

Tropical Cyclone Report
Tropical Storm Gabrielle
(AL072007)
8-11 September 2007

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Gabrielle was a tropical storm that made landfall along the Cape Lookout National Seashore in eastern North Carolina, and then exited the coast less than 12 hours later near Kill Devil Hills.

a. Synoptic History

The genesis of Gabrielle can be traced back to a low pressure area that formed along the coast of Georgia on 3 September. This low developed along a frontal boundary that initially moved off the southeastern United States coast on 1 September. After forming, the weak low moved eastward and remained non-tropical during the next several days. The low weakened and became ill-defined on 5-6 September. The next day, an upper-level trough over the western Atlantic began to cut off several hundred miles southwest of Bermuda. This mid-to upper-level cut-off low moved slowly southwestward and aided in the regeneration of the surface low over the western Atlantic. A Hurricane Hunter reconnaissance mission on the afternoon of 7 September was unable to find a well-defined center of circulation, but it did encounter flight-level winds consistent with tropical storm force winds at the surface. Satellite imagery suggests that the circulation became better defined late on 7 September, and based on the improved satellite appearance and the peak-flight level winds from the earlier aircraft, it is estimated that a subtropical storm formed at 0000 UTC 8 September about 360 n mi southeast of Cape Hatteras, North Carolina. The “best track” chart of Gabrielle’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.

The satellite appearance of the cyclone remained that of a subtropical storm during the next 12 hours as the primary band of thunderstorm activity remained well to the north of the center. This band gradually weakened and new convection developed just northwest of the center, which led to the transition of Gabrielle to a tropical storm by 1800 UTC 8 September. Gabrielle gradually strengthened while moving northwestward toward eastern North Carolina early on 9 September. Before reaching the coast of North Carolina, reconnaissance aircraft data revealed that the center of Gabrielle reformed closer to the thunderstorm activity, which resulted in some additional strengthening. Gabrielle reached a peak intensity of 50 kt at 1200 UTC 9 September, while centered just south-southeast of Cape Lookout, North Carolina. A few hours later, the center of Gabrielle made landfall along the Cape Lookout National Seashore; however, strong northerly upper-level winds initially kept the convection and strongest surface winds offshore. Shortly thereafter, Gabrielle weakened due to the northerly wind shear and its interaction with land. While over extreme eastern North Carolina, Gabrielle turned northeastward and exited the coast near Kill Devil Hills just after 0000 UTC 10 September.

After moving back over the Atlantic waters, thunderstorm activity continued to decrease and became even more removed from the center, and Gabrielle weakened to a tropical depression by 0600 UTC 10 September. The depression moved east-northeastward, passing well southeast of the coast of the northeastern United States. The circulation of Gabrielle weakened and dissipated ahead of a frontal boundary by 1200 UTC 11 September about 300 n mi south-southwest of Nova Scotia.

b. Meteorological Statistics

Observations in Gabrielle (Figs. 2 and 3) include satellite-based Hebert-Poteat and Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), 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 Aqua, the NASA QuikSCAT, the Department of Defense WindSat, and Defense Meteorological Satellite Program (DMSP) satellites were also useful in tracking Gabrielle. Conventional land-based surface observations, buoys, C-MAN stations, and National Weather Service Doppler radar data were helpful in tracking the path of Gabrielle over eastern North Carolina.

The strengthening of Gabrielle just southeast of the North Carolina coast was well documented by reconnaissance aircraft. The aircraft data indicate that the center of Gabrielle reformed just after 0900 UTC 9 September near a mid-level center seen in satellite imagery, which was associated with a band of very strong thunderstorms. Shortly after this time, a 925 mb flight-level wind of 61 kt was reported. A subsequent reconnaissance flight avoided this area of strong thunderstorms due to safety concerns. However, just prior to Gabrielle's landfall the aircraft flew near the edge of the strong convection and measured a peak flight-level wind of 66 kt at 850 mb. A dropsonde released near the peak flight-level winds measured a surface wind of 49 kt, however applying a standard wind reduction using the mean of the lowest 150-m winds from this sonde results in a slightly lower wind estimate. The 50 kt peak intensity is based on a consensus of the sonde data and the flight-level winds reduced to the surface using a standard reduction.

