NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE PAINE

(EP172016)

18 – 20 September 2016

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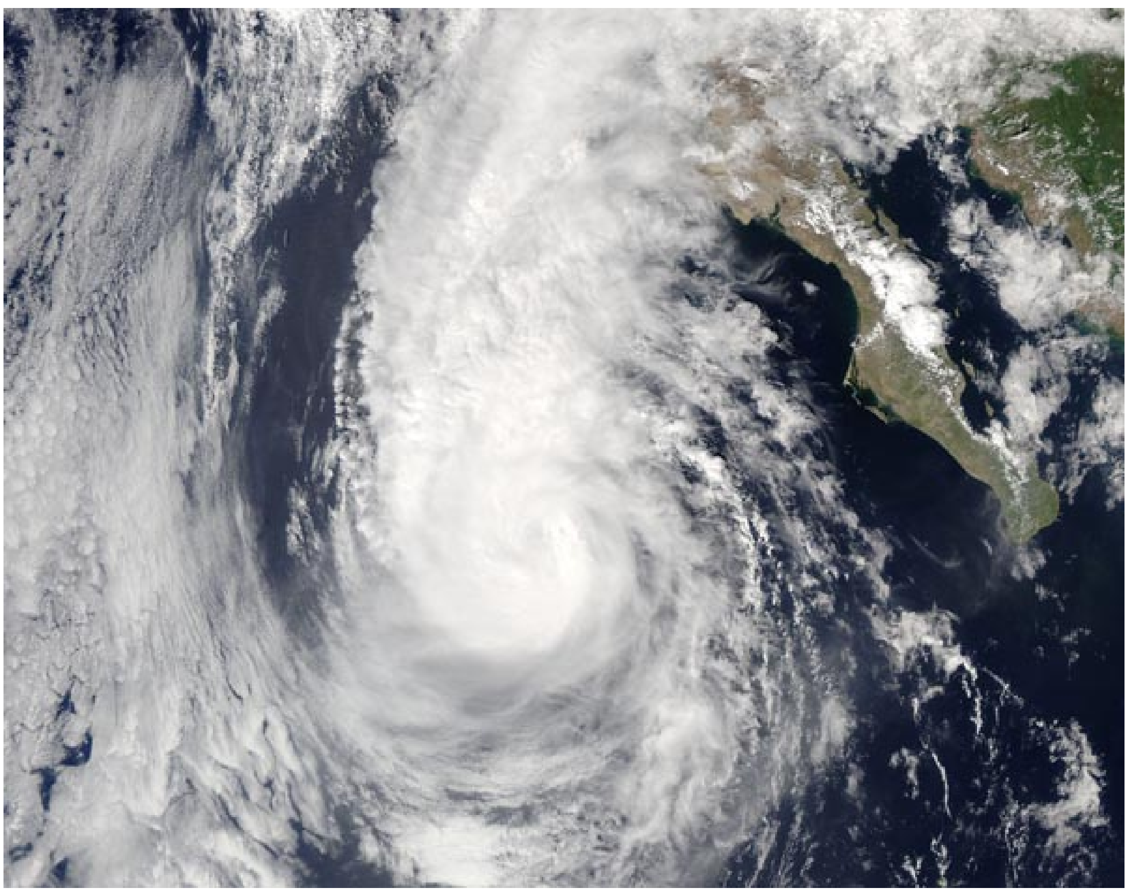

MODIS VISIBLE IMAGE OF PAINE AT 2100 UTC 19 SEPTEMBER JUST AFTER PEAK INTENSITY

Paine became a hurricane during a period of rapid intensification southwest of the Baja California peninsula, but dissipated offshore without significantly affecting land.

