Post Storm Data Acquisition
Aerial Wind Mapping
Mission
Hurricane Charley - 2004

October 25th, 2004

Overview

On August 13th, 2004, a rapidly strengthening Hurricane Charley moved ashore in the United States on the southwest Florida coast. In the five hours prior to the late afternoon landfall, the central atmospheric pressure of the tropical cyclone decreased from 965 millibars (MB) / 28.49 inches of mercury to 941 MB / 27.79 inches of mercury.

Landfall occurred at 3:35 pm EDT on the barrier islands of Lee County Florida. Charley produced a 10 to 15 mile wide swath of winds gusting in excess of 100 miles per hour (MPH) as it moved ashore from the Captiva area inland toward Punta Gorda, Port Charlotte, and Arcadia. Winds gusting to hurricane force continued near the core of the cyclone during its trek across the Florida peninsula.

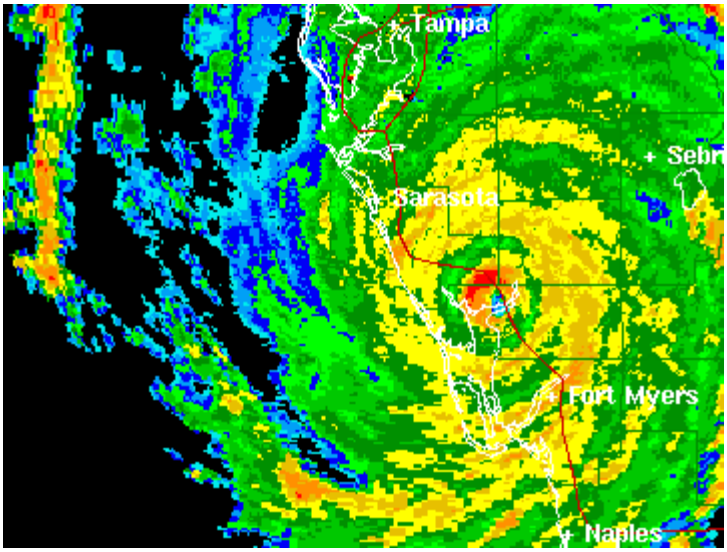

Figure 1 – NWS WSR-88D 0.5 degree Reflectivity - KTBW 4:35 PM EDT 13 August 2004

Two Post Storm Data Acquisition (PSDA) aerial wind mapping missions were conducted by the National Weather Service (NWS) in the areas affected by Charley. One on August 15th and 16th, the other on August 29th. The following summarizes both missions.

Flight Tactics and Objectives

Both PSDA aerial wind mapping missions were flown from the Fort Lauderdale Executive Airport in a Cessna 172. The aircraft was rented from Airborne Systems of Fort Lauderdale. At the time of the PSDA missions, a memorandum of understanding (MOU) between the NWS and the Civil Air Patrol (CAP) was not in place, necessitating the use of a rented aircraft. An NWS Southern Region Designated Pilot (NWS meteorologist), and a pilot from Airborne Systems flew the missions. An NWS meteorologist on board the aircraft guided the flights and recorded data for later analysis. A researcher from the National Oceanic and Atmospheric Administration (NOAA) Atlantic Oceanographic and Meteorological Laboratory was onboard the August 29th flights.

The inner core of Hurricane Charley was somewhat unique given its compact structure and intense nature. Because of these characteristics, the resources of the PSDA missions were focused on documenting the landfall area.

The mission pilots were challenged on several occasions by thunderstorms and the detailed coordination with the Federal Aviation Administration (FAA) that is inherent with flying in restricted air space. This includes being kept at a distance from Air Force One.

Data Collection

At flight levels of 1000 to 2000 feet above ground level, video of the damage was recorded. Aircraft position data, utilizing a Global Positioning System (GPS) and a laptop computer was time synchronized with the onboard cameras to facilitate a detailed analysis. During a small period of the missions, the camera and GPS system lost time synchronization, but overall the data collection was successful.

