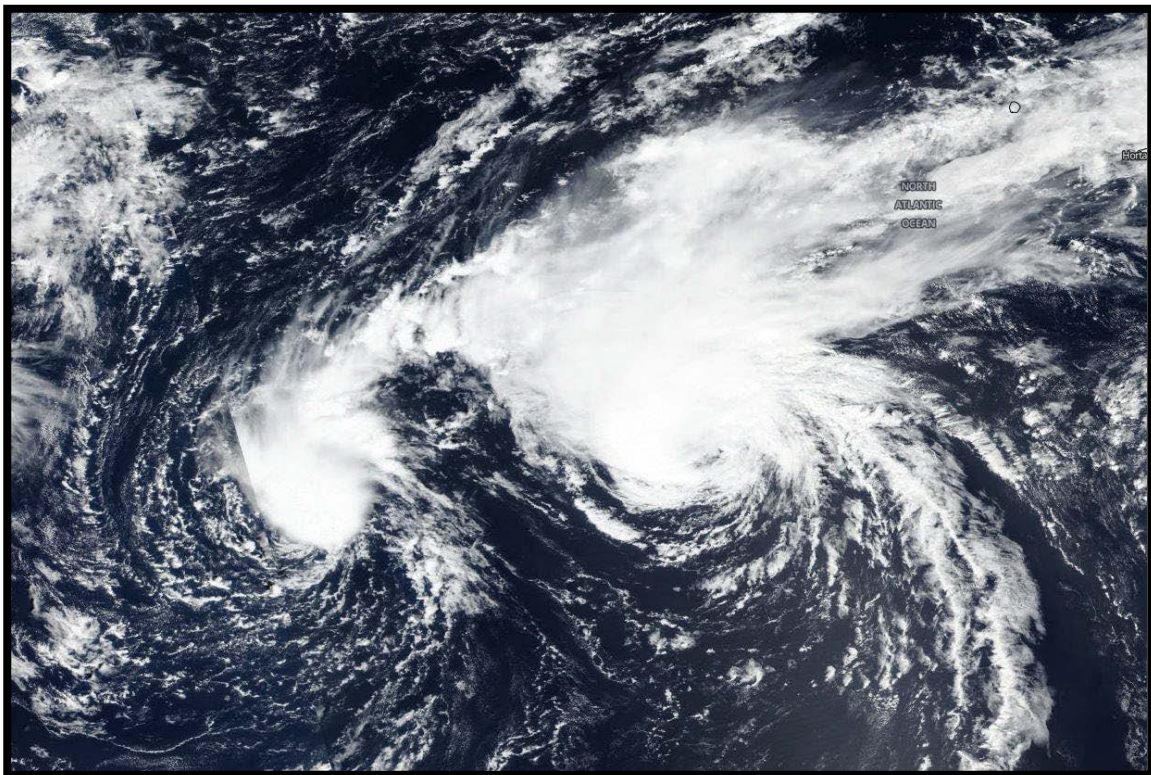# NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

TROPICAL STORM JOYCE
(AL102018)
12–18 September 2018

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30 January 2019

COMPOSITE IMAGES FROM THE NOAA/NASA SUOMI NPP VIIRS INSTRUMENT OF TROPICAL STORMS JOYCE (LEFT) AND HELENE (RIGHT) SOUTHWEST OF THE AZORES ON 14 SEPTEMBER 2018.

Joyce evolved from an extratropical low to a subtropical storm and then to a tropical storm, meandering over the north-central Atlantic Ocean well to the southwest of the Azores.

Tropical Storm Joyce

12–18 SEPTEMBER 2018

SYNOPTIC HISTORY

On 7 September, a cold front moved off the coasts of New England and Atlantic Canada and stalled over the northern Atlantic Ocean during the next few days. A wave of low pressure developed along the front late on 10 September ahead of an approaching shortwave trough and strengthened into an extratropical gale-force low pressure system by 0000 UTC 12 September about 430 n mi west-southwest of Flores Island in the western Azores. Some convection, although not very deep, formed within a cyclonically curved band near the center later that day, and since the surface low was collocated with a mid- to upper-level low and the front had dissipated, the system was designated a subtropical storm by 1200 UTC 12 September while centered about 535 n mi west-southwest of Flores Island. The "best track" chart of Joyce'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].

