NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE EPSILON

(AL272020)

19–26 October 2020

Philippe P. Papin
National Hurricane Center
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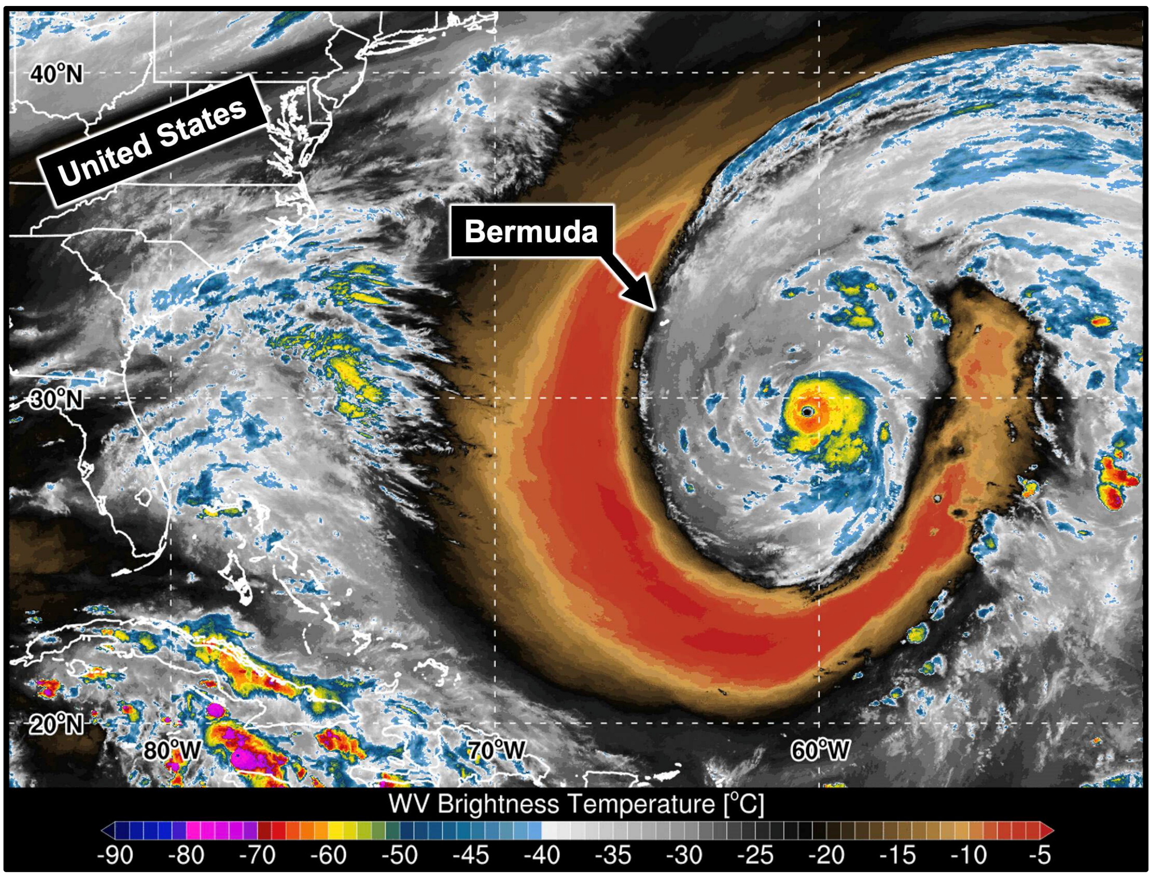

GOES-16 WATER VAPOR IMAGE AT 0000 UTC 22 OCTOBER, SHOWING A ZOOMED OUT VIEW OF HURRICANE EPSILON AT PEAK INTENSITY. DATA USED TO CREATE THIS SATELLITE IMAGERY COUTESY OF THE NOAA BIG DATA PROGRAM.

Epsilon was a late-season category 3 hurricane (on the Saffir-Simpson Hurricane Wind Scale) that formed from a non-tropical low pressure area southeast of Bermuda. Epsilon passed well east of Bermuda, but its large wind field resulted in tropical-storm-force winds affecting the island.

Hurricane Epsilon

19–26 OCTOBER 2020

SYNOPTIC HISTORY

Epsilon's origins were non-tropical. On 13 October, an upper-level trough associated with a weak baroclinic low emerged just off the eastern U.S. seaboard. While the primary low continued moving towards the northeast, a trailing cold front propagated eastward into the central Atlantic over the next several days, before stalling on 15 October and degenerating into a surface trough well east of Bermuda. The upstream synoptic flow then amplified as an expansive upper-level ridge began building across the northwest Atlantic to the west of the original upper-level trough (Fig. 1a). This synoptic pattern led to the upper-level trough cutting off while folding under the ridge. This cutoff low then interacted with the residual surface trough on 16 October, helping to increase convective activity that amplified the surface feature. As low-level cyclonic flow increased, it led to the development of a non-tropical surface low underneath the cutoff upper-level low around 1200 UTC 16 October.

In the ensuing days, the surface low remained superimposed beneath the upper-level low as it meandered slowly southward, equatorward of deep-layer ridging that resembled an omega block in the North Atlantic (Fig. 1b). The surface low only produced shallow convection as dry air associated with the upper-level low limited convective activity. However, the southward drift also allowed the surface low to move over increasingly warm sea-surface temperatures near 27°C, and convection gradually increased in coverage and intensity. This convection also helped erode the dry cyclonic flow of the associated upper-level low, allowing the system to undergo tropical transition as its radius of maximum winds slowly contracted and upper-level anticyclonic flow increased. By 0600 UTC 19 October, a large cluster of deep convection formed just east of the surface low and resulted in sufficiently organized structure to declare the formation of a tropical depression about 720 n mi east of Bermuda. The depression intensified into a tropical storm 6 h later. The "best track" chart of Epsilon's path is given in Fig. 2, with the wind and pressure histories shown in Figs. 3 and 4, respectively. The best track positions and intensities are listed in Table 1[1]. While Epsilon was never classified as a subtropical cyclone, the pre-genesis system did possess hybrid characteristics before convection eroded the upper-level cutoff cyclone overhead, and the large-scale synoptic pattern resembled the cutoff pathway that subtropical cyclones often undergo during tropical transition (Bentley et al. 2017; see their Fig. 16).

