Tropical Cyclone Report
Hurricane Darby
(EP052010)
23-28 June 2010

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18 November 2010

Darby was a small category 3 hurricane (on the Saffir-Simpson Hurricane Wind Scale) that remained offshore of the southern Mexican coast.

a. Synoptic History

The vigorous tropical wave that spawned Hurricane Darby moved off the west coast of Africa on 8 June. Thunderstorm activity associated with the wave waned significantly after 24 h over water. The wave moved westward at about 15 kt for the next 11 days, producing little or no convection until it reached the far eastern North Pacific on 19 June. On 20 June, a small low pressure system developed along the wave axis about 150 n mi southwest of Costa Rica as the disturbance slowed and began moving toward the west-northwest. Thunderstorms gradually increased and became better organized, and it is estimated that a tropical depression formed by 0000 UTC 23 June, centered about 330 n mi south-southeast of Salina Cruz, Mexico. The "best track" chart of Darby'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 relatively small tropical cyclone continued in a west-northwestward direction for the next three days with a gradual decrease in forward speed from 10 kt down to less than 5 kt by 26 June. During this time, Darby remained in a low vertical wind shear environment and underwent two periods of rapid intensification -- from 30 kt to 60 kt from 0000 UTC 23 June to 0000 UTC 24 June and then from 75 kt to 105 kt from 1800 UTC 24 June to 1800 UTC 25 June. Darby became a tropical storm by 0600 UTC 23 June and a hurricane by 0600 UTC 24 June. The west-northwestward motion kept the center of the cyclone about 200 n mi off of the coast of Mexico. Even near its peak intensity of 105 kt, tropical-storm-force winds only extended outward about 60 n mi to the northeast of the center. This was, in part, due to the very small eye diameter (< 10 n mi) that Darby possessed (Fig. 4). The small size of the cyclone also likely played a significant role in the two rapid intensification episodes.

After Darby reached its peak intensity about 215 n mi south-southwest of Acapulco, Mexico, the hurricane turned westward and its forward speed slowed. Early on 27 June, a long fetch of low- to mid-level westerly winds flowing into the large circulation of Atlantic basin Hurricane Alex, which was located well to the northeast over the Gulf of Mexico, briefly caused

[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.

Darby to become stationary about 250 n mi south-southwest of Zihuatanejo, Mexico. Later that day, Darby reversed its course and began moving slowly to the east-northeast as it was drawn into the circulation of Alex.

During this time, Darby began to weaken due to northeasterly vertical wind shear created by the massive outflow from Hurricane Alex, which caused tiny Hurricane Darby to weaken even more quickly than it had strengthened. Darby became a tropical storm around 0600 UTC 27 June and weakened to a tropical depression the next day around 1200 UTC 28 June when it was located more than 150 n mi south of Acapulco. The cyclone degenerated into a remnant low pressure system just 6 h later as the strong vertical shear conditions stripped away deep convection from the circulation. The remnant low continued to move slowly east-northeastward into the Gulf of Tehuantepec where a brief burst of convection redeveloped early on 29 June south of the low-level center. However, the convection did not persist and the remnant low dissipated after 1800 UTC that same day while it was offshore of the southern coast of Mexico.

b. 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) and the Satellite Analysis Branch (SAB), and objective Dvorak satellite analyses from the University of Wisconsin-Cooperative Institute for Meteorological Satellite Studies (UW-CIMSS). Data and imagery from NOAA polar-orbiting satellites, 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.

The estimated peak intensity of 105 kt of Darby on 25 June is based on a blend of subjective and objective Dvorak satellite classifications from the TAFB, SAB, and UW-CIMSS.

No reports of tropical-storm-force winds associated with Hurricane Darby were received, in part due to the cyclone’s very small size.

c. Casualty and Damage Statistics

There were no reports of damage or casualties associated with Darby.

d. Forecast and Warning Critique

The genesis of Hurricane Darby was reasonably well anticipated. The disturbance that eventually became Darby was first introduced in the Eastern North Pacific Tropical Weather Outlook (TWOEP) with a “low” (0 to 20%) chance of formation 48 h before genesis occurred. The genesis forecasts reached the medium category (between 30-50%) 30 h before formation, and the formation probability reached the high (>50% percent) category 24 h before tropical cyclogenesis occurred.

