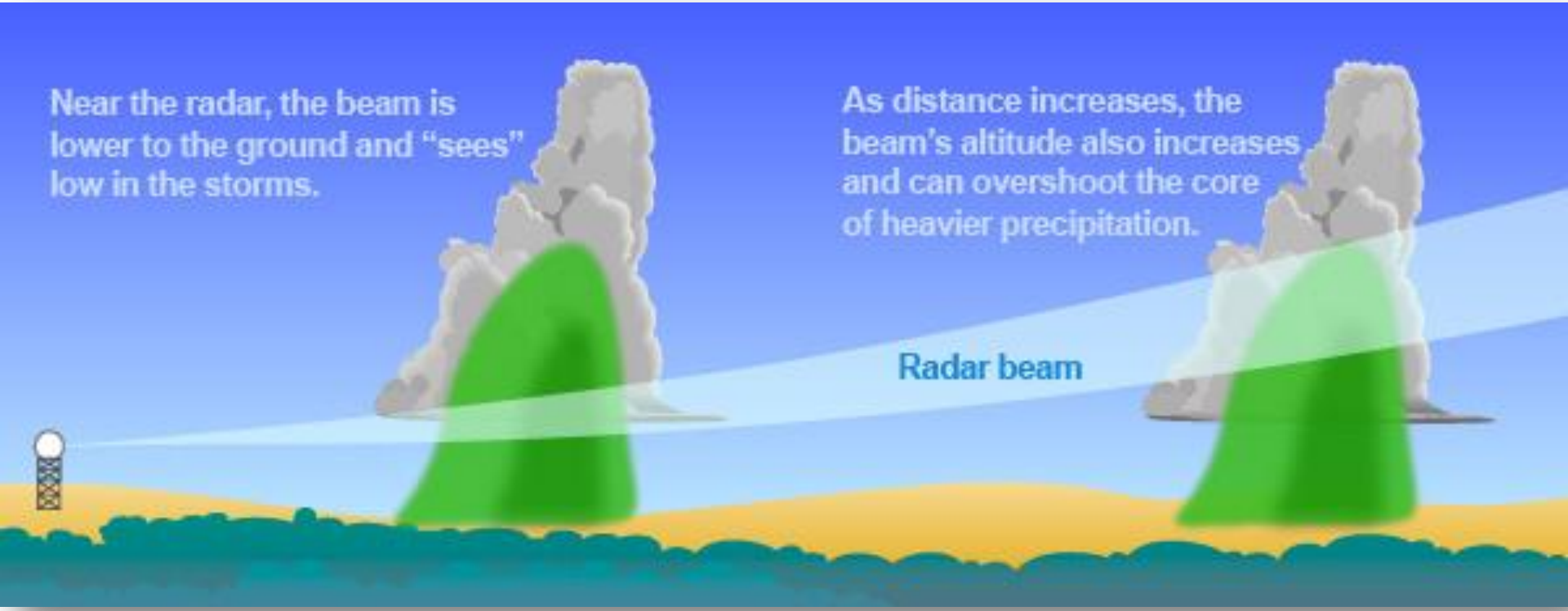


Precipitation Mode (5 minutes)



Radar Beam Characteristics

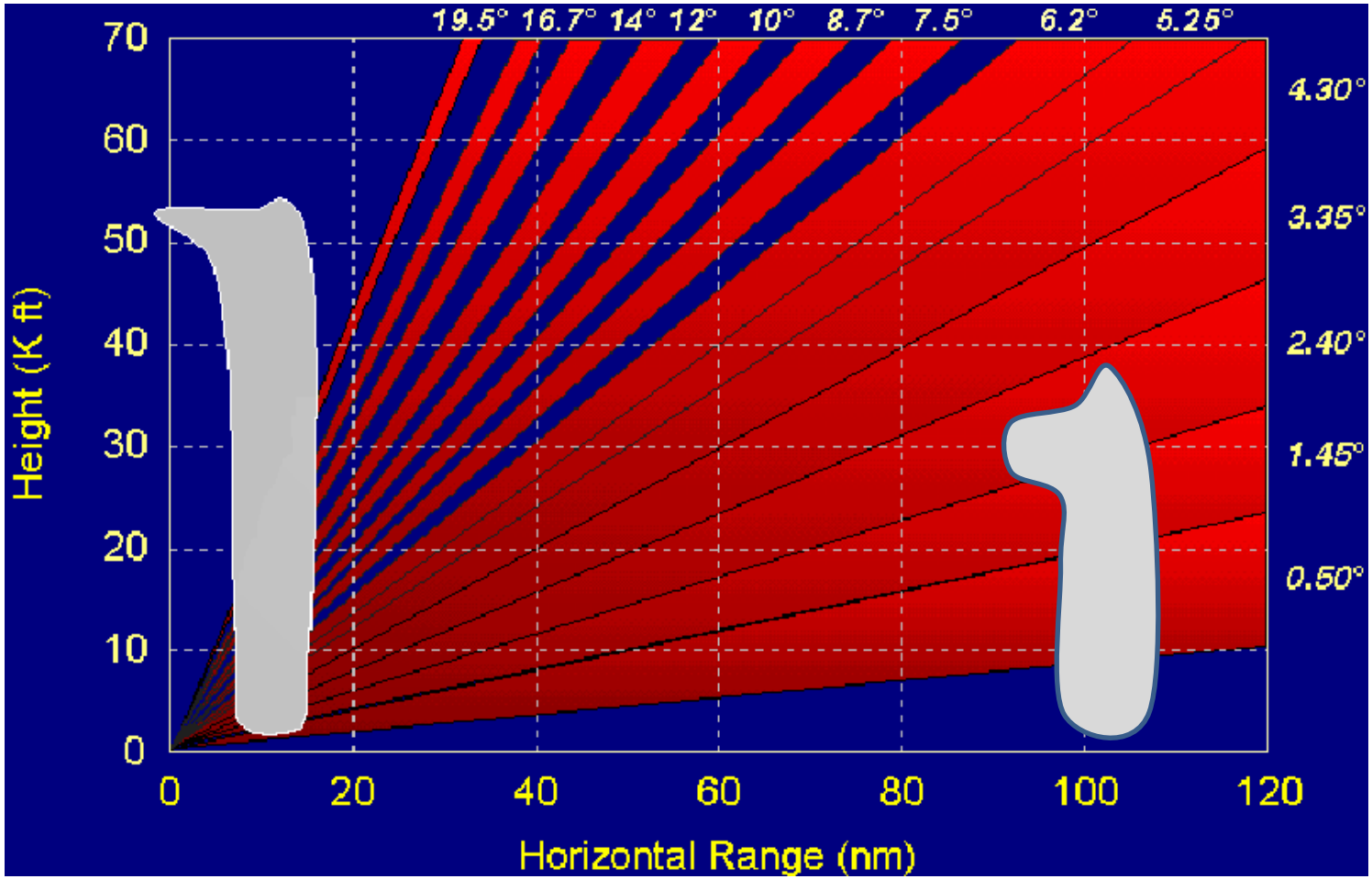
- **Beam gains elevation with height**



Beam and VCP Limits

- **Storms on top of radar are only sampled at low elevations**

Beam and VCP Limitations



Beam Characteristics

Beam spreads and rises (curvature of Earth)

Range	Beam Diameter	Center Beam height
10 nm	**1000 feet**	**600 feet**
50 nm	**1 mile**	**4400 feet**
100 nm	**2 miles**	**12500 feet**
150 nm	**3 miles**	**25000 feet**

Beam Width

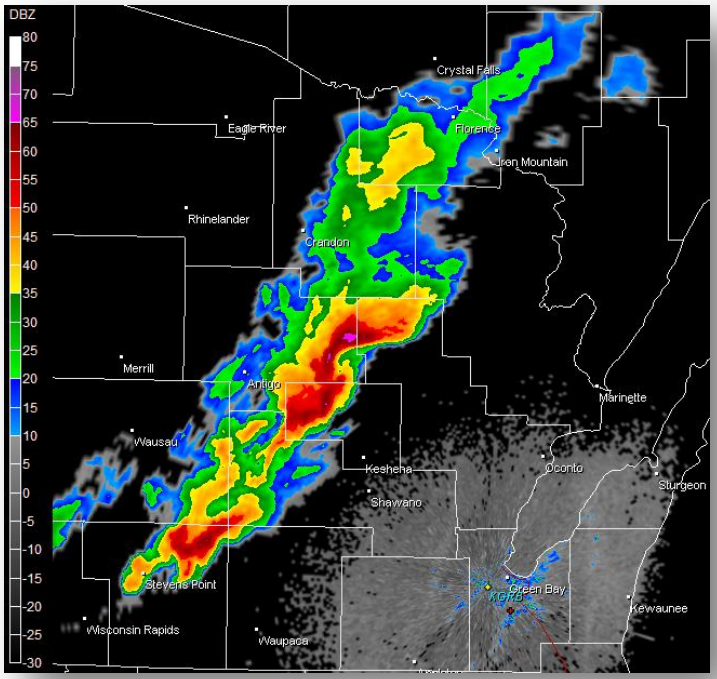
- Distance and beam width affect resolution
  - Small scale features hard to see
  - Solid line of storms at a distance may have “gaps” that the radar cannot resolve until they are closer

Basic Radar Products

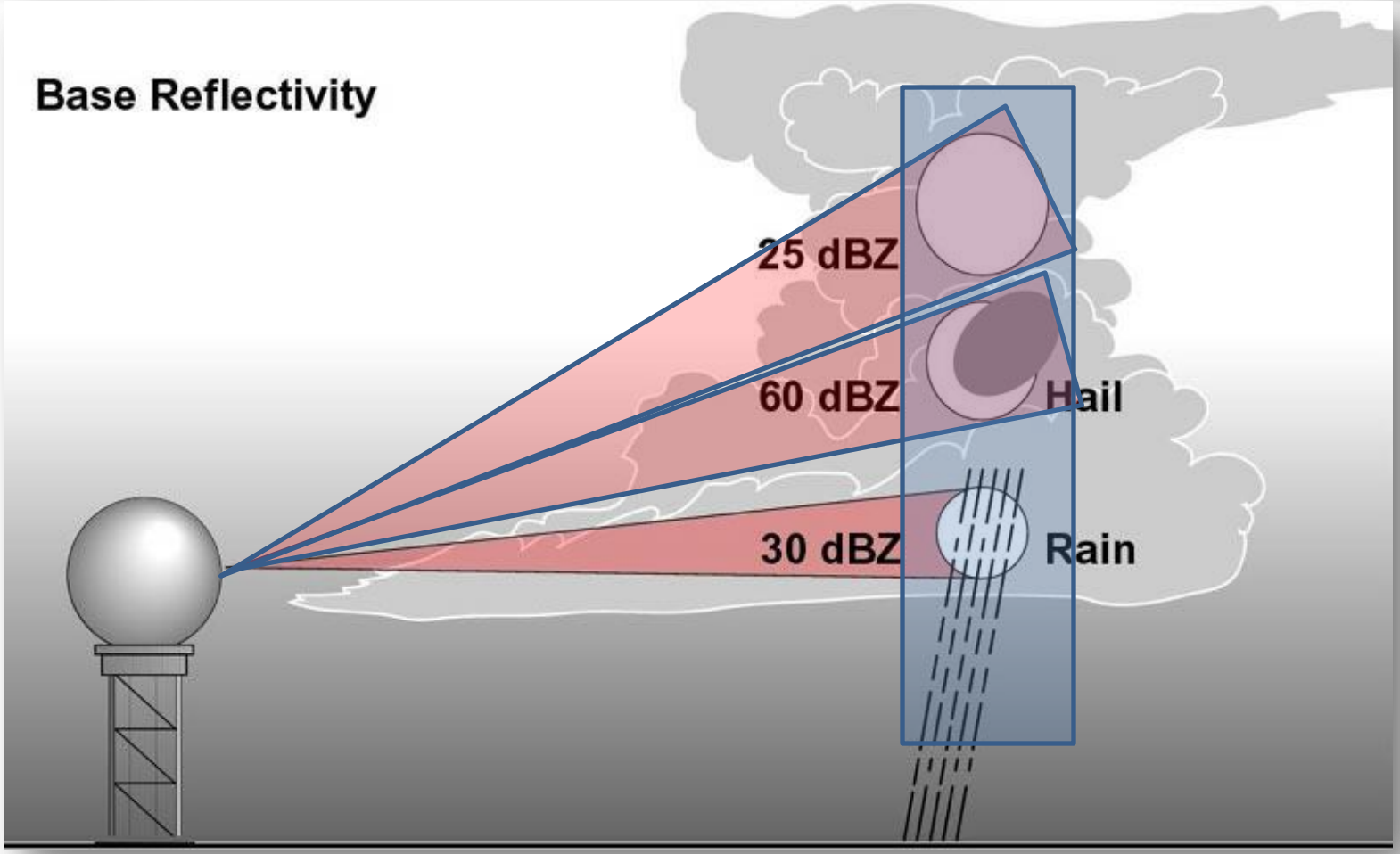
- Reflectivity
- Velocity
- Derived Products

