Tropical Storm Bertha

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a. Synoptic History

For more than a week during late July in 2014 the GFS model had been projecting a possible tropical storm developing over the central Atlantic Ocean, moving in the general direction of the U.S. Virgin Islands and Puerto Rico. As expected in its prediction so far in advance, the model initially anticipated it to move northeast of these islands while fluctuating unreliably in track between subsequent model runs. The model's anticipated track became more stable in consecutive runs during the next several days and when it was expected to move into the northeast Caribbean Sea. This gave tropical forecasters at the National Hurricane Center (NHC) in Miami, Florida and those at the Weather Forecast Office in San Juan, Puerto Rico more confidence in forecasting the outlook of this system.

By late Thursday evening, July 31, 2014, model guidance at NHC agreed well with the GFS. At the same time Air Force reconnaissance aircraft reported surface winds near 40 knots (46 mph) while deep convection had developed north and east from the

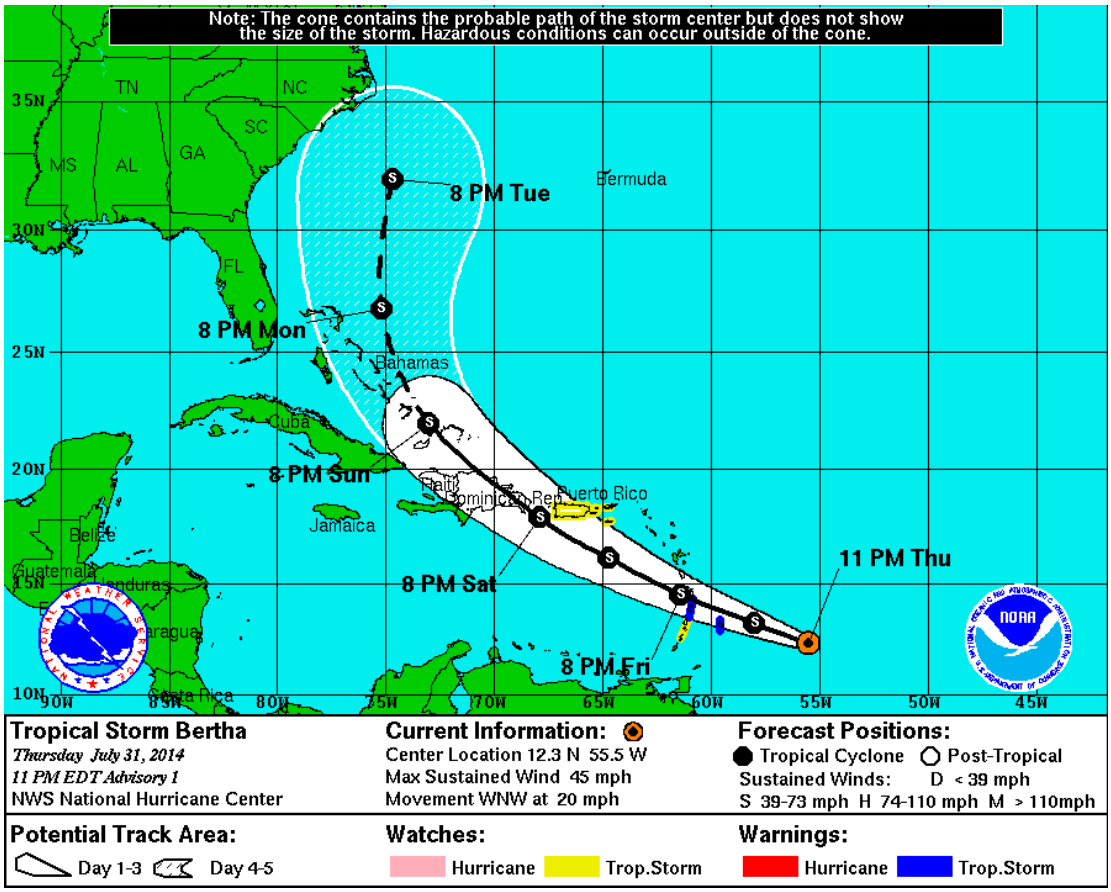

Figure 1. Initial track forecast for Tropical Storm Bertha.

center. This was enough information for tropical storm watches to be issued at 1100 pm (Puerto Rico, Vieques, Culebra, U.S. Virgin Islands British Virgin Islands, St. Vincent and the Grenadines) and warnings (Barbados, Dominica and St. Lucia). Figure 1 shows the five-day track for this forecast along with issued watches and warnings. The storm was moving west-northwest at 20 mph which contributed to the high shear it was experiencing and the belief that development would be slow.

