NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

HURRICANE FRANK

(EP072016)

21 – 28 July 2016

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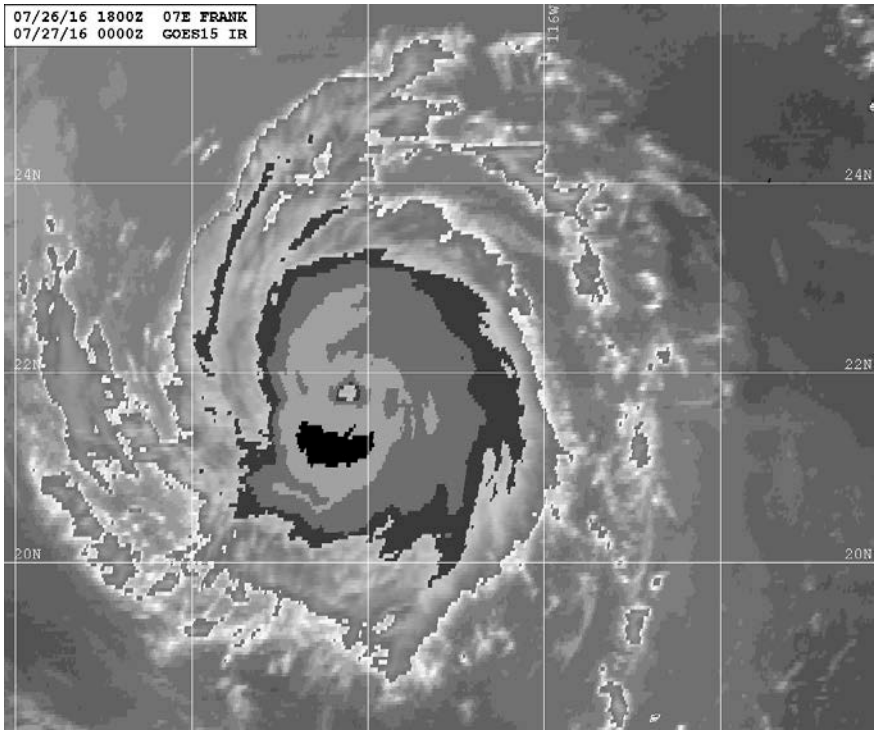

GOES 15 SATELLITE IMAGE AT 0000 UTC 27 JULY SHOWING THE EYE OF FRANK AT THE TIME THE HURRICANE REACHED ITS PEAK INTENSITY. IMAGE COURTESY OF THE NAVAL RESEARCH LABORATORY.

Frank was the fifth hurricane to form in the eastern North Pacific basin during July of 2016, marking a new record for this month. Frank produced sustained tropical-storm-force winds on Socorro Island.

Hurricane Frank

21 – 28 JULY 2016

SYNOPTIC HISTORY

Frank's origin was associated with a large-amplitude tropical wave that moved off of the west coast of Africa on 10 July. The wave travelled westward across the tropical Atlantic with little thunderstorm activity, and reached the western Caribbean Sea on 18 July. On 19 July, upper-air data from Central America showed that the wave had a well-defined mid-level circulation while the convection was increasing. The wave continued westward and its associated cloudiness and thunderstorms gradually became better organized on 20 July just south of the Gulf of Tehuantepec. The formation of a tropical depression occurred at 0600 UTC 21 July about 250 n mi south of Manzanillo, Mexico. The "best track" chart of the tropical cyclone's path is given in Fig. 1, with the wind and pressure histories shown in Figs. 2 and 3, respectively. The best track positions and intensities are listed in Table 1[1].

The cloud pattern continued to become better organized, and by 1200 UTC 21 July, the system was a tropical storm. Frank moved toward the west-northwest at 13 kt around the periphery of a large mid-level anticyclone centered over the southern plains of the United States. This motion kept the cyclone away from the southwestern coast of mainland Mexico, but took Frank very near Socorro Island on 23 July as a 55-kt tropical storm. Over the next 2 to 3 days, the steering currents weakened, and Frank slowed down. During this time, the cyclone was affected by moderate easterly wind shear and fluctuated in intensity.

