

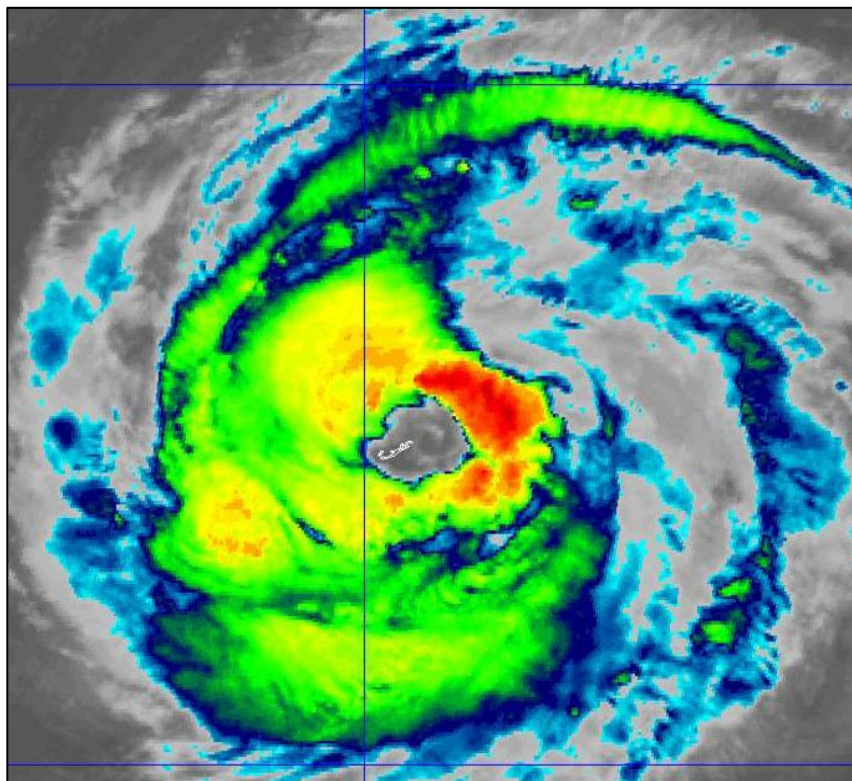


# NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

## HURRICANE PAULETTE (AL172020)

7–22 September 2020

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National Hurricane Center  
1 April 2020



GOES-16 INFRARED SATELLITE IMAGE OF HURRICANE PAULETTE AT 0850 UTC 14 SEPTEMBER 2020  
AS THE EYE PASSED OVER BERMUDA.

Paulette was a long-lived tropical cyclone that passed over Bermuda as a category 2 hurricane (on the Saffir-Simpson Hurricane Wind Scale). Paulette then became a post-tropical cyclone before regenerating into a tropical storm near the Azores.

# Hurricane Paulette

7–22 SEPTEMBER 2020

## SYNOPTIC HISTORY

Paulette formed from a tropical wave that departed the west coast of Africa on 2 September. This wave produced an extensive area of convection over the eastern Atlantic during the next couple of days as it moved westward to west-northwestward and began to interact with a slow-moving broad area of low pressure to its west. The wave and broad low merged by 5 September, and over the next day or so the associated surface low became better defined. By 0000 UTC 7 September, the convection associated with the low increased sufficiently in organization to designate the system as a tropical depression while it was located about 1000 n mi west of the Cabo Verde Islands. Later that morning, satellite wind data indicated that the cyclone was producing winds to tropical storm force, and it is estimated the depression became Tropical Storm Paulette by 1200 UTC 7 September, while located about 1200 n mi east of the northern Leeward Islands. The “best track” chart of Paulette’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<sup>1</sup>.

During the first couple of days after formation, the cyclone moved slowly west-northwestward to northwestward, and even drifted north-northwestward for a brief period, on the southwest side of a weak mid-level ridge. The ridge began to build to the north of the system by 8 September, which induced a faster west-northwestward motion over the next few days. During its first 24 h as a tropical storm, Paulette slowly strengthened, with the rate of intensification limited by moderate southwesterly vertical wind shear and some surrounding dry air. By 1200 UTC 8 September, the deep-layer shear increased as the storm approached an upper-level trough located to its northwest. This shear, which reached 40 kt at times, occasionally caused the low-level center to become exposed over the next couple of days, and Paulette’s intensity leveled off and then decreased slightly on 10 September. The next day, the shear began to gradually subside, which allowed Paulette to resume a slow strengthening trend. Around this same time a weakness developed in the subtropical ridge to the northwest of the cyclone, causing the system to turn in that direction along with a slight increase in forward speed. The shear continued to decrease, resulting in a faster rate of Paulette’s intensification, and by 0000 UTC 13 September, a U.S. Air Force Reserve reconnaissance aircraft sampling the cyclone revealed that it had strengthened into a hurricane while located about 360 n mi southeast of Bermuda. The hurricane made a turn back toward the west-northwest that day as a mid-level ridge built to its northeast. This motion continued until Paulette began to round the periphery of the ridge, which caused the hurricane to turn northward early on 14 September. This path steered Paulette toward Bermuda while it continued to slowly intensify (Fig. 4), and the large eye of the hurricane passed over the

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<sup>1</sup> 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* directory, while previous years’ data are located in the *archive* directory.

island from 0730 to 1000 UTC that day with an estimated intensity of 85 kt (cover photo). It should be noted that the 85-kt winds at that time were likely occurring in stronger bands in the northeastern portion of the hurricane offshore of and not over Bermuda.

Paulette continued to intensify after passing over Bermuda while rounding the periphery of the subtropical ridge and reached its peak intensity of 90 kt by 1800 UTC 14 September. The hurricane began to accelerate toward the northeast around that time as it became embedded in the mid-latitude flow to the north of the ridge. On 15 September, Paulette began extratropical transition as a baroclinic zone approached from the northwest, and the cyclone's peak winds started to slowly decrease as its wind field expanded. The hurricane reached the cold waters of the northern Atlantic while interacting with the baroclinic zone on 16 September and completed its transition to a hurricane-force extratropical cyclone while located about 350 n mi southeast of Cape Race, Newfoundland. The powerful extratropical cyclone gradually weakened over the next few days while it turned eastward, then its forward motion slowed as it turned southeastward and then southward when it rounded the eastern periphery of the ridge while escaping the stronger mid-latitude westerlies.

The frontal features associated with the extratropical cyclone gradually dissipated around 0600 UTC early 19 September, when the system was located about 100 n mi southwest of the Azores. The low then slowed its forward motion as the steering flow collapsed, resulting in a south-southeastward drift by late on 19 September. However, the story of Paulette was not over yet, as the convection associated with the low gradually increased in coverage and organization, and by 1800 UTC 20 September the convection organization became sufficient for the system to again be designated as a tropical storm while centered about 200 n mi south-southwest of the Azores. By this time, ridging began to build to the southwest of Paulette, resulting in the cyclone turning toward the east with an increase in forward speed. The deep convection continued near the center of Paulette and resulted in the storm reaching a secondary peak intensity of 50 kt by 0000 UTC 22 September. Increasing vertical wind shear and cooler waters finally took its toll on Paulette that day, and the convective cloud tops quickly warmed that morning, causing the storm to weaken, and Paulette again became a post-tropical cyclone by 1200 UTC that day while located about 600 n mi southeast of the Azores.

Early in this post-tropical phase, the low interacted with a baroclinic zone once again, which helped to enhance the surface winds, resulting in a brief increase in strength on 23 September. Once the associated mid- to upper-level trough lifted out and the baroclinic zone weakened, post-tropical Paulette began to weaken, and a turn toward the southwest and then the west occurred on 24–25 September as surface high pressure began to build to the north. Dry and stable air along with cool waters caused the remnant low to gradually spin down over the next few days as the ridge shifted eastward and the low turned toward the northwest, north, and ultimately northeast around the high. Finally, by 1800 UTC 28 September, the low opened into a surface trough of low pressure just southwest of the Azores.

