Preliminary Report
Tropical Storm Harvey
19 September - 22 September 1999

John L. Guiney
National Hurricane Center
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Tropical Storm Harvey, which formed in the eastern Gulf of Mexico and moved across southern Florida, produced heavy rainfall over portions of southwest Florida.

a. Synoptic History

The tropical wave that produced Harvey moved off the west coast of Africa late on 4 September with little fanfare. From the 4th through the 14th, the wave's trek across the tropical Atlantic into the eastern Caribbean Sea was uneventful. This was due, in part, to the disruptive effects of the upper-level outflow from Hurricane Floyd. By 16 September, with the influence of Floyd's circulation abating, convective activity in association with the wave began to increase over the western Caribbean Sea and a broad area of low pressure formed. Upper-air observations from the northwest Caribbean showed an associated mid-level circulation near the Cayman Islands. The system drifted northwestward during the next two days and by the morning of the 18th, the broad area of low pressure was over the south central Gulf of Mexico. Early on the 19th, satellite imagery showed increasing deep convection near and east of the broad surface circulation center. This, coupled with a sustained 30 knot wind report from the National Data Buoy Center (NDBC) buoy ***42003***, located in the eastern Gulf of Mexico, is the basis for initiating Tropical Depression Ten at 0600 UTC 19 September, at which time the circulation center was located about 350 n mi west-southwest of St. Petersburg, Florida as shown in the post-storm "best track" in Table 1 and Figure 1.

Upper-tropospheric outflow improved over the depression throughout the 19th, indicative of gradual strengthening . Surface observations and reconnaissance data from the U.S. Air Force Reserve "Hurricane Hunters" (USAFR) indicated that by 0000 UTC 20 September surface winds were near 40 knots and the system became Tropical Storm Harvey, while located about 300 n mi west-southwest of St. Petersburg, Florida. Over the next 24 hours, Harvey's central pressure dropped a modest 7 mb and the storm is estimated to have reached a peak intensity of 50 knots from 1800 UTC 20 September to 1800 UTC 21 September. Satellite images showed that the system did not become better organized during this period because of westerly vertical wind shear. Data from the NOAA G-IV synoptic flow mission over the Gulf of Mexico on the afternoon of the 20th showed 25 to 35 knot westerly upper-level winds over the cyclone. This resulted in the displacement of Harvey's center to the northwest edge of the deep convection along with restricted outflow over the western semicircle. Satellite imagery also suggested that dry air was being entrained into the circulation from the northwest.

After turning from a north to a northeast heading on the afternoon of the 19th, Harvey moved slowly eastward on the 20th. By early on the 21st, the system turned southeast and the forward speed increased to 9 knots in response to mid-level northwesterly flow depicted in NOAA G-IV synoptic flow data. Harvey's track bent back to the east by mid morning of the 21st and the cyclone accelerated in advance of a mid-latitude trough approaching from the west. Harvey made landfall near Everglades City, Florida around 1700 UTC 21 September with maximum sustained winds of 50 knots and a minimum central pressure of 999 mb. Later that afternoon, the center of Harvey became elongated while becoming absorbed by a developing extratropical cyclone located just off the coast of South Carolina with an associated front extending into south Florida. Harvey lost its identity over the western Atlantic early on the 22nd as it merged with the extratropical cyclone.

b. Meteorological Statistics

The best-track curves of minimum central sea-level pressure and maximum sustained one-minute average "surface" (10 meters above ground level) wind speed are shown in Figure 2. This figure also contains the data upon which the curves are based: USAFR reconnaissance data, satellite-based Dvorak-technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), the Satellite Analysis Branch (SAB), and the U.S. Air Force Weather Agency (AFGWC in the figures).

1. Wind and Pressure Data

The USAFR Hurricane Hunters flew five reconnaissance missions into Harvey and made 14 center fixes. The highest wind speed reported in Harvey was 58 knots, at 1500 feet, at 1554 UTC 21 September; the lowest central pressure was 994 mb at 0813 UTC 21 September. The maximum sustained wind of 50 knots at 1800 UTC 20 September was based on an observation of 47 knots from ship ***WCOB***; The C-MAN buoy at Molasses Reef (***MLRF1***) recorded a maximum wind of 47 knots, with a gust to 59 knots, at 1743 UTC 21 September while Fowey Rocks Light (***FWYF1***) reported 45 knots sustained winds, with a gust to 51 knots at 1800 UTC, and the aircraft data, all support the continuation of the 50-knot maximum sustained wind speed in the best track through 1800 UTC 21 September. These reports, along with other buoys and ship reports of 34 knot winds or higher, are listed in Table 2.

