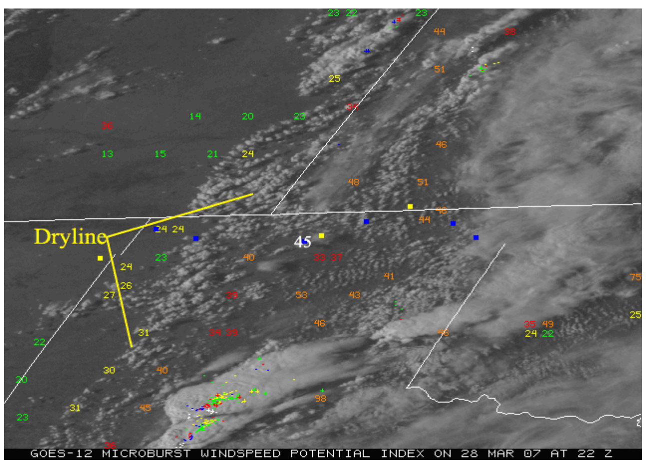
# The GOES Microburst Windspeed Potential Index

Kenneth L. Pryor
Center for Satellite Applications and Research (NOAA/NESDIS), Camp Springs, MD

## 1. INTRODUCTION

A suite of products has been developed and evaluated to assess hazards presented by convective downbursts to aircraft in flight derived from the current generation of Geostationary Operational Environmental Satellite (GOES) (11-12). The existing suite of GOES microburst products employs the GOES sounder to calculate risk based on conceptual models of favorable environmental profiles for convective downburst generation. Pryor and Ellrod (2005) outlined the development a Geostationary Operational Environmental Satellite (GOES) sounder-derived **wet microburst severity index (WMSI)** product to assess the potential magnitude of convective downbursts, incorporating **CAPE** as well as the vertical **theta-e difference (TeD)** between the surface and mid-troposphere. In addition, Pryor (2006a) developed a GOES **Hybrid Microburst Index (HMI)** product intended to supplement the use of the GOES WMSI product over the United States **Great Plains** region. The HMI product infers the presence of a **convective boundary layer (CBL)** (Stull 1988) by incorporating the **sub-cloud temperature lapse rate** as well as the **dew point depression difference** between the typical level of a warm season Great Plains convective cloud base and the sub-cloud layer. Based on **validation of the GOES WMSI** and HMI products over the Oklahoma Panhandle during the 2005 and 2006 convective seasons, Pryor (2006b) noted an **inverse proportionality between WMSI and HMI** values for convective wind gusts of comparable magnitude. The statistically significant **negative correlation between WMSI and HMI** values likely reflects a **continuum of favorable environments for downbursts**, and underscores the relative importance of **thermal and moisture stratification of the boundary layer** in the acceleration of convective downdrafts.




The **Microburst Windspeed Potential Index (MWPI)** algorithm, derived from **merging the WMSI and HMI**, is designed to infer the presence of a **CBL** by incorporating the **sub-cloud lapse rate between the 670 and 850 mb levels** as well as the **dew point depression difference** between the typical level of a convective cloud base at 670 mb and the sub-cloud layer at 850 mb. **CAPE** has an important role in precipitation formation due to the strong dependence of updraft strength and resultant storm precipitation content on positive buoyant energy. The precipitation caused by updrafts will produce the **sub-cloud evaporational cooling** and **negative buoyancy** that accelerates convective downdrafts. Thus, the **Microburst Windspeed Potential Index (MWPI),** is defined as

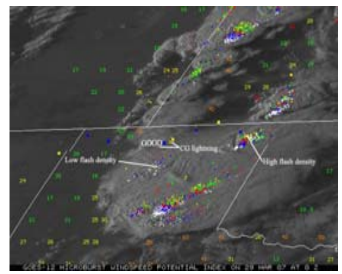
$$MWPI = (CAPE/100) + G + (T - Td)_{850} - (T - Td)_{670} \quad (1)$$

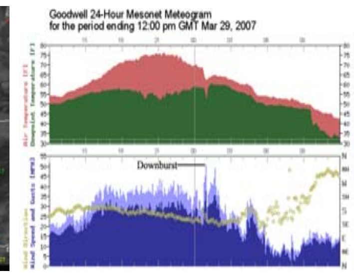
where G is the lapse rate in degrees Celsius (C) per kilometer from the 850 to the 670 mb level, T is temperature in degrees Celsius, and Td is the dewpoint temperature (C). A climatology of severe storm environmental parameters (Nair et al. 2002) has found that a deeper **convective mixed layer**, as represented by large LFCs, predominates in the warm season over the southern Plains. The presence of a deep, **dry sub-cloud (mixed) layer** will enhance **evaporational cooling** and **downdraft intensification** as precipitation falls below the convective storm cloud base. Thus, this paper proposes to merge the WMSI and HMI algorithms into the Microburst Windspeed Potential Index (MWPI) algorithm for implementation in the **GOES-R Advanced Baseline Imager (ABI)**.

## 2. CASE STUDIES:

### 29 March 2007 Downbursts

During the evening of **28 March 2007**, strong downbursts were observed over the Oklahoma Panhandle. Downburst wind gusts of **45** and **47 knots** were recorded by the Goodwell and Beaver, Oklahoma mesonet stations at **0055 and 0350 UTC 29 March 2007**, respectively. Late afternoon (**2200 UTC 28 March 2007**) Geostationary Operational Environmental Satellite (GOES) **Microburst Windspeed Potential Index (MWPI)** imagery indicated **elevated values** along and to the east of the **dryline** that was located over the western Oklahoma Panhandle. Elevated MWPI values indicated favorable boundary layer thermodynamic conditions for convective downbursts most likely resulting from the presence of the dryline (Schaefer 1986). The dryline established favorable conditions for downbursts by enhancing vertical circulation and hence, the depth of the convective boundary layer.

