NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

HURRICANE NATE

(AL162017)

4–8 October 2017

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National Hurricane Center
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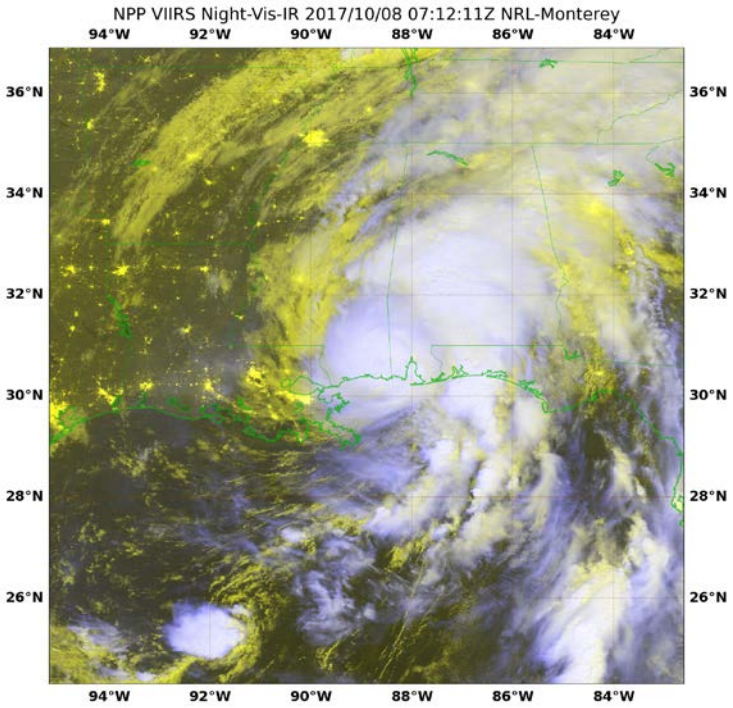

COMBINED NIGHTTIME VISIBLE/INFRARED IMAGERY OF NATE AT 0712 UTC 8 OCTOBER FROM THE VIIRS INSTRUMENT ON THE SUOMI-NPP SATELLITE. IMAGE COURTESY OF NRL MONTEREY.

Nate crossed northeastern Nicaragua and eastern Honduras as a tropical storm, then made landfall on the northern Gulf Coast as a Category 1 hurricane on the Saffir-Simpson Hurricane Wind Scale. Its rains caused significant impacts in Central America.

Hurricane Nate

4–8 OCTOBER 2017

SYNOPTIC HISTORY

Nate had a complex origin that involved several different weather systems. A large area of low pressure in the eastern Pacific Intertropical Convergence Zone and over Central America (a Central American gyre; Papin et al., 2017) gradually developed in early October. As this occurred, a tropical wave moved through the eastern Caribbean Sea, and the southern end of the wave interacted with the gyre. The northern end of the wave amplified into a sharp trough as it interacted with a large mid- to upper-level low pressure area over the eastern and central Gulf of Mexico. This pattern produced multiple small low pressure areas and vorticity centers. One low pressure area in the eastern North Pacific would become Tropical Storm Ramon on 4 October. Another vorticity center, associated with the northern part of the tropical wave, moved westward across Florida into the Gulf of Mexico on 4–5 October. A third vorticity center, over the southwestern Caribbean Sea, caused an area of convection to form on 2 October. Scatterometer data indicated that this system developed a closed wind circulation on 3 October, and by 1200 UTC 4 October it had a sufficiently well-defined circulation and enough organized convection to be considered a tropical depression about 35 n mi south of San Andres Island. 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[1].

The depression moved generally northwestward after genesis, steered by a weak subtropical ridge to the northeast. Gradual strengthening occurred, and it is estimated the cyclone became a tropical storm shortly before it made landfall in northeastern Nicaragua near 1200 UTC 5 October (Fig. 4). Nate changed little in strength as it moved north-northwestward across northeastern Nicaragua and eastern Honduras for the next 15 h or so, and it was still at tropical storm strength when the center emerged off of the coast of Honduras near 0300 UTC 6 October. While Nate was over Central America, the tropical wave over the Gulf of Mexico merged with the mid- to upper-level low to form a deep-layer low pressure area over the western Gulf. At the same time, the subtropical ridge intensified over the western Atlantic and the Florida Peninsula. This pattern produced a strong deep-layer south-southeasterly flow over the eastern Gulf of Mexico and the northwestern Caribbean, and as Nate encountered this flow later on 6 October it accelerated toward the north-northwest. Strengthening occurred while the center moved over the northwestern Caribbean Sea and the Yucatan Channel, and the cyclone reached hurricane strength over the southeastern Gulf of Mexico early on 7 October. Subsequently, the hurricane reached a peak intensity of 80 kt near 1200 UTC that day as it moved across the Gulf at forward speeds of up to 25 kt.

[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.

Thereafter, Nate entered an area of strong southwesterly vertical wind shear which caused weakening as the hurricane approached the northern Gulf Coast. Slowing to a forward speed of 15 kt, Nate made landfall at the mouth of the Mississippi River near 0000 UTC 8 October with maximum winds near 75 kt, then continued northward to its final landfall near Biloxi, Mississippi at 0520 UTC that day with maximum winds of 65 kt. Nate accelerated northeastward after landfall, with the center moving through western and northern Alabama and into central Tennessee by 0000 UTC 9 October. Steady weakening over land led to the cyclone decaying to a remnant low over Tennessee, and a few hours later the low became extratropical over the Ohio Valley. The extratropical low moved northeastward into New England by 10 October, then east-northeastward across the Canadian Maritime Provinces. The cyclone dissipated early on 11 October near Newfoundland as it became a trough rotating around another extratropical low to the north.

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 nine flights of the 53rd Weather Reconnaissance Squadron of the U.S. Air Force Reserve Command and the NOAA Aircraft Operations Center. 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 Nate. A data source used for the first time was the Colombian radar on San Andres Island, which provided important information on Nate when it was located near Central America.

Ship reports of winds of tropical storm force associated with Nate are given in Table 3, and selected surface observations from land stations and data buoys are given in Table 4.

Nate's forward motion of 25 kt over the Gulf of Mexico makes it the fastest-moving tropical cyclone of record in the Gulf. This fast forward motion created a highly asymmetric wind structure, with the winds and the associated impacts being diminished to the west of the center, even in the eyewall of the cyclone.

Winds and Pressure

Nate's initial upgrade to a tropical storm was based on a pressure of 1001 mb from Puerto Cabezas, Nicaragua on 5 October and a well-organized convective pattern seen in the San Andres radar (Figure 4). Aircraft data as the storm emerged from the northern coast of Honduras showed a higher intensity than estimated at landfall. However, other data in the region were too sparse to show whether this intensification occurred prior to landfall in Nicaragua or while the center traversed Central America.

Nate caused tropical-storm-force gusts over portions of western Cuba as the center moved through the Yucatan Channel, with the highest report being a 46-kt gust at Cabo San Antonio. No significant winds occurred over the northeastern coast of the Yucatan Peninsula as the center of Nate passed to the east.

The 80-kt maximum intensity of Nate is based on an aircraft-measured flight-level wind of 89 kt at an altitude of 8000 ft and a surface wind estimated of 79 kt from the SFMR – both near 1332 UTC 7 October. Another flight-level wind of 89 kt was measured at 850 mb near 0115 UTC 8 October as the center was near the southeastern coast of Louisiana. The minimum pressure of 981 mb is based on several dropsondes of 982-984 mb with surface winds of 20-30 kt around 1800 UTC 7 October.

Aircraft data suggest Nate caused hurricane conditions at the mouth of the Mississippi River in a small area near and east of the center. However, there were no surface reports of sustained hurricane-force winds. The strongest reported wind in this area was from the Main Pass 140B oil platform (call sign KMIS), which reported sustained winds of 62 kt and a gust to 77 kt at 0055 UTC 8 October at an elevation of 85 m. This was just before contact with the station was lost. The platform also reported a minimum pressure of 985.0 mb at 0034 UTC 8 October.

Elsewhere in southeastern Louisiana and along the Mississippi coast, a combination of aircraft data and surface observations suggest that hurricane conditions were confined to a small area along the Mississippi coast between Biloxi and Pascagoula. The highest maximum sustained wind from a surface observing site was 52 kt (averaging period unknown) from a United States Geological Survey (USGS) platform in the Mississippi Sound (call sign GRPL1) at 0230 UTC 8 October, with this station situated just northwest of the center at the time. The highest gust was 71 kt at the Ingalls Shipbuilding facility in Pascagoula at 0505 UTC 8 October at an elevation of 19.5 m, and there was a reported 66-kt gust from a storm chaser near Biloxi Bay at 0427 UTC 8 October. The lowest reported pressure, 984.6 mb, was also from this chaser, measured at the same time as the strongest winds.

Tropical storm conditions occurred elsewhere along the coast from southeastern Louisiana to the western Florida Panhandle, and extended inland across extreme southeastern Mississippi and southwestern Alabama. It should be noted that an inland private weather station in Calvert, Alabama, which reported a 39-kt peak gust as the core of Nate passed nearby (Table 4), reported a 65-kt gust due to a severe thunderstorm several hours before the center of the hurricane made landfall In Mississippi.

At sea, NOAA buoys 42040 and 42056 reported 1-min average winds of 49 kt on 6 October as the center of Nate passed nearby. In addition, the drill ship *Pacific Sharav* (call sign D5DY4) reported 47-kt winds at 1800 UTC 7 October (Table 3).

