Convective Downburst Potential Using GOES Sounder Derived Products

Kenneth L. Pryor and Gary P. Ellrod
Office of Research and Applications (NOAA/NESDIS)
Camp Springs, MD

Andrew A. Bailey
Raytheon ITSS, Landover, MD

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Abstract

Retrieved profiles of temperature and moisture obtained from the Geostationary Operational Environmental Satellite (GOES) Sounders have been shown to be useful in assessing the potential for convective downbursts. Sounder-derived parameters used for this purpose include the Wind Index (WINDEX) for estimating the maximum wind gusts, a Dry Microburst Index (DMI) and maximum Theta-e Difference (TeD) for dry and wet microburst potential, respectively. These parameters are conditional on the development of convection, however, thus requiring analysis of other environmental factors as well. The experimental indices are plotted on regional GOES images (Visible, Infrared, or Water Vapor) and made available on the GOES Microburst Products web page(URL: http://orbit-net.nesdis.noaa.gov/arad/fpdt/mb.html). This paper briefly reviews each of the GOES microburst products, describes recent improvements, provides updated verification and a case study, and discusses future plans. Recent improvements include a change in the first guess numerical model, use of single field-of-view retrievals, a filter for removing high DMI values where convection is unlikely, animation of many sectorized products, and color-coding of TeD or WINDEX ranges for data plots. A case study on a dry microburst event that occurred in southern Idaho and produced wind gusts of over 50 kt is presented. Validation continues by comparing product output values to preliminary severe weather reports from the Storm Prediction Center, surface observations, and summaries from the Cape Canaveral, FL mesonet. Mean error, determined from the difference between mean GOES WINDEX and mean measured wind reports, was <3 kt for 92 daytime events during Summer 2001, but GOES WINDEX underestimated wind gusts for 38 out of 55 nighttime events. In addition, mean error for GOES WINDEX is about 2 kt less than mean error for WINDEX derived from the National Centers for Environmental Prediction (NCEP) Aviation (AVN) model first guess. A planned enhancement is to calculate WINDEX at night using data from the top of the boundary layer instead of the surface to reduce the negative bias. Also, the microburst products are scheduled to be implemented in the Advanced Weather Interactive Processing System (AWIPS) at National Weather Service Forecast Offices as part of Build 5.2.

1. Introduction

The downburst is defined as a strong convective downdraft that induces an outburst of damaging winds

on or near the earth's surface (Fujita and Wakimoto 1983). Downbursts are a hazard to aircraft in flight, especially during takeoff and landing phases. Downbursts can be classified into two types based on the temporal and spatial scale of the event. A macroburst is a large downburst with 4 km or larger outflow size with damaging wind persisting for 5 to 20 minutes. A microburst is defined as a small downburst, less than 4 km in outflow diameter, with peak winds persisting for 2 to 5 minutes (Fujita and Wakimoto 1983). Based on the amount of precipitation measured during a microburst event, the term can be divided into dry and wet microbursts (Wakimoto 1985). A dry microburst is accompanied by little or no rainfall between the onset and the end of the high winds and is usually associated with virga from high-based cumulonimbus clouds. A wet microburst is accompanied by heavy rainfall between the onset and end of the high winds and is associated with intense precipitation shafts from thunderstorms. A hybrid microburst is intermediate between a wet and dry microburst and is usually associated with high-based thunderstorms. Atmospheric conditions typically associated with dry microbursts include a deep, dry-adiabatic sub-cloud layer, a shallow moist layer near 500 mb, weak synoptic-scale forcing with only moderate winds aloft, and weak instability [lifted index (LI) usually > or = -2 K] (Wakimoto 1985). Atmospheric conditions favorable for wet microbursts entail a shallow dry-adiabatic subcloud layer, overlain by a moist adiabatic layer, moderate or strong instability [lifted index <-3 K, convective available potential energy (CAPE) >1500 J kg-1], and the presence of a dry air layer at midtropospheric levels (above 500 mb). The temperature and moisture profiles associated with wet microbursts result in a strong vertical gradient of equivalent potential temperature (theta-e), which usually exceeds 20 K from near the surface to the middle troposphere (Atkins and Wakimoto 1991). The primary physical process that contributes to the development of dry microbursts is generally considered to be subcloud evaporative cooling. The primary physical process for wet microbursts is evaporative cooling from the entrainment of dry ambient air into the precipitation core with some contribution from precipitation loading. (Rinehart 1991).

Retrieved profiles of temperature and moisture obtained from the Geostationary Operational Environmental Satellite (GOES) Sounders have been shown to be useful in assessing the potential for convective downbursts. For example, in the 1999 National Weather Service (NWS) Field Assessment of GOES Sounder Products, Final Report, a representative with the NWS Office, Grand Rapids, MI stated that "The WINDEX derived product...proved very useful in detecting microburst potential." This paper will review each of the GOES microburst products: Wind Index (WINDEX) for estimating maximum wind gusts, a Dry Microburst Index (DMI) and maximum Theta-e Difference (TeD) for dry and wet microburst potential, respectively. This paper will also describe recent product improvements, discuss updated validation, and present case studies highlighting the utility of the microburst products. In addition, future plans will be discussed, including further improvements of the microburst products, additional product validation, and incorporation of the microburst products in the National Weather Service (NWS) Advanced Weather Interactive Processing System (AWIPS) at NWS Forecast Offices.

2. Overview of Products

Three GOES microburst products are currently being generated: one to determine the maximum possible convective wind gusts, and two other indices to assess conditions associated with either dry or wet microbursts. These indices are plotted on regional GOES images (Visible, Infrared, or Water Vapor) and

made available hourly on the GOES Microburst Products web page (URL: http://orbit-net.nesdis.noaa.gov/arad/fpdt/mb.html).

a. Wind Index

The Wind Index (WINDEX) is defined as a parameter, developed by McCann (1994), that indicates the maximum possible convective wind gusts that could occur in thunderstorms. The WINDEX is represented by the following equation:

$$WI = 5[H_M R_Q (G^2 - 30 + Q_L - 2Q_M)]^{0.5} \quad (1)$$

where H_M is the height of the melting level in km above the ground; $R_Q = Q_L/12$ but not greater than 1; G is the lapse rate in degrees Celsius per kilometer from the surface to the melting level; Q_L is the mixing ratio in the lowest 1 km above the surface; and Q_M is the mixing ratio at the melting level.

The significance of the melting level height (H_M) in the generation of downbursts is that the melting level represents the altitude where cooling due to latent heat of melting gives additional negative buoyancy in the descending parcel within the convective downdraft. A strong wet microburst requires both a large supply of small rain droplets, whose fast evaporative efficiency helps initiate but not sustain a microburst downdraft, and a large supply of graupel, whose slow melting helps sustain the microburst downdraft to low altitudes. That process continues via evaporative cooling in the subcloud layer, resulting in significant negative buoyant energy, and strong downdrafts that may reach the surface (Ellrod et al 2000).

The radicand in the WINDEX equation is multiplied by five as an arbitrary conversion factor to convert the dimensionally inconsistent radicand into the maximum potential wind gusts at the surface in knots. The term R_Q is a factor to account for an overestimation of WINDEX in dry environments. The R_Q term assumes that when the low- level mixing ratio is less than 12 g kg^{-1}, there is insufficient moisture available to produce heavy rainfall in a convective storm and it is more likely that precipitation will evaporate before reacing the surface. As a result, the strength of the downdraft is reduced. In addition, when the lapse rate is low (<5.5 degrees C km^{-1}), the radicand may become less than zero. At this point, the WINDEX is set to zero and microburst probabilities are considered to be nil (McCann 1994). The maximum wind gusts are conditional upon the occurrence of convection. Also, WINDEX may be used in any type of microburst environment (Ellrod et al 2000).

b. Theta-e Deficit (TeD)

The Theta-e Deficit (TeD) is defined as the maximum vertical difference in theta-e from the surface to the middle troposphere (Ellrod et al 2000). Research by Atkins and Wakimoto (1991) based on the Microburst and Severe Thunderstorm (MIST) project conducted in northern Alabama during June and July 1986 noted five very active microburst days. The afternoon soundings were determined to best

represent the themodynamic properties of the wet microburst environment. Upon analysis of afternoon soundings (1300 CDT) from four of the five active microburst days, Atkins and Wakimoto found the following similarities between the sounding profiles: the vertical theta-e difference computed from the afternoon soundings was greater than or equal to 20 K and the theta-e minimum was typically located between the 650 and 500 mb levels. Other reasearch by Roeder and Wheeler (1996) has indicated a theta-e difference threshold for the occurrence of microbursts of 30 K for the Cape Canaveral and Kennedy Space Center, FL area. This threshold was based on local empirical tuning and demonstrates the importance regionally adjusting theta-e difference thresholds based on climatological representativeness. The Applied Meteorology Unit (AMU) and the Air Force's 45th Weather Squadron (45th WS) developed and implemented the Microburst-Day Potential Index (MDPI) in support of the U.S. Space Program at Kennedy Space Center. The MDPI is computed by dividing TeD by a critical threshold (CT), determined to be 30 K at Kennedy Space Center. MDPI values of 1.0 or greater indicate a high likelihood of wet microbursts, assuming development of heavy precipitation (Wheeler and Roeder 1996).

The theta-e minimum aloft is important in indicating the presence of a layer in the atmosphere favorable for the production of large negative buoyancy due to evaporative cooling. If a precipitation core within a thunderstorm reaches the level of minimum theta-e, evaporative cooling takes place as dry air is entrained into the thunderstorm cell. The result is the generation of large negative buoyancy and the formation of a strong downdraft that becomes a downburst when reaching the surface (Atkins and Wakimoto 1991).

c. Dry Microburst Index (DMI)

The Dry Microburst Index (DMI) is defined as

$$DMI = G + (T - T_d)_{700} - (T - T_d)_{500} \quad (2)$$

where G is the lapse rate in degrees Celsius (C) per kilometer from the 700 to the 500 mb level, T is temperature is degrees Celsius, and T_d is the dewpoint temperature (C). It has been demonstrated that dry microbursts occur frequently in regions (i.e. High Plains) where cloud bases are high and the subcloud environment is sufficiently dry so that little or no rainfall reaches the surface. A deep, dry subcloud layer with a dry adiabatic lapse rate is favorable for evaporative cooling of precipitation within a downdraft and the subsequent formation of a downburst (Wakimoto 1985). Based on previous research, the DMI should exceed a value of 6 for dry microbursts to occur (Ellrod et al 2000).

3. Summary of Improvements

a. First Guess

The Aviation(AVN) model was implemented as the first guess for GOES retrievals during November, 1999. Based on a NESDIS evaluation, it was found that corresponding precipitable water and stability indices were found to be significantly improved when the AVN model was used as a first guess instead

of the Eta model. The improvement was most apparent in moist atmospheric conditions when convection was most likely. It is possible that using the AVN first guess data in the initial retrieval processing could have resulted in improvement upon the first guess in more than 46% of the cases (Ellrod et al 2000).

b. Animation of Products

During May 2000, animation of WINDEX and DMI were made available for each region between 12Z and 23Z each day on the GOES Microburst Products web page. Figure 1 is an example of an animation of WINDEX over Florida on 21 June 2001 which demonstrates the operational utility microburst products in the short-range forecasting of thunderstorm development and downburst production. The animation displays convective activity initiated by sea breeze fronts along the east and west coasts of Florida that eventually propagated inland to converge over the central Florida peninsula. The presence of enhanced cumulus over central Florida was an indicator of convective instability. The initial thunderstorm activity produced outflow boundaries that moved into the convectively unstable region over central Florida with high WINDEX values in excess of 50 kt. The appearance of overshooting thunderstorm tops in the visible satellite imagery signified the presence of intense convection while the subsequent collapse of overshooting tops indicated possible occurrence of downbursts. The animation also displays the diurnal variation of WINDEX. As typical for WINDEX on a summer day, values increased rapidly during the morning hours, reaching a maximum by mid-afternoon (1400 LST), then remained fairly constant until a more gradual decline in WINDEX began around 1700 LST. This diurnal variability in the WINDEX is a result of its dependence on the square of the lapse rate (Ellrod et al 2000). During the afternoon of 21 June 2001, downbursts were observed in Jacksonville and Orlando with a maximum wind gust of 76 kt recorded in Jacksonville. A WINDEX value of 53 kt was indicated in the Jacksonville area before the onset of thunderstorm activity. Since WINDEX does not account for the translational speed of convective storms (Ellrod et al 2000), the underestimation of the wind gust recorded in Jacksonville was most likely attributable to the motion of the storm (~ 22 kt).

