NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

TROPICAL STORM JULIA

(AL112016)

13 – 18 September 2016

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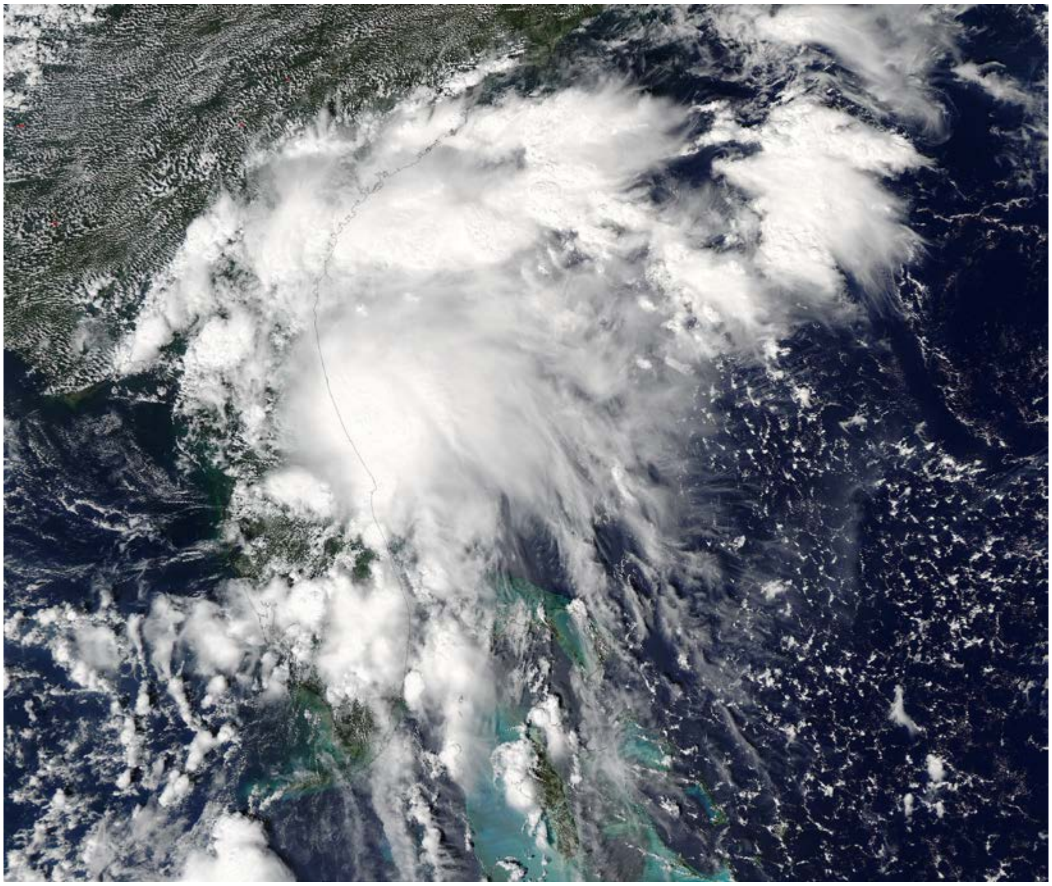

NASA-MODIS VISIBLE IMAGE OF JULIA NEAR PEAK INTENSITY OVER FLORIDA AT 1825 UTC 13 SEPTEMBER 2016.

Julia was a tropical cyclone that formed unexpectedly near the coast of southeastern Florida. It produced relatively minor impacts over land.

Tropical Storm Julia

13 – 18 SEPTEMBER 2016

SYNOPTIC HISTORY

The genesis of Julia is traceable to a tropical wave that left western Africa on 1 September. The wave lost almost all of its deep convection shortly after departing the coast, with any remaining convection lingering in the Intertropical Convergence Zone. Thunderstorm activity stayed at minimal levels for the next several days due to the system's moving through an unusually dry and subsident environment. On 6 September, convection increased near the wave when it moved over warmer waters a few hundred miles east of the Leeward Islands. The convective burst spawned a small low pressure area that moved west-northwestward during the next two days before opening up into a trough, and westerly vertical wind shear and dry mid-level air helped keep the system disorganized while it moved slowly northwestward through the Bahamas. Convection increased late on 12 September when the trough was moving south of the northwestern Bahamas. Although the shear remained high, the increase in convection caused a surface low to form between south Florida and Grand Bahama Island early the next day. By 0600 UTC 13 September, the small low had acquired enough convective organization to be considered a tropical depression at about the time it was making landfall near Jensen Beach, Florida, with sustained winds of 30 kt. The "best track" chart of the cyclone'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].

