

Tropical Cyclone Report
Hurricane Lili
21 September - 04 October 2002

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Updated April 3, 2003 to include four flood-related deaths in Haiti
Updated August 10, 2011 to revise damage estimate

Hurricane Lili crossed western Cuba as a category two hurricane on the Saffir-Simpson Hurricane Scale and made landfall on the Louisiana coast as a category one hurricane. Lili also affected the Windward Islands as a tropical storm, the northeastern Cayman Islands as a category one hurricane and caused serious rainfall flooding in Jamaica. Thirteen deaths are attributed to Lili. Lili reached category four intensity over the Gulf of Mexico.

a. Synoptic History

Lili originated from a tropical wave that moved over the tropical Atlantic Ocean from the west coast of Africa on September 16th. The wave developed a low-level cloud circulation center midway between Africa and the Lesser Antilles on the 20th. Convective clouds became sufficiently well organized on the 21st to qualify the system as a tropical depression, centered about 900 n mi east of the Windward Islands. The “best track” of the tropical cyclone’s path starts at this stage and is shown in Fig. 1. Graphs of best-track maximum one-minute surface wind speed and minimum central surface pressure, as a function of time, are shown in Figs. 2 and 3, respectively. The six-hour best track positions and intensities are listed in Table 1.

Lili’s track followed the pressure contours of the southern and western periphery of the semi-permanent Atlantic subtropical high pressure ridge. The tropical cyclone moved just north of due westward at over 20 knots, crossed the Windward Islands as a developing tropical storm on the 23rd and then its winds briefly reached 60 knots on the 24th. The storm weakened to an open tropical wave on the 25th and 26th in the east-central Caribbean as its organization was disrupted by vertical wind shear.

Lili re-acquired a low-level closed circulation on the 27th, then its forward speed slowed to about 5 knots by the 28th while beginning a slow northward jog around the north coast of Jamaica. The storm dumped heavy rain on Jamaica and also Haiti. Resuming a west-northwestward track, Lili became a hurricane on the 30th, while passing over Cayman Brac and Little Cayman Islands.

The center of the hurricane moved over the southwest tip of the Isle of Youth on the morning of October 1st, and over western mainland Cuba a few hours later, with wind speeds as high as 90 knots. Gradually accelerating its forward speed to about 15 knots, Lili turned northward and made landfall on the Louisiana coast on the 3rd, with an estimated 80-knot maximum wind speed. However, between Cuba and Louisiana, Lili

intensified to 125 knots early on the 3rd over the north-central Gulf of Mexico and then rapidly weakened to 80 knots during the 13 hours until landfall. Lili was absorbed by an extratropical low on the 4th while moving northeastward near the Tennessee/Arkansas border. Lili was the first hurricane to make landfall in the United States since Irene hit Florida in 1999.

b. Meteorological Statistics

Observations used to estimate wind speed and pressure are plotted in Figs. 2 and 3, along with the best-track wind speed and pressure curves. These observations include 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), as well as flight-level and selected dropwindsonde observations from flights of the 53rd Weather Reconnaissance Squadron of the USAF Reserve Command and from the NOAA Aircraft Operations Center.

Ship reports of winds of tropical storm force or higher are given in Table 2, and selected surface observations from land stations and data buoys are given in Table 3.

Sustained wind speeds were near 45 to 50 knots as Lili moved quickly across the Windward Islands. A sustained wind speed of 47 knots with a gust to 68 knots was observed at Martinique early on the 24th.

The forward motion slowed to five knots as Lili moved between Haiti, Jamaica and eastern Cuba. This slow motion contributed to the copious rainfall over Jamaica from the 27th through the 30th, where over 20 inches of rainfall was recorded (Table 3). Haiti also received considerable rainfall.

Lili developed an eye which passed over the Isle of Youth and then western mainland Cuba on October 1st. The highest wind report from Cuba was a ten-minute average of 87 knots with a gust to 98 knots from Francia on the Isle of Youth and this is the basis for a best-track wind speed of 90 knots over Cuba. The highest aircraft -measured flight-level wind speed during this time was 87 knots. Over six inches of rainfall was recorded at locations in Granma and Santiago de Cuba provinces in eastern Cuba.

