NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE NORMAN

(EP162018)

28 August–8 September 2018

Daniel P. Brown
National Hurricane Center
Jeff Powell
Central Pacific Hurricane Center
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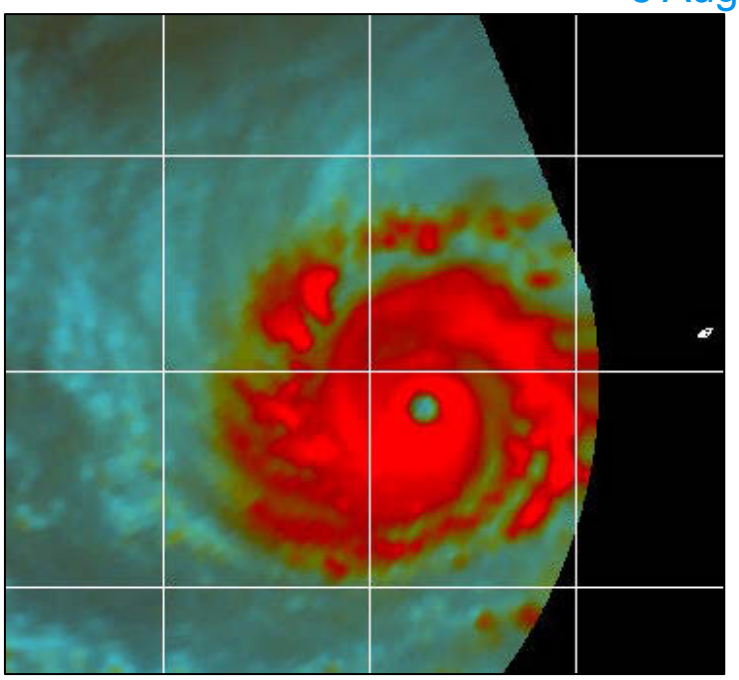

89-GHZ COLOR COMPOSITE IMAGE OF HURRICANE NORMAN AT 1151 UTC 30 AUGUST FROM THE GLOBAL PRECIPITATION MEASUREMENT (GPM) SATELLITE NEAR THE TIME OF NORMAN'S PEAK INTENSITY. IMAGE COURTESY OF THE FLEET NUMERICAL METEOROLOGY AND OCEANOCGRAPHY CENTER (FNMOC).

Norman was a category 4 hurricane (on the Saffir-Simpson Hurricane Wind Scale) that went through multiple rapid strengthening phases over the eastern and central North Pacific basins. Norman passed east of the Hawaiian Islands before becoming a post-tropical cyclone.

[1] Original report date 8 February 2019. Updated 24 June 2019 to include analyses from CPHC.

Hurricane Norman

28 AUGUST–8 SEPTEMBER 2018

SYNOPTIC HISTORY

The precursor disturbance from which Norman formed was a tropical wave that departed the west coast of Africa on 14 August. The wave moved westward across the tropical Atlantic with limited shower activity. On 22 August, the wave crossed Central America and reached the far eastern Pacific Ocean later that day, where the associated shower and thunderstorm activity began to increase. A broad low pressure area formed in association with the wave a couple of days later when the system was located several hundred n mi south of Acapulco, Mexico. The broad low moved westward to west-northwestward to the south and southwest of the southern coast of Mexico, and by 27 August scatterometer data indicated that the circulation became better defined. Early the next day, the associated deep convection increased and became better organized, and it is estimated that a tropical depression formed by 1200 UTC 28 August when the system was located about 425 n mi west-southwest of Manzanillo, Mexico. The depression moved northwestward and strengthened into a tropical storm 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[2].

After development, Norman turned west-northwestward to the south of a subtropical ridge that extended westward across the eastern Pacific from northwestern Mexico. The tropical cyclone was located within a very favorable environment consisting of low vertical wind shear, a moist mid-level atmosphere, and warm 29–30°C waters. As a result, the storm began a 48-h period of rapid strengthening around 1800 UTC 28 August. Norman became a 65-kt hurricane 24 h later and reached its estimated peak intensity of 130 kt at 1800 UTC 30 August (cover photo), when it was located about 450 n mi southwest of the southern tip of the Baja California peninsula. The largest 24-h increase in intensity during that period occurred between 1200 UTC 29 August and 1200 UTC 30 August, when Norman's wind speed increased by 70 kt (55 to 125 kt). During the period of rapid strengthening, the hurricane turned westward, then west-southwestward as the subtropical ridge strengthened and built westward to the north of the system.

The next day, an increase in northeasterly shear caused the cyclone to gradually weaken while it continued to move west-southwestward. Norman weakened to a 90-kt (category 2) hurricane by 0600 UTC 1 September, and then remained at that intensity through 0000 UTC 2 September. The hurricane turned west-northwestward and the shear relaxed shortly thereafter, while Norman traversed sea surface temperatures of 27–28°C. As a result,

[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.

the storm began to rapidly re-strengthen, and it became a category 3 hurricane again by 1200 UTC 2 September, reaching a second peak intensity of 120 kt (category 4) 6 h later. Shortly thereafter, while moving at an atypically fast forward speed of 16–18 kt toward the west-northwest, Norman began to gradually weaken as it moved over slightly cooler waters. The hurricane weakened below major hurricane strength at 1800 UTC 3 September and moved into the central Pacific basin (west of 140°W longitude) as a 80-kt hurricane shortly after 0000 UTC 4 September. The hurricane was the fourth tropical cyclone to cross into the central Pacific basin from the eastern Pacific in 2018.

