

Tropical Storm Erika

Gary Votaw, Althea Austin-Smith, Ernesto Rodriguez, Ernesto Morales, Felix Castro

a. Synoptic History

Late on the evening of Sunday, August 23, 2015, a tropical storm watch that had been in effect for the U.S. Virgin Islands and Puerto Rico on the weakening remnants of Hurricane Danny had been discontinued. By the next evening late, on August 24th, the National Hurricane Center (NHC) had collected enough data on a tropical wave they had been monitoring, including the ASCAT image below (Fig. 1), the satellite image (Fig. 2), and a NOAA buoy reporting sustained winds at 39 knots. Both the center of the storm and convection surrounding it had become better defined and prompted NHC to name the storm Erika, the 5th named storm in the Atlantic Basin. For 48 hours, Erika was expected to move over warm water while in a moist air mass with low vertical wind shear. These conditions were favorable for possible strengthening though models disagreed beyond 72 hours regarding track and strength (NHC discussion). It was moving quickly at 20 mph, slightly north of westward.

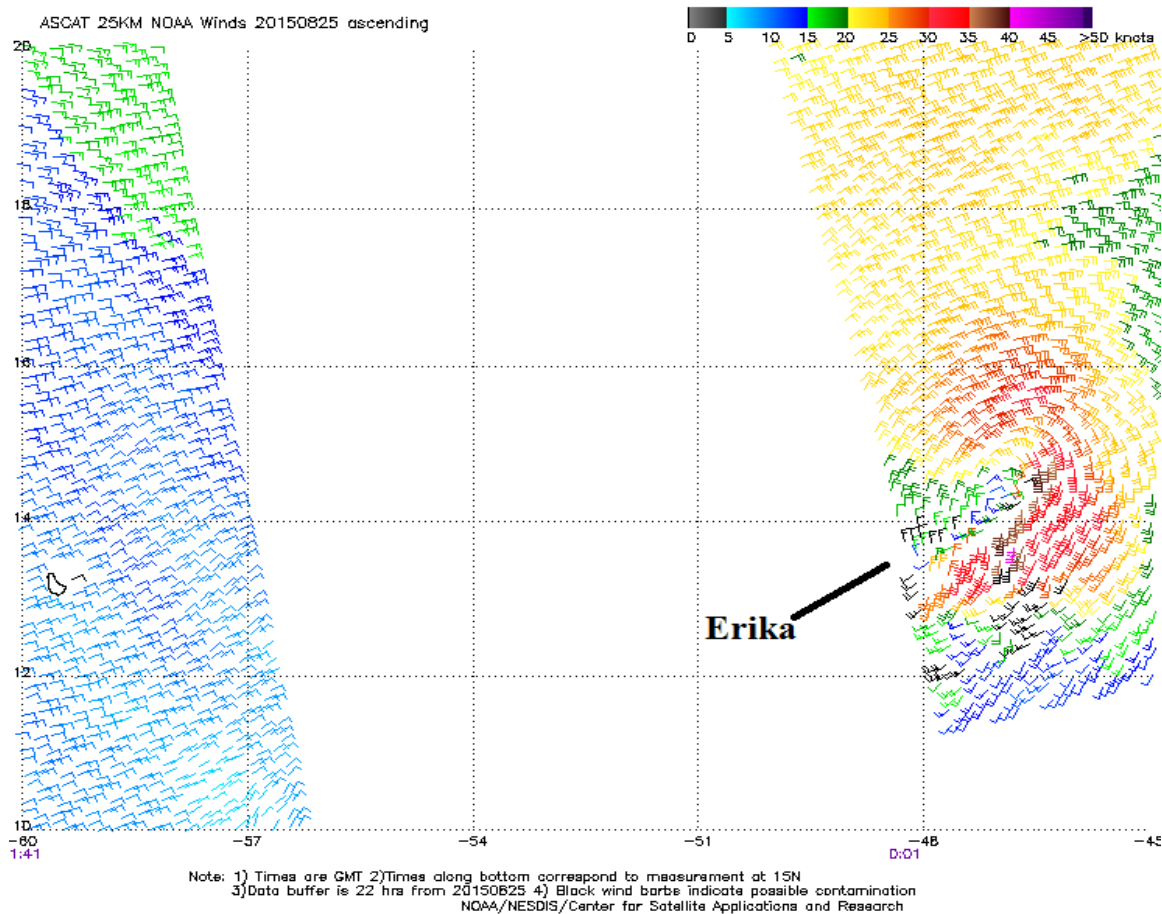


Fig. 1. ASCAT satellite pass late on August 24, 2015. Brown wind barbs on the east and southeast sides of the center indicate winds between 35 and 40 knots (Center for Satellite Application and Research, STAR).

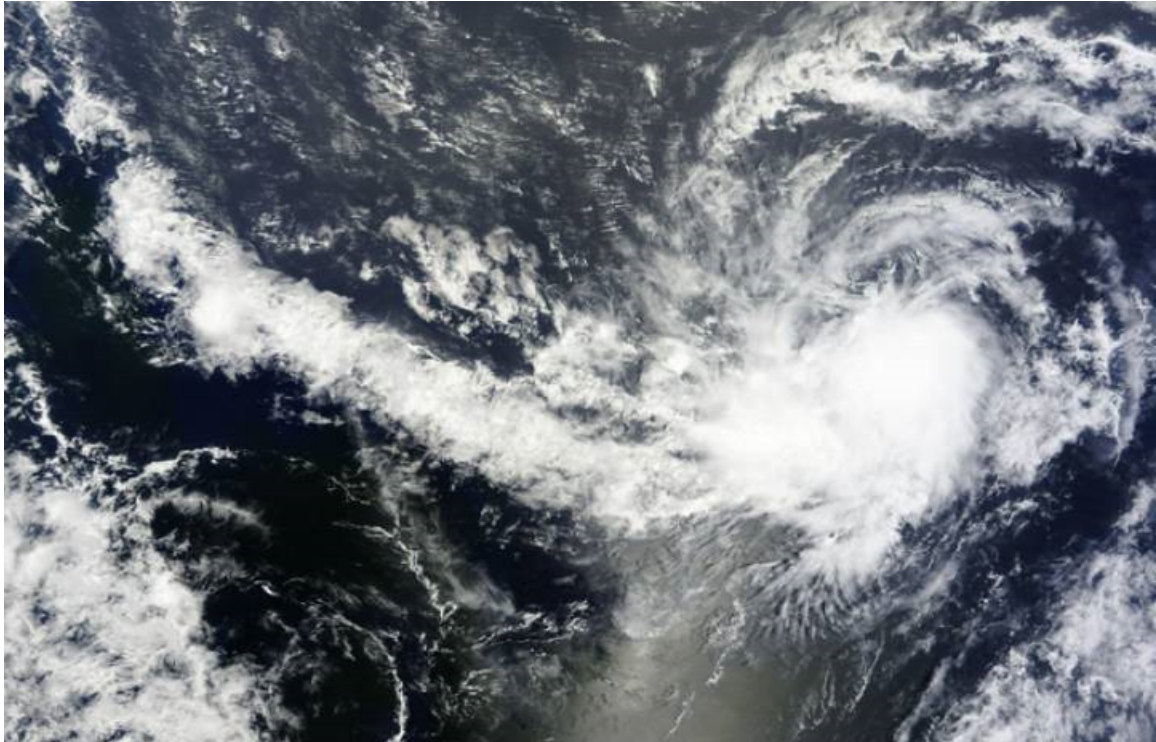


Fig. 2. Tropical Storm Erika late on August 24, 2015 (NASA/EOSDIS).

