Threat Assessment

Advanced Warning Operations Course

IC Severe 2

Lesson 1

Outlook and Short-Term Assessment

Warning Decision Training Branch

The title for this Instructional Component (IC) is “Threat Assessment.” This is the 2nd instructional component for the AWOC Severe Track. Lesson 1 in this IC is on outlook and short-term assessment of hazards.

AWOC Severe Track Training Components

IC 1 – Conceptual Models

IC 2 – Threat Assessment

IC 3 – Storm Interrogation Strategies

IC 4 – Application and Review

This IC (one of 4 in Severe Track) is devoted to environmental threat assessment. There are 3 lessons in this IC.

The IC will address the process for evaluating the threat for severe weather hazards (hail ,high winds, flash flooding, and tornadoes). Background for this training is from PCUs 3 and 4 in the Severe Convection Forecasting and Warning PDS. See http://www.nwstc.noaa.gov/nwstrn/d.ntp/meteor/svrpds.html.

IC2 Performance Objective

- Demonstrate processes for continuous evaluation of hazardous weather threats (tornadoes, damaging winds, hail, and flash floods) to support effective warning methodologies.

The performance objective (the desired trainee behavior from training) for this IC is to demonstrate the ability to monitor the mesoscale environment to anticipate and identify storm types, storm evolutions, and hazardous severe weather threats to support severe weather warning methodologies. This would include some of the following:

1) Demonstrating ability to coordinate with SPC and adjacent WFOs on watch decisions (for ex. watch extensions and cancellations)
2) Demonstrate the ability to utilize full suite of products to issue short-term forecasts of convection.
3) Demonstrate ability to monitor mesoscale conditions (including near-storm environment) and provide input to warning decisions based on that data.

IC2 Outline

Lesson 1: Outlook and Short-term Assessment

Lesson 2: Lifting Mechanisms

Lesson 3: Updraft Persistence

These are are the 3 lessons in this IC.

Lesson 1 Learning Objectives

1. Identify purposes of threat assessment
2. Identify key job tasks for threat assessment for 0 to 24 hour time period
3. Identify 3 key job tasks for threat assessment in the 0 to 6 hour time period

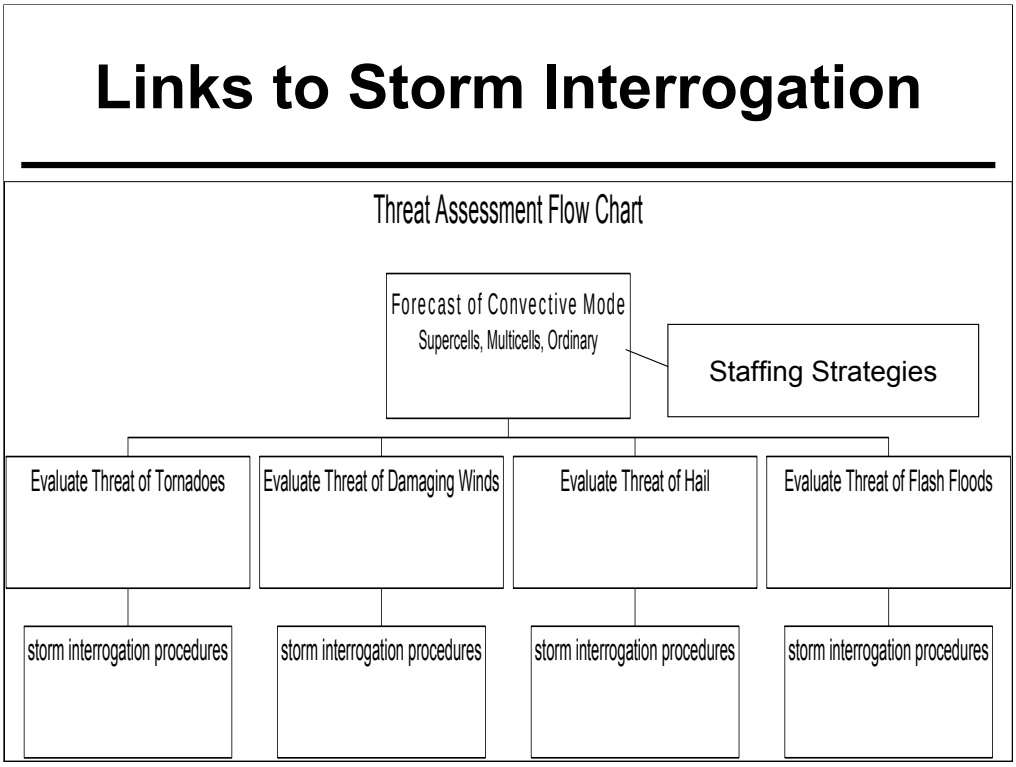
These are the learning objectives for lesson 1. The test will cover all objectives from all three lessons in the IC.

Purpose for Threat Assessment

- TA determines what products/procedures will be used in warnings
- TA is a key factor in establishing mental models for the entire event
- TA sets the tone for severe awareness (anticipation factor) in local office and user community

Threat assessment (TA) is an important part of an effective warning methodology. It is important in determining the tone of awareness for the subsequent event. This step enables the severe weather warning team to begin to focus on specific threat areas and specific storms within the CWA (how to initially sectorize the CWA for severe weather operations). By assessing the spatial and temporal evolution of the mesoscale convective environment, forecasters can improve their decision making skills because they can acquire an increasing knowledge of the perceived level of threat for each storm. Threat assessment is a continuous process, not a one-time action. Thus, many of the key job task skills presented here are applicable throughout the entire severe weather event, especially during warning mode, because forecasters often lose their situational awareness of the environment once warnings commence.

The assessment of potential hazards influences what radar products you might look at and how you will look at them , which is related to interrogation strategies (one of the steps in a warning methodology). One way to think about this is that there is a range of possibilities for all severe weather. After the synoptic and mesoscale assessment, you have narrowed down your expectations. When storms develop and you detect them on radar, you then compare that data to the mental images that have been processed in your brain. Even though the initial expectations provide an important working framework for subsequent warning sequences, individual and collective expectations must be re-evaluated during the event . This is another vital part of warning methodologies.



Environmental threat assessment influences subsequent actions in a warning methodology. There is an initial assessment of convective storm mode (supercells, multicells, or ordinary convection) , then an evaluation of specific hazards. These threats for each storm help determine interrogation procedures.

