

Tropical Cyclone Report
Hurricane Florence
10-17 September 2000

James L. Franklin
National Hurricane Center
9 November 2000

Hurricane Florence was a category one hurricane (on the Saffir-Simpson Hurricane Scale) of subtropical origins that passed within about 65 n mi of Bermuda.

a. Synoptic History

During the first week of September a cold front edged off the North American continent and became stationary over the western subtropical Atlantic. A weak wave along the front amplified slowly on the 8th and 9th of September, and then began to deepen more rapidly on the 10th underneath an upper-level cold low. During the day the flow around the developing low became less wavelike and more circular, and it is estimated that the low had lost its surface frontal structure and become a subtropical depression by 1800 UTC on the 10th, when it was about 325 miles west-southwest of Bermuda. At this time convection was present west of and close to the circulation center, but very limited in areal coverage. It is presumed that the upper circulation was still cold-core, hence the subtropical designation. After 0000 UTC on the 11th, the convection began to increase in depth and coverage as it rotated to the south side of the low-level circulation center. An Advanced Microwave Sounder Unit (AMSU) temperature cross-section analysis from the Cooperative Institute for Research in the Atmosphere (CIRA) suggests a weak warm core had developed by 1243 UTC on the 11th, and it is estimated that the subtropical depression had become tropical (or at least sufficiently so to warrant the designation) by 0600 UTC. The “best track” chart of the tropical cyclone’s path, including the subtropical stage, is given in Fig. 1, with the wind and pressure histories shown in Figs. 2 and 3, respectively. The best track is listed in Table 1.

The convective burst early on the 11th continued to rotate around to the east side of the low-level circulation center where it was associated with a rapid increase in wind speed. The depression reached tropical storm strength by 1200 UTC and hurricane strength by 1800 UTC that day, the latter event occurring when Florence was about 425 n mi west-southwest of Bermuda. However, the strong winds were confined to a very small area near the edge of the convection, and after 0000 UTC on the 12th, when the cyclone entrained some drier mid-tropospheric air and the convection collapsed, Florence’s winds temporarily weakened below hurricane strength. A reconnaissance aircraft later on the 12th reported pressure falls, the development of an elliptical eyewall, and a return of hurricane force winds.

On the 11th, Florence moved very slowly westward under the influence of a middle-level ridge along the mid-Atlantic coast; however, this flow was soon balanced by ridging to the southeast of the cyclone and Florence moved little from the 12th to the 14th. By 1200 UTC on the 13th central pressures began to rise and Florence again weakened to a tropical storm, due in part perhaps to local

reduction of the sea-surface temperatures under the hurricane. (Sea-surface temperature analyses from Johns Hopkins University Applied Physics Laboratory show decreases of up to 6°C near the cyclone center during this time.) North-northwesterly shear began to increase as well on the 14th, and the maximum winds dropped to 40 kt.

An approaching short-wave trough in the westerlies broke the steering stalemate and began to accelerate Florence to the east-northeast on the 15th. With most of the convection and strong winds in its southeast quadrant, Florence strengthened late on the 15th, turned rapidly to the northeast, and attained hurricane strength for the third time at 0000 UTC on the 16th, when it was about 175 n mi west-southwest of Bermuda. Florence made its closest approach to Bermuda, passing about 65 n mi to the northwest of the island, around 0800 UTC on the 16th. Later on the 16th an eye was briefly apparent as Florence reached its peak intensity of 70 kt. Weakening ensued over cooler waters, and Florence became a tropical storm for the fourth time at 0000 UTC on the 17th, when it was about 425 n mi northeast of Bermuda. After 1800 UTC on the 17th, when it was about 125 n mi south of St. Johns Newfoundland, the circulation of Florence was absorbed by the extratropical surface low associated with the short wave trough.

b. Meteorological Statistics

Observations in Florence (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. Although not included in Fig. 2, a QuikSCAT analysis from 1014 UTC 11 September suggests that the maximum winds at that time were at least 40 kt, and is the basis for the designation of the cyclone as a tropical storm. Florence was upgraded to a hurricane based on an aircraft reconnaissance report of 79 kt at a flight altitude of 1500 ft, a speed which corresponds to 67 kt at the surface using the standard reduction for that altitude (85%). Although not reflected in the best track, the flight meteorologist made a visual (sea-state) surface wind estimate of 80 kt shortly thereafter. Florence's second upgrade to hurricane strength was based on a visual estimate of 65-70 kt over a substantial area. The timing of the peak intensity (70 kt) was based on satellite imagery showing the brief appearance of an eye.

