

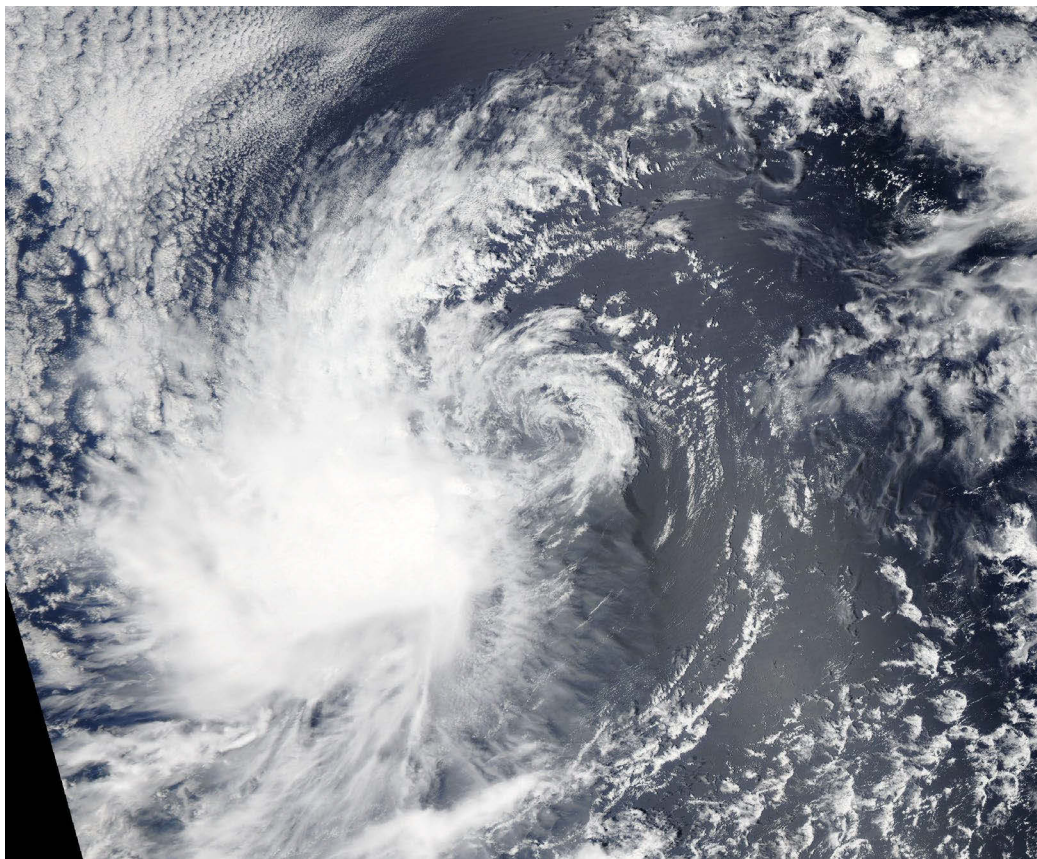


NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

TROPICAL STORM PAUL (EP182018)

8–11 September 2018

David A. Zelinsky
National Hurricane Center
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NASA AQUA/MODIS TRUE COLOR IMAGE OF TROPICAL STORM PAUL AT 2102 UTC 9 SEPTEMBER 2018

Paul was a weak tropical storm that moved generally northwestward across the central portion of the eastern North Pacific basin over the course of a few days.

Tropical Storm Paul

8–11 SEPTEMBER 2018

SYNOPTIC HISTORY

The development of Paul can be traced to an easterly wave that emerged from the west coast of Africa on 17 August. The wave produced very little convection while it moved westward across the Atlantic, eventually crossing Central America on 30 August. Convection associated with the wave began to increase a few days later while it continued westward across the eastern North Pacific. However, strong northeasterly wind shear prevented the system from organizing quickly. The wave continued to produce intermittent disorganized convection through 1200 UTC 7 September, when a well-defined surface low formed about 500 n mi south-southwest of the southern tip of the Baja California peninsula. Convection associated with the low consolidated and became persistent by 0600 UTC 8 September, marking the formation of a tropical depression about 590 n mi south-southwest of the southern tip of the Baja California peninsula. Although strong vertical wind shear affected the depression for several more days, the cyclone strengthened into a tropical storm by 0000 UTC 9 September. The “best track” chart of Paul’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 1¹.

