

Preliminary Report  
Hurricane Danielle  
24 August - 3 September, 1998

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Danielle had a long track across the Atlantic. Although it did not seriously impact land as a tropical cyclone, it battered portions of Great Britain as an extratropical system.

a. Synoptic History

A tropical wave moved off the west coast of Africa on 21 August accompanied by disorganized cloudiness and showers. Within 24 hours, deep convection became somewhat more consolidated in clusters near an ill-defined center of cyclonic cloud rotation. Initial Dvorak technique classifications were assigned at 1100 UTC 22 August. Thereafter, the organization of the disturbance continued to gradually improve as cloudiness and showers became concentrated in a circular area. By 0600 UTC 24 August, the Dvorak T-number was analyzed at 2.0 and it is estimated that Tropical Depression Four formed around this time, centered a little less than 600 n mi west-southwest of the Cape Verde Islands (Fig. 1 and Table 1 give the overall "best track" of this system). Strengthening continued, as satellite images showed convection becoming more tightly wrapped around the center, and the tropical cyclone is estimated to have become Tropical Storm Danielle by 1800 UTC 24 August. Upper-tropospheric outflow was well-defined over the area, and Danielle intensified further. The first visible satellite pictures on 25 August revealed a "pinhole" eye, indicating that the system had become a hurricane. Danielle was a quite compact system, with tropical storm force winds covering an area estimated to be only a little more than 100 n mi in diameter. Based on satellite data, this rapidly strengthening hurricane reached a peak intensity of near 90 knots around 0600 UTC 26 August, while centered about 900 n mi east of the Leeward Islands.

After reaching its first peak in strength, some southeasterly vertical shear appeared to disrupt Danielle's organization. By the time the first reconnaissance aircraft reached the hurricane around 0000 UTC 27 August, the system was not as well-organized on satellite imagery as it had been. This first aircraft mission found a maximum wind of 90 knots at the 850 mb flight level, but a remarkably high central pressure of 993 mb. Such values of wind and pressure show how much deviation from the typical wind vs. pressure relationship can occur in compact hurricanes. In contrast to this, the much larger hurricane Bonnie, which was in progress over the western Atlantic around the same time with a comparable maximum wind speed, had

a minimum central pressure that was 25 mb lower than the value noted in Danielle.

Moderate vertical shear continued to preclude much strengthening of Danielle. However, aircraft data indicate that a second 90-knot intensity peak occurred around 1200 UTC on the 27th. For the next few days, some weakening took place even though the eyewall structure was generally maintained and atmospheric conditions seemed to be favorable for intensification. By the 30th, Danielle was barely of hurricane strength. Movement over waters that were cooled by the earlier passage of Hurricane Bonnie may have been the main cause of weakening, but this is uncertain.

From the time the cyclone formed, and for about six more days, the motion was toward the west-northwest, with the forward speed gradually slowing from 18-20 knots over the eastern Atlantic to 9 or 10 knots on 30 August. By the latter time, Danielle was nearing the western periphery of the subtropical anticyclone which had steered it across much of the Atlantic. Continuing to decelerate, the hurricane turned toward the northwest and north, reaching its westernmost longitude, about 74°W, early on the 31st. The hurricane began to restrengthen, and a third 90-knot intensity peak was noted around 1200 UTC that day.

In response to increasing southwesterly mid-tropospheric steering flow, ahead of a trough near the United States east coast, Danielle completed its recurvature and began to move northeastward on 1 September. It also regained 90-knot maximum winds for the fourth, and final, time. The center of the accelerating hurricane passed slightly less than 200 n mi northwest of Bermuda early on the 2nd. Danielle began to lose its tropical characteristics on 3 September, as its center passed about 200 n mi south of Cape Race, Newfoundland. It is estimated that Danielle became an extratropical cyclone by 0000 UTC 4 September, although it was still a strong storm with hurricane force winds. The storm moved eastward to east-northeastward across the north Atlantic for the next couple of days, with only slow weakening. It turned northeastward several hundred miles to the west of the British Isles on the 6th, its forward speed slowing to 6-10 knots. The cyclone became indistinct when it merged with another extratropical low a couple hundred miles north of Ireland on 8 September.

