NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

HURRICANE BERTHA

(AL032014)

1 – 6 August 2014

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National Hurricane Center
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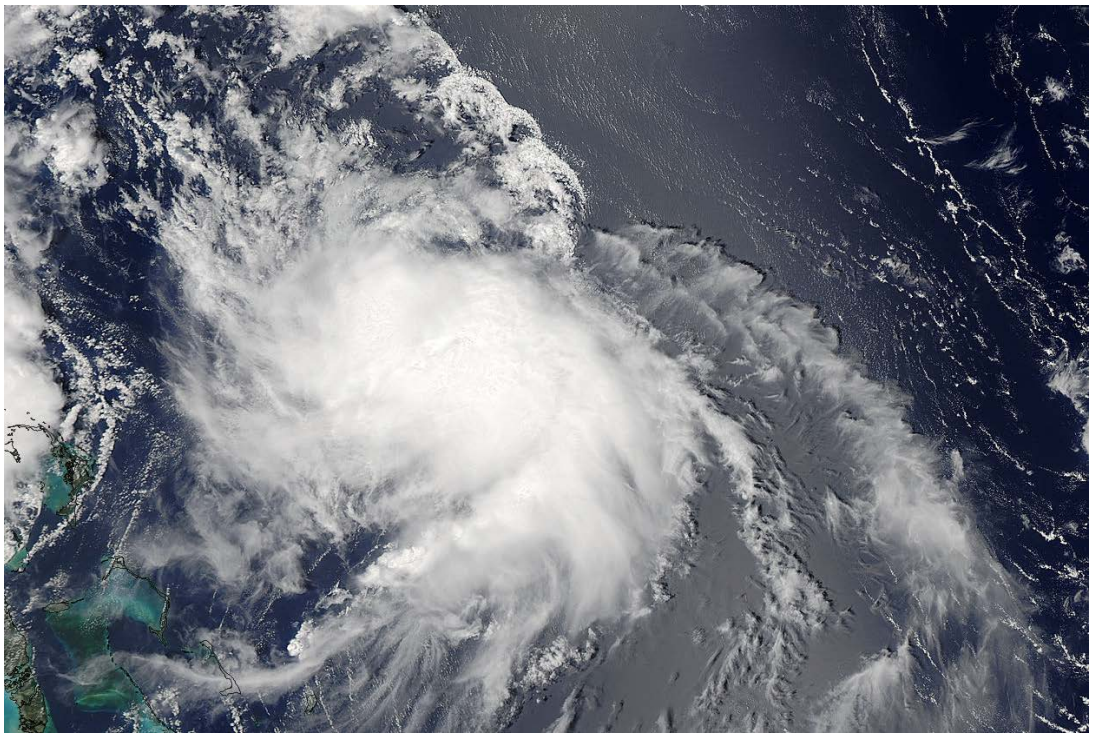

MODIS VISIBLE IMAGE OF BERTHA AT 1750 UTC 4 AUGUST 2014, NEAR THE TIME OF ITS PEAK INTENSITY. IMAGE COURTESY OF NASA.

Bertha was a category one hurricane (on the Saffir-Simpson Hurricane Wind Scale) that caused flooding, mudslides and power outages in the northeastern Caribbean islands when it passed through as a tropical storm. It also caused two rip-current deaths in the United States.

[1] Original report date 18 December 2014. Updated Table 2 for new observations from Martinique on 23 January. Added landfall point for Middle Caicos Island in this update.

Hurricane Bertha

1 – 6 AUGUST 2014

SYNOPTIC HISTORY

Bertha originated from a tropical wave that moved off of the west coast of Africa on 24 July with limited thunderstorm activity. Convection temporarily increased with the westward-moving wave on 26 July, although there was no organization noted. A more significant burst of convection occurred on 28 July due to a convectively coupled Kelvin wave passing through the region, resulting in a low pressure area forming the following day. However, thunderstorm activity was limited due to northeasterly shear and some drier air. The shear weakened some late on 30 July, and scatterometer data indicate that the system was producing gale-force winds by early on 31 July due to a convective burst. The low finally acquired enough persistent deep convection to be declared a tropical storm at 0000 UTC 1 August, when it was located about 300 n mi east-southeast of Barbados. The "best track" chart of Bertha'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*.

