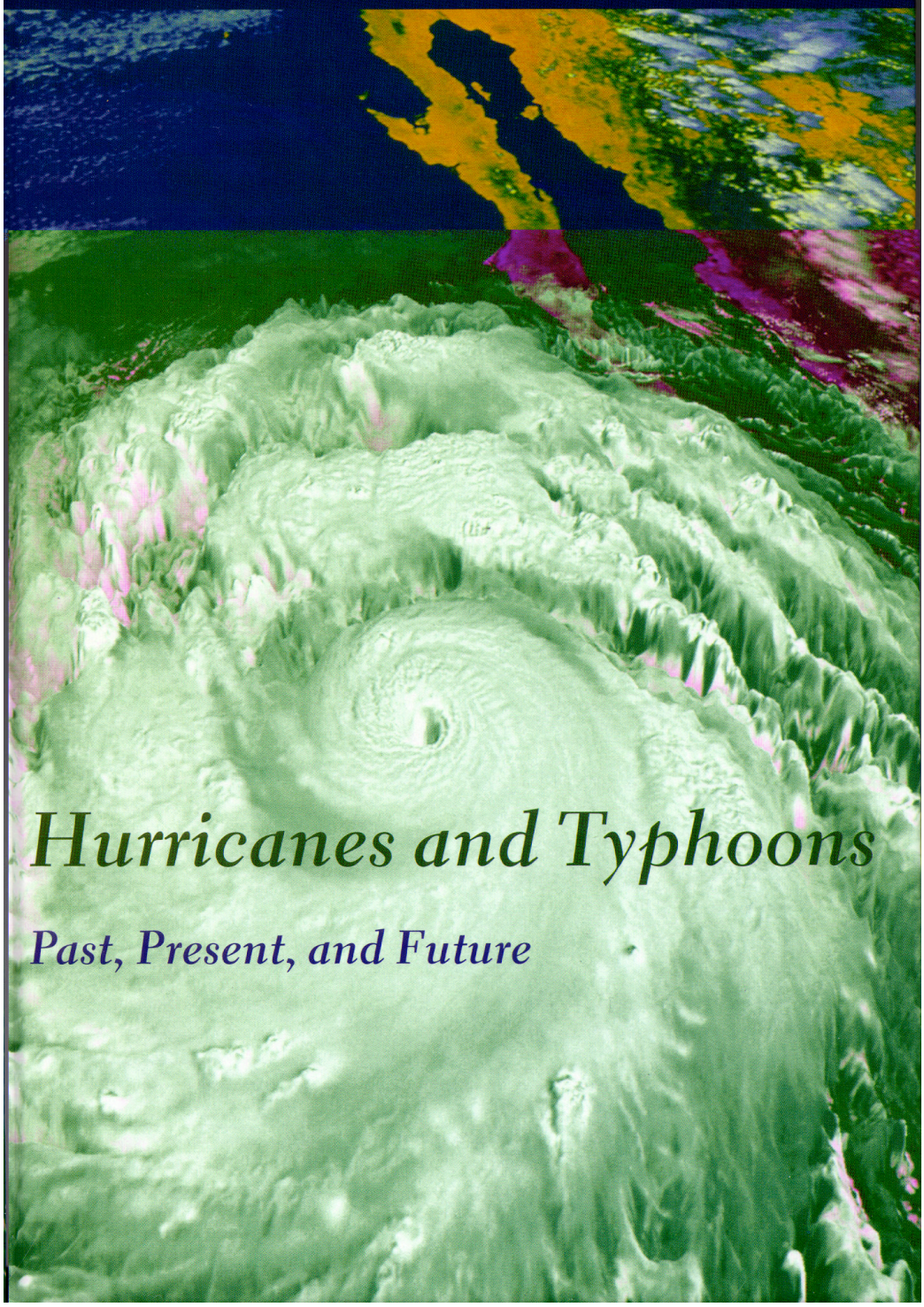
RICHARD J. MURNANE AND KAM-BIU LIU, EDITORS



Hurricanes and Typhoons

Past, Present, and Future

The Atlantic Hurricane Database Re-analysis Project:

Documentation for 1851-1910 Alterations and Additions to the HURDAT Database

Christopher W. Landsea, Craig Anderson, Noel Charles, Gilbert Clark, Jason Dunion, Jose Fernandez-Partagas, Paul Hungerford, Charlie Neumann, Mark Zimmer

1

NOAA Technical Memorandum

OUTLINE OF DATABASES PROVIDED IN THE RE-ANALYSIS

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THE WORK OF JOSE FERNANDEZ-PARTAGAS

Monthly Weather Review

Table 7.1 Sources utilized by Partagas and Diaz in their original work

Ships' reports published in *The New York Times*, *The Times* (London) and *Gaceta de la Habana*,
the *Monthly Weather Review* individual storm and seasonal summaries
the Historical Weather Maps series
Reports of the Chief of the Weather Bureau (U.S.)
Other sources

- Academia de Ciencias (1970)
- Alexander (1902)
- Cline (1926)
- Dunn and Miller (1960)
- Garcia-Bonnelly (1958)
- Garriott (1900)
- Gutierrez-Lanza (1904)
- Ho et al. (1987)
- Instituto Cubano de Geodesia y Cartografia (1978)
- Ludlum (1963)
- Martinez-Fortun (1942)
- Mitchell (1924)
- Neumann et al. (1993)
- Ortiz-Hector (1975)
- Rappaport and Partagas (1995)
- Rodriguez-Demorizi (1958)
- Rodriguez-Ferrer (1876)
- Salivia (1972)
- Sarasola (1928)
- Simpson and Riehl (1981)
- Sullivan (1986)
- Tannehill (1938)
- Tucker (1982)
- Vines (1877)
- Vines (1895)

<u>Sources utilized in the re-analysis effort beyond those listed above:</u>
Abraham et al. (1998), Barnes (1998a, 1998b), Boose et al. (2001, 2002), Coch and Jarvinen (2000), Connor (1956), Doehring et al. (1994), Ellis (1988), Hebert and McAdie (1997), Ho (1989), Hudgins (2000), Jarvinen (1990), Jarrell et al. (1992), Neumann et al. (1999), Parkes et al. (1998), Perez et al. (2000), Roth (1997a, 1997b), Roth and Cobb (2000, 2001), Sandrik (2002), and Sandrik and Jarvinen (1999).

CENTER-FIX FILES

Table 7.2 Wind,Pressure, and Location Data for Two Storms

Storm 1, 1856[1]

Date	Time	Wind/Dir.	Pressure[2]	Location		Source[3]
8/10/1856	???? UTC	40 kt/??	???? mb	29.3N	89.9W	Fort Livingston
8/10/1856	???? UTC	60 kt/??	???? mb	30.3N	91.4W	Iberville Parish
8/10/1856	0900 UTC	70 kt/N-S	955 mb	28.6N	90.2W	*C.D. Mervin*
8/10/1856	1400 UTC	40 kt/E	???? mb	30.0N	90.1W	New Orleans
8/10/1856	2100 UTC	70 kt/??	???? mb	29.0N	90.9W	Last Island
8/10/1856	2200 UTC	70 kt/??	???? mb	29.7N	91.2W	Bayou Boeuf
8/11/1856	???? UTC	40 kt/??	???? mb	30.4N	91.2W	Baton Rouge
8/11/1856	???? UTC	40 kt/??	???? mb	32.2N	91.1W	New Carthage
8/11/1856	???? UTC	60 kt/??	???? mb	31.6N	91.4W	Natchez

Storms 5, 1852 (center positions)[4]

Date	Time	Wind/Dir.	Pressure	Location		Source
10/9/1852	???? UTC	90 kt/ENE-SSW	???? mb	25.6N	86.5W	*Hebe*

1) No center-fix locations are available for this storm. The latitudes refer to observation locations.
2) In center-fix files, if the sea lvel pressure measurement was determined to be a “central pressure,” C is indicated after the value. Otherwise, the pressure value was considered to be a peripheral(either eyewall or rainband environment of the storm) observation.
3) Sources are either from coastal or inland station data or from ship data are indicated by the name of the ship in italics.
4) Latitude and longitude indicate center-fix location for this storm. This entry shows format for center-fix files in HURDAT reanalysis.

