SPC Mesoscale Analysis and Convective Parameters

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Where Americas Climate and Weather Services Begin

Part I:

SPC Mesoscale Analysis

A Key Part of the Diagnostic Process in the Prediction of Severe Thunderstorms

Why do Surface Mesoanalysis?

- Forecast = diagnosis + trend

- Incorrect diagnosis of atmosphere reduces the probability of making a correct forecast

- Current operational models poorly predict specific atmospheric characteristics critical in convective forecasting, such as:

  - *vertical thermodynamic structure*
  - *boundary layer conditions*
  - *sub synoptic low-level boundaries*
  - *affects of ongoing convection*

Why do Surface Mesoanalysis? (cont.)

- Mesoanalysis facilitates our ability to synthesize data from a variety of observational sources

- Gain a better perspective of actual environmental conditions

- Critical to track and identify mesoscale boundaries

Use Computer and Forecaster Analyses Together

- Software quickly displays derived computer fields
- Animation of fields provides unique visual information about trends
- **Let the computer do what it is best at doing** => number crunching and visualization techniques
- **Let the human brain do what it is best at doing** => synthesizing information from many sources and applying conceptual models

<u>Map Analysis</u>
A Cornerstone of the SPC

Analyze temperatures, dew points, pressure and pressure changes on surface map

Identify features such as ***gust front/outflow boundary***, ***cold pool/mesohigh***, ***mesolow***, and ***wake depressions***

Also analyze 850 mb, 700 mb, 500 mb and 250 mb each raob run

Temperatures (2C) and heights (60m) analyzed at 850 mb, 700 mb and 500 mb.

Also include dew points at 850mb, 12 hours height changes at 500 mb and isotachs at 250 mb.

Observational Sources used in SPC Mesoanalysis

- Surface observations, including mesonets
- Satellite imagery
- Radar
- Animation of satellite and radar imagery
- Lightning Detection Network

Boundaries of Convective Interest

- Synoptic Scale Fronts (thermal boundaries)

  - cold front, warm front, quasi-stationary front

- Mesoscale Fronts

  - sea/lake breeze fronts, convective outflow boundaries, differential heating boundaries owing to clouds, fog, vegetation, and terrain

- Dry Lines (moisture boundaries)
- Pressure Trough Lines
- Convergence Zones

Techniques to Help Identify Surface Boundaries

Basic Principles of Mesoanalysis (after Fujita, Miller, etc.)

• Incorporate all available data to find sub-synoptic features

• Be careful ignoring data that may appear "not to fit" with surrounding stations

****This is very important****
Continuity – What/where boundaries were located on previous analysis -- Best accomplished by hourly analyses!!!

Thermal and Moisture Gradients – Useful in locating Boundaries

• Analyze isotherms (red) / isodrosotherms (green) at 4-5F deg. intervals (warm season 2F deg. intervals)

• Temperature analysis may be crucial at locating outflow boundaries (especially for weak wind/pressure fields)

Thermal and moisture patterns help locate areas of convergence and severe storm potential

Mesoanalysis Pressure/Wind Data

- Analyze pressure at 2 mb intervals (1 mb in summer).
- Analyze 2 or 3-hourly pressure changes (1 mb)
- Surface wind streamline analysis helpful in locating areas of convergence.
- Wind shifts typically associated with boundaries
- A wind speed decrease in unidirectional flow often associated with areas of convergence/divergence

Surface Pressure Changes

1-2 hourly pressure changes help identify:

-- mesolow /mesohigh couplets and boundaries

** Concentrated fall/rise couplet enhance low-level convergence/shear by backing surface winds (enhancing tornado threat)

-- clouds associated with surface pressure falls may be linked to a dynamical feature

-- implications on thermal advection

Severe Weather Forecast Tools

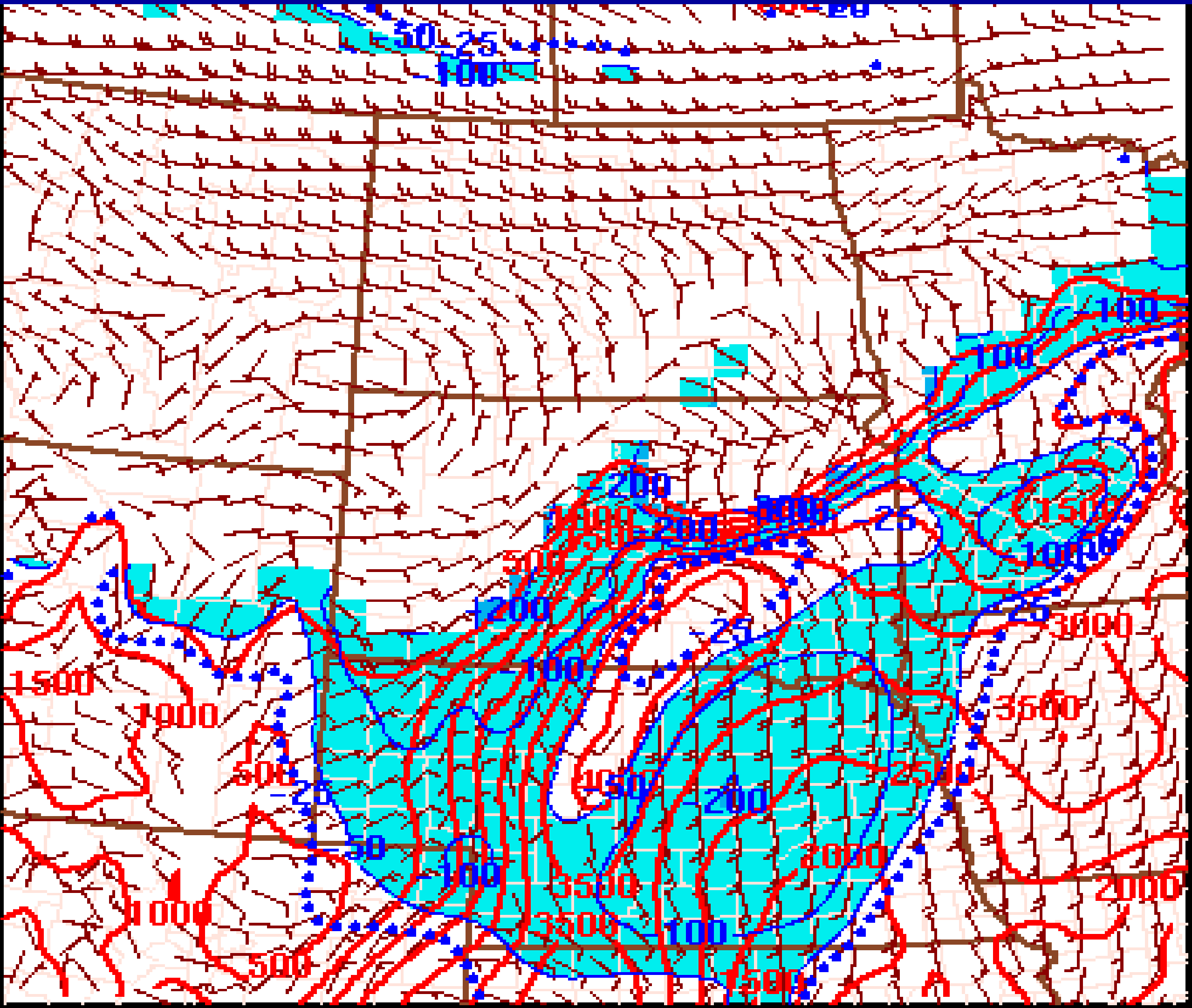
Convective Available Potential Energy (CAPE)

