NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE EARL

(AL052016)

2 – 6 August 2016

Stacy R. Stewart
National Hurricane Center
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2245 UTC 3 AUGUST 2016 VIIRS VISIBLE IMAGE WHEN EARL WAS NEAR PEAK INTENSITY AS IT APPROACHED BELIZE. (IMAGE COURTESY OF NAVAL RESEARCH LABORATORY, MONTEREY, CA)

Earl was a category 1 hurricane (on the Saffir-Simpson Hurricane Wind Scale) that made landfall in Belize and crossed Guatemala and southern Mexico. Earl caused considerable wind damage and storm surge flooding in Belize, and produced very heavy rainfall across much of Central America, as well as eastern and southern Mexico, resulting in widespread flooding and mudslides. Earl was responsible for 81 direct deaths in Mexico. After moving westward across Mexico, Earl's remnants helped trigger the development of Tropical Storm Javier in the eastern North Pacific basin.

Hurricane Earl

2 – 6 AUGUST 2016

SYNOPTIC HISTORY

The tropical wave that led to the formation of Earl moved off of the west coast of Africa on 26 July. The disturbance moved rapidly westward across the tropical Atlantic at speeds of 25-30 kt for the next several days, producing limited deep convection until it reached the Lesser Antilles on 30 July. As the wave moved across the eastern and central Caribbean Sea on 31 July-1 August, the system's forward speed slowed to 20-25 kt and easterly 850−200-mb vertical wind shear decreased to 5-10 kt, which allowed the associated thunderstorm activity to increase and become better organized along the wave axis. On 1 August, ship reports and scatterometer surface wind data indicated that tropical-storm-force winds were already occurring in the northern and eastern portions of the fast-moving disturbance. Early on 2 August, a strong burst of deep convection developed along the wave axis and persisted through 1200 UTC, which likely contributed to the development of a small low pressure area and the spin-up of a well-defined low-level circulation center; an Air Force Reserve reconnaissance aircraft found a closed circulation and 40-kt winds around 1400 UTC. Based on the well-defined structure of the low noted in the aircraft wind data and in earlier microwave satellite imagery (not shown), it is estimated that a tropical storm formed around 0600 UTC 2 August when the system was located about 100 n mi south of Jamaica. 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.

Tropical Storm Earl moved in a general west-northwestward direction for the next three days along the southern periphery of a strong deep-layer ridge that extended from the central Atlantic Ocean westward across Florida, the Gulf of Mexico, and into mainland Mexico. Under the influence of light shear and 30^{O}C waters, the tropical cyclone steadily intensified, exhibiting a well-defined low- to mid-level eye (Fig.4), and becoming a hurricane around 1800 UTC 3 August. Reconnaissance data indicate that Earl reached its peak intensity of 75 kt by 0400 UTC 4 August, just before the hurricane made landfall on the Belize island of Turnleffe Caye (Fig. 5).

Earl made a second landfall 2 h later along the coast of Belize just south of Belize City, also with an intensity of 75 kt. Earl weakened to a tropical storm 6 h later when it was located over extreme northeastern Guatemala, and it maintained tropical storm status while it moved slowly west-northwestward across southeastern Mexico and into the southern Bay of Campeche. After Earl moved back over water, reconnaissance wind data indicated the cyclone had re-strengthened to an intensity of 50 kt before the tropical cyclone made its third and final landfall around 0230 UTC 6 August, along the eastern coast of mainland Mexico to the southeast of Veracruz near Salinas.

While under the influence of the strong ridge to its north, Earl moved inland and encountered the rugged terrain of central Mexico, quickly weakening to a tropical depression by

1200 UTC and dissipating 6 h later near Mexico City. Earl's remnants turned westward and moved across central Mexico and emerged over the eastern North Pacific Ocean a few days later, triggering the formation of Tropical Storm Javier in that basin.

METEOROLOGICAL STATISTICS

Observations in Earl (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, stepped frequency microwave radiometer (SFMR), and dropwindsonde observations from four flights made by the 53rd Weather Reconnaissance Squadron (53WRS) of the U. S. Air Force Reserve Command and from three flights conducted by NOAA/AOC "Hurricane Hunter" reconnaissance aircraft; those flights yielded a total of 24 center fixes (16 from the 53WRS and 8 from the NOAA/AOC). Data and imagery from NOAA polar-orbiting satellites, including the Advanced Microwave Sounding Unit (AMSU), the NASA Global Precipitation Mission (GPM), 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 Earl.

Ship and buoy reports of winds of tropical storm force associated with Hurricane Earl are given in Table 3, and selected surface observations from inland and coastal stations are given in Table 4.

Winds and Pressure

Earl's estimated peak intensity of 75 kt at 0400 UTC 4 August is based on SFMR-measured surface winds of 77 kt at 0257 UTC and a 700-mb flight-level wind of 85 kt at 0440 UTC. A peak wind of 63 kt and a gust of 90 kt were measured at Xcalak in Quintana Roo state in the Yucatan Peninsula of Mexico.

The estimated minimum central pressure of 979 mb is based on a dropwindsonde surface pressure measurement of 980 mb at 0432 UTC, which was accompanied by a surface wind of 11 kt. A storm chaser in Belize City, positioned several nautical miles northeast of the landfall point, measured a minimum pressure of 982.2 mb in the northern edge of the eye at 0510 UTC 4 August, which corroborates the minimum pressure of 979 mb measured earlier by an Air Force Reserve Unit reconnaissance aircraft.

Rainfall

The highest recorded rainfall totals occurred along and just north of Earl's track (Fig. 6) through the Mexican state of Veracruz, where amounts in excess of 7 inches were common. In Martinez de la Torre, 7.72 inches of rainfall was measured, which was the highest recorded rainfall total. Other rainfall observations include, 7.44 inches in El Raudal and 7.31 inches in Libertad. Rainfall amounts of up to 2 inches were reported across southern Mexico and the Yucatan peninsula. Significant rain-induced flooding and mudslides occurred across much of Belize and

northern and central Guatemala. Storm-total rainfall of more than 5 inches was measured at the Philip S. W. Goldson International Airport (MZBZ) in Belize City, Belize, and amounts near 5 inches were measured around Lake Petén Itzá in northern Guatemala (Fig. 7).

Prior to genesis, when Earl's pre-cursor disturbance was centered south of Hispaniola, 4.13 inches of rain was measured in a 24-h period ending on 1 August at La Romana International Airport (ICAO identifer: MDLR), located on the southeastern coast of the Dominican Republic.

Storm Surge

Storm surge heights reached 4-6 ft along and just north of where Earl made landfall on Turnleffe Caye and also along the coast of Belize; a storm chaser in Belize City reported surge values of 5-6 ft. Farther north, lower surge heights of up to 4 ft occurred across portions of the southern Yucatan peninsula. In the Mexican state of Veracruz where Earl made its third landfall, storm surge heights were generally only 1-2 ft.

CASUALTY AND DAMAGE STATISTICS

Earl was responsible for 81 direct deaths, all occurring in Mexico. An additional 13 deaths were reported in the Dominican Republic when Earl's precursor disturbance passed over that country. Media reports and information from emergency management agencies indicate that torrential rains and strong winds associated with Hurricane Earl caused considerable damage across portions of the northern Caribbean Islands, Central America, and Mexico.

