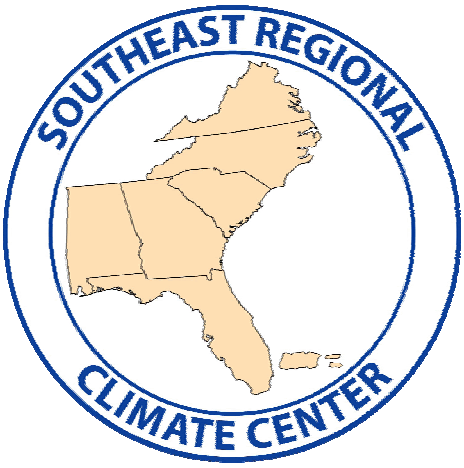
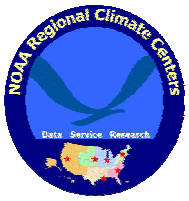
SERCC RESEARCH SERIES



TROPICAL SYSTEMS AFFECTING THE U.S. VIRGIN ISLANDS 1989-1999 AS COMPARED TO HURRICANE HUGO

Gloria Forthun

Regional Climatologist



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AUGUST 2005 REPORT 1

TROPICAL SYSTEMS AFFECTING THE U.S. VIRGIN ISLANDS 1989-1999 AS COMPARED TO HURRICANE HUGO

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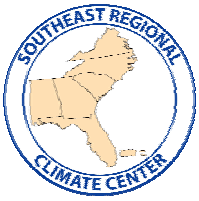


REPORT 1
2005

Objective

The objective of this study was to examine the climatology of tropical storms that impacted the U.S. Virgin Islands from Hurricane Hugo (1989) through Hurricane Lenny (1999).

Data

Other than storm surge, some of the greatest impacts from hurricanes come from heavy precipitation and high winds. Precipitation records were obtained from the National Weather Service's (NWS) Cooperative Observer Network. Volunteers who run these weather stations report minimum and maximum temperatures and precipitation once a day. Some observers, however, report precipitation only when there is a weather event. Since 1989 the U.S. Virgin Islands has had between five and thirteen cooperative sites with some of these being event reporters. Table 1 shows a list of cooperative sites with name, county, latitude, longitude, elevation, and period of record.

COOPERATIVE STATION NAME	COUNTY NAME	LATITUDE (DECIMAL DEGREES)	LONGITUDE (DECIMAL DEGREES)	COOPERATIVE STATION NO.	ELEVATION (FEET)	STATION BEGIN DATE	STATION END DATE
Annaly	St. Croix	17.750000	-64.85000	670240	700	01/01/1972	Present
Beth Upper New Works	St. Croix	17.716667	-64.80000	670480	110	01/01/1972	Present
Christiansted Fort	St. Croix	17.750000	-64.798889	671740	30	01/01/1972	12/31/1995
Cotton Valley 2	St. Croix	17.766667	-64.616667	371810	140	01/01/1982	Present
East Hill	St. Croix	17.756111	-64.649444	672560	120	01/01/1972	Present
Estate The Sight	St. Croix	17.750000	-64.666667	672870	130	01/01/1979	Present
Granard	St. Croix	17.716667	-64.716667	673677	65	01/01/1972	Present
Hamilton Field	St. Croix	17.703889	-64.798889	670198	34	01/01/1972	Present
Montpellier	St. Croix	17.766667	-64.750000	674900	200	01/02/1979	Present
Caneel Bay Plantation	St. John	18.350000	-64.783333	671316	60	01/01/1972	05/06/2002
Catherineburg	St. John	18.345278	-64.760556	671348	845	01/01/1972	02/01/1997
Coral Bay	St. John	18.333333	-64.700000	671790	30	01/01/1972	Present
Cruz Bay	St. John	18.334722	-64.794167	671980	8	01/01/1972	Present
East End	St. John	18.335833	-64.676389	672551	150	01/01/1972	Present
Estate Fort Mylner	St. Thomas	18.333333	-64.900000	672823	200	01/01/1972	09/01/1995
Redhook Bay	St. Thomas	18.326111	-64.859722	677600	4	01/02/1980	Present
Truman Field	St. Thomas	18.340278	-64.97000	678905	55	01/01/1972	Present
Wintberg	St. Thomas	18.350000	-64.916667	679450	645	01/01/1972	Present

Table 1. National Weather Service cooperative stations in the U.S. Virgin Islands.

Additional weather stations report pressure, temperature, wind direction, and other meteorological information on an hourly basis. Wind speed and gusts are measured at two stations in the U.S. Virgin Islands. On St. Croix, measurements are taken at Hamilton Field in Christiansted, and on St. Thomas the measurements are taken at Truman Field in Charlotte (Table 2). Between 1989 and 1999 Christiansted

and Charlotte have at times reported weather observations 24 hours a day and at other times reported only during daylight hours.

HOURLY STATION NAME	COUNTY NAME	STATE NAME	LATITUDE (DECIMAL DEGREES)	LONGITUDE (DECIMAL DEGREES)	HOURLY STATION #	ELEVATION (FEET)	STATION BEGIN DATE	STATION END DATE
Hamilton Field, Christiansted	St. Croix	U.S. Virgin Islands	17.703889	-64.798889	11624	34	06/30/1993	Present
Truman Field, Charlotte	St. Thomas	U.S. Virgin Islands	18.340278	-64.970000	11640	55	06/30/1993	Present

Table 2. Hourly stations in the U.S. Virgin Islands

Intensity of Tropical Storms

On the basis of wind speed (ws), storms in the tropics are grouped into four classifications: 1) tropical disturbance (ws $\leq$ 23mph); 2) tropical depression (23 <ws $\leq$39mph, and the storm is numbered); 3) tropical storm (39 <ws $\leq$74mph, and the storm is named); and 4) hurricane (ws > 74mph). To estimate the damage potential of a hurricane, the Saffir-Simpson scale (Table 3) rates the intensity of hurricanes on a scale of 1 to 5, with 5 being the strongest.

CATEGORY	CENTRAL PRESSURE (INCHES)	WINDS (MPH)	STORM SURGE (FEET)
1	$\geq$28.94	74-95	4-5
2	28.50-28.91	96-110	6-8
3	27.91-28.47	111-130	9-12
4	27.17-27.88	131-155	13-18
5	<27.17	>155	>18

Table 3. The Saffir-Simpson hurricane damage potential scale.

All tropical storms form around areas of low pressure. In most tropical systems lower barometric pressure corresponds to higher wind speeds. Wind speed and precipitation also increase with proximity to the eyewall (the area around the eye or center of a hurricane). Typically, the highest wind speeds are found on the north/northwest side of easterly moving hurricanes and the south/southeast side of westerly moving storms. Tropical storms have the potential to be preceded by rain bands well ahead of the main storm.

Storm Tracks

Since Hurricane Hugo passed over the U.S. Virgin Islands in September 1989 until the end of 1999, there were nine named storms that impacted the islands (Table 4).

STORM	DATE
Hurricane Hugo	September 17-18, 1989
Hurricane Klaus	October 07, 1990
Hurricane Luis	September 05-06, 1995
Hurricane Marilyn	September 15-16, 1995
Tropical Storm Sebastien	October 23-24, 1995
Hurricane Bertha	July 08-09, 1996
Hurricane Hortense	September 09, 1996
Hurricane Georges	September 21, 1998
Hurricane Jose	October 20-21, 1999
Hurricane Lenny	November 16-18, 1999

Table 4. Tropical storms impacting the U.S. Virgin Islands and the dates of impact (source: NOAA/NHC).

Of these nine storms, eight were hurricanes and one was a tropical storm. The paths of these storms, including Hurricane Hugo, and their intensity are shown in Figure 1. Each circle was plotted at 6-hour intervals. The closer the circles are to each other the faster the storm was moving.