Table 3 lists a selection of surface observations from land stations. The highest official sustained surface wind observed over land was 32 knots at the Key West Airport at 1956 UTC 21 September. The Turkey Point Nuclear Power Plant recorded a 10-minute 46 knot wind, at a 9 meter elevation, at 1610 UTC 21 September while the highest gust, 48 knots, was recorded at Tenraw in the Everglades in Dade County (25.6N/81.9W) at 1700 UTC. The lowest pressure observed in south Florida was 999.4 mb at the Fort Lauderdale Airport at 1953 UTC 21 September.

A ***Carnival Cruise Line*** vessel provided two observations on 20 September of tropical storm-force winds. These reports were used to help define the tropical storm-force wind and the 12-foot sea radii.

2. Rainfall Data

The highest storm-total rainfall recorded in Harvey was 10.03 inches at the Naples Conservancy in Collier County. Naples Lakewood measured 10 inches of rainfall while Naples/Collier County Emergency Management *estimated* a similar amount at their operations center. These measurements are consistent with NWS doppler radar estimates. Substantial street flooding was reported in the Naples area. Street flooding was also reported in portions of Lee County, with two homes flooded in Bonita Springs. Rainfall totals of 5.53 and 6.72 inches were observed at Immokalee and Everglades City, respectively. Storm total rainfall across Miami-Dade, Broward, and Palm Beach counties ranged from 0.75 inches (West Palm Beach Airport) to 2.85 inches (Coral Springs).

3. Storm Surge Data

The maximum recorded storm surge was 2.41 feet at Fort Myers with estimates of 2 to 3 feet common elsewhere in Charlotte County. Storm surge values ranged from 1 to 2 feet elsewhere in southwest Florida and in the Florida Keys. Tidal flooding was reported in Everglades City including the county airport where a portion of the runway was flooded resulting in the closure of the airport. Minor coastal flooding was also reported along the south-facing portions of the Florida Keys and the west-facing shores of Florida Bay. Sections of Highway A1A in the Keys were closed due to the flooding. The combined effect of wave action and the storm surge resulted in minor beach erosion in Sarasota County, along the south-facing shores of the Keys, and in the back country of Everglades National Park.

4. Tornadoes

Harvey resulted in two confirmed tornadoes. One tornado, an F0, touched down briefly in Collier County near Paradise Point taking the roof off one house, while the other touched down in Dade County with no reported damage.

c. Casualty and Damage Statistics

No reports of casualties due to Harvey have been received at the National Hurricane Center.

Property damage estimates supplied by the Property Claims Services Division of the American Insurance Services Group indicate that Harvey caused about $7.5 million in insured losses in southern Florida. This estimate excludes storm surge damage. To determine the total estimated damage, a ratio of 2:1 is applied to the insured property damage; this is based on comparisons done in historical hurricanes. Thus, the total estimated damage from Harvey is $15 million.

d. Forecast and Warning Critique

The incipient disturbance that was to become Harvey was first identified as a candidate for development in NHC's Tropical Weather Outlook about two and a half days before it became a tropical depression.

There were only nine forecasts issued while Harvey was a tropical storm with only one verifying at 48 hours and none at 72 hours. This number of cases is too small to obtain a meaningful quantitative evaluation of forecast accuracy. However, Harvey was forecast to move across central Florida by most of the computer guidance as well as the official forecasts, and instead moved through south Florida.

Table 4 lists the various watches and warnings that were issued for Harvey. The formation of Harvey in the eastern Gulf of Mexico prompted the issuance of a tropical storm watch for the west coast of Florida, from the mouth of the Swannee River to Bonita Beach, with the first advisory. A tropical storm warning and a hurricane watch were issued six hours later with the warning extended southward to east Cape Sable at 2100 UTC 20 September. This was 20 hours prior to Harvey's landfall in southwest Florida near Everglades City. By early on the 21st, Harvey turned southeast and the forward speed increased, necessitating the extension of tropical storm warnings at 0900 UTC 21 September from Cape Sable to Boca Raton, including the Florida Keys.

