

Preliminary Report
Hurricane Lenny
13 - 23 November 1999

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Hurricane Lenny was the fifth category-four hurricane on the Saffir/Simpson Hurricane Scale (SSHS) of the 1999 season - a record. This hurricane had a major impact on numerous land areas in the Caribbean Sea. Moreover, Lenny was the first storm to have an extended west-to-east track across the central and eastern Caribbean Sea in the 113-year Atlantic tropical cyclone record.

a. Synoptic History

A broad area of low pressure was first identified in the southwest Caribbean Sea early on 8 November. Later that day, there was sufficient convective banding to warrant a T1.0 Dvorak satellite-based intensity classification from the Tropical Analysis and Forecast Branch (TAFB) at TPC. Although thunderstorm activity associated with the low remained poorly organized, locally heavy rains and strong gusty winds occurred over the northwest Caribbean Sea and adjacent portions of Central America and Mexico for several days. On 12 November, a U.S. Air Force Reserve (USAFR) Hurricane Hunter aircraft investigated the disturbance but failed to find a well-defined surface circulation center. Early on the 13th, satellite imagery showed that the system was gradually becoming better organized. Later that afternoon the Hurricane Hunters found 30 knot surface winds and a 1003 mb central pressure. Tropical Depression Sixteen formed about 150 n mi south of the Cayman Islands at 1800 UTC 13 November (This is when the best track begins in Table 1 and Figure 1). By mid morning of the 14th, the overall organization of the depression was improving and the depression was estimated to have become Tropical Storm Lenny at 1200 UTC 14 November.

A USAFR reconnaissance mission the afternoon of the 14th found maximum flight-level (1500 ft) winds of 84 knots and a central pressure of 988 mb. Lenny became a hurricane at 0000 UTC 15 September while centered about 150 miles southwest of Kingston, Jamaica. DMSP SSM/I imagery near this time showed a banding-type eye 15-20 n mi in diameter. During the next 12 hours, the central pressure fell 10 mb and Lenny strengthened to a 85-

knot, category two hurricane on the SSHS.

By the evening of the 15th, the eye was no longer discernible in satellite imagery, the overall cloud pattern became less organized, and Lenny weakened to 75 knots - see Figure 2a.

One of the most interesting aspects of Lenny was its extended west-to-east motion through the Caribbean, unprecedented in the 113-year Atlantic basin tropical cyclone record. For its first 48 hours, Lenny moved on a east to east-southeast course. This motion was induced by the flow around the southern portion of a deep-layer trough located over the western Atlantic. Several shortwave troughs helped to amplify the mean western Atlantic trough through the period which increased the westerly steering flow. From 1200 UTC 15 November to 1800 UTC 16 November, Lenny's mean forward motion was 14 knots.

The weakening on the 15th was temporary and Lenny re-intensified early on the 16th. During a 24 hour period beginning about midday on the 16th, the central pressure dropped 34 mb. Lenny's maximum sustained surface winds of 135 knots and minimum central pressure (933 mb) occurred at 1800 UTC 17 November when the hurricane was centered about 18 n mi south of St. Croix in the U.S. Virgin Islands. However, the 135-knot winds were confined to the southeast quadrant of the hurricane and these strongest wind speeds did not occur over land.

Lenny moved into a col point between two mid-level ridges late on the 17th and its forward motion slowed. The hurricane drifted east-northeastward before turning southeastward early on the 19th. Despite what appeared in satellite imagery as a favorable upper-level outflow pattern, Lenny weakened, perhaps due to upwelling. Lenny was gradually weakening when its center passed very slowly over St. Maarten during the afternoon of the 18th, Anguilla later that evening, and St. Barthelemy early on the 19th. Lenny weakened to a tropical storm on the 19th just south of St. Barthelemy. The storm made its final landfall in Antigua late on the 19th.

Lenny continued to move southeastward and the forward motion increased to near 8 knots. The motion turned again toward the northeast as Lenny weakened to a depression at 0000 UTC 21 November. The depression turned back to the east early on the 21st and Lenny dissipated on the morning of the 23rd about 600 n mi east of the leeward islands.

b. Meteorological Statistics

The best-track intensities in Table 1 were obtained from the data in Figures 3 (a) and 4 which depict the curves of maximum sustained one-minute average "surface" (10 meters above ground level) wind speed and minimum central sea-level pressure, respectively, as a function of time. These figures also contain data upon which the curves are based: USAFR and NOAA aircraft reconnaissance flight level wind speeds and GPS dropsonde data, intensity estimates from surface synoptic data, and 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). The flight-level wind data in Figures 3a and 3b have been adjusted for elevation (90% of 700 mb wind speeds, 80% of 850 mb wind speeds, and 85% of 1500 ft speeds). Dropsonde wind speed measurements that terminate above the 10 meter level are adjusted to 10 meters using a mean hurricane eyewall profile determined by previous dropsonde measurements. For clarity, Figure 3(b) shows only the aircraft flight level and dropsonde data

1. Wind and Pressure Data

The majority of the aerial reconnaissance flights into Lenny were done by the USAFR "Hurricane Hunters". The Hurricane Hunters flew 17 reconnaissance missions, and made 46 center fixes while NOAA aircraft performed two missions contributing four center fixes. Lenny also featured the first utilization of the new USAFR WC130-J model aircraft for reconnaissance. Figure 5 is a radar image from the new J model at 0321 UTC 18 November right before it penetrated the eye for a fix.

The peak intensity of Lenny, 135 knots, is based on 90% of the 149 knot flight-level (700 mb) wind speed reported at 1702 UTC 17 November. The GPS dropsonde from this fix operationally measured 180 knots at 891 mb. Post-flight processing corrected this value to 183 knots, a record dropsonde wind speed in a hurricane. Figure 6 shows the eyewall dropsonde wind profile at 1940 UTC 17 November; the 10-meter wind was 125 kt. The lowest pressure recorded by the aircraft was 934 mb at 1929 UTC 17 November. However, the minimum central pressure of 933 mb was assigned based on the lower 700 mb height on the 1702 UTC fix. The 929 mb pressure from the 2134 UTC fix was an extrapolated value and has been discounted.

