Tropical Cyclone Report
Hurricane Paul
(EP162012)
13 – 17 October 2012

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Paul was a category 3 hurricane (on the Saffir-Simpson Hurricane Wind Scale) that rapidly intensified near Clarion Island and then rapidly weakened as it approached the Baja California peninsula. Paul made landfall along the west coast of Baja California Sur as a post-tropical cyclone and then dissipated northwest of Punta Eugenia.

a. Synoptic History

Paul originated from a tropical wave that moved off the west coast of Africa on 28 September. The wave moved westward across the tropical Atlantic during the next few days, with convection near the northern end of the wave axis developing into Tropical Storm Oscar over the central Atlantic on 3 October. The tropical wave continued westward but lost most of its deep convection when it approached the Lesser Antilles on 4 October. Convection remained limited through 8 October while the wave moved across the Caribbean Sea and Central America, but showers and thunderstorms increased over the far eastern Pacific Ocean by 10 October. The convective activity increased in organization by 13 October—the same time that a well-defined low-level center of circulation developed—and the disturbance is estimated to have become a tropical depression at 1200 UTC that day while centered about 560 n mi south-southwest of Cabo San Lucas, Mexico. The cyclone steadily strengthened, becoming a tropical storm 6 h later. 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 1[1].

Located on the southwestern periphery of a subtropical ridge, Paul moved westward for a short time after becoming a tropical storm. The cyclone then reached a break in the ridge caused by a mid- to upper-level low located west of the Baja California peninsula, and Paul subsequently slowed down and turned northward by 0000 UTC 15 October. At the same time, the cyclone began a period of rapid intensification (Fig. 4a) and became a hurricane at 0600 UTC when centered about 515 n mi southwest of Cabo San Lucas. The hurricane turned north-northeastward and accelerated later that day as it became embedded in southwesterly flow between the mid- to upper-level low to the west of the Baja peninsula and a ridge over northern Mexico. The eye of Paul moved 25 to 30 n mi east of Clarion Island, and the hurricane reached its peak intensity of 105 kt around 1800 UTC 15 October (Fig. 4b).

[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.

The hurricane weakened slightly but maintained major hurricane status until just after 0600 UTC 16 October when deep-layer southerly to southwesterly vertical shear increased substantially. Due to the shear, Paul weakened rapidly as it approached the southern part of the Baja California peninsula (Fig. 4c). The hurricane turned northward just before reaching land due to its interaction with the mid- to upper-level low, and the center of circulation paralleled the coast of Baja California Sur for about a day. Paul weakened to a tropical storm by 0000 UTC 17 October while located just to the northwest of Cabo San Lazaro, Mexico, and the system became a post-tropical cyclone only 6 h later when all deep convection associated with the system dissipated.

Paul continued to produce gale-force winds for about 18 h while the circulation gradually spun down, and the post-tropical cyclone turned northwestward and grazed the coastline, making landfall around 1600 UTC at Bahía Asunción in Baja California Sur with 35-kt winds. The low weakened while its center passed by Isla Cedros and then dissipated just after 0000 UTC 18 October when it was located about 60 n mi northwest of Punta Eugenia, Mexico.

b. Meteorological Statistics

Observations in 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 Dvorak estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Data and imagery from NOAA polar-orbiting satellites, the NASA Tropical Rainfall Measuring Mission (TRMM) and Aqua, 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 estimated peak intensity of 105 kt is based on a blend of subjective Dvorak satellite intensity estimates of T5.5/5.5 (102 kt) from TAFB and SAB and an objective UW-CIMSS ADT estimate of T5.7 (107 kt) at 1800 UTC 15 October. After 1800 UTC, objective ADT estimates increased to T6.2 (120 kt) while subjective data-T estimates from TAFB and SAB decreased. Since convective cloud tops were warming during that time, the analysis assumes that the subjective numbers were more accurate and indicates that Paul weakened slightly after 1800 UTC.

Selected surface observations from land stations are given in Table 2. A few observing sites reported sustained tropical-storm-force winds, one on Clarion Island and the others on the Baja California peninsula. The station on Isla Clarión measured a maximum sustained wind of 51 kt and a gust to 67 kt at an elevation of 3 m, while another station reported a sustained wind of 45 kt and a gust to 62 kt at an elevation of 3 m on the west coast of Baja California Sur at Puerto Cortes. The only ship that reported tropical-storm-force winds was the cruise ship *Carnival Splendor* (call sign 3EUS), which measured maximum winds of 47 kt at an elevation of 44 m at 0900 and 1300 UTC 16 October. Sustained hurricane-force winds likely got very close to the coast of the Baja California peninsula, but it is estimated that Paul weakened to a tropical storm before it made its closest approach to land. In addition, there were no reports of sustained

hurricane-force winds. The lowest pressure reported on land was 974.3 mb at San Lucas in Baja California Sur.

