



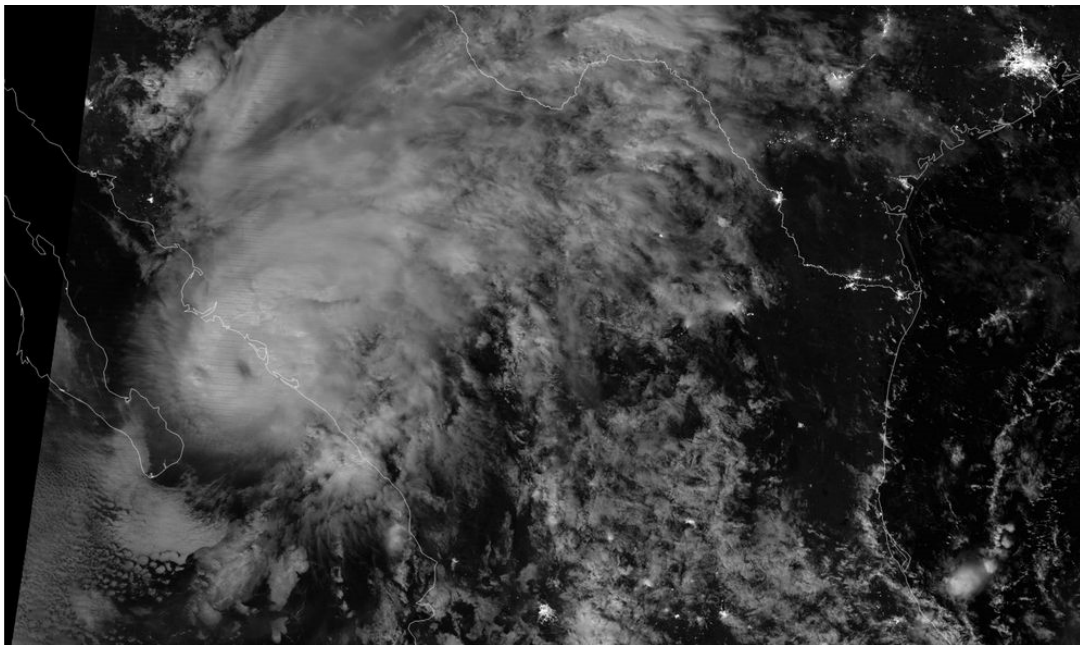
# NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

## HURRICANE MANUEL (EP132013)

13 – 19 September 2013

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(revised 14 April 2014 for the death toll in Mexico)



HURRICANE MANUEL NEAR PEAK INTENSITY, 0937 UTC 19 SEPTEMBER, SHORTLY BEFORE LANDFALL IN MEXICO AS SHOWN BY THE SUOMI NPP VIIRS DAY/NIGHT BAND. CREDIT: NASA

Manuel was a category 1 hurricane (on the Saffir-Simpson Hurricane Wind Scale) that made landfall as a tropical storm on the southern coast of Mexico, and dissipated. It then reformed in the Gulf of California and made a second landfall in Mexico as a hurricane. Manuel was responsible for widespread flooding and mud slides, resulting in 123 deaths in Mexico. Manuel was the first eastern North Pacific tropical cyclone since records began in 1949 to make landfall in mainland Mexico, redevelop over water, and go on to become a hurricane.

# Hurricane Manuel

13 – 19 SEPTEMBER 2013

## SYNOPTIC HISTORY

Manuel developed from a tropical wave that moved off the west coast of Africa in late August, entered the Caribbean Sea around 5 September, and crossed Central America on 10–11 September. While the northern portion of the wave spawned Hurricane Ingrid in the Bay of Campeche on 12 September, the southern portion became less pronounced after moving into the eastern Pacific basin. Widespread deep convection and a broad surface trough persisted, however. A surge of low-level southwesterly winds near the southern coast of Mexico, likely associated with a broad clockwise near-equatorial gyre over the far eastern Pacific, began late on 12 September. This southwesterly flow may have contributed to the initiation of a concentrated convective burst that began around 0000 UTC 13 September within the broad trough. The convective burst resulted in the development of a well-defined surface circulation and a tropical depression by 1200 UTC that day, centered about 275 n mi southeast of Manzanillo, Mexico. The cyclone strengthened and became a tropical storm by 1800 UTC 13 September. 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<sup>1</sup>

Manuel initially moved slowly northwestward before slowing down and turning toward the north-northeast on 14 September, in response to the weakening of a mid-level ridge over central Mexico and the close proximity of Hurricane Ingrid, located about 550 n mi to the northeast. A gradual turn back toward the northwest followed while Manuel accelerated a little and steadily strengthened. The tropical storm reached an intensity of 60 kt before making landfall in the state of Michoacán, near Pichilinguillo, around 1200 UTC 15 September (Fig. 4). The tropical storm then moved almost parallel to the coast for several hours, and passed very near Manzanillo. Although the circulation center aloft appeared to move well inland after passing Manzanillo, it is unclear exactly how far inland the surface center penetrated. Regardless, Manuel quickly weakened while a substantial portion of the circulation interacted with the high terrain of the states of Jalisco and Colima. The tropical storm brought very heavy rains to a large portion of southwestern Mexico, resulting in deadly flash flooding and mud slides that persisted even as the circulation weakened. Satellite and surface observations indicate that Manuel degenerated into a weak low-level trough by 0600 UTC 16 September.

Although the surface circulation had dissipated, the mid-level circulation and low-level trough continued to move northwestward around a low- to mid-level ridge over the northern Gulf of Mexico and southeastern United States. The remnants of Manuel emerged over the southern

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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 *bt* directory, while previous years’ data are located in the *archive* directory.

Gulf of California around 1800 UTC 16 September, and convective activity began to increase shortly thereafter. A well-defined surface circulation redeveloped by 1800 UTC 17 September, about 150 n mi east of Cabo San Lucas, Mexico, and Manuel once again became a tropical depression. The depression began moving slowly northwestward around the southwestern periphery of the ridge to the northeast. The cyclone was located in an environment that was highly conducive for intensification, with very high sea surface temperatures and low vertical wind shear. Convective activity increased and became organized in spiral bands after 0600 UTC 18 September, and a period of rapid intensification followed. An intermittent eye-like feature appeared in visible satellite imagery later on 18 September, and it is estimated that Manuel reached its peak intensity of 65 kt at 0000 UTC 19 September. The period of rapid intensification ended as Manuel approached land, and Manuel maintained its intensity for 12 h until it made landfall just west of Culiacán, Mexico at 1200 UTC 19 September (Fig. 5). The second landfall of Manuel was associated with additional flash flooding and mud slides in Mexico. The hurricane quickly weakened after landfall, and degenerated into a broad area of low pressure over the Sierra Madre Occidental mountain range shortly after 1800 UTC 19 September.