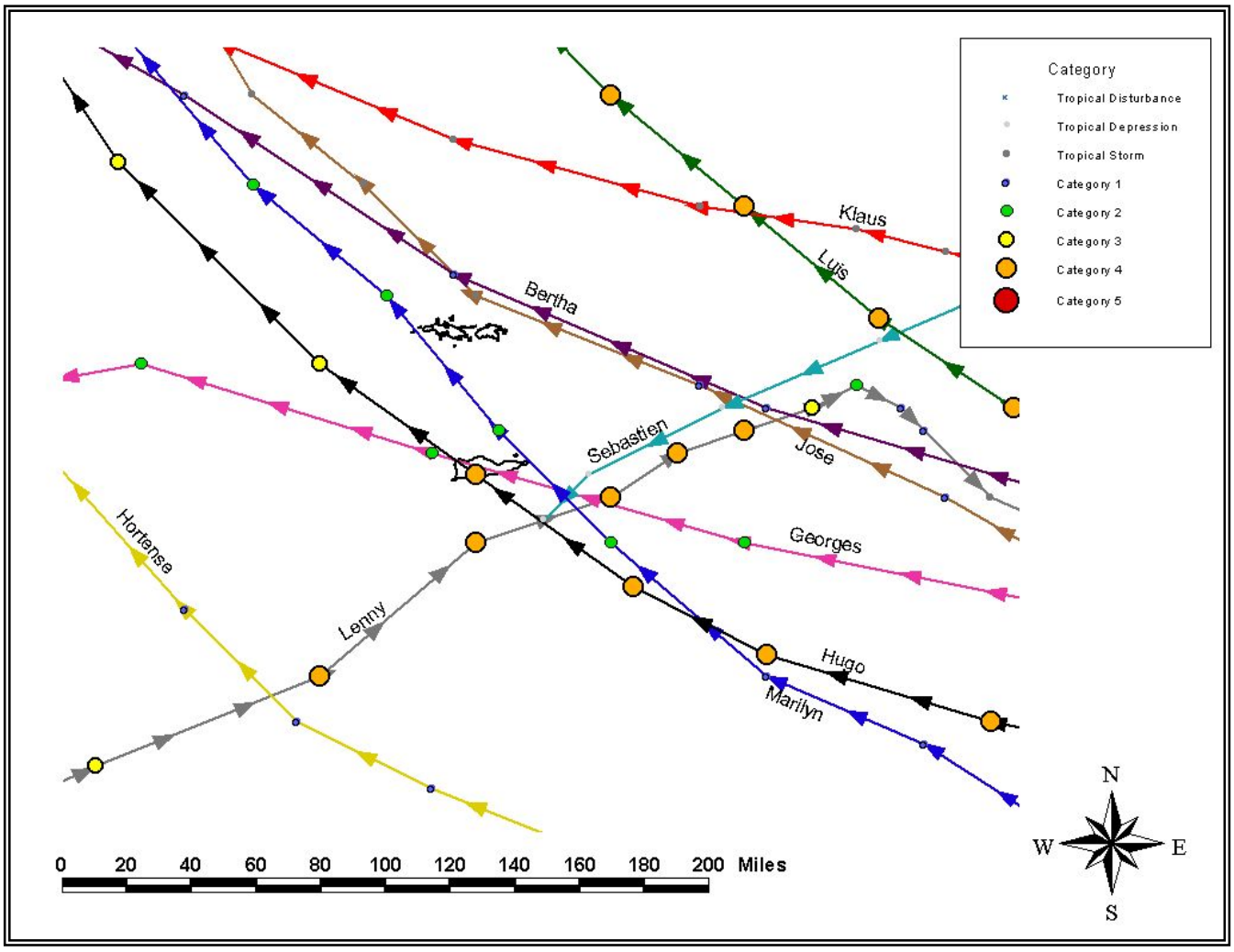


Figure 1. Storm tracks and their intensity for all storms impacting the U.S. Virgin Islands (1989-1999).

Four storms, Hurricanes Hugo, Marilyn, and Georges, and Tropical Storm Sebastien were moving in a westerly direction and their paths took them to the south of at least one of the U.S. Virgin Islands (north side of the storm has the highest winds). Hurricane Lenny traveled south of the U.S. Virgin Islands and was moving from east to west with its winds strongest in the south/southeast area of the storm. Lenny was a category 4 hurricane when it traveled south of St. Croix and Hugo was a category 4 hurricane when it passed over St. Croix. Georges was a category 2 hurricane as it moved over St. Croix and stayed south of St. Thomas and St. John, and Marilyn was a category 2 hurricane and passed north of St. Croix and south of St. Thomas and St. John. Sebastien was a tropical storm that moved south of St. Croix. Hurricanes Hugo, Lenny, Marilyn, and Georges should have had the highest wind speeds and precipitation amounts of all the storms to impact the U.S. Virgin Islands, owing to their strengths and their positions with regard to the U.S. Virgin Islands (although Hurricane Lenny had stronger winds on the opposite side of the U.S. Virgin Islands, it was a category 4 hurricane at that time).

Precipitation

Figure 2 shows a comparison of precipitation amounts for each storm including Hurricane Hugo. Storm totals were calculated from precipitation reports from the day before to the day after the official storm dates to capture all rainfall from these storms including any rain bands. To summarize the storm conditions, weather stations were grouped according to island.

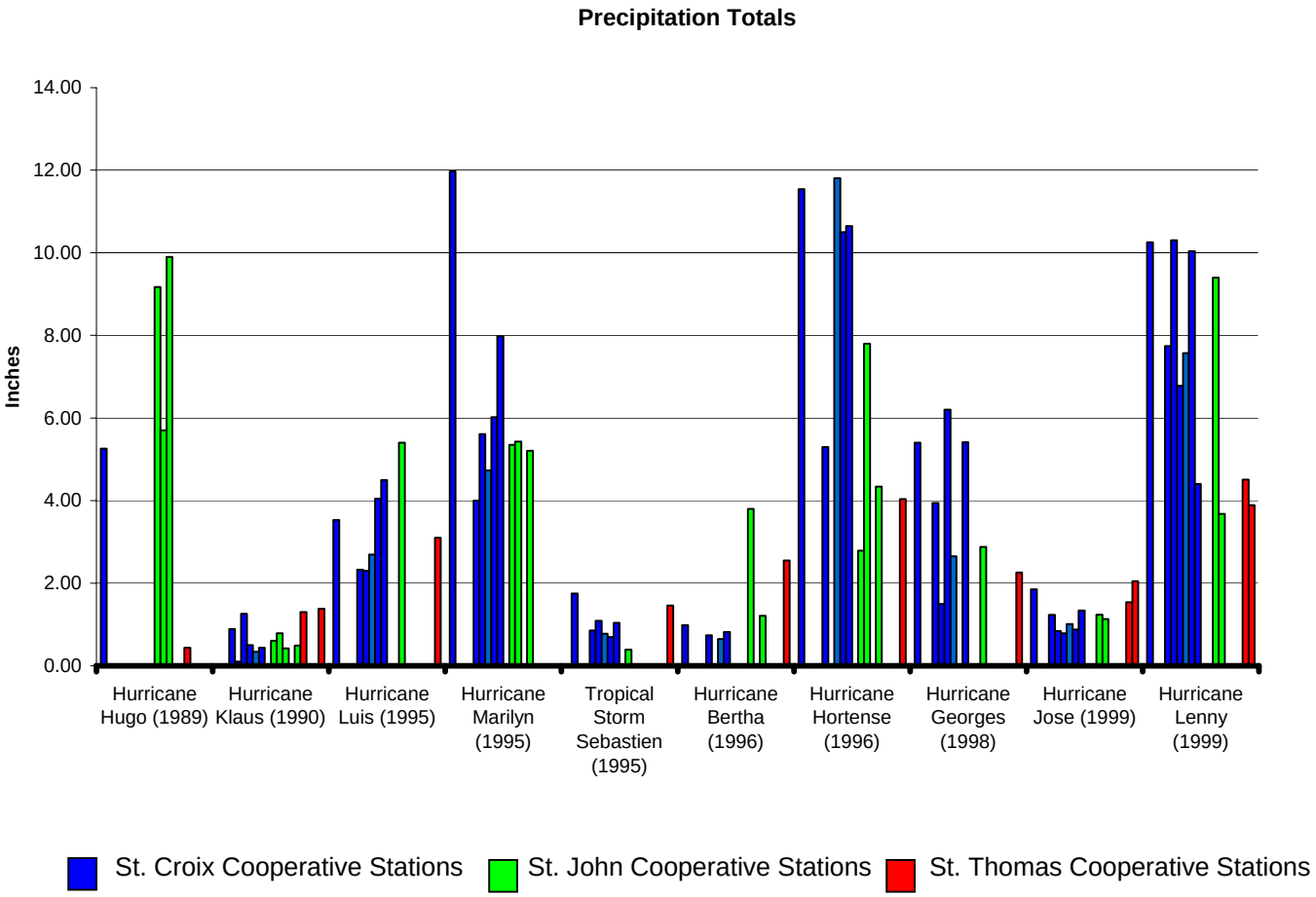


Figure 2. Comparison of total precipitation from all reporting stations during storms impacting the U.S. Virgin Islands (1989-1999).

The number and location of reporting stations changed during each storm; no station had complete reports for each storm and some storms had only a few reports of rainfall. Missing precipitation reports during tropical storms and hurricanes is a problem; however, in some cases, the lack of precipitation data may be important in what it portends. Since volunteers run cooperative stations, they may be busy protecting themselves and their families, or their lives may be endangered if they venture out into the storm to collect data. Storm winds can tip over precipitation

gages, blow debris into the gages, and/or knock down trees or tree limbs that can damage equipment or cut off communications.

On the basis of their proximity to the Islands and their precipitation reports, an in-depth look at Hurricanes Hugo, Georges, Hortense, Marilyn, and Lenny was conducted. On September 18 Hurricane Hugo passed over St. Croix. Only one precipitation report was available for St. Croix as well as for St. Thomas. Three stations on St. John were able to record precipitation and they reported 5.7 to 9.9 inches of rainfall. To display the spatial distribution of rainfall, Hurricane Hugo's path and precipitation totals are shown in Figure 3a. The lack of precipitation reports is almost certainly a reflection of the storm's severity.

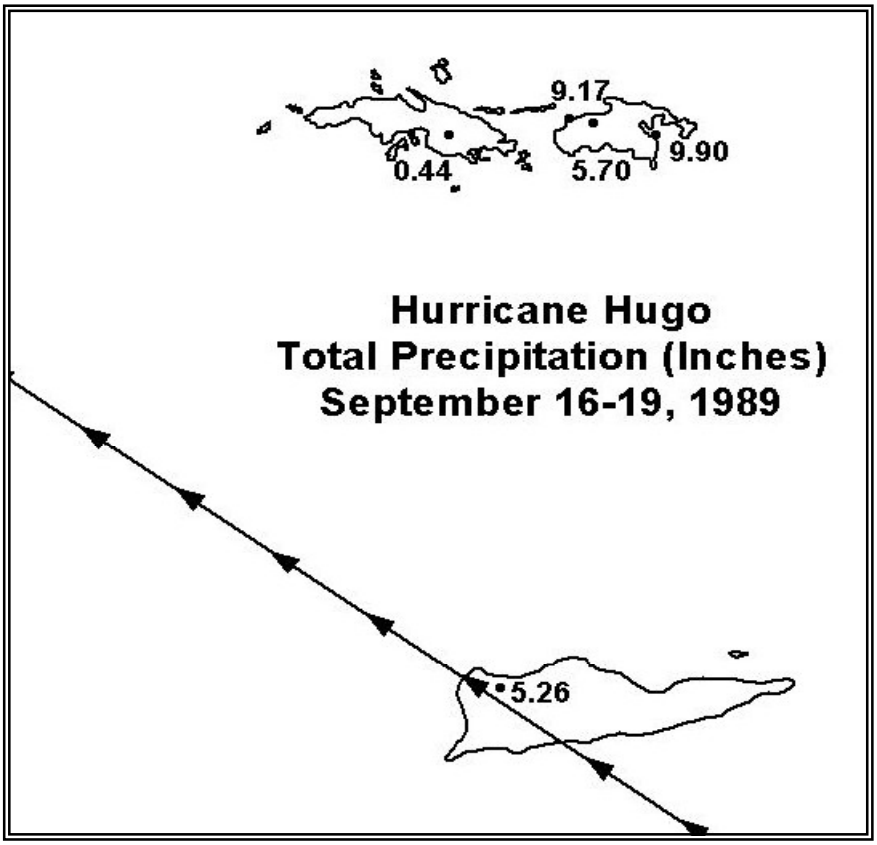


Figure 3a. Hurricane Hugo's track and precipitation totals.

