Tropical Cyclone Report
Hurricane Debby
19-24 August 2000

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Debby struck the islands of the northeast Caribbean as a 65-knot hurricane, but the impact was not very significant. It appeared that Debby was going to be a significant threat to south Florida, but the system dissipated rather unexpectedly.

a. Synoptic History

A strong tropical wave moved off the west coast of Africa on 16 August, accompanied by winds to near 50 kt at the 650 mb level over Dakar. The following day, a broad area of low pressure associated with this wave was noted in the vicinity of 10°N 30°W, but there was insufficient curvature in the associated bands of deep convection for a Dvorak classification of the system. A low-level circulation center was identified by the Tropical Analysis and Forecast Branch (TAFB) at 0000 UTC 18 August, but the system was still considered "too weak to classify". An initial classification was done by TAFB at 1145 UTC on the 18th. By that time the curvature of the convective bands had increased, however the system was still broad and poorly organized. As the disturbance continued westward around 15 kt, it gradually became better organized. By 1800 UTC 19 August the cloud pattern had become consolidated around a well-defined center and it is estimated that the fourth tropical depression of the season developed, about 900 n mi east of the Windward Islands (Table 1, Fig. 1).

Vertical shear was weak over the area, with anticyclonic outflow developing aloft. In this environment, the cyclone strengthened and became Tropical Storm Debby around 0600 UTC 20 August. A pronounced mid-level ridge to the north of the cyclone maintained a west-northwestward motion. By midday on the 20th, microwave imagery data began to suggest some southwesterly shearing over Debby, with the low-level center displaced a bit to the southwest of the mid- to upper-level center. Nonetheless the storm strengthened further and is estimated to have become a hurricane by 0600 UTC 21 August. By this time the infrared imagery also showed the signature of a sheared system. Even though Debby was not well organized it strengthened even further, and reconnaissance data indicated that its maximum winds increased to 75 knots, which was the peak intensity, a little later on the 21st.

Radiosonde data from the Lesser Antilles indicated that the southwesterly shearing

may initially have been due to strong lower-tropospheric easterly flow, with the low-level center "outrunning" the mid- to upper-level center. By late on 21 August, the strengthening ceased. Debby was a 65-knot hurricane when its center moved across the extreme northern Leeward Islands from 0600 to 1200 UTC on the 22nd. Continuing west-northwestward, Debby's center moved over the British Virgin Islands around 1500 UTC on the 22nd, and passed about 30 n mi off the northeast coast of Puerto Rico a few hours later. By early on the 23rd, southwesterly shearing over Debby increased (dropsonde data from a two-aircraft synoptic flow mission revealed that upper-tropospheric flow was now largely responsible). Although not well organized, the system maintained minimal hurricane strength until around 1200 UTC on the 23rd when the cloud pattern became even more disorganized-looking.

The weakening storm turned toward the west and moved along the northern coast of Hispaniola. Although the mountainous land mass of that island may have played some role in the weakening by restricting inflow from the south and disrupting the southern part of the cyclone's circulation, it appears that vertical shear was the main cause for weakening. Around midday on the 23rd, a distinct low-cloud circulation center was evident just to the north of Hispaniola, displaced well to the west of the main area of deep convection. The cyclone continued westward, entering the Windward Passage around 0000 UTC 24 August. It dissipated near the south coast of eastern Cuba on the morning of the 24th. Debby's remnant, a strong tropical wave, continued to track westward, spreading locally heavy showers and gusty winds over Cuba, the Straits of Florida, and southern Florida over the next couple of days.

b. Meteorological Statistics

Table 1 lists the best track positions and intensities of Debby at six-hourly intervals. Figure 1 is a display of this track. Figures 2 and 3 depict the curves of maximum one-minute average "surface" (10 m above ground level) wind speed and minimum central sea-level pressure, respectively, as a function of time. Also plotted are the observations on which the curves are based. These consist of measurements by reconnaissance aircraft, Global Positioning System (GPS) dropsondes, Dvorak-technique estimates using satellite imagery from the Tropical Analysis and Forecast Branch (TAFB), the Satellite Analysis Branch (SAB), and the U.S. Air Force Weather Agency (AFWA).

