NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT[1]

HURRICANE FLOSSIE

(EP072019)

28 July–5 August 2019

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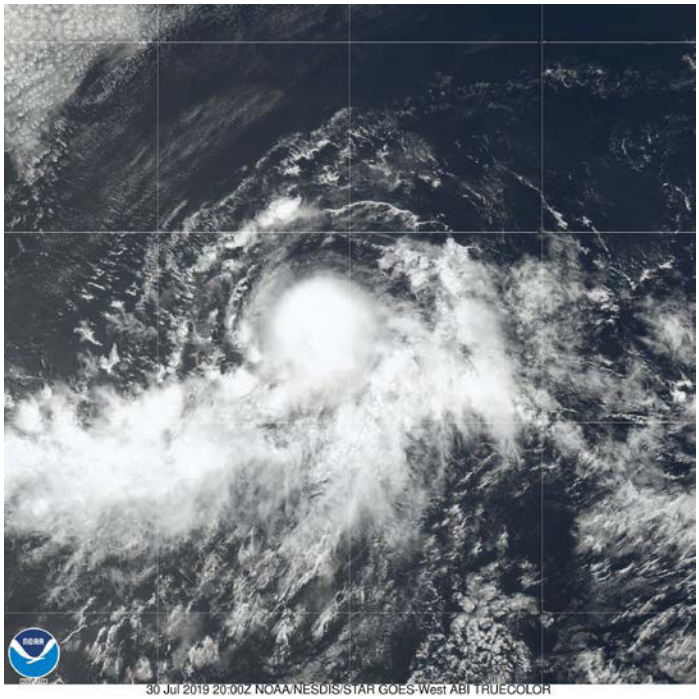
20 April 2020[1]



GOES-WEST TRUE COLOR VISIBLE IMAGE OF HURRICANE FLOSSIE AT 2000 UTC 30 JULY 2019. IMAGE COURTESY OF NOAA/NESDIS/STAR.

Flossie was a category 1 hurricane (on the Saffir-Simpson Hurricane Wind Scale) that eventually moved into the central North Pacific basin as a tropical storm and passed near the Hawaiian Islands as a remnant low.

[1] Original report released 9 January 2020. Updated 20 April 2020 to include best track analysis, summary, and verification from Central Pacific Hurricane Center.

Hurricane Flossie

28 JULY–5 AUGUST 2019

SYNOPTIC HISTORY

Flossie appears to have originated from a tropical wave that moved off the west coast of Africa on 16 July. The wave crossed Central America on 24 July, and moved westward over the far eastern North Pacific for the next few days while producing disorganized and intermittent deep convection. By late on 27 July, thunderstorms became more persistent and better organized. The convection continued to become better organized early on 28 July, and by 1200 UTC that day, the low-level circulation became sufficiently well-defined to designate the formation of a tropical depression centered about 525 n mi south of Manzanillo, Mexico. The "best track" chart of the tropical cyclone's path is shown in Fig. 1, with the wind and pressure histories displayed in Figs. 2 and 3, respectively. The best track positions and intensities are listed in Table 1[2].

Initially, the system moved rapidly west-northwestward along the southern periphery of a mid-level ridge. By early on 29 July, the cyclone turned toward the west and strengthened into a tropical storm while centered about 635 n mi south-southwest of the southern tip of the Baja California Peninsula. Flossie continued westward at a slower forward speed and slowly intensified in an environment of weak to moderate north-northwesterly shear. The cyclone became a hurricane around 1800 UTC on 30 July, and reached its peak intensity of 70 kt near 0000 UTC 31 July. Flossie maintained this intensity through 0600 UTC that day, and then a slow weakening trend began as westerly shear increased. By 1800 UTC on 31 July, Flossie weakened below hurricane strength while its low-level center temporarily became exposed to the west of the main area of deep convection. During this time, the cyclone had turned back toward the west-northwest, and it would maintain that heading for several days along the south side of a large subtropical ridge. On 1 August, the westerly shear abated somewhat, but not enough to allow for restrengthening. By 0000 UTC 2 August, however, the storm's inner core became a little better defined, and the system re-intensified slightly to 60 kt. A gradual weakening trend commenced later that day as the cyclone became less organized, and Flossie crossed into the central Pacific basin as a 50-kt tropical storm by 0000 UTC 3 August.