Acknowledgements

Some of the data in this report was provided by the National Weather Service Forecast Offices in Tampa, Melbourne, Key West, and Miami . James Franklin produced the wind and pressure plots.

Table 1.

Preliminary Best Track - Tropical Storm Harvey, 19 - 21 September 1999.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
19/0600	25.0	87.8	1005	30	Tropical Depression
19/1200	25.5	87.8	1004	30	"
19/1800	26.0	87.8	1003	30	"
20/0000	26.3	87.4	1002	40	Tropical Storm
20/0600	26.6	86.9	1001	40	"
20/1200	27.0	86.3	998	40	"
20/1800	27.0	85.5	998	50	"
21/0000	27.1	84.6	995	50	"
21/0600	26.5	83.9	995	50	"
21/1200	26.0	82.8	996	50	"
21/1800	25.9	81.5	999	50	"
22/0000	26.9	78.6	1000	40	"
22/0600					Merged with Low
21/0800	26.3	83.7	994	50	Minimum Pressure
21/1700	25.9	81.7	999	50	Landfall near Everglades City, FL

Table 2.

Tropical Storm Harvey selected National Buoy Data Center (NBDC) and ship observations, September 1999.

Location	Press (mb)	Date/ Time (UTC)	Sust. Wind (kt)[a]	Peak Gust (kt)	Date/ Time (UTC)[b]	Significant Wave Height (FT)
CMAN Stations						
Lake Worth, FL (LKWF1)	1010.0	25/1100	30	35	25/1400	
Fowey Rocks, FL (FWYF1)			45	51	21/1800	
Molasses Reef, FL (MLRF1)	1001.5	21/1800	47	59	21/1743	
Long Key, FL (LONF1)	1003.1	21/1800	28	40	21/1200	
Sombrero Key, FL (SMKF1)		21/1600	36	41	21/1400	
Sand Key, FL (SANF1)	1002.9	21/1700	35	40	21/1305	
Dry Tortugas, FL (DRYF1)			25	31	21/1200	
NBDC Buoys						
42003 (25.9N / 89.9W)	1001.6	20/2200	34	42	20/0400	
42036 (28.5N / 84.5W)	1003.5	20/2200	26	32	20/1800	
34-Knot Ship Reports						
WCPU (25.6N / 86.7W)	1004.0	19/2300	40		19/2300	23.0
PFFV (25.3N / 85.8W)	1003.2	20/1200	40		20/1200	16.0
WCHF (25.0N / 84.8W)	1004.8	20/1500	40		20/1500	15.0
WCOB (25.7N / 85.2W)	1003.0	20/1800	47		20/1800	18.0
Carnival Cruise Line (26.2N/83.6W)		20/2200	40			12.0
Carnival Cruise Line (26.0N/83.3W)		21/0000	35			10.0
ELXB9 (24.3N / 83.2W)	1007.0	21/0000	35			
ELBM9 (25.7N / 83.6W)		21/0600	40		21/0600	
WCOB (25.5N / 79.7W)	1000.5	21/1800	45		21/1800	16.4

[a] Standard NWS C-MAN averaging period is 2 min; buoys are 8 min.
[b] Date/time is for sustained wind when both sustained and gust are listed.

Table 3.
Tropical Storm Harvey selected surface observations, September 1999.