Table 2 lists a selection of surface observations from land stations. The highest official sustained surface wind speed (gust) observed over land was 73 knots (90 knots) at the St. Maarten Meteorological Office in Phillipsburg at 0200 UTC 19 November. However, the meteorological antenna fell down during the strongest winds. Hamilton Airport on St. Croix recorded sustained 1-minute winds of 60 knots, with a gust to 80 knots, at 1933 UTC 17 November. The lowest official pressure observed in the northern Leeward Islands was 972.1 mb at the St. Maarten Meteorological Office at 0200 UTC 19 November. Table 3 lists ship reports of 34 knot winds or higher associated with Lenny.

Table 4 lists selected amateur radio weather reports. The maximum sustained surface wind speed reported via amateur radio operators was 81 knots on St. John in the U.S. Virgin Islands at 1900 UTC 17 November. During the peak of the hurricane, Saba recorded a gust of 145 knots (2600 ft elevation) before the anemometer blew away. The highest measured gust on St. Croix was 97 knots at 2000 UTC 17 November, two hours after Lenny reached its peak intensity. This gust measurement coincides with Lenny's closest approach to the island. The minimum central pressure at St. Croix, 980 mb, was also recorded at this time.

2. Rainfall Data

Lenny's slow drift across the northern Leeward Islands for a 36-hour period resulted in some very high rainfall amounts. For many locations heavy rains over several days was the primary impact of Lenny. Portions of French St. Martin, St. Barthelemy, and Guadeloupe received record rains. The highest reported storm-total rainfall was 34.12 inches on St. Martin at Gendarmerie. This included a 24-hour record of 18.98 inches on the 18 November. St. Martin Marigot D.D.E. recorded 26.10 inches. Of this total, a record 22.64 inches fell in a 24-hour period beginning around midday on the 17th. Rainfall totals on St. Barthelemy were about 15 inches while 6 to 12 inch totals were typical on Guadeloupe. The highest rainfall total in Dutch St. Maarten was 27.56 inches recorded at the meteorological office in Phillipsburg resulting in mud slides in the area. V.C. Bird International Airport in Antigua reported 18.32 inches in association with Lenny. A little over 25 inches was recorded in the southern portion of the island. There were reports of mud slides from St. Kitts.

Rainfall totals averaged 3 to 4 inches across the U.S. and British Virgin Islands. Hamilton Airport in St. Croix measured 8.05 inches of rain, resulting in widespread flooding around the island inundating many homes. The highest official rainfall total in Puerto Rico was 9.39 inches on Magueyes Island, Lajas. Co-op observer rainfall totals across Puerto Rico averaged 4 to 8 inches with the highest value, 12.39 inches, reported in Toro Negro Orocovis. Landslides and mud slides were reported in interior and west sections of Puerto Rico.

3. Storm Surge/Tide Data

Fredericksted in St. Croix was inundated by an estimated 15 to 20 ft storm surge. However, a complete storm surge survey has not been completed at this time. The maximum recorded storm tide was 2.9 feet at the NOAA National Ocean Service (NOS) gage in Lime Tree Bay on St. Croix. NOAA NOS gages recorded 1.8 feet on St. Thomas and in Puerto Rico (San Juan). There was also considerable coastal erosion reported on St. Croix.

Lenny's approach from the west produced unprecedented wave and storm surge impact on westward-facing coasts and harbors. The meteorological service in Dutch St. Maarten reported that southern and western coastal areas

were significantly impacted by wave action. The Metro-France meteorological station in Gustavia on St. Barthelemy estimated waves of up to 16 feet in the harbor on 17 November. A platform near La Desirade, just east of Grande-Terre Guadeloupe, recorded a significant wave height of 9.8 ft at 2300 UTC 20 November. Estimates range up to 13 ft in the harbor.

Lenny generated large waves and swells that propagated across much of the southern and eastern Caribbean, affecting the Guajira Peninsula of Colombia, Aruba, Bonaire, Curacao, and much of the remainder of the Leeward and Windward Islands.

c. Casualty and Damage Statistics

There were 17 deaths directly associated with Lenny, 3 in Dutch St. Maarten, 2 in Colombia, 5 in Guadeloupe, 1 in Martinique, and 6 offshore. Two of the deaths in St. Maarten were caused by flying debris while the other was the result of a collapsed roadway. The remainder of the onshore fatalities, based on media reports, are presumed to be due to freshwater flooding. Two of the offshore deaths occurred when the sailing yacht **VIDAR** was lost somewhere in the southern Caribbean Sea.

Lenny produced considerable damage on many of the islands in the northeast Caribbean due to the heavy rains and unprecedented wave and storm surge action. St. Croix sustained moderate damage. Many boats were washed ashore along the north coast of the island. In Christiansted Harbor, several boats sunk and south and east portions of the island suffered roof damage. Lenny also impacted the agricultural areas of the island. Both the Dutch and French portions of St. Maarten/Martin were severely impacted with many buildings damaged and boats damaged or lost. In St. Lucia, at least 70 homes were reported damaged. In Saba, the airport tower and several other buildings were severely damaged. Guadeloupe sustained a large amount of damage along the west coast due to the wave action and inland due to heavy rains.

In Grenada, ten homes were destroyed and 21 small boats were lost. There were also reports of damage St. Vincent and the Grenadines, and Montserrat.

Insured losses of 165 million U.S. dollars have been reported from Puerto Rico and the U.S. Virgin Islands. Using a factor of 2.0, the total U.S. damages from Lenny is estimated at 330 million dollars.

d. Forecast and Warning Critique

With guidance from global models, the incipient disturbance that was to become Lenny was first identified as a candidate for development in NHC's

Tropical Weather Outlook about five days before it became a tropical depression.