Hurricane Paine

18 – 20 SEPTEMBER 2016

SYNOPTIC HISTORY

A series of tropical waves led to the genesis of Paine. The first tropical wave moved into the eastern Pacific basin on 10 September, spawning a small area of low pressure within the Intertropical Convergence Zone a few hundred miles south of southeastern Mexico on 12 September. The low drifted westward for the next few days, producing disorganized thunderstorms in an easterly shear environment. On 16 September, another tropical wave overtook the small low and entrained it into its large circulation. The combined system produced a rather large area of showers and thunderstorms, although the surface circulation was elongated from the south-southwest to the north-northeast with several embedded low-level swirls. On the next day, the deep-layer vertical wind shear decreased and convection became more concentrated in the northern semicircle of the system. This convection lead to the development of a well-defined low-level circulation, resulting in the formation of a tropical depression near 0000 UTC 18 September, centered about 325 n mi west-southwest of Manzanillo, Mexico. Six hours later, the depression strengthened into a tropical storm. The "best track" chart of Paine'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].

Initially, Paine was moving generally northwestward around the southwestern periphery of a subtropical ridge over Mexico. Despite the large size of its precursor system, Paine had a relatively small radius of maximum wind and compact area of deep convection around the center, and the cyclone rapidly intensified almost immediately after genesis, with tightly wrapped bands forming near and northwest of the center due to light southeasterly shear. Satellite images later on 18 September show that the storm had already formed a central dense overcast, accompanied by very deep convection. Paine became a hurricane early on 19 September and reached a peak intensity of 80 kt near 1800 UTC that day, centered about 335 n mi west of Cabo San Lucas, Mexico.

During the next 12 h, Paine turned northward around the subtropical ridge, and the hurricane rapidly weakened while it moved across the tight sea-surface temperature gradient of the northeastern Pacific. Only 24 h after reaching its peak wind speed, Paine lost all deep convection and became a post-tropical low at 1800 UTC 20 September about 125 n mi southwest of Punta Eugenia, Mexico. The low turned northeastward and continued to weaken over the cold waters, degenerating into a trough just offshore of Baja California south of El Rosario by midday on 21 September.

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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.

METEOROLOGICAL STATISTICS

Observations in Paine (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 Paine.

The estimated 80-kt peak intensity of Paine is based on a blend of Dvorak satellite intensity estimates from TAFB and SAB and the CIMSS ADT.

There were no tropical-storm-force wind reports from ships associated with Paine.

Moisture that was transported around the outer circulation of Paine resulted in generally beneficial rains over the southwestern United States. The San Diego Padres had a rare rain delay on 20 September due to this moisture surge.

CASUALTY AND DAMAGE STATISTICS

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

FORECAST AND WARNING CRITIQUE

The genesis forecasts for Paine were outstanding (Table 2). The disturbance from which the cyclone developed was first mentioned in the 5-day Tropical Weather Outlook 126 h before formation, and given a high (>60%) chance of formation 78 h before genesis. The 48-h genesis forecast first entered the medium (40-60%) category 54 h before Paine formed, and a high chance of formation was assigned 36 h prior to genesis. The ECMWF, CMC and UKMET models all showed genesis roughly 5 days before formation and were reasonably consistent thereafter. Although the GFS did not show genesis at longer-lead times, forecasters had noted the low bias of the GFS for eastern Pacific systems in 2015 and up to that point in 2016 and had accounted for that factor in their genesis forecasts.

A verification of NHC official track forecasts for Paine is given in Table 3a. Official forecast track errors after 12 h were below the mean official errors for the previous 5-yr period, although the sample size is small. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The track model consensus (TVCN) was very difficult to beat for Paine, although most of the guidance models had fairly low errors. Notably, the

COAMPS-TC model (CTCI) and the Canadian model (CMCI) were the best individual models, albeit for a small sample. The HWRF and the ECMWF forecasts did not verify particularly well for Paine.

A verification of NHC official intensity forecasts for Paine is given in Table 4a. Official forecast intensity errors were higher 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 rapid intensification of Paine and the magnitude of its peak intensity were not forecast well, which led to the poor performance (Figure 4). Paine also rapidly weakened faster than it intensified, which caused significant errors near the end of the cyclone's lifecycle. Overall, the NHC intensity forecasts did well in comparison to the guidance, and the NOAA-corrected consensus model (HCCA) provided the best guidance for Paine. Interestingly, while CTCI had a great track verification, it had the worst intensity performance among the standard intensity aids.