The highest best-track wind speed is estimated at 125 knots at 0000 UTC on the 3rd, while the hurricane was centered in the north-central Gulf of Mexico. This is based on an aircraft 700-mb flight-level wind speed of 142 knots along with 938-mb surface pressure. The aircraft flight level-wind speed reduces to a surface wind of 128 knots using a 90 percent eyewall reduction factor. There were also several GPS-sonde surface wind speed measurements of 115 to 123 knots near this time. The east eye wall passed over NOAA data buoy 42001 at 2000 UTC on the 2nd. This buoy reported a ten-minute wind speed of 98 knots with a gust to 130 knots, which is the highest wind speed ever recorded by a National Data Buoy Center buoy.

Hurricane Lili made landfall along the south-central coast of Louisiana near Intracoastal City. The highest observed sustained wind over land is 64 knots (Table 3), from a Texas

Tech. tower near Kaplan or about 15 n mi north-northwest of Intracoastal City. The highest recorded wind gust is 104 knots at Intracoastal City. The highest aircraft flight level wind speed near the time of landfall is 88 knots at 700 mb. The highest surface wind speed estimate obtained from GPS- sondes during the last few hours before landfall is 73 knots. A mobile SMART radar measured 101 knots just above the surface south of New Iberia. The lowest surface pressure observed was 963.9 mb at the Louisiana Agriclimate Information System at Crowley. Based on the above data, the best-track maximum wind speed at landfall is estimated at 80 knots. The landfall area is sparsely populated. Most of southern Louisiana experienced sustained winds of 65 knots or less.

Lili's eyewall collapsed as its wind speed decreased during the 13 hours before landfall. The radius of maximum wind speed may not have been close to the center at landfall. Aircraft Flight level winds near the coast just south of Morgan City suggest that the highest winds were perhaps 50 n mi east of the center, so that wind speeds near the coast south of Morgan City could have been as high or higher than wind speeds near Intracoastal City, where the center crossed the coast.

Rainfall across south-central and southeastern Louisiana ranged from four to eight inches, with the highest amount of 8.57 inches at Perry, just north of Intracoastal City. Over four inches was measured in northern Louisiana and southern Mississippi and over two inches spread into Arkansas. Portions of Florida and Alabama had over an inch of rain. A tide gage at Crewboat Channel near Calumet measured a storm tide water height of 12.3 feet and another at Vermillion Bay measured 11.7 feet. The water height at Burn's Point, south of Morgan City, is estimated at 10 to 12 feet above normal, based on the observed water level inside a house. A combination of storm surge and heavy rain caused levees to fail at Montegut and Franklin, Louisiana. Tide gauge waters levels were already 2 to 4 ft above normal prior to Lili's arrival.

Tornadoes were reported in Acadia, Evangeline, Lafayette, Rapides, and St. Landry Parishes. Most were short-lived and damage was in the F-0 to F-1 range on the Fujita scale.

c. Casualty and Damage Statistics

Lili went through the Windward Islands as a tropical storm. Landslides killed four in St. Vincent, including an infant. There was damage to 400 homes in Barbados and half the banana crop of St. Lucia was destroyed.

Jamaica was hard hit by heavy rain from Lili. Four people, including a 3-year-old child, died when flood waters swept them away. Flood waters also swept away livestock and crops and caused extensive damage to homes, bridges, roadways, and other infrastructure. Flood damage was compounded by heavy rain earlier in September from Hurricane Isidore. This is also the case with rainfall over western Cuba and Louisiana. Lili also pelted Haiti's south coast with wind and rain and four flood-related deaths occurred there.

There are news reports of high winds uprooting trees, knocking out electricity and damaging roofs in Cayman Brac in the northeastern Cayman Islands.

The hurricane cut a swath of destruction across western Cuba, damaging buildings and farmland and disrupting communications. Some 360,000 people were reported to have been evacuated from their homes. There was one direct death in Pinar del Rio province.

Lili made landfall on the central Louisiana coast as a category one hurricane and left behind a trail of muck and misery from widespread wind and flood damage. Strong winds toppled trees onto houses and into roadways, stripped shingles from roofs, and blew out windows. The wind and driving rain flattened sugar cane fields throughout southern Louisiana. A combination of storm surge and rain caused levees to fail in the southeastern part of the state. Lili also temporarily curtailed all oil production in the Gulf of Mexico. The latest insured property damage total from the American Insurance Services Group is \$430 million U.S. dollars, \$415 million for Louisiana and \$15 million for Mississippi. The total dollar damage estimate is twice this value or \$860 million dollars. President Bush declared that Louisiana is eligible for federal assistance. *10 August 2011 update - the total damage estimate has been revised to \$925 million.*