c. Single Field-of-View Retrievals

During October 2000, GOES sounding retrievals were changed from 3 X 3 pixel retrievals to single field-of-view (FOV) retrievals. The main purpose of reducing the number of FOVs in retrieval processing was to increase spatial resolution as well as to increase available sounding coverage in regions of partial cloudiness. Since infrared satellite retrievals can only be obtained in conditions of clear skies or partial cloudiness, reducing the FOV coverage area will in some cases reduce the cloud fraction in a retrieval box and therefore increase the likelihood of a clear sky sounding retrieval in regions of scattered cloudiness. It is noted that in the analysis of many convective environments, clear skies allow for maximum incoming solar radiation and surface heating and is thus an important precursor to convective storm initiation. Also, the increased spacial resolution reduces the amount of averaging of convective parameters (i.e. CAPE, lifted index. etc.) over the FOV, yielding an improved display of gradients, which are important in downburst prediction. In addition to increased resolution and coverage and an improved display of gradients, single FOV retrievals have demonstrated a decrease

in error and bias thus increasing sounding derived product quality (Gray and Daniels 2001).

d. Reduction of Dry Microburst Index (DMI) False Alarms

Beginning in June, 2001, GOES sounding retrievals which contain convective available potential energy (CAPE) values of less than 50 J kg^{-1} are filtered out to make the displayed DMI correspond to where convection, and associated downdrafts, is most likely. The calculation of CAPE by the GOES sounder is based on the most unstable parcel lifted in the lowest 300 mb of the atmosphere. NWS Storm Prediction Center (SPC) has designated a CAPE value of 50 J kg^{-1} as a minimum threshold in assessing the likelihood of "dry" thunderstorms (Ellrod et al 2000). Figure 2 is an example of the DMI product with stable soundings (CAPE <50 J kg^{-1}) filtered and removed from the image.

e. Product Availability for Inclusion in NWS AWIPS

In June 2001, GOES microburst products became available for the NWS Western Region via file transfer protocol (FTP) for inclusion in AWIPS. Eventual upgrades to AWIPS nationwide will allow forecasters at NWS offices to locally generate WINDEX, DMI or TeD from either GOES sounding, numerical model or radiosonde data.

f. Color-coding of Theta-e Differential (TeD)

Beginning in July, 2001, TeD values plotted in the GOES TeD product are being assigned colors based on the range in which each value is designated (i.e. <20, 20-30, 30-40, etc.). Figure 3 is an example of a TeD product with color-coded values plotted. An advantage of color-coding TeD values is to highlight those areas with a high risk of wet microbursts using a locally defined threshold based on empirical tuning and regional climatological representativeness. Color-coding is planned for other products as well during 2002.

g. New High Speed Workstations

Generation of GOES microburst products began in August, 2001 on new high speed Hewlett-Packard (HP) workstations at the National Oceanic and Atmospheric Administration (NOAA) Science Center in Camp Springs, Maryland. The new HP workstations consists of two Central Processing Units (CPUs) and each workstation is approximately 12 times faster than previous workstations used for generating microburst products.

4. Validation

Data from the GOES microburst products were collected during the convective seasons of years 2000 and 2001 and validated against conventional surface and upper-air data as well as numerical model data. Correlation with observed data was computed for both the WINDEX and TeD. The following sections

discuss the validation of each of the products from these data.

a. Wind Index

During the year 2001 convective season, June through October, WINDEX values recorded during daytime microburst events were compared with 92 measured maximum convective wind gusts from Storm Prediction Center (SPC) storm reports and METAR observations. In order to assess the predictive value of WINDEX, GOES data used in validation were obtained for retrieval times one to three hours prior to the observed surface wind gust. Correlation of WINDEX to measured wind gusts was computed to be 0.414. This is a significant improvement from a previously calculated correlation value of 0.25, based on measured data from 1997 to 1999 (Ellrod et al 2000). Also, correlation of GOES WINDEX to WINDEX derived from radiosonde observations at Cape Canaveral Air Force Station, FL (Figure 4) was calculated to be 0.685, based on 1500 UTC observations during the year 2000 season. The mean absolute error (difference in mean values of GOES WINDEX from mean observed wind gusts) was calculated to be <3 kt, with a slight high bias. This mean error is approximately 2 kt better than the AVN first guess mean error (~5 kt), an improvement over no difference between GOES and AVN first guess mean errors computed from the 1997 to 1999 data. However, for nighttime events, mean error for GOES WINDEX was found to be >6 kt, but still a significant improvement over nighttime mean error of 22 kt calculated from 1997 to 1999 data. The nighttime low bias for WINDEX could most likely be attributable to the diminished boundary layer lapse rate due to the radiational cooling that typically begins around sunset (Ellrod et al 2000).

In addition to a nighttime low bias, the WINDEX also demonstrates a tendency to underestimate peak wind gusts associated with synoptically-forced, frontal convective systems. In studies conducted of two severe squall line events that occurred during the 2001 convective season, GOES WINDEX underestimated observed surface wind gusts by over 40 kt. In a severe squall line event that occurred over eastern North Dakota on 8 August 2001, a downburst wind gust of 99 kt was recorded at Grand Forks Air Force Base. A GOES WINDEX value of 53 kt was indicated in the vicinity of Grand Forks one hour prior to the onset of downburst winds. A severe squall line that tracked eastward over the Misssissippi and Ohio Valleys on 24 October 2001 produced a downburst wind gust of 77 kt at South Bend, IN. GOES WINDEX values of 36 kt were indicated over northern Indiana prior to the onset of severe thunderstorm activity. In both cases, the squall lines were triggered by strong, rapidly moving cold fronts and the translational motion of the squall lines was determined to be approximately 40 kt. These results highlight the importance of accounting for the translational motion of squall lines when forecasting maximum convective wind gusts.

b. Theta-e Deficit

During the year 2000 convective season, 1500 UTC TeD values derived from GOES were compared to values observed at Cape Canaveral Air Force Station, FL derived from radiosonde observations. A scatterplot (Figure 5) for 42 data points indicates good agreement, with a correlation coefficient of 0.72.

5. Case Studies

a. Microbursts in southern Idaho:

During the afternoon of 13 September 2001, a line of thunderstorms tracked through southern Idaho producing damaging downburst winds. Maximum winds were recorded as high as 50 kt with a microburst at Fort Hall, ID near Pocatello. Another measured wind report in the area was 47 kt at Pocatello Airport (PIH). In this case, atmospheric conditions were intermediate between those conditions associated with dry and wet microbursts. This downburst event was driven by a combination of processes associated with both wet and dry microbursts, resulting in "hybrid" type of microburst. Only light rain was observed at the surface at the time of high winds, conditions normally associated with dry microbursts. A tabulation compares WINDEX and DMI values from the GOES sounding vs. the Salt Lake City (SLC) radiosonde observation (Table 1). The distance between the location of the GOES sounding retrieval (near Pocatello) and Salt Lake City, UT is 125 nm.

Table 1. WINDEX/DMI: GOES Sounding vs. SLC RAOB

Parameter	GOES (PIH 2100 UTC)	SLC RAOB (0000 UTC)
WINDEX (kt)	50	32
DMI	7	19

GOES derived products, such as the WINDEX, proved to be useful in the analysis of this downburst event. A line of thunderstorms developed over southern Idaho in an environment in which atmospheric conditions were intermediate between those favorable for the production of both wet and dry microbursts. As shown in Figure 6, a GOES sounding at 2100 UTC located 5 nm south-southeast of Pocatello, a classic "hourglass" profile normally associated with dry microbursts was apparent. The sounding profile featured a deep, nearly dry adiabatic subcloud layer and a shallow moist layer between the 500 and 600 mb levels (Ellrod et al 2000). Figure 7, the sounding at 0000 UTC at Salt Lake City (SLC) displayed a similar temperature and moisture profile with a moist layer based at approximately 500 mb. The lower DMI indicated in the GOES sounding was most likely the result of the moist layer placement at approximately 575 mb, lower than the typical placement at 500 mb for dry microbursts. At 2100 UTC, visible imagery overlain by WINDEX, Figure 8, displayed a developing comma cloud system over southern Idaho with a vorticity maximum over southwestern Idaho. The line of thunderstorms was embedded within the comma-cloud "tail" over southern Idaho in a zone of vigorous upward vertical motion ahead of the trough line. Figure 9, 2100 UTC WINDEX product, displayed values near 50 kt in the vicinity of Pocatello (KPIH), ahead of the line of thunderstorms. Based on regional climatology (Water Information Center 1974), surface dew points were relatively high for the time of year: 52F (11C) observed at Pocatello prior to the onset of the thunderstorm activity. The climatological mean dew point for Pocatello for a September day at 1700 LST (2300 UTC) is 41F. There was strong instability (lifted index = -7, CAPE= 1854) present, due most likely to significant cold

air aloft associated with the upper-level trough. The strong instability was more typically associated with conditions favorable for wet microbursts. However, the deep, dry subcloud layer increased the thunderstorm downdraft strength due to the evaporational cooling that occurs as a moist downdraft falls through the layer and entrains dry air (Weisman et al 1986). Although the instability and significant low level moisture in place was more typical for a wet microburst environment, "hybrid" microburst development in this case was driven primarily by sub-cloud evaporation (Ellrod et al 2000).

b. Wet Microbursts in central Florida:

During the early afternoon of 18 June 2001, convection developed along the sea breeze front over the central west coast of Florida. Figure 10a, 1700 UTC WINDEX product overlying a visible image, displays enhanced cumulus developing along both the east and west coast sea breeze fronts. Diurnal heating has resulted in a very unstable atmosphere by 1700 UTC which can be inferred from the relatively high WINDEX values (> 50 kt) over central and south Florida. Atmospheric conditions were favorable for the production of wet microbursts as displayed in Figure 11, a GOES sounding at 1700 UTC located 4 nm southwest of Orlando. The Orlando GOES sounding displayed a classic wet microburst profile: shallow dry-adiabatic layer near the surface overlain by a moist adiabatic layer and the presence of a midtropospheric dry air layer near the 625 mb level. The sounding also indicated strong instability was present over central Florida with a lifted index of -5. 1800 UTC TeD product, Figure 12, indicated relatively high theta-e difference values of 32 K in the vicinity of St. Petersburg and over central Florida. By 1900 UTC, Figure 10b displayed that strong convection was developing along the east and west coast sea breeze fronts. The shape of the coastline in the vicinity of St. Petersburg was enhancing convergence along the sea breeze front, resulting in the strengthening of convection and the development of enhanced cumulus over St. Petersburg. At 1900 UTC, a WINDEX value of 55 kt was indicated in the vicinity of St. Petersburg. By 1945 UTC, Figure 10c shows that a single thunderstorm cell has developed over St. Petersburg. A downburst wind gust of 51 kt was observed at St. Petersburg Airport (KPIE) at 1941 UTC. The downburst was associated with heavy rainfall at the surface classifying this downburst event as a wet microburst. By 2100 UTC, Figure 10d shows that the thunderstorm cell over St. Petersburg had decayed, however, new convection was developing along outflow boundaries, produced by the initial west coast sea breeze front thunderstorm activity, further east over central Florida. The thunderstorm activity that was initiated by the east and west coast sea breeze fronts during the early afternoon eventually propogated inland to converge over central Florida by 2200 UTC, as shown in Figure 10e, producing additional wet microbursts. In this case, unlike the hybrid microburst case discussed previously, wet microburst activity was the result of both evaporative cooling and precipitation loading.

6. Future Plans

Investigation continues in the reduction of the nighttime low bias (~6 kt)in the WINDEX. A possible solution to the nighttime low bias problem would be to calculate WINDEX from the top of the boundary layer instead of the Earth's surface. Due to the dependence of WINDEX on the square of the lapse rate, the development of the nocturnal temperature inversion after sunset results in the decrease of WINDEX

during the evening hours (Ellrod et al 2000). GOES soundings from 2200 UTC 8 August 2001 and 0300 UTC 9 August 2001 at Aberdeen, SD, Figure 13, illustrate the development of this nocturnal inversion due to radiational cooling. Replacing the surface with top of the boundary layer in the nighttime calculation of WINDEX is based on the assumption that the top of the nocturnal temperature inversion coincides with the top of the boundary layer.

Product validation is expected to continue through the 2002 convective season. WINDEX validation will continue (mainly to assess improvements in nighttime low bias) while validation will also be conducted on the DMI product.

Upon color-coding of the Theta-e Differential (TeD) product, it has been determined that it is now feasible to animate TeD. Investigation is in progress to develop an animation of TeD similar to the animation of the WINDEX and DMI products.

