

Preliminary Report
Hurricane Opal
27 September - 6 October 1995

Max Mayfield
National Hurricane Center
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Hurricane Opal made landfall near Pensacola Beach, Florida as a marginal Category 3 hurricane on the Saffir/Simpson Hurricane Scale, causing extensive storm surge damage to the immediate coastal areas of the Florida panhandle. It was the first major hurricane to strike the Florida panhandle since Eloise in 1975.

a. Synoptic History

Satellite imagery and synoptic analyses indicate that Opal originated from a tropical wave that emerged from the west coast of Africa on 11 September. The wave moved westward across the Atlantic into the western Caribbean Sea by 23 September and merged with a broad area of low pressure centered in the vicinity of 15°N 80°W. The combined system drifted west-northwestward toward the Yucatan peninsula over the following few days without significant development. Deep convection increased near the center of the low and the post-analysis "best track" in Figure 1 shows that a tropical depression formed about 70 n mi south-southeast of Cozumel, Mexico at 1800 UTC 27 September. Best track position, central pressure and maximum one-minute sustained wind speed are listed for every six hours in Table 1.

Steering currents were weak and the tropical depression moved slowly over the Yucatan peninsula for the following three days. Convective banding increased and ship reports suggest that the depression became Tropical Storm Opal at 1200 UTC 30 September while centered near the north-central coast of the Yucatan peninsula. The storm gradually strengthened and moved slowly westward into the Bay of Campeche.

Air Force Reserve unit aircraft investigating Opal over the southwestern Gulf of Mexico reported that the minimum central pressure steadily dropped. Aircraft reports and satellite estimates suggest that Opal strengthened into a hurricane near 1200 UTC 2 October while centered about 150 n mi west of Merida, Mexico. A banding type eye appeared in satellite imagery later in the day while a large amplitude mid- to upper-level trough moving into the central United States began turning Opal slowly toward the north.

On 3 and 4 October, the hurricane turned toward the north-northeast to northeast and gradually accelerated. During this period, the water temperature beneath the hurricane's circulation was near 28 to 29C, and a large upper-level anticyclone was well established over the Gulf of Mexico. Rapid intensification

occurred not only as a result of these favorable environmental conditions on the large scale but, and perhaps more importantly, due to significant changes on a smaller scale within the hurricane's inner core. Opal intensified into a category four hurricane on the Saffir/Simpson Hurricane Scale early on 4 October at which time reconnaissance aircraft reported a small, 10 n mi diameter eye. The minimum central pressure of 916 mb, with maximum sustained surface winds estimated at 130 knots, occurred when the hurricane was centered about 250 n mi south-southwest of Pensacola, Florida near 1000 UTC 4 October. The peak intensity appears to have occurred near the end of an eyewall contraction cycle. Soon thereafter, the small inner eyewall diminished as an outer eyewall became more dominant. The hurricane weakened during this process, but was still a marginal Category 3 hurricane as the center made landfall at Pensacola Beach, Florida near 2200 UTC 4 October. The collapse of the inner eyewall, reduced sea surface temperatures along the Gulf coast and increased upper-level westerlies likely contributed to the weakening.

The hurricane was moving north-northeastward near 20 knots at landfall with the sustained hurricane force winds in the eastern quadrants of the circulation primarily between Pensacola Beach and Cape San Blas. **The minimum central pressure at landfall was 942 mb. Maximum sustained surface winds are currently estimated at 100 knots in a narrow swath at the coast near the extreme eastern tip of Choctawhatchee Bay about midway between Destin and Panama City.** Although no official reports of surface winds were received within this area, data from reconnaissance aircraft and Doppler radar suggest that the peak winds occurred in this location. It should be emphasized that the strongest winds were in a very limited area and most of the coastal areas of the Florida panhandle experienced winds of a Category 1 or Category 2 hurricane (between 65 and 95 knots). Although the winds were diminishing at the time of landfall, extensive damage due to storm surge and breaking waves occurred over most of the coastal areas of the Florida panhandle.

