

Tropical Cyclone Report
Tropical Storm Chantal
14-22 August 2001

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Best track revised 15 November 2001

Poorly-organized for most of its life cycle, Chantal was a tropical storm that made landfall near the Mexico-Belize border. Development was hindered by a strong low- to mid-level easterly flow that contributed to a rapid translation speed and persistent westerly shear.

a. Synoptic History

Chantal developed from a tropical wave that crossed the coast of Africa and entered the far eastern Atlantic on 11 August. Although convection diminished after the system left the African continent, a broad surface low and a closed circulation developed by the 13th. Early on the 14th, convection increased northwest of the center. By 1800 UTC on the 14th, when the system was about 1300 n mi east of the southern Windward Islands, the convection was sufficiently well-established and organized to consider the low to be a tropical depression. A QuikSCAT pass near this time (at 2000 UTC), indicated a broad closed cyclonic surface circulation.

The “best track” chart of Chantal’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. South of a strong mid-level ridge, the depression moved rapidly westward at about 23 kt. The convective structure changed little for the next 36 hours under easterly wind shear, but banding developed early on the 16th. Even though the satellite presentation continued to improve throughout the day, reconnaissance aircraft data near 2100 UTC could not define a closed circulation. It is impossible to determine precisely when the depression’s surface circulation degenerated into an open wave, but a QuikSCAT pass suggests that this may have occurred near 1200 UTC on the 16th, when the consensus of Dvorak intensity estimates reached tropical storm strength. At this time the system’s forward speed was increasing to near 30 kt.

Early on the 17th, the wave sped through the Windward Islands, where there was a report of sustained tropical storm force winds from Martinique. After passing through the islands, the wave’s speed slowed to about 20 kt and its convective pattern, which had been limited and linear, expanded and became more symmetric. At 1400 UTC, a reconnaissance aircraft was able to determine that a small closed circulation had redeveloped about 250 n mi south of St. Croix; with winds still near 35 kt, the wave had become a tropical storm.

Over the next 18 h the pressure fell from 1010 mb to 1003 mb and Chantal’s maximum winds increased to 55 kt. During the morning of the 18th, however, Chantal weakened slightly as its

forward speed increased again (to 24 kt) and its low-level center raced ahead of the deep convection. This was followed by a second episode of slowing and strengthening that ended at 0600 UTC on the 19th, when the pressure fell to 997 mb and the winds increased to 60 kt. At this time Chantal was moving westward at 12 kt about 160 n mi south of Kingston, Jamaica. It is possible that the apparent reduction in forward speed was a result of a reorganization or reformation of the low-level circulation.

During the day on the 19th, Chantal again became disorganized with an ill-defined center located well to the west-southwest of the main area of deep convection. Although the pressure rose sharply, to 1008 mb, reconnaissance aircraft continued to report strong winds in the trailing convection. Chantal turned slightly to a west-northwesterly heading, and maintained a near steady state structure in the northwestern Caribbean Sea with 50 kt winds until late on the 20th. (During this time, there were large differences, often 60 n mi or more, between aircraft- and satellite-based position fixes. Since the wind centers found by the aircraft were probably not representative of the vorticity center of the system, the best track through this period is based primarily on the satellite data.)

When Chantal approached Belize and the Yucatan Peninsula late on the 20th, the storm became much better organized. Reconnaissance aircraft, which had for days had difficulty closing off the circulation on the cyclone's south side, found a well-defined center for the first time, with the strongest winds closer to the center than was observed previously. Water vapor imagery indicated that the upper-level westerly vertical wind shear was decreasing, and the cyclone's forward speed again decreased, from 15 to 10 kt. That these latter two events would occur simultaneously suggests that a reduction in the low-level easterly flow also contributed to this final period of development. The pressure dropped steadily in the final hours before landfall, reaching an estimated 999 mb when the center came ashore near the Belize/Mexico border around 0200 UTC on the 21st. The maximum winds at landfall are estimated to be 60 kt. As Chantal made landfall its forward speed continued to slow, and radar imagery from Belize showed that the system's organization continued to improve for several hours as it slowly moved inland. Had Chantal remained over water for another hour or two, it is quite likely that it would have become a hurricane.

Over the next day and a half Chantal moved westward and then southwestward over the Yucatan and southeastern Mexico, weakening to a depression on the 22nd at 0000 UTC, and dissipating by 1800 UTC that day.

b. Meteorological Statistics

Observations in Chantal (Figs. 2 and 3) include 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 (AFWA), as well as flight-level and dropwindsonde observations from flights of the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command. Dropwindsonde data just prior to landfall were also obtained from a NOAA Office of Marine and Aviation Operations WP-3D research flight of the NOAA Hurricane Research Division.

