5A.5 PROVIDING SHORT-FUSED WARNINGS FOR THE ONSET OF EXTREME HURRICANE WINDS – A FINAL OPPORTUNITY TO MINIMIZE CASUALTIES

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1. INTRODUCTION

The primary responsibility of a National Weather Service (NWS) Forecast Office (WFO) is to protect life and property through the issuance of short-fused warnings when severe weather becomes imminent. While well established policies are in place to accommodate the issuance of severe thunderstorm and tornado warnings during extra-tropical situations (severe squall lines, derechos, discrete supercells, etc.), similar short-fused warning strategies have not been employed for extreme winds associated with tropical cyclone landfalls. Recently, however, a methodology was devised to provide local warnings for the rapid and imminent onset of extreme winds associated with major hurricanes, thus providing a final opportunity for the protection of lives.

This paper will explain the rationale used by the WFO Melbourne warning meteorologists for issuing special bulletins for extreme winds during two recent hurricanes. The real-time meteorological assessments and specific warning strategies employed during Hurricanes Charley and Jeanne (2004) will be discussed. Radar imagery of the eye-wall features will be shown, along with samples of actual warning products. Detailed, post-hurricane ground and air damage survey results will be shared, which confirm tornado-like damage enhancements within widespread regions of lesser wind damage. Additionally, the utility of the special warnings will be shown from customer feedback obtained by a NWS Service Assessment on Hurricane Charley. Finally, a three-phased approach will be introduced which transitions the special warning product used during 2004 to a new official NWS warning designed to save lives in the final moments.

2. RATIONALE FOR SPECIAL WARNING

On 13 August 2004, major Hurricane Charley made landfall along the southwest Florida coast, then was forecast to accelerate rapidly northeast across the central Florida peninsula by late in the evening (Fig. 1). This track would bring the core of the strongest winds directly across Orlando, Florida, the most densely populated interior city of the state. Until this time, the highest documented wind gust to affect Metro Orlando from a tropical cyclone was 63.5 kt (73 mph), during the passage of Hurricane Donna in 1960 (http://www.ncdc.noaa.gov/oa/ncdc.html). Therefore, the large majority of interior Central Florida residents, visitors, and evacuees from the Florida Gulf coast, had never experienced conditions even close to those which were fast-approaching. The unprecedented nature of the imminent threat required an urgent and decisive alert to focus attention and to prompt immediate protective responses.

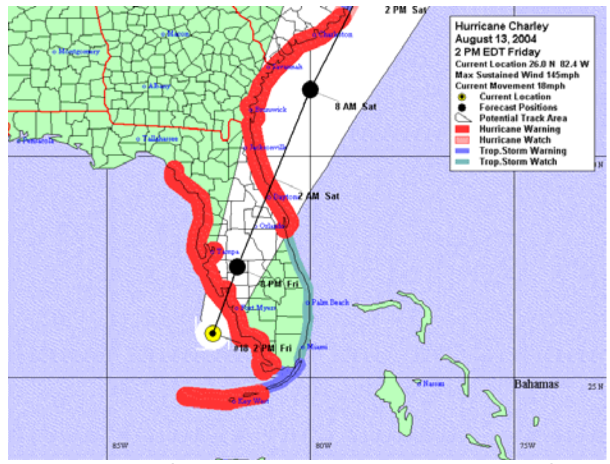

Fig. 1 1800 UTC 13 August 2004 National Hurricane Center forecast for Hurricane Charley. The forecast moves the center of the hurricane across the WFO Melbourne forecast and warning area between 0200 and 0600 UTC 14 August 2004.

Given the radar-detected presence of extreme winds over 120 kt (140 mph) spreading far inland from the Southwest Florida coast, innovative measures were needed to warn inland locations along the projected track of the hurricane eye-wall convection. In addition, it was known that "streaks" of extreme tornado-like damage had occurred in the past in association with the passage of the core of intense eye-wall convection (Fujita 1992, Wakimoto and Black 1994), and similar occurrences could add to the wind hazards from Charley.

Several hours prior to the onset of extreme winds across East-Central Florida, WFO Melbourne warning meteorologists devised a specific and extraordinary strategy. The strategy called for the production and dissemination of a special bulletin one hour prior to impact, to prompt immediate action for the protection of lives prior to the onset of destructive winds and the associated likelihood of embedded tornado-like damage. The bulletin was issued as a tornado warning to ensure maximum visibility and universal dissemination, but the text emphasized the rapid and imminent onset of extreme winds with a high potential for damage and casualties. The warning recommended the same protective actions as for tornadoes and used concise and explicit terminology to urge residents to

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react immediately, while providing a distinction from traditional tornado warnings.

Special tornado warnings for extreme winds also were issued in September 2004 when major Hurricane Jeanne made landfall along the Southeast Florida coast. More thorough meteorological assessments of the two hurricane events are provided below.