A strong band of convection developed near the coast and offshore after landfall in the northeastern quadrant of the asymmetric cyclone, with almost no significant weather on the western side of the circulation due to the westerly shear. Surface and radar data indicate that the depression strengthened to a tropical storm 6 h after formation. Julia moved erratically north-northwestward, parallel to but just inland of the east coast of Florida, with the center periodically reforming near the persistent band of convection. Surface data indicated that Julia reached a peak intensity of 45 kt around 1800 UTC, but the cyclone's strongest winds were confined to the band northeast of the center, located along and offshore of the Florida coast. Early on 14 September, Julia turned northward and northeastward around the subtropical ridge, moving over southeastern Georgia with 40-kt winds. The storm maintained this intensity for a couple of days while it moved erratically eastward then southeastward before strong northwesterly flow caused weakening behind a mid-latitude trough. Julia became a tropical depression at 0000 UTC 17 September about 250 n mi southeast of Charleston, South Carolina, and was caught in an area of light steering beneath a weak mid-level ridge. Julia produced bursts of convection during the next day or two under high shear conditions while it executed a small clockwise loop, but it finally

[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.

lost all deep convection late on 18 September, marking its decay to a remnant low at 0000 UTC 19 September about 80 n mi southeast of Charleston. The system moved slowly northward then northeastward near the coast of the Carolinas, transitioning to a weak extratropical low by 0000 UTC 20 September due to baroclinic forcing from a nearby mid- to upper-level trough. The extratropical cyclone hooked back westward over coastal North Carolina before dissipating early on 21 September.

METEOROLOGICAL STATISTICS

Observations in Julia (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). Other data include flight-level and stepped frequency microwave radiometer (SFMR) observations from two flights of the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command. 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 Julia.

The genesis of Julia in post-analysis was backed up 21 h from the operational designation of 0300 UTC 14 September. A post-analysis of all available data suggest that Julia initially met the tropical cyclone requirements at 0600 UTC 13 September, although in terms of convective organization and center definition just barely so. Operationally, the decision not to designate the system as a tropical cyclone during its initial hours over land was influenced by NHC's expectation that the system would push farther inland and quickly dissipate. This post-analysis also shows that the genesis of Julia occurred while the center was over water, although just barely so.

Selected surface observations are given in Table 2. The estimated 45-kt peak intensity of Julia is based on surface wind reports from the east coast of Florida. The peak winds reported were from a private weather station at Crescent Beach, Florida, with sustained winds of 45 kt gusting to 51 kt. Melbourne 88-D Doppler radar also showed up to 55-kt winds from 3000-5000 ft, which generally supports that intensity. Sustained tropical-storm-force winds were measured in northeastern Florida, coastal Georgia and southeastern South Carolina.

One ship, an unnamed NOAA research vessel located 7 n mi east of Daytona Beach, reported tropical-storm-force winds. The peak sustained winds were 35 kt at about 1730 UTC 13 September, with gusts to 55 kt for several hours.

One tornado was reported with Julia: an EF-0 tornado near Barefoot Bay, Florida.

Rainfall accumulations were generally low in association with Julia due to the storm's asymmetric structure. A small area of heavy rainfall occurred along the coast of Georgia in Glynn County. The peak total was 6.49 inches near St. Simons Island.

During the extratropical portion of its track, Julia helped contribute to very heavy rainfall and flooding in northeastern North Carolina and the Hampton Roads area of Virginia.

CASUALTY AND DAMAGE STATISTICS

No casualties were reported in association with Julia. Minor damage was reported in northeastern Florida with a few trees down, and part of a roof of a home was torn off due to the Barefoot Bay tornado. Some flooding was mentioned in media reports in the Charleston, SC area.

FORECAST AND WARNING CRITIQUE

Genesis forecasts for Julia were poor (Table 3). The system was first put in the Tropical Weather Outlook (TWO) 114 h before formation with a low (< 40%) probability of 5-day and 2-day genesis. However, the system never entered the medium or high categories before genesis occurred, and TWO products consistently downplayed the system's potential due to seemingly unfavorable environmental conditions. Global models did not provide much useful guidance, with the major models showing, at best, a weak low. Near the time of formation, while the environment looked slightly more favorable, it was thought that the system's movement over land would prevent any significant organization from occurring.