## b. Meteorological Statistics

Figures 2 and 3 depict 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 aircraft reconnaissance data from the U.S. Air Force Reserves (the Hurricane Hunters) and NOAA, surface synoptic data, as well as Dvorak-technique estimates from the Tropical Analysis and Forecast Branch, TAFB, the Satellite Analysis Branch, SAB, and the U.S. Air Force Weather Agency (AFGWC in the figures) using satellite imagery.

The highest wind reported in Danielle was 97 knots, at 700 mb from the Hurricane Hunters at 1141 UTC 27 August. Additional Hurricane Hunter wind observations of 95 knots at 850 mb and 92 knots at 700 mb were taken at 1235 UTC 31 August and 1656 UTC 1 September, respectively. These data, along with satellite-based intensity estimates on 26 August, are the main bases for the four intensity peaks of 90 knots in the best track. The minimum pressure estimate, 960 mb, was derived from a lowest pressure observation of 962.6 mb from the (Canadian) Laurentian Fan buoy, 44141 at 0900 UTC 3 September. This observation, as well as other ship and buoy reports of tropical storm force or greater windspeeds associated with Danielle, are listed in Table 3. It is also noteworthy that the aforementioned buoy measured a significant-wave height of 52 feet with a maximum wave height of 88 feet at the time of its lowest pressure.

Sustained winds of 34 knots with gusts to 47 knots were observed at Bermuda at 1100 UTC 2 September.

#### c. Casualty and Damage Statistics

No reports of casualties due to Danielle have been received at the National Hurricane Center. The western part of Great Britain was lashed by Danielle as an extratropical storm on 6 September. Several persons were rescued from treacherous sea conditions in the area. On the coast of Cornwall, beach areas had to be evacuated after waves became so high that they were breaking over some houses. A police all-terrain vehicle on the Isles of Scilly was swept into the sea by a rogue wave as it was being driven down a concrete pier in one of the island's main towns.

#### d. Forecast and Warning Critique

Danielle's track was "well-behaved" and, overall, very well-predicted in the official forecasts. Table 3 shows the average track forecast errors from the various objective techniques as well as the average official errors for Danielle. It can be seen that, at all time periods, the mean official forecast errors are substantially lower than the most recent ten-year averages. Also, the mean official forecasts were as good as, or (in most cases) better, than the corresponding objective track predictions. An inspection of a number of individual NHC forecasts reveals that the recurvature of the hurricane was forecasted quite accurately.

Most of the official forecasts predicted too much strengthening, by as much as 30 to 40 knots in the 48- to 72-h time ranges. A similar bias can be seen in the output from the Statistical Hurricane Intensity Prediction Scheme (SHIPS), which is perhaps the best available intensity forecast tool.

A tropical storm warning was issued for Bermuda at 1500 UTC 1 September since

the southern portion of Danielle's circulation was likely to affect that island. Sustained winds of tropical storm force occurred at Bermuda about 20 h after the issuance of this warning as the center passed well to the northwest and north. No other warnings (or watches) were necessary for this tropical cyclone.

Table 1. Best track, Hurricane Danielle, 24 August - 3 September, 1998

Date/Time (UTC)	Position		Pressure (mb)	Wind Speed (kt)	Stage
	Lat. (°N)	Lon. (°W)			
24/0600	13.4	34.3	1007	25	tropical depression
1200	13.8	36.1	1006	30	“
1800	14.2	37.9	1005	35	tropical storm
25/0000	14.8	39.8	1003	40	“
0600	15.3	41.6	997	50	“
1200	16.2	43.3	990	65	hurricane
1800	16.9	45.3	982	75	“
26/0000	17.6	47.3	980	80	“
0600	18.4	49.1	975	90	“
1200	19.1	51.1	980	85	“
1800	19.7	52.8	985	80	“
27/0000	20.1	54.9	993	80	“
0600	20.6	56.7	994	85	“
1200	21.2	58.5	994	90	“
1800	21.8	60.1	994	85	“
28/0000	22.4	61.7	992	80	“
0600	22.7	63.2	992	80	“
1200	23.0	64.4	989	80	“
1800	23.4	65.7	986	80	“
29/0000	23.9	66.9	989	75	“
0600	24.3	68.2	990	70	“
1200	24.8	69.4	988	70	“
1800	25.4	70.5	987	70	“
30/0000	25.9	71.4	987	65	“
0600	26.4	72.2	988	65	“
1200	26.9	73.1	990	65	“
1800	27.5	73.9	987	65	“
31/0000	27.9	74.1	983	70	“
0600	28.4	74.3	980	75	“
1200	29.2	74.1	977	90	“
1800	30.0	73.7	975	85	“
1/0000	30.9	73.3	973	85	“
0600	31.7	72.7	972	85	“
1200	32.2	72.0	968	85	“
1800	32.9	70.7	965	90	“
2/0000	33.7	69.1	967	80	“
0600	34.6	67.6	970	75	“
1200	36.0	65.4	975	70	“

