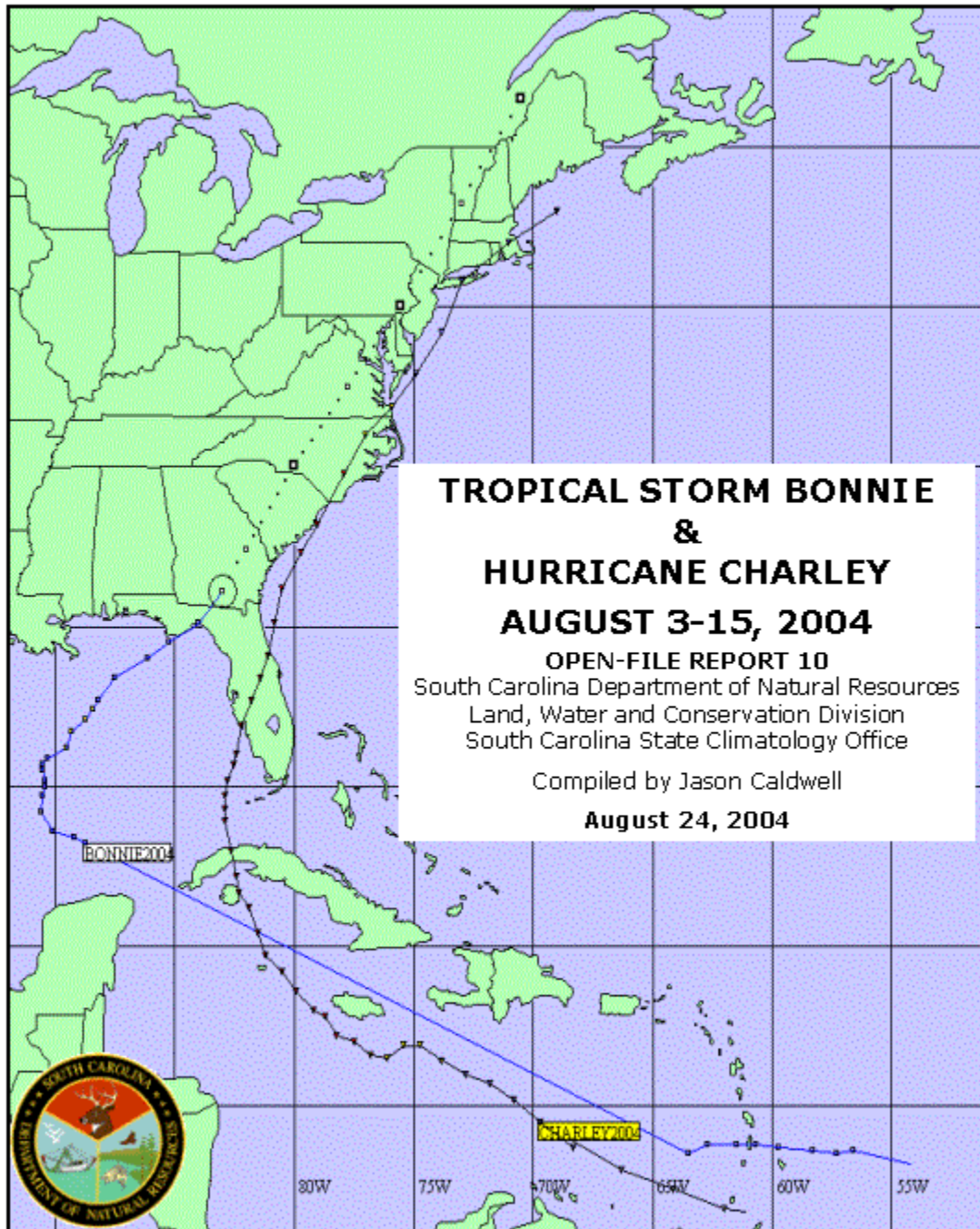


Tropical Storm Bonnie and Hurricane Charley



Publication of the South Carolina State Climatology Office

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Figure 1

TROPICAL STORM BONNIE

August 3-12, 2004

EVENT SUMMARY

The second tropical depression of the season formed east of the Lesser Antilles on Tuesday, August 3, 2004, but quickly weakened to a tropical wave by late afternoon on Wednesday. As the tropical disturbance entered the Gulf of Mexico over the weekend, upper level conditions improved and re-development of the circulation center at the surface resulted in the National Hurricane Center naming the second storm of the season, Tropical Storm Bonnie, late on August 9th.

With an extremely small circulation center, Bonnie underwent rapid fluctuations in intensity from the initial estimates of 45 mph. Sustained winds reached 60 mph by mid-morning on Tuesday, August 10th (Figure 1) after an intensification period associated with divergence aloft associated with an upper level disturbance crossing the southeast United States. The diffluent flow pattern provided support for convection near the center, subsequent pressure falls at the surface, and the increase in wind speeds.