Table 7.3 The Beaufort Wind Scale

Beaufort Number	Knots	Description	Specifications at Sea
0	< 1	Calm	Sea like a mirror
1	1-3	Light air	Ripples with the appearance of scales are formed, but without foam crest
2	4-6	Light breeze	Small wavelets, still short but more pronounced; crests have a glassy appearance and do not break
3	7-10	Gentle breeze	Large wavelets; crests begin to break; foam of glassy appearance; perhaps scattered white horses
4	11-16	Moderate breeze	Small waves, becoming longer; fairly frequent white horses
5	17-21	Fresh breeze	Moderate waves, taking a more pronounced long form; many white horses are formed (chance of some spray)
6	22-27	Strong breeze	Large waves begin to form; the white foam crests are more extensive everywhere (probably some spray)
7	28-33	Near gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks in the direction of the wind
8	34-40	Gale	Moderately high waves of greater length; edges of crests begin to break into spindrift; foam is blown in well-marked streaks along the direction of the wind
9	41-47	Strong gale	High waves; dense streaks of foam along the direction of the wind; crests of waves begin to topple, tumble, and roll over; spray may affect visibility
10	48-55	Storm	Very high waves with long overhanging crests; the resulting foam, in great patches, is blown in dense white streaks along the direction of the wind; on the whole, the surface of the sea takes on a white appearance; the tumbling of the sea becomes heavy and shock-like; visibility affected
11	56-63	Violent storm	Exceptionally high waves (small and medium-sized ships might be for a time lost to view behind the waves); the sea completely covered with long white patches of foam lying along the direction of the wind; everywhere the edges of wave crests are blown into froth; visibility affected
12	> 63	Hurricane	The air is filled with foam and spray; sea completely white with driving spray; visibility very seriously affected

Source: Fitzpatrick(1999)

Table 7.4: The Smithsonian Institute and Military Fort Wind Force Scale

Category	Description	Wind speed
1	Very light breeze	2 mph (2 kt)
2	Gentle breeze	4 mph (4 kt)
3	Fresh breeze	12 mph (10 kt)
4	Strong breeze	25 mph (22 kt)
5	High breeze	35 mph (30 kt)
6	Gale	45 mph (39 kt)
7	Strong gale	60 mph (51 kt)
8	Violent gale	75 mph (65 kt)
9	Hurricane	90 mph (78 kt)
10	Most violent	100 mph (87 kt)

(Ludlum 1963, Ho 1989, M. Chenoweth, personal communication, 2001). Values are estimates of the highest gusts.

WIND-PRESSURE RELATIONSHIPS

For GMEX	Wind (kt)=10.627*(1013-P_o)$^{0.5640}$
	Sample size =664; r=0.991
For < 25^{o}N	Wind (kt)=12.016*(1013-P_o)$^{0.5337}$
	Sample size =1033; r=0.994
For 25-35^{o}N	Wind (kt)=14.172*(1013-P_o)$^{0.4778}$
	Sample size =922; r=0.996
For 35-45^{o}N	Wind (kt)=16.086*(1013-P_o)$^{0.4333}$
	Sample size =492; r=0.974
For Kraft	Wind (kt)=14.000*(1013-P_o)$^{0.5000}$
	Sample size =13

Table 7.5: Newly developed regionally-based wind-pressure relationships for the Atlantic basin. Winds are maximum sustained surface winds in knots and pressures are central pressures in mb at sea level.

P(MB)	GMEX	<25N	25-35N	35-45N	KRAFT	DVORAK
1000	45	47	48	49	50	45
990	62	64	63	63	67	61
980	76	78	75	73	80	76
970	89	89	85	82	92	90
960	100	100	94	90	102	102
950	110	110	103	97	111	113
940	119	119	110	103	120	122
930	128	127	117		128	132
920	137	135	124		135	141
910	145	143			142	151
900	153	150			149	161
890		157				170

