Tropical Cyclone Report
Hurricane Flossie
26 August - 2 September 2001

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After a quick start to the season with a major hurricane in May, Flossie became the third hurricane (category 2 on the Saffir-Simpson Hurricane Scale) to develop in the northeastern Pacific Ocean. It remained well offshore the west coast of Mexico and was only a threat to marine interests.

a. Synoptic History

Flossie originated from a tropical wave that moved off the west coast of Africa on 11 August. This wave initially spawned Atlantic Tropical Storm Chantal on 14 August, about 1300 n mi east of the southern Windward Islands. Chantal and the subsequent wave envelope in which it was embedded continued to track rapidly westward at 20 to 25 kt across the tropical Atlantic and into the Caribbean Sea.

By 19 August, Chantal and the associated wave had slowed down significantly as the system moved into the western Caribbean Sea. Chantal eventually stalled along the east coast of the Yucatan Peninsula late on 20 August. While Chantal remained quasi-stationary near Chetumal, Mexico, the southern portion of the wave crossed over Central America and emerged over the northeastern Pacific Ocean south of Guatemala on 21 August, as indicated by surface observations and QuikSCAT satellite-derived winds.

For the next two days, a pre-Flossie disturbance of cloudiness and showers tracked westward parallel to the southwest coast of Mexico and changed little in overall organization. On 23 August, however, a closed surface circulation appeared in QuikSCAT imagery (not shown). The associated convection was not particularly well organized. The system tracked west-northwestward close to the Mexican coast until 25 August. Later that day, outer convective bands of the broad circulation moved onshore near Manzanillo, Mexico, and produced wind gusts to tropical storm force. Satellite classifications and QuikSCAT wind data, however, indicated that the circulation was still too broad and disorganized to be classified as a tropical depression.

By 0000 UTC 26 August, the pre-Flossie circulation had moved far enough away from the negative influence of the Mexican coastal mountains. The low-level circulation became better defined and deep convection consolidated closer to the system center. Satellite intensity estimates continued to increase and, by 0600 UTC, they suggested that the system had developed into Tropical Depression Seven-E about 235 n mi south-southeast of Baja California. The “best track” chart of the tropical cyclone’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.

The depression tracked westward and convective organization continued to improve during the day. At 1800 UTC, the cyclone strengthened into Tropical Storm Flossie about 195 n mi south of the southern tip of Baja California. Flossie continued to move westward and passed about 7 n mi north of Socorro Island. By 1800 UTC 27 August, Flossie slowed from 9 kt down to 5 kt, and rapidly intensified into a hurricane. The intensification process leveled off when Flossie began to experience

southwesterly shear while interacting with an upper-level low pressure system located to the west. Over the next 24 h, Flossie turned sharply southward and made a small cyclonic loop about 200 n mi west of Socorro Island. The sharp change in track motion was probably due to binary interaction between Flossie and the upper-level low that moved cyclonically around the south and east side of the hurricane before eventually weakening and lifting out to the northeast. Once the upper-level low and its negative shear effects moved away from Flossie, the hurricane began to intensify again late on 28 August and eventually peaked at 90 kt at 1800 UTC 29 August. Tropical Rainfall Measurement Mission (TRMM) microwave satellite imagery (Figs. 4 and 5) indicated that Flossie had become significantly better organized during an 18 h period with the eye decreasing to nearly half its original size. Eye contraction often corresponds with rapid intensification. However, an approaching mid-latitude trough began to induce southwesterly upper-level shear on Flossie, disrupting a possible rapid intensification process. Instead, Flossie began a slow weakening trend while tracking northwestward for the next day and a half and became a tropical storm again at 0600 UTC 31 August, when it was located about 470 miles west of the southern tip of Baja California. At 1800 UTC, the cyclone began moving over sharply lower sea-surface temperatures, which helped to bring about its rapid demise. Flossie weakened to a depression at 1200 UTC 1 September and completely dissipated later that day about 200 n mi west of Punta Eugenia in western Baja California.