SBCAPE CAPE calculated using a Surface Based parcel

MUCAPE CAPE calculated using the Most Unstable parcel in the lowest 300 mb

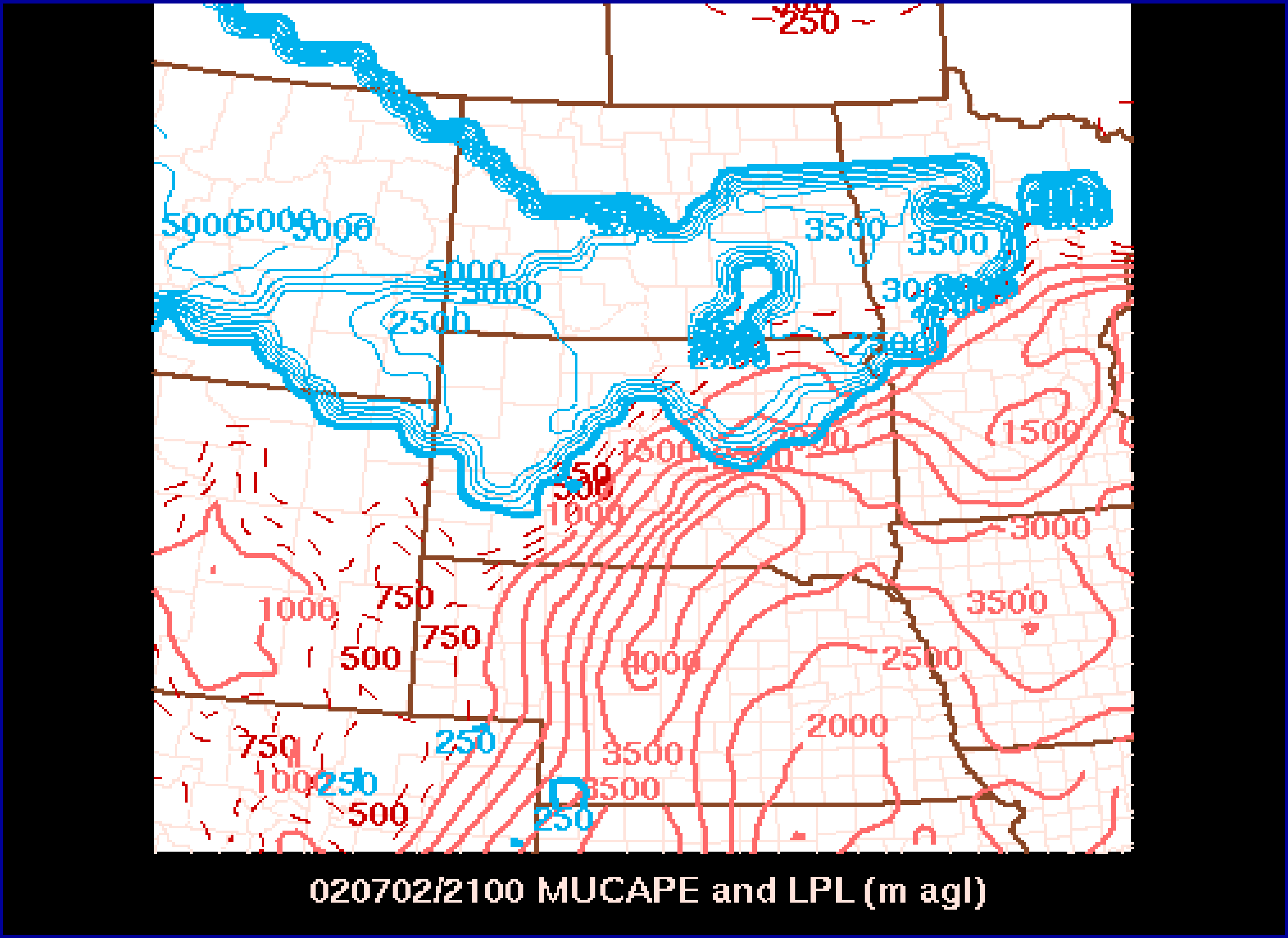
MLCAPE CAPE calculated using a parcel consisting of Mean Layer values of temperature and moisture from the lowest 100 mb AGL

SBCAPE

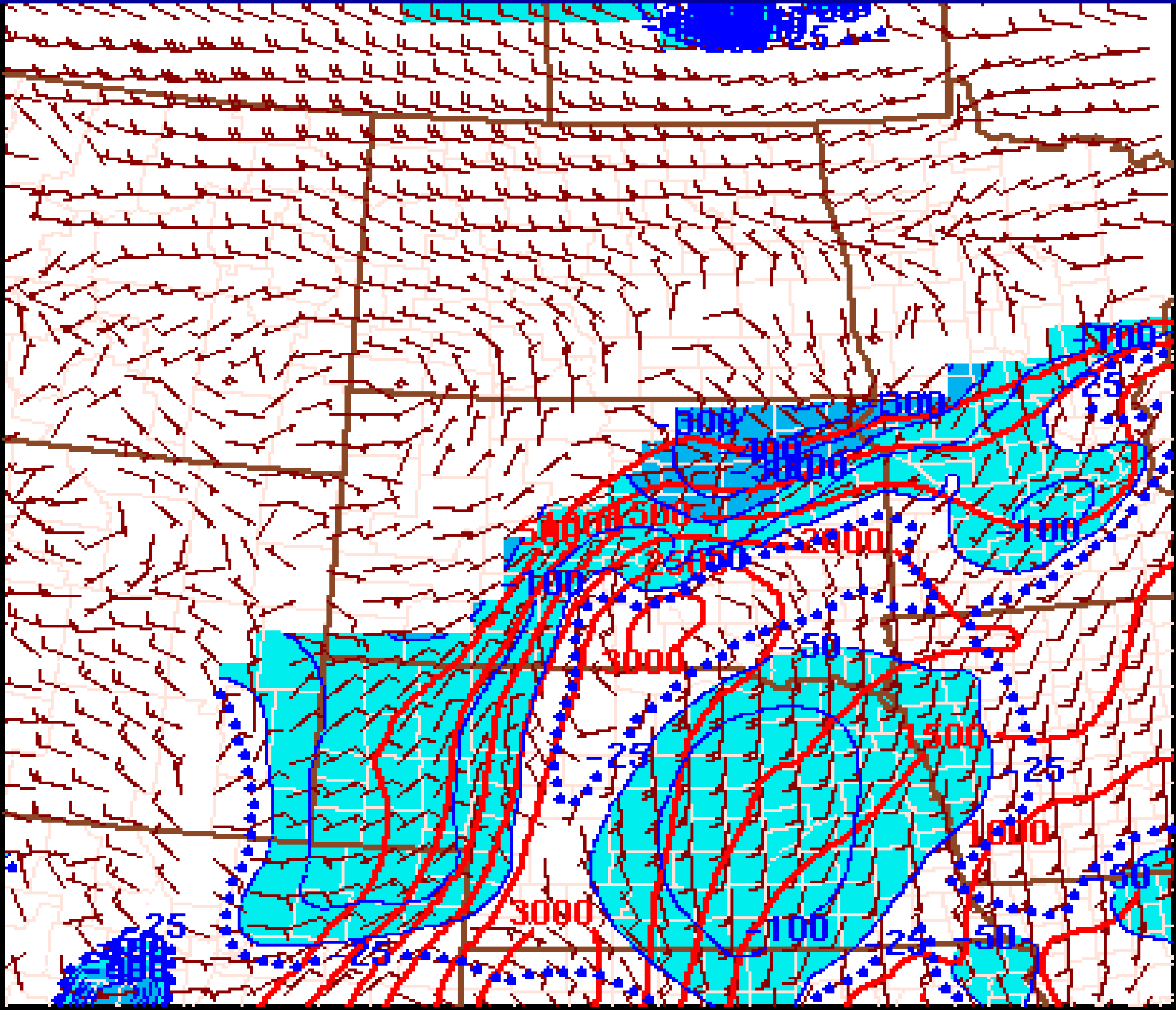


020702/2100 Surface Based CAPE/CINH

MUCAPE



100 mb MLCAPE



020702/2200 100mb Mixed Layer CAPE/CINH (J/kg)

Degree of Instability (MLCAPE)

0-1000	J/kg	weakly unstable
1000-2500	J/kg	moderately unstable
2500-3500	J/kg	very unstable
3500+	J/kg	extremely unstable

Research Proximity Soundings

** Proximity soundings -- observed soundings considered to be "representative" of the storm environment

** Proximity sounding parameters vary, but typically +/- 3 hours and located within 100 nm of "storms"

** Given the temporal/spatial resolution of radiosonde network, obtaining a large collection of proximity soundings is difficult.