Epsilon slowly intensified over the next 24–36 h as it continued to encounter sporadic bouts of dry-air intrusion imported by moderate vertical wind shear, which occasionally interrupted

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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.

convective development near the surface low. The tropical storm first moved slowly to the southeast, but then curved back northward and then northwestward, executing a cyclonic loop as its smaller circulation interacted with the large-scale upper-level cyclonic flow. Between 20–21 October, the vertical wind shear near Epsilon subsided, and the remaining dry air mixed out of the core, allowing for more organized convective activity to develop near the center (Fig. 5a). This focused convection helped in the formation of a small inner-core (Fig. 5b), and Epsilon underwent a period of rapid intensification, its wind speed increasing by 45 kt in the 24-h period ending at 1800 UTC 21 October. During this time, Epsilon strengthened from a strong tropical storm (55 kt) to a major hurricane (100 kt) while located about 300 n mi southeast of Bermuda. At the time of Epsilon’s peak intensity around 0000 UTC 22 October, its well-defined, small inner core (Fig. 5c) was situated within a small area of deep-layer moisture (cover photo) helping to insulate the hurricane from very dry mid-latitude air associated with an upper-level trough that was wrapped three-quarters of the way around Epsilon’s broader circulation (Fig. 1c). Even though Epsilon maintained a small radius of maximum winds during this period, its 34-kt wind radii remained expansive, stretching more than 300 n mi from the center in its northern semicircle.

After rapidly intensifying, Epsilon quickly weakened back to 75 kt later on 22 October due to nearby dry air disrupting the inner-core structure (Fig. 5d). At this point, the large deep-layer ridge that had been stationary over the northern Atlantic began to gradually weaken, allowing the cyclone to begin moving northward. The cyclone maintained its intensity over the next 48 h, passing about 160 n mi east of Bermuda on 0000 UTC 23 October, with its large outer wind field producing tropical-storm-force winds over the island. On 24 October, Epsilon interacted with another upper-level trough (Fig. 1d) and baroclinic enhancement helped to expand the inner-core wind field. The hurricane also made a sharp turn toward the northeast and accelerated as it became embedded in the westerly mid-latitude flow. Epsilon slowly weakened as it moved north of the Gulf Stream and dropped below hurricane intensity at 1800 UTC 25 October. The cyclone became extratropical about 12 h later about 490 n mi east of Cape Race, Newfoundland, as its circulation became elongated without deep central convection ahead of a strong mid-latitude trough. The aforementioned trough spawned a much larger extratropical low, and this feature absorbed what was left of Epsilon by 1800 UTC 26 October as it raced northeastward into the far north Atlantic.

METEOROLOGICAL STATISTICS

Observations in Epsilon (Figs. 3 and 4) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), 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 three flights of the 53rd Weather Reconnaissance Squadron of the U.S. Air Force Reserve Command, which provided eight center fixes. Another reconnaissance mission flew north of Epsilon in order to drop a linear array of research buoys ahead of the hurricane. 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 Epsilon.

Ship reports of winds of tropical storm force associated with Epsilon are given in Table 2, and selected surface observations from land stations and ocean buoys are given in Table 3.

Winds and Pressure

Epsilon's estimated peak intensity of 100 kt between 1800 UTC 21 October to 0000 UTC 22 October is based on data from several Air Force Reserve Hurricane Hunter aircraft. One aircraft measured peak 700-mb flight-level winds of 110 kt at 2300 UTC 21 October. Using the standard 700-mb flight-level to surface wind reduction in Epsilon's eyewall yields an estimated intensity of 99 kt. The same aircraft also measured a peak SFMR surface wind speed of 97 kt on 2255 UTC 21 October. Another earlier aircraft also measured a peak SFMR wind of 98 kt at 1658 UTC 21 October. A blend of the aforementioned data supports an estimated peak intensity of 100 kt. Epsilon's estimated minimum pressure of 952 mb is also based on Air Force Reserve Hurricane Hunter aircraft. A dropsonde released in the eye of Epsilon at 2257 UTC 21 October measured a minimum pressure of 953 mb and a surface wind of 15 kt, which supports the 952 mb minimum pressure.

Several locations in Bermuda recorded sustained tropical-storm-force winds as the cyclone's center passed east of the island. The Maritime Operational Center (MAROPS; elevation 290 ft) recorded a peak sustained wind of 43 kt and a gust to 52 kt at 0516 UTC 23 October. Other automated weather stations at Pearl Island and The Crescent also reported sustained tropical-storm-force winds.

As previously mentioned, another Air Force Reserve aircraft flew a research mission that launched an array of drifting buoys to the north of the tropical cyclone, along Epsilon's forecast track as it moved poleward of Bermuda. The data these buoys provided were very helpful in providing in-situ measurements of the minimum central pressure of Epsilon early on 24 October. Drifting buoy 4101823 measured a minimum pressure of 957.6 mb at 1000 UTC 24 October as Epsilon's center passed within 20 n mi to the west. Another drifting buoy (4101819) at 0334 UTC 24 October measured a minimum pressure of 958.3 mb with sustained winds at 10 kt as Epsilon's center passed by about 20 n mi to the east. These buoy observations support Epsilon's minimum central pressure of 957 mb on 0600–1200 UTC 24 October. The highest winds observed from this array were from drifting buoy 4101817 which reported sustained winds of 57 kt at 1100 UTC 24 October.

Epsilon's location where it became a major hurricane in the subtropical North Atlantic (29.3°N, 59.6°W) was quite unusual so late in the hurricane season, and the storm appears to be the farthest-east major hurricane to form after 20 October. Prior to Epsilon, the last major hurricane in late October to be located outside of the Caribbean and Gulf of Mexico was Wilma (2005) after it had emerged off the east coast of Florida on 25 October 2005.

Rainfall and Flooding

Only scattered showers were reported on the island of Bermuda from outer rain bands associated with Epsilon, with a precipitation total of 0.42 inches recorded between 22–23 October at the L.F. Wade International Airport.

CASUALTY AND DAMAGE STATISTICS

Hurricane Epsilon's expansive wind field generated large swells and life-threatening surf and rip currents along the coasts of Bermuda, the Bahamas, the Greater Antilles, Leeward Islands, and the eastern United States and Canada. The cyclone was responsible for one direct death[2] in the United States as a 27-year-old man drowned in Epsilon-induced rip currents in Daytona Beach, Florida. While Epsilon produced strong winds up to tropical storm force over portions of Bermuda, overall wind damage from the hurricane there was limited.

FORECAST AND WARNING CRITIQUE

Genesis

The genesis of Epsilon was well anticipated (Table 4), especially given its non-tropical origin which often has lower genesis predictability (e.g., Kimberlain 2014, Wang et al. 2018). The feature that became Epsilon was introduced in the Tropical Weather Outlook 102 h prior to genesis with a low (<40%) chance of formation during the next 5 days. The 5-day probabilities were increased to the medium (40–60%) and high (>60%) categories 66 h and 54 h before Epsilon developed, respectively. For the 2-day probabilities, a low chance of genesis was introduced 78 h, a medium chance 60 h, and a high chance 48 h before development. The global models, notably the Global Forecast System (GFS) and European Centre for Medium-Range Weather Forecasts (ECMWF), provided good guidance in highlighting the likelihood of development from the non-tropical low that ultimately became Epsilon. However, both models depicted a more subtropical structure after genesis, and did not anticipate the small core that Epsilon developed near the center after the system became a tropical cyclone.

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[2] 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.

