

## TROPICAL DISTURBANCES OF JULY 1933

By CHARLES L. MITCHELL

*June 27–July 6.*—This disturbance was first noted the evening of June 27, central in about latitude  $9^{\circ}$  north and longitude  $59^{\circ}$  west. It was the earliest known in that general area and also the only one in a record of nearly 50 years to pass south of the Island of Trinidad and over the northeastern corner of Venezuela. On the morning of June 28 the center was over the southwestern part of the Gulf of Paria. An Associated Press dispatch from Port of Spain, estimated that in the Island of Trinidad there were 13 deaths, 1,000 persons rendered homeless, about \$3,000,000 property damaged, practically all in the southern part of the island.

Through the courtesy of the United States Chargé d'Affaires at Caracas, Venezuela, the following report has been received:

*Hurricanes in eastern Venezuela.*—On June 28 a devastating hurricane swept through eastern Venezuela, the towns of Carúpano and Rio Caribe, on the mainland, and the island of Margarita suffering the most damage. Telephonic and telegraphic communications were cut for several days. Many business houses and private dwellings were destroyed, several small trading and fishing boats sunk and a number of lives lost. The losses from this hurricane alone are estimated at several millions of bolivars [1 bolivar=

19.3 cents]. During July there were several more hurricanes in the vicinity of Pedernales, at the mouth of the Orinoco, and along the river itself up as far as the Apure. However, most of them did not strike towns of any size.

During the next several days this disturbance moved first west-northwestward and later northwestward over the Caribbean Sea. It passed over extreme western Cuba the night of July 2–3, but did not cause much damage. By the morning of the 4th a strong area of high pressure, that spread southward from Hudson Bay over the eastern part of the United States, blocked the northward progress of this disturbance and deflected it toward the west. After moving westward until the evening of the 5th it turned southwestward and crossed the Mexican coast line about midway between Tampico and Brownsville, Tex., the evening of the 6th, where it caused several deaths and considerable property damage in the sparsely-settled coast region.

The usual twice-daily advisory warnings were issued in connection with this disturbance. Northeast storm warnings were ordered at noon of the 5th from Brownsville to Port O'Connor, Tex., and the warnings at Browns-

ville were changed to hurricane at 4 p.m. of the same date.

*July 14-19.*—On the morning of the 14th a minor disturbance appeared near St. Kitts, West Indies. It moved almost directly westward, passed near Jamaica on the 16th, over the Yucatan Peninsula on the 18th, and finally inland north of Vera Cruz, Mexico, the night of the 19th-20th.

*July 21-27.*—This disturbance, which also was of minor intensity, was first noted about 200 miles northwest of Progreso, Yucatan, the morning of the 21st. It moved northwestward to the coast of Texas, then inland near Matagorda Bay the night of the 22d-23d, and finally dissipated near Memphis, Tenn., during the 27th.

*July 25-August 5.*—This disturbance was centered a short distance southeast of the Island of Antigua, West Indies, the morning of the 25th. It passed south of St. Thomas the following night, causing a wind velocity of 60 miles per hour from the northeast. Continuing west-northwestward its center passed north of Puerto Rico on the 26th and almost over Turks Island on the 27th. The lowest barometer reading at Turks Island was 29.37 inches, accompanied by a wind velocity estimated as 85 miles per hour from the northeast. The disturbance moved northwestward during the 27th-28th, then west-northwestward over the northern Bahamas. The center crossed the coast line of Florida a short distance south of Fort Pierce on the 30th, accompanied by a wind at that place of 60 miles per hour from the southeast. However, no great amount of damage resulted as the disturbance moved westward over the Florida Peninsula and passed into the Gulf of Mexico

between Tampa and Fort Myers. Storm warnings were displayed on the east Florida coast from Miami to Titusville and on the west coast from Tarpon Springs to Punta Rassa.

This disturbance continued to move westward but vessel reports on the 1st and 2d indicated a decrease in intensity. From the morning of the 3d until the center passed over the coast line near Brownsville no vessel reports were received near or west of the center, and it was impossible to indicate accurately its position or intensity. However, advices were issued twice daily giving estimates of its position and probable movement until noon of the 3d when storm warnings were ordered for the Texas coast between Freeport and Brownsville. On the evening of the 3d Texas stations were advised that the center probably would reach the south Texas coast between Brownsville and Corpus Christi and be attended by strong shifting winds, possibly reaching gale force near the center with moderately high tides from Port O'Connor southward to Brownsville. The advices on the morning of the 4th were that the center would cross the Texas coast between Corpus Christi and Brownsville, but somewhat nearer Brownsville, and that winds would reach gale force over a very small area but probably would not attain hurricane velocity. The center crossed the coast nearly over but slightly south of Brownsville during the early night of the 5th with greatly increased intensity, the highest velocity being 72 miles at Brownsville. No doubt the increase in intensity began as early as the 4th. Considerable damage was caused in the vicinity of Brownsville and over a strip westward to Monterey, Mexico, owing largely to torrential rains.

## TROPICAL DISTURBANCES OF AUGUST 1933

By R. HANSON WEIGHTMAN

[Weather Bureau, Washington, D.C., September 1933]

The number of tropical disturbances this month was unusually large, 7 disturbances being reported, 4 of which were of slight intensity and 3 of hurricane intensity.

*August 12-20.*—The first disturbance of the month made its appearance in the region of Barbadoes, West Indies, whence it moved first west-northwest, passing south of Jamaica, then northwestward over Grand Cayman, thence more to the northward over extreme western Cuba, and finally northward to a point off the northwestern Florida coast where it lost intensity. The few reports available would indicate that the winds of this storm may have reached gale force while its center was south of Jamaica; otherwise, it was of minor consequence. Heavy rains attending thunderstorms, caused damaging floods in eastern Jamaica.