## METEOROLOGICAL STATISTICS

Observations in Paulette (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. Observations also include flight-level, stepped frequency microwave radiometer (SFMR), and dropwindsonde observations from five flights of the 53<sup>rd</sup> Weather Reconnaissance Squadron of the U.S. Air Force Reserve Command and one flight of the NOAA WD-P3 Hurricane Hunter aircraft from the NOAA Aircraft Operations Center. 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 Paulette. In addition, the Bermuda Weather Service radar provided data for tracking Paulette while it was near and over the island.

Selected ship reports of winds of tropical storm force or greater associated with Paulette are given in Table 2. Selected surface observations from land stations and data buoys are given in Table 3.

### *Winds and Pressure*

Paulette's peak intensity of 90 kt at 1800 UTC 14 September is based on a combination of aircraft data and satellite intensity estimates. At 1046 UTC, a dropwindsonde observation by an Air Force Reserve reconnaissance aircraft measured mean boundary layer winds in the lowest 150 m of 108 kt. Applying a reduction factor of 83% based off the mean layer height of 86 m yields an estimated surface wind of 90 kt. However, at around the same time that observation occurred, the 700 mb flight level winds of the aircraft were 93 kt (which reduces to 84 kt at the surface), and peak SFMR winds were 80 kt, indicating surface winds speeds may have been closer to 85 kt at that time. Since the cyclone's appearance in satellite images improved over the next few hours, and satellite intensity estimates also increased after the aircraft observations, it is reasonable to assume the hurricane's intensity had reached 90 kt by 1800 UTC that day. The lowest pressure sampled by the aircraft was 969 mb from a dropwindsonde released at 1039 UTC that day. Although there were no additional flights to sample Paulette's intensity after that morning, several satellite intensity estimates continued to support a 90 kt intensity through early 15 September, while the wind field gradually expanded. The estimated minimum pressure of 965 mb at 1800 UTC 14 September is based on a deepening of around 4 mb after the 969-mb aircraft observation earlier that day. This minimum pressure is slightly higher than that indicated by the Knaff-Zehr-Courtney pressure wind relationship at that time.

The western eyewall of the cyclone affected Bermuda prior to and after landfall. The highest sustained surface wind speed reported on the island was 69 kt at a height of 8 m on Pearl Island at 0654 UTC 14 September, which is located in Great Sound in the southwestern portion of Bermuda; this wind speed converts to approximately 71 kt at a standard 10-meter elevation. The highest official surface wind gust measured was 84 kt at the L.F. Wade International Airport heliport at around 1056 UTC 14 September when Paulette's southern eyewall passed over the

airport. A wind gust to 102 kt at 0745 UTC 14 September was measured at the Maritime Operations Center (MAROPS) at an elevation of 91 meters. An amateur radio report indicated that a sustained wind of 70 kt and a gust to 93 kt occurred at Hog Bay in the southwestern portion of the island after the center of the eye of Paulette had passed north of Bermuda. The lowest pressure reported on Bermuda was 972.0 mb at 0928 UTC that day at the Bermuda Weather Service office, which is located on the airport property.

## Storm Surge<sup>2</sup>

A U.S. National Ocean Service (NOS) station on the eastern side of Bermuda at the Bermuda Biological Station reported a storm surge of 2.38 ft (0.73 m) above normal tide levels. Combined with the tide, the surge produced a peak water level of 1.7 ft (.51 m) above Mean Higher High Water (MHHW). There were no reports of damage in Bermuda caused by the storm surge.

## Rainfall and Flooding

Rainfall reports from Bermuda were sparse, as many of the observing stations lost power at one point or another during the hurricane's passage. The highest official rainfall total reported on Bermuda was 2.91 inches (74 mm) at the Bermuda Weather Service Office, where manual observations were taken every 6 h. However, an amateur radio operator in Hog Bay measured 5.45 inches (138 mm).

## CASUALTY AND DAMAGE STATISTICS

There were two direct<sup>3</sup> deaths and one injury associated with Paulette, all of which occurred due to rip currents along the east coast of the United States. Although Paulette passed well offshore of the United States coast, the primary wave energy along the coast when the casualties occurred came from the tropical cyclone, while local winds may have enhanced the surf and rip currents. Therefore, these deaths are considered to be directly due to Paulette. In

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<sup>2</sup> Several terms are used to describe water levels due to a storm. **Storm surge** is defined as the abnormal rise of water generated by a storm, over and above the predicted astronomical tide, and is expressed in terms of height above normal tide levels. Because storm surge represents the deviation from normal water levels, it is not referenced to a vertical datum. **Storm tide** is defined as the water level due to the combination of storm surge and the astronomical tide, and is expressed in terms of height above a vertical datum, i.e. the North American Vertical Datum of 1988 (NAVD88) or Mean Lower Low Water (MLLW). **Inundation** is the total water level that occurs on normally dry ground as a result of the storm tide, and is expressed in terms of height above ground level. At the coast, normally dry land is roughly defined as areas higher than the normal high tide line, or Mean Higher High Water (MHHW).

<sup>3</sup> Deaths occurring as a direct result of the forces of the tropical cyclone are referred to as "direct" deaths. These would include those persons who drowned in storm surge, rough seas, rip currents, and freshwater floods. Direct deaths also include casualties resulting from lightning and wind-related events (e.g., collapsing structures). Deaths occurring from such factors as heart attacks, house fires, electrocutions from downed power lines, vehicle accidents on wet roads, etc., are considered "indirect" deaths.



Folly Beach, South Carolina, two children and a woman were caught in rip currents near a county park late on 13 September. The woman sustained minor injuries, while one of the children, a six-year-old boy, died. In New Jersey, several water rescues were reported during the period of 13–15 September. In Lavalette, New Jersey, a 60-year-old man drowned because of rip currents.

Bermuda was directly impacted by the western eyewall of Paulette, and the sustained hurricane-force winds along with higher gusts caused 25,000 power outages (about 70% of the island's customers) and about \$50 million USD in damage.

## FORECAST AND WARNING CRITIQUE

### *Genesis*

The first genesis of Paulette was well anticipated. Initially, the cyclone was expected to form a little sooner than when it eventually occurred, as it became apparent after the disturbance was first introduced into the Tropical Weather Outlook (TWO) that it would likely interact with another disturbance prior to formation. The wave from which Paulette developed was first introduced into the TWO with a low chance (<40%) of development within the next 5 days about 180 h before genesis (Table 4a). The 5-day probabilities were raised to the medium (40–60%) and high category (>60%) 132 and 90 h prior to formation, respectively. The 2-day probabilities were first introduced 120 h prior to genesis, mentioning a low chance for development. The 2-day probabilities remained in that category until they were raised to medium 54 h prior to genesis and to high 24 h prior to formation.

Paulette's redevelopment was not well anticipated. The extratropical cyclone was first introduced in the TWO as having a chance for redevelopment in the low category for both the 5-day and 2-day time frames 60 h prior to reformation (Table 4b). The 5-day probabilities were increased to the medium category 48 h prior to genesis, while the 2-day probabilities reached the medium category 36 h prior to formation. Neither the 5-day or 2-day probabilities reached the high category before Paulette redeveloped. The marginal environmental conditions that the post-tropical cyclone was expected to encounter near the Azores caused uncertainty over whether or not reformation would occur.

### *Track*

The verification of NHC official track forecasts for Paulette is given in Table 5a. Official forecast track errors (OFCL) were below the long-term mean at 12 and 24 h, but larger than the 5-year mean at 36 through 120 h. The magnitude of the OFCL errors increased with lead time, and surpassed 100 n mi more than the long-term mean by 120 h. The climatology-persistence model (OCD5) errors were close to their long term means at all forecast times, indicating that the track forecasts were not more difficult than normal to predict. A closer examination of the forecast track errors (Table 6, Figure 5) indicates that there were substantial cross-track and along-track biases in the OFCL forecasts, the GFS and ECMWF models, and TVCA multi-model consensus. The cross-track biases were most prevalent early on during Paulette's lifecycle (Fig. 6), while the sheared system interacted with an upper-level trough. As Paulette approached Bermuda, the

cross-track biases were quite low, and the NHC forecast correctly called for a very close approach to the island several days in advance (Fig. 7). However, both the models and NHC track forecast were too slow, and likely underestimated the strength of the ridge that Paulette was steered around during its approach, and after it passed over Bermuda. This resulted in a slow bias that averaged over 220 n mi over the entire time Paulette was a tropical cyclone, with the most of this bias occurring while forecasting Paulette's re-curvature near Bermuda and its quick northeast motion until extratropical transition about a day thereafter.