Track

A verification of NHC official (OFCL) track forecasts for Epsilon is given in Table 5a. Official forecast track errors were comparable to the mean official errors for the previous 5-yr period at 12 h, lower than the mean official errors between 24–96 h, and above the mean at 120 h. Climatology-persistence (OCD5) track errors were significantly higher than their respective 5-yr mean from 12–96 h, suggesting that Epsilon's track was harder-than-usual to forecast for a typical Atlantic tropical cyclone. The higher OCD5 track errors were likely related to the unusual track early in the system's lifespan as it looped cyclonically from a southeast to northwest heading. However, OFCL in general performed well, capturing Epsilon's loop back westward before it turned northward, well to the east of Bermuda (Fig. 6). A homogeneous comparison of the official track errors with selected guidance models is given in Table 5b. The best-performing deterministic track guidance from 12–48 h was the ECMWF (EMXI), while at longer lead times from 72–120 h the Canadian (CMCI) and UKMET (EGRI) had superior track forecasts compared to NHC. The GFS (GFSI) also outperformed the OFCL at 12, 36, and 96 h, while HMNI outperformed OFCL at 96–120 h. Most of the ensemble and consensus aids also outperformed the official track forecast over the majority of the forecast period.

Intensity

A verification of NHC official intensity forecasts for Epsilon is given in Table 6a. Official forecast intensity errors were slightly higher than the mean official errors for the previous 5-yr period from 12–48 h, but then were less than the mean official errors from 60–120 h. The higher than average short-term intensity forecasts were likely related to Epsilon's unexpected rapid intensification and then rapid weakening that occurred while it was located southeast of Bermuda. Historically, there have been very few cases of tropical cyclones rapidly intensifying that far north and east in the subtropical Atlantic in late October. The OFCL forecasts indicated more gradual intensification (Fig. 7) due to the relatively marginal environment around Epsilon, as the hurricane was surrounded by dry air and over sea-surface temperatures of 26°–27°C. Once Epsilon reached major hurricane intensity, it was also forecast to weaken more gradually than what actually occurred. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 6b. The best-performing deterministic guidance was from the statistical-dynamical models (DSHP, LGEM), which bested the OFCL from 12–60 h, with LGEM also outperforming the OFCL at 72 h and 120 h. However, even their short-term forecasts failed to predict Epsilon's rapid intensification/weakening on 21–22 October. Other consensus guidance (ICON, IVCN, HCCA) also outperformed the official forecast from 12–48 h.

Watches and Warnings

Coastal watches and warnings associated with Epsilon are given in Table 7. The Bermuda Weather Service issued a Tropical Storm Watch for the island at 1500 UTC 20 October and upgraded the watch to a Tropical Storm Warning at 1500 UTC 21 October. Tropical Storm Warnings were discontinued at 0300 UTC 23 October.

References

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Wang, Z., W. Li, M. S. Peng, X. Jiang, R. McTaggart-Cowan, and C. A. Davis, 2018: Predictive skill and predictability of North Atlantic tropical cyclogenesis in different synoptic flow regimes. *J. Atmos. Sci.*, **75**, 361–378, https://doi.org/10.1175/JAS-D-17-0094.1.

Acknowledgements

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Table 1. Best track for Hurricane Epsilon, 19–26 October 2020.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
16 / 1200	31.5	54.9	1013	20	low
16 / 1800	31.2	55.1	1011	25	"
17 / 0000	30.9	55.5	1009	30	"
17 / 0600	30.7	55.9	1009	30	"
17 / 1200	30.3	56.2	1008	30	"
17 / 1800	29.7	56.3	1008	30	"
18 / 0000	28.9	56.3	1006	30	"
18 / 0600	28.1	56.3	1004	30	"
18 / 1200	27.3	56.4	1004	30	"
18 / 1800	26.4	56.6	1003	30	"
19 / 0000	25.7	56.3	1003	30	"
19 / 0600	25.5	55.9	1003	30	tropical depression
19 / 1200	25.4	55.6	1000	35	tropical storm
19 / 1800	25.3	55.4	998	40	"
20 / 0000	25.2	55.2	998	40	"
20 / 0600	25.5	54.9	996	45	"
20 / 1200	26.2	54.7	994	50	"
20 / 1800	27.3	55.3	992	55	"
21 / 0000	28.3	56.3	987	65	hurricane
21 / 0600	28.7	57.7	976	75	"
21 / 1200	28.9	58.7	968	85	"
21 / 1800	29.3	59.6	955	100	"
22 / 0000	29.5	60.4	952	100	"
22 / 0600	30.2	60.9	958	90	"
22 / 1200	30.8	61.3	965	80	"
22 / 1800	31.5	61.5	968	75	"
23 / 0000	32.2	61.6	968	75	"
23 / 0600	32.9	61.6	968	75	"
23 / 1200	33.7	61.6	966	75	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
23 / 1800	34.9	61.7	964	75	"
24 / 0000	36.1	62.0	962	75	"
24 / 0600	36.8	62.1	957	75	"
24 / 1200	37.4	61.3	957	75	"
24 / 1800	38.6	59.7	960	70	"
25 / 0000	40.3	57.6	962	65	"
25 / 0600	42.0	55.2	963	65	"
25 / 1200	43.3	51.8	964	65	"
25 / 1800	45.0	46.9	966	60	tropical storm
26 / 0000	47.2	41.2	968	60	"
26 / 0600	49.5	34.7	969	60	extratropical
26 / 1200	52.1	28.5	964	60	"
26 / 1800					Merged with larger extratropical low
22 / 0000	29.5	60.4	952	100	maximum wind and minimum pressure

Table 2. Selected ship reports with winds of at least 34 kt for Hurricane Epsilon, 19–26 October 2020.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
23 / 0400	2IYH5	39.2	62.2	050 / 35	1018.6
23 / 0800	2IYH5	39.0	61.0	070 / 37	1017.2
23 / 1900	2IYH5	38.3	57.9	080 / 36	1013.2
24 / 1500	2IYH5	37.3	53.2	180 / 37	1013.2
24 / 1900	2IYH5	37.0	52.1	190 / 40	1014.1

