PRELIMINARY REPORT

Hurricane Klaus (3 - 9 October 1990)

a. Synoptic History

Klaus originated from a tropical wave that moved off the coast of Africa on 27 September. The wave was convectively active as it moved westward across the tropical Atlantic. Evidence of a circulation was detected from METEOSAT imagery as early as the 28th when the system was located 350 nautical miles south of the Cape Verde Islands. The wave moved across the Atlantic for several days, occasionally showing signs of becoming a depression. Finally, on 3 October, when located just east of the Lesser Antilles, the wave began a steady strengthening even though there appeared to be a strong shearing environment.

Klaus' best track starts with a tropical depression centered 100 nautical miles east of Dominica, at 1200 UTC on 3 October. The best track is plotted on Fig. 1 and six-hour center positions, central pressures and maximum one-minute surface wind speeds are listed in Table 1.

The system drifted slowly toward the northwest for three days, caught in a weak steering current between high pressure to its east and west and with short-wave troughing to the north. It quickly strengthened to a tropical storm at 1800 UTC on the 3rd and reached hurricane strength at 1200 UTC on the 5th. At this time, the center was at its point of closest approach to the Leeward Islands and was only about 25 nautical miles east of Antigua and, shortly thereafter, ten nautical miles east of Barbuda. Tropical storm and hurricane warnings were issued as appropriate for the islands near Klaus' path as summarized in Table 2.

Klaus reached its peak on the 5th with 70-knot winds and a 985-millibar central pressure and was a hurricane for only 15 hours. Although it moved close to the Leeward Islands as a hurricane, there were no observations of sustained tropical-storm-force winds at Antigua or other nearby islands. This was due to the frequent shearing conditions that caused most of the deep convection and strong winds to be located north and east of the circulation center.

On the 6th, Klaus weakened to a tropical storm and turned slightly toward the west northwest, its center remaining rather close to the northern Leeward Islands and then the U.S. and British Virgin Islands. By 0000 UTC on the 8th, Klaus was north of the Mona Passage when it weakened to a tropical depression in response to persistent strong shearing.

Klaus regained deep convection near its center and also regained tropical storm status at 1200 UTC on the 8th. With the storm's forward motion toward the northwest at 12 to 15 knots, tropical storm warnings were subsequently issued for the central

and northern Bahamas. Klaus peaked, for the second time, late on the 8th and early on the 9th, with 45-knot winds.

A secondary low pressure center was noted at mid-atmospheric levels as early as the 6th near eastern Cuba. This low drifted westward and gradually worked its way to the surface near western Cuba. By late on the 9th, this low became the dominant feature and absorbed the now rapidly-weakening Klaus, as the low developed into Tropical Storm Marco. The remnants of Klaus, interacting with Marco and a slow-moving cold front, were responsible for some heavy rainfall that spread across portions of the southeastern United States.

b. Meteorological Statistics

Figure 2 is a plot of the pressure data for Klaus and of the best track pressure curve. Figure 3 is a plot of all wind speed observations for Klaus and contains the best-track wind speed curve.

There were 13 aircraft reconnaissance missions into Klaus with a total of 40 center fixes during the seven-day period from 3 to 9 October. In addition, there were several investigative missions before Klaus became a tropical cyclone. The best track peak wind of 70 knots on the 5th is based on an aircraft measurement of 72 knots at 1500 feet. The highest satellite-based intensity estimate during this time was 55 knots.

There were 18 ship reports with sustained wind speeds of tropical storm force. All but a few of these were well removed from the circulation center and were more closely associated with a strong pressure gradient caused by nearby high pressure. The highest wind report from a ship was 47 knots at 1500 UTC on the 8th, located 80 nautical miles northeast of the center.

There were 15 radar center fixes from St. Martin in the Leeward Islands on the 5th and 6th. The accuracy of all of these fixes was given as poor since the center was not well defined.