A verification of NHC official track forecasts (OFCL) for Darby is given in Table 2a. Official forecast track errors were smaller than the mean official errors for the previous five-year period at all time periods through 96 hours. A homogeneous comparison of the official track errors with selected guidance models is given in Table 2b. The 5-day CLIPER model (OCD5) forecast errors were larger than the five-year average, which indicates that the official forecasts were more difficult than normal. The NHC official track forecasts were outperformed by only two models -- the GFNI (GFDL model using NOGAPS model fields) at 72 and 96 hours, and the EMXI at all times.

A verification of NHC official intensity forecasts for Darby is given in Table 3a. Official forecast intensity errors were larger than the mean official errors for the previous five-year period at all forecast times. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 3b. The NHC official intensity forecasts were comparable to or better in accuracy than all of the guidance through 48 h, but were worse than the available intensity models after that. Although the dynamical models GHMI, HWFI, and GFNI performed poorly through 24 h, they excelled after that with forecast errors that ranged from about 40 percent to 70 percent better at 72 h and 96 h, respectively. The first period of rapid intensification from 0000 UTC 23 June to 0000 UTC 24 June was well forecast. However, the subsequent rapid intensification episode from 1800 UTC 24 June to 1800 UTC 25 June was not forecast and neither was the peak intensity of 105 kt. These were the main reasons for the larger than average intensity errors in the latter forecast periods. In contrast, the weakening phase of Darby was predicted fairly well by the NHC official intensity forecasts, especially given the very sharp turn and non-climatological motion toward the east-northeast that occurred after 27 June.

No watches or warnings were required with Hurricane Darby.

Table 1. Best track for Hurricane Darby, 23-28 June 2010.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
20 / 1200	7.9	88.0	1009	20	low
20 / 1800	8.1	88.8	1009	20	"
21 / 0000	8.4	89.4	1009	20	"
21 / 0600	8.8	90.0	1009	20	"
21 / 1200	9.1	90.6	1009	20	"
21 / 1800	9.4	91.1	1008	25	"
22 / 0000	9.6	91.5	1008	25	"
22 / 0600	9.8	91.9	1008	25	"
22 / 1200	10.0	92.2	1008	25	"
22 / 1800	10.2	92.5	1008	25	"
23 / 0000	10.9	92.9	1006	30	tropical depression
23 / 0600	11.3	93.7	1005	35	tropical storm
23 / 1200	11.7	94.6	1000	45	"
23 / 1800	11.9	95.6	994	55	"
24 / 0000	12.2	96.6	990	60	"
24 / 0600	12.5	97.5	987	65	hurricane
24 / 1200	12.7	98.3	984	70	"
24 / 1800	12.8	99.0	981	75	"
25 / 0000	13.1	99.7	977	80	"
25 / 0600	13.2	100.4	970	90	"
25 / 1200	13.4	100.9	962	100	"
25 / 1800	13.6	101.3	960	105	"
25 / 2100	13.7	101.6	959	105	"
26 / 0000	13.7	101.8	961	100	"
26 / 0600	13.5	102.2	962	100	"
26 / 1200	13.5	102.5	965	95	"
26 / 1800	13.5	102.7	975	85	"
27 / 0000	13.5	102.9	984	70	"
27 / 0600	13.5	103.1	991	60	tropical storm
27 / 1200	13.6	103.0	997	50	"
27 / 1800	13.7	102.6	1001	40	"
28 / 0000	13.8	102.2	1002	35	"
28 / 0600	14.1	101.3	1003	35	"
28 / 1200	14.2	100.1	1004	30	tropical depression
28 / 1800	14.3	98.9	1004	25	low
29 / 0000	14.6	97.9	1005	25	"
29 / 0600	14.9	97.1	1005	25	"
29 / 1200	15.1	96.5	1006	20	"
29 / 1800	15.3	96.1	1006	20	"
30 / 0000					dissipated
25 / 2100	13.7	101.6	959	105	minimum pressure