A verification of NHC official track forecasts for Julia is given in Table 4a. Official forecast track errors were generally above the mean official errors for the previous 5-yr period, especially during the first 48 h of the forecast period. A homogeneous comparison of the official track errors with selected guidance models is given in Table 4b. Model guidance had a pronounced leftward bias early on for Julia, which resulted in relatively large errors at the shorter lead times (Figure 4). Julia appears to be a case where the models had a real challenge with the depth of a tropical cyclone in a high-shear environment. Early on, much of the model guidance was suggesting that Julia would stay weak and move well inland. However, Julia stayed more vertically coherent and moved to the right or faster than all of the model forecasts, remaining intact despite the strong shear. Among the model guidance, the UKMET (EGRI) and the TVCN/X consensus aids had a very good performance for this cyclone. The GFS model had much larger errors than the other historically high-performing guidance.

A verification of NHC official intensity forecasts for Julia is given in Table 5a. Official forecast intensity errors were much lower than the mean official errors for the previous 5-yr period at all time periods. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 5b. The NHC intensity forecasts were outstanding for Julia with very low errors, besting almost all of the model guidance. NHC forecasters realized that Julia would likely not strengthen or weaken much in a marginal environment near land. The GFDL model had a rather poor performance for Julia with a marked high bias, while the HWRF model consistently weakened the cyclone too much.

A Tropical Storm Warning was issued from Ponte Vedra Beach to Altamaha Sound concurrently with the first advisory at 0300 UTC 14 September, and discontinued 9 h later. In 2017, NHC is expected to have the ability to issue watches and warnings before tropical cyclone formation, which will likely increase the lead time possible for tropical cyclone events.

Table 1. Best track for Tropical Storm Julia, 13-18 September 2016.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
13 / 0600	27.3	80.2	1010	30	tropical depression
13 / 1200	28.0	80.7	1010	35	tropical storm
13 / 1800	29.0	81.2	1010	45	"
14 / 0000	29.8	81.5	1010	45	"
14 / 0600	30.5	81.7	1011	40	"
14 / 1200	31.3	81.5	1011	40	"
14 / 1800	31.8	80.7	1009	40	"
15 / 0000	31.9	80.1	1007	40	"
15 / 0600	31.9	79.5	1007	40	"
15 / 1200	31.9	78.7	1007	40	"
15 / 1800	31.9	77.9	1007	40	"
16 / 0000	31.5	77.2	1007	40	"
16 / 0600	31.2	76.6	1008	40	"
16 / 1200	31.1	75.9	1008	40	"
16 / 1800	30.9	75.7	1008	40	"
17 / 0000	30.4	76.0	1009	30	tropical depression
17 / 0600	30.3	76.1	1009	30	"
17 / 1200	30.2	76.2	1010	30	"
17 / 1800	30.4	76.3	1010	30	"
18 / 0000	30.7	76.4	1010	30	"
18 / 0600	31.1	76.6	1010	25	"
18 / 1200	31.7	77.0	1010	25	"
18 / 1800	32.0	77.8	1010	25	"
19 / 0000	32.2	78.3	1010	30	low
19 / 0600	32.4	78.2	1011	30	"
19 / 1200	32.8	77.7	1011	30	"
19 / 1800	33.2	77.0	1011	30	"
20 / 0000	33.6	76.5	1011	30	extratropical

20 / 0600	34.3	76.1	1011	30	"
20 / 1200	35.0	76.0	1011	25	"
20 / 1800	35.5	76.3	1011	25	"
21 / 0000	35.6	76.9	1011	25	"
21 / 0600	35.4	77.4	1012	20	"
21 / 1200					dissipated
13 / 0600	27.3	80.2	1010	30	landfall near Jensen Beach, Florida
15 / 0000	31.9	80.1	1007	40	minimum pressure
13 / 1800	29.0	81.2	1010	45	maximum winds

Table 2. Selected surface observations for Tropical Storm Julia, 13-18 September 2016

