PRELIMINARY REPORT
Hurricane Roxanne
7 - 21 October 1995

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Roxanne was the first October hurricane that formed and reached Category 3 intensity on the Saffir/Simpson Hurricane Scale (SSHS) in the western Caribbean Sea since Hurricane Hattie (Category 4) in October 1961. After hitting the Yucatan peninsula, Roxanne meandered in the Bay of Campeche for several days causing death and destruction along the coast of Mexico from the States of Yucatan through Campeche and Tabasco.

a. Synoptic History

Roxanne formed from a complex combination of several synoptic-scale features (a broad low-pressure area, a tropical wave and an upper trough) which interacted over the western Caribbean. Formation of tropical cyclones from this combination has been commonly observed in the western Caribbean during previous decades, (e.g., 1930, 1940).

As early as 6 October, radiosonde data from the western Caribbean indicated a broad well-established low- to middle- level cyclonic circulation with cloudiness and showers between the Cayman Islands and Honduras. A distinct tropical wave, tracked from the coast of Africa on 26 September, became convectively active over the central Caribbean on 4 October. The wave reached the western Caribbean early on the 7th and interacted with the pre-existing area of disturbed weather. A slow-westward moving upper-level trough was at that time located over the Windward Passage, to the east of an upper-level anticyclone centered over the southeastern Gulf of Mexico and left by Hurricane Opal. This combination of the high and the trough aloft resulted in diffluent northerly winds over the low-level disturbance. Dunn (1960) and Riehl (1951) recognized this pattern as favorable for the development of incipient disturbances by. The 200 and 850 mb data for 1200 UTC 6 October and the schematic pattern suggested by Dunn are displayed in Fig. 1. Note that the prevailing meteorological conditions on that day were similar to those suggested in Fig. 1c.

On 6 October, the National Hurricane Center (NHC) surface analysis showed a broad 1004 mb low not too far from the east coast of Nicaragua. Associated winds were only 10 to 15 knots. Satellite images indicated a gradual increase in organization and cloud banding features began to develop early on the 7th as the tropical wave reached the area. It is estimated that the system became a tropical depression at 1800 UTC 7 October just east of Nicaragua. The next day, a reconnaissance plane confirmed the presence of a tropical depression with a pressure center of 1004 mb and 30 knot

winds. Satellite images and surface observations indicated a steady intensification. The depression became Tropical Storm Roxanne at 0000 UTC 9 October and a hurricane by 0600 on the 10th. During that period, data from reconnaissance planes indicated that the pressure dropped to 989 mb and by 1200 UTC on the 10th the pressure was down to 972 mb. Prior to intensification, the low-level center was located on the northern edge of the deep convection due to the northerly winds produced by the upper high over the Gulf of Mexico. However, the upper trough previously located over the Windward Passage became a cut-off low and moved west-southwest into Central America. This allowed the outflow to become established in all quadrants.

Initially, Roxanne was a threat to Cuba and the Cayman Islands as it moved northward in response to a weak trough over Florida and the eastern Gulf of Mexico. The trough moved eastward and was replaced by a high pressure system. Roxanne turned northwestward and then westward toward the Yucatan peninsula and intensified. A similar abrupt change in motion, not expected by climatology, was taken by Hurricane Hattie in 1961.

During the early afternoon of the 10th, a well-defined eye became apparent on satellite images. Roxanne reached its maximum intensity of 100 knots and a minimum pressure of 956 mb about 2152 UTC just to the southeast of Cozumel.

Figure 2 shows the northern eyewall viewed from the Cancun radar, crossing Cozumel at 2340 UTC 10 October. Roxanne made landfall just north of Tulum, on the mainland, Mexico just to the southwest of Cozumel about 0200 UTC 11 October. The hurricane continued westward over the Yucatan peninsula and emerged over the Gulf of Campeche as a minimal hurricane. It then temporarily weakened to tropical storm status. Once the center of circulation was completely over the waters, the tropical cyclone regained hurricane intensity and maintained that status for about 60 hours. It gradually weakened to a tropical storm and then to a tropical depression.

The steering currents were weak when Roxanne was in the Bay of Campeche. Consequently, the hurricane meandered within an area of less than 250 n mi for almost a week. During that period, several shortwave troughs and ridges rapidly passed by to the north of Roxanne, forcing the tropical cyclone to swing either southeastward or northwestward. Feeder bands and waves of 15 to 20 feet were pounding the coastal section from the State of Campeche to Veracruz throughout that time. Eventually, Roxanne was forced to move southward into the area near Veracruz by an approaching strong cold front. The remnants of the tropical cyclone moved southwestward into Mexico.

