Tropical Cyclone Report
Hurricane Florence
(AL062006)
3 – 12 September 2006

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(corrected best track table 4 January 2007)

Florence was a category 1 hurricane (on the Saffir-Simpson Hurricane Scale) that brought hurricane conditions to Bermuda. As an extratropical low, it brought hurricane-force winds to portions of Newfoundland.

## a. Synoptic History

Florence had a complex genesis tied to the interaction between two tropical waves. A tropical wave moved westward across the coast of Africa on 29 August. The wave moved slowly westward and first showed signs of convective organization on 31 August. On that day another wave moved westward from Africa at a faster forward speed than its predecessor. By 2 September, these two waves combined to form a large area of disturbed weather over the eastern tropical Atlantic. Convection increased in organization, and it is estimated that a tropical depression formed near 1800 UTC 3 September about 855 n mi west of the 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.

The depression initially had a large circulation with multiple vorticity centers rotating around the mean center, a condition which persisted into 8 September. This structure, combined with southwesterly vertical shear caused by an upper-level trough to the west, resulted in very slow development for the first several days of the cyclone's life. The depression became a tropical storm on 5 September, and the estimated maximum sustained winds fluctuated between 35 and 45 kt for the next three days as Florence moved west-northwestward. The shear decreased on 8 September as an upper-level ridge developed over Florence. Late that day, the storm started to consolidate around a vorticity center on the western side of the large cyclonic envelope, which caused a westward jog followed by a turn toward the northwest. Florence strengthened slowly on 9 September and at a faster pace the next day, with the storm becoming a hurricane early on 10 September about 340 n mi south of Bermuda.

Florence gradually turned northward on 10-11 September. It reached its peak intensity of 80 kt late on 10 September, then maintained maximum sustained winds of 70-75 kt as the center passed about 50 n mi west of Bermuda on 11 September. The hurricane recurved northeastward into the westerlies the next day, and it maintained hurricane strength until it became extratropical early on 13 September about 420 n mi south-southwest of Cape Race, Newfoundland.

As an extratropical low, Florence maintained its large size and hurricane-force winds as it approached Newfoundland. The center passed near Cape Race late on 13 September, then moved east-northeastward over the open North Atlantic the next day. The low moved eastward on 15-16 September as the associated winds weakened to gale force. Florence then made a broad cyclonic half-loop over the Atlantic waters southwest of Iceland until 19 September, when it was absorbed by a developing extratropical low to its south.

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. Microwave satellite imagery from NOAA polar-orbiting satellites, the NASA Tropical Rainfall Measuring Mission (TRMM), the NASA Aqua, the NASA QuikSCAT, the Department of Defense WindSat, and Defense Meteorological Satellite Program (DMSP) satellites were also useful in tracking Florence.

The 53rd Weather Reconnaissance Squadron flew five missions into Florence, producing 15 center fixes. The maximum flight-level winds observed were 96 kt in the northeastern eyewall at 700 mb at 1724 UTC 10 September. While this would normally support surface winds of 85 kt, a subsequent pass through the northeastern eyewall measured winds of only 74 kt. This suggests the possibility the 96 kt winds were transient. Based on this assumption, the peak intensity of Florence is set at 80 kt – a category 1 hurricane. However, it cannot be ruled out the system briefly had category 2 status near 1800 UTC 10 October.

Ship reports of winds of tropical storm force associated with Florence are given in Table 2, and selected surface observations from land stations and data buoys are given in Table 3. Ships mostly avoided Florence during its life as a tropical cyclone, and there were no reports from the inner core. The highest ship-reported wind was 44 kt from the **Lykes Discoverer** (call sign WGXO) at 0600 UTC 12 September. A drifting buoy reported 45-kt winds at 0500 UTC 11 September.