One indirect fatality occurred in Crowley, Louisiana, when an elderly woman died from carbon monoxide poisoning from a generator. Another indirect fatality occurred in Vermilion Parish where a 79 year old Erath man died when he fell from a ladder cleaning up storm debris.

d. Forecast and Warning Critique

Table 4 is a listing of average errors (with the number of cases in parentheses) for official forecasts and for a selection of guidance models. The official track errors are between 30 and 48 percent lower than the average official track errors for the previous 10-yr period, also listed in Table 4. The GUNS and GUNA guidance consistently had smaller errors than the official forecast at all forecast periods. These two guidance models are equally-weighted combinations of the GFDI, UKMI, and NGPI models (GUNS) and of GFDI, UKMI, NGPI, and AVNI models (GUNA).

Average official intensity errors are near the previous 10-yr averages and are smaller than all of the guidance errors.

Table 5 lists the watches and warnings issued for Lili. The hurricane made landfall on the Isle of Youth, Cuba 20 h after hurricane warnings were issued and made landfall on the western Cuba mainland 23 hours after warnings were issued. Hurricane warnings were issued for coastal Louisiana 28 h before landfall.

Table 1. Best track for Hurricane Lili, 21 September - 4 October 2002. Positions and pressures during the tropical wave stage are representative of the low-level vorticity center.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed(kt)	Stage
21 / 1800	10.2	44.6	1009	25	tropical depression
22 / 0000	10.3	46.5	1007	30	“
22 / 0600	10.8	48.5	1006	30	“
22 / 1200	11.2	50.4	1006	30	“
22 / 1800	11.8	52.2	1005	30	“
23 / 0000	12.1	54.6	1005	35	tropical storm
23 / 0600	12.2	56.8	1005	40	“
23 / 1200	12.4	58.7	1004	45	“
23 / 1800	12.5	60.4	1005	50	“
24 / 0000	12.7	62.1	1006	50	“
24 / 0600	12.8	63.7	1006	50	“
24 / 1200	13.0	64.9	1004	60	“
24 / 1800	13.2	66.0	1007	50	“
25 / 0000	13.5	66.9	1008	35	“
25 / 0600	13.7	67.5	1008	35	“
25 / 1200	14.0	68.2	1008	40	tropical wave
25 / 1800	14.2	68.9	1007	40	“
26 / 0000	14.5	69.8	1007	35	“
26 / 0600	14.9	71.0	1007	35	“
26 / 1200	15.3	72.2	1007	30	“
26 / 1800	15.6	73.0	1006	30	“
27 / 0000	15.7	73.5	1006	30	tropical depression
27 / 0600	15.9	74.0	1006	30	“
27 / 1200	16.1	74.6	1003	35	tropical storm
27 / 1800	16.7	75.0	1004	40	“
28 / 0000	17.4	75.1	999	45	“
28 / 0600	17.5	75.6	999	45	“
28 / 1200	18.1	75.4	1002	45	“
28 / 1800	18.5	75.7	1003	45	“
29 / 0000	18.8	76.1	1001	45	tropical storm

Table 1. Cont.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed(kt)	Stage
29 / 0600	18.8	76.8	999	40	“
29 / 1200	18.7	77.2	994	45	“
29 / 1800	18.7	77.6	994	50	“
30 / 0000	19.0	78.1	993	55	“
30 / 0600	19.1	78.7	990	60	“
30 / 1200	19.6	79.6	986	65	hurricane
30 / 1800	20.0	80.3	984	65	“
01 / 0000	20.5	81.1	978	70	“
01 / 0600	21.0	82.2	970	75	“
01 / 1200	21.6	83.2	971	90	“
01 / 1800	22.4	84.4	971	90	“
02 / 0000	23.0	85.7	967	90	“
02 / 0600	23.6	87.2	954	100	“
02 / 1200	24.4	88.3	954	110	“
02 / 1800	25.4	89.5	941	120	“
03 / 0000	26.7	90.3	940	125	“
03 / 0600	28.1	91.4	957	105	“
03 / 1200	29.2	92.1	962	80	“
03 / 1800	30.5	92.4	976	60	tropical storm
04 / 0000	31.9	92.1	985	40	“
04 / 0600	33.5	91.4	994	30	tropical depression
04 / 1200	35.8	90.0	997	25	“
04 / 1800	absorbed by extratropical low				
02 / 2013	25.9	89.9	938	125	minimum pressure
30 / 1400	19.7	79.8	986	65	landfall-Little Cayman and Cayman Brac
01 / 1100	21.3	83.0	971	90	landfall-Isle of Youth, Cuba
01 / 1400	22.1	84.0	971	90	landfall-Pinar del Rio Province, Cuba
03 / 1300	29.5	92.2	963	80	landfall-near Intracoastal City, LA