While Nate weakened rapidly after landfall, it maintained an area of strong winds above the surface to the east and southeast of the center. When these elevated winds encountered the higher terrain of the southern Appalachian Mountains, there were sporadic reports of sustained winds up to near 30 kt and gusts to tropical-storm force from northeastern Alabama to southwestern Virginia (Table 4). The maximum winds observed in this area were 31 kt sustained and a gust to 54 kt near Silverstone, North Carolina at 0319 UTC 9 October. The observations

show that these winds were strongly influenced by the terrain, so they are not considered representative of the best track intensity of the cyclone.

In addition, while not included in Table 4, there were a few gusts to gale force across portions of New England when Nate passed through the area as an extratropical low.

Storm Surge[2]

Nate produced a significant storm surge along portions of the northern Gulf Coast as shown by analyzed inundation heights (Fig. 5) and peak water levels recorded by tide gauges (Fig. 6). The combined effect of the surge and tide produced maximum inundation levels of 6 to 9 ft above ground level near and to the east of Nate's landfall along much of the coast of Mississippi and the coast of Alabama west of Mobile Bay. Although no storm tide sensors were deployed along the Mississippi coast, the USGS and Harrison County surveyed several drift lines deposited on the north side of U.S. Highway 90, measuring peak surface water elevations of 10.5 ft and 11.1 ft above the North American Vertical Datum of 1988 (NAVD88), respectively. A conversion of Harrison County's measurement yields an estimate of 9.7 ft above Mean Higher High Water (MHHW), suggesting that maximum inundation heights were about 9 ft above ground level along the immediate coastline in the vicinity of Biloxi and Ocean Springs. The highest water levels measured by National Ocean Service (NOS) tide gauges were 6.20 ft MHHW at the Pascagoula NOAA Lab and 6.15 ft MHHW at Dock E at the Port of Pascagoula in Mississippi. A water level of 5.6 ft MHHW was also measured at the Bay Waveland Yacht Club. In Alabama, the highest water level measured by a NOS tide gauge was 5.9 ft MHHW at the Bayou La Batre Bridge.

Given Nate's fast forward speed, the fetch of onshore winds was short-lived, and water levels along the immediate open coastline were likely higher than in the back bays. A USGS river gauge on a bridge in the back bay of Biloxi measured a peak water level of 8.14 ft NAVD88, which converts to 6.7 ft MHHW. The USGS also surveyed several high water marks between 2 and 5 ft above ground level around Biloxi Bay, suggesting that water levels there were slightly lower than on the Gulf-facing beaches.

Elsewhere in Alabama, maximum inundation levels of 4 to 7 ft above ground level occurred in Mobile Bay, and 3 to 5 ft above ground level occurred on the barrier islands east of the entrance to the bay. The highest water level measured by a tide gauge within Mobile Bay was 5.6 ft MHHW at the West Fowl River Bridge, and 5.4 ft MHHW was measured at the Coast Guard Sector in Mobile. On the barrier islands, a tide station at Dauphin Island measured a water level of 3.3 ft MHHW. Two USGS storm tide sensors in the area recorded wave-filtered water levels of 1.1 ft

[2] Several terms are used to describe water levels due to a storm. **Storm surge** is defined as the abnormal rise of water generated by a storm, over and above the predicted astronomical tide, and is expressed in terms of height above normal tide levels. Because storm surge represents the deviation from normal water levels, it is not referenced to a vertical datum. **Storm tide** is defined as the water level due to the combination of storm surge and the astronomical tide, and is expressed in terms of height above a vertical datum, i.e. the North American Vertical Datum of 1988 (NAVD88) or Mean Lower Low Water (MLLW). **Inundation** is the total water level that occurs on normally dry ground as a result of the storm tide, and is expressed in terms of height above ground level. At the coast, normally dry land is roughly defined as areas higher than the normal high tide line, or Mean Higher High Water (MHHW).

and 1.7 ft above the sensor elevations, which convert to 5-6 ft above MHHW and suggest maximum inundation heights of about 5 ft on the barrier islands east of Mobile Bay.

Maximum inundation levels of 2 to 4 ft above ground level occurred along the Florida Panhandle. The highest water level measured by an NOS tide gauge in Florida was 3.1 ft MHHW at Pensacola, while 3.0 ft MHHW was measured at Apalachicola.

Maximum inundation levels of 3 to 5 ft above ground level occurred in southeastern Louisiana north and east of the mouth of the Mississippi River, including in some parts of Lake Pontchartrain. The NOS tide gauge at Shell Beach in Lake Borgne measured a peak water level of 5.1 ft MHHW. Within Lake Pontchartrain, water levels of 3.2 ft MHHW and 3.1 ft MHHW were measured at the New Canal Station and the Interstate 10 Bonnet Carre Floodway, respectively. Maximum inundation levels west of the mouth of the Mississippi River were 1 to 3 ft above ground level. Tide gauges at the mouth of the Mississippi River measured peak water levels of 3.0 ft MHHW, but tide gauges farther west along the Louisiana coast all measured peak water levels 2.2 ft MHHW or less.

Rainfall and Flooding

The combination of Nate and the large gyre caused widespread rains over portions of Central America from 3–7 October. Costa Rica was particularly hard hit, with numerous totals over 10 inches (254 mm) and a maximum total of 19.19 inches (487.3 mm) at Maritima. Elsewhere in Central America, rainfall totals were generally 4–7 inches (100–175 mm). In Cuba, the cyclone produced generally light rains, with the maximum reported amount being 4.04 inches (112 mm) at San Juan y Martinez. Rains of 4–5 inches also occurred in the Cayman Islands.

In the United States (Fig. 8), Nate generally produced 3–7 inches (75–175 mm) of rain from the central Gulf Coast northeastward to the southern Appalachian Mountains, and over portions of central and western Kentucky. Locally heavier amounts occurred in some areas, with a maximum amount of 9.93 inches (252.2 mm) reported near Gulf Breeze, Florida. Elsewhere along the track of Nate, the rainfall totals were generally 1–3 inches (25–75 mm). These rains caused localized freshwater flooding.

Tornadoes

Nate produced 16 known tornadoes in portions of Mississippi, Alabama, South Carolina, and North Carolina on 8 October (Fig. 9). All of the tornadoes were rated EF-1 or EF-0 on the Enhanced Fujita scale.

CASUALTY AND DAMAGE STATISTICS

The widespread heavy rains over Central America produced widespread flooding and mudslides, and media reports indicate that these caused 44 deaths in the region: 16 in Nicaragua,

13 in Costa Rica, 6 in Panama, 5 in Guatemala, 3 in Honduras, and 1 in El Salvador. An additional death in Panama was due to a “shipwreck”, bringing the death toll directly associated with Nate to 45. An additional 9 people were missing in the region. No deaths were directly associated with Nate in the United States. However, there were two fatalities indirectly related to the storm due to traffic accidents.

Media reports indicate that the flooding and mudslides in Central America damaged or destroyed thousands of homes, with Costa Rica and Nicaragua reporting the greatest damage. There was also significant damage to agriculture and the transportation infrastructure in the region, with the Instituto Meteorológico Nacional of Costa Rica reporting a total of $562 million in damage. The locally heavy rains that occurred in the Cayman Islands and western Cuba, apparently produced only minor damage in these areas. In the United States, the National Centers for Environmental Information reported that a combination of winds, storm surge, freshwater flooding, and tornadoes caused $225 million damage to property and agriculture.

FORECAST AND WARNING CRITIQUE

The area of disturbed weather that eventually spawned Nate was mentioned in the Tropical Weather Outlook (TWO) 54 h before genesis, however, the TWO probabilities were for the medium (5-day) time range over the northwestern Caribbean Sea - well to the north of where the cyclone developed (Table 2). Overall, the genesis of Nate was poorly forecast, as the system was not recognized as a threat to develop in the short range (48 h or less) until the initial formation of the low pressure area over the southwestern Caribbean on 3 October – about 18 h before genesis occurred. The genesis probabilities were not raised into the high category in either the medium or the short range until 12 h before genesis.

A verification of NHC official track forecasts for Nate is given in Table 5a. Official forecast track errors were lower than the mean official errors for the previous 5-yr period through 36 h, then they were significantly larger than the previous 5-yr mean from 48–96 h. Examination of the individual forecasts (not shown) suggests three error mechanisms at work. First, although the forecasts correctly indicated that Nate would move quickly through the Gulf of Mexico, the forecast forward speeds were consistently slower than what actually happened. Second, early forecasts called for a premature recurvature to the northeast and forecast Nate to be east of the actual track after the 72-h points. Finally, while the forecasts showed a north-northwestward motion across the Gulf prior to recurvature, they were biased to the left of the actual track.

A homogeneous comparison of the official track errors with selected guidance models is given in Table 5b. Several of the consensus models, including the Atlantic variable consensus (TVCA) and the HFIP Corrected Consensus (HCCA) had average errors similar to or lower than the official forecasts, with TVCA beating the official average errors at all forecast times. The official forecasts had lower errors than the individual dynamical models through 36 h. After that time, the HWRF model (HWFI) and the Canadian model (CMCI) had lower errors than the official forecasts.

A verification of NHC official intensity forecasts for Nate is given in Table 6a. Official forecast intensity errors were near or greater than the mean official errors for the previous 5-yr period. Examination of the individual forecasts indicates that many of them underestimated how strong Nate would get while crossing the Gulf of Mexico, and then also underestimated how quickly the cyclone would weaken as it moved through the Gulf Coast states. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 6b. The official forecasts generally had errors near or below that of the guidance from 12–72 h. However, the HMON (HMNI) model beat the official forecasts at 12–36 h, and the HWRF model beat the official forecasts at 36–72 h.