Threat Assessment
Outlook Phase (0 – 24 hr)

- Applies climatology and pattern recognition
- Includes synoptic/mesoscale analysis
- Evaluation of model signals and parameter output (forecast fields/soundings)
- Evaluate accuracy of model fields (impacts of convection)

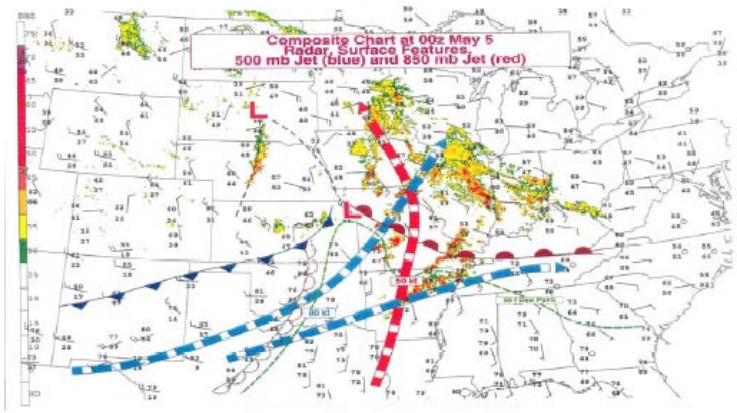
An important aspect of threat assessment is comparing observations to known patterns. The role of climatology is important in recognizing relative seasonal threats. As you analyze large scale features and make the forecast for potential severe weather, it is important to not get caught up in evolution of model details, but try to target relative threats from the potential convective storm types.

The evaluation of the quality of model fields, especially at 24 hrs, is an important factor in conducting threat assessment. Strong synoptically-forced events are often much better handled by the models than events where the synoptic forcing is weak and/or mesoscale is the critical aspect for the environment. Another important task in this phases is knowing how the model handles convection and the results of the convection on other fields.

Methodically, the process includes analyzing fields of shear, available potential buoyancy, potential storm/system movement, and all potential lifting mechanisms. These would help you define the highest threat areas within the CWA. Hourly model forecast soundings can help you to predict convective storm mode and evolution. Coordinate your forecasts with the SPC outlooks, mesoscale discussions and watches.

Pattern Recognition Ex. 1

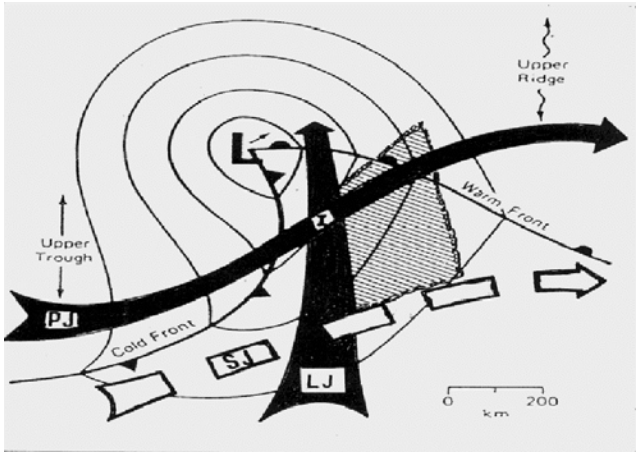
Does this …



It is important to compare synoptic patterns to analog events.

Pattern Recognition Ex. 1

Look like this?



Classic Tornado Outbreak Pattern
(from Newton, 1967)

This is a pattern well known to severe storm forecasters (see http://www.nwstc.noaa.gov/METEOR/SynPat/synpat_main_frm.htm).

Pattern Recognition Ex. 1

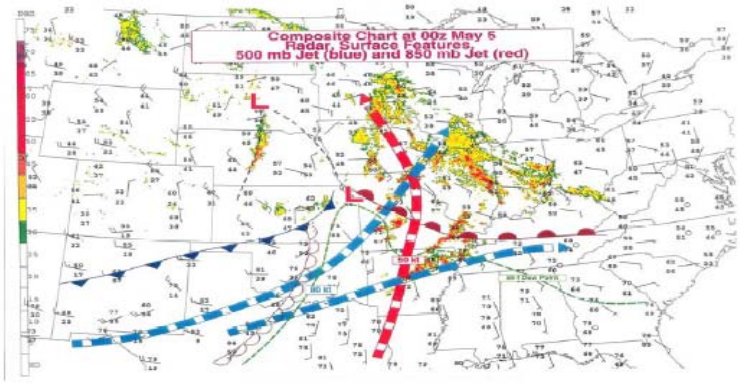
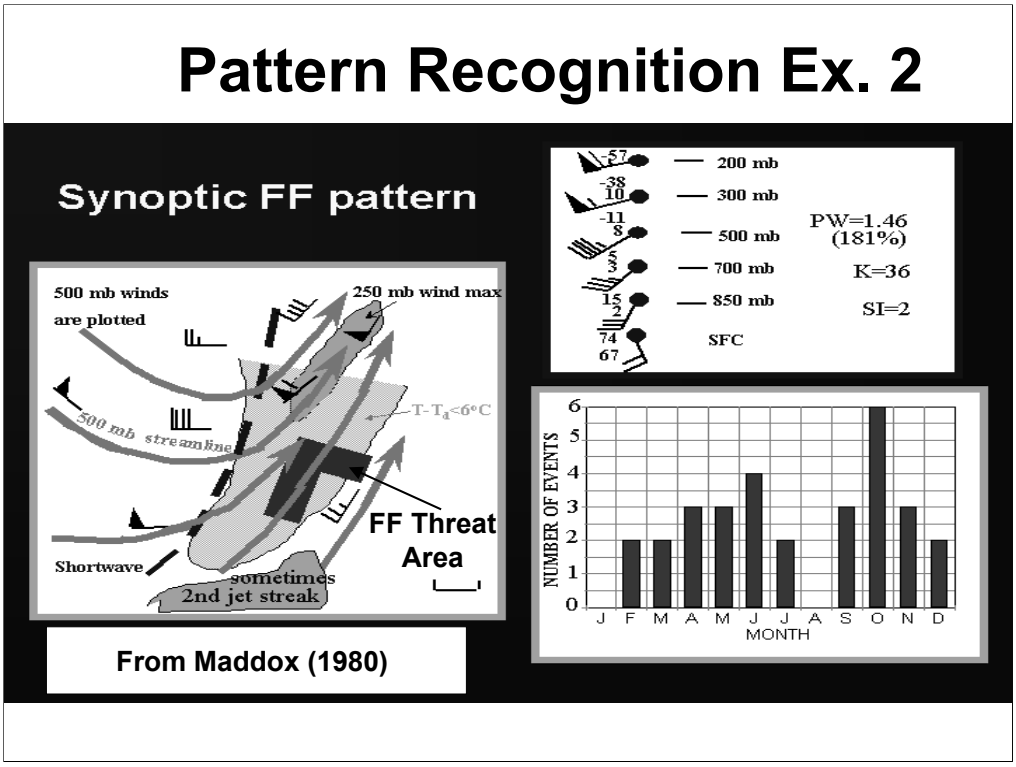


Figure 2. Composite Radar Reflectivity, Surface Fronts, 500 millibar and 850 millibar jet streams at 0000 UTC, (7:00 p.m. CDT May 4, 2003) May 5, 2003. Courtesy of SPC.

