

Preliminary Report
Hurricane Cindy
19 August - 31 August, 1999

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Cindy had a long track across the Atlantic with no direct impact on land.

a. Synoptic History

The origin of Cindy can be traced back to a tropical wave that crossed the west coast of Africa early on the 18th, accompanied by 4.5 mb 24-hour surface pressure falls and a 50-knot 700 mb jet as seen in Dakar, Senegal rawinsonde data and Shortly after entering the eastern tropical Atlantic, deep convection began to gradually become better organized. By the evening of the 18th, satellite imagery and ship reports indicated that shower and thunderstorm activity became more consolidated near the center of a broad circulation. It is estimated that a tropical depression formed from this system around 0000 UTC on 19 August, centered about 250 n mi east-southeast of the Cape Verde Islands, as shown in the post-storm "best track" (Table 1, Figure 1).

Persistent 20 to 30 knot easterly vertical shear, as shown in analyses from the University of Wisconsin Cooperative Institute for Meteorological Satellite Studies, prevented the system from becoming significantly better organization during the next 36 hours. By the afternoon of the 20th, the shear relaxed and the center of the depression became more co-located with the deep convection. The system is estimated to have become Tropical Storm Cindy by 1800 UTC 20 August, in agreement with Dvorak satellite classifications from the Tropical Analysis and Forecast Branch (TAFB), the Satellite Analysis Branch (SAB), and the U.S. Air Force Weather Agency. Cindy continued to become better organized on the 21st as banding features developed and a CDO formed over the center. Cindy reached hurricane strength at 0000 UTC 22 August, about 390 n mi west of the Cape Verde Islands. Further intensification was arrested as easterly shear became more pronounced. Cindy weakened to a tropical storm at 1800 UTC 22 August.

By the afternoon of the 25th, the easterly shear slackened and Cindy re-strengthened to hurricane intensity at 0000 UTC 26 August, while located about 1100 n mi southeast of Bermuda. Cindy continued to intensify during the next several days as banding features became more prominent and the upper tropospheric outflow improved. A ragged eye first appeared in visible satellite imagery on the morning of the 27th, and by that afternoon a 25 n mi diameter banding-type eye became evident. The hurricane continued to strengthen and reached an estimated peak intensity of 120 knots at 1200 UTC 28 August, while centered about 375 miles east-southeast of Bermuda.

On 29 and 30 August, Cindy began to weaken in response to increasing westerly, then southwesterly shear. The overall cloud pattern gradually degenerated and the eye became indiscernible, the cloud tops warmed, and the deep convection became displaced north, and eventually mainly east, of the center.

For its first five days Cindy had a motion toward the west-northwest at 6 to 12 knots. The motion was northwestward at 12 to 18 knots from late on the 24th through the 26th under the influence of the subtropical anticyclone over the north Atlantic. On the 27th, a mid-to upper-level low located southwest of Cindy helped steer the hurricane more to the west. By late on the 27th, the tropical cyclone began to decelerate when an upper-level trough along 55W-60W began to pull Cindy on a more northwesterly, then northerly heading. Cindy reached its westernmost longitude, about 58.5°W, on the afternoon of the 28th. On 29 August, the system turned northeast and it began to accelerate late on the 30th. Cindy's closest approach to Bermuda, about 325 n mi, occurred at 0600 UTC 29 August.

Cindy was downgraded to a tropical storm at 0600 UTC 31 August as the system continued to accelerate northeastward into progressively cooler waters. By that afternoon, Cindy became indistinct when it merged with a large extratropical cyclone over the north Atlantic about 850 n mi west of the Azores.

b. Meteorological Statistics

Figure 2 depicts the curves of minimum central sea-level pressure and maximum one-minute average "surface" (10 meters above ground level) wind speed, respectively, as a function of time. Also plotted are the observations on which the curves are based, consisting of Dvorak-technique estimates from TAFB, SAB, and the U.S. Air Force Weather Agency (AFWA) using satellite imagery.

Satellite-based intensity estimates on 28 August are the main basis for the peak intensity estimate of 120 knots in the best track; the objective-based Dvorak intensity estimate is the basis for the minimum central pressure of 942 mb at 1200 UTC 28 August. Ship reports of tropical storm force or greater wind speeds associated with Cindy are listed in Table 2.