A homogeneous comparison of the official track errors with selected guidance models is given in Table 5b. The NHC track forecast performed better than the global models at the 12–96-h forecast times, and was comparable to the models at 120 h. All of the consensus models had lower errors than OFCL at most forecast times, with the FSU Superensemble (FSSE) outperforming OFCL at all time periods. The Hurricanes in a Multi-scale Ocean-coupled Non-hydrostatic model (HMNI) also performed better than NHC at every forecast lead time except 12 h. OFCL errors were comparable to the simple consensus aids TVCX, TVCA, and the HFIP corrected consensus (HCCA) at all time periods.

### **Intensity**

A verification of NHC official intensity forecasts for Paulette is given in Table 7a. Official forecast intensity errors were lower than the mean official errors for the previous 5-yr period for all forecast times except 120 h, when it was equal to the mean. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 7b. The NHC intensity forecast errors were slightly higher but generally comparable to most of the models and consensus aids through 36 h, and had smaller errors than most of these intensity models at 48–120 h. The best performing intensity models were the Coupled Ocean/Atmosphere Mesoscale Prediction System for Tropical Cyclones (CTCI), and the variable consensus aids IVDR and IVCN, which performed better than the NHC intensity forecasts at most lead times.

### **Watches and Warnings**

Watches and warnings associated with Paulette are given in Table 8. The Bermuda Weather Service issued a Tropical Storm Watch for the island at 0300 UTC 12 September and upgraded the watch to a Tropical Storm Warning at 0900 UTC 12 September. A Hurricane Watch was issued at that same time, and this watch was upgraded to a Hurricane Warning at 1500 UTC that day.

### **Impact-Based Decision Support Services (IDSS) and Public Communication**

NHC coordinated frequently with the Bermuda Weather Service on the issuance of watches and warnings and the provision of hazard information for that island.



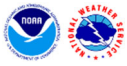
## ***Acknowledgements***

The Bermuda Weather Service provided data on Paulette for that country. National Weather Service Weather Forecast Offices in Charleston, South Carolina and Mt. Holly, New Jersey provided details regarding the rip current casualties and/or injuries in their respective areas of responsibility.



Table 1. Best track for Hurricane Paulette, 7–22 September 2020.

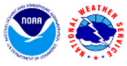
Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
07 / 0000	16.9	41.3	1006	30	tropical depression
07 / 0600	17.0	41.8	1006	30	"
07 / 1200	17.1	42.1	1005	35	tropical storm
07 / 1800	17.3	42.3	1005	35	"
08 / 0000	17.6	42.4	1004	40	"
08 / 0600	17.9	42.6	1000	45	"
08 / 1200	18.3	43.0	997	50	"
08 / 1800	18.6	43.7	997	50	"
09 / 0000	18.9	44.5	997	50	"
09 / 0600	19.2	45.2	997	50	"
09 / 1200	19.6	46.0	996	50	"
09 / 1800	20.0	46.8	996	50	"
10 / 0000	20.4	47.6	996	50	"
10 / 0600	20.8	48.3	996	50	"
10 / 1200	21.3	48.9	998	45	"
10 / 1800	21.8	49.6	998	45	"
11 / 0000	22.3	50.3	994	50	"
11 / 0600	22.8	51.1	991	55	"
11 / 1200	23.4	52.1	990	55	"
11 / 1800	24.3	53.1	989	55	"
12 / 0000	25.4	54.3	987	60	"
12 / 0600	26.4	55.6	986	60	"
12 / 1200	27.3	56.7	985	60	"
12 / 1800	28.0	57.8	984	60	"
13 / 0000	28.6	59.1	981	65	hurricane
13 / 0600	29.1	60.3	980	65	"
13 / 1200	29.6	61.4	976	70	"



Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
13 / 1800	30.2	62.6	974	75	"
14 / 0000	30.9	63.6	974	75	"
14 / 0600	31.8	64.4	973	80	"
14 / 0850	32.3	64.7	971	85	"
14 / 1200	32.9	64.9	968	85	"
14 / 1800	33.9	64.4	965	90	"
15 / 0000	35.1	63.3	965	90	"
15 / 0600	36.3	62.0	965	90	"
15 / 1200	37.6	59.5	965	90	"
15 / 1800	38.7	56.7	966	85	"
16 / 0000	40.0	54.0	966	85	"
16 / 0600	41.2	50.8	968	80	"
16 / 1200	42.6	46.9	973	75	extratropical
16 / 1800	44.3	43.1	974	70	"
17 / 0000	45.9	39.3	975	65	"
17 / 0600	47.0	36.5	977	60	"
17 / 1200	47.0	34.5	979	55	"
17 / 1800	46.6	33.0	982	50	"
18 / 0000	46.0	31.8	986	45	"
18 / 0600	44.6	31.4	989	45	"
18 / 1200	42.8	31.3	997	40	"
18 / 1800	41.0	31.2	999	40	"
19 / 0000	39.1	31.1	1002	40	"
19 / 0600	37.7	31.1	1002	40	low
19 / 1200	36.5	30.5	1006	40	"
19 / 1800	35.9	29.8	1008	35	"
20 / 0000	35.7	29.5	1008	35	"
20 / 0600	35.5	29.4	1008	35	"



Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
20 / 1200	35.1	29.7	1008	35	"
20 / 1800	34.7	30.6	1008	35	tropical storm
21 / 0000	34.1	31.2	1008	35	"
21 / 0600	33.3	31.2	1008	35	"
21 / 1200	32.9	29.8	1008	35	"
21 / 1800	33.3	28.1	1008	40	"
22 / 0000	33.8	26.3	1004	50	"
22 / 0600	34.5	24.6	1002	50	"
22 / 1200	34.8	23.1	1004	40	low
22 / 1800	34.7	21.8	1006	35	"
23 / 0000	34.8	20.5	1006	35	"
23 / 0600	35.0	19.2	1006	40	"
23 / 1200	35.6	18.1	1003	45	"
23 / 1800	36.2	17.2	1003	45	"
24 / 0000	36.2	16.7	1008	40	"
24 / 0600	35.9	16.6	1010	35	"
24 / 1200	35.4	17.2	1012	35	"
24 / 1800	34.6	18.4	1013	35	"
25 / 0000	33.7	19.8	1016	35	"
25 / 0600	33.4	21.4	1017	30	"
25 / 1200	33.0	23.2	1017	30	"
25 / 1800	33.0	25.1	1017	30	"
26 / 0000	33.2	26.8	1017	30	"
26 / 0600	33.7	28.4	1017	25	"
26 / 1200	34.6	29.5	1017	25	"
26 / 1800	35.4	30.2	1017	25	"
27 / 0000	36.3	30.3	1017	25	"
27 / 0600	36.7	29.5	1017	25	"



<b>Date/Time (UTC)</b>	<b>Latitude (°N)</b>	<b>Longitude (°W)</b>	<b>Pressure (mb)</b>	<b>Wind Speed (kt)</b>	<b>Stage</b>
27 / 1200	37.0	28.4	1017	25	"
27 / 1800	36.9	27.3	1018	20	"
28 / 0000	36.8	26.4	1018	20	"
28 / 0600	36.5	25.8	1018	20	"
28 / 1200	36.1	25.5	1018	20	"
28 / 1800					dissipated
14 / 1800	33.9	64.4	965	90	minimum pressure and maximum winds
14 / 0850	32.3	64.7	970	85	landfall near Tucker's Town, Bermuda

Table 2. Selected ship reports with winds of at least 34 kt for Hurricane Paulette, 7–22 September 2020.

