NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT[1]

HURRICANE DARBY

(EP052016)

11 – 25 July 2016

John P. Cangialosi
National Hurricane Center
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MODIS VISIBLE SATELLITE IMAGE OF HURRICANE DARBY AT 2115 UTC 15 JULY.

Darby was a category 3 hurricane (on the Saffir-Simpson Hurricane Wind Scale) over the eastern Pacific Ocean. The cyclone was weakening when it reached the central Pacific basin, and it moved across portions of the Hawaiian Islands as a tropical storm.

[1] This report focuses on Darby's history in the National Hurricane Center's area of responsibility (east of 140°W longitude). The report will be updated once the Central Pacific Hurricane Center completes its analysis of the storm for the time the cyclone spent west of 140°W.

Hurricane Darby

11 – 25 JULY 2016

SYNOPTIC HISTORY

The primary weather feature that led to the formation of Darby was a tropical wave that moved off of the west coast of Africa on 28 June. The wave moved westward across the tropical Atlantic and reached the eastern Caribbean Sea about a week later. Showers and thunderstorms associated with the wave began to increase when it moved across Central America and into the eastern Pacific basin on 7 and 8 July, and a broad area of low pressure developed along the wave axis a day or so later. Satellite images indicate that a well-defined center of circulation developed with sufficiently organized deep convection around 1200 UTC 11 July, marking the formation of a tropical depression about 250 n mi south-southwest 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[2].

Northeasterly 200 to 850-mb wind shear of about 15 kt prevented strengthening for the next 18 h after genesis, but by 1200 UTC 12 July the shear began to relax and the cyclone strengthened to a tropical storm. In generally conducive environmental conditions, Darby strengthened quickly during the next 24 h as deep convection increased and became more symmetric around the center. While the storm intensified it moved just south of due west, steered by a strong mid-level ridge to its north. Darby reached hurricane intensity by 1800 UTC 13 July when it was about 450 n mi south-southwest of the southern tip of the Baja California peninsula. Occasional intrusions of dry air slowed the intensification rate, but Darby still gradually gained strength during the next few days while it moved westward to west-northwestward. A ragged eye was first apparent in geostationary satellite images by 0000 UTC 15 July, and the eye became well defined the next day. Darby became a major hurricane by 1200 UTC 16 July, and it reached its peak intensity of 105 kt 6 h later when it was located about 875 n mi west-southwest of the southern tip of the Baja California peninsula.

The hurricane did not maintain category 3 intensity for long, as it was in the process of moving over sub-26°C waters when it reached its maximum strength. However, since the shear was light and because Darby had an annular structure (Knaff and Kossin 2003), only gradual weakening occurred over the cool waters. While continuing to move westward to west-northwestward, the cyclone fell below hurricane strength around 0600 UTC 19 July, and moved into the central Pacific basin as a 50-kt tropical storm shortly after 1200 UTC 20 July.

[2] 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.

METEOROLOGICAL STATISTICS

Observations in Darby (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), the Satellite Analysis Branch (SAB), the Central Pacific Hurricane Center (CPHC), and the U.S. Joint Typhoon Warning Center (JTWC), plus and objective Advanced Dvorak Technique (ADT) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Observations also include flight-level, stepped frequency microwave radiometer (SFMR), and dropwindsonde observations from flights of the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Tropical Rainfall Measuring Mission (TRMM), 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 Darby.

There were no observations of tropical-storm-force or greater winds from Darby in the eastern Pacific basin.

The estimated peak intensity of 105 kt was based on subjective Dvorak classifications of 5.5/102 kt and 6.0/115 kt from TAFB and SAB, respectively, and on an objective CI-number of 5.6/105 kt from CIMSS at the University of Wisconsin.

CASUALTY AND DAMAGE STATISTICS

There were no reports of damage or casualties associated with Darby in the eastern Pacific basin.

FORECAST AND WARNING CRITIQUE

The genesis forecasts for Darby were of mixed quality. The system was first mentioned in the Tropical Weather Outlook about 102 h before genesis, at which time it was given a low (less than 40%) chance of development during the 5-day forecast period (Table 2). However, the chance of development in the 5-day period was not raised to the medium (40-60%) and high (greater than 60%) categories until 48 h and 30 h before genesis, respectively. The system was given a low chance of development in the 2-day period 42 h prior to genesis and a high chance 18 h before formation occurred.

