THE HURRICANE-TORNADO

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ABSTRACT

Climatological data in recent years have become sufficient for the further study of tornadoes which occur in hurricane systems. Several characteristics of the hurricane tornado are determined from data for an 8-yr. period by plotting the center positions of each hurricane and its associated tornadoes. The data show: (1) a comparison between hurricane and non-hurricane tornadoes; (2) a "Significant Sector" for tornado-genesis; (3) a "Preferred Quadrant" of the hurricane for tornado-genesis; (4) the most favorable time of day for tornado occurrence; (5) tornado frequencies with respect to various speeds and distances of the hurricane on and off shore; (6) a tenative hurricane model.

1. INTRODUCTION

Although considerable research has been done on the forecasting problems presented by both tornadoes and hurricanes, relatively little investigation has been made into the forecasting problems of tornadoes associated with hurricanes. In this study of the hurricane-tornado problem, a climatological analysis has been made by plotting the center position of each hurricane and its associated tornadoes.

Recognition of hurricane tornadoes prior to 1955 was apparently limited—unless there has been a sudden rash of hurricane-tornadoes in recent years, for since 1955, the number of tornadoes reported with hurricanes has more than tripled. It is likely that the reporting system has improved rather than that there has been an actual increase in the number of hurricane-tornadoes. Data previous to 1955 were therefore considered insufficiently complete to be included in the study.

The data sources used were the U.S. Weather Bureau records [5, 6, 7]. The criteria for inclusion in this study were: (1) the tornado occurred within the cyclonic circulation of the hurricane; (2) some type of verification was possible.

In early studies, only brief statements were made with the limited data sample that was available. In one of the earliest studies, Mitchell [1] stated that the right-rear quarter of the hurricane produced the most tornadoes. As the data sample increased, Dunn [2] concluded that sufficient information was not available to designate which quadrant of the hurricane produced the most tornadoes. Malkin and Galway [3] stated that tornadoes had been observed only in the forward semicircle of the hurricane.

As the data sample increased (tripled), more definite patterns developed and the previous remarks can now be adjusted. It will be shown that an area of greatest concentration of tornadoes within a hurricane can be delineated. This area will be called the "Significant Sector." It will also be shown that one quadrant of the hurricane has more tornadoes than the others and this will be called the "Preferred Quadrant." Other significant patterns are established from the relationship of the tornado to the hurricane.

2. GENERAL CLIMATOLOGY

Of 15 hurricanes that entered the United States from the Gulf of Mexico and through the Atlantic Coastal States, 11 produced tornadoes. A total of 98 tornadoes was produced during the period from hurricane Connie in August 1955, to hurricane Carla in September 1961. Of the hurricanes producing tornadoes, the average number of tornadoes per hurricane is 9, although hurricanes Audrey and Carla spawned more than 20 tornadoes each.

Hurricane paths from the time of occurrence of the first known to the last known tornado produced by the hurricane are plotted in figure 1. The geographical location of these tornadoes is shown in figure 2. These figures show that hurricanes moved inland with greater frequency through the Gulf Coast States than through the Atlantic Coast States and that tornadoes occurred in greater number in the Gulf Coast States than in the Atlantic Coast States. Of the tornadoes produced by these hurricanes, the greater number was produced by the Gulf Coast hurricanes (see Appendix).

By States, Alabama ranks first with 20 hurricane-tornadoes. Texas and Louisiana are second with 14 each. The northern and western limits of the hurricane-tornadoes are Vermont and Oklahoma. The southern and eastern limits are unknown, but they have been reported in Cuba and the Bahamas [2].

Table 1 shows that tornadoes occurred in all the months of the hurricane season in 1955–1961, and that the seasonal

TABLE 1.—*Monthly distribution of hurricanes and tornadoes during the hurricane season, 1955–1961*

	June	July	August	September	October
Hurricanes	1	2	2	5	1
Tornadoes	23	16	8	50	1

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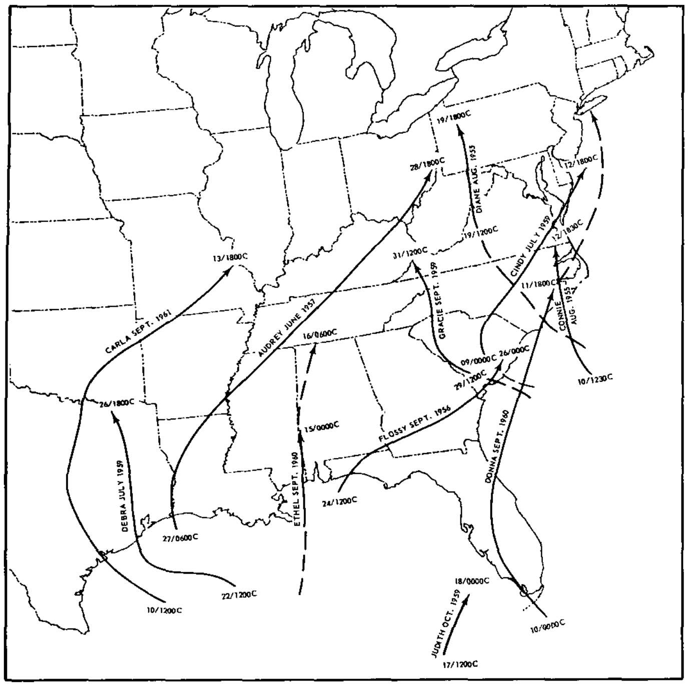

FIGURE 1.—Approximate paths of hurricanes during the occurrence of associated tornadoes, 1955–1962. Date-time groups are to the nearest 6-hr. synoptic map time.

