# Research activities at the NOAA National Severe Storms Laboratory:

## Ideas for collaboration

***Dr. Robert Rabin***
***NOAA/National Severe Storms Lab***
***Norman, Oklahoma***

***Cooperative Institute For Meteorological Satellite Studies***
***University of Wisconsin-Madison***

# Robert M. Rabin

## Born: Evanston, IL

## Education:

1974 B.Sc. McGill University in Montreal, Canada
1977 M. Sc. McGill
1987 Doctorate in meteorology University Pierre et Marie Curie in Paris, France.

## Affiliations:

Research meteorologist NSSL (1978–Present)

Honorary Fellow: CIMSS (1989–Present), collaboration with NESDIS/STAR/ASPT

NOAA research prof: CREST and CCNY (2009–Present)

CIRA fellow (2011–Present), collaboration with NESDIS/RAMMB

## Research History:

1978–1988: Studies of the prestorm PBL using Doppler radar (NSSL)

1987–1993: Landscape variability and initiation of local convection (OSU, NSSL,CIMSS)

1989–1993: Atmospheric moisture distributions Using passive microwave and IR satellite observations (GUFMEX, etc).

1991–1994: Influence of vegetation and moisture on Clouds and regional energy budgets (deforestation, Agricultural heat islands, etc).

## Research History (continued):

1993-1997: Multi-satellite estimates of land-surface
Properties for determination of energy and water budgets

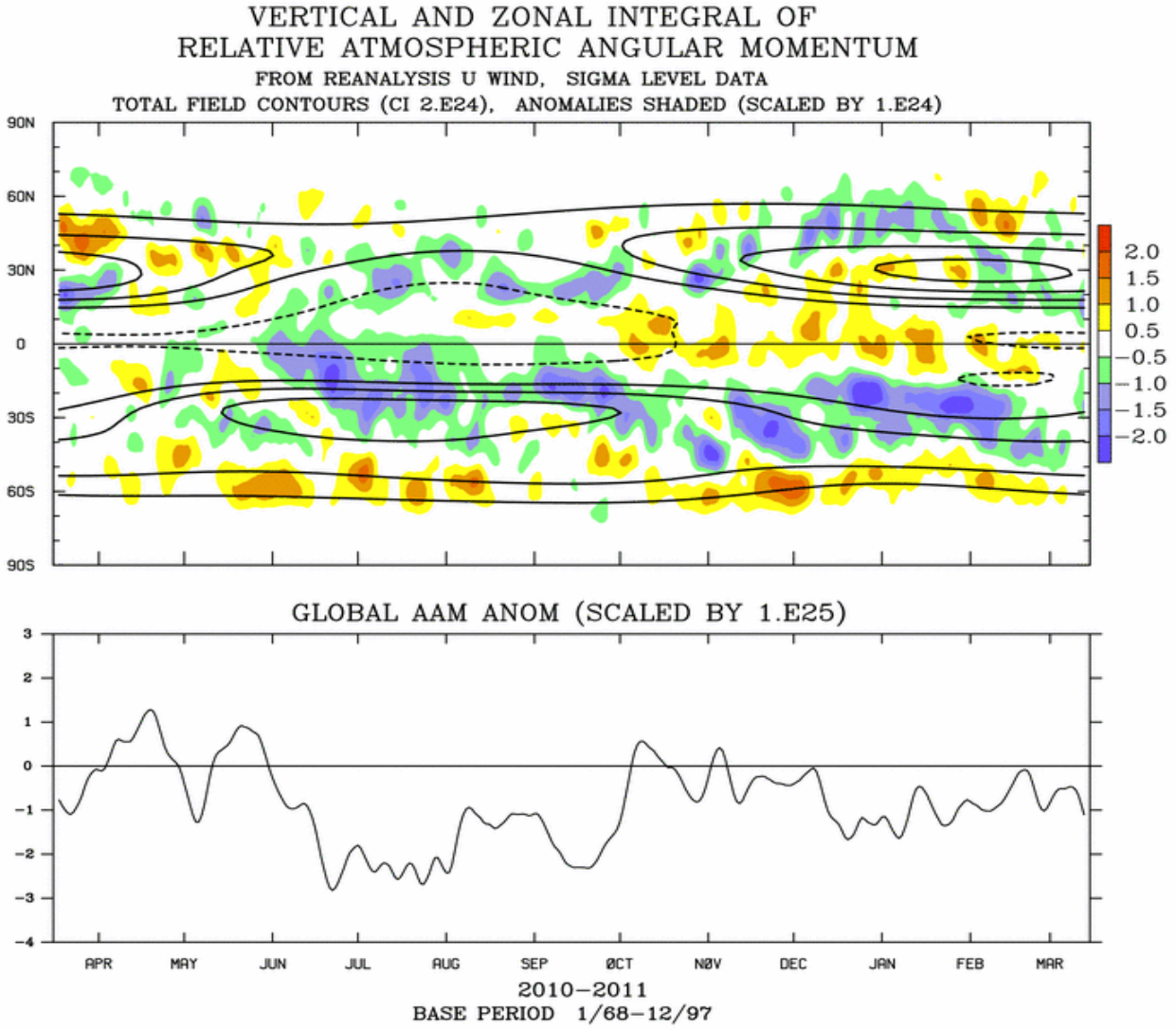
1993-2011: Applications of GOES and WSR-88D for
Detection and short-range forecasting of local convection:

NESDIS GOES I-M Product Assurance Program (GIMPAP)

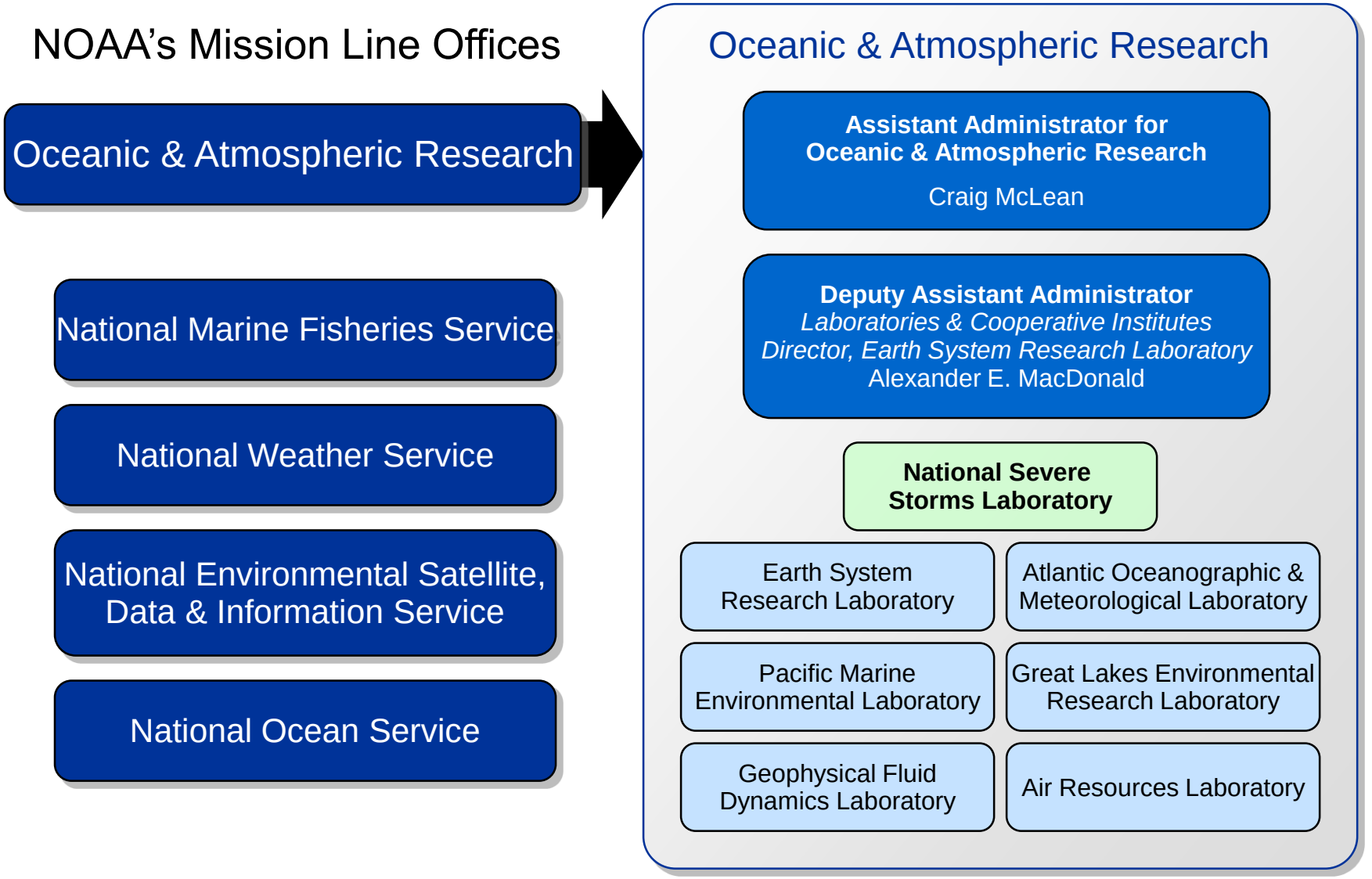
## Current Interests:

Applications of satellite observations in thunderstorm research and in weather forecasting.

Medium and long-range weather forecasting of extreme weather.


VERTICAL AND ZONAL INTEGRAL OF
RELATIVE ATMOSPHERIC ANGULAR MOMENTUM
FROM REANALYSIS U WIND, SIGMA LEVEL DATA
TOTAL FIELD CONTOURS (CI 2.E24), ANOMALIES SHADED (SCALED BY 1.E24)
90N
60N
30N
0
30S
60S
90S
2.0
1.5
1.0
0.5
−0.5
−1.0
−1.5
−2.0
GLOBAL AAM ANOM (SCALED BY 1.E25)
3
2
1
0
−1
−2
−3
−4
APR
MAY
JUN
JUL
AUG
SEP
ØCT
NØV
DEC
JAN
FEB
MAR
2010−2011
BASE PERIOD 1/68−12/97

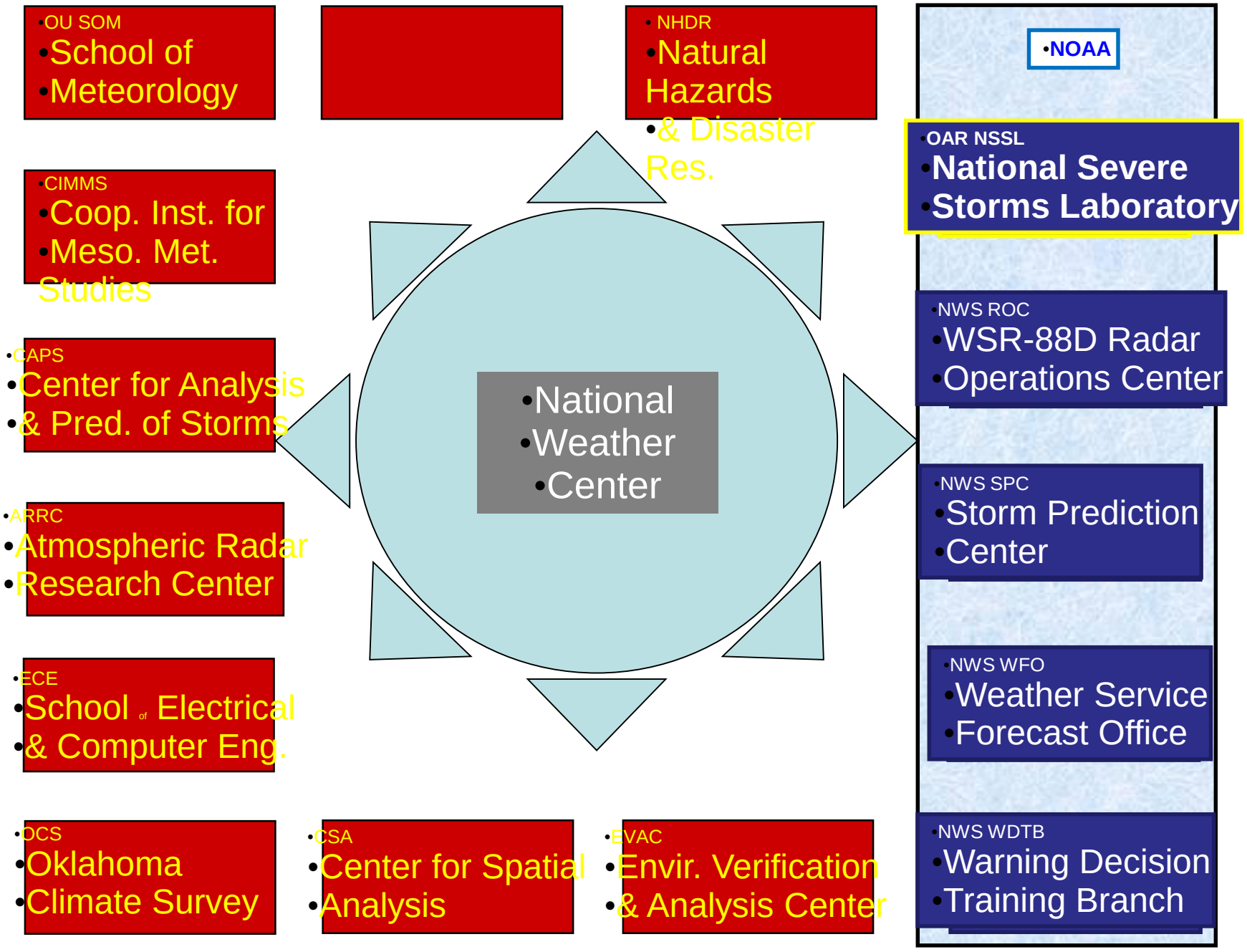
# National Severe Storms Laboratory in NOAA



# The National Weather Center Building

Collocation of ~600 meteorology-related personnel from OU and NOAA organizations

$67M
244 square feet
“Collaborative architecture”
Opened in summer 2006


•OU SOM
•School of
•Meteorology
• NHDR
•Natural Hazards
•& Disaster Res.
•NOAA
•OAR NSSL
•National Severe
•Storms Laboratory
•CIMMS
•Coop. Inst. for
•Meso. Met. Studies
•NWS ROC
•WSR-88D Radar
•Operations Center
•CAPS
•Center for Analysis
•& Pred. of Storms
•National
•Weather
•Center
•NWS SPC
•Storm Prediction
•Center
•ARRC
•Atmospheric Radar
•Research Center
•NWS WFO
•Weather Service
•Forecast Office
•ECE
•School of Electrical
•& Computer Eng.
•NWS WDTB
•Warning Decision
•Training Branch
•OCS
•Oklahoma
•Climate Survey
•CSA
•Center for Spatial
•Analysis
•EVAC
•Envir. Verification
•& Analysis Center

# •RADAR ADVANCES

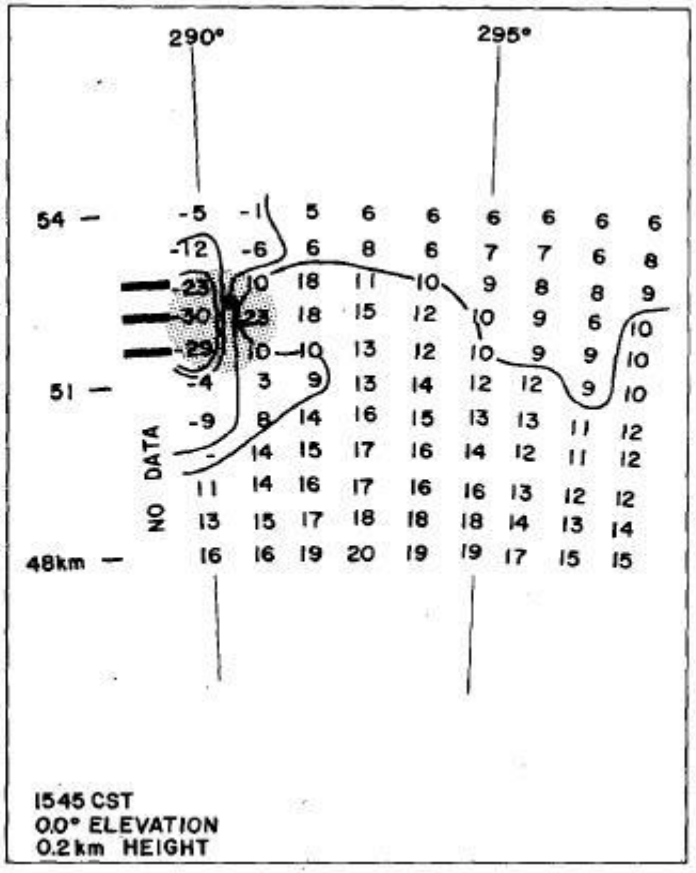
# • IN STORM DETECTION

•

# *Tornado detection by pulsed Doppler radar*

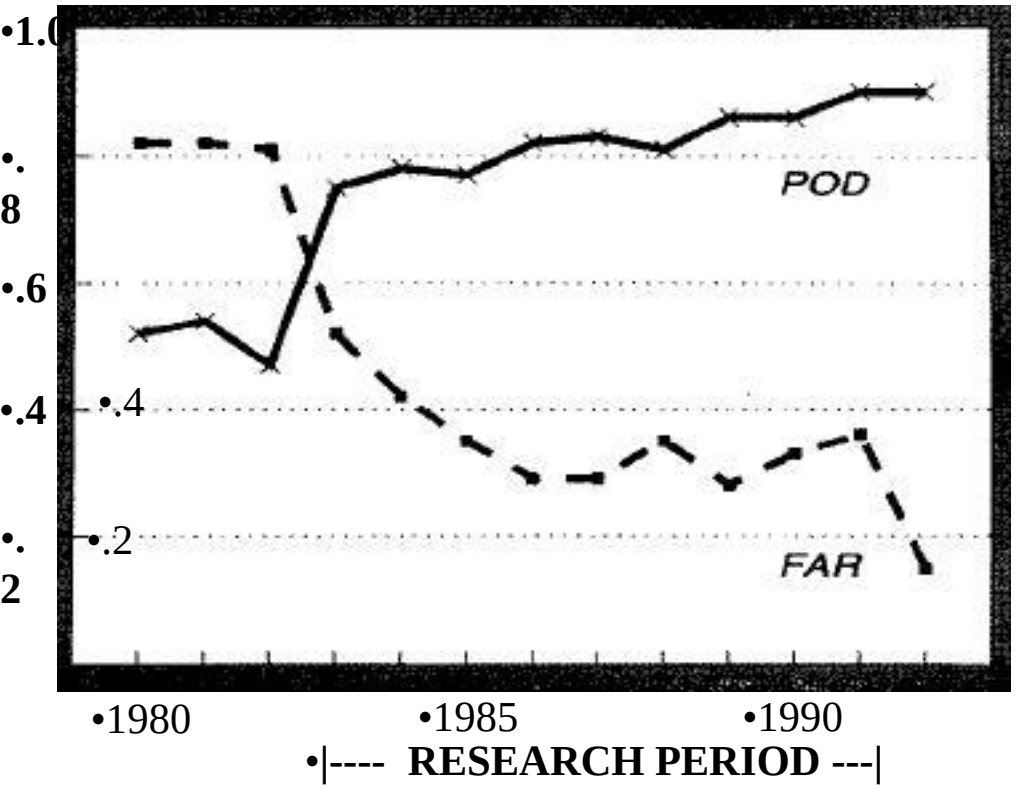
R.A. Brown, L.R. Lemon, D.W. Burgess

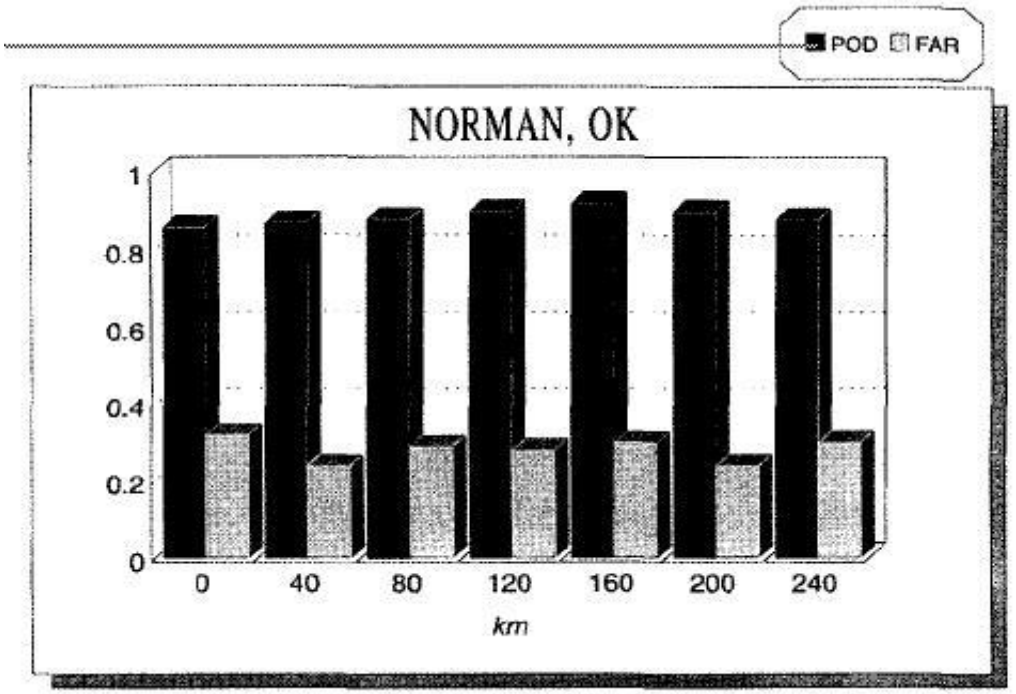
1978, MWR



# •*National Weather Service warning performance based on the WSR-88D*

•P.D. Polger, B.S. Goldsmith, R.C. Przywarty, J.R. Bocchieri, 1994, BAMS



# NSSL Radar History

First Dual Doppler Analysis

Cimarron upgraded Dual-polarization

First dual-polarization real time displays

Helped build first DOWS

Initial algorithm development

First WSR-88D installed

WDSS

Norman 10cm Doppler

Cimarron 10cm Doppler

JDOP

mesocyclone

1970

1980

1990

2000

## Source: NESDIS GIMPAP program

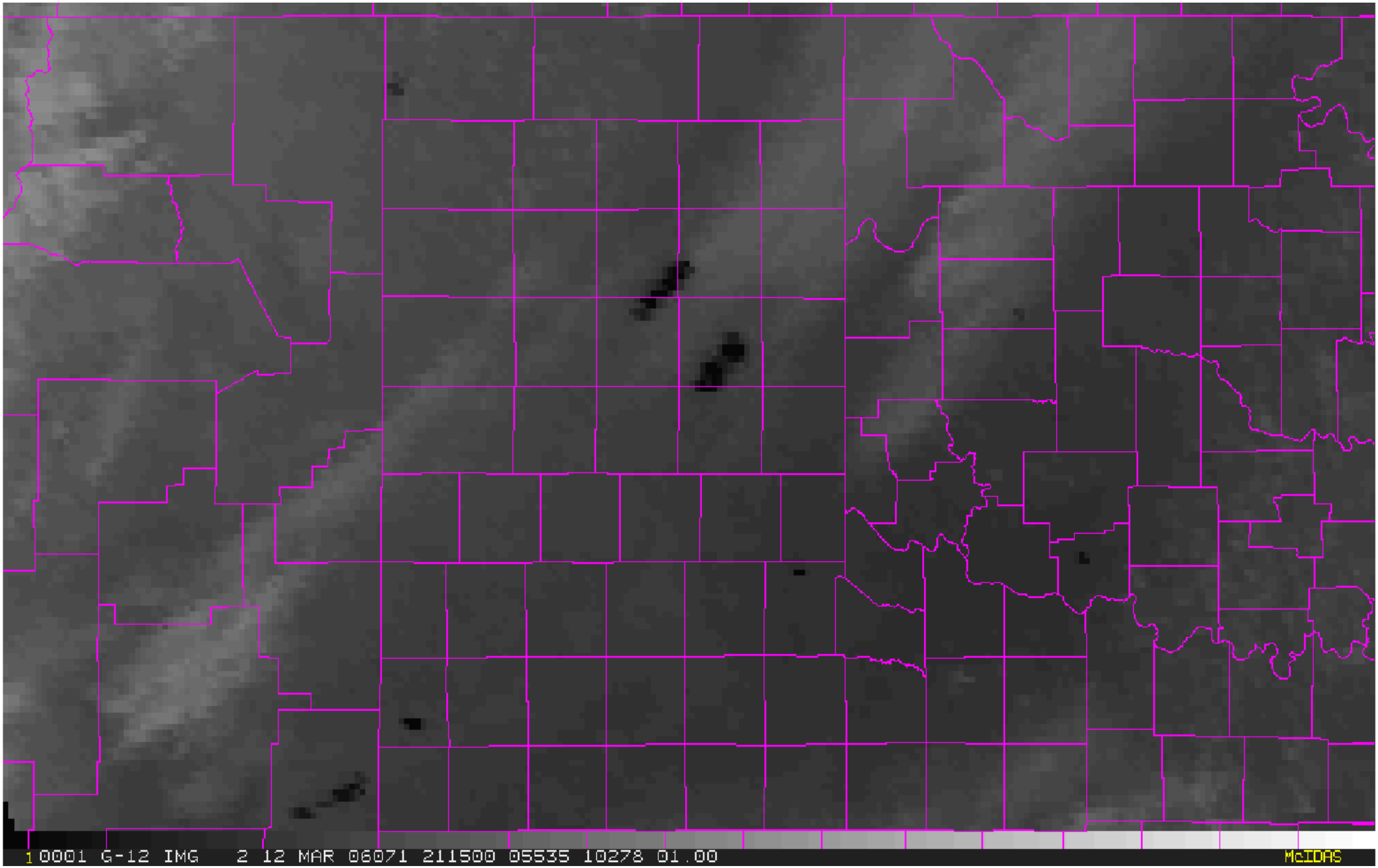
1) Improvement and Validation of Convective Initiation/Cloud Top Cooling Rate Using WDSS-II Object Tracking: with CIMSS

2) Enhanced use of GOES for estimating land surface wetness with application to wildfire forecasting at the NOAA Storm Prediction Center: with SPC

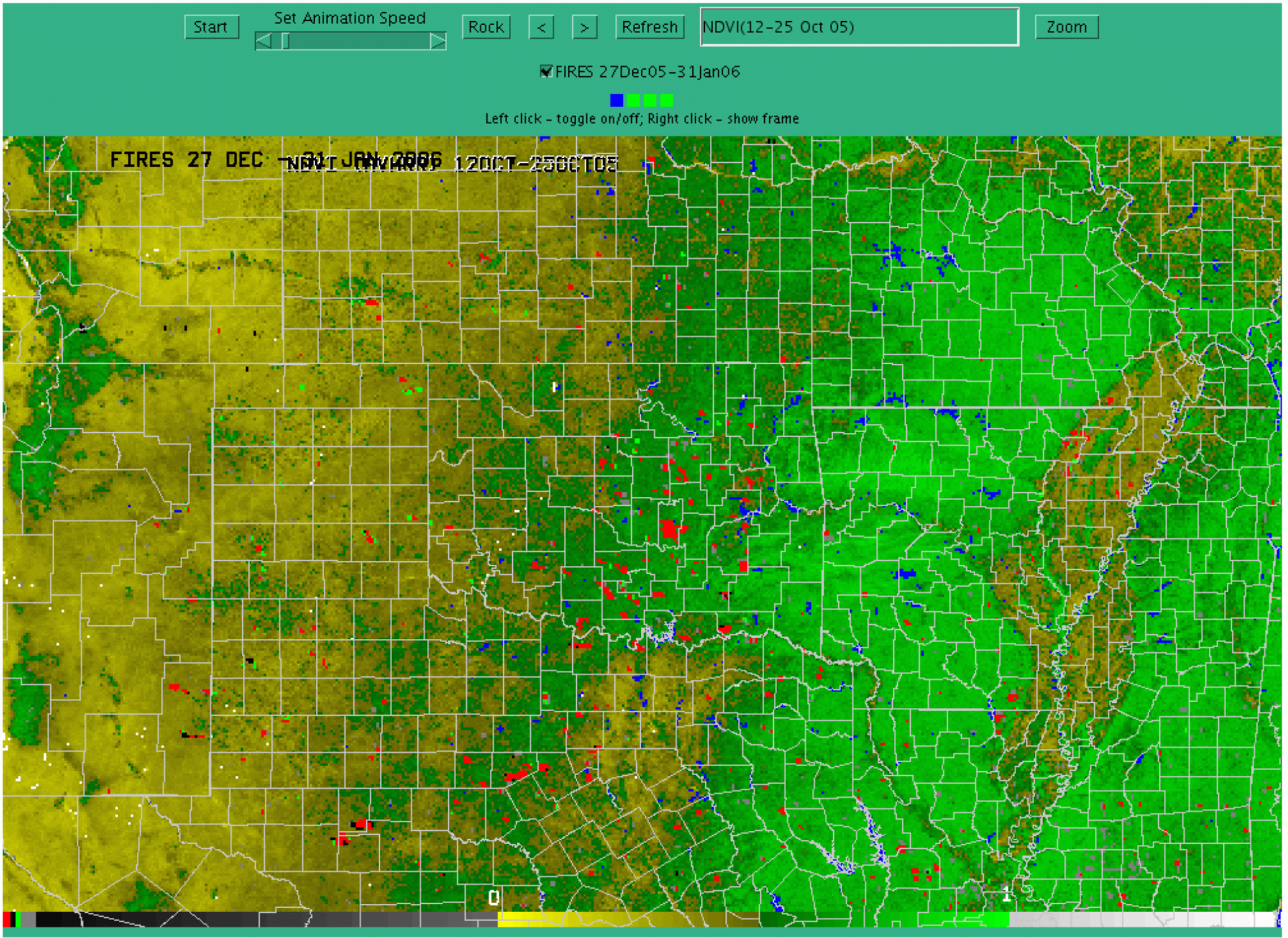
3) Using Quantitative GOES Information to Improve Short-Term Severe Weather Forecasts: with CIRA

4) GOES Biomass Burning Research and Applications: with SPC and CIMSS (collaboration)

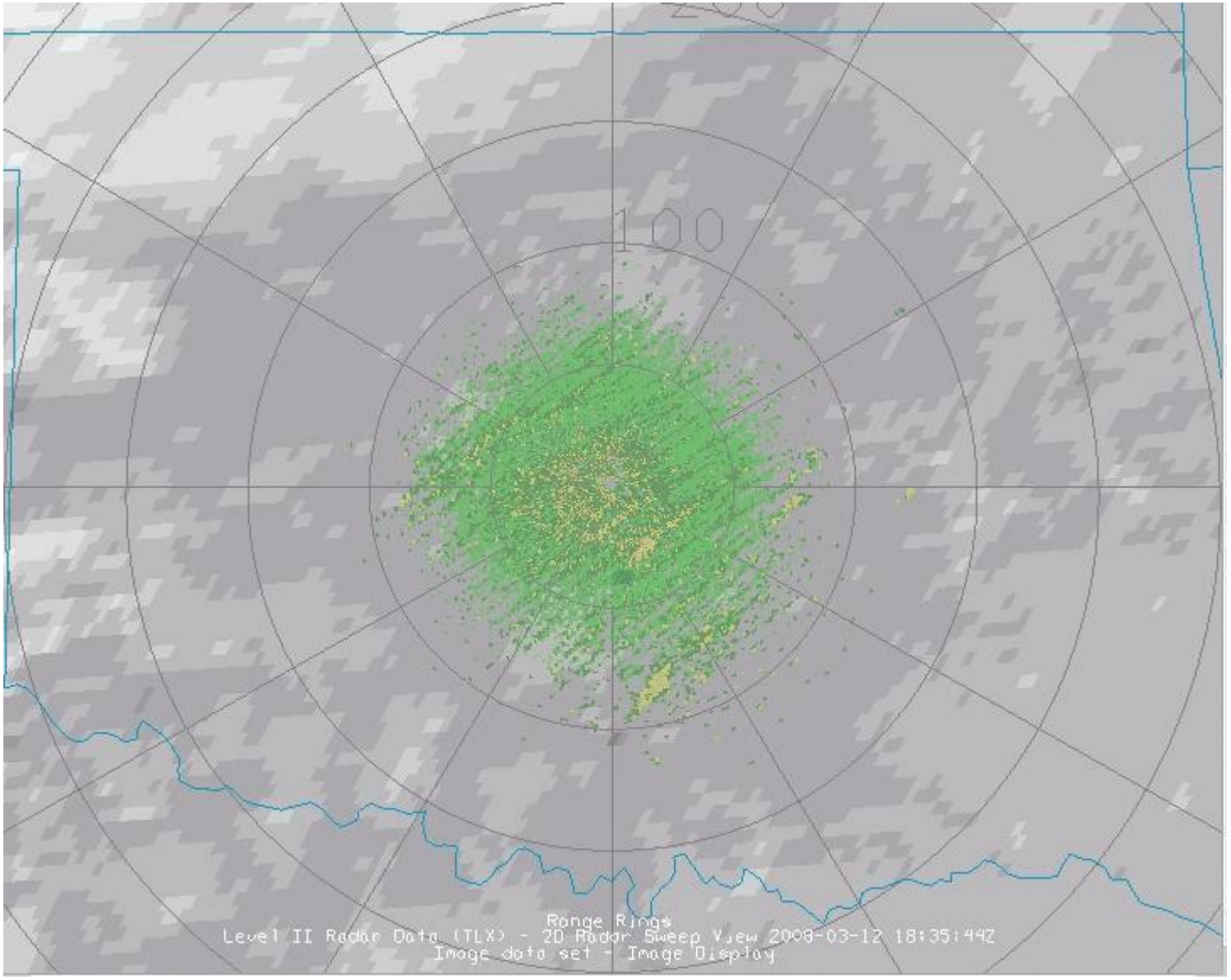
# Texas fires 12 March: GOES vis and near IR