Chantal's maximum intensity of 60 kt was attained on two occasions. In the first instance, the peak flight-level wind from reconnaissance aircraft in Chantal was 82 kt, measured at a flight level of 850 mb at 1123 UTC on the 19th. While the standard reduction for this altitude would indicate that Chantal was a hurricane with a surface equivalent of 66 kt, several factors suggest that this was not the case. First, the area of flight-level winds that supported hurricane intensity were extremely limited, and therefore may not have been representative of the cyclone's circulation. Second, Chantal's minimum pressure was rising rapidly at the time of the observation; this is consistent with the view that the peak wind observed by the aircraft was primarily a local convective, rather than a cyclone-scale event. The most convincing evidence, however, comes from soundings in the storm core and environment in the right semicircle, which show significant shear in the lower troposphere. The Kingston sounding from 1200 UTC on the 18th, for example, shows about 20 kt of easterly shear between 925 and 700 mb. A dropwindsonde at 2340 UTC 19 August, which reported 700 mb winds of 60 kt, had a surface wind of only 38 kt. In this environment, a lower than normal surface wind reduction would be appropriate on the right-hand side of the cyclone.

Chantal also reached an intensity of 60 kt just prior to landfall. This estimate is supported by a surface wind of 58 kt from a GPS dropwindsonde, and a surface-adjusted flight-level wind of 57 kt. Numerous dropsonde profiles from Air Force and NOAA aircraft just before landfall indicate that the surface adjustment factors had returned to more typical values. The estimated landfall pressure of 999 mb is based largely on an extrapolation of the deepening trend observed by reconnaissance aircraft up until the last report at 2307 UTC on the 20th.

Ship reports of winds of tropical storm force associated with Chantal are given in Table 2, and selected surface observations from land stations are given in Table 3. In the Lesser Antilles, the automated site on Martinique (78922, station elevation 33 m) reported a 10-min sustained wind of 34 kt at 0600 UTC on the 17th. Based on aircraft and dropsonde reports, the strongest winds at landfall in the western Caribbean were likely in a band roughly 30-40 n mi north of the center, near Chinchorro Banco. Unfortunately, there are no observing stations in this area. Caye Caulker, Belize reported a gust of 62 kt, and Chetumal, Mexico reported a gust of 54 kt.

Chantal produced copious amounts of rain (Table 3). The largest storm total (13.41 in) was reported from Chetumal. Several sites in Belize reported totals in the 8-10 in range.

c. Casualty and Damage Statistics

There are no deaths officially associated with Chantal while it was a tropical cyclone. However, two deaths were reported in Trinidad on the 16th from lightning associated with the passage of the tropical wave through the Lesser Antilles.

In Belize, damage estimates are near \$4 million, primarily from wave damage to sea-walls and piers, agricultural losses from wind and floods, and erosion of roads due to floods. About 8000 persons were evacuated, mainly from offshore islands. About 2500 persons were evacuated from vulnerable areas in Mexico. Reports from Mexico indicate downed trees but otherwise no significant damage.

d. Forecast and Warning Critique

Average official track errors for Chantal were 44, 74, 84, 106, and 135 n mi for the 12, 24, 36, 48, and 72 h forecasts, respectively (Table 4). The number of cases ranged from 16 at 12 h to 6 at 72 h. These errors are lower than the average official track errors for the 10-yr period 1991-2000 (44, 82, 118, 151, and 226 n mi, respectively). This is not surprising for a relatively straight-moving storm in the deep tropics. A number of guidance models had lower errors than the official forecast through 36 h, including the GFDL and UKMI. None of the guidance models (other than CLIPER) had errors lower than the official forecast at 72 h. It should be noted that forecast errors during the tropical depression stage, which are not part of the official verification, were considerably higher.

Average official track errors were close to those of the AVNI. Of interest is a modest but persistent rightward bias in the official forecasts (Fig. 4). This was related to a reliance on the AVNI, which has performed well so far this year. While the formal AVNI verification for Chantal (Table 4) shows good results, this is misleading. The AVN center-tracking algorithm frequently failed to follow the cyclone for the duration of the forecast period (there were only four 48 h AVNI forecasts and no 72 h AVNI forecasts). Nonetheless, a low-level vorticity center was easily followed in the AVN fields, and this influenced the official forecasts. While the AVN repeatedly took the vorticity center into the eastern Gulf of Mexico, none of these poor forecasts are officially verified because the tracker did not recognize the vorticity center as the tropical cyclone.

Average official intensity errors were 6, 8, 12, 23, and 23 kt for the 12, 24, 36, 48, and 72 h forecasts, respectively. For comparison, the average official intensity errors over the 10-yr period 1991-2000 are 7, 11, 14, 16, and 20 kt, and the SHIPS model for Chantal had errors of 8, 9, 10, 16, and 16 kt, respectively. While the shorter-range forecasts for Chantal were more accurate than the official long-term averages and the SHIPS guidance, the 48 and 72 h forecasts were not. Inspection shows that every 36, 48, and 72 official intensity forecast was an overestimate (Fig. 5). Two factors may have contributed to these overly-aggressive forecasts: reliance on global model predictions of a developing anticyclone over Chantal, and, in the western Caribbean Sea, an atypical vertical shear distribution that forced the low-level circulation center to repeatedly move out ahead of the main convection.

