

Preliminary Report
Hurricane Ivan
19-27 September 1998

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a. Synoptic History

Hurricane Ivan was the first in a trio of hurricanes to form and then remain over the eastern Atlantic Ocean during the latter part of September. The wave from which Ivan developed was rather easily identified by its concentrated area of thunderstorms seen on satellite pictures (not shown) over western Africa near the Greenwich Meridian on 14 September. Although deep convection diminished when the wave neared the coast, the residual cloudiness and sounding data up through 700 mb from Dakar, Senegal showed the system's passage into the Atlantic on the 16th.

Strong convection associated with the wave redeveloped to the south of the Cape Verde Islands on the 17th. Position estimates from satellite analysts began that day. The cloudiness became more concentrated near the apex of the wave on the 18th. Late that day, Dvorak T-numbers first reached 2.0 from the NOAA TPC Tropical Analysis and Forecast Branch (TAFB) and 1.5 from the NOAA Synoptic Analysis Branch (SAB). Slow development followed and it is estimated that the system became a tropical depression near 0000 UTC on the 19th, about 175 n mi to the southwest of the Cape Verde Islands (Fig. 1 and Table 1).

The tropical cyclone was influenced by mid- to upper-level cyclonic flow centered to its northwest, over the central Atlantic. At first, that pattern consisted of a trough elongated southward from 30°N. During Ivan's development, however, water vapor imagery showed the trough become a closed circulation that partially enveloped the tropical cyclone. A second trough later affected Ivan as well. These features influenced the details of Ivan's track (see Fig. 1), which was generally northwestward at 10-15 kt from the 20th-25th.

The troughs also created an environment of vertical shear that led to Ivan's rather slow development (Table 1). Ivan became a tropical storm late on the 20th and during the following 48 hours wind speeds increased to around 55 kt as estimated from the appearance of what could have been an eye on satellite pictures for about an hour.

Ivan's hurricane stage occurred rather far to the north. At 1400 UTC on the 23rd, the eye reappeared and was more prominent than earlier, indicating that Ivan was becoming a hurricane as it neared 30°N. After again disappearing, the eye became its most

distinct with a diameter of about 20 n mi, and Ivan is estimated to have reached its peak intensity of about 80 kt on the morning of the 26th. The hurricane was then located about 300 n mi to the west of the Azores Islands. At that time, the influence of the upper troughs on Ivan was decreasing and the track of the hurricane was increasingly controlled by the westerlies just to the north. Late on the 26th, the eye disappeared. The inner convective structure rapidly deteriorated while Ivan passed eastward over cooler waters to the north of the Azores Islands on the 27th. Ivan was then becoming a weakening extratropical storm, and then gale, which moved northeastward according to analyses issued in the United Kingdom.

b. Meteorological Statistics

The "best track" intensity was obtained from the data presented in Figs. 2 and 3. Those figures show Ivan's estimated central pressure and maximum one-minute wind speed, respectively, versus time. Position and intensity estimates were obtained from analyses of satellite pictures by the SAB and TAFB, and by the Air Force Weather Agency (AFGWC in figures). Analyses also included surface observations.

There were no reports of tropical storm force winds on land. The ships listed below reported sustained tropical storm force winds. The reports of northerly or northwesterly winds of 35-38 kt from the ship DACF near 16°N 25°W on 19 September do not seem compatible with other ship reports in that vicinity, or with the analysis of the cyclone--centered a few hundred nautical miles to the southwest at that time. In addition, the speeds shown for ship PJOX at 23/1800 UTC and 24/0300 UTC are probably double the actual winds based on analysis of data by the NWS Marine Prediction Center.

Date/time (UTC)	Ship Id	Lat.(N)	Lon.(W)	Wind (kt)
19/1000	DACF	17.2	25.4	360/35
19/1200	DACF	16.6	25.6	340/37
19/1300	DACF	16.3	25.7	360/38
19/1500	DACF	15.7	26.0	350/38
19/1600	DACF	15.4	26.1	330/37
22/0600	9HPM3	22.5	35.0	110/35
23/0600	PJOX	31.0	35.4	110/35
23/1200	ELBX4	31.4	35.6	100/35
23/1800	PJOX	30.8	39.6	090/76
24/0300	PJOX	29.4	41.8	220/89
24/0600	PJOX	28.9	42.8	220/43

c. Casualty and Damage Statistics

Ivan is not known to have caused casualties or damages.

d. Forecast and Warning Critique

The average NHC track forecast errors were about 20% larger than the most-recent 10-year averages, but were comparable in magnitude to most of the numerical model guidance (Table 2). The best performance came from the NOGAPS model.