Figure 3 is a series of SSM/I (A) and TRMM microwave images produced by the Naval Research Laboratory that depict Cindy 24 hours prior to peak intensity (A), near peak intensity (B), and 24 hours (C) and 48 hours (D) after the peak. The eye diameter in (B) is about 30 n mi. The small circulation in the bottom center of (B) is Tropical Depression Emily.

Figure 4 is a sequence of surface wind estimates from NASA's Quick Scatterometer (QuikSCAT) for Cindy. This figure shows the surface wind field of Cindy about 24 hours prior to peak intensity (A), near peak intensity (B), after recurvature (C), and after absorption by an extratropical cyclone over the north Atlantic (D). Although these data are still experimental and subject to calibration,

they shows both the size and evolution of the wind field from near peak intensity to recurvature and the resulting circulation asymmetry.

c. Casualty and Damage Statistics

No reports of casualties or damage due to Cindy have been received at the National Hurricane Center.

d. Forecast and Warning Critique

The official forecast errors for Cindy were generally low relative to the most recent ten-year averages. The average 12-, 24-, 36-, 48-, and 72-hr official forecast errors and associated number of cases (in parenthesis) were 42 (42), 81 (40), 118 (38), 154 (36), and 226 (32) n mi, respectively. While the official forecast errors were below the most recent ten-year averages, many of the objective techniques were even better (Table 3). In particular, LBAR, BAMD, NGPI, and the UKMI all had substantially lower track errors than the official forecast (with the exception of the 12 h UKMI). These models did especially well with the recurvature portion of the hurricane.

An inspection of several NHC forecasts showed that the 72 h forecasts issued between 0000 and 1800 UTC 27 August and valid from 30/00 UTC to 30/18 UTC indicated an acceleration from 12 to 19 knots. During this period, Cindy moved on a general northeast heading at 8 to 10 knots and did not begin to accelerate until 0000 UTC 31 August.

The average absolute official intensity forecasts errors ranged from 5 to 10 knots between 12 and 36 hours and 12 to 16 knots from 48 to 72 hours. These errors are 20% to 30% below the most recent ten-year averages. The Statistical Hurricane Intensity Prediction Scheme (SHIPS) did equally well. The official forecasts, however, under-estimated the peak intensity by 25 to 35 knots in the 24- to 72-h time periods.

No watches or warnings were necessary for Cindy.

Table 1.
Preliminary Best Track - Hurricane Cindy, 19 - 31 August 1999.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
19/0000	13.5	18.9	1003	30	Tropical Depression
19/0600	13.8	20.3	1003	30	"
19/1200	13.9	21.5	1003	30	"
19/1800	13.8	22.5	1003	30	"
20/0000	13.7	23.4	1002	30	"
20/0600	13.6	24.3	1002	30	"
20/1200	13.5	25.4	1002	30	"
20/1800	13.6	26.6	1001	35	Tropical Storm
21/0000	13.6	27.7	1000	40	"
21/0600	13.8	28.8	997	50	"
21/1200	13.9	29.7	994	55	"
21/1800	14.1	30.8	990	60	"
22/0000	14.2	31.7	987	65	Hurricane
22/0600	14.4	32.3	987	65	"
22/1200	14.5	32.7	987	65	"
22/1800	14.6	33.1	990	60	Tropical Storm
23/0000	14.9	33.9	997	50	"
23/0600	15.3	34.9	997	50	"
23/1200	15.7	35.9	997	50	"
23/1800	16.1	36.9	997	50	"
24/0000	16.6	38.0	997	50	"
24/0600	16.9	39.2	997	50	"
24/1200	17.2	40.6	997	50	"
24/1800	17.5	42.2	997	50	"
25/0000	17.8	43.6	994	55	"
25/0600	18.4	44.8	994	55	"
25/1200	19.3	45.9	994	55	"
25/1800	20.4	47.1	990	60	"