Grand Turk in the Bahamas reported 4.00 inches in 36 hours. There may well have been much higher totals recorded in the Leeward Islands since Klaus moved so slowly through this area. The remnants of Klaus brought 10 to 15 inches of rain to the South Carolina midlands on the 10th and 11th of October. Ten inches of rain in the southern piedmont section of North Carolina is also attributed to the remnants of Klaus. Georgia also received some rain from the remnants. Details of rainfall totals in the southeastern United States are contained in the Marco preliminary report.

c. Casualty and Damage Statistics

Four drowning deaths were reported from South Carolina when a dam burst and swept away a car and its occupants. Dollar damage

estimates are contained in the Marco report.

d. Warning and Forecast Critique

A preliminary analysis shows the official track forecast errors to be small, ranging from 84 nautical miles at 24 hours to 197 nautical miles at 72 hours. The guidance models were not very useful as the official errors were smaller than all of the models at 48 and 72 hours. Only the CLIPER an NHC90 models did better than the official forecast at 24 hours.

Table 3 lists the 72-hour probabilities that were issued with the National Hurricane Center Advisories during this event.

Miles Lawrence

Table 1. Preliminary best track, Hurricane Klaus, 3 - 9 October 1990.

Date/Time (UTC)	Position Lat(°N)	Lon(°W)	Pressure (mb)	Wind Speed (kt)	Stage
03/1200	15.6	59.3	1008	30	Trop Depression
1800	16.2	59.6	1007	35	Trop Storm
04/0000	16.4	59.8	1005	45	
0600	16.5	60.1	997	50	
1200	16.6	60.4	997	50	
1800	16.8	60.7	997	55	
05/0000	16.9	60.9	996	55	
0600	17.0	61.1	993	60	
1200	17.2	61.2	985	70	Hurricane
1800	17.4	61.4	991	70	
06/0000	17.7	61.6	992	65	
0600	18.1	61.8	994	60	Trop Storm
1200	18.3	62.1	995	60	
1800	18.6	62.3	996	55	
07/0000	18.7	62.7	998	55	
0600	18.8	63.1	1000	55	
1200	18.9	63.8	1001	50	
1800	19.2	64.9	1004	40	
08/0000	19.7	66.1	1005	30	Trop Depression
0600	20.4	67.5	1005	30	
1200	21.1	68.9	1005	40	Trop Storm
1800	21.9	70.1	1004	45	
09/0000	22.6	71.2	1004	45	
0600	23.4	72.3	1006	45	
1200	24.5	73.4	1007	35	
1800					Dissipated
05/1200	17.2	61.2	985	70	Minimum Pressure

Table 2. Warning summary, Hurricane Klaus, October 1990.

date/time(UTC) action	location
04/0230	
tropical storm warning	The northern Leeward Islands from St. Martin to Antigua
tropical storm watch	Guadeloupe and neighboring is.
04/1300	
tropical storm warning	Guadeloupe and neighboring is.
04/1600	
hurricane warning	St. Martin to Antigua
05/1600	
hurricane watch	U.S. and British Virgin Islands
06/0700	
tropical storm warning	St. Martin to Guadeloupe
tropical storm watch	U.S. and British Virgin Islands
06/1300	
tropical storm watch discont.	U.S. and British Virgin Islands
06/1600	
tropical storm warning discont.	St. Martin to Guadeloupe
08/1900	
tropical storm warning	Central Bahamas
tropical storm watch	Northern Bahamas
09/1300	
tropical storm warning	Northern Bahamas
09/1600	
tropical storm warning discont.	Central and Northern Bahamas

Table 3. 72-hour probability, in percent, of center of Tropical Storm Klaus passing within 65 miles of listed locations(time is AST).