Table 3. Selected surface observations for Hurricane Epsilon, 19–26 October 2020.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)	Gust (kt)	
Bermuda						
International Civil Aviation Organization (ICAO) Sites						
L.F. Wade IAP (TXKF) elevation 18 ft. (32.36N, 64.68W)	23/0755	1004.1	22/0755	24 10 m/10 min	33	0.42
Airport AviMet-12 (32.36N 64.67W)				30 10 m/10 min	37	
Pearl Island (near shore)[i] (32.29N, 64.84W)			21/2105	36[i] 8 m/10 min	42[i]	
Maritime Operations Centre (MAROPS) elev. 290 ft (32.38N, 64.68W)	23/0804	1005.6	23/0516	43 1 min	52	
The Crescent (offshore) Marie NAVAID (32.42N, 64.82W)			23/0811	36 6 m/10 min	41	
Other Sites						
Gilbert Hill (32.31N, 64.74W)	23/0800	1003.0	23/0815	30	40	
Flatts (32.32N, 64.74W)	23/0757	1005.0	23/0857	34	41	
Devon Point Lane (32.30N, 64.74W)	23/0800	1004.0	22/0650	45	56	
Offshore Sites						
ECC Canada Buoy 44137 (42.26N,62.00W)	24/1720	1000.4	24/1720	34	44	
Research Buoys						
Drifting Buoy (4101806) (36.36N, 60.82W)	24/1100	978.7	24/0800	52		
Drifting Buoy (4101817) (36.22N, 60.27W)	24/1100	985.9	24/1230	57		
Drifting Buoy (4101818) (36.75N, 60.76W)	24/1300	972.3	24/1100	48		
Drifting Buoy (4101819) (36.15N, 62.48W)	24/0334	958.3	24/1230	54		
Drifting Buoy (4101820) (36.22N, 62.90W)	24/0302	968.6	24/0204	52		
Drifting Buoy (4101821) (36.67N, 60.14W)	24/1300	980.0				
Drifting Buoy (4101822) (36.66N, 60.66W)	24/1230	974.8				
Drifting Buoy (4101823) (36.86N, 61.68W)	24/1000	957.6				
Drifting Buoy (4101824) (35.83N, 62.82W)	24/0230	969.0				
Drifting Buoy (4101825) (35.81N, 63.47W)	24/0400	984.9				

[a] Date/time is for sustained wind when both sustained and gust are listed.
[i] Incomplete data

Table 4. 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%)	78	102
Medium (40%-60%)	60	66
High (>60%)	48	54

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Epsilon. 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	26.7	**30.8**	**38.5**	**41.6**	**48.9**	**61.6**	**120.2**	245.4
OCD5	69.6	135.2	208.4	253.8	314.8	380.6	510.2	440.7
Forecasts	26	24	22	20	18	16	12	8
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 Epsilon. 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	26.2	30.4	38.4	41.6	49.2	62.2	123.8	249.8
OCD5	64.4	134.6	212.3	255.3	316.9	383.5	518.3	429.4
GFSI	**22.2**	30.8	**38.1**	47.5	54.2	69.5	**122.7**	267.1
HMNI	30.0	35.3	48.0	47.3	72.4	84.8	**99.3**	**224.9**
HWFI	30.0	41.4	57.1	54.8	67.2	92.8	160.0	395.9
EGRI	27.1	34.4	45.9	48.8	56.2	**54.2**	**105.4**	**189.6**
EMXI	**23.4**	**27.4**	**35.6**	**36.6**	51.4	87.4	185.0	294.7
CMCI	27.5	37.5	45.7	46.9	53.1	**55.3**	**82.6**	**135.8**
NVGI	31.4	37.7	49.2	59.8	75.3	85.2	147.4	**227.0**
AEMI	**23.6**	**29.2**	**37.8**	**39.7**	**44.6**	72.4	134.6	271.2
HCCA	**22.0**	**27.3**	**34.5**	**39.4**	51.0	64.8	**107.5**	**210.5**
FSSE	**24.2**	**27.7**	**36.4**	42.1	55.1	**54.7**	**88.4**	**176.6**
TVCX	**22.5**	**27.5**	**35.2**	**34.4**	**38.7**	**59.0**	134.5	284.0
GFEX	**21.2**	**26.1**	**36.6**	**39.6**	**46.4**	68.5	144.1	280.2
TVCA	**22.7**	**27.6**	**35.6**	**35.5**	**40.3**	**59.0**	131.7	282.3
TABD	42.9	64.3	77.9	98.0	123.8	159.3	197.3	**157.1**
TABM	41.9	72.4	89.0	94.3	117.7	159.3	155.8	**109.6**
TABS	47.2	92.6	118.0	114.7	119.1	147.8	149.1	**171.1**
Forecasts	23	22	21	19	17	15	11	7

Table 6a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Epsilon. 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	7.1	9.8	11.8	12.5	**10.8**	**6.2**	**4.2**	**5.6**
OCD5	7.5	11.5	14.6	15.2	15.1	13.1	14.1	10.6
Forecasts	26	24	22	20	18	16	12	8
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 6b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Epsilon. 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 6a due to the homogeneity requirement.

Model ID	Forecast Period (h)							
	12	24	36	48	60	72	96	120
OFCL	7.6	10.7	12.1	12.1	9.1	5.0	4.1	6.4
OCD5	8.1	12.0	14.5	14.3	12.6	11.0	13.3	9.3
HWFI	9.0	12.5	14.4	15.8	15.6	13.1	9.6	10.1
HMNI	**7.1**	10.7	13.9	15.7	14.1	12.9	9.5	11.0
DSHP	**6.8**	**8.4**	**9.7**	**10.4**	9.2	10.1	14.7	21.3
LGEM	**6.6**	**8.7**	**10.0**	**9.8**	**7.6**	**4.0**	4.2	**6.0**
ICON	**7.0**	**9.2**	**10.9**	**11.2**	9.3	6.8	5.5	7.6
IVCN	**7.0**	**9.5**	**11.4**	**11.5**	9.7	6.9	5.3	7.3
GFSI	9.6	15.4	17.4	18.4	17.2	14.7	12.0	**4.9**
EMXI	9.2	14.8	18.4	21.8	21.8	20.3	21.6	17.6
HCCA	**6.9**	**10.1**	**10.7**	**11.7**	10.8	8.8	8.6	8.1
FSSE	**6.7**	**9.0**	**10.0**	**9.8**	**5.9**	**3.8**	4.9	**4.4**
Forecasts	23	22	21	19	17	15	11	7

Table 7. Watch and warning summary for Hurricane Epsilon, 19–26 October 2020.

Date/Time (UTC)	Action	Location
20 / 1500	Tropical Storm Watch issued	Bermuda
21 / 1500	Tropical Storm Watch changed to Tropical Storm Warning	Bermuda
23 / 0300	Tropical Storm Warning discontinued	All