Paul initially moved westward after forming, but turned toward the northwest on 9 September while moving along the southwest side of a mid-level ridge centered over central Mexico. The tropical storm strengthened slightly, reaching its peak intensity of 40 kt around 1800 UTC that day. By 10 September, a combination of wind shear, dry air wrapping around the cyclone, and cooler sea surface temperatures caused Paul to weaken, and the cyclone became a tropical depression around 0600 UTC 11 September. Deep convection associated with Paul ceased that afternoon, and the cyclone became a remnant low around 0000 UTC 12 September when it was located nearly 900 n mi west of the southern tip of the Baja California peninsula. As Paul weakened, a low-level ridge to the north caused the vertically shallow cyclone to turn back toward the west. The remnant low continued to move westward for two more days while its winds gradually subsided, before a large high pressure system over the central North Pacific caused it to turn abruptly southwestward on 14 September. The low-level circulation of Paul became elongated later that day, and dissipated by 0000 UTC 15 September.

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 *bt*k directory, while previous years’ data are located in the *archive* directory.

METEOROLOGICAL STATISTICS

Observations in Tropical Storm Paul (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 (UW-CIMSS). 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 Paul.

The maximum intensity of Paul is estimated to be 40 kt based on an ASCAT overpass at 1739 UTC 9 September that indicated peak winds of 35–40 kt in the southeast quadrant of the tropical storm. A blend of satellite intensity estimates from TAFB, SAB, and the UW-CIMSS SATCON also supported a maximum intensity of around 40 kt.

There were no ship or land reports of tropical-storm-force winds associated with Paul.

CASUALTY AND DAMAGE STATISTICS

There were no reports of damage or casualties associated with Tropical Storm Paul.

FORECAST AND WARNING CRITIQUE

The genesis of Tropical Storm Paul was well forecast. Table 2 provides the number of hours in advance of formation associated with the first NHC Tropical Weather Outlook (TWO) forecast in each likelihood category. The development of a low pressure system southwest of Mexico was first mentioned in the Tropical Weather Outlook 168 h (7 days) prior to the formation of Paul, and was given a low probability (<40%) of becoming a tropical cyclone within 120 h (5 days). The 120-h probability was increased to the medium (40%–60%) and high (>60%) categories 66 h and 42 h prior to the formation of a tropical depression, respectively. The wave from which Paul developed was first given a low chance of formation in the 48-h (2-day) forecast 66 h before genesis. This chance was increased to the medium and high categories 30 and 12 h prior to the formation of Paul, respectively.

A verification of NHC official track forecasts for Paul is given in Table 3a. Official forecast track errors were generally much lower than the mean official errors for the previous 5-yr period at all verifying forecast times. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. While all of the track consensus aids had low errors, the HFIP Corrected Consensus Approach (HCCA) was generally the best track model at all times



during Paul. No single model consistently outperformed the consensus aids or the official track forecasts.

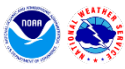
A verification of NHC official intensity forecasts for Paul is given in Table 4a. Mean official forecast intensity errors were lower than those for the previous 5-yr period through 36 h, but were much higher at 48 h and 72 h. The initial few NHC forecasts that make up most of the verifying sample at 48 h, and all of the sample at 72 h, anticipated that Paul would strengthen more than it did. However, later forecasts correctly expected Paul to remain weak and become a remnant low, which is reflected in the lower forecast errors at 12 to 36 h. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. Most of the intensity guidance had lower errors than the NHC forecasts at 36 h and beyond. While several models incorrectly forecast Paul to strengthen immediately after it formed, nearly all of the intensity guidance changed 6 h later, showing little to no intensification at the time of the second NHC advisory. The NHC intensity forecast was not changed abruptly to maintain continuity with the previous advisory, but this ultimately resulted in higher errors at 36 h and beyond. The official and model intensity forecasts were excellent at 12 h and 24 h.

There were no coastal watches or warnings issued in association with Tropical Storm Paul.