3. REAL-TIME ASSESSMENTS AND DECISIONS

As the inner core of a hurricane circulation moves within 465 km (250 nmi) of the United States coast, WFO operations shift from a more general assessment of hazard threats toward dedicated radar analyses of mesoscale rain-band features. Increasingly detailed statements and calls-to-action are provided as landfall is approached and throughout transit over land. The following sections detail radar-based assessments and associated warning decisions which were made in real-time at WFO Melbourne as Hurricanes Charley and Jeanne impacted East Central Florida.

3.1 HURRICANE CHARLEY (2004)

Hurricane Charley underwent rapid intensification just prior to landfall, with minimum pressure falling nearly 30 mb in the 12 hours prior to reaching the Southwest Florida coast. The wind field responded quickly to the pressure falls, with maximum sustained winds peaking at 130 kt at landfall, and a corresponding eye diameter contraction to only 5 nmi (from 20 nmi, only 12 hours earlier).

After making landfall as a category four hurricane around 1945 UTC 13 August 2004 along the Southwest Florida coast, the very compact eye-wall feature of Charley was tracked by the Melbourne WSR-88D as it accelerated rapidly northeast at 20 kt towards interior Central Florida. Given Charley's rapid forward motion, strength at landfall, and the minimal topographic relief across Central Florida, a (small) area of extreme winds persisted well inland along the track of the tight convective core. During this time, as the center traveled across the WFO Tampa Bay forecast and warning area, the WFO Melbourne staff devised the strategy to issue a special tornado warning an hour in advance of eye-wall impact to provide a final opportunity for residents, visitors, and emergency personnel to take life-saving precautions prior to the rapid onset of extreme winds. A warning threshold of 100 mph (87 kt) winds was established based on the potential to produce destructive effects to average built homes. Coordination with county emergency management agencies within the area of concern was performed prior to issuing the special tornado warning to minimize confusion and foster the desired societal response.

At 2244 UTC, Melbourne WSR-88D indicated the central core of Hurricane Charley approximately one hour away from the southwest portion of the WFO Melbourne forecast and warning area (Fig. 2). Although the south and west portions of the eye-wall had eroded, the north and east quadrants continued to possess very intense convection, with 50-60 dBZ reflectivity cores. Velocity data (not shown) revealed winds in excess of 100 kt at the 1500 m level (lowest sampled elevation) and recent reports from emergency management personal along the (inland) path of the center indicated extensive to catastrophic wind damage. Based upon earlier staff discussions and up-to-the-minute radar analyses of persistent deep convection and co-located significant wind fields, the final decision was made to produce and disseminate the special tornado warning (Fig. 3).

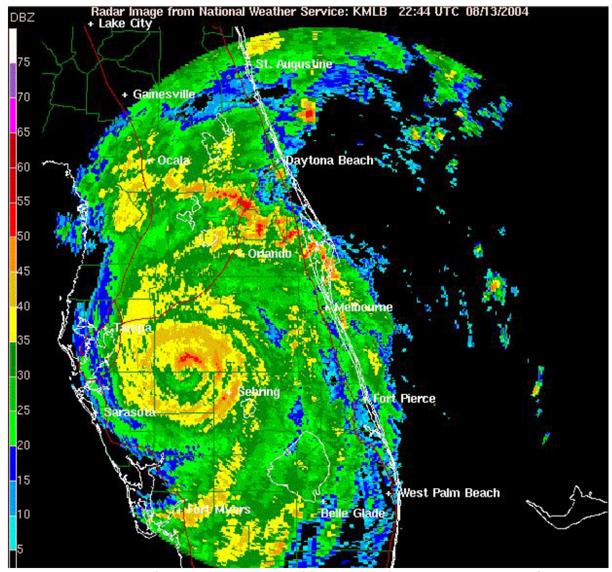
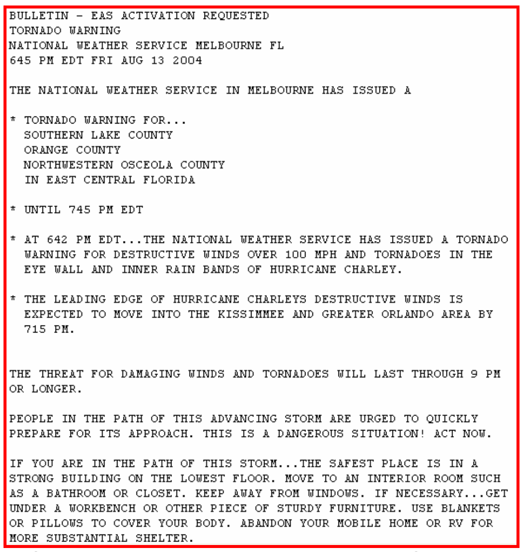


Fig. 2 Base reflectivity image from WFO Melbourne WSR-88D at 2244 UTC 13 August indicating the center of Hurricane Charley advancing toward the Melbourne forecast and warning area.

