NOAA Technical Memorandum
NWS HYDRO 43 A

EXTREME HURRICANES IN THE NINETEENTH CENTURY

Water Management Information Division
Office of Hydrology, National Weather Service
Silver Spring, MD
March 1989

Study completed under agreement EMW-84-E-1589 for FEDERAL EMERGENCY MANAGEMENT AGENCY

U.S. DEPARTMENT OF COMMERCE / National Oceanic and Atmospheric Administration / National Weather Service

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Silver Spring, MD

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EXTREME HURRICANES IN THE NINETEENTH CENTURY

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ABSTRACT This report provides available meteorological information pertinent to coastal flooding risk assessment of severe hurricanes in the nineteenth century. Pertinent hurricane parameters included are: the central pressure, the radius of maximum winds, and the direction and speed of the storm's forward motion. This report also gives brief discussions of available data and informative newspaper accounts of individual hurricanes which helped in determining the hurricane track and the point of landfall.

1. INTRODUCTION

1.1 Authorization

The National Flood Insurance Act of 1968, Title XIII, Public Law 90-448, enacted August 1, 1968, provides for a National Flood Insurance Program for insuring residences and small businesses against hazard of damage or destruction by flood. The Federal Insurance Administration (FIA), a component of the Federal Emergency Management Administration (FEMA), is the executive agency for the National Flood Insurance Program. In July 1982, a Joint Technical Assistance Work Plan was signed between FEMA and the National Oceanic and Atmospheric Administration (NOAA). The plan, among other things, allows for the National Weather Service (NWS), NOAA, to provide technical support to FEMA upon request. Authorization for this particular study is Project No. 53967 under agreement No. EMW-84-E-1589 between the FIA, FEMA and the NWS, NOAA, dated March 15, 1984 and amended January 29, 1987.

1.2 Purpose

The purpose of this report is to supply factual data, analyses, and reasonable inferences on the characteristics of severe hurricanes of the nineteenth century, important to coastal flooding risk studies. Such information is indispensable to storm-surge modelers concerned with model calibrations using historical data and officials responsible for the evaluation of risk assessments of hurricane surges. Even though a destructive hurricane is a relatively rare event at any one location on the United States coast, no part of the Atlantic or Gulf coasts is immune from hurricane incidence. Lack of previous hurricane damage at a particular place should not lead to a false sense of security. There is no reason to believe that localized factors would prevent the occurrence of severe

hurricanes. Nor should we assume that the most severe Atlantic hurricane that the atmosphere is capable of producing has been detected during the relatively brief period of observation. It was our intent to document selected severe hurricanes in the nineteenth century to supplement the record of well known cases of extreme hurricanes of more recent years. This will enable the user to find a typical example of a severe hurricane of record reasonably close to his area of interest.

1.3 Scope of Report

This report provides available meteorological information pertinent to coastal flooding risk assessments on severe hurricanes in the nineteenth century and pertinent hurricane parameters for the extreme cases studied. These parameters are the central pressure, the radius of maximum winds, and the direction and speed of the storm's forward motion. This report describes briefly the life history of each hurricane and presents the track of each storm as it approached and entered the coast. This report also gives brief discussions of available data and pertinent newspaper accounts of individual storms which helped in determining the hurricane track, the point of landfall and the hurricane parameters.

A summary of selected data and most informative newspaper accounts for each storm is included to provide a readily available source of information for future reference. Discussions of the material on extreme hurricanes that struck the Atlantic coast are presented chronologically in chapters 3-12. Similarly, Gulf coast hurricanes are discussed in chapters 13-21. Discussions of severe hurricanes that affected northeastern Florida are included in the appendix.

The criteria in selecting extreme hurricanes of the 19th century were based on combinations of the following factors:

1. The hurricane which produced the highest storm tide of record in a coastal community,

2. The most severe hurricane that was experienced in a coastal region within a reasonably long time interval, and

3. The severity in property damage or loss of life in a hurricane.

These selected hurricanes were considered as representative extreme hurricanes of the 19th century for the selected coastal regions. The number of coastal segments selected and the total number of hurricanes studied were limited by the amount of funding and the availability of meteorological data.

2. DATA AND ANALYSIS

Although the history of Atlantic hurricanes extends back to 1494, the earlier records are fragmentary. As the Caribbean islands and the Gulf and Atlantic coasts of the United States became more densely populated, hurricanes were more often mentioned in historical records. The amount of observed data available from historical hurricanes varies greatly and almost all of the past hurricane data required further analysis and interpretation before it could be of use to storm-surge computation. These data are subject to numerous uncertainties in interpretation. We have attempted to bring this information together to make a comprehensive analysis, to develop accurate storm tracks from which speed and direction of the storm's forward motion, and in some cases, the point of landfall, were determined. This section describes the data sources and our analyses which resulted in our estimates of the hurricane tracks as well as the hurricanes' central pressure and radii of maximum winds.

2.1 Sources of Data

Federal agencies that have engaged in the collection, compilation and interpretation of meteorological observations include the Surgeon General's Office of the Army, the General Land Office, the Smithsonian Institution, the Signal Office of the Army, and the Weather Bureau. In 1814, the regulations of the army provided that a hospital surgeon at each military post should keep a diary of the weather. Organized meteorological observations were also attempted by the Commissioner of the General Land Office in 1817. The meteorological work of the Smithsonian Institution began in 1847. The institution collected records of observations and instituted its own system of obtaining weather data from voluntary observers. With the establishment of the meteorological service of the Signal Corps in 1870, the work of the Smithsonian Institution declined and the institution's extensive collection of meteorological reports from 383 observers was transferred to the Signal Office. By an act of Congress in October 1890, the Weather Bureau was officially recognized and was transferred to the Department of Agriculture.

Aside from a national weather observing service dated from 1814, collections of individual hurricane accounts by private citizens constitute a major source of information. In the mid 1800's, William C. Redfield maintained a manuscript, "Record Book of Storms," in which he jotted down notes and pasted clippings about major storm events both past and contemporary. Lt. Col. William Reid of the Royal Engineers took up the study of individual hurricanes and presented detailed studies of certain storms, primarily those occurring in the year 1780 and in the decade of 1830's. In 1857, Lorin Blodget published his impressive "Climatology of the United States, and the Temperate Latitudes of the North American Continent," which included 55 American storm notices with brief data on each; some of these were major hurricanes. Prof. Increase Lapham of Wisconsin presented, in 1872, a 6-page listing of storms of all types known to have affected the American continent. He uncovered several hurricane occurrences not found in previous lists. Prof. Elias Loomis of Yale listed 30 hurricanes which approached the American mainland since 1815 in his paper published in the American Journal of Science (1876).

Ivan Ray Tannehill brought out the first edition (1938) of his useful and interesting reference work: Hurricanes. This contained a "List of Tropical Storms of the North Atlantic, including the Gulf of Mexico and Caribbean Seas,

from 1494 to 1900." Gordon E. Dunn and Banner I. Miller of the National Hurricane Research Center at Miami, Florida, contributed a compilation of hurricanes affecting the United States, by coastal section, in the appendix of their authoritative book, Atlantic Hurricanes (1960). The most recent compilation of historical hurricanes, including some meteorological situations attending the occurrence of hurricanes prior to 1870, which affected the present United States was presented by David M. Ludlum (1963). Arnold L. Sugg et al. (1969), published storm track maps of "Memorable Hurricanes of the United States Since 1873." Information on extreme tide levels and maximum observed winds are also included on these maps. Since 1872, descriptions of individual hurricanes and related meteorological data have been published in the Monthly Weather Review. Additional information on hurricane surges can be found in "Survey Report on Hurricanes" for various coastal regions, prepared by the U.S. Army Corps of Engineers in the early 1960's (e.g., U.S. Army Corps of Engineers 1961). These and other regional studies are included in the list of references (e.g., Sidney Perly 1891, John Purvis 1956, Carney and Hardy 1962, Dunn et al. 1967).

2.2 Hurricane Central Pressure

The most important factor in storm-surge modeling is the intensity of the hurricane, which is directly related to its central pressure. Harris (1959) demonstrated that storm-surge height is approximately proportional to the central pressure depression, other factors being constant. In this report, the estimates of hurricane central pressure were based on pressure readings taken at land stations. Since observed pressures were rarely recorded at the storm center, the pressure readings were extrapolated inward to obtain central pressure values by using a visually-fitted radial pressure profile based on the formula (Schloemer 1954):

$$\frac{P - P_o}{P_n - P_o} = \exp\,(-R/r) \qquad (1)$$

where P is the pressure at radius r, P_o is the pressure at the storm center, P_n is the peripheral pressure at the outer limit of a hurricane where the cyclonic circulation ends, and R is the radius at which the windspeed is greatest.

In cases where barometric pressure could not be obtained near the coast, the central pressures were determined at the location nearest the coast where reliable observations could be obtained. These estimates were then adjusted downward to a coastal value by using the filling rate given in Chapter 10 of Ho et al. (1987). This was done for those central pressures for which the lowest observed pressure was from an inland station. Because of uncertainty in pressure readings prior to the establishment of standardized instruments and observational procedure and a lack of observed pressures in some cases, the estimations of central pressure values were, in some cases, based on comparisons with observed high water levels of recent hurricanes in the same geographical region; e.g., New England hurricanes. These estimates obtained from an indirect method of analysis are less reliable than most of the corresponding values derived from observed data.

2.3 Radius of Maximum Winds

2.3.1 Introduction

The radius of maximum winds (R) is the radial distance from the hurricane center to the band of strongest winds outside the hurricane eye. It is commonly accepted as a numerical index of the lateral extent or size of hurricanes and is an important parameter in the generation of storm surge. In a mature hurricane, the wind usually increases radially outward from slight values near the center to hurricane force then decreases gradually. It is evident that the maximum shoreward component of hurricane winds is experienced at a given coastal site when the hurricane center crosses the coast at approximately a distance R to the left. On straight coasts with uniform bathymetry, the highest surge along the coast will be experienced at this point of high wind. Variable bathymetry modifies this location somewhat. In a bay, the propagation of high water and the wind setup are related to the strength and direction of the wind, which are related, in turn, to the storm track and landfall point. Hence, the radius of maximum winds together with the point of landfall influence the position of the band of strongest winds, a critical factor for the maximum wind setup effect.

2.3.2 Analysis

In this report, the values of R were derived in the following manner:

(1) deduced from the observed wind record: Observed maximum winds are determined by noting the time when a wind-reporting station experienced the highest wind speed prior to the wind slackening in the hurricane eye. From a knowledge of the location of the storm center at that time, one can deduce a value of R.

(2) computed from pressure fit: R's can be estimated by fitting an exponential pressure profile (eq. 1) to the data from a given hurricane. By their nature, computed values of R are more susceptible to error than observed values of R.

(3) estimated from the measured time interval between the slackening and resumption of hurricane-force winds over some point near the coast if the speed of the storm's forward motion is known.

(4) approximated by using the distance of observed maximum water level from the storm center.

2.4 Hurricane Track

2.4.1 Introduction

Hurricane track information was used to determine the direction and speed of the storm's forward motion and, in some cases, the point of landfall. The observations along the path of each hurricane, applied to determining the best track of the storm, consisted of wind records, barograph traces, observations from land stations and ships, unofficial pressure observations, and estimates of wind velocities. During the earlier days of hurricane reporting, only meager information was obtained when a storm was located some distance from land. The scanty information came from the logs of ships, eyewitness accounts, and other

ship reports. With few official observations over land, pressure observations, wind information, and accounts of damage reported by private citizens and newspapers of that time became the primary source of hurricane information. With the organization of voluntary meteorological observers by the Smithsonian Institution, the volume of available data increased significantly.

Smoothed "best track" information have been given since 1871 in several NOAA publications (e.g., Garriott 1900, Fassig 1913, Norton 1936). Cry (1965) combined data from available sources into a comprehensive report showing the most accurate and consistent tracks of all tropical cyclones for the period 1871-1963. This report was later updated and revised by Neumann et al. (1981). These smoothed tracks are the best estimates of the large-scale storm motion for individual storms. However, the analysis of the large-scale motion may not describe the storm track with the precision needed for storm-surge modeling. Track differences of a few miles is insignificant in determining the large-scale motion, but can be significant for replicating high water on the open coast and inside bays and estuaries. A surge model requires, among other factors, specific information at closely spaced time intervals along the hurricane track prior to and after the hurricane's landfall or along the track while the hurricane is bypassing the coast.

In this report, the best tracks for the hurricanes studied were based on pressure and wind observations. Information on the time of lowest pressure and the lull in wind velocity at a station, wind shifts, and comparative pressure readings aided in defining the hurricane track. Particular attention was paid to the period just before and after landfall since this is the time interval most critical for storm-surge computation. Locations of the hurricane center were determined at 6-hourly intervals during this period. Three-hourly positions were derived in the fast moving New England hurricanes of 1815, 1821 and 1869.

2.4.2 Regional Grouping of Hurricanes

Figures 1a and 1b give the best tracks for the nineteenth century hurricanes striking the Atlantic coast. Figure 2 shows the tracks of severe hurricanes which struck the Gulf of Mexico coast in the nineteenth century. Brief discussions of these hurricanes are given in regional groupings. The reader interested only in one geographical area may proceed from this chapter to the hurricanes in the region of his interest. Each hurricane is discussed individually in chronological order within the two major geographical groups. The Atlantic hurricanes are presented in Chapters 3-12 and Gulf hurricanes in Chapter 13-21.

2.4.3 Atlantic Coast Hurricanes

2.4.3(a) New York and New England States

The hurricanes of 1815, 1821 and 1869 were among the most severe that affected New York and New England in the nineteenth century (fig. 1a). The September 1815 storm was the most destructive hurricane to strike this area since 1635. Storm tides of 10 and 12 ft above the height of normal spring tide were reported in New Bedford, MA and Providence, RI, respectively. The track of the hurricane of September 1869 paralleled the path of the 1815 hurricane but was displaced somewhat towards the east. The wind-driven waters in this storm funneled up Buzzard's Bay to its head at Warham, MA, and reached the highest level in

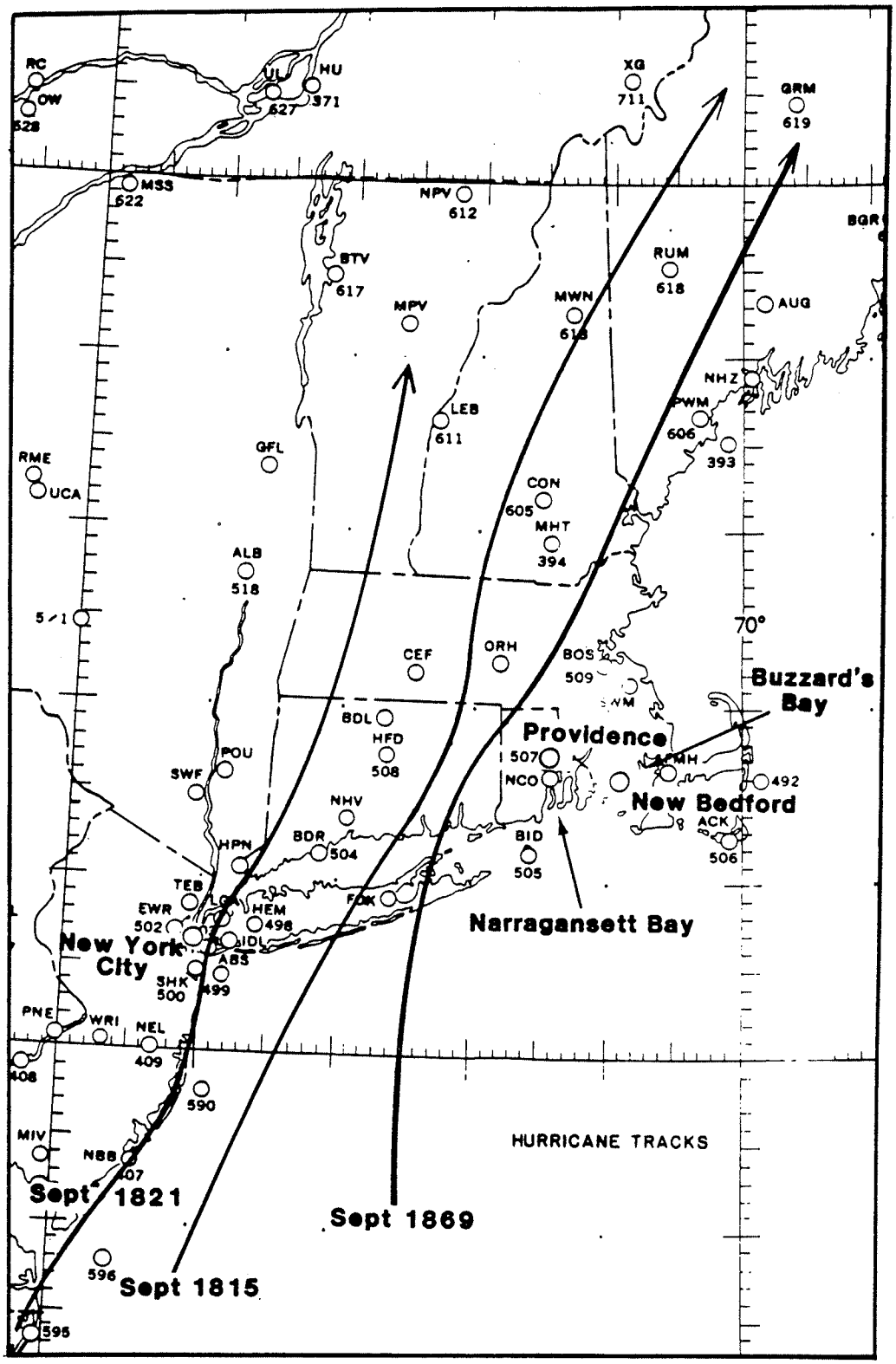

Figure 1a.—Hurricane tracks - New England states.

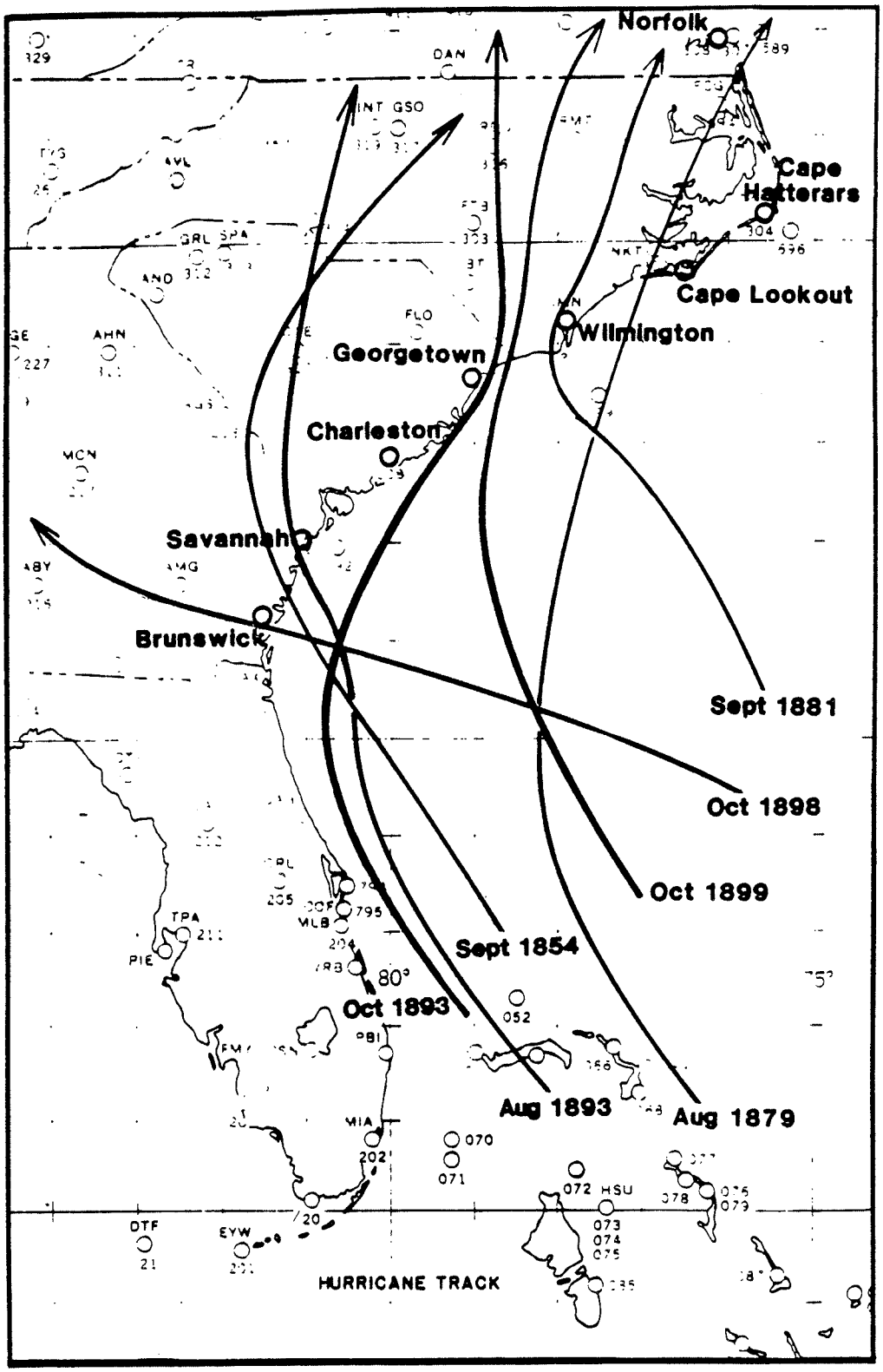

Figure 1b.--Hurricane tracks - Atlantic coast.

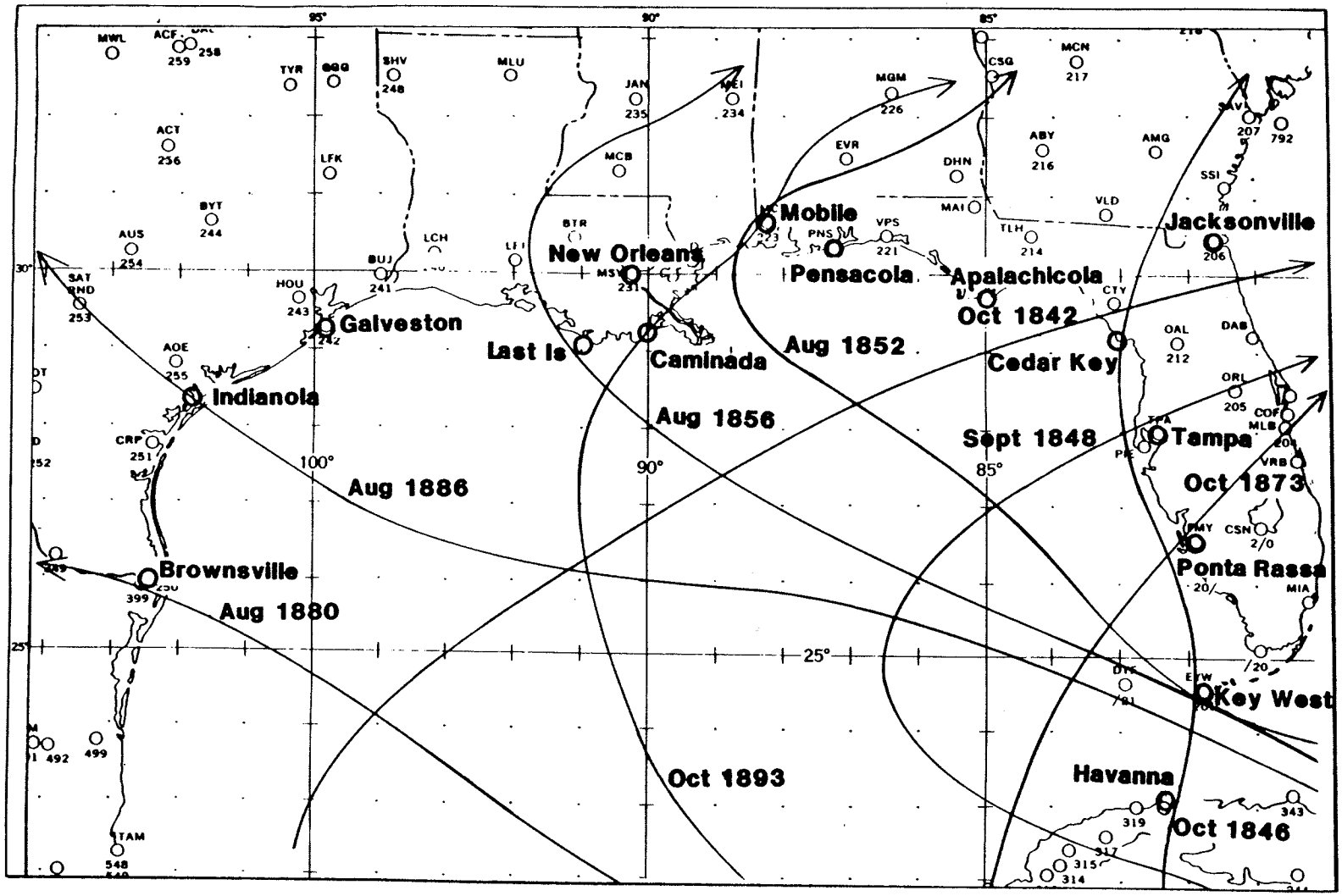

Figure 2.--Hurricane track - Gulf of Mexico.

234 years, or since the legendary Great Colonial Hurricane of 1635. The hurricane of September 1821 was the most intense storm to pass over New York City in 200 years. The tide at New York harbor rose 13 ft in just one hour.

2.4.3(b) Norfolk, Virginia to Southeastern North Carolina

The hurricane of August 18, 1879 was selected as representative of hurricanes that struck the southeastern North Carolina area (fig. 1b) during the nineteenth century. Other destructive hurricanes which hit the Outer Banks of North Carolina in the last century included the hurricanes of 1842 and 1846. A maximum wind of 165 mph was reported at Cape Lookout in the August 1879 hurricane. At Norfolk, the tide reached a point never before witnessed by any but the oldest inhabitants of the city at that time. (The highest tide of record reached 15.5 ft in the hurricane of 1749.)

2.4.3(c) Wilmington, North Carolina to Georgetown, South Carolina

The most severe hurricanes to move across the coast from Georgetown, SC, to Wilmington, NC, in the last century included those of September 1881, October 1893, and October 1899 (fig. 1b). The 1881 hurricane approached the coast in a northwestward direction. It recurved and entered the coast just west of Smithville, NC. It was reported as the most violent storm at Smithville in 50 years. A short period of calm wind was observed at Wilmington, NC, in this storm indicating that its center passed over the city.

The hurricane of October 1893 moved parallel to the Atlantic coast and passed over the entrance of Winyah Bay, SC. This hurricane inflicted heavy damage along coastal beaches just north of Georgetown, SC. At South Island, SC, a high tide of 9.3 ft MSL and a minimum pressure of 959 mb were reported. After crossing the coast north of Myrtle Beach, SC, the 1893 hurricane accelerated northward and passed over Raleigh, NC. The highest wind in this storm was 94 mph reported at Southport, NC. In Wilmington, NC, the tide was reported as the highest known to date, being 16 in. above the high-water mark of 1853.

The October 1893 hurricane was the most devastating storm to hit the Winyah Bay area since 1822. Even though the 1822 hurricane was not included in this study, it is of interest to note the flooding condition associated with it. The 1822 hurricane was a small, intense storm which struck the South Carolina coast just south of Georgetown near midnight of September 27-28. In this 1822 hurricane, an unprecedented storm tide reached a height far exceeding that of any other tide within the memory of the oldest living inhabitants. The high water engulfed the extensive lowlands surrounding Winyah Bay, causing several hundred deaths by drowning. At the height of the storm, only a very small portion of North Island, astride the entrance of the bay, remained above the ocean level.

The hurricane of October 1899 moved across central Cuba and reached the Carolina coast on the 30th. Its center entered the coast near the NC-SC state line at a moderately slow speed. A tremendously high tide almost reached the highest tide of record in the port city of Wilmington, NC, as the hurricane moved along a critical path parallel to the Cape Fear River at a slow speed.

2.4.3(d) Charleston, South Carolina to Savannah, Georgia

The most severe hurricanes in the nineteenth century to strike the vicinity of Savannah, GA, and to affect the southern part of South Carolina included the hurricanes of 1804, 1854, and 1893. Because of a lack of recorded meteorological information, the 1804 storm was not included in this study. The 1854 hurricane (fig. 1b) was a slow-moving storm of rather large size and was first encountered by the brig Reindeer in the northern Bahamas. The ship stayed with the gale for a duration of 5 days, and her barometer dropped to 938 mb at one time. The extremely intense hurricane of August 1893 entered the coast just south of Savannah, GA (fig. 1b). This hurricane was accompanied by very high tides which submerged the islands along the Georgia and South Carolina coasts. Between 2000 and 2500 people lost their lives on the coastal islands and in the low lands between Tybee Island, GA and Charleston, SC. The highest tide in the storm was estimated to have a range of 17.0 to 19.5 ft MSL at Savannah Beach, GA.

2.4.3(e) Brunswick, Georgia Area

The hurricane of October 1898 moved in a west-northwestward direction and entered the coast just south of Brunswick, GA (fig. 1b). The center of the storm passed over Blackshear, and Douglas, GA, and then gradually turned northwestward. The Brunswick area experienced its worst flooding since 1812 and the storm tide reached 13.2-13.4 ft MSL in the city. The height of the storm tide was 18 ft (datum unknown, but probably MSL) at Sapelo Lighthouse on Sapelo Island, while inland at Darien, the surge was about 13 ft above mean high water mark or approximately 18 ft MSL. Darien was a tidal port on the Atamaha River and the coastal islands of Sapelo and St. Simon flanked the river delta. These coastal islands were subject to storm-surge inundation since the whole delta area lies only on a few feet above sea level. The first severe hurricane of the nineteenth century to strike this area, passed over St. Simon Island on September 12, 1804. High water at St. Simon's reached 7 ft above the height of an ordinary high tide. Tides near Savannah reached 10 ft above sea level while at Isle of Hope, GA, the storm tide was measured at 12.5 ft MSL. The severity of this disaster was exceeded by that of the hurricane of September 15, 1824, according to the "Savannah Georgian" of that date. However, meteorological information on these early storms was scanty. Extreme hurricanes in the later half of the century entered the Georgia coast north of this delta area (such as hurricanes of 1854 and 1893) and caused severe damage and loss of life to the Savannah area and coastal islands of South Carolina. These extreme hurricanes were briefly discussed in preceding paragraphs.

2.4.3(f) Florida Coasts

Hurricanes off the east coast of the United States frequently recurve between latitude 27° and 29°N during the months of July through September. For the other months of the hurricane season, recurvatures occur at latitudes farther south, following the shift of the subtropical pressure ridge. The northern limit of hurricane recurvature at about 29°N appears to coincide with an area of minimum frequency of landfalling hurricanes along the east coast. Hurricane Dora of September 1964 is the only hurricane that struck this section of the coast since 1844, lashing the Jacksonville area with 82-mph winds. In the nineteenth century, hurricane winds were experienced in the northeastern Florida coastal area during the passage of hurricanes of September 1844, August 1871 and September 1878. The hurricane of September 1844 struck the coast near St.

Augustine, while the other two storms entered the southern Florida coast and moved northward across the entire stretch of the peninsula. These storms were less intense and do not satisfy the criteria for extreme southern hurricanes previously stated in Section 1.3. They are discussed in the appendix to emphasize the distinction between the two categories.

The lack of extreme hurricanes on the southern Florida coast during the nineteenth century is not believed real. This area was very sparsely settled and almost all of the hurricanes reaching this coast in the last century were not recorded. Generally speaking, southern Florida experiences, on the average, more intense hurricanes than coastal areas to the north and they are most frequent in the extreme southern portion of the peninsula.

2.4.4 Gulf Coast Hurricanes

2.4.4(a) Florida Coast

Severe hurricanes of the nineteenth century in this group struck the west coast of Florida from Key West to Cedar Key. These storms include the hurricane of September 1848, October hurricanes of 1842, 1846 and 1873 (fig. 2). Hurricanes which struck the Florida coast north and west of Cedar Key can be traced in the literature. The earliest hurricane of record since 1494 that affected the Gulf coast struck the Mobile, AL, and Pensacola, FL, area on September 19, 1559. This disaster, among others that followed, forced the retreat of the expedition which intended to establish a colony on the Gulf coast. In 1778, the British governor at Pensacola reported to the Colonial Office on the storm of October 9, 1778 that was the most severe hurricane ever known in west Florida since the establishment of the colony. All ships and vessels in the Pensacola Harbor were either lost or driven ashore, except for the Sylph, a sloop of the Royal Navy.

By early 1800's, there was considerably more shipping activity in the area reporting storm occurrences; the setting up of local printing presses also provided an additional source of local news. Thus, there is more information about severe hurricanes which devastated a large number of coastal settlements. The hurricane of August 30, 1837 was considered as the most severe gale ever felt in St. Marks and St. Joseph since the settlement of Florida by the Americans, according to correspondents of local newspapers. The high tide at Apalachicola was estimated to have reached from 10-15 ft above normal low water. At St. Marks a storm wave 10-ft high hit the lighthouse and the village was inundated to a depth of 7 ft. Presumably, these storms were less intense than those selected. Available information is not sufficient to make a definite judgment.

Among the most severe storms of the last century, the hurricane of October 1842, originated in the southwestern corner of the Gulf of Mexico and moved northeastward across the Gulf. The center of the hurricane entered the west coast of Florida, north of Cedar Key, in the evening of October 5. At Apalachicola the storm was thought to be one of the most severe on record. At Cedar Key, the water rose 20 ft above high water mark, and within 6 ft of covering the island. St. Augustine experienced the greatest gale ever remembered.

The most intense storm among the Florida hurricanes of last century was the hurricane of October 1846. The pressure at Havanna, Cuba, dropped to 27.06 in. (916.2 mb) as the storm center passed over the city in the morning of

the 11th. All but 12 of the 104 vessels in Havanna Harbor were either sunk, wrecked, dismasted or otherwise seriously damaged. In addition, some 40 to 50 small coastal vessels were destroyed. As the hurricane passed within a few miles of Key West in the late afternoon, 5 ft of water was running through the center of the town at 6 mph. Almost all of the 600 houses in town were destroyed and blown down. It was considered the most destructive hurricane that ever visited these latitudes. Its intensity as measured by lowest pressure was second only to the hurricane of September 1935, which struck the Florida Keys with a central pressure of 892 mb, the lowest accepted sea-level pressure, not including tornadoes, on the United States coasts.

Another severe hurricane to strike the Florida coast passed just north of Tampa Bay on September 25, 1848. At Fort Brook (near the present site of Tampa) the pressure dropped to 28.18 in. (954 mb). High winds and tides destroyed most of the buildings at Fort Brook. All the wharves and buildings on the bay and river were destroyed; all the vessels in port were driven up the river and lodged in the pine-woods. The high tide was estimated to have reached 14 ft above mean sea level.

An extreme hurricane affecting southern Florida entered the coast near Punta Rassa on October 6, 1873. Maximum winds were estimated at 90-100 mph and a pressure of 28.40 in. (961.6 mb) was recorded at Punta Rassa. A high water of 14 ft above mean tide was reported there and the entire settlement was destroyed. As the storm center passed at a distance of about 65 nmi northwest of Biscayne, an unusual rise of water at Biscayne from 6 to 8 ft above ordinary high tide was reported.

2.4.4(b) Alabama and Louisiana Coasts

This group of severe hurricanes in the nineteenth century included the August hurricanes of 1852, 1856 and hurricane of October 1893 (fig. 2). Major hurricanes of the early 1800's were reported in August 1812, September 1821, August 1831 and September 1837. The calamity of these hurricanes was over shadowed by the fatalities caused by hurricanes in the later half of the century.

After entering the Mississippi coast between Biloxi and Pascagoula, the hurricane of August 26, 1852 turned slowly towards the head of Mobile Bay. Because its critical path skirted Mobile Bay with a slow forward motion, the prolonged southeasterly winds over the bay caused extraordinary flooding and the highest tide in Mobile since 1772.

After passing west of Key West, the hurricane of August 1856 moved northwestward and passed just west of Last Island, Louisiana, on August 10. A resort hotel on the island was destroyed with loss of 320 lives. The highest portion of this island was inundated to a depth of 5 ft.

The hurricane of October 1893 was one of the most disastrous hurricanes to have occurred on the United States coast. This intense but small hurricane caused a fatality of nearly 2,000 along the Louisiana coastal area and along the Mississippi and Alabama coasts. The greatest loss of life occurred at Cheniere Caminada, a fishing village on a low-lying spit of land just west of Grand Isle, where 1,650 persons out of a population of 1,800 perished. The New Orleans Times-Democrat reported that "the water at Caminada rose to a height of 20 ft and swept everything before them." South of New Orleans, the water from the Gulf and

its bays rose 15 ft and swept away the fishing hamlets along the coast. Along the shores of bayou Cook, Oster bayou, bayou Challin, Adam's Bay and Grand Bay, a very small percentage of the inhabitants survived this disastrous hurricane. It was estimated that at least 350 craft were wrecked along the Mississippi and Alabama coasts and few survived to tell the tales.

2.4.4(c) Texas Coast

The first hurricane that affected the Texas coast of which there is any authentic record was in 1818, when four of Lafitte's vessels were sunk or driven ashore on Galveston Island. The village on Galveston Island was inundated to a depth of 4 ft (Frazier 1921). Destruction of the settlements at Port Isabel and Brazos Santiago by hurricanes of the early 1800's occurred in 1829, 1831 and 1835. The most severe hurricane which struck this stretch of the coast in the last century occurred in 1880 and 1886 (fig. 2).

The hurricane of August 1880 crossed the Yucatan peninsula into the western Gulf of Mexico on August 9. Its center moved northwestward in the direction of Brownsville, Texas. It entered the Mexican coast just south of the United States border and passed over Matamoras, about 5 nmi southwest of Brownsville. More than 300 houses were blown down or rendered uninhabitable in Matamoras. In Brownsville, buildings were unroofed or completely blown down, shipping all destroyed and telegraph lines all prostrated. At Port Isabel, eight vessels were wrecked and numerous small boats were sunk. The few houses in Brazos Santiago were washed away with the exception of the life-saving station, which was badly damaged.

