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The GOES Hybrid Microburst Index

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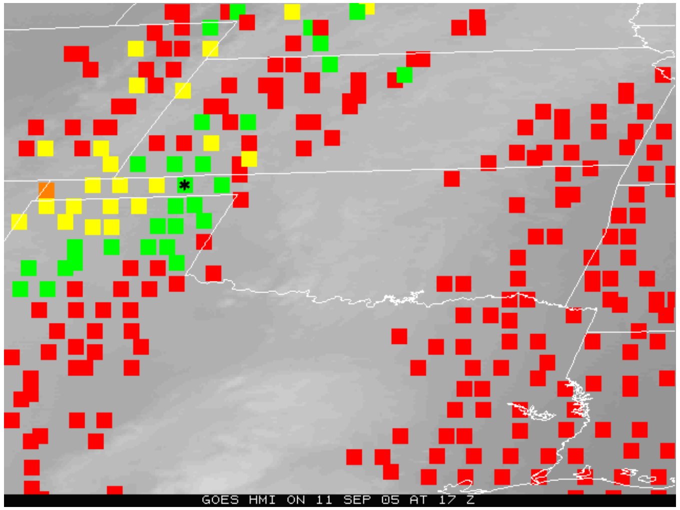
1. INTRODUCTION

A **favorable environment** for **downbursts** associated with **deep convective storms** that occur over the central and eastern continental United States includes **strong static instability** with large amounts of convective available potential energy and the presence of a **mid-tropospheric layer of dry air**. However, previous research (Fujita 1985, Ellrod 1989) has identified that over the central United States, especially in the **Great Plains** region, an environment between that favorable for **wet** (Atkins and Wakimoto 1991) and **dry** (Wakimoto 1985) **microbursts** may exist during the convective season, resulting in the generation of **hybrid** type microbursts. **Hybrid microbursts** have been found to originate from deep convective storms that generate **heavy precipitation**, with **sub-cloud evaporation** of precipitation a significant factor in **downdraft acceleration**. Accordingly, a new GOES sounder derived product, the **GOES Hybrid Microburst Index**, is under development and is designed to assess the potential for **convective downbursts** that develop in an **intermediate environment** between a wet type, associated with heavy precipitation, and a dry type associated with convection in which very little to no precipitation is observed at the surface. The GOES HMI product appears similarly to the GOES Dry Microburst Index (DMI) product, with **color coded boxes**, representing a range of risk values, plotted over a **water vapor satellite image**. An example of the GOES HMI product is displayed below.



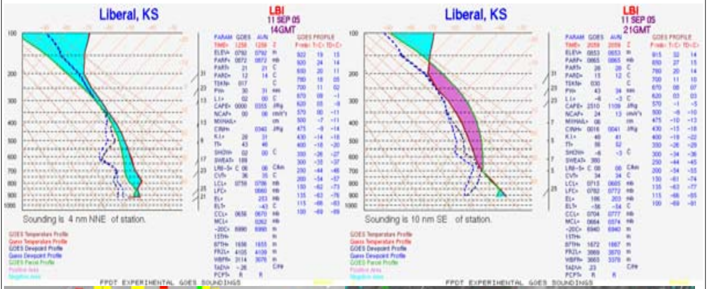
The **GOES Hybrid Microburst Index (HMI)** algorithm is designed to infer the presence of a **convective boundary layer (CBL)** by incorporating the sub-cloud temperature **lapse rate** (between the 670 and 850 millibar (mb) levels) as well as the **dew point depression difference** between the typical level of a convective cloud base (670 mb) and the sub-cloud layer (850 mb). Thus, the **GOES HMI**, intended to serve as a **supplemental index** to the **GOES Wet Microburst Severity Index (WMSI)** product (Pryor and Ellrod 2005), is defined as

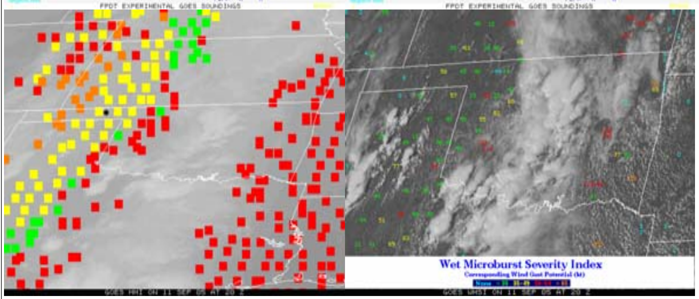
$$HMI = G + (T - T_d)_{850} - (T - T_d)_{670} \quad (1)$$

