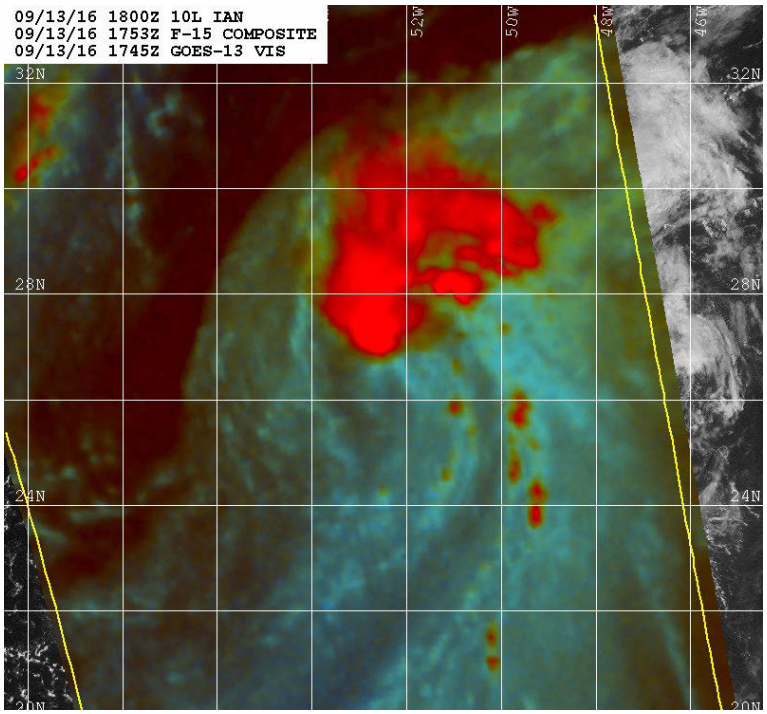
NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

TROPICAL STORM IAN

(AL102016)

12 – 16 September 2016

Lixion. A. Avila[1]
National Hurricane Center
6 June 2019



MICROWAVE IMAGE AT 1753 UTC 13 SEPTEMBER SHOWING THE LOW-LEVEL CENTER OF IAN WELL REMOVED FROM THE CONVECTION. IMAGE COURTESY OF THE NAVAL RESEARCH LABORATORY.

Ian was a sheared cyclone that spent its lifetime over the Atlantic Ocean.

[1] Original report dated 3 January 2017. Updated 6 June 2019 to correct storm location at 0600 UTC 16 September in Table 1.

Tropical Storm Ian

12 – 16 SEPTEMBER 2016

SYNOPTIC HISTORY

Ian originated from a tropical wave that crossed the west coast of Africa on 6 September, accompanied by a large area of cloudiness and thunderstorms that exhibited signs of cyclonic rotation on satellite images. The wave and its associated convective activity continued westward for a few days, and when the wave was reaching 50°W on 10 September, it encountered a broad mid- to upper level trough. A low pressure area was spawned from the wave and then moved northward within the southerly flow ahead of the trough. On 11 September, the low was already producing winds of near tropical storm force, but the system lacked a well-defined center. Late that day there was evidence that a well-defined center had formed, but due to strong southwesterly shear, the convection was well removed to the northeast and north of the center. The organization of the cloud pattern improved when the shear relaxed slightly, and it is estimated that Tropical Storm Ian formed at 0600 UTC 12 September over the open waters of the Atlantic about 990 n mi southeast of Bermuda. The "best track" chart of the tropical 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[2].

Ian moved toward the north-northwest and north between the trough and a subtropical ridge over the eastern Atlantic for a couple of days. Ian then became collocated with the upper-trough, and both the convection and the strongest winds spread out away from the center. With this change in structure, Ian is best classified as a subtropical storm for a short period beginning late on 14 September. Figure 4 shows the subtropical cloud pattern associated with Ian. By 1200 UTC the next day, Ian had turned northeastward away from the trough, and deep convection re-developed near the center. The cyclone reacquired tropical storm status, and it is estimated that Ian reached its peak intensity of 50 kt at 0600 UTC 16 September while it continued to move northeastward within the mid-latitude flow. Ian reached the cooler waters of the North Atlantic and became a strengthening extratropical cyclone 6 h later. It was finally absorbed by a much larger extratropical low at 0600 UTC 17 September.