From NOAA/NWS Service Assessment of May 4-10, 2003 Tornado Outbreak

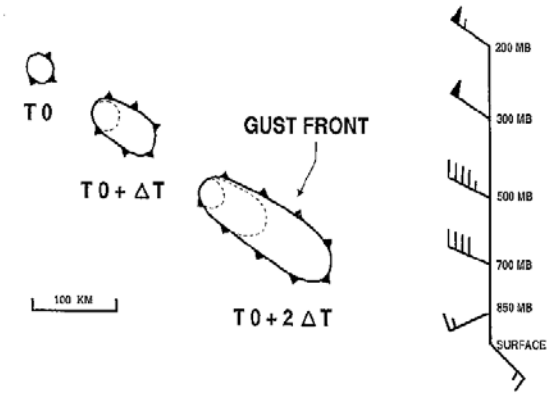
For more details on the May 4, 2003 tornado outbreak, which was a well forecast event, see http://www.noaanews.noaa.gov/stories/s1136.htm.



Another pattern to recognize, this one for heavy rain/flash floods events from Maddox (1980).

Pattern Recognition Ex. 3

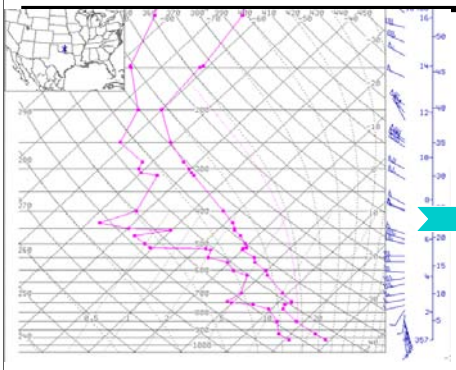
- For Forward Propagating MCSs (Corfidi, 2003)
  - System-relative convergence and instability present in downshear direction
  - Produces forced ascent along gust front
  - Propagation occurs in the downshear direction



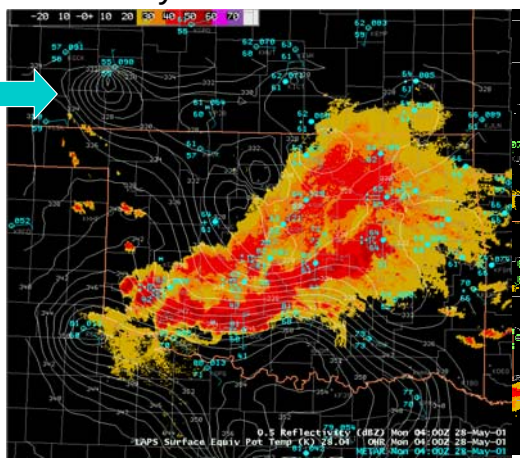
This one is for forward-propagating MCSs (Corfidi, 2003).

Pattern Recognition Ex. 3

Anticipating Forward Propagation



28 May 01 00 – 07Z



1) 50-60 kt WNW winds, dry air in midlevels (~ 500 mb)
2) Strong (3000-4000 J/Kg) downstream SBCAPE
3) Inflow vector ~180 deg of cloud bearing wind direction

There are 3 ingredients for forecasting the potential a downstream (or forward) propagating MCS motion based on Corfidi (2003):

1) Relatively dry conditions in midlevel and/or in the subcloud layer (to increase tendency to produce strong convective-scale downdrafts)
2) Storm-relative inflow strongest on the periphery of the cold pool (portions of gust front oriented parallel to the mean wind vector)
3) Surface-based instability is present downshear.

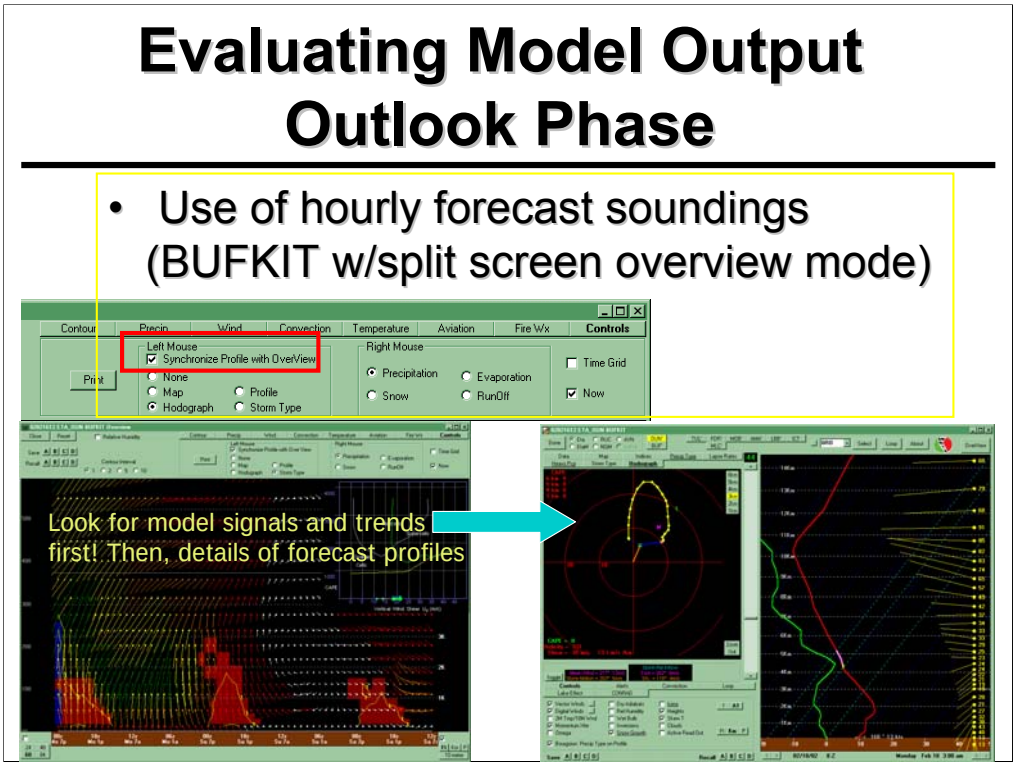
Evaluating Model Signals and Parameter Output

- Once confidence in model solution is established:
  - Evaluate output (from plan view plots and forecast profiles)
  - Verify threat assessment

Establishing confidence in the model solutions involves several components that include, but are not limited to, these factors:

1) Knowledge of the model characteristics (fundamentals, strengths and weaknesses)
2) Knowledge of the role of precipitation, cloud and convective parameterization schemes
3) Knowledge of post-processing of model data
4) Knowledge of model physics
5) Knowledge of model data assimilation and initialization problems

