Recent developments in microburst nowcasting using GOES

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1. INTRODUCTION

Recent testing and validation have found that the Geostationary Operational Environmental Satellite (GOES) microburst products are effective in the assessment and short-term forecasting of downburst potential and associated wind gust magnitude. Two products, the GOES sounder Microburst Windspeed Potential Index (MWPI) and a new two-channel GOES imager brightness temperature difference (BTD) product have demonstrated capability in downburst potential assessment (Pryor 2009; Pryor 2010). The GOES sounder MWPI algorithm is a predictive linear model developed in the manner exemplified in Caracena and Flueck (1988):

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

where Γ is the lapse rate in degrees Celsius (C) per kilometer from the 850 to the 670 mb level, and the quantity $(T–T_d)$ is the dewpoint depression (C).

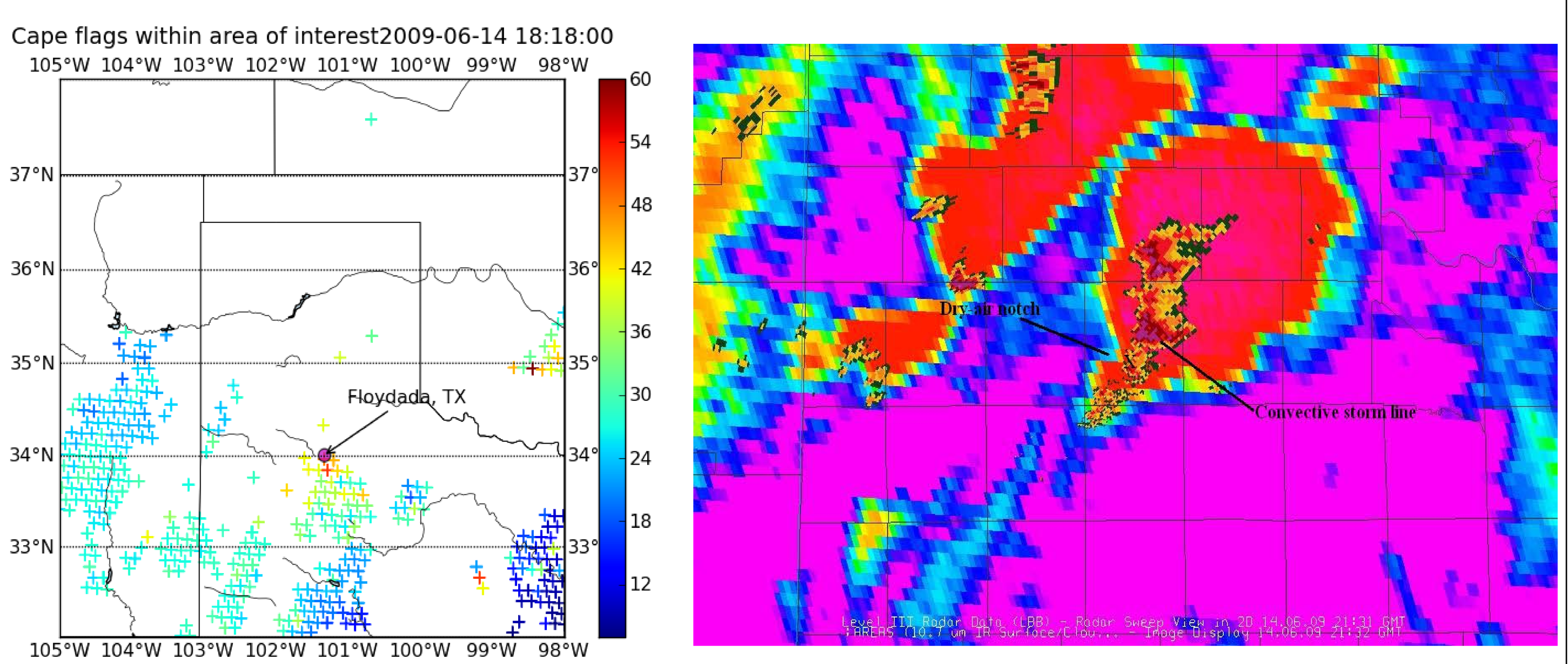

Figure 1. MWPI product image at 1818 UTC 14 June 2009 compared to a BTD image at 2131 UTC visualized by McIDAS-V .