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)	Stor m tide (ft)	Estimated Inundation (ft)	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
METAR Sites									
Craig Municipal Airport (KCRG)	14/0253	1012.9	14/0130	21	39				
Mayport Naval Station (KNRB)	14/0652	1012.8	14/0149	29	42				3.01
St. Augustine Airport (KSGJ)	14/0058	1012.3	13/2316	31	39				
St. Simons/Malcom McKinnon Airport (KSSI)	14/0853	1011.5	14/0602	28	36				6.49
Buoy, CMAN & NOS Sites									
St. Augustine FL (SAUF1)	14/1400	1012.6	13/2250	33	40				
Gray's Reef GA (41008)	14/1450	1012.4	14/0700	29	35				
Folly Island SC (FBIS1)	15/0900	1013.9	14/2220	33	41				
Edisto 41 NM SE of Charleston SC (41004)	15/0950	1010.7	14/2210	31	39				
South Hatteras 225 NM S of Cape Hatteras NC (41002)	16/0750	1011.0	16/0640	30	43				
Mayport NOS Station (MYPF1)	14/0700	1011.7	14/0136	33	42				
WeatherFlow Sites									
Jekyll Island GA (XJEK)			14/0610	35	43				
Huguenot Park (XHUP)	14/0608	1010.7	14/0138	37	45				
Crescent Beach Summerhouse (XHSE)	13/2210	1010.2	13/2200	30	40				
Jacksonville Beach Pier (XJAX)			14/0124	30	40				
Buck Island (XJAK)			14/0153	31	42				
New Smyrna Beach (XNSB)			13/1554	37	48				
Folly Beach Pier (XFOL)			14/2306	37	45				
Isle of Palms Pier (XIOP)			14/2335	34	40				
Other Sites									
Butler Beach FL			13/2221	38					
Vilano Beach FL			13/2250	39	46				
Crescent Beach FL			13/2213	45	51				
Hilton Head Island GA			14/1647	35	39				
Ponce Inlet Jetty FL			13/1601	43					

[a] Date/time is for sustained wind when both sustained and gust are listed.
[b] Sustained wind averaging periods for C-MAN and METAR reports are 2 min; buoy averaging periods are 8 min; WeatherFlow and other sites are 1 min.

Table 3. 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%)	114	114
Medium (40%-60%)	-	-
High (>60%)	-	-

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Julia. 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	37.4	69.2	104.5	137.0	116.5	**137.8**	
OCD5	53.1	116.2	193.8	293.1	482.0	740.2	
Forecasts	18	16	14	12	5	1	
OFCL (2011-15)	28.4	45.0	60.4	77.1	113.1	157.8	
OCD5 (2011-15)	48.3	101.5	161.5	222.6	329.8	412.6	

Table 4b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Julia. 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	36.5	59.6	81.5	95.2	107.0	137.8	
OCD5	54.0	116.8	193.4	294.3	458.2	740.2	
GFSI	39.9	69.7	98.9	124.8	146.5	218.8	
GFEX	40.4	67.3	90.4	108.1	132.5	165.1	
EMXI	41.6	69.0	90.9	106.2	126.5	**123.8**	
HWFI	**32.9**	60.7	90.0	119.7	**106.4**	**93.5**	
GHMI	44.1	68.0	100.8	118.9	120.4	**82.5**	
EGRI	**35.1**	**54.8**	**70.9**	**87.0**	**94.0**	**78.2**	
CMCI	**35.3**	**57.1**	**71.0**	95.6	130.4	209.5	
NVGI	43.3	81.3	103.0	129.0	135.6	**128.4**	
GFNI	45.0	87.8	121.9	150.9	222.2	193.1	
AEMI	39.6	66.6	93.5	115.4	127.1	154.9	
HCCA	**32.9**	**52.2**	**70.2**	**90.4**	115.7	**86.8**	
TVCN	**32.3**	**50.9**	**67.5**	**79.8**	**81.2**	**67.5**	
TVCX	**33.2**	**53.0**	**69.1**	**82.0**	**83.7**	**74.0**	
LBAR	44.7	83.3	136.5	202.2	385.3	623.8	
BAMD	56.4	111.6	166.1	214.0	311.1	436.4	
BAMM	40.3	65.1	87.1	**91.7**	**73.0**	**46.2**	
BAMS	52.0	91.2	130.0	162.2	204.3	239.0	
Forecasts	15	13	11	9	4	1	