Although this critical information was also included within frequently issued Hurricane Local Statements, a higher priority message type was needed to assure receipt by the largest audience possible. Of all available short-fused products, the tornado warning receives the highest level of visibility via the Emergency Alert System (EAS) and is easily distinguishable from short-fused statements, whose issuance often becomes "routine" during hurricane landfalls. In addition to the EAS-activated special tornado warning, numerous weather statements were also issued prior to and subsequent to the warning to provide additional details on the timing, location, and degree of anticipated extreme wind impacts. User feedback regarding the special tornado warning will be discussed in Section 4 below.

Fig. 4 illustrates the northeast quadrant of the hurricane core spreading into the warning area, south and west of Orlando. This image from the Melbourne WSR-88D at 0006 UTC 14 August has reflectivity values below 40 dBZ filtered out. The higher reflectivity area correlated well with the excessive base velocity values, shown in Fig. 5, with outbound velocities below

64 kt filtered out. In this image, base velocity values (3-4kft height) greater than 70 kt were evident across much of the warning area, with peak winds of 90-100 kt coincident with the location of the highest reflectivity returns (50-55 dBZ) in Fig. 4. The wind direction (120-160 degrees) during the time of the highest winds across this region provided excellent sampling of the extreme winds by the Melbourne radar, with only slight underestimation. Over the next 2-hr period, wind gusts between 65 and 91 kt were recorded by airport Automated Surface Observing Systems (ASOS) within the warning path (Table 1). Data transmission and archival failed at all of these ASOS sites just prior to the arrival of the maximum winds; therefore, the peak winds may not have been captured (most notably at Kissimmee; Table 1).



BULLETIN - EAS ACTIVATION REQUESTED
TORNADO WARNING
NATIONAL WEATHER SERVICE MELBOURNE FL
645 PM EDT FRI AUG 13 2004

THE NATIONAL WEATHER SERVICE IN MELBOURNE HAS ISSUED A

* TORNADO WARNING FOR...
SOUTHERN LAKE COUNTY
ORANGE COUNTY
NORTHWESTERN OSCEOLA COUNTY
IN EAST CENTRAL FLORIDA

* UNTIL 745 PM EDT

* AT 642 PM EDT...THE NATIONAL WEATHER SERVICE HAS ISSUED A TORNADO WARNING FOR DESTRUCTIVE WINDS OVER 100 MPH AND TORNADOES IN THE EYE WALL AND INNER RAIN BANDS OF HURRICANE CHARLEY.

* THE LEADING EDGE OF HURRICANE CHARLEYS DESTRUCTIVE WINDS IS EXPECTED TO MOVE INTO THE KISSIMMEE AND GREATER ORLANDO AREA BY 715 PM.

THE THREAT FOR DAMAGING WINDS AND TORNADOES WILL LAST THROUGH 9 PM OR LONGER.

PEOPLE IN THE PATH OF THIS ADVANCING STORM ARE URGED TO QUICKLY PREPARE FOR ITS APPROACH. THIS IS A DANGEROUS SITUATION! ACT NOW.

IF YOU ARE IN THE PATH OF THIS STORM...THE SAFEST PLACE IS IN A STRONG BUILDING ON THE LOWEST FLOOR. MOVE TO AN INTERIOR ROOM SUCH AS A BATHROOM OR CLOSET. KEEP AWAY FROM WINDOWS. IF NECESSARY...GET UNDER A WORKBENCH OR OTHER PIECE OF STURDY FURNITURE. USE BLANKETS OR PILLOWS TO COVER YOUR BODY. ABANDON YOUR MOBILE HOME OR RV FOR MORE SUBSTANTIAL SHELTER.

Fig. 3 Special tornado warning issued by WFO Melbourne at 2245 UTC 13 August for Metro Orlando to heighten awareness of the imminent onset of destructive winds associated with the eye-wall of Hurricane Charley. Emergency Alert System (EAS) activation ensured widespread dissemination – to provide a final opportunity to take protective action.

Since the strategy called for issuing a 1-hr duration tornado warning for the *onset* of the extreme winds for the smallest possible area, the warning was not re-issued even though the conditions persisted beyond the 2345 UTC expiration time. Severe Weather Statements and Hurricane Local Statements were instead used to provide detailed follow-up information to the tornado warning. Likewise, the warning was not extended to upstream counties along the track, as radar-detected maximum winds decreased below the established criteria of 100 mph beyond Orange County (Orlando vicinity). Data from a preliminary post-analysis of the surface wind produced by the Hurricane Research Division (Burpee et al. 1994; Powell 1998) confirms the lessening of winds below 100 mph along the track north of Orange County (Fig. 6).

Fig. 7 provides a summary of the track of Hurricane Charley and the progression of the stronger, inner rain-bands across the interior of Central Florida (radar reflectivity values below 40 dBZ have been removed). The geographic region of the tornado warning issued for the destructive eye-wall winds (Fig. 3) is indicated by the region shaded red in the figure.