The NHC generally forecast an intensity for Ivan that was too low by about 10 kt at 24 hours and 20 kt at 72 hours.

Watches and warnings were not issued for Ivan, but NHC advisories did indicate the possibility that tropical storm or hurricane force winds could spread over the Azores.

Table 1. Preliminary best track, Hurricane Ivan, 19-27 Sept. 1998.
 revised extratropical stage 1/22/99

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
19/0000	13.4	26.6	1010	25	Tropical Dep.
0600	13.1	27.5	1010	25	" "
1200	12.9	28.2	1010	25	" "
1800	13.1	29.0	1010	25	" "
20/0000	13.4	29.6	1009	30	" "
0600	14.3	30.6	1009	30	" "
1200	15.2	31.5	1008	30	" "
1800	16.0	32.6	1006	35	Tropical Storm
21/0000	16.8	33.7	1005	35	" "
0600	17.4	34.9	1003	35	" "
1200	18.2	35.6	1003	35	" "
1800	19.0	36.0	1002	40	" "
22/0000	20.0	36.1	1001	40	" "
0600	21.3	36.1	1000	45	" "
1200	22.9	36.4	997	45	" "
1800	24.2	37.1	994	55	" "
23/0000	25.6	37.7	996	50	" "
0600	26.9	38.4	997	45	" "
1200	28.3	39.2	990	55	" "
1800	29.6	40.2	987	65	Hurricane
24/0000	30.5	40.9	986	65	" "
0600	31.3	41.6	985	70	" "
1200	32.3	42.0	985	70	" "
1800	33.4	42.3	985	70	" "
25/0000	34.4	42.3	984	70	" "
0600	35.3	41.9	984	70	" "
1200	36.3	41.3	984	70	" "
1800	37.2	40.2	983	75	" "
26/0000	38.1	38.7	980	75	" "
0600	39.2	36.3	975	80	" "
1200	40.1	33.1	977	75	" "
1800	40.7	29.7	982	75	" "
27/0000	40.7	25.7	994	60	Tropical Storm
0600	40.9	22.7	997	50	Extratropical
1200	41.3	19.2	1000	45	" "
1800	41.5	15.5	1002	40	" "
26/0600	39.2	36.3	975	80	Minimum Pressure

**Table 2. Preliminary forecast evaluation of Hurricane Ivan--
Heterogeneous sample**

(Errors in nautical miles for tropical storm
and hurricane stages with number
of forecasts in parenthesis)

Technique	Period (hours)				
	12	24	36	48	72
CLIP	79 (24)	155 (22)	230 (20)	285 (18)	348 (14)
GFDI	87 (17)	179 (15)	282 (13)	315 (11)	461 (9)
GFDL*	84 (9)	154 (8)	240 (7)	278 (5)	312 (5)
NGPS*	81 (11)	114 (11)	151 (10)	175 (9)	229 (5)
NGPI	58 (22)	99 (20)	133 (18)	159 (16)	246 (8)
LBAR	64 (24)	118 (22)	182 (20)	250 (18)	434 (14)
AVNI	122(20)	252 (18)	345 (15)	431 (13)	589 (10)
BAMD	61 (24)	125 (22)	207 (20)	304 (18)	544 (14)
BAMM	67 (24)	130 (22)	203 (20)	277 (18)	441 (14)
BAMS	81 (24)	162 (22)	241 (20)	291 (18)	391 (14)
A90E	70 (24)	124 (22)	198 (20)	294 (18)	501 (14)
UKMI	63 (23)	105 (22)	149 (20)	189 (18)	298 (12)
A9UK	63 (11)	109 (10)	165 (9)	222 (8)	328 (7)
NHC OFFICIAL	53 (24)	114 (22)	179(20)	241(18)	305(14)
NHC OFFICIAL (1988-1997 10- year average)	47 (1838)	88 (1633)	127 (1449)	165 (1006)	248 (1006)

* Output not available until after forecast issued.