METEOROLOGICAL STATISTICS

Observations in Tropical Storm Ian (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

[2] 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.

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 Ian.

The estimated peak intensity of Ian was based on ASCAT surface wind data.

CASUALTY AND DAMAGE STATISTICS

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

FORECAST AND WARNING CRITIQUE

The genesis of Ian occurred much later than anticipated, particularly in the long range. The system that became Ian was introduced into the Tropical Weather Outlook (TWO) with a low (< 40%) chance of formation during the next 5 days 162 h before genesis, and it was included in the 48-h TWO 132 h before formation. The probability first reached the high category (> 60% chance of formation) 132 h before genesis in the 5-day TWO, but the genesis was delayed, and the probabilities were lowered to the medium category for about a day and half. The probability reached the high category (> 60% chance of formation) 54 h before formation in the 48-h TWO. All of the genesis forecast lead times are given in Table 2.

A verification of NHC official track forecasts for Tropical Storm Ian is given in Table 3a. Official forecast track errors were higher than the mean official errors for the previous 5-yr period for all forecast periods. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The lowest track errors were produced by the GFS, the GFS ensemble mean (AEMI) and the HCCA models for the three days that Ian existed.

A verification of NHC official intensity forecasts for Tropical Storm Ian is given in Table 4a. Official forecast intensity errors were lower than the mean official errors for the previous 5-yr period. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. Only the ECMWF scored better than the official forecast at most of the forecast periods.

There were no coastal watches and warnings associated with Ian.

Table 1. Best track for Tropical Storm Ian, 12-16 September 2016.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
12/ 0000	20.0	48.5	1007	35	low
12 / 0600	20.5	49.3	1007	35	tropical storm
12 / 1200	21.2	50.2	1006	35	"
12 / 1800	22.2	50.6	1003	35	"
13 / 0000	23.0	51.2	1000	35	"
13 / 0600	23.9	51.7	1000	40	"
13 / 1200	24.8	52.1	999	45	"
13 / 1800	26.0	52.4	998	45	"
14 / 0000	27.3	52.6	998	45	"
14 / 0600	28.9	53.0	998	45	"
14 / 1200	30.5	53.5	998	45	"
14 / 1800	32.1	53.8	998	45	subtropical storm
15 / 0000	33.5	53.5	998	45	"
15 / 0600	34.9	53.0	998	45	"
15 / 1200	36.3	51.5	998	45	tropical storm
15 / 1800	38.3	49.2	998	45	"
16 / 0000	41.2	46.8	998	45	"
16 / 0600	44.0	42.8	994	50	"
16 / 1200	46.8	38.6	990	55	extratropical

16 / 1800	50.4	34.4	985	55	"
17 / 0000	55.1	30.3	984	55	"
17 / 0600					Absorbed by a larger cyclone
16 / 0600	43.2	42.9	994	50	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%)	132	162
Medium (40%-60%)	60	144
High (>60%)	54	132

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Ian. 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	30.2	48.6	65.3	98.0	213.4		
OCD5	62.3	131.7	191.4	317.9	555.7		
Forecasts	14	12	10	8	4		
OFCL (2011-15)	28.4	45.0	60.4	77.1	113.1	157.8	210.0
OCD5 (2011-15)	48.3	101.5	161.5	222.6	329.8	412.6	483.9

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Tropical Storm Ian. 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	27.3	49.2	67.7	101.7	240.2		
OCD5	56.3	133.6	219.6	362.1	740.2		
GFSI	33.9	51.2	**62.5**	**75.6**	**188.2**		
EMXI	28.7	49.8	75.4	107.5	**190.1**		
EGRI	30.8	58.8	95.6	157.3	288.1		
NVGI	39.4	65.7	101.1	180.3	394.1		
CMCI	28.9	50.6	88.1	137.0	**135.5**		
GHMI	31.7	56.8	96.8	175.0	483.1		
HWFI	32.7	55.4	87.2	139.7	335.0		
CTCI	29.4	58.3	105.1	158.7	377.2		
GFNI	28.8	61.0	107.6	180.8	458.1		
TVCA	28.4	**47.5**	78.0	127.1	307.8		
TVCX	29.3	**45.9**	77.1	123.0	291.1		
TCON	28.2	**48.9**	78.5	130.2	321.9		
GFEX	30.2	**41.5**	**56.5**	**74.8**	**185.2**		
FSSE	28.3	**42.7**	**58.0**	**96.7**	260.7		
AEMI	33.2	**48.9**	**63.8**	**82.9**	**228.1**		
BAMM	49.8	88.8	127.3	146.7	311.2		
BAMD	42.8	61.6	70.9	**79.5**	**67.0**		
HCCA	27.9	**42.1**	**56.1**	**80.8**	**196.5**		
Forecasts	10	9	8	6	2		