Table 1 (continued).
Preliminary Best Track - Hurricane Cindy, 19 - 31 August 1999.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
26/0000	21.7	48.2	987	65	Hurricane
26/0600	22.9	49.5	987	65	"
26/1200	24.2	50.8	987	65	"
26/1800	25.4	52.0	984	70	"
27/0000	26.4	53.1	978	80	"
27/0600	27.2	54.3	978	80	"
27/1200	27.8	55.4	970	90	"
27/1800	28.3	56.2	970	90	"
28/0000	28.7	56.9	961	100	"
28/0600	29.3	57.5	948	115	"
28/1200	30.1	58.0	942	120	"
28/1800	30.8	58.5	943	120	"
29/0000	31.5	58.4	944	120	"
29/0600	32.3	58.4	948	115	"
29/1200	33.1	58.2	961	100	"
29/1800	33.8	57.4	965	95	"
30/0000	34.3	56.3	970	90	"
30/0600	34.7	55.5	970	90	"
30/1200	35.3	54.9	978	80	"
30/1800	36.1	54.2	978	80	"
31/0000	37.0	52.6	984	70	"
31/0600	38.2	50.6	990	60	Tropical Storm
31/1200	40.4	48.2	997	50	"
31/1800					Absorbed By Extratropical Low
28/1200	30.1	58.0	942	120	minimum pressure

Table 2.

Hurricane Cindy ship observations of 34-Knot or greater winds,
19 August - 31 August 1999.

LOCATION	Press (mb)	Date/Time (UTC)	Sust. Wind (KT)	Sgnft. Wave Ht. (FT)
ZCBB9 (26.5N 47.0W)	1015.2	26/0600	37	13
ELUU6 (26.5N 51.8W)	1015.1	26/1200	36	16
ELUU6 (26.8N 51.7W)	1012.4	26/1500	38	16
ELUU6 (26.9N 51.4W)	1009.7	26/1800	60	23
ELUU6 (27.1N 51.1W)	1017.7	27/0000	62	30
ELUU6 (27.4N 49.8W)	1016.7	27/0900	40	16

Table 3.

Preliminary track forecast evaluation of Hurricane Cindy - heterogeneous sample. Errors in nautical miles for tropical storm and hurricane stages with number of forecasts in parenthesis. Numbers in italics represent forecasts which were better than the official forecast.

Forecast Technique	Period (hours)				
	12	24	36	48	72
CLIP	52 (42)	96 (40)	145 (38)	194 (36)	260 (32)
GFDI	44 (34)	82 (32)	114 (32)	151 (32)	225 (30)
GFDL*	37 (17)	75 (17)	113 (16)	145 (16)	223 (16)
LBAR	38 (42)	64 (40)	102 (38)	140 (36)	196 (32)
AVNI	52 (39)	92 (37)	133 (34)	177 (30)	288 (22)
AVNO*	47 (39)	91 (36)	127 (34)	166 (30)	249 (22)
BAMD	38 (42)	69 (40)	97 (38)	119 (36)	204 (32)
BAMM	39 (44)	72 (44)	109 (44)	147 (43)	243 (39)
BAMS	45 (42)	83 (40)	125 (38)	179 (36)	303 (32)
NGPI	41 (41)	76 (39)	87 (35)	105 (33)	153 (27)
NGPS*	45 (21)	61 (20)	77 (18)	96 (17)	128 (14)
UKMI	49 (40)	70 (38)	94 (36)	103 (34)	177 (30)
UKM*	41 (21)	73 (20)	87 (19)	106 (18)	139 (16)
A90E	46 (42)	77 (40)	110 (38)	149 (36)	224 (32)
A98E	45 (41)	75 (39)	107 (38)	153 (36)	224 (32)
A9UK	41 (19)	72 (18)	95 (17)	110 (16)	182 (15)
NHC Official	42 (42)	81 (40)	118 (38)	154 (36)	226 (32)
NHC Official 10-Year Average (1989-1998)	48 (2005)	89 (1790)	128 (1595)	164 (1410)	242 (1107)

* - Output from these models was unavailable at time of forecast issuance.

