NOAA's National Weather Service
Milwaukee/Sullivan

Radar & Satellite Interpretation

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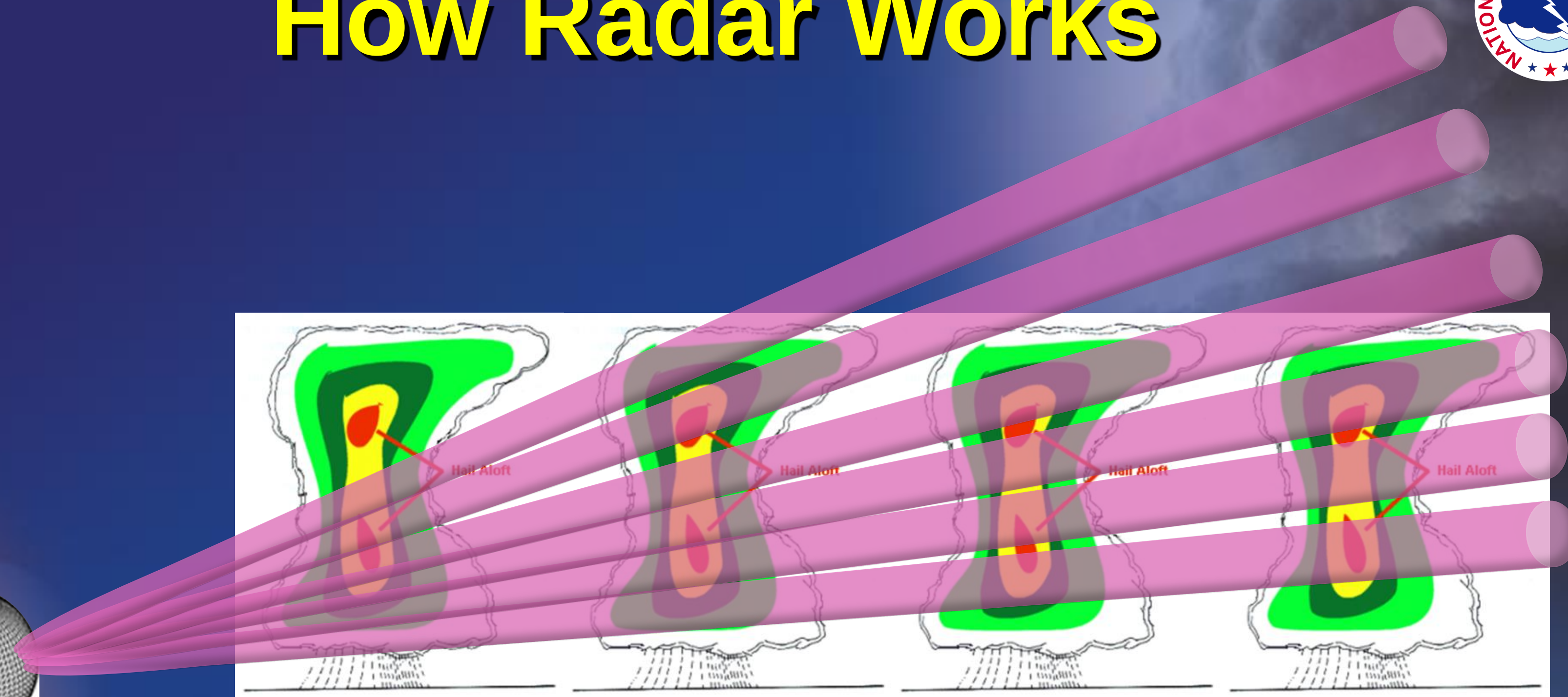
weather.gov/milwaukee

How Radar Works

How Radar Works

The radar transmits pulses of microwave radiation. Part of the energy of each pulse bounces off raindrops, insects, snowflakes, etc. back to the radar.

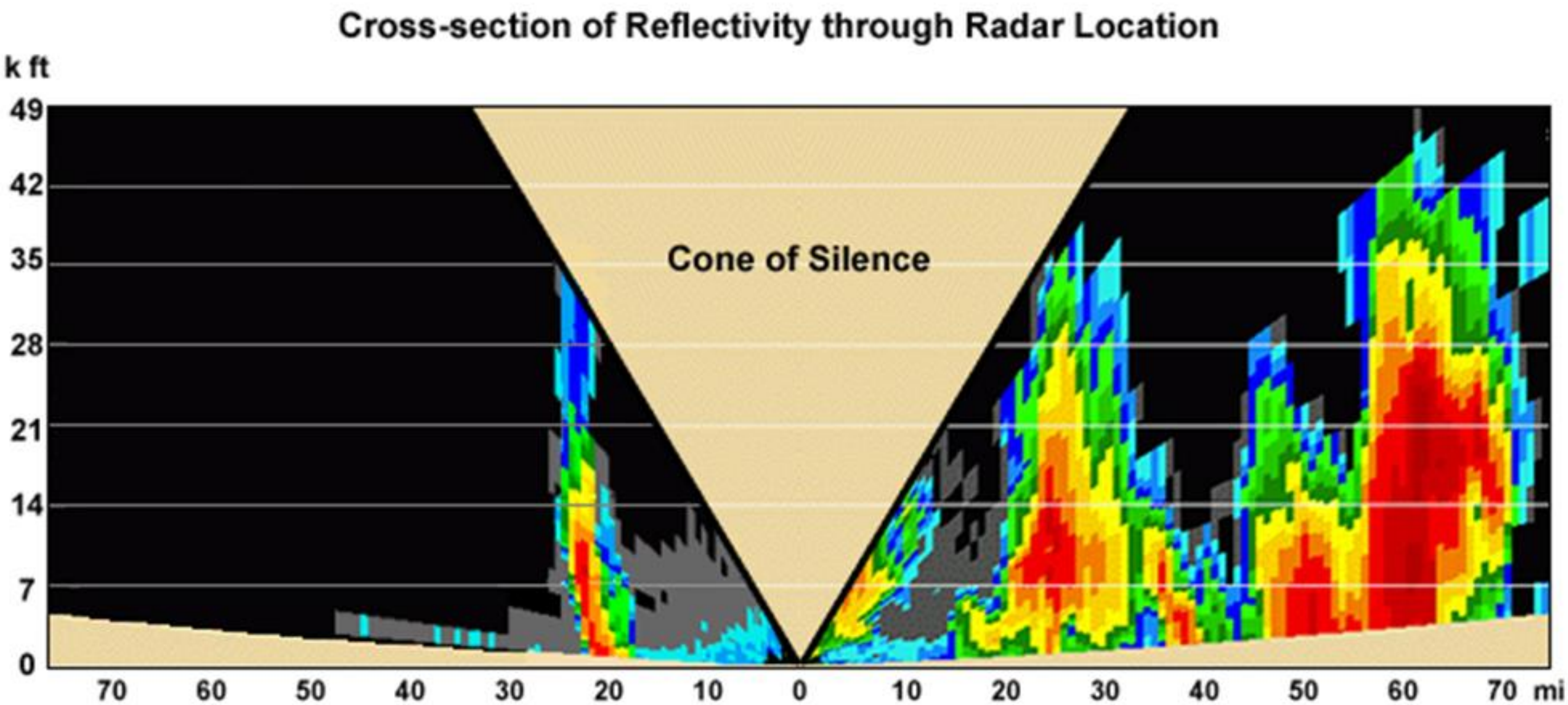
How Radar Works



Base level (0.5°) radar scan "sees" the lower parts of storms when they're close to the radar and higher parts of storms when they're further away from the radar (due to Earth's curvature)

The radar then tilts upward and does another rotation for a higher elevation scan. This process repeats several times, depending on which scanning mode it's in.

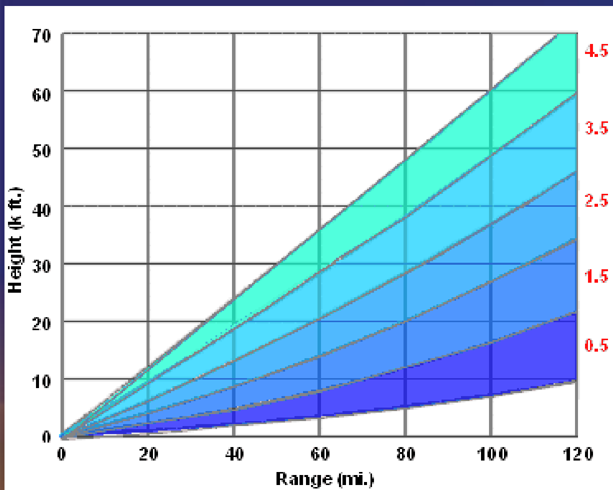
“Cone of Silence”

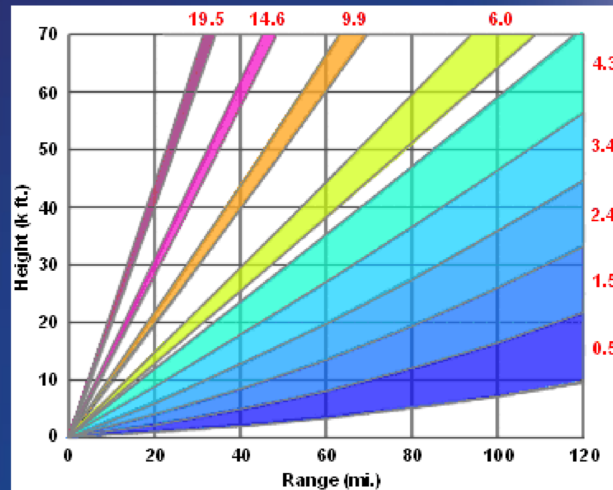


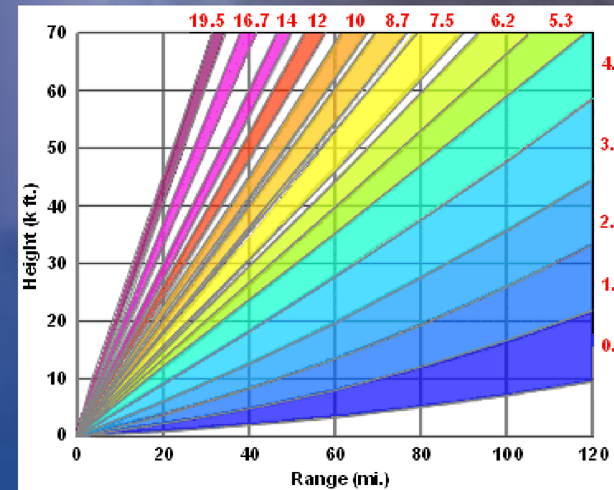
The radar cannot detect signals directly above it due to the limited range of radar beam tilts. This area is termed the “Cone of Silence.”

Radar Sampling Patterns

Radar automatically detects clear air vs. precip mode. NWS employee manually switches it to storm mode when necessary.







Clear Air Mode

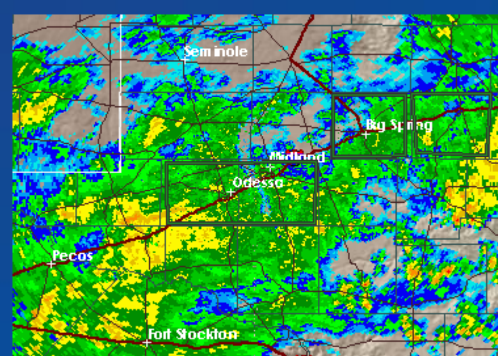
~ 2 min per elevation

Precip Mode

~ 1 min per elevation

Storm Mode

~ 30 sec per elevation



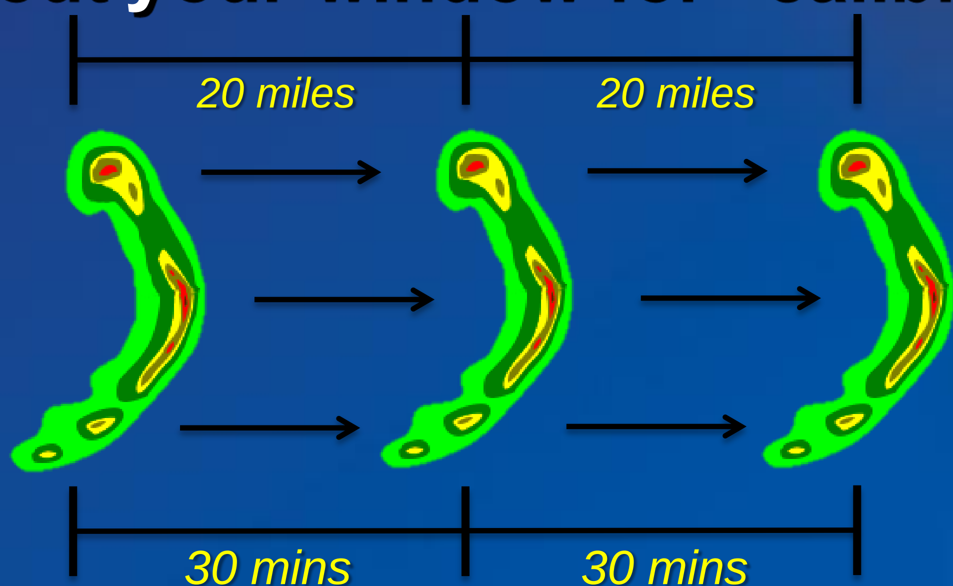
10 minutes

5 - 6 minutes

4 - 5 min (full volume scan)→
2 – 3 min (base scans)

Radar

- How to figure timing or onset of precip using radar
- Use time of radar and your fingers
- Look out your window for “calibration”



If you’re in the “green” area on radar reflectivity and you see yellow or red heading toward you, you can expect the rain to become heavier.

weather.gov

NWS radar Image from Milwaukee, WI

Milwaukee, WI Radar

Go to: Enhanced Version | Local weather forecast by "City, St" City, St Go | Radar Status Message

Adjacent Radars:

MKX

Short Range Images

Reflectivity:

Composite Loop

Base Loop

Velocity:

Storm Relative Loop

Base Loop

Rainfall:

1-Hour Total Loop

Storm Total Loop

Long Range Images

Reflectivity:

Base Loop

U.S. Views

Reflectivity:

National Loop

Alaska Loop

Hawaii Loop

Guam Loop

Puerto Rico Loop

Radars by State

Additional Info:

Radar FAQ

Downloading Images

Mobile Users

GIS Users KML

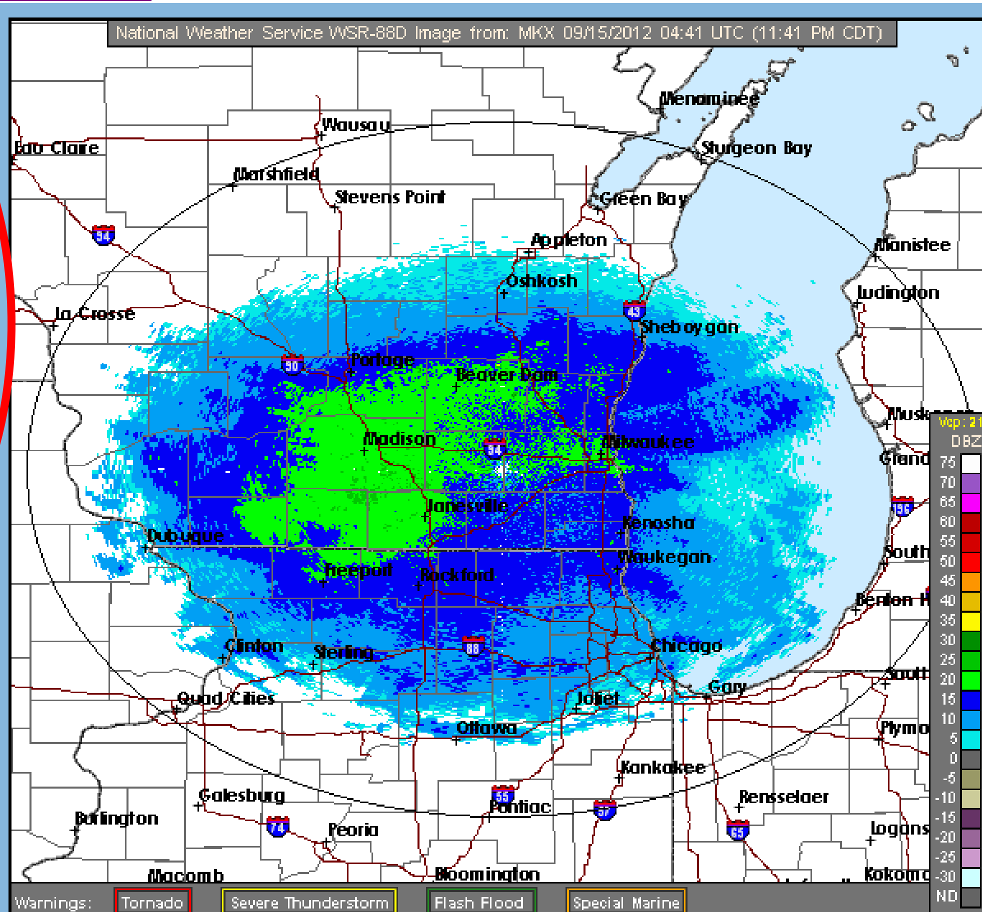
Doppler University

Color Blindness Tool

Credits

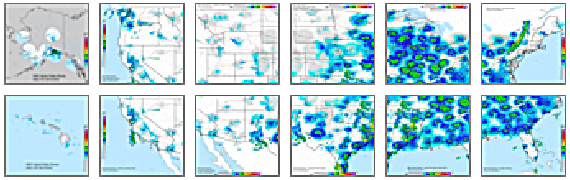
Base Reflectivity

NWS Milwaukee, WI

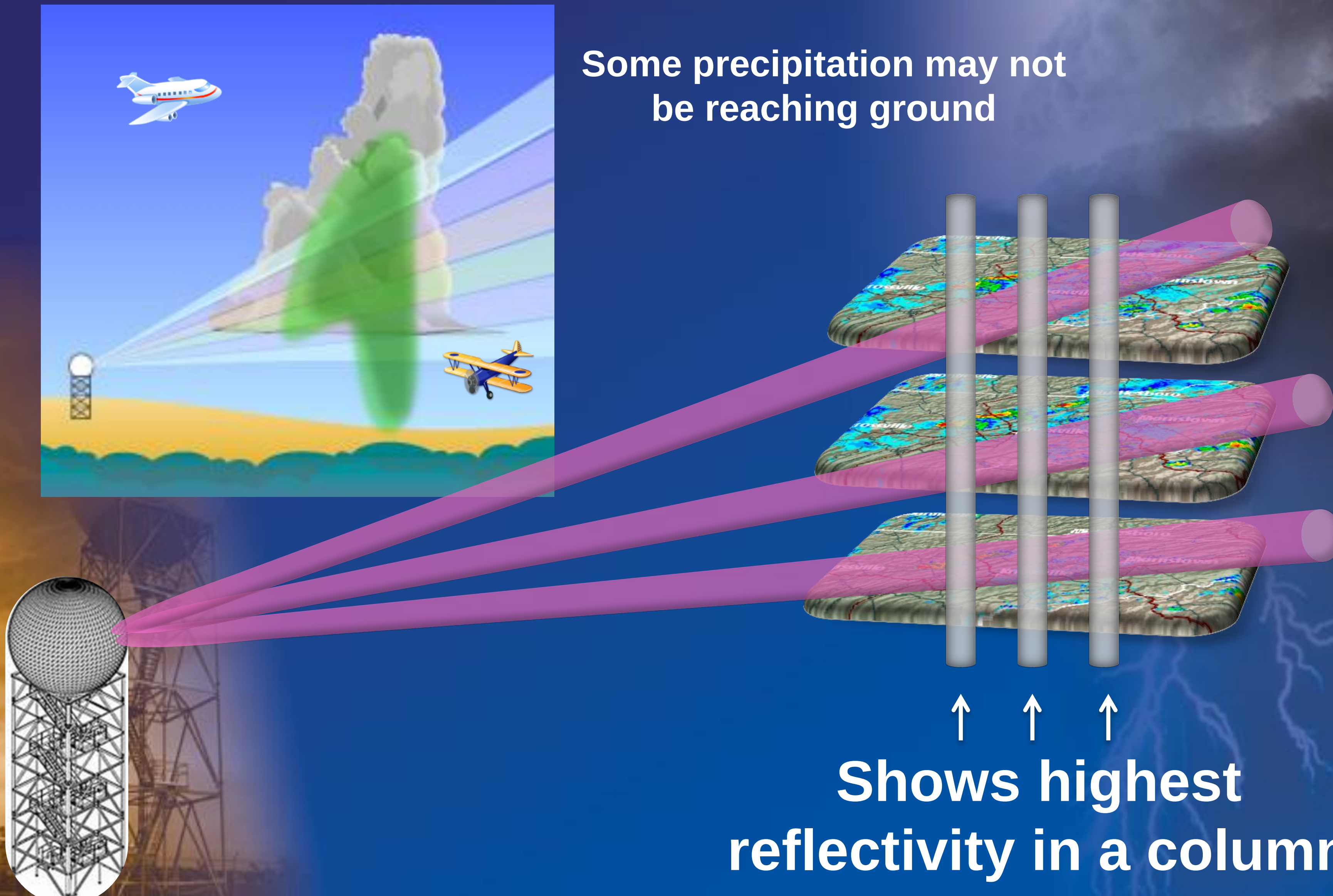


National Radar Mosaic Sectors

(click image)



Composite Reflectivity

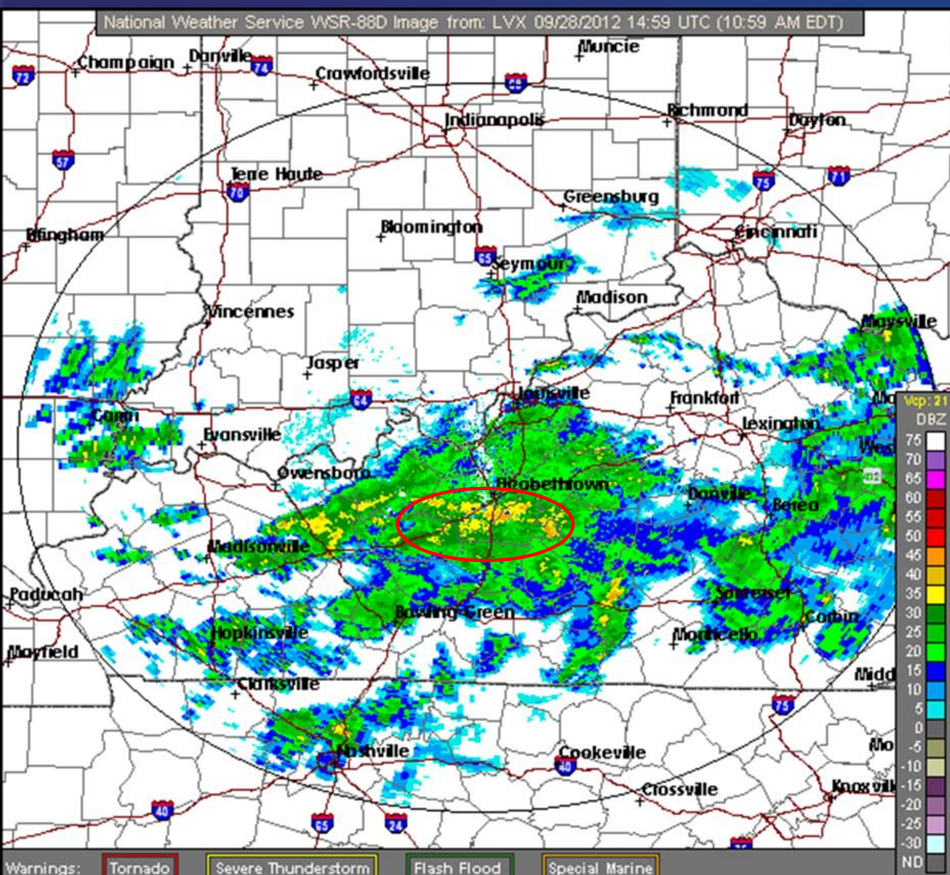


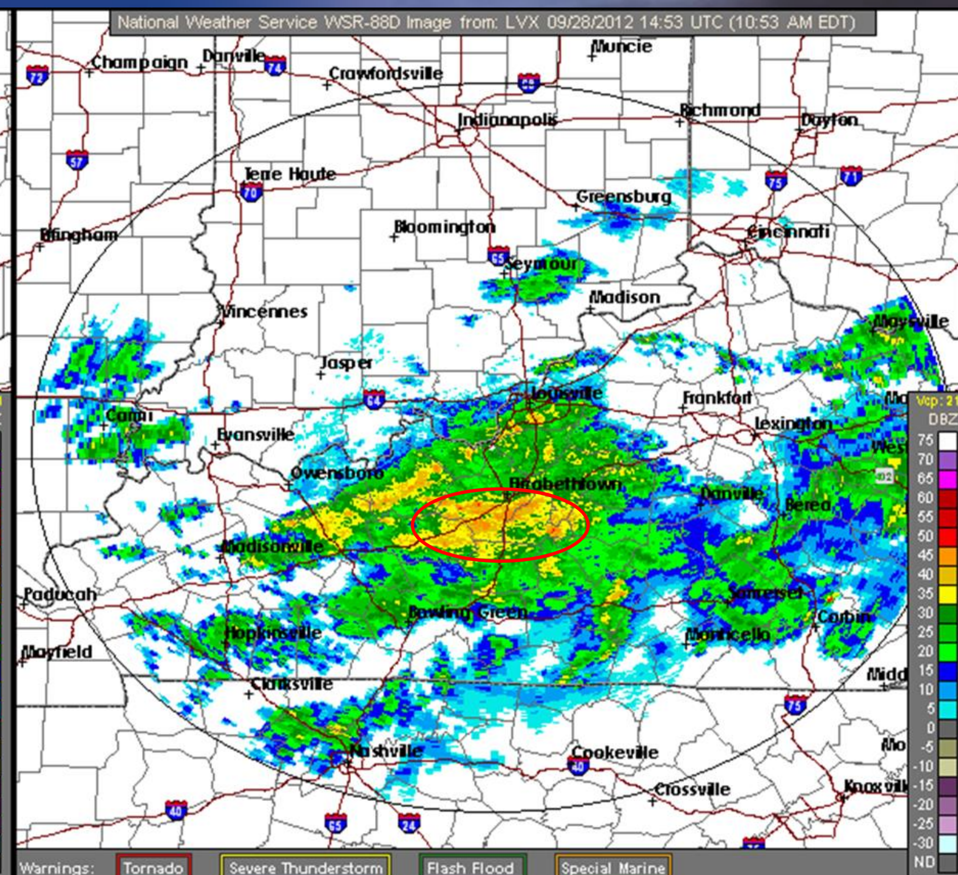
Some precipitation may not be reaching ground

↑ ↑ ↑

Shows highest reflectivity in a column

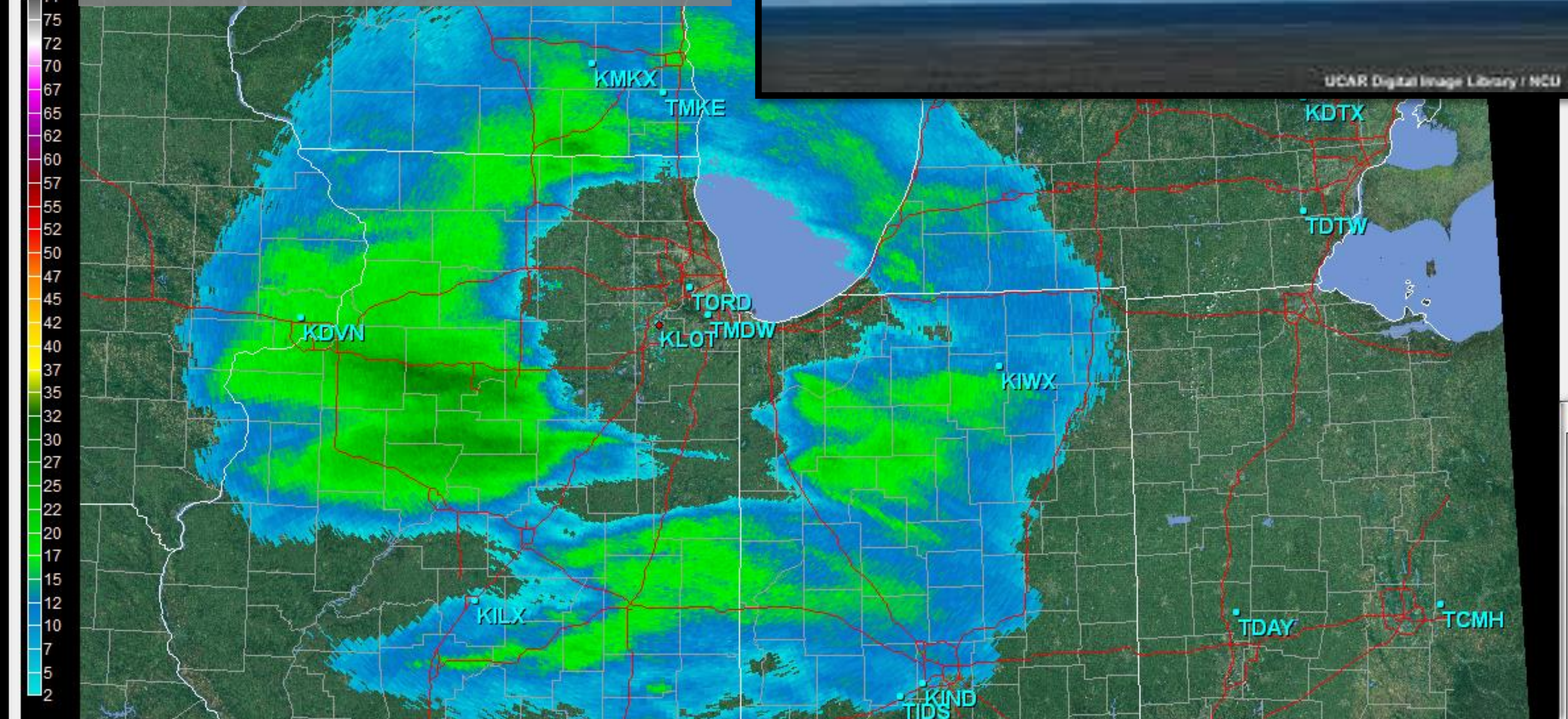
Base vs. Composite Reflectivity



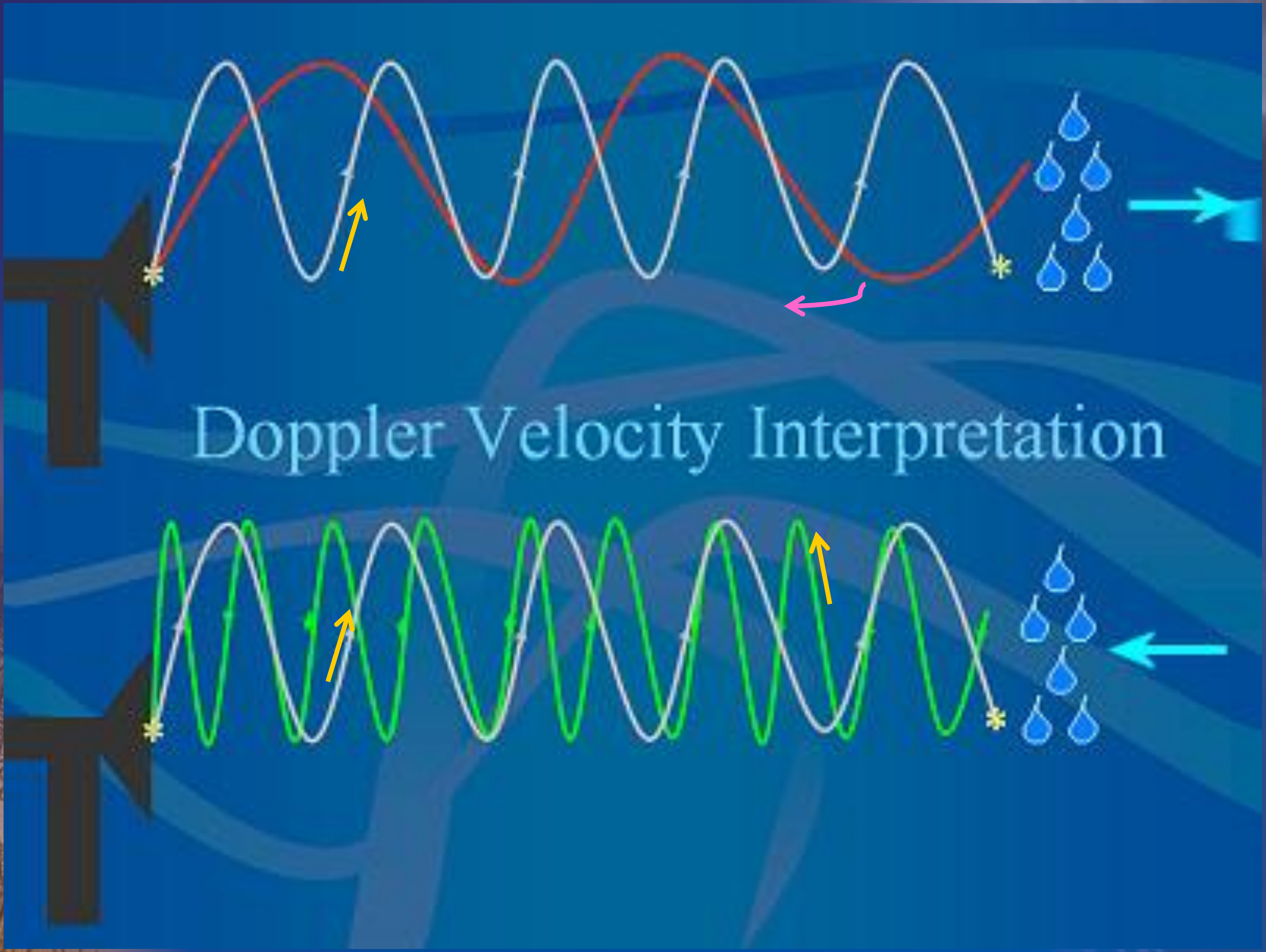


Virga

A “donut” around a single radar indicates precip falling but not hitting ground. There may be strong downdrafts beneath cloud bases.