The hurricane of August 20, 1886, is the most intense hurricane ever to strike the Texas coast. The center of the storm crossed the island of Cuba on August 16, 1886 and then turned west-northwestward into the Gulf of Mexico. The steamship San Marcos, encountered an easterly gale near 28°N 91°W on the 19th. By 0700 on the 20th, the winds at Indianola reached 72 mph from the northeast and the barometer dropped to 28.89 in. (978.2 mb). Two hours later, the storm center crossed the central section of Matagorda Island and reached San Antonio at 1440 in the afternoon. Every house on the upper part of Matagorda Island except the life-saving station was washed away. The settlement of Indianola was almost completely destroyed. There were not more than half a dozen residences left standing after the storm. The influx of water inundated several miles inland and washed away four miles of railroad tracks.

ATLANTIC COAST HURRICANES

3. HURRICANE OF SEPTEMBER 23, 1815

3.1 Introduction

Of all the intensely damaging storms in New England's history, the 1815 hurricane was long accorded first place by local historians of the region. The most destructive storm since 1635 formed near the Cape Verde Island off West Africa. It struck the Leeward Islands on September 18 and passed the extreme southeastern Bahamas two days later. It made landfall on the south shore of Long Island, NY, near Center Moriches on the 23rd, and passed to the east of New Haven, CT, very close to Saybrook at the mouth of the Connecticut River (Darling 1842). Its path took it through the middle of the New England states, into the hill country of New Hampshire (fig. 3).

The force of the storm was most severely felt along the coast in Narragansett Bay and Providence suffered from its effect more than any other place. The tide was 10 to 12 ft above the height of the usual spring tides and 7.5 ft higher than ever known before. All the vessels in the bay were driven ashore or destroyed. Nine vessels were successfully launched again, but more than thirty were totally lost (Perly 1891).

3.2 Data

Details of the storm were taken from newspapers of that time, published in New York City, Hartford, CT, and Providence, RI. These newspapers included the **New York Spectator**, the **Connecticut Herald**, the **Connecticut Courant** and the **Rhode Island American.** The article "Notice of a hurricane that passed over New England in September 1815," written by Noyes Darling was published in the American Journal of Sciences (1842). Ludlum (1963) presented a summary of the life history of the storm and described some of the damage inflicted by the hurricane in New England states. The most informative excerpts from newspapers are listed below:

New York Spectator, Saturday, September 23, 1815

"The storm, which commenced yesterday morning, continued with violence until 10 o'clock this day. At this hour, the wind shifted from the N.E. around to the S.W. when its force was soon diminished. The flood-tide, although two or three hours before high-water, had already overflowed many of the docks, and threatened incalculable injury."

Monday, September 25, 1815

"By the Pilot Boat Rambler, from Sandy Hook, we learn that the Pilot Boats Erie and Science, are on shore at the Cove with the loss of their anchors. The British brig Friendship, bound to Jamaica, is also on shore.---- The bridge at Ward's Island, near Hurl-gate, was swept away and drifted down the East River."

Wednesday, September 27, 1815

"The Military telegraph, on Signal Hill, at the Narrows, was blown down by the late gale. The drawbridge at Flushing, L.I. was swept away on Saturday last (Sept. 23). The tide rose during the storm three ft. higher than was ever before known."

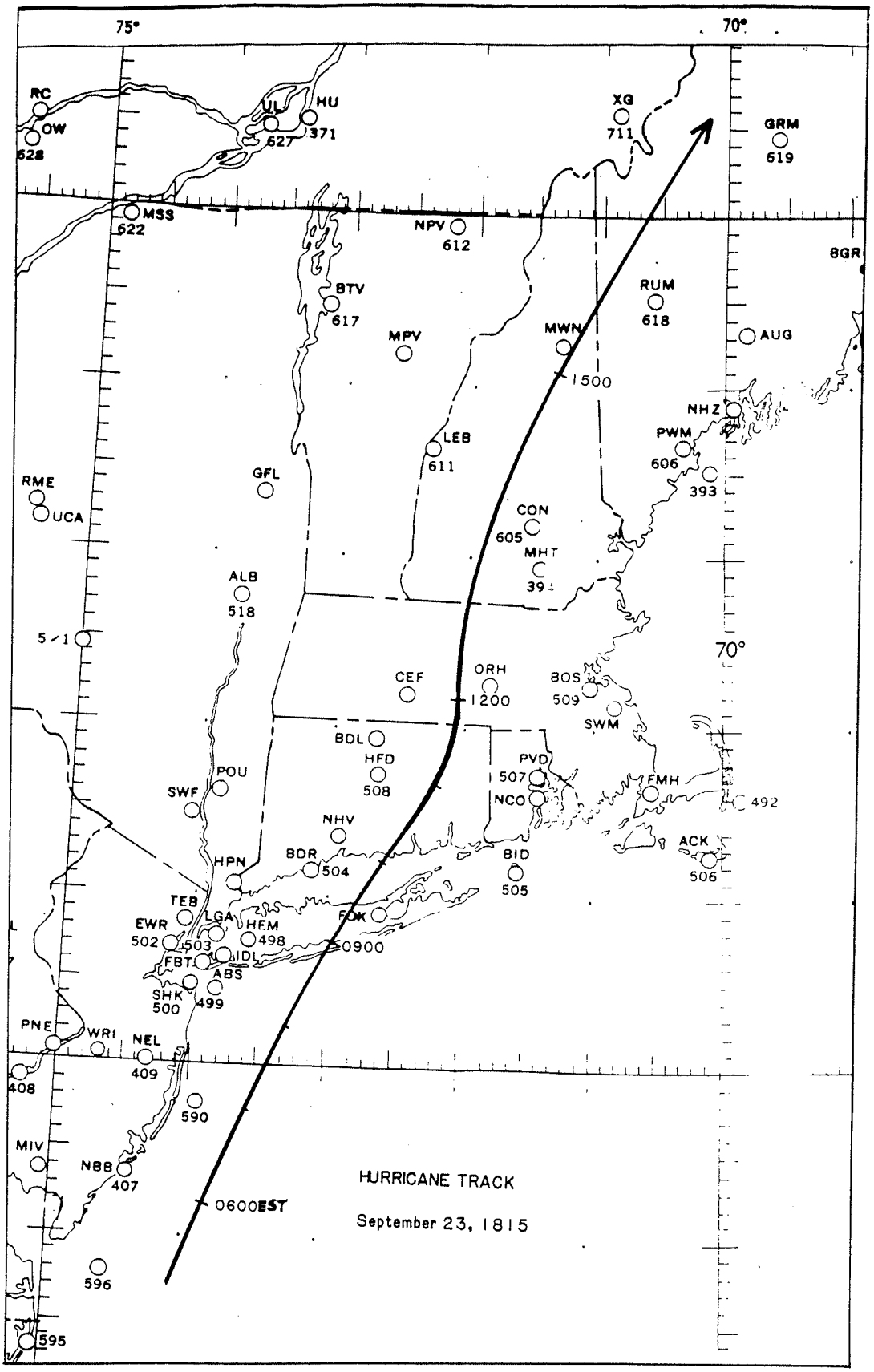

Figure 3.—Hurricane track, September 23, 1815.

The Connecticut Courant (Hartford, CT), October 4, 1815

"Bridgeport, September 27 -- The late storm, which commenced on Thursday, but continued with increasing violence until 11 o'clock on Saturday (23rd) morning, the wind during the whole time blew a severe gale accompanied with rain from the N.E. and had so much increased the waters in the Sound, that the tide which in ordinary weather would have been full at 2 o'clock and 44 minutes, attained its greatest height at 12 o'clock 30 minutes, and was then near six feet above common flood tides, and had it not fortunately happened that the wind some hours before the tide was at full veered round to the N.W. it must have risen to an alarming height. The oldest inhabitants do not remember so high a tide by nearly one foot."

"Connecticut Herald (New Haven) September 25, 1815

"On Friday night and Saturday morning last (23rd) a severe storm of wind and rain was experienced in this vicinity, which extended into the country, and has done considerable damage to the roads, bridges, etc. The west bridge, on the Milford Turnpike, is rendered impassable by the destruction of the causeway on each side of it.... Long-Wharf was entirely inundated by the highest tide known for a great number of years. Everything movable on the wharf was swept away. The water in some of the stores was nearly two feet deep, but no great loss took place."

October 5, 1815

"An old citizen of New Haven who has been particularly attentive to the subject has informed us that forty-five years ago there was a remarkably high tide in this town which did not, however, rise as high by four inches, as the one on Saturday last (September 23).... Had not the wind, two hours and a half before high water, suddenly shifted to the westward, it is impossible to tell what damage might have been sustained by inhabitants on the Sound."

New York Spectator, September 30, 1815

"River Head, Lyme, September 23 -- The violence of the wind increased gradually till 9 o'clock at which time it blew a perfect hurricane, and continued with the utmost fury until 11 a.m.... At River Head the tide rose 6 feet higher than ever it was known to rise before, carrying away bridges, etc.... The forest from New London to Connecticut River, exhibits to the eye the most dreadful destruction ever made by a tornado in this part of the country, (according to a first hand account of Mr. V. Utley)."

Connecticut Courant, October 4, **Rhode Island American**, October 3, 1815

"New London, September 27 -- The equinoctial storm commenced here on Friday last; and during that day and night there was a heavy fall of rain; wind N.E.-On Saturday morning the wind increased, at 7 o'clock was very violent, and soon after became almost a hurricane. The tide which commenced flood at about 6, had covered the wharves before 9, and at 10

had risen from three to four feet higher than it had ever been known before, by the oldest inhabitants. The rise of water had been so rapid, (in just 30 min) ... the waves were running from four to six feet high through the streets.... Soon after 11, the wind shifted to the westward, and abated."

"At Stonington the storm raged with great violence. Every vessel in the harbour went on shore.... About 30 buildings, large and small, were destroyed or considerably injured. But the most heart-rending scene, was a dwelling-house floating off with its inhabitants...."

Connecticut Courant, October 4, 1815

"Norwich, September 27 -- The most destructive gale of wind within the memory of the oldest inhabitant was experienced at this town on Saturday morning.... On Friday night the wind blew fresh at N.E. gradually increasing until about 8 o'clock on Saturday morning, when it veered to E.S.E. and blew with the most tremendous fury from that point to W.S.W. until near 12, when it abated.... The water beat over the wharf-bridge with incredible force, its depth there was at least six feet.... The water on the wharves and in Lower-street was four feet higher than can be remembered on any former occasion.

"Middletown, September 28 -- The gale, on Friday night and Saturday morning last was very severe, much damage was done on the sound shore, the tide having risen in an extent beyond the recollection of the oldest persons insomuch as to destroy the crops of corn and potatoes to a considerable extent, many vessels were sunk at Saybrook.

"Newport, September 27 -- The tremendous storm commenced on Saturday morning last, at about nine o'clock, the wind blowing S.E. by S. accompanied with unabated fury for about two hours and a half, when it happily in a great degree subsided.... During this tremendous gale, the tide rose about 4 1/2 feet higher than it was ever known in the town, about 8 feet above the normal tides."

Rhode-Island American (Providence, R.I.), September 26, 1815

"AWFUL STORM!--A storm of rain from the N.E. commenced on Friday last and continued with little intermission till Saturday morning, when the wind was from the East. Between 8 and 9, however, it shifted to the S.E. and continued to blow with increasing violence till half past eleven, when suddenly changing to the West.... The tide rose to an unprecedented and terrifying height, (12 feet higher than spring tides) and inundated the streets in various parts of the town.... It is computed that five hundred buildings of various descriptions have been destroyed."

October 3, 1815

"In Warren the tide rose about 7 feet higher than common spring tides. All the vessels in the harbour but 3 were forced from the wharves and driven on the shores of the cove.

"Nearly all the vessels at Briston were driven a great distance on the land, and considerably injured. The tide rose 7 feet higher than was ever before known, it carried away the building occupied as the post-office, and several houses and stores.... The wharves were completely swept.

"In little Compton, the salt-works were carried away, and the valuable firm at Seconnet Point, occupied by J. Shearman, was nearly overflowed with the tide. About 10 acres of it is covered with gravel....

"In East-Greenwich the gale commenced about 7 o'clock, and continued until 12, the tide rose about 7 feet higher than was ever before known.

"In New-Bedford, the tide rose about 10 feet above high water mark, and four feet higher than ever before known. The whole of the salt work at the south part of the town, with about 100 bushels of salt, were carried away." (The tide was 12 to 14 feet higher than usual, according to **Rhode-Island American** of September 29)

"The melancholy march of this Destroyer appears to have been from nearly a southeast to a northwest direction, and its extent in width above 80 miles. Its influence was felt much further.

"A Worcester paper says, neither the memory of man, or the annals of the country can furnish any parallel to this storm, and that it is estimated that the ordinary consumption of ten years of the whole town will not exhaust the wood which is now prostrated. It was severe at Concord (N.H.).

"In no place we learn has the tempest exercised greater force than in Braintree, where houses, barns, etc., etc., were prostrated, and cattle killed. The tide in the river was kept back two hours by the wind.

"At Woods Hole, five or six vessels were driven ashore, but not materially injured.

"At Martha's Vineyard, the gale was very severe. The salt-works were entirely destroyed.

"In Nantucket very little injury was experienced from the wind and tide was not unusually high."

3.3 Summary

The most important meteorological data and high-water information about the September 23, 1815 hurricane, taken from newspaper accounts, are summarized. The list of events are arranged according to geographical locations from west to east.

New York City:	NE gale shifted to SW at 10 a.m.
Flushing, Long Island:	Tide rose 3 ft higher than ever known before.
Sag Harbor, Long Island:	Tide rose 6 ft higher than ever known before.

Bridgeport, CT:	Wind shifted to NW some hours before highest tide was observed at 12:30 p.m., reaching nearly 6 ft above common flood tides.
New Haven, CT:	Long-Wharf was entirely inundated by the highest tide known for a great number of years. No great loss in property took place.
River Head, Lyme, CT:	Tide rose 6 ft higher than ever known before. Highest wind intensity reached at 9 a.m.
New London, CT:	Highest water attained at 10 a.m., 3-4 ft higher than ever known before.
Stonington, CT:	Tide rose 17 ft above normal.
Newport, RI:	Tide rose 8 ft above normal tide.
Warren, RI:	Tide rose 7 ft higher than common spring tide.
Briston, RI:	Tide rose 7 ft higher than ever known before.
East Greenwich, RI:	Tide rose 7 ft higher than ever known before
Providence, RI:	Wind shifted to westerly at half past eleven, tide rose 12 ft higher than spring tides.
New Bedford, MA:	Tide rose about 10 ft above highwater mark (or 12 to 14 ft higher than usual).
Boston, MA	The editor of the Farmer's Cabinet reported: "at 1130 the severest gale of wind from the Southeast ever known."

3.4 Discussion

Detailed descriptions of damages inflicted by the 1815 hurricane from newspaper accounts were omitted from the excerpts above for conciseness. However, damage reports for various locations were examined. Since coastal areas located to the right of the storm track suffer more severe damage, the results of these analyses helped in the determination of the storm track and the radius of maximum winds. The occurrence of high water in Long Island Sound after the storm passage indicated that resurgence was observed to the left of the landfall point. Other phenomena which gave a good indication of the storm size came directly from the magnitude of the wind and the height of water levels. The time of occurrence of maximum winds at a station and the distance of the location of observed peak coastal surges from the landfall point also helped in estimating the radius of maximum wind for the storm.

The track of the 1815 hurricane (fig. 3) crossed Long Island in a north-northeast direction and entered the Connecticut coast near Saybrook, west of the mouth of Connecticut River. The time of landfall was estimated at about 10 a.m. because the maximum winds at Lyme occurred near 9 a.m. and the peak surge at New London at 10 a.m. An earlier report of the hurricane's position was made at 7 a.m. on the morning of September 23 by a ship located off Barnegat

Inlet, NJ, indicating that a dead calm existed as an interim between 'severe gales of great violence,' first from east-northeast and then from the west-northwest (Darling 1842). This report indicated that the eye of the hurricane passed over the ship located at about 60 nmi south of the Long Island coast. Hence, the locations of the storm center, thus determined, at 7 a.m. and 10 a.m. gave an average speed of translation of 34 knots for the storm, near the time of landfall.

Examinations of damage reported from various localities led us to believe that wind damage was most severe in Stonington, CT and in Providence, RI. In addition to damage reports, the extent of flooding and the time of maximum wind occurrences at various places were useful information in determining the size of the storm. The highest tide level in the 1815 storm reported at Stonington, CT, also helped to place the area of maximum winds near the time of landfall. We concluded that the distance of 30 nmi would be an appropriate estimate for the radius of maximum winds for the storm of 1815.

High water levels observed along the coastal locations of southern New England states in the 1815 hurricane are comparable to those observed in the New England hurricane of 1938. The 1815 hurricane crossed the Connecticut Coast in an east-northeast direction, while the 1938 hurricane moved in a northerly direction across Long Island and Connecticut. Both hurricanes induced extensive flooding in the Narragansett Bay area. Providence, RI, sustained greater damages from the 1815 hurricane because of the storm's north-northeastward track which brought the maximum destructive force upon the city. The highest tide (17 ft above normal) in the storm which was observed at Stonington, CT, indicated that the severity of the 1815 hurricane might have exceeded that of the 1938 storm. We conclude that a central pressure value of 940 mb may be assigned to this 1815 hurricane near the time of landfall. This value is close to that of the 1938 storm while it approached the Long Island coast. The central pressure of this hurricane would probably have risen to 945-mb by the time its center crossed the Connecticut coast.

Because of the qualitative nature of the observations and the indirect method of analysis, the derived values of the hurricane parameters, given in the following table, are not as reliable as most of the corresponding values derived from observed data for more recent hurricanes.

Parameter of hurricane of September 23, 1815, off Long Island, NY, coast

Central pressure	27.75 in. or 940 mb
Radius of maximum winds	30 nmi
Direction of forward motion	210°
Speed of forward motion	34 kt

4. HURRICANE OF SEPTEMBER 3, 1821

4.1 Introduction

This hurricane was the most intense hurricane to pass over New York City in the past 200 years (Ludlum 1963). The maximum storm surge at the Battery, NYC, was estimated to be 10 ft (**Mercantile Advertiser**, NY, September 5, 1821). The water in East River rose 13 ft in just one hour (**Gazette and General Advertiser**, September 7, 1821). It is most fortunate for the city that the peak surge occurred at low tide. If the storm surge had occurred at high tide, the water level would have reached 14-15 ft MSL above normal (U.S. Army Corps of Engineers, 1964).

The hurricane, first observed off Turks Island, Bahamas, on September 1, 1821, moved through the Outer Banks of North Carolina. It then moved north-northeastward from the Chesapeake Bay region and caused extensive damage in Philadelphia and the southern New Jersey coastal communities. It continued into the New York City metropolitan area. Its center passed within a few miles east of New York harbor and moved across Long Island Sound into Fairfield County of Connecticut. It weakened rapidly and became an extratropical storm as its center moved across the western part of Massachusetts into Vermont. The track of this storm is shown in figure 4.

4.2 Data

Most of the observations pertaining to this 1821 hurricane are from newspapers. The articles include information pertinent to the storm track, the storm intensity and size, and the level of the storm surge. Detailed descriptions of damages inflicted by the hurricane were omitted in the following excerpts for conciseness. Some of this information was summarized by Redfield (1831) and Ludlum (1963). The most informative excerpts are listed below.

U.S. Gazette (Philadelphia), September 8, 1821.

"At Cape Henlopen, DE, the gale had commenced there at 1130 from the east-southeast, shifted twenty minutes later to east-northeast and blew hard for three hours. A calm of about thirty minutes followed. Then the wind picked up from the west-northwest and raged with still greater violence than before. At Cape May (NJ), 15 miles to the northeast across the (Delaware) Bay, the wind commenced from the northeast, but veered to the southeast at 1400 and blew with great violence. Cape May had a 15-minute calm" (Ludlum 1963).

New York Spectator, New York, September 4, 1821

TREMENDOUS GALE

"Last evening we were visited with the most tremendous gales of wind ever experienced in this city. We had rain most of the day, with the wind from S. to SE. Between 4 and 5 o'clock it changed to N.E. and blew

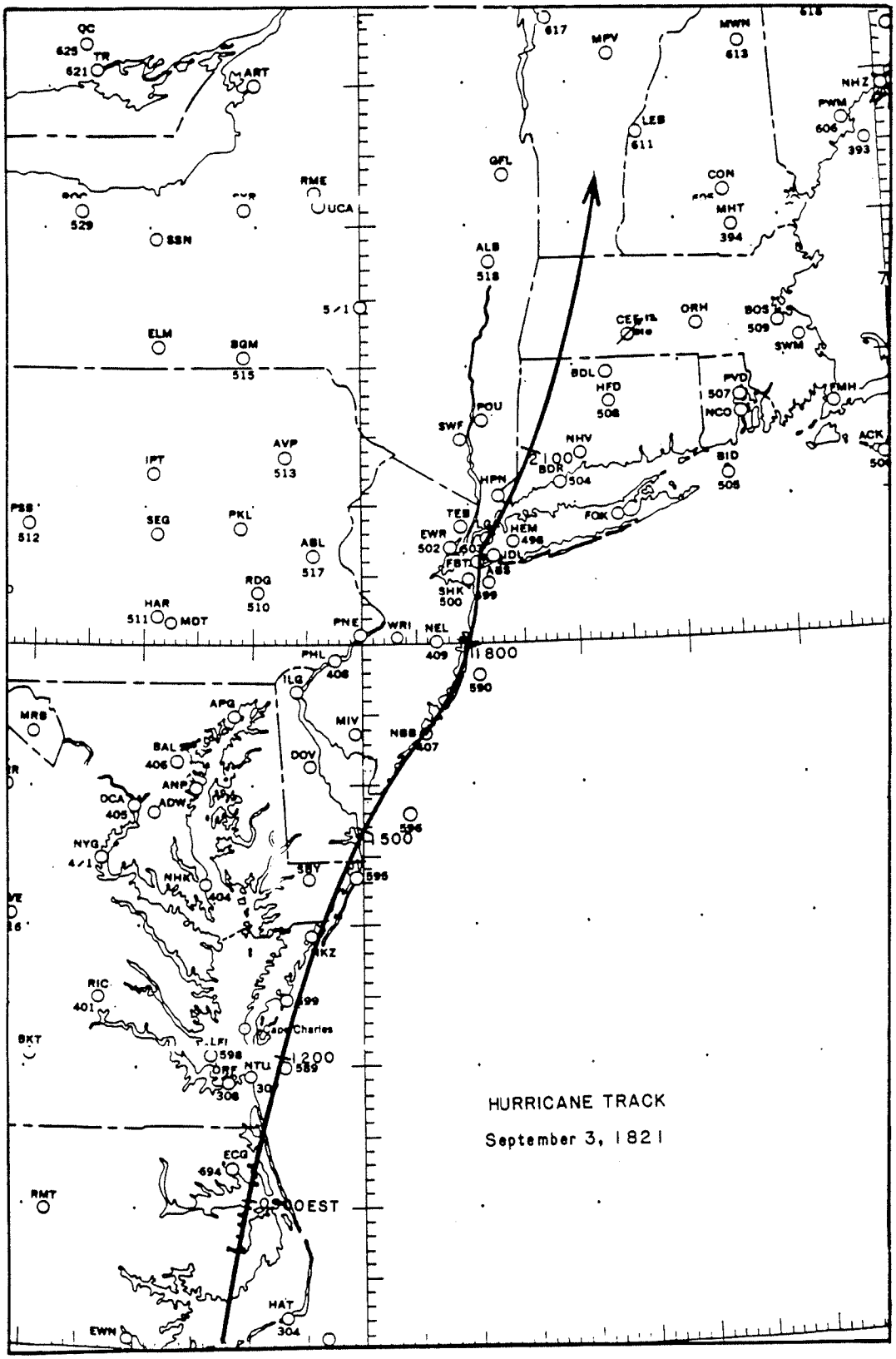

Figure 4.--Hurricane track, September 3, 1821.

until near 7 o'clock with great violence. About that hour, the wind abated, and soon after shifted to W.N.W. At this time it was the hour for low water, but such had been the violence of the tempest, that the sea was forced in to such a degree, that the wharves were overflown to the depth of from 12 to 20 inches."

The Mercantile Advertiser, New York, September 4, 1821

TREMENDOUS GALE

"Yesterday from about 9 a.m. till evening, we had rain most of the time, with occasional heavy showers. The wind during most of the day was fresh from S to SE, but between 4 and 5 o'clock changed to NE, and began to blow a gale. At about 5, it became variable, blew unusually hard, and continued to increase in violence till about half past 7. Between 6 and 7 the gale was at its height, and more tremendous than ever before recollected. At this hour many vessel in the east river had broken adrift, and though it was the hour for low water, the sea was forced in so as to overflow the wharves to the depth of about a foot.... Fortunately, when the panic was greatest, the gale abated ... the wind veered to WNW when it gradually subsided ... and the water receded."

September 5 1821, "Yesterday morning, a more disastrous scene was presented than was anticipated from the accounts we gathered the night previous. Almost all the vessels in the East River are more or less injured and the wharves have sustained great damage. The water rose about ten feet above its height at that time of tide. It is most fortunate for the city, that the gale did not happen when the tide was on the flood, in that case, the damage would inevitably have been incalculable."

The Gazette and General Advertiser, September 7, 1821

"Singular fact - In one hour during the tornado of Monday evening, the water was forced into the East River 13 ft and 4 in. above low water mark. On the sudden shifting of the wind, the water went off in half the time that it came in. The regularity of the tide had no effect upon the water, which yielded entirely to the force of the wind."

New York Daily Advertiser, September 5, 1821

"The gale commenced on the afternoon of Monday, and very soon became almost a hurricane - blowing with greater violence, it is said, than has been ever before known even by the oldest inhabitants. It raged for about 3 hours; and so sudden and unexpected was its approach, that the inhabitants and those who had the charge of the vessels in the harbour and neighborhood of the city had very little warning or opportunity to guard against its violence.... Some idea of the strength of the gale may be derived from the fact that though it occurred at the time of low water, the tide almost immediately rose to such a height as to overflow the wharves in the East River, and entirely to cover South Street.

The American, New York City, September 5, 1821

The following is an extract from an eyewitness report:

"September 3, 1821 -- In the early part of the day, and at intervals till late in the afternoon, heavy showers, with steady breezes from the southeast. From 5 to 6 p.m. the wind and rain increasing, with every indication of a settled storm. From 6 to about 7:30 p.m. the wind from ESE, but varying to E and ENE accompanied with rain, blew with extreme violence. From 7:30 to 8 p.m. the wind had much abated. It then veered to the SW and clouds were swept away with astonishing quickness.

"The following account of the gale is copied from the **Bridgeport, CT Farmer:**

Tremendous Gale -- After two or three days of dull cloudy weather, with frequent heavy showers of rain, we were on Monday evening visited by the most dreadful hurricane which has been experienced for many years. The wind commenced blowing hard from the S.E. about 6 o'clock p.m. accompanied with rain, and continued to increase in violence until about 9 o'clock, when the tempest raged with a degree of fury the most awful and destructive. The storm continued with unabated force, until near 11 o'clock, when the wind hauled round to S.W. and gradually subsided."

4.3 Summary

The most important meteorological statements about the storm, taken from newspaper and eye-witness accounts, are summarized.

At Edenton, NC	Wind shifted to NW at 9 a.m., September 3.
At Norfolk, VA	Wind shifted to NW near 12 noon.
At Cape Henlopen, DE	Wind shifted to WNW after a calm of 30 min.
At Cape May, NJ	Wind shifted to NW after a calm of 15 min.
At Newark, NJ	NE gale commenced at 1700, maximum intensity reported between 1830-1930 wind shifted to NW at 1930.
At New York City, NY	Lowest pressure of 29.38 in. (994.8 mb) reported at 1930, wind shifted to WNW soon after the wind abated between 1900-1930.
At Stratford, CT	Maximum winds from the south experienced at 2000.
At Bridgeport, CT	Strongest winds occurred between 9 o'clock and 11 o'clock in the evening of September 3.
At Newhaven, CT	Prof. Benjamin Silliman described the southeast gale and stated that the wind shift there was through south to southwest.

4.4 Discussion

Observations of calm winds and wind shifts from easterly to northwesterly helped to determine the storm's position at various times. At New York City, the editors of two newspapers, the **New York Spectator** and the **Mercantile Advertiser**, reported that the wind shifted to WNW soon after a lull in the wind speed occurred between 7 and 7:30 p.m. The shifting of wind direction to the northwest indicated that the storm center passed some distance to the east of the reporting stations. According to the **American**, an eye-witness report stated that winds veered to the southwest after the wind had abated from 7:30 to 8 p.m. These reports suggest that northeasterly winds shifted to west-northwesterly after a lull and continued backing to southwesterly as the storm center moved northward away from the city. It follows that the backing of wind would place the path of the storm center passing to the east of the city. The occurrence of a lull indicated that the center passed within a few miles of New York City harbor. This conclusion results in a path that is different from the approximate path for this storm given by Graham and Hudson (1960) which, based solely on an eyewitness report, placed the storm track to the west of the city.

The lowest reported pressure was 29.38 in. at some distance from the storm center. Graham and Hudson (1960) gave a range of 28.70 to 29.30 in. as probable center pressure values. Because of the lack of quantitative information on this storm the central pressure estimate is subject to error. Considering the surge height of 10 ft in New York harbor, the flooding along East River, and the severe damage suffered at Flushing, Long Island, the intensity of the hurricane was probably comparable to that of Carol (1954) and Donna (1960). We recommend that a central pressure of 28.50 in. (965 mb) would be appropriate for this hurricane.

The information on maximum winds experienced at Neward, NJ, and Stratford, CT, were used in the analysis to determine the radius of maximum winds (R). The assessment of R is described in Section 2.3. As indicated earlier, detailed descriptions of damages inflicted by the hurricane were omitted in the data summary for conciseness. However, the analysis of this information was made and the result of which helped in the determination of R. An example of this analysis is given in Section 3.4.

Because of the qualitative nature of the observations and the indirect method of analysis, the derived value of the hurricane parameters given in the following table are not as reliable as most of the corresponding values derived from observed data for other more recent hurricanes.

Parameters of hurricane of September 3, 1821 at Long Island, NY coast

Central pressure	28.50 in. or 965 mb
Radius of maximum winds	30 nmi
Direction of forward motion	180°
Speed of forward motion	30 kt

5. HURRICANE OF SEPTEMBER 8,1854

5.1 Introduction

The hurricane of September 8, 1854 was the most severe storm to affect the Georgia and South Carolina coasts since the great 'Gale' of 1804. (Because of a lack of recorded meteorological information, the 1804 storm was not selected for further study.) The 1854 hurricane was a slow-moving storm of rather large size. The storm approached the southeastern United States from the south-southeast after having moved through the northern Bahamas. It was first encountered by the brig Reindeer about 60 miles northwest of Abaco Island in northern Bahamas on September 7. The ship's barometer at one time dropped to 27.70 in. (938 mb) as she stayed with the gale for a duration of five days. The massive extent of this hurricane was further demonstrated by the vast inundation that took place from Savannah, GA, to Winyah Bay area, SC, approximately a hundred miles apart. The center of the storm entered the coast south of Savannah, GA and then gradually recurved northeastward (fig. 5).

5.2 Data Summary

The Smithsonian Institution collected meteorological records of observations beginning in 1847 and instituted its own system of obtaining weather data from voluntary observers. With the establishment of the meteorological service of the Signal Corps in 1870, the work of the Smithsonian Institution declined and the institution's extensive collection of meteorological reports from 383 observers was transferred to the Signal Office. These records are stored on microfilm at the National Climatic Data Center in Asheville, NC.

The Smithsonian records of meteorological conditions during the 1850's included contributions made by R.J. Gibson of Whitemarsh Island near Savannah, GA. Professor Lewis R. Gibbs of Charleston College gave a summary of this hurricane in a letter to William C. Redfield of New York that has been preserved in the Redfield Collection at the Yale University (Ludlum 1963).

According to Gibson, "the storm of the 8th was by much the severest which has occurred in the last twenty years. But one tide (that of the Gale of 1804) is remembered which overtopped that of the 8th. The barometer fell steadily until 4 p.m. of the 8th, then began to rise. The wind hauled toward East from N.E. about 1 p.m. and blew its heaviest puffs about 2 p.m. from S.E. by E. By midnight it had got to south or near it and blew at times very hard from that quarter."

The following information are extracted from Professor Gibbs collection and other Smithsonian records of meteorological observations taken during the passage of this 1854 hurricane through the southeastern states.

At St. Simon Island, GA (from Professor Gibbs' collection)

0800:	wind N by W
1200:	wind NNW
1400:	wind NW/N barometer lowest
1600:	wind WSW
1800:	wind SE/S
2000:	wind SW
2400:	gale abating

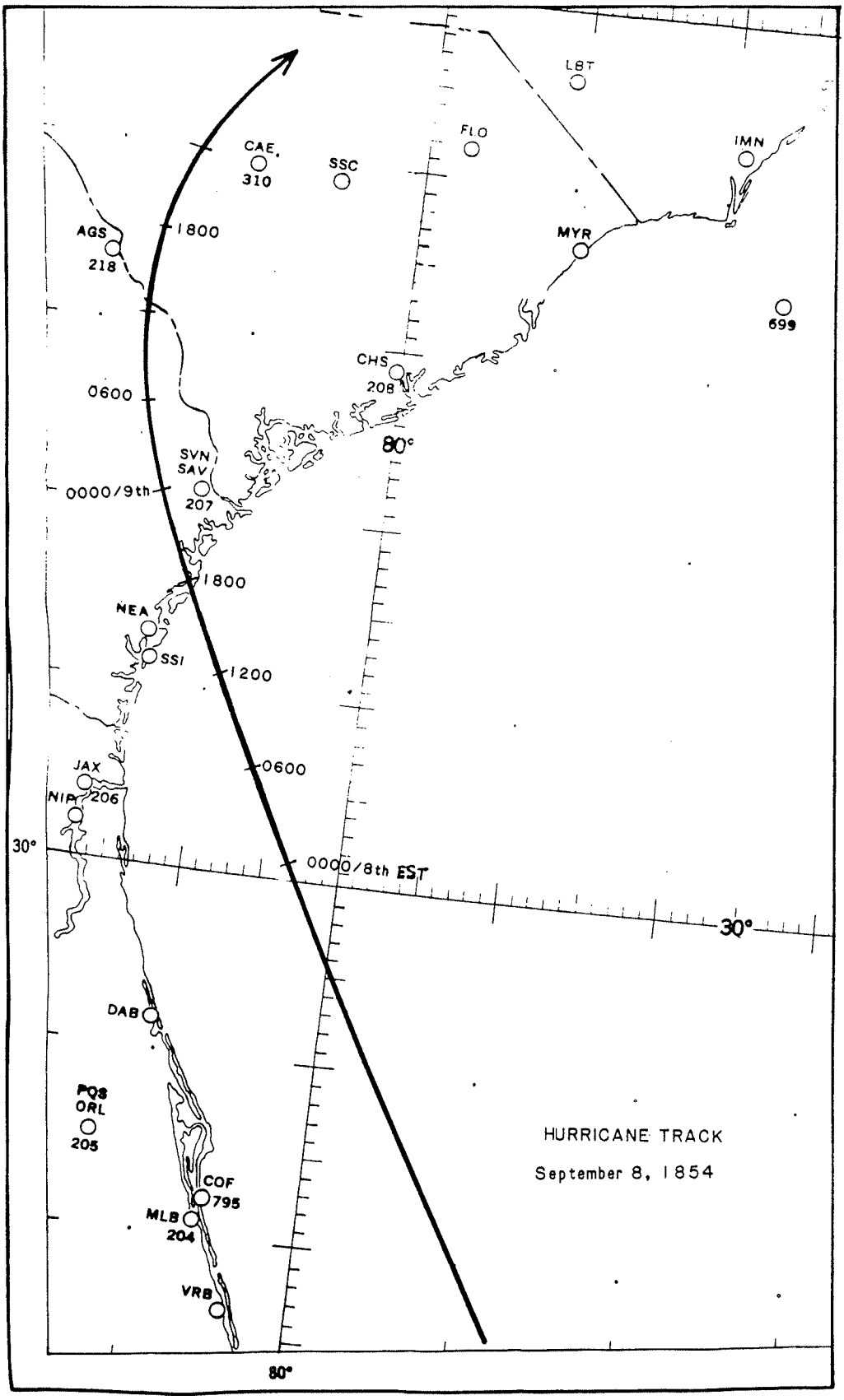

Figure 5.--Hurricane track, September 8, 1854.

At Savannah, GA (from Smithsonian Observer)

Time (EST)	Corrected Barometer	Wind Estimated
0700	29.455 in.	ENE 60 mph
1400	29.037	ENE 75 mph
1600	28.737	ESE 90 mph
1800	28.975	SE 75 mph
2000	29.167	SE 75 mph

At Charleston, SC (from Gibbs)

0800	Wind from the northeast
1400	Barometer lowest, wind shifted to east
1700	Wind shifted to southeast

At Columbia, SC (from Gibbs)

Sept. 8	High winds veering from NE to E
Sept. 9	Winds veering to SE and S at night barometer lowest 28.96 (uncorrected) at 4 p.m.
Sept. 10	Wind veered to the west

The **Charleston Mercury** (September 12) reported on the gale in Savannah by reprinting the news account from the **Savannah Republican** of Saturday evening (September 9). The account included the following pertinent information:

> "The gale continued to abate from 11 o'clock Friday night, and by Saturday morning at 4 o'clock, it had subsided into a rather gentle wind from the Southwest. It set in from the Northeast Thursday forenoon (September 7), and continued to blow from that quarter until half past three p.m. Friday, when it slowly shifted to the East. At 10 o'clock at night, it had changed to the Southeast, and from that point it gradually wore around to the Southwest, the opposite point of the compass from whence it started."
>
> "Hutchinsons Island - The whole of this island opposite the city, except a few high places, was submerged. The water was five or six feet deep upon it in many places."

The following excerpts came from correspondence dispatched to the **Charleston Mercury** and reported on September 13. The descriptions on wind conditions experienced at Edisto Island and Georgetown, SC, demonstrated the size and lateral extent of the hurricane.

> "Georgetown, SC, September 11 -- We have had a terrible gale, and one of long continuance. The tide was as high as in 1822, but the wind not so high. The wind then blew a gust at N.E. and S.E. for only four hours, and S.W. for six hours. This gale was at N.E. and S.E. for forty eight hours, and at S.S.W. for twelve hours.

"Edisto Island, September 10 -- One of the most terrific hurricanes within the recollection of any of our inhabitants has just passed over us, leaving ruin and desolation behind it... Owing to the prevalence of Northeasterly winds, which commenced to blow fresh on Wednesday morning, and continued to increase in violence until Thursday night, when the storm burst upon us in all its fury, a great accumulation of water was thrown upon our coast, and the tide rose here higher on Friday morning than it has ever been known before."

