

Tropical Cyclone Report  
Hurricane Carlotta  
(EP032012)  
14-16 June 2012

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20 December 2012

Carlotta was a strong category 2 hurricane (on the Saffir-Simpson Hurricane Wind Scale) that made landfall near Puerto Escondido, Mexico. It was the easternmost landfalling hurricane in the eastern North Pacific basin since 1966.

a. Synoptic History

The genesis of Carlotta can be traced back to an area of disturbed weather that moved westward from Colombia to near and just south of Panama on 11 June. Extrapolation and analyses from the National Centers for Environmental Prediction's Global Forecast System suggest that this system was associated with a tropical wave that departed Africa in early June, although this is uncertain since the wave became ill-defined over the central Atlantic. An eastward-moving Kelvin wave that moved over Central America during the second week of June was also a likely contributor to development. The disturbance continued westward and by 1800 UTC 13 June it spawned a well-defined low-level circulation several hundred n mi south of Guatemala. By 0000 UTC 14 June, the associated deep convection became better organized and it is estimated that a tropical depression formed at this time, centered about 460 n mi south-southeast of Huatulco, Mexico. Figure 1 is the "best track" chart of the tropical cyclone's path, and the wind and pressure histories shown in Figs. 2 and 3, respectively. The best track positions and intensities are listed in Table 1<sup>1</sup>.

The cyclone was situated on the southwestern periphery of a mid-tropospheric ridge and shortly after genesis, it turned from a west-northwestward to a northwestward heading. Vertical shear was quite weak over the area, which allowed the system to strengthen into a tropical storm by 0600 UTC 14 June. Carlotta continued to gradually intensify over the next day or so, and it became a hurricane at about 1200 UTC 15 June, while centered about 170 n mi south-southeast of Puerto Escondido, Mexico. Not long after becoming a hurricane, Carlotta underwent a period of rapid intensification, with its maximum winds increasing to 95 kt by 2100 UTC 15 June. As it neared the coast, the hurricane turned toward the north-northwest, and the forward speed increased from around 10 kt to 16 kt. Carlotta made landfall in the Mexican state of Oaxaca, about 10 n mi east-southeast of Puerto Escondido, around 0100 UTC 16 June (Fig. 4). Satellite imagery showed that the eye became less well-defined just before landfall, suggesting that the hurricane had weakened slightly to an intensity of 90 kt, likely due to the partial interaction of

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<sup>1</sup> 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 circulation with the rugged terrain of Mexico. After the center crossed the coast, it turned toward the northwest and moved over the southern portion of Oaxaca and, later on 16 June, over the state of Guerrero. Carlotta weakened very rapidly while it traversed the mountainous terrain of southern Mexico, and by 1200 UTC 16 June the cyclone was reduced to a tropical depression, centered about 60 n mi northeast of Acapulco, Mexico. The system turned to the west-northwest while decelerating and degenerated into a remnant low around 0000 UTC 17 June. Later that day, the low dissipated over the western part of Guerrero, Mexico.

#### b. Meteorological Statistics

Observations in Carlotta (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 a flight of the 53<sup>rd</sup> Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command. 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 Carlotta.

Carlotta's estimated peak intensity of 95 kt is based on a blend of a maximum bias-corrected SFMR wind speed of 97 kt and a 700-mb flight-level wind of 99 kt, which corresponds to a peak surface wind of 89 kt. Surface observations associated with Carlotta are listed in Table 2. All of the wind observations are from automated sites in the Mexican state of Oaxaca. The Pluma Hidalgo site reported wind gusts to hurricane force for about 1 h 40 min. Since the pressures at these sites have not been reduced to sea level values, they are not included in the table. There was one ship report of tropical-storm-force winds associated with Carlotta. The vessel *Decisive* (call sign V7DI7), a cable-laying ship, reported winds of 320°/37 kt and a pressure of 999.0 mb at 2100 UTC 14 June, at 10.9°N 94.6°W.

In the eastern North Pacific best track records going back to 1966, Carlotta is the easternmost landfalling hurricane.