Flossie moved west-northwestward to westward, and crossed 140W into the central North Pacific basin around 0000 UTC 03 August as a weakening tropical storm. Flossie was the second tropical cyclone to cross into this basin during the 2019 season. As Flossie continued generally west-northwestward, increasing deep-layer wind shear of 20 to 25 kt, and cooler sea surface temperatures further weakened the cyclone to a tropical depression around 0000 UTC 5 August, while centered a few hundred n mi east of the island of Hawaii. The system ultimately

[2] A digital record of the complete best track, including wind radii, can be found on line at ftp://ftp.nhc.noaa.gov/atcf. Data for the current year's storms are located in the *btk* directory, while previous years' data are located in the *archive* directory.

degenerated to a remnant low while moving west-northwestward to northwestward just to the north of the eastern Hawaiian Islands on 6 August. The low turned north-northwestward and dissipated early on 7 August.

METEOROLOGICAL STATISTICS

Observations in Flossie (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), the Central Pacific Hurricane Center (PHFO), the Joint Typhoon Warning Center (JTWC), and the Satellite Analysis Branch (SAB), and objective Advanced Dvorak Technique (ADT) estimates and satellite consensus (SATCON) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Global Precipitation Mission (GPM), the European Space Agency's Advanced Scatterometer (ASCAT), and Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in constructing the best track of Flossie.

Flossie's estimated peak intensity of 70 kt is based on a blend of subjective Dvorak estimates from TAFB and SAB along with SATCON estimates.

Flossie's remnant low produced locally heavy rains over portions of the Hawaiian Islands.

No ship reports of winds of tropical storm force associated with Flossie have been received in the eastern or central North Pacific basins.

CASUALTY AND DAMAGE STATISTICS

There were no reports of damage or casualties associated with Flossie.

FORECAST AND WARNING CRITIQUE

The National Hurricane Center's (NHC's) forecasts for the genesis of Flossie were of mixed quality (Table 2). It was first noted in the Tropical Weather Outlook (TWO) 138 h prior to genesis that an area of low pressure was expected to form to the south of Mexico with a low (<40%) chance of development within 120 h. The 120-h genesis probability was raised to medium (40%–60%) 96 h before genesis, and was raised to high (>60%) just 36 h prior to genesis. The 48-h genesis chance was set to low 42 h before Flossie formed, was raised to medium only 18 h prior to genesis, and was set to high just 12 h prior to genesis.

Flossie's track was reasonably well forecast. A verification of NHC official track forecasts for Flossie is given in Table 3a. Official forecast track errors were lower than the mean official errors for the previous 5-yr period at all forecast intervals except at 72 h, where it was comparable to the longer-term mean. It is worth noting that the mean official error at 120 h was only 80.5 n mi, well below the long-term mean. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. In most cases, the official forecasts were better than or comparable to the models.

Flossie's intensity was not well predicted beyond a couple of days. A verification of NHC official intensity forecasts is given in Table 4a. Official forecast intensity errors were comparable to the long-term mean through 48 h and were much larger than average at 3 to 5 days. Practically all of the official intensity forecasts had a high bias that was as large as 50 kt at long ranges. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. It can be seen that in quite a few cases, the models had lower errors than the NHC forecasts. Interestingly LGEM and DSHP, which have not been particularly good performers in recent years, had among the lowest errors. HWFI had the largest errors of any of the models at 3, 4, and 5 days. In general, that model had a substantial high bias that influenced the official forecasts (Fig. 4).

A comparison between CPHC official and climatology-persistence skill baseline (OCD5) track forecast errors is presented in Table 5a. CPHC performed better than OCD5 at all forecast times. A verification of CPHC official track forecasts for Flossie is given in Table 5b. CPHC track errors for this system were smaller than the five-year average at all forecast times. In general, CPHC performed better than most global and regional dynamic models like EMXI, CMCI, NVGI and lastly GFEX, which is a blend of GFS and EMXI. CPHC also performed better than trajectory models like TABD. Ensemble and consensus models like HCCA and TVCE performed best against CPHC.

A comparison between CPHC official and OCD5 intensity forecast errors is presented in Table 6a. CPHC performed better than OCD5 at 36 and 48 h, but worse at 12 and 24 h. A verification of CPHC official intensity forecasts for Flossie is given in Table 6b. CPHC intensity errors for this system were smaller than the five-year average at 36 and 48 h, but larger at 12 and 24 h. CPHC performed better than HMNI, EMXI, and FSSE, while performing poorly against DSHP and GFSI.

There were no coastal watches and warnings associated with Flossie.