Debby's peak intensity of 75 kt on 21 August is based on 85% of the maximum 1500-ft flight level wind speed, 88 kt, measured by aerial reconnaissance. Interestingly, the minimum central pressure was about 1004 mb at that time, well above the values typically associated with even minimal hurricane intensity. A central pressure of 991 mb was measured about 12 hours *after* the occurrence of Debby's estimated peak winds.

Wind gusts to 48 kt were reported at Antigua late on 21 August during the passage of a band of convection in advance of Debby. Maximum sustained winds there were only 25 kt. At St. Barthelemy, a gust to 66 kt was reported at 0830 UTC on the 22nd (that station was in the eye at 0915 UTC), and at St. Maarten, sustained winds of 33 kt with gusts to 52 kt were reported at 0900 UTC, with a minimum pressure of 998 mb at 1000 UTC. There were no measurements of sustained tropical storm force winds from the U.S. Virgin Islands or Puerto Rico, however, wind gusts of 39 and 37 kt were reported from St. Thomas and St. Croix, respectively, on 22 August.

Rainfall totals were as high as 12.63 in at Rio Piedras and 10.28 in at Rio de la Plata, Puerto Rico. These heavy rains occurred mainly after the center of Debby had moved northwest of the island.

c. Casualty and Damage Statistics

A man died in Puerto Rico when he fell off the roof of his home while trying to remove a satellite antenna. This was an indirect fatality.

There was moderate damage to the roofs of a few structures in Barbuda. There, and in several of the other islands of the extreme northern Leewards, some damage to fruit trees, utility poles and lines took place. Overall, the damage did not appear to be severe, but there are no monetary estimates available.

In Puerto Rico, the main impact came from heavy rainfall. There were reports of mud slides and damaged or collapsed bridges. Over 400 homes were reportedly "affected" by flood waters. Five homes suffered moderate to severe structural damage. Total damage estimate is 0.5 million dollars.

There was also some damage due to storm surge and wave action along the northern coast of the Dominican Republic.

Debby's rains were beneficial over eastern Cuba, since that region had been suffering from a severe drought.

d. Forecast and Warning Critique

Table 2 lists the average track prediction errors for Debby, for a selection of the numerical models and for the official forecast, as well as the long-term averages of the latter. The average official track forecast errors were lower than the most recent ten-year averages. The average official forecast errors for Debby are generally of comparable magnitude to, or below, the corresponding average model errors. It should be added, however, that several of the official and model forecasts having a northward bias were not verified because of Debby's unpredicted dissipation.

The numerical track predictions for 0000 UTC 23 August are of particular interest, since GPS dropsonde data from a two-aircraft synoptic flow surveillance mission appeared to have a significant impact on some of the models. In comparison to earlier forecasts, there was a significant southward shift in the model tracks. This was particularly noticeable in the U.K. Met. Office global model (UKM), whose 72-h forecast shifted from near or just east of Florida, to near western Cuba. Dropsonde measurements of the steering flow around the above time showed that there was a strong mid-level anticyclone to the north of Debby, and that a trough was bypassing the hurricane. It should be added that later sensitivity runs of the UKM from the above initial time, with and without the dropsonde input, confirmed that the track forecast improvements were attributable to these data.

The Debby case reminds us, all too well, of our limitations in forecasting tropical cyclone intensity change. In spite of the sheared nature of the system, the GFDL model repeatedly predicted that Debby would reach southern Florida area with a central pressure corresponding to a major hurricane. Moreover, the best available intensity guidance, SHIPS, consistently forecasted Debby to intensify (even when it was apparent that the tropical cyclone was dissipating). Given the objective guidance, and the possibility that the vertical shear could diminish, the official forecasts mostly over-predicted the wind speeds. The average bias in the official intensity forecasts ranged from +5.8 knots at 24 h to +28.0 knots at 72 h. These are similar to the biases shown by SHIPS.