Table 2. Selected ship reports with winds of at least 34 kt for Hurricane Lili, 21 September - 4 October 2002.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
24 / 1200	3FOB5	17.0	68.5	100 / 45	1015.0
28 / 1200	DEFL	19.4	74.3	110 / 73	1008.7
01 / 1800	KAFO	24.4	82.2	120 / 39	1012.1
02 / 0300	KRNJ	24.7	84.1	100 / 38	1010.0
02 / 1200	KSPH	23.8	86.8	180 / 36	1005.2
02 / 1500	ELYN2	21.0	85.6	*** / 82	1014.5
02 / 1500	KSPH	24.2	87.3	160 / 35	1007.2
02 / 1800	KSPH	24.7	87.8	170 / 40	1007.1
02 / 2100	KSPH	24.6	87.9	180 / 35	1006.8
03 / 0300	KSPH	25.4	89.1	180 / 35	1008.2
03 / 0300	WG XO	29.0	88.5	100 / 41	1009.2
03 / 0600	KSPH	25.7	89.6	180 / 35	1007.2
03 / 0600	WG XO	28.8	88.0	110 / 39	1009.5
03 / 0900	KSPH	26.1	90.2	190 / 35	1006.0
03 / 0900	WG XO	28.6	87.4	120 / 36	1009.1
03 / 1500	KSPH	27.0	91.4	240 / 35	1007.9
03 / 1500	WG XO	28.0	88.7	170 / 36	1010.2
03 / 1500	WZJE	28.3	93.0	300 / 37	1003.0
03 / 1800	KSPH	27.3	91.9	240 / 35	1007.2

Table 3. (Cont.)

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft) ^c	Storm tide (ft) ^d	Total rain (in)
	Date/time (UTC)	Press. (mb)	Date/time (UTC) ^a	Sustained (kt) ^b	Gust (kt)			
Picayune, Mississippi								4.14
Connerly Bayou, Arkansas								4.34
Chicago-Midway, Illinois								1.04
Bloomington, Indiana								0.85
Padukah/Barkley, Kentucky								0.91
Cincinnati-Luken, Ohio								0.59
Pensacola, Florida								1.04
Fairhope, Alabama								1.20
NOAA buoy and Cman								
42001			02/2010	98	130			
42003	02/0800	1009.0	02/0720	36	49			
42007			03/1140	36	47			
42041	03/0300	984.0	03/0220	56	70			
BURL1			03/1020	52	70			
DRYF1	01/0810	1010.8	01/1714		46			
DPIA1	03/1559	1010.5	03/1559	31	35			
GDIL1			03/0640	36	69			
Jamaica								
Cedar Valley in St. Thomas								23.11
Craighead in Manchester								20.26
Knock Patrick in Manchester								21.66
Shewsbury in Westmoreland								23.82
Sunny Hill in St. Thomas								22.06
Cuba								
Francia	01/1100	991.2	01/1120	87	98			
Isabel Rubio	01/1550	971.4	01/1625	43	63			
Matias, Santiago de Cuba								6.22
Pilon, Granma								6.20
Pinar del Rio	01/1500	990.0	01/1450	59	76			
Punta del Esta	01/0905	989.7	01/1030	77	93			
San Juan y Martinez	01/1550	981.4		72	88			
Morne des Cadets, Martinique			24/0300	47	68			
Pt. Salines, Grenada	24/0700	1006	24/0800	40				
Grantley Adams, Barbados			23/1700	41	65			
Hewanorra, St. Lucia			23/2100	35	47			

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

^b Except as noted, sustained wind averaging periods for C-MAN and land-based ASOS reports are 2 min; buoy averaging periods are 8 min.

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

^d Storm tide is water height above National Geodetic Vertical Datum (1929 mean sea level).

Table 4. Official and selected model forecast errors for Hurricane Lili, 2002. Errors are for tropical storm and hurricane stages and are followed by the number of forecast cases in parentheses. Errors smaller than official forecast errors are shown in bold-face type.