Table 5 lists the watches and warnings associated with Chantal. Although Chantal was not a tropical storm when it moved through the Lesser Antilles, the remnant wave did produce some tropical storm force winds. Since the system was not a tropical cyclone at that time, no warnings were in effect during the passage. Had a mechanism existed to issue tropical storm warnings in the absence of a tropical cyclone, it would have been possible to maintain warnings for tropical storm force winds.

Official track forecasts anticipated a close approach to Jamaica and the Cayman Islands, which resulted in warnings that did not verify. Chantal made landfall near the Mexico/Belize border, roughly in the center of the warning area. A tropical storm warning was issued for a portion of the Gulf coast of Mexico in anticipation of Chantal's re-emergence over water into the Gulf. However, Chantal remained over land.

Table 1. Best track for Tropical Storm Chantal, 14-22 Aug. 2001. Positions and pressures given during the tropical wave stage are representative values for the low-level vorticity center.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
14 / 1800	12.8	37.0	1010	25	tropical depression
15 / 0000	12.9	39.3	1010	25	"
15 / 0600	12.6	41.6	1010	25	"
15 / 1200	12.3	43.9	1010	30	"
15 / 1800	12.3	46.3	1010	30	"
16 / 0000	12.4	48.8	1010	30	"
16 / 0600	12.4	51.3	1011	30	"
16 / 1200	12.7	53.9	1012	30	tropical wave
16 / 1800	12.7	57.2	1012	30	"
17 / 0000	13.1	60.6	1011	35	"
17 / 0600	13.3	62.8	1011	35	"
17 / 1200	13.7	64.6	1010	35	tropical storm
17 / 1800	14.2	66.4	1006	35	"
18 / 0000	14.4	68.2	1004	45	"
18 / 0600	14.6	70.4	1003	55	"
18 / 1200	14.8	72.9	1006	50	"
18 / 1800	15.3	75.2	1003	50	"
19 / 0000	15.3	77.2	1002	55	"
19 / 0600	15.4	78.4	997	60	"
19 / 1200	15.7	79.6	1004	60	"
19 / 1800	16.2	81.1	1005	55	"
20 / 0000	16.7	82.6	1007	50	"
20 / 0600	17.1	84.1	1008	50	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
20 / 1200	17.5	85.6	1007	50	"
20 / 1800	17.9	86.7	1006	55	"
21 / 0000	18.1	87.7	1000	60	"
21 / 0600	18.2	88.1	1000	55	"
21 / 1200	18.4	88.7	1002	45	"
21 / 1800	18.6	89.5	1006	35	"
22 / 0000	18.7	90.3	1007	25	tropical depression
22 / 0600	18.4	91.2	1008	25	"
22 / 1200	17.9	92.2	1009	25	"
22 / 1800					dissipated
21 / 0200	18.1	87.8	999	60	landfall near Mexico/Belize border
19 / 0600	15.4	78.4	997	60	minimum pressure

Table 2. Selected ship reports with winds of at least 34 kt for Tropical Storm Chantal, 14-22 Aug. 2001.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
18 / 1200	C6LF8	16.4	71.4	090/37	1011.5
18 / 1200	C6RO7	16.3	71.1	110/37	1012.0
18 / 1500	C6RO7	15.7	70.9	100/38	1012.8

Table 3. Selected surface observations for Tropical Storm Chantal, 14-22 Aug. 2001.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft) ^c	Storm tide (ft) ^d	Total rain (in)
	Date/time (UTC)	Press. (mb)	Date/time (UTC) ^a	Sustained(kt) ^b	Gust (kt)			
Lesser Antilles								
Martinique-Caravelle			17/0600	34 ^e	41			
Martinique-Vauclin			17/0400		49			
Belize								
Towerhill								9.81
Libertad	21/0900	1001.5						9.08
Consejo								8.99
Belize City Intl. Airpt.	21/0500	1007.0	21/0500	19	35			8.24
Middlesex								7.93
Melinda								7.06
Gales Point								6.80
Bigfalls Plantation								5.20
Half Moon Caye	20/2100	1007.1						
Caye Caulker	21/0200	1005.8	21/0100		62			
Mexico								
Chetumal Tecnologico								13.41
Chetumal Observatorio	21/0800	1005.4	21/0700		54			13.05
Chetumal (Air Force)	21/1000	1008.0	21/1000	35	45			
Nicolas Bravo								11.28
La Union								5.59
Cancun								1.68

^a Date/time is for sustained wind when both sustained and gust are listed.

^b Except as noted, sustained wind averaging periods for C-MAN and land-based ASOS reports are 2 min; buoy averaging periods are 8 min.

^c Storm surge is water height above normal astronomical tide level.