5.3 Discussion

The hurricane made landfall on the Georgia coast somewhere between Brunswick and Savannah. At St. Augustine, Jacksonville and St. Simon Island, the gales backed from northeast into northwest, while at Savannah and Whitemarsh Island, GA, and at Beaufort and Charleston, SC, the gales veered from northeast to southeast and finally to south as the storm passed abreast of each station. Figure 5 shows the track of this storm for September 7-9.

The wind observed at St. Simon's Island backed to NNW at noon on the 8th and barometric pressure reached its lowest point at 4 p.m., while the southeasterly gales at Whitemarsh Island (near Savannah) did not veer to the south until midnight. These observations indicated that the storm took almost 12 hours to traverse from the latitude of St. Simon's Island to Savannah, GA (about 1 degree) at an average speed of about 5 knots. The information on the time of maximum winds reported at Whitemarsh Island and at Savannah formed the basis in determining the radius of maximum winds. The assessment of R is described in Section 2.3 and an example of damage analysis is given in Section 3.4.

The September storm was an extremely intense hurricane when she was located at about 60 miles northeast of Abaco Island in northern Bahamas. The lowest pressure observed at the brig Reindeer was 27.70 in. (938 mb). The storm weakened considerably as she moved slowly north-northwestward towards the Georgian coast. The lowest pressure at Savannah of 28.737 in. (973 mb) was observed as the hurricane was approaching the coast at 1600 on September 8. The highest wind of 90 mph from ESE which was observed at the same time, placed the location of the storm center just off the coast, 40 nmi south of Savannah.

Assuming that the pressure of 973 mb at Savannah was observed at the time of maximum winds, we obtain the central pressure by the following estimate, derived from equation 1.

$$P_o = \frac{P_r - P_n[\exp(-R/r)]}{1 - \exp(-R/r)},$$

where, $r = R$, $P_r = 973$ mb and $P_n = 1012$ mb

Parameters of hurricane of September 8, 1854 at the coast, south of Savannah, GA

Central Pressure	28.07 in. or 950 mb
Radius of Maximum Winds	40 nmi
Direction of Forward Motion	200°
Speed of Forward Motion	5 kt

6. HURRICANE OF SEPTEMBER 8, 1869

6.1 Introduction

The storm center probably cut across the eastern tip of Long Island, NY, before striking eastern New England on September 8, 1869. It crossed the Connecticut coast near Stonington and passed to the west of Providence (fig. 6). The storm moved north-northeastward through eastern Massachusetts between Worcester and Boston. The barometric pressure at Milton, MA, dropped to 28.75 in. (973.5 mb) at 1800 EST on September 8. The storm continued on its course, rapidly crossing southeastern New Hampshire into western Maine, probably along a Milford-Farmingham-Concord-Lawrence axis (Ludlum 1963).

The main scene of the hurricane's destruction came in the complex of bays, inlets, islands and low-lying ground that make up Narragansett Bay. Disaster strikes here whenever a major tropical storm moves inland to the west. In 1769, 1815, here in 1869, and subsequently in 1938 and 1954, the waters of the bay have been driven up the narrowing estuary by hurricane winds. Along Buzzard's Bay, the wind-driven waters of the 1869 storm funneled up the bay to its head at Warham and reached the highest point in 234 years, or since the legendary Great Colonial Hurricane of 1635 (Ludlum 1963).

6.2 Data

As for other New England hurricanes previously discussed, most of the observations pertaining to this 1869 hurricane are from newspapers. The most informative excerpts are listed below:

Providence Daily Journal, September 9, 1869

"We were visited yesterday afternoon (September 8), by a fearful gale, which, although of short duration, caused an immense destruction of property and sad loss of life. The weather had been fitful and squally all day, with rain at intervals. About 4 o'clock the wind increased to a hurricane from south-southeast, and for an hour spread havoc and devastation on every side. Old citizens who recollect the "Great Gale" of 1815 tell us that the force of the wind yesterday seemed fully equal to that remarkable tempest, the only difference being in the duration of the storm." (This storm lasted for about one hour while the storm of 1815 continued its fearful severity for three hours.)

"The tide fortunately was out when the gale commenced its severity, but the wind sent the surges up through the Great Bridge with the rapidity of a torrent. For more than an hour, the tide rose a foot every ten minutes, (until 6 p.m.) three hours before the time for high tide, the water stood within a few inches of the floor of the horse railroad depot on Weybosset bridge. At this time the wind shifted to the westward, and abated its fury, and soon the flood began to subside. Had the gale continued another hour at its highest force, we see no reason why the water would not have touched as high a point as at the great flood of 1815. As it happily proved, the tide came no nearer than about six feet of that famous flood of 1815."

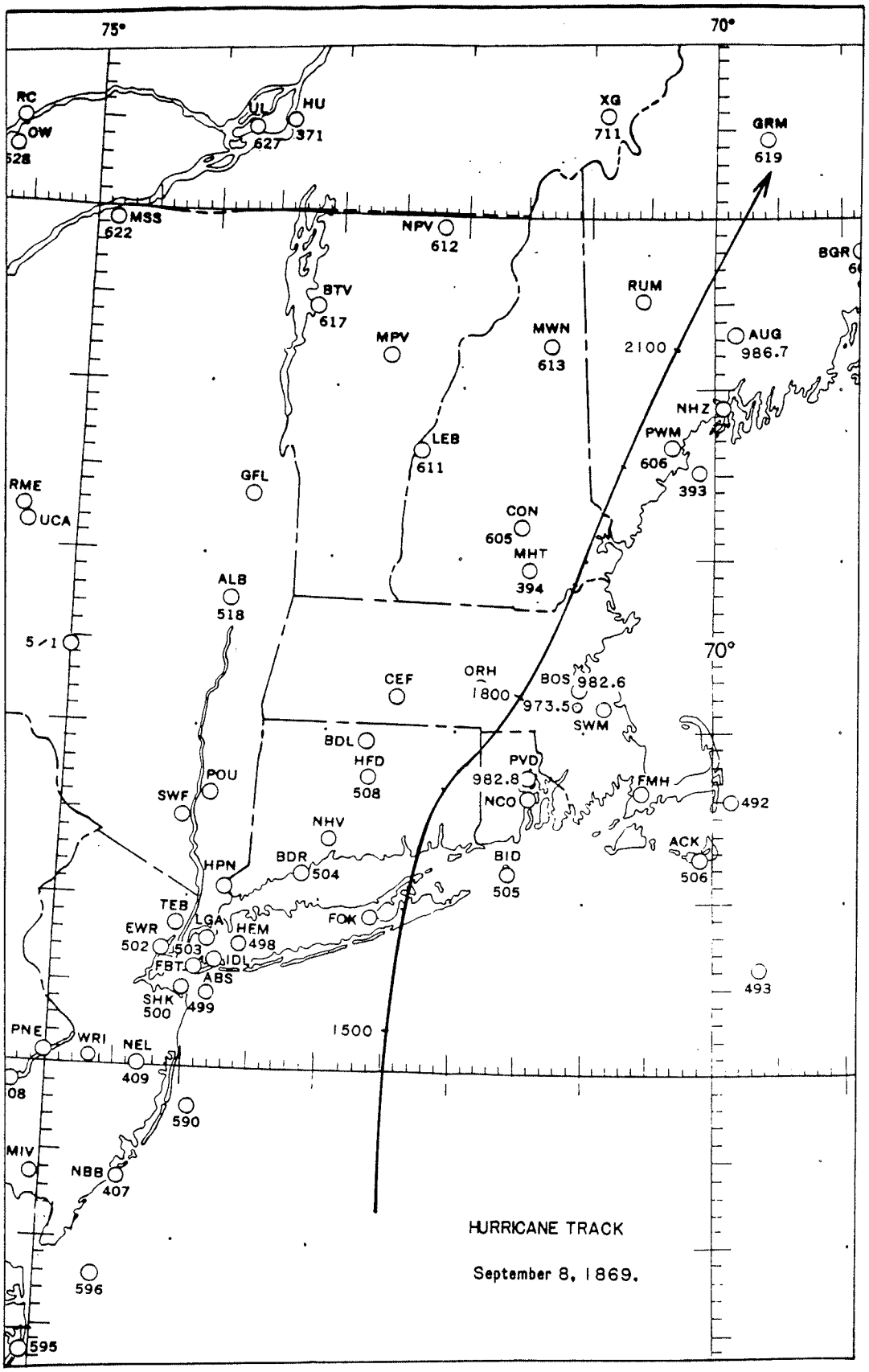

Figure 6.--Hurricane track, September 8, 1869.

"In the City -- The tide rose rapidly from 4 to 5 o'clock, when the gale was at the highest, and soon after 5 ft overflowed the wharves...until the wind lulled, at about 6 o'clock, and at half past 6 the water began to recede and fell rapidly from that time, although it was not high water until quarter past nine."

"The Gale in Apponang and East Greenwich -- The storm in this vicinity has been such as the oldest inhabitant has not witnessed in his lifetime.... The water rose eight feet in the docks at Apponang and Greenwich in two hours."

"Elsewhere -- Vessels were ashore at New London, Mystic, Stonington and Westerly."

September 10, 1869

"In Barrington -- The water rose very fast in Barrington River, coming up close to the houses and threatening to inundate them.

"In Bristol -- The tide rose very rapidly. At 5 1/2 o'clock (5:30 p.m.) it was six feet above high water mark. Had the wind held southeast two hours longer, the destruction by water would have been immense: at the height of the gale the wind veered to the southwest and blowing offshore checked the inward flow.

"In Westerly -- One of the most severe gales experienced here for many years commenced about 2 o'clock Wednesday afternoon, and continued for about three hours, when it abated.

"In Woonsocket -- The gale here was not so severe as reported in places nearer the sea coast....

"At Centreville and vicinity -- The gale was severe....

"In Stonington -- During the violent gale, Wednesday afternoon, wind from southeast to south-southwest.... At the time indicated for low water, the water was higher than has been known for years, rising very rapidly. The veering of the wind to the westward saved much damage.

"The gale for a few hours was of fearful severity, and had the tide been flood, must have done much damage. Fortunately, at about 5 p.m., the wind hauled to the southwest, blowing very heavy, and immediately checked the tide.... For a short time, the gale almost equaled that of 1815. Stonington must have been nearly the western limit of the gale.

"At Watch Hill -- Some damage has been done to the Watch Hill House and the Larkin House.

"In Newport -- A southeast rain storm commenced here this noon about 1:30, and continued to rain by spells until 3 o'clock, when the wind commenced to rise and increased in fury every minute, until it broke into a violent gale accompanied by heavy rain.... The tide kept rising

as the wind increased, at 5 o'clock the tide was within one foot of the top of the wharf.

"In Portsmouth -- On Monday the wind was at southeast, and continued in that quarter until Wednesday afternoon, when at about 6 o'clock it changed to southwest.... From noon, the wind continued to rise until 5 o'clock, at which time the gale was more severe than any we have had here since the great September gale of 1815.

"In Lousdale -- The wind and rain continued incessantly, increasing in violence till it reached a perfect hurricane. About half-past 5 the gale had reached its height."

6.3 Summary

The most important meteorological data and high water information about the 1869 hurricane are summarized from newspaper reports as well as local observations collected by the Smithsonian Institution.

0800-1200 A vessel experienced a severe hurricane at latitude 72°40°W (directly south of Moriches on Long Island).

At Moriches - 1530-1630 - NE winds of force 4-6
1700 backed to NW, winds moderating
By sunset, winds from SW at force 2.

At Nantucket - Wind from SE increased steadily until 1900 when it veered to SW.

Fort Trumbull (near New London) 1400 - winds from east at force 5.

At Newport 1600 - Violent gale from the southeast reached its peak at about 5 hours before high tide.

At Bristol 1730 - Tide rose 6 ft above normal high water mark, wind from southeast.

At Providence 1400 - Barometer dropped to 29.66 in.

The following meteorological data was observed by A. Caswell of Brown College.

1500 - Wind became heavy from SE
1700-1730 - SE winds reached its highest intensity
1700 - Barometer reading 29.106 in.
1730 - Barometer reading 29.026 (minimum observed)
1740 - Barometer reading 29.10 in.,
Wind shifted to the southwest.
1800 - Barometer reading 29.206 in.
2000 - Barometer reading 29.55 in.
2200 - Barometer reading 29.608 in.

At Wareham along Buzzard Bay

The southeasterly wind maxima coincided with near high tide, the water reached the highest point in 234 years, or since the legendary Great Colonial Hurricane of 1635.

At New Bedford - Barometer dipped to 29.51 in.

At Nantucket - SE winds increasing till 1900 when they veered to SW.

At Milton -	0700	29.50 in. wind SE at force 8.
(south of Boston)	1800	28.75 in.
	1810	Barometer rising, wind abated
At Boston -	1645	Severe wind from ESE
	1750	Wind shifted to south
	1800	29.14 in.
	1812	Lowest pressure 29.02 with maximum winds.
	1900	29.25 in., wind abated
	1930	Wind veered around to SSW

At Gardiner (50 miles NE of Portland, ME) - The gale began at 1900 reaching near hurricane intensity by 2000. Soon after 2200 the wind lulled and by 2300 was blowing strong from the southwest. Barometer reading at 2100 - 29.14 in.

6.4 Discussion

Newspaper accounts and reports from local observers were used in determining the parameters for the September 1869 hurricane. The track of this storm can be traced from available information. It was first encountered by ships at sea, but the locations of the ships were uncertain. One vessel located at 72°40'W longitude experienced a severe hurricane from 0800 to 1200 with the wind veering from southeast to south-southwest. The Smithsonian observer at Moriches on Long Island, about 50 miles west of the eastern tip reported that the highest winds from the northeast occurred from 1530 to 1630 and backed into the northwest by 1700. At Newport, RI the violent southeast winds began at 1500 and reached their peak at 1600. President Alexis Caswell of Brown College at Providence gave his detailed account of wind and pressure observations during the storm passage. From his data it was determined that the storm center passed near Providence at 1730 when a minimum pressure of 29.026 in. (982.8 mb) was observed.

The lowest pressure in this storm was observed at Milton, immediately south of Boston. The barometer there fell from 29.50 in. (998.9 mb) at 0700 to a low of 28.75 in. (973.5 mb) at 1800. The pressure rise began 10 minutes later and the wind began to abate immediately. The Smithsonian observer there reported winds at force 8 as early as 1400 when the regular afternoon observation was taken. At Boston, the observer thought that the heaviest blast of wind came at 1812 when the lowest pressure of 29.02 in. (982.6 mb) was reached. The information on maximum winds reported at Providence, RI, and at Gardiner, ME, were also used in the determination of the radius of maximum winds. The assessment of R is described in Section 2.3. Detailed descriptions of damages inflicted by the hurricane were omitted in the data summary for conciseness. However, an analysis

of this information was made and the result used in the determination of R. An example of this analysis is given in Section 3.4.

Ludlum (1963) gave a brief account of the asymetry in the wind field for this storm. He noted that the Smithsonian weather observer located at Mendon, MA, close to the Rhode Island border, had a southeast gale of force 8, while Worcester, only 18 miles to the northwest, had southwest force 4. The observer at Lunenberg, just east of Fitchburg, reported little damage at his place, but great destruction 20 miles to the south. According to Ludlum, the same pattern continued farther north where southeast gales caused havoc along the Maine coast, but only light northwesterly winds prevailed over eastern New Hampshire.

The central pressure for this hurricane was derived from equation (1) using the lowest pressure observed at Milton, MA, when the storm center was located at about 18 miles from the station. The computed central pressure was then adjusted to the coast by using an empirical filling rate of over-land hurricanes (Ho et al. 1987).

Parameters for the hurricane of September 8, 1869 at Long Island Coast

Central Pressure	28.44 in. or 963 mb
Radius of Maximum Winds	40 nmi
Direction of Forward Motion	190°
Speed of Forward Motion	45 kt

7. HURRICANE OF AUGUST 18, 1879

7.1 Introduction

The hurricane of August 18, 1879 was selected as the representative extreme hurricane in the nineteenth century for the southeastern North Carolina area. Its existence can be traced to the afternoon of August 17 when a sharp 9.5-mb drop in barometric pressure was recorded at coastal stations from Smithville, NC, to Jacksonville, FL. The storm was probably centered some 200 miles east of the central Florida coast at this time. At Savannah, heavy rain fell from 11:25 a.m. to 6 p.m. with southeasterly winds backing to northwest during the afternoon. At Cape Lookout, the gale commenced at 7:50 p.m. with a heavy southeast rain-squall. By midnight of the 17th, high winds were reported on the Carolina coast ranging from NE at 25 mph at Charleston to SE at 32 mph at Cape Lookout, NC. The storm was then off the South Carolina coast. After midnight, the northeast wind at Smithville, NC, backed to northwest with increasing force and reached its greatest velocity of 37 mph at 5 a.m. on the 28th. At the same time, the wind had increased to 68 mph from the west at Wilmington, NC, and 80 mph from the southeast at Cape Lookout. At 6:30 a.m., the barometer reading at Cape Lookout dropped to 29.15 in. (987.0 mb) and the wind velocity reached 138 mph as the anemometer cups were blown away. By 7:30 a.m. the wind at Cape Lookout reached its maximum, estimated at 165 mph from the southwest. At 8 a.m. the tide at Macon, NC, rose four ft above the ordinary high tide. At 8:30 a.m. the maximum recorded wind velocity at Cape Hatteras was 74 mph when the anemometer cups were blown away. Maximum winds of 97 mph were recorded at Portsmouth, NC, at 8:45 a.m. and 100 mph at Kittyhawk, NC, at 9:50 a.m.

Figure 7 shows the track of this 1879 hurricane entering the North Carolina coast west of Cape Lookout. A newspaper account of that time indicated that a lull in the hurricane was experienced at Morehead City, NC. This suggested that the eye of the storm passed over that place, probably just a few miles to the west. As the storm moved over land, its center accelerated and re-entered the Atlantic south of Cape Henry, VA. The tide at Norfolk, VA, reached a point never witnessed by any but the oldest inhabitants of the city. After leaving the Virginia coast, the hurricane continued on a northeastward course and crossed the southeastern corner of Massachusetts near New Bedford.

7.2 Data Summary

Pertinent meteorological data were summarized and tabulated from reports published in the Monthly Weather Review. Table 1 gives the minimum pressure and maximum winds observed in the August 1979 hurricane at selected stations.

Selected meteorological data are tabulated as follows:

Time (EST)	Pressure (in.)	Pressure (mb)	Wind (mph)	Remarks
At Cape Lookout, NC				
0500	-	989.4	SE 60	
0600	29.22	987.0		
0630	29.15	987.0	SE 138	wind estimated
0700	29.15	987.0		lowest pressure
0730	29.18	988.0	SW 165	wind estimated
0735	29.24	990.1		

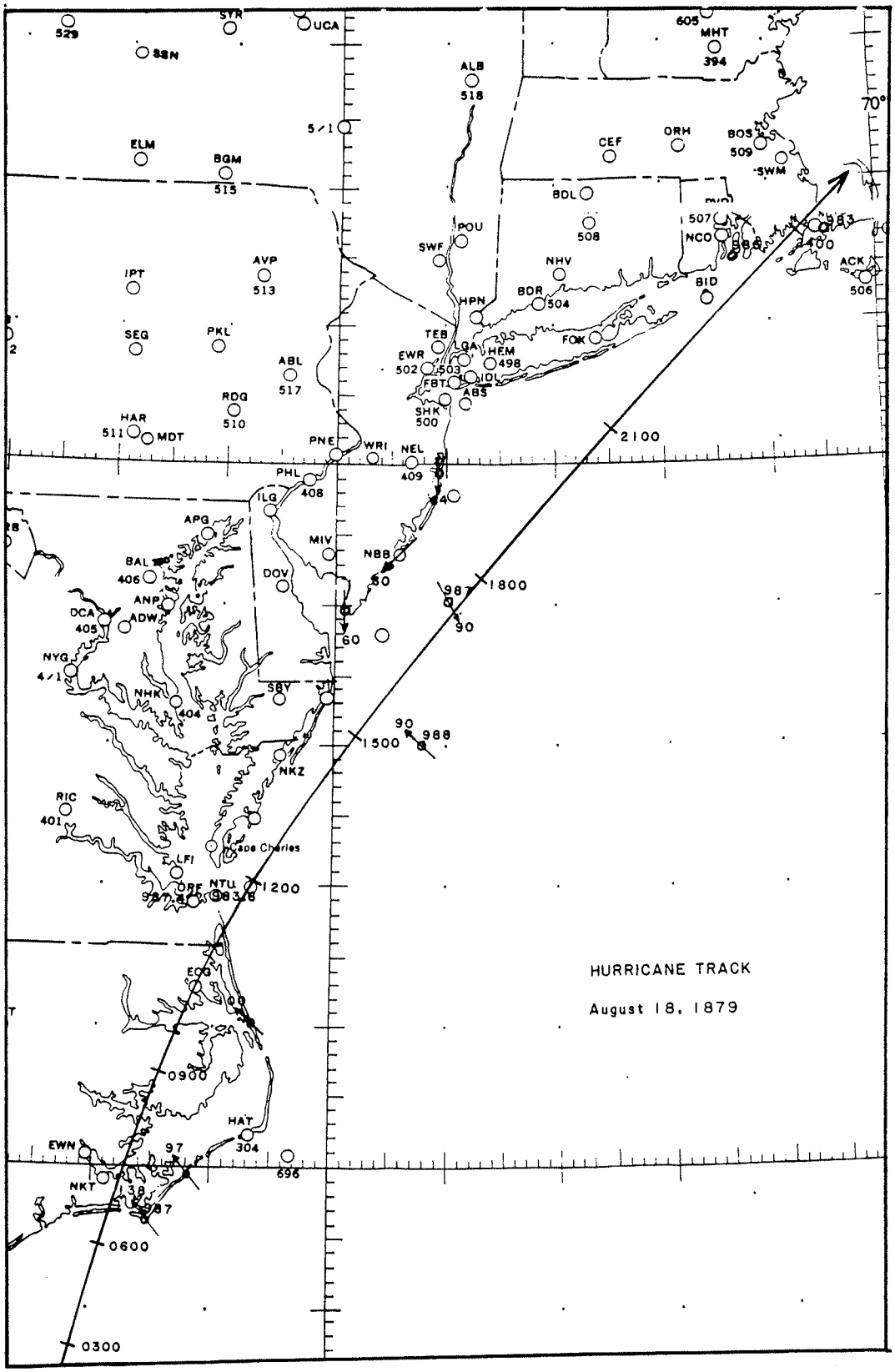

Figure 7.--Hurricane track, August 18, 1879.

Time (EST)	Pressure (in.)	Pressure (mb)	Wind (mph)	Remarks
At Norfolk, VA				
0945	29.58	1001.6	NE 24	
1045	29.16	987.3	NE 48	
1115	29.12	986.0	NE 39	lowest pressure
1145	29.20	988.7	N 72	
1230	29.42	996.2	NW 60	
At Cape Henry, VA				
1100			N 66	
1115	29.05	983.6	N 35	lowest pressure
1130			NW 70	
1230			NW 76	anemometer cups failed
1400			NW 100	estimated
U.S.S. Wachusett				
0400	30.04	1017.2	SSE 28	off Virginia capes
0800	30.03	1016.8		
1000	30.01	1016.1		
1200			E 28	38°45'N 73°51'W heading NNE
1400	29.71	1006.0	E 50	heading E by N
1600	29.46	997.5	SE 69	
1730	29.12	986.0	SE by E 78	39°N 74°W
1745			calm	
1800	29.32	992.8	NW 78	
2000	29.52	999.5	NNW 90	
U.S.S. Constellation				
1200	30.02	1016.5		
1400				left Newport, RI
1500	29.96	1014.4		
1600	29.90	1012.4		
1700	29.80	1009.0		
1800	29.75	1007.3		
1900	29.63	1003.3		
2000	29.43	996.5		
2100	20.30	992.1		1 mile off Red Flash Race Light
2200	29.25	990.4		
2215	29.23	989.7		minimum pressure
2300	29.27	991.1		
2400	29.35	993.8		

Table 1.--Minimum pressures and maximum winds reported in the hurricane of August 18, 1879.

Location	Lowest pressure (in.)	Lowest pressure (mb)	Maximum winds (mph) ahead of storm		Maximum winds (mph) in rear of storm		Remarks
Macon, NC	-	-	SE	100	-	-	
Cape Lookout, NC	29.15	987.0	SE	138*	SW	165*	-
Portsmouth, NC	-	-	SE	97	-	-	
Kitty Hawk, NC	-	-	SE	100	-	-	
Norfolk, VA	29.12	986.0	NE	48	N	72	
Cape Henry, VA	29.05	983.6	N	65	NW	100	calm at 11:10 am
Schr. "H.A. Bently" 38°N 74°W	29.20	988.7	SE	90*	-	-	
U.S.S. Wachusett 39°N 74°W	29.15	987.0	SE/E	75	NNW	90	15 min. calm
Newport, RI	29.11	985.7	N	26	NW	44	wind lulled to 6 mph at 11:23 pm
New Bedford, MA	29.05	983.6	E/S	50*	NW	50*	calm at midnight

* Estimated

The most informative excerpts from newspaper accounts are listed below.

The Morning Star, Wilmington, NC, -- August 20, 1879

"The storm in its greatest fury struck Beaufort about 1 A.M., the wind blowing a hurricane from the east, finally veering to the southwest, thereby saving both Beaufort and Morehead City from total destruction. As it is, $75,000 will scarcely cover the loss of the former, and $80,000 at the latter place.

"The Atlantic Hotel was entirely demolished - not a vestige being left. There were one hundred and fifty guests in the hotel, and there was not a particle of clothing saved by any of them, except what they had on.

"The Ocean View Hotel was the next victim, and the spectators who had watched the destruction of the Atlantic made preparations to save such stuff as was conveniently portable, and then sought a refuge from the fury of the elements."

The Observer, Raleigh, NC, August 20, 1879
The Storm at Newbern

"The winds reached the utmost limit of their fury at between five and six o'clock.... The tide at one time came rushing in with race-horse speed; it soon flooded our wharves. When the wind suddenly veering to the west, it with equal speed receded."

Richmond Dispatch, August 20, 1879

"[From the Norfolk Ledger. 18th] Our city and section were visited this morning by the severest storm of wind and rain which has occurred for more than a score of years.... The storm attained its height between half-past 11 and 12 o'clock.

"The tremendous force of the wind also backed the water up in the harbor until it reached a height which we have never seen equaled.

"In consequence of the strong easterly wind, the tide, which should have been full about half-past 9 o'clock, continued to rise rapidly until nearly 12, when it reached a point never before witnessed by any but our oldest inhabitants."

7.3 Discussion

The August 1879 hurricane was one of the most intense storms to strike the southeastern North Carolina coast in the 19th century. The damage done by this storm can not be enumerated. Reports were received of over 100 large vessels shipwrecked or that suffered serious damages. The number of yachts and smaller vessels which were destroyed or seriously damaged exceeded two hundred. Other destructive hurricanes which struck the Outerbanks of North Carolina in the last century included the hurricanes of 1842 and 1846. The hurricane of 1842 was the most violent storm experienced at Ocracoke Bay for eighty years, while the hurricane of 1846 cut open two new inlets of major commercial importance - the new Hatteras Inlet between Ocracoke and Hatteras and the Oregon Inlet between Bodie Island and Nags Head.

The information on maximum winds and minimum pressures observed at selected stations, given in Table 1, was used to determine the hurricane track. Supplemental to the recorded pressure and wind data, reports also included information on the time and direction of wind shifts and the period of calm wind. These reports gave good indications of hurricane track positions relative to the observation location. They were used as an aid in determining the storm track and, to some extent, the radius of maximum winds. More detailed discussions on the assessment of R are presented in Sections 2.3 and 3.4.

The central pressure of the hurricane near the time of landfall was determined by using the pressure profile formula presented in Section 2.2 (eq. 1). To solve for central pressure (P_o), we need to have values of the peripheral pressure (P_n), the radius of maximum wind (R) and the pressure (P_r) at a distance r.

Since we have the pressure value at the time when maximum wind was observed at Cape Lookout, we have a known pressure value of 987 mb at a distance r = R. A peripheral pressure of 1014 mb was obtained from inspection of weather maps. Substituting these known values into the equation:

$$P_o = \frac{P_r - P_n\,[\exp(-R/r)]}{1 - \exp(-R/r)}$$

we have, $P_o = \frac{987 - 1015 \exp(-1)}{1 - \exp(-1)} = 971$ mb

Parameters of hurricane of August 18, 1879, at the coast near Cape Lookout, NC

Central pressure	971 mb
Radius of maximum winds	16 nmi
Direction of forward motion	195°
Speed of forward motion	25 kt

8. HURRICANE OF SEPTEMBER 9, 1881

8.1 Introduction

This severe hurricane moved in a northwestward direction while approaching the North Carolina coast. It recurved to a northeasterly direction after making landfall west of Smithville, NC. Its center passed over Wilmington, NC, shortly after 1300 on September 9, 1881 (fig. 8). At Smithville, NC, it was reported to be the most violent storm in 50 years. Many ships were sunk or driven ashore. At Wrightsville, NC, the tide "marked a height never before witnessed and water washed over the turnpike carrying large quantities of earth out to sea and making the road impassable." The center of the storm continued its northeasterly course and passed to the west of Fort Macon, NC. It then gradually turned towards the north-northeast and exited the Virginia coast, north of Norfolk.

8.2 Data Summary

Meteorological observations at selected hours were taken at regularly reporting stations of the Signal Corps. The stations located near coastal areas affected by this September 9, 1881 hurricane included Smithville, Wilmington, and Fort Macon, NC. The data collections are stored at the National Climatic Data Center in Asheville, NC, and were readily available. Selected data from these stations are tabulated at the end of this section. Eyewitness accounts of this hurricane were obtained from articles printed in local newspapers which are available at the Library of Congress in Washington, DC. Pertinent meteorological information was extracted from various sources and reproduced in the following paragraphs.

Excerpts from the **Wilmington Morning Star** give eyewitness accounts of this hurricane which was considered the most severe storm there since 1822.

> "Terrific storm at Wrightsville, (N.C.) -- Turnpike washed away --bath houses gone -- trees uprooted and twisted off -- landmarks gone. Soon after 7 o'clock (September 9) the wind rose and by 8 the boats were drifting away and the marsh hens flying in. The wind continued to increase in velocity, and the whole sound was full of white-capped waves, equal to an ordinary ocean surf, not a vestige of marsh grass being visible. The tide marked a height never before witnessed by this generation, it swept over the turnpike, washing away that part of the curve, rendering it impassable.
>
> "Before 2 o'clock the wind which was blowing from the east, increased in velocity to such an extent that it was difficult to move against it. Several trees were blown down. The old cedar at Lippitt's Point, being undermined by the water, was blown over. All the boats dragged anchor and no boat could live in such a sea. The grandstand at the banks is a thing of the past, being completely swept away. One or two planks only marked the spot.
>
> "After 12 the wind shifted in a directly opposite direction with redoubled fury, and then the great damage was done to property.
>
> "At Fort Fisher, where there is a small fishing village, all houses but one were swept away. One house, located near the water, was washed entirely away, not a vestige of it being left.

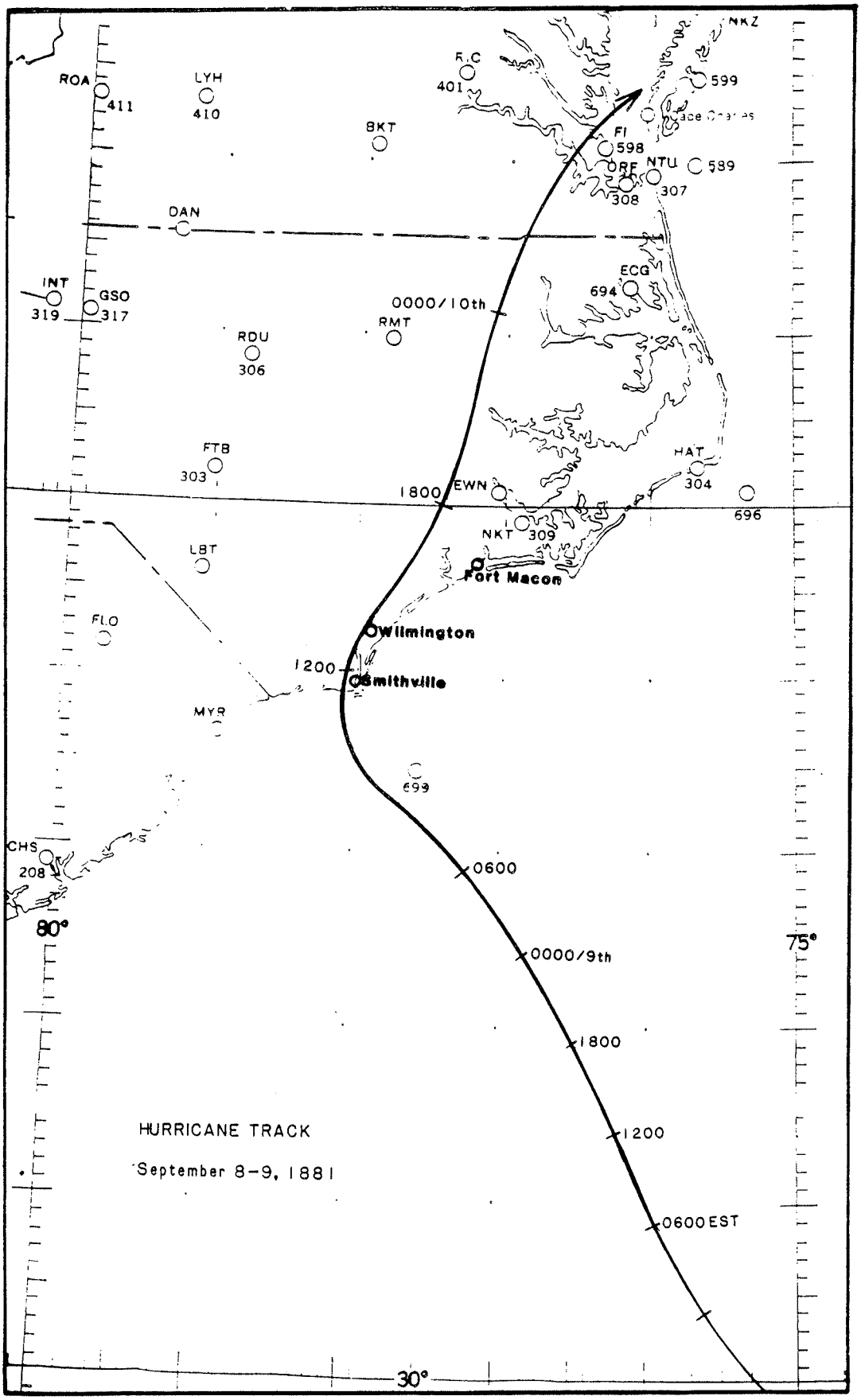

Figure 8.--Hurricane track, September 8-9, 1881.

"At Wilmington, NC, the oldest inhabitants say that it has been many years since this immediate section has been visited by such storms as those of yesterday. One old gentleman says Wilmington experienced such a gale in the year 1822, and another remembers one that occurred in 1838, at which time the water in the river was up to Front Street, which he thinks will compare with the hurricanes of yesterday. The Signal Officer here reported the velocity of the wind at one time during the last gale at 90 mph.

"It was related as a fact that three large trees were uprooted at Masonboro Sound by the first of the storms on the eventful Friday of last week, which was from the northeast, and that the second and more severe one, which was from the southwest, blew them back into position again, where they are standing at the present, looking as if nothing ever happened to them.

"A report at the Signal Corps' office in Wilmington, NC, reads as follows: Brisk NE winds and light rain early at 9:45 a.m. "UP SIGNALS" received. At 10 a.m. the wind increased to a gale (35 miles). The lowest barometer reading was 29.302 at 1 p.m., when the storm center passed the station. The wind veered to the SW and to the west at 1:15 p.m. when the wind suddenly increased to a hurricane blowing at the rate of 90 miles an hour for 4 minutes when the wires of the anemometer were carried away...."

News and Courier, Raleigh, NC, September 12, 1881

"The Wilmington Star of Saturday says that two terrible cyclones passed over the city on Friday. The first warning of the approach of the storm was given by the signal office at half-past 9 o'clock, and the hurricane struck the city an hour later, the wind soon attaining to a velocity of fifty miles per hour, and finally, at one time, reaching as high as sixty miles. The hurricane, which was from the northeast, with the usual variation incident to such a storm, swept through the streets with fearful violence, threatening destruction to everything that resisted its power, and, of course, entailing a good deal of damage to property.

"A lull succeeded the first fury of the gale, but in a little while the calm was succeeded by a terrific gale from the southeast, accompanied by a drenching rain, and which swept through the streets with unprecedented violence, ..."

The following table gives pertinent parameters of the September 9, 1881 hurricane at the coast:

Selected meteorological data for September 9, 1881 are tabulated as follows:

Time (EST)	Pressure (in.)	Pressure (mb)	Wind (mph)
At Wilmington, NC			
0700	29.91	1012.7	NE 13
0945	29.81	1009.4	
1045	29.63	1003.3	E 30
1056	29.62	1002.9	
1200	29.39	995.1	
1300	29.30	992.1	W 64
1400	29.50	998.9	
1500	29.69	1005.3	W 26
1900	29.92	1013.1	W 14
2300	30.01	1016.1	W 11
At Smithville, NC			
0700	29.85	1010.3	N 18
1000	29.22	989.4	NE 60
1100	29.24	990.1	E 48
1500	29.53	999.9	W 24
1900	29.98	1015.1	W 16
2100	30.02	1016.5	W 8
At Fort Macon, NC			
0700	29.98	1015.1	E 24
1100	29.91	1012.7	SE 88
1500	29.82	1009.7	SE 50
1900	29.88	1011.7	S 42
2300	29.95	1014.1	SW 22

8.3 Discussion

The track of the September 1881 hurricane (fig. 8) was traced by using all available wind and pressure data. The lowest pressure at Smithville was observed at 1000 on September 9 when the wind was 60 mph from the northeast. The veering of winds at Smithville from NE through E to the west indicated that the center of the storm passed to the south of Smithville near 10 a.m. At this time, the central pressure was estimated by using the pressure profile formula, to be 28.79 in. (975 mb). The storm weakened at its center, recurved and crossed the coast west of Smithville. Shortly after 1 p.m., the storm passed over Wilmington and extremely high winds were experienced at the station. A short duration of calm wind was followed by a suddenly increasing gale of 90 mph prior to the failure of the anemometer connections. Information on maximum winds reported at Wilmington and Smithville were used in determining the radius of maximum winds. Additional comments on the assessment of R are described in Sections 2.3 and 3.4.