The official track forecast errors for Lenny, along with those of the various objective techniques, are listed in Table 5. With the exception of the 12 hour time period, the errors for Lenny were 5% (24 h) to 33% (72 h) above the most recent ten-year averages. Lenny's unique track likely contributed to the larger-than-normal track errors. In contrast to the official forecast errors, the UKM 24 h, 36 h, 48 h, and 72 h track forecast errors were below the most recent ten-year averages. The UKMI errors were 12% (24 h) to 40% (72 h) below the official forecast. Most of the remaining objective guidance forecast errors were above the official forecast at all time periods.

An examination of the official intensity forecasts for Lenny show that the strengthening of Lenny was under-forecast prior to its peak intensity and over-forecast thereafter. Intensity forecast errors were as large as 35 to 45 knots at 24 to 36 hours and 60 to 75 knots in 48 to 72 hours. These errors are not surprising given the unusual strength of Lenny. Meanwhile, the official forecasts were as much as 40 to 45 knots too high 24 to 36 hours after the peak intensity was reached. The Statistical Hurricane Intensity Prediction Scheme (SHIPS), typically the best intensity guidance, under-forecast Lenny's peak intensity by 41 to 51 knots at 24 to 36 hours.

Table 6 lists the various watches and warnings that were issued for Lenny. Hurricane warnings were posted for the U.S. Virgin Islands about 36 hours before the onset of hurricane-force winds. Similar lead times were provided to the northern Leeward Islands.

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(The Metro-France Service Regional de Guadeloupe report on Lenny can be accessed from the Metro-France Web Site <http://www.meteo.gp/webAG/cyclone/cyclone.htm>)

Table 1.
Preliminary Best Track - Hurricane Lenny, 13 - 23 November 1999.

Date/Time (UTC)	Lat. (°N)	Long. (°W)	Pressure (mb)	Wind Speed (kt)	Stage
13/1800	16.7	81.6	1003	30	Tropical Depression
14/0000	16.5	81.1	1003	30	"
14/0600	16.4	80.5	1002	30	"
14/1200	16.4	79.9	1000	40	Tropical Storm
14/1800	16.3	79.3	992	55	"
15/0000	16.0	78.6	988	70	Hurricane
15/0600	15.5	77.7	977	75	"
15/1200	15.1	76.4	971	85	"
15/1800	14.8	74.8	983	75	"
16/0000	15.0	73.4	982	75	"
16/0600	15.1	72.0	974	75	"
16/1200	15.1	70.5	971	85	"
16/1800	15.4	69.0	967	85	"
17/0000	15.9	67.6	959	100	"
17/0600	16.4	66.5	952	105	"
17/1200	16.8	65.5	946	115	"
17/1800	17.4	64.8	933	135	"
18/0000	17.6	64.2	940	130	"
18/0600	17.8	63.9	944	125	"
18/1200	17.9	63.6	953	120	"
18/1800	18.0	63.3	966	110	"
19/0000	18.1	63.1	972	85	"
19/0600	18.0	62.9	979	75	"

Table 1 (continued).
Preliminary Best Track - Hurricane Lenny, 13 - 23 November 1999.

Date/Time (UTC)	Lat. (°N)	Long. (°W)	Pressure (mb)	Wind Speed (kt)	Stage
19/1200	17.9	62.8	986	70	Hurricane
19/1800	17.6	62.5	994	60	Tropical Storm
20/0000	17.3	61.8	994	55	"
20/0600	17.0	61.1	995	55	"
20/1200	16.5	60.4	996	50	"
20/1800	15.9	59.8	998	45	"
21/0000	16.0	59.0	998	40	"
21/0000	16.5	58.1	998	30	Tropical Depression
21/1200	17.2	57.1	999	30	"
21/1800	18.0	56.7	1000	25	"
22/0000	18.4	56.1	1001	25	"
22/0600	18.5	55.7	1002	25	"
22/1200	18.5	55.3	1004	25	"
22/1800	18.5	54.7	1005	20	"
23/0000	18.5	53.8	1006	20	"
23/0600	18.5	52.8	1006	20	"
23/1200					Dissipated
17/1800	17.4	64.8	933	135	Minimum Pressure
L a n d f a l l s					
17/1800	17.4	64.8	933	135	St. Croix USVI
18/1800	18.0	63.3	966	110	St. Martin
19/0000	18.1	63.1	975	85	Anguilla
19/0600	18.0	62.9	979	75	St. Barthelemy
20/0000	17.3	61.8	994	55	Antigua

Table 2.
Hurricane Lenny selected surface observations, November 1999.

Location	Pres. (mb)	Date/ Time (UTC)	Sust. Wind (kt)	Peak Gust (kt)	Date/ Time (UTC) ^b	Storm Surge (ft) ^c	Storm Tide (ft) ^d	Total Rain (in)
St. Maarten								
Met. Office (Roof) - Phillipsburg	972.1	19/0200	73	90	19/173			18.65
Met. Office FMC8 Auto. Rain								27.56
Antigua								
V.C. Bird International Airport	994.5	20/0100	35	50	19/204			18.32
English Harbour				69	19/XXX			
U.S. Virgin Islands								
<i>St. Croix</i>								
Hamilton Airport	981.7	17/1933	60	80	17/203			8.05
Maria Hill [®]	969.9	17/2010	72	97	17/183			
USDA MET STN Frederk								2.78
Lime Tree Bay/NOAA NOS Gage							2.9	
<i>St. Thomas</i>								
Cyril E. King Airport	993.2	17/1654	46	61	18/041			4.34
USGS/Bonne Resolution GUT								2.01
USGS/National Park Service								3.44
Charlotte Amalie/NOAA NOS							1.8	
<i>St. John</i>								
Health Center/NWS Sensor				80	17/XXX			3.41
USGS/Met Stn Lind Point								2.95
Coral Bay/CO-OP Observer	986.7	17/1900		65	17/171			2.40
Puerto Rico								
Luis Munoz Marin Intl. Airport	1000.0	17/0914	29	34	17/142			2.51
La Puntilla, San Juan/NOAA NOS							1.8	
Ceiba/Roosevelt Roads NS	1001.0	17/1355	29	42	17/134			4.25
Magueyes Isl., Lajas/NOAA NOS							1.1	9.39
NWS CO-OP Observer Rainfall								
Toro Negro Orocovis								12.39
Pico Del Este								11.75
Jayuya								11.41
Rio De La Plata								10.51
Aibonito								9.90
Villalba 3NE								8.46
Rio Blanco Naguabo								7.95
Maunabo								7.45
Rio Orocovis								6.97
Gurabo AG EXP STN								6.71
Cayey 1E								6.61
Lago De Matrullas								6.61
Rio Fajardo Nr Fajardo								6.48
Lago El Guineo								6.35
Pueblo Del Rio Gurabo								6.03
Cerro La Punta / Jayuya								5.94
Juncos 1NNE								5.24
La Plaza 7S Caguas								5.15
Rio Cerrillos Ponce								5.11
Rio Maunabo								5.01
Central Aguirre - South Coast								4.55
Barrio Beatriz/Caguas								4.48
Montones Las Piedras								4.42
Bisley STN El Yunque								4.26
Bairro Arriba/Caguas								3.01