The MWPI algorithm, as shown in Figure 1, has been integrated into the Graphyte Toolkit as an executable Python script. The MWPI program reads GOES sounding profile data files in binary format, processes the data set, and generates output based on the above MWPI formula. A Python script, running in the Graphyte environment, produces an image with color-coded markers, representing relative wind gust potential. The output image, as visualized in Figure 1, can serve as a prototype for the GOES-R Microburst Windspeed Potential product. Derivation of the MWPI algorithm is primarily based on **parameter evaluation** and **pattern recognition** techniques as employed in the **severe convective storm forecasting** process (Johns and Doswell 1992). Comparing the sum of the hybrid microburst index (HMI) to CAPE resulted in a strong negative correlation (r=-.82), with a confidence level above 99%. This emphasizes the complementary nature of the HMI and CAPE in generating a robust and physically meaningful MWPI value.

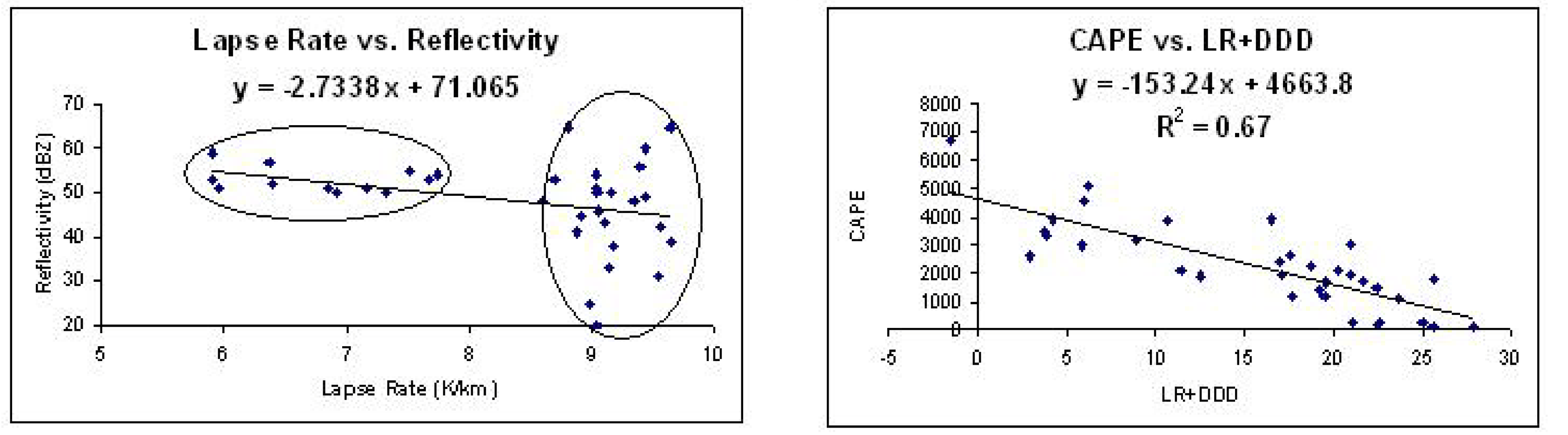

Figure 2. Scatterplot of lapse rate versus radar reflectivity for 35 downburst events over Oklahoma during the 2009 convective season compared to a scatterplot of the HMI vs. CAPE.