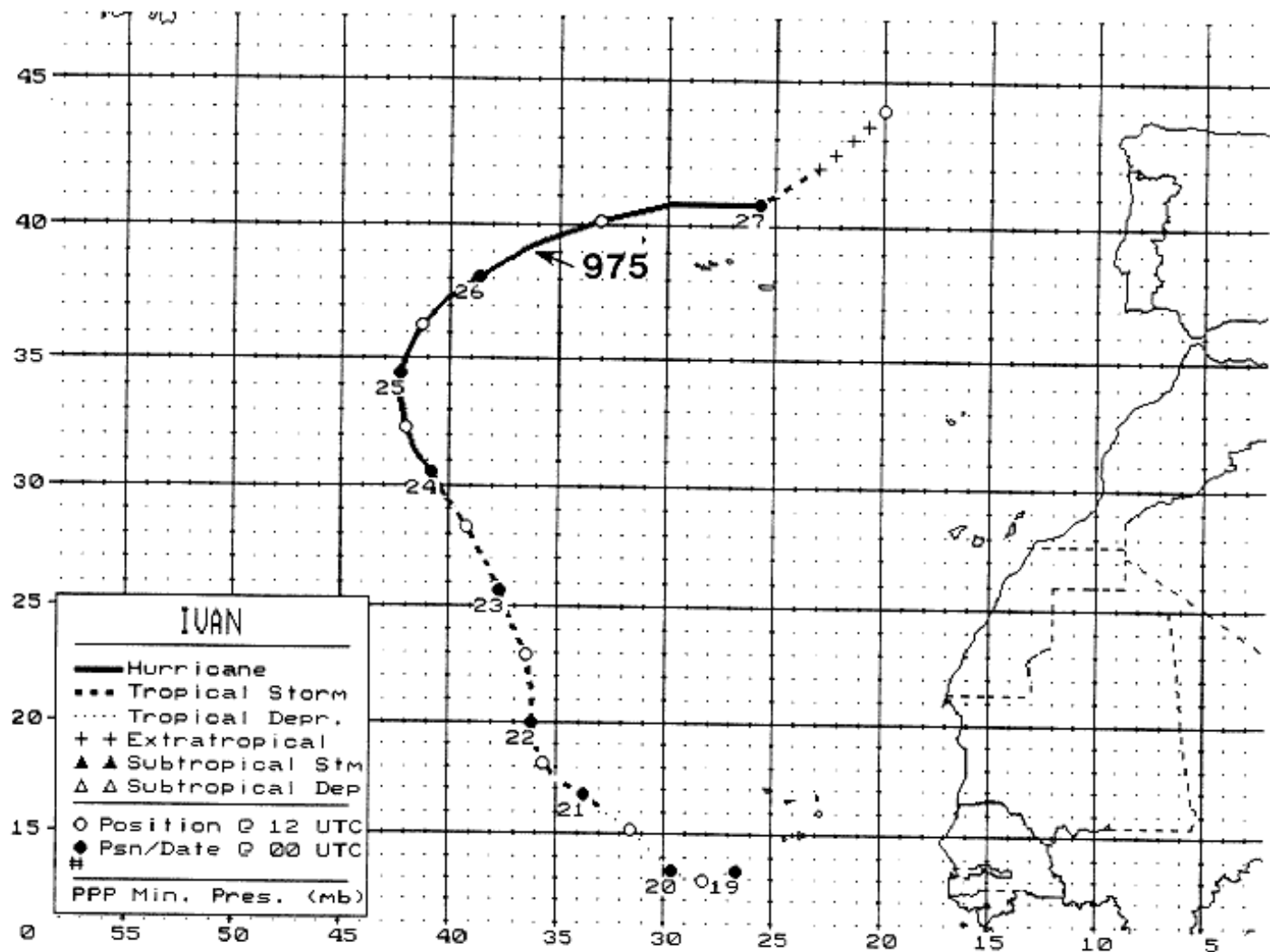


Figure 1. Best track positions for Hurricane Ivan.