Roxanne's track is shown in Fig. 3. Table 1 is a listing, at six-hour intervals, of the "best-track" position, estimated minimum central pressure and maximum 1-min sustained surface wind speed.

b. Meteorological Statistics

The best track pressure and wind curves as a function of time, shown in Figures 4 and 5, are primarily based on reconnaissance aircraft, satellite intensity estimates from the National Hurricane Center (NHC), Satellite Analysis Branch (SAB) and the Air Force Global Weather Central (AFGWC). The analysis used numerous observations taken from ships in the northwestern Caribbean and the Gulf of Mexico.

The maximum intensity occurred about 2152 UTC 10 October when a reconnaissance plane measured 956 mb and wind of 114 knots at the 700 mb level. Table 2 lists ship reports with 34 knot winds or higher and Table 3 lists selected surface observations associated with Roxanne. Information provided by the Servicio Meteorologico de Mejico indicated that an automatic station near Merida reported sustained winds of 65 knots with gusts to 109 knots at 1900 UTC 11 October. A weather station in Veracruz reported nearly 12 inches of rain and the Tabasco Observatory reported 9.5 inches. The other reports from the region affected by Roxanne indicate that the rainfall totals were of only one or two inches there.

Very interesting observations were collected by Mr. Dan Hartman during the passage of Roxanne. He was located at 20°.30'N 86°.57'W, (southwest of Cozumel and along the coast of Yucatan). Pressure was measured with a **HUGER** mercury barometer. Wind speed was obtained from a **Rainwise** wind speed/direction receiver located on the roof of Mr. Hartman's home which is the top floor of a two story dwelling. The rain gauge is an **All-Weather** made to "U.S Weather Bureau specifications" and was located on the roof in an unobstructed location. The Log and Comments of Mr. Hartman are:

"On Sunday Oct. 8 approximately 5-6 PM (All times are local time which are two hour earlier than EST) winds from the north 0-10 mph.

1:45 PM Tuesday	pressure	1000 MB	and winds NW 30-40 MPH
3:30 PM	pressure falling	988 MB	winds NW 30-40 MPH
4:30 PM		980 MB	winds NW 40-74 MPH
5:00 PM		978 MB	winds shifting to NE and for a short time the winds seemed to decrease, then wind gusts increased to over 100 MPH (limit of the wind gage)
6:00 PM		983 MB	winds likely over 100 MPH coming from anywhere from NE to SE. At this point the wind gauge had blown over and it became very difficulty to tell true wind direction. From various windows we have I could estimate wind direction by the rain blowing into the house.
6:45 PM		988 MB	winds still decreasing from NE to SE.
7:10 PM		991 MB	winds dropping
8:00 PM		995 MB	
8:35 PM		998 MB	
9:00 PM		999 MB	
12:00 AM Wednesday		1002 MB	
1:30 AM		1003 MB	
6:30 AM		1010 MB	overcast scattered showers, winds E-SE

The various times of the barometric reading are irregular due to problems dealing with the hurricane as it impacted our home. It is quite possible that the actual barometric pressure was lower than 978 MB that I recorded. I just was too busy to spend too much time taking notes every 5 minutes. Likewise the wind speeds. As a subjective observation the winds in the storm seem to rise and fall quite a bit. It was not a steady wind force of so many miles and hour rather than ebbs and flows which build up into a higher tempo as the storm approached. Rainfall was also not a large factor. My readings showed approximately

5.4 inches falling from Monday night till Wednesday morning when I took the final readings. I did record 2.4 inches of this total falling Monday night. The storm surge on the east side of the island appears to have been on the order of 10 feet. This is based on my estimate of the high between the water line and the high water mark of the storm as shown by the trash line".

c. Casualty and Damage Statistics

Mixed reports of damage have been received at the NHC. The death toll so far is 14 according to the Ft. Lauderdale Sun-Sentinel, 20 October, 1995. U.S. Coast Guard, a C-130 reconnaissance plane investigating Roxanne and Mexican helicopters searched for people missing from a petroleum work-barge that sank with 245 people on board. Five of these 14 deaths appear to be related to this event including one American. According to Mexican authorities, more than 40,000 homes were damaged by Roxanne in the States of Campeche, Quintana Roo, Tabasco Veracruz and Yucatan. Numerous crops were damaged, cattle drowned and roads were washed out or blocked by mud and rock slides. The road between the City of Carmen and Campeche was completely destroyed. Thousands of people were evacuated. There are unconfirmed reports that many hotel lobbies in Cancun and Cozumel were damaged from pounding waves. Extensive tree damage was observed in Cozumel. Storm tides and swollen rivers caused the worst flooding in Campeche and Tabasco since 1927. It appears the worst damage was produced by the pounding of 15 to 20 foot waves along the shore for several days. The waters from the Gulf of Mexico surged hundred of yards inland.

