Tropical Cyclone Report
Hurricane Danielle
13-21 August 2004

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Danielle was a high-end category 2 hurricane that remained over the open waters of the far eastern Atlantic Ocean without threatening land.

a. Synoptic History

The vigorous westward-moving tropical wave that spawned Danielle moved off the west coast of Africa early on 12 August. While over land, the system already possessed several characteristics associated with tropical cyclones – a well-defined low-level wind field, bands of deep convection spiraling into the center, and a well-established anticyclonic outflow pattern. After the wave reached the warm Atlantic waters about 450 n mi southeast of the Cape Verde Islands, more deep convection developed near the center of circulation. Curved convective bands became better defined and Dvorak satellite classifications were initiated at 1800 UTC that day. The wave moved west-northwestward at 12-14 kt, becoming better organized, and it is estimated that a tropical depression formed from it around 1200 UTC 13 August about 210 n mi southeast of the southernmost Cape Verde Islands. 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.

Owing to the already well-organized structure, low vertical shear, and very warm sea-surface temperatures, deep convection continued to become better organized and it is estimated that the cyclone became a tropical storm at 0000 UTC 14 August. Upon reaching an intensity of 45 kt just 12 h later, the favorable environmental conditions enabled Danielle to undergo a period of rapid intensification ($\geq$ 30 kt/24 h), with the cyclone becoming a hurricane at 0000 UTC 15 August about 295 n mi west-southwest of the southernmost Cape Verde Islands. Rapid intensification continued until an intensity of 80 kt was obtained around 1200 UTC that day. Afterwards, the intensification trend leveled off to a slower than average rate, possibly due to the eye and radius of maximum winds having decreased and subsequently stabilized to a small diameter (for example, see Fig. 4).

Moving northwestward toward a weakness in the subtropical ridge, Danielle reached its estimated maximum intensity of 95 kt (category 2 on the Saffir-Simpson Hurricane Scale) at 1800 UTC 16 August about 755 n mi west of the northwesternmost Cape Verde Islands. Shortly after Danielle reached its peak intensity, a large mid- to upper-level trough that had eroded the subtropical ridge and enhanced the poleward outflow also began to increase the southwesterly vertical shear across the cyclone. The increasing shear brought about steady weakening over the next 72 h as the hurricane moved northward through a large break in the subtropical ridge. Danielle became a tropical storm by 1200 UTC 18 August and turned northeastward under the influence of the moderate southwesterly mid-level flow ahead of the approaching diffluent trough. The vertical shear continued to increase and caused most of the deep convection to separate from the circulation, and Danielle weakened to a tropical depression around 1800 UTC 20 August when the cyclone was located about 600 n mi south-southwest of the westernmost Azores Islands. The now vertically shallow cyclone continued to weaken while moving west and west-northwestward around the southern periphery of a high pressure system situated over the Azores Islands. Danielle degenerated into a non-convective remnant low pressure system by 1800 UTC the next day. The remnant low moved slowly northwestward and remained devoid of significant convection for the next 3 days. It dissipated at 0000 UTC 25 August about 690 n mi west-southwest of the westernmost Azores Islands.

b. Meteorological Statistics

Observations in Hurricane Danielle (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). Microwave imagery from NOAA polar-orbiting satellites, the NASA Tropical Rainfall Measuring Mission (TRMM), the NASA QuikSCAT program, and the Defense Meteorological Satellite Program (DMSP) was also useful in tracking Hurricane Danielle.

The peak intensity of 95 kt and minimum pressure of 964 mb at 1800 UTC 16 August is based on a combination of subjective Dvorak satellite intensity estimates and Objective Dvorak T-numbers at that time. A 2322 UTC 16 August TRMM composite overpass (Fig. 4) indicated Danielle possessed a small eye, but that the cyclone had likely just passed its peak intensity based on the erosion and warming of the cloud tops in the eastern semicircle since 1800 UTC. Degradation of the inner core convective cloud pattern and overall structure continued after this time based on subsequent conventional and microwave satellite data.