St. Croix reported almost 12 inches of precipitation associated with Hurricane Marilyn, and St. John reported an average of over 5 inches of precipitation (Figure 3b). There were no rainfall reports from St. Thomas; however, it is likely that St. Thomas was substantially impacted, considering that it was on the north/northeasterly side of Hurricane Marilyn and within 20 miles of the eyewall.

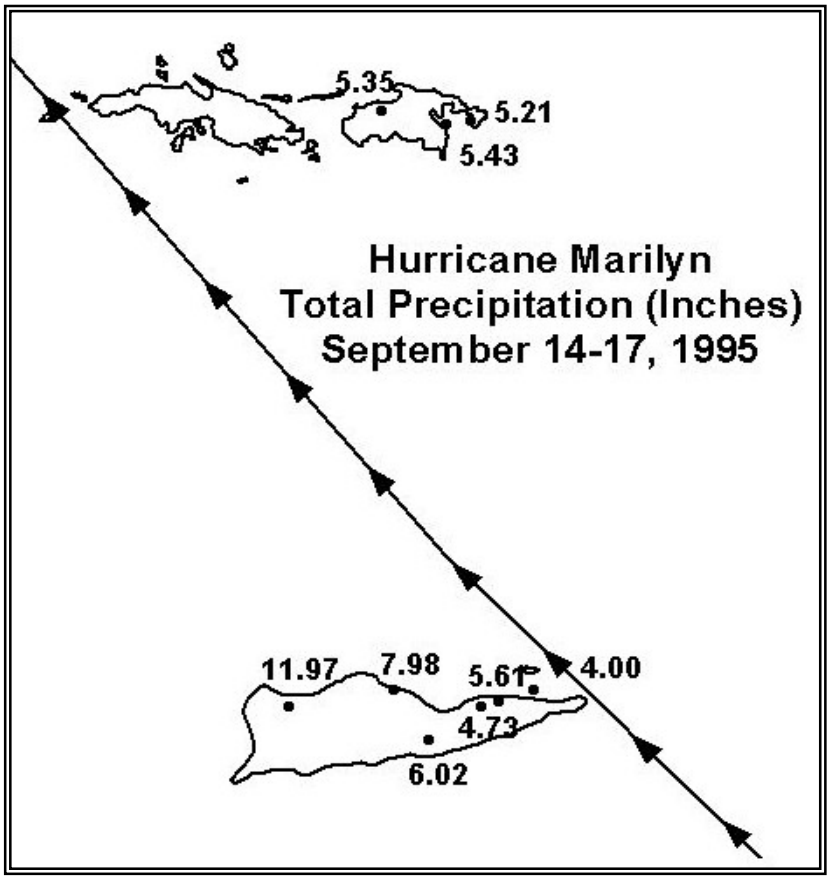


Figure 3b. Hurricane Marilyn's track and precipitation totals.

Hurricane Hortense delivered 5.3 to 11.8 inches over St. Croix and 2.8 to 7.8 inches of rainfall over the two northern islands (Figure 3c). Hurricane Hortense moved a little slower past the U.S. Virgin Islands than Hurricanes Georges and Marilyn but was farther away from the islands.

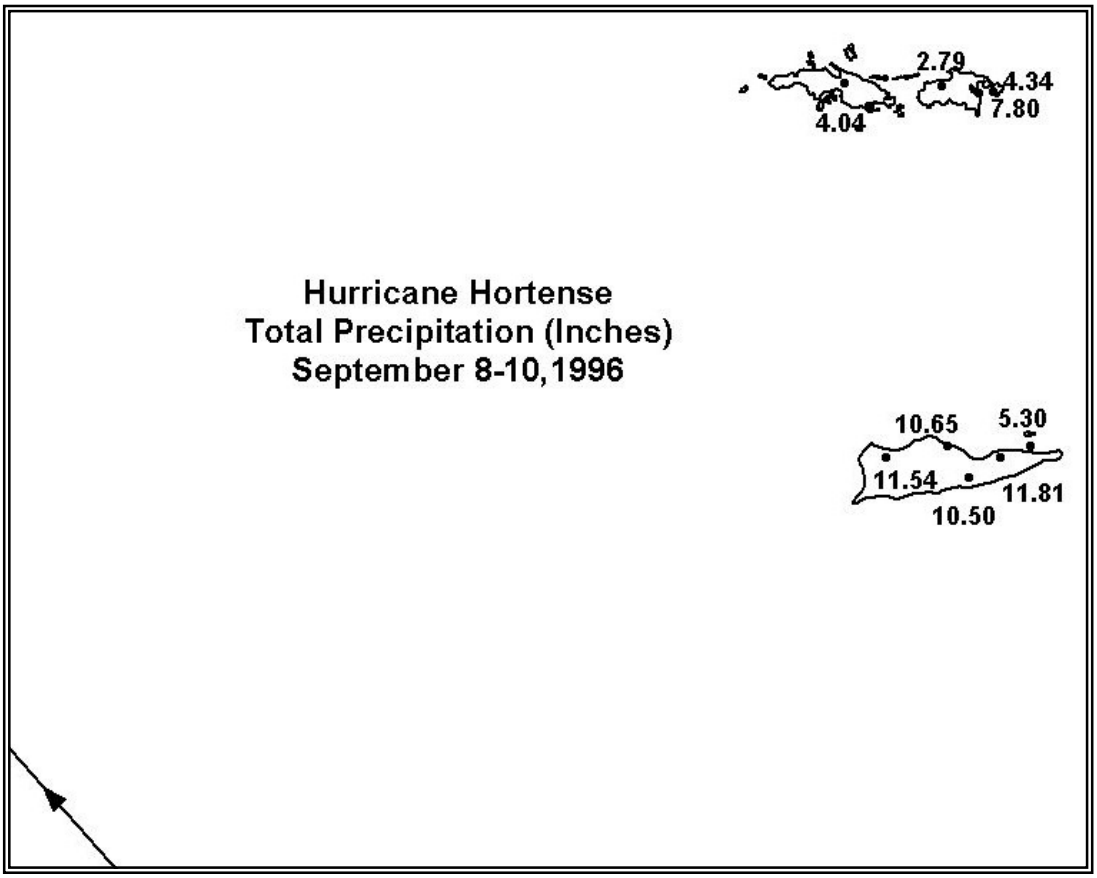


Figure 3c. Hurricane Hortense's track and precipitation totals.

Hurricane Georges brought a lower amount of precipitation than all the other storms, with totals of 1.5 to 6.2 inches overall and had a good distribution of reporting sites on all the islands (Figure 3d).

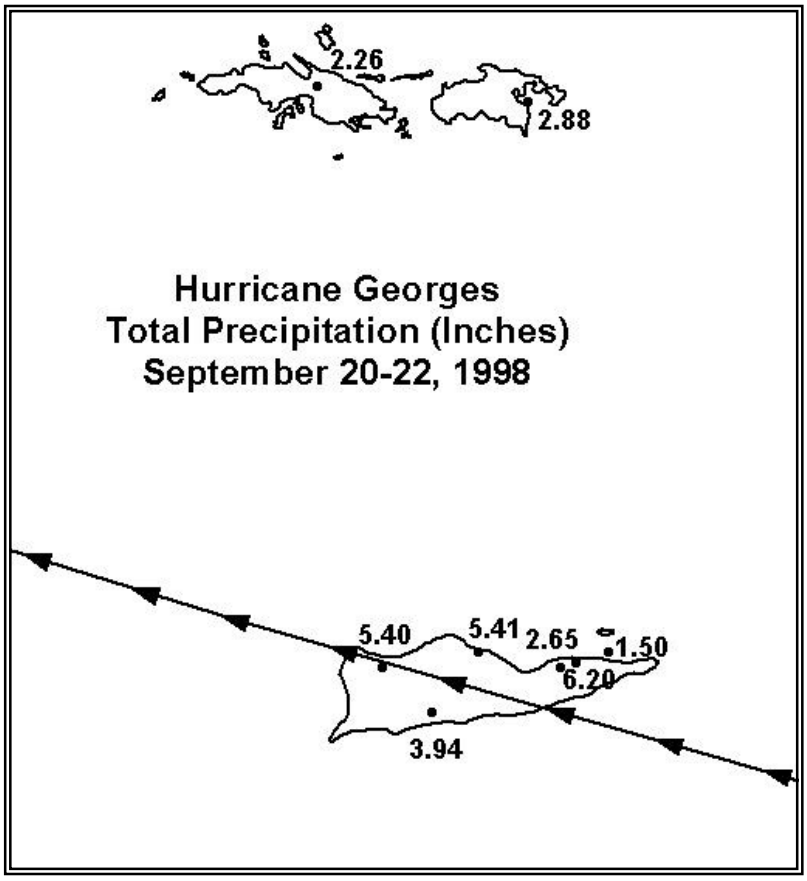


Figure 3d. Hurricane Georges' track and precipitation totals.