Florence brought hurricane conditions to Bermuda on 11 September (Table 3). An automated station at St. David's (elevation 48 m) reported sustained winds of 71 kt at 1340 UTC that day with a gust to 97 kt. The Bermuda Maritime Operations Centre reported a wind gust of 100 kt at 1001 UTC. The Bermuda Airport reported a peak gust of 78 kt at 1555 UTC along with 1.32 in of rain.

As an extratropical low, Florence brought hurricane-force winds to portions of Newfoundland. Sagona Island reported sustained winds of 66 kt with a gust to 81 kt at 1500 UTC 13 September. The oil platform VEP717 located approximately 180 n mi east of Cape Race reported sustained winds of 73 kt (elevation unknown) at 0000 UTC 14 September.

c. Casualty and Damage Statistics

Media reports indicate that Florence caused no deaths on Bermuda and only a few minor injuries. The hurricane caused minor wind damage and power outages on the island. Similar impacts were felt in Newfoundland when Florence passed as an extratropical low.

d. Forecast and Warning Critique

The disturbed weather area that became Florence was first mentioned in the Atlantic Tropical Weather Outlook about 21 h before genesis occurred. The potential for the system to become a tropical depression was first mentioned about 16 h before genesis

A verification of official and guidance model track forecasts is given in Table 4. Average official track errors for Florence were 40, 59, 72, 70, 61, 94, and 160 n mi for the 12, 24, 36, 48, 72, 96, and 120 h forecasts, respectively. The number of forecasts ranged from 35 at 12 h to 17 at 120 h. These errors are lower than the average long-term official track errors (Table 4) for the 24-h and longer forecast periods. The official errors were generally less than that those of the numerical guidance, with only the GUNA consensus model and the Florida State University Superensemble showing consistently lower errors than the official forecast.

Average official intensity errors were 6, 9, 12, 15, 19, 21 and 22 kt for the 12, 24, 36, 48, 72, 96, and 120 h forecasts, respectively. For comparison, the average long-term official intensity errors are 6, 10, 12, 14, 18, 20, and 22 kt, respectively. While these average errors are close to the long-term average, they were considerably higher than those for the climatology-persistence SHIFOR model, indicating that the forecasts had no skill. It should be noted that the official average errors were lower than those of the guidance, except for the interpolated GFDL model (GFDI), indicating that most of the guidance also had no skill. The official forecasts showed a large positive bias resulting from many forecasts of significantly greater intensification than what was observed.

A hurricane watch was issued for Bermuda at 2100 UTC 8 September, while a tropical storm warning was issued for the island at 1500 UTC 9 September. These were superseded by a hurricane warning issued for the island at 0900 UTC 10 September. After Florence made its closest approach, the hurricane warning was changed to a tropical storm warning at 2100 UTC 11 September, with all warnings for the island discontinued 6 h later.

*Acknowledgements*

Mark Guishard of the Bermuda Weather Service provided the data on Florence's impact on Bermuda. Chris Fogarty of the Canadian Hurricane Center in Dartmouth, Nova Scotia provided the data on Florence's impact in Canada.

Table 1. Best track for Hurricane Florence, 3- 12 September 2006. Track during the extratropical stage is based on analyses from the NOAA Ocean Prediction Center.

