

Tropical Cyclone Report
Hurricane Gaston
27 August – 1 September

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Gaston was a category 1 hurricane that made landfall along the central South Carolina coast. After moving inland, Gaston produced heavy rainfall across portions of the Carolinas and Virginia. Flooding in the Richmond, Virginia metropolitan area resulted in 8 deaths.

a. Synoptic History

The genesis of Gaston can be traced to a cold front that moved off the coast of the Carolinas into the Atlantic on 22 August, and drifted southward the following day before stalling on 24 August. Surface observations indicate that a broad low formed along the weakening front on 25 August. Thunderstorm activity associated with the low remained sporadic and disorganized until late on 26 August, when the convective activity began to increase and acquire a more banded structure. Early morning visible and microwave satellite imagery on 27 August suggest that the low had developed into the seventh tropical depression of the season by 1200 UTC that day, about 115 n mi east-southeast of Charleston, South Carolina. It is of note that the frontal zone from which Gaston formed also initiated the development of Tropical Storm Hermine two days later.

The “best track” chart of Gaston’s path is given in Fig. 1, with the wind and pressure histories shown in Figs. 2 and 3, respectively. The best track positions and intensities are listed in Table 1. Steering currents were very weak initially and the depression drifted slowly southward. Convective banding continued to increase on 27 August and the depression slowly strengthened, becoming a tropical storm early the next day as it drifted westward about 130 n mi southeast of Charleston. Strengthening continued on 28 August, and the first reconnaissance aircraft to reach the cyclone found maximum flight level winds of 59 kt shortly after 1800 UTC.

Early on 29 August steering currents became better defined, with the development of a mid- to upper-level ridge northeast of Gaston and the approach of a mid-latitude trough into the Appalachians. This steering pattern allowed the tropical cyclone to begin moving northwestward toward the South Carolina coast, and the forward motion of the cyclone increased from about 3 kt to 7 kt between 0000 UTC and 1200 UTC 29 August. Radar and satellite imagery showed that Gaston continued to get better organized as it approached the coast. Doppler radar observations indicate that Gaston reached hurricane strength just before it made landfall near Awendaw, South Carolina, between Charleston and McClellanville, around 1400 UTC 29 August, with maximum sustained winds estimated near 65 kt. The tropical cyclone then steadily weakened while moving northward across northeastern South Carolina.

At 0000 UTC 30 August Gaston weakened to a tropical depression over northeastern South Carolina. Gaston then turned north-northeastward ahead of the trough moving into the eastern United States and the cyclone crossed eastern North Carolina and southeastern Virginia during the day. Data from the Chesapeake Light C-MAN site and a ship near the mouth of Chesapeake Bay indicated that Gaston had regained tropical storm strength by 0000 UTC 31 August, while the center was still inland near Yorktown, Virginia. Tropical storm force winds at this time were confined to a small area over water southeast of the center; however, the primary impact of Gaston in Virginia was flooding produced by 6-12 in rains that occurred over about an 8 h period.

Gaston moved across the southern portion of Chesapeake Bay and crossed the Delmarva Peninsula shortly before 0600 UTC 31 August. The tropical cyclone then accelerated northeastward, passing about 60 n mi south of Nantucket Island, Massachusetts later that day. Gaston strengthened slightly as it continued to accelerate to the east-northeast, before becoming extratropical south of the Canadian Maritimes at 1200 UTC 1 September. The extratropical remnants of Gaston were finally absorbed by a larger extratropical system on 3 September about 750 n mi south-southeast of Reykjavik, Iceland.

b. Meteorological Statistics

Observations in Gaston (Figs. 2 and 3) 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 dropwindsonde observations from flights of the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command. Microwave satellite imagery from NOAA polar-orbiting satellites, the NASA Tropical Rainfall Measuring Mission (TRMM), the NASA QuikSCAT, and Defense Meteorological Satellite Program (DMSP) satellites were also useful in tracking Gaston. Ship reports of tropical storm force winds associated with Gaston are given in Table 2, and selected surface observations from land stations and data buoys are given in Table 3.