<b>Date/Time (UTC)</b>	<b>Ship call sign</b>	<b>Latitude (°N)</b>	<b>Longitude (°W)</b>	<b>Wind dir/speed (kt)</b>	<b>Pressure (mb)</b>
<b>11 / 0600</b>	9V6246	27.4	48.2	080 / 35	1013.4
<b>13 / 1000</b>	9VHK7	33.6	63.9	090 / 35	1024.3
<b>13 / 1800</b>	9VHK7	34.6	61.0	120 / 35	1023.4
<b>13 / 1900</b>	9VHK7	34.7	60.7	110 / 36	1026.4
<b>13 / 2000</b>	9VHK7	34.9	60.3	110 / 35	1026.4
<b>13 / 2100</b>	9VHK7	35.0	59.9	120 / 35	1026.4
<b>13 / 2300</b>	9VHK7	35.1	59.5	110 / 35	1026.4
<b>13 / 2300</b>	9VHK7	35.2	59.2	100 / 35	1026.4
<b>14 / 0000</b>	9VHK7	35.2	58.8	110 / 35	1026.4
<b>14 / 0100</b>	9VHK7	35.3	58.4	110 / 36	1026.4
<b>24 / 0000</b>	OZSK2	37.6	18.8	030 / 39	1017.0
<b>24 / 1200</b>	OZSK2	37.2	15.3	050 / 35	1018.0
<b>24 / 1500</b>	3FVW3	32.1	10.6	070 / 35	1011.6
<b>27 / 1500</b>	OVZV2	40.7	33.4	020 / 36	1019.7

Table 3. Selected surface observations for Hurricane Paulette, 7–22 September 2020.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft) <sup>c</sup>	Storm tide (ft) <sup>d</sup>	Estimated Inundation (ft) <sup>e</sup>	Total rain (in)
	Date/time (UTC)	Press. (mb)	Date/time (UTC) <sup>a</sup>	Sustained (kt) <sup>b</sup>	Gust (kt)				
<b>Bermuda</b>									
Bermuda Biological NOS Station (32.37N 64.68W)	13/0936	972.7				2.38		1.7	
Bermuda Weather Service Office (32.37N 64.68W)	14/0928	972.0							2.91
Hog Bay, Amateur Radio (32.27N 64.88W)			14/1257	70	93				5.45
L.F. Wade Intl. AP AWOS (32.36N 64.67W)	14/0929	972.1	14/1056	54 (2 min, 8 m)	77				
L.F. Wade Intl. AP Heliport (32.36N 64.67W)			14/0705	57 (1 min, 12 m)	84				
Pearl Island AWOS (32.37N 64.70W)			14/0654	69 (1 min, 8 m)	82				1.36
Southampton Parish (32.25N 64.85W)	14/0704	982.1	14/0647	66	77				
The Crescent MAROPS (32.42N 64.82W)			14/0445	48 (10 min, 6 m)	64				
<b>NDBC Offshore Buoys</b>									
41049 (300 SSE Bermuda) (27.49N 62.94W)	13/1030	1005.6	13/1030	29	36				

<sup>a</sup> Date/time is for sustained wind when both sustained and gust are listed.  
<sup>b</sup> Except as noted, sustained wind averaging periods for C-MAN and land-based reports are 2 min; buoy averaging periods are 8 min.  
<sup>c</sup> Storm surge is water height above normal astronomical tide level.  
<sup>d</sup> For most locations, storm tide is water height above the North American Vertical Datum of 1988 (NAVD88).  
<sup>e</sup> Estimated inundation is the maximum height of water above ground. For NOS tide gauges, the height of the water above Mean Higher High Water (MHHW) is used as a proxy for inundation.  
<sup>f</sup> Incomplete data



Table 4a. Number of hours in advance of initial 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%)	120	180
Medium (40%-60%)	54	132
High (>60%)	24	90

Table 4b. Number of hours in advance of Paulette’s second genesis 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, and the maximum potential lead time for this case is 102 h.

	Hours Before Genesis	
	48-Hour Outlook	120-Hour Outlook
Low (<40%)	60	60
Medium (40%-60%)	36	48
High (>60%)	-	-

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Paulette, 7–22 September 2020. 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	60	72	96	120
OFCL	<b>18.0</b>	<b>33.7</b>	49.8	68.7	95.4	132.7	212.4	277.4
OCD5	42.5	100.5	167.1	212.2	248.5	270.9	327.3	536.5
Forecasts	36	34	32	30	28	26	22	21
OFCL (2015-19)	24.1	36.9	49.6	65.1	80.7	96.3	133.2	171.6
OCD5 (2015-19)	44.7	96.1	156.3	217.4	273.9	330.3	431.5	511.9

Table 5b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Paulette 7–22 September 2020. 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 5a due to the homogeneity requirement.

Model ID	Forecast Period (h)							
	12	24	36	48	60	72	96	120
OFCL	19.0	35.5	51.2	72.4	101.4	138.2	221.8	300.3
OCD5	43.3	102.3	171.2	211.7	233.8	259.7	334.7	466.0
GFSI	22.4	38.6	56.3	81.3	117.9	167.2	286.4	398.6
HMNI	24.9	<b>33.9</b>	<b>42.5</b>	<b>55.1</b>	<b>71.5</b>	<b>100.4</b>	<b>176.2</b>	<b>221.5</b>
HWFI	21.0	<b>33.0</b>	51.4	78.0	102.1	<b>130.5</b>	<b>200.8</b>	<b>274.5</b>
EGRI	20.1	41.5	64.4	90.6	127.5	177.8	287.1	430.1
EMXI	23.5	47.1	63.2	78.5	105.2	140.9	225.3	<b>290.2</b>
CMCI	23.5	43.3	61.3	88.2	122.8	168.9	254.9	344.3
CTCI	<b>18.6</b>	<b>31.6</b>	51.5	75.8	111.6	151.2	<b>217.4</b>	<b>291.1</b>
NVGI	23.3	39.3	61.0	88.8	123.2	159.6	247.3	317.1
AEMI	21.7	40.0	61.7	86.3	118.1	156.8	257.3	369.0
HCCA	<b>18.3</b>	<b>33.6</b>	<b>49.0</b>	<b>68.8</b>	<b>96.8</b>	<b>130.2</b>	<b>213.1</b>	<b>284.5</b>
TVCA	<b>17.5</b>	<b>31.7</b>	<b>48.9</b>	<b>71.6</b>	<b>100.3</b>	<b>138.1</b>	<b>218.0</b>	<b>295.8</b>
TVCX	<b>17.8</b>	<b>33.1</b>	<b>50.0</b>	<b>71.8</b>	<b>100.4</b>	<b>137.4</b>	<b>219.8</b>	<b>298.4</b>
TVDG	<b>17.8</b>	<b>32.8</b>	<b>50.4</b>	<b>71.5</b>	<b>101.0</b>	140.6	227.5	316.0
FSSE	<b>17.6</b>	<b>29.6</b>	<b>44.5</b>	<b>61.1</b>	<b>81.2</b>	<b>108.9</b>	<b>187.6</b>	<b>254.6</b>
GFEX	20.5	39.2	57.0	78.1	109.7	152.5	252.8	336.3
TABS	46.3	100.7	144.3	171.9	197.4	241.3	353.6	483.4
TABM	28.1	52.9	73.2	89.9	111.4	150.4	262.7	<b>285.3</b>
TABD	37.7	77.4	124.5	181.6	240.6	307.6	484.4	550.9
Forecasts	31	29	27	25	23	22	19	15

Table 6. Homogeneous comparison of biases of selected track forecast guidance models (in n mi) for Hurricane Paulette 7–22 September 2020. Negative values for cross-track biases indicate a left-of-track bias, while negative values for along-track biases indicate a slow bias.

