Tropical Cyclone Report
Tropical Storm Emily
(AL052011)
2-7 August 2011

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Emily became a tropical storm in the eastern Caribbean Sea and degenerated into a tropical wave near the southwestern peninsula of Haiti. Emily then reformed in the northwestern Bahamas as a tropical storm.

a. Synoptic History

Emily formed from a tropical wave that emerged from the west coast of Africa on 25 July. The next day a broad and poorly defined cyclonic gyre formed in association with the wave over the eastern tropical Atlantic. On the south side of a mid-level ridge, the large cyclonic circulation moved west-northwestward at low latitudes and remained devoid of convection. Transient bursts of convection occurred within the circulation beginning on 28 July, but there was little change in the overall organization of the system. The convection became more concentrated on 30 July, but the circulation contained at least two centers that were several hundred miles apart. A more dominant low-level center developed on 1 August near a new convective burst that formed, and the new circulation gradually consolidated. As it passed through the Lesser Antilles, a large area of winds near tropical-storm force was already present in association with this new circulation center that was gradually becoming better defined. Air Force reconnaissance data indicate that a tropical storm formed around 0000 UTC 2 August about 30 n mi northwest of Martinique. The "best track" chart of the Emily'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].

Emily continued moving west-northwestward to the south of a mid-level subtropical ridge located over the central Atlantic and developed an irregularly shaped central dense overcast as it passed about 150 n mi south of Puerto Rico on 2 and 3 August. There was some increase in westerly shear by 3 August, and Emily did not strengthen as the low-level center of the cyclone became partially exposed to the west of the main convective mass that morning. A vigorous burst of thunderstorms developed east of the center early the next day while Emily was passing to the south of Hispaniola, and the aircraft data indicated that a low-level center reformed closer to the convection. Later on 4 August, the low-level center accelerated west-northwestward, leaving behind a mid-level cyclonic circulation within the convection that later moved inland over Hispaniola. Now lacking convective support, Emily's surface circulation degenerated into an open wave as it approached the southwestern tip of Haiti around 1800 UTC.

[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.

The mid-level remnants of Emily moved west-northwestward around the western periphery of a low- to mid-level ridge through the southern and central Bahamas on 5 August. Surface pressures began falling as this feature reached the western Bahamas early on 6 August, and surface observations indicated that a new low pressure center formed by 1200 UTC that day just north-northwest of Andros Island. The low turned northward as it reached the western extent of the subtropical ridge, and an Air Force Reserve Hurricane Hunter aircraft indicated that the system regenerated into a tropical depression around 1800 UTC as it was approaching the eastern end of Grand Bahamas Island. Emily then strengthened into a tropical storm 6 h later.

Northerly to northeasterly vertical wind shear over the cyclone inhibited further development, and displaced the strongest convection and winds south of the center while Emily moved through the northwestern Bahamas. The strong shear caused Emily to degenerate into a remnant low by 1200 UTC 7 August while centered about 230 n mi northeast of Grand Bahamas Island. This weakening occurred when it entered a region of increasing southwesterly vertical wind shear associated with a strengthening deep-layer southwesterly flow ahead of a shortwave trough moving through the western Atlantic. Emily then became an open trough around 0000 UTC 8 August and accelerated east-northeastward across the central Atlantic on 8 August, producing a large area of gale-force winds. Although the system briefly became better organized on 9 August when it began to slow down, its rapid forward motion and strong westerly wind shear prevented regeneration from occurring. The remnants re-acquired a closed circulation and turned north-northeastward ahead of a mid-latitude trough before dissipating shortly after 1200 UTC 11 August about 850 n mi west of the Azores.

b. Meteorological Statistics

Observations in Emily (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 Dvorak estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Observations also include flight-level, stepped frequency microwave radiometer (SFMR), and dropwindsonde observations from eight 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 Sounder Unit (AMSU) intensity estimates from CIMSS, the NASA Tropical Rainfall Measuring Mission (TRMM) and Aqua, the European Space Agency's ASCAT, and Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in constructing the best track of Emily.

The estimated peak intensity of 45-kt between 0000 UTC 3 August and 0000 UTC 4 August is based on numerous SFMR values of 42-44 kt and maximum flight-level winds between 45 and 50 kt during the same time period.

Ship reports of winds of tropical storm force associated with Emily are listed in Table 2, and selected surface observations from land stations and data buoys are shown in Table 3.

