Forecasting Convective Downburst Potential Using GOES Sounder Derived Products

Ken Pryor

Center for Satellite Applications and Research (NOAA/NESDIS)

The Downburst

- The **downburst** is defined as a strong downdraft produced by a **convective storm** (i.e., thunderstorm) that induces an **outward burst of damaging winds** on or near the earth's surface (Fujita and Wakimoto 1983) .
- Due to the **intense wind shear** they produce, downbursts are a **hazard to aircraft** in flight, especially during takeoff and landing phases.

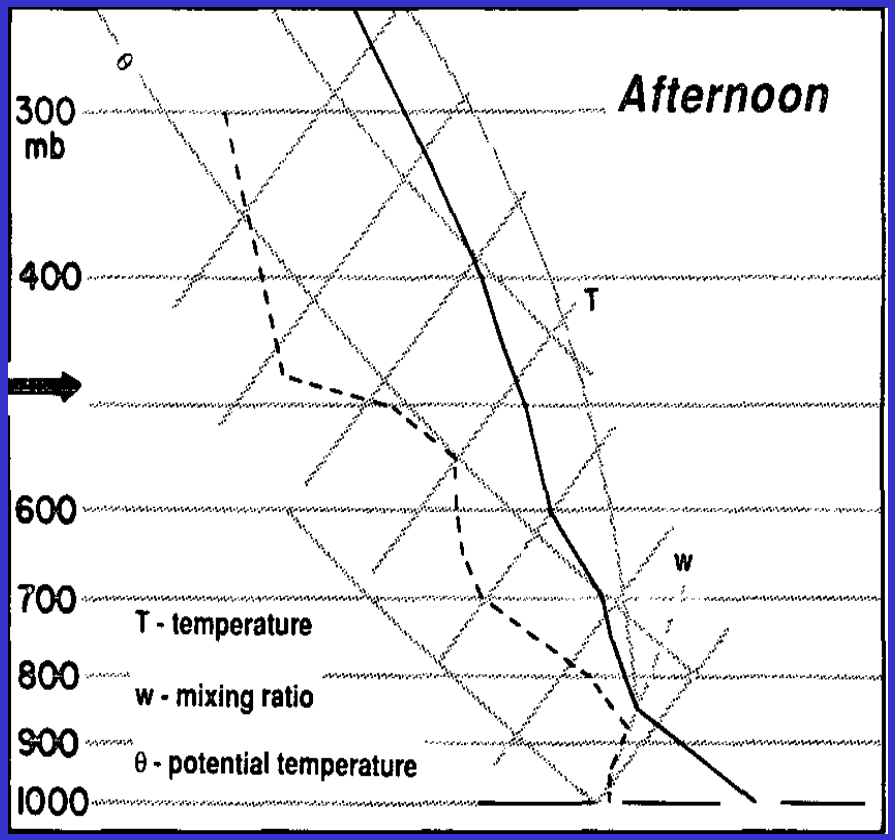
GOES Microburst Products

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

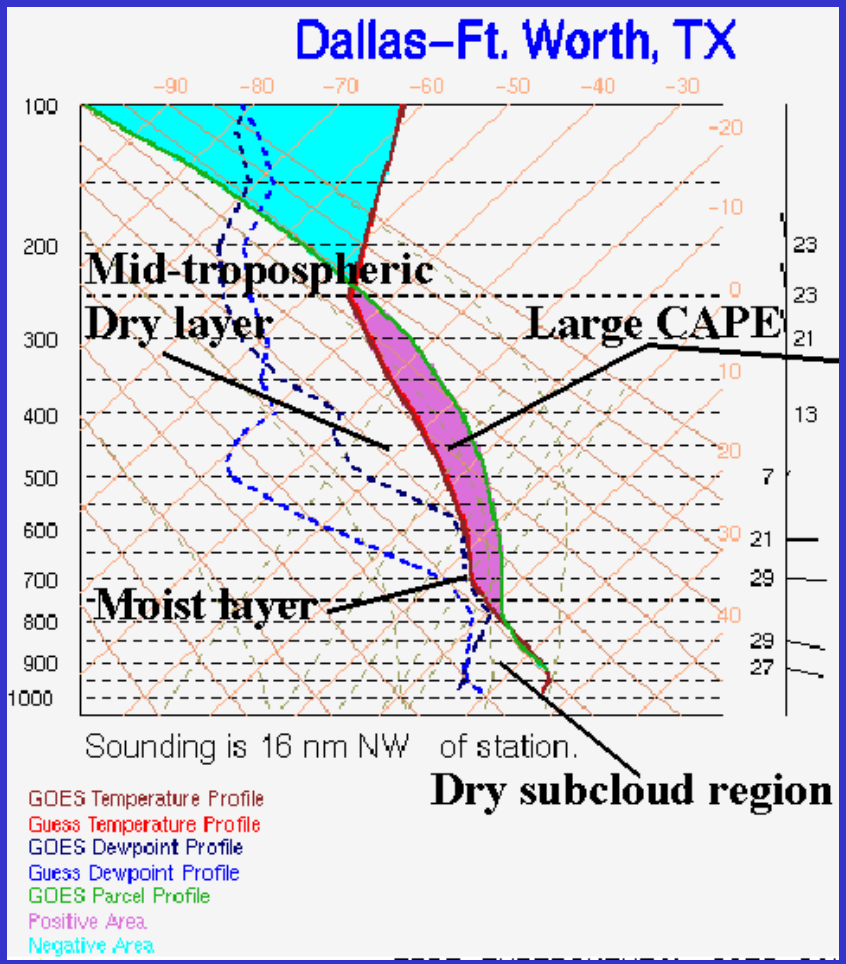
GOES Microburst Products

- Generated hourly at the NOAA Science Center in Camp Springs, MD
- Based on prototype vertical temperature and moisture profiles derived from GOES sounder radiances
- Available on the GOES Microburst Products web page at the following URL:
  http://www.orbit.nesdis.noaa.gov/smcd/opdb/aviation/mb.html

Wet Microburst



From Atkins and Wakimoto (1991)

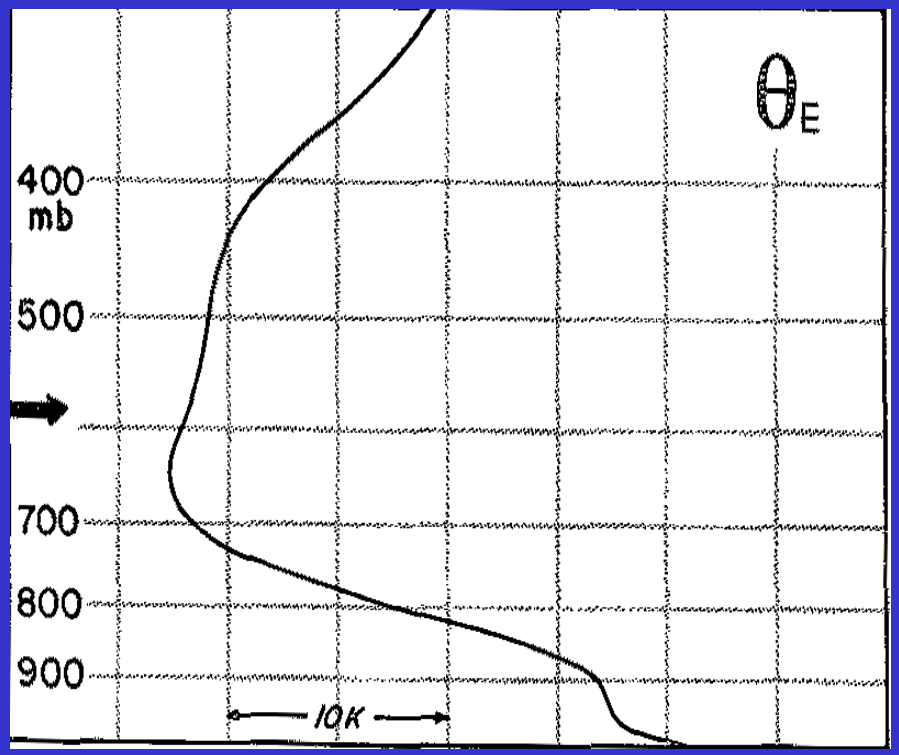


Wet Microburst Severity Index (WMSI)