A verification of NHC official track forecasts for Darby is given in Table 3a. Official forecast track errors were lower than the mean official errors by about 25% from the previous 5-yr period for all forecast times. A homogeneous comparison of the official track errors with selected

guidance models is given in Table 3b. The most skillful models for Darby were the GFS ensemble mean (AEMI), the GFS, and the Florida State Superensemble (FSSE), which all outperformed the official forecasts at most lead times.

A verification of NHC official intensity forecasts for Darby is given in Table 4a. Official forecast intensity errors were also lower than the mean official errors for the previous 5-yr period at all forecast times. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. The only model that consistently beat the official forecasts was the HWRF (HWFI) model. Nearly all of the models had a low bias for Darby.

There were no coastal watches or warnings for Darby in the eastern Pacific basin.

REFERENCES

Knaff, J.A. and J.P. Kossin, 2003: Annular Hurricanes. *Weather and Forecasting*, 18, 204–223.

Table 1. Best track for Hurricane Darby, 11-25 July 2016. A post-storm analysis has not yet been completed for the portion of the track west of 140°W longitude, and all data for this portion of the storm's history reflect near real time estimates from the Central Pacific Hurricane Center.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
11 / 1200	14.5	105.2	1008	25	tropical depression
11 / 1800	15.0	105.7	1007	30	"
12 / 0000	15.5	106.4	1007	30	"
12 / 0600	15.8	107.2	1007	30	"
12 / 1200	15.9	108.2	1006	35	tropical storm
12 / 1800	15.6	109.2	1002	45	"
13 / 0000	15.4	110.1	1000	55	"
13 / 0600	15.3	111.0	998	60	"
13 / 1200	15.3	111.9	996	60	"
13 / 1800	15.4	112.9	992	65	hurricane
14 / 0000	15.5	114.0	989	70	"
14 / 0600	15.6	115.2	989	70	"
14 / 1200	15.7	116.3	987	70	"
14 / 1800	15.8	117.5	984	75	"
15 / 0000	15.9	118.6	982	80	"
15 / 0600	16.0	119.5	979	85	"
15 / 1200	16.3	120.3	974	90	"
15 / 1800	16.7	121.1	972	90	"

16 / 0000	17.1	121.9	971	90	"
16 / 0600	17.4	122.7	968	95	"
16 / 1200	17.7	123.5	964	100	"
16 / 1800	17.9	124.4	958	105	"
17 / 0000	18.0	125.3	962	100	"
17 / 0600	18.1	126.2	967	95	"
17 / 1200	18.2	127.0	971	90	"
17 / 1800	18.3	127.8	975	85	"
18 / 0000	18.3	128.7	979	80	"
18 / 0600	18.4	129.6	982	75	"
18 / 1200	18.5	130.6	986	70	"
18 / 1800	18.8	131.6	988	65	"
19 / 0000	19.0	132.7	988	65	"
19 / 0600	19.3	133.8	990	60	tropical storm
19 / 1200	19.6	134.9	992	60	"
19 / 1800	19.8	136.0	994	55	"
20 / 0000	19.9	137.2	995	55	"
20 / 0600	19.9	138.4	996	55	"
20 / 1200	19.9	139.6	999	50	"
20 / 1800	19.9	140.7	1002	45	"
21 / 0000	19.7	142.0	1000	50	"
21 / 0600	19.4	143.3	998	55	"
21 / 1200	19.0	144.6	998	55	"

21 / 1800	18.8	145.7	998	55	"
22 / 0000	18.7	146.9	997	55	"
22 / 0600	18.6	148.1	997	55	"
22 / 1200	18.5	149.3	999	50	"
22 / 1800	18.5	150.5	999	50	"
23 / 0000	18.6	151.6	1000	50	"
23 / 0600	18.7	152.6	1000	50	"
23 / 1200	18.7	153.5	1001	45	"
23 / 1800	18.8	154.4	1002	40	"
24 / 0000	19.3	155.3	1006	35	"
24 / 0600	19.4	156.3	1004	35	"
24 / 1200	19.6	157.0	1004	35	"
24 / 1800	20.4	157.7	1008	35	"
25 / 0000	21.2	158.4	1009	35	"
25 / 0600	22.1	159.1	1009	35	"
25 / 1200	22.3	160.3	1011	30	tropical depression
25 / 1800	22.0	160.6	1012	30	"
26 / 0000	22.4	161.4	1012	25	low
26 / 0600	22.8	162.0	1013	20	"
26 / 1200					dissipated
16 / 1800	17.9	124.4	958	105	minimum pressure and maximum winds