The remnant low-level circulation drifted slowly westward over the northeastern Pacific Ocean as a swirl of low clouds for several more days. The mid- to upper-level circulation moved rapidly northeastward across northen Baja California before dissipating over the desert region of the southwestern United States.

b. Meteorological Statistics

Observations in Flossie (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). Flossie's peak intensity of 90 kt at 1800 UTC on 29 August is based on a Dvorak satellite classification of 90 kt (T5.0) from the TAFB.

There were no ship or surface reports of sustained tropical storm force winds associated with Flossie. However, sustained winds of 30 kt with gusts to 40 kt were reported in squalls at Manzanillo, Mexico (MMZO) at 1645 UTC 25 August.

c. Casualty and Damage Statistics

The remnant moisture from Flossie helped to trigger strong thunderstorms, deadly lightning, and flash floods across portions of Southern California. While there were no directly-related deaths or damage reported with Flossie when it was a tropical cyclone, there were deaths due to lightning strikes reported in southwestern California up to 36 h after Flossie had dissipated as a tropical cyclone. Four people were struck by lightning in the San Diego and San Bernardino Mountains on 2 and 3 September, and 2 of the 4 victims died. A 53-year old man was killed on 2 September when he was struck in the head by lightning while hiking and a 13-year old boy was also struck in the head and killed while standing in an open field.

In addition, more than 2 inches of rain fell in one hour and caused flash flooding in San Diego and Riverside Counties on 2-3 September. Strong downdraft winds also knocked down a tree

onto a house. Total damage from Flossie's remnants was estimated at $35,000.

d. Forecast and Warning Critique

Average official track errors for Flossie were 30, 60, 94, 123, and 186 n mi for the 12, 24, 36, 48, and 72 h forecasts, respectively (Table 2). The number of cases ranged from 21 at 12 h to 11 at 72 h. These errors are lower than the average official track errors for the 10-year period 1991-2000 (37, 68, 99, 128, and 185 n mi, respectively), except at 72 h. While not included in the normal verification process, it is worth noting that forecast errors during all stages (including the tropical depression stage; number of cases indicated in parentheses), were slightly lower at 30 (26), 59 (24), 91 (22), 121 (20), and 182 (16) at the same time periods, respectively. Higher than average CLIPER errors, along with the best track plot (Fig. 1), indicate that Flossie posed many forecast challenges. The NHC official forecast, however, correctly captured the small cyclonic loop and subsequent short-term southwesterly motion near Socorro Island on 28 August. In fact, some of the smallest official forecast (OFCL) errors occurred prior to and during this time of erratic motion, whereas all of the NHC model guidance produced large errors during this same period. The largest OFCL track errors occurred toward the end of Flossie's lifetime when the system was forecast to move slowly northwestward over colder water, while it continued on a northerly track. The best performing NHC track forecast guidance was the AVNI and GUNA models.

Average official intensity errors were 6, 8, 8, 10, and 19 kt for the 12, 24, 36, 48, and 72 h forecasts, respectively. This is slightly better than the average official intensity errors over the 10-yr period 1991-2000 (7, 11, 14, 16, and 20 kt, respectively). These errors were slightly better than the SHIPS intensity model forecasts.

There were no watches or warnings associated with Flossie.

