ANNUAL SUMMARY

Atlantic Hurricane Season of 1985

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ABSTRACT

A summary of the 1985 hurricane season is presented, including detailed accounts of individual hurricanes. There were eleven named tropical cyclones, seven of which reached hurricane force. A record-tying six hurricanes crossed the U.S. coastline causing a record damage of $4 billion.

1. Introduction

The 1985 hurricane season produced 11 named tropical cyclones in the Atlantic basin, seven of which became hurricanes. Statistics for the year are given in Table 1. This is close in number to the long-term average of ten tropical cyclones, of which six usually attain hurricane strength. However, in 1985, unlike any year since 1916, six hurricanes and two tropical storms struck the continental United States (Fig. 1).

The eight landfalling tropical cyclones resulted in gale warnings being issued for the entire coastline from Brownsville, Texas to Eastport, Maine. Also portions of every coastal state were at one time or another placed under a hurricane warning. The Texas coast south of Freeport, a small section of the southwest Florida coast, the east Florida coast north of Jupiter Inlet, and most of the Georgia coast were the only coastal sections not to be placed under hurricane warnings (Fig. 2). Portions of Louisiana, Mississippi and Alabama were placed under hurricane warnings for three different hurricanes. In addition, Mississippi and Alabama had warnings posted, discontinued, and then placed in effect for a second time within a three-day period for Elena.

Louisiana was struck by three hurricanes (Danny, Elena, Juan). During this century only North Carolina (1955) and Florida (1964) have been struck by as many as three hurricanes in a given year. Hurricane Kate, a mid-November hurricane, became the fourth November hurricane to strike the U.S. coastline this century. All four November strikes have been in Florida.

The large number of cyclones striking the coastline affected a record number of people and produced a dollar loss of more than $4 billion, the largest in history. Fortunately, most coastal residents apparently took corrective action since loss of life was relatively low (30), considering the number of coastal strikes and the population affected.

Finally, for the fourth straight year, no hurricanes were recorded over the Caribbean Sea. This event is unprecedented since records began in 1871. However, what appears to be an unusual event may just be reflective of the large natural variability of hurricane occurrences and the relatively short climatological record on which to base our determination of what is unusual.

2. Individual storms

a. Tropical Storm Ana, 15–19 July

Ana, the season's first tropical storm had its origin in the upper atmosphere about 2400 km to the east-northeast and nearly a week prior to where the depression first formed. A 200 mb cutoff low formed on 8 July near 30°N, 45°W. During the following week an area of showers and thunderstorms, which had formed in response to the upper low, drifted toward the west-southwest with the upper low.

By 0000 GMT 14 July, a weakness in the surface ridge of high pressure, which had been well established along 35°N, began to appear about 800 km southeast of Bermuda. At 0000 GMT 15 July, a surface low pressure area had formed near 29°N, 62°W. Ship data confirmed that a circulation developed within the following 12 to 18 hours and a depression advisory was issued at 2200 GMT 15 July.

The 200 mb low continued to drift toward the west-southwest for the following few days while the newly formed depression began to move toward the northwest. The depression deepened slowly and made an archlike curve to the west of Bermuda. At 1925 GMT 16 July, Air Force reconnaissance found a surface pressure of 1009 mb with surface winds of 18–21 m s^{-1} and the depression was immediately upgraded to Tropical Storm Ana.

Ana continued to strengthen as it recurved and began to accelerate toward the northeast in response to an advancing frontal trough. The center of the tropical storm passed within 80 km of Sable Island, where the weather office recorded maximum wind gusts of 28 m s^{-1} and a minimum pressure of 996.7 mb.

TABLE 1. 1985 Hurricane season statistics.

Number	Name	Type*	Dates**	Maximum sustained wind[a] ($m\ s^{-1}$)	Lowest pressure (mb)	U.S. damage ($millions)	U.S. deaths
1	Ana	T	7/15–7/19	31	996		
2	Bob	H	7/21–7/26	34	1002		
3	Claudette	H	8/09–8/17	39	980		
4	Danny	H	8/12–8/20	40	987	50	1
5	Elena	H	8/28–9/04	56	951	1250	4
6	Fabian	T	9/15–9/19	29	992		
7	Gloria	H	9/16–10/02	65	919	900	8
8	Henri	T	9/21–9/25	26	996		
9	Isabel	T	10/07–10/15	31	997		
10	Juan	H	10/26–11/01	38	971	1500	12
11	Kate	H	11/15–11/23	54	953	300	5

* T: tropical storm, wind speed 17–32 $m\ s^{-1}$. H: hurricane, wind speed 33 $m\ s^{-1}$ or higher.
** Date begins at 0000 GMT.
[a] Estimated maximum one-minute average surface wind speed.

When Ana moved over Newfoundland on 19 July it had already lost most of its tropical characteristics. Large temperature gradients existed within the system and maximum winds were no longer near the center of the storm but had spread several hundred km to the east and south of the center. Strongest winds reported on the island were only 10 $m\ s^{-1}$, while oil rigs and ships located over the waters well to the east received sustained winds of 23 $m\ s^{-1}$. By the afternoon of 19 July, the extratropical storm was well entrenched in the frontal trough and continued to accelerate toward the east-northeast over the cold waters of the open North Atlantic.

b. Hurricane Bob, 21–26 July

Bob was a tropical storm that briefly reached hurricane force before moving inland across the South Carolina coast.

Satellite pictures suggest that Bob developed within the cloud remnants of a tropical wave which moved into the eastern Gulf of Mexico on 20 July. On the 21st, a reconnaissance aircraft found that a low pressure center had formed off the southwest Florida coast. The system moved slowly eastward and was named Tropical Storm Bob at 2200 GMT 22 July after an aircraft measured a wind speed of 19 $m\ s^{-1}$ at an altitude of 500 meters.

The storm center moved onshore across the southwest Florida coast between Naples and Fort Myers midday on the 23rd. Strongest winds and heaviest rains occurred over the southern quadrant of the storm. Naples had sustained winds of 18 $m\ s^{-1}$ with gusts to 26 $m\ s^{-1}$ and received 306.6 mm of rain, while the storm total at Everglades City was 546.1 mm. Rainfall amounts were considerably less across the remainder of South Florida as Bob's forward speed increased and the storm turned sharply toward the north. By 0000 GMT 24 July, Bob was moving due north at 5 $m\ s^{-1}$ near Vero Beach on the Florida east coast. The storm had little effect other than to produce beach erosion on the eastern Florida or Georgia coast as it moved northward.

Reconnaissance aircraft reported minimal hurricane force winds and Bob was upgraded to a hurricane prior to making landfall on the South Carolina coast. Bob's central pressure never fell below 1002 mb, which is a rather high central pressure even for a minimal hurricane. However, ambient surface pressures near and to the east of the hurricane were very high, as Bob was embedded in the western extension of the subtropical high pressure ridge, resulting in strong pressure gradients.

Even though the center of Hurricane Bob crossed the South Carolina coast near Beaufort, maximum winds were recorded in rainbands well to the east. A U.S. Coast Guard station at Georgetown, South Carolina, reported winds of 26 $m\ s^{-1}$, which were the strongest sustained winds reported by a coastal station. Peak gusts of 37 $m\ s^{-1}$ were reported in spiral rainbands at Holden Beach, North Carolina, at 0730 GMT 25 July, some 220 km east of the center. Table 2 contains additional meteorological data.