Table 3 summarizes the various watches and warnings issued in connection with Debby. The hurricane warning for the northern Leeward Islands was issued 15 to 18 h prior to the arrival of the center in that area.

Watches and warnings are not always necessary to trigger preparedness actions. Based on the official 3-day forecasts which brought Debby near south Florida, an evacuation of non-residents from the Florida Keys was ordered, resulting in a significant loss of tourism revenue for Monroe County.

Table 1. Best track, Hurricane Debby, 19-24 August 2000.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
19 / 1800	12.0	44.5	1010	30	tropical depression
20 / 0000	12.6	45.3	1010	30	"
20 / 0600	13.3	46.8	1009	35	tropical storm
20 / 1200	14.0	48.8	1008	40	"
20 / 1800	14.7	50.6	1007	45	"
21 / 0000	15.1	52.1	1006	55	"
21 / 0600	15.4	54.0	1005	65	hurricane
21 / 1200	15.7	56.3	1004	75	"
21 / 1800	16.1	58.5	1004	75	"
22 / 0000	16.8	60.1	995	70	"
22 / 0600	17.5	61.7	993	65	"
22 / 1200	18.1	63.5	994	65	"
22 / 1800	18.8	65.4	995	65	"
23 / 0000	19.2	66.7	995	65	"
23 / 0600	19.5	68.1	995	65	"
23 / 1200	19.8	69.7	1005	60	tropical storm
23 / 1800	20.0	71.5	1009	50	"
24 / 0000	19.9	73.3	1010	40	"
24 / 0600	19.6	75.1	1011	35	"
24 / 1200	19.5	77.0	1011	30	tropical depression
24 / 1800					dissipated
21 / 1200	15.7	56.3	1004	75	maximum intensity
22 / 0300	17.1	60.9	991	70	minimum pressure
22 / 0600	17.5	61.7	993	65	landfall near Barbuda
22 / 0915	17.9	62.8	993	65	landfall near St. Barthelemy
22 / 1500	18.5	64.4	994	65	landfall near Virgin Gorda

Table 2.

Preliminary forecast evaluation of Hurricane Debby
Heterogeneous sample

(Errors in nautical miles for tropical storm
and hurricane stages with number
of forecasts in parenthesis)

Technique	**Period (hours)**				
	12	**24**	**36**	**48**	**72**
AVNI	54 (15)	82 (13)	106 (11)	85 (9)	37 (5)
CLIP	48 (15)	91 (13)	138 (11)	172 (9)	378 (5)
GFDI	45 (15)	74 (13)	100 (11)	106 (9)	145 (5)
NGPI	43 (15)	80 (13)	112 (11)	138 (9)	149 (5)
UKMI	37 (14)	75 (12)	96 (10)	80 (8)	87 (5)
NHC OFFICIAL	43 (15)	75 (13)	90 (11)	85 (9)	132 (5)
NHC OFFICIAL 1990-1999 10-year average	46 (2057)	85 (1842)	122 (1650)	158 (1471)	235 (1164)

Table 3. Watch and warning summary, Hurricane Debby, August 2000.