A large mid-level ridge over the central tropical Atlantic caused Bertha to move quickly westward to west-northwestward. Southwesterly shear from a trough over the western Atlantic and dry air aloft prevented much strengthening, and the cyclone reached a first peak intensity of about 45 kt while it passed just north of Martinique late on 1 August. The cyclone became less organized when it was in the northeastern Caribbean Sea due to an increase in shear and continued dry air entrainment, and Bertha could have briefly lost a closed circulation on 2 August when it was south of Puerto Rico. However, reconnaissance data indicated that the circulation became better defined the next day while Bertha moved near the northeast coast of the Dominican Republic and the southeastern Bahamas. This increase in organization was concurrent with a decrease in wind shear and an increase in mid-level humidity over very warm waters. The small storm then rapidly intensified, becoming a hurricane early on 4 August about 170 n mi north-northeast of San Salvador in the central Bahamas.

The intensification was short-lived due to shear increasing ahead of a mid-latitude trough and gradually decreasing sea-surface temperatures. Bertha weakened by late on 4 August and turned northward to the east of the trough. Increasing southwesterly flow aloft caused Bertha to accelerate northeastward on 5 August, with the cloud pattern of the cyclone becoming distorted due to stronger shear and interaction with a surface trough. On the following day, Bertha become embedded within the surface trough that was in the process of developing into a cold front, and by 1800 UTC 6 August, the tropical cyclone transitioned into a frontal extratropical cyclone about 250 n mi south-southeast of Halifax, Nova Scotia. After briefly intensifying, the cyclone gradually

* 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.

weakened and moved eastward over the next couple of days before decaying into a trough several hundred miles southwest of Ireland.

METEOROLOGICAL STATISTICS

Observations in Bertha (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). Observations also include flight-level, stepped frequency microwave radiometer (SFMR), and dropwindsonde observations from flights of the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command and the NOAA Hurricane Hunters. 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 Bertha.

Bertha's estimated peak intensity of 70 kt is based on a blend of 850 mb flight-level winds of 86 kt with 72-kt winds measured from the SFMR. It is worth noting that the concurrent Dvorak estimates were in the 45-55 kt range.

Bertha's estimated minimum pressure of 998 mb is based on a dropsonde that reported 999 mb with 18 kt of wind.

Tropical-storm-force wind gusts were reported on many islands of the Caribbean, including Puerto Rico, Dominca, Guadeloupe and Martinique. Selected surface observations are in Table 2. One ship reported winds of tropical storm force in association with Bertha. The Wellington Express (call sign DFCX2) recorded winds of 35 kt at 2100 UTC 2 August.

Heavy rain was one of the main impacts of Bertha with the montainous central region of Puerto Rico receiving the most rainfall (Figure 4). The maximum amount reported on Puerto Rico was 11.11 inches in Adjuntas. Reports of heavy rain were also received in the Dominican Republic, with the highest total reported from Bayaguana of 119.5 mm (4.7 inches) of rain.

CASUALTY AND DAMAGE STATISTICS

There were two direct deaths[†] in association with rip currents generated by Bertha: a man died near Frisco, North Carolina, and a woman died near Atlantic City, New Jersey. There were

[†] Deaths occurring as a direct result of the forces of the tropical cyclone are referred to as "direct" deaths. These would include those persons who drowned in storm surge, rough seas, rip currents, and freshwater floods. Direct deaths also include casualties resulting from lightning and wind-related events (e.g., collapsing structures). Deaths occurring from such factors as heart attacks, house fires, electrocutions from downed power lines, vehicle accidents on wet roads, etc., are considered indirect" deaths.

no reports of significant damage associated with the cyclone. The most significant impacts reported by the media were on Martinique, where power outages affected 150,000 buildings. Flooding was also noted in the Dominican Republic and Puerto Rico, causing some mudslides and collapsed roads. No damage estimates are available but the damage is believed to be relatively minor.

FORECAST AND WARNING CRITIQUE

The genesis forecasts for Bertha were a mixed bag. Table 3 shows the number of hours in advance of formation that the Tropical Weather Outlook first included each likelihood category. While the eventual formation of Bertha was well forecast, Bertha did not form as quickly as expected, leading to rather large lead times especially in the 2-day forecasts. This timing, along with large convective variations of Bertha, also led to somewhat erratic genesis probabilities before formation.

A verification of NHC official track forecasts for Bertha is given in Table 4a. Official forecast track errors were lower than the mean official errors for the previous 5-yr period at all forecast times except 120 h. A homogeneous comparison of the official track errors with selected guidance models is given in Table 4b. The official track forecasts had lower errors than just about all of the models at all forecast times. The European Center for Medium-Range Forecasts (EMXI) model was the best individual model, and the Florida State Superensemble (FSSE) bested the dynamical model consensus TVCA at most forecast times.