#### c. Casualty and Damage Statistics

There were three direct deaths<sup>2</sup> associated with Carlotta. A mud-brick house collapsed in the town of Pluma Hidalgo, Oaxaca, killing a 13-year-old girl and her 7-year-old sister. A 56-

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<sup>2</sup> 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.

year-old woman from the coastal city of San Jose Manialtepec, Oaxaca was killed when the vehicle she was driving was flipped over by the wind. Some sources indicate that at least seven people died in Mexico due to Carlotta. However, other than the three casualties listed above, it cannot be confirmed whether these deaths were direct. At least 29,000 homes and 2,500 businesses in Mexico were affected by flooding and high winds, primarily in the state of Oaxaca, although structural damage did not appear to be very severe. While monetary damage totals are sketchy, it is worth noting that the state of Oaxaca requested 1.444 billion pesos (\$113 million US) for repairs to public infrastructure.

d. Forecast and Warning Critique

The genesis of Carlotta was reasonably well forecast. The precursor disturbance was first included in the Tropical Weather Outlook 36 h prior to genesis, and given a “low” (less than 30%) chance of development. The probability of tropical cyclone formation was increased to “medium” (30-50%) 30 h prior to genesis, and later changed to “high” (greater than 50%) 12 h before genesis.

A verification of NHC official track forecasts for Hurricane Carlotta is given in Table 3a. There were no forecasts to verify beyond 48 h. Official forecast track errors were slightly greater than the mean official errors for the previous 5-yr period. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The GFSI, CMCI, FSSE, and LBAR models had lower mean errors than the official forecasts at most forecast intervals. Most of the model guidance, along with the official forecast, suffered from a left bias, generally suggesting a landfall (or a track skirting the coast) farther to the west, and at a later time, than what actually occurred.

A verification of NHC official intensity forecasts for Carlotta is given in Table 4a. Official intensity forecast errors were considerably higher than the mean official errors for the previous 5-yr period. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. Model forecast errors were also very high. The high errors associated with both the model guidance and the official forecasts were a result of successive episodes of rapid intensification and rapid weakening. While the official forecasts consistently predicted Carlotta to intensify into a hurricane as it approached the Mexican coast, the rapid rate at which that intensification occurred was not forecast. In addition, while Carlotta rapidly weakened after landfall, the forecasts called for gradual weakening, since the cyclone was anticipated to make landfall at a later time, and not move as far inland.

Watches and warnings associated with Carlotta are given in Table 5. A hurricane warning was issued for the southern coast of Mexico 34 h prior to the arrival of the center in the warning area.

Table 1. Best track for Hurricane Carlotta, 14-16 June 2012.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
13 / 1800	8.7	91.5	1006	30	low
14 / 0000	9.2	92.3	1005	30	tropical depression
14 / 0600	9.8	92.9	1003	35	tropical storm
14 / 1200	10.5	93.4	1001	40	"
14 / 1800	11.3	94.0	999	45	"
15 / 0000	12.0	94.5	994	55	"
15 / 0600	12.7	95.0	993	60	"
15 / 1200	13.5	95.6	988	65	hurricane
15 / 1800	14.4	96.1	978	85	"
15 / 2100	14.9	96.3	973	95	"
16 / 0000	15.6	96.7	976	90	"
16 / 0600	16.5	97.9	982	70	"
16 / 0900	16.9	98.5	992	45	tropical storm
16 / 1200	17.3	99.0	1000	30	tropical depression
16 / 1800	17.7	99.6	1005	25	"
17 / 0000	18.0	100.1	1006	20	low
17 / 0600	18.0	100.3	1009	20	"
17 / 1200					dissipated
15 / 2100	14.9	96.3	973	95	maximum wind and minimum pressure
16/0100	15.8	96.9	976	90	landfall near Puerto Escondido, Mexico

Table 2. Selected surface observations for Hurricane Carlotta, 14-16 June 2012. For the stations reporting winds the elevation above sea level (ft), if available, is shown in parentheses after the name of the station.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)	Storm tide (ft)	Total rain (in) <sup>c</sup>
	Date/time (UTC)	Press. (mb)	Date/time (UTC) <sup>a</sup>	Sustained (kt) <sup>b</sup>	Gust (kt)			
<b>Mexico</b>								
<b>International Civil Aviation Organization (ICAO) and Synoptic Sites</b>								
Huatulco			15/2315	33	48			
Pinotepa (640)			16/0430	19	33			
Pluma Hidalgo (4500)			16/0030	49	72			
Puerto Angel (298)			15/2340	58	86			
Salina Cruz			15/2245	22	37			
San Jose del Progreso (8712)			16/0010	12	41			
<b>Other</b>								
Coyuquilla								11.02
Presa la Villita								8.62
Tuxtepec								13.78
Villa Azveta								6.34

<sup>a</sup> Date/time is for sustained wind when both sustained and gust are listed.