Watches and warnings associated with Paine are listed in Table 5.

Table 1. Best track for Hurricane Paine, 18-20 September 2016.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
18 / 0000	16.1	109.1	1006	30	tropical depression
18 / 0600	16.8	110.1	1004	35	tropical storm
18 / 1200	17.4	111.2	1002	40	“
18 / 1800	18.1	112.4	998	50	“
19 / 0000	19.0	113.5	992	60	“
19 / 0600	20.0	114.4	987	70	hurricane
19 / 1200	21.0	115.3	981	75	“
19 / 1800	22.0	116.1	979	80	"
20 / 0000	23.1	116.6	983	70	"
20 / 0600	24.2	117.0	995	55	tropical storm
20 / 1200	25.4	117.1	1001	45	"
20 / 1800	26.6	117.0	1003	35	low
21 / 0000	27.5	116.6	1005	30	"
21 / 0600	28.3	116.2	1006	25	"
21 / 1200	29.1	115.8	1008	20	"
21 / 1800					dissipated
19 / 1800	22.0	116.1	979	80	minimum pressure & 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%)	96	126
Medium (40%-60%)	54	108
High (>60%)	36	78

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Paine. 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	25.2	**27.4**	**30.5**	**49.4**			
OCD5	35.0	73.7	140.9	183.8			
Forecasts	9	7	5	3			
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 Paine. 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	25.2	27.4	30.5	49.4			
OCD5	35.0	73.7	140.9	183.8			
GFSI	25.6	34.9	30.6	**47.3**			
GHMI	27.1	30.9	31.0	**32.3**			
HWFI	29.6	40.5	61.0	82.3			
CTCI	**24.3**	**25.5**	**26.5**	**48.3**			
EMXI	**25.1**	30.6	47.3	80.7			
CMCI	**23.0**	29.1	**26.5**	**38.5**			
GFNI	31.9	55.7	67.2	87.6			
AEMI	27.0	31.7	**27.9**	**33.3**			
HCCA	26.5	31.5	**25.7**	**41.6**			
TVCN	**24.6**	**22.3**	**23.5**	**35.6**			
TVCX	**23.1**	**24.2**	**24.4**	**42.1**			
GFEX	**24.6**	27.6	**28.1**	**49.0**			
LBAR	33.1	52.8	81.2	126.3			
BAMD	29.8	41.6	43.7	60.8			
BAMM	27.3	34.2	**27.7**	**30.3**			
BAMS	25.7	30.7	33.9	**31.0**			
NVGI	28.9	42.3	49.1	67.6			
Forecasts	9	7	5	3			

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Paine. 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	10.0	14.3	17.0	15.0			
OCD5	14.4	20.0	23.6	19.0			
Forecasts	9	7	5	3			
(EP) OFCL (2011-15)	5.9	9.8	12.5	14.0			
(EP) OCD5 (2011-15)	7.7	12.8	16.4	18.8			

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Paine. 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	10.0	14.3	17.0	15.0			
OCD5	14.4	20.0	23.6	19.0			
GFSI	15.8	24.6	25.2	23.7			
EMXI	15.7	22.1	23.6	21.3			
DSHP	11.8	15.1	18.8	**7.3**			
LGEM	11.7	15.6	21.0	**14.0**			
IVCN	11.4	17.1	20.8	16.0			
ICON	11.4	16.0	19.0	**13.0**			
HCCA	**9.4**	**12.4**	**16.0**	**12.3**			
HWFI	10.2	16.0	**15.6**	15.3			
GHMI	13.3	22.0	26.8	21.0			
GFNI	13.0	18.9	20.4	17.7			
CTCI	12.6	22.6	31.6	27.7			
Forecasts	9	7	5	3			

Table 5. Watch and warning summary for Paine, 18 – 20 September 2016.