LOCATION	Press. (mb)	Date/Time (UTC)	Sust. Wind (kts)[a]	Peak gust (kts)	Date/Time (UTC)[b]	Storm Surge (ft)[c]	Storm Tide (ft)[d]	Total rain (in)
Florida								
Key West Airport	1004.1	21/1956	32	37	21/1404			0.33
Tavernier								1.13
Marathon								0.04
Key West						0.8		
Vaca Key						1.0		
Homestead								0.96
Turkey Pt. Nuclear Plant			46*		21/1800			
Tamiami Aprt (KTMB)			25	36	21/1909			1.26
Miami Int. Aprt (KMIA)			23	36	21/1925			1.52
NWSFO Miami	29.6	21/1930						
Hollywood								3.29
Ft. Lauderdale								6.62
Ft. Lauderdale Beach								3.88
Ft. Lauderdale (KFLL)	999.4	21/1953	23	33	21/1904			1.87
Ft. Lauderdale (KFXE)	999.5	21/1953						
Pompano Beach (KPMP)	999.5	21/1950						
W. Palm Beach (KPBI)								0.73
Tenraw WIMS (Dade)			28	48	21/1700			1.61
Naples/Collier EM	29.6	21/1445		34	21/XXXX			10.00
Immokalee (Collier)								5.53
Everglades City (Collier)								6.72
Naples Conserv (Collier)								10.03
Naples Lkwd (Collier)								10.00
Ochopee WIMS (Collier)								2.06
Coral Springs (Broward)								2.85
Sarsota Aprt (KSRQ)	1003.1	21/1053	25	31	21/0410			1.80
Sunshine Skywy (Hillsb)				31	21/0006			
Venice Dardc (Sarsota)			21		21/2000			
St Petersburg (KPIE)	1003.1	21/1053	14	19	21/0117			
Tampa Arpt (KTPA)	1004.5	21/0956	11	17	20/0320		1.79	
Fort Myers (KFMY)	1004.0	21/1053	14	20	21/0853		2.41	
Levy County							1-2	
Citrus County							1-2	
Hernando County							1-2	
Pasco County							1-2	
Pinellas County							1-2	
Hillsborough County							1-2	
Manatee County							1-2	
Sarasota County							1-2	
Charlotte County							2-3	

[b]Date/time is for sustained wind when both sustained and gust are listed.
[c]Storm surge is water height above normal astronomical tide level.
[d]Storm tide is water height above NGVD.
[e]Estimated.
***10 miniute/9 meter wind**
XXXX - time unknown

Table 4.

Watch and warning summary, Tropical Storm Harvey, September 1999.

Date/Time (UTC)	Action	Location
19/0300	Tropical Storm Watch Issued	Florida West Coast: Bonita Beach Florida to the mouth of the Suwannee River
20/1500	Tropical Storm Warning and Hurricane Watch Issued	Florida West Coast: Bonita Beach Florida to the mouth of the Suwannee River
	Tropical Storm Watch Issued	Florida East Coast: North of Jupiter Inlet to just south of Flagler Beach...including Lake Okeechobee
20/2100	Tropical Storm Warning Extended	Florida West Coast: East Cape Sable to the mouth of the Suwannee River
	Tropical Storm Watch Extended	Florida East Coast: Florida City to just south of Flagler Beach ...including Lake Okeechobee
21/0000	Tropical Storm Watch Issued	Northwest Bahamas: Grand Bahama Island and the Abacos
21/0300	Tropical Storm Warning Extended	Florida East Coast: south of Flagler Beach to Boca Raton... including Lake Okeechobee
21/0900	Tropical Storm Warning Issued	Northwest Bahamas: Grand Bahama Island and the Abacos
	Tropical Storm Warning Extended	Boca Raton to East Cape Sable including the Florida Keys... the Dry Tortugas...Florida Bay and the Florida Straits
	Tropical Storm Warning Discontinued	Florida East Coast: North of Sebastian Inlet Florida West Coast: North of Longboat Key
	Hurricane Watch Discontinued	Florida West Coast: Bonita Beach to the mouth of the Suwannee River
21/1500	Tropical Storm Warning Discontinued	Florida East Coast: North of Jupiter Inlet to just south of Flagler Beach ...including Lake Okeechobee Florida West Coast: Bonita Beach to the mouth of the Suwannee River
21/2100	Tropical Storm Warning Discontinued	South of Bonita beach southward through the Florida Keys to just west of Craig Key...including the Dry Tortugas
22/0000	Tropical Storm Warning Discontinued	Florida East Coast: Craig Key to Jupiter Inlet...including Florida bay and the Florida Straits
22/0300	Tropical Storm Warning Discontinued	Northwest Bahamas: Grand Bahama Island and the Abacos