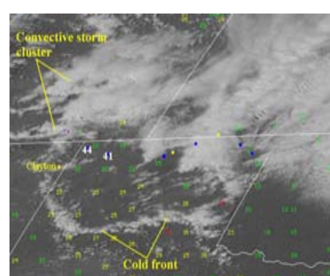


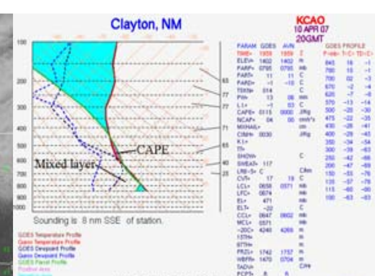




GOES **MWPI** product images at **2200 UTC 28 March 2007** and at **0000 UTC 29 March 2007**, respectively, display the development of convective storm activity over the Texas and Oklahoma Panhandles. The **2200 UTC** image indicates **elevated values** (plotted in red and orange) along and to the east of the **dryline**. The **0000 UTC** image displays cloud-to-ground (CG) lightning activity near the time of downburst occurrence at Goodwell (45 knots at 0055 UTC). Noteworthy is a **lack of CG lightning** in the vicinity of Goodwell at the time of downburst occurrence as well as decreased CG lightning flash density associated with convective storms near the dryline. A meteogram from the Goodwell mesonet station, reflected **downburst** occurrence by displaying a **sharp peak in wind speed** at approximately **0055 UTC**. Atkins and Wakimoto (1991) related this peak in wind speed to downburst observation at the surface by mesonet stations. Interesting to note was an increase in MWPI values downstream of the convective storm activity through the evening in the region of downburst occurrence. Thus, **MWPI** product imagery indicated **favorable environmental conditions** for **downburst** occurrence associated with the convective storm cluster as it tracked through the Oklahoma Panhandle during the evening of 28 March.

### 10 April 2007 Downbursts

During the afternoon of **10 April 2007**, strong downbursts, associated with convective storms initiated by an upper-level disturbance, were observed over the western Oklahoma Panhandle. The first and strongest **downburst wind gust (44 knots)** was recorded by the Kenton mesonet station where the highest MWPI value in the panhandle was indicated over an hour earlier at 2000 UTC. Strong surface winds and **solar heating of the boundary layer** after the passage of a cold front resulted in the development and evolution of a **deep convective mixed layer** through mid-afternoon, establishing favorable conditions for **downburst generation**. Favorable environmental pre-conditioning for downbursts was apparent in **2000 UTC MWPI imagery** with the highest risk values located over Cimarron County, Oklahoma. The **GOES sounding** from Clayton, New Mexico at 2000 UTC in Figure 6 echoed a favorable environment for downbursts by displaying an **inverted V profile**, similar to the **type A** profile as described by Wakimoto (1985). This event demonstrated a **strong correlation** between **MWPI** values and observed convective **surface wind gusts**.




## 3. METHODOLOGY AND VALIDATION

Data from the **GOES HMI and MWPI** was collected over the **Oklahoma Panhandle** for downburst events that occurred on **29 March** and **10 April 2007** and **validated** against conventional surface data. Images were generated by Man computer Interactive Data Access System (McIDAS) and then archived on an FTP server. The Oklahoma Panhandle 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 High Plains region during the warm season, proximity to the **dryline**, and relatively **homogeneous topography**. **Correlation** between GOES MWPI values and observed surface wind gust velocities was computed to assess the significance of a linear relationship between observed downburst wind gust magnitude and MWPI values. Validation based on these events over the Oklahoma Panhandle indicated a strong correlation (**r = 0.93**) between **MWPI** values and observed **surface convective wind gusts**. As exemplified in the case studies, the GOES MWPI product demonstrated utility in the short-term prediction of downburst magnitude. Future validation effort will focus on upcoming **warm season** (June-August) downburst events that occur over the **High Plains**, specifically the Oklahoma Panhandle region.

**Correlation:**

| | | | | | |
|---|---|---|---|---|---|
| MWPI to measured wind: | 0.93 | MWPI to HMI: | 0.94 | Mean HMI: | 22.25 |
| HMI to measured wind: | 0.99 | MWPI to ET: | 0.92 | Mean MWPI: | 28.5 |
| | | No. of events: | 4 | Mean Wind Speed: | 44 |

| Date | Time | Measured Wind Speed kt | Location | GOES-12 HMI | GOES-12 MWPI | Max ET |
|---|---|---|---|---|---|---|
| 29-Mar-07 | 0:55 | 45 | Goodwell | 24 | 35 | 40000 |
| | 3:50 | 47 | Beaver | 26 | 38 | 45000 |
| 10-Apr-07 | 21:25 | 44 | Kenton | 22 | 23 | 20000 |
| | 21:45 | 41 | Boise City | 17 | 18 | 25000 |

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Corresponding author address: Mr. Kenneth Pryor, Satellite Meteorology and Climatology Division, Operational Products Development Branch, NOAA/NESDIS/STAR, Room 711, 5200 Auth Rd., Camp Springs, MD 20746-4304
E-mail: Ken.Pryor@noaa.gov
http://www.orbit.nesdis.noaa.gov/smcd/opdb/kpryor/bio.html