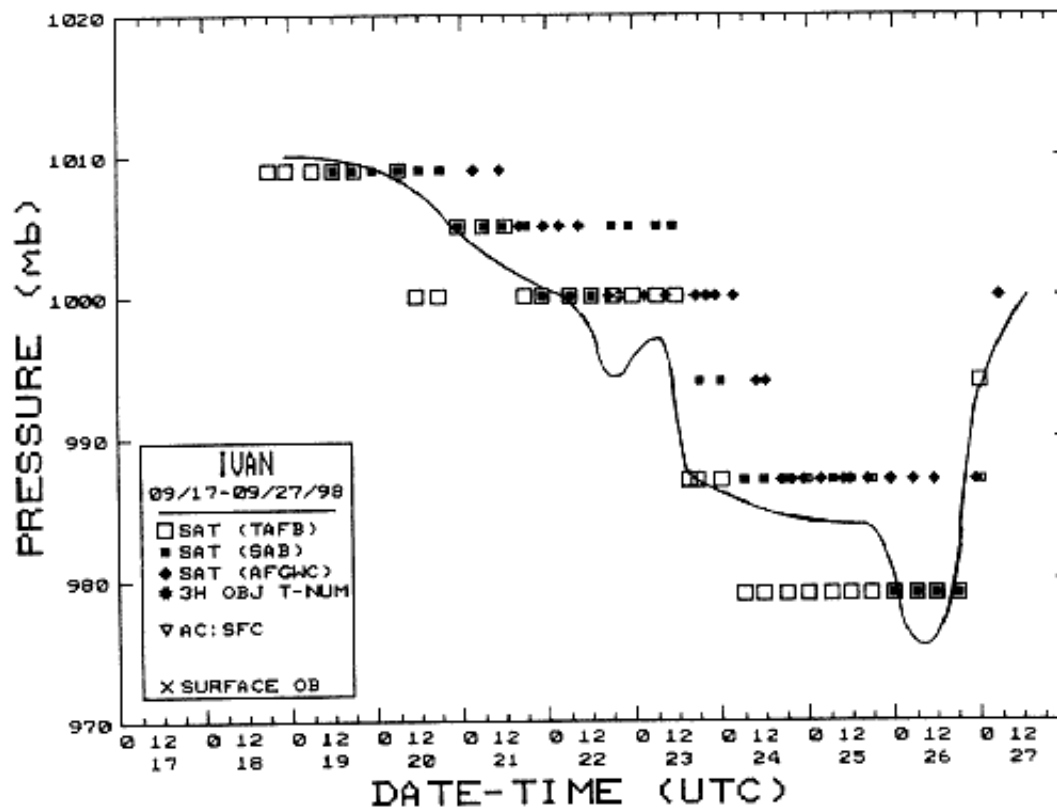


Figure 2. Best track central pressure curve for Hurricane Ivan, September 1998.

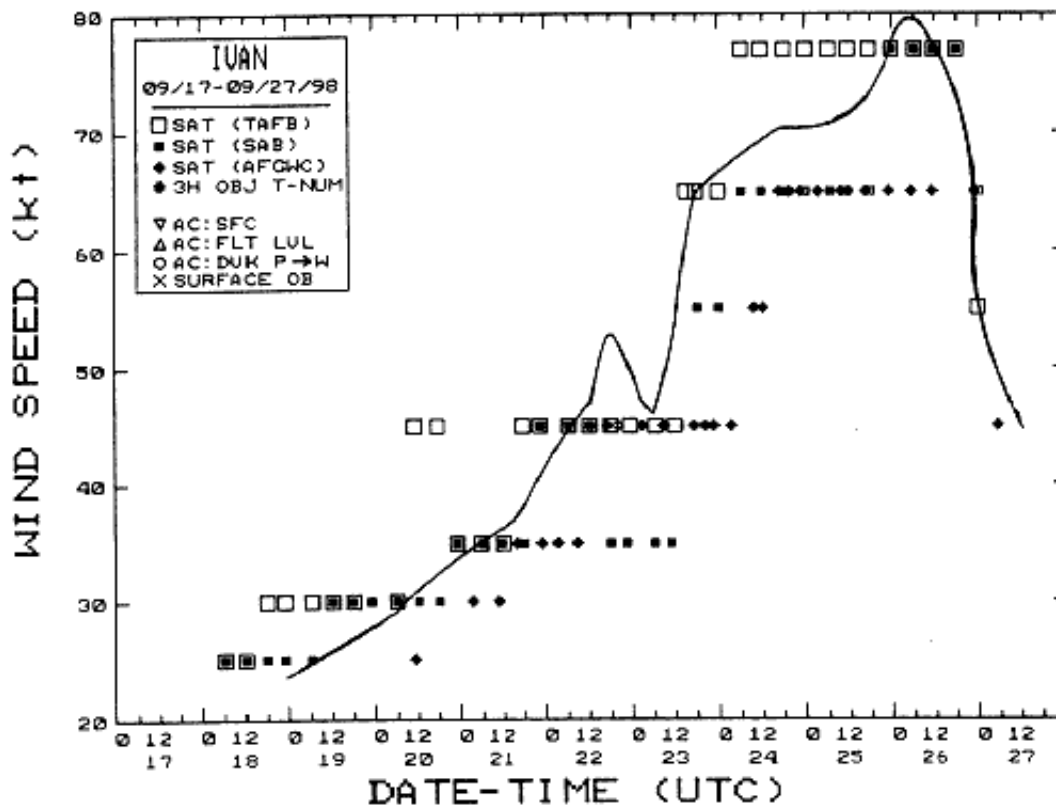


Figure 3. Best track maximum one-minute wind speed curve for Hurricane Ivan, September 1998.