NESDIS Forecast Products Development Team will continue to assist the National Weather Service (NWS) in the implementation of the microburst products into AWIPS Build 5.2. This upgrade to AWIPS will allow NWS forecasters to locally generate WINDEX and DMI from either satellite sounder, numerical model, or radiosonde data (Ellrod et al 2000). This capability should prove to be useful as a short-range ("nowcasting") tool to assist in the issuing of local severe weather warnings.

Improvements in the quality of satellite soundings derived from GOES-11/12 since activation will be monitored to assess the possibility of incorporating the soundings into the microburst product generation.

7. Summary

Recent changes and improvements to GOES Sounder downburst products have lead to higher accuracy and greater ease of use. Higher accuracy was demonstrated by the statistical correlation of WINDEX to measured daytime wind reports of 0.414, calculated for the 2001 convective season. This is a significant improvement from a correlation of 0.25, based on data from 1997 to 1999. The mean absolute WINDEX error for 92 measured daytime wind gusts was calculated to be <3 kt. This mean error was approximately 2 kt better than the AVN first guess mean error, improving over no difference between GOES and first guess mean errors computed from the 1997 to 1999 data. Animation of the microburst products, filtering out sounding retrievals which contain CAPE values of less than 50 J kg>$^{-1}$ to reduce Dry Microburst Index false alarms, and color coding of Theta-e Differential have contributed to greater ease of use, especially in the preparation of short-range weather forecasts (nowcasts) and severe weather warnings. In order to continue to make improvements and further upgrades to the microburst products, user feedback is necessary. Microburst product users can submit feedback via the GOES Microburst Products web page: http://orbit-net.nesdis.noaa.gov/arad/fpdt/mb.html.

8. References

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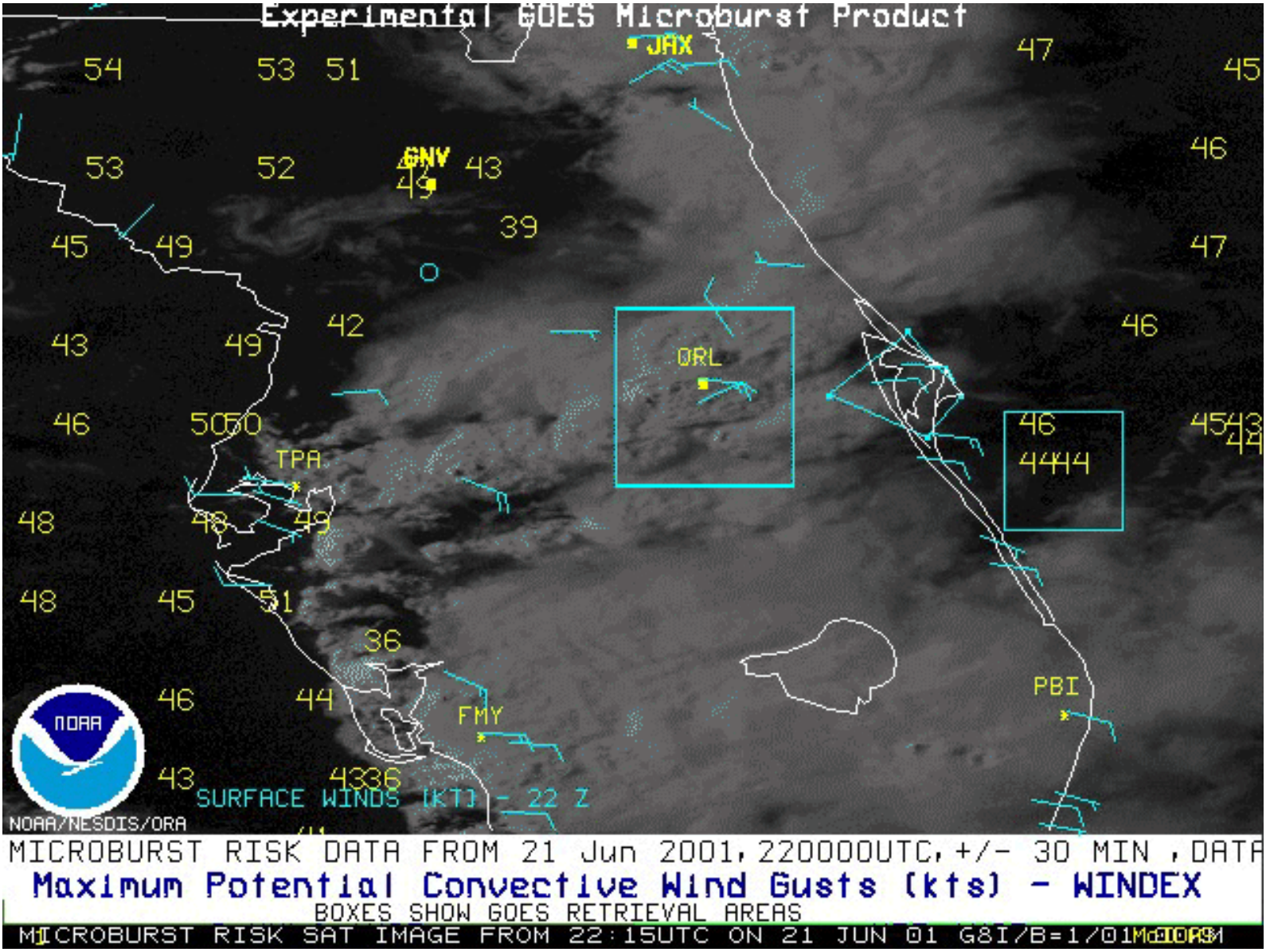

Figure 1. An example of an animation of WINDEX over Florida on 21 June 2001. The animation displays convective activity, initiated by the east and west coast sea breeze fronts, that eventually converged over the central Florida peninsula where convective instability and high WINDEX values were present. The animation also displays the diurnal variation of WINDEX. During the afternoon of 21 June 2001, downbursts were observed in Jacksonville and Orlando.

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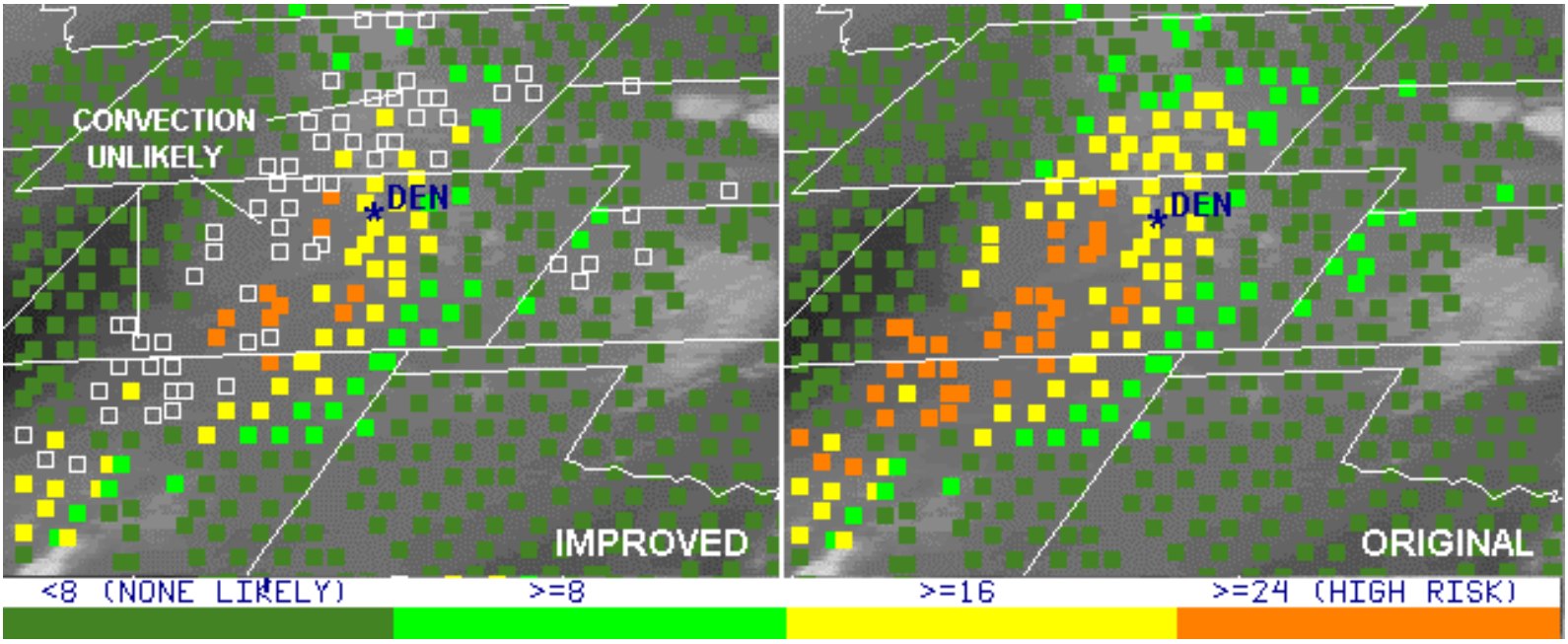
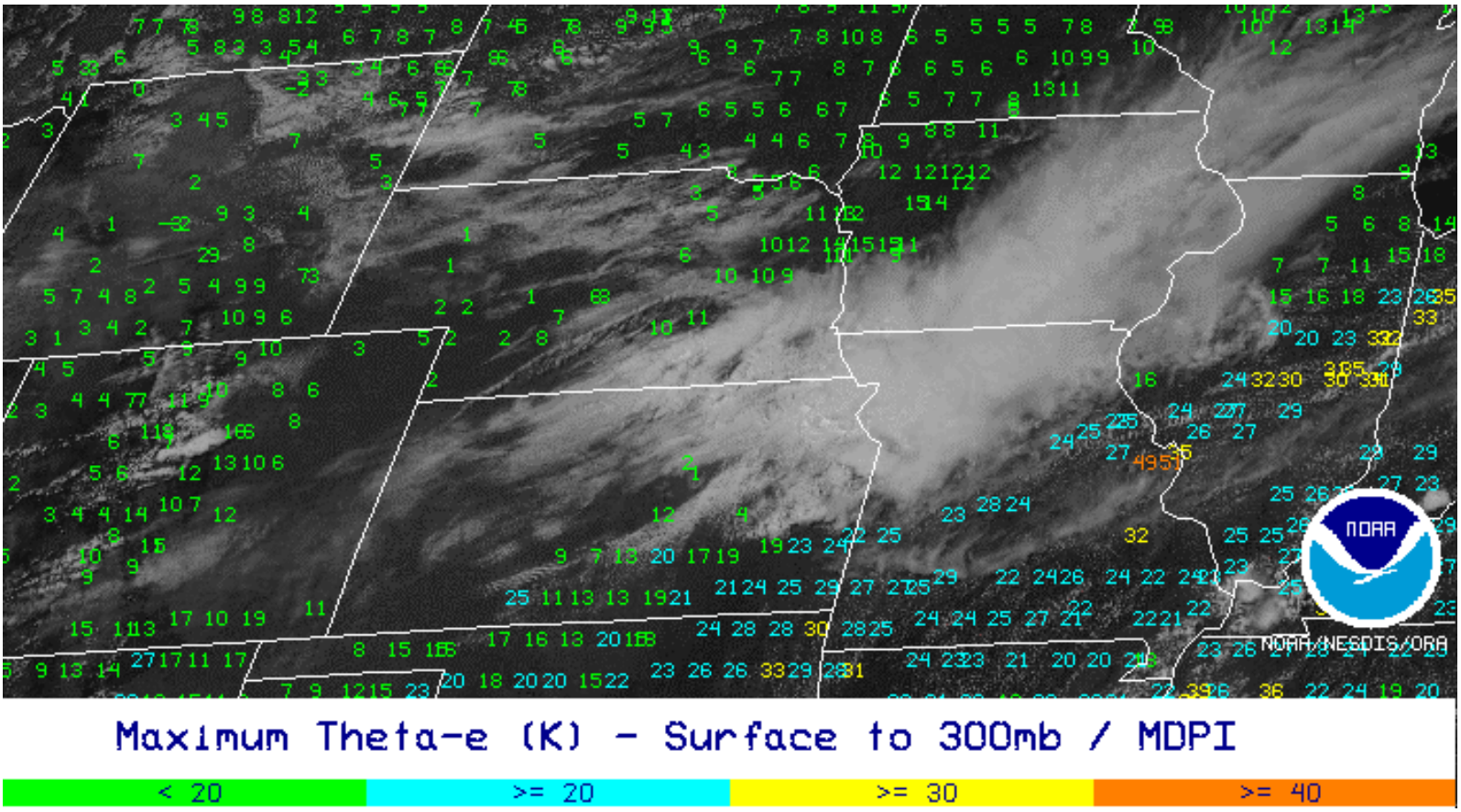
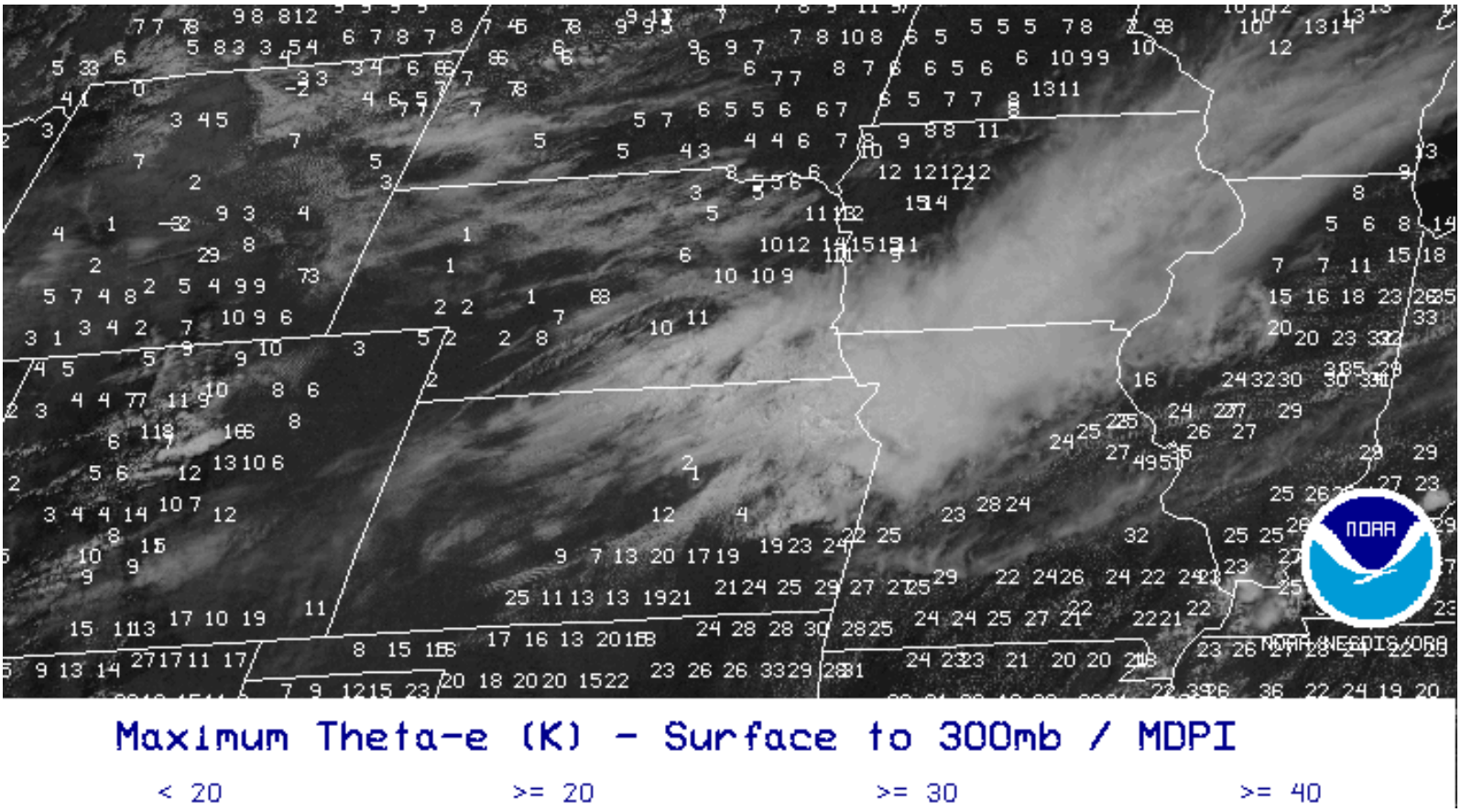