Gaston was strengthening up until landfall, and was operationally assessed to be a strong tropical storm when it crossed the coast. Unfortunately, no reconnaissance data were available in these last hours. However, a post analysis of Doppler velocity data from the Charleston and Wilmington NWS radars shows that Gaston had winds aloft that support a reclassification to a hurricane. The Wilmington radar observed a roughly 3 n mi wide patch of average winds of 71 kt or more in the southeast quadrant between 1130 and 1200 UTC on 29 August. These winds were observed at an altitude of about 11000 ft, and would correspond to roughly 64 kt at the surface using standard adjustment factors. The Charleston radar observed a similarly-sized area in the northwest quadrant that also supports 64 kt surface winds. Neither radar had a good look at the northeast quadrant, where the strongest winds would have been expected. Based on these observations, Gaston has been posthumously upgraded to a hurricane.

No land-based observations support hurricane force surface winds, although the area was not particularly well-sampled. A gust to 71 kt was recorded by a Carolinas Coastal Ocean Observing and Prediction System station just south of Capers Island, South Carolina, with

minimum pressure of 985.1mb. A gust to 70 kt was recorded by a storm chaser on the Isle of Palms. The highest surge report was over 4 ft inside of Bulls Bay.

In South Carolina, rainfall was heaviest in a swath from Berkeley and western Williamsburg counties through Florence and Darlington counties. Kingstree reported 10.5 in of rainfall, which produced urban flooding of up to 5 ft. Radar data suggest that up to 15 in may have fallen in some areas. Flash floods occurred in Lake City. One F1 tornado was reported in Marlboro county South Carolina. Rains tapered off somewhat as Gaston moved through North Carolina, with accumulations there being generally less than 6 in. Two tornados were confirmed in North Carolina on 29 August: an F0 in Scotland County and an unrated tornado in Hoke County.

Gaston produced very heavy rains and flash floods as it moved through southeastern Virginia on 30 August, with the most severe conditions in the Richmond metropolitan area. Two locations in Richmond reported over 12 in of rain (Table 3). Most of this rain occurred during an eight hour period late on 30 August. The cyclone also produced a dozen F0 tornadoes in eastern Virginia.

c. Casualty and Damage Statistics

Flash floods in the Richmond area directly resulted in 8 fatalities. Five of these were from motorists attempting to drive through flooded roadways, including one who drove around a barricade to do so. Three individuals were killed during rescue attempts. One indirect death was also reported.

Major fresh-water flooding occurred in South Carolina. In Berkeley County, 20 structures were severely damaged or destroyed, and dozens of other structures suffered minor flooding damage. Winds associated with Gaston caused minor damage to roughly 3000 structures in Charleston, Berkeley, and Dorchester counties. Downed tree limbs resulted in scattered power outages.

In Virginia, Gaston washed out roads and bridges. Damage was concentrated in Chesterfield, Dinwiddie, Hanover, Henrico, and Prince George counties. About 350 homes and 230 businesses were either damaged or destroyed. Tornadoes mostly downed trees, but several roofs were also damaged.

The American Insurance Services Group reports \$65 million in insured losses associated with Gaston in South Carolina (\$20M), North Carolina (\$15M), and Virginia (\$30M). Total damage is estimated to be near \$130 million.

d. Forecast and Warning Critique

Average official track errors for Gaston are given in Table 4. These errors were generally smaller than the long-term averages. The official errors were also generally lower than the errors

of the best dynamical guidance models and very close to the errors of the GUNA, CONU, and FSSE consensus models.

Average official intensity errors were 8, 13, 12, 7, 5, and 10 kt for the 12, 24, 36, 48, 72, and 96 h forecasts, respectively. For comparison, the average official intensity errors over the 10-yr period 1994-2003¹ are 6, 10, 12, 15, 19, and 20 kt, respectively. Although the errors are not particularly large, early forecasts did not anticipate that Gaston would become a hurricane, and as a result a hurricane warning was issued only about 14 h prior to landfall. A tropical storm warning was first issued at 1500 UTC 28 August; Gaston made landfall roughly in the center of the warning area 23 h later. The complete set of watches and warnings associated with Gaston are listed in Table 5. No coastal warnings were issued when Gaston re-strengthened to a tropical storm over Virginia because the tropical storm force winds were expected to remain exclusively over water.