Reflectivity

- Most widely used
- Units of decibels (dbz), proportional to rainfall/precipitation rate
- Base and composite
- Base refers to a single elevation slice (NWS websites show 0.5)

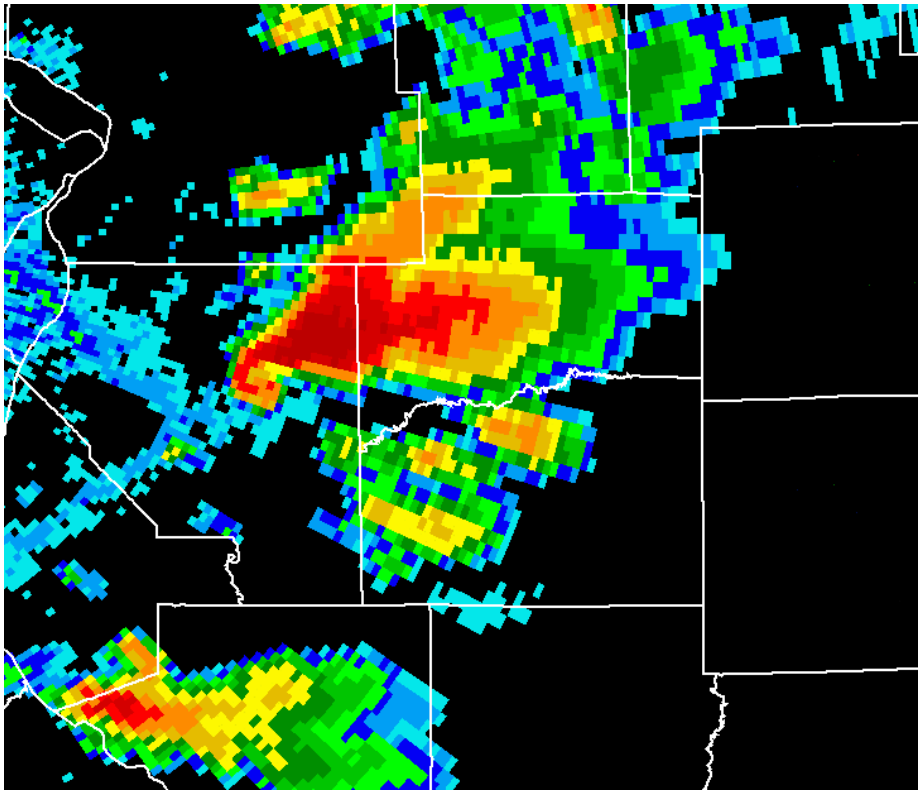


Base Reflectivity

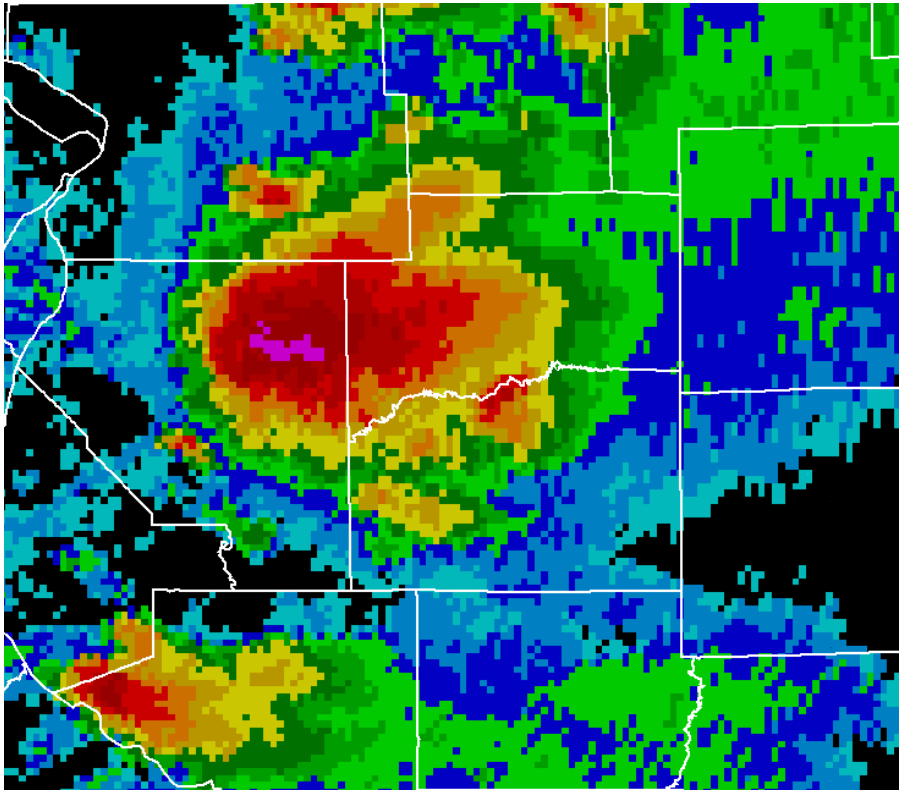


Composite Reflectivity

- **Displays the highest value in a vertical column: But you do not know where it is**



0.5° Base Reflectivity

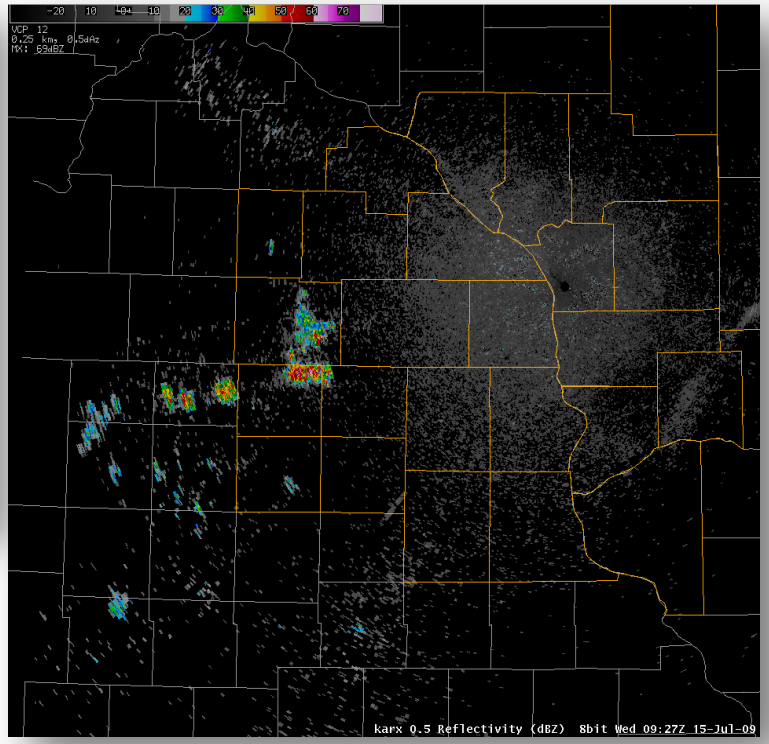


Composite Reflectivity

Ground Clutter

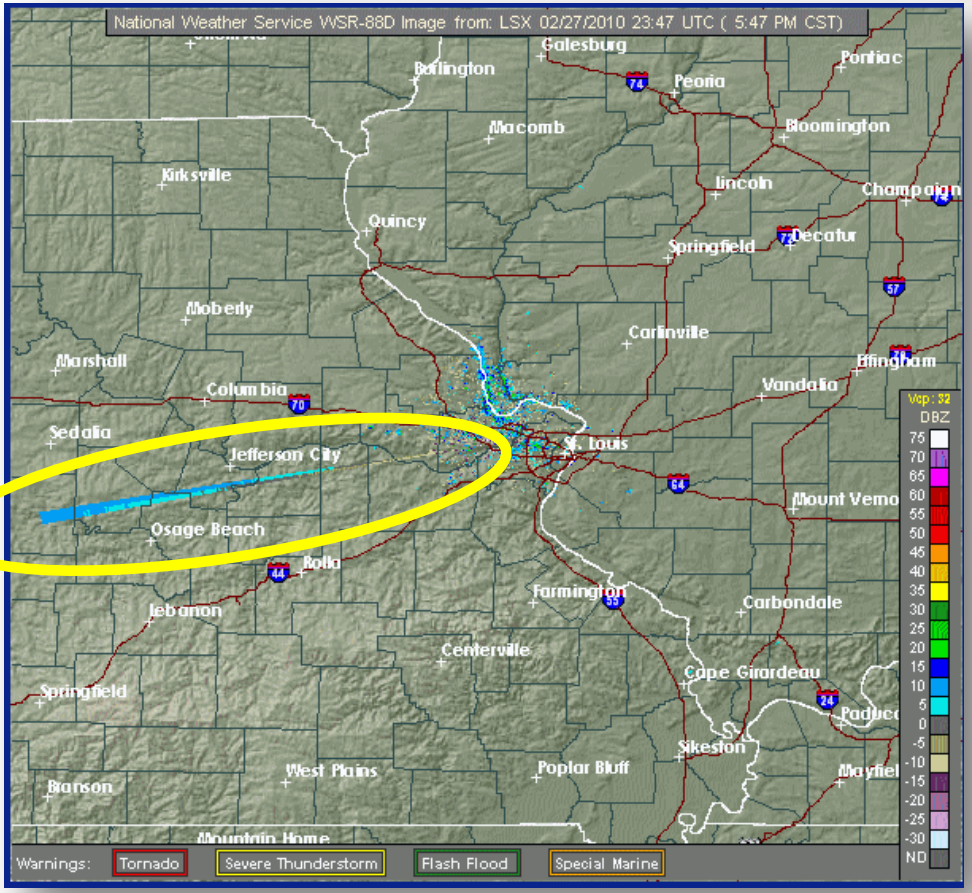
- Due to atmosphere, beam is bent to the Earth (Ducting). Objects on ground appear as precipitation anomalous propagation (AP)
- Radar has algorithms which eliminates most AP

Ground Clutter



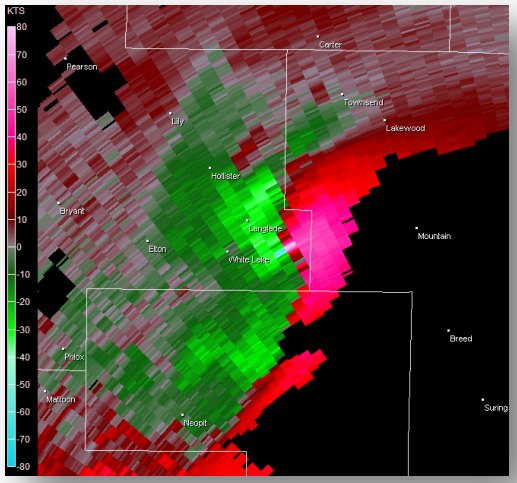
Sunrise/Sunset

- Electromagnetic interference
- Radar points directly at the sun
- One volume scan