Figure 2. An example of the DMI product with stable soundings (CAPE<50 J kg^{-1}) filtered and removed from the image. Thus the display of DMI helps forecasters focus only on areas where convection and possible downbursts are likely.

Figure 3


NOAA
NOAA/NESDIS/ORA
Maximum Theta-e (K) - Surface to 300mb / MDPI
< 20
>= 20
>= 30
>= 40

a


NOAA
NOAA/NESDIS/ORA
Maximum Theta-e (K) - Surface to 300mb / MDPI
< 20
>= 20
>= 30
>= 40

b

Figure 3. a) An example of a TeD product with color coded values plotted. Note lack of data where clouds interfere with the GOES sounder; b) An example of a TeD product with uncolored values plotted.

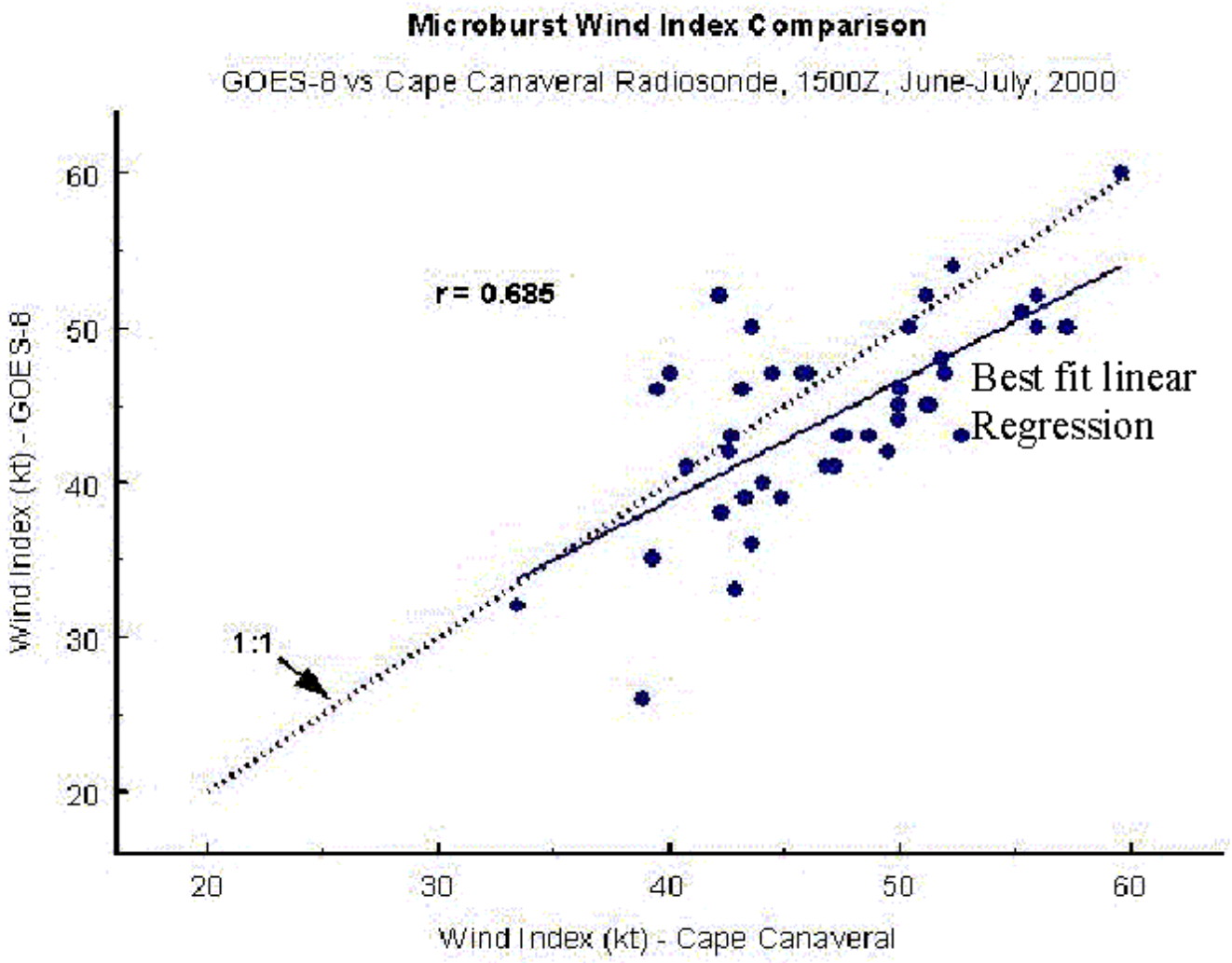


Figure 4. Correlation of GOES WINDEX to WINDEX derived from radiosonde observations at Cape Canaveral Air Force Station, FL based on 1500 UTC observations during the year 2000 convective season.

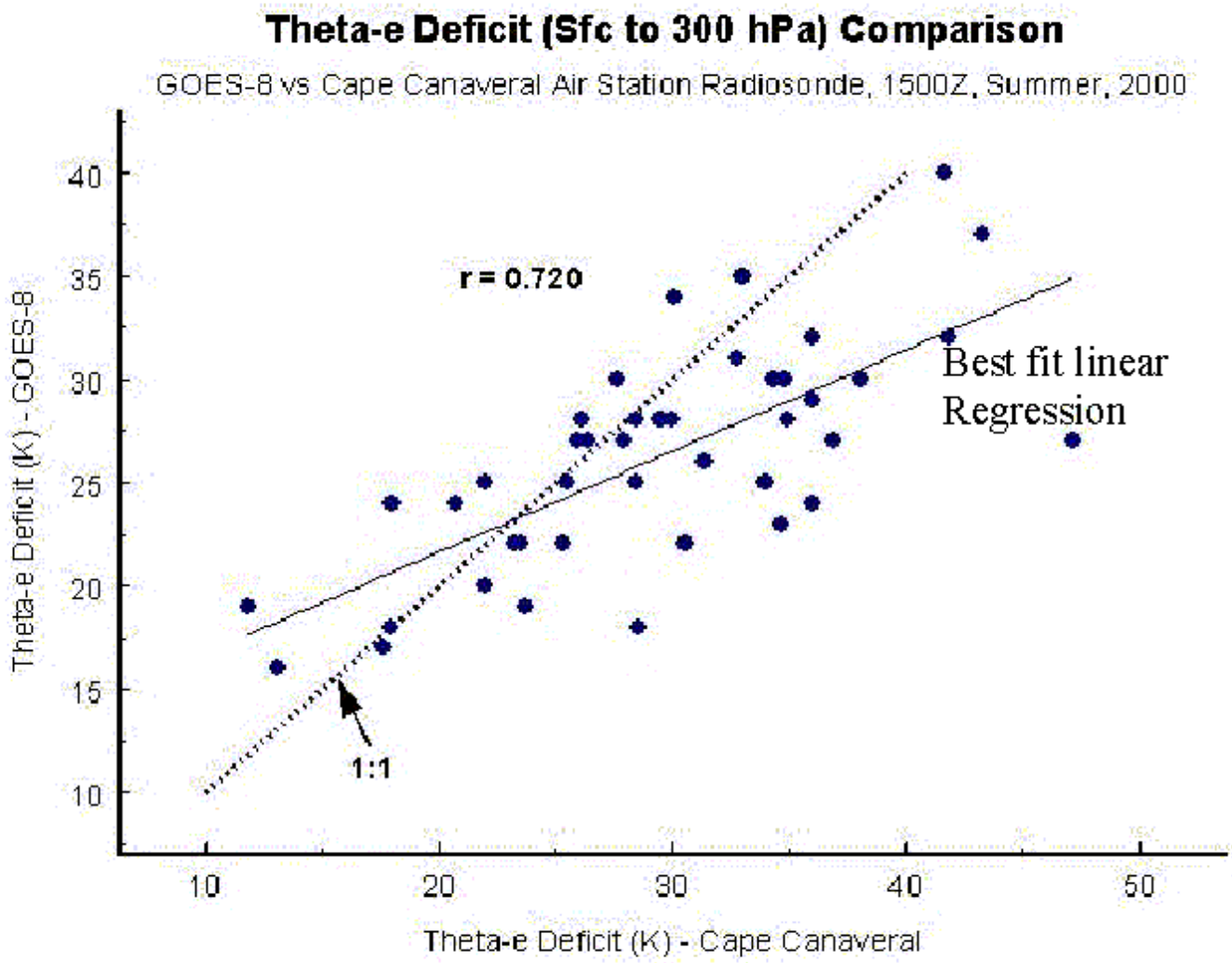


Figure 5. A scatterplot for 42 data points that indicates good agreement between GOES derived TeD values and values observed at Cape Canaveral Air Force Station, FL derived from radiosonde observations.