Norman initially moved westward in the central Pacific along the southern flank of a strong subtropical ridge to its north and northeast. Norman continued to gradually weaken as it passed over marginally warm SSTs and the eye became cloud filled. However, about 24 hours after entering the central Pacific, Norman moved over warmer SSTs and remained within an area of low vertical wind shear, this allowed the hurricane to rapidly strengthened and the cyclone reached an intensity of 105 kt by 1800 UTC 05 September. Norman maintained this intensity through 0600 UTC 06 September, developing a well-defined eye, before beginning its final decline. By 1200 UTC 06 September, the system moved away from the higher SST area and the vertical wind shear increased to 20 kt or more. Norman turned northwesterly as it began to round the southwestern portion of the subtropical ridge and its forward increased slightly. The cyclone weakened below hurricane strength at 1800 UTC 07 September, when it was located several hundred miles northeast of the Hawaiian Islands. After that time, the vertical shear became strong and the low-level center became exposed which resulted in additional weakening. Norman turned northward between the subtropical ridge to its east and a mid- to upper-level low to its west. The system lost its tropical characteristics by 0000 UTC 9 September but the gradient flow between the ridge and the cutoff low caused the system to maintain gale-force winds around the northern portion of the circulation. The post-tropical low turned north-eastward and maintained gale-force winds until dissipation occurred by 1200 UTC 10 September about 700 n mi north-northeast of the Hawaiian Islands.

METEOROLOGICAL STATISTICS

Observations in Norman (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), the Satellite Analysis Branch (SAB), the Central Pacific Hurricane Center (HFO), the Joint Typhoon Warning Center (JTWC), 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 Norman. The NOAA G-IV aircraft flew a couple of synoptic surveillance missions around Norman releasing dropwindsondes while the hurricane was over the central Pacific basin to provide additional data for the numerical models to support forecast operations at the Central Pacific Hurricane Center. An Air Force Reserve C-130

aircraft from the 53rd Weather Reconnaissance Squadron that was flying to Hawaii in support of missions into Hurricane Olivia briefly flew through Norman when it was a tropical storm, helping to define the radius of tropical storm force winds at that time.

Norman's estimated peak intensity of 130 kt is based on a blend of subjective Dvorak classifications of T6.0 (115 kt) from TAFB and SAB, and ADT intensity estimates that peaked at T6.8 (135 kt) around 1800 UTC 30 August, and a couple of SATCON estimates of 130 kt from 1431 and 1705 UTC 30 August. The TAFB Dvorak Final T-number at 1200 UTC 30 August was constrained due to Dvorak rules, although the data T-number was analyzed at T6.5. Norman's 70-kt increase in wind speed between 1200 UTC 29 August and 1200 UTC 30 August is the largest 24-h increase in intensity in the eastern Pacific basin since Hurricane Patricia (2015).

Sustained winds of 33 kt with a gust to 39 kt were reported at an automated observing site on Clarion Island at 1515 UTC 29 August when the center of then Tropical Storm Norman passed about 50 n mi southwest of the island. The station reported a minimum pressure of 1002.2 mb at 1300 UTC that day.

There were no ship reports of winds of tropical storm force in association with Norman.

CASUALTY AND DAMAGE STATISTICS

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

FORECAST AND WARNING CRITIQUE

While the genesis of Norman was anticipated only a few days in advance, the short-term forecasts were very good. The disturbance from which Norman formed was introduced in the Tropical Weather Outlook with a low (<40%) chance of development during the next 5 days at 0600 UTC 25 August, a little more than 3 days before genesis. The 5-day chance of development was raised to the medium category (40–60%) at 1800 UTC 25 August and to the high category at 0600 UTC 26 August, a little more than 2 days before formation. The 2-day chance of formation reached the medium category 54 h before development, and the high category 30 h before formation.

A verification of NHC official track forecasts for Norman is given in Table 3a. Official forecast track errors were slightly higher than the mean official errors for the previous 5-yr period, except at 12 and 120 h. The OCD5 errors were significantly larger than their 5-yr means, suggesting that the track forecasts for Norman were more difficult than normal. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. None of the individual dynamical models exhibited lower track errors than the official forecast through 36 h. The GFS (GFSI) was the best dynamical model at 48 h and beyond and had a mean 5-day track error of 104.6 n mi. The GFS ensemble mean (AEMI) also preformed quite well and had lower errors than the NHC track forecasts at 48 h and beyond, but its errors

were slightly larger than the deterministic GFSI at 72 through 120 h. Most of the various consensus aids had mean errors lower than the official forecasts at some lead times. The overall best performing consensus aids for Norman were the HFIP corrected consensus model (HCCA) through 36 h, and the GFS/ECMWF consensus (GFEX) at 48 h and beyond. The GFEX model had mean track errors of only 72 n mi at 96 h and 96.5 n mi at 120 h.