A verification of NHC official intensity forecasts for Bertha is given in Table 5a. Official forecast intensity errors were lower than the mean official errors for the previous 5-yr period at all forecast times. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 5b. Although the official intensity forecasts (OFCL) performed reasonably well against the statistical-dynamical SHIPS and LGEM models, most of the other guidance outperformed the official forecast. The large OFCL errors were due to two factors. While the official forecasts anticipated that Bertha would eventually become a hurricane, it occurred sooner than expected by about a day. After Bertha became a hurricane, it also weakened faster than forecast. The HWRF, GFDL and dynamical model consensus aids had the best overall performance for Bertha.

Table 6 shows the coastal watches or warnings in association with Bertha.

Table 1. Best track for Hurricane Bertha, 1 - 6 August 2014.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
29 / 0600	9.6	37.1	1013	25	low
29 / 1200	9.5	38.6	1012	30	"
29 / 1800	9.5	40.1	1012	30	"
30 / 0000	9.6	41.5	1012	30	"
30 / 0600	9.7	43.0	1012	30	"
30 / 1200	9.8	44.7	1012	30	"
30 / 1800	10.0	46.4	1011	30	"
31 / 0000	10.4	48.0	1010	35	"
31 / 0600	10.7	49.7	1009	35	"
31 / 1200	11.0	51.4	1008	40	"
31 / 1800	11.5	53.1	1007	40	"
01 / 0000	12.2	54.6	1007	40	tropical storm
01 / 0600	13.0	56.2	1007	40	"
01 / 1200	13.8	58.1	1006	45	"
01 / 1800	14.5	60.3	1006	45	"
02 / 0000	15.2	62.3	1007	45	"
02 / 0600	15.9	64.1	1008	40	"
02 / 1200	16.7	65.9	1009	40	"
02 / 1800	17.9	67.6	1010	40	"
03 / 0000	19.2	69.0	1011	40	"
03 / 0600	20.3	70.4	1012	40	"
03 / 1200	21.4	71.6	1013	40	"
03 / 1400	21.8	71.9	1013	40	"
03 / 1800	22.7	72.5	1012	45	"
04 / 0000	24.1	73.1	1007	55	"
04 / 0600	25.4	73.5	1004	60	"
04 / 1200	26.8	73.6	998	70	hurricane
04 / 1800	28.5	73.6	999	70	"
05 / 0000	30.5	73.4	1001	65	"
05 / 0600	32.5	73.2	1003	55	tropical storm

05 / 1200	34.2	72.7	1005	50	"
05 / 1800	35.5	71.2	1006	45	"
06 / 0000	36.8	69.3	1007	45	"
06 / 0600	38.1	66.9	1007	45	"
06 / 1200	39.4	64.1	1006	45	"
06 / 1800	40.8	61.3	1002	45	extratropical
07 / 0000	42.1	58.4	996	50	"
07 / 0600	43.4	55.6	998	45	"
07 / 1200	44.6	52.5	999	40	"
07 / 1800	46.0	49.5	1000	40	"
08 / 0000	47.4	46.6	1001	35	"
08 / 0600	47.9	43.0	1001	35	"
08 / 1200	47.5	39.4	1002	35	"
08 / 1800	46.9	34.9	1002	35	"
09 / 0000	47.0	29.0	1003	35	"
09 / 0600	47.1	22.0	1003	35	"
09 / 1200	47.5	15.0	1003	35	"
09 / 1800					dissipated
03 / 1400	21.8	71.9	1013	40	landfall on Middle Caicos Island
04 / 1200	26.8	73.6	998	70	minimum pressure and maximum winds

Table 2. Selected surface observations for Hurricane Bertha, 1 – 6 August.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)	
Coastal-Marine Automated Network (C-MAN) Sites and Buoys						
Buoy 42060 16.33N 63.24W Height: 5.0m	02/0650	1010.0	02/0642	35	39	
Buoy 41043 21.06N 64.97N Height: 5.0 m	01/0850	1016.0	02/1716	33	39	
Buoy 41046 23.89N 68.37N Height: 5.0 m	01/0950	1015.7	03/1430	31	39	
Buoy 41051 18.26N 65.00W Height 4.0m	02/0840	1012.3	02/1620	38	59	
Buoy 41052 18.25N 64.76W Height 4.0m			02/1500	30	41	
International Civil Aviation Organization (ICAO) Sites						
Melville-Hall Airport, Dominica (TDPD)	01/2100	1011.0	01/2000		37	
Point-a-Pitré International Airport, Guadeloupe (TFFR)			02/0030		37	
Lamentin Airport Martinique (TFFF)	01/2000	1008.9	01/1348		38	0.91
Fort de France Martinique 14.61N 61.05N Height: 143 m	01/2000	1008.6	01/1659		34	
Trinite-Caravelle Martinique WMO # 78922 Height: 26 m	01/2000	1007.0	02/0240	40[c]	47	
Morne-Cadet Martinique 14.74N 61.15W Height: 510 m			01/1415		47	
Ponce, PR (TJPS)			02/1250	26	34	
St. Thomas, VI (TIST)			02/1553	27	40	