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Julia. 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	**4.4**	**4.4**	**5.0**	**6.7**	**1.0**	**5.0**	
OCD5	5.1	9.1	14.1	20.4	30.8	37.0	
Forecasts	18	16	14	12	5	1	
OFCL (2011-15)	6.2	9.4	11.5	13.3	14.6	14.6	
OCD5 (2011-15)	7.3	10.8	13.3	15.3	17.7	17.8	

Table 5b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Julia. 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	72	96	120
OFCL	4.4	4.4	5.0	6.7	0.0		
OCD5	5.1	9.1	14.1	20.4	32.0		
GFSI	6.7	6.6	7.4	7.5	6.3		
EMXI	6.4	6.9	7.0	6.8	5.7		
DSHP	4.9	5.9	7.5	8.6	3.3		
LGEM	5.6	6.3	7.2	7.8	3.7		
IVCN	4.4	5.1	6.3	7.8	6.0		
HCCA	4.9	5.1	5.7	**5.8**	3.3		
HWFI	**3.9**	5.5	6.9	7.4	7.7		
GHMI	**3.8**	7.1	14.4	16.4	25.7		
GFNI	5.6	8.3	8.9	8.9	6.7		
Forecasts	18	16	14	12	3		

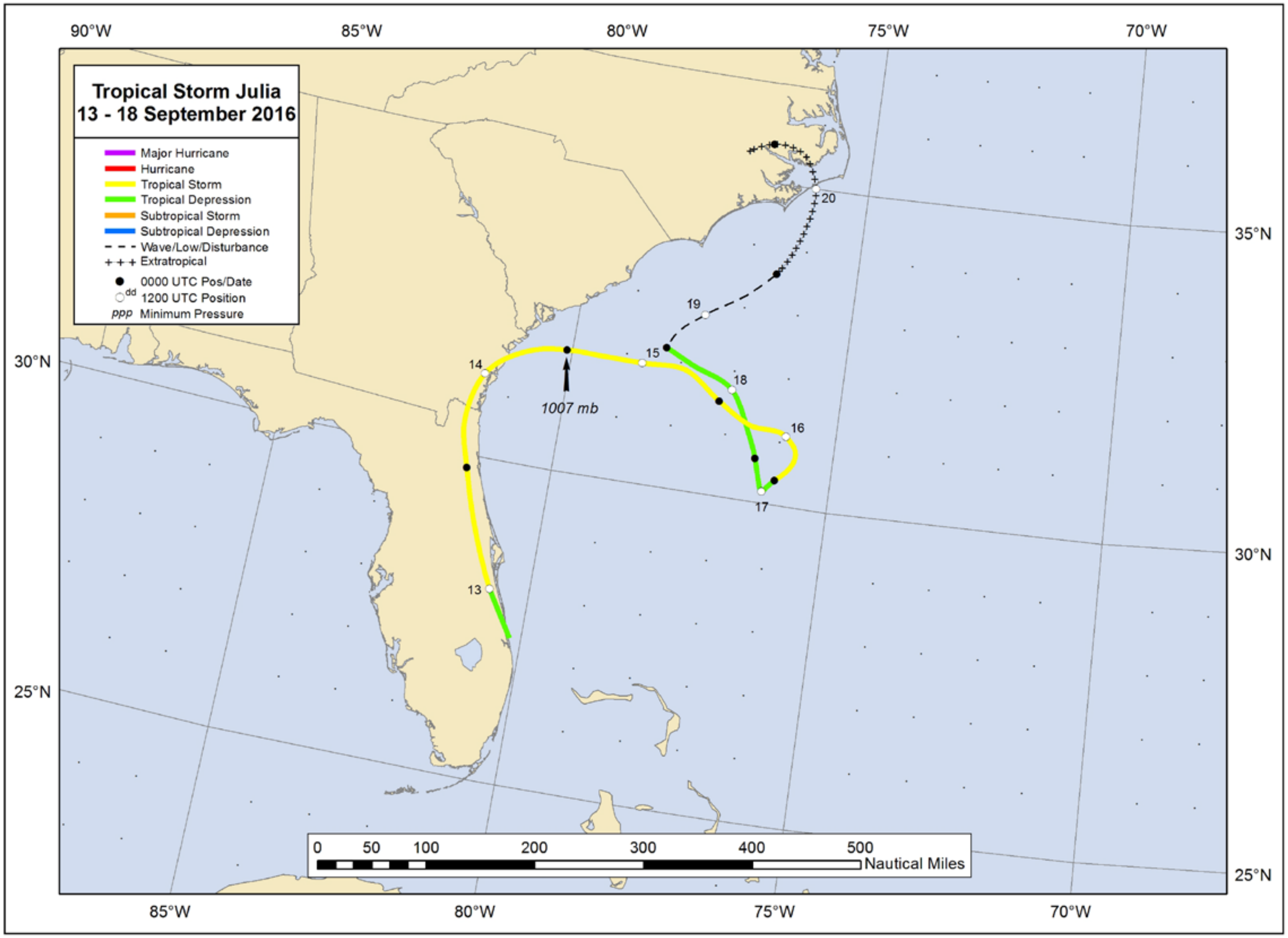

Figure 1. Best track positions for Tropical Storm Julia, 13-18 September 2016.

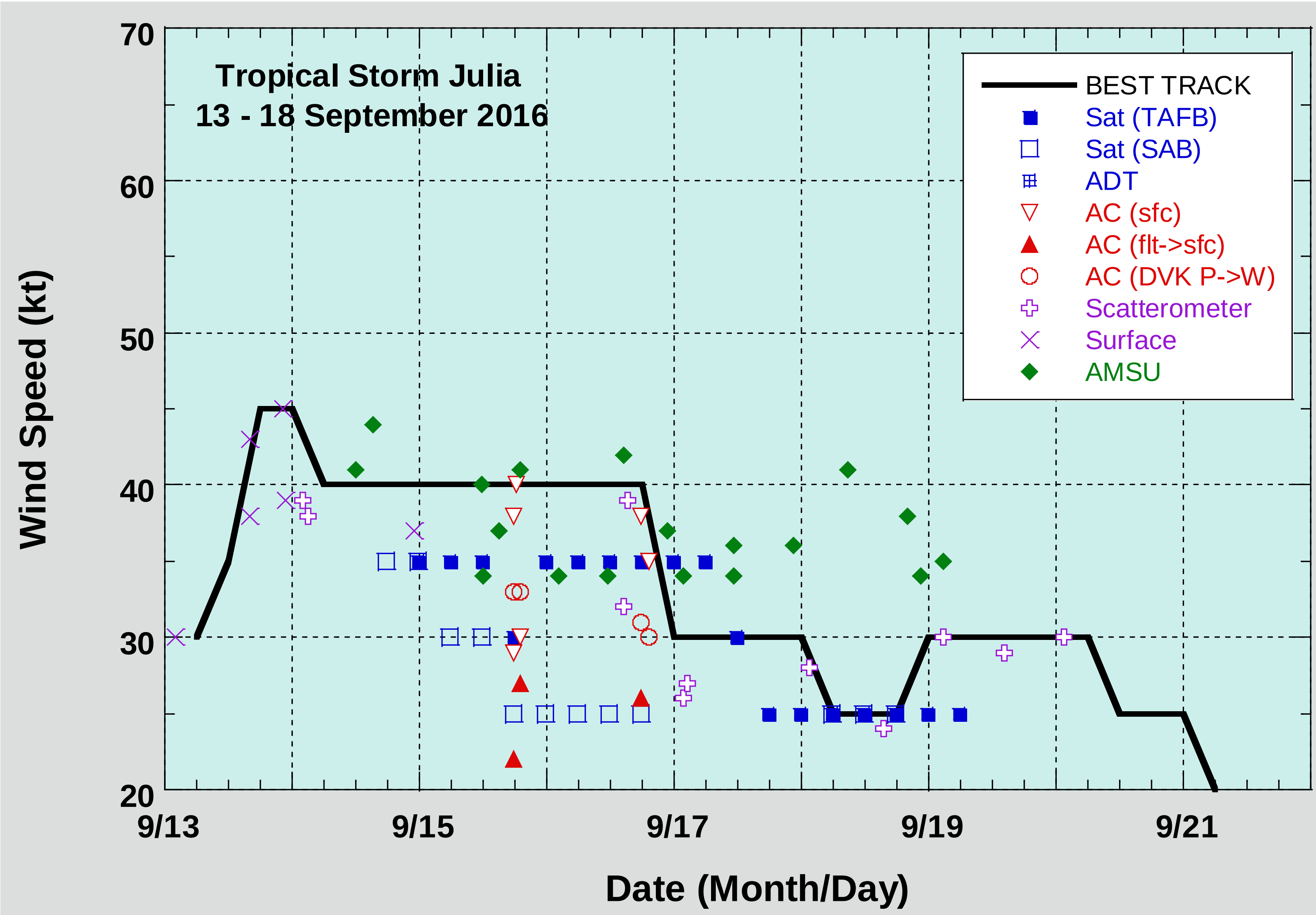

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Julia. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. Dashed lines refer to 0000 UTC.