*August 16-21.*—A disturbance of slight intensity appeared over the Windward Islands on the 16th and moved westward. It was last traceable about 300 miles east of the Honduras coast on the 21st.

*August 17-26.*—This disturbance originated some distance to the east of the Windward Islands. It was first located from telegraphic reports on the morning of the 18th, about 900 miles east of Puerto Rico. The S.S. *Western Prince* in latitude  $19^{\circ}30'$  N., longitude  $51^{\circ}$  W., reported barometer 29.76 inches, wind northeast 42 m.p.h. with heavy southeast swell. It moved westward until the 18th, then followed a course northwest by north until the 21st, when it was central about 150 miles southwest of Bermuda, a maximum wind velocity of 64 miles from the east being reported at St. Georges. During the next 24 hours it bore more to the westward, with somewhat decreased speed and then turned to the northwest, passing nearly over but slightly to the east of Cape Hatteras, with lowest barometer 28.67 inches and maximum wind velocity 64 m.p.h. from the northeast. When the disturbance was about 150 miles southwest of Bermuda on the morning of the 21st, storm warnings were ordered between Cape Hatteras and Boston, with the information

that the tropical disturbance was of great intensity. On the morning of the 22d, these storm warnings were continued with the following information:

Tropical disturbance attended by fresh to strong gales, central about 350 miles southwest of Bermuda and same distance southeast of Cape Hatteras, direction of movement uncertain but probably will remain nearly stationary next 12 hours. Strong northeast winds probably reaching gale force off the coast.

At 4 p.m. of the 22d, storm warnings were extended south of Cape Hatteras to Southport, N.C. On the evening of the 22d, the following bulletin was issued:

Atlantic coast disturbances central about 150 miles southeast of Cape Hatteras, moving slightly north of west. Center will cross southern coast of North Carolina early Wednesday forenoon, preceded by dangerous shifting gales tonight between Virginia Capes and Southport, N.C. Advise all interests.

On the morning of the 23d the center was a few miles south of Norfolk, Va., where the pressure was 28.84 inches. It passed over Norfolk with lowest pressure 28.68 inches at 9:20 a.m. and a maximum wind velocity of 56 miles, while Cape Henry had a maximum velocity of 68 m.p.h. The center was near Washington, D.C., that evening, with a pressure of 28.94 inches. It moved northward to central Pennsylvania with decreasing intensity and then turned northeastward down the St. Lawrence Valley with further decrease in intensity.

This was one of the most severe storms that has ever visited the Middle Atlantic coast. It caused great damage in northeastern North Carolina, central and eastern Virginia, and in Maryland, Delaware, and portions of New Jersey, due to severe gales and high tides, largely the latter. While hurricane velocities were not actually recorded at any Weather Bureau station, it seems quite probable that along the coast between Delaware Breakwater and Cape Hatteras winds may have reached the lower limits of hurricane force (75 m.p.h.) for short intervals. Warnings of high tides for the Norfolk area were given out preliminarily as early as the 21st and more specifically and positively during the afternoon and evening of the 22d. A tide of 7 feet above normal occurred, flooding the downtown business section of Norfolk as never before. The official in charge at Norfolk reports that plate-glass windows were broken in the business section by the wind, and states that:

Loss to shipping in this remarkably severe storm, which has been characterized as the worst ever experienced in this section, was practically negligible. The warnings were so widely disseminated that vessels stayed in port, or sought shelter if at sea, except in 1 or 2 cases. \* \* \*

A great deal of damage resulted to resorts on the Virginia, Maryland, Delaware, and New Jersey coasts and also in Chesapeake Bay. Power, telephone, and telegraph services were disrupted for a time in portions of Delaware southward to Cape Charles. An extract from the report of the Weather Bureau official at Baltimore, gives details regarding the extent of the damage in the State of Maryland:

The damage to property, exclusive of crops, is estimated to be in excess of \$10,000,000, and to crops about \$7,000,000. Crop damage in Maryland alone, estimated by the State Experiment Service of the University of Maryland, from the reports of county agents, was as follows: Tobacco crop, more than \$1,500,000 (Baltimore tobacco experts estimate \$2,000,000, including stocks in warehouses); tomatoes somewhat more than \$1,000,000; corn crop, including loss of fodder, more than \$2,000,000. Worcester County suffered the most damage to the corn crop \$300,000. The least was \$6,000 in Allegany County.

The fisheries industry was injured severely, the amount being difficult to estimate but probably around \$3,000,000. Many boats were destroyed and a larger number sunk and damaged, buildings and wharves were wrecked, etc. At Crisfield, Md.,

alone, the damage to the industry was \$100,000. The damage to highways was \$406,851 in Maryland and \$150,000 in Delaware. Railroads suffered a property loss of about \$555,000; telephone and electric companies about \$364,000; Federal buildings and works probably about \$1,100,000 (Naval Academy at Annapolis alone \$90,000); passenger, freight, and pleasure boats and establishments about \$392,000 (Maryland Yacht Club at Baltimore in excess of \$60,000); miscellaneous damage to dwellings, pleasure resorts, coast towns, etc., about \$2,000,000; shore land lost in Maryland by wave action (estimated by State conservation commissioner) about 2 square miles; in Delaware about 1 square mile.

*August 24-30.*—A disturbance of slight intensity first appeared on the 24th, central apparently about 340 miles north by east of Antigua, West Indies. It moved northwestward during the following 2 days, then recurved to the northward and passed about 160 miles west of Bermuda during the night of the 27th. By the morning of the 30th it was central about 250 miles south of Cape Race, Newfoundland, moving northeastward.