Table 2a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Darby. Mean errors for the five-year period 2005-9 are shown for comparison. Official errors that are smaller than the five-year means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**24.9**	**43.2**	**56.8**	**67.2**	**83.2**	**103.8**	**72.3**
OCD5	39.6	93.3	151.9	216.0	326.6	424.5	394.0
NF	21	19	17	15	11	7	3
(EP) OFCL (2005-9)	30.8	51.5	71.6	89.6	120.9	155.0	192.0
(EP) OCD5 (2005-9)	38.9	75.3	115.7	155.8	226.9	275.1	321.5

Table 2b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Darby. 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 2a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	22.4	40.3	55.1	71.6	86.9	142.2	
OCD5	35.7	89.5	150.5	223.7	340.7	508.3	
GFSI	40.6	74.6	106.7	145.1	225.2	389.4	
GHMI	28.8	47.5	70.8	96.1	111.0	143.2	
HWFI	35.0	65.3	104.1	159.0	203.4	267.8	
GFNI	32.3	59.2	78.4	97.4	**75.2**	**110.3**	
NGPI	26.5	55.3	75.1	105.7	144.4	183.1	
UKMI	24.7	44.6	61.4	81.4	104.3	214.2	
EMXI	**17.5**	**27.8**	**41.7**	**54.4**	**72.5**	**75.7**	
AEMI	36.7	66.3	96.5	128.8	168.5	282.7	
FSSE	24.1	41.0	58.2	78.6	93.5	167.8	
TVCN	25.9	43.7	60.4	80.4	**86.3**	146.5	
TVCC	23.2	41.0	59.4	91.4	119.5	171.2	
LBAR	38.7	111.2	193.6	280.6	401.6	551.0	
BAMD	44.3	100.9	149.5	208.4	289.2	457.3	
BAMM	36.1	76.7	114.9	162.8	234.6	388.4	
BAMS	37.8	73.3	109.6	151.9	216.0	342.8	
NF	15	15	14	13	9	3	

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Darby. Mean errors for the five-year period 2005-9 are shown for comparison. Official errors that are smaller than the five-year means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	7.6	14.5	20.3	25.0	28.2	30.7	**16.7**
OCD5	7.6	13.7	21.3	27.3	30.1	22.9	23.7
NF	21	19	17	15	11	7	3
(EP) OFCL (2005-9)	6.3	10.5	13.8	15.5	17.5	19.0	18.8
(EP) OCD5 (2005-9)	7.1	11.6	15.0	17.4	18.7	19.8	19.4

Table 3b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Darby. 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	7.6	14.2	20.0	24.6	26.0	31.7	22.5
OCD5	7.6	**14.1**	22.3	29.0	29.8	**25.5**	23.5
DSHP	**6.9**	**13.8**	21.6	27.8	**24.1**	**26.0**	30.0
LGEM	**7.1**	**13.8**	20.9	26.0	**22.1**	**28.3**	28.0
GHMI	9.8	17.9	20.2	**19.4**	**15.4**	**4.2**	**7.5**
HWFI	11.8	20.2	28.7	33.2	**23.9**	**6.8**	**7.0**
GFNI	13.1	20.3	23.2	**22.6**	**15.4**	**7.2**	**15.5**
NF	19	18	16	14	10	6	2