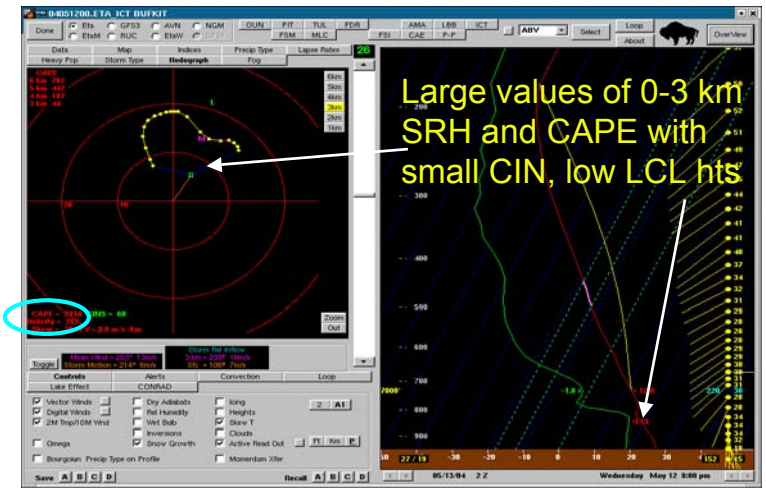
For example, model convective precip. can affect the model precip forecast and models soil moisture availability , which will affect evaporation and subsequent boundary-layer dewpoints and CAPE. Incorrect timing, placement, and amount of model precip can cause errors in the model forecast variables, even if they are treated in a consistent, physically realistic manner. Model soundings are affected where model convection occurs, and these effects are advected downstream. For more information on model precipitation and cloud parameterization issues, visit the COMET NWP web site at http://meted.ucar.edu/nwp/pcu1/ic3/index.htm.



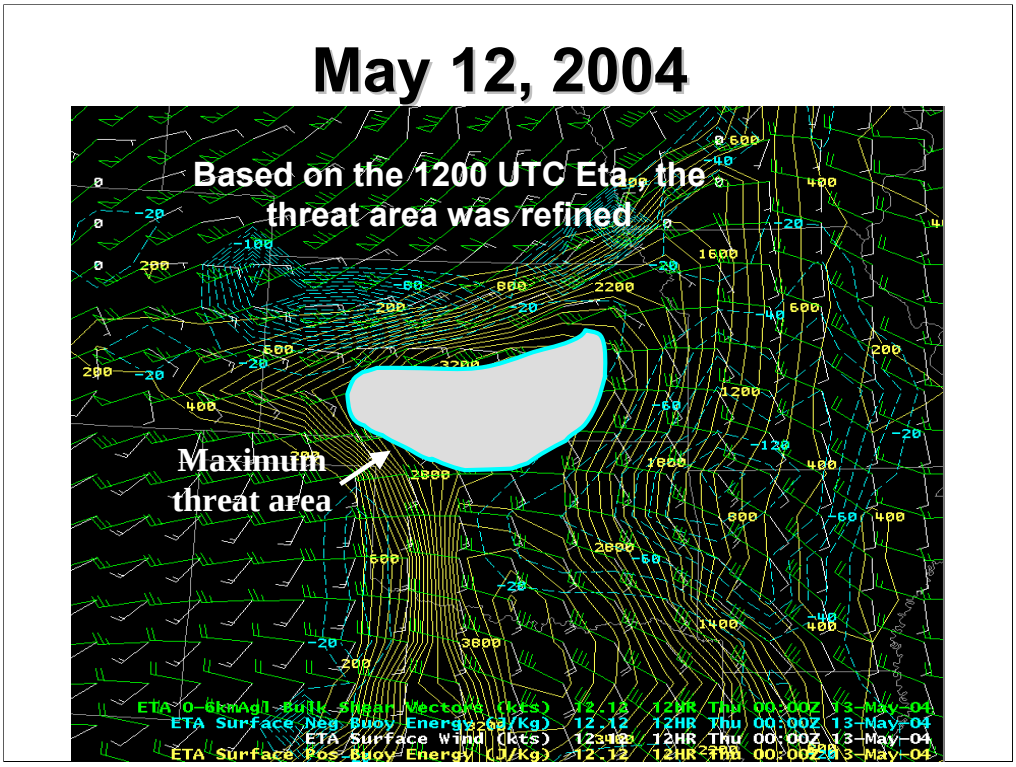
With the split screen mode and synchronized profile with overview option on BUFKIT, one can more easily analyze model signals and process single forecast profile output (See http://wdtb.noaa.gov/resources/projects/BUFKIT/index.html) for the latest version of BUKIT.

May 12, 2004

- **Model forecasts for 36 hours out indicated a high potential for tornadic supercell storms in Southern KS/Northern Oklahoma**

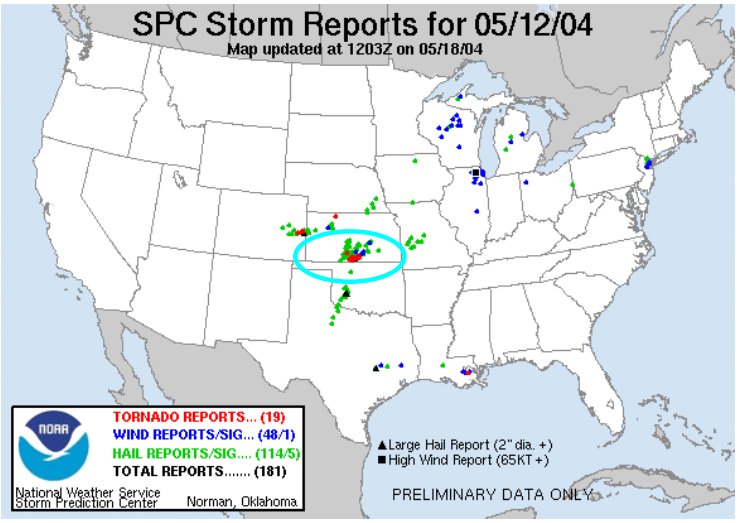


Note this is a 36 hr forecast!



The 12z Eta was suggesting a high potential for tornadic supercells in Southern KS by 00z

May 12 Results



Reports were concentrated in south central KS where the models were showing the highest threat would be.

Threat Assessment
Short-Term Forecast Phase (0 to 6 hrs)
3 Key Job Tasks

1. Initially define storm interrogation process
2. Analyze mesoscale environment to determine changes that may affect model and public forecasts
3. Determine representativeness of environmental data
4. Provide warning forecasters with continuous decision inputs of environmental data

Proper threat assessment on the mesoscale adds accuracy to the initial convective outlook process. The analysis of mesoscale data helps to determine when and where convection will develop, and, on some occasions, may yield clues to the probability of a specific hazard occurring. Since thunderstorms are a function of the environment within which it forms, if we can understand that environment, we have an advantage when it comes to accurately warning before events occur (i.e. increasing lead times). Thus, with environmental recognition of parameters we achieve heightened awareness of threats (for significant tornado events for example). The goals of these efforts are improved warning service. This phase is difficult because of the level of effort that must be made to ensure the assessment is thorough. It is also difficult because of the level of uncertainties in the data sets used in the analyses. How can forecasters provide useful information in a short-term threat assessment which supports the ongoing warning methodology? There are several ways. We will discuss briefly all 4 key tasks shown here.

