

Tropical Cyclone Report
Hurricane Felix
7-19 September 2001

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Felix was the second major hurricane (category 3 on the Saffir-Simpson Hurricane Scale) of the season. It remained over the open waters of the eastern Atlantic Ocean, but briefly threatened the Azores Islands.

a. Synoptic History

Felix developed from a tropical wave and associated weak surface low that crossed the African coast on 5 September. The wave and low pressure area tracked westward for the next two days. On 6 September, QuikSCAT satellite wind data (not shown) indicated that a surface circulation near the wave axis had become better defined. Deep convection continued to increase and weak banding features developed later that day as the system tracked a few hundred miles south of the Cape Verde Islands. By early 7 September, QuikSCAT satellite wind data and nearby ship observations indicated the low pressure system had become better defined with westerly winds of 10 to 15 kt noted about 120 n mi southwest of the low-level center. Deep convection became more centralized and banding features became more pronounced in visible satellite imagery. Dvorak satellite intensity estimates indicated the system had developed into Tropical Depression Seven at 1200 UTC that same day about 360 n mi southwest of the Cape Verde Islands. The “best track” chart of Felix’s path is given in Fig. 1, while the best track positions and intensities are listed in Table 1. Wind and pressure plots are shown in Figs. 2 and 3, respectively.

Tropical Depression Seven tracked rapidly westward between 18 to 20 kt for the next day or so. Despite the otherwise favorable upper-level ridging across the system, the depression failed to develop any further. It is surmised that the rapid westward motion may have been associated with a low-level shear condition, which resulted in the deep convection becoming displaced farther to the east of the low-level center. Another possibility, based on satellite water vapor and AMSU (Advanced Microwave Sounding Unit) temperature data, is that the surrounding environment was more stable than usual, which could also have been an inhibiting factor to maintaining persistent deep convection near the center. By 1800 UTC on 8 September, convection became disorganized and QuikSCAT surface wind data, plus a few ship reports, indicated that Tropical Depression Seven had degenerated into a northeast-to-southwest oriented open wave about 650 n mi west-southwest of the Cape Verde Islands.

The wave tracked westward at around 15 kt for the next 36 hours. An unfavorable vertical shear pattern developed across the system when an upper-level trough amplified southward into the deep tropics to the west of the wave. Eventually, the southwesterly upper-level shear relaxed enough to allow for the redevelopment of deep convection near the mid-level vorticity center late on 9 September. By 0600 UTC 10 September, conventional satellite data suggested that a closed surface circulation had reformed and the system became again Tropical Depression Seven. A QuikSCAT overpass (data not shown) at 0816 UTC confirmed the existence of a broad cyclonic circulation in

the surface wind field.

Tropical Depression Seven tracked west-northwestward and maintained a steady intensity of 30 kt for the next 24 hours. By 1200 UTC 11 September, the depression had acquired more convective banding features and satellite intensity estimates indicated the system had become Tropical Storm Felix.

The cyclone gradually turned northwestward and slowly intensified, reaching hurricane strength around 0000 UTC on 13 September. Shortly after reaching hurricane status, Felix underwent a period of rapid intensification (RI) in which the cyclone strengthened 30 kt in an 18 h period. It is estimated that Felix reached a peak intensity of 100 kt around 0000 UTC 14 September, when it was situated about 1400 miles southwest of the Azores Islands. It maintained that intensity until 0600 UTC, after which it began to recurve to the northeast and gradually turned more eastward ahead of an approaching mid-latitude trough.

Shortly after reaching its peak intensity, Felix began to weaken at a slow but steady pace as upper-level westerly shear began to increase. Late on 16 September, Felix turned northeastward and began moving over much cooler water. The cyclone weakened to tropical storm status at 1200 UTC 17 September, when it stalled about 350 miles southwest of the Azores. Increasing upper-level northwesterly shear and cold upwelling (as indicated by sea-surface temperature reports from nearby buoys and ships) caused Felix to weaken more rapidly as it drifted southward over its cold wake. It weakened to a depression at 1800 UTC 18 September and dissipated at 0000 UTC on 19 September, when it was about 400 miles southwest of the Azores Islands.

b. Meteorological Statistics

Observations in Felix (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). Felix's peak intensity of 100 kt at 0000 and 0600 UTC on 14 September is based on a Dvorak satellite classification of 102 kt (T5.5) from the TAFB.