Paul produced heavy rainfall and flooding mainly over Baja California Sur and in isolated areas in the state of Sinaloa on the mainland of Mexico. The highest reported amounts were 6.03 in (153.2 mm) of rain at Puerto Cortes and 5.11 in (129.8 mm) at Ciudad Constitución, both in Baja California Sur. About 2 in (50 mm) were reported at Topolobampo in Sinaloa, on Isla Clarión, and on Isla Socorro.

c. Casualty and Damage Statistics

Media reports indicated that Paul affected almost 16,000 people and damaged about a thousand homes. The city most affected was Loreto, with damaged roads due to fresh water flooding cutting the city off from the rest of the state and inadequate drinking water due to broken pipes. Elsewhere, almost 500 families in Comondú and 300 people in Mulege had damage to their homes. The Federal Electricity Commission stated that about 30% of customers in Baja California Sur lost power. Although total costs are not available, the city of La Paz stated that damage to the roads in the city was estimated at 200 million pesos (about 15.5 million USD). There were no reports of casualties associated with Paul.

d. Forecast and Warning Critique

The genesis of Paul was only somewhat well forecast. The area of disturbed weather that Paul originated from was introduced in the Tropical Weather Outlook at 1200 UTC 10 October and given a low (< 30%) chance of development during the next 48 h, or 3 days before the actual time of genesis. The probability was raised to a medium (30 – 50%) chance at 1800 UTC that same day. However, the chance of genesis was not raised to high (> 50%) until 1200 UTC 13 October, the time when genesis is now estimated to have occurred.

A verification of NHC official track forecasts for Paul is given in Table 3a. Official forecast track errors were slightly greater than the mean official errors for the previous 5-yr period at all forecast times between 12 and 72 h. The climatology and persistence model CLIPER (OCD5) errors were substantially higher than the OCD5 errors for the previous 5-yr period, probably because Paul took a track that is not typical of most eastern North Pacific tropical cyclones. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The only track model that had lower errors than the official forecast at all verified forecast times was the Global Forecast System (GFSI); however, the European Centre for Medium-Range Weather Forecasts (EMXI) model also had lower errors than the official forecasts for most forecast times. The official forecasts did have lower average track errors than the multi-model consensus TVCE and the Florida State Superensemble (FSSE) at all forecast times. Most of the track models, and consequently the official forecasts, were too far to the west and south (Fig. 5). In effect, the models did not forecast Paul to get as close to the Baja California peninsula as it did, and they did not show the hurricane accelerating toward the Baja

peninsula as fast as it did. The GFSI had some of the lowest track errors because it most accurately forecast Paul's north-northeastward acceleration.

A verification of NHC official intensity forecasts for Paul is given in Table 4a. Paul's intensity was difficult to forecast due to its period of rapid intensification and subsequent rapid weakening, which is reflected by higher-than-normal OCD5 errors. Official forecast intensity errors were greater than the mean official errors for the previous 5-yr period at 12 through 48 h, yet they still had skill relative to OCD5. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. The intensity model with the overall lowest errors (and which beat the official forecasts at 24 through 48 h) was the Hurricane Weather Research and Forecasting (HWFI) model. The Statistical Hurricane Intensity Prediction System (Decay-SHIPS, or DSHP) and Florida State Superensemble (FSSE) had lower errors than the official forecasts at 36 and 48 h.

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

Table 1. Best track for Hurricane Paul, 13 – 17 October 2012.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
13 / 1200	13.8	112.0	1006	30	tropical depression
13 / 1800	13.9	113.1	1005	35	tropical storm
14 / 0000	14.0	113.8	1003	40	"
14 / 0600	14.1	114.2	1001	45	"
14 / 1200	14.3	114.6	1001	50	"
14 / 1800	14.6	115.0	996	55	"
15 / 0000	15.1	115.1	991	60	"
15 / 0600	15.8	115.1	988	65	hurricane
15 / 1200	16.8	114.8	979	80	"
15 / 1800	17.9	114.4	959	105	"
16 / 0000	19.2	113.8	960	100	"
16 / 0600	20.7	113.1	962	100	"
16 / 1200	22.7	112.5	971	85	"
16 / 1800	24.2	112.4	982	70	"
17 / 0000	25.2	112.5	988	55	tropical storm
17 / 0600	26.0	113.0	990	40	low
17 / 1200	26.7	113.7	993	35	"
17 / 1800	27.5	114.7	995	35	"
18 / 0000	28.4	115.9	998	30	"
18 / 0600					dissipated
15 / 1800	17.9	114.4	959	105	maximum wind and minimum pressure
17 / 1600	27.1	114.3	994	35	landfall near Bahía Asunción, Baja California Sur (as a post-tropical cyclone)