Heavy rains associated with Emily occurred over portions of the Lesser Antilles. Martinique recorded a total of 5.9 inches (150 mm). Although the center of Emily remained south of the U.S./British Virgin Islands, Puerto Rico and Hispaniola, heavy rains, high winds, and rough surf affected these areas. The largest rainfall totals in Puerto Rico were generally over the eastern part of the island, with Caguas reporting the largest amount of 8.22 inches (209 mm). An unofficial rainfall total of 21 inches (528 mm) was reported in Neiba in the Dominican Republic. Although no sustained tropical-storm-force winds were observed throughout this region, wind gusts in some of the passing bands were of tropical storm strength (e.g., a gust to 52 mph were observed at Buck Island in the British Virgin Islands)

Heavy rains and gusty winds also likely affected portions of the Bahamas as Emily regenerated on 5-6 August. There are no official rainfall measurements or surface observations.

c. Casualty and Damage Statistics

Press reports indicate that Emily was directly responsible for three direct deaths due to the heavy rains and subsequent flooding in the Dominican Republic. Heavy rains also caused several rivers to overflow their banks in Hispaniola. Three hundred homes were reportedly damaged in Haiti, but damage elsewhere on the island was light.

Floods caused several large landslides near the capital of Martinique, but damage was minor. There was one indirect death attributed to Emily in Martinique when a man was electrocuted by an exposed wire in his flooded home.

Heavy rains caused the overflow of three rivers in Puerto Rico. The flooding resulted in the closure of several of the main roadways on the island, and associated landslides made other roads on the island impassable. News reports also indicate minor flooding to some homes in Ceiba, as well as minor agricultural losses.

d. Forecast and Warning Critique

The initial genesis of Emily was generally well forecast. The disturbance from which Emily formed was introduced with a ‘low’ chance of development 96 h prior to genesis. The likelihood of tropical cyclone formation was increased to a ‘medium’ and then a ‘high’ chance 90 h and 42 h before genesis, respectively. The reformation of Emily was also well anticipated. The remnants of Emily were included in the Tropical Weather Outlook with a ‘high’ chance of development immediately after the cyclone degenerated into an open trough on 4 August, about 48 h before it regenerated.

A verification of NHC official track forecasts for Emily is given in Table 4a. Official forecast track errors were larger than the mean official errors for the previous 5-yr period through 48 h. The official errors were smaller than the 5-year mean after that time, but the sample size is too small to draw any meaningful conclusions. The climatology and persistence model (OCD5) errors were generally higher than their 5-yr mean at all times, indicating that predicting the track of Emily was more difficult than average at those time ranges. A homogeneous comparison of the official track errors with selected guidance models is given in Table 4b. It should be noted that the homogeneity requirement was relaxed in this case, as most of the models had limited availability for Emily. In general, the BAMS and BAMM models performed well and beat the official forecast through 24 h. Beyond 24 h there were too few cases to make any substantive comparison.

A verification of NHC official intensity forecasts for Emily is given in Table 5a. Short-term forecasts early in the lifecycle of Emily correctly anticipated little strengthening of the cyclone in the Caribbean Sea due to its potential interaction with Hispaniola as well as the presence of enhanced vertical wind shear and dry air in the middle to upper troposphere in the storm environment. As a result, official forecast intensity errors were lower than the mean official errors for the previous 5-yr period through 48 h. Official forecast errors were higher than the 5-yr averages from 72-120 h because of forecasts that over-predicted Emily's intensity near the southeast U.S. coast. They also failed to predict Emily's degeneration to a remnant low northeast of the Bahamas. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 5b. Despite some of the inadequacies of the official forecast, only the FSSE consistently outperformed through 96 h.

Watches and warnings associated with Emily are given in Table 6.