Parameters of hurricane of September 8, 1881 off the coast, south of Smithville, NC.

Central Pressure	28.79 in. or 975 mb
Radius of Maximum Winds	15 nmi
Direction of Motion	170°
Speed of Forward Motion	12 kt

9. HURRICANE OF AUGUST 27, 1893

9.1 Introduction

This extreme hurricane which originated in the Cape Verde Island reached the Georgia coast on August 27. It was first detected at 22°N 56°W when a pressure of 28.70 in. (971.8 mb) was reported on August 22. A minimum pressure of 28.28 in. (957.6 mb) was observed at 0030 EST on August 28 at Savannah, GA, when the storm center was located on the Georgian coast (fig. 9). A low pressure of 27.70 in. (937.9 mb) was reported at midnight of the 27th by a private citizen on Wilmington Island, approximately 8 nmi south of the Weather Bureau office at Savannah. This intense hurricane was accompanied by extremely high storm tides which submerged the islands along the Georgia and South Carolina coasts. Between 2000 and 2500 people lost their lives on the coastal islands and in the low lands between Tybee Island, GA and Charleston, SC. Nearly every building on Tybee Island was damaged and the railroad to the island was wrecked. The highest tide known to have occurred in the storm was estimated to have a range of 17.0 to 19.5 ft MSL at Savannah Beach (18.2 ft given in a Corps of Engineers report, U.S. Army Corps of Engineers 1968).

After crossing the coast, this August 1893 hurricane moved northward passing over Charlotte, NC, on the 28th and then turned to the northeast. There was great destruction in the southeastern Atlantic states. A number of ships were lost at sea off the North Carolina coast in the Cape Fear area. Maximum winds of 72 mph from the south were reported at Southport and Wilmington, NC, on the 28th. At Wilmington, "the river tide was the highest ever known here" (Carney and Hardy 1962). A newspaper report stated that the sea washed across Wrightsville Beach and Carolina Beach, NC, (U.S. Army Corps of Engineers 1961). A high tide of 6.7 ft MSL was observed at South Island, Winyah Bay, SC and prevailed along the middle and south Atlantic coasts (U.S. Weather Bureau 1893).

9.2 Data Summary

The following are pertinent excerpts of meteorological information extracted from available newspapers:

The Morning News, Savannah, GA, August 28, 1893

"The storm was at its highest pitch between 10 and 11 o'clock when the wind reached a velocity of 70 mph, the greatest ever recorded by the Weather Bureau.... At midnight all the wharves along the river front were under water and the tide was still rising rapidly. Hutchinson Island was inundated and those who did not leave were probably drowned.

"The storm ceased entirely shortly after midnight and for nearly an hour there was a period of entire calm. The moon rose and everything was as bright as day almost.

"Observer Smythe of the Weather Bureau, who was in the Morning News Office at midnight, stated that the barometer had fallen and was again rising, and predicted as a consequence that the wind would be blowing as heavily as before within another hour. Observer Smythe's prediction was

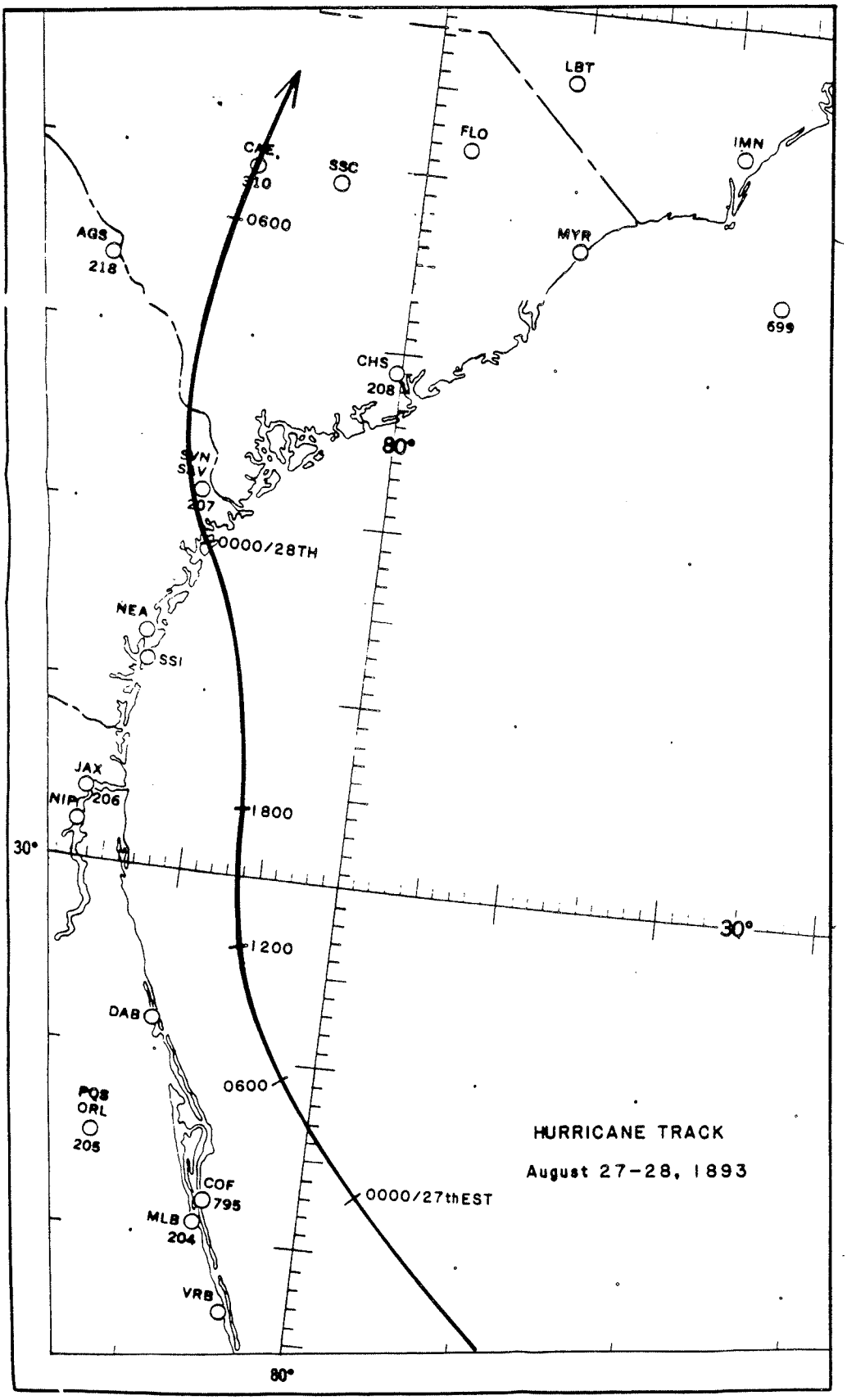

Figure 9.--Hurricane track, August 27-28, 1893.

finally realized. The wind raged furiously from 11:30 o'clock (sic, should have been 1:30) until the time of going to press this morning. The wind veered around from the northeast to the south, however. It carried away the last remaining portion of the Morning News skylight."

The Morning News, Savannah, GA, August 29, 1893

"The view of the city at daylight yesterday morning revealed a scene of wreck and ruin that surpassed even that after the great hurricane of 1881. The streets were impassable from the debris, trees, twisted roofs, etc....

"The first thought of loss of life outside of the city was Hutchinson Island, which was a broad sheet of water. Rescuing parties were organized and went across to the island in boats.

"Dr. Graham gives the following account of the work of the storm at the station (quarantine station):

"The wind blew about fifty miles an hour all day Sunday.... About half past six the gale struck heavy from the northeast, the tide immediately began to rise and in half an hour a foot of water covered the island. At 10:30 o'clock the gale was howling its worst, and six feet of water covered the island.

"The Tybee track between Savannah and the island was simply impassable from the island up to the city. The water which covered it entirely at an early hour yesterday morning had not subsided at noon yesterday, and in the fields near the Tybee depot the water stood three and four feet deep.

"There was great anxiety for the people at Tybee, and the first news from there was learned when the steam tug Paulsen, ..., which went down in the morning, arrived with about seventy-five passengers who had spent the night on the island. Those who remained there Sunday night experienced the most terrific storm and the greatest fright of their lives. The first storm commenced about 4 o'clock and lasted until 11:30, after which the wind changed and blew at a fearful rate in an opposite direction. Nearly every building on the island was more or less damaged and three lives were lost.

"According to an eyewitness report, Isle of Hope felt the full effect of the storm....The waves rolled up to the freight depot. At midnight the bath houses were nearly submerged by the flood. Nearly every bath house south of the rail depot was demolished. Heavy damages along the bluff were reported from Thunderbolt. Every bath house and Ambos' and Sawyer's wharves were destroyed. The yacht fleet at Thunderbolt suffered heavily.

"The storm at Bonabella and Cattle Park was particularly severe. Massive oaks and other trees were uprooted and broken off like pipe stems."

"Captain George W. Rossignol, the pilot of the streamer Camusi, gives the **Morning News** a graphic description of the scenes at Warsaw on the night of the storm. The Camusi left Thunderbolt Sunday at 10 o'clock on her usual trip and, after a stormy passage in which she had great difficulty in getting to her landing at Warsaw Creek, she arrived at 1 o'clock in the afternoon....

"Captain Oiler, Purser Kidwell, Pilot Rossignol, and the crew of the Camusi assisted by a few passengers, took the women in their arms and carried them safely to the woods, and thence they went over to the pavilion, where they remained until the first storm abated."

"Charleston, SC, August 29 -- The old earthquake city is once more engaged in rebuilding her waste places. The cyclone of 1893 arrived here on Sunday last.... At about 2 o'clock Sunday the fury of the gale set in, and by 7 o'clock it was blowing at the rate of 100 miles an hour accompanied by a drenching rain. By 4 p.m. pretty much all the streets and lots south of Calhoun street and west of Coming street were under water.... In an hour the water had risen to a depth of four feet in Lynch and Gadsden streets, and at 8 o'clock (near time of high tide) the entire western section of the city was from six to ten feet under water."

"Charleston, SC, September 2 -- The News and Courier had a careful investigation of the condition of affairs on the coast of South Carolina and finds that the reports have not been exaggerated. The loss of life will aggregate 800 in the belt country. Between Charleston and Savannah the storm wiped out most of the homes as well as the crops and left the property in a terrible state. The loss of life and property was found to be greatest on St. Helena, Ladies', Coosaw, Paris, Danfuskie and Dawthan Islands. These islands, with the Port Royal Islands, have a population of about 15,000....

"Beaufort, SC, September 2 -- The finding of dead bodies around this point, Port Royal and outlying islands, has about ceased today, but it is believed that there are many more yet to be discovered.... Sheriff Bedford and the coroner of Beaufort County have been busy all day perfecting a list of the dead, and they both estimate the loss at over 1000."

Entries in the Wilmington, NC, weather station journal read in part as follows:

"Wind continued to increase in force during early a.m. hauling to SE. Pressure decreased to a reduced reading of 29.60 in. at 9:30 a.m. At 10:15 a.m. wind was blowing at the terrific rate of 49 mph from SE, veering to S and SW and moderating towards midnight. The damage in this immediate vicinity was very slight from wind, but considerable damage (probably amounting to several thousand) was done to merchandise in stores along river front. The river tide was highest ever known there. All the wharves being submerged. The greatest damage was to shipping. The Norwegian bark Bonita was blown ashore in Cape Fear River near Southport and a number of vessels wrecked on the coast."

Table 2.-- Pertinent meteorological data observed at Savannah, GA, during the passage of August 27-28, 1893 hurricane

Time (EST)	Pressure (in.)	Pressure (mb)	Wind (mph)
August 27			
1400 EST	29.57	1001.2	NE 32
1600	29.45	997.2	NE 46
1800	29.29	991.8	NE 42
2000	29.13	986.3	NE 36
2200	28.83	976.2	NE 42
2300	28.45	963.3	NE 43
2340	28.36	960.3	NE 72
2400	28.29	957.9	NE 60
August 28			
0035	28.28	957.6	* 18
0100	28.30	958.2	* 13
0115	28.35	959.9	* 10
0200	28.40	961.6	SW 30
0230	28.57	967.4	SW 48
0300	28.65	970.1	SW 43
0400	28.87	977.5	SW 40
0600	29.12	986.0	SW 32

*The following note was written on the dual register: "Sudden gust of wind forced the wind vane upward, causing the chain collar attachment to strike the top of the contact box and forcing it down about 1/2 inch causing the wind to register NW instead of SW. Defect remedied at 4:30 p.m."

Table 2 gives the wind and pressure data observed in the hurricane at Savannah, GA.

Selected meteorological data for Jacksonville, FL, and Augusta, GA, are tabulated as follows:

Time (EST)	Pressure (in.)	Pressure (mb)	Wind (mph)
at Jacksonville, FL			
1400	29.31	992.4	NW 31
1600	29.20	988.7	NW 30
1800	29.11	985.7	NW 31
1900	29.08	984.6	NW 31
2000	29.10	985.3	NW 27
2200	29.18	988.0	W 31
2400	29.26	990.7	

Time (EST)	Pressure (in.)	Pressure (mb)	Wind (mph)
at Augusta, GA			
August 27			
2200	29.62	1002.9	26
2300			31
2400	29.48	998.2	35
August 28			
0100			29
0200	29.29	991.8	34
0300			32
0400	29.09	985.0	37
0500			35
0600	28.93	979.6	33
0630	28.92	979.2	33
0700	28.93	979.6	29
0800	28.96	980.6	
1000	29.16	987.4	

9.3 Discussion

The track of this storm was obtained by supplementing information available in Cry (1965) with analysis of daily weather maps. Descriptions of the storm (including flooding conditions and high water marks) and resulting damage, reported in the Monthly Weather Review (U.S. Weather Bureau 1893) and in newspaper accounts of August 1893, were also used as an aid to determine the landfall point and the storm path in the vicinity of Savannah, GA. The most informative news items included the following: (1) the veering of winds from east through south to southwest at Savannah, (2) a period of calm at Savannah shortly after midnight, (3) the shift of wind directions at Tybee Island just after 11:30 p.m., and (4) "a lull between storms" at Warsaw Creek. These reports helped to place the storm track crossing the coast south of Warsaw Island and passing within a few miles west of Savannah.

Table 2 shows that maximum winds of 72 mph and sea-level pressure of 28.36 (960.3 mb) were observed at Savannah, GA, at 2350 EST on August 27. At the time of maximum winds, by definition, the estimated distance between Savannah and the storm center was one radius of maximum winds. Peripheral pressure of 1010 mb was determined from weather maps. To estimate the storm's central pressure, the hydrometeorology pressure profile equation 1 was used:

$$\frac{P_r - P_o}{P_n - P_o} = \exp(-R/r)$$

or

$$P_o = \frac{P_r - P_n\,[\exp(-R/r)]}{1 - \exp(-R/r)}$$

Here, $r = R$, $P_r = 960.3$ mb, $P_n = 1010$ mb

Substituting, we get $$P_o = \frac{960.3 - 1010\ [\exp\ (-1)]}{1 - \exp\ (-1)} = 931.3 \text{ mb}$$

We directly applied observed data to the equation without assuming either a radius of maximum wind or the distance of the storm center from the station. If we had first estimated R and the distance of the storm center (r), we would have obtained a comparable value for the central pressure. The central pressure value, thus obtained, departs from the parameters given in an earlier report (U.S. Weather Bureau 1957). In the earlier report, the lowest pressure observed at Savannah was adopted as the central pressure of the storm. Since the purpose of this report is to determine hurricane parameters for storm-surge computations, the minimum central pressure of a storm approaching the coast should be used. As shown in figure 9, the point of landfall was some 24 nmi south of Savannah. We concluded that the estimated central pressure value of 931 mb for the hurricane at the coast would be appropriate for our purposes.

The radius of maximum winds was determined from 10-min wind speed values, with emphasis on the Savannah data. While this approach is not as desirable as using aircraft data, the general approach has been used by the National Weather Service for a number of more recent storms. The maximum surge in this storm occurred at Savannah Beach, GA about 24 nmi to the right of the storm track. This is consistent with the R value of 23 nmi determined from analysis of wind data since the maximum surge usually occurs at a distance of about one radius of maximum winds to the right of the storm center. The assessment of R is discussed in more detail in Sections 2.3 and 3.4.

Parameters of hurricane of August 27, 1893 at the coast of Georgia, south of Savannah

Central pressure	27.50 in. or 931 mb
Radius of maximum winds	23 nmi
Direction of forward motion	150°
Speed of forward motion	17 kt

10. HURRICANE OF OCTOBER 13, 1893

10.1 Introduction

This late season hurricane originated near the Cape Verde Islands off the coast of Africa. During the first 10 days of its life cycle, the path of the storm was not clearly determined due to confusing reports received at Antilles, Antigua and Dominica. The location of the storm was, however, reported by the steamer Ciudad Condal which moved within 30-70 miles of the storm center during October 11-13. A low pressure of 729 millimeter (972 mb) was recorded by the steamer on the 13th when the storm was about 30 miles southeast of the vessel (Monthly Weather Review, U.S. Weather Bureau 1893). Another low pressure of 28.40 in. (961.6 mb) was reported by Captain Kirwan of the steamship Wm Lawrence on the 13th when the steamer was located somewhere between the Frying Pan shoals and Charleston, SC, (**The Morning News**, Savannah, GA, October 15, 1893).

The hurricane passed over the entrance to Winyah Bay and crossed the South Carolina coast near Myrtle Beach (fig. 10). A low pressure of 28.33 in. 959.2 mb) was observed at South Island at 1000 on the 13th. After crossing the coast, the center of the storm moved northward at a faster speed passing over Raleigh, NC. This October hurricane was similar to Hurricane Hazel of 1954, except that its path was a little more to the west and the damage was not quite as severe.

The highest wind in this storm was 94 mph reported at Southport, NC. In the Wilmington, NC, area, the tide and high water were reported as the highest known to date, being 16 in. above the high-water mark of 1853. At South Island, near Winyah Bay, SC, the maximum recorded wind was 90 mph from the northeast and a high tide of 9.3 ft MSL was reported in the Monthly Weather Review (U.S. Weather Bureau 1893).

10.2 Data Summary

The most informative excerpts and selected meteorological data are listed below:

The Sunday News, Charleston, SC, October 15, 1893

"Jacksonville, FL, October 13 - The wind and rain broke upon the city (of St. Augustine) about 8 o'clock Wednesday night, and raged with fury for nearly twenty-four hours. The waters of the Matanzas River on the east swept over the sea wall and met those of the San Sebastian from the west, and wharves, warehouses, bath houses, steamers and small craft went crashing together down the stream and to the sea."

"Jacksonville, FL, October 14 - Tidings of damages by the storm along the east coast of Florida are just beginning to come in. All along the Indian and Hillsboro Rivers the wind reached a velocity of sixty miles an hour. Towns along the banks were flooded, wharves swept away and houses unroofed, and from 10 to 15 percent of the orange crop was blown from the trees."

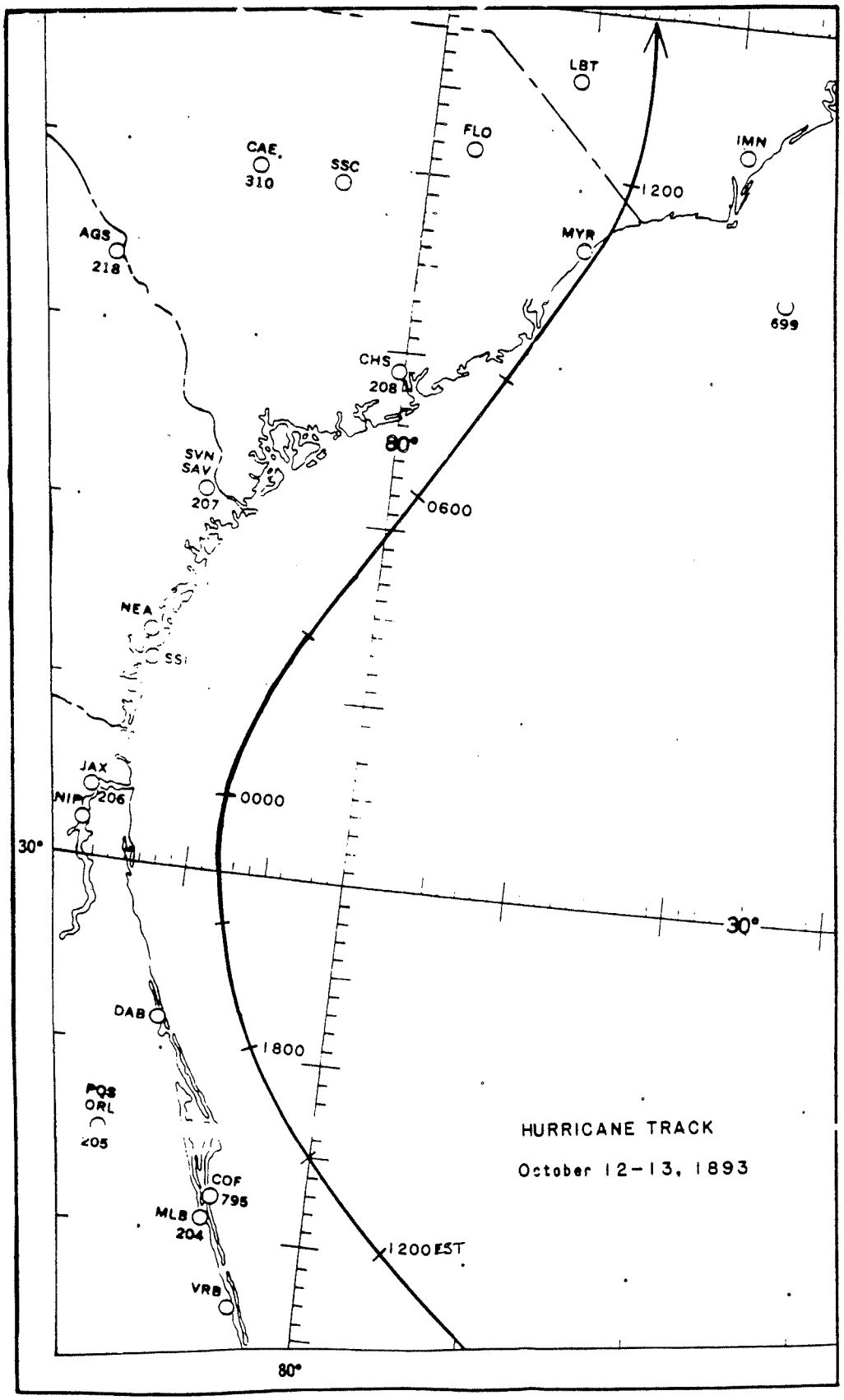

Figure 10.--Hurricane track, October 12-13, 1893.

The Morning Star, Wilmington, NC, October 15, 1893

"Columbia, SC, October 14 - A special (dispatch) to the State from Georgetown tells a terrible story of devastation and death wrought by the hurricane in and around that city and the adjacent Sea Islands. The entire water-front of Georgetown was flooded, and much damage was done to merchandise stored in warehouses.

"At Magnolia Beach almost every house was washed away and thirteen white and six colored people were drowned. A number escaped by taking refuge in trees...."

The News and Courier, Charleston, SC, October 16, 1893

"Georgetown, October 15 - Every little settlement along the beach for about forty miles above here has now been heard from, although the cyclone has left desolation and destruction everywhere in its tracks, yet only on Magnolia Beach has grim death lent its terrors to the storm. Here every house was swept away except the residence of Mrs. Hazel, which is built on the highest point of the island.... On Pawley's Island a number of buildings were washed away.... All of this destruction was done in about two hours between 9 and 11 on Friday morning. The water rose four feet in ten minutes, and reached fully fourteen feet above the ordinary high water mark, leaping over the high sand hills and sweeping to destruction horses, cattle and animals of all kinds."

[Magnolia Beach, a sandy peninsula, located just north of Pawley's Island, is low with neither hills nor trees to afford shelter, and the people were exposed to the full fury of Thursday night's hurricane.]

The Morning News, Savannah, GA, October 15, 1893

"Columbia, SC, October 14 - The **State's Georgetown Special** says: The West Indian cyclone left destruction in its path here. At 2 o'clock on the morning of the 13th the wind was blowing sixty miles an hour, and the tide came all over the water front. At 10 o'clock it was blowing harder, the tide reaching a height of ten inches above the mark of the hurricane of August 27" (1893).

"The whole water front was from one to four feet under water and thousands of dollars' worth of merchandise were damaged."

The Morning Star, Wilmington, NC, October 14, 1893

"The oldest inhabitant was forced to admit that the terrific outburst of wind and wave that swept through the city yesterday surpassed any storm in his day or generation....

"The wind was from the southeast and held in this quarter until about 2 o'clock p.m. when it gradually veered around to the southwest and the rest of the gale was from this direction....

"The tide was the highest known even in the memory of most antiquated resident, being 16 inches above the high-water mark registered and recorded in 1853, which had surpassed all previous known records, it is believed, since the deluge.

"The storm at Southport was more severe than in Wilmington,...the wind had reached the velocity of eighty miles an hour at about 11:30 a.m."

The following extract comes from a letter by Gen. E.P. Alexander of Georgetown, SC, reproduced in the Monthly Weather Review (U.S. Weather Bureau 1893):

"The gale of 1822, September 27 and 28, is the most memorable of all prior to 1893 among the traditions of this section, the loss of life being very great for those days, forty were drowned at North Inlet, twenty on Murphys Island, and probably in all 200 at various points along the coast.... Records of high water in previous gales have been preserved by means of notches on trees, and by comparison it appears that the high water of October 13-14 exceed that of September, 1822, and also that of August 28, 1881, by nearly 3 feet. It exceeded that of August 27, 1893, by at least 2 feet, 4 inches. I have had a level taken from the inside of the North Island lighthouse tower, where the water mark is least likely to be obscured by wave action, and the level reached was 11.3 feet on the U.S. Engineer's tide gauge, whose zero mark is one foot below ordinary low water, this would give 10.3 feet above ordinary low water and 6.8 above ordinary high water, which is 4.5 on that gauge. The popular report is that the water rose on Magnolia Beach, a sandy peninsula about 25 miles northeast of Georgetown, 6 feet above the August gale, but this needs to be verified by an expert. What between the two gales, August and October, and one or two freshets in the river, the average production of rice in all this region will hardly exceed one-sixth or one-seventh of the estimated crop. The total loss of life in this vicinity in the October storm is 22 and the loss of property at least $250,000. Almost worse than the physical losses to the fisherman, and those who were much exposed, is their demoralization and discouragement and loss of confidence. They are prepared to believe all sorts of absurd predictions of more storms coming, which are circulated among them without any one knowing who is responsible for them."

The following is from the Weather Bureau station journal at Wilmington:

"Rain continued from yesterday, becoming heavy at times. NE gale set in during early morning. Barometer fell steadily all night and until 12:15 p.m. today, reaching 29 inches even, the lowest on record at this station. The wind held steadily from NE until about 10:35 a.m. when it shifted to SE blowing from that direction until 2 p.m. when it began to work around to SW, increasing very regularly until 12:25 p.m. at which time the highest velocity (56 mph) was attained. The wind was remarkable for the very regular rate of speed maintained, the instrument recording 45 to 48 mph for several hours. Very heavy gusts, of only a few seconds duration, caused extreme velocity of 60 mph several different times, extreme for the day 68 mph, and the high puffs doubtless reached as much as 75 or 80 miles. The wind so steady from SE caused the highest tide in the memory of the oldest river men, exceeding

the previous highest tide (that of 1853) by 16 inches. The water in the river was forced upstream by the tide and wind until it rose over the docks, flooding Water Street and destroying great quantities of stores, cotton, hay, flour, etc. Great damage was done to rice fields and river docks.

"The storm had been heralded by the Weather Bureau and no doubt much loss and greater disasters were avoided by the public heeding the warnings. About 12:45 p.m. the barometer began to rise and it went up nearly as fast and steadily as it had gone down. The most severe storm that has visited this station in its history of 23 years was over."

Selected meteorological data for October 13, 1893 are tabulated as follows:

Barometric pressure readings at South Island, SC.

Time (EST)	Pressure (in.)	Pressure (mb)
0200	29.40	995.5
0400	29.30	992.1
0600	29.18	988.0
0800	28.95	980.2
1000	28.33	959.2
1200	28.95	980.2
1400	29.16	987.3
1600	29.30	992.1

Meteorological data taken at Wilmington, NC.

Time (EST)	Pressure (in.)	Pressure (mb)	Wind (mph)
0800	29.34	993.5	E 26
0900	29.30	992.1	E 27
1000	29.23	989.7	E 26
1100	29.18	988.0	ESE 29
1200	29.09	985.0	SE 35
1300	29.11	985.7	- 38
1400	29.13	986.3	- 34
1500	29.20	988.7	- 30
1600	29.28	991.4	- 35
1700	29.34	993.5	- 29

10.3 Discussion

This hurricane evidently was very destructive in the southeastern North Carolina area. The Charleston records make no mention of the storm. It was small in diameter but of great intensity. According to local newspapers of that time, Wilmington experienced the highest tide known even in the memory of the oldest resident. The reference to the previous highest tide occurring in 1853 on

the Cape Fear river in the Wilmington station journal was not corroborated by other sources of information. There was insufficient data on the hurricane of September 7, 1853, which hit the Cape Hatteras area to support this statement.

The lowest pressure reported in the 1893 storm by ships and at South Island, SC, indicated that the central pressure of the storm was lower than 959 mb. Flooding conditions along the Florida coast and Winyah Bay, SC (see news reports) suggested that the hurricane moved northward off the Florida coast, passed near South Island, SC, before entering the coast north of Myrtle Beach, SC, (fig. 10). It is of interest to note that this October 1893 hurricane was the most devastating storm to hit the Winyah Bay area since 1822. The highwater at North Island light house tower reached 10.3 ft above low water which exceeded that of September 1822 by nearly 3 ft. On Pawley's Island, the water rose 4 ft in 10 minutes, reaching a height of 14 ft above the ordinary high water mark. Almost all the houses were washed away at Magnolia Beach (just north of Pawley's Island). The entire waterfront of Georgetown, SC, was under 1 to 4 ft of water.

At South Island, the maximum recorded wind was 90 mph from the northeast and the barometric pressure dropped to 959.2 mb in this hurricane. The maximum winds reported at South Island and Wilmington were the primary sources of information used in determining the radius of maximum winds. The assessment of R is described in Sections 2.3 and 3.4.

Pertinent parameters of the hurricane of October 13, 1893 were determined by using available pressure data observed both at South Island, SC, and Wilmington, NC. We assume that there was no change in the intensity of the hurricane when it was located off the South Carolina coast prior to landfall. These parameters may be used in surge computations for both the Wilmington, NC, and Winyah Bay, SC, areas.

Parameters of the hurricane of October 13, 1893

Central pressure	28.20 in. 955 mb
Radius of maximum winds	15 nmi
Direction of forward motion	200°
Speed of forward motion	25 kt

11. HURRICANE OF OCTOBER 2, 1898

11.1 Introduction

This storm first appeared to the east of the Leeward Islands on September 25. By the evening of October 1, the storm passed 150 miles to the northeast of Jupiter, FL, (fig. 11). During the night the storm was deflected to a more westerly course by an extensive high-pressure ridge located to the north of its position. By the morning of October 2, the storm center was located off the coast of Jacksonville, FL. At Jacksonville, the barometer fell to a minimum of 29.07 in. at 11 a.m. and the maximum wind of 60 mph occurred at 11:10 a.m. The storm center appeared to have passed north and east of Jacksonville, probably 40 to 50 nmi distant.

The storm center entered the Atlantic coast near Brunswick, GA. The Brunswick area experienced its worse flooding since 1812. The height of the storms tide at Darien was about 13 ft above the mean high water mark, inland, and 18 ft at Sapelo Lighthouse. Campbell Island, 12 miles from Darien, on the Attahama River, was swept by water, and more than 20 of its inhabitants were drowned. At least 120 people were killed around Darien and Brunswick, mainly by drowning on Butler Island (Monthly Weather Review 1898).

In the Savannah area, Hutchinson Island, opposite Savannah, was submerged to a depth of 4 to 8 ft. At the Isle of Hope the water rose 15 ft. All the lowland to the east of Savannah was inundated. The coastal islands on the Carolina coast escaped severe damage, although the tide was very high and the wind heavy.

11.2 Data Summary

Excerpts from the Monthly Weather Review (U.S. Weather Bureau 1898) give a summary of eyewitness accounts of the storm as reported by Weather Bureau observers in Jacksonville, FL, Savannah, GA, and Charleston, SC. A vivid description of the eye passage over Blackshear, GA, was extracted from the **Morning News** of Savannah, GA. Meteorological data observed at Jacksonville, FL, and Savannah, GA are also included in the following paragraphs:

> Monthly Weather Review (October 1898)
> A.J. Mitchell, Section Director, Weather Bureau, Jacksonville, FL:
>
> "The barometer fell rapidly during the day and night of October 1, and reached a minimum of 29.07 in. at 11 a.m. of the 2nd. The storm center appeared to pass north and east of Jacksonville, probably 50 to 60 miles distant. The maximum wind velocity, 60 miles an hour, occurred about 11:10 a.m.....The coast district from Mayport to Fernandina suffered heavily, in fact Fernandina was nearly destroyed."
>
> H.B. Boyer, Observer, Weather Bureau, Savannah, GA:
>
> "...The greatest loss was sustained south of Savannah and nearer the storm center. Great havoc was caused at Brunswick, where a conservative estimate places the losses at $500,000. Nearly every business house and residence and business thoroughfares were 4 to 8 ft under water. Nearly all docks suffered from lifting, one to two hundred thousand feet of lumber and hundreds of barrels of naval stores were washed away, and five vessels were washed ashore. At New Town, records kept by the

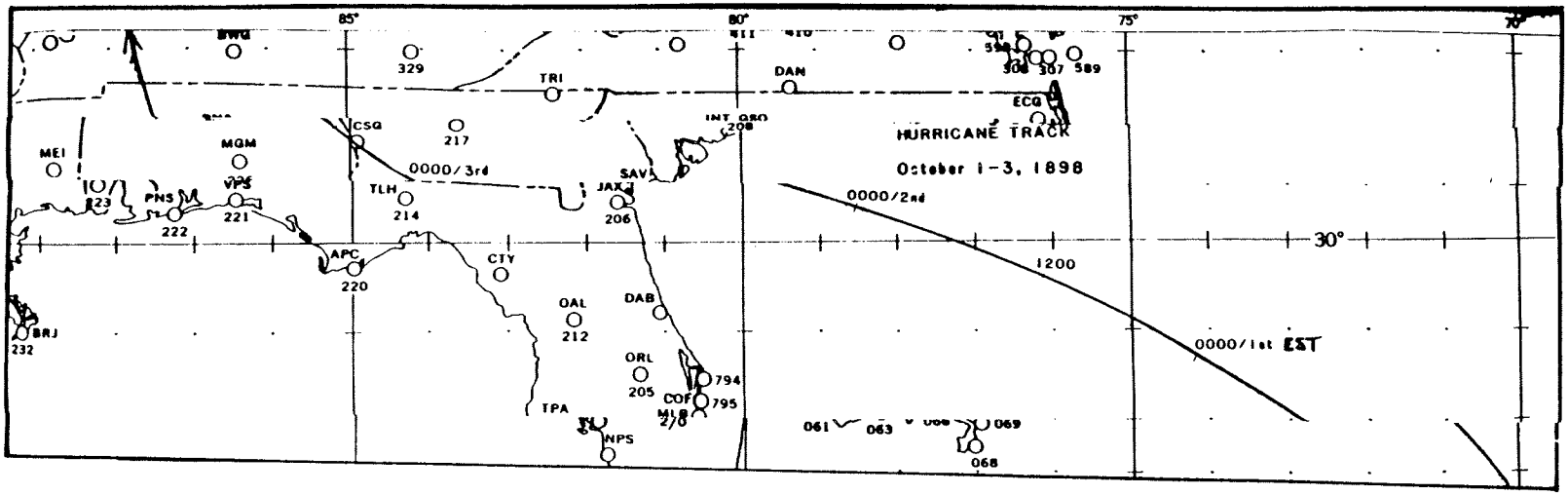

Figure 11.--Hurricane track, October 1-3, 1898.

family of Egbert Dart, show that not since 1812 has such a flood been known in that section.

"Campbell Island, 12 miles from Darien, on the Attahama, was swept by water, and all of its inhabitants, except three, were drowned - not less than 20 and perhaps 50. At Darien, there were 31 persons drowned and 1 killed, and the loss to rice, stock, lumber, vessels, etc., aggregated $350,000. The height of the tidal wave at that place was about 13 ft above mean high water mark, inland, and 18 ft at Sapelo Island Light-house."

The Morning News, Savannah, GA, October 4, 1898

"Jesup, GA, October 3 -- Jesup was visited by a terrific storm yesterday, it began about 8:30 a.m. and reached its greatest velocity about 3 p.m. and lasted until about 8 p.m. Nothing as severe was ever felt here before in the history of the place.

"Blackshear, GA, October 3 -- Blackshear and vicinity yesterday experienced the most terrific storm on record. The wind began blowing in the early morning from a northeasterly direction, gradually gaining in violence, until its greatest velocity was reached between 1 and 2 o'clock in the afternoon. From 2 to 3 o'clock there was a lull, and it seemed the storm was over, but, singularly enough, shortly after 3 o'clock the wind began blowing again, and this time it came from the south. The second gale played some unusual pranks and while not so violent as the other, it was ever enough. In more than one instance trees that had been laid low by the first storm were picked up and righted by the second.

"Waycross, GA, October 3 - The storm yesterday did considerable damage to houses, electric wires, fences and crops in Waycross and vicinity.

"Baxley, GA, October 3 -- Brunswick was visited by a terrific wind and rain storm Sunday. For eighteen hours, commencing at 4 o'clock in the morning, the storm king reigned supreme, as if backing in the mighty effort to destroy the place, comfort and property of the citizens.

"The tide got high favor, and for hours the flow of water poured over Brunswick's streets inundating hundreds of houses, flooding practically every business and warehouse in the city, and entitling thousands upon thousands of dollars of loss upon the people....

"The storm commenced at 4 o'clock with a heavy wind and driving rain. The wind increased in intensity with the rising of the tide. At 7 o'clock the wind was blowing about forty miles an hour. Limbs from the trees were cracking and falling and a few fences were going down.