# Fires and Surface Factors

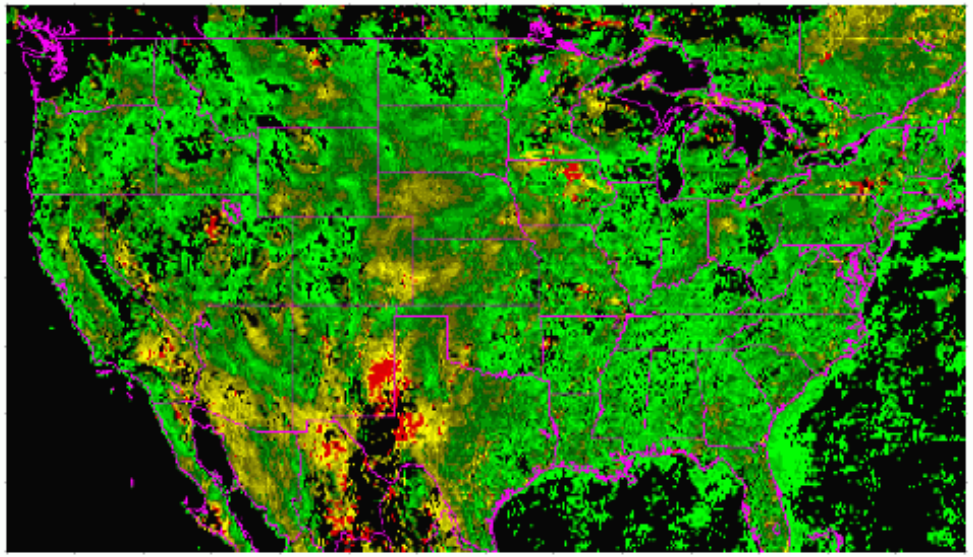


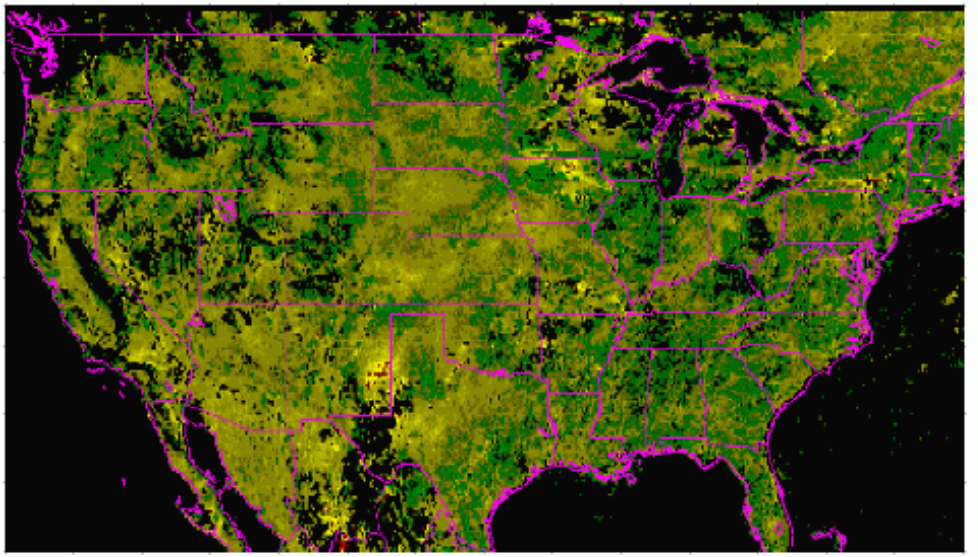
# Wildfires from radar and satellite: 12 March 2008:



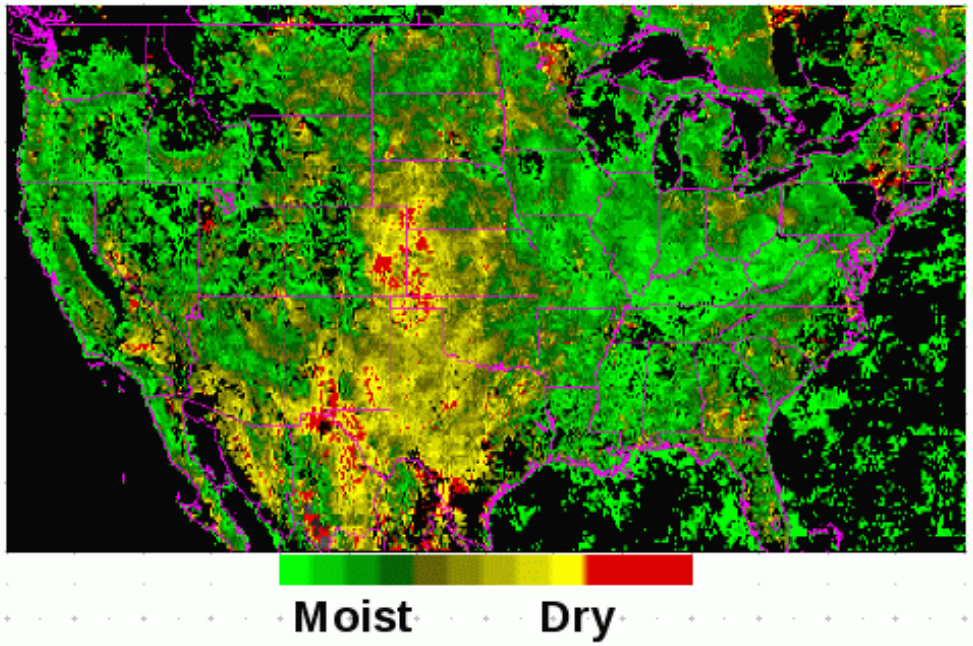
## Normalized Heating Rate

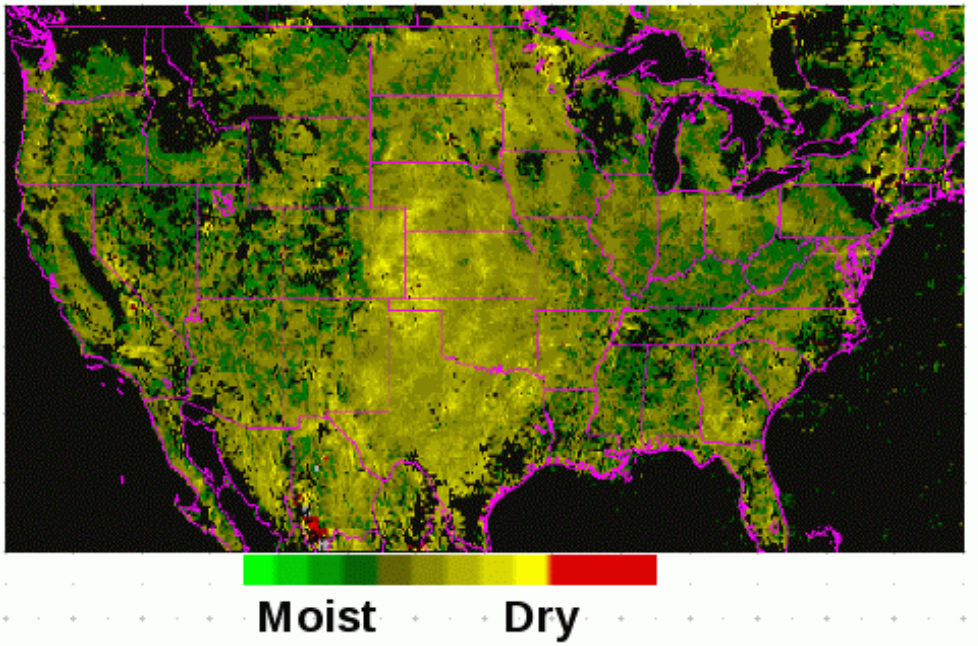
## Heating Rate Anomaly





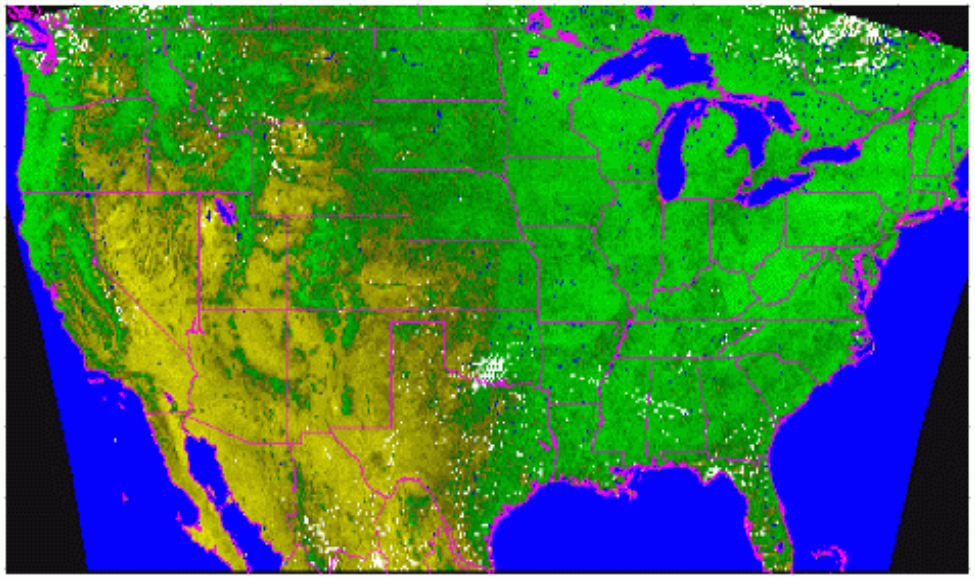
**01 July 2010**

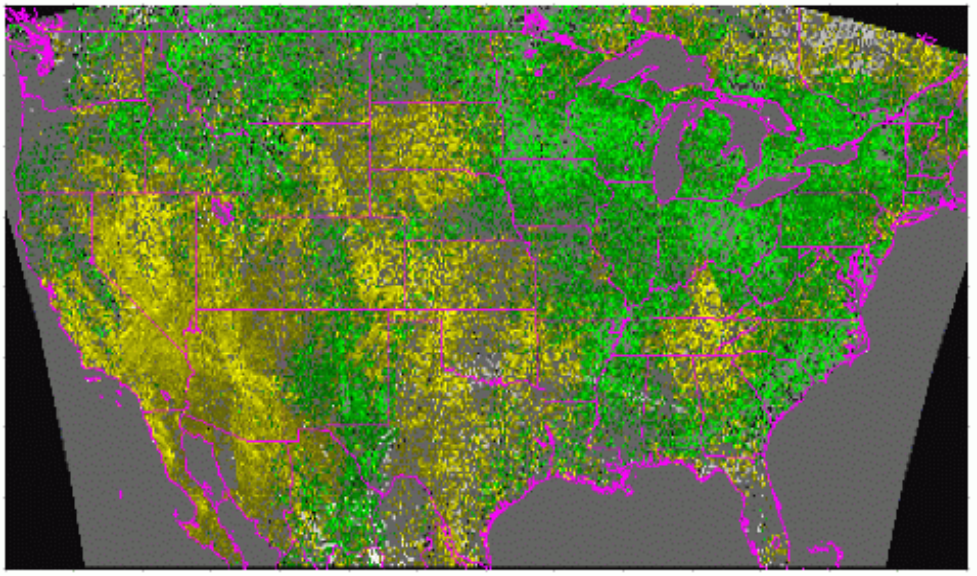


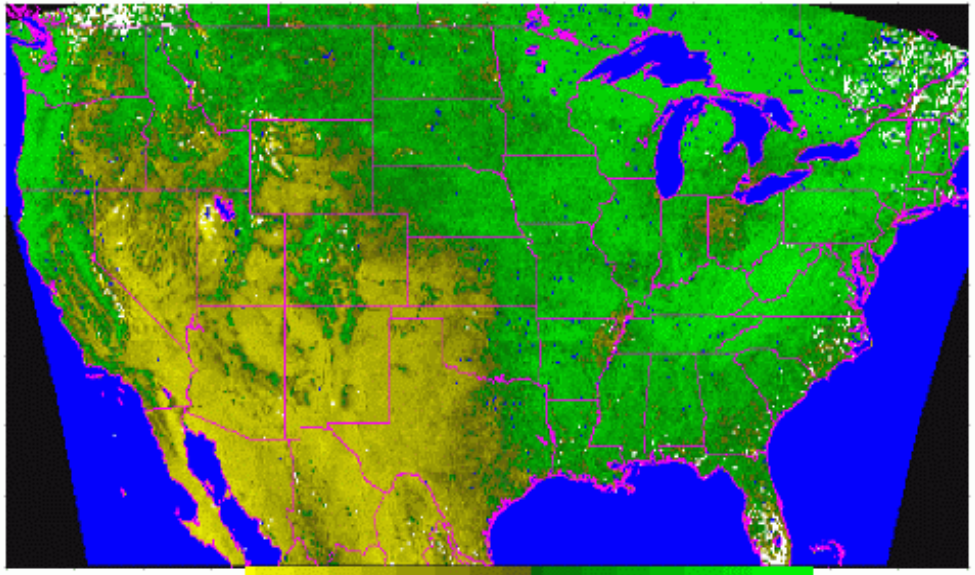



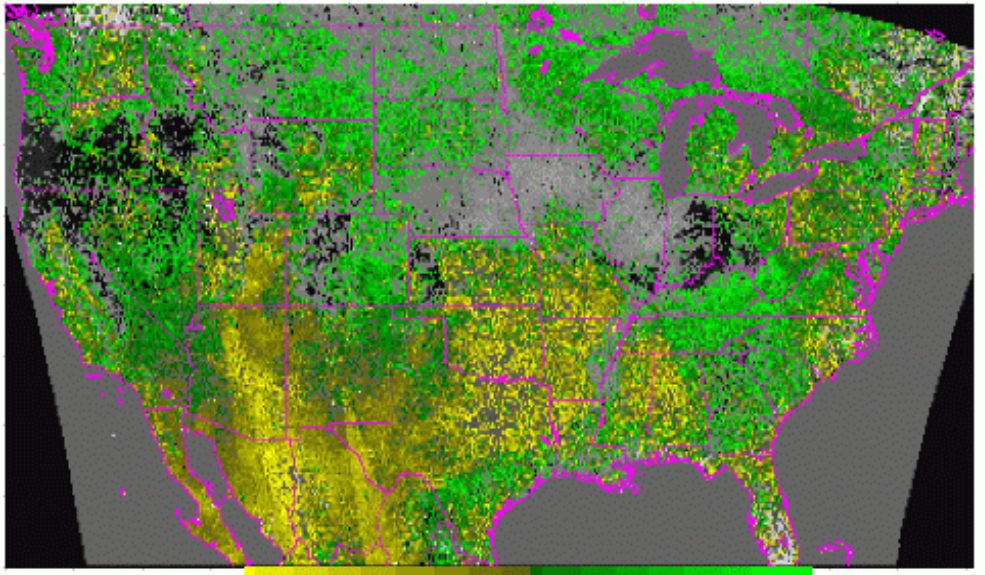

**01 July 2011**

NDVI









Low High

Decrease Increase

## Source: NESDIS GOES-R Risk Reduction Program

**1) Improvements to QPE using GOES visible ABI and model data**

**with CIRA, CIMSS, NESDIS**

**2) Convective Storm Forecasting 1-6 Hours Prior to Initiation**

**with CIRA, CIMSS, UAH, CREST**

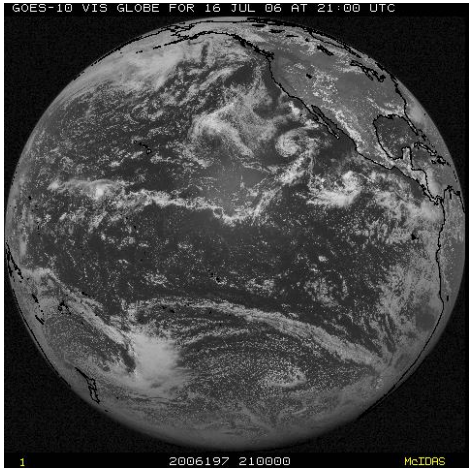
**3) Cloud-top Relief Spatial Displacement Adjustments for GOES-R Images**

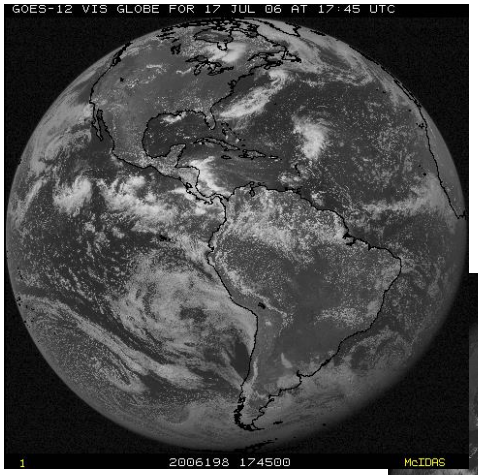
**with CREST**

# •GOES Constellation

•GOES-11
•(135W)

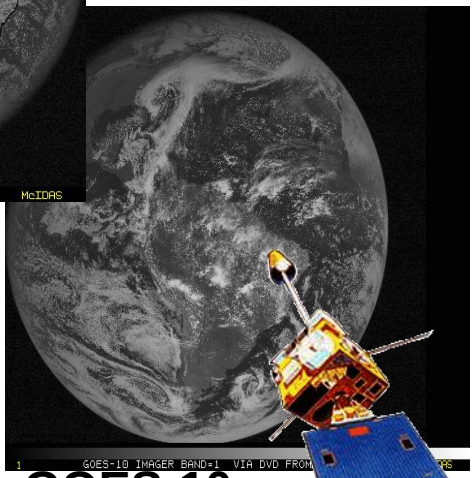
•Operational

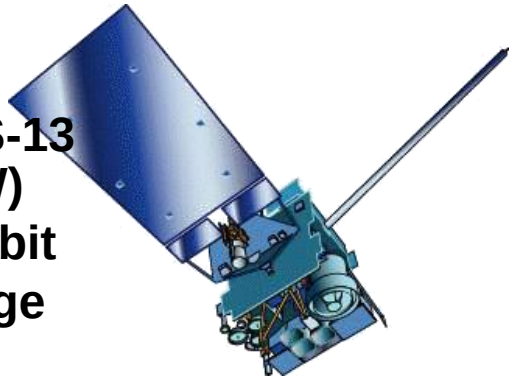



•GOES-12
•(75W)

•Operational



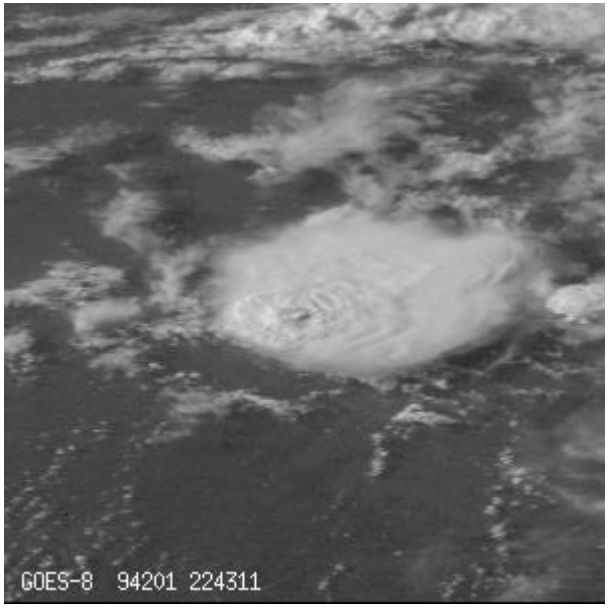



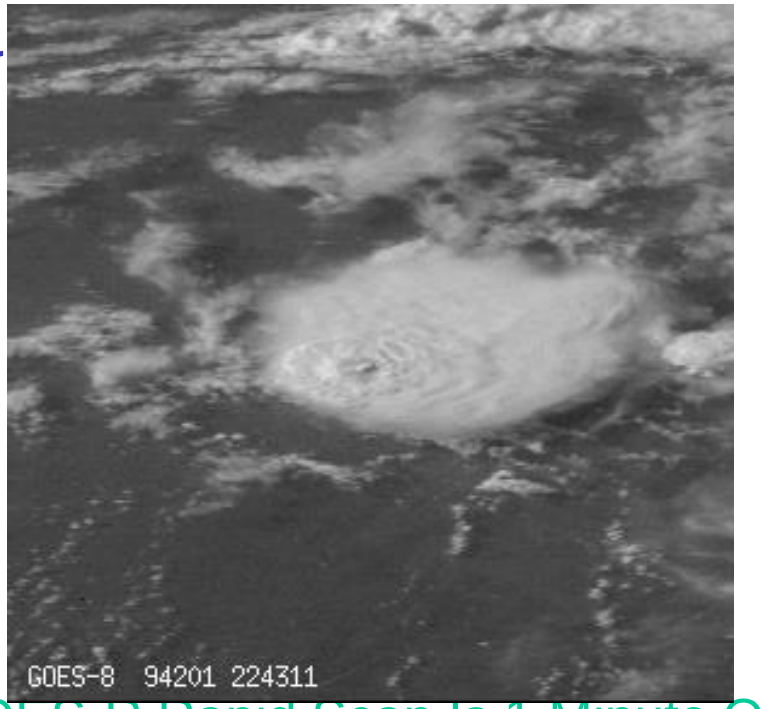
•GOES-13
•(105W)
•On-orbit
•Storage

•GOES-10
•(60W)
•South America

# •GOES-R Will Lead To Improvements . . .

•Observe Phenomena With Greater Frequency

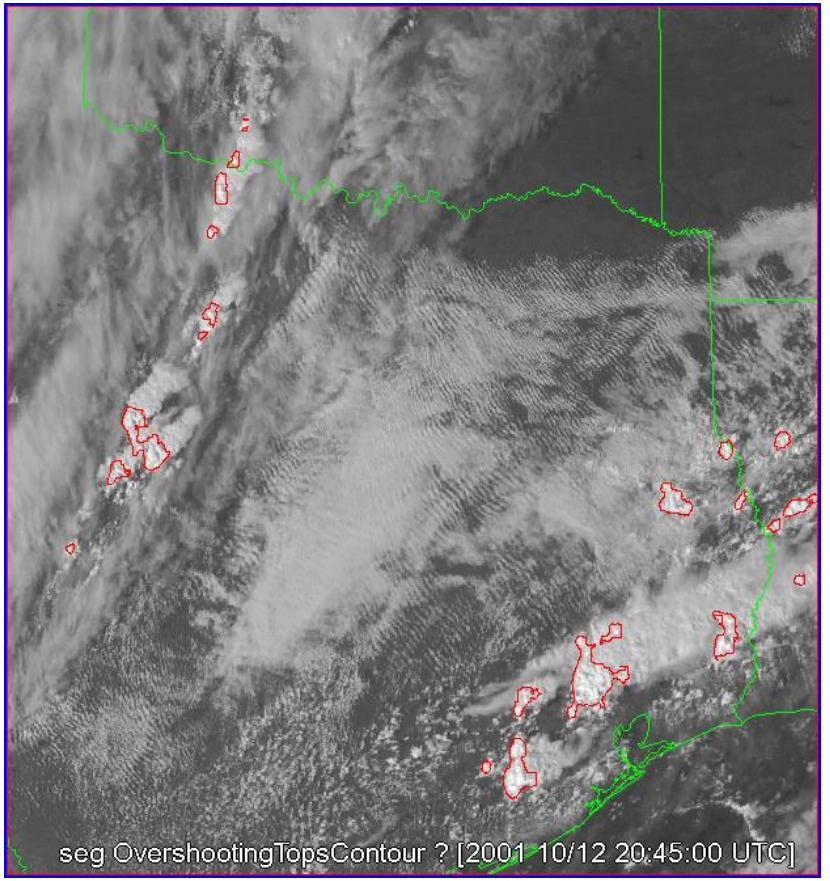


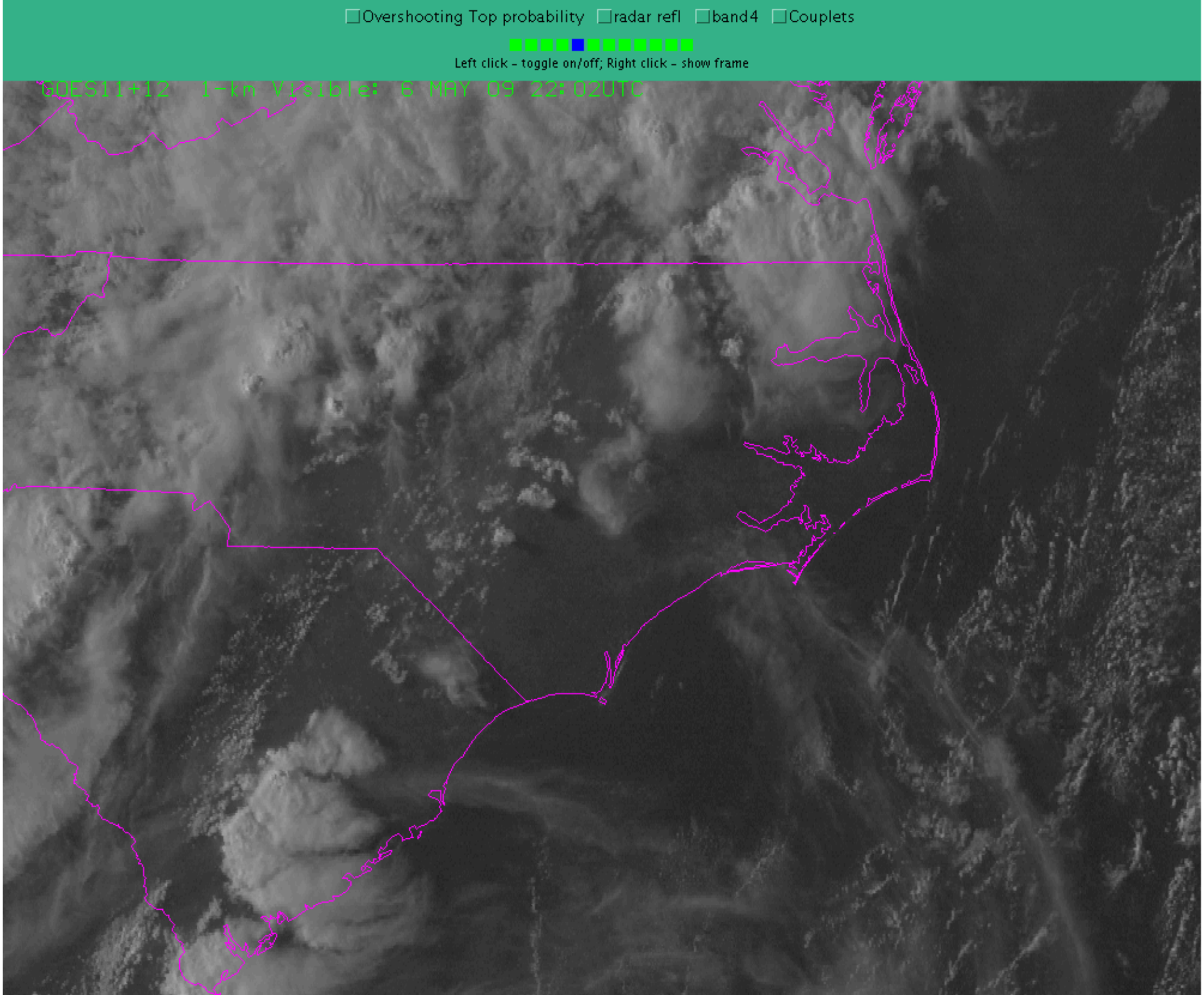



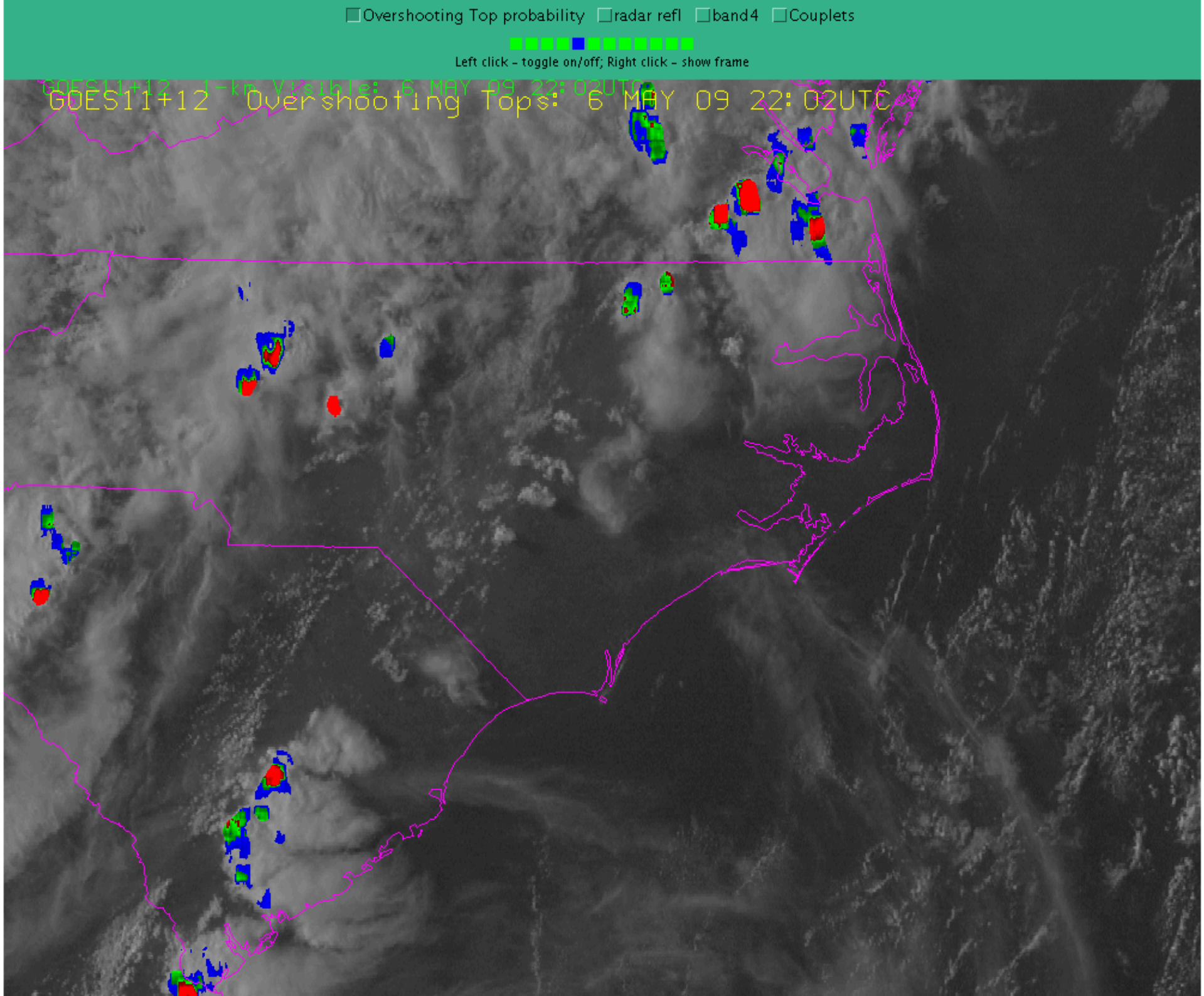

- Less! GOES-R Rapid Scan Is 1 Minute Or
- •GOES-I/P Rapid Scan Is 5 Minutes

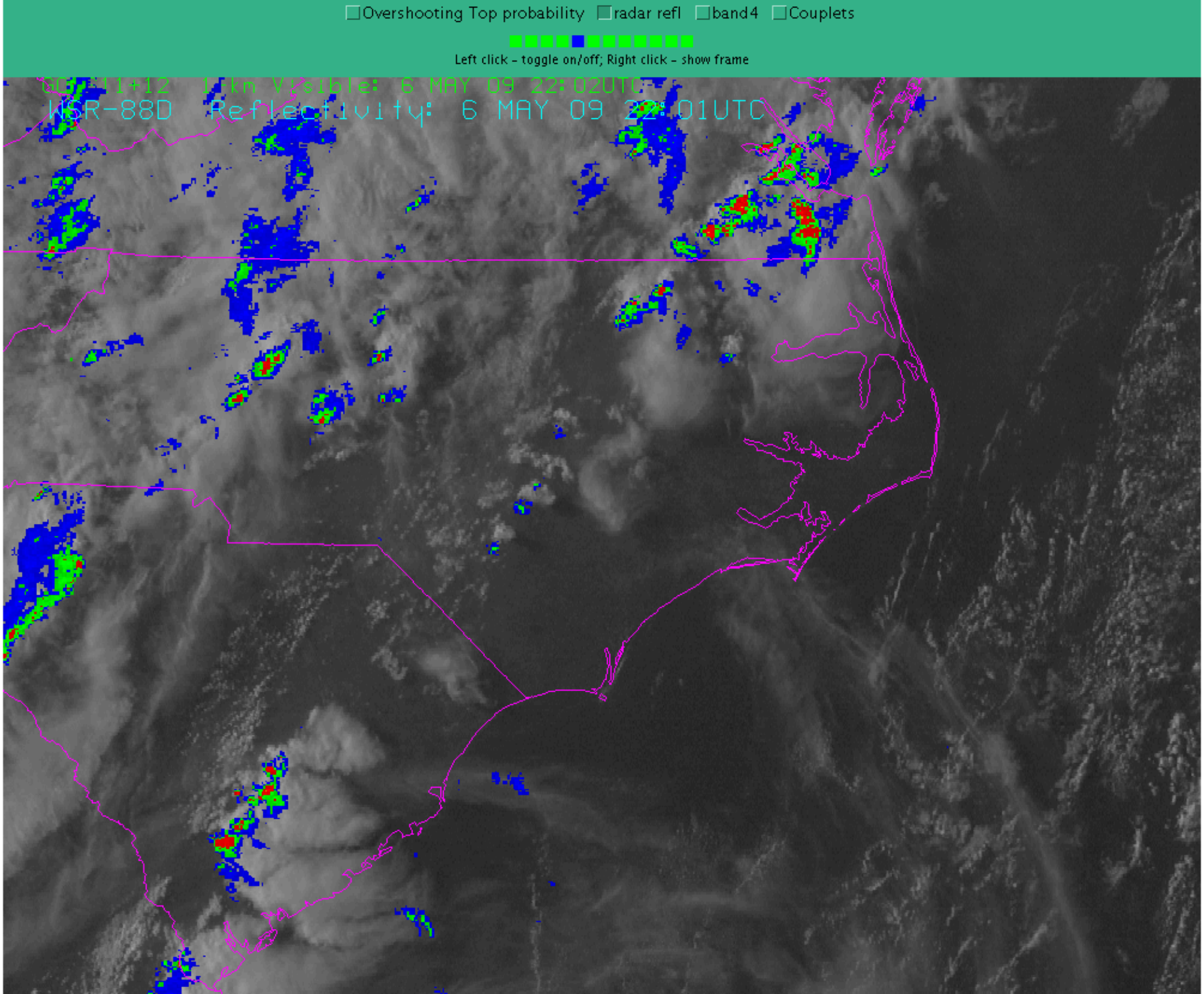
# Detecting Overshooting Tops

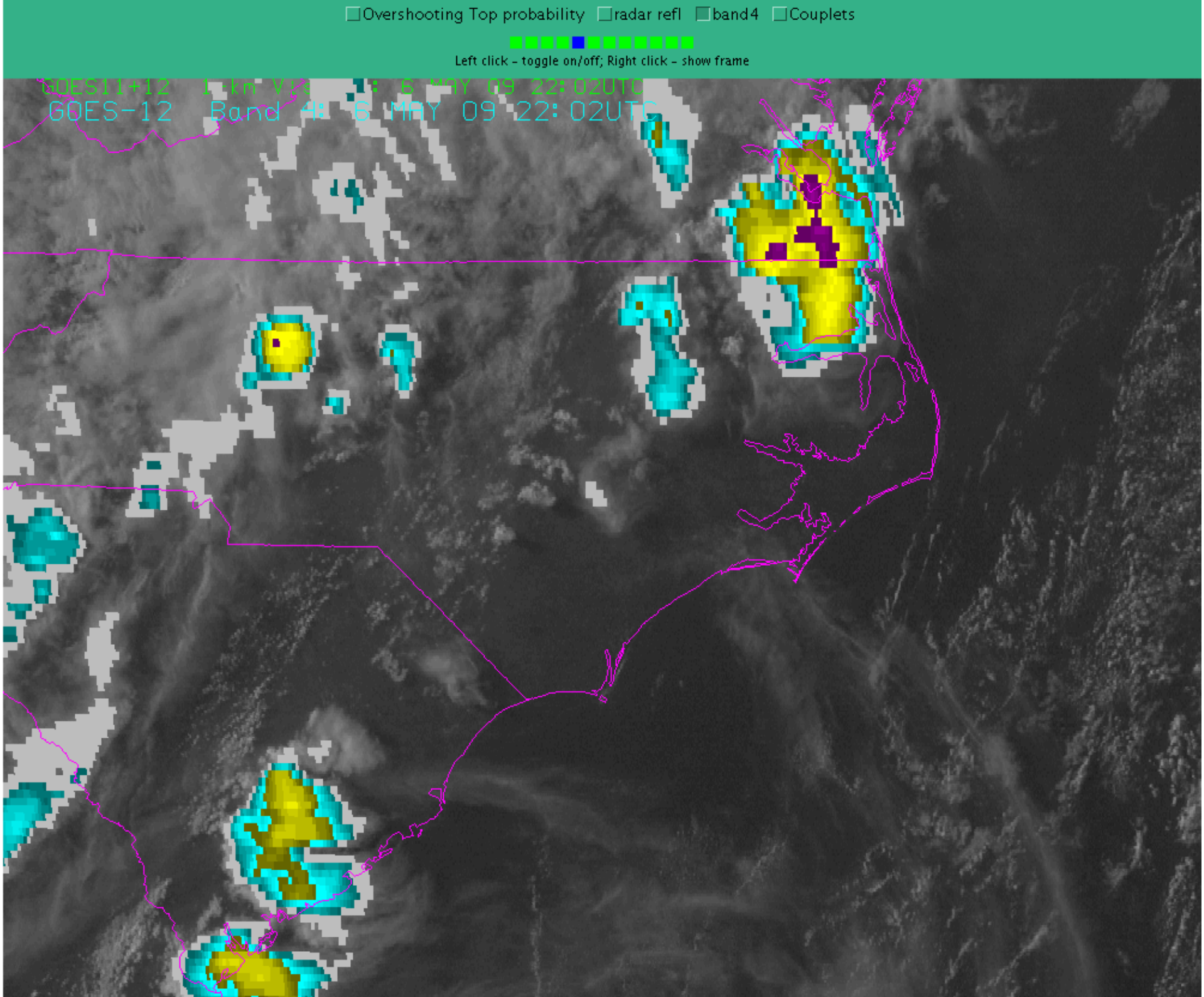
- Looked for high textural variability in visible images
  - These are the thunderstorms to be identified and forecast
  - Shown outlined in red
- Detection algorithm now running in real-time at NSSL
  - http://www.nssl.noaa.gov/users/rabin/public_html/vis_1km/

