Tropical Cyclone Report
Hurricane Nate
(AL152011)
7-11 September 2011

Todd B. Kimberlain
National Hurricane Center
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Updated 1 February 2012 for best track data in Table 1

Nate meandered over the Bay of Campeche for a day or so and briefly was a category 1 hurricane (on the Saffir-Simpson Hurricane Wind Scale). It then moved inland over eastern Mexico as a weak tropical storm.

a. Synoptic History

Nate originated from the frontal trough that was responsible for the extratropical transition of Tropical Storm Lee. The front moved through the western half of the Gulf of Mexico on 5 September and became stationary from the south-central Gulf of Mexico to the Bay of Campeche later that day. Cloudiness and showers gradually increased over this area the next day, and an area of low pressure formed along the southern end of the front around 1800 UTC 6 September about 160 n mi northwest of Ciudad del Carmen, Mexico. The circulation of the low separated from the front on 7 September while convection increased but remained disorganized. Scatterometer data indicated that the low had gale-force winds by this time, but these winds were at least partially associated with a strong low-level pressure gradient behind the weakening cold front. A curved convective band then formed over the western semicircle of the circulation later that day, marking the formation of a tropical cyclone around 1800 UTC 7 September about 140 n mi north of Villahermosa, Mexico. The "best track" chart of Nate'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].

Nate was initially trapped in a weak steering environment between a mid-level ridge over the northern Caribbean Sea and a stronger ridge over Mexico, a pattern that imparted a southeastward drift to the cyclone. Nate gradually strengthened, but an abundance of dry low- to mid-level air behind the original front slowed the intensification process. A new convective band developed south of the center early on 8 September while Nate turned southward and then completed a cyclonic loop. Data from a reconnaissance aircraft and a nearby oil rig indicated that Nate reached hurricane strength around 1800 UTC that day when it was located about 70 n mi north-northwest of Ciudad del Carmen, despite a satellite appearance uncharacteristic of a hurricane. The broad wind field and slow forward motion of the cyclone over the shallow waters of the Bay of Campeche caused significant upwelling of the oceanic mixed layer, which resulted in a large area of significantly cooler waters under Nate (Fig. 4). The combination of dry air and

[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 substantially lower oceanic heat content caused the intensity and coverage of deep convection in the cyclone to decrease considerably early on 9 September, and Nate weakened to a tropical storm by 0600 UTC that day. Nate continued to weaken during the day while the associated convection further eroded due to the effects of dry air and cooler waters, and the cyclone was nearly devoid of deep convection. The mid-level ridge over Mexico then shifted eastward, causing Nate to turn west-northwestward and then westward over the central Bay of Campeche late on 9 September.

As Nate moved away from the upwelled waters on 10 September, convection around the circulation became reinvigorated. A brief re-intensification of the cyclone began around 1200 UTC that day, despite the relatively dry air in the near-storm environment. The mid-level ridge over Mexico strengthened around this time, and Nate responded by moving more quickly toward the west. Additional low- to mid-level dry air wrapping into the circulation caused the new convective growth to collapse, and Nate began to weaken again early on 11 September. After 0600 UTC 11 September, the low- and mid-level became detached; the mid-level center moved inland north of Veracruz while the low-level center of the weakening tropical storm crossed the coast of northeastern Mexico near Barra de Tecolutla at 1600 UTC that day. Rapid weakening occurred after landfall, and Nate degenerated into a remnant low by 0000 UTC 12 September around 20 n mi west of Poza Rica, Mexico. It then dissipated by 0600 UTC that day.

b. Meteorological Statistics

Observations in Nate (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 flights of the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command. Data and imagery from NOAA polar-orbiting satellites, including the Advanced Microwave Sounding Unit (AMSU), the NASA Tropical Rainfall Measuring Mission (TRMM) and Aqua, 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 Nate.

Air Force Reserve Hurricane Hunter aircraft flew a total of six missions in Nate and obtained sixteen fixes. The maximum observed flight-level wind (850 mb) in Nate was 82 kt southeast of the center at 1815 UTC on 8 September. The 82-kt 850 mb observation would typically support an estimate intensity of 65 kt. However, the maximum coincident SFMR wind estimate was only 60 kt, and operationally Nate was not upgraded to a hurricane, in part because of its satellite appearance. Data received in post-analysis from Eco-1, a Petróleos Mexicanos (PEMEX) oil rig located in the southeast quadrant of the cyclone in the maximum wind band (Fig. 5), indicated a 1-minute sustained wind of 72 kt at an elevation of 30 m. This occurred several hours after the time of the peak winds measured by the aircraft, also to the southeast of the center. An adjustment of the oil rig observation to the standard 10 m height, using the mean hurricane dropwindsonde profile, yields a peak surface sustained wind estimate of 67 kt. These

data and the earlier reconnaissance measurements support the estimate of Nate's peak intensity of hurricane strength.

Ship reports of tropical-storm-force winds or greater associated with Nate are given in Table 2, and selected surface observations from land stations, data buoys, and PEMEX oil rigs are given in Table 3.

c. Casualty and Damage Statistics

There were four direct deaths and one indirect death associated with Nate. Ten workers were forced to abandon their lifeboat on 8 September after evacuating the Trinity II oil rig. Seven of the ten men were rescued, but one later died from an unknown cause. The bodies of the three remaining workers were eventually recovered. A nine-year-old child was killed when he/she was struck by a bolt of lightning in the state of Veracruz.

No serious damage was reported in association with Nate's landfall in eastern Mexico. However, press reports indicated that about 800 homes were damaged in Veracruz. No monetary estimate of damage is available.

d. Forecast and Warning Critique

The formation of Nate was not particularly well forecast. The system from which Nate developed was introduced in the Tropical Weather Outlook 30 h before genesis and given a "low" (< 30%) chance of tropical cyclone formation. The disturbance was then assessed a "medium" chance (30-50%) and a "high" chance (> 50%) of development 24 h and 6 h prior to genesis, respectively.

A verification of NHC official track forecasts for Nate is given in Table 4a. Official forecast track errors were lower than the mean official errors for the previous 5-yr period through 48 h but higher at 72 h and 96 h. Although OCD5 errors indicate that the track of Nate was easier than average to forecast through 72 h, the larger errors at 72 h and 96 h resulted from early forecasts that showed Nate moving farther northward before turning toward the west. The rationale behind these forecasts was the expectation that Nate would interact more strongly with a shortwave trough moving slowly through the lower Mississippi valley. A homogeneous comparison of the official track errors with selected guidance models is given in Table 4b. The consensus track guidance generally outperformed the official forecast, with TVCA and TVCC having the smallest errors. It should be noted that only one model (GFNI) had lower errors than the 5-yr mean OFCL error at 72 h.

A verification of NHC official intensity forecasts for Nate is given in Table 5a. Official forecast intensity errors were greater than the mean official errors at all times for the previous 5-yr period, especially after 36 h. The larger errors after 36 h were associated with early forecasts that indicated more intensification than what was observed. These high-biased forecasts underestimated the degree to which oceanic upwelling and the presence of dry air would inhibit

the intensification process. A homogeneous comparison of intensity errors reveals that nearly all of the guidance performed well relative to the official forecast. The regional dynamical models (GHMI and HWFI) had the lowest overall errors at all times. DSHP and FSSE as well as the objective intensity aids (ICON and IVCN) also generally performed better than the official forecast, while the LGEM did poorly.

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

Acknowledgements.

Fabián Vazquéz Romaña of PEMEX provided observations from several oil rigs affected by Nate in the south-central Gulf of Mexico and Bay of Campeche.

Table 1. Best track for Hurricane Nate, 7-11 September, 2011.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
06 / 1800	20.3	93.9	1006	30	low
07 / 0000	20.3	93.7	1006	30	"
07 / 0600	20.3	93.3	1005	30	"
07 / 1200	20.3	92.9	1005	35	"
07 / 1800	20.3	92.6	1004	40	tropical storm
08 / 0000	20.2	92.5	1003	45	"
08 / 0600	20.1	92.4	1000	50	"
08 / 1200	19.9	92.3	997	55	"
08 / 1800	19.7	92.3	995	65	hurricane
09 / 0000	19.7	92.1	994	65	"
09 / 0600	19.9	92.2	998	55	tropical storm
09 / 1200	20.0	92.4	999	50	"
09 / 1800	20.0	92.7	999	45	"
10 / 0000	20.0	93.0	1000	45	"
10 / 0600	20.0	93.4	1000	45	"
10 / 1200	20.1	93.8	1000	50	"
10 / 1800	20.1	94.2	1000	55	"
11 / 0000	20.1	94.7	1000	55	"
11 / 0600	20.0	95.4	1003	50	"
11 / 1200	20.3	96.4	1005	40	"
11 / 1600	20.5	97.0	1006	40	"
11 / 1800	20.5	97.2	1009	35	"
12 / 0000	20.5	97.8	1012	25	low
12 / 0600					dissipated
11 / 1600	20.5	97.0	1006	40	Landfall near Barra de Tecolutla, Mexico
09 / 0000	19.7	92.1	994	65	Maximum wind and minimum pressure

Table 2. Selected ship reports with winds of at least 34 kt for Hurricane Nate, 7-11 September 2011.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
08 / 1500	C6FV4	19.8	91.8	170 / 52	1004.0
09 / 0300	C6FV4	19.8	91.8	170 / 40	999.0
09 / 1200	C6FV4	19.7	91.8	190 / 48	1005.0
11 / 1400	ZCDJ3	20.7	96.5	130 / 40	1012.5

Table 3. Selected surface observations for Hurricane Nate, 7-11 September, 2011.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)			
Mexico								
Poza Rica (MMPA)			11/1643	25	35			
Veracruz (MMVR)	11/0000	1007.7	10/0300	20	25			
Marine Observations								
Veracruz, Mexico Harbor (VERV4/19.20N 96.11W)	09/2200	1008.8	09/2100	30	39			
Sacrifice Island, Veracruz (SACV4/19.17N -96.09W)	09/2200	1009.1	09/0010	32	38			
La Mancha Beach, Veracruz (LMBV4/19.59N 96.38W)	09/2200	1009.2	09/2040	22	35			
Buoy 42055 (22.20N 94.00W)	07/2139	1007.9	07/2057	31	37			
PEMEX Oil Rigs								
Ixtoc-A (43 m)	08/1416	998.7[e]	08/1409	62(58[f])				
Eco-1 (30 m)	09/0212	1000.0[e]	08/2359	72(67[f])				
Carmen (10 m)	08/2219	1004.9[e]	09/0255	45				
Ku-H (26 m)	08/2101	996.5[e]	08/0718	47(44[f])				
Rebombeo (30 m)	08/1632	1001.8[e]	08/1230	59(55[f])				
Cayo Arcas (30 m)			08/1551	49(46[f])				

[a] Date/time is for sustained wind when both sustained and gust are listed.
[b] Except as noted, sustained wind averaging periods for C-MAN and land-based ASOS reports are 2 min; buoy averaging periods are 8 min.
[c] Storm surge is water height above normal astronomical tide level.
[d] Storm tide is water height above National Geodetic Vertical Datum (1929 mean sea level).
[e] Pressure reduced to a standard height of 10 m using the Hypsometric equation
[f] Wind after a reduction to a standard height of 10 m using the mean hurricane dropwindsonde profile.

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Nate, 7-11 September, 2011. Mean errors for the 5-yr period 2006-10 are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL (Nate)	**23.8**	**33.7**	**57.7**	**88.4**	188.0	193.7	
OCD5 (Nate)	30.4	53.0	91.0	139.5	252.2	409.3	
Forecasts	15	13	11	9	5	1	
OFCL (2006-10)	31.0	50.6	69.9	89.5	133.2	174.2	
OCD5 (2006-10)	47.7	98.3	156.4	218.1	323.3	402.2	

Table 4b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Nate, 7-11 September, 2011. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 4a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	21.5	29.9	59.6	90.3	204.1		
OCD5	27.7	47.0	91.0	139.8	251.1		
GFSI	26.9	41.9	71.8	124.9	305.1		
GHMI	26.4	41.4	67.6	**88.0**	**182.0**		
HWFI	25.3	33.5	63.7	91.9	239.9		
GFNI	35.1	43.7	66.4	99.2	**75.5**		
EGRI	30.4	50.8	75.3	99.8	**138.5**		
EMXI	29.6	46.5	70.9	98.7	204.9		
CMCI	27.1	46.7	89.8	158.9	415.7		
TCON	**20.8**	32.6	**55.6**	**79.4**	**189.9**		
TCCN	**20.6**	32.6	**56.6**	**75.3**	**180.1**		
TVCA	**20.6**	**27.6**	**48.9**	**70.9**	**170.6**		
TVCC	21.5	**27.7**	**48.8**	**68.3**	**154.4**		
GUNA	22.6	33.6	**55.7**	**78.7**	**178.9**		
FSSE	24.2	36.1	61.8	**85.8**	219.5		
AEMI	22.8	39.5	74.4	134.3	419.0		
BAMS	22.1	33.2	**54.7**	**69.6**	242.4		
BAMM	27.6	37.2	**47.9**	**64.4**	**203.5**		
BAMD	31.3	53.2	65.8	**82.6**	**180.7**		
Forecasts	12	10	9	7	3		

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Nate, 7-11 September, 2011. Mean errors for the 5-yr period 2006-10 are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL (Nate)	10.7	14.2	17.3	26.7	25.0	40.0	
OCD5 (Nate)	11.7	14.2	13.7	18.3	17.8	18.0	
Forecasts	15	13	11	9	5	1	
OFCL (2006-10)	7.2	11.0	13.2	15.1	17.2	17.9	
OCD5 (2006-10)	8.5	12.3	15.4	17.8	20.2	21.9	

Table 5b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Nate, 7-11 September, 2011. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 5a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	11.2	14.1	20.0	28.6	22.5		
OCD5	12.8	15.4	**14.8**	**18.0**	**15.0**		
HWFI	**8.3**	**9.3**	**14.0**	**16.0**	35.5		
GHMI	**9.2**	**7.5**	**12.9**	**17.9**	32.5		
GFNI	**7.8**	**10.2**	**14.6**	**17.4**	33.0		
DSHP	12.2	**14.0**	**15.4**	**19.4**	**19.0**		
LGEM	13.6	17.1	20.8	**27.7**	25.5		
ICON	**10.7**	**10.5**	**13.2**	**20.6**	28.5		
IVCN	**9.9**	**9.7**	**13.4**	**19.3**	27.0		
FSSE	**10.3**	**11.5**	**14.3**	**21.1**	**16.5**		
Forecasts	13	11	9	7	2		

Table 6. Watch and warning summary for Hurricane Nate, 7-11 September, 2011.

Date/Time (UTC)	Action	Location
7 / 2100	Tropical Storm Warning issued	Chilitepec to Celestún
8 / 1500	Tropical Storm Watch issued	Celestún to Progreso
9 / 1500	Tropical Storm Watch issued	La Cruz to Tampico
9 / 1500	Tropical Storm Watch issued	Veracruz to Punta El Lagarto
9 / 1500	Hurricane Watch issued	Tampico to Veracruz
9 / 1800	Tropical Storm Watch discontinued	Celestún to Progreso
9 / 1800	Tropical Storm Warning discontinued	All
10 / 0300	Tropical Storm Watch discontinued	Veracruz to Punta El Lagarto
10 / 0300	Tropical Storm Warning issued	Tampico to Punta El Lagarto
10 / 1500	Tropical Storm Watch discontinued	All
10 / 2100	Tropical Storm Warning area modified to	Tampico to Tuxpan
10 / 2100	Hurricane Watch area modified to	Tampico to Tuxpan
10 / 2100	Hurricane Warning issued	Tuxpan to Veracruz
11 / 0900	Hurricane Warning changed to Tropical Storm Warning	Tuxpan to Veracruz
11 / 0900	Tropical Storm Warning area modified to	Tuxpan to Veracruz
11 / 0900	Tropical Storm Warning area modified to	Tuxpan to Veracruz

11 / 0900	Hurricane Watch discontinued	All
11 / 2100	Tropical Storm Warning discontinued	All

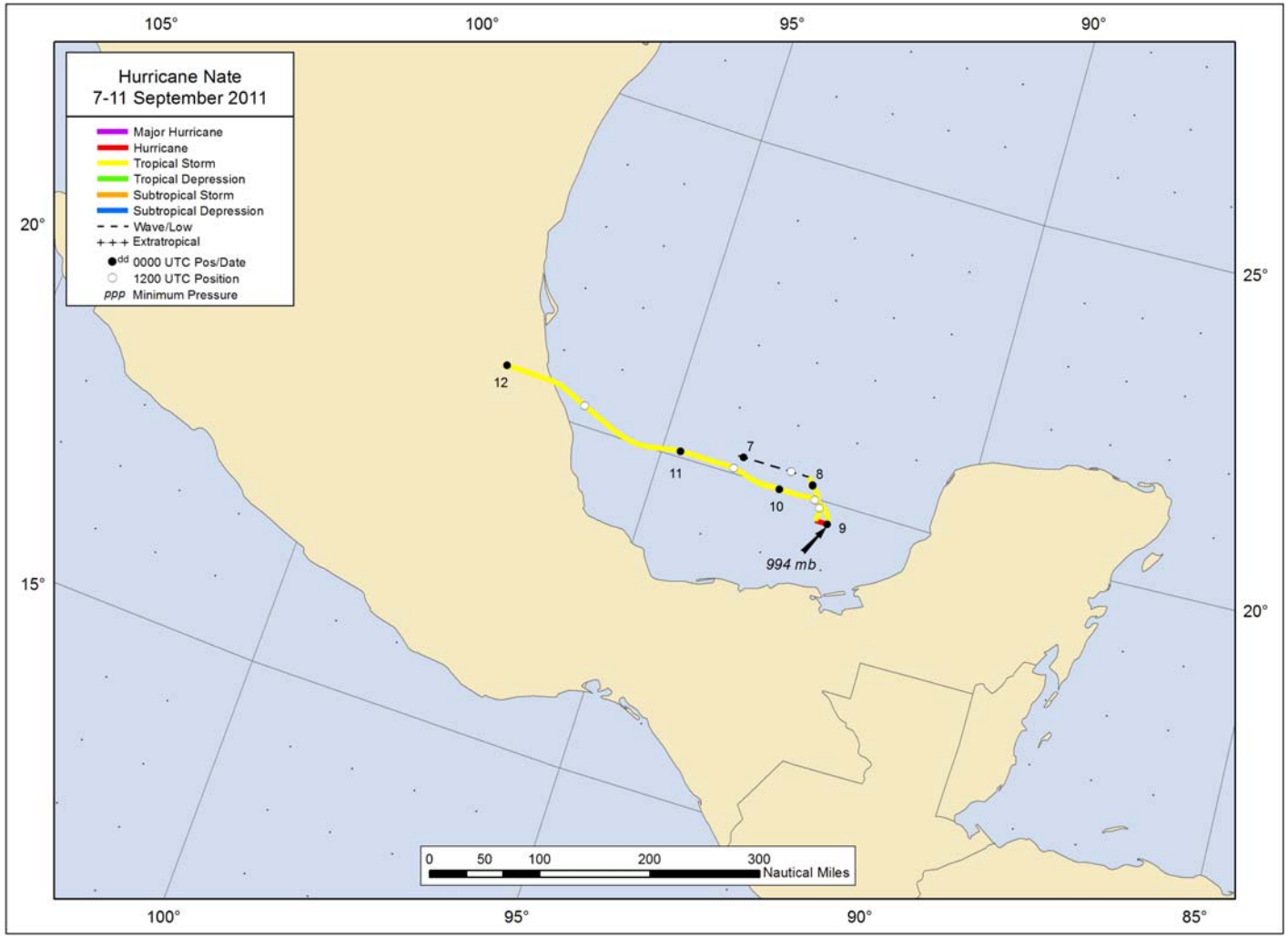

Figure 1. Best track positions for Hurricane Nate, 7-11 September, 2011.

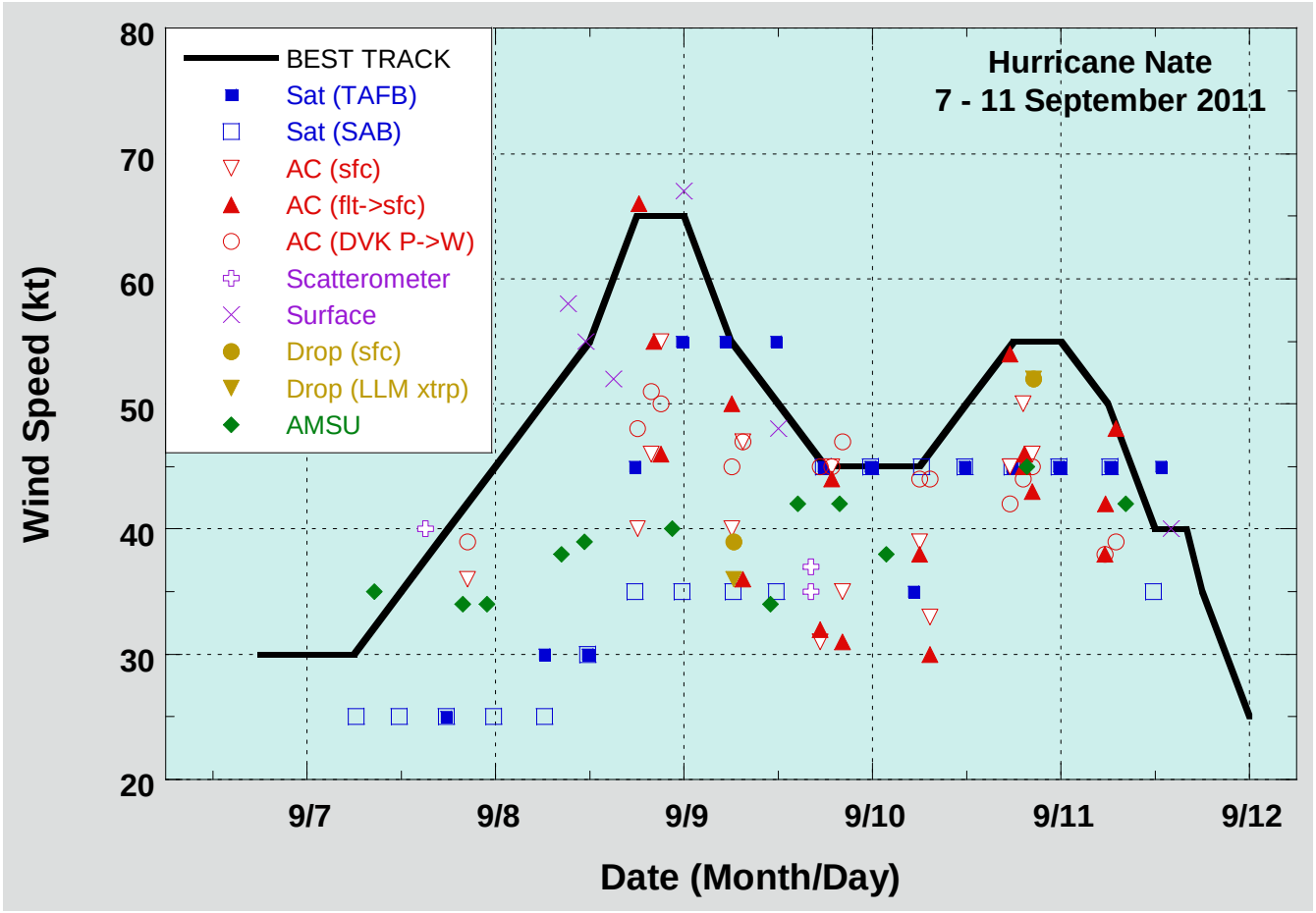

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Nate, 7-11 September, 2011. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% adjustment factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Dropwindsonde observations include actual 10 m winds (sfc), as well as surface estimates derived from the mean wind over the lowest 150 m of the wind sounding (LLM). Advanced Dvorak Technique estimates represent linear averages over a three-hour period centered on the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC.

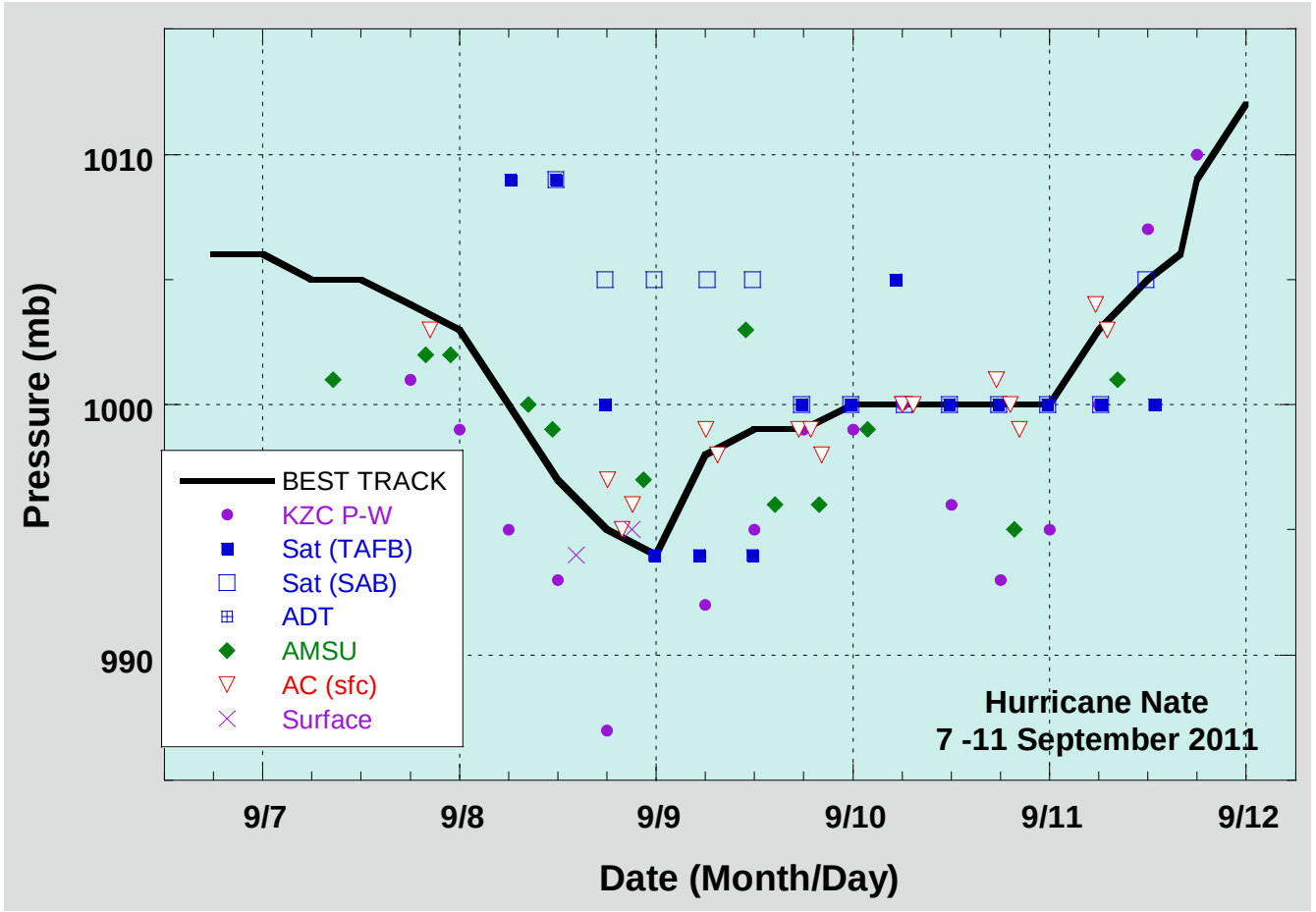

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Nate, 7-11 September, 2011. Advanced Dvorak Technique estimates represent linear averages over a three-hour period centered on the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. The KZC P-W values are obtained by applying the Knaff-Zehr-Courtney pressure-wind relationship to the best track wind data. Dashed vertical lines correspond to 0000 UTC.

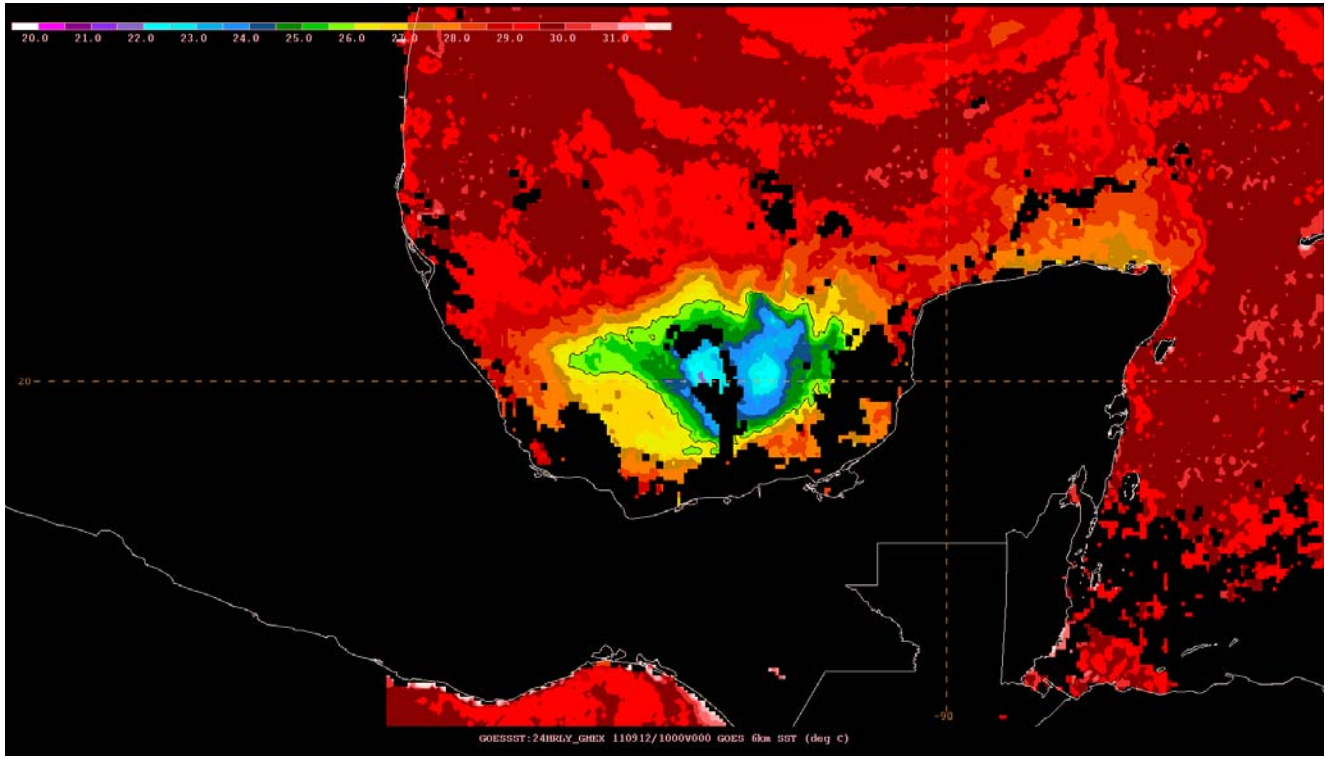

Figure 4. Geostationary satellite-derived sea surface temperature analysis from 1000 UTC 12 September 2011 after the passage of Hurricane Nate through the Bay of Campeche. The color shading in the legend located in the upper left-hand corner indicates sea surface temperature (°C).

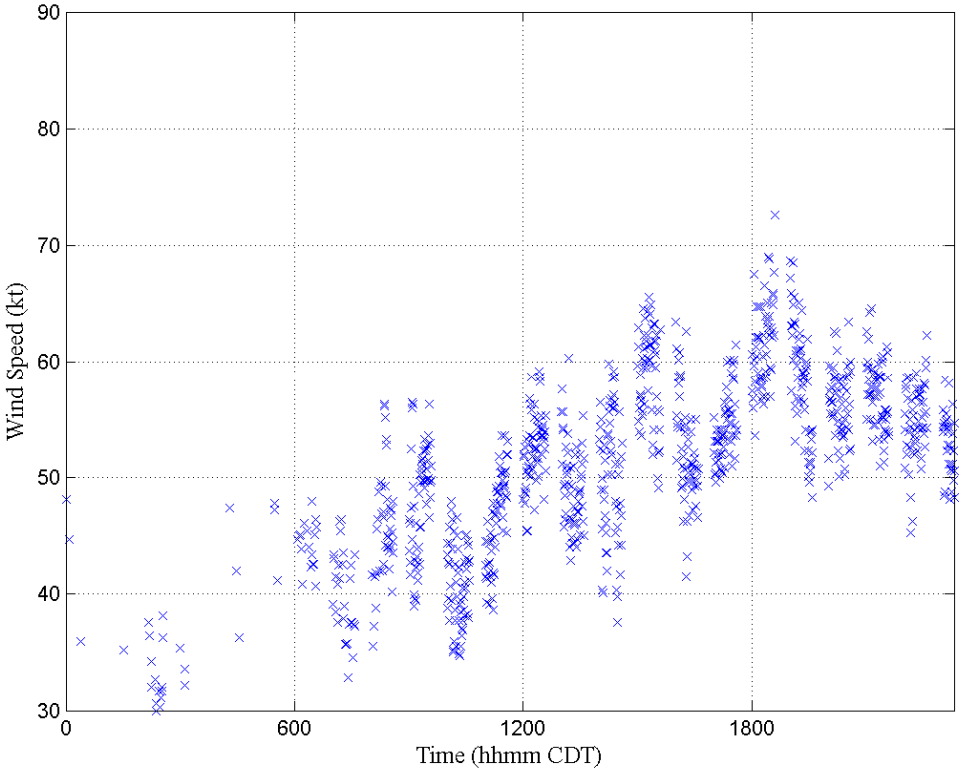

Figure 5. Time series plot of one-minute wind (prior to surface adjustment) from PEMEX oil rig Eco-1 at an elevation of 30 m in the Bay of Campeche from 8 September 2011.