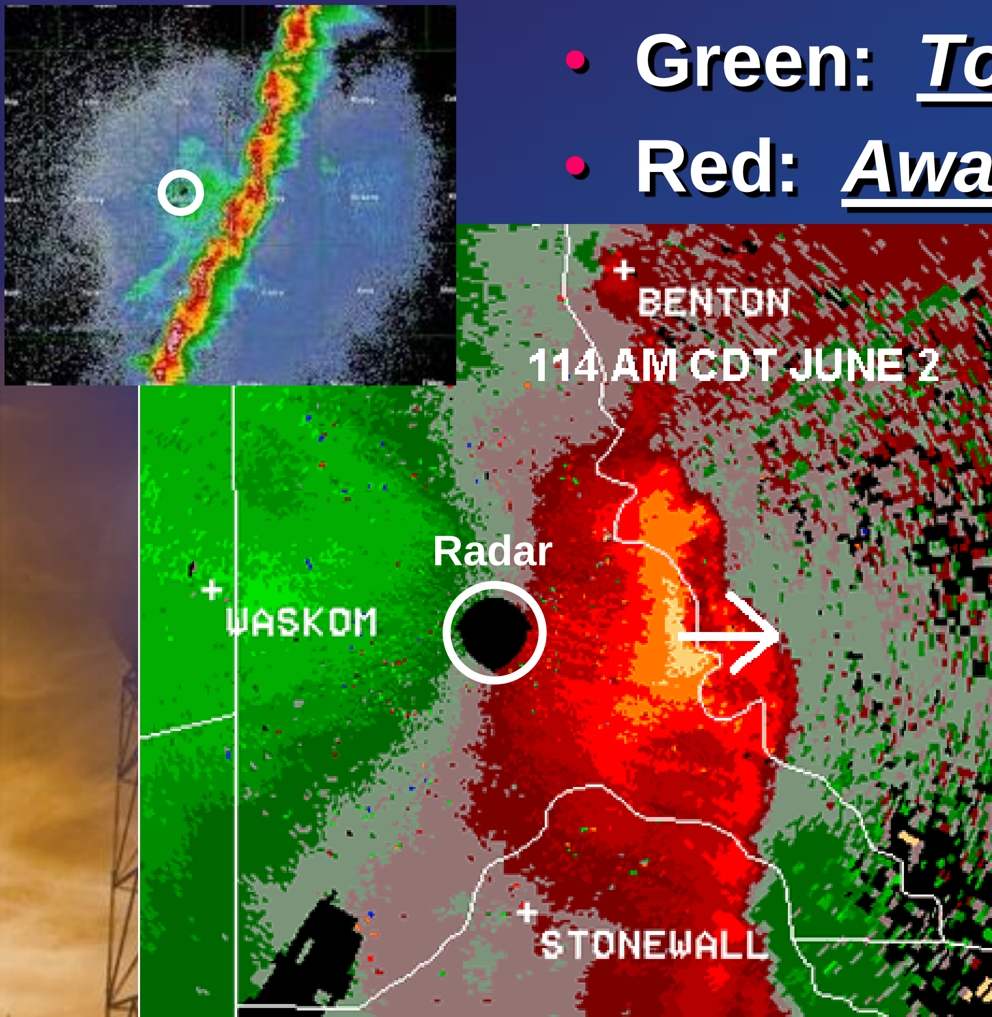


Radar Velocity

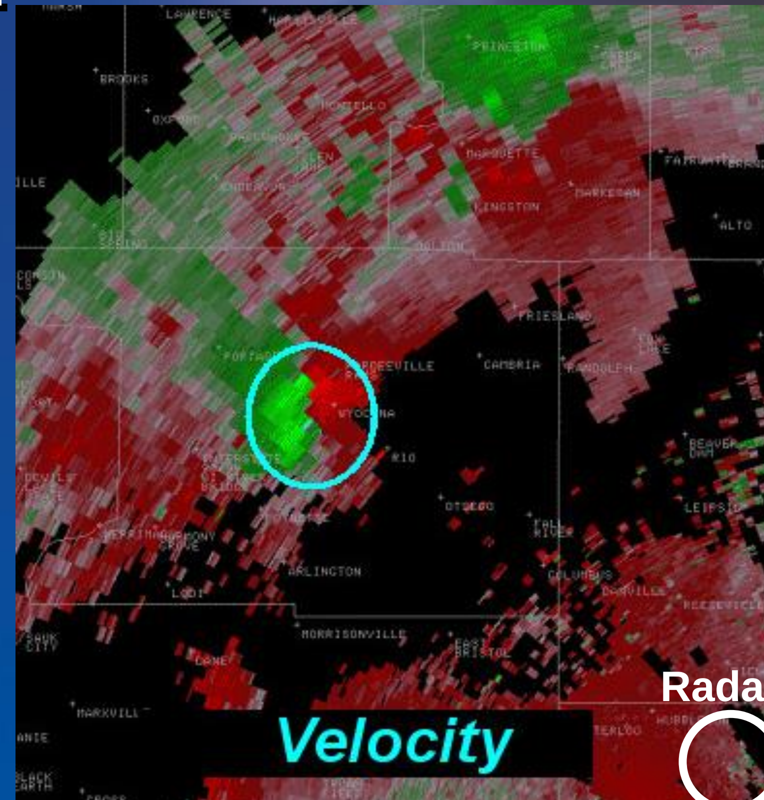


Radar Velocity Interpretation

- Green: ***Toward*** the radar
- Red: ***Away*** from the radar

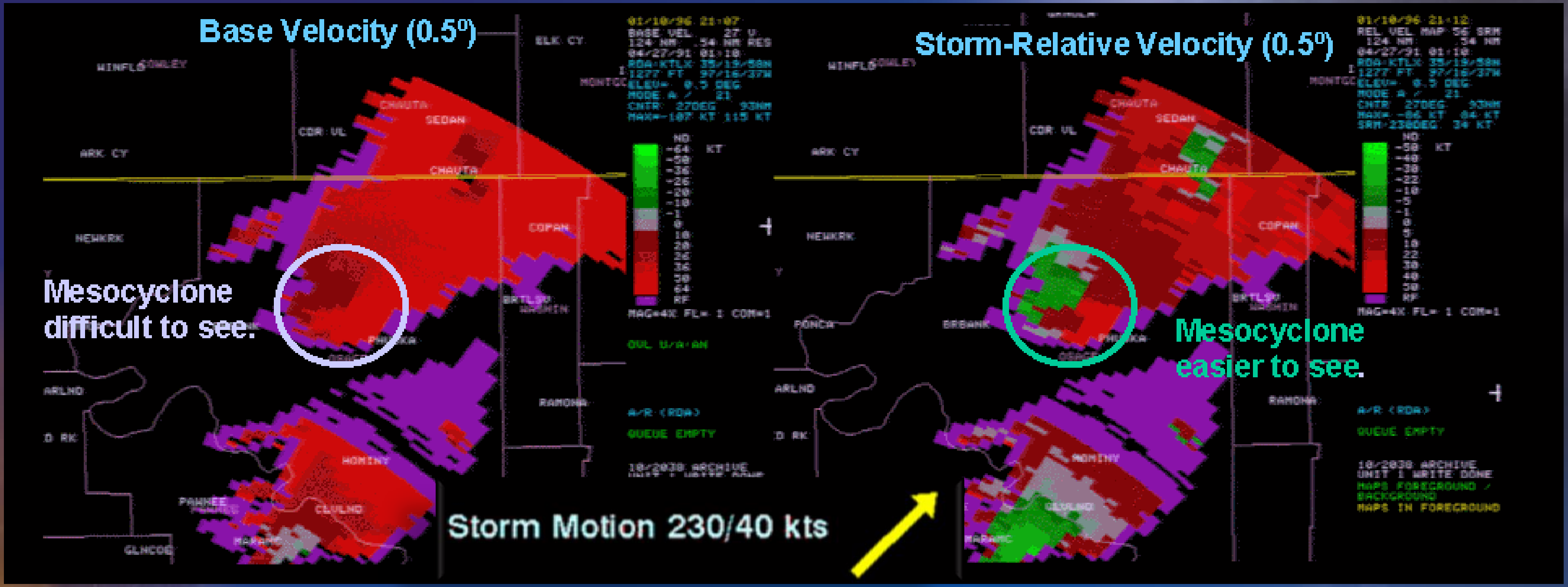


Highest winds are near leading edge of a squall line



Red and green together show rotation (above) or divergence (e.g. microburst), depending on the couplet's orientation in reference to the radar location.

Base vs. Storm Relative Velocity

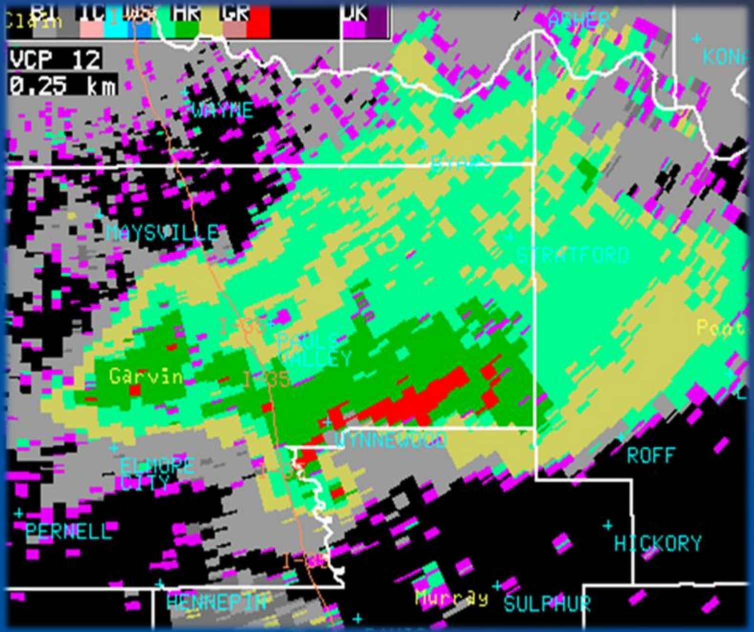


- The motion of the storm is removed from the mean velocity
- Storm-relative velocity shows velocity in the storm as if it were stationary
- You may not be able to configure this feature correctly, depends on radar vendor

Source: http://okfirst.mesonet.org/train/materials/radar/srm1.gif

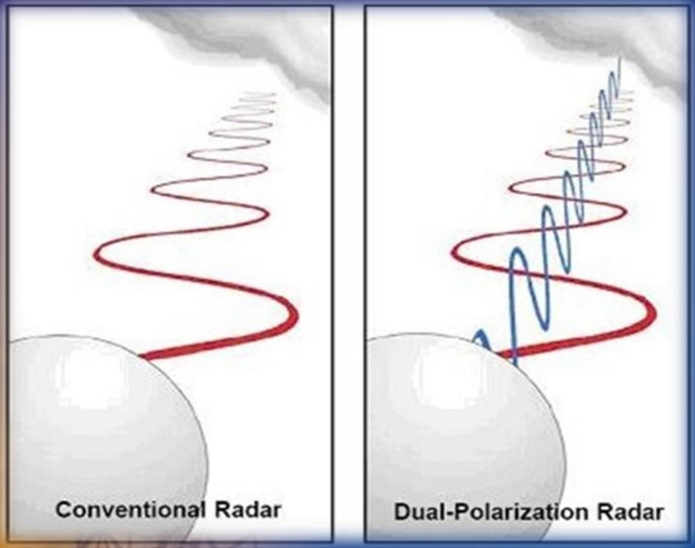
Dual-Polarization Radar
"Dual-Pol"

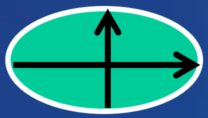
- **Improvements to Conventional Doppler Radar Products**
  - ***Precipitation classification***
  - ***Feature identification***
  - ***Better estimate of rainfall amounts***



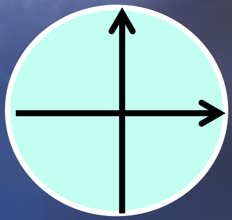
Dual-Pol Radar

- **Transmits pulses in <u>two</u> orientations**



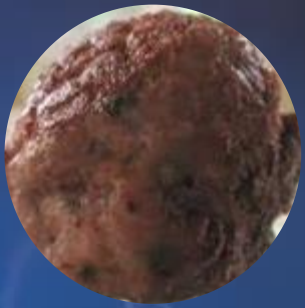


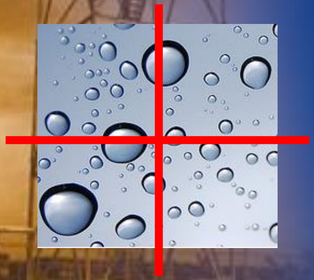
Versus

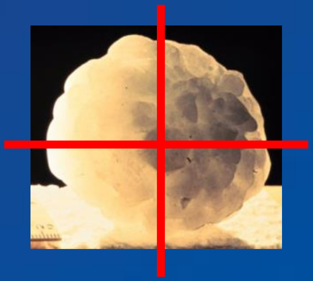


Drag causes large raindrops to “flatten”

Hail has a tumbling motion and appears spherical







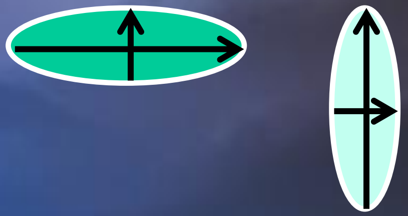
Dual-Pol Radar Products

- Reflectivity
- Velocity
- Spectrum Width
- Differential Reflectivity
- Correlation Coefficient
- Specific Differential Phase
- Hydrometeor Classification Algorithm

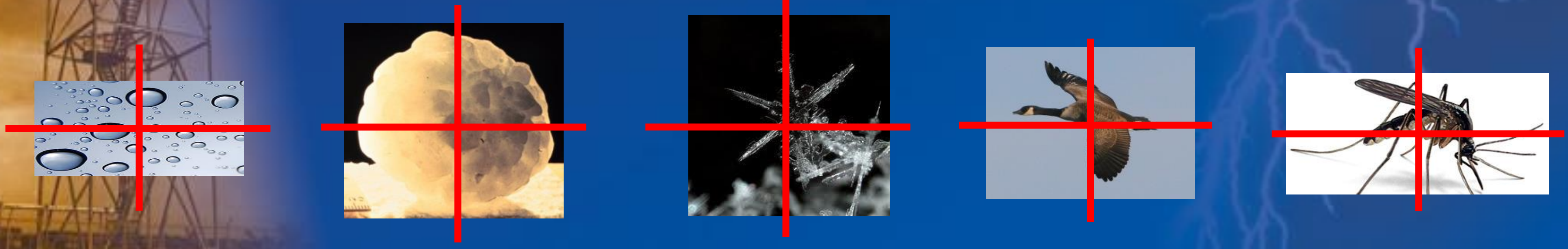
Differential Reflectivity

- Tells us the shape of the target

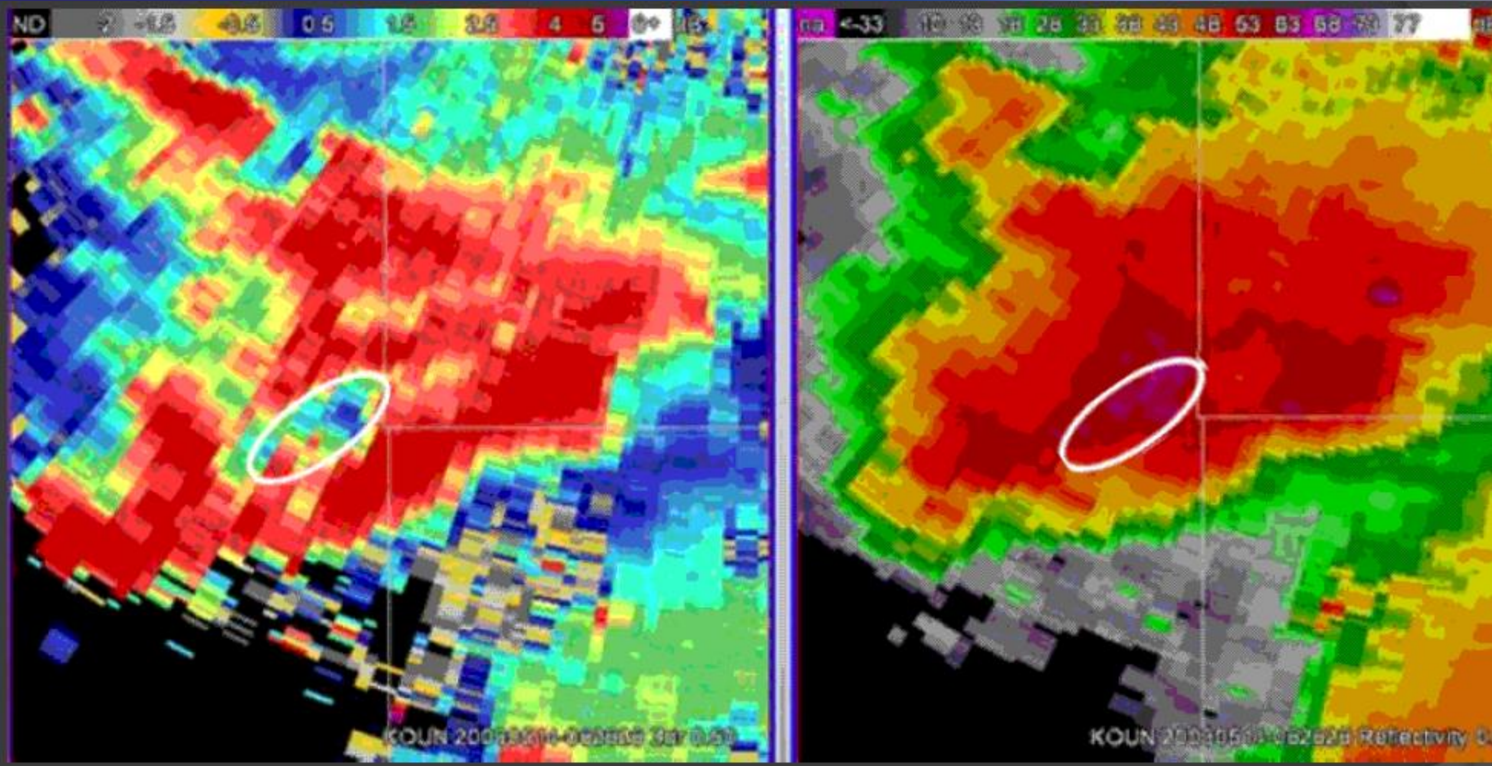
$$\frac{\textit{Horizontal power returned}}{\textit{Vertical power returned}}$$