## METEOROLOGICAL STATISTICS

Observations in Manuel (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. 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 Manuel.

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

### *Winds and Pressure*

Manuel's estimated peak intensity of 65 kt is based on a Dvorak estimate of 65 kt from TAFB. Even though the Dvorak classifications from TAFB and SAB corresponded to intensities of 65 and 55 kt, respectively, prior to both landfalls, Manuel is estimated to have reached a higher intensity in the Gulf of California based on the presence of a ragged eye in visible satellite imagery.

## Rainfall and Flooding

Manuel produced very heavy rainfall over portions of Mexico, and contributed to a major rainfall event that affected nearly the entire country between 12 and 20 September 2013 (Fig. 6). The combination of Hurricane Ingrid, Hurricane Manuel, and the moist southwesterly flow that contributed to the genesis of Manuel resulted in very high precipitation totals, especially in mountainous coastal locations. Figure 6 shows a fairly clear separation between the rainfall due to Ingrid over the northeastern states and the rainfall produced by Manuel in the western states. However, there is no clear separation between the rainfall produced by Hurricane Manuel and the rainfall due to the large-scale southwesterly flow over southern Mexico. Satellite observations suggest that locations along the Pacific coast from the state of Oaxaca eastward were well removed from the outer rainbands of Manuel, so those rainfall totals were likely not directly associated with Manuel. Total rainfall accumulations for the period 12-20 September are given in Table 3, and are from the state of Michoacán westward and northward since it is believed that most, if not all, of the rainfall in these locations can be directly attributed to Manuel. Rainfall totals in excess of 10 inches were observed in a number of locations and there was one total, measured in the vicinity of Acapulco, of 43.6 inches.

## CASUALTY AND DAMAGE STATISTICS

According to a report from the Meteorological Service of Mexico and the Mexican Civil Protection agency, 123 deaths in Mexico have been attributed to Manuel. At least 104 of these were direct deaths<sup>2</sup>. Nearly all of these deaths were the result of heavy rains, especially in mountainous areas. At least 97 direct deaths occurred in the state of Guerrero, many of which occurred when a mud slide destroyed nearly half of the village of La Pintada. Two people in Acapulco were killed due to the collapse of a building and a wall. In the state of Jalisco, two men were swept away by flash floods, a man drove a car into a flooded ravine, and a 12 year-old boy fell into a flooded dam and drowned. In the state of Sinaloa, a fisherman fell off a boat and drowned, and a trucker drove into a flooded canal. A five year old child was also drowned after being swept away in a flooded canyon. The child's mother was reported missing.

Based on reports from AON Benfield and Eqecat, Inc., estimates of total insured losses due to Manuel range from \$200 to 685 million (US). The total economic impact is estimated to be around \$4.2 billion (US), with the biggest losses occurring in Guerrero.

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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.

## FORECAST AND WARNING CRITIQUE

The genesis of Manuel was not particularly well forecast. An area of low pressure was introduced into the Tropical Weather Outlook (TWO) with a 20% chance of formation in 5 days at 1800 UTC 7 September. However, the probabilities were lowered over the next couple of days, and the system was removed from the TWO at 1200 UTC September 9. It was not reintroduced until 0000 UTC 11 September, at which time it was again given a 20% chance of formation in 5 days. The lead time provided for each genesis likelihood category, beginning with the time that the system was reintroduced into the TWO, is given in the table below.

	Hours Before Genesis	
	48-Hour Outlook	120-Hour Outlook
Low (<30%)	42	60
Medium (30%-50%)	18	18
High (>50%)	6	12

The decision to remove the precursor disturbance from the TWO at 1200 UTC September 9 was based primarily on the National Centers for Environmental Prediction’s Global Forecast System (GFS) deterministic model. After several consecutive longer range (5 - 7 day) forecasts which suggested genesis might occur near 100°W, the model predictions changed after 1800 UTC 8 September. Genesis was instead forecast to occur in 120-178h, near the Gulf of Tehuantepec. The European Centre for Medium-Range Forecasts (ECMWF) deterministic model did not show very much likelihood for genesis before or after that time. After 10 September, forecasts from United Kingdom Meteorology Office (UKMET) also suggested that genesis was less likely. The GFS, ECMWF, and UKMET models didn’t consistently forecast genesis until 11 September, coinciding with the reintroduction of the system in the TWO.

The second genesis was also poorly forecast, even though the last couple of Tropical Cyclone Discussions before the first dissipation of Manuel mentioned the possibility of reformation in a couple of days. Manuel’s remnants were officially introduced into the TWO with a low chance of development in 48 h at 1200 UTC 16 September, the first forecast issued after tropical cyclone advisories were discontinued. Although the environment was seemingly favorable for genesis, the genesis probabilities were low because it is very rare for systems to redevelop in the Gulf of California after interacting with the high terrain of Jalisco and Colima. Genesis forecasts first reached the indicated likelihood categories with lead times as shown in the table below.

	Hours Before Genesis	
	48-Hour Outlook	120-Hour Outlook
Low (<30%)	30	30
Medium (30%-50%)	6	6
High (>50%)	0	0

A verification of NHC official track forecasts for Hurricane Manuel is given in Table 4a. Official forecast track errors were slightly lower than the mean official errors for the previous 5-yr period, except at the 48-h period. Although the mean forecast errors were small, the first four official forecasts after the second genesis of Manuel incorrectly called for the cyclone to turn toward the west and make landfall in Baja California Sur, largely based on forecasts from the GFS and ECMWF global models (Fig. 7). Despite this, the mean forecast error was low because the cyclone dissipated very quickly after making landfall, and forecasts valid at times after dissipation are not included in the verification. A homogeneous comparison of the official track errors with selected guidance models is given in Table 4b. It should be noted that the sample size for this verification is very small, especially at 36 h (3 forecasts) and 48 h (1 forecast). Several of the global dynamical models produced forecasts with very low errors; however, none of the models consistently outperformed the official forecast.

A verification of NHC official intensity forecasts for Manuel is given in Table 5a. Official intensity forecast errors were greater than the mean official errors for the previous 5-yr period in the 12- and 24-h period, and lower than the mean official errors after that. The high errors in the 12- and 24-h forecasts can in part be attributed to the rapid intensification of Manuel. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 5b. Most of the models performed poorly, struggling to properly capture the rapid intensification of Manuel and the rapid weakening that occurred after both landfalls.

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

## ACKNOWLEDGEMENTS

We are grateful to Dr. René Lobato Sánchez and his team at the National Meteorological Service of Mexico, who provided the individual rainfall totals and produced the accompanying total accumulated rainfall graphic.