Table 1. Best track for Tropical Storm Emily, 2 – 7 August 2011. Positions and pressures given during the wave stage are representative values for the low-level vorticity center.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
02 / 0000	14.9	61.4	1007	35	tropical storm
02 / 0600	15.1	62.5	1007	35	"
02 / 1200	15.4	63.6	1006	35	"
02 / 1800	15.7	64.8	1005	40	"
03 / 0000	16.0	66.2	1004	45	"
03 / 0600	16.3	67.7	1003	45	"
03 / 1200	16.6	69.1	1003	45	"
03 / 1800	16.8	70.3	1003	45	"
04 / 0000	16.9	70.7	1003	45	"
04 / 0600	16.9	71.3	1004	40	"
04 / 1200	17.3	72.2	1006	40	"
04 / 1800	17.9	73.4	1009	30	tropical wave
05 / 0000	18.8	74.6	1010	25	"
05 / 0600	19.8	75.5	1011	25	"
05 / 1200	21.0	76.3	1011	25	"
05 / 1800	22.4	76.9	1012	25	"
06 / 0000	23.6	77.4	1012	25	"
06 / 0600	24.6	77.9	1012	25	"
06 / 1200	25.6	78.1	1011	25	low
06 / 1800	26.4	78.2	1011	30	tropical depression
07 / 0000	27.2	78.1	1010	35	tropical storm
07 / 0600	28.4	77.4	1009	35	"
07 / 1200	29.7	76.4	1009	30	low
07 / 1800	30.7	74.8	1009	30	"
08 / 0000					dissipated
03 / 0000	16.0	66.2	1005	45	maximum wind
03 / 0600	16.3	67.7	1003	45	minimum pressure

Table 2. Selected ship reports with winds of at least 34 kt for Tropical Storm Emily, 2-7 August 2011.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
04 / 0600	DQVK	17.8	70.6	080 / 35	1009.0
05 / 1800	KS088	19.7	77.1	210 / 39	1012.5
08 / 0400	CHLV2	36.9	75.7	310 / 35	1006.2
08 / 1400	HPHV	39.9	62.9	160 / 35	1005.0

Table 3. Selected surface observations for Tropical Storm Emily, 2-7 August 2011.

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)			
Martinique								
Le Raizet (TFFR)	01/2200	1007.1	01/2200	23	29			5.9
St. Thomas								
Buck Island			02/1850		45			
Puerto Rico								
Río Guayanilla (GYAP4)								5.09
Patillas (PATP4)								5.17
Quebrada Arenas (SLMP4)								5.27
Lago Loco (LOCP4)								5.65
Yabucoa (YBUP4)								5.68
Bairoa Arriba (BZBP4)								6.05
Río Cayaguas (SLKP4)								6.11
Río Cagitas (CAMP4)								6.21
Lago Luchetti (LLUP4)								6.25
Bisley Met Station near Río Grande (MSCP4)								6.34
Bo Marín near Patillas (PARP4)								6.86
Quebrada Guaba near Naguabo (NGHP4)								6.98
Caguas								8.22
Dominican Republic								

La Neiba								21.00
Bermuda								
Hamilton	08/1300	1009.2	08/1500	32	38			
Marine Observations								
Buoy 42060 16.3N 63.5W	02/0957	1008.1	02/1831	33[e]	41			
Buoy 42059 15.1N 67.5W	03/0813	1005.8	03/1024	35[e]	43			
Buoy 41043 21.1N 65.0W	03/0750	1013.2	03/0935	31[e]	35			
Caricoos Buoy 42085 (Ponce, PR) 17.9N 66.5W	03/0720	1008.4	03/0900	25[e]	35			
Buoy 41048 32.0N 69.6W	08/0800	1006.6	08/0800	43				
Buoy 44905 33.5N 60.1W	08/2200	1005.4						
Buoy 41912 33.1N 57.0W	09/0600	1006.1						
Ship ELPP9	09/1200	1003.0						
Buoy 44943 36.4W 52.8W	09/1800	1003.7						
Buoy 41591 36.4N 47.2W	10/1100	1006.5						

[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] Anenometer height is 5 m.

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Emily, 2-7 August 2011. Mean errors for the 5-yr period 2006-10 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 (Emily)	51.7	86.5	91.6	127.8	**49.1**	**116.1**	**134.7**
OCD5 (Emily)	59.0	88.3	87.8	154.7	370.6	278.6	414.1
Forecasts	10	7	5	3	3	3	2
OFCL (2006-10)	31.0	50.6	69.9	89.5	133.2	174.2	214.8
OCD5 (2006-10)	47.7	98.3	156.4	218.1	323.3	402.2	476.1