-7 dB	0 dB	+7 dB
Vertically oriented Ice crystals	Drizzle, Small Hail Birds	Rain, Melting Hail, Insects, Birds



Differential Reflectivity



Differential Reflectivity (ZDR) Reflectivity (Z)

The new differential reflectivity product will allow to more closely pinpoint location of largest hail in supercells (areas of ZDR near zero)

Correlation Coefficient

- **Shows us similarities or differences between the scatterers**

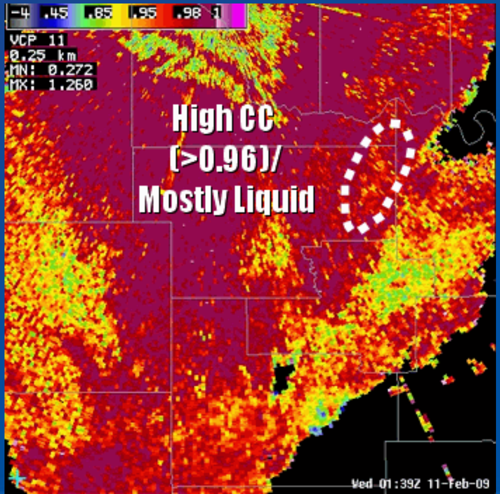
CC

Low | **High**

0.2 ⟵⟶ **1.05**

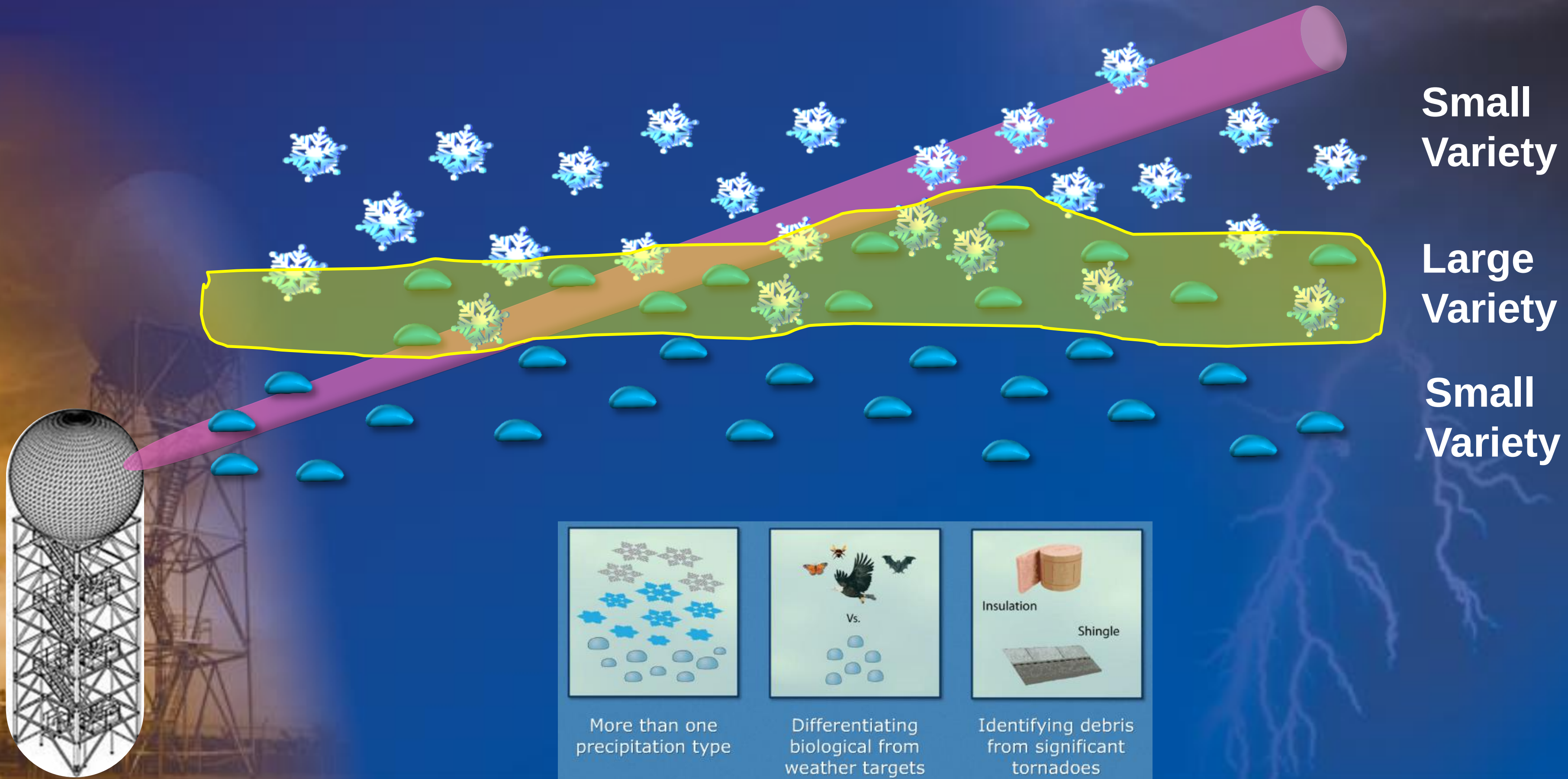
Mixed precip types,
Range of drop sizes,
Non-meteorological echoes

Same precip type,
Similar particle sizes



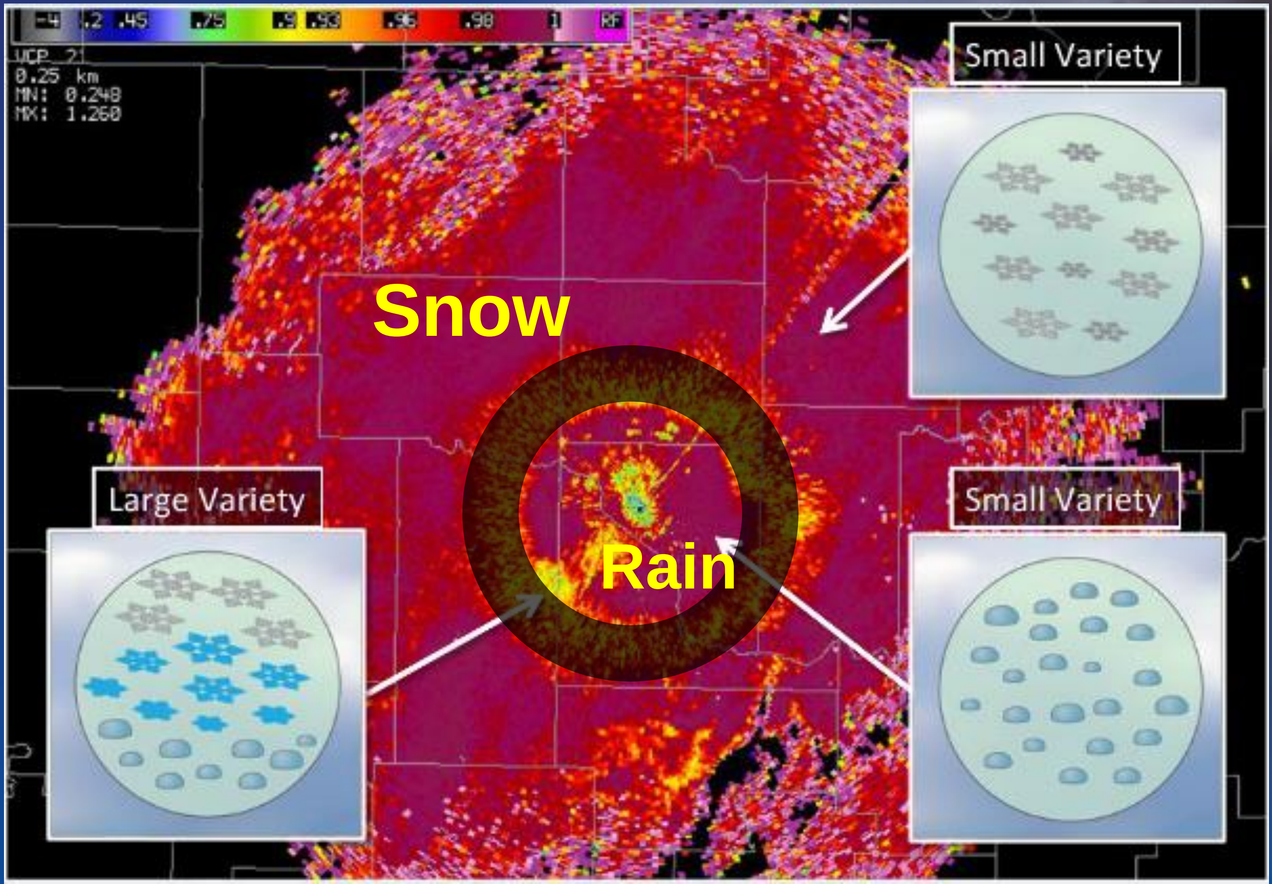
Correlation Coefficient

- Helps identify the melting layer
- Icing usually occurs just above the melting layer



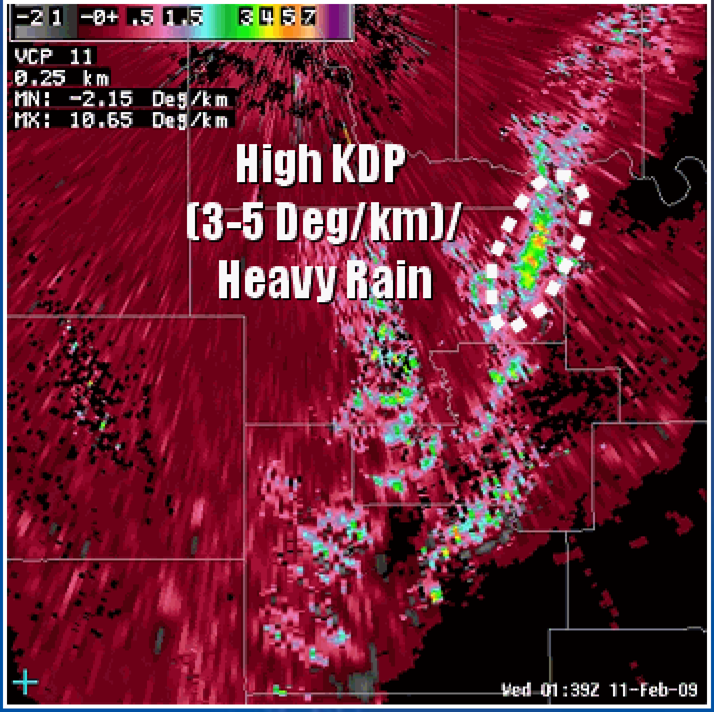
Correlation Coefficient

- Where's the melting layer?
- If no melting layer: expect all snow or freezing drizzle



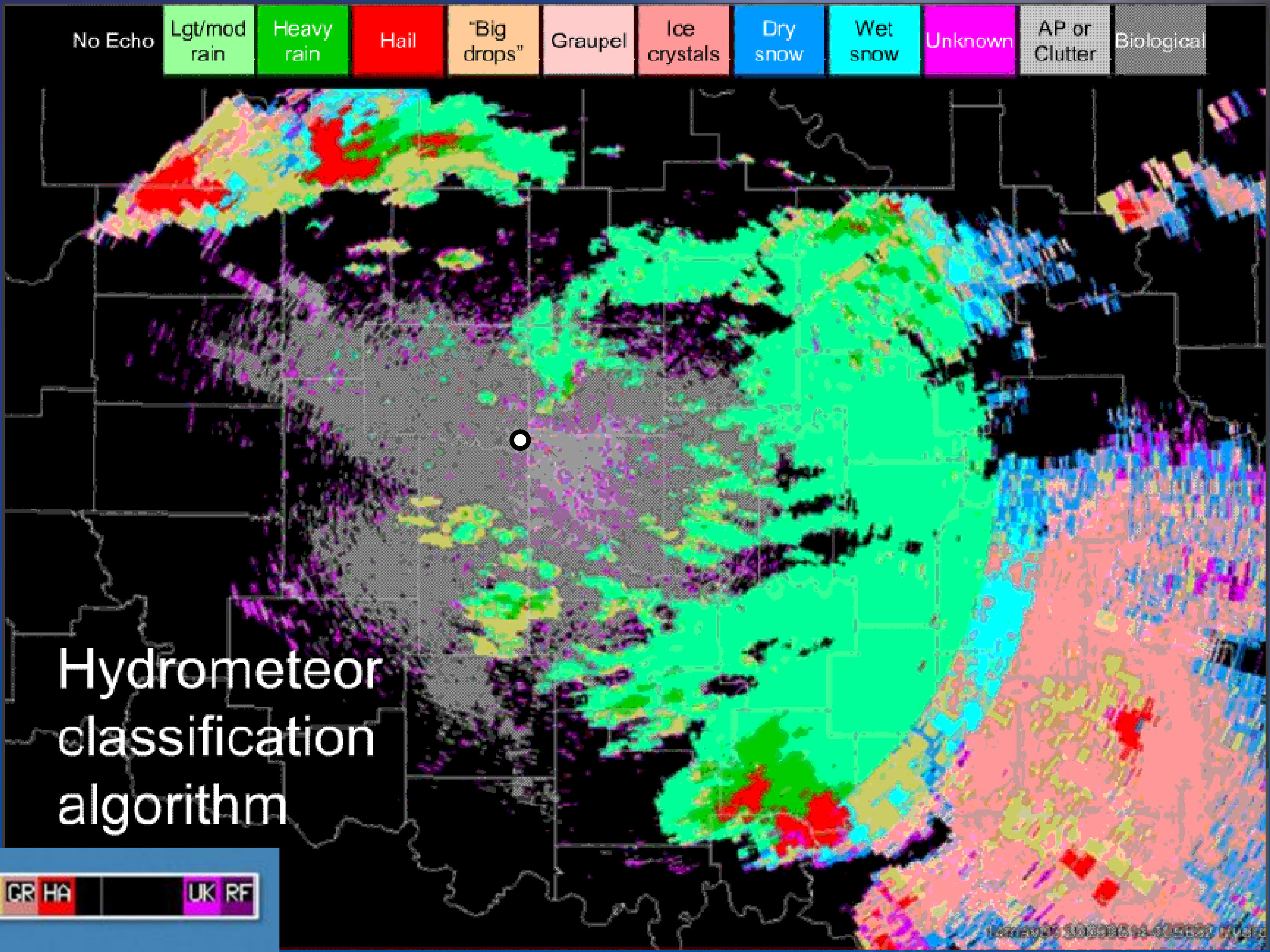
Specific Differential Phase

- Tells us how much liquid water is present in an area of precipitation
- Heavy Rain Detection
- Higher in hamburger buns than in meatballs



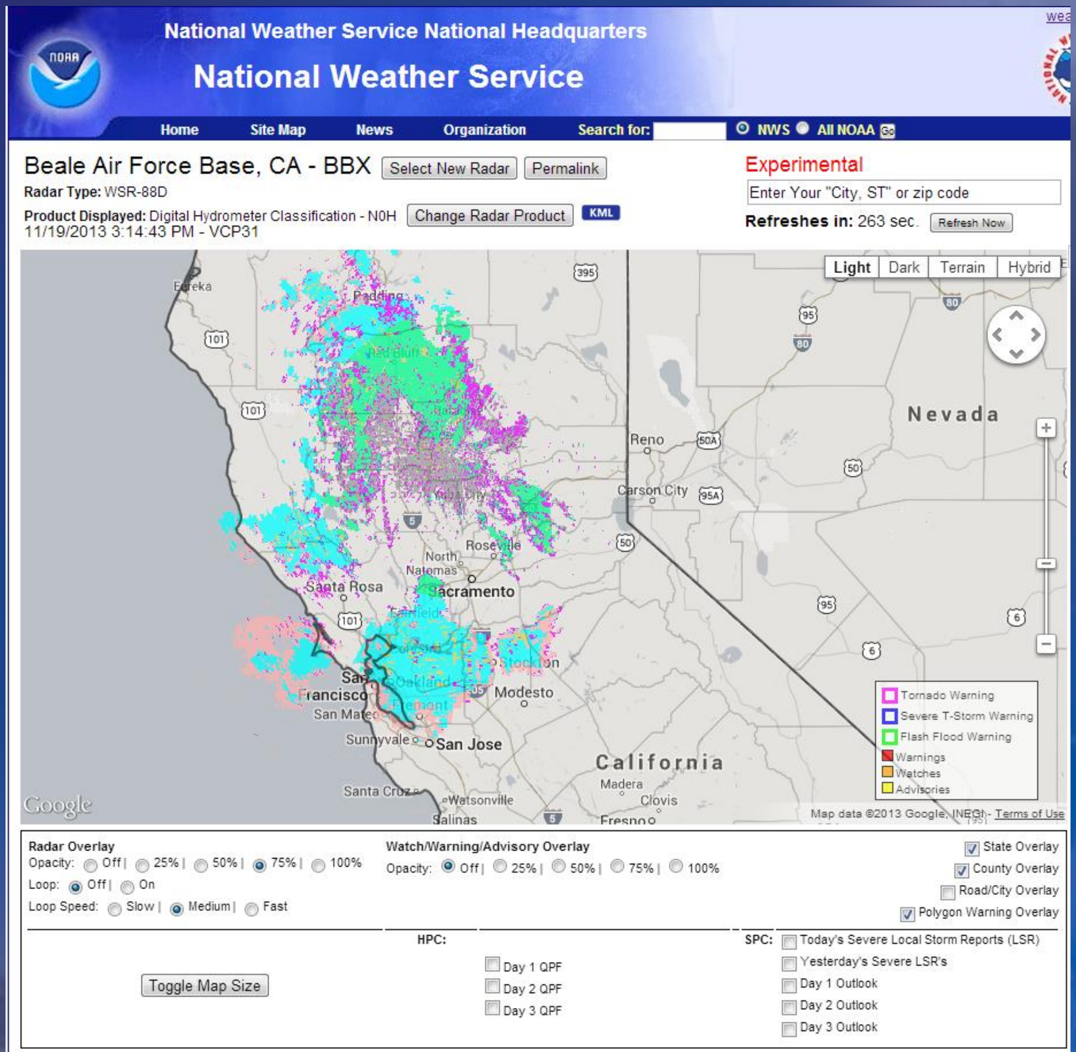
Hydrometeor Classification Algorithm

- BI - Biological
- GC - Ground clutter
- IC - Ice crystals
- DS - Dry snow
- WS - Wet snow
- RA - Rain
- HR - Heavy rain
- BD - Big drops
- GR - Graupel
- HA - Hail-rain
- UK - Unknown
- RF - Range folded