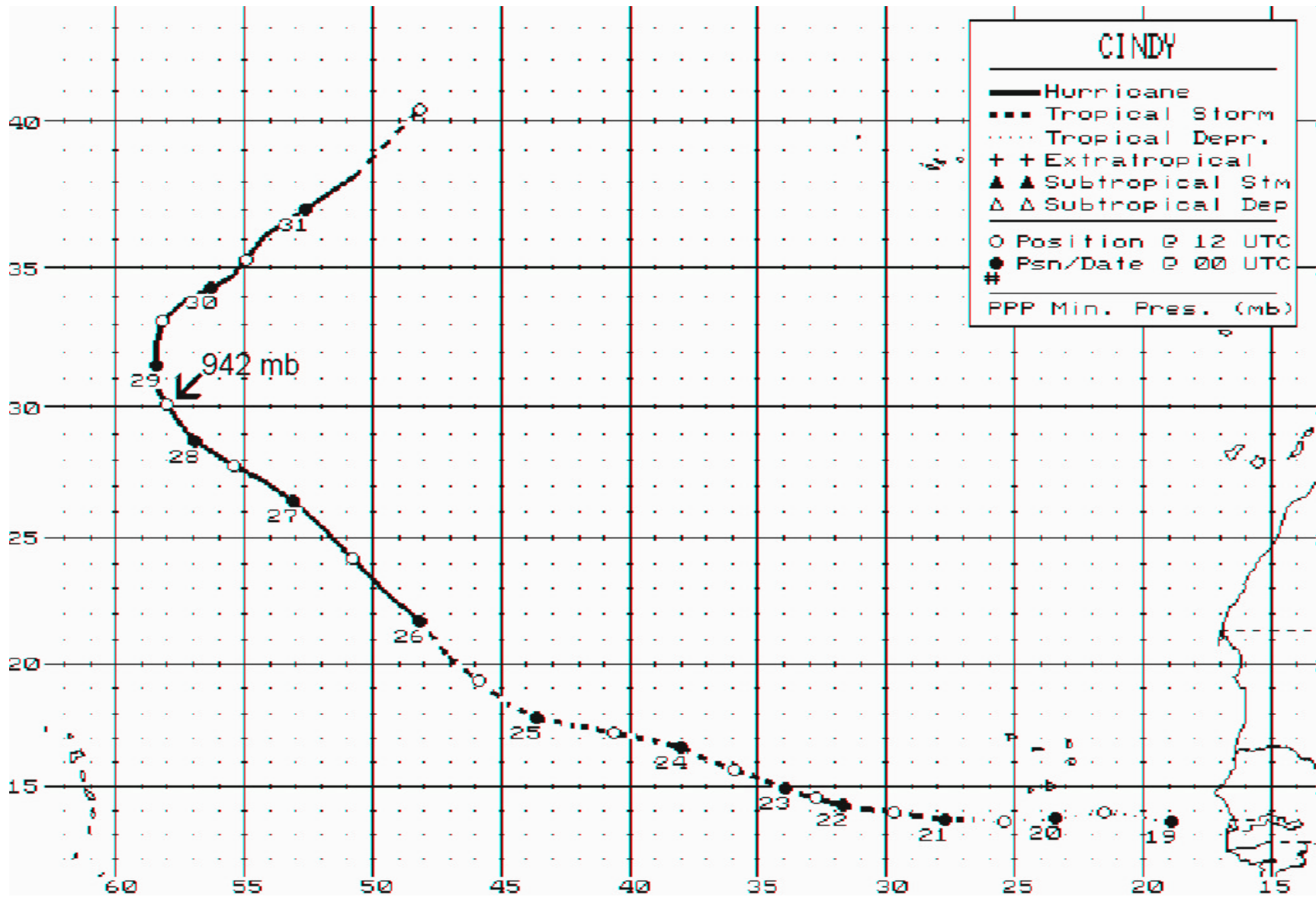


Figure 1. Best track positions for Hurricane Cindy, 19-31 August 1999.

