NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE MIRIAM

(EP152018)

26 August–2 September 2018

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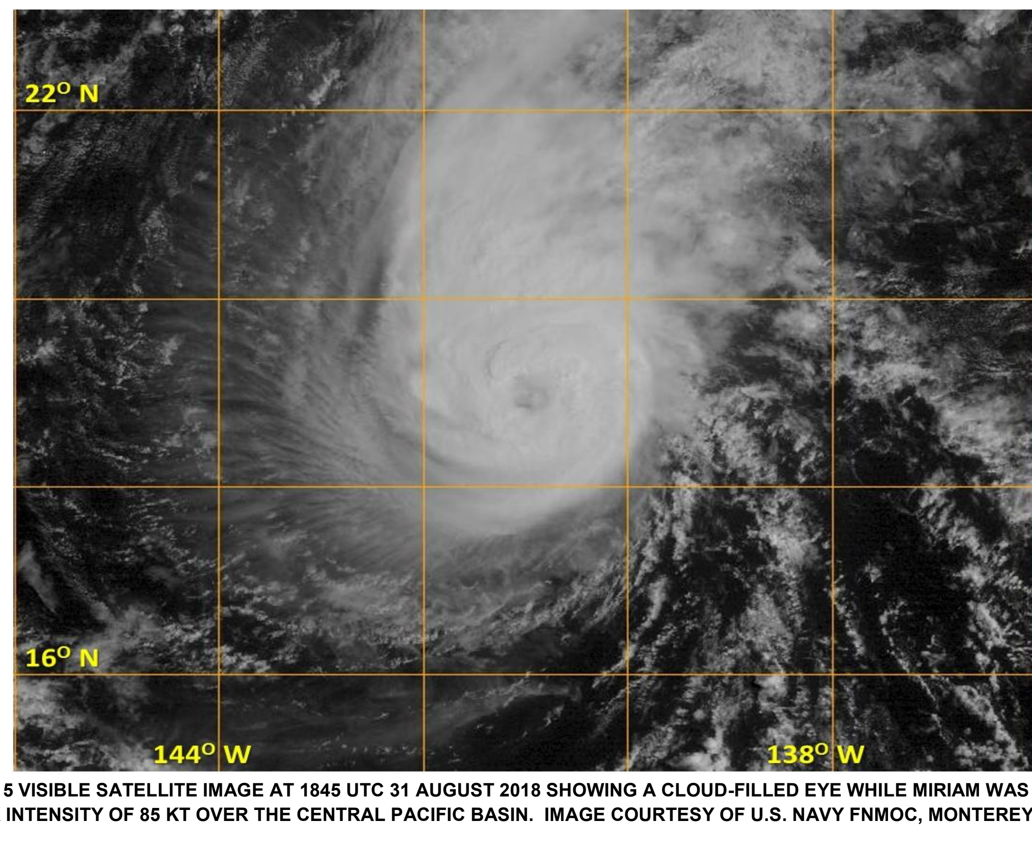

GOES-15 VISIBLE SATELLITE IMAGE AT 1845 UTC 31 AUGUST 2018 SHOWING A CLOUD-FILLED EYE WHILE MIRIAM WAS AT ITS PEAK INTENSITY OF 85 KT OVER THE CENTRAL PACIFIC BASIN. IMAGE COURTESY OF U.S. NAVY FNMOC, MONTEREY, CA.

Miriam was a category 2 hurricane (on the Saffir-Simpson Hurricane Wind Scale) that formed over the eastern North Pacific Ocean, crossed into the central North Pacific basin where it reached its peak intensity, and threatened no land areas during its lifetime.

Hurricane Miriam

26 AUGUST–2 SEPTEMBER 2018

SYNOPTIC HISTORY

Miriam originated from a tropical wave that emerged off the west coast of Africa on 11 August. The wave moved westward for the next 3 to 4 days, producing very little shower and thunderstorm activity. By 15–16 August, deep convection and its organization increased enough for the disturbance to be mentioned in the Atlantic Tropical Weather Outlook (TWO). However, entrainment of drier and more stable air coming from anomalously colder waters just to the north of the wave, in conjunction with modest easterly deep-layer vertical wind shear, caused the convection to wane significantly before the system moved across the southern Windward Islands on 17–18 August. Over the next two days, the wave maintained a westward motion over extreme northern South America and the southern Caribbean Sea, entering the eastern North Pacific basin by early 20 August. Upon encountering the active monsoon-like environment that was present over the eastern portion of the basin, deep convection began to gradually increase and a broad low pressure system formed along the wave axis by 23 August. The low moved west-northwestward over the next few days, and convection continued to increase and become better organized while the surface low became better defined. It is estimated that a tropical depression formed by 0600 UTC 26 August when the system was located about 980 n mi west-southwest of the southern tip of the Baja California peninsula. Steady development ensued and the depression reached tropical storm status 6 h later. 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[1].