Table 1 (continued). Best track, Hurricane Danielle, 24 August - 3 September, 1998

2/1800	37.9	63.1	975	70	hurricane
3/0000	39.9	60.1	970	70	“
0600	42.1	57.5	960	70	“
1200	43.4	54.8	965	70	“
1800	44.6	51.9	965	65	“
4/0000	44.8	48.5	975	65	extratropical
0600	44.9	44.0	985	60	“
1200	45.0	40.5	978	60	“
1800	45.3	37.0	976	60	“
5/0000	45.9	33.0	975	60	“
0600	46.5	28.0	973	60	“
1200	47.0	25.0	970	60	“
1800	48.0	22.0	967	60	“
6/0000	50.0	19.0	964	60	“
0600	51.5	18.0	965	55	“
1200	52.8	17.1	965	55	“
1800	53.3	16.7	967	55	“
7/0000	53.8	16.2	970	50	“
0600	54.5	16.0	975	45	“
1200	55.0	15.0	977	40	“
1800	55.8	14.0	979	35	“
8/0000	56.4	13.1	980	30	“
0600	57.0	12.0	980	30	“
1200					merged with low

26/0600	18.4	49.1	975	90	maximum wind
27/1200	21.2	58.5	994	90	“
31/1200	29.2	74.1	977	90	“
1/1800	32.9	70.7	965	90	“
3/0600	42.1	57.5	960	70	minimum pressure

Table 2. Ship and buoy reports of 34 knot or higher wind speeds associated with Hurricane Danielle, August/September, 1998.

date/time (UTC)	ship call sign	latitude (°N)	longitude (°W)	wind dir/ speed(knots)	pressure (mb)
31/0600	<b>P3ZH4</b>	28.3	71.5	160/35	1014.0
1/0000	<b>C61O5</b>	29.8	70.8	210/35	1016.0
1/0300	<b>C61O5</b>	29.9	71.5	210/35	1014.0
1/0600	<b>C61O5</b>	30.0	72.2	210/40	1010.0
1/0900	<b>C61O5</b>	30.3	72.8	210/43	1008.5
1/1200	<b>C61O5</b>	30.8	73.1	250/43	1009.0
1/1500	<b>C61O5</b>	31.1	73.3	280/40	1010.5
1/1800	<b>C61O5</b>	31.8	73.5	300/35	1011.0
1/2100	<b>MSJY8</b>	28.6	68.5	210/35	1011.5
1/2100	<b>WCHF</b>	31.3	71.8	280/37	1003.1
1/2100	<b>C61O5</b>	32.4	73.8	310/35	1010.0
2/0000	<b>PJJU</b>	30.7	66.3	190/35	1010.5
2/0000	<b>WQVY</b>	31.4	69.4	240/37	1004.0
2/0600	<b>WQVY</b>	32.1	67.2	230/37	1004.0
2/0600	<b>ATMC</b>	35.3	67.7	120/55	997.6
2/0900	<b>ATMC</b>	35.5	68.4	360/54	1002.6
2/1200	<b>ATMC</b>	35.8	69.0	300/36	1006.6
2/1800	<b>WQVY</b>	33.2	63.6	230/35	1009.7
2/1800	<b>ATMC</b>	36.5	70.5	340/35	1010.6
3/0000	<b>PCSV</b>	39.5	55.9	170/41	1008.2
3/0300	<b>PCSV</b>	39.3	55.5	180/47	1005.5
3/0300	<b>PFDC</b>	41.9	61.1	020/39	993.8
3/0600	<b>44141</b>	42.1	56.2	160/45	983.0
3/0600	<b>WSQ273</b>	44.0	59.6	060/41	1000.4
3/0700	<b>44141</b>	42.1	56.2	/66	976.0
3/0900	<b>44138</b>	44.3	53.6	080/35	1001.4
3/0900	<b>44141</b>	42.1	56.2	220/54	962.6
3/0900	<b>PCSV</b>	38.9	55.2	220/45	1008.5
3/1100	<b>44139</b>	44.2	57.6	010/37	997.3
3/1200	<b>44138</b>	44.3	53.6	080/37	989.5
3/1200	<b>SKOZ</b>	46.1	54.4	060/44	1004.2
3/1500	<b>44138</b>	44.3	53.6	070/37	972.3
3/1600	<b>44138</b>	44.3	53.6	/45	972.0
3/1800	<b>44138</b>	44.3	53.6	350/45	987.5
3/1800	<b>44145</b>	46.7	48.7	090/38	1005.9
3/1800	<b>SKOZ</b>	46.6	52.4	050/44	1002.2