This area had previously been affected by Hurricane Opal a week or two before and it is difficult to separate the damage caused by Opal and Roxanne. Best estimate of the combined damage in the Yucatan peninsula is $1.5 billion, according to insurance company estimates.

d. Forecast and Warning Critique

Table 4 lists the watches and warnings associated with Roxanne. Initially when Roxanne was in the western Caribbean moving northward, watches and warnings were issued for portions of Cuba and the Cayman Islands. In the advisories, the NHC emphasized that Roxanne was expected to turn toward the northwest and west and that the threat was the greatest for the Yucatan peninsula. Numerical models provided excellent guidance when forecasting the turn to the left toward Yucatan, even when Roxanne was moving northward 4 to 8 knots (See Fig 6). Track models generally kept the hurricane moving west or northwest south of 25°N and almost never suggested a U.S. landfall.

Due to the erratic motion of the tropical cyclone in the Bay of Campeche, watches and warnings had to be extended, discontinued and reissued for portions of the coast of Mexico. Overall, Mexico was under watches and warnings almost continuously for 10 days. A hurricane warning for the landfall area near Cozumel was issued 23 hours in advance.

The individual errors of each track model as well as the errors of the official forecast are shown in Table 5. The official forecast was generally comparable with the past 10-year average, but slightly better than average for the 72-h period. It is interesting to note that in the case of Roxanne, the models A90E and BAMD performed better than the usually more reliable GFDL at the 72-h period. Most of the largest model and official forecast track errors occurred when Roxanne was meandering in the Bay of Campeche and steering currents were weak.

As occurred in other storms this season, the tropical cyclone intensified faster than forecast during the early stage. There was a negative bias (underforecast) at the 72-h period throughout much of Roxanne's lifetime.

Figure Captions:

Fig. 1 850 mb (a) and 200 mb (b) radiosonde data combined with the AVN model operational analysis for 1200 UTC 6 October. (c) Streamlines representing the upper-level flow favorable for initial development according to Dunn(1960) and Riehl (1951). Black dot represents the location of the center of the disturbance.

Fig. 2 Radar presentation of Hurricane Roxanne while the northern eyewall was moving over Cozumel. Radar site is Cancun.

Fig. 3. Best track positions for Hurricane Roxanne, 7-21 October 1995.

Fig. 4. Best track one-minute surface wind speed curve for Hurricane Roxanne.

Fig. 5. Best track minimum central pressure curve for Hurricane Roxanne.

Fig. 6. Model forecast tracks for 1200 UTC 9 October when Roxanne was moving north toward Cuba.

Table 5.

PRELIMINARY FORECAST EVALUATION HURRICANE ROXANNE
HETEROGENEOUS SAMPLE

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

Forecast Technique	Period (hours)				
	12	24	36	48	72
GFDI	55 (34)	113 (32)	173 (30)	240 (28)	363 (17)
GFDL*	48 (18)	100 (17)	158 (16)	225 (15)	315 (9)
VBAR*	54 (37)	129 (35)	210 (33)	292 (31)	456 (27)
AVNI	45 (35)	82 (33)	130 (31)	190 (25)	392 (25)
BAMD	49 (38)	96 (36)	147 (34)	194 (32)	266 (28)
BAMM	55 (38)	121 (36)	196 (34)	277 (32)	417 (28)
BAMS	79 (38)	170 (36)	274 (34)	377 (32)	539 (28)
A90E	43 (38)	72 (36)	114 (34)	164 (32)	251 (28)
CLIP	47 (38)	93 (36)	151 (34)	214 (32)	354 (28)
NHC Official	43 (38)	83 (36)	138 (34)	198 (32)	269 (27)
NHC Official (1985-94 10-yr average)	50	98		194	296

* GFDL output not available until after forecast issued. VBAR output sometimes not available until after forecast issued.