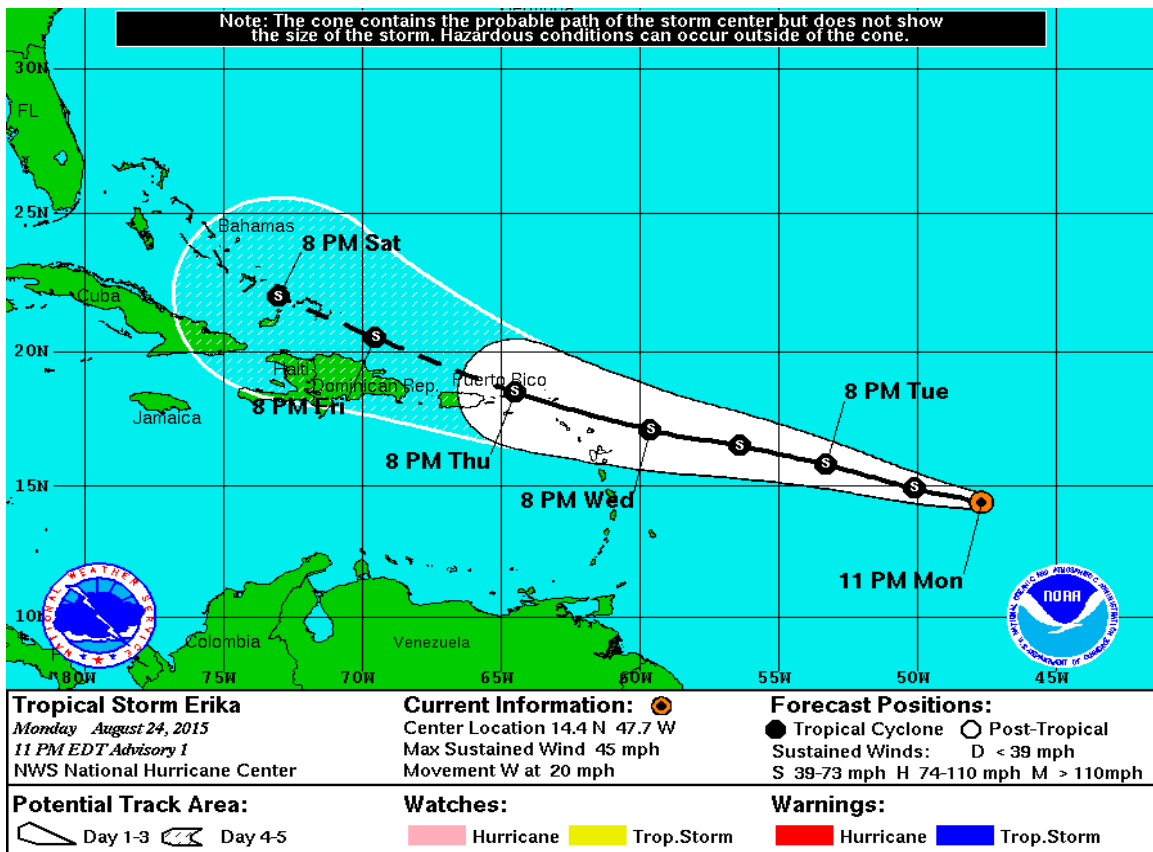


Fig. 3. Tropical Storm Erika, Advisory 1 (NHC), 1100 pm AST on August 24, 2015.

In the initial official forecast advisory of Erika, sustained winds were set at 45 mph with gusts to 50 mph. It was expected to move west-northwest for several days (Fig. 3). Differences in track beyond 72 hours were believed to hinge on the storm intensity. Some models strengthened it which would cause it to turn more northwest but other models, such as the GFS and ECMWF, expected Erika to weaken, and kept it farther south and moving west. Little about Erika changed over the next couple of days as it moved westward, slightly south of the forecast track but within the “cone” of the forecast.

By Thursday morning, August 27th, Erika had arrived in the Leeward Islands with the center passing between Guadeloupe and Antigua. A NOAA Hurricane Hunter aircraft flying through Erika confirmed that it had strengthened a little with sustained winds of 50 mph but it was encountering wind shear. Consensus of models was for it to strengthen and move northwest, except the GFS and ECMWF still showed it weakening and remaining south of the expected track. The NHC forecast was for Erika to eventually move west-northwest and over Saint Thomas by that evening. A tropical storm watch for the U.S. Virgin Islands and Puerto Rico was issued at 1100 pm AST on Tuesday, August 25th and then upgraded to a tropical storm warning the following morning at 500 am AST (Fig. 4).

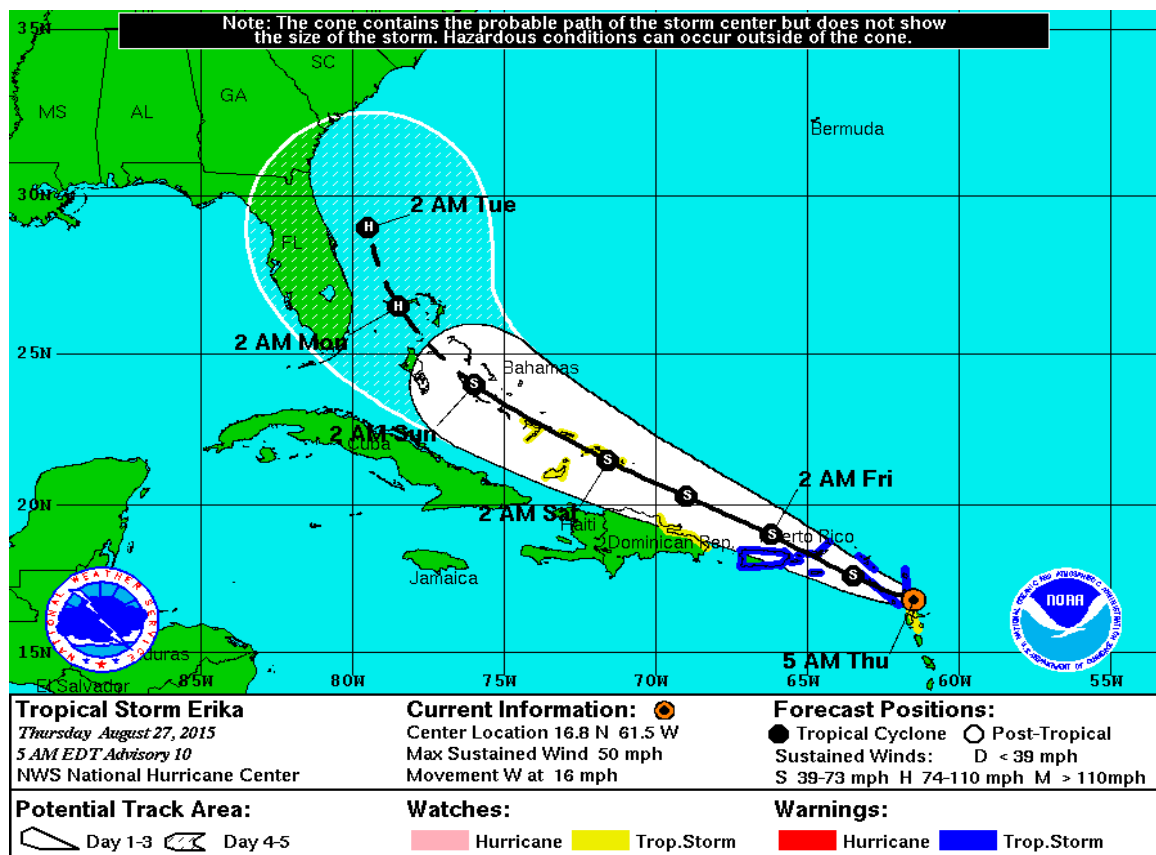


Fig. 4. Tropical Storm Erika, Advisory 10 (NHC) 500 am AST on August 27, 2015.