ACKNOWLEDGMENTS

John P. Cangialosi produced the track map, and Andrew B. Penny produced the HWFI intensity forecast figure.

Table 1. Best track for Hurricane Flossie, 28 July–5 August 2019.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
28 / 1200	11.1	106.8	1008	25	tropical depression
28 / 1800	11.7	108.6	1007	30	"
29 / 0000	12.2	110.4	1006	30	"
29 / 0600	12.5	112.1	1005	35	tropical storm
29 / 1200	12.5	113.8	1002	45	"
29 / 1800	12.5	115.5	1001	50	"
30 / 0000	12.3	117.1	1001	55	"
30 / 0600	12.1	118.6	1001	55	"
30 / 1200	12.2	119.9	998	60	"
30 / 1800	12.5	121.2	995	65	hurricane
31 / 0000	13.0	122.4	990	70	"
31 / 0600	13.3	123.8	987	70	"
31 / 1200	13.6	125.2	991	65	"
31 / 1800	13.8	126.6	994	60	tropical storm
01 / 0000	14.1	128.1	997	55	"
01 / 0600	14.5	129.5	996	55	"
01 / 1200	15.0	131.0	996	55	"
01 / 1800	15.6	132.5	995	55	"
02 / 0000	16.2	134.0	994	60	"
02 / 0600	16.6	135.6	993	60	"
02 / 1200	16.9	137.1	993	60	"
02 / 1800	17.3	138.8	994	55	"
03 / 0000	17.7	140.3	996	50	"
03 / 0600	18.1	141.7	998	50	"
03 / 1200	18.4	142.9	998	50	"
03 / 1800	18.6	143.9	1003	45	"
04 / 0000	18.8	145.0	1005	40	"
04 / 0600	18.9	146.1	1005	40	"
04 / 1200	18.9	147.1	1007	35	"
04 / 1800	18.9	148.0	1007	35	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
05 / 0000	18.9	149.2	1009	30	tropical depression
05 / 0600	19.2	150.6	1009	30	"
05 / 1200	19.5	152.0	1009	30	"
05 / 1800	20.0	153.0	1009	30	"
06 / 0000	20.6	154.1	1009	30	low
06 / 0600	21.4	155.3	1010	30	"
06 / 1200	22.4	156.2	1011	30	"
06 / 1800	23.6	156.8	1012	30	"
07 / 0000	24.7	157.1	1013	30	"
07 / 0600					dissipated
31 / 0600	13.3	123.8	987	70	maximum winds and minimum pressure

Table 2. Number of hours in advance of formation associated with the first NHC Tropical Weather Outlook forecast in the indicated likelihood category. Note that the timings for the "Low" category do not include forecasts of a 0% chance of genesis.

	Hours Before Genesis	
	48-Hour Outlook	**120-Hour Outlook**
Low (<40%)	42	138
Medium (40%-60%)	18	96
High (>60%)	12	36

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Flossie, 28 July–5 August 2019. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**20.1**	**31.1**	**38.6**	**51.1**	77.6	**84.8**	**80.5**
OCD5	36.7	67.6	93.3	116.6	162.0	222.8	285.0
Forecasts	22	22	22	22	22	18	14
OFCL (2014-18)	21.1	32.2	41.8	51.8	75.7	101.1	133.7
OCD5 (2014-18)	34.0	69.7	109.0	148.4	223.5	285.5	356.7

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Flossie for forecasts made in the eastern North Pacific basin. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 3a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	22.1	34.9	42.4	57.7	79.6	78.4	60.6
OCD5	36.1	65.9	91.6	117.4	171.2	211.6	255.7
TABS	25.9	38.6	49.5	76.6	166.2	229.0	277.0
TABM	26.3	41.7	65.1	89.6	147.3	191.2	212.3
TABD	41.8	91.5	149.4	209.1	322.1	421.1	518.4
TVDG	**21.8**	**33.2**	43.0	**56.3**	80.1	80.2	**52.7**
TVCE	24.9	38.6	49.2	63.6	87.5	85.6	75.2
GFEX	22.5	36.7	50.3	68.1	101.6	115.4	98.7
TVCX	**21.9**	35.0	44.1	**57.6**	80.6	84.6	**59.9**
FSSE	**20.7**	**32.9**	44.3	59.0	91.1	96.2	119.3
HCCA	23.2	37.2	48.4	62.9	90.0	93.2	102.8
AEMI	23.9	**34.8**	46.8	65.8	97.6	94.5	99.2
CTCI	27.0	45.2	60.5	75.7	101.1	109.2	112.0
NVGI	30.5	51.1	65.7	82.0	127.6	161.4	90.4
CMCI	25.7	45.2	59.2	74.6	100.2	112.8	142.4
EMXI	**21.9**	**34.4**	**41.3**	**53.0**	83.8	105.9	89.7
EGRI	24.2	**33.9**	43.0	58.6	80.5	101.0	159.4
HWFI	40.3	69.6	90.3	110.6	149.7	177.9	214.0
HMNI	30.8	52.3	71.3	91.2	124.1	135.5	136.6
GFSI	31.0	53.7	75.8	98.0	138.3	154.0	200.0
Forecasts	15	15	15	15	15	14	10