Similar conditions during the following 24 hours promoted additional changes in the storm's intensity with estimated maximum sustained winds of near 65 mph through the day on Wednesday, August 11th. Bonnie finally neared the northwest coastline of Florida at 1100 EDT on Thursday as a weak and disorganized cluster of thunderstorms located 30 miles southwest of Apalachicola, Florida (Figure 2). The last advisory was issued for Bonnie at 1700 EDT as the storm traveled across Georgia 30 miles northeast of Valdosta.

BONNIE

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Figure 2

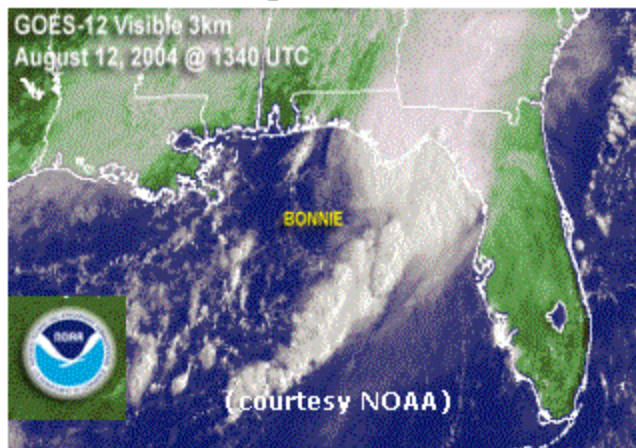
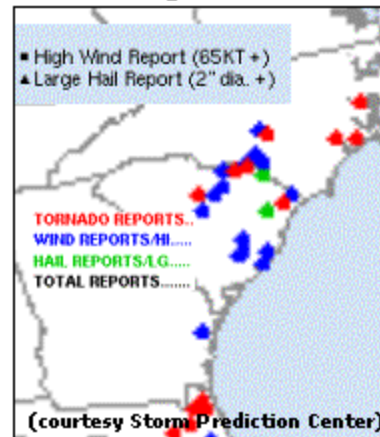


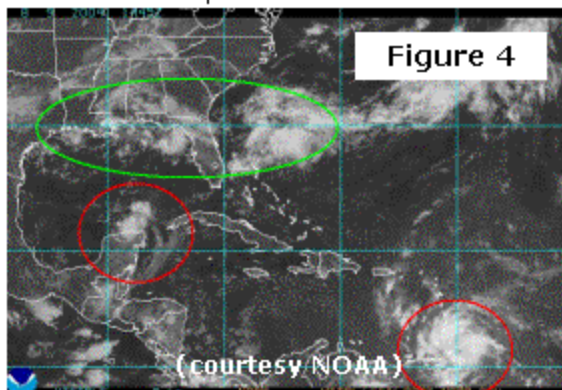
Figure 3



FORECAST CONSIDERATIONS

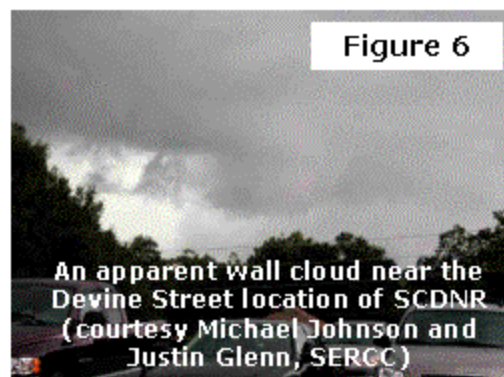
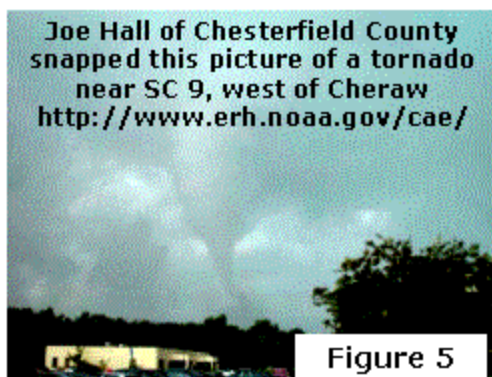
The determination of the forecast track for Bonnie was based on the influence of a deep trough at middle and upper levels in the atmosphere building into the eastern half of the United States throughout the period. Initially tracking the storm to the north, impending southwest flow turned the storm north-northeast across Florida, Georgia, and the Carolinas (Figure 4).

In association with the trough digging into the Southeast, a cold frontal boundary, stretched across the Appalachian Mountains, provided a mechanism for additional lift over the Upstate as warm, moist tropical air flowed north over the cooler, drier air at the surface. Orographic precipitation in the upslope terrain of the northwest Upstate created conditions favorable for heavy rainfall.



The green region denotes the short-wave trough responsible for diffluent flow at upper levels that resulted in intensification of Bonnie during the 24 hours following this satellite image [valid mid-morning August 9, 2004]. Red regions indicate soon-to-be Tropical Storms Bonnie (left) and Charley (right).