Table 1. Best track for Tropical Storm Paul, 8–11 September 2018.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
07 / 1200	14.7	111.9	1008	25	low
07 / 1800	15.0	112.7	1008	25	"
08 / 0000	15.3	113.6	1008	25	"
08 / 0600	15.5	114.5	1006	30	tropical depression
08 / 1200	15.7	115.4	1006	30	"
08 / 1800	15.8	116.3	1006	30	"
09 / 0000	16.0	117.0	1004	35	tropical storm
09 / 0600	16.6	117.6	1004	35	"
09 / 1200	17.3	118.1	1004	35	"
09 / 1800	18.1	118.6	1002	40	"
10 / 0000	18.9	119.1	1003	40	"
10 / 0600	19.7	119.7	1004	35	"
10 / 1200	20.4	120.3	1004	35	"
10 / 1800	20.9	120.9	1004	35	"
11 / 0000	21.4	121.7	1004	35	"
11 / 0600	21.8	122.6	1005	30	tropical depression
11 / 1200	22.0	123.6	1005	30	"
11 / 1800	22.2	124.7	1005	30	"
12 / 0000	22.3	126.0	1005	30	low
12 / 0600	22.4	127.0	1005	30	"
12 / 1200	22.5	128.0	1006	25	"
12 / 1800	22.5	128.9	1006	25	"
13 / 0000	22.5	129.8	1006	25	"
13 / 0600	22.5	130.6	1006	25	"
13 / 1200	22.5	131.4	1006	25	"
13 / 1800	22.4	132.1	1006	25	"
14 / 0000	22.0	132.6	1007	20	"
14 / 0600	21.6	132.9	1007	20	"



Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
14 / 1200	21.2	133.1	1007	20	"
14 / 1800	20.8	133.3	1007	20	"
15 / 0000					dissipated
09 / 1800	8.1	118.6	1002	40	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	168
Medium (40%-60%)	30	66
High (>60%)	12	42



Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Paul, 8–11 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	12.7	22.3	26.3	37.4	59.4		
OCD5	34.7	79.0	133.2	188.9	243.1		
Forecasts	12	10	8	6	2		
OFCL (2013-17)	21.8	33.2	43.0	53.9	80.7		
OCD5 (2013-17)	34.9	70.7	109.1	146.1	213.8		



Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Tropical Storm Paul, 8–11 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	8.5	22.5	30.2	51.3	73.9		
OCD5	38.6	86.8	149.8	226.7	290.4		
TABS	24.5	62.3	102.3	115.7	130.2		
TABM	24.9	40.7	41.5	25.2	172.2		
TABD	25.2	43.4	52.1	46.0	47.5		
TVCE	9.9	22.4	36.7	61.6	87.2		
TVCN	10.7	23.5	39.0	61.5	77.2		
GFEX	9.0	19.8	31.0	54.0	92.8		
TVCX	10.8	22.2	33.1	53.8	76.7		
HCCA	10.7	19.0	29.0	42.6	55.5		
NAMI	33.7	49.1	66.2	49.6	58.4		
AEMI	13.3	34.0	59.2	81.5	87.2		
CTCI	16.4	43.0	73.3	98.4	111.0		
NVGI	20.3	39.7	71.3	86.6	96.2		
CMCI	14.8	35.5	54.8	60.5	88.7		
EMXI	16.6	30.9	39.0	52.5	106.5		
EGRI	16.9	34.0	48.9	81.7	127.7		
HWFI	18.2	29.4	44.5	73.4	102.2		
HMNI	13.5	23.6	41.9	74.2	151.6		
GFSI	15.5	35.6	67.3	92.6	126.1		
Forecasts	8	6	5	3	1		



Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Paul, 8–11 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	1.2	4.5	8.1	15.0	32.5		
OCD5	2.9	4.6	5.5	8.3	21.5		
Forecasts	12	10	8	6	2		
OFCL (2013-17)	5.8	9.6	11.8	13.2	15.1		
OCD5 (2013-17)	7.6	12.4	15.6	17.7	19.8		