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Flossie, 28 July–5 August 2019. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**4.3**	**8.4**	**10.7**	14.8	23.6	32.5	37.9
OCD5	4.8	7.4	9.0	9.7	12.7	16.1	17.2
Forecasts	22	22	22	22	22	18	14
OFCL (2014-18)	6.1	10.0	12.2	13.7	15.5	15.4	15.7
OCD5 (2014-18)	7.9	13.1	16.7	19.2	21.8	22.9	22.1

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Flossie for forecasts made in the eastern North Pacific basin. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 4a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	3.7	9.7	13.3	19.0	26.3	32.5	38.5
OCD5	4.8	**8.3**	**9.7**	**9.9**	**14.7**	**19.5**	**22.7**
IVDR	**3.2**	**7.1**	**10.8**	**14.3**	**20.5**	**24.8**	**31.2**
IVCN	**3.3**	**7.1**	**10.3**	**13.6**	**18.7**	**22.0**	**28.0**
ICON	**3.4**	**7.4**	**10.7**	**13.9**	**17.3**	**21.1**	**26.9**
LGEM	4.5	**6.9**	**9.2**	**10.0**	**8.3**	**6.6**	**7.9**
DSHP	4.2	**8.5**	**10.4**	**11.3**	**8.8**	**9.6**	**12.1**
FSSE	4.6	10.0	15.9	21.2	27.6	**30.6**	**35.9**
HCCA	5.7	10.3	14.9	**18.8**	**23.3**	**29.9**	**34.1**
CTCI	4.3	**8.7**	**11.7**	**15.0**	**23.3**	**25.6**	**33.1**
EMXI	6.7	10.7	**9.5**	**7.2**	**5.3**	**6.8**	**6.4**
HWFI	**3.6**	**7.1**	**12.7**	**18.9**	30.1	41.1	57.0
HMNI	5.1	**9.3**	16.1	20.1	**24.6**	**30.1**	**30.2**
GFSI	6.1	**7.6**	**9.5**	**10.1**	**11.9**	**14.7**	**19.6**
Forecasts	15	15	15	15	15	14	10

Table 5a. CPHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Flossie. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**22.9**	**35.7**	**52.1**	**64.2**	-	-	-
OCD5	32.5	52.4	68.1	80.5	-	-	-
Forecasts	10	8	6	4	-	-	-
OFCL (2014-2018)	26.7	40.8	53.9	68.8	106.5	144.0	185.2

Table 5b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Flossie for forecasts made in the central North Pacific basin. Errors smaller than the CPHC official forecast are shown in boldface type.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	22.9	35.7	52.1	64.2	-	-	-
OCD5	32.5	52.4	68.1	80.5	-	-	-
GFSI	**19.3**	**28.7**	**41.5**	**53.0**	-	-	-
HMNI	**22.5**	**27.7**	**42.9**	**48.5**	-	-	-
HWRF	26.5	41.0	**46.9**	**63.4**	-	-	-
EGRI	**22.7**	**33.9**	**52.0**	65.8	-	-	-
EMXI	28.0	49.1	70.2	87.2	-	-	-
CMCI	26.0	40.5	58.0	80.7	-	-	-
NVGI	30.4	42.7	53.9	96.3	-	-	-
AEMI	**20.5**	**29.2**	**37.5**	**34.5**	-	-	-
HCCA	**19.9**	**28.5**	**41.6**	**54.5**	-	-	-
FSSE	**21.1**	**31.7**	**41.6**	**38.7**	-	-	-
TVCX	**19.7**	**29.9**	**44.6**	**53.8**	-	-	-
GFEX	**20.5**	**35.4**	53.1	65.8	-	-	-
TVCN	**19.7**	**28.2**	**43.1**	**50.7**	-	-	-
TVCE	**20.5**	**24.8**	**39.0**	**42.7**	-	-	-
TABD	55.3	136.0	219.5	301.7	-	-	-
TABM	33.8	64.6	104.3	151.4	-	-	-
TABS	32.3	59.3	93.4	120.3	-	-	-
Forecasts	10	8	6	4	-	-	-