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Ian. 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	**4.6**	**5.8**	**4.5**	**4.4**	**3.8**		
OCD5	2.7	4.3	5.6	8.0	7.5		
Forecasts	14	12	10	8	4		
OFCL (2011-15)	6.2	9.4	11.5	13.3	14.6	14.6	15.8
OCD5 (2011-15)	7.3	10.8	13.3	15.3	17.7	17.8	17.6

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Tropical Storm Ian. 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	5.0	4.4	5.8	2.5		
OCD5	**2.8**	**4.7**	7.0	9.5	7.5		
DSHP	**4.2**	6.3	7.8	8.0	**2.0**		
LGEM	**3.8**	5.7	6.9	7.3	7.0		
GHMI	5.3	6.9	12.1	10.3	10.5		
CTCI	**3.6**	8.4	10.3	12.5	17.0		
GFNI	7.5	9.6	8.4	8.0	7.5		
ICON	**3.5**	5.3	7.0	7.5	2.5		
IVCN	**3.3**	5.1	7.5	8.0	4.5		
FSSE	**3.8**	7.6	10.9	10.2	2.5		
GFSI	**4.2**	5.8	8.1	7.3	8.5		
EMXI	**3.6**	**2.9**	**4.1**	**4.0**	5.0		
HWFI	**3.2**	**4.6**	7.4	11.7	3.5		
HCCA	**3.3**	**4.7**	6.9	8.3	3.0		
Forecasts	10	9	8	6	2		