The period of rapid intensification that occurred is not unusual for a tropical cyclone that moves through a weakness in the subtropical ridge. Once on or just north of the ridge axis, the upper-level shear is usually at a minimum, which allows for the inner-core circulations to become more vertically aligned. Figures 4a and 4b are 85 GHz microwave satellite images of Felix obtained from the Defense Meteorological Satellite Program (DMSP). The images clearly show a significant change in the inner-core region, as well as the outer banding features, during the 21 h period between the two images. As often is the case during RI periods, the eye diameter of Felix at the end of the RI cycle had contracted down to nearly half its original size. It also worth noting that the first indication of an eye in the microwave data became evident several hours before it appeared in conventional satellite imagery (data not shown).

Ship reports of tropical storm force winds associated with Felix are given in Table 2. Pressure reports from drifting buoys 41644 and 44765 were critical in determining the strength of Felix since satellite intensity estimates became less reliable once the cyclone began to lose its central deep convection and overall convective organization.

There were no reports of tropical storm force winds in the Azores Islands because Felix rapidly weakened and eventually turned southwestward away from the islands.

c. Casualty and Damage Statistics

No reports of damage or casualties associated with Hurricane Felix were received by the National Hurricane Center.

d. Forecast and Warning Critique

Average official track errors (with the number of cases in parentheses) for Felix were 33 (27), 57 (25), 72 (23), 90 (21), and 142 (17) n mi for the 12, 24, 36, 48, and 72 h forecasts, respectively. These errors are much better than the previous 10-year averages, especially in the 24-72 h time periods. (Table 3). The Aviation (AVNI) model was the only forecast guidance to outperform the official forecast throughout 72 h forecast period..

The average intensity errors were similar to the long-term averages through 48h, but were significantly better at 72 h. The average official intensity errors were 6, 11, 14, 15, and 16 kt for the 12, 24, 36, 48, and 72 h forecasts, respectively. For comparison, the average official intensity errors over the 10-yr period 1991-2000 are 7, 11, 14, 16, and 20 kt, respectively. The SHIPS intensity forecast model had errors similar the official forecast. The GFDI performed slightly better through 36 h, but was worse at 48 and 72 h. The AVNI intensity forecasts were significantly worse (almost double) than the official and SHIPS forecasts at all time periods.

No watches or warnings were required for Hurricane Felix.

Table 1. Best track for Hurricane Felix, 7-19 September 2001.

| Date/Time (UTC) | Latitude (°N) | Longitude (°W) | Pressure (mb) | Wind Speed (kt) | Stage |
|-----------------|---------------|----------------|---------------|-----------------|---------------------|
| 07 / 1800 | 13.9 | 28.4 | 1008 | 30 | tropical depression |
| 08 / 0000 | 14.4 | 29.5 | 1007 | 30 | " |
| 08 / 0600 | 14.8 | 31.0 | 1007 | 30 | " |
| 08 / 1200 | 15.0 | 33.0 | 1008 | 30 | " |
| 08 / 1800 | 15.0 | 35.1 | 1009 | 25 | tropical wave |
| 09 / 0000 | 15.0 | 37.0 | 1009 | 25 | " |
| 09 / 0600 | 15.0 | 38.7 | 1009 | 25 | " |
| 09 / 1200 | 15.0 | 40.2 | 1009 | 25 | " |
| 09 / 1800 | 15.0 | 41.7 | 1009 | 25 | " |
| 10 / 0000 | 15.2 | 43.1 | 1009 | 25 | " |
| 10 / 0600 | 16.0 | 43.7 | 1008 | 30 | tropical depression |
| 10 / 1200 | 16.5 | 44.8 | 1008 | 30 | " |
| 10 / 1800 | 16.9 | 45.8 | 1007 | 30 | " |
| 11 / 0000 | 17.3 | 46.8 | 1006 | 30 | " |
| 11 / 0600 | 17.8 | 47.4 | 1004 | 30 | " |
| 11 / 1200 | 18.6 | 47.7 | 1003 | 35 | tropical storm |
| 11 / 1800 | 19.4 | 48.0 | 1003 | 35 | " |
| 12 / 0000 | 20.2 | 48.4 | 1000 | 40 | " |
| 12 / 0600 | 21.0 | 48.8 | 998 | 45 | " |
| 12 / 1200 | 22.0 | 48.9 | 994 | 55 | " |
| 12 / 1800 | 22.9 | 49.0 | 993 | 60 | " |
| 13 / 0000 | 23.9 | 48.9 | 987 | 65 | hurricane |
| 13 / 0600 | 24.8 | 48.6 | 979 | 75 | " |
| 13 / 1200 | 25.9 | 48.4 | 972 | 85 | " |
| 13 / 1800 | 27.1 | 48.0 | 966 | 95 | " |
| 14 / 0000 | 28.2 | 47.2 | 962 | 100 | " |