	Forecast Period (h)							
	12	24	36	48	60	72	96	120
OFCL Cross Track Bias	-6.6	-17.3	-29.2	-39	-48.7	-54.9	-69.2	-20.9
OFCL Along Track Bias	1.4	-6.8	-17.2	-34.9	-59.5	-94.8	-174	-226.1
GFSI Cross Track Bias	-7.8	-16.7	-30.9	-45.3	-59.3	-73.6	-97.6	-48.1
GFSI Along Track Bias	4.9	-0.4	-11.9	-30.9	-57.5	-96.4	-211.3	-273.4
EMXI Cross Track Bias	-6.7	-15.5	-28.1	-39.5	-51	-57.7	-76.8	-18.3
EMXI Along Track Bias	-1.8	-11.7	-22.5	-38.1	-59.4	-87.5	-159.3	-211.2
TVCA Cross Track Bias	-5.6	-11.8	-21.7	-31.5	-39.7	-48.6	-59.5	1.0
TVCA Along Track Bias	-0.8	-10.7	-21.7	-38.9	-63.4	-96.1	-173.7	-222.9

Table 7a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Paulette, 7–22 September 2020. 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	60	72	96	120
OFCL	<b>4.3</b>	<b>6.9</b>	<b>7.8</b>	<b>7.7</b>	<b>7.3</b>	<b>8.3</b>	<b>12.5</b>	15.5
OCD5	4.1	6.0	8.3	9.3	9.4	10.7	11.4	15.9
Forecasts	36	34	32	30	28	26	22	21
OFCL (2015-19)	5.2	7.7	9.4	10.7	11.9	13.0	14.4	15.5
OCD5 (2015-19)	6.8	10.8	14.1	17.0	18.8	20.6	22.5	24.6

Table 7b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Paulette, 7–22 September 2020. 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 7a due to the homogeneity requirement.

Model ID	Forecast Period (h)							
	12	24	36	48	60	72	96	120
OFCL	4.0	6.9	7.8	7.6	7.6	8.6	13.2	19.3
OCD5	4.0	<b>5.7</b>	<b>7.5</b>	9.0	9.6	11.1	<b>11.3</b>	<b>11.3</b>
GFSI	<b>3.7</b>	<b>5.5</b>	<b>5.3</b>	8.7	12.1	15.1	22.2	34.1
EMXI	6.3	9.9	11.6	13.7	16.3	19.9	30.7	42.1
HWFI	4.6	<b>6.3</b>	<b>6.9</b>	10.0	11.8	13.2	14.9	19.5
HMNI	6.4	10.0	11.1	10.4	9.0	9.4	<b>12.6</b>	20.7
CTCI	<b>3.5</b>	<b>4.9</b>	<b>6.4</b>	<b>7.5</b>	7.7	9.7	<b>10.1</b>	<b>12.9</b>
LGEM	<b>3.6</b>	<b>5.9</b>	<b>7.3</b>	9.8	11.3	14.0	21.5	31.0
DSHP	<b>3.2</b>	<b>5.3</b>	<b>6.7</b>	9.3	10.7	13.5	20.2	27.8
IVDR	<b>3.5</b>	<b>5.4</b>	<b>6.1</b>	<b>7.2</b>	7.6	<b>8.4</b>	<b>12.6</b>	<b>17.9</b>
IVCN	<b>3.3</b>	<b>5.0</b>	<b>5.8</b>	<b>7.2</b>	<b>7.3</b>	8.9	13.5	<b>18.5</b>
ICON	<b>3.4</b>	<b>5.1</b>	<b>6.1</b>	8.0	8.1	9.6	15.5	22.1
FSSE	<b>3.7</b>	<b>6.2</b>	8.0	8.8	8.9	10.1	18.4	27.5
HCCA	4.1	7.1	9.1	9.1	7.8	<b>7.8</b>	<b>10.9</b>	<b>14.1</b>
Forecasts	31	29	27	25	23	22	19	15

Table 8. Watch and warning summary for Hurricane Paulette, 7–22 September 2020.

<b>Date/Time (UTC)</b>	<b>Action</b>	<b>Location</b>
<b>12 / 0300</b>	Tropical Storm Watch issued	Bermuda
<b>12 / 0900</b>	Tropical Storm Watch changed to Tropical Storm Warning	Bermuda
<b>12 / 0900</b>	Hurricane Watch issued	Bermuda
<b>12 / 1500</b>	Tropical Storm Warning and Hurricane Watch changed to Hurricane Warning	Bermuda
<b>14 / 1800</b>	Hurricane Warning changed to Tropical Storm Warning	Bermuda
<b>14 / 2100</b>	Tropical Storm Warning discontinued	Bermuda



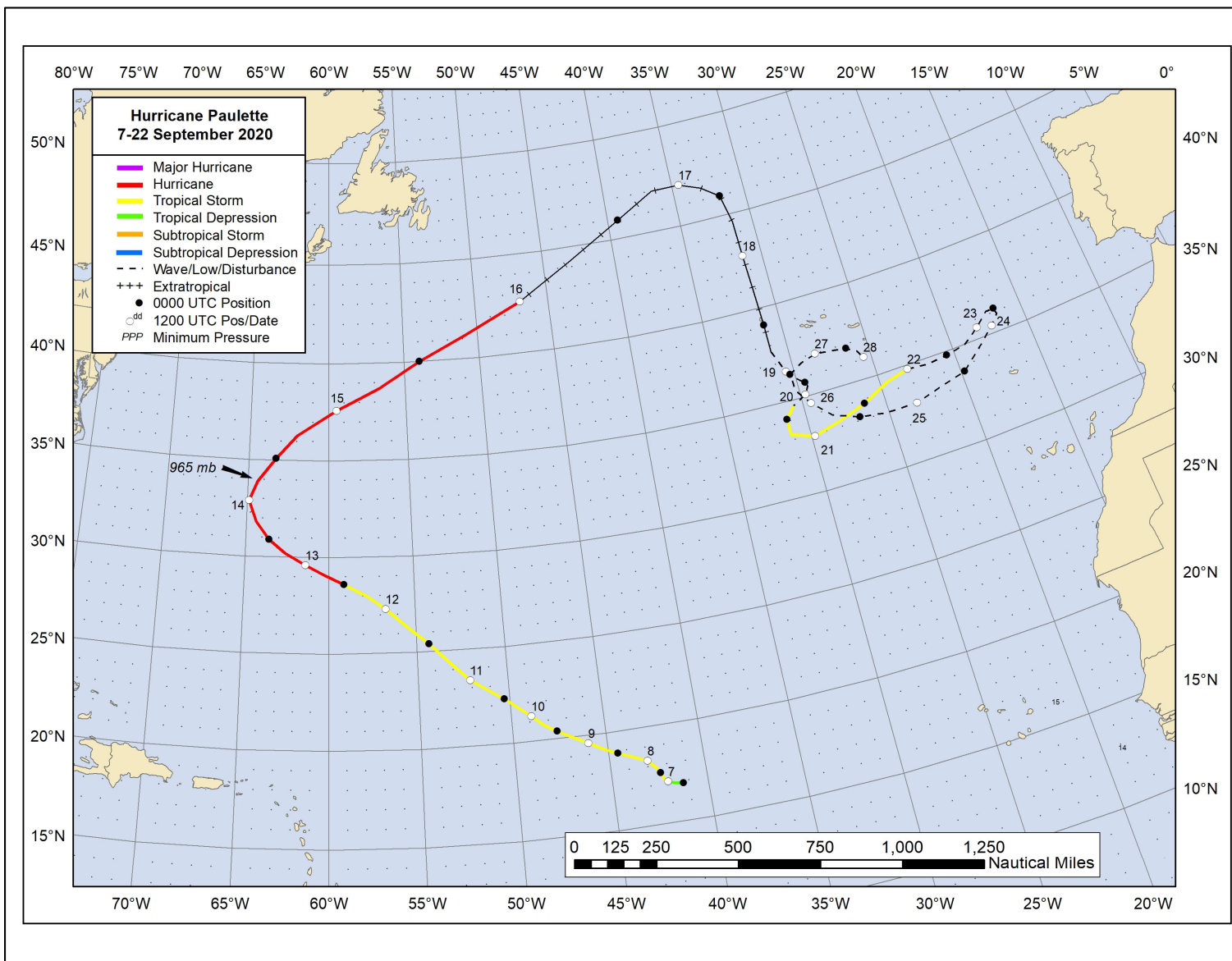


Figure 1. Best track positions for Hurricane Paulette, 7–22 September 2020.

