THE HURRICANE SEASON OF 1964

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1. GENERAL SUMMARY

Twelve tropical cyclones, six of hurricane intensity, developed over tropical Atlantic waters during 1964. This is the largest number since 1955 and compares with an average of 10 during the past three decades. The centers of four hurricanes penetrated the mainland of the United States, the largest number to do so since the five in 1933. There have been only four other years with four or more since 1900; four in 1906, 1909, and 1926, and six in 1916. While none of the four reaching the mainland in 1964 was a major hurricane at the time of landfall, three—Cleo, Dora, and Hilda—were severe.

Florida was struck by three hurricanes in addition to dying hurricane Hilda and one tropical cyclone of less than hurricane intensity; thus ended an unequalled relatively hurricane-free period of 13 years from 1951 through 1963. During this period Florida experienced three hurricanes compared with a normal expectancy of 11.7, and only one major hurricane (Donna) compared to a normal of 3+.

The tropical Atlantic atmosphere was unstable throughout the summer and fall with numerous disturbances and depressions. One reached tropical storm intensity early in June and another in late July, but no storm of hurricane intensity was noted until August 21. There was a tropical cyclone on the chart on all but two days from August 20 through October 4. With the exception of Florence all moved or recurved west of longitude 60° W. (fig. 1). The number of *hurricane days* was 46, which in the past 11 years was exceeded by 49 in 1961 and 56 in 1955 (table 1).

August 1964 was considered an active month from a tropical standpoint. According to Posey [1] the 700-mb. mid-latitude winds in the Northern Hemisphere were quite zonal. A negative height anomaly band almost encircled the globe to the south of a large positive anomaly over the Atlantic and was associated with a slight southward displacement of the westerlies. Major long-wave troughs were located very close to the west and east coasts of the United States near their usual positions; however, the east coast trough was weak south of latitude 35° N. and during the period August 25–29, when Cleo was approaching and moving northward over Florida, the long wave had retrograded into the Great Plains. The mean 700-mb. height anomalies for August 1964 do not correspond very well with the composite chart for average departures from normal for seasons of maximum tropical cyclone incidence in the southeastern United States as developed by Ballenzweig [2].

September was an even more active month and correspondence between Ballenzweig's composite chart and the observed values was better, particularly south of latitude 40° N. According to Green [3] the subtropical High was abnormally strong and displaced slightly northward from normal (favorable for tropical cyclone formation) while the 700-mb. jet was slightly south of normal (unfavorable). The long-wave position fluctuated back and forth from the Rockies and Great Plains eastward and the tropical cyclones experienced considerable difficulty in penetrating the westerlies. During the major hurricane months in 1964 the long-wave trough failed to remain along the east coast of the United States for any sustained period, and when there its amplitude was very weak, in strong contrast to the hurricane seasons of 1962 and 1963.

In October at 700 mb. the low-latitude trough was located in the Gulf of Mexico near longitude 90° W. from the 1st to the 5th, and Hilda recurved just east of its axis [4]. By the middle of October a long-wave position along the east coast of the United States had become established which caused the recurvature of Isbell over southern Florida.

Statistics on casualties and damage for the 1964 hurricane season are shown in table 2. It is interesting to note that as much as $500 million hurricane damage can occur in the United States in a single season without any major hurricane.

TABLE 1.—*Hurricane days*

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1954						1		5	8	16		1	31
1955	4							22	28	2			56
1956							1	9	2		3		15
1957						3			19				22
1958								14	16	5			35
1959						1	2		10	11			24
1960							4	2	13				19
1961							4		*35	9	1		49
1962								1		10			11
1963								11	7	23			41
1964								7	33	6			46
Total	4	0	0	0	0	5	11	71	171	82	4	1	449

*If two hurricanes are in existence on one day, this is counted as two hurricane days.

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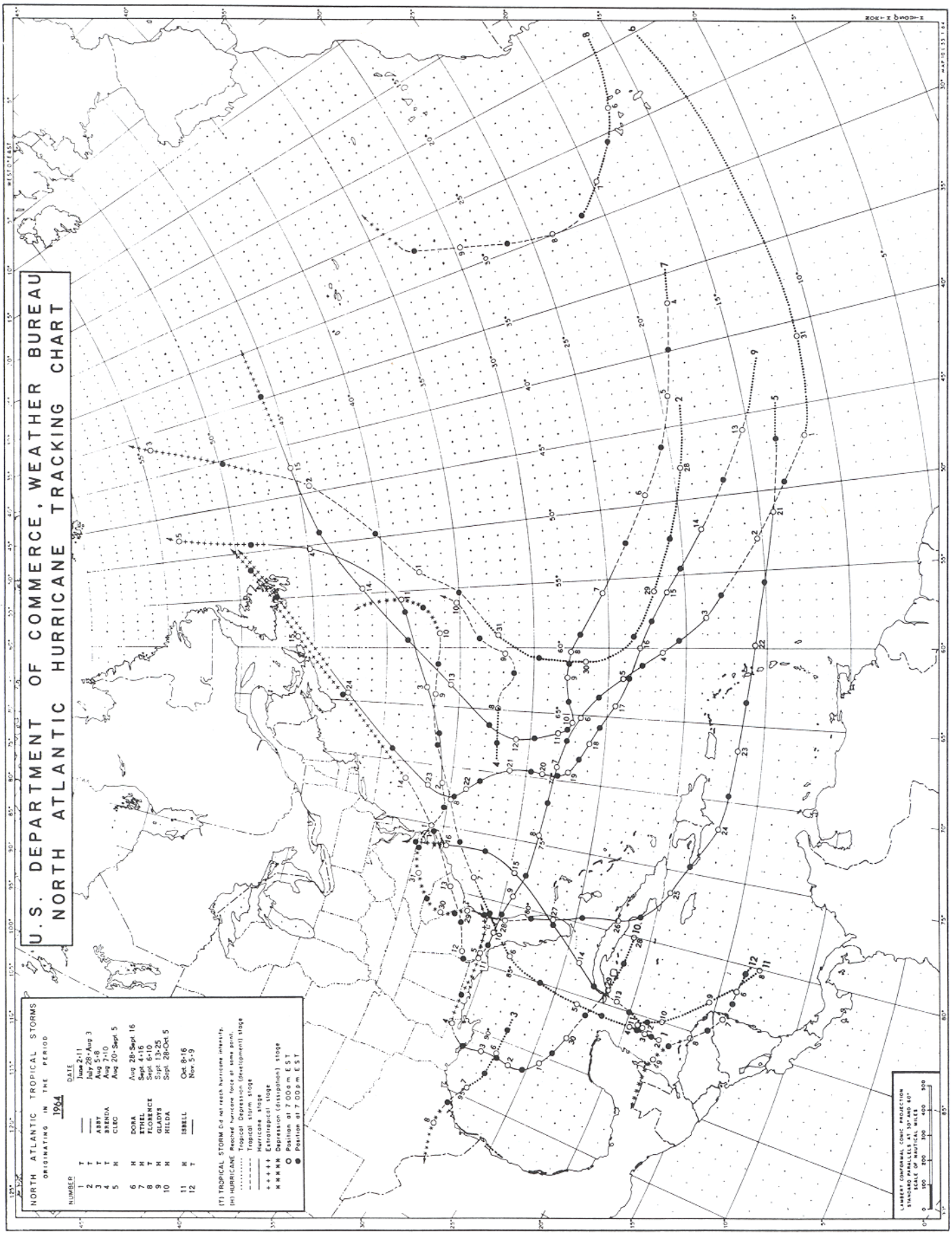

FIGURE 1.—Tracks of hurricanes and tropical storms in the North Atlantic, 1964.

TABLE 2.—*Damage and casualties, hurricane season 1964*

Date	Storm	United States		Other areas	
		Deaths	Damage	Deaths	Damage
June 2–11	Unnamed (T)	0	$1,000,000	0	0
July 28–Aug. 3	Unnamed (T)	0	0	0	0
Aug. 5–8	Abby (T)	0	750,000	0	0
Aug. 7–10	Brenda (T)	0	0	0	$275,000
Aug. 20–Sept. 5	Cleo (H)	3	128,500,000	214	70,000,000
Aug. 28–Sept. 16	Dora(H)	5	250,000,000	0	0
Sept. 4–16	Ethel (H)	0	0	0	Very minor
Sept. 6–10	Florence (T)	0	0	0	0
Sept. 13–25	Gladys (H)	0	0	0	0
Sept. 28–Oct. 5	Hilda (H)	38	125,000,000	0	1,000,000
Oct. 8–16	Isbell (H)	3	10,000,000	3	10,000,000
Nov. 5–9	Unnamed (T)	0	0	0	5,000,000
Total	6(T) 6(H)	49	$515,250,000	217	$86,275,000

T=Tropical storm. H=Hurricane.