| Date/Time (UTC) | Latitude (°N) | Longitude (°W) | Pressure (mb) | Wind Speed (kt) | Stage |
|--------------------|------------------|-------------------|------------------|--------------------|---------------------|
| 14 / 0600 | 29.3 | 46.6 | 962 | 100 | " |
| 14 / 1200 | 30.1 | 45.5 | 966 | 95 | " |
| 14 / 1800 | 30.9 | 44.3 | 970 | 90 | " |
| 15 / 0000 | 31.2 | 42.8 | 970 | 90 | " |
| 15 / 0600 | 31.5 | 41.4 | 970 | 90 | " |
| 15 / 1200 | 31.7 | 39.5 | 970 | 90 | " |
| 15 / 1800 | 32.1 | 37.6 | 975 | 85 | " |
| 16 / 0000 | 32.1 | 36.0 | 975 | 85 | " |
| 16 / 0600 | 32.6 | 34.8 | 976 | 80 | " |
| 16 / 1200 | 33.4 | 33.3 | 977 | 75 | " |
| 16 / 1800 | 34.3 | 32.4 | 979 | 70 | " |
| 17 / 0000 | 35.1 | 32.0 | 981 | 70 | " |
| 17 / 0600 | 35.4 | 31.7 | 983 | 65 | " |
| 17 / 1200 | 35.3 | 31.5 | 985 | 60 | tropical storm |
| 17 / 1800 | 35.2 | 31.8 | 990 | 55 | " |
| 18 / 0000 | 35.0 | 32.0 | 995 | 45 | " |
| 18 / 0600 | 34.8 | 32.0 | 998 | 40 | " |
| 18 / 1200 | 34.7 | 31.9 | 1001 | 35 | " |
| 18 / 1800 | 34.7 | 31.7 | 1002 | 30 | tropical depression |
| 19 / 0000 | 34.6 | 31.6 | 1002 | 25 | " |
| 19 / 0600 | | | | | dissipated |
| 14 / 0000 | 28.2 | 47.2 | 962 | 100 | minimum pressure |
| 14 / 0600 | 29.3 | 46.6 | 962 | 100 | " |

Table 2. Selected ship reports for Hurricane Felix, 7-19 September 2001.

| Date/Time (UTC) | Ship call sign | Latitude (°N) | Longitude (°W) | Wind dir/speed (kt) | Pressure (mb) |
|-----------------|----------------|---------------|----------------|---------------------|---------------|
| 13 / 1200 | ELSW5 | 27.5 | 45.8 | 120 / 33 | 1011.0 |
| 16 / 1800 | KAKG | 36.4 | 32.2 | 090 / 35 | 1000.5 |
| 17 / 1200 | C6PW2 | 37.5 | 33.8 | 040 / 34 | 1008.0 |

Table 3. Preliminary track forecast evaluation (homogeneous sample) for Hurricane Felix, 7-19 September 2001. 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.

| Forecast Technique | Forecast Period (h) | | | | |
|-------------------------------|---------------------|----------------|----------------|----------------|-----------------|
| | 12 | 24 | 36 | 48 | 72 |
| CLIP | 51 (27) | 122 (25) | 200 (23) | 267 (21) | 454 (17) |
| GFDI | 29 (27) | 58 (25) | 85 (23) | 120 (21) | 219 (17) |
| LBAR | 34 (27) | 63 (25) | 89 (23) | 114 (21) | 187 (17) |
| AVNI | 29 (27) | 44 (25) | 61 (23) | 89 (21) | 129 (17) |
| BAMD | 52 (27) | 96 (25) | 137 (23) | 169 (21) | 231 (17) |
| BAMM | 43 (27) | 87 (25) | 126 (23) | 162 (21) | 228 (17) |
| BAMS | 47 (27) | 89 (25) | 127 (23) | 173 (21) | 280 (17) |
| NGPI | 36 (27) | 69 (25) | 103 (23) | 134 (21) | 194 (17) |
| UKMI | 38 (27) | 73 (25) | 98 (23) | 108 (21) | 137 (17) |
| GUNS | 30 (27) | 61 (25) | 89 (23) | 110 (21) | 150 (17) |
| NHC Official | 33 (27) | 57 (25) | 72 (23) | 90 (21) | 142 (17) |
| NHC Official (1991-2000 mean) | 44 (2049) | 82 (1835) | 118 (1646) | 151 (1475) | 226 (1187) |