HCA Online

- http://www.srh.noaa.gov/ridge2/



More Information

- http://www.wdtb.noaa.gov/courses/dualpol/outreach/

WARNING DECISION TRAINING BRANCH
WDTB

Training for the Non-Meteorologists:

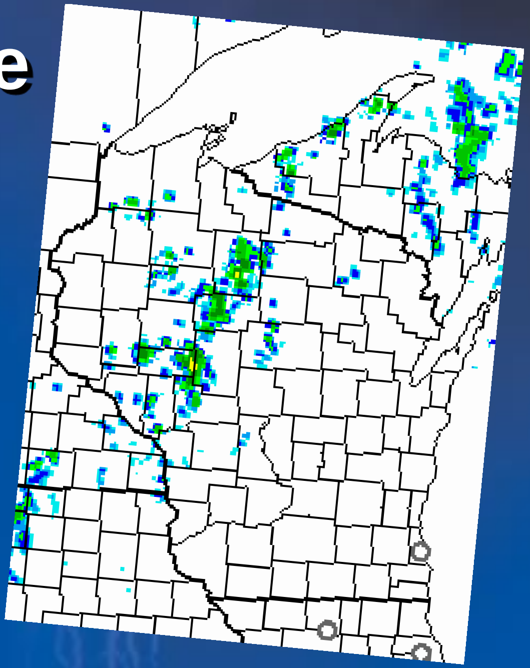
The following lessons were developed to help non-meteorologists who rely on WSR-88D data to make weather-related decisions. These lessons are available in a streaming format that uses Adobe Flash Player and can be viewed using the links below. We recommend that students attempt these lessons **no more than 1 month prior** to the installation of dual-polarization technology at their local WSR-88D site.

- Dual-Polarization Technology Overview **Download**
- Best Uses for the Hydrometeor Classification Product **Download**
- Best Uses for the Dual-Polarization Estimated Rainfall Amount Products **Download**

Forecast “Radar”

- http://rapidrefresh.noaa.gov/HRRR
- HRRR Model (hourly out to 15 hours)

- Get idea for precipitation coverage
- Use with caution – models have limitations!



HRRR Model Fields - Experimental

Model: HRRR-primary Area: NC Date: 20 Jul 2014 - 01Z

Model: HRRR-primary **Domain:** NC **Date:** 20 Jul 2014 - 01Z

			Valid Time: Sun 01	Sun 02	Sun 03	Sun 04	Sun 05	Sun 06	Sun 07	Sun 08	Sun 09	Sun 10	Sun 11	Sun 12	Sun 13	Sun 14	Sun 15	Sun 16
	All times	Loop	Forecast: 00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
all fields			00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
1 km agl reflectivity	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
composite reflectivity	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
ensemble comp reflectivity	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
max 1 km agl reflectivity	✔	✔		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
surface CAPE	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
surface CIN	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
mixed CAPE	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
most unstable CAPE	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
most unstable layer CAPE	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
best LI	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
LCL	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
0-1 km shear	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
0-6 km shear	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
0-1 km helicity, storm motion	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
0-3 km helicity, storm motion	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
2-5 km updraft helicity	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
1-6 km updraft helicity	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
2-5 km max updraft helicity	✔	✔		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
1-6 km max updraft helicity	✔	✔		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
ensemble updraft helicity	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
convective activity 1	✔	✔		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15

Earth System Research Laboratory

High Resolution Rapid Refresh (HRRR)

Current and Forecast Graphics

3km HRRR-CONUS hourly

Alternative 3km HRRR prods

3km HRRR-CONUS 15min

3km HRRR-Avi

3km HRRR-Avi

3km HRRR So

Domain: NC

- Full
- NW
- NC
- NE
- SW
- SC
- SE

Date: 20 Jul 2014 - 01Z

- 20 Jul 2014 - 02Z
- 20 Jul 2014 - 01Z
- 20 Jul 2014 - 00Z
- 19 Jul 2014 - 23Z
- 19 Jul 2014 - 22Z
- 19 Jul 2014 - 21Z
- 19 Jul 2014 - 20Z
- 19 Jul 2014 - 19Z
- 19 Jul 2014 - 18Z
- 19 Jul 2014 - 17Z
- 19 Jul 2014 - 16Z
- 19 Jul 2014 - 15Z
- 19 Jul 2014 - 14Z
- 19 Jul 2014 - 13Z
- 19 Jul 2014 - 12Z
- 19 Jul 2014 - 11Z
- 19 Jul 2014 - 10Z
- 19 Jul 2014 - 09Z
- 19 Jul 2014 - 08Z
- 19 Jul 2014 - 07Z

	All times	Loop
all fields		
1 km agl reflectivity	✔	✔
composite reflectivity	✔	✔
ensemble comp reflectivity	✔	✔
max 1 km agl reflectivity	✔	✔

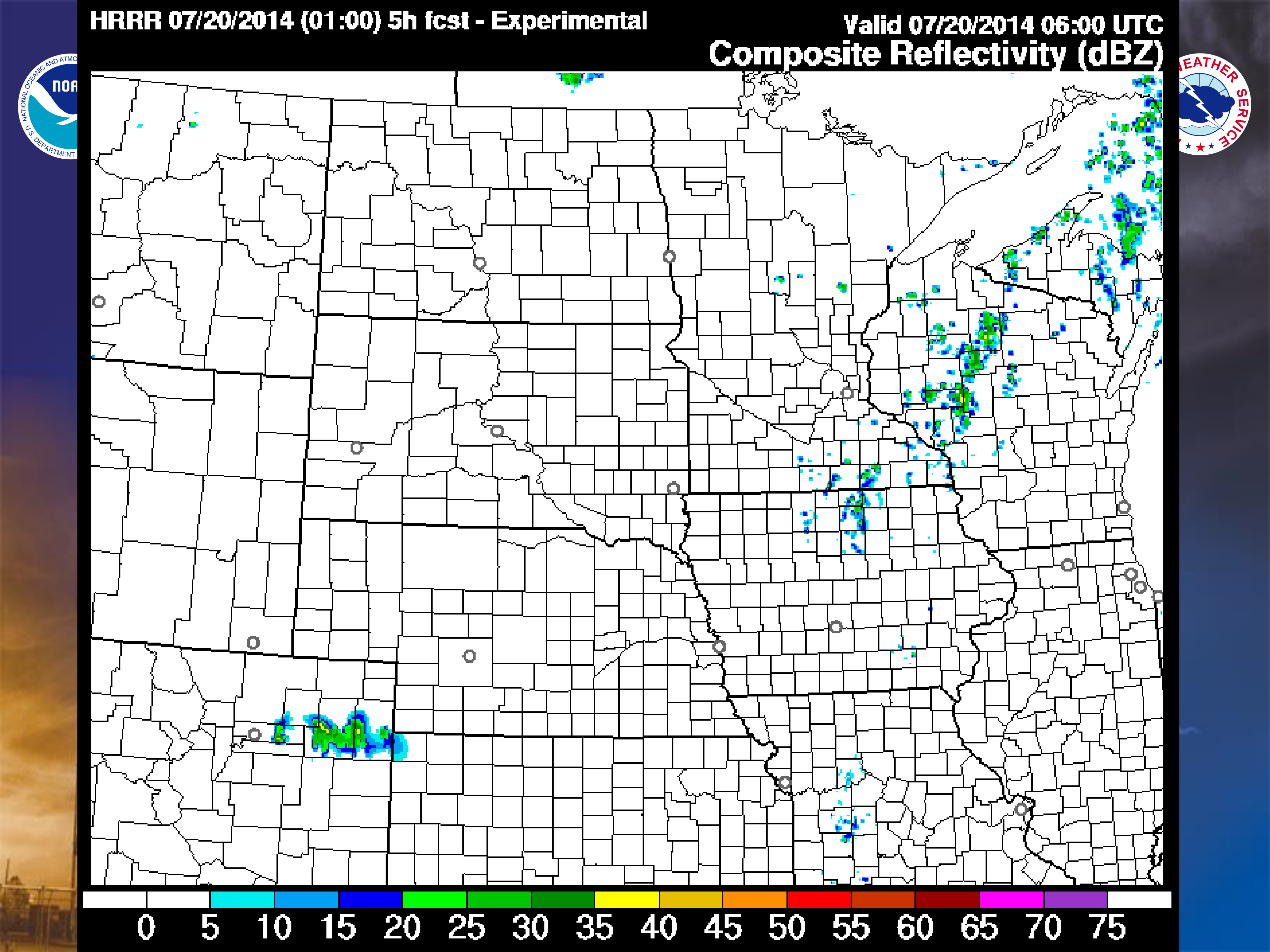
HRRR WPS Namelist
HRRR WRF Namelist
HRRR GRIB2 Table 2-D Hourly
HRRR GRIB2 Table 2-D 15 min
HRRR GRIB2 Table Native
HRRR GRIB2 Table Press
HRRR/RAP diagnosis of output fields
Rapid Refresh web page
RUC GRIB viewer
HRRR FAQ page

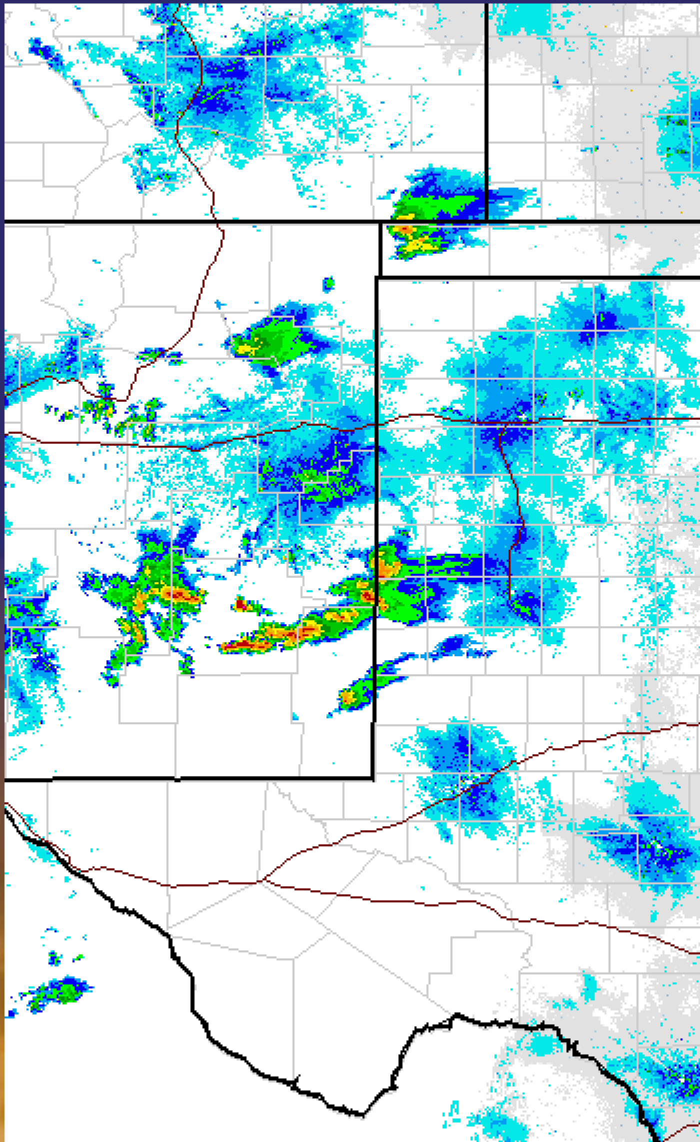
HRRR Status

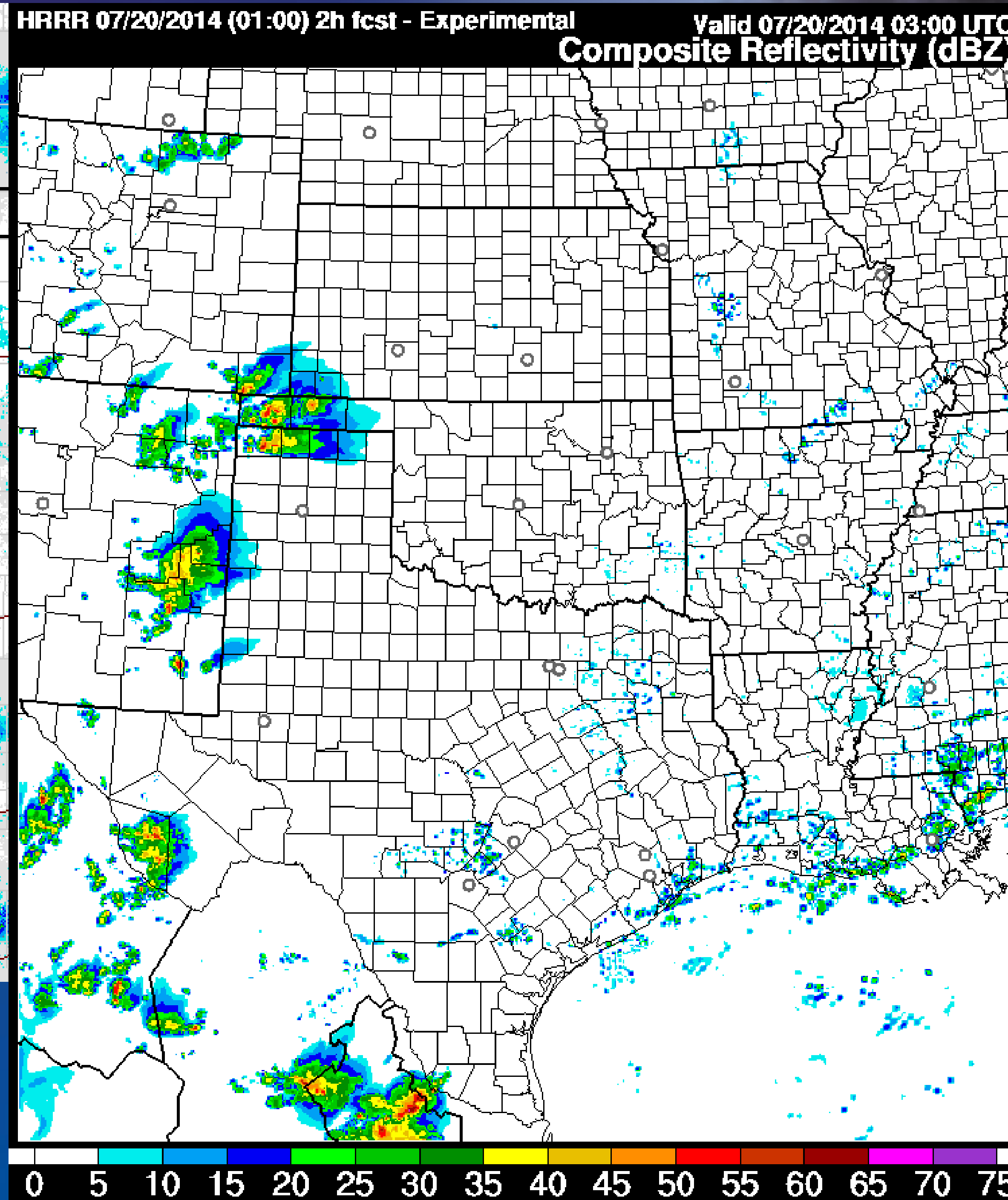
HRRR Status
HRRR Status (Past 24 hrs)
HRRR Dev1 Status
HRRR Dev1 Status (Past 24 hrs)
HRRR Dev2 Status
HRRR Dev2 Status (Past 24 hrs)
RAP-ESRL (HRRR Parent)
RAP Dev1 (HRRR Dev1 Parent)

HRRR Convective Probabilities

	All times	Loop																
most unstable layer CAPE	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
best LI	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
LCL	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
0-1 km shear	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
0-6 km shear	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
0-1 km helicity, storm motion	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
0-3 km helicity, storm motion	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
2-5 km updraft helicity	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
1-6 km updraft helicity	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
2-5 km max updraft helicity	✔	✔		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
1-6 km max updraft helicity	✔	✔		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
ensemble updraft helicity	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
convective activity 1	✔	✔		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15


HRRR 07/20/2014 (01:00) 5h fcst - Experimental
Valid 07/20/2014 06:00 UTC
Composite Reflectivity (dBZ)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75