*August 27-29.*—A disturbance of slight intensity developed in a region of unsettled weather over Mexico near Frontera during the 26th and 27th. From vessel reports subsequently received, it apparently moved northwestward to the vicinity of Tampico by the 28th attended by heavy rains at Mexican coast stations but without strong winds. By the evening of the 28th, available vessel observations over the northwestern Gulf showed that the wind velocities had increased to 22 m.p.h., and shifted from northeast and east to southeast. Consequently, on the morning of the 29th, with the uncertainty regarding the advance of the center northward, storm warnings were ordered from Port Arthur to Corpus Christi, as follows:

Tropical disturbance of slight intensity about 125 miles southeast of Corpus Christi apparently moving northward; will cause fresh to strong northeast winds late this afternoon and tonight, with strong shifting winds over very small area around center.

Special observations received during the afternoon of the 29th showed rather definitely that the center was south of Brownsville and at 9 p.m. storm warnings were ordered down.

*August 28-September 6.*—This disturbance first appeared the evening of the 28th, a short distance northeast of the Windward Islands. By the morning of the 29th, ship reports showed that it was attended by gales and moving west or west-northwest. It continued to move west by north, passing slightly north of Turks Islands with lowest barometric pressure at Grand Turk of 29.41 inches at 3 p.m., of the 30th, and maximum wind of 56 miles from the southwest. By the following morning its center was a short distance southwest of Crooked Island, Bahamas, and 24 hours later near Sagua la Grande on the north coast of Cuba, attended by winds of hurricane force.

On the evening of the 30th, storm warnings were ordered for southern Florida.

During the late afternoon of September 1, the barometer at Habana read 28.92 inches as the storm center passed a short distance north of the city. The highest wind velocity at Habana was 94 m.p.h. from the south, while at Key West, Fla., the maximum was 42 m.p.h. from the east. Little damage was done at Key West, but, according to press reports there was considerable loss of life and much property damage along the north coast of Cuba and probably also some distance inland.

Moving westnorthwestward across the Gulf of Mexico, the storm center reached the ninety-fifth meridian, approximately 150 miles east of Brownsville, Tex., the morning of September 4, after which it moved directly westward, and passed inland just north of Brownsville

the following night. Brownsville reported a barometer reading of 28.02 inches at 1:30 a.m. of the 5th, and an estimated maximum wind of 80 m.p.h. from the northwest earlier in the night. According to an Associated Press dispatch from Brownsville there were 22 known deaths and property damage running into millions of dollars in the area from Corpus Christi to some distance south of Brownsville in extreme northeastern Mexico. However, no lives were lost in either Brownsville or Corpus Christi. The remarkable escape of Brownsville citizens was attributed to the fact that all had ample warning that the tropical hurricane was approaching the city.

Realizing that the storm was a major hurricane and that the week-end holiday would extend over Labor Day, the district forecaster sent the following warning to all Texas coast stations on the morning of Saturday, September 2:

Uncertain where tropical storm in Gulf will reach coast line, but all persons should be warned to remain away from inaccessible places on Texas coast over week end.

That the warning was heeded was attested by the following excerpt from the report of the official in charge, Corpus Christi, Texas:

\* \* \* Probably never before in the history of Texas hurricanes have such widespread and early warnings been given as were received from Washington in advance of this one. The telegram of Saturday, September 2, warning all persons to avoid

inaccessible places over the week end probably saved thousands of lives. Major Swan, owner of the Don Patricio Causeway, estimated that between 2,500 and 4,000 visitors would have passed over the causeway to Padre Island during Sunday and Monday had it not been for the timely warning sent out from the central office. The same is true of Mustang Island, Bird Island, and the many other places north and south of this city. It is not an exaggerated estimate to state that between 6,000 and 10,000 persons might have been in inaccessible places had it not been for the advance warning to stay away from those places. \* \* \*

At 10 p.m. of September 3, hurricane warnings were ordered displayed from Corpus Christi to Freeport and storm warnings on the remainder of the Texas coast. The storm at this time was central about 300 miles due east of Brownsville and still moving west-northwestward. No reports were received from the vicinity of the storm the morning of the 4th, but when it became apparent during the late afternoon and evening that the storm was moving directly westward and would reach the coast not far north of Brownsville, hurricane warnings were ordered south of Corpus Christi to Brownsville, while the hurricane warnings north of Corpus Christi were changed to storm warnings.

*August 31-September 5.*—On the morning of the 31st, another tropical disturbance was about 225 miles north-northeast of Antigua, West Indies. It subsequently passed over Florida. An account of this disturbance will appear in the September issue of the Monthly Weather Review.

## BIBLIOGRAPHY

C. FITZHUGH TALMAN, in charge of library

### RECENT ADDITIONS

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3. L'orage du 12 juin 1929. (Repr.: Association française pour l'avancement des sciences. Congrès de Bruxelles 25 au 30 juillet 1932.) Paris. 1932. p. 163-173. figs. 24 cm.

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# LOW BAROMETER READINGS IN WEST INDIAN DISTURBANCES OF 1932 AND 1933

By W. F. McDONALD

[Weather Bureau, Washington, October 1933]

The summer of 1933 was, even at the end of September, characterized by a record-breaking number of West Indian disturbances, and these storms produced five ships' barometer observations between 27.40 and 27.99 inches. Five other pressure readings on ships at sea were reported in the range from 28 to 28.50 inches, making 10 cases this year (up to September 30), in which ships have experienced and verified in mail reports to the Weather Bureau, such uncommonly low barometric minima in their encounters with West Indian hurricanes.