Bob contained to move northward through South Carolina and fell below storm strength as the center moved into Virginia by 1800 GMT 25 July. The remnants of Bob merged with a frontal trough early on the 26th over West Virginia. There were no deaths attributed to Bob and damage was minor.

c. Hurricane Claudette, 9–17 August

The incipient stage of Claudette can be traced to a trough aloft over the Mississippi Valley with a weakness at the surface near the north-central coast of the Gulf of Mexico on 7 August. A closed circulation at 700 mb appeared on the 8th and at 850 mb on the 9th as the system moved eastward. A low pressure area formed

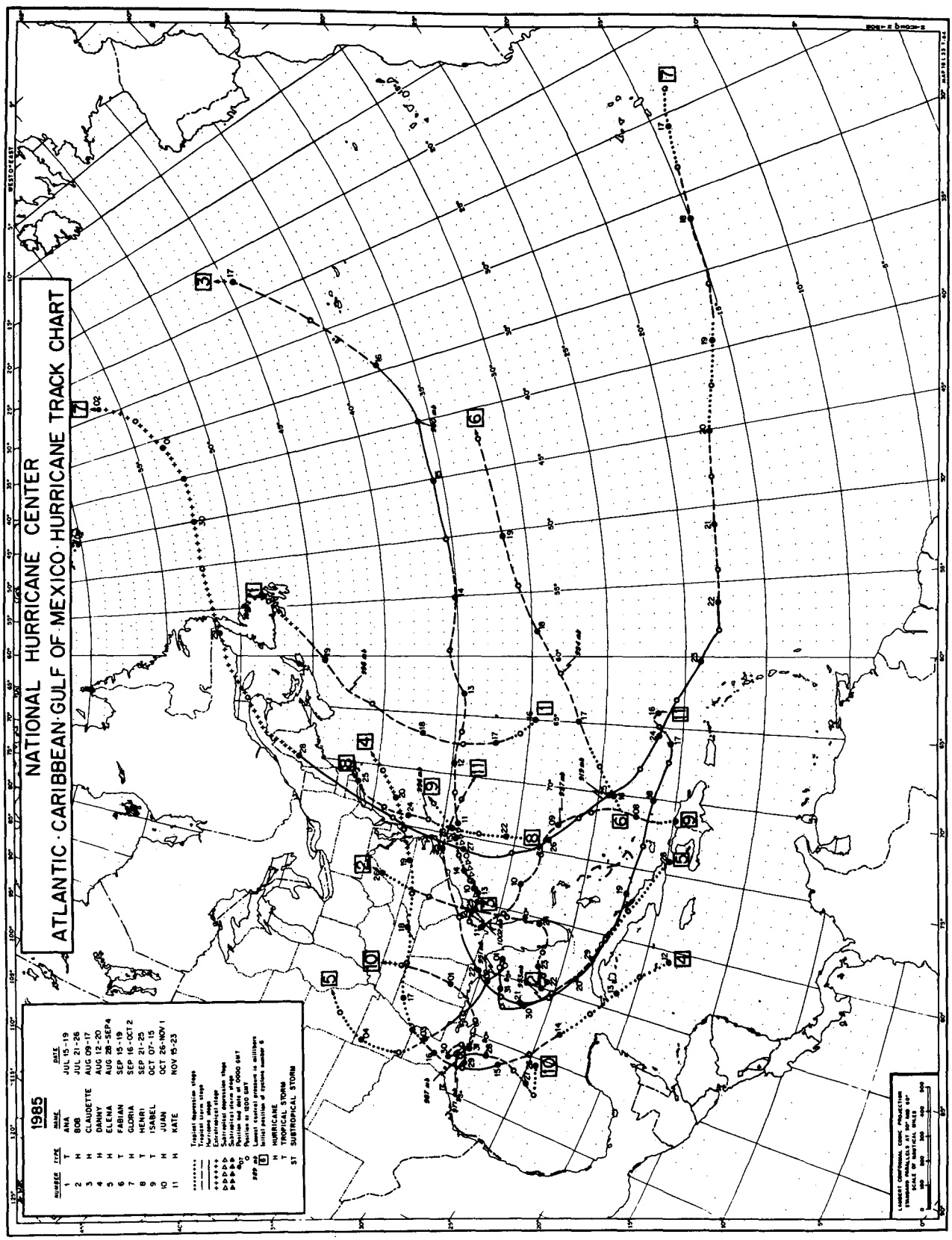

FIG. 1. Tracks of the 1985 tropical storms and hurricanes.

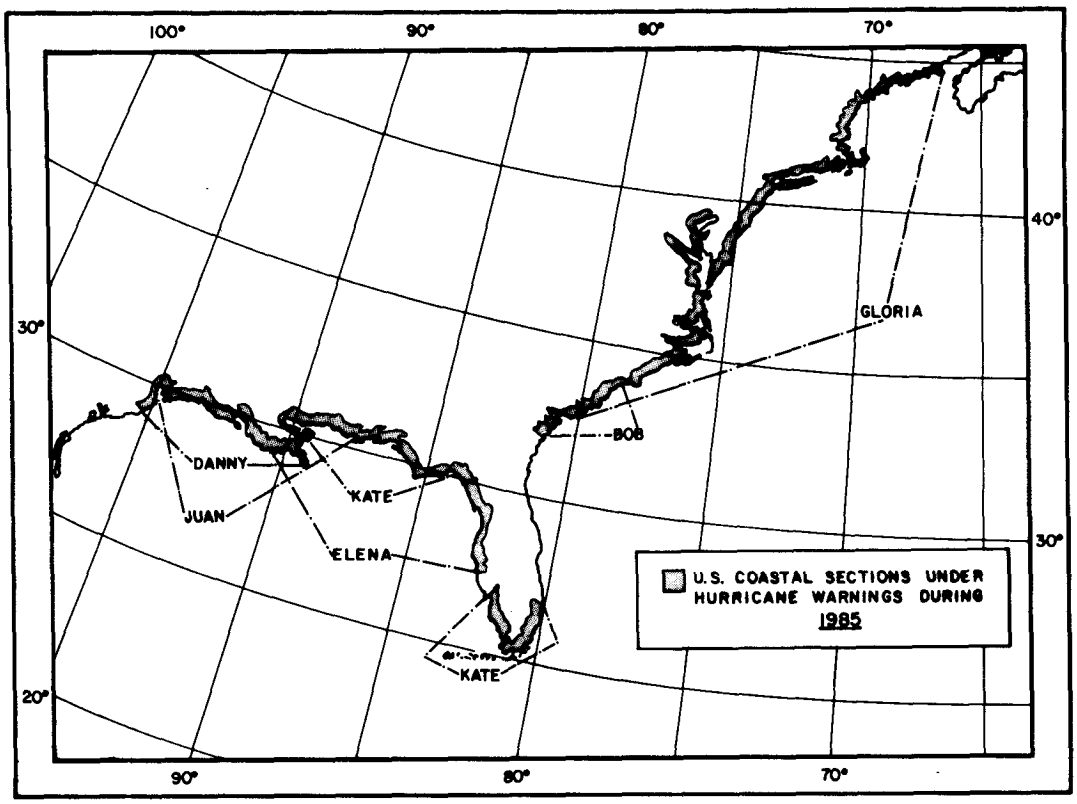

FIG. 2. Shaded areas indicate sections of the U.S. coastline placed under hurricane warnings during the 1985 season.

at the surface just off the Georgia coast by 1800 GMT on the 9th.

The center of the subtropical low moved toward the northeast across the warm waters of the Gulf Stream. Convection around the system organized into spiral bands and reconnaissance aircraft indicated that a warming in the core of the system had begun. Within 36 hours (0000 GMT 11 August) the subtropical system attained tropical characteristics and reached tropical storm strength while located about 225 km southeast of Cape Hatteras, North Carolina. Maximum wind gusts of 19 m s^{-1} and a pressure of 1006.1 mb were recorded by NOAA Data Buoy 41001 (34.9°N, 72.9°W) as the developing storm passed within 70 km to the south of the buoy on the 11th.