Even though Gabrielle's intensity is estimated at 50 kt at landfall, these strong winds never reached the coast, as northerly shear kept the strongest thunderstorm activity offshore for several hours. By the time this activity reached the coast, the maximum winds had decreased a little. Selected surface observations from land stations and data buoys are given in Table 2. The highest sustained wind measured in eastern North Carolina was 38 kt at Frisco Pier. A wind gust to 46 kt was reported at Cape Hatteras and a wind gust to 53 kt was observed at Ocracoke. Heavy rainfall associated with Gabrielle was confined to a rather small area of eastern North Carolina. Four to eight inches of rain fell across southern Craven and eastern Carteret Counties with a maximum amount of 9.03 inches reported near Harlowe in Carteret County. An estimated storm surge of 1 to 2 ft occurred along the Atlantic facing beaches of Carteret, Hyde and Dare counties, and a sound-side storm surge of 2 to 3 ft was reported in portions of Dare County.

Two ship reports of tropical storm force winds were received in association with Gabrielle. A history of quality controlled data from these ships suggests that these winds are likely too high.

c. Casualty and Damage Statistics

Overall, impacts from Gabrielle were minimal in eastern North Carolina. Reports indicate that storm surge and higher than normal tidal levels contributed to an over-wash of Highway 12 in Dare County, north of Cape Hatteras near Salvo and Rodanthe. Minor beach erosion was also reported along the south facing beaches of Carteret, Hyde, and southern Dare Counties. A few streets in Morehead City and Beaufort were closed due to heavy rainfall and several homes and businesses suffered minor flood damage. There were no reports of casualties associated with Gabrielle.

d. Forecast and Warning Critique

The genesis of Gabrielle was well anticipated in Tropical Weather Outlooks issued by the National Hurricane Center. The incipient disturbance from which Gabrielle formed was first discussed in the Outlook at 1530 UTC 2 September. This and subsequent Outlooks issued during the next couple of days discussed the possibility of slow development of this system. The first explicit mention of possible tropical or subtropical cyclone formation was made at 0930 UTC 4 September, several days before Gabrielle formed. Experimental probability of genesis forecasts made during the 48-h period prior to formation of this system ranged from 20 to 90%.

A verification of official and guidance model track forecasts is given in Table 3. Average official track errors (with number of cases in parenthesis) for Gabrielle were 20 (12), 31 (10), 46 (8), 62 (6), 154 (2) n mi for the 12, 24, 36, 48, and 72 h forecasts, respectively. There were no 96 or 120 h forecasts that verified. The official track errors through 48 hours are nearly half of the average 5-year (2002-2006) official track errors (Table 3), while the 72 h error is slightly below the 5-year mean. The NHC forecasts in general accurately predicted Gabrielle's path across eastern North Carolina, but showed a little northwestward bias after its re-curve. The official forecasts were better than all the track guidance through 24 h and only the medium Beta and Advection Model (BAM) and the interpolated GFS model were better than the NHC predictions at 36, 48 and 72 h. The NHC track forecasts were better than the CONU and GUNA model consensus forecasts at all time periods.

Average official intensity errors (Table 4) were 5, 6, 12, 16, and 15 kt for the 12, 24, 36, 48, and 72 h forecasts respectively. The intensity forecast errors are a little smaller than the 5-year mean, except at 48 h. The official intensity forecasts predicted that Gabrielle would remain a tropical storm after exiting the coast of North Carolina, and this resulted in a high bias in some of the forecasts.

Table 5 is a summary of coastal watches and warnings issued in association with Gabrielle. Tropical storm warnings were issued in a timely manner (24 h or more in advance of landfall) for eastern North Carolina.

e. Acknowledgements

Most of the surface observations in this report were provided by National Weather Service (NWS) Offices in Morehead City, North Carolina and Wakefield, Virginia. Additional observations from buoys and C-MANs were provided by the National Data Buoy Center (NDBC). WeatherFlow provided additional surface observations that were useful both operationally and in the post-storm analysis.