| Date/Time (UTC) | Latitude (°N) | Longitude (°W) | Pressure (mb) | Wind Speed (kt) | Stage |
|---|---|---|---|---|---|
| 03 / 1800 | 14.1 | 39.4 | 1007 | 30 | tropical depression |
| 04 / 0000 | 14.7 | 40.0 | 1007 | 30 | " |
| 04 / 0600 | 15.4 | 41.0 | 1007 | 30 | " |
| 04 / 1200 | 16.0 | 42.3 | 1007 | 30 | " |
| 04 / 1800 | 16.4 | 43.5 | 1007 | 30 | " |
| 05 / 0000 | 16.6 | 44.8 | 1007 | 30 | " |
| 05 / 0600 | 16.8 | 46.1 | 1007 | 35 | tropical storm |
| 05 / 1200 | 17.0 | 46.9 | 1005 | 35 | " |
| 05 / 1800 | 17.3 | 47.8 | 1003 | 40 | " |
| 06 / 0000 | 17.6 | 48.6 | 1003 | 40 | " |
| 06 / 0600 | 18.1 | 49.7 | 1003 | 40 | " |
| 06 / 1200 | 18.5 | 50.6 | 1003 | 45 | " |
| 06 / 1800 | 19.0 | 51.3 | 1000 | 45 | " |
| 07 / 0000 | 19.3 | 51.9 | 1000 | 45 | " |
| 07 / 0600 | 19.6 | 52.6 | 1000 | 45 | " |
| 07 / 1200 | 19.9 | 53.3 | 1002 | 40 | " |
| 07 / 1800 | 20.3 | 54.3 | 1002 | 40 | " |
| 08 / 0000 | 20.9 | 55.7 | 1002 | 40 | " |
| 08 / 0600 | 21.5 | 57.1 | 1002 | 40 | " |
| 08 / 1200 | 21.7 | 58.8 | 1002 | 40 | " |
| 08 / 1800 | 21.9 | 60.1 | 1000 | 45 | " |
| 09 / 0000 | 22.7 | 61.0 | 997 | 50 | " |
| 09 / 0600 | 23.8 | 62.3 | 993 | 50 | " |
| 09 / 1200 | 24.4 | 63.2 | 992 | 50 | " |
| 09 / 1800 | 25.1 | 64.0 | 991 | 50 | " |
| 10 / 0000 | 26.2 | 64.6 | 987 | 60 | " |
| 10 / 0600 | 27.1 | 65.3 | 980 | 70 | hurricane |
| 10 / 1200 | 28.1 | 65.9 | 978 | 75 | " |
| 10 / 1800 | 29.3 | 66.1 | 976 | 80 | " |
| 11 / 0000 | 30.4 | 66.2 | 975 | 80 | " |
| 11 / 0600 | 31.3 | 66.2 | 977 | 70 | " |
| 11 / 1200 | 32.4 | 65.7 | 974 | 75 | " |
| 11 / 1800 | 33.6 | 65.0 | 974 | 75 | " |
| 12 / 0000 | 34.9 | 64.1 | 975 | 70 | " |
| 12 / 0600 | 36.3 | 63.2 | 976 | 65 | " |
| 12 / 1200 | 37.4 | 61.9 | 976 | 65 | " |
| 12 / 1800 | 38.5 | 60.2 | 977 | 65 | " |
| 13 / 0000 | 40.6 | 57.9 | 978 | 70 | extratropical |
| 13 / 0600 | 43.1 | 56.3 | 972 | 70 | " |
| 13 / 1200 | 45.5 | 55.6 | 967 | 70 | " |

| | | | | | |
|---|---|---|---|---|---|
| 13 / 1800 | 46.4 | 54.0 | 963 | 70 | " |
| 14 / 0000 | 47.6 | 51.3 | 965 | 65 | " |
| 14 / 0600 | 48.6 | 48.3 | 967 | 60 | " |
| 14 / 1200 | 49.2 | 45.2 | 970 | 55 | " |
| 14 / 1800 | 49.8 | 42.6 | 976 | 50 | " |
| 15 / 0000 | 50.0 | 39.6 | 981 | 45 | " |
| 15 / 0600 | 49.7 | 35.8 | 982 | 45 | " |
| 15 / 1200 | 49.5 | 31.7 | 984 | 45 | " |
| 15 / 1800 | 49.8 | 27.5 | 986 | 40 | " |
| 16 / 0000 | 50.6 | 23.9 | 987 | 40 | " |
| 16 / 0600 | 52.5 | 21.0 | 987 | 40 | " |
| 16 / 1200 | 54.6 | 20.5 | 985 | 40 | " |
| 16 / 1800 | 56.6 | 20.5 | 983 | 40 | " |
| 17 / 0000 | 58.2 | 20.5 | 980 | 40 | " |
| 17 / 0600 | 59.6 | 20.6 | 980 | 40 | " |
| 17 / 1200 | 60.9 | 21.2 | 979 | 40 | " |
| 17 / 1800 | 62.0 | 22.5 | 978 | 45 | " |
| 18 / 0000 | 62.6 | 24.5 | 976 | 50 | " |
| 18 / 0600 | 63.0 | 26.5 | 977 | 50 | " |
| 18 / 1200 | 63.0 | 29.0 | 978 | 50 | " |
| 18 / 1800 | 63.0 | 31.4 | 979 | 50 | " |
| 19 / 0000 | 62.0 | 34.0 | 982 | 50 | " |
| 19 / 0600 | | | | | absorbed by extratropical low |
| 11 / 1200 | 32.4 | 65.7 | 974 | 75 | minimum pressure |
| 10 / 1800 | 29.3 | 66.1 | 976 | 80 | maximum wind |