Table 2. Selected surface observations for Hurricane Paul, 13 – 17 October 2012.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)	Storm tide (ft)	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)			
Mexico								
Colima								
Isla Clarión (76639) (18.35N 114.73W)	15/2000	989.9	15/1930	51 (3 m)	67			1.88
Isla Socorro (76724) (18.73N 110.95W)								1.98
Baja California Sur								
Puerto Cortes (BS07) (24.48N 111.83W)	16/1945	992.2	16/1830	45 (3 m)	62			6.03
San Lucas (BS03) (22.88N 109.93W)	16/1200	974.3	16/1200	33	52			1.70
La Paz (76406) (24.09N 110.36W)	16/2100	1002.1	16/1945	25 (6.3 m)	34			1.35
Ciudad Constitución (BS02) (25.01N 111.66W)		999.0			43			5.11
Loreto (MMLT) (25.99N 111.35W)	16/1646	1005.6	16/1731	35	45			1.22
San Juanico (BS05) (26.26N 112.48W)	16/2230	996.2	16/2230	20	43			1.11
Santa Rosalia (76252) (27.09N 112.10W)	17/0500	999.8	17/0345		39 (3 m)			0.01
Diaz Ordaz (BS04) (27.64N 113.46W)		995.9			31			0.10
Baja California								
Isla Cedros (76058) (28.03N 115.19W)	17/2030	996.0	17/2030	36 (50 m)	44			0.01
Bahia Angeles (BC05) (28.90N 113.56W)	17/1300	1003.7	17/2020		38			0.05
Sinaloa								
Topolobampo (76320) (25.59N 109.06W)	17/0030	1004.7	17/0130		38 (3 m)			2.06
Culiacan (SI07) (24.80N 107.40W)								1.80

[a] Date/time is for sustained wind when both sustained and gust are listed. Elevation of the site is provided if known.

[b] Sustained wind averaging periods are generally 10 min.

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Paul, 13 – 17 October 2012. Mean errors for the five-year period 2007-11 are shown for comparison. Official errors that are smaller than the five-year means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	30.9	51.5	73.6	91.7	115.4		
OCD5	66.8	160.3	323.7	502.5	887.1		
Forecasts	12	10	8	6	2		
OFCL (2007-11)	28.6	46.3	62.7	78.1	108.0		
OCD5 (2007-11)	38.5	74.8	116.0	159.8	246.1		

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Paul, 13 – 17 October 2012. 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	34.3	51.9	76.0	102.4			
OCD5	65.2	143.1	336.4	504.5			
GFSI	**31.2**	**43.7**	**66.7**	**81.2**			
EMXI	**28.1**	55.6	**73.0**	**89.8**			
EGRI	80.1	117.3	123.5	139.1			
CMCI	46.1	85.3	86.2	**57.4**			
GHMI	39.2	63.0	103.1	132.0			
HWFI	34.8	59.8	115.3	164.8			
AEMI	35.0	55.2	76.2	**101.6**			
TVCE	35.8	54.1	78.2	105.1			
FSSE	36.4	56.1	87.4	107.7			
LBAR	54.6	108.6	225.2	291.5			
BAMS	61.4	102.8	127.0	177.4			
BAMM	36.5	56.9	78.3	**80.1**			
BAMD	43.9	57.3	94.1	**92.3**			
Forecasts	9	6	4	4			

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Paul, 13 – 17 October 2012. Mean errors for the five-year period 2007-11 are shown for comparison. Official errors that are smaller than the five-year means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	8.8	16.0	18.8	24.2	**7.5**		
OCD5	12.8	22.1	24.4	30.2	12.5		
Forecasts	12	10	8	6	2		
OFCL (2007-11)	6.4	10.6	13.7	15.1	17.0		
OCD5 (2007-11)	7.5	12.4	16.1	18.4	20.1		

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Paul, 13 – 17 October 2012. 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	9.5	17.8	20.7	21.0	5.0		
OCD5	13.7	23.8	26.1	26.2	12.0		
HWFI	12.0	**16.9**	**15.4**	**11.8**	16.0		
GHMI	10.8	20.8	26.6	23.0	18.0		
DSHP	12.1	21.8	**18.7**	**17.4**	12.0		
LGEM	12.8	22.8	24.1	24.2	**1.0**		
FSSE	11.5	18.2	**16.0**	**11.2**	16.0		
ICON	11.5	19.7	20.7	**18.8**	12.0		
IVCN	11.5	19.7	20.7	**18.8**	12.0		
Forecasts	11	9	7	5	1		

Table 5. Watch and warning summary for Hurricane Paul, 13 – 17 October 2012.