There were no reports of winds of tropical storm force associated with Hurricane Danielle.

c. Casualty and Damage Statistics

There were no reports of damage or casualties associated with Hurricane Danielle.

d. Forecast and Warning Critique

Average official (OFCL) track errors (with the number of cases in parentheses) for Danielle were 36 (31), 65 (29), 103 (27), 148 (25), 232 (21), 332 (17), and 452 (13) n mi for the 12, 24, 36, 48, 72, 96, and 120 h forecasts, respectively. Through 48 h, the OFCL errors are near or less than the average official track errors for the 10-yr period 1994-2003 of 44, 78, 112, 146, 217, 248, and 319 n mi, respectively (Table 4). However, the NHC track errors at 72-120 h are much higher than average for that time period[1]. The reason for the larger track errors at the longer time periods was due to the unanticipated turn to the northeast and an associated decrease

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[1] Errors given for the 96 and 120 h periods are averages over the three-year period 2001-3.

in forward speed that occurred on 18 August. Nearly all of the global and regional models, including the Florida State University Superensemble (FSSE) model, considerably outperformed the OFCL forecasts; the exception was the U.S. Navy NOGAPS model. The poor performance of the NOGAPS model, which kept Danielle moving in a general west to west-northward direction for several days, contributed to a significant degradation in the performance of the usually reliable consensus models GUNS (GFDL-UKMET-NOGAPS) and GUNA (GFDL-UKMET-NOGAPS-GFS).

Average official intensity errors were 6, 11 13, 16, 23, 24, and 23 kt for the 12, 24, 36, 48, 72, 96, and 120 h forecasts, respectively. Through 48 h, these errors were near or slightly below average (average official intensity errors over the 10-yr period 1994-2003 of 6, 11, 15, 17, 20, 18, and 19 kt, respectively), and higher than average at 72, 96, and 120 h. The largest errors occurred as a result of the period of rapid intensification that was not reflected in the official forecasts. Those 35-40 kt underforecasts were partly due to the SHIPS intensity model forecasting a less-than-average rate of intensification, especially during the first 24 h of the Danielle's existence. The SHIPS model underforecasts appear to have been due to its reliance on intensity persistence. Large overforecasts of 30-35 kt also occurred toward the middle of Danielle's lifetime when significant weakening was not indicated in the official NHC intensity forecasts after the hurricane had reached its maximum intensity. While the SHIPS intensity model did capture the weakening trend reasonably well after Danielle peaked, its forecast winds were too strong.

Table 1. Best track for Hurricane Danielle, 13-21 August 2004.

Date/Time (UTC)	Latitude (EN)	Longitude (EW)	Pressure (mb)	Wind Speed (kt)	Stage
13 / 1200	12.3	21.8	1009	30	tropical depression
13 / 1800	12.4	23.0	1009	30	"
14 / 0000	12.6	24.2	1009	35	tropical storm
14 / 0600	12.9	25.5	1004	40	"
14 / 1200	13.2	26.8	1004	45	"
14 / 1800	13.5	28.1	994	55	"
15 / 0000	13.8	29.3	987	65	hurricane
15 / 0600	14.1	30.8	981	75	"
15 / 1200	14.7	32.1	978	80	"
15 / 1800	15.2	33.5	975	85	"
16 / 0000	16.0	34.8	970	90	"
16 / 0600	16.8	36.0	970	90	"
16 / 1200	17.7	37.2	970	90	"
16 / 1800	19.0	38.2	964	95	"
17 / 0000	20.3	38.9	965	95	"
17 / 0600	21.7	39.6	970	90	"
17 / 1200	23.3	40.0	970	90	"
17 / 1800	24.6	40.3	974	85	"
18 / 0000	25.9	40.6	981	75	"
18 / 0600	27.3	40.3	985	65	"
18 / 1200	28.1	39.8	994	55	tropical storm
18 / 1800	28.9	38.9	1005	45	"
19 / 0000	29.3	37.8	1007	40	"
19 / 0600	29.7	37.7	1007	40	"
19 / 1200	29.9	37.7	1007	35	"
19 / 1800	29.9	37.2	1007	35	"
20 / 0000	29.8	36.8	1009	35	"
20 / 0600	30.2	37.0	1010	35	"
20 / 1200	30.5	37.2	1011	35	"
20 / 1800	30.9	37.6	1012	30	tropical depression
21 / 0000	30.9	38.0	1012	30	"
21 / 0600	30.6	38.6	1013	30	"
21 / 1200	30.7	38.9	1014	25	"
21 / 1800	30.5	39.2	1014	25	remnant low
22 / 0000	30.3	39.8	1015	25	"
22 / 0600	30.2	40.3	1015	25	"
22 / 1200	30.3	40.8	1015	25	"
22 / 1800	30.4	41.2	1016	25	"
23 / 0000	30.8	42.0	1016	25	"
23 / 0600	31.7	42.5	1017	25	"