Table 1. Preliminary best track, Hurricane Roxanne, 7- 21 October, 1995

Date/Time (UTC)	Position Lat.(°N)	Lon.(°W)	Pressure (mb)	Wind Speed (kt)	Stage
7/1800	14.0	82.1	1005	25	Tropical Depression
8/0000	14.2	82.7	1005	25	" "
0600	14.8	83.0	1005	25	" "
1200	15.0	83.2	1005	25	" "
1800	15.7	83.2	1004	30	" "
9/0000	16.5	83.1	1002	35	Tropical Storm
0600	17.2	83.0	1001	40	" "
1200	17.9	82.9	999	45	" "
1800	18.4	82.9	995	50	" "
10/0000	18.9	83.7	989	60	" "
0600	19.2	84.3	985	70	Hurricane
1200	19.4	85.0	972	80	"
1800	19.9	86.0	966	95	"
11/0000	20.0	87.0	958	100	"
0600	20.0	88.1	970	90	"
1200	19.9	89.1	983	75	"
1800	19.7	90.0	987	70	"
12/0000	19.5	90.8	990	65	"
0600	19.5	91.5	992	65	"
1200	19.5	92.2	994	55	Tropical Storm
1800	19.7	92.6	995	55	" "
13/0000	20.1	92.8	993	55	" "
0600	20.5	93.1	993	55	" "
1200	21.0	93.6	992	55	" "
1800	21.4	93.9	988	55	" "
14/0000	21.8	93.9	982	55	" "
0600	22.2	93.9	981	60	" "
1200	22.3	93.8	980	65	Hurricane
1800	22.3	93.3	980	70	"
15/0000	21.8	92.9	979	70	"
0600	21.4	92.4	979	75	"
1200	21.0	91.9	980	75	"
1800	20.6	91.6	980	75	"
16/0000	20.4	91.5	981	75	"
0600	20.3	91.7	984	70	"
1200	20.3	92.0	985	65	"
1800	20.4	92.2	987	65	"
17/0000	20.6	92.4	991	65	"
0600	20.9	92.6	995	60	Tropical Storm
1200	21.2	92.9	998	55	" "
1800	21.3	93.1	1000	50	" "
18/0000	21.5	93.3	1003	45	" "
0600	21.8	93.6	1004	40	" "
1200	22.2	94.2	1005	35	" "
1800	22.3	94.7	1008	35	" "
19/0000	22.3	95.1	1009	30	Tropical Depression
0600	22.4	95.4	1009	30	" "
1200	22.3	95.5	1009	30	" "
1800	22.3	95.6	1009	30	" "
20/0000	22.4	95.6	1009	30	" "
0600	22.0	95.5	1009	30	" "
1200	21.5	95.5	1009	25	" "
1800	20.5	95.5	1010	25	" "
21/0000	19.5	96.0	1011	25	Dissipating
10/2152	20.0	86.7	956	100	Minimum Pressure
11/0200	20.0	87.6	958	100	Landfall (near Tolum)

Table 2

Tropical Cyclone Winds
(Ship encounters of 35 Knots or more)

