NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

TROPICAL STORM HOWARD

(EP092016)

31 July – 3 August 2016

Richard J. Pasch
National Hurricane Center
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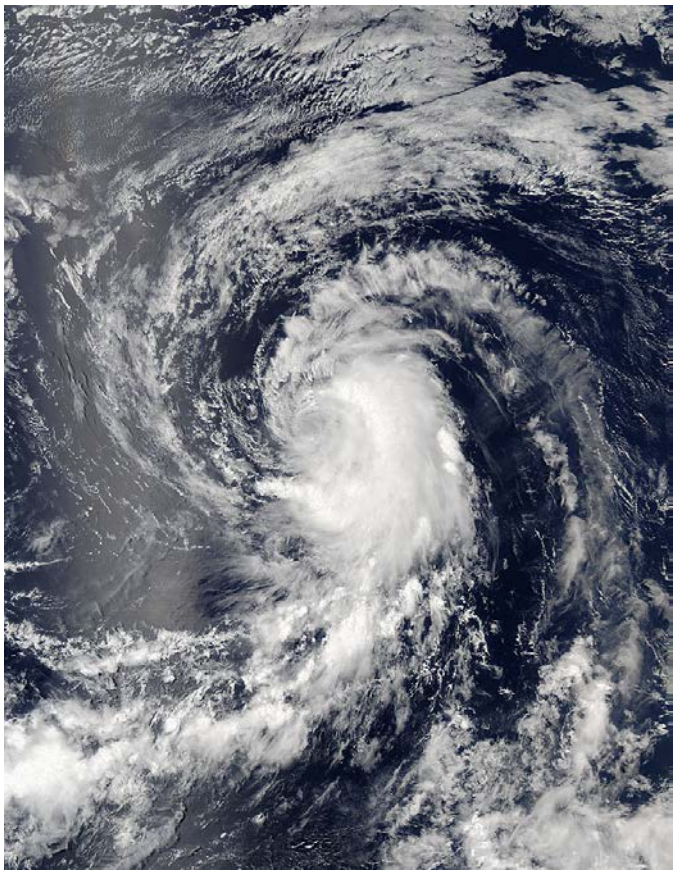

MODIS VISIBLE SATELLITE IMAGE OF TROPICAL STORM HOWARD AT 2155 UTC 1 AUGUST 2016. IMAGE COURTESTY OF NASA.

Howard was a short-lived tropical storm whose remnants passed near the Hawaiian Islands.

Tropical Storm Howard

31 JULY – 3 AUGUST 2016

SYNOPTIC HISTORY

Howard cannot be clearly traced back to a tropical wave coming from Africa. An area of disturbed weather was noted within the eastern Pacific Intertropical Convergence Zone to the south of eastern Mexico on 26 July. The disturbance moved westward and spawned a broad low pressure area several hundred n mi south-southwest of Manzanillo, Mexico, the next day. Over the next several days, the low moved west-northwestward with little indications of development, but early on 31 July the associated deep convection increased and became more consolidated. By 1200 UTC that day, satellite images indicated that the low-level circulation had become better defined and it is estimated that a tropical depression formed while centered about 750 n mi southwest of the southern tip of the Baja California peninsula. 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].

The tropical cyclone moved west-northwestward while a mid-level ridge to its north built westward. Early on 1 August, the system's cloud pattern became better organized and the cyclone strengthened into a tropical storm around 0600 UTC that day. Howard gradually strengthened over the following day as convective banding features became better defined and the center became more embedded within the dense overcast. Although significant strengthening was limited by moderate vertical shear and marginal sea surface temperatures, the storm was able to reach a peak intensity of 50 kt by 0600 UTC 2 August while centered about 1000 n mi west-southwest of the southern tip of the Baja California peninsula. Howard maintained 50-kt winds for about 18 h; it then moved over cooler waters and weakened while its associated deep convection gradually diminished. By 1200 UTC 3 August, the convection had decreased to the extent that the system could be designated as a post-tropical cyclone. Despite the fact that the low no longer had sufficient deep convection to be classified as a tropical cyclone, its maximum winds were slow to diminish, and the system maintained winds of near 35 kt through 1800 UTC 4 August. The low moved westward in the low-level tradewind flow for a couple of days while slowly weakening, and it opened up into a trough when it passed near the island of Oahu around 1800 UTC 7 August.

[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.

METEOROLOGICAL STATISTICS

Observations in Howard (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 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 Howard. The storm's estimated peak intensity of 50 kt is based on ASCAT measurements, as well as a blend of Dvorak estimates from SAB and TAFB.