Table 1. Best track for Hurricane Manuel, 13-19 September 2013.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
13 / 1200	15.3	101.4	999	30	tropical depression
13 / 1800	15.3	101.9	998	35	tropical storm
14 / 0000	15.4	102.2	997	40	"
14 / 0600	15.5	102.3	995	45	"
14 / 1200	15.9	102.1	993	45	"
14 / 1800	16.4	102.1	990	50	"
15 / 0000	17.0	102.2	987	55	"
15 / 0600	17.6	102.6	984	60	"
15 / 1200	18.2	103.2	985	60	"
15 / 1800	18.9	104.0	996	45	"
16 / 0000	19.6	104.7	1000	30	tropical depression
16 / 0600	20.2	105.2	1002	25	disturbance
16 / 1200	20.6	105.5	1003	25	"
16 / 1800	21.0	105.8	1004	20	"
17 / 0000	21.4	106.1	1004	20	"
17 / 0600	21.8	106.4	1003	20	"
17 / 1200	22.2	106.8	1002	25	"
17 / 1800	22.5	107.2	1001	30	tropical depression
18 / 0000	22.7	107.5	1000	30	"
18 / 0600	22.9	107.7	998	35	tropical storm
18 / 1200	23.2	107.9	995	45	"
18 / 1800	23.6	108.1	989	55	"
19 / 0000	24.1	108.2	984	65	hurricane
19 / 0600	24.5	108.2	983	65	"
19 / 1200	24.8	108.0	984	65	"
19 / 1800	25.3	107.6	999	40	tropical storm



20 / 0000					dissipated
19 / 0600	24.5	108.2	983	65	Minimum pressure and maximum winds
15 / 1200	18.2	103.2	985	60	Landfall near Pichilinguillo, Mexico
19 / 1200	24.8	108.0	984	65	Landfall near Culiacán, Mexico





Table 2. Selected ship reports with winds of at least 34 kt for Hurricane Manuel, 13-19 September 2013.

<b>Date/Time (UTC)</b>	<b>Ship call sign</b>	<b>Latitude (°N)</b>	<b>Longitude (°W)</b>	<b>Wind dir/speed (kt)</b>	<b>Pressure (mb)</b>
<b>13 / 1800</b>	DFZB2	16.6	101.1	090 / 35	1001.5
<b>14 / 0800</b>	DFZB2	14.6	97.1	200 / 35	1005.0
<b>14 / 1200</b>	DGDD	16.8	102.7	040 / 40	997.1
<b>14 / 1800</b>	WDG855	17.0	101.2	120 / 45	999.0
<b>15 / 0000</b>	A8HS3	13.9	99.6	220 / 35	1006.3

Table 3. Selected surface observations for Hurricane Manuel, 13-19 September 2013.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			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>Guerrero</b>						
San Isidro, Protección Civil (16.91°N 99.93°W)						43.60
Acapulco (16.76°N 99.93°W)						17.80
Huamuxtitlán (17.81°N 98.57°W)						12.90
Puerto Vicente (17.27°N 101.01°W)						11.18
Las Flores (16.69°N 99.56°W)						7.06
Cocula (18.26°N 99.65°W)						5.82
Iguala (18.36°N 99.52°W)						5.31
<b>Morelos</b>						
Jojutla (18.60°N 99.20°W)						7.02
Zacatepec Observatory (18.64°N 99.21°W)						6.74
Presa El Rodeo (18.80°N 99.40°W)						6.58
Moyotepec (18.73°N 99.00°W)						6.08
Cuernavaca Observatory (18.93°N 99.23°W)						5.06
<b>México</b>						
Texcaltitlán (18.93°N 99.94°W)						6.33
Totolica (19.45°N 99.28°W)						5.66
El Molinito, Naucalpan (19.45°N 99.24°W)						5.08
<b>Michoacán</b>						
La Villita (18.05°N 102.18°W)						22.11
Lázaro Cárdenas (17.94°N 102.18°W)						14.79
Piedras Blancas (19.25°N 102.77°W)						6.48



Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Total rain (in) <sup>c</sup>
	Date/time (UTC)	Press. (mb)	Date/time (UTC) <sup>a</sup>	Sustained (kt) <sup>b</sup>	Gust (kt)	
Zicuiran (18.92°N 101.93°W)						5.87
Apatzingán (19.08°N 102.37°W)						5.08
<b>Colima</b>						
Peñitas (19.27°N 103.82°W)						12.67
El Chanal (19.30°N 103.70°W)						12.31
El Trapiche (19.28°N 103.67°W)						11.87
Comala (19.32°N 103.76°W)						11.86
Buenavista (19.25°N 103.61°W)						10.89
Tecomán (18.93°N 103.88°W)						10.33
Jala (19.11°N 103.88°W)						8.52
Cerro de Ortega (18.75°N 103.72°W)						7.77
Cuauhtémoc (19.32°N 103.60°W)						6.45
Laguna de Amela (18.90°N 103.87°W)						5.61
Manzanillo (19.04°N 104.32°W)						5.22
<b>Jalisco</b>						
Cajón de Peña (20.03°N 105.07°W)						9.69
Ciudad Guzmán (19.73°N 103.47°W)						7.03
El Cuale (20.58°N 105.05°W)						6.95
<b>Nayarit</b>						
Pajaritos (22.38°N 105.02°W)						8.60
Acaponeta (22.48°N 105.40°W)						6.13
<b>Durango</b>						
Presas Caboraca (24.52°N 104.80°W)						6.78
Peña del Águila (24.24°N 104.66°W)						6.04



Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Total rain (in) <sup>c</sup>
	Date/time (UTC)	Press. (mb)	Date/time (UTC) <sup>a</sup>	Sustained (kt) <sup>b</sup>	Gust (kt)	
Santiago Bayacora (23.87°N 104.67°W)						5.39
<b>Sinaloa</b>						
Culiacán (24.82°N 107.40°W)						18.52
Sanalona (24.81°N 107.15°W)						15.32
Humaya (125.10°N 107.158°W)						14.39
Culiacán Observatory (24.63°N 107.44°W)						12.97
San Juan (25.30°N 107.50°W)						8.93
Adolfo López Mateos (25.09°N 107.39°W)						8.32
Mazatlán Observatory (23.22°N 106.41°W)						8.22
Vinoramas (24.75°N 107.06°W)						8.19
Badiraguato (25.33°N 107.54°W)						8.09
Presa Derivadora Andrew Weiss (25.03°N 107.47°W)						7.93
Mazatlán (23.23°N 106.40°W)						7.49
Guatenipa (25.34°N 107.22°W)						7.44
Guamúchil, Presa Eustaquio Buelna (25.47°N 108.08°W)						6.26
<b>Chihuahua</b>						
Parral (26.92°N 105.68°W)						8.94
Hidalgo del Parral Observatory (26.92°N 105.67°W)						8.65
Melchor Ocampo (28.95°N 105.30°W)						6.03

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

<sup>b</sup> Except as noted, sustained wind averaging periods for C-MAN and land-based reports are 2 min; buoy averaging periods are 8 min.