"At 8 o'clock the wind was still increasing, and from then until 3 o'clock in the afternoon, with but slight cessation, the velocity of it was all-powerful.

"By 9:30 the wind and tide had full sweep and the surging mass from the bay, creeks and rivers was forcing its way into the city from three different directions.

"At 10:30 The **Morning News** correspondent waded from the city hall, in the business portion, to the Mallory Lime and Southern Railroad docks. The water was one to four feet deep.

"In returning to the city at 11 o'clock, the water was shoulder deep on the docks and four feet deep at the junction of New Castle and Mansfield. From that hour on, the three great bodies (of water) coming respectively from the point off quarantine, the back landing opposite St. Simons, and Oglethorpe Bay across from Turtle River, were drawing nearer.

"At 12 o'clock they met, and then at least twenty blocks of business houses and residences were in four to eight feet of water."

October 5, 1898

"Fernandina, FL, October 4 -- The water during the hurricane on Sunday was never known to be so high in the history of this city. It was six and eight feet deep over some of the docks and a tug lying by the side of a wharf was lifted on it, and settling down smashed it.

"The water at the court house was a foot deep and several feet deep in the stores on central street. Every day goods and grocery stock on that street was damaged by the high water or by the rain coming through ruined roofs.

"Every building at quarantine station was completely swept out of existence, and not a vestige of any was reported to remain.

"The damage and ruin at Amelia Beach was almost as complete. All the cottages but two were said to have been carried out to sea, besides the entire south end of the Strathmore Note, which is a wreck."

11.3 Discussion

Because of inadequate wind data, we made use of the fact that the highest surge in the storm was reported at Sapelo Lighthouse (18 ft above mean high water). It is generally accepted that the highest surge in a storm occurs at a distance close to one radius of maximum winds to the right of the storm center. Since the actual relationship between location of peak surge and radius of maximum winds depends on a complex interaction of meteorological factors and bathymetry, and considering the limited data, it was decided to use the distance of peak surge from the landfall point (24 nmi) as the radius of maximum winds.

Selected meteorological data for October 2, 1898 are tabulated in tables 3 and 4:

Table 3.--Pressure and wind data observed at Jacksonville, FL, October 2, 1898

Time (LST)	Pressure (in.)	Pressure (mb)	Wind (mph)
0400	29.60	1002.3	
0500	29.57	1001.2	
0600	29.52	999.5	
0700	29.48	998.2	NW 20
0800	29.39	995.1	NW 20
0900	29.35	993.8	NW 19
1000	29.22	989.4	WNW 28
1100	29.12	986.0	W 40
1200	29.17	987.7	W 24
1300	29.23	989.7	SW 15
1400	29.31	992.4	SW 11
1500	29.38	994.8	SW 13
1600	29.47	997.9	SSW 12
1700	29.54	1000.2	S 10
1800	29.60	1002.3	S 14

Table 4.--Pressure and wind data observed at Savannah, GA, October 2, 1898

Time (LST)	Pressure (in.)	Pressure (mb)	Wind (mph)
0400	29.71	1006.0	NE 36
0500	29.69	1005.3	NNE 40
0600	29.67	1004.6	NE 50
0700	29.66	1004.3	NE 42
0800	29.64	1003.6	NE 40
0900	29.61	1002.6	NE 48
1000	29.58	1001.6	NE 54
1100	29.54	1000.2	NE 54
1200	29.52	999.5	NE 59
1300	29.48	998.2	NE 54
1400	29.47	997.9	ENE 58
1500	29.49	998.5	E 48
1600	29.52	999.5	SE 52
1700	29.54	1000.2	SE 46
1800	29.58	1001.6	SE 42

We also obtained the other parameters for estimating the central pressure by using the pressure profile equation (sec. 2.2). A low pressure of 986 mb was observed at Jacksonville (table 3) when the storm center was 45 nmi NNE of the station. A peripheral pressure of 1015 mb was determined by examining available weather maps. We then obtained, from applying the above data in the equation, a central pressure of 945 mb and a pressure deficit (the difference of peripheral and central pressure) of 70 mb near the time of landfall.

To verify the reasonableness of this central pressure value, we also examined data for Atlanta, GA, and Montgomery, AL, for October 3. Atlanta reported a sea-level pressure (SLP) of 29.68 in. (1005.1 mb) and Montgomery a SLP of 29.66 in. (1004.4 mb), at 0800 EST. Using an average pressure of 1004.7 mb and a distance of 70 nmi from the storm center, we obtained, from equation (1), a central pressure of 979 mb. However, on the basis of consideration of weather maps, we obtained a higher pressure of 985 mb. We decided to adopt this higher value for the central pressure at 0800 EST on October 3. This was 20 hours after landfall. Using average filling rates for Atlantic hurricanes, north of 32°N, we calculated a P_o = 944 mb or the pressure deficit of 71 mb at the time of landfall, which agrees closely with the estimates from Jacksonville.

The following table gives pertinent parameters of the hurricane of October 2, 1898 at Georgia coast off Brunswick:

Parameters of hurricane of October 2, 1898 at Georgia coast off Brunswick

Central pressure	27.91 in. or 945 mb
Radius of maximum winds	24 nmi
Direction of forward motion	120°
Speed of forward motion	13 kt

12. HURRICANE OF OCTOBER 31, 1899

12.1 Introduction

This hurricane advanced from the west part of the Caribbean Sea along the Atlantic coast of the United States from October 28 to 31. The development of the tropical cyclone began on the evening of the 27th south of central Cuba. In the next 48 hours, the storm moved across central Cuba in a northerly direction (fig. 12). On October 30, the center of the storm was located off the Carolina coast. The intensity of the storm increased greatly and severe gales were encountered along the Atlantic coasts south of Wilmington, NC. At Charleston, SC, the wind reached a velocity of 58 mph from the northwest at 10:05 p.m. of the 30th. The hurricane which was one of the most severe on record along the North Carolina coast near Wilmington, moved inland near the South Carolina state line on October 31 (fig 12). The pressure at Wilmington dropped to 28.96 in. (980.6 mb) while the wind reached a maximum velocity of 43 mph from the southeast at 4:50 a.m. on October 31.

12.2 Data Summary

The most informative newspaper excerpts and selected meteorological data are listed below:

The News and Courier, Charleston, SC, October 31, 1899

"At the Weather Bureau, in the Custom House, at 11 o'clock last night Mr. L.N. Jesunofsky was asked to give the meteorological aspects of the storm.

"...This storm center, after lingering in the Caribbean Sea for several weeks, suddenly moved northward and it is now just off Charleston, the center being some miles at sea. The approach of this storm has caused wind velocities ranging from thirty to forty miles per hour during the day and at 10 o'clock the recorded velocity was fifty-eight miles per hour. It has caused (wind) velocities of twenty-eight to forty-eight miles per hour along the entire Atlantic coast. At 4:10 p.m. the wind was at forty miles and the barometer 29.44. At 10 o'clock the velocity was fifty-eight miles and the barometer 29.12. The wind has increased a little since that time."

The News and Courier, Charleston, SC, November 1, 1899

"Florence, October 31 - Special: Florence was visited by a severe gale last night, during which many buildings were either unroofed or moved from their foundations, a large amount of fencing blown down and the trees badly twisted and broken. Nearly every store and residence in the city suffered more or less damage from water.

"Between 11 and 2 o'clock the wind seemed to have reached its height, which was very nearly 70 miles an hour, while the rain seemed to be coming down in sheets."

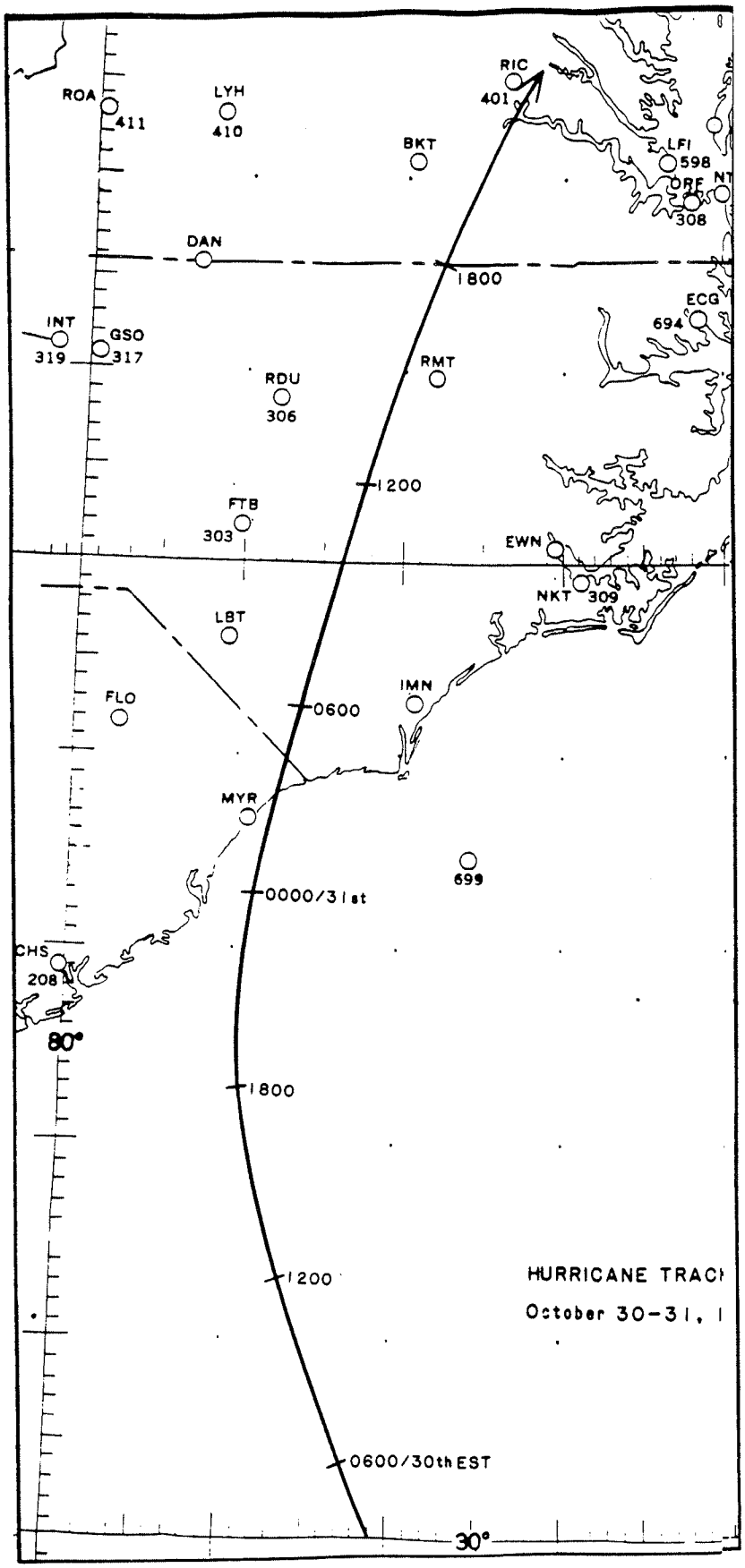

Figure 12.—Hurricane track, October 30–31, 1899.

The Morning Star, Wilmington, NC, November 1, 1899

"The Caribbean storm which reached Wilmington in full force Monday night at 10 o'clock increased in velocity till 5:30 o'clock yesterday morning, and it will go down in history as one of the worst wars of elements ever experienced on the coast. The tides at the seaside and in the river were enormous. At Wrightsville Beach the tide was eight feet above the high water mark, and in the City the river came over the wharves and flooded Water and Nutt Streets.

"The storm in the city reached the height of its fury at about 4:45 o'clock yesterday morning. The barometer at the Weather Bureau was lower than it has been since the establishment of the bureau (in Wilmington) and the wind attained a maximum velocity of 54 miles per hour, though there were gusts when it went as high as 60 miles. At 5 o'clock yesterday morning the barometer began to rise from 28.98 inches, the lowest registered, and continued to rise until the normal was reached. The rainfall for the 24 hours ending yesterday at 8 o'clock was 1 1/2 inches.

"The strong southeast wind which kept up its blow during the night ran the tide up to nearly the highest point it has reached in the river during the history of the port, and much damage was done to submerged wharves and warehouse floors. Only at one time, during the fearful storm of September 1893, has it been higher (by only about one inch).

"The storm at Wrightsville Beach was awful and havoc was wrought by wind and waves....Fishermen who have lived at Wrightsville Beach and on the river for forty years say that if there was ever a greater storm on this part of the coast they do not recollect it.

"The storm was very severe at Southport. The water was higher and rougher than the oldest inhabitant has any recollection of. The steamer Southport belonging to the New Hanover Transit Company, of which Captain Harper is General Manager, was thrown up on the shore one hundred feet from high water mark."

November 4, 1899

"The American Steamer Catherine Whiting, Captain F.C. Miller of New York, was wrecked during the hurricane last Tuesday morning at Goss Beach, Brunswick County, about forty miles below Southport and twenty miles south of Frying Pan Shoals light ship."

Captain Miller gave a **Star** reporter the following account of the loss of his ship:

"About 12 o'clock on Tuesday, there was a dead calm for fifteen minutes, and then the wind shifted to the east....The wind then shifted to southeast and caused the ocean to sweep right in towards shore....The ship began to drift rapidly towards the land which was some two or three miles away....About 4 a.m. Tuesday the ship got in the breakers and struck bottom with a heavy thump, in four fathoms of water...."

Following is the record of this storm as written up in the Wilmington Weather Bureau station journal:

"Inappreciable showers during night. Light rain began at 8:20 a.m., became heavy toward evening and continued at midnight. Generally cooler and rapidly decreasing pressure after 10 a.m. The wind gradually increased in force from the NE reaching a gale velocity at 3 p.m. and became very severe during evening. Maximum velocity of wind to midnight 42 mph from the NE. The gale continued very severe during the night and forenoon accompanied by heavy rain till 4:50 a.m. and light showers from 8:10 a.m. to 3:30 p.m. Rapid and decided fall in barometer till 5 a.m. when it reached 28.90 (actual). After this time it began to rise sharply. The wind gradually veered from NE to SE during the night, blowing with increased force, reaching a maximum velocity of 43 miles from the SE at 4:50 a.m. The wind came in great gusts at times, reached extreme velocities of 50 to 55 miles. Toward noon the wind began to shift to southwesterly becoming steady from that direction at 4 p.m. and gradually decreasing in force. Gale ended at 8:07 p.m. Much higher temperatures after midnight, falling slowly during the day. The amount of damage done in Wilmington and vicinity is enormous, not so much by the high winds but by the tremendously high tide accompanying. The tide reached nearly the highest point in the history of the port, and much damage was due to submerged wharves and warehouse floors. At many points the overflow covered Water and Nutt Streets. In the city proper only a few other minor damages were done--such as trees, signs, and awnings blown down and to a section of the north wall of the Masonic Temple in the course of erection.

"At the summer resort beaches - Wrightsville Beach 10 miles due east and Carolina Beach, 18 miles southeast - the wind and tide played havoc. Sixteen cottages were washed away at Wrightsville Beach and the remainder more or less damaged. A large section of the railway trestle connecting the beach with the mainland and the track on the beach was washed away.

"At Carolina Beach the devastation was about as great and but few of the cottages remain. From Southport only meager reports are to be had as the telegraph wires are down. Such reports as received indicate much damage.... The tug Blanche was thrown high and dry on the beach. The launch Naptha costing $1800 was smashed and is a total wreck. All wharves excepting the Government dock were demolished. Several houses near the water edge were washed away. The most conservative estimates place the known damage at and near Wilmington as $200,000."

Selected meteorological data for October 30-31, 1899 are tabulated as follows:

Observations Taken at Wilmington, NC

Time (EST)	Pressure (in.)	Pressure (mb)	Wind (mph)
1800/30th	29.45	997.2	NNE 26
1900	29.41	995.8	NE 23
2000	29.36	994.1	NNE 22
2100	29.31	992.4	NE 21
2200	29.24	990.1	NE 26
2300	29.17	987.7	NE 31
0000/31st	29.13	986.3	NE 30
0100	29.05	983.6	NE 28
0200	29.03	983.0	E 26
0300	28.99	981.6	E 28
0400	28.98	981.3	E 26
0450			SE 43
0500	28.96	980.6	SE 35
0600	29.00	981.9	SE 25
0700	29.08	984.6	SSE 35
0800	29.13	986.3	S 28
0900	29.16	987.4	S 24
1000	29.18	988.0	S 19

Observations Taken at Charleston, SC

1800/30th	29.48	998.2	N 29
1900	29.43	996.5	NNW 29
2000	29.38	994.8	NNW 31
2100	29.29	991.8	NNW 38
2200	29.18	988.0	NNW 44
2300	29.15	987.0	NNW 37
0000/31st	29.10	985.3	NW 36
0100	29.09	985.0	NW 33
0200	29.08	984.7	NW 30
0300	29.08	984.7	NW 25
0400	29.08	984.7	NW 23
0500	29.10	985.3	NW 22
0600	29.13	986.4	WNW 21
0700	29.19	988.4	W 18
0800	29.25	990.4	W 21
0900	29.28	991.4	W 18
1000	29.31	992.4	W 21

12.3 Discussion

This hurricane entered the Carolina coast between Wilmington, NC and Charleston, SC at a moderately slow pace. Winds of less than hurricane intensity were recorded at these locations. However, tremendously high tides almost reached the highest point in the history of the port city of Wilmington because the hurricane took a critical path parallel to Cape Fear River and moved at a slow speed.

In an earlier report, National Hurricane Research Project Report No. 5, (U.S. Weather Bureau 1957) the central pressure of this storm (972 mb) was based on the lowest pressure (979 mb) observed at Charleston, SC. The asymptotic pressure of 1033 mb used in the earlier report is different from the peripheral pressure suggested in equation (1) of this report (sec. 2.2). Both pressures are intended to be representative of the environment removed from the dynamics of the tropical cyclone. The asymptotic pressure is that value to which an exponential pressure profile is asymptotic. It is a parameter for defining the intensity of the pressure gradient and does not actually have a physical counterpart in the pressure field. Our estimates, based on analyses of weather maps and pressure readings at Wilmington, NC, having a peripheral pressure of 1012 mb and a central pressure of 955 mb give a pressure deficit (the difference of peripheral and central pressure) of 57 mb which is comparable to that given in the Weather Bureau (1957) report.

Information on maximum winds experienced at Wilmington was the primary source of data in determining the radius of maximum winds. Reports from Southport and other North Carolina beaches also aided in the analysis. The assessment of R is described in Sections 2.3 and 3.4.

Parameters of hurricane of October 31, 1899 at the coast, north of Myrtle Beach, SC

Central pressure	28.20 in. or 955 mb
Radius of maximum winds	35 nmi
Direction of forward motion	190°
Speed of forward motion	11 kt

GULF COAST HURRICANES

13. HURRICANE OF OCTOBER 5, 1842

13.1 Introduction

This hurricane originated in the Gulf of Campeche whicd at the southwestern corner of the Gulf of Mexico. The centeirm moved northeastward across the Gulf and entered the west coast north of Cedar Key, in the evening of October 5, 1842 (fig. 13). cola the storm was "thought to be one of the most severe on record Key, the water rose 20 ft above high water mark, within 6 ft of covand. The center moved across the Swanee River Basin in an east-noirection. It then turned northeastward and exited the Atlantic coast rlle, FL.

13.2 Data Summary

The most informative excerpts of newspaper accounts and srological data observed at various military posts are listed as follow

Pensacola Gazette, October 15, 1842

"The Merchant left New Orleans on Sunday evening The next day the wind blew heavily, and the vessel labi under a heavy ground swell, leaking beyond the power of keep her free from water. The wind soon increased to a and the water augmented so fast, that it was thought insave the vessel, and she was steered for the beach of the Island). At 2 o'clock on the morning of the fourth, the ilir, after being lightened of early her entire cargo, struck! divided in half...."

Florida Herald, St. Augustine, October 10, 1842

"Our city has been visited by a greatest gale ed by our oldest inhabitants who can't remember back fab years. Altogether it has been a tremendous blow, which reht about midday on Thursday (6th). Walls of deserted stave been blown down and the chambers of wooden houses have upon by the torrents of rain, in a manner altogether disagr

New York Tribune, October 18, 1842

"Shipwreck - The bark Virginia, Sinclair of NeMotanaza for Cowes, with a cargo of sugar, was abandoned sea, in Lat. 30°30', Long. 78°30', in a sinking condition.ntered a tremendous gale on the 6th, during which she was her beam end and dismasted."

"The Weather Observer at Fort Poinsett, Cedard south-southeast winds in the morning changing to so in the afternoon on October 5, 1842. He also noted::h about sundown, wind commenced blowing strong from SSE g during the night, veering steadily to the south. At 5th the water of the ocean had attained the height usual aThe wind increased in violence and the water continued to ruptedly until about 9 p.m., when they began to subside. The wind

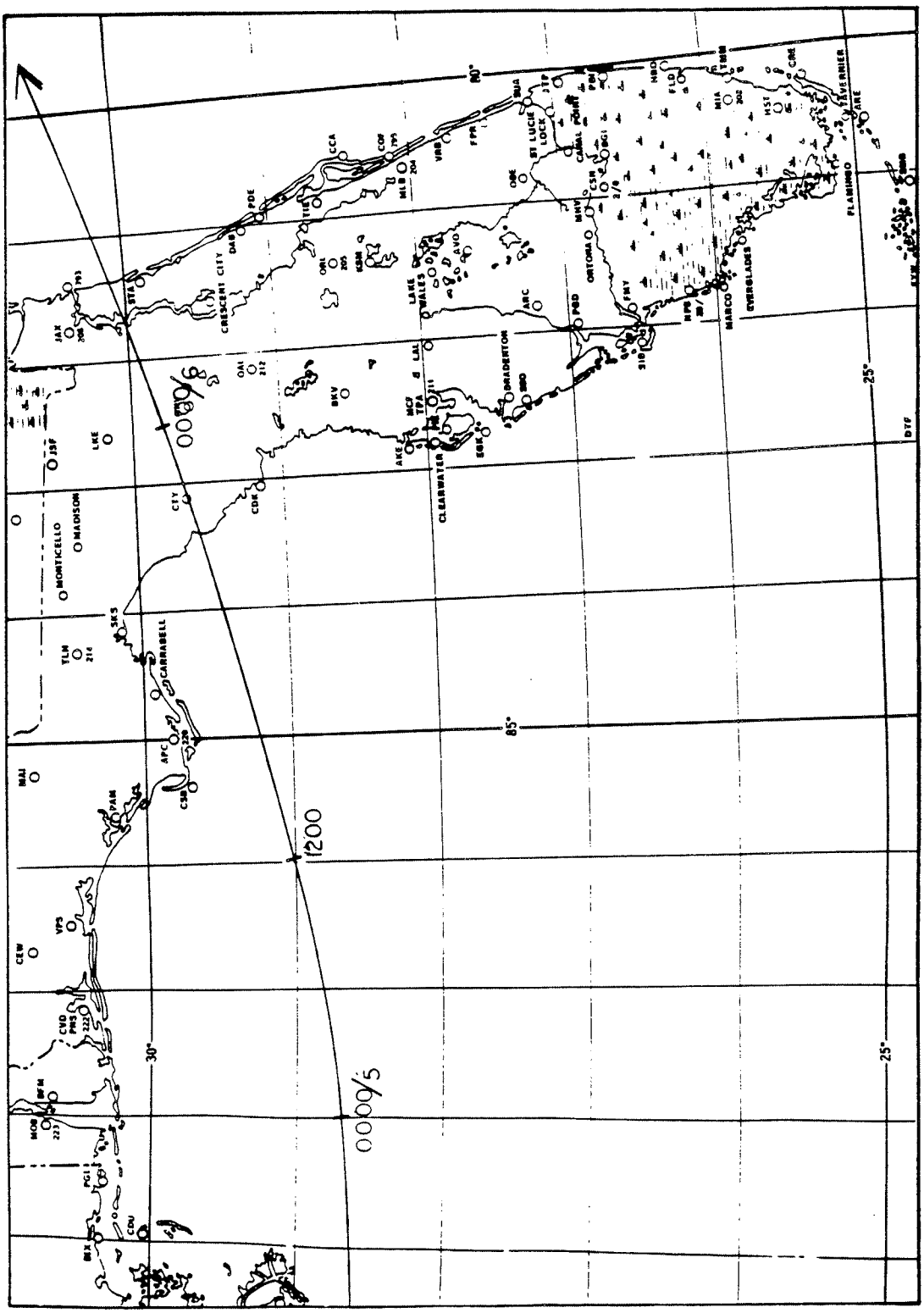

Figure 13.—Hurricane track, October 4–6, 1842

shifted to the west and ultimately got around to the NW, from which point it continued to blow during the 6th. Maximum height above high water mark - twenty feet."

Winds recorded at various military posts in northern Florida on October 5 and 6, 1842, are listed as follows:

Location	October 5		October 6	
	A.M.	P.M.	A.M.	P.M.
Fort King 29.30'N 80°42''W	SE	SE	SE	E
Fort Wacessassa 29°31'N 82°50'W	E	SE	W	NE
Fort Micanopy 29.30N 82.30'W	E	NE	NE	NE
Fort Shannon 29°38'N 81°52'W	N	NE	SW	NW
Fort Stansburg 30°18'N 84°8'W	NE	NE	N	NW
Fort Robert Gamble 30°25'N 83°30'W	NE	NE	NW	NW
Fort Brooke 27°57'N 82°35'W	E	NE	NE	E

13.3 Discussion

As the hurricane traversed northeastward over the Gulf of Mexico, its gale force winds were felt along the northern section of the Gulf coast to within 100 miles of Tortugas. Ship reports, together with wind observations from military posts, and newspaper accounts from Apalachicola, Cedar Key and St. Augustine were useful in determining the path of the hurricane.

There were contradicting accounts concerning the time of maximum winds at Apalachicola and a lull experienced by the brig, Simon. The brig experienced a severe hurricane which drove her from her anchors off St. Mark at 0400 on October 5 until a lull occurred at 1600 in the afternoon. While, the **Apalachicola Journal** (in **Florida Herald**, Nov. 14, 1842) stated that the wind reached its maximum intensity there at 1600 on the same day. We believe that the brig had drifted toward Apalachicola from 0400 to 1600, when she experienced a 15-min calm shortly after 1600. The center of the storm was located east of the Apalachicola at that time. It moved across Apalachee Bay and arrived at the coast near 2100. At this time, the tide at Cedar Key reached its highest point and the wind shifted to the west, according to the observer at Fort Poinsett on Cedar Key.

Reports from Apalachicola and Cedar Key indicated that the hurricane was a fast moving storm. It moved across Apalachee Bay, a distance of about 90 nmi, in just five hr (1600-2100) at an average speed of 18 kt. Reports of northeasterly winds at Fort Micanopy, Fort Shannon and Fort Brooke in the afternoon of October 5 revealed that the cyclonic circulation of the hurricane stayed within 120 nmi of the storm center. This suggested that the hurricane was of modest size.

There was no report of barometric pressure near the path of the hurricane in northern Florida at that time. To estimate the storm's central pressure, we take into consideration the surge heights produced by other hurricanes at Cedar Key. Comparable but somewhat lower storm tides submerged the lower part of Cedar Key in the hurricane of October 10, 1882. At Cedar Key, the maximum winds reached a velocity of 56 mph and the pressure dropped to 29.20 in. (989 mb) when this 1882 hurricane center passed west of the station at a distance of about 30 nmi. The central pressure of the 1882 hurricane was estimated to be 28.47 in. (964 mb). Since the difference in tide heights between this and the 1842 hurricane was small, we believe that a central pressure of 28.20 in. (955 mb) may be appropriately assigned to the hurricane of October 5, 1842.

The logic and reasonableness in estimating the hurricane parameters based on indirect information have been previously discussed. The reader is referred to Sections 2.2 to 2.4 for detailed discussions on the assessment of hurricane parameters. Parameters of the hurricane of October 5, 1842, located near the coast north of Cedar Key, are listed as follows:

Central pressure	28.20 in. or 955 mb
Radius of maximum winds	18 nmi
Direction of forward motion	250°
Speed of forward motion	18 kt

14. THE HURRICANE OF OCTOBER 11, 1846

14.1 Introduction

This October hurricane probably originated in the Caribbean Sea. Its presence was first reported from the Isle of Cuba and its full impact was experienced in Havana in the morning of October 11, 1846. The lowest barometric reading of 27.06 in. (916.2 mb) at Havana was observed near 1000 on the 11th. All but 12 of the 104 vessels in the harbor at that time were either sunk, wrecked, dismasted or otherwise seriously damaged. In addition, some 40 to 50 small coastal vessels were destroyed (Ludlum 1963).

As the hurricane passed within a few miles west of Key West (fig. 14), 5 ft of water was running through the center of the town at 6 mph. Almost all of the 600 houses in town were unroofed and blown down. The Custom House was damaged and the Light House destroyed, but the U.S. Barracks at the east end of town suffered no damages. Colonel Maloney in his history of Key West (1876) considered this hurricane as "the most destructive of any that has ever visited these latitudes."

As the storm approached the west coast of Florida, it turned slightly toward the west and moved parallel to the coast. The center of the hurricane passed a short distance west of Tampa Bay and then entered the Florida coast near Cedar Key. It turned northeastward and moved, some distance inland, along the Atlantic seaboard at the time of low tides. There was less damage sustained by the shipping in port than was anticipated. As the hurricane continued its northward trek, its center passed to the west of Norfolk, VA, Baltimore, MD, and Philadelphia, PA. To the right (east) of the storm track, a southeasterly gale persisted over the waters of Chesapeake and Delaware Bays. "At Baltimore all the commercial wharves were flooded at the height of the storm and much of Pratt Street along the harbor put under water. The Potomac at Alexandria and Washington reached its highest tidal mark in 20 years. The lowlands along the Delaware near New Castle were overflowed in the greatest storm surge in 70 years, probably a reference back to the September hurricane of 1775" (Ludlum 1963).

14.2 Data Summary

The first report of this already mature hurricane came from Cuba. The gale at Havana began shortly before midnight of October 10 and reached its peak force about 0900 next morning. The gale-force wind backed gradually from the northeast to northwest and west, indicating that the path of the storm center passed close to, but to the east of the city. The eye of the hurricane then passed over the U.S. Brig, Perry, which was located just five miles off the coast. A detailed account of this encounter was reported by an officer on board the Perry and published in the **Raleigh Register** on November 6, 1846. This interesting account will not be reproduced but informative facts are summarized.

The Perry left Havana on the 10th and encountered the hurricane the next morning. At about 1000, the wind increased in intensity and veered to NNE, driving the ship at the rate of 15 mph towards the coast of Cuba. Then, suddenly, the wind hauled and turned the ship around, heading towards the northeast. At this time, the ship was located within five miles of the coast of Cuba. The brig was then driven before the wind until she struck the Florida reefs, about 35 nmi east of Key West. An officer of the Perry landed on Key

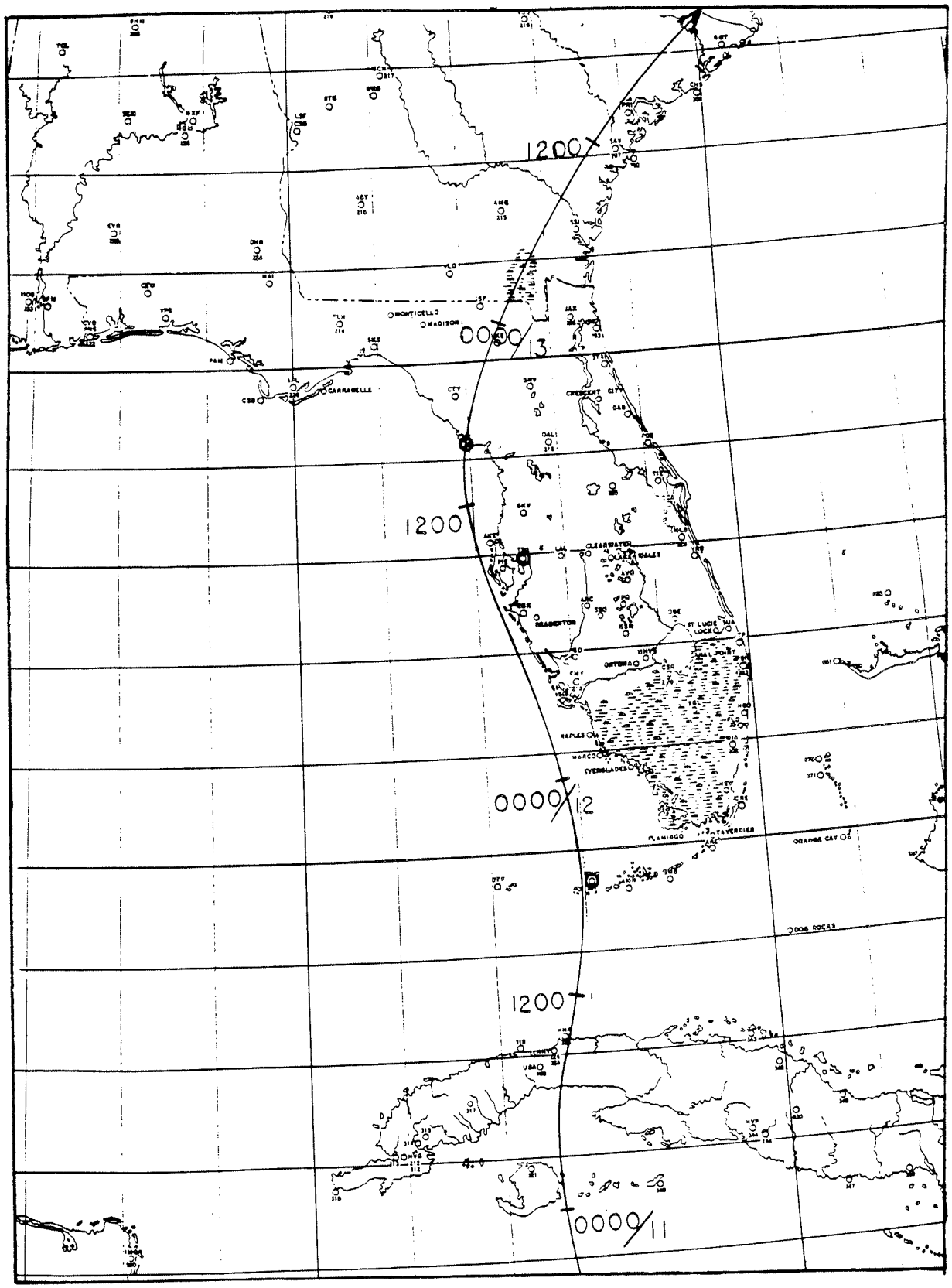

Figure 14.--Hurricane track, October 11-13, 1846.

West three days after the ship went aground at Sombrero Key in the morning of the 12th. He gave a summary of the devastation of that place:

> "But of all scenes of desolation Key West presents the most ruinous. Not a house is left uninjured. Half of them are unroofed - blown down or gone to sea. The light house is gone. Sand Key Light is gone, and with it, every vestige of the Islet.... Every vessel in the harbor is either sunk or driven ashore, and most melancholy of all, more than forty lives have been lost."

In this section, we include excerpts of eyewitness and newspaper accounts which followed the trail of the storm through Florida and along the eastern seaboard.

Lt. Pease of the revenue cutter Morris, which was anchored off Key West prior to the arrival of the hurricane, gave the most informative account of the storm in the **Daily Picayune** of October 23, 1846. He stated that the gale commenced at about 1000 on October 11 and reached hurricane intensity by 1400. At 1615, the starboard chain parted and the ship began dragging. After drifting about three miles in the next hour, the ship stuck on the reef. The tide rose rapidly and the storm raged with incredible violence until near midnight.

> "At Key West, the tide was five-ft high, and running six miles an hour through the center of the town. The citizens fled to the back part of the town, which is rather higher than the rest, into the bushes....
>
> "All the wharves are washed away or injured - not one warehouse escaped the fury of the storm - wood and stone seemed all alike going to destruction. There are not more than 6 out of 600 houses but are unroofed or blown down.
>
> "The public buildings at the Fort, as well as the wharf, are all gone, and the Fort itself is a mass of ruins.... The Custom-House is much injured, but the U.S. Army barracks at the East end of the town sustained no injury and are occupied by the crew of the brig Perry and the revenue cutter Morris, and those whose houses have been blown down."

Some meteorological details at Key West were included in a letter to the editor of the **Tallahassee Floridian** (Ludlum 1963):

> "About day-light Sunday (October 11) morning, Capt. Minor made moor fast to the wharf; before breakfast all passengers left the vessel and went into town, it blowing a perfect gale. At 12 o'clock wind still increasing; after dinner the whole island was in a commotion, the sea was all up in the town; houses in every direction were falling.... There is not a dwelling, store, warehouse or wharf uninjured, nor a vessel of any size in the harbor or on the coast that is not a wreck."

Weather observations taken by the surgeon at Fort Brooke, on the shores of Tampa Bay, revealed the intensity of the hurricane at that latitude. The pressure and wind data together with the surgeon's notes are listed as follows:

Time (EST)	Pressure (in.)	Pressure (mb)	Wind (mph)
October 11			
Sunrise	30.05	1017	NE25
0900	30.02	1016	E12
1500	29.92	1013	NE12
2100	29.84	1010	NE25
October 12			
Sunrise	28.94	980	NE75
0900	28.94	980	SE75
1500	29.45	997	S35
2100	29.67	1005	S25

Note: Severe storm commenced at 4 p.m. on the 11th and increased until 6 p.m. on the 12th. A large number of live oak in the cantonment are prostrated. Some have been righted up but little prospect of living. A large number of fruit trees have been broken off at the limbs and uprooted.

Jacksonville News in **Charleston Courier** of October 24, 1846:

"On Monday last (October 12), this place was visited with a gale, which, in severity, was beyond anything in the recollection of that ancient individual, the oldest inhabitant. it commenced to blow Sunday evening. The gale increased until Monday, the wind coming from the eastward. The river rose six feet above high water mark, at two o'clock on Monday afternoon had flooded all the wharves, and had entered the lower floor of nearly all the stores on Bay Street which runs parallel to the river."

The **Charleston Courier** reported the storm's movement up the eastern seaboard in the issues of October 12 through 16, 1846.

"Savannah, October 13 - 7 p.m. -- The high wind we noticed yesterday as indicating a gale on the coast, increasing violence on Monday evening, prostrating not only many of our shade trees, such as wild olivers, etc., but breaking off the trunks or limbs of the old China trees which have stood many a tempest.