Table 3.

**Preliminary forecast evaluation of Hurricane Danielle  
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
CLIP	37 (39)	80 (37)	130 (35)	183 (33)	291 (29)
GFDI	31 (38)	49 (37)	71 (35)	103 (33)	189 (29)
GFDL*	30 (24)	51 (24)	61 (23)	86 (22)	153 (20)
LBAR	28 (39)	49 (37)	71 (35)	94 (33)	163 (29)
AVNI	37 (37)	66 (35)	91 (33)	113 (31)	225 (27)
BAMD	29 (39)	49 (37)	74 (35)	94 (33)	157 (29)
BAMM	26 (39)	44 (37)	65 (35)	83 (33)	150 (29)
BAMS	43 (39)	77 (37)	116 (35)	152 (33)	245 (29)
A98E	34 (39)	53 (37)	69 (35)	105 (33)	185 (29)
NGPI	29 (28)	54 (26)	84 (24)	115 (22)	209 (18)
UKMI	28 (39)	57 (37)	94 (35)	142 (33)	270 (29)
NHC OFFICIAL	31 (39)	47 (37)	66 (35)	79 (33)	146 (29)
NHC OFFICIAL 1988-1997 10-year average	47 (1838)	88 (1633)	127 (1449)	165 (1284)	248 (1006)

\* GFDL output not available until after forecast issuance.