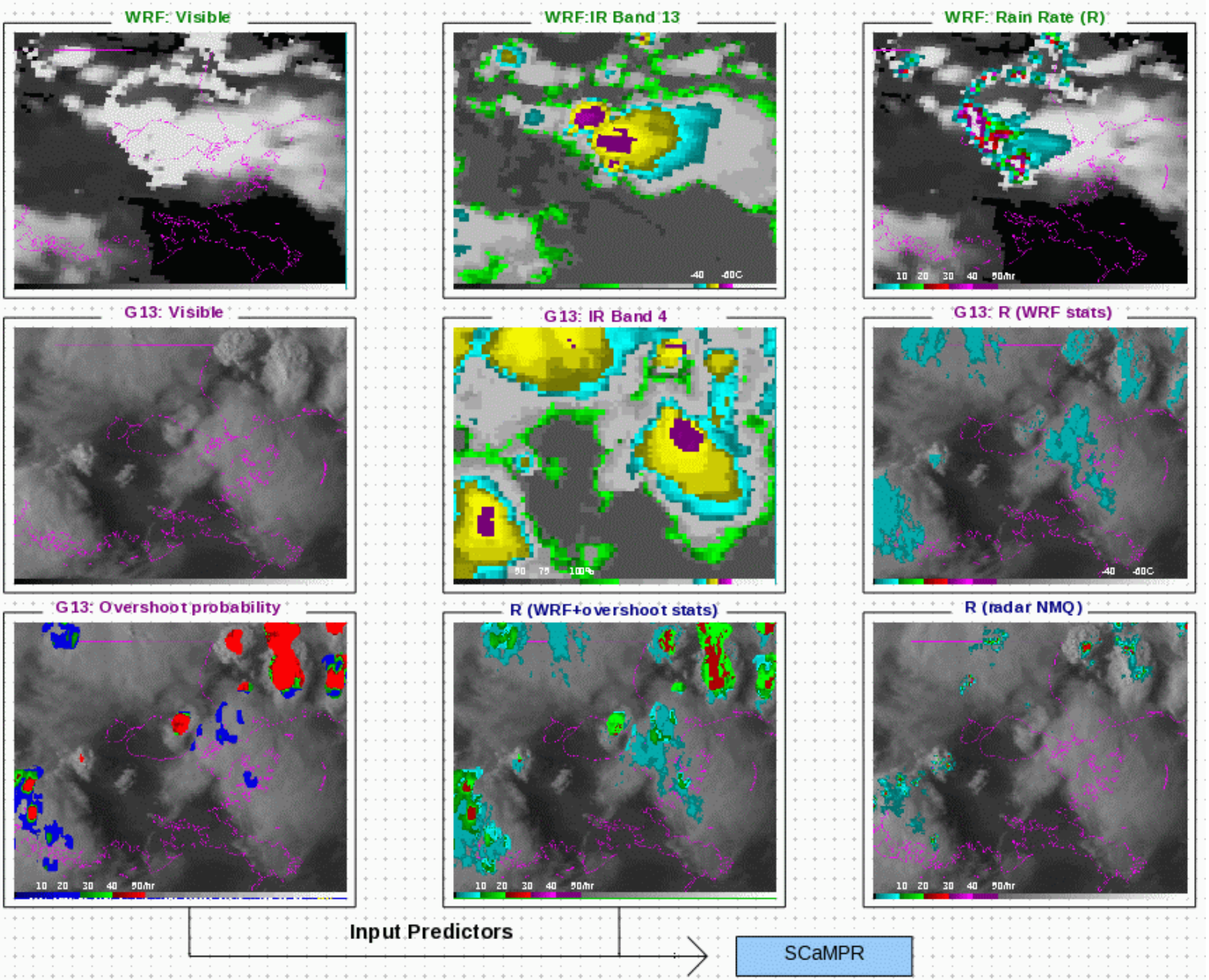



Overshooting Top probability
radar refl
band4
Couplets
Left click - toggle on/off; Right click - show frame
GOES11+12 1-km Visible: 6 MAY 09 22:02UTC

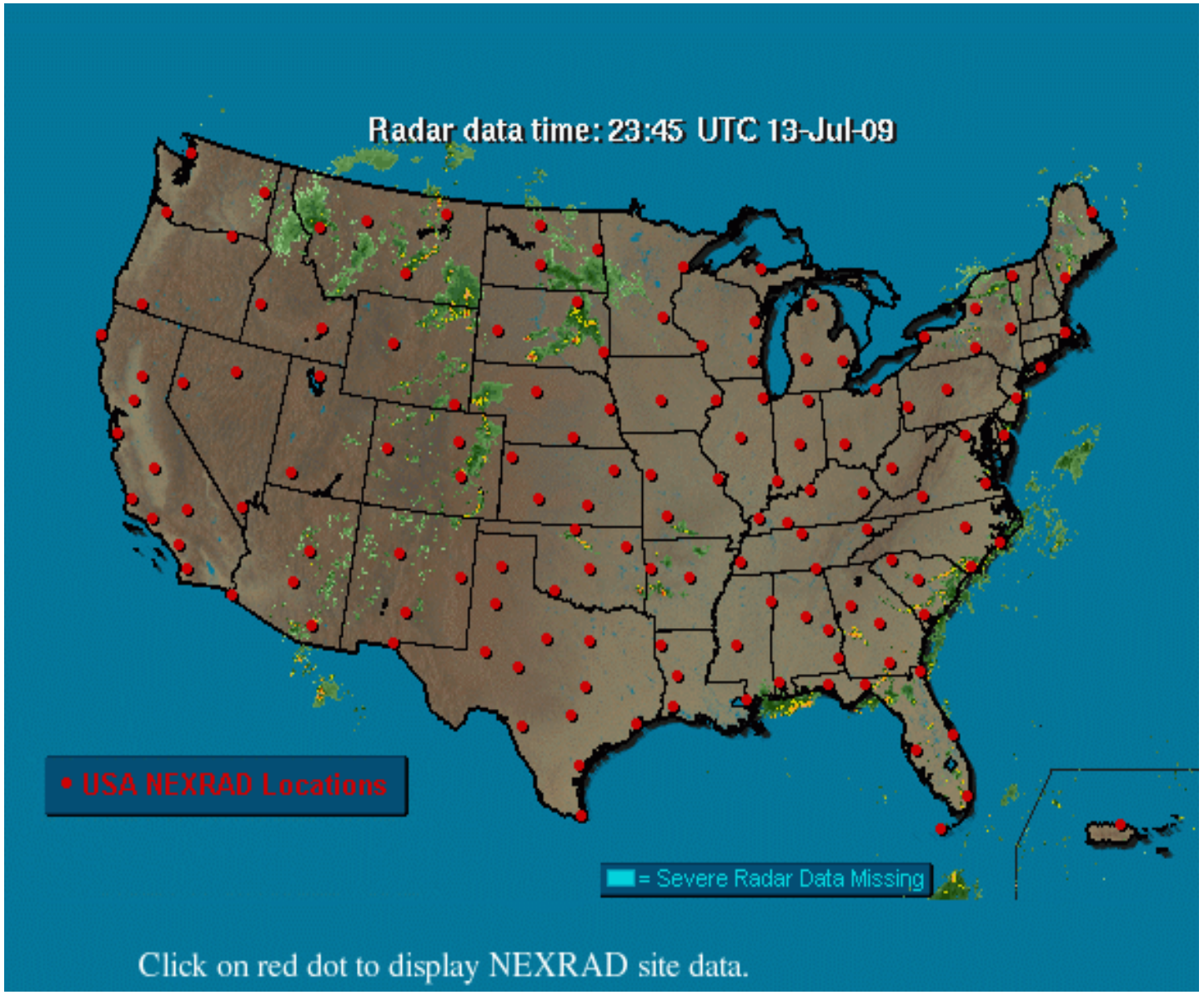

Overshooting Top probability
radar refl
band4
Couplets
Left click - toggle on/off; Right click - show frame
GOES11+12 Overshooting Tops: 6 MAY 09 22:02UTC


Overshooting Top probability
radar refl
band4
Couplets
Left click - toggle on/off; Right click - show frame
WSR-88D Reflectivity: 6 MAY 09 22:01UTC

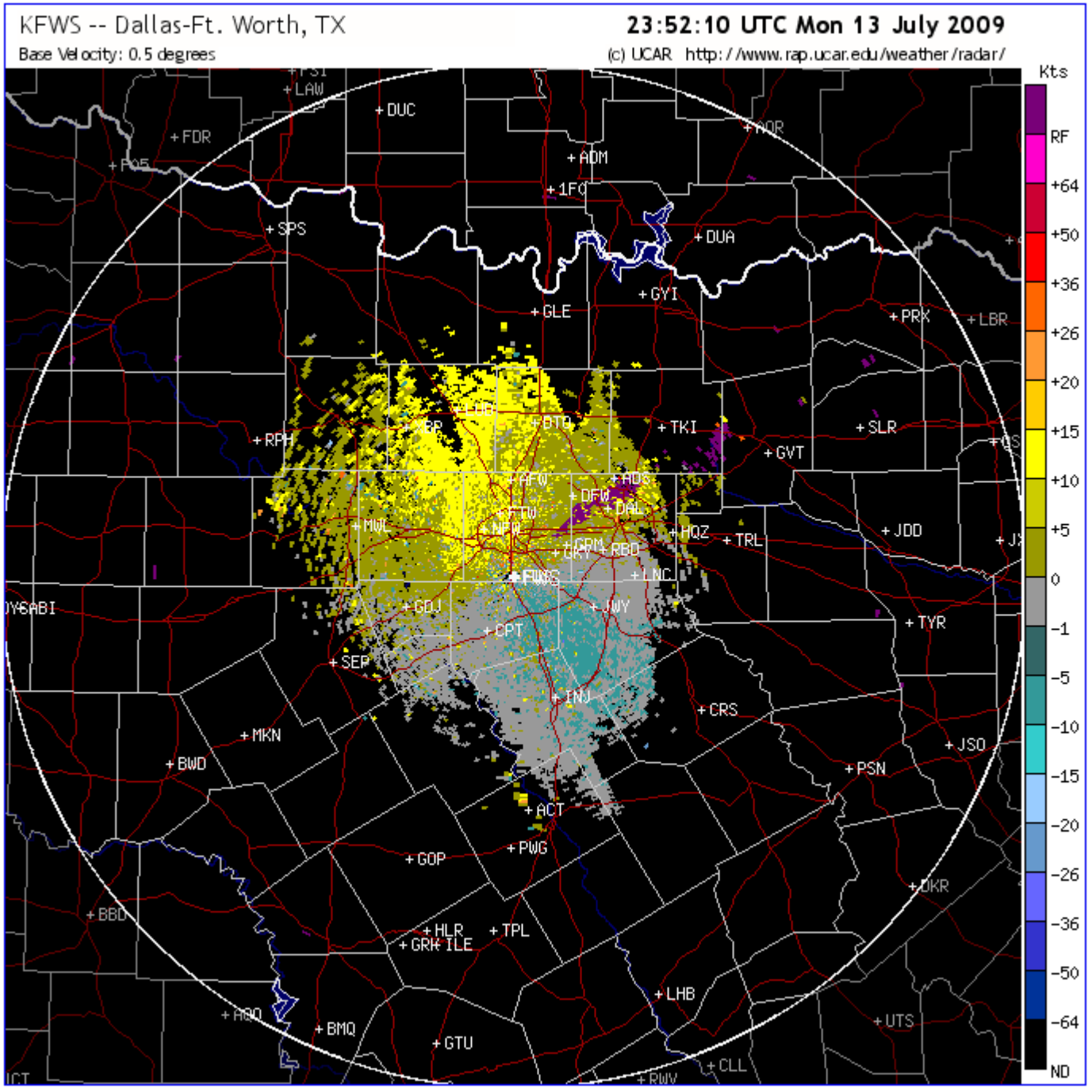

Overshooting Top probability
radar refl
band4
Couplets
Left click - toggle on/off; Right click - show frame
GOES-12 Band 4: 6 MAY 09 22:02UTC


WRF: Visible
WRF:IR Band 13
WRF: Rain Rate (R)
G13: Visible
G13: IR Band 4
G13: R (WRF stats)
G13: Overshoot probability
R (WRF+overshoot stats)
R (radar NMQ)
Input Predictors
SCaMPR

# •National Doppler radar network (WSR-88D)



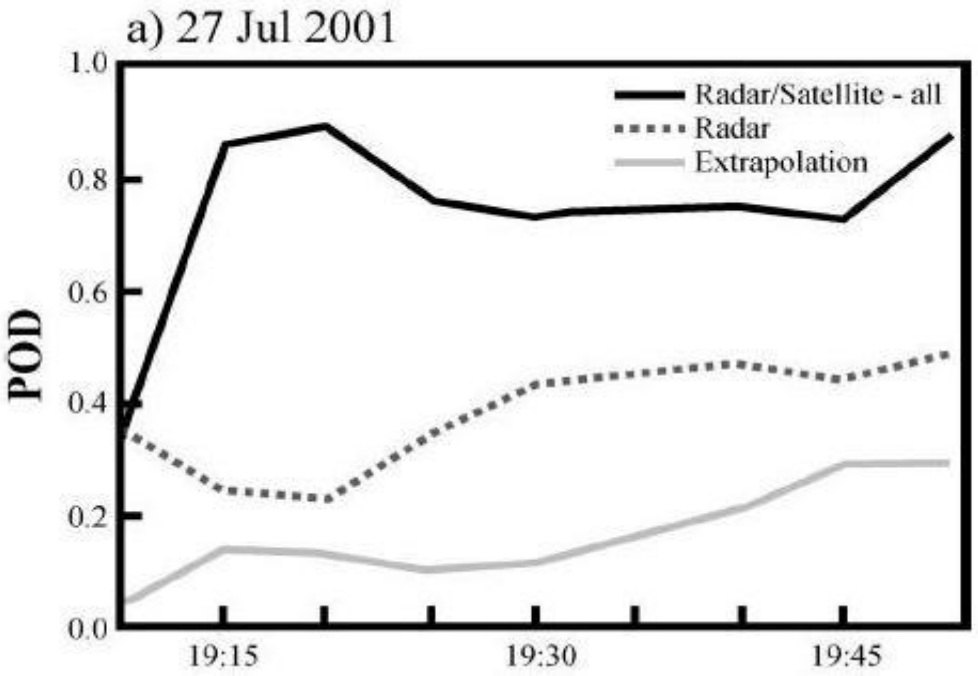
# •Boundary layer wind from Doppler radar

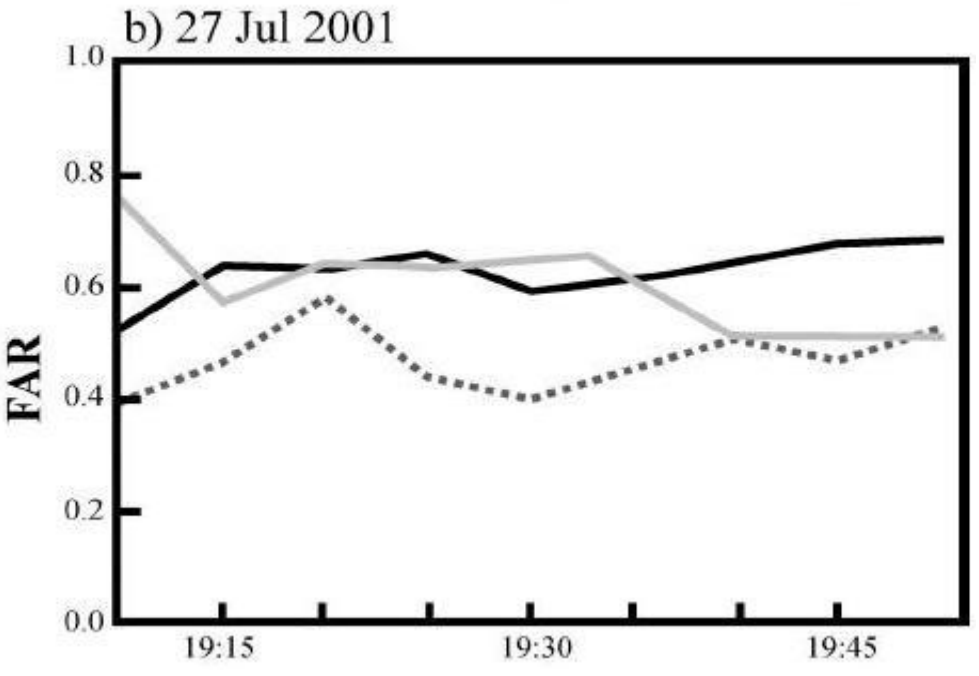


# *Nowcasting storm initiation and growth using GOES-8 and WSR-88D data*

Rita Roberts, Steven Rutledge

2003 WF



- Intensity related to rate of cooling
- Increased lead time

槍 - 15 minutes prior to 10 dBZ echoes aloft

槍 - 30 minutes prior to 30 dBZ echoes aloft

- NCAR automated nowcasting system

- Provides short-term (0-1 hr) nowcasts of storm location
- Identify boundary layer convergence lines
- Fuzzy logic to combine predictor fields
  - Radar, satellite, mesonet, profilers, models
- Improves over extrapolation and persistence
  - Tested at 3 locations (3 years)
  - Plans to include in NWS AWIPS

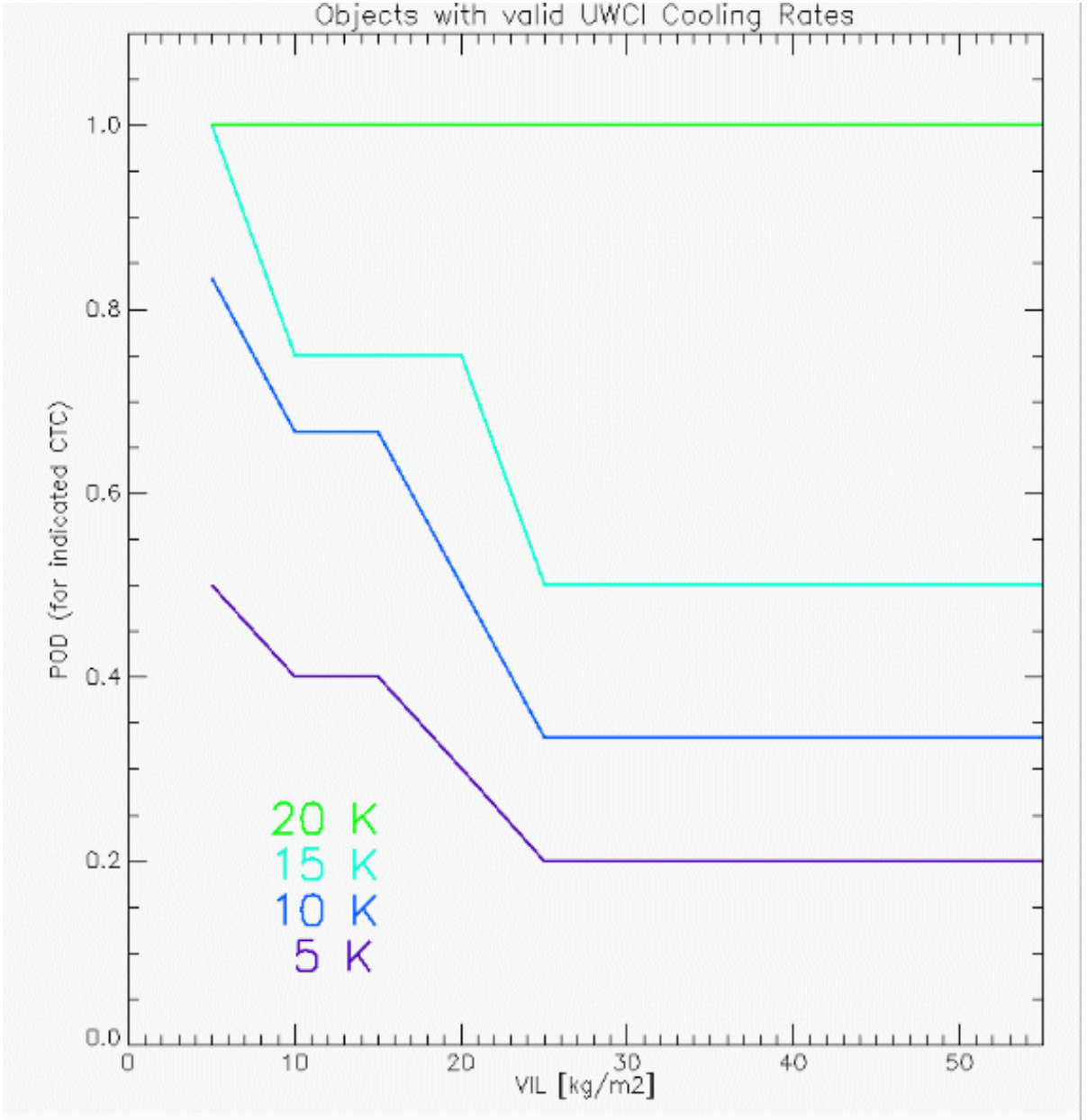
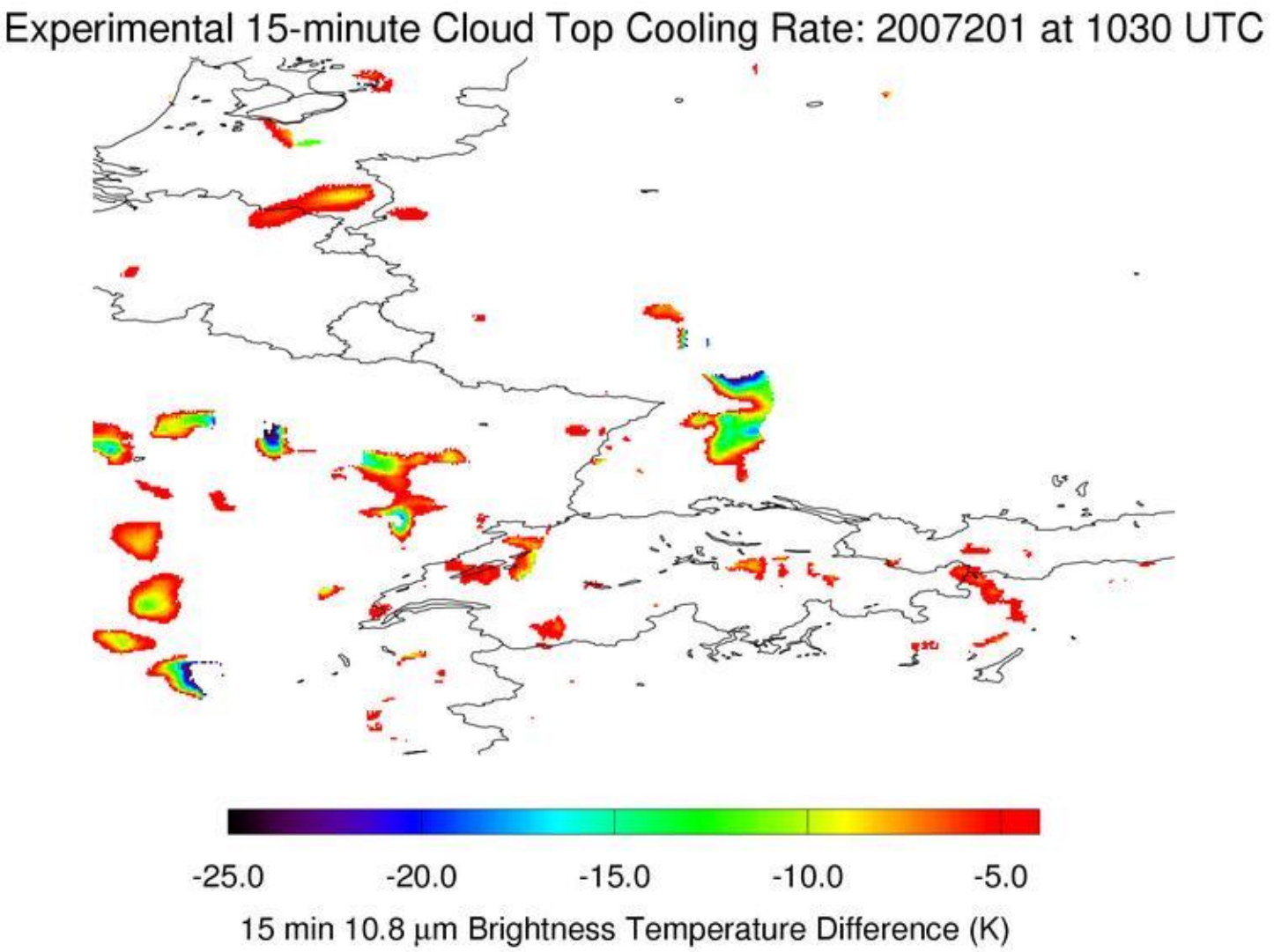
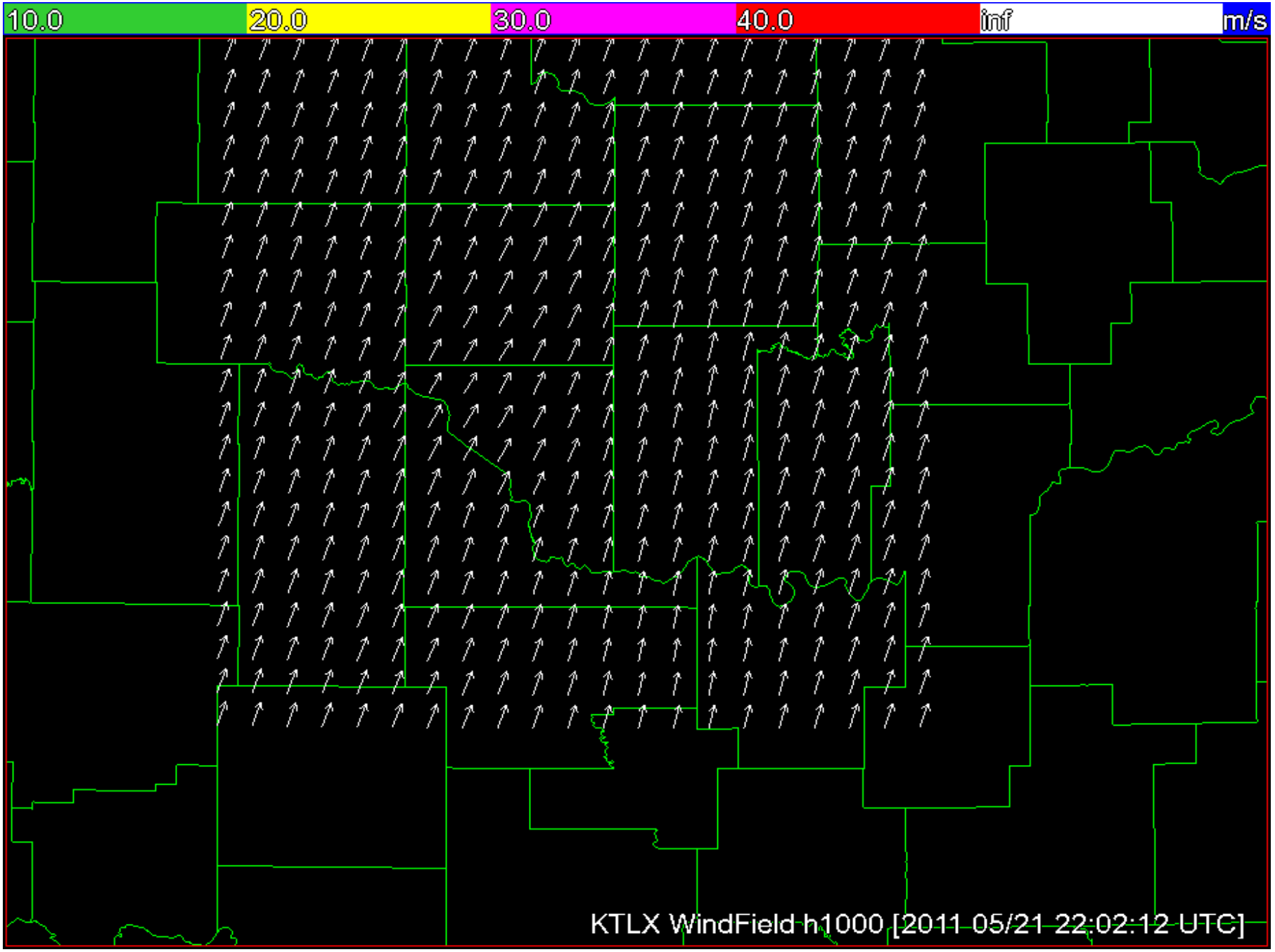


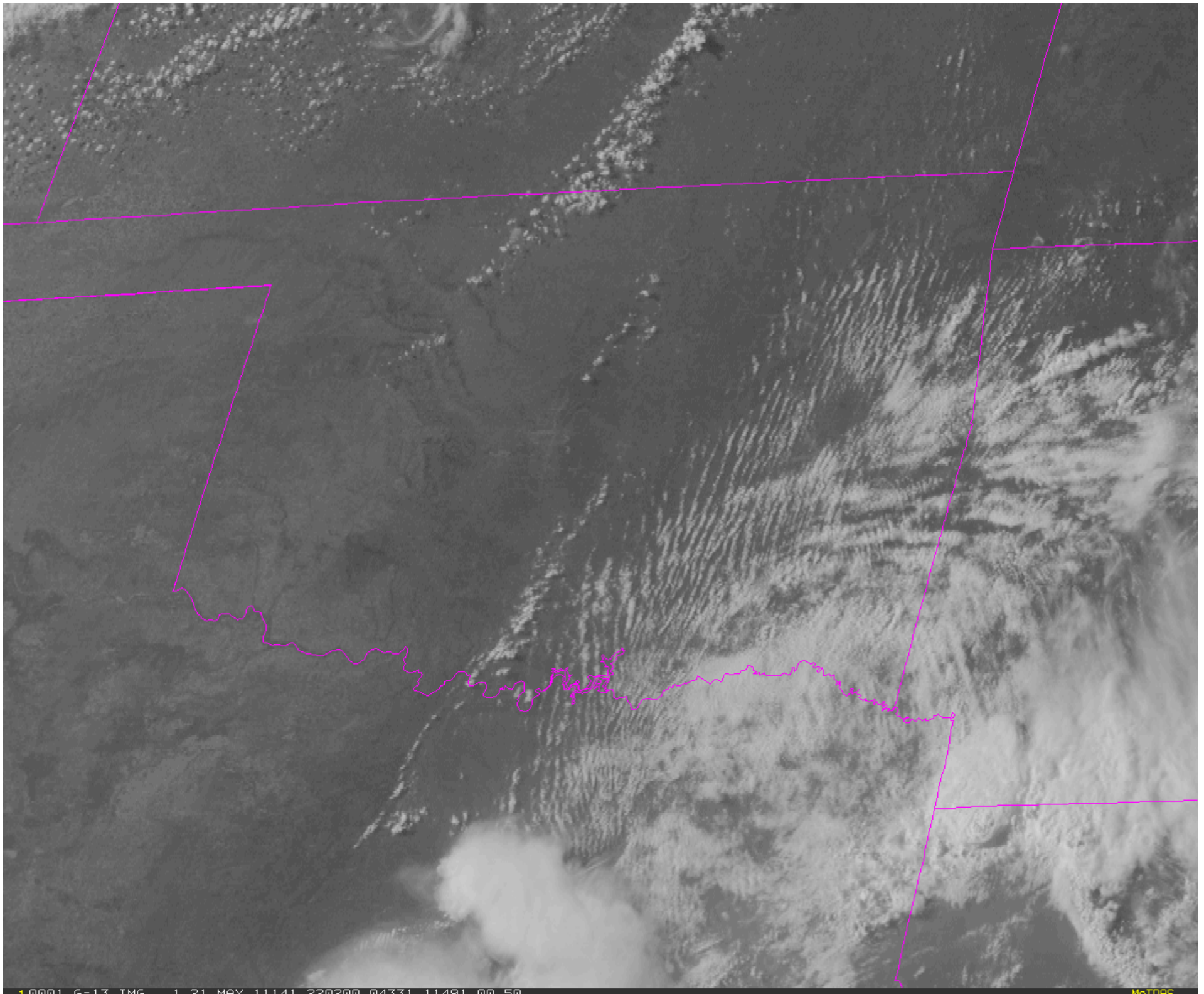

Figure 2.2: Probability of a storm achieving a given value of Vertically Integrated Liquid (VIL) for various magnitudes of UWCI Cloud-Top Cooling Rate for the afternoon of 29