Due to the shear Erika was experiencing most of the rain was east of the center which followed onto the Leeward Islands later on Thursday the 27th, when 12.64 inches of rain was recorded on Dominica. At least 20 deaths occurred there according to NBCNews

(<http://www.nbcnews.com/news/weather/tropical-storm-erika-deluge-florida-flooding-high-winds-n418631>). Figure 5 shows water rushing down a street in Dominica on this afternoon. A flash flood watch was issued on the U.S. Virgin Islands and Puerto Rico for 4 to 8 inches of rainfall with the risk of 12 inches locally.



Fig. 5. Flash flooding on Dominica (<http://mashable.com/2015/08/27/tropical-storm-erika-dominica/>).

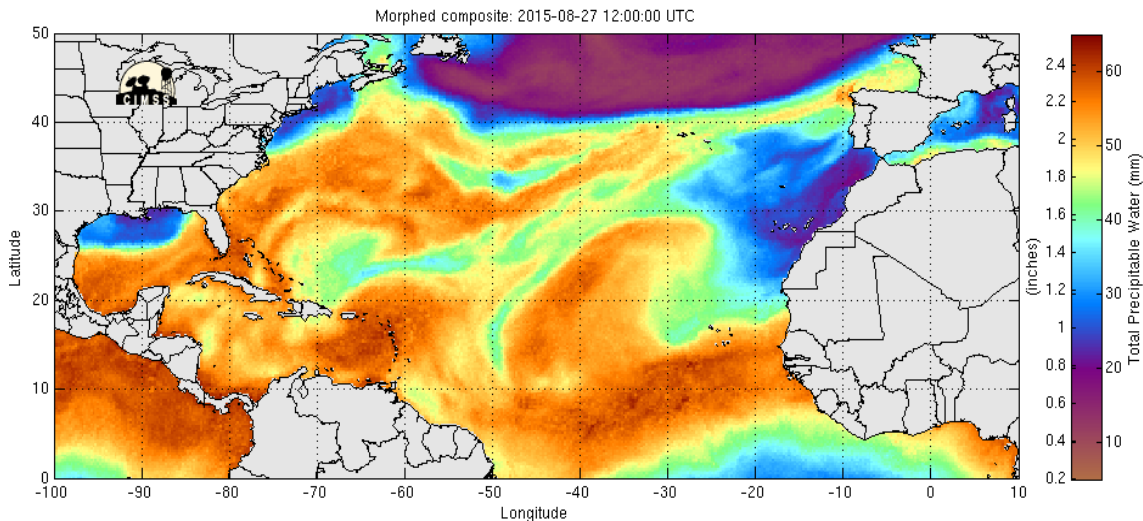


Fig. 6. Water vapor image showing a large area of high moisture enveloping the Leeward Islands and moving towards the U.S. Virgin Islands and Puerto Rico (Morphed Integrated Microwave Imagery at CIMSS).

The rainfall that occurred on the Leeward Islands was embedded in a large and deep area of moisture surrounding Erika (Fig. 6) which had already reached the eastern Caribbean Sea and encircling Puerto Rico and the U.S. Virgin Islands. Erika had either developed multiple centers extending to the southwest or was opening to a wave and the strongest winds were on the north and northeast side of the system (Fig. 7). The anticipated turn

towards the west-northwest had not yet occurred and the track forecast was adjusted late Thursday morning westward, to cross Puerto Rico rather than Saint Thomas (Fig. 8).

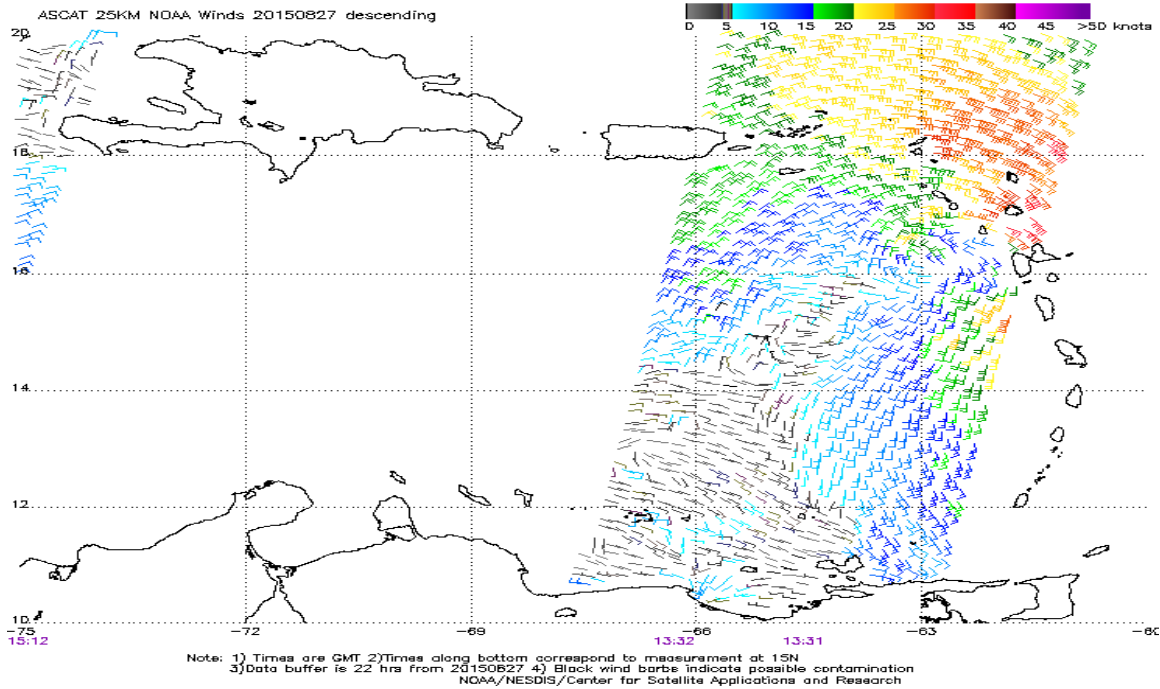


Fig. 7. ASCAT satellite pass on August 27 showing circulation around a low center south of St. Kitts and other possible circulating centers or a trough extending southwest. Strong winds were over the northern Leeward Islands and moving westward towards USVI.