Table 1. Best track for Tropical Storm Gabrielle, 8-11 September 2007.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
08 / 0000	30.1	71.8	1011	40	subtropical storm
08 / 0600	30.5	72.8	1010	40	"
08 / 1200	31.1	73.8	1010	35	"
08 / 1800	31.8	74.6	1009	35	tropical storm
09 / 0000	32.6	75.4	1007	40	"
09 / 0600	33.5	76.0	1004	45	"
09 / 1200	34.3	76.4	1004	50	"
09 / 1800	35.2	76.3	1006	45	"
10 / 0000	36.0	75.8	1007	40	"
10 / 0600	36.7	75.0	1008	30	tropical depression
10 / 1200	37.1	73.8	1009	30	"
10 / 1800	37.5	72.0	1010	30	"
11 / 0000	37.9	70.0	1010	30	"
11 / 0600	38.4	68.0	1010	30	"
11 / 1200					dissipated
09 / 1200	34.3	76.4	1004	50	Maximum wind and minimum pressure
09/1530	34.8	76.4	1005	50	Landfall along Cape Lookout National Seashore, NC

Table 2. Selected surface observations for Gabrielle, 8-11 September 2007.

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)			
North Carolina								
Official								
Beaufort (KMRH)	09/1315	1008.5	09/1907	29	38			7.43
Beaufort 6 N								8.30
Cape Hatteras (KHSE)	09/2015	1010.5	09/2341	34	46			0.23
Cedar Island (CITN7)	09/1550	1008.0						
Cherry Point (KNKT)	09/1954	1010.5						4.52
New Bern (KEWN)	09/2001	1010.5						1.89
New Bern RAWS								1.12
Newport NWS								5.36
Ocracoke COOP					49			
Stumpy Point (SP0N7)	09/2220	1009.0	09/1820	30	36			
Swanquarter (SWQN7)	09/1820	1007.0						
Unofficial								
Avon Ocean (WeatherFlow)	09/1931	1009.0	09/1800	34	40			
Davis Mesonet								4.88
Frisco Pier (WeatherFlow)	09/1928	1009.5	09/2330	38	45			
Frisco Woods (WeatherFlow)	09/1946	1009.5	09/2237	35	43			
Harlowe (7.2 ENE Newport) (COCORAHS)								9.03
Indian Beach			09/2000		37			
Indian Beach Mesonet								2.19
Morehead City								7.70
Morehead City Waste Water Plant								7.53
Morehead City (2.9 WNW) (COCORAHS)								7.07
Morehead City Mesonet								6.93
Morehead City State Port					41			

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)			
Newport (0.2 SW) (COCORAHS)								5.50
Ocracoke					53			
Ocracoke (WeatherFlow)	09/1803	1008.1	09/1711	37	43			
Ocracoke Island (Weather Underground)	09/1750	1007.3	09/2000		37			
Smyrna (COCORAHS)								6.85
Buoy/CMAN								
41035- Inner Onslow Bay (34.5°N 77.3°W)	09/0920	1011.0	09/2200	27 ^e	34			
Cape Lookout (CLKN7) (34.6°N 76.5°W)	09/1400	1007.3	09/2030	24 ^e	35			
41025- Diamond Shoals (35.0°N 75.4°W)	09/1950	1010.6	10/0120	36 ^e	45			
44014-E of Virginia Beach (36.6°N 74.8°W)	10/0550	1009.3	10/0430	28 ^e	35			

^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 10-minute average.

Table 3. Preliminary track forecast evaluation (heterogeneous sample) for Tropical Storm Gabrielle, 8-11 September 2007. 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.