Acknowledgements:

Landfall observations, as well as damage and casualty information, were compiled and provided by the NWS/Weather Forecast Offices in Charleston, SC, Wilmington, NC, Jacksonville, FL, and Wakefield, VA.

¹ Errors given for the 96 and 120 h periods are averages over the three years 2001-2003.

Table 1. Best track for Hurricane Gaston, 27 Aug. - 1 Sept. 2004.

Date/Time (UTC)	Latitude (EN)	Longitude (EW)	Pressure (mb)	Wind Speed (kt)	Stage
27 / 1200	31.8	78.1	1015	25	tropical depression
27 / 1800	31.6	78.0	1014	25	"
28 / 0000	31.4	78.0	1011	30	"
28 / 0600	31.3	78.2	1005	35	tropical storm
28 / 1200	31.3	78.5	1000	45	"
28 / 1800	31.3	78.8	997	50	"
29 / 0000	31.5	79.1	994	55	"
29 / 0600	32.1	79.4	991	60	"
29 / 1200	32.8	79.5	986	65	hurricane
29 / 1800	33.5	79.6	992	45	tropical storm
30 / 0000	34.2	79.4	995	30	tropical depression
30 / 0600	34.9	79.1	998	30	"
30 / 1200	35.6	78.7	1000	25	"
30 / 1800	36.4	77.8	1002	30	"
31 / 0000	37.2	76.6	1001	35	tropical storm
31 / 0600	38.1	74.8	1001	35	"
31 / 1200	39.1	72.9	1001	35	"
31 / 1800	40.2	70.5	999	35	"
01 / 0000	41.0	67.5	999	40	"
01 / 0600	41.7	63.5	999	45	"
01 / 1200	43.0	59.6	999	45	extratropical
01 / 1800	45.0	55.0	998	45	"
02 / 0000	47.0	50.0	997	45	"
02 / 0600	48.5	44.0	996	45	"
02 / 1200	50.0	38.0	994	45	"
02 / 1800	51.1	32.0	994	40	"
03 / 0000	52.0	28.9	998	35	"
03 / 0600					absorbed by extratropical low
29 / 1400	33.0	79.6	985	65	landfall near Awendaw, S.C.
29 / 1400	33.0	79.6	985	65	minimum pressure

Table 2. Selected ship reports with winds of at least 34 kt for Hurricane Gaston, 27 Aug. - 1 Sept. 2004.

Date/Time (UTC)	Ship call sign	Latitude (EN)	Longitude (EW)	Wind dir/speed (kt)	Pressure (mb)
29 / 0300	A8DO7	31.5	79.8	310 / 41	1006.0
29 / 0900	KRHX	31.9	79.6	270 / 38	1003.0
29 / 1800	VRCV	32.8	79.0	210 / 36	1006.7
30 / 1200	OXKO2	33.9	76.6	200 / 35	1016.3
31 / 0000	H9YY	36.5	75.1	170 / 36	1010.0
31 / 0000	H9YY	36.5	75.1	170 / 36	1010.0
31 / 1900	HZZD	40.6	68.9	130 / 37	1006.8
01 / 0600	WRYG	40.6	63.2	240 / 44	1006.8
01 / 0600	DGTX	46.1	54.4	210 / 41	1010.3
01 / 1200	HP6038	46.4	48.4	210 / 43	1011.6
01 / 1200	VEP717	46.7	48.7	210 / 43	1009.9
01 / 1200	YJUF7	46.8	48.0	210 / 38	1010.5
01 / 1500	HP6038	46.4	48.4	210 / 41	1010.1
01 / 1500	VEP717	46.7	48.7	210 / 41	1008.0
01 / 1500	YJUF7	46.8	48.0	210 / 40	1008.9
01 / 1800	HP6038	46.4	48.4	210 / 41	1008.2
01 / 1800	VEP717	46.7	48.7	230 / 36	1007.3
01 / 1800	YJUF7	46.8	48.0	220 / 36	1007.4
01 / 1800	SBFC	47.3	41.8	220 / 45	1007.0
02 / 0000	VEP717	46.7	48.7	170 / 38	1000.0
02 / 0000	YJUF7	46.8	48.0	180 / 35	1000.9
02 / 0600	SBFC	46.3	45.6	230 / 45	998.6
02 / 0600	LANT5	48.6	31.3	220 / 36	1006.0
02 / 1200	LANT5	48.1	33.0	200 / 35	1005.0
02 / 1800	LANT5	48.2	34.6	220 / 38	1000.0