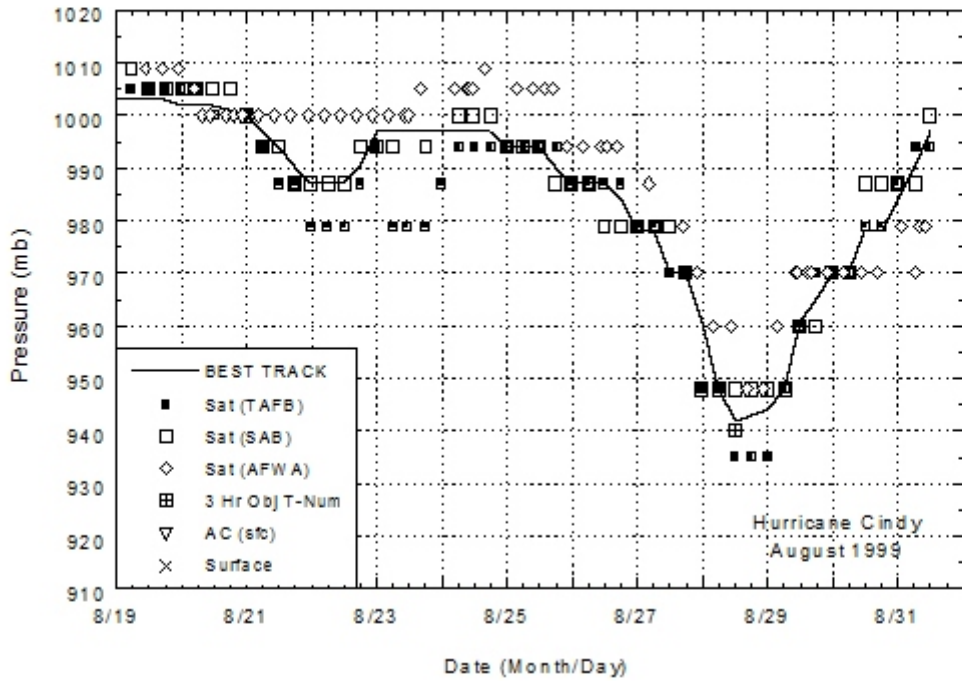


Figure 2a. Best track minimum central pressure curve for Hurricane Cindy, 19 - 31 August 1999.

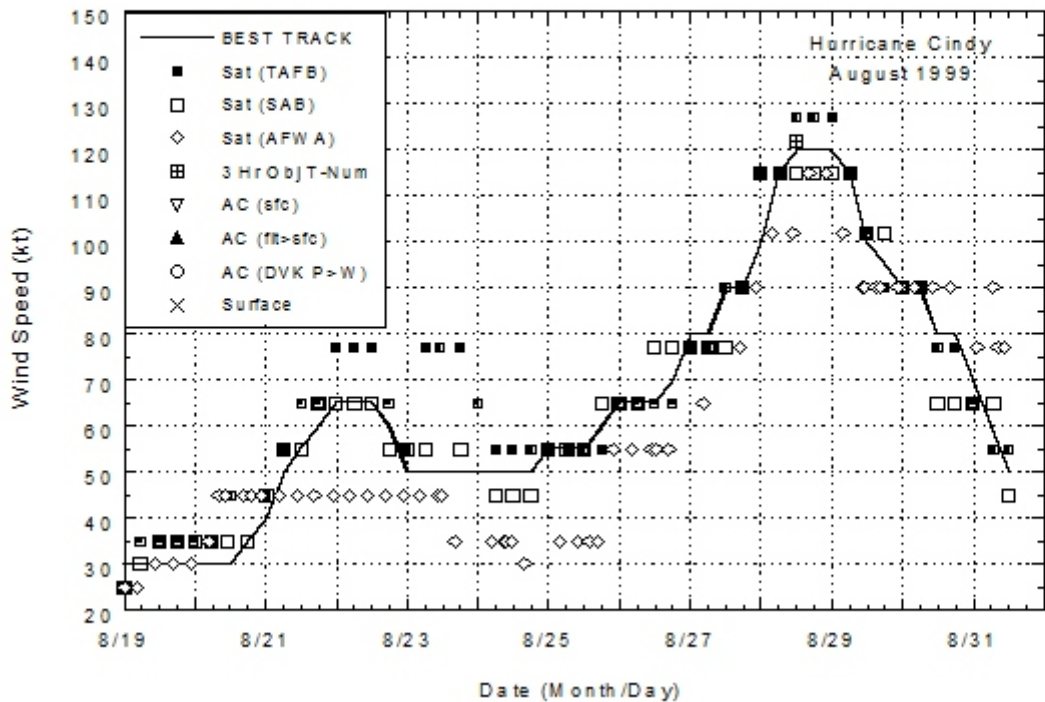
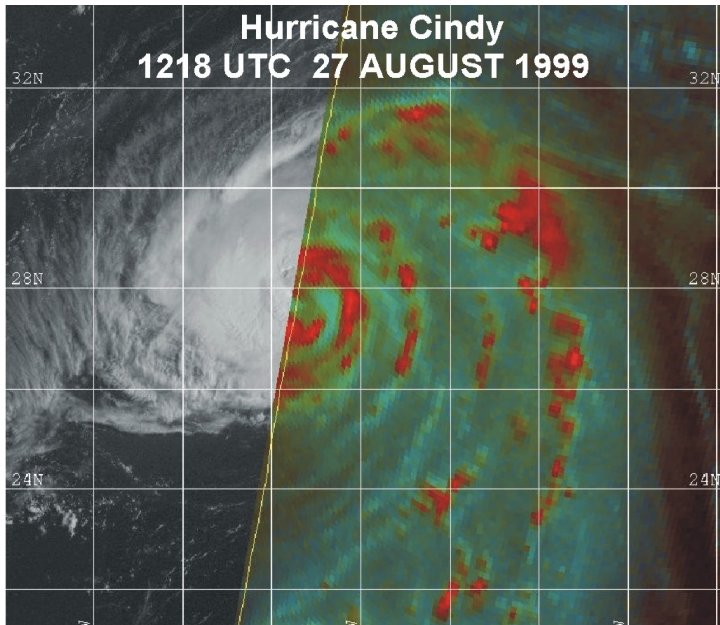
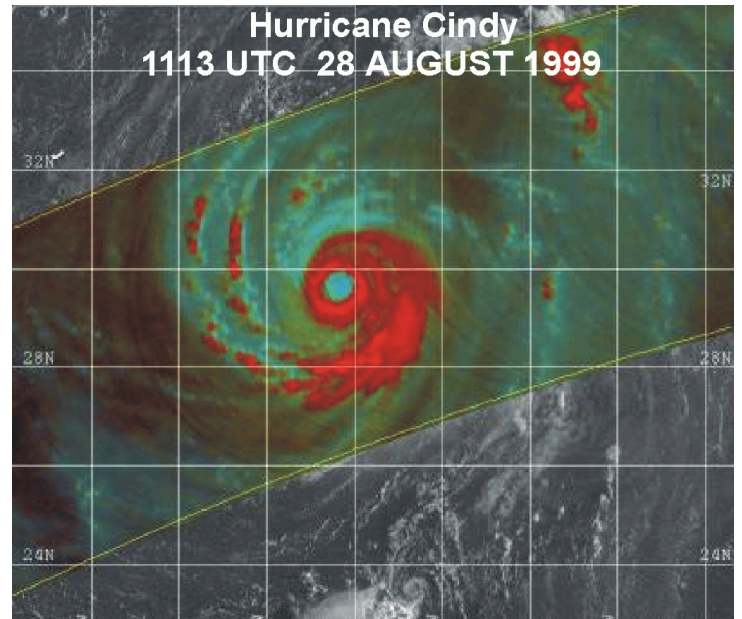


