Florida Tornado Outbreaks Associated With Tropical Cyclones

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1. INTRODUCTION

The information presented in this paper is part of the continuing, comprehensive effort to document the characteristics of Florida tornadoes (Hagemeyer and Schmocker 1991,1992; Hagemeyer and Matney 1993a-b, 1994). This brief paper serves as a climatological introduction to Florida tropical cyclone tornadoes. Work continues on an in-depth investigation.

The publications Storm Data (NOAA 1959-1993), Significant Tornadoes 1680-1991 (Grazulis 1994), and Tornado Occurrences in the United States 1916-1958, (DOC 1960) were reviewed for documented tornadoes in Florida associated with tropical cyclones. Cyclone track information was obtained from the CD-ROM, Global Tropical/Extratropical Cyclone Climatic Atlas (USN/DOC 1994). An effort was made to identify tornadoes associated with hybrid cyclones (tropical and extratropical characteristic) based on lessons learned in Hagemeyer and Matney (1994), and tropical disturbances, which were not documented in the official literature.

Sixty-one tornado cases (214 tornadoes) were identified. Information on the date, system type at the time of tornado occurrence, number of tornadoes (* indicates funnel clouds and/or waterspouts reported), maximum F-Scale, time of occurrence, number of deaths and/or injuries, and location of tornadoes in Florida and in relation to storm-center movement of each case are found in Table 1.

Location of tornadoes is given by county if only one county was affected, otherwise the general area of the state is given. The general location of the tornadoes in relation to storm center movement is given as right-front quadrant (RF), left-front quadrant (LF) or near the center (cntr).

A plot of tornado reports by county is shown in Figure 1. The monthly distribution of tropical and hybrid cyclones producing tornadoes is shown in Figure 2. Figure 3, Figure 4, and Figure 5 show track segments for the approximate periods of tornado activity for each of the 52 tropical/subtropical cyclones with officially documented tracks. The nine cases (5 hybrids and 4 tropical disturbances) without official tracks are not shown on the figures. The numbers near each track segment refer to the case numbers on Table 1.

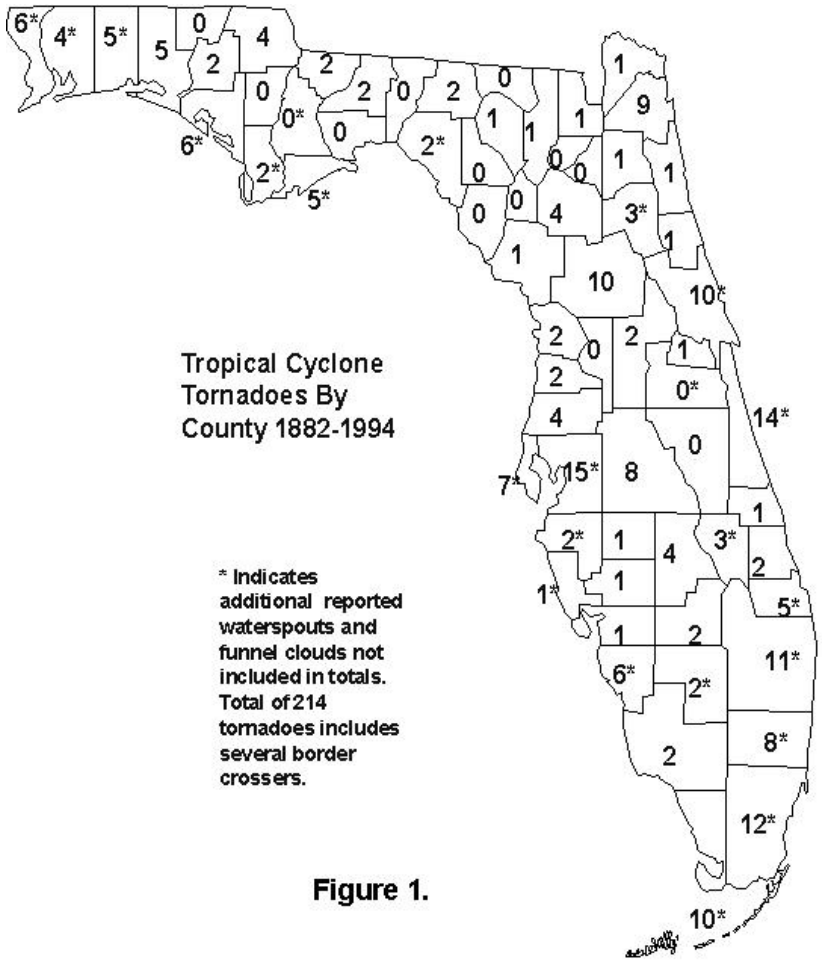

Figure 1.