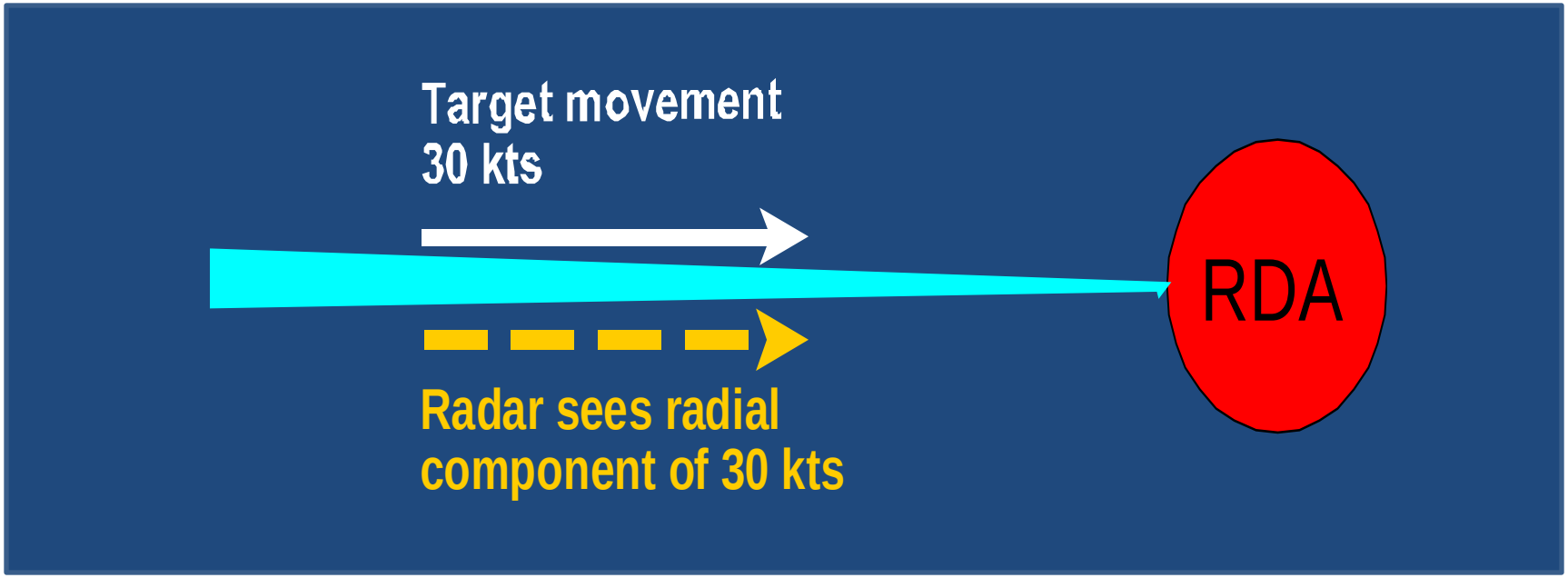
Velocity

- **Doppler effect: return signal changes if object is moving**
- **See wind fields in a storm: Circulation**
- **Not total velocity: Radial Velocity**
- **Base Velocity and Storm Relative**



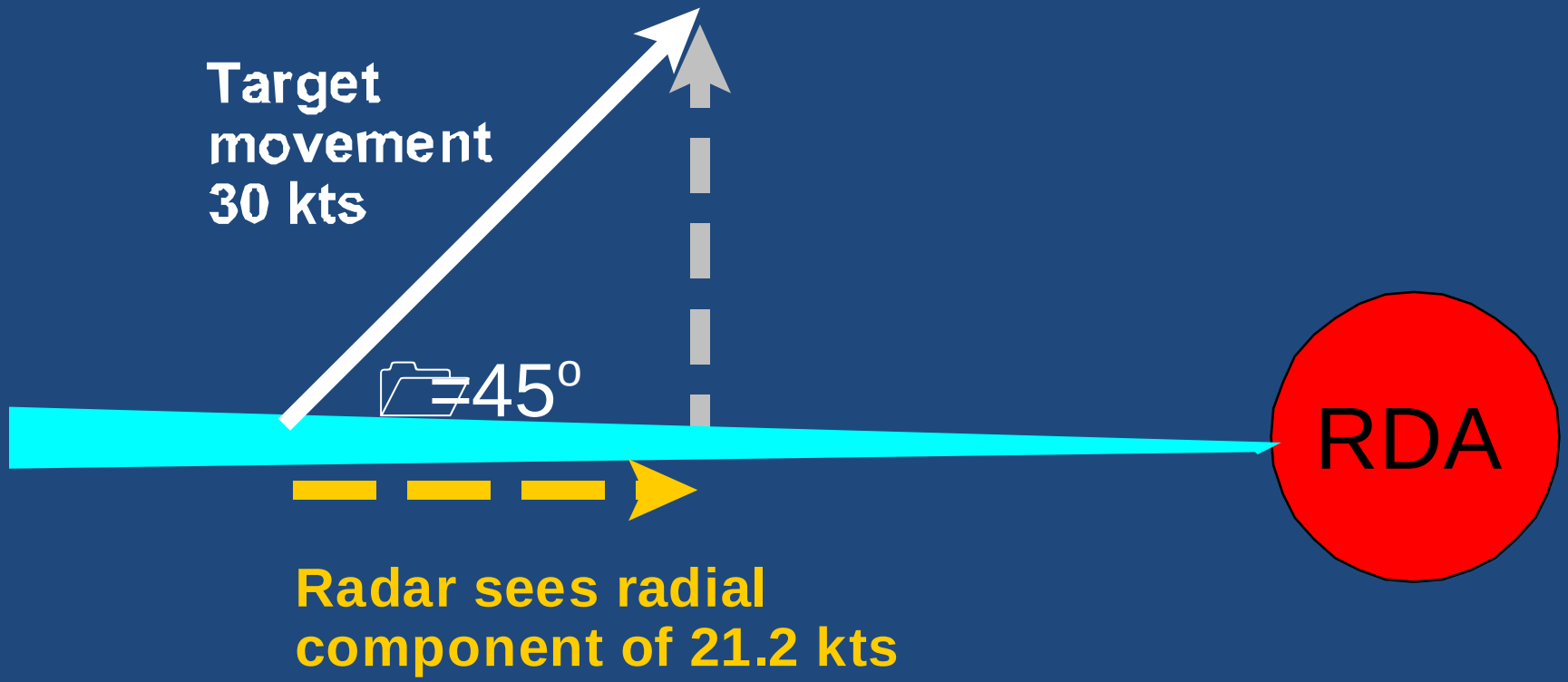
Velocity

True velocity only if moving directly toward or away from radar



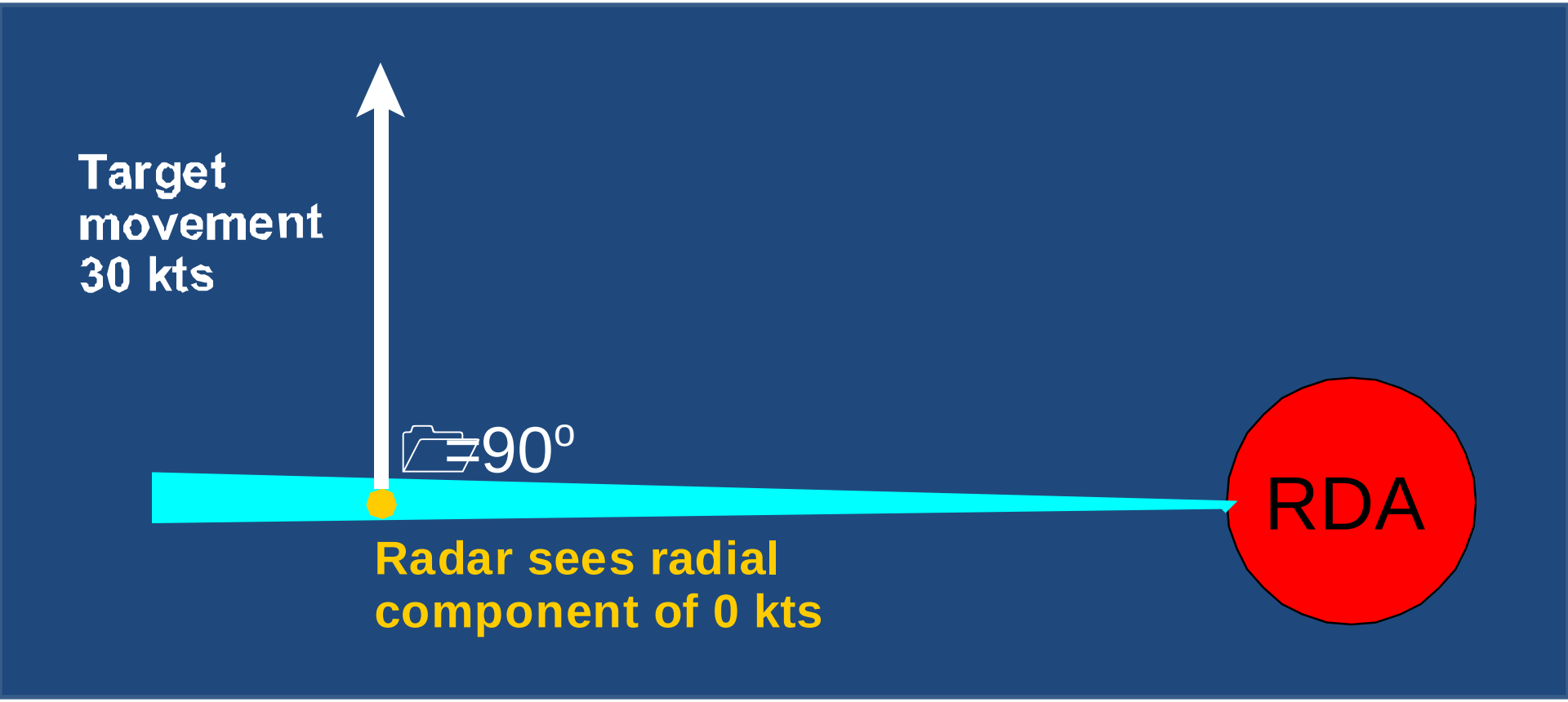
Velocity

- **Radar sees portion of velocity**



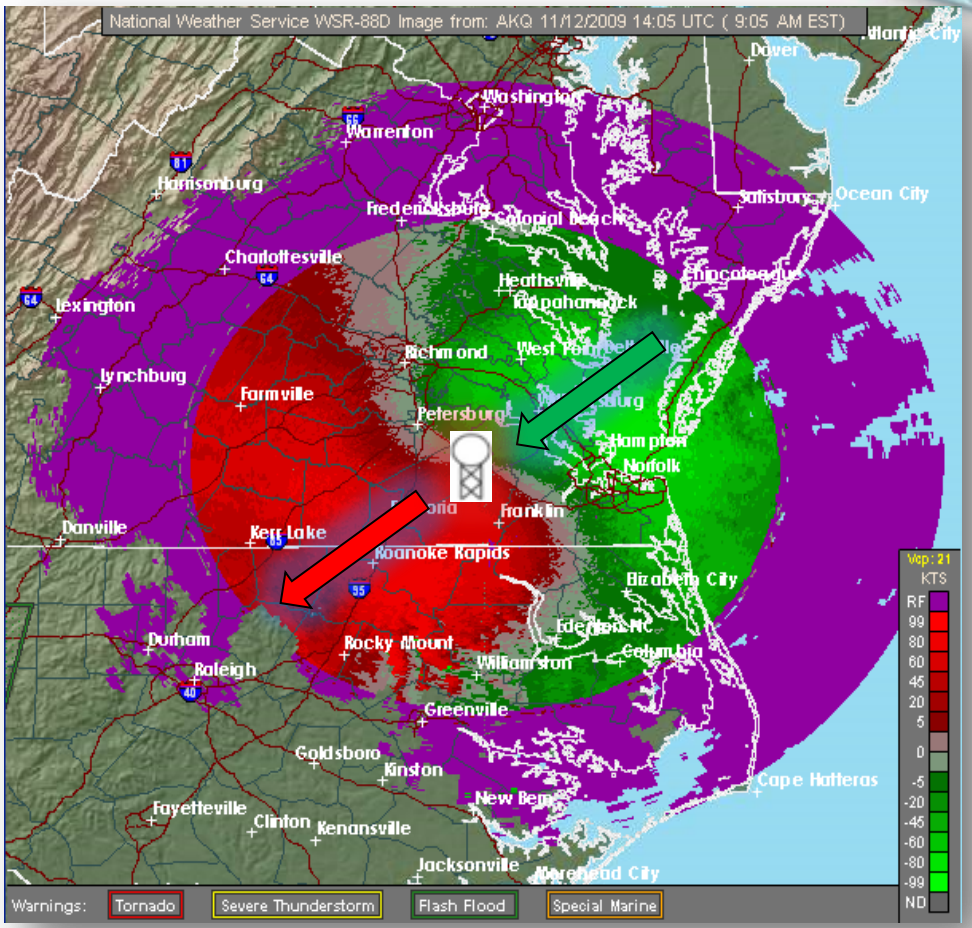
Velocity

- **Radar sees zero velocity**



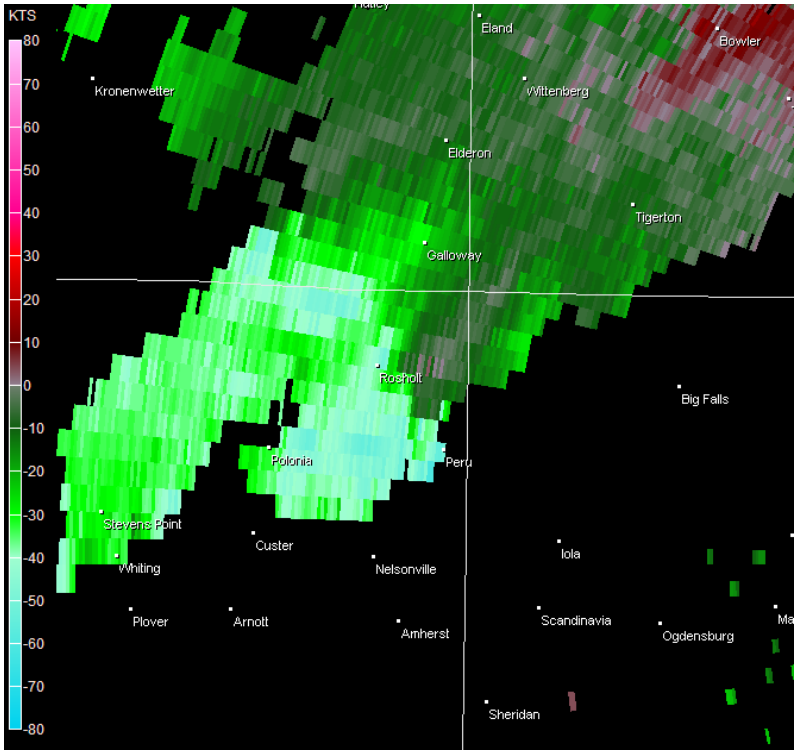
Velocity

- Warm colors (red) positive values away from radar
- Cool colors (green) negative values toward the radar
- Purple Haze "Range folding":??