Dominican Republic

The northern portion of Earl's precursor disturbance passed over Hispaniola on 1 August, producing strong gusty winds and heavy rainfall that caused flooding and mudslides across parts of the Dominican Republic. Gusty winds knocked a power line onto a bus in Nagua, causing a fire that killed 6 people and injured 12 others who were returning from a beach excursion. Rough surf and large waves generated by Earl caused a boat loaded with nine passengers to capsize in Samaná Bay; seven people drowned, but the boat captain and a woman were rescued.

Haiti

In the Cité Soleil community, heavy rains caused rivers and canals to overflow, filling them with water, garbage, and human waste. As many as 6,000 families were affected by the contaminated waters.

Jamaica

Heavy rains produced flooding in parts of Montego Bay, Jamaica, causing considerable disruption to commercial activities. Numerous cars were reported submerged in the flood waters.

Honduras

The combination of gusty winds and heavy rains knocked down trees and utility lines on the Bay Islands of Honduras, including Roatan, were the airport there was forced to close. Honduran officials reported a lobster fishing boat had capsized after being struck by a large wave. Most of the 83 people on board were rescued, but the navy was looking for 2 people who were missing. Heavy rainfall of more than 5 inches fell across northern Honduras, causing flooding that damaged three homes in Cortés Department. One person was injured in San Pedro Sula.

Guatemala

Earl produced almost 7 inches of rainfall across northern Guatemala in Melchor de Mencos. In Flores, the capital of Petén Department, rainfall amounts of 5-6 inches caused the water level of the Chixoy River to reach a depth of 11 ft. The heavy rains along with tropical-storm-force wind gusts also knocked out two main power lines in the city, leaving more than 6,300 people without power. In Melchor de Mencos, flooding and mudslides knocked down numerous trees and swelled rivers, a powerful combination that destroyed a bridge in the township. The flooding damaged at least 160 homes and 1,250 acres of crops, with 200 farms suffering total losses. At least 500 people were left homeless across Guatemala.

Belize

Significant storm surge, accompanied by freshwater runoff caused by 9–12 inches of rainfall, caused coastal flooding across central and northern Belize, including Ambergris Caye, Turneffe Caye, and other offshore islands. In San Pedro Town located on the southern end of Ambergris Caye, the hurricane damaged many tourist-related businesses, such as docks and scuba shops.

On the mainland, nearly 80% of the houses in Belize City were flooded, causing the displacement of more than 1,000 people, which created overcrowding conditions in 13 shelters. Flooding in the city damaged many houses made primarily of wood. The Belize City Emergency Management Organization and the Belize Defense Force conducted more than 100 search and rescue operations. All power and some communications went down during the hurricane, which made it difficult to relay the city's conditions to the outside world. In the Cayo District, flash flooding forced numerous residents to evacuate their homes. High water levels continued in rivers and dams for almost a week after Earl had passed.

Across much of the country, the hurricane’s category 1 winds caused widespread damage to power lines, transformers, cell phone towers, and roofs, disrupting utility service to all but the northernmost regions of Belize. Traffic was disrupted due to widespread debris in roads and highways, and some bridges were damaged in San Ignacio and Calla Creek. Earl damaged or destroyed at least 2,000 homes. The most significant damage occurred in the central and western portions of Belize, where several rivers overflowed their banks. Damage to water systems resulted in decreased water pressure in buildings, possibly contaminating some of the nation's water supply. Agricultural damage across the country was estimated at over US$100 million, and overall damage was estimated at US$110 million by *Aon Benfield Analytics*.

Mexico

Although Earl’s eye and strongest winds passed well south of the Yucatán Peninsula, the cyclone still produced tropical-storm-force wind gusts in Ciudad del Carmen, Campeche.

However, the greatest hazard associated with the hurricane was the torrential rainfall that occurred over eastern Mexico (Fig. 6). A peak rainfall total of 12.41 inches was measured in Huauchinango and more than 7 inches of rain occurred in Chiapas. The flooding rains caused mudslides in the mountainous regions of eastern Mexico, burying some areas in several feet of mud. At least 81 people, including 7 children, were killed.

In the Mexican states of Veracruz and Puebla, flash floods and mudslides heavily damaged roads in mountainous and other isolated areas. More than 1,700 families were forced to leave their homes.

In Veracruz, mudslides damaged at least 6,300 homes and 26 roadways, affecting more than 32,000 people and killing 13 people in the state. Floods isolated at least 18 villages in the southern and central portions of the state, and more than 65 schools were damaged.

Puebla was hit particularly hard. In the northern portions of that state, mudslides covered several homes, killing at least 41 people, with an additional 10 people reported missing. In the village of Chicahuaxtla, mudslides damaged 350 homes, blocked roads, and cut off power and water utilities. In the city of Huauchinango, a month's worth of rain fell in about 24 hours, triggering massive mudslides that killed at least 13 people, including 7 children. Damage estimates in the city exceed US$5.5 million. A mudslide in Xaltepec killed 11 people, and three fatalities were reported in Tlaola. Two bridges and several highways were damaged in the city of Puebla, and at least ten homes were destroyed in the state of Hidalgo.

Earl was the deadliest Atlantic tropical cyclone to affect Mexico since Hurricane Stan in 2005. *Aon Benfield Analytics* indicates that total damage in Mexico is estimated to be at least US$132 million.

FORECAST AND WARNING CRITIQUE

The genesis of Earl was well forecast, especially given the uncertainty concerning when the fast-moving tropical wave would slow down enough for the disturbance to close off and develop a well-defined low-level circulation center. Table 2 provides the number of hours in advance of formation associated with the first NHC Tropical Weather Outlook (TWO) forecast in each likelihood category. A low (< 40%) chance of formation during the next 5 days was introduced into the TWO 114 h before Earl developed, and the probability was raised to medium (40%-60%) and high (> 60%) categories 66 h and 48 h, respectively, before genesis occurred. The precursor disturbance was given a low chance of genesis during the next 2 days 114 h before Earl formed, and the 48-h probability was raised to medium and high chances 48 h and 24 h, respectively, before genesis occurred.

A verification of NHC official track forecasts (OFCL) for Earl is given in Table 5a. Official forecast track errors were comparable to the previous 5-yr period at 12 h and were lower than the mean official errors for the 24-96 h period. OFCL track forecasts were characterized by small cross-track and along-track biases despite the sharp decrease in forward speed as Earl approached Belize and the Yucatan peninsula, and were evenly distributed on either side of the hurricane's final track (Fig. 8). A homogeneous comparison of the official track errors with selected guidance models is given in Table 5b. NHC track forecasts were superior to all of the available

model guidance at 48 h and 72 h, and were comparable to most of the models at 12-36 h. The ECMWF (EMXI), HCCA (NOAA corrected consensus model), and GFDL (GHMI and GFNI) model forecast errors were unusually large at 36 h and beyond, exceeding OFCL track errors by a factor of almost ten at 72 h. The ECMWF's relatively large errors were due to pronounced left-of-track and fast forward-speed biases, a result of the model maintaining the precursor disturbance as a shallow open wave rather than a vertically deep tropical cyclone.