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Tropical Storm Paul, 8–11 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	1.9	2.5	7.0	13.3	30.0		
OCD5	3.9	4.7	6.2	7.7	21.0		
DSHP	3.2	4.5	4.6	6.3	18.0		
LGEM	4.0	4.8	4.2	5.3	1.0		
HWFI	3.5	3.2	5.8	9.7	22.0		
HMNI	2.9	2.0	3.4	2.0	9.0		
CTCI	2.8	1.7	2.4	2.3	2.0		
GFSI	2.0	2.2	3.0	6.3	17.0		
EMXI	2.9	4.2	3.8	3.7	4.0		
NAMI	2.2	3.0	1.6	1.3	1.0		
HCCA	3.0	1.5	4.6	4.3	13.0		
IVCN	2.8	2.2	3.2	2.7	10.0		
ICON	2.5	2.3	3.2	3.3	12.0		
Forecasts	8	6	5	3	1		

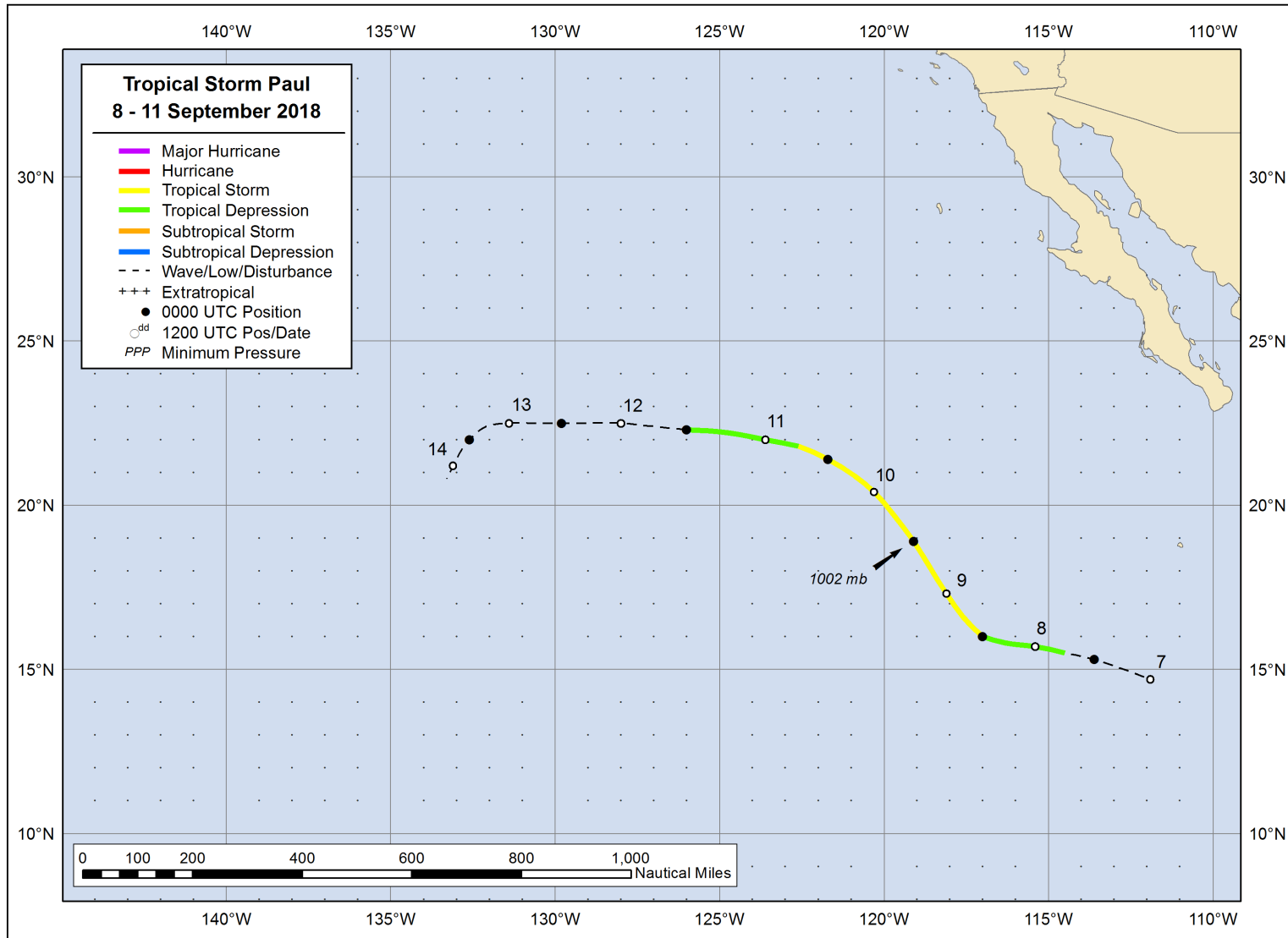


Figure 1. Best track positions for Tropical Storm Paul, 8–11 September 2018.