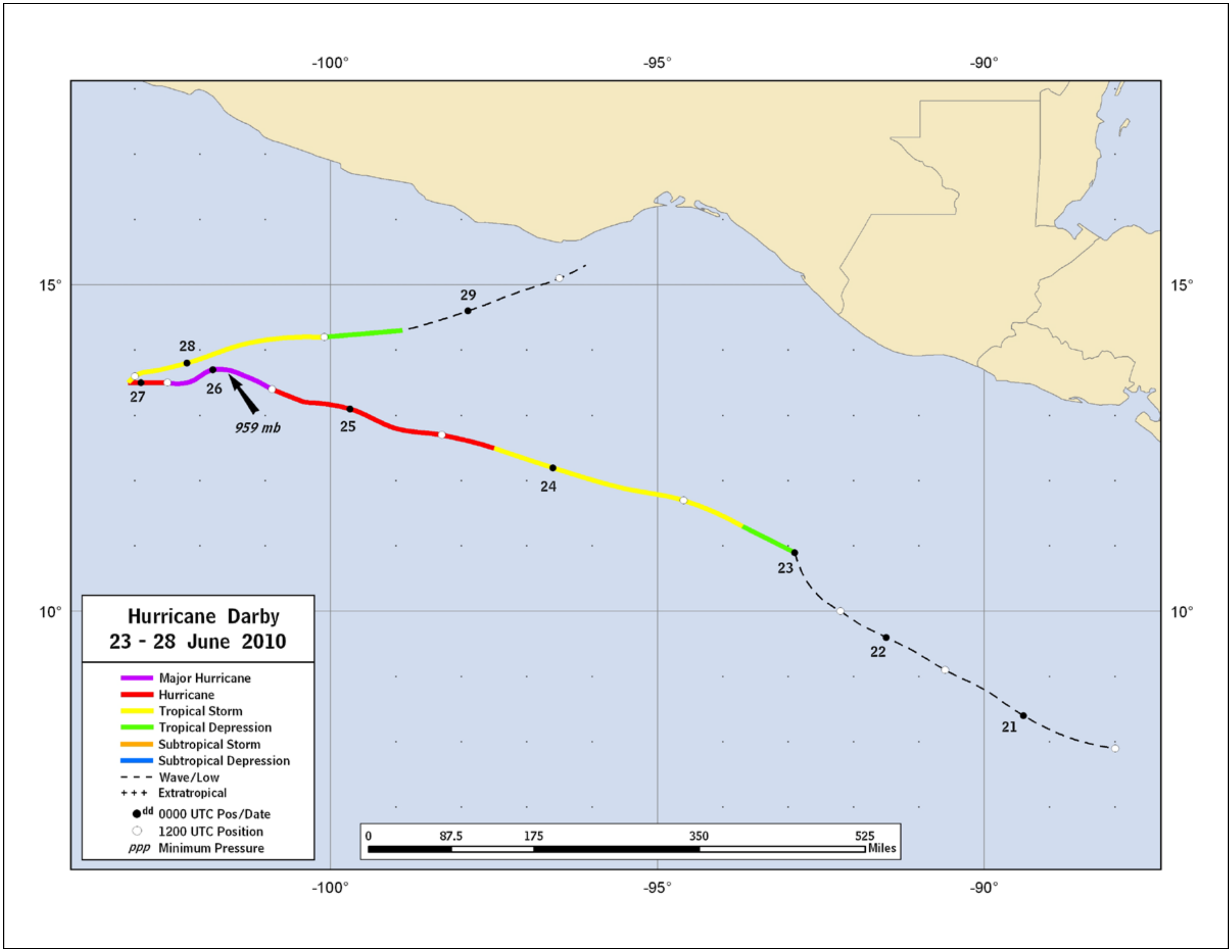

Figure 1. Best track positions for Hurricane Darby, 23-28 June 2010.