2. INDIVIDUAL TROPICAL CYCLONES

Unnamed Tropical Storm, June 2–11.—During June 2 and 3, a weak tropical depression slowly developed over the extreme northwestern Caribbean just to the east of British Honduras and the Yucatan Peninsula. The original disturbance apparently moved out of the Intertropical Convergence Zone (ITC). On the 4th, the depression began drifting slowly northward and reached the extreme southeastern Gulf of Mexico by the 5th. During this period, maximum winds were generally 25 to 30 m.p.h. in scattered squalls.

Moving north-northeastward to northeastward at 15 m.p.h., the depression crossed extreme northern Florida the afternoon of June 6 with no significant intensification, but later developed tropical storm intensity on the morning of the 7th off the Georgia and South Carolina coasts. It then moved on an east-northeastward course at 15 to 20 m.p.h., and continued to intensify slowly.

Reaching a position some 200 mi. north of Bermuda by June 9, the storm changed to an easterly course around 10 m.p.h. under the influence of an intensifying high pressure system to the northeast. Maximum intensity was reached at this time with winds of about 60 m.p.h. reported by ships.

On June 11 the storm turned northward and was soon absorbed by a large extratropical Low over the Canadian Maritimes.

There was local flooding in western Cuba and in a few areas in the Southeastern States. Strong winds and hail associated with thunderstorm activity caused considerable damage in northeastern Florida. Damage in the Jacksonville area was estimated in excess of $300,000, and there was a local windstorm near Cross City.

Unnamed Tropical Storm, July 28–August 3.—During the night of July 27–28, ship reports indicated a perturbation in the central Atlantic near 20° N., 45° W., which was quite likely related to a cloud vortex viewed by TIROS near 14° N., 24° W. on July 25, and a weak surface circulation observed simultaneously in the Cape Verdes. A reconnaissance plane dispatched to the area of suspicion on the 28th reported no westerly winds although maximum surface easterly winds of 50 m.p.h. were observed near 21° N., 50° W. The lowest sea level pressure was 1011 mb.

The next morning reconnaissance found that the pressure had dropped to 1006 mb. with a small wind and pressure eye near 22.15° N., 56.40° W.; maximum surface winds of 50 m.p.h. were observed in the northwest and northeast quadrants. That afternoon a second reconnaissance flight found that no intensification had occurred. The central pressure was 2 mb. higher than in the morning and the wind field remained about the same.

On July 30 the system persisted as it turned toward the north-northwest. A squall area oriented north-northwest to south-southeast was located 60 to 80 mi. east of a weak wind circulation centered at 29.0° N., 61.3° W., at 1400 EST. The lowest pressure was 1012 mb. and the wind near the center was less than 10 kt. However, winds up to 55 to 65 m.p.h. were reported in the squall band. Rapid movement of the center (20 m.p.h. or more) contributed to the maximum winds observed, but the strong basic current also tended to mask and perhaps to inhibit the development of a well-defined vortical wind field.

On the morning of the 31st, the center was located some 300 mi. east of Bermuda moving toward the northeast. There was little organization and central pressure remained at 1012 mb., with winds of 55 to 65 m.p.h. east of the center. During the day as the pressure dropped to 1008 mb., a well-defined radar band appeared northeast of the center and winds in the western portion of the circulation increased to 25 to 30 m.p.h. It is believed that the cyclone met the specifications of a tropical storm beginning about midday on the 31st. Some further intensification and better organization was noted on August 1 with ships reporting winds of 45 m.p.h. or higher; and one, apparently in a squall, reported 80 m.p.h. A cold front was beginning to enter the inner portion of the circulation but the center was still warm. Data were insufficient to describe the storm's subsequent history completely, but it seems likely that it did not become extratropical until late on August 2 near 47° N. Strong gales persisted around the center as it moved southeast of Greenland on the 3d.

Tropical Storm Abby, August 5–8.—Tropical storm Abby developed rapidly about 30 mi. southeast of Freeport, Tex., a little before noon on August 7. Formation occurred in a weak trough which had moved from northern Florida into the northeastern Gulf of Mexico on the 5th. It then drifted slowly westward across the northern Gulf, with no indication of development or intensification until it approached the central Texas coast.

The storm developed under the surveillance of coastal radars at Galveston, Victoria, Lake Charles, and Brownsville, all of which indicated a sudden development of spiral bands and an eye during the late forenoon of August 7. A reconnaissance plane was in the area and reported a center fix at 1115 CST. Abby was an extremely small storm; its complete circulation at the surface was considerably less than 100 mi. in diameter. It moved westward, averaging about 10 m.p.h., and crossed the Texas coast just northeast of Matagorda about 1600 CST. Over land, Abby gradually dissipated as it moved westward and lost its identity during the morning of the 8th southwest of San Antonio.

Reconnaissance aircraft estimated the highest winds about 85 m.p.h. (probably an overestimate), in squalls, and reported a central pressure of 1000 mb. (29.53 in.). The highest sustained wind reported along the coast was 45 m.p.h., with gusts to 65 m.p.h., and the lowest pressure was 1004 mb. (29.66 in.). These were observed by the Corps of Engineers at Matagorda. Highest tides were 2 to 4 ft. m.s.l. from Matagorda to Freeport.

Heavy rains occurred in a narrow belt along the storm track. Some of the heavy amounts reported were: Victoria 6.14, Palacios 3.81, Pettus 5.00, Falls City 5.09, and Pearsall 5.00 in. The rainfall was very beneficial and only minor flooding occurred.

The predominantly agricultural coastal area between Matagorda and Freeport felt the main effects of Abby. Damage was light, and no deaths or injuries were reported.

Tropical Storm Brenda, August 7–10.—Observations from Bermuda first indicated the existence of tropical storm Brenda. During the morning of August 8, the pressure began to fall, dropping from 1018 mb. at 0100 EST to 1008 mb. at 0800 EST. Winds increased briefly to 45 m.p.h., with gusts to 65 m.p.h. as the center passed over the island. No casualties were reported. A small tornado or waterspout spawned by the storm damaged a commercial airliner and several privately-owned aircraft and was apparently responsible for winds of 92 m.p.h. measured atop a 100-ft. NASA tower. Spiral bands were observed on the U.S. Air Force radar at Bermuda after passage of the center.

After passing over Bermuda, the storm drifted slowly east-southeastward before recurving and accelerating northeastward ahead of a cold front on the 9th. The circulation could not be tracked north of 35° N. where reconnaissance aircraft reported it had dissipated on August 10. Brenda was of minimal tropical storm intensity. Highest winds were those associated with small-scale circulations near the center as it passed over Bermuda. Lowest central pressure was 1006 mb. on the 9th.

Post analysis of the storm indicates that it probably began its development in a minor trough of low pressure some 400 mi. west of Bermuda on August 7. An airline crewmember recalled observing a low-level circular cloud formation in the vicinity of 32° N., 69° W. at 1300 EST on August 7, though the pattern did not then appear significantly different from many cloud formations frequently observed.

Prior to the storm's passage over Bermuda, there was no evidence from available sparse ship reports or other data of the development of the storm. Not until August 8 was sufficient information available to substantiate that a tropical storm and not a frontal wave or local disturbance was responsible for the conditions observed at Bermuda.

Hurricane Cleo, August 20–September 5.—The disturbance in which Cleo later formed appears to have moved off the African coast south of Dakar as a 1010-mb. Low accompanied by continuous rain and thundershowers, on August 15. Later, a TIROS VIII photograph at 1044 EST August 18 showed a cloud mass covering the region from 7° to 12° N., 32° to 37° W., centered at 10° N., 34° W. At 1300 EST on the same date, the German ship *Lichtenstein* reported a light east wind, continuous rain, and pressure of 1008.9 mb. (29.79 in.) at 12° N., 33.5° W. From this area the disturbance moved west-northwestward about 16 m.p.h. until located by reconnaissance aircraft on the 20th.

At 0100 EST on the 20th, a ship report (name unknown) indicated the existence of a circulation. A Navy reconnaissance plane that afternoon found a tropical cyclone at 13.2° N., 44.5° W., in a very early stage of development, with minimum pressure of 1006 mb. (29.71 in.) and a few squalls up to 35 m.p.h.

The next day the central pressure had deepened to 993 mb. (29.32 in.) and winds had reached hurricane force. The hurricane steadily intensified during the next several days as it moved west-northwestward at 20 to 25 m.p.h., an unusually rapid motion for low latitudes.