Wind watches and warnings associated with Nate are given in Table 7a, with the associated storm surge watches and warnings given in Table 7b. A hurricane and a storm surge watch were first issued for the northern Gulf Coast 45 h before the center reached the mouth of the Mississippi River and about 50 h before landfall on the Mississippi coast. A hurricane warning and a storm surge warning were issued for this area 33 h before the center reached the mouth of the Mississippi River and about 38 h before the Mississippi coast landfall. A tropical storm warning was issued for the coast of Nicaragua 21 h before the center made landfall on the coast of northeastern Nicaragua. A hurricane watch was also issued for parts of the coast of the Yucatan Peninsula of Mexico, but was later cancelled when the center of Nate stayed east of that area.

Storm surge watches and warnings were issued for portions of the northern Gulf Coast from Morgan City, Louisiana, eastward to the Okaloosa/Walton County Line in Florida, including Mobile Bay and portions of Lake Pontchartrain. In addition, a storm surge watch was issued for other portions of the Florida coast from the Okaloosa/Walton County Line eastward to Indian Pass. With the exception of the area covered by the storm surge warning west of the mouth of the Mississippi River, water level observations indicate that at least 3 ft of inundation (which NHC uses as a first-cut threshold for the storm surge watch/warning) occurred in areas within the bounds of the warning area in Louisiana, Mississippi, Alabama, and Florida (Fig. 6).

NHC's initial forecast for maximum storm surge heights along the northern Gulf Coast (first issued coincident with the storm surge warning at 1500 UTC 6 October) was 4 to 7 ft above ground level from Morgan City, Louisiana, to the Alabama/Florida border. The range of maximum inundation levels was increased to 7 to 11 ft above ground level in the area between the mouth of the Mississippi River and the Mississippi/Alabama border at 1500 UTC 7 October. Water level observations and high water mark surveys indicate that peak water levels reached about 9 ft above ground level along the coast of Mississippi, slightly above the initial forecast range but well within the ultimate range.

The NHC began providing Impact-Based Decision Support Services (IDSS) to emergency managers on October 3, when Nate was a broad area of low pressure over the southwestern Caribbean Sea and continued through October 8, as Nate weakened over the southeast United States. This IDSS included calls and briefings coordinated through the FEMA Hurricane Liaison Team, which is embedded at the NHC. The briefings included the state of Florida, FEMA Regions 4 and 6, and FEMA Headquarters, as well as Federal/State video-teleconferences.

Acknowledgements

The National Weather Service Forecast Offices in Slidell, Louisiana, Mobile, Alabama, Birmingham, Alabama, and Tallahassee, Florida provided much of the data for their areas of responsibility. The USGS provided storm surge data from the affected areas. The Aeronáutical Civil of Colombia provided radar data used to track Nate near Central America, and the Instituto Meteorológico Nacional of Costa Rica provided the rainfall map and data for that country. The Storm Surge Unit of the National Hurricane Center provided the Storm Surge graphics. David Roth of the Weather Prediction Center in College Park, Maryland, provided the rainfall graphic, while Roger Edwards of the Storm Prediction Center in Norman, Oklahoma provided the tornado graphic. The National Centers for Environmental Information provided the damage estimate.

References

Papin, Philippe P., L. F. Bosart, and R. D. Torn, 2017: Climatology of Central American Gyres. *Monthly Weather Review*, **145**, 1983-2009.

Table 1. Best track for Hurricane Nate, 4–8 October 2017.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage*
03 / 1200	10.7	80.8	1008	20	low
03 / 1800	11.1	81.1	1007	25	"
04 / 0000	11.4	81.2	1007	25	"
04 / 0600	11.7	81.4	1006	25	"
04 / 1200	12.0	81.8	1005	25	tropical depression
04 / 1800	12.3	82.3	1005	30	"
05 / 0000	12.6	82.7	1004	30	"
05 / 0600	13.1	83.1	1001	35	tropical storm
05 / 1200	13.9	83.5	999	35	"
05 / 1800	14.5	84.0	1000	35	"
06 / 0000	15.3	84.4	1000	35	"
06 / 0600	16.3	84.7	999	40	"
06 / 1200	17.9	84.7	996	40	"
06 / 1800	19.5	85.2	995	45	"
07 / 0000	21.3	85.9	990	55	"
07 / 0600	23.5	86.5	987	70	hurricane
07 / 1200	25.7	87.9	986	80	"
07 / 1800	27.6	88.9	981	80	"
08 / 0000	29.1	89.2	983	75	"
08 / 0600	30.5	88.9	984	60	tropical storm
08 / 1200	32.2	88.0	993	35	"
08 / 1800	34.1	87.1	996	25	tropical depression
09 / 0000	36.2	85.7	999	20	low
09 / 0600	39.1	83.4	1004	20	extratropical
09 / 1200	41.5	80.5	1005	25	"
09 / 1800	43.1	76.3	1005	25	"
10 / 0000	44.2	72.0	1006	25	"
10 / 0600	45.6	67.6	1006	25	"
10 / 1200	46.1	63.9	1007	25	"
10 / 1800	46.5	60.4	1004	25	"
11 / 0000	47.5	56.0	1001	25	"
11 / 0600					dissipated

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage*
05 / 1200	13.9	83.5	999	35	landfall on the coast of northeastern Nicaragua
08 / 0000	29.1	89.2	983	75	landfall at the mouth of the Mississippi River
08 / 0520	30.4	89.0	984	65	landfall near Biloxi, Mississippi
07 / 1800	27.6	88.9	981	80	minimum pressure and maximum wind

Table 2. Number of hours in advance of formation of Hurricane Nate 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%)	N/A	54
Medium (40%-60%)	18	18
High (>60%)	6	12

Table 3. Selected ship reports with winds of at least 34 kt for Hurricane Nate, 4–8 October 2017.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
06 / 1400	3ETA8	23.6	82.6	140 / 35	1010.4
07 / 0100	3FMK7	23.5	82.5	140 / 37	1010.0
07 / 0400	H3GS	27.0	84.9	100 / 35	1011.0
07 / 0500	3FMK7	23.6	81.4	140 / 35	1011.0
07 / 1200	H3GS	25.8	84.0	140 / 35	1009.0
07 / 1800	D5DY4	28.1	87.7	150 / 47	1005.0
08 / 0000	H3GS	26.6	84.3	160 / 35	1011.0

Table 4. Selected surface observations for Hurricane Nate, 4–8 October 2017.

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)				
Nicaragua									
Puerto Cabezas (MNPC) (14.05N 83.39W) (Inc)	05/1108	1001.0	05/1900	28					
Costa Rica									
Liberia (MRLB) (10.59N 85.54W)									16.22
Maritima (9.39N 84.04W)									19.19
Cuba									
Cabo San Antonio	06/2350	1001.2	07/0100	27	50				
Isabel Rubio					45				
San Juan y Martinez					42				4.04
Santa Lucia					44				
NOAA/Partner Marine Buoys									
42039 NOAA (28.79N 86.01W) (5.0m)	08/0650	1006.1	08/0540	28	35				
42040 NOAA (29.21N 88.23W) (4.0m)	08/0010	998.5	07/2359	49 (1-min)	52				
42056 NOAA (19.92N 84.94W) (4.0m)	06/1940	995.6	06/2001	49 (1-min)	60				
42057 NOAA (16.91N 81.42W) (4.0m)	05/1940	1004.3	06/0558	35 (1-min)	39				
Offshore Oil Platforms									
Viosca Knoll 956 (42364) (29.06N 88.09W) (122m)	08/0030	1002.4	08/0030	47					
Mississippi Canyon 809 (42365) (28.20N 89.12W) (122m)			07/2130	45					
West Delta (KDLP) (29.12N 89.55W) (34.7m)			07/2335	39	48				
Mississippi Canyon (KMDJ) (28.64N 89.79W)			07/2255	32	37				

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)				
Main Pass 140B (KMIS) (29.30N 88.84W) (85m)(inc)	08/0034	985.0	08/0055	62	77				
Main Pass 289 (KVKY) (29.25N 88.44W) (115m)			07/2135	36	46				
Viosca Knoll (KVOA) (29.23N 87.78W)			08/0005	45	54				
United States									
Louisiana									
International Civil Aviation Organization (ICAO) Sites									
Slidell Airport (KASD) (30.34N 89.82W)	08/0453	998.1	08/0153	17	24				0.45
Bootheville (KBVE) (29.33N 89.40W)	08/0051	991.1	07/2227	25	40				0.67
New Orleans International (KMSY) (29.99N 90.25W)	08/0453	1001.6	07/1826	21	28				1.13
Belle Chase NAS (KNBG) (29.92N 90.03W)	07/2255	1001.7	07/1755	26	35				
New Orleans Lakefront (KNEW) (30.04N 90.03W)	08/0401	992.8	08/0201	26	32				1.13
Coastal-Marine Automated Network (C-MAN) Sites									
SW Pass C-MAN (BURL1) (28.91N 89.43W) (38m)	07/2300	989.5	07/2200	46 (10-min)	55				
Louisiana Offshore Oil Port (LOPL1) (28.89N 90.03W) (57.9m)	07/2216	998.1	07/2011	29	37				
LSU CSI06 (SPLL1) (28.87N 90.48W) (10m)			07/2000	24	39				
National Ocean Service (NOS) Sites									
Shell Beach (SHBL1) (29.87N 89.67W) (16m)	8/0224	996.7	8/0212	34	40	5.51		5.1	
New Canal Station (NWCL1) (30.03N 90.11W) (12m)	8/0412	1000.3	8/0200	25	32	2.93		3.2	
I-10 Bonnet Carre Floodway (BCFL1) (30.07N 90.39W)						2.77		3.1	
Pilots Station East, SW Pass (PSTL1) (28.93N 89.41W) (24m)	7/2306	991.3	7/2154	46	57	2.96		3.0	
Pilottown (PILL1) (29.18N 89.26W) (12m)	8/0018	985.7	8/0100	32	43	3.12		3.0	
Port Fourchon, Belle Pass (PTFL1) (29.11N 90.20W)						2.02		2.2	

