

Tropical Cyclone Report
Hurricane Juan
24-29 September, 2003

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(Updated damage section)

Juan made landfall near Halifax, Nova Scotia as a category two hurricane on the Saffir-Simpson Hurricane Scale, and will be recorded as one of the most damaging tropical cyclones in modern history for Halifax.

a. Synoptic History

The formation of Hurricane Juan was rather complex. Its origin was a large tropical wave accompanied by a broad area of low pressure that moved off the coast of Africa on 14 September and continued westward over the tropical Atlantic. On 20 September, the shower activity increased significantly but remained disorganized. By then, the wave was located about 600 n mi east of the Lesser Antilles and interacting with the circulation of a large upper-level low. This low was partially associated with the outflow of powerful Hurricane Isabel, then located well to the northwest, and the mid-oceanic upper-level trough. The wave spawned a middle-level circulation that moved northwestward away from the Lesser Antilles around the upper-low and then interacted with a frontal zone. A low-level circulation developed late on the 23rd, but there was not enough organized convection to classify the system as a tropical depression. The disturbance had some extratropical characteristics since it appeared to be attached to the frontal zone. However, it made the transition to a tropical cyclone, when the deep convection increased near the center and the cyclone developed banding features with a distinct outflow. It is estimated that a tropical depression formed at 1200 UTC 24 September, about 300 n mi southeast of Bermuda. The cyclone reached tropical storm status by 0000 UTC September 25. The cloud pattern continued to organize and the cyclone developed an eye, becoming a hurricane by 1200 UTC 26 September.

Juan moved toward the north and then toward the northwest as the subtropical ridge to the northeast of the cyclone briefly expanded westward. The cyclone gradually intensified and reached its maximum intensity of 90 knots, with a minimum pressure of 969 mb, at 1800 UTC 27 September. Juan then turned northward again, with an increase in forward speed, and made landfall near Halifax, Nova Scotia, between Prospect and Peggy's Cove around 0300 UTC 29 September with estimated 1-min sustained winds of 85 knots and a minimum pressure of 973 mb. The cyclone weakened, but it crossed Nova Scotia as a hurricane and retained its tropical characteristics as it moved over Prince Edward Island. It became absorbed by a large extratropical low by 1800 UTC 29 September in the Gulf of St. Lawrence.

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.

b. Meteorological Statistics

Observations in Hurricane Juan (Figs. 2 and 3) primarily consists of satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), the Satellite Analysis Branch (SAB) and the U.S. Air Force Weather Agency (AFWA). Ship and buoy observations and surface reports of winds of tropical storm force or higher associated with Juan are given in Tables 2 and 3, respectively.

A post-analysis of satellite imagery, scatterometer winds, AMSU data, ship and drifting buoy observations indicate that Juan had reached tropical storm strength by 0000 UTC 25 September. Data from a QuikSCAT pass at 0925 UTC 25 September (indicated by an X in Fig.2) suggest that the winds associated with Juan were between 40 and 45 knots. AMSU data were used to classify the cyclone as tropical since it showed a weak warm core at the mid- to upper levels of the cyclone. In addition, as the developing center passed near the drifting buoy 41537, the surface pressure dropped to 992.6 mb at 2000 UTC from 996.6 mb at 1800 UTC. This suggested that Juan had the tight inner core of a tropical cyclone. Operationally, Juan was upgraded to hurricane status based on the development of an eye feature on both visible and infrared satellite imagery, and AMSU data that suggested winds of 66 knots and a minimum pressure of 985 mb. However, because the convection was not very deep at such high latitude, the Dvorak intensity estimates did not support 65 knots at that time (Fig. 2).

The center of Juan passed over a Canadian buoy (44142) between 2300 UTC 28 September and 0000 UTC 29 September, producing a wind change from the east at 54 knots to the southwest at 37 knots. The buoy pressure dropped to 974.7 mb.

The estimated intensity of 85 knots at landfall was primarily based on a report from McNab’s Island, a small piece of land in Halifax Harbor. An anemometer at this location reported 2-min sustained wind of 81 knots. While the instrument is located at 10 m above the surface, the station elevation is 17 m above sea level. It is therefore possible that this measurement may not be fully representative of a surface winds. In addition, there was on an oil rig observation (not included on Table 3) in Halifax Harbor of sustained winds near 99 knot but at an elevation of 62 m. The instrument stopped recording at 99 knots. The intensity at landfall of 85 knots is in agreement with the estimates obtained by meteorologists from the Canadian Hurricane Center (CHC).