Table 3. Selected surface observations for Hurricane Gaston, 27 August – 1 September.

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)			
South Carolina								
Charleston (CHS)	29/1330	999	29/1457	37	48			4.05
Florence (FLO)	30/0058	998.6	29/2300	30	41			4.36
North Myrtle Beach (CRE)	29/2234	1004.7	30/0040	31	39			1.69
Myrtle Beach (MYR)			29/1945	35	45			0.47
S.C. (Unofficial)								
South Capers Island	29/1254	985.1	29/1124	46 ^c	71	2		
Downtown Charleston			29/0818	28 ^g	42			4.63
Pineville			29/1820	37 ^g	51			5.01
Isle of Palms	29/1350	987	29/1239		70			
Myrtle Beach Springmaid Pier	29/2124	1002.6	29/2200	39 ^f	50			
Georgetown			29/1820		43			
Jamestown								7.05
Fort Moultrie								5.05
Charleston Harbor						1	7.03 ^h	
Bulls Bay Charleston County						~4.5		
Loris								2.87
Outland Georgetown County								3.91
Lake City								6.45
Hartsville								2.81
Darlington Airport								6.00
Darlington								5.55
McColl								5.84
Mullins								2.24
Pee Dee								3.41
Dillon								4.46
Cades								9.83
Kingstree								10.50
Georgetown								3.80

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)			
Andrews								5.30
North Carolina								
Lumberton (LBT)	30/0641	1001.4	30/0326	27	35			3.37
Wrightsville Beach NOS Jonnie Mercer Pier	29/2300	1008.8	30/0412	33 ^f	38			
Sunset Beach Pier NOS	29/2200	1005.8	29/2100		36			
N.C. (Unofficial)								
Carolina Beach			30/0250		39			
Lumberton 3SE								3.36
Longwood								2.68
Fair Bluff								3.01
Red Springs								6.10
Virginia (Official)								
Richmond (RIC)								6.68
Wakefield (NWS Office)								2.51
Chesapeake Bay Bridge Tunnel NOS			31/0142	37	45			
Kiptopeke NOS			31/0236	38	48			
Rappahannock Light NOS	31/0224	1000.9	31/0506	34	39			
Sewells Point NOS			31/0118	35	43			
Yorktown NOS	30/2342	1001.4	30/1900	32	42			
Virginia (Unofficial)								
Ashland								10.61
Richmond (Math & Science Center)								12.30
Richmond (West End)								12.60
Richmond (Science Museum)								6.56
Richmond (St. Christopher's School)								6.40
Mechanicsville								10.70

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)			
Chester								6.20
Winterpock								5.69
Sandston								8.10
Buoys and CMAN sites								
TYBG1 (Navy Tower R8)	29/0532	1004.3	29/0432	39	47			
SPAG1 (Navy Tower R2)	29/0800	1003						
DUCN7 (Duck Pier)	30/2100	1009.7	31/0100	29	40			
FBIS1 (Folly Beach)	29/1200	998	29/1200	32 ^g	44			
CHLV2 (Chesapeake Lt.)	31/0200	1006	31/0150	44 ^g	51			
41004	29/0850	996						
44004	31/1500	1012.2	31/1700	33 ^g	43			
44008	31/2000	1000.4	31/2200	31	42			
44009	31/0700	1003.3	31/0940	27 ^g	34			
44011	01/0200	1001.4	01/0310	28 ^g	38			
44014	30/2300	1009.7	31/0500	28	36			
44137	01/0820	1000.4	01/0920	30	43			

^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).