Date/Time (UTC)	Action	Location
15 / 0900	Tropical Storm Watch issued	Santa Fe to Puerto San Andresito
15 / 1500	Tropical Storm Watch changed to Tropical Storm Warning	Santa Fe to Puerto San Andresito
15 / 1500	Tropical Storm Watch issued	Puerto San Andresito to El Pocito
15 / 2100	Tropical Storm Warning changed to Hurricane Warning	Santa Fe to Puerto San Andresito
15 / 2100	Tropical Storm Watch modified to	Punta Abreojos to El Pocito
15 / 2100	Tropical Storm Warning issued	Agua Blanca to Santa Fe
15 / 2100	Tropical Storm Warning issued	Puerto San Andresito to Punta Abreojos
16 / 0300	Tropical Storm Watch changed to Tropical Storm Warning	Punta Abreojos to El Pocito
16 / 0300	Tropical Storm Watch issued	El Pocito to Punta Eugenia
16 / 0300	Tropical Storm Warning modified to	Punta Abreojos to El Pocito
16 / 0300	Tropical Storm Warning issued	La Paz to Bahia San Juan Bautista
16 / 0300	Hurricane Warning modified to	Santa Fe to Punta Abreojos
16 / 1500	Tropical Storm Warning modified to	La Paz to San Evaristo
16 / 1500	Hurricane Warning issued	San Evaristo to Mulege
17 / 0000	Tropical Storm Warning modified to	Santa Fe to El Pocito
17 / 0000	Tropical Storm Warning modified to	Bahia San Juan Bautista to San Evaristo
17 / 0000	Hurricane Warning discontinued	All
17 / 1500	Tropical Storm Watch discontinued	All
17 / 1500	Tropical Storm Warning discontinued	All