WMSI = (CAPE)(TeD)/1000

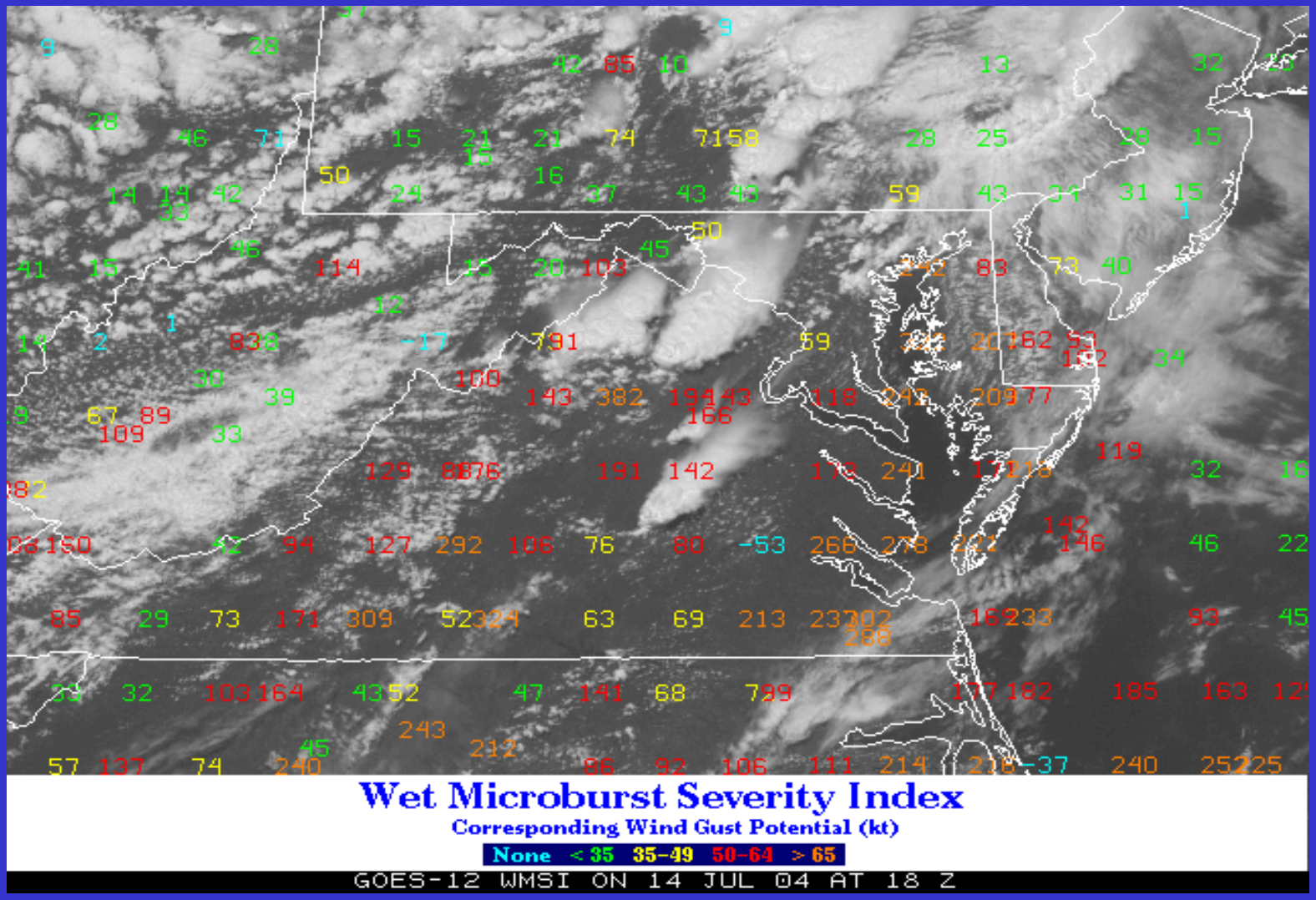
- Large Convective Available Potential Energy (CAPE) results in strong updrafts that lift the precipitation core within a convective storm to minimum theta-e level.
- Theta-e Difference (TeD) indicates the presence of a dry (low theta-e) layer in the middle troposphere that would be favorable for the production of large negative buoyancy due to evaporative cooling.

Theta-e Difference (TeD)



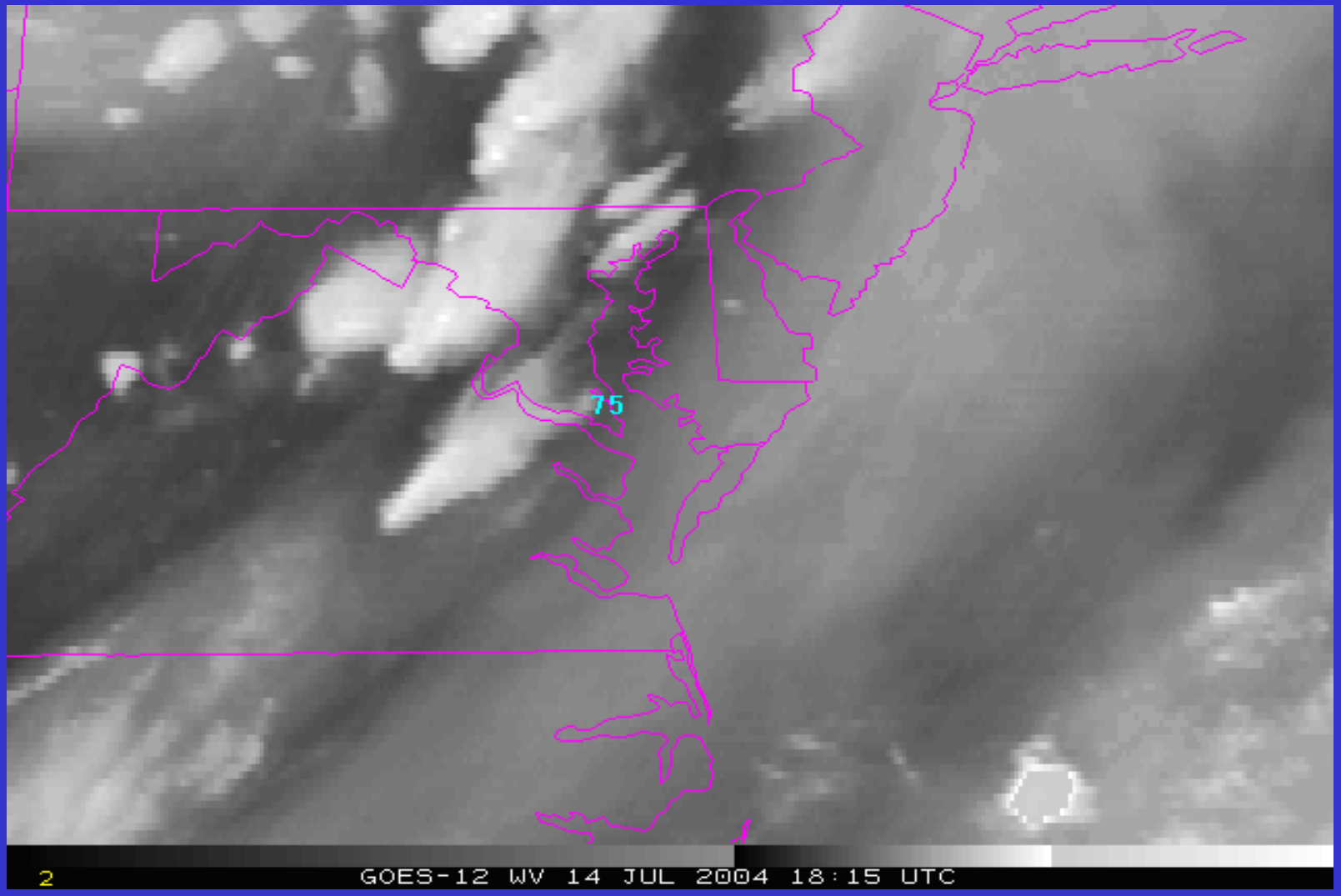
- Maximum vertical difference in equivalent potential temperature (θ_e) from the surface to the middle troposphere (Atkins and Wakimoto 1991).