Hurricane Cleo reached Guadeloupe early in the afternoon of August 22. The center crossed the island of Marie Galante at 1137 EST and the southern tip of Basseterre at 1240 EST. At Raizet Airport, about 15 mi. north of the eye, minimum pressure was 1003 mb. (29.62 in.), and the highest wind 44 m.p.h., with gusts to 81.

In the French West Indies, Cleo caused 14 deaths and 40 injuries; destruction of the banana crop and 1,000 homes; and extensive damage to roofs, roads, and communication lines.

The hurricane center passed about 90 mi. south of St. Croix, V.I. at midnight, August 23, and 83 mi. south of Cabo Rojo on the southwestern tip of Puerto Rico at 1300 EST the same day. Highest observed winds were 50 m.p.h. at Ham Bluff, St. Croix, and 52 m.p.h. at Point Tuna, Puerto Rico, although Cleo had intensified with

central pressure of 950 mb. (28.05 in.), and winds had increased to 140 m.p.h. The hurricane remained small and concentrated and destructive winds were confined to a small area near the eye. At flight level the Weather Bureau research aircraft measured 132 kt. (152 m.p.h.) winds. A Navy hurricane hunter plane was badly damaged on this date and seven crewmen injured. It was estimated that as the plane left the eye and entered the wall cloud, the recorded wind increased by 90 m.p.h. within a distance of 1 mi. No penetration was made of this dangerous hurricane on the 24th and its maximum intensity on this date is unknown.

Cleo passed south of the Dominican Republic early on the 24th with its closest approach about 30 mi. south of Isla Beata, just off the Barahona Peninsula at 0600 EST. Seven lives were reported lost in the Dominican Republic. As hurricane Cleo passed south of Haiti on August 24 it veered northward momentarily, enough to move onto the southwestern peninsula. The hurricane entered land just east of the city of Les Cayes, still a very small intense hurricane. It came and went within 90 to 115 min. Aerial surveys indicated that severe damage extended only 3.7 mi. west of the center and 13.7 mi. east of the center. At Les Cayes, several miles west of the center, there was no calm and the lowest pressure was 964 mb. From 1500 to 1535 LST the pressure fell 34 mb. and by 1600 LST had risen 37 mb. The lowest barometer reading at Camp Perrin, which is about 12.5 mi. inland along the center track, was 950 mb.

Within a short time the hurricane reached the slopes of the Massif de la Hotte. During the next few hours the movement of Cleo was obscure. Mr. Michel A. Frère, WMO representative in Haiti, believes it continued northwestward and reached the north coast of the peninsula near Roseaux. Evidence from reconnaissance aircraft would indicate the greatly diffused center turned westward along the southern slopes of the mountain range and eventually passed out into the Caribbean over the western tip of the peninsula. Damage in Haiti was considerable and 192 persons were killed.

The reason for the sharp turn of Cleo toward the southwestern peninsula of Haiti cannot be explained on the basis of available data. A short-wave trough had already passed eastward to the north of the hurricane and it was under rising heights. It may be that previous reconnaissance fixes were in error and that the correct track during the previous 12 to 18 hr. was farther north than reported. However, the south shore of Hispaniola should have been on the radar scope of the plane and the reason for the error, if any, is not obvious.

Cleo never regained its former intensity. However, as a minimal hurricane, it passed over a narrow peninsula of Cuba, east of Cabo Cruz, and thence moved into the Golfo de Guacanayabo. The center remained a short distance off the southern coast of Cuba until it again re-entered the coast near longitude 79° W. Cleo probably was of slightly less than hurricane intensity during the journey across Cuba until emerging from the northern coast east of Caibarien around 0700 EST on the 26th. Winds in Júcaro, Majagua, Tamarindo, and Florencia were estimated about 60 to 70 m.p.h., and in Jatibonico 70 to 75 m.p.h. Damage in Cuba was not serious with apparently only one casualty.

Shortly after emerging from the northern coast of Cuba, Cleo regained hurricane intensity and then moved on a mildly zigzag course north-northwestward to northward toward the lower east coast of Florida. Beginning at 1030 EST, August 26, hurricane Cleo was under constant radar surveillance by the Miami and Key West radars and later by the Tampa and Daytona Beach radars. By midday, the hurricane had intensified with maximum winds of 85 m.p.h. and minimum pressure around 984 mb. (29.06 in.). Throughout the afternoon and evening, instrumented Research Flight Facility aircraft repeatedly crisscrossed through the storm, including the center, and at flight level found no winds of hurricane force in the western semicircle, and the central pressure stable at around 984 mb.

At 0200 EST August 27, the edge of the eye moved onto Key Biscayne. Cleo was the first hurricane to strike the greater Miami area with full force since October 17, 1950; and, indeed, the tracks from Cuba to the greater Miami area of the two hurricanes were very similar. The lowest barometer reading in Florida was 967.5 mb. (28.57 in.) in North Miami. It is estimated that maximum sustained winds were in the 100 to 110 m.p.h. range, with gusts to 135 m.p.h. It is certain that Cleo intensified very rapidly in the 3 hr. between the time when the aircraft left the storm and when the eye reached Key Biscayne and several hours later passed through North Miami. In the western semicircle, winds increased from less than hurricane force to 100 m.p.h. or more and the central pressure fell about 16 mb. (0.5 in.). This may be explained by (a) the fact that the temperature of the shallow water between the western edge of the Gulf Stream and the coast is even higher than that of the warm Gulf Stream, 86° to 90° F. vs. 83° F., and (b) as the portion of the hurricane circulation over land increased, the inflow toward the center also became greater with resultant increased lift and latent heat from condensation.

As the hurricane moved along the lower east coast of Florida, the eye continually expanded and contracted from a minimum diameter of 8 mi. to a maximum of 16 mi. The eye consistently moved north-northwestward for a number of hours and then northward for a number of hours. The longest central calm at any reporting point was 1 hr. 25 min.

The major damage from the hurricane was felt in a relatively narrow strip 20 to 35 mi. wide along the eastern Florida coast from Miami to about Melbourne. Although the geometric center of the eye apparently passed over Virginia Key and reached the west side of Biscayne Bay at about the 36th Street Causeway, damage was minor at nearby Perrine and Homestead and west of Bird Road

TABLE 3.—*Tornadoes in connection with Hurricane Cleo*

Date	Time (EST)	Area	Injuries	Damage
Aug. 27	?	Broward County, Fla.	0	Considerable tree and citrus damage.
Aug. 27	1900	Titusville, Fla.		
Aug. 27	2010	New Smyrna Beach, Fla.		
Aug. 29	0106	James Island, S.C.		$5,000.
Aug. 29	0125	Lawton Bluff, S.C.	3	Minor.
Aug. 29	1440	Laurinburg, N.C.	15	$250,000.
Aug. 29	0440	Betherea, S.C.		
Aug. 29	1600	Lake Murray 14 mi. NW of Columbia, S.C.		$25,000.
Aug. 29	late afternoon	Cassat, S.C.		
Aug. 29	2130	Darlington, S.C.	2	$3,000.
Aug. 29	12 midnight	Timmonsville, S.C.		
Aug. 30	0030	Sansbury Crossroads, S.C.		$5,000.
Aug. 30	0400 (approx.)	Laurinburg, N.C.		
Aug. 31	1600 (approx.)	Bethel, Stokes, Beargrass, N.C.	2	$90,000.

TABLE 4.—*Hurricane Cleo casualty and damage statistics*

Location	Deaths	Injuries	Damage
French West Indies	14	40	$50,000,000
Dominican Republic	7		2,000,000
Haiti	192	350	15,000,000
Cuba	1	?	3,000,000
Florida	0	?	125,000,000
Georgia			50,000
South Carolina		1	100,000
North Carolina	0	17	345,000
Virginia	3	(*)	3,000,000
Total	217	(*)	198,495,000

*Some but number unknown.

and 90th Avenue. Storm intensity north of Melbourne was such that only minor damage resulted. There were only isolated reports of local flooding anywhere in the State. The tide did not reach 4 ft. above normal in the Miami area, but was 5 ft. above normal in Fort Lauderdale, and 5 to 6 ft. above normal at Pompano Beach. There was no serious tidal damage reported anywhere in the State. Even in Dade and Broward Counties, little structural damage to buildings resulted. In these counties the principal damage was glass breakage in unprotected store fronts, beach hotels and motels, and other unprotected glass. Many beach hotels and motels suffered water damage after the windows gave way. Principal damages in Florida, in addition were uprooted trees, disrupted communications and power failures in the southern sections, sand blasted buildings and automobiles, overturned parked aircraft, and agricultural losses. Early estimates indicate about 10 percent of the oranges and 20 to 30 percent of the grapefruit were lost in the Indian River citrus producing area, with the greatest loss in the southern sections. Total citrus damage is estimated at $9 million. Total damage from hurricane Cleo in Florida to property is estimated at $112.5 million. Apparently these figures do not include other direct or indirect losses such as cleanup of debris, which would amount to several million dollars. It is believed that direct and indirect costs would total about $125 million. There was no loss of life or serious injury in Florida and damage to small craft was minimal.