"Charleston - October 14, 1846 -- The dry gale which commenced blowing on Saturday evening last, continued until Monday morning, when it was accompanied by a fall of rain, continuing throughout the day, the wind increased considerably. Towards night-fall on Monday, a regular northern gale set in, and continued to rage with great violence until 3 o'clock yesterday morning, the wind changing early in the night, from NE to SE. It was the most severe gale we have experienced for some dozen years past....

"Georgetown, October 14, 1846 -- Severe gale - the wind commenced blowing hard at the North-East on Sunday morning last, and continued at that quarter till about 4 o'clock yesterday morning when it shifted to S.E. and blew a hurricane - raising the tide about two feet above high water mark.

"**Baltimore American** October 14, 1846 -- Our city was visited on yesterday with a heavy rain, commencing at an early hour in the morning and continuing, with little intermission, through the whole day. The rain was accompanied by a strong southeasterly gale, which, by driving the water back and preventing its egress from the mouth of the basin, raised the tide higher than it has been known for several years.... About 5 o'clock in the afternoon the wind veered round to the southwest and the water rapidly subsided."

14.3 Discussion

As previously indicated, the center of the hurricane passed within a few miles east of Havana, Cuba. The lowest barometric pressure of 27.06 in. (916.2 mb) at Havana was recorded some time in the morning of October 11. We assumed that this occurred near 1000 since the eye of the storm was located five miles off the coast, passing over the U.S. Brig Perry, shortly after that time. From eyewitness accounts, the eye of the storm reached Key West at 1800 that afternoon. The elapsed time of 8 hours (1000 to 1800) for the storm to travel a distance of 90 nmi (Havanna to Key West) gives an average speed of 11 kt as the hurricane approached Key West.

The hurricane of October 11, 1846 is the most destructive storm ever to visit Key West, FL. Its intensity as measured by lowest pressure was exceeded only by the Labor Day hurricane of September 1935 which struck the Florida Keys with a central pressure of 892 mb, the lowest accepted sea-level pressure, not including tornadoes, on the U.S. coasts. The high tide in the 1935 hurricane, excluding wave action, reached 12 ft MSL (U.S. Army Corps of Engineers 1961) while, the high water in this 1846 storm reached approximately 11 ft above MSL.

Based on the lowest pressure reading (916.2 mb) recorded at Havana, we obtained, by using the pressure profile formula, 26.64 in. (902 mb) as the central pressure of the hurricane at the time when the storm center was located off the coast of Cuba near Havana. It is not unreasonable to assume that the hurricane maintained its intensity in the next 8 hr as it approached Key West. Hence, we adopted this pressure value (902 mb) as the central pressure for the hurricane at Key West. A hurricane of such a magnitude would produce a storm tide that is consistent with observations.

The fact that hurricane force winds were reported at Key West near 1400 when the storm center was located about 45 nmi from the station suggested that the lateral extent of the hurricane was small. In an earlier study, Ho et al. (1987), found that radii of maximum winds ranging from 6 to 15 nmi were consistently observed in severe hurricanes since 1900 with central pressure less than 920 mb. They concluded that a radius of maximum winds of 9 nmi was likely for storms with central pressure less than 908 mb. Therefore, This same value is considered a reasonable estimate for this 1846 hurricane.

Estimations of central pressure, radius of maximum winds and speed of forward motion are discussed in preceding paragraphs and in Sections 2.2 to 2.4. The parameters of the hurricane of October 11, 1846 when the storm was located off Key West, FL, are:

Central pressure	26.64 in. or 902 mb
Radius of maximum winds	9 nmi
Direction of forward motion	180°
Speed of forward motion	11 kt

15. HURRICANE OF SEPTEMBER 25, 1848

15.1 Introduction

After crossing western Cuba into the Gulf of Mexico, this hurricane recurved slowly and moved east-northeastward on September 24, 1848. The ship Oxnard encountered the severe hurricane on that day near 27°N, 85°34'W (fig. 15). The center of the storm passed just north of Tampa Bay, between 1300 and 1600 on September 25. A minimum barometric pressure of 28.18 in. (954.2 mb) was observed at Fort Brooke (near the present site of Tampa) prior to 1500 on the 25th. High winds and tides destroyed most of the buildings at Fort Brooke. All the wharves and buildings on the bay and river (except one hotel) were destroyed. All the vessels in port were driven up the river and lodged in the pine-woods. The high tide was estimated to have reached 14 ft above MSL. At Clearwater harbor and in parts of Benton County, the destruction was very great.

After crossing the Florida peninsula, the storm center entered the Atlantic and moved east-northeastward. Several ships reported encountering the storm on the 25th and 26th.

15.2 Data Summary

Major R.D.S. Wade, the commanding officer of Fort Brooke, in his report to headquarters in Washington, gave details of the damage caused by the most severe hurricane of the century to strike the central part of the west coast of Florida. He reported: "The storm began at 8 a.m. from the southeast and raged with great violence until past 4 p.m. after which it veered to the south and southwest and lulled very much toward 8 p.m. Its greatest force was from 1 to 3 p.m. The water rose to an unprecedented height, and the waves swept away the wharves and all the buildings that were near the bay or river."

The Surgeon General of Fort Brooke estimated that the tide rose 15 ft above low water. He also noted the fall of the barometer from a reading of 30.12 in. at 0900/24th and 29.92 in. at 2100 to a low of 28.18 in. (954 mb) sometime prior to 1500/25th. By 1500 the pressure had recovered to 28.55 in. and the wind was coming out of the south (Ludlum 1963).

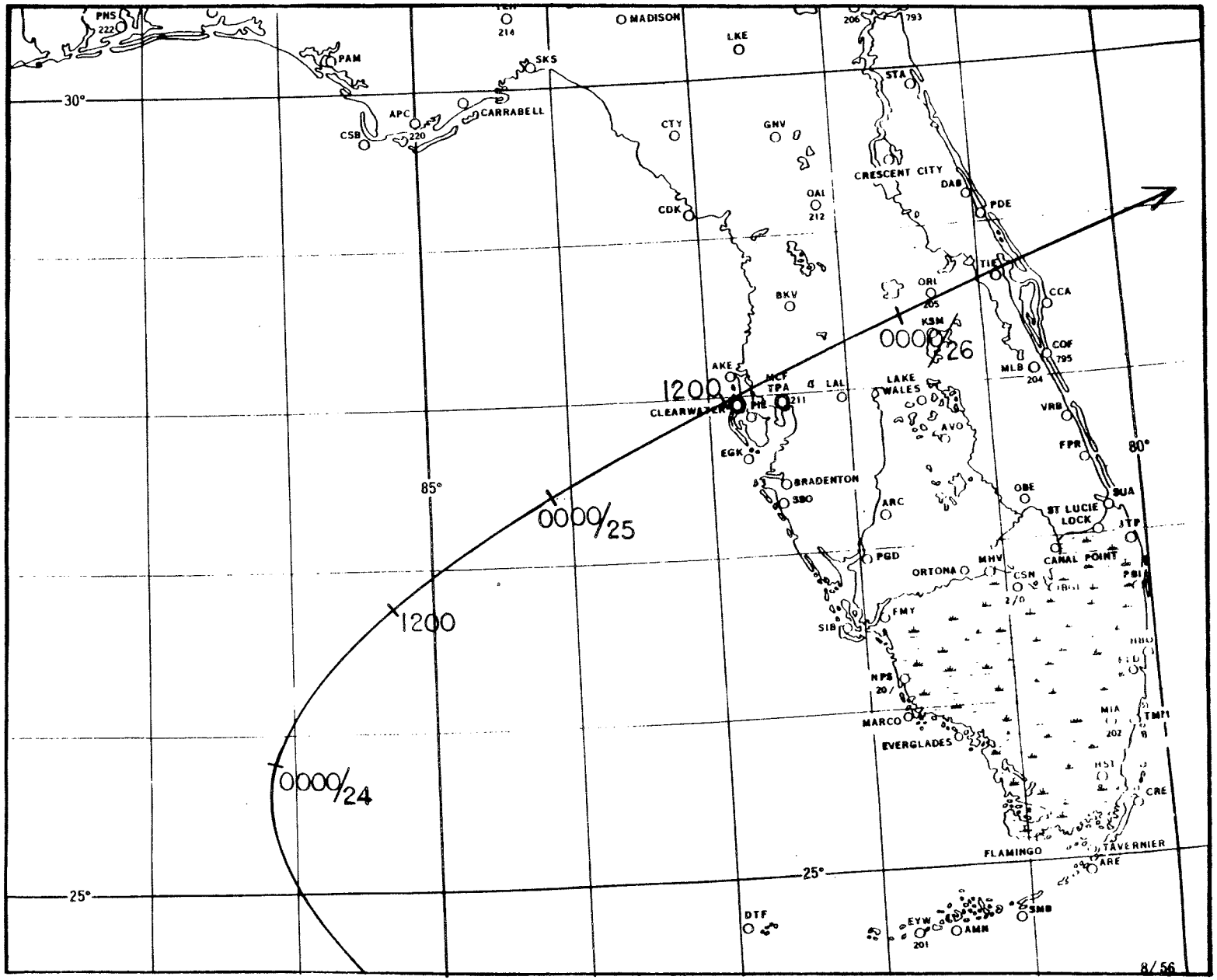

Figure 15.—Hurricane track, September 24-26, 1848.

Pertinent meteorological data observed at Fort Brooke, FL, during the passage of September 23-25, 1848, hurricane are listed as follows:

	Time (EST)	Pressure (in.)	Pressure (mb)	Wind (mph)
September 23				
	Sunrise	30.13	1020	N 35
	0900	30.13	1020	NE 45
	1500	30.12	1020	NE 35
	2100	30.14	1021	NE 4
September 24				
	Sunrise	30.03	1017	NE 35
	0900	30.02	1016	NE 45
	1500	29.95	1014	NE 45
	2100	29.93	1013	NE 35
September 25				
	Sunrise	29.46	997	S 60
	0900	29.17	988	S 75
	1500	28.55	967	SW100
	2100	-	-	- -

Minimum pressure 28.18 (954.2 mb) observed prior to 1500

The most informative excerpts of newspaper accounts obtained from ships and land stations are listed as follows:

Daily Picayune, October 10, 1848

"Ship Oxnard experienced a severe hurricane on the 24th of September at Lat. 26°47', Long. 85°34' from the SE which lasted 7 hours and then hauled around to the NW.

"Captain Dunbar of the ship Camera reported that on the 25th inst., while at Lat. 29°10'N, Long. 75°30'W, he experienced a violent hurricane which lasted 14 hours, carrying away fore and main topsails."

October 19, 1848

"Key West, September 30, 1848 - The brig Warcaller sailed for St. Marks on the 24th, by which the enclosed letter was dispatched. On the 28th, she returned to port, having experienced off Tampa Bay, in eight fathoms water, a severe hurricane, which threw her on beam ends, when it was found necessary to cut away foretopmast to relieve her."

Charleston Mercury, October 2, 1848

Bark Edwin of Wales arrived Charleston on September 30 from Havana:

"September 23 about thirty miles N.N.W of Gun Key, experienced a heavy gale of wind, which lasted until the 26th, when it increased to a hurricane, which lasted from 8 p.m. to 10 a.m. next day.... About thirty-two hours after the heaviest of the hurricane, picked up the crew of the British bark Ganges, eighteen in number, bound from Honduras to London, she having foundered at 8 a.m. on the 26th. On the 27th, in lat. 30, long. 80, passed a brig with loss of foretop mast.

"Brig Palmetto, Axworthy, New Orleans.... On Monday, September 25, between the Cape of Florida and Canaveral, experienced a hurricane, commencing at S.E. and ending at N, during which split and blew away nearly all the sails, carried away foretop gallant mast, and swept the decks.

"British bark Royal Mint, Fraser, Mansanilla (Cuba).... In distress, bound to London. On the 26th September, Lat. 29, Long. 74 West, experienced a terrible hurricane from S.E. to N.N.W., which lasted about ten hours, during which lost spars, bulwarks, and caused the vessel to leak so much as to render it almost impossible to get her to port."

Jacksonville News, October 7, 1848

"We regret to communicate to our readers the information intelligence, that the beautiful village of Tampa is at the present moment in ruins. In consequence of the severity of the gale, the waters of the bay rose some ten to twelve feet higher than was ever before known. Nearly the whole village was washed away...."

Charleston Courier, October 18, 1848 (correspondence of **Savannah Republican**, Tampa Bay, FL, October 2, 1848).

"Gentlemen:-I have volunteered to give you some little account of the disastrous storm which visited us on the 25th ultimo. It commenced about 9 A.M., wind S.E., and continued with unprecedent violence until 6 P.M., during which time it hauled round from S.E. to N.W. Every building on the Bay and river, public and private, (except Mr. Palmer's Hotel and that much injured,) is destroyed. The water rose ten feet or more above high water mark, and such was the force of the wind and waves that the strongest buildings were driven from their places crushing everything in their course.

"We learn that the fishery, dwellings & Co., on Old Tampa were totally destroyed - the people, with difficulty, escaping with their lives. At Clear Water Harbor, and in parts of Benton County, the destruction is very great.... This storm has been much more destructive than that of 1846."

Daily Picayune, New Orleans, October 17, 1848

"Storm at Tampa Bay.-We have been favored with the use of a letter from Tampa Bay, FL, from which we make an extract. The letter is dated:

"Tampa Bay, FL, September 26, 1848 -- Yesterday we had the equinoctal, and here it far exceeded in violence that of 1846. This port and the neighboring town are utterly wrecked. The public storehouses and their contents were carried off by the breakers, and but little subsistence has been recovered....

"The wind was N.E. until 8 or 9 A.M. yesterday, when after a heavy rainy night, it veered to S.E. and increased rapidly till 1 P.M. (the barometer fell from 30 to 28 in.) and roared till 3 P.M. Then it began slowly to veer to S. and S.W. and was less steady, and towards sunset there was only a strong W. wind left and the water ran out."

Charleston Courier, October 2, 1848

"Savannah Republican September 29, 1848 -- During the late easterly storm the steamer Ocmulgae experienced a very severe storm in the St. John's River. It began raining on Monday evening last (Sept. 25) at five o'clock, and continued until two o'clock on Tuesday morning (26th), when the wind shifted from E.S.E. to N.N.W. blowing 'great guns' - the hardest blow felt there for several years."

Savannah Republician, October 3, 1848

"We learn that the two wharves in St. Augustine were destroyed by the late gale. - The water was at one time a foot and a half deep in the Post Office. Nearly all enclosures in town were blown down, and very few houses have escaped injury."

15.3 Discussion

The report from the ship Oxnard which encountered the hurricane on September 24, near 26.5°N 85.5°W suggests that the storm approached the west coast of Florida from the west-southwest. The information on another Gulf hurricane occurring at about the same time allowed us to retrace the storm path prior to the 24th. According to the **Daily Picaynne**, New Orleans, of October 4, 1848, a cyclone raged off Brazos, Texas, between the 16th and 24th of September. Brazos, Padre Island, and part of Point Isabel were covered with water on the 22nd and 23rd. The northerly wind at Brazos Santiago moderated on the 24th. This report revealed that a semi-stationary cyclone stayed off Brazos for eight days and moved away on the 24th, probably towards the north. It is very unlikely that this would be the same storm reported by the ship Oxnard near 85°W on the 24th. Since only slight damage was inflicted by the storm at Key West, FL, we believe that the Tampa Bay hurricane passed some distance west of Key West. We, then, traced the position of this hurricane to western Cuba based on a ship report off the Cuban coast. It is reasonable to assume that the center of this storm crossed western Cuba on the 23rd and recurved east-northeastward on the 24th. It reached the coast near Clearwater, FL, in the afternoon of the

25th. After crossing the Florida peninsula, the hurricane traversed the shipping lanes in the Atlantic and was met by several ships.

All the accounts seem to agree that the peak of the storm at Tampa occurred between 1400 and 1500 on September 25. A southwest wind of 100 mph was reported at 1500 after the lowest pressure was observed at Tampa. Reports of the wind shifted from southeast through south to southwest indicating that the center of the hurricane passed just north of Tampa Bay. Hence, the central pressure of the hurricane at the coast was estimated to be about 10 mb lower than the minimum observed at Tampa.

The extent of hurricane winds was felt as far north as Cedar Key, near which place the brig Wakulla was dismasted. To the south, considerable damage was reported at Charlotte Harbor near Ft. Myers, a distance of less than 100 nmi from the point of landfall. Ship reports, indicating that the hurricane lasted for 14 hr, also suggested that the extent of hurricane winds stayed within a 100-nmi radius of the storm center. Based on this information, we concluded that the storm was of average size and a radius of maximum winds of 15 nmi would be a reasonable estimate.

The assessment of hurricane parameters as discussed in detail in Sections 2.2 to 2.4. Hurricane parameters of hurricane of September 25, 1848, off Clearwater, Florida:

Central pressure	27.91 in. or 945 mb
Radius of maximum winds	15 nmi
Direction forward motion	240°
Speed of forward motion	10 kt

16. HURRICANE OF AUGUST 26, 1852

16.1 Introduction

After passing to the southwest of Key West in the afternoon of August 22, 1852, the hurricane moved northwestward in the direction of the Mississippi Delta. By the morning of August 25, the center of the hurricane was located about 70 nmi east of the Delta and slowly recurved as it approached the coast (fig. 16). It passed east of the Chandeleur Islands and entered the Mississippi coast between Biloxi and Pascagoula moving in a northerly direction. The storm continued its slow recurvature and passed just north of the head of Mobile Bay, south of Mount Vernon, AL. Because of its slow movement skirting Mobile Bay, prolonged southeasterly winds over the Bay caused extraordinary flooding on bay shores and produced the highest tide in Mobile since 1772 (**Mobile Register**, Oct. 3, 1893).

16.2 Data Summary

Pertinent meteorological data were summarized and tabulated from records of selected Signal Offices. These tabulations together with the most informative excerpts of newspaper accounts are listed in following paragraphs.

Mobile Tribune, August 29, 1852

"On Tuesday (August 24) night, the wharf at East Pascagoula was swept entirely away, shortly after the New Orleans steamer Oregon left it. Four white persons and a negro who were on it were carried away with it, and have not since been heard of."

Daily Picayune, New Orleans, September 4, 1852

"A correspondent of the **Mobile Tribune**, writing from West Pascagoula, said that the storm raged as violently at that point as at any other along the coast. Not only were the wharves, bath houses and out-houses carried away, but thousands of trees were laid level with the ground. Those stately live oaks that had braved the storm for centuries fell before its fury. The very leaves were stripped from the trees.

"Daphne, Alabama, August 26, 1852. -- 10:30 am, We are in the midst of a tremendous storm of wind and rain, which commenced on Tuesday afternoon, 24th, and has continued with but little or no abatement since.

"It is now a quarter past 11 o'clock, and the storm is terrific. You cannot conceive how bad it is. The wind east by north, changing at times to southeast. The tide is coming up, and will be full at 2 o'clock, or thereabout.

"Half-past 4 P.M. - The angry waters have receded five feet. The wind has hauled round to the southwest, and blow a gale....

"The wind subsided on Thursday morning, the wind shifting to northwest."

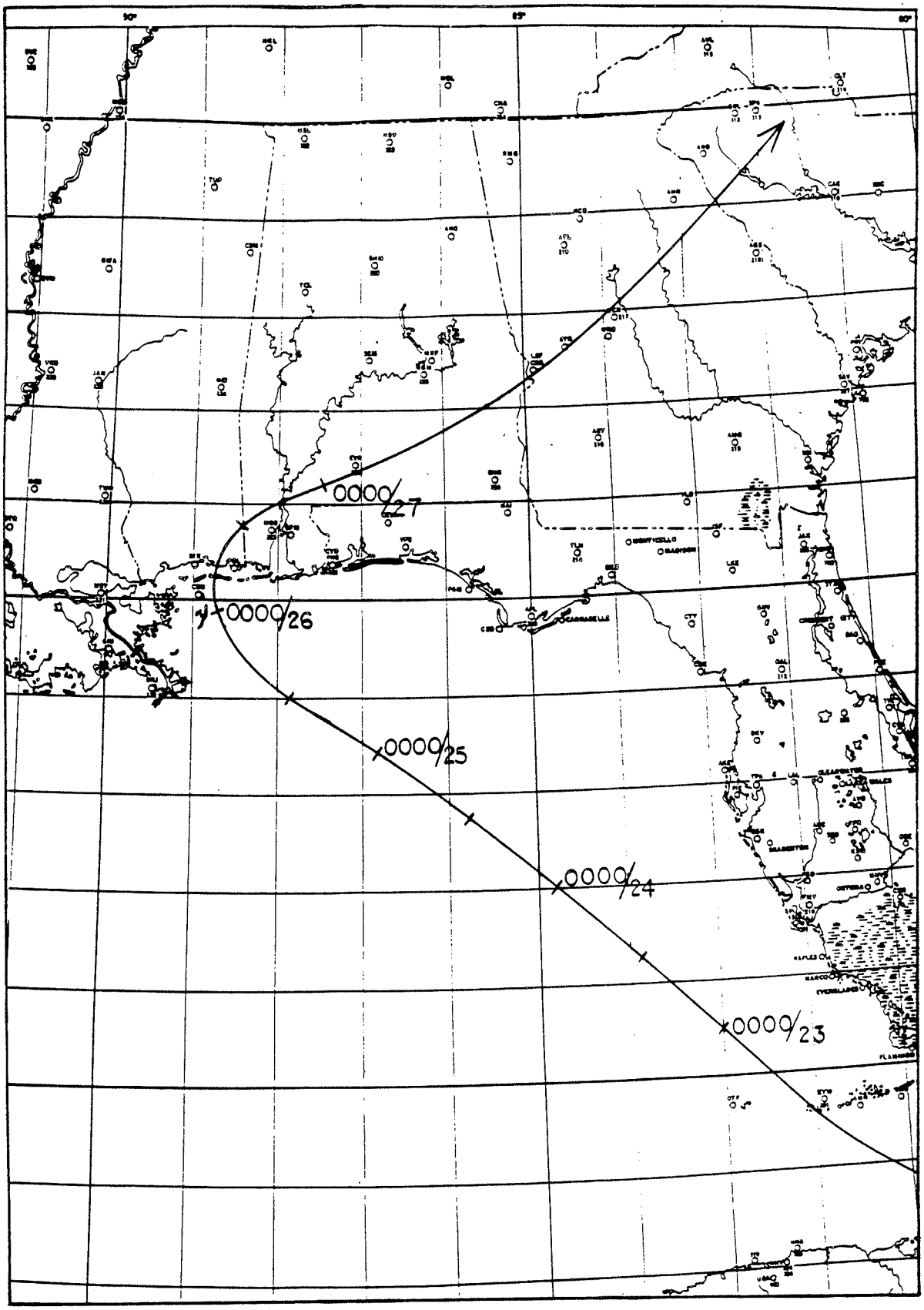

Figure 16.--Hurricane track - August 23-26, 1852.

Mobile Tribune August 27, 1852

"The storm which we mentioned in our last (report) continued to rage yesterday until about noon, when it began to subside. The wind blowed all night (August 25) and yesterday morning (August 26) from the southeast. About mid-day it shifted farther south then to the west and finally set in from the north, or a point in that direction.

"The flood began to decrease at noon, and towards night it fell back as far as Front Street, leaving a deposit of mud and board and wood, and the debris of timber, everywhere in the lower streets."

Mobile Advertiser, August 26, 1852,

"The wind which had comparatively lulled at 11 o'clock last evening, soon after blew with renewed violence, but yet, little serious apprehension of a further rise in the water was manifested.... At 1 o'clock (August 26) this morning the gale raged with terrible fury. Immense trees were torn up by the roots, falling into the streets or into the yards...with rising tide, the flood was progressing with alarming rapidity. By 2 o'clock it became evident that Water Street could not escape submersion.

"At sunrise and later this morning, the aspect of the city was gloomy indeed. The flood having submerged Water Street, forced its way into the stores, offices and dwellings of St. Francis, Dauphin, Conti and Government streets, nearly up to their several intersections with Royal.... Twelve o'clock, noon, the flood is thought to be at a stand, though the storm still prevails.... Six, P.M. - The water is now rapidly subsiding."

Daily Picayune, September 4, 1852

"The **Pensacola Gazette** of the 28th Oct. had the following:

"On Tuesday last there commenced one of the most severe storms that we have witnessed for many years. The wind, at just easterly, gradually shifted round first southerly then westerly. Wednesday and Thursday the wind blew steadily with tremendous force, and the rain fell in great quantities. From two-thirds to three-fourths of the main wharf was carried away - leaving only the outer end remaining. All the bathing houses have been swept away."

Selected meteorological data observed at Key West, and Pensacola, Florida, East Pascagoula, Mississippi, and Mount Vernon, Alabama, are listed as follows:

Key West, FL

Time (EST)	Pressure (in.)	Pressure (mb)	Wind (mph)
August 21, 1852			
Sunrise	30.134	1020	ENE25
9 am	30.154	1021	NE 25
3 pm	30.095	1019	ENE25
9 pm	30.099	1019	ENE25
August 22			
Sunrise	30.055	1018	NE 35
9 am	30.044	1017	NNE45
3 pm	29.961	1015	E 75
9 pm	29.921	1013	S 75
August 23			
Sunrise	30.008	1016	S 25
9 am	30.150	1021	SE 25
3 pm	30.126	1020	SE 25
9 pm	30.150	1021	SE 12

Pensacola, FL

August 24, 1852			
Sunrise	30.07	1018	NE 4
Noon	29.99	1015	NE 2
Sunset	29.87	1011	E 45
August 25			
Sunrise	29.80	1009	ESE45
Noon	29.83	1010	SSE45
Sunset	29.87	1011	SSE45
August 26			
Sunrise	29.72	1006	SSE45
Noon	29.63	1003	SW 45
Sunset	29.72	1006	SSE35
August 27			
Sunrise	29.71	1006	W 12
Noon	29.80	1009	WNW12
Sunset	29.82	1010	N 2

East Pascagoula, MS

Time (EST)	Pressure (in.)	Pressure (mb)	Wind (mph)
August 24, 1852,			
Sunrise	30.138	1020	NW 4
9 am	30.142	1021	N 4
3 pm	29.996	1016	N 12
9 pm	29.921	1013	N 12
Remarks: High tide. The island entirely under water			
August 25			
Sunrise	29.658	1004	N 35
9 am	29.540	1000	N 90
3 pm	29.236	990	NE 90
9 pm	28.961	981	NE 90
Remarks: Tide continued rising until midnight. Hurricane caused great destruction			
August 26			
Sunrise	29.162	987	SE 90
9 am	29.504	999	SW 75
3 pm	29.630	1003	SW 25
9 pm	29.693	1005	SW 12

Mount Vernon, AL (wind speed in mph)

Date/Time	Sunrise	9am	3 pm	9 pm
August 24, 1852	NE 12	NE 4	NE 25	NE 35
August 25	NE 35	NE 60	E 35	E 60
August 26	E 75	E 100	E 45	NE 45
August 27	NW 12	NW 4	SW 12	SW 2

16.3 Discussion

Analysis of observations taken at Key West and Pensacola, FL, East Pascagoula, MS, and Mount Vernon, AL, yielded results which traced the path of the hurricane from the time it entered the Gulf of Mexico, decelerating and recurving slowly west of Mobile Bay, until it passed south of Mount Vernon in an east-northeastward direction. Based on winds observed at East Pascagoula and Mount Vernon, we determined the time at which the storm center passed near each station. The news account from Daphne on the eastern shore, near the head of Mobile Bay, reporting south-easterly winds at 1100 and southwesterly winds at 1630, also aided in determining the storm's positions at those times. The veering of winds at Mobile, reported by the **Mobile Tribune**, confirmed the storm's movement just north of the bay.

As previously indicated, this hurricane produced the highest tide in Mobile since 1772. This record height was later exceeded by 3 in. during the passage of the hurricane of October 1893 which was a more intense storm. It is of interest to take a look at high tides at Mobile produced by various hurricanes in the last century. The following list of highwater marks, recording tide heights in selected hurricanes, is a summary based on a newspaper account printed in the **Mobile Register** (October 3, 1893) and information compiled by Ludlum (1963).

1819 July 27-28, the tide was thought to have been nearly as high as in the great storm and high water of August 1852.

1821 September 16, the water was 1 ft higher than it rose in the gale of 1819.

1852 August 26, highest storm tide ever known since 1772.

1860 August 11, high-water mark was 18 in. lower than that of 1852.

1860 September 15, another storm whose high-water mark was 12 in. lower than that of 1852.

1870 July 30, the high-water mark was about the same as that of 1860.

1888 August 18-20, very high tide about equal to that of 1860.

1893 October 13, the water at Mobile rose 3 in. above the flood line of 1852, and all recognize it as the worst that has ever been experienced.

The central pressure for this hurricane at the coast was derived from pressure observations at Pascagoula, MS, using equation (1). The radius of maximum winds estimate was based on winds reported at Mount Vernon, AL. The determination of the storm track and the speed of forward motion was previously discussed. The reader is referred to Sections 2.2-2.4 for detailed discussions on the assessment of these parameters. Parameters of the hurricane of August 26, 1852, off the Mississippi coast are listed as follows:

Central pressure	28.38 in. or 961 mb
Radius of maximum winds	30 nmi
Direction of forward motion	180°
Speed of forward motion	4 kt

17. HURRICANE OF AUGUST 10, 1856

17.1 Introduction

The casualties in the August 1856 hurricane were far less in number than those which occurred in the disaster of October 1893 at Cheniere Caminada. The 1856 storm is well remembered in the history of Louisiana as the Last Island Disaster because of the loss of more than one hundred prominent citizens of the Louisiana society on the island. Last Island was located at the western end, and therefore, termed the 'Last' of a chain of islands extending from the Mississippi Delta westward. It was a summer resort for people of the lower Louisiana Parishes. The island is about 25 miles in length and less than one mile wide, only 3 or 4 ft above the level of the Gulf.

Figure 17 shows the track of this August 1856 hurricane which passed near Key West, FL, on the 8th. The storm decelerated to a speed of 8 mph as it approached the Louisiana coast. The center of the storm passed just west of Last Island at about 5 in the afternoon of August 10. It passed to the south of Eugene Island and entered the coast near the western end of St. Mary Parish. Its forward motion decelerated further as it moved over land and slowly recurved towards the northeast on August 11. Its center crossed into Mississippi, north of Baton Rouge and accelerated in a northeastward direction.

Devastation of Last Island occurred as the hurricane passed to the west and a resort hotel was destroyed with loss of 320 lives. On the mainland, Bayou Lafourche rose 5 ft in a very short period of time and considerable flooding must have occurred in the lower section. To the east, there were reports of flooding to depth of 4 to 5 ft along the lower reaches of the Mississippi River. Hurricane winds at the southern end of the Mississippi Delta severely damaged installations at South West Pass, about 65 nmi east of the storm center.

17.2 Data Summary

The most significant data on the storm's intensity was reported by the ship C.D. Mervin which passed directly through the eye of the hurricane on August 10. The New Orleans **Commercial Bulletin** (August 23, 1856) described the experience of the Captain who braved the storm off the South West Pass. As the ship moved toward the center of the hurricane, its foremast gave way at 0500 on Sunday (10th) morning, to be followed by the main and mizzen masts. The Captain noted the following meteorological observations:

9th/0800	barometer reading, 29.90 in. (1012 mb)
10th/0800	barometer reading, 28.20 in. (954.9 mb)
0900	calm lasted for 5 minutes, the wind suddenly struck the ship from the opposite direction
0905-1030	hurricane force wind from the south
1100	wind gradually abating
1130	ship's position: South West Pass lay only 60 miles to the east-northeast.

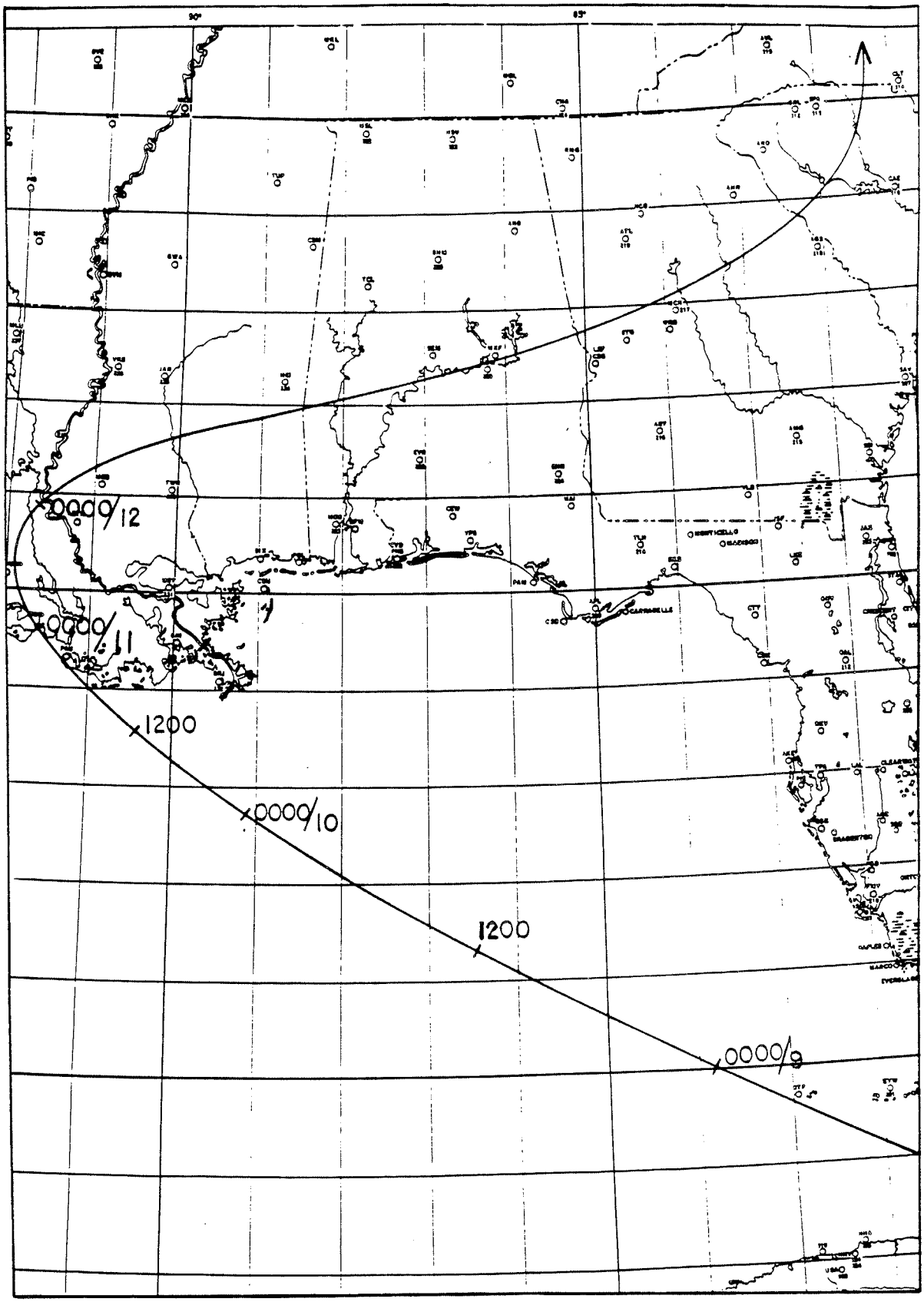

Figure 17.--Hurricane track, August 9-12, 1856.

Other informative excerpts of newspaper accounts are listed as follows:

Daily Picayune, New Orleans, August 13, 1856

"The express train, with those of the survivors of the Last Island calamity rescued by the steamboat Major F.X. Aubrey, whose destination was this city, arrived at Algiers at an early hour this morning. By it we have further particulars respecting the awful occurrence.

"The storm commenced about 10 o'clock on Sunday morning (August 10).... The island was swept by 2 o'clock on Sunday, having been overflowed between noon and that hour. The wind blew first from the north, and the northern part of the island was then overflowed. Next the wind came from the east, which beat the water off from the north side of the island; afterwards the wind shifted to due south, and then the island became overwhelmed by the waters of the Gulf.

"Bayou Boeuf, August 14, 1856 -- The wind increased gradually until about 10 o'clock on Sunday morning, when there existed no longer any doubt that we were threatened with imminent danger. From that time the wind blew a perfect hurricane; every building upon the island giving way, one after another, until nothing remained.... The water at this time (about 2 o'clock P.M.) commenced rising so rapidly from the bay side, that there could be no longer any doubt that the island would be submerged.... About 4 o'clock, the Bay and Gulf currents met and the sea washed over the whole island...."

August 14, 1856

"The depth of water on the island (Last Island), referring, as we understand it, to the highest portion, is reported at five ft. The wreck of the steamboat Star is stated to be lying on the island, near where the hotel of John Muggah formerly stood.

"Mandeville, August 12, 1856: Our town was visited on Sunday and Monday by one of the most disastrous storms ever witnessed here. The wind began to blow from the east on Sunday noon, and kept increasing until Monday morning, when it shifted to south by east, and then it was awful to witness the progress of destruction.... About dark on Monday it was thought that the storm had subsided, but at 10 o'clock P.M., it assumed its former strength, and continued until today.

"The oldest inhabitant says that this has been the most severe storm since 1812, at which time many residences were carried away."

August 16, 1856

"Thibodeaux, August 14, 1856. - The Lafourche has risen about five feet at this point; and the air is filled with sea-gulls.

"Callou Island. - The storm commenced there at 12 o'clock on Sunday, and continued with unabated fury until 4 P.M. on Monday. All the

people, however, clustered together on an elevated portion of the island, close to the house of Mr. B.G. Thibodeaux, where they remained in perfect security until the storm abated."

The **Natchez Courier** described the storm passage near Natchez:

"About dark on Sunday the wind rose rapidly, though the sky was almost cloudless, or only slightly and occasionally overcast.... Towards morning yesterday the leaden clouds gathered, and from that time on during the day, it was a continual repetition of gusty showers....

"After dark, the storm grew still wilder, and from that time on until towards noon yesterday (Tuesday, August 12) we have rarely seen a gale of greater violence.... For over thirty six hours as the storm prevailed - probably rivaling in its fury any September or midwinter gale ever known."

17.3 Discussion

Newspaper accounts, indicating the time at which the storm center passed over or abreast of individual locations, are summarized: (1) A calm period was reported by ship at 0900 on August 10. (2) The highest tide reached Last Island at about 1600 on the same day. (3) The wind shifted to south by east on Monday (August 11) morning at Maudeville, and (4) the storm prevailed for over 36 hr at Natchez, Mississippi. These reports indicated that the storm center moved at a slow speed of 7 kt as it approached the coast. It became almost stationary and recurved northeastward on August 12.