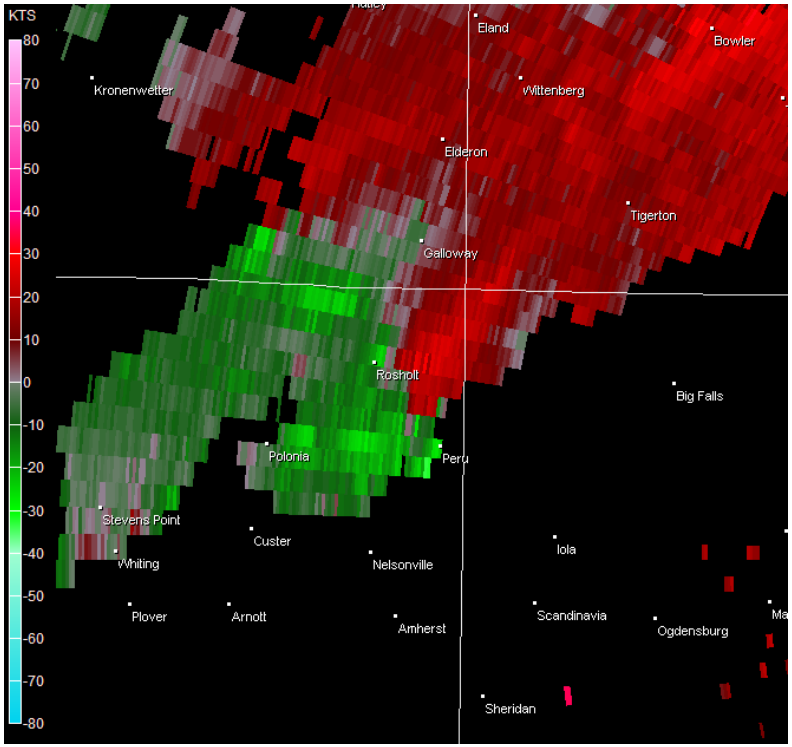


Base – Storm-Relative

Base Velocity

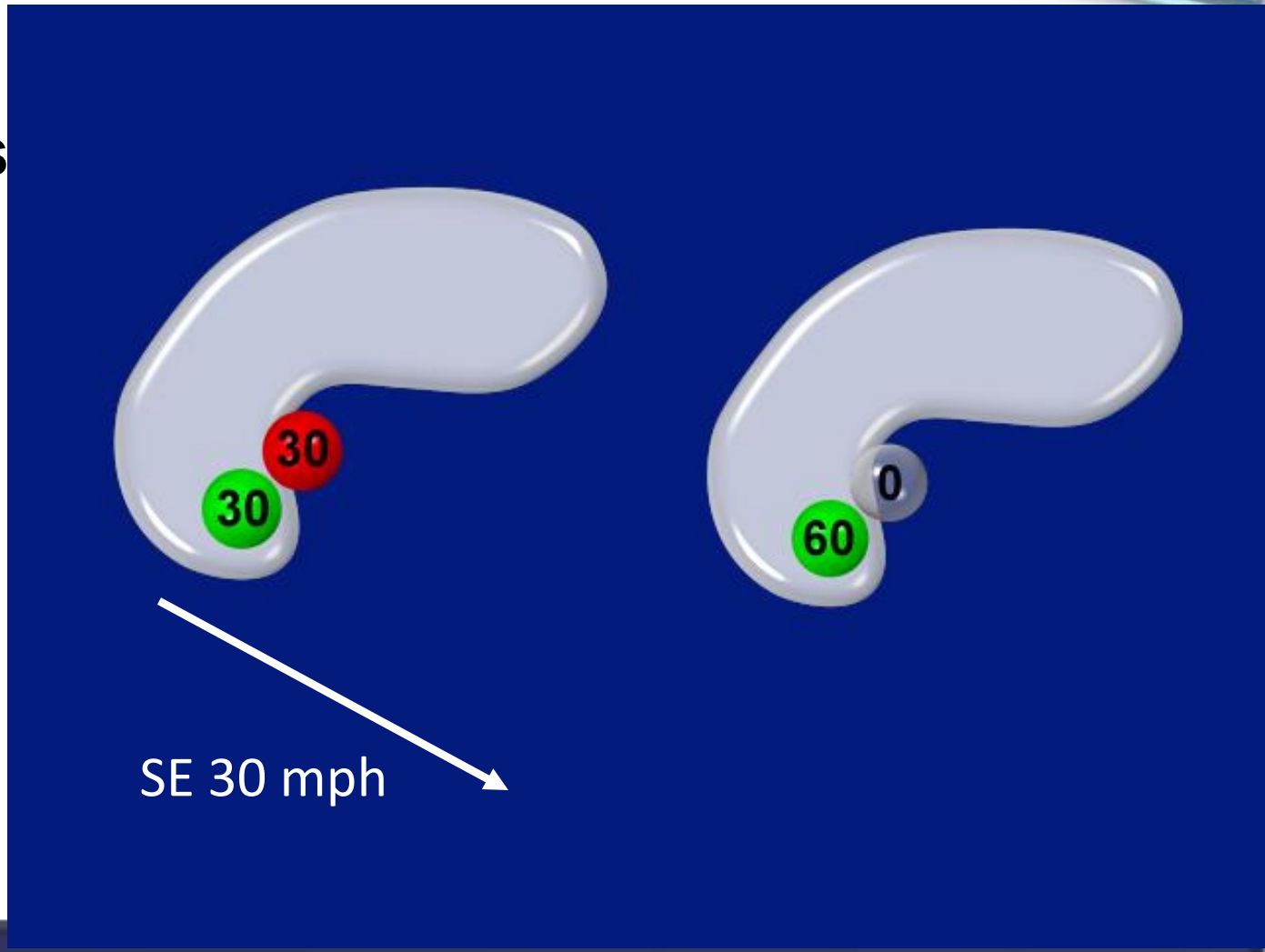


Storm-Relative Velocity



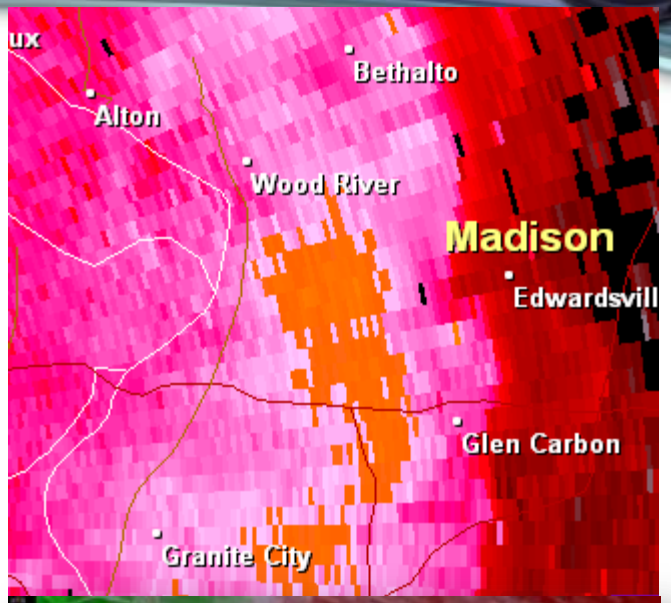
Storm Relative Velocity

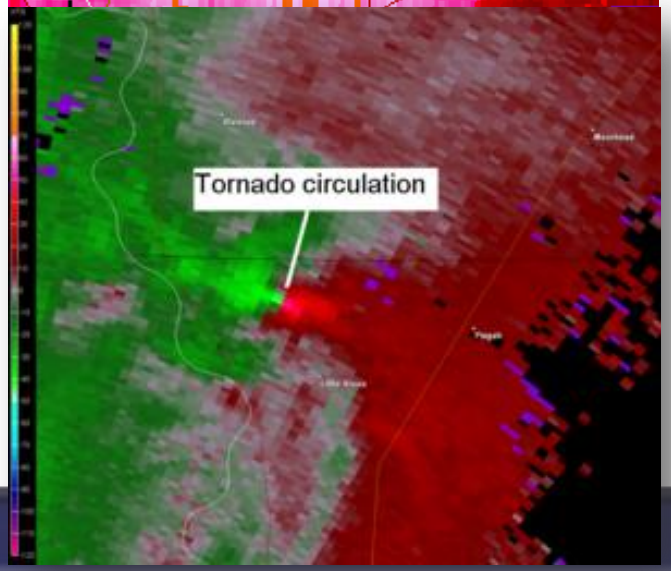
Subtract out the storms motion. What is left is the wind motion as if the storm were stationary.



Base vs. Storm-Relative

- **Base velocity used for straight-line wind gusts**
- **Storm-relative velocity used to identify circulations that may be masked by the storm motion**