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)				
Grand Isle (GISL1) (29.26N 89.96W) (9 m)	7/2324	998.7	8/0224	26	32	2.16		2.2	
Freshwater Canal Locks (FRWL1) (29.55N 92.31W) (20m)	7/2142	1003.6	6/1830	14	21	2.58		2.1	
Calcasieu Pass (CAPL1) (29.77N 93.30W) (12m)	8/0006	1003.2	6/0054	16	20	2.21		1.9	
Lake Charles Bulk Terminal (BKTL1) (30.19N 93.30W)						2.16		1.8	
Lake Charles (LCLL1) (30.22N 93.22W)	7/2354	1003.6				1.87		1.8	
Eugene Island (EINL1) (29.37N 91.38W) (10m)	7/2236	1002.7	7/1900	24	33	2.28		1.8	
LAWMA, Amerada Pass (AMRL1) (29.45N 91.34W) (11m)	7/2136	1003.2	7/1900	16	23	1.89	2.45	1.6	
Berwick, Atchafalaya River (TESL1) (29.67N 91.24W) (13m)	8/0048	1003.5	6/1818	15	21	1.20		0.3	
Hydrometeorological Automated Data System (HADS) Sites (NWS)									
Bay Gardene USGS (BGNL1) (29.59N 89.61W)			08/0000	42					
Lake Pontchartrain Rigolets (RIGL1)			07/2200	13					2.67
Mississippi Sound USGS (GRPL1) (30.12N 89.25W)			08/0230	52					
Weatherflow									
Bayou Bievenue (XBVU) (30.00N 89.90W) (10.4m)			07/2253	30	37				
Mississippi									
International Civil Aviation Organization (ICAO) Sites									
Biloxi Keesler AFB (KBIX) (30.41N 88.92W)	08/0522	985.7	08/0453	46	61				4.56
Gulfport Airport (KGPT) (30.41N 89.08W)	08/0453	986.2	08/0445	31	45				2.71
Pascagoula Airport (KPQL) (30.46N 88.53W)	08/0553	992.5	08/0540	39	54				2.65
Coastal-Marine Automated Network (C-MAN) Sites									
Grand Bay NERRS (GDXM6) (30.36N 88.42W) (4.5m)			08/0645	37	45				
National Ocean Service (NOS) Sites									

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)				
Pascagoula Dock C (DCKM6) (30.36N 88.57W) (8.4m)	08/0524	992.1	08/0524	48	60				
Pascagoula NOAA Lab (PNLM6) (30.37N 88.56W)						6.04		6.2	
Petit Bois (PTBM6) (30.21N 88.51W)	08/0436	995.2	08/0506	46	58				
Pascagoula Range A Rear (RARM6) (30.34N 88.51W) (22.9m)	08/0524	993.4	08/0624	45	60				
Pascagoula Dock E (ULAM6) (30.35N 88.51W)						5.99		6.2	
Waveland Yacht Club (WYCM6) (30.33N 89.33W) (9.9m)	08/0448	992.2	08/0336	34	44	5.33	6.67	5.6	
USGS High Water Marks									
Biloxi (MSHAR23449) (30.39N 88.97W)							10.63		
Ocean Springs (MSJAC23455) (30.40N 88.81W)							10.51		
Biloxi (MSHAR23453) (30.39N 88.91W)							10.06		
Gulfport (MSHAR23448) (30.38N 89.03W)							9.47		
Ocean Springs near Shearwater Bridge (MSJAC23456) (30.41N 88.82W)							8.74	3.3	
Old Fort Bayou Bridge (MSJAC23457) (30.42N 88.83W)							8.65	5.2	
Biloxi (MSHAR23452) (30.39N 88.86W)							8.61		
D'Iberville at I-110 Bridge (MSHAR23450) (30.43N 88.89W)							8.55		
Gulfport (MSHAR23447) (30.36N 89.11W)							8.55		
Gulfport (MSHAR23446) (30.37N 89.09W)							8.40	0.5	
Ocean Springs (MSJAC23459) (30.36N 88.76W)							8.32	2.8	

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)				
Biloxi, Back Bay (MSHAR23451) (30.41N 88.98W)							8.29	3.0	
Pass Christian (MSHAR23445) (30.33N 89.20W)							8.23		
Tchoutacabouffa River at I-110 Bridge (MSHAR23460) (30.46N 88.90W)							8.04	4.6	
Ocean Springs (MSJAC23458) (30.36N 88.70W)							7.77	3.5	
Waveland (MSHAN23441) (30.28N 89.37W)							6.90	0.6	
US Hwy 90 Bridge over Pascagoula River (MSJAC23461) (30.37N 88.56W)							6.86	0.5	
US Hwy 90 Bridge over St. Louis Bay (MSHAN23440) (30.32N 89.32W)							6.78	0.2	
Waveland Yacht Club (MSHAN23439) (30.32N 89.33W)							6.67	1.9	
Wolf River at W. Wittman Road Bridge (MSHAR23444) (30.36N 89.27W)							6.63	0.2	
Jack C. Hanson Memorial Bridge, Moss Point (MSJAC23462) (30.42N 88.54W)							6.23		
Pascagoula River at I-10 Bridge (MSJAC23463) (30.44N 88.62W)							6.15		
I-10 Bridge over Jourdan River (MSHAN23443) (30.37N 89.40W)							5.74		
State Hwy 43 Bridge over Bayou La Croix (MSHAN23442) (30.33N 89.42W)							5.21	0.5	
Hydrometeorological Automated Data System (HADS) Sites (NWS)									
Wortham (BLWM6) (30.59N 89.12W)									3.33

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)				
Weatherflow									
Biloxi (XBIL) (30.44N 88.98W) (10.4m)			08/0446	16	43				
Gulfport (XGPT) (30.36N 89.11W) (10.4m)			08/0128	30	41				
Ship Island (XSHI) (30.23N 88.98W) (11.9m)			08/0319	51	63				
Remote Automated Weather Stations (RAWS)									
Camp Keller (CKWM6) (30.52N 89.98W) (6.1m)			08/0450	21	37				4.56
Grand Bay (GRBM6) (30.44N 88.43W) (6.1m)			08/0525	17	36				
Greene (LKKM6) (31.14N 88.60W) (6.1m)			08/0714	14	34				2.84
Sandhill Crane (SHCM6) (30.45N 88.66W) (6.1m)			08/0551	20	39				5.27
State/Local Mesonets									
Pascagoula (USA101) (30.36N 88.50W)			08/0346		39				
Public/Other									
Biloxi Bay	08/0427	984.6	08/0427	50	66				
Ingalls Shipbuilding Pascagoula (30.35N 88.58W) (19.8m)			08/0505		71				
Ocean Springs (30.45N 88.84W)	08/0531	985.5							
NWS Cooperative Observer Program (COOP) Sites									
Long Beach (LNGM6) (30.35N 89.16W)									3.32
Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) Sites									
Lucedale 13SE (MS-GG-2) (30.79N 88.44W)									4.50
Biloxi 13.1NNW (MS-HR-34) (30.50N 89.05W)									3.11
Ocean Springs 3.2SE (MS-JC-8) (30.37N 88.77W)									5.51

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)				
Ocean Springs 3.6ESE (MS-JC-12) (30.38N 88.75W)									5.04
Ocean Springs 1.7W (MS-JC-15) (30.41N 88.83W)									5.99
Gautier 4.9N (MS-JC-22) (30.46N 88.65W)									4.97
Vancleave 9.5 WSW (MS-JC-23) (30.50N 88.82W)									5.37
Waynesboro 5.4WNW (MS-WY-2) (31.70N 88.73W)									4.19
Alabama									
International Civil Aviation Organization (ICAO) Sites									
Albertville (K8A0) (34.23N 86.26W)			08/1515	16	35				
Anniston (KANB) (33.59N 85.85W)	08/1853	1002.0	08/1546	23	39				2.19
Talladega (KASN) (33.57N 86.05W) (inc)			08/1435	21	35				
Mobile Brookley (KBFM) (30.64N 88.07W)	08/0753	998.0	08/0611	31	47				4.91
Birmingham International (KBHM) (33.56N 86.75W)	08/1553	999.8	08/1953	23	35				2.81
Fairhope (KCQF) (30.46N 87.88W)	08/0755	999.9	08/0615	23	36				
Demopolis (KDYA) (32.46N 87.95W)	08/1255	994.3	08/1115	13	19				
Enterprise (KEDN) (31.29N 85.90W)			08/1315	20	34				
Calera (KEET) (33.18N 86.78W)	08/1453	999.3	08/1548	19	35				3.34
Evergreen (KGZH) (31.41N 87/04W)	08/0753	1001.3	08/1335	23	31				2.14
Gulf Shores (KJKA) (30.29N 87.67W)	08/0815	1001.0	08/0335	24	39				
Mobile Regional (KMOB) (30.67N 88.24W)	08/0756	996.0	08/0711	40	57				4.36
Fort Rucker (KOZR) (31.29N 85.72W)	08/1024	1005.3	08/1316	21	37				
Greenville (KPRN) (31.84N 88.61W)	08/0856	1001.9	08/0856	24	34				
Selma (KSEM) (32.24N 86.99W)			08/1055	22	38				