Compare to Reality

Forecast Aviation Fields

Current and Forecast Graphics

3km HRRR-CONUS hourly

Alternative 3km HRRR prods

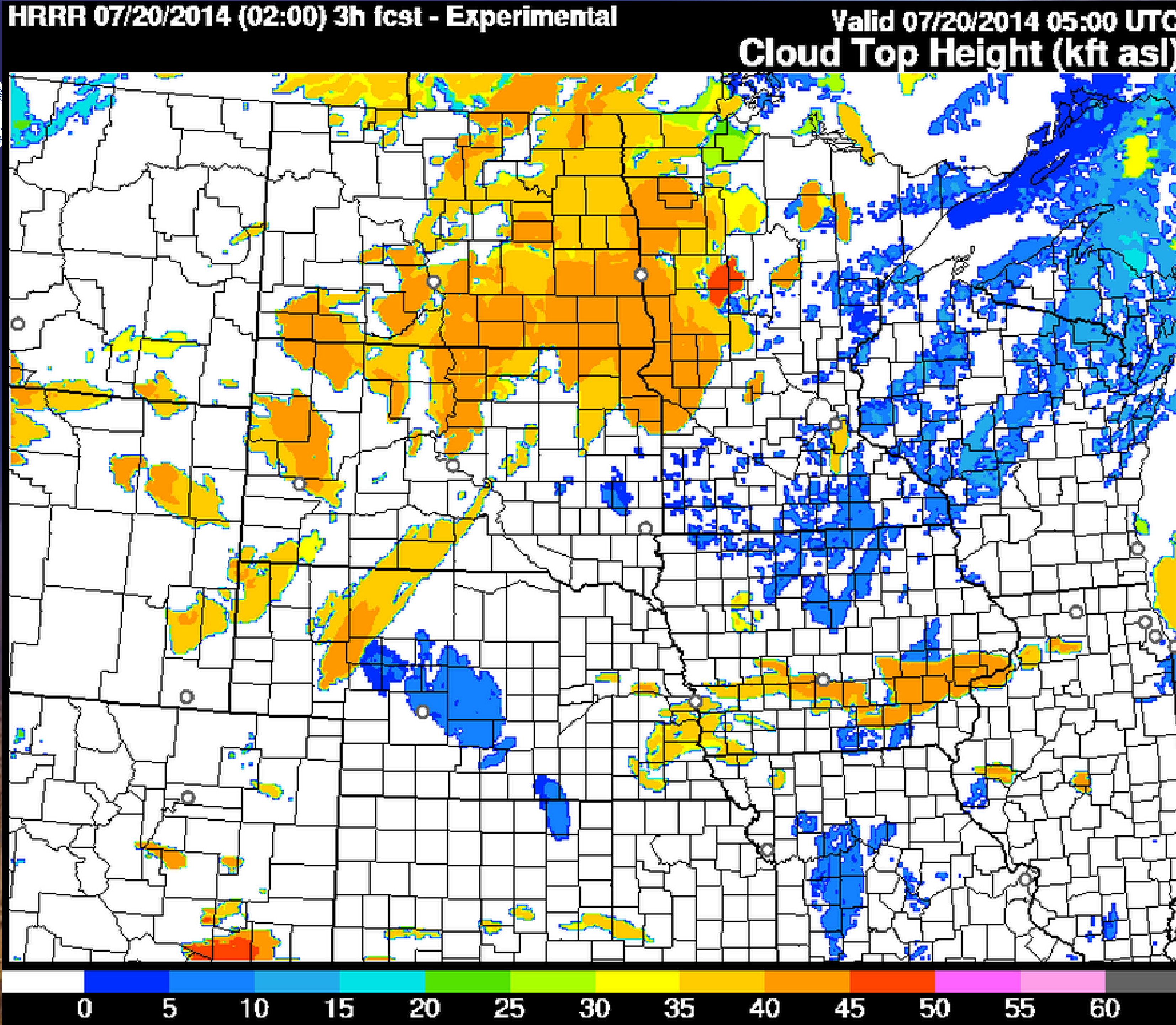
3km HRRR-CONUS 15min

3km HRRR-Aviation hourly

3km HRRR-Aviation 15min

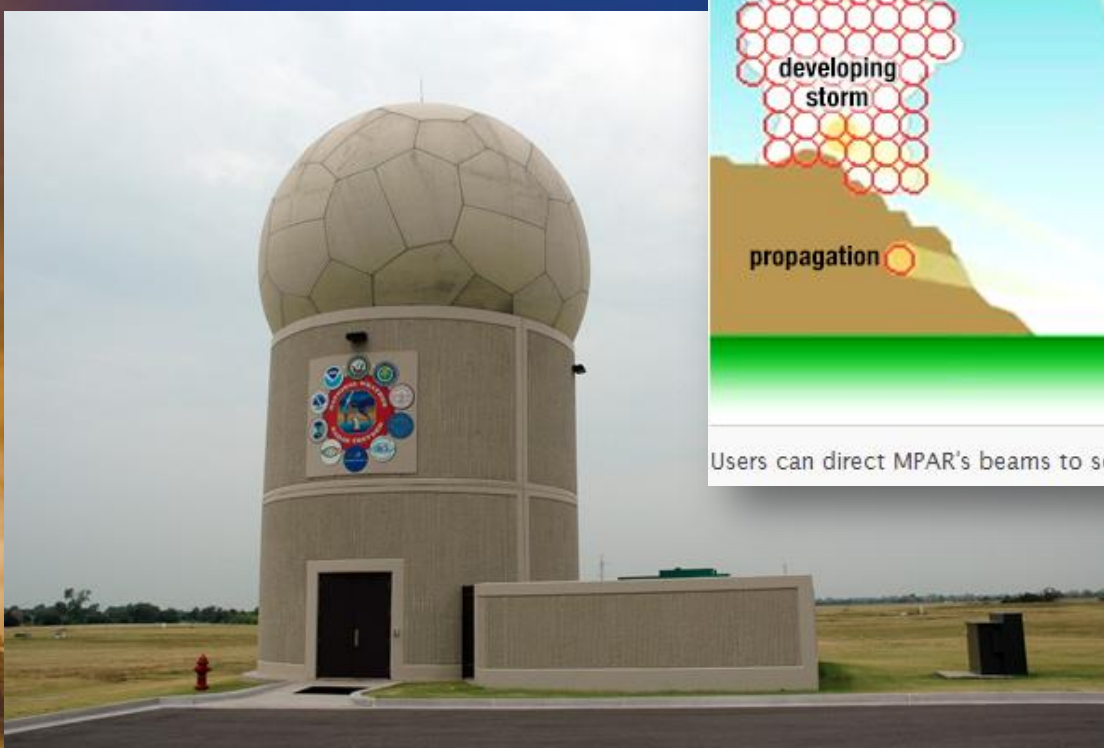
3km HRRR Soundings

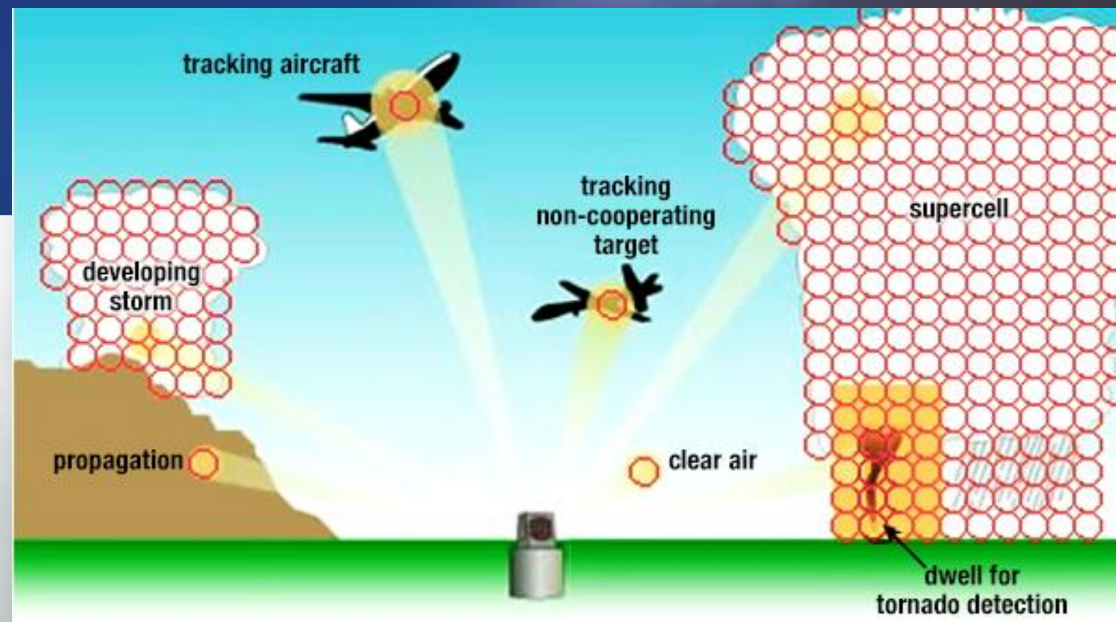
	All times	Loop
all fields		
composite reflectivity	✔	✔
RADAR VIL	✔	✔
echotop height	✔	✔
visibility	✔	✔
cloud top height	✔	✔
ceiling	✔	✔
aviation flight rules	✔	✔
10m wind	✔	✔
10m wind gust	✔	✔
precip type	✔	✔
1h acc snowfall	✔	✔


HRRR 07/20/2014 (02:00) 3h fcst - Experimental
Valid 07/20/2014 05:00 UTC
Cloud Top Height (kft asl)
0
5
10
15
20
25
30
35
40
45
50
55
60

New Technology on Horizon

- Phased Array Radar





Users can direct MPAR's beams to scan different targets as needed.

Phased Array Radar

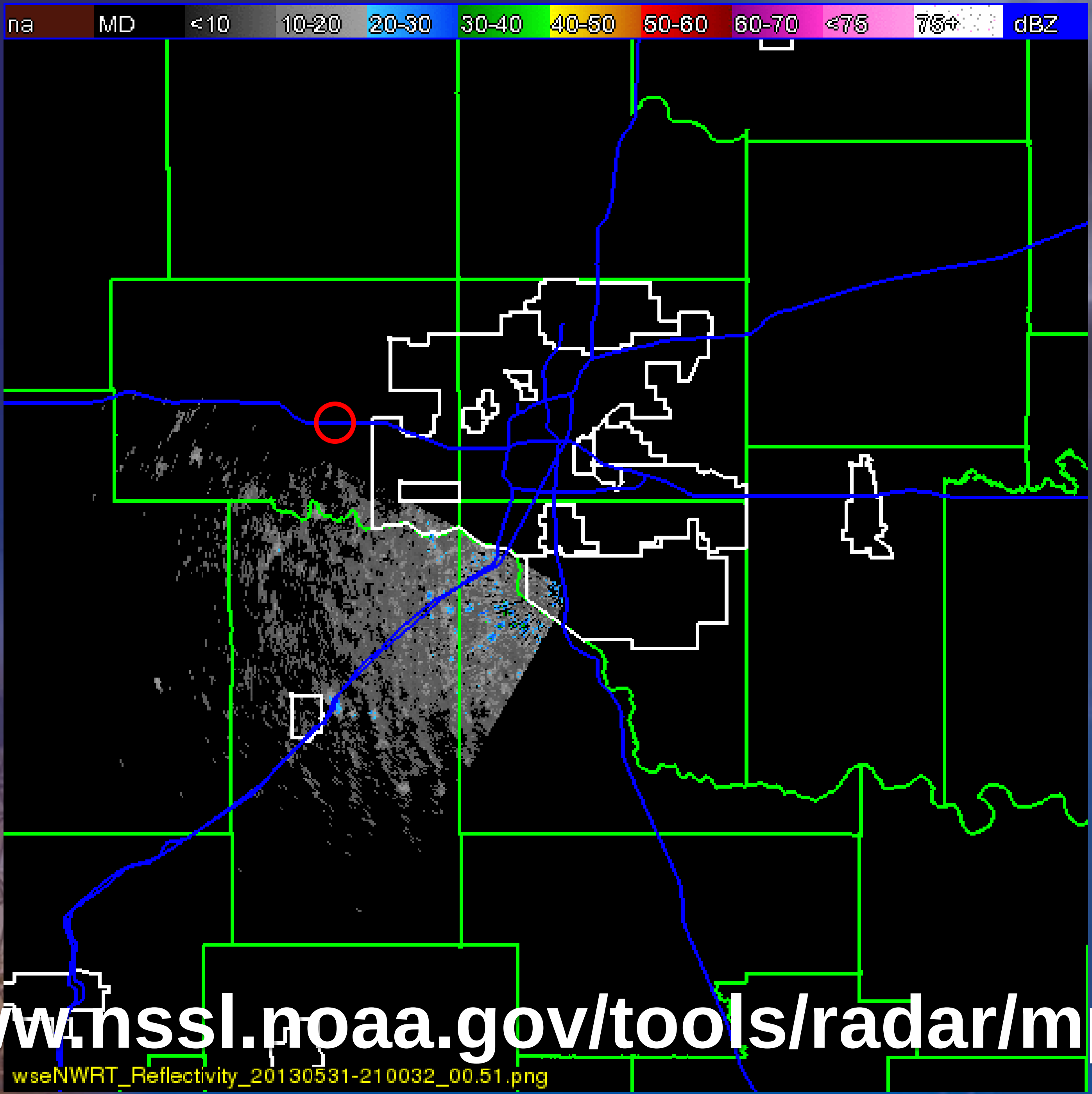
- **National Weather Radar Testbed (NWRT)**
  - ***Military technology – used by Navy ships to protect naval battle groups from missile threats***
  - ***Flat panel antenna***
  - ***Scans sky in less than 1 minute***
  - ***Possible cost-effective replacement for aging weather and aircraft tracking radars***

www.nssl.noaa.gov/tools/radar/mpar

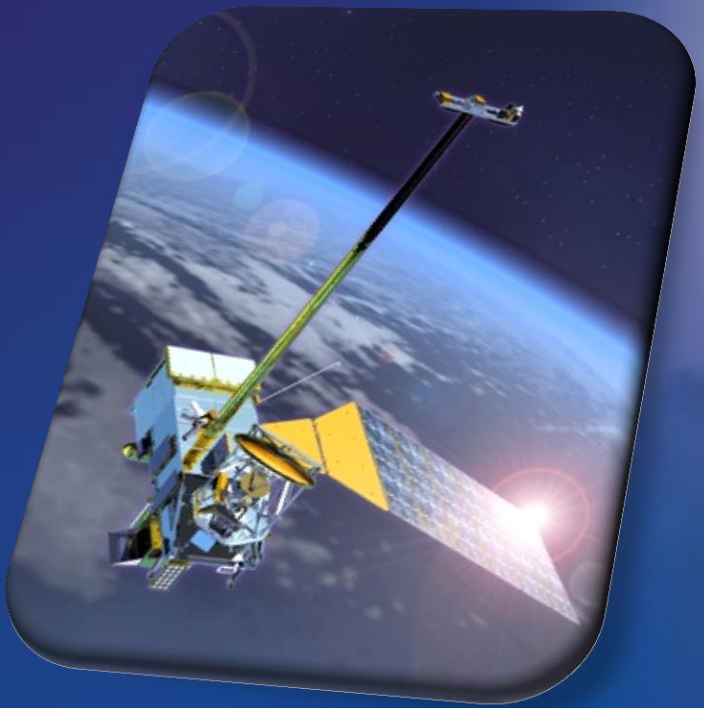
El Reno Tornado

- **National Weather Radar Testbed (NWRT) Phased Array Radar**
  - *May 31, 2013*
  - *1-minute resolution depicts the fluid motion of supercell development*
  - *Path along the Interstate*

www.nssl.noaa.gov/tools/radar/mpar



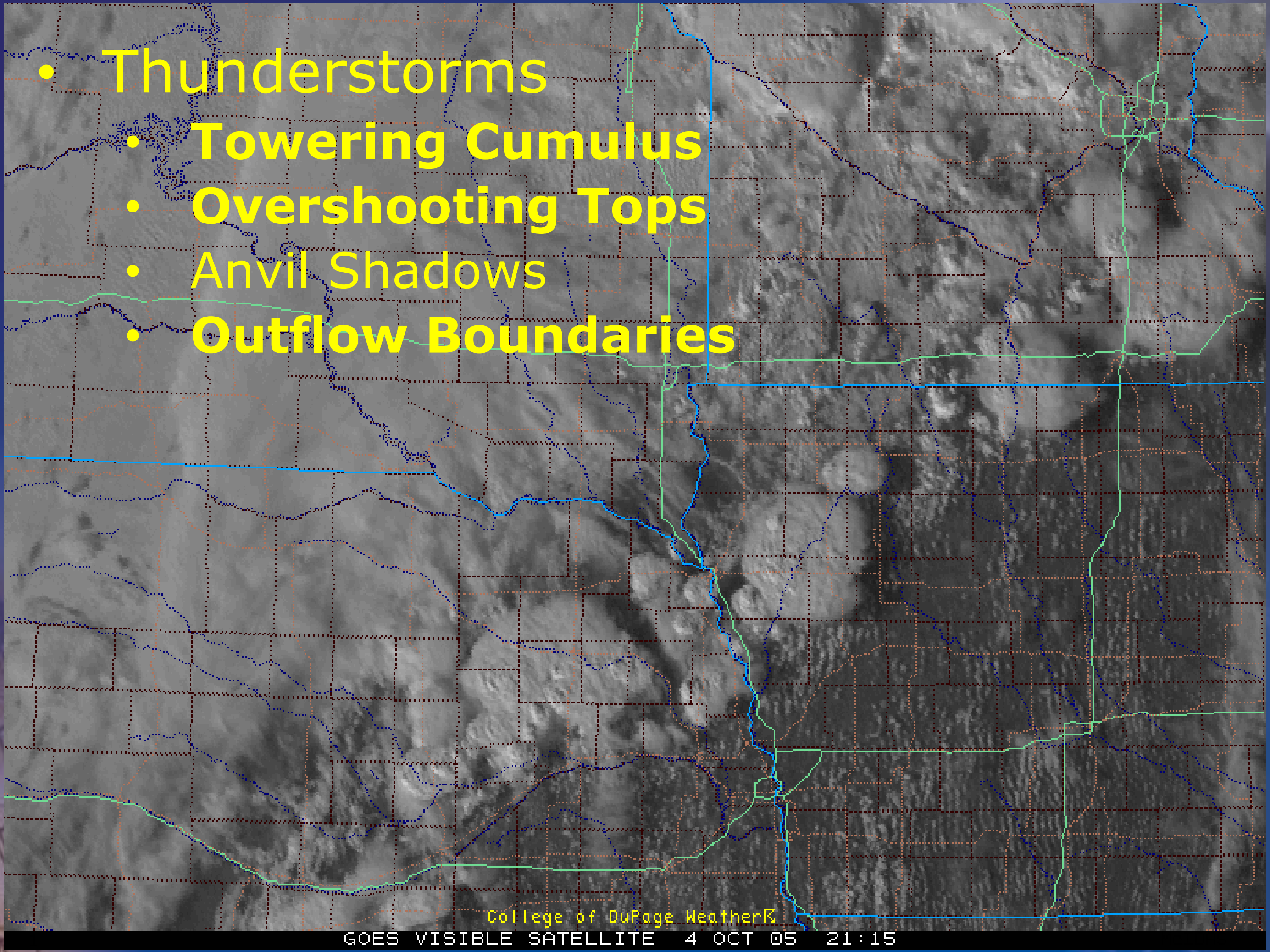
www.nssl.noaa.gov/tools/radar/mpar



SATELLITE INTERPRETATION

Visible Satellite (VIS)