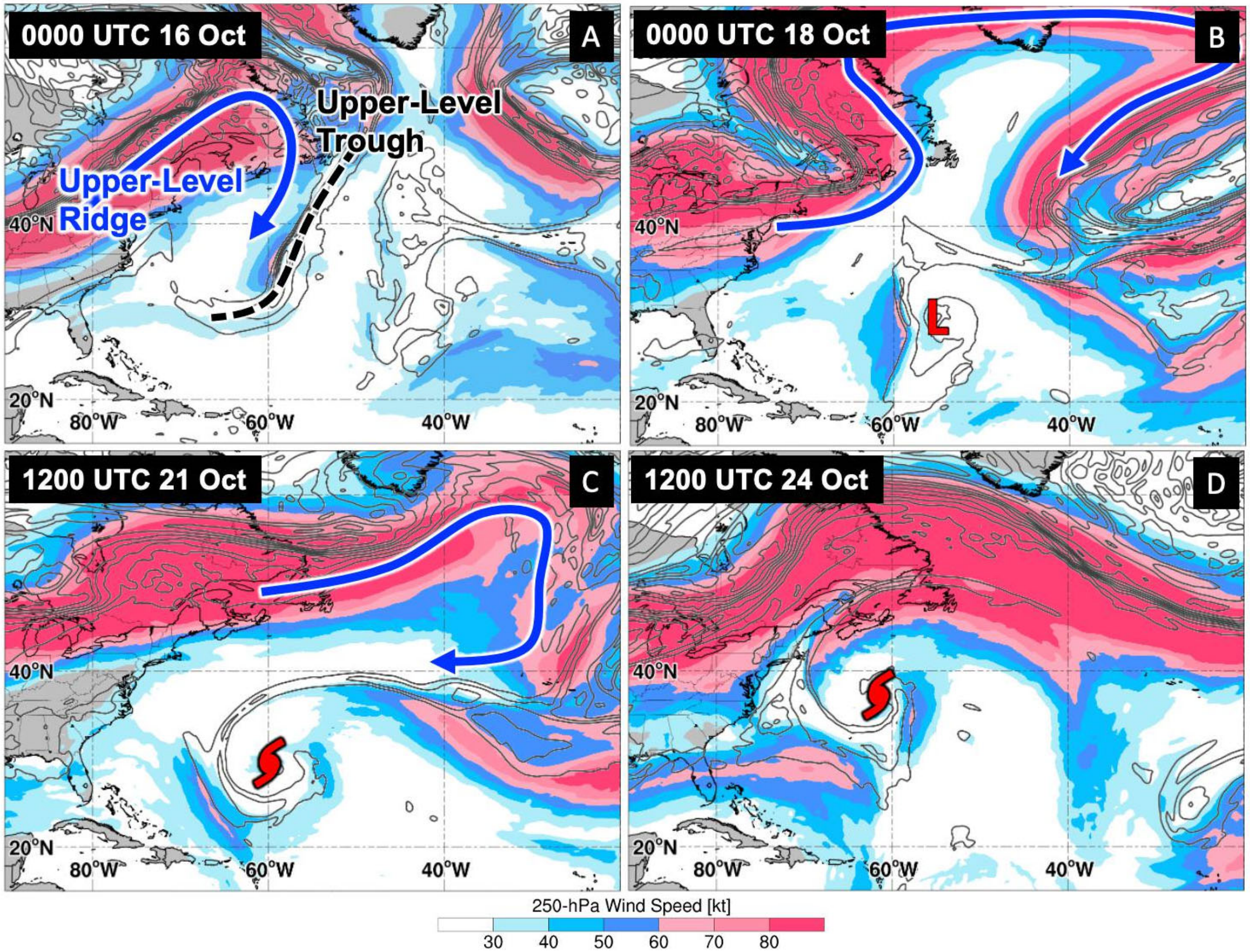

Figure 1. GFS model analysis at select times of Epsilon's lifespan illustrating the synoptic-scale pattern over the north Atlantic. Plotted are 250-hPa wind magnitude (shaded, kt) and 300–200-hPa layer-mean Potential Vorticity (gray contours, >1 PVU). The blue line with arrow denotes the direction of the upper-level anticyclonic flow, the black dotted line denotes the initial upper-level trough related to Epsilon's genesis, and the low and hurricane symbols denote the position of Epsilon in the best track as a non-tropical surface low and hurricane as it interacted with the upper-level cyclonic flow.

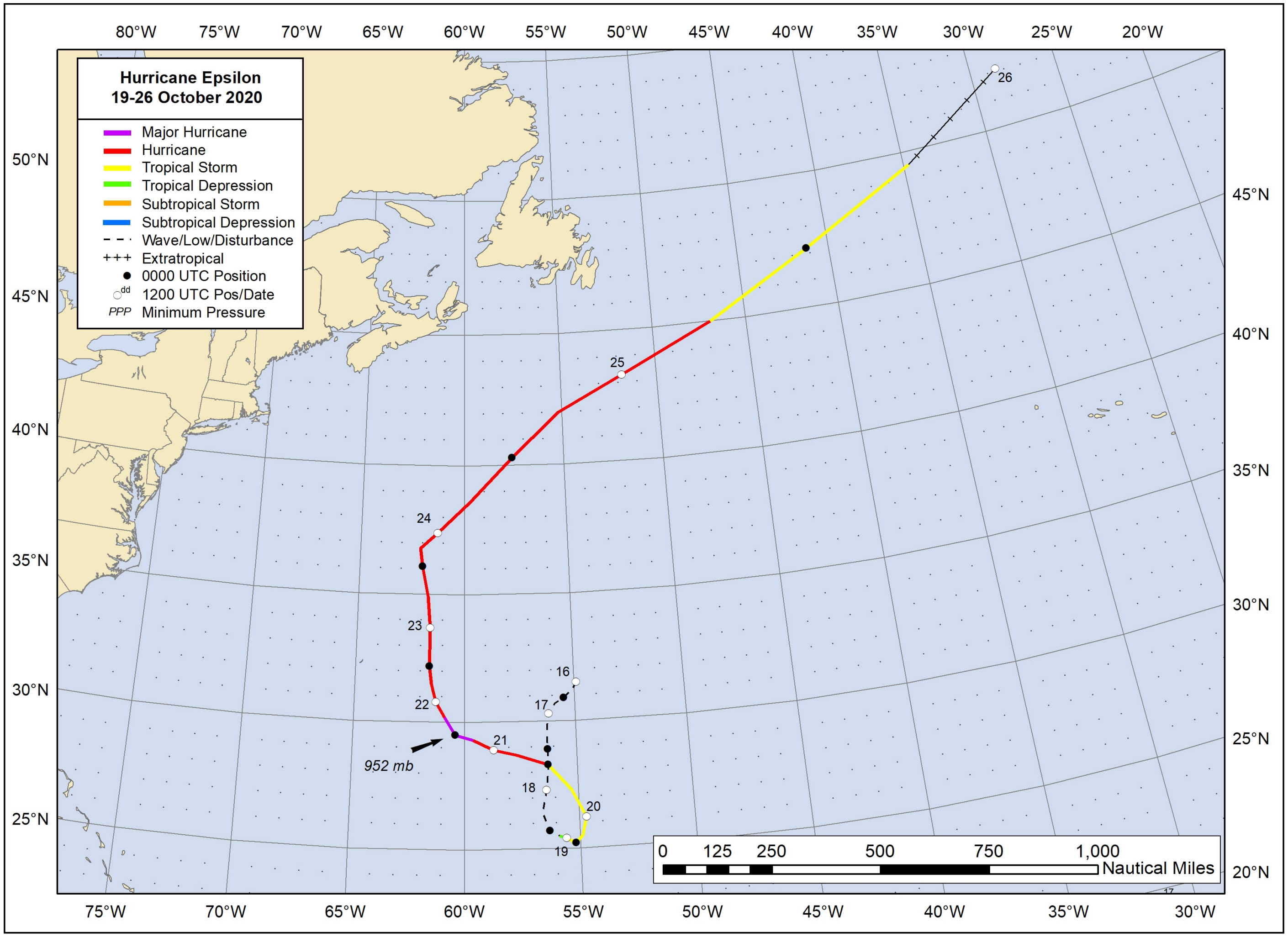

Figure 2. Best track positions for Hurricane Epsilon 19–26 October. Tracks during the low and extratropical stage are partially based on analyses from the NOAA Ocean Prediction Center.