** Two results discussed: 1) Craven and Brooks (2001)
2) Edwards and Thompson (Sep 2000)

Craven (SPC)-Brooks (NSSL) Research

- **Initially examined 0000 UTC soundings from 1996-1999 (~60,000) and associated each sounding within 5 classes:**
- ***No Thunderstorms* (45508 soundings)**
- ***Non-Severe Thunderstorms* (11339 soundings)**
- ***Severe Thunderstorms* (2644 soundings)**
- ***Significant Hail or Wind* (512 soundings)**
- ***Significant Tornado* (87 soundings)**

- **CG lightning data and Storm Reports were used to determine the convective classes**
- **Proximity defined as within 185 km of sounding and event occurring between 21-03 UTC (+/- 3 hours)**

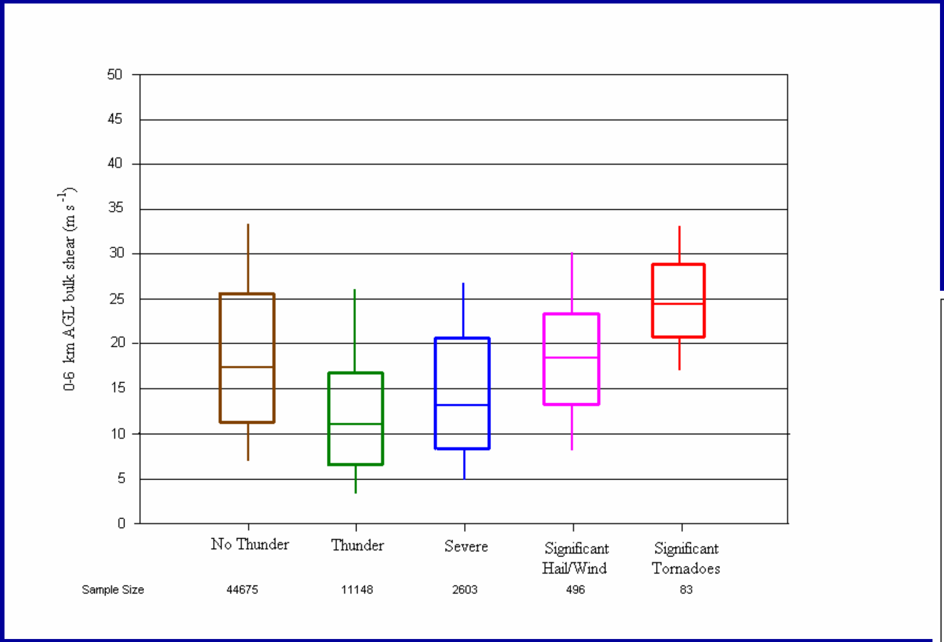
Edwards/Thompson (SPC) Research

Used RUC2 proximity soundings for identified supercells

Supercell sample included 96 tornadic and 92 non tornadic supercells

Craven/Brooks 0-6km Vector Shear

0-6 km AGL Vector Shear



Large overlap between thunder/severe, better discrimination between severe and sig. severe (especially sig. tornadoes)

Seasonal Variation

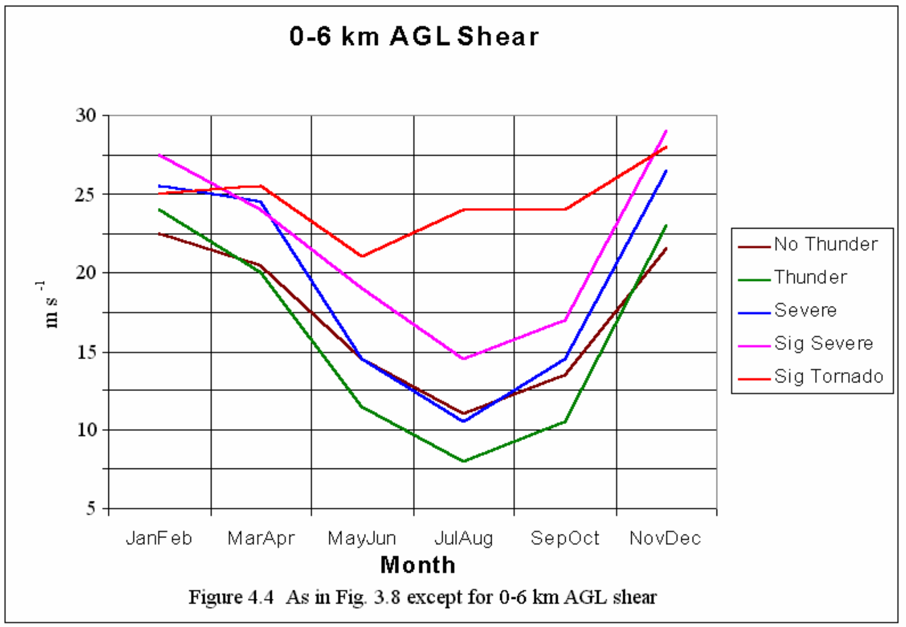


Figure 4.4 As in Fig. 3.8 except for 0-6 km AGL shear

Deep Layer Shear

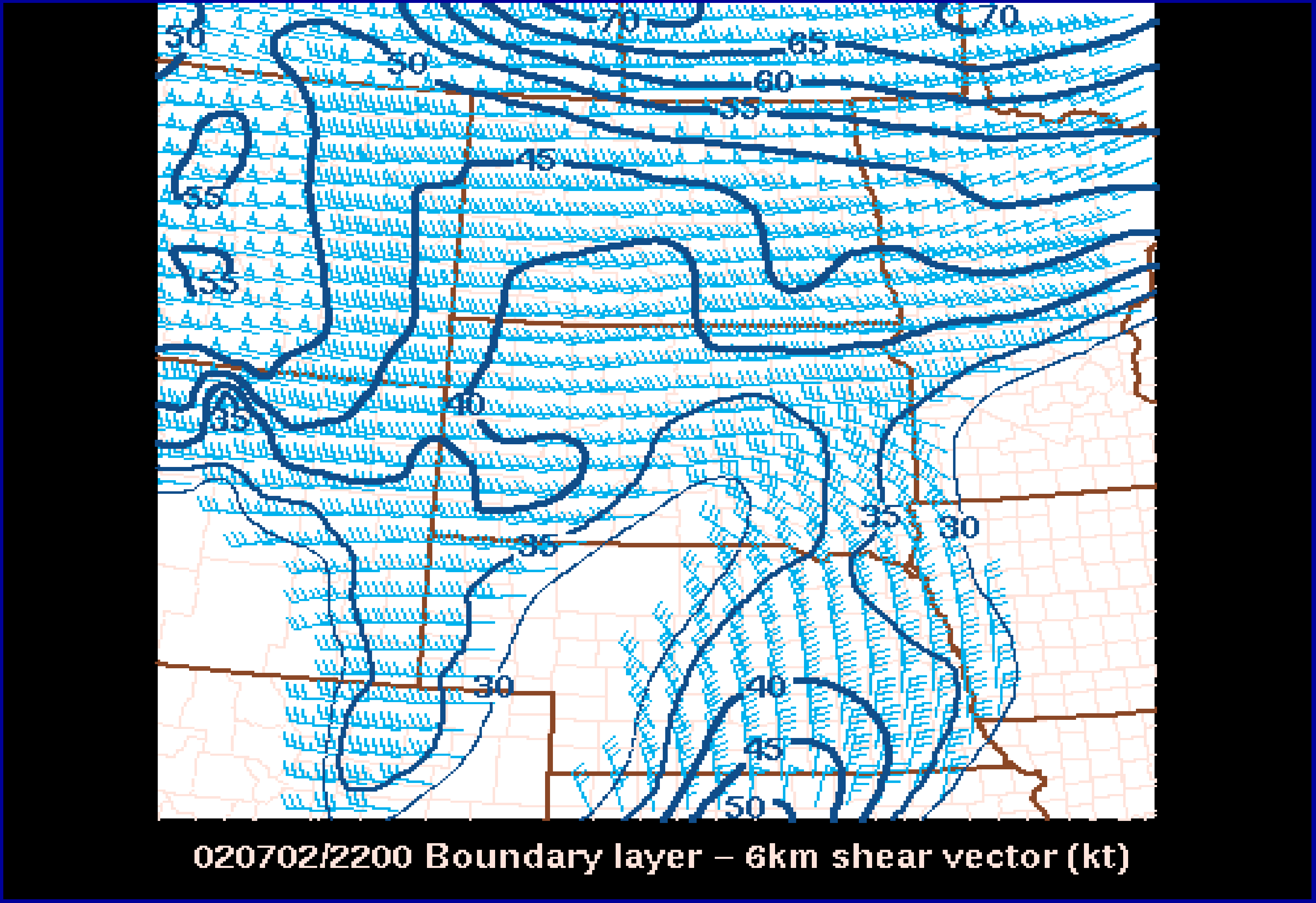
Deep layer shear = 0-6 km shear vector

40+ kt suggests -- if storms develop -- supercells are likely

30-40 kt -- supercells also possible if environment is very or extremely unstable