<sup>b</sup> Sustained wind averaging period is 10 min.

<sup>c</sup> All rainfall amounts are 24-h totals on 16 June.

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Carlotta, 14-16 June 2012. Mean errors for the 5-yr period 2007-11 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	29.0	48.7	68.2	90.8			
OCD5	29.3	63.1	107.0	162.0			
Forecasts	10	8	6	4			
OFCL (2007-11)	28.6	46.3	62.7	78.1			
OCD5 (2007-11)	38.5	74.8	116.0	159.8			

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Carlotta, 14-16 June 2012. 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 3a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	28.0	53.7	79.6	105.7			
OCD5	<b>27.2</b>	58.8	102.2	146.6			
GFSI	<b>23.4</b>	<b>42.5</b>	<b>71.4</b>	<b>89.6</b>			
GHMI	38.2	84.7	129.0	175.2			
HWFI	28.7	55.4	<b>73.6</b>	<b>97.5</b>			
EGRI	61.4	123.6	162.6	155.8			
EMXI	<b>24.9</b>	54.6	93.5	117.5			
CMCI	30.5	<b>44.3</b>	<b>59.4</b>	<b>56.3</b>			
AEMI	34.4	58.3	87.6	122.4			
FSSE	<b>24.2</b>	<b>53.1</b>	<b>77.7</b>	<b>82.5</b>			
TVCE	29.8	65.9	99.7	123.4			
LBAR	<b>24.5</b>	<b>49.5</b>	<b>54.6</b>	<b>45.4</b>			
BAMS	59.8	130.2	192.8	255.7			
BAMM	39.5	79.5	117.2	160.1			
BAMD	33.6	69.1	101.8	128.5			
Forecasts	8	7	5	3			

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Carlotta, 14-16 June 2012. Mean errors for the 5-yr period 2007-11 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	11.5	20.0	26.7	32.5			
OCD5	8.7	12.6	25.2	33.5			
Forecasts	10	8	6	4			
OFCL (2007-11)	6.4	10.6	13.7	15.1			
OCD5 (2007-11)	7.5	12.4	16.1	18.4			

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Carlotta, 14-16 June 2012. 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	12.2	21.4	30.0	35.0			
OCD5	<b>9.4</b>	<b>13.9</b>	30.2	41.3			
GHMI	12.2	<b>21.0</b>	<b>29.0</b>	36.7			
HWFI	13.0	<b>10.4</b>	<b>15.0</b>	42.3			
FSSE	13.2	22.1	32.0	39.3			
IVCN	12.2	<b>17.9</b>	<b>26.6</b>	<b>33.3</b>			
ICON	12.2	<b>17.9</b>	<b>26.6</b>	<b>33.3</b>			
DSHP	<b>12.0</b>	<b>20.7</b>	30.6	<b>29.3</b>			
LGEM	<b>12.6</b>	<b>22.9</b>	35.6	<b>34.0</b>			
Forecasts	9	7	5	3			



Table 5. Watch and warning summary for Hurricane Carlotta, 14-16 June 2012.

Date/Time (UTC)	Action	Location
14 / 0300	Hurricane Watch issued	Barra de Tonalá to Punta Maldonado
14 / 1500	Hurricane Watch modified to	Barra de Tonalá to Salina Cruz
14 / 1500	Hurricane Warning issued	Salina Cruz to Punta Maldonado
15 / 1500	Hurricane Watch modified to	Acapulco to Tecpan de Galeana
15 / 1500	Hurricane Warning modified to	Salina Cruz to Acapulco
15 / 1800	Tropical Storm Warning issued	Barra de Tonalá to Salina Cruz
16 / 0300	Tropical Storm Warning discontinued	Barra de Tonalá to Salina Cruz
16 / 0300	Tropical Storm Warning issued	Punta Maldonado to Acapulco
16 / 0300	Hurricane Watch discontinued	Barra de Tonalá to Salina Cruz
16 / 0300	Hurricane Watch modified to	Punta Maldonado to Acapulco
16 / 0300	Hurricane Warning modified to	Salina Cruz to Punta Maldonado
16 / 1200	Hurricane Watch changed to Tropical Storm Warning	Punta Maldonado to Acapulco
16 / 1200	Hurricane Warning discontinued	All
16 / 1500	Tropical Storm Warning discontinued	All