Forecast technique	Forecast period (h)				
	12	24	36	48	72
Track errors (n mi)					
CLP5	38 (33)	87 (29)	142 (25)	213 (21)	341 (19)
GFDI	30 (33)	51 (29)	72 (25)	89 (21)	178 (19)
LBAR	33 (33)	58 (29)	76 (25)	84 (21)	124 (19)
AVNI	36 (33)	66 (29)	90 (25)	99 (21)	141 (19)
AEMI	45 (26)	77 (23)	99 (20)	104 (16)	162 (15)
BAMD	40 (33)	67 (29)	87 (25)	96 (21)	151 (19)
BAMM	35 (33)	57 (29)	70 (25)	71 (21)	132 (19)
BAMS	43 (33)	72 (29)	89 (25)	90 (21)	120 (19)
NGPI	37 (33)	53 (29)	80 (25)	89 (21)	147 (18)
UKMI	38 (32)	70 (29)	91 (25)	102 (21)	135 (18)
GUNS	30 (32)	49 (29)	65 (25)	67 (21)	95 (17)
GUNA	27 (32)	49 (29)	65 (25)	68 (21)	93 (17)
OFCL	30 (33)	54 (29)	73 (25)	84 (21)	115 (19)
Official mean (1992-2001)	43 (2199)	81 (1965)	115 (1759)	148 (1580)	222 (1272)
Intensity errors (kt)					
SHF5	13 (33)	17 (29)	19 (25)	21 (21)	27 (19)
SHIP	13 (33)	16 (29)	16 (25)	19 (21)	24 (19)
GFDI	14 (33)	18 (29)	20 (25)	20 (21)	26 (19)
AVNI	13 (33)	19 (29)	21 (25)	25 (21)	30 (19)
UKMI	15 (27)	20 (24)	20 (20)	21 (16)	25 (12)
OFCL	9 (33)	13 (29)	13 (25)	14 (21)	21 (19)
Official mean (1992-2001)	7 (2198)	11 (1963)	14 (1760)	16 (1576)	19 (1272)

Table 5. Watch and warning summary, Hurricane Lili, 21 September - 4 October 2002.

Date/time (UTC)	Action	Location
22/2100	tropical storm watch	Guadeloupe to Grenadines including Barbados
23/1800	tropical storm warning	St Lucia to Grenadines including Barbados
24/0300	all watches and warnings discontinued	Lesser Antilles
24/1500	tropical storm watch	S. coast of Dominican Republic from Punta Galente to Haiti border
24/1800	tropical storm watch	S. coast of Haiti
25/2100	tropical storm watch	Jamaica
26/1500	all watches discontinued	Hispaniola and Jamaica
27/0900	tropical storm warning	Jamaica
27/2100	tropical storm warning	Haiti
27/2100	tropical storm watch	Cuba provinces of Camaguey, Las Tunas, Granma, Santiago de Cuba
28/0300	tropical storm warning	Cuba: Granma, Santiago de Cuba, Guantanamo, Holguin
28/0300	tropical storm watch	all of Cayman Islands
28/0600	tropical storm watch discontinued	Cayman Island, still in effect for Little Cayman and Cayman Brac
29/0300	tropical storm warning	Cuba: Camaguay, Las Tunas
29/0300	tropical storm watch	Cuba: Matanzas, Cienfuegos, Villa Clara, Sancti Spiritus, Ciego de Avila
29/1500	tropical storm warning	Little Cayman and Cayman Brac
29/1500	tropical storm watch	Grand Cayman
29/1800	tropical storm warning	Grand Cayman
29/2100	hurricane watch	Cuba: Matanzas, Ciudad de la Habana, La Habana, Pinar del Rio, Isle of Youth
30/0000	Hurricane warning	all of Cayman Islands
30/0300?	tropical storm warning	all of Cuba
30/1500	hurricane warning	Cuba: Matanzas, Ciudad de la Habana, La Habana, Pinar del Rio, Isle of Youth

Table 5. (Cont.)