2. CASE STUDY: 10 May 2010 Oklahoma Downbursts and Tornadoes

A significant tornado outbreak in Oklahoma was observed during the afternoon and evening of 10 May 2010. Associated with the tornado activity were numerous downbursts, especially over central Oklahoma. The period between 2218 and 2238 UTC 10 May was especially active with two tornado touchdowns and reports of wind gusts between 51 and 56 knots in the Norman area. The GOES MWPI and GOES imager band 3-4 BTD products effectively indicated the potential for severe downbursts from three hours to 10 minutes prior to the observation of high winds in the Norman area. For this event, the GOES MWPI algorithm output was visualized with the Graphyte Toolkit with assistance from M. Grossberg and P. Alabi (NOAA-CREST, City College of New York).

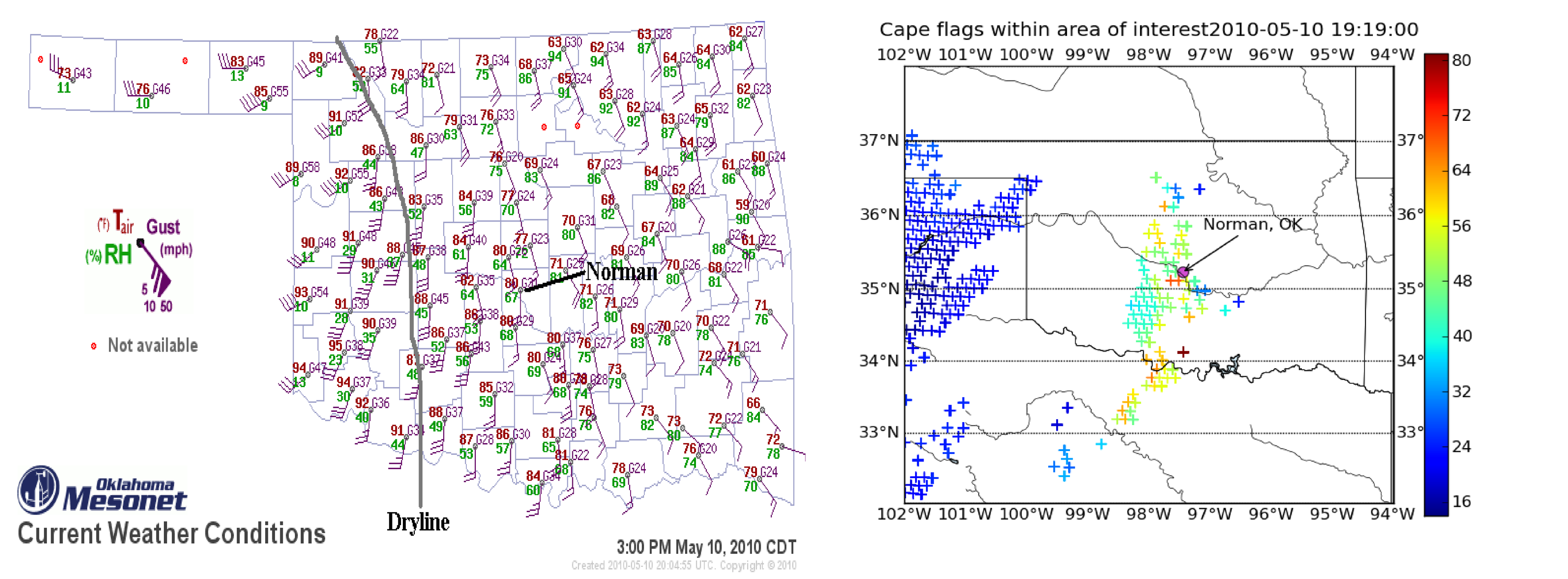

Figure 3. Surface analysis of Oklahoma Mesonet observations at 2000 UTC (left) and Geostationary Operational Environmental Satellite (GOES) MWPI product at 1919 UTC (right).