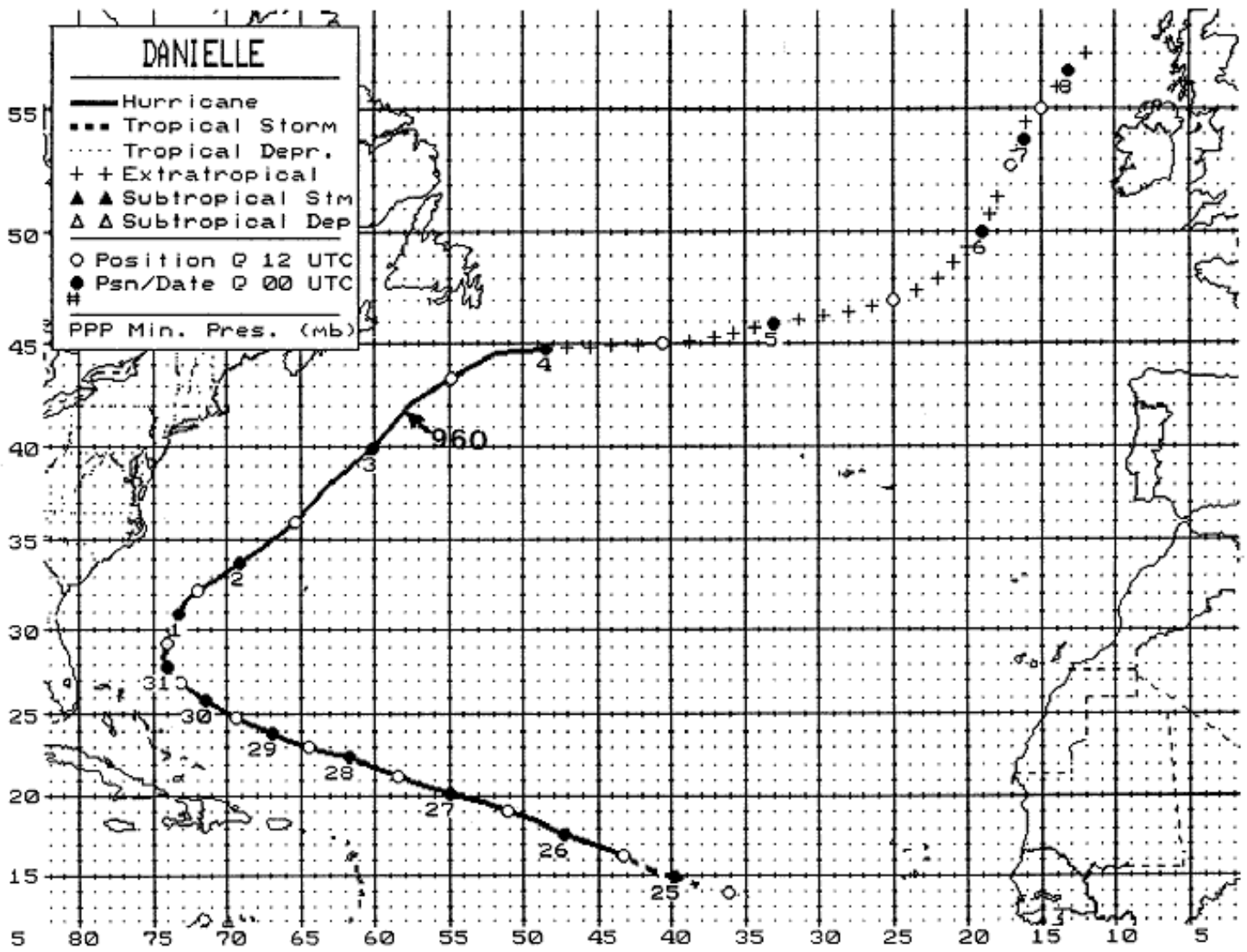


Figure 1. Best track positions for Hurricane Danielle, 24 August - 3 September, 1998.