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)				
Coastal-Marine Automated Network (C-MAN) Sites									
Cedar Point DISL (CTRA1) (30.31N 88.14W) (12.2m)	08/0617	996.3	08/0540	44					
Dauphin Island (DPIA1) (30.25N 88.08W) (13.5m)	08/0600	998.7	08/0400	39	50	3.09	3.96	3.26	
Katrina Cut DISL (KATA1) (30.26N 88.21W) (15.7m)	08/0520	996.6	08/0521	47					
Middle Bay Lighthouse DISL (MBLA1) (30.44N 88.01W) (14.2m)	08/0812	999.7	08/0826	47					
Meaher Park DISL (MHPA1) (30.67N 87.94W) (8.5m)	08/0715	997.6	08/0826	40					
Perdido Pass DISL (PPTA1) (30.28N 87.56W)	08/0730	1001.4							
National Ocean Service (NOS) Sites									
Dog River Bridge (BYSA1) (30.57N 88.09W)						4.04		4.6	
East Fowl River Bridge (EFRA1) (30.44N 88.11W)						3.74		3.9	
Chickasaw Creek (CIKA1) (30.78N 88.07W)						4.62		4.9	
West Fowl River Bridge (WFRA1) (30.38N 89.16W)						4.12	6.50	5.6	
Bayou La Batre (BLBA1) (30.41N 88.25W)						4.61	6.78	5.9	
Fort Morgan (FMOA1) (30.23N 88.02W) (38m)	08/0548	996.8	08/0118	48	61				
Mobile Coast Guard Sector (MCGA1) (30.65N 88.06W) (7m)	08/0748	997.7	08/0700	27	43	5.73		5.4	
Mobile State Docks (OBLA1) (30.71N 88.04W)	08/0754	998.0				5.14	6.27	5.1	
Weeks Bay (WYBA1) (30.42N 87.83W)						4.61		4.4	
USGS Storm Tide Sensors									
Mobile Bay near Daphne (ALBAL00005) (30.63N 87.92W)							6.59		
Mobile Bay near Fairhope (ALBAL00004) (30.53N 87.91W)							5.73		
Bon Secour (ALBAL00002) (30.30N 87.73W)							4.71		
Mobile Bay near Fort Morgan (ALBAL00003) (30.23N 88.02W)							4.21		

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)				
Weatherflow									
Buccaneer Yacht Club (XBUC) (30.58N 88.07W) (10m)			08/0647	38	49				
Foley (XGLF) (30.36N 87.65W) (10m)			08/0455	25	41				
Perdido Bay (XMLP) (30.27N 87.56W) (5m)	08/0752	1000.0	08/0607	30	42				
Remote Automated Weather Stations (RAWS)									
Gasque (BONA1) (30.25N 87.81W)			08/0617		23				5.70
Grove Hill (TT399) (31.69N 87.76W)			08/1126	21	38				
Terrapin Creek (TT276) (33.89N 85.53W) (6.1m)			08/1634	16	34				
State/Local Mesonets									
Grand Bay (USA304) (30.51N 88.4W)			08/0544		47				
Mobile Dog River (USA305) (30.56N 88.10W)			08/0633	34	40				
Saraland (USA306) (30.83N 88.1W)			08/0707		35				
Bay Minette (USA401) (30.89N 87.8W)			08/0301		39				
Elberta (USA403) (30.41N 87.6W)			08/0310	28	38				
Fairhope (USA404) (30.54N 87.90W)			08/0702	33	38				
Foley (USA405) (30.37N 87.60W)			08/0627		35				
Loxley (USA406) (30.64N 87.70W)			08/0616	37	44				
Atmore (USA501) (31.02N 87.40W)			08/0703	29	36				
Poarch Creek (USA503) (31.09N 87.50W)			08/0847		36				
Andalusia (USA702) (31.29N 86.5W)			08/0948		34				
Public/Other									
Calvert ARPSWXNET (E0390) (31.15N 88.00W)	08/0842	994.3	08/0922	16	39				
Clanton ARPSWXNET (F0039) (32.78N 86.72W)			08/1517	21	40				
Clanton ARPSWXNET (F0139) (32.92N 86.67W)			08/1416	17	34				

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)				
Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) Sites									
Orange Beach 2.1NE (AL-BW-27) (30.32N 87.55W)									7.06
Loxley (AL-BW-26) (30.61N 87.75W)									5.34
Daphne 4.2NE (AL-BW-36) (30.64N 87.85W)									5.81
Elberta 3.1SSW (AL-BW-53) (30.37N 87.61W)									6.96
Spanish Fort 1.2NE (AL-BW-58) (30.68N 87.86W)									4.73
Bay Minette 10.9N (AL-BW-59) (31.03N 87.77W)									3.83
Silverhill (AL-BW-65) (30.54N 87.75W)									6.52
Foley 4.5SE (AL-BW-74) (30.35N 87.63W)									7.71
Fairhope (AL-BW-82) (30.52N 87.90W)									6.32
Grove Hill 6SW (AL-CK-3) (31.64N 87.85W)									3.72
Tillmans Corner 4.3WNW (AL-MB-1) (30.61N 88.24W)									7.37
Mobile 2.6W (AL-MB-4) (30.72N 88.23W)									6.30
Saraland 6.8NNW (AL-MB-14) (30.91N 88.12W)									4.72
Mobile 7.4W (AL-MB-35) (30.65N 89.07W)									6.63
Mobile 10.2WSW (AL-MB-60) (30.44N 88.71W)									7.20
Uriah 8W (AL-MN-3) (31.30N 87.64W)									3.84
Jackson 4.3WSW (AL-WS-1) (31.48N 87.96W)									4.70

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)				
Pine Hill 3.6WSW (AL-WX-1) (31.96N 87.64W)									4.02
Florida									
International Civil Aviation Organization (ICAO) Sites									
DeFuniak Springs (K54J) (30.70N 86.20W)			08/0815	26	35				
Crestview (KCEW) (30.79N 86.52W)	08/0753	1003.6	08/1353	22	36				
Destin (KDTS) (30.40N 86.47W)	08/0853	1003.7	08/1031	27	50				2.90
Panama City NW (KECP) (30.36N 85.80W)	08/1053	1007.2	08/1446	24	34				
Duke Field (KEGI) (30.85N 86.52W)	08/0831	1002.6	08/1048	27	45				
Hurlbert Field (KHRT) (30.43N 86.69W)	08/0940	1002.8	08/0747	34	45				
Pensacola NAS (KNPA) (30.36N 87.32W)	08/0856	1001.6	08/0422	35	46				
Tyndall AFB (KPAM) (30.07N 85.59W)	08/0940	1007.0	08/0929	25	34				
Pensacola Regional (KPNS) (30.47N 87.20W)	08/0853	1001.5	08/0605	33	46				3.28
Eglin AFB (KVPS) (30.48N 86.53W)	08/0855	1003.9	08/0955	29	42				
Coastal-Marine Automated Network (C-MAN) Sites									
Tyndall AFB Tower (SGOF1) (29.41N 84.86W) (35.1m)	08/0700	1009.0	08/0730	30 (10-min)	36				
National Ocean Service (NOS) Sites									
Apalachicola (APCF1) (29.72N 84.98W) (9m)	8/0712	1008.6	8/0930	24	28	2.88	3.88	3.0	
Pensacola (PCLF1) (30.40N 87.21W)	08/0836	1001.4				3.22	4.01	3.1	
Panama City (PACF1) (30.15N 85.67W) (8.2m)	08/0936	1006.8	08/1206	26	33	2.52	3.18	2.4	
Panama City Beach (PCBF1) (30.21N 85.88W) (8.6m)	08/1018	1006.0	08/0954	33	43	2.88	3.60	2.6	
USGS High Water Marks									
Santa Rosa Island (FLSAN23280) (30.38N 86.86W)							8.11		

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)				
Pensacola Beach (FLESC23282) (30.33N 87.14W)							5.56		
Okaloosa Island (FLOKA23279) (30.39N 86.59W)							4.61		
St. Marks River (FLWAK03364) (30.15N 84.21W)							4.51		
Bayou Chico (FLESC03320) (30.40N 87.25W)							4.19		
US98 Bridge over Perdido Bay (FLESC03324) (30.40N 87.43W)							4.13		
Bayou Grande (FLESC03321) (30.37N 87.28W)							3.68		
Choctawhatchee Bay (FLOKA03301) (30.44N 86.58W)							3.63		
Big Lagoon State Park (FLESC03323) (30.31N 87.42W)							3.60		
Pensacola (FLESC03319) (30.41N 87.19W)							3.60		
USGS Storm Tide Sensors									
Santa Rosa Island (FLSAN23280) (30.38N 86.86W)							7.67		
St. Marks River (FLWAK03364) (30.15N 84.21W)							4.61		
Bayou Grande (FLESC03321) (30.37N 87.28W)							4.04		
Bayou Chico (FLESC03320) (30.40N 87.25W)							3.93		
US90 Bridge over Perdido Bay (FLESC03324) (30.40N 87.43W)							3.78		
Pensacola (FLESC03319) (30.41N 87.19W)							3.70		