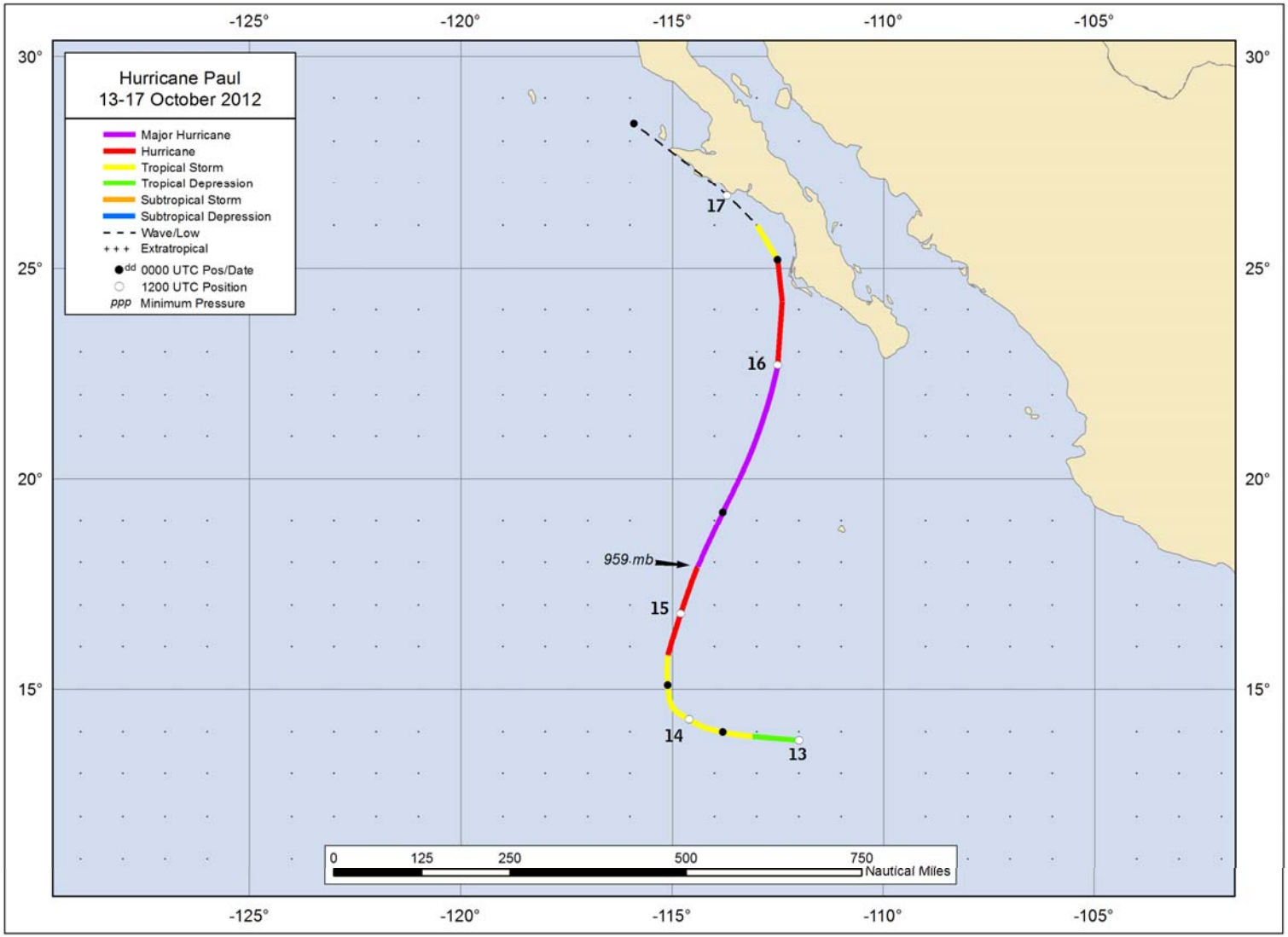

Figure 1. Best track positions for Hurricane Paul, 13 – 17 October 2012.