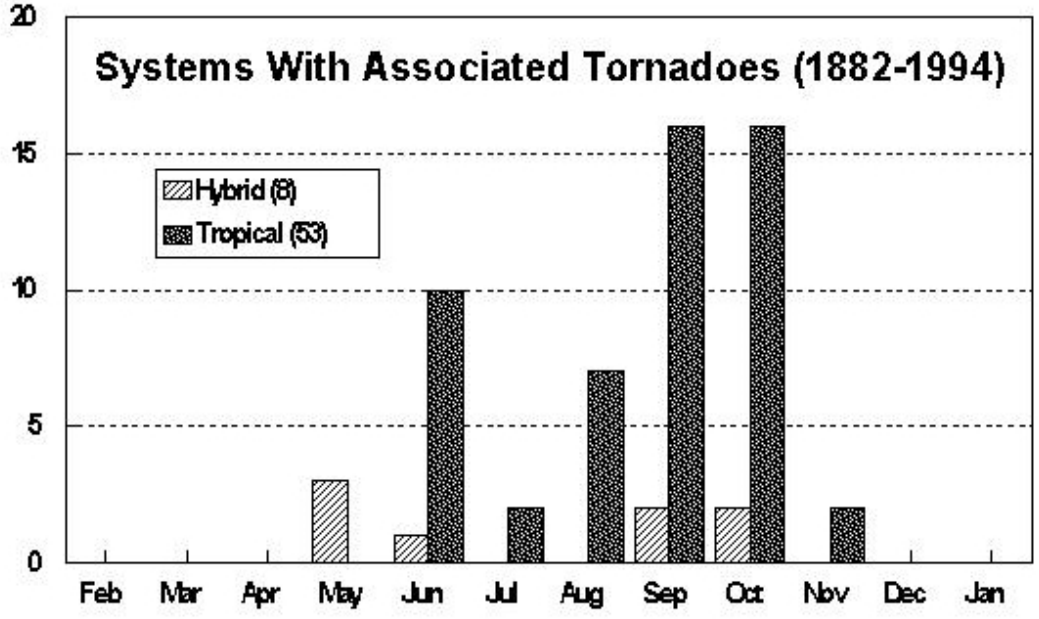

Figure 2.

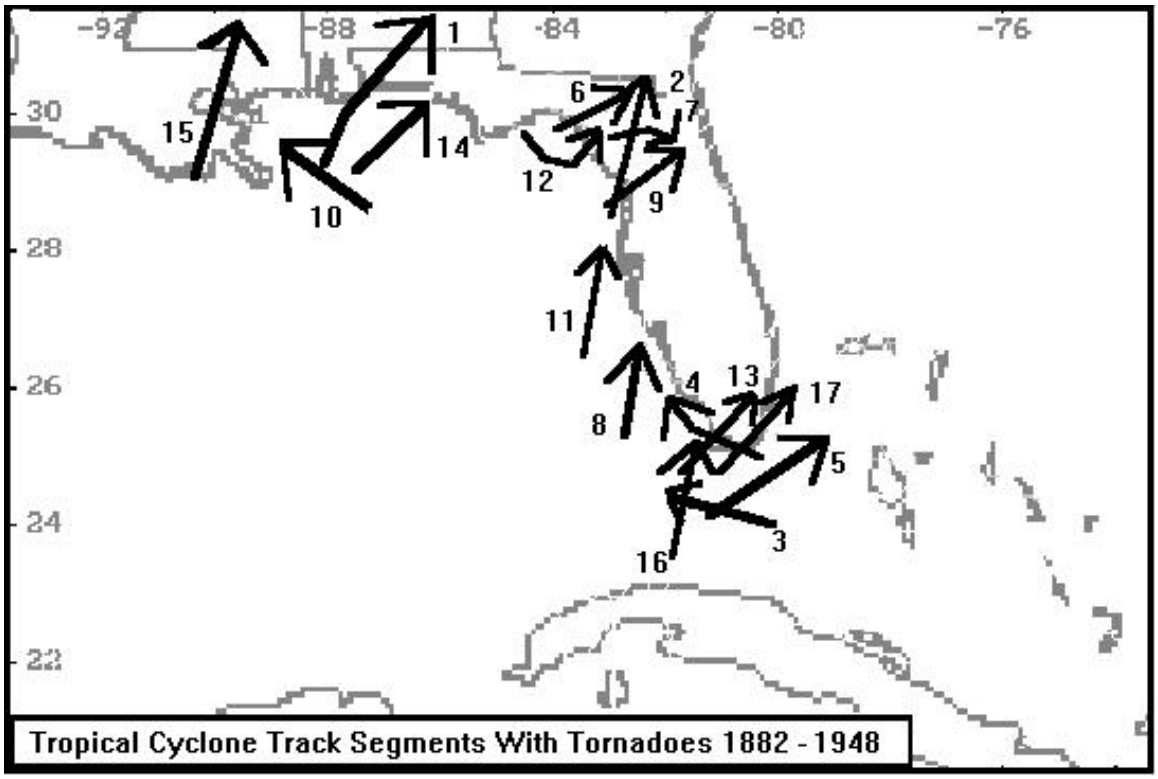

Figure 3. Tropical Cyclone Track Segments with Tornadoes 1882 – 1948.