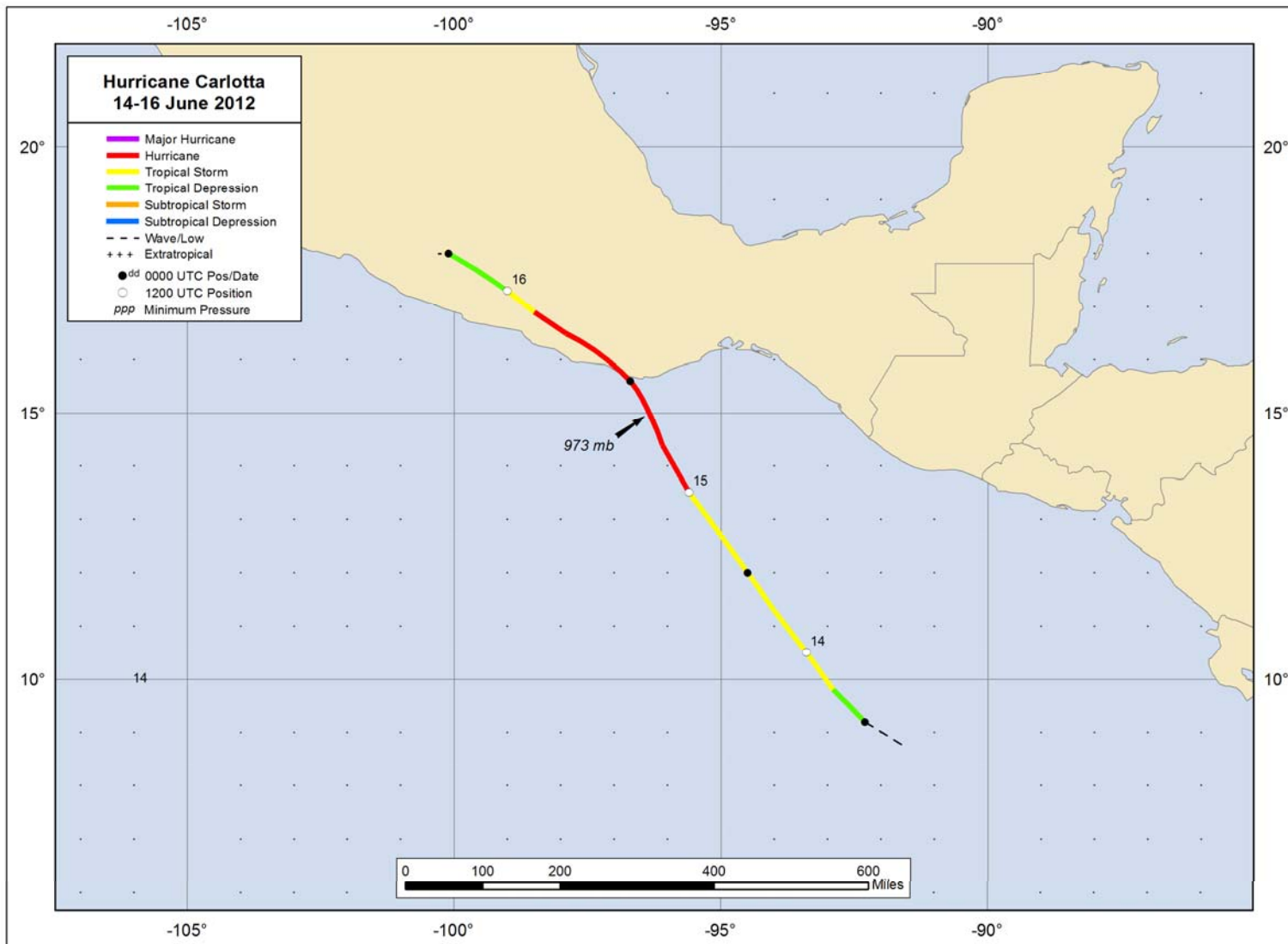


Figure 1. Best track positions for Hurricane Carlotta, 14-16 June 2012.