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)				
Big Lagoon State Park (FLESC03323) (30.31N 87.42W)							3.65		
Choctawhatchee Bay (FLOKA03301) (30.44N 86.58W)							3.49		
Niceville Landing (FLOKA03300) (30.52N 86.49W)							3.42		
USGS Rapid Deployment Gauges									
US90 Bridge over St. Andrew Bay (FLBAY03331) (30.19N 85.74W)							3.22		
Destin (FLOKA23273) (30.39N 86.52W)							3.16		
Weatherflow									
Pensacola Bay (XFPL) (30.36N 87.21W) (5m)	08/0807	1001.5	08/0432	35	49				
Choctawatchee Bay (XFWB) (30.40N 86.56W)			08/0728	34	45				
Gulf Breeze (XGBZ) (30.36N 87.16W) (15m)			08/0418	24	39				
Panama City Beach (XPAN) (30.23N 85.88W)			08/1022		38				
St. Andrews Bay (XSTA) (30.13N 85.72W)			08/0937		36				
Remote Automated Weather Stations (RAWS)									
Naval Live Oaks (TR992) (30.37N 87.13W) (6.1m)			08/0422	20	35				
State/Local Mesonets									
Jay (USA1601) (30.95N 87.2W)			08/0541		44				
Jay (FAWN110) (30.78N 87.14W)			08/0545		39				
Public/Other									
Panama City FSU WeatherSTEM (30.19N 85.72W)			08/0406	30	39				
Southport ARPSWXNET (AT414) (30.31N 85.61W)			08/1240		35				

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)				
Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) Sites									
Gonzalez 2.5NNW (FL-ES-4) (30.60N 87.31W)									3.40
Pensacola 2.3NE (FL-ES-37) (30.44N 87.17W)									6.80
Century 12.1W (FL-ES-39) (30.97N 87.47W)									3.04
Pensacola Beach 3.8ENE (FL-ES-49) (30.35N 87.08W)									5.94
Eglin AFB 5.6NW (FL-OK-2) (30.51N 86.48W)									4.89
Crestview 1.9SE (FL-OK-23) (30.74N 86.55W)									8.15
Mary Esther (FL-OK-29) (30.42N 86.64W)									6.17
Niceville 2.1SE (FL-OK-37) (30.47N 86.44W)									4.53
Pace 2.4N (FL-SR-4) (30.63N 87.16W)									4.64
Milton 5.6NW (FL-SR-18) (30.67N 87.09W)									4.05
Gulf Breeze 7.2ENE (FL-SR-19) (30.39N 97.08W)									9.93
Navarre 6.2E (FL-SR-21) (30.40N 86.76W)									6.75
Georgia									
Remote Automated Weather Stations (RAWS)									
Cohutta (COHG1) (34.92N 84.66W) (6.1m)			08/2005	15	36				2.84
State/Local Mesonets									
Gainesville (GA335) (34.27N 83.82W)			08/1620	21	35				

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)				
Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) Sites									
Dillard 3.5NE (GA-RB-1) (34.99N 83.30WS)									8.44
Tennessee									
Public/Other									
Roan Mountain 4WSW ARPSWXNET (D5724) (36.17N 82.15W)			09/0203		36				2.36
South Carolina									
Public/Other									
Zirconia ARPSWXNET (D1971) (35.16N 82.46W)			09/0200	25	44				
North Carolina									
Public/Other									
Barrett ARPSWXNET (D4539) (36.51N 80.95W)			09/0623	21	41				
Whitehead 2S ARPSWXNET (E4486) (36.43N 81.15W)			09/0104	17	37				7.22
Rominger 2SSW ARPSWXNET (E9464) (36.20N 81.85W)			08/2319	28	43				1.06
Silverstone 1E ARPSWXNET (F0218) (36.30N 81.72W)			09/0319	31	54				4.06
Beach Mountain ARPSWXNET (F0759) (36.19N 81.88W)			09/0331	17	37				
Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) Sites									

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)				
Jonas Ridge 1.4S (NC-BK-13) (35.95N 81.89W)									8.16
Virginia									
International Civil Aviation Organization (ICAO) Sites									
Hillsville (KHLX) (36.77N 80.82W)			09/0535	18	37				
Public/Other									
Roanoke 2SE ARPSWXNET (AP504) (37.25N 79.93W)			09/0715	21	40				0.72
Vesuvius 1WSW ARPSWXNET (E4884) (37.89N 79.22W)			09/0907		37				0.96

[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. For some USGS storm tide pressure sensors, inundation is estimated by subtracting the elevation of the sensor from the recorded storm tide. For other USGS storm tide sensors and USGS high-water marks, inundation is estimated by subtracting the elevation of the land derived from a Digital Elevation Model (DEM) from the recorded and measured storm tide. For NOS tide gauges, the height of the water above Mean Higher High Water (MHHW) is used as a proxy for inundation.

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Nate, 4–8 October 2017. 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	**24.6**	**35.5**	**53.4**	79.6	177.4	220.6	
OCD5	62.2	153.6	277.1	434.2	704.5	892.7	
Forecasts	16	14	12	10	6	2	
OFCL (2012-16)	24.9	39.6	54.0	71.3	105.8	155.4	208.9
OCD5 (2012-16)	47.3	103.9	167.8	230.3	343.1	442.6	531.0

Table 5b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Nate, 4–8 October 2017. 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	25.7	37.8	56.7	86.5	184.7	223.1	
OCD5	64.8	161.5	293.7	461.5	733.4	938.6	
GFSI	30.6	58.5	94.1	131.9	198.9	235.4	
HMNI	30.3	58.0	90.2	133.0	268.1	441.1	
HWFI	30.4	51.6	67.1	**72.9**	**94.5**	**114.4**	
EGRI	32.8	59.6	84.9	96.3	**84.5**	**160.3**	
EMXI	29.9	57.5	71.0	88.0	204.6	416.6	
CMCI	32.3	54.4	63.1	**73.5**	**72.9**	**66.9**	
NVGI	27.3	41.3	68.9	99.6	205.9	300.0	
AEMI	27.0	53.9	80.3	104.9	198.1	246.0	
HCCA	**20.9**	**36.0**	**54.8**	**77.3**	**131.8**	247.9	
TVCX	**22.0**	37.9	**54.3**	**80.7**	**144.2**	**216.5**	
GFEX	**25.6**	50.7	72.9	105.8	191.3	290.9	
TCON	**24.4**	42.5	68.1	89.7	**108.4**	**78.0**	
TVCA	**21.1**	**35.7**	**54.4**	**81.4**	**135.4**	**162.3**	
TABD	31.9	59.8	116.2	173.6	309.2	281.6	
TABM	36.3	68.7	114.3	154.5	215.8	**149.0**	
TABS	41.7	81.4	124.6	162.3	185.1	256.8	
Forecasts	15	13	11	9	5	1	

Table 6a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Nate, 4–8 October 2017. 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	10.7	10.8	12.0	15.8	37.5	
OCD5	7.0	12.2	18.3	25.7	31.2	2.0	
Forecasts	16	14	12	10	6	2	
OFCL (2012-16)	5.5	8.2	10.5	12.0	13.4	14.0	14.5
OCD5 (2012-16)	7.1	10.5	13.0	15.1	17.4	18.2	20.6

Table 6b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Nate, 4–8 October 2017. 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	7.7	10.4	11.0	10.6	18.0	35.0	
OCD5	**7.3**	12.2	20.5	25.1	27.6	**3.0**	
HWFI	8.9	13.2	**10.3**	**9.4**	**14.8**	**17.0**	
HMNI	**6.1**	**6.6**	**9.3**	11.6	26.8	**2.0**	
COTI	8.0	11.2	13.9	11.0	49.4	35.0	
DSHP	**7.5**	11.1	14.5	16.8	20.4	**18.0**	
LGEM	8.3	12.3	17.4	21.0	22.4	**13.0**	
ICON	**7.4**	11.3	13.7	14.6	19.0	**16.0**	
IVCN	**6.6**	11.1	14.6	15.8	18.0	**16.0**	
HCCA	**6.4**	**10.2**	12.3	11.9	**16.6**	**15.0**	
GFSI	9.9	13.8	20.0	22.9	26.0	**3.0**	
EMXI	10.3	15.7	19.7	20.6	20.8	**7.0**	
Forecasts	15	12	10	8	5	1	

Table 7a. Wind watch and warning summary for Hurricane Nate, 4–8 October 2017.

Date/Time (UTC)	Action	Location
4 / 1500	Tropical Storm Warning issued	Sandy Bay Sirpi, Nicaraguai to Punta Castilla, Honduras
5 / 0300	Hurricane Watch issued	Coast of Mexico from Punta Herrero to Cabo Catoche
5 / 0900	Hurricane Watch modified to	Coast of Mexico west of Cabo Catoche to Rio Lagartos
5 / 1500	Tropical Storm Warning issued	Coast of Mexico from Punta Herrero to Rio Lagartos
6 / 0300	Hurricane Watch issued	Gulf Coast from Morgan City, Louisiana to the Mississippi/Alabama Border including metropolitan New Orleans, Lake Pontchartrain, and Lake Maurepas
6 / 0300	Tropical Storm Watch issued	Gulf Coast east of the Mississippi/Alabama Border to the Okaloosa/Walton county line in Florida, and west of Morgan City to Intracoastal City, Louisiana
6 / 0300	Tropical Storm Warning discontinued	Nicaragua
6 / 1500	Hurricane Warning Issued	Gulf Coast from Grand Isle, Louisiana to the Alabama/Florida Border
6 / 1500	Hurricane Watch issued	Florida Coast east of the Alabama/Florida Border to the Okaloosa/Walton county line
6 / 1500	Tropical Storm Warning issued	Metropolitan New Orleans, Lake Pontchartrain, and Lake Maurepas, and the Gulf Coast west of Grand Isle to Morgan city
6 / 1500	Tropical Storm Warning issued	Cuban provence of Pinar del Rio
6 / 1500	Tropical Storm Watch issued	Florida Coast east of the Okaloosa/Walton county line to Indian Pass, Florida
6 / 1500	Tropical Storm Watch issued	Cuban provence of Isle of Youth
6 / 1500	Tropical Storm Warning discontinued	Honduras
6 / 2100	Hurricane Warning issued	Metropolitan New Orleans and Lake Pontchartrain
6 / 2100	Tropical Storm Warning issued	Florida Coast east of the Alabama/Florida Border to the Okaloosa/Walton county line
7 / 0300	Hurricane Watch discontinued	Coast of Mexico
7 / 0900	All coastal watches and warning discontinued	Cuba and Mexico
7 / 1500	Tropical Storm Warning issued	Florida Coast east of the Alabama/Florida Border to Indian Pass, Florida
7 / 2100	Hurricane Watch discontinued	Louisiana Coast west of Grand Isle