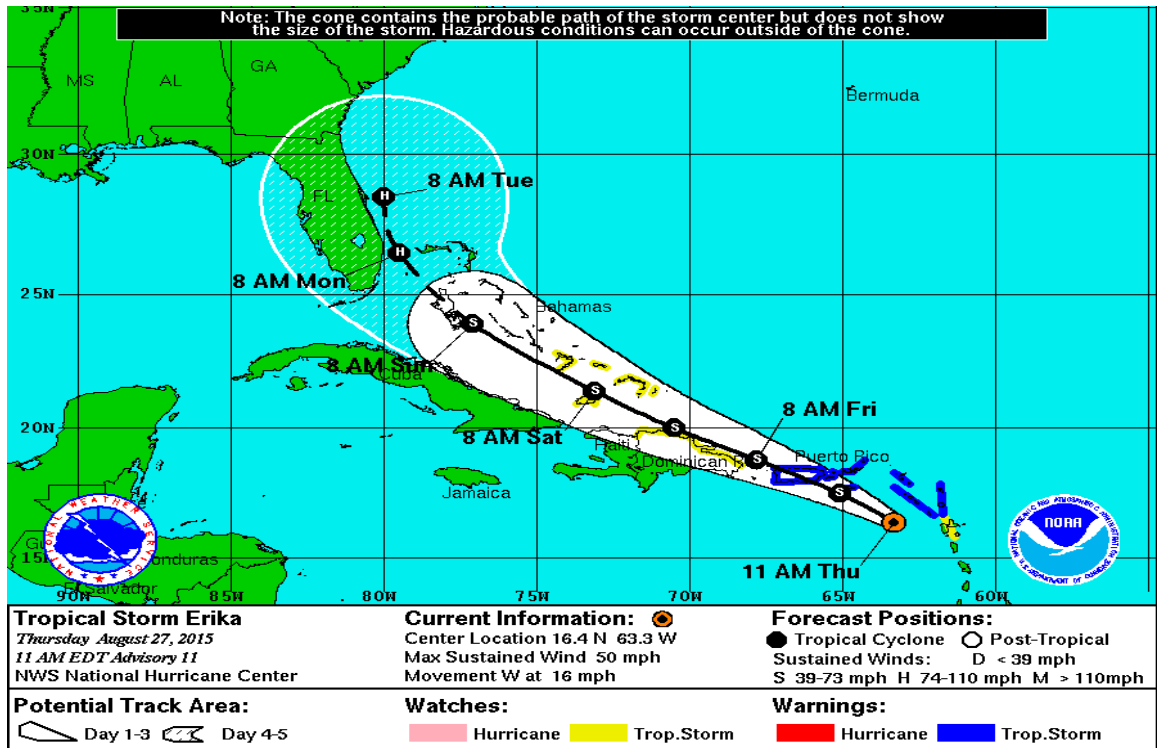


Fig. 8. Tropical Storm Erika, Advisory 11 (NHC), 1100 am AST on August 27, 2015.

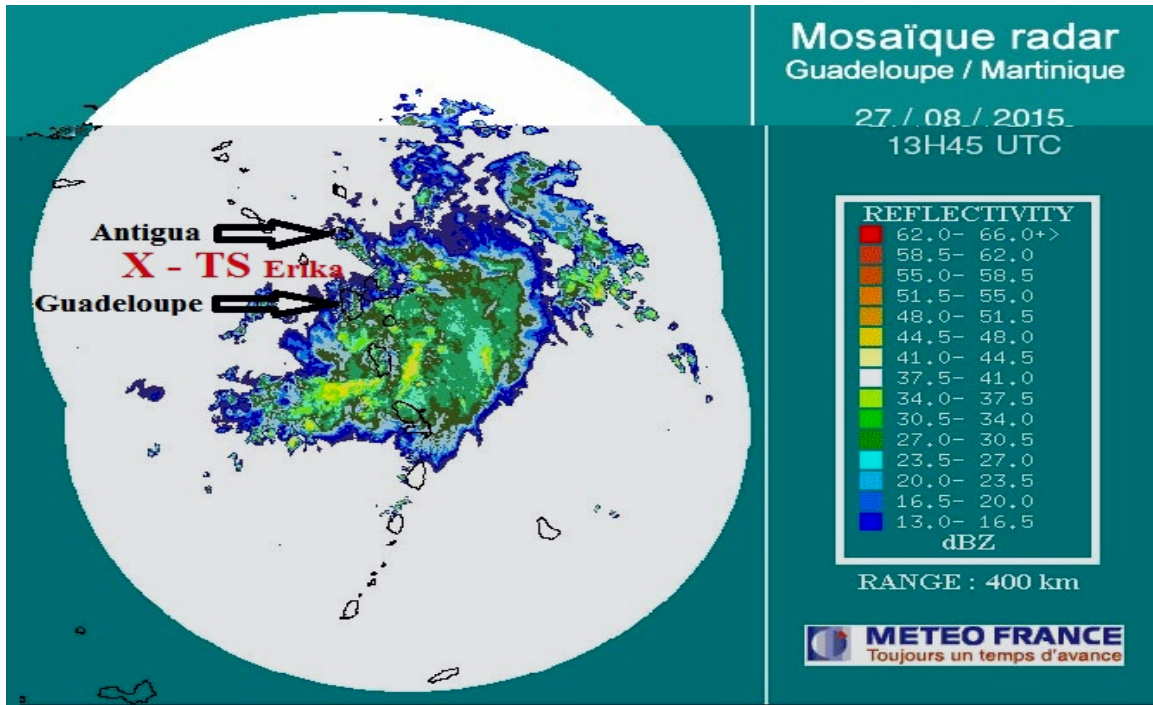


Fig. 9. Radar image of rainfall from Guadeloupe and Martinique. General location of the center of Erika is shown by the red X while most of the rain was well to the east. (<http://www.meteofrance.gp/previsions-meteo-antilles-guyane/animation/radar/antilles>).

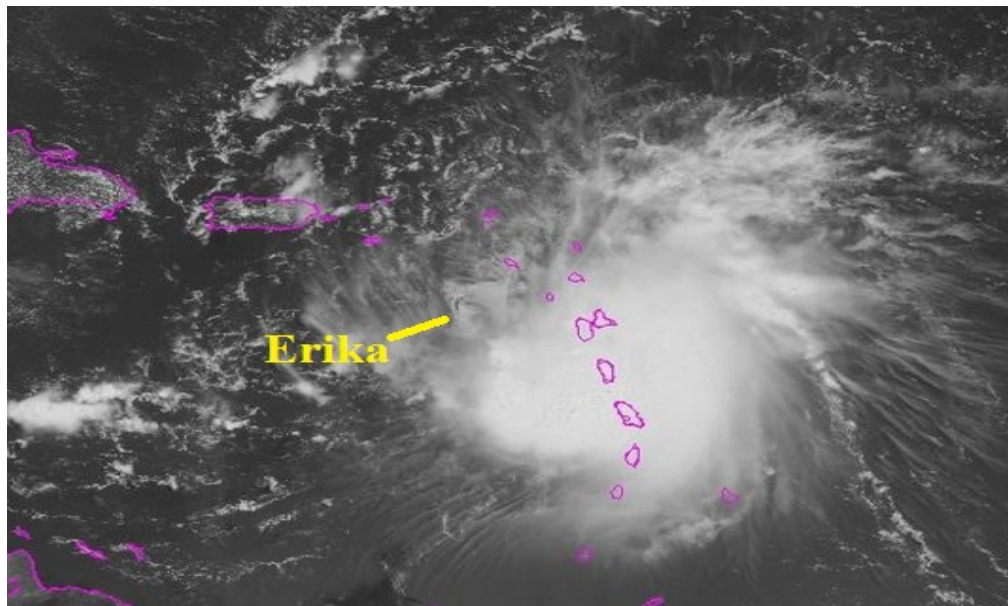


Fig. 10. Satellite image of Tropical Storm Erika on Thursday afternoon, August 27, with its suspected center exposed and west of convection over the Leeward Islands (NOAA).