Pressures of 28.50 or lower in tropical disturbances characterize storms of severe hurricane intensity. The following table records all such observations so far in hand for the 3 months, July to September, inclusive, 1933.

Table of ships' barometer observations, 28.50 inches or lower, in West Indian hurricanes of July, August, and September 1933

Date	Name of vessel	Position		Lowest barometer
		Latitude N.	Longitude W.	
July 5, 1933	Am. S.S. Lena Luckenbach	25 32	90 40	28.50
Aug. 18, 1933	Nor. S.S. Tana	123 00	154 30	27.98
Aug. 30, 1933	Br. S.S. Jamaica Pioneer	22 10	72 30	27.47
Sept. 2, 1933	Am. S.S. Harvester	125 00	186 00	27.99
Sept. 11, 1933	Fr. S.S. Washington <sup>1</sup>	23 15	61 40	27.96
Sept. 15, 1933	Am. S.S. El Oceano <sup>2</sup>	134 00	174 30	28.24
Sept. 16, 1933	Am. S.S. Shenandoah <sup>3</sup>	36 35	75 00	28.43
Do	Am. S.S. Gulf of Mexico <sup>3</sup>	36 35	74 41	28.48
Sept. 17, 1933	Ger. S.S. Bremen <sup>3</sup>	39 54	69 16	28.50
Sept. 20, 1933	Am. S.S. Virginia	118 30	183 05	27.40

<sup>1</sup> Positions closely estimated.  
<sup>2</sup> Uncorrected aneroid reading, but evidence indicates instrument in good order.  
<sup>3</sup> Observations of Sept. 11-17, all obtained in same storm.

The 5 readings below 28 inches were obtained in 4 separate storms. Furthermore, the lowest reading in each of these storms was observed within 1 or 2 days after the time at which the disturbance became definitely located in our reports, and no lower readings thereafter have as yet come to light, although in all cases these storms appear to have increased in extent and destructive power as they passed onward to later stages of development.

This group of records therefore supports the view that tropical disturbances often, or perhaps commonly, arise as intense vortices of small diameter, which expand in area and decrease in intensity as they progress.

As bearing upon this question, it may be pointed out that the lowest of the readings, 27.40 inches (reported from the American liner *Virginia*), was observed under the following circumstances that clearly indicate a recently developed vortex of extraordinary sharpness. Meteorological conditions were somewhat disturbed in the Caribbean Sea for almost a week prior to September 20, when the *Virginia* encountered the storm described below, but no ship reported stormy weather until the 19th, when definite signs of development were observable in the region south and west of Jamaica. The following afternoon revealed the focus of activity as a small but intense hurricane near Swan Island.

The report of J. E. Handran and J. F. Wilson, observers on the *Virginia* (Capt. C. V. Richardson), is worthy of quotation at length and extracts are given below. The aneroid barometer used on the ship is subject to a cor-

rection of -0.05 inch, which was applied to the readings before quotation in this report, which says:

At 5 p.m. (Sept. 20) it was blowing a moderate (NNE.) gale. At 6 p.m. the wind had further backed into the NE., force 8, with the barometer reading 29.95 inches. A speed of 17.5 knots was at this time cut down to 14 knots due to the heavy head swell which was being encountered.

At 6:55 p.m. the wind and sea had increased to such an extent that a further reduction in speed was necessary, to about 8 knots. Position 18°38' N., 83°07' W.

Shortly before 8 p.m. a squall of great violence struck the ship and at 8 the ship was hove to, heading 180°, bringing the wind on the port quarter. Revolutions were adjusted to keep bare steerage-way. The aneroid barometer at this time, approximately 8 p.m., was reading 28.74 inches. Five minutes later it was down to 28.50 inches. The wind was now blowing in almost continuous squalls of great violence, with torrential rain. The noise from the wind was terrific, it being impossible to hear.

At 8:20 p.m. the wind suddenly ceased and looking directly overhead a few stars were visible over a small area. Men's ear drums were ringing, with the barometer standing at 27.40 inches during the calm center or "eye" of the hurricane. While in the calm area in a high confused sea the vessel was headed 55° true in anticipation of a change of wind. At 8:35 p.m. the wind struck in from the SSW, with slightly less force than before.

The wind continued to blow in squalls of hurricane violence from the SSW., with a rapidly rising barometer, when at 9 p.m. the glass stood at 28.60. Between 9 and 10 p.m. the wind moderated sufficiently to allow of bringing the vessel back to the course (150°) with the wind about 4 points on the starboard bow. Barometer reading 29.20. From 10 p.m. the speed was increased to full at 11 p.m., at which time the barometer stood at 29.40; wind S., force 9. At midnight the wind had further decreased to force 8; barometer, 29.66.

Careful examination of the information given in this report shows that the diameter of the ring of pressure below 29.50 inches could not have been much more than 50 miles when the ship crossed the storm area. The inner area of extreme violence, encompassing pressures below 28.50 inches, passed while the vessel was hove to. That part of the vortex, therefore, may be estimated as not over 10 to 12 miles in diameter, because 1 hour's progression carried that section of the hurricane past the drifting ship, and the evidence at hand indicates that the storm movement between the evening of the 20th and the morning of the 21st was not rapid.

Increase in the hurricane area during the few hours covered by these observations is indicated by the slower rate of rise than of fall in the barometer. This hardly could be attributed to a variation in the ship's movements relative to the storm for the route of the ship was about 90° to the storm track and the variations in sailing speed were similar in entering and leaving the hurricane. The later synoptic charts also carry the story of increase in size as this storm moved along its track westward to Tampico, where the hurricane struck with great violence on September 24 when the diameter of the 29.50 isobar was about 300 miles.

The fact that the center of this very small vortex had a clear spot "directly overhead", also indicates that at that time the disturbance was moving rather slowly, for there is much reason to think that with rapid movement the core of a tropical disturbance commonly is inclined in the direction of advance, with no clear sky visible in the region of lowest pressure. This point is not yet fully established; it is worthy of special notice and ships' observers are requested to supply more information on the character of the sky at the center of such disturbances when encountered.

The pressure (27.47 inches) observed on the British steamer *Jamaica Pioneer*, August 30, near Turks Island, ranks next lowest among the cases here reviewed. Examination of the detailed report in this instance also shows a very sharp vortex. The ship was only 7½ hours within the circle of pressures below 29.50 inches, and about an hour and 10 minutes while it was below 28.50 inches. The storm could not have been more than 2 days old at the time the *Jamaica Pioneer* crossed the center. This hurricane was moving quite rapidly at the time, and no clear eye was reported. Three days later the American steamer *Harvester* recorded 27.99 inches in this storm.

Readings below 28 inches in the other two storms, as reported by the Norwegian steamship *Tana* (Aug. 18), and the French ship *Washington* (Sept. 11), were also obtained at times when we must assume the cyclones to have been at a comparatively early stage of development. In neither of these storms can any center be definitely located or actual storm winds found in our reports more than 1 or 2 days prior to the date of the ship's encounter with the vortex.

The table carries five records taken at different times in the same storm, between September 11 and 17. It is of interest to note that these readings together constitute a consistent progression of dates, positions, and pressure values; this must be because the central pressure slowly increased as the storm progressed along its track.

In this connection, and bearing upon the question of the pressure distribution in tropical disturbances, reference is made to a report (not previously published in the REVIEW) obtained from the British steamer *PheMIus*, which was involved for 4 days in intense hurricane conditions in the western Caribbean Sea in early November 1932. The meteorological log of this ship's experience, as given in detail in the British MARINE OBSERVER for October 1933 (vol. 8, pp. 123-125), indicates a hurricane

of full maturity and of what appears to be unusual complexity of structure.

The lowest pressure observed on the *PheMIus*, 27.01 inches (914.6 mb.), was reached on the 5th near 14° N. 79° W., and within a few hours after the vessel entered the hurricane area. This is one of the lowest barometer readings ever observed at sea level, and the lowest fully authenticated reading in the West Indian region so far as can be ascertained at this writing.

The fall in barometer as this vortex approached was very rapid, and was attended by hurricane winds so intense that superstructures on shipboard were badly damaged, and the ship's funnel actually torn out and blown overboard. The vessel was from that time disabled, and wallowed in the seas throughout the remainder of the storm.

The barometer did not rise with equal promptitude, however, and the height that prevailed a few hours before the vessel's encounter with this terrific vortex was not again reached for 4 days. Instead, there was a partial rise, followed by several marked decreases, to 28 inches on the third day and 27.92 on the fourth, as if there might have been either a family of subvortices or vacillation in the movement of the primary storm center. During those 4 days the ship was involved in continuous storm conditions of great severity, with the barometer for 3 days never rising above 28.50 inches.

This hurricane was the same that on November 9, 1932, advanced northward across Cuba and devastated the city of Santa Cruz del Sur, with the loss of several thousand lives. Its meteorological history in the western Caribbean has not been fully worked out, but the record of the *PheMIus* very clearly shows an extent and complexity of structure that throws this case into great contrast with the simpler vortices reported in the ship's observations of 1933.

## TROPICAL DISTURBANCES OF SEPTEMBER 1933

By C. L. MITCHELL

[Weather Bureau, Washington, October 1933]

*Tropical disturbance of August 31-September 7.*—This disturbance was central about 150 miles north of Puerto Rico the morning of the 1st. It evidently was attended by winds of hurricane force nearer its center at this time, inasmuch as the S.S. *Gulf Wing* reported a barometer reading of 28.98 inches and a wind velocity of 80 miles per hour about 150 miles east of Turks Island the evening of the 1st. The center passed some distance north of Turks Island during the night of the 1st-2d and over Harbour Island, about 2 miles northwest of the island of Eleuthera, Bahamas, the morning of the 3d. There was a calm of 30 minutes at this place. Previously the wind had reached an estimated velocity of 140 miles per hour. At 4 p.m. of the 3d, northwest storm warnings were ordered displayed at Miami, hurricane warnings north of Miami to Melbourne, Fla., and northeast storm warnings north of Melbourne to Jacksonville. At 10 p.m. storm warnings were displayed on the west Florida coast north of Key West to Cedar Keys.

The storm center apparently passed directly over Jupiter Inlet, Fla., where there was a lull of 40 minutes beginning near midnight of the 3d. The lowest barometer reading at Jupiter was 27.98 inches and the estimated maximum wind velocity 125 miles per hour. At West Palm Beach the lowest barometer reading was 28.77 inches with a maximum wind velocity close to 80 miles per hour. According to the official in charge at Miami,

the only evidence of damage at West Palm Beach was the effects of high winds upon trees and shrubbery. However, a number of plate glass windows were broken and the damage in this respect would have been much greater except for the extensive protective measures taken. Between West Palm Beach and Jupiter, and extending northward to Fort Pierce, there was serious damage to electrical transmission lines and to telephone and telegraph wires, with many poles broken off or blown over. At Stuart there was serious damage from both wind and water. The most extensive damage in the entire storm area was at Olympia Beach, north of Jupiter Inlet, where there was widespread destruction of trees and shrubbery and serious damage to houses. The greatest loss was to the citrus crop in the Indian River section from Jupiter to Fort Pierce. In the vicinity of Stuart there are several groves that sustained a 100 percent loss of fruit and the uprooting of many trees. The estimated loss of citrus fruit for the State is 16 percent, or 4,000,000 boxes.

This storm recurved to the north during the afternoon of the 4th when its center was near the coast north of Tampa. Moving very slowly northward with diminishing intensity during the next 2 days it dissipated over Georgia on the 7th.

*Tropical disturbance of September 10-21.*—Although conditions were disturbed over and east of the Leeward Islands from the 7th to the 9th, it was not until the 10th

that a definite center could be located. This center was then about 300 miles northeast of the Island of St. Martin. By the morning of the 11th it was evident that the disturbance was one of considerable intensity, and it was so stated in the advisory issued at 10 a.m. of that date. This disturbance continued to move northwestward with gradually increasing intensity until the 15th, when it recurved and moved almost directly northward. Its center passed slightly west of Cape Hatteras about 8 a.m. of the 16th, after which it moved north-northeastward for about 12 hours, and then northeastward, reaching Nova Scotia the morning of the 18th, and extreme southern Iceland on the 21st.

Storm warnings were ordered at 4 p.m. of the 14th from Jacksonville, Fla., to Beaufort, N.C. At that time the disturbance had not begun to recurve and it was apparently headed for the northern South Carolina, or southern North Carolina, coast. At 10 p.m., storm warnings were extended northward along the coast to the Virginia Capes. The following morning the storm center was about 350 miles east of Savannah, Ga., and the indications were that it would reach the North Carolina coast not far from Cape Lookout in about 12 hours. Accordingly, hurricane warnings were ordered displayed at 10:30 a.m., from Wilmington to Cape Hatteras, and northeast storm warnings north of the Virginia Capes to Boston.

At 4 p.m. whole-gale warnings were displayed north of Hatteras to the Virginia Capes. At 8 p.m., the center was about 100 miles south of Cape Hatteras, moving almost directly northward, and the hurricane warnings at Wilmington were changed to northwest storm warnings at 9:30 p.m. At 10:30 a.m. of the 16th whole-gale warnings were ordered along the coast (but not at Baltimore and Philadelphia) north of the Virginia Capes to Atlantic City, and hurricane warnings were changed to storm warnings north of Wilmington to Hatteras. The 2 p.m. special reports indicated that the storm was beginning to recurve toward the northeast and that the center would pass some distance east of Cape Henry and the whole-gale warnings north of Hatteras to the Virginia Capes were changed to northwest storm warnings at 4 p.m. At 8 p.m. the storm was central about 125 miles south of Atlantic City, apparently moving northeastward. At 9:30 p.m., northeast storm warnings were extended north of Boston to Eastport, Maine, and whole-gale warnings on the coast north of the Virginia Capes to Atlantic City were changed to northwest storm warnings. The following morning when the storm center was about 150 miles east of Atlantic City, whole-gale warnings were ordered displayed from Provincetown to Nantucket, Mass.

The principal damage done by this storm was from a short distance south of New Bern, N.C., to the Virginia Capes. The following is quoted from a report by the official in charge, Wilmington, N.C., relative to a trip of inspection of the storm area:

\* \* \* Very little damage was noted until a point a few miles southwest of New Bern was reached. Great damage was done by wind and high water in New Bern and vicinity; many telephone- and power-line poles blown down, numerous large trees uprooted or broken off, and houses and other buildings injured by falling trees and in some cases unroofed. At least one tree 4 feet in diameter in the heart of the city was uprooted. Water reached a height of 3 to 4 feet in some of the streets which is about 2 feet higher than the previous record which occurred in September 1913. Along the highway from New Bern toward Beaufort at least 100 trees 10 inches or more in diameter were blown down. In Morehead City and Beaufort damage was apparently slightly less than in New Bern, but old residents in Beaufort declare the storm was the worst they had ever experienced. It is estimated that the maximum velocity of the wind in the New Bern-Beaufort area was at least

125 miles per hour. Loss of life was due chiefly to high water in isolated localities north of Beaufort from which escape was difficult or impossible. According to the latest reports a total of 21 lives were lost. Property damage along the entire North Carolina coast will total, according to early estimates, more than \$1,000,000.

At Cape Hatteras the lowest barometer reading was approximately 28.25 inches about 7 a.m. of the 16th. The highest wind velocity preceding the arrival of the center was 68 miles per hour from the east and the highest after the center passed, 76 miles per hour from the northwest (estimated because 1 cup of the anemometer was blown away).

The damage done by the storm at Norfolk and the other places in the Virginia Capes section was comparatively slight and was far less than that caused by the August 1933 storm. Much credit is given by the business interests and newspapers of Norfolk to the Weather Bureau for its timely and accurate warnings. There was ample time for complete preparation for the storm, thus holding losses to a minimum. The highest wind velocity in the Capes section was 68 miles per hour from the northeast at Cape Henry. Farther north along the Atlantic coast the highest velocities were 48 miles per hour at Atlantic City and 52 miles per hour at Block Island, R.I., and Nantucket, Mass. No great amount of damage was reported north of the Virginia Capes.

*Tropical disturbance of September 10-15.*—Weather conditions over the extreme western Caribbean Sea became disturbed on the 9th and a center was located between Tela and Belize the evening of the 10th. During the next 2 days the disturbance moved very slowly north by east toward Cozumel Island, with gradually increasing intensity; however, after the evening reports of the 12th were received, the direction of movement changed abruptly and the center moved inland over the Yucatan Peninsula north of Payo Obispo. The disturbance then moved west-northwestward across the Peninsula and the southwestern Gulf of Mexico during the next 48 hours, and there was a marked increase in intensity while the disturbance was passing over the Gulf. The center passed directly over Tampico, Mexico, the morning of the 15th. There was a period of calm between 8 a.m. and 10 a.m., and the lowest barometer reading reported was 28.34 inches. Much damage was done in Tampico and vicinity but details are not available.