Figure 3 shows a favorable environment for severe convective storms and downbursts during the afternoon of 10 May. The MWPI image, visualized by the Graphyte toolkit, indicated a local maximum (orange markers) in index values in close proximity to Norman. Figure 4, a radiosonde observation (RAOB) from Norman at 2000 UTC, displayed a classic "loaded gun" profile with large CAPE, and a significant dry-air layer between the 500 and 700-mb levels. The dry-air layer, in conjunction with heavy precipitation resulting from large CAPE, played a major role in forcing intense convective downdrafts in the supercell storms.

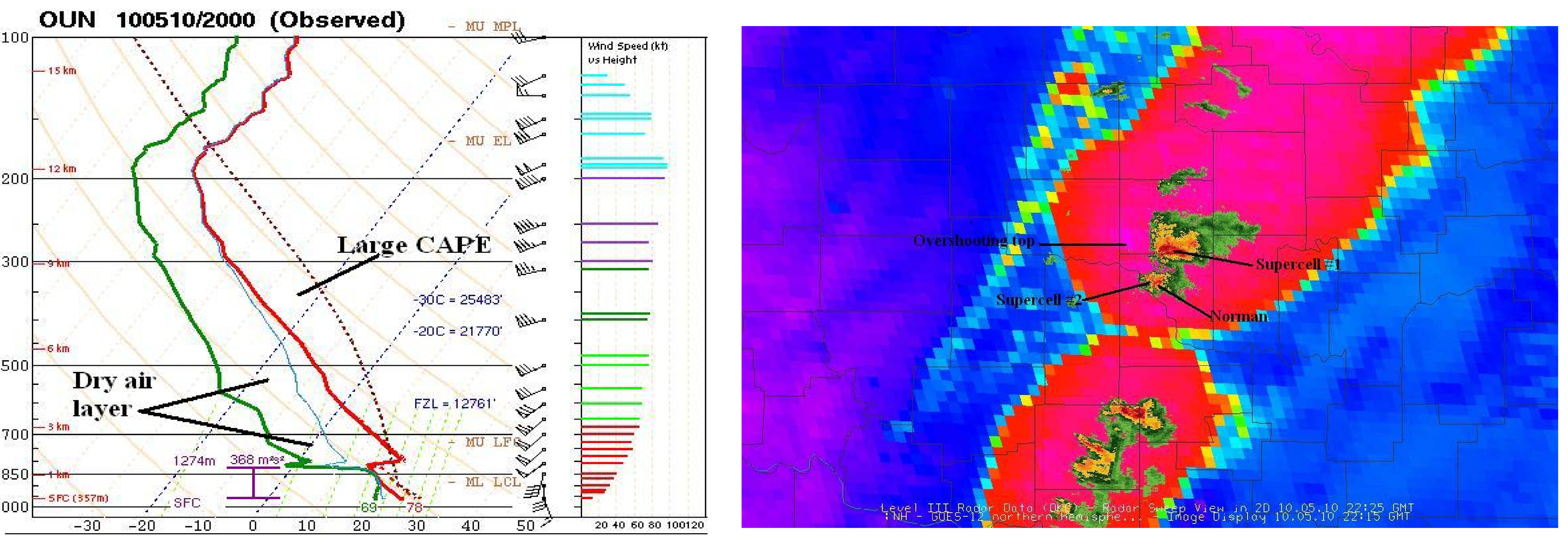

Figure 4. Radiosonde observation (RAOB) from Norman, OK (left) and GOES BTD image product at 2215 UTC (right) with overlying radar reflectivity image from Oklahoma City TDWR.

As shown in the sounding profile, mid-tropospheric dry air was channeled into the southwestern flank of the supercell storms and provided the energy for intense downdrafts due to evaporation within the precipitation core.

3. METHODOLOGY AND VALIDATION

The objective of this validation effort was to **qualitatively and quantitatively assess** the performance of the **GOES MWPI product** by employing classical statistical analysis of real-time data as illustrated in Figure 5. Data from the **GOES MWPI** product was collected over **Oklahoma and western Texas** for downburst events that occurred between **1 June 2007 and 30 September 2009** and validated against **surface observations** of convective wind gusts as recorded by **Oklahoma** and **West Texas Mesonet** stations.