Table 6a. CPHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Flossie. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**3.0**	**4.4**	**3.3**	**3.8**	-	-	-
OCD5	2.5	2.5	3.5	6.5	-	-	-
Forecasts	10	8	6	4	-	-	-
OFCL (2014-2018)	5.8	9.2	11.8	13.3	15.7	17.4	18.4

Table 6b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Flossie for forecasts made in the central North Pacific basin. Errors smaller than the CPHC official forecast are shown in boldface type.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	3.0	4.4	3.3	3.8	-	-	-
OCD5	**2.5**	**2.5**	3.5	6.5	-	-	-
GFSI	**2.9**	**2.8**	**1.7**	**1.0**	-	-	-
HMNI	3.5	4.9	4.5	**3.5**	-	-	-
HWFI	**2.6**	**3.1**	4.3	4.0	-	-	-
EMXI	4.0	6.4	5.8	7.0	-	-	-
HCCA	**2.8**	**2.8**	**3.2**	**2.3**	-	-	-
FSSE	4.3	6.1	6.7	7.5	-	-	-
LGEM	**2.8**	**3.0**	3.7	**1.8**	-	-	-
DSHP	**2.2**	**2.1**	**2.8**	**2.3**	-	-	-
ICON	**2.4**	**2.8**	3.5	**2.3**	-	-	-
IVCN	**2.8**	**3.3**	4.0	**3.3**	-	-	-
Forecasts	10	8	6	4	-	-	-