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

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

[®] Unofficial observer data

^d Storm tide is water height above NGVD

Table 3.

Hurricane Lenny ship observations of 34 knots or higher winds,
November 1999.

Location	Date/ Time (UTC)	Pressure (mb)	Sustained Wind (kt)	Significant Wave Height (FT)
LAUS4 (18.4N / 76.7W)	14/0000	1013.9	36	7
PDXQ (14.0N / 81.8W)	15/0900	1006.5	37	M
ELVB6 (13.4N / 78.8W)	15/1500	1005.0	37	M
ELVK5 (16.6N / 74.5W)		1001.0	39	M
OYUY4 (15.2N / 72.2W)	15/1800	1002.0	35	10
FNIH (14.0N / 72.2W)	15/2100	1000.2	40	16
OYUY4 (14.9N / 72.1W)		999.8	35	10
ELVK5 (15.4N / 76.0W)		1002.0	35	M
FNIH (13.9N / 72.7W)	16/0000	998.2	40	20
OYUY4 (14.3N / 71.9W)		998.5	37	13
FNIH (13.9N / 73.0W)	16/0300	999.8	44	20
OYUY4 (14.0N / 72.0W)		1000.0	37	M
OYUY4 (13.5N / 72.1W)	16/0600	999.0	45	20
OYUY4 (13.4N / 72.2W)	16/0900	1000.0	40	20
PEXV (12.6N / 71.4W)	16/1200	1005.6	39	13
ZCBH9 (12.7N / 71.2W)		1003.6	35	13
OYUY4 (13.5N / 72.3W)		1003.5	40	10
OYUY4 (13.3N / 72.8W)	16/1500	1007.9	40	10
OYUY4 (12.3N / 73.5W)	16/2100	1005.0	35	13
V7BV7 (14.7N / 67.6W)	17/0000	996.6	50	10
V2DW (14.6N / 70.0W)	17/0300	1006.0	41	M
V7BV7 (14.6N / 68.1W)	17/0600	1002.5	50	13
PFRO (15.8N / 62.8W)	18/2100	1005.0	41	20
ELTO4 (15.7N / 62.4W)	20/0000	1002.0	38	3
MOBILE (15.7N / 59.1W)	20/1200	1009.5	35	10

^aDate/time is for sustained wind when both sustained and gust are listed
M - missing data

Table 4.

Hurricane Lenny selected amateur radio surface weather reports, November 1999.

CALL SIGN	LOCATION	DATE/TIME (UTC)	PRESSURE (mb)	SUSTAINED WIND (MPH)	PEAK WIND (MPH)
BN2BT	St. Thomas USVI	17/1656	995.0	35	71
G0PBQ/FS	St. Martin - North End	18/2110	988.5		
KC6OXM	Tortola - East End	17/0130	996.0	110-120*	130*
		17/2125	995.0	65-70	102
KF4SZ	Viequez Island	17/1550		40	53
KP2G	St. John USVI	17/1900	993.2	81	85+
KV4F2	St. Croix USVI	17/1423	997.3	45	75
		17/1506		50	80
		17/2125	995.0	65-70	102
N3YMJ	Virgin Gorda BVI	17/0159	988.8	55	85
NP2B	St. Croix USVI	17/1410	1002.0	30-40	63
		17/1509	999.7	45-50	63
		17/1705	993.7	50-55	78
		17/1800	988.5	60	94
		17/1850	984.1	60+	94
		17/2000	980.0	60-70	112
		17/2115	984.4	50-60	75-80
		17/2301	988.8	70-80	90+
PJ8DM	Saba (Elev:2600 Feet)	17/1714	1005.3	40	66
		17/1916	1003.4	40	64
		17/2335			80
		18/0345	1000.0	67	80
		18/0426	998.0	79	
	Report from Neighbor @ 700 ft	18/0435	998.0		101
		18/1148	994.0		
		18/1345	984.0		82
		18/1430	983.0	79	108
VA3GSG	St. Martin	18/0340		45-50	
W0NB/KP2	St. John USVI	17/1843	995.3	73	75

* - Estimated

Table 5.

Preliminary track forecast evaluation of Hurricane Lenny - heterogeneous sample. Errors in nautical miles for tropical storm and hurricane stages with number of forecasts in parenthesis. Numbers in bold type represent forecasts which were better than the official forecast.