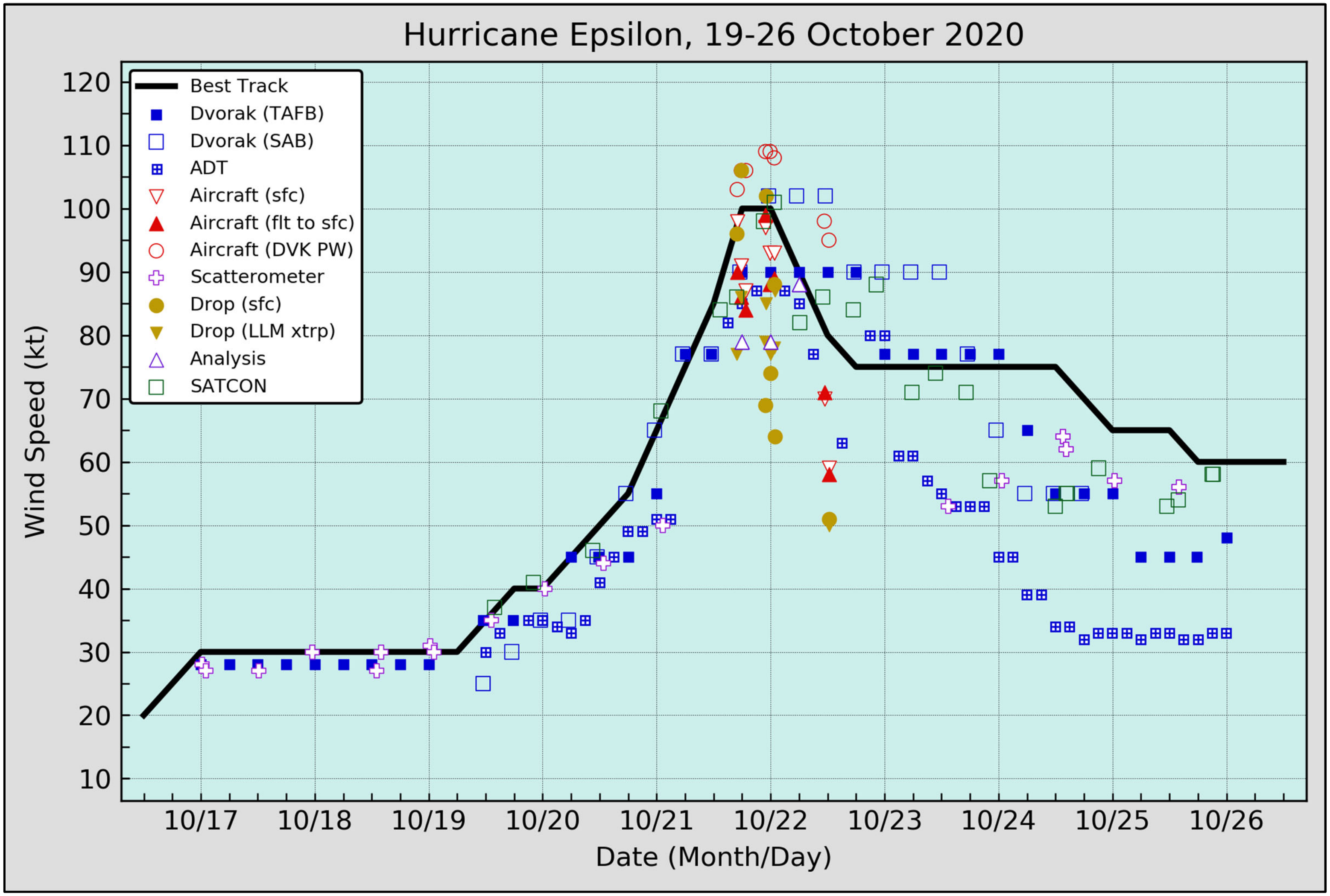

Figure 3. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Epsilon 19–26 October. Aircraft observations have been adjusted for elevation using 90% adjustment factor for observations from 700 mb. Dropwindsonde observations include actual 10 m winds (sfc), as well as surface estimates derived from the mean wind over the lowest 150 m of the wind sounding (LLM xtrp). 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.