Table 1. Best track for Hurricane Flossie, 26 August - 2 September 2001.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
26 / 0600	19.1	108.5	1004	30	tropical depression
26 / 1200	19.7	109.7	1004	30	"
26 / 1800	20.0	110.6	1003	35	tropical storm
27 / 0000	20.1	111.6	1002	40	"
27 / 0600	20.2	112.5	1000	45	"
27 / 1200	20.1	113.3	994	55	"
27 / 1800	19.9	113.8	989	65	hurricane
28 / 0000	19.5	114.1	989	65	"
28 / 0600	19.2	114.3	989	65	"
28 / 1200	19.1	114.3	985	70	"
28 / 1800	19.4	114.7	985	70	"
29 / 0000	19.8	115.1	983	75	"
29 / 0600	20.1	115.4	980	80	"
29 / 1200	20.6	116.2	977	85	"
29 / 1800	20.9	116.6	972	90	"
30 / 0000	21.5	117.1	975	85	"
30 / 0600	21.9	117.7	979	80	"
30 / 1200	22.4	118.0	983	70	"
30 / 1800	22.9	118.1	987	65	"
31 / 0000	23.4	118.4	989	65	"
31 / 0600	23.6	118.6	994	60	tropical storm
31 / 1200	23.9	118.9	997	55	"
31 / 1800	24.3	119.2	999	50	"
01 / 0000	24.8	119.3	1002	40	"
01 / 0600	25.2	119.1	1005	35	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
01 / 1200	25.6	118.9	1005	30	tropical depression
01 / 1800	26.0	118.6	1006	30	"
02 / 0000	26.6	118.4	1007	25	"
02 / 0600					dissipated
29 / 1800	20.9	116.6	972	90	minimum pressure

Table 2. Preliminary forecast evaluation (heterogeneous sample) for Hurricane Flossie, 26 August - 2 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. *Note: GUNS is the GFDI-UKMI-NGPI model ensemble average and GUNA is the GFDI-UKMI-NGPI-AVNI model ensemble average.

Forecast Technique	Forecast Period (h)				
	12	24	36	48	72
CLIP	34 (21)	78 (19)	127 (17)	175 (15)	262 (11)
GFDI	31 (21)	67 (19)	110 (17)	165 (15)	288 (11)
GFNI	43 (20)	84 (18)	128 (16)	172 (14)	292 (10)
LBAR	36 (21)	79 (19)	124 (17)	167 (15)	276 (11)
AVNI	33 (20)	68 (19)	102 (17)	128 (15)	**141** (9)
BAMD	33 (21)	67 (19)	97 (17)	125 (15)	193 (11)
BAMM	35 (21)	78 (19)	134 (17)	197 (15)	305 (11)
BAMS	37 (21)	75 (19)	129 (17)	194 (15)	320 (11)
NGPI	48 (21)	95 (19)	132 (17)	173 (15)	268 (11)
UKMI	33 (20)	63 (19)	103 (17)	138 (15)	218 (11)
GUNS*	33 (20)	64 (19)	96 (17)	127 (15)	210 (11)
GUNA*	31 (20)	63 (19)	**91** (17)	**118** (15)	**166** (9)
NHC Official	30 (21)	60 (19)	94 (17)	123 (15)	186 (11)
NHC Official (1991-2000 mean)	37 (2273)	68 (1835)	99 (1646)	128 (1475)	185 (1187)