A verification of NHC official intensity forecasts for Earl is given in Table 6a. Official forecast intensity errors were comparable to the previous 5-yr period at 12 h and 36 h, and were lower than the mean official errors at the 24-, 48-, 72-, and -96 h periods. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 6b. NHC official intensity errors were comparable to the available model guidance at 12 h, but were worse than the models at 36 h and 48 h. However, OFCL intensity forecasts were much better than the guidance at 24 h and 72 h.

Watches and warnings associated with Earl are given in Table 7.

ACKNOWLEDGEMENTS

The Belize Weather Service, the Instituto de Sismologia, Vulcanologia, Meteorologia e Hidrologia (National Meteorological Service of Guatemala), and the Servicio Meteorológico Nacional Mexican Meteorological Service) provided data and damage reports from their respective countries. The Caribbean Disaster Emergency Management Agency (CDERA) also provided reports on the effects from Earl elsewhere within the Caribbean area. Josh Morgerman of *iCyclone* contributed detailed pressure observations and eyewitness accounts of conditions in Belize City, Belize, during the height of Earl's passage. Estimated economic losses in Belize and Mexico were obtained from the "Global Catastrophe Recap Report: August 2016" prepared by *Aon Benfield Analytics*.

Table 1. Best track for Hurricane Earl, 2-6 August 2016.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
02 / 0600	16.3	77.5	1004	40	tropical storm
02 / 1200	16.3	79.2	1003	40	"
02 / 1800	16.3	80.8	1001	45	"
03 / 0000	16.4	82.2	994	55	"
03 / 0600	16.0	83.1	993	55	"
03 / 1200	16.3	84.3	989	60	"
03 / 1800	16.9	85.4	988	65	hurricane
04 / 0000	17.3	86.9	984	70	"
04 / 0400	17.4	87.8	979	75	"
04 / 0600	17.4	88.3	979	75	"
04 / 1200	17.4	89.4	989	60	tropical storm
04 / 1800	17.6	90.3	995	40	"
05 / 0000	18.0	91.2	1000	35	"
05 / 0600	18.3	92.3	1001	35	"
05 / 1200	18.5	93.5	1001	40	"
05 / 1800	18.7	94.7	999	50	"
06 / 0000	18.9	95.6	999	50	"
06 / 0230	19.0	96.0	999	50	"
06 / 0600	19.0	96.5	1004	45	"
06 / 1200	19.0	97.5	1008	25	tropical depression
06 / 1800					dissipated
04 / 0400	17.4	87.8	979	75	landfall on Turnleffe Caye, Belize
04 / 0600	17.4	88.3	979	75	landfall 5 n mi south of Belize City, Belize
06 / 0230	19.0	96.0	999	50	landfall near Salinas, Mexico
04 / 0400	17.4	88.3	979	75	minimum pressure and maximum intensity

Table 2. Number of hours in advance of formation of Hurricane Earl 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 (<40%)	114	114
Medium (40%-60%)	48	66
High (>60%)	24	48

Table 3. Selected ship and buoy reports with winds of at least 34 kt for Hurricane Earl, 2-6 August 2016.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
03 / 0000	A8OK7	16.7	83.0	060 / 37	1007.5
03 / 0600	A8OK7	16.9	82.0	090 / 45	1008.0
03 / 1200	9VMG5	19.6	82.2	090 / 36	1010.7
04 / 0200	ZCDK2	19.7	91.8	050 / 50	1006.0
05 / 0400	Buoy 42055	22.1	93.9	080 / 35G39	1009.8
05 / 0600	A8VG4	19.9	91.0	100 / 37	1009.5
05 / 0600	C6FN5	23.2	89.3	120 / 35	1016.5
05 / 2100	BATFR5	18.4	94.4	180 / 40	1006.3

Table 4. Selected surface observations for Hurricane Earl, 2-6 August 2016.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Estimated Inundation (ft)[e]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
Mexico									
Boca del Cerro (Tabasco)									5.64
Campeche IAP (MMCP)	04/2346	1007.2	03/2308		30				
Cuidad del Carmen IAP (MMCE)	04/2300	1003.4	04/2348	30	46				
Mezcalapa (Tabasco)									2.35
Huauchinango									12.41
Monclova (Campeche)									2.42
Palizada (Campeche)									5.41
Peto (Yucatan)									4.25
Puerto Angel (Oaxaca)									3.80
Sacrifice Island (SACV4) 19.17^{O} N 96.09^{O} W	06/0100	1003.0	05/2300	36	45				
Veracruz						1-2			2.07
Veracruz Harbor (VERV4) 19.20^{O} N 96.11^{O} W	06/0200	1002.3	05/2200	37	43				
Xcalak (Quintana Roo) 18.28^{O} N 87.83^{O} W			04/0730	63	90				
Yamonho (Chiapas)									7.63
Belize									
Belize City 17.49032^{O} N 88.18706^{O} W	04/0510	982.2							
Belize City IAP (MZBZ)	04/0600	988.5	04/0600	30	50	4-6			5.08
Turnleffe Caye						4-6			
Guatemala									
Mundo Maya IAP (MMGM)	04/1200	989.2	04/0800[f]	38					3.85
San Andrés (Petén)									4.89
San José (Petén)									2.92
Honduras									
Juan Manuel Gálvez IAP (Roatan/MHRO)	04/0000	1004.1							
La Cieba IAP (MHLC)									4.09
Tela IAP (MHTE)									5.35

[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] Storm surge is water height above normal astronomical tide level.
[d] For most locations, storm tide is water height above the North American Vertical Datum of 1988 (NAVD88).
[e] Estimated inundation is the maximum height of water above ground.
[f] Last of several occurrences.

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Earl, 2-6 August 2016. 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	28.8	**32.9**	**21.2**	**25.0**	**26.2**	**66.3**	
OCD5	35.4	59.5	69.2	74.3	94.4	185.5	
Forecasts	15	13	11	9	5	1	
OFCL (2011-15)	28.4	45.0	60.4	77.1	113.1	157.8	210.0
OCD5 (2011-15)	48.3	101.5	161.5	222.6	329.8	412.6	483.9

Table 5b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Earl, 2-6 August 2016. 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	26.0	26.3	21.2	21.2	12.2		
OCD5	39.8	59.2	66.6	66.9	77.7		
GFSI	26.2	36.9	59.6	61.0	65.3		
EMXI	**25.0**	26.9	43.1	72.2	117.8		
CMCI	33.0	50.9	56.1	55.9	105.4		
NVGI	31.8	46.2	64.1	99.6	161.7		
CTCI	**19.8**	30.0	48.1	47.0	60.8		
AEMI	**25.9**	38.9	59.2	67.9	64.7		
GFEX	**22.3**	**25.0**	31.0	40.7	64.9		
TVCA	**21.5**	**23.9**	22.2	29.5	22.9		
TVCX	**22.0**	**24.3**	**19.5**	30.7	31.0		
HCCA	**25.8**	32.0	41.0	61.4	102.7		
FSSE	**23.5**	28.9	31.3	36.3	32.8		
HWFI	**22.3**	32.5	41.9	52.4	90.9		
GHMI	**23.8**	35.6	57.8	73.3	150.3		
GFNI	37.5	63.9	91.2	115.5	168.9		
BAMD	29.7	44.5	52.4	59.2	81.8		
BAMM	**22.5**	**23.5**	**18.3**	22.9	37.2		
BAMS	28.9	39.0	48.0	56.6	49.7		
Forecasts	10	9	9	7	3		