Opal weakened rapidly after moving inland, becoming a tropical storm over southern Alabama and a tropical depression over southeastern Tennessee. The cyclone was declared extratropical on the best track as it moved northeastward over the Ohio Valley and eastern Great Lakes into southwestern Quebec. The strongest winds occurred well away from the center of the cyclone during the extratropical stage.

b. Meteorological Statistics

Figures 2 and 3 show the curves of minimum central pressure and maximum one-minute wind speed, respectively, versus time, along with the observations on which they are based.

U.S. Air Force Reserve aircraft provided a total of 38 operational center fixes during approximately 122 flying hours of reconnaissance on this hurricane. The minimum central pressure

reported by aircraft was 916 mb at 0945 UTC 4 October. This represented a 53 mb drop in pressure within 24 hours and a 42 mb fall within about 12 hours. This was a very rapid rate of deepening, but it is not unprecedented. Several western North Pacific typhoons have deepened at an even faster rate. The maximum winds of 152 knots from a flight-level of 700 mb were measured shortly after the 916 mb pressure report. At 2006 UTC, approximately two hours prior to landfall, the aircraft reported 126 knots 59 n mi east of the center. At 2203 UTC, near the time of landfall, the aircraft reported 115 knots 54 n mi east of the center. In addition to the Air Force Reserve reconnaissance, a NOAA aircraft flew a 10 hour research mission at the time of landfall.

A ship with call sign **XCKX** reported 75 knot winds at 1200 UTC 4 October while located about 90 n mi west-southwest of the hurricane center. Several other ship reports were helpful in defining the extent of tropical storm force winds. Table 2 lists ship reports of at least tropical storm force winds in the vicinity of Opal.

The strongest winds reported by a land station were 73 knots with gusts to 125 knots from Hurlbert Field, Florida. Table 3a lists selected surface observations, and Table 3b lists selected observations made by NOAA's National Data Buoy Center (NDBC) platforms near the path of Opal.

Isolated tornadoes were reported from the Florida panhandle to the mid-Atlantic states. One fatality occurred in Crestview, Florida as a result of a tornado. Another tornado injured several people and severely damaged a number of structures as it swept through Charles, Prince Georges and Anne Arundel Counties in Maryland.

At the time of this report a post-storm high water mark survey was being conducted by the U.S. Army Corps of Engineers and the U.S. Geological Survey. Many high water marks remain to be surveyed and "tied into" bench marks. The locations of the maximum values cannot be finalized until the survey is complete. However, initial survey results show an extensive storm surge from southeastern Mobile Bay and Gulf Shores, Alabama, eastward through the Florida panhandle to Cedar Key, Florida. Still water mark elevations inside of buildings or tide gage maximums, which damp out breaking wave effects and are indicative of the storm surge, ranged from 5 to 14 feet above mean sea level. Outside water marks on buildings or debris lines on sand dunes within 200 feet of the Gulf of Mexico shoreline generally ranged from 10 to 21 feet. For example, the tide gage at the Panama City Beach pier recorded a maximum of approximately 8.3 feet above mean sea level, indicative of storm surge. At the end of the pier a debris line elevation of approximately 18 feet above mean sea level was recorded. Thus, the breaking waves on top of the storm surge added approximately 10 feet. Many structures in this combined storm surge and breaking wave zone that were not elevated high enough suffered major

structural damage.

