NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

TROPICAL STORM GABRIELLE

(AL072013)

4 – 13 September 2013

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Satellite image of Tropical Storm Gabrielle located south of Puerto Rico at 1132 UTC 5 September 2013 (Courtesy of NASA).

Gabrielle affected Puerto Rico, the Dominican Republic as a tropical depression and passed near Bermuda as a tropical storm.

Tropical Storm Gabrielle

4 – 13 SEPTEMBER 2013

SYNOPTIC HISTORY

A tropical wave accompanied by a broad area of low pressure moved off the west coast of Africa on 24 August, and cloudiness and thunderstorms were concentrated when the disturbance moved between Africa and the Cape Verde Islands the next day. Once in the tropical Atlantic, the convection spread out and became intermittent, but animation of satellite imagery showed that a large cyclonic rotation in the low clouds persisted for a few days. A smaller area of low pressure formed within the weakening large gyre on 31 August, and then separated from the parent wave on 1 September. Although the low became better defined over the Lesser Antilles that day, it lacked organized deep convection. The low moved very slowly toward the west-northwest for the next two days, while the main wave continued westward across the southern Caribbean Sea. Another tropical wave that had been trailing this disturbance reached the low when it was located just south of Puerto Rico. There was an increase in convection, and data from an Air Force Reserve Reconnaissance aircraft suggested that a tropical depression had formed at 1800 UTC 4 September about 100 n mi south-southeast of Puerto Rico. The "best track" chart of the tropical cyclone'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[1].

The depression developed a large and circular area of deep convection during the next several hours, but by 1200 UTC 5 September the low-level center had separated from a vigorous mid-level circulation center located to the east-northeast. Later that day, the depression lost its closed surface circulation and degenerated into a tropical disturbance near the eastern tip of Hispaniola. The disturbance moved northward and then northeastward within the flow ahead of a relatively strong mid- to upper-level low over the western Atlantic over the following 3 to 4 days. During this time the disturbance nearly redeveloped a closed circulation on several occasions, but the prevailing strong southwesterly wind shear prevented it. On 9 September, however, the shear relaxed some, and a surface center developed near the convection, marking the reformation of a tropical depression at 0000 UTC 10 September about 300 n mi south of Bermuda. The depression became a tropical storm 6 h later. Gabrielle continued moving northward toward Bermuda and intensified, reaching its peak intensity of 55 kt with a minimum pressure of 1003 mb at 1200 UTC 10 September. Gabrielle moved to the northwest around a mid-to upper-level low for about 24 h, and the center passed about 20 n mi west of Hamilton, Bermuda, around 0100 UTC 11 September. Gabrielle then turned north-northeastward toward a highly sheared environment, but the cyclone was still able to produce intermittent bursts of deep convection near the center while it fluctuated in intensity from 30 to

[1] A digital record of the complete best track, including wind radii, can be found on line at ftp://ftp.nhc.noaa.gov/atcf. Data for the current year's storms are located in the *btk* directory, while previous years' data are located in the *archive* directory.

35 kt. Gabrielle's surface circulation dissipated by 1800 UTC 13 September, although gale-force winds associated with the disturbance persisted a little longer. The remnants of Gabrielle were absorbed by a cold front later that day.

METEOROLOGICAL STATISTICS

Observations in Tropical Storm Gabrielle (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), and objective Advanced Dvorak Technique (ADT) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Observations also include flight-level, and stepped frequency microwave radiometer (SFMR) observations from flights of the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Tropical Rainfall Measuring Mission (TRMM), the European Space Agency's Advanced Scatterometer (ASCAT), and Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in constructing the best track of Gabrielle.