Wet Microburst Severity Index (WMSI)



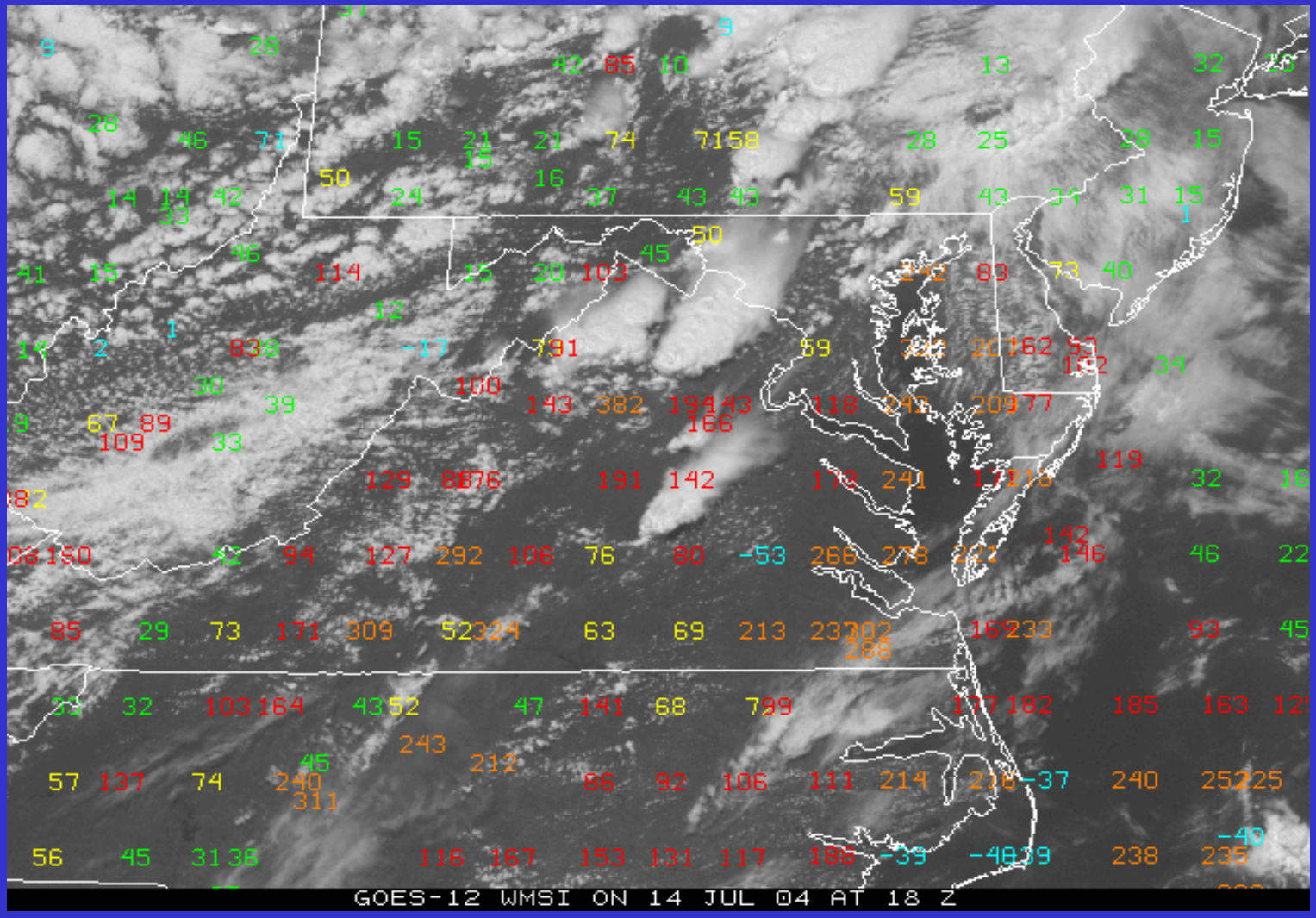
Forecasting Convective Downburst Potential Using GOES Sounder Derived Products
Ken Pryor (NOAA/NESDIS/ORA/STAR)

Wet Microburst Severity Index (WMSI)



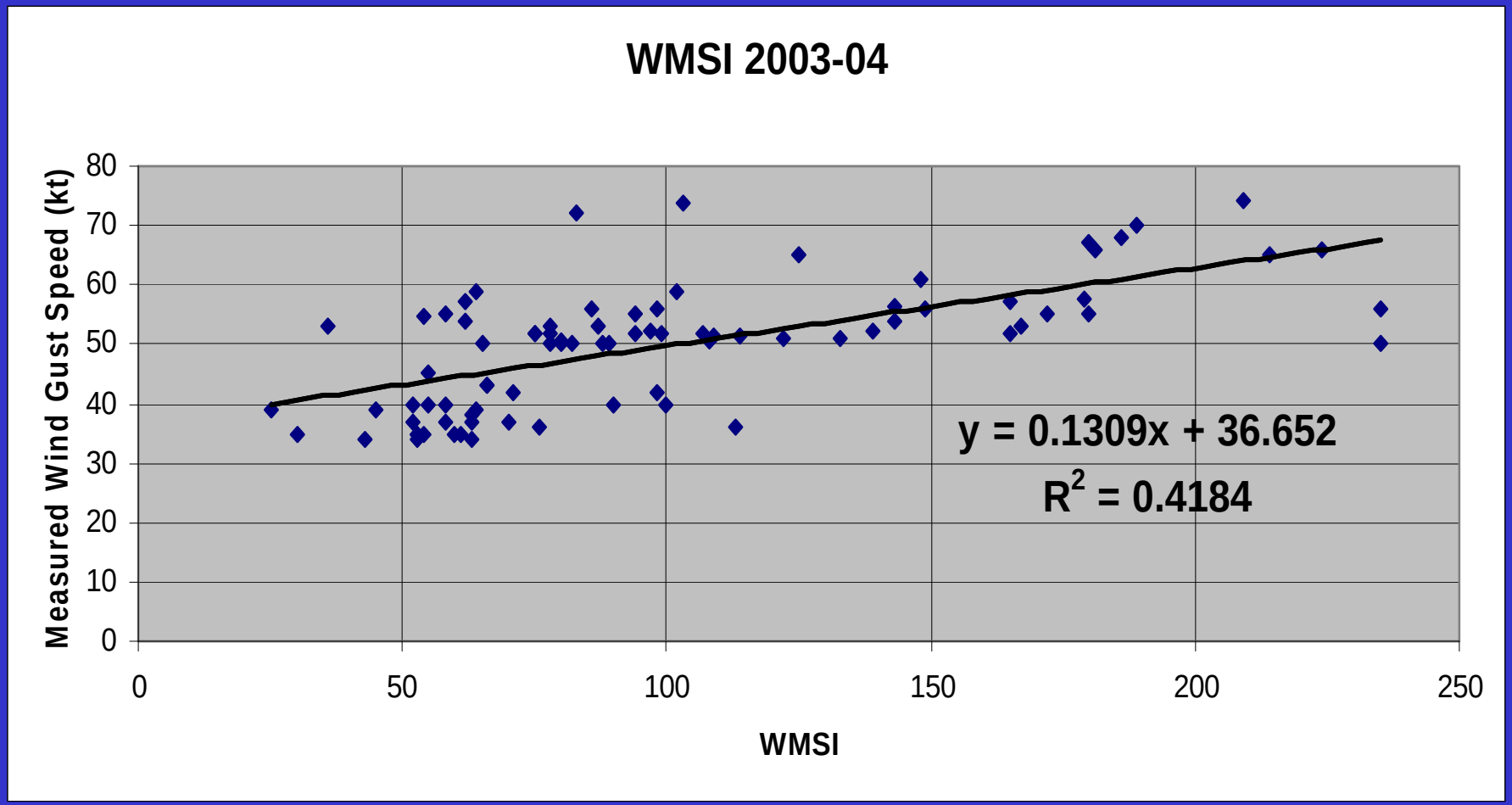
Forecasting Convective Downburst Potential Using GOES Sounder Derived Products
Ken Pryor (NOAA/NESDIS/ORA/STAR)