The combination of Opal and a frontal system resulted in heavy rains along the path of the hurricane. Rainfall totals generally ranged from 5 to 10 inches over portions of the Florida panhandle, Alabama and Georgia. Rains in South Carolina averaged 2 to 4 inches while in North Carolina 3 to 5 inches were common. Highlands, North Carolina recorded 8.95 inches and Robinson Creek, North Carolina recorded 9.89 inches. Elsewhere, 1 to 3 inch totals occurred over portions of the northeast U.S. from Maryland northward. These rains have been described as beneficial to areas of the northeast U.S. that had been experiencing a prolonged dry period.

c. Casualty and Damage Statistics

The total number of deaths directly associated with Opal is currently set at 59, and were distributed as follows:

- Guatemala - 31 (from flooding during the developing stages of Opal)
- Mexico - 19 (from flooding)
- U.S. - 9 including
 - Florida (1 from a tornado)
 - Alabama (2 from a tree falling on a mobile home)
 - Georgia (5 from falling trees)
 - North Carolina (1 from a tree falling on a mobile home)

There were no reported deaths due to storm surge flooding, which is remarkable in view of the vulnerable population and extensive salt water damage observed.

The Property Claim Services Division of the American Insurance Services Group preliminary estimate of insured property damage for the United States is \$2.1 billion. Considerable uncertainty exists concerning the amount of additional damage due to flood claims, uninsured property damage (including damage to roads and bridges and other government property) and the cost of cleanup. If the estimate of insured property damage proves to be correct, the total damage estimate from Hurricane Opal could reach \$3 billion. Without adjustments for inflation, Opal could rank as high as third on the list of costliest twentieth-century U.S. hurricanes. With adjustments for inflation, Opal will likely still be ranked in the top ten on that list.

Most of the severe structural damage occurred at the coastline. The crumbled piers, demolished homes and eroded or submerged highways were primarily a result of the storm surge. In addition, however, strong winds spread damage well inland. Opal downed numerous trees, knocking out power to nearly 2 million people in Florida, Alabama, Georgia and the Carolinas. The Robert Trent Golf Course in Opelika, Alabama lost over 7000 trees during the storm. Many people in Florida were without water for several days.

d. Forecast and Warning Critique

During the time when Opal was of tropical storm or hurricane strength, the mean official track forecast errors of 42 (18 cases), 102 (16 cases), 161 (14 cases), 231 (12 cases) and 326 (8 cases) n mi at 12, 24, 36, 48 and 72 hours respectively were slightly larger than the long-term averages from the previous ten years.

The intensity forecasts showed a negative bias (i.e., intensity was underestimated). The trend for the strengthening of Opal while over water was correctly forecast by the NHC, but the amount of rapid deepening was not anticipated by the official forecasts or by any available objective intensity prediction techniques.

Table 4 lists the coastal watches and warnings issued during Opal. Approximately 31 hours elapsed between the time a hurricane watch was issued and the time of landfall on the Florida panhandle. Approximately 19 hours elapsed between the time of issuance of a hurricane warning was issued and the time of landfall.

Table 1. Preliminary best track, Hurricane Opal, 27 September - 6 October 1995.

Date/Time (UTC)	Position		Pressure (mb)	Wind Speed (kt)	Stage
	Lat. (°N)	Lon. (°W)			
1800	19.1	87.3	1004	25	Trop. Depression
28/0000	19.4	87.5	1004	25	" "
0600	19.4	87.9	1004	25	" "
1200	19.3	88.2	1003	25	" "
1800	19.3	88.4	1003	25	" "
29/0000	19.4	88.4	1003	25	" "
0600	19.5	88.4	1003	25	" "
1200	19.6	88.3	1003	25	" "
1800	19.8	88.2	1003	30	" "
30/0000	20.1	88.2	1002	30	" "
0600	20.6	88.3	1002	30	" "
1200	21.1	88.5	1001	35	Tropical Storm
1800	21.4	89.1	1000	40	" "
01/0000	21.3	89.9	994	45	" "
0600	21.1	90.7	987	45	" "
1200	20.9	91.2	986	45	" "
1800	20.8	91.6	985	50	" "
02/0000	20.7	91.9	984	55	" "
0600	20.8	92.1	980	60	" "
1200	21.0	92.3	973	65	Hurricane
1800	21.2	92.3	972	65	"
03/0000	21.7	92.2	970	70	"
0600	22.2	92.0	969	75	"
1200	22.8	91.6	968	80	"
1800	23.5	91.0	965	85	"
04/0000	24.5	90.1	953	100	"
0600	25.9	89.4	935	110	"
1200	27.3	88.5	919	130	"
1800	29.0	87.7	938	110	"
05/0000	31.0	86.8	950	80	"
0600	33.2	86.2	974	50	Tropical Storm
1200	35.4	85.7	982	30	Trop. Depression
1800	38.5	83.5	986	40	Extratropical
06/0000	40.5	82.3	989	40	"
0600	42.0	80.5	991	40	"
1200	43.3	78.4	997	35	"
1800	44.5	76.5	1002	30	"

