9A.5 MESOCYCLONE-INDUCED DOWNBURSTS ASSOCIATED WITH THE LANDFALL OF HURRICANE IRENE (1999) OVER SOUTH FLORIDA

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1. INTRODUCTION

This paper examines the occurrence of multiple damaging downbursts or "miniswirls" with the passage of Hurricane Irene across South and Central Florida on 15-16 October 1999. NEXRAD WSR-88D Doppler radar data from Miami, FL (KAMX), Key West, FL (KBYW), and Melbourne, FL (KMLB) indicate that the downbursts were associated with fairly deep and well organized mesocyclone (>3.5 km deep in some instances) and bow echo signatures. Of particular interest is the occurrence of high winds and damage on the left-side outer convective bands and left-side "eyewall" region relative to Irene's forward track.

2. S. FLORIDA LANDFALL MESOSCALE DISCUSSION

A full history on Irene can be found in Avila (1999). In the 24-hour period prior to making landfall over the South Florida peninsula near Flamingo around 2000 UTC, 15 Oct 99, Irene's overall convective cloud pattern had been asymmetrical with most of the deep convection displaced in the east semicircle owing to the southwesterly vertical wind shear. However, shortly after landfall as Irene tracked northeast from Flamingo to near West Palm Beach, the deep convection shifted to the west semicircle along with an increase in convective coverage and intensity in the west eyewall. After 2300 UTC, the highest radar reflectivities and echo tops (coincident with the coldest cloud tops in satellite IR imagery) shifted from offshore to inland over the middle portion of the peninsula, south of Lake Okeechobee.

The westward shift in the convection was likely due to a westward shift in the low-level convergence field caused by increased frictional convergence as the surface flow over land backed to a more northerly component. A further indication of frictional effects increasing the low-level convergence could be seen in Irene's ragged eye becoming better defined and more distinct in radar imagery (not shown) after landfall when compared to the pre-landfall pattern.

WSR-88D radar data also indicate the development of several mesoscale convective features after landfall in the form of merging/converging convective bands in the northwest quadrant away from the center, and multiple converging bands into the northwest "eyewall" convection. It was near the path of the eyewall-convective band intersection where some of the strongest winds and most significant wind damage were reported.

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3. WIND DAMAGE AND GUST REPORTS

During the passage of Irene across South Florida, five of the South Florida Water Management District (SFWMD) anemometers recorded wind gusts above hurricane force, including a gust to 93 mph (42 ms $^{-1}$) recorded at Belle Glade, FL (Table 1). In addition, at least 35 separate wind damage reports occurred in conjunction with the wind gust reports contained in Table 1. This has raised some question as to whether or not a hurricane warning, rather than a tropical storm warning, should have been issued for portions of the southeast Florida coast. However, damage surveys along with photographs from SFWMD indicate that damage was the result of straight line winds, with some indications of weak rotation. Most damage was confined to trees and mobile homes.

It is also noteworthy to mention that four confirmed tornadoes were reported along the immediate southeast Florida coast (not shown) during the afternoon and early evening hours of 15 October in association with Irene's outer convective bands moving onshore. However, radar data analyses indicate that these convective bands weakened considerably after moving onshore, which suggests that the favorable tornado conditions were limited to the immediate coastal areas.

Table 1. SFWMD Anemometer Gust Reports

Site No.	Lat.	Lon.	Date/Time	Wind(MPH)
1	26 47 23	81 18 10	15/1712Z	49.4
2	25 36 39	80 30 35	15/2003Z	57.0
3	26 19 55	80 52 48	15/2226Z	91.3
4	26 57 35	80 58 37	15/2239Z	64.9
5	26 19 17	81 04 04	15/2249Z	56.9
6	26 20 09	80 32 12	15/2314Z	55.9
7	26 49 21	80 46 58	16/0034Z	75.4
8	26 37 21	80 26 20	16/0055Z	59.2
9	26 39 25	80 37 47	16/0230Z	93.3
10	26 54 06	80 47 20	16/0522Z	81.3
11	27 08 20	80 47 16	16/0530Z	78.7
12	27 24 05	81 06 53	16/1007Z	44.8

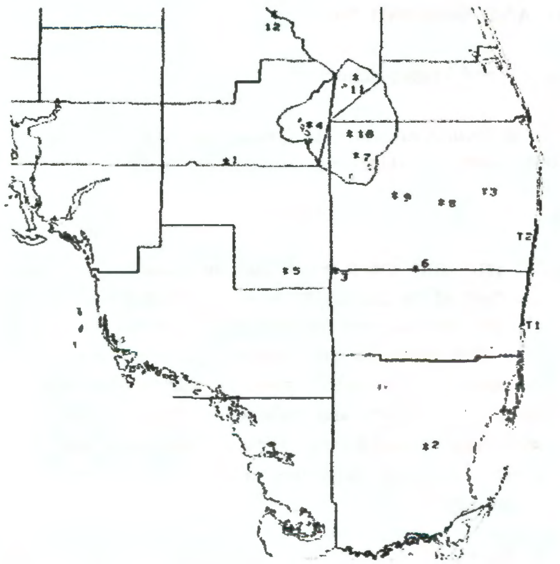

Figure 1. Location of SFWMD anemometer reports contained in Table 1. Asterisk indicates anemometer and T is tornado location.