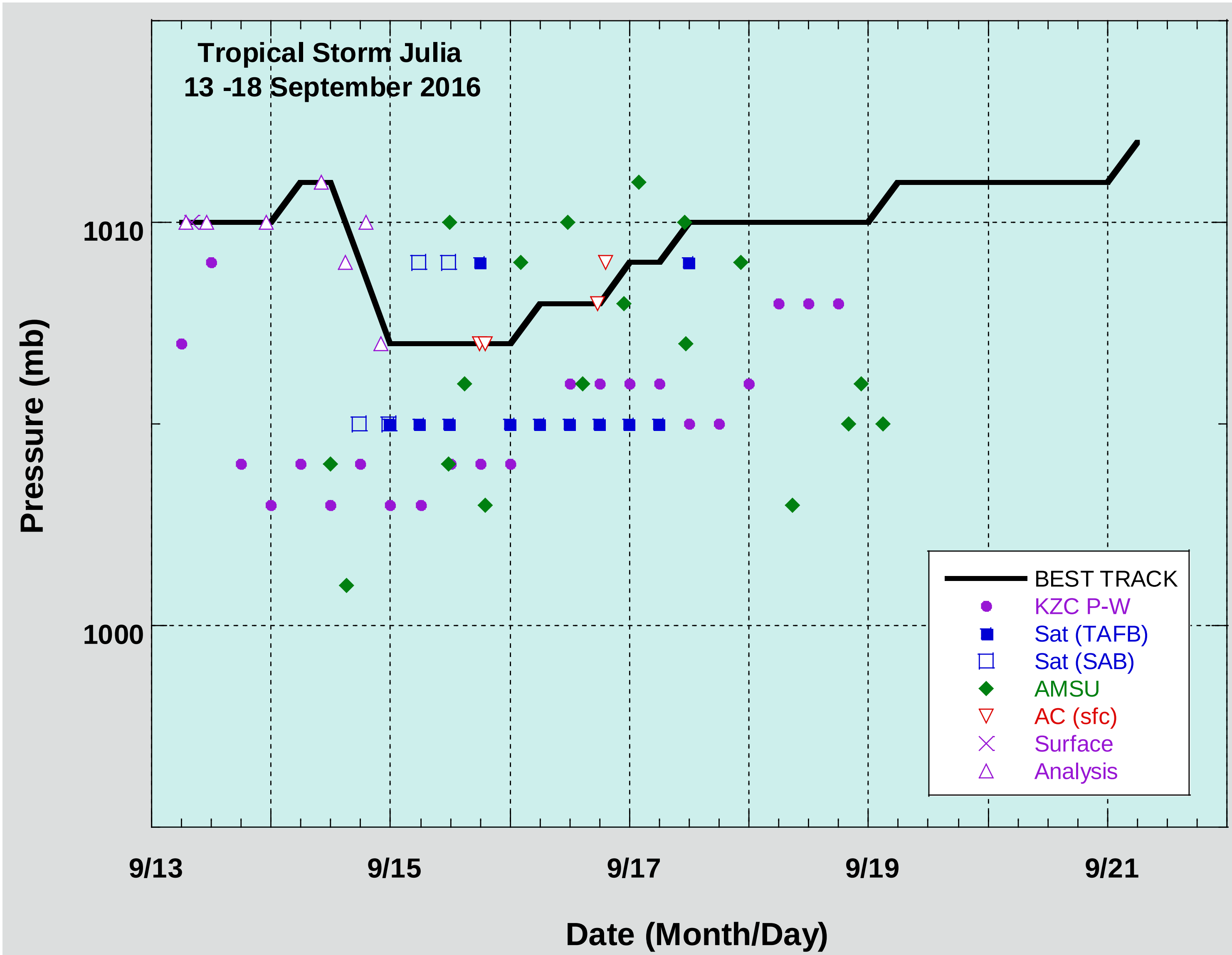

Figure 3. Selected pressure observations and best track minimum central pressure curve for Julia. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship.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