Although Hurricane Lenny's most damaging side was away from the U.S. Virgin Islands, it was a category 4 hurricane and produced over 10 inches of rain on St. Croix, over 9 inches on St. John, and over 4 inches on St. Thomas (Figure 3e).

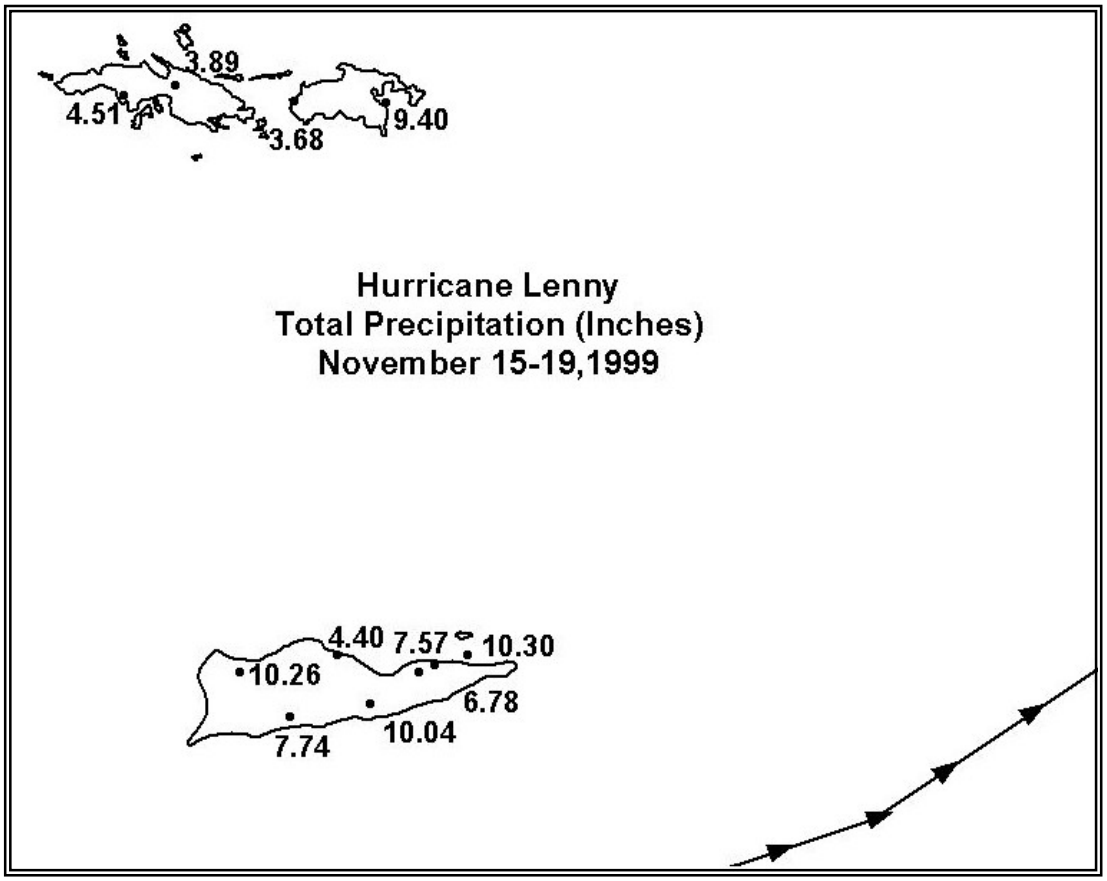


Figure 3e. Hurricane Lenny's track and precipitation totals.

Wind Speed and Gusts

Two weather stations in the U.S. Virgin Islands report hourly wind speed, wind gusts, and wind direction: 1) Hamilton Field, Christiansted, St. Croix; and 2) Truman Field, Charlotte, St. Thomas (Table 2). The reasons for missing wind data during tropical storms are usually a matter of broken equipment and/or lack of communications due to the storm intensity and destructive ability. Strong sustained winds over the U.S. Virgin Islands during these storms can greatly increase in speed due to the mountainous terrain of the islands.

Hurricane Klaus had weakened to a tropical storm as it passed the U.S. Virgin Islands and had little impact on the islands. The highest recorded wind speed was 17 miles per hour (mph) with a 33 mph gust on St. Croix and 18 mph on St. Thomas[1] (Figure 4a). Hurricane Luis brought the U.S. Virgin Islands tropical storm conditions with the highest wind speed of 21 mph and a gust of 29 mph on St. Croix, while on St. Thomas the highest wind speed was 32 mph with a 52 mph gust (Figure 4b). Tropical Storm Sebastien had little impact on the U.S. Virgin Islands since it was dissipating into a tropical depression as it passed the islands and it caused no tropical storm conditions over land. Winds on St. Croix reached 13 mph and on St. Thomas 14 mph with a 17 mph gust (Figure 4c). There were missing reports for each of these storms, but since damage was minimal and precipitation amounts were lower than the other storms, these wind speeds should be representative of the storms.

Although there are no reports for wind speed or wind gusts during Hurricane Bertha, the National Hurricane Center believes that winds could have reached 86 mph on St. Thomas and St. John[2]. This is based, in part, on the fact that the eyewall of Hurricane Bertha was 23-35 miles wide and on observations from ships in the area. The U.S. Virgin Islands was declared a federal disaster area due to Hurricane Bertha.

Hurricane Jose's winds reached speeds of 23 mph on St. Croix with gusts to 29, and on St. Thomas winds of 44 mph with gusts of 52 mph (Figure 4d). An automated station on St. John recorded a wind speed of 60 mph and a wind gust of 69 mph. Damage totals were minimal. St. Croix recorded wind speeds of 29 mph and a gust of

[1] Wind speeds and gusts are in the Unedited Climate Data publications from the National Climatic Data Center (NCDC).
[2] Preliminary Report, Hurricane Bertha, National Hurricane Center, Nov. 9, 1996.

36 mph when Hurricane Hortense traveled past the U.S. Virgin Islands (Figure 4e). St. Thomas received winds of 29 mph with a gust of 34 mph.

When Hurricane Georges impacted the U.S. Virgin Islands it left only a small record of wind speed and gusts (Figure 4f). St. Croix had winds of 18 mph and St. Thomas recorded winds of 30 mph with a gust of 55 mph. Records were also incomplete for Hurricanes Marilyn and Lenny. St. Croix recorded wind speeds of 19 mph (with a gust of 31 mph) from Hurricane Marilyn and 16 mph from Hurricane Lenny (Figures 4g-4h). St. Thomas received winds of 21 mph with a 29 mph gust from Hurricane Marilyn and 48 mph winds with a gust of 66 mph from Hurricane Lenny. Records from St. Thomas were almost complete during Hurricane Lenny. There are no records from Hurricane Hugo.

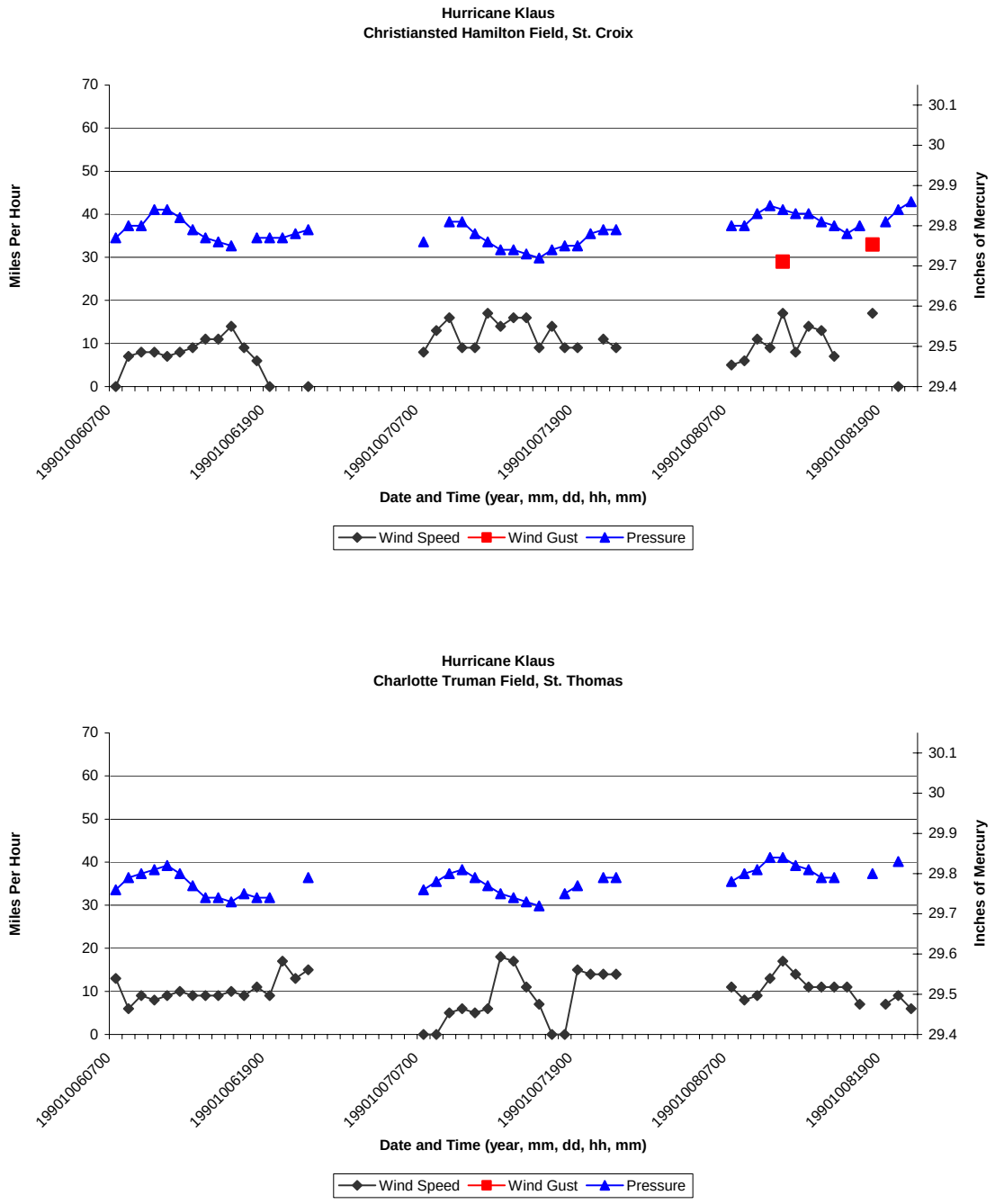
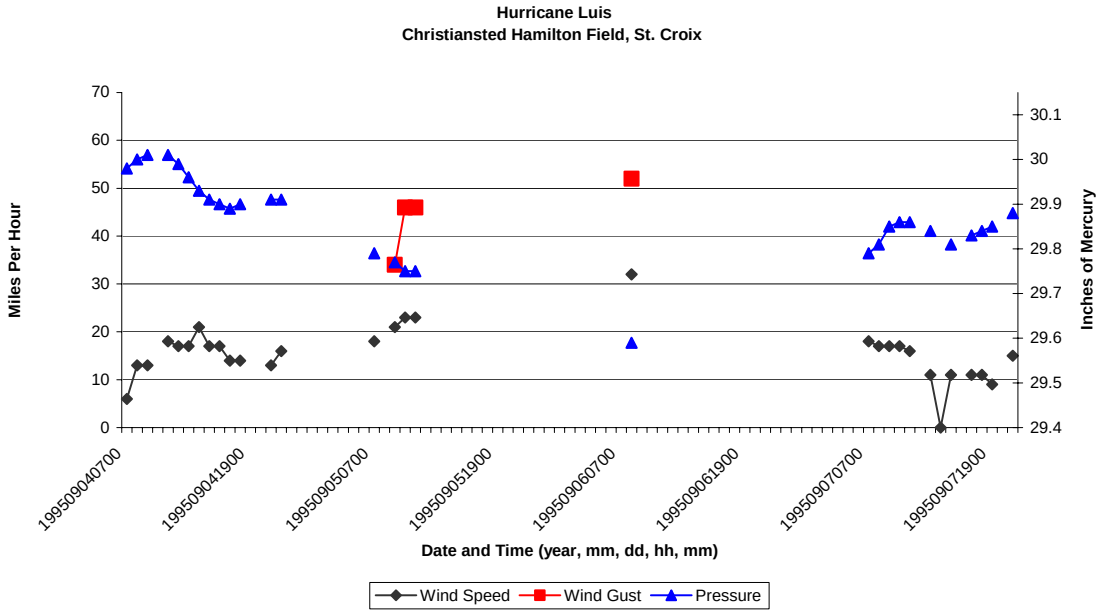