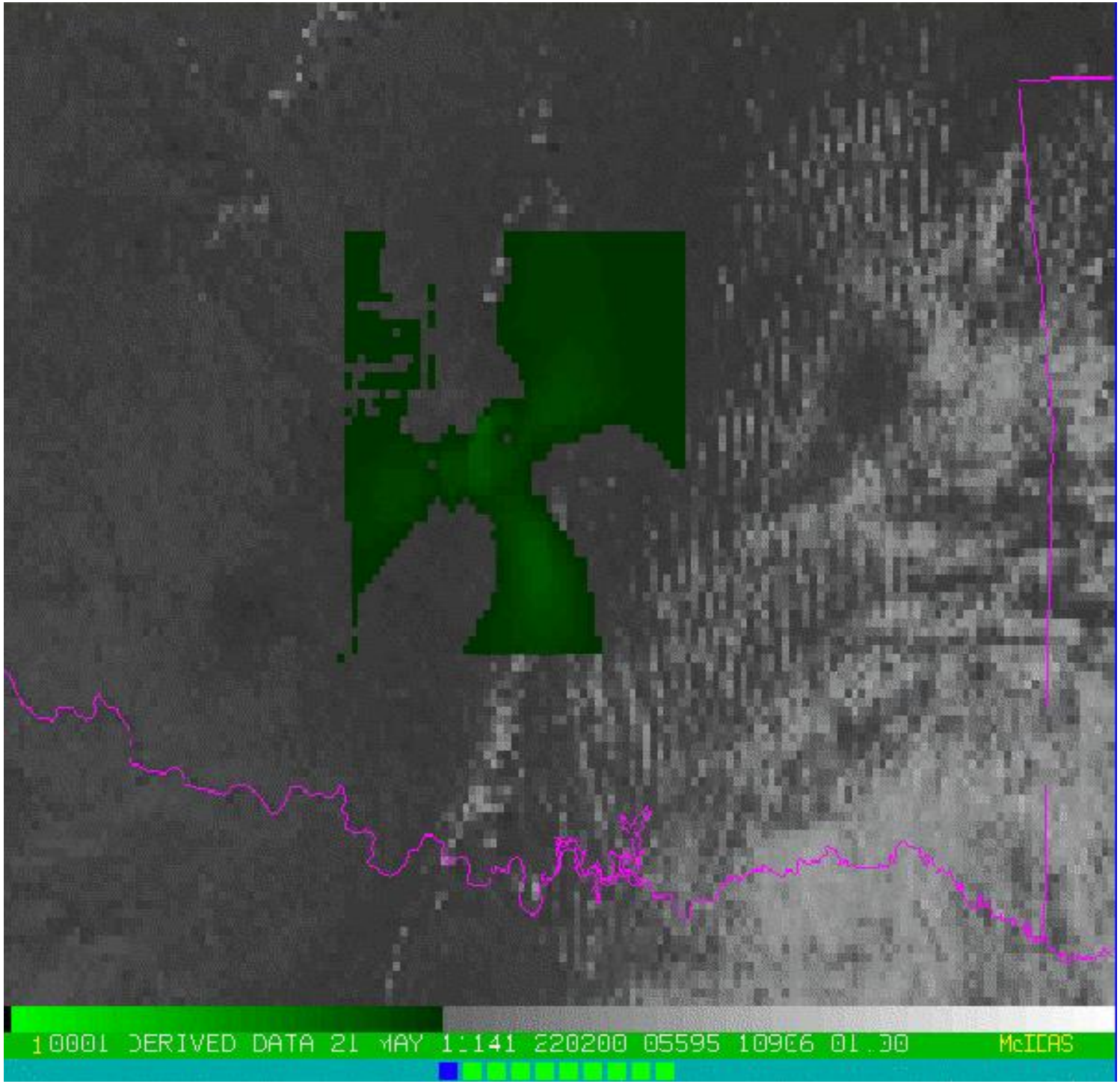
# *SEVIRI Convective Storm Nowcasting Product Examples*



# Doppler Radar observation of Winds

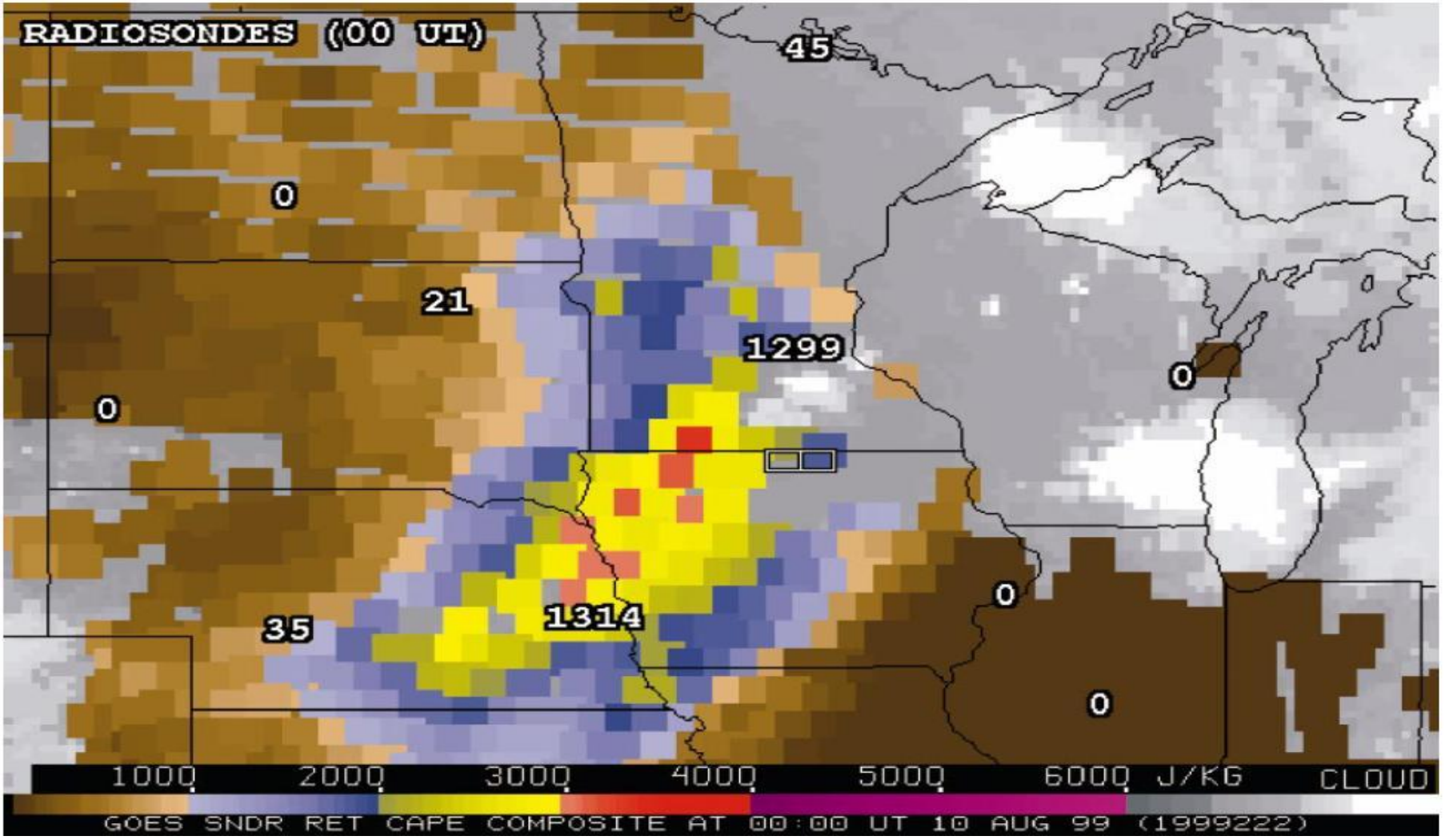



1.0001 G-13 IMG 1 21 MAY 11141 220200 04331 11481 00 50
McIDAS

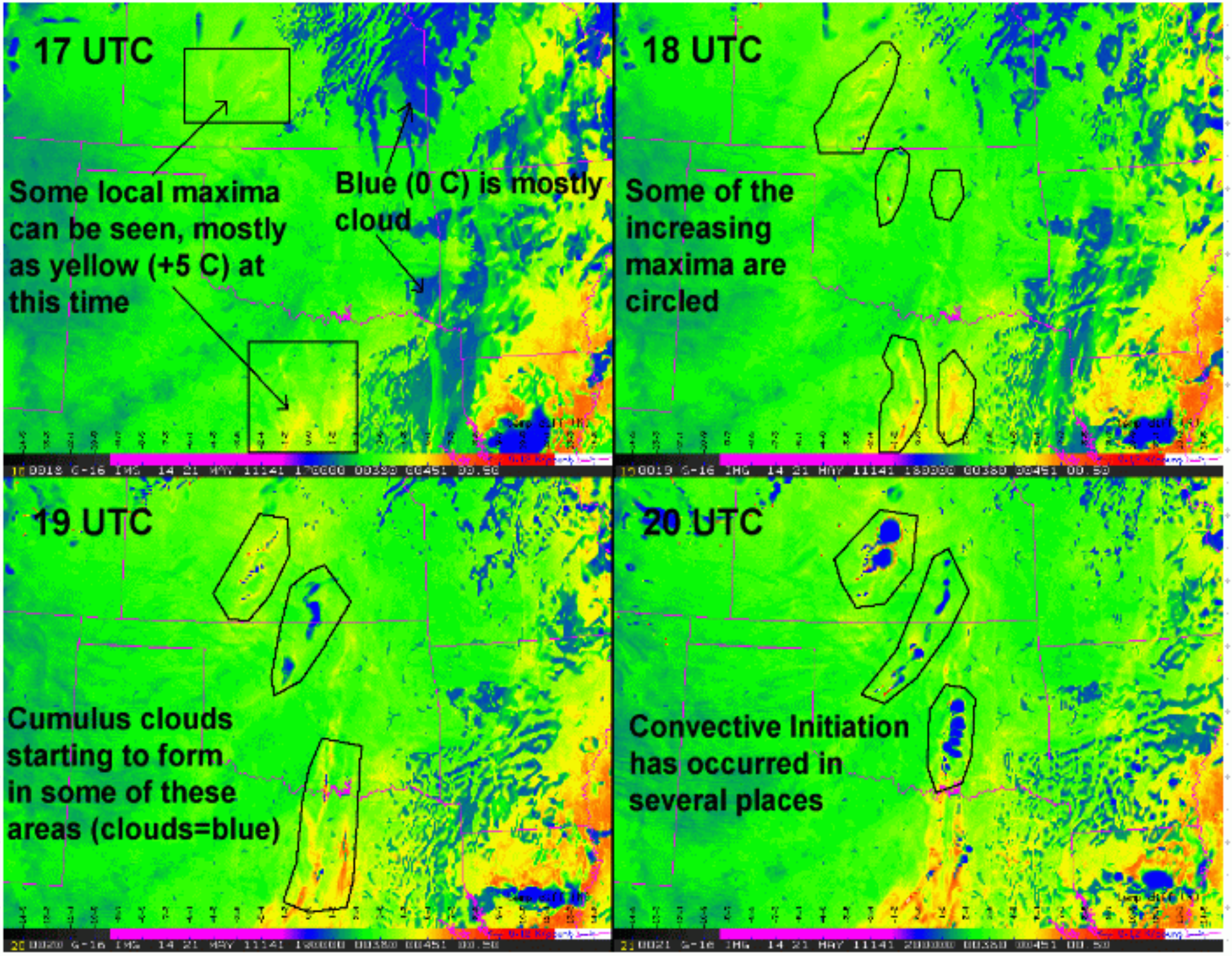

10001 DERIVED DATA 21 MAY 1:141 220200 05595 10966 01.00 McIDAS

# *Validation and use of GOES sounder information*

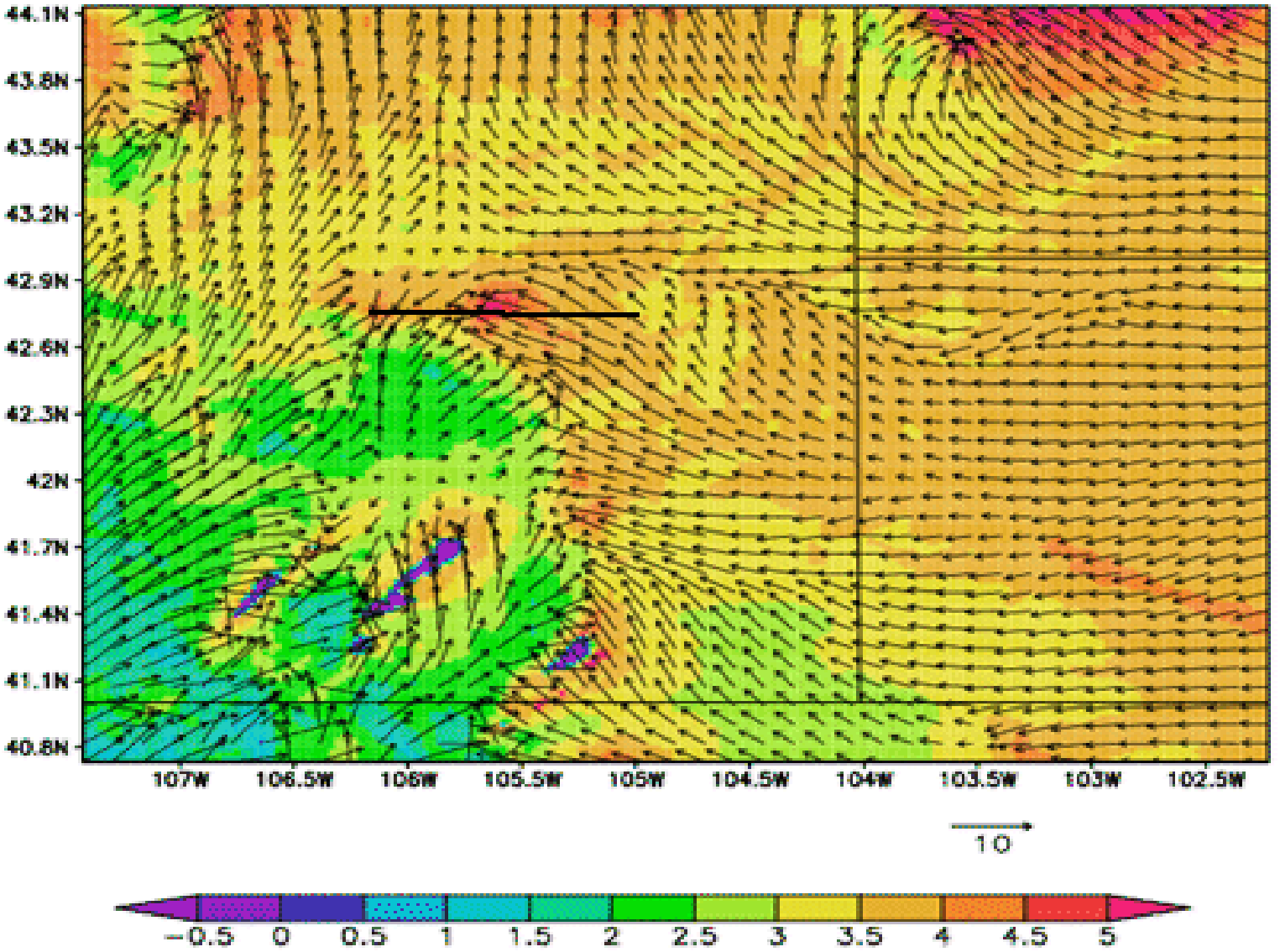
Tim Schmit, et al., 2002 WF

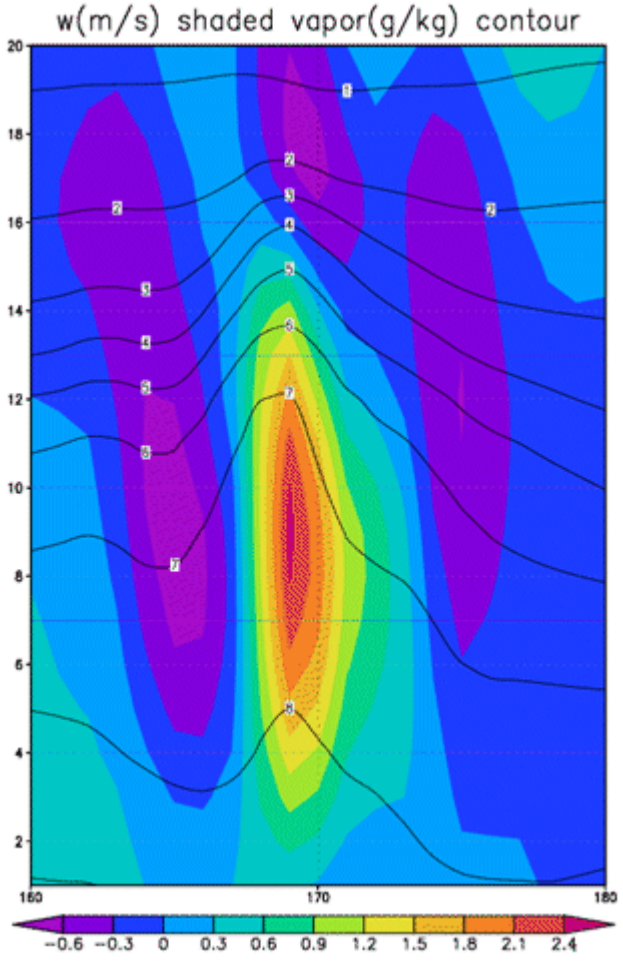


# Simulated 10.35 – 12.3 µm 21 May 2011



GOES-R simulated PBL moisture, WRF winds




w(m/s) shaded vapor(g/kg) contour
20
18
16
14
12
10
8
6
4
2
160
170
180
-0.6 -0.3 0 0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4

# Mesoscale Wind Analysis from Water Vapor Imagery

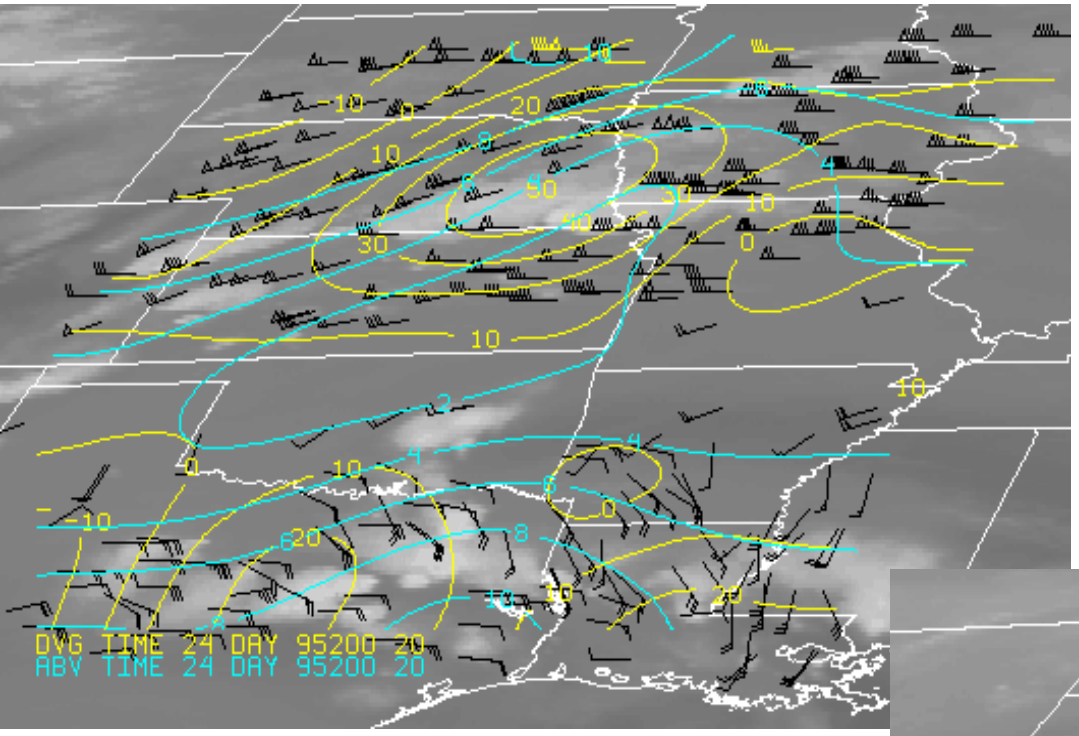
Detecting Winds Aloft from Water Vapour Satellite Imagery in the Vicinity of Storms

Rabin, R.M., Corfidi, S.F., Brunner, J.C., Hane, C.E.

Weather, 59, 251-257

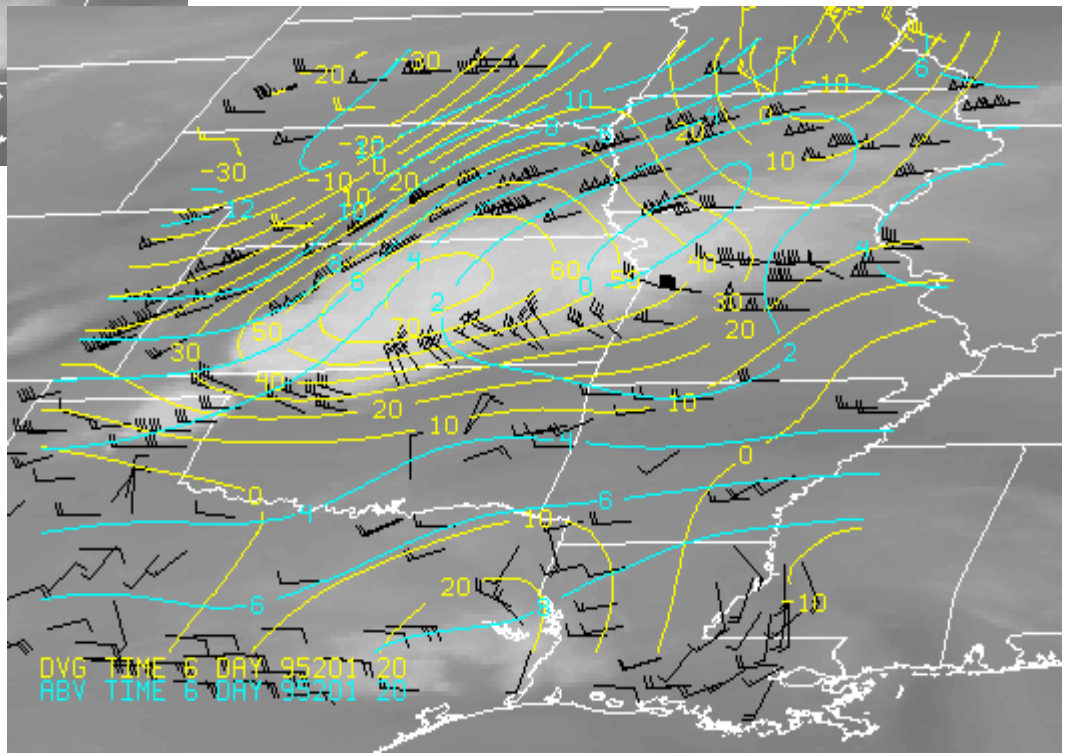
# •GOES-8 Water Vapour Imagery

•divergence (yellow, 10-5s-1), and absolute vorticity (red, 10-5s-1)

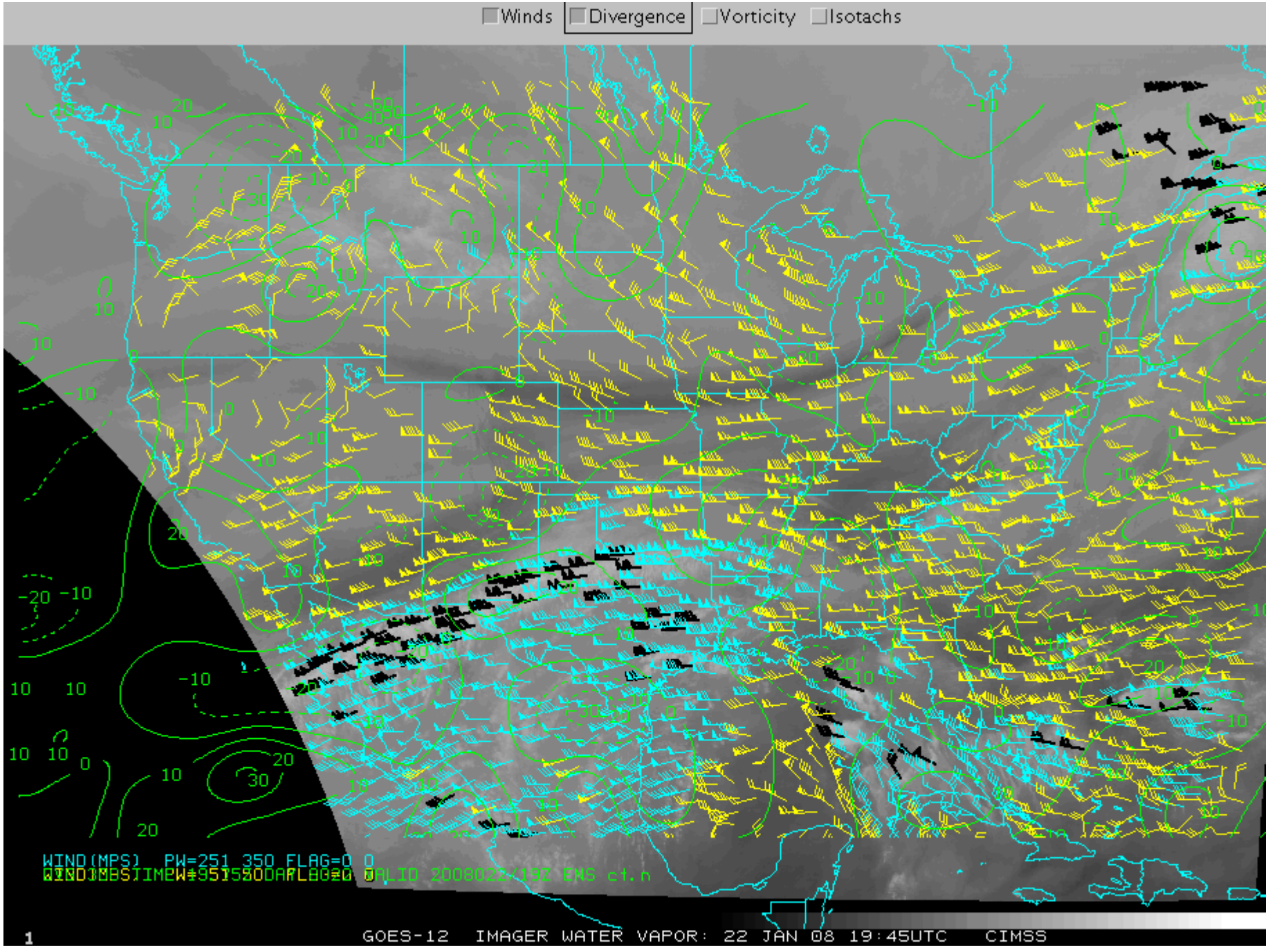



•2300 UTC 19 July 1995

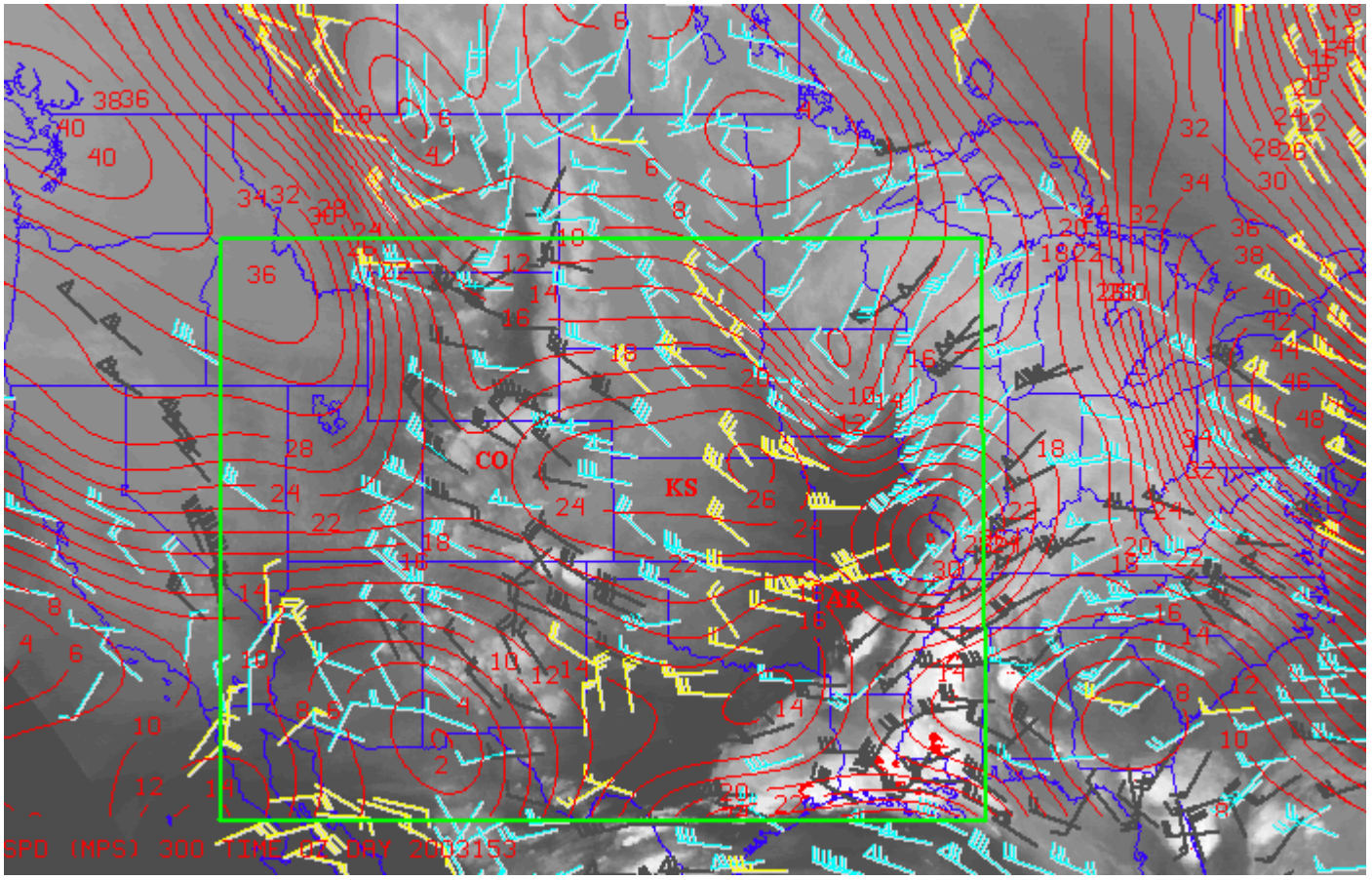
•0445 UTC 20 July 1995



# Wind vectors and horizontal divergence at 300 mb (green contours) from GOES water vapor imagery.

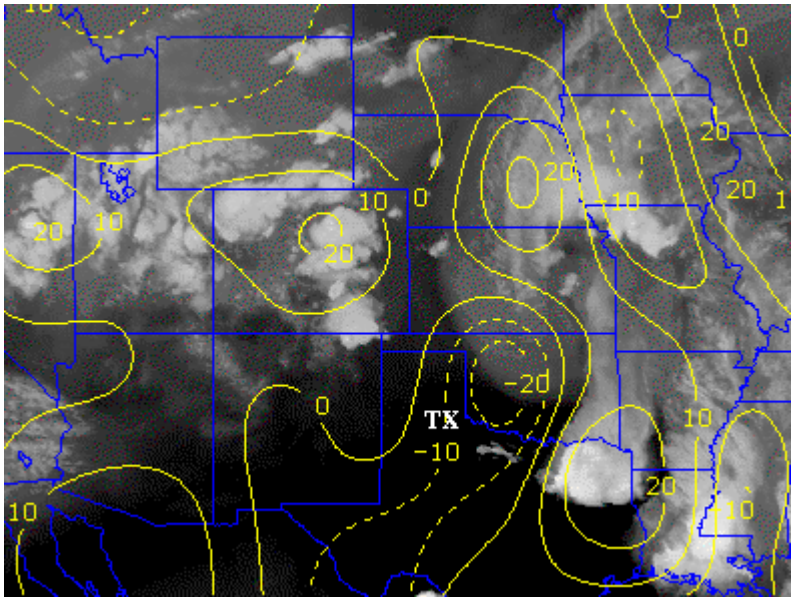


•Upper air winds at 0000 UTC on 03 June 2003 from satellite
•*black: 100-250, cyan: 251-350, yellow: 351-500 hPa*

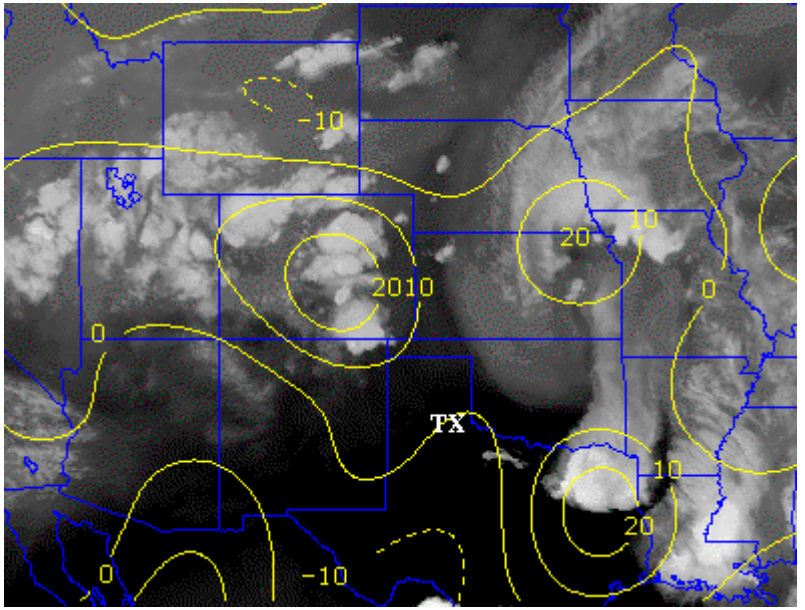


•GOES-12 divergence at 300 hPa  on 12 June 2003
•2145 UTC

•derived from
•satellite-winds




•first guess model
•(NOGAPS)