The barometer reading of 28.20 in. (954.9 mb) was taken on board the C.D. Mervin, 1 hr before the storm center passed directly over the ship. At this time, the storm center was moving at a speed of 7 kt as previously indicated and the ship was drifting with the inward spiral of the wind. It is reasonable to assume that the ship was only 8-9 nmi from the storm center when the pressure reading of 28.20 in. (954.9 mb) was taken at 0800 on the 10th. Reports of hurricane winds on Last Island commencing at 1000 in the morning, only 6 hr before the storm center passed abreast of the island, suggest that the storm was small in size. Since the storm center was moving at 7 kt, the extent of hurricane winds in this storm would have reached a radial distance of approximately 42 nmi (6 hr X 7 kt) from the center.

Assuming that the hurricane was located at 9 nmi from the ship when the pressure reading of 955 mb was observed, we obtained, by applying equation (1), a central pressure of 27.58 in. (934 mb). The assessment of hurricane parameters is discussed in detail in Sections 2.2 to 2.4. Parameters of hurricane of August 10, 1856, off Last Island, LA, are listed as follows:

Central pressure	27.58 in. or 934 mb
Radius of maximum winds	12 nmi
Direction of forward motion	140°
Speed of forward motion	7 kt

18. HURRICANE OF OCTOBER 6, 1873

18.1 Introduction

After crossing the Windward Islands, this hurricane moved west-northwestward into the northwestern Caribbean Sea. Its center turned north-northeastward into the Gulf of Mexico and passed west of Tortugas on the morning of October 6. The center of the hurricane then turned toward the northeast, in the direction of Punta Rassa, FL (fig. 18). It crossed Captiva Island and entered the west coast of Florida near 2100 on the 6th. It turned eastward in the next few hours and then resumed its northeastward course in the early morning hours of the 7th. After it exited the coast south of Cape Canaveral, the hurricane passed to the east of Cape Hatteras.

As the storm moved into the Gulf of Mexico, winds of hurricane intensity were felt at Tortugas from 0700 to 2100 on October 6. At Punta Rassa, a wind velocity of 64 mph was recorded prior to the failure of the anemometer at 1611 on the 6th. Maximum winds at Punta Rassa were estimated to have reached 90-100 mph and a low pressure of 28.04 in. (961.6 mb) was recorded during the storm passage. A high water of 14 ft above ordinary tide destroyed the entire settlement. At Biscayne, winds reached their maximum intensity at 0100 on October 7 and an unusual rise of water from 6 to 8 ft above ordinary tide was reported.

18.2 Data Summary

Information on this storm was scanty because the path of the hurricane passed through the lightly populated section of southern Florida and moved out to sea. Meteorological data from selected weather stations were obtained from the National Climatic Data Center in Asheville, NC. The pressure and wind observations, together with the observers' remarks, are listed as follows:

Pressure and (wind) (mph) observed at Fort Jefferson, Tortugas, FL, October 1873

Date/Time	7 AM (in.) (mb)	2 PM (in.) (mb)	9 PM (in.) (mb)
4th	29.97 1015 (E 45)	29.97 1015 (E 60)	29.95 1014 (NE 60)
5th	29.54 1000 (SE 45)	29.50 999 (SE 45)	29.50 999 (SE 60)
6th	29.14 987 (SE 90)	29.07 984 (S 100)	29.35 994 (SW 100)
7th	30.11 1019 (NE 35)	30.11 1019 (NE 35)	30.11 1019 (N 35)

Remarks (October 6): Violent hurricane from 10 AM to 9 PM and in the morning at 7 AM a large waterspout seen, passing from NE to SE. Pressure observations were copied from the book at Sogger Head Light 2 1/4 miles westward from this post, and were taken from a mercurial barometer.

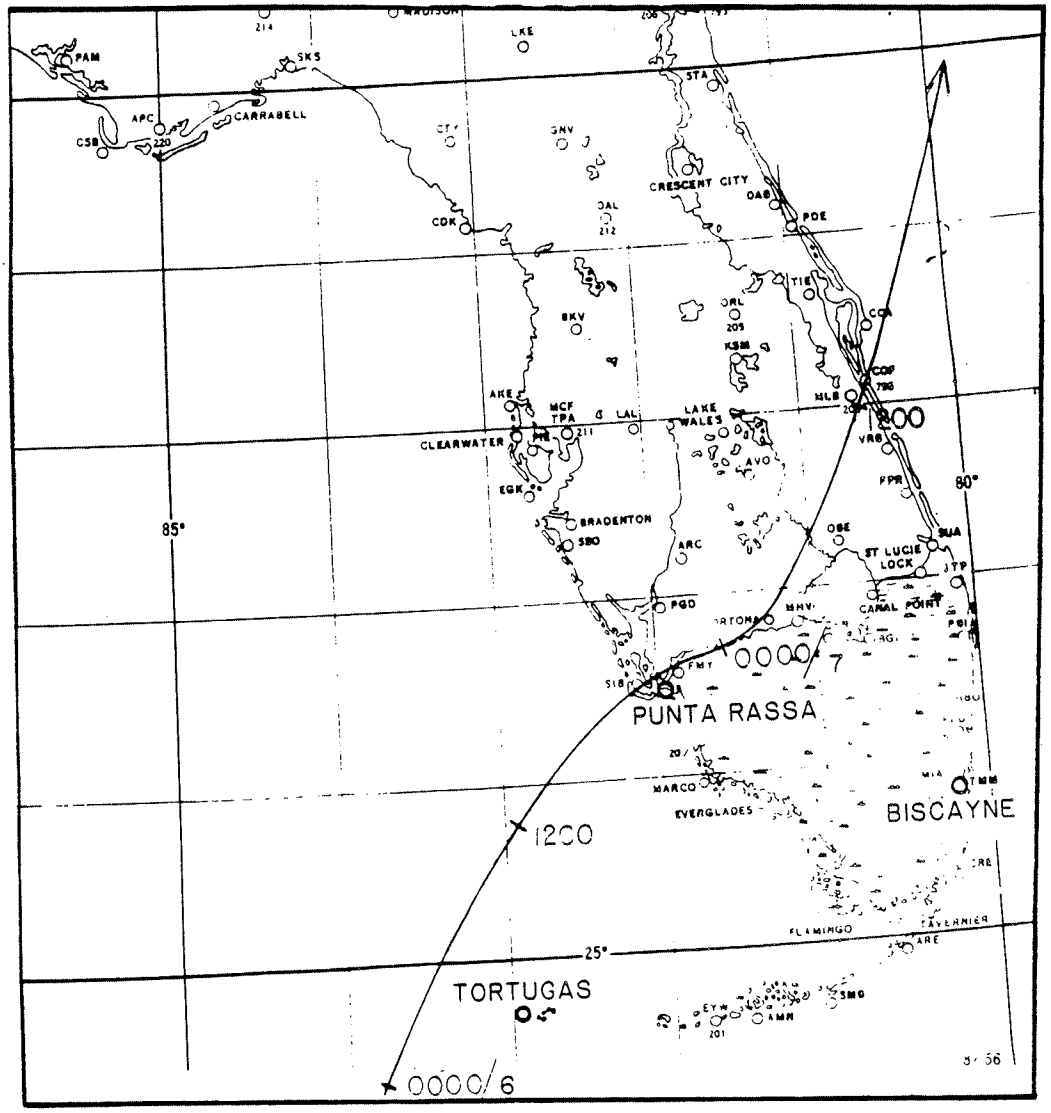

Figure 18.--Hurricane track, October 5-6, 1873.

Pressure readings taken at Key West, FL, October 1873

Date/Time	7 AM (in.)	7 AM (mb)	4 PM (in.)	4 PM (mb)	Midnight (in.)	Midnight (mb)
4th	29.91	1013	29.85	1011	29.87	1011
5th	29.84	1010	29.77	1008	29.76	1008
6th	29.63	1003	29.29	992	29.50	999
7th	29.72	1006	29.82	1010	29.91	1013

Remarks: Maximum velocity of wind 62 miles an hour recorded (80 mph estimated in hurricane of the 6th).

Pressure readings taken at Punta Rassa, FL, October 1873

Date/Time	AM (in.)	AM (mb)	PM (in.)	PM (mb)	PM (in.)	PM (mb)
4th	29.94	1014	29.84	1010	29.94	1014
5th	29.91	1013	29.85	1011	29.81	1009
6th	29.67	1005	29.10	985	29.02	983
7th	29.75	1007	29.86	1011	29.99	1015

Remarks: Cups and arms of anemometer blew off and lost during cyclone at 4:11 p.m. on October 6th.

Selected pressure and wind data (mph) taken at Punta Rassa on October 6, 1873

Time	Pressure (in.)	Pressure (mb)	Wind	Remarks
0100	29.81	1009	(E 17)	
0735	29.67	1005	(E 39)	
0945	29.60	1002	(SE 33)	from notes on weather map
1245	29.46	997	(SE 44)	from notes on weather map
1611	-	-	(S 64)	anemometer broken
1635	29.10	985	(S -)	-

Remarks: Lowest pressure, 28.04 in. (961.6 mb) by special observation. Maximum velocity of wind, 64 mph by special observation, supposed to have reached 90 mph during cyclone of 6th. Captain of U.S. Army Cutter, Northerner, said he believed the wind to have exceeded one hundred miles an hour.

Winds (mph) observed at Biscayne, FL, October 1873

Date/Time	7 AM	2 PM	9 PM
5th	(SE 4)	(SE 4)	(E 4)
6th	(SE 4)	(SE 35)	(SE 75)
7th	(NW 25)	(SE 4)	(SE 2)

Remarks: 1-2 AM October 7, the wind reached maximum velocity. The rise of water on the coast reached 6-8 ft above ordinary flood tides.

The following excerpts from the Biscayne weather station journal give the time of maximum winds and the level of high tide:

> "October 6, 1873. A severe gale of unusual violence, but, of comparatively short duration occurred on this day.... About 1 P.M. the rain and winds burst upon us with frightful power and violence.... By 1 A.M. (on the 7th) the wind seemed to have reached its greatest violence. By 2 o'clock, there seemed a manifest giving back of the storm and at 3, there was a perfect calm. The storm was attended with an unusual rise of the water on the coast. At this place, the rise was from 6 to 8 ft above ordinary flood tides. Vegetation suffered severely in exposed localities and had the wind and rain continued as long as the gale of August 24th and 25th 1871, not a green leaf would have been left."

Winds (mph) observed at Tampa, FL - October 1873

Date/Time	7 AM	2 PM	9 PM
4th	(S 4)	(SE 4)	(SE 25)
5th	(SE 4)	(SE 12)	(NE 4)
6th	(E 4)	(NE 4)	(N 45)
7th	(NE 4)	(NE 4)	(E 2)

Winds (mph) observed at Daytona, FL, - October 1873

Date/Time	7 AM	2 PM	9 PM
4th	(S 2)	(NE 2)	(N 2)
5th	(SW 2)	(SE 2)	(SE 2)
6th	(SE 2)	(S 2)	(N 60)
7th	(NW 12)	(NE 4)	(NW 2)

18.3 Discussion

The station record of Tortugas showed that hurricane winds, veering from southeast through south to southwest, were observed between 0700 and 2100 on October 6. These wind reports indicated that the hurricane center passed west of Tortugas in the morning of the 6th. At 2100 on the 6th, the pressure at Tortugas rose to 29.35 in. (993.8 mb) while the wind velocity remained at 100 mph. This high wind speed was probably over-estimated. At Punta Rassa, the wind velocity reached 64 mph prior to the failure of the anemometer at 1611 on the 6th. Maximum winds were estimated to have reached 90-100 mph from the south. The weather map of 2335 on the same day, showing a northwesterly wind at Punta Rassa, indicated that the center of the storm had passed near the station earlier in the evening. These reports indicated that the storm approached the west coast of Florida from the southwest, passing west of Tortugas in the morning of the 6th. The track of this hurricane, thus determined, differed from the one shown in the

hurricane track maps compiled by Cry and others (1963), in which the path of this hurricane moved in a west to east direction across the Gulf of Mexico.

At Tampa, winds of 4 mph from the northeast and 45 mph from the north were reported at 1400 and 2100 on the 6th, respectively. At Biscayne, hurricane-force winds were reported at 2100 on the 6th and reached its maximum at 0100-0200 on the 7th. These wind reports showed that hurricane-force winds, which were experienced for a duration of 4-5 hours at Biscayne, stayed within a radius of about 100 nmi from the storm center. These observations suggested that the lateral extent of the hurricane was larger than that of an average storm. An estimate of 26 nmi for the radius of maximum winds is considered appropriate.

The assessment of hurricane parameters is discussed in Sections 2.2 to 2.4. Parameters of hurricane of October 6, 1873 off Captiva Island, FL, are listed as follows:

Central pressure	28.32 in. or 959 mb
Radius of maximum winds	26 nmi
Direction of forward motion	220°
Speed of forward motion	8 kt

19. HURRICANE OF AUGUST 12-13, 1880

19.1 Introduction

After crossing the Leeward Island, the hurricane of August 1880 moved into the Caribbean Sea. The center of the storm passed to the south of Jamaica on August 6 and turned gradually northwestward on the 7th. It then crossed the Yucatan peninsula and moved into the western Gulf of Mexico, heading towards the southern Texas and Mexico coast (fig. 19). The barometer fell rapidly at Brownsville, Texas, reaching 28.315 in. (958.7 mb) at 11:45 pm on August 12, and the wind increased to hurricane force. For the next hour, the pressure at Brownsville became steady and the wind lulled. The center of the storm passed over Matamoros, about 5 miles southwest of Brownsville, where a calm period of 1 hr was reported. The storm turned slowly toward the northwest on the 13th and dissipated over western Texas on the following day.

In Matamoros, over 300 houses were blown down or rendered uninhabitable, and many others seriously damaged. The loss of property was estimated at $500,000. In Brownsville, buildings were unroofed or completely blown down, trees uprooted, all shipping destroyed and all telegraph lines knocked down. At Port Isabel, 8 vessels were wrecked and numerous small boats were sunk. The entire mosquito fleet of Point Isabel, consisting of about a dozen small sloops, was broken up. The few houses at Brazos de Santiago were washed away with the exception of the life-saving station which was badly damaged. Ten miles of railway between Brazos de Santiago and Brownsville were swept away or badly damaged.

19.2 Data Summary

The available data revealed that the center of the hurricane entered the Mexican coast, south of Port Isabel at approximately 2000 on August 12, 1880. The hurricane was small in size and moving at a slow speed of 10 kt. Selected meteorological data observed at Brownsville, Fort Brown and Indianola, Texas, and excerpts from the **Daily Picayune**, New Orleans, are listed as follows.

Pressure and (wind) observations (mph) taken at Brownsville, TX, on August 12 and 13, 1880

Date/Time	7:35 AM	2:35 PM	11:00 PM
12th	29.841 1010 (N 12)	29.833 1010 (N -)	28.791 975 (N -)
13th	29.423 996 (S gale)	29.772 1008 (S -)	29.843 1010 (E -)

Remarks: Lowest pressure of 28.315 in. or 958.7 mb recorded at 11:45 p.m. on August 12; highest wind recorded, 48 mph from the north, at 10:48 p.m. prior to the anemometer becoming inoperative.

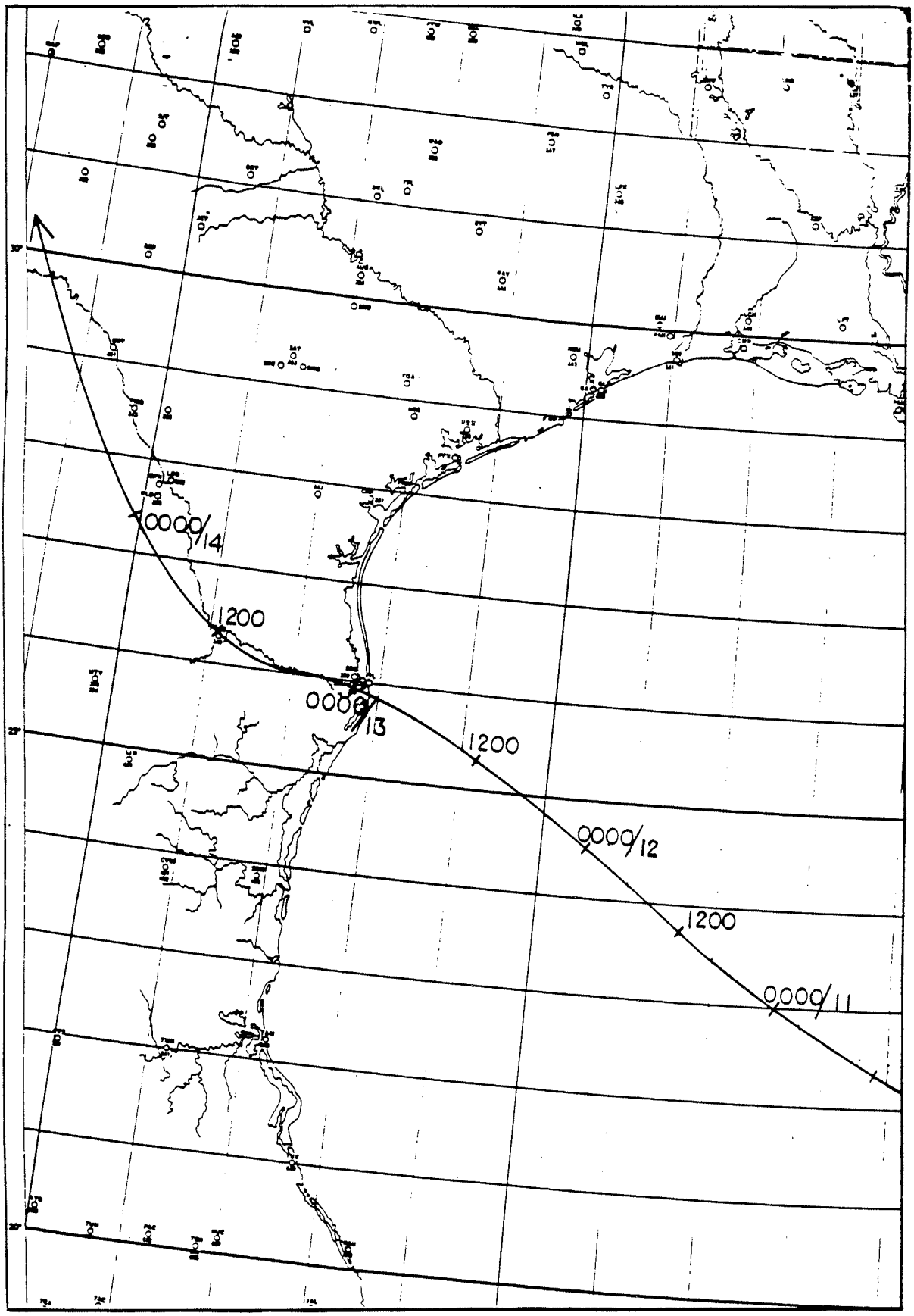

Figure 19.--Hurricane track, August 11-14, 1880.

Pressure and wind observations (mph) taken at Fort Brown, TX, on August 12, 1980

Date/Time	7 AM	2 PM	9 PM
12th	N 45 N (SW 90)	90 (S 4)	N 100 (SE 25)

Pressure and (wind) (mph) observations taken at Indianola, TX, on August 12 and 13, 1880

Date/Time	7 AM (in.) (mb)	2 PM (in.) (mb)	9 PM (in.) (mb)
12th	29.933 1014 (NE 36)	29.925 1013 (NE -)	29.865 1011 (NE -)
13th	29.784 1008 (E 36)	29.865 1011 (SE -)	29.913 1013 (SE -)

Remarks: Maximum winds NE/52 on the 12th; NE/64 on the 13th.

Daily Picayune, August 22, 1880

"Galveston, August 21. - The News' Corpus Christi special says: The **Brownsville Cosmopolitan** gave the following account of the storm: The gale commenced at 8:20 on the morning of the 12th. All day the wind blew, increasing in violence. Rain fell in torrents, filling the streets of Brownsville and Matamoros and deluging buildings. The storm subsided on the morning of the 13th. In Brownsville buildings were blown down, trees uprooted, shipping all destroyed and telegraph lines all prostrated. In Matamoros brick buildings were torn out of the center of a block, frame houses wrecked, streets filled with torn and twisted remains of trees and tin roofs. It is estimated that over 300 houses were blown down or unroofed...."

19.3 Discussion

Based on available wind observations and damage reports, we conclude that this hurricane was of small size for the following reasons: (1) winds of hurricane intensity were reported at Fort Brown at 2100 on August 12, while the highest recorded wind of 48 mph was observed at Brownsville at 2248, just before the anemometer cups were blown away. These observations showed that wind speeds decreased rapidly outward from the storm center, a typical wind distribution of small sized storms; (2) on the coast, the damages at Point Isabel and Brazos de Santiago were severe and yet, the light-house on Padre Island was only slightly damaged, and (3) at some distance inland, the loss of property at Matamoros was twice as heavy as the damages suffered at Brownsville. These facts implied that the intensity of the hurricane dropped off rapidly with increasing distances outward from the center.

The central pressure for this hurricane was derived from the pressure observed at Brownsville, and then adjusted to the coast. The pressure reading of 28.62 in. (969 mb) was taken at Brownsville when the storm center was 12 nmi from the station of (radius of 12 nmi). We, then, obtained the central pressure by applying the pressure profile equation (eq. 1). Adjusting the central pressure of 943 mb, thus obtained, to the coast, we have a central pressure of 931 mb.

The assessment of hurricane parameters is discussed in Sections 2.2 to 2.4. Parameters of hurricane of August 12, 1880 at the Mexican coast, just south of the U.S. border are listed as follows:

Central pressure	27.50 in or 931 mb
Radius of maximum winds	12 nmi
Direction of forward motion	120°
Speed of forward motion	10 kt

20. HURRICANE OF AUGUST 20, 1886

20.1 Introduction

After crossing the Windward Islands near Barbados, the storm moved west-northwestward across the Caribbean Sea. The center of the storm entered Cuba near Manzanillo on the evening of August 16, crossed the island and left it near Sagua. Resuming its west-northwestward course, the storm passed near Tortugas in the early hours of the 18th. The steamship San Marcos, located near 27°55'N 91°22'W, encountered easterly gale and very heavy southeast swell on the 19th. By this time, the winds at stations on the western Gulf of Mexico coast had shifted to northerly and increased from light to moderate.

At Indianola, Texas, the wind velocity reached 40 mph by midnight and increased steadily. By 0500 of the 20th, most of the damage to property was done. The water in the bay commenced to rise rapidly at about daylight. Nearly every sailing craft along this part of the coast either washed away or barely escaped. At 0700, the barometer at Indianola dropped to 28.89 in. (978.2 mb) and the wind velocity reached 72 mph from the northeast. At about 0900, the center of the hurricane crossed the central section of Matagorda Island (fig. 20). Every house on the upper part of the island except the life-saving station was washed away. Nearly all the cattle and sheep on the island were drowned.

As the storm moved inland, the settlement of Indianola was almost completely destroyed. The influx of water reached several miles inland and washed away four miles of railroad. Reports from Victoria and Cuero, Texas, indicated that the hurricane was the most destructive ever known in that region. By 1440, the storm center passed over San Antonio where a low pressure of 28.02 in. (948.8 mb) was recorded. Continuing its northwestward course, the storm passed to the south of Abilene and weakened over the high land of western Texas.

20.2 Data Summary

Excerpts of informative accounts from newspapers are listed in this section. Observations were taken at Indianola, Texas, until the Signal Office building collapsed. A barometric pressure of 28.89 in. (978.2 mb) and northeasterly winds reaching 72 mph were observed at Indianola at 0700 on August 20. The most useful meteorological data for estimating the central pressure of the storm were recorded at San Antonio during the storm's passage. These data are tabulated as follows:

Meteorological data taken at San Antonio on August 20, 1886

Date/Time	Pressure (in.)	Pressure (mb)	Wind (mph)
0700	29.69	1005	NE/20
1130	28.74	973	NE gale
1230	28.59	968	
1330	28.35	960	
1430	28.03	949	over 80 mph at 1400
1440	28.02	949	
2000	29.08	985	SE/-

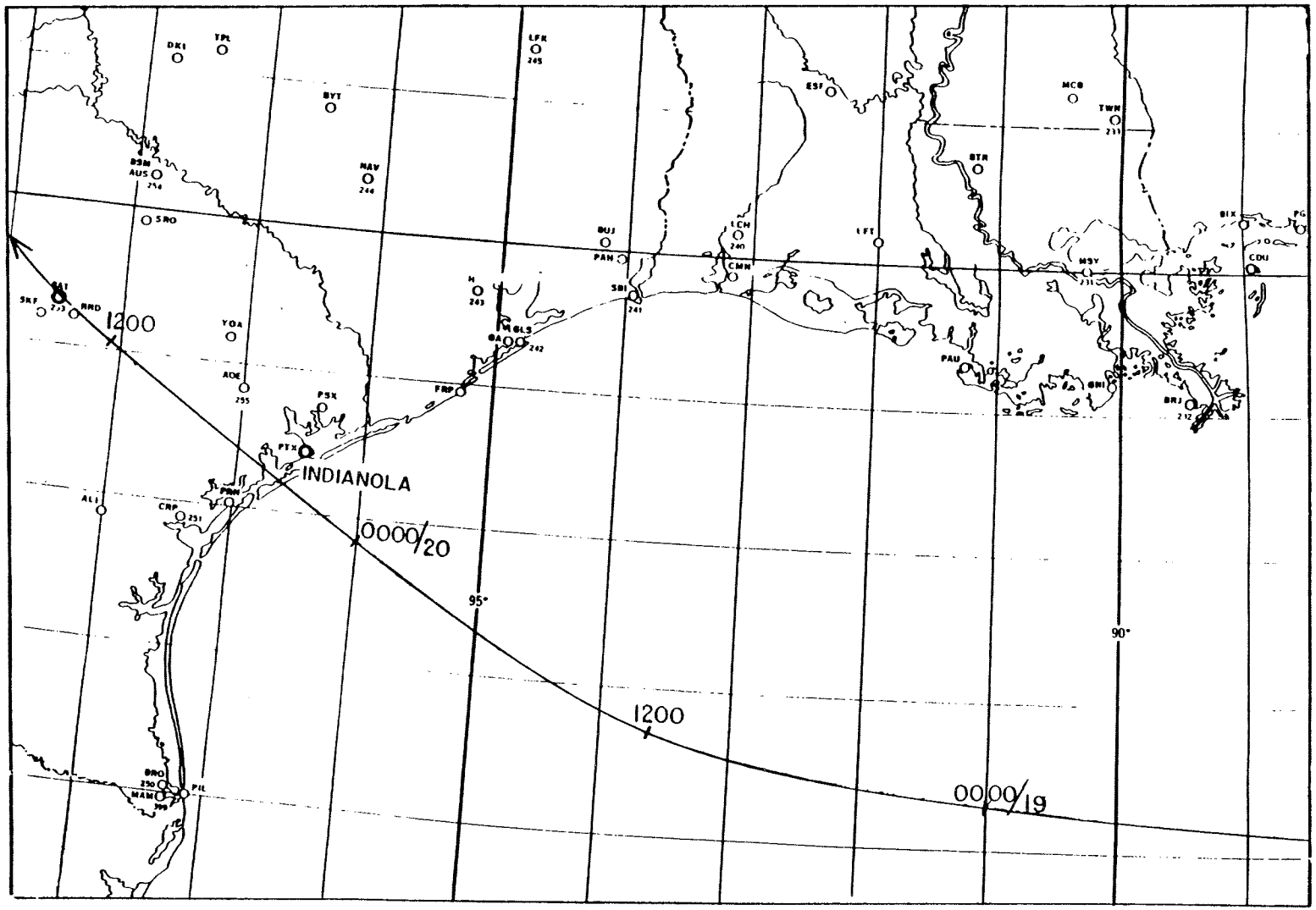

Figure 20.--Hurricane track, August 19-20, 1886.

The following ship reports along the path of the hurricane were published in the New Orleans **Daily Picayune** (August 20, 1886), and in the August Monthly Weather Review (U.S. Weather Bureau 1886).

"Captain Kelly of the S.S. Ozana made the following report: On the night of August 14th a hurricane passed San Domingo City, accompanied by heavy rain; barometer fell to 29.53 (in.) at 2 a.m. of the 15th, after which the weather cleared...."

"Hariett S. Jackson at Cardenas, Cuba, on the 17th stated: hurricane reaching maximum intensity at 3 p.m., wind from NE and backed to W and S."

"Captain F. Stevens of the S.S. Manhattan made the following report while passing Alligator Reef at 0152 of the 18th: barometer 29.36 in. and falling; wind from E by S and ESE and E by N, reaching 75 or 80 mph."

"The Ayrshire encountered a terrific gale on the night of 17th off Tortugas. The sea swept the decks, flooding the engine-room and coal bunkers, putting out the fires and shifted the cargo.

"The U.S. light-house tender Arbutus, at Tortugas on the 17th and 18th, was in the direct track of the cyclone which passed over that position between 12 midnight and 2 a.m. of the 18th, during which time the wind attained a velocity of about seventy miles per hour."

Daily Picayune New Orleans, August 20-24, 1886

"An inspection of the devastated town (Indianola) leaves little hope of its ever recovering from the severe storm of Friday. There are not more than half a dozen residences left even in good condition..... Four miles of the track were washed away, rendering it impossible for trains to approach any nearer than that distance of Indianola.

"The depth of water is reported as great as it was during the great storm of 1875, when Indianola had nearly 200 persons swept away. On Friday the influx of water over the doomed town was so rapid that within two hours after the first apprehensions were felt every street was submerged many feet. At Lavaca, twelve miles above Indianola, four feet of water is reported. In 1875 the streets were not submerged at all, which indicates that the water was higher on Friday last than in 1875.

"About fifteen houses were blown or washed down at Lavaca. Mr. John Roemen, who lives on Hine's Bay, reports great destruction through that vicinity. He says the water came in showing an almost perpendicular face of fully ten feet.

"Victoria, Texas, August 21 1886 -- Reports from all directions indicate that yesterday's storm was the most destructive ever known in this section. The wind was at a velocity of at least seventy-miles an hour and continued for about eight hours.

"News from Goliad, 28 miles west of Victoria, is to the effect that the storm raged there with great violence. Many houses were unroofed, while a considerable number were destroyed.

"The storm at Cuero, forty miles north of Victoria, was one of the severest ever known in that section. It raged from 5 o'clock to 11:30 a.m. on Friday. The wind blew a hurricane and the rain fell in torrents, both increasing in velocity and volume until the storm abated.

"Victoria, Texas, August 23, 1886 -- Reports just received from Saluria (on Matagorda Island) indicate the loss of a colored woman named Betty Mead and her two children, drowned in Friday's storm. Every house on the upper part of the island except the life-saving station was washed away.... Nearly all the cattle and sheep on the island were drowned, and it is likely the remainder will perish for want of water."

20.3 Discussion

After moving over land for a period of 5 hours, the center of the hurricane passed over San Antonio where a minimum pressure of 28.02 in. (948.8 mb) was recorded at 1440 on August 20. Assuming that this observed value was the central pressure of the hurricane, we could, then, estimate the central pressure of the storm at the coast by using the filling rate of over-land hurricanes established for this region in an earlier study (Ho et al. 1987). The resultant value of 27.02 in. (915 mb) gave us the central pressure of the hurricane at the time when its center crossed the coast. This is the most intense hurricane ever experienced on the Texas coast but the size of this hurricane was rather small. The maximum winds at Corpus Christi, Texas, about 50 nmi southwest of the point of landfall, reached 77 mph while the damage sustained at Matagorda (50 nmi to the northeast) was light. These observations showed that hurricane force winds stayed within a radius of 50 nmi from the storm center. At San Antonio, maximum winds, exceeding 80 mph, were reported at 1400, only 40 minutes ahead of the storm passage over the city. Since the storm center was moving at 18 mph, we estimated that maximum winds were observed at San Antonio when the storm center was about 12 nmi from the station.

It is of interest to note that this hurricane, because of its small size, was not extremely destructive at Galveston, Texas. The lowest pressure of 29.67 in. (1007.7 mb) and the maximum wind of 53 mph from the northeast were observed at Galveston during the storm passage. The principal streets were covered with water to a depth of three ft. As many as 300 houses in the vicinity of the beach were totally wrecked and a thousand rendered unfit for habitation. The damage in Galveston was the most severe since 1875 when more houses were swept away and the city submerged. But, the most disastrous event caused by a hurricane at this place did not emerge until the turn of the century when 6,000 persons were drowned in the hurricane of September 8, 1900.

The assessment of hurricane parameters is discussed in Sections 2.2 to 2.4. Parameters of hurricane of August 20, 1886, off Matagorda Island, Texas, are listed as follows:

Central pressure	27.02 in. or 915 mb
Radius of maximum winds	12 nmi
Direction of forward motion	120°
Speed of forward motion	16 kt

21. HURRICANE OF OCTOBER 1-2, 1893

21.1 Introduction

This hurricane formed in the Caribbean Sea and moved northwestward into the Gulf of Mexico. It recurved northeastward and approached the Louisiana coast on October 1, 1893. The center of the hurricane moved over the Caminada Pass, at the western end of Grand Isle, Louisiana, at about 2030 on the same day (fig. 21). Continuing northeastward, the storm center crossed the northern portion of the Mississippi Delta, just south of Bohemia, LA. It then moved up the coast, along the eastern shore of St. Bernard Parish, LA, and passed over Ship Island, south of Biloxi, Mississippi. It then re-entered the coast just west of Pascagoula at about 1000 on October 2. Continuing its northeastward course, it crossed Alabama, Georgia and western South Carolina. It then turned eastward and exited the coast north of Cape Hatteras.

This intense but small sized hurricane caused nearly 2,000 fatalities along the coastal areas of Louisiana, Mississippi and Alabama. The greatest loss of life occurred at Chemiere Caminada, a fishing village on a low-lying spit of land, west of Grand Isle, where 1,650 persons out of a population of 1,800 perished.

The New Orleans **Times-Democrat** of October 7, 1893 reported that "the waters rose to a height of 20 ft (at Caminada) and swept away everything before them." South of New Orleans, in the vicinity of Porte-a-la-Hache, the wind reached an estimated speed of 100 miles per hour shortly after midnight on October 2. The water of the Mississippi rose 9 ft and poured over the levees in some places, presumably, south of Porte-a-la-Hache. After a calm, the hurricane winds blew from the west and, according to newspaper accounts, the water from the Gulf and its bays rose 15 ft and swept away the fishing hamlets at Oyster Bayou, Bayou Cook and Adams Bay and poured over the levee into the river. It inundated the highest orange groves and the railroad to a depth of 4 ft. A very small percentage of the inhabitants in the fishing hamlets survived this disastrous storm.

The storm moved up the eastern Louisiana coast in the early morning hours of October 2, inundating the Chandeleur Islands and the islands along the Mississippi coast and causing great damage to coastal shipping. It was estimated that at least 350 craft were wrecked and few survived to tell their tale. As the hurricane moved inland towards Mobile, Alabama, the water in Mobile Bay rose rapidly to 8 ft above normal tide (as much as 2 ft in half an hour). The marshes around Mobile were flooded and all the houses in them destroyed.

21.2 Data Summary

Since many recording instruments in the path of the hurricane were blown down, no complete history of winds and pressures is available. The wind instrument at Port Eads, Louisiana, was destroyed hours before the approaching hurricane reached the coast. "The gauge of the wind at Port Eads indicated about eighty miles an hour when it was blown down," according to Christopher Valley, a river pilot (**Daily Picayune**, October 6, 1893). At West End, north of New Orleans on Lake Pontchartrain, winds of 65 mph were measured prior to when the instrument becoming inoperative. The Secretary of the Louisiana State Weather Service stated that "the wind must have blown at the rate of 100 miles per hour in the

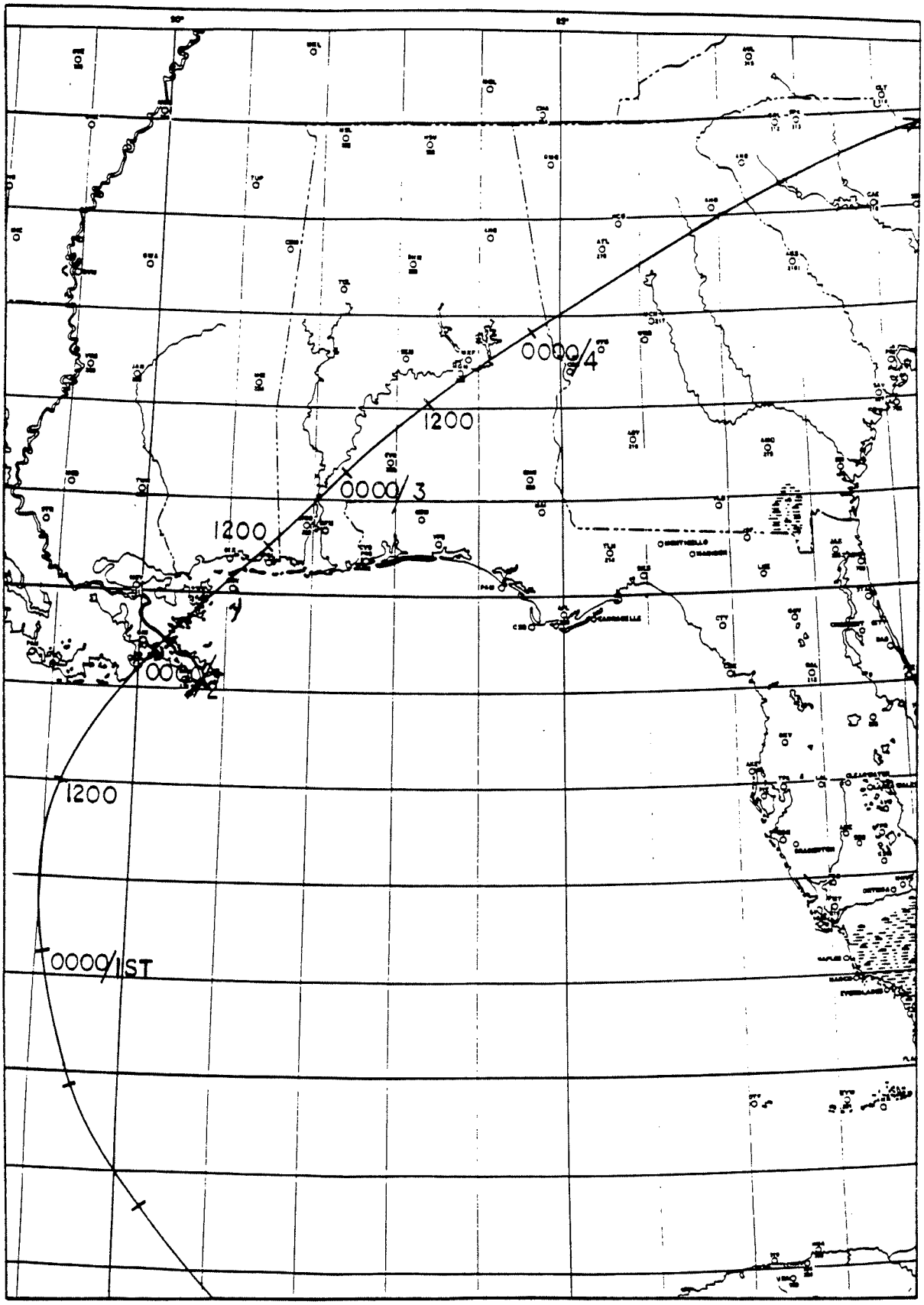

Figure 21.--Hurricane track, October 1-3, 1893.

vicinity of Porte-a-la-Hache and along the islands on the coast" (October Monthly Weather Review, U.S. Weather Bureau 1893).