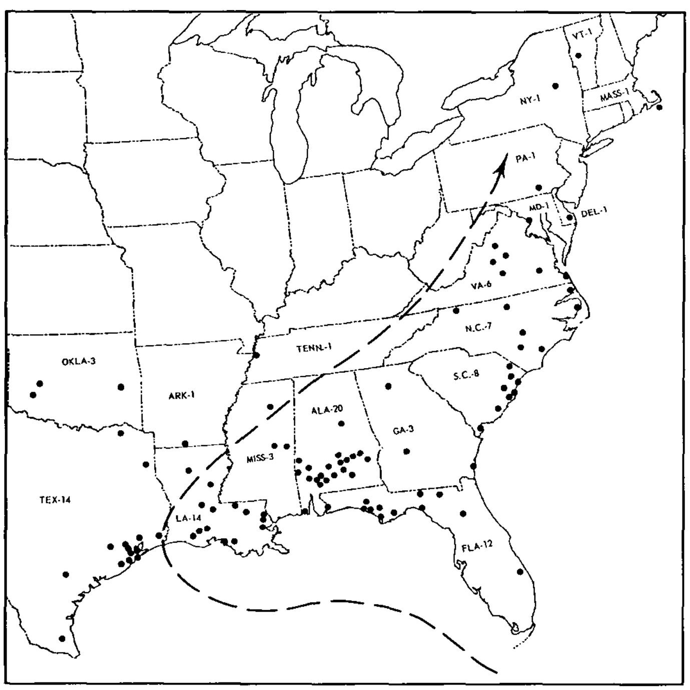

FIGURE 2.—Known hurricane tornadoes from 1955 to 1962. Dashed line is path of the tornado-producing hurricane model.

maximum occurred during the month of September. Five hurricanes spawned 50 tornadoes during this month. The seasonal minimum occurred in the month of October with one hurricane producing only one tornado.

3. TORNADO COMPARISONS

In comparing hurricane and non-hurricane tornadoes, it is noted that the non-hurricane tornado is approximately twice as large in path length and width. Because of the conditions within a hurricane, less than half of the tornado reports included details on path length, width, direction of movement or related statistics; however, the statistics that were available are worth noting and comparing although they may change with improved and more numerous data. Based on 35 reports, the hurricane-tornado traveled on the ground an average distance of 7.6 mi. and had an average width of 97 yd. The non-hurricane tornado had an average path length of 16 mi. on the ground [8] and an average width of 250 yd. [9].

The largest reported dimensions of a hurricane-tornado were a length of 35 mi. and a width of 800 yd. These figures are an order of magnitude smaller than the largest for the non-hurricane tornado [8].

The only apparent similarity in the statistics of the two types of tornadoes is their direction of travel. The predominant direction of travel for both types was to the northeast (8-point scale). The second most frequent direction of movement was to the northwest for the hurricane-tornado as compared to an eastward direction for the non-hurricane tornado.

Hailstorms reported within the vicinity of the hurricane tornadoes were rare (7 cases), but it is interesting to note that all 7 cases occurred in the right quadrants of the hurricane. Some of the hurricane centers were over land and some over sea during the occurrence of hail. The size of the hailstones ranged from ¼ in. in diameter to the size of golfballs. Duration of the hailstorms varied from a few minutes to half an hour (see Appendix).

4. CHARACTERISTICS OF THE HURRICANE TORNADO

Spatial distribution of tornadoes associated with hurricanes is shown in figure 3. Distance from tornado occurrence to the hurricane center was measured from the location of the tornado to the hurricane's center position at the synoptic time nearest to the time of the tornado. Quadrants were determined by the direction of the hurricane's motion during the time of tornado occurrence. The hurricane center positions at synoptic observation times were considered to be more accurate and consistent than center positions given by hourly sources.

The most significant information revealed by figure 3 is the high concentration of tornadoes (55 tornadoes—56 percent of the cases) in the area between the radii at 30° and 120° from the path of the hurricane's movement and 100 mi. to 250 mi. from the hurricane center. This area will be referred to as the "Significant Sector" of the hurricane. The Significant Sector contained the largest number of tornadoes whether the hurricane center was over land or sea. Of the tornadoes within this area, 61 percent occurred when the hurricane center was over land.