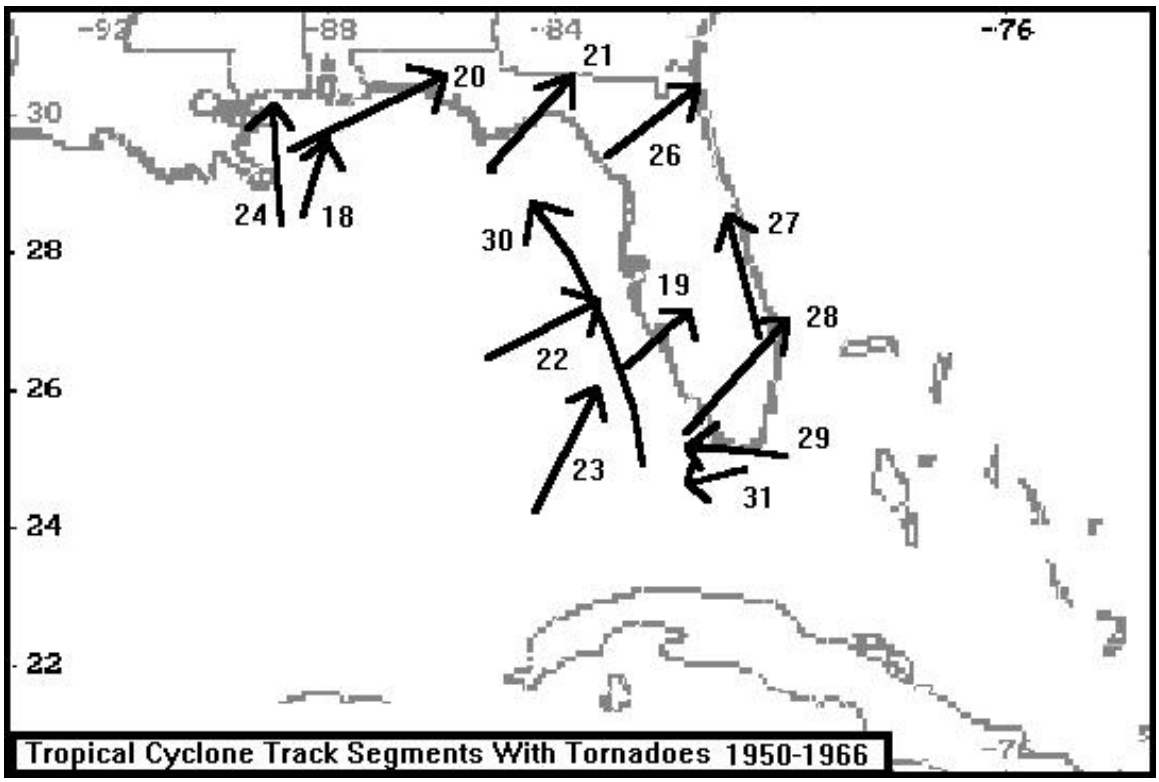

Figure 4. Tropical Cyclone Track Segments with Tornadoes 1950 – 1966.