Ship reports of winds of tropical storm force associated with Florence are given in Table 2. The report from ELVO3 has been questioned and is not reflected in the best track. Bermuda reported a maximum sustained wind of 36 kt with a peak gust of 50 kt at 0400 UTC on the 16th. The minimum pressure observed there was 1007.5 mb, and the storm total precipitation was 0.47 inches.

c. Casualty and Damage Statistics

Rip currents associated with Florence were blamed for three surf deaths in North Carolina on the 12th. There were no reports of damage associated with Florence.

d. Forecast and Warning Critique

Average official track errors (with the number of cases in parentheses) for Florence were 42 (24), 78 (22), 118 (20), 142 (18), and 168 (14) n mi for the 12, 24, 36, 48, and 72 h forecasts, respectively. These errors are comparable to, or smaller than the average official track errors for the 10-yr period 1990-1999 (46, 85, 122, 158, and 235 n mi, respectively). However, Fig. 4 shows that the earlier forecasts tended to begin the eastward acceleration too soon, and did not anticipate the southward component of motion associated with the northwesterly shearing flow. The official forecasts were better than the interpolated GFDL and UKMET guidance. The forecasts from the Aviation model (AVNI) were very good, and on average, better than the official forecast at all times except 72 h (Table 3).

Average official intensity errors were 8, 13, 16, 16, and 12 kt for the 12, 24, 36, 48, and 72 h forecasts, respectively. For comparison, the average official intensity errors over the 10-yr period 1990-1999 are 7, 11, 13, 16, and 19 kt, respectively. Florence's intensity was consistently over-forecast during the first half of the cyclone's existence when it was moving more slowly than forecast. The intensification to hurricane strength as Florence accelerated northeastward was under-forecast.

Table 4 lists the watches and warnings associated with Florence. The tropical storm watch and warnings for Bermuda were issued approximately 38 and 20 hours in advance, respectively, of the observed sustained tropical storm force winds. Although a hurricane warning was posted for Bermuda, only tropical storm conditions occurred there.

Table 1. Best track for Hurricane Florence, 10-17 September 2000.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
10 / 1800	30.9	70.9	1007	30	subtropical depression
11 / 0000	30.8	71.3	1007	30	"
11 / 0600	30.7	71.8	1006	30	tropical depression
11 / 1200	30.4	72.2	1002	45	tropical storm
11 / 1800	30.1	72.6	998	65	hurricane
12 / 0000	30.1	72.7	992	65	"
12 / 0600	30.2	72.8	993	60	tropical storm
12 / 1200	30.3	73.1	991	60	"
12 / 1800	30.6	73.3	987	65	hurricane
13 / 0000	30.8	73.7	986	65	"
13 / 0600	30.7	74.0	986	65	"
13 / 1200	30.7	73.8	987	60	tropical storm
13 / 1800	30.5	73.7	989	55	"
14 / 0000	30.2	73.6	991	50	"
14 / 0600	29.6	73.6	993	45	"
14 / 1200	29.5	73.4	994	45	"
14 / 1800	29.3	73.1	995	45	"
15 / 0000	29.2	72.8	995	45	"
15 / 0600	29.1	72.4	996	45	"
15 / 1200	29.8	71.2	997	50	"
15 / 1800	30.1	69.7	997	60	"
16 / 0000	30.8	67.5	994	65	hurricane
16 / 0600	32.6	66.1	988	65	"
16 / 1200	34.3	64.2	987	65	"
16 / 1800	36.1	61.8	985	70	"
17 / 0000	37.9	59.5	990	60	tropical storm
17 / 0600	40.1	57.4	995	55	"
17 / 1200	42.5	55.0	1000	50	"
17 / 1800	45.5	53.0	1002	50	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
18 / 0000					absorbed by extratropical low
16 / 1800	36.1	61.8	985	70	minimum pressure

Table 2. Selected ship reports with winds of at least 34 kt for Hurricane Florence, 10-17 September 2000.