Forecast Technique	Forecast Period (h)						
	12	24	36	48	72	96	120
CLP5	35 (12)	87 (10)	124 (8)	142 (6)	170 (2)		
GFNI	29 (10)	55 (8)	109 (6)	154 (4)			
GFDI	33 (12)	58 (10)	109 (8)	171 (6)	335 (2)		
HWFI	30 (12)	63 (10)	97 (8)	124 (6)	182 (2)		
GFSI	26 (12)	31 (10)	36 (8)	58 (6)	121 (1)		
AEMI	25 (12)	40 (10)	53 (8)	60 (5)	26 (1)		
NGPI	25 (12)	34 (10)	48 (8)	69 (6)	132 (2)		
UKMI	65 (11)	218 (9)	457 (6)	120 (2)	122 (1)		
BAMD	41 (12)	66 (10)	103 (8)	149 (6)	228 (2)		
BAMM	24 (12)	40 (10)	43 (8)	53 (6)	34 (2)		
BAMS	37 (12)	62 (10)	73 (8)	92 (6)	158 (2)		
CONU	25 (12)	51 (10)	93 (8)	82 (6)	174 (2)		
GUNA	29 (11)	64 (9)	130 (6)	59 (2)			
FSSE	21 (9)	36 (9)	60 (7)	97 (4)	140 (1)		
OFCL	20 (12)	31 (10)	46 (8)	62 (6)	154 (2)		
NHC Official (2002-2006 mean)	35 (1852)	61 (1686)	86 (1519)	112 (1362)	162 (1100)	221 (885)	290 (723)

Table 4. Preliminary intensity forecast evaluation (heterogeneous sample) for Tropical Storm Gabrielle, 8-11 September 2007. Forecast errors (kt) 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.

Forecast Technique	Forecast Period (h)						
	12	24	36	48	72	96	120
SHF5	8.8 (12)	11.3 (10)	21.5 (8)	28.8 (6)	42.5 (2)		
GHMI	7.6 (12)	7.8 (10)	9.1 (8)	14.5 (6)	30.5 (2)		
HWFI	6.0 (12)	4.5 (10)	6.0 (8)	7.5 (6)	16.0 (2)		
SHIP	7.8 (12)	8.8 (10)	12.6 (8)	18.8 (6)	35.0 (2)		
DSHP	8.0 (12)	9.6 (10)	13.0 (8)	13.8 (6)	15.5 (2)		
FSSE	8.3 (9)	9.6 (9)	14.6 (7)	22.3 (4)	35.0 (1)		
ICON	7.1 (12)	6.1 (10)	8.6 (8)	11.7 (6)	17.5 (2)		
OFCL	5.0 (12)	6.0 (10)	11.9 (8)	15.8 (6)	15.0 (2)		
NHC Official (2002-2006 mean)	6.4 (1852)	9.8 (1686)	12.0 (1519)	14.1 (1362)	18.3 (1100)	19.8 (885)	21.8 (723)

Table 5. Watch and warning summary for Tropical Storm Gabrielle, 8-11 September 2007.

Date/Time (UTC)	Action	Location
8/ 0300	Tropical Storm Watch issued	Edisto Beach, SC to Oregon Inlet, NC including Pamlico Sound
8/ 1500	Tropical Storm Warning issued	Surf City, NC to the NC/VA border including the Pamlico and Albermarle Sounds
8/ 1500	Tropical Storm Watch issued	NC/VA border to Cape Charles Light on the Atlantic Coast and to New Point Comfort along the Chesapeake Bay
8/ 1500	Tropical Storm Watch discontinued	Edisto Beach to Cape Fear
8/ 2100	Tropical Storm Watch discontinued	South of Surf City to Cape Fear
9/ 0300	Tropical Storm Warning issued	NC/VA border to Cape Charles Light
9/ 0300	Tropical Storm Watch modified to	Lower Chesapeake Bay south of New Point Comfort
10/ 0000	Tropical Storm Warning discontinued	Surf City to Cape Lookout
10/ 0300	Tropical Storm Warning discontinued	All
10/ 0900	Tropical Storm Watch discontinued	All