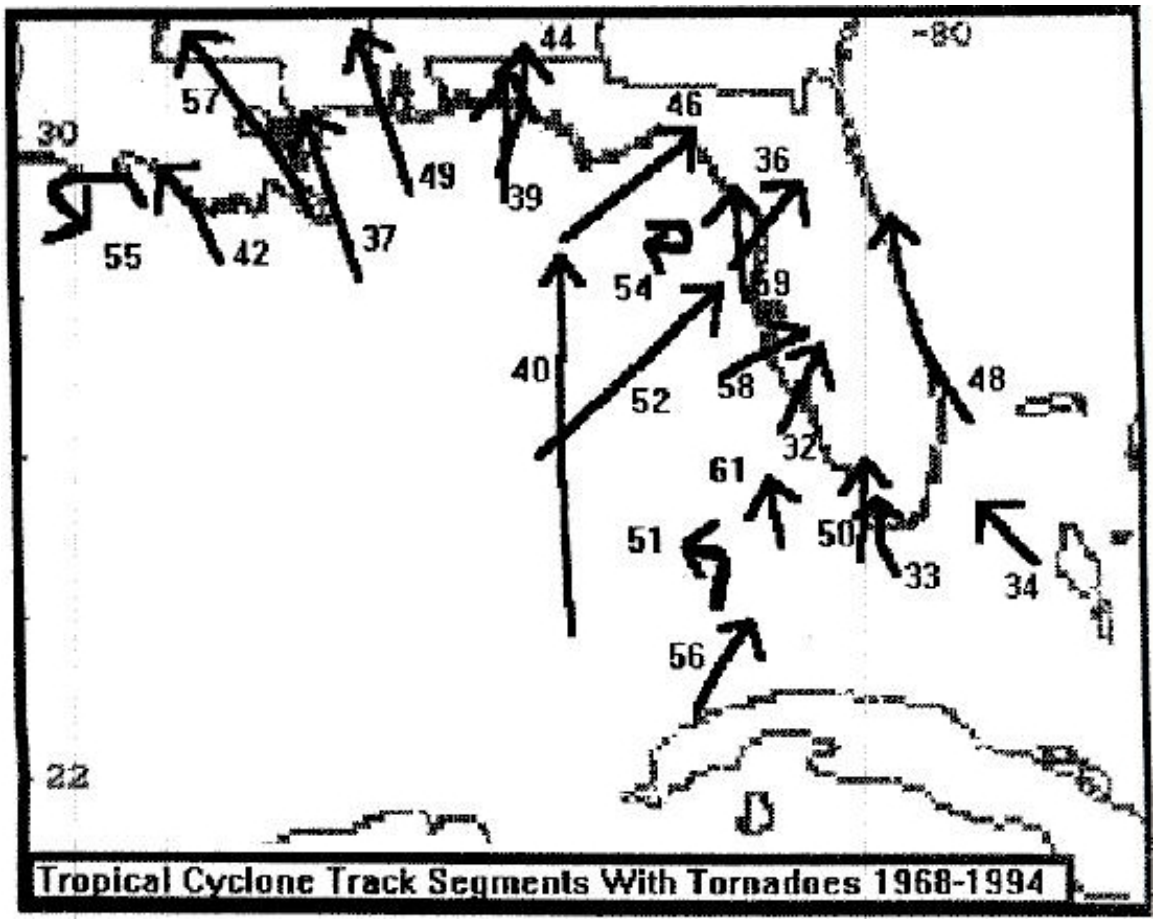

Figure 5. Tropical Cyclone Track Segments with Tornadoes 1968 – 1994.

A plot of the number of tropical/hybrid cyclone tornadoes per tornado day with power regression curve overlaid is shown as Figure 6. It can be seen that most of the days (34 out of 61) consist of only 1 or 2 tornadoes. The definition of a Florida tornado outbreak was found by Hagemeyer and Matney (1994) to be at least 4 tornadoes in 4 hours or less. Their data was dominated by extratropical cases. For the subcategory of tropical cyclone tornado outbreaks, a definition of more than 4 tornadoes associated with the system, without regard for time, seems reasonable. Based on this criterion, 14 of the 61 cases could be considered tornado outbreaks (indicated by a "star" in column 2 of Table 1). Maps of the track segments during tropical and hybrid cyclone tornado outbreaks are shown on Figure 7.

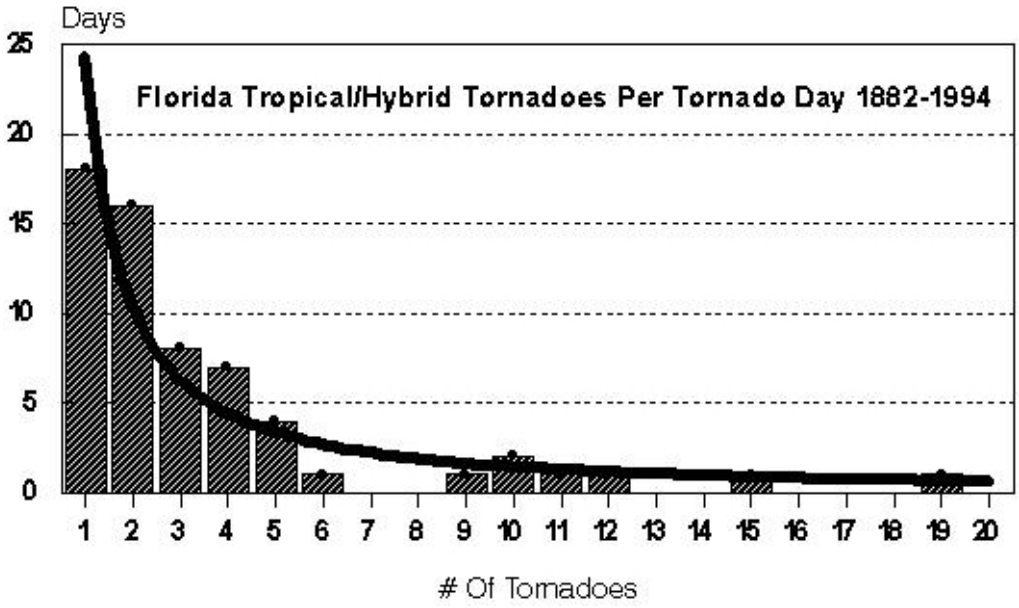

Figure 6. Florida Tropical/Hybrid Tornadoes Per Torando Day 1882 – 1994.