^d Storm tide is water height above National Geodetic Vertical Datum (1929 mean sea level).

^e 10-min average.

Table 4. Preliminary forecast evaluation (heterogeneous sample) for Tropical Storm Chantal, 14-22 Aug. 2001. Forecast errors for tropical storm and hurricane stages (n mi) are followed by the number of forecasts in parentheses. Errors smaller than the NHC official forecast are shown in bold-face type.

Forecast Technique	Forecast Period (h)				
	12	24	36	48	72
CLIP	43 (16)	81 (14)	97 (12)	92 (10)	125 (6)
GFDI	35 (13)	56 (13)	67 (11)	77 (9)	176 (5)
LBAR	43 (16)	79 (14)	107 (12)	137 (10)	214 (6)
AVNI	44 (10)	70 (10)	97 (8)	105 (4)	
BAMD	45 (16)	77 (14)	119 (12)	171 (10)	298 (6)
BAMM	43 (16)	60 (14)	83 (12)	111 (10)	161 (6)
BAMS	68 (16)	108 (14)	146 (12)	170 (10)	195 (6)
NGPI	75 (5)	89 (5)	104 (5)	150 (5)	242 (4)
UKMI	43 (14)	55 (12)	79 (11)	117 (9)	182 (2)
GUNS	57 (4)	65 (4)	62 (4)	100 (4)	164 (3)
NHC Official	44 (16)	74 (14)	84 (12)	106 (10)	135 (6)
NHC Official (1991-2000 mean)	44 (2049)	82 (1835)	118 (1646)	151 (1475)	226 (1187)

Table 5. Watch and warning summary for Tropical Storm Chantal, 14-22 Aug. 2001.

Date/Time (UTC)	Action	Location
16/0300	Tropical Storm Watch issued	Barbados, St.Vincent, and St.Lucia
16/0900	Tropical Storm Watch changed to Tropical Storm Warning	Barbados, St.Vincent, and St.Lucia
16/0900	Tropical Storm Watch	Grenadines and Dominica
16/1200	Tropical Storm Watch	Martinique
16/1500	Tropical Storm Watch changed to Tropical Storm Warning	Grenadines and Dominica
16/1500	Tropical Storm Watch issued	Grenada and Tobago
16/1600	Tropical Storm Watch issued	Guadeloupe
17/0000	Tropical Storm Watches/Warnings discontinued	Barbados, St.Vincent, St.Lucia, Grenadines, Dominica, Grenada and Tobago
17/1200	Tropical Storm Watch discontinued	Martinique and Guadeloupe
17/2100	Hurricane Watch issued	Jamaica
18/0000	Tropical Storm Watch issued	Cayman Is.
18/0900	Hurricane Warning replaces Hurricane Watch	Jamaica
18/1500	Tropical Storm Warning/Hurricane Watch replace Hurricane Warning	Jamaica
18/1500	Tropical Storm Warning/Hurricane Watch replace Tropical Storm Watch	Cayman Is.
19/0000	Tropical Storm Watch issued	Belize
19/0300	Tropical Storm Watch issued	Chetumal to Cancun, Mexico
19/0900	Hurricane Watch discontinued	Jamaica
19/1500	Hurricane Watch replaces Tropical Storm Watch	Belize City, Belize to Cancun, Mexico
19/1500	Tropical Storm Warning discontinued	Jamaica
20/0000	Hurricane Watch discontinued	Cayman Is.
20/0300	Tropical Storm Warning issued	Belize

20/0300	Tropical Storm Warning issued	Chetumal to Cancun, Mexico
20/1200	Tropical Storm Warning discontinued	Cayman Is.
20/2100	Tropical Storm Warning issued	Progreso to Carmen, Mexico
21/1500	Hurricane Watch discontinued	Belize
21/1500	Hurricane Watch discontinued	Chetumal to Cancun, Mexico
21/2100	Tropical Storm Warning discontinued	Belize
21/2100	Tropical Storm Warning discontinued	Chetumal to Cancun, and Campeche to Progreso, Mexico
21/2100	Tropical Storm Watch issued	Carmen to Veracruz, Mexico
22/1500	All watches/warnings discontinued	Campeche to Veracruz, Mexico