It is interesting to note that the wind field associated with Juan was not symmetric, probably because the transition to extratropical was beginning to take place. Wind reports provided by CHC indicate that wind gusts west of the track of Juan were half values of those to the right of its track. Radar observations from Halifax indicate that the eye diameter at landfall was 18 n mi.

c. Casualty and Damage Statistics

The last time that the city of Halifax was hit by the eyewall of a hurricane was 22 August, 1893. Juan will be recorded as one of the most damaging tropical cyclones in modern history for Halifax, N.S. Damage included widespread falling trees, power outages and damaged homes. Hundreds of thousands of Maritimers in Nova Scotia and Prince Edward Island lost power. There were four direct deaths (two inland and two marine) associated with Juan. In addition, four indirect deaths occurred in the aftermath. Halifax Harbor recorded an all time record water level of 4.9 feet above the normal tide levels, which resulted in extensive flooding of the Halifax and Dartmouth waterfront properties. The building where the CHC is located was also damaged.

d. Forecast and Warning Critique

The average official track errors for Juan were 38, 63, 87, 108, 61 and 129 n mi for the 12, 24, 36, 48, 72 and 96 h forecasts, respectively¹. Juan did not last long enough to verify any 120-h forecasts. These errors are much lower than the average official track errors for the 10-yr period 1993-2002² of 45, 81, 116, 150, 225 and 282 n mi, respectively. Table 4 includes a summary of track guidance during Juan.

Average official intensity errors were 8, 13, 16, 20, 20 and 10 kt for the 12, 24, 36, 48, 72 and 96 h forecasts, respectively. The intensity errors were a bit higher than the average official intensity errors over the 10-yr period 1993-2002² of 6, 10, 13, 15, 19 and 21 kt, respectively.

It is rather difficult to determine accurately if a cyclone is tropical, subtropical or extratropical when characteristics of these various cyclone types are present, and Juan was no exception. The decision to classify the cyclone tropical was heavily based on AMSU data which showed a weak warm core at the mid- to upper levels of the cyclone. Advisories on the tropical depression were initiated on 25 September. Operationally, there was not enough evidence of a closed circulation and organization to start advisories on the 24th. However, a post-analysis using scatterometer data from 0925 UTC 25 September, suggested that Juan had a well-defined closed circulation at that time. This data has led us to assume that there was enough circulation for Juan to be classified as a tropical depression on the 24th, as indicated in the best track

Juan was forecast to reach Nova Scotia as a 65- to 70-kt hurricane. However, it did so with 85 knots. The fact that Juan maintained its tropical characteristics longer than anticipated continues to reflect the uncertainties and the limited skill in predicting the timing of the extratropical transition. Historically, most of the tropical cyclones affecting Nova Scotia are in their transition to an extratropical low. It was stated in the tropical cyclone discussions from the time of Juan's formation

¹ All forecast verifications in this report include the depression stage of the cyclone. National Hurricane Center verifications presented in these reports prior to 2003 did not include the depression stage.

² Errors given for the 96 h period are averaged over the two-year period 2001-2002.

that the cyclone would likely retain its tropical characteristics at landfall. This was because Juan was forecast to spend little time over cool waters as it moved rapidly toward Nova Scotia .

A tropical storm warning was issued for Bermuda at 21,00 UTC 25 September and was discontinued at 1800 UTC 26 September. The CHC does not issue coastal hurricane warnings. Instead, a rain and high wind warning was issued for portions of Nova Scotia, Prince Edward Island and the marine areas.

Acknowledgments:

Most of the data and damage reports have been provided by meteorologists from the Canadian Hurricane center. A more detailed of the local effects in Nova Scotia can be found the web page of the Environment Canada Hurricane Center at: http://www.atl.ec.gc.ca/weather/hurricane/index_e.html