After leaving Florida between St. Augustine and Jacksonville, the center remained at sea a short time and then re-entered the coastline near Savannah without much increase in intensity. Cleo continued as a weakening tropical cyclone through the interior of the Carolinas, passing out to sea again near Norfolk, Va., where it gave record-breaking precipitation. Very heavy rainfall developed from the Hampton Roads area southward over extreme southeastern Virginia during the night of August 31–September 1 as Cleo moved offshore and a cold front approached the region. Rainfall amounts at several points exceeded previous all-time 24-hr. records. The largest reported storm total was 14.09 in. at Back Bay Wildlife Refuge. At Norfolk WBAS, 10.40 in. of rain fell between 1100 EST August 31 and 1100 EST September 1, shattering the previous 24-hr. record of 6.78 in. on June 2–3, 1963. Considerable flooding occurred in the Hampton Roads area with many streets blocked and roads washed out. Hundreds of homes were flooded and several areas were evacuated.

The storm again attained hurricane intensity at sea, but as it passed east of Newfoundland on September 4 it lost its tropical features [1].

Nine or more tornadoes and several probable tornadoes were reported in connection with Cleo in Florida and the Carolinas (table 3). There was evidence of a tornado in the Davie area of Broward County, Fla., with a path ¼ mi. wide and ½ mi. long. In one 100-acre grove, 2,400 of 6,000 trees were uprooted. In this small area tree loss ranged from 5 to 40 percent, grapefruit 85 percent, navel oranges 65 percent, and Valencia and other oranges 35 percent. There were other reports of twisters in Florida but none could be substantiated. Casualties and estimated damages resulting from Cleo are given in table 4. Meteorological data are summarized in table 5.

It has now become well established that lightning is rather common in the hurricane eye wall cloud whenever this is present. During daylight hours lightning is usually not noticed by observers because flashes are cloud-to-cloud rather than cloud-to-ground and thunder is not audible over the high noise level of the wind. In Cleo lightning was noted in the wall cloud by numerous observers. There were some reports of "greenish" and "pink" lightning. Whether these were actual lightning or discharges from high tension lines or transformers is not known. During the lull at the National Hurricane Center, when the edge of the wall cloud was less than 1 mi. away, and perhaps directly overhead several thousand feet aloft, flashes were observed directly above but no thunder was heard, although it was almost normally quiet.

Some observations were made on the morning of August 27 by an experienced meteorologist in the extreme northern part of Dade County (Miami) as follows:

"0116 EST—Occasional dim lightning apparently from edge northern portion wall cloud beginning at this time.

"0147 EST—Phenomenal rain. Most of time rain appeared as great billows of dense black smoke, reducing visibility to 25 ft. or less, using as reference a street light

TABLE 5.—*Hurricane Cleo, meteorological data, Aug. 20–Sept. 5, 1964*

Station	Date	Pressure (in.)		Wind (miles per hour)				Tide above mean sea level (ft.)	Storm rainfall (in.)
		Low	Time (EST)	Fastest mile**	Time (EST)	Gusts	Time (EST)		
FLORIDA	Aug.								
Key West	27	29.72	0258	NE 22	1236 (26)	NE 28	1236 (26)		0.15
Plantation Key						40			
Key Largo						50*			
Key Biscayne	27	28.73	0215					*3.6	
Miami NHC	27	28.74	0306	N 110*	0230*	N 135*	0230*	*3.6	
Miami WBAS	27	28.71	0308			100	0311		6.80
North Miami	27	28.57							
Fort Lauderdale	27							*5.0	
Pompano Beach	27							*5.5	
Hillsboro Inlet Light	27	28.96	0500	NE 68	0235				
West Palm Beach	27	29.14	0842	ESE 86	0840	ESE 104	0840	Unk.	3.99
Jupiter Inlet Light	27	29.43	1030	SW 74	0850				
Fort Myers	27	29.73	0430	WNW 23	1446	WNW 32	1415		T
Sanibel Island						52	0830		
Clewiston						50			
East side Lake Okeechobee						80			
Tampa WBAS	28	29.73	0255	NNE 28	1729 (27)	NW 33	1340	1.3	.05
Lakeland WBO	28	29.66	0100	NE 26	1342 (27)	NE 40			.30
Orlando	28	29.43	0130	N 32	0055	NNE 46	1930 (27)		3.20
Vero Beach	27	29.37		ESE 97	1515				
Ponce de Leon Inlet	28	29.46	0430	NNE 62	2035 (27)				
Jacksonville WBAS	28	29.58	1730	NE 43	0805	ENE 44	0818	3–4	2.71
Daytona Beach WBAS	28	29.43	0430	E 40	0359	E 60		1.0	3.82
GEORGIA									
St. Simons Island	28					NE 39	1400		5.26
Savannah	29	29.61	0356	NE 34	2120 (28)	NE 44	2047 (28)		6.26
Vernon View								2.3	8.63
SOUTH CAROLINA									
Charleston WBAS	29	29.78	0449	SE 42	1635				5.84
Charleston WBO	29			E 57	0109			2.6	4.46
Columbia	29	29.78	1705	NNE 21	0700	NNE 28	0700		4.51
VIRGINIA	Sept.								
Norfolk	1	29.66	0340			E 40	0035	1	11.40
Norfolk Navy									13.32
NAS Oceana	1					ESE 42	0002		13.70
Langley AFB									6.59

*Estimated. **Or 1 Minute.

close by my house. During this period wind had a constant 'freight-train-like' roar amplification as extreme gusts approached. These extreme gusts occasionally sounded like the mid-range of a pipe organ. These conditions continued until about 0330.

"0250 EST—St. Elmo's fire was apparently observed and thunder heard. Some evidence of ball lightning seen. Looking south-southeastward from my house the sequence of events would be: St. Elmo's fire, then ball of light, then discharge, then thunder. This was observed about four times. In addition, frequent lightning was observed. Occasional thunder was heard—at least 10 peals.

"0332 EST—Entering north edge of eye. Between 0332 and 0334 air temperature increased 3° to 4° F., and wet-bulb temperature increased 1.5° F. (76.0° to 77.5°).

"0354 EST—Flat calm to light airs. Frequent lightning in wall cloud north-northwest through southeast. Four peals of thunder were heard from lightning associated with one cell in wall to east-northeast of my house.

"0445 EST—Wind southwest fresh to strong—from radar picture, the location of my house (plus or minus a couple of blocks) was in geometric center of eye. (The wind at the time would indicate the wind center was slightly northeast of radar center.)

"0550 EST—Large and small trees were observed to extend out nearly parallel to the ground in estimated 140 m.p.h. gusts."

Hurricane Dora, August 28–September 16.—Hurricane Dora was the first hurricane of record to move inland from the east over extreme northeastern Florida. The eye passed over St. Augustine, and Jacksonville recorded sustained winds of hurricane force (82 m.p.h.) for the first time in nearly 80 years of record.

A large envelope of low pressure moved through the Cape Verde area on August 28. On the 31st a TIROS picture located a cloud mass near 11° N., 41° W. The following day reconnaissance aircraft located a tropical storm with a central pressure of 998 mb. The storm was enclosed in an envelope of low pressure approximately the same size as that which had moved through the Verdes. The 1008-mb. isobar was about 300 mi. in diameter in both locations.

Dora moved west-northwestward and reached hurricane force on the 2d. It continued to intensify while gradually expanding. When over 300 mi. south of Bermuda, it turned on a course only slightly north of due west. It had missed the trough associated with the redeveloped hurricane Cleo. At this time Dora was a large severe hurricane with a central pressure of 942 mb. (27.82 in.). During this intensification there was low-level inflow. Following its turn, the inflow stopped and a gradual decrease in intensity occurred for about 24 hr., central pressure rising about 22 mb.