23 / 1200	32.3	43.3	1017	25	"
23 / 1800	33.1	43.8	1017	25	"
24 / 0000	33.9	44.2	1018	20	"
24 / 0600	34.7	44.6	1018	20	"
24 / 1200	35.5	45.0	1019	20	"
24 / 1800	36.4	45.2	1019	20	"
25 / 0000					dissipated
16 / 1800	19.0	38.2	964	95	minimum pressure

Table 4. Preliminary forecast evaluation (heterogeneous sample) for Hurricane Danielle, 13-21 August 2004. Forecast errors (n mi) are followed by the number of forecasts in parentheses. Errors smaller than the NHC official Forecast are shown in bold-face type. Verification includes the depression stage.

Forecast Technique	Forecast Period (h)						
	12	24	36	48	72	96	120
CLP5	47 (31)	104 (29)	177 (27)	260 (25)	424 (21)	547 (17)	667 (13)
GFNI	50 (26)	84 (24)	107 (22)	**138** (19)	260 (13)	334 (10)	**433** (7)
GFDI	41 (30)	78 (28)	108 (26)	**130** (24)	**182** (20)	**244** (16)	**241** (12)
GFDL	43 (31)	74 (29)	107 (27)	**129** (25)	**162** (21)	**231** (17)	**236** (13)
GFDN	56 (26)	98 (24)	120 (22)	**132** (19)	**210** (13)	**295** (10)	**393** (8)
GFSI	59 (30)	115 (28)	172 (26)	223 (24)	291 (20)	350 (12)	495 (7)
GFSO	62 (31)	115 (29)	168 (27)	226 (25)	282 (20)	348 (12)	483 (7)
AEMI	50 (29)	88 (27)	129 (25)	165 (23)	**200** (20)	**274** (16)	**270** (11)
NGPI	47 (29)	75 (27)	111 (25)	165 (23)	308 (19)	486 (15)	619 (11)
NGPS	56 (29)	88 (27)	111 (25)	150 (23)	257 (19)	434 (15)	551 (12)
UKMI	43 (29)	75 (27)	109 (25)	**140** (23)	**193** (20)	**209** (14)	**229** (8)
UKM	64 (16)	103 (15)	121 (14)	148 (13)	**194** (11)	**204** (8)	**186** (5)
A98E	43 (31)	89 (29)	140 (27)	192 (25)	330 (21)	452 (17)	533 (13)
A9UK	37 (15)	81 (14)	136 (13)	192 (12)	257 (10)		
BAMD	63 (31)	122 (29)	170 (27)	206 (25)	257 (21)	342 (17)	**359** (13)
BAMM	42 (31)	82 (29)	119 (27)	**145** (25)	**194** (21)	**242** (17)	**287** (13)
BAMS	54 (31)	105 (29)	150 (27)	190 (25)	274 (21)	350 (17)	**394** (13)
CONU	39 (30)	67 (28)	**95** (26)	**124** (24)	**201** (20)	**287** (16)	**355** (12)
GUNA	39 (28)	69 (26)	**100** (24)	**128** (22)	**195** (19)	**290** (10)	**295** (3)
FSSE	40 (27)	74 (26)	104 (24)	**137** (22)	**197** (18)	**281** (10)	**301** (3)
OFCL	36 (31)	65 (29)	103 (27)	148 (25)	232 (21)	332 (17)	452 (13)
NHC Official (1994-2003 mean)	44 (3172)	78 (2894)	112 (2636)	146 (2368)	217 (1929)	248 (421)	319 (341)