Wet Microburst Severity Index (WMSI)



Forecasting Convective Downburst Potential Using GOES Sounder Derived Products
Ken Pryor (NOAA/NESDIS/ORA/STAR)

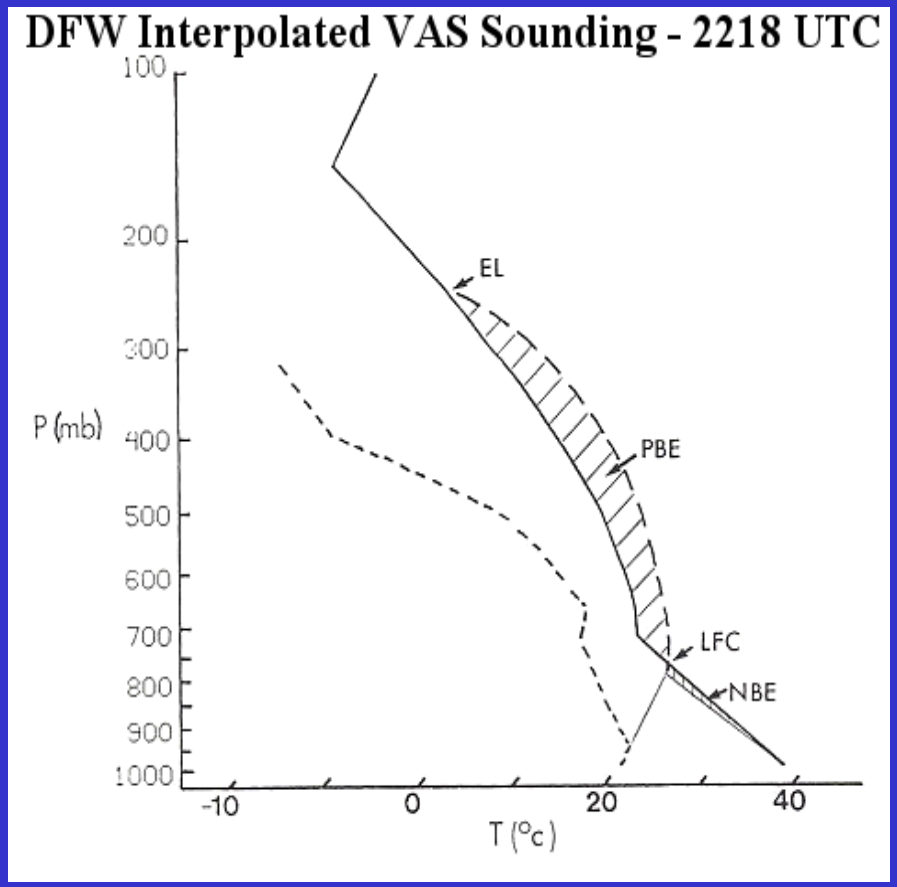
Validation: Summer 2003-2004



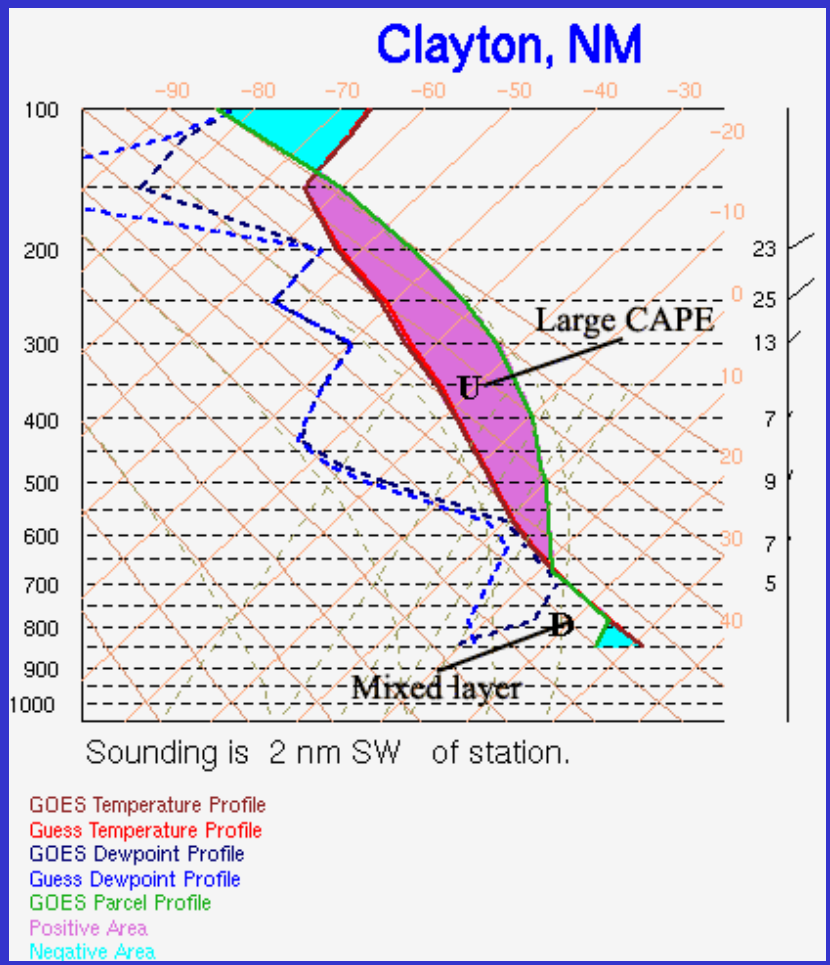
Validation: Other Results

- Loconto (2006):
  - Comparison of RAOB-derived WMSI to surface observations of downburst wind at KSC, FL, 1995-2006
  - Overall Probability of Detection (POD): 52%
  - Higher POD (>70%) associated with southeasterly flow regime
  - Higher POD during late summer (August, >60%), Higher Critical Success Index (CSI) values during early and late summer (~ 0.6)

Hybrid Microburst



From Ellrod (1989)