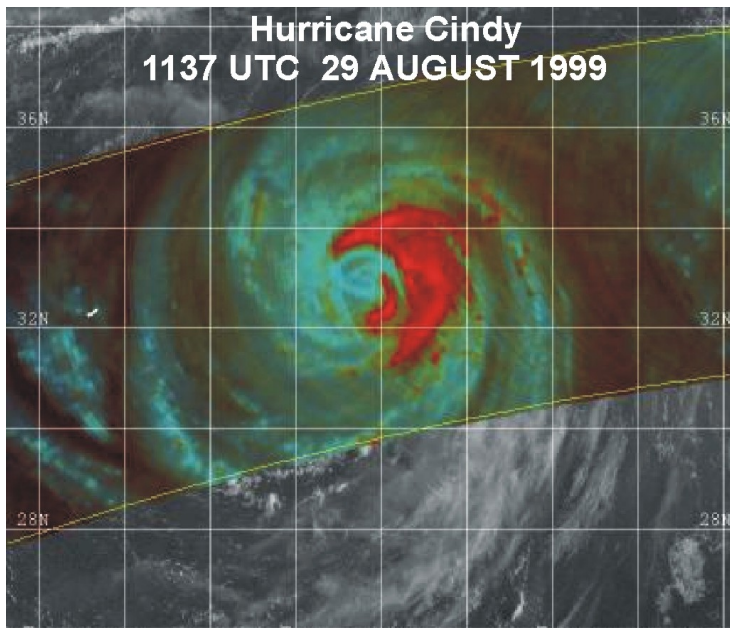
Figure 2b. Best track maximum sustained 1-minute 10 meter wind speed curve for Hurricane Cindy, 19 - 31 August 1999.