Figure 4a. Pressure, wind speeds, and gusts for Hurricane Klaus, October 6-8, 1990. The day before and day after the official storm dates have been graphed to capture any evolving or lingering impacts. (Source: Unedited Climate Data, NOAA/National Climatic Data Center).



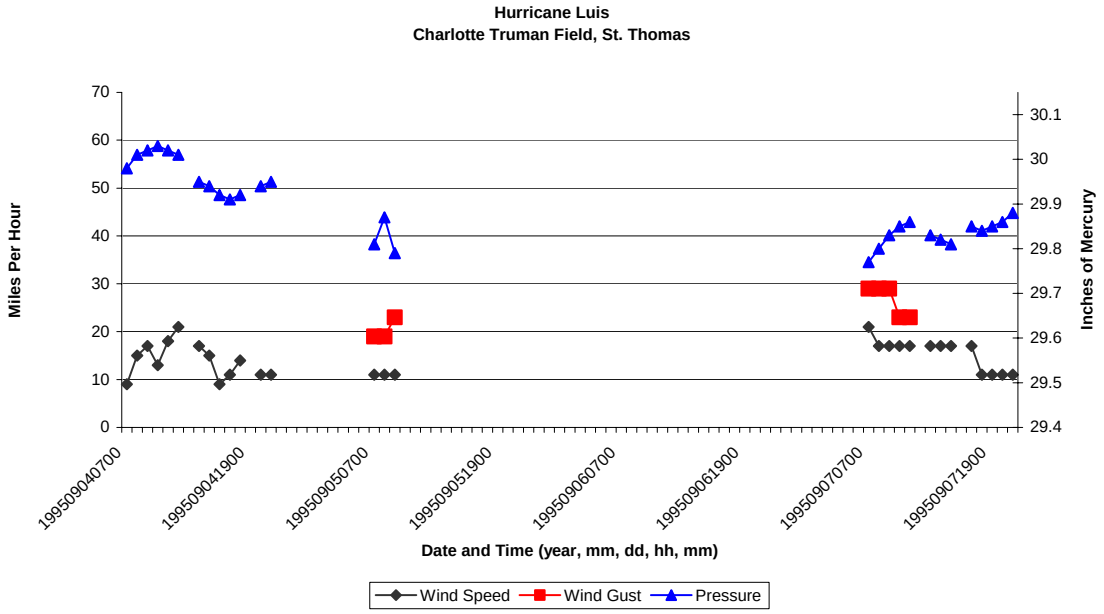


Figure 4b. Pressure, wind speeds, and gusts for Hurricane Luis, September 4-7, 1995. The day before and day after the official storm dates have been graphed to capture any evolving or lingering impacts. (Source: Unedited Climate Data, NOAA/National Climatic Data Center).

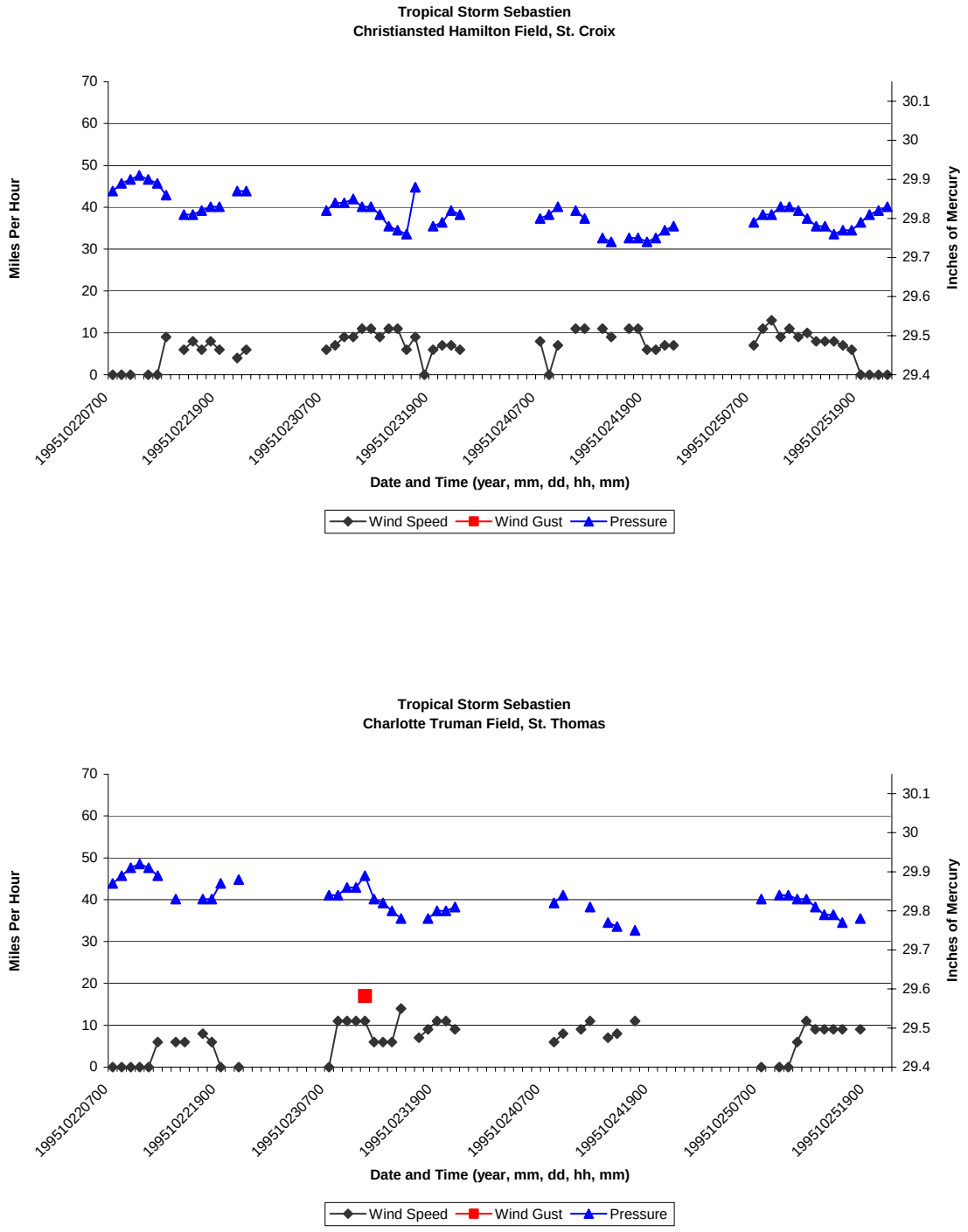
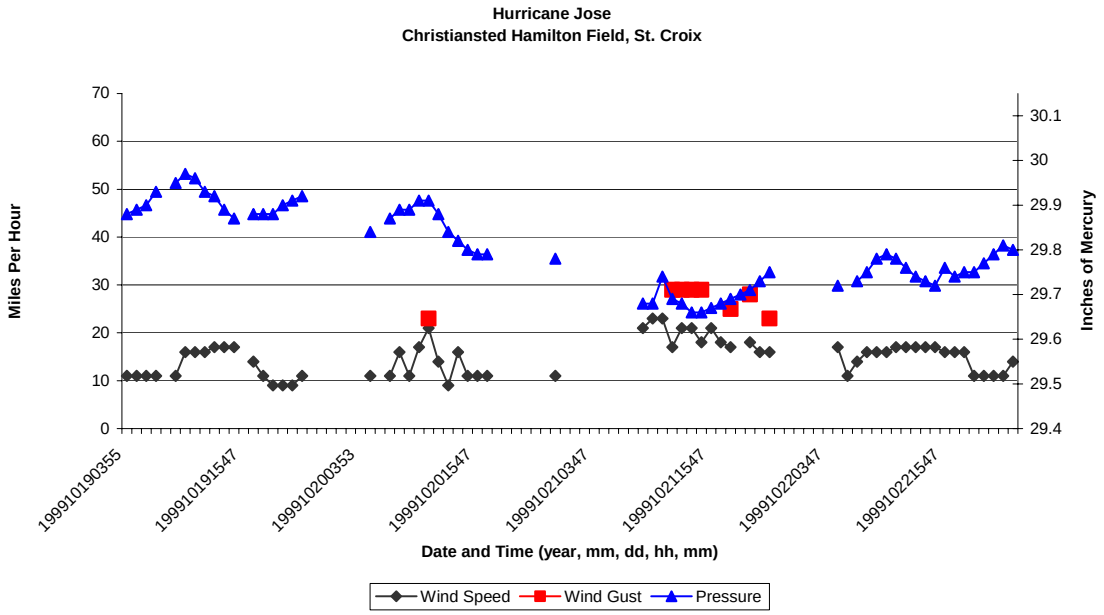