Table 4b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Tropical Storm Emily, 2-7 August 2011. 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	47.4	96.2	37.8	111.7		112.0	
OCD5	**38.1**	**70.1**	**23.7**	**34.6**		345.0	
GFSI	60.8	105.5	47.9	**36.0**		**96.6**	
GHMI	66.5	124.4	84.8	171.4		156.1	
HWFI	50.7	96.8	70.8	171.4		237.8	
EGRI	80.6	132.4	106.3	193.8		338.8	
EMXI	59.5	122.4	90.6	**62.4**		**81.2**	
CMCI	65.2	**81.2**	47.8	137.7		262.7	
AEMI	70.8	121.8	62.7	**92.5**		**84.8**	
FSSE	57.6	108.9	**30.5**	**98.5**		134.6	
TVCA	57.9	109.0	**29.5**	**79.9**		101.6	
TVCE	56.9	112.9	**29.5**	**79.9**		109.4	
TVCC	55.9	108.4	**25.9**	**72.9**		**89.1**	
LBAR	49.6	97.9	109.8	173.7		**99.6**	
BAMS	58.2	**91.5**	78.2	120.8		481.6	
BAMM	**43.5**	**65.0**	78.7	101.9		334.2	
BAMD	45.9	**76.2**	116.7	161.2		427.0	
Forecasts	5	3	1	1		1	

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Emily, 2-7 August 2011. Mean errors for the 5-yr period 2006-10 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 (Emily)	**2.0**	**4.3**	**7.0**	**6.7**	21.7	21.7	27.5
OCD5 (Emily)	3.8	6.7	7.6	6.7	19.7	4.0	38.5
Forecasts	10	7	5	3	3	3	2
OFCL (2006-10)	7.2	11.0	13.2	15.1	17.2	17.9	18.7
OCD5 (2006-10)	8.5	12.3	15.4	17.8	20.2	21.9	21.7

Table 5b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Tropical Storm Emily, 2-7 August 2011. 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	1.7	4.3	7.0	6.7	21.7	21.7	25.0
GHMI	3.7	5.0	**4.2**	7.3	47.7	45.7	29.0
HWFI	7.0	7.6	8.4	**5.7**	39.0	20.7	**19.0**
DSHP	3.6	7.4	7.6	6.7	27.0	25.7	**16.0**
LGEM	3.3	6.1	**4.0**	**5.7**	29.7	35.7	32.0
FSSE	3.1	**4.1**	**3.8**	**4.0**	**19.0**	**19.7**	**9.0**
ICON	3.8	**3.4**	**3.2**	**3.3**	36.0	32.3	**24.0**
IVCN	3.6	**3.4**	**3.2**	**3.3**	31.7	34.3	**24.0**
Forecasts	9	7	5	3	3	3	1

Table 6. Watch and warning summary for Tropical Storm Emily, 2-7 August 2011.

Date/Time (UTC)	Action	Location
2 / 0000	Tropical Storm Watch issued	U.S. Virgin Islands/St. Kitts/Nevis/Montserrat/Antigua
2 / 0000	Tropical Storm Watch issued	Dominican Republic to Haiti
2 / 0000	Tropical Storm Warning issued	Dominica
2 / 0000	Tropical Storm Warning issued	Guadeloupe
2 / 0000	Tropical Storm Warning issued	Puerto Rico
2 / 0300	Tropical Storm Watch changed to Tropical Storm Warning	Dominican Republic
2 / 0300	Tropical Storm Watch issued	Haiti
2 / 0600	Tropical Storm Warning discontinued	Dominica
2 / 1200	Tropical Storm Watch discontinued	U.S. Virgin Islands/St. Kitts/Nevis/Montserrat/Antigua
2 / 1200	Tropical Storm Watch issued	U.S. Virgin Islands
2 / 1500	Tropical Storm Watch changed to Tropical Storm Warning	Haiti
2 / 1500	Tropical Storm Warning discontinued	Guadeloupe
2 / 2100	Tropical Storm Watch issued	Southeastern Bahamas/Turks and Caicos Is.
3 / 0300	Tropical Storm Watch changed to Tropical Storm Warning	Southeastern Bahamas/Turks and Caicos Is.
3 / 0900	Tropical Storm Watch discontinued	All