Date/time (UTC)	Action	Location
30/1800	tropical storm warning discontinued	Jamaica
30/2100	tropical storm watch	Mexico: Cozumel to Progreso
30/2100	tropical storm watch	Mexico: Cozumel to Progreso
01/0900	tropical storm warning discontinued	Cienfuegos, Villa Clara, Sancti Spiritus, Ciego de Avila, Granma, Santiago de Cuba, Guantanemo, Holguin, Camaguay, Las Tunas
01/1200	hurricane warning discontinued	Cayman Islands
01/2100	hurricane watch	San Louis Pass, Texas to mouth of Mississippi River, Louisiana
01/2100	tropical storm watch	east of mouth of Mississippi River to Pascagoula, Mississippi including New Orleans and Lake Ponchartrain
02/0000	hurricane warning discontinued	Cuba: Matanzas, Ciudad de la Habana, La Habana, Pinar del Rio, Isle of Youth
02/0900	hurricane warning	east of High Island, Texas to mouth of Mississippi River
02/0900	tropical storm warning	Freeport to High Island, Texas and east of mouth of Mississippi River to Alabama/Florida border including New Orleans and Lake Pontchartrain
02/0900	tropical storm watch discontinued	Mexico: Cozumel to Progreso
03/0900	tropical storm warning discontinued	Freeport to High Island, Texas
03/1900	all warnings discontinued	U.S. Gulf of Mexico coast

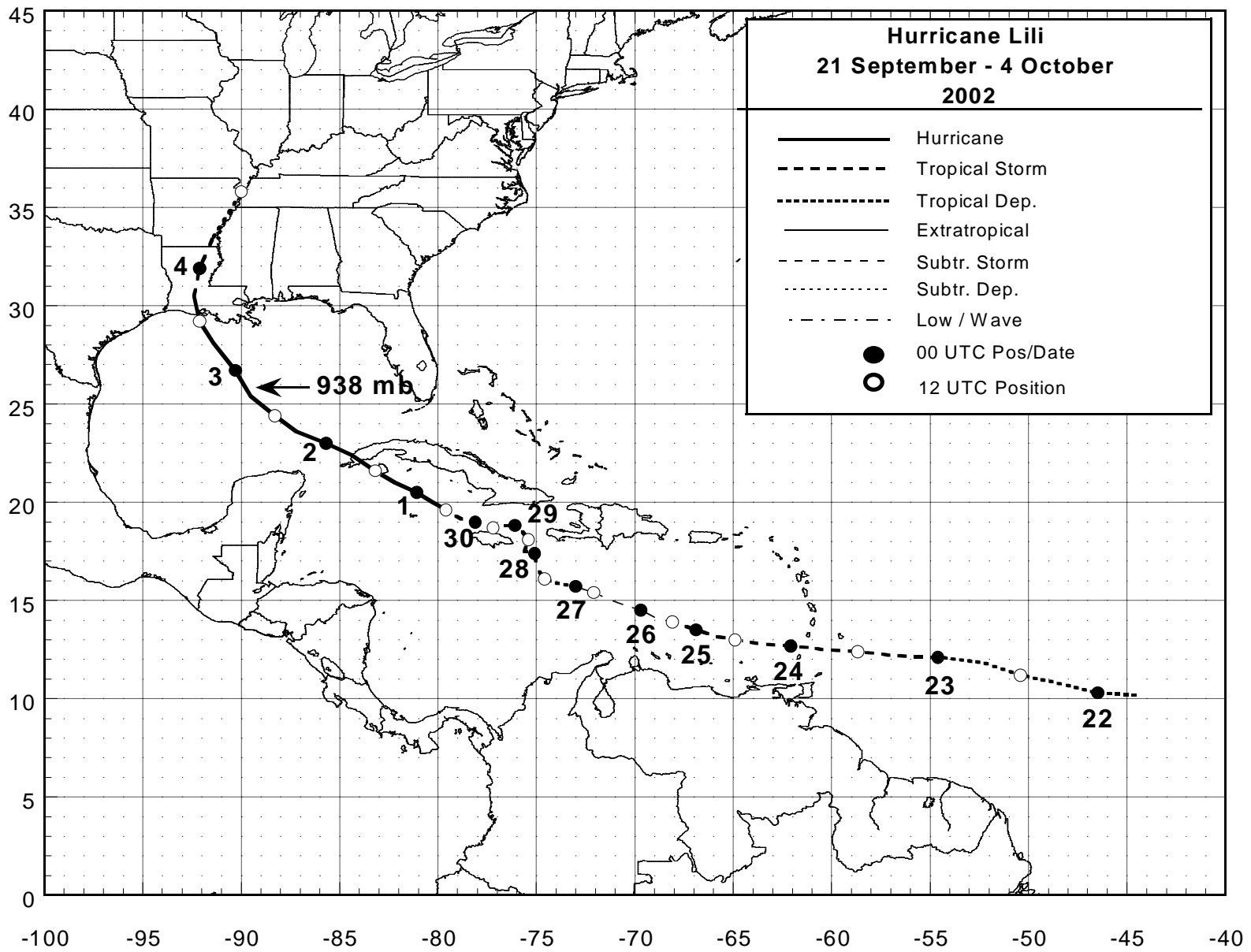


Figure 1. Best track positions for Hurricane Lili, 21 September - 4 October 2002.