Operationally, the depression was upgraded to tropical storm status south of Puerto Rico at 0000 UTC 5 September based on Dvorak intensity estimates from both TAFB and SAB. However, a post-analysis using scatterometer data indicates that the depression was not a tropical storm south of Puerto Rico, despite the excellent satellite presentation. In fact, the scatterometer data around 0130 UTC 5 September indicated that the circulation was already becoming less defined than when the reconnaissance plane investigated the area and its data supported the initiation of advisories. The satellite images displayed in Fig. 4 were extremely useful in determining the structure of the tropical cyclone south of Puerto Rico, and confirmed the weakening of the system as the low- and mid- level centers became detached.

The estimated 55-kt peak intensity of Gabrielle at 1200 UTC 10 September was based on the satellite presentation which showed a center embedded within the deep convection. By the time the reconnaissance plane reached Gabrielle later that day, the low-level center had become separated from the convection and the cyclone had weakened to 50 kt.

During the time the depression was over the eastern Caribbean Sea, stations at Puerto Rico and the U.S. Virgin Islands measured storm surge inundations of less than 1 ft. Rains associated with the cyclone in Puerto Rico and the U.S Virgin islands are displayed in Fig. 5. The buoy 41051 located just south of St. Thomas reported a peak wind gust of 44 kt at 1040 UTC 5 September when the cyclone was south of Puerto Rico. This gust was associated with a squall line and not directly associated with the circulation of the cyclone.

When Gabrielle moved near Bermuda, it produced tropical-storm-force winds over that island and these observations are summarized in Table 2. At the Bermuda Weather Service (BWS) office, 1.43 inches of rain were observed, although greater amounts likely fell across other parts of the island based on informal reports and radar imagery.

CASUALTY AND DAMAGE STATISTICS

The main impacts from Tropical Storm Gabrielle on Bermuda were the strong winds, which downed tree branches, palm fronds and other foliage. Some minor infrastructure damage occurred (a dock and a boat damaged in Dockyard), and a minimal storm surge (estimated around 1 foot by a BWS forecaster) occurred on the south side of the town of St George. Minor power outages were recorded across the Island.

There were no reports of casualties associated with Gabrielle.

FORECAST AND WARNING CRITIQUE

The 5-day genesis potential of Gabrielle was introduced in the Tropical Weather Outlooks (TWO) on 24 August with a low (<30%) chance of formation, when the tropical wave was near the west coast of Africa. The 5-day chances of development increased to medium on 26 August, but after that the assigned potential for genesis fluctuated between 30% and 50% until 1200 UTC 4 September, only 6 h before formation, when the chances were increased to the high (>50%) category. Although the cyclone dissipated near Hispaniola, medium chances of regeneration were re-introduced in the TWO, but then lowered. Gabrielle became a tropical cyclone again at 0000 UTC 10 September when the assigned 5-day formation probability was in the medium category.

A verification of NHC official track forecasts for Gabrielle is given in Table 3a. Official forecast track errors were lower than the mean official errors for the previous 5-yr period only at the 12 and 24 h forecast times. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. In general, most of the models had lower errors than the NHC forecasts primarily between 24 and 72 h. There were only two forecasts to verify at the 5-day period.

A verification of NHC official intensity forecasts for Gabrielle is given in Table 4a. Official forecast intensity errors were lower than the mean official errors for the previous 5-yr period. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. Most of the models had lower errors than the NHC forecast at those time periods. There was only two forecasts to verify at the 72- and 120- h periods.

Watches and warnings associated with Gabrielle are given in Table 5.