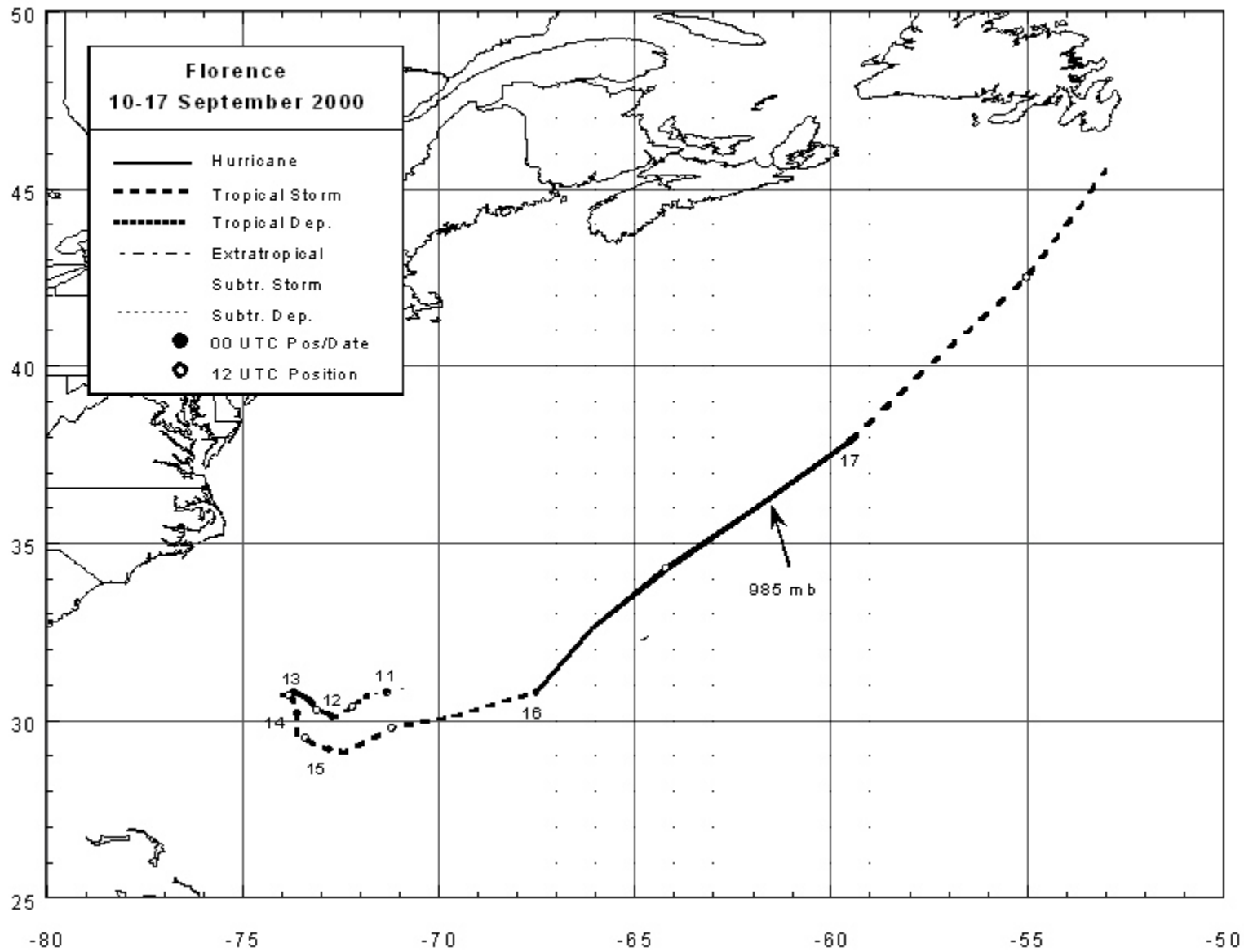
Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
11 / 0000	ELVO3	31.7	72.2	050/39	1009.0
16 / 1800	WWXA	39.8	58.0	170/35	1006.1
17 / 0000	WWXA	40.1	58.4	160/49	1005.2
17 / 1200	C6JS	41.8	56.8	000/34	1007.0
17 / 1800	C6JS	42.2	54.2	320/34	1011.0

Table 3. Preliminary forecast evaluation (heterogeneous sample) for Hurricane Florence, 10-17 September 2000. 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. NGPI and GUNS forecasts are not included due to their small sample sizes.

Forecast Technique	Forecast Period (h)				
	12	24	36	48	72
CLIP	62 (24)	143 (22)	247 (20)	360 (18)	481 (14)
GFDI	42 (24)	84 (22)	131 (20)	173 (18)	242 (14)
LBAR	42 (24)	81 (22)	127 (20)	156 (18)	219 (14)
AVNI	34 (23)	49 (21)	76 (19)	118 (17)	203 (13)
BAMD	42 (24)	74 (22)	117 (20)	169 (18)	331 (14)
BAMM	40 (24)	67 (22)	93 (20)	130 (18)	293 (14)
BAMS	56 (24)	91 (22)	120 (20)	147 (18)	231 (14)
UKMI	62 (21)	95 (20)	113 (18)	162 (18)	169 (8)
NHC Official	42 (24)	78 (22)	118 (20)	142 (18)	168 (14)
NHC Official (1990-99 mean)	46 (2057)	85 (1842)	122 (1650)	158 (1471)	235 (1164)

Table 4. Watch and warning summary for Hurricane Florence, 10-17 September 2000.