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)	
St. Croix, VI (TISX)			02/2100	30	40	
Tortola, BVI (TUPJ)			02/1600		35	
Citizen Weather Observer Program						
Culebra (DW1296) 18.30N 65.29W Height: 65 m			02/1409		45	
National Ocean Service (NOS)						
Yabucoa (YABP4) 18.06N 65.83W			02/1554	28	37	
Esperanza Vieques (ESPP4) 18.09N 65.47W			02/1352	30	37	
Christiansted Harbor St. Croix (CHSV3) 17.75N 64.70W			02/1903	23	37	
Lime Tree Bay St. Croix (LTBV3) 17.70N 64.75W			02/2100	30	39	

[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 reports are 2 min; buoy averaging periods are 8 min.
[c] 1-min average wind.

Table 3. Number of hours in advance of formation associated with the first NHC Tropical Weather Outlook forecast in the indicated likelihood category. Note that the timings for the "Low" category do not include forecasts of a 0% chance of genesis.

	Hours Before Genesis	
	48-Hour Outlook	**120-Hour Outlook**
Low (<30%)	96	138
Medium (30%-50%)	90	114
High (>50%)	66	90

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Bertha, 1 - 6 August 2014. 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	**27.2**	**38.3**	**39.4**	**43.0**	**66.1**	**154.3**	253.4
OCD5	54.6	122.0	206.0	315.6	564.0	829.9	1031.9
Forecasts	21	19	17	15	11	7	3
OFCL (2009-13)	28.8	45.5	61.2	77.8	114.5	158.4	208.2
OCD5 (2009-13)	48.2	100.1	160.2	220.8	326.6	410.7	479.4

Table 4a. Homogeneous comparison of selected track forecast guidance models (in n mi) for Bertha. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than shown in Table 4a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	25.5	34.9	32.8	34.0	56.8	115.6	
OCD5	53.0	121.4	208.2	324.1	630.4	954.4	
GFSI	**24.8**	40.0	48.2	57.2	79.8	153.6	
GHMI	27.8	48.6	58.3	59.4	116.0	147.2	
HWFI	**24.9**	38.6	53.1	59.1	87.3	134.8	
EMXI	26.2	37.4	36.9	47.6	76.7	**38.6**	
CMCI	**24.6**	43.1	61.6	93.5	191.7	297.3	
AEMI	27.0	38.4	37.0	41.7	90.7	192.2	
FSSE	**24.0**	34.9	36.1	40.2	**55.7**	**60.6**	
TVCA	**24.6**	37.2	35.5	41.0	59.3	**93.4**	
LBAR	44.0	79.7	125.8	160.4	219.3	285.7	
BAMS	53.6	94.2	137.1	192.4	383.7	690.9	
BAMM	50.4	93.6	143.6	198.6	366.5	592.2	
BAMD	74.5	137.7	188.2	250.0	418.1	626.1	
Forecasts	19	17	15	13	7	4	

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Bertha. 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	**5.5**	**8.9**	**10.6**	**11.0**	15.5	**15.0**	**1.7**
OCD5	7.8	12.5	14.9	15.1	12.7	6.1	6.0
Forecasts	21	19	17	15	11	7	3
OFCL (2009-13)	6.3	9.7	11.9	13.7	15.3	15.4	15.7
OCD5 (2009-13)	7.4	11.1	13.8	15.7	18.3	18.2	18.1

Table 5b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Bertha. 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 5a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	5.5	9.2	10.9	11.4	13.8	17.5	
OCD5	8.1	13.1	15.2	15.2	**11.9**	**7.8**	
HWFI	6.3	**7.2**	**9.1**	**8.0**	**10.1**	23.0	
GHMI	7.9	**8.6**	**8.4**	**10.1**	**10.0**	**11.3**	
IVCN	6.9	**9.1**	**10.6**	**9.6**	**10.9**	23.0	
DSHP	7.7	10.3	11.9	12.9	15.5	27.0	
LGEM	8.0	11.3	12.8	**10.5**	**11.8**	30.8	
FSSE	5.9	**7.9**	**10.0**	**8.9**	**12.0**	**15.3**	
EMXI	7.7	10.7	12.1	12.3	**13.1**	**1.3**	
GFSI	6.9	**8.6**	**9.3**	**10.1**	**11.3**	14.8	
Forecasts	20	18	16	14	8	4	

Table 6. Watch and warning summary for Bertha.