3 / 1200	Tropical Storm Watch issued	Central Bahamas
3 / 1500	Tropical Storm Warning discontinued	Puerto Rico
3 / 1500	Tropical Storm Warning issued	Guantanamo to Holguin
3 / 2100	Tropical Storm Watch discontinued	Central Bahamas
3 / 2100	Tropical Storm Watch issued	Northwestern Bahamas
3 / 2100	Tropical Storm Warning discontinued	Southeastern Bahamas/Turks and Caicos Is.
3 / 2100	Tropical Storm Warning issued	Central and Southeastern Bahamas and Turks and Caicos Is
4 / 0000	Tropical Storm Warning discontinued	Dominican Republic
4 / 0000	Tropical Storm Warning issued	Cabo Engano to the southern border of the Dominican Republic/Haiti
4 / 0000	Tropical Storm Warning issued	Cabo Francis Viejo to northern border of Dominican Republic/Haitian
4 / 1800	Tropical Storm Warning modified to	Santo Domingo to the southern border between the Dominican Republic/Haiti
4 / 1800	Tropical Storm Warning discontinued	Cabo Francis Viejo to northern border between the Dominican Republic/Haiti
4 / 2100	Tropical Storm Watch discontinued	All
4 / 2100	Tropical Storm Warning discontinued	All