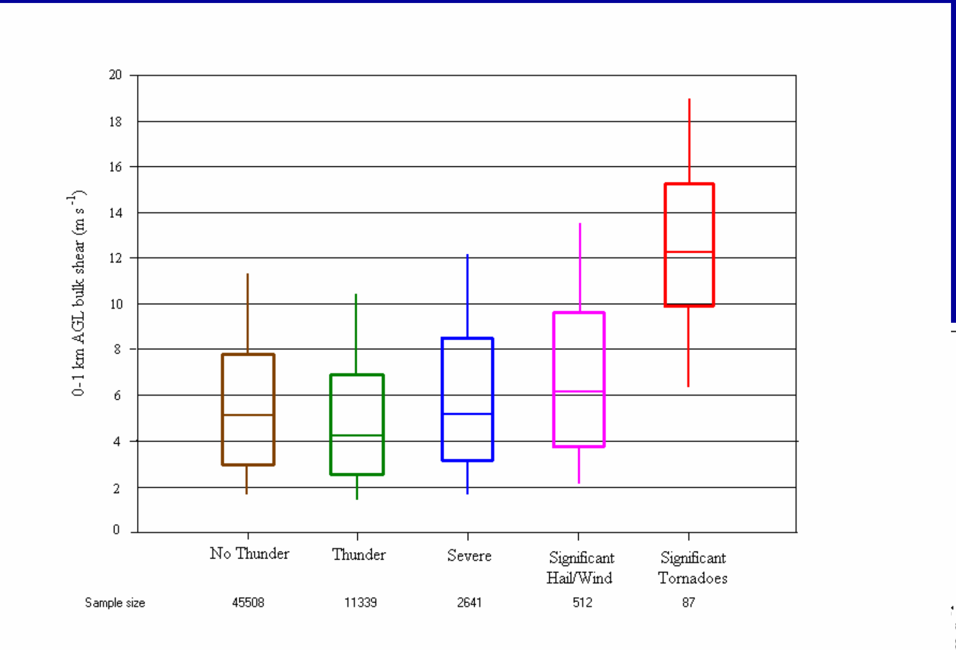
About 15-20 kt shear needed for organized convection with mid level winds at least 25 kt

0-6 km Shear Vector



Craven/Brooks 0-1km Vector Shear

0-1 km AGL Vector Shear



Seasonal Variation

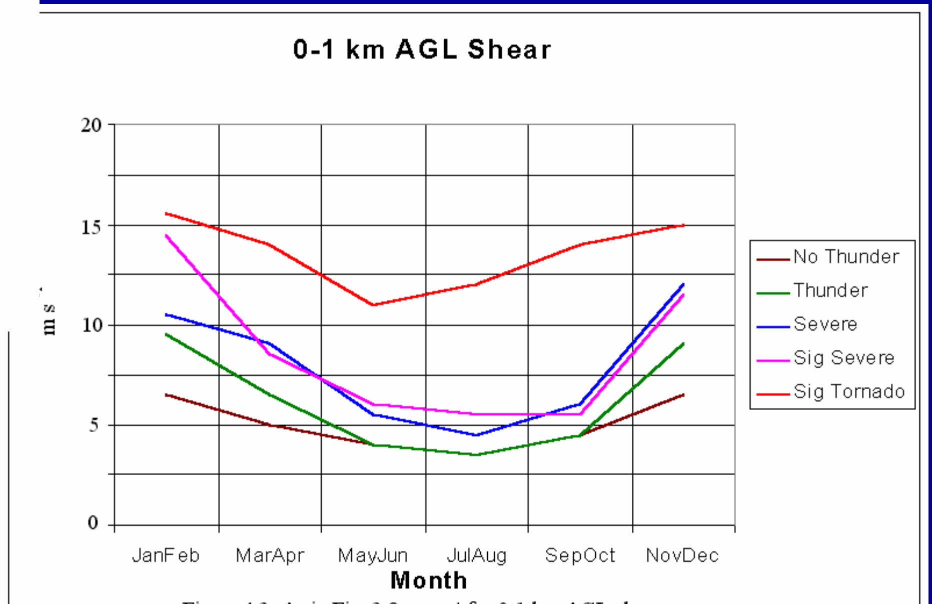
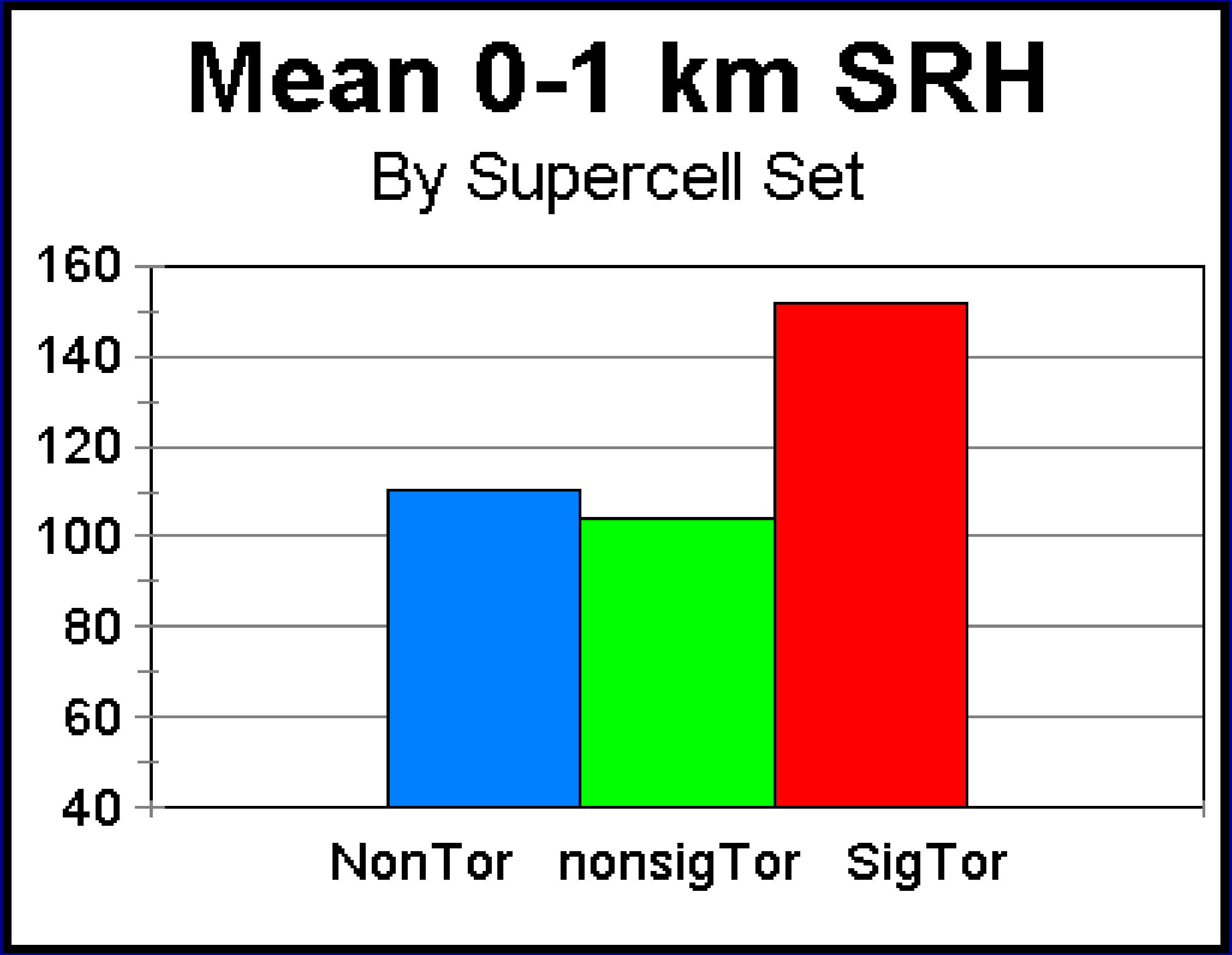