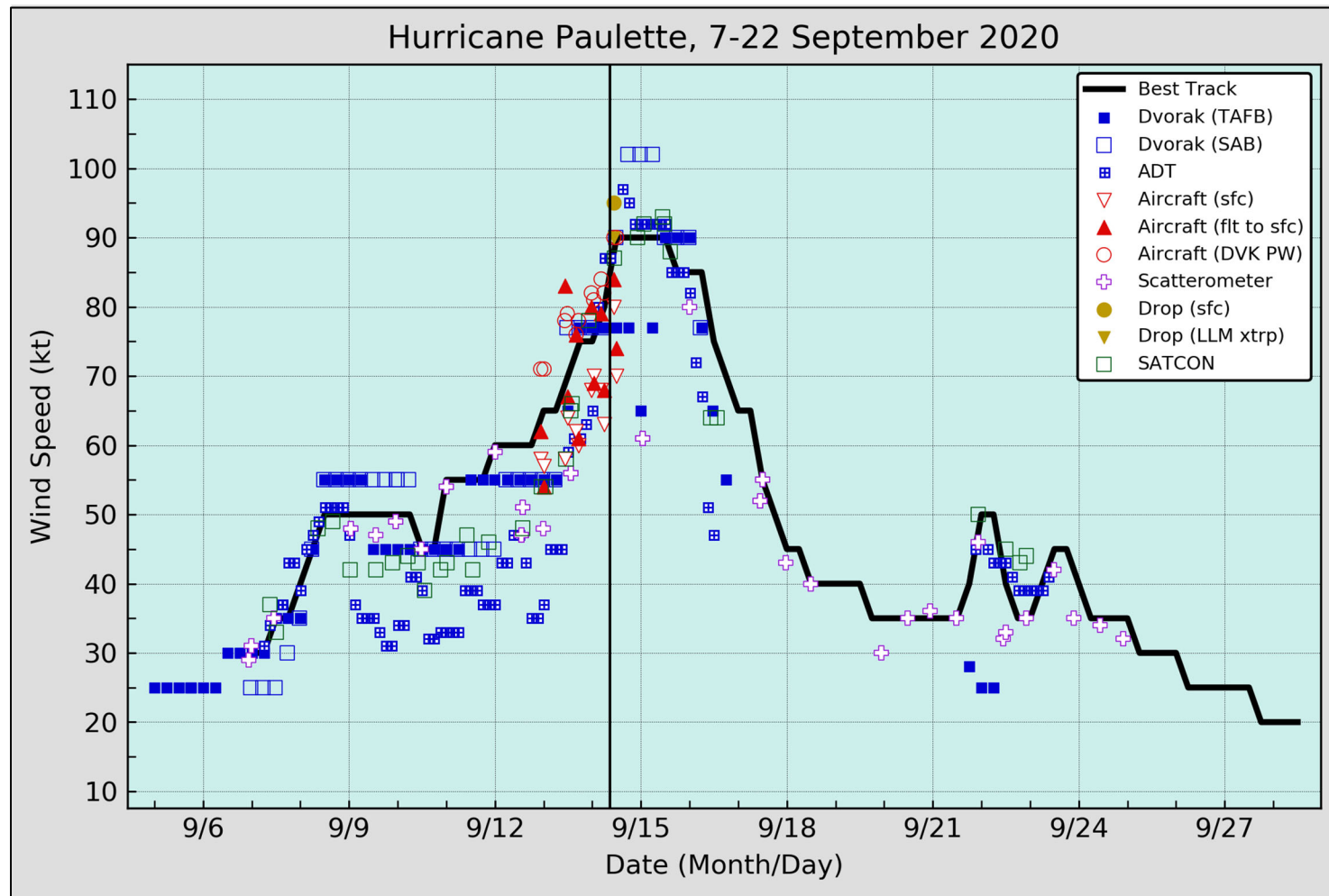


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Paulette, 7–22 September 2020. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% adjustment factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Dropwindsonde observations include actual 10 m winds (sfc), as well as surface estimates derived from the mean wind over the lowest 150 m of the wind sounding (LLM). 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, and the solid vertical line corresponds to landfall.

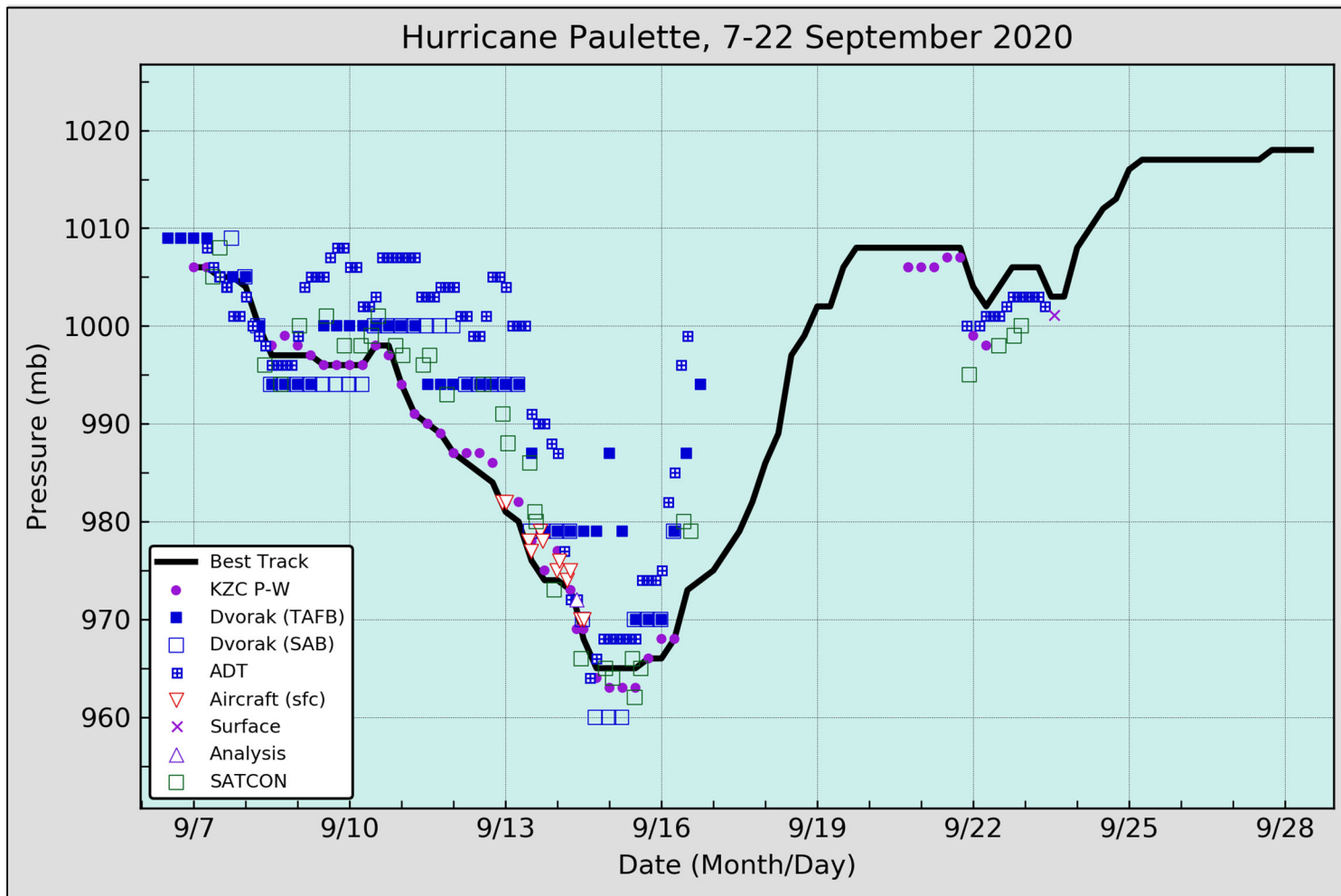


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Paulette, 7–22 September 2020. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological 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, and the solid vertical line corresponds to landfall.