Date/Time (UTC)	**Action**	**Location**
19 / 1500	Tropical Storm Watch issued	Punta Eugenia to Cabo San Quintin
19 / 2100	Tropical Storm Watch changed to Tropical Storm Warning	Punta Eugenia to Cabo San Quintin
20 / 0900	Tropical Storm Warning changed to Tropical Storm Watch	Punta Eugenia to Cabo San Quintin
20 / 1500	Tropical Storm Watch discontinued	All

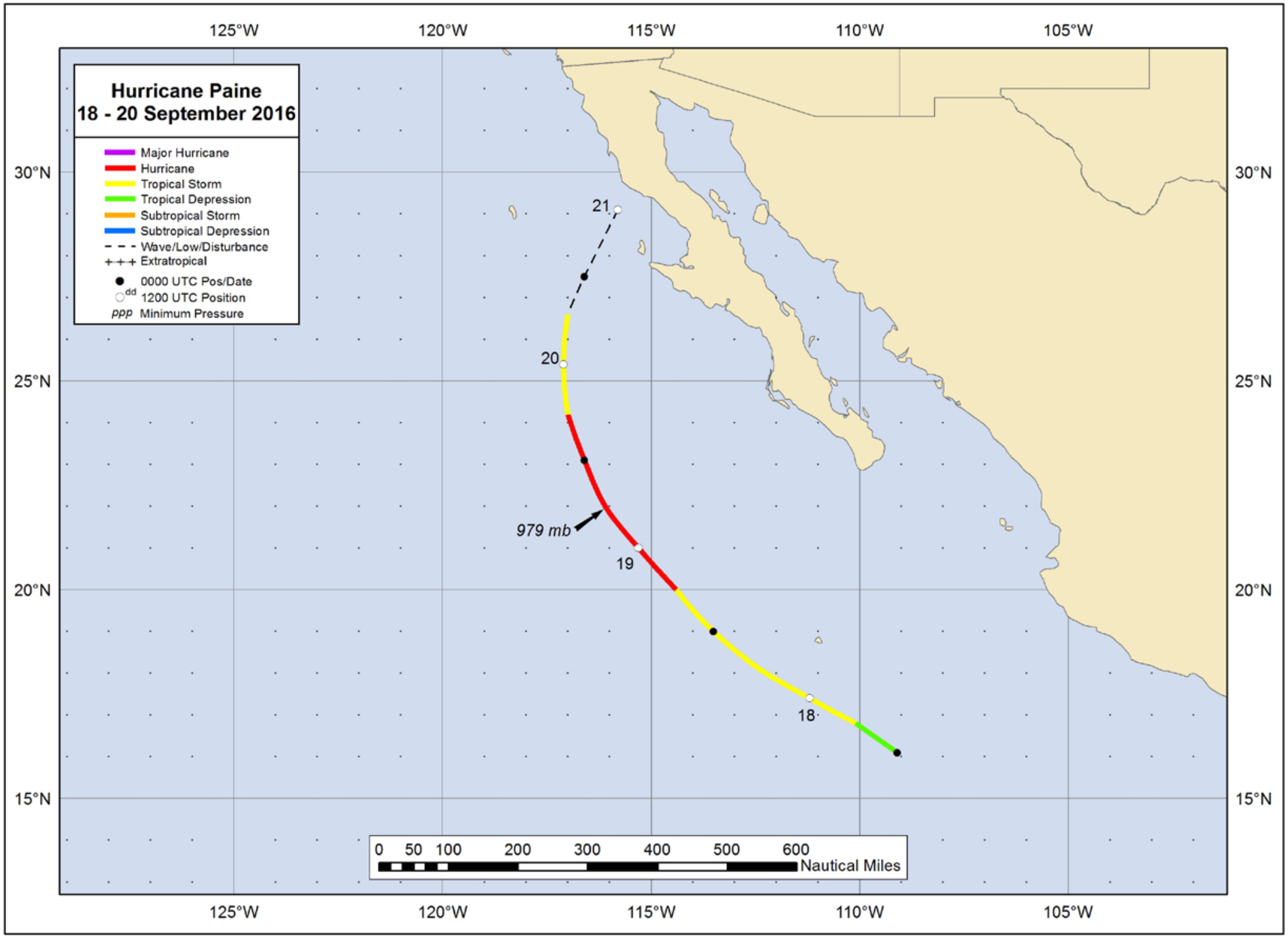

Figure 1. Best track positions for Hurricane Paine, 18-20 September 2016.