Embedded within favorable conditions consisting of modest vertical wind shear of about 10 kt, a moist, unstable environment, and sea-surface temperatures (SST) $\geq$28°C, Miriam strengthened at the climatological rate of 20 kt/24 h, reaching an intensity of 55 kt by 1200 UTC 27 August while located about 1290 n mi west-southwest of the southern tip of the Baja California peninsula. Miriam turned westward later that day and maintained that motion for the next 48 h. During that time, northwesterly vertical wind shear increased to around 15 kt (Fig. 4), causing the strengthening trend to end, even though the cyclone had been moving through a generally favorable environment characterized by SSTs near 28°C and mid-level humidity values of 65–70%. By 1200 UTC 29 August, however, the shear began to decrease, resulting in a significant increase in organized deep convection near and around the previously exposed low-level circulation center. Modest strengthening resulted, with Miriam becoming a hurricane 6 h later when the cyclone was located about 900 n mi east-southeast of Hilo, Hawaii. The 65-kt hurricane

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[1] 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.

crossed 140°W longitude and moved into the central North Pacific basin around 0000 UTC 30 August.

Shortly after entering the central Pacific basin, Miriam turned quickly toward the northwest, followed by a northward motion late on 30 August, as the hurricane was steered between a large mid-level ridge over the southwestern United States and an upper-level trough centered northeast of Hawaii. Miriam gradually intensified on 30–31 August as it moved northward over warm SSTs and remained far enough away from the upper trough to take advantage of weak to moderate vertical wind shear. The cyclone reached a peak intensity of 85 kt around 1800 UTC 31 August, while located about 790 n mi east of Hilo, Hawaii.

Southwesterly deep-layer vertical wind shear strengthened to more than 30 kt during the subsequent 12-h period due to increasing proximity of the approaching upper-level trough. Miriam commenced a rapid weakening trend on 1 September (Fig. 4) as the combination of strong shear and cooler waters took a toll on the cyclone. Miriam weakened to a tropical storm by 1800 UTC 1 September when the low-level circulation center became completely exposed and began moving toward the northwest within southeasterly low-level flow. Southwesterly wind shear increased even further to greater than 50 kt on 2 September, preventing any deep convection from redeveloping near Miriam's exposed center. The cyclone weakened to a tropical depression by 1200 UTC 2 September, and was declared a post-tropical remnant low 6 h later when the system was located more than 700 n mi northeast of the Hawaiian Islands. The low maintained a northwestward motion during the next several hours, and dissipated around 0600 UTC 3 September when an ASCAT pass showed that the remnants of Miriam had degenerated into an open trough.

METEOROLOGICAL STATISTICS

Observations in Miriam (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) 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 Miriam.

Miriam's estimated peak intensity of 85 kt is based on a blend of Dvorak satellite intensity estimates of 90 kt from CPHC, JTWC, and SAB, and 78–80 kt from UW-CIMSS ADT and SATCON estimates. The estimated minimum pressure of 974 mb is based on the Knaff-Zehr-Courtney and SATCON pressure-wind relationships.

There were no land-based or ship reports of tropical-storm-force winds in association with Miriam areas of responsibility.

CASUALTY AND DAMAGE STATISTICS

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

FORECAST AND WARNING CRITIQUE

The genesis of Miriam was not forecast particularly well. The wave from which Miriam developed was introduced in the Tropical Weather Outlook only 78 h prior to genesis with a low probability (<40%) of formation in the 120-h forecast period. The probabilities were increased to the medium category (40–60%) 48 h prior to genesis, but were only increased into the high category (>60%) 6 h before Miriam formed (Table 2). In the 48-h forecast period, Miriam was introduced with a low probability of genesis 42 h prior to becoming a tropical cyclone. The short-range probabilities never reached the high category and only reached the medium category 6 h prior to formation. The cause of the poor genesis forecasts was the expectation that modest vertical wind shear, along with an elongation of the disturbance's surface wind field, would suppress tropical cyclone development until the day 4 and 5 periods.

A verification of NHC official track forecasts for Miriam is given in Table 3a. Official forecast track (OFCL) errors were lower than the mean official errors for the previous 5-yr period by 10–15% through 96 h and more than 30% at 120 h. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. NHC OFCL forecasts outperformed most individual dynamical models at nearly every forecast time period, with the exception of Naval Research Laboratory's COAMPS-TC model (CTCI). However, NHC official track forecasts were bested by all of the corrected-consensus models and the simple consensus models at nearly every forecast time.

A verification of NHC official intensity forecasts for Miriam is given in Table 4a. Official forecast intensity errors were comparable to the mean official errors for the previous 5-yr period at 12 h and 24 h, better than average at 96 h and at 120 h (52% better), but were significantly worse than the previous 5-yr mean errors at 36-72 h. The first few NHC OFCL intensity forecasts had a pronounced high bias at 36-72 h (Fig. 4), which was due to the GFS-based deep-layer vertical wind shear expected to be low (≤10 kt), which did not materialize until about 72 h after Miriam had formed. In contrast, the ECMWF-based shear was forecast to be higher (Fig. 5), an indication that strengthening would not have been as likely. Although the differences in the shear values between the two models are only 5–7 kt and might appear to be minor, shear values greater than 10 kt, such as those that were forecast by the ECMWF, can hinder development of small and weak tropical cyclones, especially when those systems are embedded within a marginal mid-level moisture environment. Subsequent NHC OFCL intensity forecasts, however, performed reasonably well by closely predicting the onset and magnitude of the weakening trend that began late on 31 August and continuing into 1 September.

A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. NHC OFCL intensity forecasts were better than all of the available dynamical and statistical-dynamical intensity guidance at the 12-, 96-, and 120-h periods. At 24–72 h, NHC

OFCL intensity forecasts were bested by nearly all of the model guidance, except for the HWRF (HWFI) and HMON (HMNI) models. Interestingly, the simple climatological model OCD5 outperformed not only the NHC OFCL forecasts at 12–72 h, but also most of the other more sophisticated intensity forecast models.