ADVISORY ISSUANCE TIME:	03/6PM	03/1030	04/6AM	04/NOON	04/6PM
PROBABILITY END TIME:	06/2PM	06/8PM	07/2AM	07/8AM	07/2PM
SKPG 125N 717W	2	2	X	X	X
TNCC 122N 690W	3	2	X	X	X
SVMG 110N 640W	2	X	X	X	X
TGPY 120N 618W	3	X	X	X	X
TBPB 131N 595W	3	2	2	2	X
TVSV 131N 612W	4	3	3	2	X
TLPL 138N 610W	6	4	4	4	2
TFFF 146N 610W	10	7	9	9	5
TDPR 153N 614W	15	12	15	17	13
TFFR 163N 615W	25	24	29	99	99
TAPA 171N 618W	29	29	31	42	99
TKPK 173N 627W	21	20	20	25	38
TNCM 181N 631W	22	20	19	22	32
MDSD 185N 697W	6	6	6	6	8
MDCB 176N 714W	4	4	4	4	6
MTPP 186N 724W	3	3	3	3	5
MTCA 183N 738W	2	2	2	2	4
MKJP 179N 768W	X	X	X	X	2
MUGM 200N 751W	X	X	X	X	3
MDPP 198N 707W	4	5	5	5	8
MBJT 215N 712W	3	4	4	4	7
MYMM 224N 730W	X	2	2	3	4
MYSM 241N 745W	X	X	X	X	3
MYEG 235N 758W	X	X	X	X	2
ST CROIX VI	16	14	12	14	17
ST THOMAS VI	15	14	13	14	17
SAN JUAN PR	12	12	10	11	14
PONCE PR	11	11	9	10	13

Table 3(cont.). 72-hour probability, in percent, of center of Hurricane Klaus passing within 65 miles of listed locations(time is AST).

ADVISORY ISSUANCE TIME:	04/1030	05/6AM	05/NOON	05/6PM	05/1030
PROBABILITY END TIME:	07/8PM	08/2AM	08/8AM	08/2PM	08/8PM
TFFF 146N 610W	3	2	X	X	X
TDPR 153N 614W	9	7	5	3	2
TFFR 163N 615W	99	99	99	19	6
TAPA 171N 618W	99	99	99	99	99
TKPK 173N 627W	42	38	41	31	23
TNCM 181N 631W	39	36	39	30	30
MDSD 185N 697W	9	8	8	7	7
MDCB 176N 714W	6	5	6	4	4
MTPP 186N 724W	6	5	6	4	5
MTCA 183N 738W	4	4	4	3	4
MKJP 179N 768W	2	2	2	2	2
MKJS 185N 779W	2	2	2	X	2
MUGM 200N 751W	4	4	4	3	4
MUCM 214N 779W	2	2	2	2	2
MDPP 198N 707W	8	8	8	7	7
MBJT 215N 712W	7	8	8	7	8
MYMM 224N 730W	5	6	6	5	6
MYSM 241N 745W	3	4	4	3	X
MYEG 235N 758W	3	3	3	3	3
MYAK 241N 776W	X	2	2	X	2
MYNN 251N 775W	X	2	2	X	2
BERMUDA	X	2	2	2	2
ST CROIX VI	19	16	17	13	11
ST THOMAS VI	19	17	18	14	13
SAN JUAN PR	15	14	14	11	11
PONCE PR	13	12	12	10	9

Table 3(cont.). 72-hour probability, in percent, of center of Tropical Storm Klaus passing within 65 miles of listed locations(time is AST).