Date/Time (UTC)	Action	Location
1 / 0300	Tropical Storm Watch issued	Puerto Rico to the US Virgin Islands
1 / 0300	Tropical Storm Watch issued	St. Vincent and the Grenadines
1 / 0300	Tropical Storm Warning issued	Barbados, Dominica, St. Lucia
1 / 0600	Tropical Storm Watch issued	British Virgin Islands
1 / 0900	Tropical Storm Watch changed to Tropical Storm Warning	Puerto Rico to the US Virgin Islands
1 / 0900	Tropical Storm Watch changed to Tropical Storm Warning	British Virgin Islands
1 / 1200	Tropical Storm Warning issued	Martinique
1 / 1500	Tropical Storm Watch discontinued	St. Vincent and the Grenadines
1 / 1500	Tropical Storm Watch issued	Cabo Frances Viejo to Isla Saona, Dominican Republic
1 / 1500	Tropical Storm Warning discontinued	Barbados
1 / 1800	Tropical Storm Warning discontinued	St. Lucia
1 / 2100	Tropical Storm Watch issued	Southeastern Bahamas and the Turks and Caicos
2 / 0300	Tropical Storm Warning discontinued	Dominica
2 / 0900	Tropical Storm Watch changed to Tropical Storm Warning	Southeastern Bahamas and the Turks and Caicos
2 / 0900	Tropical Storm Watch issued	Central Bahamas
2 / 1500	Tropical Storm Watch changed to Tropical Storm Warning	Cabo Frances Viejo to Isla Saona
2 / 1500	Tropical Storm Warning discontinued	Martinique
2 / 2100	Tropical Storm Warning discontinued	British Virgin Islands
3 / 0000	Tropical Storm Warning discontinued	Puerto Rico
3 / 1200	Tropical Storm Warning discontinued	Cabo Frances Viejo to Isla Saona
3 / 1500	Tropical Storm Watch discontinued	All
3 / 2100	Tropical Storm Warning discontinued	All