Table 1. Best track for Hurricane Juan, 24-29 September 2003.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
24 / 1200	28.2	62.4	1009	25	tropical depression
24 / 1800	28.3	62.2	1007	30	"
25 / 0000	28.4	62.0	1006	35	tropical storm
25 / 0600	28.8	61.7	1002	40	"
25 / 1200	29.2	61.4	1000	45	"
25 / 1800	30.4	61.6	996	50	"
26 / 0000	30.9	61.8	992	55	"
26 / 0600	31.1	61.8	990	60	"
26 / 1200	31.8	62.0	987	65	hurricane
26 / 1800	32.5	62.0	987	70	"
27 / 0000	33.3	62.0	984	75	"
27 / 0600	34.4	62.2	981	75	"
27 / 1200	35.2	62.8	979	75	"
27 / 1800	35.5	63.2	969	90	"
28 / 0000	36.3	63.6	970	90	"
28 / 0600	37.1	64.0	970	90	"
28 / 1200	38.5	64.1	970	90	"
28 / 1800	40.2	64.1	970	90	"
29 / 0000	42.8	63.9	972	85	"
29 / 0600	46.0	63.8	982	65	"
29 / 1200	49.8	62.4	995	45	tropical storm
29 / 1800					absorbed
27 / 1800	35.5	63.2	969	90	minimum pressure
29 / 0300	44.4	63.8	973	85	landfall near Halifax, Nova Scotia

Table 2. Selected ship and buoy reports with winds of at least 34 kt for Hurricane Juan, 24-29 September 2003.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
24 / 2110	41537	30.3	61.5	*** / 47	1014.9
25 / 0310	41537	30.3	61.5	*** / 43	1014.8
25 / 0410	41537	30.3	61.5		1014.3
25 / 0810	41537	30.4	61.6	*** / 51	1011.4
25 / 1510	41537	30.4	61.6	*** / 52	007.9
28 / 1800	WCY533	43.8	60.3	120 / 36	1019.2
28 / 2100	WCY533	43.8	60.3	120 / 38	1017.2
28 / 2200	44137	42.3	62.0	130 / 35	1009.2
28 / 2200	44142	42.5	64.0	080 / 41	995.8
28 / 2300	44137	42.3	62.0	130 / 35	1007.9
28 / 2300	44142	42.5	64.0	090 / 54	981.0
29 / 0000	WCY533	43.8	60.3	120 / 45	1015.2
29 / 0000	44137	42.3	62.0	150 / 41	1008.3
29 / 0000	44142	42.5	64.0	210 / 37	974.7
29 / 0100	44137	42.3	62.0	170 / 37	1009.8
29 / 0100	44142	42.5	64.0	220 / 37	993.3
29 / 0200	44258	44.5	63.4	070 / 39	1000.8
29 / 0300	VOCJ	44.7	63.6	130 / 49	982.9
29 / 0300	44258	44.5	63.4	100 / 47	
29 / 0400	VOCJ	44.7	63.6	160 / 48	981.1
29 / 0600	VOGT	46.1	61.5	130 / 60	1006.5

Table 3. Selected surface observations for Hurricane Juan, 24-29 September, 2003

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft) ^c	Storm tide (ft) ^d	Total rain (in)
	Date/time (UTC)	Press. (mb)	Date/time (UTC) ^a	Sustained (kt) ^b	Gust (kt)			
Canada								
<i>Nova Scotia</i>								
Shearwater	29/0400	987.5	29/0349	54	70	4.9	9.5	2.20
McNabs's Island	29/0400	982.1	29/0324	81	95			
Halifax Int. Air	29/0400	987.4	29/0404	54	77			2.90
Beaver Island	29/0440	998.3	29/0440	55	71			
Lunenburg	29/0400	990.2	29/0200	36	57			
Caribou Point	29/0546	996.3	29/0546	46	64			0.70
Confederation Bridge	29/0600	984.9	29/0600	60	74			
Hart Island, NS	29/0600	1010.1	29/0640	46				
CHC (West of CYAW)	29/0310	984.3						3.40
<i>Prince Edward Island</i>								
North Cape	29/0800	989.6	29/0700	37	48			
Charlottetown	29/0700	991.2	29/0617	50		4.1	9.6	0.80
East Point	29/0700	1000.8	29/0700	36	52			0.25
Iles de la Madeleine	29/0800	1000.6	29/0900	40	58			

^a Date/time is for sustained wind when both sustained and gust are listed.

^b reports is 2- min sustained.

^c Storm surge is water height above normal astronomical tide level.

^d Storm tide is water height above National Geodetic Vertical Datum (1929 mean sea level).

Table 4. Preliminary forecast evaluation (heterogeneous sample) for Hurricane Juan, 24-29 September. Forecast errors (n mi) are followed by the number of forecasts in parentheses. Errors smaller than the NHC official forecast are shown in bold-face type. Verification includes the depression stage, but does not include the extratropical stage.