A verification of CPHC official track forecasts for Miriam is given in Table 5a. CPHC OFCL track errors were lower than the mean official errors for the previous 5-yr period (2013–17) for all forecast times. A homogeneous comparison of the official track errors with selected guidance models in given in Table 5b. The CTCI was the overall best performing track model, and had the lowest errors of any track model included in the homogeneous comparison for the 36 h, 48 h and 72 h forecast times. The HWFI also performed quite well, as did the consensus TCON and TVCE for all except the 72-h forecast time. Most of the track models, including many of the constituent models of the TCON and TVCE, had rather large errors, ranging from 130 n mi to over 220 n mi, for the 72-h forecast time. The ECMWF model (EMXI) performed quite poorly with Miriam's track, with the largest errors of any of the typically reliable guidance at the 12-h through 48-h forecast times. Analysis of individual official and guidance track forecasts (not shown) indicates that both were consistently left (to the south and west) of the observed best track during the time period of 30 August–1 September when Miriam was moving northward due to the nearby deep-layer trough. Miriam moved northward longer before turning back to the northwest than was depicted by both the model guidance and the official track forecasts.

A verification of CPHC official intensity forecasts for Miriam is given in Table 6a. The official forecast intensity error was slightly higher (<1-2 kt) than the mean official errors for the most recently available previous 5-yr period for the 12-h forecast time. The official forecast errors were lower than the mean errors for the previous 5-yr period from 24 h through 72 h. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 6b. The CTCI model was the best performing intensity forecast aid overall, with lower errors than the official intensity forecasts for the 12-, 36- and 48-h time periods, with mean errors less than 10 kt for all time periods. The consensus IVCN also performed quite well. The EMXI did not perform well, with mean errors greater than the other intensity guidance at 24 h and beyond, with mean errors near or greater than OCD5 at the 24-h through 48-h forecast times.

No coastal watches or warnings were required with Miriam.

ACKNOWLEDGEMENTS

Special thanks to John Cangialosi of the NHC Hurricane Specialist Unit for creating the best track map.

Table 1. Best track for Hurricane Miriam, 26 August–2 September 2018.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
25 / 1200	12.8	120.8	1009	25	low
25 / 1800	12.9	121.7	1009	25	"
26 / 0000	13.0	122.6	1009	30	"
26 / 0600	13.2	123.7	1008	30	tropical depression
26 / 1200	13.5	124.9	1005	35	tropical storm
26 / 1800	13.7	126.1	1004	40	"
27 / 0000	13.8	127.3	1002	45	"
27 / 0600	13.9	128.6	1000	50	"
27 / 1200	13.9	129.9	999	55	"
27 / 1800	14.0	131.1	999	55	"
28 / 0000	14.0	132.3	999	55	"
28 / 0600	14.1	133.5	999	55	"
28 / 1200	14.1	134.7	999	55	"
28 / 1800	14.1	135.8	1000	50	"
29 / 0000	14.1	136.9	1000	50	"
29 / 0600	14.0	137.9	999	55	"
29 / 1200	14.0	138.7	996	60	"
29 / 1800	14.0	139.4	992	65	hurricane
30 / 0000	14.1	140.1	988	65	"
30 / 0600	14.4	140.8	985	70	"
30 / 1200	14.9	141.3	985	70	"
30 / 1800	15.5	141.5	982	75	"
31 / 0000	16.1	141.5	981	75	"
31 / 0600	16.9	141.5	978	80	"
31 / 1200	17.8	141.3	978	80	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
31 / 1800	18.7	141.2	974	85	"
01 / 0000	19.7	140.9	974	85	"
01 / 0600	20.7	141.0	980	75	"
01 / 1200	21.8	141.1	986	65	"
01 / 1800	22.8	141.3	997	50	tropical storm
02 / 0000	23.8	142.0	1004	40	"
02 / 0600	24.7	142.8	1005	35	"
02 / 1200	25.4	143.7	1006	30	tropical depression
02 / 1800	26.0	144.3	1008	30	low
03 / 0000	26.8	145.3	1009	30	"
03 / 0600					dissipated
31 / 1800	18.7	141.2	974	85	maximum intensity and minimum pressure

Table 2. Number of hours in advance of Miriam's formation associated with the first NHC Tropical Weather Outlook forecast in the indicated likelihood category. Note: 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	78
Medium (40%-60%)	6	48
High (>60%)	0	6

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (NHC-OCD5) track forecast errors (n mi) for Miriam. 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	**19.3**	**29.9**	**36.3**	**47.3**	**68.1**	**76.5**	**100.5**
OCD5	29.0	62.5	106.8	169.7	328.8	457.1	459.7
Forecasts	15	15	15	15	15	14	10
OFCL (2013-17)	21.8	33.2	43.0	53.9	80.7	111.1	150.5
OCD5 (2013-17)	34.9	70.7	109.1	146.1	213.8	269.0	339.7