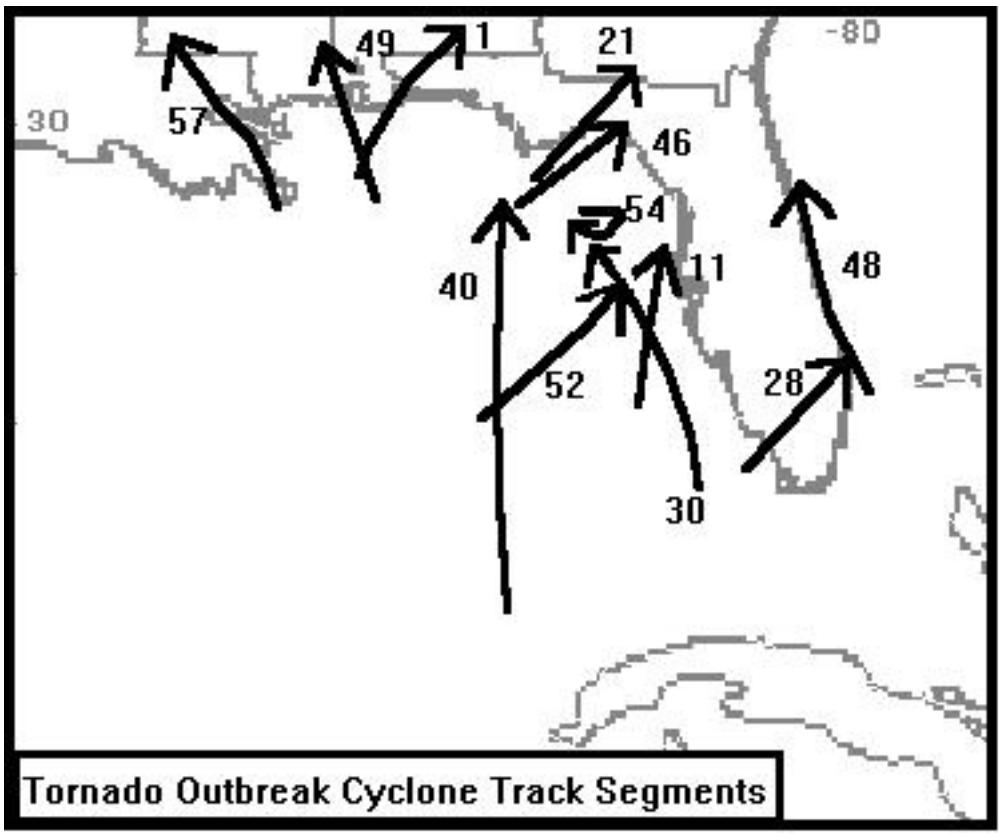

Figure 7. Tornado Outbreak Cyclone Track Segments

2. DISCUSSION

Between 1882 and 1994 only about 14% of all tropical cyclones that could have affected Florida, had reported tornadoes. Factors such as population density and reporting practices affect completeness and accuracy of the tornado database in this study, however, some useful general conclusions can be drawn.

Tornadoes were associated with 31 hurricanes, 13 tropical storms, 5 tropical depressions, 3 subtropical storms, 4 tropical disturbances, and 5 hybrid systems. The 14 tornado outbreaks were associated with eight hurricanes, 2 tropical storms, 2 subtropical storms, and two hybrids. Ten killer tornado events have been recorded, 5 through 1972, and 5 since 1979. All five since 1979, including Tropical Storm Gordon, had hybrid characteristics. This may be due to greater awareness and documentation of hybrid systems since the late 60's and below average tropical activity near Florida in the 80's, but it appears hybrid system tornadoes may be a more significant threat than purely tropical system tornadoes. Fatalities in the two deadliest outbreaks resulted from tornadoes hitting poorly constructed tenant homes (9/9/1882) and older mobile home parks (6/18/72). A strong F3 tornado with the hybrid system of 10/3/92 destroyed well-built concrete block and wood homes, killing one, but three other deaths were in mobile homes from lesser tornadoes.

The tornadoes in most of cases (53 of 61) occurred in the right-front quadrant with respect to system movement. This is consistent with previous research. Eighty-seven percent (53/61) of the systems approached Florida from the Gulf of Mexico. Outbreak storm tracks (Fig. 7) have a strong northerly component (except Elena, #54, which was looping), and only David (#48) struck the Atlantic coast. More than half of the systems produced tornadoes at/after landfall, but it is not uncommon for systems to produce tornadoes far from their centers. In 25 cases tornadoes occurred on the outer fringes of systems.