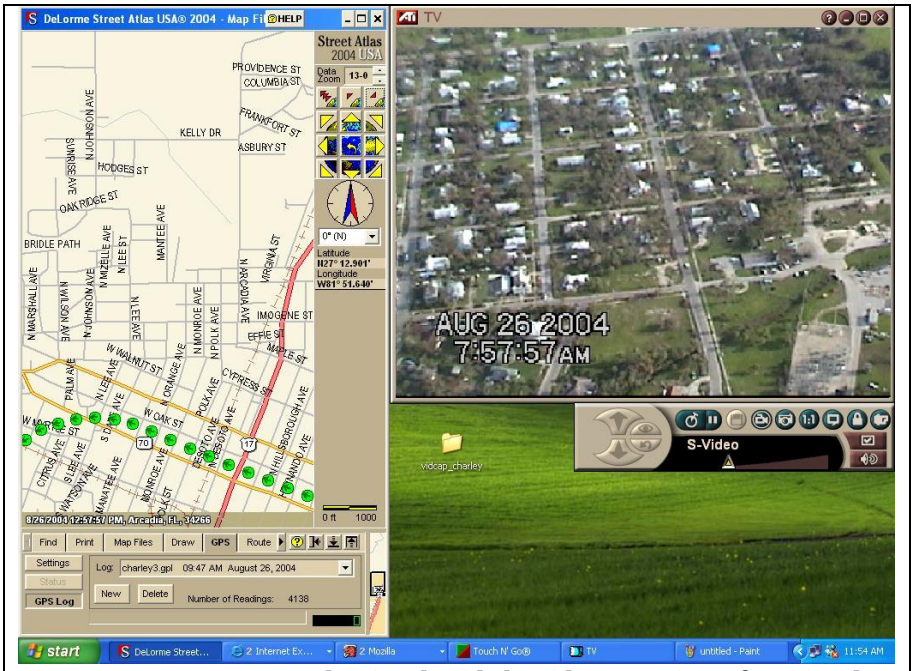

Figure 2 – Screen Capture showing the side-by-side comparison of position data (left) and damage video (right).

Data Analysis

Digital video of damage and aircraft position data were reviewed subsequent to the flights (Figure 2), using subjective estimation techniques associated with determining Fujita Scale damage ratings. Such techniques can be used to estimate peak wind values that are considered to be 3 to 5 second gusts. Where possible, observed wind data were used to calibrate the visually determined damage ratings, but as is typical, such observations were limited in the area of strongest winds due to instrument failures. Additionally, the exposure and performance characteristics of wind equipment that record extreme data actually increased the uncertainty in some situations when damage patterns did not appear to be consistent with measured value.

It should be noted that the accuracy of gust estimates from just an airborne inspection of the damage is limited due to a lack of first-hand knowledge of the affected building construction quality, soil conditions, and vegetation characteristics. Therefore, the analysis below should be just one input into any final wind field analysis of Hurricane Charley.

At many locations in the damage area, seemingly contradictory degrees of building damage occurred in close proximity to each other. Therefore, the wind gust estimate for any particular area was biased toward the characteristics of the majority of the damage and not the most extreme. It is highly likely that this process is valid for the vast majority of the damage locations, and reduces over-estimating that could occur from observing enhanced damage that was the result of a structural weakness. However, it is also possible that some areas were underestimated. In these cases, only the first-hand inspection of the affected structure would offer a better estimate. Such inspections were beyond the scope of these PSDA missions. The PSDA team is aware the Federal Emergency Management Agency (FEMA) contracted with the URS Corporation to produce wind speed estimates based on ground surveys. The information from URS's work would be an invaluable addition to a final analysis.

A limited degree of coordination has occurred between the FEMA contracted team and this PSDA mission team. While the findings of both teams have not been received by the other, conversations suggest some degree of agreement between the two analyses.