ADVISORY ISSUANCE TIME:	06/6AM	06/NOON	06/6PM	06/1030	07/6AM
PROBABILITY END TIME:	09/2AM	09/8AM	09/2PM	09/8PM	10/2AM
TFFR 163N 615W	2	2	X	X	X
TAPA 171N 618W	99	19	7	3	X
TKPK 173N 627W	32	26	16	8	2
TNCM 181N 631W	99	99	99	30	99
MDSD 185N 697W	9	9	8	7	11
MDCB 176N 714W	6	6	5	5	7
MTPP 186N 724W	7	7	6	6	8
MTCA 183N 738W	5	6	5	5	7
MKJP 179N 768W	3	3	3	3	5
MKJS 185N 779W	3	3	3	3	4
MWCG 193N 814W	2	2	2	2	3
MUGM 200N 751W	6	6	6	6	8
MUCM 214N 779W	4	4	5	5	6
MUCF 214N 779W	2	2	3	3	4
MUSN 216N 826W	X	X	X	2	2
MUHA 230N 824W	X	X	2	2	3
MDPP 198N 707W	10	10	9	9	13
MBJT 215N 712W	11	11	11	11	14
MYMM 224N 730W	9	9	10	10	12
MYSM 241N 745W	7	7	8	8	9
MYEG 235N 758W	6	6	7	7	8
MYAK 241N 776W	4	4	5	6	6
MYNN 251N 775W	4	4	4	5	6
MYGF 266N 787W	2	2	3	4	4
BERMUDA	2	2	3	3	2
ST CROIX VI	15	15	12	10	14
ST THOMAS VI	19	19	17	15	29
SAN JUAN PR	15	15	13	12	20
PONCE PR	12	12	9	9	13
MARATHON FL	X	2	X	3	3
MIAMI FL	X	2	X	3	3
W PALM BEACH FL	X	2	X	3	3
FT PIERCE FL	X	X	X	X	2
COCOA BEACH FL	X	X	X	X	2
KEY WEST FL	X	X	X	X	3
MARCO ISLAND FL	X	X	X	X	2
FT MYERS FL	X	X	X	X	2

Table 3(cont.). 72-hour probability, in percent, of center of Tropical Storm Klaus passing within 65 miles of listed locations(time is AST).

ADVISORY ISSUANCE TIME:	07/NOON	07/6PM	07/1030	08/6AM	08/NOON
PROBABILITY END TIME:	10/8AM	10/2PM	10/8PM	11/2AM	11/8AM
TKPK 173N 627W	3	X	X	X	X
TNCM 181N 631W	29	X	X	X	X
MDSD 185N 697W	14	16	15	X	X
MDCB 176N 714W	9	9	7	X	X
MTPP 186N 724W	10	12	12	3	X
MTCA 183N 738W	9	10	10	3	X
MKJP 179N 768W	6	7	7	3	X
MKJS 185N 779W	6	7	8	4	2
MWCG 193N 814W	3	5	5	4	3
MUGM 200N 751W	9	12	13	10	7
MUCM 214N 779W	7	10	11	12	11
MUCF 214N 779W	4	7	7	9	9
MUSN 216N 826W	3	5	5	7	6
MUHA 230N 824W	3	5	5	8	8
MUAN 219N 850W	X	3	3	4	5
MMCZ 205N 869W	X	2	2	2	2
MDPP 198N 707W	15	19	30	28	6
MBJT 215N 712W	14	19	33	60	74
MYMM 224N 730W	12	16	20	40	51
MYSM 241N 745W	9	12	14	24	31
MYEG 235N 758W	8	12	13	20	25
MYAK 241N 776W	6	9	10	16	18
MYNN 251N 775W	6	9	9	15	18
MYGF 266N 787W	4	6	6	12	14
ST CROIX VI	24	3	X	X	X
ST THOMAS VI	41	27	X	X	X
SAN JUAN PR	32	34	6	X	X
PONCE PR	22	17	2	X	X
MARATHON FL	3	6	6	10	11
MIAMI FL	3	6	6	11	13
W PALM BEACH FL	3	5	5	10	12
FT PIERCE FL	2	4	4	9	11
COCOA BEACH FL	X	3	3	8	10
DAYTONA BEACH FL	X	2	2	7	9
JACKSONVILLE FL	X	X	X	5	7
SAVANNAH GA	X	X	X	3	5
CHARLSTON SC	X	X	X	3	5
MYRTLE BEACH SC	X	X	X	2	4
WILMINGTON NC	X	X	X	2	3
MOREHEAD CITY NC	X	X	X	2	3
CAPE HATTERAS NC	X	X	X	2	3
KEY WEST FL	3	5	5	9	10
MARCO ISLAND FL	2	4	4	9	11
FT MYERS FL	2	4	3	8	10
VENICE FL	X	3	3	7	9
TAMPA FL	X	2	2	7	9
CEDAR KEY FL	X	X	X	5	7
ST MARKS FL	X	X	X	3	5
APALACHICOLA FL	X	X	X	3	5
PANAMA CITY FL	X	X	X	2	4
PENSACOLA FL	X	X	X	X	2
MOBILE AL	X	X	X	X	2
BURAS LA	X	X	X	X	2

Table 3(cont.). 72-hour probability, in percent, of center of Tropical Storm Klaus passing within 65 miles of listed locations(time is AST).