The subtropical ridge re-amplified and a stronger steering pattern became established again. Frank began to move a little faster on 26 July, and the thunderstorm activity increased in organization with the development of a ragged eye. Frank became a hurricane at 1200 UTC 26 July, and is estimated that it reached its peak intensity of 75 kt and a minimum pressure of 979 mb at 0000 UTC 27 July. After that time, the circulation of Frank moved over cooler waters and the cyclone weakened rapidly. Most of the deep convection vanished and by 1200 UTC 28 July, Frank had degenerated into a remnant low.

METEOROLOGICAL STATISTICS

Observations in Hurricane Frank (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), and objective Advanced Dvorak Technique (ADT) estimates from

[1] A digital record of the complete best track, including wind radii, can be found on line at ftp://ftp.nhc.noaa.gov/atcf. Data for the current year's storms are located in the *btk* directory, while previous years' data are located in the *archive* directory.

the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Global Precipitation Mission (GPM), the European Space Agency's Advanced Scatterometer (ASCAT), and Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in constructing the best track of Frank.

The center of Frank moved over or just to the north of Socorro Island, and a Mexican Navy automatic weather station installed on that island reported sustained west winds of 39 kt with gusts to 55 kt around 2315 UTC 23 July. The island reported tropical-storm-force wind gusts for about 12 h that day. Frank's estimated peak intensity was based on the presence of an eye on satellite and a blend of both subjective and objective Dvorak estimates.

CASUALTY AND DAMAGE STATISTICS

There were no reports of damage or casualties associated with Hurricane Frank.

FORECAST AND WARNING CRITIQUE

Although a low possibility of Frank's genesis during the following 5 days was first indicated in the Tropical Weather Outlook 102 h before it occurred, the short-range formation was not well forecast. Given uncertainty over whether the system had a closed circulation, and the fact that within the 2-day window most of global models did not show genesis, the NHC 48-h formation probability was still in the medium category when genesis was assigned in post-analysis. The analyzed time of genesis (0600 UTC 21 July) was based on a subsequent ASCAT pass at 1600 UTC that showed winds of 40 kt and a well-defined circulation. All of the genesis forecast lead times are included in Table 2.

A verification of NHC official track forecasts for Hurricane Frank is given in Table 3a. Official forecast track errors were lower than the mean official errors for the previous 5-yr period. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. In general, there were no models that performed better than the official forecast at all times. However, the HWRF performed quite well in the short range, while the consensus TVCX had lower errors than the NHC official for the longer ranges.

A verification of NHC official intensity forecasts for Hurricane Frank is given in Table 4a. Official forecast intensity errors were lower than the mean official errors for the previous 5-yr period except at 36, 48 and 120 h. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. The intensity consensus (ICON) and the Florida State Super Ensemble model (FSSI) produced lower errors than the NHC official forecast and the rest of the models. Figure. 4 reveals that the NHC forecast intensified Frank too early and weakened it too soon. There were no watches and warnings associated with Hurricane Frank.

Table 1. Best track for Hurricane Frank, 21-28 July 2016.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage*
21 / 0600	13.2	101.5	1007	30	tropical depression
21 / 1200	14.0	102.5	1006	35	tropical storm
21 / 1800	14.8	103.6	1005	40	"
22 / 0000	15.6	104.7	1004	45	"
22 / 0600	16.4	105.8	1000	45	"
22 / 1200	17.2	106.9	1000	45	"
22 / 1800	17.7	107.8	1000	50	"
23 / 0000	18.0	108.5	998	55	"
23 / 0600	18.3	109.1	994	55	"
23 / 1200	18.6	109.7	994	55	"
23 / 1800	19.0	110.3	994	55	"
24 / 0000	19.3	110.8	994	55	"
24 / 0600	19.6	111.4	994	55	"
24 / 1200	19.8	111.9	994	55	"
24 / 1800	19.9	112.3	992	60	"
25 / 0000	20.1	112.8	992	60	"
25 / 0600	20.2	113.2	994	55	"
25 / 1200	20.3	113.7	994	50	"
25 / 1800	20.5	114.2	996	45	"
26 / 0000	20.7	114.7	994	50	"
26 / 0600	20.9	115.4	994	55	"
26 / 1200	21.1	116.2	989	65	hurricane
26 / 1800	21.3	117.2	986	70	"
27 / 0000	21.6	118.2	979	75	"
27 / 0600	22.0	119.2	985	75	"
27 / 1200	22.4	120.3	993	60	tropical storm
27 / 1800	22.9	121.4	996	55	"
28 / 0000	23.2	122.4	1000	45	"
28 / 0600	23.4	123.3	1004	35	"
28 / 1200	23.6	124.1	1006	30	low