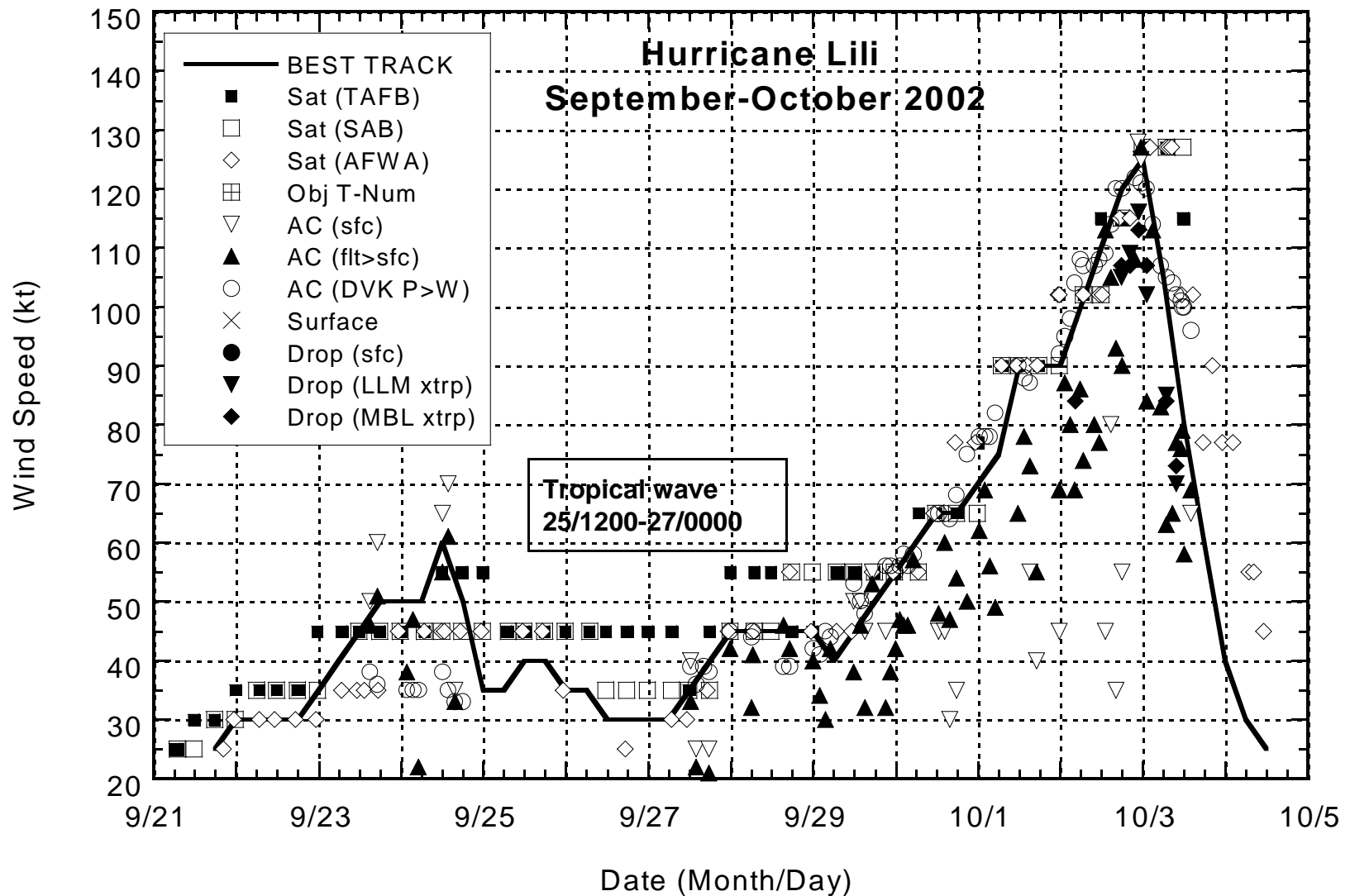


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Lili, 21 September - 4 October 2002. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% reduction factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Dropwindsonde observations include surface estimates derived from the mean wind over the lowest 150 m of the wind sounding (LLM) and from the sounding boundary layer mean (MBL).