Table 2. Selected ship and drifting buoy reports with winds of at least 34 kt for Hurricane Florence, 3 – 12 September 2006.

| Date/Time (UTC) | Ship name/call sign | Latitude (°N) | Longitude (°W) | Wind dir/speed (kt) | Pressure (mb) |
|---|---|---|---|---|---|
| 08 / 0000 | **Marlene Green** | 23.6 | 49.3 | 090 / 39 | 1015.4 |
| 08 / 1500 | Drifting buoy 41657 | 18.3 | 55.8 | 230 / 39 | 1012.0 |
| 11 / 0500 | Drifting buoy 41646 | 25.8 | 68.6 | 260 / 45 | 1009.8 |
| 12 / 0600 | **Lykes Discoverer** | 41.3 | 65.8 | 050 / 44 | 1017.0 |

Table 3. Selected surface observations for Hurricane Florence, 3 – 12 September 2006.

| 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) | | | |
| **Bermuda** | | | | | | | | |
| Bermuda Airport (TXKF; Elev. 12 m AMSL) | N/A | 985.3 | 11/1602 | 57 | 78 | | | 1.32 |
| Commisioner's Point (Elev. 30 m AMSL) | | | 11/1400 | 67 | 95 | | | |
| Esso Pier | 11/1500 | 983.8 | 11/2000 | 38 | 61 | | | |
| Fort Prospect (Elev. 70 m AMSL) | | | 11/1340 | 49 | 82 | | | |
| Maritime Operations Centre (Elev. 78 m AMSL) | N/A | 980.8 | 11/1001 | | 100 | | | |
| St. David's (Elev. 48 m AMSL) | | | 11/1340 | 71 | 97 | | | |

[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).

Table 4. Preliminary track forecast evaluation (heterogeneous sample) for Hurricane Florence, 3 – 12 September 2006. 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, but does not include the extratropical stage.