Date/time (UTC)	Action	Location
20/2100	Hurricane watch issued	St. Maarten, Saba, and St. Eustatius
20/2100	Tropical storm watch issued	Antigua, Barbuda, and Anguilla
21/0300	Hurricane watch issued	U.S. Virgin Islands
21/0300	Tropical storm watch issued	British Virgin Islands, St. Martin, St. Barthelemy, Nevis, St. Kitts, Montserrat, and Guadeloupe and its surrounding islands
21/0900	Hurricane watch issued	Puerto Rico
21/1500	Hurricane warning issued	Guadeloupe northward and northwestward through the British and U.S. Virgin Islands
21/1500	Tropical storm warning and hurricane watch issued	Dominica
21/2100	Hurricane warning issued	Puerto Rico and its adjacent islands
21/2300	Tropical storm watch issued	Dominican Republic
22/0300	Hurricane watch issued	Haiti north of Port au Prince
22/0300	Tropical storm warning issued	Dominican Republic from Punta Palenque to Cabrera
22/0400	Tropical storm watch issued	Southeastern Bahamas and the Turks and Caicos Islands
22/0900	Hurricane warning issued	Northern coast of the Dominican Republic
22/0900	Tropical storm watch changed to hurricane watch	Southeastern Bahamas and the Turks and Caicos Islands
22/1200	Hurricane warning discontinued	Guadeloupe, Antigua, Barbuda, Nevis, St. Kitts, and Montserrat
22/1200	Tropical storm warning discontinued	Dominica

Date/time (UTC)	Action	Location
22/1500	Hurricane warning issued	Southeastern Bahamas and the Turks and Caicos Islands
22/1500	Hurricane watch issued	Central Bahamas
22/1500	Hurricane warning discontinued	St. Maarten, Saba, and St. Eustatius
22/2100	Hurricane watch issued	Northern coast of Cuba for the provinces of Holguin and Las Tunas
22/2100	Tropical storm warning issued	Haiti north of Port au Prince
22/2100	Hurricane warning changed to tropical storm warning	U.S. Virgin Islands and Puerto Rico
22/2100	Hurricane warning discontinued	All islands east of the U.S. Virgin Islands
23/0300	Tropical storm warning discontinued	U.S. Virgin Islands and Puerto Rico
23/0600	Hurricane warning issued	Central Bahamas
23/0600	Hurricane watch issued	Northwestern Bahamas
23/1500	Hurricane warning issued	Northern coast of Cuba for the provinces of Guantanamo, Holguin, and Las Tunas
23/1500	Hurricane watch issued	Northern coast of Cuba for the provinces of Camaguay and Ciego de Avila and southern coast of Cuba for the provinces of Santiago de Cuba and Granma
23/1800	Hurricane watch discontinued	Haiti north of Port au Prince
23/2100	Hurricane warning changed to tropical storm warning	Central and Southeastern Bahamas and the Turks and Caicos Islands, northern coast of Cuba for the provinces of Guantanamo, Holguin, and Las Tunas

Date/time (UTC)	Action	Location
23/2100	Hurricane watch changed to tropical storm watch	Northern coast of Cuba for the provinces of Camaguay and Ciego de Avila and southern coast of Cuba for the provinces of Santiago de Cuba and Granma
23/2100	Hurricane warning discontinued	Northern coast of the Dominican Republic
23/2100	Hurricane watch discontinued	Northwestern Bahamas
24/0300	Tropical storm warning discontinued	Haiti, Turks and Caicos Islands
24/1000	Tropical storm warning discontinued	Central and southeastern Bahamas
24/1500	All tropical storm watches and warnings discontinued	Cuba