By the following morning the approaching Bertha threatened the U.S. Virgin Islands and Puerto Rico within 36 hours. The NHC then upgraded the watch for these islands to a warning and adjusted its expected track very slightly to the north. This track turned out to be an excellent forecast though it would actually arrive at southwest Puerto Rico a few hours sooner.

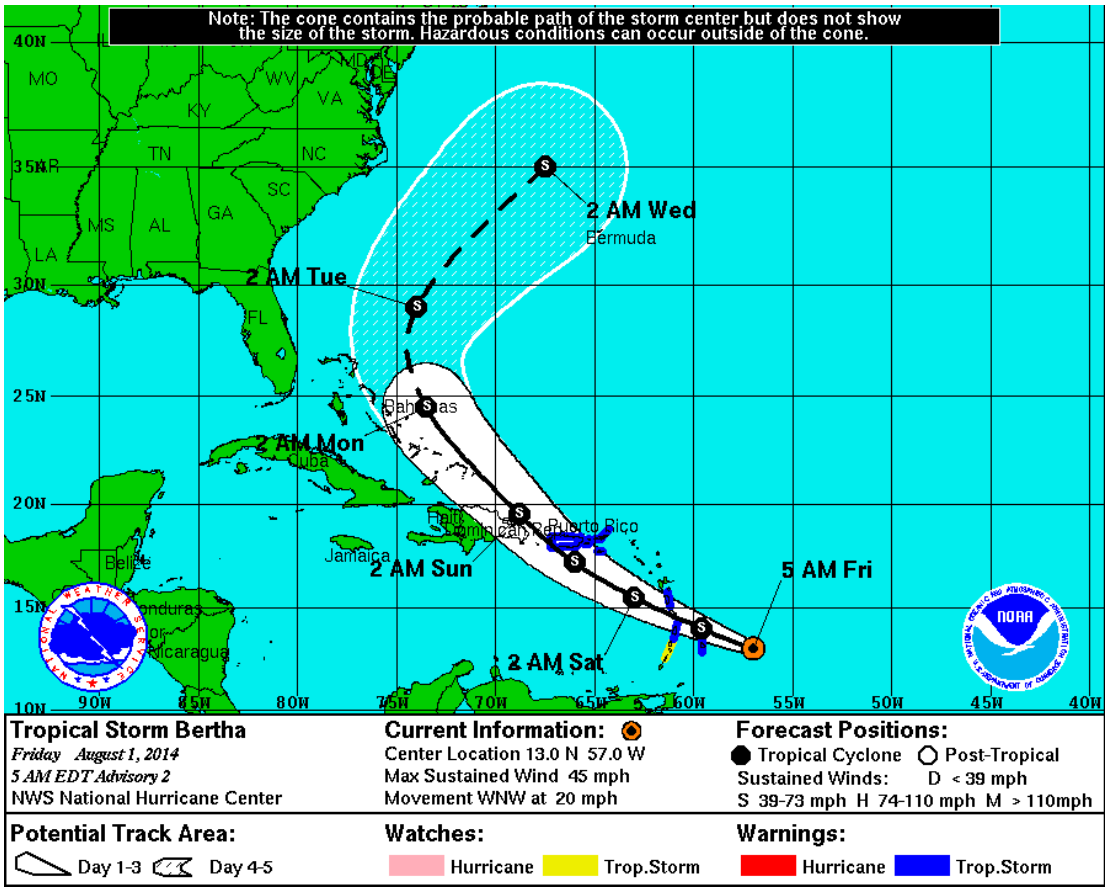

Figure 2. Forecast for Tropical Storm Bertha at 500 am AST, August 1, 2014.

Bertha battled a considerable amount of dry air lying in its path which also hindered its development. Figure 3 displays the dry air beginning to entrain into the circulation on the west side while Figure 4 confirms the dry air as measured on the morning upper air sounding at Saint Martin with only 35.35 mm (1.39 in.) of precipitable water.