Cut off from the mid-latitude westerlies to the north and located to the east of a large area of high pressure located over the western Atlantic, Joyce moved generally southwestward for much of 12–13 September. Deep convection became rather sparse near the cyclone on 13 September due to increasing westerly shear and dry air (mid-level relative humidity was only about 40%), but new convection began developing near the center late that day. In addition, Joyce began separating from its parent upper-level low, and its strongest winds pulled in closer to the cyclone center, indicating that Joyce had completed a transition to a tropical storm by 0000 UTC 14 September, while located about 740 n mi west-southwest of Flores Island.

On 14 September, Tropical Storm Helene passed about 400 n mi to the east of Joyce (cover photo), and the tropical cyclones' interaction caused Joyce to turn sharply southward and then eastward during the day. At the same time, deep convection increased despite a continued strengthening of southwesterly shear, and Joyce's maximum winds reached an estimated peak of 45 kt by 0000 UTC 15 September. Joyce moved east-northeastward to eastward from 15–17 September, following in Helene's footsteps between a large high over the far eastern Atlantic and a mid- to upper-level trough over the central Atlantic. Strong shear and cool waters ultimately caused the associated deep convection to wane and lose organization, and Joyce weakened to a tropical depression by 1200 UTC 16 September while centered about 360 n mi south-southwest of Flores Island. Occasional bursts of convection allowed Joyce to remain as a tropical depression through 18 September, but the cyclone finally degenerated into a remnant low by 0000 UTC 19 September about 565 n mi south-southeast of Flores Island. The remnant low

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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.

moved westward for several days, ultimately dissipating after 1200 UTC 21 September about 550 n mi south-southwest of Flores Island.

METEOROLOGICAL STATISTICS

Observations in Joyce (Figs. 2 and 3) include subjective satellite-based Dvorak technique and Hebert-Poteat subtropical cyclone technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), subjective Dvorak technique estimates from 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. 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 Joyce.

Joyce's estimated peak intensity of 45 kt from 0000 to 0600 UTC 15 September is based on a consensus of satellite intensity estimates of T3.0/45 kt from TAFB and SAB. The estimated minimum central pressure of 995 mb is based on the Knaff-Zehr-Courtney pressure wind relationship.

There were no land-based or ship reports of winds of tropical storm force in association with Joyce.

CASUALTY AND DAMAGE STATISTICS

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

FORECAST AND WARNING CRITIQUE

As is often the case with prospective high-latitude extratropical lows becoming tropical or subtropical cyclones, confidence was never very high that Joyce's formation would occur, even though NHC recognized the possibility of genesis several days beforehand. Table 2 provides the number of hours in advance of formation associated with the first NHC Tropical Weather Outlook (TWO) forecast in each likelihood category. The TWO first mentioned the expected formation of a non-tropical low, with some possibility of tropical or subtropical development, and a low (<40%) chance of genesis during the next five days 90 h (3.75 days) before Joyce became a subtropical storm. The five-day chance of formation was raised to the medium (40–60%) category 60 h (2.5 days) before genesis, but it was never raised to the high (>60%) category. The non-tropical low

was given a low chance of formation within the next two days 30 h (1.25 days) before genesis and a medium chance of formation only 6 h before genesis. The two-day probabilities also never reached the high category before Joyce formed.

A verification of NHC official track forecasts for Joyce is given in Table 3a. Official forecast track errors were higher than the mean official errors for the previous 5-yr period at all time periods for which official forecasts verified (12–96 h). However, Joyce's track predictability was lower than that of most Atlantic tropical cyclones, as climatology and persistence model (OCD5) errors were significantly higher than their respective mean errors during the previous 5-yr period at all verifying forecast times, including up to twice as high at 72 h. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The NHC official forecasts were not particularly skillful compared to much of the track guidance. Of the dynamical models, the Canadian (CMCI) and COAMPS-TC (CTCI) had the lowest errors and beat the NHC official forecasts at all forecast times. Many of the consensus and corrected consensus aids also performed well, with TVCA, TVCX, the HFIP Corrected Consensus (HCCA) aid, and the Florida State Superensemble (FSSE) all having lower errors than the official forecasts at all verifying times. For most tropical cyclones, the GFS (GFSI) and the European (EMXI) models tend to be skillful overall, yet both models, as well as their consensus GFEX, performed worse than NHC's forecasts for Joyce at most lead times (Fig. 4).