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Miriam for forecasts originating 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	21.1	31.2	34.7	46.0	70.5	82.9	115.4
OCD5	29.7	63.6	109.9	180.3	354.0	491.1	503.2
GFSI	26.1	40.6	43.0	50.7	86.7	152.9	142.8
EMXI	**20.0**	**31.0**	44.5	66.4	128.2	196.6	327.3
CMCI	40.0	78.6	114.4	154.2	250.2	371.4	496.1
NVGI	32.1	53.3	71.5	96.6	148.8	202.8	252.6
AEMI	23.0	34.3	38.5	**45.8**	**65.5**	113.0	132.3
HMNI	24.2	40.7	51.4	56.9	**70.0**	93.8	**56.7**
HWFI	33.5	51.9	59.6	57.4	**63.2**	145.3	241.6
EGRI	**20.4**	**27.4**	**34.0**	47.7	100.7	157.9	236.9
CTCI	**20.5**	**31.1**	**32.3**	**29.4**	**23.0**	**71.0**	118.0
HCCA	21.5	31.5	**33.4**	**39.5**	**53.9**	**67.1**	**80.4**
FSSE	**20.4**	33.5	39.1	**45.8**	**60.0**	**79.9**	**74.6**
TVCE	22.1	33.0	35.4	**38.1**	**55.8**	**70.6**	**63.7**
TVCX	21.7	**30.8**	**33.1**	**37.8**	**59.2**	**72.7**	**88.1**
TCON	23.8	33.4	**33.6**	**31.1**	**51.5**	**82.1**	**72.9**
GFEX	21.7	34.5	39.2	48.6	73.4	85.1	118.3
TABD	**20.9**	34.1	55.8	83.0	146.1	244.8	256.7
TABM	22.1	30.6	45.8	59.6	81.3	88.8	**87.3**
Forecasts	11	11	11	11	11	10	6

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (NHC-OCD5) intensity forecast errors (kt) for Miriam. 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	**4.7**	9.7	15.3	22.0	18.3	**9.6**	**7.5**
OCD5	4.2	7.5	10.1	11.7	11.7	15.9	19.8
Forecasts	15	15	15	15	15	14	10
OFCL (2013-17)	5.8	9.6	11.8	13.2	15.1	15.1	14.6
OCD5 (2013-17)	7.6	12.4	15.6	17.7	19.8	20.8	19.6

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Miriam for forecasts originating 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	4.5	11.4	16.8	23.6	18.6	7.5	7.5
OCD5	**4.1**	**7.5**	**10.5**	**13.6**	**13.2**	18.2	20.5
HWFI	6.5	16.4	23.8	26.2	24.5	11.2	8.8
HMNI	6.5	15.5	25.5	30.8	20.7	12.9	15.7
CTCI	5.5	**6.8**	**7.1**	**10.4**	**12.0**	8.7	**6.5**
DSHP	5.4	**9.7**	**12.5**	**16.8**	**16.5**	15.2	13.0
LGEM	4.8	**7.6**	**10.5**	**15.4**	19.5	19.7	20.7
ICON	5.3	**11.1**	**16.2**	**20.3**	**18.2**	10.6	9.3
IVCN	5.3	**10.0**	**13.6**	**16.7**	**15.1**	8.4	7.8
HCCA	6.5	13.5	**15.2**	**17.6**	**18.0**	**6.4**	**5.8**
FSSE	5.5	12.2	18.3	**23.1**	19.0	8.1	9.2
GFSI	6.2	**9.8**	**12.6**	**15.8**	**12.7**	8.1	9.5
EMXI	4.5	**5.5**	**9.0**	**13.7**	**11.9**	13.4	14.3
Forecasts	11	11	11	11	11	10	6

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

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**14.5**	**23.2**	**35.0**	**61.3**	**112.8**		
OCD5	45.1	112.1	198.0	304.6	572.1		
Forecasts	13	11	9	7	3		
OFCL (2013-17)	28.2	43.2	58.0	75.6	121.0	163.2	208.4

Table 5b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Miriam for forecasts originating 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	14.5	23.2	35.0	61.3	112.8		
OCD5	45.1	112.1	198.0	304.6	572.1		
FSSE	17.2	33.4	49.3	75.2	**97.7**		
HWFI	15.1	25.3	**32.5**	**49.4**	**98.1**		
HMNI	16.8	30.8	59.4	83.7	134.4		
GFSI	**12.2**	25.1	39.8	64.1	155.9		
AEMI	17.7	33.1	55.2	76.8	120.6		
EGRI	16.7	**21.8**	**26.4**	**51.9**	220.9		
EMXI	29.5	61.2	99.8	132.7	128.9		
CTCI	17.8	**22.4**	**25.1**	**42.8**	**62.4**		
TCON	**12.1**	**19.7**	**27.9**	**51.9**	153.4		
TVCE	**13.3**	24.6	40.5	64.2	113.9		
GFEX	18.3	38.6	61.7	88.9	113.7		
TVCX	**13.7**	28.2	42.3	67.2	114.4		
TABD	60.4	134.2	220.4	294.8	446.5		
TABM	34.9	65.1	93.2	112.7	124.7		
TABS	39.2	80.0	125.8	185.9	378.2		
Forecasts	13	11	9	7	3		

Table 6a. CPHC official (OFCL) and climatology-persistence skill baseline (CPHC-OCD5) intensity forecast errors (kt) for Miriam. Mean OFCL errors for the most recently available 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	6.2	**8.2**	**11.1**	**10.7**	**3.3**		
OCD5	6.6	13.6	16.0	17.1	25.3		
Forecasts	13	11	9	7	3		
OFCL (2013-17)	5.6	9.0	11.3	12.9	15.7	17.4	18.9