ADVISORY ISSUANCE TIME:	08/6PM	08/1030	09/6AM
PROBABILITY END TIME:	11/2PM	11/8PM	12/2AM
MKJS 185N 779W	X	X	X
MWCG 193N 814W	X	X	X
MUGM 200N 751W	X	X	X
MUCM 214N 779W	4	X	2
MUCF 214N 779W	4	X	3
MUSN 216N 826W	2	X	X
MUHA 230N 824W	4	X	4
MUAN 219N 850W	2	X	X
MMCZ 205N 869W	X	X	X
MDPP 198N 707W	X	X	X
MBJT 215N 712W	99	99	X
MYMM 224N 730W	48	66	99
MYSM 241N 745W	40	50	66
MYEG 235N 758W	23	28	71
MYAK 241N 776W	16	17	47
MYNN 251N 775W	20	21	47
MYGF 266N 787W	16	18	30
MARATHON FL	9	9	13
MIAMI FL	12	13	22
W PALM BEACH FL	13	15	23
FT PIERCE FL	13	15	21
COCOA BEACH FL	13	14	19
DAYTONA BEACH FL	12	13	17
JACKSONVILLE FL	11	12	15
SAVANNAH GA	10	11	13
CHARLSTON SC	10	11	12
MYRTLE BEACH SC	9	10	11
WILMINGTON NC	8	9	10
MOREHEAD CITY NC	8	9	9
CAPE HATTERAS NC	7	8	7
NORFOLK VA	5	7	7
OCEAN CITY MD	4	5	5
ATLANTIC CITY NJ	3	4	4
NEW YORK CITY NY	2	3	3
MONTAUK POINT NY	X	2	2
PROVIDENCE RI	X	2	2
NANTUCKET MA	X	2	2
HYANNIS MA	X	2	2
BOSTON MA	X	X	2
KEY WEST FL	8	7	10
MARCO ISLAND FL	10	10	15
FT MYERS FL	10	11	15
VENICE FL	10	10	14
TAMPA FL	10	11	15
CEDAR KEY FL	10	10	14
ST MARKS FL	8	9	12
APALACHICOLA FL	7	8	11
PANAMA CITY FL	7	7	10
PENSACOLA FL	5	5	8
MOBILE AL	4	4	7
GULFPORT MS	4	4	6
BURAS LA	3	3	5
NEW ORLEANS LA	3	3	4
NEW IBERIA LA	2	2	3
PORT ARTHUR TX	X	X	2