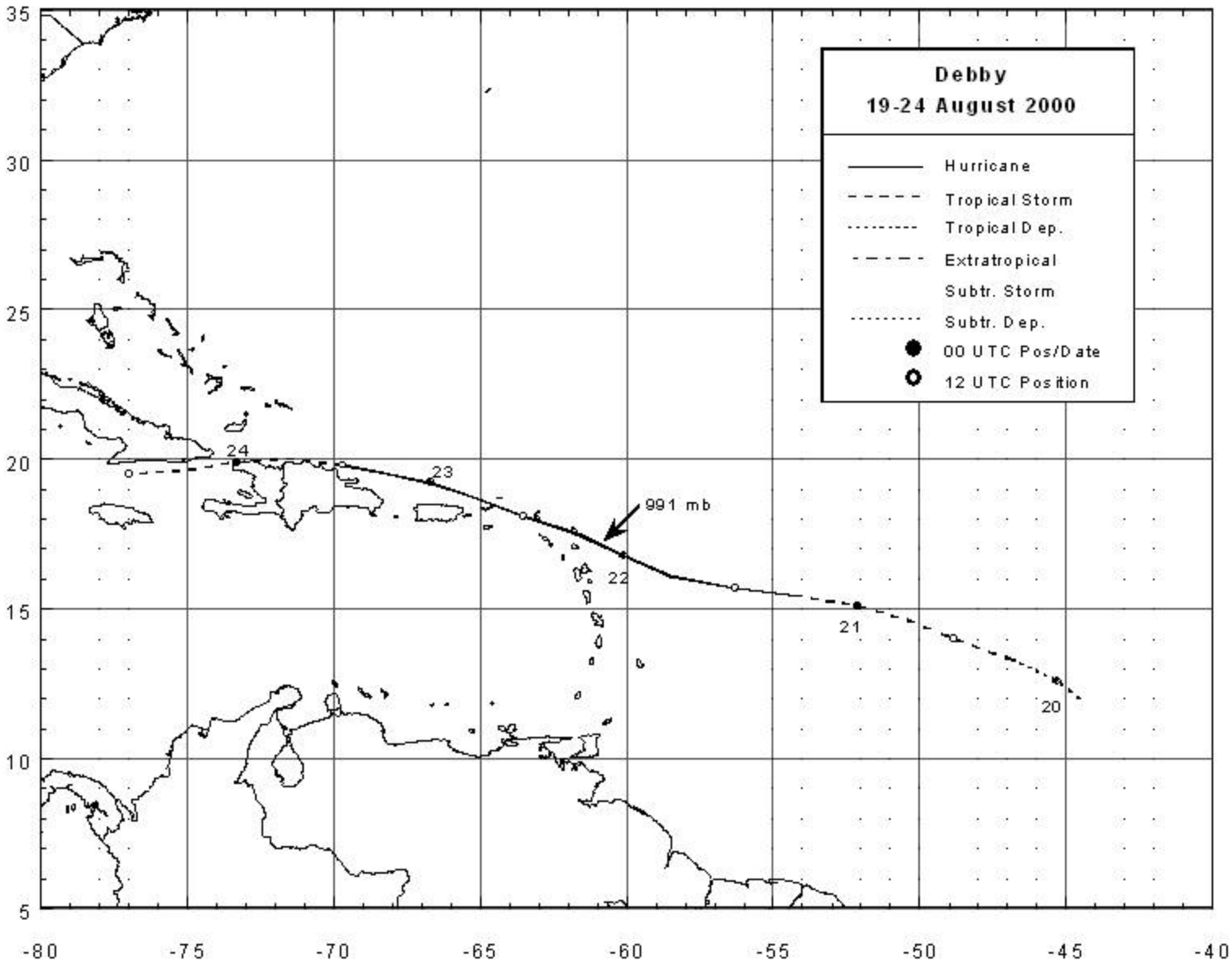

Fig. 1. Best track positions for Hurricane Debby, 19-24 August 2000.