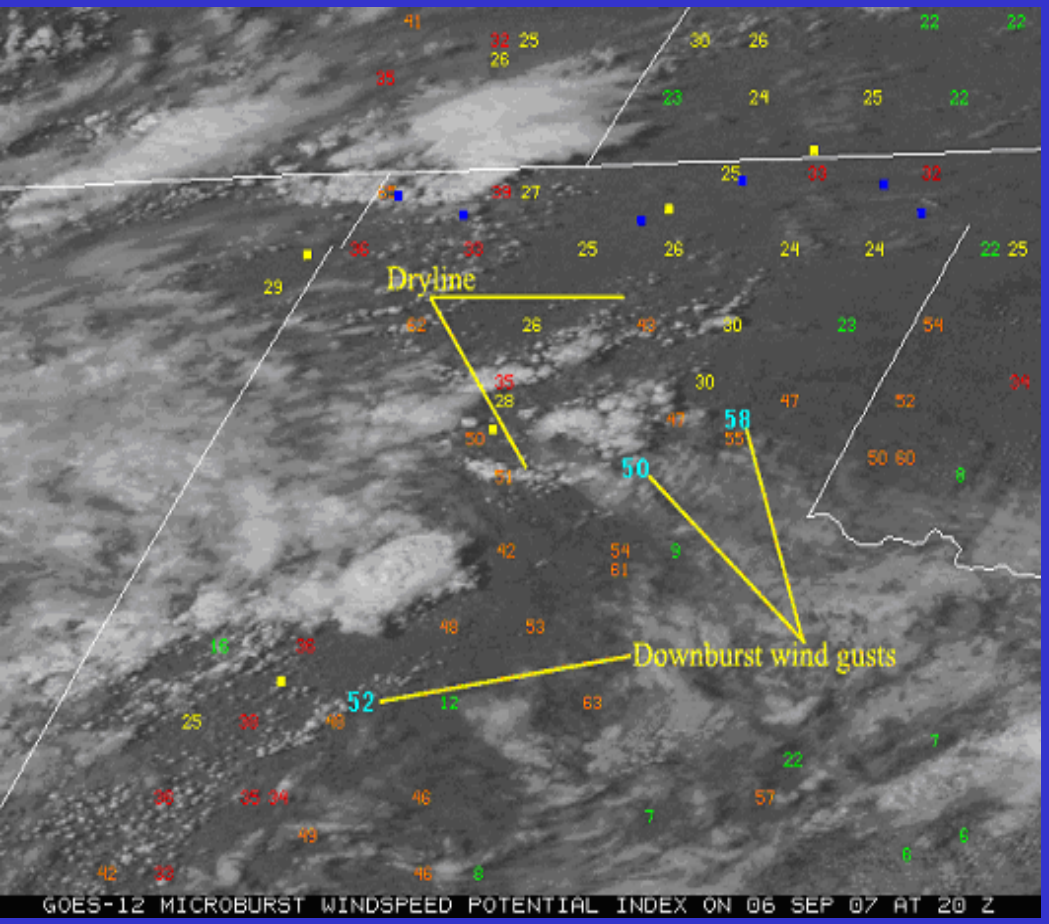


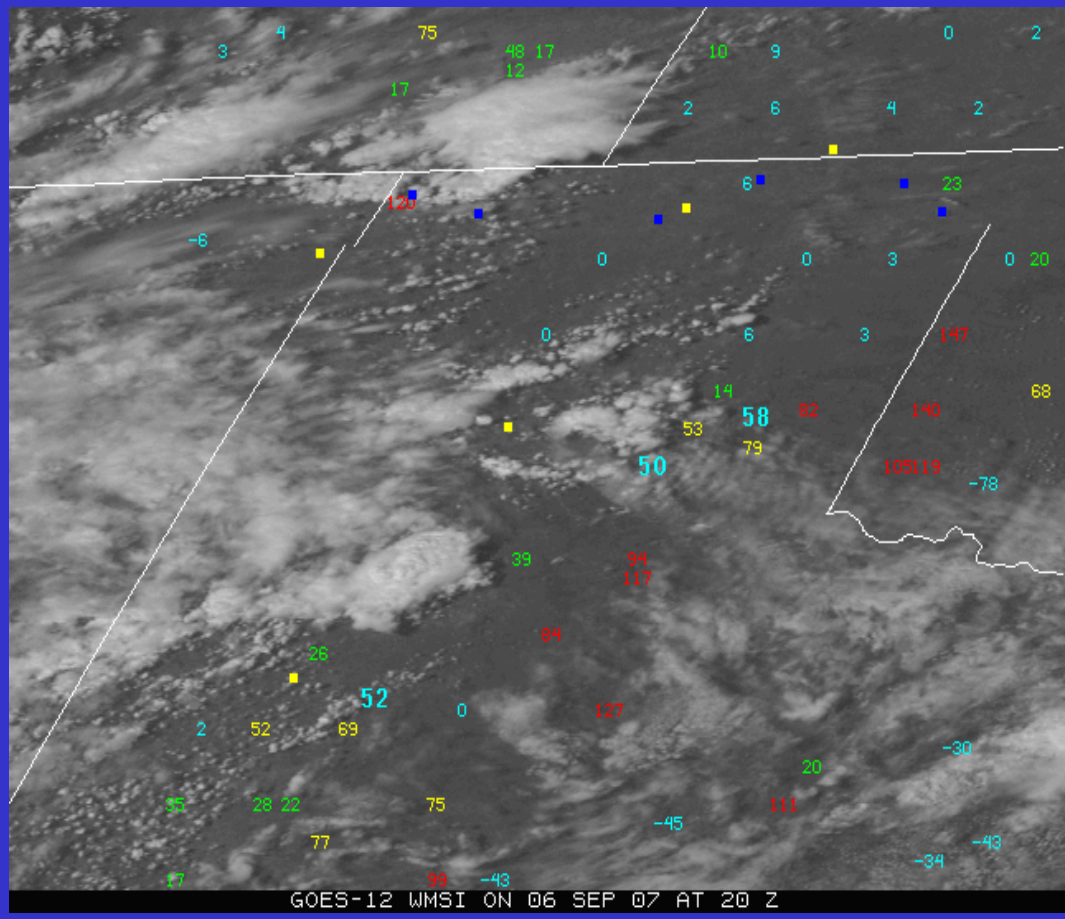
Microburst Windspeed Potential Index (MWPI)

$MWPI = CAPE/100 + \Gamma + (T - T_d)_{850} - (T - T_d)_{670}$

- Γ = temperature lapse rate (°C km^{-1}) from 850 to 670 mb
- T = temperature (°C)
- T_d = dew point temperature (°C)
- Severe microbursts may occur when the MWPI > **50**