The convective activity trailed well towards the east of the center (Figs. 9 and 10). Defining a center was difficult for this stage of strongly sheared Erika, making a forecast equally troublesome. The center of Erika became even more difficult to locate that

evening, even as the Hurricane Hunters were flying in the area and was challenging for them to find a center. Swirls were believed to be rotating within a larger gyre (NHC discussion). General west-northwest movement for the center was still expected.

Convection flared north of the main convective area (Fig. 11) during the evening. The thunderstorms passed over the U.S. Virgin Islands and contributed to some of the highest winds experienced from Erika. The recorded gusts included 48 mph at Cyril E. King Airport on Saint Thomas at the time of Figure 11, with 62 mph 3 hours earlier at Henry E. Rohlsen Airport and 66 mph at Sandy Point NWR on Saint Croix. Many wind gusts exceeding 40 mph were also recorded later on Puerto Rico during the night (Table 1).

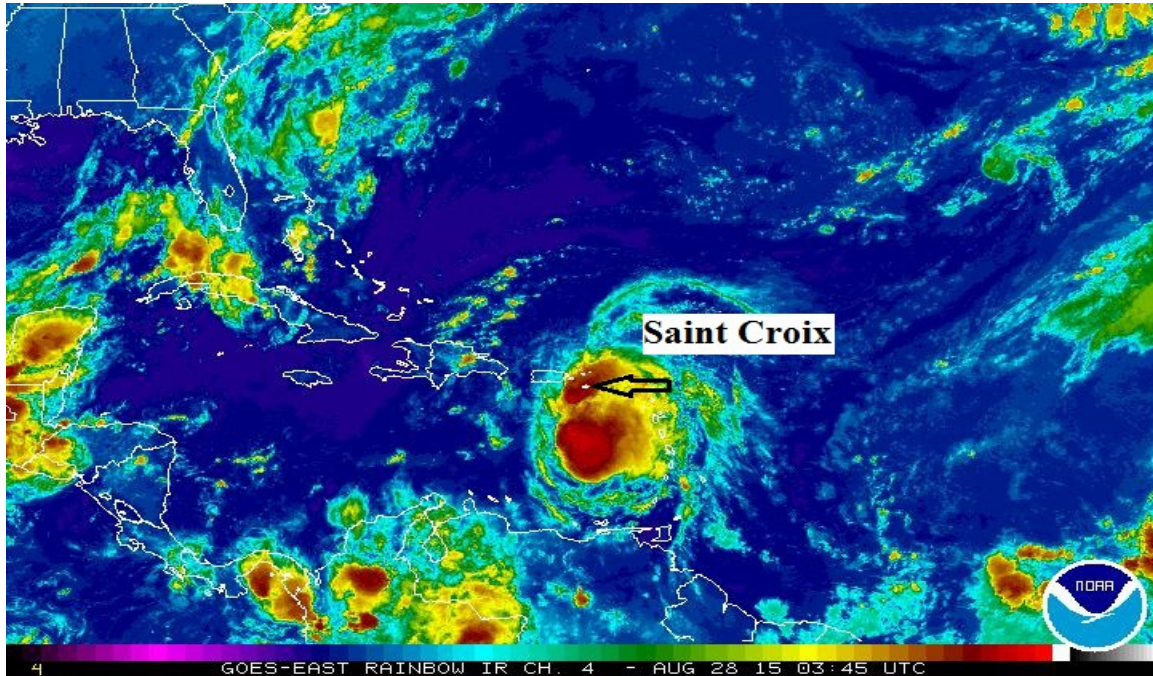


Fig. 11. Infra-red satellite image, August 27 at 1145 pm AST, showing convection flaring up over the U.S. Virgin Islands.

The next morning, Friday the 28th, the center of Erika and most of the thunderstorms remained south of Puerto Rico until it slipped westward towards Hispaniola (Fig. 12). Winds were still quite strong during the morning and measured wind gusts over southwestern Puerto Rico were in excess of 50 mph between 600 am and 900 am AST (Table 1).

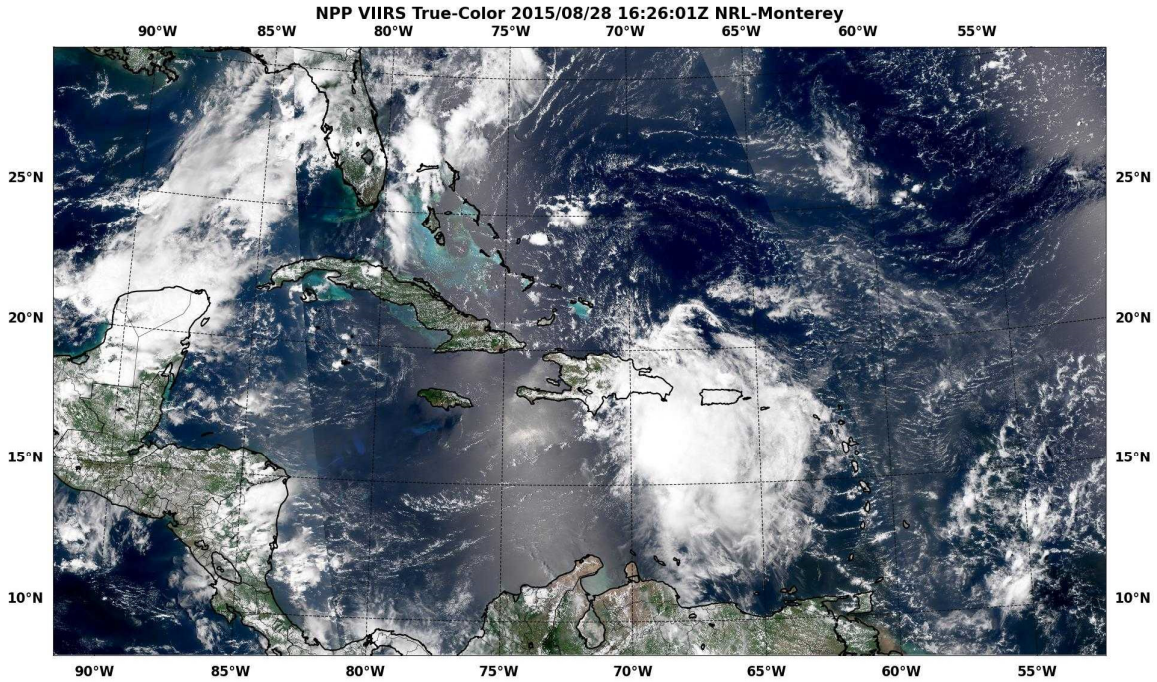


Fig. 12. Erika passing southwest of Puerto Rico in the Mona Passage, continuing westward on August 28th at 1226 pm AST.

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

The storm surge experienced from Erika was minimal, arriving as the highest winds arrived on the islands, less than one foot and little more than the tidal range (Fig. 13).