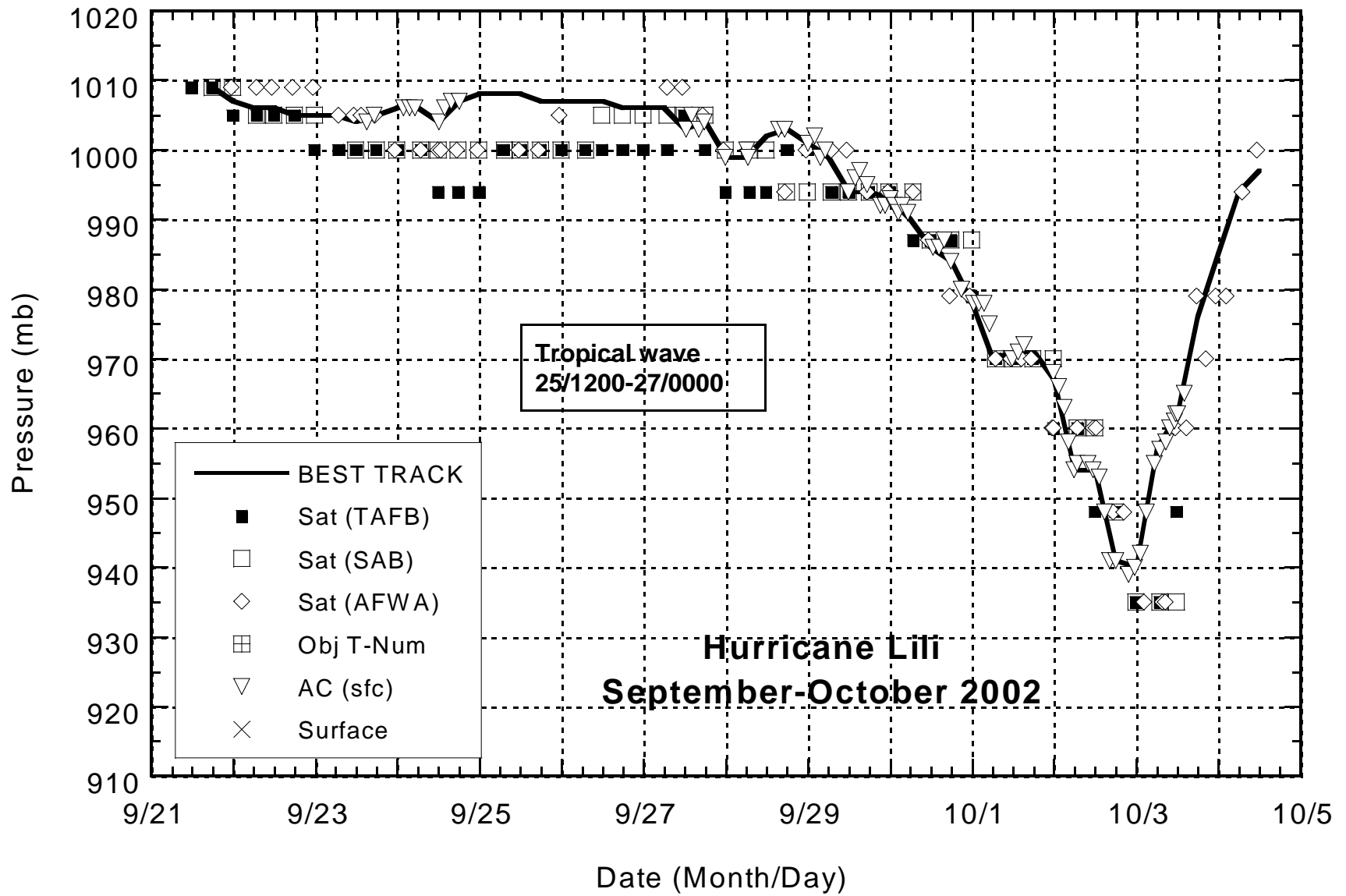


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Lili, 21 September - 4 October 2002.