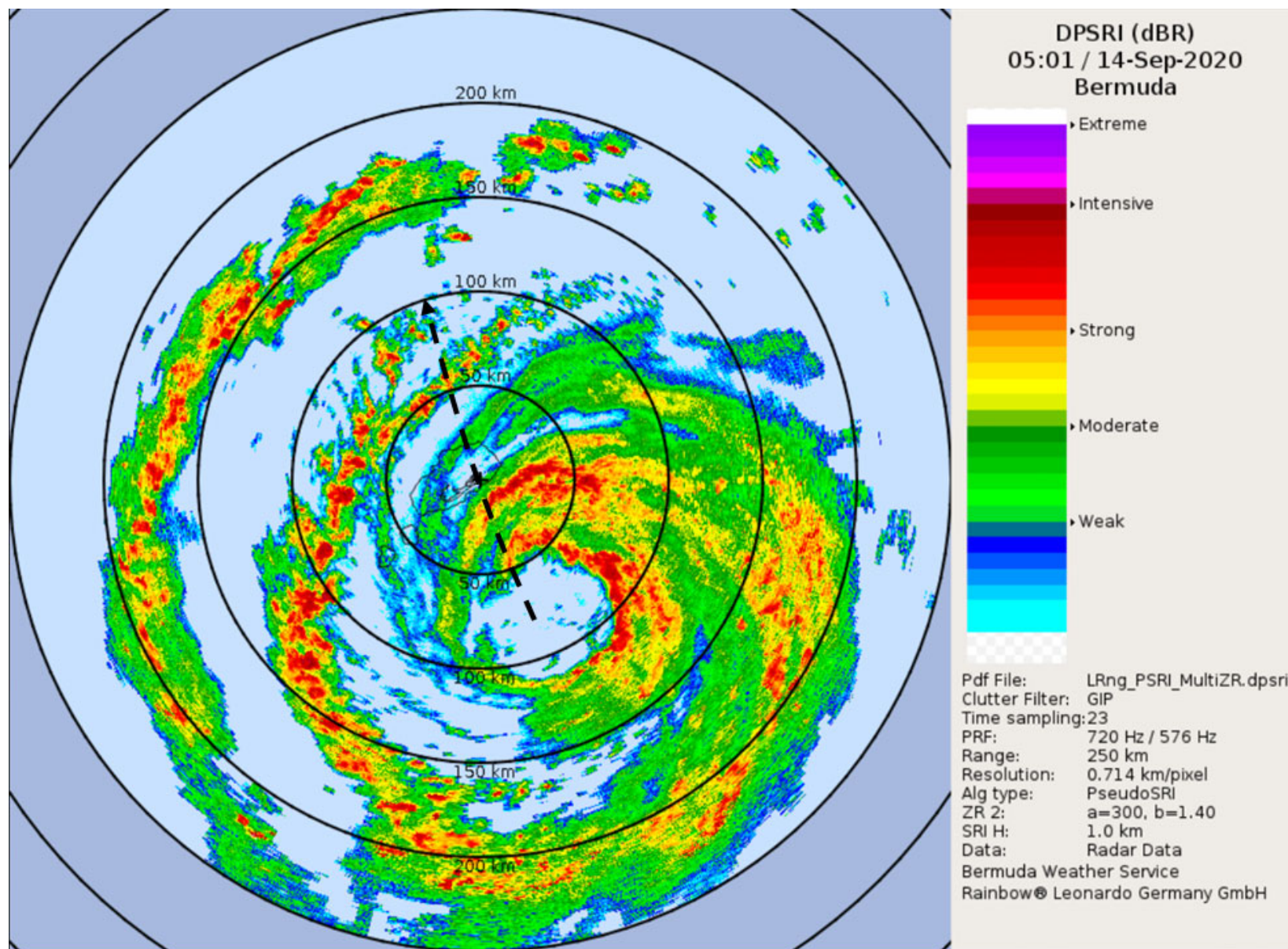


Figure 4. Radar image of Hurricane Paulette during its Bermuda approach. Image courtesy of the Bermuda Weather Service.



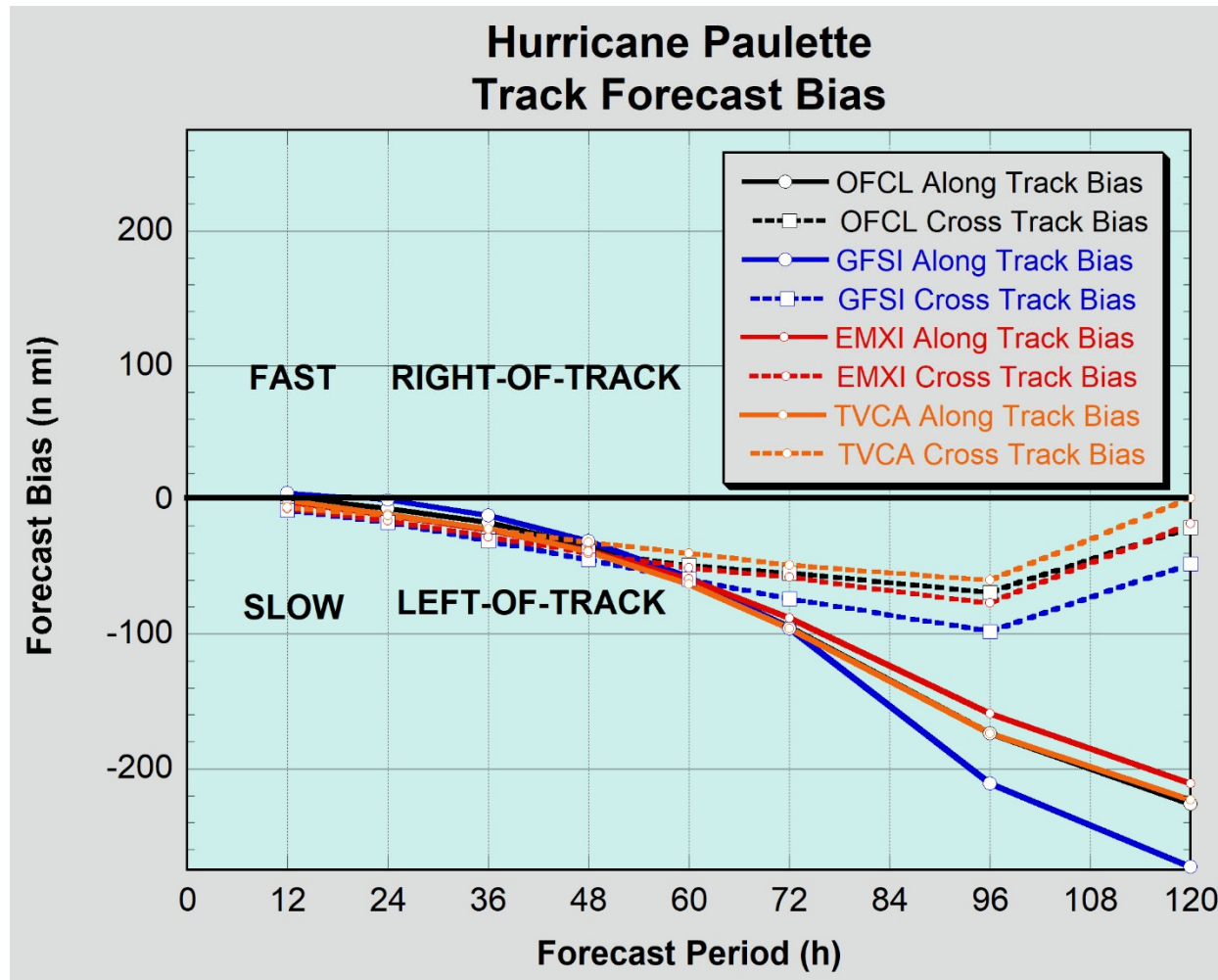


Figure 5. Cross-track (dashed lines) and along-track (solid lines) biases, in n mi during the tropical phases of Paulette.