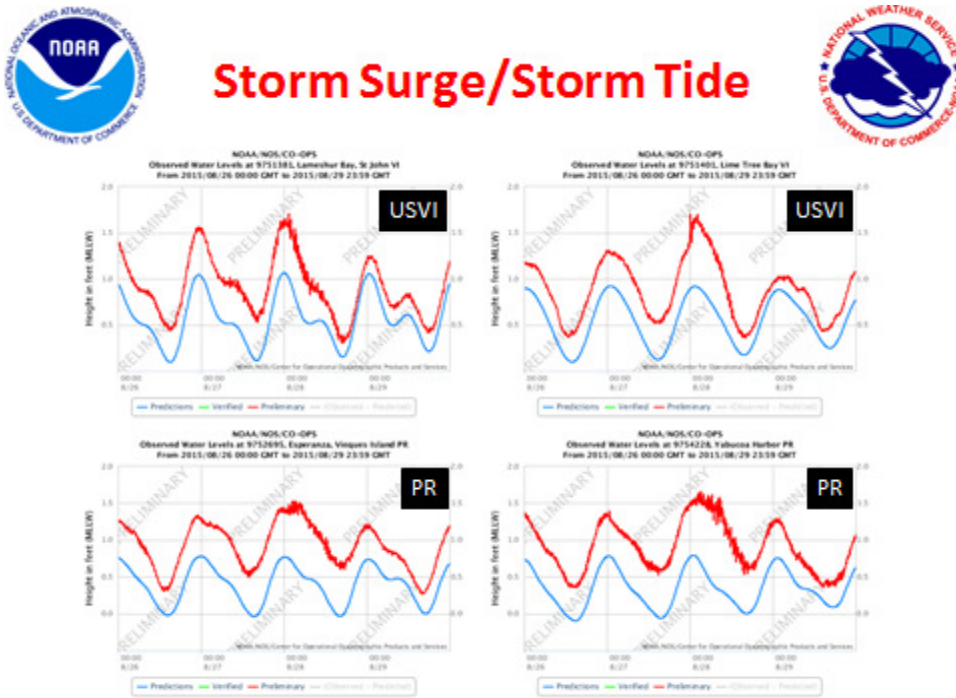


Fig. 13. Storm surge/tidal buoys at various locations.

The highest winds recorded while Erika was passing are shown in Table 1. Listed in chronological order, the highest overall winds were noted on and near St. Croix, mainly as the convection temporarily increased on the north side of the storm.

Highest verified sustained winds (and gusts) in mph, by station, date and time (AST) - (*) indicates winds occurred during previous hour		
# Buck Island, Saint Thomas	August 27 / 830 pm	54 (60)
% Buoy 41052, St. John	August 27 / 830 pm	36 (54)
Henry E. Rohlsen Airport, St. Croix	August 27 / 839 pm	46 (62)
# Sandy Point NWR, St. Croix	August 27 / 903 pm	56 (66)
* Cotton Valley (CVAV3), St. Croix	August 27 / 913 pm	* 30 (54)
% Buoy 41051, St. Thomas	August 27 / 920 pm	38 (47)
% Buoy 41056, Vieques	August 27 / 1000 pm	36 (51)
# Del Rey Marina, Puerto Rico	August 27 / 1005 pm	38 (46)
# Yabucoa-El Negro, Puerto Rico	August 27 / 1010 pm	46 (58)
* Vieques (VIEP4), Puerto Rico	August 27 / 1011 pm	* 23 (45)
# Savana Island, St. Thomas	August 27 / 1014 pm	40 (54)
San Juan Luis Munoz Marin Int'l Airport, PR	August 27 / 1025 pm	30 (41)
% Buoy 41053, San Juan, Puerto Rico	August 27 / 1030 pm	29 (40)
# San Juan NAVAID, Puerto Rico	August 27 / 1035 pm	34 (41)
# Two Brothers, St. Thomas-St. John	August 27 1106 pm	43 (56)
Cyril E. King Airport, St. Thomas	August 27 / 1151 pm	37 (48)
# Crown Mountain, St. Thomas	August 28 / 1230 am	28 (44)
* Camp Santiago (CSAP4), Puerto Rico	August 28 / 109 am	* 27 (47)
# Rupert Rock, St. Thomas	August 27 / 247 am	35 (45)
# Las Mareas, Puerto Rico	August 28 / 404 am	52 (58)
% Buoy 42085, near Ponce, Puerto Rico	August 28 / 520 am	40 (51)
# Club Deportivo Del Oeste, Puerto Rico	August 28 / 650 am	26 (40)
* Cabo Rojo (CRRP4), Puerto Rico	August 28 / 657 am	* 31 (54)
* Maricao (MAOP4), Puerto Rico	August 28 / 834 am	* 33 (61)

Table 1. Highest recorded sustained winds and (gusts) and times during passage of Erika across the USVI and Puerto Rico, listed in chronological order. If several occurrences then listed value is the first recorded. The times are for sustained winds but gusts may have occurred at a different time. (# courtesy of WeatherFlow.com) - (% courtesy of National Data Buoy Center) - (* courtesy of Bureau of Land Management and Dept. of Interior Fish & Wildlife Service, data occurred in previous hour indicated).

Tropical storm force winds (sustained 39 mph or more) were recorded on all of the major islands for the U.S. Virgin Islands and Puerto Rico, with the strongest across southern portions. In most instances the wind remained at storm force for no more than an hour or two.

Beneficial rainfall with no significant flooding was noted across much of the area including drought stricken areas of eastern and central parts of Puerto Rico, Vieques, and

over Saint Croix. An analysis of rainfall amounts (Fig. 14) shows average values of two to three inches over De La Plata, Carite, Cidra, Carraizo, and Patillas basins, helping replenish reservoirs there. It was less than the 4 to 8 inches expected as the heavier rains stayed farther south in the Caribbean Sea as Erika refused to move northwest. No river flooding was reported partly due to dry soils that were across the region.