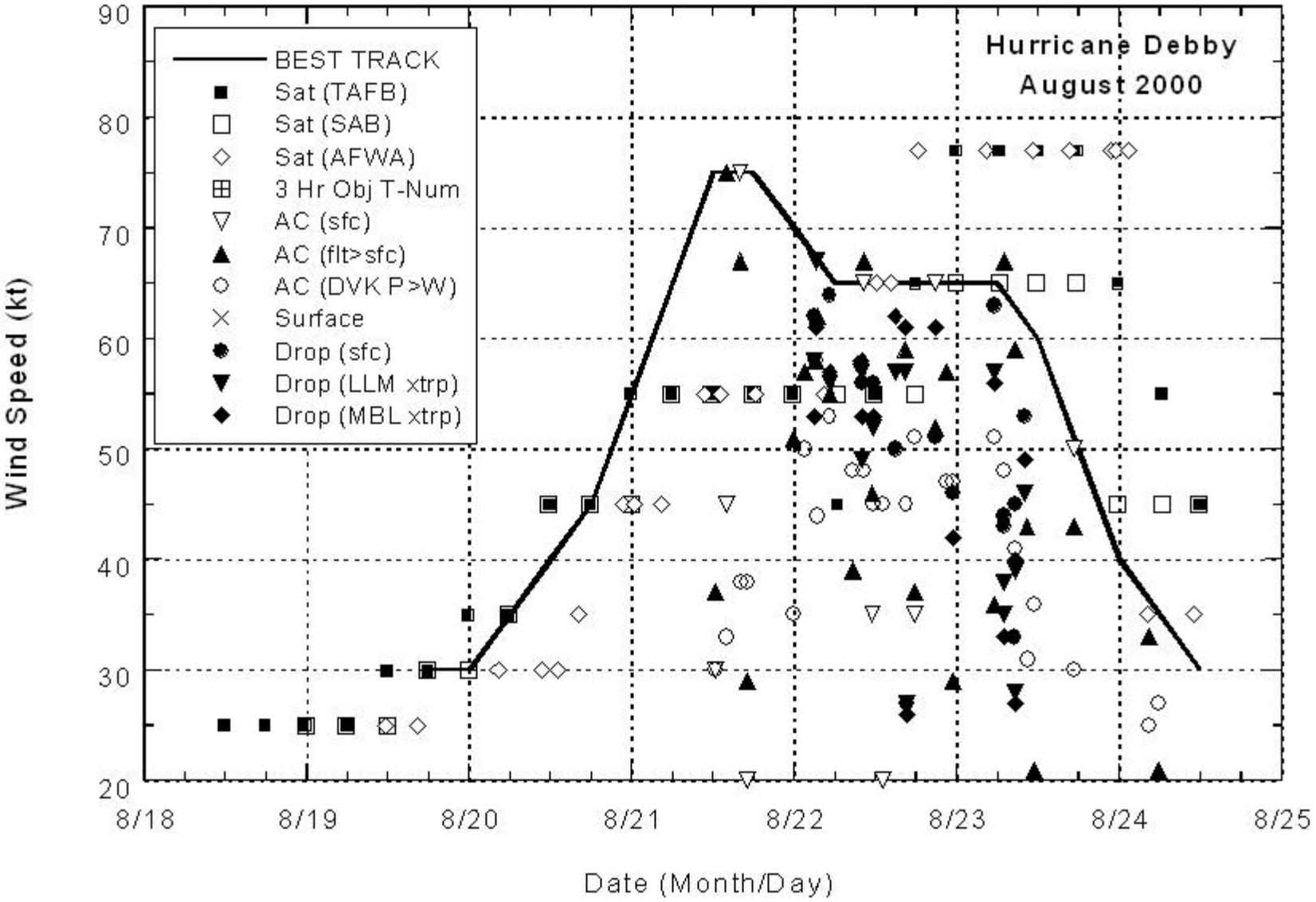

Fig. 2. Best track maximum sustained surface wind speed curve for Hurricane Debby, 19-24 August 2000, and the observations on which the best track curve is based. Aircraft observations have been adjusted for elevation using 90%, 80%, and 85% reduction factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Dropsonde observations include actual 10 m winds (sfc), as well as surface estimates derived from the mean wind over the lowest 150 m of the wind sounding (LLM) , and from the sounding boundary layer mean (MBL).