Hurricane Dora slowed considerably before reaching

TABLE 6.—*Hurricane Dora, meteorological data, Aug. 28–Sept. 16, 1964*

Station	Date Sept.	Pressure (in.)		Wind (miles per hour)				Tide above mean sea level (ft.)	Storm rainfall (in.)
		Low	Time (EST)	Fastest mile **	Time (EST)	Gusts	Time (EST)		
FLORIDA									
Apalachicola	11	29.44	0140	NW 39	1416 (10)			2 MLW [c]	4.95
Daytona Beach	9	29.04	2015	W 46	1424	W 71	1715	7.0	9.32
Fernandina Beach	10	29.28	0145	100 [b]	2200 (9)			10.0	
Gainesville	10	29.08	0700						10.74
Jacksonville Beach	9					84 [a]			
Jacksonville WBAS	10	29.05	0314	N 82	1948 (9)	NE 85*		7.0*	8.67
Jacksonville, Navy	10	28.87	0255	N 53	1832 (9)	N 81			
Jacksonville, Cecil Field	10	28.91	0455	NE 44	0555	NNW 71			
Lakeland	10	29.56	0300	W 27	1039	W 42*			1.50
Marineland	10	28.80	0000	NW 60 [a]	1700 (9)				5.85
Mayport	10	29.03	0130	NNE 74		NNE 101			
Orlando	9	29.41	1937	WSW 40	1955				5.99
St. Augustine	10	28.52	0100	SW 125*	0130				7.10
Anastasia Island	10							12 [d]	
Tallahassee	11	29.29	0230	N 35	1335 (10)	N 44	2030 (10)		6.11
Tampa	10	29.57	0358	WSW 44	2120 (12)	WSW 52 (12)			2.39
GEORGIA									
Brunswick	10	29.40	0030			NE 90*			6.23
Brunswick	12	29.47	1700			SSW 50*		13–14 MLW [c]	
Homerville	13								8.10
Jesup	9					E 50*	2000–0000		5.81
Savannah Airport	10	29.66	0014	E 37	0327	NE 53	2345 (9)	2.4 (9)	3.81
Savannah Airport	13	29.51	0335			S 59	0748		
Savannah Beach	9	29.60	1600			NNE 64	1720		
SOUTH CAROLINA									
Charleston WBAS	13	29.51	0542	SE 46	1704 (12)				2.53
Charleston WBO	12–13			S 47	2018 (12)			2.6 (9)	1.35
Georgetown	13	29.52	0700	SSW 45	1430	55	1445		2.85
McClellansville	13	29.54	0800			SW 55	2100 (12)		3.00
NORTH CAROLINA									
Hatteras	13	29.50	1852	NNE 35	0018 (14)	NNE 41	0012–14	2.5	2.52
Raleigh	13	29.75	0827	WNW 25	0858				2.75
Wilmington	13	29.54	1230	N 28	1653	N 35	1356	3.0	3.41
VIRGINIA									
Cape Henry	13			NE 66	1231			3.5	2.63
Norfolk, Navy	13					NE 69	1545		
Norfolk WBAS	13	29.74	1510			NE 61	1617		4.80
MASSACHUSETTS									
Nantucket	14	29.62		NE 42	1133	N 50	1420	1.3	2.53

*Estimated.
**Or one minute.
[a] Anemometer failed.
[b] 115 m.p.h. beach.
[c] Mean low water.
[d] Datum plane unknown.

land, and consequently the winds and tides increased slowly. This was fortunate, for many residents who had felt that this section of the coast was immune to hurricanes and might have remained if the hurricane had moved at an average forward speed, were persuaded to evacuate the area.

Winds exceeded hurricane force along the coast from extreme southeastern Georgia southward to Flagler County, Fla. Highest sustained winds, estimated at 125 m.p.h. from the southwest, occurred at St. Augustine, immediately following the passage of the center. The lowest pressure on land also occurred at St. Augustine, 966 mb. (28.52 in.), at 0100 EST on the 10th. The station was in the eye from 0015 to 0130. Sustained winds near 100 m.p.h. were reported along the coastline north of St. Augustine.

The strong, long-duration, onshore winds produced unusually high tides, from 5 to 8 ft. or more above normal, along the entire coast from the Daytona Beach area northward into Georgia. Tides estimated at 12 ft.[2] (4 ft. higher than any previously known) swept across Anastasia Island off St. Augustine, and the water level reached 10 ft. above normal at Mayport. The storm surge caused extensive beach erosion, inundated many coastal communities, washed out beach roads, and swept several residences into the sea. Along the Gulf Coast between St. Marks and Tampa, tides ran from 2 to locally 6 ft. above normal (at Yankeetown) as gale force southwesterly winds were sustained from the 10th through most of the 12th. Flooding was increased by runoff from heavy rains on September 11 and 12.

Winds gradually diminished as Dora moved inland on its unusual westward course, but very heavy rainfall spread over interior sections of northern Florida and southeastern Georgia. This rainfall continued in many areas during both the westward and eastward passages of the storm center. Storm totals in excess of 10 in. fell over an estimated 10,000-sq.-mi. area, and totals more than 6 in. were general from near Brunswick and Waycross, Ga. to near Tallahassee and Orlando, Fla. The most intense rains fell in Lafayette and Suwannee Counties, Fla. on the 12th. Mayo recorded 23.73 in. (10th–13th), with 14.62 in. during the 24-hr. period ending at 1800 on the 12th; Live Oak had 18.62 in. during the 4-day storm period. (See table 6.)

Wind damage was extensive in coastal areas north of Daytona Beach with the greatest destruction from St. Augustine to the Georgia border. High winds in Duval

[2] Datum plane unknown.

County, including Jacksonville metropolitan area, caused massive utility failures. Structural damage to buildings was limited to the coastal areas and to older frame buildings a short distance inland. Numerous trees were uprooted throughout the coastal counties, adding to damage as they fell on buildings or across utility lines. Extensive wind-induced river flooding occurred in Jacksonville along the banks of the St. Johns River.

In addition to flooding along lakes and streams, many poorly-drained areas were completely inundated in northern Florida. Damage to roads and bridges was extensive and several communities were isolated for several days by high waters.

Considerable agricultural damage was sustained by flooding of unharvested corn, cotton, and peanuts in both Florida and Georgia. Damage was severe in many low-lying fields. Final storm damage estimates are $200 million to $230 million for Florida; $9 million has been reported for Georgia.

Only one direct storm fatality—a drowning at Live Oak, Fla.—has been reported. Two Navy personnel died near Sanford, Fla., on September 9 when an aircraft being evacuated crashed on takeoff. Two men succumbed while securing boats—one near Brunswick, Ga., and another near Norfolk, Va.

Damage resulting from Dora in South Carolina was minor but rains in the eastern part of the State ranged from 3 to over 8 in. Several waterspouts were reported between 1300 and 1400 EST September 12 near Garden City Beach.

The only significant structural damage in North Carolina was caused by local storms—a waterspout at Carolina Beach, south of Wilmington, at 0725 EST September 10, and a tornado at Howell's Point, southwest of Wilmington, about 2100 EST September 12. Heavy rainfall and tides of 2 to 3 ft. above normal were reported along the coastal sections.

Dora's effects in Virginia were confined to heavy rainfall over the southeastern section, tides up to about 3.5 ft. above normal, and downed tree limbs and awnings.

In Maryland, Delaware, and New Jersey tides reached only 1.5 to locally 4 ft. above normal and rainfall totaled 1.00 to 2.50 in. No reports of injury or damage have been received. Only the fringes of Dora were experienced in southeastern Massachusetts. The principal effect was timely, badly-needed rainfall. Amounts were near 1.00 in. on Cape Cod and 2.50 in. at Nantucket. No significant damage was reported.

Hurricane Ethel, September 4–16.—The first evidence of the incipient stage of Ethel was a cloud mass observed by TIROS near 18° N., 37° W. on September 4. A reconnaissance aircraft dispatched to the suspicious area on the 5th found evidence of storm development but was unable to completely reconnoiter the area because of the extreme range from the operating base. A poorly-defined eye was located near 20° N., 45° W., with a central pressure of 1005 mb. Maximum observed winds were 25 m.p.h. south of the center but sea return and other radar echoes indicated much higher winds to the north.

Ethel moved on a course toward the west-northwest with little development during the next two days. Sparse data in the area indicate that the storm was passing beneath a cold upper-tropospheric trough during this period, a situation unfavorable for intensification.

During this period hurricane Dora was located approximately 575 mi. to the west and Ethel was moving faster than Dora; therefore forecasters considered it possible that Ethel might be absorbed in the circulation of the much larger and more intense Dora, and lose its identity. However, on September 7, a period of intensification began, establishing Ethel as a hurricane and eliminating the probability of absorption by Dora. The deepening persisted through the 10th when a central pressure of 977 mb. and maximum observed winds of 100 m.p.h. were reported by reconnaissance aircraft. The hurricane moved very slowly westward on the 10th, then turned northward, and began to accelerate, with the center passing 100 mi. west of Bermuda on the afternoon of September 12. Gusts of about 70 m.p.h. were reported in the islands during the afternoon and evening and gales continued during the night.