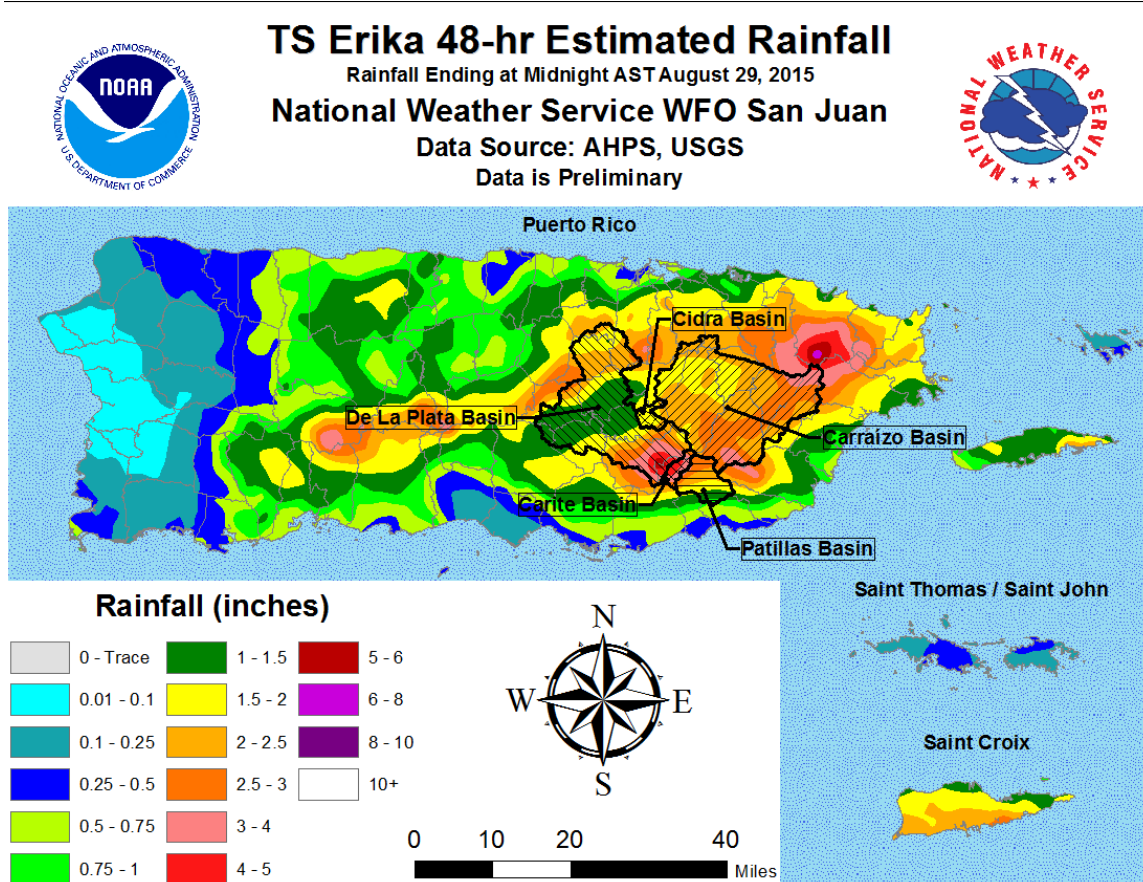


Fig. 14. Rainfall analysis estimate of rainfall for the period from midnight, August 27 to midnight, August 29, 2015.

c. Effect on Drought and Reservoirs

While Erika was not expected to be a “drought breaker” it was expected to help. Not as much widespread heavy rain occurred during the storm as was expected, however levels of water in reservoirs on Puerto Rico did begin to recover. Even heavier rains were a “near miss” with larger and more widespread thunderstorms occurring towards the south over the Caribbean Sea.

Figures 15 through 17 show hydrographs at the dam sites of three reservoirs in eastern Puerto Rico. For each site the larger graph shows a one week trend in the level, beginning just before the arrival of Erika. The smaller inset graph shows the long-term trend since January, along with the historical trend from last year and also from 1994, the last time water rationing was required on the island. While Erika did provide rises in reservoir levels, ranging from 2.5 feet at the dam site near Patillas to 10 feet at for the dam at Trujillo Alto, the insets show that these rises represent only progress and did not end the

drought (Fig. 18). While the trends in short term hydrographs look impressive the long term shows a different perspective.

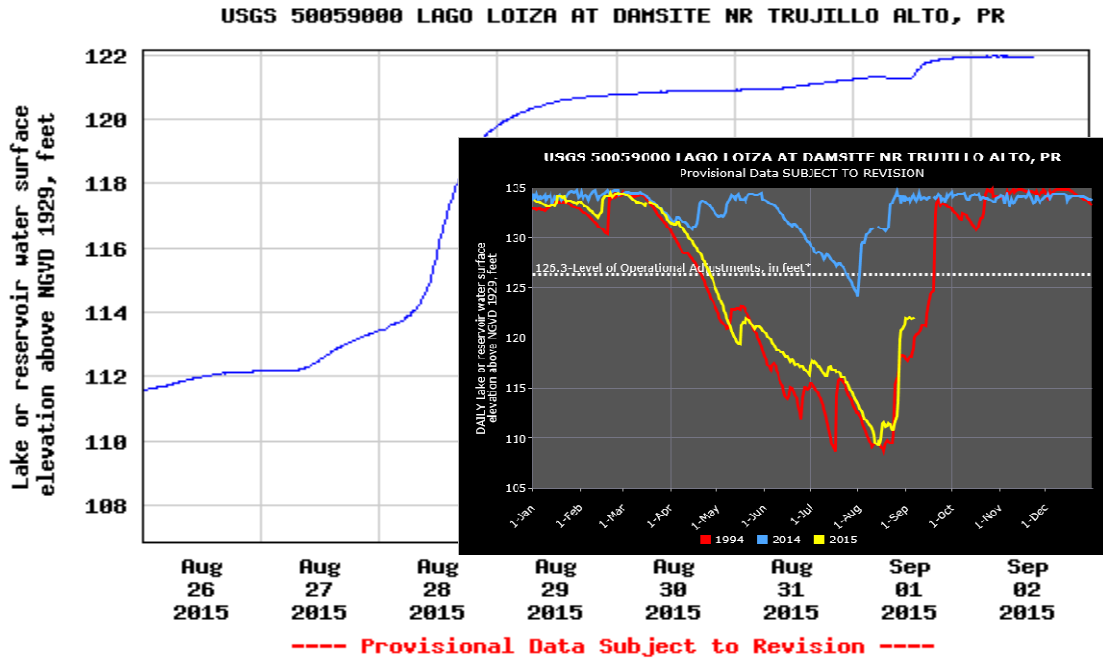


Figure 15. Lago Patillas at damsite near Patillas, Puerto Rico. Reservoir levels shown for the week from just before Erika and progress since the beginning of 2015. Yellow is the current year compared to 1994 (red) and in 2014 (blue).

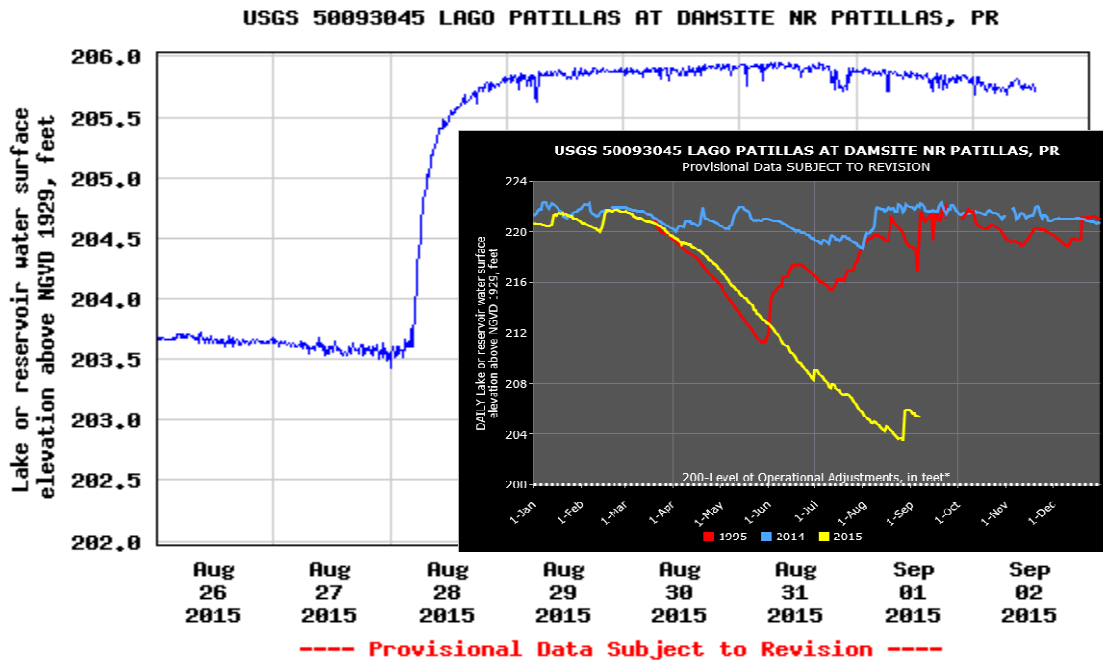


Figure 16. Lago Loiza at damsite near Trujillo Alto, Puerto Rico. Reservoir levels shown for the week from just before Erika and progress since the beginning of 2015. Yellow is the current year compared to 1994 (red) and in 2014 (blue).