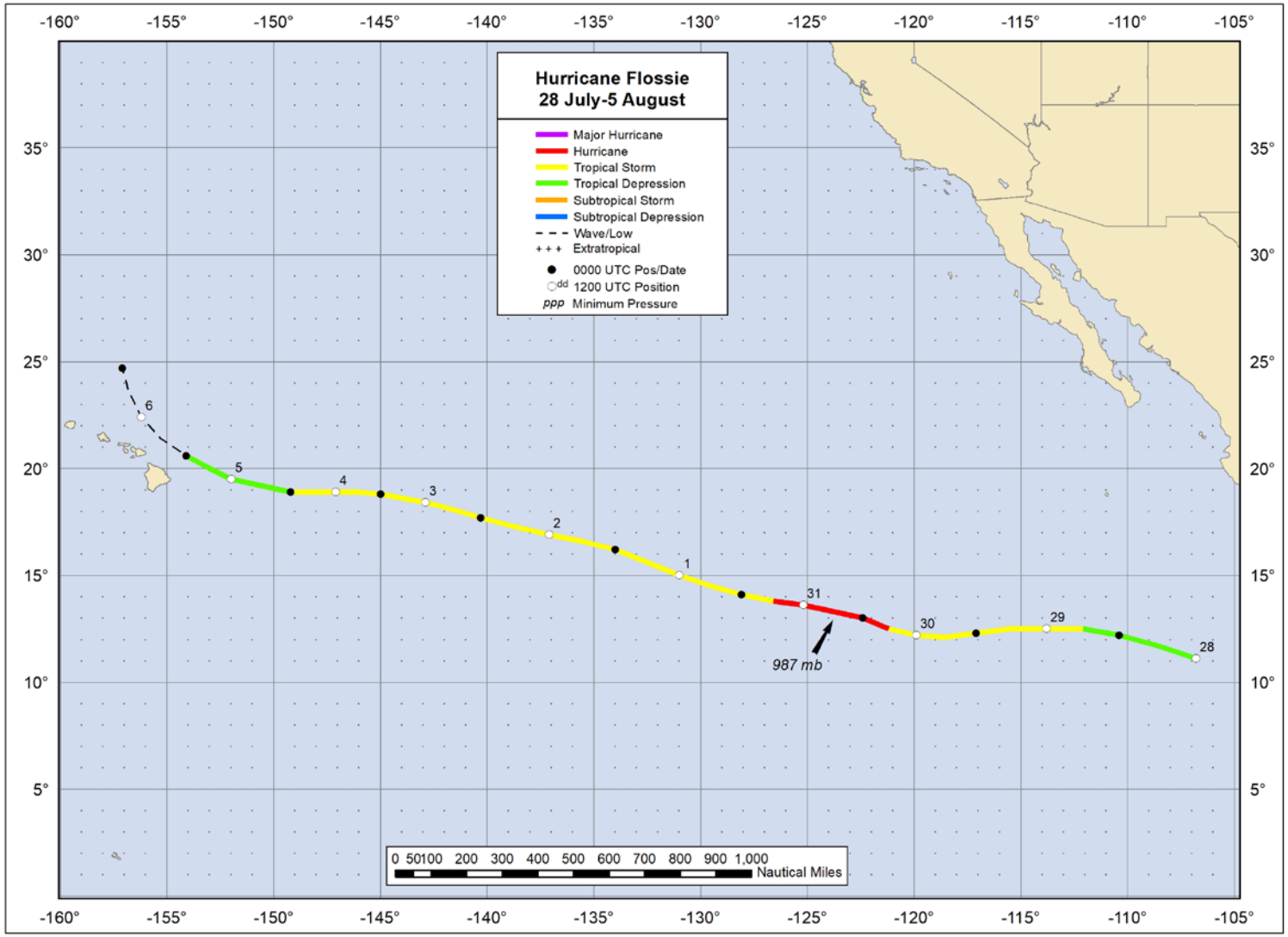


Figure 1. Best track positions for Hurricane Flossie, 28 July–5 August 2019.