BONNIE



SOUTH CAROLINA EFFECTS

In South Carolina, reports of several tornadoes, high winds from severe thunderstorms, and heavy rainfall predominated. Heavy rainfall began across the Upstate of South Carolina early on the 12th along a stalled frontal boundary and created flooded roadways in Greenville County. By midday, severe thunderstorms erupted as a mesoscale disturbance that ejected from the primary circulation center of Bonnie crossed into South Carolina.

For August 12, 2004, the Storm Prediction Center in Norman, Oklahoma, received unofficial reports of 5 tornadoes, 9 high wind, and 2 large hail events throughout the State (Figure 3). Tornado reports were received from Fairfield, Chesterfield, Marlboro, Horry, and Charleston Counties. Williamsburg and Dillon Counties reported large hail up to nickel size that significantly damaged tobacco crops in the region. Storm reports were received across most of the eastern half of South Carolina including the Piedmont, Midlands, Pee Dee, and Coastal regions of the State (Figures 5-8).

National Weather Service damage surveys indicated three F1 tornadoes within the State. A one-quarter mile wide tornado cut a 2 mile path parallel to SC Highway 3 near Longtown in Fairfield County. Several homes, 6 mobile homes, and 6 outbuildings were damaged or destroyed. A second F1 tornado followed a path 6 miles long from 6 miles southeast of Chesterfield to 1 mile west of Cheraw and had damage associated with an estimated 110 mph wind (Figure 5). The final tornado reported in Isle of Palms damaged 30 homes.

BONNIE

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SOUTH CAROLINA EFFECTS (CONT.)

Rainfall during Bonnie across the State was generally in the 1 to 3 inch range with locally higher amounts up to 5 inches in parts of Aiken and Lexington Counties. Some locations did not receive any rain. Charleston Waterfront Park reported a daily record rainfall of 2.52 inches on August 12th, breaking the old record of 1.67 inches set in 1978. Columbia Metropolitan Airport also set a new daily record with 1.52 inches. The old record was 1.10 inches in 1970.

CLIMATOLOGICAL PERSPECTIVE

The National Weather Service Office in Columbia issued a statement on Wednesday, August 3, 2004, regarding the unusual circumstance of two tropical systems affecting South Carolina within 24 hours. Since 1900, only two sets of storms [Gordon and Helene (2000) and Babe and Clara (1977)] have brought tropical weather conditions to the State within a period of several days. Neither of these coupled events occurred within the short time span associated with Bonnie and Charley.

The State Climatology Office used Hurricane Dennis (1981) and Tropical Storm Cleo (1964) as reference storms for predicting rainfall totals associated with the one-two punch of Bonnie and Charley. Cleo brought 3 to 6 inch precipitation totals across much of the State while Dennis brought similar totals to the Pee Dee and Coastal sections. The highest precipitation from either climatological storm was 9.45 inches in Georgetown, relatively close to the maximum rainfall totals during Bonnie and Charley.

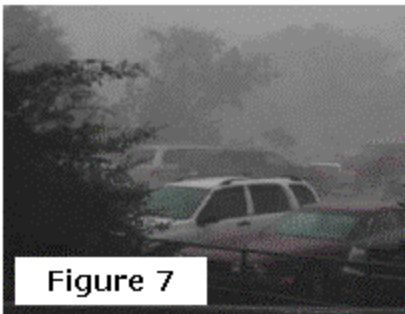


Figure 7

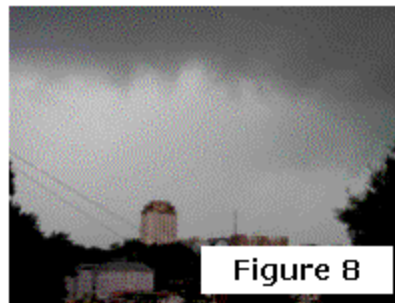


Figure 8

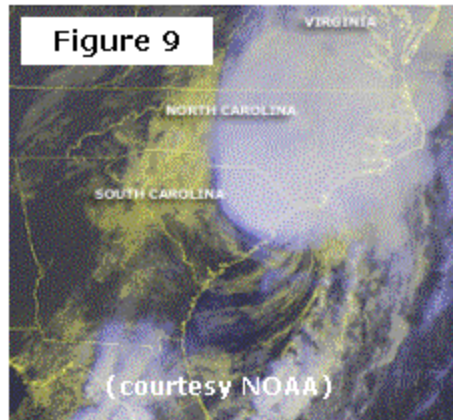
Additional photographs from the Devine Street Parking Deck as a lead disturbance plowed into the Midlands on August 12th ahead of Bonnie (courtesy Michael Johnson and Justin Glenn, SERCC)

BONNIE

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HURRICANE CHARLEY

August 9-15, 2004



EVENT SUMMARY

At 1345 EDT near the Windward Islands on Monday, August 9, 2004, Tropical Depression Three developed as a well-defined mid-level and low-level circulation center east of Grenada with extremely favorable conditions over and ahead of the tropical cyclone's path. For the first 24 hours, the rapid forward motion of the storm (west-northwest at 20 to 25 mph) hindered rapid development over the warm waters of the southeastern Caribbean Sea. By 0500 EDT on the 10th, Charley, the third tropical storm of the 2004 Atlantic Basin Hurricane Season, was born.