04/1000 26.6 88.8 916 130 Minimum Pressure

Landfall:

Pensacola Beach, Florida

04/2200 30.3 87.1 942 100 Hurricane

TABLE 2. Ship encounters of 34 knots or higher associated with Hurricane Opal.

Tropical Cyclone	Ship Call Sign	Tropical Cyclone Winds (ship encounters of 34 knots or higher)		Position		Wind (kt)	Pressure
		Date Mo/Da	Time UTC	LatN	LonW	Dir/Speed	(mb)
Opal	C6CM7	9/29	0000	22.6	85.0	120/35	1006.4
	KAFG	9/30	1800	20.9	85.0	140/38	1005.7
	C6JN	10/01	1800	21.9	94.7	340/34	1003.3
	C6JN	10/02	0600	19.2	94.5	290/40	1000.8
	3EWJ9	10/03	1200	20.6	86.5	140/58	1007.0
	C6KE8	10/03	1800	27.6	94.4	010/34	1003.0
	WBVY	10/04	0000	27.5	91.4	030/38	997.3
	C6KJ5	10/04	0600	23.1	86.6	160/37	997.5
	XCKX	10/04	0600	27.2	88.8	110/48	991.0
	ELIU2	10/04	1200	24.7	84.3	160/40	-
	SHIP	10/04	1200	26.8	84.7	170/46	997.2
	XCKX	10/04	1200	26.8	90.1	340/75	984.0
	KGBE	10/04	1200	27.6	86.0	140/48	993.0
	VSBZ5	10/04	1200	28.4	88.8	080/55	983.5
	ELIU2	10/04	1800	24.4	84.5	170/40	1008.5
	XCKX	10/04	1800	26.7	90.3	290/40	997.0
	KGBE	10/04	1800	27.4	85.6	210/52	994.6
VSBZ5	10/04	1800	27.5	89.3	310/47	988.0	

TABLE 3a (cont.). Hurricane Opal selected surface observations, October 1995.

Location	Minimum sea-level pressure		Maximum surface wind speed (knots)			Storm surge (tide height above normal) (ft)	Rain (storm total) (in)
	Pressure (mb)	Date/time (UTC)	Sustained	Peak gust	Date/time (UTC)*		
Florida (continued)							
Hurlburt Field (HRT)	960.3	04/2255	73	125	04/2155		6.64
Fort Walton Beach	960.3	04/2229					
Eglin AFB (VPS)	966.5**	04/2155	70**	100**	04/2304		
Panama City (PAM)	977.7	04/2206	55	74	04/2252		
Apalachicola (AQQ)	991.2	04/2120	28	51	04/2206	5-6	2.56
St. George Island Causeway				62	04/2149		
Tallahassee (TLH)	993.9	04/2225	28	45	05/0250		1.25
Tallahassee (FSU Weather Station)	995.0	04/2216		55	04/2226		
Turkey Point (TUPF)			36	61	04/2047		
Brooksville (BKV)	1001.6	04/2106	20	28	04/2115		
New Port Richey	1003.5	04/2116	24	31	05/0445		
Tampa (TPA)	1002.1	04/2050	21	39	04/1652		1.57
St. Petersburg (PIE)	1001.6	04/2000	25	38	04/1948		1.63
Sarasota	1002.3	04/1848	27	36	04/1648	2-4	2.80
Winter Haven	1003.5	04/2103	29	36	04/2341		
Georgia							
Fort Benning (LSF)	984.5**	05/0656	40**	50**	05/0555		5.25
Warner Robbins AFB (WRB)	994.3	05/0656	29	44	05/0555		0.99
Atlanta (ATL)	987.5	05/0731	27	43	05/0556		6.59
Dobbins AFB (MGE)	987.0	05/0755	37**	60**	05/0608		5.14
Marietta			23	60	05/0734		
Fulton Co. (FTY)							6.22
Peach Tree City (FSC)							7.66