A verification of NHC official intensity forecasts for Joyce is given in Table 4a. Official forecast intensity errors were lower than the mean official errors for the previous 5-yr period at all forecast times for which the official forecasts verified (12–96 h). A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. Nearly all of the dynamical models and consensus aids had lower errors than the official forecasts from 12 to 48 h. However, the statistical-dynamical SHIPS and LGEM models were not very skillful, having higher errors than the NHC forecasts at almost every forecast time.

There were no coastal watches or warnings issued in association with Joyce.

Table 1.   Best track for Tropical Storm Joyce, 12–18 September 2018.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
12 / 0000	37.0	39.8	1012	45	extratropical
12 / 0600	36.6	40.7	1011	45	"
12 / 1200	35.8	41.5	1010	40	subtropical storm
12 / 1800	34.8	41.9	1008	40	"
13 / 0000	34.3	42.4	1006	40	"
13 / 0600	34.0	42.9	1005	40	"
13 / 1200	33.9	43.4	1004	35	"
13 / 1800	33.6	43.9	1003	35	"
14 / 0000	33.1	44.4	1002	35	tropical storm
14 / 0600	32.5	44.8	1001	35	"
14 / 1200	31.8	44.9	1000	35	"
14 / 1800	31.5	44.5	997	40	"
15 / 0000	31.4	43.9	995	45	"
15 / 0600	31.5	42.8	995	45	"
15 / 1200	31.9	41.6	1001	40	"
15 / 1800	32.5	40.3	1003	40	"
16 / 0000	33.2	38.8	1005	35	"
16 / 0600	33.8	37.1	1006	35	"
16 / 1200	34.3	35.2	1006	30	tropical depression
16 / 1800	34.4	33.2	1006	30	"
17 / 0000	34.3	31.4	1006	30	"
17 / 0600	34.2	30.1	1006	30	"
17 / 1200	34.1	28.9	1006	30	"
17 / 1800	33.9	28.0	1006	30	"
18 / 0000	33.5	27.5	1006	30	"
18 / 0600	32.8	27.3	1006	30	"
18 / 1200	32.0	27.3	1007	30	"
18 / 1800	31.1	27.5	1008	25	"
19 / 0000	30.4	27.9	1009	25	low
19 / 0600	30.0	28.5	1010	20	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
19 / 1200	29.9	29.2	1011	20	"
19 / 1800	29.9	29.9	1012	20	"
20 / 0000	29.8	30.6	1013	20	"
20 / 0600	29.6	31.4	1014	20	"
20 / 1200	29.5	32.3	1014	20	"
20 / 1800	29.6	33.2	1014	20	"
21 / 0000	29.7	34.0	1014	20	"
21 / 0600	30.1	34.7	1014	20	"
21 / 1200	30.8	35.0	1014	20	"
21 / 1800					dissipated
15 / 0000	31.4	43.9	995	45	maximum wind and minimum pressure

Table 2.   Number of hours in advance of formation associated with the first NHC Tropical Weather Outlook forecast in the indicated likelihood category. Note that the timings for the "Low" category do not include forecasts of a 0% chance of genesis.