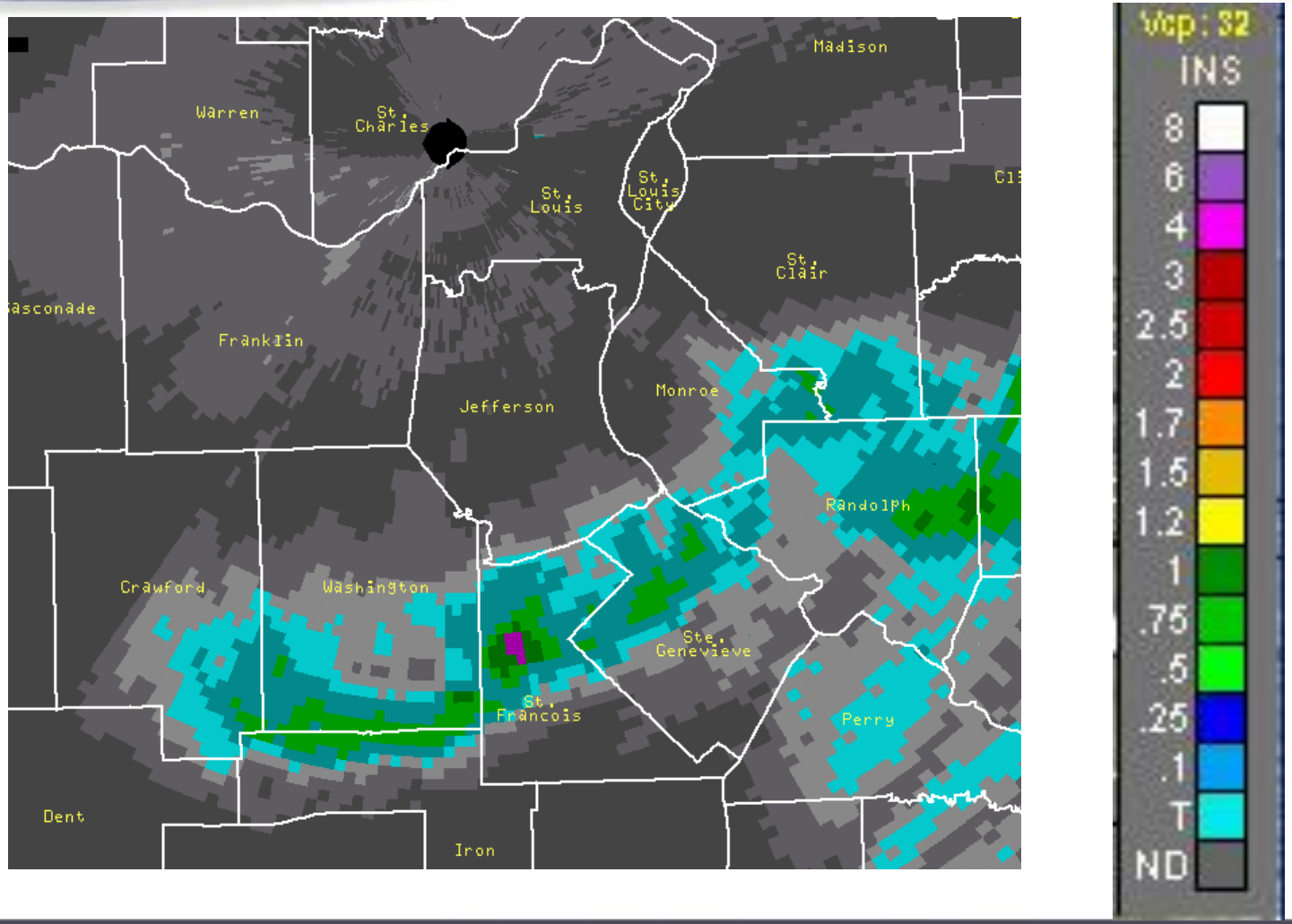




Precipitation Estimates

- **ESTIMATE!!!**
- **Good with location**
- **Amount can be close, too high or too low**
- **Usually amounts are too high due to hail or ice contamination**
- **1 Hour / Storm Total products**

Precipitation Estimates



Other Products (algorithms)

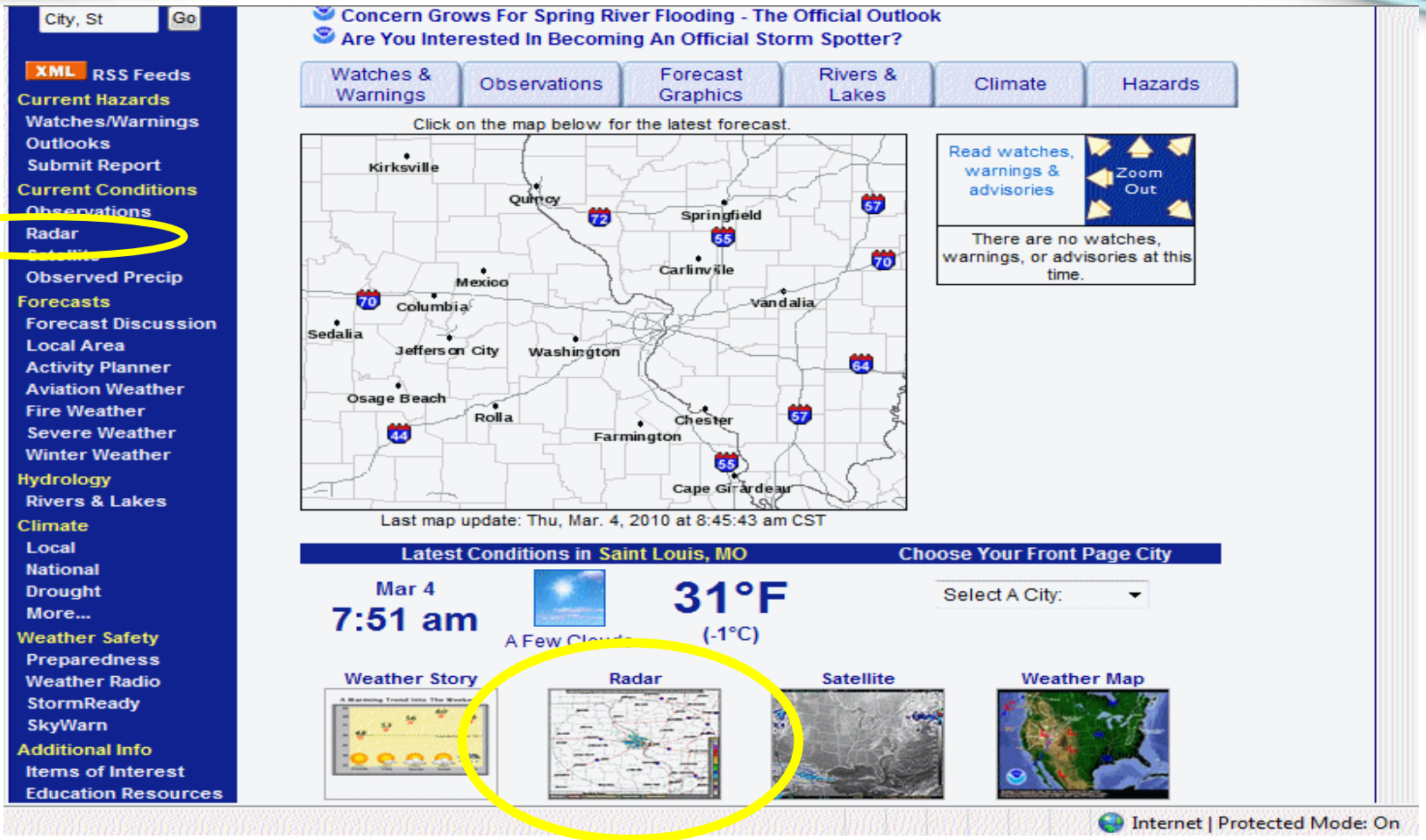
- **Vertically Integrated Liquid**
  - **Hail and heavy rain location**
- **Hail : Maximum expected hail**
  - **Often overestimates**
- **Mesocyclone**
- **Tornado Vortex Signature**
  - **False alarms!!!**
- **Storm Track**

Radar on the Internet (NWS)

- Base Reflectivity (0.5)
- Composite Reflectivity
- Base Velocity
- Storm-Relative Velocity
- Rainfall Estimates
  - 1 Hour
  - Storm Total

National Weather Service
St. Louis, MO

NWS Radar



NWS Radar


National Weather Service Enhanced Radar Image
St. Louis, MO Radar
Go to: Standard Version
Local weather forecast by "City, St"
City, St
Go
Radar Status Message
Adjacent Radars:
LSX
Short Range Images
Reflectivity:
Composite Loop
Base Loop
Velocity:
Storm Relative Loop
Base Loop
Rainfall:
1-Hour Total Loop
Storm Total Loop
MouseOver Off
Long Range Images
Reflectivity:
Base Loop
Reflectivity:
National Loop
Alaska Loop
Hawaii Loop
Base Reflectivity
NWS is accepting comments on proposed combined warning and radar displays until October
NWS St. Louis, MO
National Weather Service WSR-88D Image from: LSX 03/02/2010 04:41 UTC (10:41 PM CST)
Galesburg
Burlington
Peoria
Pontiac
Macomb
Bloomington
Kirksville
Lincoln
Champaign
Quincy
Springfield
Decatur
Moberly
Carlinville
Marshall
Effingham
Columbia
Vandalia
Sedalia
Jefferson City
St. Louis
Mount Vernon
Osage Beach
Rolla
Farmington
Lebanon
Carbondale
Vcp: 32
DBZ
75
70
65
60
55
50
45
40
35
30
National Weather Service - St.

National Weather Service
St. Louis, MO

NWS Radar

Sectors

Northern U.S.

Pac. Northwest	Loop
Nrn. Rockies	Loop
Upper Miss. Vly.	Loop
Great Lakes	Loop
Northeast	Loop

Southern U.S.

Pac. Southwest	Loop
Srn. Rockies	Loop
Southern Plains	Loop
Srn. Miss. Vly.	Loop
Southeast	Loop

U.S. Views

Reflectivity:

National	Loop
Alaska	Loop
Hawaii	Loop
Guam	Loop
Puerto Rico	Loop

Radars by State

Go!

Additional Info:

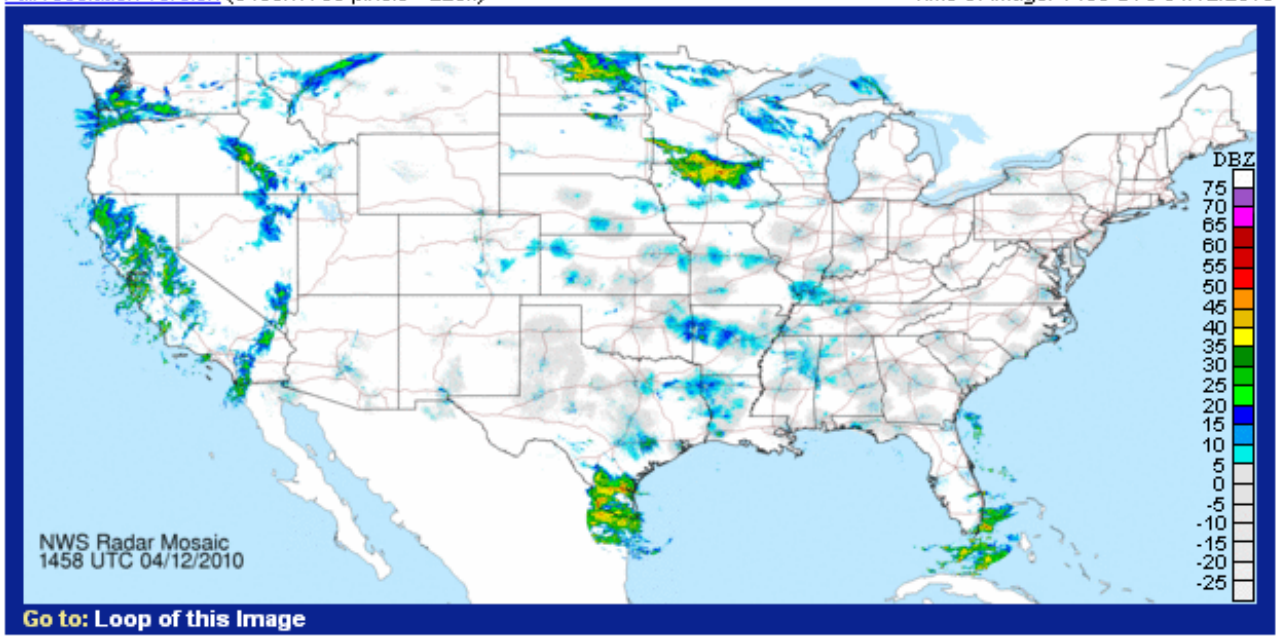
Radar FAQ
Downloading Images
GIS Users
Doppler University

Base Reflectivity

NWS is accepting comments on proposed combined warning and radar displays until October

Full resolution version (3400x1700 pixels - 220k)

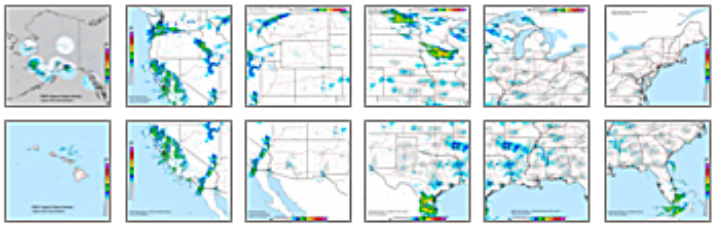
Time of image: 1458 UTC 04/12/2010



Go to: Loop of this Image

National Radar Mosaic Sectors

(click image)