By quadrants, the maximum number (46 tornadoes—

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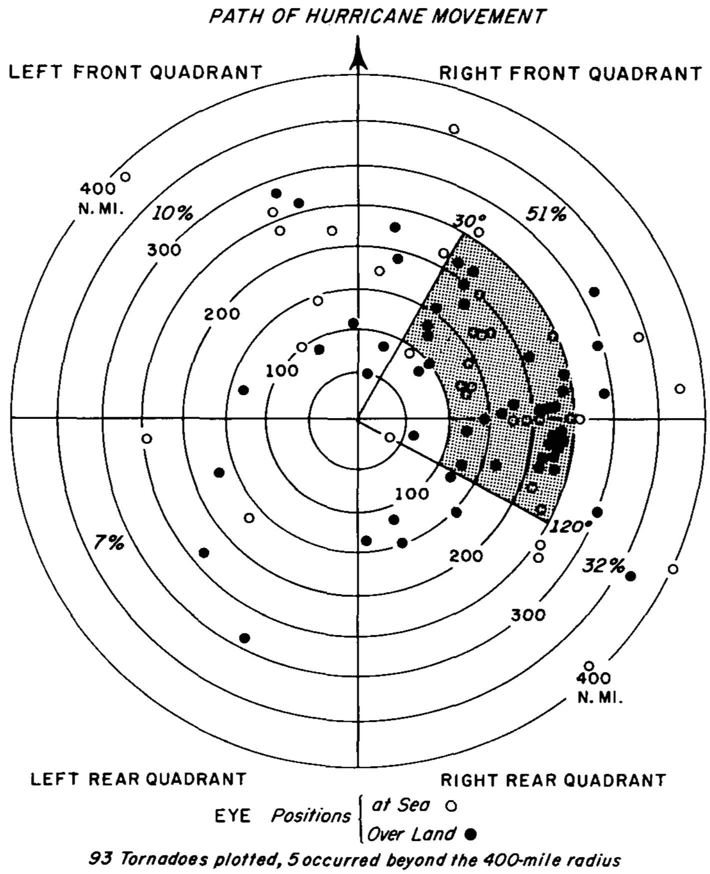

Figure 3.—Tornadoes associated with hurricanes (1955–1962) with reference to center and direction of movement of the hurricanes. Hurricane center positions at sea and over land are shown by open and solid circles respectively. Range marks are 50 n. mi. apart. "Significant Sector" (shaded area) contains 56 percent of the tornadoes.

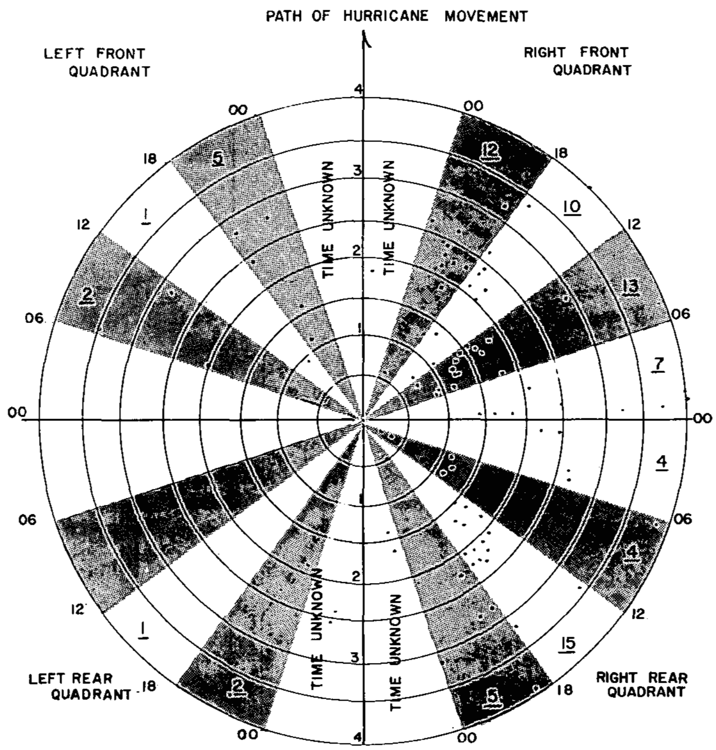

Figure 4.—Each quadrant's tornadoes are plotted into four 6-hr. time periods (alternate shaded areas). Distances of tornadoes are estimated in the unknown-time sectors. Time is GMT.

51 percent) occurred in the right-front quadrant. This quadrant is therefore designated at the "Preferred Quadrant." Fifty percent of the tornadoes in the Preferred Quadrant occured during the hurricane's movement over land. The second greatest number per quadrant (29 tornadoes—32 percent) occurred in the right rear quadrant. Seventy-five percent of the tornadoes in this quadrant occurred when the hurricane center was over land. In all quadrants, 62 percent of the tornadoes occurred with the hurricane center over land.

The most favorable time of day for the development of the hurricane-tornado has varied with the size of the data sample. At one time, Brooks [4] found that 80 percent of all the cases occurred between 1800 and 0300 GMT. In a later study, Malkin and Galway [3], using a larger data sample, found no apparent time period favored over another. The size of the data sample used by Malkin and Galway was approximately 25 cases; however, less than 50 percent gave tornado observation times to the nearest hour. In this study 80 tornadoes (82 percent) occurred between 0900 and 2100 GMT (fig. 4).