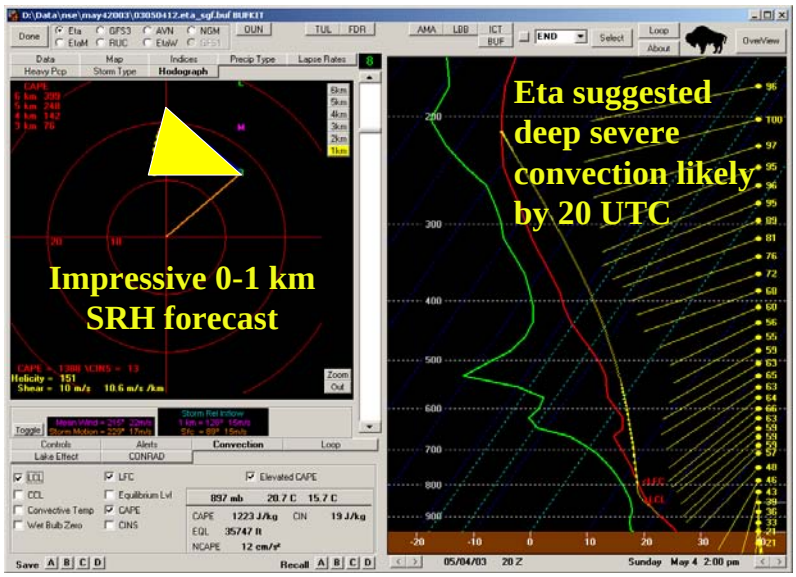
It is important to note that time and **data quality** are big factors in this process. How good are the objective analyses (OA) of thermodynamic and kinematic fields that are displayed on AWIPS? Are there observations to support the analysis? Important questions to ask as this component is performed in the warning methodology. Try to improve your local OA by getting more observations into the analysis. As time approaches the expected severe event, you will typically be analyzing mesoscale features using observed data and high-resolution models. Remember, this information will help you determine how you will interrogate these storms and can have a very strong influence effect on how you weigh radar and other information in the eventual warning decision.

Short-Term Assessment (0-6 hr) "Nowcasting"

- Determine mesoscale (or storm-induced) changes to current forecast
  - July 2, 1997 (Lower Michigan tornado outbreak)
  - April 21, 2001 (Hoisington, KS tornado)
  - May 31,1998 (NY tornado outbreak)
  - Check the WES Case Library

Many of these cases have been developed into good training cases and are available from the Convective PDS web site at http://www.nwstc.noaa.gov/nwstrn/d.ntp/meteor/svrpds.html.

May 4, 2003 12z Eta

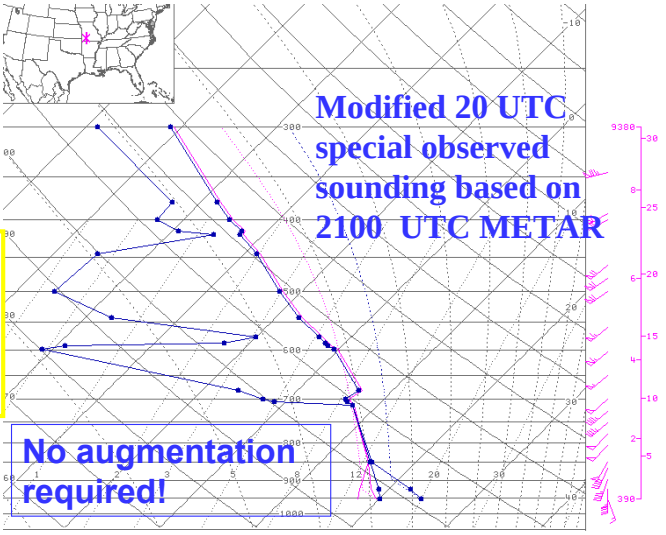


This is an example of short-term threat assessment. Based on the model forecasts, both the low-level CAPE (0-3 km CAPE = 76) and Shear (0-1 km SRH = 151 m2/s2) were very favorable for significant tornadic development. LCL height = 3137 ft (957 m) AGK, LFC = 4916 ft (1500 m) AGL.

The model signals were indicating increasing probability for tornadic supercells. But, could observations tell us even more?

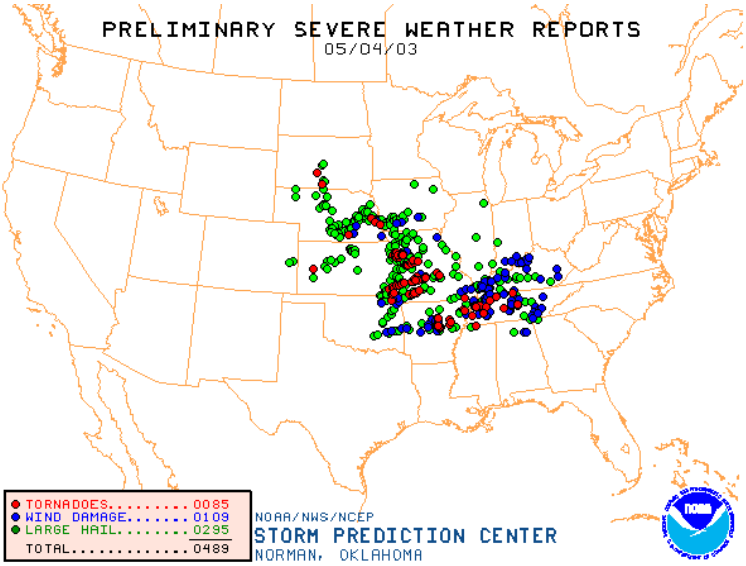
May 4, 2003 20z - Observed

- Turned out the moisture was even deeper than Eta forecasted and surface dew points 2-3 deg F higher.
- LCL ht = 2100 ft (640 m)
- CIN ~ 6 J/kg
- SBCAPE ~ 3068 J/kg
- SRH (0-3km) = 522 m2/s2



Much more impressive parameters from observed sounding (no storm influences either!). This mesoscale sounding indicated that conditions were already extremely high in terms of tornado potential, and that most storms that developed were going to be tornadic once they developed – and they did.

May 4, 2003 Results



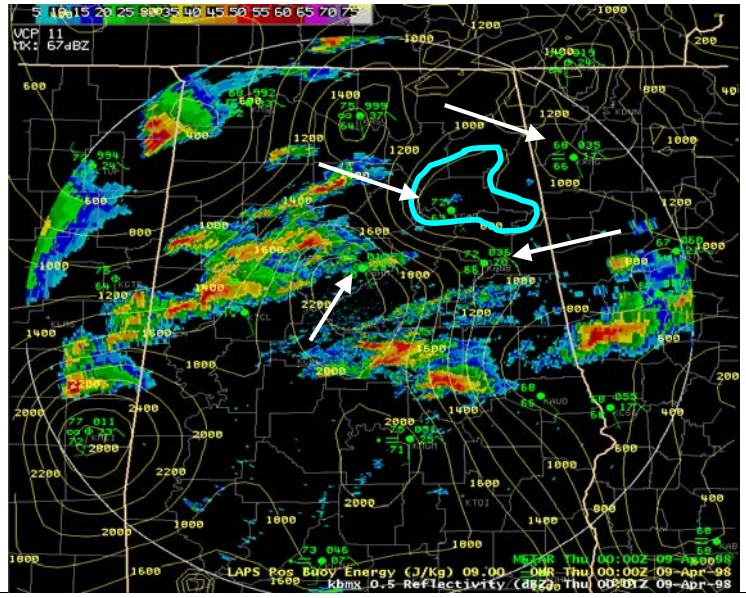
Short-Term Assessment (0-6 hr) "Nowcasting"

- Important to evaluate the representativeness of the data
  - How to "quality control" the model analysis
  - How to anticipate how convection will modify its environment

It is important to QC environment data because using "bad" data can be an impediment to effective warning methodologies. Misinterpreted or inappropriate data can mislead the warning team.