Table 6a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Earl, 2-6 August 2016. 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	7.3	**7.3**	11.8	**11.7**	**6.0**	**0.0**	
OCD5	6.3	8.7	13.1	9.3	9.0	3.0	
Forecasts	15	13	11	9	5	1	
OFCL (2011-15)	6.2	9.4	11.5	13.3	14.6	14.6	15.8
OCD5 (2011-15)	7.3	10.8	13.3	15.3	17.7	17.8	17.6

Table 6b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Earl, 2-6 August 2016. 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 6a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	7.3	7.9	11.8	11.7	6.0		
OCD5	**6.3**	8.8	13.1	**9.3**	9.0		
GFSI	10.7	12.0	11.9	**11.4**	6.4		
EMXI	11.7	15.3	14.5	**10.9**	14.6		
CMCI	11.9	17.2	15.1	12.6	13.6		
AEMI	12.2	13.3	**10.0**	**9.7**	6.8		
HCCA	8.8	10.6	**10.5**	**7.7**	10.4		
HWFI	10.1	14.8	12.2	**8.8**	13.4		
GHMI	12.3	12.9	**10.5**	**8.8**	12.6		
GFNI	9.9	12.3	**9.5**	**7.4**	11.6		
DSHP	7.3	**7.6**	11.8	**9.7**	9.0		
LGEM	7.3	8.1	12.0	**8.1**	9.2		
IVCN	8.8	9.4	**10.2**	**7.1**	8.2		
ICON	8.6	9.7	**9.8**	**7.1**	9.0		
Forecasts	15	12	11	9	5		

Table 7. Watch and warning summary for Hurricane Earl, 2-6 August 2016.

Date/Time (UTC)	Action	Location
2 / 1600	Tropical Storm Watch issued	Cayman Islands
2 / 1600	Tropical Storm Warning issued	Honduras
2 / 1600	Tropical Storm Warning issued	Belize
2 / 1600	Tropical Storm Warning issued	Bel/Mex border to Punta Allen
2 / 1600	Hurricane Watch issued	Belize
2 / 1600	Hurricane Watch issued	Bel/Mex border to Punta Allen
2 / 2100	Tropical Storm Watch discontinued	All
3 / 0300	Tropical Storm Warning modified to Hurricane Warning	Belize
3 / 0300	Tropical Storm Warning modified to	Puerto Costa Maya to Punta Allen
3 / 0300	Hurricane Watch discontinued	All
3 / 0300	Hurricane Warning issued	Puerto Costa Maya to Bel/Mex border
3 / 1200	Hurricane Warning issued	Bay Islands
4 / 0300	Tropical Storm Warning discontinued	Honduras
4 / 0300	Hurricane Warning discontinued	Bay Islands
4 / 1200	Hurricane Warning changed to Tropical Storm Warning	Belize
4 / 1200	Tropical Storm Warning discontinued	Puerto Costa Maya to Punta Allen
4 / 1200	Hurricane Warning discontinued	All
4 / 1500	Tropical Storm Warning discontinued	All
5 / 0300	Tropical Storm Warning issued	Ciudad del Carmen to Laguna Verde
5 / 1800	Tropical Storm Warning modified to	Puerto Dos Bocas to Laguna Verde
5 / 2100	Tropical Storm Warning modified to	Puerto Dos Bocas to Tecolutla
6 / 0300	Tropical Storm Warning modified to	Roca Partido to Tecolutla
6 / 1200	Tropical Storm Warning discontinued	All

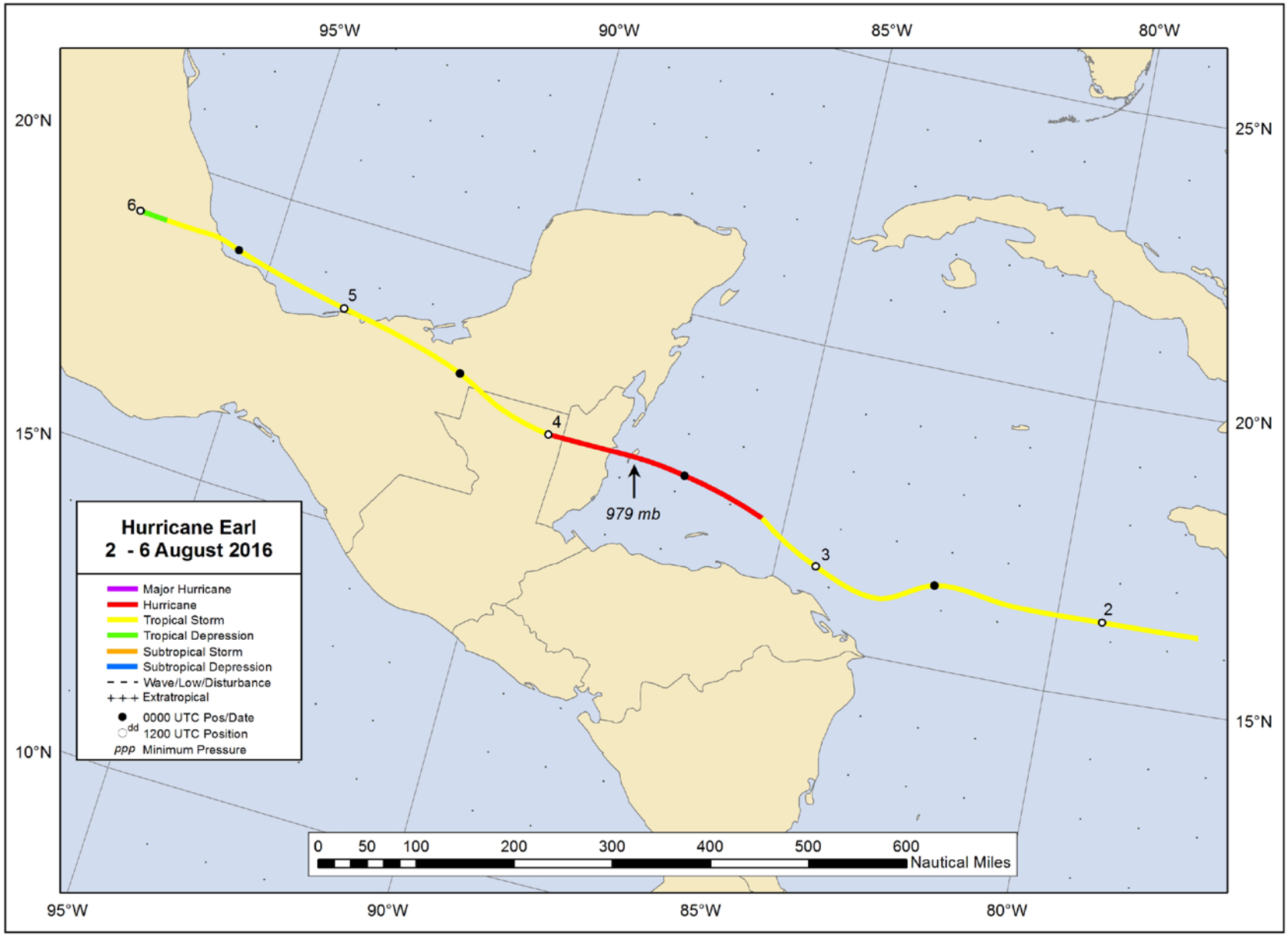

Figure 1. Best track positions for Hurricane Earl, 2-6 August 2016.