The fact that only 8 tornado events were reported near the centers of cyclones is probably due to the various complications that hinder the ability to separate distinct tornado damage from general wind damage in and near the radius of maximum winds after a storm. These 8 cases were also associated with relatively weak tropical systems without widespread general wind damage to mask tornado effects. The data is naturally biased toward tornadoes reported outside the radius of strong system winds, but this is not a problem. The essence of the tropical cyclone tornado challenge is predicting the occurrence of tornadoes outside the area where people are prepared for the maximum winds from a strong storm, and predicting tornadoes from weaker systems where tornadoes may pose the greater threat. Detailed analysis of the meteorological data for these 61 systems must be completed before further insights into the problem can be made.

TABLE 1

#	DATE	SYSTEM TYPE	#TCR	F#		DEATH/	LOCATION/STM CTR
1	9/9/1882★	HURRICANE	5+	2	EVE-AM 10TH	6/17	N CENTRAL/RF
2	10/21/85	HURRICANE	1	2	2355	0/8	ALACHUA/RF
3	9/10/1919	HURRICANE	1	2	0112	0/6	DADE/RF
4	9/28/29	HURRICANE	4	2	AFT-EVE	0/16+	SOUTH/RF
5	10/4/33	HURRICANE	3	2	EVE-AM 5TH	0/3	SOUTHEAST/LF
6	9/20/37	T. STORM	1	2	2100	0/0	ST.JOHNS/ RF
7	10/20/41	T. STORM	2	2	AFTERNOON	1/1	N CENTRAL/ RF
8	10/18/44	HURRICANE	3	1	AFTERNOON	0/0	W CENTRAL/ RF
9	6/24/45	HURRICANE	1	1	AM	0/0	BREVARD/ RF
10	9/19/47	HURRICANE	1	3	0030	2/100	FRANKLIN/ RF
11	9/22/47★	T. STORM	11	2	EVE-EVE23RD	0/1	WC-NE/RF
12	10/7/47	T.DEP.	1	2	1915	0/10	DUVAL/RF
13	10/21/47	HURRICANE	1	2	2300	0/0	DADE/ RF
14	7/9/48	T. STORM	1	2	0400	0/2	WASHINGTON/CNTR
15	9/4/48	HURRICANE	2	2	LATE EVE	2/12	PANHANDLE/RF
16	9/21/48	HURRICANE	1	2	1000	0/0	DADE/RF
17	10/5/48	HURRICANE	3+	2	AFTERNOON	0/27	SOUTHEAST/CNTR
18	8/30/50	H. BAKER	2	2	AFT-AM31ST	0/0	PANHANDLE/ RF
19	10/9/53	T.S.HAZEL	1	1	0900	0/0	LEE/ RF
20	9/24/56	H. FLOSSY	3	2	AM-EVE	0/0	NW FLORIDA/ RF
21	6/8/57★	T. STORM	6	2	EVENING	0/0	NC-NORTH/ RF
22	6/17/59	T.DEP.	*2	2	EVENING	0/77	SOUTHEAST/ RF
23	10/27/59	T.S.JUDITH	1	0	1530	0/0	MARTIN/ RF
24	9/15/60	H. ETHEL	*4	2	MORNING	0/0	BAY/ RF
25	5/2/64	HYBRID	*1	1	AFTERNOON	0/0	N & NE/RF
26	6/6/64	T.DEP.	*3	2	AFTERNOON	0/5	WC-NE/ RF
27	8/27/64	H. CLEO	3	1	EVENING	0/1	E COAST/RF
28	10/14/64★	H. ISBEL	9+	2	AFT-EVE	0/48	SE-EC/CNTR - RF
29	9/8/65	H. BETSY	2	2	AFTERNOON	0/0	KEYS/CNTR
30	6/8/66★	H. ALMA	*4+	1	AFT-AM 9TH	0/0	E. COAST/ RF
31	10/4/66	H. INEZ	2	1	EVENING	0/0	PUTNAM/ RF
32	6/4/68	T.S. ABBY	3	1	AM-AM 5TH	0/0	BREVARD/ RF
33	6/17/68	TD (BRENDA)	*1	0	AM-AFT	0/0	KEYS-SE/ RF
34	8/9/68	TD (DOLLY)	*1	1	AFTERNOON	0/0	SW-W/LF
35	8/29/68	T.DIST	2	1	MORNING	0/0	VOLUSIA/RF
36	10/17/68	H. GLADYS	*2	2	AM-PM 18TH	0/0	W CENTRAL/RF
37	8/17/69	H. CAMILLE	*2	1	AFT-EVE	0/0	PANHANDLE/ RF
38	9/20/69	HYBRID	2	1	EVENING	0/3	PANHANDLE/RF
39	10/1/69	SUB TROP	*1	1	MORNING	0/0	FRANKLIN/RF
40	6/18/72★	H. AGNES	*15+	3	AM-AM19TH	7/119	KEYS-EC/ RF
41	6/26/74	T. DIST.	1	0	EVENING	0/0	SARASOTA/RF
42	9/7/74	H. CARMEN	*1	1	EVENING	0/0	PANHANDLE/ RF
43	7/30/75	TROP DIST.	2	1	PM-AM 31ST	0/0	N & PANHANDLE/RF
44	9/22/75	H. ELOISE	*4	1	EVE-AM 23RD	0/0	PANHANDLE/RF
45	10/16/75	TROP DIST.	2	1	EVENING	0/0	PANHANDLE/RF
46	5/22/76★	SUB TROP	5	1	AFT-AM 23RD	0/2	CENTRAL/ RF
47	5/8/79★	HYBRID	*19	2	AM-PM	1/47	CENTRL/RF
48	9/3/79★	H. DAVID	10+	2	AM-AM 4TH	0/0	E COAST/NR CNTR
49	9/12/79★	H FREDERICK	*5	1	EVE-AM 13TH	0/4	PANHANDLE/RF
50	8/16/81	TS DENNIS	2	0	EVENING	0/0	S & EC/RF
51	6/3/82	H. ALBERTO	2	1	AFT-EVE	0/0	KEYS/RF
52	6/17/82★	ST STORM	12	2	AM-AM 18TH	1/13	SW-EC/RF
53	9/26/82	HYBRID	3	2	EARLY AM	1/7	SW/RF
54	8/31/85★	H. ELENA	5	2	AM-PM	0/0	W CENTRAL/RF
55	10/28/85	H. JUAN	*4	1	MORNING	0/6	PANHANDLE/ RF
56	10/11/87	T.S. FLOYD	1	1	EVENING	0/0	KEYS/ RF
57	9/10/88★	H. FLORENCE	*4+	0	AM-AFT	0/0	PANHANDLE/ RF
58	11/23/88	TS KEITH	2	0	LATE PM	0/0	PINELLAS/NR CNTR
59	10/11/90	TS MARCO	2+	0	AFTERNOON	0/0	WC-NC/RF
60	10/3/92★	HYBRID	10	3	AM-PM	4/77+	W CENTRAL/RF
61	11/15/94	TS GORDON	*4	2	EVENING	1/40	E CENTRAL/ RF