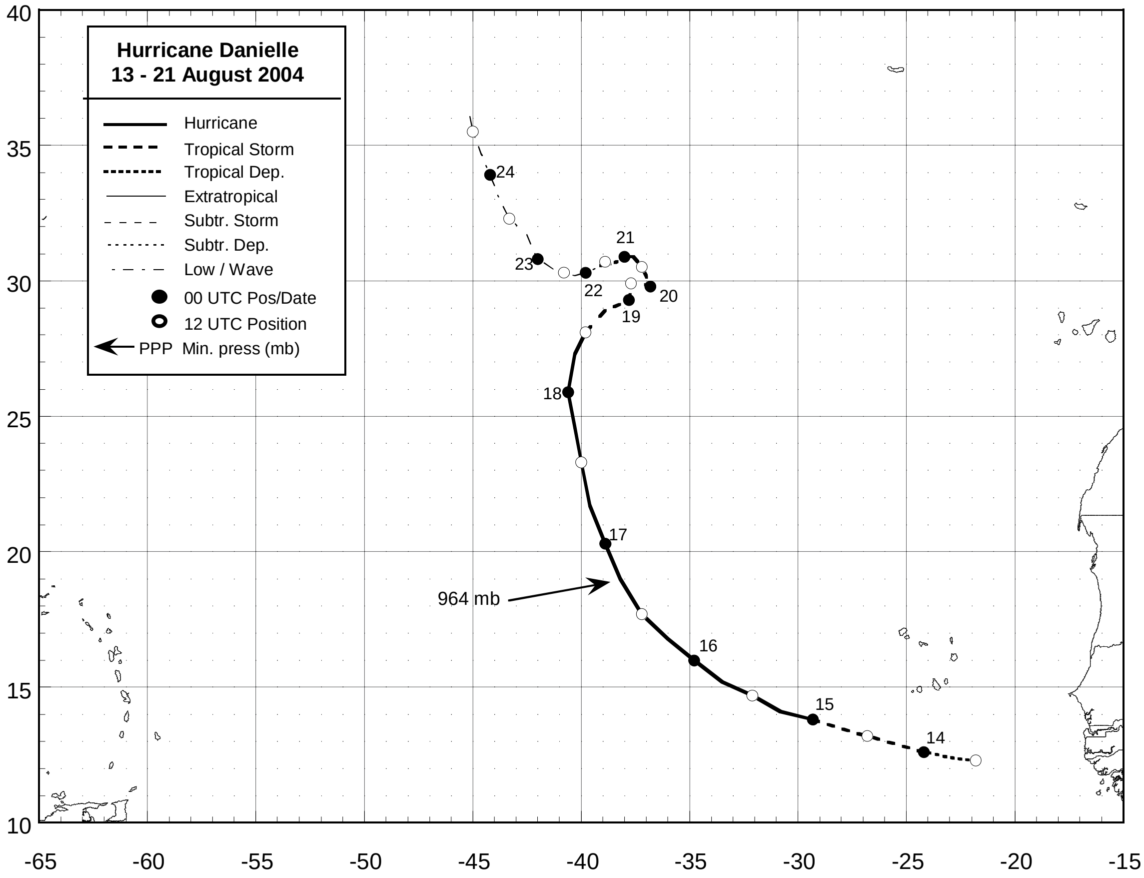

Figure 1. Best track positions for Hurricane Danielle, 13-21 August 2004.