<sup>c</sup> Rainfall totals are total accumulated precipitation 12-20 September 2013.

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Manuel 13-19 September 2013. 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	<b>22.4</b>	<b>36.4</b>	<b>53.5</b>	78.4			
OCD5	36.6	77.8	121.6	150.9			
Forecasts	16	12	8	4			
OFCL (2008-12)	27.0	43.1	57.8	71.9			
OCD5 (2008-12)	37.4	73.0	114.9	158.3			

Table 4b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Manuel 13-19 September 2013. 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	22.8	26.4	22.4	45.4			
OCD5	37.2	86.6	146.1	144.5			
GFSI	<b>20.5</b>	52.1	75.7	<b>45.3</b>			
GHMI	32.4	31.1	36.9	88.4			
HWFI	31.6	43.1	95.5	159.3			
EMXI	24.9	44.2	24.9	<b>20.8</b>			
CMCI	40.0	57.6	65.5	<b>17.0</b>			
AEMI	<b>22.2</b>	41.5	32.6	<b>13.3</b>			
FSSE	<b>19.9</b>	32.1	<b>21.3</b>	<b>29.0</b>			
TVCN	<b>18.2</b>	<b>22.7</b>	32.7	57.1			
LBAR	27.4	52.6	71.5	<b>30.0</b>			
BAMS	25.9	37.6	54.8	80.1			
BAMM	27.9	50.9	54.6	<b>29.0</b>			
BAMD	27.9	50.8	61.1	<b>29.4</b>			
Forecasts	10	4	3	1			

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Manuel 13-19 September 2013. 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	7.5	12.1	<b>11.3</b>	<b>13.8</b>			
OCD5	10.4	16.3	15.4	19.3			
Forecasts	16	12	8	4			
OFCL (2008-12)	6.3	10.5	13.4	14.5			
OCD5 (2008-12)	7.6	12.5	16.5	18.8			

Table 5b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Manuel 13-19 September 2013. 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	7.5	5.8	6.7	7.5			
OCD5	9.8	13.3	<b>5.7</b>	26.0			
GHMI	10.1	12.5	21.7	11.0			
HWFI	11.3	20.0	31.3	29.0			
EMXI	11.3	15.2	13.3	8.0			
DSHP	9.7	11.0	8.0	10.5			
LGEM	11.2	8.7	<b>6.0</b>	11.5			
FSSE	8.3	6.3	10.0	7.5			
IVCN	9.3	12.7	13.3	10.0			
Forecasts	12	6	3	2			



Table 6. Watch and warning summary for Hurricane Manuel, 13-19 September 2013.

<b>Date/Time (UTC)</b>	<b>Action</b>	<b>Location</b>
13 / 1500	Tropical Storm Warning issued	Acapulco to Lázaro Cárdenas
13 / 2100	Tropical Storm Warning modified to	Acapulco to Punta San Telmo
14 / 0900	Tropical Storm Warning modified to	Acapulco to Manzanillo
15 / 0300	Tropical Storm Warning modified to	Acapulco to Lázaro Cárdenas
15 / 0300	Hurricane Warning issued	Lázaro Cárdenas to Manzanillo
15 / 1500	Tropical Storm Watch issued	Manzanillo to Cabo Corrientes
15 / 1800	Tropical Storm Warning discontinued	Acapulco to Lazaro Cardenas
15 / 1800	Tropical Storm Warning issued	Zihuatanejo to Manzanillo
15 / 1800	Hurricane Warning discontinued	All
15 / 0300	Tropical Storm Watch discontinued	All
15 / 0300	Tropical Storm Warning discontinued	All
17 / 2100	Tropical Storm Watch issued	Mazatlán to Altata
17 / 2100	Tropical Storm Watch issued	Cabo San Lucas to San Evaristo
18 / 1500	Tropical Storm Watch discontinued	Mazatlán to Altata
18 / 1500	Tropical Storm Warning issued	Mazatlán to Topolobampo
18 / 1800	Hurricane Watch issued	La Cruz to Topolobampo
18 / 2100	Hurricane Watch changed to Hurricane Warning	La Cruz to Topolobampo
18 / 2100	Tropical Storm Warning modified to	Mazatlán to La Cruz
19 / 0300	Tropical Storm Watch discontinued	Cabo San Lucas to San Evaristo
19 / 0300	Tropical Storm Watch issued	Topolobampo to Huatabampito
19 / 0300	Tropical Storm Warning discontinued	All
19 / 1500	Tropical Storm Watch discontinued	All
19 / 1800	Hurricane Warning changed to Tropical Storm Warning	La Cruz to Topolobampo
19 / 2100	Tropical Storm Warning discontinued	All