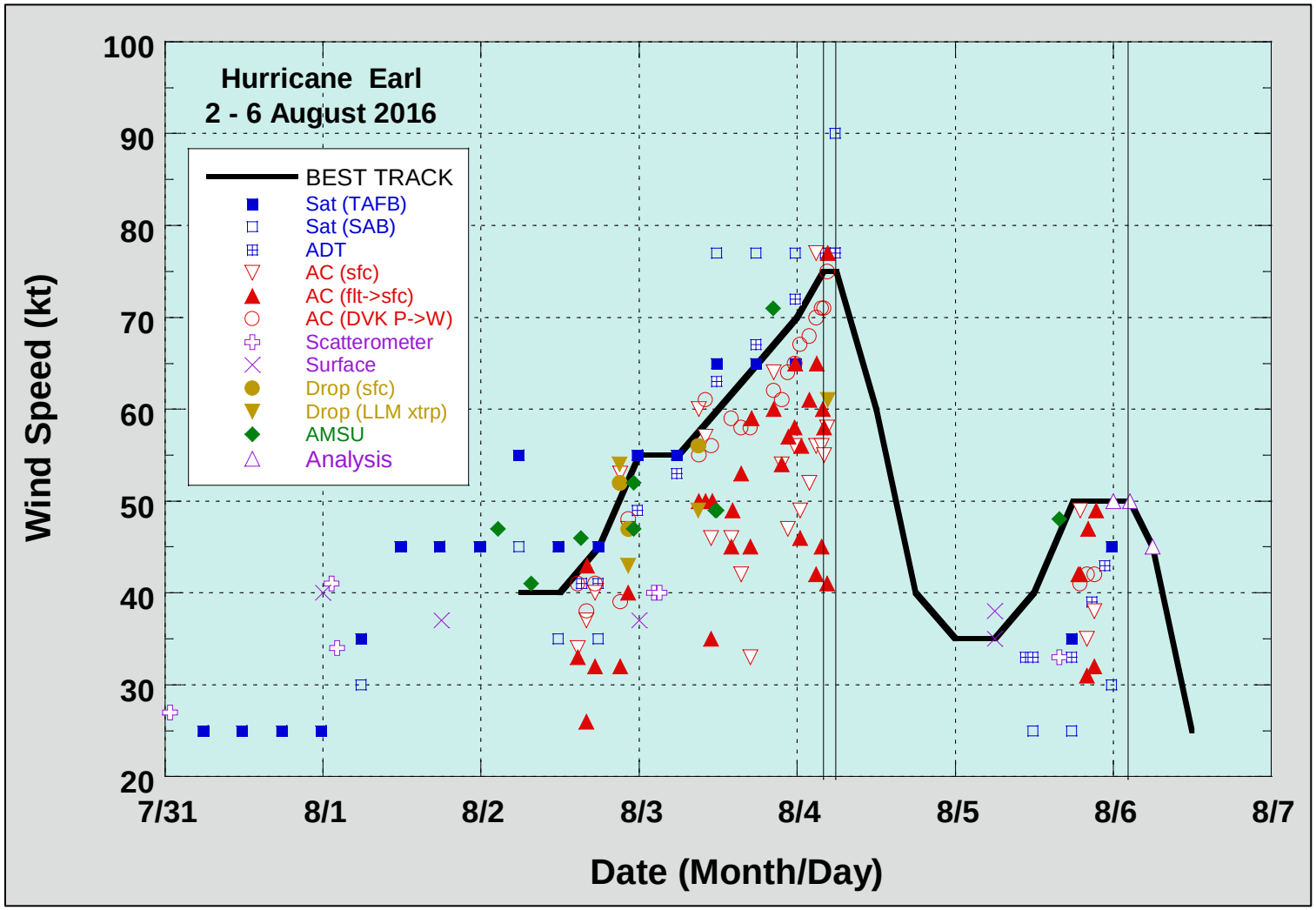

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Earl, 2-6 August 2016. Aircraft observations have been adjusted for elevation using 80% and 90% adjustment factors for observations from 850 mb and 700 mb, respectively. The dropwindsonde observation includes actual 10 m winds (sfc). 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. Dashed vertical lines correspond to 0000 UTC, and the solid vertical lines correspond to landfalls.