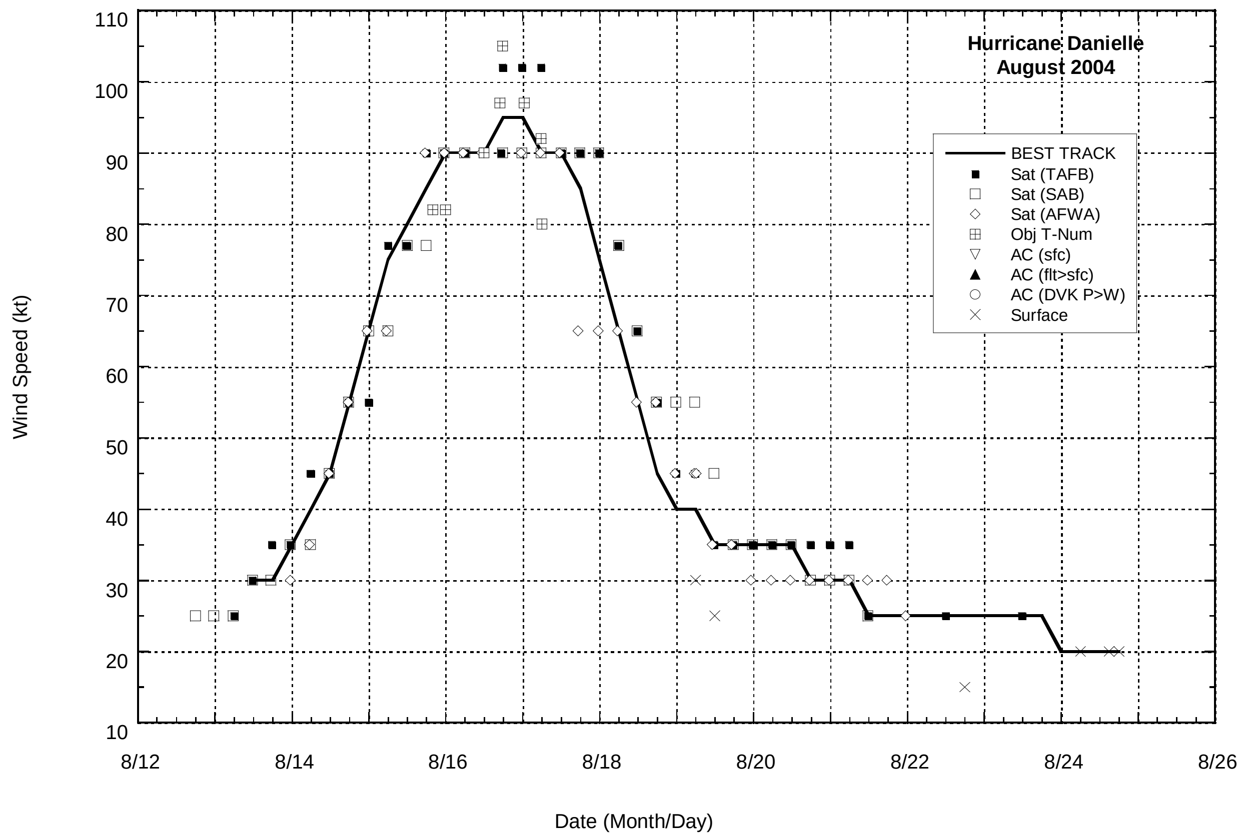

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Danielle, 13-21 August 2004.