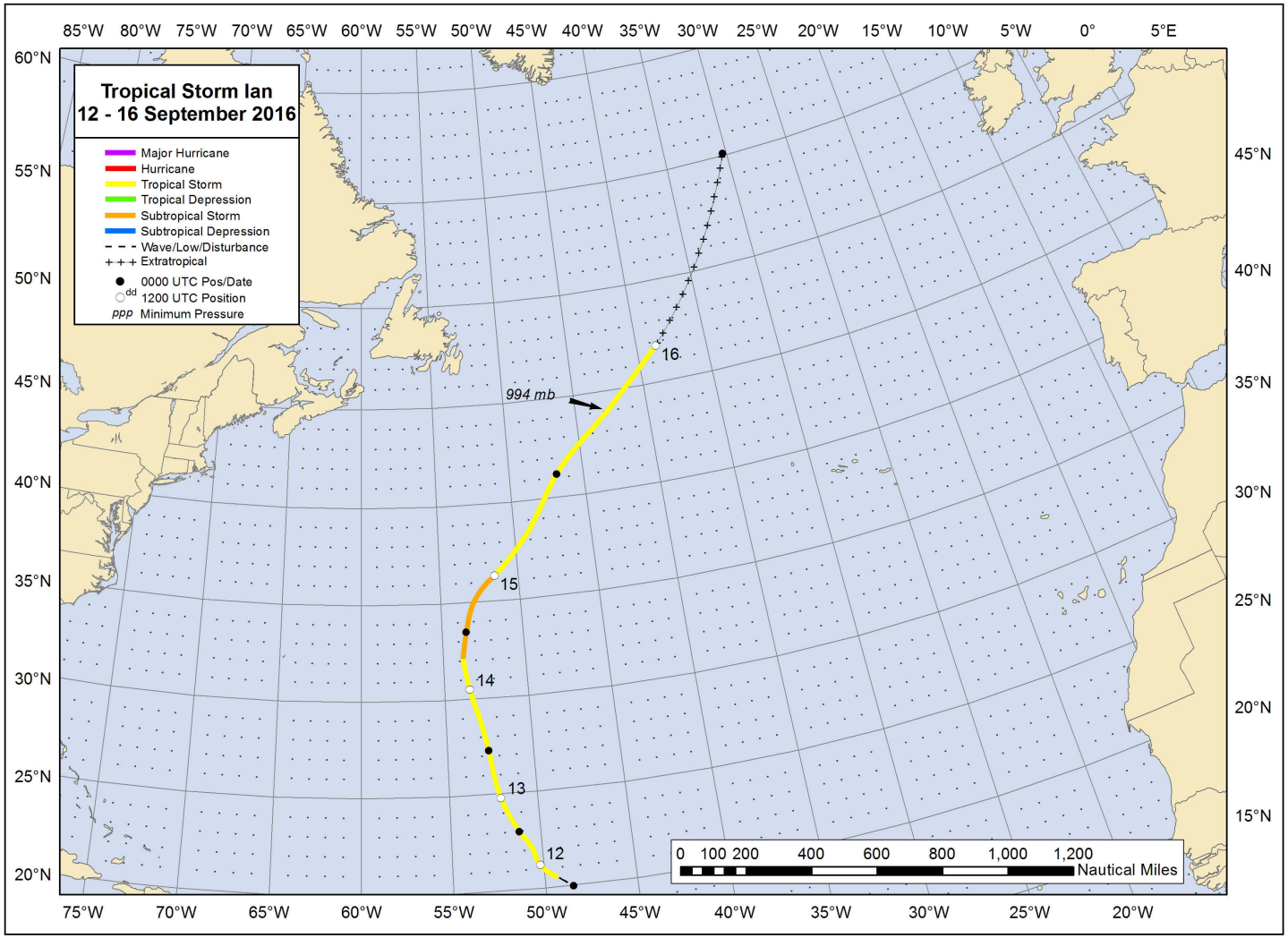


Figure 1. Best track positions for Tropical Storm Ian, 12-16 September 2016. Track during the extratropical stage is partially based on analyses from the NOAA Ocean Prediction Center.