Forecast Technique	Period (hours)				
	12	24	36	48	72
CLIP	53 (24)	131 (22)	226 (20)	326 (18)	526 (14)
LBAR	52 (24)	120 (22)	198 (20)	295 (18)	668 (14)
BAMD	58 (25)	122 (23)	183 (21)	246 (19)	398 (15)
BAMM	52 (24)	108 (22)	165 (20)	239 (18)	393 (14)
BAMS	70 (25)	135 (23)	192 (21)	241 (19)	305 (15)
NGPI	66 (15)	165 (13)	281 (10)	326 (8)	362 (4)
NGPS*	252 (13)	266 (12)	316 (10)	367 (9)	334 (7)
UKMI	55 (15)	103 (14)	138 (13)	169 (12)	195 (10)
UKM*	52 (13)	87 (12)	122 (11)	158 (10)	233 (8)
A90E	54 (24)	115 (22)	177 (20)	243 (18)	371 (14)
A98E	54 (24)	116 (22)	186 (20)	262 (18)	368 (14)
A9UK	57 (12)	125 (11)	192 (10)	240 (9)	257 (7)
NHC Official	40 (25)	93 (23)	156 (21)	213 (19)	323 (15)
NHC Official 10-Year Average (1989-1998)	48 (2005)	89 (1790)	128 (1595)	164 (1410)	242 (1107)

* - Output from these models was unavailable at time of forecast issuance.

Table 6. Watch and warning summary, Hurricane Lenny, November 1999.(updated 3/31/00)

Date/Time (UTC)	Action	Location
14/2100	Tropical Storm Warning and Hurricane Watch Issued	Jamaica
15/0000	Hurricane Watch Issued	South coast of Haiti
15/1700	Hurricane Watch Issued	South coast of the Dominican Republic, Perdenales to Cabo Engano
15/1800	Tropical Storm Warning and Hurricane Watch Discontinued	Jamaica
15/2100	Hurricane Watch Issued	Puerto Rico and the U.S. and British Virgin Islands
16/0300	Tropical Storm Warning Issued	South Coast of the Dominican Republic from Cabo Beata to Cabo Engano
	Hurricane Warning Issued	Puerto Rico and the U.S. and British Virgin Islands
16/1500	Tropical Storm Warning and Hurricane Watch Issued	Dutch St. Maarten, St. Eustatius, Saba, Anguilla, Nevis, St. Kitts, Montserrat, Barbuda and Antigua
	Hurricane Watch Discontinued	Haiti
16/2100	Hurricane Warning Issued	Dutch St. Maarten, St. Eustatius, Saba, Anguilla, Nevis, St. Kitts
	Tropical Storm Warning and Hurricane Watch Issued	Dominican Republic, Punta Palenque to Sabana De La Mar
	Tropical Storm Warning and Hurricane Watch discontinued	Elsewhere in the Dominican Republic
17/0300	Hurricane Warning Issued	Montserrat, Barbuda and Antigua
	Tropical Storm Warning and Hurricane Watch discontinued	Dominican Republic
17/0500	Hurricane Warning Issued	French St. Martin
17/2100	Hurricane Warning Downgraded to Tropical Storm Warning	Mainland Puerto Rico
18/0300	Tropical Storm Warning Discontinued	Mainland Puerto Rico west of a Ponce-Manati line
18/1500	Tropical Storm Warning Discontinued	Mainland Puerto Rico east of a Ponce-Manati line
	Hurricane Warning Downgraded to Tropical Storm Warning	Culebra and Vieques
18/2100	Hurricane Warning Discontinued	U.S. and British Virgin Islands
	Tropical Storm Warning Discontinued	Culebra and Vieques
19/2100	Hurricane Warning Discontinued	Dutch St. Maarten, St. Eustatius, Saba, Anguilla, Nevis, St. Kitts
	Hurricane Warning Downgraded to Tropical Storm Warning	Montserrat, Barbuda and Antigua
20/0900	Tropical Storm Warning Discontinued	Montserrat, Barbuda and Antigua