Table 1. Best track for Tropical Storm Gabrielle, 4 -13 September 2013.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
04 / 1800	16.2	65.9	1010	30	tropical depression
05 / 0000	16.7	66.3	1008	30	"
05 / 0600	17.1	67.0	1008	30	"
05 / 1200	17.4	67.7	1010	30	"
05 / 1800	17.9	68.4	1010	25	disturbance
06 / 0000	18.8	68.4	1010	25	"
06 / 0600	19.5	68.5	1010	20	"
06 / 1200	20.0	68.6	1010	20	"
06 / 1800	20.4	68.7	1010	20	"
07 / 0000	21.2	68.7	1010	20	"
07 / 0600	22.0	68.8	1010	20	"
07 / 1200	22.8	69.2	1009	25	"
07 / 1800	23.6	69.2	1009	25	"
08 / 0000	24.4	69.1	1009	25	"
08 / 0600	24.7	68.9	1009	25	"
08 / 1200	24.8	68.8	1008	25	"
08 / 1800	24.9	68.7	1008	25	"
09 / 0000	25.1	68.2	1008	25	"
09 / 0600	25.4	67.8	1008	25	"
09 / 1200	25.9	66.9	1008	30	low
09 / 1800	26.6	65.9	1008	30	"
10 / 0000	27.6	65.1	1007	30	tropical depression
10 / 0600	29.0	65.0	1005	40	tropical storm
10 / 1200	30.1	64.8	1003	55	"
10 / 1800	31.1	64.7	1004	50	"
11 / 0000	31.9	64.9	1004	50	"
11 / 0600	32.3	65.4	1008	45	"
11 / 1200	32.5	65.7	1009	40	"
11 / 1800	32.6	66.2	1009	35	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
12 / 0000	32.9	66.8	1009	30	tropical depression
12 / 0600	33.2	67.4	1009	30	"
12 / 1200	33.6	67.6	1008	35	tropical storm
12 / 1800	34.0	67.9	1008	35	"
13 / 0000	34.7	68.1	1008	35	"
13 / 0600	35.9	67.5	1007	30	tropical depression
13 / 1200	37.7	66.6	1005	30	"
13 / 1800					dissipated
10 / 1200	30.1	64.8	1003	55	minimum pressure

Table 2. Selected surface observations for Tropical Storm Gabrielle, 4 to 13 September 2013. These winds occurred between 00 and 02 UTC.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)	Gust (kt)	
Bermuda						
LF Wade International Airport			10/00-02	39	49	
Commissioner's Point*			10/00-02	48	59	
Causeway Sensor			10/00-02		56	
Harbour Radio**			10/00-02	50	65	
Bermuda Weather Service						1.43

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

* Anemometer elevation 150 feet ** Anemometer elevation 200 feet

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Gabrielle. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**19.9**	**44.0**	77.2	102.1	132.0		**164.0**
OCD5	48.3	131.7	241.5	371.0	575.8		410.0
Forecasts	14	10	8	6	2		2
OFCL (2008-12)	28.6	45.8	62.2	78.6	116.6		206.4
OCD5 (2008-12)	47.5	99.7	161.4	224.0	329.7		493.1

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Tropical Storm Gabrielle. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 3a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	18.1	46.8	78.2	103.5	131.5		
OCD5	58.6	132.0	233.4	353.1	526.5		
GFSI	24.2	46.8	**71.5**	**74.3**	**50.8**		
GHMI	20.4	**40.1**	**59.4**	**70.0**	**129.6**		
HWFI	22.2	48.3	**71.3**	**65.5**	**78.7**		
EMXI	**16.3**	**37.3**	**51.9**	**90.8**	207.1		
CMCI	20.7	**38.2**	87.1	124.1	**30.9**		
AEMI	18.6	**42.3**	**65.5**	**70.4**	**63.0**		
FSSE	18.4	**42.6**	**65.7**	**77.0**	139.2		
TVCA	**15.0**	**38.8**	**56.7**	**63.1**	**83.8**		
LBAR	36.3	71.8	122.0	140.9	**120.3**		
BAMD	35.0	67.2	86.9	133.3	229.7		
BAMM	22.5	**28.0**	**58.3**	**84.5**	201.5		
BAMS	28.8	**34.2**	**44.8**	**47.1**	133.4		
NAMI	40.1	78.3	112.3	215.1	191.1		
Forecasts	8	7	7	5	1	0	0

