Forecasting Convective Downburst Potential Using GOES Sounder Derived Products

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Topics of Discussion

- Description of the GOES Microburst Products
- Case Studies
- Use of the GOES Microburst Products with Other Satellite and Radar Data

Introduction

- GOES sounder-derived parameters have been shown to be useful in assessing the potential for convective downbursts. Products include:
- **Wet Microburst Severity Index (WMSI)**
- **Dry Microburst Index (DMI)**
- **Wind Index (WINDEX)**

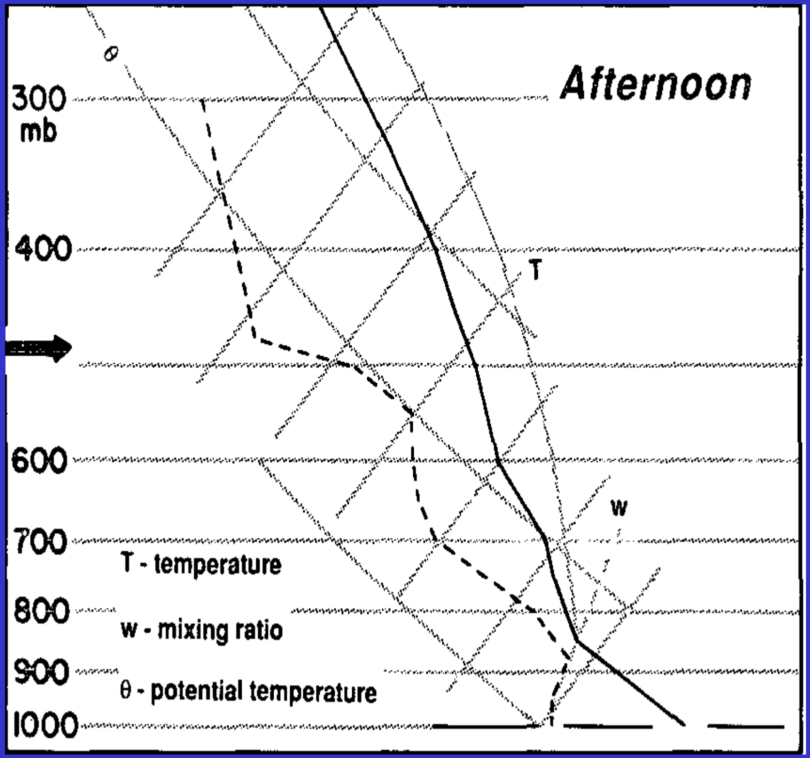
GOES Microburst Products

- Generated hourly at the NOAA Science Center in Camp Springs, MD.
- Available on the GOES Microburst Products web page at the following URL: **http://www.orbit.nesdis.noaa.gov/smcd/opdb/aviation/mb.html**

GOES Microburst Products

- Microburst program ingests the vertical temperature and moisture profiles derived from GOES sounder radiances, using a subset of single field of view.
- Microburst products are available approximately 50 minutes after sounder scan.
- Based on the **thermodynamic structure** of the ambient atmosphere.

Wet Microburst



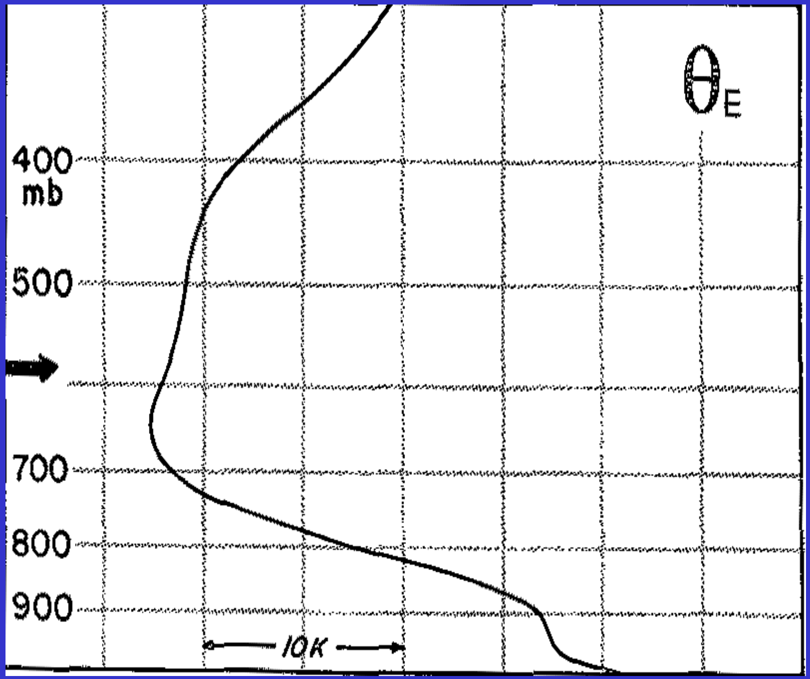
From Atkins and Wakimoto (1991)

Wet Microburst Severity Index (WMSI)

WMSI = (CAPE)(TeD)/1000

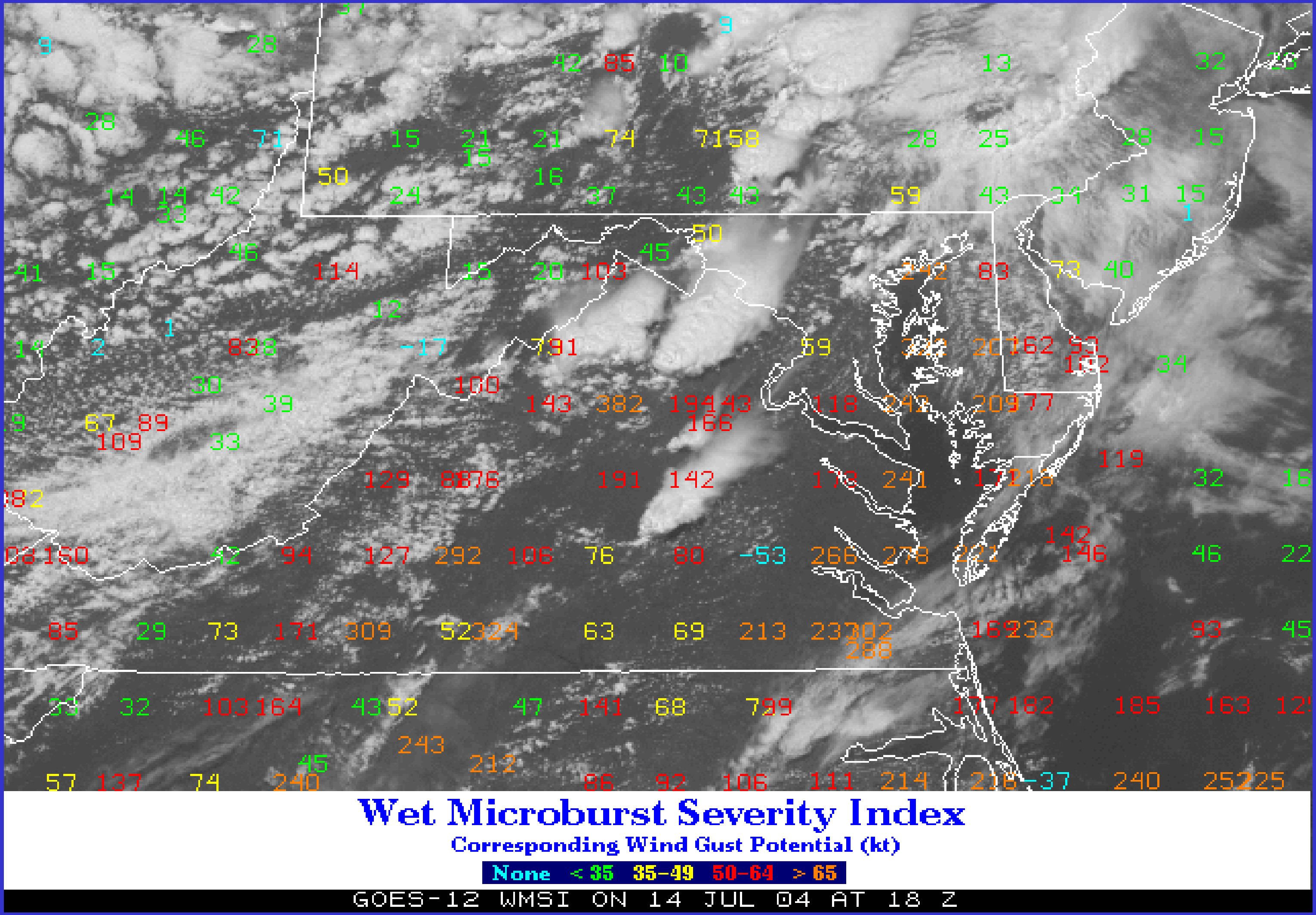
- CAPE (positive buoyancy):
  - updraft strength and precipitation formation
- Theta-e Difference (TeD):
  - Presence of a dry (low theta-e) layer in the middle troposphere
  - favorable for the production of large negative buoyancy due to evaporative cooling.

Theta-e Difference (TeD)



- Maximum vertical difference in equivalent potential temperature (θ_e) from the surface to the middle troposphere (Atkins and Wakimoto 1991).

Wet Microburst Severity Index (WMSI)



Wet Microburst Severity Index (WMSI)

WMSI	Predicted Wind Gust Magnitude
< 10	Downbursts unlikely
10 to 50	< 35 knots
50 to 80	35 to 50 knots
> 80	> 50 knots

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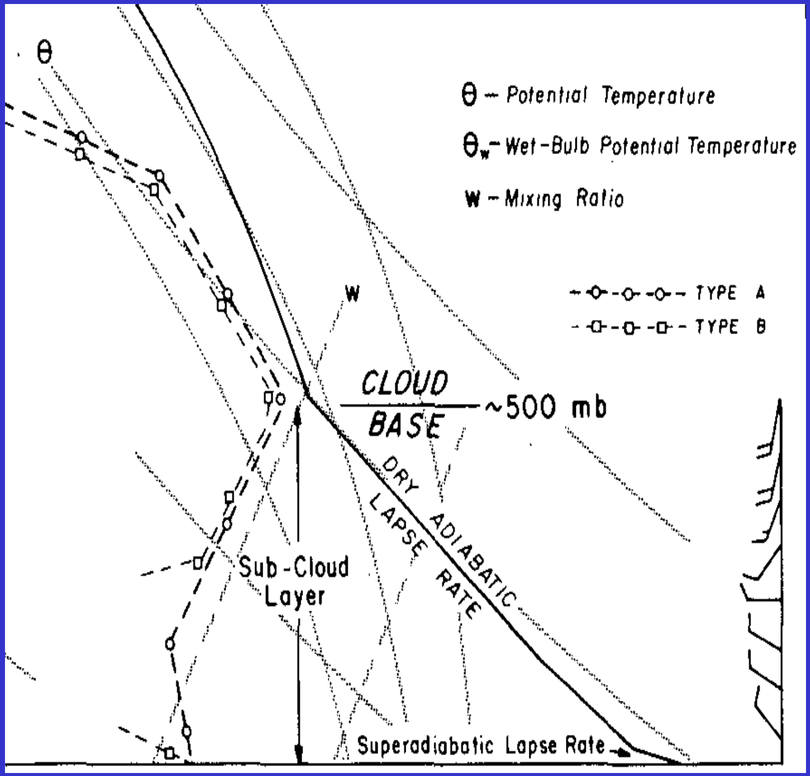
U.S. DEPARTMENT OF COMMERCE

Dry Microburst



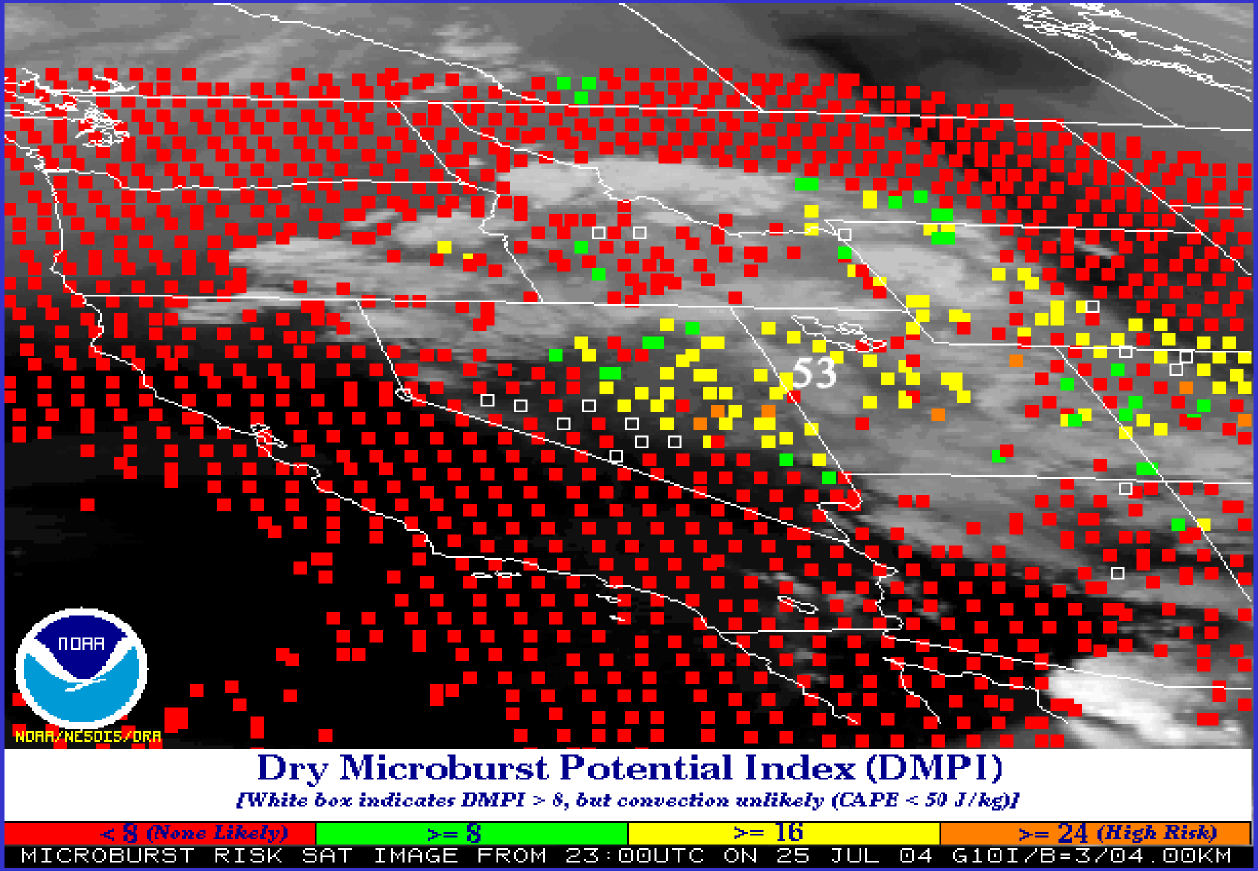
From Wakimoto (1985)

Dry Microburst Index (DMI)

$DMI = \Gamma + (T - T_d)_{700} - (T - T_d)_{500}$

- Γ = temperature lapse rate (°C km^{-1}) from 700 to 500 mb
- T = temperature (°C)
- T_d = dew point temperature (°C)
- Dry microbursts may occur when the **DMI > 6** (Ellrod et al 2000)

Dry Microburst Index (DMI)

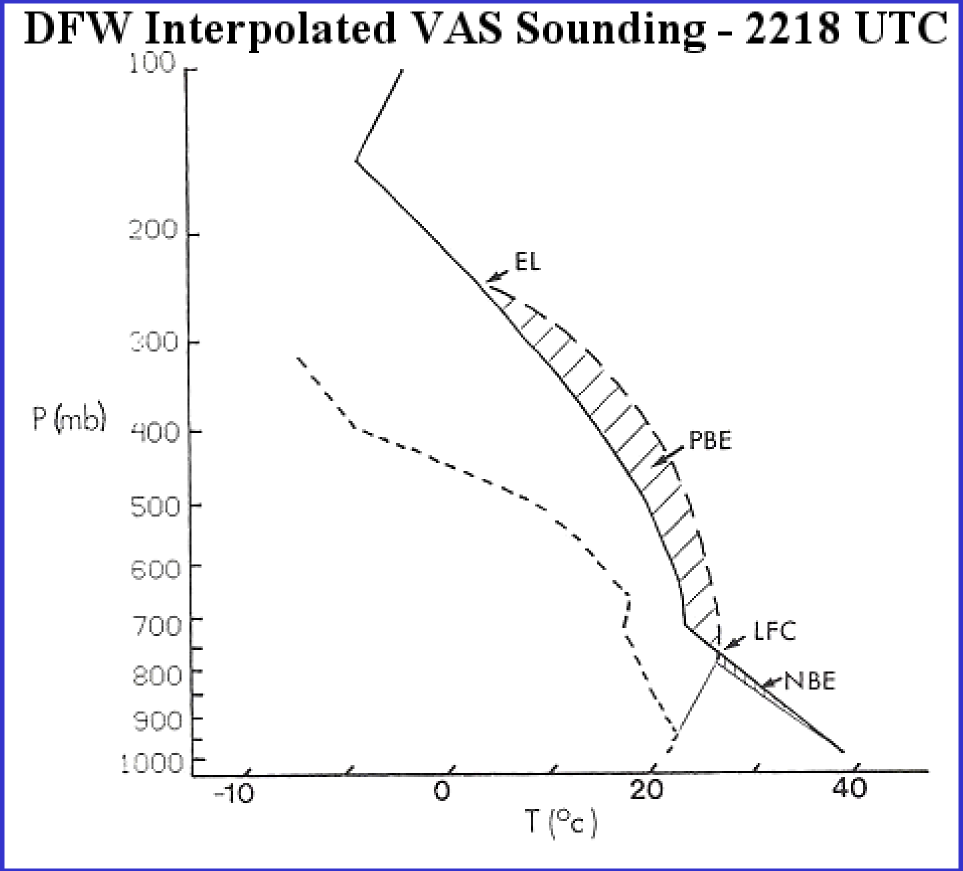


An example of the DMI product with stable soundings (CAPE<50 J kg^{-1}) filtered and removed from the image.

Summary of Microburst Generation Processes

- **DMI**: subcloud evaporative and sublimational cooling
- **WMSI**: strong updrafts, precipitation loading, and evaporative cooling from the entrainment of dry ambient air into the precipitation core
- A continuum between wet and dry microbursts ("hybrid") based on the depth of the moist layer and sub-cloud dry air layer

Hybrid Microburst



Cold Season Downbursts

- Strong and diffluent winds aloft with significant vertical wind shear
- Strong correlation found between mid-tropospheric and surface winds:
  - suggests downward transport of momentum from the midlevels of a convective storm environment to the surface is a major factor in downburst magnitude.

Cold Season Downbursts

- Sasaki and Baxter (1986): Downward transfer of entrained momentum from the strong flow aloft was responsible for the generation of strong surface winds in convective systems.
  - Descending evaporatively cooled air tends to carry the horizontal momentum that it had at its original level.

Cold Season Downbursts

- Weisman and Klemp (1982):
- Bulk Richardson Number: $R = B / .5\bar{u}^2$
- $\bar{u}^2$ represents inflow kinetic energy made available to the storm by vertical wind shear.
- Large $\bar{u}^2$ can be associated with strong forced convection:
  - supplemental convective energy source

WMSI Validation

2003-04 Convective Seasons:

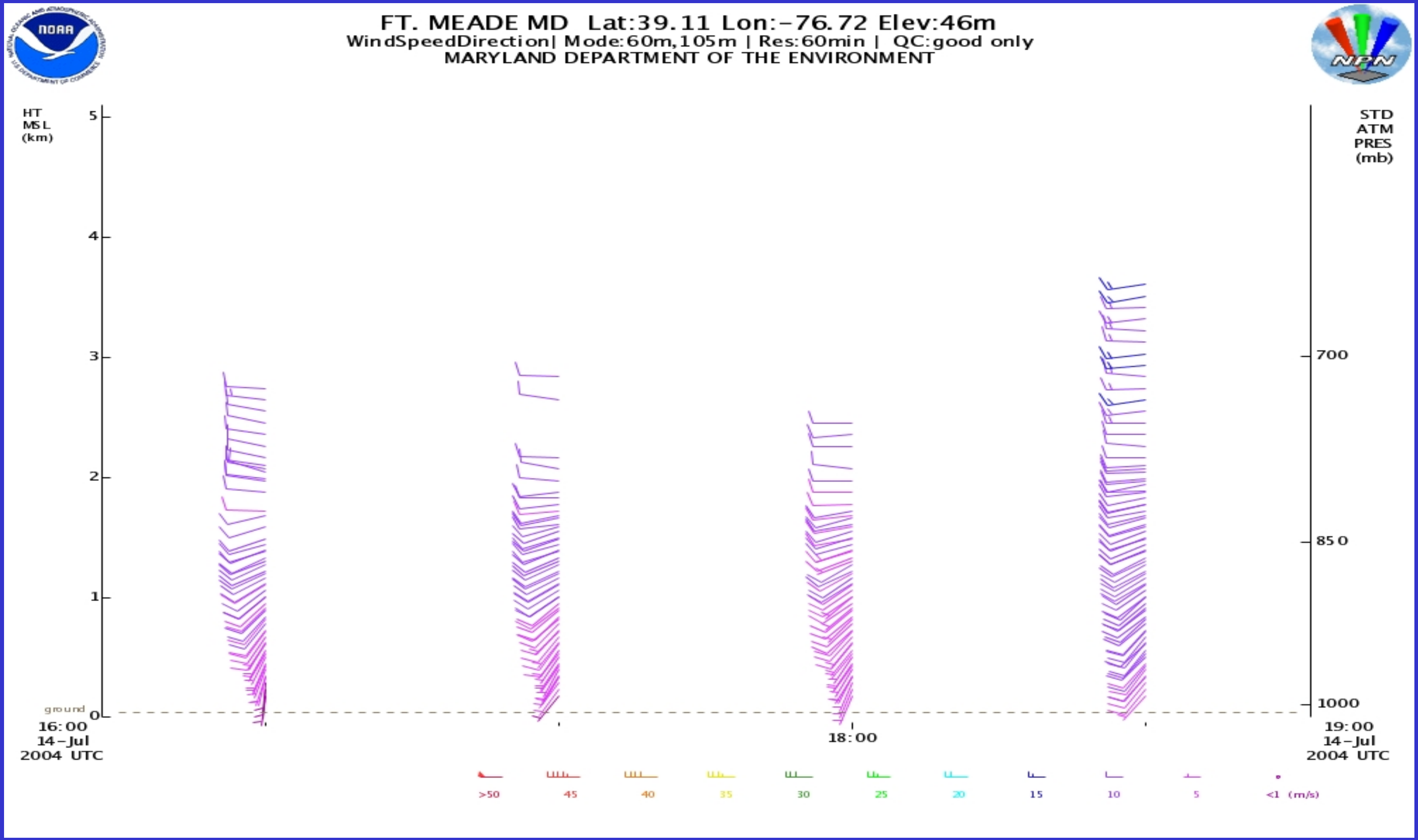
- Strong positive linear relationship (correlation) between GOES WMSI and surface wind gusts for both daytime and nighttime events.
- Complete discussion in online paper:

http://www.orbit.nesdis.noaa.gov/smcd/opdb/kpryor/mburst/wmsipaper/wmsi.html

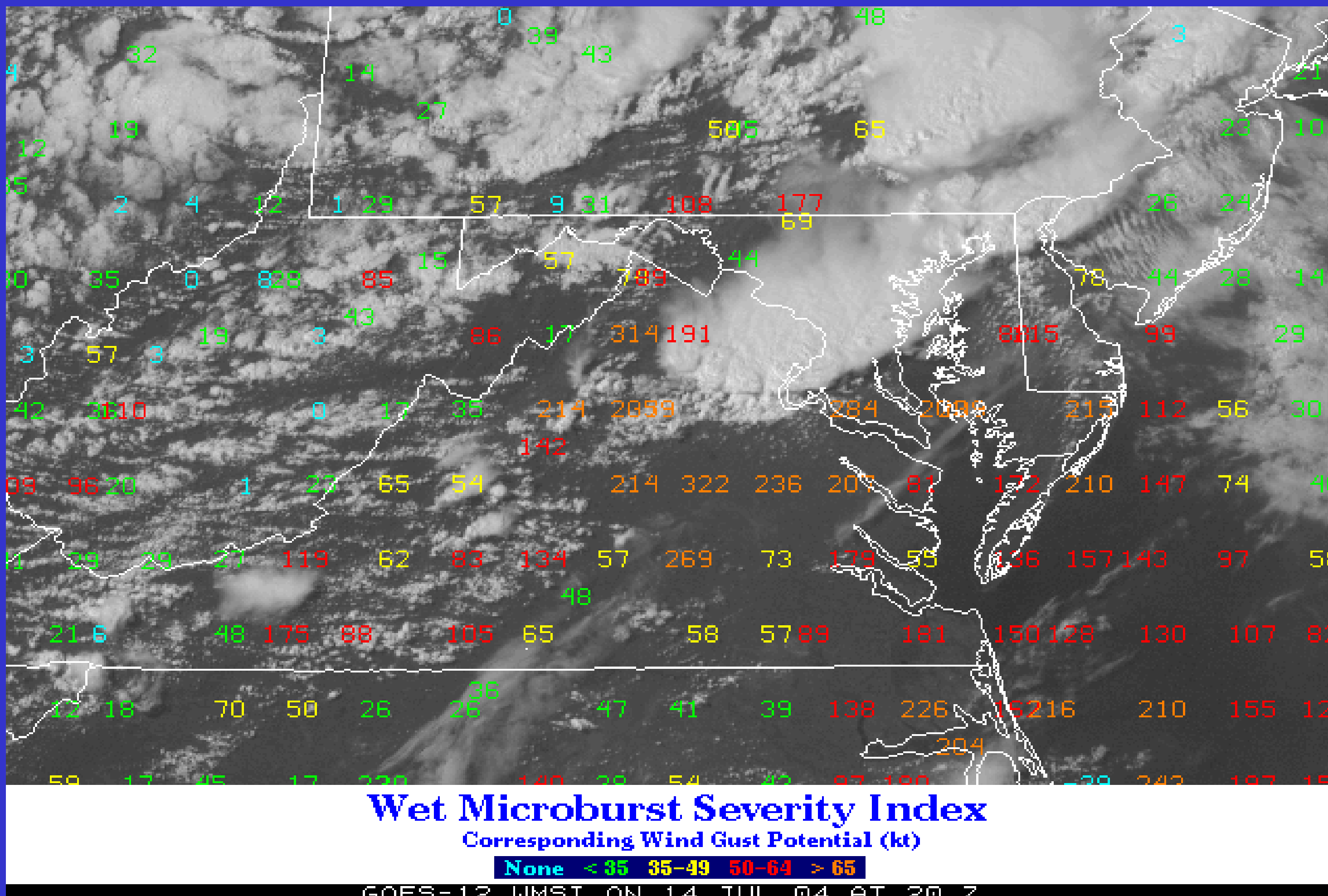
14 July 2004 Downburst

- Convective cluster merged to form a squall line- broken areal evolution (Bluestein and Jain 1985).
  - Weakly-forced environment
- Evolved into a bow echo pattern. (Przybylinski 1995)
- 74 knot wind gust at Patuxent River Naval Air Station, MD (2105 UTC)

14 July 2004 Downburst



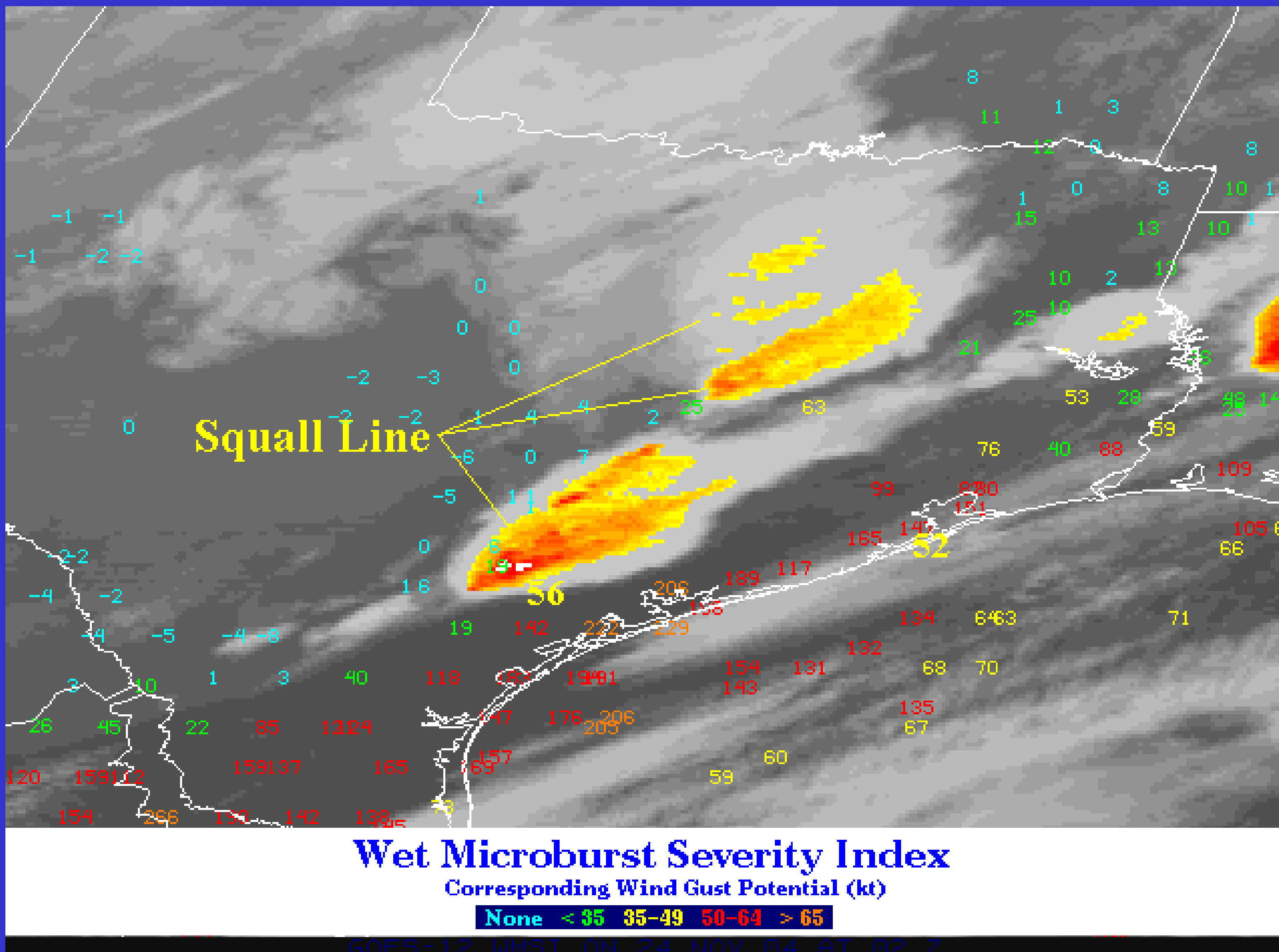
14 July 2004 Downburst



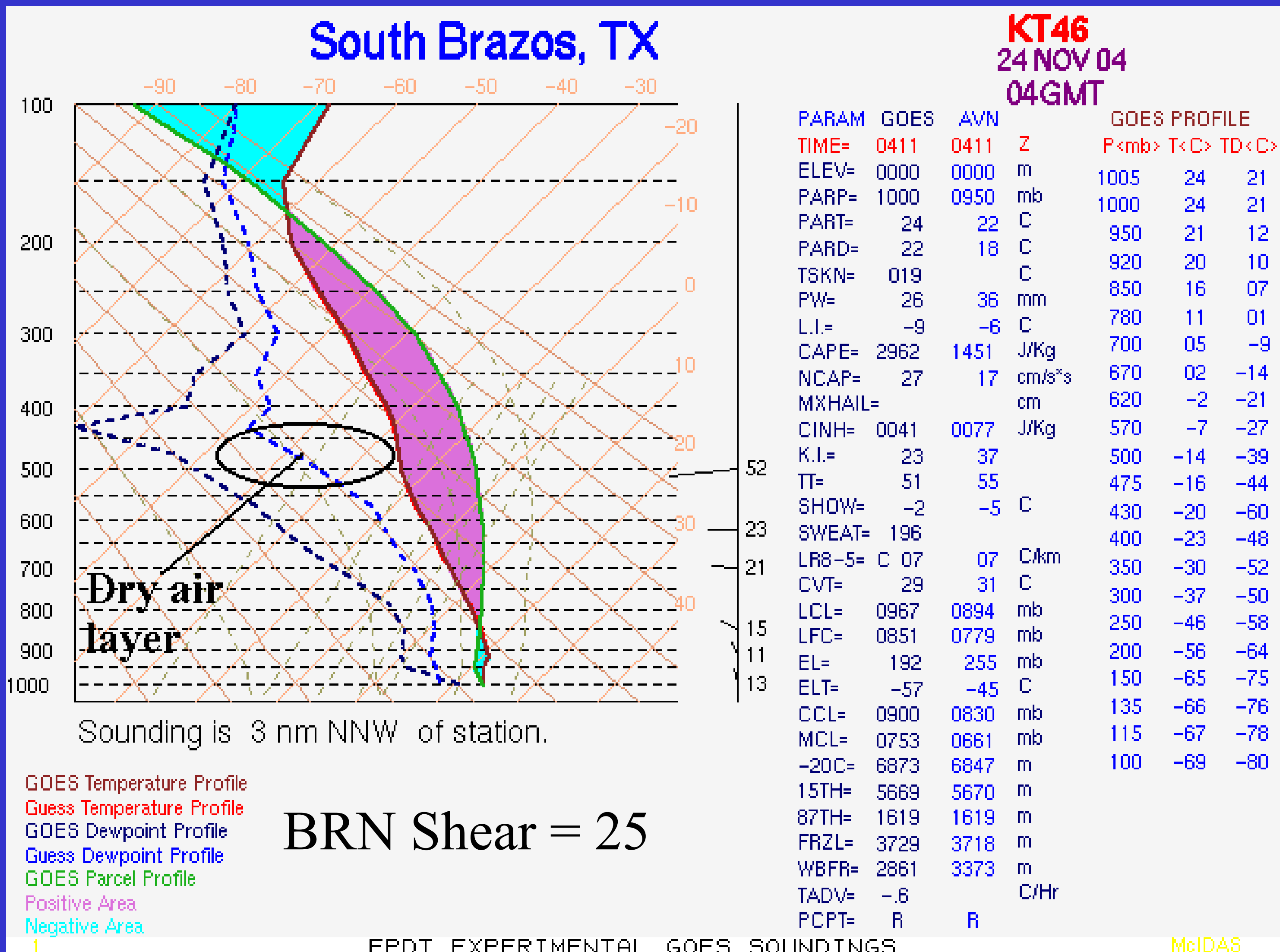
24 Nov 2004 Squall Line

- Strong frontal convergence and negatively-tilted short wave trough served as an initiating mechanism for deep convection.
  - enhanced vertical circulation and static instability
- Downward momentum transport, by the strong convective downdrafts, from the mid-troposphere to surface
  - Strong vertical wind shear

24 Nov 2004 Squall Line



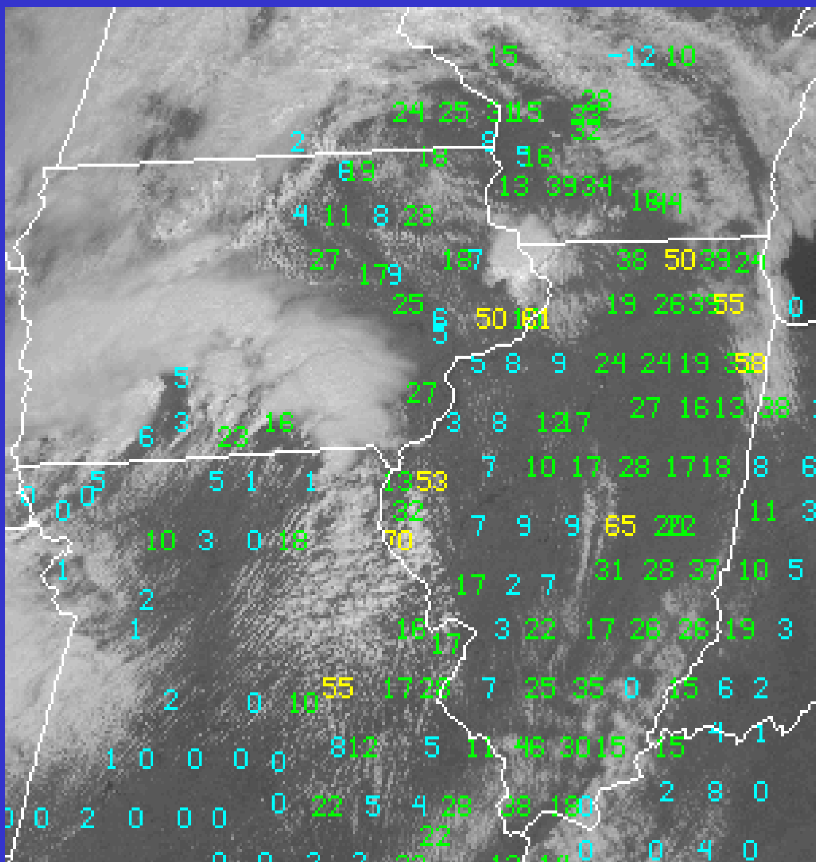
24 Nov 2004 Squall Line



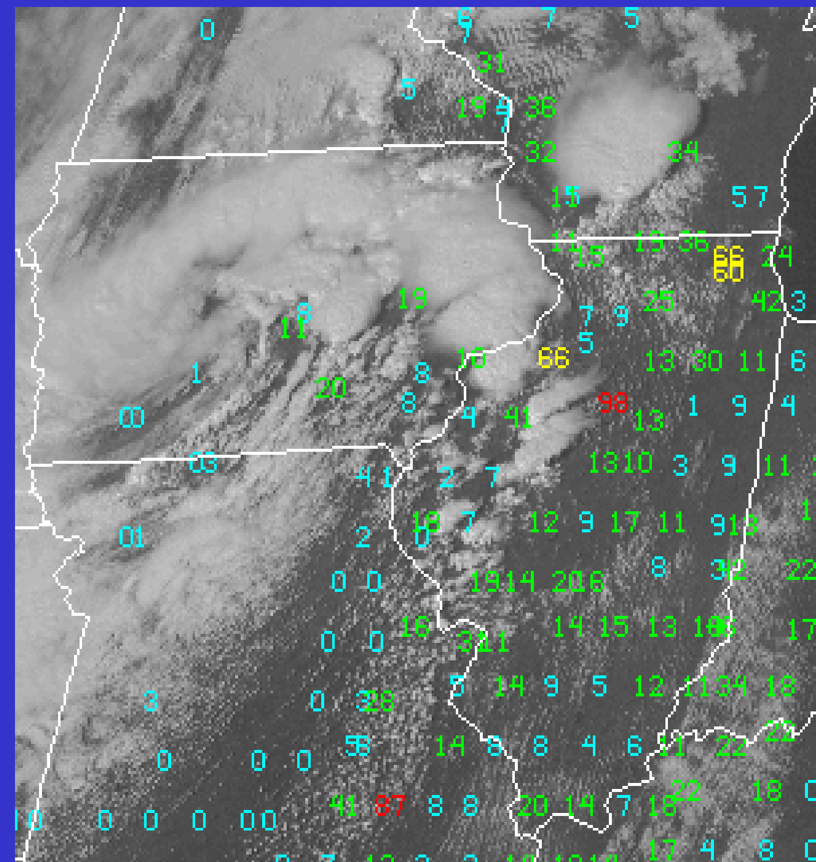
30 March 2005 Squall Line

- Several downburst wind gusts between 35 and 55 knots over eastern Iowa, southern Wisconsin and northern Illinois.
- Elevated WMSI values in excess of 50 extended from east-central Iowa to the Chicago metro area.
- Strong vertical wind shear :
  - served as a source of inflow kinetic energy to enhance convective updrafts
  - downward momentum transfer was a factor in the magnitude of downburst wind gusts.

30 March 2005 Squall Line

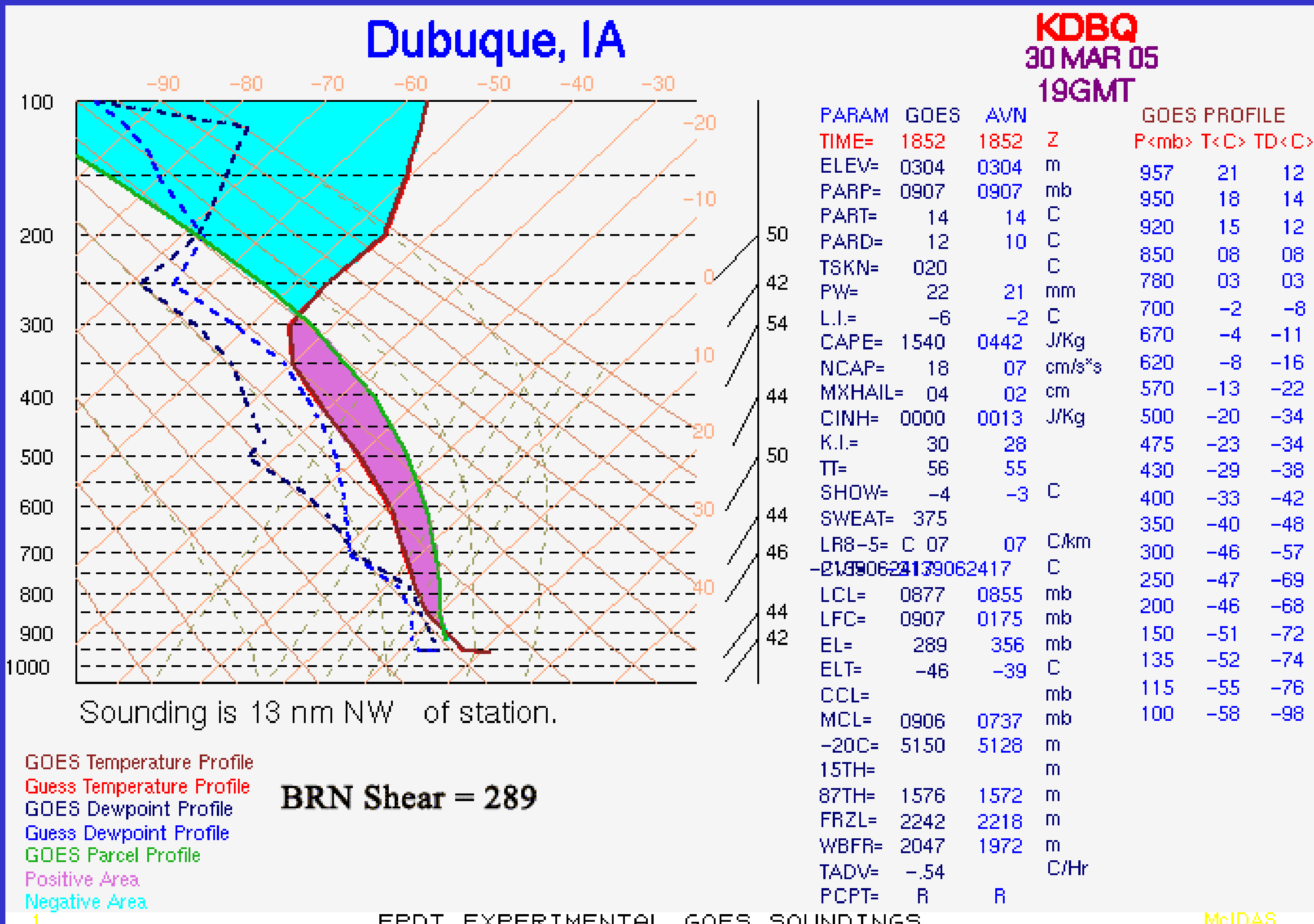


1800 UTC



2000 UTC

30 March 2005 Squall Line



Cold Season Forecast Technique

- WMSI:
  - Identify regions of static instability and elevated downburst potential
- GOES sounding profiles:
  - Wind shear: presence of inflow kinetic energy to enhance convective updrafts
  - Dry layer wind speed: estimate magnitude of downbursts observed at surface

Use with Other Data Types

- Radar imagery to identify and monitor:
  - Convergence boundaries (i.e. outflow boundaries) that could initiate deep convection
  - Cell mergers
- Visible satellite imagery can also be used to identify and track outflow boundaries during daylight hours.

Future Research Directions

- Use of the microburst products during the cold season:
  - Environment, physical processes
- Coordinated use of WMSI and DMI to forecast "hybrid" microburst potential:
  - Focus on Western High Plains region
- Establish severity thresholds for DMI.

References

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Questions?

Thank You!