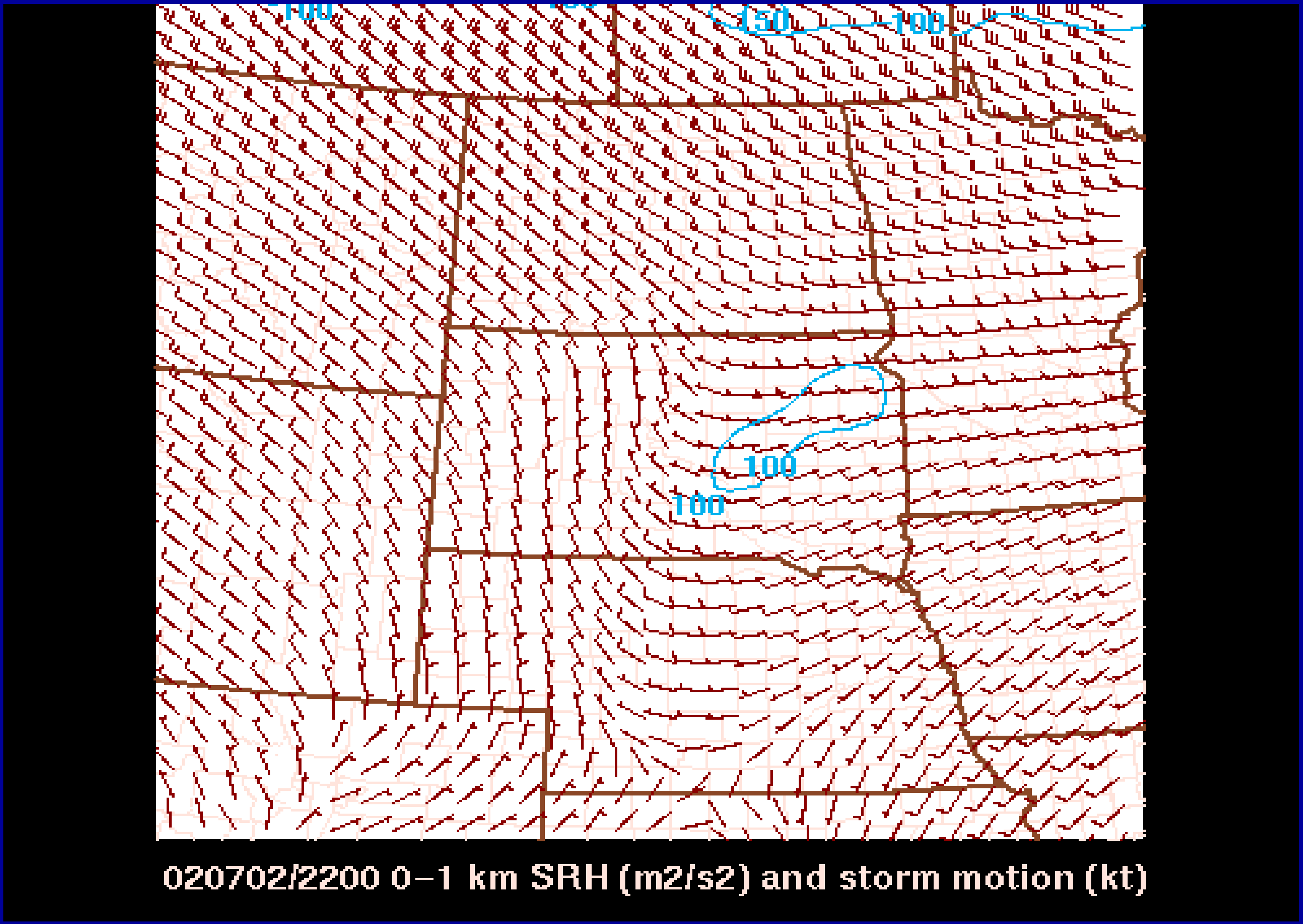
Figure 4.3 As in Fig. 3.8 except for 0-1 km AGL shear

Considerable overlap except for sig. tornadoes

Edwards/Thompson 0-1 km SRH

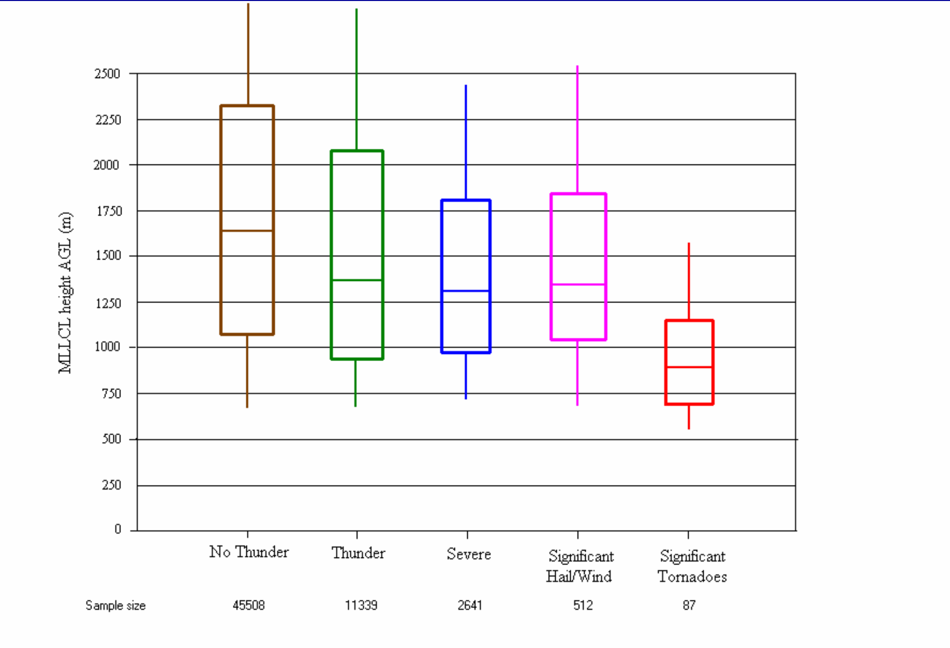


0-1 km SRH


100
150
100
100
100
100
020702/2200 0-1 km SRH (m2/s2) and storm motion (kt)