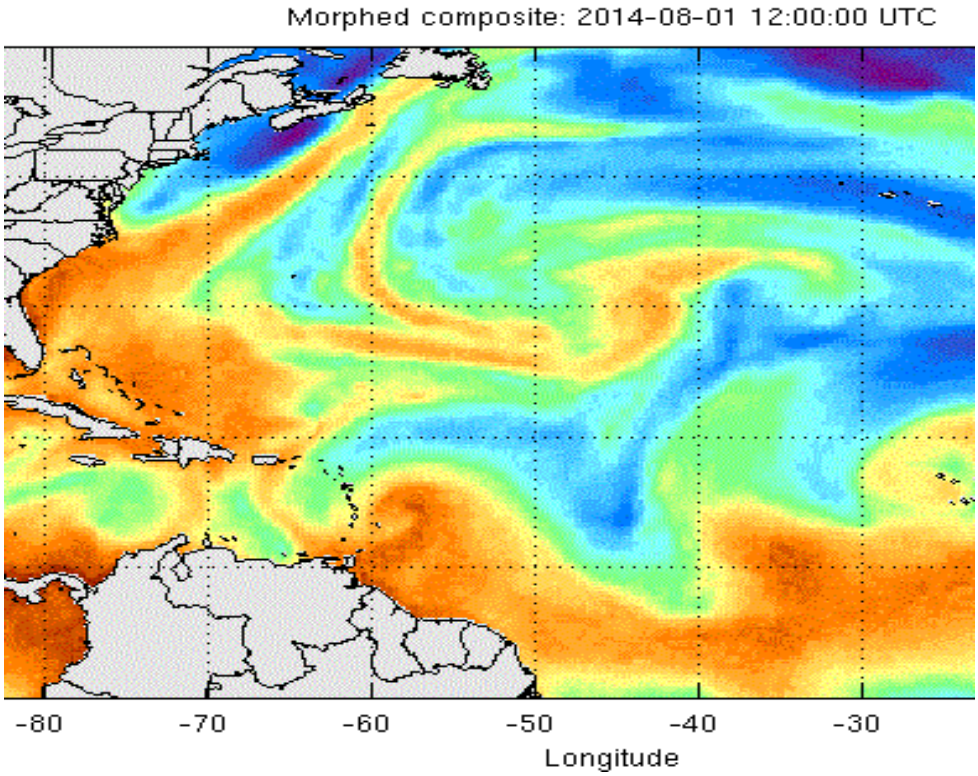

Figure 3. Morphed integrated microwave image (total precipitable water) from the Cooperative Institute for Meteorological Satellite Studies (CIMSS), August 1, 2014 for 1200 UTC.