^e 2 min average.

^f 6 min average.

^g 10 min average.

^h Water height above mean lower low water.

Table 4. Preliminary forecast evaluation (heterogeneous sample) for Hurricane Gaston, 27 Aug. - 1 Sept. 2004. Forecast errors (n mi) are followed by the number of forecasts in parentheses. Errors smaller than the NHC official forecast are shown in bold-face type. Verification includes the depression stage, but does not include the extratropical stage.

Forecast Technique	Forecast Period (h)						
	12	24	36	48	72	96	120
CLP5	35 (15)	80 (13)	128 (11)	167 (10)	315 (8)	306 (4)	
GFNI	33 (9)	30 (7)	70 (7)	141 (7)	364 (5)	1000 (1)	
GFDI	30 (11)	55 (9)	82 (8)	141 (8)	301 (6)	418 (2)	
GFDN	36 (10)	56 (9)	62 (8)	111 (8)	277 (5)	799 (2)	
GFSI	20 (11)	42 (9)	60 (8)	84 (8)	176 (6)	379 (2)	
AEMI	21 (13)	42 (11)	51 (9)	81 (9)	168 (7)	206 (3)	
NGPI	24 (11)	46 (9)	74 (8)	130 (8)	305 (6)	801 (2)	
UKMI	26 (7)	41 (6)	77 (6)	150 (6)	375 (4)		
A98E	32 (15)	51 (13)	71 (11)	108 (10)	221 (8)	410 (4)	
A9UK	30 (7)	52 (6)	85 (5)	155 (5)	239 (4)		
BAMD	27 (15)	56 (13)	96 (11)	129 (10)	152 (8)	315 (4)	
BAMM	31 (15)	54 (13)	79 (11)	97 (10)	200 (8)	308 (4)	
BAMS	44 (15)	82 (13)	114 (11)	153 (10)	315 (8)	376 (4)	
CONU	21 (11)	31 (9)	44 (8)	72 (8)	185 (6)	519 (2)	
GUNA	17 (7)	26 (6)	46 (6)	75 (6)	175 (4)		
FSSE	18 (8)	32 (6)	46 (6)	65 (6)	153 (4)		
OFCL	19 (13)	36 (11)	54 (9)	66 (9)	159 (7)	258 (3)	
NHC Official (1994-2003 mean)	44 (3172)	78 (2894)	112 (2636)	146 (2368)	217 (1929)	248 (421)	319 (341)

Table 5. Watch and warning summary for Hurricane Gaston 27, August – 1 September, 2004.

Date/Time (UTC)	Action	Location
27 / 2100	Tropical Storm Watch issued	Surf City to Fernandina Beach
28 / 1500	Tropical Storm Watch modified to	Little River Inlet to Surf City
28 / 1500	Tropical Storm Warning issued	Savannah River to Little River Inlet
28 / 2100	Hurricane Watch issued	Savannah River to Little River Inlet
29 / 0000	Tropical Storm Warning/Hurricane Watch changed to Hurricane Warning	Savannah River to Little River Inlet
29 / 0300	Tropical Storm Watch changed to Tropical Storm Warning	Little River Inlet to Surf City
29 / 1200	Tropical Storm Watch discontinued	All
29 / 1500	Tropical Storm Warning modified to	Edisto Beach to Little River Inlet
29 / 1500	Hurricane Warning discontinued	All
29 / 2100	Tropical Storm Warning modified to	South Santee River to Little River Inlet
30 / 0000	Tropical Storm Warning discontinued	All