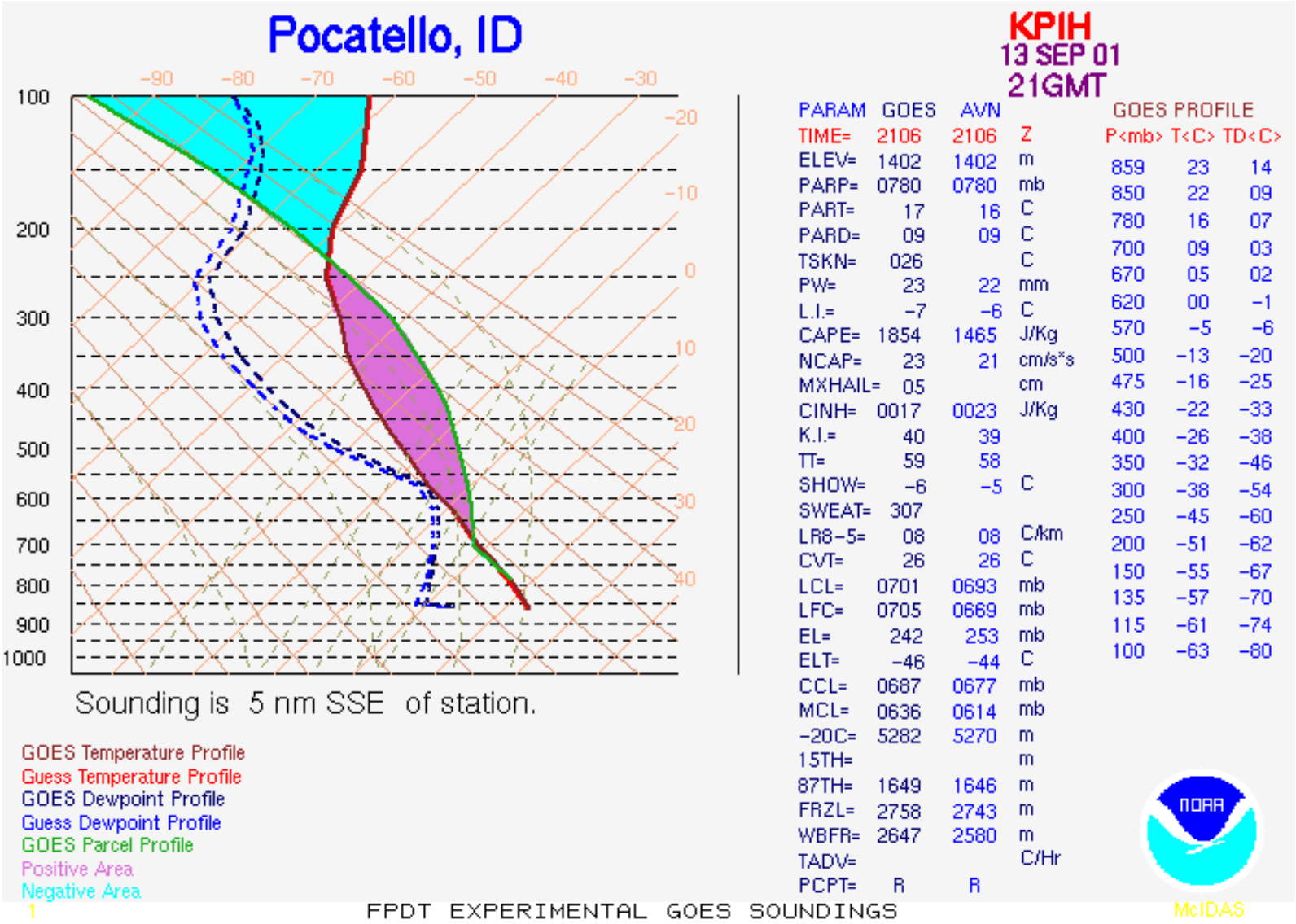


Figure 6. GOES sounding at 2100 UTC located 5 nm south-southeast of Pocatello, ID. This sounding exhibits a classic "hourglass" profile for dry microbursts.

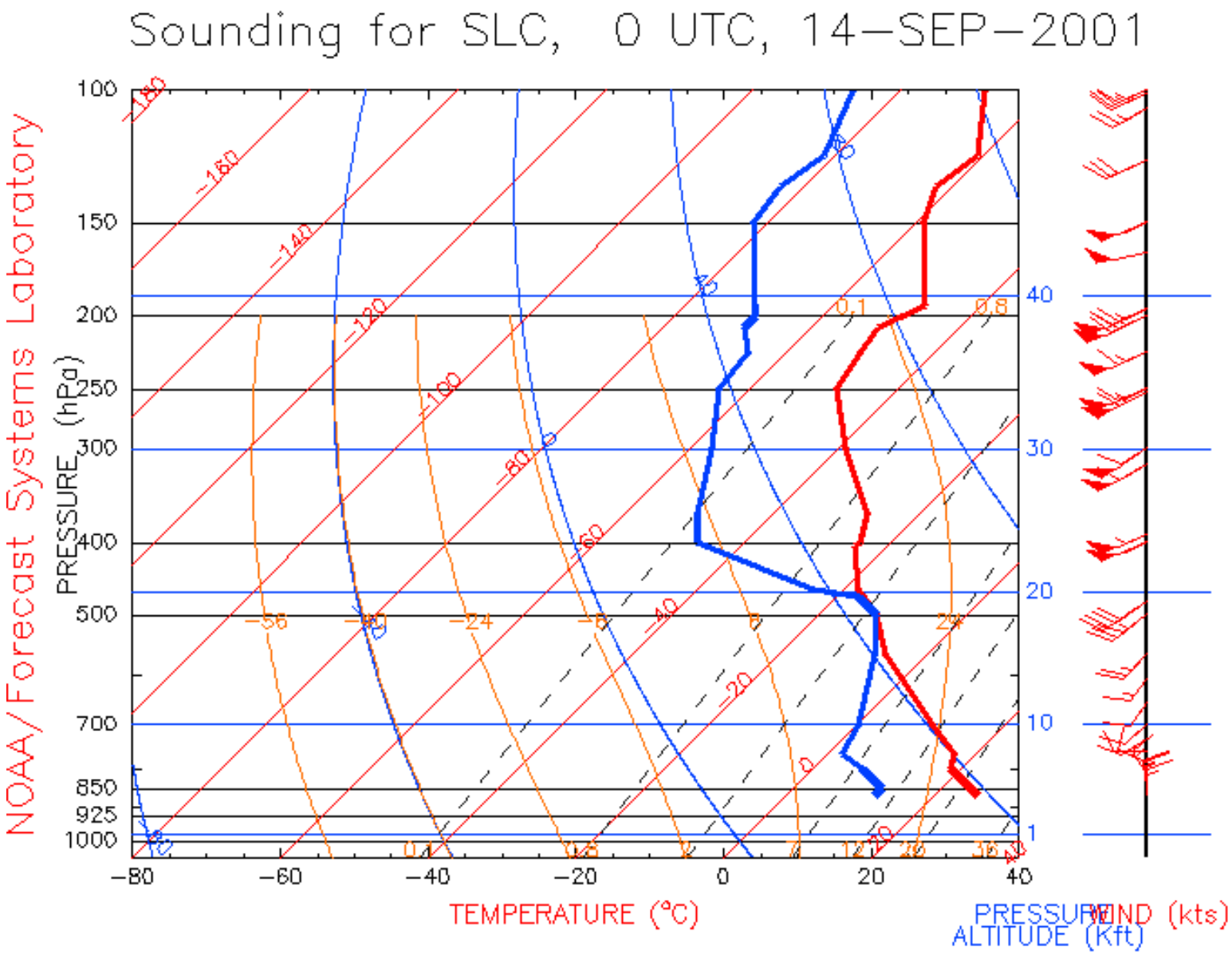


Figure 7. Radiosonde observation at Salt Lake City, UT, 0000 UTC 14 September 2001.

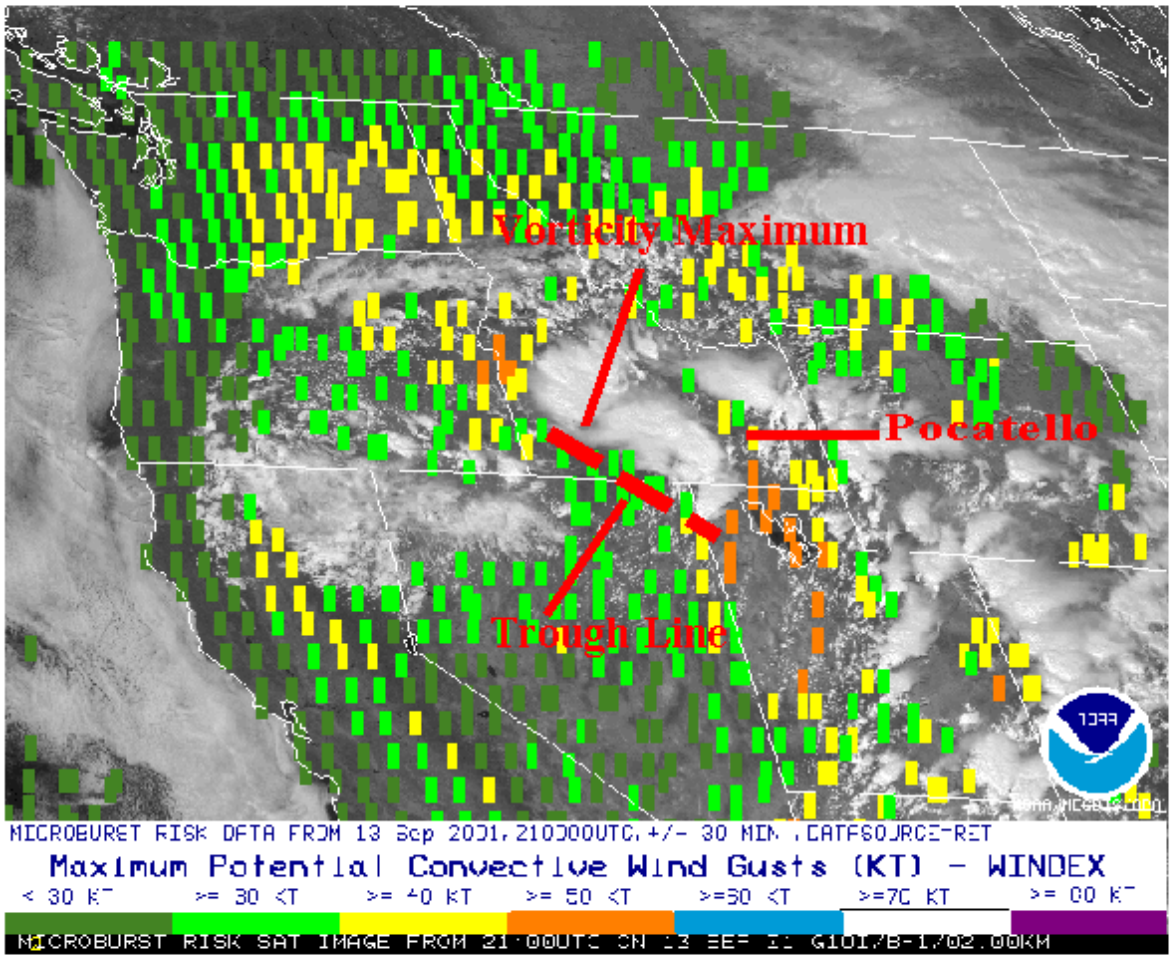


Figure 8. 2100 UTC 13 September 2001 visible satellite image overlain by GOES WINDEX displaying a developing comma cloud system over southern Idaho.