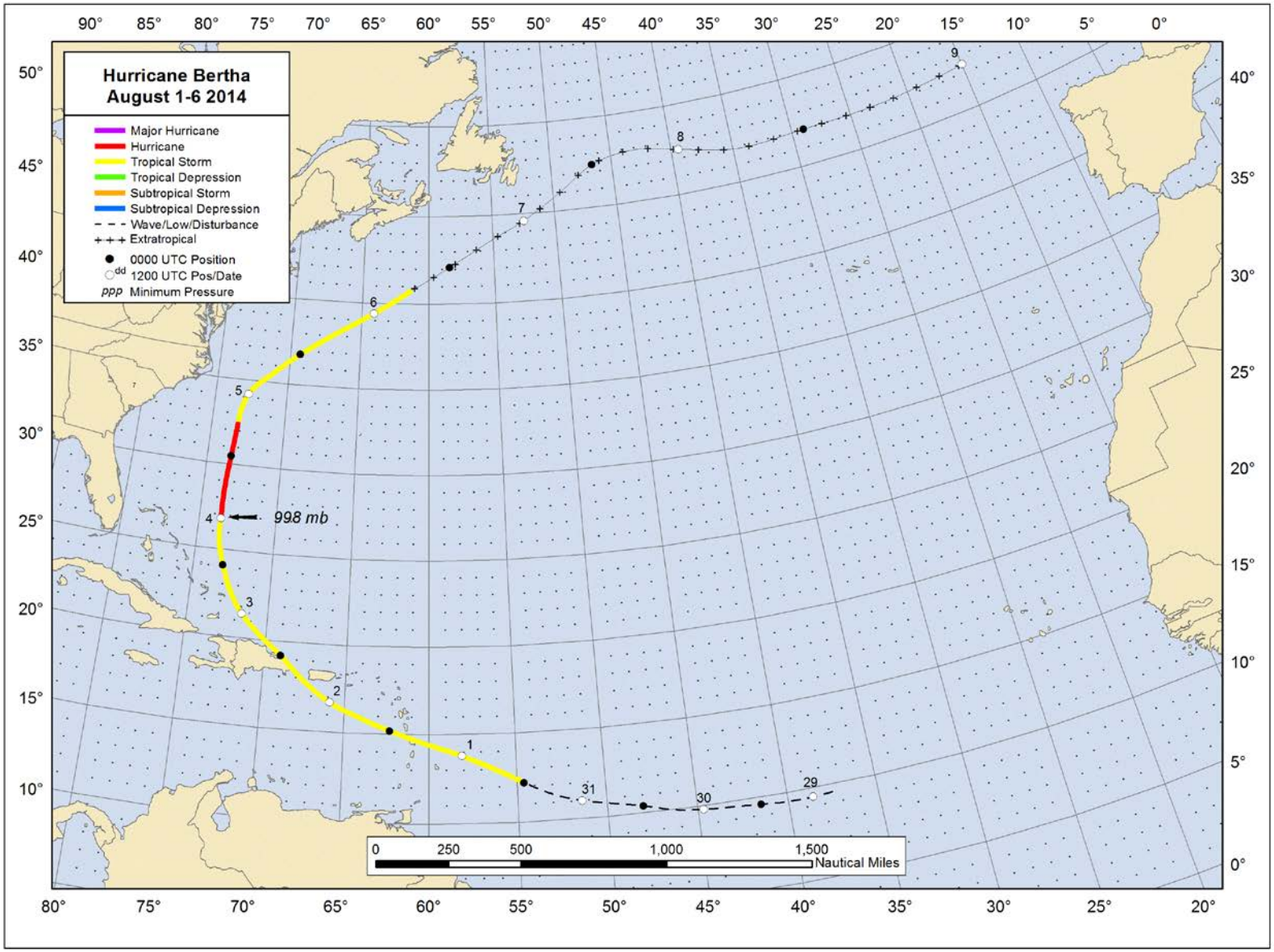

Figure 1. Best track positions for Hurricane Bertha, 1 - 6 August 2014. Track during the extratropical stage is partially based on analyses from the NOAA Ocean Prediction Center.