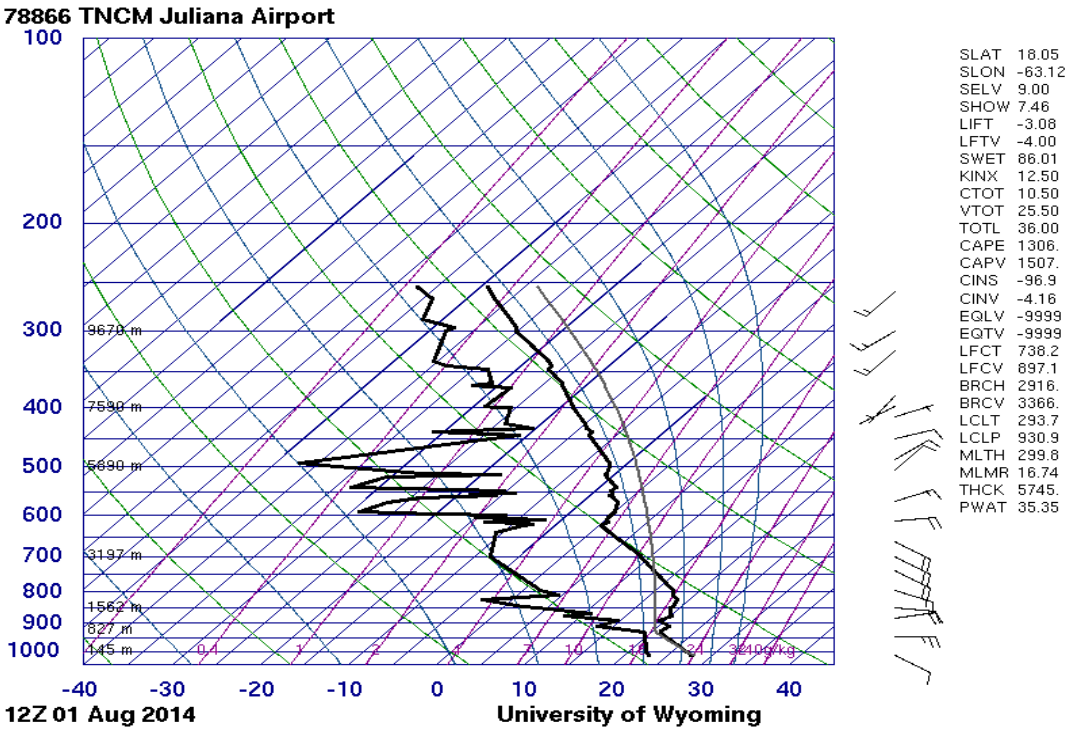

Figure 4. Upper air sounding at Saint Martin for 1200 UTC August 1, 2014.

By early afternoon on Friday, August 1 the circulation was shown to be exposed with no deep convection over the center. Arc clouds reveal gusty winds generating shallow convective clouds while dry air at middle levels flow towards the center (Fig. 5).

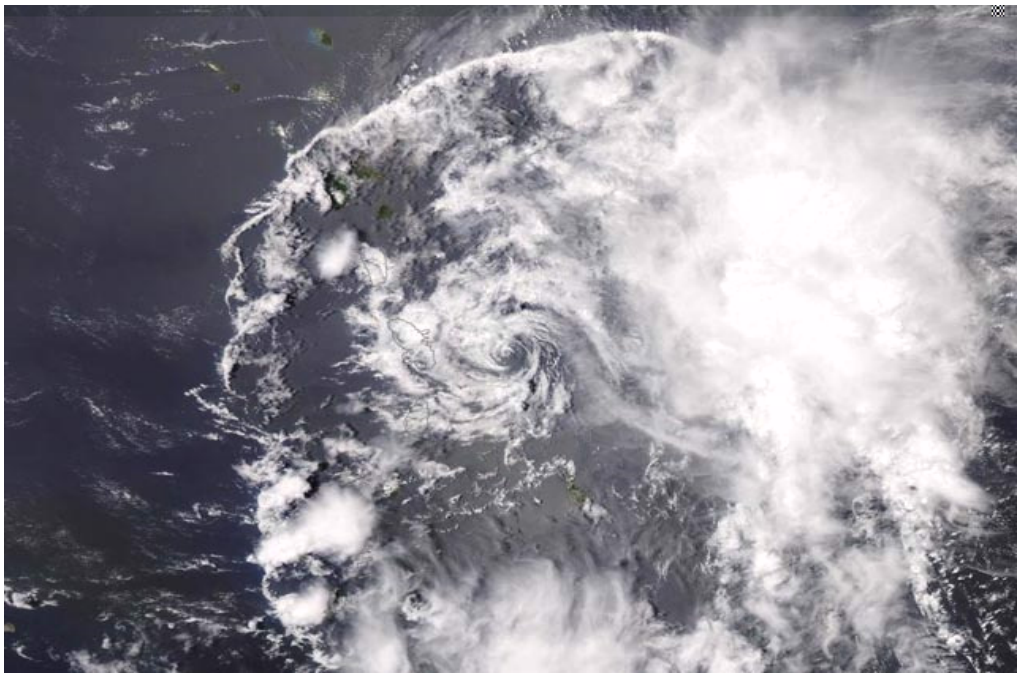

Figure 5. True color MODIS satellite image of Tropical Storm Bertha at about 115 pm AST on August 1, 2014 while passing through the Lesser Antilles, showing its exposed center and arc clouds towards the west and north.