| Forecast Technique | Forecast Period (h) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 72 | 96 | 120 |
| CLP5 | 46 (35) | 76 (33) | 111 (31) | 151 (29) | 228 (25) | 305 (21) | 395 (17) |
| GFDI | 46 (34) | 75 (32) | 93 (30) | 102 (28) | 115 (24) | 104 (20) | **143** (16) |
| GFNI | 45 (31) | 71 (28) | 88 (26) | 108 (23) | 148 (19) | 218 (15) | 283 (11) |
| GFSI | 41 (34) | 66 (32) | 82 (30) | 90 (28) | 110 (24) | 143 (20) | 186 (15) |
| AEMI | **39** (35) | 63 (33) | 83 (31) | 89 (29) | 105 (25) | 113 (21) | **130** (17) |
| NGPI | 48 (32) | 74 (29) | 99 (27) | 123 (25) | 182 (21) | 233 (17) | 274 (13) |
| UKMI | 50 (33) | 78 (31) | 98 (29) | 117 (27) | 203 (23) | 298 (19) | 274 (15) |
| A98E | 44 (33) | 71 (31) | 101 (29) | 124 (27) | 168 (23) | 199 (20) | 303 (17) |
| A9UK | 47 (15) | 71 (14) | 104 (13) | 140 (12) | 191 (10) | | |
| BAMD | 55 (35) | 94 (33) | 129 (31) | 148 (29) | 162 (25) | 169 (21) | 189 (17) |
| BAMM | 53 (35) | 85 (33) | 115 (31) | 131 (29) | 139 (25) | 136 (21) | 245 (17) |
| BAMS | 60 (35) | 96 (33) | 123 (31) | 140 (29) | 184 (25) | 188 (21) | 253 (17) |
| LBAR | 46 (35) | 79 (33) | 110 (31) | 132 (29) | 184 (25) | 204 (21) | 265 (17) |
| CONU | 40 (34) | 61 (32) | 75 (30) | 82 (28) | 93 (24) | 115 (20) | **136** (16) |
| GUNA | **39** (31) | **56** (29) | **69** (27) | 72 (25) | 85 (21) | **87** (17) | **95** (12) |
| FSSE | **34** (28) | **48** (26) | **61** (24) | **69** (22) | 95 (18) | 99 (14) | **134** (10) |
| OFCL | 40 (35) | 59 (33) | 72 (31) | 70 (29) | 61 (25) | 94 (21) | 160 (17) |
| NHC Official (2001-2005 mean) | 37 (1930) | 65 (1743) | 91 (1569) | 118 (1410) | 171 (1138) | 231 (913) | 303 (742) |

Table 5. Preliminary intensity forecast evaluation (heterogeneous sample) for Hurricane Florence, 3 – 12 2006. Forecast errors (kt) 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, but does not include the extratropical stage.

| Forecast Technique | Forecast Period (h) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 24 | 36 | 48 | 72 | 96 | 120 |
| SHF5 | **5.9** (35) | **6.6** (33) | **8.4** (31) | **9.5** (29) | **10.5** (25) | **10.3** (21) | **6.5** (17) |
| GFDI | 7.5 (34) | **8.2** (32) | **10.2** (30) | **12.7** (28) | **17.2** (24) | **19.8** (20) | 23.8 (16) |
| SHIP | 6.8 (34) | 10.8 (33) | 14.7 (31) | 18.8 (29) | 24.5 (25) | 25.4 (21) | 23.4 (17) |
| DSHP | 6.8 (34) | 10.8 (33) | 14.7 (31) | 18.8 (29) | 24.5 (25) | 25.4 (21) | 23.4 (17) |
| FSSE | 7.9 (28) | 12.0 (26) | 16.6 (24) | 22.5 (22) | 30.4 (18) | 35.1 (14) | 32.5 (10) |
| ICON | 7.0 (33) | 9.5 (32) | 12.8 (30) | 16.9 (28) | 22.0 (24) | 24.6 (20) | 25.4 (16) |
| OFCL | 6.1 (35) | 9.2 (33) | 12.4 (31) | 15.3 (29) | 19.4 (25) | 21.4 (21) | 21.8 (17) |
| NHC Official (2001-2005 mean) | 6.3 (1930) | 9.8 (1743) | 12.1 (1569) | 14.3 (1410) | 18.4 (1138) | 19.8 (913) | 21.8 (742) |