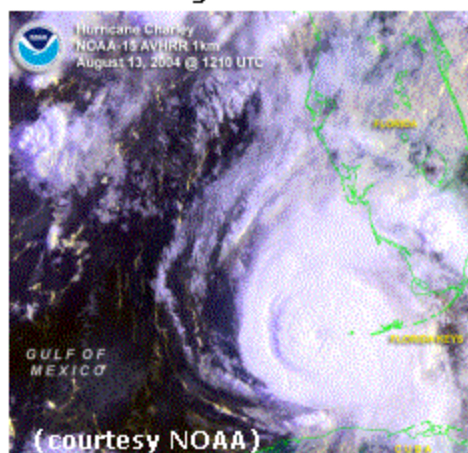
Charley continued a rapid progression across the central Caribbean Sea from the Windward Islands toward the island nation of Jamaica, gaining strength to near hurricane force winds of 65 mph by late on Tuesday evening. By early Wednesday afternoon, August 11th, Charley slammed into Jamaica as a minimal hurricane with wind speeds of 75 mph and minimum central pressure down to 993 millibars.

As the storm continued moving to the west-northwest, slow strengthening occurred as conditions remained favorable for continued development. Sustained winds climbed to 90 mph as Charley passed between the Cayman Islands and turned northwest toward Cuba mid-morning on Thursday (Figure 10). Rapid intensification brought Charley to category 2 status on the Saffir-Simpson hurricane intensity scale by the 1400 EDT advisory on the 12th as hurricane reconnaissance aircraft found a minimum central pressure of 980 millibars and maximum sustained winds of 105 mph.

Figure 10



Figure 11



EVENT SUMMARY (CONT.)

Crossing over the mountainous terrain of western Cuba had little effect on the intensity of Charley as the storm was undergoing additional strengthening as the trough over the eastern United States provided excellent outflow to the north and east of the center. Wind gusts to 124 mph were observed in Cuba during the early morning hours on Friday, August 13, 2004.

The storm continued to gain momentum as it approached the Florida Keys (Figure 11) and became a category 3 storm with 125 mph sustained winds by the 1300 EDT advisory on Friday (Figure 12) and a category 4 storm with 145 mph sustained winds only an hour later in a special advisory. Reconnaissance aircraft penetrating the storm found minimum central pressure of 945 millibars and a track deviation to the east of the forecast. Landfall occurred near Fort Myers, Florida, in the Punta Gorda and Charlotte Harbor areas later in the day Friday around 1700 EDT (Figure 12). Pressure within the storm had dropped to 941 millibars and winds remained at category 4 strength at an estimated 140 mph.

By 2100 EDT, Charley was moving north-northeast over the central Florida peninsula near Orlando with wind gusts to 105 mph observed. The track of Charley took the storm back over the open waters of the western Atlantic Ocean during the overnight period, taking aim on the South Carolina coastline Saturday morning.

CHARLEY

EVENT SUMMARY (CONT.)

Moving northeastward at nearly 30 mph, the eyewall of Charley came inland over South Carolina near Bulls Bay and McClellanville in northern Charleston County around 0900 EDT with maximum sustained winds estimated between 75 and 85 miles per hour. By 1100 EDT, the center of the storm was exiting the State along the border of North Carolina and South Carolina in Horry County where the official landfall, according to the National Hurricane Center, occurred near Little River Inlet, South Carolina and Calabash, North Carolina.

The storm weakened over land in North Carolina and became a tropical storm by early afternoon on the 14th and was rapidly losing tropical characteristics as the center neared Norfolk, Virginia, later in the evening at 2000 EDT on August 14th. Charley continued to race to the north-northeast making a second landfall on Long Island, New York, with 40 mph winds around 0500 EDT on Sunday, August 15th. By late morning, the tropical nature of Charley had vanished as the extratropical remnants passed off the coast of Cape Cod and out into the North Atlantic Maritimes.

Figure 12

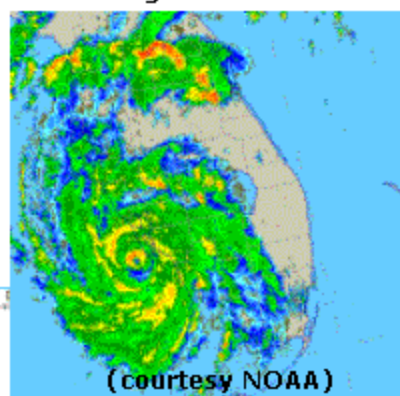
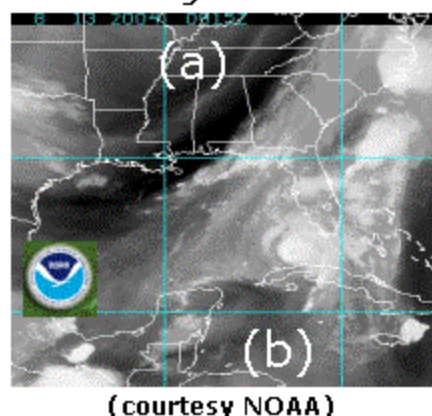


Figure 13



FORECAST CONSIDERATIONS

The same frontal boundary that stretched across the Appalachian Mountains in association with Bonnie remained in place as Hurricane Charley approached the Southeast United States. Interaction between the cold frontal boundary and tropical moisture flowing north from Charley created a prime environment for heavy rainfall amounts to occur.