Thereafter, the storm turned eastward and gradually strengthened as it continued to move in this direction through midday on the 15th. Estimates based upon satellite imagery indicated that the storm attained hurricane strength by 0600 GMT 14 August. An estimated minimal central pressure of 980 mb was attained near 1200 GMT 15 August, while the hurricane was located over water with temperatures of 26°–27°C. Soon thereafter Claudette began a gradual turn to the northeast and weakened to a tropical storm over the colder water. Claudette passed directly over Corvo in the Azores. Maximum wind recorded in the islands was a peak gust of 34 m s^{-1} reported near Lajes. Claudettte became extratropical about midway between the Azores and Ireland by 0000 GMT 17 August while moving toward the northeast over 22°C water.

d. Hurricane Danny, 12–20 August

The system which was to become Hurricane Danny moved off the west coast of Africa as a tropical wave on 30 July. The tropical wave moved westward in the trade wind belt, entering the eastern Caribbean on 8 August. Shower activity associated with the system increased as it moved through the eastern Caribbean. By midday on 10 August, a broad low pressure area with a minimal central pressure of 1010 mb developed over the central Caribbean. An Air Force reconnaissance aircraft investigated the area early on 12 August and found that a tropical depression had formed just west of Grand Cayman Island.

After moving northwestward over the western tip of Cuba into the southeast Gulf of Mexico, the depression intensified rapidly, reaching hurricane strength on the afternoon of 14 August, about 200 miles off the Louisiana coast. Hurricane Danny reached its maximum strength of 987 mb as it made landfall just southeast of Lake Charles, Louisiana midday on 15 August. The hurricane quickly weakened to tropical storm strength as it moved inland across Louisiana. The system remained identifiable as a tropical depression and low

TABLE 2. Hurricane Bob surface observations, July 1985.

Location	Pressure (mb)	Date/time (GMT)	Wind (m s^{-1}) 1-min average	Gust	Date/time (GMT)	Tide (m) Height above normal	Rain (mm) Storm total
Florida							
Everglades City							546.1
Naples			18	26	23/1535		306.6
Georgia							
Savannah Light (C-Man)	1002.8	25/0100	22		25/0000		
South Carolina							
Beaufort	1003.1	25/0308	10	14	25/0027		34.8
Charleston WSO	1010.1	25/0510	17	21	25/0237		127.0
Charleston Harbor			20	35	25/0300	0.5	
Crescent Beach			8	15	25/1153		97.5
Edisto Beach	1009.8	25/0430	12	26	25/0300	0.8 est	
Folly Beach (C-Man)			22	25	25/0300		
Georgetown			26	28	25/1000		
Hilton Head			7	12	25/0100		
McClellanville			23	27	25/0530		
Myrtle Beach	1014.9	25/0900	15	26	25/1153		197.9
Springmaid Pier			19	25	25/0900	0.3 est	
North Carolina							
Greensboro	1008.3	25/1530	10		25/1550		62.2
Holden Beach			16	37	25/1200		
Leland							100.8
Pope AFB			9	18	25/1430		
Red Springs							166.4
Raleigh	1015.6	25/1550	11	16	25/1550		48.3
Seymour Johnson AFB			8	12	25/1555		
Wilmington	1019.3	25/0351	13	19	25/1235		62.7

TABLE 3. Hurricane Danny surface observations, August 1985.

Location	Pressure (mb)	Date/time (GMT)	Wind (m s^{-1}) 1-min average	Gust	Date/time (GMT)	Tide (m) Height above normal	Rain (mm) Storm total
Texas							
Port Arthur	1005.4	15/2048	10	17	15/1952		
Sabine Pass						0.9	
Louisiana							
New Orleans NWS	1007.5	15/2153	15	21	15/1313		76.2
Lake Charles NWS	997.3	15/1843	15	23	15/1850		104.1
Old Vermilion Locks						2.4 est	
Bayou Boeff						1.6 est	
Baton Rouge	1002.1	15/2107	11	16	15/2158		97.5
Kentwood							217.7
Mississippi							
Keesler AFB	1010.5	15/2155	11	21	15/1548		52.3
Alabama							
Mobile NWS	1012.2	16/0045	10	16	15/1410	0.5	
Dauphin Island						0.9	
Selected oil rig, ship and data buoy observations (anemometer heights and characteristics vary from site to site).							
Conoco Oil Rigs							
EC 42B 29.5°N 92.8°W			41	52	15/1327		
VR 242A 28.2°N 92.6°W			31	49	15/1200		
SM 108G 28.4°N 92.0°W			36	44	15/0500		
NOAA Data Buoy							
25.9°N 89.7°W			21	27	14/1800		
Ship WFGW							
23.7°N 87.3°W			18				

pressure system as it moved northeast toward the Atlantic coast where it merged with a frontal trough and became extratropical.

Maximum winds measured by aircraft near the coast at the time of landfall were 40 m s^{-1}. Table 3 lists various surface observations taken during Danny. The core of the hurricane moved over a sparsely populated coastal region in Louisiana, thus damage was minimized. Estimated tides ranged from 1.5 to 2.7 m along the Louisiana coast to 0.6 to 1.0 m above normal along the Alabama and Mississippi coasts. One life was lost and estimated damages ranged from $50 million to $100 million.

e. Hurricane Elena, 28 August–4 September

1) GENERAL DESCRIPTION

Elena, like Danny, had its beginnings over Africa. A well-organized cloud pattern moved off the African coast and was first identified on satellite imagery north of the Cape Verde Islands on 23 August. An unusually fast forward speed of 15 m s^{-1}, combined with the dry Saharan air mass surrounding the disturbance, apparently inhibited the formation of a tropical cyclone until the system approached Cuba the evening of 27 August.

Elena was named on 28 August when the center was over central Cuba and reconnaissance aircraft measured 26 m s^{-1} winds north of the center. The tropical storm moved toward the northwest and intensified to hurricane strength on 29 August after it moved over the open waters of the southeast Gulf of Mexico.

A collapse of the steering currents over the hurricane caused a marked decrease in Elena's forward speed as the hurricane moved into the north central Gulf on 30 August. A frontal trough turned Elena toward the east-northeast, thereby posing a threat to the Florida panhandle and the west coast of Florida. Elena made an anticyclonic loop off Cedar Key, as the steering currents again collapsed. High pressure began building over the eastern U.S. behind the trough and the hurricane began a gradual acceleration toward the west-northwest. Figure 3 shows the erratic track of Elena. The hurricane reached a minimum pressure of 951 mb at 1939 GMT 1 September while centered about 120 km south of Apalachicola, Florida. Figure 4 shows Elena about an hour prior to its lowest pressure. The hurricane weakened somewhat thereafter, and the center made landfall near Biloxi, Mississippi, with a central pressure of 959 mb.

2) DATA

Maximum winds reported from the coast were on Dauphin Island, Alabama, with sustained winds of 47 m s^{-1} and gusts to 61 m s^{-1}. Highest tides along the coast occurred near Apalachicola, Florida, where storm surge reached 3 m. Heaviest rainfall occurred over the northern Florida peninsula, where a storm total of 290.6 mm was recorded. See Table 4 for additional data on Elena.