Craven/Brooks MLLCL Heights

Mean Layer LCL Height



Seasonal Variation

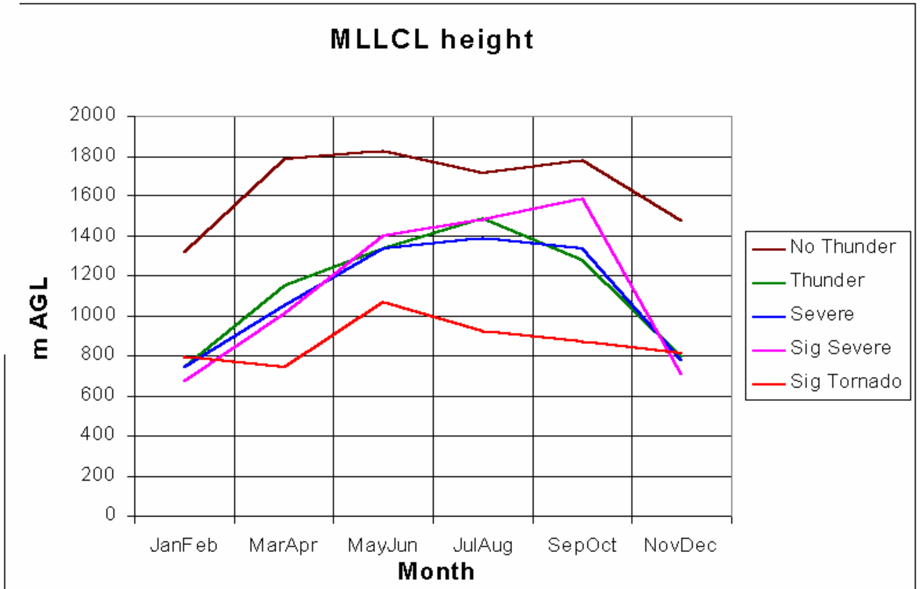
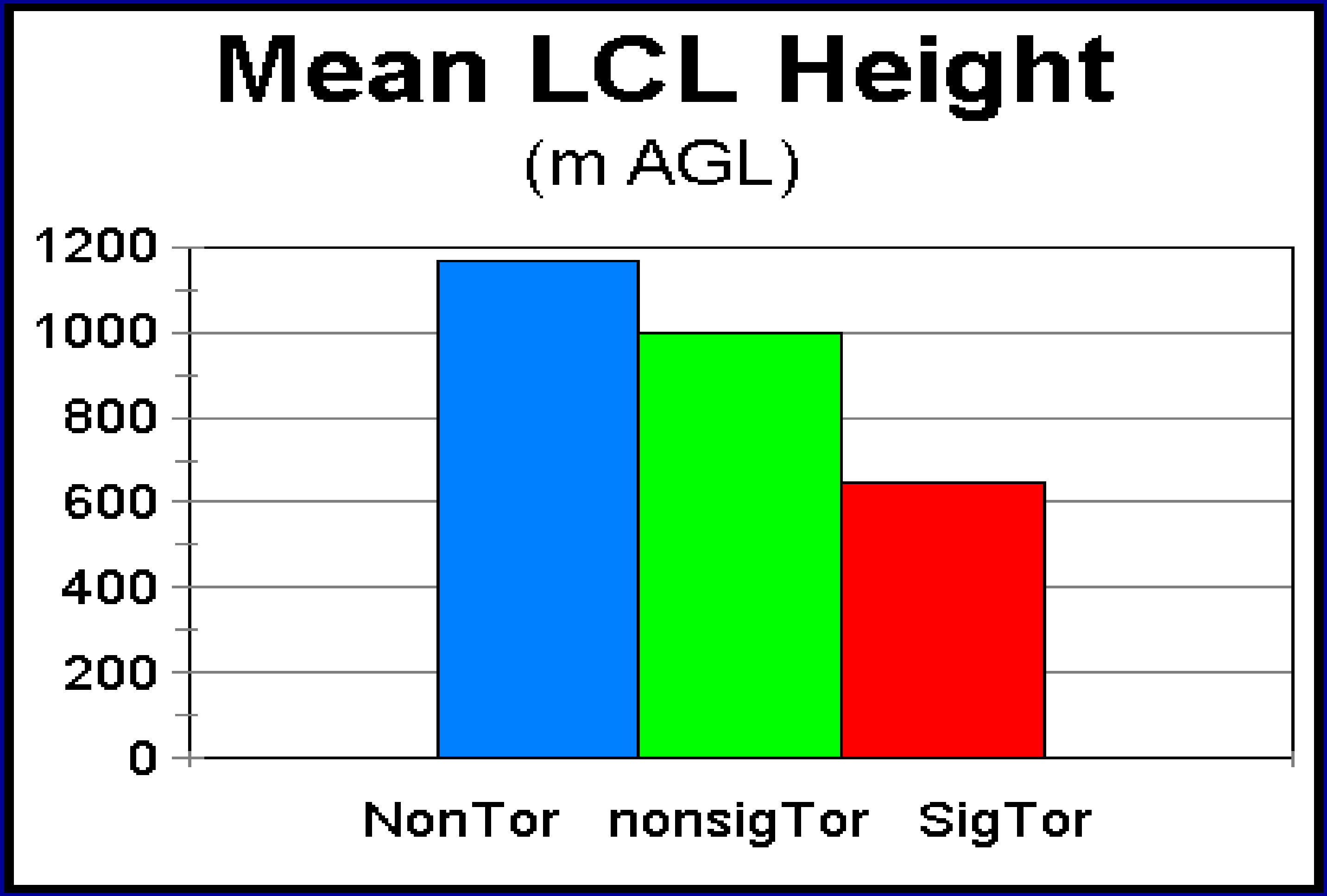


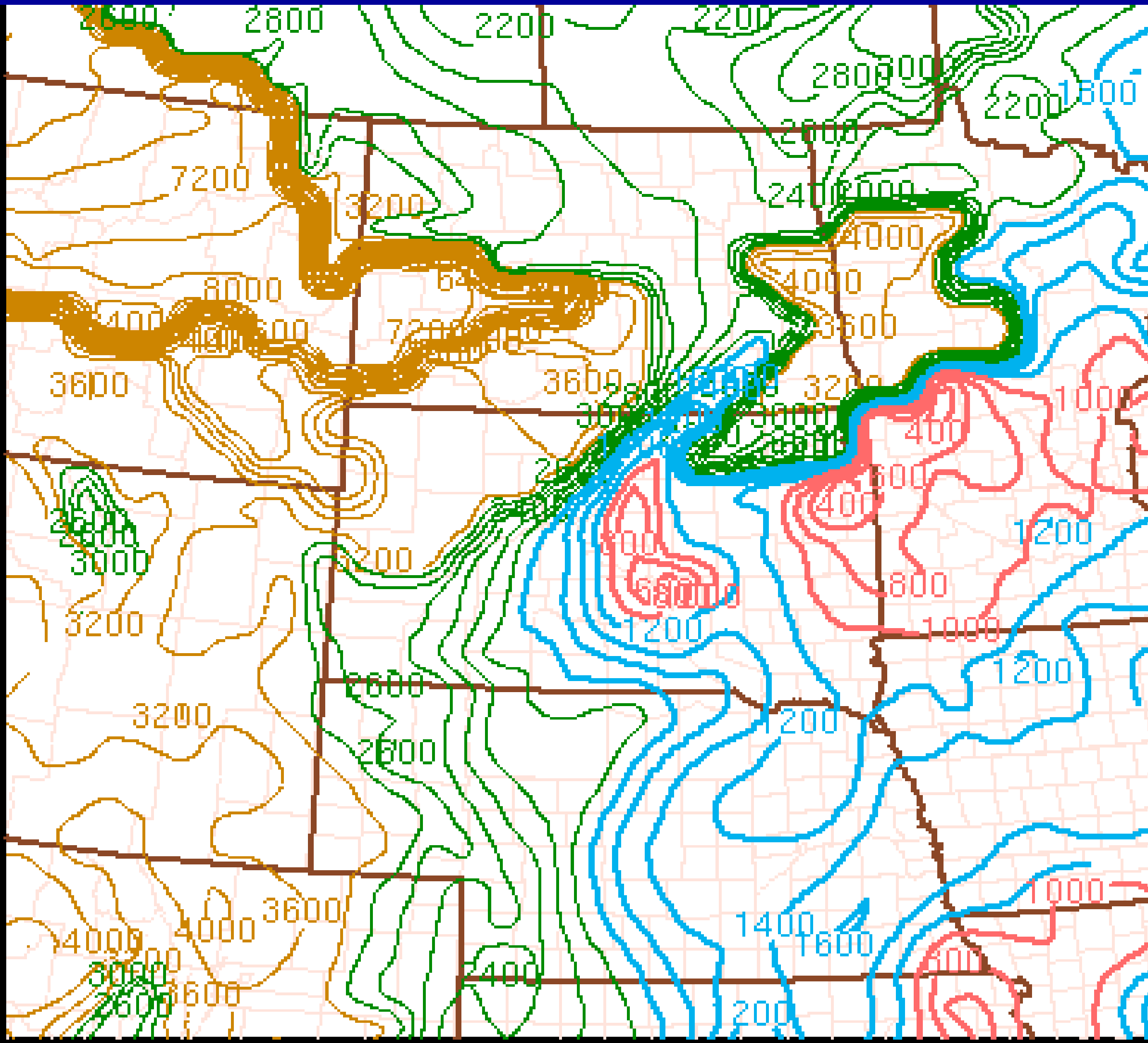
Figure 5.6 As in Fig. 3.8 except for MLLCL height AGL

Again, isolates sig. Tornado from all other classes

Thompson/Edwards MLLCL Heights



MLLCL Heights



020702/2200 LCL height (m AGL)

Craven/Brooks Findings

- MLCAPE and 0-6 km shear did not discriminate between various classes of significant hail, wind, and tornado events

- Best discriminators between significant tornadoes (F2-F5) and all other classes were 0-1 km vector shear and MLLCL heights

Thompson/Edwards Findings

- **Used RUC-2 analysis proximity soundings, but results consistent with Craven/Brooks findings**