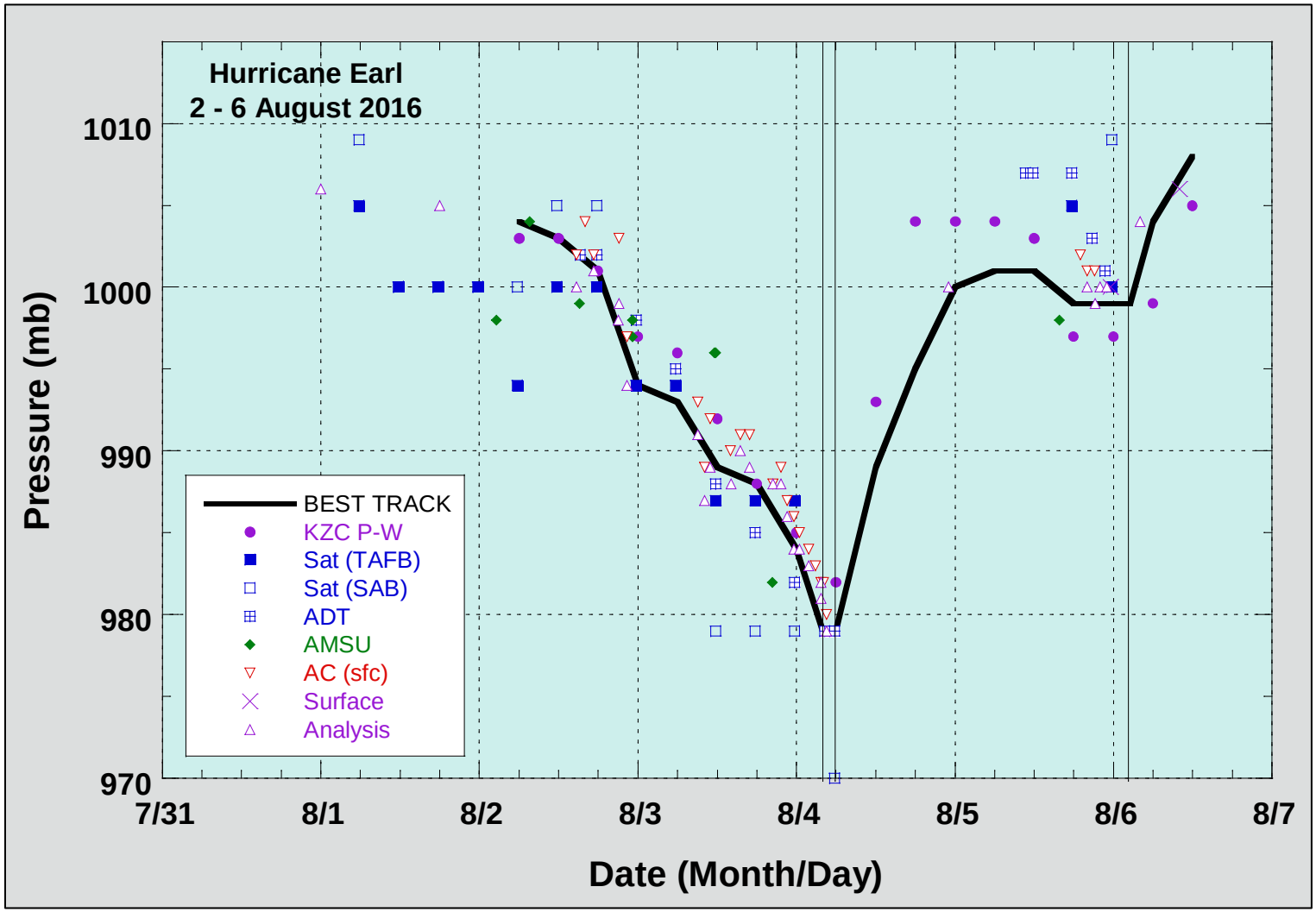

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Earl, 2-6 August 2016. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological 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, and the solid vertical lines correspond to landfalls.

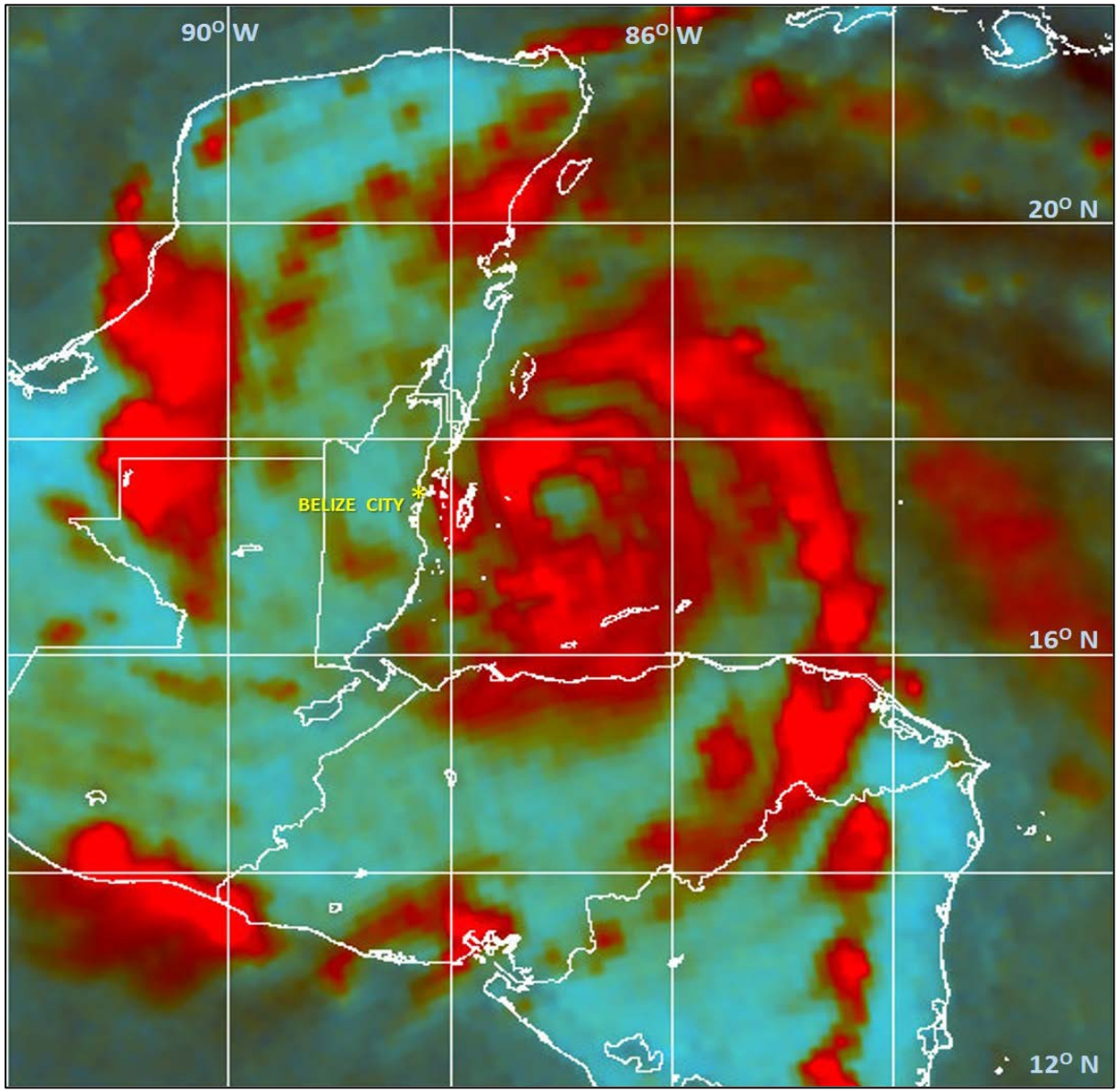

Figure 4. 0033 UTC 4 August 2016 SSMI/S microwave image depicting the well-defined eye that formed a few hours prior to Earl reaching its peak intensity of 75 kt. Image courtesy of Naval Research Laboratory, Monterey, CA.