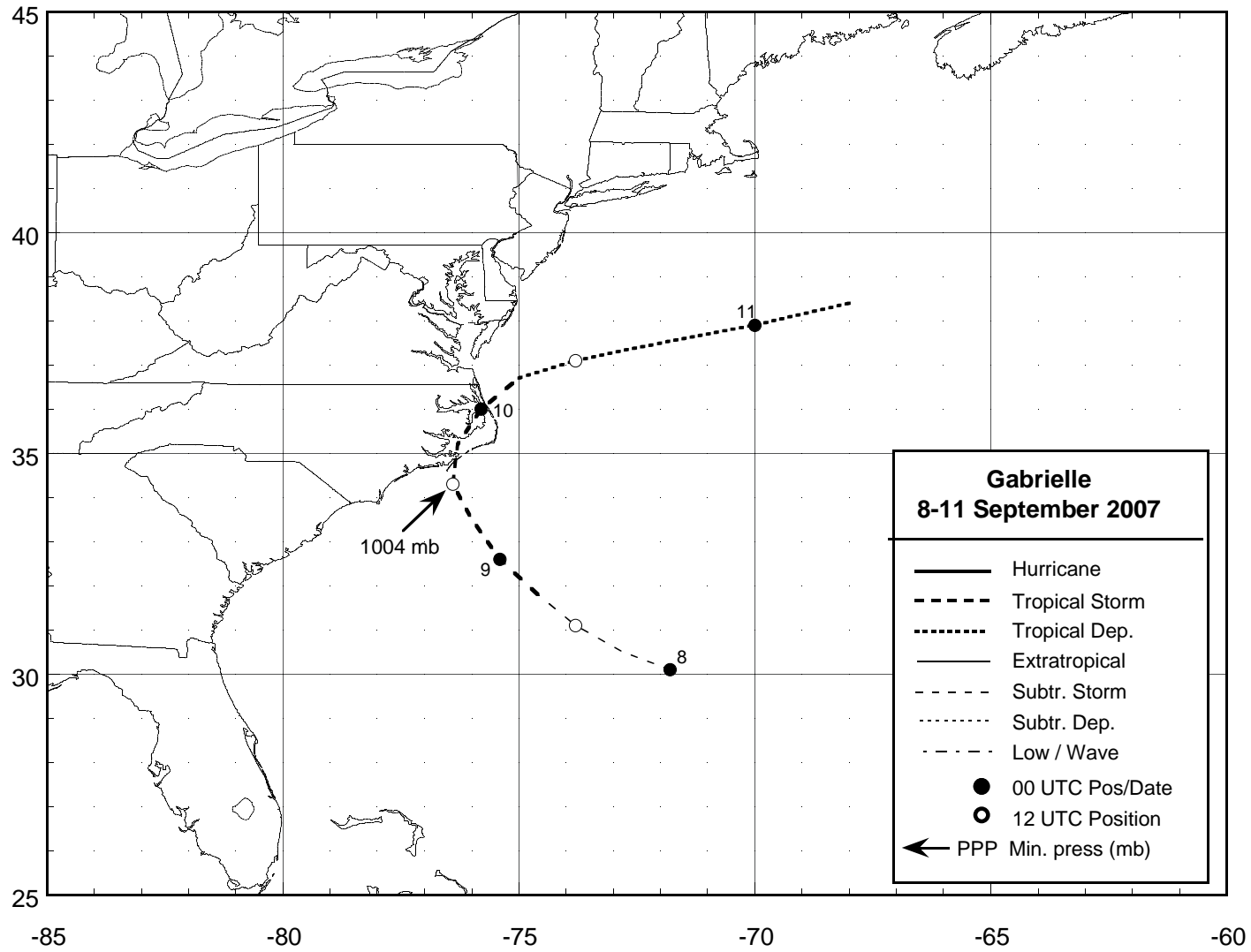


Figure 1. Best track positions for Tropical Storm Gabrielle, 8-11 September 2007.