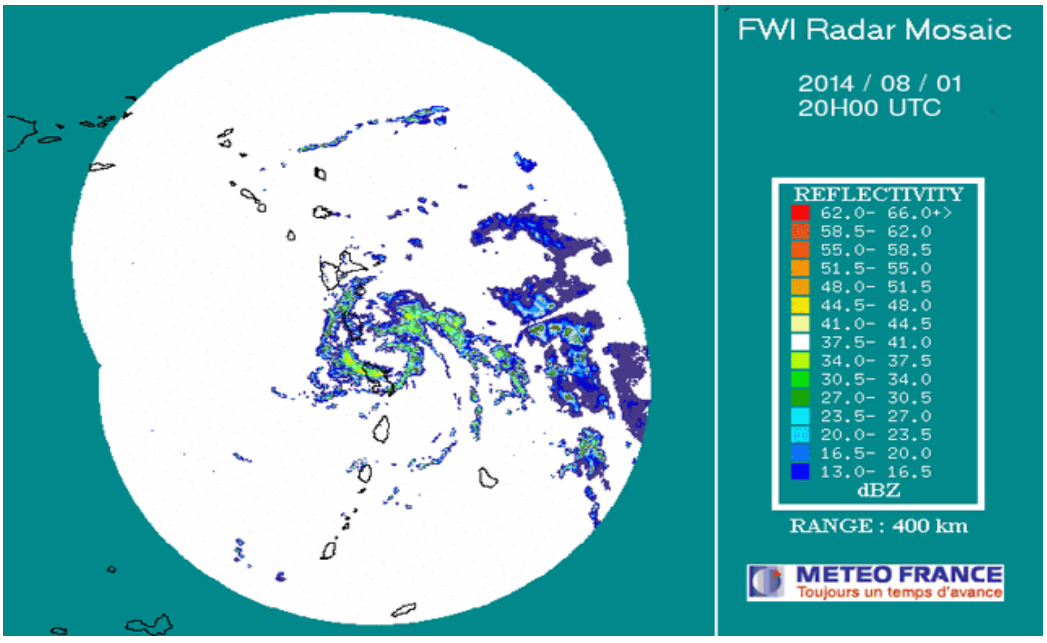

Figure 6. Radar image from Guadeloupe of Bertha while between Dominica and Martinique.

The center of Bertha passed over the Lesser Antilles between Dominica and Martinique during that Friday afternoon with winds gusting to 46 mph at Melville Hall Airport on Dominica. Figure 6 shows how radar showed the center of Bertha with the shallow convection. All airports in the Lesser Antilles reported less than one inch of rainfall during the afternoon that Bertha passed by though the heavier convection shown towards the east by the radar followed later.

b. Meteorological Effects on Puerto Rico and the U. S. Virgin Islands

On Saturday morning, as the tropical storm approached on August 2, the routine upper air sounding at San Juan, PR measured wind sustained at 30 mph only 1,000 feet off the ground and 40 mph at 2,000 feet AGL (Fig. 7). This plus precipitable water measured at 54.27 mm (2.14 in.) and sufficient instability made strong wind gusts in thunderstorms highly likely.