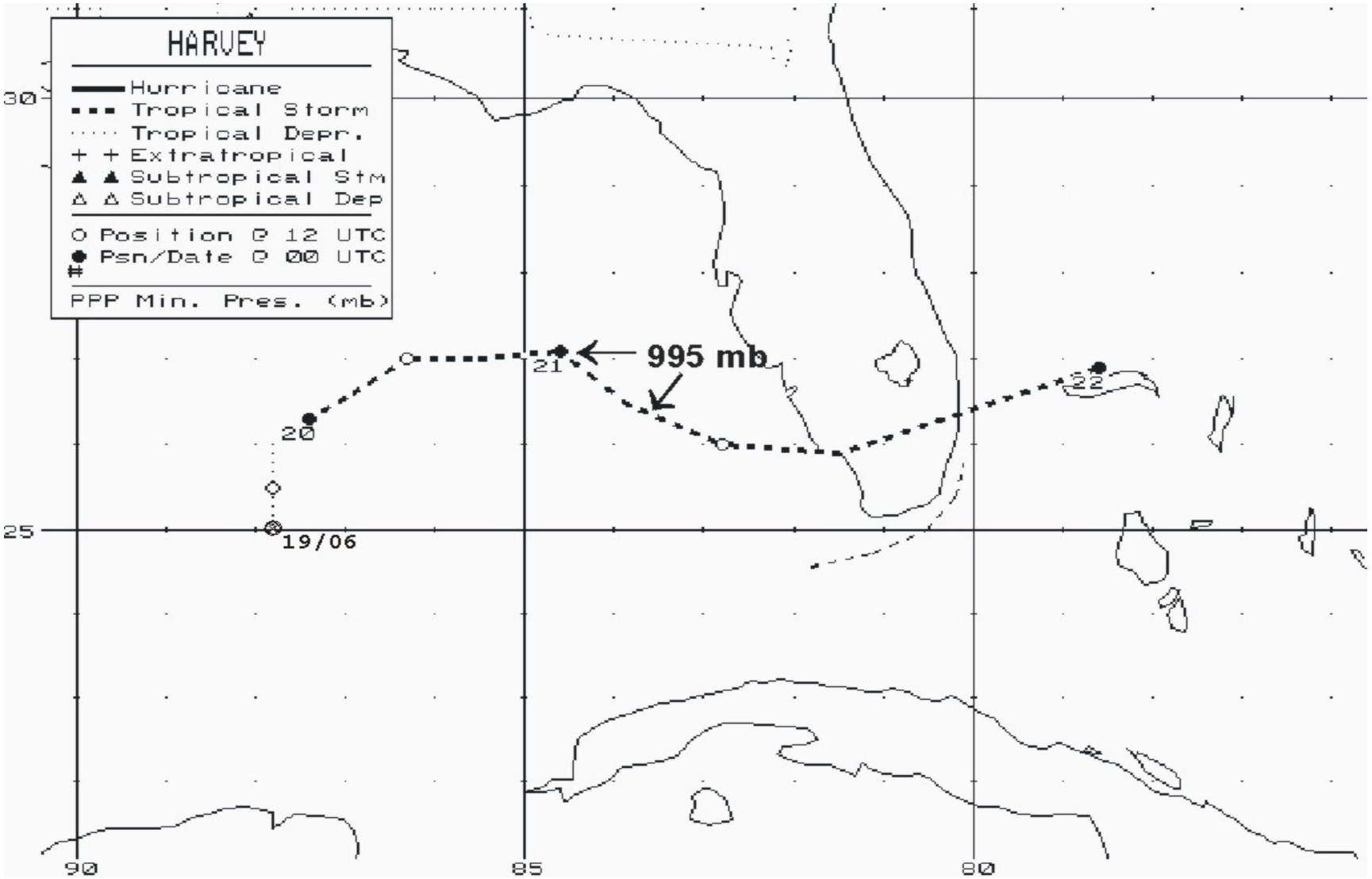

Figure 1. Best track positions for Tropical Storm Harvey, 19-21 September 1999.