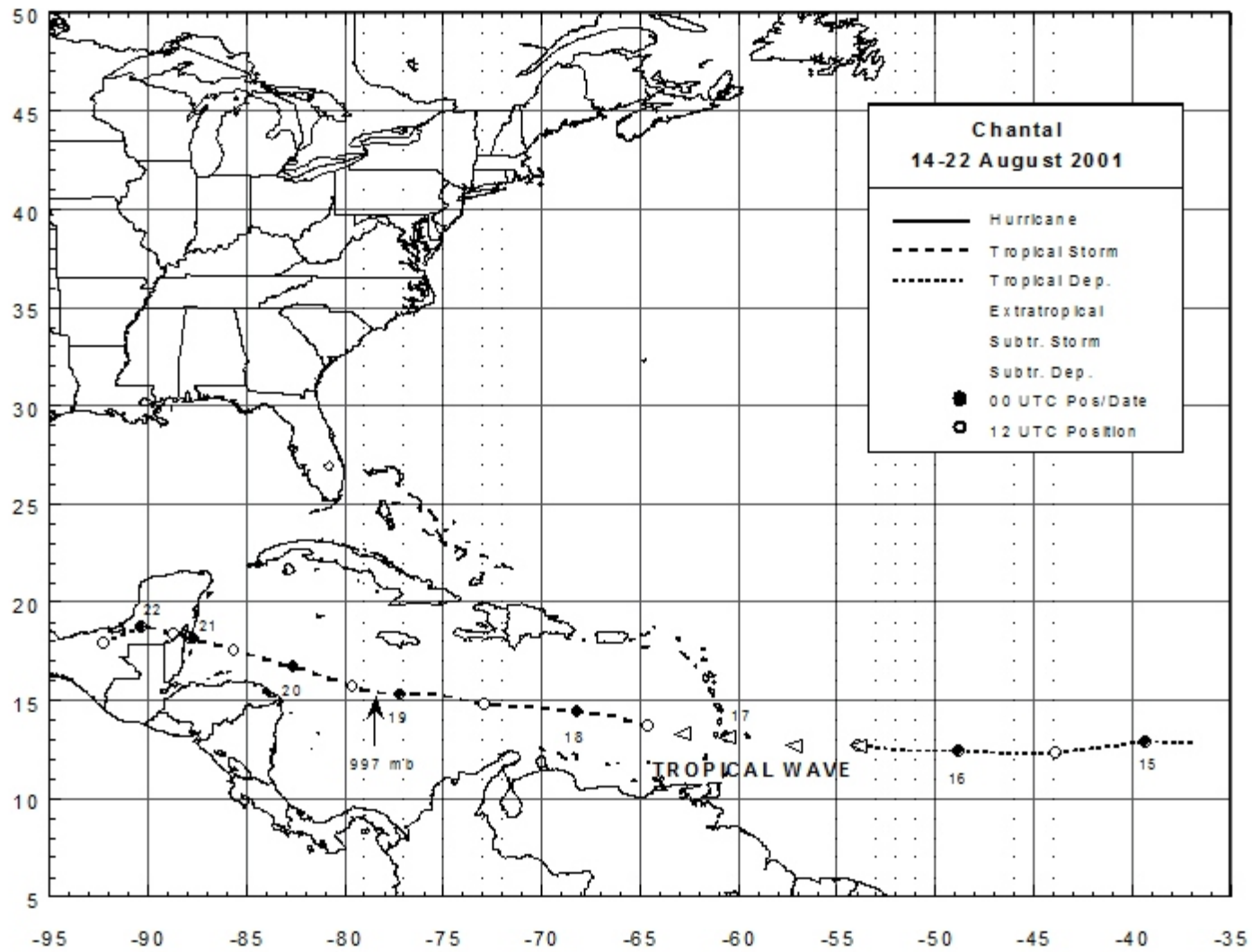


Figure 1. Best track positions for Tropical Storm Chantal, 14-22 Aug. 2001. Positions given by arrowheads during the tropical wave stage represent the location of the low-level vorticity center.