Ethel moved rapidly northeastward after passing Bermuda and maintained hurricane force during the conversion to an extratropical cyclone near 45° N., 40° W., on September 15.

Tropical Storm Florence, September 6–10.—Weather conditions reported in the Cape Verdes and by nearby ships indicated that a strong perturbation on the ITC was moving westward off French West Africa on the 4th and 5th of September. On the morning of the 6th there was a low pressure area, estimated at 1002 mb. (29.59 in.), just north of the Cape Verdes. Although data were sparse, there was some evidence of cold air aloft over the surface Low. It appeared to be a very wet system but with highest winds probably no more than 25 m.p.h. at this time. The Low was moving northwestward at about 10 m.p.h.

Some intensification occurred later although indications are that highest winds were never greater than about 50 m.p.h. Florence headed in a northerly direction toward the Azores but weakened on the night of September 9–10. An Air Force tanker found only an area of squalls south of the islands during the early morning hours of September 10.

Hurricane Gladys, September 13–24.—A weak low pressure system that was first observed off the west coast of Africa on September 9 may have been the first indication of the disturbance that later developed into hurricane Gladys.

On the morning of September 13, a report of 63 m.p.h. winds and heavy rain was received from the SS *Gerwi*, confirming the existence of a tropical storm near 15.5° N., 46° W. A reconnaissance aircraft reached the area during the afternoon but was unable to measure maxi-

mum winds because of darkness. Early on September 14 reconnaissance aircraft found Gladys had intensified to hurricane force and was moving on a west-northwestward course at about 18 m.p.h. Gladys continued to intensify and follow the same course, reaching maximum intensity of 945 mb., with 140 m.p.h. winds, on September 17.

On September 19 Gladys turned northward in response to a weak trough in the westerlies. A slow northward drift continued for almost 48 hr., until rising pressures to the north turned the hurricane's track back to the northwest. This course continued until the 23d when Gladys reached its closest point to the United States, some 140 mi. east of Cape Hatteras. Slow filling persisted through this period and the highest winds decreased to 85 m.p.h.

As a low pressure system deepened in the Great Lakes area Gladys turned northeastward during September 23. The storm moved rapidly on this course gradually assuming extratropical characteristics. During the afternoon of September 24, remnants of the storm passed through Newfoundland with no unusually strong winds.

Damage from Gladys was mainly confined to the outer banks of North Carolina where high tides and wave action produced considerable erosion.

Hurricane Hilda, September 28–October 5.—Hilda developed in an easterly wave which was moving slowly westward through the western Caribbean Sea. On the morning of September 28, a weak cyclonic circulation formed just off the southern coast of central Cuba. The circulation became organized and gradually intensified as it moved slowly westward. It reached storm intensity as it crossed the western tip of Cuba near Cape San Antonio.

Hilda moved west-northwestward at an average speed of 9 m.p.h. for 48 hr., and intensified steadily while in the southern Gulf of Mexico. The storm reached hurricane force early on September 30 and reached maximum intensity about 350 mi. south of New Orleans on October 1. The minimum computed sea level pressure from reconnaissance aircraft at that time was 941 mb. (27.79 in.), and winds were estimated at 150 m.p.h. A severe hurricane by this time, Hilda turned gradually northward on October 1. It moved northward at an average speed of 6 m.p.h. for the next two days and crossed the central Louisiana coast about dark on October 3. Some decrease in intensity had occurred on October 2 but Hilda was still a severe hurricane when it reached the coast.

As pre-hurricane squall lines moved into southeastern Louisiana during the morning of the 3d, several tornadoes occurred. In one at Larose, La., 22 persons were killed and 200 injured. Three tornadoes in the New Orleans metropolitan area caused much damage but no deaths.

After the eye moved inland the storm gradually weakened and moved north-northeastward toward Baton Rouge. When the center approached the Baton Rouge area, the storm was forced eastward as cold air and associated strong pressure rises moved into the circulation from the northwest. Soon after the eastward turn, the winds decreased to less than hurricane force. Hilda continued to weaken as cold air moved rapidly into its circulation, and the storm became extratropical over extreme southern Mississippi. The Low continued eastward and moved into the Atlantic Ocean near Jacksonville, Fla. The rapid

TABLE 7.—*Hurricane Hilda, meteorological data, Sept. 28–Oct. 5, 1964*

Station	Date	Pressure (in.)		Wind (miles per hour)				Tide above MSL (ft.)	Time	Storm rainfall (in.)	Remarks
		Low	Time (CST)	Fastest mile**	Time (CST)	Gusts	Time (CST)				
LOUISIANA	Oct.										
Baton Rouge	4	28.97	0200	NE 46	2358 (3)	69	0624			8.88	
Bogalosa	4	29.25	1030	NW 60*	1330					3.67	
Buras	3	29.60	0745	S 75	1040	80	1040			2.11	
Clinton	4	29.18	0425	62+						10.65	Anemometer blown down.
Franklin	3	28.40	1810	NNE 135*	1800						
Jeanerette	3			N 75+*	1900					17.71	
Jennings	3	29.34	2135	NE 67	2130					2.78	
Lafayette FAA	3	29.10	1958	N 69	1858	92	1836			8.04	
Melville	4	28.98	1530	NE 95*	1600					7.82	
New Orleans WBAS	4	29.29	0330	S 40	0156	54	1331			3.26	
New Orleans WBO	4	29.34	0400	W 52	1400	71	0100			3.58	
Oaknolia	4			N 60*	0900	80*	0900			8.98	
Plaquemine	4	28.96	0215	75–80*	0300						
Reserve	4	29.12	0330	E 58	0200	70				4.42	
Thibodaux	3	29.18		NE 100	2200					7.50	
TEXAS											
Port Arthur C. of E	3	29.57	1500	N 29	1400			2.2	0600		
Port Arthur WBAS	3	29.64	1525	N 37	1203					T	
Sabine, C.G	3	29.54	1500	N 35				2.6	0900		
ALABAMA											
Mobile	4	29.41	1630	S 30	0809	S 46	0809	5.2	1500	1.65	Tides above normal.
FLORIDA											
Apalachicola WBO	5	29.54	0345 a	NE 36	0720 a	NE 50	0843 a			7.90	
Pensacola WBAS	4	29.50	2050	NW 44	2146	54	2146	3.1	1200	5.03	
Tallahassee WBAS	5	29.56	0500 a	SSW 27	0858 a (4)					3.87	

*Estimated.
**Or one minute.
a Eastern Standard Time.

advance of cold air into the storm was manifested by abrupt wind shifts to the north and increased speeds. This sharp increase in northerly winds across Lake Pontchartrain caused large waves to break and spill over the seawall along the New Orleans lake front. Flooding occurred between the seawall and the back levee. The high waves on the lake caused considerable damage to fishing camps and some business establishments which were built out over the water and on the lake shore. To the east of New Orleans, the strongest winds in most areas occurred after the cold front had passed rather than in the southerly flow ahead of the Low.

Data are scarce from the hard-hit areas of south-central Louisiana. The highest wind reported was an estimated 135 m.p.h. at Franklin, La. The lowest pressure at Franklin was 962 mb. (28.40 in.) as the eye of the storm passed over. About 100 mi. south of Morgan City, winds of 120 m.p.h. were recorded on the "Oil Driller" at 2300 CST October 2. This was the peak that the instrument could record. During the night "substantially higher winds" were apparent. The eye of the hurricane passed during the morning of October 3, when the winds dropped to 30 m.p.h., but after the eye moved toward shore the winds again exceeded 120 m.p.h. Huge waves, 50 ft. or higher, lashed the rig for hours. The highest tide reported was an unofficial estimate of 10 ft.[3] near Point-au-Fer. Tides were 2 to 6 ft. above m.s.l. from the mouth of the Mississippi River eastward to Apalachicola, Fla., and 2 to 5 ft. above m.s.l. on the extreme western Louisiana and upper Texas coasts.

Rainfall was excessive over most of southeastern Louisiana and southern Mississippi. Amounts in excess of 10 in. occurred over much of that area and considerable flooding resulted. The greatest rainfall accumulation in Louisiana was 17.71 in. at Jeanerette Experiment Farm, with 16.01 in. in the 25½ hr. ending at 0900 CST October 4. In Mississippi the largest storm total reported was 12.57 in. at McComb FAA. On the 4th, 10.98 in. fell there, an all-time Mississippi October 24-hr. rainfall. (See table 7.)

In Louisiana 37 lives were lost, primarily in tornadoes. Excluding the tornadoes, the hurricane death toll was less than 10 persons. Most of the non-tornado deaths occurred at Erath, La., when a large water tower fell on the City Hall where Civil Defense activities were being directed. Almost complete evacuation of the entire Louisiana coastal area accounts for this low death toll. Civil Defense records indicate that more than 150,000 persons evacuated the low-lying coastal areas and moved to higher ground.