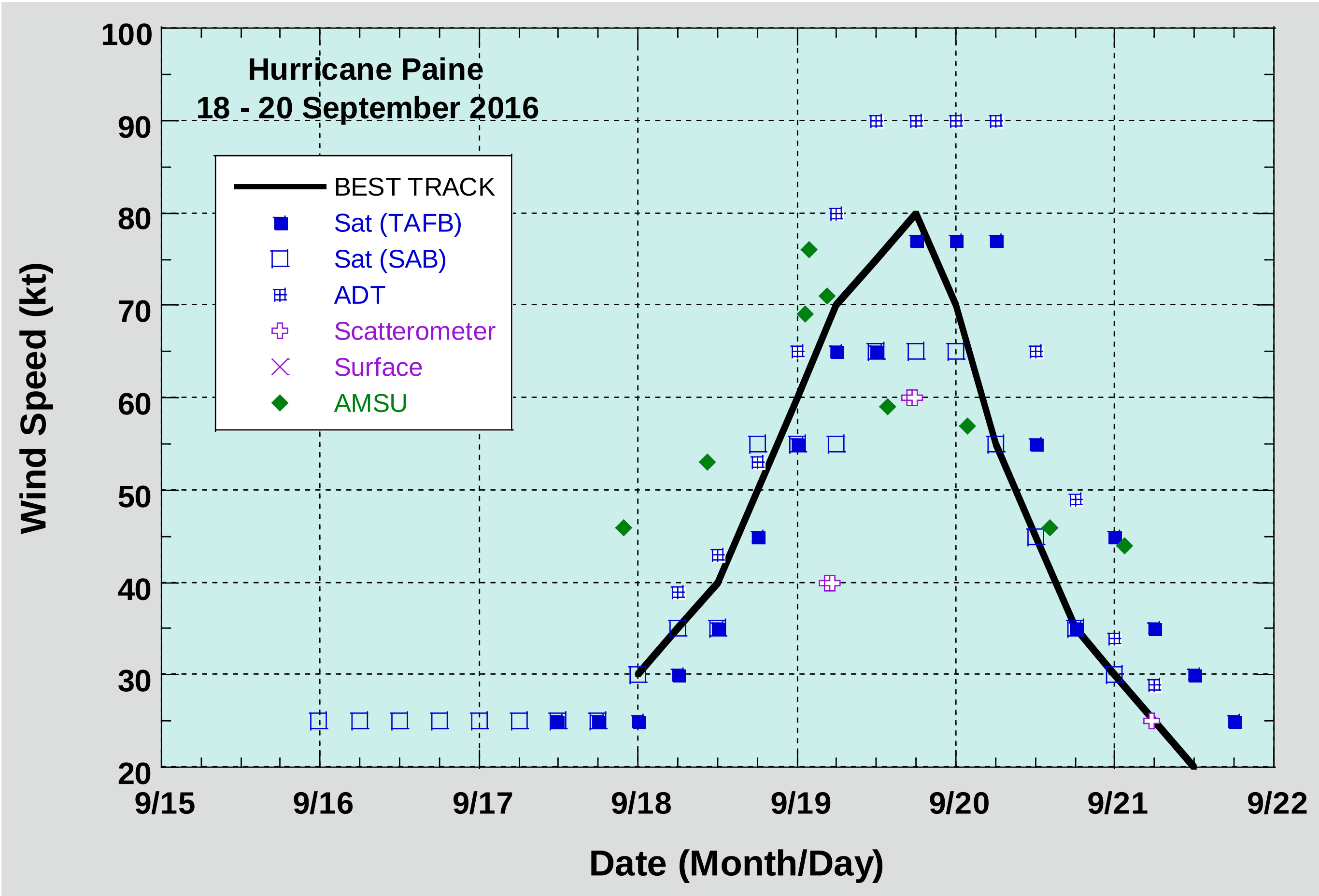

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Paine. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. Dashed vertical lines refer to 0000 UTC.