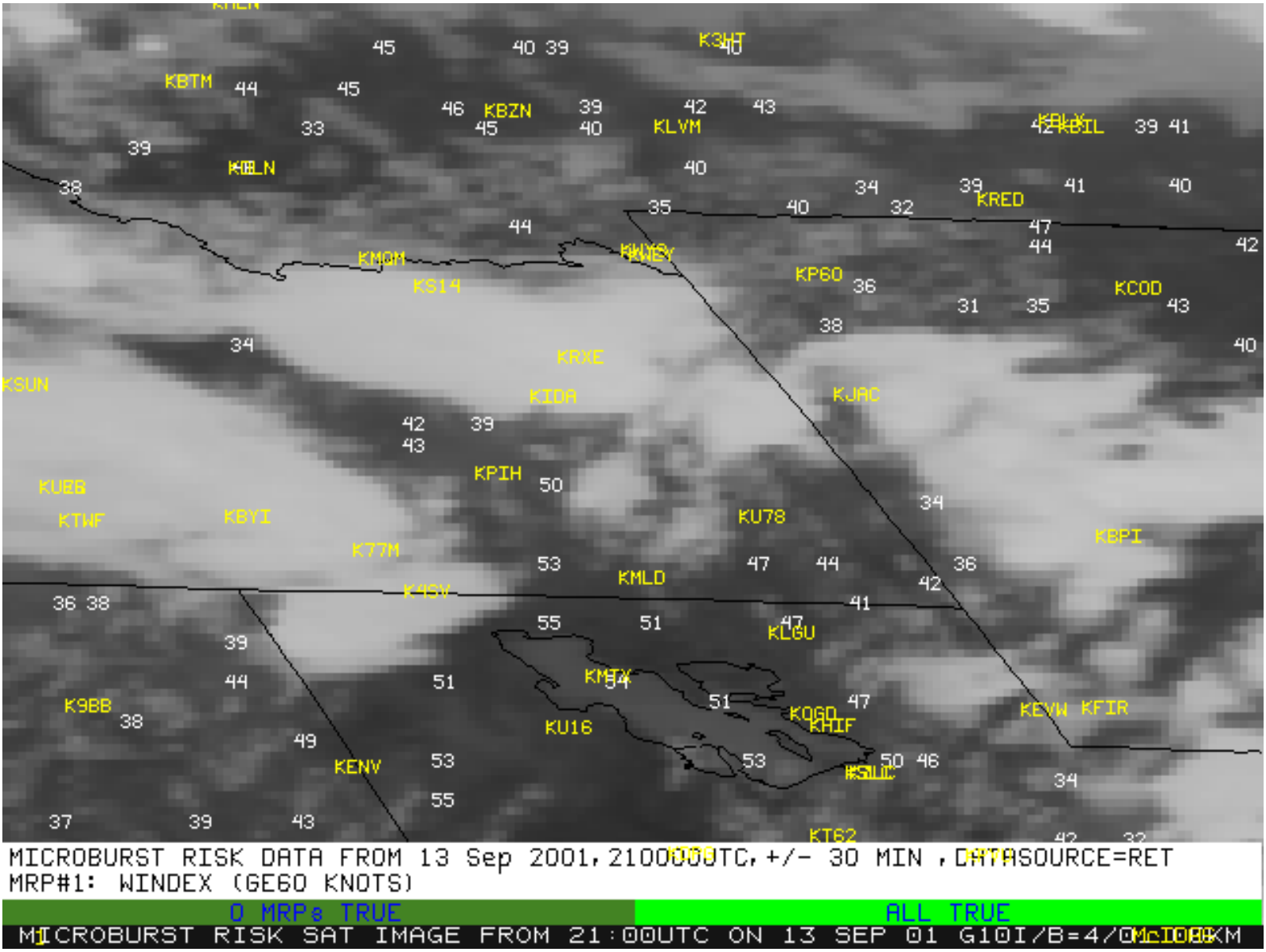
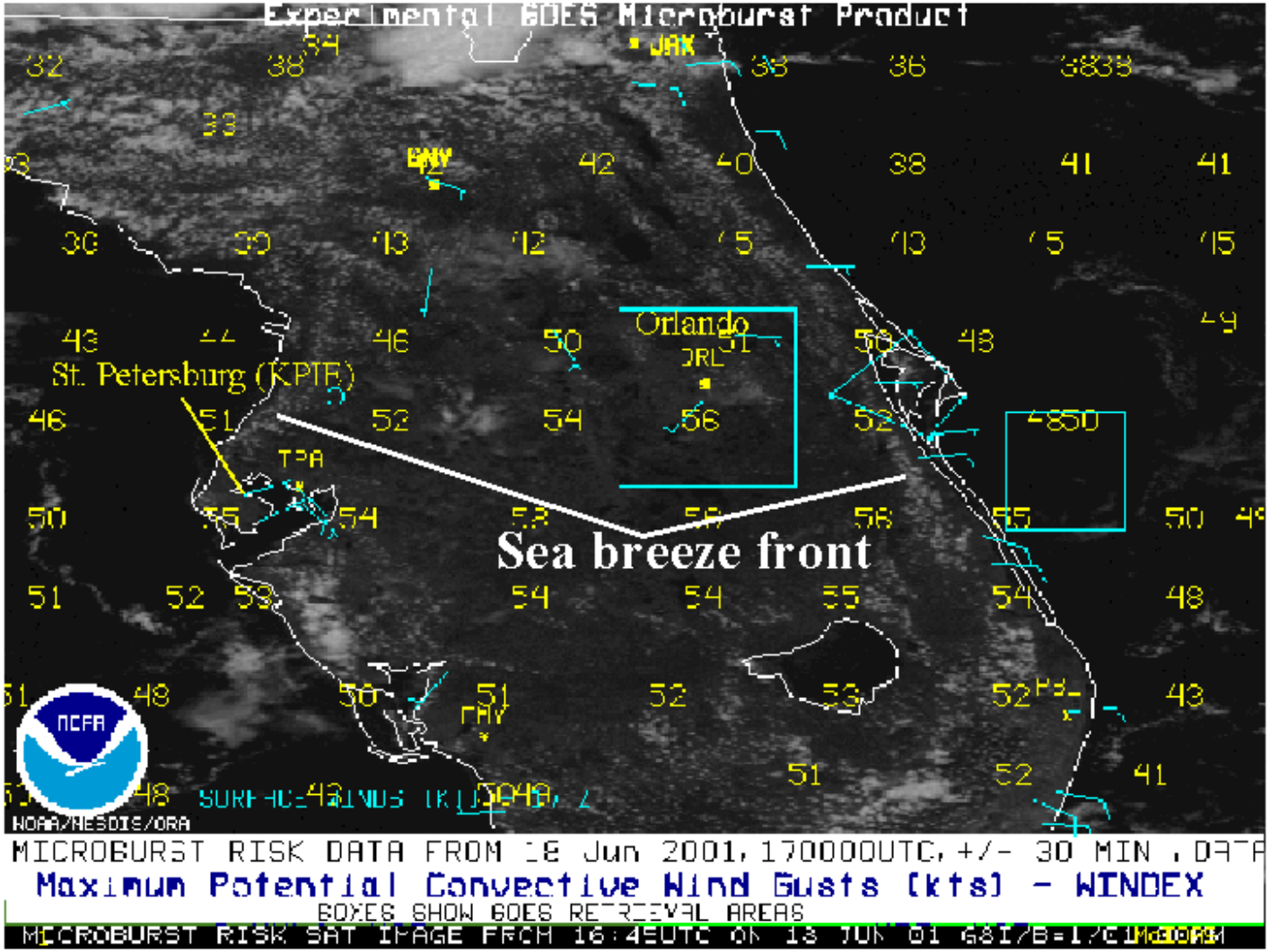
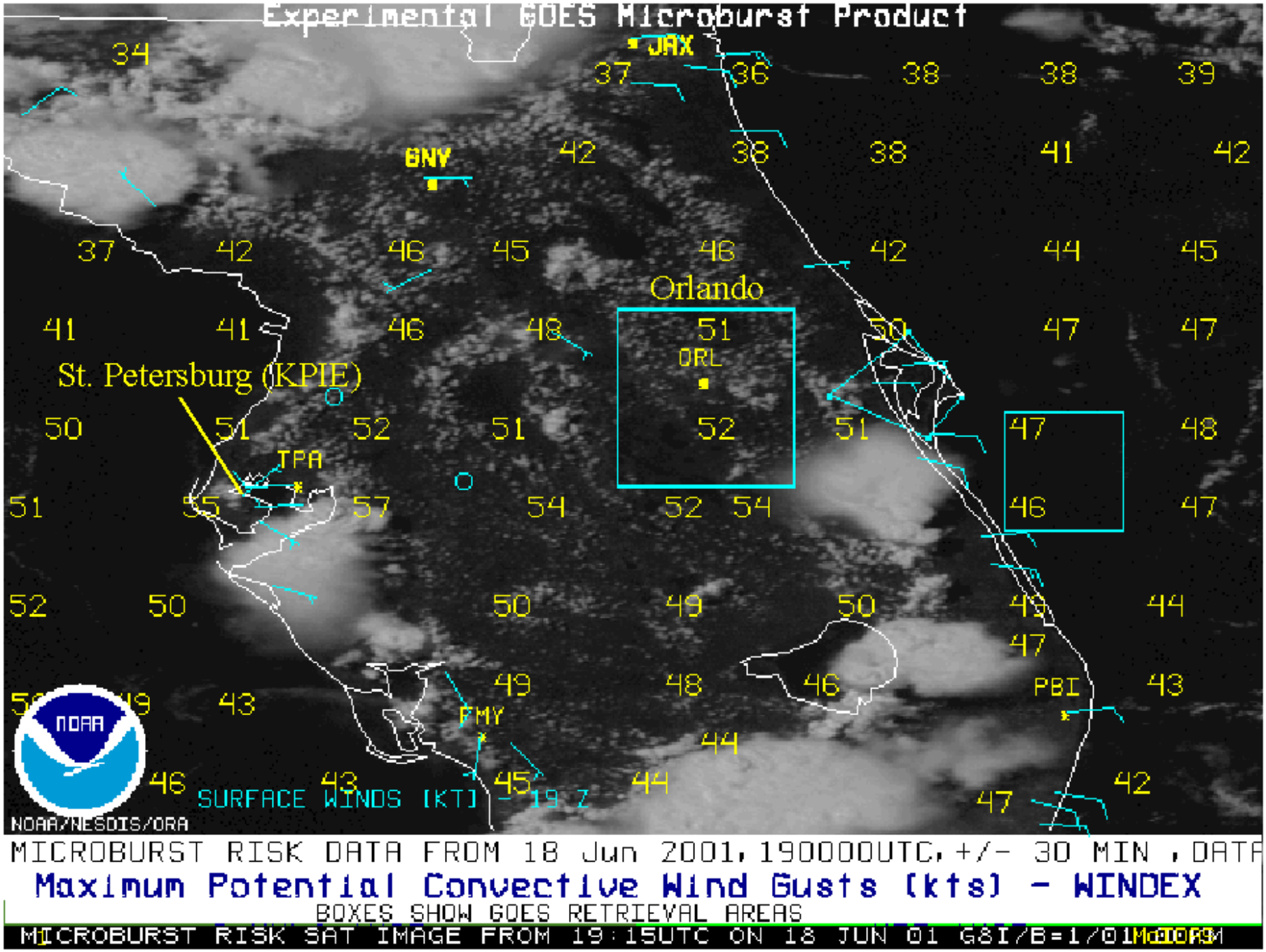


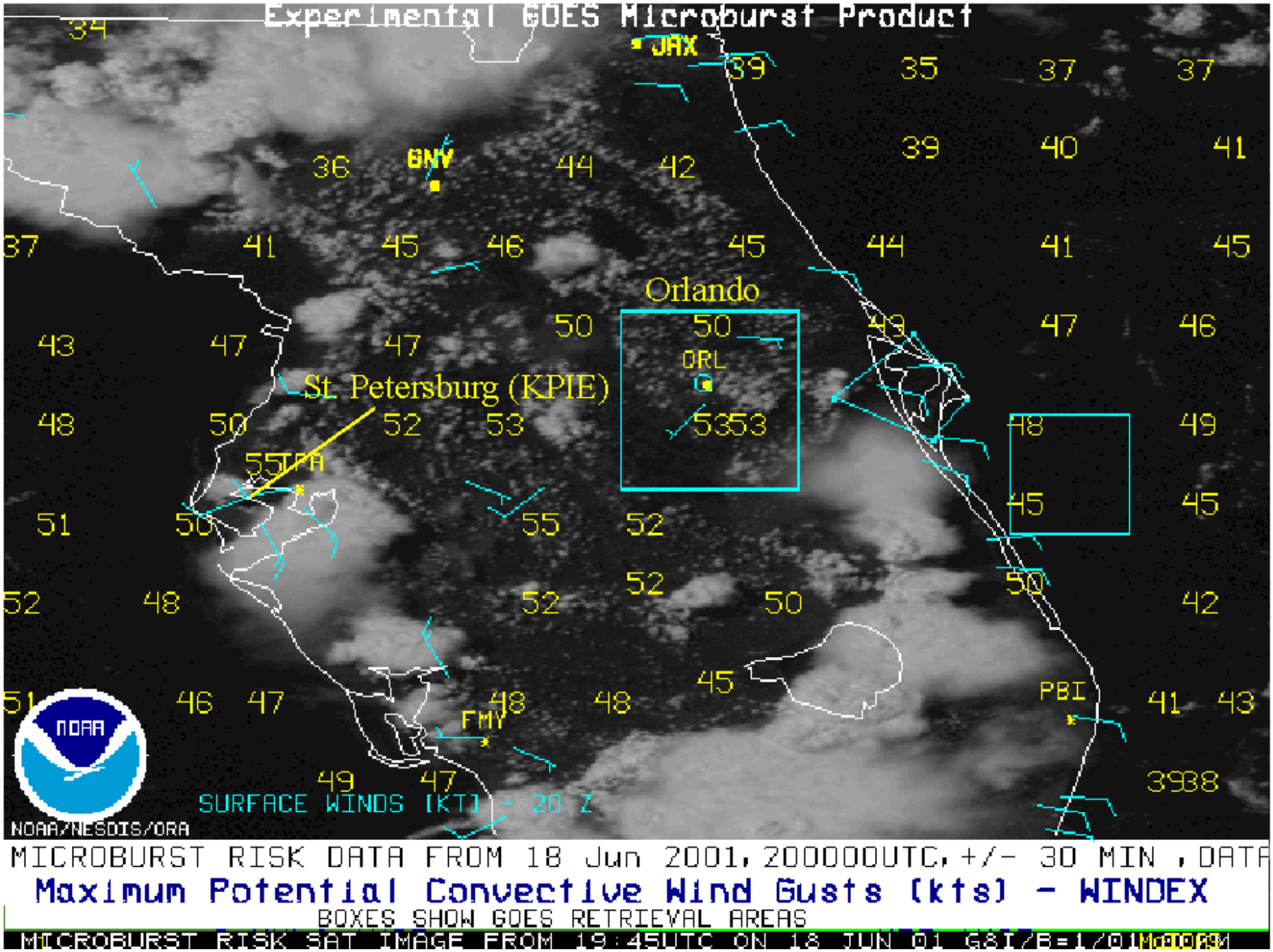
Figure 9. 2100 UTC 13 September 2001 GOES WINDEX product displaying values near 50 kt in the vicinity of Pocatello (KPIH), ID.