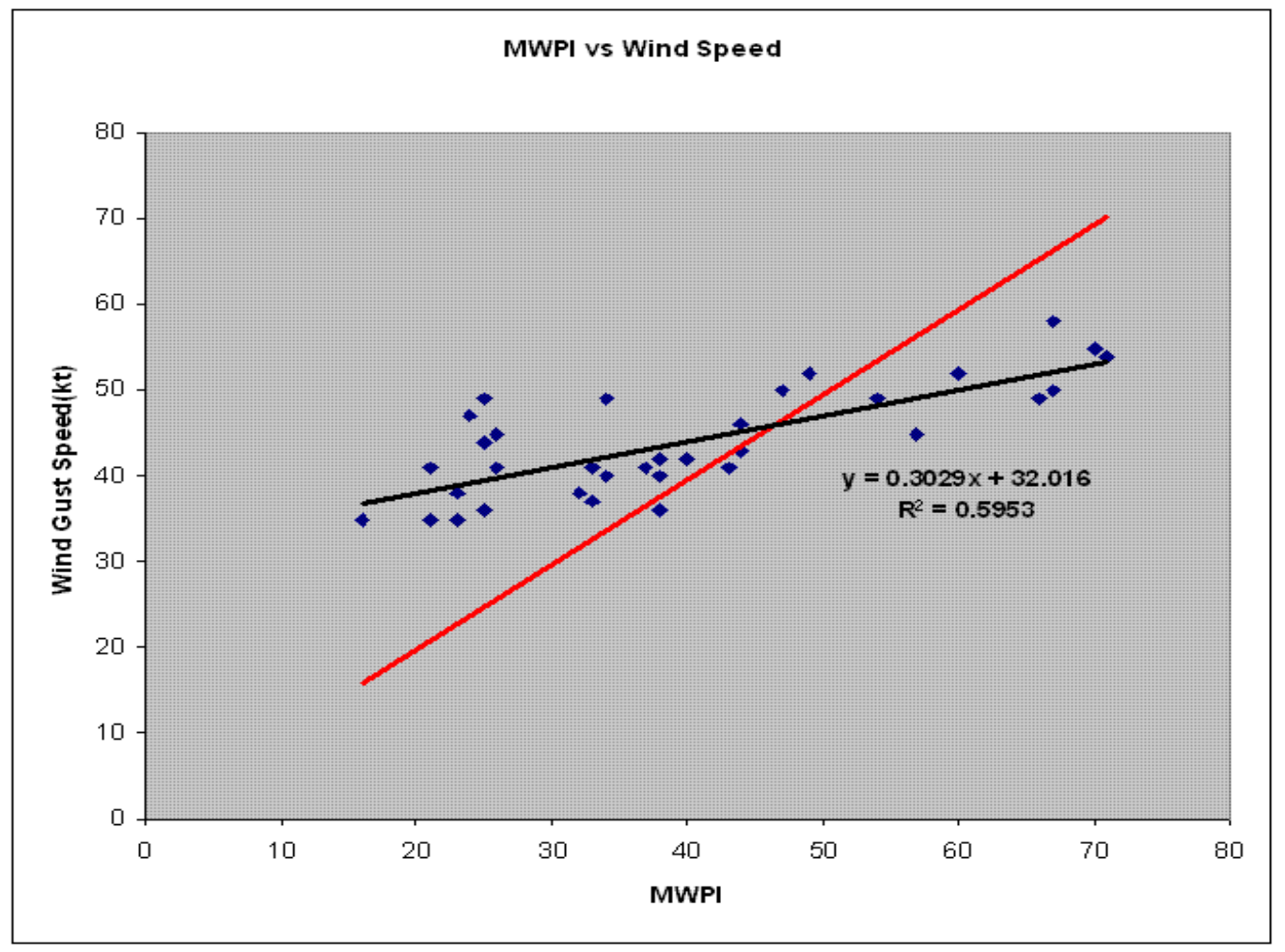
MWPI vs WMSI



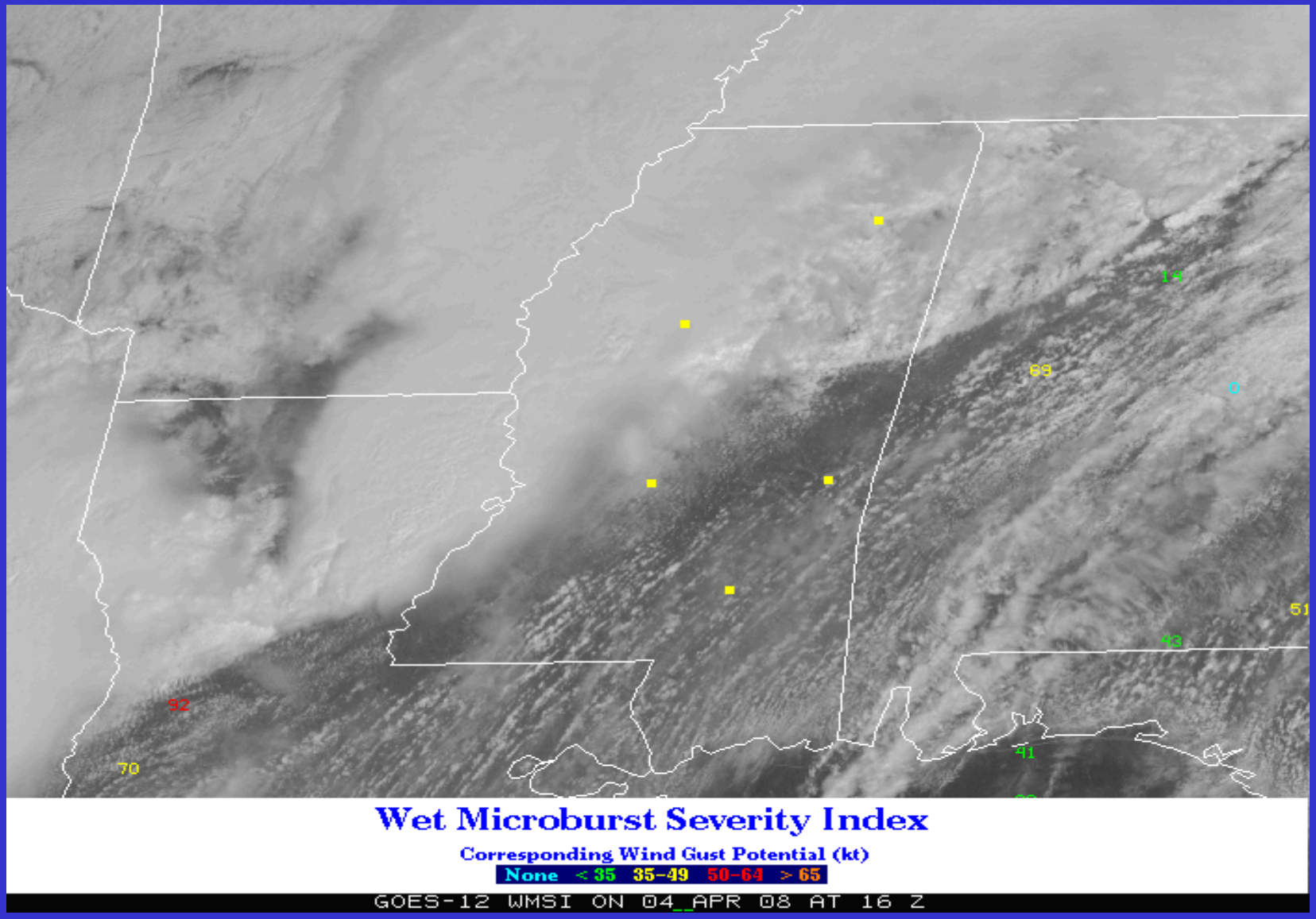


Forecasting Convective Downburst Potential Using GOES Sounder Derived Products
Ken Pryor (NOAA/NESDIS/ORA/STAR)