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Gabrielle. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	6.8	**7.5**	**10.6**	**13.3**	**15.0**		**15.0**
OCD5	8.2	9.8	16.6	24.2	30.0		29.5
Forecasts	14	10	8	6	2		2
OFCL (2008-12)	6.6	10.1	12.2	14.1	15.4		16.1
OCD5 (2008-12)	7.8	11.6	14.0	15.6	17.9		17.9

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Tropical Storm Gabrielle. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 4a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	7.5	9.3	10.7	13.0	15.0		10.0
OCD5	9.4	12.1	16.6	23.8	31.0		24.0
DSHP	8.5	10.0	12.4	16.0	24.0		20.0
LGEM	8.5	10.9	12.1	18.8	24.0		23.0
HWFI	**6.9**	**7.9**	**5.3**	**6.6**	**1.0**		28.0
GHMI	**6.5**	**7.1**	**7.6**	**10.2**	30.0		13.0
FSSE	**7.0**	**7.7**	**8.7**	**10.4**	16.0		10.0
ICON	7.9	**8.3**	**9.6**	**12.8**	20.0		21.0
IVCN	7.9	**8.3**	**9.6**	**12.8**	20.0		21.0
Forecasts	10	7	7	5	1		1

Table 5. Watch and warning summary for Tropical Storm Gabrielle, 4 -13 September 2013.

Date/Time (UTC)	Action	Location
4 / 2100	Tropical Storm Watch issued	Santo Domingo to Cabo Engano, Dominican Republic
4 / 2100	Tropical Storm Warning issued	Puerto Rico
4 / 2100	Tropical Storm Warning issued	Cabo Engano to Cabo Frances Viejo, Dominican Republic
5 / 1500	Tropical Storm Warning changed to Tropical Storm Watch	Cabo Engano to Cabo Frances Viejo, Dominican Republic
5 / 1500	Tropical Storm Watch modified to	Cabo Engano to Cabo Frances Viejo, Dominican Republic
5 / 1500	Tropical Storm Warning discontinued	All
5 / 1800	Tropical Storm Watch discontinued	All
10 / 0900	Tropical Storm Warning issued	Bermuda
11 / 1200	Tropical Storm Warning discontinued	Bermuda