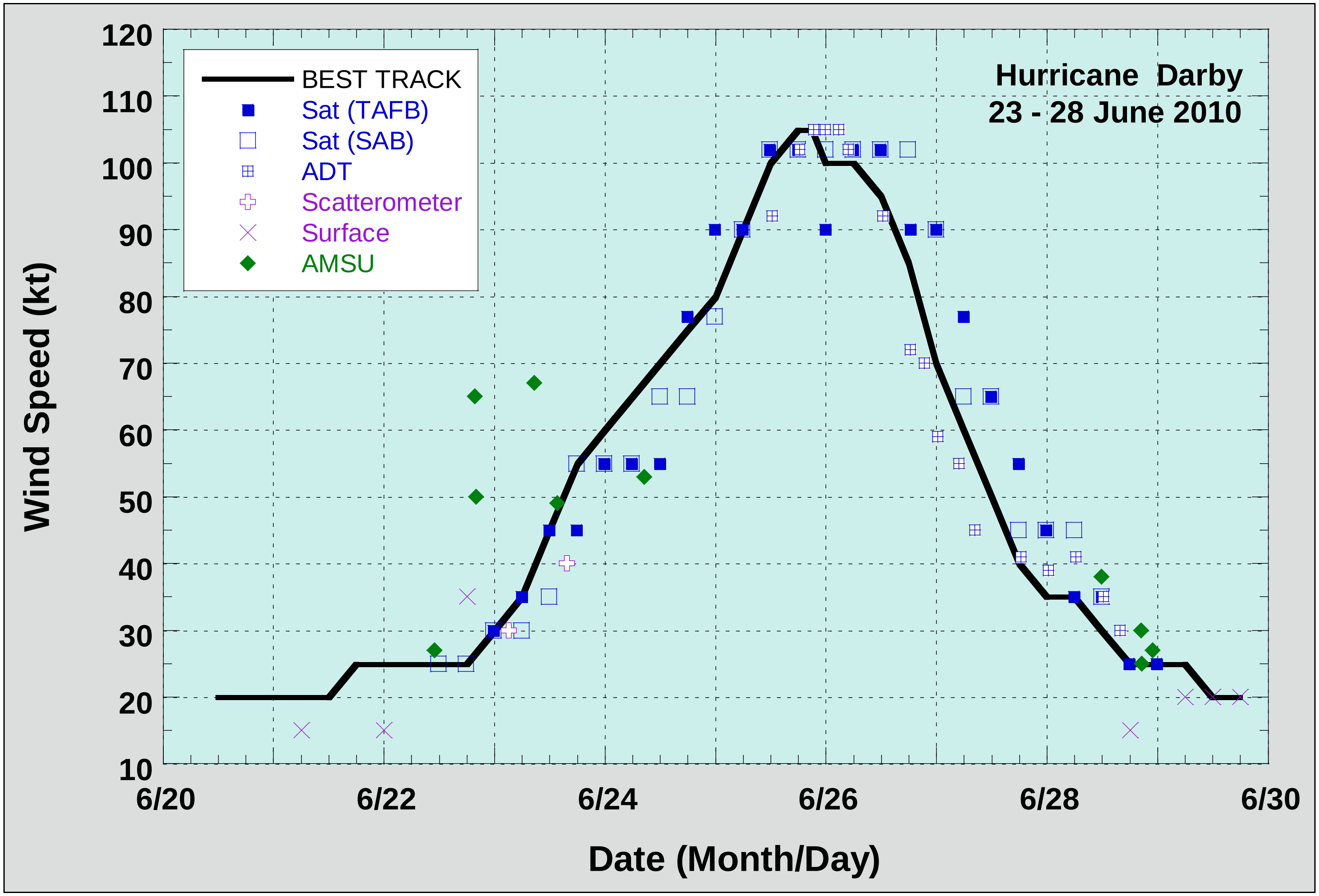

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Darby. Advanced Dvorak Technique estimates represent linear averages over a three-hour period centered on the nominal observation time. Dashed vertical lines correspond to 0000 UTC.