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 (<40%)	42	102
Medium (40%-60%)	30	48
High (>60%)	18	30

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Darby, 11-25 July 2016. 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	**13.7**	**25.1**	**36.3**	**44.1**	**68.0**	**95.8**	**127.1**
OCD5	25.1	53.3	78.5	102.6	153.8	202.0	242.0
Forecasts	36	36	36	36	36	36	36
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 Darby, 11-25 July 2016. 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	12.3	22.3	36.1	47.0	71.1	91.8	145.3
OCD5	20.2	42.5	64.3	87.8	135.5	196.2	219.4
GFSI	**11.7**	**20.1**	**28.9**	**36.1**	**50.9**	**79.2**	146.9
GHMI	21.3	45.3	65.2	80.4	103.2	145.0	188.9
HWFI	17.4	32.1	47.5	59.7	71.8	**80.8**	**116.9**
EGRI	14.0	28.2	43.9	58.6	87.2	123.2	193.7
EMXI	17.1	29.9	44.4	60.0	92.1	130.6	214.7
CMCI	12.8	23.3	**33.5**	**45.0**	**68.8**	**85.3**	**121.8**
NVGI	15.4	26.5	**35.4**	**44.9**	81.1	160.7	258.5
CTCI	15.9	30.8	44.7	59.9	87.8	115.3	171.3
GFNI	17.4	41.2	63.9	87.6	146.4	210.6	278.0
AEMI	**11.7**	**20.8**	**27.1**	**33.4**	**51.5**	**81.9**	**135.8**
FSSE	**10.7**	**20.8**	**33.8**	**44.0**	**64.9**	**87.7**	**137.4**
TVCX	12.7	24.6	36.7	48.2	**67.1**	**88.5**	**137.6**
GFEX	12.4	22.8	**34.2**	**44.5**	**67.6**	97.9	168.8
TCON	12.3	24.7	36.8	47.1	**58.1**	**72.0**	**109.9**
TVCE	12.4	24.3	37.0	48.5	**64.5**	**83.3**	**128.5**
BAMS	28.4	51.0	76.5	100.2	138.7	153.3	153.7
BAMM	27.0	52.8	78.7	106.8	162.7	200.2	231.4
BAMD	28.4	58.2	90.1	124.0	205.0	307.9	458.8
Forecasts	27	27	27	27	27	27	22

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Darby, 11-25 July 2016. 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	**5.8**	**7.8**	**9.0**	**8.9**	**11.9**	**15.1**	**14.2**
OCD5	7.1	10.4	14.8	17.6	21.6	20.4	15.6
Forecasts	36	36	36	36	36	36	36
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 Darby, 11-25 July 2016. 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	5.4	6.7	7.4	8.1	13.1	15.0	11.0
OCD5	6.4	8.1	11.7	15.1	20.1	18.1	11.7
HWFI	7.4	**6.2**	**6.1**	**7.2**	**11.9**	**11.7**	**9.0**
GHMI	8.3	10.9	12.1	13.4	15.7	16.0	17.4
DSHP	6.1	7.2	8.9	11.6	17.2	18.8	13.8
LGEM	6.7	8.7	11.3	13.7	17.8	18.4	13.5
GFNI	8.2	11.8	13.2	13.6	16.9	21.7	24.7
IVCN	6.2	**6.3**	8.0	9.6	**13.0**	**14.2**	12.0
GFSI	**5.0**	**6.1**	**7.0**	8.6	**12.7**	**14.5**	13.7
EMXI	5.5	8.3	10.2	12.9	18.2	19.8	19.3
FSSE	6.5	7.6	8.1	9.2	14.4	18.6	15.8
CTCI	7.3	10.0	11.5	12.8	15.0	18.5	19.6
Forecasts	27	27	27	27	27	26	21