APPENDIX: TABLE 2 (same as Table 1 except through 1996)

#	date	system type	#tor	f#	time (est)	death/injuries	location/stm ctr relative
1	9/9/1882	hurricane	5+	2	eve-am 10th	6/17	n central/rf
2	10/11/85	hurricane	1	2	2355	0/8	alachua/rf
3	9/10/1919	hurricane	1	2	0112	0/6	dade/rf
4	9/28/29	hurricane	4	2	aft-eve	0/16+	south/rf
5	10/4/33	hurricane	3	2	eve-am 5th	0/3	southeast/lf
6	9/20/37	t. storm	1	2	2100	0/0	st.johns/ rf
7	10/20/41	t. storm	2	2	afternoon	1/1	n central/ rf
8	10/18/44	hurricane	3	1	afternoon	0/0	w central/ rf
9	6/24/45	hurricane	1	1	am	0/0	brevard/ rf
10	9/19/47	hurricane	1	3	0030	2/100	franklin/ rf
11	9/22/47	t. storm	11	2	eve-eve23rd	0/1	wc-ne/rf
12	10/7/47	t.dep.	1	2	1915	0/10	duval/rf
13	10/11/47	hurricane	1	2	2300	0/0	dade/ rf
14	7/9/48	t. storm	1	2	0400	0/2	washington/cntr
15	9/4/48	hurricane	2	2	late eve	2/12	panhandle/rf
16	9/21/48	hurricane	1	2	1000	0/0	dade/rf
17	10/5/48	hurricane	3+	2	afternoon	0/27	southeast/cntr
18	8/30/50	h. baker	2	2	aft-am31st	0/0	panhandle/ rf
19	10/9/53	t.s.hazel	1	1	0900	0/0	lee/ rf
20	9/24/56	h. flossy	3	2	am-eve	0/0	nw florida/ rf
21	6/8/57	t. storm	6	2	evening	0/0	nc-north/ rf
22	6/17/59	t.dep.	*2	2	evening	0/77	southeast/ rf
23	10/17/59	t.s.judith	1	0	1530	0/0	martin/ rf
24	9/15/60	h. ethel	*4	2	morning	0/0	bay/ rf
25	5/2/64	hybrid	*1	1	afternoon	0/0	n & ne/rf
26	6/6/64	t.dep.	*3	2	afternoon	0/5	wc-ne/ rf