Forecast Technique	Forecast Period (h)						
	12	24	36	48	72	96	120
CLP5	67 (16)	165 (14)	255 (12)	330 (10)	532 (6)	746 (2)	
GFNI	30 (10)	64 (10)	109 (9)	157 (7)	133 (3)		
GFDI	31 (12)	49 (12)	63 (10)	83 (8)	105 (4)	146 (1)	
GFDL	31 (15)	47 (13)	51 (11)	59 (9)	74 (5)	165 (1)	
GFDN	33 (7)	48 (6)	67 (5)	125 (4)	81 (2)		
LBAR	39 (16)	78 (14)	91 (12)	98 (10)	200 (6)	608 (2)	
AVNI	33 (12)	48 (11)	52 (9)	70 (7)	95 (3)		
AVNO	47 (14)	58 (12)	58 (10)	54 (8)	87 (4)		
AEMI	42 (7)	81 (7)	89 (6)	240 (4)	429 (2)	857 (1)	
BAMD	44 (16)	72 (14)	87 (12)	88 (10)	107 (6)	218 (2)	
BAMM	40 (16)	66 (14)	72 (12)	76 (10)	177 (6)	343 (2)	
BAMS	45 (16)	80 (14)	101 (12)	140 (10)	264 (6)	469 (2)	
NGPI	28 (13)	67 (11)	110 (9)	125 (7)	155 (3)		
NGPS	29 (14)	49 (12)	84 (10)	111 (8)	99 (4)		
UKMI	44 (12)	90 (12)	148 (10)	188 (8)	336 (4)		
UKM	88 (8)	123 (7)	137 (6)	198 (4)	247 (3)	1021 (1)	
A98E	47 (16)	91 (14)	88 (12)	88 (10)	147 (6)	485 (2)	
A9UK	41 (9)	91 (8)	115 (7)	146 (6)	260 (4)		
GUNS	29 (11)	60 (11)	98 (9)	120 (7)	109 (3)		
GUNA	27 (11)	49 (11)	81 (9)	92 (7)	75 (3)		
OFCL	38 (15)	63 (13)	87 (11)	108 (9)	61 (5)	229 (1)	
NHC Official (1993-2002 mean)	45 (2985)	81 (2726)	116 (2481)	150 (2230)	225 (1819)	282 (265)	