At Bohemia, 50 miles south of New Orleans, Louisiana, an eye-witness report stated that the wind was most fearful between 2330 and 0130 on Sunday night. A calm, which occurred at 0130 on October 2, lasted for seven or eight minutes and then the wind shifted, blowing from a northerly direction for almost an hour. Periods of calm winds were also reported by survivors from Caminadaville on Chemiere Island and Grand Isle, Louisiana. The most informative excerpts from eye-witness accounts in the **Daily Picayune** of New Orleans (October 3-6, 1893) are listed as follows:

"Chemiere is one of that group of islands which extended along the lower coast (lying to the west of Grand Isle). It is a long, low, flat strip of earth, about three miles long by one in width. It was the old favored haunt of Lafitte and his band. Of late it was a station for fishing boats. It contained one town, Caminadaville, of about 1,600 people population, the majority of whom are fishermen.

"It is said that on Sunday evening there were 1,200 dwelling within its limits but today (October 6, 1893) twenty-five only remain standing, and of these there is not one which is uninjured."

Mr. George Reed, a resident of Chemiere Island related the following:

"... An object appeared in the distance. I fondly hoped that it was some member of my family. The hope, however, was not realized, for the object proved to be the roof of a house. I climbed on to this. The wind calmed half an hour later.... In five minutes the storm was again upon us."

The crew of the Joe Webre, which was wrecked at the western end of Grand Isle, gave the following account:

"At about ten minutes past 10 the wind lulled for about a quarter of an hour before it changed to the northwest and began that strange series of fluctuations between that point and the southwest, which constitute the most inexplicable feature of the storm....

"One of the party, interested in this phenomena, managed to observe the height of the water as marked against the facade of a ruined house which lay banked against the streets. It rose steadily till midnight, at which time it must have been fully 6 feet deep over that part of the island."

Captain McSweeny of the Joe Webre, who stayed home with his family on Grand Isle during the storm, also stated that:

"... This was when the wind calmed and the water commenced to recede. I was then in great hope that the storm had concluded. In a space of fifteen minutes, the water returned, increasing at a rate in excess of its previous performance."

The **Daily Picaynue** summarized the disastrous event as related by survivors from the area southwest of Port Sulphur, Louisiana.

"It was about 6 o'clock in the afternoon of Sunday (October 1) when the weather assumed a threatening aspect. The wind was blowing from the southeast at a lively, but not dangerous rate, and the tide was much higher than usual. Later in the night, the wind shifted to the northward and began blowing very heavily. Again about midnight its course was changed, and in a southwesterly direction. This was taken as a steady course. By this time the blast howled over the miles of marshes at the rate of 100 miles an hour. It took a very short time for the sea to be driven up towards the inland. Within an hour after the wind had taken its permanent course, the tide rose 5 feet, covered the settlements along the shores of the bayous and bays, and was making its way rapidly towards the tracks of the New Orleans, Fort Jackson and Grand Isle Railroad."

Survivors from Bayou Cook (southwest of Port Sulphur) described the situation there:

"The water had risen there to a height of 5 feet almost in an instant. At about 11:30 Sunday night, much to the horror of the inhabitants of this vicinity, a mammoth wave was discerned in the distance, apparently coming from the sea, to overwhelm them. They did not have even a chance to leave their homes. The wave struck and literally swallowed up the place. The place had no particular name. It figured among the mariners by the name simply of Bayou Cook. It had 300 inhabitants on Sunday afternoon. Of these but twenty-three have been accounted for.

"At the settlement on bayou Challen about forty fishermen had their homes. Not a single soul survived. Oyster bayou had thirty inhabitants, now it had none."

Daily Picayune, October 5, 1893:

"When the storm came up, which was a genuine cyclone, there were many Biloxi boats in the Louisiana march fishing for oysters, and it is almost certain that in many cases a number, if not all, of their boats have gone down with all on board. Of eight schooners that were known to be there on Sunday evening, three have been picked up, bottom up, with masts and rigging all gone and not a soul on board, and it is believed that the loss of life will not fall short of 100.

"Probably the worst damage and loss of property was at Chandeleurs Island....At this point, the fullest strength of the storm was developed, resulting not only in the almost complete destruction of all buildings on the island, but a fearful loss of life. The velocity of the wind reached 100 miles per hour."

Daily Register, Mobile, AL, October 5, 1893

"Scranton, October 3, 1893 -- The wind reached its highest velocity about 8 a.m. Monday and at 11 a.m. shifted suddenly to the southwest and

Table 5.--Ship observation at Moss Point, Mississippi, on October 2, 1893

Date/time	Pressure (in.)	Pressure (mb)	Remarks
0600	29.70	1005.6	Blowing heavy from ESE
0700	29.30	992.1	Wind SE by E
0800	29.00	981.9	No change in the wind
0900	28.85	976.9	Heavier and heavier
1030	28.65	970.1	Wind abated nearly to calm and gradually went around by south to southwest
1200			Came out heavy from west-southwest and west
1600			Cleared away
2100			Nearly calm

blew at an enormous velocity. I presume about eighty miles an hour. Scranton is about nine miles from the Gulf of Mexico.

"The water rose about nine feet above the ordinary high tide watermark when the wind was from the east, the current being driven up the Pascagoula River at a rate of eight miles an hour."

Mr. John Rolston of Dauphin Island reported:

"There was no apparent rise in the waters until after 11 o'clock, when the flood came with the force and suddenness of a tidal wave. This submerged a portion of the island to a depth of nearly eight feet and washed into the upper bay and drowned about three hundred head of cattle."

As the center of the hurricane entered the coast west of Pascagoula, Mississippi, the lowest recorded pressure in this storm was observed on board the schooner, B. Frank Really, lying at anchor at Moss Point. The pressure readings and the description of the storm are extracted from the Captain's report and listed in Table 5. Pressure and wind observations taken on October 1-2, 1893, at New Orleans, Louisiana, and Mobile, Alabama, are listed in Tables 6 and 7, respectively.

21.3 Discussion

The track of this hurricane along the coast was determined with the aid of wind information, including calm periods and wind shifts, reported at Caminadaville, Grand Isle, and Bohemia, Louisiana, and at Moss Point, Mississippi. The hurricane track, thus determined, showed that the center of the storm moved over the Caminada Pass and northeastward across the Barataria Bay. This finding differs from the storm track given in previous studies (e.g., Cry 1963) which showed the storm making landfall on the western shore of the Mississippi Delta. The path of this storm, shown in figure 21, is located some 10-15 nmi north of the previously designated tracks.

Table 6.--Hourly observations of pressure and wind taken at New Orleans, Louisiana, on October 1-2, 1893

Date/Time	Pressure (in.)	Pressure (mb)	Wind (mph)
2000	29.62	1003	28
2100	29.61	1003	30
2200	29.60	1002	32
2300	29.55	1001	-
0000	29.50	999	-
0100	29.45	997	-
0200	29.40	995	-
0300	29.35	994	-
0345	29.32	993	-
0400	29.35	994	-
0500	29.40	995	-
0600	29.47	998	-
0700	29.52	999	32
0800	29.54	1000	22
0900	29.55	1001	21
1000	29.60	1002	18
1100	29.65	1004	21
1200	29.65	1004	18

Remarks: minimum pressure for month of October 1893: 29.36 in. maximum winds for month of October 1893: SE/48 prior to instrument failure

The bays, inlets, bayous and lakes along the coast of Louisiana from Timbalier Bay to Lake Borgue, were fully exposed to the fury of the storm. There was scarcely a boat or a lugger caught on the water that was able to escape. The loss of life was frightful and the destruction of property was immense. Some of the luggermen who claimed to be well informed declared after the storm that the Louisiana fishing industry had been wiped out. At least ten schooners, sloops and tugs which plied their trade along the Chemiere coast were wrecked. Eight schooners were lost off the Mississippi coast and seven, on Ship Island. A total of 80 luggers which performed nearly all the transportation of fruit from the lower coast, oysters from the bayous and fish from the Gulf, were lost. Many of the Biloxi boats in the Louisiana marsh, fishing for oysters, went down with all hands on board.

Table 7.--Hourly observations of pressure and wind taken at Mobile, Alabama, on October 1-2, 1893

Date/Time	Pressure (in.)	Pressure (mb)	Wind (mph)
2000	29.77	1008	8
2100	29.75	1007	9
2200	29.74	1007	11
2300	29.72	1006	7
0000	29.70	1006	8
0100	29.68	1005	18
0200	29.65	1004	10
0300	29.64	1004	12
0400	29.62	1003	16
0500	29.60	1002	16
0600	29.57	1001	21
0700	29.55	1001	21
0800	29.54	1000	24
0900	29.50	999	33
1000	29.45	997	34
1100	29.40	995	39
1200	29.33	993	43
1300	29.27	991	49
1400	29.21	989	45
1600	29.23	990	25
1700	29.30	992	21

Remarks: minimum pressure for month of October 1893: 29.10 in. maximum winds for month of October 1893: SE/72 mph

Some of the pertinent observations along the path of the storm are summarized and listed as follows:

At Caminadaville	A lull of 5 minutes; 20-ft tide
At Grand Isle	A lull of 15 minutes at 2210 on October 1; wind shifted to northwest; island inundated to a depth of 6 ft above the highest ground
At Oyster Bayou and Adams Bay	15-ft tide
At Buras (8 miles inland)	Buras and Festerling settlements were 'wiped out'
At Bohemia	A calm period lasted for 7 or 8 minutes commencing at 0130 on October 2; wind shifted to northerly afterwards
At Porte-a-la-Hache	Maximum winds reached 100 mph shortly after midnight

At Chandeleurs Island	Maximum winds reached 100 mph
At Moss Point	Minimum pressure, 28.65 in. (970.1 mb) observed at 1030 on October 2
At Scranton (9 mi from Gulf coast)	Wind shifted to the southwest at 1100 on October 2, velocity 80 mph; water rose 9 ft above high tide
At Pass Christian	10-12 ft tide
At Waveland	10-ft tide
At Dauphin Island	Lower portion of island inundated to a depth of nearly 8 ft
At Cedar Point	6.5 ft above high tide
At Mobile	Tide 8.4 ft; maximum winds, 72 mph

21.4 Hurricane Parameters

The parameters for the hurricane of October 1893 at the Mississippi coast were adopted from an earlier report (Graham and Hudson 1960). In Graham's report, the central pressure of 28.22 in. (955.5 mb) was derived from the hurricane pressure profile formula by applying the lowest observed pressure at Moss Point and using an estimated radius of maximum wind of 17 nmi. The 1960 report showed the storm entered the western Mississippi Delta and, therefore, did not consider the parameters when the storm was located off Grand Isle, Louisiana. To do this, we made use of an earlier study on hurricane wind fields over the Mississippi Delta area (Ho 1978). This study considered hypothetical effects on hurricane intensity when a storm traverses the marshy terrain of the Mississippi Delta area. It determined the filling rate of such storms by using surface wind records taken during the passage of Hurricane Camille of 1969, Hurricane Betsy of September 1965 and the hurricane of September 1947. It concluded that the filling rate for these hurricanes is similar to the adjustment used in hurricanes moving over the Florida peninsula.

The center of the 1893 hurricane took eight hours to traverse a distance of 90 nmi from Grand Isle through the northern portion of the Mississippi Delta to the eastern shore of St. Bernard Parish. By using the central pressure determined for the hurricane off Biloxi and the previously established filling rate, we estimated the central pressure for the hurricane (27.85 in. or 940 mb) when its center was located off Grand Isle, Louisiana.

The assessment of hurricane parameters is described in Sections 2.2 to 2.4. Parameters of hurricane of October 1, 1893 off Grand Isle, Louisiana are listed as follows:

Central Pressure	27.85 in. or 940 mb
Radius of maximum winds	12 nmi
Direction of forward motion	220°
Speed of forward motion	8 kt

Parameters of hurricane of October 2, 1893, at Mississippi coast

Central pressure	28.22 in. or 955.5 mb
Radius of maximum winds	17 nmi
Direction of forward motion	220°
Speed of forward motion	9 kt

22. SUMMARY

In summary, the intensities of severe hurricanes of the nineteenth century are comparable to extreme hurricanes of the present century. Damage to properties and crops due to hurricanes has increased in value as the population and development in coastal areas has increased in recent years. But, the severity of these disasters, as measured by number of fatalities caused by hurricanes of the last century, has not been sustained in recent decades. (This does not mean to say that history will not repeat itself. Hopefully, the impact of such a disaster on coastal zones has been lessened by timely warnings and improvements in community preparedness.)

The loss of lives in the Louisiana hurricane of October 1893 almost reached the 2000 mark. This compares to the most disastrous incidence in Galveston where about 6,000 people drowned in the hurricane of September 1900. The most intense hurricane to strike the Texas coast destroyed the settlement of Indianola in August 1886. On the Atlantic coast, storm tides of about 18 ft MSL were experienced on the Georgia coast during the hurricanes of October 1893 and October 1898. In the 1893 storm, between 2,000 and 2,500 persons lost their lives on the coastal islands and the lowlands between Tybee Island, Georgia, and Charleston, South Carolina.

Almost all of the calamities along the coast have been due to storm surges. The height of these surges can be reproduced by using numerical models, if the driving forces and other factors in the generation processes are known. These driving forces, the pressure gradient force and the wind stress, are related to specific parameters of a hurricane. Pertinent parameters for the extreme hurricanes of the nineteenth century discussed in this study are summarized and tabulated in chronological order in Table 8. These parameters are described as follows:

1. Central pressure - an index of the hurricane's intensity. Storm-surge magnitude varies approximately with the strength of the wind that is putting stress on the water surface, other factors being constant. An index of this wind stress in hurricanes is the intensity of the storm.

2. Radius of maximum winds - an index of the lateral extent of the storm. In steady state, mature hurricanes, winds increase from low values at the center of the eye, proceeding outward to their most intense velocity just beyond the edge of the eye, then decrease gradually. The average distance from the storm center to the circle of maximum wind speed is called the radius of maximum winds.

3. Direction and speed of the storm's forward motion. Generally, surge height on the coast increases with increasing storm speed, while in bays and estuaries, highest surge levels are associated with slow moving storms. The path of the storm acting in conjunction with other factors influences the location on the coast of peak surges which can be greatly amplified in bays and estuaries.

Table 8.--Summary of parameters of extreme hurricanes of the nineteenth century

Date	Central pressure[1] (mb)	Radius of maximum winds[2] (nmi)	Direction and Speed of forward motion[3] (° from N)	(kt)
Sept. 23, 1815	940	30	210	34
Sept. 3, 1821	960	30	180	30
Oct. 5, 1842	955	18	250	18
Oct. 11, 1846	902	9	180	11
Sept. 25, 1848	945	15	240	10
Aug. 26, 1852	961	30	180	4
Sept. 8, 1854	950	40	200	5
Aug. 10, 1856	934	12	140	7
Sept. 8, 1869	963	40	190	45
Oct. 6, 1873	959	26	220	8
Aug. 8, 1879	971	16	195	25
Aug. 4, 1880	931	12	120	10
Sept. 9, 1881	959	15	170	10
Aug. 20, 1886	915	12	120	16
Aug. 27, 1893	931	23	150	17
Oct. 1, 1893	940	12	220	8
Oct. 13, 1893	955	15	200	25
Oct. 2, 1898	945	24	140	13
Oct. 31, 1899	955	35	190	11

[1]The highest intensity (lowest pressure of 902 mb) occurred in the hurricane of October 11, 1846. This intensity was exceeded by the Labor Day hurricane of 1935 (892 mb) which struck the Florida Keys. Hurricanes outside the tropics generally become weaker as they move northward.

[2]The radius of maximum winds ranged from 9 to 40 nmi. Generally speaking, the radius of hurricanes outside the tropical regime increases with increasing latitude.

[3]The three fastest moving storms were hurricanes affecting the northeast. It is generally true that hurricanes move faster in higher latitudes. Slow moving storms along a critical path can produce extraordinary flooding in bays and estuaries. An example of this phenomenon is illustrated by the hurricane of 1852, which affected the Mobile Bay area.

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APPENDIX

HURRICANES AFFECTING NORTHEASTERN FLORIDA

Hurricanes affecting northeastern Florida appear to be less intense than the extreme hurricanes studied in the main body of this report. They are discussed in this appendix to emphasize the distinction between the two categories. Hurricane Dora of September 1964 is the only hurricane to strike this section of the coast since 1896, lashing the Jacksonville area with 82 mph winds. The September 1896 hurricane entered the west coast of Florida, north of Cedar Key, causing severe damage on that coast. The center of this storm passed inland, some 70 nmi from the Atlantic coast. Jacksonville experienced a wind velocity of 76 mph. The effect of this storm was minimal on the Atlantic coast of Florida. No attempt was made to further investigate this 1896 storm. In the nineteenth century, hurricane winds were experienced in northeastern Florida during the passage of hurricanes of September 1844, August 1871 and September 1878. The hurricane of September 1844 struck the coast near St. Augustine, while the other two storms entered the southern Florida coast and moved northward across the entire stretch of the peninsula (fig. 22). The particular features of these hurricanes are briefly discussed in this appendix.

Hurricane of September 7, 1844

The most severe hurricane in the nineteenth century to strike the northeastern coast of Florida moved across the northern portion of the peninsula on September 8, 1844. Fort Marion (20 mi southwest of St. Augustine), located at 29°40'N 81°35'W on the St. John's river reported that a great storm commenced to blow at 1445 and winds reached 75 mph from the northeast at 2100 on September 7. The highest velocity of the storm was not recorded as the center of the hurricane passed south of the station during the night. It is probable that the hurricane accounted for the highest wind velocity ever observed in the vicinity of St. Augustine. The size of the storm was rather small since only light easterly winds were reported at Tampa, FL, on the 7th, and 25-knot winds in the morning of the 8th.

After traversing the Florida peninsula, the center of the hurricane moved across the Apalachee Bay and passed over Apalachicola in the afternoon of September 8. A calm period of about an hour was reported at Apalachicola. As the storm center remained semi-stationary just east of St. Joseph Bay, waves washed over the narrow sand barrier which separated the bay from the Gulf. The tide flooded and undermined the streets of St. Joseph which was located on an elevation of 5-10 ft above mean sea level. The town was completely destroyed by the storm.

Hurricane Parameters

The assessment of hurricane parameters is discussed in Sections 2.2 to 2.4. Parameters of hurricane of September 7, 1844, when the storm center was located off St. Augustine, FL, are listed as follows:

Central pressure	28.05 in. or 950 mb
Radius of maximum winds	12 nmi
Direction of forward motion	130°
Speed of forward motion	15 knots

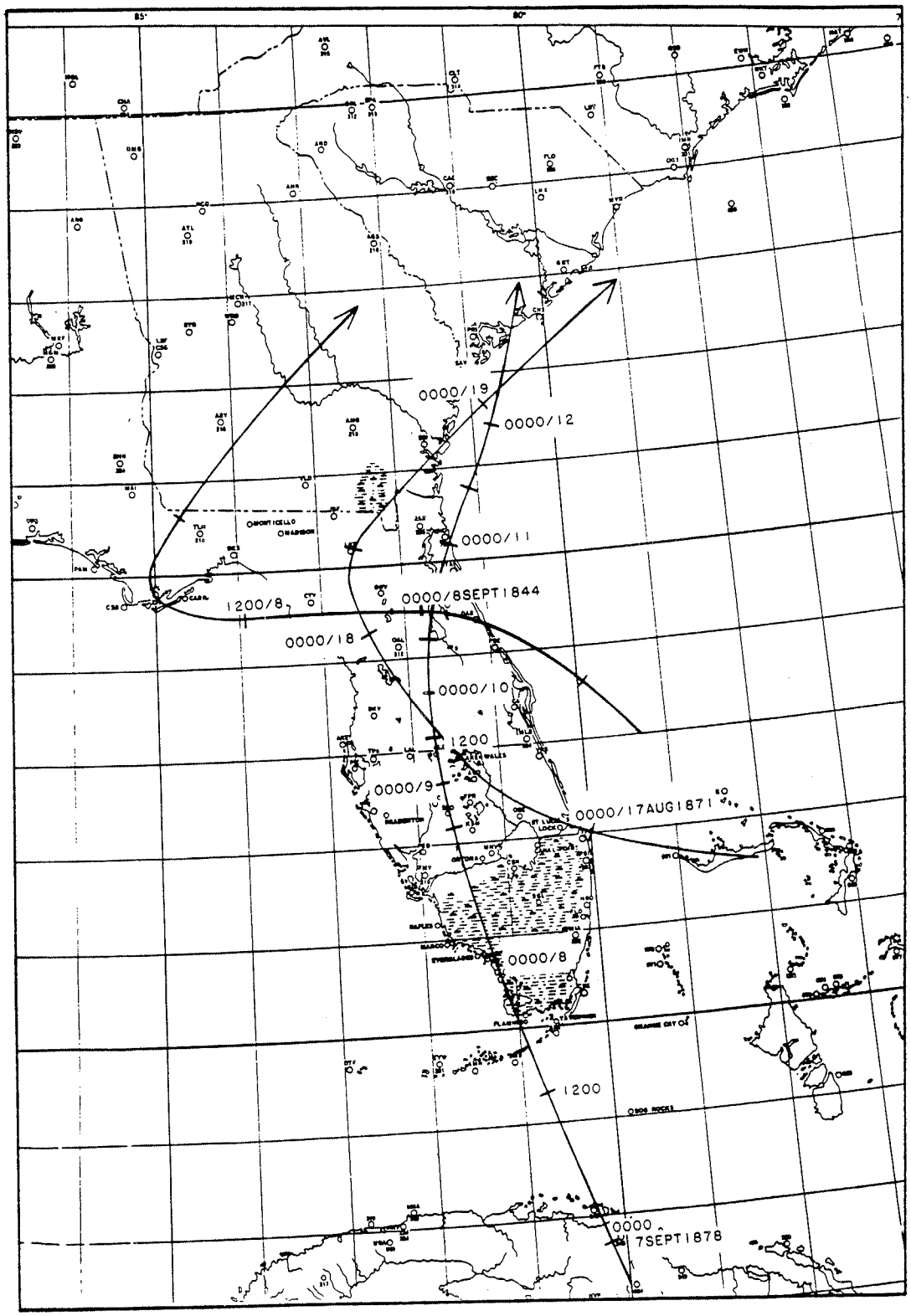

Figure 22.--Tracks of hurricanes affecting northeastern Florida.

Data Summary

Selected pressures (in.) and winds (mph) recorded at army posts and the most informative excerpts of newspaper accounts are listed as follows:

Fort Marion, St. Augustine, FL - September 1844

Date/Time	Sunrise		9 AM		3 PM		9 PM	
	Pressure	Wind	Pressure	Wind	Pressure	Wind	Pressure	Wind
5th	30.173	calm	30.177	N25	30.177	NE60	30.177	SE60
6th	30.083	SE4	30.091	SE12	30.020	SE12	30.004	SE2
7th	29.925	E25	29.961	E35	29.935	NE60	29.921	NE75
8th	30.000	SE12	30.020	SE25	30.020	NE12	30.020	SE2

Remarks: (7th: Rain commenced in the course of the night. Commenced to blow a great storm at 2 3/4 p.m.)

Fort Brooke, (Tampa, FL)

5th	30.095	E2	30.095	E2	30.114	E2	30.041	NE2
6th	30.191	NE4	30.191	calm	30.059	E2	30.059	E2
7th	29.977	E	29.977	calm	29.965	E2	29.965	E2
8th	29.977	E25	29.953	E25	29.953	calm	29.977	NE2
9th	29.953	S4	29.947	S25	29.949	S12	29.949	SW12
10th	30.012	S2	30.110	SW12	30.110	SW12	30.110	calm

Fort Barancas, (Pensacola, FL)

5th	30.142	NE12	30.110	E25	30.083	S	30.133	NE
6th	30.107	E25	30.122	E12	30.114	SE	30.091	-
7th	30.083	N12	30.110	E25	30.083	NE35	30.083	E45
8th	30.110	N25	30.079	N35	30.004	N12	30.012	N25
9th	29.992	NE35	29.973	NE25	29.973	N45	29.945	N25
10th	29.921	NW4	29.788	W4	29.953	SW35	29.923	W2

Pensacola Gazett, September 21, 1844

"Apalachicola Commercial Advertiser, September 9, 1844 -- As was anticipated yesterday morning [September 8], we were visited last evening by a tremendous gale which has done extensive damage throughout the city. It commenced blowing from the NE about three o'clock and gradually increased to a perfect hurricane, till about half past five, when it suddenly lulled, and became a dead calm, which continued about an hour - the wind then hauled around to the NW and blew with extreme violence till 8 o'clock when it ceased altogether."

Tallahassee Sentinel, September 9, 1844

"Last night our annual September gale came in all its fury. The wind blew in fitful and furious gusts, driving before it a deluge of rain, from about half past seven P.M. to about one o'clock in the morning, veering in its direction from N.N.E. to S.S.E. We dread to hear of its effect on the cotton crop, fearing they must be disastrous." (from Ludlum 1963)

Hurricane of August 17, 1871

After passing the Bahamas in a west-northwestward direction, the center of this storm entered the Florida coast shortly after midnight of August 16. It turned northwestward in the morning and was located south of Gainsville that evening. It then turned slowly toward the northeast on the following day and exited the coast near Brunswick, Georgia. Hurricane-force winds extended more than 150 nmi to the north of the point of landfall. Fairview, FL, 20 nmi south of St. Augustine, experienced the most severe storm in 50 years. The persistent hurricane-force winds observed at New Smyrna on August 17 suggested that the storm's intensity remained almost constant as the hurricane moved over central Florida.

The lack of land stations and eyewitness accounts along the thinly populated coast of southern Florida were augmented by reports from ships passing off the coast. The report from the steamship Victor, which encountered the hurricane off Jupiter Inlet and experienced a lull and a shift of wind direction, helped us to determine the point of landfall with some degree of accuracy. The observation of a low pressure of 28.20 in. (954.9 mb) from the steamship, City of Houston, at some distance from the storm center, led us to believe that this storm was of severe intensity. At New Smyrna, hurricane-force winds were reported at 0700 on September 17 when the storm center was approximately 100 nmi south of the station. This suggested that the storm size was of large dimension for this latitude.

Hurricane Parameters

The assessment of hurricane parameters is discussed in Sections 2.2 to 2.4. Parameters of hurricane of August 17, 1871, when the storm center was located off Jupiter Inlet, FL, are listed as follows:

Central pressure	27.91 in. or 945 mb
Radius of maximum winds	30 nmi
Direction of forward motion	110°
Speed of forward motion	8 kt

Data Summary

The most informative excerpts of newspaper accounts and station journals are listed in following paragraphs. Selected meteorological data are also included in this section:

A great storm at sea was reported by the **Daily Picayune** of New Orleans on August 22, 1871:

"New York, August 21. The steamer Victor, from New Orleans on August 15, arrived at 8 A.M. Off Jupiter Inlet took gale from north-northwest, which increased to a hurricane. At 8 P.M. the ship was lying on her beam ends. At 12 (2400) midnight the gale moderated. Suddenly at 1230 (0030) it came from southeast. At 2 A.M. the ship was lying with fair streaks of deck under water, the sea making a clear breach over her and stove in the cabin, which was filled with water."

The **Charleston Courier**, August 28, 1871

"The streamer City of Houston, 1220 tons, Captain Partridge, of the Galveston and Key West line, which left New York on the 12th instant, encountered a severe hurricane on the night of Wednesday, the 16th instant, while off Cape Canaveral. All sails were blown away, tiller ropes parted, and so much water was shipped as by 2 A.M. of the 17th to put out the furnace fire and render the ship helpless....

"During the storm, the barometer fell as low as 28.20 (inches)."

The **Observer** at New Smyrna, FL, made the following notes on August 17, 1871

"At 1 A.M., wind changed to east and increased to a violent gale with heavy driving rain squalls. Thunder and bright flashes of lightning in the east and northeast. Large live oak trees blown off at the trunks. Orange groves badly injured. Wind changed to SE at about 2 P.M. on the 17th where it blew the hardest. Storm abated about 10 P.M. on the 17th. Ceased blowing at 2 A.M. on the 18th. The most violent gale known in this coast since October 23, 1865. Homes and fences blown down. Sea beach strewn with wrecks from 6 miles north of Cape Canaveral to the south. Houses unroofed at Enterprise 30 miles west from this place."

The **Observer** at Fairview (29°36'N 81°37'W) placed in his register of meteorological observations the following note:

"During the month our state has been visited by one of those terrible cyclones which are peculiar to this section and which occur at intervals more or less irregular. The last was perhaps the most severe that has occurred during the past half century.

"The storm commenced with a high wind from the NE during the afternoon and evening of Wednesday the 16th, gradually increasing in intensity during the night and amount to a gale on the morning of the 17th accompanied by a copious and driving rain. During the whole of the 17th, the storm continued to increase in intensity and force. The wind bearing from NE in the morning around to SE at midnight when the storm

was at its maximum - the rain falling in driving sheets all this time and accumulating to 8 1/2 inches during the first 24 hours. On the morning of Friday the storm still continued to rage with little apparent abatement but as the wind beared around to the SW during the day, its force became gradually lessened and finally the storm ceased at about midnight of the 18th with winds from the west."

The **Observer** at Ocala, FL, made the following note:

"August 16. From early morning until midnight a very strong E wind blew. Then, on a sudden, the wind blew N.E. and at 5 o'clock A.M. of the 17th it began to rain with frightful gusts of wind and continues both to rain and blew frightfully. This P.M., 5 o'clock (17th), I have seen a home blown down and six full grown trees lie prostrate on my five acre lot....the wind shifted last night (17th) at 9 o'clock from N.E. to S.W....

The **Observer** at Picolata (29°55'N 81°35'W) noted:

"At daylight of 16th instant there was a heavy fog or rain, wind NE which gradually increased until about 6 AM of the 17th when it attained its maximum. The wind during the whole storm coming in puffs, lasting from 3 min. to 15 min. The wind shifted permanently from NE to E between 5 PM and 7 PM of the 17th, from E to SE between 8 and 9 PM of 17th, and from SE to SW between 1 and 1:30 PM of 18th. The gale decreased in violence after 6 PM of the 18th."

The following wind observations (mph) are extracted from the registers of meteorological observations of selected stations:

Date/Time	7 AM		2 PM		9 PM	
			New Smyrna, FL			
August 16	NNE	12	N	25	N	45
17	NNE	75	SE	75	SE	75
18	SE	12	SW	25	SW	2
			Port Orange, FL (12 miles north of Mosquito Inlet)			
August 16	N	4	N	25	N	25
17	NE	45	E	75	SE	60
18	SE	4	SE	12	W	12
			Fairview (near Pilathka), FL (29°36'N 81°37'W)			
August 16	NE	4	NE	35	NE	35
17	NE	45	NE	75	E	75
18	SE	60	S	60	SW	45
			Picolata (29°55'N 81°35'W), FL			
August 16	N	25	NE	35	NE	45
17	NE	60	NE	60	E	45
18	SE	45	SW	60	SW	45
			Tampa, FL			
August 16	N	4	NW	4	NE	25
17	NW	45	NW	75	W	60
18	NW	35	W	25	W	12

Pressure (in.) and wind observations (mph) copied from weather maps
August 1871

	7:35 AM		4:35 PM		11:35 PM	
			Punta Rassa, FL			
August 16	29.97	N20	29.87	NW18	29.79	NW33
17	29.82	W36	29.74	SW35	29.96	SW25
18	29.85	SW24	29.85	SW18	29.93	SW15
			Lake City, FL			
August 16	29.97	NE3	29.87	NE10	29.87	N9
17	29.76	NE13	20.60	NE17	29.51	NE23
18	29.36	E5	29.44	NW14	29.71	NW12
			Jacksonville, FL			
August 16	29.98	NE4	29.98	NE2	29.93	NE25
17	29.87	NE35	29.86	NE45	29.83	NE45
18	29.72	NE60	29.67	SE45	29.74	SW25
			Savannah, GA			
August 16	30.04	N2	29.98	E14	29.94	E6
17	29.91	N8	29.87	E19	29.88	E15
18	29.80	E16	29.57	NE42	29.55	N60

Hurricane of September 7–10, 1878

This hurricane is of special interest because of its peculiar features while over southern Florida. The center of the storm entered Florida near Cape Sable on September 7 and moved slowly northward over the middle portion of the peninsula. From the afternoon of the 8th until the morning of the 10th, it moved at an average speed of 2–3 mph. During this period, hurricane-force winds were reported at St. Augustine for a total duration of 40 hours, and the hurricane appeared to have intensified. Easterly winds of hurricane intensity wrecked three ships near Mosquito Inlet, just south of Daytona Beach, FL. Other damage to shipping in this area, extracted from the September Monthly Weather Review (U.S. Weather Bureau 1878) are listed as follows:

Brig Sabre, from Tampico to Havre, was driven ashore 60 miles south of Cape Canaveral in hurricane, total loss.

Schooner Jessie B. Smith, from Old Harbor, Jamaica, was driven on to Jacksonville bar September 10th, after 5 days continued gales; let go both anchors but was driven ashore 5 miles south of St. John's bar at daybreak of 11th. Hurricane so fierce that it blew the light house down.

Schooner Hattie Ross, driven ashore 12 miles south of Cape Canaveral.

Brig Sallie Brown abandoned September 11th, 29°40'N 80°40'W, dismasted and water logged.

Steamer City of New York (arrived Havanna on September 13, from New York) reported hurricane lasting 40 hours between Cape Hatteras and Charleston.

Steamer Santiago de Cuba (at Havanna September 14, from New York), reported tremendous hurricane off Florida coast, lay to for 4 days off Cape Canaveral.

Schooner Ocean Pearl from San Blas, Baltimore, was totally wrecked 30 miles north of Cape Canaveral in hurricane.

Hurricane Parameters

The assessment of hurricane parameters is discussed in Sections 2.2 to 2.3. Parameters of hurricane of September 9, 1878 - storm center located at 28.2°N 81.7°W - are listed as follows:

Central pressure	28.35 in. or 960 mb
Radius of maximum winds	20
Direction of forward motion	360°
Speed of forward motion	2 knots

Data Summary

Wind and pressure observations taken at selected stations during the passage of hurricane of September 7-10, 1878 are listed as follows:

Key West, FL

Date/Time	Pressure (in.)	Pressure (mb)	Wind (mph)
07/0735	29.70	1006	N 43
1635	29.56	1001	NW 40
2335	29.60	1002	NW 40
08/0735	29.63	1003	W 34
1635	29.61	1003	W 32
2335	29.63	1003	W 31
09/0735	29.58	1002	
1635	29.53	1000	SW 48
2335	29.52	999	
10/0735	29.49	998	W 48
1635	29.44	997	SW 48
2335	29.53	1000	

Remarks: Maximum winds: 59 mph from NW on the 7th.

Punta Rassa, FL

Date/Time	Pressure (in.)	Pressure (mb)	Wind (mph)
07/0735	29.87	1011	NE 18
1635	29.69	1005	NE 29
2335	29.61	1003	N 42
08/0735	29.22	989	NW
1635	29.24	990	NW 40
2335	29.24	990	W 40
09/0735	29.22	989	
1635	29.22	989	
2335	29.22	989	
10/0735	29.20	989	
1635	29.19	988	
2335	29.26	991	

Remarks: Maximum wind: 60 mph from N on 8th; 60 mph from W on 11th.

St. Augustine, FL

Date/Time	Pressure (in.)	Pressure (mb)	Wind (mph)
07/0700	29.80	1009	NE 12
1400	29.67	1005	SE 45
2100	29.66	1004	SE 65
08/0700	29.58	1002	SE 65
1400	29.56	1001	E 75
2100	29.56	1001	SE 75
09/0700	29.54	1000	SE 65
1400	29.46	998	NE 75
2100	29.45	997	NE 75
10/0700	29.11	986	NE 75
2100	29.09	985	SW 4
11/0700	29.31	992	SW 50
1400	29.43	996	SW 50
2100	29.59	1002	SW 12

Jacksonville, FL

Date/Time	Pressure (in.)	Pressure (mb)	Wind (mph)
07/0735	30.02	1016	NE 5
1635	29.98	1015	E 6
2335	29.99	1015	E 6
08/0735	29.92	1013	NE 14
1635	29.86	1011	NE 18
2335	29.85	1010	NE 22
09/0735	29.79	1009	
1635	29.76	1008	
2335	29.77	1008	NE 26
10/0735	29.72	1006	
1635	29.62	1003	
2335	29.58	1002	NE 28
11/0735	29.36	994	
1635	29.23	990	
2335	29.30	992	

Remarks: Maximum wind: 48 mph from the NE on the 11th.

Wind observations (mph) taken at selected stations, September 1878:

Date/Time	0700 (mph)	1400 (mph)	2100 (mph)
Biscayne, FL			
September			
7	NE 22	NE 12	NE 35
8	SE 50	SE 50	S 50
9	S 35	S 35	S 22
10	SE 35	SE 35	SE 35
Daytona, FL			
September 7	E 12	SE 22	E 12
8	E 22	E 50	E 50
9	SE 50	E 65	NE 50
10	SE 22	SE 12	SW 2
11	SE 22	SE 12	SW 2

Remarks: A severe storm of wind and rain commenced on the 8th and continued until the 11th. The wind veered but little from the east; sometimes veering to the NE and SE. A bark and two schooners were wrecked near Mosquito Inlet.