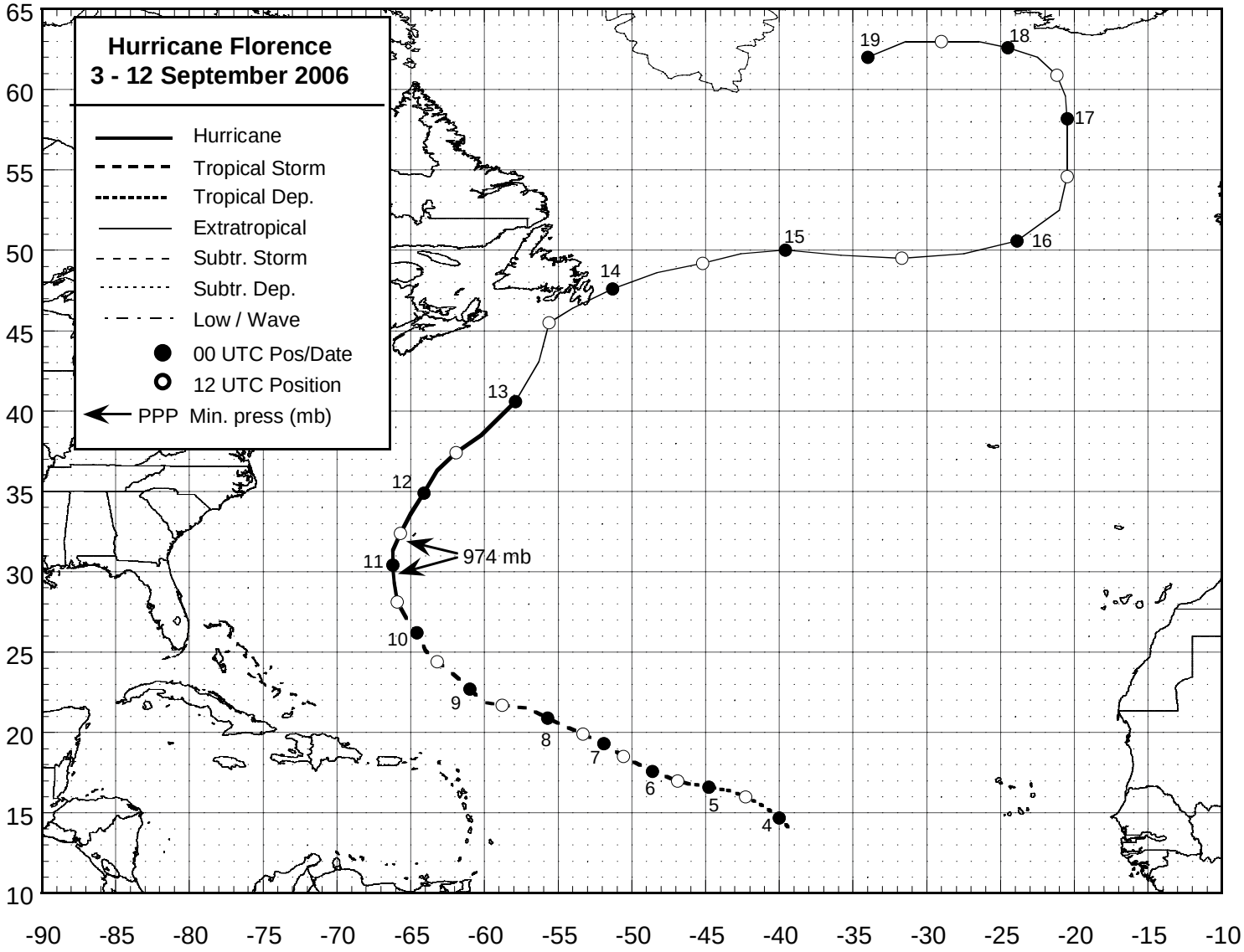


Figure 1. Best track positions for Hurricane Florence, 3- 12 September 2006. Track during the extratropical stage is based on analyses from the NOAA Ocean Prediction Center.