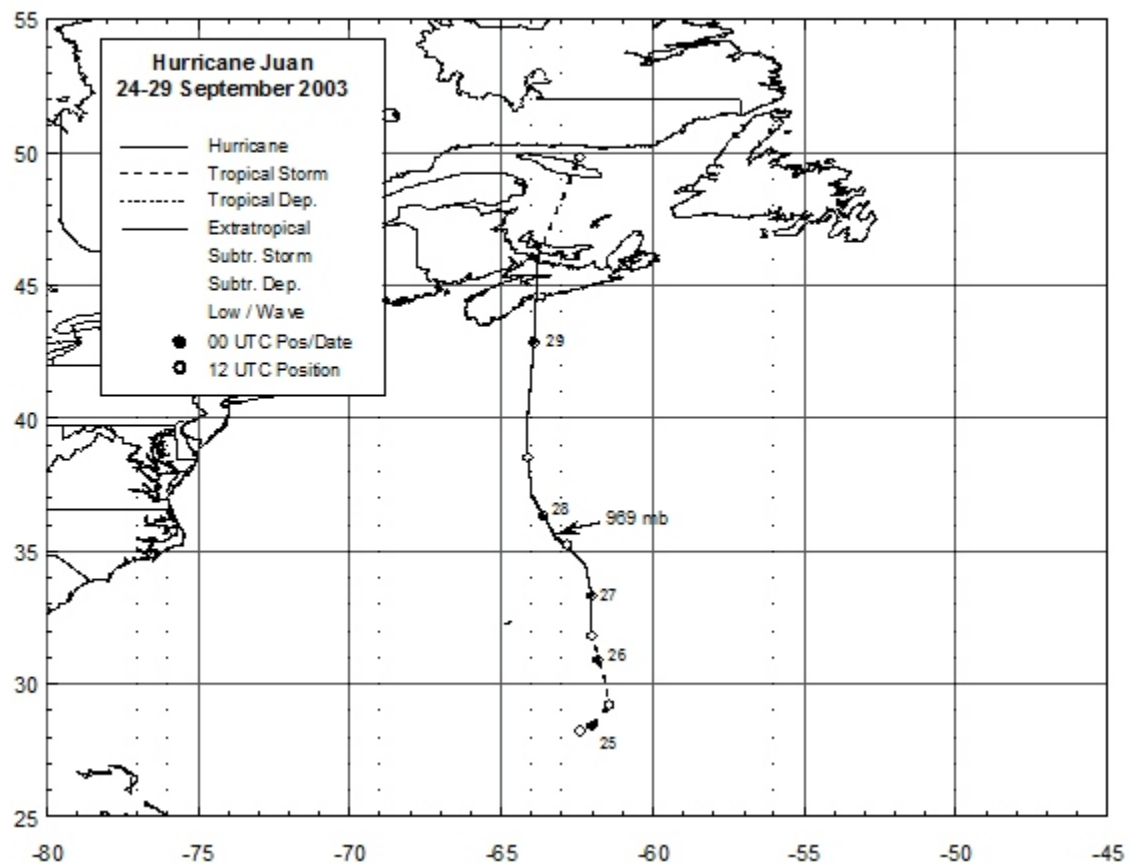


Figure 1. Best track positions for Hurricane Juan, 24-29 September, 2003. Track after landfall was based on analyses from the Canadian Hurricane Center.

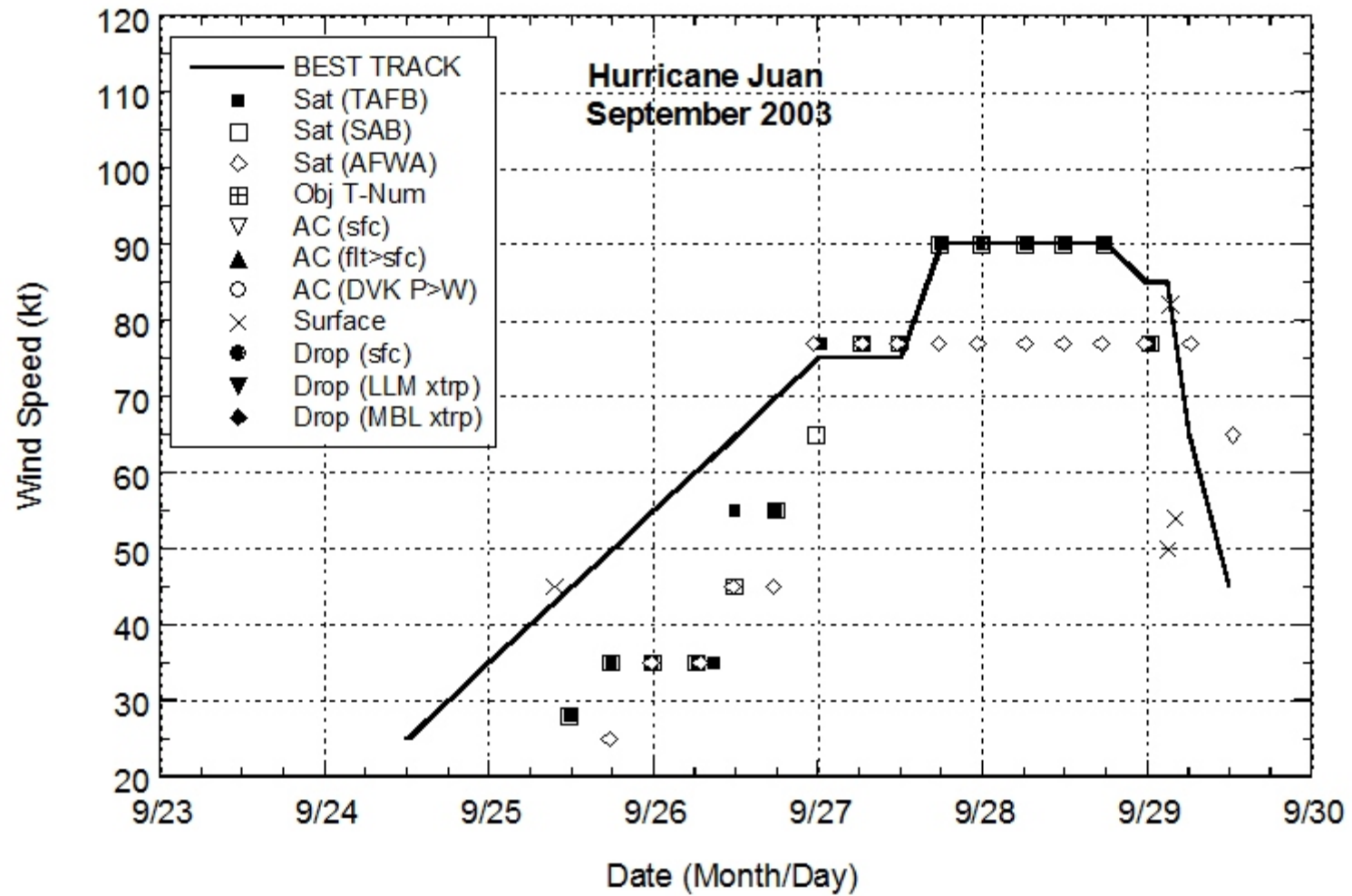


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Juan, 24-29 September, 2003.