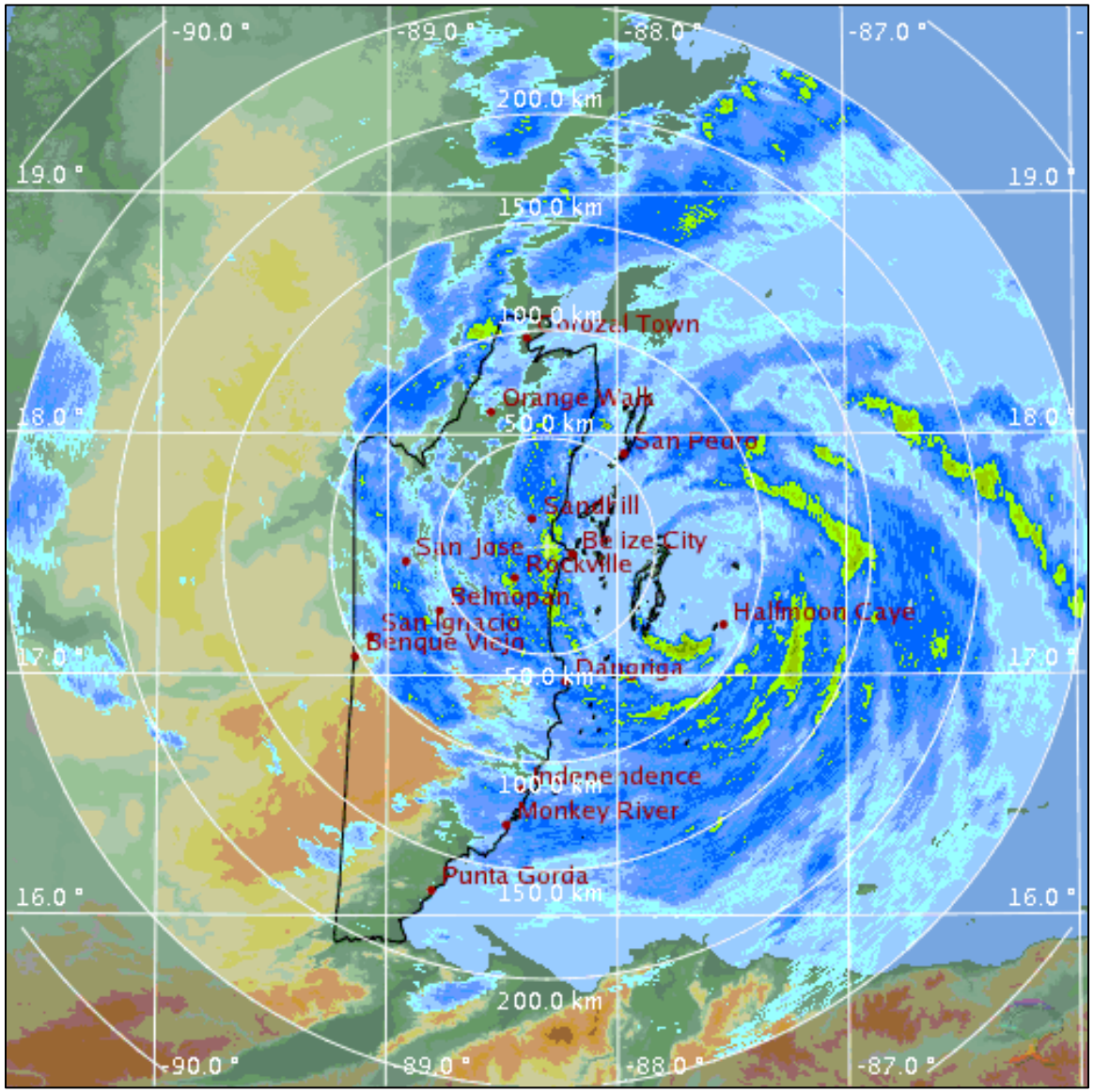

Figure 5. Belize City Doppler weather radar 1-km altitude CAPPI reflectivity image at 0315 UTC 4 August 2016 depicting the center of Hurricane Earl near 17.4^{O} N about 13 n mi (25 km) east of Turnleffe Caye (range rings in km; image courtesy of National Meteorological Service of Belize).

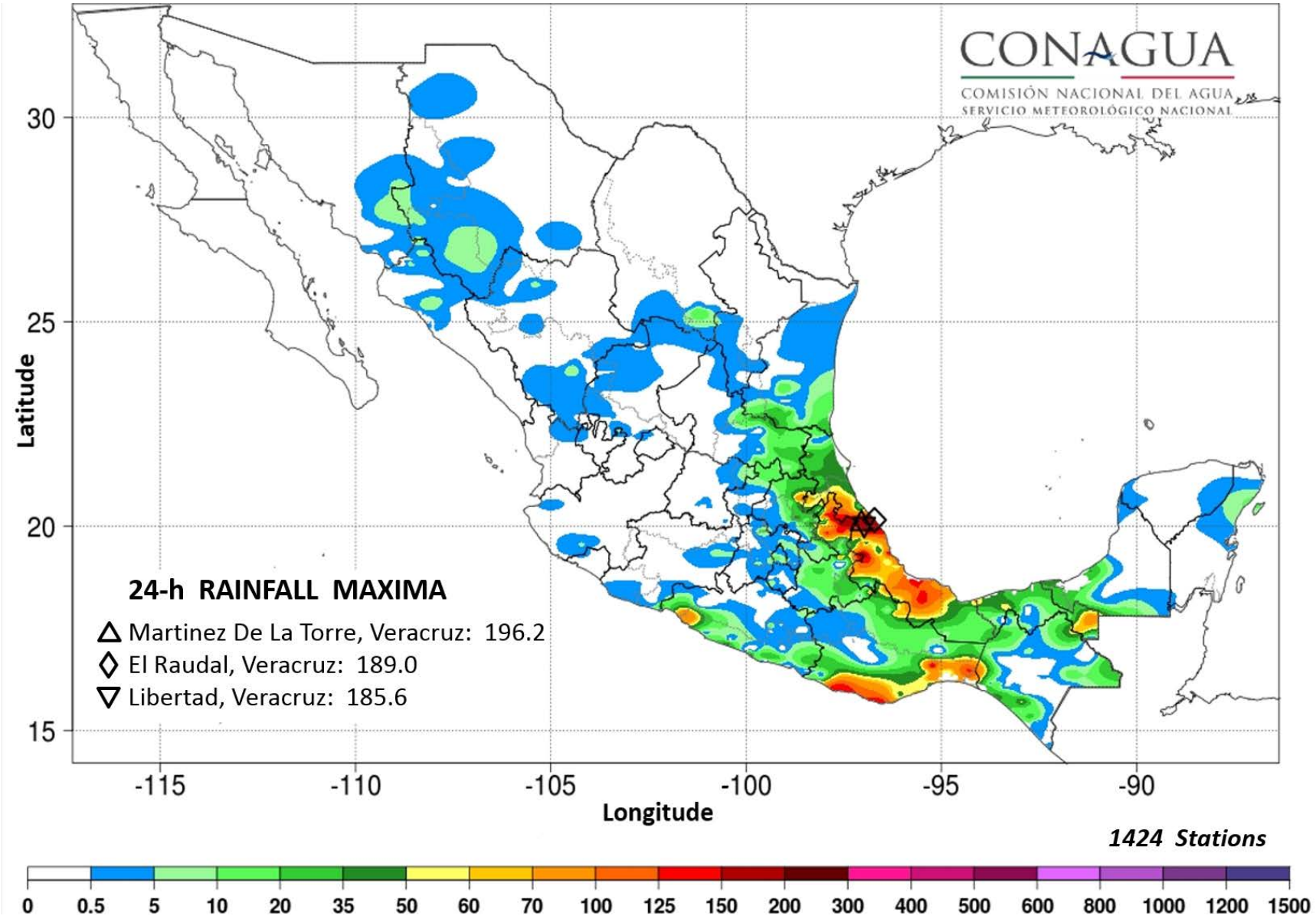

Figure 6. Mexico 24-h rainfall totals (mm) during the period 5-6 August 2016 associated with Hurricane Earl. Map courtesy of the Servicio Meteorológico Nacional (Mexican Meteorological Service).