Date/Time (UTC)	Action	Location
14 / 1500	Tropical Storm Watch issued	Bermuda
15 / 0900	Tropical Storm Warning issued	Bermuda
15 / 2130	Hurricane Warning replaces Tropical Storm Warning	Bermuda
16 / 0900	Tropical Storm Warning replaces Hurricane Warning	Bermuda
16 / 1500	Tropical Storm Warning Discontinued	Bermuda



Best track positions for Hurricane Florence, 10-17 September 2000.

Figure 1.

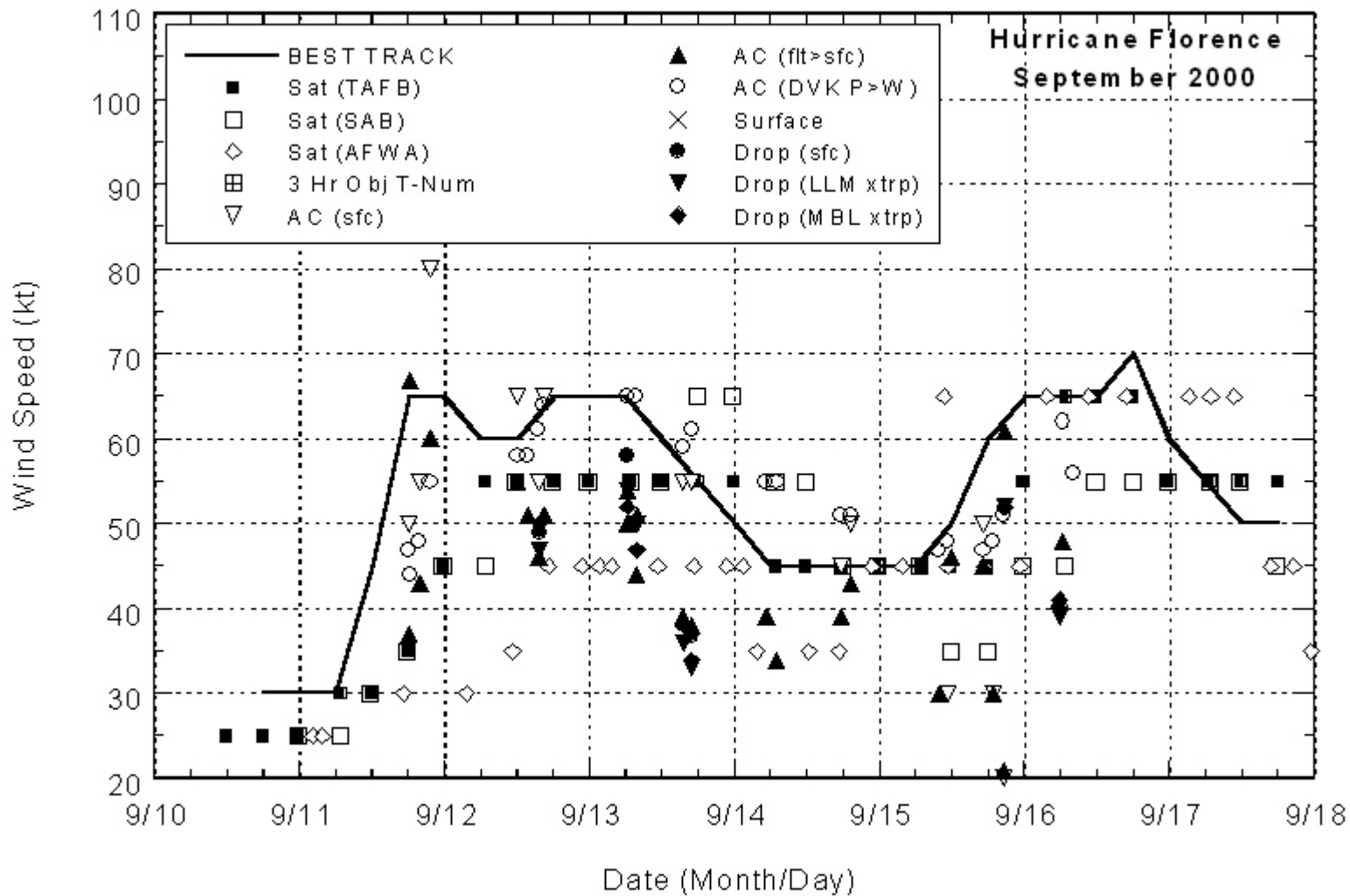