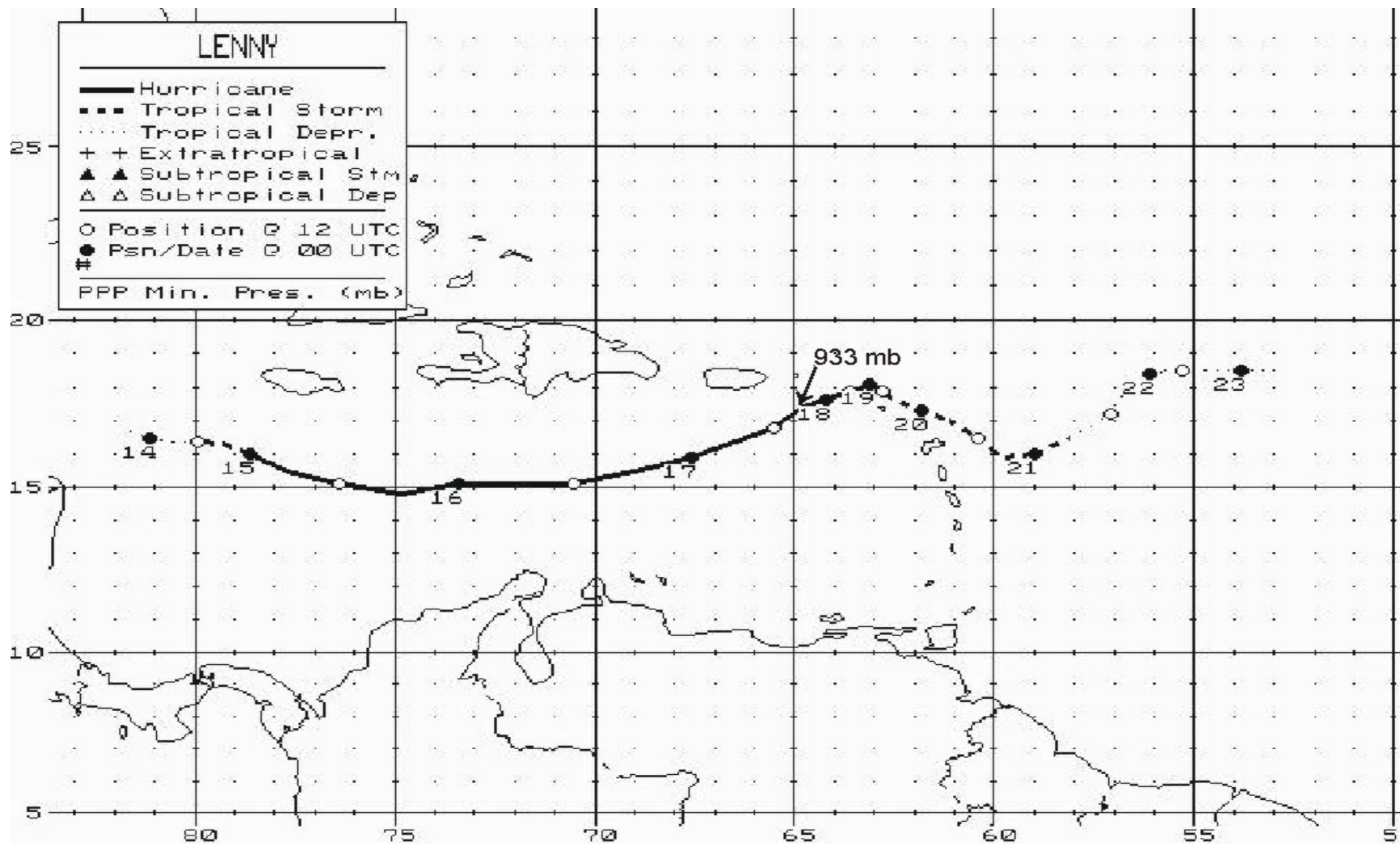
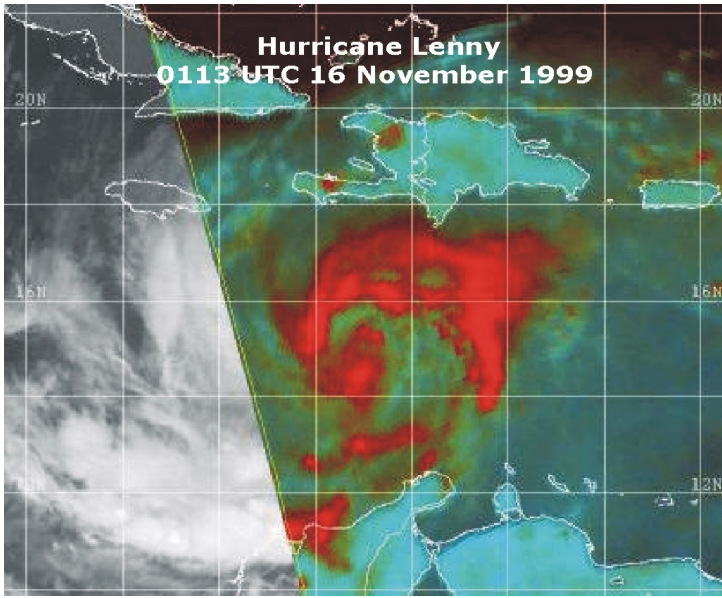
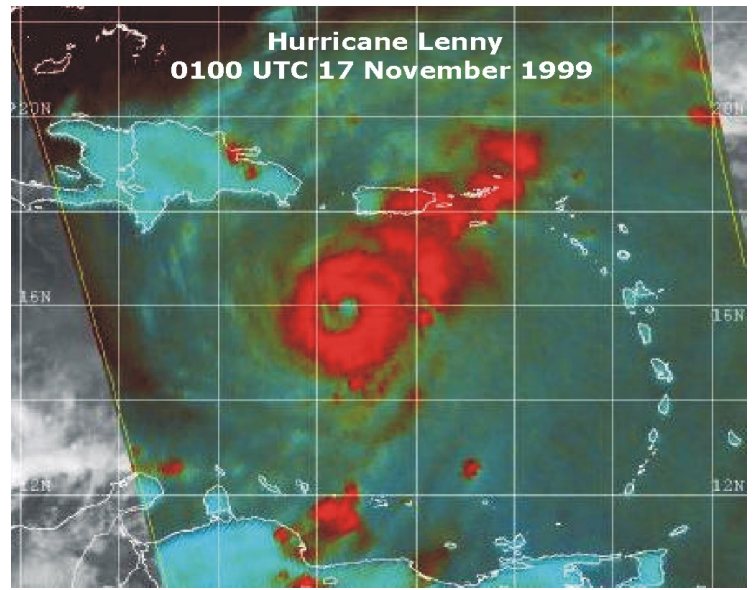


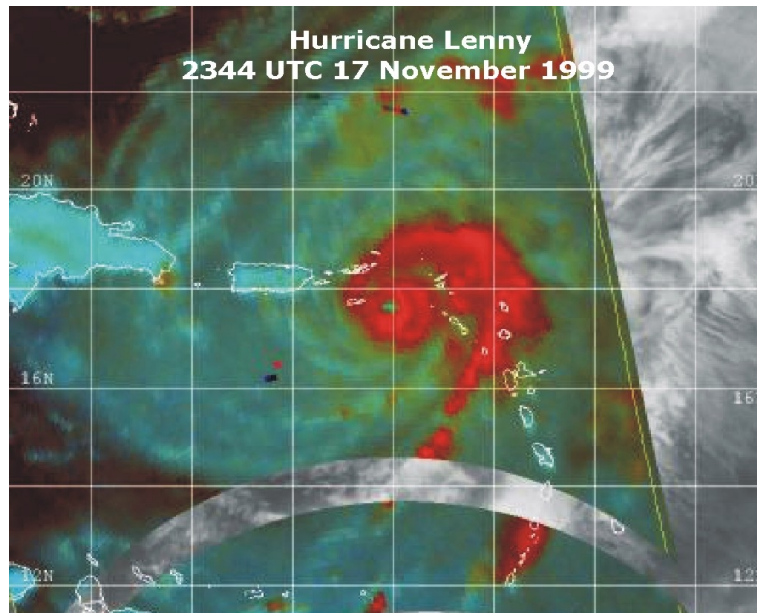
Figure 1. Best track positions for Hurricane Lenny, 13-23 November 1999.