To increase further the usability of figure 3, each quadrant's tornadoes were plotted into four 6-hr. time sectors (fig. 4) to determine the most favorable time period per quadrant. The time sectors marked "unknown" were used when tornado observation times were reported as late afternoon, etc. Distances from tornado to hurricane center were estimated from the tornado location to the nearest 6-hr. position of the hurricane.

Optimum time frequency per quadrant is most clearly defined by the cluster of tornadoes in the right rear quadrant between 1200 and 1800 GMT. The center of the cluster is about 200 mi. from the hurricane center and has a radius of about 50 mi. Fifty-one percent of the tornadoes in the right-rear quadrant occurred in this cluster.

In the right-front quadrant, there are two clusters of occurrences at center distances of 140 mi. and 225 mi. from the hurricane center. The time periods of the clusters are 0900 to 1200 GMT and 1500 to 2100 GMT, respectively. Sixty percent of this quadrant's tornadoes are in these two clusters.

The reliability of these quadrant time frequencies is questionable because of the small data sample of each quadrant; however, because of the high ratio of tornadoes in each cluster to the total number of tornadoes in each quadrant, these time frequencies may be sufficiently reliable for limited use when applied with other probabilities.

The distribution of tornado frequency as a hurricane moves from the sea to inland areas is shown in figure 5.

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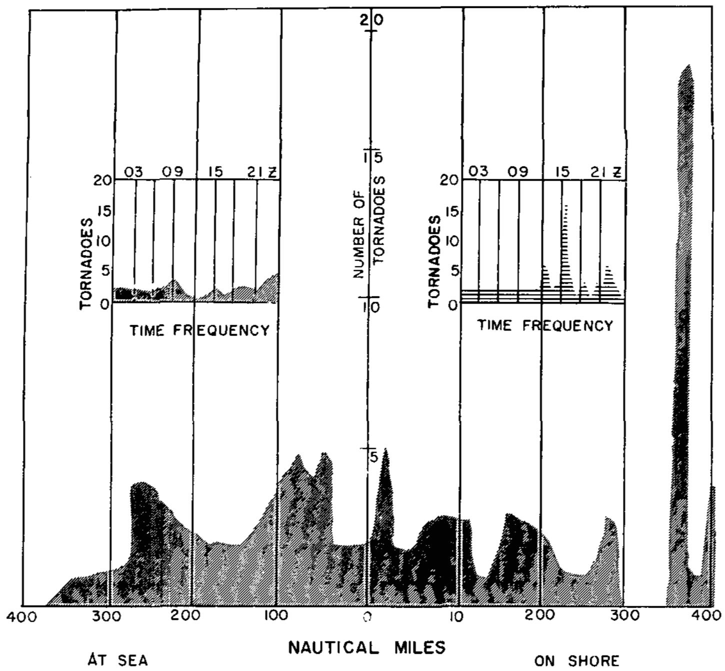

Figure 5.—Tornado frequencies with respect to the distance of the hurricane center from the coast line (point zero). Time frequencies (inset) of tornado occurrences with respect to hurricane center positions at sea and over land.

Distance from the coast line (point zero in the figure) was determined from the actual path and coastal entry point of each hurricane. The first significant increase in number of tornadoes occurred as the hurricane center reached a distance of about 275 mi. from the coast (offshore). A second increase in tornado frequency occurred as the hurricane center reached the vicinity of the coast (75 mi. at sea to 25 mi. on shore) and the peak frequency occurred after the hurricane had traveled some 375 mi. over land.

In plotting the individual hurricane-tornadoes (see Appendix) of these three frequency peaks it was noted that tornado outbreaks (several tornadoes occurring in a 6-hr. time period) occurred more often with the coastal area and 375 mi. inland peaks than when the center was 275 mi. at sea. The only significant time period (inset time graphs) occurred at 1600 GMT during the maximum frequency over land.

The frequency of occurrence of hurricane-tornadoes in relation to varying speeds of the hurricane is shown in figure 6. The figure is divided into periods when the hurricane center was at sea and over land. It clearly shows that the number of tornado occurrences varied directly with the speed of the hurricane's movement over land and inversely with the speed of the hurricane's movement at sea. In general, as the hurricane progressed from the sea to inland areas, the maximum frequency of tornadoes (60 percent) occurred when the speed of the hurricane was 0.5° to 1.5° of latitude per 6 hr. (5–15 kt.). The frequency then slowly decreased to the minimum at 2.5° to 3° of latitude per 6 hr. (25–30 kt.) and then