* Time of sustained wind speed unless only gust is given.

** Estimated.

TABLE 3b. Hurricane Opal selected NDBC observations, October 1995.

Platform/ Location	Minimum sea-level pressure		Maximum wind speed (knots)		
	Pressure (mb)	Date/time (UTC)	average*	Peak gust	Date/time (UTC)
Grand Isle, LA C-MAN GDIL1 / 29.3N 90.0W	990.0	04/1900	40	52	04/1400
Southwest Pass, LA C-MAN BURL1 / 28.9N 89.4W	985.4	04/1700	64	75	04/1700
Dauphin Island, AL C-MAN DPIA1 / 30.2N 88.1W	970.0	04/2126	53	67	04/2150
Keaton Beach, FL C-MAN KTNF1 / 29.8N 83.6W	998.0	04/2000	30	47	04/2100
Cedar Key, FL C-MAN CDRF1 / 29.1N 83.0W	1000.2	04/2100	32	46	04/2300
42001 / 25.9N 89.7W	963.7	04/0600	53	66	04/1000
42003 / 25.9N 85.9W	992.8	04/1200	43	54	04/0900
42007 / 30.1N 88.8W	979.5	04/2100	52	68	04/1900
42036 / 28.5N 84.5W	995.4	04/2100	35	43	04/1800

*NOAA buoys report an 8-minute average wind and C-MAN stations report a 2-minute average wind.

TABLE 4. Watch and warning summary, Hurricane Opal.

Date/Time (UTC) /Action	Location
30/1500 Tropical Storm Warning	Northeast portion of the Yucatan Peninsula from Cozumel and Cancun to Progreso
01/0300 Tropical Storm Warning extended	Yucatan Peninsula from Progreso to Celestun
01/2100 Tropical Storm Warning extended	Yucatan Peninsula from Progreso to Veracruz
01/2100 Tropical Storm Warning discontinued	Yucatan Peninsula east of Progreso
03/0900 Hurricane Watch	Morgan City, Louisiana to just west of Pensacola, Florida
03/1500 Hurricane Watch extended	Pensacola to the Mouth of the Suwannee River, Florida
03/1500 Tropical Storm Warning discontinued	All portions of the Yucatan Peninsula
03/2100 Tropical Storm Warning	Morgan City, Louisiana to the Mouth of the Suwannee River, Florida
04/0300 Hurricane Warning	Mobile, Alabama to Anclote Key, Florida
04/0300 Tropical Storm Warning extended	South of Anclote Key to Venice, Florida
04/0300 Tropical Storm Warning and Hurricane Watch discontinued	West of Grand Isle to Morgan City, Louisiana
04/0900 Hurricane Warning extended	Mobile, Alabama westward to the Mouth of the Mississippi River including coastal Mississippi
04/0900 Tropical Storm Warning and Hurricane Watch extended	Grand Isle, Louisiana westward to just east of Morgan City, Louisiana including Metropolitan New Orleans
05/0300 Tropical Storm Warning, Hurricane Warning, and Hurricane Watch discontinued	West of Mobile, Alabama
05/0500 All remaining coastal Watches and Warnings discontinued	