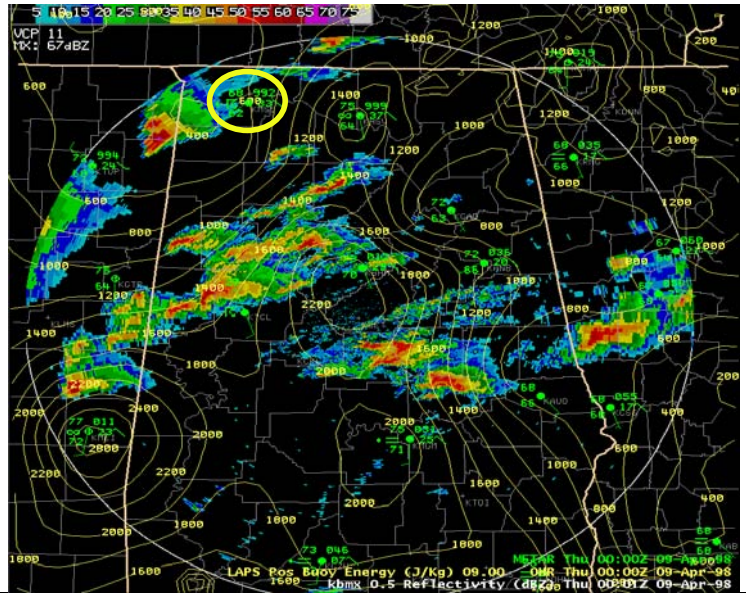
Most staffing strategies recommend a dedicated threat assessment forecaster, due to this reason.

QC-ing Model Forecast
April 8, 1998



Look at this area in northeast AL. How does the CAPE analysis compare to the observations?

April 8, 1998



Look at this area in northwest AL. How has CAPE LAPS analysis been affected by the 00z ob at MSL?

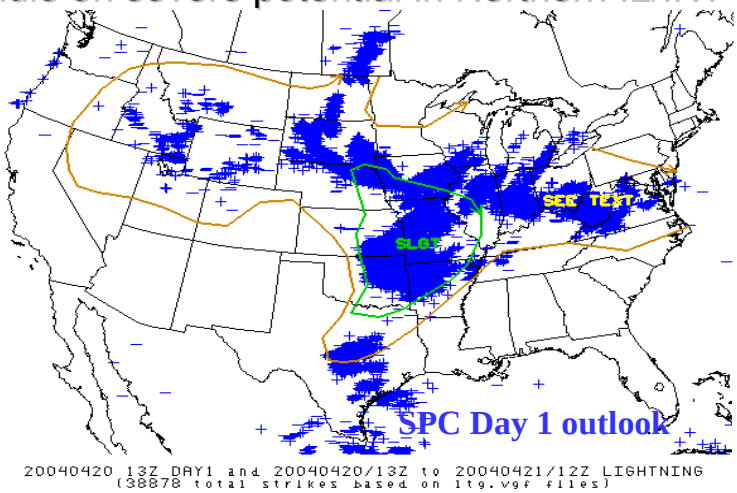
QC-ing Model Forecast

- LAPS and RUC often show spurious signals in CAPE fields
- April 8 ,1998 WES case is a good case to evaluate the “goodness” of the LAPS analysis from 22-01 UTC

Check out this WES case at
http://www.wdtb.noaa.gov/resources/docs/simulationguide/

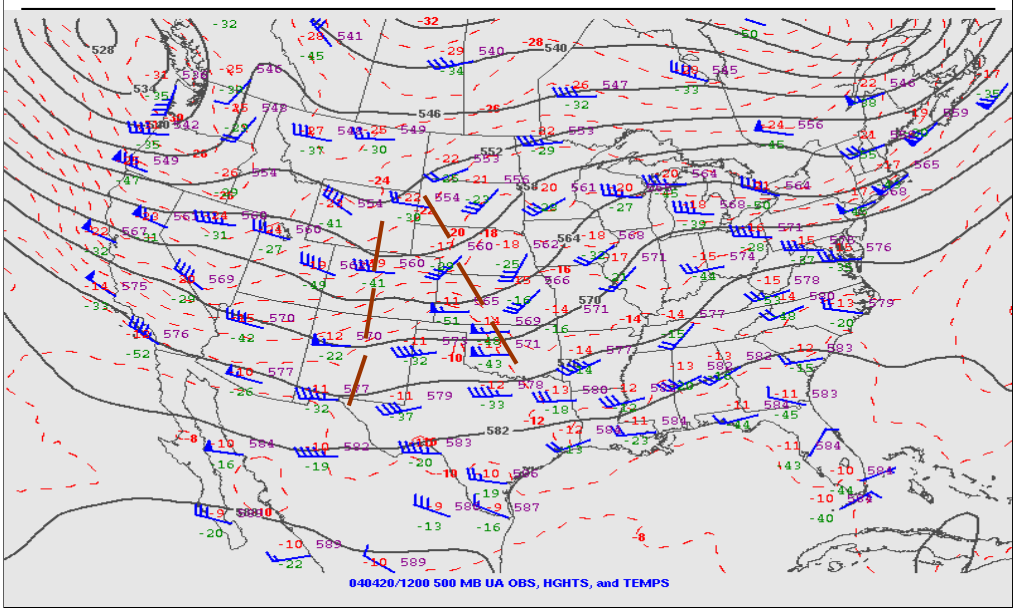
Evaluating Representativeness of Model Data – 4/20/04

- Did the models and current forecasts have a good handle on severe potential in Northern IL/IN?