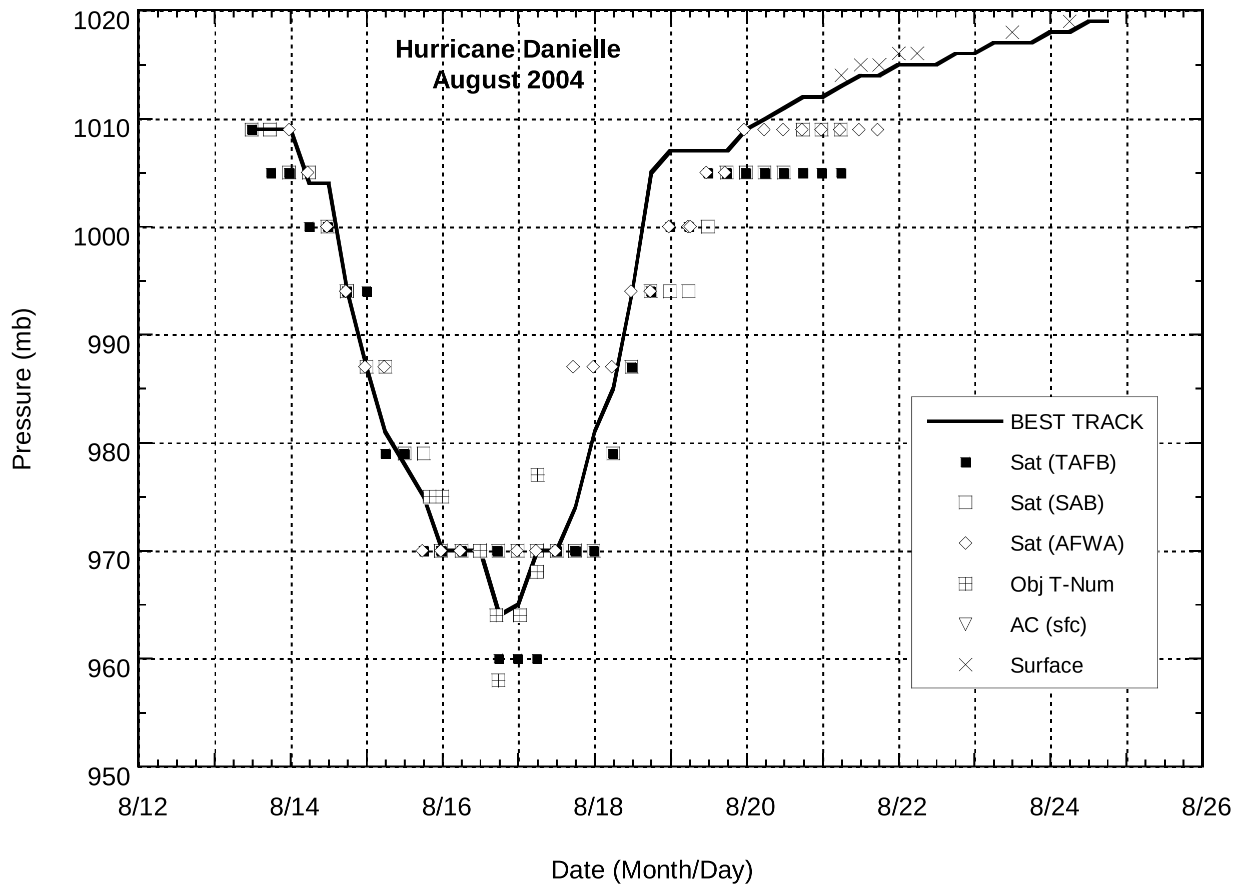

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Danielle, 13-21 August 2004.