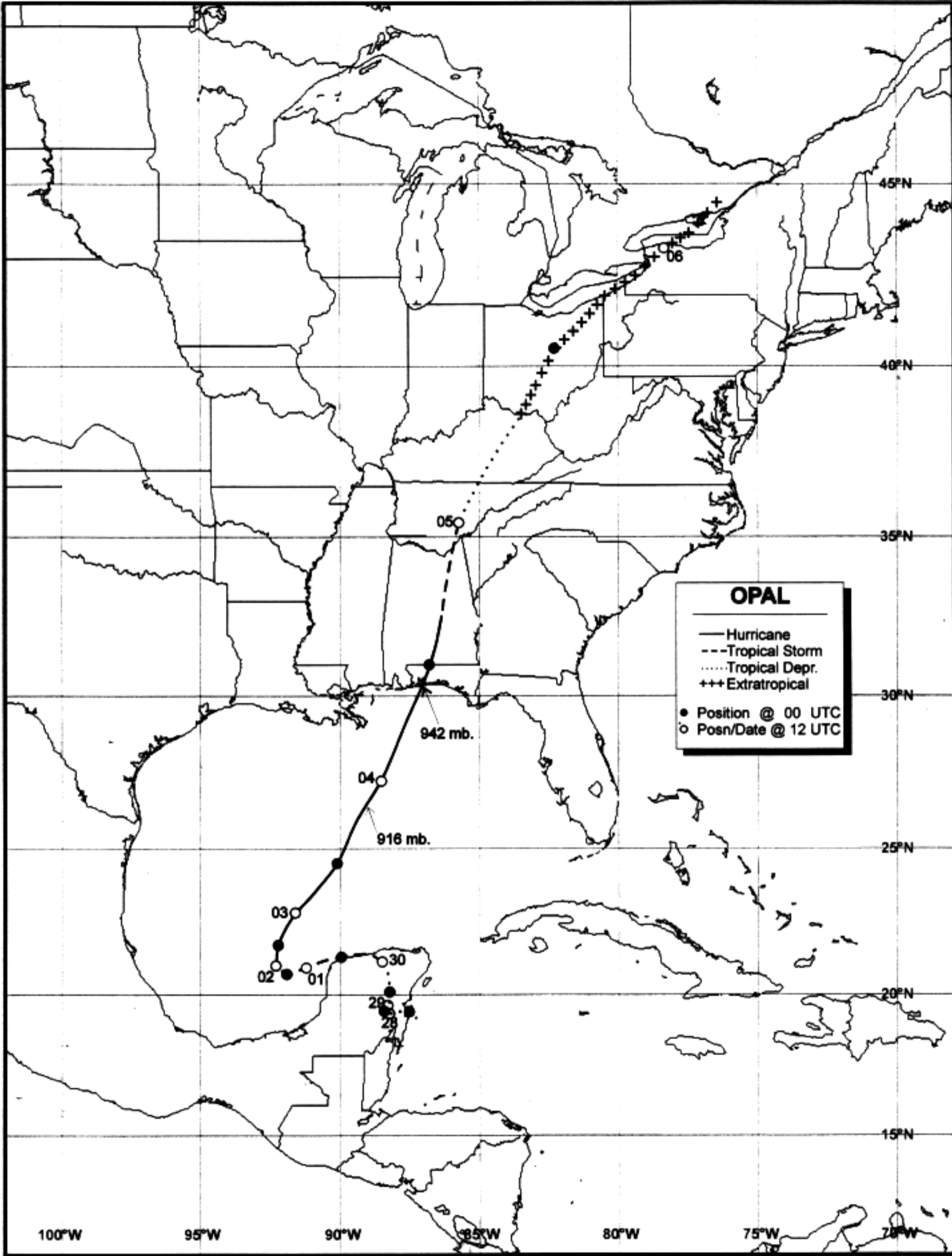


Figure 1. Best track positions for hurricane Opal, 27 September—06 October 1995.