- Thunderstorms
  - **Towering Cumulus**
  - **Overshooting Tops**
  - Anvil Shadows
  - **Outflow Boundaries**

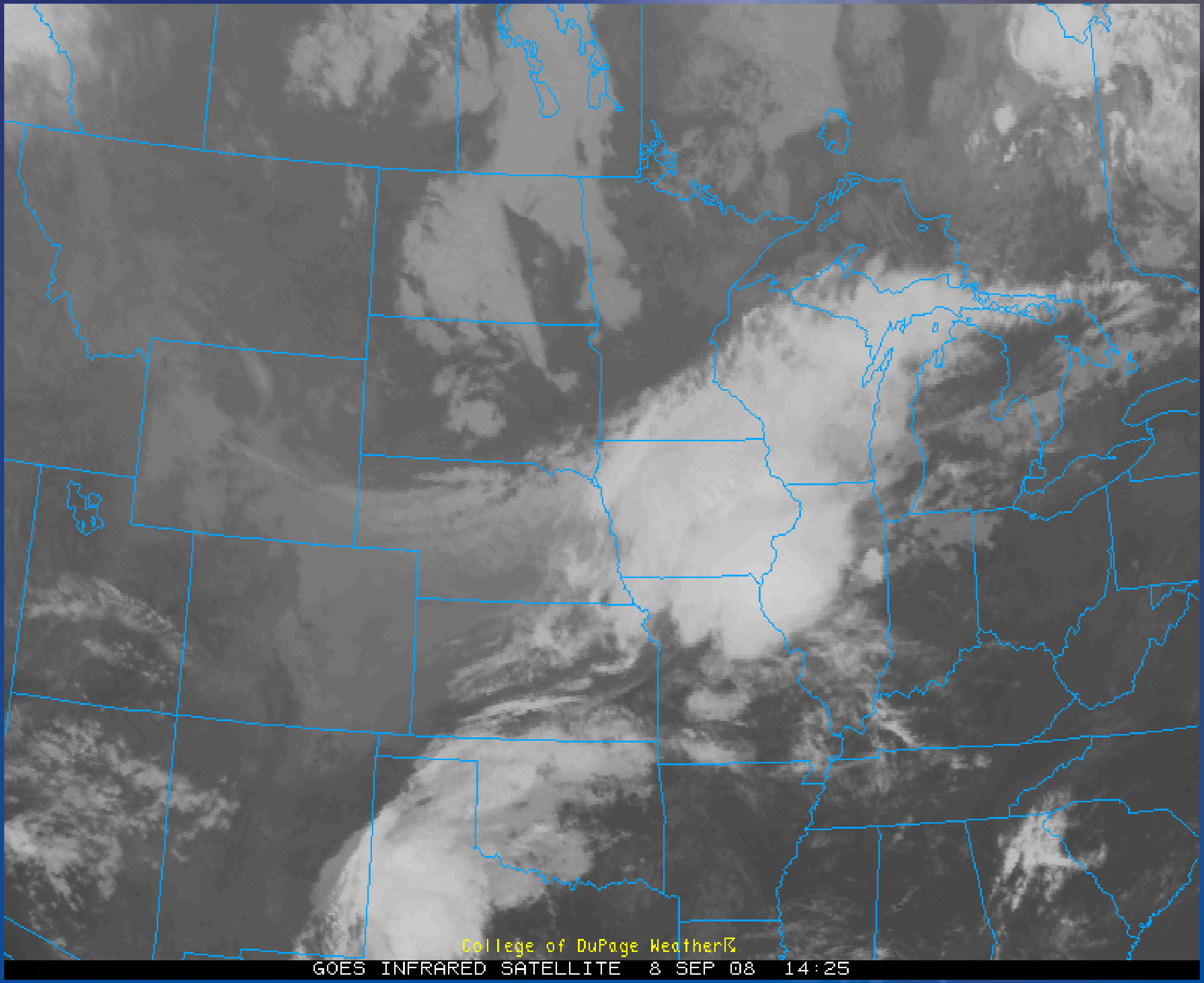


Visible Satellite (VIS)

- Other Features
  - Lake Effect Clouds
  - Snow Cover
  - Fog
  - Marine Layer Clouds/Fog
  - Cirrus streaks (Jet Stream Features)
  - Hurricane Features

Infrared Satellite (IR)

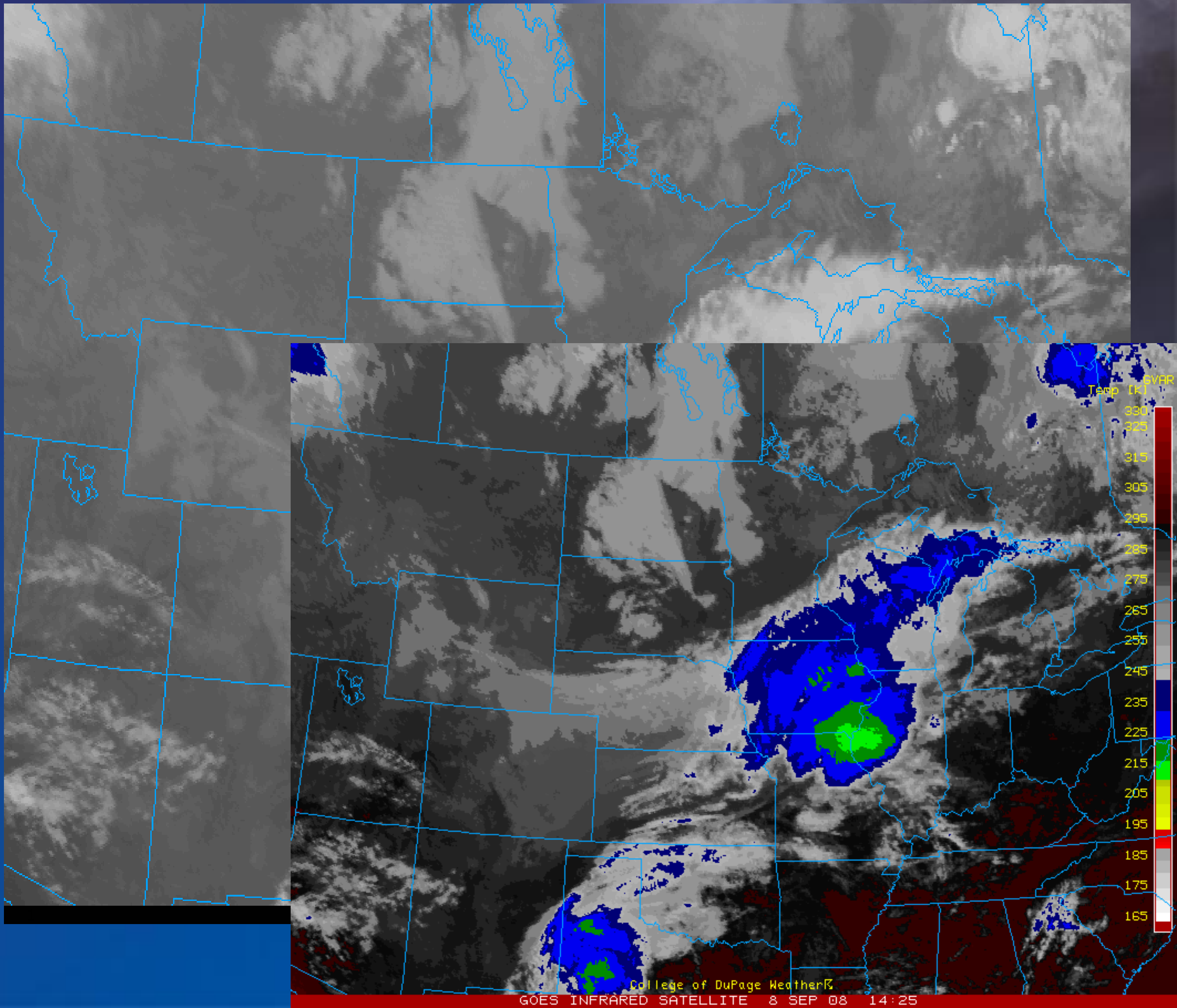
- **Measures Temperature of Cloud Tops**
  - Colder is Brighter (higher clouds)
  - Warmer is Darker (lower clouds)



Infrared Satellite (IR)

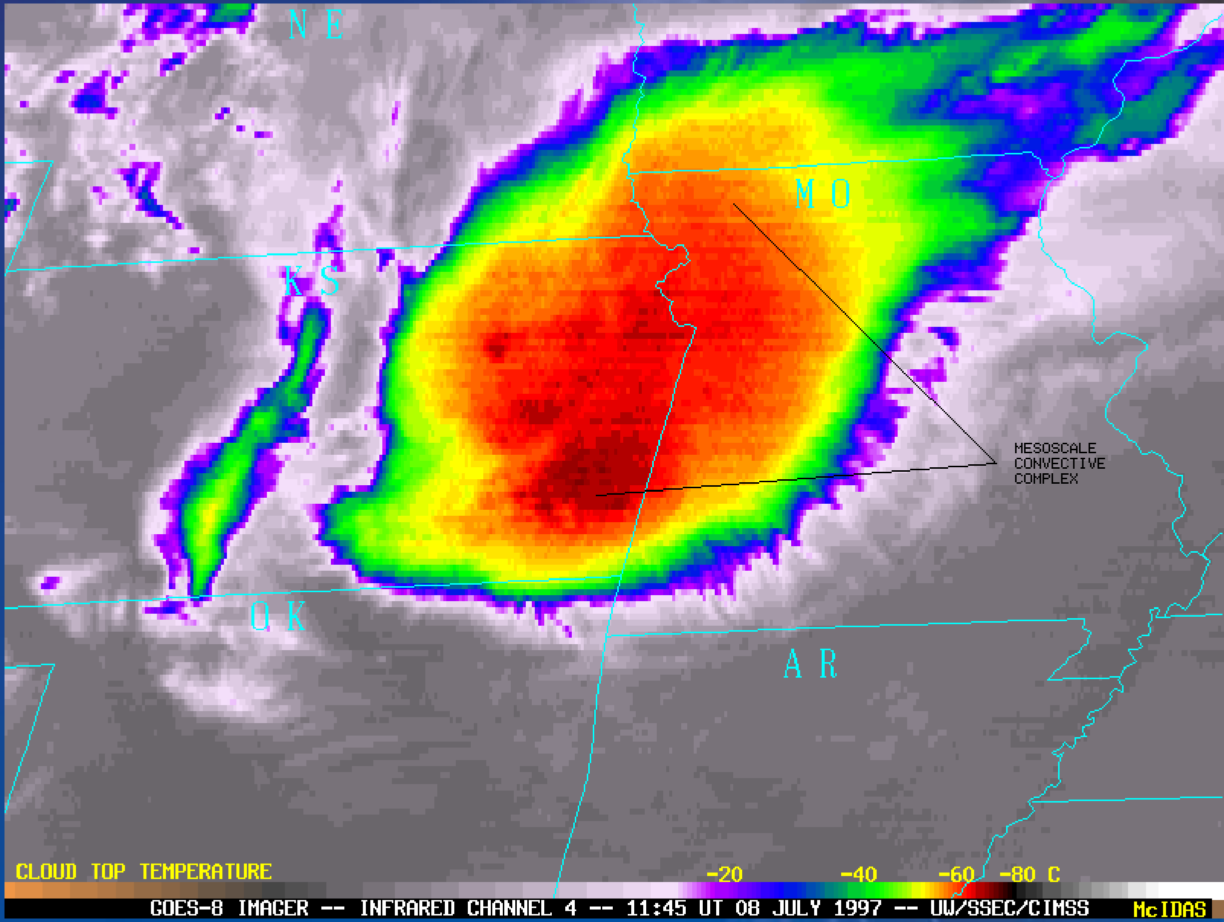
- **Measures Temperature of Cloud Tops**
  - Colder is Brighter (higher clouds)
  - Warmer is Darker (lower clouds)

- *Now… Use an enhancement*



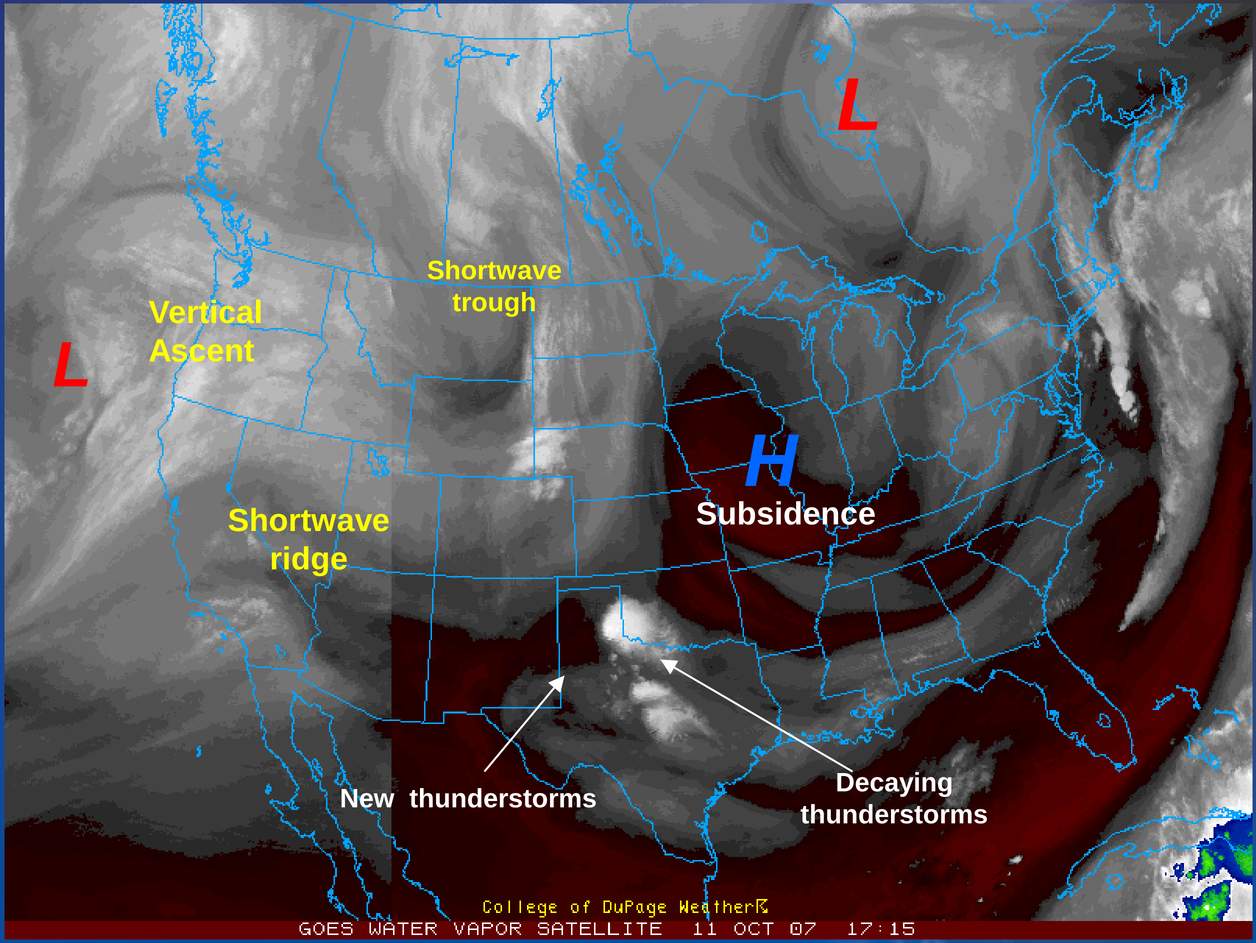
Infrared Satellite (IR)

- Many Uses for IR
  - Convection Strength
  - Afternoon Drylines
  - Cyclone Development
  - Approach of Cold Airmasses
  - Hurricane Strength & Analysis