Table 6b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Miriam for forecasts originating 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	6.2	8.2	11.1	10.7	3.3		
OCD5	6.6	13.6	16.0	17.1	25.3		
FSSE	**4.9**	8.3	12.4	13.4	5.7		
HWFI	6.6	8.9	12.7	15.1	**3.0**		
GFSI	**4.9**	11.7	13.9	14.0	5.3		
EMXI	6.3	13.6	15.7	19.3	15.7		
CTCI	**4.1**	9.2	**8.6**	**5.7**	4.3		
ICON	**4.5**	9.5	13.3	12.4	**2.3**		
IVCN	**3.9**	**7.2**	**10.3**	11.1	**3.0**		
DSHP	**4.2**	10.1	12.9	**10.3**	**2.0**		
LGEM	**5.5**	11.1	13.9	13.6	7.0		
Forecasts	13	11	9	7	3		

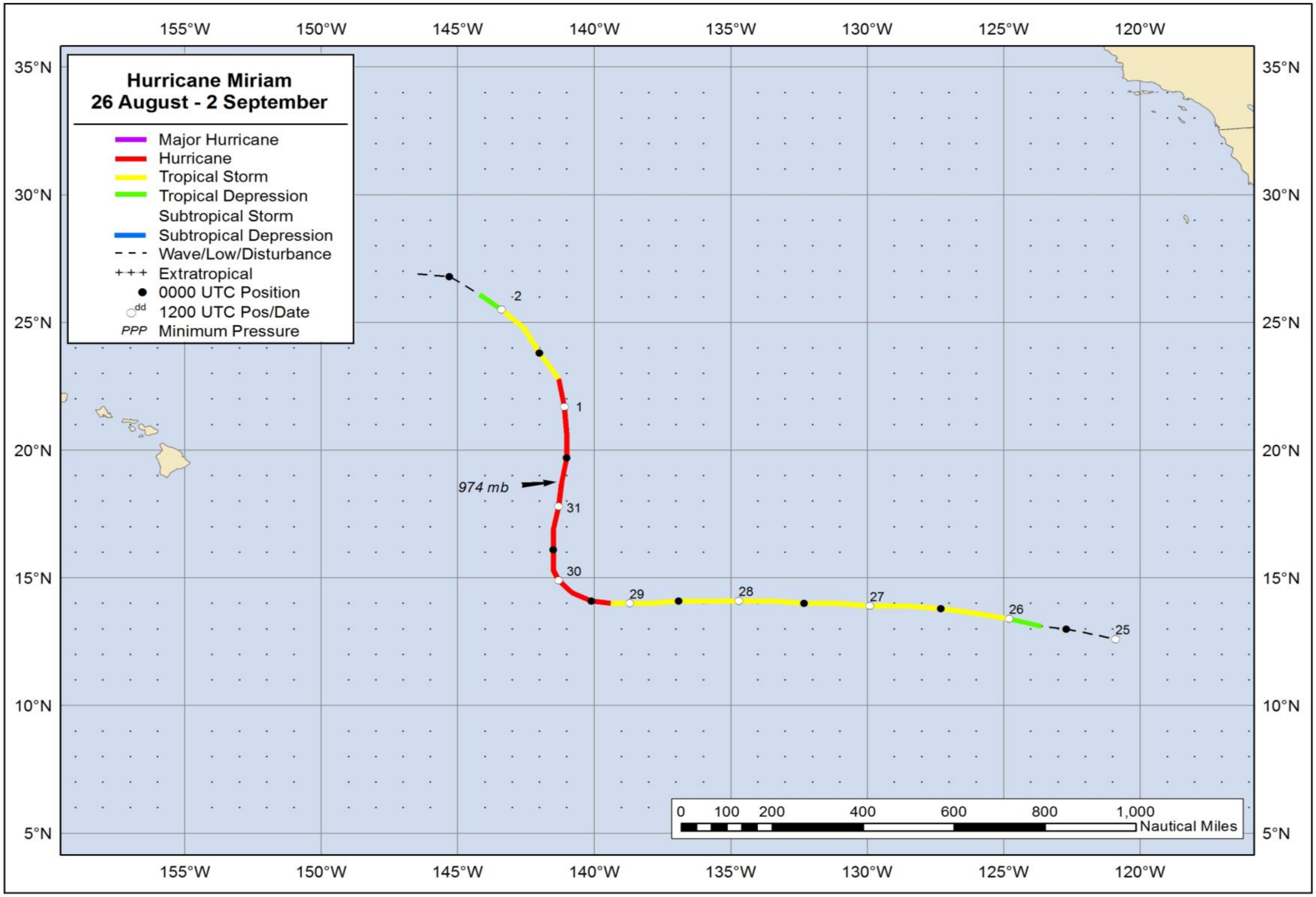

Figure 1. Best track positions for Hurricane Miriam, 26 August–2 September 2018.