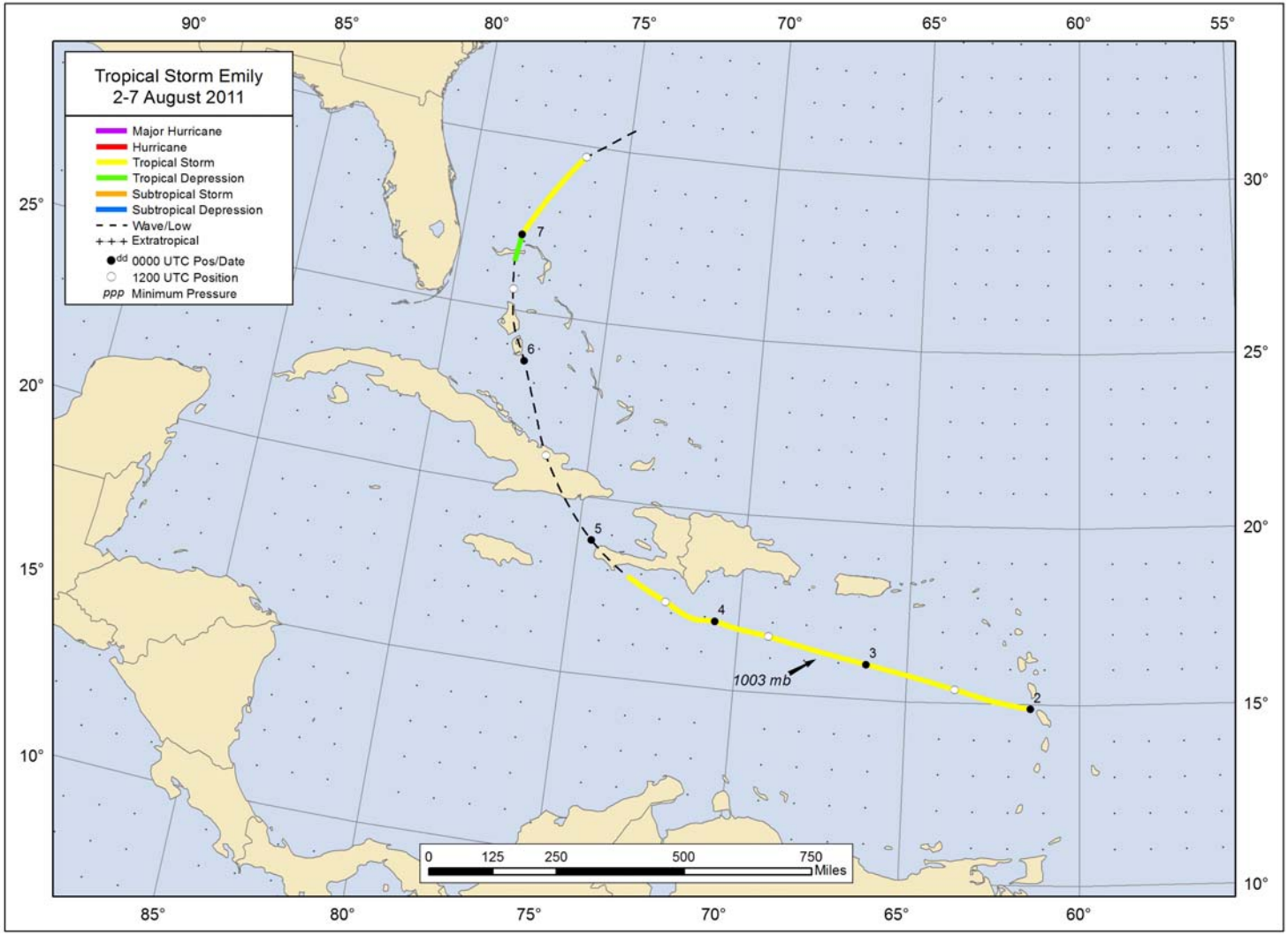

Figure 1. Best track positions for Tropical Storm Emily, 2-7 August 2011.

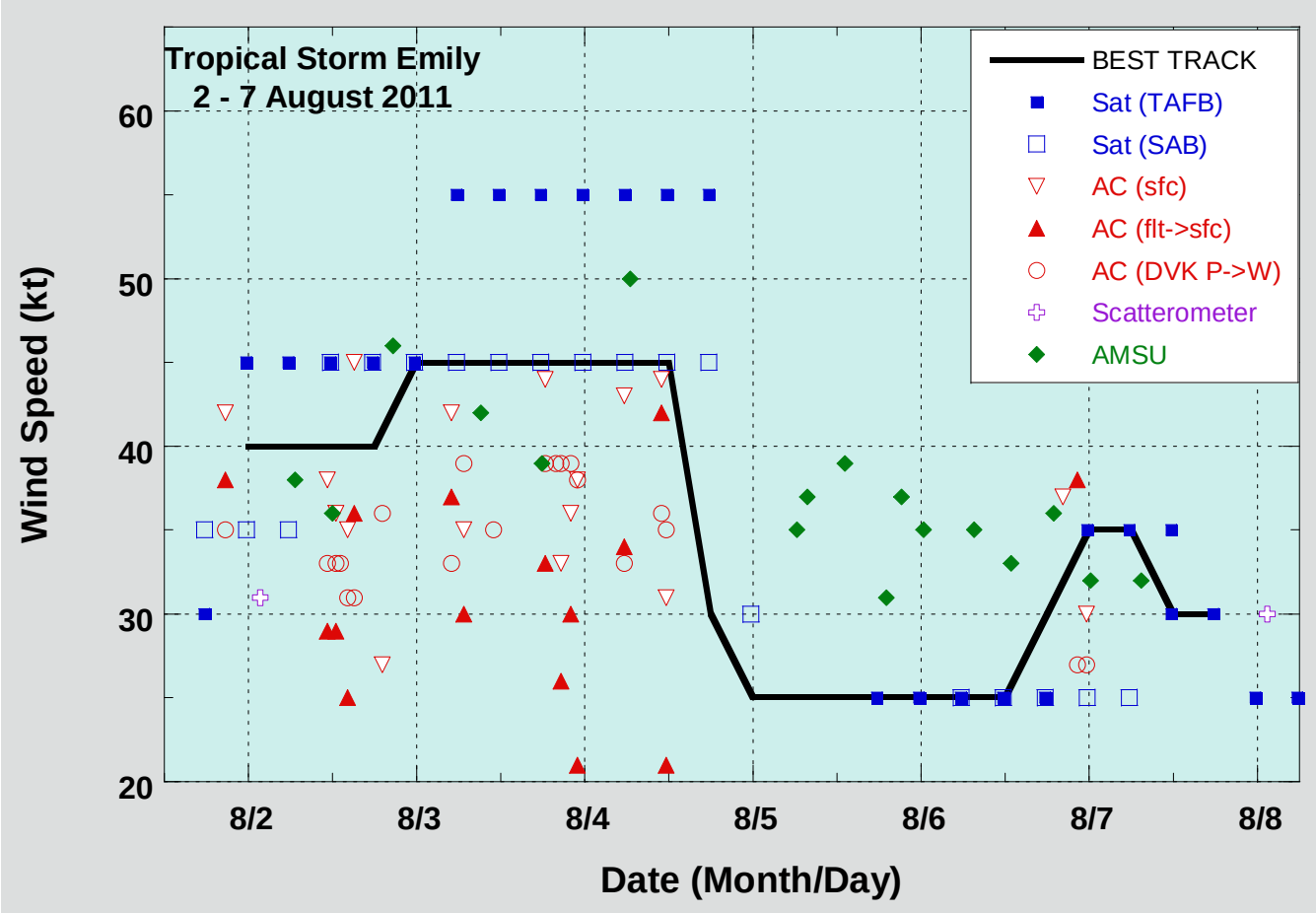

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Emily, 2-7 August 2011. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% adjustment factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC.