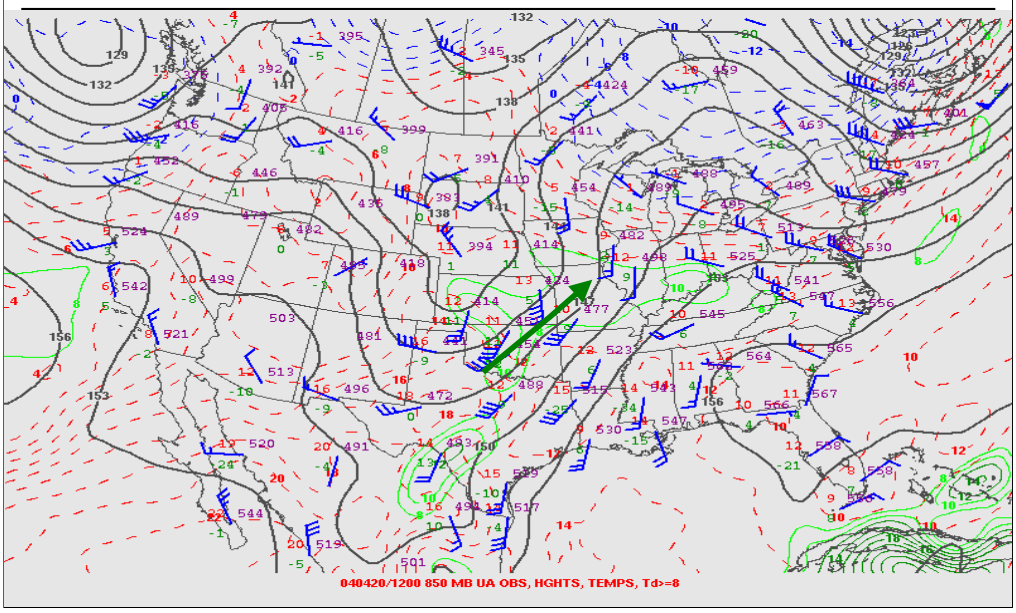
No risk of severe in northern IL/IN. Let's see what happened.

Evaluating Representativeness of Model Data – 4/20/04



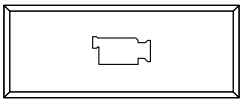
Satellite trends – large scale pattern indicating broad scale lift across central plains into the Ohio Valley (from distinct shortwave troughs).

Evaluating Representativeness of Model Data – 4/20/04



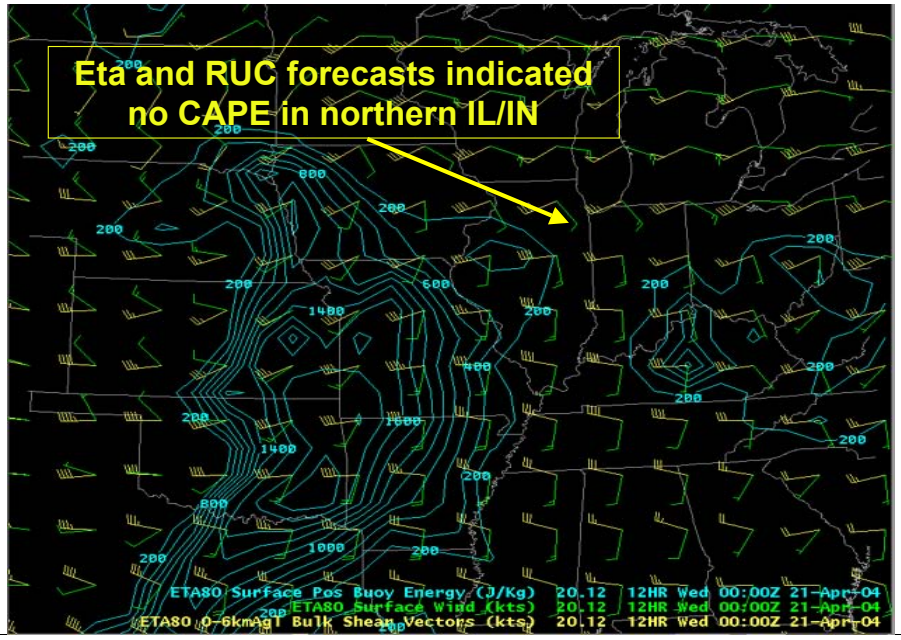
Strong H85 moisture advecting northward into Mid Ms Valley

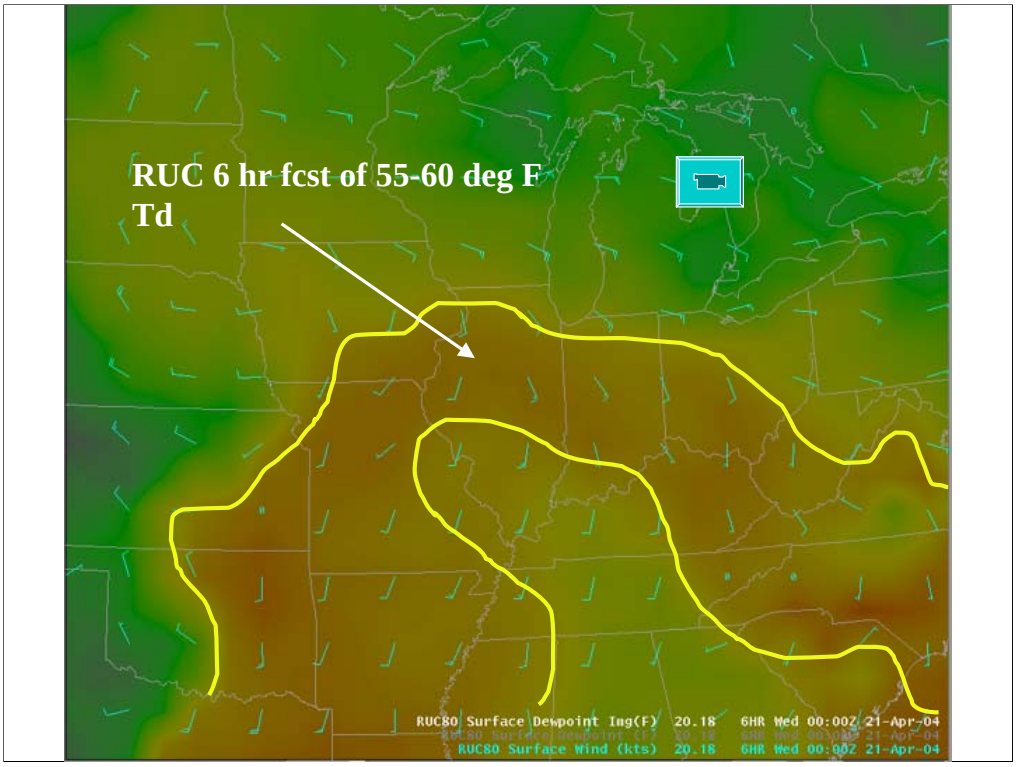
4/20/04 Satellite Loops



There are flash loops showing the satellite imagery.