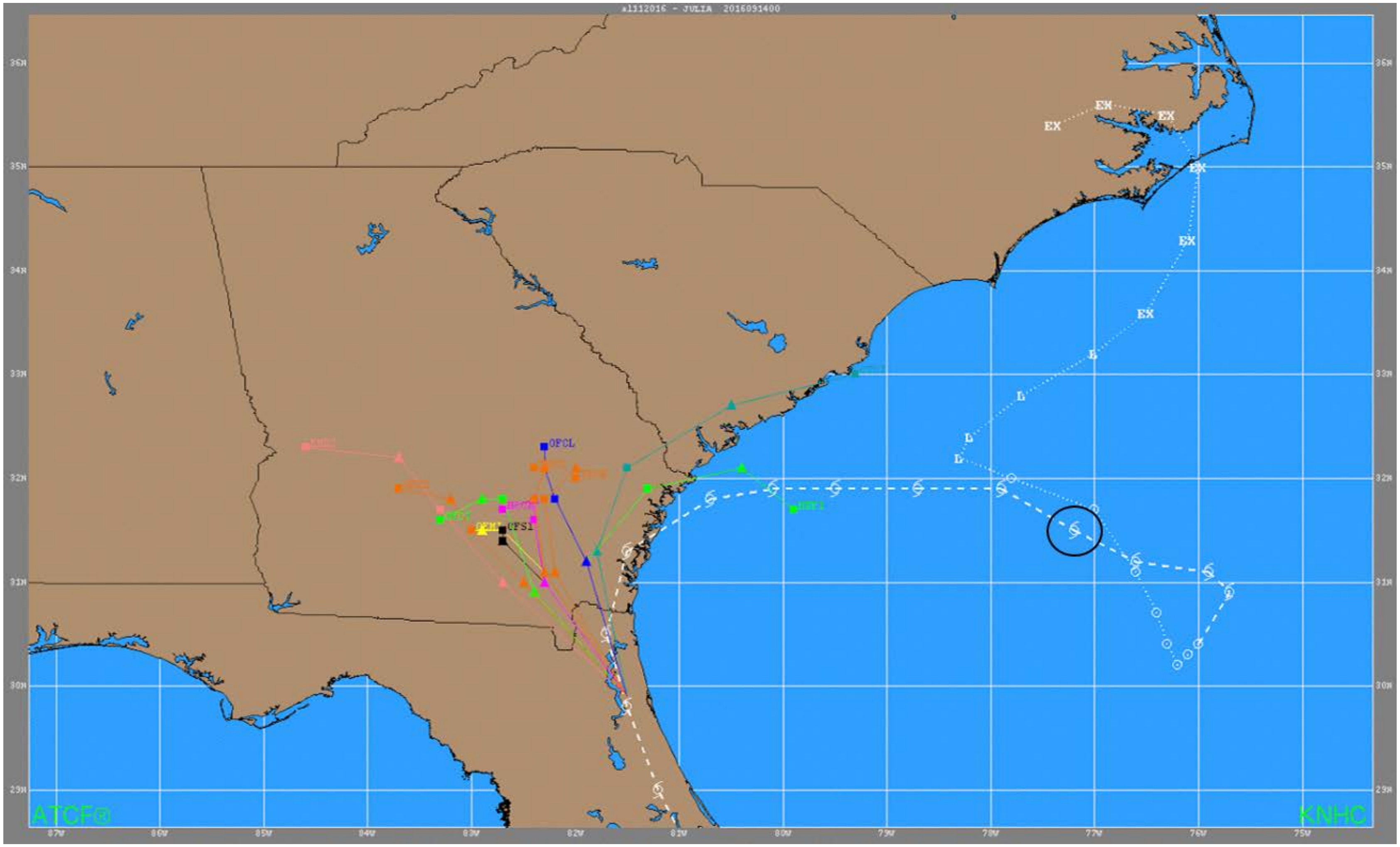

Figure 4. Julia 48-h guidance for the first NHC advisory at synoptic time 14 Sep 0000 UTC, with the verification point circled in black.