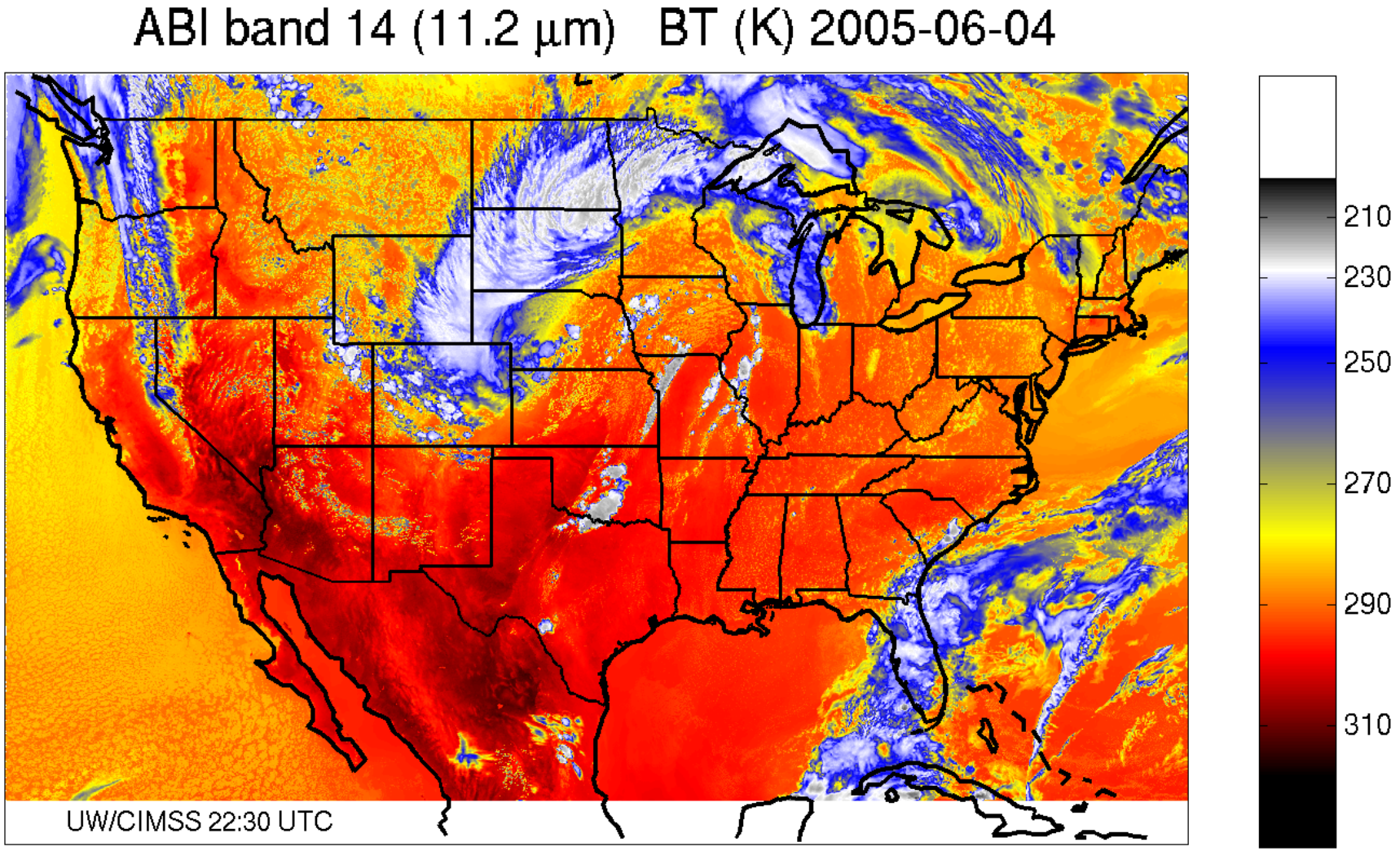


- **Real-time and archive:**

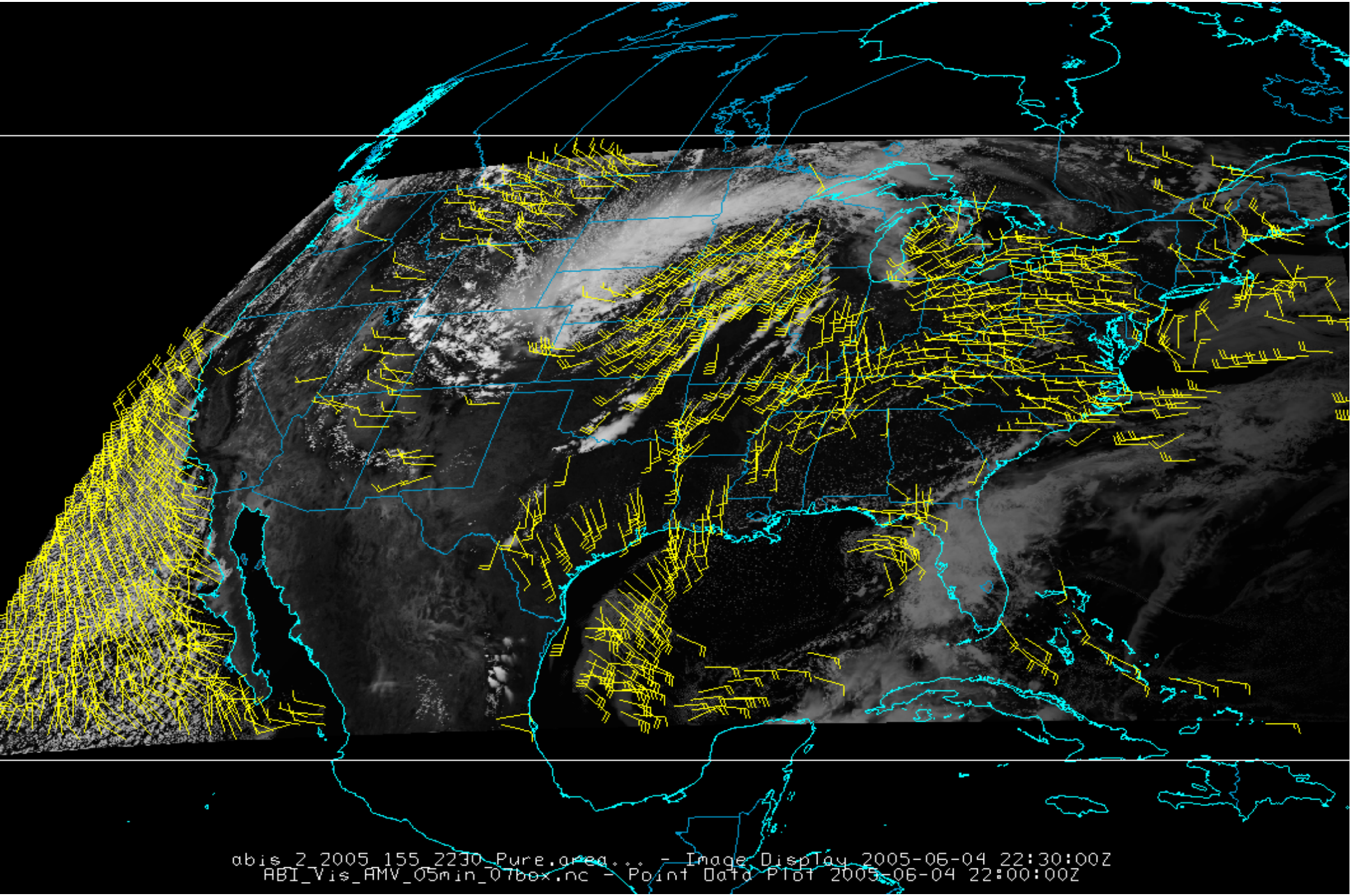
- **http://cimss.ssec.wisc.edu/mesoscale_winds**

- **http:/www.nssl.noaa.gov/~rabin/winds**
- **http://www.nssl.noaa.gov/~rabin/winds/pac**

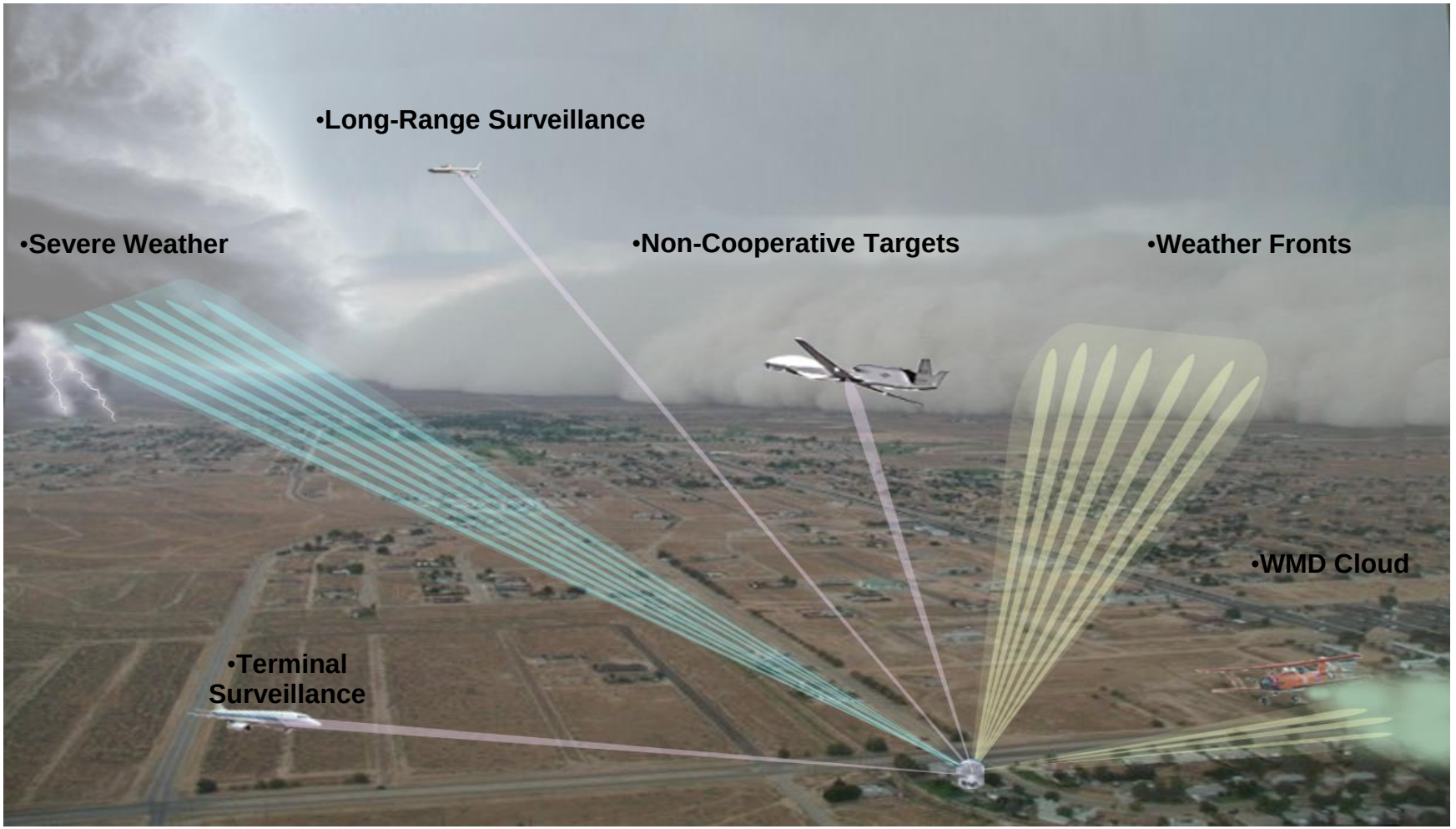
Simulated GOES-R window channel



# GOES-R simulated visible and AMVs



# •Phased-Array radar: fast scanning



# Oklahoma Tornado Photos: May 24, 2011

Photo Published: Mon May 23 2011

49 of 92 photos | display thumbs

« PREV > PLAY NEXT »

A half-mile-wide tornado moves north in Canadian County having just crossed SH 3, the Northwest Expressway, west of SH 4 moving towards Piedmont Tuesday, May 24, 2011. Photo by Paul B. Southerland, The Oklahoman ORG XMIT: KOD

# Oklahoma Tornado Photos: May 24, 2011

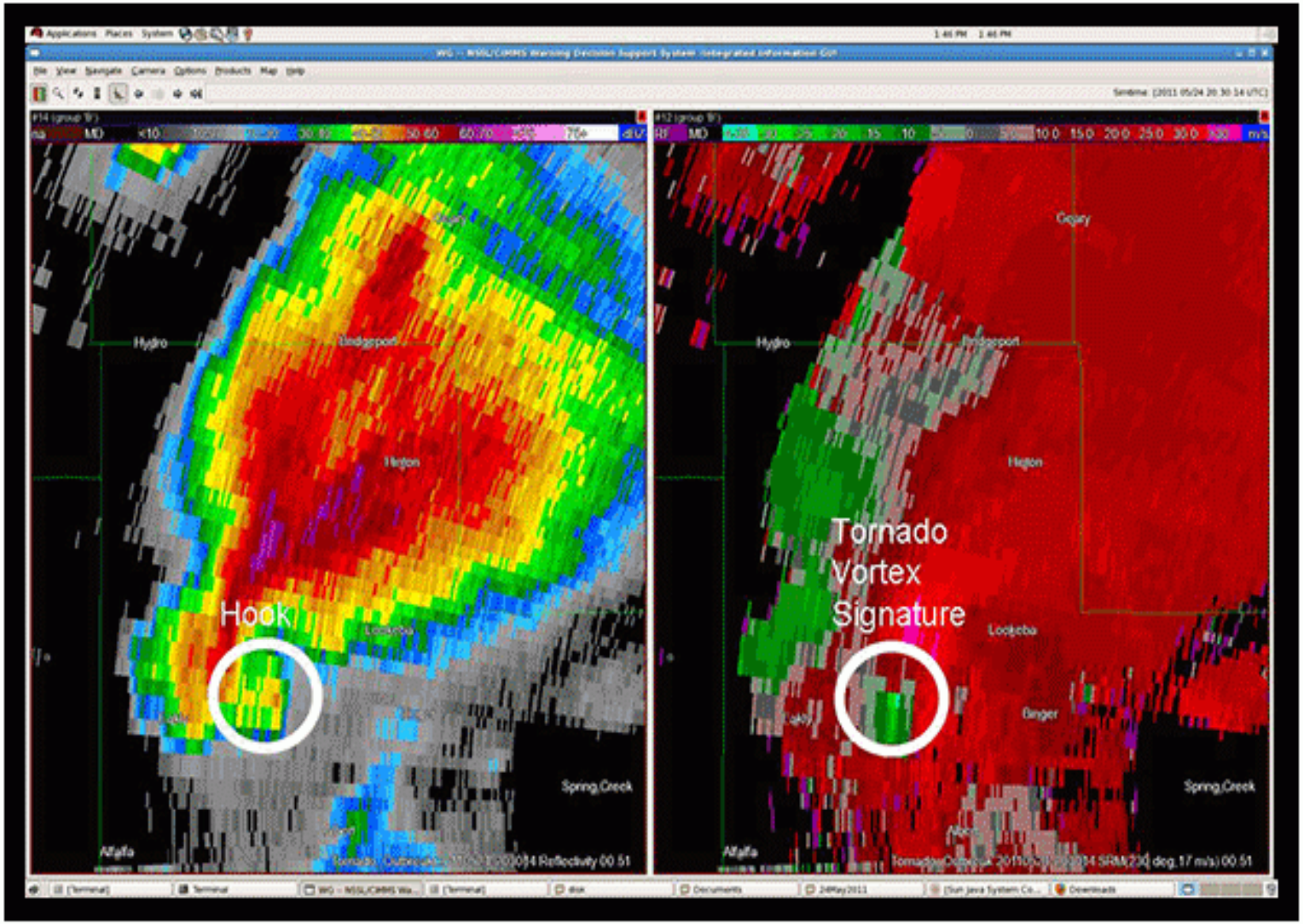
Photo Published: Mon May 23 2011

55 of 92 photos | display thumbs

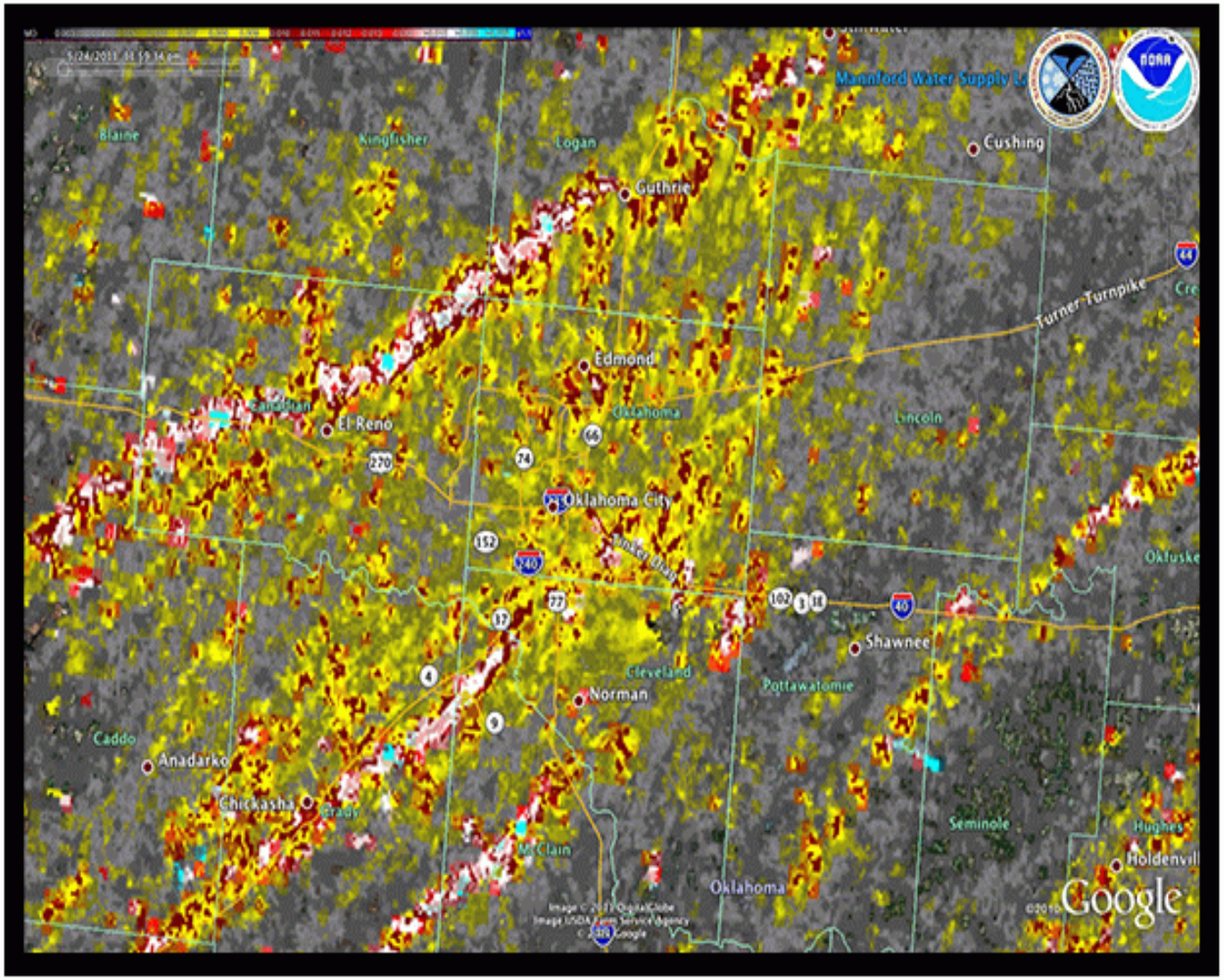
« PREV > PLAY NEXT »

Neighbors pitch in to help recover items out of the home of Scott and M'Lynn McCann's home that was destroyed by a tornado west of El Reno, Tuesday, May 24, 2011. Photo by Chris Landsberger, The Oklahoman ORG XMIT: KOD

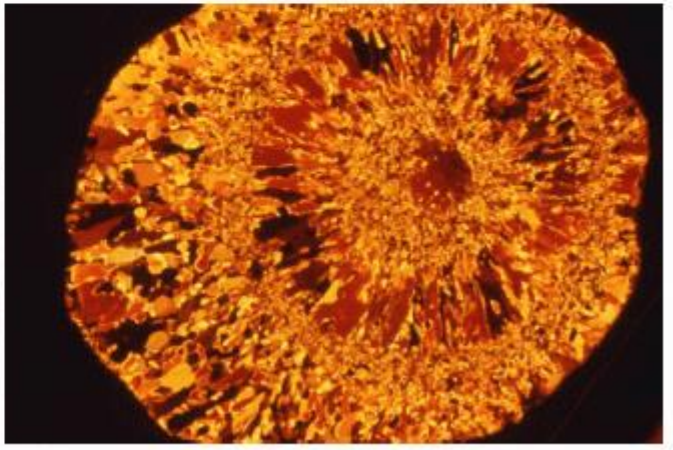
# Multi-function Phased Array Radar

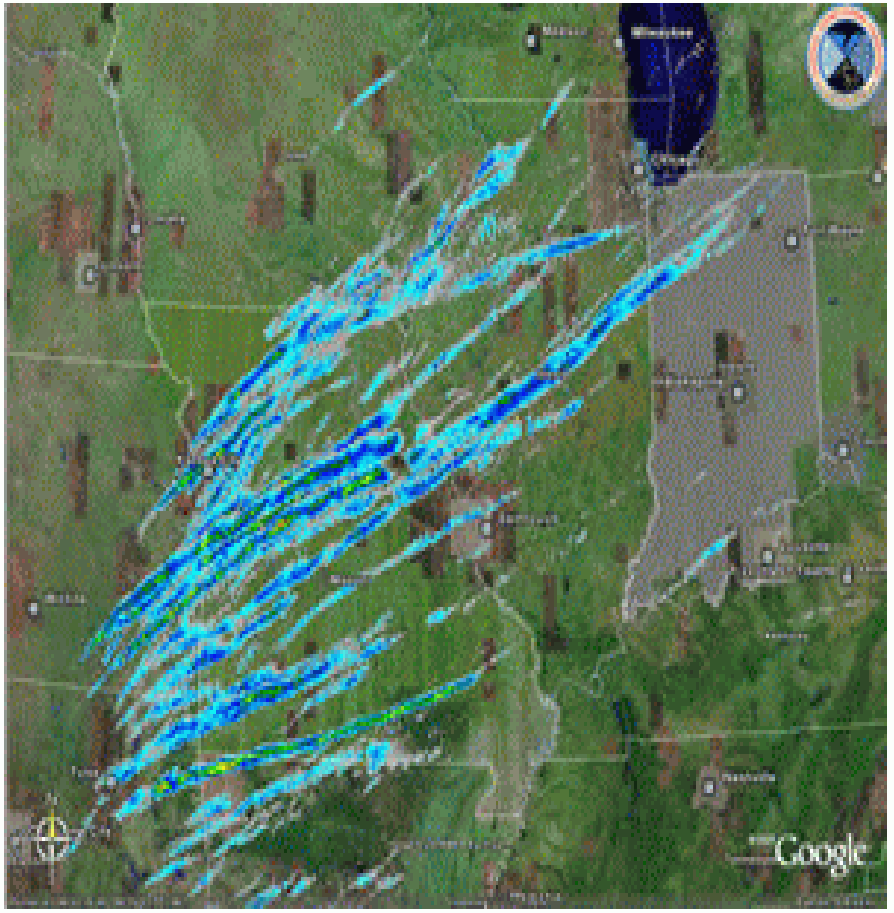


# Rotation Tracks on Demand

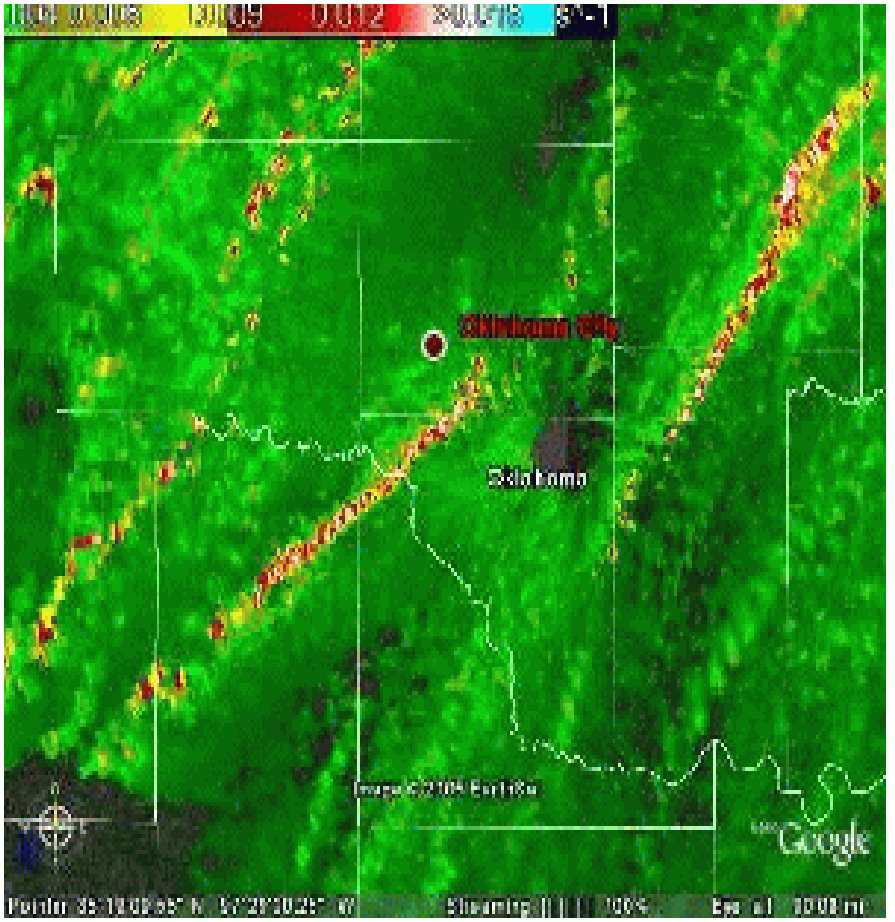


70-30 01



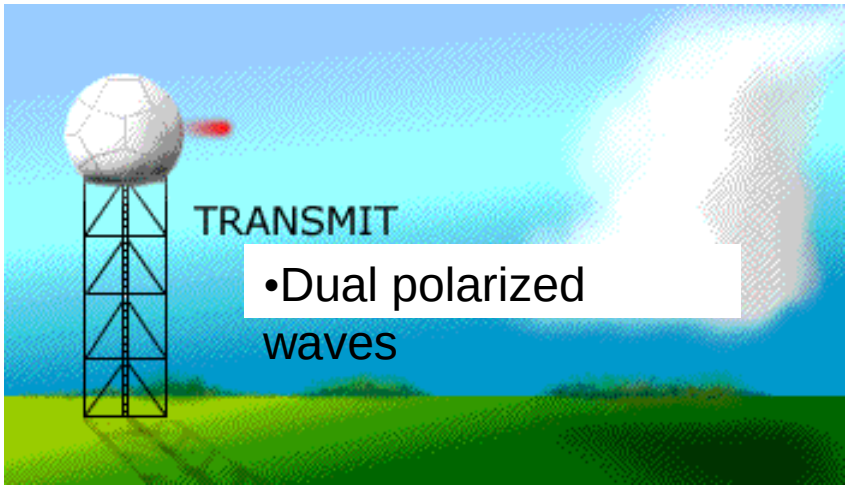


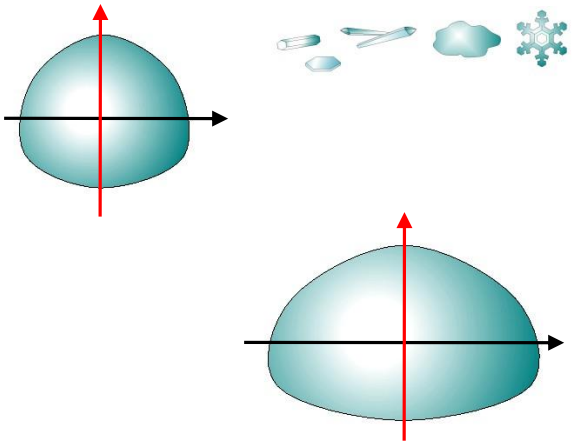

Hail Swath of maximum hail size

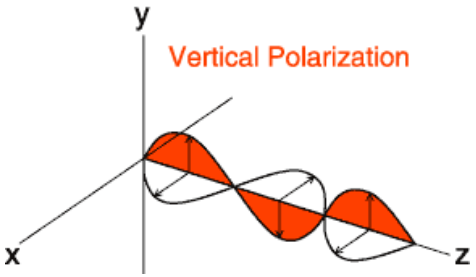


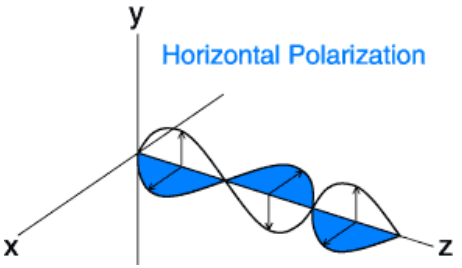

Rotation Tracks of mesocyclones

# •Dual-polarization Radar

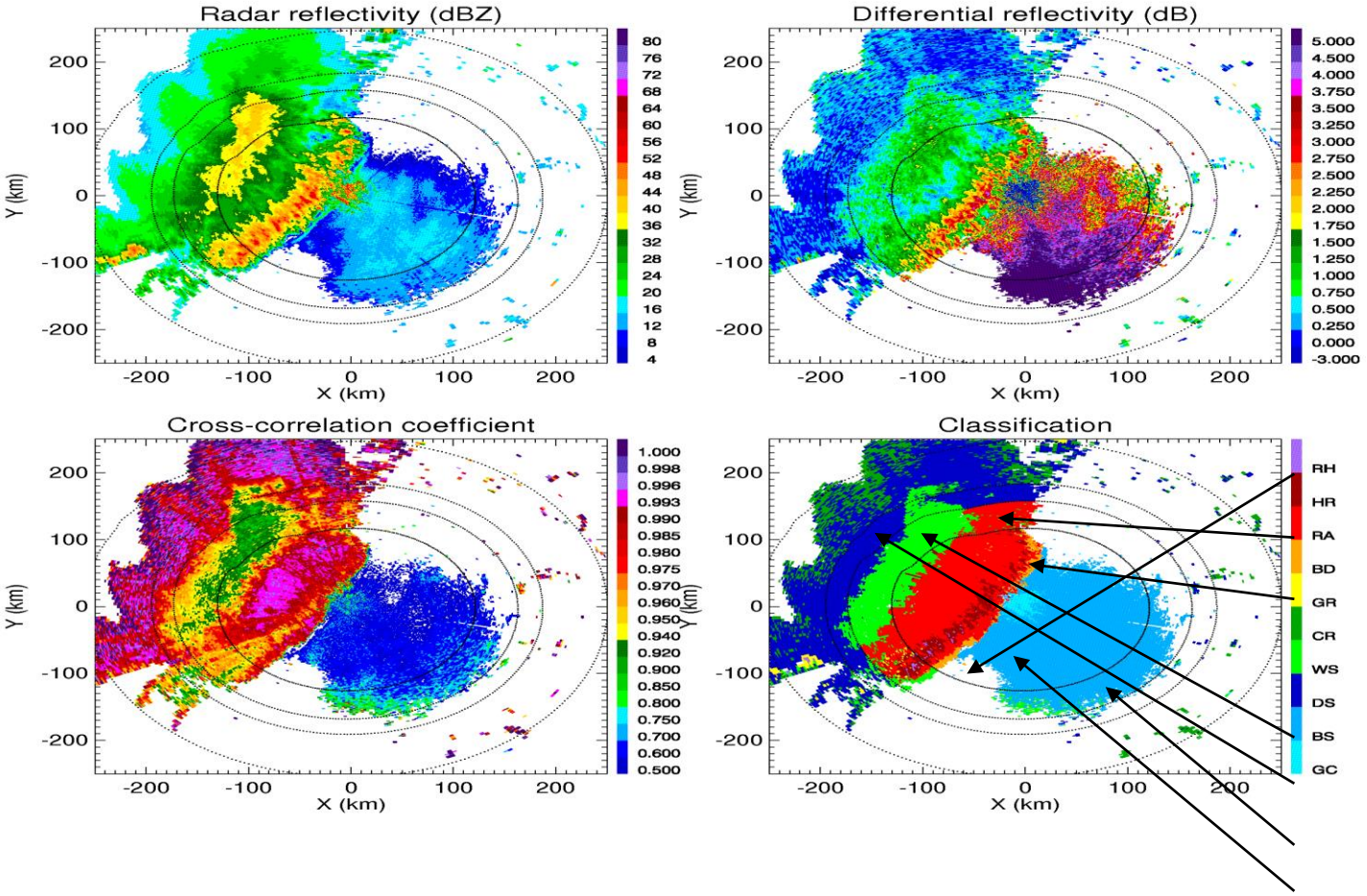




# •Fields of Z, ZDR, ρhv, and Classes of Returns

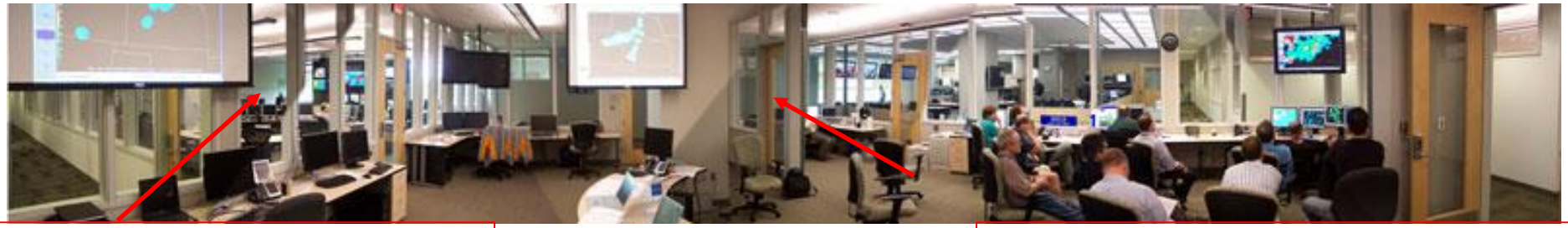



•(05/13/2005)

•RH – rain / hail
•HR – heavy rain
•RA – rain
•BD – “big drops”
•GR – graupel
•CR – crystals
•WS – wet snow
•DS – dry snow
•BS – bio scatterers
•GC – ground clutter/AP