A verification of NHC official intensity forecasts for Norman is given in Table 4a. Official forecast intensity errors were greater than the mean official errors for the previous 5-yr period, with the largest errors as compared to the long-term mean at 36 and 48 h. The OCD5 intensity errors were also significantly higher than the long-term means, suggesting that the intensity forecasts for Norman were more difficult than normal. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. The HMNI and HWFI models had lower mean errors than the NHC forecast at nearly all lead times beyond 12 h. Several of the intensity consensus aids also bested the official forecast at various times through 48 h, with the HCCA model also exhibiting lower mean errors at 96 and 120 h. Beginning with the third NHC advisory that was issued at 0300 UTC 29 August when Norman was estimated to be a 45-kt tropical storm, the official forecast correctly predicted that rapid strengthening (a 30-kt increase in intensity over 24 h) would occur, and predicted a 48-h intensity of 110 kt (the verifying intensity was 130 kt). Although the NHC forecast and the dynamical hurricane models (HWRF and HMON) generally predicted this period of rapid intensification, the NHC forecast and the dynamical model guidance did not accurately predict the weakening that occurred shortly after Norman reached its peak intensity (Fig. 4). The NHC forecast and most of the model guidance also did not anticipate Norman's re-strengthening on 2 September or its final peak in intensity over the central Pacific basin on 5–6 September. These unanticipated changes in strength led to the higher-than-average NHC intensity errors. Also contributing to the large NHC intensity errors were the poor performance of the DSHP and LGEM statistical models, which exhibited a significant low bias and did not capture any of the periods of significant strengthening very well (Fig. 5).

A verification of CPHC official track forecasts for Norman is given in Table 5a. CPHC track errors for Norman were smaller than its five-year average at all forecast times. A homogeneous comparison of the CPHC track forecast errors with selected guidance models is given in Table 5b. In general, CPHC performed better than most global and regional dynamic models including the GFS, EMXI, CMCI, and NVGI. Ensemble and consensus models like HCCA, TCON and TVCE had lower mean errors than the CPHC forecast. The top performing consensus model was HCCA, which bested the CPHC track forecast at all times.

A verification of CPHC official intensity forecasts for Norman is given in Table 6a. CPHC intensity errors for Norman were near the long term mean through 36 h and smaller than the long-term mean from 48-96 h. A homogeneous comparison of CPHC intensity errors with selected guidance models is given in Table 6b. The CPHC intensity forecasts performed quite well, with lower mean errors than the LGEM and DSHP models at all forecast times. The ICON and IVCN intensity consensus models performed better than CPHC only at the 36 hour forecast point. The dynamical models HMNI and HWFI performed better than CPHC at multiple forecast times and the global models EMXI and GFSI performed better than the official forecasts at 72 and 96 hours.

There were no coastal watches or warnings issued in either the eastern or central Pacific basins for Norman.

Table 1. Best track for Hurricane Norman, 28 August–8 September 2018.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage*
27 / 1800	14.6	109.4	1008	25	low
28 / 0000	15.3	110.3	1007	25	"
28 / 0600	16.0	111.0	1006	25	"
28 / 1200	16.7	111.7	1006	30	tropical depression
28 / 1800	17.2	112.5	1004	35	tropical storm
29 / 0000	17.4	113.4	1000	45	"
29 / 0600	17.5	114.3	999	50	"
29 / 1200	17.6	115.1	995	55	"
29 / 1800	17.7	115.7	988	65	hurricane
30 / 0000	17.7	116.3	982	75	"
30 / 0600	17.7	117.0	968	95	"
30 / 1200	17.7	117.7	941	125	"
30 / 1800	17.6	118.4	937	130	"
31 / 0000	17.4	119.2	937	130	"
31 / 0600	17.1	119.9	940	125	"
31 / 1200	16.8	120.5	949	115	"
31 / 1800	16.6	121.1	953	110	"
01 / 0000	16.4	121.8	961	100	"
01 / 0600	16.3	122.5	970	90	"
01 / 1200	16.2	123.3	970	90	"
01 / 1800	16.2	124.3	970	90	"
02 / 0000	16.5	125.5	970	90	"
02 / 0600	16.9	126.7	966	95	"
02 / 1200	17.4	128.3	950	115	"
02 / 1800	17.9	130.0	947	120	"
03 / 0000	18.4	131.8	950	115	"
03 / 0600	18.8	133.8	954	110	"
03 / 1200	19.1	135.7	963	100	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage*
03 / 1800	19.4	137.6	970	90	"
04 / 0000	19.7	139.4	978	80	"
04 / 0600	19.9	141.0	982	75	"
04 / 1200	19.9	142.6	982	75	"
04 / 1800	19.8	143.9	984	70	"
05 / 0000	19.8	145.1	984	70	"
05 / 0600	19.6	146.1	978	80	"
05 / 1200	19.5	147.2	962	100	"
05 / 1800	19.6	148.0	960	105	"
06 / 0000	19.8	148.8	960	105	"
06 / 0600	20.1	149.5	958	105	"
06 / 1200	20.5	150.2	960	100	"
06 / 1800	21.0	150.6	963	95	"
07 / 0000	21.6	151.1	970	85	"
07 / 0600	22.1	151.6	976	75	"
07 / 1200	22.8	152.1	983	65	"
07 / 1800	23.7	152.6	989	60	tropical storm
08 / 0000	24.6	153.1	991	60	"
08 / 0600	25.1	153.5	995	55	"
08 / 1200	25.7	154.1	998	50	"
08 / 1800	26.4	154.4	1000	45	"
09 / 0000	27.1	154.1	1000	45	extratropical
09 / 0600	27.9	153.9	1000	45	"
09 / 1200	28.6	153.9	1000	45	"
09 / 1800	29.6	153.5	1002	40	"
10 / 0000	30.8	153.2	1002	40	"
10 / 0600	31.9	152.4	1002	40	"
10 / 1200					dissipated
30 / 1800	17.6	118.4	937	130	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%)	66	78
Medium (40%-60%)	54	66
High (>60%)	30	54