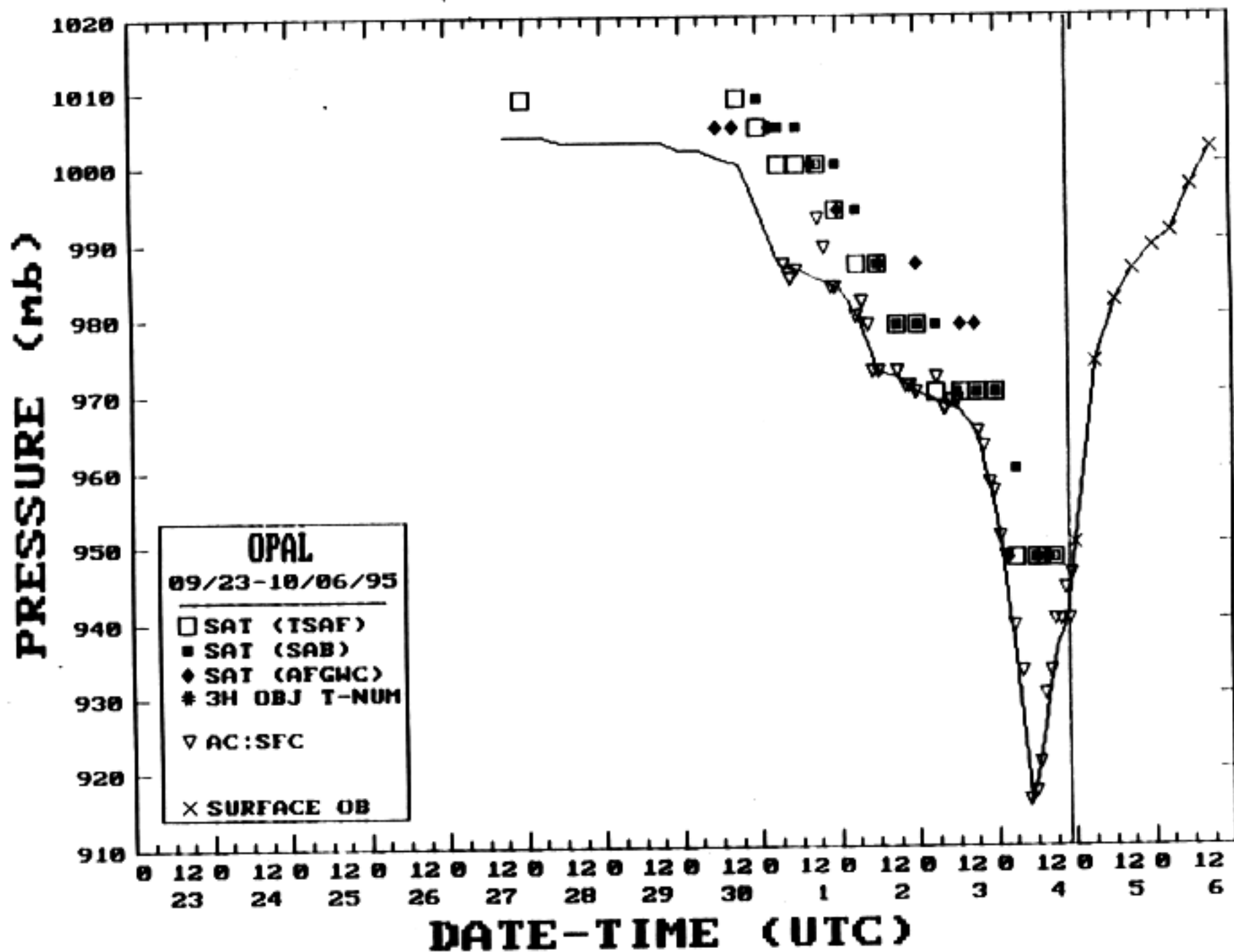


Figure 2. Best track minimum central pressure curve for Hurricane Opal, 1995. Landfall noted by vertical line.