FORECAST CONSIDERATIONS (CONT.)

In water vapor imagery (Figure 13), two notable features assisted forecasters in predicting the eventual track and intensity of the storm: (a) deep, southwesterly flow over the South at mid- and upper- levels associated with a trough, and (b) an upper level low pressure system ahead of Charley that moved westward with time. Due to the enhanced outflow provided by these features, pressures continued to fall and rapid intensification occurred during the pre-landfall time frame over the extreme southeastern Gulf of Mexico. Both steered the storm to the north-northeast as the storm passed Cuba.

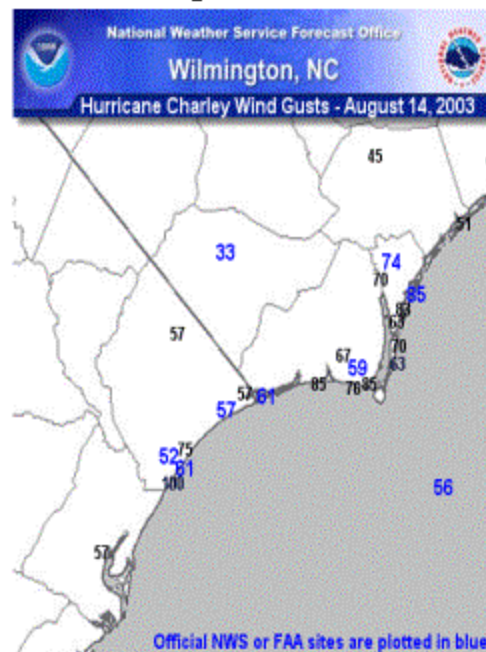
SOUTH CAROLINA EFFECTS

The storm reports from Charley are separated from those associated with Bonnie by a delineation of time in the early morning hours on Friday after the F1 tornado touched down near the Isle of Palms around 2355 EDT on Thursday evening.

A complete listing of observed winds, rainfall, and other significant weather events can be found in Table 1 on page 14 of this publication. Some selected observations for the north coast of South Carolina and, more specifically, Springmaid Pier are shown in Figures 14 and 16.

Tropical Storm Watches were issued from Altamaha Sound, Georgia, to South Santee River, South Carolina, on Thursday evening. This watch was upgraded to a Hurricane Watch/Tropical Storm Warning late Friday morning for the entire South Carolina coast. The entire area eventually saw a Hurricane Warning issued as the storm neared the State from the south-southwest.

Figure 14



(courtesy NWS Wilmington, NC)

CHARLEY

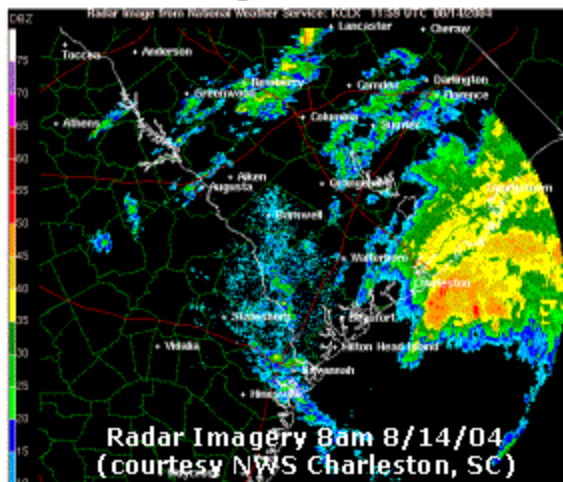
SOUTH CAROLINA EFFECTS (CONT.)

Unofficial reports of 25 to 35 mph wind gusts were received as early as 0500 EDT on Saturday in downtown Charleston, Folly Beach, Isle of Palms, and Hilton Head Island. The Edisto Buoy (41004), forty miles east of Charleston, reported peak winds of 40 mph. Sabsoon Tower, off the coast of Georgia near the path of Charley, reported a 60 mph wind gust before losing signal around 0528 EDT.

As Hurricane Charley accelerated toward the north-northeast, the threat for heavy rainfall in southern South Carolina diminished; hence, the Flood Watch for that region was cancelled around 0500 EDT. However, the threat for damaging winds remained.