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Norman, 28 August–8 September 2018. 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	**17.1**	33.3	46.9	58.8	86.5	119.8	**144.1**
OCD5	35.4	81.1	138.0	197.2	311.1	392.9	467.2
Forecasts	27	27	27	27	27	27	26
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 Hurricane Norman, 28 August–8 September 2018. 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	15.5	31.6	45.8	58.6	84.4	116.2	144.7
OCD5	32.3	78.5	138.3	202.2	309.1	383.5	455.5
GFSI	20.4	38.5	50.0	**55.9**	**52.1**	**57.6**	**103.9**
HMNI	19.3	37.0	49.6	60.2	**84.0**	**116.0**	**133.2**
HWFI	19.3	34.7	48.2	60.1	94.2	165.9	226.2
EGRI	23.2	49.0	76.4	107.1	160.7	197.6	215.0
EMXI	16.3	33.4	48.8	61.0	86.3	**114.6**	**138.9**
CMCI	26.0	53.0	81.7	107.4	143.4	157.5	168.7
NVGI	30.4	62.7	94.7	121.7	161.1	191.9	220.3
AEMI	22.5	38.4	48.1	**53.9**	**74.5**	**99.5**	**130.3**
HCCA	**14.5**	**28.7**	**41.4**	**52.6**	**79.6**	119.1	168.2
FSSE	**15.3**	**29.9**	**41.3**	**56.2**	103.8	158.4	212.2
TVCX	16.8	31.9	**45.3**	**57.3**	**75.3**	**101.0**	**125.2**
GFEX	15.5	**30.6**	**41.8**	**49.7**	**57.9**	**72.5**	**97.6**
TCON	18.3	34.8	49.1	63.5	**80.6**	**101.7**	**126.3**
TVCE	16.4	32.0	**45.1**	**57.1**	**76.2**	**99.8**	**122.4**
TABD	18.2	37.1	58.0	74.8	91.5	133.5	217.5
TABM	20.9	41.0	62.3	81.0	89.9	**109.8**	157.0
TABS	37.4	76.2	93.7	96.0	**77.5**	120.1	149.2
Forecasts	24	24	24	24	24	24	23

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Norman, 28 August–8 September 2018. 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	8.5	13.9	17.6	20.2	18.5	15.9	19.2
OCD5	12.6	22.6	30.5	34.5	35.5	34.2	32.0
Forecasts	27	27	27	27	27	27	26
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 Hurricane Norman, 28 August–8 September 2018. 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	8.4	14.0	17.0	17.0	17.4	16.8	18.1
OCD5	12.4	22.4	29.1	30.1	32.9	33.1	28.3
GFSI	9.5	16.1	22.2	21.5	**15.6**	19.7	20.2
HMNI	8.6	**11.0**	**15.0**	**16.6**	17.6	**14.5**	**17.0**
HWFI	9.8	**12.8**	**12.1**	**15.7**	**16.4**	**13.8**	**14.5**
EMXI	13.5	21.9	23.3	19.6	**16.9**	21.2	26.5
HCCA	**8.0**	**11.2**	**12.8**	**15.0**	18.6	**16.2**	**15.9**
FSSE	**8.2**	**11.2**	**13.1**	**16.7**	23.0	20.3	23.3
LGEM	10.0	16.1	21.2	21.5	25.1	29.2	28.5
DSHP	10.3	17.9	21.8	21.7	23.4	27.1	27.0
ICON	**7.9**	**12.2**	**15.8**	**16.0**	19.0	20.4	21.0
IVCN	**7.8**	**12.0**	**15.0**	**14.8**	18.8	19.8	21.0
Forecasts	25	25	25	25	25	25	24

Table 5a. CPHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Norman. 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.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**18.9**	**27.1**	**41.1**	**50.9**	**40.7**	**43.9**	
OCD5	27.7	63.5	117.7	187.4	340.8	432.1	
Forecasts	16	14	12	10	6	2	
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 Hurricane Norman. 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	18.9	27.1	41.1	50.9	40.7	43.9	
OCD5	27.7	63.5	117.7	187.4	340.8	432.1	
GFSI	19.4	29.8	53.0	66.0	84.2	78.6	
HMNI	19.6	29.6	**37.1**	**45.2**	66.8	75.0	
HWRF	20.8	**26.0**	**38.3**	51.0	99.3	94.8	
EGRI	**17.9**	28.7	42.9	56.9	86.1	124.3	
EMXI	19.4	37.4	52.9	70.6	85.5	80.7	
CMCI	21.3	40.0	61.3	84.7	100.0	109.2	
NVGI	21.9	31.5	49.7	65.2	80.1	214.2	
AEMI	24.4	38.4	51.9	56.8	50.0	**17.8**	
HCCA	**16.4**	**24.5**	**39.1**	**47.7**	**40.2**	57.6	
FSSE	**17.5**	**26.9**	**35.8**	**44.2**	47.8	61.5	
TVCX	**16.1**	**24.6**	**34.9**	**46.3**	44.9	**40.5**	
GFEX	**17.5**	30.2	47.5	62.0	62.7	**39.5**	
TCON	**17.1**	**24.2**	**38.8**	**49.9**	56.1	**43.4**	
TVCE	**16.3**	**23.5**	**35.6**	**44.7**	48.2	**42.2**	
TABD	47.4	108.4	179.9	262.8	473.3	800.1	
TABM	22.9	**22.6**	**22.8**	**28.0**	79.8	198.9	
TABS	51.5	121.4	185.9	233.7	260.5	265.1	
Forecasts	16	14	12	10	6	2	

Table 6a. CPHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Norman. 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.