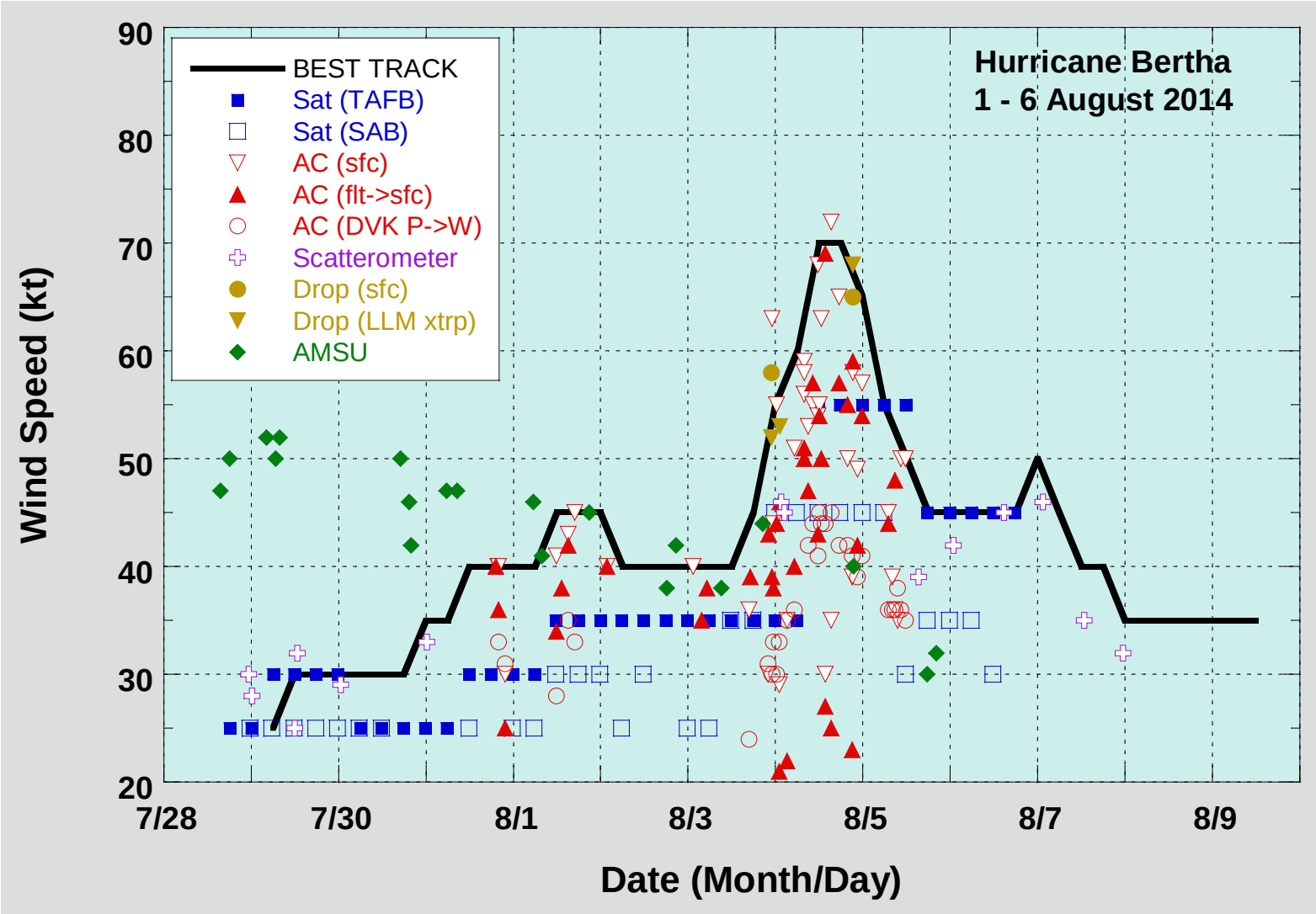

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Bertha, 1 - 6 August 2014. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% adjustment factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Dropwindsonde 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). Dashed vertical lines correspond to 0000 UTC.

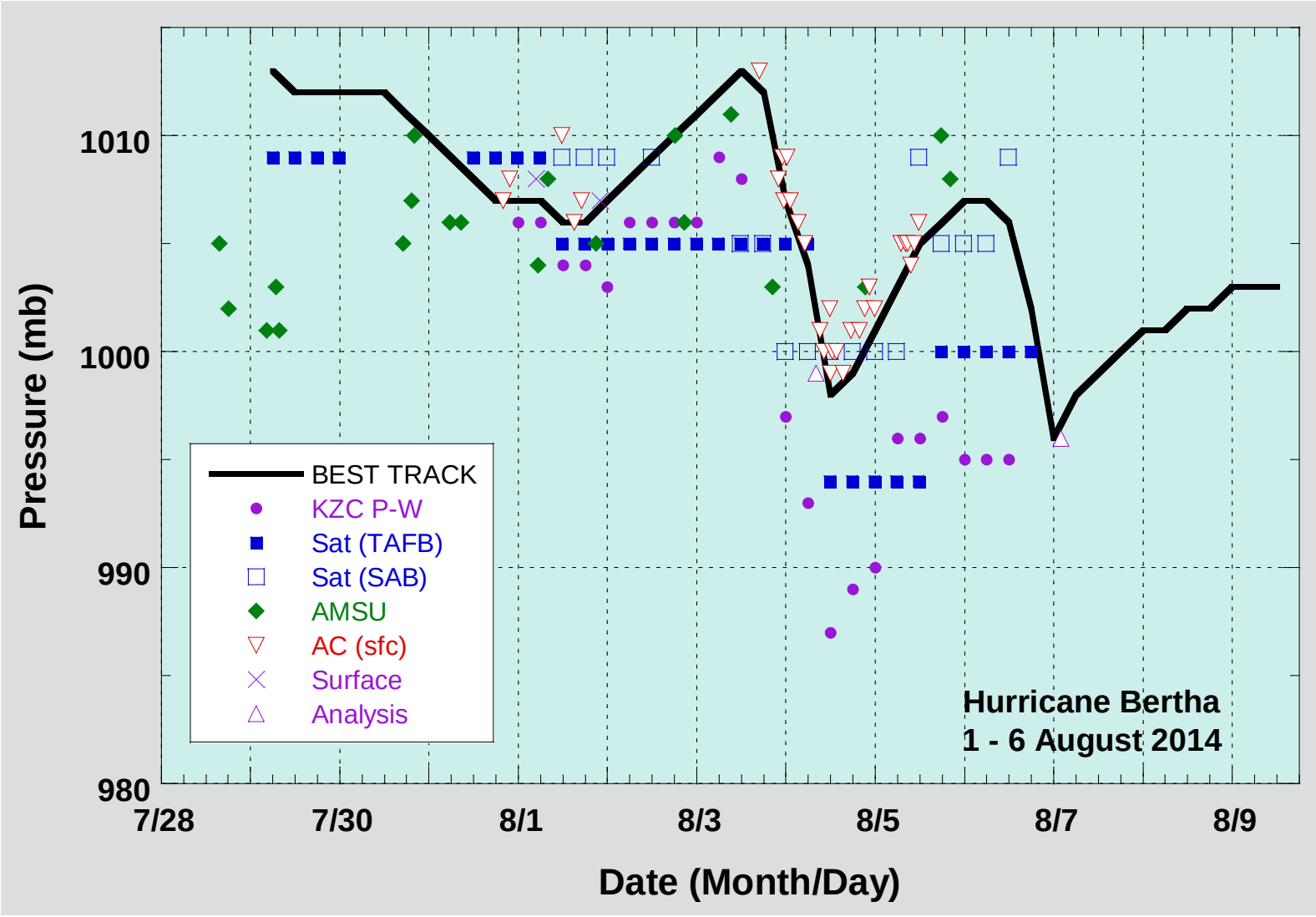

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Bertha, 1 - 6 August 2014. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