There were no ship reports of winds of tropical storm force associated with Howard.

CASUALTY AND DAMAGE STATISTICS

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

FORECAST AND WARNING CRITIQUE

The genesis of Howard was fairly well anticipated (Table 2). It was first mentioned in the Tropical Weather Outlook that an area of low pressure could form well to the south-southwest of the southern tip of the Baja California 138 h prior to formation, with the initial 5-day genesis probability in the "low" category. An area of low pressure did form, albeit a couple of days sooner than expected, to the south-southwest of Manzanillo. The 5-day genesis probability was raised to medium 120 h prior to tropical cyclone formation, and to high 72 h prior to genesis. The 2-day genesis probability was set to low 84 h prior to formation, raised to medium 66 h prior to genesis, and raised to high only 18 h before the tropical cyclone formed.

A verification of NHC official track forecasts for Howard is given in Table 3a. The official forecast track errors were quite low (for a limited sample), with mean errors that were well below the mean official errors for the previous 5-yr period for the 12- to 48-h forecast intervals. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The GFS and its ensemble mean, AEMI, were good overall performers for the prediction of Howard's track.

A verification of NHC official intensity forecasts for Howard is given in Table 4a. Official forecast intensity errors were substantially lower than the mean official errors for the previous 5-yr period. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. The GFDL Hurricane Model (GHMI) was among the better

performers and, atypically, the LGEM guidance did not perform well in predicting Howard's intensity.

There were no coastal watches or warnings issued for Howard.

Table 1. Best track for Tropical Storm Howard, 31 July – 3 August 2016.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
31 / 1200	14.7	119.8	1007	30	tropical depression
31 / 1800	15.1	120.6	1006	30	"
01 / 0000	15.5	121.5	1006	30	"
01 / 0600	15.9	122.4	1005	35	tropical storm
01 / 1200	16.4	123.4	1001	40	"
01 / 1800	16.8	124.5	1001	40	"
02 / 0000	17.4	125.8	999	45	"
02 / 0600	18.0	127.0	998	50	"
02 / 1200	18.5	128.3	999	50	"
02 / 1800	19.0	129.5	999	50	"
03 / 0000	19.5	130.7	1003	45	"
03 / 0600	20.1	131.9	1005	40	"
03 / 1200	20.6	133.1	1006	35	low
03 / 1800	21.1	134.5	1007	35	"
04 / 0000	21.5	135.9	1007	35	"
04 / 0600	21.8	137.4	1007	35	"
04 / 1200	22.0	138.8	1007	35	"
04 / 1800	22.2	140.1	1008	35	"
05 / 0000	22.2	141.5	1008	30	"
05 / 0600	22.2	143.0	1008	30	"
05 / 1200	22.2	144.4	1008	30	"
05 / 1800	22.2	145.8	1009	25	"
06 / 0000	22.2	147.2	1009	25	"
06 / 0600	22.2	148.6	1009	25	"
06 / 1200	22.1	150.0	1009	25	"
06 / 1800	22.1	151.6	1009	25	"
07 / 0000	22.0	153.3	1009	25	"
07 / 0600	21.8	154.8	1009	25	"
07 / 1200	21.7	156.4	1009	25	"
07 / 1800					dissipated
02 / 0600	18.0	127.0	998	50	minimum pressure and maximum winds

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%)	84	138
Medium (40%-60%)	66	120
High (>60%)	18	72

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Howard, 31 July – 3 August 2016. 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	**17.4**	**26.5**	**27.9**	**31.9**			
OCD5	25.6	68.5	131.3	185.2			
Forecasts	10	8	6	4			
OFCL (2011-15)	23.4	36.4	47.2	59.4			
OCD5 (2011-15)	36.6	74.2	116.5	159.7			

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Tropical Storm Howard, 31 July – 3 August 2016. Errors smaller than the NHC official forecast are shown in boldface type.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	17.4	26.5	27.9	31.9			
OCD5	25.6	68.5	131.3	185.2			
GFSI	19.0	31.0	30.4	**25.4**			
GHMI	30.0	51.9	60.7	64.7			
HWFI	22.1	32.6	37.9	41.3			
EMXI	21.1	32.0	39.7	62.7			
NVGI	21.0	40.6	58.7	78.7			
GFNI	28.2	59.5	82.7	126.2			
CMCI	18.6	35.4	50.1	64.0			
CTCI	25.0	38.8	47.4	44.5			
TVCE	19.5	31.1	34.0	38.2			
TVCX	19.6	31.0	33.2	41.2			
HCCA	18.0	28.5	31.8	44.7			
GFEX	20.2	28.2	31.1	41.8			
AEMI	17.4	**24.8**	**27.2**	**25.6**			
BAMS	**15.3**	**25.0**	34.6	52.8			
BAMM	**16.2**	29.2	47.4	73.1			
BAMD	21.0	41.1	57.7	72.0			
Forecasts	10	8	6	4			