Model ID							
	12	24	36	48	72	96	120
OFCL	6.9	11.8	12.5	**10.0**	**6.7**	**7.5**	
OCD5	8.2	15.9	19.4	20.4	17.7	12.0	
Forecasts	16	14	12	10	6	2	
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 Hurricane Norman. 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	6.9	11.8	12.5	10.0	6.7	7.5	
OCD5	8.2	15.9	19.4	20.4	17.7	12.0	
GFSI	9.5	12.4	13.6	12.9	**4.7**	**5.0**	
HMNI	7.0	13.2	**9.9**	**9.5**	7.3	8.5	
HWFI	9.6	14.4	**11.8**	11.8	**4.8**	11.5	
EMXI	7.6	13.3	16.2	14.2	**5.7**	**6.5**	
HCCA	7.7	13.9	13.7	13.0	**3.2**	9.0	
FSSE	**6.8**	13.1	**11.3**	11.8	9.8	16.0	
LGEM	7.6	15.5	15.4	14.5	14.3	18.0	
DSHP	8.4	17.2	18.5	18.2	14.8	21.0	
ICON	7.8	14.3	**12.3**	12.2	9.5	14.5	
IVCN	7.6	13.3	**11.3**	10.3	7.0	11.5	
Forecasts	16	14	12	10	6	2	

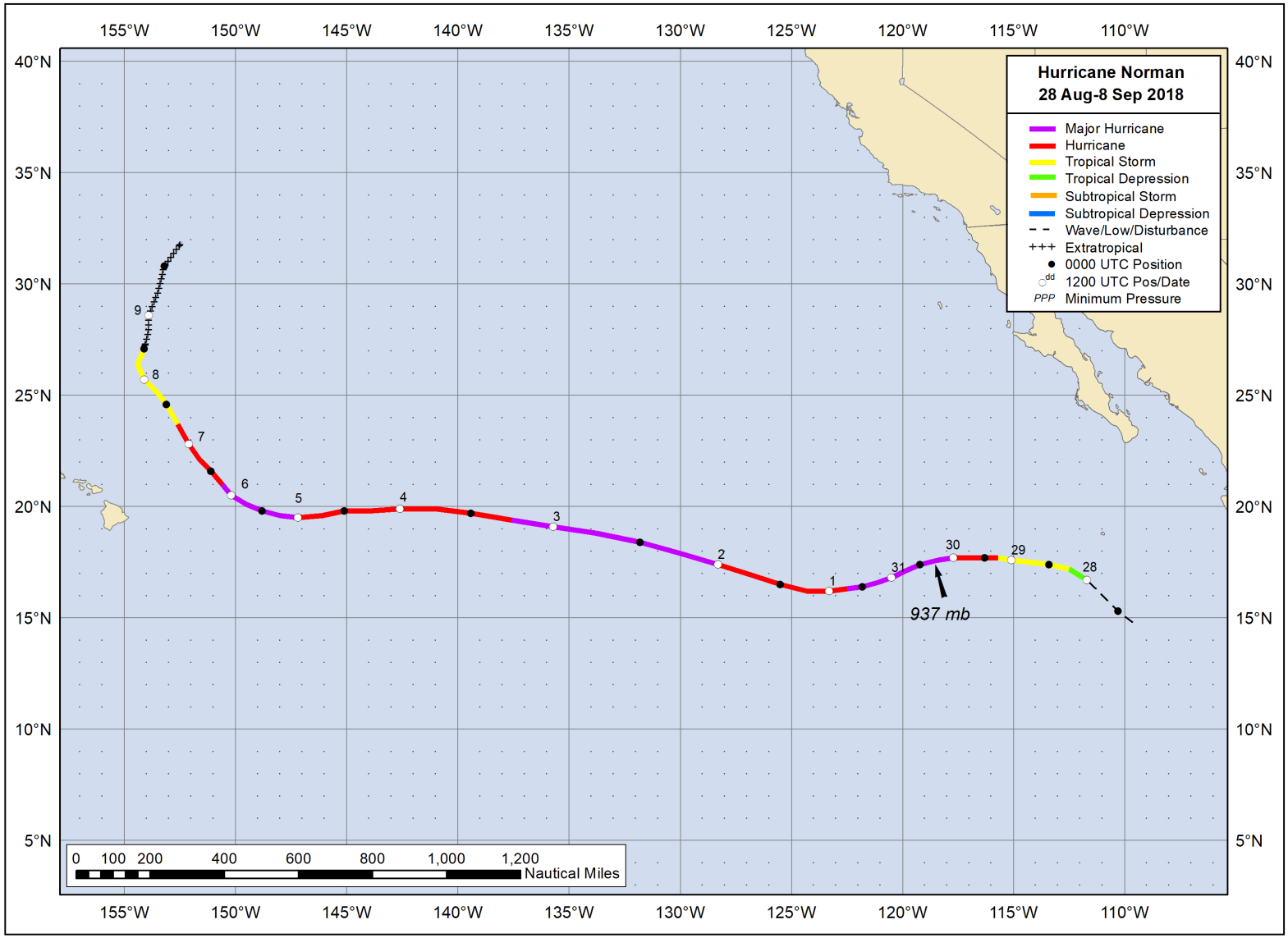

Figure 1. Best track positions for Hurricane Norman, 28 August–8 September 2018.