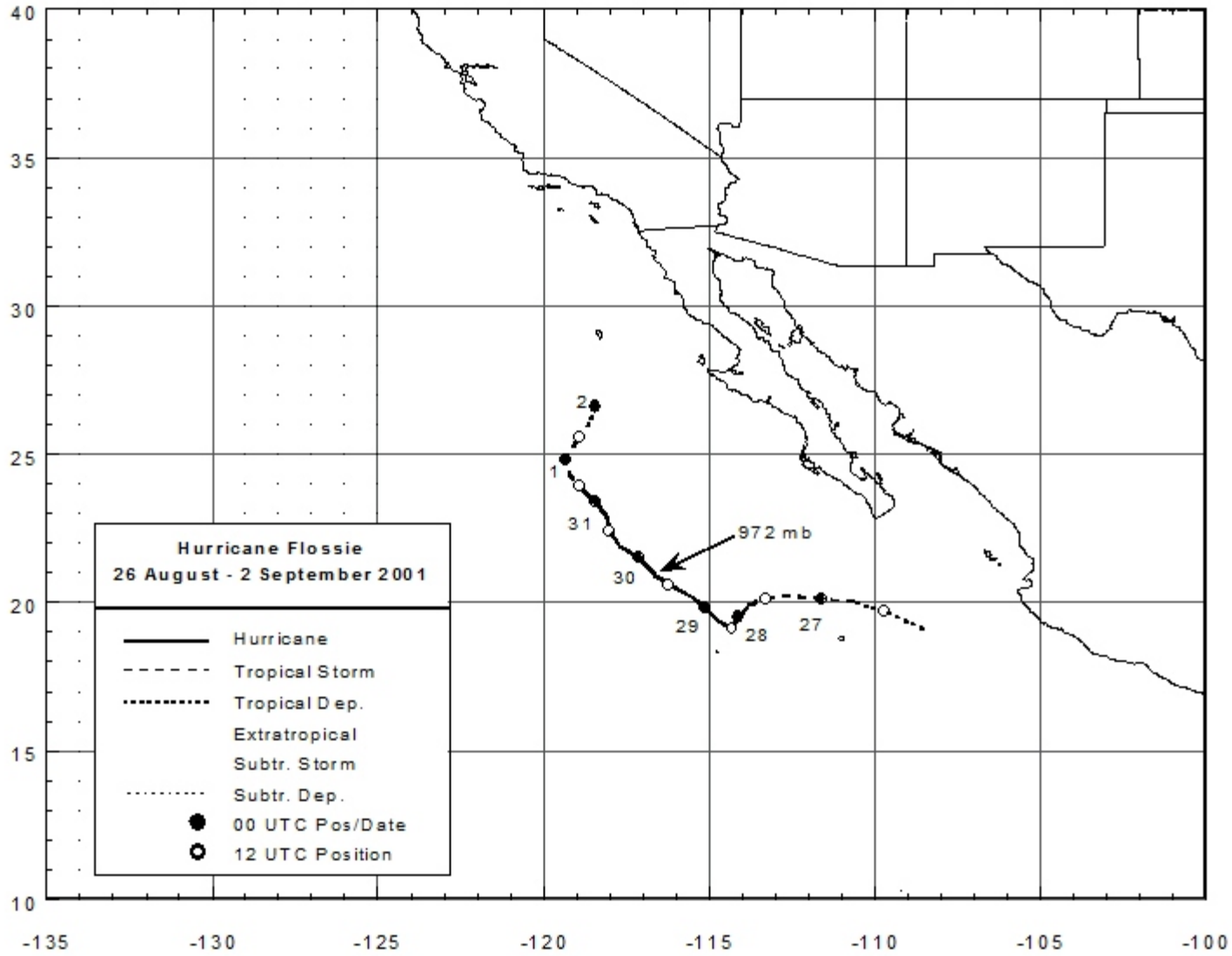

Figure 1. Best track positions for Hurricane Flossie, 26 August - 2 September 2001.