Validation: Summer 2007

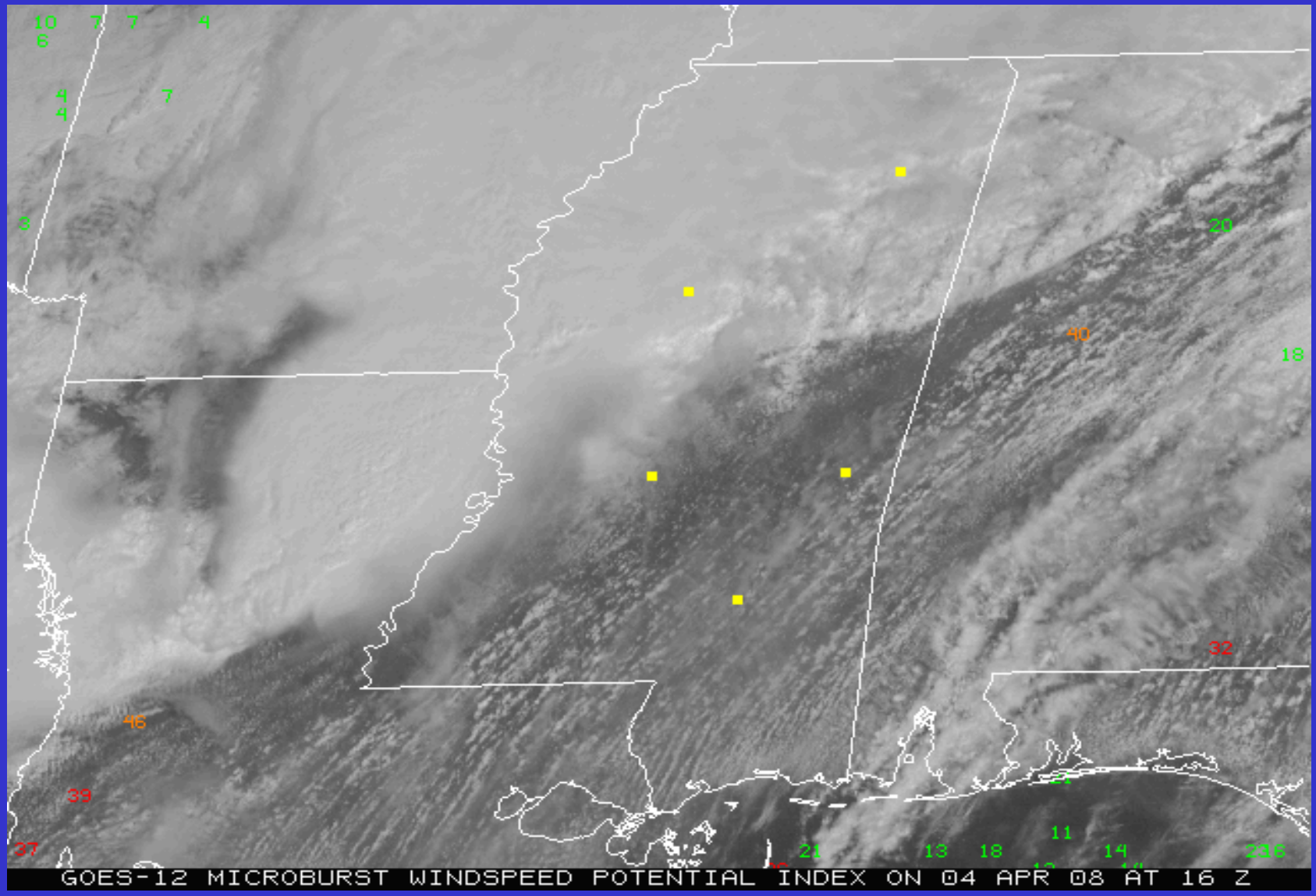


4 April 2008 Downbursts



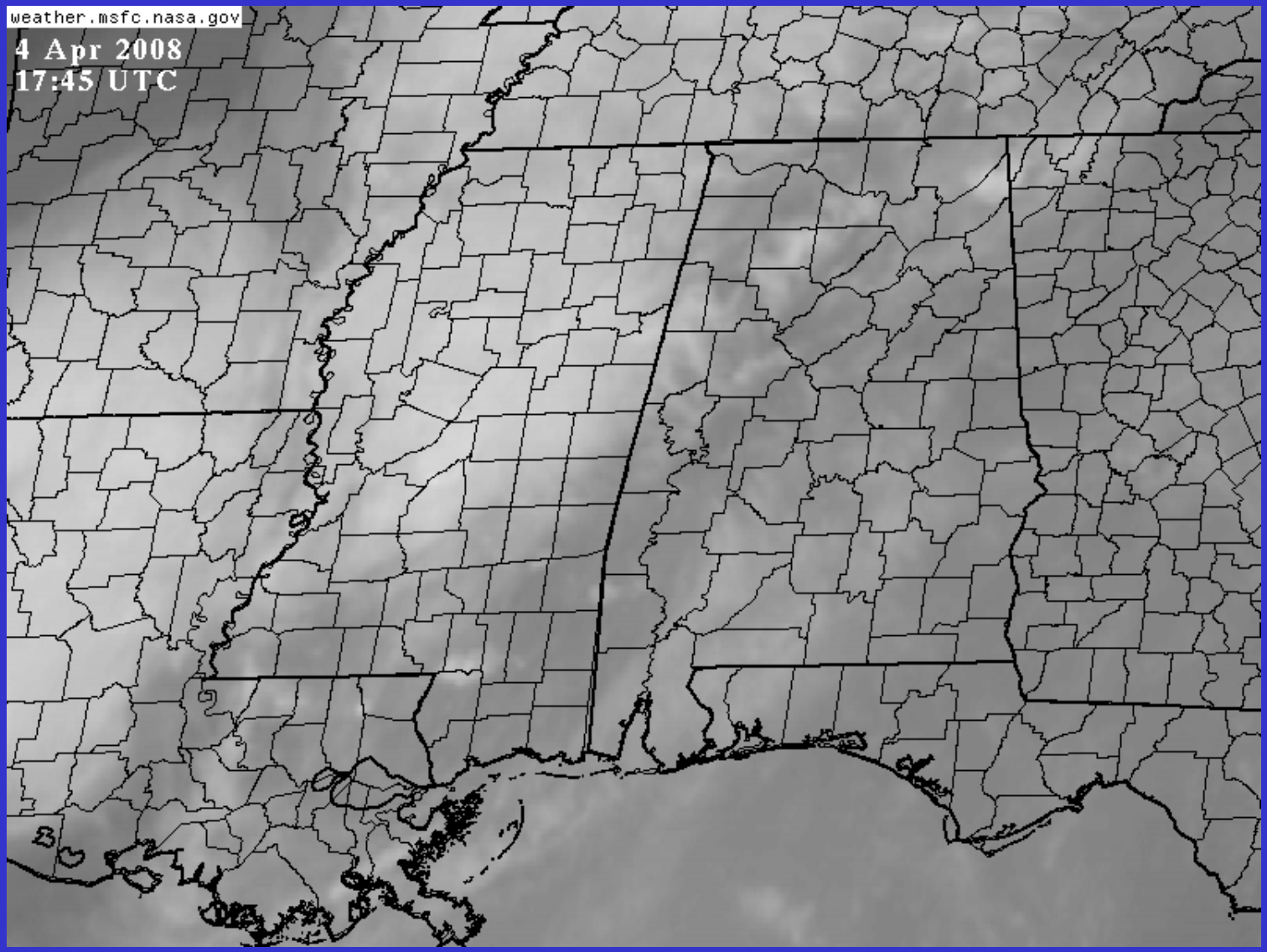
Forecasting Convective Downburst Potential Using GOES Sounder Derived Products
Ken Pryor (NOAA/NESDIS/ORA/STAR)