28 / 1800	24.0	124.6	1007	25	"
29 / 0000	24.1	125.1	1008	25	"
29 / 0600	24.2	125.6	1009	25	"
29 / 1200	24.2	126.0	1011	20	"
29 / 1800	24.1	126.4	1011	20	"
30 / 0000	23.8	126.7	1011	20	"
30 / 0600	23.6	127.0	1011	20	"
30 / 1200	23.4	127.3	1011	20	"
30 / 1800	23.2	127.7	1011	20	"
31 / 0000					dissipated
27 / 0000	21.6	118.2	979	75	Maximum winds and minimum pressure

Table 2. Number of hours in advance of formation associated with the first NHC Tropical Weather Outlook forecast in the indicated likelihood category. Note that the timings for the "Low" category do not include forecasts of a 0% chance of genesis.

	Hours Before Genesis	
	48-Hour Outlook	**120-Hour Outlook**
Low (<30%)	30	102
Medium (30%-50%)	6	78
High (>50%)	0	48

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Frank. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**19.9**	**33.2**	**41.9**	**48.0**	**55.3**	**70.5**	**120.4**
OCD5	28.5	56.7	90.6	125.6	162.2	160.1	148.2
Forecasts	25	23	21	19	15	11	7
OFCL (2011-15)	23.4	36.4	47.2	59.4	89.0	123.6	159.5
OCD5 (2011-15)	36.6	74.2	116.5	159.7	245.6	331.1	427.4

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Frank. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 3a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	18.9	31.0	42.7	50.7	53.8	64.8	116.5
OCD5	30.2	61.0	95.1	130.0	164.3	149.2	147.3
GFSI	**18.0**	**25.8**	**38.5**	**50.3**	70.3	67.9	**76.6**
EMXI	26.3	46.3	58.4	69.0	75.6	72.8	**38.5**
EGRI	27.2	47.5	64.1	74.8	87.5	78.6	**76.4**
NVGI	29.5	49.1	75.4	98.7	105.4	91.7	179.1
CMCI	21.0	31.2	44.7	60.3	97.0	165.7	314.9
GHMI	24.3	43.4	65.7	91.3	152.7	238.9	332.3
HWFI	**17.6**	**28.1**	**40.0**	**47.2**	65.7	102.6	149.9
CTCI	19.1	**27.8**	**38.4**	**43.5**	54.7	131.1	288.6
GFNI	28.9	44.4	68.1	95.6	141.0	214.6	379.6
TVCE	19.2	**29.2**	**41.4**	**48.0**	**51.9**	67.1	119.4
TVCX	20.0	31.6	**42.2**	**49.8**	**51.4**	**61.3**	**104.2**
TCON	19.1	**29.8**	42.8	52.7	64.1	74.6	**108.7**
GFEX	21.0	34.9	45.5	55.3	61.9	**60.6**	**44.9**
FSSE	20.4	**29.0**	**39.7**	**46.4**	60.8	69.8	118.8
AEMI	**18.8**	31.1	45.5	59.6	76.9	76.2	118.9
BAMS	25.4	43.0	62.5	78.1	82.4	86.9	**109.3**
BAMM	25.4	40.2	55.4	68.2	89.1	109.1	**95.2**
BAMD	29.7	49.3	63.0	75.8	91.2	96.1	**76.1**
Forecasts	19	18	18	16	12	8	4

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Frank. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	6.6	9.8	**10.7**	**13.9**	18.3	16.8	**14.3**
OCD5	6.5	11.0	10.8	12.4	11.7	15.9	21.4
Forecasts	25	23	21	19	15	11	7
OFCL (2011-15)	5.9	9.8	12.5	14.0	15.5	16.3	14.9
OCD5 (2011-15)	7.7	12.8	16.4	18.8	21.1	20.9	19.7