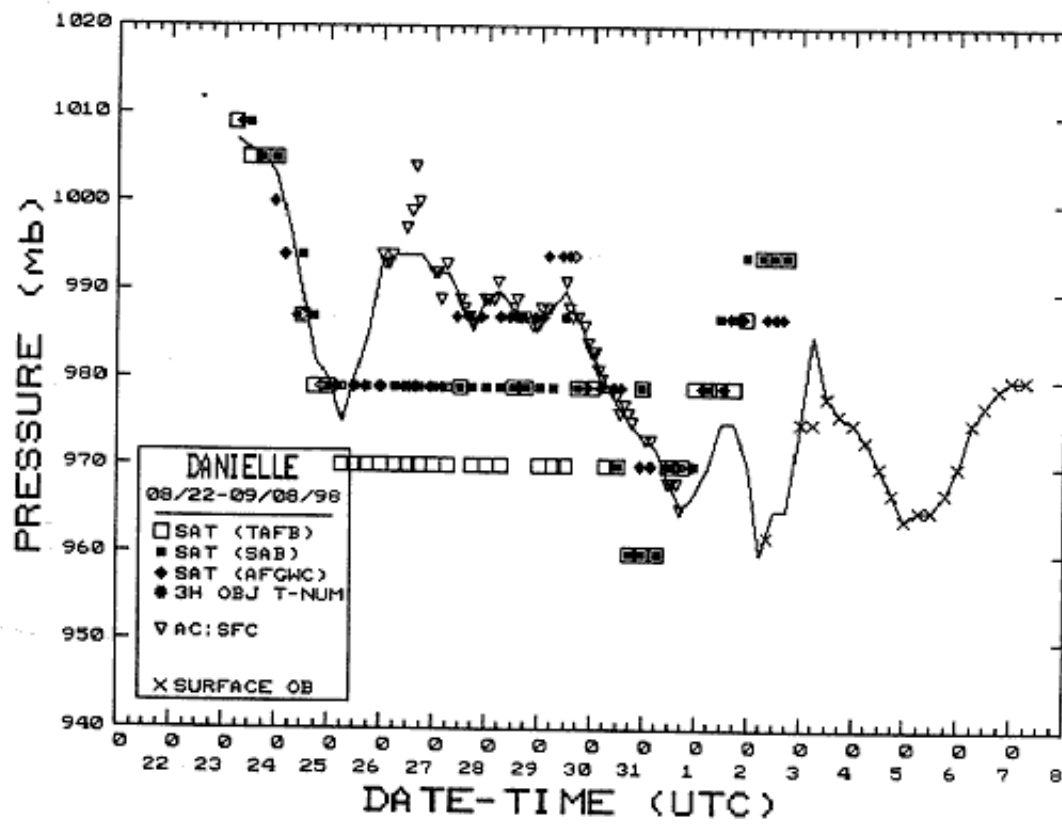


Figure 2. Best track minimum central pressure curve for Hurricane Danielle.

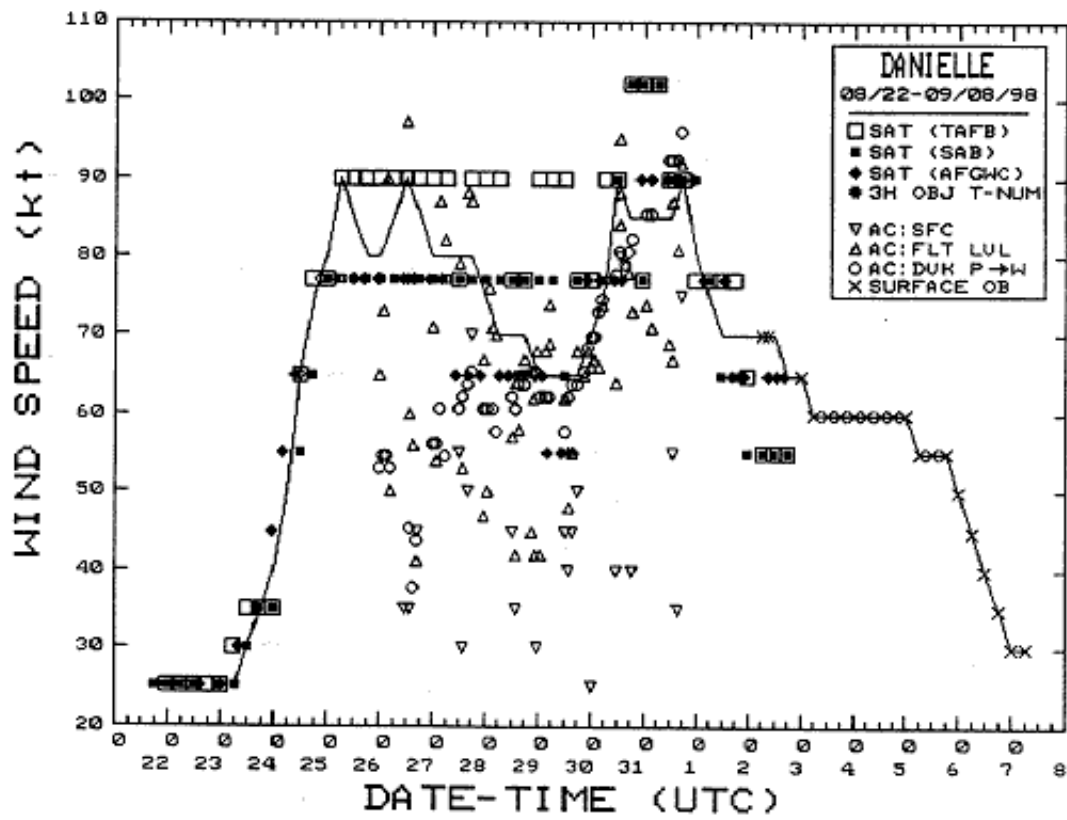


Figure 3. Best track maximum sustained wind speed curve for Hurricane Danielle.