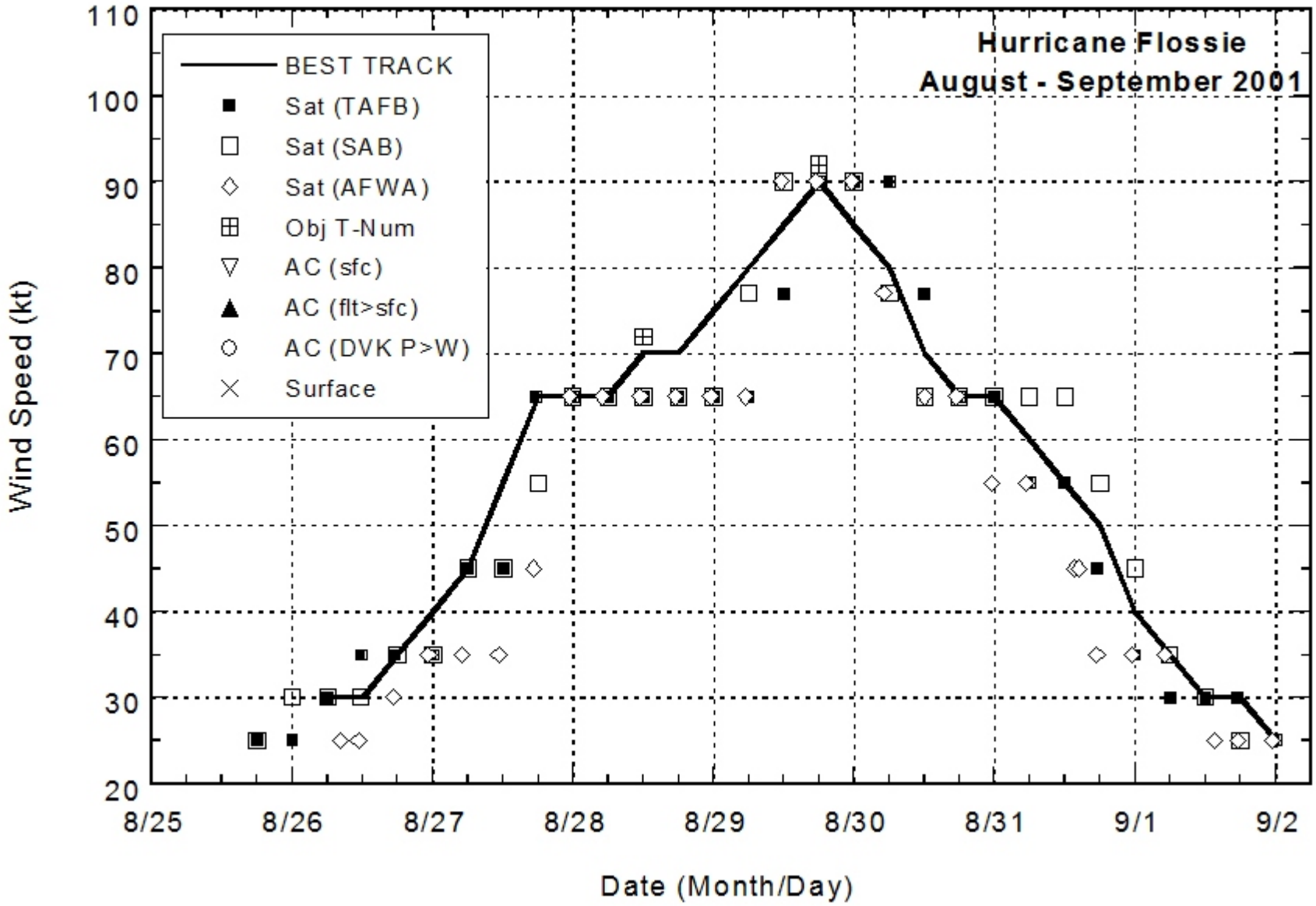

Figure 2. Best track maximum sustained surface wind speed curve for Hurricane Flossie, 26 August - 2 September 2001, and the observations on which the best track curve is based.