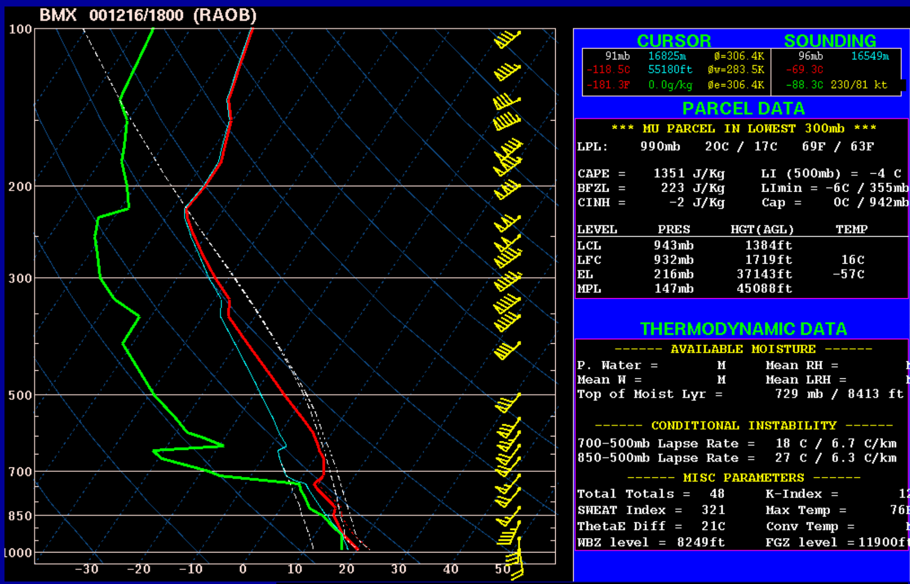
  - ***0-6 km shear is a good discriminator between supercells and non-supercells***

  - ***0-1 km SRH and MLLCL showed best discrimination between supercells producing significant tornadoes and other event classes***

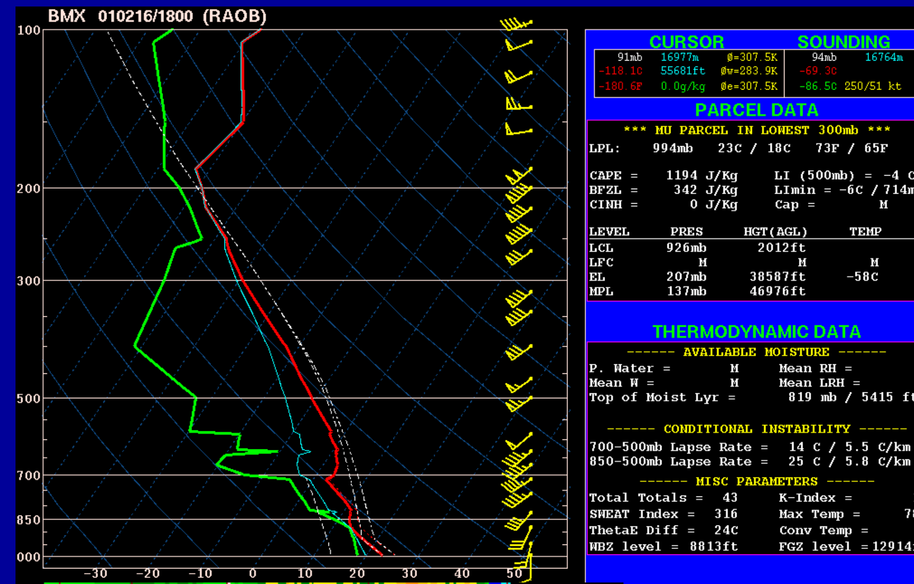
- **Application of parameter assessment depends on convective mode (discrete cells versus lines/multicell complexes).**

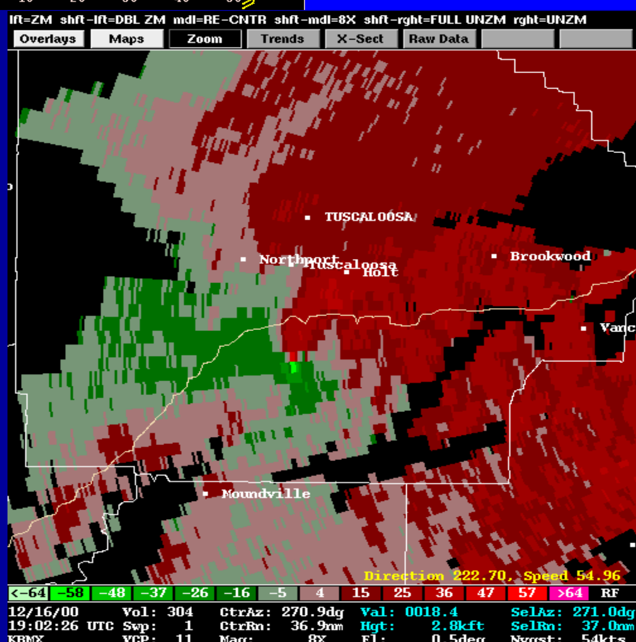
SIMILAR SOUNDINGS - DIFFERENT CONVECTIVE EVENTS

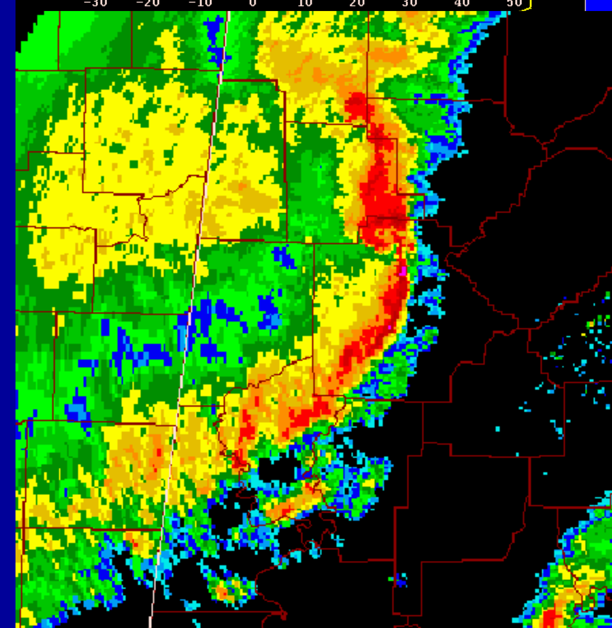
18 UTC BMX 16 Dec 2000



18 UTC BMX 16 Feb 2001







Two SPC Experimental Research Derived Products

Supercell Composite Parameter (SCP)

Significant Tornado Parameter (STP)

Supercell Composite Parameter (SCP)

** Designed to identify areas for supercell development

** Incorporates: MUCAPE (lowest 300 mb)

0-3 km SRH, and

BRN denominator (1/2U**2)