4. WSR-88D RADAR DATA ANALYSES

All available WSR-88D base and derived products from KAMX, KMLB, and KBYX were examined in detail. These data reveal that numerous mesocyclonic signatures (mesocyclone and 3-D correlated shear) developed in the convection in the west semicircle of Irene after landfall (Figure 2). Surprisingly, only a few brief, shallow low-level mesocyclones were detected in the eastern semicircle bands where the tornadoes were reported, even though those cells were roughly the same distance from the KAMX radar.

Between 15/2200 UTC and 16/0200 UTC, the KAMX WSR-88D mesocyclone algorithm indicated that several of the mesocyclones were relatively shallow (<2km deep) and based in the low- to mid-levels (1.5-3 km ASL). This would suggest that some of the damage reports were the result of miniswirls (Fujita 1993) created from local stretching of the pre-existing vorticity field in the vicinity of the short-lived (< 20 min), strong convective bursts where radar echo tops frequently increased from 12 km to greater than 15 km ASL in less than 10 min.

After 16/0200, the mesocyclonic signatures developed primarily in the mid- and high-levels (between 3 km and 8 km)of the convection. Sounding data from Tampa Bay on the Florida west coast along with water vapor imagery indicate the presence of dry mid-level air impinging on the west side of Irene's circulation. This dry, lower theta-e air would have been available for entrainment into the mid-levels of some of the stronger cells. This became evident in the radar reflectivity data in the form of echo-free holes, rear inflow notches, and occasional bow echo patterns. In the case of the bow echo signatures, each bow contained an algorithm-detected mesocyclone on the north end, indicative of a classic mid-latitude "bookend" vortex-type downburst.

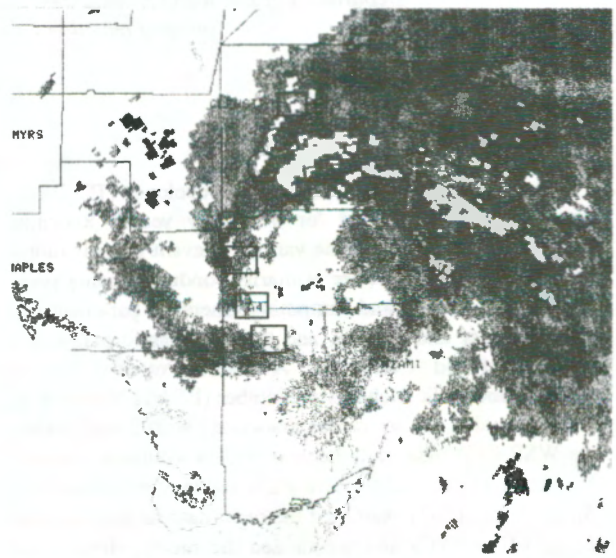

Figure 2. KAMX 0.5° elev. Base Reflectivity data for 0048 UTC, 16 Oct 99. 45 dBZ and higher indicated by white embedded in darker shades. Broad, ragged eye located 25 km nw of KAMX. Note 4 mesos (rectangles) and four 3-D correlated shear (circles) signatures in the northwest quadrant while no mesocyclonic signatures were detected with convection in the east semicircle.

5. SUMMARY

Doppler radar data and various damage surveys suggest that the strong wind gusts and wind damage observed across South Florida during the passage of Hurricane Irene (then only a tropical storm) were caused by the development of short-lived, multiple mesocyclonic circulations that induced strong, localized downbursts or enhanced low-level cyclonic inflow (miniswirls). Further, Doppler velocity data and vertical wind profiles indicate that no <u>sustained</u> hurricane force wind speeds below 3 km ASL occurred after 2200 UTC, 15 Oct 99, when most of the strong winds and damage were reported. Therefore, the National Hurricane Center was justified in lowering hurricane warnings to tropical storm warnings across South Florida.

6. REFERENCES

Avila, L.A., 1999: Preliminary report on Hurricane Irene. Available upon request from the Tropical Prediction Center (TPC) and from the TPC web site.

Fujita, T.T.,1993: Wind fields of Andrew, Omar, and Iniki, 1992. Preprints, *20th Conf. Hurr. And Trop. Met., Amer. Meteor. Soc., San Antonio,* 46-49.