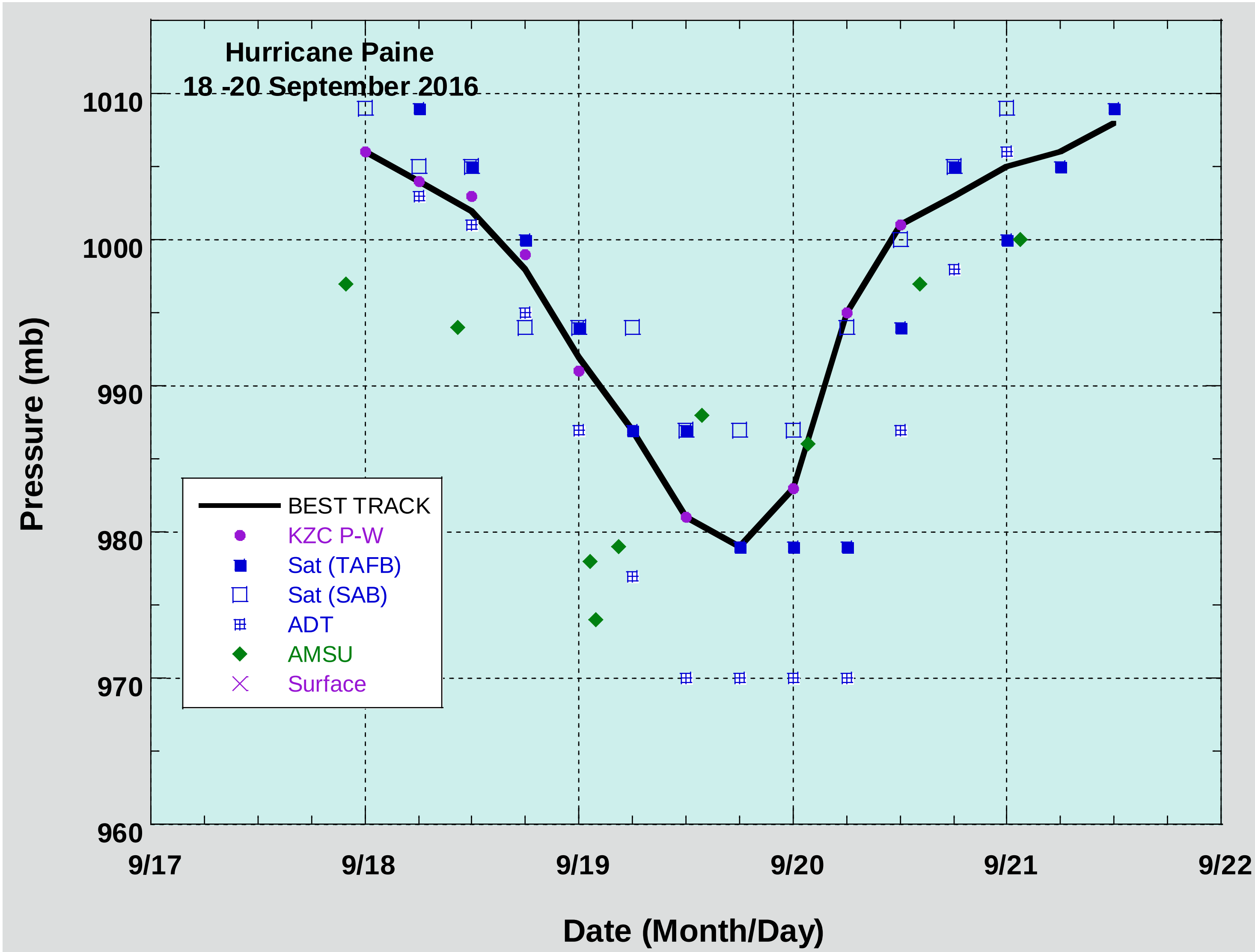

Figure 3. Selected pressure observations and best track minimum central pressure curve for Paine. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines refer to 0000 UTC.