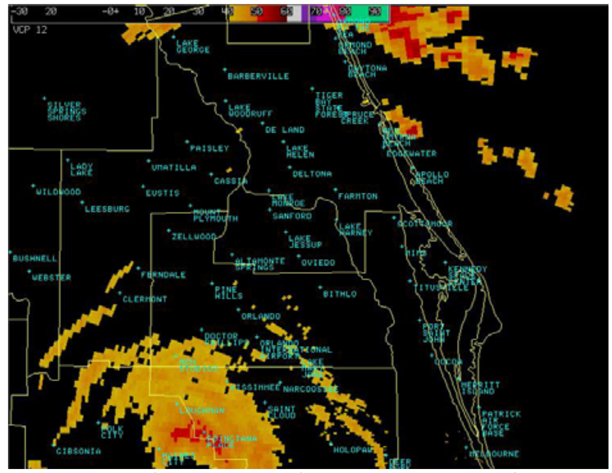


Fig. 4 Base reflectivity image from the Melbourne WSR-88D at 0006 UTC 14 August 2004 indicating the eye-wall of Hurricane Charley approaching the Orlando Metro area (reflectivity values below 40 dBZ have been removed).

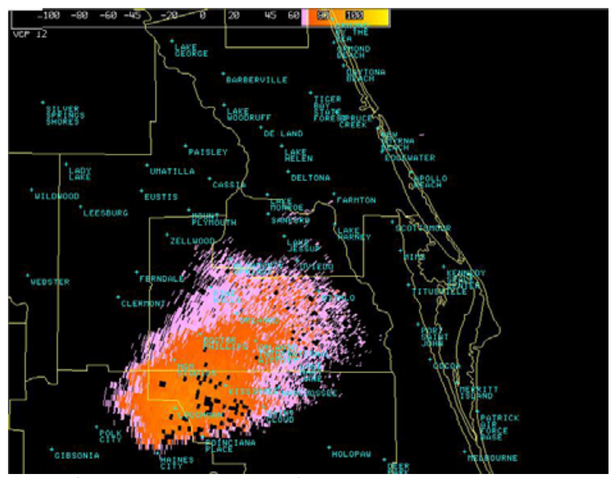


Fig. 5 Same as Fig. 4 except for base (radial) velocity (velocity values below 64 kt have been removed).

Airport (ID)	Direction (degrees)	Gust (kt)	Time (UTC)
Kissimmee (KISM)	Missing	65	0035
Orlando International (KMCO)	160	91	0105
Orlando Executive (KORL)	120	74	0129
Orlando-Sanford (KSFB)	120	80	0210

Table 1 Highest gusts (3 sec average) recorded at airport ASOS sites in the vicinity of Orlando (except Automated Weather Observing System, AWOS, at KISM). The data transmission and archival at all sites failed just prior to the onset of maximum winds, therefore peak winds may not have been sampled.

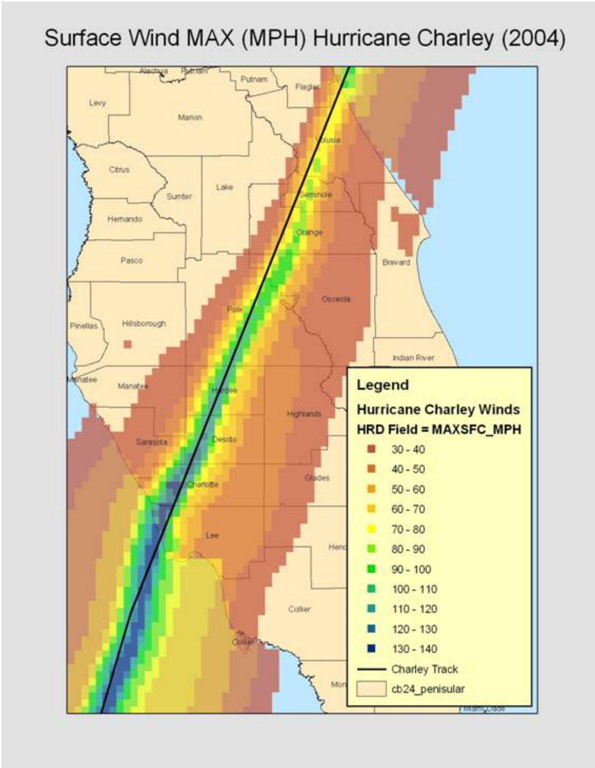


Fig. 6 Preliminary maximum sustained wind swath (mph) from Hurricane Charley. Data was obtained from the Hurricane Research Division and re-plotted by WFO Melbourne. Note winds decreasing below the 90-100 mph range beyond Orange County (Metro Orlando area).