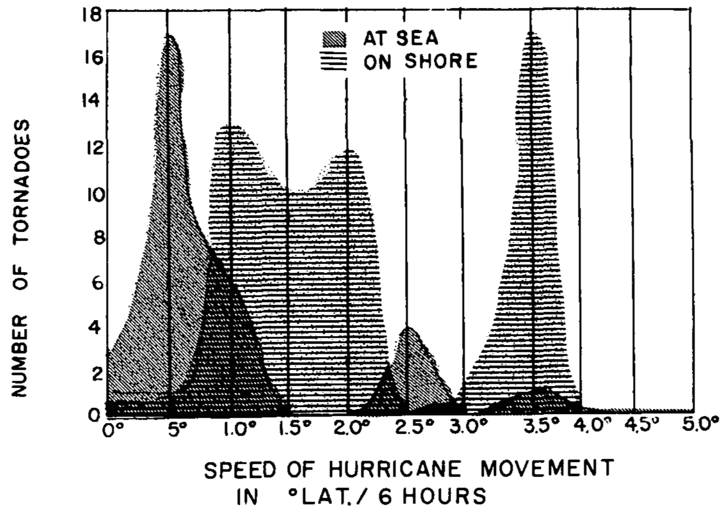

Figure 6.—Tornado frequencies with respect to the speed of the hurricane at sea and over land.

increased again at a speed of 3.5° of latitude per 6 hr. (35 kt.).

During the period when the hurricane center was at sea, a maximum tornado frequency occurred with a hurricane speed of 0.5° of latitude per 6 hr. (5 kt.). A second but much smaller tornado frequency peak occurred with a hurricane speed of 2.5° of latitude per 6 hr. (25 kt.).

As the hurricane center moved inland from the coast line, the first maximum frequency occurred as the hurricane accelerated to a speed of 2° of latitude per 6 hr. (20 kt.). As the hurricane continued to accelerate the frequency diminished rapidly at 2.5° to 3° of latitude per 6 hr. (25–30 kt.) before increasing sharply at the speed of 3.5° of latitude per 6 hr. (35 kt.).

5. TENTATIVE HURRICANE MODEL

By combining the characteristics related to maximum tornado possibilities, we can construct the tentative pattern of a tornado-producing hurricane model. This hurricane model under certain conditions would be capable of producing a maximum number of tornadoes. The primary conditions necessary are a prescribed motion vector for the hurricane, and its entry on shore during the most favorable time period for tornado occurrence.

In direction, the hurricane should follow an approximate path (fig. 2) from 2° longitude west of Key West, Fla., to 2° latitude south of Lake Charles, La., and then recurve northward to enter the coast in the vicinity of Beaumont, Tex. From this point the hurricane should continue to recurve and move north-northeastward to northeastern Louisiana, extreme northwestern Alabama, and to central Pennsylvania.

The speed of the hurricane in the vicinity of Key West, Fla., should be approximately 0.5° of latitude per 6 hr. This same speed should be maintained in the area south of Louisiana until the hurricane has recurved and entered the coast. The hurricane should then accelerate to 1.5°

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of latitude per 6 hr. through southern Louisiana, then accelerate to, and continue at, the speed of 3.5° of latitude per 6 hr. from Mississippi northeastward to Pennsylvania.

With this prescribed direction and speed of the hurricane, it can be seen that the maximum tornado possibilities described in the previous section can be attained, with the maximum number of tornadoes occurring from Texas eastward to Alabama.

6. CONCLUSIONS

The more significant of the findings from this sample of data are:

1. The average hurricane-tornado was about 50 percent smaller in path length and width than the average non-hurricane tornado.
2. The predominant direction of travel of the hurricane-tornado was to the northeast.
3. A greater number of tornadoes occurred with hurricanes moving inland over the Gulf Coast than over the Atlantic Coast.
4. A greater number of tornadoes occurred when hurricane centers were moving over land rather than over the sea.
5. The right front quadrant, with 51 percent of the tornadoes, was the "Preferred Quadrant."
6. A "Significant Sector" of the hurricane can be delineated by the radii at 30° and 120° from the path of the hurricane's movement and between 100 mi. and 250 mi. from the hurricane center.
7. The frequency of tornadoes was inversely proportional to the speed of the hurricane at sea and directly proportional to the speed of the hurricane over land.
8. The maximum frequency probability (60 percent) of tornadoes occurred when the speed of the hurricane was 0.5° to 1.5° of latitude per 6 hr. (5–15 kt.).
9. The maximum frequency of tornadoes in a hurricane moving from the sea to inland areas occurred when the hurricane center was (1) 275 mi. from the coast; (2) 75 mi. at sea to 25 mi. inland; (3) 375 mi. inland from the point of its entry on shore.
10. Hurricanes accelerating over land with an easterly component produced more tornadoes than those with a westerly component.
11. Hurricanes moving slowly at sea with a westerly component produced more tornadoes than those with an easterly component.

APPENDIX

This Appendix contains a list of known hurricane tornadoes from 1955 through the 1961 hurricane season. Tornadoes are listed under the hurricane from which they were spawned; location, date, and time are given. Comments considered pertinent are made in the remarks section. Tornado path lengths and widths are given in miles and yards, respectively. "Direction" means direction toward which the tornado moved. Time is Central Standard (unk=unknown).