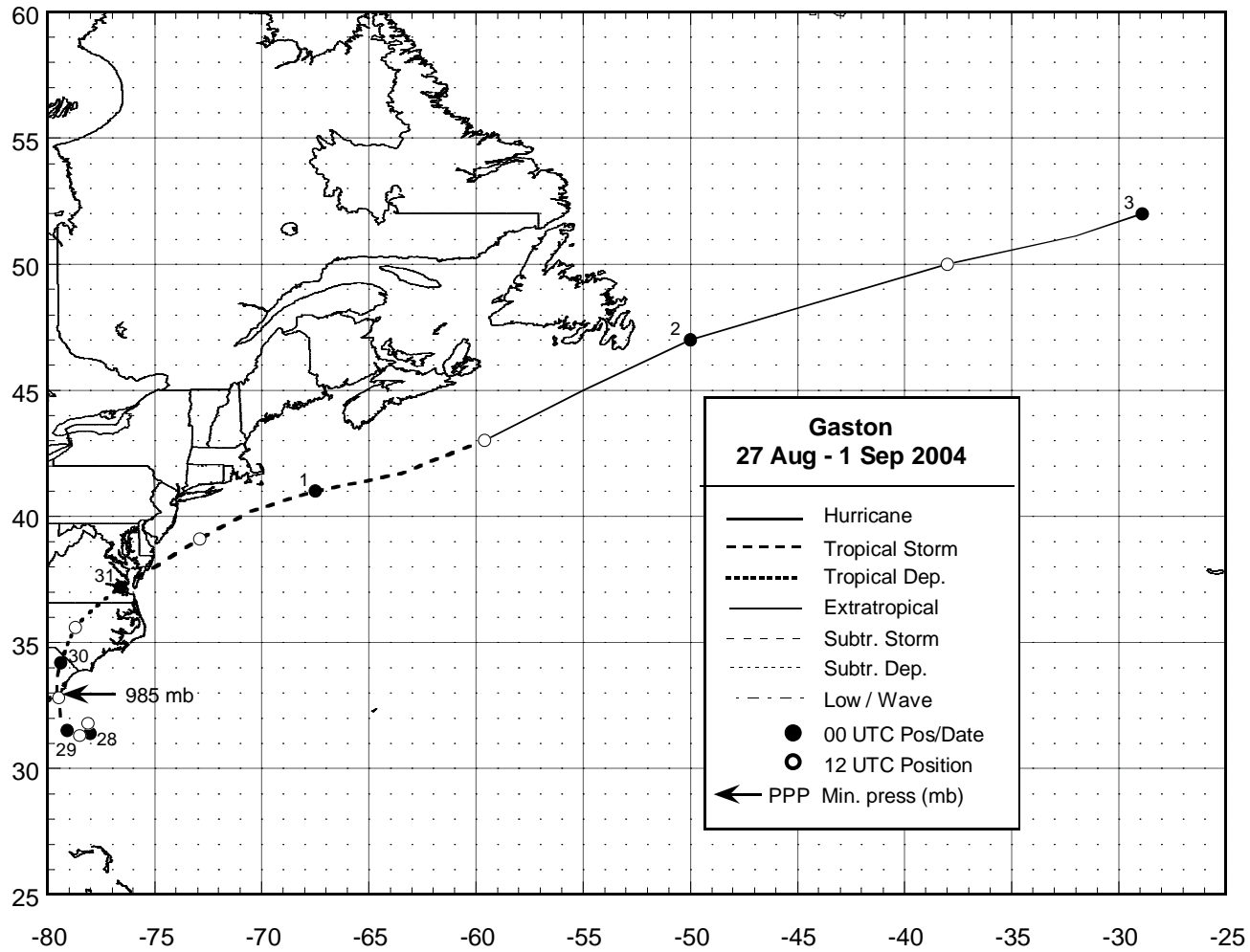


Figure 1. Best track positions for Hurricane Gaston, 27 Aug. - 1 Sept. 2004. Track during the extratropical stage is based, in part, on analyses from the NOAA Ocean Prediction Center.