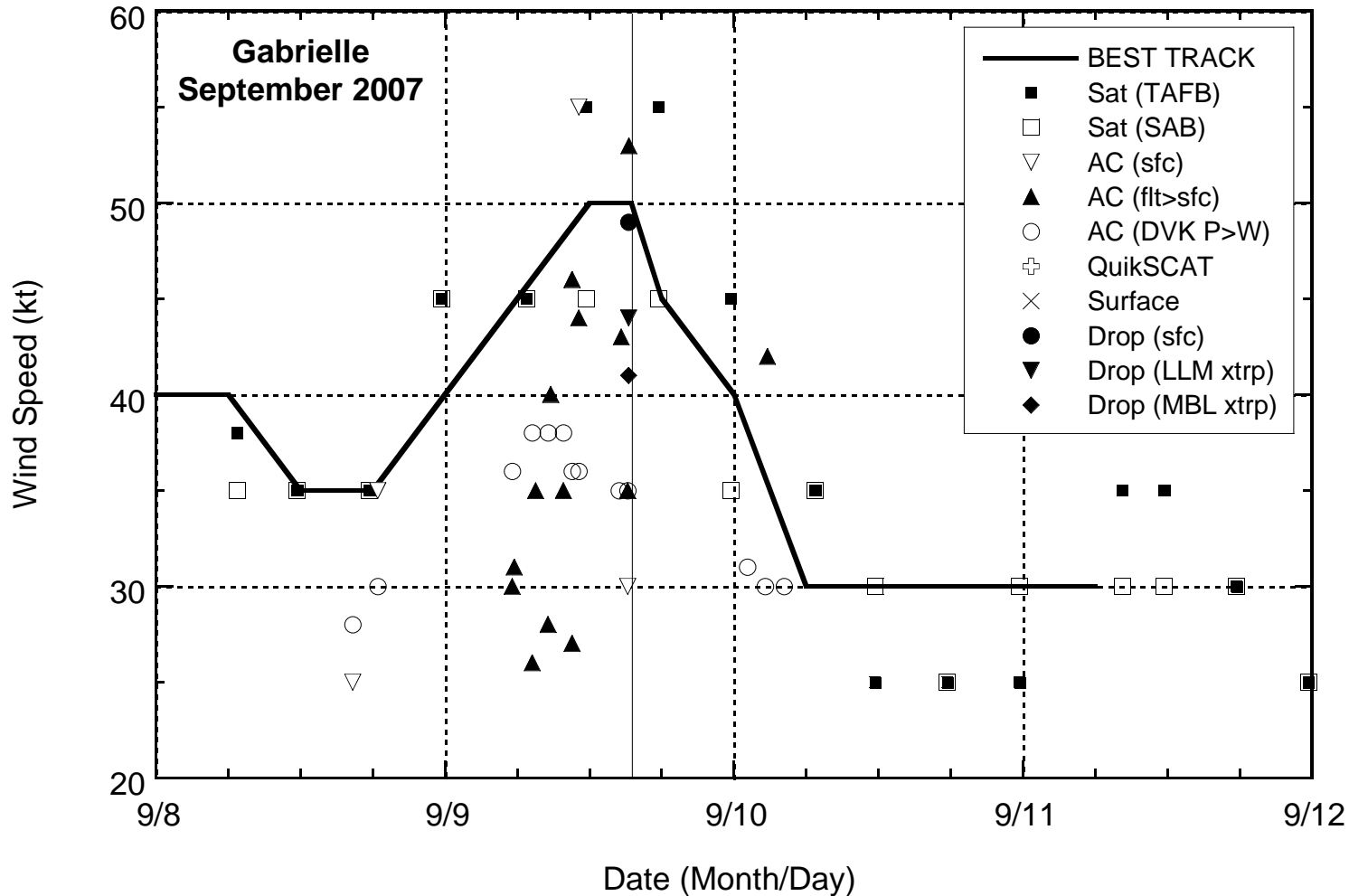


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Gabrielle, 8-11 September 2007. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% reduction factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Dropwindsonde observations include actual 10 m winds (sfc), as well as 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). Thin solid vertical line denotes landfall.