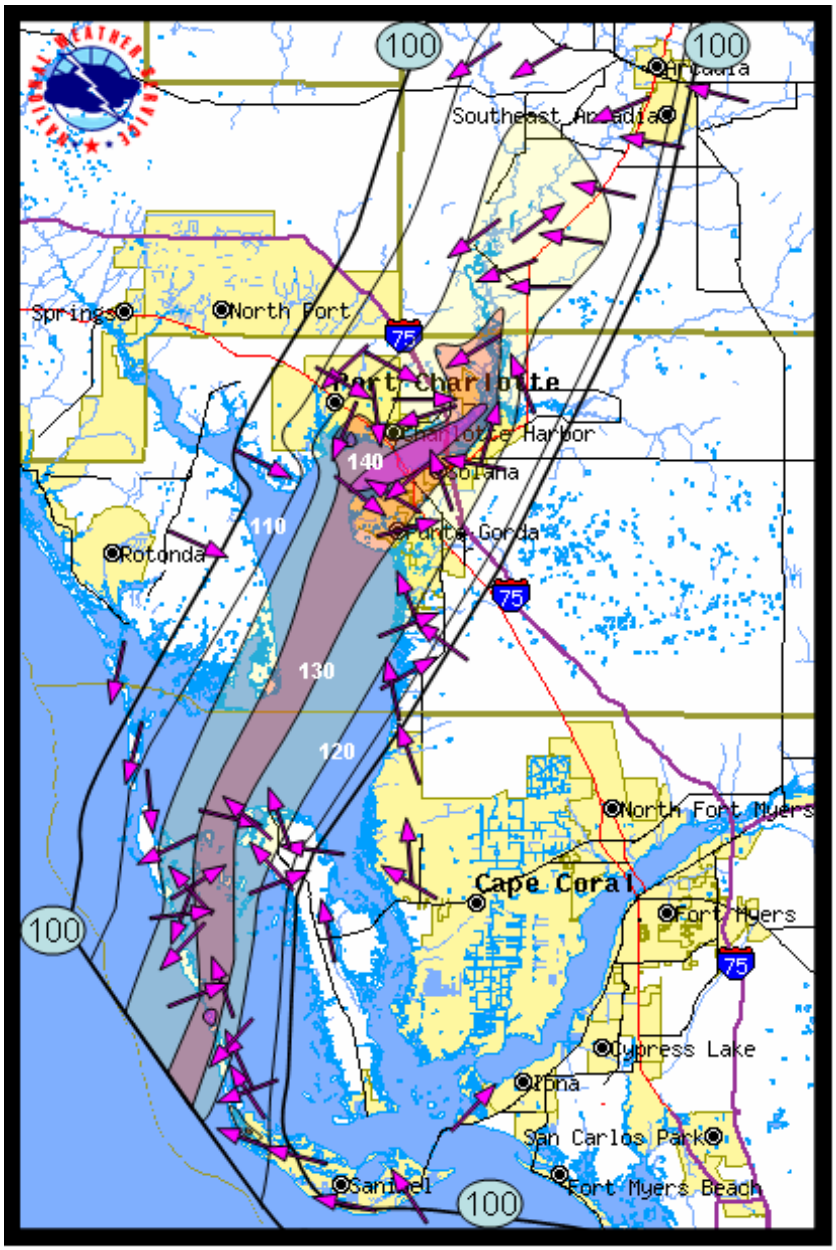

Figure 3 – PSDA Aerial Wind Mapping Derived Peak Gust Estimates. Contoured at 10 MPH interval from 100 to 140 MPH. Arrows depict the predominate fall direction of damaged items.

The Analysis

The analysis of information collected during the Hurricane Charley PSDA Aerial

Wind Mapping Missions suggested that peak wind gusts at landfall were near 145 MPH (Figure 3). Because of the inherent limitations associated with this analysis, as described above, the variation within each contour could easily be +/ 15 MPH.