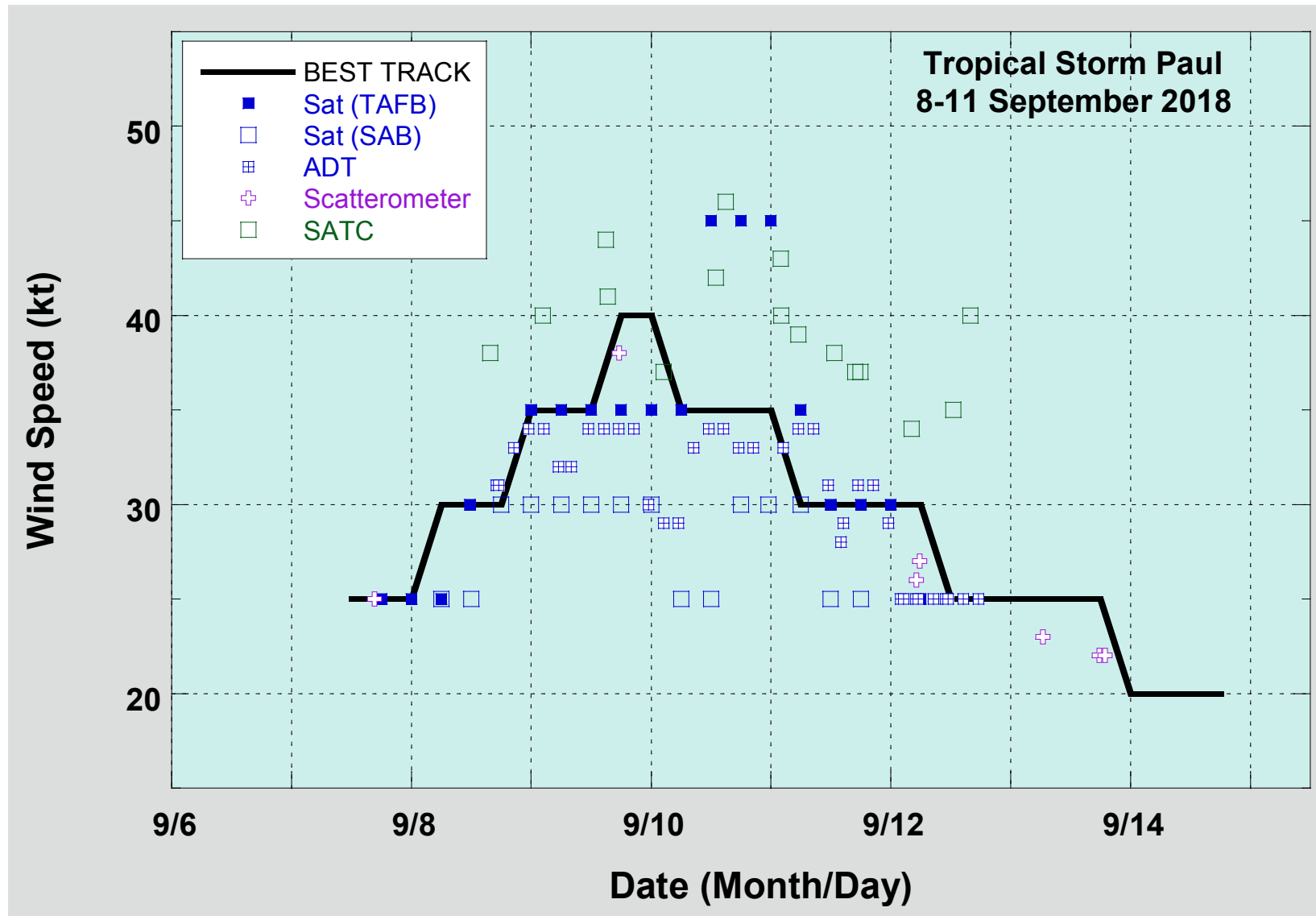


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Paul, 8–11 September 2018. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies.