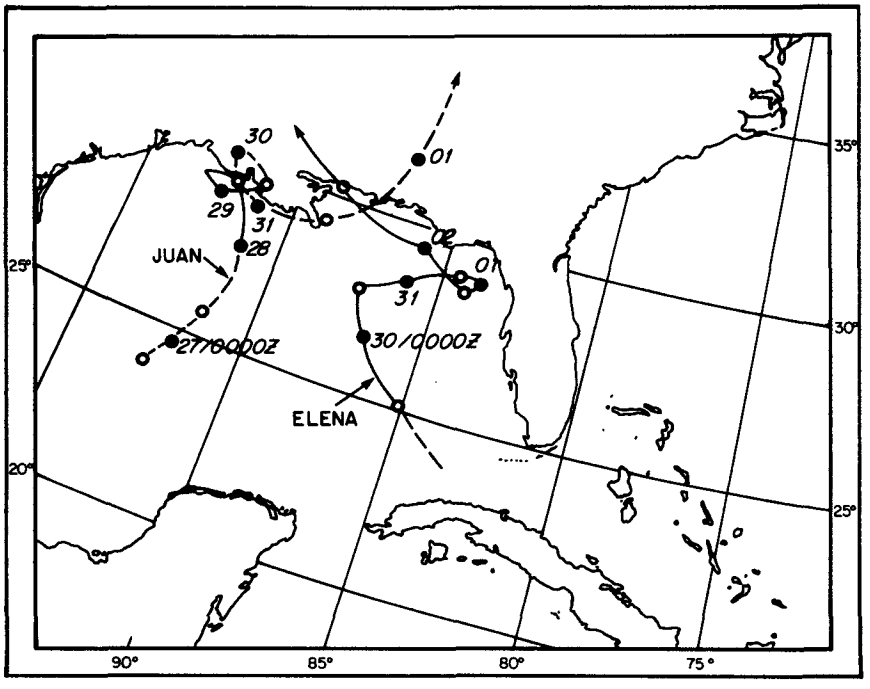

FIG. 3. The erratic tracks taken by Hurricanes Elena and Juan as they approached the U.S. coastline.

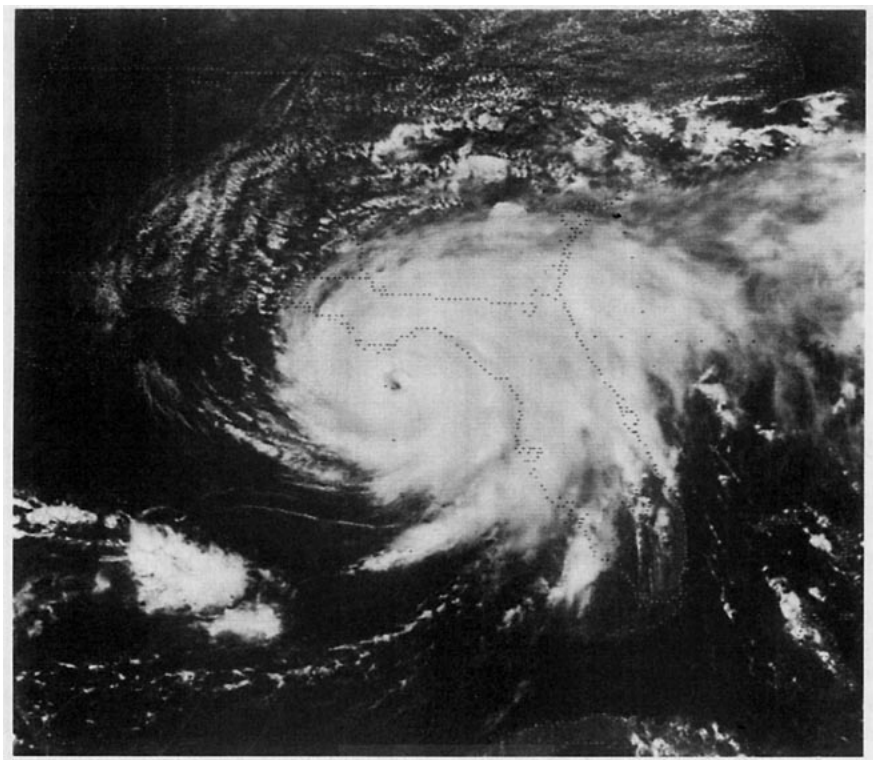

FIG. 4. GOES-West visible satellite picture of Hurricane Elena at 1831 GMT 1 September. The well-defined eye (954 mb) is located about 120 km south of Apalachicola, Florida.

3) DEATHS AND DAMAGE

Nearly a million people were evacuated from low-lying coastal areas in the warning area, with a large section of the middle Gulf of Mexico coast being asked to evacuate twice within a three-day period. This is the largest number of people ever evacuated and may account for the fact there were no deaths in the area of landfall. The four deaths attributed to Elena were caused by falling trees, automobile accidents and heart attacks.

Estimates of total economic loss from Elena are near 1.25 billion. This includes a devastating blow to the oyster industry in the Apalachicola area as well as extensive beach erosion and damage to Gulf front property from the mouth of the Mississippi River to the Fort Myers area of Florida.

f. Tropical Storm Fabian, 15–19 September

Fabian formed from an area of disturbed weather which combined with an old frontal system in the Atlantic several hundred miles north of the island of Hispaniola. On 15 September, the depression began to move along the front toward the northeast and attained storm strength by the afternoon of 16 September. Fabian reached its lowest pressure of 992 mb by the morning of 17 September. Thereafter, a new low pressure center began to develop to the northeast of Fabian and the tropical storm lost its identity in the circulation of the new, much larger, nontropical storm by midday on 19 September.

g. Hurricane Gloria, 16 September–2 October

1) GENERAL DESCRIPTION

The disturbance which was to become Hurricane Gloria moved off the west African coast on 15 September. Based upon the European METEOSAT satellite, the system became a tropical depression near the Cape Verde Islands on 16 September and remained near minimal storm strength for several days while traveling toward the west-northwest at 8 to 10 m s^{-1} across the tropical Atlantic Ocean.

Aircraft reconnaissance began on the 21st, when the storm was centered about 750 km east of the Lesser Antilles. On the next day, a reconnaissance aircraft measured winds of 35 m s^{-1} at an altitude of 500 m, and Gloria was upgraded to a hurricane.

The two previous tropical storms (Fabian and Henri) had created a weakness over the western portion of the strong Atlantic surface ridge of high pressure. The ridge had forced Gloria to maintain its westerly course across the tropical Atlantic. However, by the 22nd, the hurricane began to respond to this weakness and changed its direction of motion from due west to northwest, placing it on a track to the north of the Leeward Islands.

TABLE 4. Hurricane Elena surface observations, 28 August–04 September 1985.