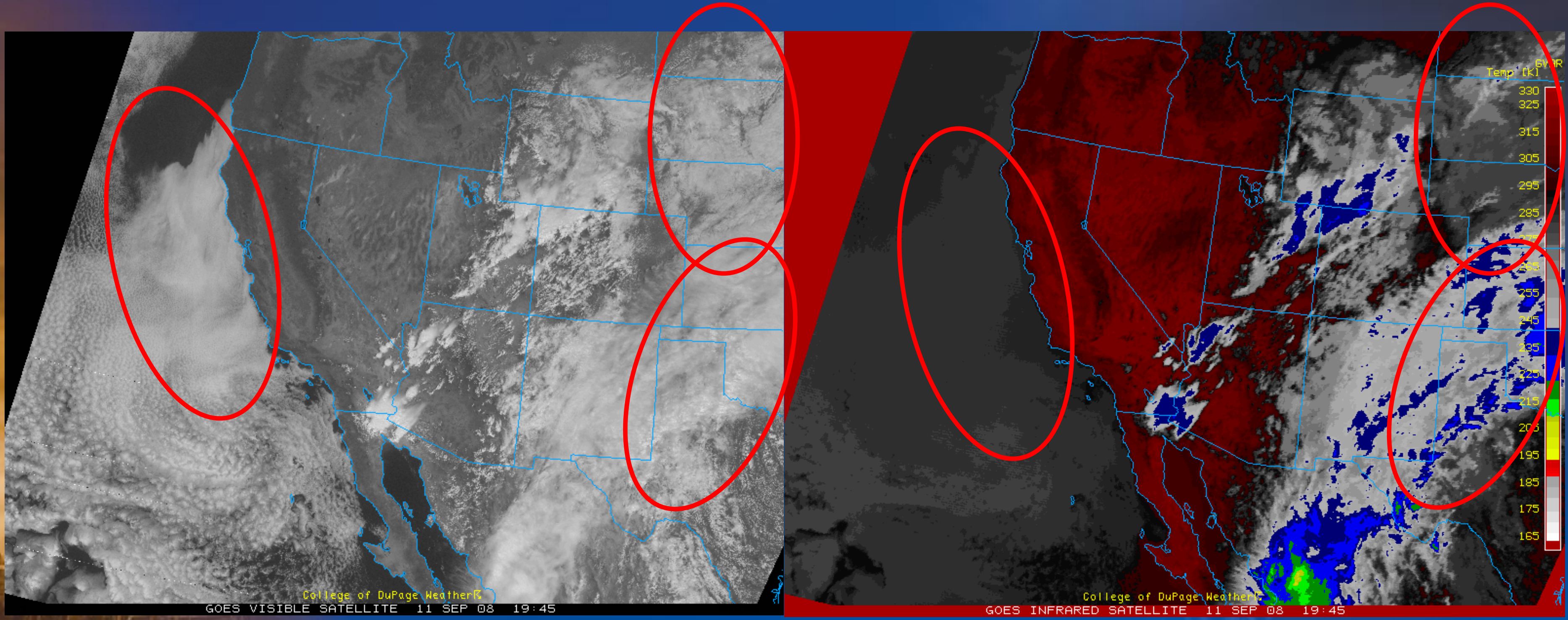
Water Vapor Satellite (WV)

- Mid and Upper Levels of Atmosphere
  - **Brighter → More Moisture**
  - **Darker → Drier Air**

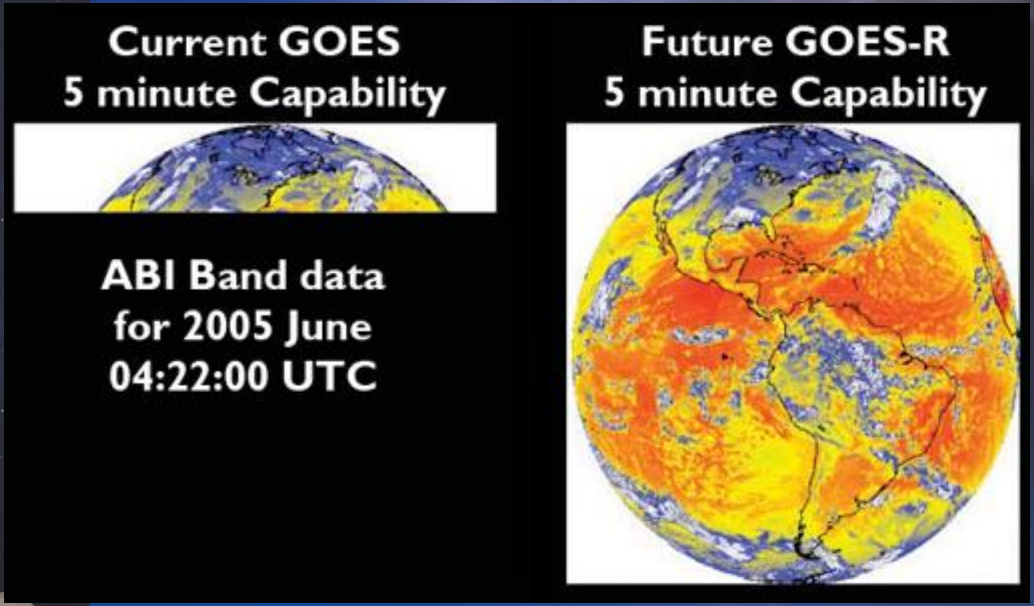


Applications of Satellite Products

- CA Coast: Marine Layer
- Dakotas/NE: Low Clouds
- Mexico → TX → KS: High Clouds



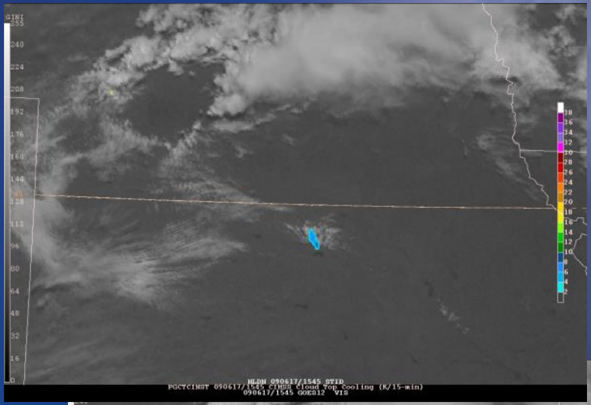
Future Satellite



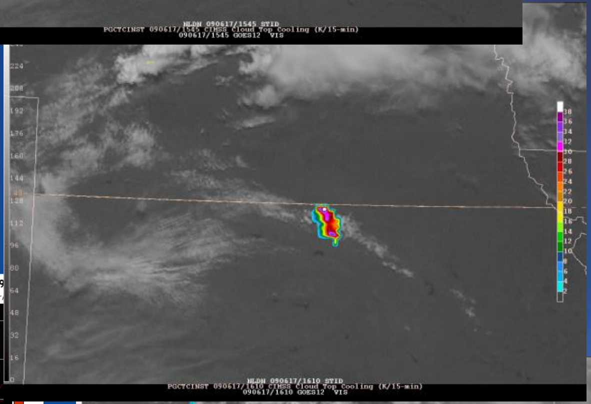
- **1 minute data!**
- **Higher Resolution**

Future Satellite Applications

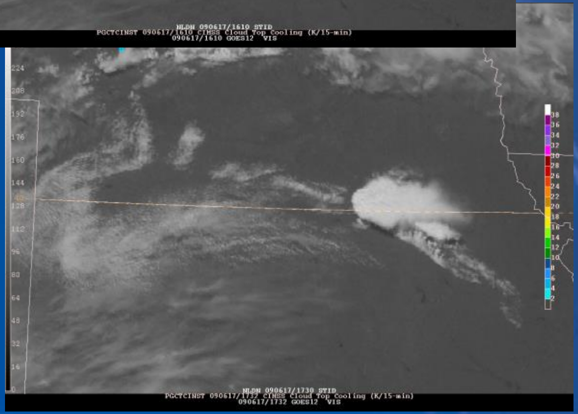
- **University of Wisconsin (CIMSS)**
  - ***Cloud Top Cooling → Convective Initiation (UWCI)***



1545 UTC – first cloud top cooling signal

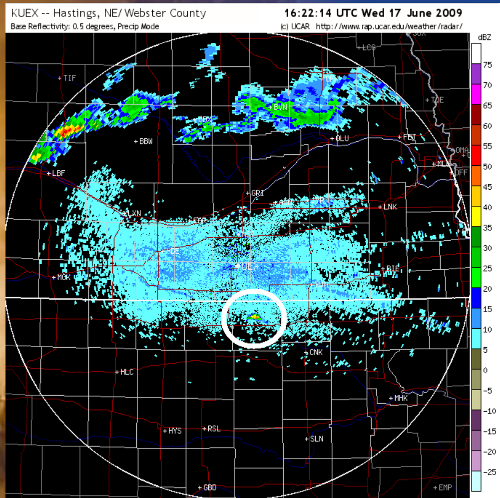


1610 UTC - Continued cooling signal

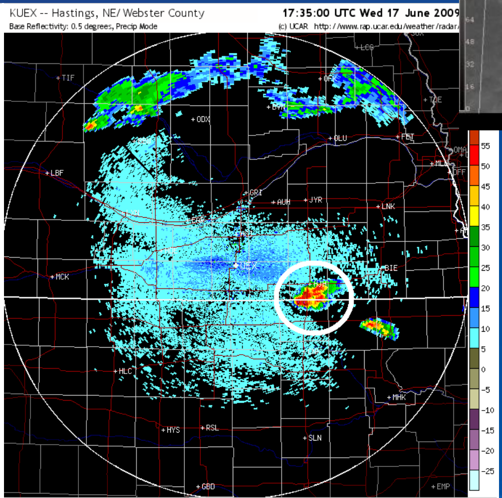


1732UTC - Severe t-storm

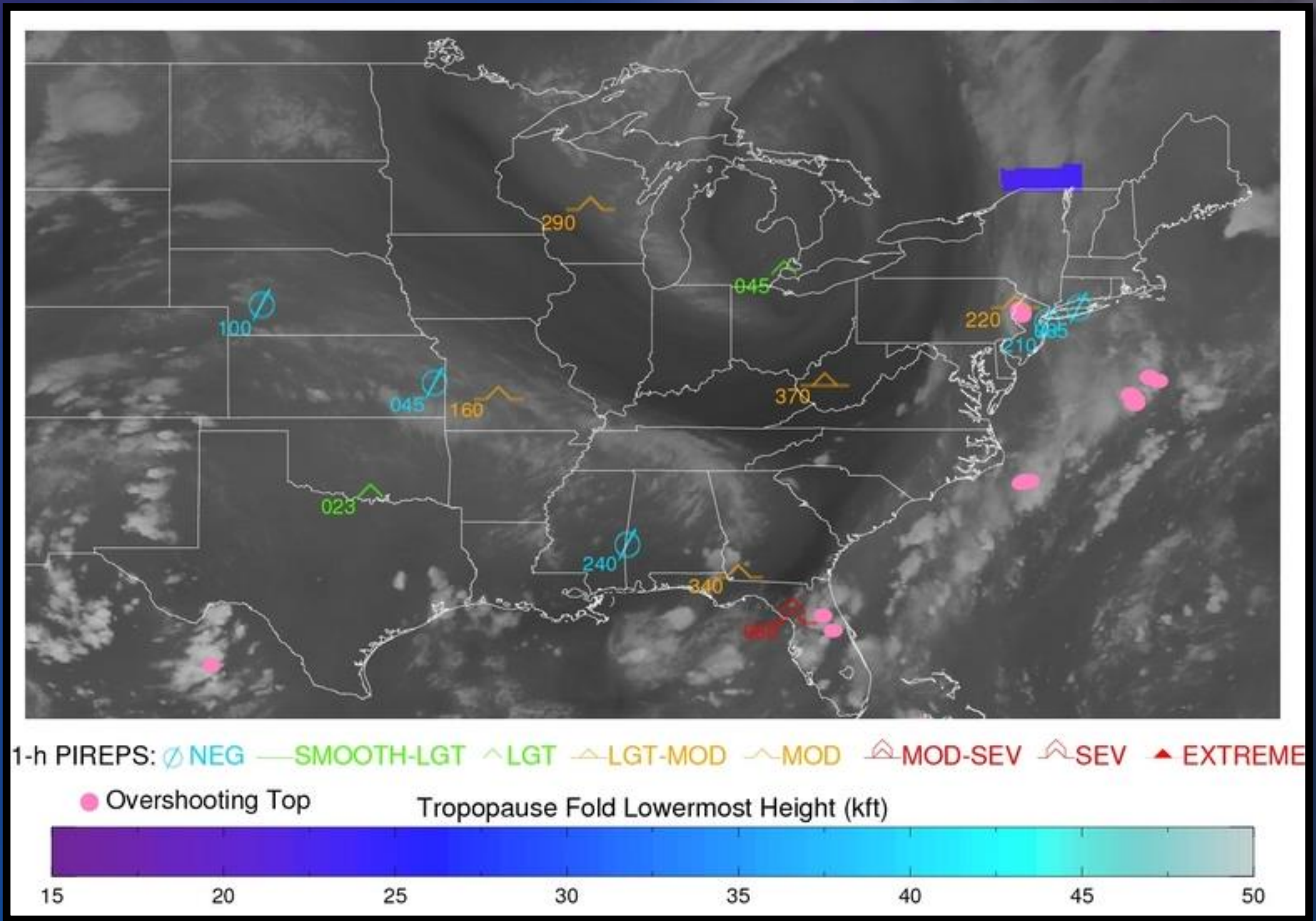
First NEXRAD 35+ dBz echo at 1622 UTC



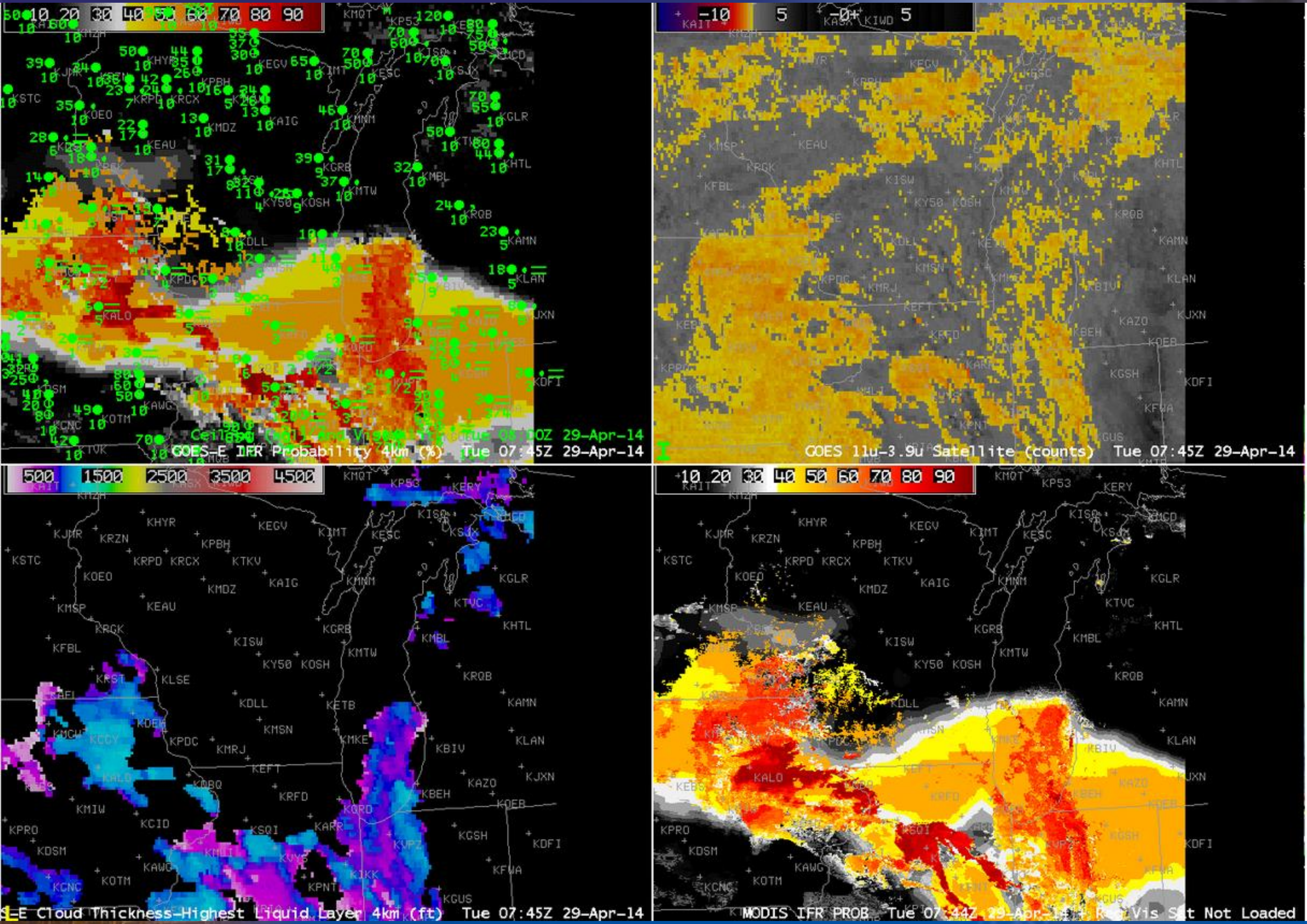
NEXRAD at 1735 UTC



Future Satellite Applications



- **University of Wisconsin (CIMSS)**
  - ***Overshooting Tops → Turbulence Risk***


GOES-E IFR Probability 4km (%) Tue 07:45Z 29-Apr-14
GOES 11u-3.9u Satellite (counts) Tue 07:45Z 29-Apr-14
Cloud Thickness-Highest Liquid Layer 4km (ft) Tue 07:45Z 29-Apr-14
MODIS IFR PROB Tue 07:44Z 29-Apr-14
10 20 30 40 50 60 70 80 90
-10 5 -0+ 5
500 1500 2500 3500 4500

Any Questions?

- Marcia.Cronce@noaa.gov