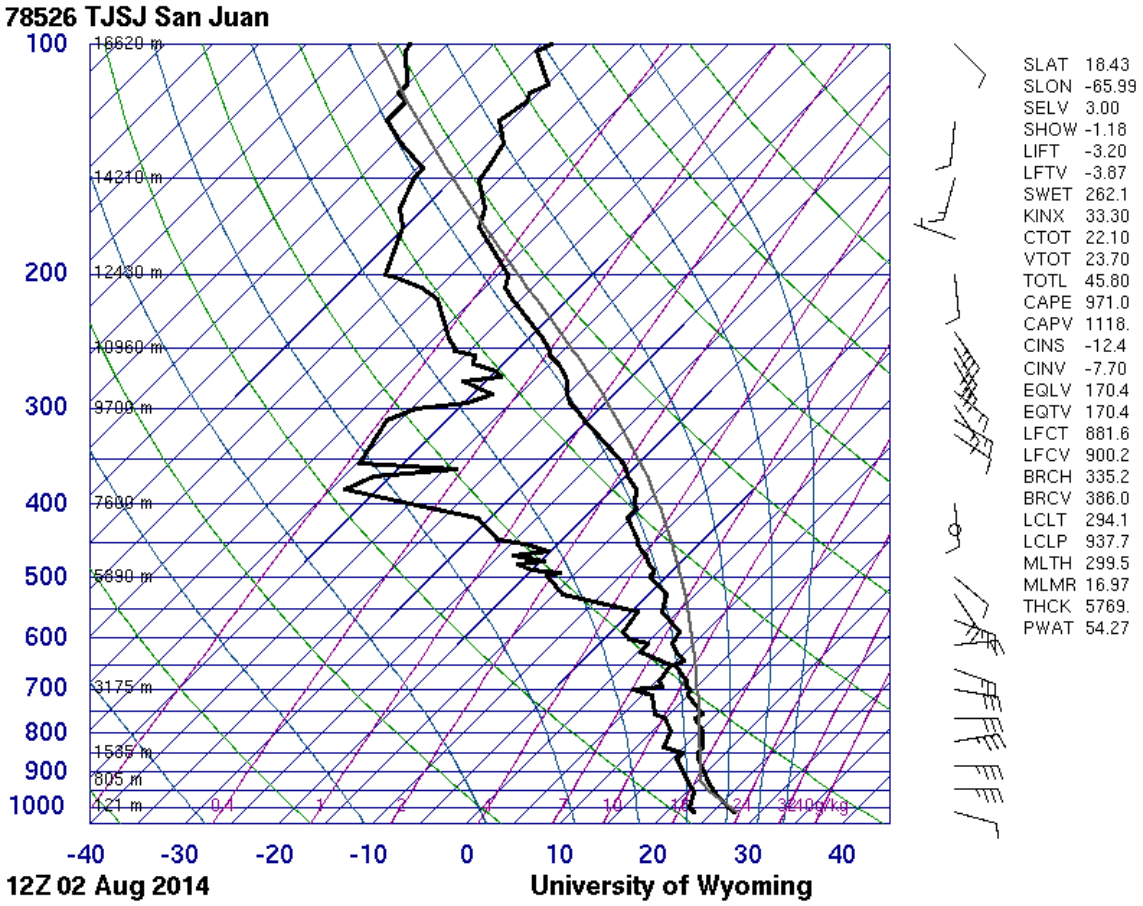

Figure 7. Upper air sounding for San Juan International Airport (TJSJ) at 1200 UTC August 2, 2014.

The outer rain bands of Bertha began affecting southern and eastern Puerto Rico and also the U.S. Virgin Islands on Saturday morning. The highest recorded and verified gusts were 67 mph at Buoy 41051 south of Saint Thomas and 50 mph on Culebra. Most of the strongest wind gusts (Table 1) occurred during or close to the heavy thunderstorms. The day began with very dry soils for most places so heavy rain did not become a significant issue until it saturated the soils, and then the rain kept coming. The heaviest rainfall totals for the day are also listed in Table 1. A graphical look at how much and where the rain occurred are shown in Figure 8.

Highest Verified Wind Gusts, by station, time (AST), speed in mph		
Cotton Valley, St. Croix	Aug. 2 / 709 am	42
Yabucoa Harbor, PR	Aug. 2 / 754 am	43
Buck Island, south of Saint Thomas	Aug. 2 / 604 am	55
Merceditas Airport, Ponce, PR	Aug. 2 / 850 am	39
Esperanza, Vieques	Aug. 2 / 952 am	42
Ensenada Bay, Culebra	Aug. 2 / 1009 am	50
Buoy 41051, south of St. Thomas	Aug. 2 / 1020 am	67
Buoy 41052, south of St. John	Aug. 2 / 1100 am	47
TIST, King Airport, St. Thomas	Aug. 2 / 1153 am	46
TUPJ, Beef Island (British VI)	Aug. 2/ 1200 noon	40
LTBV3 Lime Tree Bay, St. Croix	Aug. 2 / 100 pm	45
Christiansted Harbor, St. Croix	Aug. 2 / 103 pm	42
TISX, Rohlsen Airport, St. Croix	Aug. 2 / 300 pm	46

Highest reported rainfall from Aug. 2 / 6am to Aug. 3 / 6am by Station					
Lago Adjuntas - Adjuntas	11.11	Rio Saliente	6.33	Lago de Cidra	3.56
Rio Tanama	8.60	Rio Caonillas	5.68	Rio Portugues	3.50
Adjuntas Lago Garza	8.29	Lago Yahuecas	5.40	Lago Toa Vaca at Dam	3.48
Arecibo Observatory	7.60	Lago Matrullas	4.85	Rio Coamo at Rd 14	3.14
Villalba	7.29	Rio Limon	4.35	Rio Camuy - Bayaney	3.12
Ciales	6.63	Lago Caonillas	4.32		
Lago Vivi - Utuado	6.48	Lago Carite	3.72		

Table 1. Highest wind gusts and rainfall totals during the passage of Bertha.

The 7.6 inches recorded at the Arecibo Observatory represents the second wettest day on record there. Also, precipitation records for the calendar day (August 2) were set at several other weather stations, including Mayaguez Airport (3.40 inches), Corral Viejo (2.95) Penuelas 1E (2.89), Toa Baja Levittown (2.25), Culebra Hill (0.91), and Humacao Natural Reserve (0.77).