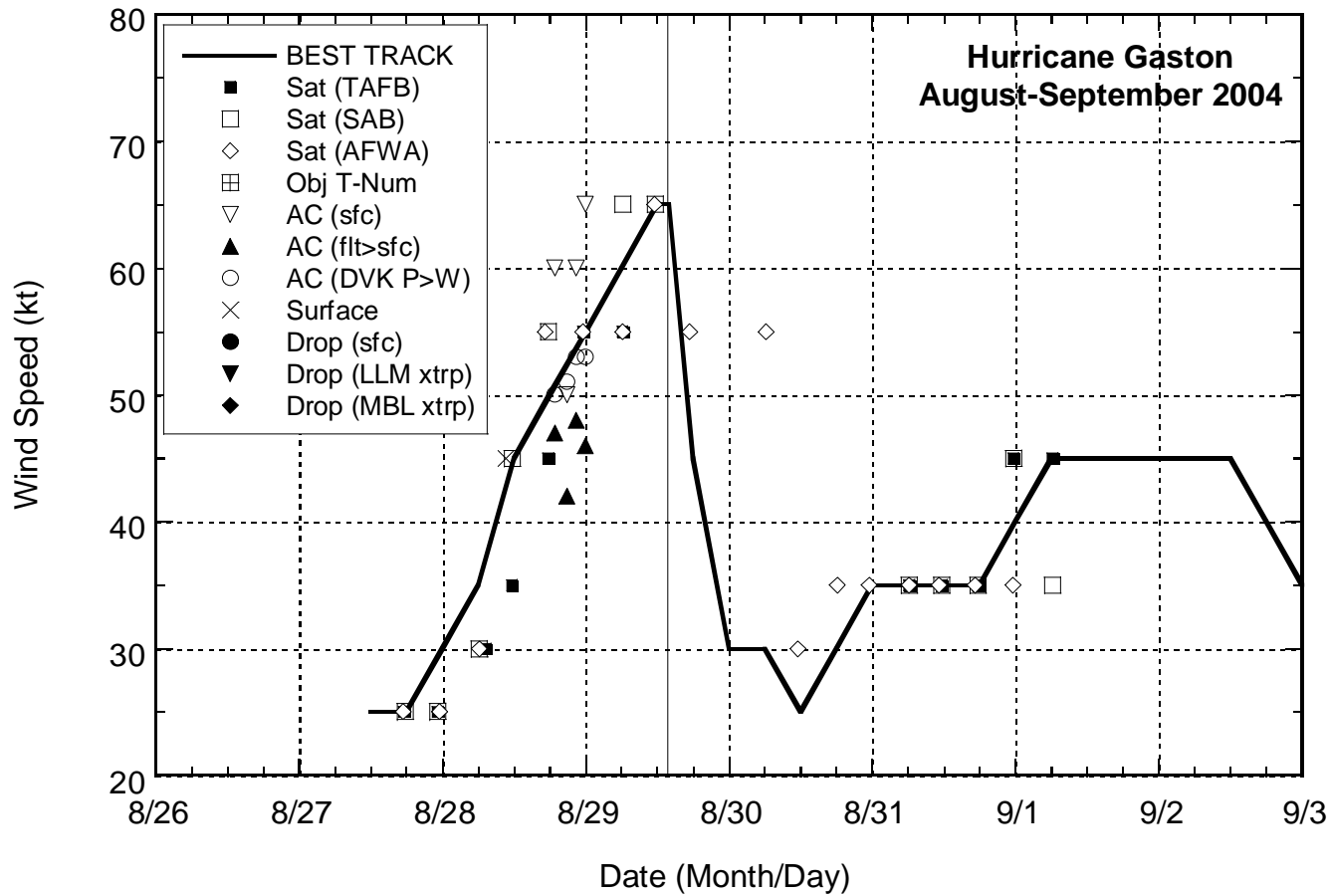


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Gaston, 27 Aug. - 1 Sept. 2004. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% reduction factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Estimates during the extratropical stage are based, in part, on analyses from the NOAA Ocean Prediction Center. Thin vertical line denotes landfall.