Figure 4c. Pressure, wind speeds, and gusts for Tropical Storm Sebastien, October 22-25, 1995. The day before and day after the official storm dates have been graphed to capture any evolving or lingering impacts. (Source: Unedited Climate Data, NOAA/National Climatic Data Center).



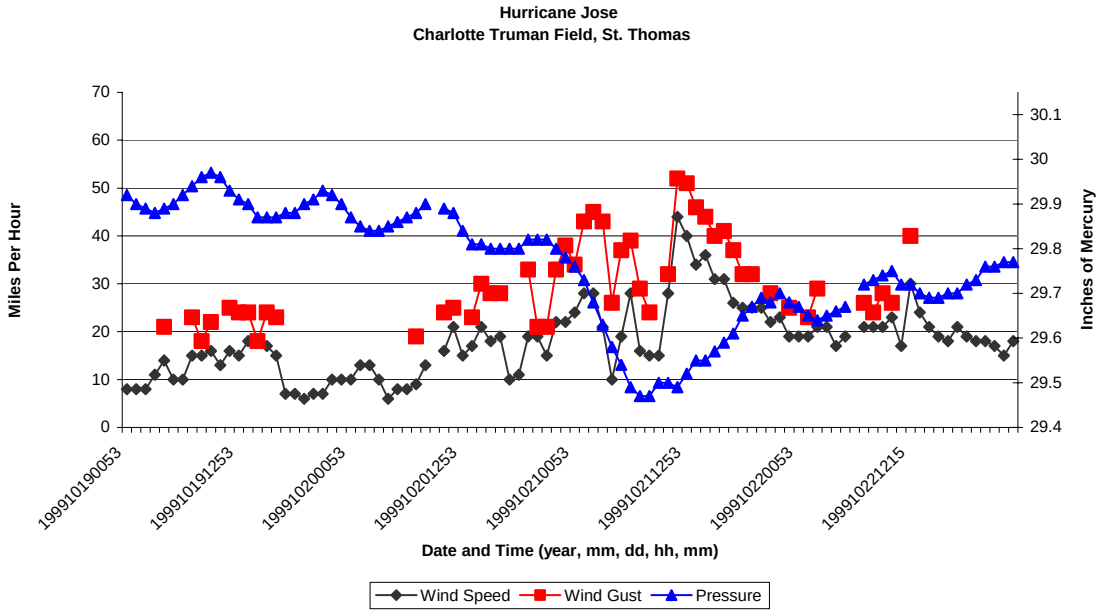
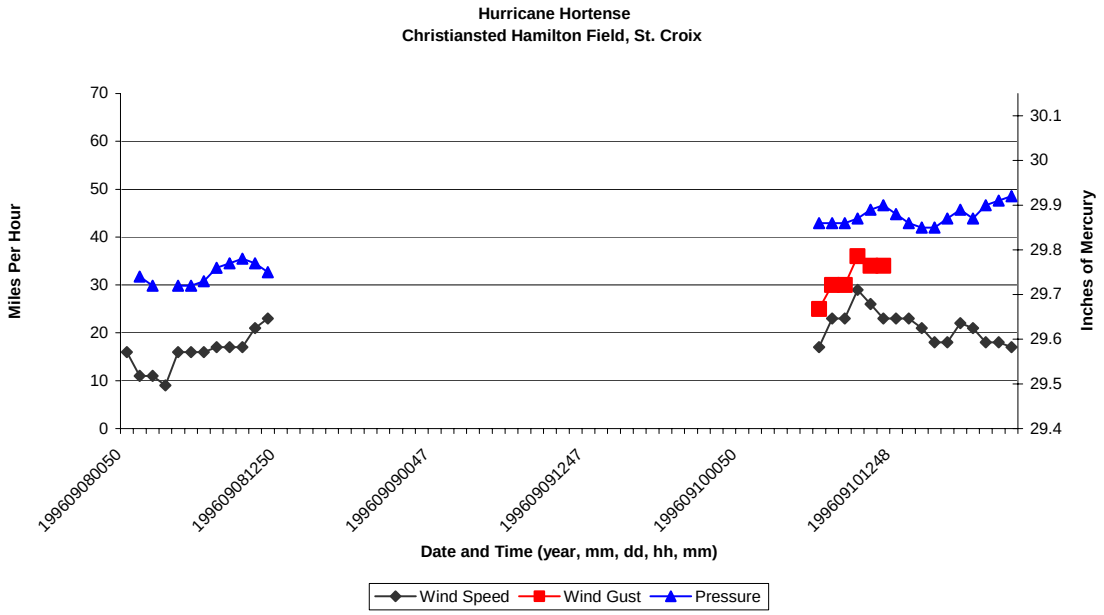


Figure 4d. Pressure, wind speeds, and gusts for Hurricane Jose, October 19-22, 1999. The day before and day after the official storm dates have been graphed to capture any evolving or lingering impacts. (Source: Unedited Climate Data, NOAA/National Climatic Data Center).



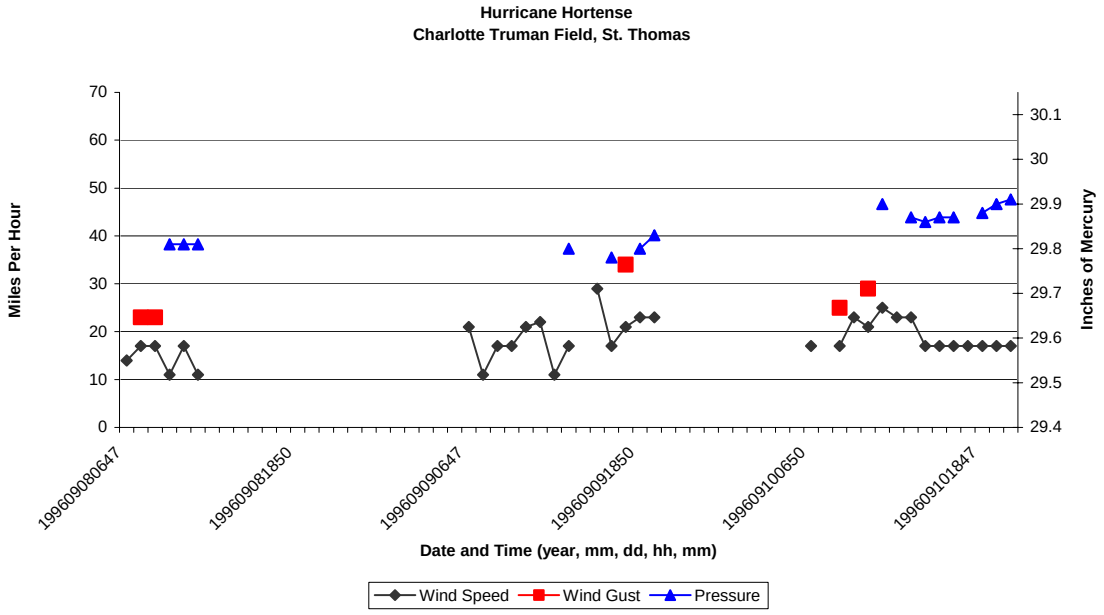


Figure 4e. Pressure, wind speeds, and gusts for Hurricane Hortense, September 8-10, 1996. The day before and day after the official storm dates have been graphed to capture any evolving or lingering impacts. (Source: Unedited Climate Data, NOAA/National Climatic Data Center).