Figure 2. Best track maximum sustained surface wind speed curve for Hurricane Florence, 10-17 September 2000, and the observations on which the best track curve is based. Aircraft observations have been adjusted for elevation using 90%, 80%, and 85% reduction factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Dropwindsonde 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).

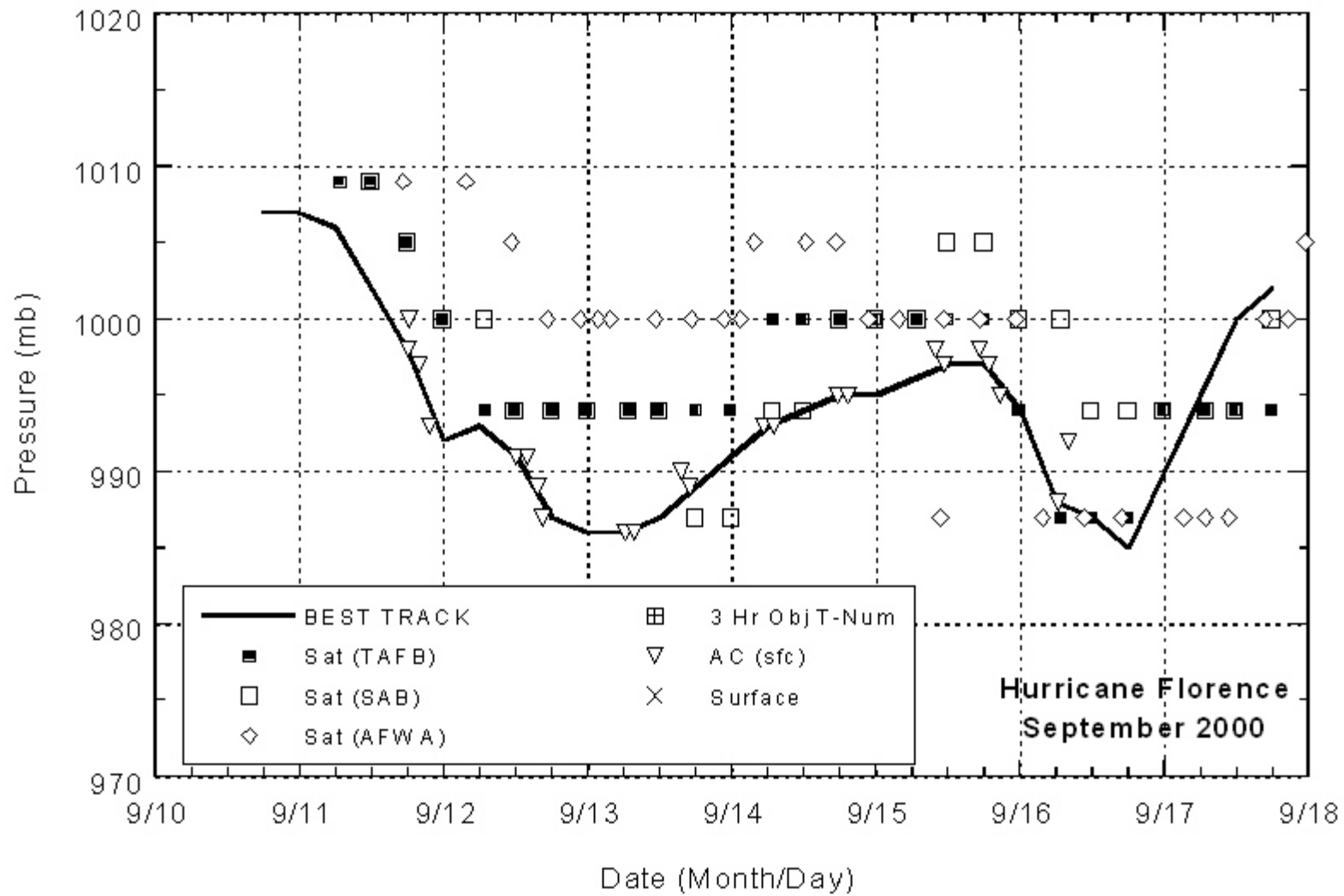


Figure 3. Best track minimum central pressure curve for Hurricane Florence, 10-17 September 2000, and the observations on which the best track curve is based.