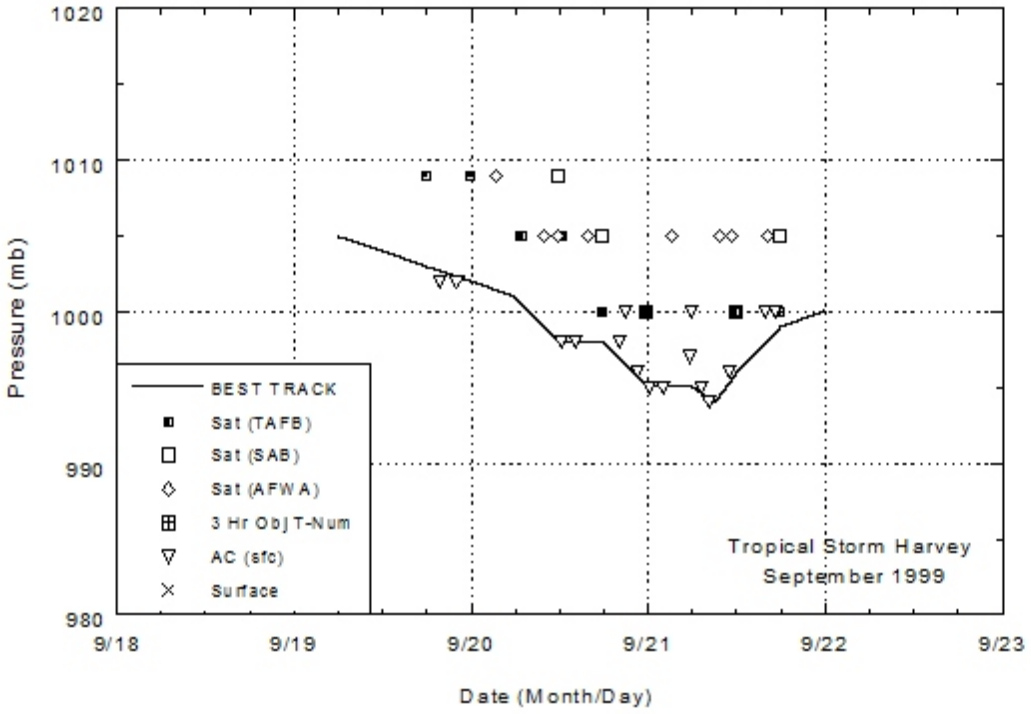

Figure 2a. Best track minimum central pressure curve for Tropical Storm Harvey, 19-22 September 1999.

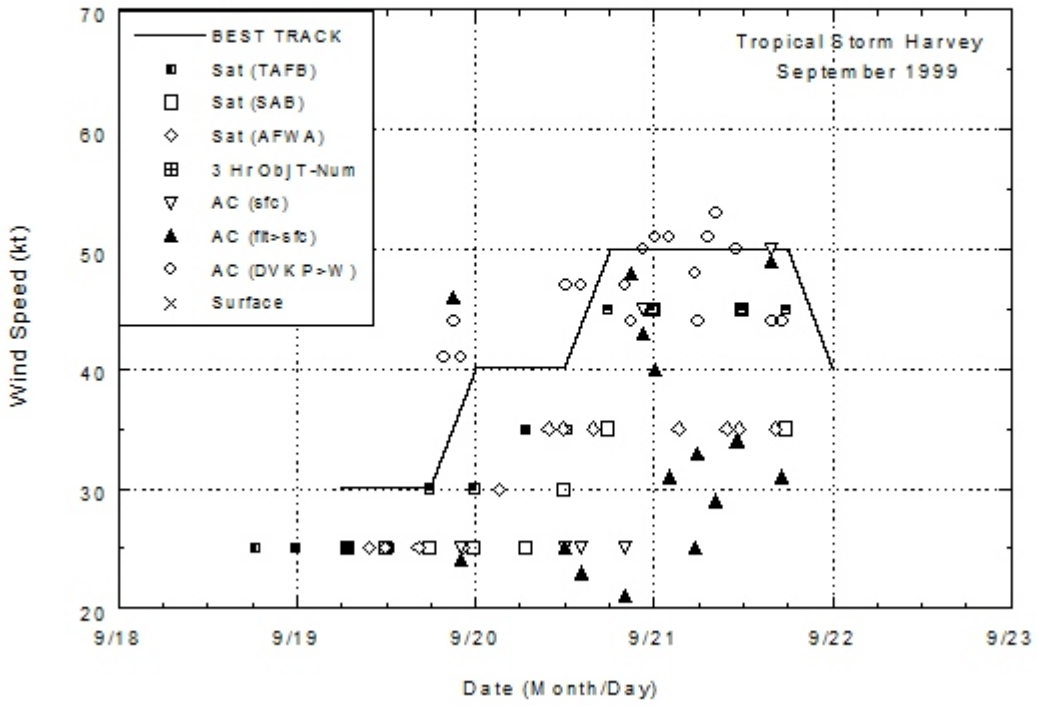

Figure 2b. Best track maximum sustained 1-minute 10 meter wind speed curve for Tropical Storm Harvey, 19 - 22 September 1999.