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BEST TRACK FILES

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00820 08/09/1856 M= 4  1 SNBR=  29 NOT NAMED   XING=1 SSS=4
00825 08/09*250 839  70    0*257 851  80    0*263 865  90    0*270 878 100    0
00830 08/10*277 891 110    0*282 898 120    0*287 905 130    0*292 911 130  934
00835 08/11*297 916 110    0*300 918  80    0*303 919  60    0*306 918  50    0
00840 08/12*309 916  40    0*313 910  40    0*  0   0   0    0*  0   0   0    0
00845 HR LA4
```

Month	Day	Hour	Lat.	Long.	Dir.	Speed		Wind		Pressure	Type
					deg	mph/	km/hr	mph/	km/hr	mb	
8	9	0 UTC	25.0N	83.9W				80	130		H-Cat. 1
8	9	6 UTC	25.7N	85.1W	305 deg	13	22	90	150		H-Cat. 1
8	9	12 UTC	26.3N	86.5W	295 deg	14	24	100	170		H-Cat. 2
8	9	18 UTC	27.0N	87.8W	300 deg	14	24	120	190		MH-Cat. 3
8	10	0 UTC	27.7N	89.1W	300 deg	14	24	130	200		MH-Cat. 3
8	10	6 UTC	28.2N	89.8W	310 deg	8	12	140	220		MH-Cat. 4
8	10	12 UTC	28.7N	90.5W	310 deg	8	12	150	240		MH-Cat. 4
8	10	18 UTC	29.2N	91.1W	315 deg	8	12	150	240	934	MH-Cat. 4 - Landfall
8	11	0 UTC	29.7N	91.6W	320 deg	6	11	130	200		MH-Cat. 3
8	11	6 UTC	30.0N	91.8W	330 deg	3	5	90	150		H-Cat. 1
8	11	12 UTC	30.3N	91.9W	345 deg	3	5	70	110		TS
8	11	18 UTC	30.6N	91.8W	15 deg	3	5	60	90		TS
8	12	0 UTC	30.9N	91.6W	30 deg	3	5	50	70		TS
8	12	6 UTC	31.3N	91.0W	50 deg	6	11	50	70		TS

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LIMITATIONS AND ERRORS

1800s	Ship logs provided tropical cyclone observations (after returning to port)
1845	First telegraph line completed from Washington, D.C. to Boston
1846	The cup anemometer invented by Robinson
1848	Smithsonian Institute volunteer weather observer network started in United States
1870	U.S. national meteorological service begun through the Army Signal Corps
1875	First hurricane forecasting system started by Benito Vines in Cuba
1890	U.S. weather service transferred to civilian agency
1898	U.S. Weather Bureau establishes observation stations throughout Caribbean
1905	Transmitted ship observations of tropical storms and hurricanes (via radio)

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Table 7.7: Estimated average position and intensity errors in best track for the years 1851-1910. Negative bias errors indicate an underestimation of the true intensity.

Situation	Dates	Position Error	Intensity Error (absolute)	Intensity Error (bias)
Open ocean	1851-1885	120 nmi/220 km	25 kt/13 m s^{-1}	-15 kt/-8 m s^{-1}
	1886-1910	100 nmi/185 km	20 kt/10 m s^{-1}	-10 kt/-5 m s^{-1}
Landfall at sparsely populated area	1851-1885	120 nmi/220 km	25 kt/13 m s^{-1}	-15 kt/-8 m s^{-1}
	1886-1910	100 nmi/185 km	20 kt/10 m s^{-1}	-10 kt/-5 m s^{-1}
Landfall at settled area	1851-1885	60 nmi/110 km	15 kt/8 m s^{-1}	0 kt/0 m s^{-1}
	1886-1910	60 nmi/110 km	12 kt/6 m s^{-1}	0 kt/0 m s^{-1}

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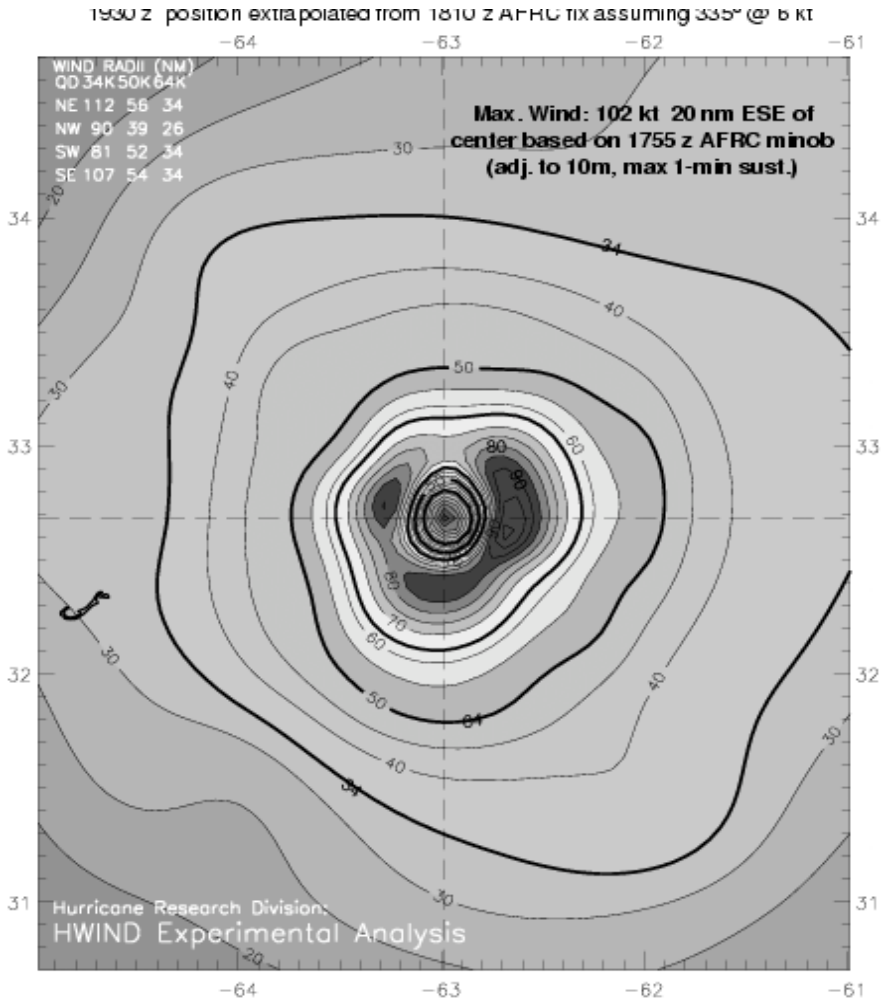

Figure 7.1: Surface windfield analysis for Major Hurricane Erin on 9 September 2001 at 1930 UTC. This analysis utilizes all available surface and near surface wind data including surface-reduced aircraft reconnaissance winds, surface-reduced cloud-drift winds, and ship and buoy observations. These data are all storm-relative composited for the period of 1500 to 1900 UTC, 9 September 2001 and are adjusted to a standard maximum sustained surface (1 min, 10 m) measurement. Peak sustained winds are analyzed to be 102 kt (52 m s^{-1}) to the east-southeast of Erin's center at a radius of 20 nmi (37 km).

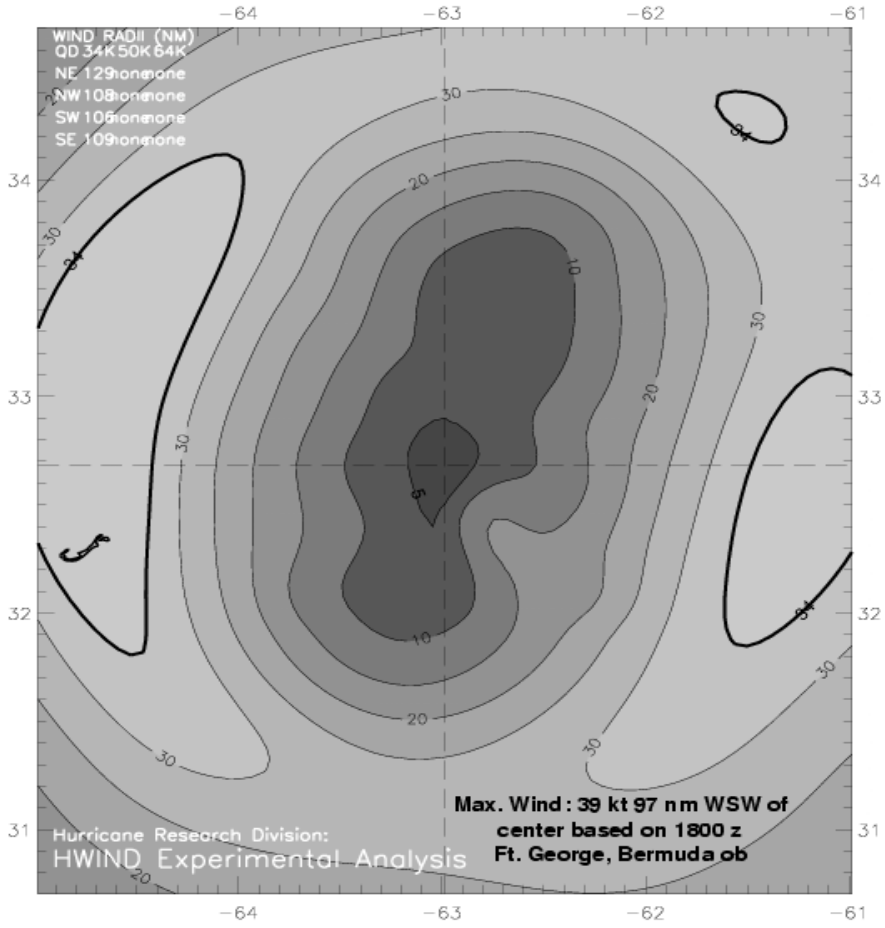

Figure 7.2 Same as Figure 3, but without the benefit of surface-reduced aircraft reconnaissance flight-level winds. In this case, highest analyzed surface winds were only 39 kt (20 m s^{-1}) based upon observations from Bermuda about 100 nmi (160 km) from Erin's center. Such an analysis is typical of data available before the advent of aircraft reconnaissance data in the mid-1940s and is illustrative of the underestimation bias that occurred for many tropical cyclones during the era of the late 19th and early 20th Centuries being re-analyzed.

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METADATA FILES

UNITED STATES TROPICAL CYCLONES

Table 7.8 Continental United States Hurricanes: 1851-1910