A comprehensive summary of the impacts from Hurricane Charley upon East Central Florida, including multiple radar loops, meteorological data, and the complete suite of products issued by WFO Melbourne is available on the NWS Melbourne website at: http://www.srh.weather.gov/mlb/charley/index.html

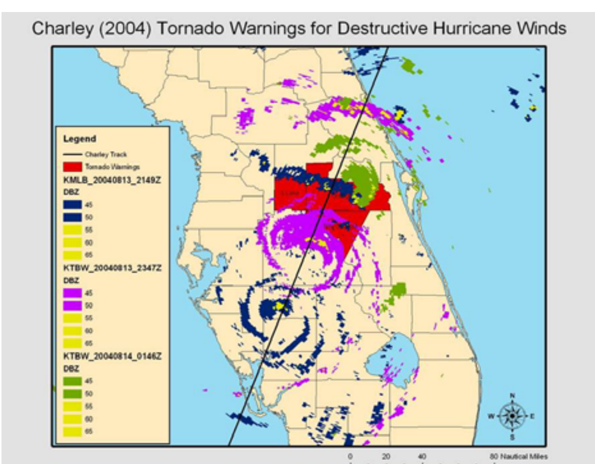


Fig. 7 Track of Hurricane Charley across the Florida peninsula with a temporal composite of high reflectivity returns from the Melbourne WSR-88D to mark the movement of the intense, inner rain-bands. The area of red shading was placed under a tornado warning for destructive winds over 100 mph.

3.2 HURRICANE JEANNE (2004)

Several weeks after Hurricane Charley's passage across Central Florida, Hurricane Frances made landfall along the Southeast Florida coast and crossed Central Florida from the opposite direction. Although Frances' impacts were significant, maximum winds across the WFO Melbourne forecast and warning area remained below the threshold of 100 mph (87 kt) established earlier for the special tornado warning and, therefore, no such warnings were issued. However, a few weeks later, a third hurricane made landfall on the Florida peninsula, nearly at the same location as Frances. Hurricane Jeanne was a Category 3 hurricane at landfall with maximum sustained winds of 105 kt, and tracked inland across Central Florida and into the Gulf of Mexico north of Tampa. Based on experiences gained from using the special tornado warning during Hurricane Charley, the strategy was again implemented and several tornado warnings for the onset of extreme hurricane winds were issued – this time for the Southeast Florida coast.

The first tornado warning was issued at 0058 UTC Sept 26 for two coastal counties (Fig. 8) as the leading edge of the inner eye-wall was expected to begin impacting the coast around 0200 UTC. Radar imagery indicated deterioration of the eastern portion of the eye-wall as landfall approached; however, the western half remained strong, with a wide rain-band containing reflectivity above 40 dBZ and radial velocity values above 100 kt. One particular feature of interest was a cell containing high reflectivity echoes (50-55 dBZ), embedded within and rotating around the inner edge of the eye-wall. The feature initially became apparent on radar at 0216 UTC (Fig. 9), just offshore the tornado warning area, and rotated rapidly southwest and onshore by 0232 UTC (Fig. 10) with a forward speed near 50 kt. The enhanced reflectivity area remained intact for over 30 minutes, before weakening well inland.

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BULLETIN - EAS ACTIVATION REQUESTED
TORNADO WARNING
NATIONAL WEATHER SERVICE MELBOURNE FL
858 PM EDT SAT SEP 25 2004

THE NATIONAL WEATHER SERVICE IN MELBOURNE HAS ISSUED A

* TORNADO WARNING FOR...
  MARTIN COUNTY
  ST. LUCIE COUNTY
  IN EAST CENTRAL FLORIDA

* UNTIL 1000 PM EDT

* AT 855 PM EDT...THE NATIONAL WEATHER SERVICE HAS ISSUED A TORNADO
WARNING FOR MARTIN AND ST LUCIE COUNTIES MAINLY FOR THE ONSET OF
EXTREME HURRICANE WINDS AND EMBEDDED TORNADOES ASSOCIATED WITH THE
INNER CORE OF HURRICANE JEANNE AS THE CENTER NEARS THE COAST. WINDS
TO 100 MPH WITH GUSTS TO 120 MPH ARE EXPECTED...ALONG WITH
TORNADOES.

* OTHER LOCATIONS IN THE WARNING INCLUDE INDIAN RIVER ESTATES...SAINT
  LUCIE VILLAGE...JUPITER ISLAND...LAKEWOOD PARK...NORTH RIVER
  SHORES...QUEENS COVE...PORT SALERNO...PORT SAINT LUCIE RIVER
  PARK...SAINT LUCIE AIRPORT...SAINT LUCIE WEST...NETTLES ISLAND AND
  ROCKY POINT

THE SAFEST PLACE TO BE DURING A LANDFALLING MAJOR HURRICANE WITH
EMBEDDED TORNADOES IS IN A STRONG BUILDING ON THE LOWEST FLOOR IN AN
INTERIOR ROOM AWAY FROM WINDOWS. GET UNDER A WORKBENCH OR OTHER
PIECE OF STURDY FURNITURE. USE BLANKETS OR PILLOWS TO COVER YOUR
HEAD AND BODY.
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Fig. 8 Same as Fig. 3 except for Hurricane Jeanne at 0058 UTC 25 Sept 2004.