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Frank. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 4a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	7.1	9.7	10.8	13.8	19.2	18.1	12.5
OCD5	**6.6**	10.7	11.7	**13.3**	**13.0**	**17.1**	17.0
DSHP	**6.1**	10.7	11.1	**10.4**	**14.6**	**14.8**	**6.8**
LGEM	**6.3**	10.9	11.6	**12.6**	**18.4**	23.1	20.8
GHMI	**7.7**	**8.4**	10.9	**12.6**	24.1	31.4	21.3
HWFI	**5.3**	**7.4**	**8.8**	**9.3**	**13.0**	19.4	16.5
CTCI	7.7	12.0	11.9	**12.8**	27.0	40.0	41.3
GFNI	7.7	**7.8**	**8.3**	**8.5**	**14.3**	19.5	20.0
ICON	**5.9**	**7.7**	**8.8**	**9.1**	**14.2**	**16.3**	**8.0**
IVCN	**6.1**	**7.8**	**7.9**	**8.0**	**14.8**	20.0	14.8
FSSE	**6.4**	**8.3**	**8.6**	**9.3**	**16.0**	**17.9**	**11.5**
GFSI	7.3	**9.3**	**10.1**	**8.8**	**10.8**	**12.5**	16.3
EMXI	**6.7**	**9.6**	**8.4**	**6.1**	**13.4**	24.9	23.0
NF	19	18	18	16	12	8	4