#/Date	Time	Lat	Lon	Max Winds	Saffir-Simpson	RMW	Storm Surge	Central Pressure	Environ. Pressure	States Affected
1-6/25/1851$	2100Z	28.2N	96.8W	80kt	1	---	---	(977mb)	------	BTX1
4-8/23/1851$	2100Z	30.1N	85.7W	100kt	3	---	12'%	(960mb)	------	AFL3,GA1
1-8/22/1852$*	1200Z	23.8N	81.3W	80kt	1	---	---	(977mb)	------	BFL1
1-8/26/1852	0600Z	30.2N	88.6W	100kt	3	30nmi	12'%	961mb	------	AL3,MS3,LA2,AFL1
3-9/12/1852$	0000Z	28.0N	82.8W	70kt	1	---	---	(985mb)	------	BFL1
5-10/9/1852$	2100Z	29.9N	84.4W	90kt	2	---	7'%	(969mb)	------	AFL2,GA1
8-10/21/1853*	0600Z	30.9N	80.9W	70kt	1	---	---	(965mb)	------	GA1
1-6/26/1854$	1300Z	26.2N	97.2W	70kt	1	---	---	(985mb)	------	ATX1
3-9/8/1854	2000Z	31.7N	81.1W	100kt	3	40nmi	---	950mb	------	GA3,SC2,DFL1
4-9/18/1854	2100Z	28.9N	95.3W	90kt	2	---	---	(969mb)	------	BTX2
6-9/16/1855$	0300Z	29.2N	89.5W	110kt	3	---	10-15'%	(950mb)	------	LA3,MS3
1-8/10/1856$	1800Z	29.2N	91.1W	130kt	4	12nmi	11-12'%	934mb	------	LA4
5-8/31/1856$	0600Z	30.2N	85.9W	90kt	2	---	6'%	(969mb)	------	AFL2,AL1,GA1
2-9/13/1857&	1100Z	35.2N	75.7W	80kt	1	---	---	961mb	------	NC1
3-9/16/1858	1700Z	40.9N	72.2W	80kt	1	45nmi	---	(976mb)	------	NY1
3-9/16/1858	1800Z	41.3N	72.0W	70kt	1	45nmi	---	979mb	------	CT1,RI1,MA1
5-9/16/1859	0000Z	30.3N	88.1W	70kt	1	---	---	(985mb)	------	AL1,AFL1
1-8/11/1860$	2000Z	29.2N	90.0W	110kt	3	---	12'%	(950mb)	------	LA3,MS3,AL2
4-9/15/1860$	0400Z	29.3N	89.6W	90kt	2	---	10'%	(969mb)	------	LA2,MS2,AL1
6-10/2/1860$	1700Z	29.5N	91.4W	90kt	2	---	---	(969mb)	------	LA2
2-8/16/1861$*	0000Z	24.2N	82.0W	70kt	1	---	---	(970mb)	------	BFL1
5-9/27/1861	1700Z	34.5N	77.4W	70kt	1	---	---	(985mb)	------	NC1
8-11/2/1861	1000Z	34.7N	76.6W	70kt	1	---	---	(985mb)	------	NC1
4-9/13/1865$	2100Z	29.8N	93.4W	90kt	2	---	---	(969mb)	------	LA2,CTX1
7-10/23/1865$	1000Z	24.6N	81.7W	90kt	2	---	---	(969mb)	------	BFL2
7-10/23/1865$	1400Z	25.4N	81.1W	90kt	2	---	---	(969mb)	------	BFL2,CFL1
1-7/15/1866	1200Z	28.5N	96.5W	90kt	2	---	---	(969mb)	------	BTX2
1-6/22/1867	1400Z	32.9N	79.7W	70kt	1	---	---	(985mb)	------	SC1
7-10/2/1867$#	1500Z	25.4N	97.1W	70kt	1	---	---	(969mb)	------	ATX1
7-10/4/1867$	1500Z	29.2N	91.0W	90kt	2	---	7'%	(969mb)	------	LA2,CTX1
7-10/6/1867$	1500Z	29.6N	83.4W	70kt	1	---	---	(985mb)	------	AFL1
2-8/17/1869	0700Z	28.1N	96.8W	90kt	2	---	---	(969mb)	------	BTX2
5-9/5/1869$	1200Z	29.2N	90.0W	70kt	1	---	---	(985mb)	------	LA1
6-9/8/1869&	2100Z	41.0N	71.9W	80kt	1	30nmi	---	963mb	------	NY1
6-9/8/1869	2200Z	41.4N	71.7W	100kt	3	30nmi	8'%	965mb	------	RI3,MA3,CT1
10-10/4/1869&	1900Z	41.3N	70.5W	80kt	1	30nmi	---	(965mb)	------	MA1
10-10/4/1869&	2000Z	41.7N	70.4W	80kt	1	30nmi	---	(965mb)	------	MA1
10-10/4/1869	2300Z	43.7N	70.1W	90kt	2	30nmi	---	(968mb)	------	ME2
1-7/30/1870	1800Z	30.5N	88.0W	70kt	1	---	---	(985mb)	------	AL1
6-10/10/1870$*	0500Z	24.6N	80.8W	70kt	1	---	---	(970mb)	------	BFL1,CFL1
9-10/20/1870$	1400Z	24.7N	82.8W	80kt	1	---	---	(977mb)	------	BFL1
9-10/20/1870$	2000Z	26.0N	81.6W	80kt	1	---	---	(977mb)	------	BFL1
3-8/17/1871$	0200Z	27.1N	80.2W	100kt	3	30nmi	---	955mb	1016mb	CFL3,DFL1,AFL1
4-8/25/1871$	0500Z	27.6N	80.3W	90kt	2	---	---	(965mb)	------	CFL2,DFL1
6-9/6/1871$	1400Z	29.2N	83.0W	70kt	1	---	---	(985mb)	------	AFL1
3-9/19/1873$	1500Z	29.9N	84.4W	70kt	1	---	---	(985mb)	------	AFL1
5-10/7/1873$	0100Z	26.5N	82.2W	100kt	3	26nmi	14'%	959mb	1014mb	BFL3,CFL2,DFL1
6-9/28/1874$	0300Z	29.1N	82.9W	70kt	1	---	---	(985mb)	------	AFL1
6-9/28/1874	1800Z	32.8N	80.0W	80kt	1	---	---	981mb	------	SC1,NC1
3-9/16/1875	2100Z	27.7N	97.2W	100kt	3	---	15'%	(960mb)	------	BTX3,ATX2
2-9/17/1876	1400Z	34.4N	77.6W	80kt	1	---	---	980mb	------	NC1,VA1
5-10/20/1876$	0500Z	25.8N	81.4W	90kt	2	---	---	973mb	------	BFL2,CFL1
2-9/18/1877$	1600Z	29.2N	91.0W	70kt	1	---	---	(985mb)	------	LA1
2-9/19/1877$	2000Z	30.4N	86.6W	70kt	1	---	---	(985mb)	------	AFL1
4-10/3/1877$	0500Z	30.0N	85.5W	100kt	3	---	12'%	(960mb)	------	AFL3,GA1
5-9/10/1878$	1100Z	28.6N	82.6W	90kt	2	---	---	(970mb)	1010mb	BFL2,DFL1
5-9/12/1878	1200Z	32.5N	80.4W	80kt	1	---	---	(976mb)	------	SC1,GA1
11-10/23/1878	0400Z	34.8N	77.1W	90kt	2	---	12'%	(963mb)	------	NC2,VA1,MD1,DE1,NJ1,PA1
2-8/18/1879	1200Z	34.7N	76.7W	100kt	3	16nmi	7'	971mb	1014mb	NC3,VA2
2-8/19/1879&	0600Z	41.4N	70.8W	60kt	TS	---	---	984mb	------	(None)
3-8/23/1879	0200Z	29.6N	94.4W	90kt	2	---	---	964mb	------	CTX2,LA2
4-9/1/1879$	1600Z	29.5N	91.4W	110kt	3	---	---	(950mb)	------	LA3