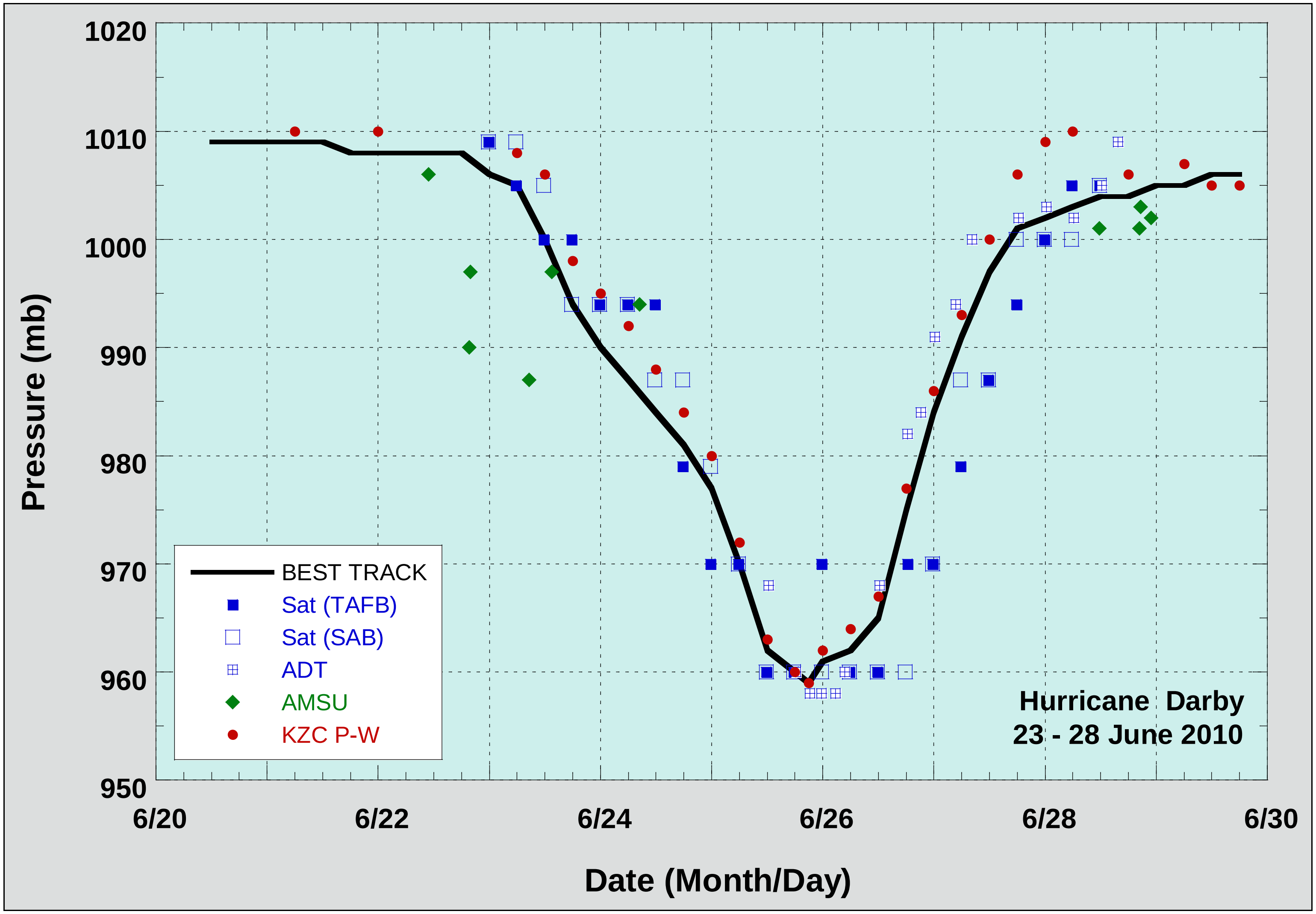

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Darby. Advanced Dvorak Technique estimates represent linear averages over a three-hour period centered on the nominal observation time. Dashed vertical lines correspond to 0000 UTC. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship.