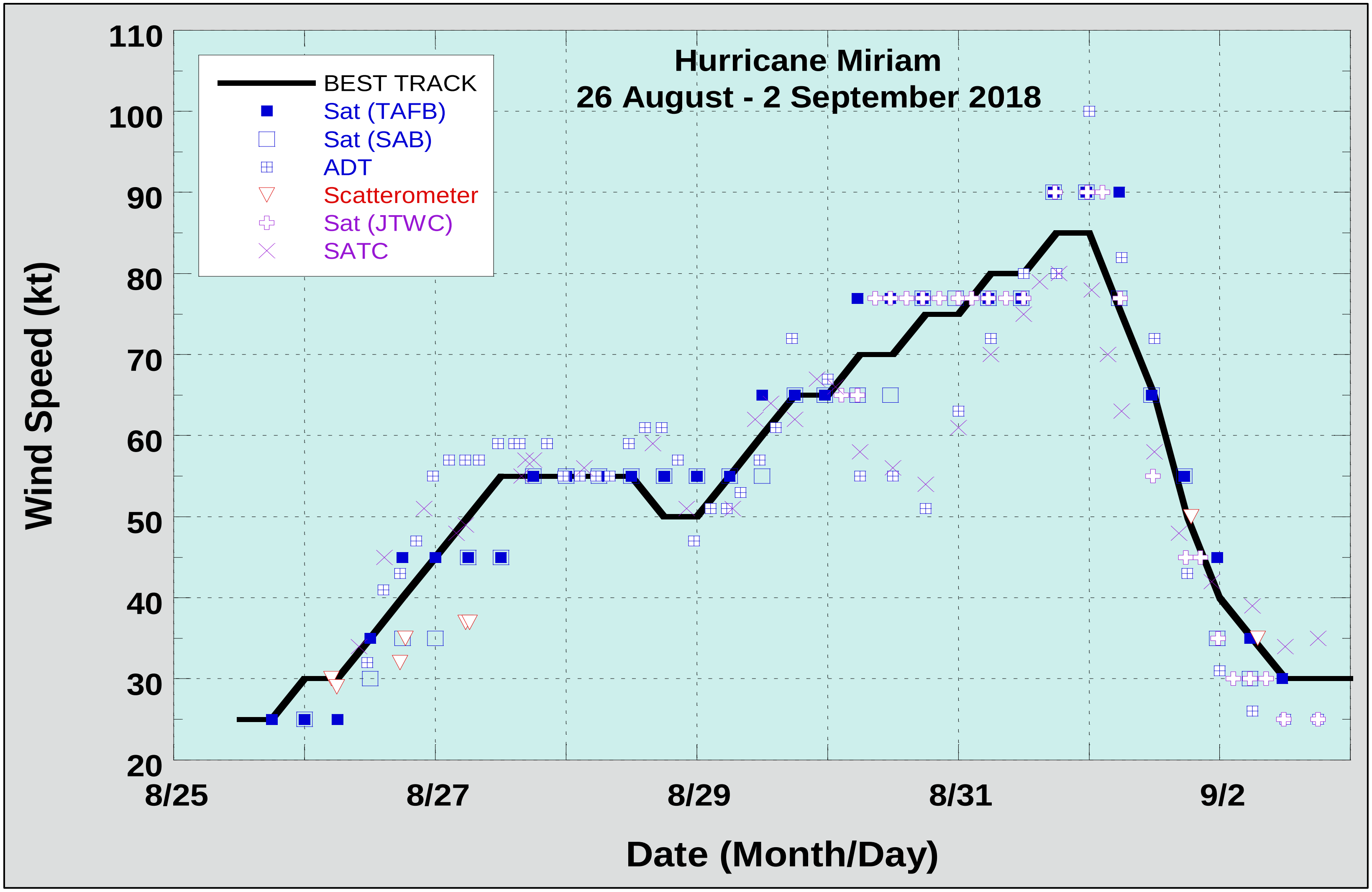

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Miriam, 26 August–2 September 2018. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC.