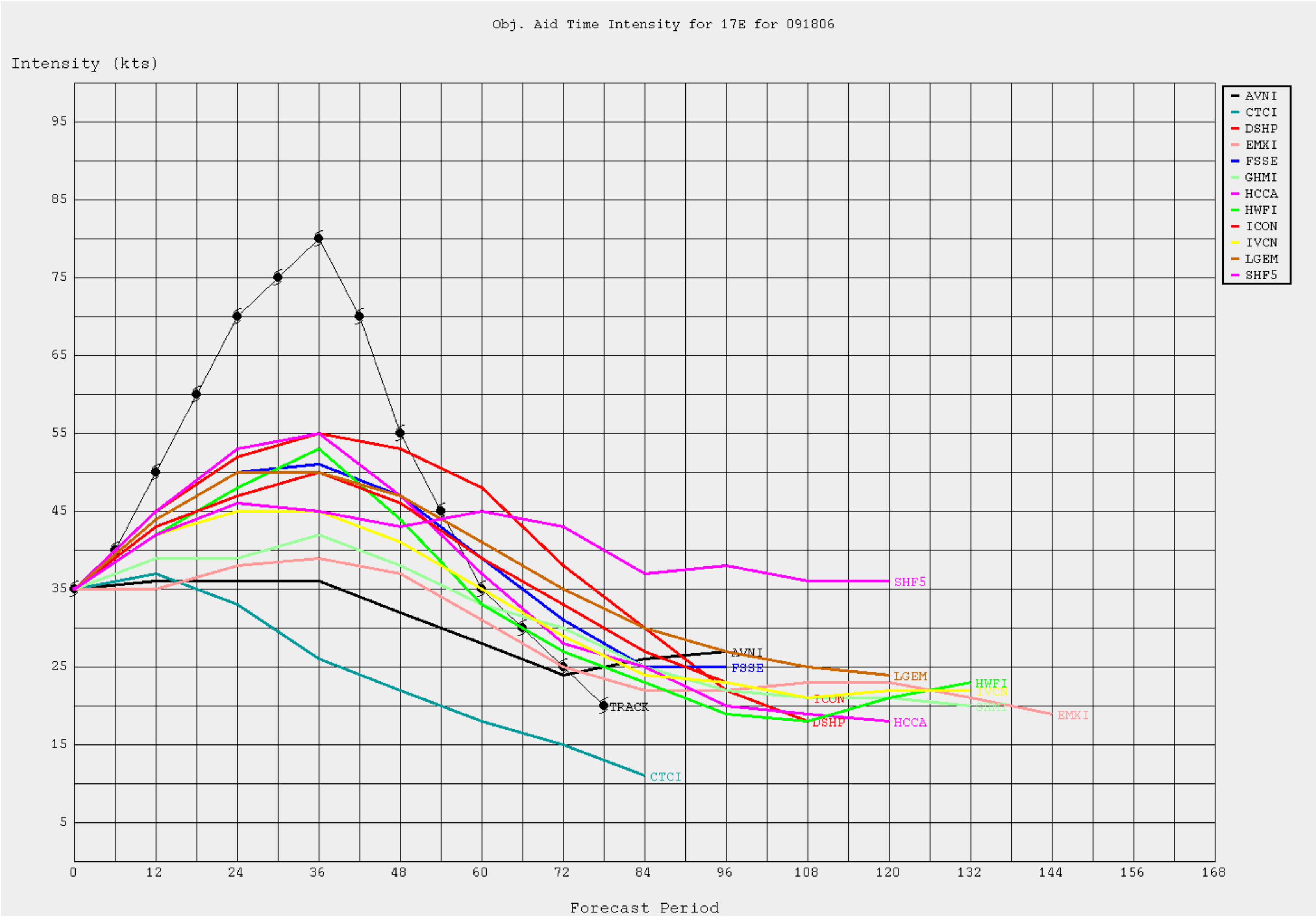

Figure 4. Selected model guidance on 0600 UTC 18 September (colored lines) with the verifying intensities (tropical cyclone symbols) just before the rapid intensification of Paine.