4 April 2008 Downbursts



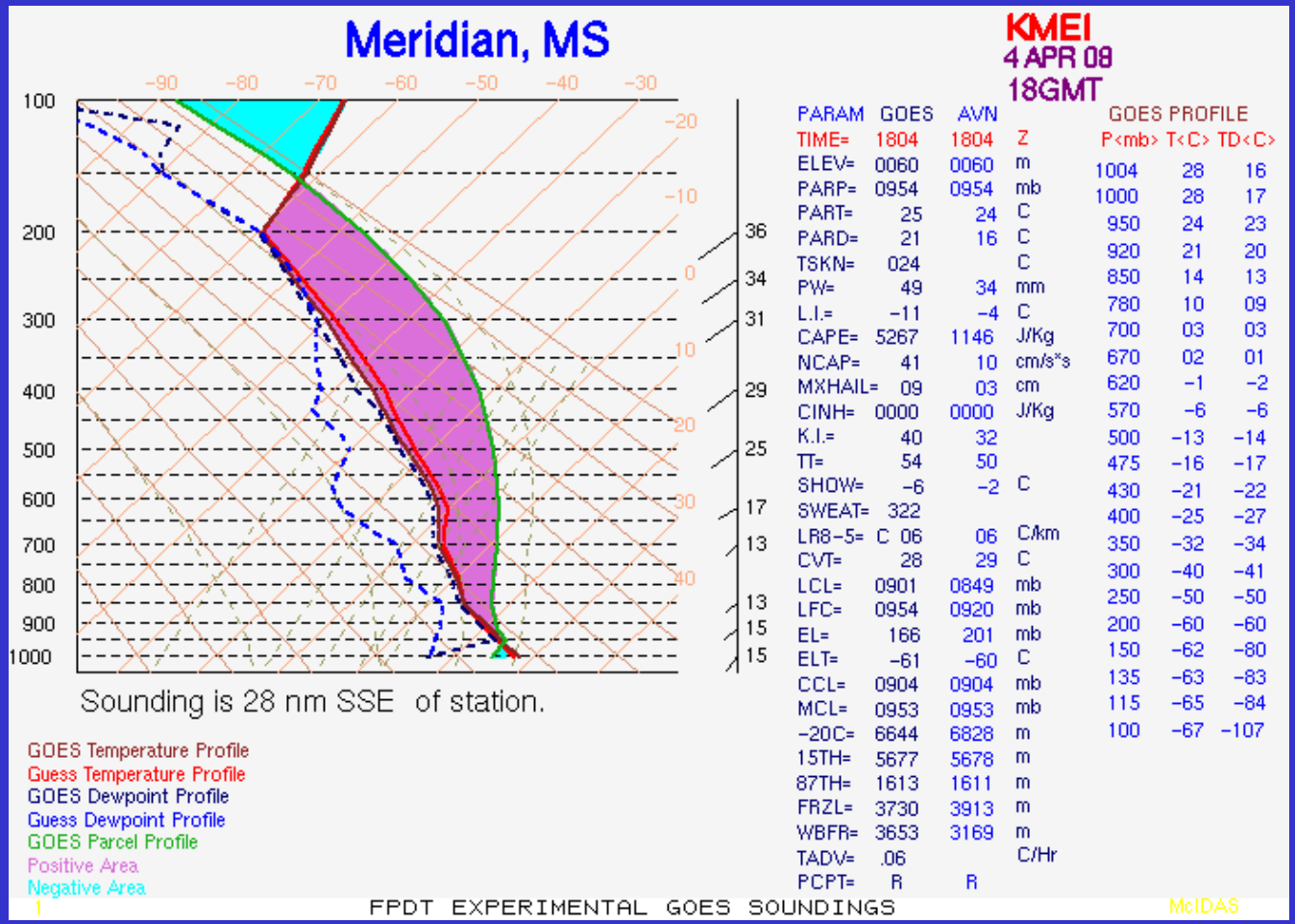
Forecasting Convective Downburst Potential Using GOES Sounder Derived Products
Ken Pryor (NOAA/NESDIS/ORA/STAR)

4 April 2008 Downbursts

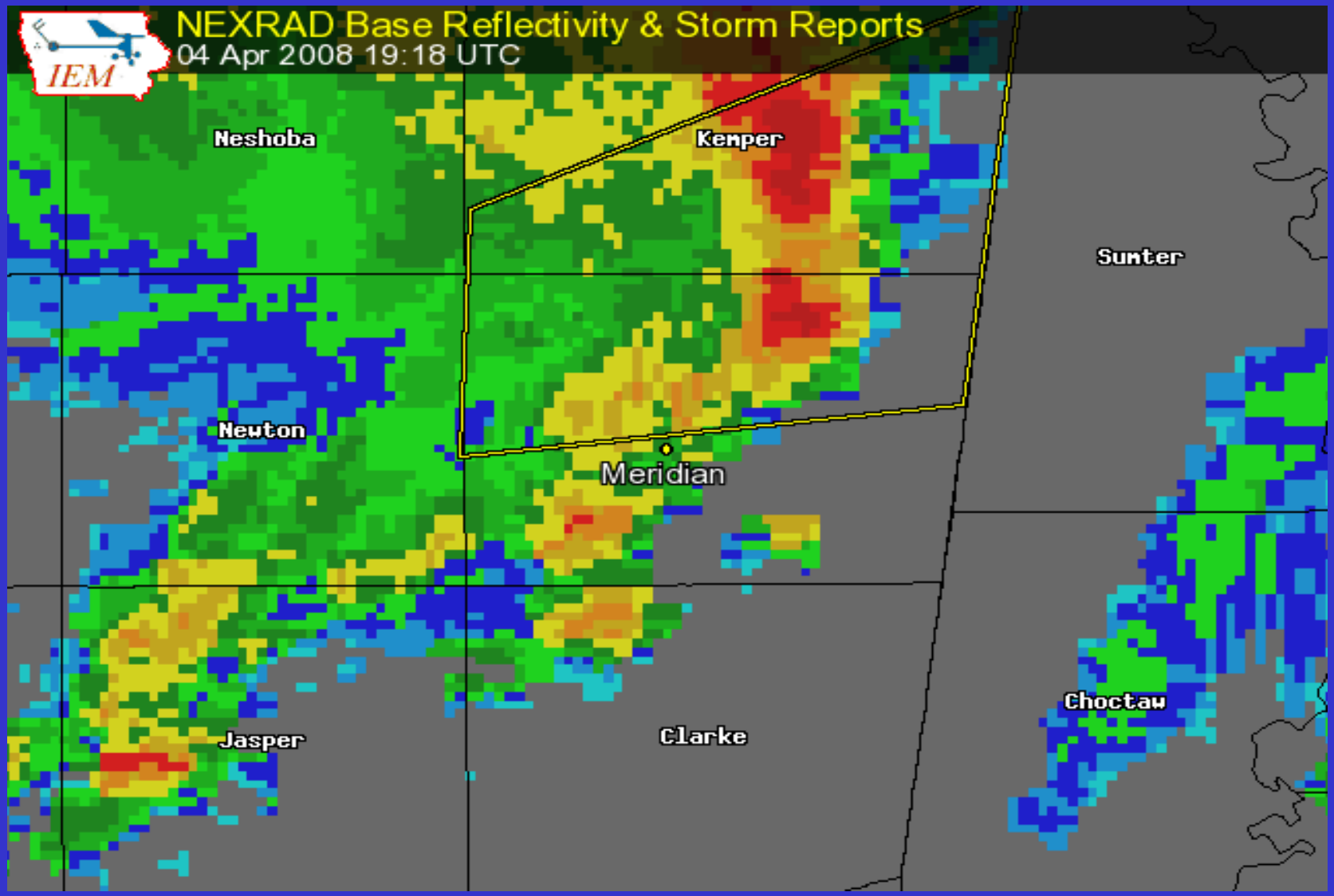


Forecasting Convective Downburst Potential Using GOES Sounder Derived Products
Ken Pryor (NOAA/NESDIS/ORA/STAR)

4 April 2008 Downbursts



4 April 2008 Downbursts



Forecasting Convective Downburst Potential Using GOES Sounder Derived Products
Ken Pryor (NOAA/NESDIS/ORA/STAR)

Summary of Microburst Generation Processes

- **WMSI**: strong updrafts, precipitation loading, and evaporative cooling from the entrainment of dry ambient air into the precipitation core
- **MWPI:** strong updrafts, precipitation loading, and subcloud evaporative and sublimational cooling

Future Research

- Validation of WMSI and MWPI products over Intermountain Western U.S. and Southeastern U.S. using high-quality mesonet data
- GOES-R microburst potential algorithm
- ArXiv.org:
  - http://arxiv.org/find/physics/1/au:+Pryor_K/0/1/0/all/0/1

References

Atkins, N.T., and R.M. Wakimoto, 1991: Wet microburst activity over the southeastern United States: Implications for forecasting. *Wea. Forecasting*, **6**, 470-482.

Ellrod, G. P., 1989: Environmental conditions associated with the Dallas microburst storm determined from satellite soundings. *Wea. Forecasting*, **4**, 469-484.

Fujita, T.T., and R.M. Wakimoto, 1983: Microbursts in JAWS depicted by Doppler radars, PAM and aerial photographs. Preprints, *21st Conf. on Radar Meteorology*, Edmonton, Amer. Meteor. Soc., 638-645.

Loconto, A.N., 2006: Improvements of warm-season convective wind forecasts at the Kennedy Space Center and Cape Canaveral Air Force Station. M.S. Thesis, Dept. of Chemical, Earth, Atmospheric and Physical Sciences, Plymouth State University, Plymouth, NH

Wakimoto, R.M., 2001: Convectively Driven High Wind Events. *Severe Convective Storms*, C.A. Doswell, Ed., Amer. Meteor. Soc., 255-298.

Questions?

Thank You!