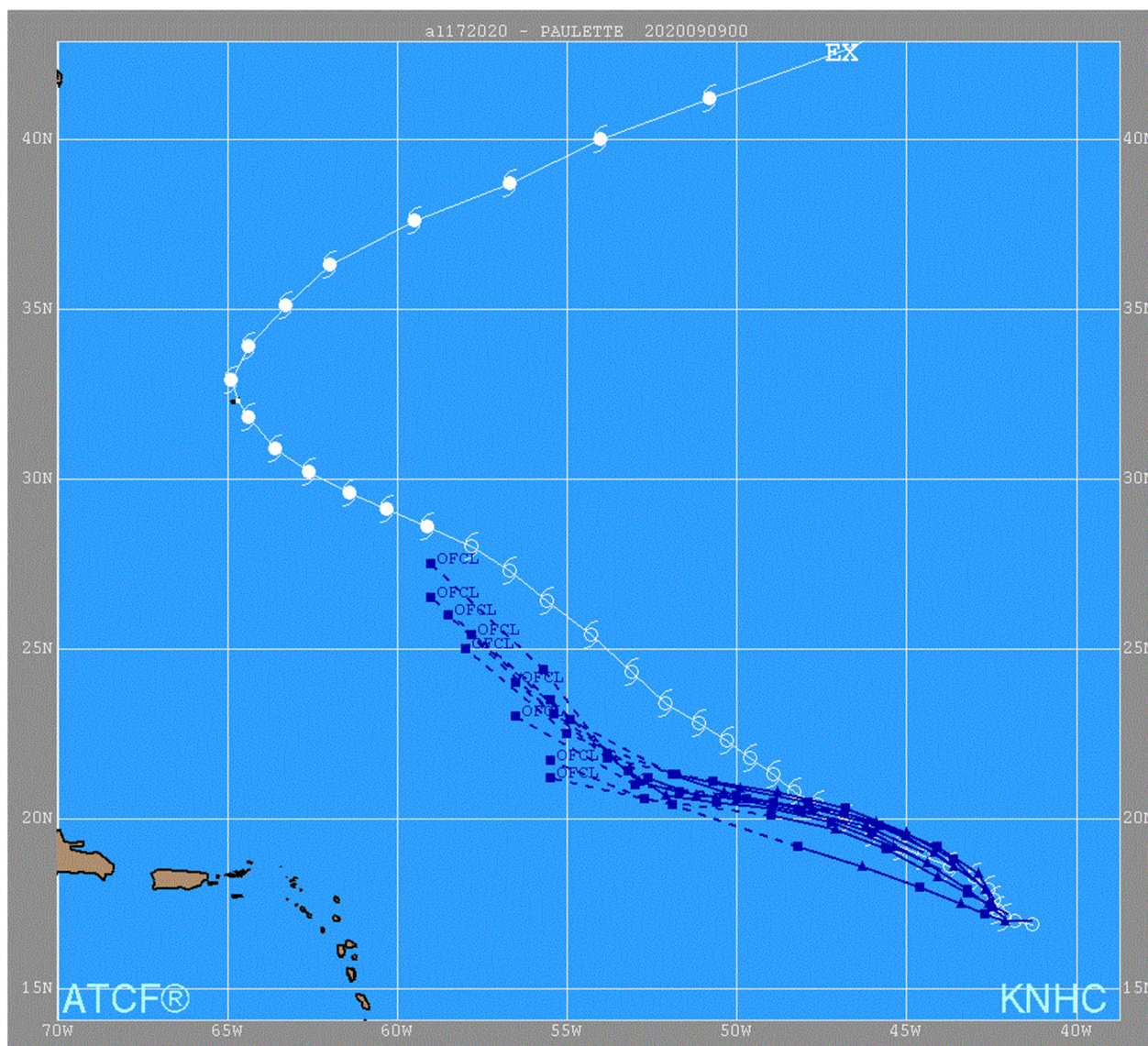


Figure 6. Official track forecasts (blue lines, with 0, 12, 24, 36, 48, 60, 72, 96, and 120 h positions indicated) for Paulette from 0000 UTC 7 September to 0000 UTC 9 September. The best track is given by the white line with positions shown at 6 h intervals.



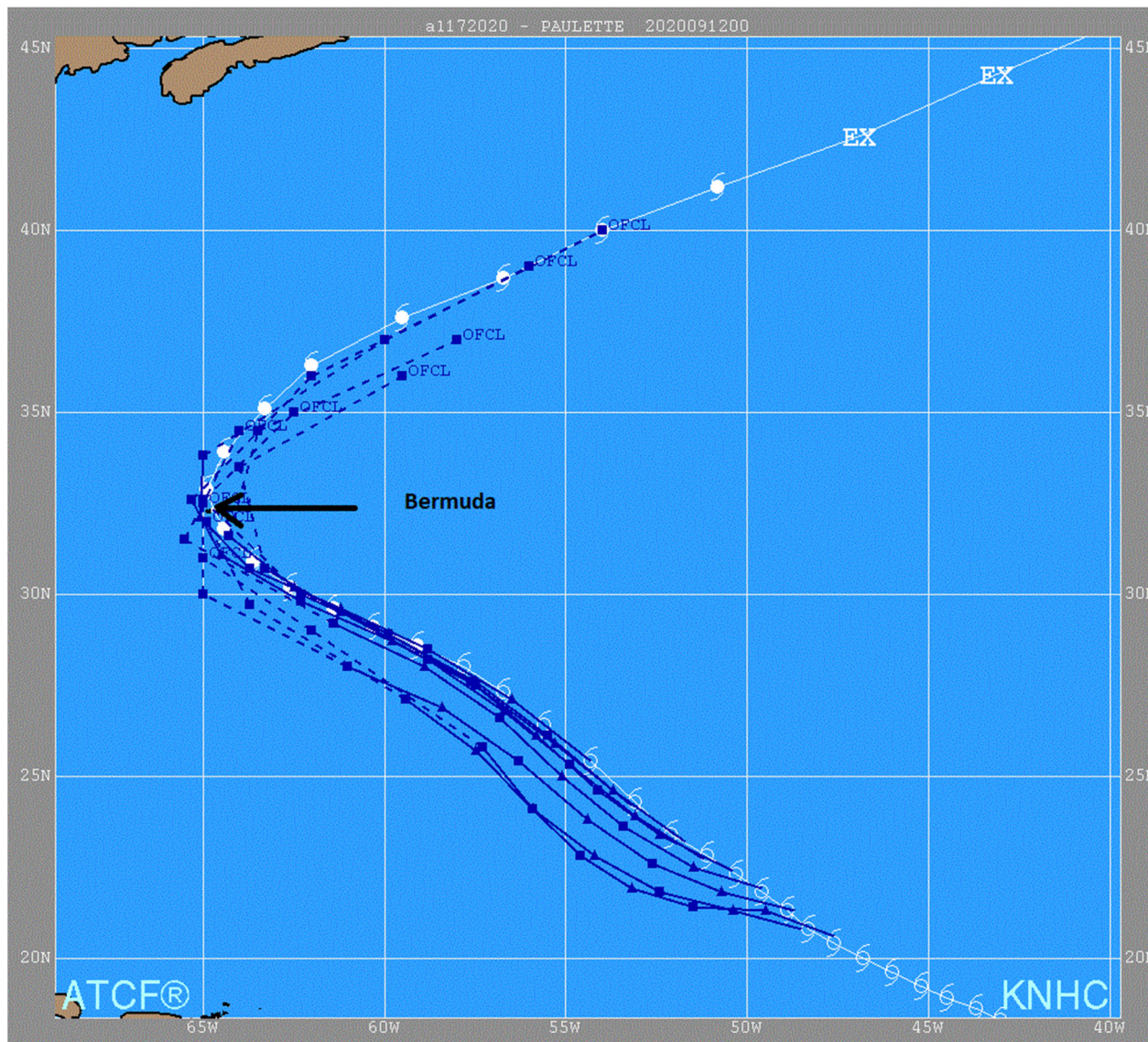


Figure 7. Official track forecasts (blue lines, with 0, 12, 24, 36, 48, 60, 72, 96, and 120 h positions indicated) for Paulette from 0000 UTC 10 September to 0000 UTC 12 September. The best track is given by the white line with positions shown at 6 h intervals.