HURRICANE CONNIE

August 10–12, 1955

Place	Date/Time	Remarks
13 NW Myrtle Beach, S.C. Conway, S.C. Horry Co.	10/1330	PATH: Short, 200 yd. DIRECTION: W DAMAGE: Leveled svrl bldgs. INJURIES: 4
30 ENE Florence, S.C. 6 NE Dillon, S.C. Dillon Co.	10/1700	PATH: 8 mi., 75 yd. DIRECTION: WSW
21 N Wilmington, S.C. Penderlea, N.C. Pender Co.	10/1730	PATH: 1 mi., 50 yd. DIRECTION: W DAMAGE: 5 barns
27 SSW Myrtle Beach, S.C. Near Georgetown, S.C.	10/unk	
Georgetown, S.C.	10/unk	
35 ENE Salisbury, Md. Bethany Beach, Del. Sussex Co.	12/1500	PATH: 3 mi., 50 yd. DIRECTION: WNW DAMAGE: Timber—bldgs.

HURRICANE DIANE

August 19, 1955

Place	Date/Time	Remarks
38 ESE Harrisburg, Pa. Honey Grove, Pa. Lancaster Co.	19/unk	DAMAGE: Farm crops, barns.
Nantucket, Mass.	19/unk	Funnel cloud near ground

HURRICANE FLOSSY

September 24–25, 1956

Place	Date/Time	Remarks
60 WSW Tallahassee Wewahitchka, Fla. Gulf Co.	24/1300	PATH: 20 mi. DIRECTION: NNE
35 ESE Tallahassee Eridu, Fla. Taylor Co.	24/early eve	PATH: 5 mi. DIRECTION: NNE DAMAGE: Bldgs. and timber
30 NNE Cross City, Fla. Srn Pth of Suwannee Co., Fla.	24/2000	PATH: 3 mi., 50 yd. DIRECTION: NNE DAMAGE: Bldgs.
50 WNW Daytona Beach, Fla. Candler, Fla.	25/early p.m.	PATH: Short, narrow DAMAGE: Home and timber
20 NNE Savannah, Ga. Hiltonhead, S.C. Beaufort Co.	25/2200	PATH: ½ mi., 35 yd. DIRECTION: NNW DAMAGE: Sheds, barns

HURRICANE AUDREY

June 27–28, 1957

Place	Date/Time	Remarks
15 NE New Orleans, La. Michaud, La.	27/1000	DIRECTION: NE Seen on radar.
30 N Lafayette, La. Arnaudville, La.	27/1030	DIRECTION: NE DAMAGE: Svrl houses damaged and trees uprooted.
8 W Dyersburg, Tenn. Tennessee	27/1832	PATH: 100 yd. long DAMAGE: Saw mill and barn destroyed. Trees uprooted.
36 NW Meridian, Miss. 3 W Philadelphia, Miss.	27/2030	PATH: 50 yd. wide DAMAGE: 5 houses destroyed. INJURIES: 9
80 SE Memphis, Tenn. 4 N Houston, Miss.	27/2210	DIRECTION: N DAMAGE: Considerable
65 N Meridian, Miss. Brookfield, Miss.	28/0032	PATH: 10 mi., 50 yd. DIRECTION: NE DAMAGE: 7 houses destroyed. INJURIES: 1 fatality
55 SSE Meridian, Miss. Clara, Miss.	28/0735	PATH: 10 mi., 50 yd. DIRECTION: NE DAMAGE: Many houses and a school
77 N Mobile, Ala. Whetly, Ala.	28/0830	PATH: 3 mi., 100 yd. DIRECTION: NE DAMAGE: 2 houses and garages, timberland
36 S Selma, Ala. Oakhill, Ala.	28/0850	PATH: 2 mi., 35 to 100 yd. DAMAGE: Church and timberland

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3 NW Evergreen, Ala.	28/0927	Stn abandoned. Fish and crayfish fell with precip.
20 SW Montgomery, Ala. 3 S Haynesville, Ala.	28/0935	PATH: 13 mi., 120 yd. DIRECTION: NE to Hope Hull, Ala. DAMAGE: Houses and barns. When one home destroyed, owner inside said dark mist was present surrounding home area.
20 W Evergreen, Ala.	28/0945	PATH: 20 mi., 150 to 400 yd. DAMAGE: 7 houses
25 W Evergreen, Ala. Frisco City, Ala.	28/1002	PATH: 4 DIRECTION: NE to Excell, Ala. DAMAGE: Svrl bldgs mostly at Excell INJURIES: 8 Funnel cloud passed over city abt 5 min. prev to tornado
45 SSW Montgomery, Ala. 6 SW Greenville, Ala.	28/1015	PATH: 14 mi., 125 yd. DIRECTION: NE DAMAGE: To Jr. College
5 W Evergreen, Ala. nr arpt	28/1025	PATH: 10 mi., 150 yd. DIRECTION: NE DAMAGE: House and store barn. On ground 50 percent of time.
6 W Evergreen, Ala.	28/1025	PATH: 1 mi., very narrow DIRECTION: NE Abt 500 yd. NW from tornado listed above.
20 SSW Montgomery, Ala. Davenport, Ala.	28/1000–1100	PATH: 35 mi., 150 to 200 yd. and skipping DIRECTION: NE from 2S Ft. Deposit to Sprague Junct. Abt. 1100 CST at Sprague Junct.
16 ENE Evergreen, Ala. Brooke, Ala.	28/1100	PATH: 12 mi., 200 yd. DIRECTION: NE DAMAGE: Considerable INJURIES: 2
45 S Montgomery, Ala. Luverne, Ala.	28/1105	DIRECTION: NE thru Luverne, Ala. DAMAGE: Open country.
20 S Montgomery, Ala. 1 N of Sellers, Ala.	28/a.m.	PATH: Short, 100 yd. DIRECTION: NE DAMAGE: Timber
20 SE Montgomery, Ala. Downing, Ala.	28/a.m.	PATH: 5 mi., 150 yd. DIRECTION: NE DAMAGE: House and barn. On ground 75 percent of time.
40 ESE Montgomery, Ala.	28/1207	PATH: Short, 150 yd. DIRECTION: NE DAMAGE: House and barn.
65 ESE Montgomery, Ala. Batesville, Ala.	28/1745	PATH: 14 mi., 100 yd. DAMAGE: 2 houses and barns INJURIES: 1