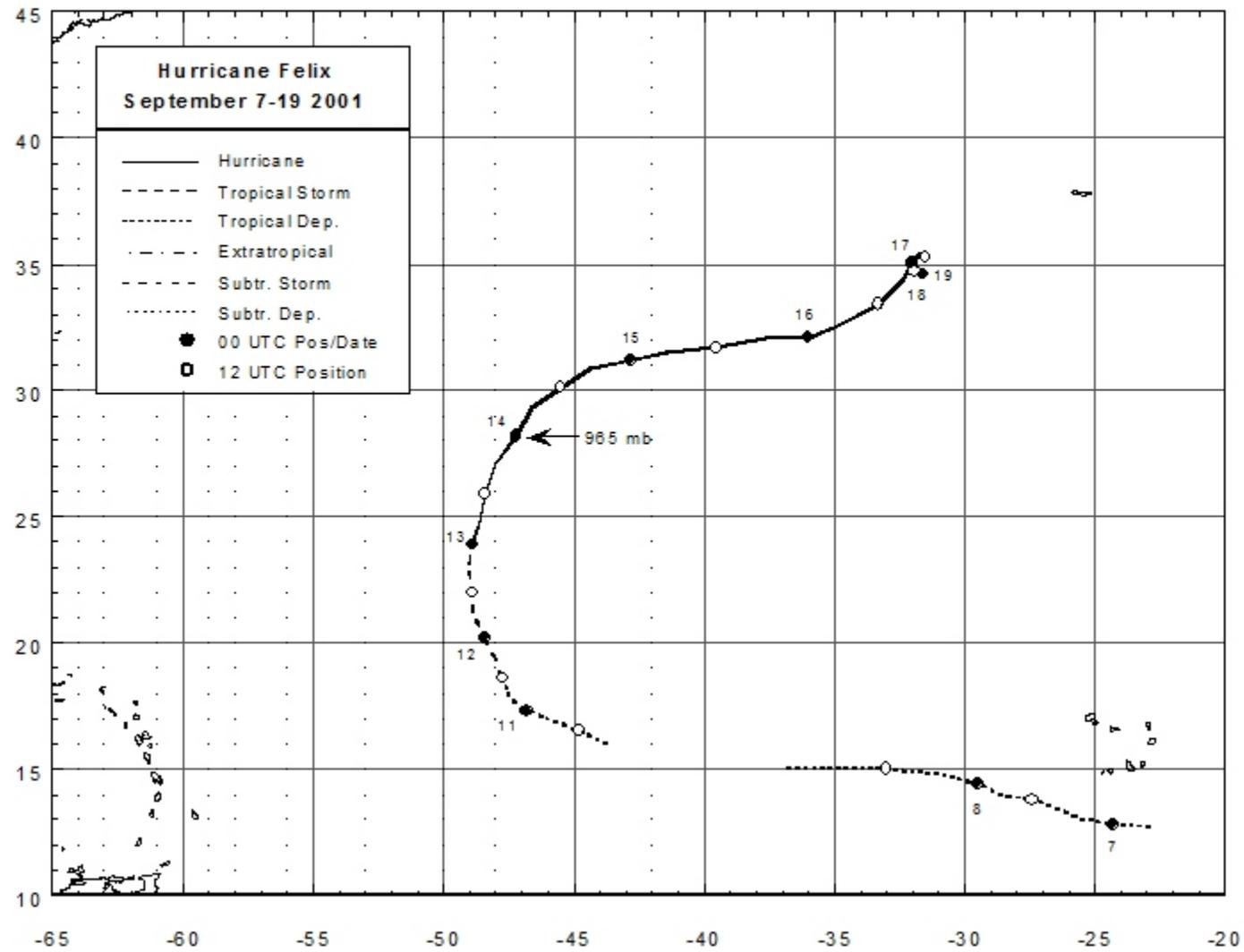


Figure 1. Best track positions for Hurricane Felix, 7-19 September 2001.