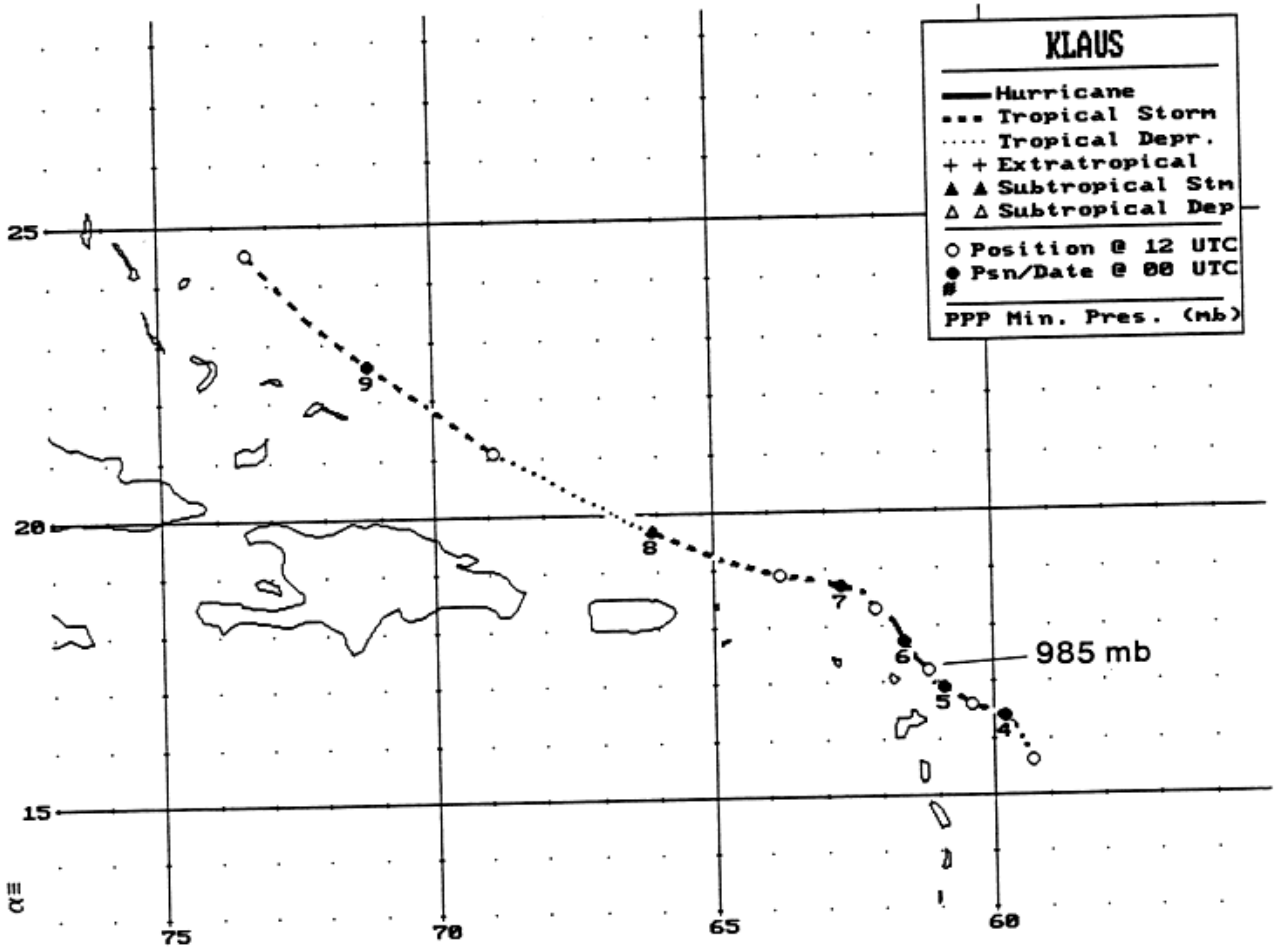

Fig. 1. Best track positions for Hurricane Klaus, 3-9 October, 1990.