2-8/13/1880#	0100Z	25.8N	97.0W	110kt	3	12nmi	---	931mb	------	ATX3
4-8/29/1880$	1200Z	28.2N	80.6W	90kt	2	---	---	972mb	------	CFL2,DFL1
4-8/31/1880	0400Z	29.7N	84.8W	70kt	1	---	---	(985mb)	------	AFL1

6-9/9/1880	1000Z	34.7N	77.1W	70kt	1	---	---	987mb	------	NC1
9-10/8/1880	1900Z	28.9N	82.7W	70kt	1	---	---	(985mb)	------	AFL1
5-8/28/1881	0200Z	31.7N	81.1W	90kt	2	15nmi	---	970mb	------	GA2,SC1
6-9/9/1881	1600Z	33.9N	78.1W	90kt	2	15nmi	---	975mb	------	NC2
2-9/10/1882	0200Z	30.4N	86.8W	100kt	3	---	---	949mb	------	AFL3,AL1
3-9/15/1882	0500Z	29.8N	93.7W	90kt	2	---	---	(969mb)	------	LA2,CTX1
6-10/11/1882	0400Z	29.5N	83.3W	70kt	1	---	---	(985mb)	------	AFL1
3-9/11/1883	1300Z	33.9N	78.5W	90kt	2	---	---	(965mb)	------	NC2,SC1
2-8/25/1885	0900Z	32.2N	80.7W	100kt	3	---	---	(953mb)	------	SC3,NC2,GA1,DFL1
1-6/14/1886	1600Z	29.6N	94.2W	85kt	2	---	7'%	(973mb)	------	CTX2,LA2
2-6/21/1886	1100Z	30.1N	84.0W	85kt	2	---	---	(973mb)	------	AFL2,GA1
3-6/30/1886	2100Z	29.7N	85.2W	85kt	2	---	---	(973mb)	------	AFL2
4-7/19/1886	0100Z	28.8N	82.7W	70kt	1	---	---	(985mb)	------	AFL1
5-8/20/1886	1300Z	28.1N	96.8W	135kt	4	15nmi	15'	925mb	------	BTX4
8-9/23/1886#	0700Z	26.0N	97.2W	80kt	1	---	---	(973mb)	------	ATX1,BTX1
10-10/12/1886	2200Z	29.8N	93.5W	105kt	3	---	12'%	(955mb)	------	LA3,CTX2
4-7/27/1887	1500Z	30.4N	86.6W	75kt	1	---	---	(981mb)	------	AFL1
6-8/20/1887*	1200Z	35.0N	75.0W	65kt	1	---	---	(946mb)	------	NC1
9-9/21/1887	1700Z	26.1N	97.2W	85kt	2	---	---	973mb	------	ATX2
13-10/19/1887	0200Z	29.1N	90.4W	75kt	1	---	---	(981mb)	------	LA1
1-6/17/1888	0600Z	28.7N	95.7W	70kt	1	---	---	(985mb)	------	BTX1
3-8/16/1888$	1900Z	25.8N	80.1W	110kt	3	---	14'%	(945mb)	------	CFL3,BFL1
3-8/19/1888	1600Z	29.1N	90.7W	95kt	2	---	---	(964mb)	------	LA2
6-9/26/1888&	1300Z	41.6N	69.9W	55kt	TS	---	---	985mb	------	(None)
7-10/11/1888	0100Z	29.2N	83.1W	95kt	2	11nmi	9'	970mb	------	AFL2,DFL1
6-9/23/1889	0400Z	29.1N	89.8W	70kt	1	---	---	(985mb)	------	LA1
1-7/5/1891	2200Z	28.8N	95.5W	80kt	1	---	---	(977mb)	------	BTX1,CTX1
3-8/24/1891$	1500Z	25.4N	80.2W	70kt	1	---	---	(985mb)	------	CFL1
4-8/24/1893	1200Z	40.6N	73.9W	75kt	1	30nmi	---	986mb	------	NY1,VA1
6-8/28/1893	0500Z	31.7N	81.1W	100kt	3	23nmi	9-10'	954mb	1010mb	GA3,SC3,NC1,DFL1
8-9/7/1893	1400Z	29.2N	91.1W	85kt	2	---	---	973mb	------	LA2
10-10/2/1893	0800Z	29.3N	89.8W	115kt	4	12nmi	---	948mb	------	LA4
10-10/2/1893	1600Z	30.3N	88.9W	95kt	2	17nmi	10-12'%	970mb	------	MS2,AL2
9-10/13/1893	1300Z	33.0N	79.5W	105kt	3	15nmi	14'%	955mb	------	SC3,NC2,VA1
4-9/25/1894$	1100Z	24.7N	82.0W	80kt	1	---	---	985mb	------	BFL1
4-9/25/1894$	1900Z	26.5N	82.0W	90kt	2	---	---	(975mb)	------	BFL2,DFL1
4-9/27/1894	0700Z	32.3N	80.7W	80kt	1	---	10'%	(976mb)	------	SC1
4-9/29/1894*	1200Z	37.0N	75.0W	70kt	1	---	---	(978mb)	------	VA1
5-10/9/1894	0300Z	30.2N	85.5W	105kt	3	---	---	(955mb)	------	AFL3,GA1
5-10/10/1894	1500Z	40.7N	72.9W	75kt	1	---	---	(978mb)	------	NY1,RI1
2-8/30/1895#	0400Z	25.0N	97.6W	65kt	1	---	---	(973mb)	------	ATX1
1-7/7/1896	1700Z	30.4N	86.5W	85kt	2	---	---	(973mb)	------	AFL2
2-9/10/1896	1300Z	41.2N	70.6W	70kt	1	30nmi	---	(985mb)	------	RI1,MA1
4-9/29/1896	1100Z	29.2N	83.1W	110kt	3	15nmi	---	960mb	1014mb	AFL3,DFL3,GA2,SC1,NC1,VA1
2-9/13/1897	0500Z	29.7N	93.8W	75kt	1	---	6'%	(981mb)	------	LA1,CTX1
1-8/2/1898	2300Z	29.7N	84.8W	70kt	1	---	---	(985mb)	------	AFL1
2-8/31/1898	0700Z	32.1N	80.8W	75kt	1	---	---	(980mb)	------	GA1,SC1
7-10/2/1898	1600Z	30.9N	81.4W	115kt	4	18nmi	16'	938mb	1010mb	GA4,DFL2
2-8/1/1899	1700Z	29.7N	84.7W	85kt	2	---	---	979mb	1017mb	AFL2
3-8/18/1899	0100Z	35.2N	75.8W	105kt	3	---	---	(945mb)	1012mb	NC3
8-10/31/1899	0900Z	33.6N	79.0W	95kt	2	35nmi	9'%	955mb	1012mb	NC2,SC2
1-9/9/1900	0140Z	29.1N	95.1W	125kt	4	14nmi	20'%	936mb	1012mb	CTX4
3-7/11/1901	0720Z	36.0N	75.8W	70kt	1	---	---	(983mb)	1016mb	NC1
4-8/14/1901	2110Z	29.3N	89.6W	80kt	1	---	8'%	(973mb)	1013mb	LA1
4-8/15/1901	1700Z	30.4N	88.8W	80kt	1	33nmi	8'%	973mb	1013mb	MS1,AL1
3-9/11/1903	2250Z	26.1N	80.1W	75kt	1	43nmi	8'%	976mb	1016mb	CFL1
3-9/13/1903	2330Z	30.1N	85.6W	80kt	1	---	10'%	(977mb)	1016mb	AFL1
4-9/16/1903	1120Z	39.1N	74.7W	70kt	1	---	---	990mb	1020mb	NJ1,DE1
2-9/14/1904	1320Z	33.1N	79.2W	70kt	1	---	---	(985mb)	1017mb	SC1
3-10/17/1904	0750Z	25.3N	80.3W	70kt	1	---	---	(985mb)	1016mb	CFL1