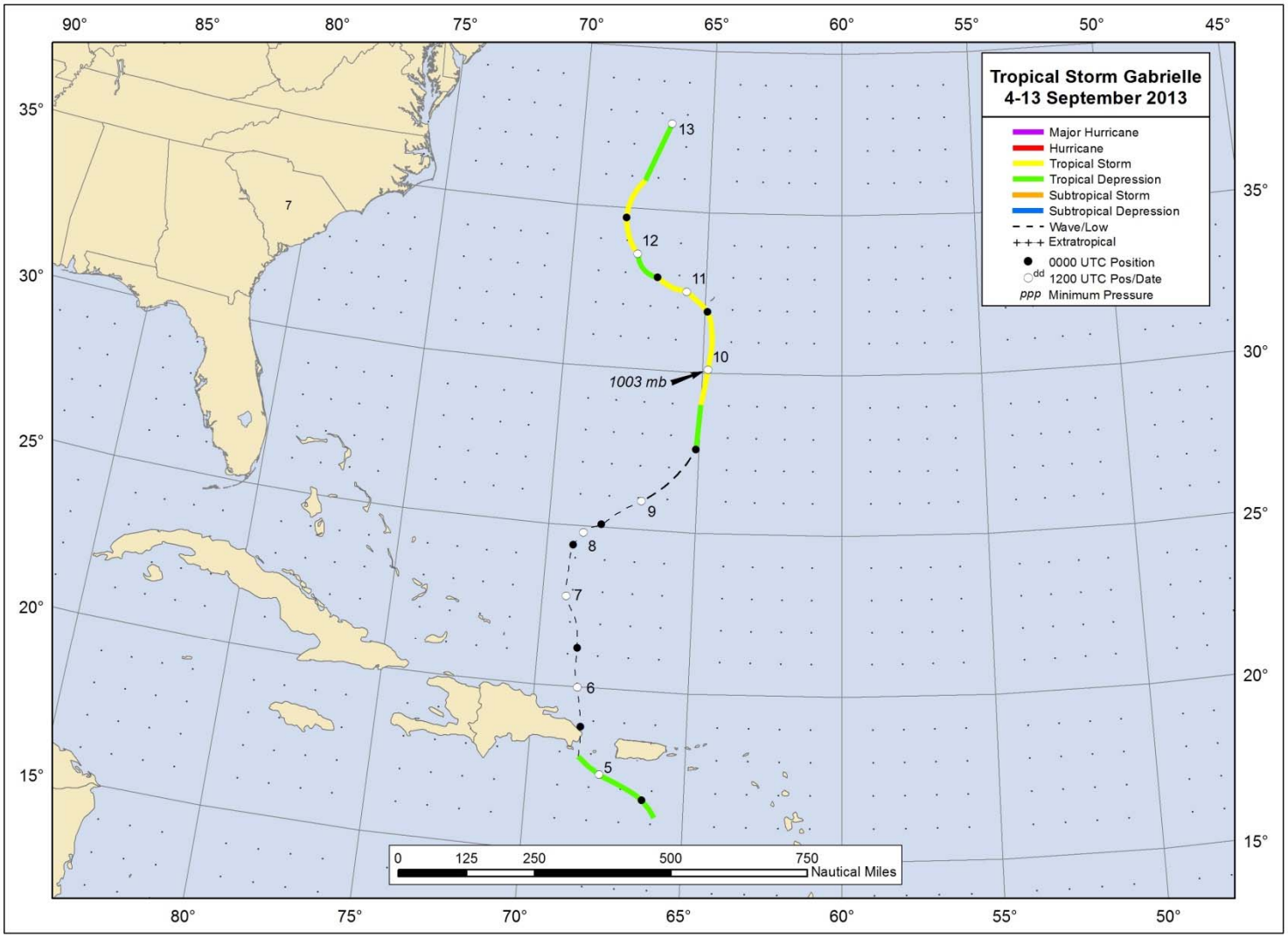

Figure 1. Best track positions for Tropical Storm Gabrielle, 4-13 September 2013

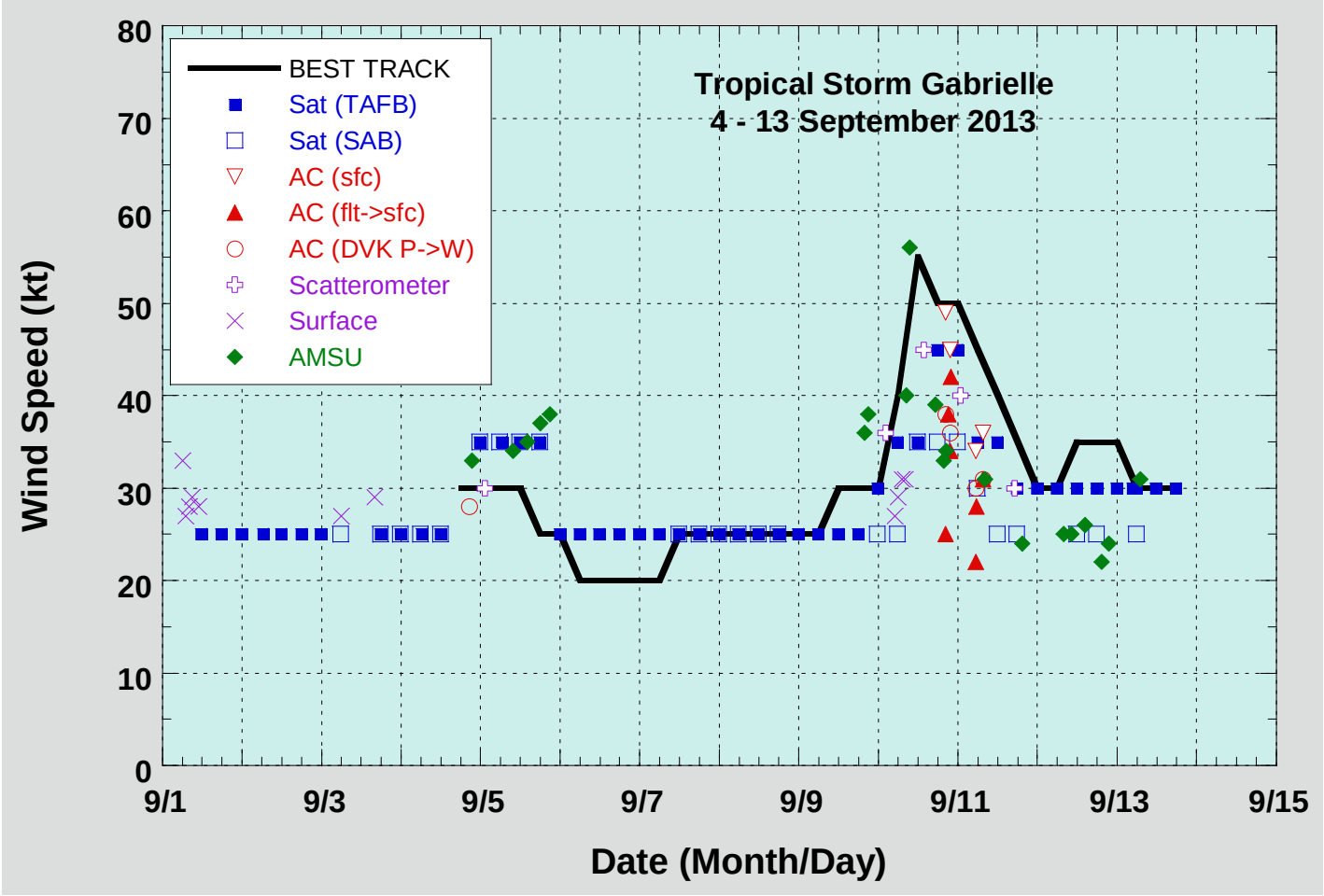

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Gabrielle, 4 -13 September 2013. Aircraft observations have been adjusted for elevation using 80% adjustment factors for observations from 1500 ft. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC.