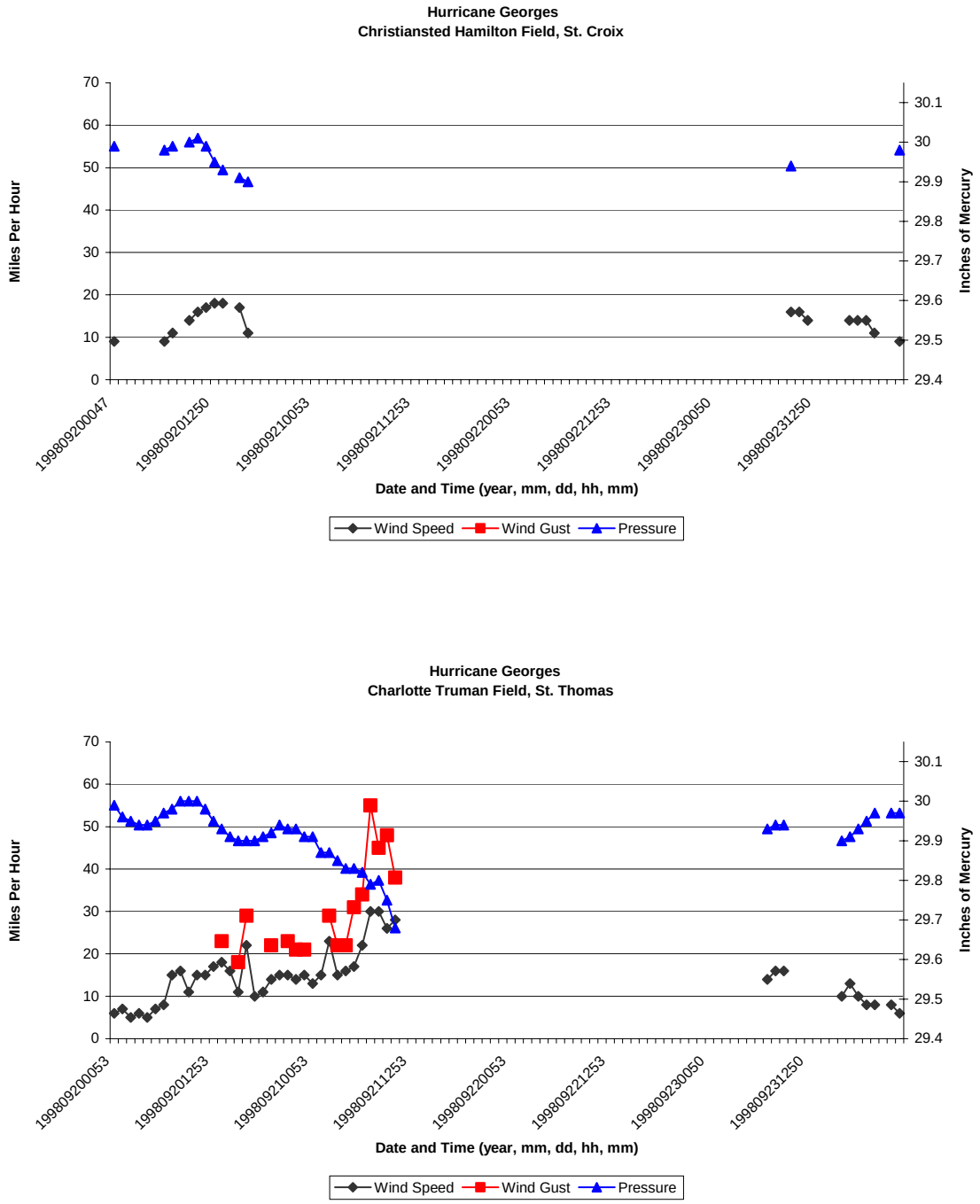
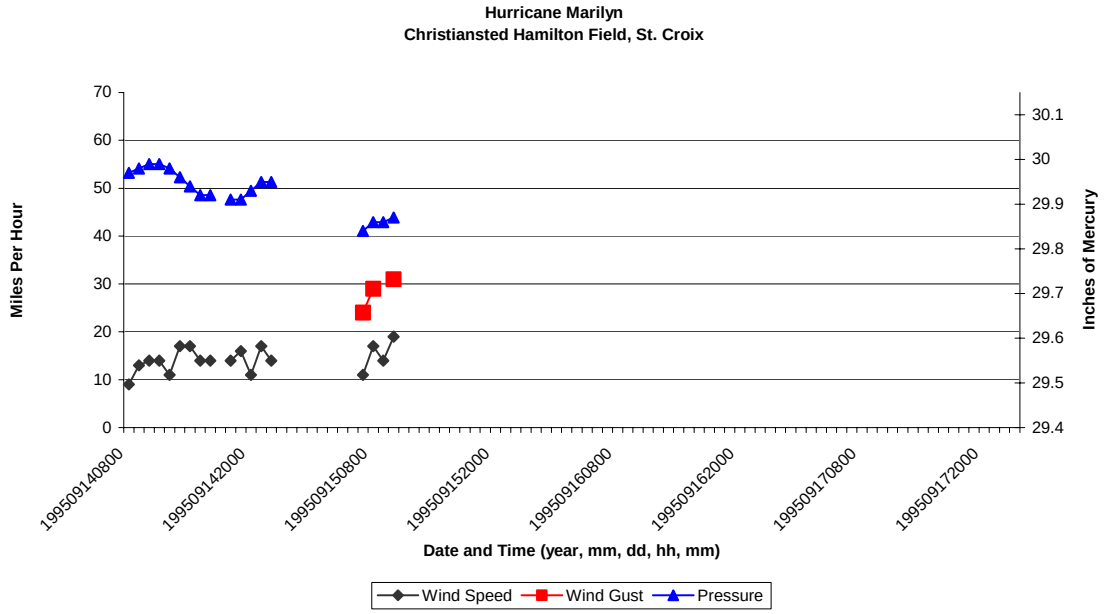


Figure 4f. Pressure, wind speeds, and gusts for Hurricane Georges, September 20-22, 1998. The day before and day after the official storm dates have been graphed to capture any evolving or lingering impacts. (Source: Unedited Climate Data, NOAA/National Climatic Data Center).



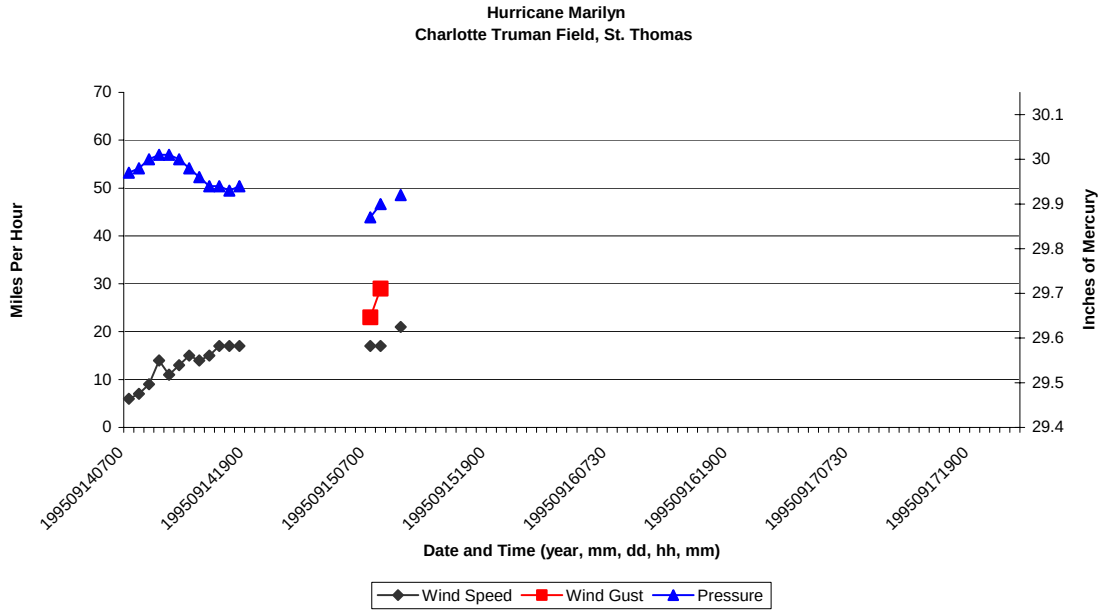
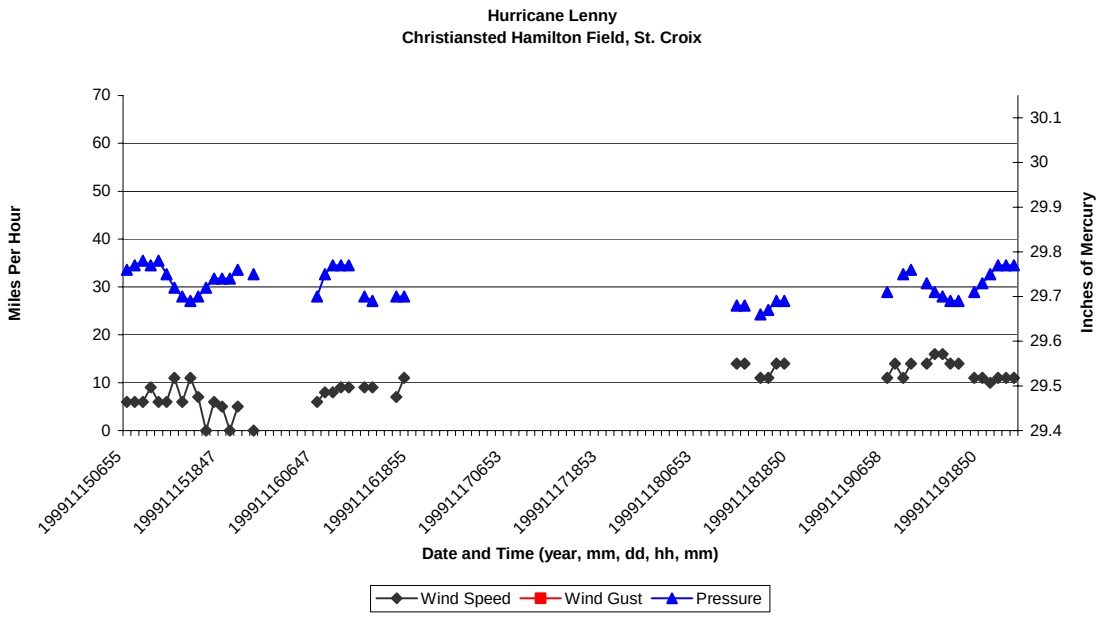


Figure 4g. Pressure, wind speeds, and gusts for Hurricane Marilyn, September 14-17, 1995. The day before and day after the official storm dates have been graphed to capture any evolving or lingering impacts. (Source: Unedited Climate Data, NOAA/National Climatic Data Center).