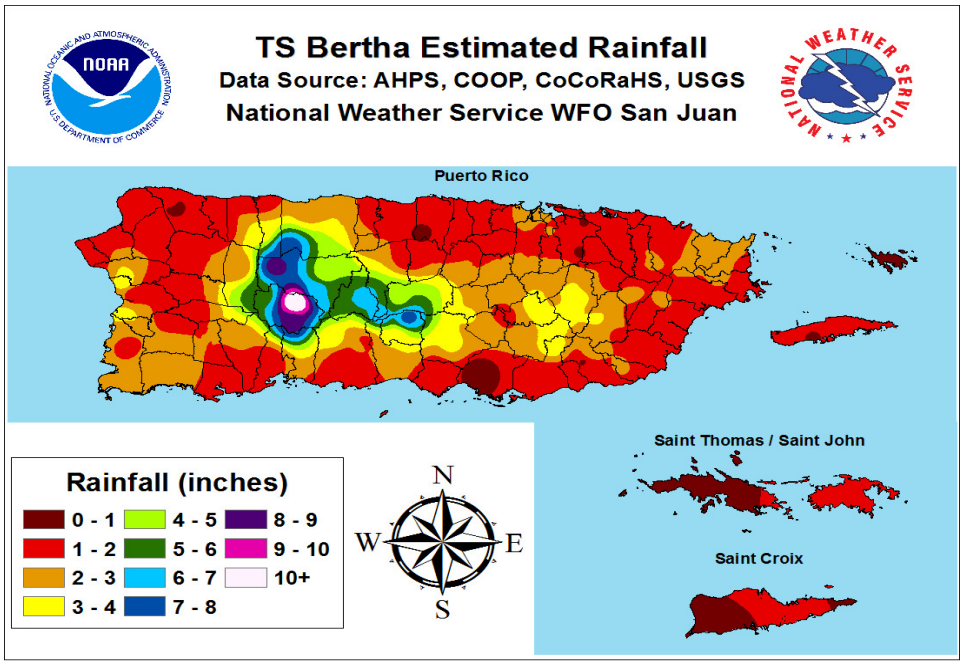

Figure 8. Total rainfall amounts during the passage of Tropical Storm Bertha.

c. Damage, Watches and Warnings

The overall damage from the tropical storm was relatively minor though that always sounds hollow to those people who experienced damage or injury. The following is a summary of reported damage with the time occurrence.

100 pm – San Lorenzo, power pole down and blocking the road in Barrio Cerro Gordo sector Los Velazquez near the intersection with PR 912.
215 pm – Villalba, flash flood as a creek was out of its banks in Barrio El Pino.
220 pm – San Juan, tree down at Eleanor Roosevelt Ave. in Hato Rey, affecting power lnes.
308 pm – Ponce, branches down on PR-10 from Ponce to Adjuntas.
345 pm – Rio Grande, branches down and partial collapse of PR-191 towards El Yunque National Park.
435 pm – Utuado, several mudslides in Utuado, urban flooding at Urbanization Cabrera, one power line collapsed on PR-111 KM 4.8 at Barrio Caguana, Rio Grande de Arecibo out of its banks at Guanico sector between PP-10 and PR-123 which closed the road.
500 pm – Barranquitas, power lines down at PR-152 KM 1.6.
500 pm – Orocovis, mudslide at Barrio Berenjales, PR-143.
520 pm – Mayaguez, Barrio Trastalleres near University of Puerto Rico at Mayaguez flooded a road, and urban flooding at Parque El Nuevo Milenio near Barrio Guanajibo.

Bertha was continuing to move west-northwest during its passage of the local islands and had even increased its forward speed to 22 mph. This quick movement, the dry air that had been entrained into the circulation and especially the dry soils that had been present prior to its arrival, were all factors in not issuing a flash flood watch before arrival. Some

flooding was expected but not to be widespread or as significant as in many typical systems. The watches and warnings (Table 2) were timely and on target for a tropical event that lasted less than 24 hours for Puerto Rico and the U.S. Virgin Islands.