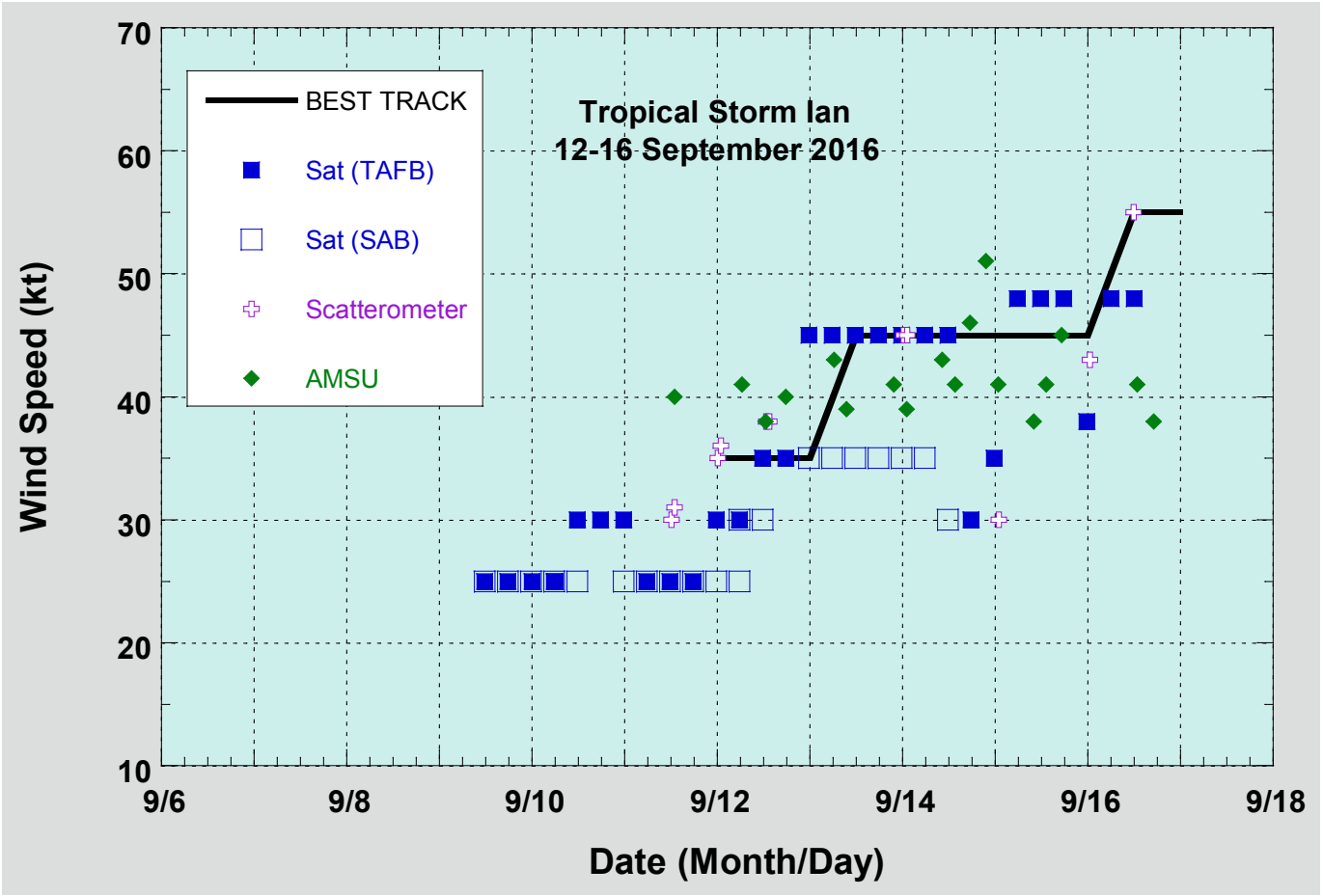


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Ian, 12-16 September 2016. Dashed vertical lines correspond to 0000 UTC.