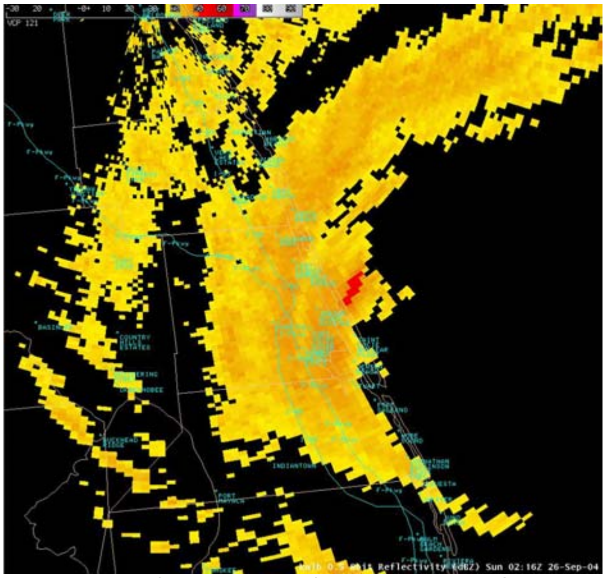

Fig. 9 Base reflectivity image from Melbourne WSR-88D at 0211 UTC 26 Sept 2004 (values below 40 dBZ removed). Note the cell with reflectivity above 50 dBZ just offshore, embedded within the eye-wall.

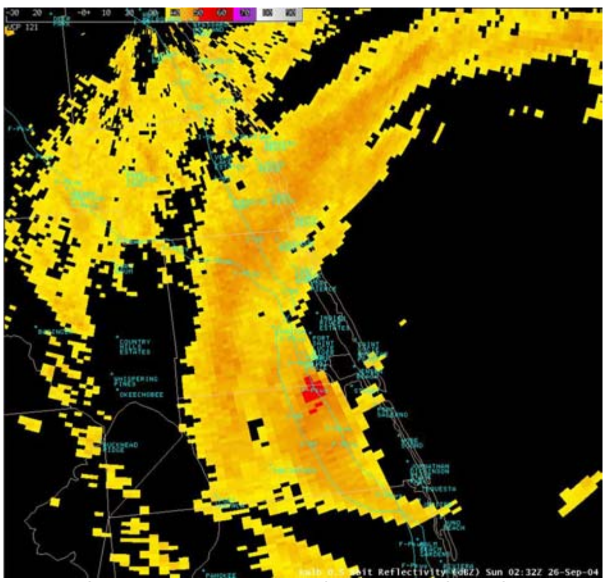

Fig. 10 Same as Fig. 9, except for 0232 UTC 26 Sept 2004. Note that the embedded 50+ dBZ cell has rotated onshore and is now located nearly 10 km inland.

As the eye-wall spread northwest during the evening, two additional tornado warnings for extreme winds were issued for coastal counties further north from the initial warning (Fig. 11). Additional transient features such as the one noted above were observed within the eye-wall during the time of landfall.

As Hurricane Jeanne continued to move inland, the intensity of the inner rain-bands gradually lessened and Doppler detected wind velocities dropped below 100 mph (87 kt) across areas north and west of those which were placed under the earlier tornado warnings. A preliminary post-event wind analysis produced by the Hurricane Research Division confirms maximum winds of 100-110 mph along the coast within the tornado warning area, north of the track of the hurricane center (Fig. 12). Table 2 contains a selection of peak wind observations taken within the warning area during passage of the eye-wall. Additional commentary concerning observed damage patterns will be provided below in Section 4.

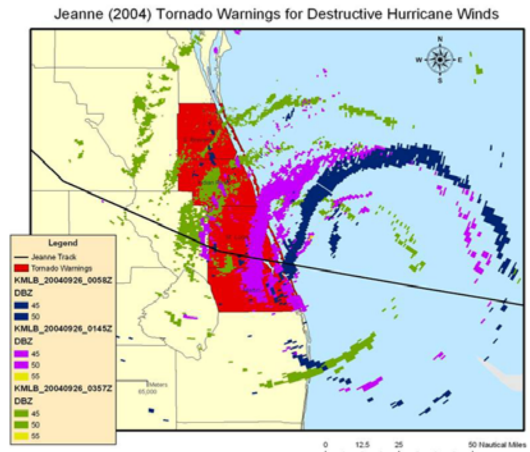

Fig. 11 Same as Fig. 7, except for Hurricane Jeanne.

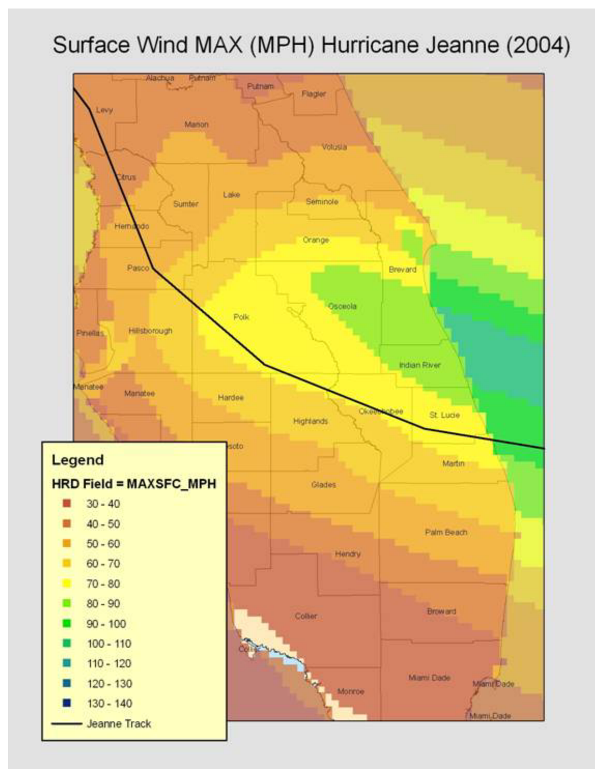

Fig. 12 Same as Fig. 6 except for Hurricane Jeanne. Note the winds of 100-110 mph along the coast north of the hurricane track and within the special tornado warning area.