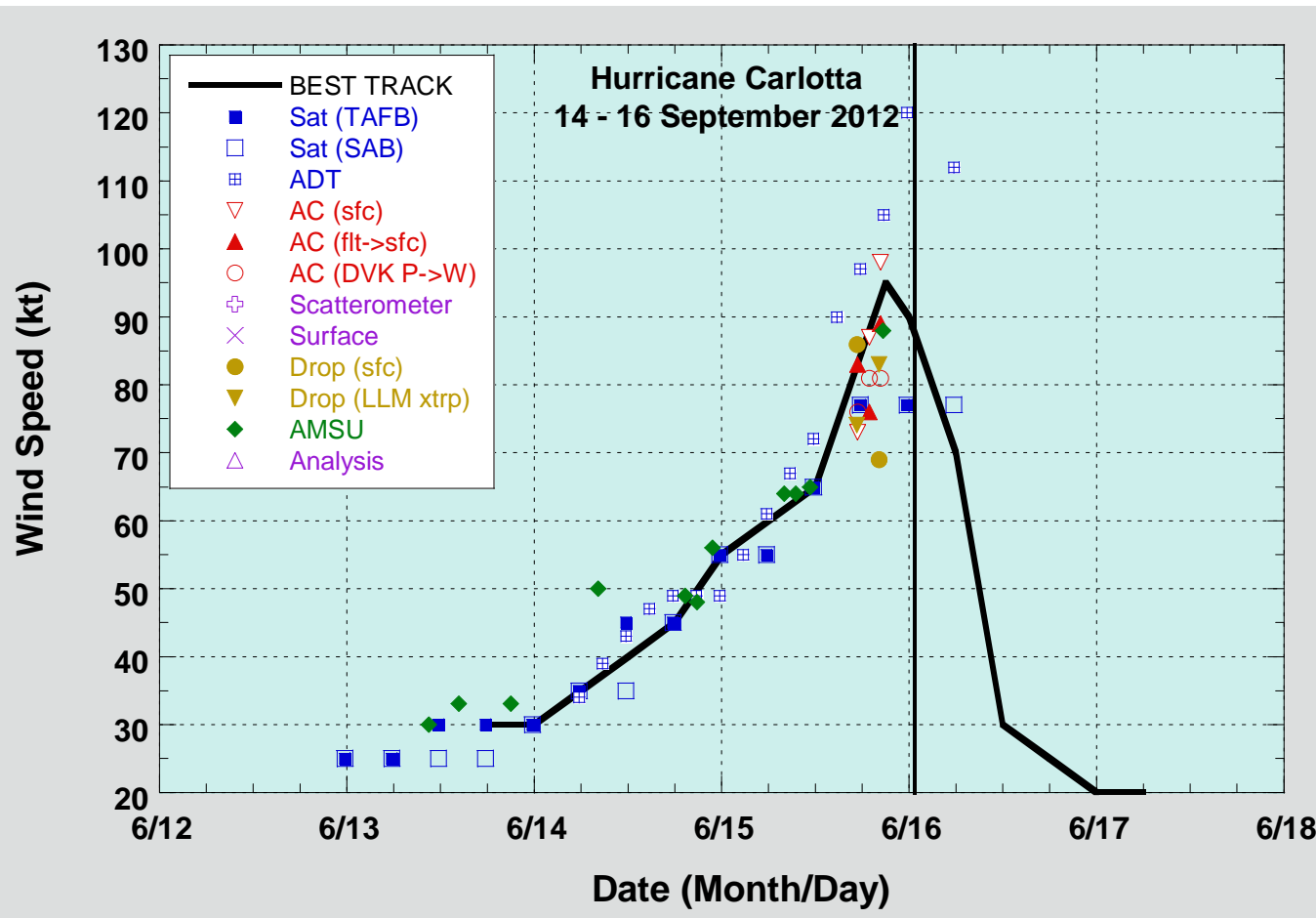


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Carlotta, 14-16 June 2012. Advanced Dvorak Technique estimates represent CI numbers. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC. Solid vertical line corresponds to landfall.