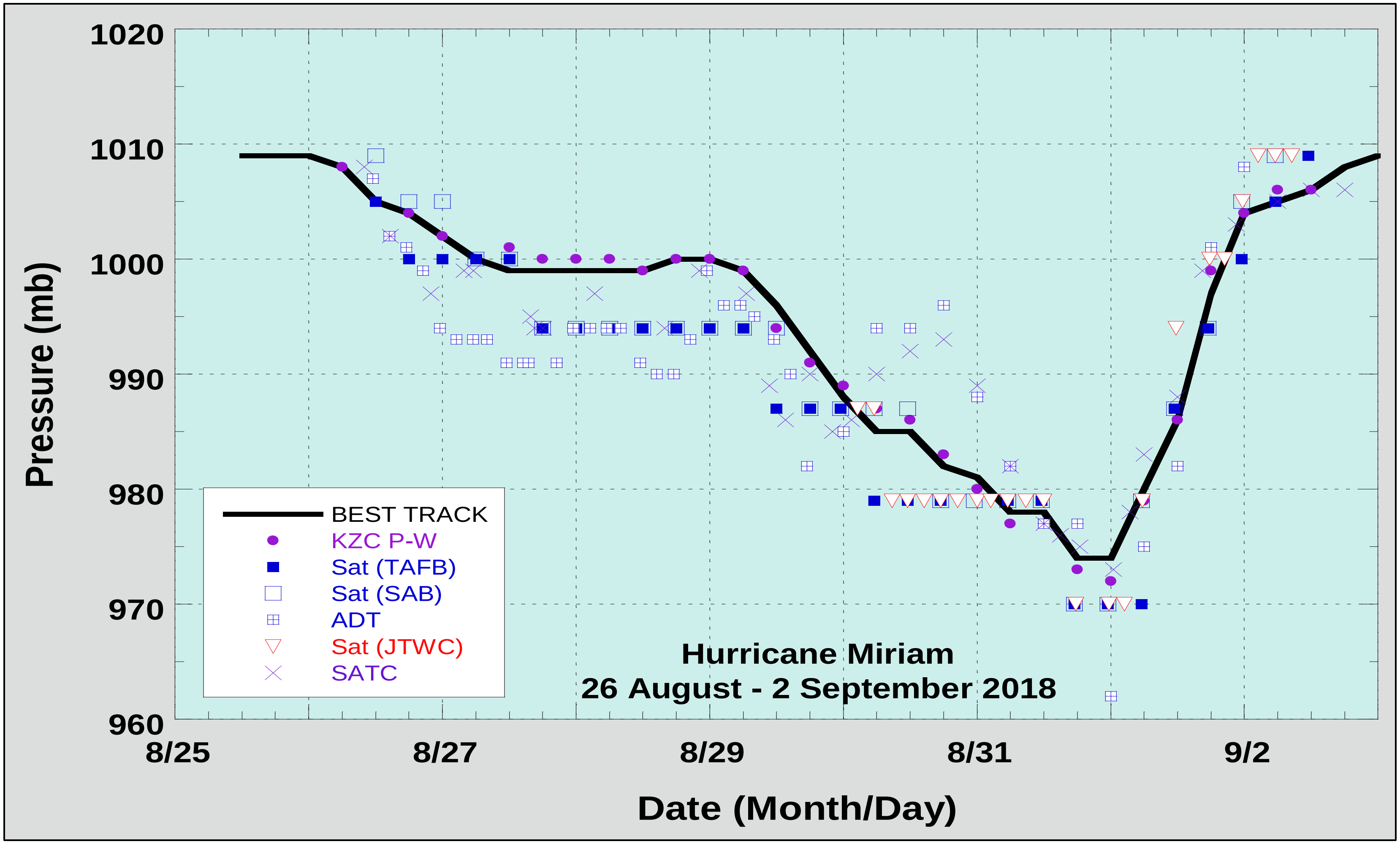

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Miriam, 26 August–2 September 2018. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for 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.