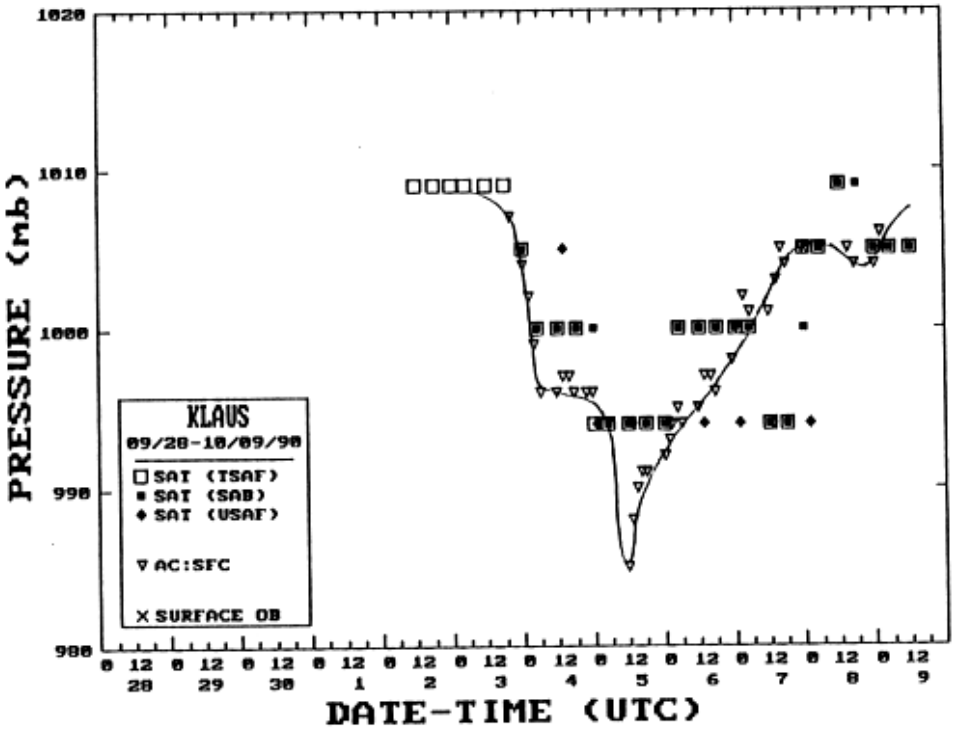

Fig. 2. Best track minimum central pressure curve for Hurricane Klaus, 3-9 October, 1990.

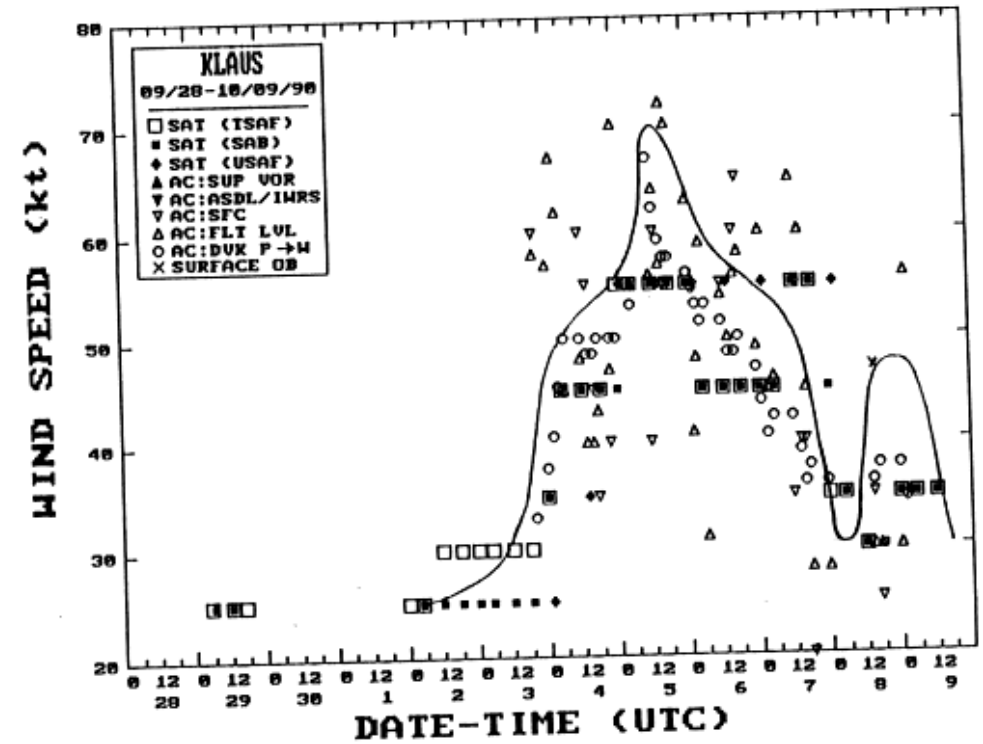

Fig. 3. Best track one-minute surface wind speed curve for Hurricane Klaus, 3-9 October, 1990.