Tropical Cyclone	Ship Name	Date Mo/Da	Time UTC	Position LatN	Position LonW	Wind(kn) Dir/Speed	Pressure (mb)
	C6VC	10/09	0600	16.9	87.5	310/36	1010.0
	WNJG	10/09	1400	18.0	83.1	340/42	998.4
	WNJG	10/09	1800	18.7	83.5	020/35	1001.6
	WNJG	10/10	0000	19.8	84.1	070/35	1000.0
	NRDC	10/10	0600	16.9	85.6	320/58	1007.2
	SHIP	10/10	0600	17.1	84.4	220/37	1004.2
	ELFT8	10/10	1200	18.0	86.7	300/40	1006.5
	3EWJ9	10/10	1200	18.0	86.9	280/35	1013.0
	OUZW	10/10	1200	20.0	83.8	160/38	1002.3
	C6CM7	10/10	1200	20.7	82.8	160/25	1004.6
	ELFT8	10/10	1800	16.9	85.6	230/45	1009.0
	OYGK2	10/10	1800	18.5	86.8	250/40	1002.6
	C6KJ5	10/10	1800	21.7	86.1	XXX/35	1000.5
	OUZW2	10/10	1800	22.0	85.1	100/50	1004.5
	OYGK2	10/11	0000	18.9	86.1	240/48	1001.0
	PJNL	10/11	0000	22.1	85.1	090/40	1004.0
	C6KJ5	10/11	0600	21.6	85.3	140/35	1004.5
	V2EM	10/12	0600	19.2	96.0	350/37	1006.0
	V2EM	10/12	1200	19.2	96.0	360/40	1004.0
	***YH	10/13	1800	19.9	84.5	120/54	1009.0
	ELSF8	10/15	0000	21.6	93.0	280/37	986.0
	C6IK8	10/15	0000	21.7	92.4	180/47	985.0
front?	WIDO	10/15	0000	26.2	96.1	360/35	1014.5
	V2EM	10/15	1200	21.2	90.5	140/48	998.0
front?	3ELF9	10/15	1200	21.9	95.0	360/40	1015.5
	V2EM	10/15	2100	19.6	93.2	270/60	1005.0
	DP3YK3	10/16	0600	22.8	92.4	030/47	1011.6
	VSBZ5	10/16	1200	23.3	92.5	040/42	1011.7
	VSBZ5	10/16	1800	23.0	92.5	040/40	1012.6
	DP3YK3	10/16	1800	23.7	92.8	050/40	1015.0
	SBZ5	10/17	0000	22.8	93.2	040/45	1009.2
	SBZ5	10/17	0600	23.1	93.1	050/38	XXXX.X
	DP3YK3	10/17	0600	23.5	93.4	050/40	1013.6
	VSBZ5	10/17	1200	23.5	92.8	050/40	1009.0
	VORX	10/17	1200	23.8	92.7	060/35	1008.7
	DP3YK3	10/17	1800	23.9	91.5	070/34	1013.0
	VSBZ5	10/18	0000	22.9	92.1	090/35	1009.5
	DP3YK3	10/18	0600	21.5	91.7	150/34	1011.0

Table 3

Hurricane Roxanne selected surface observations, October 1995

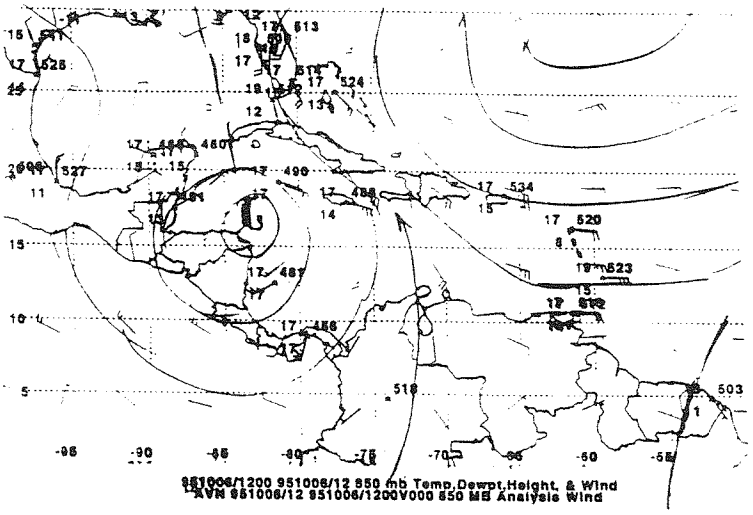
Location	Minimum sea-level pressure		Maximum surface wind speed (kt)			Storm surge[b] (ft)	Storm tide[b] (ft)	Rain (storm total) (in)
	Pressure (mb)	Date/time (UTC)	sustained wind	Peak gust	Date/time (UTC)[a]			
Merida			35[d]	40	11/1200			
Merida a. station			65	109	11/1900			
Valladolid	992.7		28		11/0900			
Coatzacoalcos			35	42	15/1900			
Paraiso			65	70	15/1800			
Champoton			56	65	15/1800			
Tuxpan			44	51	16/1800			
Villahermosa			55	70	15/xxxx			