Numerous reports of high winds and gusts were reported in the Charleston area between 0800 and 0900 EDT. Unofficial reports of 53 mph in downtown Charleston, 56 mph in Isle of Palms, and 58 mph at Folly Beach top the list. The Edisto Buoy 41004, 41 nautical miles southeast of Charleston, recorded the highest wind gust of 74 mph at 0850 EDT with 16 foot seas as the center of Charley passed by the South Coastal region. Flash flooding associated with heavy rainfall from Charley prompted a Flash Flood Warning for Charleston County in and around Sullivan's Island, Awendaw, McClellanville, and Wambaw Corner. Further warnings over the next several hours in Horry and Georgetown Counties lasted into the early afternoon

Figure 15

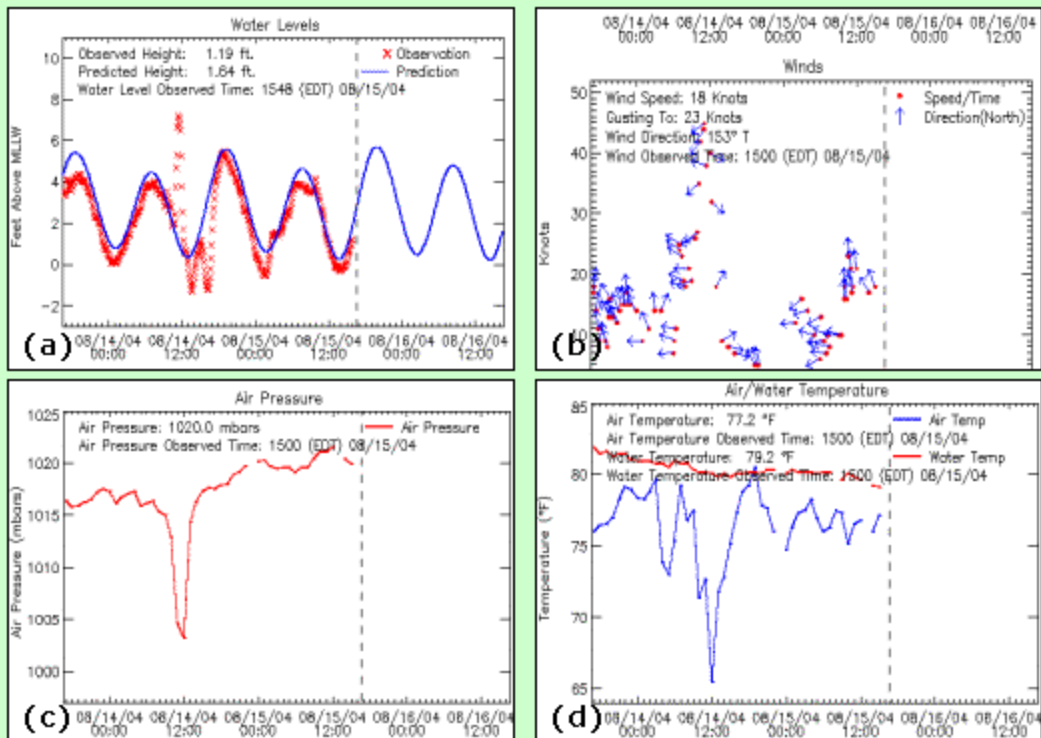


The center of Charley began losing tropical characteristics as it brushed Cape Romain and Bulls Bay in Charleston County. Radar indicated dual circulation centers along the South Carolina coast approximately 80 miles south-southwest of Georgetown at 0800 EDT (Figure 15). Typically, this signature is indicative of a separation of the mid- and low-level centers as the storm transitions to an extra-tropical low pressure system.

CHARLEY

Figure 16

DATA AT SPRINGMAID PIER (Myrtle Beach, SC)



Meteorological data from the Springmaid Pier in Myrtle Beach, SC, as Hurricane Charley passed the area on August 14, 2004, including: (a) water/tide levels, (b) wind direction/speed, (c) air pressure, and (d) air/water temperature. (Graphics courtesy NWS Wilmington)

SOUTH CAROLINA EFFECTS (CONT.)

The Storm Prediction Center in Norman, Oklahoma, issued a Tornado Watch Box effective until 1300 EDT on Saturday, August 14, 2004, in preparation for the effects of the outer bands of Hurricane Charley. Inland Tropical Storm Wind Warnings were hoisted by the National Weather Service offices in Charleston and Wilmington for inland areas of coastal South Carolina for Friday night and Saturday. Actual observed winds were within tropical storm force range (Figure 14), especially along the north coastal region.

CHARLEY

SOUTH CAROLINA EFFECTS (CONT.)

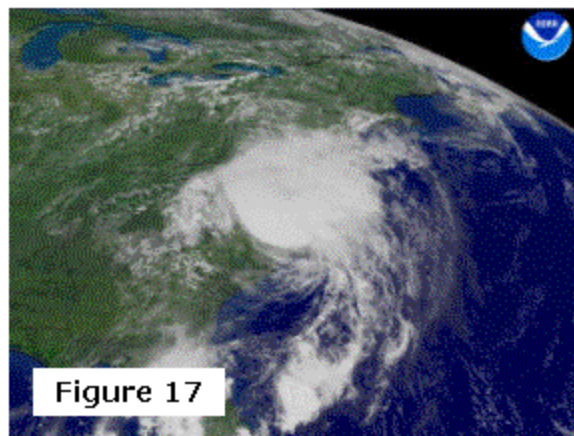
A Flood Watch was also in effect through 2000 EDT for most of eastern and central South Carolina in expectation of heavy rainfall from Charley falling in regions that received several inches from Bonnie. Hurricane Local Statements from both National Weather Service Offices throughout the predawn hours on Saturday outlined the potential for high winds of 55 to 75 mph sustained with gusts to 85 mph, storm surge reaching 3 to 5 feet above tide (up to 8 feet on south facing beaches), rip currents, high seas to 16 feet, flooding, 3 to 6 inches additional rainfall, and possible tornadoes.