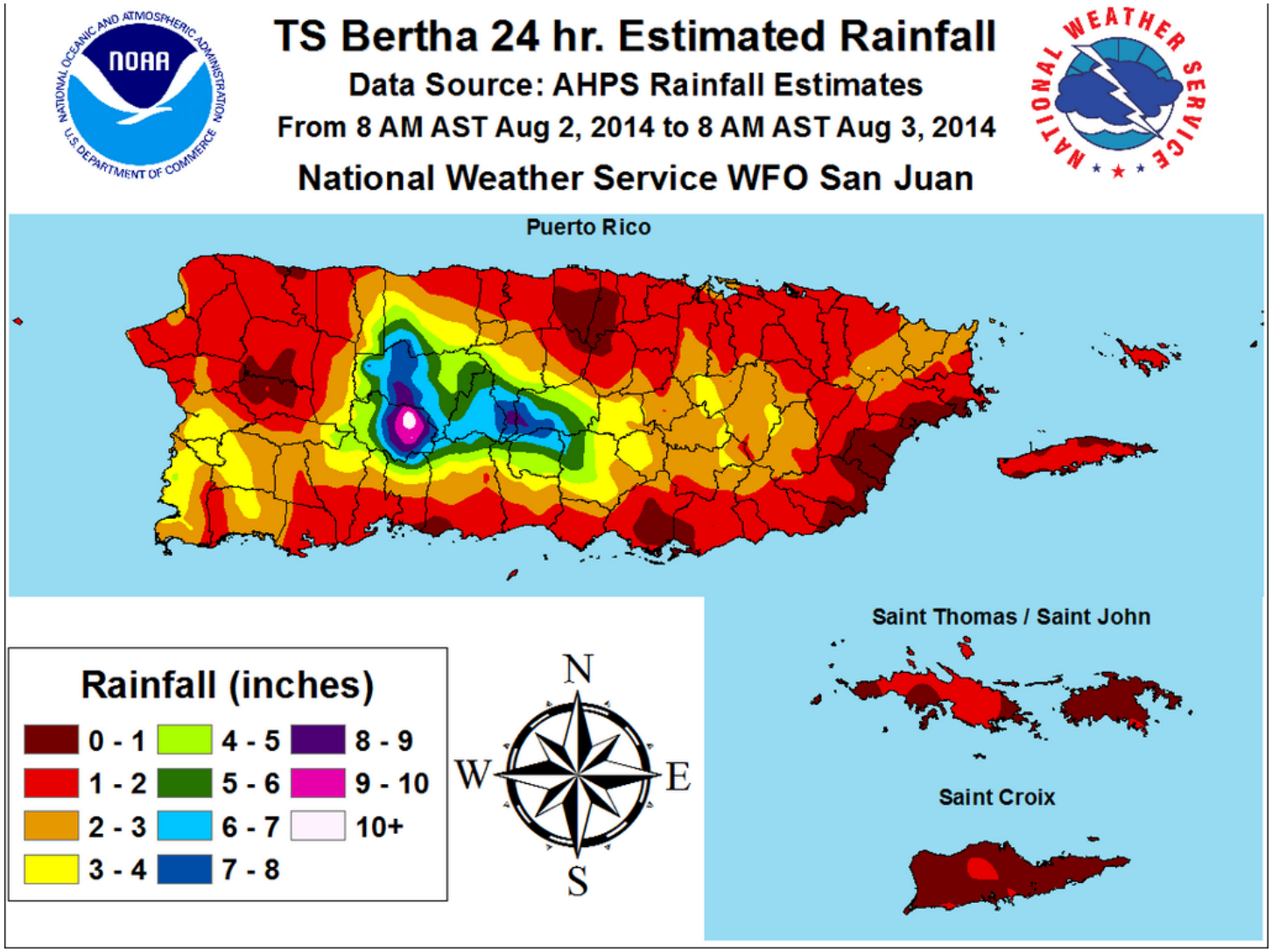

Figure 4. Estimated rainfall from the Advanced Hydrologic Prediction Service data associated with Bertha in Puerto Rico and the Virgin Islands.