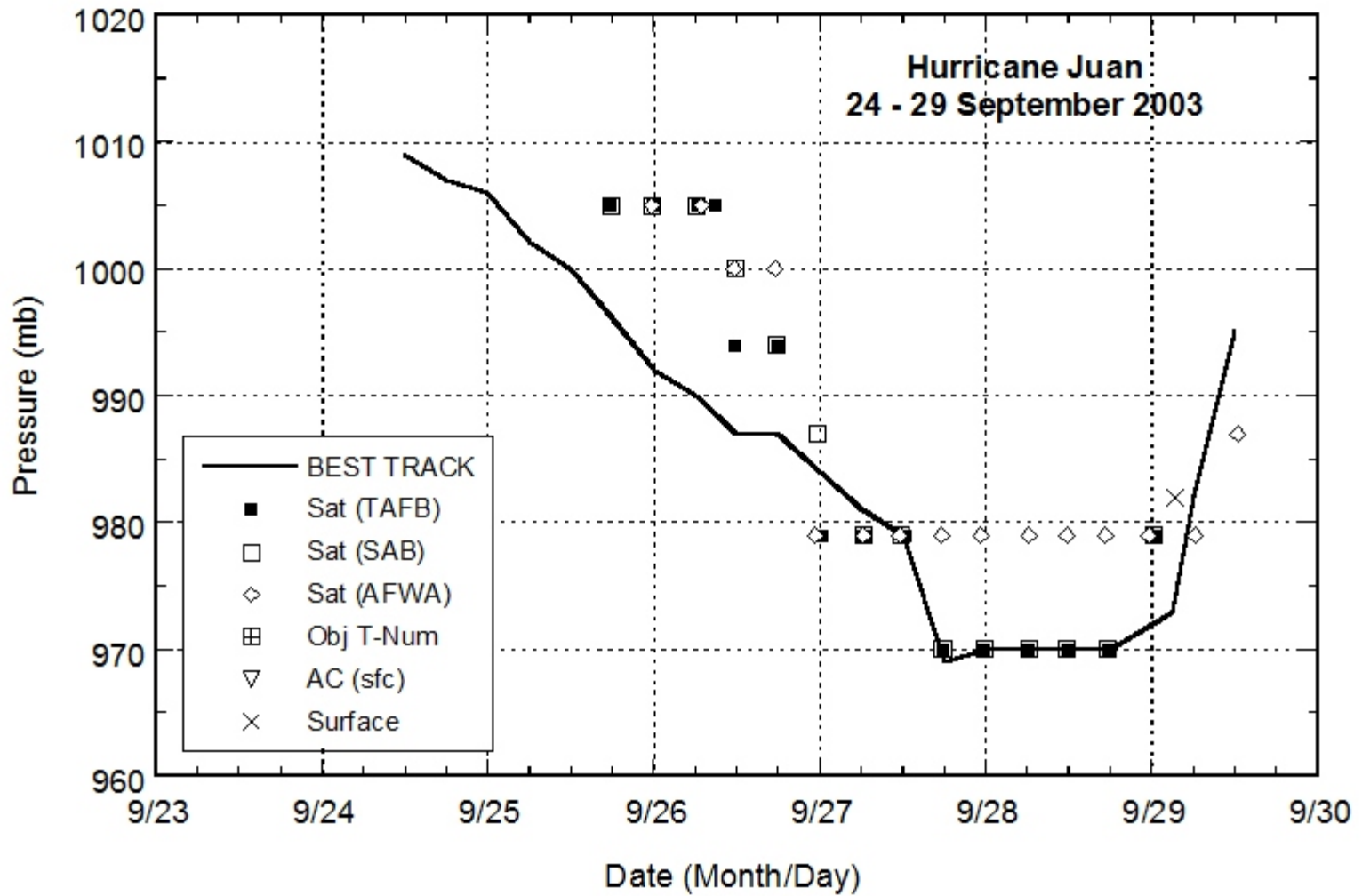


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Juan, 24-29 September, 2003.