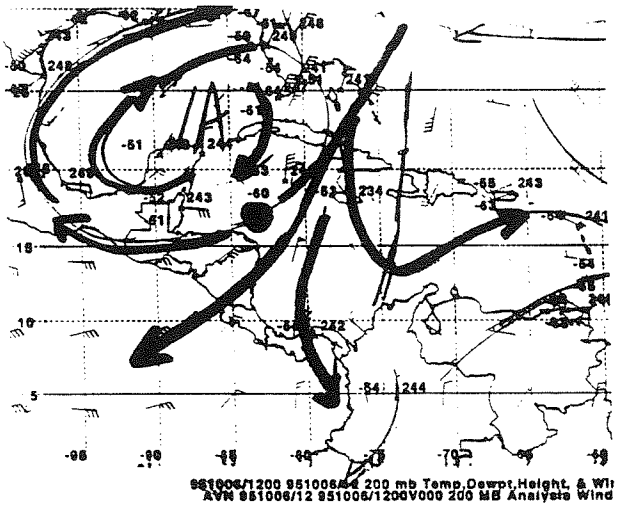
[a] Time of 1-minute wind speed unless only gust is given.
[b] Storm surge is water height above normal tide level. Storm tide is water height relative to National Geodetic Vertical Datum (NGVD) which is defined as mean sea level in 1929.
[c] One-minute averaged wind.
[d] Unknown averaging period.
[e] A more extreme value could have occurred.
[f] WMO standard 10-min wind
[g] 12-hour total

Table 4

Tropical Cyclone watch and warning summary, Hurricane Roxanne

Date/Time(UTC)/Action		Location
9/1500	Tropical Storm Warning issued	Cayman Islands
9/2100	Tropical Storm Warning and Hurricane Watch issued	Pinar del Rio and the Isle of Youth, Cuba
	Hurricane Watch issued	Chetumal to Cabo Catoche, Yucatan, Mexico
10/0300	Hurricane Warning issued	Chetumal northward and westward to Progreso
10/1500	Hurricane Watch issued	West of Progreso to City of Carmen
	Tropical Storm warning and Hurricane Watch discontinued	Cayman Islands and Cuba except for extreme western Cuba.
10/2100	Tropical Storm Warning issued	Belize City northward to just south of Chetumal
	Tropical Storm Warning discontinued	Extreme western Cuba
11/0600	Tropical Storm Warning discontinued	Belize City to just south of Chetumal
11/1500	Hurricane Warning issued	City of Carmen to Coatzacoalcos.
	Tropical Storm Warning and Hurricane Watch issued	West of Coatzacoalcos to Tuxpan
	Hurricane Warning discontinued	Chetumal to Progreso
11/2100	Hurricane Warning issued	West of Coatzacoalcos to Tuxpan
12/1500	Tropical Storm Warning and Hurricane Watch	City of Carmen to Tampico
	Hurricane Warning discontinued	West of Coatzacoalcos to Tuxpan
13/2100	Tropical Storm Warning and Hurricane Watch issued	North of Tampico to La Pesca
14/0300	Tropical Storm Warning and Hurricane Watch discontinued	City of Carmen to Veracruz
14/1500	Tropical Storm Warning and Hurricane Watch issued	Veracruz to Progreso
	Tropical Storm Warning and Hurricane Watch discontinued	North of Tampico
14/1800	Hurricane warning issued	Progreso to Tampico
16/0300	Hurricane Warning replaced by Tropical Storm Warning	Progreso to Tampico
18/1500	Tropical Storm Warning discontinued	Progreso to Tampico
18/2100	Tropical Storm Warning issued	Tuxpan to San Fernando
19/1500	Tropical Storm Warning discontinued	Tuxpan to San Fernando





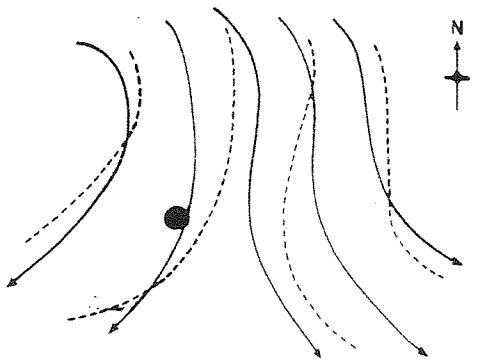


Fig. 1 850 mb (a) and 200 mb (b) radiosonde data combined with the AVN model operational analysis for 1200 UTC 6 October. (c) Streamlines representing the upper-level flow favorable for initial development according to Dunn(1960) and Riehl (1951). Black dot represents the location of the center of the disturbance.