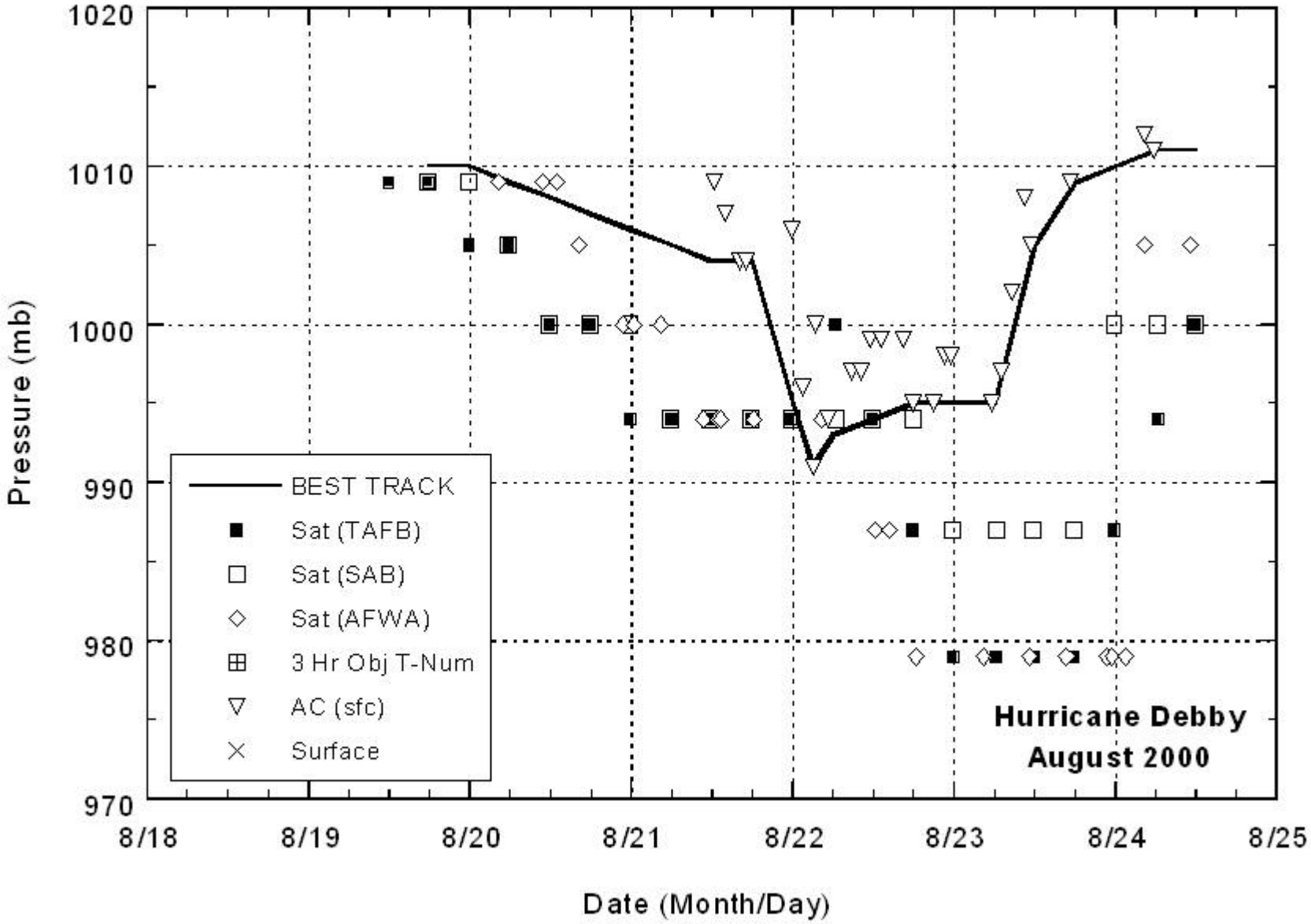

Fig. 3. Best track minimum central pressure curve and central pressure observations or estimates for Hurricane Debby, 19-24 August 2000.