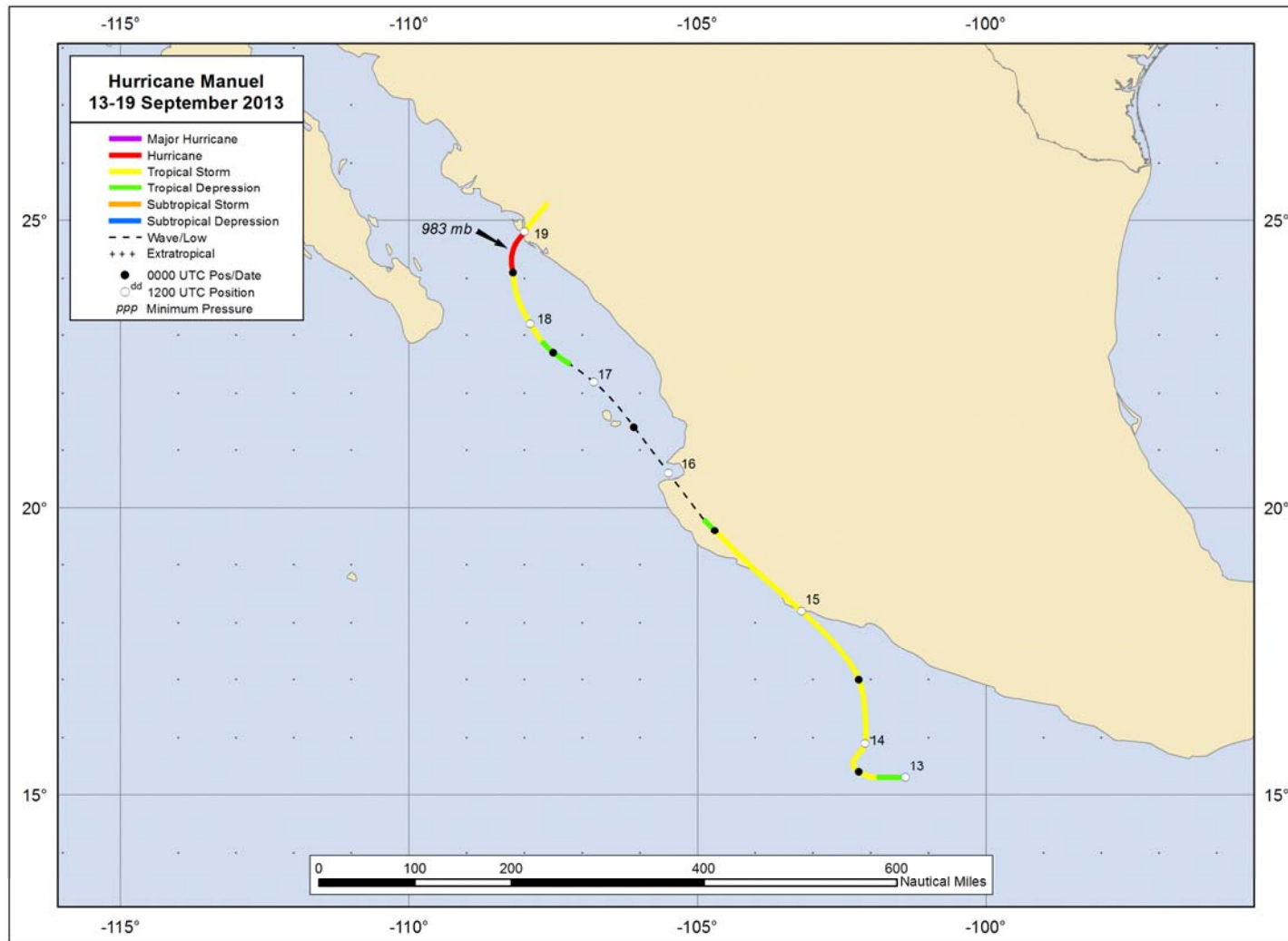


Figure 1. Best track positions for Hurricane Manuel, 13-19 September, 2013.

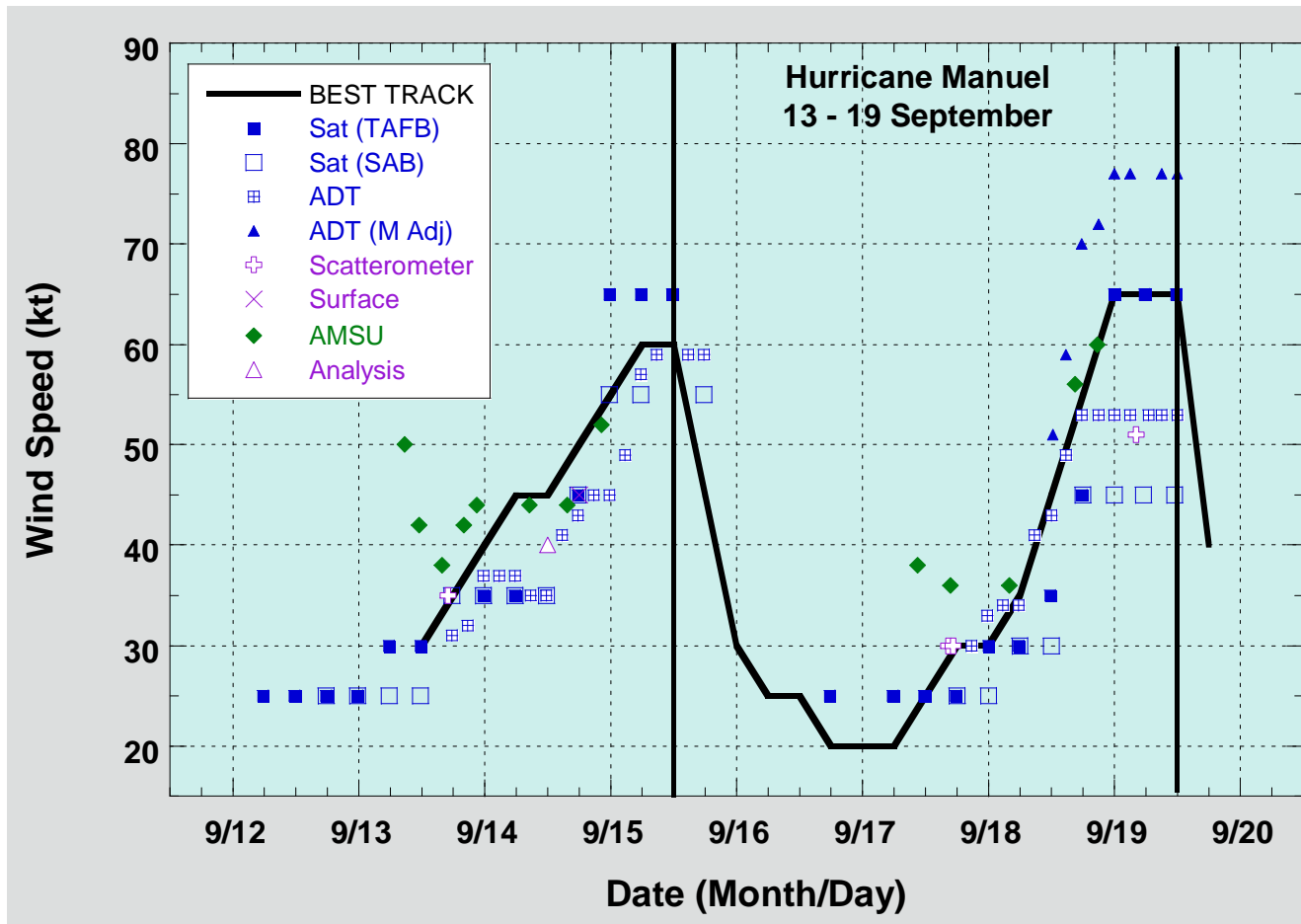


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Manuel, 13-19 September 2013. Advanced Dvorak Technique (ADT) estimates represent the Current Intensity at the nominal observation time. The ADT was re-run during post storm analysis to account for two microwave passes that were not available in real-time. The original and adjusted ADT values are both plotted here. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC, and solid vertical lines correspond to landfalls.