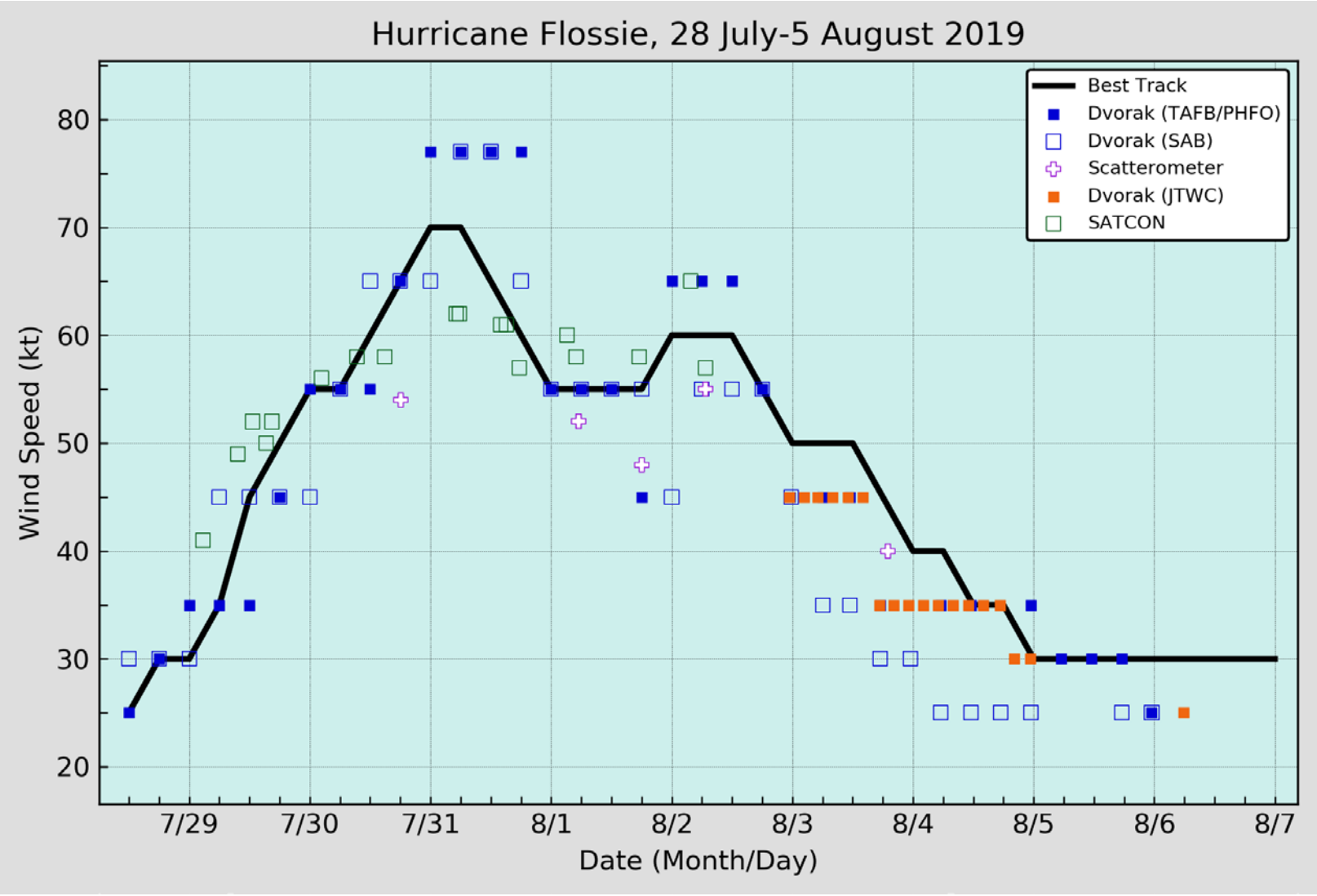


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Flossie, 28 July–5 August 2019. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC.

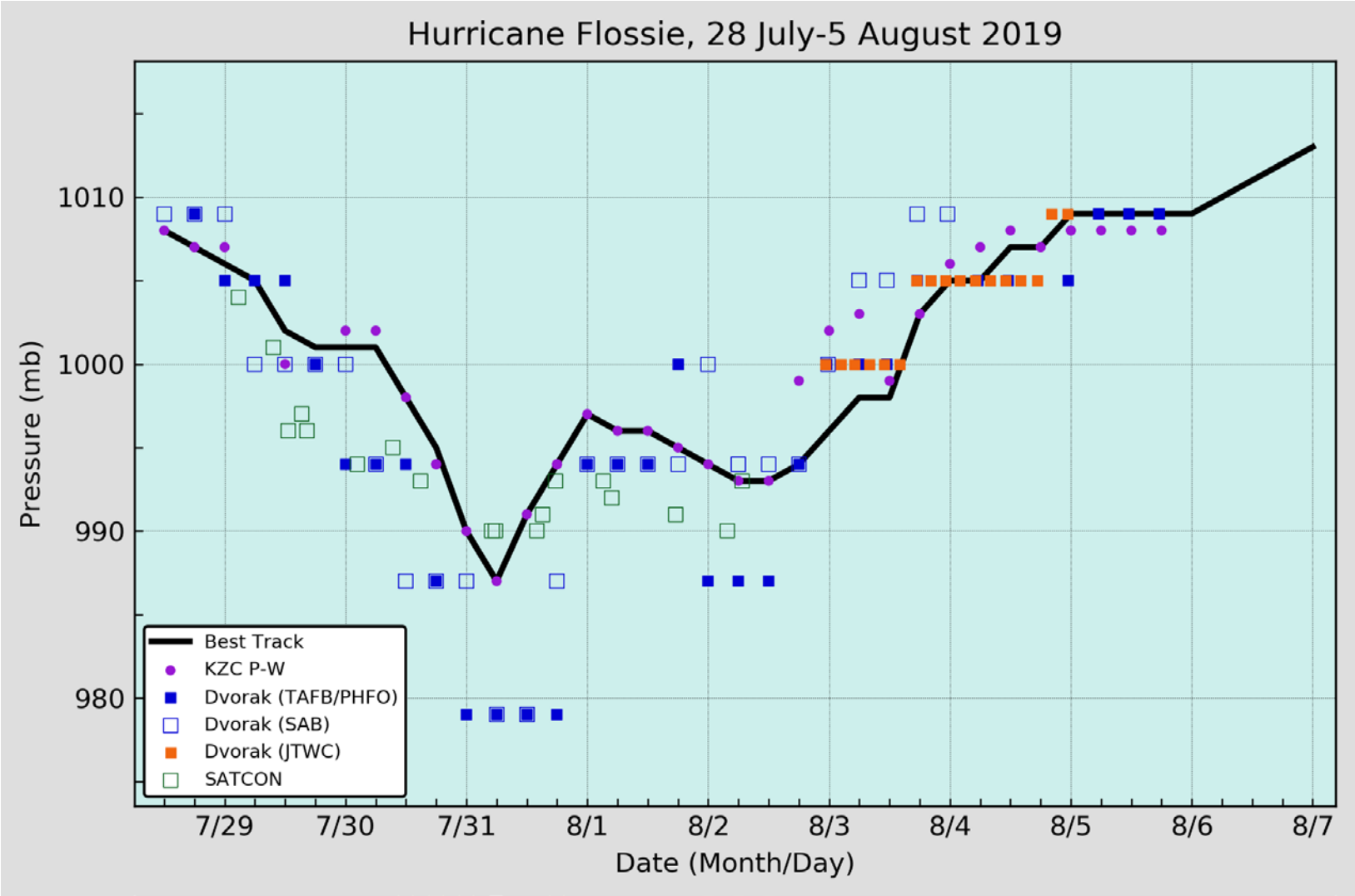


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Flossie, 28 July–5 August 2019. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