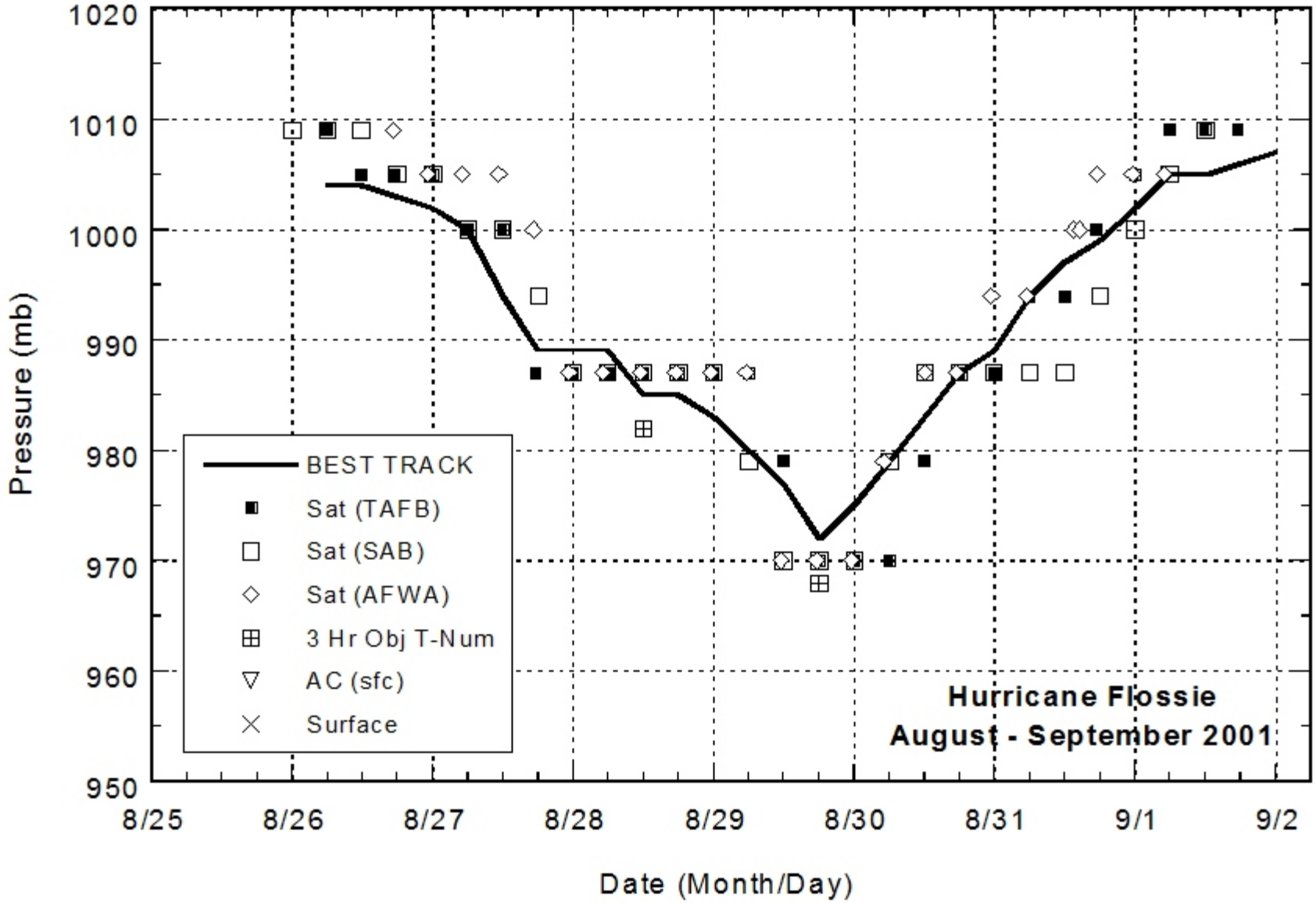

Figure 3. Best track minimum central pressure curve for Hurricane Flossie, 26 August - 2 September 2001, and the observations on which the best track curve is based.