Location	Pressure (mb)	Date/time (GMT)	Wind (m s^{-1}) 1-min average	Wind (m s^{-1}) Gust	Wind (m s^{-1}) Date/time (GMT)	Tide (m) Height above normal	Rain (mm) Storm total
Florida							
Key West	1011.0	28/2220	18	24	29/0643	0.6	44.7
Conch Key			23		29/0300		
Sarasota							87.9
Tampa (Intl Arpt)	1003.7	01/0048	14	20	31/1541		89.2
St. Petersburg							79.0
Clearwater				31	31/1232		139.7
Chiefland							224.8
Tarpon Springs							161.0
Cedar Key			20	27	31/1930	1.8	
Tallahassee	1002.9	01/2148	13	20	01/2349	1.8	84.3
Dixie County			22	31			266.7
Apalachicola	993.8	01/1935	24	30	01/2145	1.2	287.3
Tyndall AFB	998.7	01/2216	15	28			20.6
Eglin AFB			15	30			
Pensacola NAS	997.6	02/0655	24	36	02/0055		63.0
Pensacola Reg Arpt	1001.4	02/0650	22	41	02/0725		65.0
Alabama							
Mobile WSO	997.9	02/0942	24	27	02/1020	1.2	59.7
Dauphin Island	954.6	02/0905	47	59	02/0933	2.1	76.2
Mississippi							
Pascagoula	953.3	02/1015	41	53		2.4	
Harrison County CD	967.2	02/1300	41	49	02/1100	1.8	
Ocean Springs			41	52	02/1312	2.4	
Keesler AFB	963.8	02/1300				1.2	
Columbia				27	02/1615		
Tylertown			23	28	02/1700		
Magnolia				27	02/1840		32.8
Liberty			23	27	02/1930		35.6
Jackson	1009.3	02/2051	14	16	02/2057		9.4
Natchez							80.0
Louisiana							
Slidell WSFO	995.3		13	23	02/1615		66.3
New Orleans (Intl)	1003.4		12	14	02/1448		52.1
Pearl River Locks							145.5
Covington							98.6
Bogalusa							89.9
Arkansas							
Baxter County							215.9
Clinton							218.4
Little Rock							68.8
Florida							
Jacksonville (Intl Arpt)							268.5
Gainesville (Reg Arpt)				21			143.0
St Augustine				31			105.9
Manatee Springs							290.6
Carabelle	999.4	01/2019	27	43	01/2024		

Gloria reached a minimum pressure of 919 mb at 0120 GMT 25 September while located approximately 500 km north of Hispaniola, 1500 km southeast of Cape Hatteras, or 52 hours prior to landfall. The 919 mb pressure represents the lowest pressure ever measured by reconnaissance aircraft over the Atlantic Ocean. Maximum flight level winds measured by reconnaissance aircraft at this time were 65 m s^{-1}.

The hurricane began to weaken as it gradually turned northward following the western edge of the mid-Atlantic ridge of high pressure. Figure 5 shows Gloria located east of the Bahama Islands with a central pressure of 930 mb. As Gloria approached the U.S. East Coast, it passed within 75 km to the west of a NOAA data buoy. At 2000 GMT 26 September, buoy 41002, located at 32.4°N, 75.3°W (about 100 km east-north-

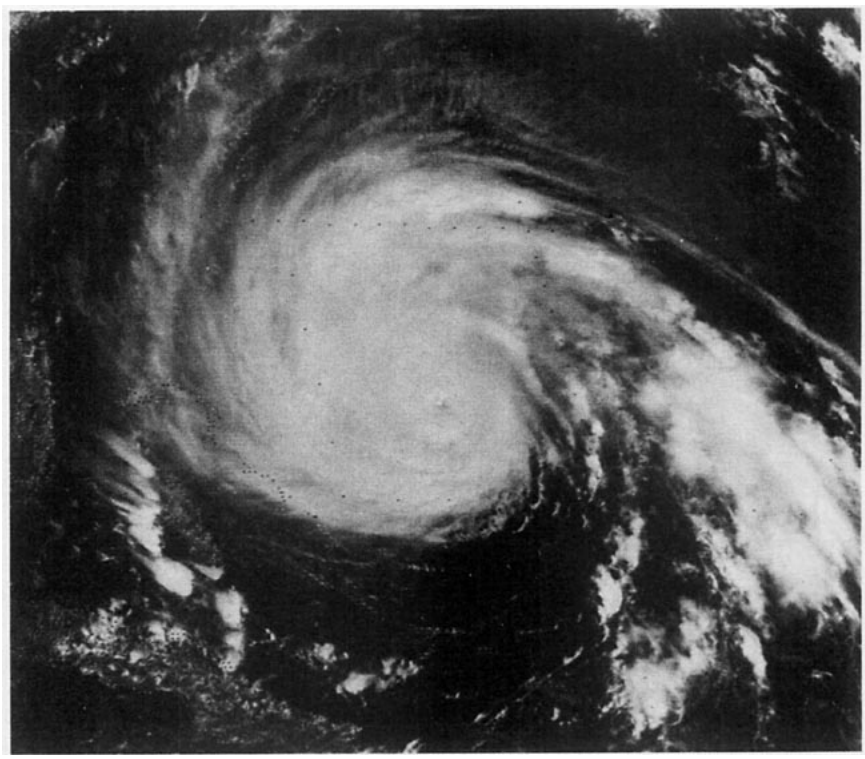

FIG. 5. GOES-West visible satellite picture of Hurricane Gloria (930 mb) at 1601 GMT 25 September.

east of the center of Gloria) measured a sea height of 14.3 m. This was the highest sea ever recorded by a NOAA data buoy in a tropical cyclone.

The center of Gloria crossed over the Outer Banks of North Carolina with a central pressure of 942 mb early on the 27th and weakened while accelerating north-northeastward. Its center passed just offshore of the mid-Atlantic states, so that the strongest winds remained over the water and these states experienced the weaker side of the hurricane. The center moved ashore over western Long Island, about ten hours after the North Carolina landfall, and Gloria became extratropical over Maine by 0000 GMT 28 September.

2) DATA

The center of Gloria passed over the U.S. coast at Hatteras Island, North Carolina, and Long Island, New York. Table 5 lists selected surface observations taken during the period of landfalls.

The NWS office at Buxton, North Carolina, reported a minimum pressure of 947.5 mb at 0536 GMT on the 27th, and an aircraft reported an extrapolation from 700 mb of 942 mb at 0542 GMT at a location within 20 km north of Buxton. The maximum sustained wind at Cape Point, near Buxton, was 33 m s^{-1}, from the east-southeast, at which time the center was located approximately 75 km to the south. An automated station at Diamond Shoal Light, 26 km east-southeast of Cape Hatteras, reported sustained winds of 44 m s^{-1} at 0500 GMT on the 27th with a peak gust of 54 m s^{-1}.

Sustained wind speeds generally remained below hurricane force to the west of the center as it accelerated toward Long Island. However, sustained winds of 41 m s^{-1} were reported at the Chesapeake Bay Bridge and Tunnel at South Island, Virginia.

Gloria's broad, poorly defined center moved ashore on western Long Island, between JFK airport and Islip. Very little wind data was available from the island; however, a peak gust of 38 m s^{-1} was recorded at Islip. In New England, sustained hurricane force winds of 33 m s^{-1} were reported at Bridgport, Connecticut, while winds of 36 m s^{-1} were experienced in isolated sections of the Boston area.

Storm surge tides ranged from 1 to 2 m above predicted astronomical tide levels over much of the coast from North Carolina through Massachusetts. However, coastal flooding was minimized by the arrival of peak surge during low tide at most locations.

3) DEATHS AND DAMAGE

There were eight deaths attributed to Gloria and total damage is estimated to be near $900 million. Wind damage was greater on the east side of the hurricane

TABLE 5. Hurricane Gloria surface observations, September 1985.