	Hours Before Genesis	
	48-Hour Outlook	**120-Hour Outlook**
Low (<40%)	30	90
Medium (40%-60%)	6	60
High (>60%)	-	-

Table 3a.   NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Joyce, 12–18 September 2018. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	25.7	40.3	58.3	77.0	147.1	191.8	
OCD5	64.5	161.5	267.8	387.0	623.1	698.5	
Forecasts	23	21	19	17	13	3	
OFCL (2013-17)	24.1	37.4	50.5	66.6	98.4	137.4	180.7
OCD5 (2013-17)	44.7	95.8	153.2	211.2	318.7	416.2	490.6

Table 3b.   Homogeneous comparison of selected track forecast guidance models (in n mi) for Tropical Storm Joyce, 12–18 September 2018. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 3a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	22.2	40.8	66.8	92.1	210.2		
OCD5	67.8	179.5	308.6	445.3	746.9		
GFSI	**20.4**	43.1	78.5	115.6	261.1		
EMXI	22.6	47.6	78.1	99.9	**194.2**		
EGRI	25.5	52.1	75.5	**85.0**	**97.3**		
NVGI	22.3	43.5	67.5	**89.3**	**129.4**		
CMCI	**21.8**	**36.2**	**58.5**	**86.8**	**168.3**		
HWFI	26.6	48.7	70.3	**91.1**	238.5		
HMNI	27.4	43.0	**63.8**	**83.5**	229.1		
CTCI	**20.6**	**36.9**	**57.0**	**86.0**	**193.6**		
TCON	**22.1**	41.6	**64.3**	**81.9**	**181.5**		
TVCA	**19.2**	**39.1**	**61.0**	**82.3**	**182.7**		
TVCX	**19.2**	**40.1**	**63.3**	**84.7**	**182.9**		
GFEX	**20.3**	44.4	75.3	105.4	224.7		
HCCA	**13.2**	**28.6**	**56.4**	**82.4**	**171.6**		
FSSE	**14.3**	**29.9**	**53.2**	**74.1**	**131.5**		
AEMI	**20.8**	**40.7**	68.2	96.7	**204.4**		
TABS	43.4	79.6	120.1	158.8	300.1		
TABM	23.4	48.6	96.2	167.3	248.0		
TABD	41.0	128.2	249.2	369.2	514.2		
Forecasts	11	11	11	11	5		

Table 4a.   NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Joyce, 12–18 September 2018. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**2.8**	**5.0**	**5.3**	**3.8**	**3.5**	**10.0**	
OCD5	4.3	6.8	9.2	13.3	25.2	38.3	
Forecasts	23	21	19	17	13	3	
OFCL (2013-17)	5.5	8.0	10.1	11.4	12.7	14.5	15.0
OCD5 (2013-17)	7.1	11.1	14.4	17.4	20.6	22.3	23.7

Table 4b.   Homogeneous comparison of selected intensity forecast guidance models (in kt) for Tropical Storm Joyce, 12–18 September 2018. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 4a due to the homogeneity requirement.