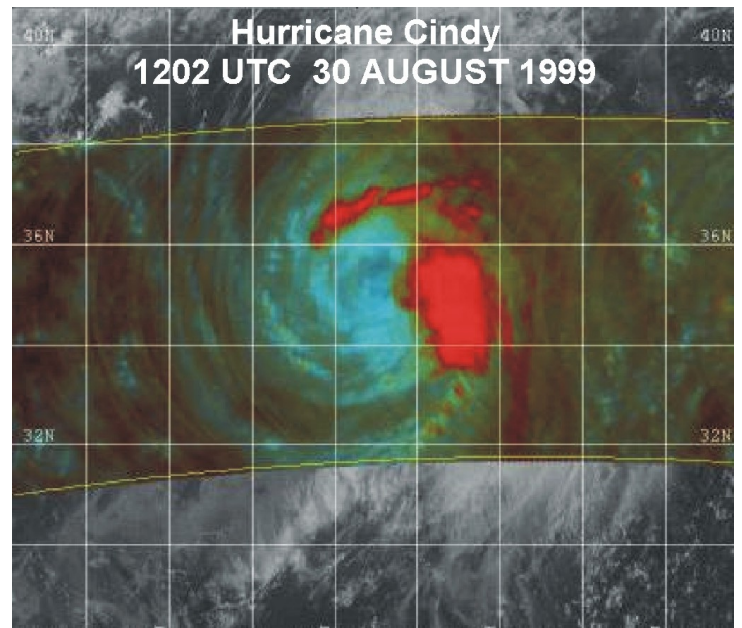
A



B

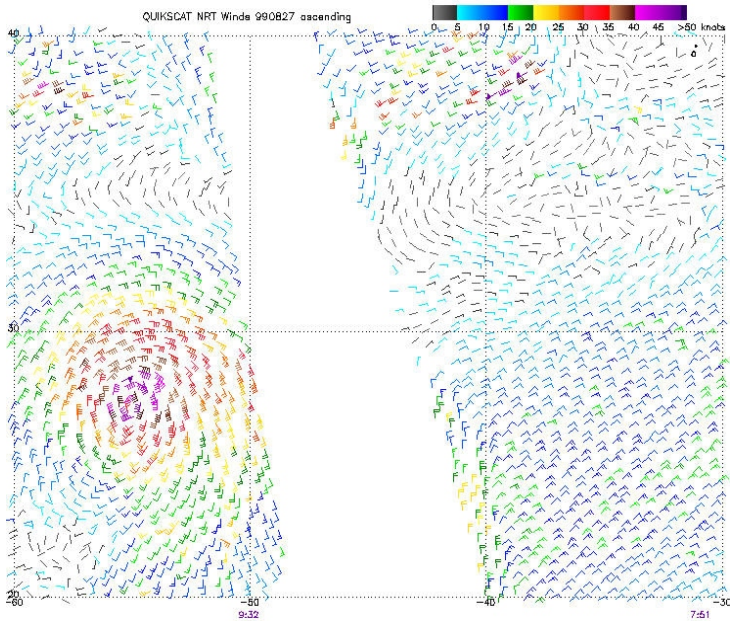


C

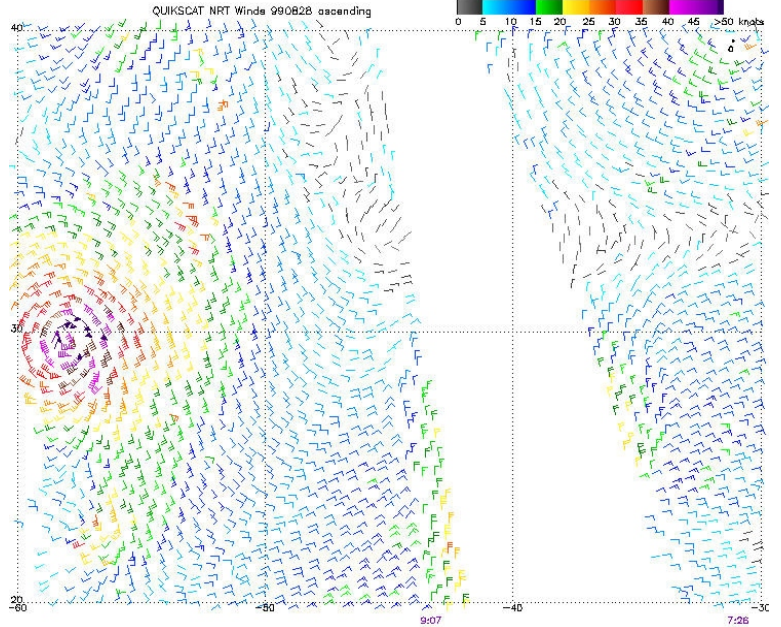


D

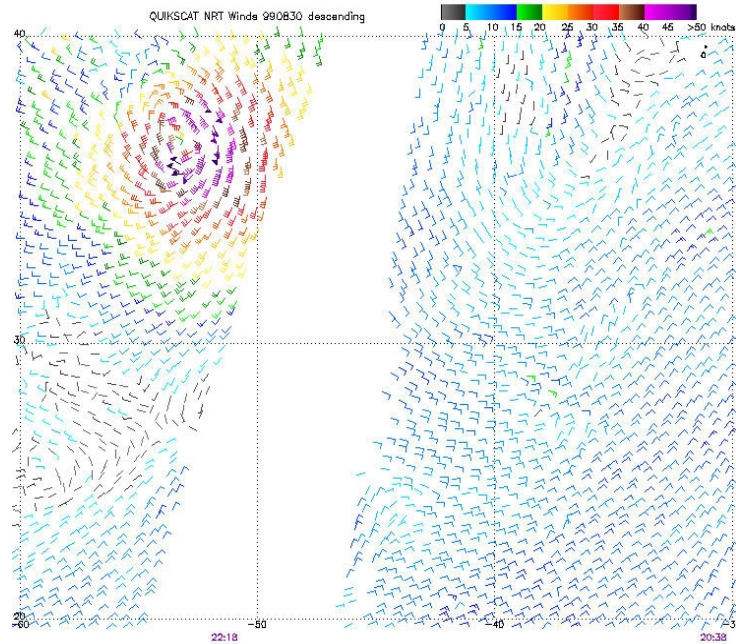
Figure 3. Sequence of SSM/I (A) and TRMM microwave images of Hurricane Cindy (A) 24 hours prior to peak intensity, (B) near peak intensity, (C) 24 hours after peak intensity, and (D) 48 hours after peak intensity. (The small circulation in the bottom center of (B) is Tropical Depression Emily).