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Howard, 31 July – 3 August 2016. 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	**2.5**	**3.1**	**2.5**	**3.8**			
OCD5	3.9	6.6	10.7	8.3			
Forecasts	10	8	6	4			
OFCL (2011-15)	5.9	9.8	12.5	14.0			
OCD5 (2011-15)	7.7	12.8	16.4	18.8			

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Tropical Storm Howard, 31 July – 3 August 2016. Errors smaller than the NHC official forecast are shown in boldface type.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	2.5	3.1	2.5	3.8			
OCD5	3.9	6.6	10.7	8.3			
HWFI	3.3	4.8	7.0	7.3			
GHMI	3.2	3.3	4.3	**2.8**			
DSHP	3.8	5.3	9.0	7.0			
LGEM	4.9	8.0	13.7	17.0			
ICON	3.1	4.8	7.5	5.5			
IVCN	3.4	4.6	6.5	4.5			
GFNI	3.5	7.3	7.7	8.5			
CTCI	4.7	6.0	6.0	4.3			
GFSI	4.8	6.9	10.0	8.5			
EMXI	4.3	7.3	11.2	10.5			
HCCA	4.6	5.9	6.2	**3.3**			
Forecasts	10	8	6	4			

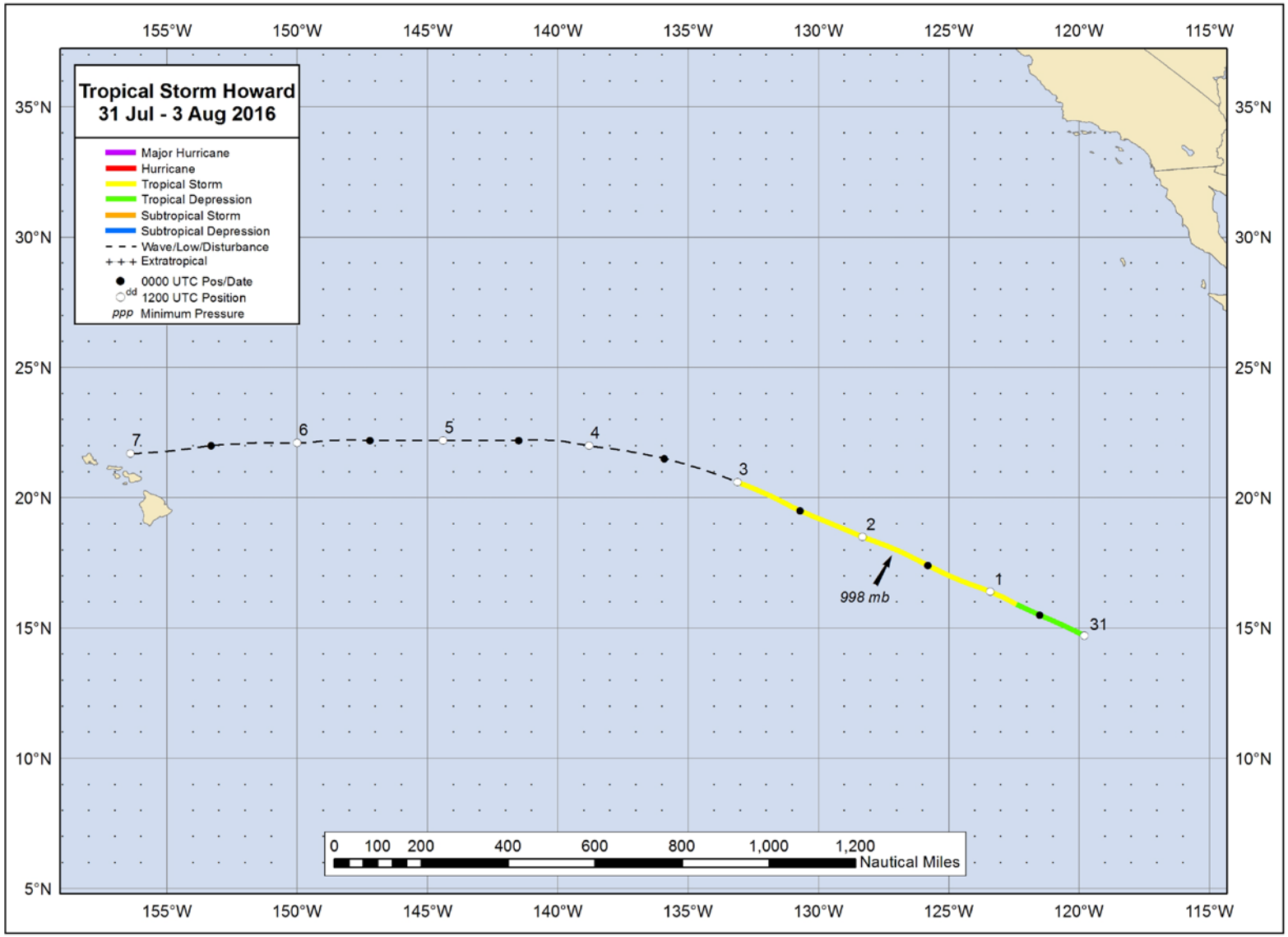

Figure 1. Best track positions for Tropical Storm Howard, 31 July – 3 August 2016.

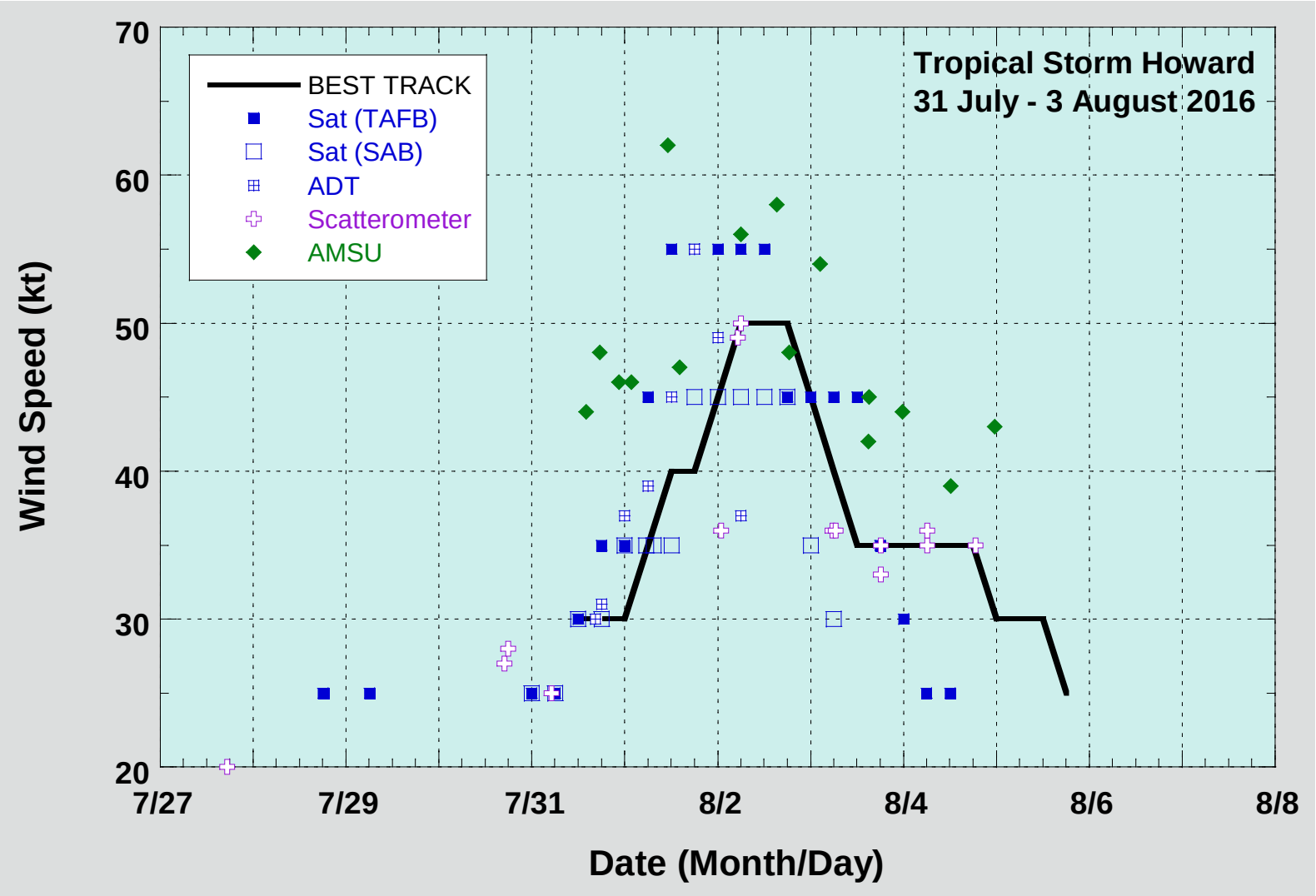

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Howard, 31 July – 3 August 2016. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC.