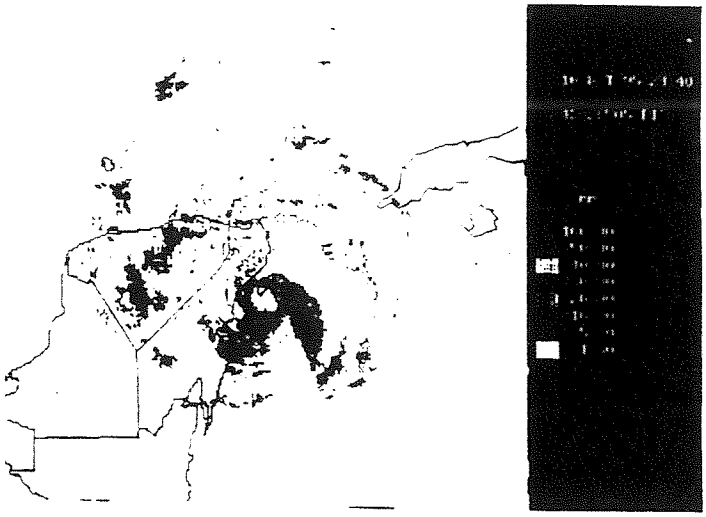


Fig. 2 Radar presentation of Hurricane Roxanne while the northern eyewall was moving over Cozumel. Radar site is Cancun.

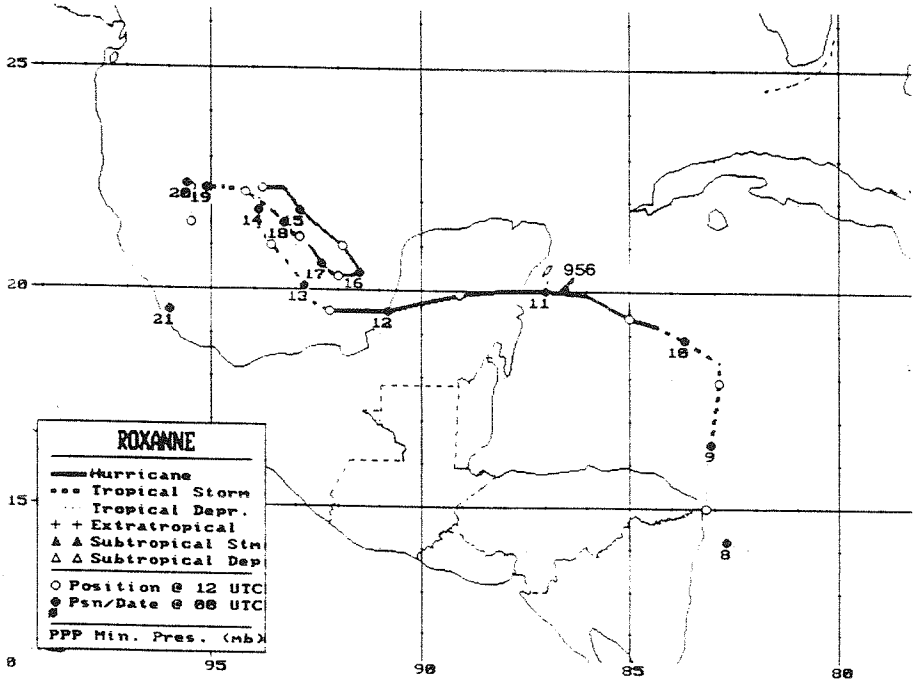


Fig. 3. Best track positions for Hurricane Roxanne, 7-21 October 1995.

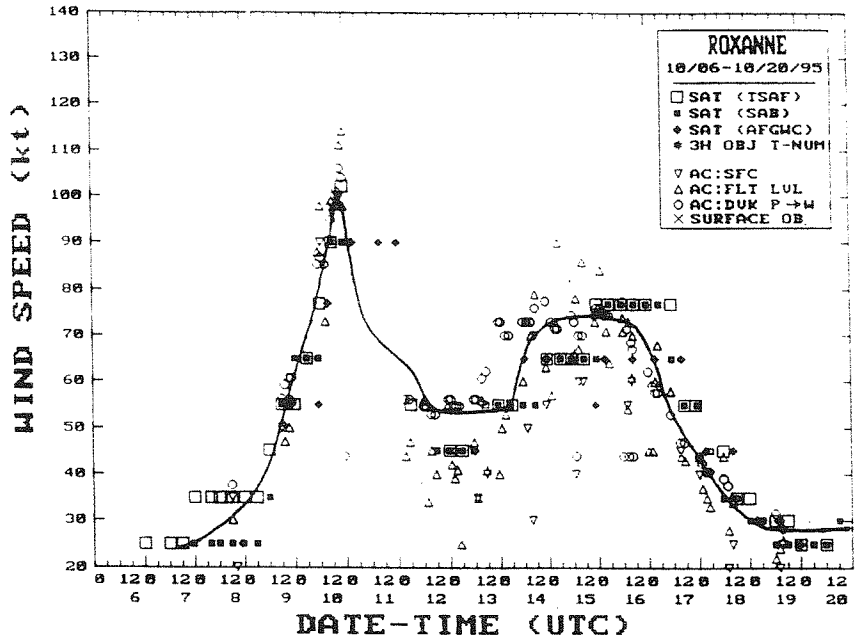


Fig. 4. Best track one-minute surface wind speed curve for Hurricane Roxanne.