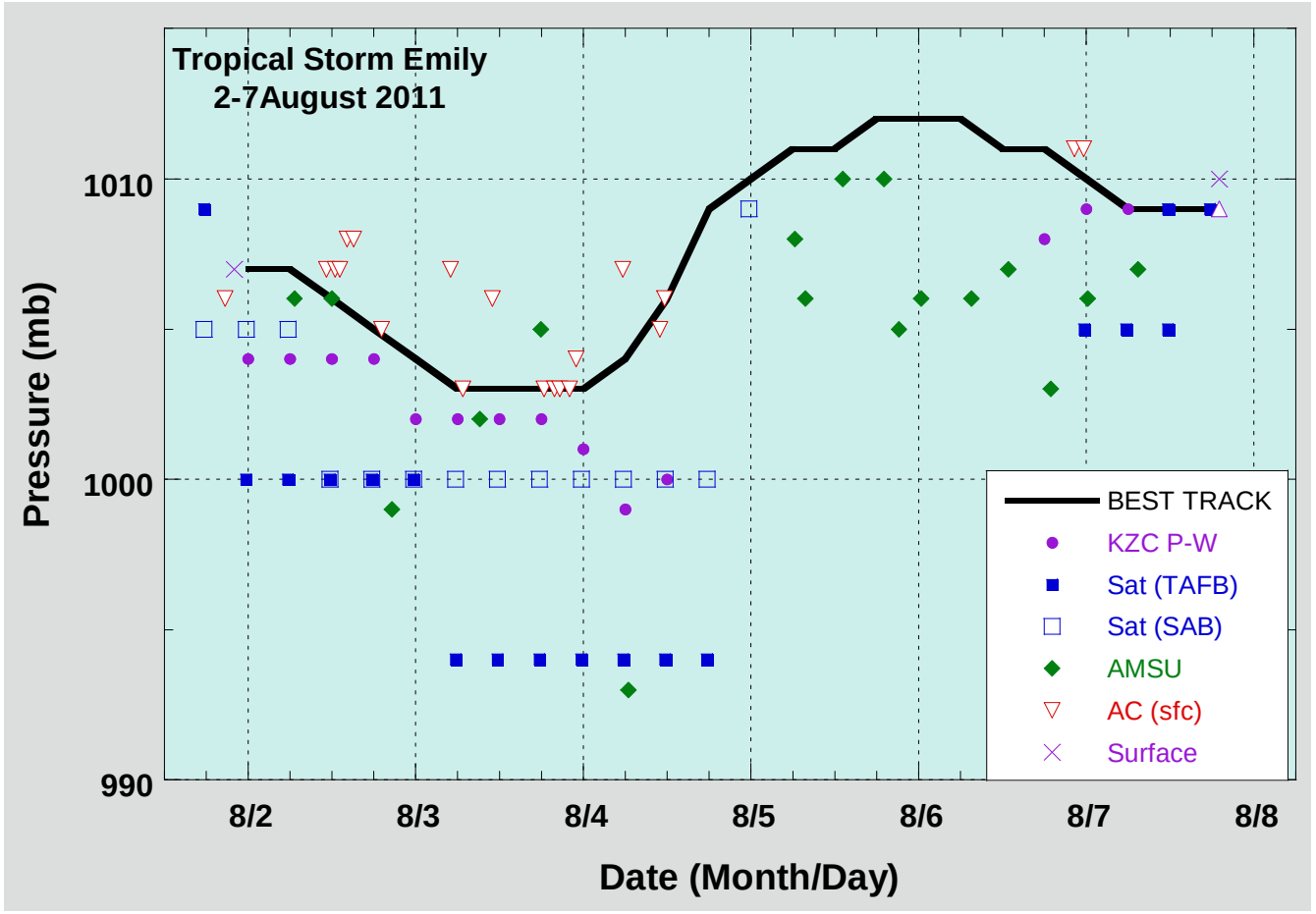

Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Emily, 2-7 August 2011. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. The KZC P-W values are obtained by applying the Knaff-Zehr-Courtney pressure-wind relationship to the best track wind data. Dashed vertical lines correspond to 0000 UTC.