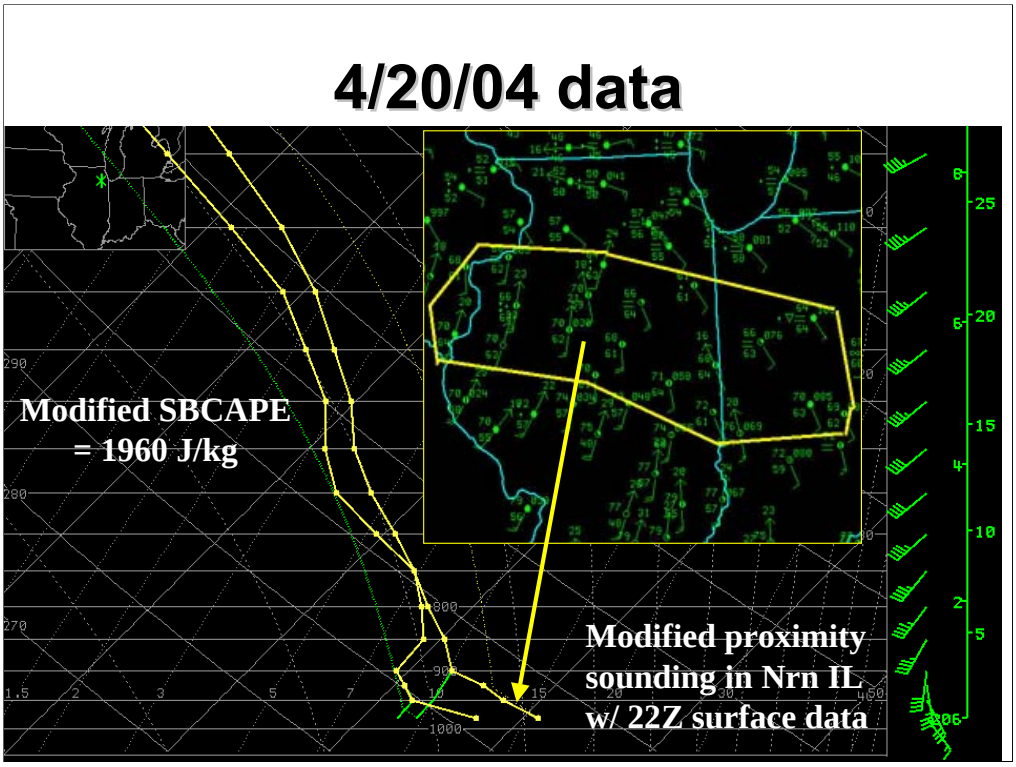
4/20/04 data


Eta and RUC forecasts indicated
no CAPE in northern IL/IN
ETA80 Surface Pos Buoy Energy (J/Kg) 20.12 12HR Wed 00:00Z 21-Apr-04
ETA80 Surface Wind (kts) 20.12 12HR Wed 00:00Z 21-Apr-04
ETA80 0-6kmAgl Bulk Shear Vectors (kts) 20.12 12HR Wed 00:00Z 21-Apr-04



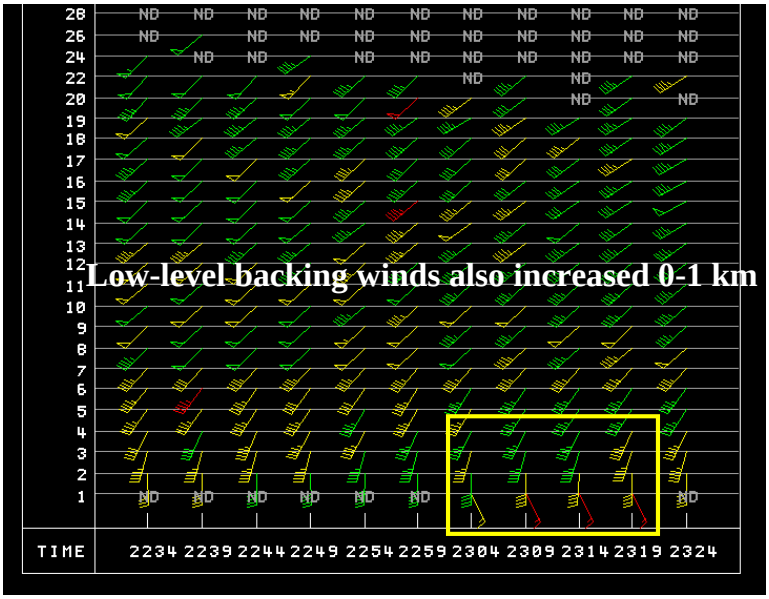
RUC dewpoint temps from 13z to 03z had forecast 60 deg F dewpoints increasing northward into central IL , but that was 5-6 deg less than what was indicated on Metars from 20-23z.

Note the animation of RUC model surface dewpoints

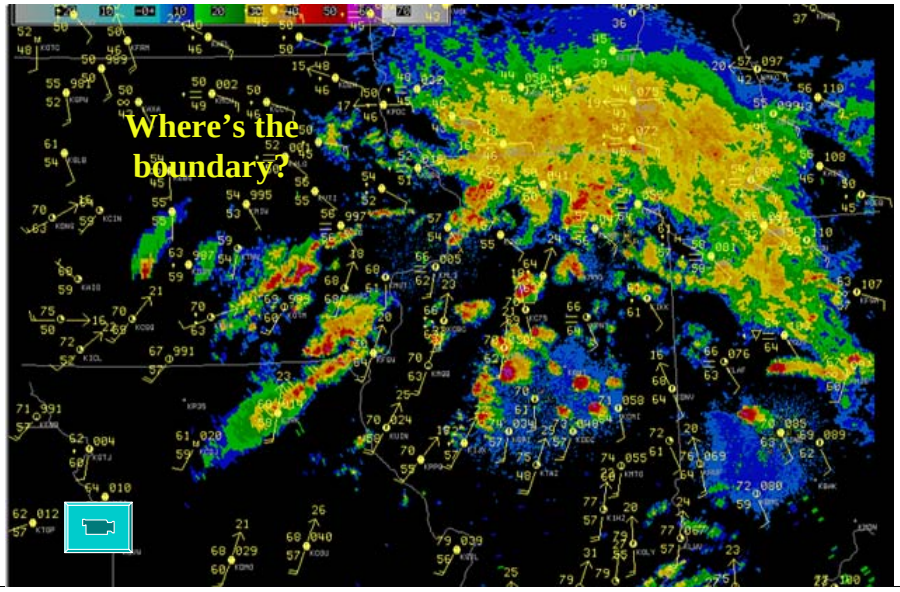


Low-level moisture was (Td > 60deg F) were starting to pool in this region.

4/20/04


Low-level backing winds also increased 0-1 km
TIME
2234 2239 2244 2249 2254 2259 2304 2309 2314 2319 2324

4/20/04



Play loop for evolution . Threat assessment helped forecasters see that the models were way underplaying the low level buoyancy and shear in northern IL/IN. The RUC was too cold and dry.

By the way, interesting supercell initiation along what? (ie. No boundary)

Short-Term Threat Assessment
Key Tasks

- Evaluating mesoscale environment to determine
  - Location of significant lifting mechanisms and associated character of lift
  - Location & timing of severe development
  - Likelihood and intensity of specific hazard (tornadoes, flash flooding, etc.)
  - Evolution of threat (especially movement)

These are some more tasks in general threat assessment, this time in the short-term and in some instances, nowcast phase.

We will discuss most of these in the next lesson.

Lesson 1 Summary

- Threat assessment is a key component in a warning methodology
  - Helps determine storm interrogation procedures
- Involves analyzing mesoscale environment
- Evaluating the “quality” of the environmental data (esp. models)