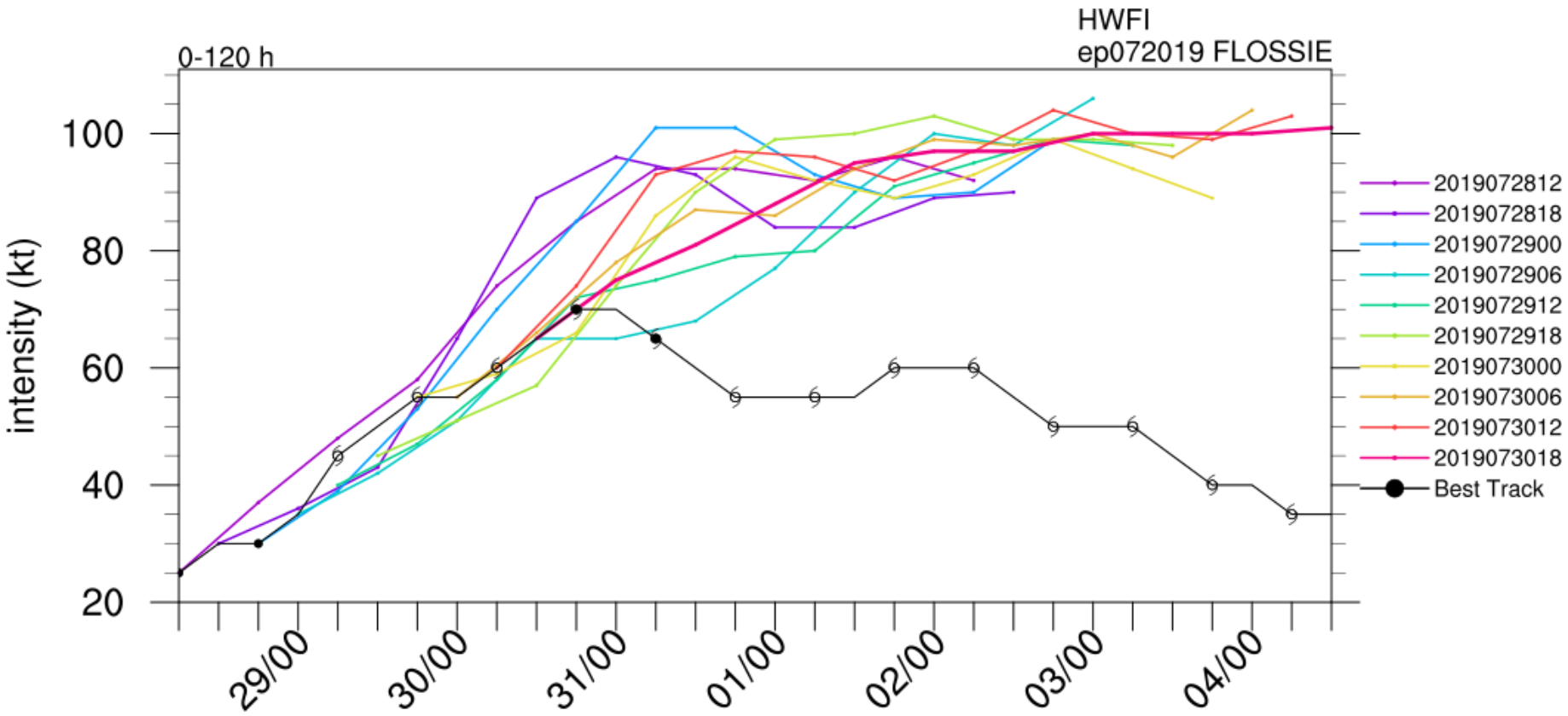


Figure 4. HWFI model intensity forecasts (kt, colors) and best track intensities (kt, black) for Hurricane Flossie.