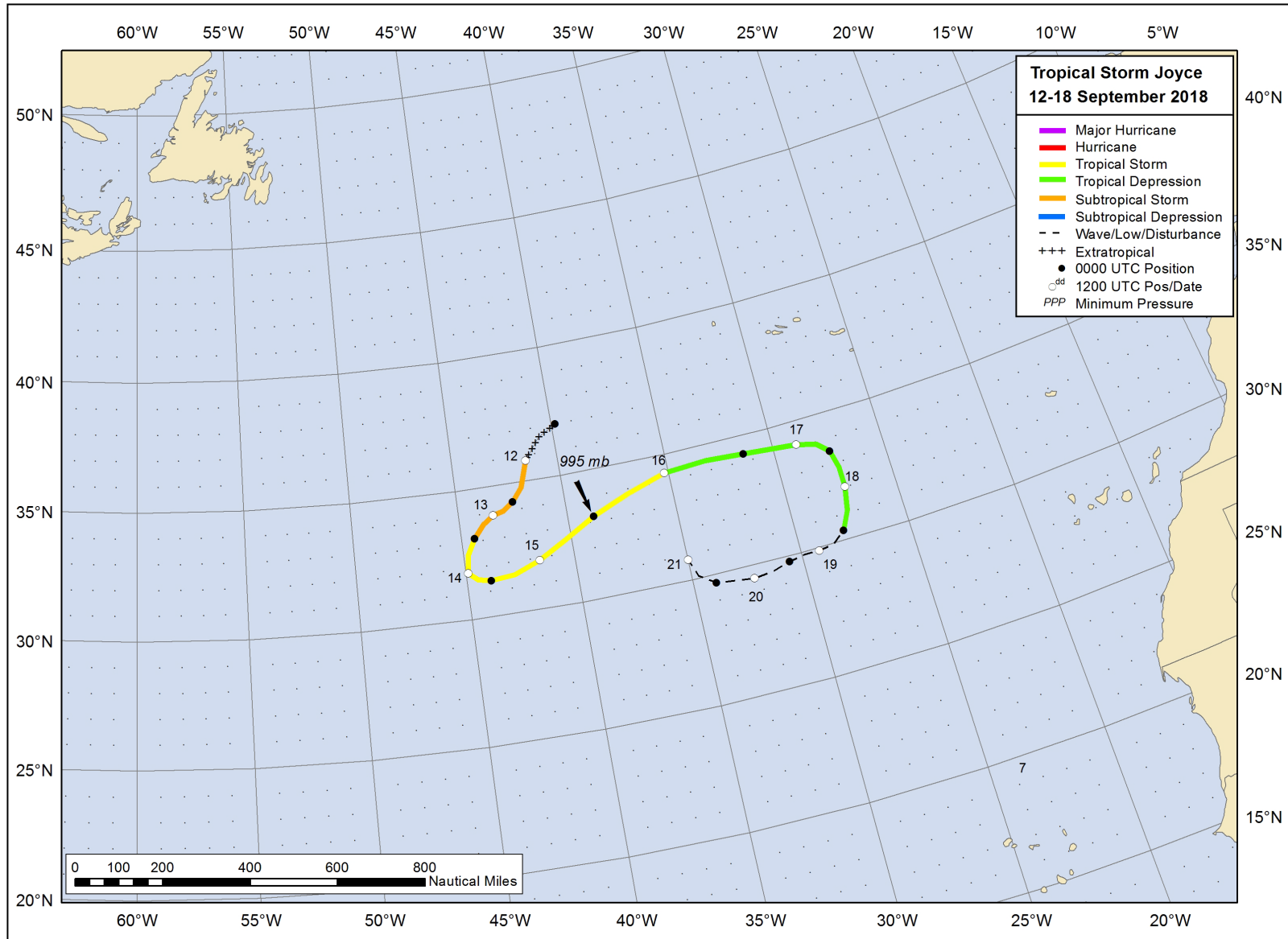| Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	4.5	6.8	5.0	4.1	1.0		
OCD5	5.4	7.8	10.5	15.5	24.6		
DSHP	5.2	7.6	9.8	10.9	8.6		
LGEM	4.6	**6.1**	5.3	5.5	8.0		
HWFI	**3.2**	**2.9**	**3.5**	**3.1**	1.6		
HMNI	5.5	**3.5**	**2.8**	**2.4**	3.4		
CTCI	**3.9**	**4.3**	**2.5**	**3.8**	4.6		
ICON	**4.4**	**3.5**	**3.5**	**3.7**	3.8		
IVCN	**4.3**	**3.6**	**2.8**	**2.6**	3.0		
HCCA	4.5	**4.1**	**4.5**	5.1	3.8		
FSSE	4.7	**3.5**	**2.8**	**2.4**	2.2		
GFSI	4.7	**6.7**	6.1	**3.9**	6.8		
EMXI	5.4	7.9	6.1	4.2	6.8		
Forecasts	11	11	11	11	5		