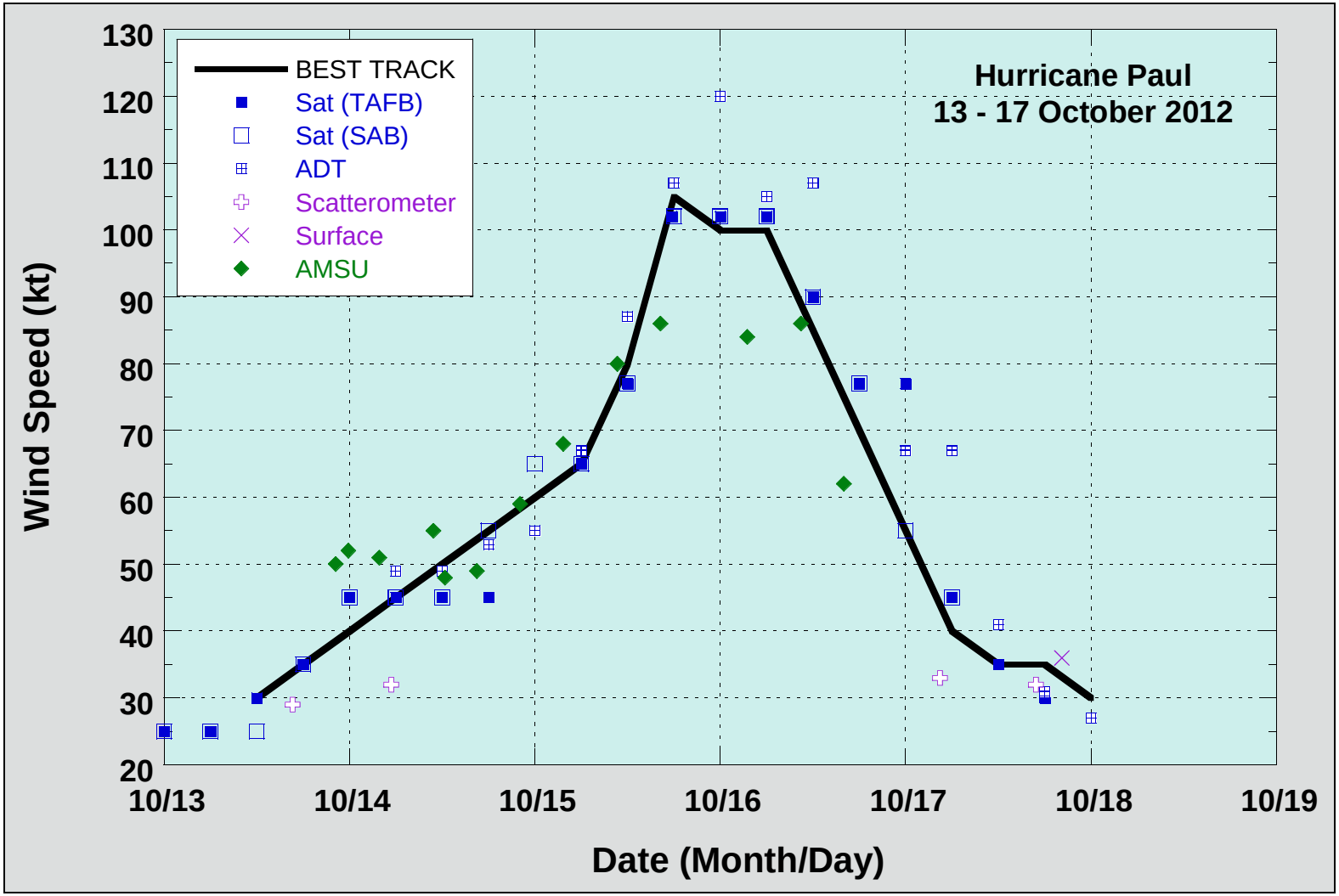

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Paul, 13 – 17 October 2012. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC.

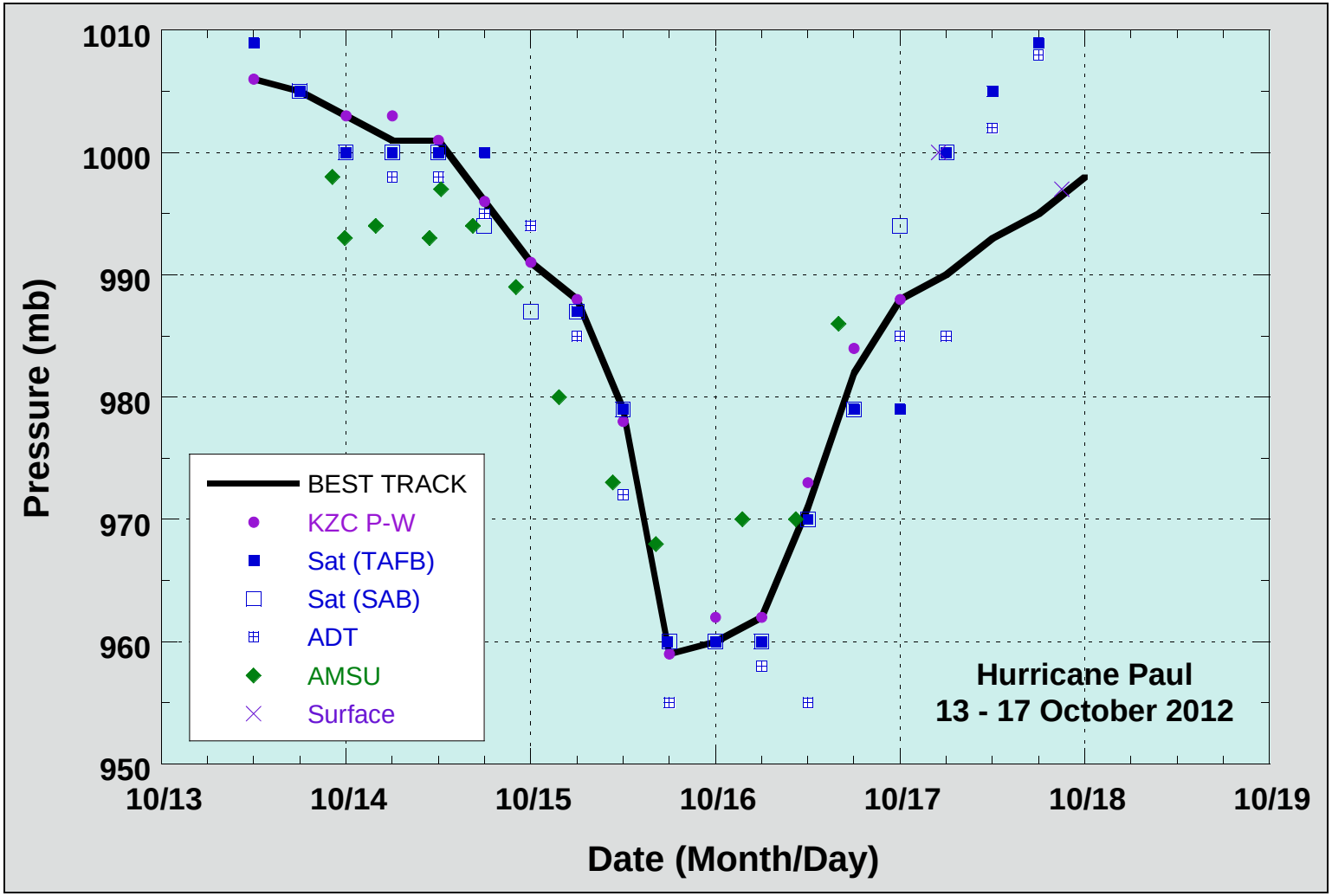

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Paul, 13 – 17 October 2012. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological 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.