Experimental GOES Microburst Product
Orlando
St. Petersburg (KPIE)
Sea breeze front
NOAA/NESDIS/ORA
MICROBURST RISK DATA FROM 18 Jun 2001, 170000UTC, +/- 30 MIN , DATA
Maximum Potential Convective Wind Gusts (kts) - WINDEX
BOXES SHOW GOES RETRIEVAL AREAS
MICROBURST RISK SAT IMAGE FROM 16:45UTC ON 18 JUN 01

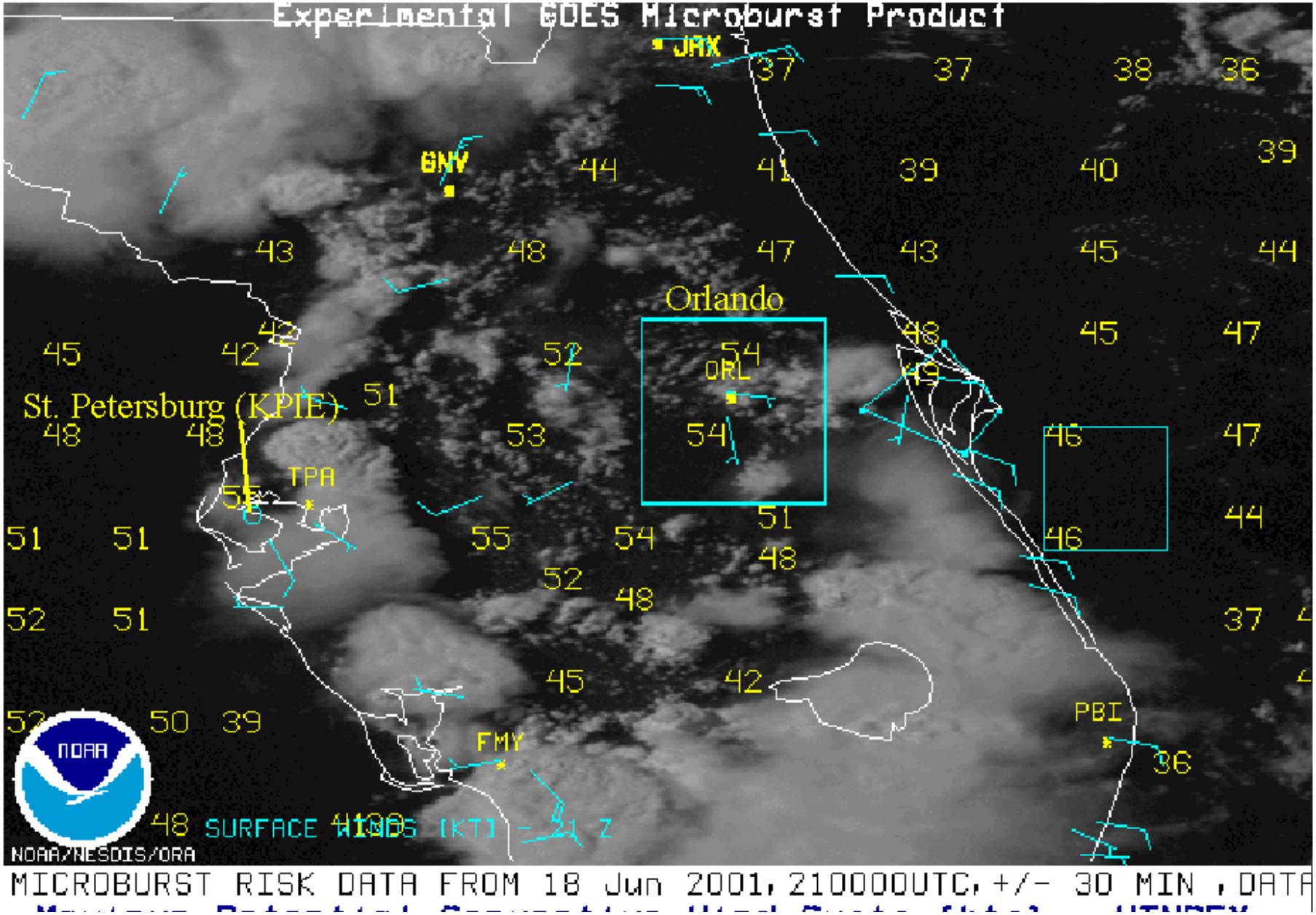
a

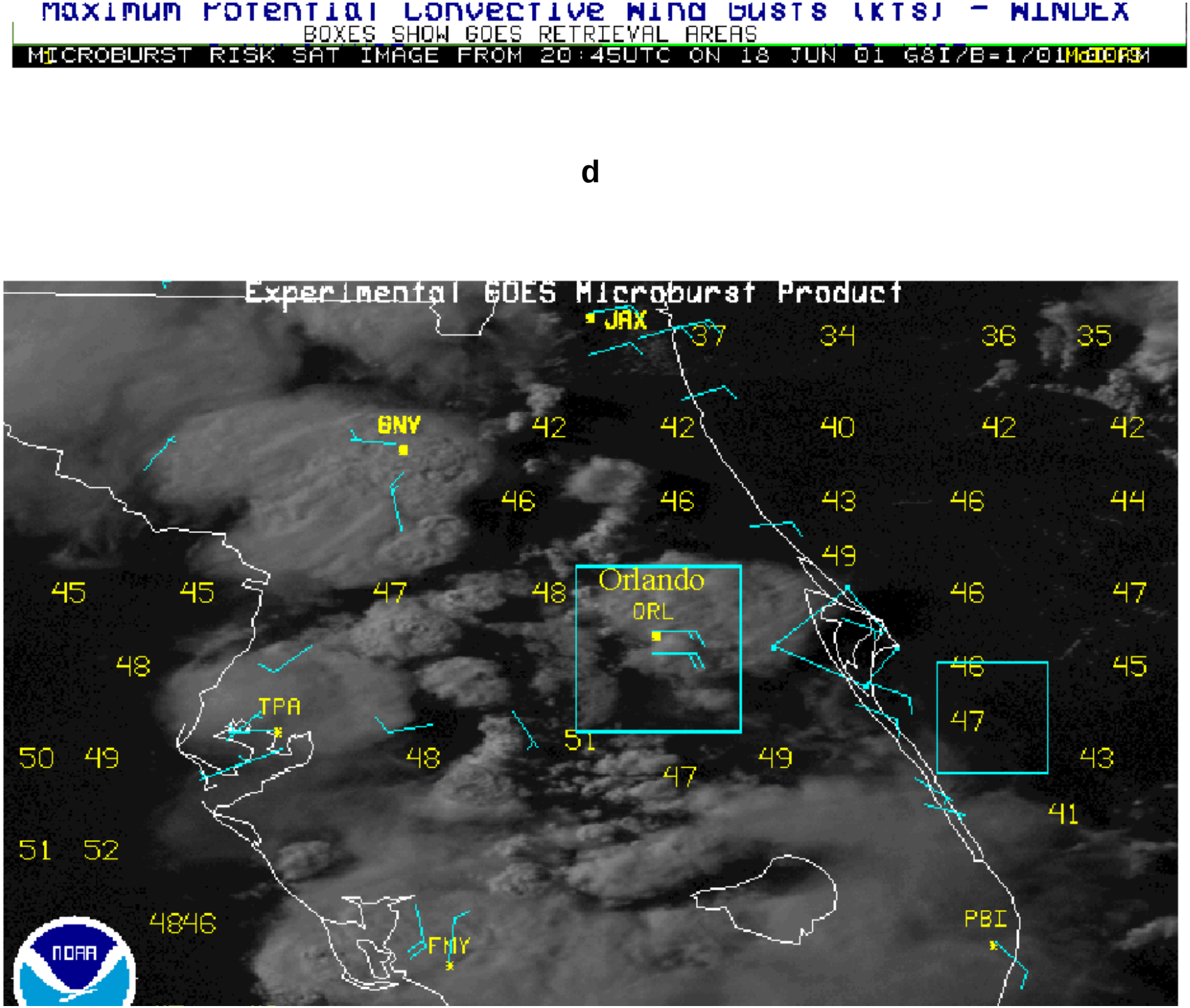

Experimental GOES Microburst Product
JAX
GNV
Orlando
ORL
St. Petersburg (KPIE)
TPA
FMY
PBI
NOAA
NOAA/NESDIS/ORA
SURFACE WINDS [KT] - 19 Z
MICROBURST RISK DATA FROM 18 Jun 2001, 190000UTC, +/- 30 MIN , DATA
Maximum Potential Convective Wind Gusts (kts) - WINDEX
BOXES SHOW GOES RETRIEVAL AREAS
MICROBURST RISK SAT IMAGE FROM 19:15UTC ON 18 JUN 01 G8I/B=1/01

b

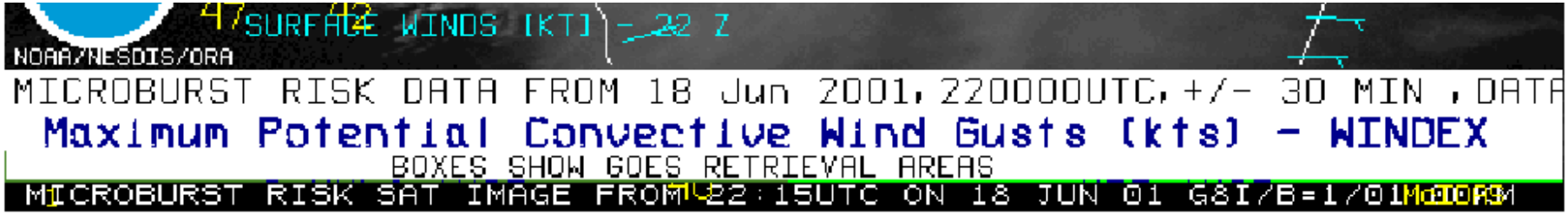

Experimental GOES Microburst Product
JAX
GNV
Orlando
ORL
St. Petersburg (KPIE)
TPA
FMY
PBI
NOAA
NOAA/NESDIS/ORA
SURFACE WINDS (KT) - 20 Z
MICROBURST RISK DATA FROM 18 Jun 2001, 200000UTC, +/- 30 MIN , DATA
Maximum Potential Convective Wind Gusts (kts) - WINDEX
BOXES SHOW GOES RETRIEVAL AREAS
MICROBURST RISK SAT IMAGE FROM 19:45UTC ON 18 JUN 01 G8I/B=1/01

c


Experimental GOES Microburst Product
JAX
GNV
Orlando
ORL
St. Petersburg (KPIE)
TPA
FMY
PBI
NOAA
NOAA/NESDIS/ORA
MICROBURST RISK DATA FROM 18 Jun 2001, 210000UTC, +/- 30 MIN , DATA


Maximum Potential Convective Wind Gusts (kts) - WINDEX
BOXES SHOW GOES RETRIEVAL AREAS
MICROBURST RISK SAT IMAGE FROM 20:45UTC ON 18 JUN 01 G8I/B=1/01
Experimental GOES Microburst Product
JAX
GNV
Orlando
ORL
TPA
FMY
PBI
NOAA

d



e

Figure 10. Florida GOES WINDEX plotted on visible imagery at a) 1700 UTC 18 June 2001; b) 1900 UTC; c) 2000 UTC; d) 2100 UTC; e) 2200 UTC.