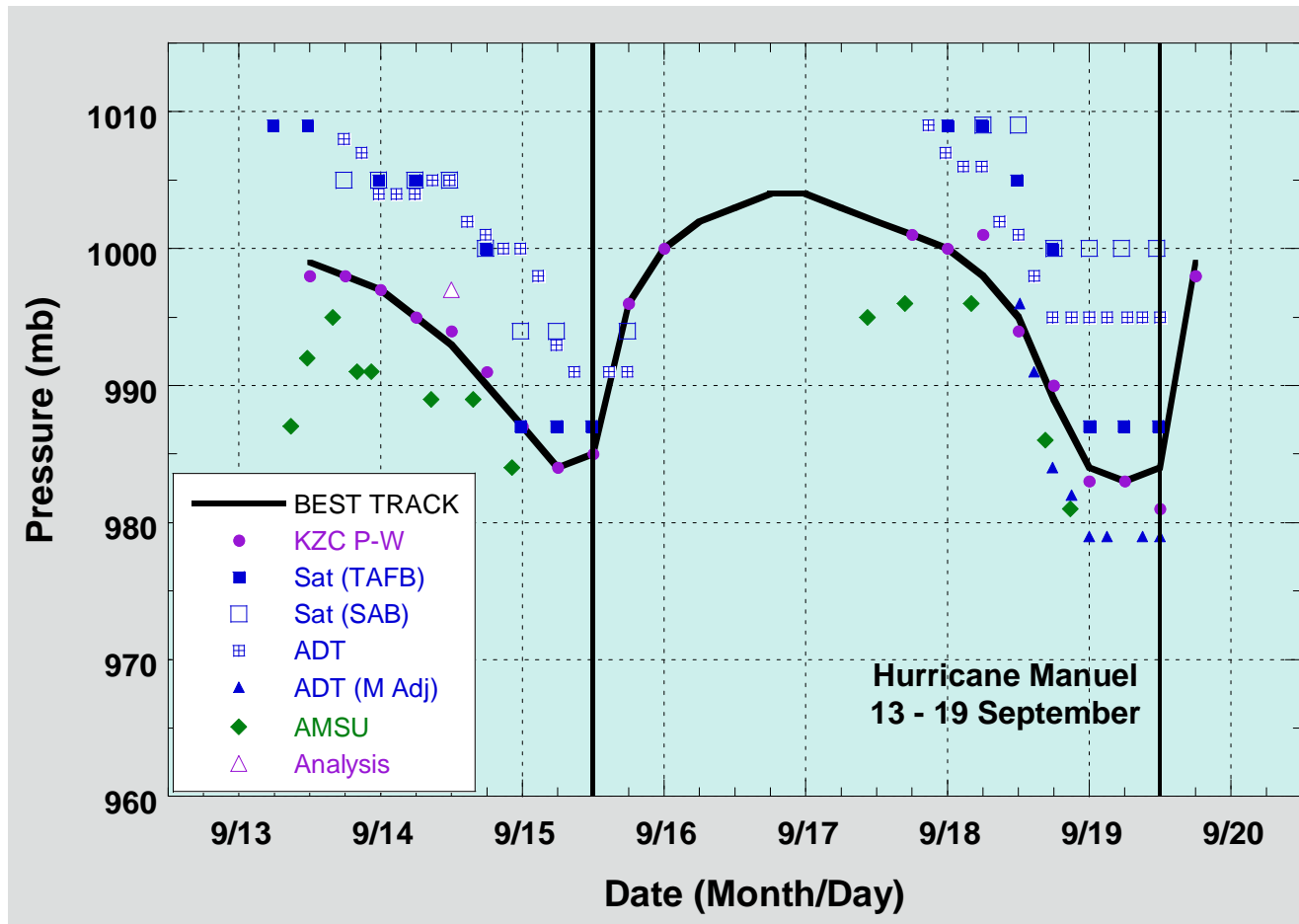


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Manuel, 13-19 September 2013. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. The ADT was re-run during post storm analysis to account for two microwave passes that were not available in real-time. The original and adjusted ADT values are both plotted here. 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 solid vertical lines correspond to landfalls.