27	**8/27/64**	**h. cleo**	**3**	**1**	**evening**	**0/1**	**e coast/rf**
28	**10/14/64**	**h. isbel**	**9+**	**2**	**aft-eve**	**0/48**	**se-ec/cntr - rf**
29	**9/8/65**	**h. betsy**	**2**	**2**	**afternoon**	**0/0**	**keys/cntr**
30	**6/8/66**	**h. alma**	***4+**	**1**	**aft-am 9th**	**0/0**	**e. coast/ rf**
31	**10/4/66**	**h. inez**	**2**	**1**	**evening**	**0/0**	**putnam/ rf**
32	**6/4/68**	**t.s. abby**	**3**	**1**	**am-am 5th**	**0/0**	**brevard/ rf**
33	**6/17/68**	**td (brenda)**	***1**	**0**	**am-aft**	**0/0**	**keys-se/ rf**
34	**8/9/68**	**td (dolly)**	***1**	**1**	**afternoon**	**0/0**	**sw-w/lf**
35	**8/29/68**	**t.dist**	**2**	**1**	**morning**	**0/0**	**volusia/rf**
36	**10/17/68**	**h. gladys**	***2**	**2**	**am-pm 18th**	**0/0**	**w central/rf**
37	**8/17/69**	**h. camille**	***2**	**1**	**aft-eve**	**0/0**	**panhandle/ rf**
38	**9/20/69**	**hybrid**	**2**	**1**	**evening**	**0/3**	**panhandle/rf**
39	**10/1/69**	**sub trop**	***1**	**1**	**morning**	**0/0**	**franklin/rf**
40	**6/18/72**	**h. agnes**	***15+**	**3**	**am-am19th**	**7/119**	**keys-ec/ rf**
41	**6/26/74**	**t. dist.**	**1**	**0**	**evening**	**0/0**	**sarasota/rf**
42	**9/7/74**	**h. carmen**	***1**	**1**	**evening**	**0/0**	**panhandle/ rf**
43	**7/30/75**	**trop dist.**	**2**	**1**	**pm-am 31st**	**0/0**	**n & panhandle/rf**
44	**9/22/75**	**h. eloise**	***4**	**1**	**eve-am 23rd**	**0/0**	**panhandle/rf**
45	**10/16/75**	**trop dist.**	**2**	**1**	**evening**	**0/0**	**panhandle/rf**
46	**5/22/76**	**sub trop**	**5**	**1**	**aft-am 23rd**	**0/2**	**central/ rf**
47	**5/8/79**	**hybrid**	***19**	**2**	**am-pm**	**1/47**	**centrl/rf**
48	**9/3/79**	**h. david**	**10+**	**2**	**am-am 4th**	**0/0**	**e coast/nr cntr**
49	**9/12/79**	**h frederick**	***5**	**1**	**eve-am 13th**	**0/4**	**panhandle/rf**
50	**8/16/81**	**ts dennis**	**2**	**0**	**evening**	**0/0**	**s & ec/rf**
51	**6/3/82**	**h. alberto**	**2**	**1**	**aft-eve**	**0/0**	**keys/rf**
52	**6/17/82**	**st storm**	**12**	**2**	**am-am 18th**	**1/13**	**sw-ec/rf**
53	**9/26/82**	**hybrid**	**3**	**2**	**early am**	**1/7**	**sw/rf**
54	**8/31/85**	**h. elena**	**5**	**2**	**am-pm**	**0/0**	**w central/rf**
55	**10/28/85**	**h. juan**	***4**	**1**	**morning**	**0/6**	**panhandle/ rf**

56	**10/11/87**	**t.s. floyd**	**1**	**1**	**evening**	**0/0**	**keys/ rf**
57	**9/10/88**	**h. florence**	***4+**	**0**	**am-aft**	**0/0**	**panhandle/ rf**
58	**11/23/88**	**ts keith**	**2**	**0**	**late pm**	**0/0**	**pinellas/nr cntr**
59	**10/11/90**	**ts marco**	**2+**	**0**	**afternoon**	**0/0**	**wc-nc/rf**
60	**10/3/92**	**hybrid**	**10**	**3**	**am-pm**	**4/77+**	**w central/rf**
61	**10/2/94**	**t. dep.**	***4**	**1**	**aft-eve**	**0/2**	**nw-ne/rf**
62	**11/15/94**	**ts gordon**	***6 0**	**2**	**evening**	**1/40**	**e central/ rf**
63	**6/4/95**	**ts allison**	**4**	**1**	**eve-am 5th**	**0/0**	**wc-ne/rf**
64	**8/2/95**	**h. erin**	***11+**	**1**	**am-am 3rd**	**0/1**	**ec/ne-panhndle/rf**
65	**8/24/95**	**td (jerry)**	**1**	**0**	**1147**	**0/0**	**pasco/nr cntr**
66	**10/3/95**	**h. opal**	***13+**	**2**	**aft-aft 4th**	**1/3**	**panhandle/rf**
67	**10/8/96**	**ts josephine**					