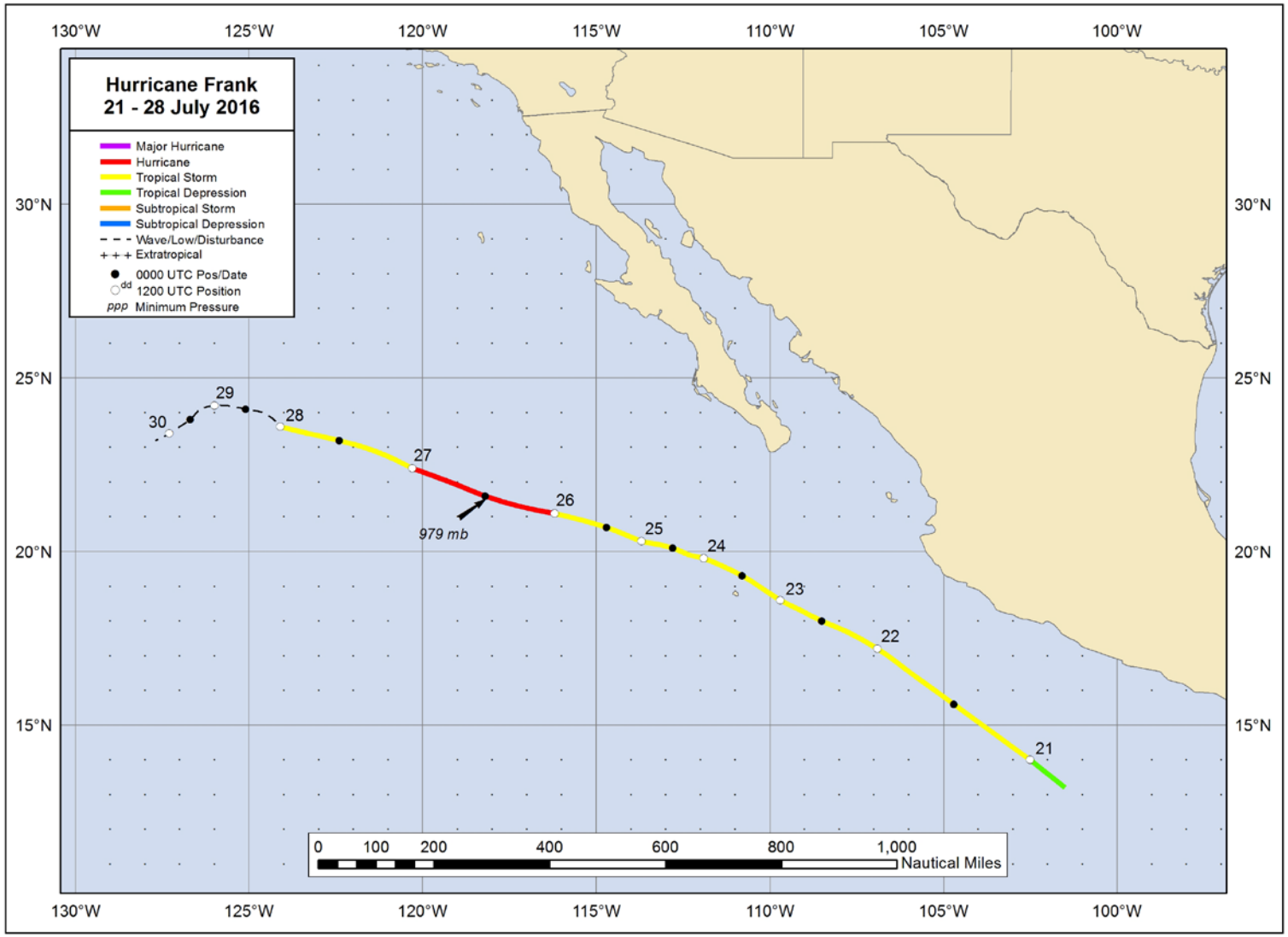

Figure 1. Best track positions for Hurricane Frank, 21-28 July 2016.

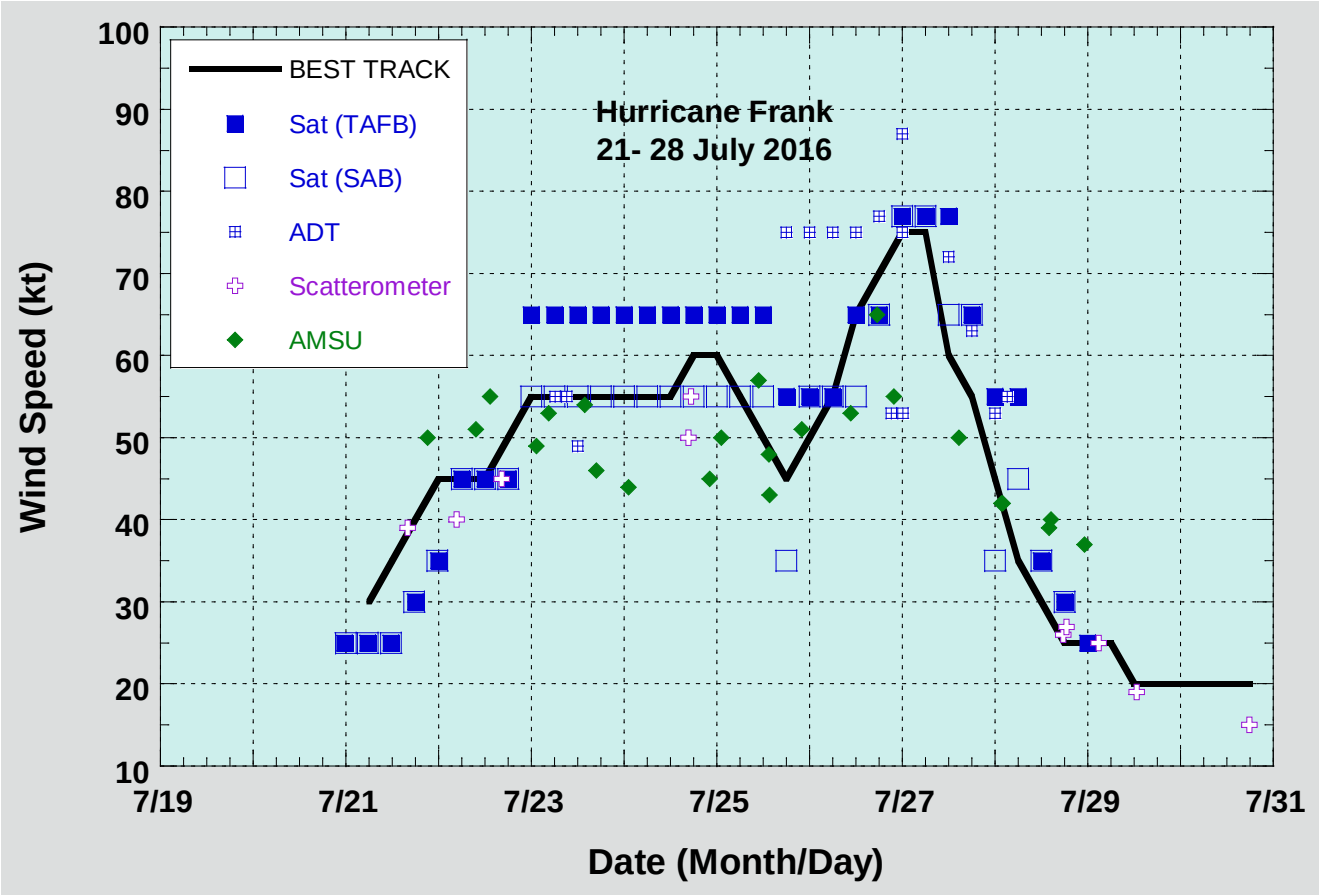

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Frank, 21-28 July 2016. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique.