Northeast storm warnings were ordered displayed at Brownsville, Tex., the evening of the 14th, at which time the indications were that the storm center would reach the coast nearly 100 miles north of Tampico and cause strong northeast winds, possibly reaching gale force at Brownsville. Upon receipt of the morning Tampico report of the 15th in the early afternoon, the warnings at Brownsville were lowered.

*Tropical disturbance of September 16-24.*—All island stations from St. Kitts to Bridgetown, Barbados, showed a 24-hour decrease in pressure of 0.06 to 0.10 inch the morning of the 14th, indicating the approach of a disturbed condition from the east, but no definite center could be found passing between any of the islands of the Windward and Leewards groups. On the 18th the barometer began to fall slowly at Kingston, Jamaica, and a heavy sea was reported at that place the evening of the 19th. At the same time three vessels about midway between Jamaica and the Isthmus of Panama reported gentle southwest winds and pressure a few hundredths below normal. However, it was not until the evening of the 20th that a center could be located, by which time the disturbance, though of very small diameter, had attained great intensity. The S.S. *President Pierce* in about



latitude 18°50' N., longitude 83°20' W., reported a barometer reading of 28.79 inches and a wind velocity of 80 miles per hour from the southwest. A later report received by mail from the S.S. *Virginia* which, at the same time, was close to the position of the *President Pierce* gives the following barometer readings: 6 p.m., 29.65 inches; 7 p.m., 29.49 inches; 8 p.m., 28.78 inches; 8:20 to 8:30 p.m. (in calm center, stars visible), 27.44 inches; 9 p.m., 28.64 inches; 10 p.m., 29.24 inches; 11 p.m., 29.40 inches; midnight, 29.70 inches.

This disturbance moved west by north passing inland over the Yucatan Peninsula with center about 40 miles south of Cozumel Island near midnight of the 21st and into the southwestern Gulf of Mexico north of Campeche the evening of the 22d. The center passed inland a short distance south of Tampico, Mexico, the evening of the 24th, attended by winds of hurricane force. The evening report of the 24th received from the S. S. *J. N. Danziger* was remarkable because of the fact that the vessel was at the time in the center of the storm and reported a wind velocity of only 2 miles per hour and a barometer reading of 28.40 inches. As in the case of the

storm of the 15th, great damage was done at and near Tampico, but details are not available.

*Tropical disturbance of September 27–October 4.*—A minor disturbance apparently moved westward between the islands of St. Kitts and St. Martin on the 27th. It was of such small diameter and slight intensity that the center could not be located definitely every 12 hours. However, available data indicate that it moved westward, until the 29th, when it turned to the north and northeast, passing some distance west of Port au Prince, Haiti, the evening of the 29th and centered north of Puerto Plata, Santo Domingo, the morning of October 1. Still of minor intensity, the disturbance then moved northwestward and later north-northwestward until the 4th, after which it could not be located.

*Tropical disturbance of September 28–30.*—This was a very minor disturbance that apparently developed northwest of the Isthmus of Panama and moved northwestward. Its center passed near Cape Gracias the evening of the 28th, then traveled west-northwestward and passed inland south of Belize, British Honduras, the morning of the 30th.

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## TROPICAL STORMS OF 1933

By G. E. DUNN

[Weather Bureau, Washington, February 1934]

Twenty-one tropical disturbances were reported this year in the Caribbean Sea, the Gulf of Mexico, and the southern portion of the Atlantic. This is the largest number observed in any one season in 46 years of record. Hitherto 16, in 1887, had been the greatest number; since that time only 9 years have reported 10 or more.

The Mexican coastal area suffered the most from these storms, for no less than 5 intense hurricanes and 2 lesser tropical disturbances crossed its coastline. Immense damage was done in and about Tampico from the two hurricanes that passed almost directly over that city. Two fully developed hurricanes and two minor storms crossed the Yucatan peninsula, but no large cities were in their paths and reports of damage are meager. The middle Atlantic coast was buffeted once in August and again in September. The earlier storm crossed the coastline at Cape Hatteras and later passed directly over Washington with diminished intensity. This was one of the most destructive storms in the history of the middle Atlantic coast. As the September storm was recurring to the northeast, the center barely touched the North Carolina coast causing great damage in the New Bern

section. Two hurricanes crossed the coastline near the mouth of the Rio Grande; the September storm caused enormous damage. The June hurricane which touched the north coast of Venezuela was the earliest known in that region and the only one to pass south of the island of Trinidad in 50 years of record.

Complete accounts of the majority of these storms may be found in the monthly issues of the REVIEW during the past year (1933).