Date/Time (UTC)	Action	Location
7 / 2100	Tropical Storm Watch discontinued	Louisiana Coast west of Morgan City
8 / 0000	Hurricane Warning changed to Tropical Storm Warning	Metropolitan New Orleans and Lake Pontchartrain
8 / 0000	Hurricane Watch discontinued	Lake Maurepas
8 / 0300	Hurricane Warning changed to Tropical Storm Warning	Louisiana Coast from Grand Isle to the mouth of Pearl River
8 / 0300	Hurricane Watch discontinued	Gulf Coast of Florida
8 / 0300	Tropical Storm Warning discontinued	Louisiana Coast west of Grand Isle
8 / 0900	Hurricane Warning changed to Tropical Storm Warning	Gulf Coast from the mouth of the Pearl River to the Alabama/Florida Border
8 / 0900	Tropical Storm Warning discontinued	Metropolitan New Orleans, Lake Pontchartrain, and Lake Maurepas, and the Louisiana Coast
8 / 1200	Tropical Storm Warning discontinued	Gulf Coast west of the Alabama/Florida Border
8 / 1500	All coastal warnings discontinued	

Table 7b. Storm surge watch and warning summary for Hurricane Nate, 4–8 October 2017.

Date/Time (UTC)	Action	Location
6 / 0300	Storm Surge Watch Issued	Gulf Coast from Morgan City, Louisiana to the Alabama/Florida Border including the northern and western shores of Lake Pontchartrain
6 / 1500	Storm Surge Warning issued	Gulf Coast from Morgan City, Louisiana to the Alabama/Florida Border including the northern and western shores of Lake Pontchartrain
6 / 1500	Storm Surge Watch Issued	Florida Coast east of the Alabama/Florida Border to Indian Pass, Florida
6 / 2100	Storm Surge Warning issued	Florida Coast east of the Alabama/Florida Border to the Okaloosa/Walton county line
7 / 2100	Storm Surge Warning discontinued	Louisiana Coast west of Grand Isle
7 / 2100	Storm Surge Watch discontinued	Florida Coast east of the Okaloosa/Walton county line to Indian Pass, Florida
8 / 0300	Storm Surge Warning discontinued	Lake Pontchartrain and the Louisiana Coast west of the mouth of the Mississippi River
8 / 0600	Storm Surge Warning discontinued	Louisiana Coast from the mouth of the Mississippi River to Pointe a la Hache
8 / 1200	Storm Surge Warning discontinued	Gulf Coast west of the Alabama/Florida Border

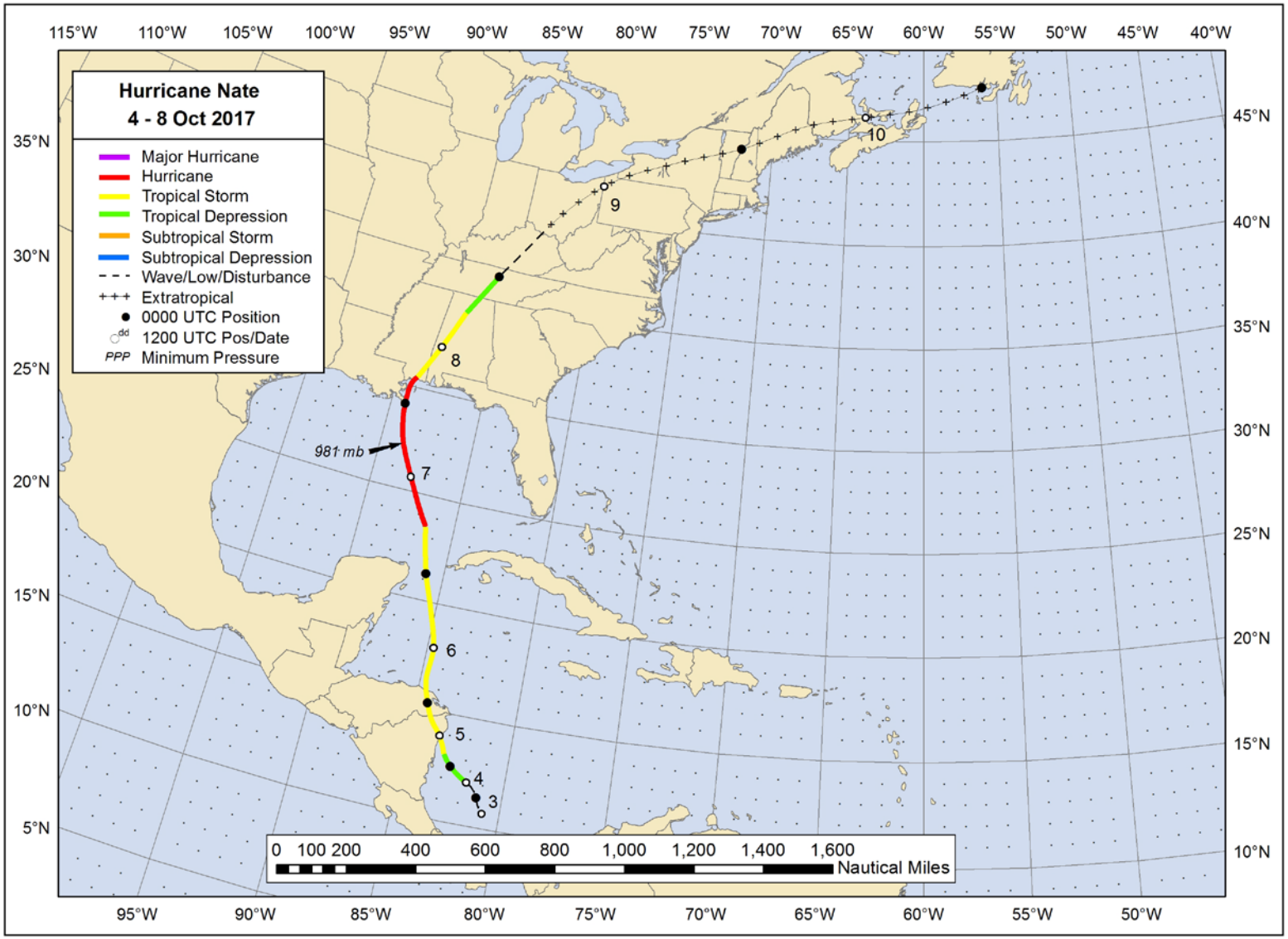

Figure 1. Best track positions for Hurricane Nate, 4–8 October 2017. Tracks over the United States and during the extratropical stage are partially based on analyses from the NOAA Weather Prediction Center.