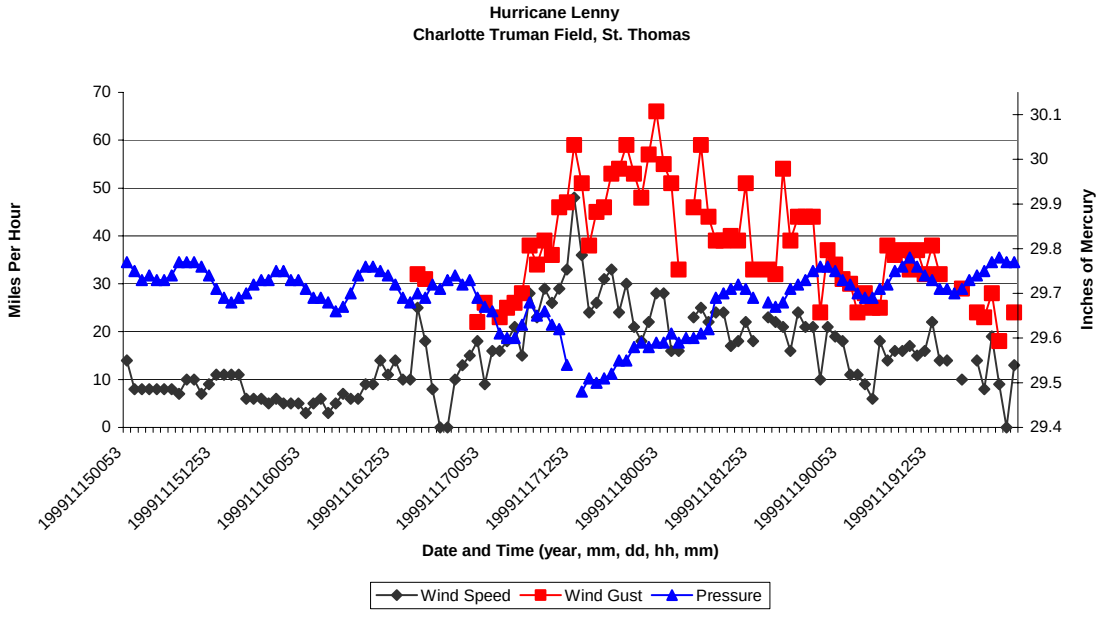


Figure 4h. Pressure, wind speeds, and gusts for Hurricane Lenny, November 15-19, 1999. The day before and day after the official storm dates have been graphed to capture any evolving or lingering impacts. (Source: Unedited Climate Data, NOAA/National Climatic Data Center).

The National Hurricane Center (NHC) publishes the official Storm Reports on tropical storms. Top wind speeds, peak gusts, and dates and times for some storms as published by NHC are shown in Table 5. Of those storms that had official wind reports, Hurricane Marilyn had the highest wind speed at both St. Croix (98 mph) and St. Thomas (104 mph) and the highest wind gust at St. Thomas (129 mph). Hurricane Lenny had wind speeds of 69 mph on St. Croix with a wind gust of 92 mph. On St. Thomas, Hurricane Lenny had wind speeds of 53 mph and a 70 mph gust. St. John recorded a 92 mph wind gust during Hurricane Lenny. Hurricane Georges also had high winds, with speeds of 74 mph and a 91 mph gust on St. Croix and 76 mph winds with a 93 mph gust on St. Thomas.

NHC STORM REPORTS

HUGO

ST. CROIX	DAY	TIME	MPH	
MAX. WINDS	18	0600	138mph	Est. 1 minute speed
MIN. PRESSURE	18	0600	27.76"	
NO REPORTS FOR ST. THOMAS OR ST. JOHN				

KLAUS

NO REPORTS FOR VIRGIN ISLANDS

LUIS

NO REPORTS FOR VIRGIN ISLANDS

MARILYN

ST. CROIX	DAY	TIME		
MAX. WINDS			98mph	Est. 1 minute speed
ST. THOMAS				
MAX. WINDS	16	0352	104mph	2 minute speed
MAX. GUST	16	0408	129mph	
MIN. PRESSURE	16	0422	28.25"	
MIN. PRESSURE			28.11"	Estimated lowest
ST. JOHN				
NO REPORTS FOR ST. JOHN				

SEBASTIEN

NO REPORTS FOR VIRGIN ISLANDS

BERTHA

ST. CROIX	DAY	TIME		
MAX. WINDS	8	1918	47mph	
ST. THOMAS				
MAX. GUST	8		86mph	Estimated
ST. JOHN				
NO REPORTS FOR ST. JOHN				

HORTENSE

ST. CROIX	DAY	TIME	
MAX. WINDS	9	1556	39mph
MAX. GUST	9	1556	52mph
ST. THOMAS			
MAX. GUST	9	2130	62mph
ST. JOHN			
NO REPORTS FOR ST. JOHN			

ERIKA

NO REPORTS FOR VIRGIN ISLANDS

BONNIE

NO REPORTS FOR ST. CROIX OR ST. JOHN			
ST. THOMAS			
MAX. WINDS	21	1128	26mph
MAX. GUST	21	1128	38mph

GEORGES

ST. CROIX	DAY	TIME	
MAX. WINDS	21	1534	90mph
MAX. GUST	21	1534	113mph
MIN. PRESSURE	21	1534	28.71"
ST. THOMAS			
MAX. WINDS	21	2031	76mph
MAX. GUST	21	2031	93mph
MIN. PRESSURE	21	2031	29.26"
ST. JOHN			
NO REPORTS FOR ST. JOHN			

JOSE

ST. CROIX	DAY	TIME	
MAX. WINDS	21	1255	31mph
MAX. GUST	21	1255	37mph
MIN. PRESSURE	21	1255	29.52"
ST. THOMAS			
NO REPORTS FOR ST. THOMAS			
ST. JOHN			
MAX. WINDS	21	1657	60mph
MAX. GUST	21	1657	69mph

GEORGES			
ST. CROIX	DAY	TIME	
MAX. WINDS	21	1534	90mph
MAX. GUST	21	1534	113mph
MIN. PRESSURE	21	1534	28.71"
ST. THOMAS			
MAX. WINDS	21	2031	76mph
MAX. GUST	21	2031	93mph
MIN. PRESSURE	21	2031	29.26"
ST. JOHN			
NO REPORTS FOR ST. JOHN			

JOSE			
ST. CROIX	DAY	TIME	
MAX. WINDS	21	1255	31mph
MAX. GUST	21	1255	37mph
MIN. PRESSURE	21	1255	29.52"
ST. THOMAS			
NO REPORTS FOR ST. THOMAS			
ST. JOHN			
MAX. WINDS	21	1657	60mph
MAX. GUST	21	1657	69mph
MIN. PRESSURE			

LENNY			
ST. CROIX	DAY	TIME	
MAX. WINDS	17	2010	83mph
MAX. GUST	17	2010	112mph
MIN. PRESSURE	17	1933	28.64"
ST. THOMAS			
MAX. WINDS	17	1654	53mph
MAX. GUST	17	1654	70mph
MIN. PRESSURE	17	1654	29.33"
ST. JOHN			
MAX. WINDS			
MAX. GUST	17		92mph
MIN. PRESSURE	17	1900	29.14"

DEBBY			
ST. CROIX	DAY	TIME	
MAX. WINDS			
MAX. GUST	22		43mph
MIN. PRESSURE			
ST. THOMAS			
MAX. WINDS			
MAX. GUST	22		45mph
MIN. PRESSURE			
ST. JOHN			
NO REPORTS FOR ST. JOHN			

DEAN			
ST. CROIX	DAY	TIME	
MAX. WINDS	22	0171	56mph
MAX. GUST	22	0171	71mph
MIN. PRESSURE	22	0115	29.96"
ST. THOMAS			
MAX. WINDS	22	0181	40mph
MAX. GUST	22	0181	48mph
MIN. PRESSURE	22	0190	29.97"
ST. JOHN			
NO REPORTS FOR ST. JOHN			

Table 5. National Hurricane Center official Storm Reports.

Summary

Some observations can be made about the strongest storms that impacted the islands:

- Hurricane Hugo was ranked as a category 4 when passing over St. Croix. The highest wind speed was estimated at 138 mph, and 9.17 inches was the highest total precipitation reported. The impact of Hurricane Hugo on the U.S. Virgin Islands was underreported, as were the meteorological conditions.
- Hurricane Marilyn was ranked as a category 2 with strong winds of 96 to 110 mph and heavy precipitation hitting St. Thomas and St. John. The eyewall, with the highest wind speeds and precipitation amounts, came very close to both St. Croix and St. Thomas. Peak wind speed was 104 mph, peak wind gust was 129 mph, and highest total precipitation was 11.97 inches.
- Hurricane Lenny was ranked as a category 4 (winds of 131-155 mph) as it passed to the south of the islands. It was a stronger storm than Hurricane

Marilyn but the winds on the north side were not as strong as on the south side since it was moving west to east. The eyewall was also farther from the islands. Peak wind speed was 69 mph, peak wind gust was 92 mph, and highest total precipitation was 10.30 inches.

- Hurricane Georges was ranked as a category 2 when it made landfall and passed over St. Croix. This means that the eyewall went directly over the island of St. Croix, producing the strongest winds there and high winds on the northern islands. Peak wind speed was 76 mph, peak wind gust was 93 mph, and highest recorded total precipitation was 5.41 inches.
- Hurricane Hortense was ranked as a category 1 as it passed south of St. Croix. Storm Reports state that flooding and mudslides were the greatest threats from Hurricane Hortense rather than wind damage. Peak wind speed was 39 mph, peak wind gust was 62 mph, and highest total precipitation was 11.81 inches.