Damages to property, crops, and industries were extremely heavy. A preliminary estimate of damage is about $100 million, with the greater part of the monetary loss borne by the oil companies and sugar cane producers.

Hilda had little direct effect on North Carolina. However, the extremely heavy rains and severe local storms which occurred in a 24- to 36-hr. period centered around October 4 may be attributed, at least in part, to Hilda, which moved into the mainstream of upper-level winds which had been flowing from the Gulf of Mexico up over the Atlantic Seaboard States for several days. The situation was brought to a climax when a cold front approaching the Appalachians from the northwest was drawn into the circulation of the dying tropical cyclone.

Rains of 5 to 15 in. fell in the southern mountains of North Carolina in 24 to 30 hr., very nearly duplicating rains that had fallen there 5 days before. Flooding on rivers and streams of the area was among the most severe in history and damage was heavy. Rainfall was also heavy in eastern North Carolina, where an estimated 4,000 persons had to leave their homes because of floodwaters. There was one death in the State from the storm.

Tornado activity occurred in two areas in eastern North Carolina between 1600 and 2000 EST October 4. One path ran from near Williamston, Martin County, about 1600 EST, to Cherry, and ended near Sandy Point, Tyrrell County. The second began near Fair Bluff, Columbus County at 1815 EST, continued to near Clarkton, and ended near Penderlea, Pender County. The tracks were not continuous, damage indicating a skipping tornado or tornadoes.

Hurricane Isbell, October 8–16.—Evidence of a new tropical disturbance appeared over the western Caribbean just south of an old diffuse frontal trough on October 7. However, it remained quite weak and poorly organized for several days and the first bulletin was not issued until October 10. It was named tropical storm Isbell at 2300 EST October 12.

From its inception on the 7th, the disturbance was underneath a basically divergent pattern at 200 mb., a situation which continued until after it crossed Florida. During the storm's early stages over the Caribbean, the upper anticyclone was almost directly above the surface disturbance; but, when it became a hurricane, and afterwards, it moved underneath a southwesterly 200-mb. flow pattern with the upper anticyclone continuing to the south. However, it was still under an area of marked speed divergence aloft.

In the middle troposphere, there was evidence of relatively warm air in the Swan Island, Caymans, San Andres area as early as the evening of October 7. There was a closed −5° C. isotherm over the western Caribbean at 500 mb. from this time until late on the 12th when Isbell reached tropical storm intensity.

The generally favorable development conditions during the entire formative period of Isbell were high-level divergence, relatively warm middle-tropospheric temperatures, adequately high sea-surface temperatures, and the presence of a surface disturbance.

Why was Isbell's development so slow? It remained a weak tropical depression over the western Caribbean for four to five days before any relatively significant intensification began. October disturbances in the western Caribbean are typically slow in development. In addition

[3] Datum plane unknown.

TABLE 8.—*Hurricane Isbell, meteorological data, Oct. 8–16, 1964*

Station	Date	Pressure (in.)		Wind (miles per hour)				Tides above mean sea level (ft.)	Storm rainfall (in.)
		Low	Time (EST)	Fastest mile**	Time (EST)	Gusts	Time (EST)		
FLORIDA	Oct.								
Dry Tortugas	14	28.67	0955	E 60	1011				
Key West	14	29.49	1145	S 73	1139	SW 76	1152	4 to 5	1.43
Everglades	14	28.75	1620	90					
Naples	14	29.35	1630			NNE 50	1620		0.40
Miami WBAS	14	29.54		37	1713	59	1711		1.69
Miami WBO	14	29.54	1805	46		63			2.26
Fort Lauderdale Airport	14	29.45	1928	52	2001	81	2001		
Fort Myers	14	29.54		NE 24		36	1701		T
Belle Glade	14	29.07	1935	N 65	1930	80*	1930		4.25
Everglades Experiment Station [a] [b]	14	28.98	1930	67	1925				5.09
Port Mayaca	14	29.35		NE 55		70			1.55
South Bay	14								4.93
Indiantown	14			90					
Pompano Beach	14	29.41	1955	48		80			1.55
Lantana Heights	14	29.26		47		72			
West Palm Beach	14	29.05	2051	SSE 74	2020	87			2.38
Juno Beach	14	28.87	2128						
Eleven tornadoes along and near coast from Coral Gables to Eau Gallie 1530 to 2200.									
SOUTH CAROLINA	Oct.								
Charleston WBAS	15	29.48		NE 23	0957	N 36	1902		1.63
Charleston WBO	15			NE 32	0815			2.1	2.06
Columbia	15	29.49		NE 15	1240	NE 28	1240		6.11
Florence	15	29.44		NNE 23	1558	NNE 38	1558		2.98
NORTH CAROLINA									
Wilmington	16	29.42	1238	SW 24	1307	SW 29	1256	0.76	2.5
Pamlico Sound	16								3.0
Hatteras	16	29.43		E 36	0558	E 51	0554	1.52	1.0
Elizabeth City	16	29.44	1400	NE 45	1000	NE 75	1000	2.16	no info.
Raleigh	16	29.30	1349	NE 23	1115			0.60	
VIRGINIA									
Norfolk	16	29.45	1430	NE 50	1119	E 62	1130	0.62	2.5
MARYLAND									
Baltimore	17	29.59	1200	NE 17	0650			[c] 5.4	
CUBA									
Guane	13	28.91		85	1730				
Havana Airport	14			70					

*Estimated.
**Or one minute.
[a] 2½ miles ESE of Belle Glade.
[b] 5-min. average.
[c] Mean low water (Ocean City).

to climatology, a partial answer may lie in the surface and low-level wind and pressure pattern. Eastward from the old frontal trough previously mentioned, winds were light and there was little evidence of any significant inflow into the depression area during the first three to four days of its existence. On several days a few north to northwest winds were reported to the south and southeast of the depression. It was not until the 10th or the 11th that a gradual pattern of low-level inflow became apparent and slow intensification began. It would appear Isbell was a case in which the development process was apparently delayed and slowed by the absence of significant low-level inflow in spite of other favorable parameters.

Isbell reached hurricane intensity as it neared the extreme western portion of Cuba on October 13. The area around Guane was most affected, resulting in heavy damage and three fatalities. The hurricane then moved on a generally northeastward course across southern Florida to near 31° N. before recurving northward and moving inland over coastal North Carolina and weakening.

In Cuba wind gusts of 70 m.p.h. occurred as far east as Boyeros Airport near Havana with pressure of 979 mb. (28.91 in.) reported in the hurricane area farther west. The center of hurricane Isbell entered Florida near Everglades City around 1600 EST October 14 where a calm was experienced from 1615 to 1640 EST. It crossed the peninsula and exited in the Jupiter-Juno Beach area around 2130 EST. This represented a northeastward movement of around 20 m.p.h. The center passed some 47 mi. to the northwest of Miami where peak gusts were 63 m.p.h. and the lowest pressure was 1000 mb. (29.54 in.). Highest winds around the eye were 90 m.p.h. along both Florida coasts.

Isbell, no longer of hurricane intensity when it entered the North Carolina coast near Morehead City, rapidly became extratropical as it continued northward toward Norfolk. Highest wind reported in this area was a gust of 75 m.p.h. at Elizabeth City, N.C., while the peak gust in the Norfolk area was 72 m.p.h.

Lowest pressure reported during the history of Isbell was 964 mb. (28.47 in.) when the center was southwest of Key West.

Radar indicated marked asymmetry in the precipitation pattern around Isbell as it approached the southwestern Florida coast. This proved to be the case; no rain of consequence occurred at Everglades City after the center passed. Winds were considerably less in the rear portion than in the forward portion of the storm which in turn accounted for the small storm surge. A surface low-pressure area appeared in the Gulf of Mexico some 300

mi. to the northwest of hurricane Isbell as it approached Florida. This Low apparently resulted from an intense cold 500-mb. Low that was moving slowly eastward over the lower Mississippi Valley. This, in turn, apparently brought cooler and drier air into the outer circulation of Isbell and resulted in the asymmetry of the cloud and precipitation pattern. This asymmetry is not uncommon in late-season hurricanes.

The northerly turn by Isbell toward the North Carolina coast at about latitude 30° N. was caused by circulation around the cold upper Low which continued to move eastward. At least eleven tornadoes occurred in eastern Florida coastal counties from Coral Gables to Eau Gallie, with reports of as many as 50 persons injured, apparently none seriously. Still another tornado may have struck between Carnestown and Ochopee in Collier County. Fatalities related to Isbell total three. Two persons died when a 42-ft. shrimp boat was destroyed off the lower Florida Keys, and one person in the Palm Beach area died of a heart attack while putting up storm shutters.