Location	Pressure (mb)	Date/time (GMT)	Wind (ms $^{-1}$) 1-min average	Gust	Date/time (GMT)	Tide (m) Height above normal	Rain (mm) Storm total
South Carolina							
Beaufort	1002.5	26/2055					trace
Charleston Harbor						0.4	
Charleston WSO	1004.1	26/2250	10	13	26/1816		trace
Charleston City			10	12	26/1925		
Edisto Beach			7	10	26/1930		
Folly Beach			9	11	16/1830		
Hilton Head Island			6	8	26/2630		
Myrtle Beach	1004.0	27/0055	9	15	27/0130	0.2	trace
Springmaid Pier			11	16	27/0130		
North Carolina							
Cape Hatteras WSO	947.5	27/0536	33	39	27/0402		53.3
Cape Lookout			24	30	27/0700		
Cherry Point	985.3	27/0353	16	27	27/0335		177.8
Diamond Shoal Light			44	54	27/0500		
Frying Pan Shaols			26	29	26/2300		
Jacksonville	990.3	27/0456	14	22	27/0256		85.3
Neuse River						1.8 est	
New Bern	987.8	27/0400					180.1
Raleigh	999.5	27/0650	10	14	27/0623		0.8
Wilmington	995.3	27/0252	12	19	26/2353		37.1
Wrightsville Beach						1.2 est	
Virginia							
Norfolk WSO	981.4	27/0830	21	30	27/0950		143.5
NGU			30	41	27/0950		
Richmond	993.7	27/0945	12	16	27/0950		102.1
Sewells Point						1.2	
South Island			41	46		1.5	
Maryland							
BWI Airport	993.5	27/1307	13	20	27/1652		153.4
Crisfield	985.4	27/1200					
Ocean City	972.6	27/1200		40			
Salisbury				29			
Delaware							
Dover AFB	982.8	27/1255		31			
Indian River Inlet				35		1.1	
Wilmington	986.1	27/1301	17	29	27/1454		95.3
New Jersey							
Atlantic City			18	30	27/1600		
Atlantic City WSO	971.2	27/1358	22	31	27/1633		46.5
Ocean City			36	45	27/1600		
Lakehurst	971			31			95.0
McGuire AFB							104.9
Port Republic	983.2						
Ventor City Pier						1.4	
Newark	974.9						
New York							
Battery Park						2.1	
Central Park	972.9	27/1605		23			88.4
Islip	968.5	27/1535		38			
Willets Point						1.3	
Connecticut							
Bridgeport	965.1		33	41			15.7
East Lyme						1.4	
Groton						1.5	
Hartford WSO	971.4	27/1810	19	29	27/1850		29.7
Waterbury (SAWRS)			37	42	27/1630		
Norfolk (COOP)							113.0
Weston (Skywarn)							119.4

TABLE 5. (*Continued*)

Location	Pressure (mb)	Date/time (GMT)	Wind (ms $^{-1}$) 1-min average	Wind (ms $^{-1}$) Gust	Wind (ms $^{-1}$) Date/time (GMT)	Tide (m) Height above normal	Rain (mm) Storm total
Rhode Island							
Providence WSO	986.0	27/1910	23	36	27/1850	0.4	2.5
Westerly Arpt				41			
Block Island Arpt				34			
Massachusetts							
Becket							101.9
Blue Hill			37	45	27/1852		
Logan Airport			27	34	27/2008		
Brant Point			23	28	27/1900		
Cape Ann			27		27/2115		
Cape Cod Canal			21	27	27/2000		
Chatham (CG)			30	49	27/2030		
Chatham WSMO			32	36	27/1833		
Colran							97.0
Chester							152.4
Knightville Dam							151.1
Littleville Lake							152.9
Menemsha			23	36	27/2000		
Merrimack River			18	31	27/1730		
New Bedford						1.8	
Provincetown			26		27/2000		
Scituate			36	45	27/1930		
Woods Hole						1.2	
Worcester	981.5	27/2000					
New Hampshire							
Concord	986.5	27/1930		19			17.0
Maine							
Cape Neddick			26	36	27/2300		
Goat Island			26	39	27/2200		
Manana Island			28	34	27/2300		
Portland	987	27/2208	24	31	27/2148	0.3	10.4

and resulted in downed trees causing extensive power outages for hundreds of thousands of people in the Long Island and New England area. To the west of the center from Virginia through New Jersey, the strongest winds were from the west to northwest and occurred after the center had passed. Beach erosion and coastal flooding were severe along portions of the North Carolina Outer Banks. Significant beach erosion was reported from Maryland, Delaware, Connecticut and Rhode Island.

h. Tropical Storm Henri, 21–25 September

Henri formed north of Hispaniola in a trough of low pressure that was left in the wake of Topical Storm Fabian. The developing area of low pressure began to drift northwestward on 18 September and became a depression at 0000 GMT 22 September while located several hundred km east of Jacksonville, Florida.

The depression continued its northerly track for the next several days and was upgraded to a tropical storm at 1030 GMT 23 September after a reconnaissance aircraft reported a pressure drop of 10 mb in four hours and 23 minutes. Henri strengthened rapidly to 996 mb by 1200 GMT on the 23rd, which was the lowest central pressure of the storm.

Shearing (a change of the horizontal wind speed and/or direction with height) took its toll on the storm, and the system gradually weakened before making landfall on the eastern tip of Long Island, New York, at 2100 GMT on the 24th.

There were no deaths reported from the storm and damage was nonexistent.

i. Tropical Storm Isabel, 7–15 October

The tropical wave which was to become Isabel moved off the African coast on 29 September and moved westward in the trade wind belt, entering the eastern Caribbean on 5 October. Shower activity was enhanced by an upper-level trough to the west of the wave as it passed through the eastern Caribbean, producing heavy rains, flash floods and mud slides with the loss of 180 lives in Puerto Rico. The wave continued

to move across the Caribbean, but the detached area of disturbed weather on the north side produced a low pressure center near Hispaniola which was classified as a tropical depression on 7 October.

The depression began drifting toward the north along the western side of the mid-Atlantic high pressure ridge and became a tropical storm by the afternoon of the 7th. Isabel became better organized and the central pressure fell quite rapidly to a minimum of 997 mb by late in the day on 8 October. However, a frontal trough approached from the northwest and strong southwesterly flow across the storm caused it to weaken and slowed its forward motion. Strong high pressure behind the frontal trough moved eastward, to the north of Isabel, bridging with the mid-Atlantic high. This blocked the storm's northward movement and sent Isabel to the west-northwest toward the Florida and Georgia coasts.

Isabel lost most of its deep convective activity by 1800 GMT on 9 October and continued to weaken as it approached the coast. As a result, no sustained gale winds were reported on the coast and no significant damage occurred. Isabel was downgraded to a tropical depression near the time of landfall and lingered near the north Florida, Georgia and South Carolina coasts for the next 48 hours before finally moving northeastward. The depression lost its identity in a strong frontal trough which approached from the west on the afternoon of the 15th.

j. Hurricane Juan, 26 October–1 November

1) GENERAL DESCRIPTION

A broad trough of low pressure formed over the central Gulf of Mexico during 24 October. The combination of the developing trough and an area of high pressure over the eastern United States produced a broad zone of winds approaching gale force over the northern Gulf of Mexico. This condition, which was well in advance of the formation of Juan, permitted only minimnal time for evacuating oil rigs in the northern Gulf of Mexico. By the morning of 26 October, satellite imagery indicated the depression had strengthened to a tropical storm and this was confirmed by reconnaissance aircraft that afternoon.

Throughout the developing process Juan moved on a very erratic course. As the storm became better organized, it began to move toward the northeast around 5 m s^{-1} in the early morning hours of 27 October. That afternoon, Juan turned toward the northwest at 8 m s^{-1} and reconnaissance aircraft reported it had attained hurricane strength.

Juan's forward speed dropped to less than 3 m s^{-1} by the morning of 28 October, and it made a cyclonic loop off the central Louisiana coast, for the next 24 hours, while under the influence of a large-scale upper-level low pressure area. Figure 6 shows Juan located just off the Louisiana, coast within an hour after reaching its lowest central pressure of 971 mb at 1800 GMT 28 October. The hurricane finally made landfall near Morgan City, Louisiana, on the morning of 29 October. The following day Juan made a second cyclonic loop around Lafayette, Louisiana, before emerging over Vermilion Bay on the 30th (see Fig. 3). While inland, Juan was downgraded to a tropical storm with gale force winds confined to the waters of the northern Gulf of Mexico.