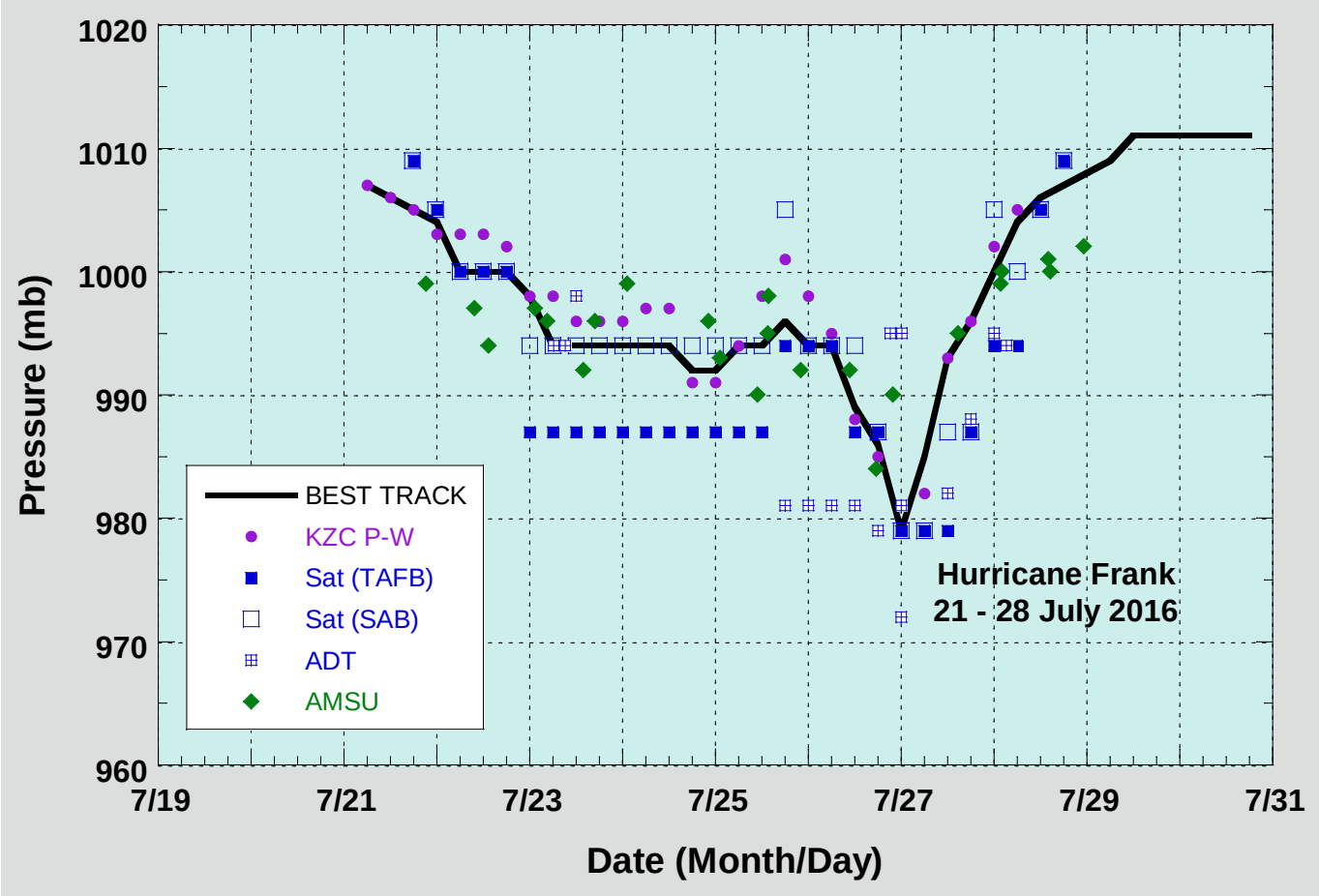

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Frank, 21-28 July 2016. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship.