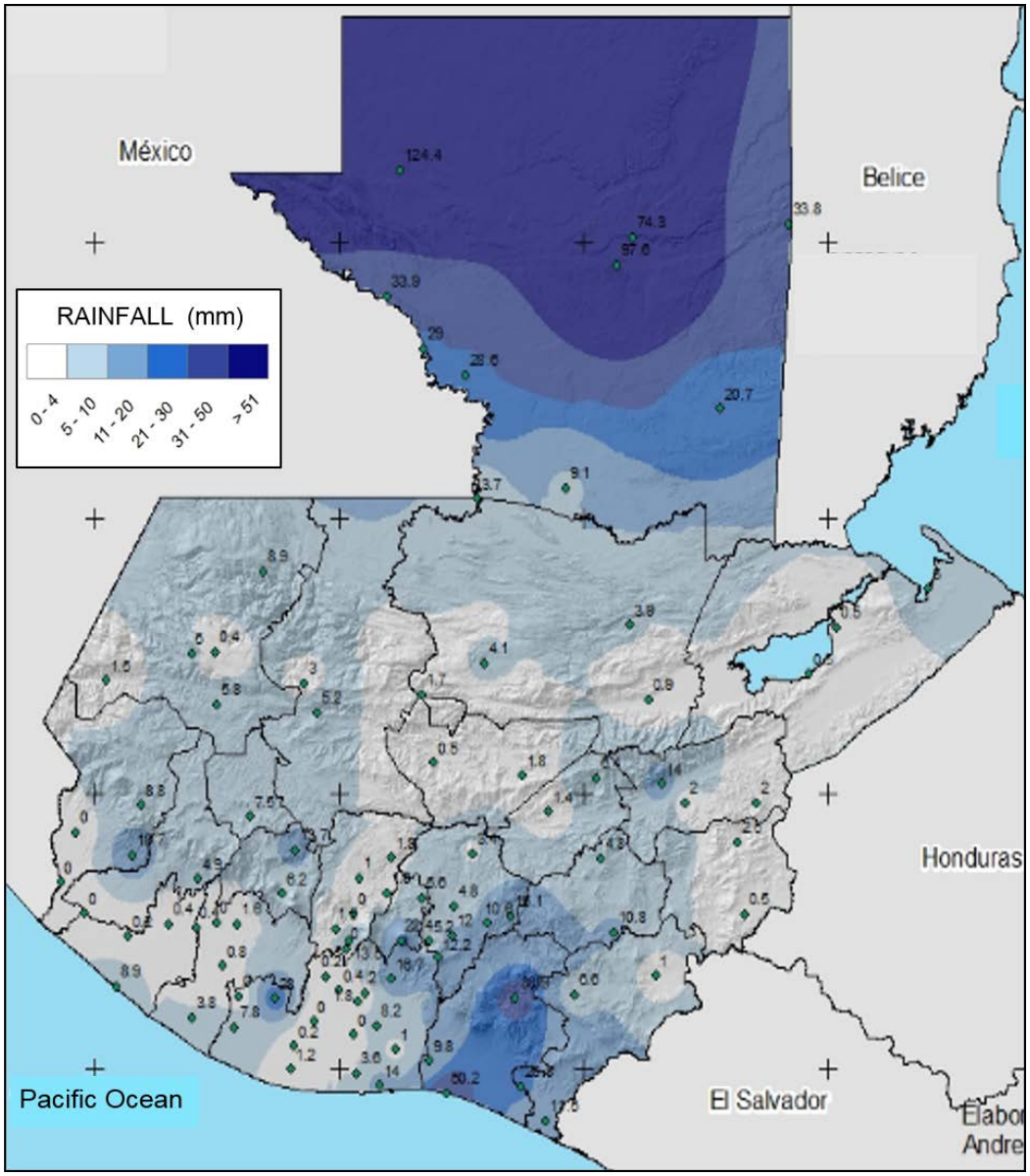

Figure 7. Guatemala 24-h rainfall totals (mm) during Earl's passage on 4 August 2016. Map courtesy of the Instituto de Sismologia, Vulcanologia, Meteorologia e Hidrologia (National Meteorological Service of Guatemala).

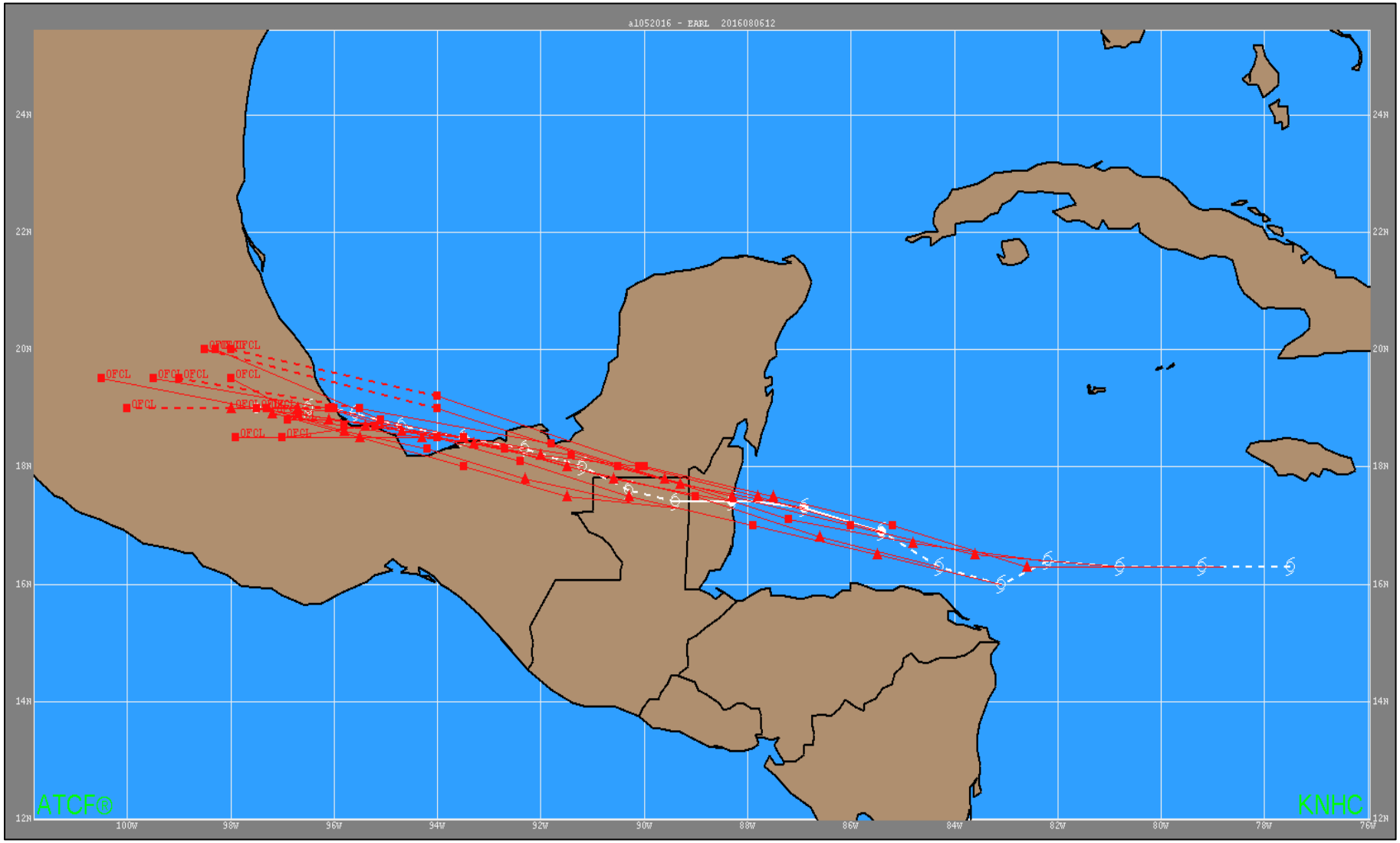

Figure 8. Selected official track forecasts (solid and dashed red lines, with 0, 12, 24, 36, 48, 72, and 96 h positions indicated) for Hurricane Earl, 2-6 October 2016. The best track is given by the solid white line with positions given at 6 h intervals.