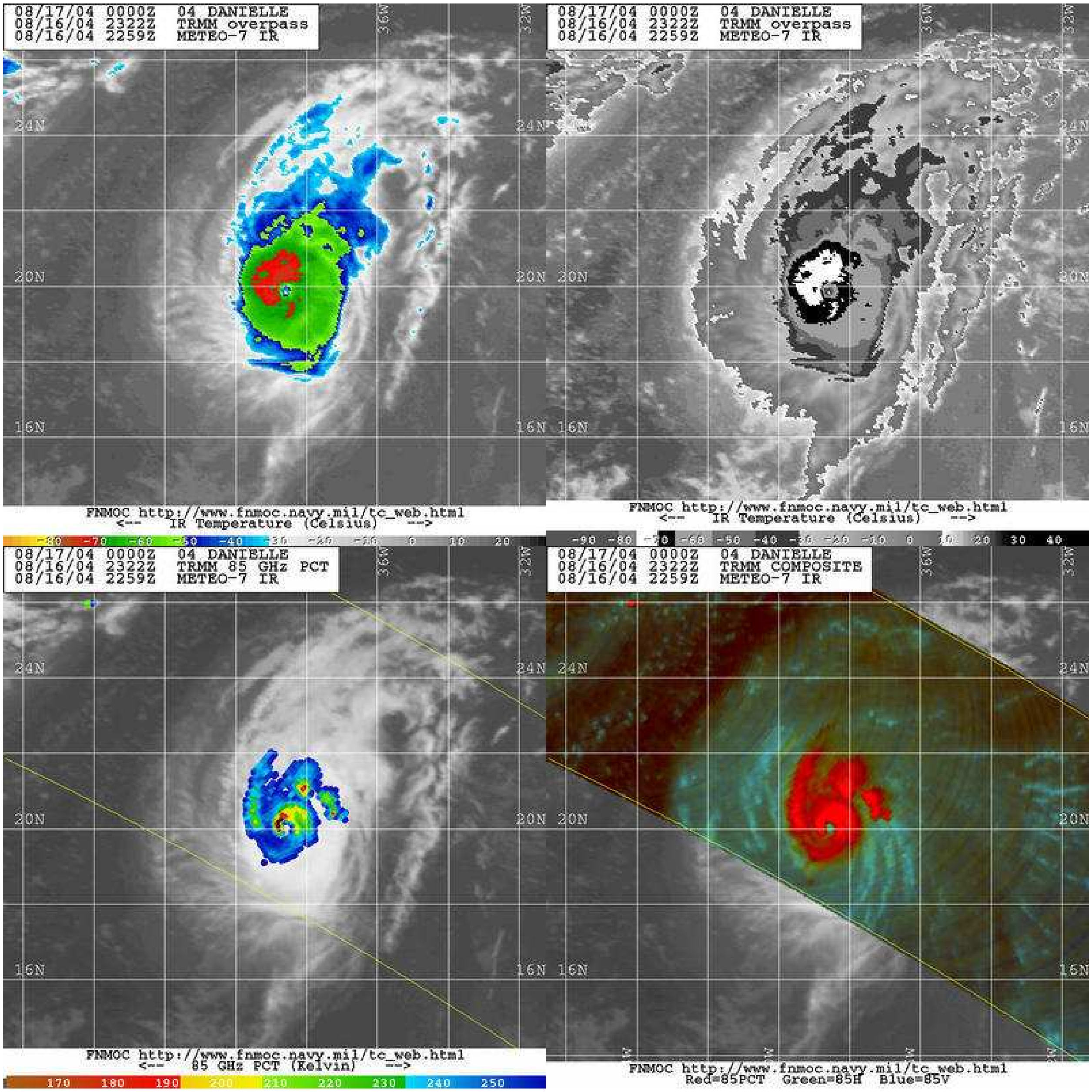

Figure 4. 2322 UTC 16 August 2004 NASA TRMM microwave overpass (lower panels) showing the small but distinct eye of relatively compact Hurricane Danielle shortly after its peak intensity of 95 kt and minimum pressure of 964 mb. In the infrared images (upper panels), increasing vertical shear was already becoming evident at this time as noted by the elongation of the cirrus outflow pattern to the northeast. A weakening trend developed within 12 h after the time of this data. (image courtesy of the U.S. Navy Fleet Numerical Meteorology and Oceanography Center, Monterey, CA).