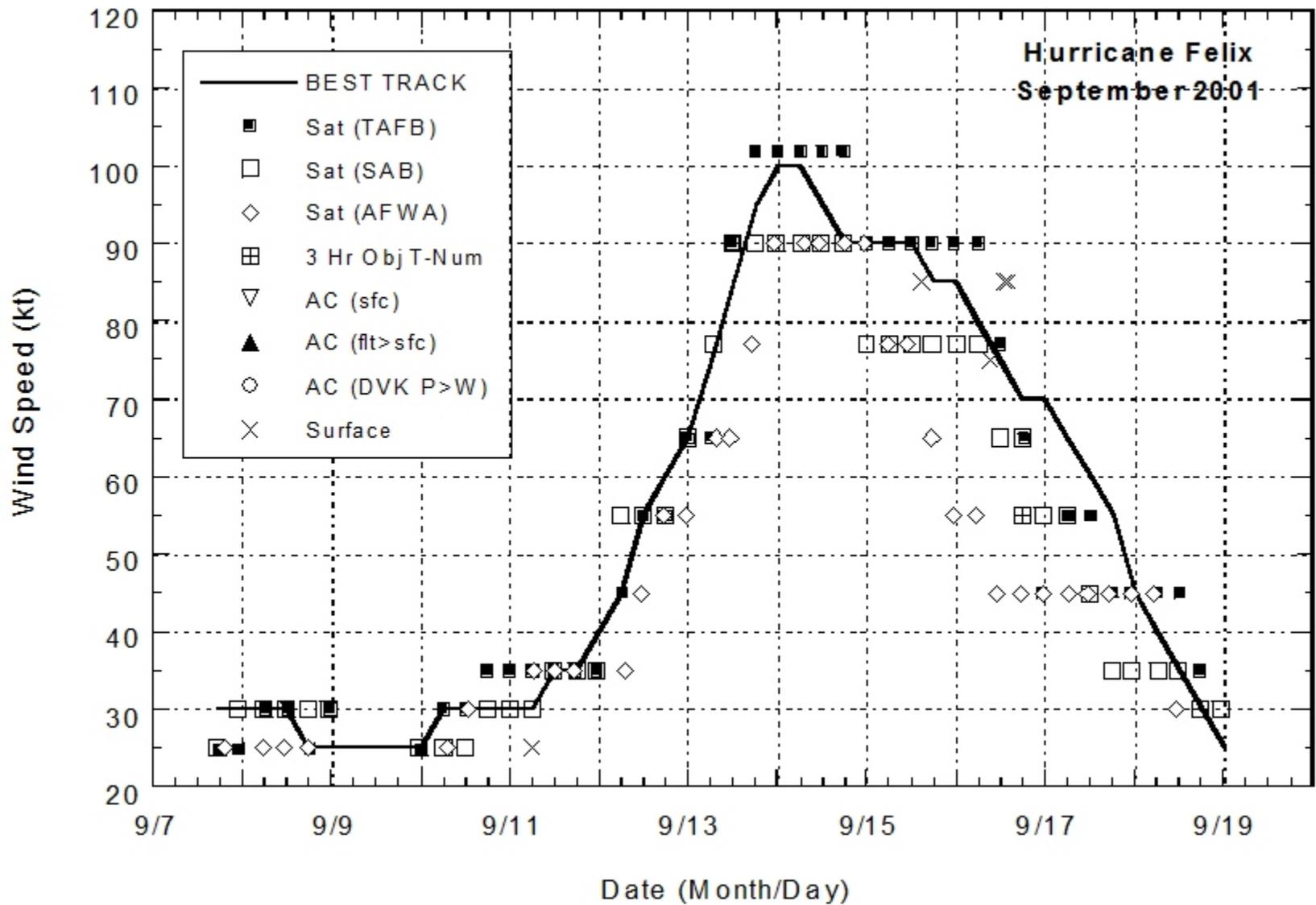


Figure 2. Best track maximum sustained surface wind speed curve for Hurricane Felix, 7-19 September 2001, and the observations on which the best track curve is based.