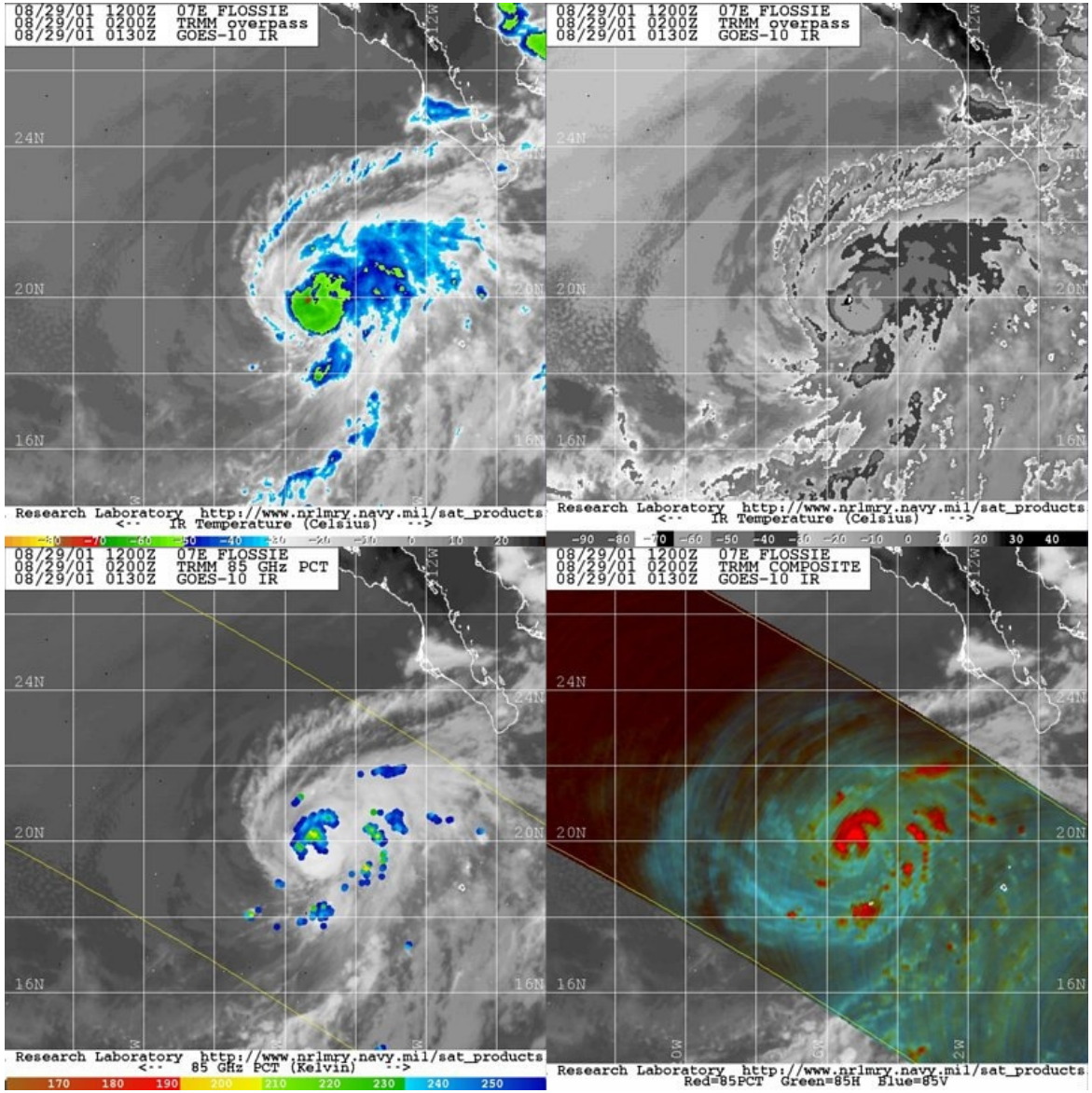

Figure 4. Flossie near 75 kt intensity (0200 UTC 29 Aug 2001) with a partial eyewall indicated in the TRMM microwave channels (lower-left and lower-right panels), whereas no eye feature is indicated in conventional infrared imagery (upper-left and upper-right panels). Image is courtesy of the Naval Research Laboratory.