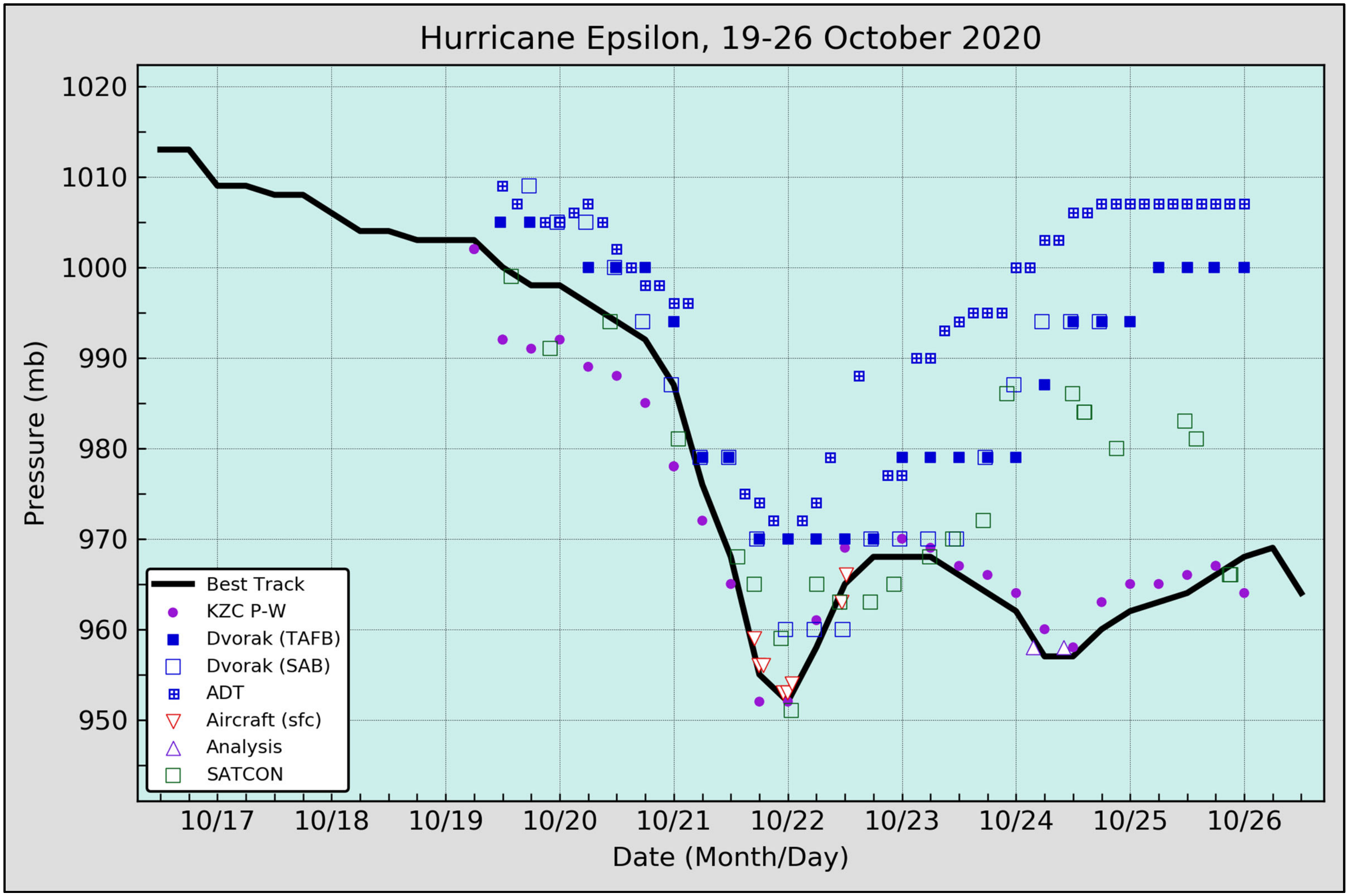

Figure 4. Selected pressure observations and best track minimum central pressure curve for Hurricane Epsilon 19–26 October. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological 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.

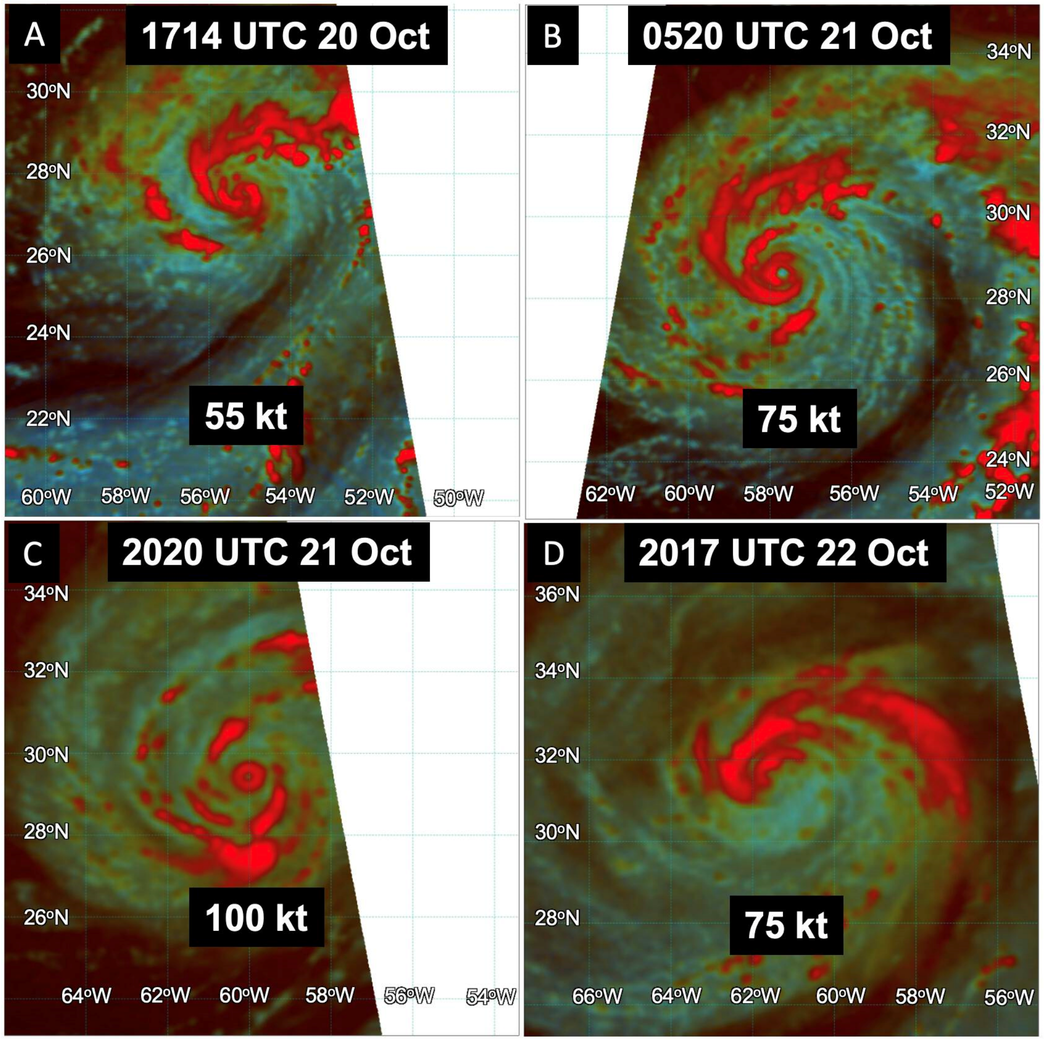

Figure 5. Passive microwave satellite color composite imagery showing Epsilon's core evolution from 20–22 October 2020. (a) 1714 UTC 20 October GCOM pass showing inner-core convection developing with Epsilon when it was a strong tropical storm. (b) 0520 UTC 21 October AMSR2 pass showing the development of an eyewall and eye as the storm intensified into a category 1 hurricane. (c) 2020 UTC 21 October SSMIS pass showing Epsilon near peak category 3 intensity with a small inner core with a closed circular eyewall. (d) 2017 UTC 22 October SSMIS pass showing Epsilon's inner core eroding due to dry air entrainment as it weakened back to a category 1 hurricane.