where G is the lapse rate in degrees Celsius (C) per kilometer from the 850 to the 670 mb level, T is temperature in degrees Celsius, and Td is the dewpoint temperature (C). In addition, the **thermodynamic structure** of the lower and middle troposphere that results in **large HMI values** signifies the presence of an **enhanced convective mixed layer**, typically found along the **dryline** zone over the southern Plains. Stull (1988) has identified that the characteristics of a **deep convective mixed layer** are caused by a combination of buoyant heat flux, due to **strong solar heating** of the surface, and **wind shear**, both typically found along the dryline. In addition, increased **vertical circulation**, resulting from the sharp temperature and moisture gradients along the dryline zone, is believed to be responsible for **enhanced mixing** and the subsequent **deepening of the CBL** and hence, the **sub-cloud layer** (Schaefer 1986). Thus, it is speculated that the presence of the dryline can establish a thermodynamic setting favorable for hybrid microburst generation by increasing the role of sub-cloud evaporational cooling in the process of downdraft acceleration.

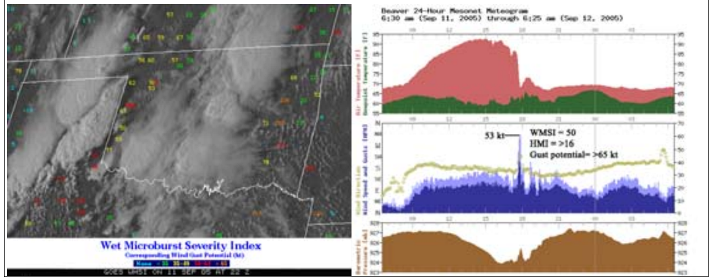
2. CASE STUDY: 11 SEPTEMBER 2005 BEAVER MICROBURST

During the afternoon of **11 September 2005**, intense **convective storms** developed along the **dryline** over the **Oklahoma Panhandle**. Over the eastern panhandle and northwestern Oklahoma, the **pre-convective environment** was characterized by **moderate static instability** and the presence of a **deep CBL**, resulting from strong solar heating. **GOES sounding profiles** at **Liberal, Kansas** and a **meteogram** from **Beaver, Oklahoma** display the **evolution of the CBL** between mid-morning (1400 UTC) through late afternoon (2100 UTC). Note the development of an **"inverted-v"** profile between 1400 and 2100 UTC (0900 and 1600 CDT) as well as a large **surface dew point depression** (34°F or 19°C) at Beaver, corresponding to a gradual increase in HMI values over the Oklahoma Panhandle. By **mid-afternoon** (2000 UTC), **HMI** values over the eastern panhandle were in **excess of 16** with corresponding **WMSI** values near **50**, indicating the presence of an intermediate thermodynamic environment favorable for hybrid microbursts.





Between **2100** and **2200** UTC an area of **convective storms** developed over the eastern Oklahoma Panhandle along the **dryline**, as indicated by visible satellite imagery. A severe **convective wind gust** of **53 knots** associated with a microburst was observed at **Beaver** at **2255 UTC** (1755 CDT). This case demonstrated the increased role of **sub-cloud evaporational cooling** in downdraft instability and the subsequent generation of a **microburst** in an environment of marginal to moderate static instability with weak dynamic forcing. As discussed earlier, the dryline zone has been identified as a region of enhanced mixing and vertical circulation. As expected during the warm season, this case emphasizes the effects of **buoyancy** and **stability** in convective **wind gust magnitude**. It is also demonstrated that the presence of the **dryline** can establish a favorable **thermodynamic structure** for **hybrid microburst generation**.



3. VALIDATION

Data from the **GOES HMI** and **WMSI** was collected over **Oklahoma** from **1 June to 31 August 2005** and validated against conventional surface data. The State of Oklahoma was chosen as a study region due to the wealth of surface observation data provided by the **Oklahoma Mesonet** (Brock et al. 1995), a thermodynamic environment typical of the southern Plains region during the warm season, and its proximity to the dryline. **Validation** was conducted in the manner described by **Pryor and Ellrod (2005)**.

A **statistically significant correlation of 0.55** was found between GOES WMSI values and the magnitude of convective wind gusts for **72 hybrid microburst events** that occurred during the validation period. Partitioning the downburst events by **HMI categories** resulted in a much **stronger correlation** of **0.69 for downburst events (N=31)** associated with an **HMI value greater than 16** (considered to be a significant risk). This result highlights the importance of both sub-cloud evaporational cooling as well as static instability in the generation of convective downbursts in an environment typical of the Southern Plains region of the United States during the warm season.

Downburst risk corresponding to HMI values.

HMI	Box Color	Downburst Risk
<8	Red	Downbursts Unlikely
> or = 8	Green	Downbursts Likely
> or = 16	Yellow	Downbursts Likely
> or = 24	Orange	High Risk of Downbursts

4. REFERENCES

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