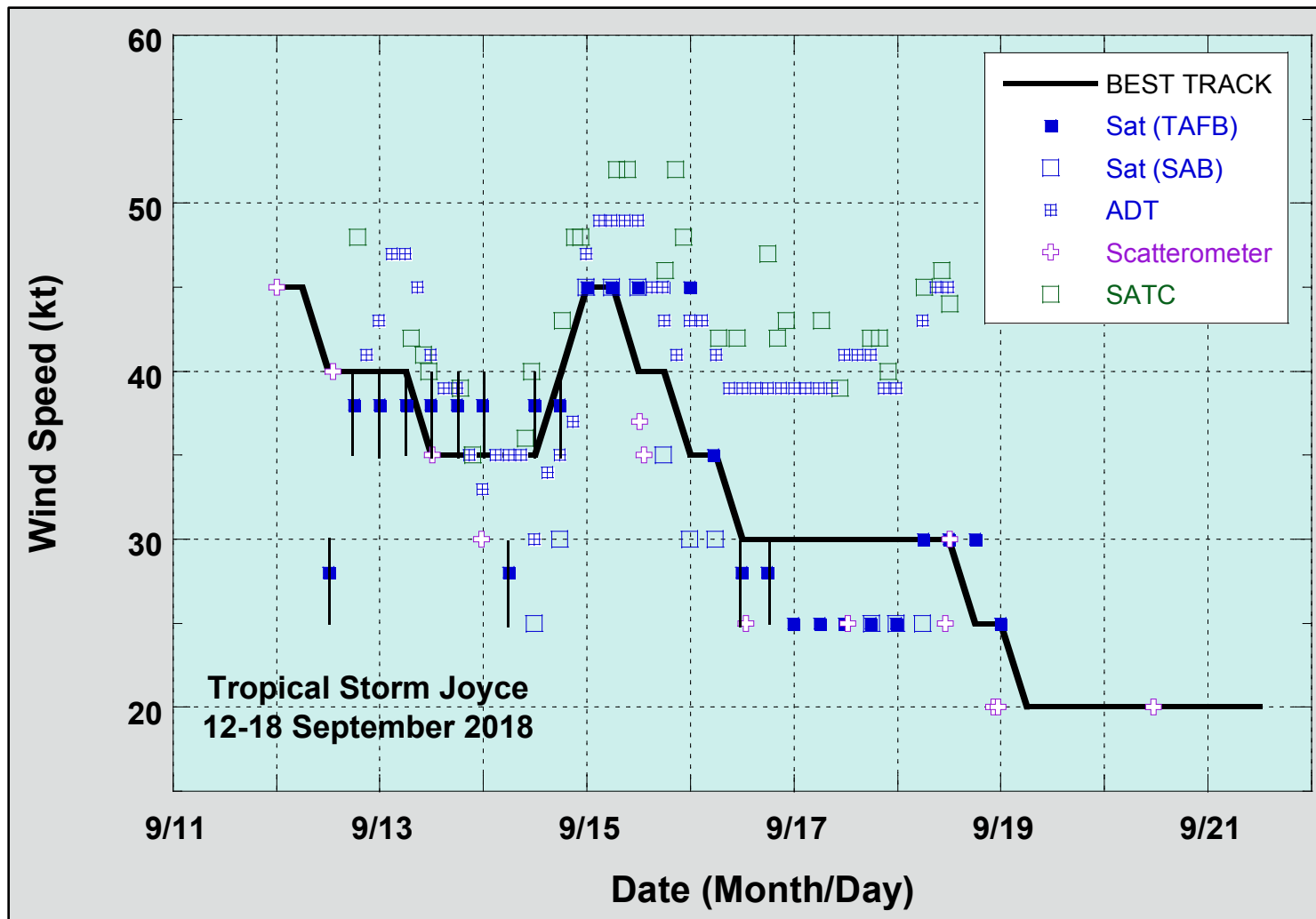Figure 1.   Best track positions for Tropical Storm Joyce, 12–18 September 2018.