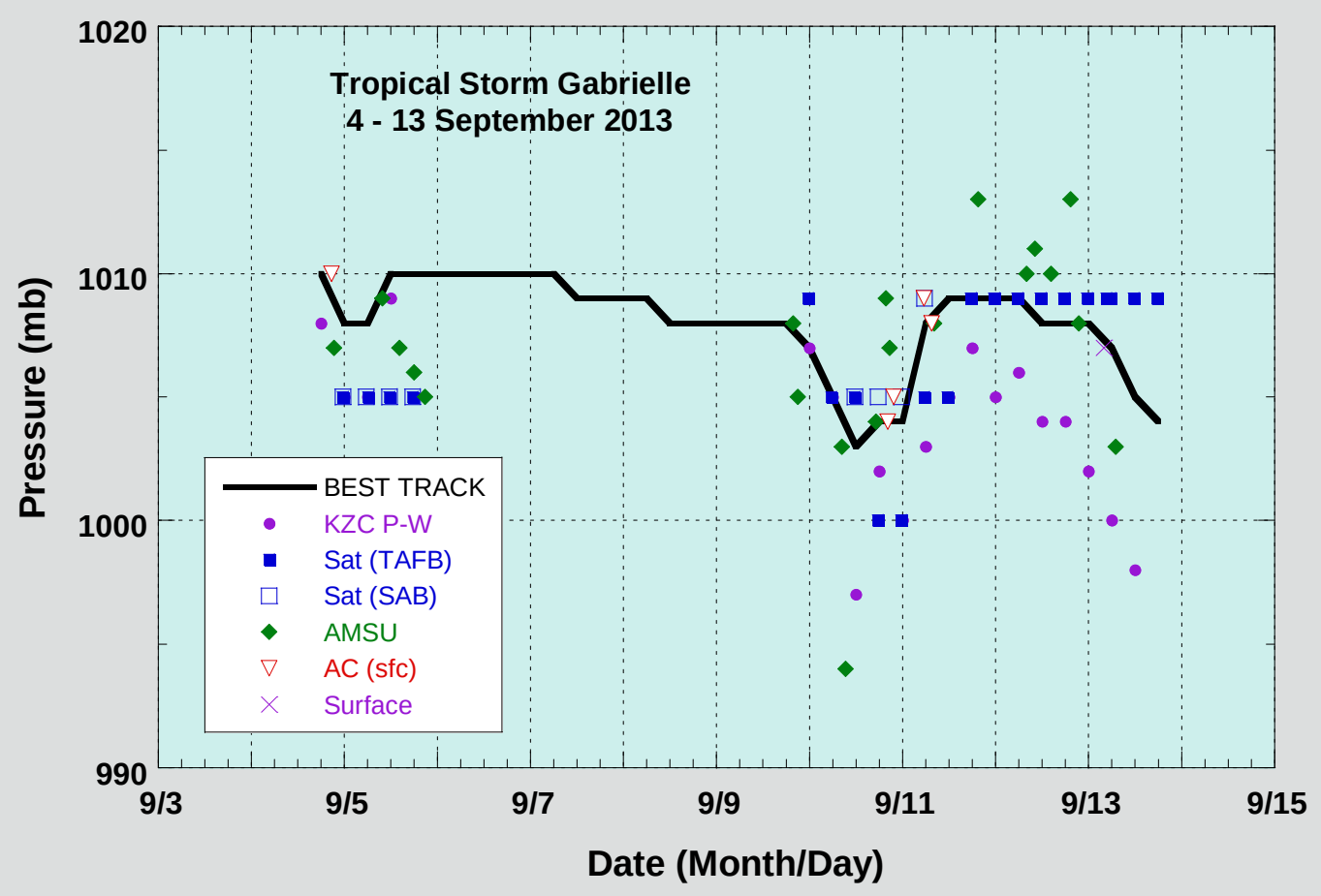

Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Gabrielle, 4-13 September 2013. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