A



B



C

Figure 2. Sequence of SSM/I microwave images of Hurricane Lenny showing the evolution of inner-core region over a 48 hour period from (A) a 75-knot hurricane to (B) a 100-knot hurricane to (C) a 130-knot category four hurricane (about six hours after peak intensity).

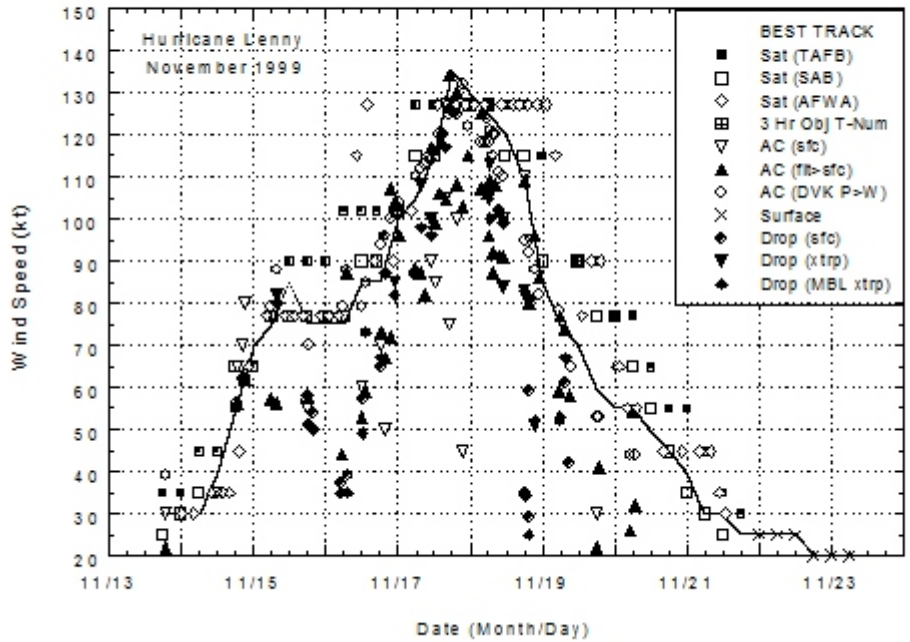


Figure 3a. Best track maximum sustained 1-minute 10 meter wind speed curve for Hurricane Lenny, 13 - 23 November 1999, showing all available intensity estimates and wind observations (aircraft observations adjusted for elevation (90% of 700 mb wind speeds, 80% of 850 mb speeds, and 85% of 1500 ft speeds).

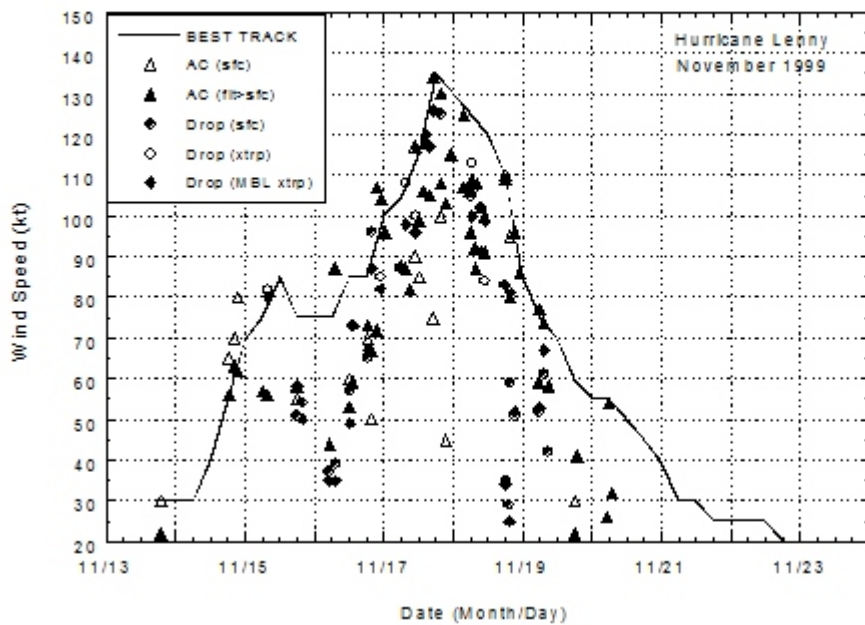


Figure 3b. Best track maximum sustained 1-minute 10 meter wind speed curve for Hurricane Lenny, 13 - 23 November 1999, showing *in situ* wind observations adjusted for elevation (90% of 700 mb wind speeds, 80% of 850 mb speeds, and 85% of 1500 ft speeds).