The strongest winds were estimated to be in a small area at the sound end of North Captiva Island, near where the barrier island was breached along an approximately 400 yard stretch. A second wind maximum was estimated to be in Charlotte Harbor and shoreline areas of Port Charlotte and Punta Gorda (See Appendix B). Overall, a 12 mile wide swath of winds gusting over 100 MPH swept inland with the hurricane's core. Wind gusts estimated at 120 MPH progressed inland to near Arcadia. Wind gusts to near 100 MPH persisted into the Orlando area, with gusts near 80 MPH still occurring as the cyclone's center exited Florida near Daytona Beach.

Measured wind gust information retrieved by NWS Weather Forecast Offices (WFOs) in Tampa and Melbourne (Figure 4) were in basic agreement with the PSDA derived gust map, except at Punta Gorda. Emergency management officials for Charlotte County reported extreme gusts at two locations in Punta Gorda. Damage near these two locations, the Charlotte Regional Medical Center (172 MPH) and Charlotte County Airport (160 MPH), appeared more typical of the mid range of Fujita Scale 2 damage. Damage in the middle of the F2 range is characterized by the loss of roofs from well constructed homes, demolished mobile homes, large trees uprooted, block structures badly damaged and light-object missiles generated. Wind gusts typically associated with this degree of damage in the Fujita Scale are in the 125 to 145 MPH range. However, it again should be noted that the lack of input from a ground survey into this analysis results in uncertainties. Also, the PSDA team was unsure of the exposure and performance characteristics of the instruments at Punta Gorda, creating some uncertainties related to the measurements.

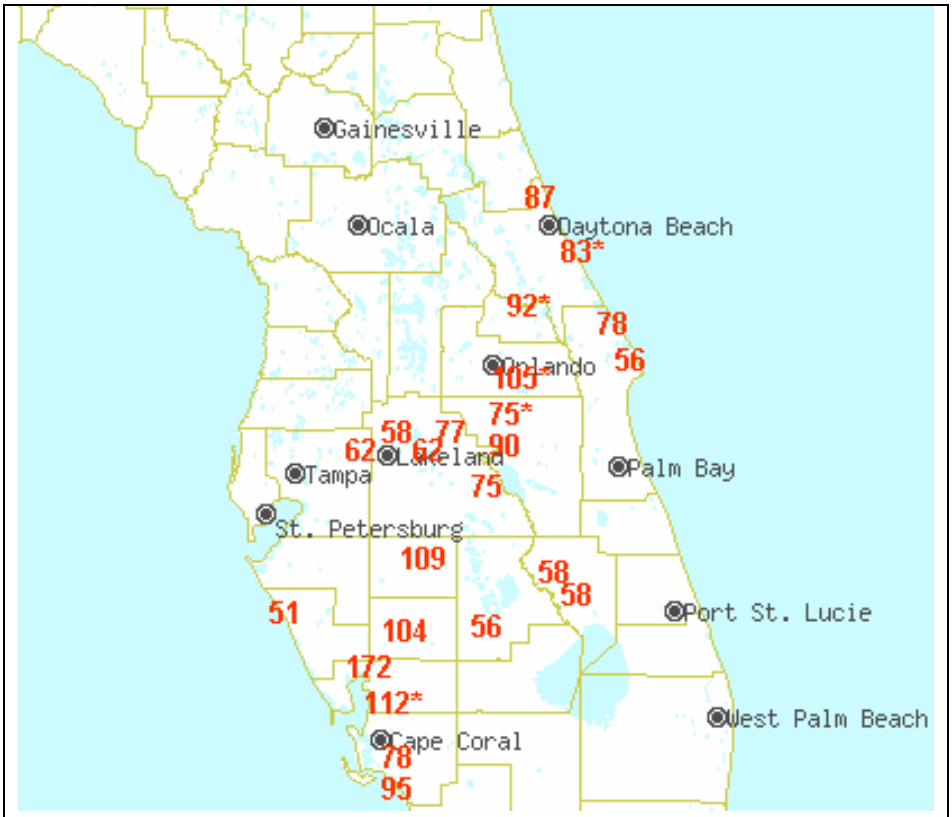

Figure 4 – Measured Wind Gusts (MPH) near the path of Hurricane Charley's core. (* denotes the instrument failed…possibly missing the peak gust)

An apparent tornado track was noted in the PSDA team's gust analysis. Damage characterized by a convergent debris pattern and an increase in apparent wind intensity was seen from northwest Sanibel Island to southern Captiva Island. The most pronounced convergent damage pattern was in a small area of southern Captiva Island. WFO Tampa did record two waterspout reports from the general area. Damage in southern Captiva reached F2 intensity and was a mix of both tornado and hurricane wind damage, making an assessment difficult.