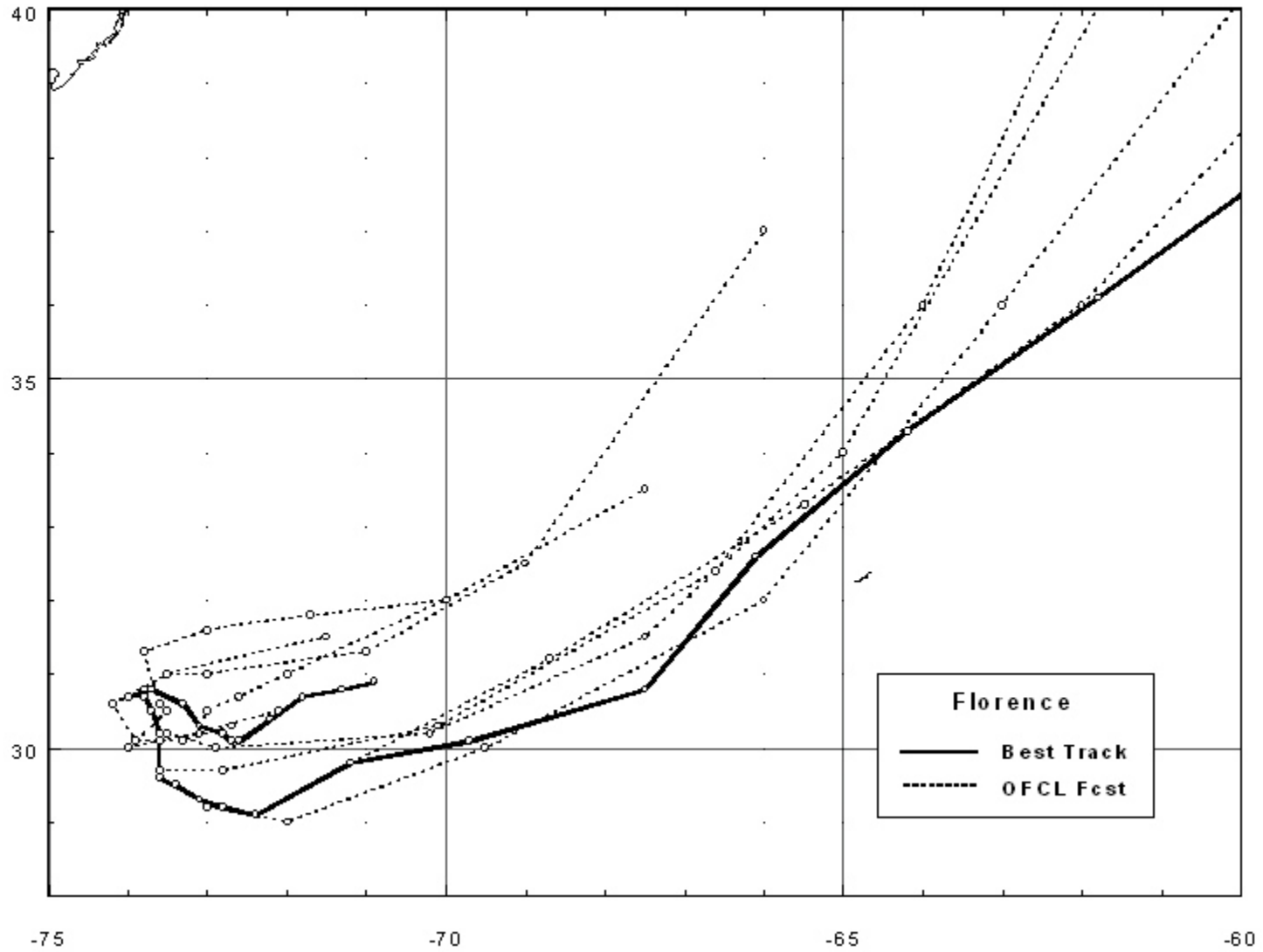


Figure 4. Official track forecasts from 0000 and 1200 UTC for the period 11-15 September (dashed lines, with 0, 12, 24, 36, 48, and 72 h positions indicated) for Hurricane Florence. The best track is given by the thick solid line with positions given at 6 h intervals.