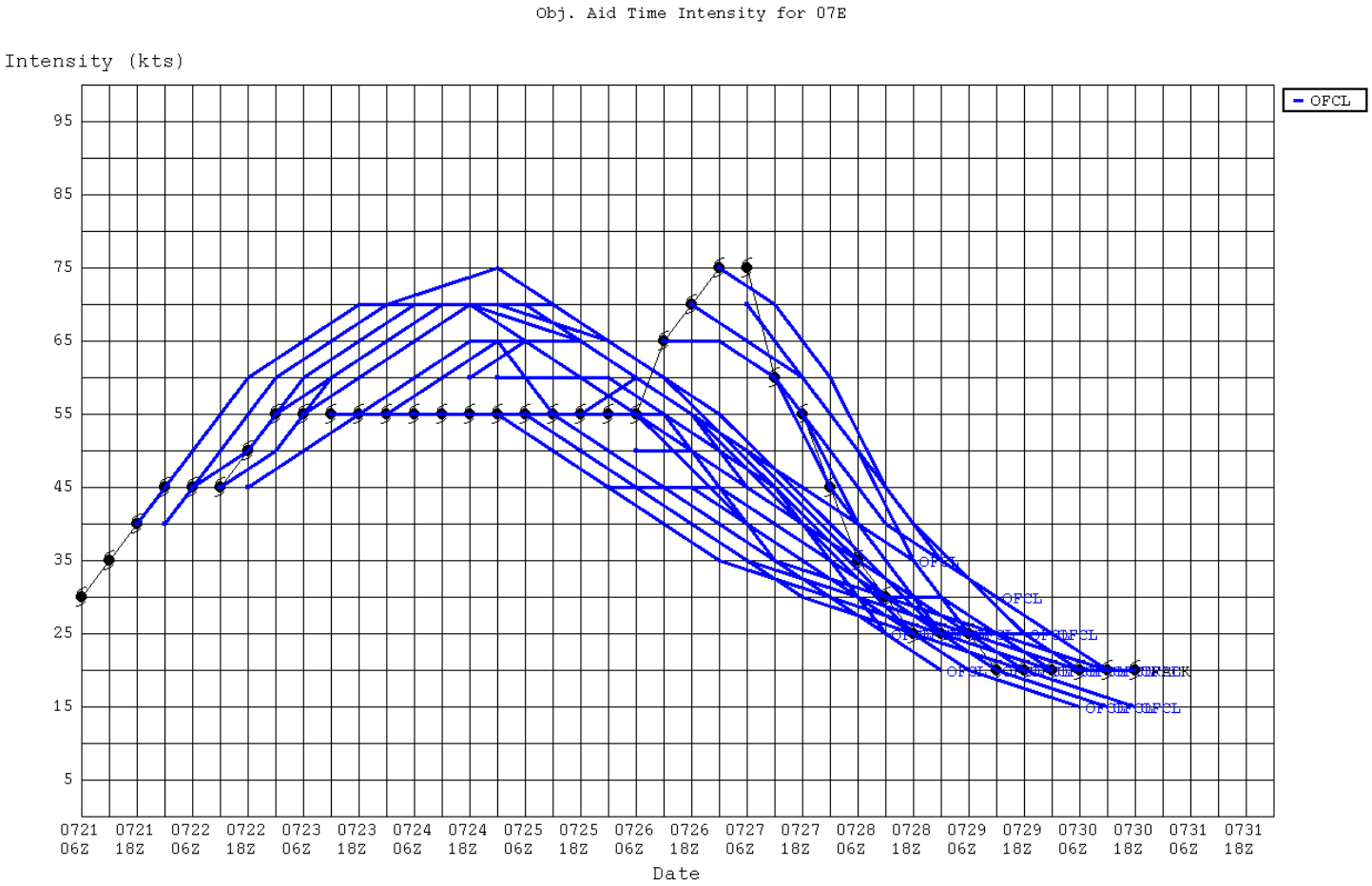

Figure 4. Selected official intensity forecasts (blue lines) for Hurricane Frank, 21-28 July 2016. The best track is given by the thick solid black line with positions given at 6 h interval.