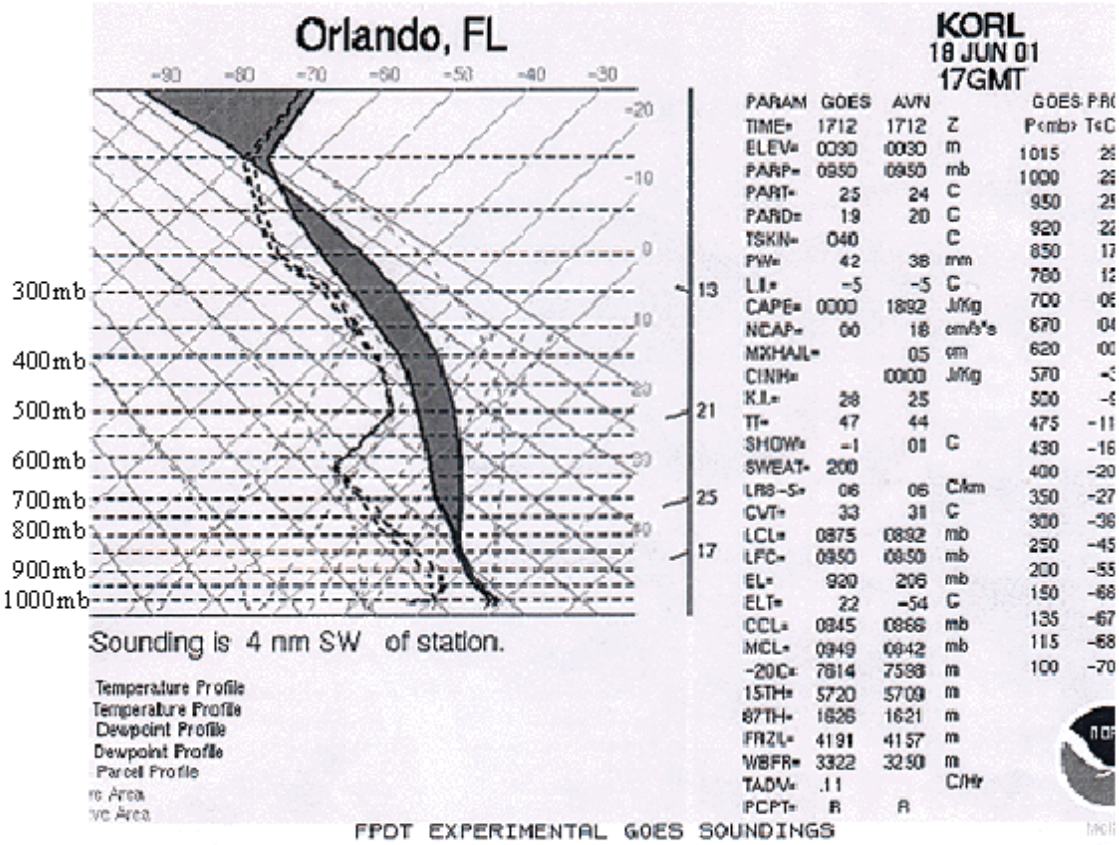


Figure 11. GOES sounding at 1700 UTC located 4 nm southwest of Orlando, FL. This sounding exhibits a wet microburst profile: shallow dry-adiabatic layer near the surface overlain by a moist adiabatic layer and the presence of a midtropospheric dry air layer near the 625 mb level.

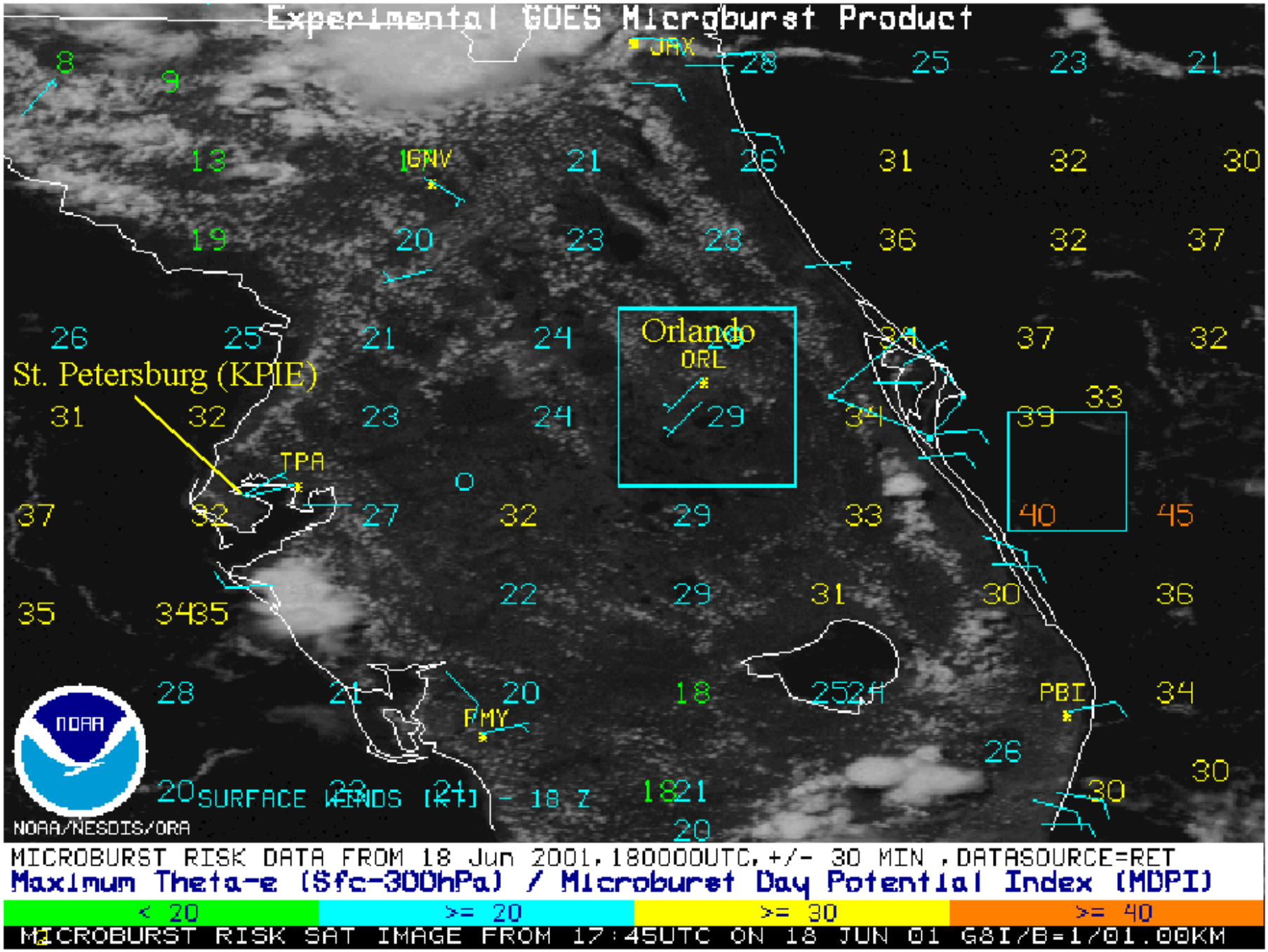

Experimental GOES Microburst Product
JAX
GNV
Orlando
ORL
St. Petersburg (KPIE)
TPA
FMY
PBI
NOAA
NOAA/NESDIS/ORA
SURFACE WINDS (KT) - 18 Z
MICROBURST RISK DATA FROM 18 Jun 2001,180000UTC,+/- 30 MIN ,DATASOURCE=RET
Maximum Theta-e (Sfc-300hPa) / Microburst Day Potential Index (MDPI)
< 20
>= 20
>= 30
>= 40
MICROBURST RISK SAT IMAGE FROM 17:45UTC ON 18 JUN 01 G8I/B=1/01.00KM

Figure 12. 1800 UTC TeD product indicating relatively high theta-e difference values of 32 K in the vicinity of St. Petersburg and over central Florida.

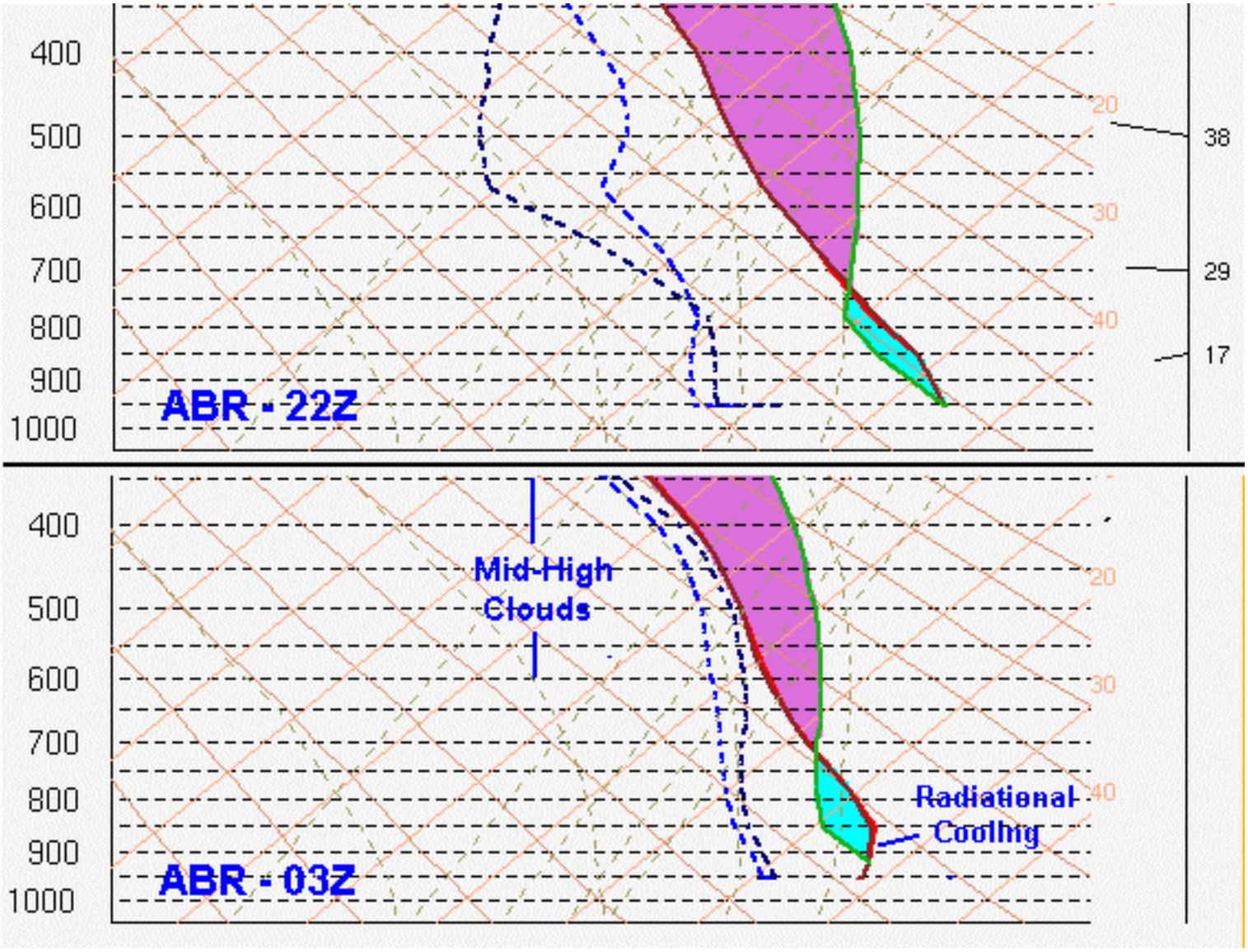


Figure 13. GOES soundings from 2200 UTC 8 August 2001 and 0300 UTC 9 August 2001 at Aberdeen, SD illustrating the development of a nocturnal temperature inversion due to radiational cooling.