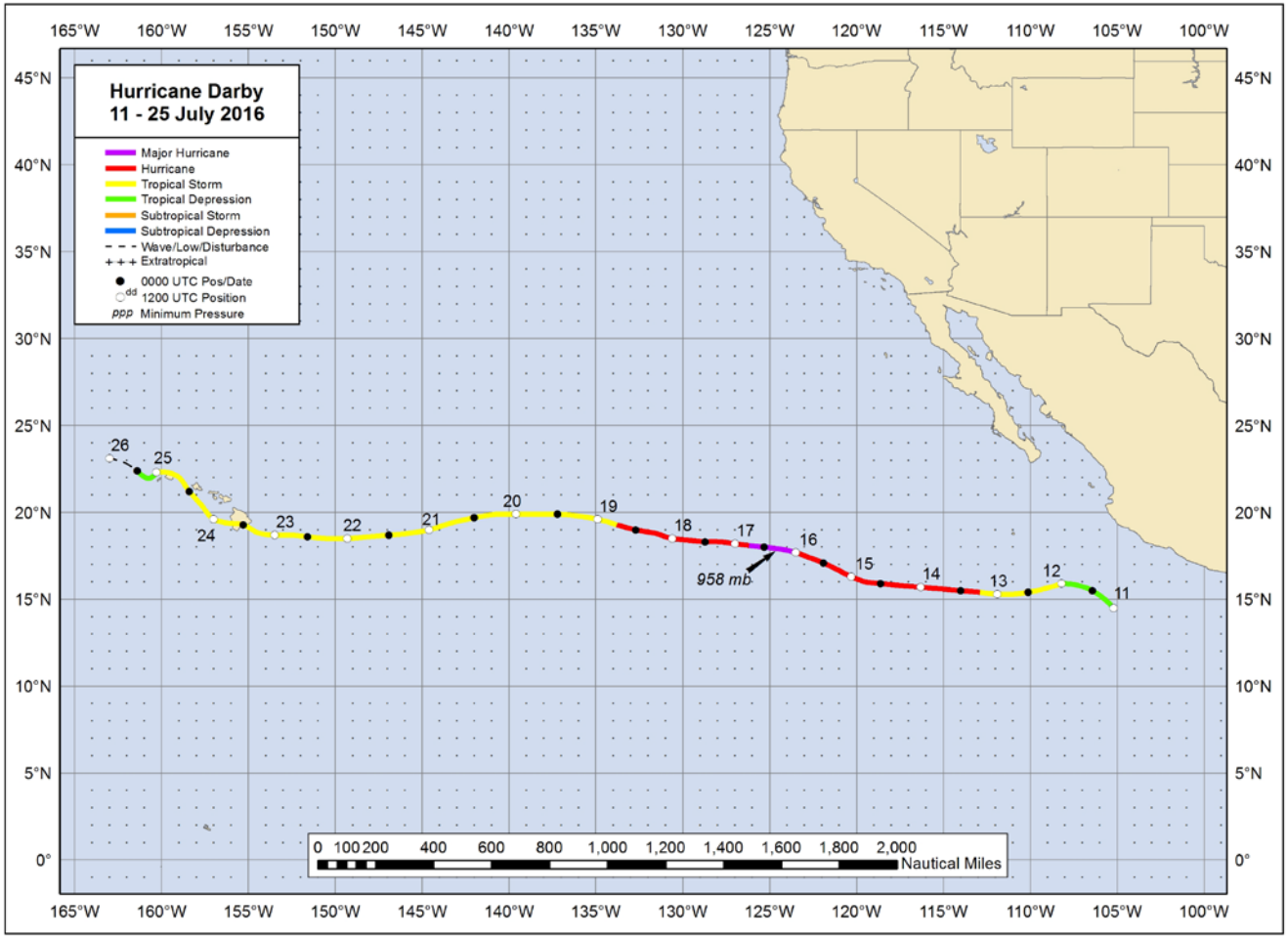

Figure 1. Best track positions for Hurricane Darby, 11-25 July 2016. A post-storm analysis has not yet been completed for the portion of the track west of 140°W longitude, and all data for this portion of the storm's history reflect near real-time estimates from the Central Pacific Hurricane Center.