2-6/17/1906	0240Z	24.7N	81.1W	70kt	1	---	---	(986mb)	1013mb	BFL1,CFL1
2-6/17/1906	0750Z	25.2N	80.7W	75kt	1	26nmi	---	979mb	1013mb	CFL1
5-9/17/1906	2140Z	33.3N	79.2W	80kt	1	30nmi	---	977mb	1018mb	SC1,NC1
6-9/27/1906	1100Z	30.2N	88.6W	95kt	2	43nmi	14'%	958mb	1013mb	MS2,AL2,AFL2,LA1
8-10/18/1906	0930Z	24.7N	81.1W	105kt	3	12nmi	---	953mb	1010mb	BFL3,CFL3
8-10/18/1906	1130Z	25.2N	80.8W	105kt	3	12nmi	---	953mb	1010mb	CFL3,BFL1
2-5/29/1908&	2100Z	35.2N	75.6W	55kt	TS	---	---	989mb	1015mb	(None)
3-7/31/1908	1130Z	34.6N	77.1W	70kt	1	---	---	(985mb)	1017mb	NC1
2-6/29/1909	1700Z	26.1N	97.2W	85kt	2	---	7'%	972mb	1012mb	ATX2
4-7/21/1909	1650Z	28.9N	95.3W	100kt	3	19nmi	10'%	959mb	1015mb	CTX3
6-8/27/1909#	2140Z	23.7N	97.7W	65kt	1	---	---	(955mb)	1014mb	ATX1
8-9/21/1909	0000Z	29.5N	91.3W	105kt	3	28nmi	15'%	952mb	1012mb	LA3,MS2
10-10/11/1909	1800Z	24.7N	81.0W	100kt	3	22nmi	---	957mb	1009mb	BFL3,CFL3
3-9/14/1910	2200Z	26.9N	97.4W	95kt	2	---	---	(965mb)	1011mb	ATX2
5-10/17/1910*	1900Z	24.6N	82.6W	90kt	2	---	---	941mb	1008mb	BFL2
5-10/18/1910	0600Z	26.5N	82.0W	95kt	2	28nmi	15'%	955mb	1008mb	BFL2

Notes:
Date/Time: Day and time when the circulation center crosses the U.S. coastline (including barrier islands). Time is estimate to the nearest hour from 1851 to 1899 and to the nearest 10 minutes from 1900 to 1910.
Lat/Lon: Location is estimated to the nearest 0.1 degrees latitude and longitude (about 6 nmi).
Max Winds: Estimated maximum sustained (1 min) surface (10 m) winds to occur along the U. S. coast.
Saffir-Simpson: The estimated Saffir-Simpson Hurricane Scale at landfall based upon maximum sustained surface winds. "TS" indicates that the hurricane's center made landfall, but that hurricane force wind remained offshore.
RMW: The radius of maximum winds (primarily for the right front quadrant of the hurricane), if available.
Storm surge: Maximum observed storm surge, if available. A higher value may have occurred, but was not recorded.
Central Pressure: The minimum central pressure of the hurricane at landfall. Central pressure values in parentheses indicate that the value is a simple estimation (based upon a wind-pressure relationship), not directly measured or calculated.
Environmental Pressure: The sea level pressure at the outer limits of the hurricane circulation dterminted by moving outward from the storm center to the first anticyclonically turning isobar in four equally spaced directions and averaging the four pressures thus obtained.
States Affected: The impact of the hurricane upon individual U.S. states by Saffir-Simpson Scale (again through the estimate of the maximum sustained surface winds at each state). (ATX-South Texas, BTX-Central Texas, CTX-North Texas, LA-Louisiana, MS-Mississippi, AL-Alabama, AFL-Northwest Florida, BFL-Southwest Florida, CFL-Southeast Florida, DFL-Northeast Florida, GA-Georgia, SC-South Carolina, NC-North Carolina, VA-Virginia, MD-Maryland, DE-Delware, NJ-New Jersey, NY-New York, PA-Pennsylvania, CT-Connecticut, RI-Rhode Island, MA-Massachusetts, NH-New Hampshire, ME-Maine. In Texas, south is roughly from the Mexico border to Corpus Christi; central is from north of Corpus Christi to Matagorda Bay and north is from Matagorda Bay to the Louisiana border. In Florida, the north-south dividing line is from Cape Canaveral [28.45N] to Tarpon Springs [28.17N]. The dividing line between west-east Florida goes from 82.69W at the north Florida border with Georgia, to Lake Okechobee and due south along longitude 80.85W.)
$ - Indicates that the hurricane may not have been reliably estimated for intensity (both central pressure and maximum sustained windspeed) because of landfall in a relatively uninhabited region. Errors in intensity are likely to be underestimates of the true intensity.
* - Indicates that the hurricane center did not make a U.S. landfall, but did produce hurricane force winds over land. Position indicated is point of closest approach. Maximum winds refer, in this table, to the strongest winds estimated for the United States. Central pressure in this case is the hurricane's value at the point of closest approach.
& - Indicates that the hurricane center did make a direct landfall, but that the strongest winds likely remained offshore. Thus the winds indicated here are lower than in HURDAT.