# •NOAA Hazardous Weather Testbed

*•Where practitioners and researchers work together…*



•Local NWS forecast office:
•Regional Warning responsibility

•Storm Prediction Center:
•Nationwide Forecast responsibility

•Warning
•Research

•Forecasting
•Research

•Satellite-based
•Research

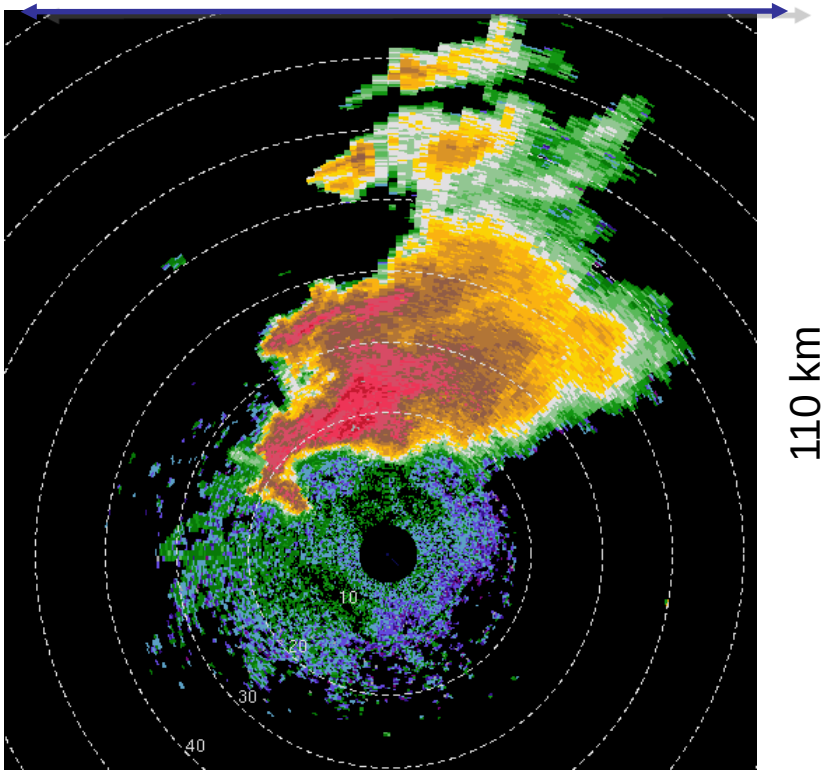
•**E**xperimental
•**W**arning
•**P**rogram

*•Detection and prediction of hazardous weather events* ***up to several hours in advance***

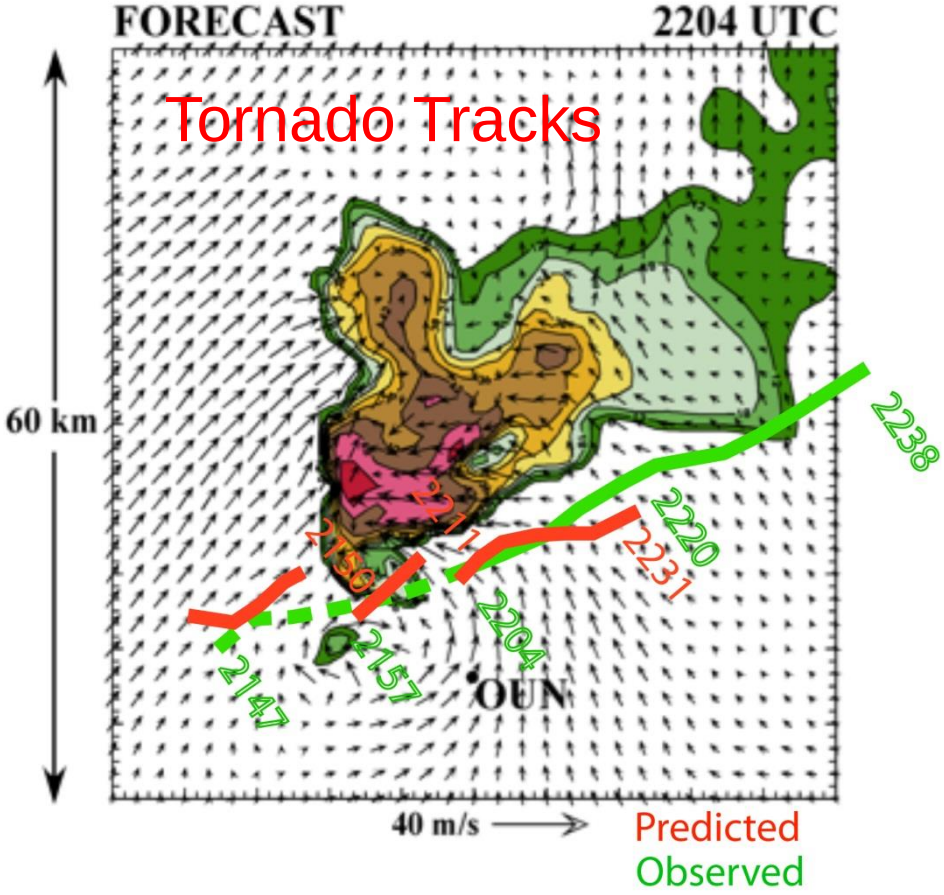
•**E**xperimental
•**F**orecast
•**P**rogram

*•Prediction of hazardous weather events from* ***a few hours to a week in advance***

# Radar Data Assimilation
## (ensemble initial perturbation method)



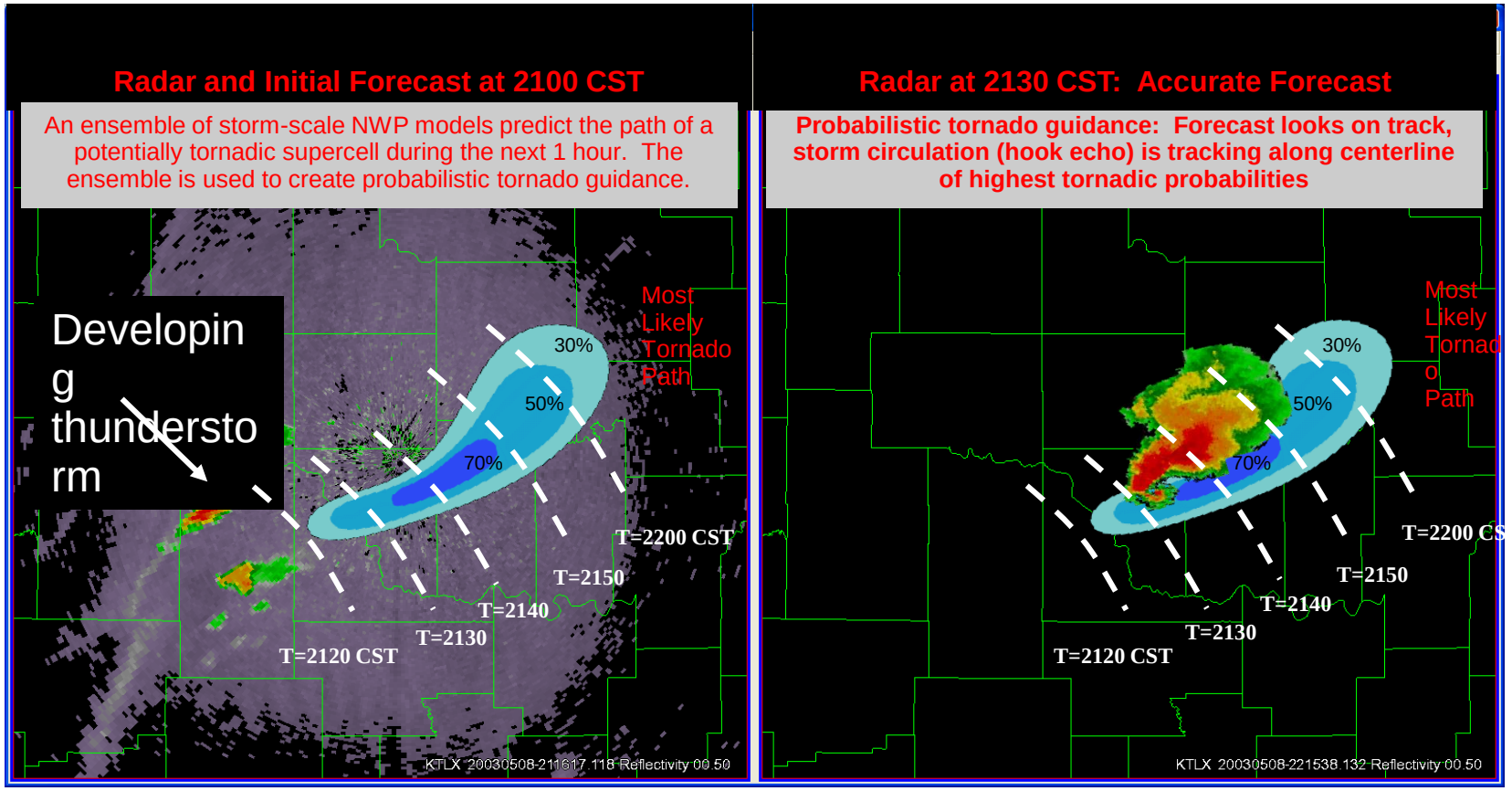

110 km




Dowell and Wicker (2009)

# Convective-scale Warn-on-Forecast Vision:

***A joint project involving NSSL,***
***OU Center for the Analysis and Prediction of Storms (CAPS),***
***NWS Storm Prediction Center (SPC)***
***NOAA Earth System Research Laboratory (ESRL)***



## Source: NOAA HPCC program

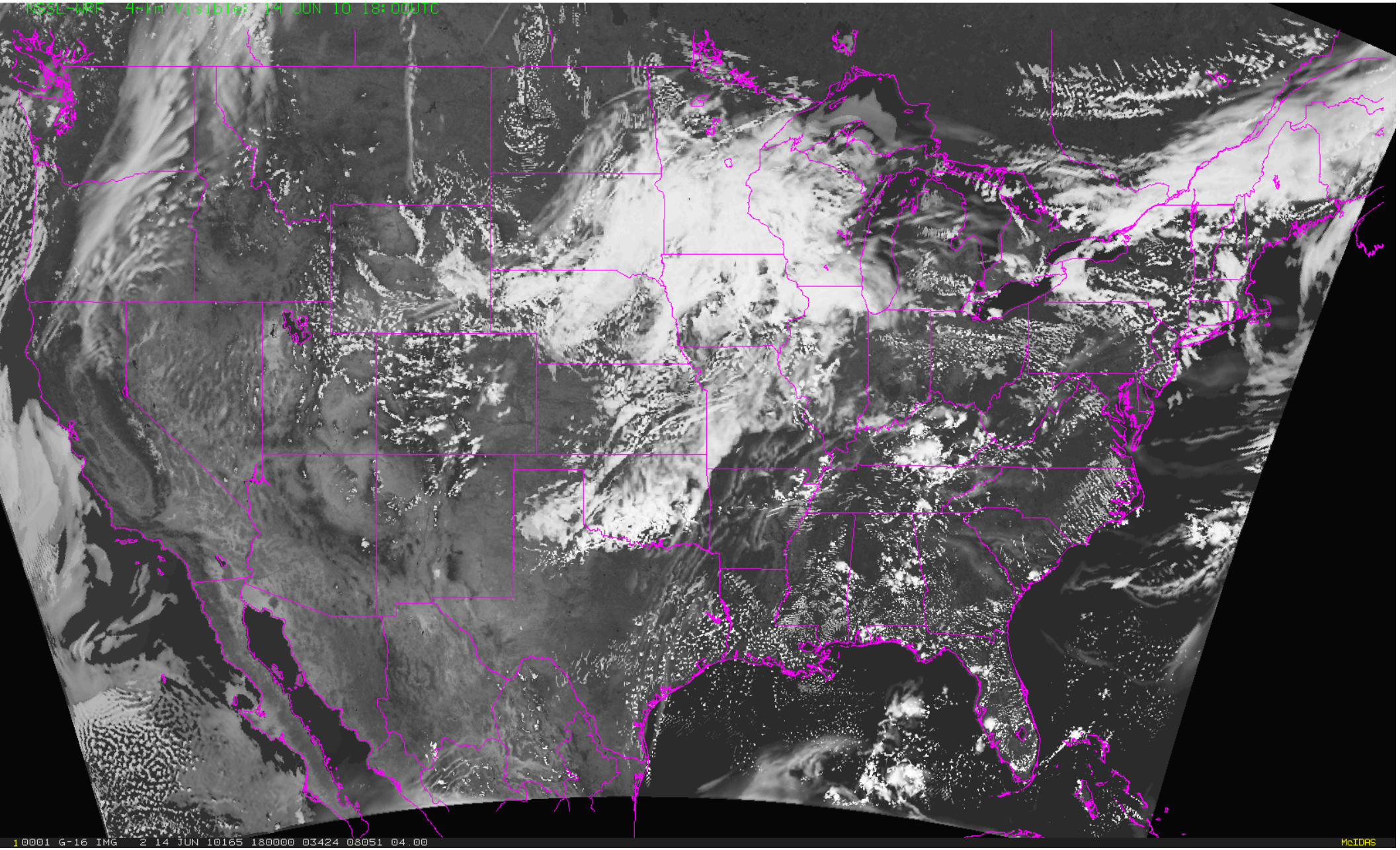
**1) System for Storm Analysis Using Multiple Data Sets (2008)**

**2) Visualization of Model Forecasts as Satellite Visible Imagery (2009) with CIMSS**

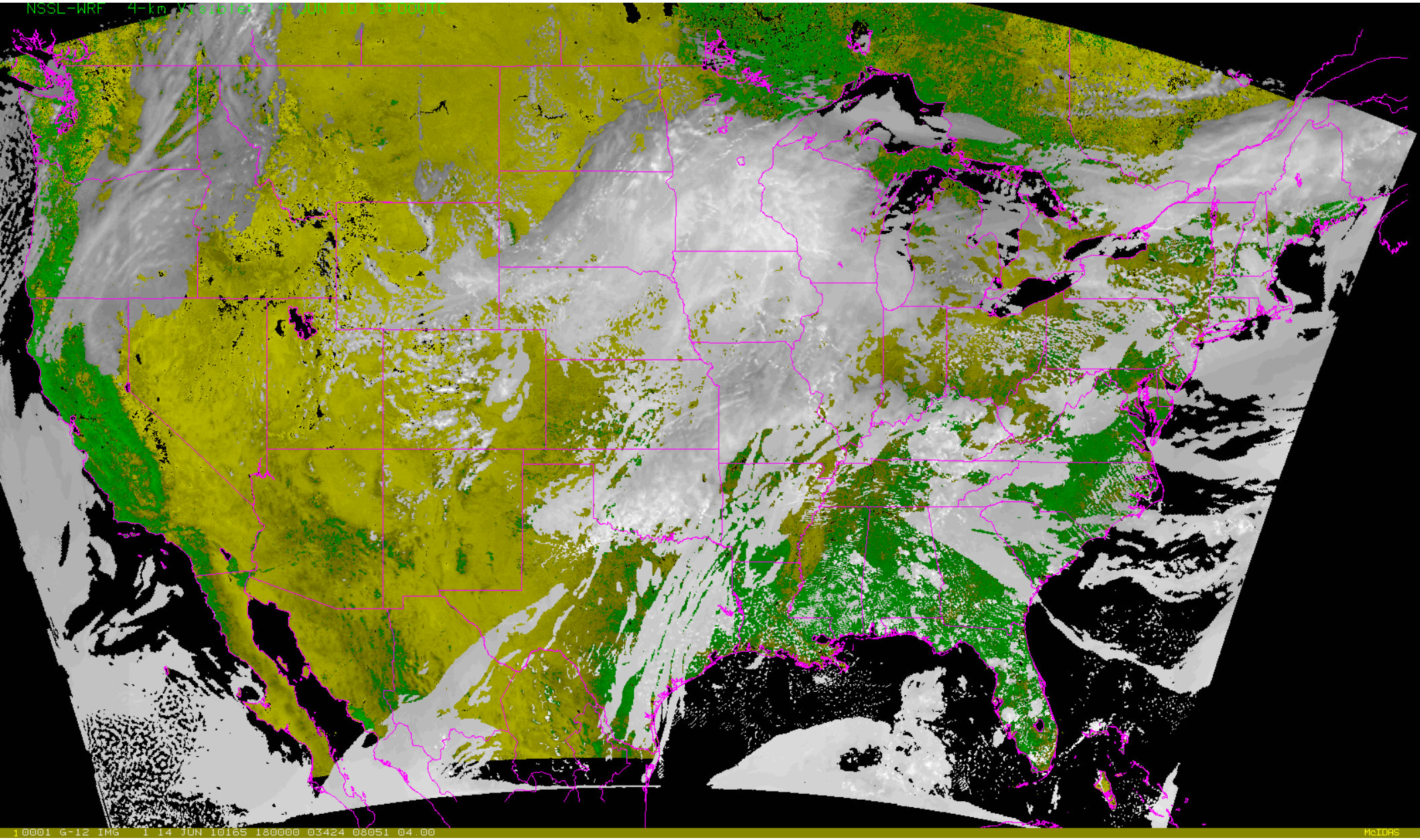
**3) Visualization of short-term forecasts of clouds and precipitation: Utilizing the nWave data circuit (2010) with ESRL/GSD**

**4) Rapid Access to real-time and forecast products through a Web Map Service and nWave data circuits with CIMSS**

# Simulated GOES vis (WRF)



# Simulated GOES vis: RAPID computation NN




http://www.nssl.noaa.gov/users/rabin/public_html/vis_wrf/

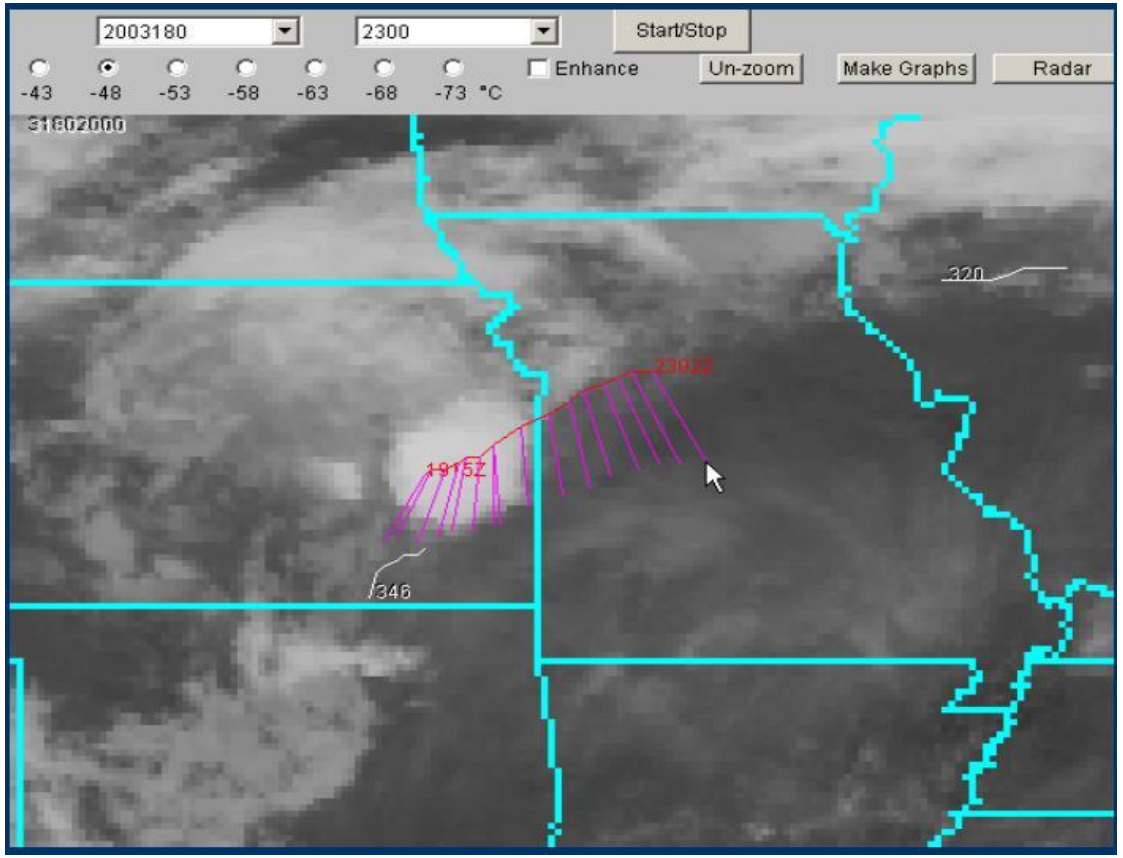
# *A Web-based tool for monitoring MCS*

## *Storm Analysis Using Multiple Data Sets.*

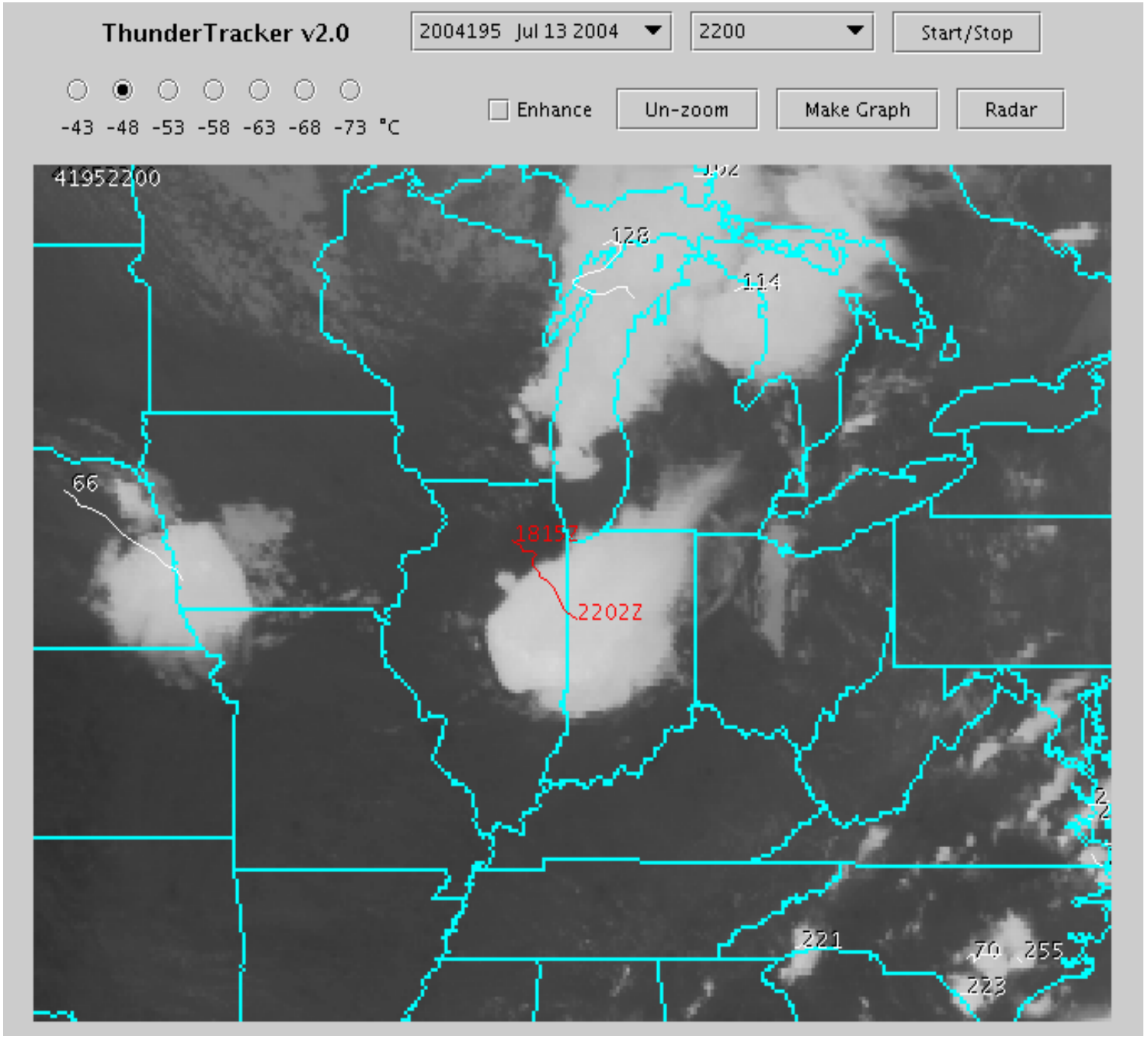
Robert Rabin, Tom Whittaker 2004

**Advances in Visual Computing,**

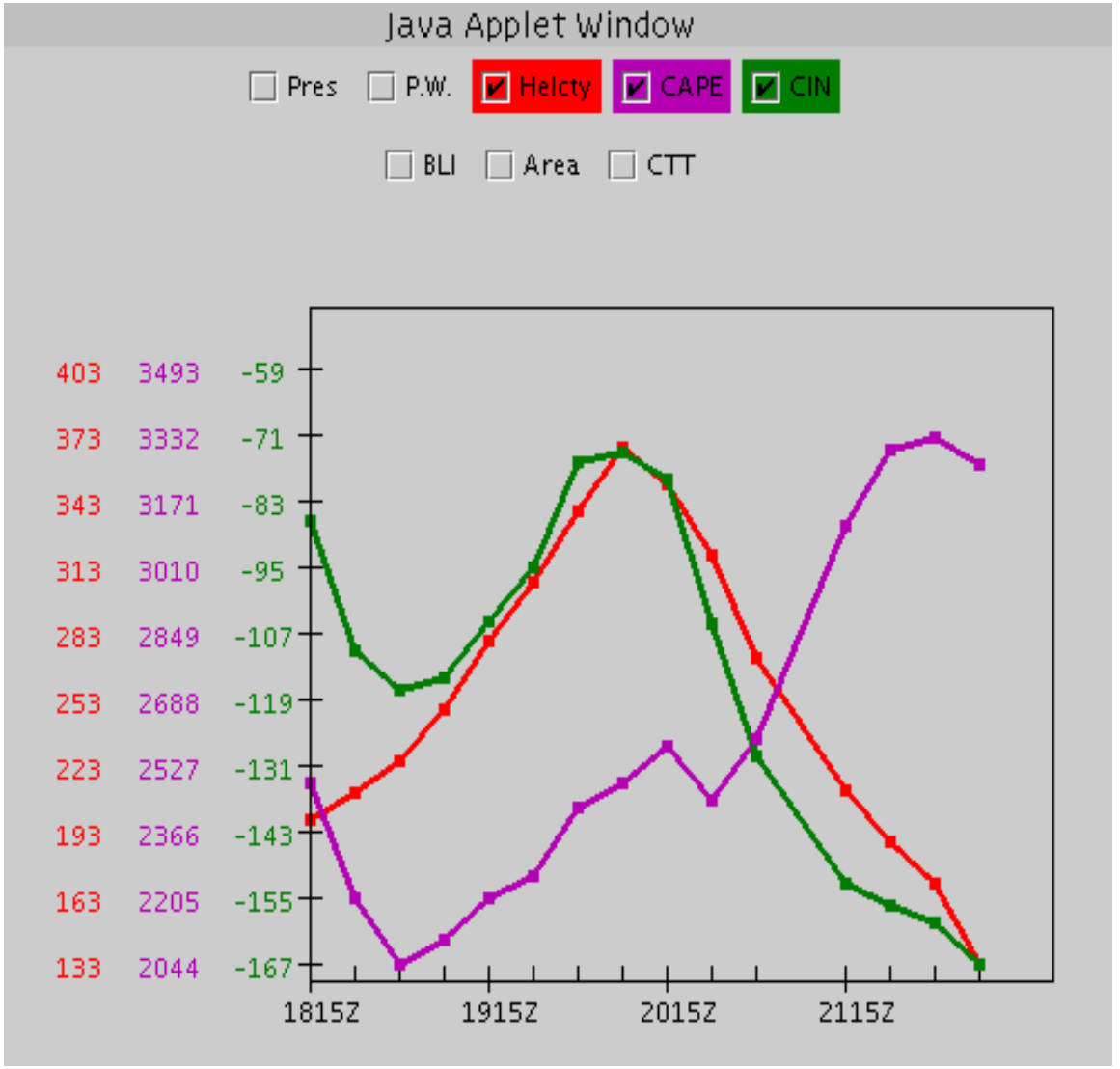
**G. Bebis, R. Boyle, D. Koracin, B. Parvin, Ed(s)., Springer, 571-578.**



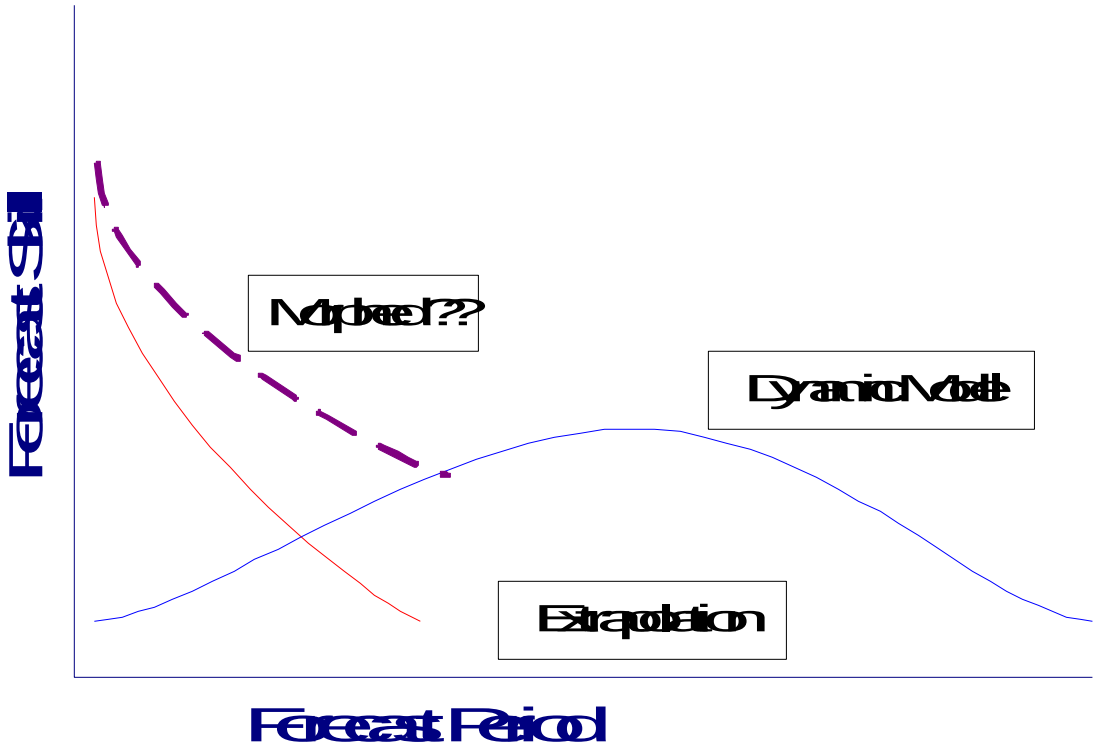
# •Tornadic Storm Track



# •Time Series: Tornadic Storm Track



- **http://stormtrack.nssl.noaa.gov**


Forecast Skill
Forecast Period
Dynamic Model
Extrapolation

# Letter of Intent to NESDIS GIMPAP program FY 2012

Identification of Dry thunderstorms using cloud top properties from GOES imagery:
Applications to Fire Weather Forecasting at the Storm Prediction Center

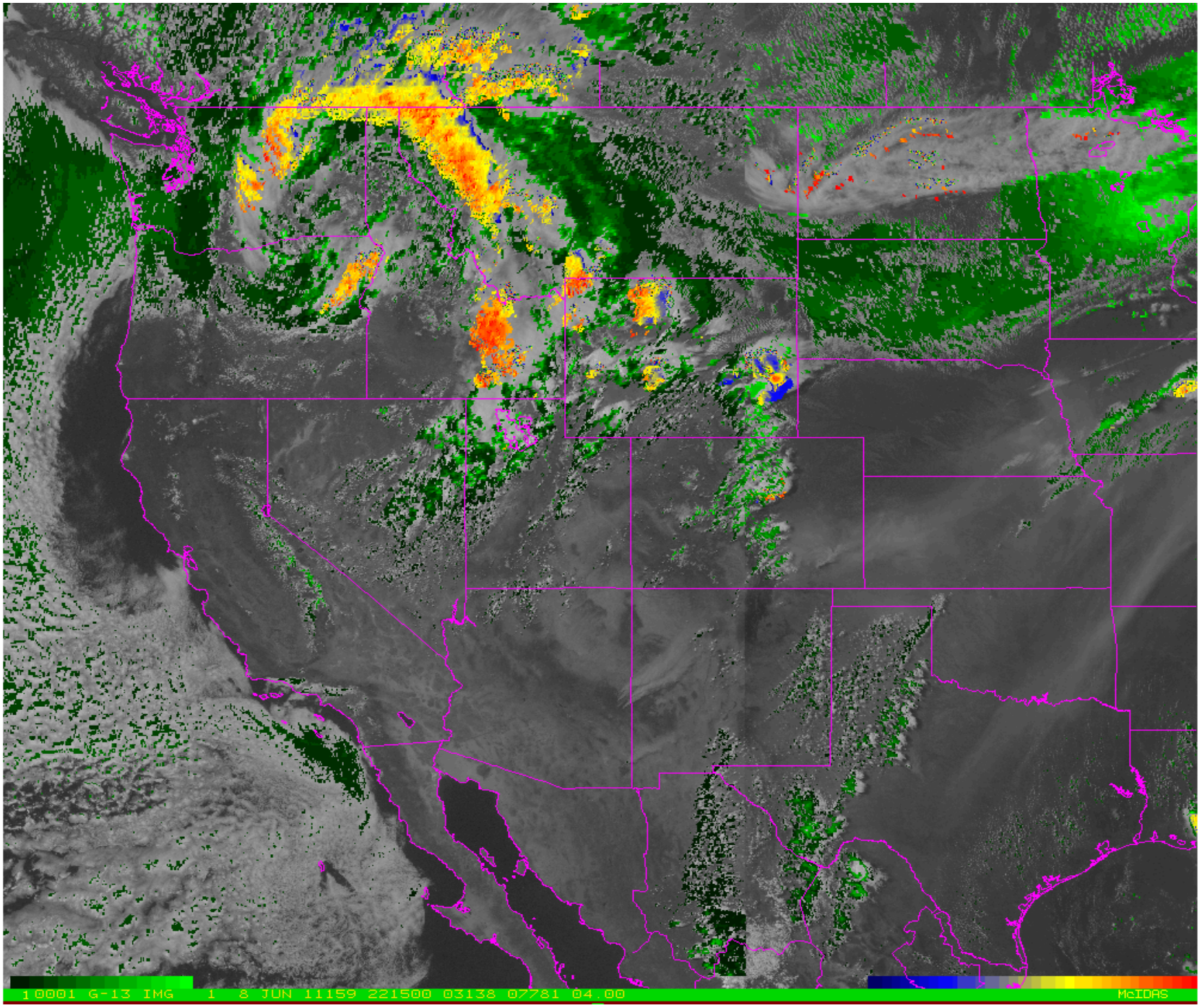
Robert M Rabin NOAA/NSSL
Phillip Bothwell NOAA/NWS/SPC
Dan Lindsey NOAA/NESDIS/RAMMS
Andrew Heidinger, NOAA/NESDIS/ASBP
William Straka CIMSS University of Wisconsin-Madison

Purpose:

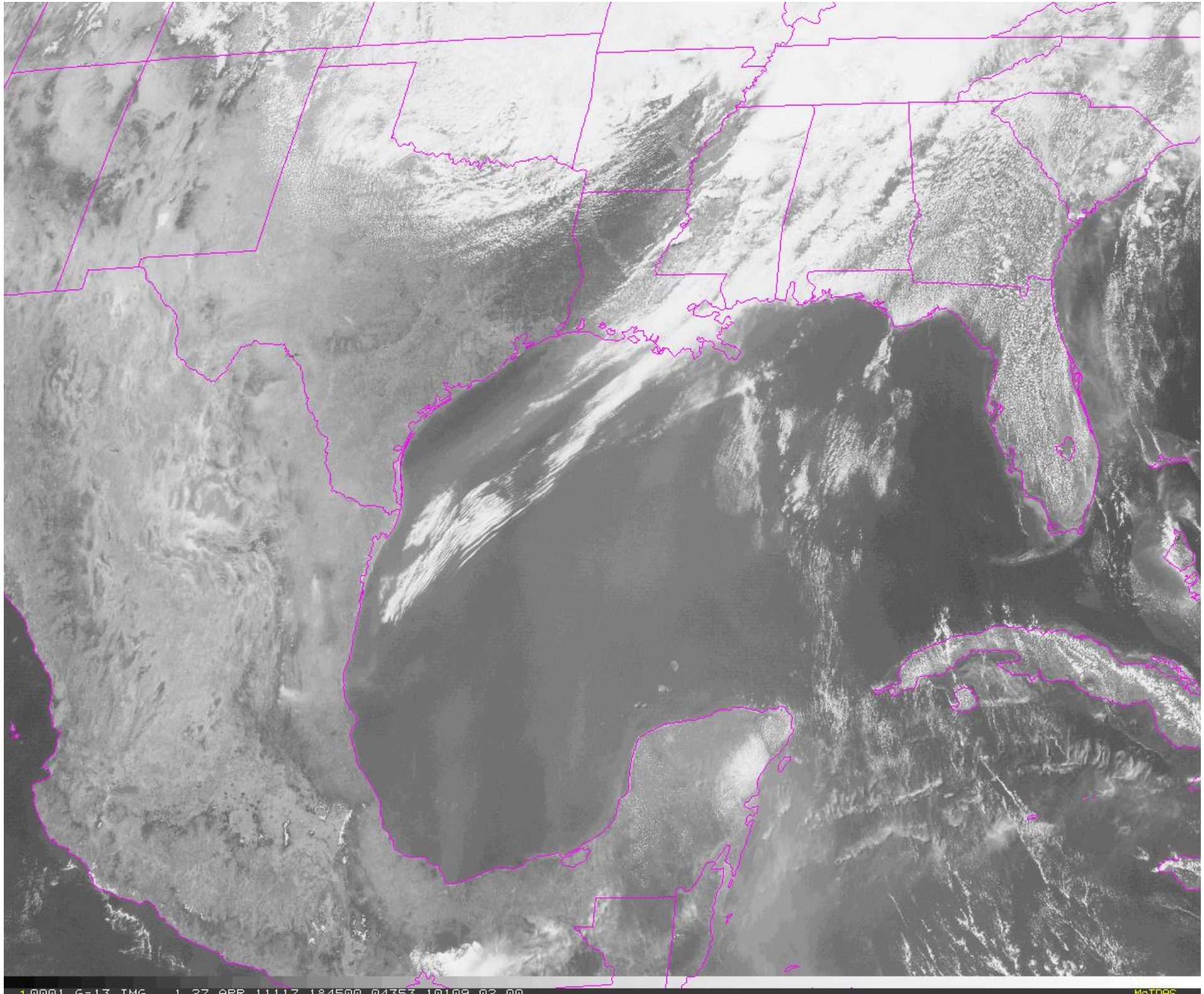
The goal of this project is to provide information on the location of “dry” thunderstorms, which produce lightning but result in light or no precipitation. Such storms, most common in the western U.S., pose a hazard for the ignition of wildfires due to the fact that they do not sufficiently wet the surface, and are accompanied by cloud to ground lightning and strong wind gusts.