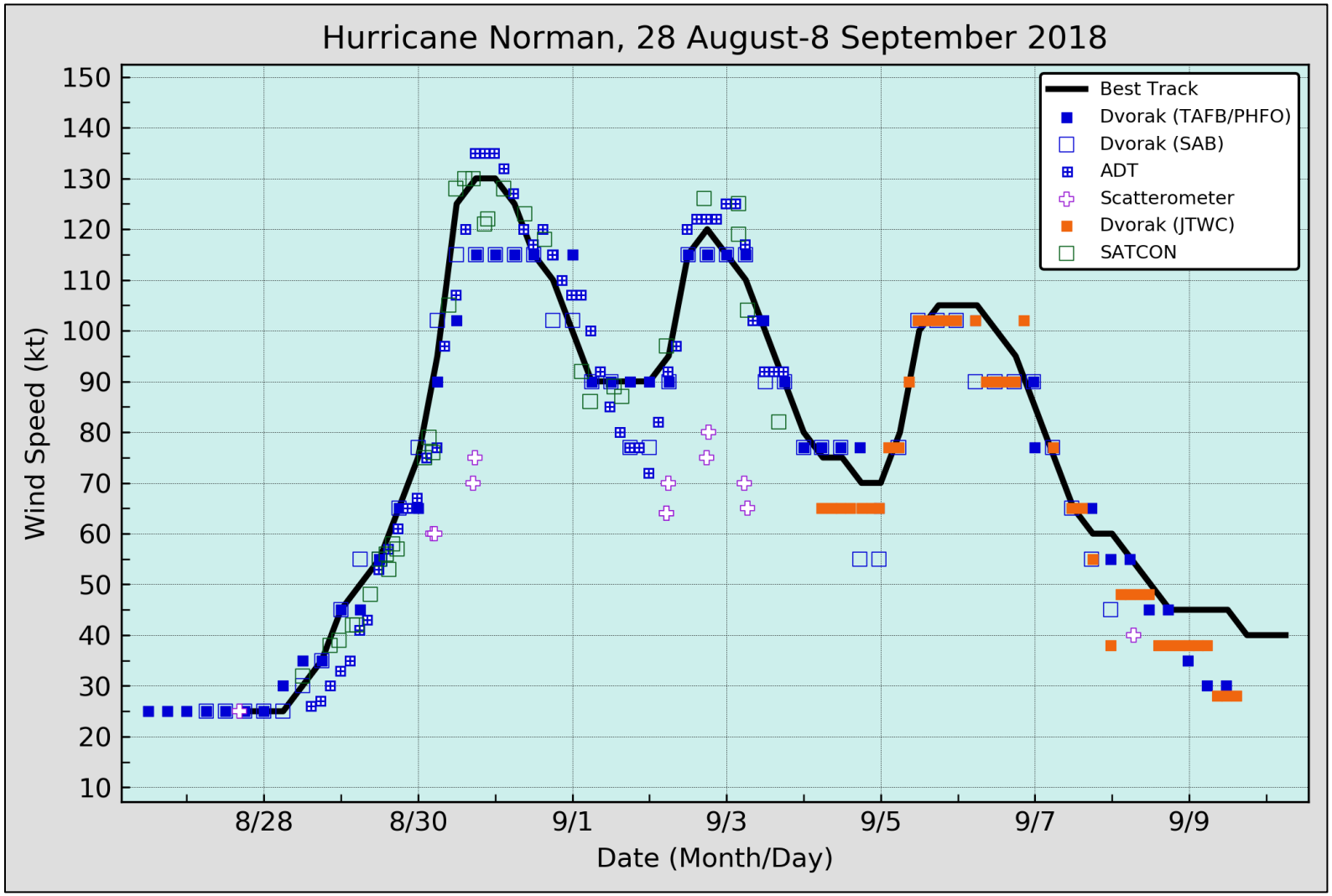

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Norman 28 August–8 September 2018. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC.

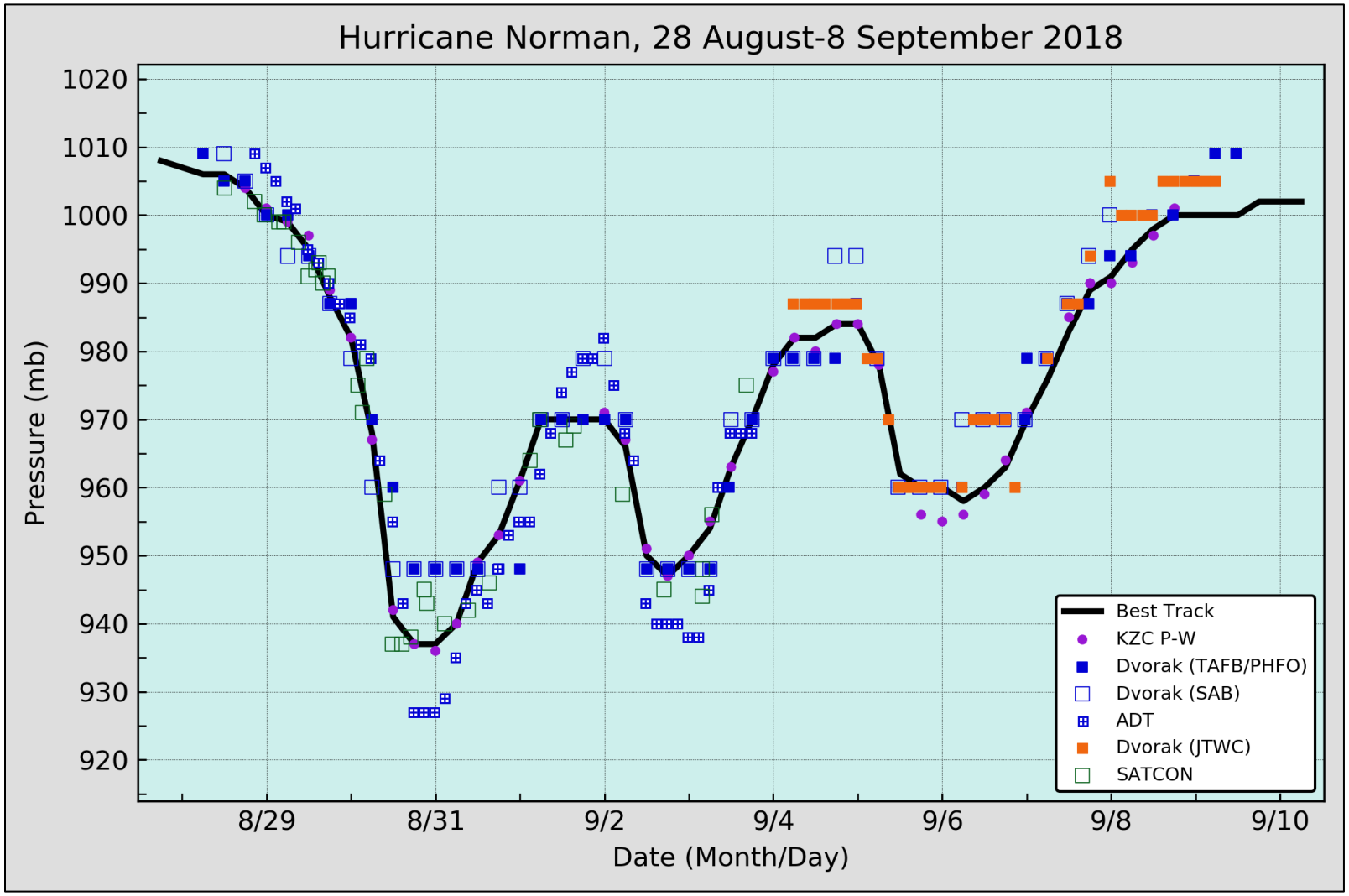

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Norman 28 August–8 September 2018. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for 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.

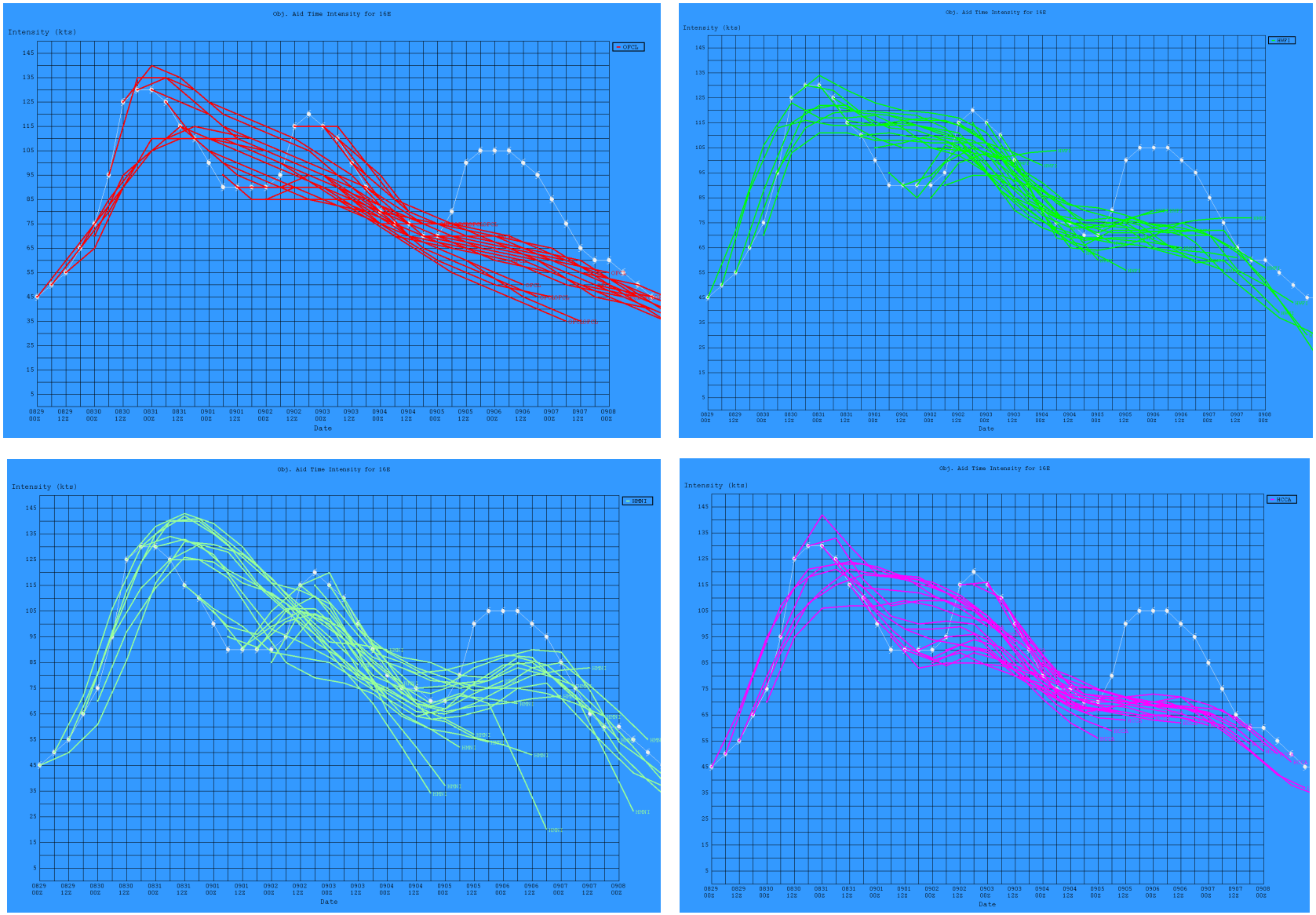

Figure 4. NHC (OFCL) intensity forecasts (kt) for Norman between 0000 UTC 29 August and 0000 UTC 4 September 2018 (top left), and HWRF (HWFI, top right), HMON (HMNI, lower left), and the HFIP corrected consensus (HCCA, lower right) model forecasts during the same time period. The verifying best-track intensity (kt) is shown in white.

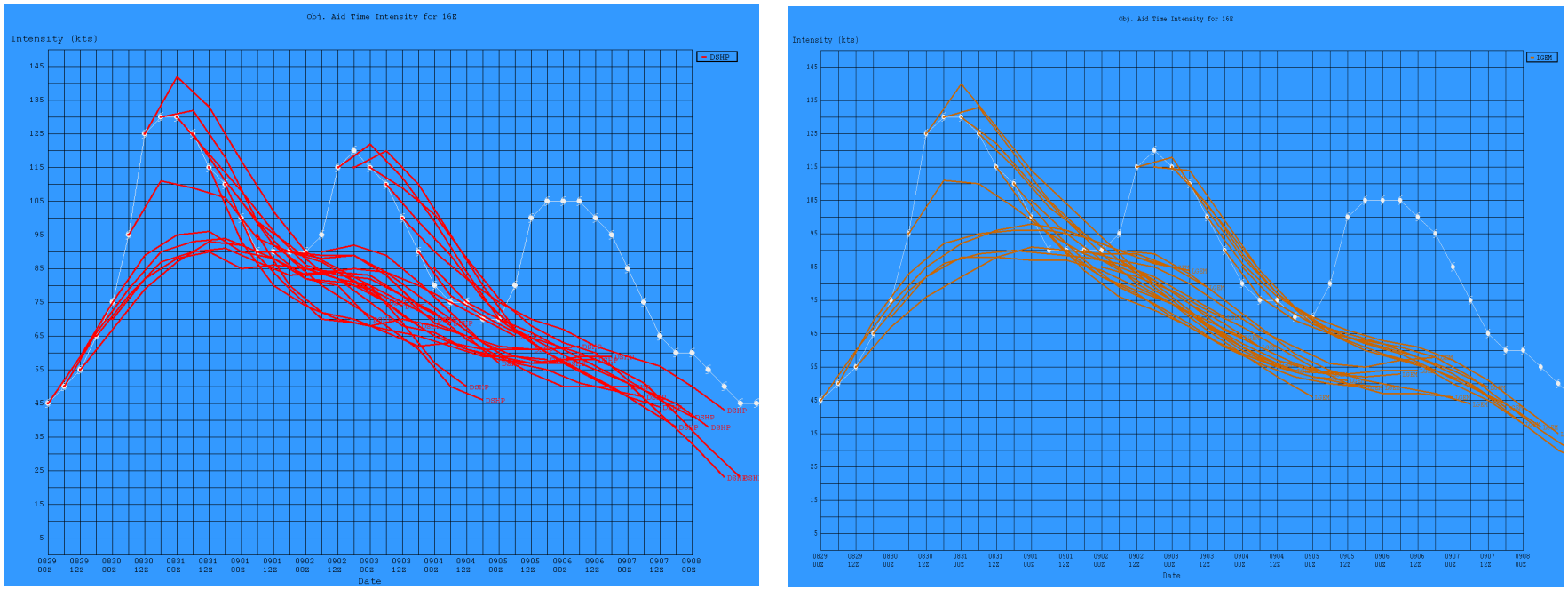

Figure 5. Statistical models DSHP (left) and LGEM (right) intensity forecasts (kt) for Norman between 0000 UTC 29 August and 0000 UTC 4 September 2018. The verifying best-track intensity (kt) is shown in white. Note the models' poor performance in predicting Norman's strengthening phases.