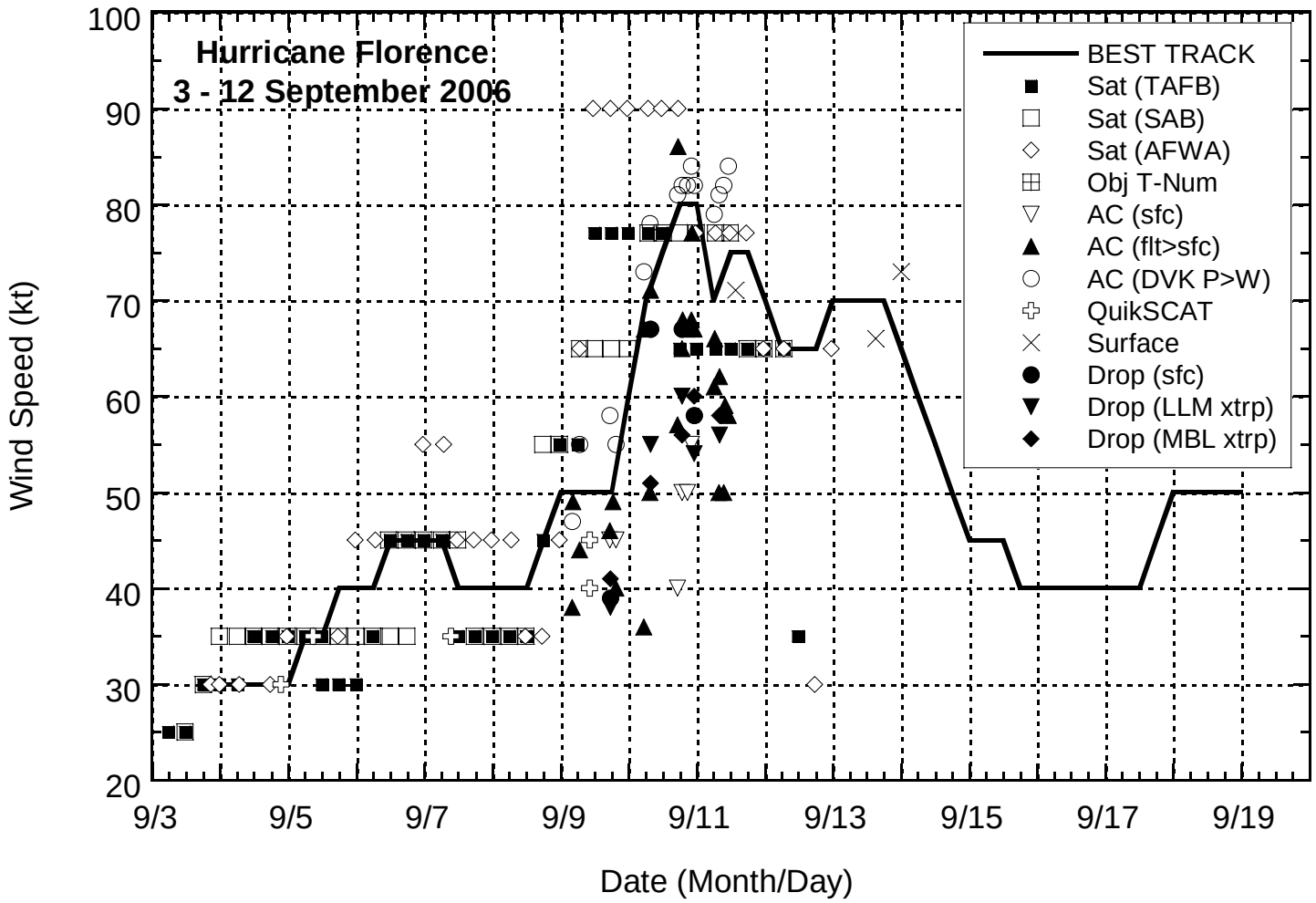


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Florence, 3 – 12 September 2006. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% reduction factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. 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). Estimates during the extratropical stage are based on analyses from the NOAA Ocean Prediction Center.