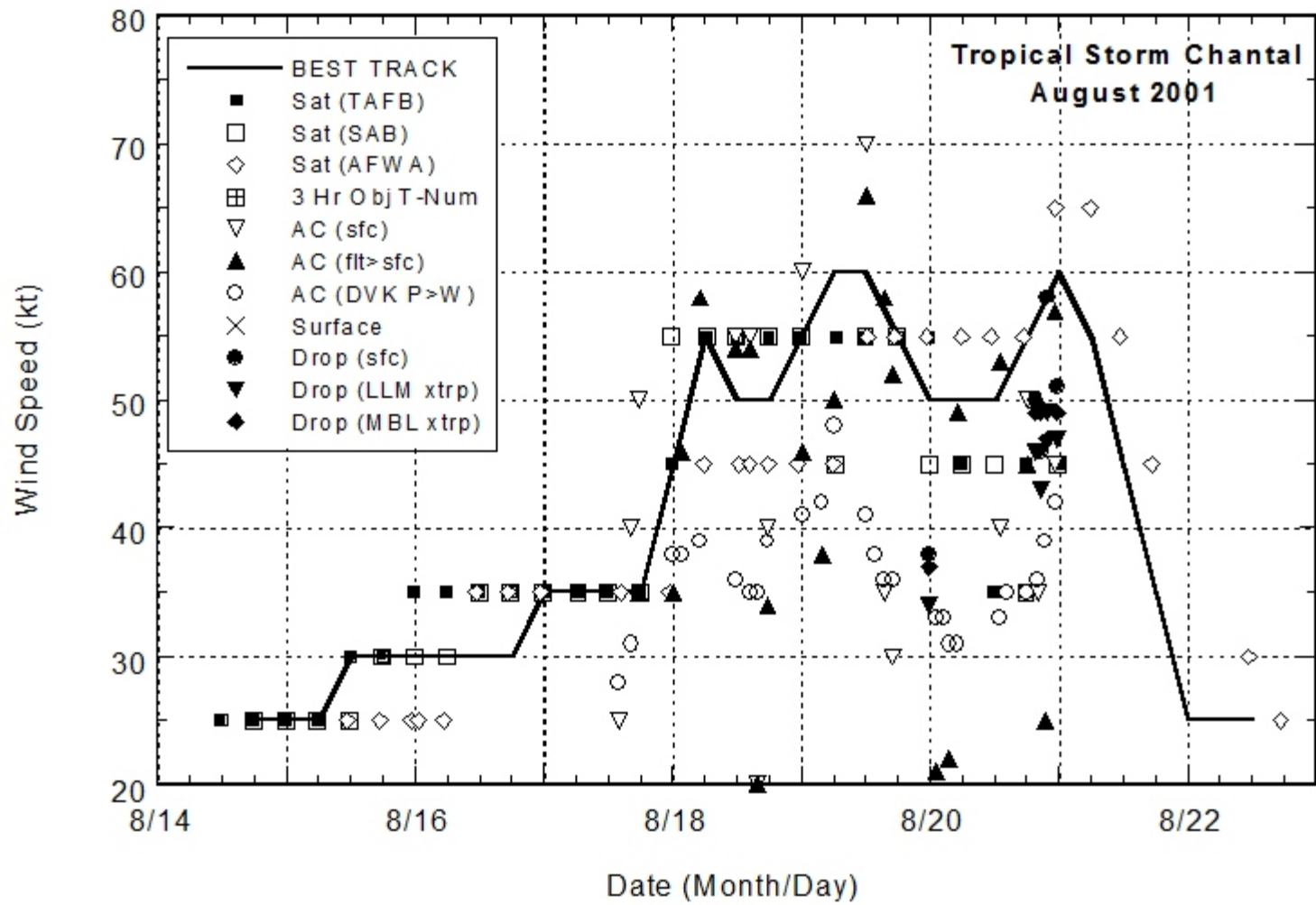
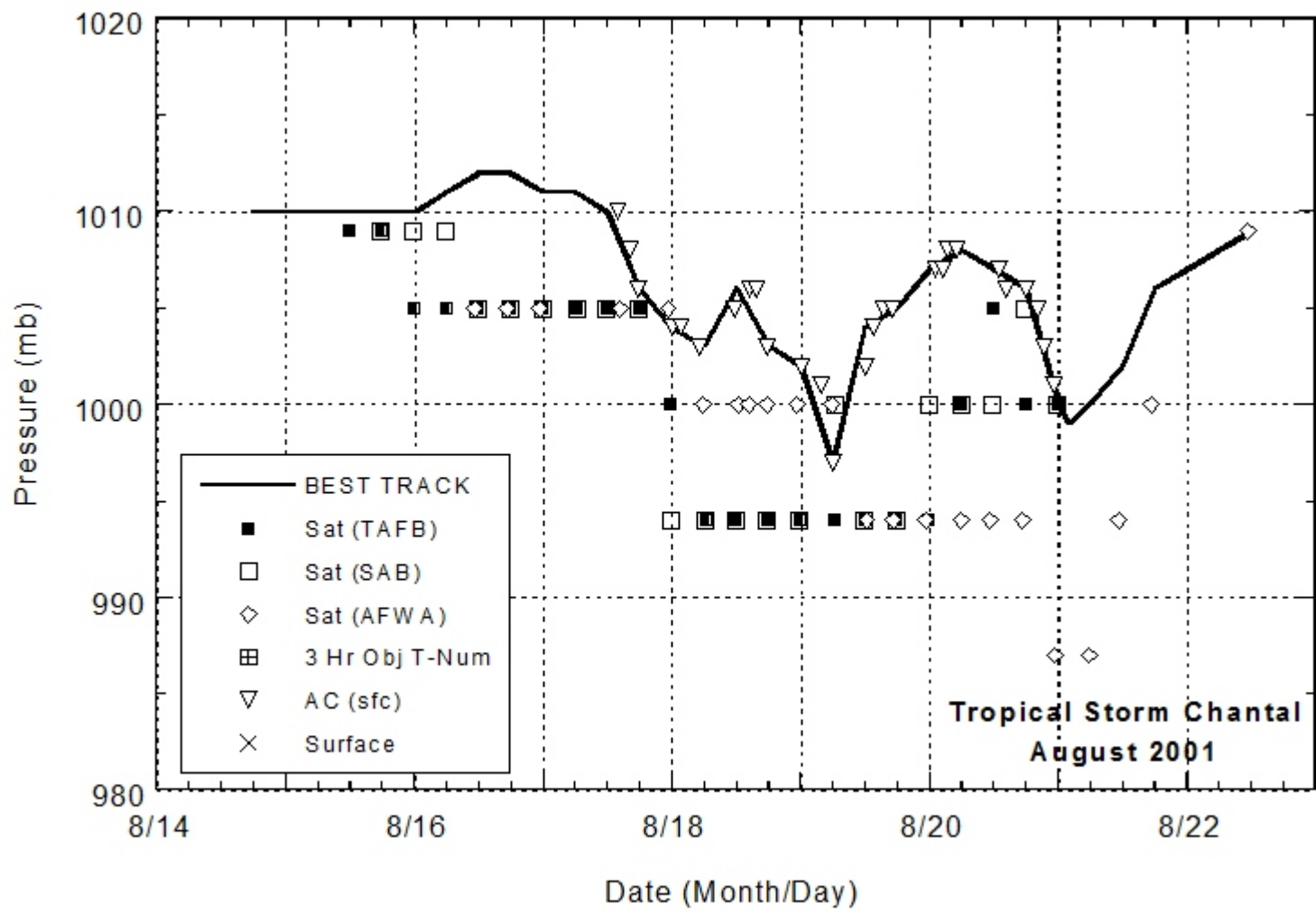