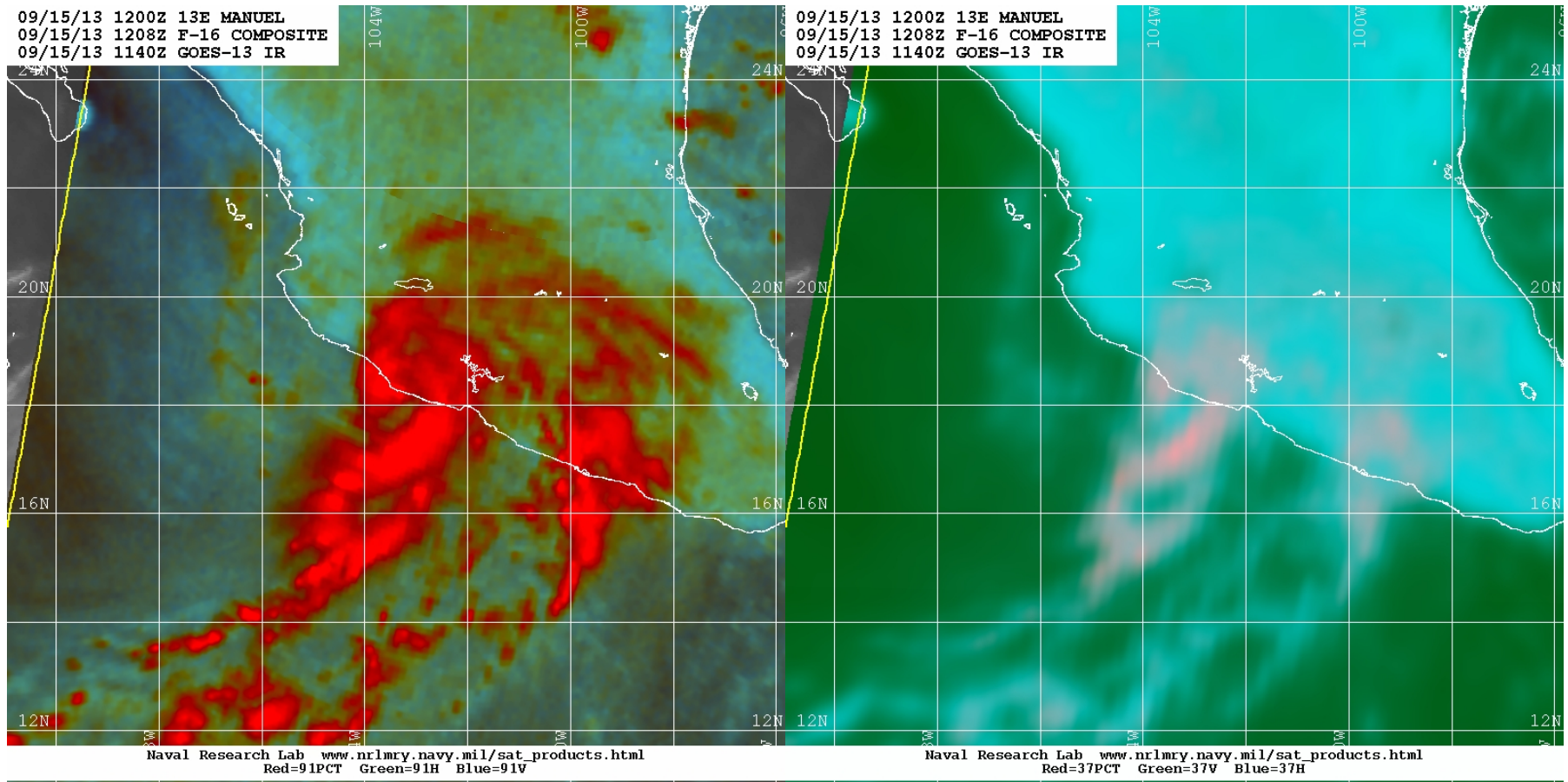


Figure 4. Composite 91 GHz (left) and 37GHz (right) SSM/I/S microwave image showing the first landfall of Manuel at 1200 UTC 15 September. A slight separation between the mid-level (left) and low level (right) centers is already visible. Images courtesy of the Naval Research Laboratory, Monterey, California.

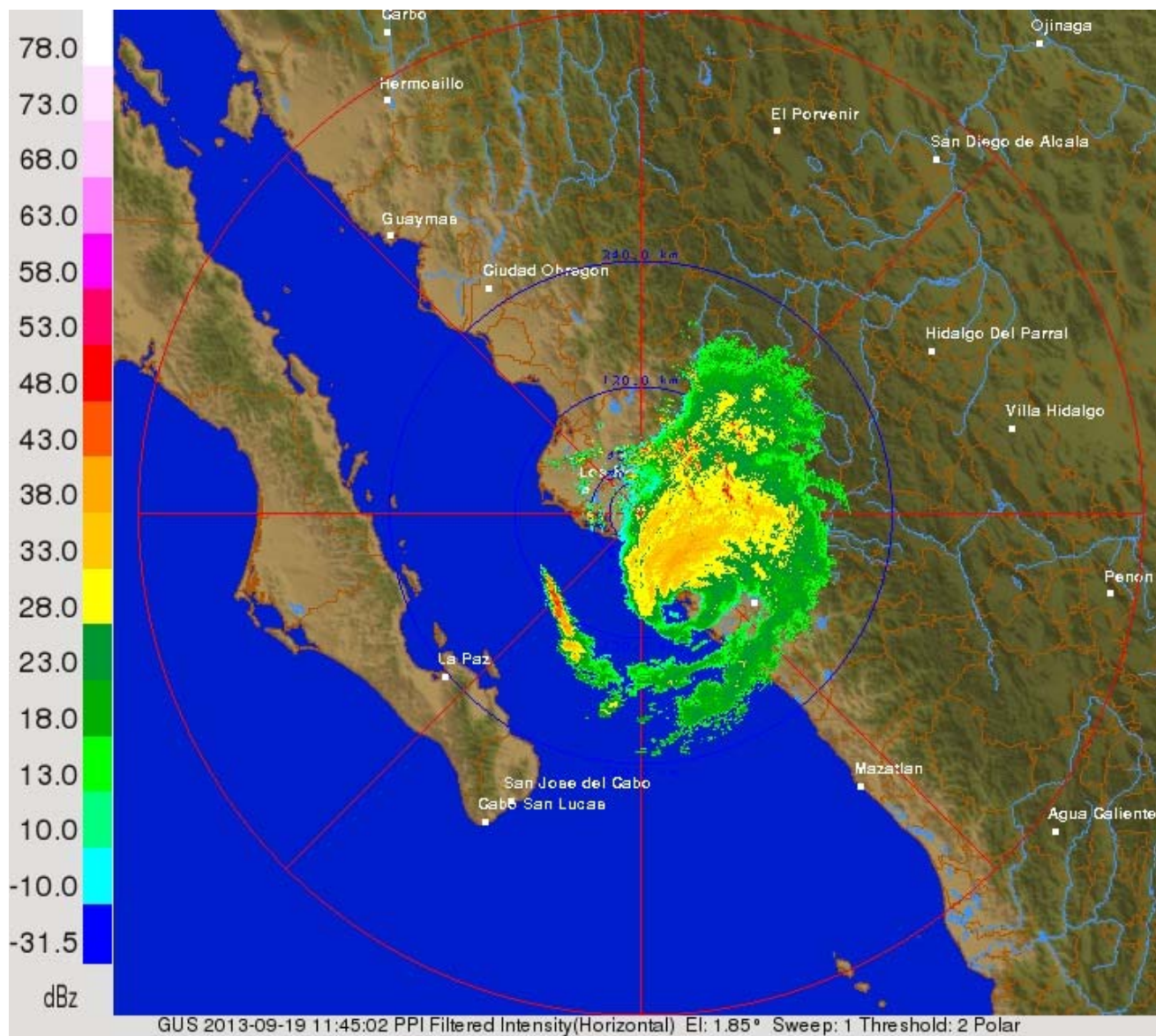


Figure 5. 1145 UTC 19 September radar image from Guasave, Mexico, showing the second landfall of Hurricane Manuel. A ragged eye was present at the time of landfall. Image courtesy of the National Meteorological Service of Mexico.