Position Locator

- **Default: Radar site**
- **Click on map to change**

Position Locator

- **Centerville is Home**
- **Curser on Rolla**

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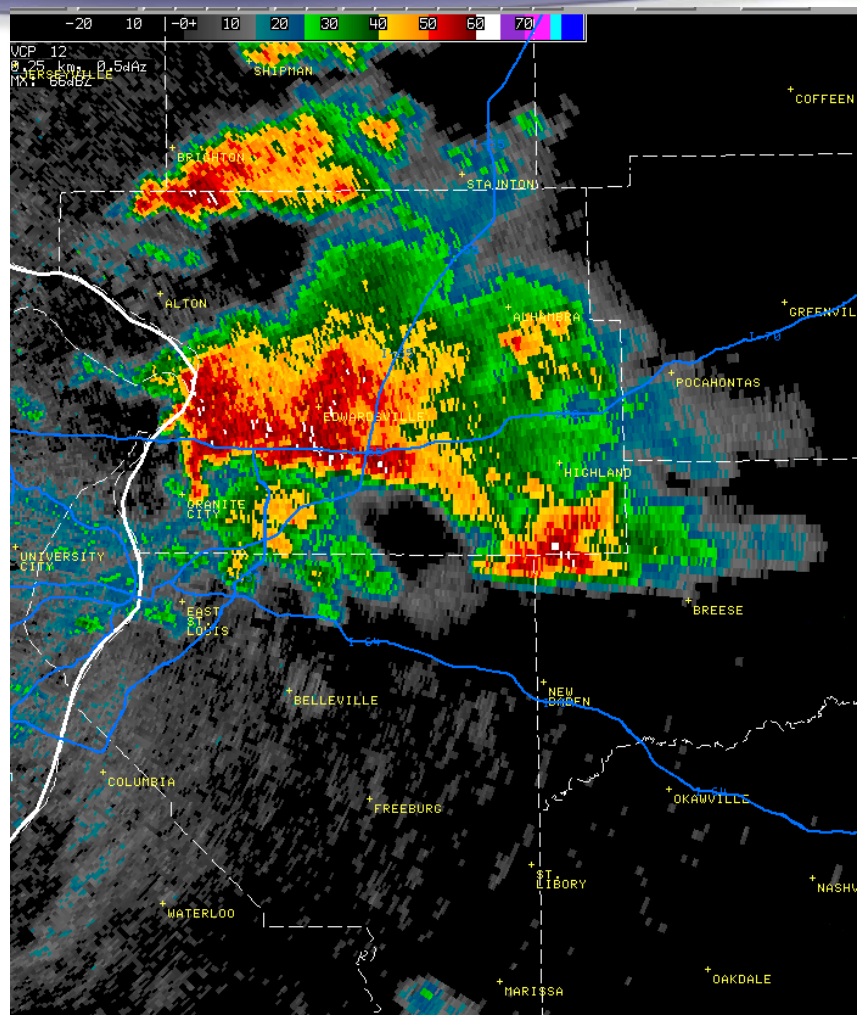
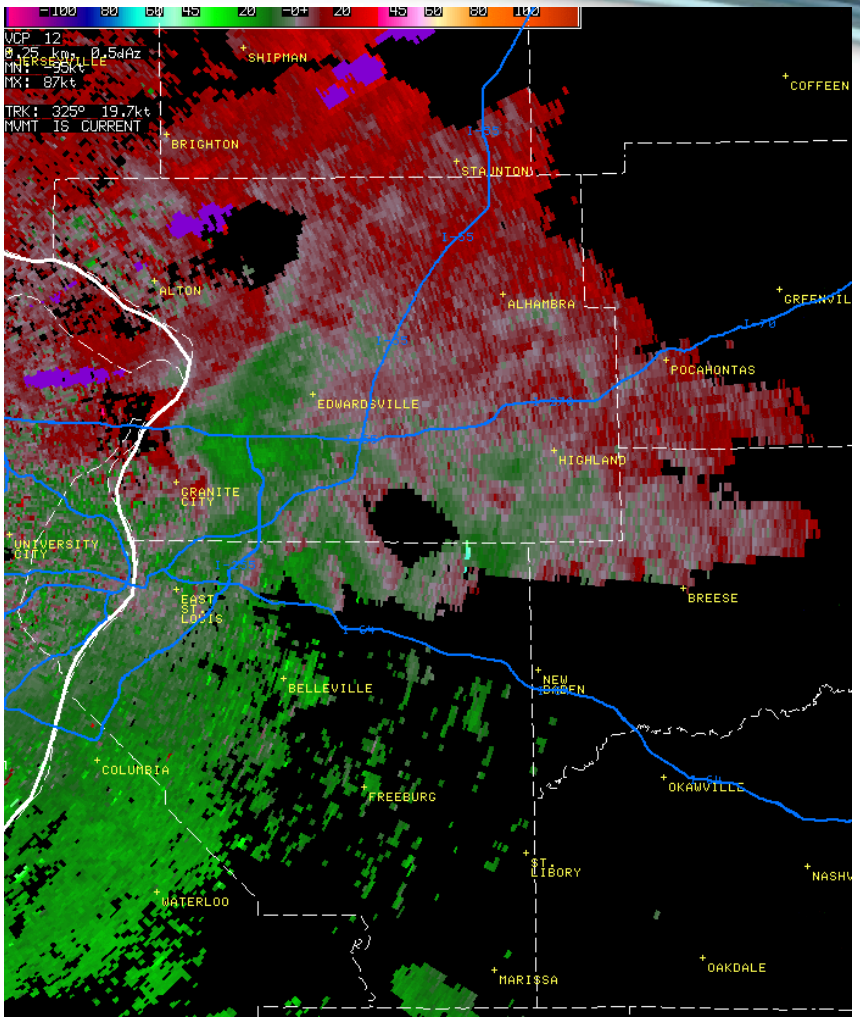
St. Louis, MO