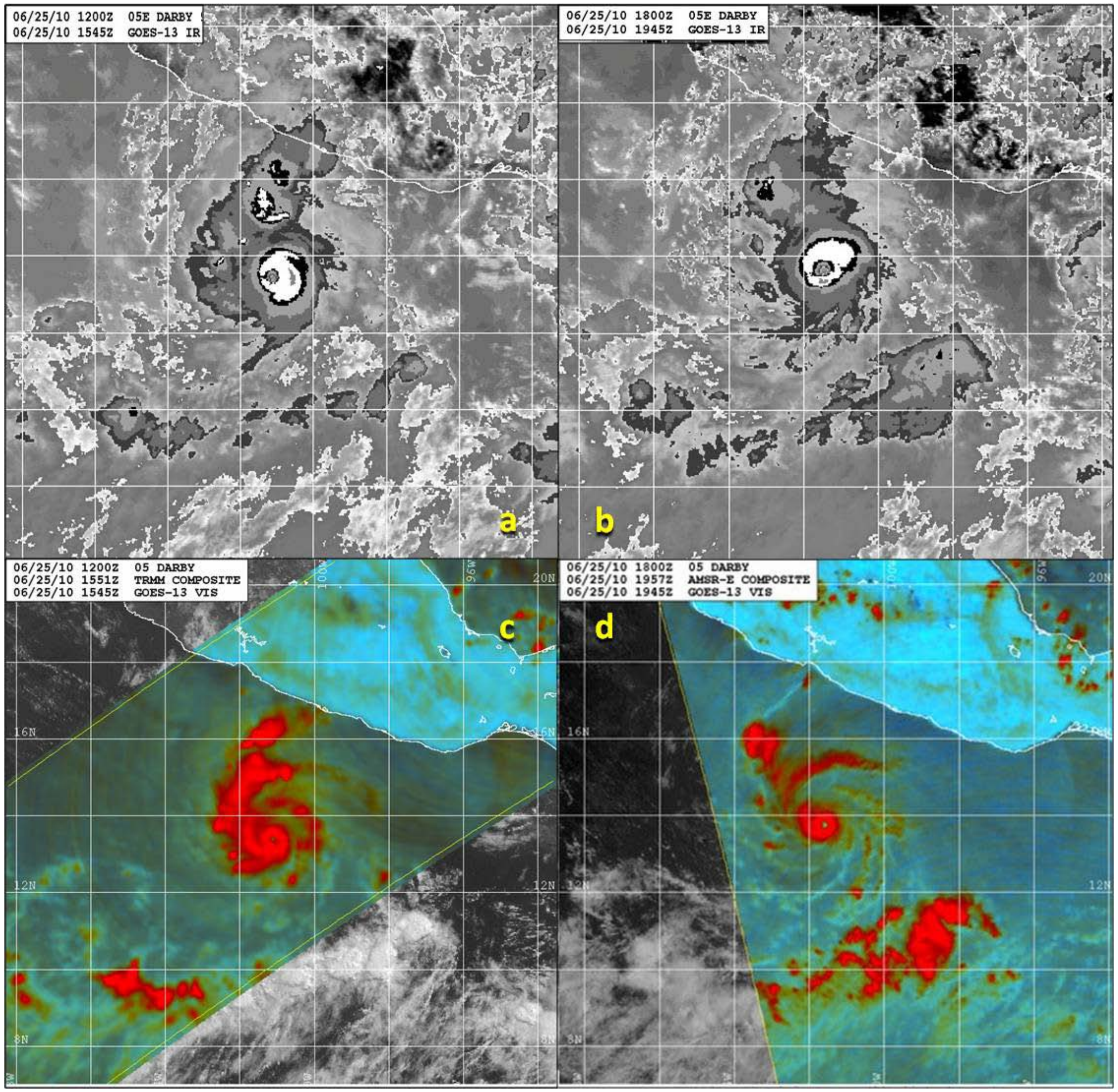

Figure 4. Satellite imagery depicting Hurricane Darby near its peak intensity on 25 June 2010 in -- GOES-13 infrared BD-curve (a) 1545 UTC and (b) 1945 UTC; microwave imagery (c) 1551 UTC TRMM 85GHz channel and (d) 1957 UTC AMSR-E 91 GHz channel.