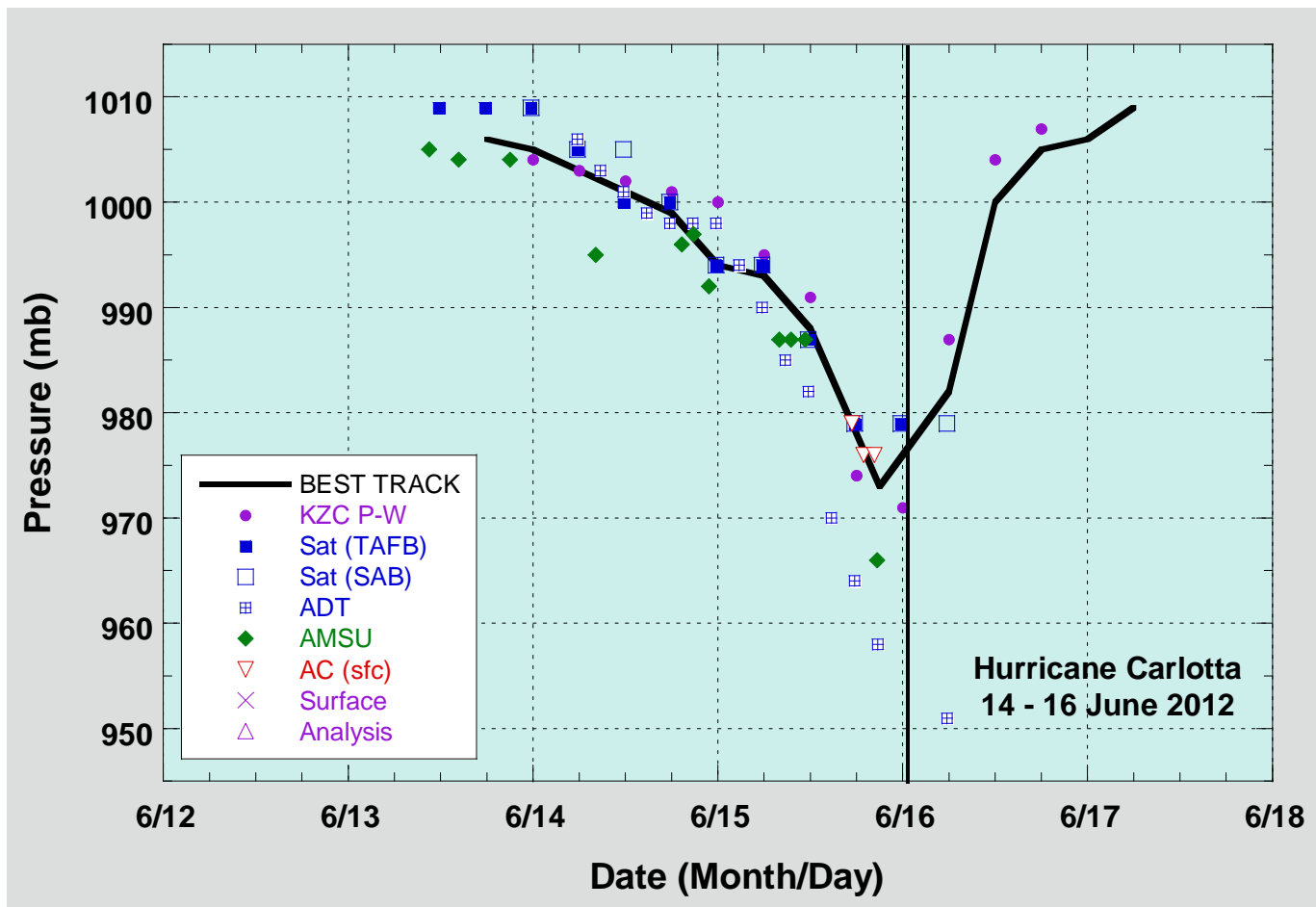


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Carlotta, 14-16 June 2012. Advanced Dvorak Technique estimates represent CI numbers. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. The KZC 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. Solid vertical line corresponds to landfall.