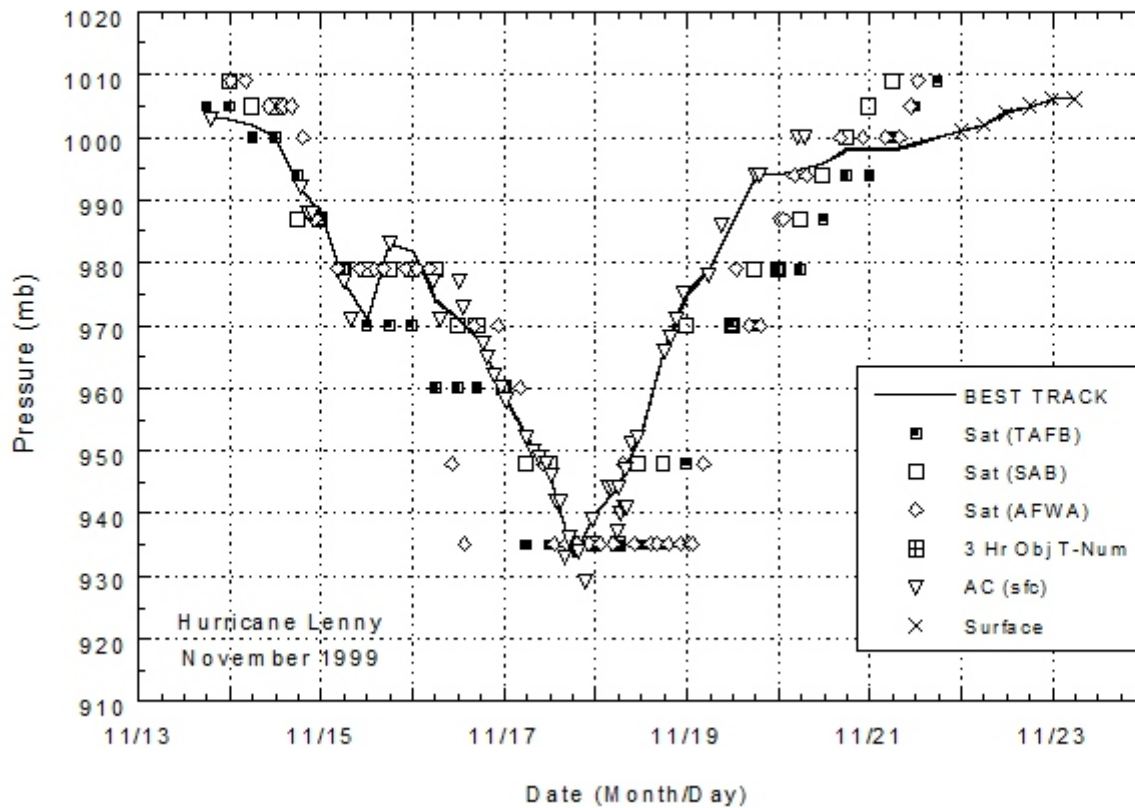


Figure 4. Best track minimum central pressure curve and central pressure observations or estimates for Hurricane Lenny, 13-23 November 1999.



Figure 5. Radar image from the new U.S. Air Force Reserve Hurricane Hunter WC-130J aircraft at 0321 UTC 18 November 1999. The aircraft penetrated the eye at 0332 UTC and reported flight-level (700 mb) winds of 119 knots and a central pressure of 944 mb.

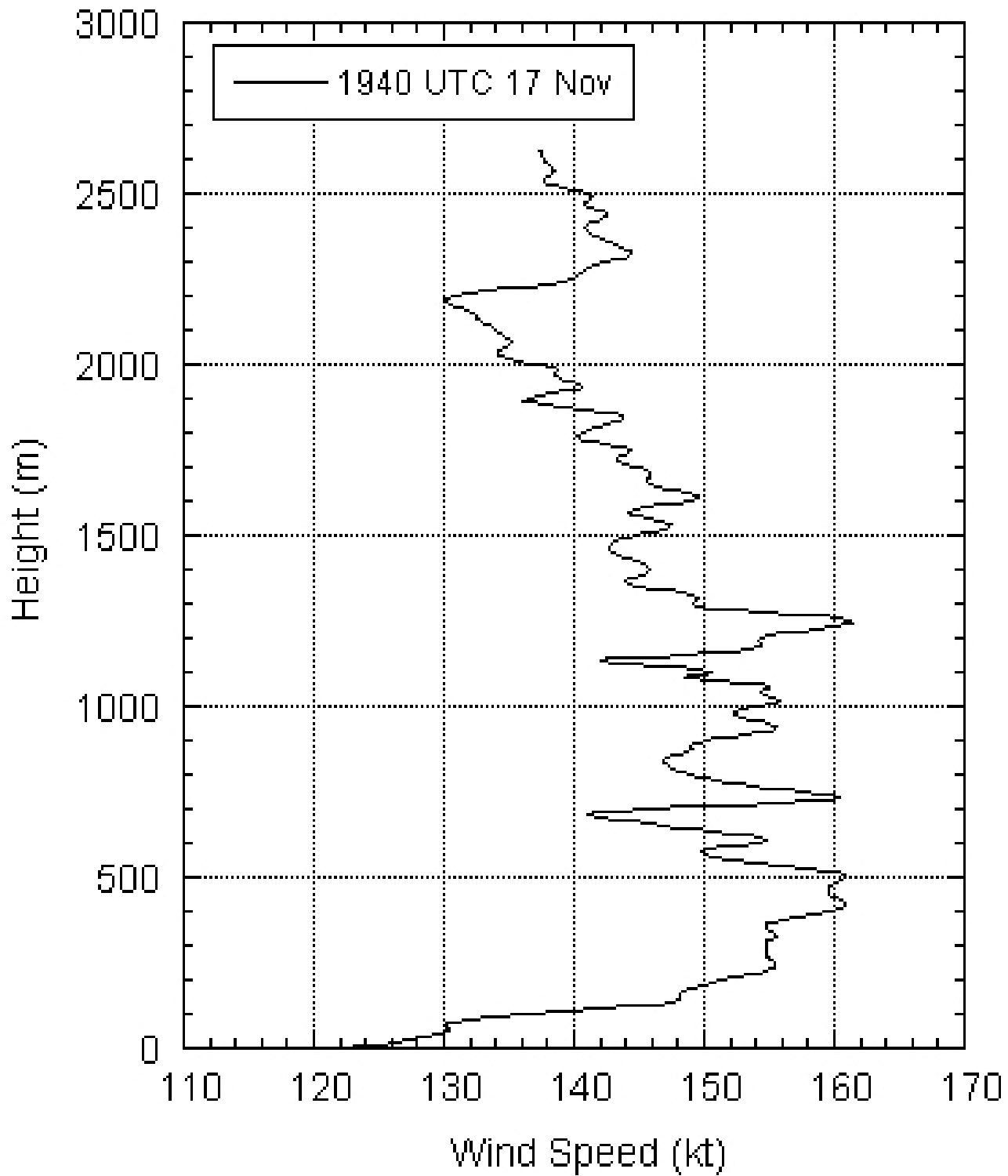


Figure 6. Hurricane Lenny eyewall GPS dropsonde wind profile near peak intensity, 1940 UTC 17 November 1999.