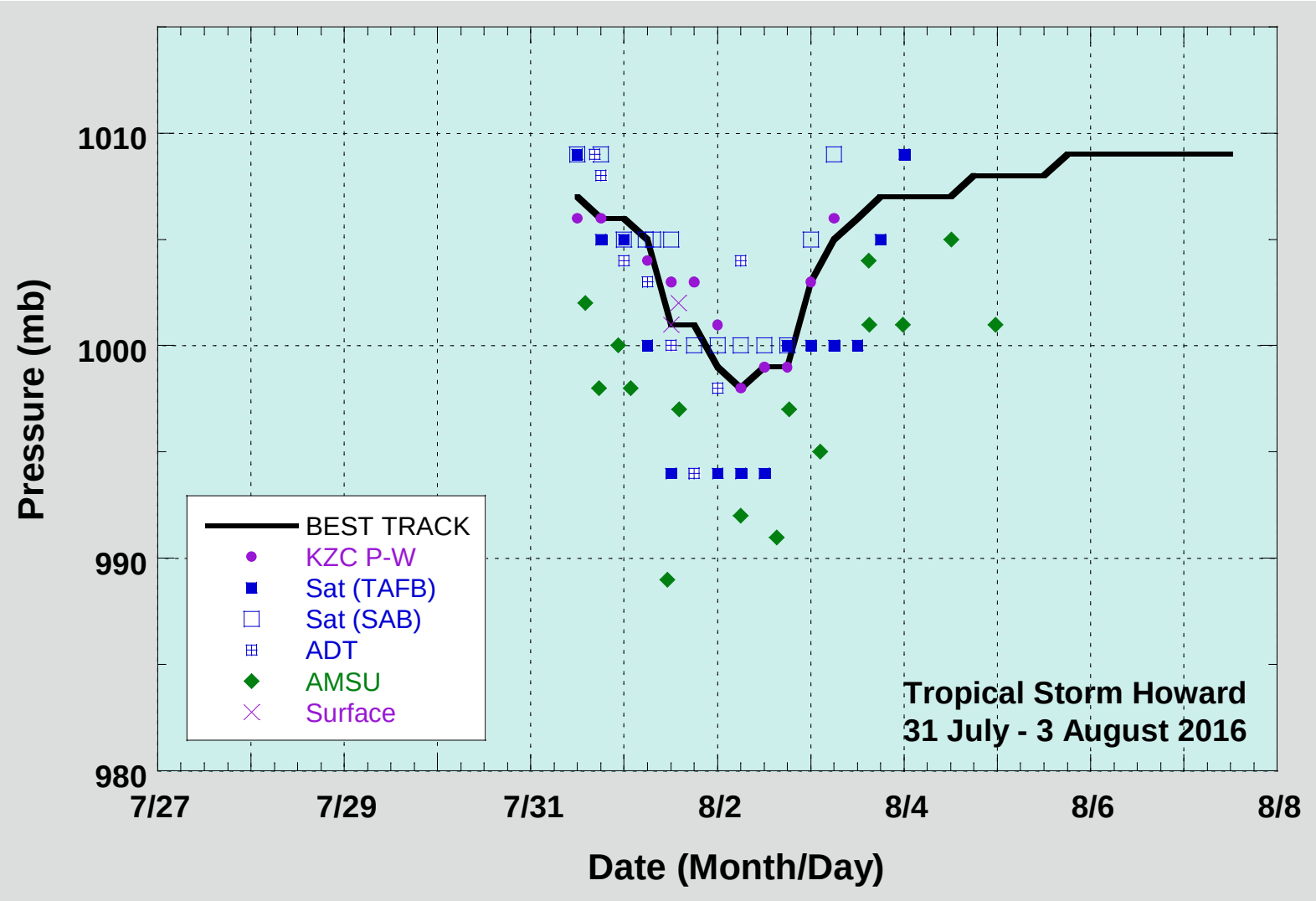

Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Howard, 31 July – 3 August 2016. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.