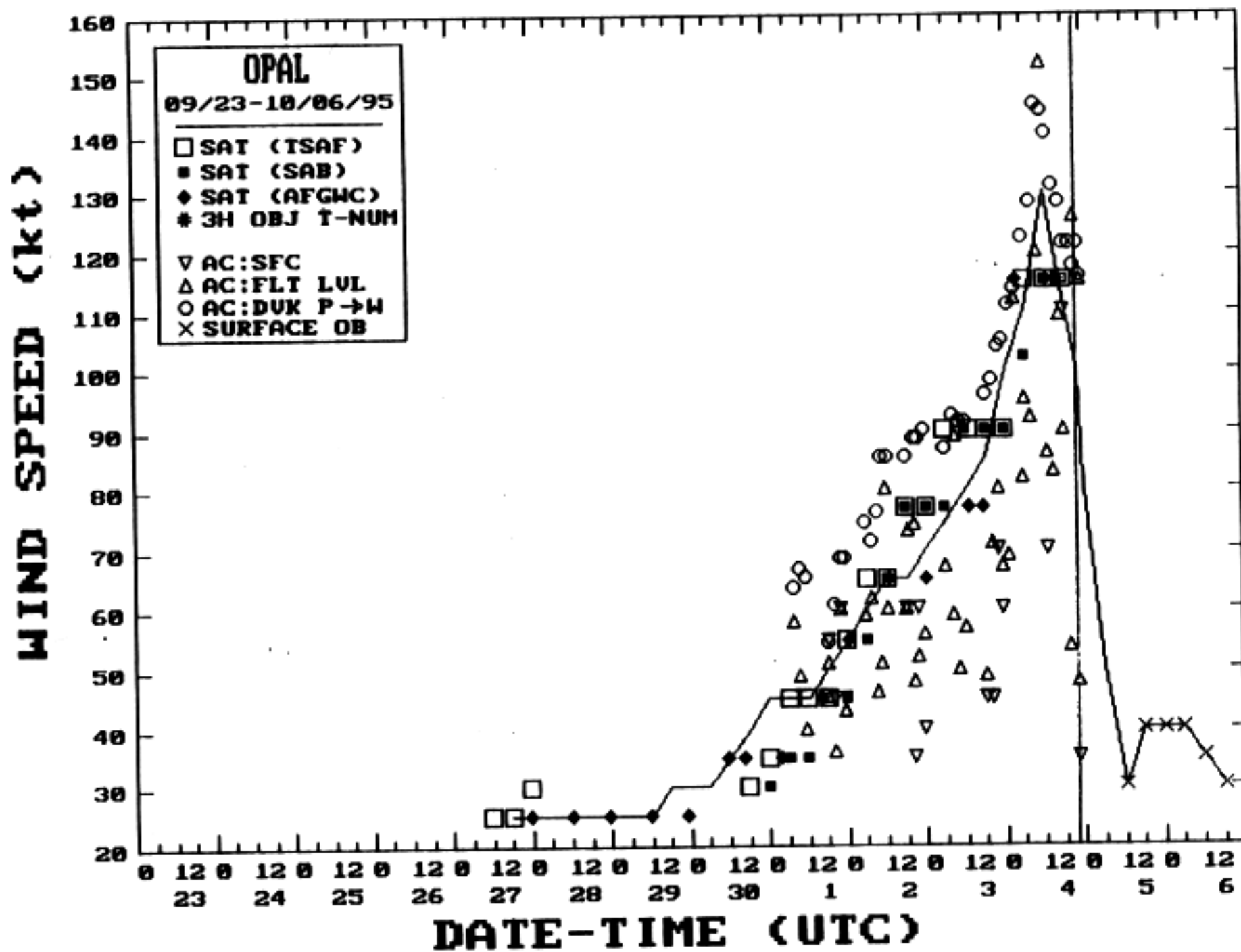


Figure 3. Best track maximum sustained wind speed curve for Hurricane Opal, 1995. Landfall noted by vertical line.