Case Study: 1 4:45 pm



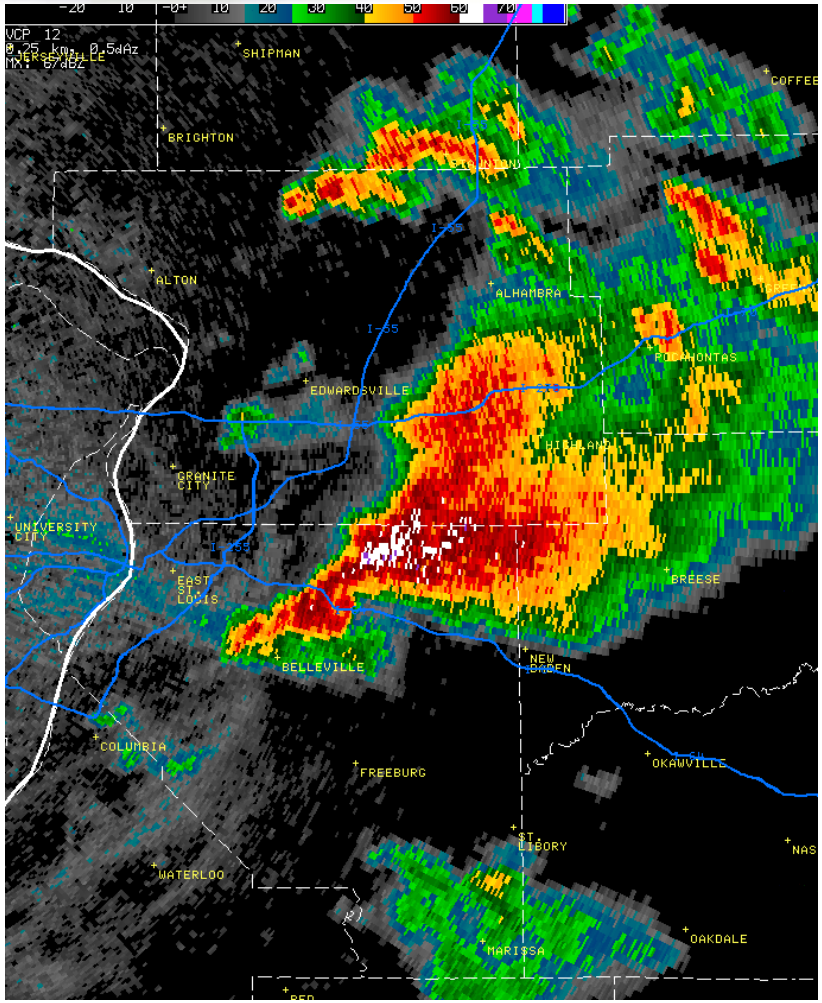
Reflectivity



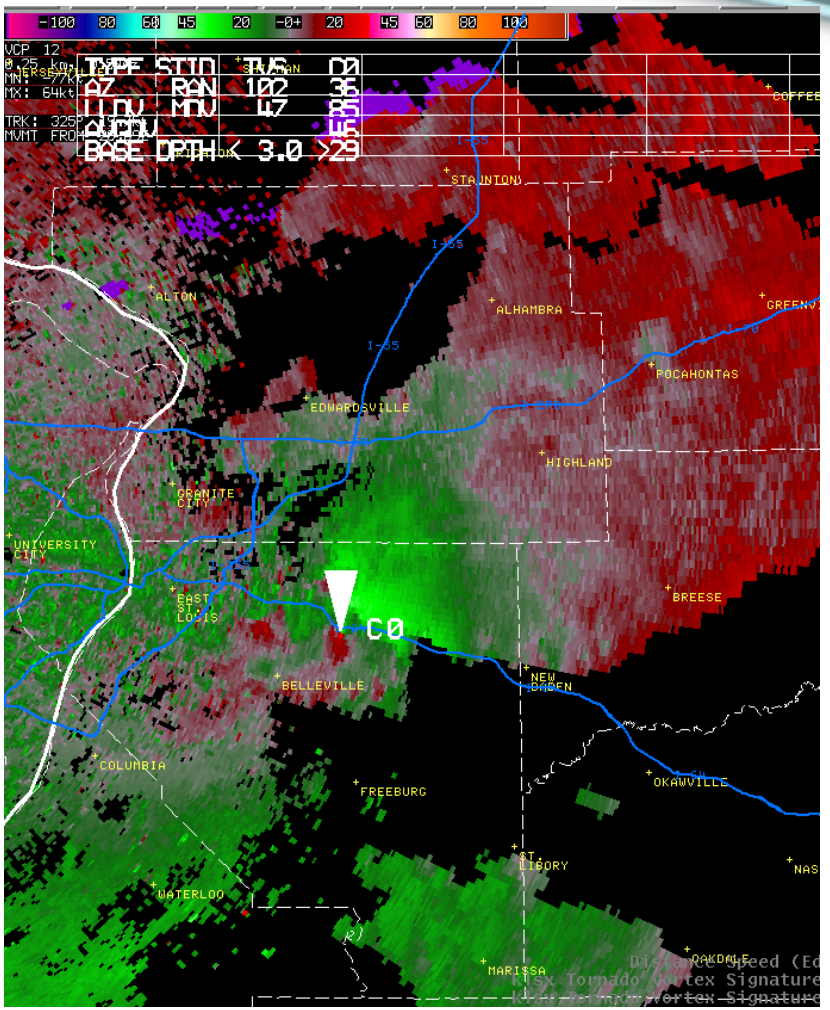
Storm Relative Velocity

National Weather Service
St. Louis, MO

Case 1 5:19 pm



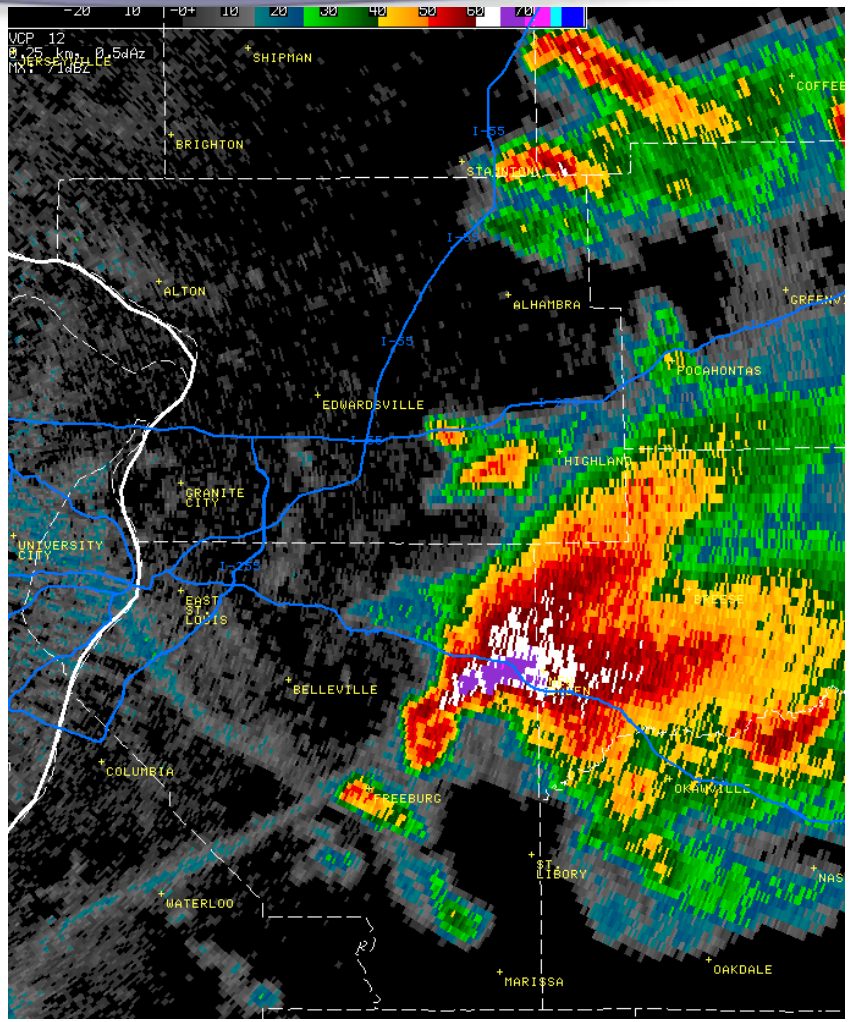
Reflectivity



Storm Relative Velocity

National Weather Service
St. Louis, MO

Case 1 5:45 pm



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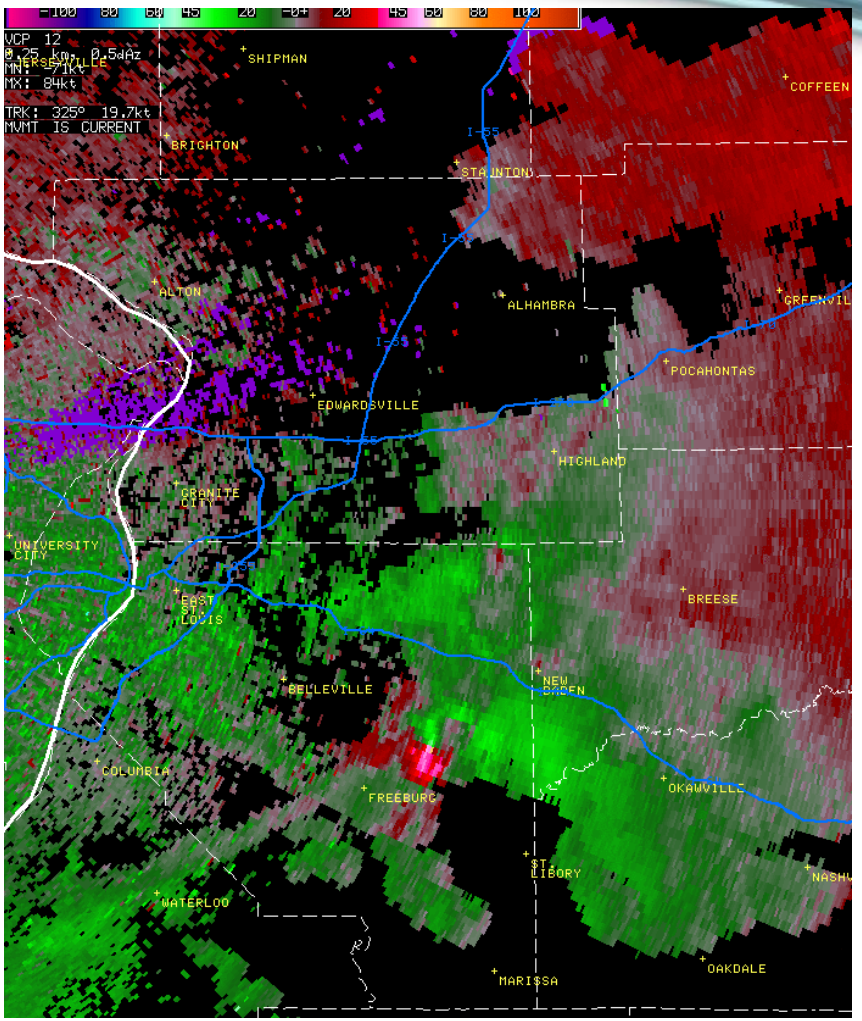
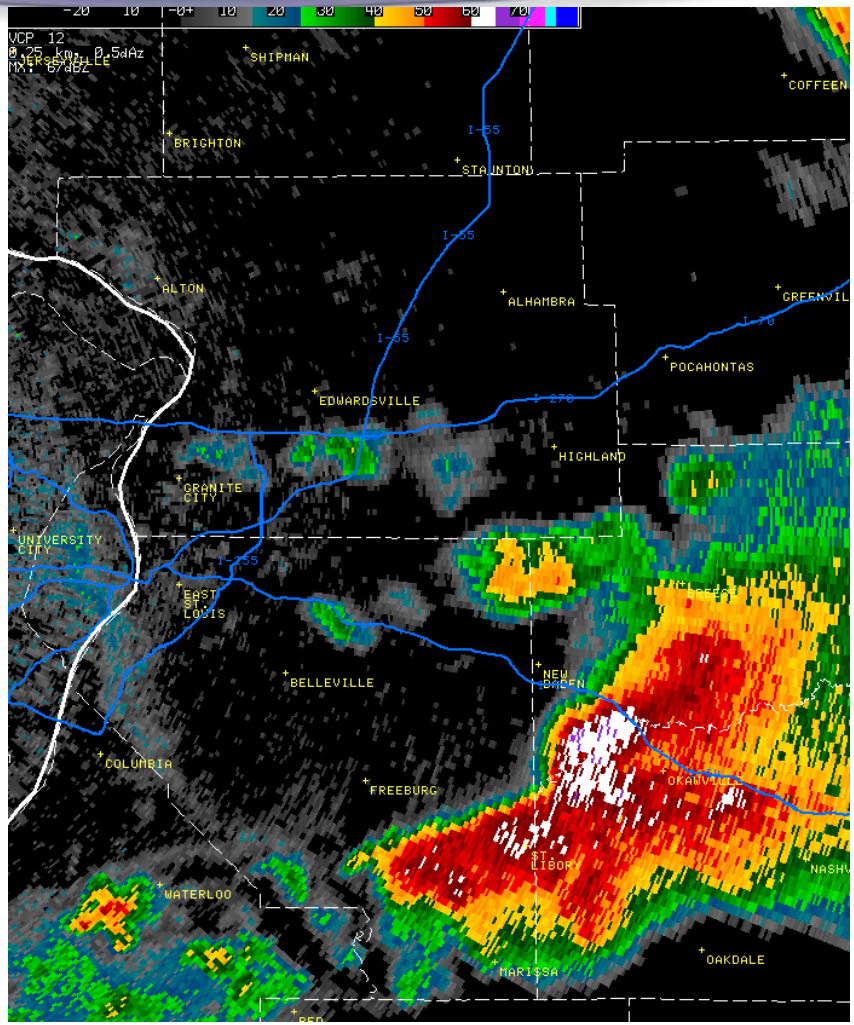