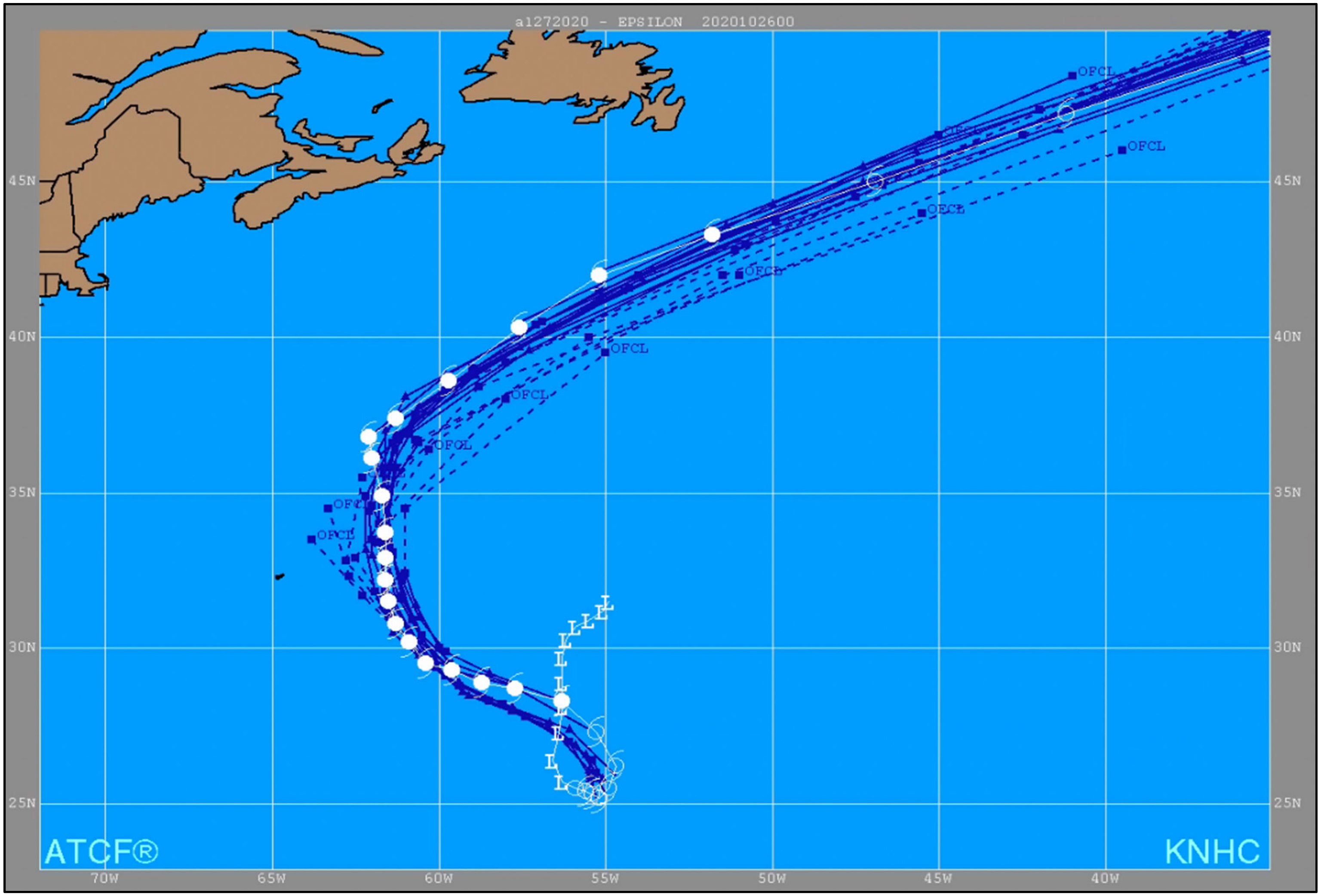

Figure 6. Selected official track forecasts (blue lines, with 0, 12, 24, 36, 48, 60, 72, 96, and 120 h positions indicated) for Hurricane Epsilon from 19–26 October. The best track is given by the white line with positions shown at 6-h interval.

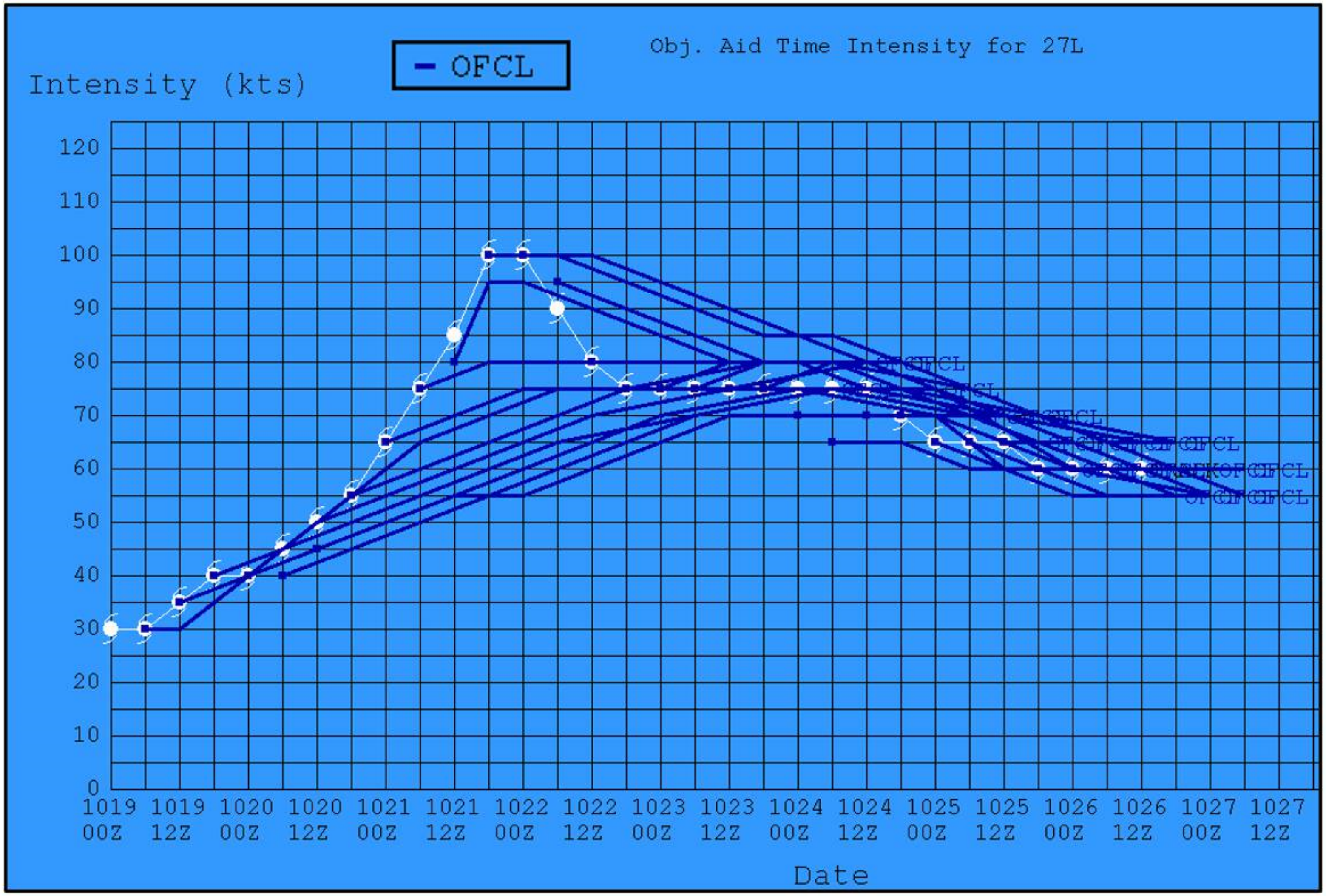

Figure 7. NHC official intensity forecasts (kt, blue lines) for Hurricane Epsilon from 0600 UTC 19 October to 0000 UTC 26 October 2020. The verifying intensity (kt) is shown in by the white line every 6 h.