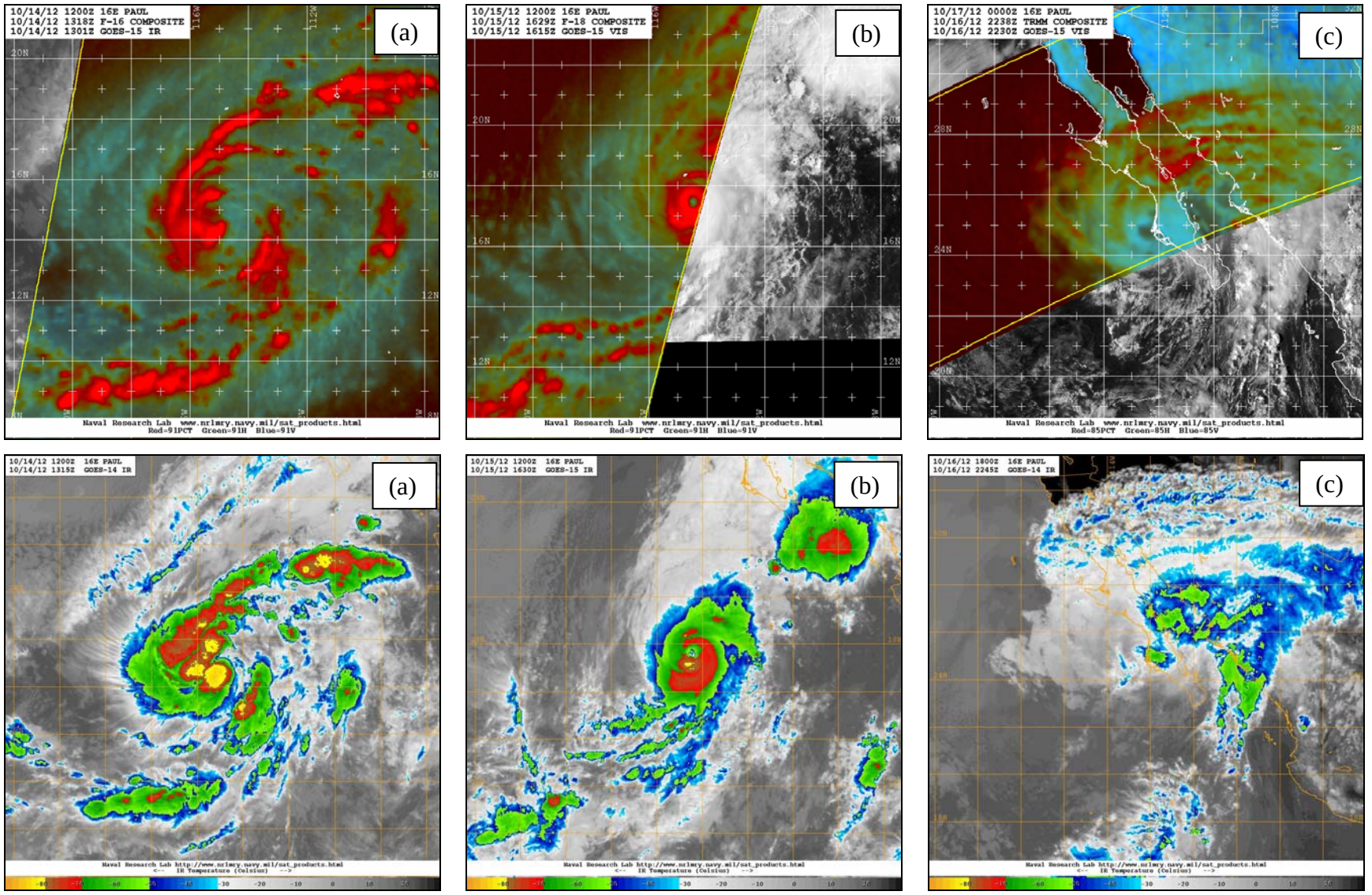

Figure 4. Two-day evolution of Hurricane Paul during its periods of rapid intensification and rapid weakening shown by 91 GHz microwave and infrared satellite images (a) near the start of rapid intensification, (b) near Paul's peak intensity, and (c) near the end of rapid weakening. Images courtesy of the Fleet Numerical Meteorology and Oceanography Center.