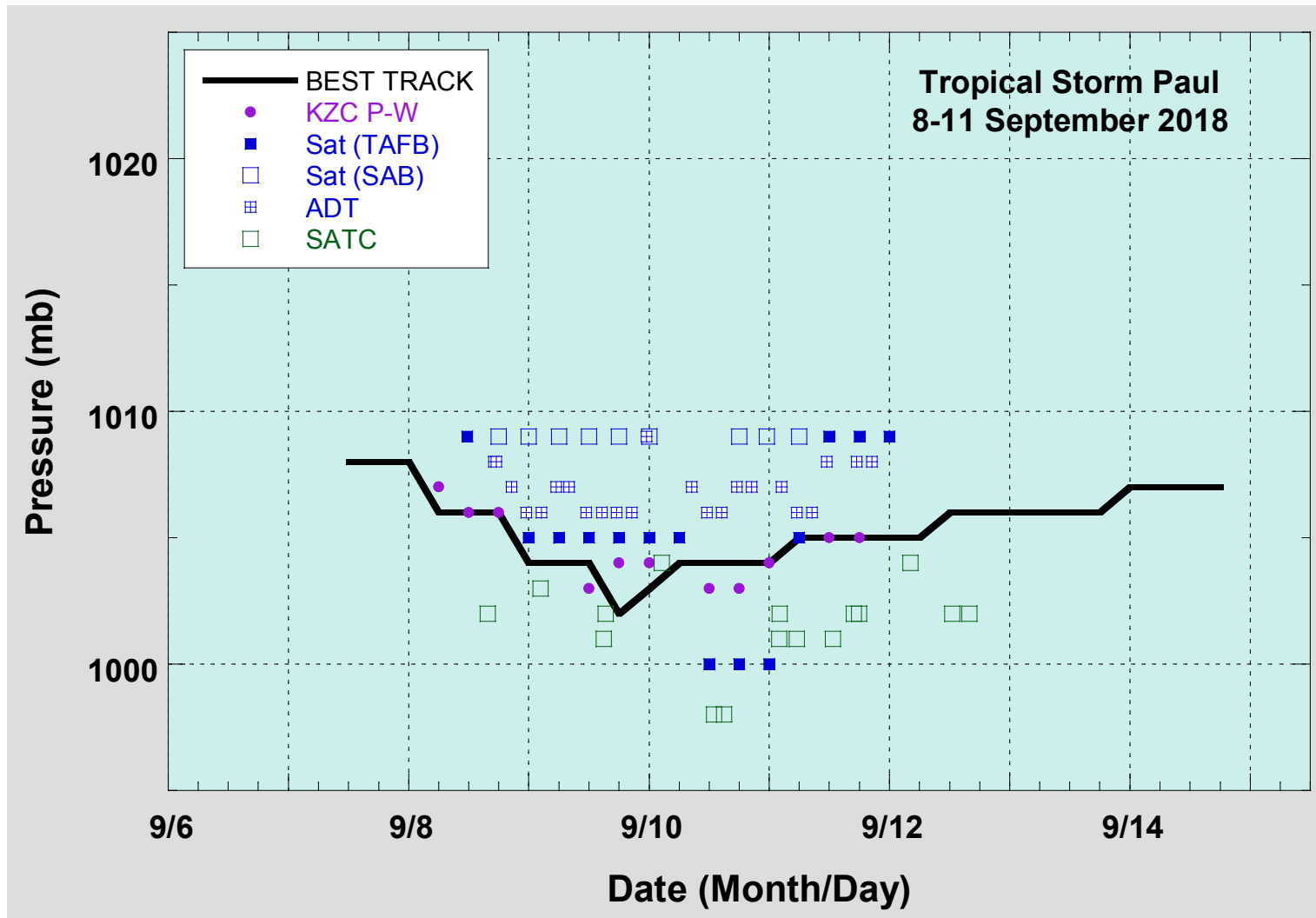


Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Paul, 8–11 September 2018. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship.