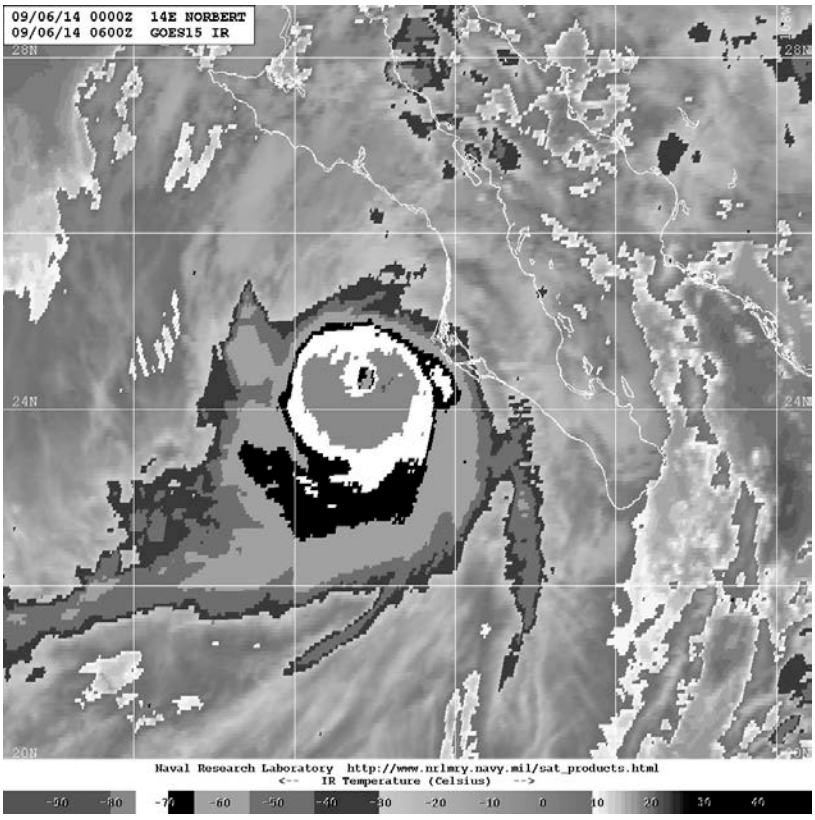
NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

HURRICANE NORBERT

EP142014

2 – 8 September 2014

Lixion A. Avila
National Hurricane Center
25 November 2014



NOAA GOES 13 INFRARED SATELLITE IMAGE AT 0600 UTC 6 JUNE 2014 OF HURRICANE NORBERT AROUND THE TIME OF ITS PEAK INTENSITY. IMAGE COURTESY OF THE U.S. NAVY RESEARCH LABORATORY.

Norbert was a category 3 hurricane (on the Saffir-Simpson Hurricane Wind Scale), the sixth major hurricane of the 2014 eastern North Pacific season. It spent most of its life moving parallel to the west coast of Mexico and the Baja California Peninsula

Hurricane NORBERT

2 – 8 SEPTEMBER 2014

SYNOPTIC HISTORY

A tropical wave moved off the west coast of Africa on 18 August, and traveled westward for nearly ten days across the tropical Atlantic and the Caribbean Sea with intermittent and disorganized shower activity. Once the wave reached the eastern North Pacific basin on 31 August the convection increased, but remained disorganized until the system reached the eastern North Pacific Intertropical Convergence Zone (ITCZ) on 1 September. A broad low pressure area formed early on 2 September a couple hundred miles southwest of Manzanillo, Mexico, with most of the associated thunderstorm activity located to the south and west of the low due to strong northeasterly wind shear. There was a large area of 30- to 35- kt winds well to the south of the area of minimum pressure, but these winds were primarily associated with the large-scale flow and not directly associated with the disturbance. The system began to move toward the north-northeast and despite the strong shear, a well-defined circulation center formed near 0000 UTC 2 September just north of an area of deep convection. Some banding features began to develop about that time, and it is estimated that a tropical storm formed at 1200 UTC 2 September, about 180 n mi south-southwest of Cabo Corrientes, Mexico. The "best track" chart of Norbert'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].

Initially, the cyclone moved northward away from the ITCZ, and it then encountered a mid-level high pressure system centered over northern Mexico, which forced Norbert to turn westward for about 12 to 24 hours away from the southwestern coast of Mexico. The eastern Pacific Ocean was warmer than normal in that region, and the northeasterly shear that was affecting the storm abated. This resulted in intensification, and is estimated that the cyclone became a hurricane at 0000 UTC 4 September about 250 n mi west of Cabo Corrientes. The hurricane moved toward the northwest on a track parallel to the Baja California peninsula around the southwestern periphery of a high pressure system over Mexico, and slowly strengthened for a couple of days.

Norbert quickly intensified around 0000 UTC 6 September, when the hurricane developed a distinct eye. It is estimated that Norbert reached its peak intensity of 110 kt and a minimum central pressure of 950 mb at 0600 UTC that day, about 50 n mi west-southwest of Cabo San Lazaro (cover image). This intensification occurred despite the hurricane was reaching a dry and stable environment. After that time, Norbert became even more deeply embedded within the dry and hostile environment and weakened. The decay was quite abrupt while the cyclone continued northwestward over increasingly cooler waters, and by 0000 UTC 8 September, most of the convection had dissipated and Norbert became a remnant low. The low became embedded within

[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.

a light steering flow and meandered about 200 n mi west of Punta Eugenia for a couple of days until dissipating by 0600 UTC 11 September.

METEOROLOGICAL STATISTICS

Observations in Hurricane Norbert (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 Hurricane Norbert. In addition, the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command flew into Norbert on 4 and 5 September. Observations from these flights were crucial in determining the structure and strength of the cyclone. During the mission on 4 September, the inner core of the hurricane was not well organized and the reconnaissance plane did not report an eyewall feature. During the mission the following day, the crew reported a circular eye of 30 n mi in diameter. The flight-level winds, however, increased only by 10 kt between the two flights. The estimated peak intensity of Norbert of 110 kt is based on a blend of subjective Dvorak classifications and objective ADT estimates of 115 kt.

Ship reports of winds of tropical storm force associated with Hurricane Norbert are given in Table 2.

CASUALTY AND DAMAGE STATISTICS

Press reports indicate that Norbert caused three casualties[2] in Mexico after individuals were swept away by swollen creeks from heavy rainfalls in the Baja California peninsula. Heavy rains also occurred over western Mexico from Norbert's outer bands (Fig 4). Although the core of the hurricane was over the ocean, media reports indicated that rains and high surf produced by Norbert damaged more than 1000 homes. The high surf and waves broke a retention wall and flooded the fishing village of Puerto San Carlos in Baja California. In Mazatlan, Sinaloa on the west coast of mainland Mexico, waves destroyed a portion of the seawall (Fig. 5).

[2] 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.

Moisture flowing northward from Hurricane Norbert and Atlantic Tropical Storm Dolly resulted in heavy rains in the southwestern United States, although neither tropical cyclone affected the area directly. Phoenix, Arizona received 3.29 inches of rain in 7 hours.

FORECAST AND WARNING CRITIQUE

Table 3 displays how far in advance of formation the NHC official genesis forecasts first reached the indicated likelihood categories. The genesis of Norbert was poorly forecast, especially in the short range, with no high probability (>50 %) forecast prior to genesis. Only 12 h of lead time in the medium (30 - 50%) category was provided. The official forecasts were influenced by satellite data that indicated stronger than normal northeasterly wind shear over the disturbance, with conditions seemingly only marginal for tropical cyclone formation.

A verification of NHC official track forecasts for Norbert is given in Table 4a. Official forecast track errors were much lower 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 4b. In general, the multi-model consensus TVCE and the Florida State Superensemble FSSE performed better than any other model and better than the NHC forecast from 12 to 72 h. After that time, several models had lower errors than the NHC forecast.

A verification of NHC official intensity forecasts for Norbert is given in Table 5a. With the exception of the 5-day forecast, the official errors were greater 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 5b. Since the hurricane was approaching a hostile environment, the abrupt intensification that occurred late on 5 and 6 September was unexpected. In fact, the SHIPS model rapid intensification index (RI) had been gradually diminishing in the previous few runs. In addition, most of the intensity guidance at that time suggested that Norbert had already reached its peak intensity. Watches and warnings associated with Norbert are given in Table 6.

Table 1. Best track for Hurricane Norbert, 2-8 September 2014.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
02 / 1200	17.0	106.5	1004	35	tropical storm
02 / 1800	18.0	106.4	1004	35	"
03 / 0000	18.9	106.7	1003	40	"
03 / 0600	19.4	107.3	1001	45	"
03 / 1200	19.5	108.1	995	55	"
03 / 1800	19.5	108.9	989	60	"
04 / 0000	19.7	109.3	985	65	hurricane
04 / 0600	20.1	109.8	982	70	"
04 / 1200	20.4	110.2	978	75	"
04 / 1800	20.9	110.6	970	80	"
05 / 0000	21.5	110.8	970	80	"
05 / 0600	22.1	111.1	970	80	"
05 / 1200	22.8	111.6	970	80	"
05 / 1800	23.5	112.0	966	80	"
06 / 0000	24.0	112.6	961	95	"
06 / 0600	24.4	113.1	950	110	"
06 / 1200	24.8	113.8	960	100	"
06 / 1800	25.1	114.5	965	90	"
07 / 0000	25.3	115.1	973	80	"
07 / 0600	25.6	116.0	979	70	"
07 / 1200	25.9	116.7	991	55	tropical storm
07 / 1800	26.3	117.3	997	45	"
08 / 0000	26.8	117.7	1000	40	low
08 / 0600	27.2	118.1	1001	35	"
08 / 1200	27.5	118.5	1002	30	"
08 / 1800	27.9	118.6	1003	30	"
09 / 0000	28.5	118.5	1004	25	"
09 / 0600	29.0	118.4	1006	20	"
09 / 1200	28.8	118.2	1006	20	"
09 / 1800	28.4	118.2	1007	20	"

10 / 0000	28.1	118.0	1008	20	"
10 / 0600	27.9	117.6	1008	20	"
10 / 1200	27.6	117.5	1009	20	"
10 / 1800	27.2	117.6	1010	20	"
11 / 0000	26.9	117.7	1010	20	"
11 / 0600					dissipated
06 / 0600	24.4	113.1	950	110	minimum pressure

Table 2. Selected ship reports with winds of at least 34 kt for Hurricane Norbert, 2-8 September 2014.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
04 / 1200	A8KY7	20.1	106.8	170 / 38	1003.0
05 / 0200	C6ZI9	19.2	111.0	250 / 35	1009.0
05 / 0500	C6ZI9	19.0	110.4	230 / 36	1011.0

Table 3. Number of hours in advance of formation 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 (<30%)	42	66
Medium (30%-50%)	12	48
High (>50%)	0	36

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Norbert. 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	**17.9**	**27.7**	**33.2**	**31.1**	**34.2**	**68.2**	**145.6**
OCD5	30.0	85.2	135.8	169.1	196.0	255.5	502.9
Forecasts	20	18	16	14	10	6	2
OFCL (2009-13)	25.7	41.4	55.0	68.6	97.8	134.2	167.1
OCD5 (2009-13)	37.2	74.8	118.0	162.5	249.4	332.6	413.3

Table 4b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Norbert 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	17.4	27.8	33.2	29.2	32.9	53.3	140.6
OCD5	37.8	85.2	128.6	160.8	176.7	215.2	454.7
GFSI	22.5	34.6	47.6	63.9	88.6	80.0	245.0
GHMI	20.1	34.1	44.9	54.4	139.6	251.6	161.6
HWFI	18.3	32.7	44.3	48.8	51.9	63.2	**60.4**
EGRI	24.0	28.2	34.8	47.4	103.7	166.9	310.9
EMXI	25.5	40.9	46.4	41.5	38.2	67.6	**138.5**
CMCI	23.9	31.9	37.5	48.0	92.5	139.9	147.6
NVGI	31.5	48.3	65.4	90.6	145.0	168.3	228.0
GFNI	26.0	46.4	62.3	77.5	87.0	91.2	161.5
AEMI	23.3	35.5	46.6	57.6	61.7	**39.3**	**110.2**
FSSE	**15.2**	**25.2**	**31.4**	31.7	**27.4**	**48.4**	**139.0**
TVCE	**16.7**	**21.4**	**26.6**	**28.3**	34.4	54.8	164.3
LBAR	25.6	56.1	85.9	117.6	166.4	189.5	156.1
BAMD	28.4	50.6	69.8	85.0	103.5	86.0	**12.3**
BAMM	29.0	52.7	74.2	84.1	79.8	64.1	**40.3**
BAMS	27.4	46.9	61.8	75.0	84.6	84.2	**130.7**
Forecasts	15	14	13	11	7	5	1

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Norbert. 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	6.3	11.7	15.9	18.6	24.0	23.3	**12.5**
OCD5	8.9	17.4	23.6	28.9	35.1	37.7	23.0
Forecasts	20	18	16	14	10	6	2
OFCL (2009-13)	6.1	10.4	13.4	14.5	15.0	16.4	16.1
OCD5 (2009-13)	7.7	12.7	16.4	18.8	20.5	20.3	20.8

Table 5b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Norbert. 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	6.6	11.8	16.0	18.1	23.3	17.0	10.0
OCD5	9.4	17.2	22.7	27.4	33.1	30.6	18.0
IVCN	7.3	14.6	20.1	22.8	28.4	22.2	**6.0**
LGEM	7.5	13.2	18.9	21.8	30.6	25.6	14.0
DSHP	6.7	**10.8**	**14.3**	18.2	29.1	24.8	**9.0**
GHMI	10.5	20.8	27.3	30.0	33.8	32.0	11.0
HWFI	8.7	16.6	22.3	23.2	**23.1**	**12.6**	**9.0**
GFNI	8.0	12.9	16.2	18.8	24.0	**13.4**	28.0
FSSE	**6.5**	**11.4**	16.5	22.3	27.3	20.0	**9.0**
Forecasts	19	17	15	13	9	5	1

Table 6. Watch and warning summary for Hurricane Norbert, 2-8 September 2014.

Date/Time (UTC)	Action	Location
2 / 2100	Tropical Storm Watch issued	La Paz to Santa Fe
3 / 0900	Tropical Storm Watch changed to Tropical Storm Warning	La Paz to Santa Fe
3 / 0900	Tropical Storm Watch issued	Santa Fe to Cabo San Lazaro
3 / 2100	Tropical Storm Watch issued	La Paz to San Evaristo
4 / 0300	Tropical Storm Watch modified to	Cabo San Lazaro to Puerto San Andresito
4 / 0300	Tropical Storm Warning modified to	La Paz to Cabo San Lazaro
4 / 2100	Tropical Storm Watch modified to	Cabo San Lazaro to Punta Abreojos
4 / 2100	Tropical Storm Watch modified to	La Paz to Loreto
5 / 0300	Tropical Storm Watch changed to Tropical Storm Warning	Punta Abreojos to Cabo San Lazaro
5 / 0300	Tropical Storm Watch modified to	San Evaristo to Loreto
5 / 0300	Tropical Storm Watch issued	Punta Eugenia to Punta Abreojos
5 / 0300	Tropical Storm Warning modified to	Punta Abreojos to Cabo San Lazaro
5 / 0300	Tropical Storm Warning issued	San Evaristo to Santa Fe
5 / 0300	Hurricane Warning issued	Santa Fe to Cabo San Lazaro
5 / 0900	Tropical Storm Watch discontinued	Punta Eugenia to Punta Abreojos
5 / 0900	Tropical Storm Warning modified to	Punta Eugenia to Cabo San Lazaro
6 / 0300	Tropical Storm Warning modified to	San Evaristo to La Paz
6 / 0900	Tropical Storm Watch changed to Tropical Storm Warning	San Evaristo to Loreto
6 / 0900	Tropical Storm Warning modified to	San Evaristo to Loreto

6 / 0900	Tropical Storm Warning modified to	Santa Fe to Punta Eugenia
6 / 0900	Tropical Storm Warning modified to	Santa Fe to Punta Eugenia
6 / 0900	Hurricane Warning discontinued	All
6 / 2100	Tropical Storm Warning modified to	Puerto San Andresito to Punta Eugenia
6 / 2100	Tropical Storm Warning discontinued	San Evaristo to Loreto
7 / 0300	Tropical Storm Warning modified to	Punta Abreojos to Punta Eugenia
7 / 0900	Tropical Storm Warning discontinued	All

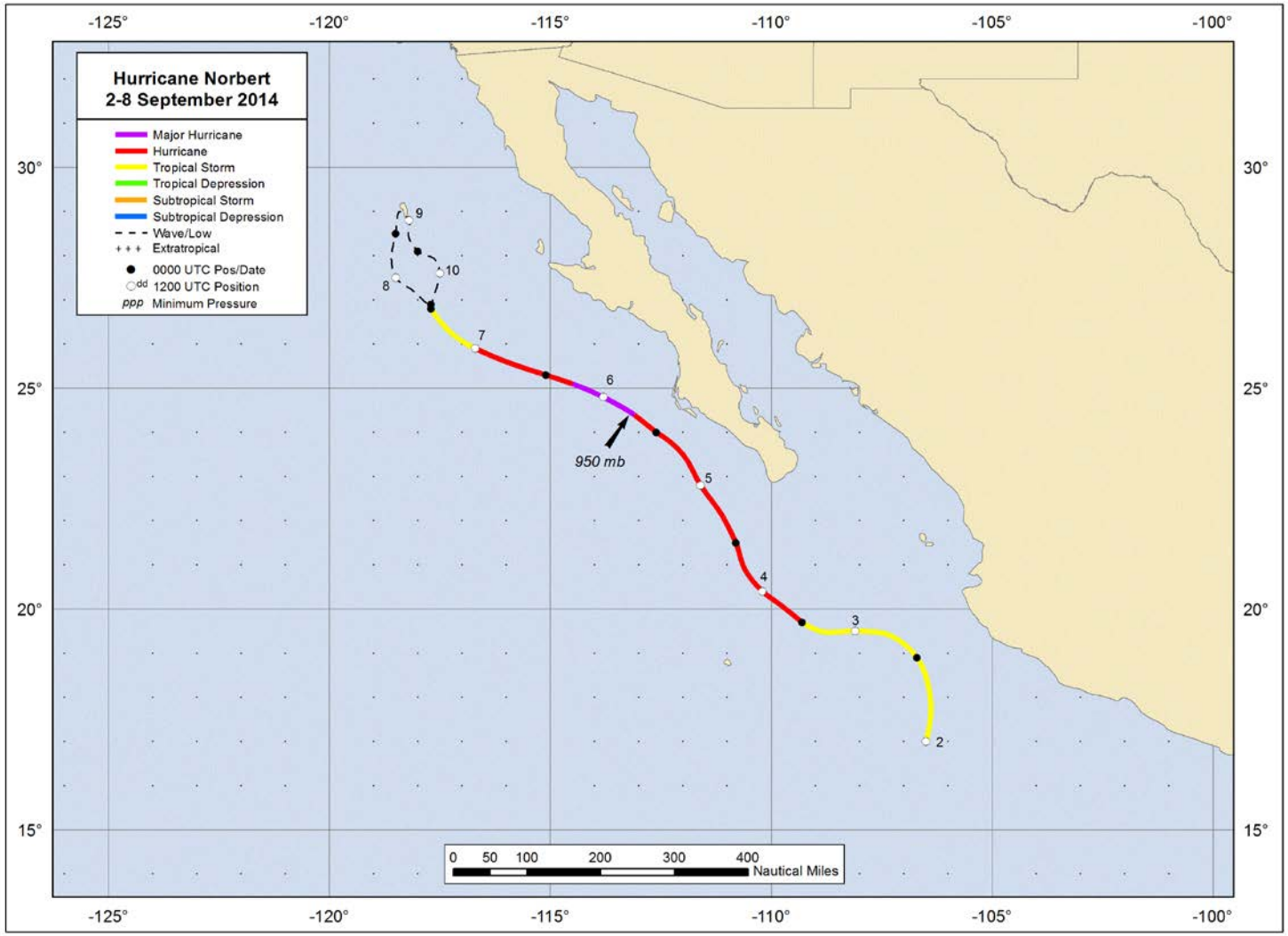


Figure 1. Best track positions for Hurricane Norbert, 2-8 September 2014.

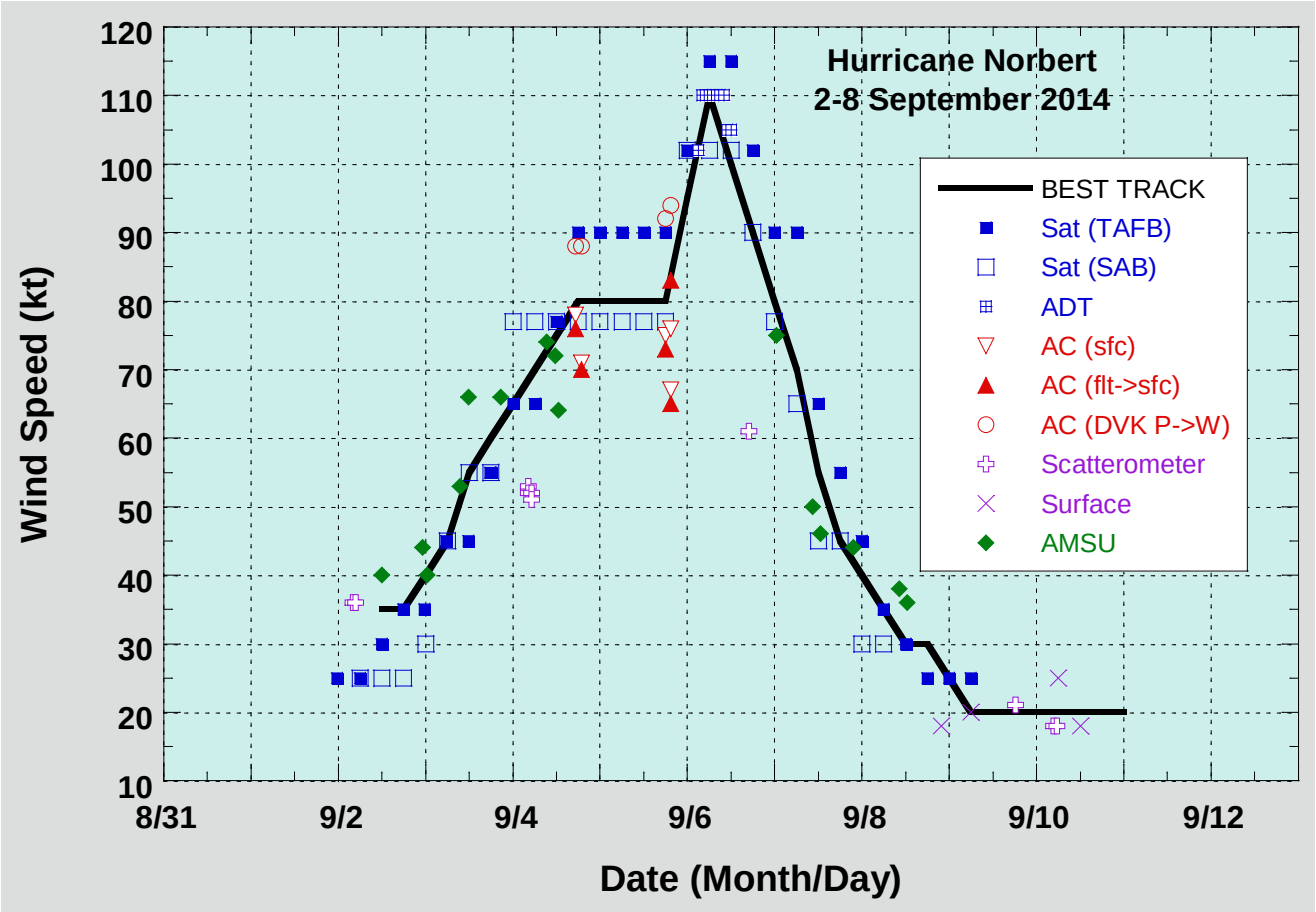


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Norbert, 2-8 September 2014. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% adjustment factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. 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.

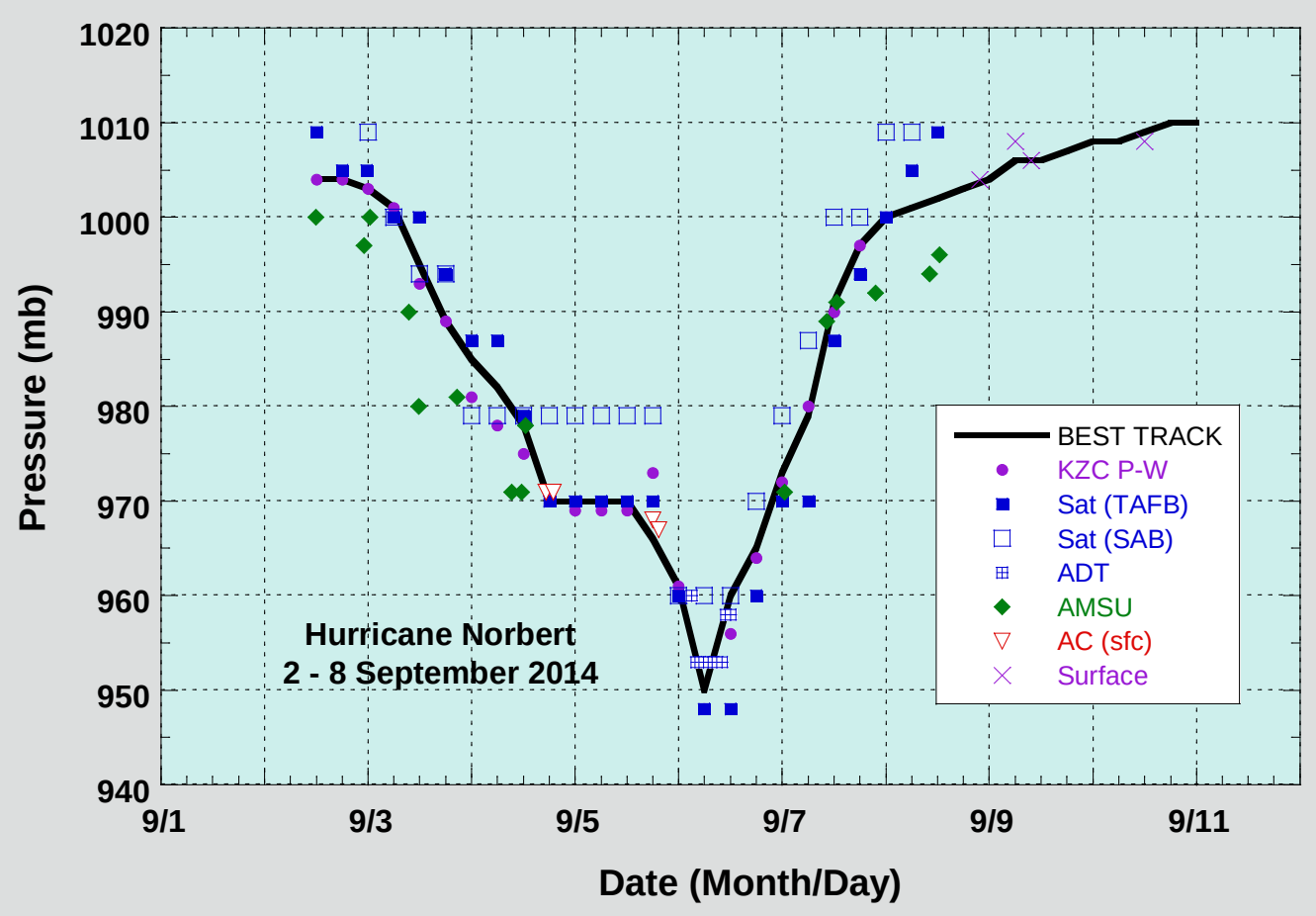


Figure 3. Selected pressure observations and best track minimum central pressure curve for name/dates. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

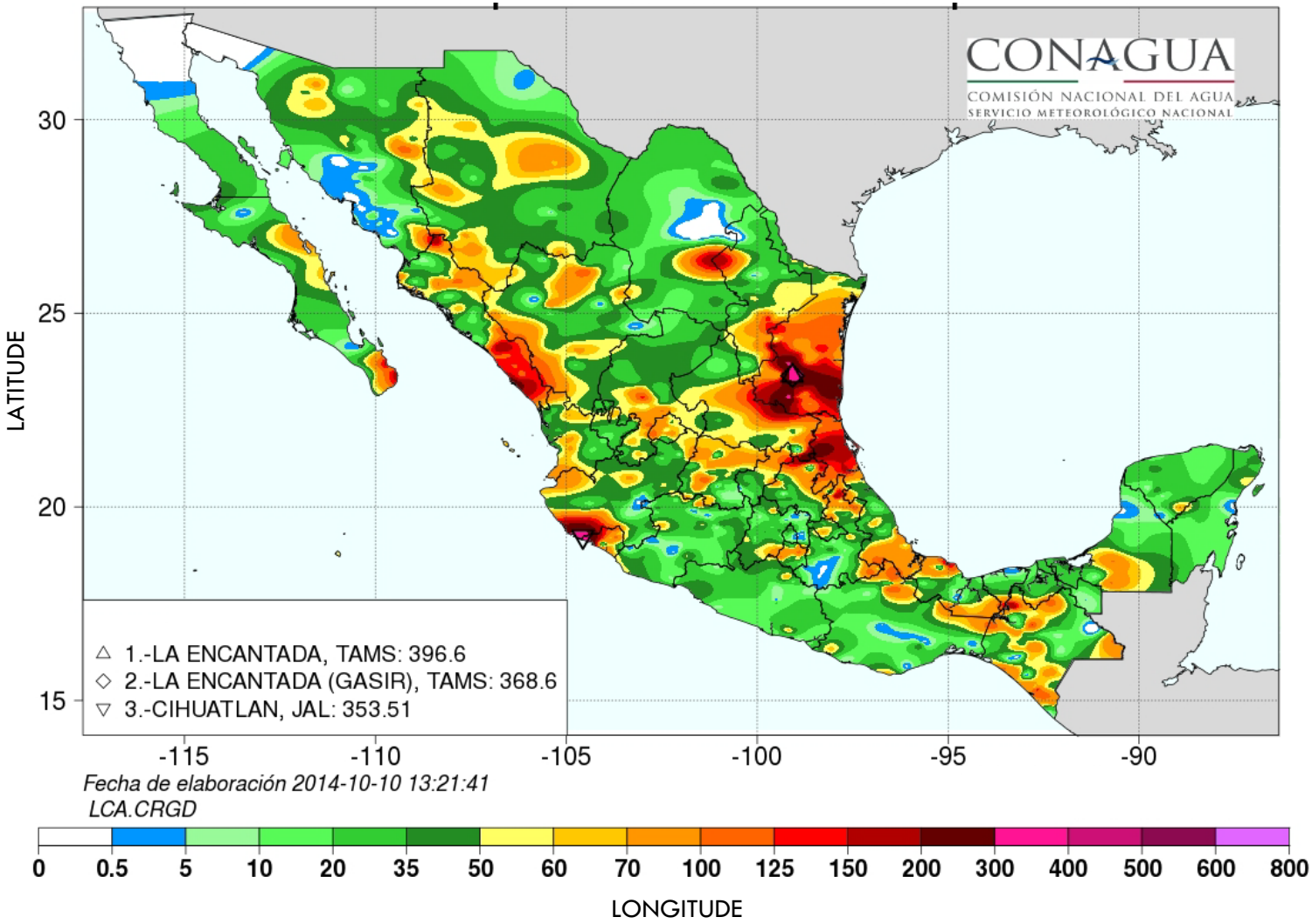


Figure 4. Rainfall totals in mm occurring over Mexico and Baja California peninsula during the period from 2 to 8 September associated with Norbert. The large area of rainfall over northeastern Mexico was associated with Tropical Storm Dolly. Figure provided by the Mexican Weather Service (CONAGUA).

Figure. 5 Impact of high waves associated with Hurricane Norbert in the port of Mazatlan, Mexico. Photo provided by the University of Guadalajara, Mexico.