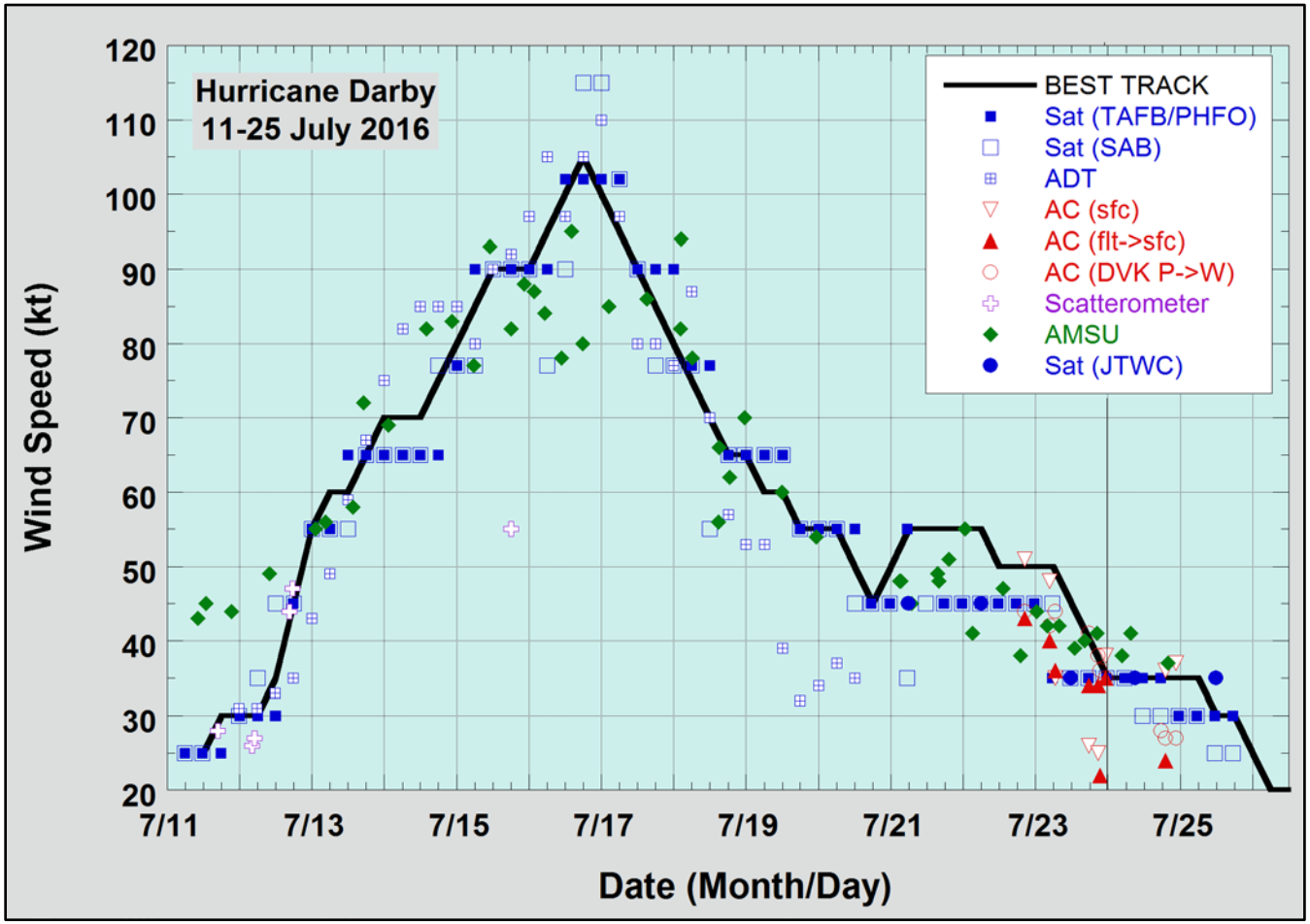

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Darby, 11-25 July 2016. Aircraft observations have been adjusted for elevation using a 90% adjustment factor for observations from 700 mb. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC. Solid vertical line corresponds to landfall. A post-storm analysis has not yet been completed for the portion of the track west of 140°W longitude, and all data for this portion of the storm's history reflect near real-time estimates from the Central Pacific Hurricane Center.