HURRICANE CINDY

July 9–12, 1959

35 NNE Jacksonville, Fla. 30 SE Brunswick, Ga.	9/0126	Near shore line
Vcnty South Annapolis River, Md. Anne Arundel Co.	10/0557	DAMAGE: Considerable
Vcnty Elizabeth City, Pasquotank Co.	10/0700	DAMAGE: Home, church
Vcnty Norfolk, Va. Portsmouth, Va.	10/0730	PATH: Short, narrow. DIRECTION: NE DAMAGE: Svrl houses. Possibility of 2 tornadoes.
23 SE Richmond, Va. Charles City, Va.	10/1025	PATH: Short, narrow DAMAGE: Barns Accompanied by funnel cloud
40 SE Elizabeth City, N.C. Nags Head, N.C.	10/1240 to 1305	PATH: 5 mi., narrow DIRECTION: NE DAMAGE: Houses and trees INJURIES: 1
30 NNE Albany, Ga. Vienna, Ga. Dooly Co.	10/1622	PATH: Short, narrow DAMAGE: Considerable INJURIES: 1 Hail downtown Columbus, Ga.
70 SW Roanoke, Va. Btn Potato Creek, Va. Turkey Knob, N.C.	10/aftn	PATH: Unk., 300 yd. DAMAGE: Trees, tobacco crops, barns—hail and wind damage. Also funnel cloud.
35 NNE Atlanta, Ga. Cumming (35E) Forsyth Co., Ga.	11/1500	PATH: Short, narrow DIRECTION: N DAMAGE: Docks, boats, resort area INJURIES: 6
38 NNW Albany, N.Y. Sacandaga Reservoir North Broadalbin, N.Y.	12/late aftn	PATH: Short—narrow DAMAGE: Considerable—timber INJURIES: 5
Troy, Vermont	12/aftn	Hail to 1 in. at Troy.

HURRICANE DEBRA

July 20–26, 1959

20 ESE Beaumont, Tex. Jefferson Co. Arpt	20/1117–1120	Several funnels and hail to 1 in.
35 WNW Law Mountain Park Kiowa Co., Okla.	22/1830	PATH: 20 mi., 2 mi. DIRECTION: SW DAMAGE: Svrl homes, trees, out bldgs. Hail golf ball size.
50 WSW Oklahoma City, Okla. Albert, Okla. Caddo Co.	22/1900	PATH: ½ mi., ¼ mi. DAMAGE: Trees, barns. ½ in. svr hail storm
35 NNW Brownsville, Tex. Sebastian, Tex. Willacy Co.	24/1750	
58 SE San Antonio, Tex. 10 NW Kennedy, Tex.	26/night	PATH: Small DAMAGE: Barns

HURRICANE GRACIE

Sept. 29–30–Oct. 1–2, 1959

23 N Raleigh-Durham, N.C. Butner, N.C. Granville Co.	29/1320	DAMAGE: Bldg roofs, trees.
55 NE Charleston, S.C. Garden City, S.C. Horry Co.	30/early mrng	
70 NNE Lynchburg, Va. Stanardsville, Va. Greene Co.	30/1500	PATH: 2 mi., 100 yd. DAMAGE: Bldgs and trees INJURIES: 1 fatality
42 NNE Lynchburg, Va. 6 W of Charlottesville Ivy, Va.	30/1530	PATH: ¾ mi., 200 yd. DAMAGE: Houses, trees INJURIES: 11 fatalities
48 NW Richmond, Va. 3 W Palmyra, Va. Fluvanna Co.	30/1645	PATH: 6 mi., ½ mi. DAMAGE: 14 houses, churches, barns, trees.