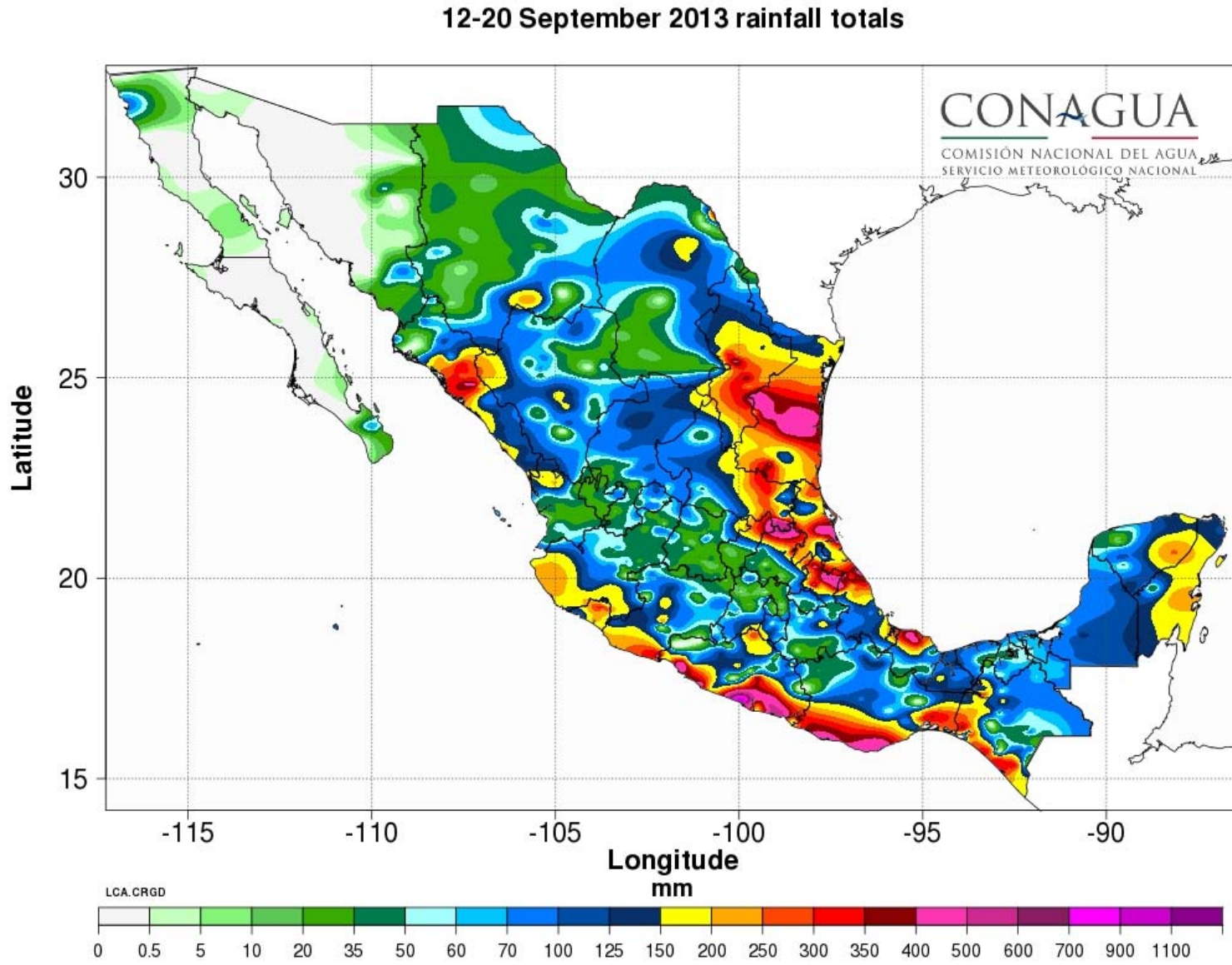


Figure 6. Total rainfall (in mm) 12 – 20 September 2013. Image provided by the National Meteorological Service of Mexico.

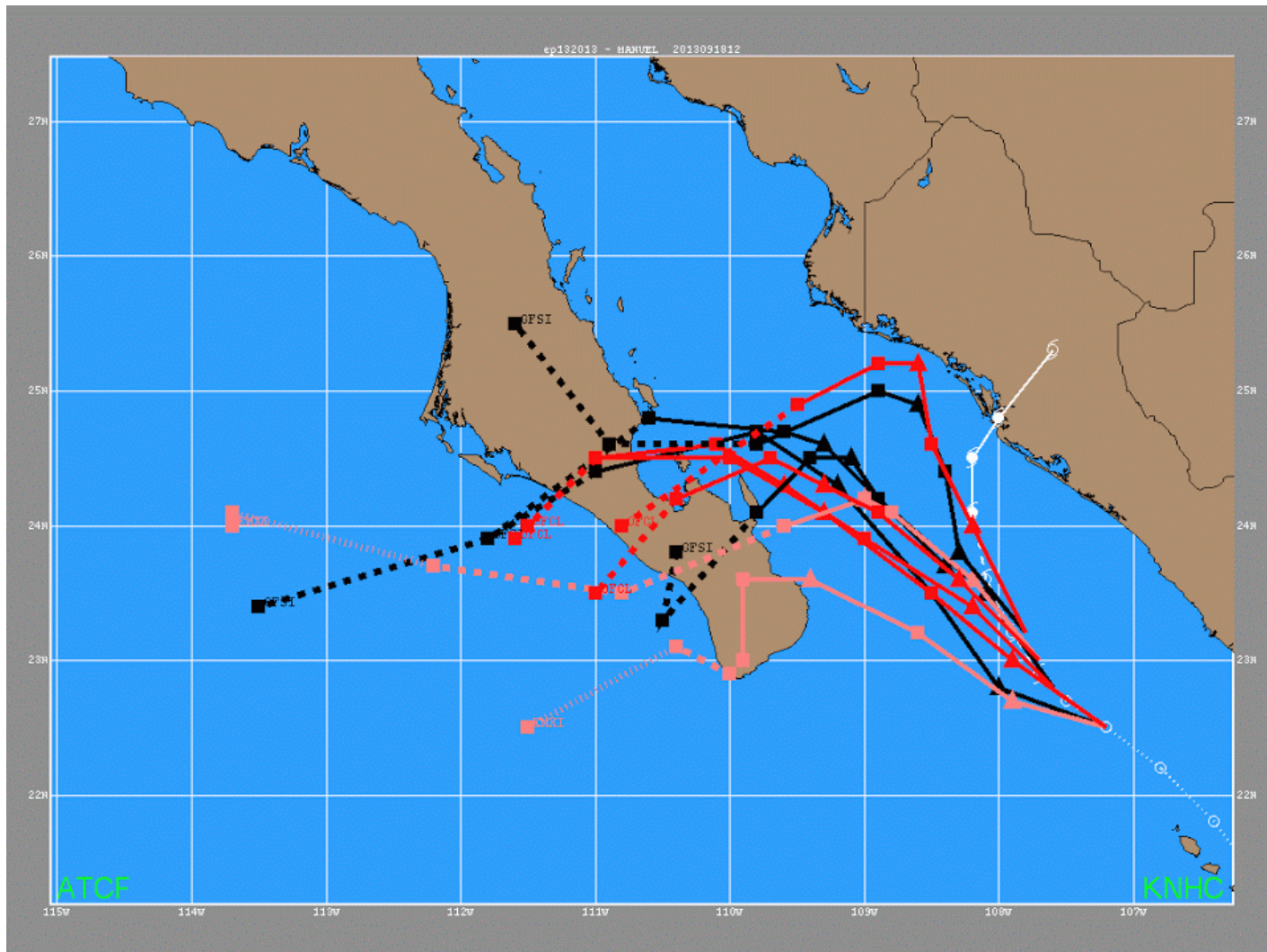


Figure 7. Track forecasts from 17 September 1800 UTC through 18 September 1200 UTC. The official forecast is shown in red, the ECMWF is in orange, and the GFS is in black. The actual track of Manuel is shown in white.