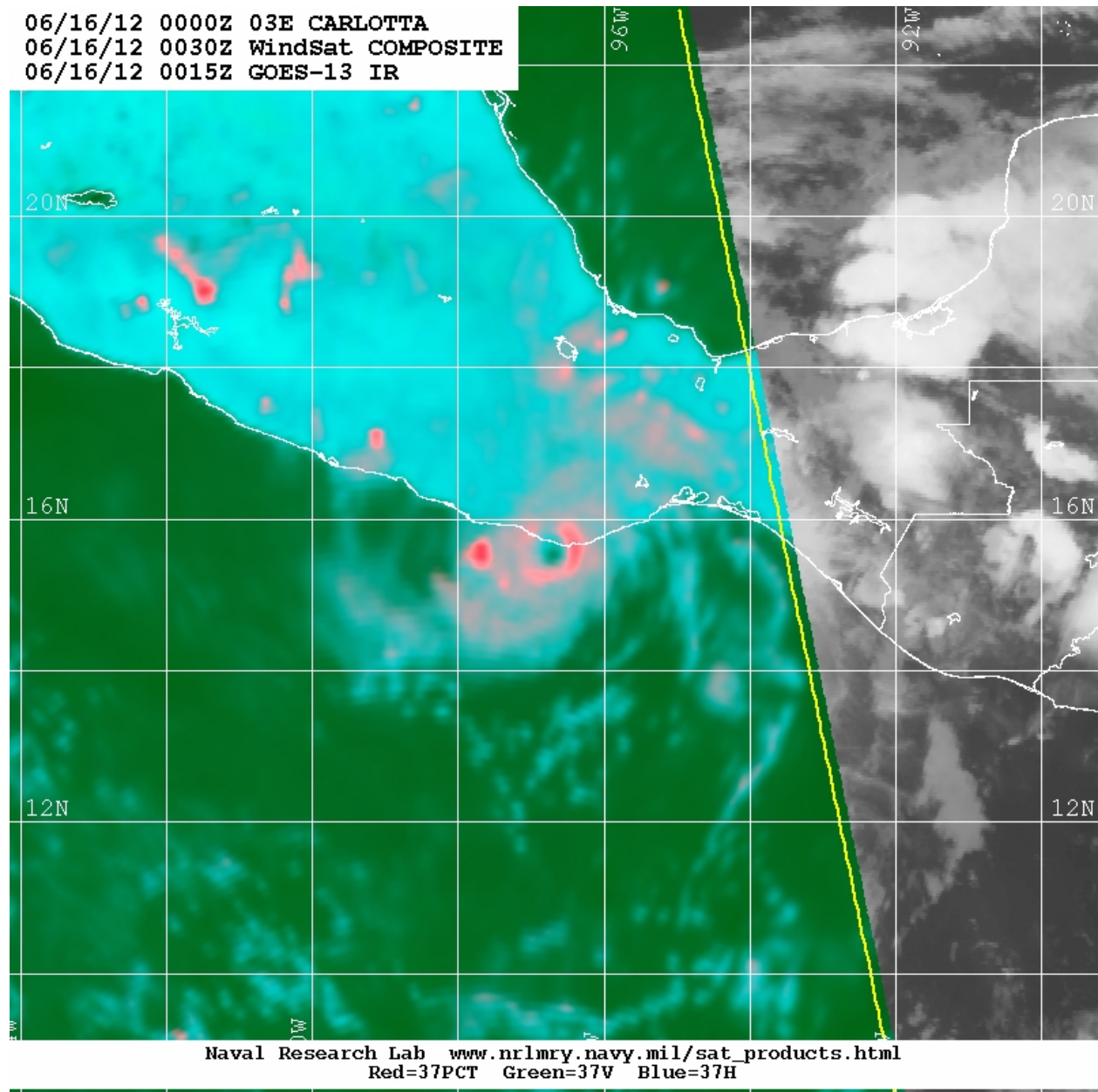


Figure 4. WindSat 37-GHz color composite image of Hurricane Carlotta at 0030 UTC 16 June 2012, very near the time of landfall. Image courtesy of the Naval Research Laboratory.