After moving offshore, the storm became a little better organized as it skirted the Louisiana coast, then moved across the mouth of the Mississippi River near Burwood, Louisiana, during the predawn hours of 31 October. Heading on a northeasterly course near 8 m s^{-1}, Juan made a second landfall (this time as a tropical storm) just west of Pensacola, Florida, at midday. Thereafter, Juan turned northward and gradually lost strength before becoming extratropical over central Tennessee on 1 November.

2) DATA

Maximum sustained winds reported by reconnaissance aircraft were 39 m s^{-1} during the early morning hours of 28 October and later that afternoon the aircraft measured the hurricane's lowest pressure (971 mb). Winds decreased and pressure rose the following day as most of the hurricane's circulation moved over land.

Coastal stations from southeast Texas to the Florida panhandle had gale force winds at times during the five-day period Juan lingered in the north-central Gulf of Mexico (Table 6). The strongest gust of wind observed (28 m s^{-1}) at a coastal location occurred on 31 October at Pensacola, Florida, about the time Juan was making landfall. The only observed hurricane force winds were from anemometers on oil rigs off the Louisiana coast. One rig reported sustained winds of 41 m s^{-1} with gusts to 49 m s^{-1}.

Tides were generally 1 to 2 m above normal from the upper Texas coast to the northwest Florida coast. East of the mouth of the Mississippi River these tides persisted most of the five-day period. Strong offshore winds along the western Louisiana and the upper Texas coasts produced below-normal tides during the latter portion of the period.

Rainfall was excessive from southeast Texas to southern Alabama due to the length of time Juan's circulation remained over the area. In fact, much of the damage was due to a combination of high fresh water flooding and gulf high tides. Alexandria, Louisiana with 406.4 mm of rain had the maximum amount of rainfall reported; however, 200 to 300 mm were common throughout the area from the upper Texas coast to the extreme western Florida Panhandle.

3) DEATHS AND DAMAGE

A total of 12 deaths were attributed to Juan. Nine were caused by toppled oil rigs or the boats lost at sea

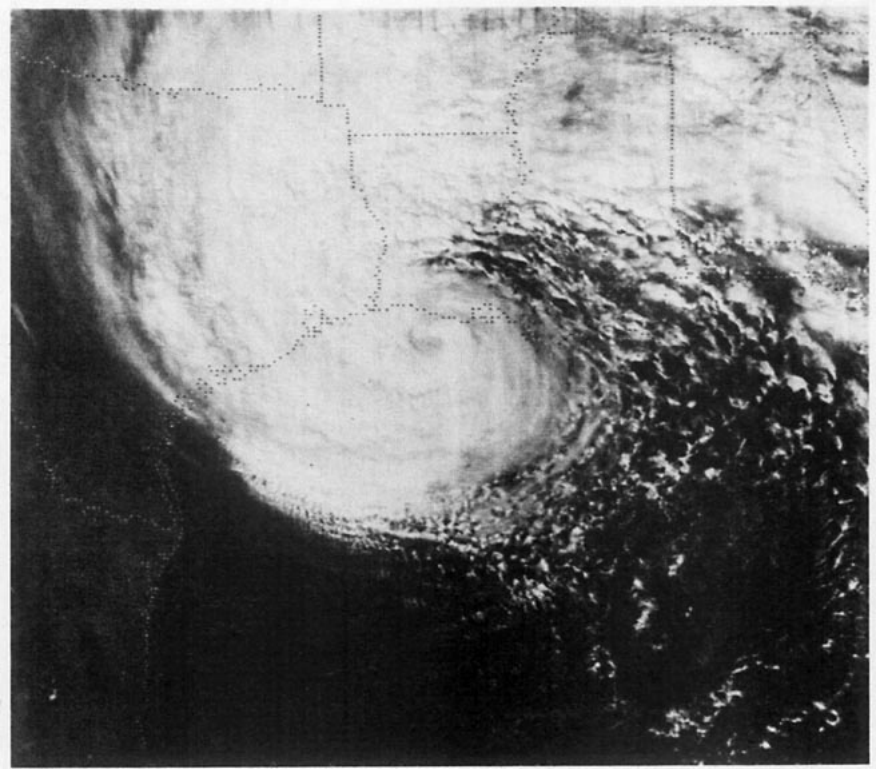

FIG. 6. GOES-West visible satellite picture of Hurricane Juan at 1900 GMT 28 October. The hurricane is at minimum central pressure of 971 mb.

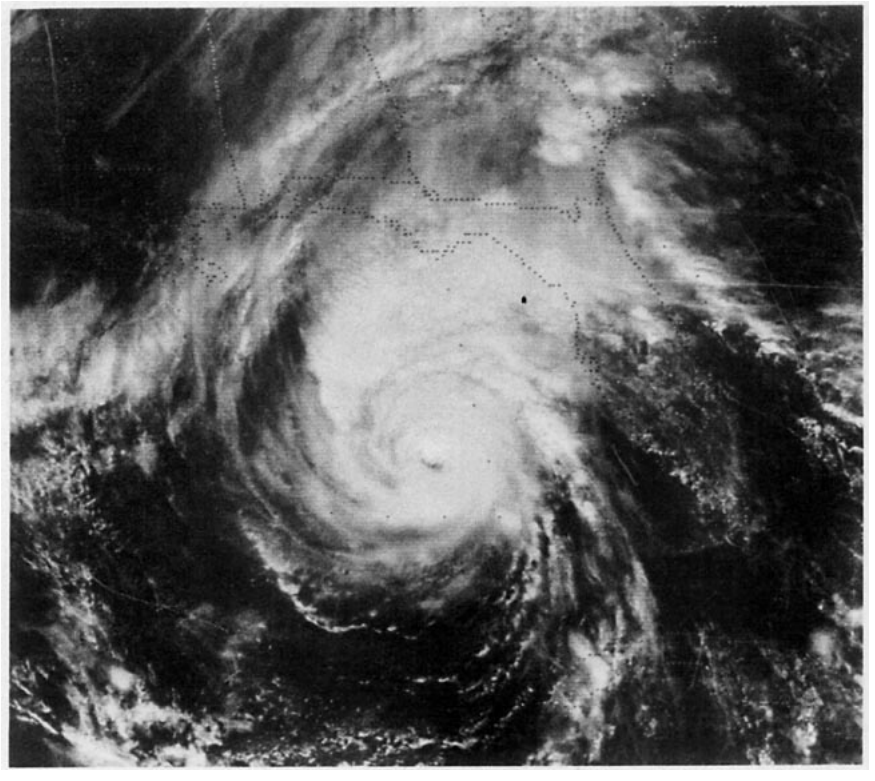

FIG. 7. GOES-West visible satellite picture of Hurricane Kate at 1801 GMT 20 November. The hurricane reached a minimum central pressure of 953 mb while located over the east-central Gulf of Mexico.

TABLE 6. Hurricane Juan surface observations, 26 October–1 November 1985.