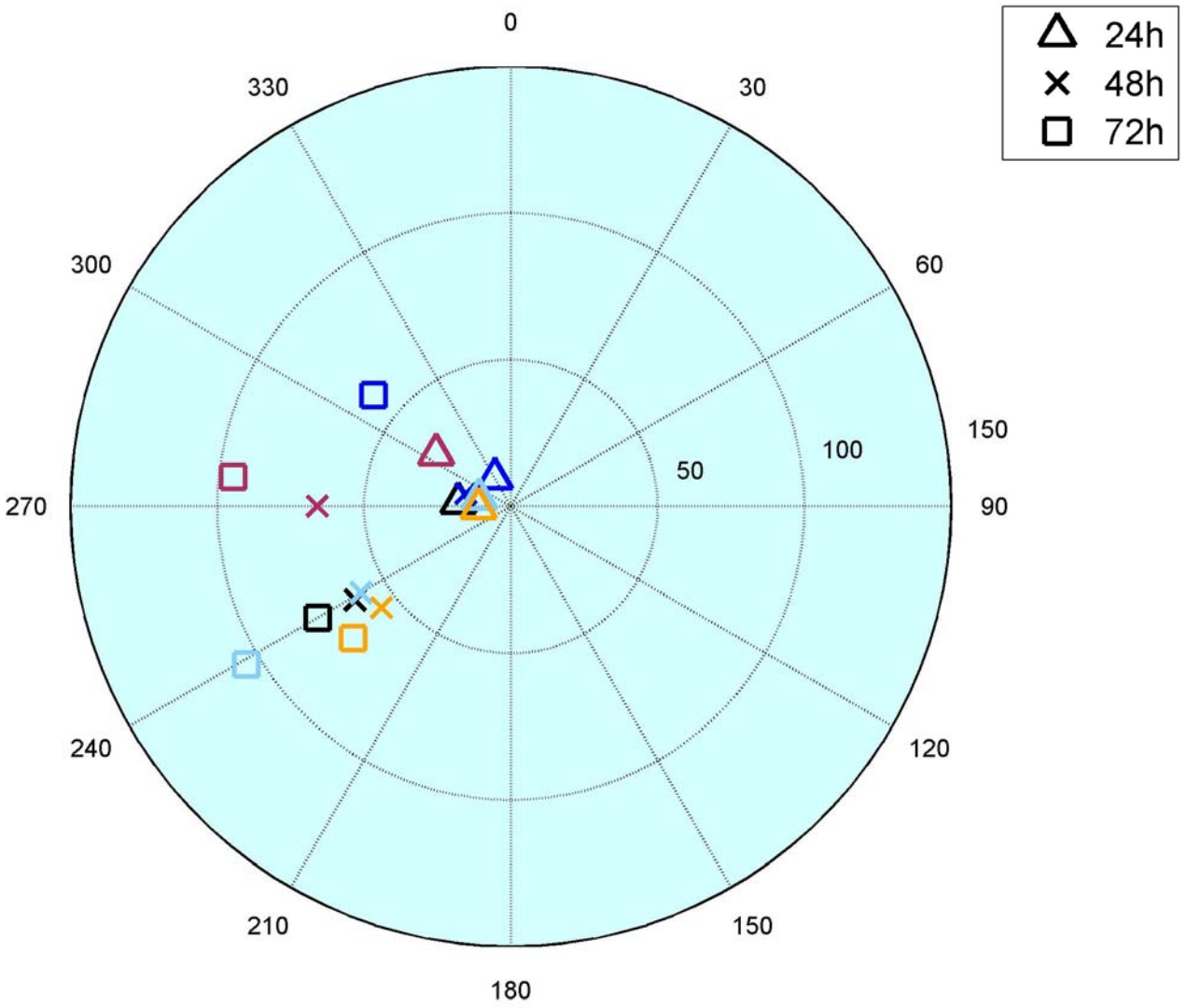

Figure 5. Polar plot of 24-, 48-, and 72-h forecast track errors (in n mi) for Hurricane Paul, 13 – 17 October 2012, from the official forecasts (black), GFSI (dark blue), EMXI (light blue), TVCE (gold), and FSSE (red).