HURRICANE JUDITH

October 17, 1959

35 NNW West Palm Beach, Fla. Stuart, Fla. Martin Co.	17/1430	

HURRICANE DONNA

September 11, 1960

55 WSW Richmond, Va. Buckingham Co., Va.	10/1700	DAMAGE: svrl homes and barns. Nelson Co. Hail for 30 min.
Charleston, S.C.	11/1300–1330	PATH: 8 mi., 100 yd. DAMAGE: Svrl houses, extensive damage. INJURIES: 10 Eye hit shore 45 mi. SW Charleston 1300, paralleled coast 20–25 m.p.h., left shore 11/1900
S Myrtle Beach, S.C. Garden City, S.C.	11/1435	

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46 NW Wilmington, S.C. Bladen Co., N.C.	11/1300	PATH: 15 mi., 800 yd. DAMAGE: Svrl bldgs.
60 NNW Wilmington, S.C. Sampson Co., N.C.	11/0600	DAMAGE: Svrl bldgs. INJURIES: 8
	HURRICANE ETHEL September 15–16, 1960	
Panama City, Fla.	15/0449	DAMAGE: Svrl houses E side
11 NW Panama City West Bay, Fla.	15/0500	PATH: Short, narrow.
1 E Panama City Springfield and Millvale, Fla.	15/0500	PATH: ½ mi., 200 yd. DIRECTION: NW
20 NW Apalachicola, Fla. Port St. Joe, Fla.	15/0655	PATH: Short—narrow. DIRECTION: NNW
48 SW Tallahassee, Fla. Sumatra, Fla.	15/0940	DIRECTION: NE
12 NE Apalachicola, Fla.	15/0950	DIRECTION: NE
Vcnty Pensacola, Fla. St. Rosa Island, Fla.	15/unk	PATH: Short, narrow Several funnel clouds over Fla. panhandle small hail 0500 NAS PNS
70 NNE Mobile, Ala. Gosport, Ala. Clarke Co.	15/night	PATH: Short, narrow DAMAGE: Barn, house, trees, crops.
40 SE Birmingham, Ala. Sylacauga, Ala. Talladega Co.	16/0020	PATH: ¼ mi., 50 yd. DIRECTION: N DAMAGE: Bldgs, autos INJURIES: 2
	HURRICANE CARLA September 10–13, 1961	
20 S Mobile, Ala	10/1455	PATH: ½ mi., narrow DIRECTION: NW (Moved inland from sea.) DAMAGE: Svrl houses
21 SW Lafayette, La. Kaplin Abbeville, La.	10/1650	DAMAGE: 150 houses INJURIES: 1 death
20 SSW Lafayette, La. Intercoastal City, La.	10/1809	
37 SW Lafayette, La. 8 S. Gueydan, La.	10/1812	
25 N. Point au Fer, La. Morgan City, La.	10/2221	
25 NNW Point au Fer, La. Paterson, La.	10/2221	
18 NNE Baton Rouge, La. Watson, La.	11/1110	Hook echo obsvd
Vcnty Houston, Tex. Bay City, Tex.	11/1147	DAMAGE: radio tower—bldgs.
15 NE New Orleans, La. Slidell, La. (at St. Joe)	11/unk	DAMAGE: Homes $25,000 INJURIES: 3
52 NNW Lufkin, Tex. Jacksonville, Tex.	11/1320	
Vcnty Houston, Tex. Channelview, Tex.	11/1750	DAMAGE: Houses $200,000 INJURIES: 22
40 NNW New Orleans, La. 6 SW Hammond, La.	11/unk	
12–15 WNW Galveston, Tex. Lamarque, Tex.	12/0230	PATH: ½ mi., 30 yd. DIRECTION: NNE DAMAGE: bldgs—houses
Galveston, Tex.	12/0305	PATH: 2.3 mi., 116 yd. DIRECTION: NNW DAMAGE: Extensive INJURIES: 7 dead, 49 injured Radar hooks indicated Entered from the sea
Galveston, Tex.	12/0400–0425	PATH: 4.7 mi., 83 yd. DIRECTION: NNW DAMAGE: Extensive—houses, bldgs Sighted on radar
Galveston, Tex.	12/0600	PATH: 2.7 mi., 167 yd. DIRECTION: N DAMAGE: Extensive
3 N Galveston, Tex. Port Bolivar, Tex.	12/0900	PATH: ⅛ mi., 66 yd. DIRECTION: NNW DAMAGE: School—houses—bldgs Sighted on radar
40 W Beaumont, Tex. Hardin, Tex.	12/0730	DAMAGE: Houses
37 SW Monroe, La. Hodge, La.	12/1300	DAMAGE: 25 houses INJURIES: 25–26 fatalities
270/65 FM Texarkana, Ark. Fulbright, Tex.	12/1645	PATH: ½ mi., 100 yd. DIRECTION: N thru town DAMAGE: Houses $45,000
50 NW Monroe, La. Junction City, La.	12/Unk	
250/18 FM Shreveport, La.	13/0500	DAMAGE: 3 houses INJURIES: 2
35 W Houston, Tex. 2 S Hockley, Tex.	13/0700	DAMAGE: Bldgs; 11,000 lb. trailer
104/116 FM Oklahoma City, Okla. Wilburton, Okla.	13/08–0900	
Vcnty New Orleans, La. Lake Ponchartrain	13/0900	
13 ENE Alexandria, La.	13/1419	DAMAGE: Trees uprooted

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