# - Indicates that hurricane made landfall first over Mexico, but caused hurricane winds in Texas. The position given is that of Mexican landfall. The strongest winds impacted Mexico. The winds indicated here are lower than in HURDAT and are lower than they were over Mexico. Central pressure given is that at Mexican landfall.
% - Indicates that the value listed is a "storm tide" observation rather than a "storm surge", which removes the astronomical tide component.

Table 7.9 Continental United States Tropical Storms: 1851-1910

#/Date	Time	Lat	Lon	Max Winds	Landfall State
6-10/19/1851	1500Z	41.1N	71.7W	50kt	NY
3- 8/19/1856	1100Z	34.8	76.4	50	NC
4- 9/30/1857$	1000Z	25.8	97.0	50	TX
3- 9/14/1858$	1500Z	27.6	82.7	60	FL
3- 9/16/1858*	0300Z	35.2	75.2	50	NC
7-10/17/1859$	1600Z	26.4	80.1	60	FL
7-10/ 7/1861	1200Z	35.3	75.3	50	NC
8-11/ 1/1861$	0800Z	26.0	81.8	60	FL
8-11/ 3/1861	0800Z	41.0	72.3	60	NY
8-11/ 3/1861	0900Z	41.2	72.0	50	CT
6- 9/18/1863	1300Z	34.6	77.1	60	NC
9- 9/29/1863$	1200Z	29.3	94.8	60	TX
2- 6/30/1865$	1800Z	26.0	97.5	50	TX
3- 8/22/1865*	1800Z	34.5	74.6	40	NC
5- 9/ 7/1865$	0000Z	29.7	92.0	60	LA
7-10/30/1866	0800Z	39.5	74.3	60	NJ
2- 8/ 2/1867*	0100Z	34.9	75.0	60	NC
2- 8/ 2/1867*	2200Z	40.9	69.3	50	MA
2-10/ 4/1868$	1600Z	29.9	85.4	60	FL
2- 9/ 3/1870*	1800Z	40.5	68.8	40	MA
1- 6/ 4/1871	0700Z	29.1	95.1	50	TX
2- 6/ 9/1871	1700Z	29.2	95.0	50	TX
3-8/23/1871	0000Z	31.2	81.3	60	GA
7-10/ 5/1871$	1600Z	30.0	83.9	60	FL
1- 7/11/1872	0500Z	29.1	89.1	50	LA
1- 7/11/1872	0800Z	30.2	89.0	50	MS
5-10/23/1872$	0800Z	27.9	82.7	50	FL
5-10/25/1872	0100Z	34.4	77.7	50	NC
1- 6/ 2/1873	1100Z	30.8	81.4	40	GA
4- 9/23/1873$	1000Z	27.8	82.8	50	FL
1- 7/ 4/1874	2000Z	28.5	96.2	50	TX
4- 9/ 4/1874$#	1200Z	25.0	97.6	40	TX
4- 9/27/1875$	1300Z	30.1	85.7	50	FL
2- 9/16/1876$*	1500Z	25.5	79.7	40	FL
7-10/26/1877$	2100Z	29.3	83.2	40	FL
1- 7/ 2/1878$	1500Z	26.0	81.8	40	FL
5- 9/ 7/1878$	2100Z	24.7	80.9	60	FL
5- 9/ 8/1878$	0200Z	25.2	81.0	60	FL
8-10/10/1878$	2100Z	29.9	85.4	50	FL
11-10/22/1878$*	0000Z	25.9	79.8	50	FL
2-8/19/1879&	0600Z	41.4	70.8	60	MA
5-10/ 7/1879	0500Z	29.0	89.2	50	LA
6-10/16/1879$	0800Z	30.4	86.6	50	FL
7-10/27/1879$	2100Z	29.0	82.7	60	FL

1- 6/24/1880	1500Z	28.7	95.7	40	TX
6- 9/ 8/1880	1600Z	29.8	83.6	50	FL
11-10/23/1880	0800Z	41.3	70.0	60	MA
11-10/23/1880	1300Z	44.0	68.8	60	ME
1- 8/ 3/1881	1300Z	30.2	88.3	50	AL
2- 8/13/1881	2100Z	28.0	96.9	40	TX
4- 9/22/1882	2200Z	34.7	77.0	50	NC
4- 9/24/1882	0500Z	40.7	72.8	40	NY
3- 9/11/1884	0100Z	31.6	81.2	40	GA
3- 8/22/1885	2300Z	30.1	85.7	50	FL
4- 9/21/1885	0300Z	29.0	89.4	50	LA
4- 9/21/1885	1200Z	30.0	85.6	50	FL
4- 9/23/1885*	0300Z	41.6	69.7	50	MA
6- 9/26/1885	0400Z	29.6	89.0	60	LA
6-10/ 2/1885*	1500Z	35.0	74.8	50	NC
8-10/11/1885	2200Z	29.4	83.2	60	FL
5-8/18/1886*$	0100Z	23.9	81.9	55	FL
3-6/14/1887	0700Z	30.2	88.7	35	MS
7-8/25/1887*	0600Z	35.0	74.4	50	NC
16-10/30/1887$	0100Z	28.1	82.8	40	FL
2-7/5/1888	1600Z	28.8	95.6	50	TX
4-9/6/1888*$	0000Z	23.0	81.9	50	FL
5-9/8/1888$	0000Z	26.7	80.0	45	FL
6-9/26/1888&	1300Z	41.6	69.9	55	MA
7-10/11/1888	1600Z	33.9	78.1	60	NC
9-11/25/1888*	1800Z	35.3	74.2	60	NC
2-6/17/1889	1500Z	29.1	82.9	45	FL
4-9/11/1889*	2100Z	38.4	72.7	60	NJ
6-9/23/1889	1300Z	30.3	87.7	60	FL
9-10/5/1889$	2300Z	24.7	81.1	40	FL
9-10/6/1889$	0100Z	25.2	80.9	40	FL
2-8/27/1890	1600Z	29.1	90.9	50	LA
7-10/7/1891$	0800Z	25.2	81.3	45	FL
1-6/10/1892$	2300Z	25.7	81.3	40	FL
4-9/12/1892	0700Z	29.0	90.6	50	LA
9-10/24/1892$	1900Z	27.6	82.8	45	FL
1-6/15/1893	2300Z	29.9	83.7	60	FL
11-10/23/1893	0300Z	35.2	75.6	50	NC
11-10/23/1893	1100Z	38.1	75.6	45	VI
12-11/8/1893*	1800Z	35.6	74.6	55	NC
2-8/7/1894	1800Z	30.3	87.6	50	AL
4-9/28/1894	1200Z	34.7	76.7	60	NC
1-8/15/1895	1900Z	29.3	89.6	50	LA
1-8/16/1895	1300Z	30.2	88.8	45	MS
4-10/7/1895	0400Z	29.3	94.8	35	TX
6-10/16/1895$	1300Z	25.7	81.3	35	FL
5-10/9/1896$	0200Z	26.4	82.0	50	FL
5-10/13/1896*	1200Z	40.0	67.2	60	RI
2-9/10/1897$&	1800Z	24.4	81.9	50	FL
3-9/21/1897$	0200Z	26.7	82.3	60	FL
3-9/23/1897&	1000Z	35.2	75.7	50	NC
3-9/24/1897	1100Z	40.8	72.7	50	NY
3-9/24/1897	1300Z	41.3	72.2	45	CT
5-10/20/1897	2000Z	35.2	75.5	55	NC
6-10/25/1897	2300Z	36.1	75.8	55	NC

1-8/2/1898$	0300Z	27.1	80.1	60	FL
5-9/20/1898	1100Z	29.6	92.8	50	LA
6-9/28/1898	0700Z	29.4	94.7	50	TX
9-10/11/1898$&	1200Z	24.5	80.0	40	FL
1-6/27/1899	0900Z	29.1	95.1	35	TX
2-7/30/1899$	1000Z	24.9	80.6	40	FL
3-8/13/1899*	1200Z	27.0	78.6	60	FL
6-10/5/1899$	1000Z	27.9	82.8	50	FL