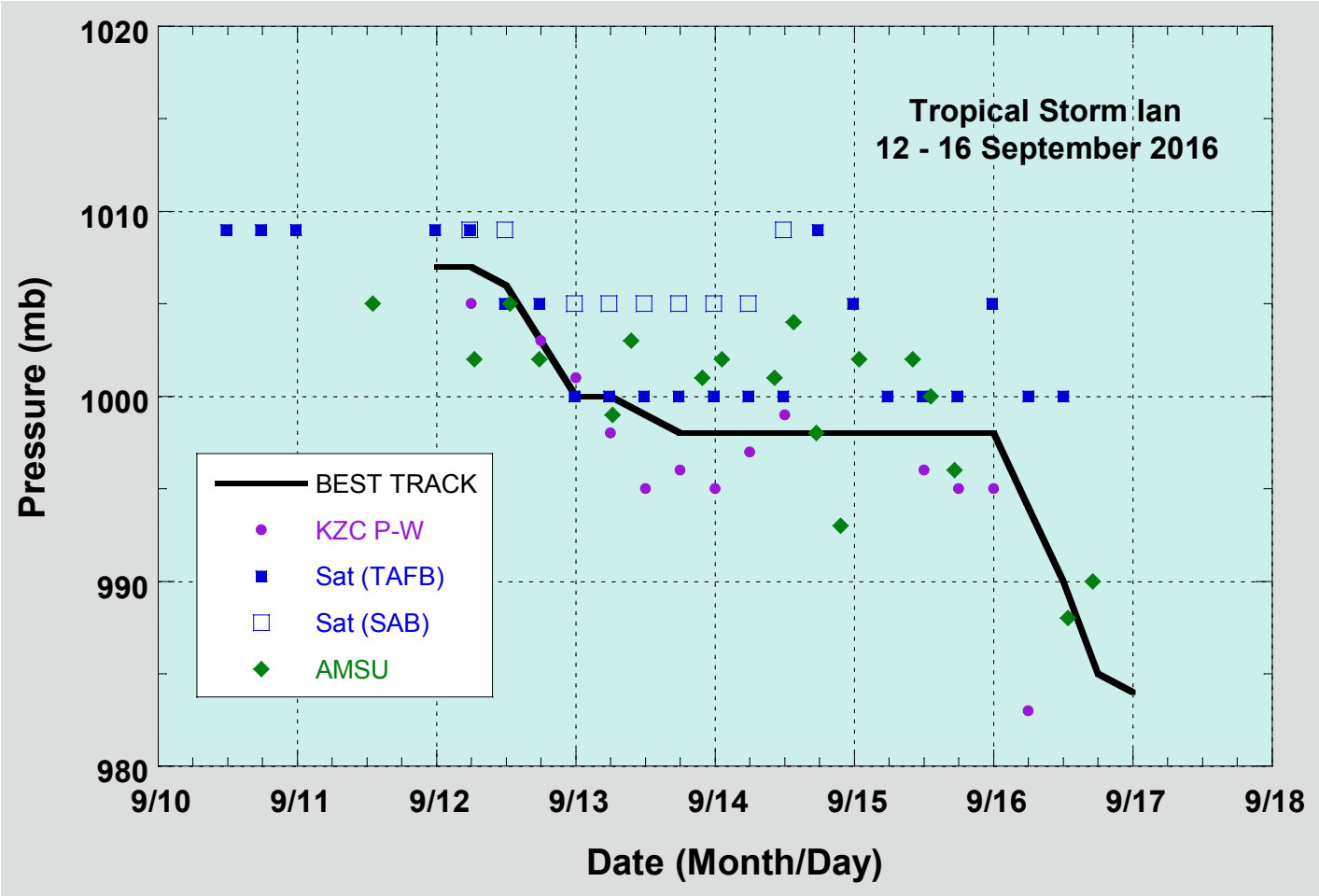


Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Ian, 12-16 September 2016. . AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

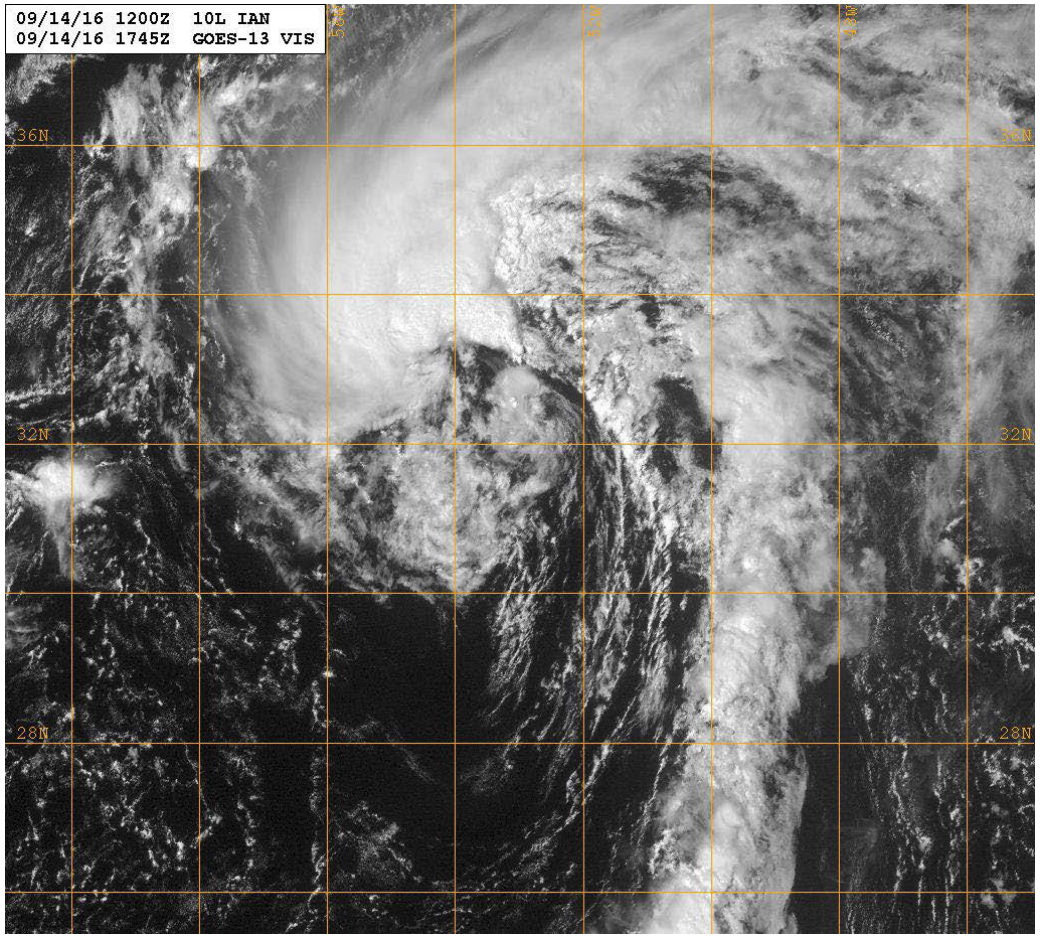


Figure 4. GOES-13 visible satellite image of Ian at 1745 UTC 14 September, near the time Ian acquired subtropical characteristics. Image courtesy of the Naval Research Laboratory.