As the cooler, drier air over the Upstate of South Carolina became entrained into the tropical cyclone from the west, a band of showers and thunderstorms erupted along the frontal boundary from near Newberry northward to near Winston-Salem. The lifting mechanism, provided by the wedge of cool, dry air sliding eastward under the warm, moist (and therefore buoyant) air associated with Charley, allowed convection to fire over inland regions.

In Chester and Union Counties, the same areas that observed heavy rains from Bonnie also received an estimated 2 inches within 3 hours time on Saturday. This resulted in Flash Flood Warnings through mid-afternoon for both counties. No official storm reports were collected in Chester County. However, Union County emergency management officials reported roads closed and a bridge washed out at Potter and McWhorter Road.

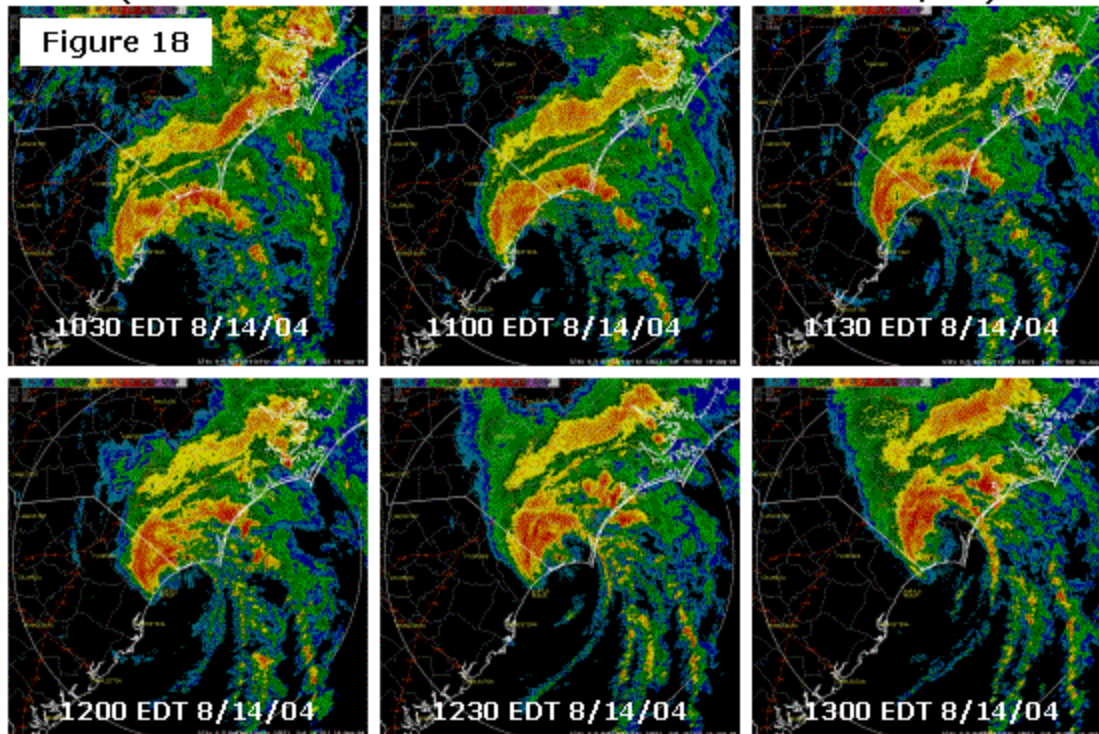
*Visible Satellite Image
of Hurricane Charley
taken August 14,
2004, at 1245 EDT.*

*(Graphics courtesy
NWS Wilmington)*



CHARLEY

CHARLEY CROSSES SOUTH CAROLINA (NWS RADAR IMAGERY FROM WILMINGTON, NC)



SOUTH CAROLINA EFFECTS (CONT.)

As the circulation passed near land, bands of thunderstorms rotating around the center increased the risk for tornadic storms along and near the path of the cyclone. Within the eye wall, at least one tornado was indicated by Doppler radar 4 miles south of the town of McClellanville in Charleston County at 0953 EDT. Shortly after 1000 EDT, an F0 tornado crossed from Berkeley County near Shulerville into Charleston County in the Francis Marion National Forest leaving a three-mile long path.

By 1100 EDT, the primary threat to South Carolina remained the potential for heavy rains and high winds in the northeastern corner of the state as the center of Charley made landfall north of Myrtle Beach and moved into North Carolina (Figures 17-18). Flash Flood Watches for the Midlands and South Coastal regions were discontinued along with any Inland Wind Warnings associated with Charley, but remained in effect for the northernmost Coastal sections of the State.