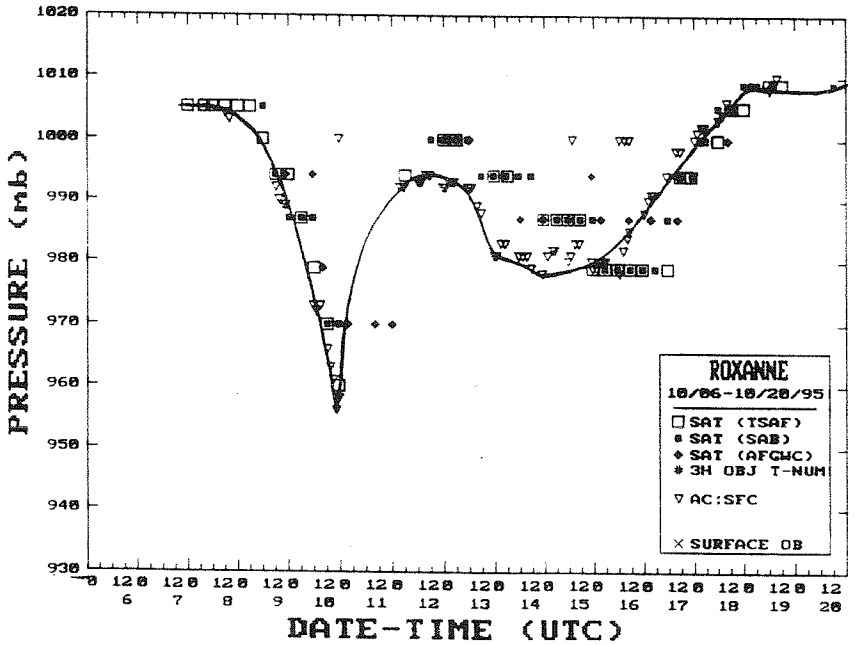


Fig. 5. Best track minimum central pressure curve for Hurricane Roxanne.

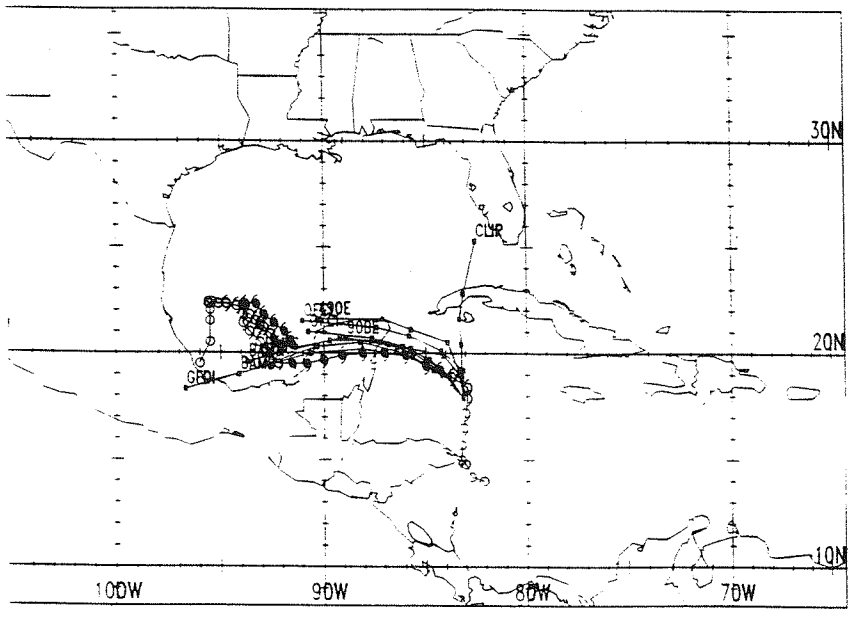


Fig. 6. Model forecast tracks for 1200 UTC 9 October when Roxanne was moving north toward Cuba.