A comprehensive summary of the impacts from Hurricane Jeanne upon East Central Florida, including multiple radar loops, meteorological data, and the complete suite of products issued by WFO Melbourne is available on the NWS Melbourne website at: http://www.srh.weather.gov/mlb/jeanne/index.html

Airport (ID) or location	Direction (degrees)	Speed (kt)	Time (UTC)
Ft. Pierce (KFPR)	360	76	0219
Vero Beach (FCMP)	045	106	0417
Ft. Pierce Inlet	Missing	111	0528
Sebastian (FCMP)	072	101	0647
NWS Melbourne	050	79	0814

Table 2 Same as Table 1, except for selected sites impacted by Hurricane Jeanne. KFPR is an airport ASOS site (3 sec average gust). The locations labeled FCMP are instantaneous (0.1 sec average) gusts recorded by mobile mesonet sites situated by the Florida Coastal Monitoring Program (FCMP; http://users.ce.ufl.edu/~fcmp/). The gust observations from NWS Melbourne and an unofficial report from a boat anchored near Ft. Piece Inlet were also instantaneous peak winds.

4. POST-HURRICANE VERIFICATION

Extensive post-hurricane air and ground surveys were conducted by WFO Melbourne staff throughout the regions impacted by Hurricanes Charley and Jeanne.

The damage swath across the interior of Central Florida associated with Hurricane Charley was very narrow, owing to the small, concentrated eye-wall (Fig. 1). Along the track of the eye-wall, damage was generally representative of a Category 1 hurricane. However, several isolated swaths of enhanced damage were apparent from air surveys. Two of the most impressive damage swaths were noted over the southeast portion of the area placed under the tornado warning for excessive winds (Fig. 7). These swaths occurred within a heavily forested area and were nearly 3 km in length, with widths ranging from 180 and 275 m. The gradient of tree damage was very distinct along the swath edges, with a majority of trees toppled within the path and few trees felled farther outward. These tornado-like damage (F1 on the Fujita scale) paths were indicative of a Category 2 hurricane. Other enhanced damage swaths were apparent elsewhere along the track of the eye-wall, but were less distinct than those cited above

During the landfall of Hurricane Jeanne, multiple enhanced swaths of wind damage were also documented along the path of the (much larger) eye-wall. Three very notable damage paths were observed from the ground and air across the northeast portion of the tornado warning area (Fig. 10). Although the character of the damage paths was similar to those observed after Hurricane Charley, the path lengths and widths were about an order of magnitude less (.2-.8 km long and 18-45 m wide). One path was through a wooded area with numerous trees blown down, directly adjacent to areas experiencing minimal tree damage. The other two paths occurred through a very large mobile home community, with a linear swath of extreme structural damage adjacent to regions of much less pronounced damage. The mobile home damage was consistent with high-end Category 2 hurricane intensity. Fig. 13 provides several examples of the damage paths which were documented after Hurricane Jeanne.

Fig. 13 Photographs of enhanced wind damage associated with Hurricane Jeanne taken from air surveys conducted by the authors. These tornado-like swaths of enhanced damage were observed in extreme Southern Brevard County and occurred as the eye-wall passed over the region. Tree and structural damage within the swaths was much greater than that observed immediately adjacent to the paths.

Other less striking, yet still apparent, short tornado-like damage paths were noted within the overall widespread damage corridor of Hurricane Jeanne. For example, a ground survey was conducted along the track of the strong convective cell noted above in Section 3.2. Along the track of the high-reflectivity echo, several areas of enhanced damage were noted (on a barrier island just inland from the beach and also beyond 10 km inland). Fig. 14 depicts the movement of the convective cell based on radar reflectivity, along with the associated locations of enhanced damage.

The authors believe that as with extra-tropical severe weather events, strong vertical, turbulent mixing occurring within the embedded convective cells likely led to the isolated regions of enhanced (tornado-like) damage. While the hypothesis of the mechanism for the enhanced damage swaths is associated with accelerated downward vertical motions within transient convective features within the eye-wall, the resultant phenomena responsible for such observed damage remain illusive. Possible candidates include downbursts (Stewart 2000), mini-swirls (Fujita 1992), tornadoes

Wakimoto and Black 1992), and roll vortices (Morrison et al 2005).