CHARLEY

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SOUTH CAROLINA RESPONSE

No mandatory evacuation orders were issued for the South Coast of South Carolina for Charley. A voluntary evacuation was recommended for people on barrier islands in Charleston County. Less than 3,000 evacuated throughout the county warning area of the Charleston National Weather Service Office. Only several hundred of the evacuees sought cover in shelter operations. The counties covered by the Charleston office include: Allendale, Beaufort, Berkeley, Charleston, Colleton, Dorchester, Hampton, and Jasper Counties in South Carolina.

Evacuations were mandatory in Georgetown and Horry Counties east of U.S. 17, and about 180,000 people left the Grand Strand.

CLIMATOLOGICAL PERSPECTIVE

For the purposes of the report on Charley, the climatological perspective will include information on the significant event data that were reported from the National Weather Service Offices in Charleston and Wilmington in their respective Post Tropical Cyclone Reports released as Public Information Statements (Table 1). This information is given in tabular format on the following page.

Both National Weather Services Offices in Wilmington, North Carolina, and Charleston, South Carolina, have provided important weather information to the public with regard to the impact of Charley on South Carolina's coastal region. Additional information may be found at their websites using the following links:

National Weather Service Forecast Office – Wilmington, NC

<http://www.erh.noaa.gov/er/ilm/>

National Weather Service Forecast Office – Charleston, SC

<http://wchs.csc.noaa.gov/>

Table 1

SOUTH CAROLINA SIGNIFICANT EVENTS

Location	Source	Sustained Wind (degrees/mph)	Peak Wind (degrees/mph)	Pressure (mb)	Rainfall (inches)	Surge + Tide (feet)	Erosion
Charleston Airport	NWS CHS	360/29	360/38	1008	1.02	---	minor
Edisto Buoy 41004	NWS CHS	160/49	160/74	1001	---	---	minor
Folly Beach CMAN	NWS CHS	070/47	070/57	1005	---	---	minor
Downtown Charleston	NWS CHS	030/37	050/51	---	2.09	---	minor
Pineville	NWS CHS	330/19	330/28	---	0.19	---	minor
Isle of Palms	NWS CHS	010/49	010/63	1001	2.00	---	minor
Hampton	NWS CHS	---	---	---	1.53	---	minor
Ravenel	NWS CHS	---	---	---	0.45	---	minor
Walterboro	NWS CHS	---	---	---	0.40	---	minor
Summerville	NWS CHS	---	---	---	0.24	---	minor
Charleston Harbor	NWS CHS	---	---	---	---	5.63	minor
Oyster Landing	NWS CHS	---	---	---	---	5.00	minor
Cape Island	NWS CHS	---	---	---	---	6.00*	minor
N. Myrtle Beach Airport	NWS ILM	110/41	110/57	998	1.52	---	none
Myrtle Beach Airport	NWS ILM	310/40	52*	---	---	---	none
Springmaid Pier	NWS ILM	055/45	61*	998.2	---	7.19	none
Little River Fire Dept.	NWS ILM	---	57*	---	1.69	---	none
Myrtle Beach Pavilion	NWS ILM	---	75*	---	2.60	---	none
Loris	NWS ILM	---	57*	---	3.09	---	none
Surfside Town Hall	NWS ILM	59*	98* and 100*	---	---	---	none
Georgetown	NWS ILM	---	57*	---	---	---	none
Florence Airport	NWS ILM	020/23	020/29	1014	0.03	---	none
Conway	NWS ILM	---	---	---	4.25	---	none
Conway (Horry EOC)	NWS ILM	---	---	---	3.97	---	none
Outland	NWS ILM	---	---	---	2.97	---	none

NWS CHS (National Weather Service - Charleston, SC) and NWS ILM (National Weather Service - Wilmington, NC)

--- indicates missing or unavailable data

* Estimated data or partial data (i.e. wind direction not given)

Horry and Georgetown Counties: The National Weather Service in Wilmington estimates about \$5 million in insurance claims in Horry and Georgetown Counties, mostly along the Grand Strand of Horry County, including: (a) downed trees, roof damage, and flooding along the coast, (b) inland flooding, (c) 65,000 people without power, (d) 50,000 dollars damage at Surfside, and (e) 1.5 million dollars damage in Georgetown County government costs and cleanup. A second study from Coastal Carolina University's Coastal Federal Center for Economic and Community Development indicated Hurricane Charley cost Grand Strand hotels an estimated \$30 million in lost revenues. Hotel occupancy dropped to 34%. A summer week usually brings \$120 million in revenue for the hotels.

ACKNOWLEDGMENTS

A special thanks to the National Oceanic and Atmospheric Administration (NOAA) and its many divisions for the wealth of weather and climate data made available to prepare this report. (<http://www.noaa.gov>)

*The State Climatology Office website is
<http://www.dnr.state.sc.us/climate/sco>*

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CHARLEY