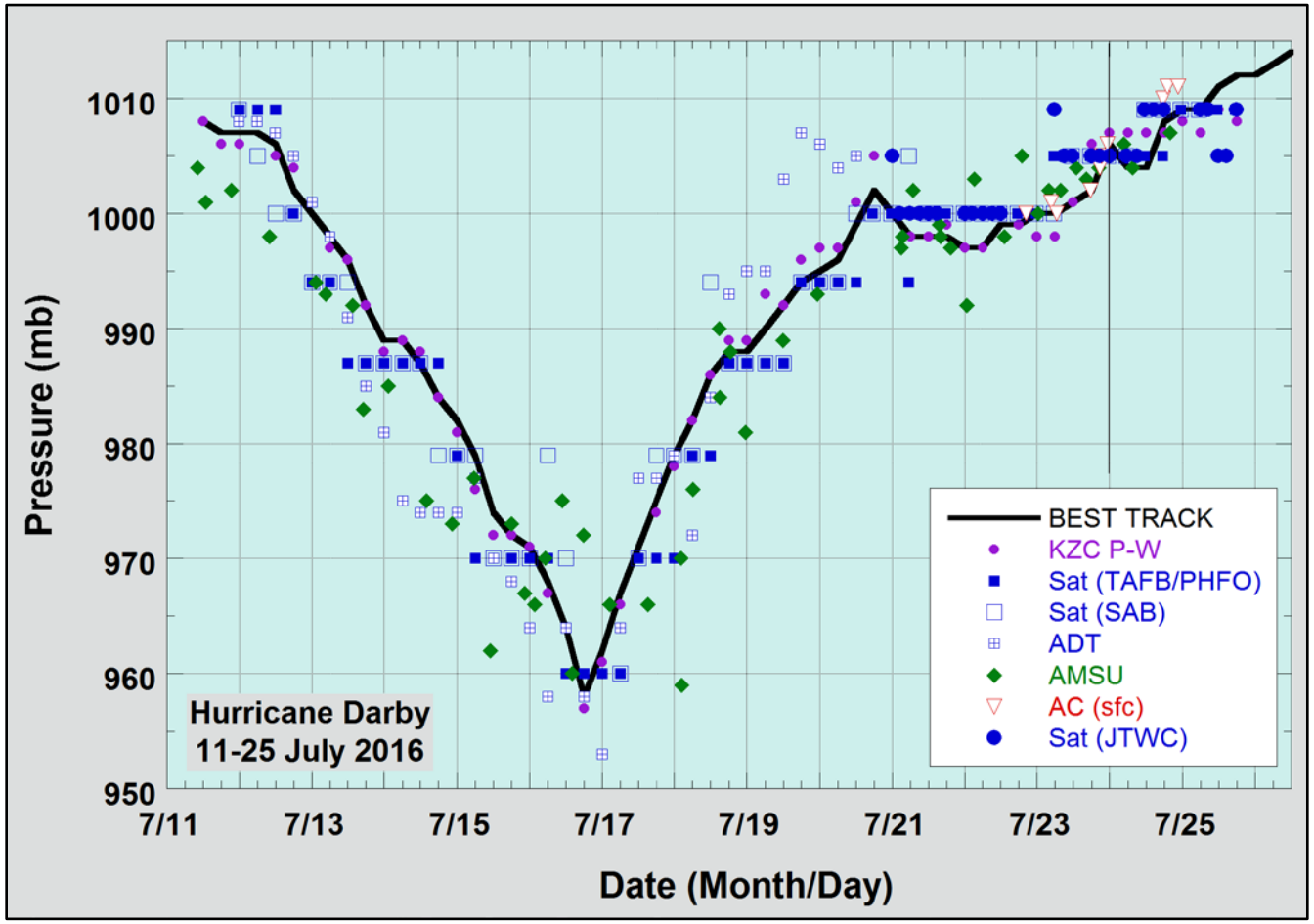

Figure 3 Selected pressure observations and best track minimum central pressure curve for Hurricane Darby 11-25 July 2016. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC. Solid vertical line corresponds to landfall. A post-storm analysis has not yet been completed for the portion of the track west of 140°W longitude, and all data for this portion of the storm's history reflect near real-time estimates from the Central Pacific Hurricane Center.