Despite widespread, extensive property damage along the tracks of Hurricanes Charley and Jeanne, no direct wind-related fatalities occurred across East Central Florida. The intense WFO Melbourne focus and communication of the hazards posed by the extreme eye-wall winds likely played a role in minimizing casualties. The effectiveness of the unique (tornado) warning strategy was further evident through positive feedback provided by several emergency managers and media representatives (Hurricane Charley Service Assessment, 2006). In addition, the Hurricane Charley Service Assessment cited the warning strategy as a "best practice."

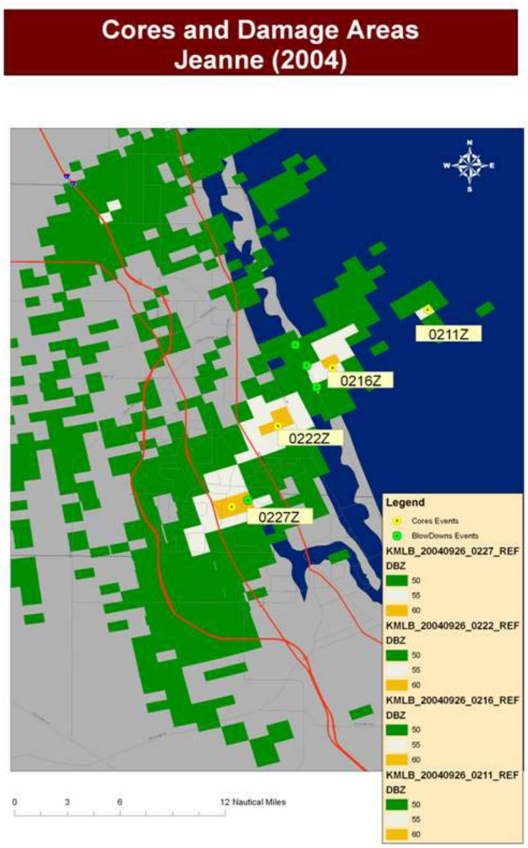

Fig. 14 Temporal composite of base reflectivity data from the Melbourne WSR-88D between 0211 and 0227 UTC 26 Sept 2004 (reflectivity below 50 dBZ removed). Note the core of the high reflectivity cell moving from offshore at 0211 UTC to nearly 10 km inland by 0227 UTC. Along the track of this intense cell, numerous areas of enhanced wind damage (noted by green circles) were observed from ground surveys.

5. FUTURE PLANS

After devising and employing a strategy for providing localized warning information for extreme hurricane winds during Hurricanes Charley and Jeanne in 2004, the WFO Melbourne staff briefed the annual NOAA Hurricane Conference on their experiences in December 2004. After debating the merits of the special tornado warning, conference attendees agreed to transition the WFO Melbourne concept into a new official NWS warning product. The approach decided upon was multi-phased. Initially, owing to a time constraint required for the technical implementation of a universal product, the tornado warning product could again be used during the 2005 hurricane season to urgently motivate the public to take shelter in an interior portion of a well-built structure prior to the imminent onset of destructive tropical cyclone winds. For 2005, the special tornado warning for destructive tropical cyclone winds (with a 2-hr warning valid time) could be issued when both of the following criteria were met:

- Imminent onset or currently occurring tropical cyclone related sustained winds, greater than or equal to 100 knots (115 mph).
- Onset of tropical cyclone related destructive winds expected to develop or occur within a WFOs county warning area within an hour.

Due to the extremely active hurricane season of 2005, four major hurricanes (Dennis, Katrina, Rita, and Wilma) made landfall along the United States Gulf Coast, and tornado warnings for extreme winds were issued by numerous WFOs.

Phase 2, tentatively scheduled for implementation prior to the 2006 hurricane season, will use the criteria established for the 2005 season, with the following modifications to help automatic warning dissemination and to further distinguish the product from an actual tornado warning:

- Implement a new VTEC Phenomena Code (see http://www.nws.noaa.gov/os/vtec) "EW" for "Extreme Wind."
- Change the first line of text in the product to "Extreme Wind Warning."
- Standardize the format for the warning to ensure consistency between WFOs.
- Issue a public information statement prior to the hurricane season to address the upcoming changes.

The third and final phase, scheduled for implementation once EAS requirements are satisfied, will establish a new official warning product (e.g., Extreme Wind Warning) for use by WFOs when the criteria defined for the 2005 season are met. Transition to the final product may not occur for several years due to the time required to implement a new EAS warning category.

6. ACKNOWLEDGEMENTS

The authors wish to thank the Hurricane Research Division for providing H-WND analyses during and immediately after hurricane landfalls. This data set is extremely valuable to WFOs as real-time guidance and also provides a consistent, objective means to communicate preliminary wind verification. The authors also wish to express their appreciation of the NOAA Hurricane Conference for debating the merits of the tornado warning for extreme hurricane winds. The subsequent formation of a team to advance the concept into a new official warning will undoubtedly result in reduced casualties as the public is afforded a final opportunity to act prior to the onset of extreme hurricane winds. As always, David Sharp engaged the authors in many insightful discussions, helping to improve the manuscript and Shirley Leslie provided a careful grammatical review.

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