Figure 2. Best track maximum

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estimates derived from the mean wind over the lowest 150 m of the wind sounding (LLM), and from the sounding boundary layer mean (MBL). Figure includes the period from 1200 UTC 16 August



through 0600 UTC 17 August when Chantal was a tropical wave.

Figure 3. Best track minimum central pressure curve for Tropical Storm Chantal, 14-22 Aug. 2001, and the observations on which the best track curve is based. Figure includes the period from 1200 UTC 16 August through 0600 UTC 17 August when Chantal was a tropical wave.

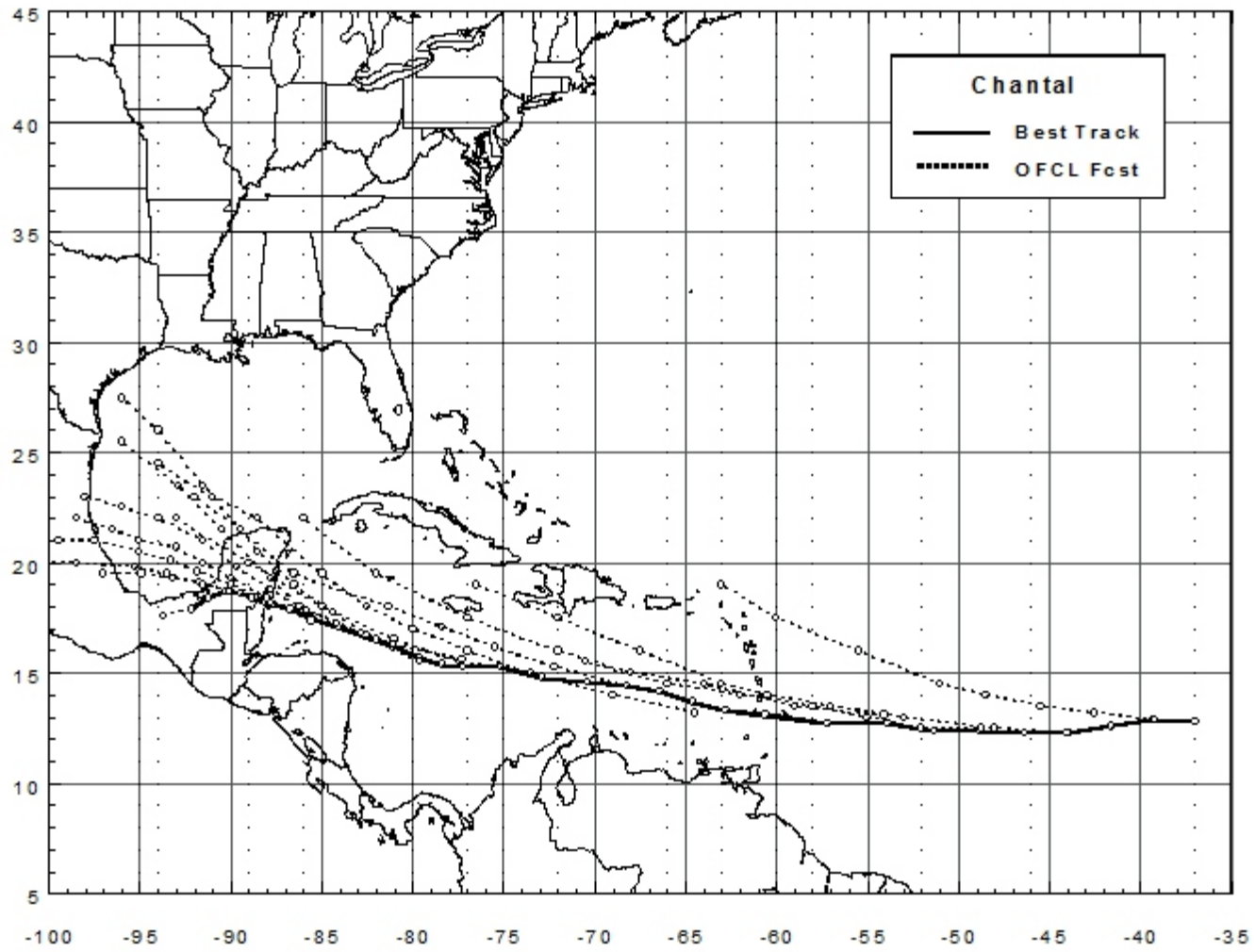
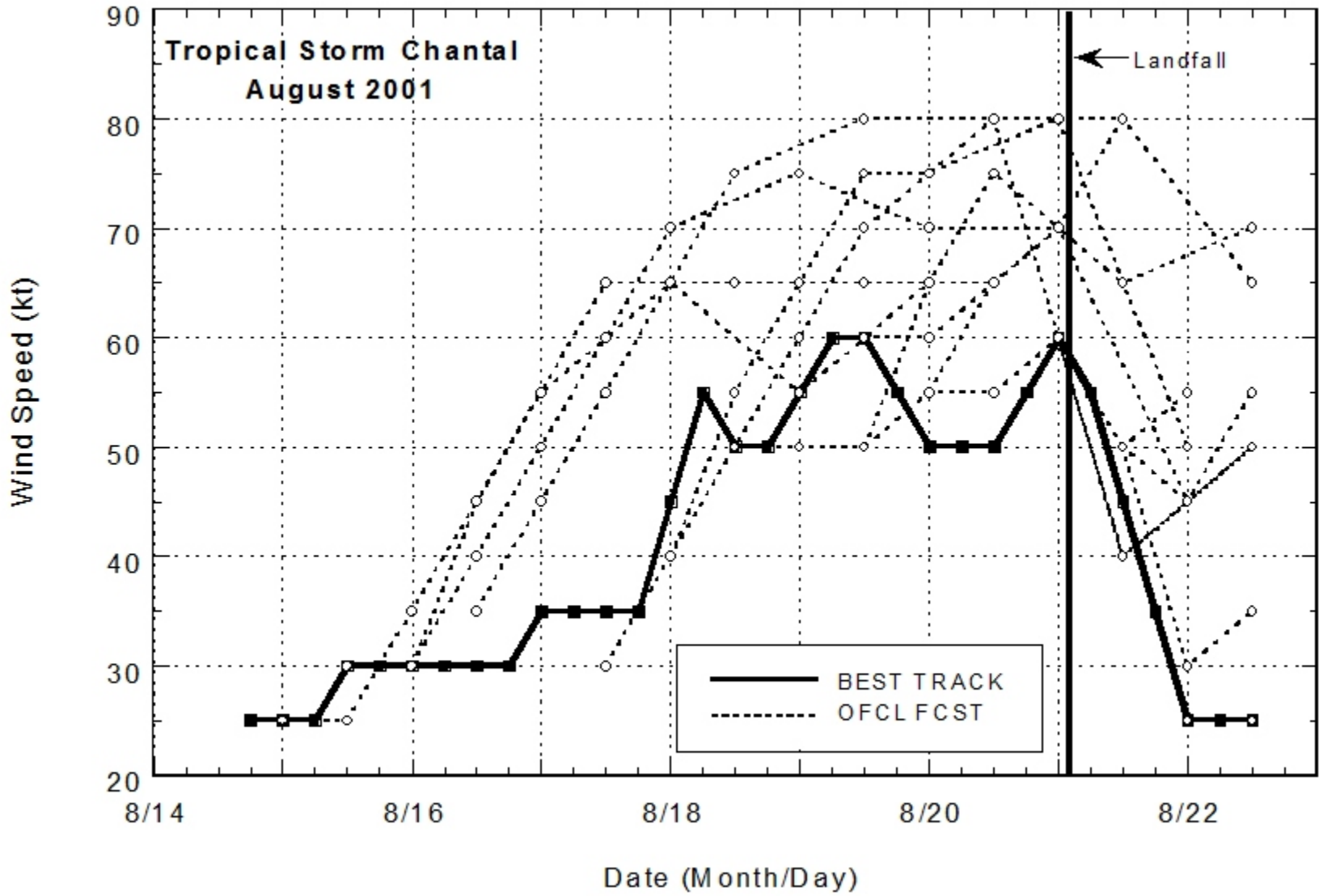


Figure 4. Selected (000

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Figure 5. Selected (0000 and 1200 UTC) official intensity forecasts (dashed lines) for Tropical Storm Chantal, 14-22 Aug. 2001. The best track intensity is given by the thick solid line.