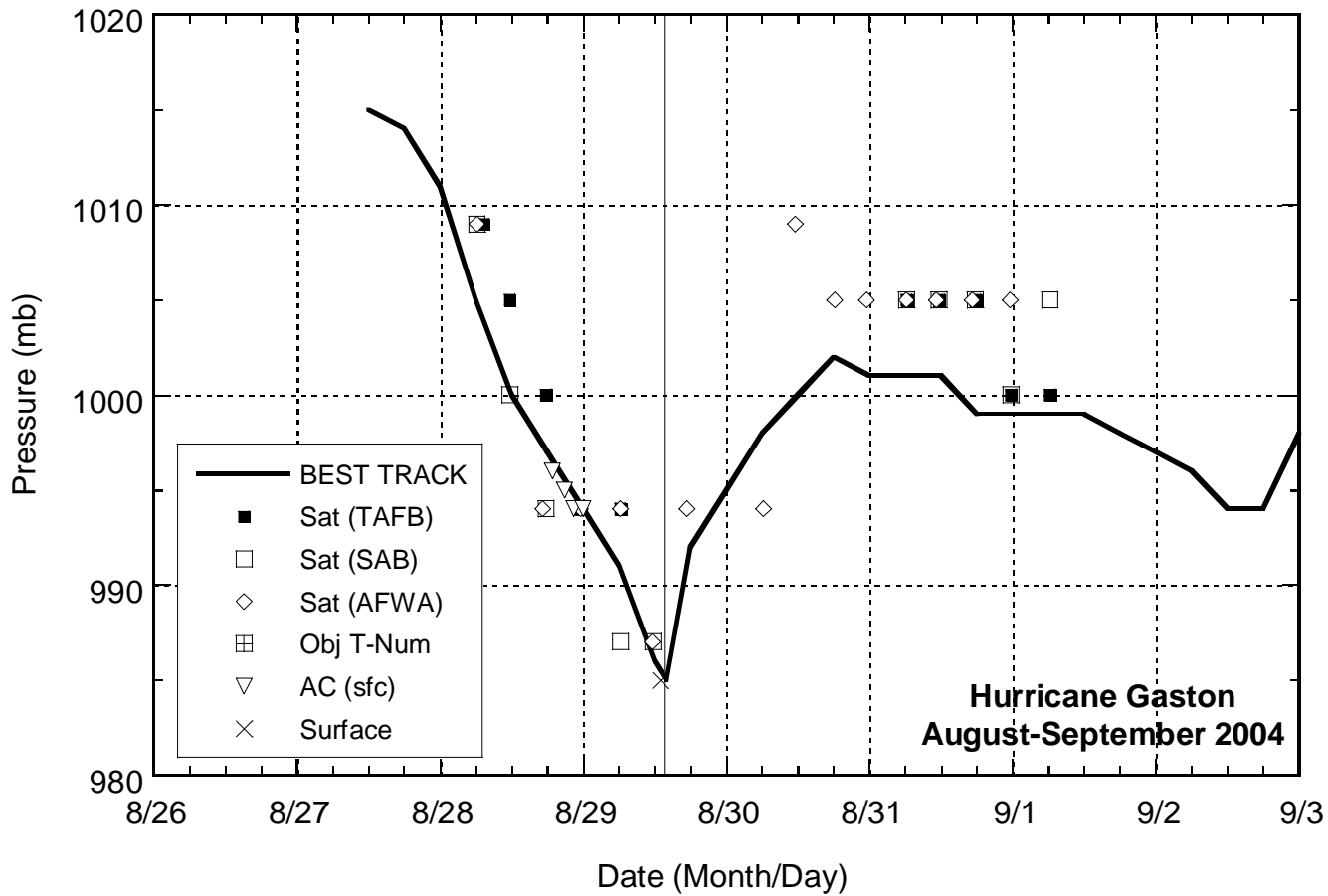


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Gaston, 27 Aug. - 1 Sept. 2004. Estimates during the extratropical stage are based, in part, on analyses from the NOAA Ocean Prediction Center. Thin vertical line denotes landfall.