Lindsey, D.T., S.D. Miller, L. Grasso, 2010: The impacts of the 9 april 2009 dust and smoke on convection. BAMS, 991-995.

# Cloud top effective radius and phase inferred from GOES



**http://www.nssl.noaa.gov/~rabin/vis_1km**

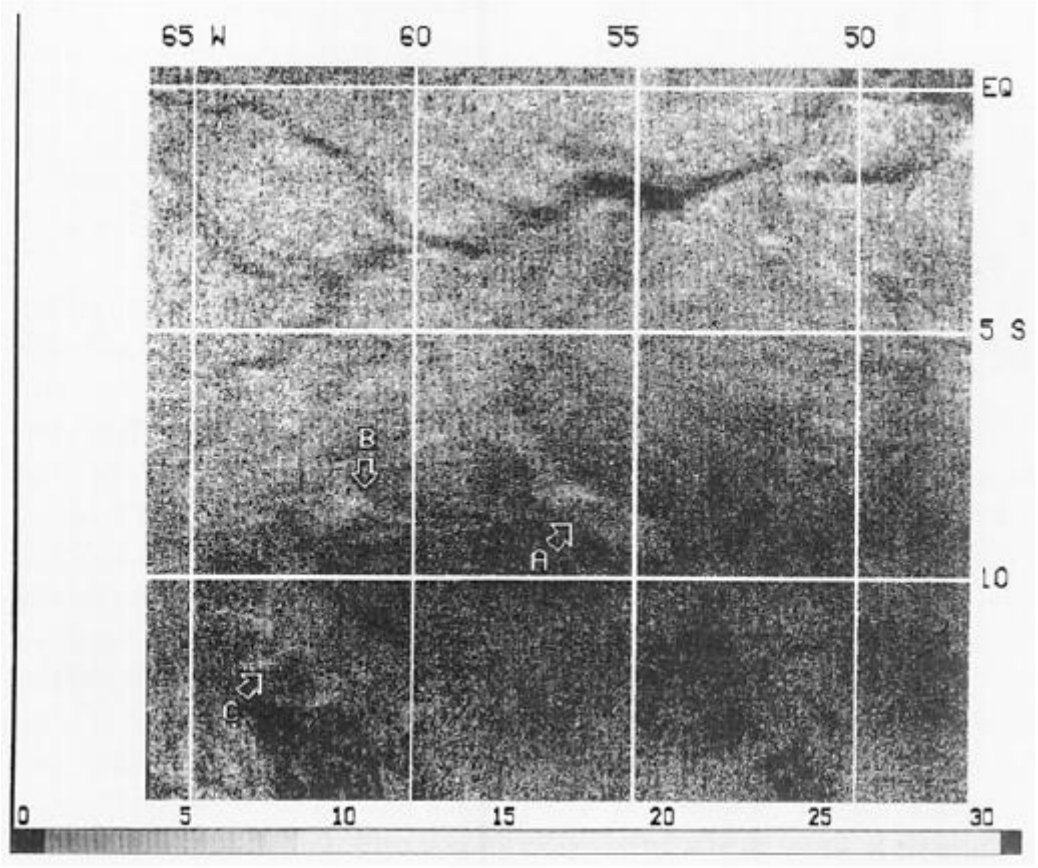

1.0001 G-13 IMG 1.37 0BB 11117 184500 04353 10100 02 00
MeTOPS

•**Enhancement of Cumulus Clouds over Deforested Lands in Amazonia**

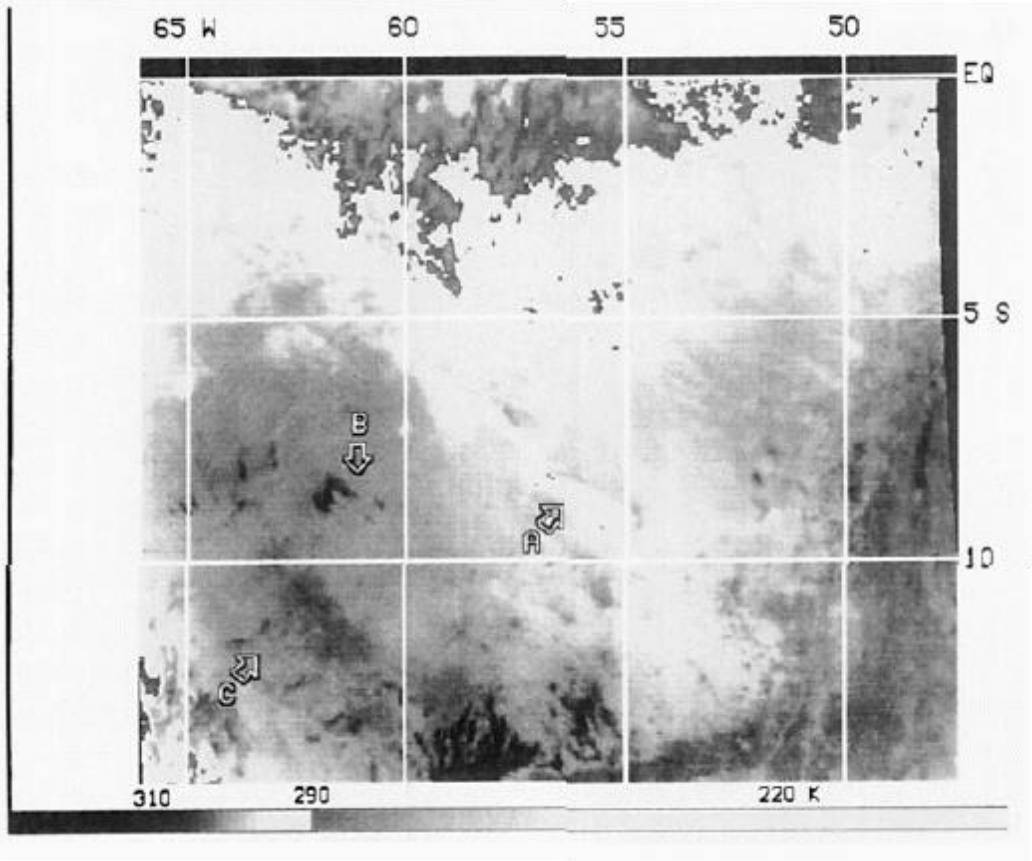
Elen Cutrim, David W. Martin, and Robert Rabin

Bulletin of the American Meteorological Society
Volume 76, Issue 10 (October 1995)

•monthly cloud cover




•IR temperature



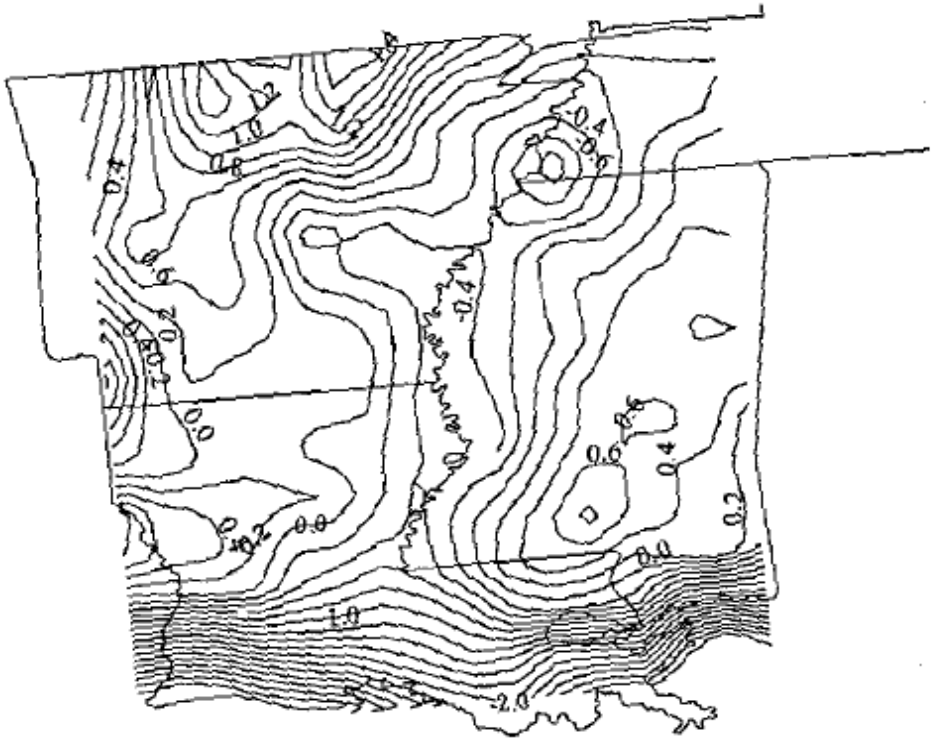
**Evidence of an Agricultural Heat Island**

**in the Lower Mississippi River Floodplain**

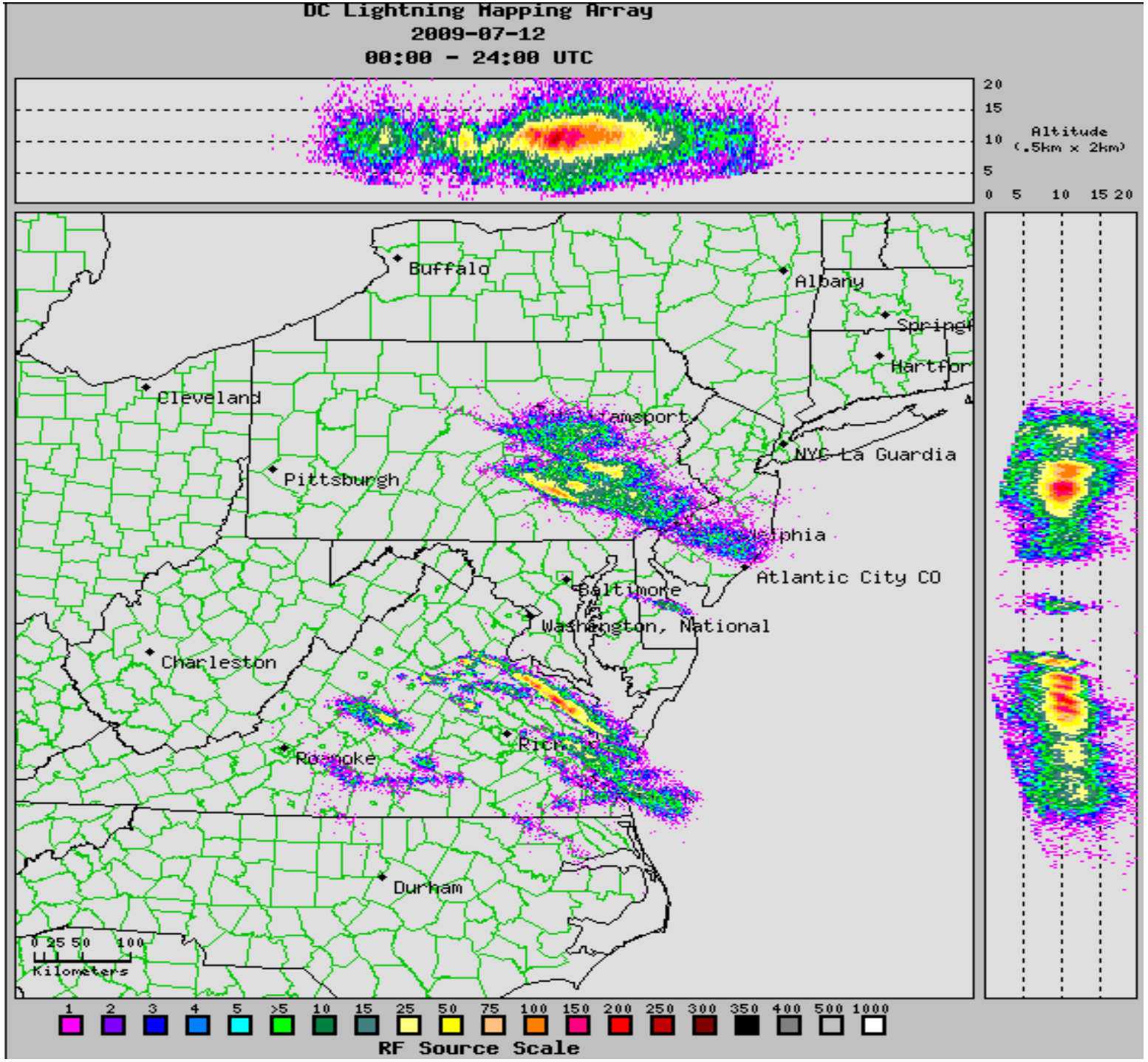
William H. Raymond,  Robert M. Rabin, and Gary S. Wade

Bulletin of the American Meteorological Society

Volume 75, Issue 6 (June 1994) pp. 1019–1025

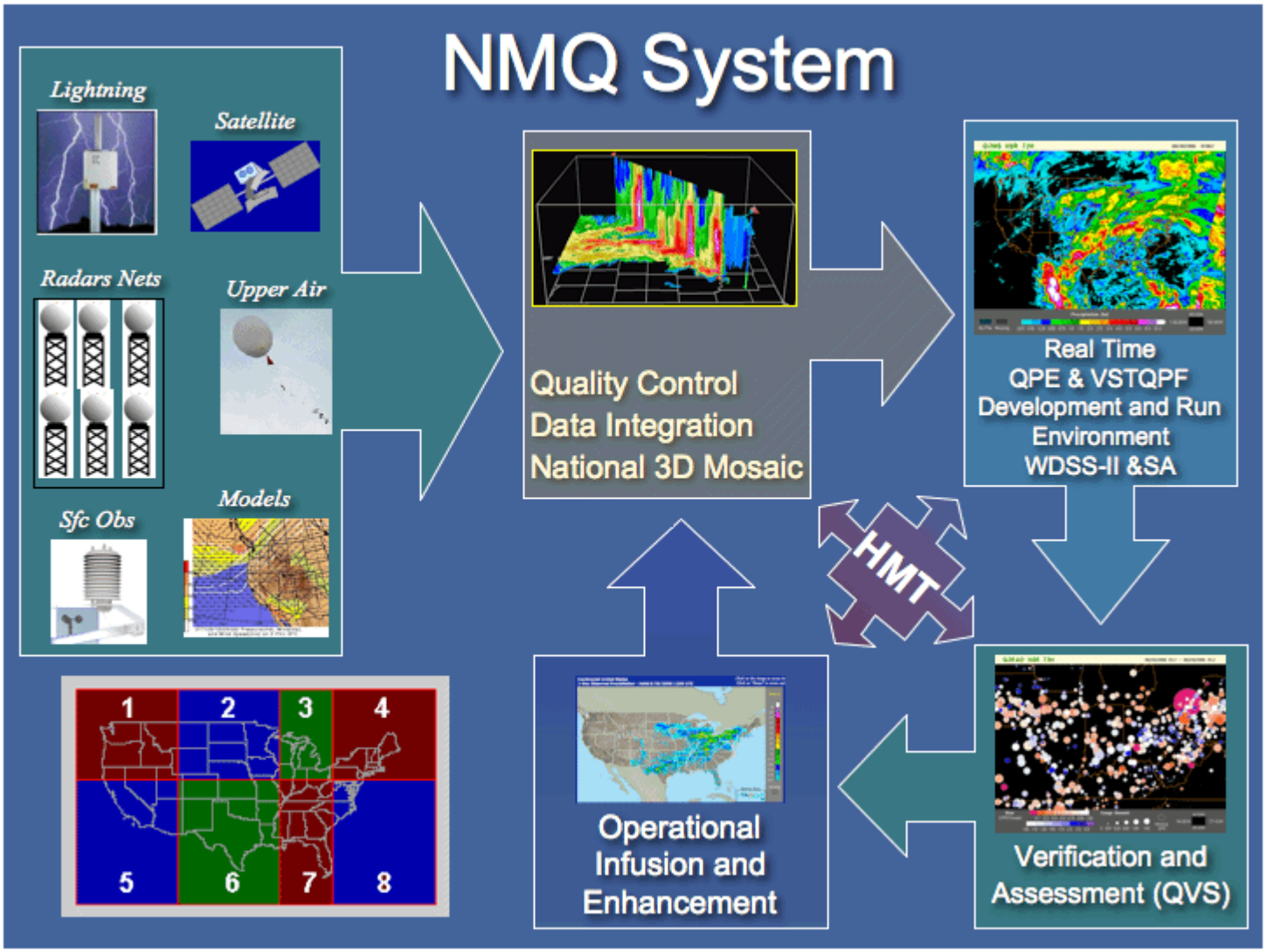


# •Detection of Total lightning (24 hr summary)

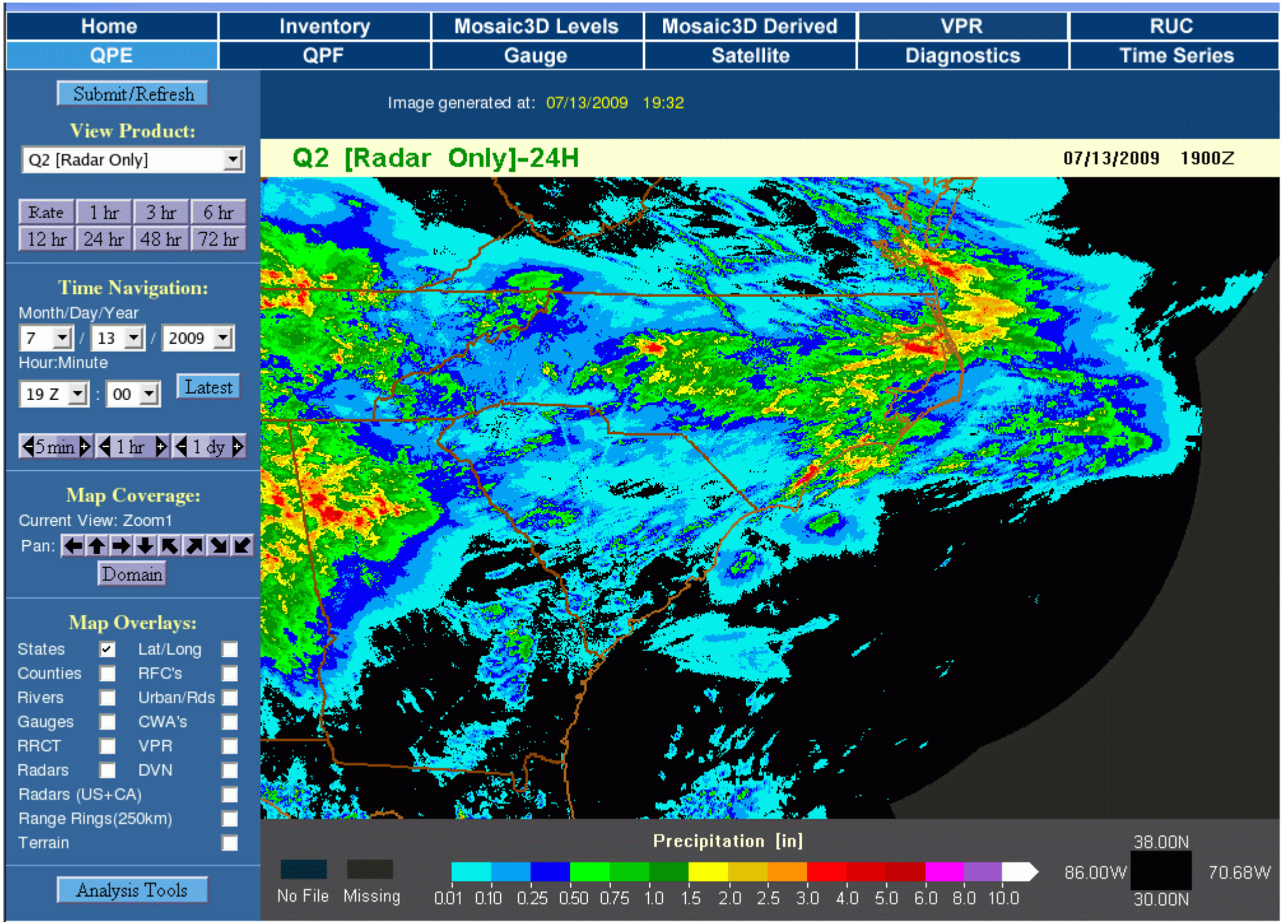


# •Precipitation Monitoring

•National Mosaic and Multisensor QPE (NMQ) system (http://nmq.ou.edu)



# •Example regional scale display: 24 hr precipitation



# NATIONAL MOSAIC & MULTI-SENSOR QPE (NMQ)

*Advancing the science and science-to-operations of QPE and very short-range QPF*

QPE | QPF | Gauge | Satellite | Diagnostics | Time Series

Submit/Refresh

**Compare Gauges:**

HADS ☑ OK Meso ☐
LCRA ☑ CoCoRah ☑
Maricopa ☑

**To QPE Product:**

Q2 [Radar Only]

1 hr | 3 hr | 6 hr
12 hr | 24 hr | 48 hr | 72 hr

**Time Navigation:**

Month/Day/Year
7 / 12 / 2009
Hour:Minute
19 Z : 00 Latest

◀ 1 hr ▶ ◀ 6 hr ▶ ◀ 1 dy ▶

**Map Coverage:**

Current View: Zoom1
Pan: ← ↑ → ↓ ↖ ↗ ↘ ↙
Domain

**Display Type:**

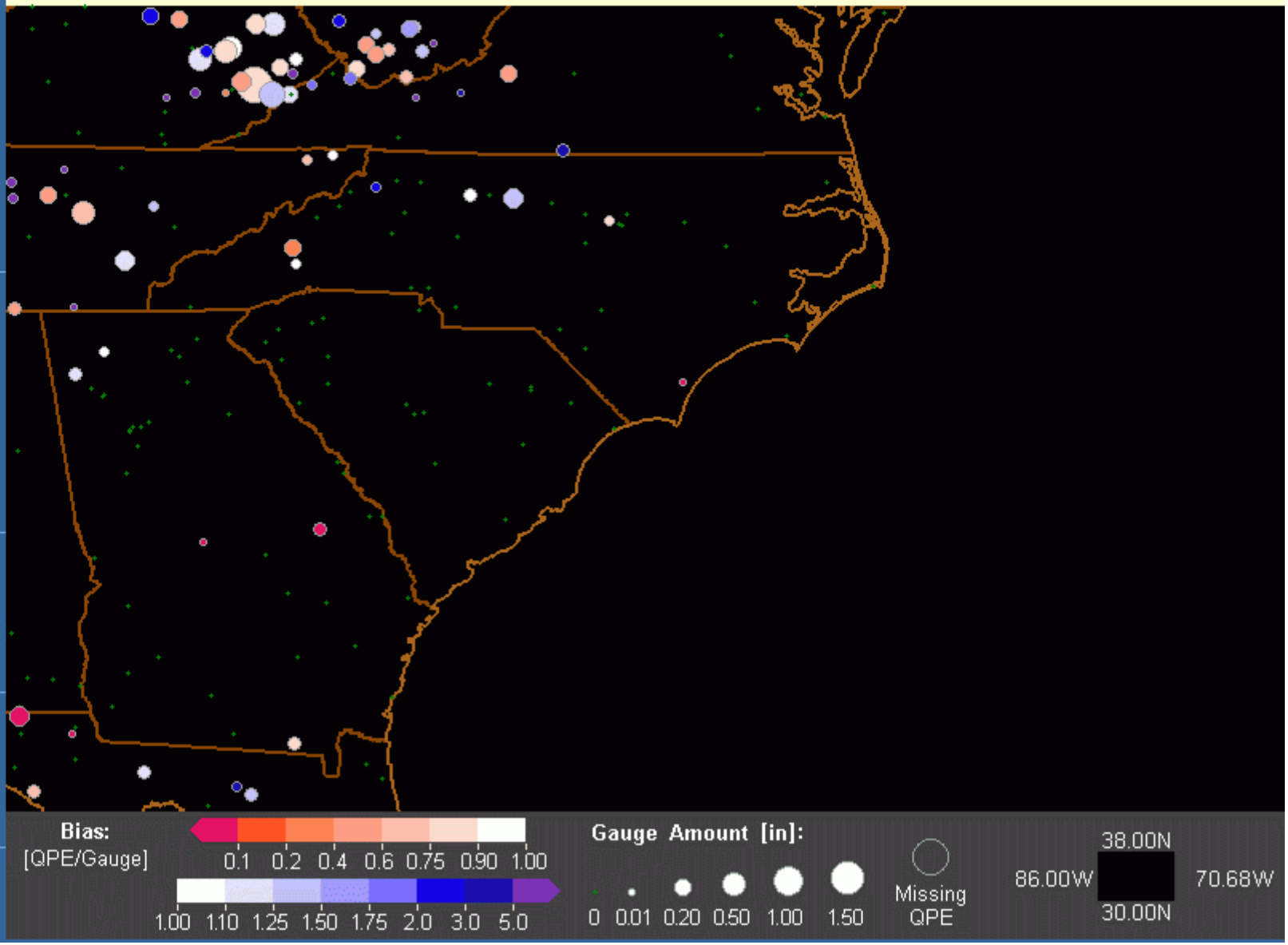
Gauge C. | QPE C.
Scatter.

**Map Overlays:**

States ☑ Lat/Long ☐
Counties ☐ RFC's ☐

Image generated at: 07/13/2009 19:35

**Gauges** [HADS/LCRA/COCO/MARI] Q2 [Radar Only]-24H07/11/2009 19Z - 07/12/2009 19Z

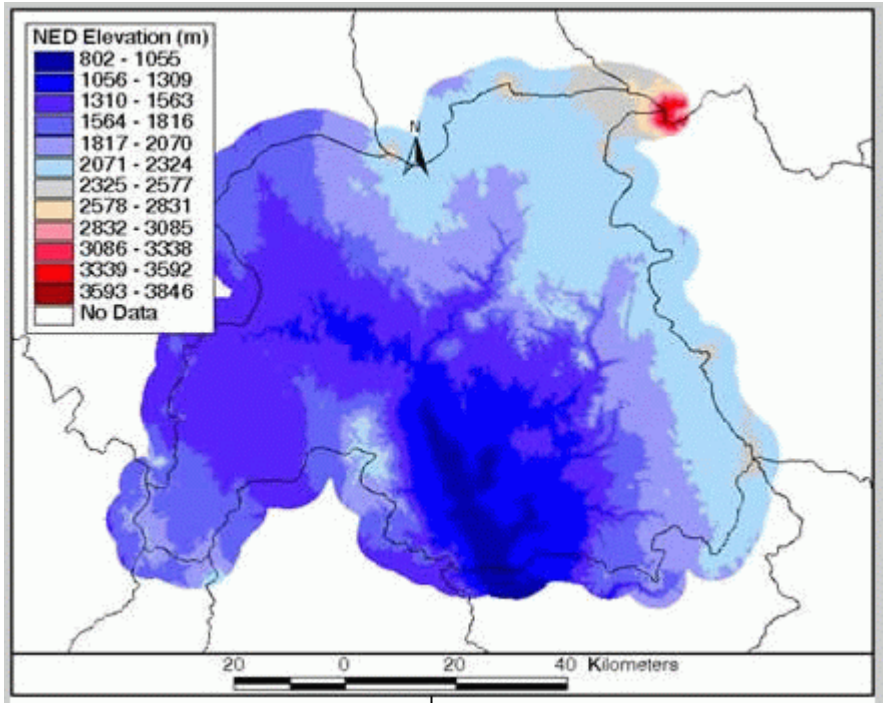


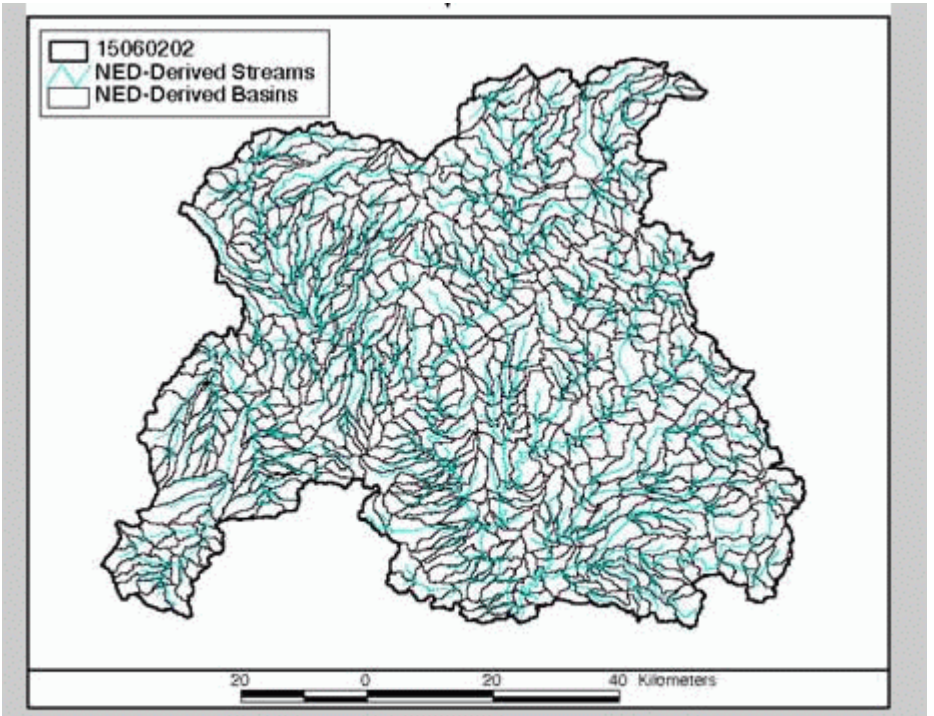
# National Basin Delineation Project (FFMP)

Home | FFMPA Datasets | Reports | Collaborators

## Objective

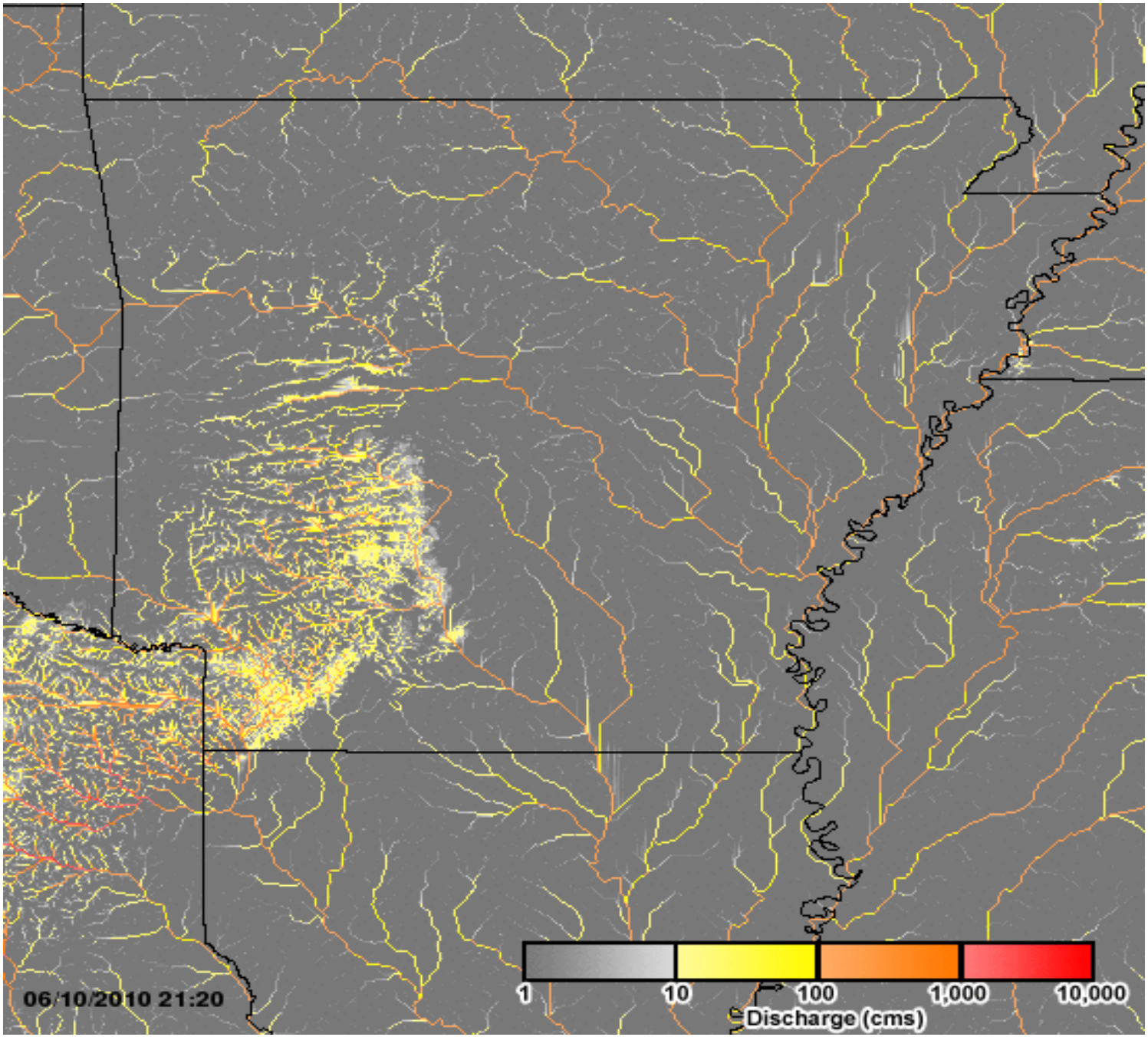
To develop, enhance and maintain a national flash-flood-scale basin dataset in support of the NWS **F**lash **F**lood **M**onitoring and **P**rediction (FFMP) system.