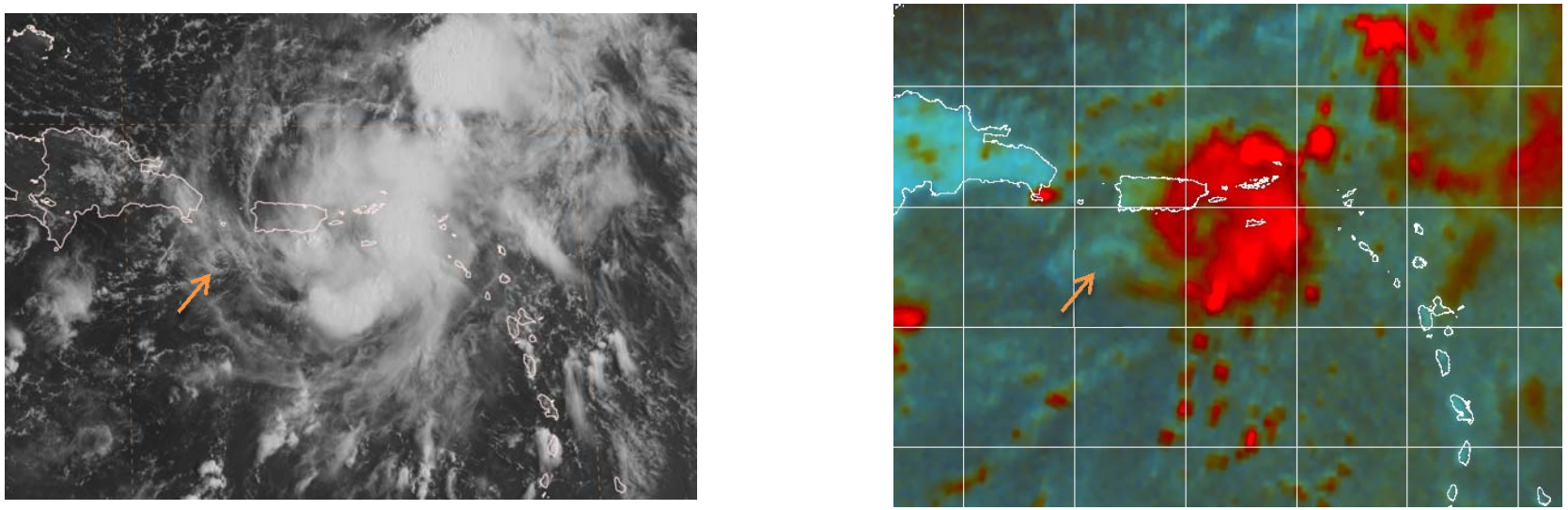

Figure 4. Visible satellite image (left) at 1130 UTC and a composite 91- GHz SSM/I microwave images (right) at 1024 UTC 5 September 2013, respectively, showing the decoupled low- and mid-level centers of Gabrielle. Note that in this particular case, the mid-level circulation was quite vigorous. The low-lever center is marked with an arrow. Microwave image is courtesy of the Naval Research Laboratory.

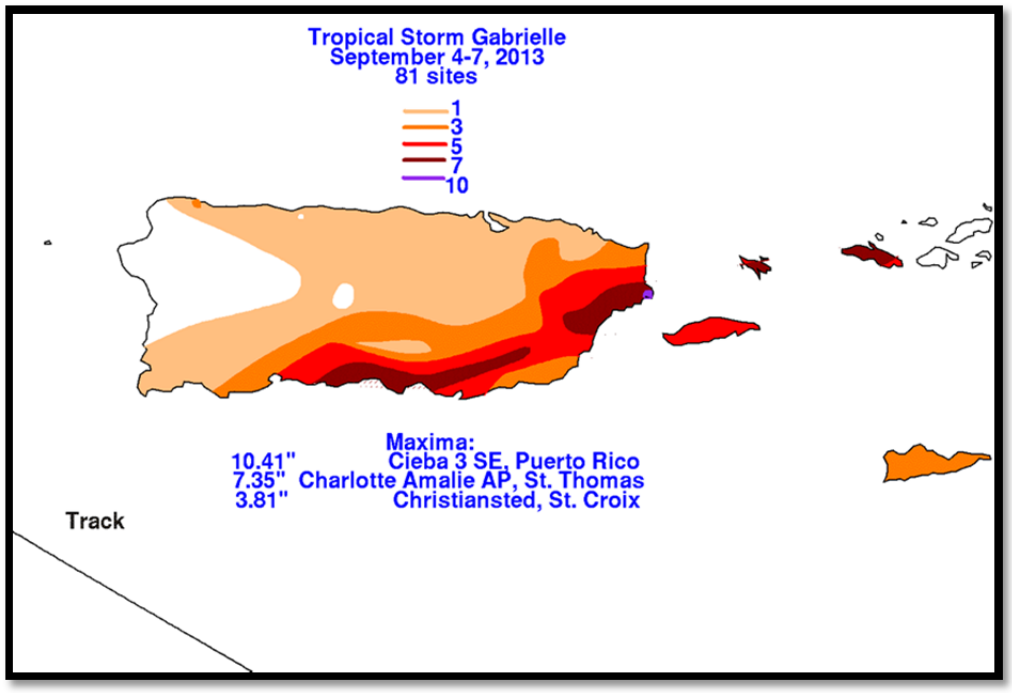

Figure 5. Rainfall totals associated with Gabrielle. The figure was provided by David Roth from the Weather Prediction Center.