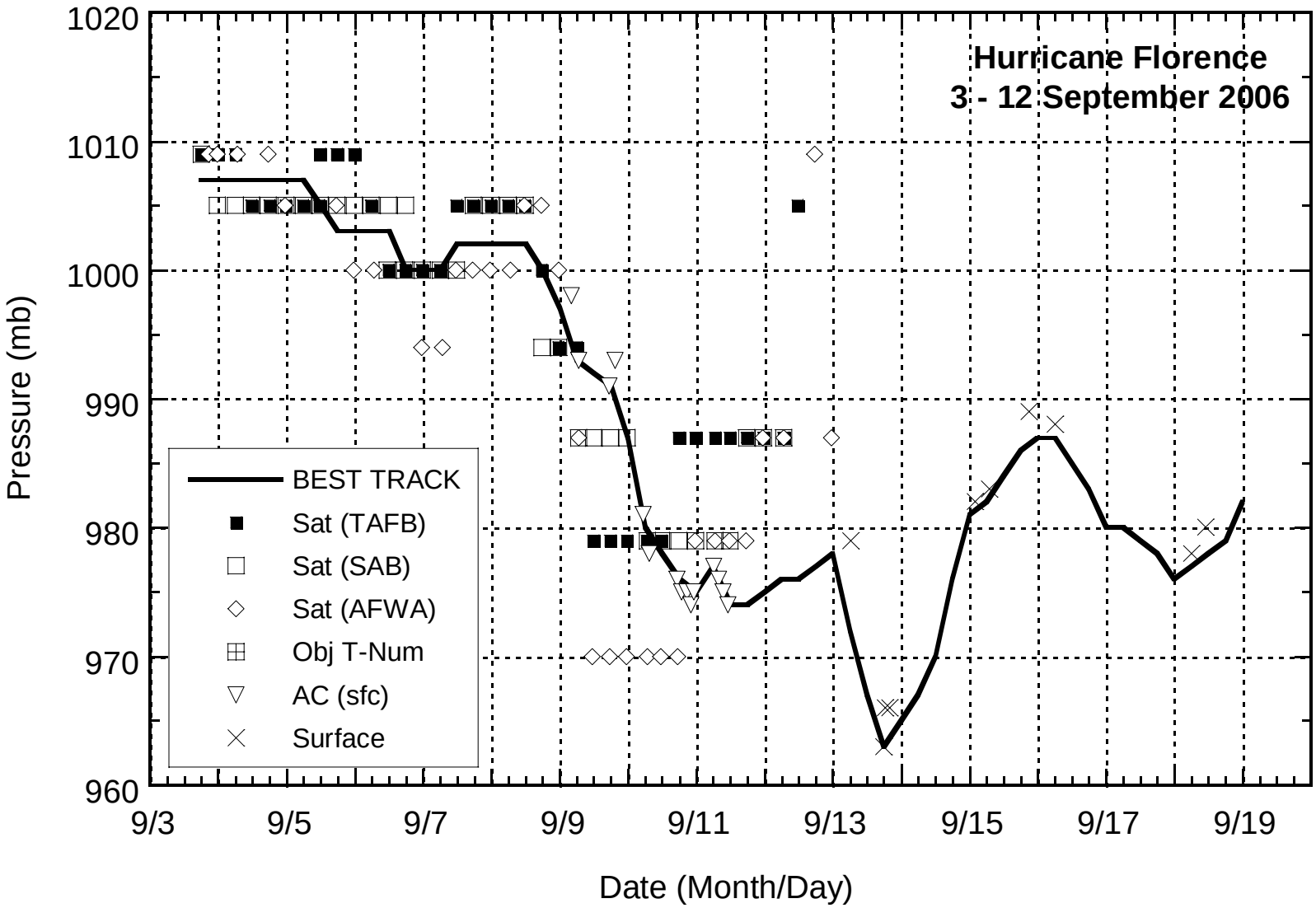


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Florence, 3 – 12 September 2006. Estimates during the extratropical stage are based on analyses from the NOAA Ocean Prediction Center.