*Digital elevation data from the NED is used to derive the stream network and define flash-flood-scale basin boundaries*

# Hydrology: Streamflow forecast model

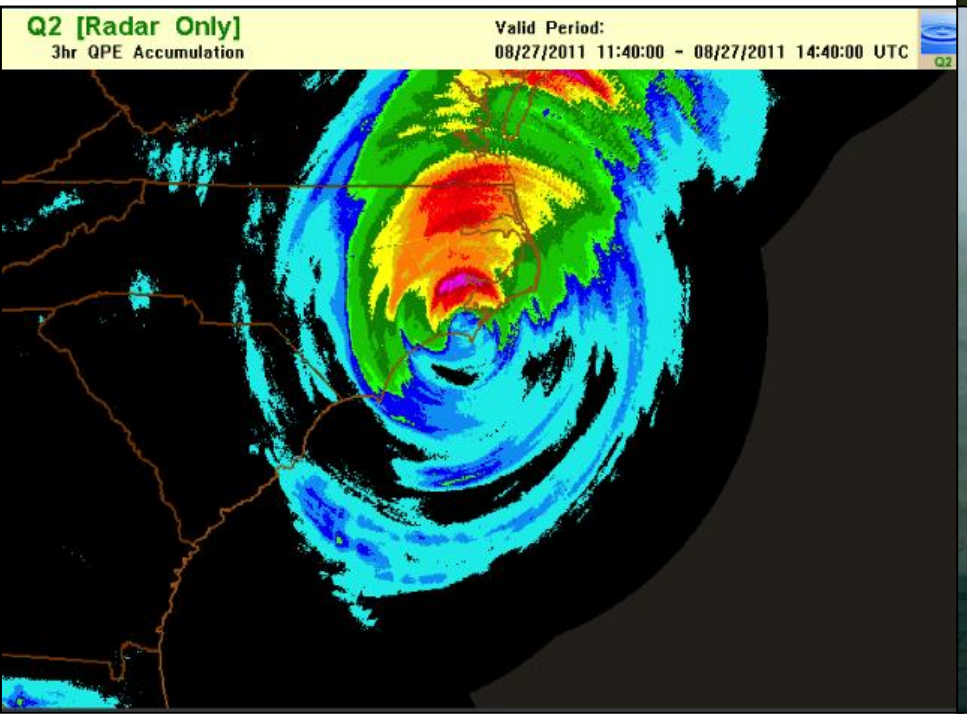


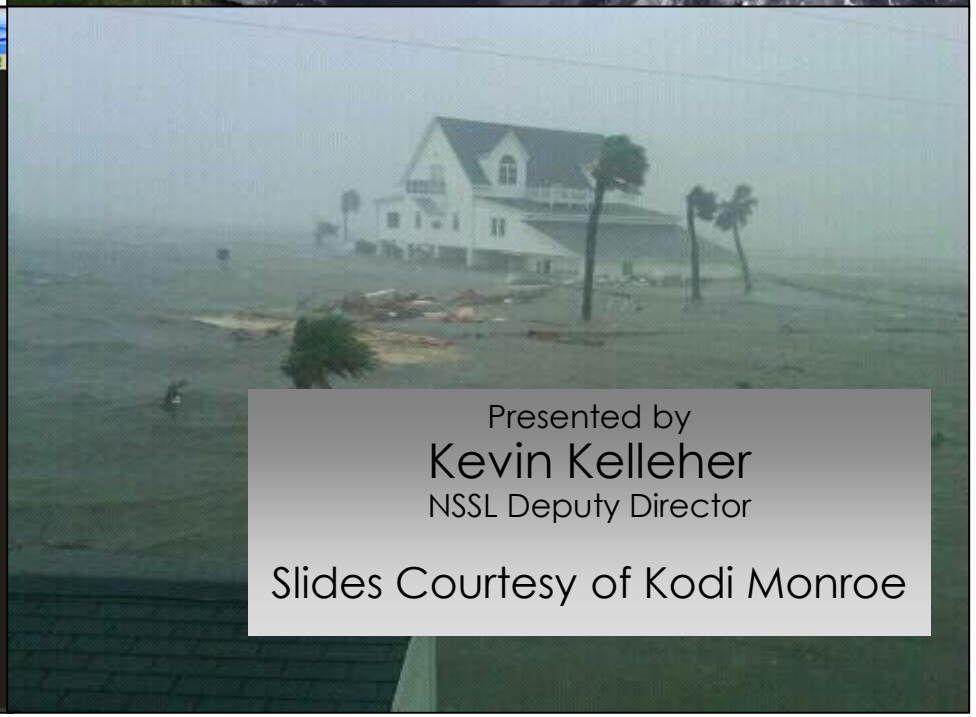
# Communications with EMS and EMA

# CI-FLOW

Coastal and Inland Flooding Observation and Warning

# Tracking the raindrop from the sky to the summit to the sea



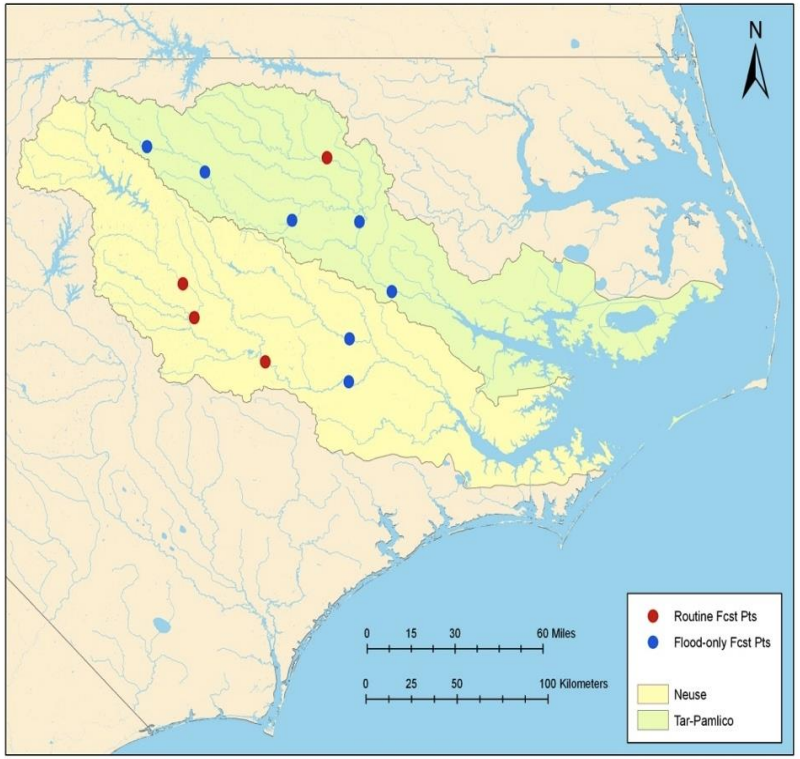



Presented by
Kevin Kelleher
NSSL Deputy Director

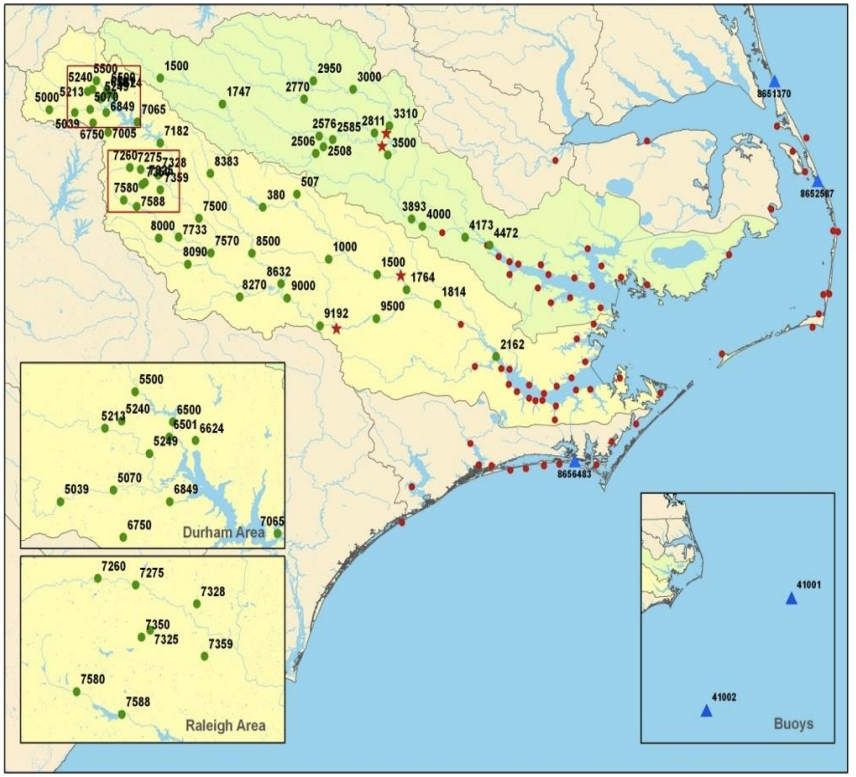
Slides Courtesy of Kodi Monroe

# Hydrologic Forecasting in Coastal Watersheds

- Current NWS Forecast Point

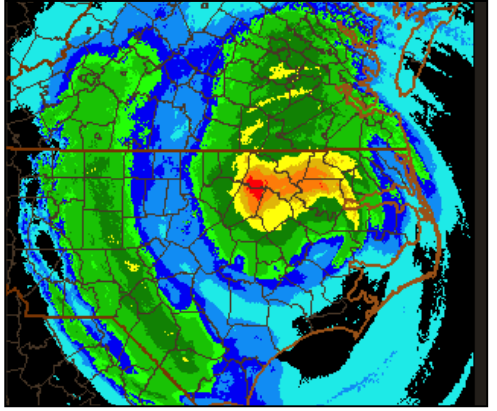



- CI-FLOW Forecast Points



## The Sky: Precipitation

- Past: Gauge-adjusted QPE from NMQ/Q2, 1-hour accumulation
- Future: QPF from HPC, 6-hour accumulation

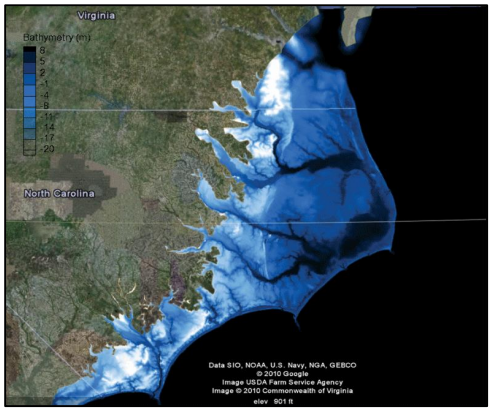


## The Summit: Hydrology

- NWS HL-RDHM
- SACramento Soil Moisture Accounting (SAC-SMA)
- Kinematic Wave Model for routing
- 4-km resolution

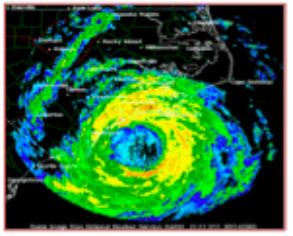
## The Sea: Storm Surge, Waves, & Tides

- ADCIRC + unSWAN predicts total water level, maximum inundation, wave height & period, & tides
- River boundary conditions at 4 hand-off points provided by HL-RDHM

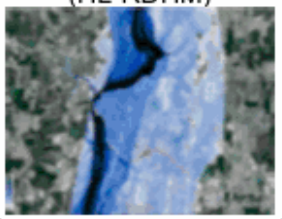


# CI-FLOW System

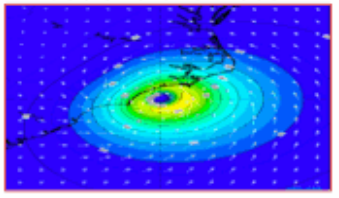
Precipitation
Hindcast: QPE
Real-time: QPE and QPF



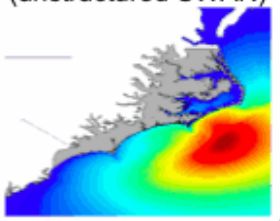
Hydrologic
Model
(HL-RDHM)



Atmospheric Model
Hindcast: PBL or data
assimilated products
Real-time: NAM or NHC
track/Holland Model



Wave Model
(unstructured SWAN)



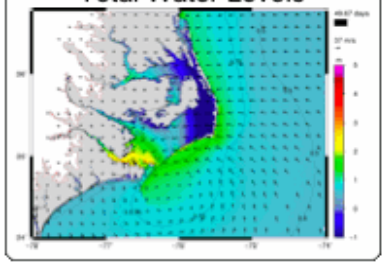
River BCs
Discharge

Surface BCs
Pressure
Wind Forcing

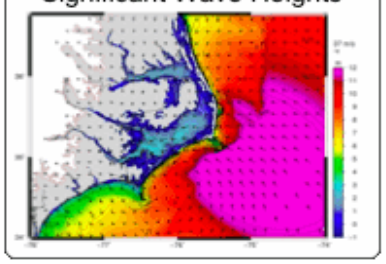
Surface BCs
Wave Forcing

Hydrodynamic Model
(ADCIRC)

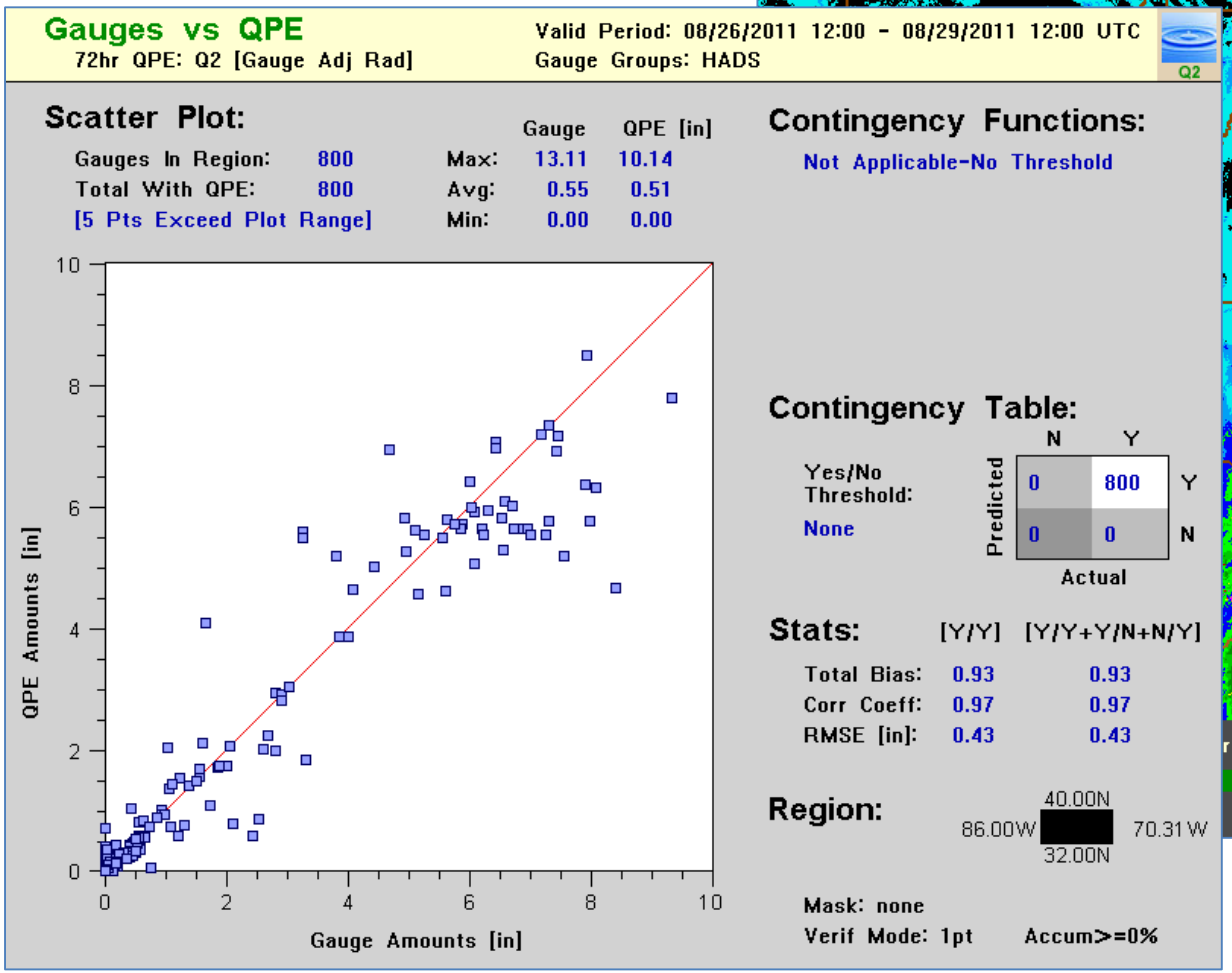
Total Water Levels

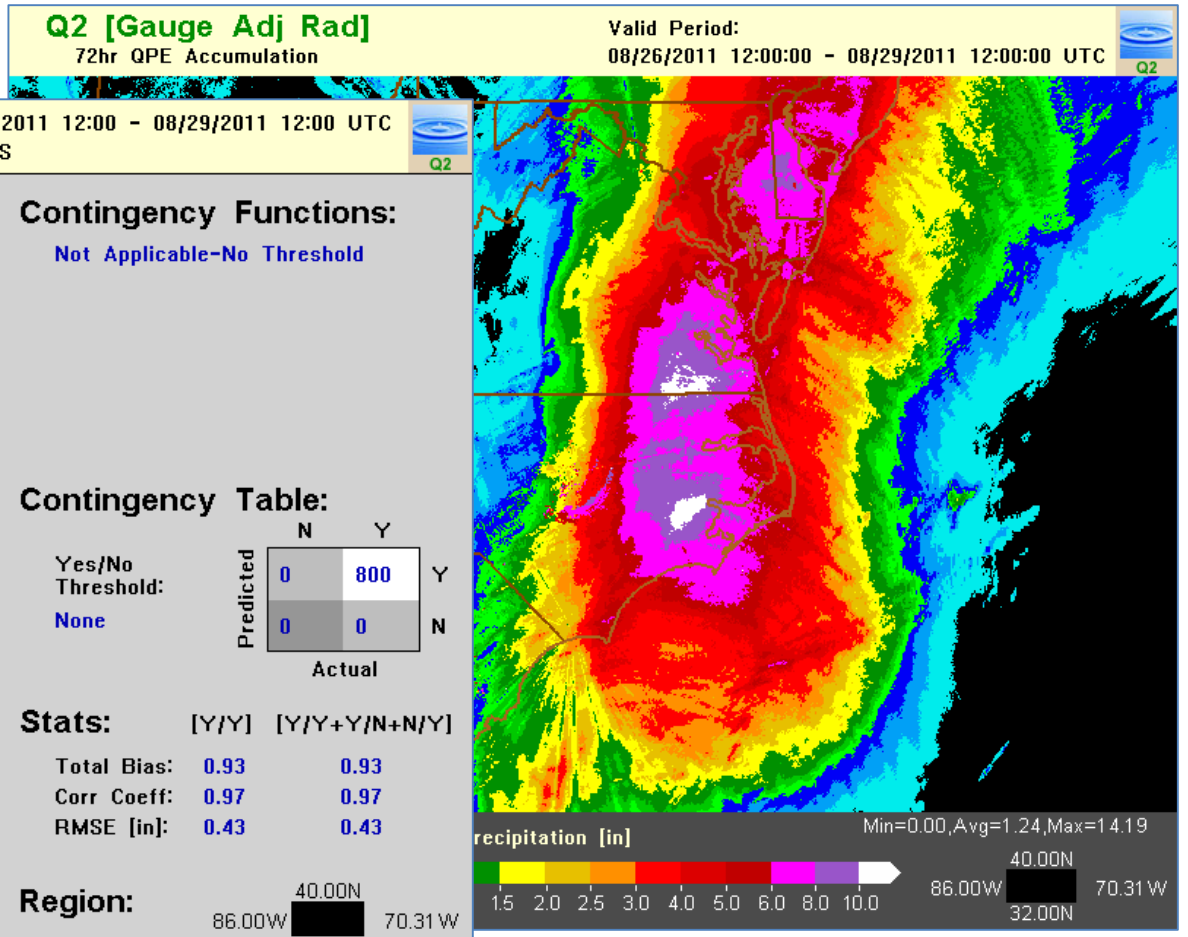


Significant Wave Heights

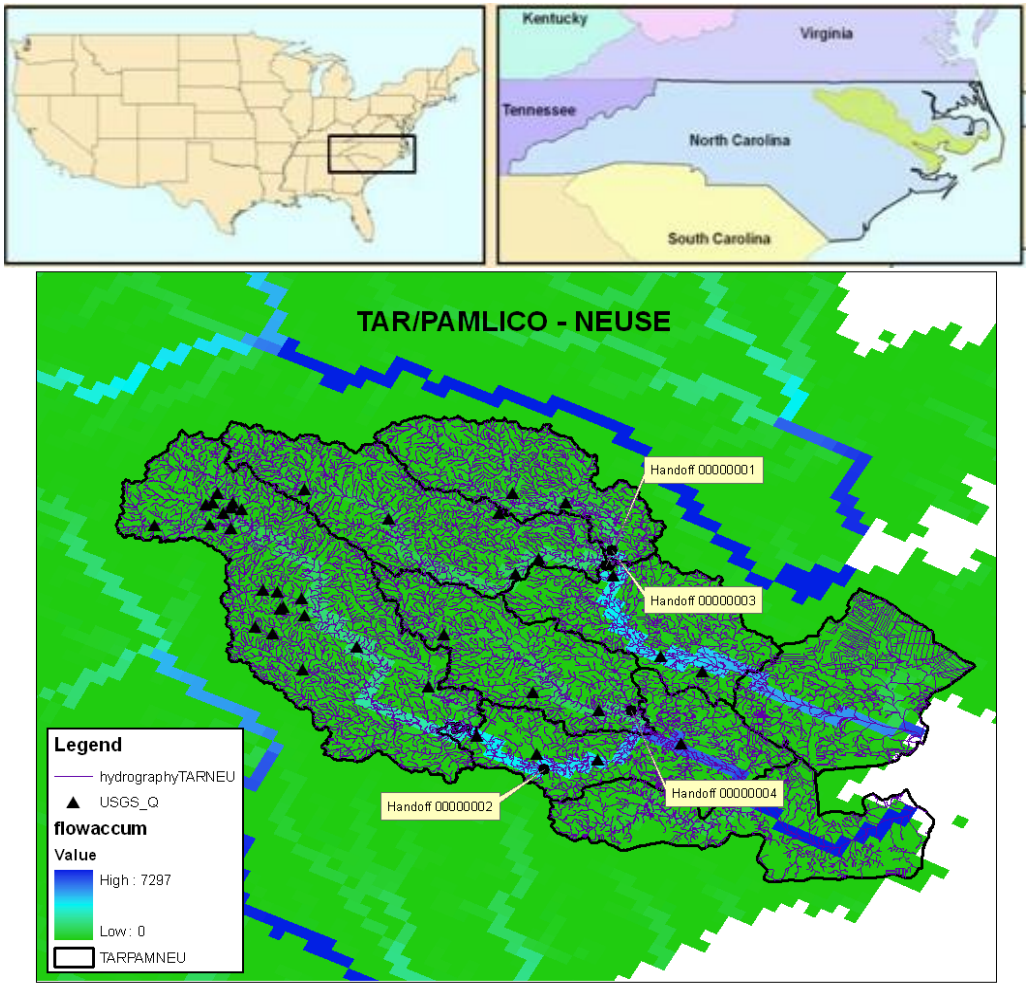


http://nmq.ou.edu

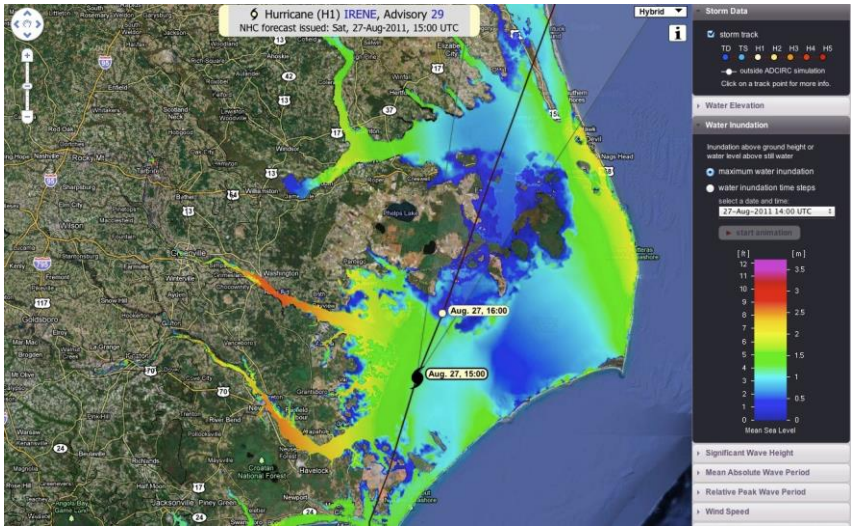


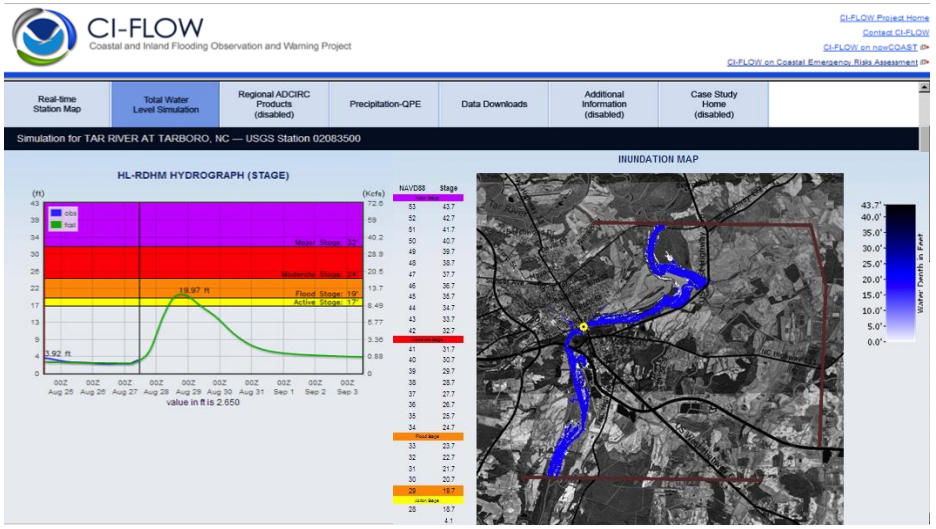



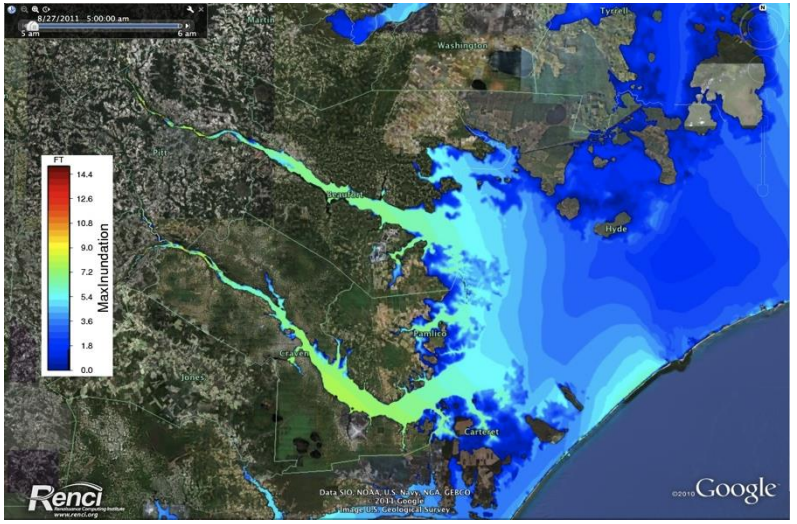
- Located on the East Coast of United States in North Carolina (SERFC)
- Major tributaries in the upper basin are Swift, Fishing & Tranters creeks & Cokey Swamp
- Basin area ≈ 14, 426 km2



# •Distribution of Information



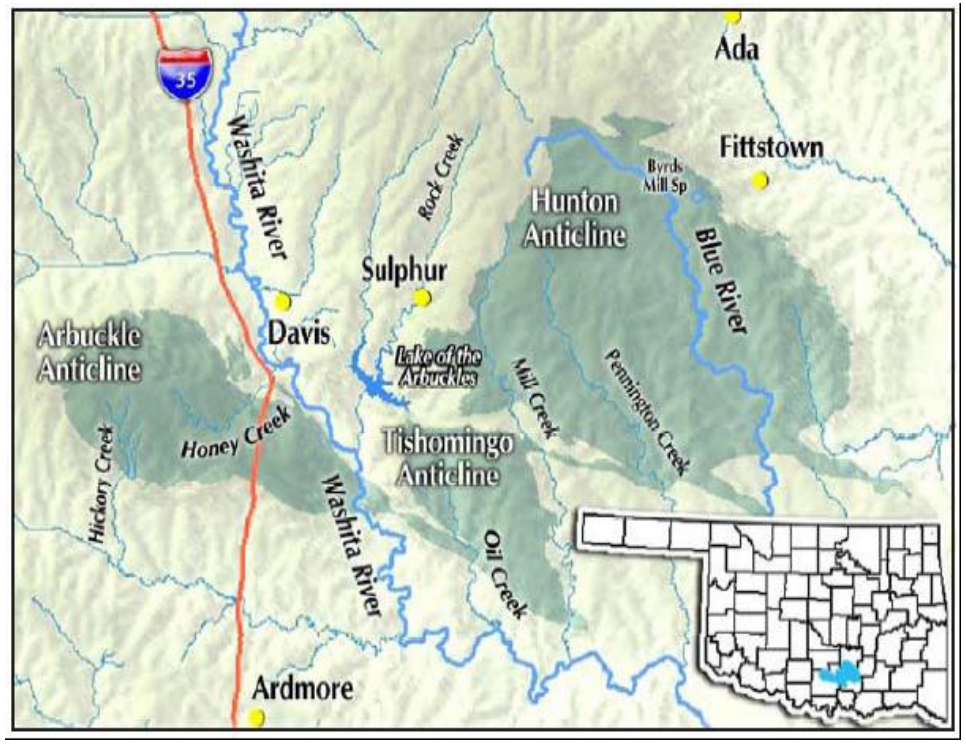
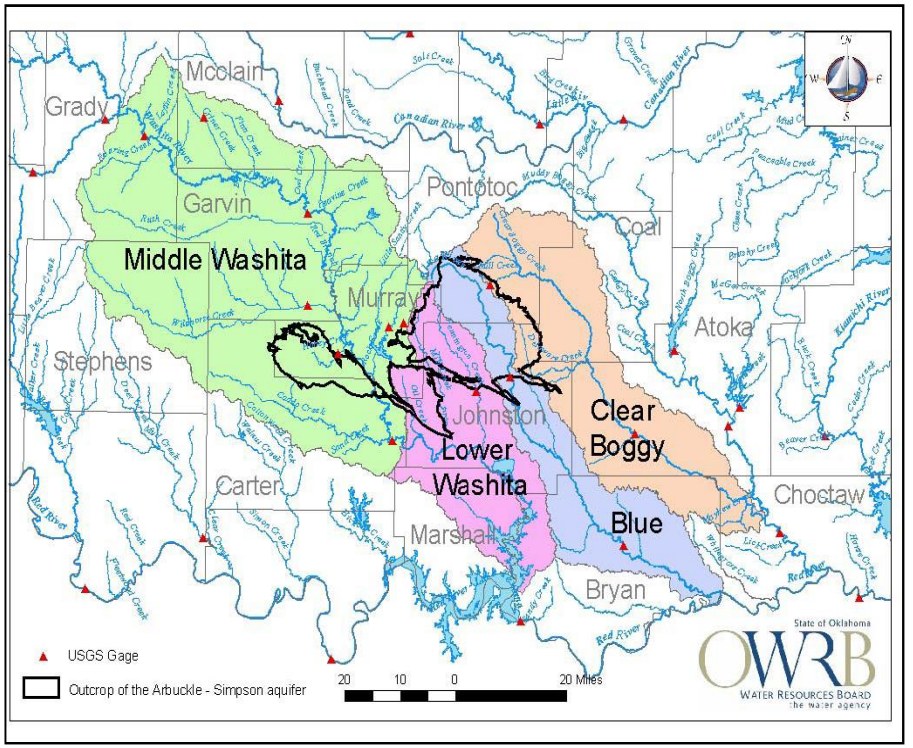



**Water Needs and Strategies for a Sustainable Future**. Western Governor's Association, July 2006

**"In the future, we may not be able to sustain unlimited growth and still maintain our current quality of life.**

**Difficult political choices will be necessary regarding future economic and environmental uses of water and the best way to encourage the orderly transition to a new equilibrium."**

# Geologic Formations of the Aquifer and Blue River Watershed

## Within Chickasaw Nation Tribal boundaries