Type of Issuance	Location	Date/Time (AST)
Tropical Storm Watch Issued	Puerto Rico, Vieques, Culebra, U.S. Virgin Islands	July 31 / 1100 pm
Tropical Storm Warning Issued	Puerto Rico, Vieques, Culebra, U.S. Virgin Islands	Aug. 1 / 500 am
Flash Flood Warning	Canovanas, Cieba, Naguabo, Fajardo, Luquillo, Rio Grande	Aug. 2 / 945 am
Special Marine Warning	Marine Zones AMZ710-712-715-725 (Atlantic costal waters of Puerto Rico and USVI and within 10 nm of Vieques/Culebra/St. Thomas)	Aug. 2 / 1051 am and again 1119 am
Flash Flood Warning	Coamo, Juana Diaz, Santa Isabel, Villalba	Aug. 2 / 130 pm
Flash Flood Warning	Guayanilla, Juana Diaz, Penuela, Ponce	Aug. 2 / 308 pm
Flash Flood Warning	Jayuya, Utuado, Adjuntas, Arecibo	Aug. 2 / 408 pm and extended at 659 pm
Flood Warning	Rio Tanama Arecibo	Aug. 2 / 805 pm
Flood Warning	Lago Dos Bocas and Rio Grande Arecibo	Aug. 2 / 1135 pm
Flood Warning	Rio Tanama Arecibo	Aug. 3 / 505 am
Tropical Storm Warning Ended	U.S. Virgin Islands	Aug. 2 / 500 pm
Tropical Storm Warning Ended	Puerto Rico, Vieques, Culebra	Aug. 2 / 800pm

Table 2. Historical timeline of watches and warnings issued by the National Hurricane Center and San Juan Weather Forecast Office.

Figure 9 shows Bertha as it was passing over Puerto Rico and the Virgin Islands. The center was about 55 miles south of Ponce at this time. Overshooting tops in this image reveal strong convection such as those near San Juan and well southwest of St. Croix. Though in this image the center is no longer exposed most of the associated convection was towards the east and north, and the arc clouds at the north and northwest periphery are still indicative of strong wind gusts moving well in advance of the system and into the Atlantic Ocean.

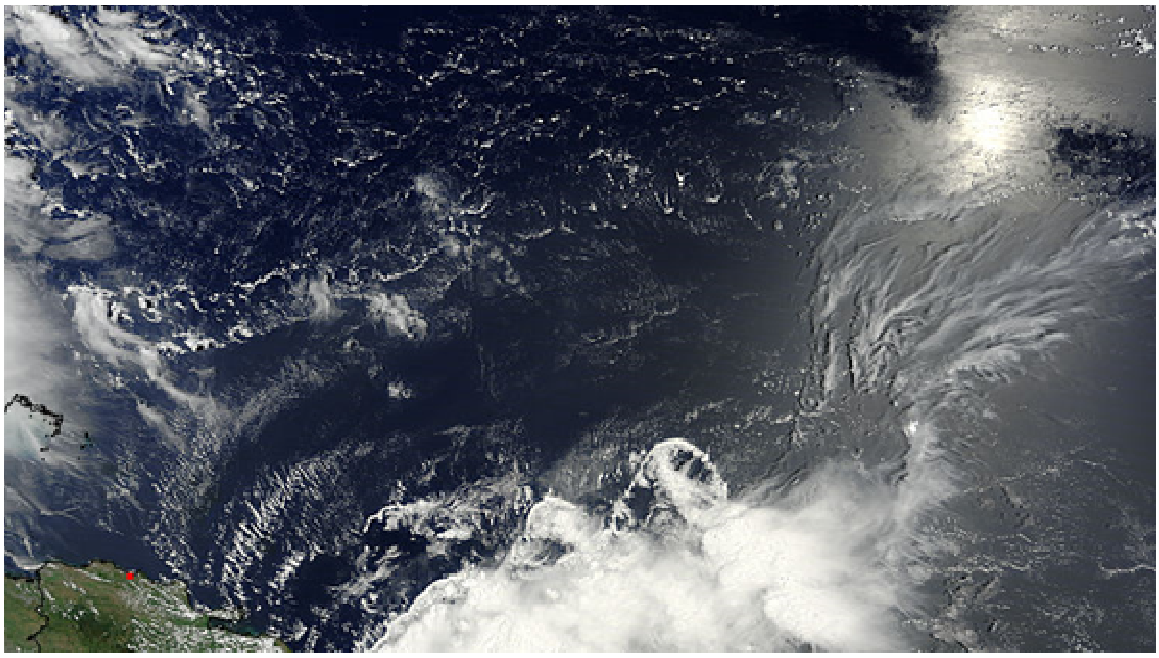

Figure 9. True color MODIS satellite image as Bertha was moving over Puerto Rico and the Virgin Islands. The center was 55 miles south of Ponce.