SCP Equation

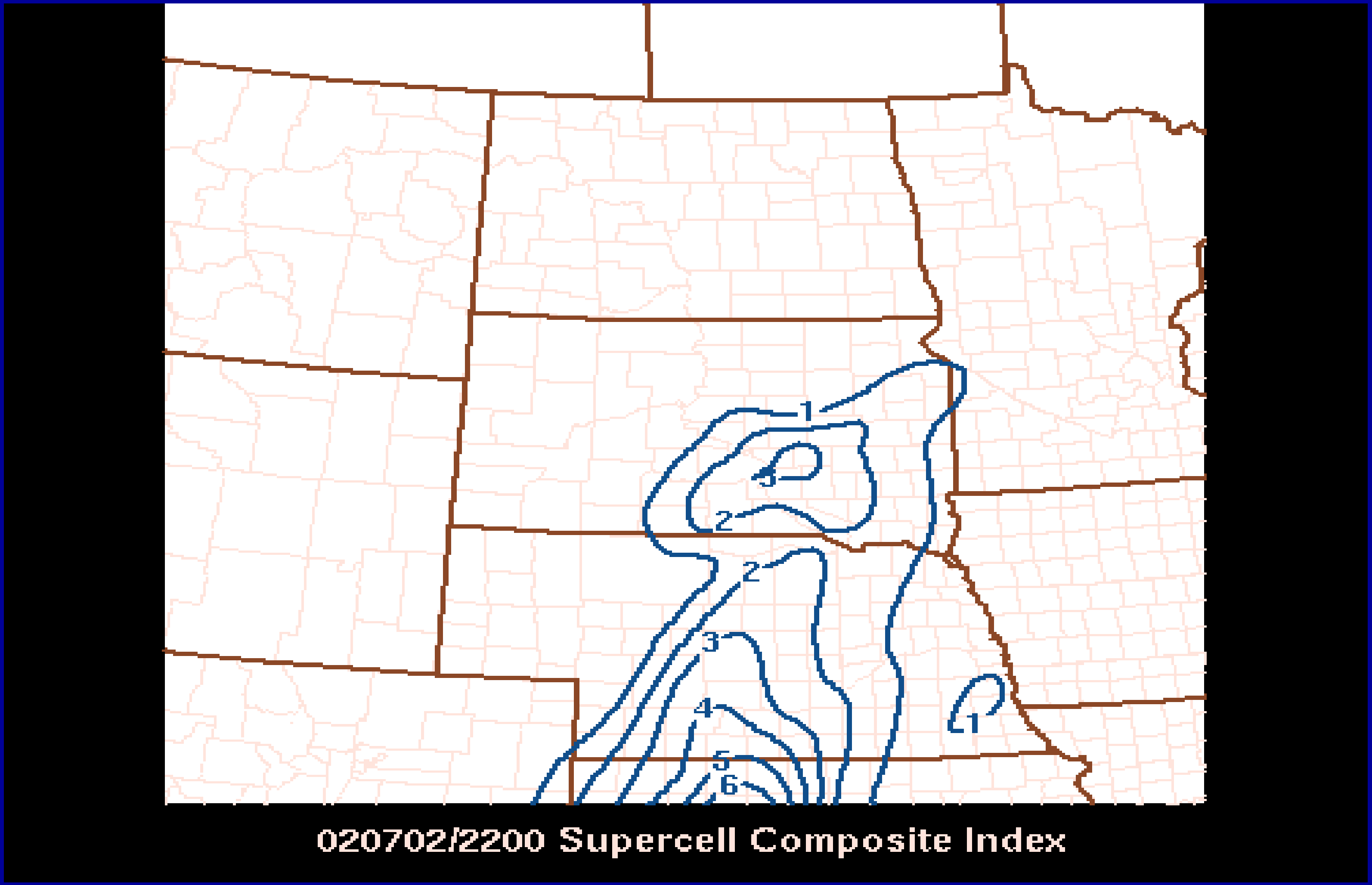
Applied to over 500 proximity soundings (458 supercell, 75 non supercell cases)

SCP = (MUCAPE/1000 J/kg) x 0-3 km SRH/150 m2/s**2 x (0-6 km BRN shear term/40 m**2/s**2)**

If MUCAPE = 1000 J/kg; SRH = 150 M2/S**2; BRN shear term = 40 m**2/s**2 , then SCP = 1**

> 1 for supercells;   <1 nonsupercell storms

Example of SCP Graphic



Significant Tornado Parameter (STP)

Parameters include:

1) 0-6 km AGL vector shear

2) MLCAPE (lowest 100 mb)

3) 0-1km SRH

4) MLLCL Height

5) MLCIN

STP Equation

STP = (MLCAPE/1000 J/kg) x (0-6 km vector shear/20 m/s) x (0-1 km SRH/100 m**2/s**2) x (2000-MLLCL/1500 m) x (150 - MLCIN/125 J/kg)

STP = 1 when, MLCAPE =1000 J/kg, 0-6km shear =20 m/s, 0-1 km shear = 100 m**2/s**2, MLLCL = 500 m, and MLCIN=25 J/kg

STP Considerations

STP = (MLCAPE/1000 J/kg) x (0-6 km vector shear/20 m/s) x (0-1 km SRH/100 m**2/s**2) x (2000-MLLCL/1500 m) x (150 - MLCIN/125 J/kg)

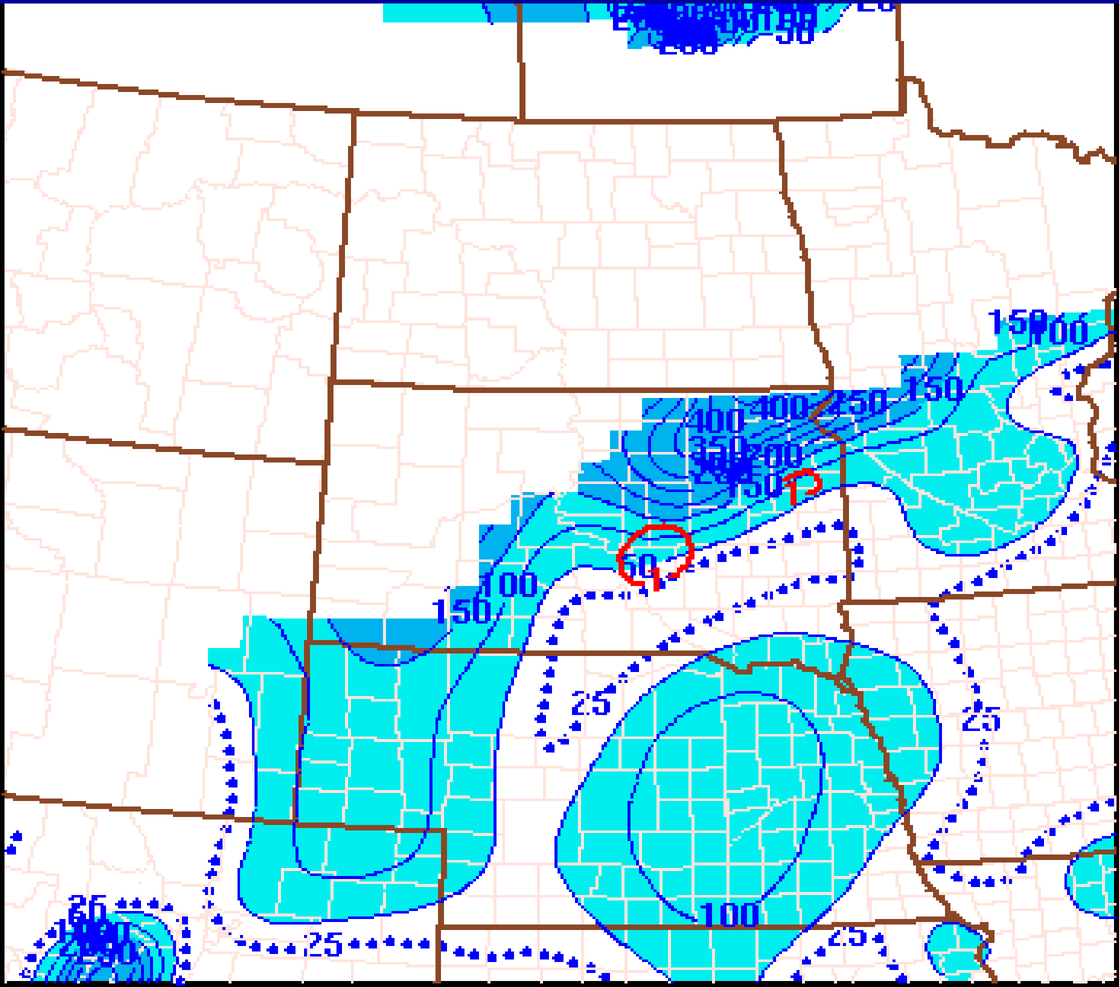
** STP approaches zero as any shear or CAPE values nears zero

** STP approaches zero as LCL height increases to 2000m

** STP approaches zero as CIN increases to 150 J/kg

MLCIN most useful prior to storm initiation

Example of STP



020702/2200 Significant Tornado Parameter and 100 mb CIN

Mesoanalysis Summary

- Use all available resources to aid in surface analysis (surface observations, mesonet data, satellite, radar, profilers, etc)

- Continuity is extremely critical for mesoanalysis; should be done hourly, if possible

- Mesoanalysis is an important part of the severe weather evaluation process

Research Summary

•Proximity sounding research has aided SPC in better tools to identify areas for severe storm potential

•Research has shown low MLLCL heights and strong 0-1 km SRH/shear vector are best predictors for stronger tornadoes (all other environmental conditions being equal)

• 30-40+ kt 0-6 km shear is favorable for supercells

•However, information misleading if initiation/ evolution of convective mode is not accurately forecast