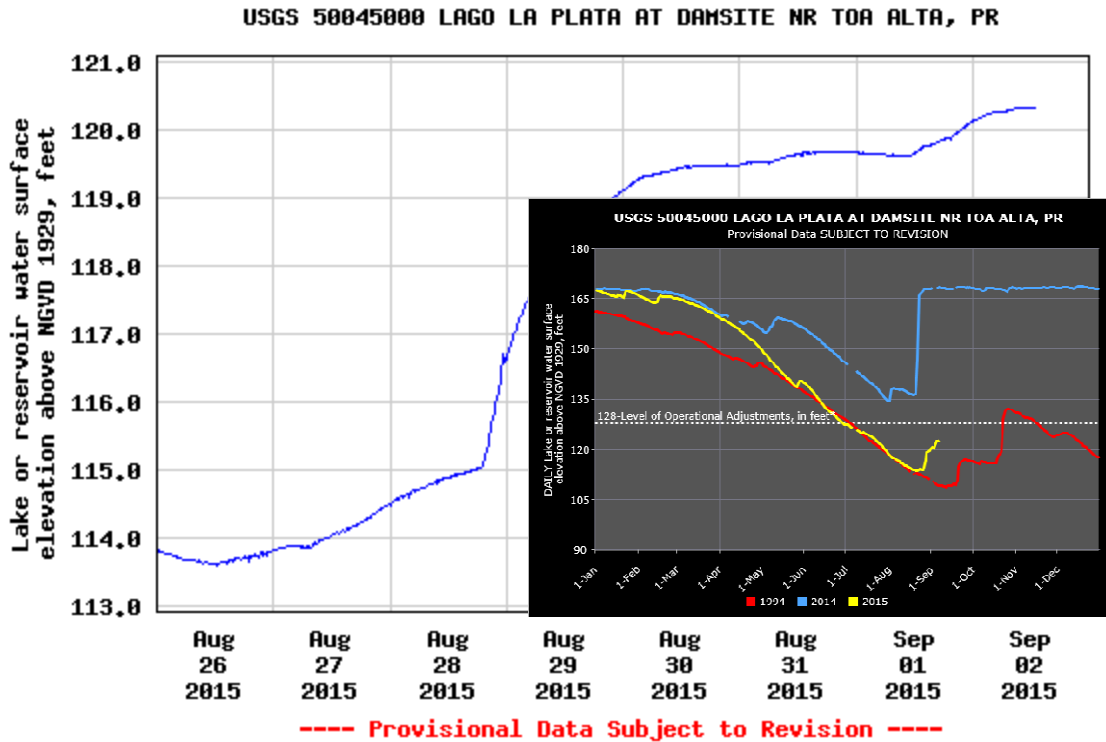
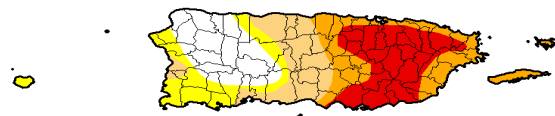


Figure 17. Lago La Plata at damsite near Toa Alta, Puerto Rico. Reservoir levels shown for the week from just before Erika and progress since the beginning of 2015. Yellow is the current year compared to 1994 (red) and in 2014 (blue).

Figure 18 (right). U.S. Drought Monitor for September 1, 2015 shows no change from the previous week (before Erika). Red in eastern Puerto Rico indicates a drought intensity of D3 (extreme drought) and orange is D2 (severe drought).



The National Drought Mitigation Center commented on their September 1st report that:

Puerto Rico received some rain recently from what were tropical storms Danny and Erika, but not as much as was hoped for. Lake levels (Carraizo and La Plata) did rise over the weekend, but the Puerto Rico Water Authority notes that water rationing continues. Generally, 1-3 inches (locally greater) of rain fell with Erika, which at least did not result in any significant flash flooding (<http://www.droughtmonitor.unl.edu/>).

d. Damage

Winds on Saint Croix caused downed light poles and power outages to approximately 11,000 customers from downed power lines. There were also downed trees and limbs (Fig. 19 through 21).



Fig. 19. Broken light pole at Turners Hole and Grass Point on Route #60, St. Croix.

Fig. 20. Downed trees at Royal Furniture, Centerline Road on Route #70, St. Croix.



Fig. 21. Broken tree limbs on Christiansted Cemetery wall, St. Croix.

Most damage from Erika in Puerto Rico occurred in the agricultural sector, with more than \$17 million mainly due to losses of plantains, bananas, and coffee (Fig 22). Otherwise the reported wind damage was relatively minor and similar to damage on St. Croix, mainly causing downed trees and power lines from high winds across the islands (Table 2).



Fig. 22. Damage to agricultural in Puerto Rico sector was estimated at more than \$17 million in crops (mainly plantains, bananas, and coffee).

e. Watches and Warnings

The tropical storm warnings issued (Tables 2 and 3) verified across all of the islands and during the period it was in place. A flash flood watch did not require upgrading to a warning for any location. No flood warnings were issued and no flooding was reported.

PR Municipality	Description	Lat/Lon
Lares	Zinc roof blown away at Barrio Bartolo in Palma Sola Sector	18.30, -66.88
Utua	Power lines and trees down at Road PR-605	18.27, -66.71
Comerio	Trees down at Road PR-778	18.22, -66.22
Aguas Buenas	Trees and power lines down in Fabian Morales sector	18.26, -66.11
Comerio	Trees down at Road PR-155	18.22, -66.22
Adjuntas	Trees down at Roads PR-123 and PR-135	18.17, -66.72
Cidra	Trees down at Barrio Rabanal in Almirante Sector	18.18, -66.16
Canovanas	Trees down at Road PR-66, KM 9.9	18.38, -65.91
Maricao and Puerto Rico	PREMA reported 36 houses with roof damage across western interior and southern slopes of PR municipalities	18.19, -66.98
San Juan and Puerto Rico	Several trees and power lines down. 250,000 people without power. Agricultural sector across PR estimated at \$17.37 million. Dozens of electrical power poles damaged.	18.41, -66.06
St. Croix	Power outages to approximately 11,000 customers, with downed light poles and power lines, and downed trees and limbs.	

Table 2. Wind damage reported on the night of August 27 or morning of August 28.

Type of Issuance	Location	Date/Time (AST)
Tropical Storm Watch issued	U.S. Virgin Islands, Culebra, Vieques, Puerto Rico	Aug. 25 / 1100 pm
Tropical Storm Warning issued	U.S. Virgin Islands, Culebra, Vieques, Puerto Rico	Aug. 26 / 500 am
Flash Flood Watch issued	U.S. Virgin Islands, Culebra, Vieques, Puerto Rico	Aug. 27 / 1103 am
Tropical Storm Warning ended	U.S. Virgin Islands	Aug. 28 / 1100 am
Flash Flood Watch Ended	U.S. Virgin Islands, Culebra, Vieques, Puerto Rico	Aug. 28 / 1159 am
Tropical Storm Warning ended	Culebra, Vieques, Puerto Rico	Aug. 28 / 200 pm

Table 3. Historical timeline of watches and warnings issued by NHC and the San Juan Weather Forecast Office.