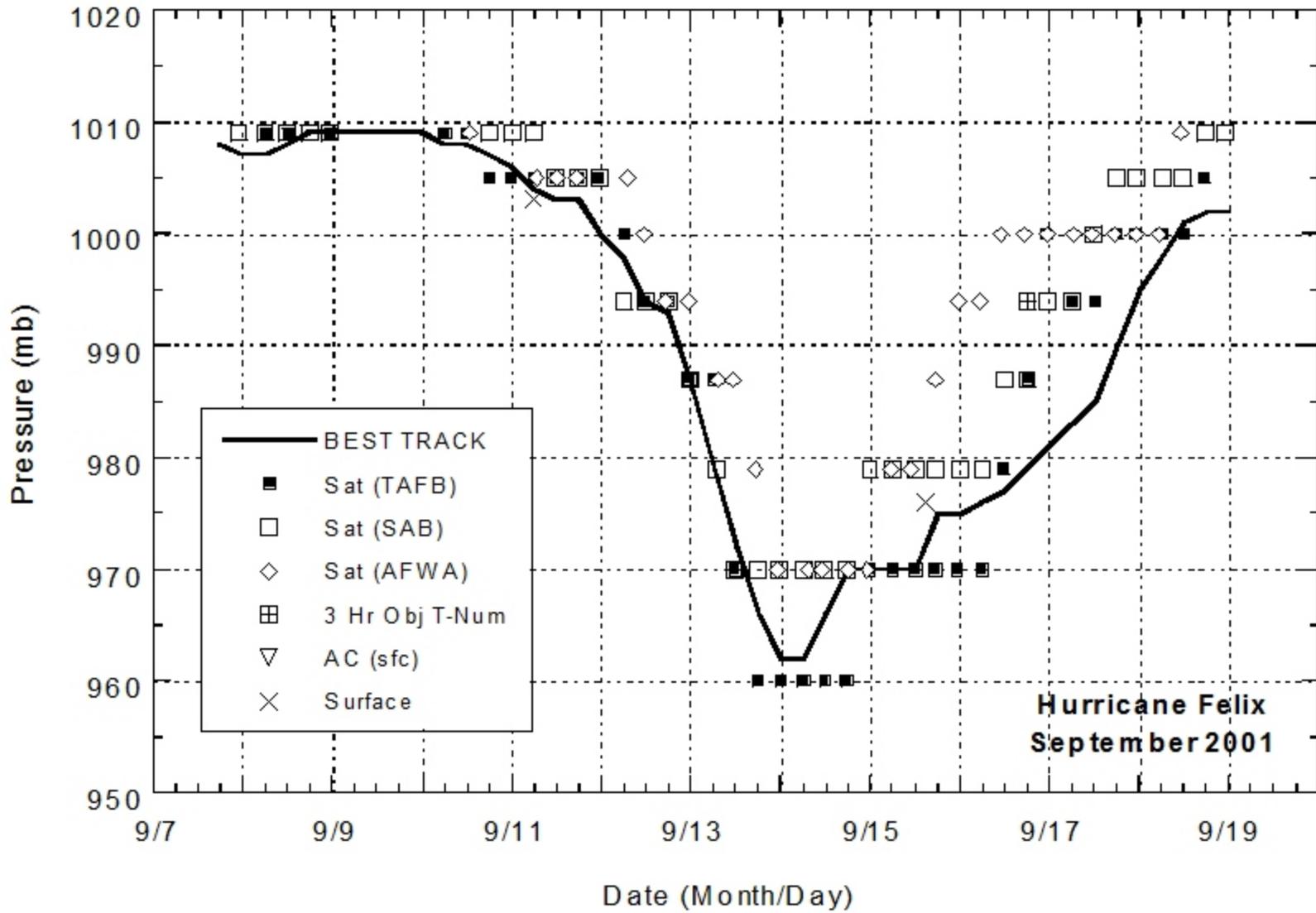


Figure 3. Best track minimum central pressure curve for Hurricane Felix, 7-19 September 2001, and the observations on which the best track curve is based.