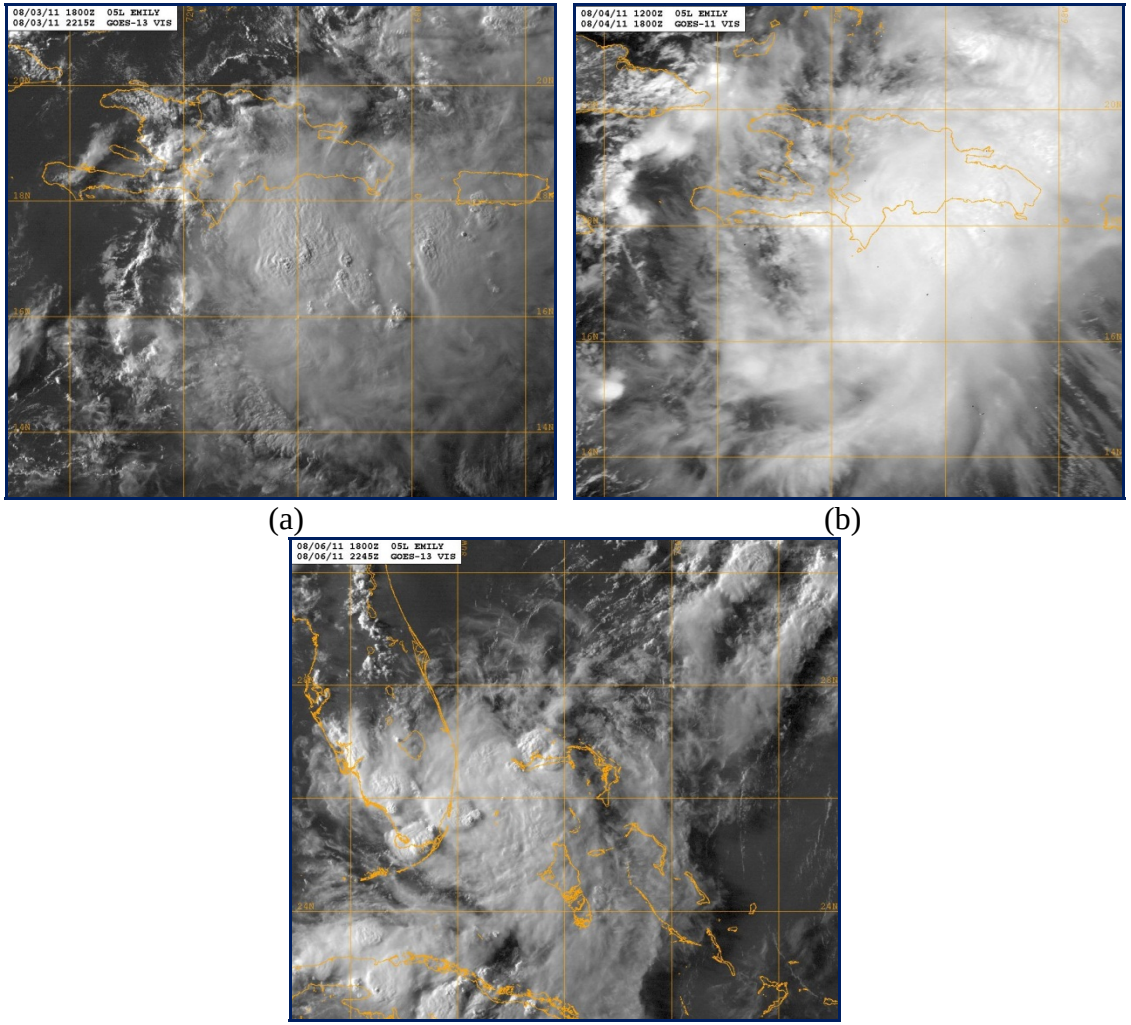

Figure 4. Geostationary satellite images of Emily, 2-7 August 2011 at, (a) peak intensity at 2215 UTC 3 August, (b) its first dissipation around 1800 UTC 4 August, (c) its regeneration as a tropical cyclone at 2245 UTC 6 August. Images courtesy of the United States Naval Research Laboratory.