*Monthly frequency of West Indian hurricanes and other tropical storms of the North Atlantic Ocean in 1933*

	Hurricane intensity	Doubtful	Not of hurricane intensity	Total
May.....	0	1	0	1
June.....	1	0	0	1
July.....	1	0	2	3
August.....	3	1	3	7
September.....	3	0	2	5
October.....	2	1	0	3
November.....	0	1	0	1
Total.....	10	4	7	21

*Synopsis of tropical storms of 1933. (Number of storm in table corresponds with number of track on accompanying chart)*

Storm	Date	Place where first reported	Coast lines crossed	Maximum wind velocity reported	Lowest barometer reported	Place of dissipation	Intensity	Remarks
1	1933 May 13-18.....	Western Caribbean. <sup>1</sup>	None.....	<i>Mi. per hr.</i> Steamship <i>Sinaloa</i> , 50.	<i>Inches</i> Steamship <i>Sinaloa</i> , 29.58.	Southwestern Gulf of Mexico.	Probably not of hurricane intensity.	
2	June 27, July 6....	Short distance north of Guiana.	De Paria Peninsula, Venezuela; Mexican coast midway between Brownsville, Tex., and Tampico, Mexico.	Hurricane winds over most of path.	Steamship <i>Texas City</i> , 28.42.	Interior of Mexico....	Hurricane.....	Earliest known in Trinidad area and the only one in a record of 50 years to pass south of that island.
3	July 13-19.....	Near St. Kitts....	Yucatan Peninsula and Mexico somewhat north of Vera Cruz.	.....	.....	.....do.....	Minor disturbance.	
4	July 21-27.....	Western Gulf of Mexico. <sup>1</sup>	Texas between Galveston and Corpus Christi.	.....	.....	Near Memphis.....	.....do.....	Torrential rains over portions of Texas and Louisiana.
5	July 25, Aug. 5....	Short distance south of Antigua. <sup>2</sup>	Florida, short distance south of Fort Pierce; later Texas and Mexico slightly south of Brownsville.	85 NE. Turks Island, 72 NW. Brownsville, Tex.	About 29.00 Brownsville, 29.02 Saba Island.	Interior of Mexico....	Hurricane.....	

<sup>1</sup> Approximate place of origin.

<sup>2</sup> Well developed when first appeared in field of observation.

Synopsis of tropical storms of 1933. (Number of storm in table corresponds with number of track on accompanying chart)—Continued.

Storm	Date	Place where first reported	Coast lines crossed	Maximum wind velocity reported	Lowest barometer reported	Place of dissipation	Intensity	Remarks
	1933			<i>Mi. per hr.</i>	<i>Inches</i>			
6	Aug. 12, 20	Near Barbados	None			Northeastern Gulf of Mexico.	Very minor disturbance.	Heavy floods in eastern Jamaica.
7	Aug. 16-21	Windward Islands.	do			Western Caribbean.	Very weak disturbance.	
8	Aug. 17-26	Quite some distance east of Windward Islands. <sup>1</sup>	Cape Hatteras, N.C., and turned northward through Middle and North Atlantic States.	Cape Henry, 66 NE, Hurricane winds over ocean area.	Steamship <i>Antiochia</i> 27.76, Cape Hatteras 28.67.	Near mouth of St. Lawrence.	Hurricane	One of worst storms in history of Middle Atlantic coast.
9	Aug. 23, Sept. 24	Several hundred miles northeast of St. Thomas.	None			Greenland	Doubtful but probably not of hurricane intensity.	
10	Aug. 27-29	Southwestern Gulf of Mexico. <sup>1</sup>	Mexico near Tampico			Interior of Mexico	Minor disturbance	
11	Aug. 28, Sept. 5	Short distance northeast of Windward Islands.	Texas and Mexico almost directly over Brownsville, Tex.	90 NW* Brownsville	28.02 Brownsville	do	Hurricane	Great damage, Rio Grande Valley.
12	Aug. 31, Sept. 7	Northeast of Antigua.	Florida near Jupiter Inlet.	125* Jupiter	27.98 Jupiter	Georgia	do	
13	Sept. 10-21	East of Leeward Islands. <sup>2</sup>	Barely touched North Carolina coast line at Cape Hatteras.	125* New Bern, N.C. 76* Hatteras.	27.96 steamship <i>Washington</i> 28.25 Hatteras.	Off east coast of Greenland.	do	
14	Sept. 10-15	Extreme western Caribbean. <sup>1</sup>	Yucatan Peninsula north of Payo Obispo and over Tampico, Mexico.	Hurricane winds	28.34 Tampico	Interior of Mexico	do	
15	Sept. 16-24	Western Caribbean. <sup>2</sup>	Yucatan Peninsula south of Cozumel and later a short distance south of Tampico.	do	Steamship <i>Virginita</i> , 27.44.	do	do	Great damage around Tampico.
16	Sept. 27, Oct. 4	Near St. Martin	None			Northeast of Bahamas.	Minor disturbance.	
17	Sept. 28-30	Northwest of Isthmus of Panama <sup>1</sup>	British Honduras south of Belize.			British Honduras	Very weak disturbance.	
18	Oct. 1-9	Western Caribbean. <sup>1</sup>	Western Cuba	Steamship <i>Kaia Kindsen</i> in Bahamas 150.*	Steamship <i>Kaia Kindsen</i> , 28.31.	Merged with another storm off British Isles.	Hurricane	
19	Oct. 26-30	Some distance northeast of Bahamas.	None	Hurricane winds	Steamship <i>Phoebus</i> 28.20.	Labrador	do	
20	Oct. 28, Nov. 7	South of Jamaica <sup>1</sup>	Western Jamaica, eastern Cuba.	Steamship <i>E. W. Sinclair</i> , 50 NE.	Santiago, 29.68	Southeast of Bermuda.	Probably not of hurricane intensity.	
21	Oct. 16	Southwest Caribbean. <sup>1</sup>	Nicaragua near Bluefields.	Bluefields 36 SW.	Bluefields, 29.40	Interior of Nicaragua	Doubtful	

\* Estimated.  
<sup>1</sup> Approximate place of origin.

<sup>2</sup> Well developed when first appeared in field observation.  
<sup>3</sup> Probably originated near the Cape Verde Islands on Aug. 13.

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