Location	Pressure (mb)	Date/time (GMT)	Wind ($m\ s^{-1}$) 1-min average	Wind ($m\ s^{-1}$) Gust	Wind ($m\ s^{-1}$) Date/time (GMT)	Tide (m) Height above normal	Rain (mm) Storm total
Texas							
Rockport				31			
Victoria				28			
Galveston				30	28/1700	1.2	
Sabine Pass				30		1.1	
Port Arthur	990.6	28/1330	14	21	28/0749		203.7
Deweyville							222.3
Orange							174.5
Jasper							176.5
Louisiana							
Lake Charles	986.5	28/1337	15	22	28/0829	1.0	252.0
Cameron			18	23	28/1812		
Shreveport							250.4
Monroe							233.4
Winnsboro							301.2
Ruston							237.2
Natchitoches							262.6
Minden							333.5
Alexandria							406.4
Mamou							287.0
New Orleans (Intl)	990.2	31/0930	15	22	28/0730		240.3
New Orleans (Lakefront)			20	26	28/0144		
Slidell (WSO)							197.1
Gretna							254.5
Hammond							190.5
Morgan City							238.5
Paradis							241.6
Grand Isle						1.5	
Rigoletts						1.8	
Paris Road						2.1	
Bayou Bienvenue						2.5	
Industrial Canal						2.2	
Orleans Marina						1.9	
Alabama							
Mobile (WSO)	988.0	31/1741	15	21	29/1100	0.9	301.0
Dauphin Island	984.4	31/1700	13	21	31/1400		
Florida							
Pensacola NAS				28	31/1700	1.2	

transporting oil workers. The oil industry reported considerable damage to offshore rigs caused by 11 to 15 m swells, with two rigs overturned. The high winds and rough seas preceding the development of Juan made evacuation of the rigs very difficult and contributed to the loss of lives.

Estimates of total damage attributed to Juan run as high as $1.5 billion. This figure includes, but is not limited to, the damages to the oil industry, extensive damage to crops and livestock in southern Louisiana from high tides and heavy rains and flooding around the Lake Pontchartrain area of Louisiana.

k. Hurricane Kate, 15–23 November

1) GENERAL DESCRIPTION

Development of Kate began just northeast of the Virgin Islands when a weak tropical wave began to interact with a 200 mb trough on 13–14 November. By the time reconnaissance aircraft investigated the area on 15 November, the system had already attained storm force winds and was immediately named Kate. On 16 November, a cutoff circulation developed in the trough at 200 mb, and by the 17th, it accelerated to the southwest in advance of Kate. Meanwhile, a large 200 mb anticyclone, located over the Florida Straits on 16 November, built northeastward and placed Kate in an excellent outflow pattern between the anticyclone and the southwestward-moving upper cold low. With these favorable atmospheric conditions and sea surface temperatures near 27°C, Kate intensified to hurricane strength by 1800 GMT on 16 November. Kate's central pressure fell to 967 mb by 0000 GMT on the 19th as the hurricane moved westward through the extreme southeastern Bahamas.

By 0600 GMT on the 19th, satellite imagery showed that the well-structured eye of Kate had reached the north-central Cuban coast. Even though the majority of the eye wall cloud moved over the land and remained inland for the following twelve hours, satellite pictures indicated that Kate maintained excellent eye definition during this entire time. Aircraft reconnaissance data indicated that Kate weakened from 967 mb, just prior to landfall, to 976 mb just after it emerged from the Cuban coast, just east of Havana at 0000 GMT on the 20th. Figure 7 shows Hurricane Kate at 1801 GMT 20 November within hours of reaching its lowest central pressure.

The center of Kate passed within 145 km to the southwest of Key West as it began to turn more toward the northwest. During the following 24 hours, Kate tracked around the western edge of the large mid-Atlantic ridge of high pressure and intensified at a rate of nearly 1 mb h^{-1} ≡ from 972 mb at 0000 GMT 20 November to 953 mb (lowest pressure) at 2000 GMT on the 20th.

As Kate moved into the east central Gulf of Mexico, a frontal trough, moving from the west, began to influence the hurricane. The combination of increasing shear from the approaching frontal trough and cooler sea surface temperatures over the northern Gulf (22°C just off the north Gulf coast) caused Kate to weaken to a central pressure of 967 mb by the time the center reached the coast at Mexico Beach, Florida, at 2230 GMT on 21 November.

Kate was downgraded to a tropical storm over south central Georgia and continued to lose strength after it emerged over the Carolina coastal waters late in the day on 22 November. The remnants of Kate produced wind gusts of 12 m s^{-1} at Bermuda as they passed over the island on the morning of the 24th.

2) DATA

The WSO in Key West recorded sustained winds of 21 m s^{-1} with gusts to 31 m s^{-1} as Kate passed within 145 km to the southwest of the island. However, unofficial wind gusts to 46 m s^{-1} were reported from the sheriff's office there where an anemometer was located on the roof of a three-story building.

The center of Kate passed very close to the NOAA data buoy, located in the eastern Gulf of Mexico, about the same time that an Air Force reconnaissance aircraft was in the hurricane. Pressure measurements from the dropsonde (956 mb) and the data buoy (957 mb) were only one millibar apart. This difference could be attributed to a time difference or to the different locations

TABLE 7. Hurricane Kate surface observations, November 1985.

			Wind (m s^{-1})			Tide (m)	Rain (mm)
Location	Pressure (mb)	Date/time (GMT)	1-min average	Gust	Date/time (GMT)	Height above normal	Storm total
Florida							
Miami WSMO	1014.6	19/0738	17	21	19/0809		5.1
Miami Beach			17	35	19/0655		
Key West	1006.8	19/2000	21	31	19/2213		52.8
Conch Key			22		19/1630		
Apalachicola	985.3	21/2210	28	38	21/2215		125.2
Cape San Blas	975.3	21/2208	33	45	21/2012	3.3	
Cedar Island						1.8	
Keaton Beach						1.8	
Turkey Point						1.5	
Panama City	973.1	21/2130	18	35	21/2001		147.1
Tallahassee (WSO)	992.0	22/0225	21	30	22/0115		92.2
Georgia							
Albany (WSO)			23	30	22/0400		127.5
Savannah (WSO)	1001.4	22/1223	18	28	22/1250		43.9
South Carolina							
Charleston (WSO)	1002.7	22/1455	17	22	22/1401		
Edisto Beach				53	22/1706		
North Carolina							
Wilmington (WSO)	1002.4	22/2220	13	18	22/1824		50.5
Frying Pan Shoals			19	21	22/2000		
NOAA Data Buoy							
26.0°N 85.9°W	957	20/1800	48	60			
34.9°N 72.9°W	1009.2	23/0600	13		23/0600		
Bermuda	1009.4	24/0900	8	12	24/0300		

in the hurricane. Also during this time the aircraft measured a flight level peak wind of 56 m s^{-1} while the data buoy recorded an eight-minute averaged wind speed of 48 m s^{-1} with a peak gust of 60 m s^{-1}.

Maximum winds measured at flight level by aircraft at the time of landfall near Mexico Beach, Florida, were near 44 m s^{-1}. Strongest winds measured on the coast were 33 m s^{-1} at Cape San Blas, which is where highest reported tides of 3.3 m occurred. See Table 7 for additional data.

3) DEATHS AND DAMAGE

Five people lost their lives in Kate in the United States and at least 100 000 people evacuated to shelters in the coastal Florida Panhandle. Unofficial reports from Cuba indicate that at least 10 people lost their lives and as many as 300 000 people fled the low-lying coastal sections in advance of Kate. Damage figures for the hurricane are estimated to be near $300 million. This figure does not include the lost jobs in the Apalachicola area due to the damage done to the oyster beds.

Kate passed just to the west of Tallahassee and produced little structural damage to the inland capital; however, numerous trees were downed across the interior panhandle and the south Georgia area, causing extensive power outage throughout the region.

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