4-9/13/1900	0630Z	29.2	89.5	40	LA
4-9/13/1900	1500Z	30.3	88.8	35	MS
6-10/12/1900	0250Z	29.5	83.3	40	FL
1-6/13/1901	2050Z	29.9	84.6	35	FL
2-7/10/1901	1010Z	28.6	96.0	45	TX
3-7/12/1901	2210Z	34.0	77.9	35	NC
4-8/10/1901	2130Z	26.3	80.1	40	FL
7-9/17/1901	1930Z	30.4	86.6	50	FL
9-9/28/1901	0250Z	29.9	84.6	40	FL
1-6/14/1902	2310Z	29.8	83.7	50	FL
2-6/26/1902	2110Z	27.7	97.2	60	TX
4-10/10/1902	2120Z	30.3	87.3	50	FL
3-10/20/1904	1010Z	25.5	81.2	35	FL
5-11/3/1904	1230Z	30.5	86.4	35	FL
3-9/29/1905	0940Z	29.6	92.6	45	LA
5-10/9/1905	1720Z	29.5	91.4	45	LA
1-6/12/1906	2030Z	30.1	85.6	45	FL
8-10/21/1906	0930Z	30.0	81.4	50	FL
1-6/28/1907	2340Z	30.3	85.9	50	FL
2-9/21/1907	1700Z	30.4	88.9	40	MS
3-9/28/1907	2020Z	30.1	85.7	45	FL
2-5/29/1908&	2100Z	35.2	75.6	55	NC
2-5/30/1908	2250Z	41.3	72.0	35	CT
4-7/31/1908	2130Z	29.5	91.9	50	LA
4-9/1/1908	0900Z	34.7	76.5	45	NC
3-6/28/1909	2010Z	26.0	80.1	45	FL
3-6/30/1909	1400Z	30.1	84.1	35	FL
7-8/29/1909	0900Z	26.4	80.1	45	FL
2-8/21/1910#	0000Z	25.7	97.2	40	TX

Notes:

Date/Time: Day and time when the circulation center crosses the U.S. coastline (including barrier islands). Time is estimate to the nearest hour.
Lat/Lon: Location is estimated to the nearest 0.1 degrees latitude and longitude (about 6 nmi).
Max Winds: Estimated maximum sustained (1 min) surface (10 m) winds to occur along the U. S. coast.
Landfall States: TX- Texas, LA-Louisiana, MS-Mississippi, AL-Alabama, FL- Florida, GA-Georgia, SC-South Carolina, NC-North Carolina, VA-Virginia, MD-Maryland, DE-Delaware, NJ-New Jersey, NY-New York, CT-Connecticut, RI-Rhode Island, MA-Massachusetts, NH-New Hampshire, ME-Maine.
$ - Indicates that the tropical storm may not have been reliably estimated for intensity (maximum sustained windspeed) because of landfall in a relatively uninhabited region. Errors in intensity are likely to be underestimates of the true intensity.
# - Indicates that the tropical storm made landfall first over Mexico, then the center crossed into Texas while over land. The position given is that ofMexican landfall. The strongest winds impacted Mexico. Thus the winds indicated here are lower than in HURDAT and are lower than they were over Mexico.

* - Indicates that the tropical storm/hurricane center did not make a U.S. landfall, but did produce tropical storm force winds over land. Position indicated is point of closest approach. Maximum winds refer, in this table, to the strongest winds estimated for the United States.
& - Indicates that the tropical storm/hurricane center did make a direct landfall, but that the strongest winds likely remained offshore. Thus the winds indicated here are lower than in HURDAT.

Table 7.10 Estimated dates when accurate tropical cyclone records began for specified regions of the United States based upon U.S Census reports and other historical analyses. Years in parenthesis indicate possible starting dates for reliable records before the 1850s that may be available with additional research.

State	Date
Texas - south	1880
Texas - central	1850
Texas - north	1860
Louisiana	1880
Mississippi	1850
Alabama	< 1851 (1830)
Florida – northwest	1880
Florida – southwest	1900
Florida – southeast	1900
Florida – northeast	1880
Georgia	< 1851 (1800)
South Carolina	< 1851 (1760)
North Carolina	< 1851 (1760)
Virginia	< 1851 (1700)
Maryland	< 1851 (1760)
Delaware	< 1851 (1700)
New Jersey	< 1851 (1760)
New York	< 1851 (1700)
Connecticut	< 1851 (1660)
Rhode Island	< 1851 (1760)
Massachusetts	< 1851 (1660)
New Hampshire	< 1851 (1660)
Maine	< 1851 (1790)

EVALUATION OF THE HURDAT REVISION BY NHC

FUTURE RE-ANALYSIS WORK

such endeavors in at least a small way.

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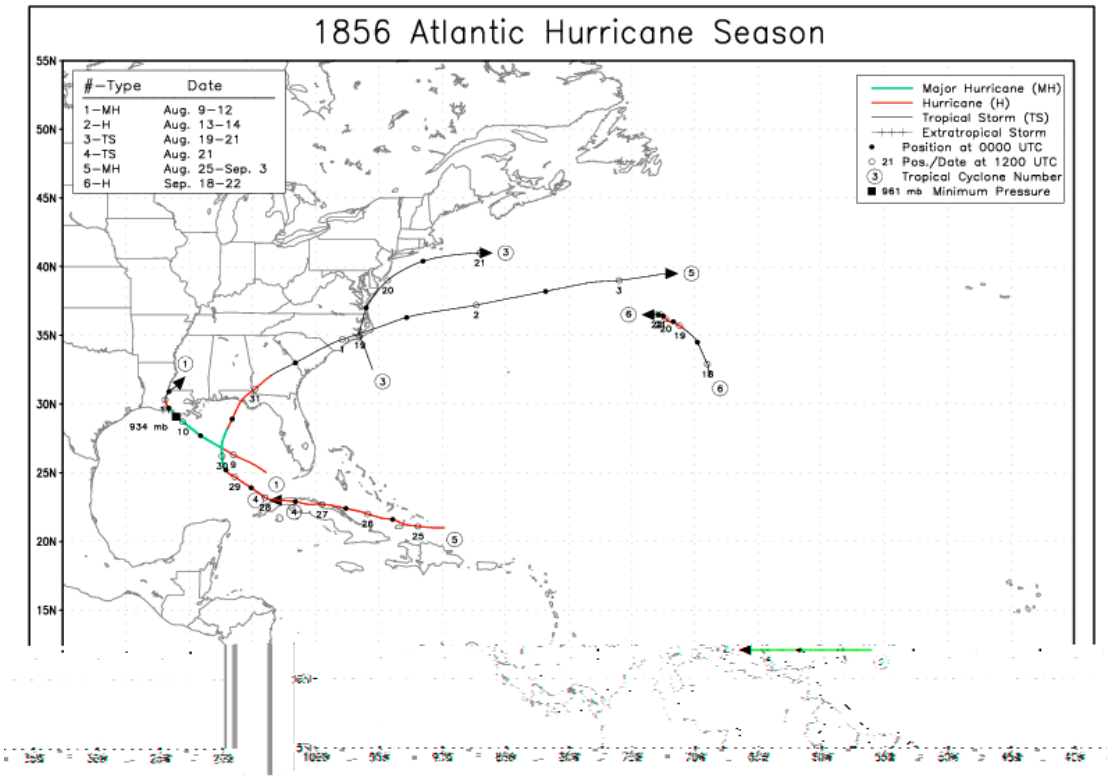
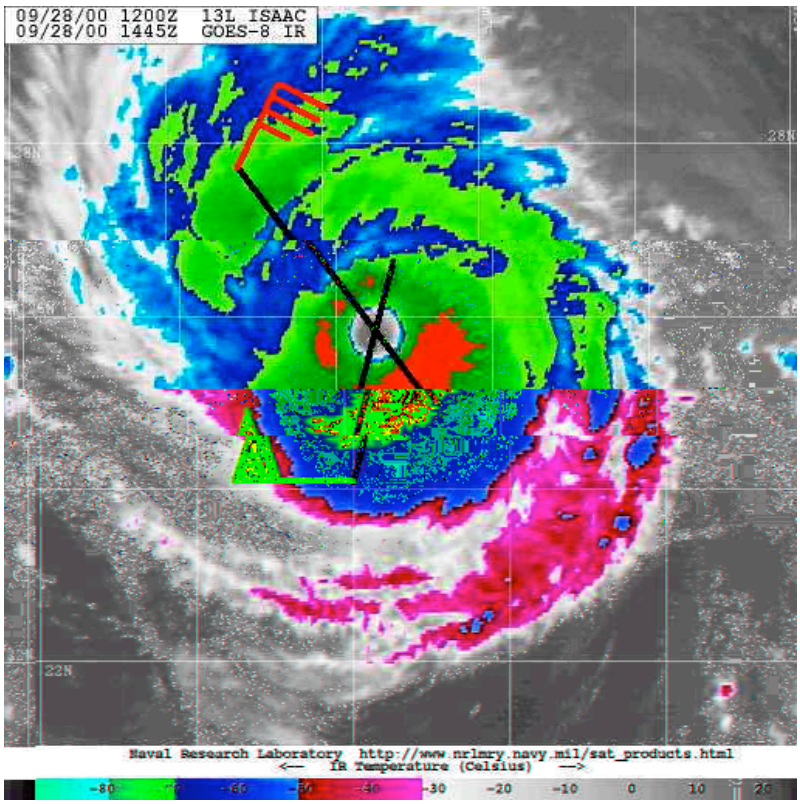

1856 Atlantic Hurricane Season
#–Type Date
1–MH Aug. 9–12
2–H Aug. 13–14
3–TS Aug. 19–21
4–TS Aug. 21
5–MH Aug. 25–Sep. 3
6–H Sep. 18–22
Major Hurricane (MH)
Hurricane (H)
Tropical Storm (TS)
Extratropical Storm
Position at 0000 UTC
21 Pos./Date at 1200 UTC
(3) Tropical Cyclone Number
961 mb Minimum Pressure
934 mb
55N
50N
45N
40N
35N
30N
25N
20N
15N


09/28/00 1200Z 13L ISAAC
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28N
23N
Naval Research Laboratory http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20

o