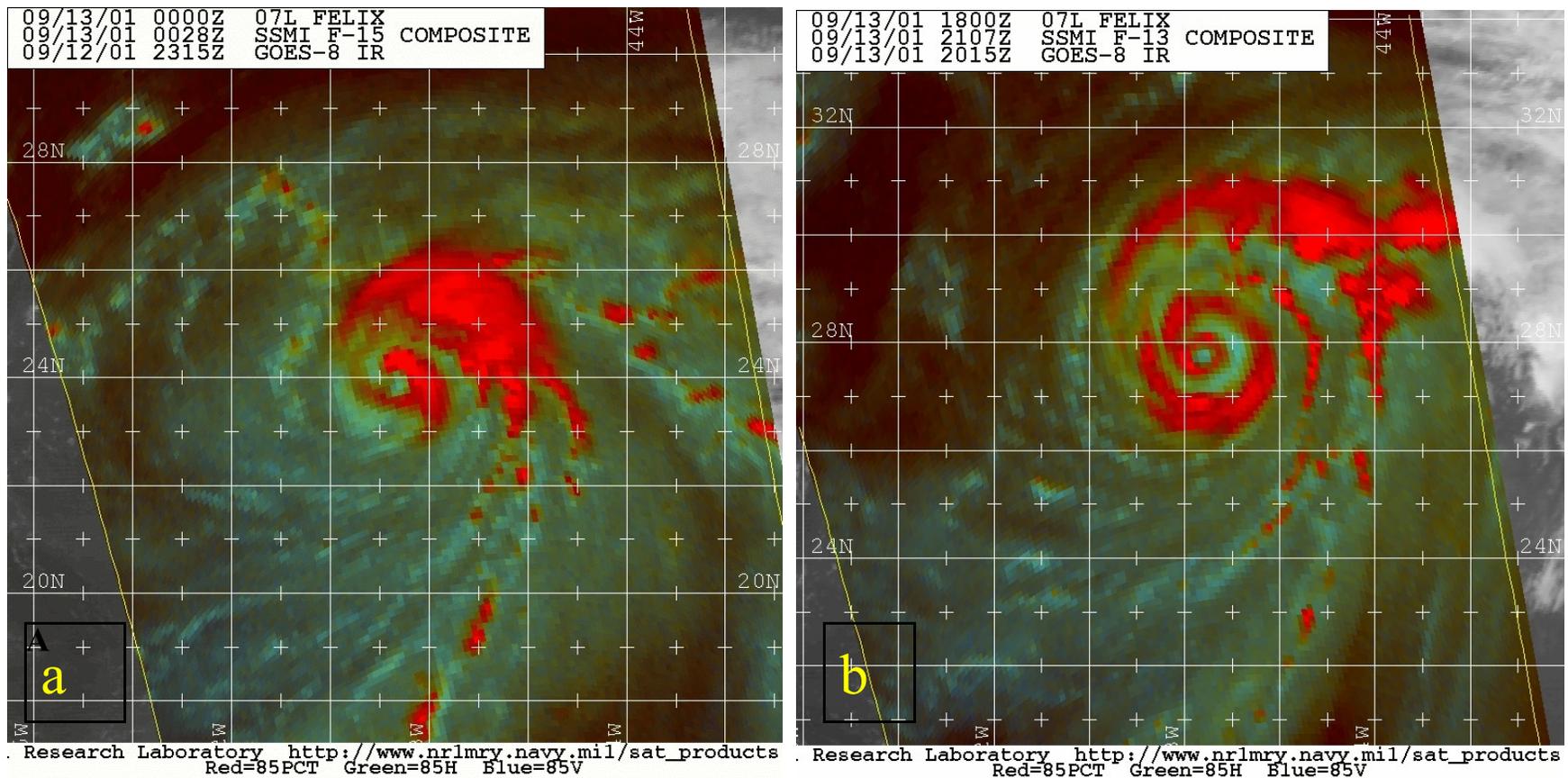


Figure 4. Microwave satellite imagery (85 GHz) from the DMSP Special Sensor Microwave Imager (SSMI). At 0028 UTC 13 September (figure 4a), an eye is clearly defined near 24N 48.5W when Felix was at 65 kt and beginning a period of rapid intensification. By 2107 UTC (figure 4b), Felix had completed the RI cycle and was near 95 kt. Note the significant change in the eye and the banding structure during the 21 h period. Felix reached its intensity a few hours after the image time in figure 4b. It is important to note that an eye did not become evident in conventional infrared imagery until 0645 UTC when the first image became available after a 3 h satellite eclipse period. Even then, the eye was only weakly apparent and did not become clearly defined until 1115 UTC.