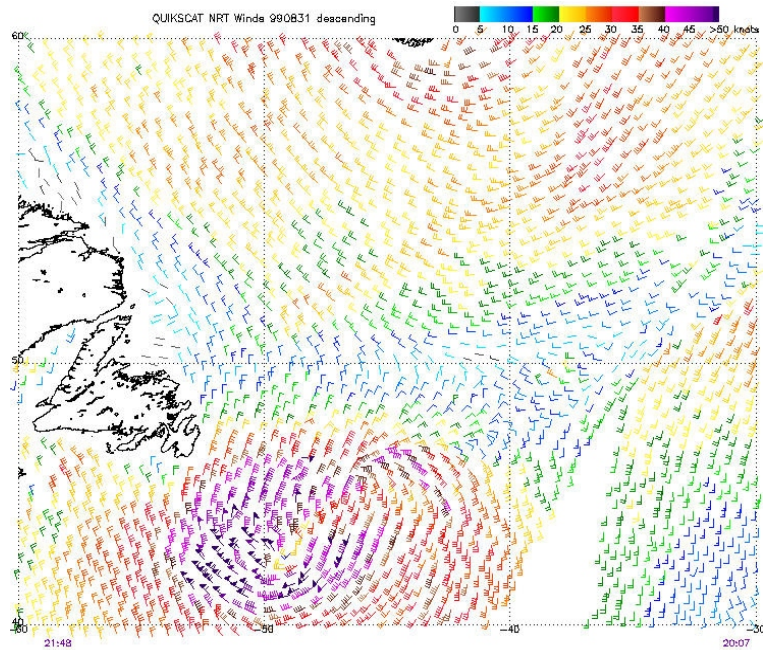
A



B



C



D

Figure 4. Surface wind estimates from NASA's Quick Scatterometer (QuikSCAT) of Hurricane Cindy (A) about 24 hours prior to peak intensity, (B) near peak intensity, (C) after recurvature, and (D) after absorption by an extratropical cyclone over the north Atlantic. (The date for each QuikSCAT image is on the top of each image while the time of the pass is denoted on the bottom).