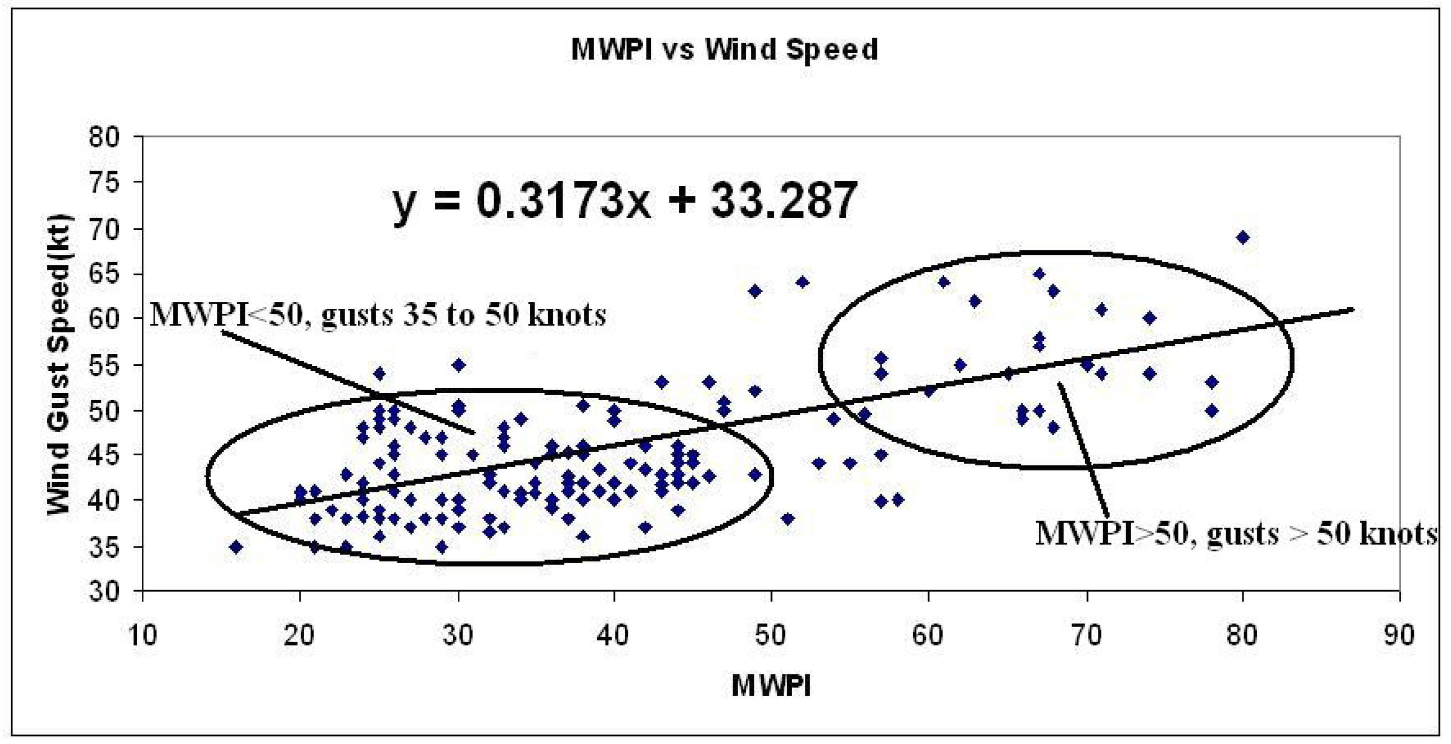

Figure 5. Statistical analysis of validation data over the Oklahoma and western Texas domain between June 2007 and September 2009: Scatterplot of MWPI values vs. measured convective wind gusts for 168 downburst events.

4. REFERENCES

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