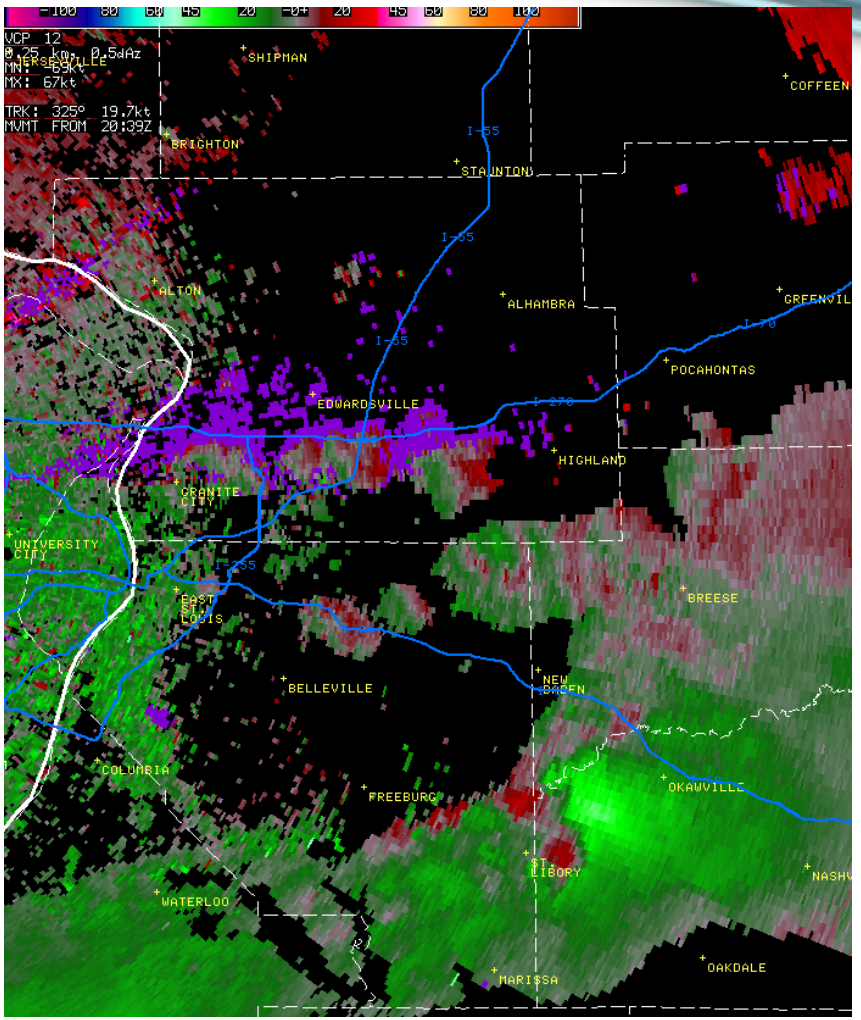
Storm Relative Velocity

National Weather Service
St. Louis, MO

Case 1 6:15 pm



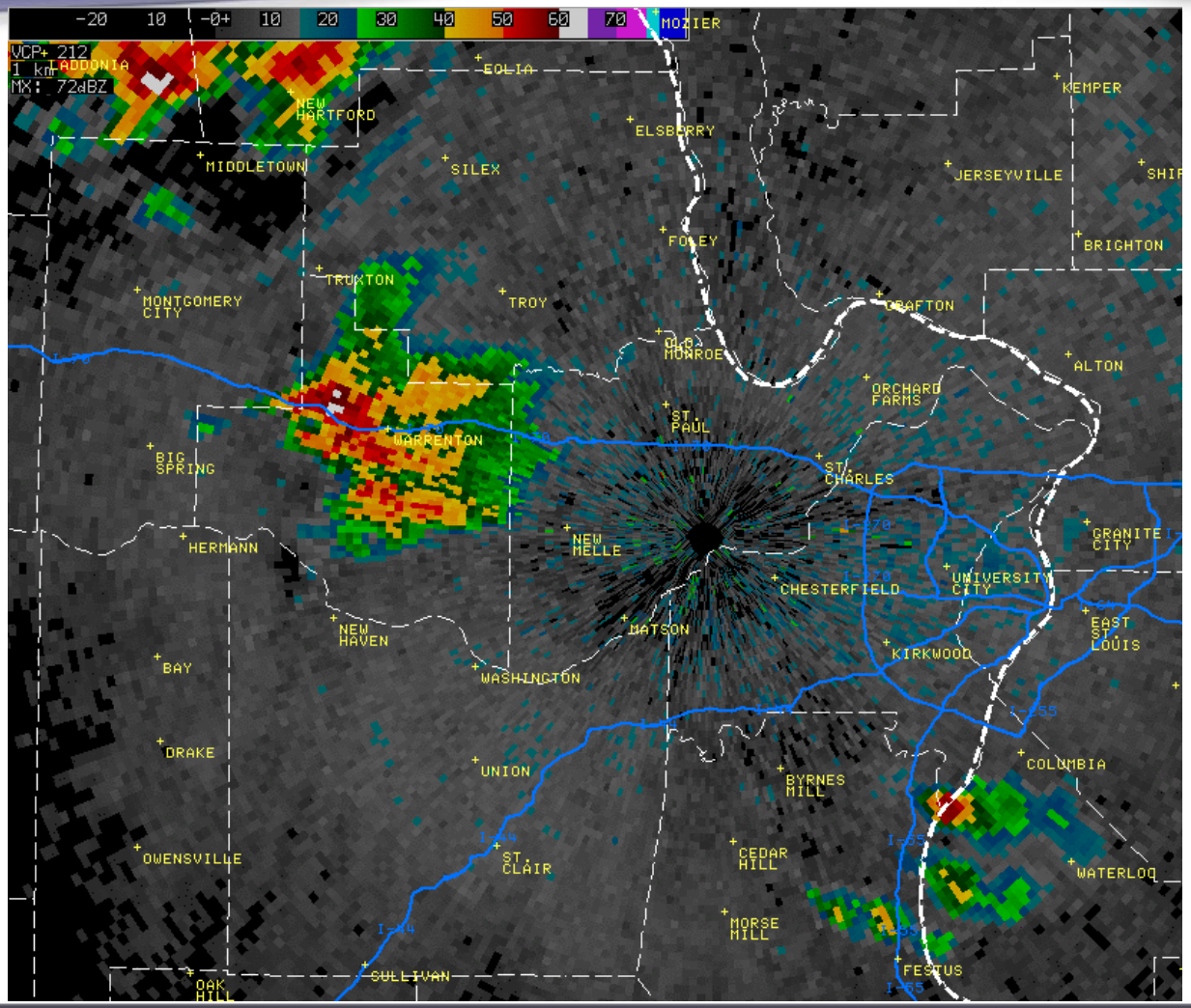
Reflectivity



Storm Relative Velocity

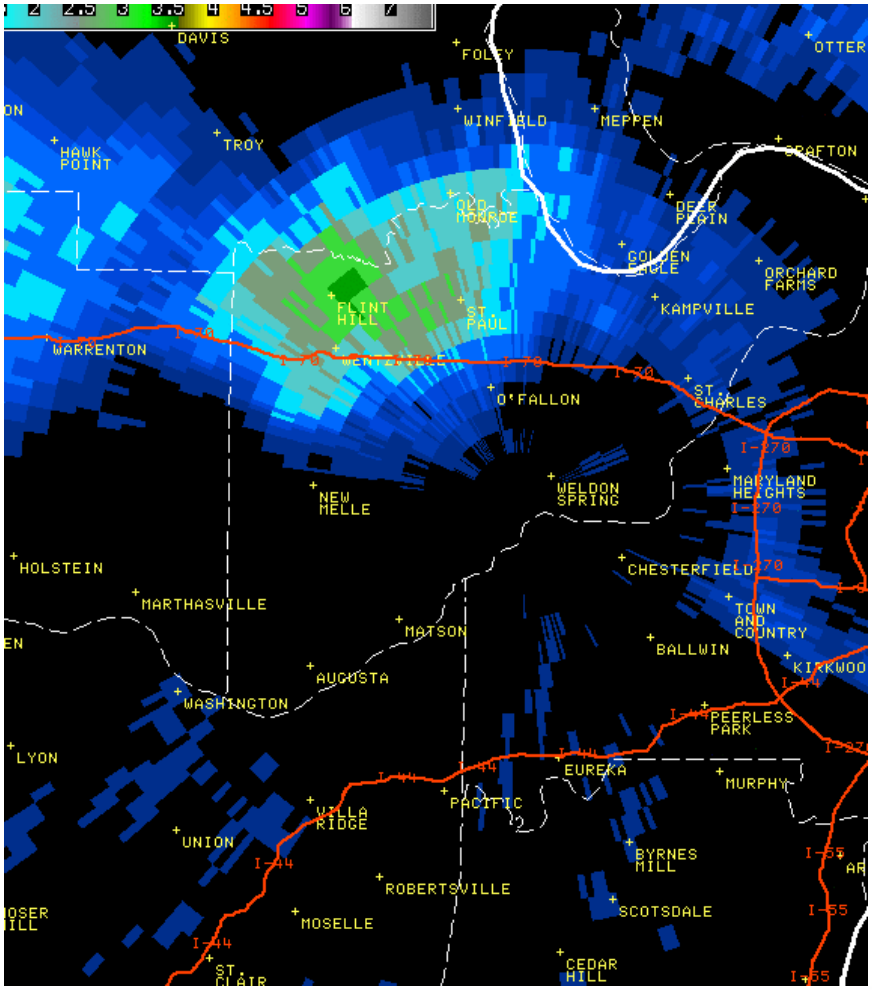
Case 1 Tornado

Case 2

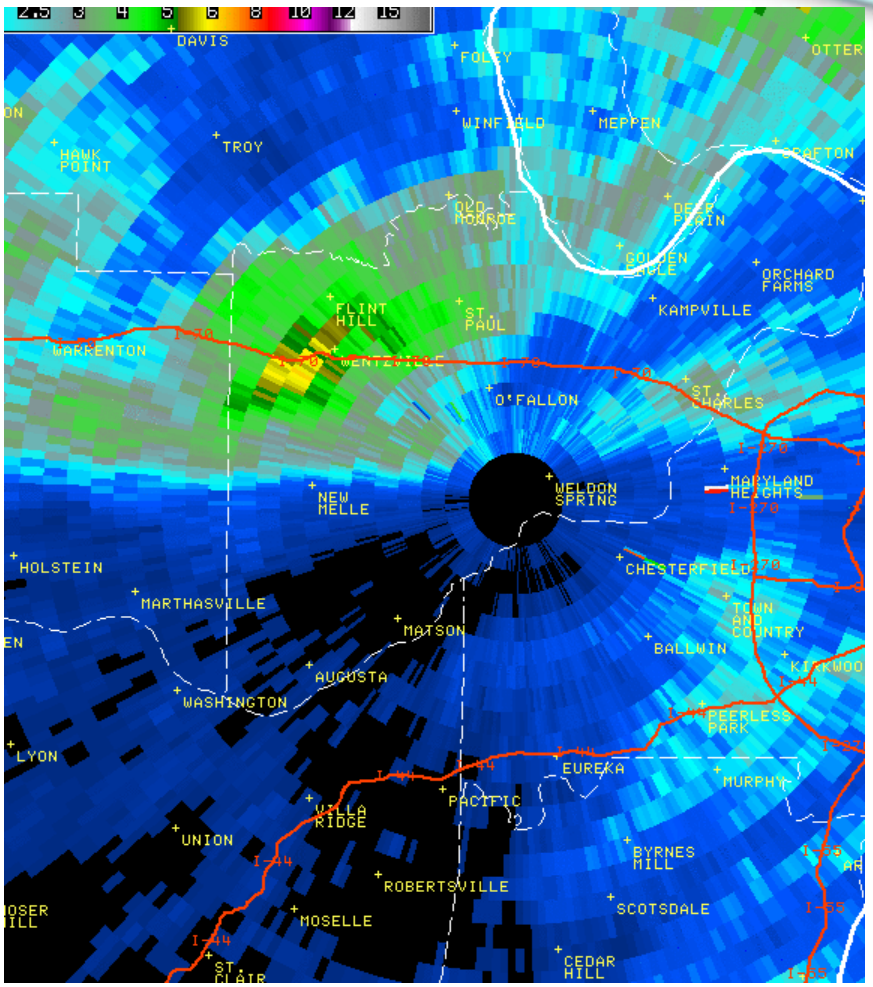

-20 10 -0+ 10 20 30 40 50 60 70
VCP: 212
1 km
MX: 72dBZ
MOZIER
EOLIA
LADDONIA
NEW HARTFORD
MIDDLETOWN
SILEX
ELSBERRY
KEMPER
JERSEYVILLE
FOLEY
BRIGHTON
TRUXTON
MONTGOMERY CITY
TROY
GRAFTON
OLD MONROE
ALTON
ORCHARD FARMS
ST. PAUL
WARRENTON
BIG SPRING
ST. CHARLES
HERMANN
NEW MELLE
GRANITE CITY
CHESTERFIELD
UNIVERSITY CITY
NEW HAVEN
WATSON
EAST ST. LOUIS
KIRKWOOD
BAY
WASHINGTON
DRAKE
UNION
COLUMBIA
BYRNES MILL
OWENSVILLE
ST. CLAIR
CEDAR HILL
WATERLOO
MORSE MILL
SULLIVAN
OAK HILL
FESTUS
I-70
I-64
I-55

National Weather Service
St. Louis, MO

Case 2 Rainfall Estimates

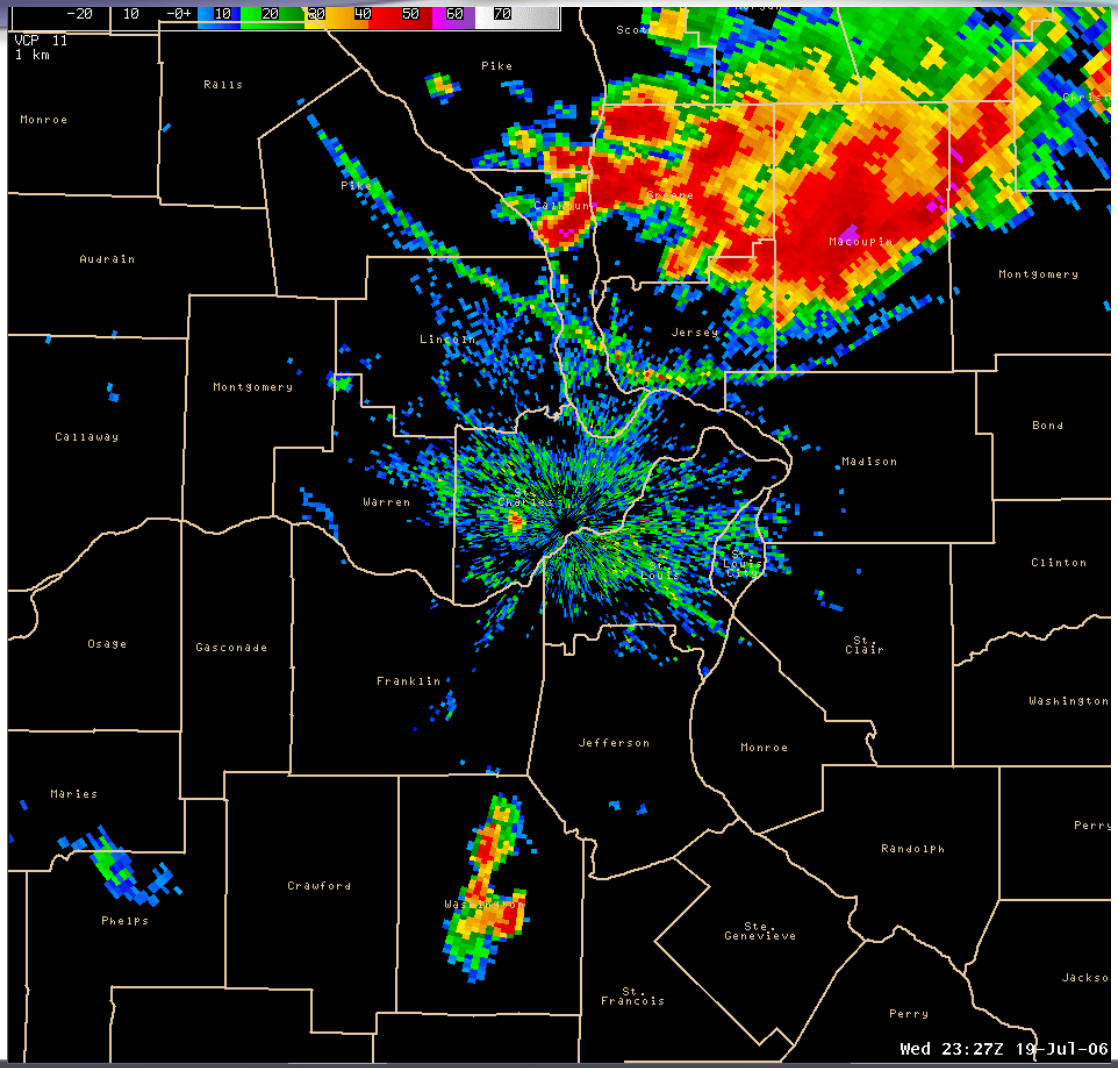


One Hour Rainfall



Storm Total Rainfall

Case 3


-20 10 -0+ 10 20 30 40 50 60 70
VCP 11
1 km
Rails
Pike
Monroe
Audrain
Montgomery
Callaway
Warren
Lincoln
Jersey
Macoupin
Montgomery
Bond
Madison
Clinton
St. Clair
Washington
Monroe
Randolph
Perry
Jackso
Ste. Genevieve
St. Francois
Perry
Osage
Gasconade
Franklin
Jefferson
Maries
Phelps
Crawford
Wed 23:27Z 19-Jul-06

Case 3 Wind Gusts