Radar data from the WSR-88D in Tampa was reviewed only after the final gust analysis was completed. It was noted that the hurricane's eye did in fact maneuver around Pine Island, as noted in the analysis.

A limiting factor in this style of gust analysis heretofore not discussed is the potential underestimation in areas where there is a paucity of structures and vegetation. The coastal area on the mainland of Florida immediately southwest of Punta Gorda is sparsely populated with limited tall vegetation. If the peak wind gust for Charley occurred in this location, it would not be discernable in this analysis due to a lack of objects to be damaged.

The fall pattern of trees and debris scatter from structures suggested that the wind center of the hurricane was near the western edge of the of the 130 MPH gust swath in the barrier islands, with the center essentially near the axis of the maximum winds in the mainland areas.

Summary

Hurricane Charley brought significant destruction to southwest Florida. Mobile homes in the maximum wind areas suffered the worst damage, with many totally destroyed. On the opposite end of the building spectrum were the homes that have been specifically designed for hurricane-prone coastal areas. Most of these homes fared much better. This variation in structural integrity not only demonstrates that homes can be better protected in extreme winds, but it also introduces additional uncertainties when applying the Fujita Scale to estimating wind speeds. Interpreting Fujita's phrase "well constructed" applies to the construction methods typical of the period around 1970 when the Fujita Scale was being developed. The much stronger construction now in place in some coastal areas is cause for adjusting the application of the Fujita Scale damage intensity descriptions.

Virtually all the imagery on the PSDA missions was collected on a consumer grade video camera; therefore, the PSDA team did not assemble a collection of high quality digital pictures for later publication. The PSDA team understands that other components of the government accomplished this.

The PSDA Team would like to thank all those at Airborne Systems of Fort Lauderdale, especially manager Vinny Billisi, for their exceptional support to these missions.

Appendix A

PSDA Hurricane Charley Wind Mapping Mission Teams

Mission 1
August 15th – 16th, 2004

Team Leader
Steven Piltz, Meteorologist in Charge, NWS Tulsa, OK (steven.piltz@noaa.gov)

Chief Mission Pilot
Jody James, Senior Forecaster, NWS Lubbock, TX

Mission Pilot
Ray Brown, Airborne Systems, Fort Lauderdale, FL

Mission 2
August 29th, 2004

Team Leader
Steven Piltz, Meteorologist in Charge, NWS Tulsa, OK (steven.piltz@noaa.gov)

Michael Black, Hurricane Research Division –
Atlantic Oceanographic and Meteorological Labratory

Chief Mission Pilot
Ray Brown, Airborne Systems, Fort Lauderdale, FL

Appendix B

Hurricane Charley

August 13th, 2004

Peak Gust Analysis

140 mph
130 mph
120 mph

Isopleths drawn at 10 mph interval from 100 to 140 mph.

Arrows represent the apparent direction of peak winds.

The analysis is derived from a visual assessment of damage as recorded on video tape during aircraft over-flights. Speeds should be interpreted as 3 to 5 second gusts, consistent with determining Fujita Scale values.

Note – The estimation of wind gusts from aerial imagery taken of the affected area should be considered as just one input into a final analysis. Information from ground surveys, where variations of building construction, soil conditions, and vegetation types can be more directly assessed, should also be integrated.

LEGEND

- State
- County
- Lake/Pond/Ocean
- Expressway
- Highway
- Connector
- Stream
- Military Area
- National Park
- City
- County

Scale 1:457167 (0 5 10 15 mi; 0 5 10 15 20 25 km)

*average--true scale depends on monitor resolution