Figure 2.   Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Joyce, 12–18 September 2018.   Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC, and short solid lines depict intensity ranges associated with subtropical satellite classifications.
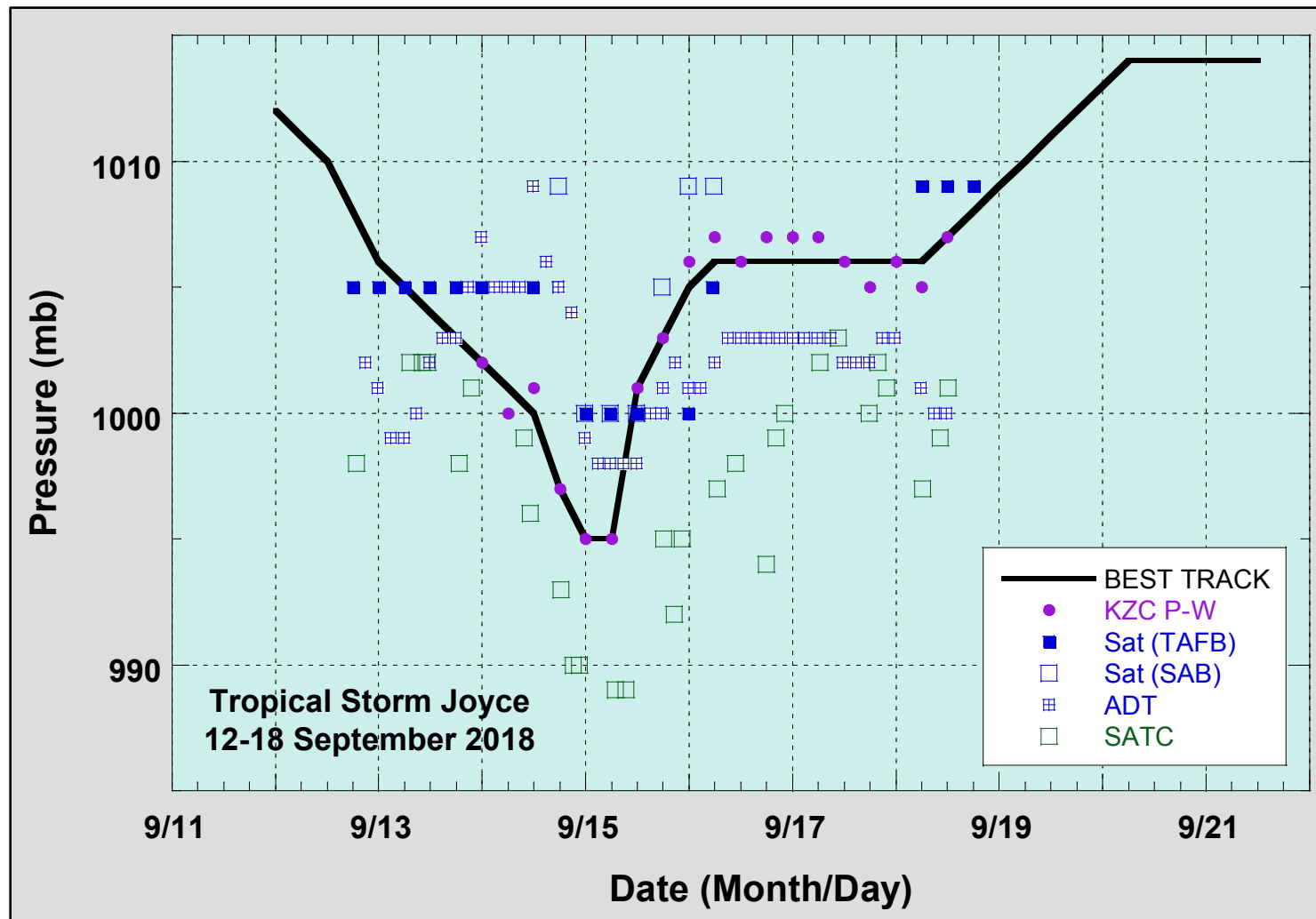
Figure 3.   Selected pressure observations and best track minimum central pressure curve for Tropical Storm Joyce, 12–18 September 2018. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.
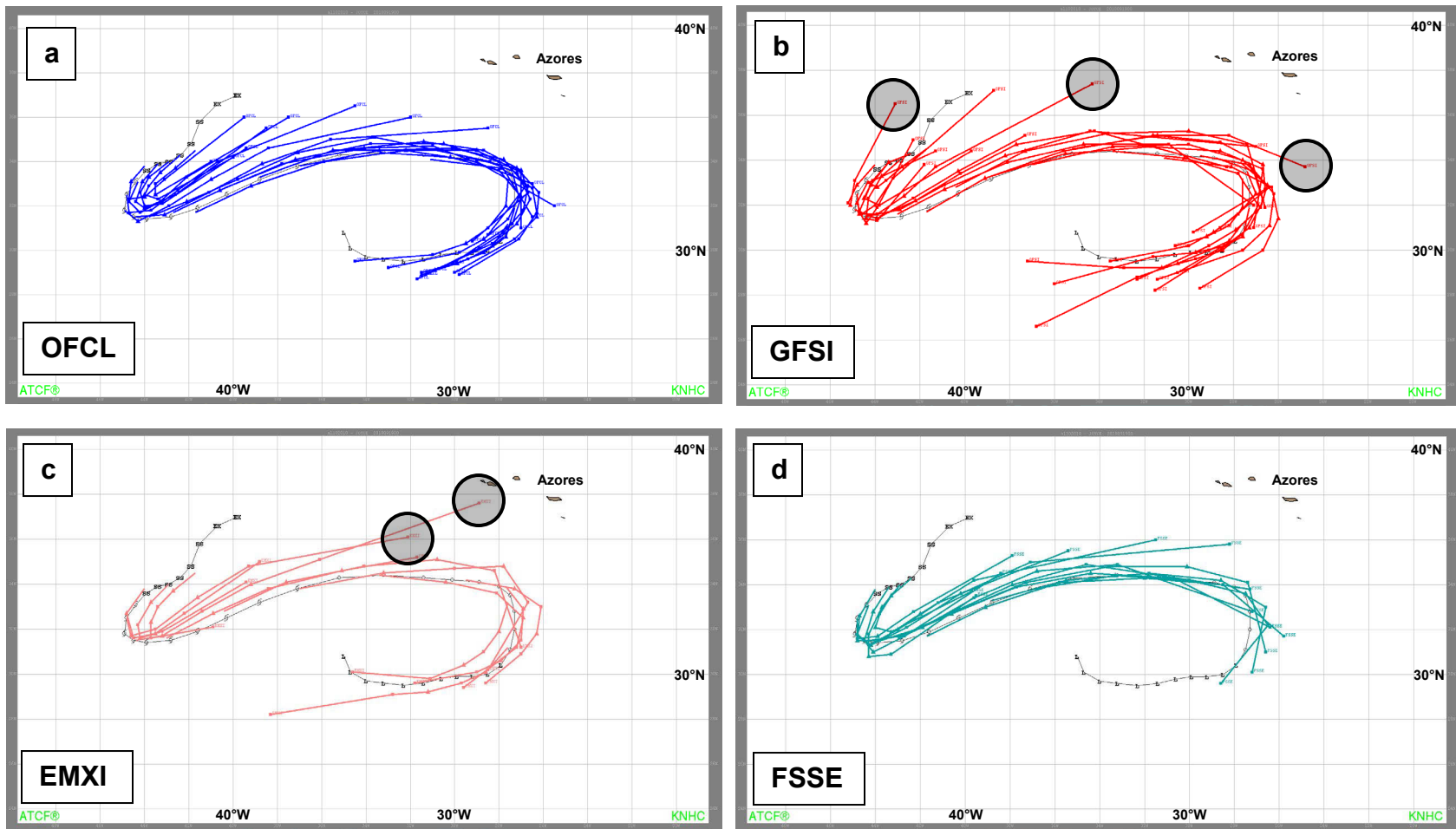
Figure 4. Three-day track plots of the (a) NHC official forecasts (OFCL, blue), (b) GFS model (GFSI, red), (c) ECMWF model (EMXI, pink), and (d) Florida State Superensemble (FSSE, aqua) for Tropical Storm Joyce, 12–18 September 2018. The best track of Joyce is indicated by the black lines with six-hourly positions. The plots show that some runs of the GFS (b) and ECMWF (c) models deviated significantly from the best track (indicated by shaded black circles), which led to higher errors compared to most of the other guidance aids. In comparison, the NHC official forecasts (a) had fewer significant outliers, and the FSSE (d) had the lowest overall track errors of any of the models.