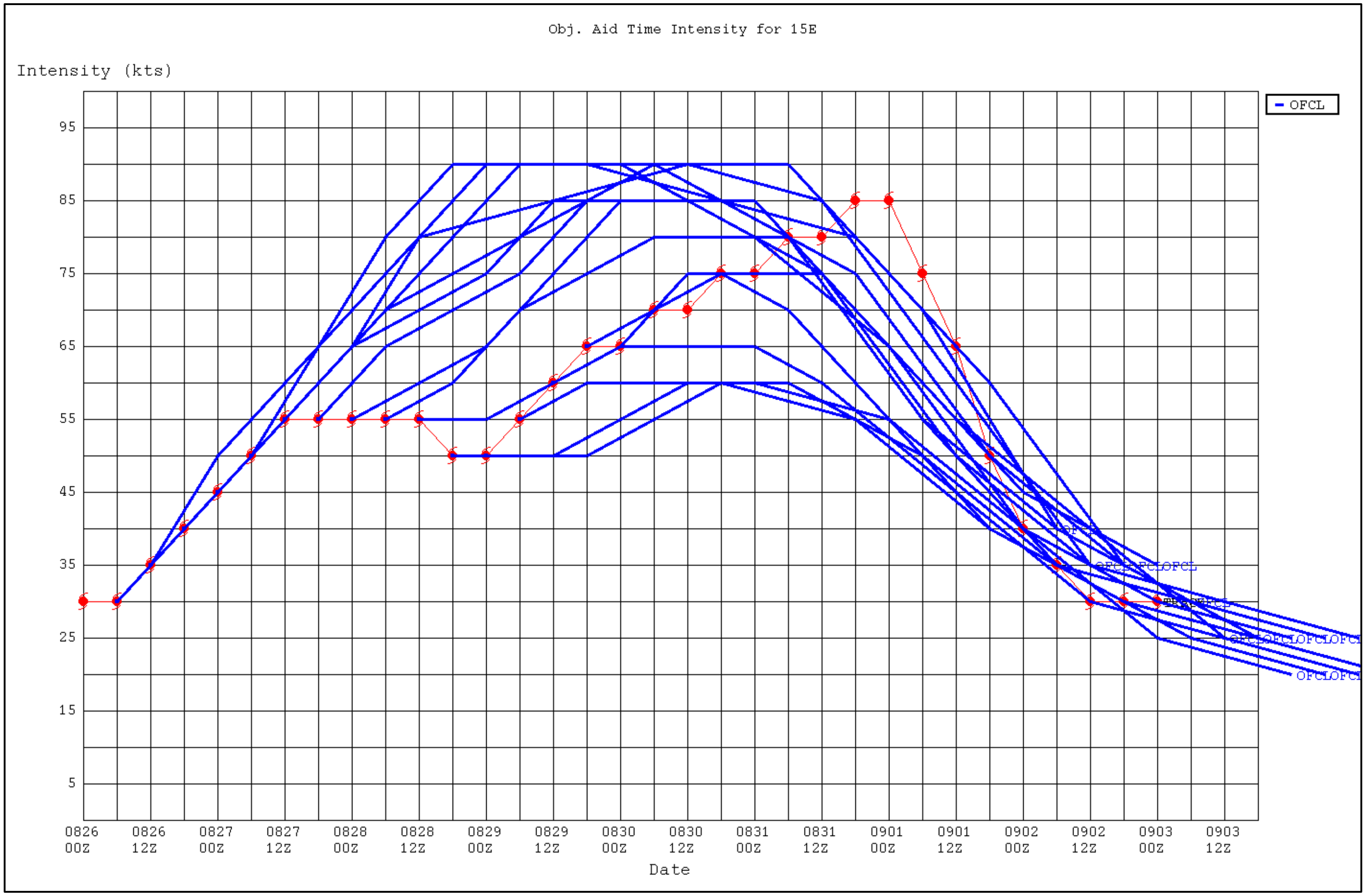

Figure 4. Selected NHC official intensity forecasts (kt, solid blue lines) for Hurricane Miriam issued on 26–29 August 2018. The best track intensity (kt) is indicated by the red line with hurricane symbols at 6-h intervals.

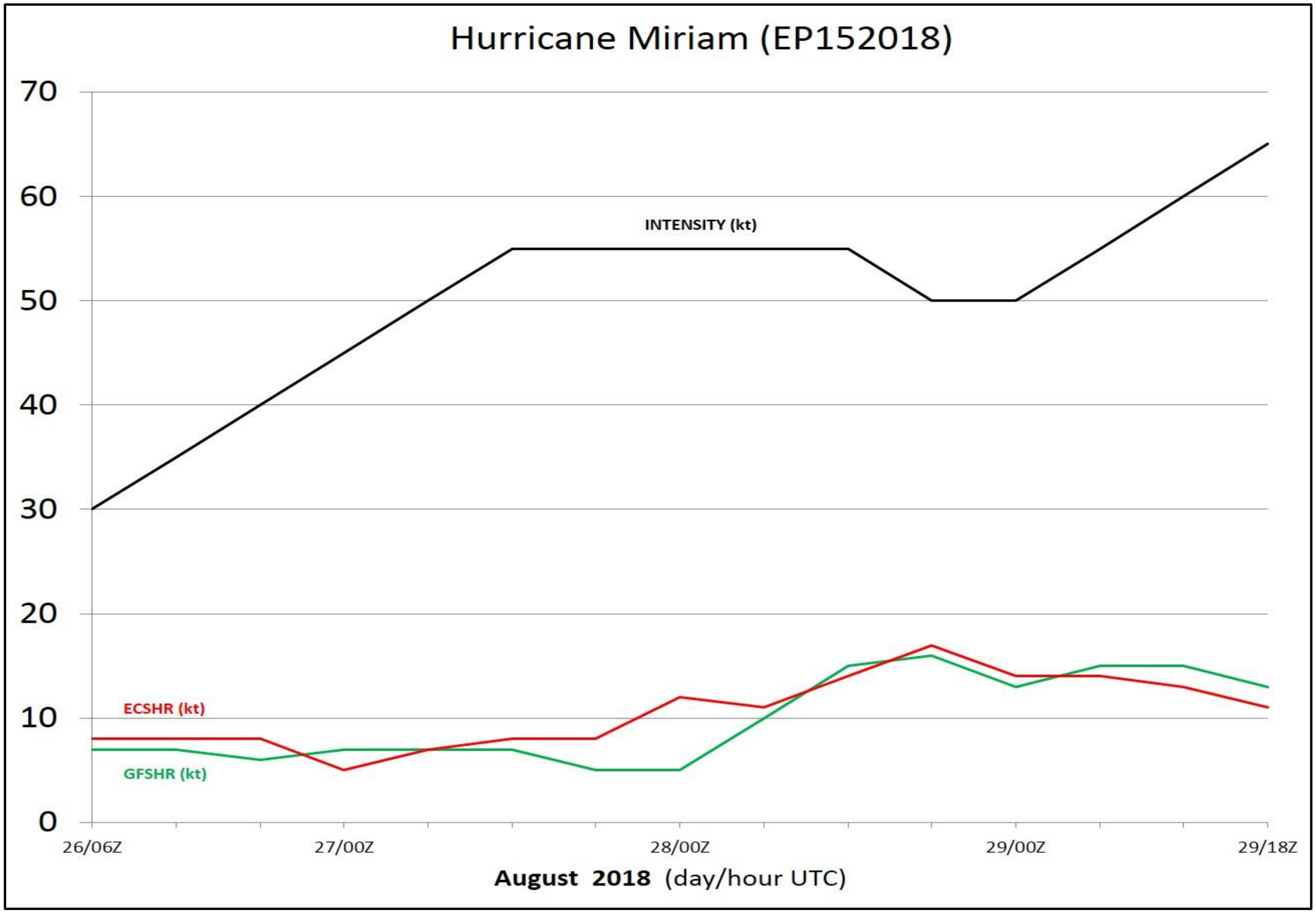

Figure 5. Graph of Miriam's intensity versus GFS- (green/GFSHR) and ECMWF-based (red/ECSHR) 850–200-mb vertical wind shear analyses (kt) derived from the NHC Statistical Hurricane Intensity Prediction Scheme (SHIPS) model during the period 26–29 August 2018 when the cyclone was in the eastern Pacific basin east of 140°W. The GFS and ECMWF shear analyses (and prior forecasts) diverged, with the GFS (ECMWF) showing decreasing (increasing) shear values, between 0600 UTC 27 August and 0600 UTC 28 August, roughly during the period when Miriam's intensity leveled off.