Rainfall in southern Florida was variable, up to 5 in. or more, with heavy rains reported over much of South Carolina and eastern North Carolina. (See table 8.)

Damage associated with Isbell was, in general, light. In Cuba there was considerable damage to tobacco crops and communications lines. In the lower Florida Keys property damages totaled about $175,000, most of which was to telephone company equipment. In Palm Beach County, Fla. damage estimates (exclusive of agricultural damage) totaled about $700,000 about half of which resulted from tornado activity. Vegetable crops in the Everglades and Pompano areas of Florida suffered heavy damage with agricultural damage in the State exceeding $5 million. In the Carolinas and tidewater Virginia, only minor property damage was reported, caused mainly by flooding of very low areas. Considerable flooding of inland streams occurred mainly in South Carolina and eastern North Carolina. There was considerable agricultural loss in this area with reports received of extensive damage to unharvested peanuts, particularly in northeastern North Carolina.

Climatologically, Isbell was in its origin and path a typical mid-October hurricane. It formed quite slowly near an old frontal trough in the western Caribbean and then crossed Florida on a general northeasterly course before becoming extratropical near latitude 35° N.

Unnamed Tropical Cyclone, November 5–9.—There was evidence of a perturbation on the ITC in northern Colombia and Venezuela as early as November 1, and heavy rains continued intermittently in the Caribbean north of Panama for the next four to five days as the disturbance drifted west-northwestward. A weak cyclonic circulation was evident on the 4th east of San Andres Island, with pressure about 2 mb. below normal. By 1900 EST November 5 the depression had moved to a position northeast of San Andres where the pressure was now 1004 mb. A plane was sent to investigate the area on the 6th and found a minimum pressure of 1001 mb. but maximum winds of only 35 m.p.h. It is believed that there must have been scattered stronger squalls. That night several ships reported winds in the 40 to 45 m.p.h. range.

The tropical storm moved inland over extreme northeastern Nicaragua and extreme northern Honduras during the night of the 6th. A reconnaissance plane found a central pressure of 997 mb. over land the next day. The storm decreased somewhat in intensity over land, and, while it moved out to sea briefly over the Gulf of Honduras, it was not over water long enough to reintensify significantly.

The meteorological service of Honduras reported on the storm as follows:

"According to reports from the people of Caukira, water flooded the entire town and five small houses were destroyed. Tides were as high as 18 feet. In the town of Rus-Rus a bridge was destroyed.

"The entire zone around Caratasca Lagoon was evacuated in order to avoid casualties.

"According to several seamen from Brus Laguna, the winds were up to 90 m.p.h. in their area.

"In Puerto Castilla the rainfall was so great that the river flooded and destroyed the bridge. In the Bay Islands and neighboring cays there was also considerable damage due to strong winds and heavy rainfall."

Press reports indicate heavy damage from wind, rain, and subsequent flooding in northeastern Nicaragua. Crops, particularly bananas, were destroyed.

It is not believed that sustained winds of hurricane force occurred in this storm. Maximum speeds were probably around 60 m.p.h. in squalls. At 200 mb., there was excellent outflow from the storm area; and, it was, no doubt, beginning to intensify fairly rapidly in the few hours before landfall on the Nicaraguan coast.

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Weather Note

RAPID INTENSIFICATION OF HURRICANE CLEO, AUGUST 1964

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Hurricane Cleo, moving northward, crossed Cuba and was over the water south of Miami on August 26, 1964 [1]. Reconnaissance aircraft were in or near the eye of the hurricane almost continuously on that date. The intensity, as indicated by their central pressure reports, remained constant at 984 mb. for 6 hr. during the afternoon and evening. As the center approached the Miami area, rapid intensification occurred. The lowest pressure in North Miami was 971 mb. This intensification caused the maximum winds to increase from 85 m.p.h. to around 105 m.p.h., or roughly an increase of 50 percent in wind force.

Figures 1 and 2 show the radar presentation at 3:00 p.m. and 11:15 p.m. EST August 26, 1964. Mr. Gordon E. Dunn, Chief Tropical Meteorologist, Homer Hiser and Harry Senn of the University of Miami's Radar Laboratory, and the Weather Bureau radar experts of Miami were asked which spiral overlay [2], the 10° or 20°, better fitted each picture. This was done without the person's knowing the reason for the question. All agreed that the 10° overlay fitted figure 1 better and that the 20° overlay fitted figure 2 better, especially in close to the eye. (Note the narrow clear area.) This increase of inward spiralling of the rain bands probably indicates the increase in the low-level flow and in the general intensity of the hurricane.

While this one case is anything but conclusive, it does indicate an avenue for further research, positive results of which would be invaluable.

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2. H. Senn, H. Hiser, and E. Low, "Studies of Hurricane Spiral Bands Observed on Radar," *Final Report* on Contract Cwb–8735, University of Miami, Oct. 1956.

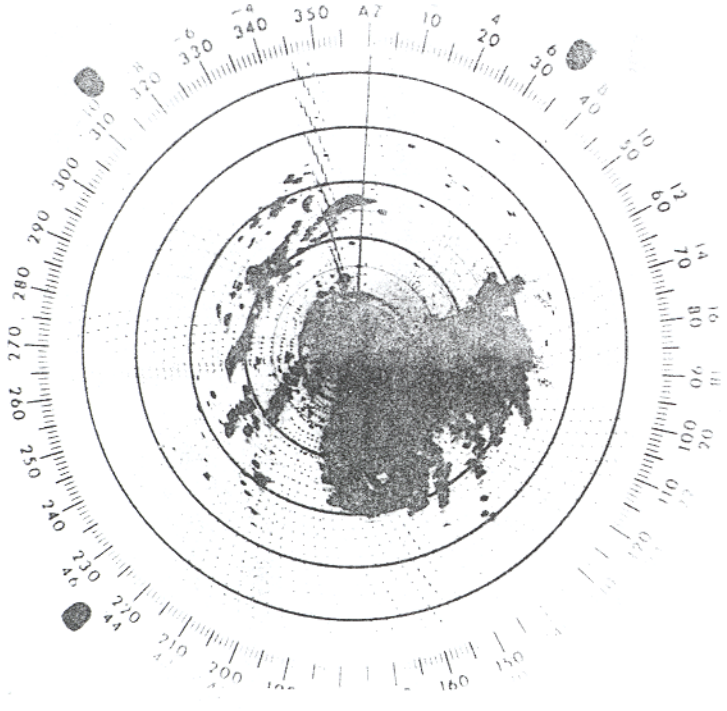

FIGURE 1.—Miami radarscope presentation of hurricane Cleo at 3:00 p.m. EST, August 26, 1964.

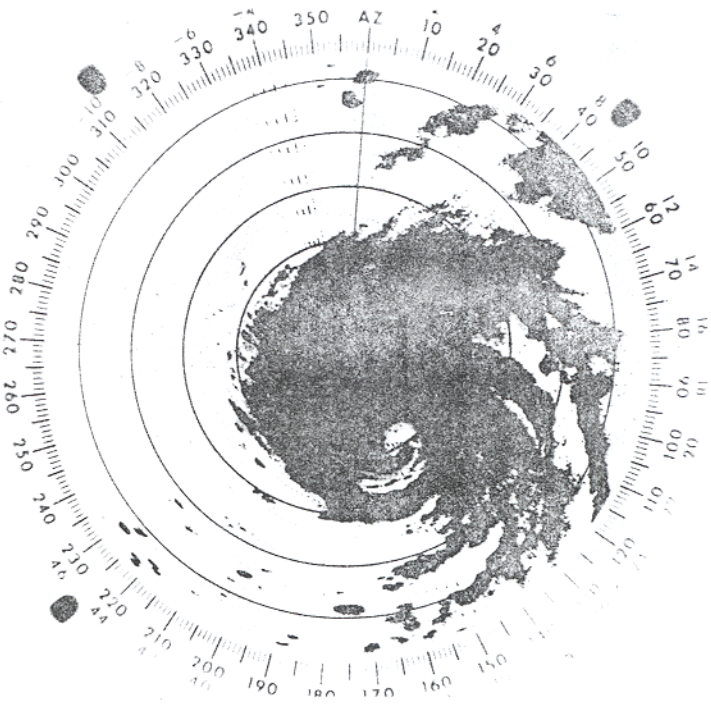

FIGURE 2.—Miami radarscope presentation of hurricane Cleo at 11:15 p.m. EST, August 26, 1964.