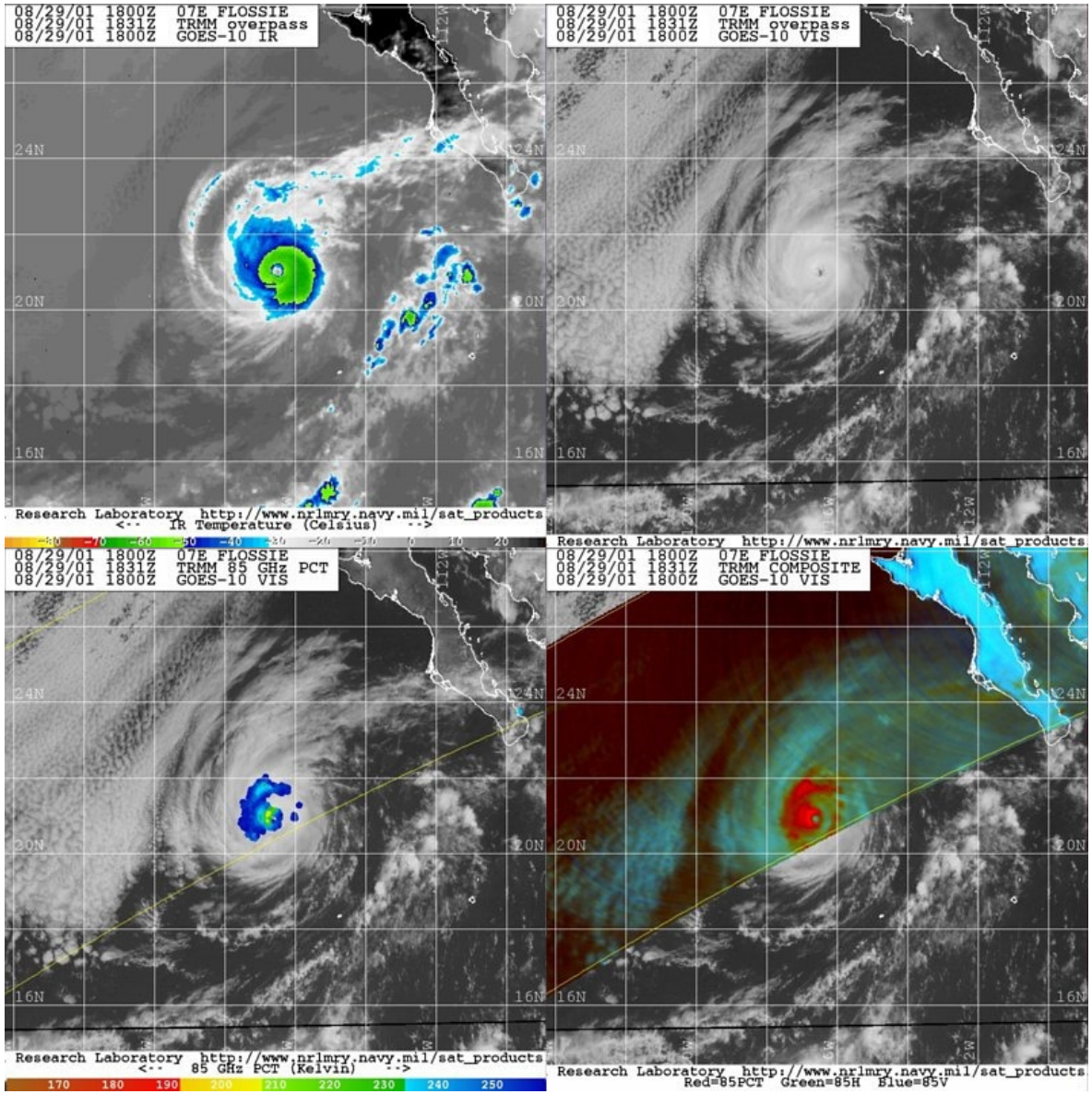

Figure 5. Hurricane Flossie at peak intensity of 90 kt (1831 UTC 29 Aug 2001). Note the small (< 10 n mi) diameter eye in the 85 GHz composite data (lower-right panel). The eye is more distinct and is almost half the size it was 18 h earlier as seen in Figure 4. Image is courtesy of the Naval Research Laboratory.