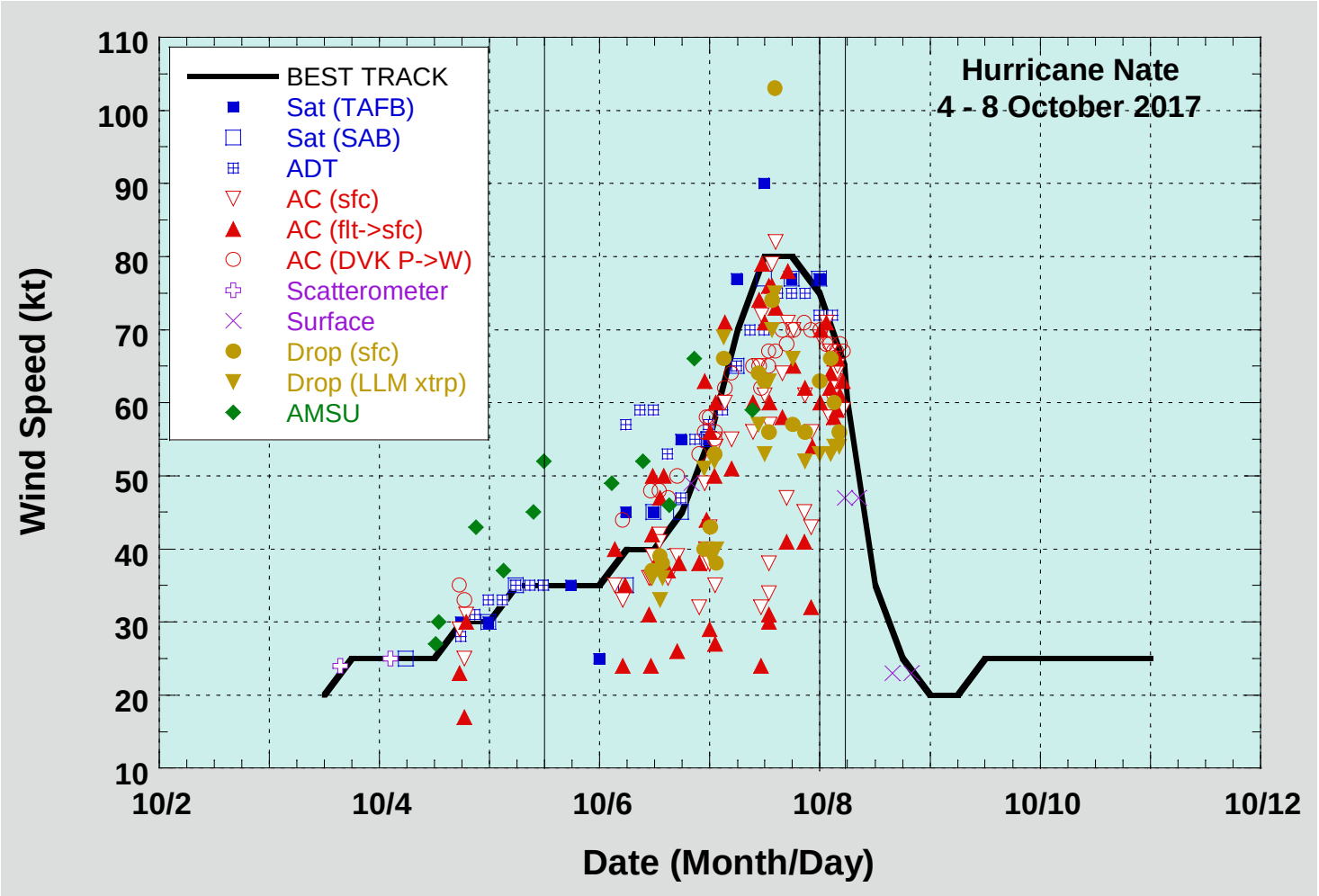

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Nate, 4–8 October 2017. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% adjustment factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Dropwindsonde 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 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 solid vertical lines correspond to landfalls.

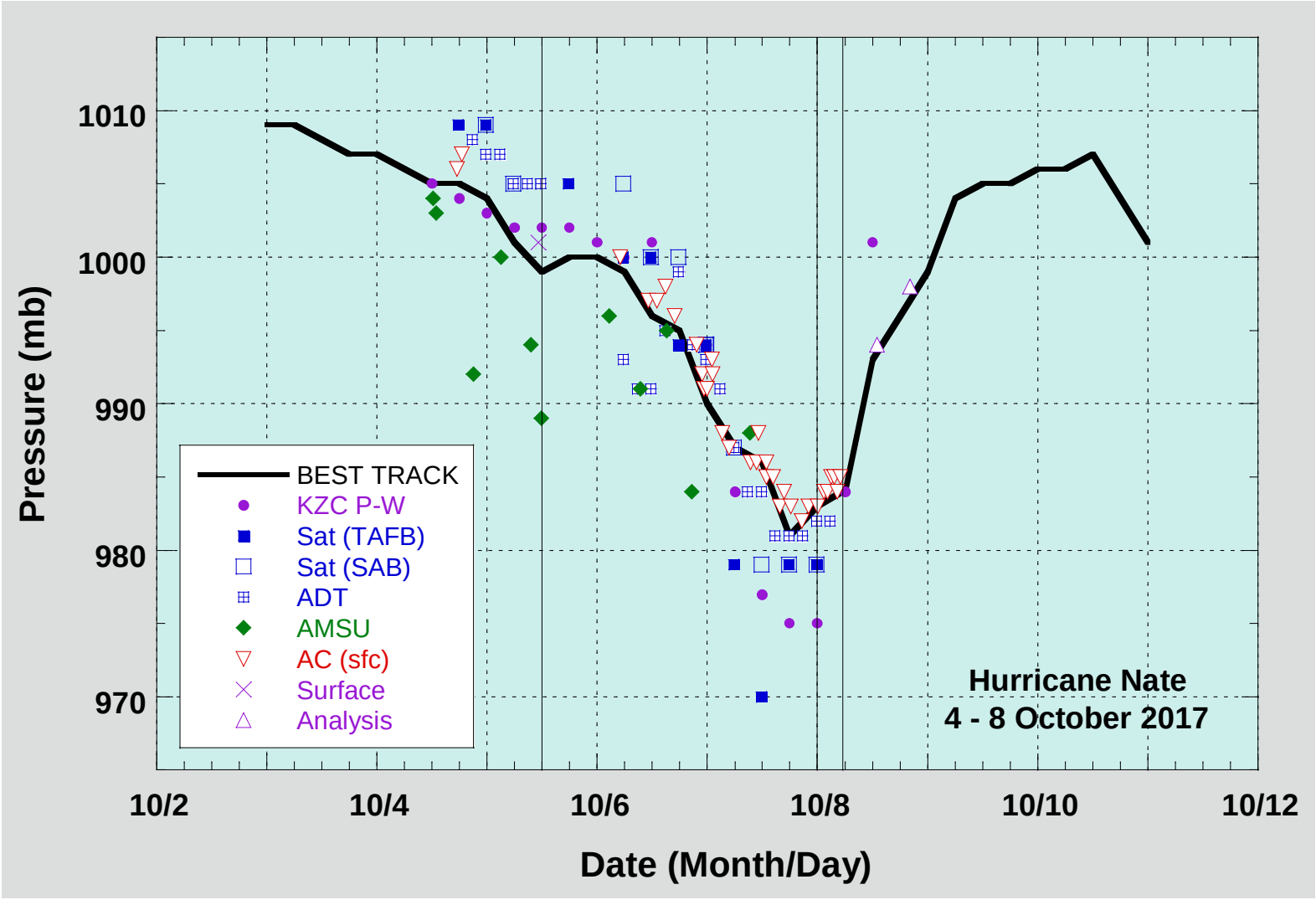

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Nate, 4–8 October 2017. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological 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 solid vertical lines correspond to landfalls.

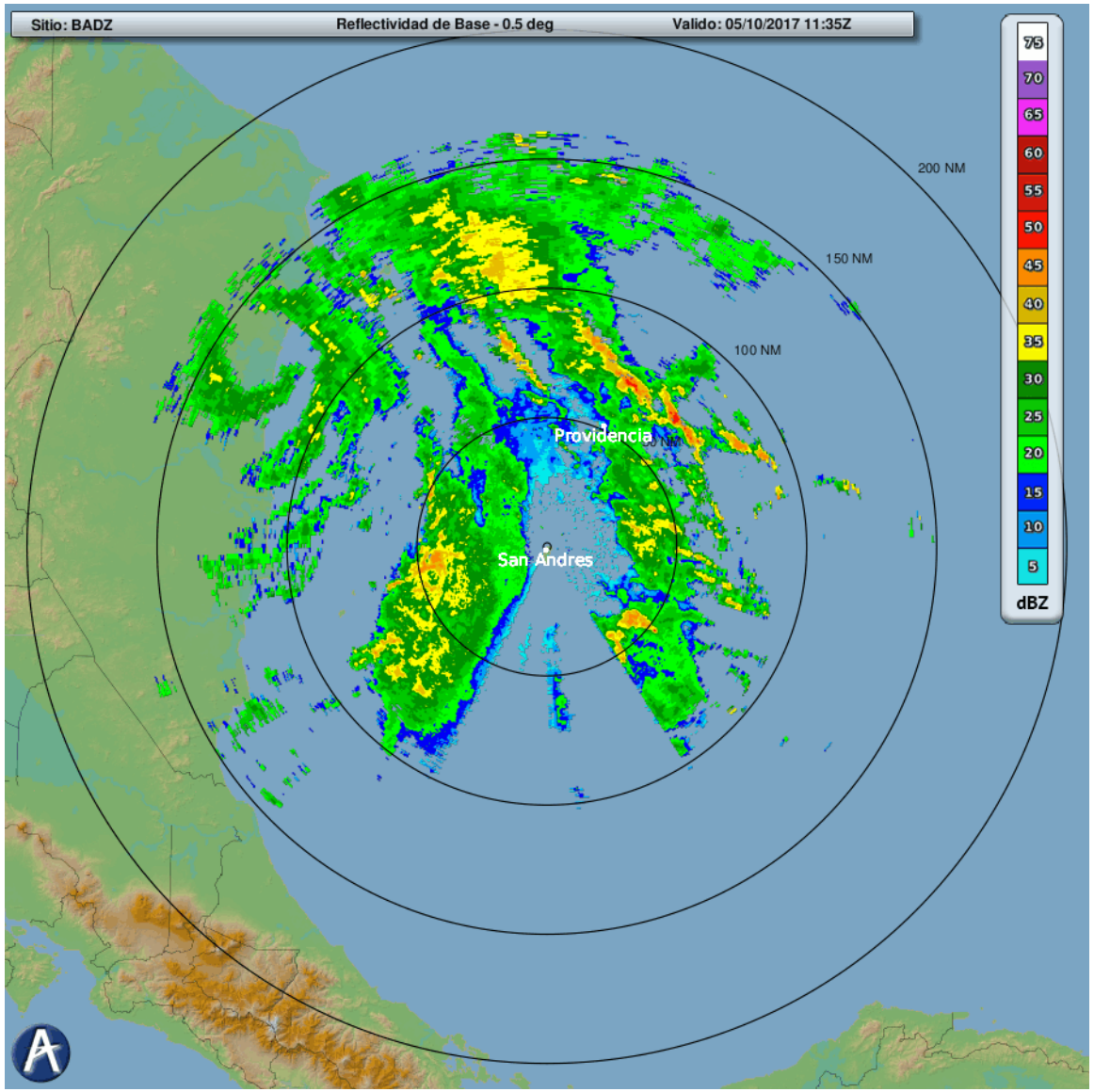

Figure 4. Radar imagery of Nate close to landfall in northeastern Nicaragua at 1135 UTC 5 October courtesy of the Aeronáutical Civil of Colombia.

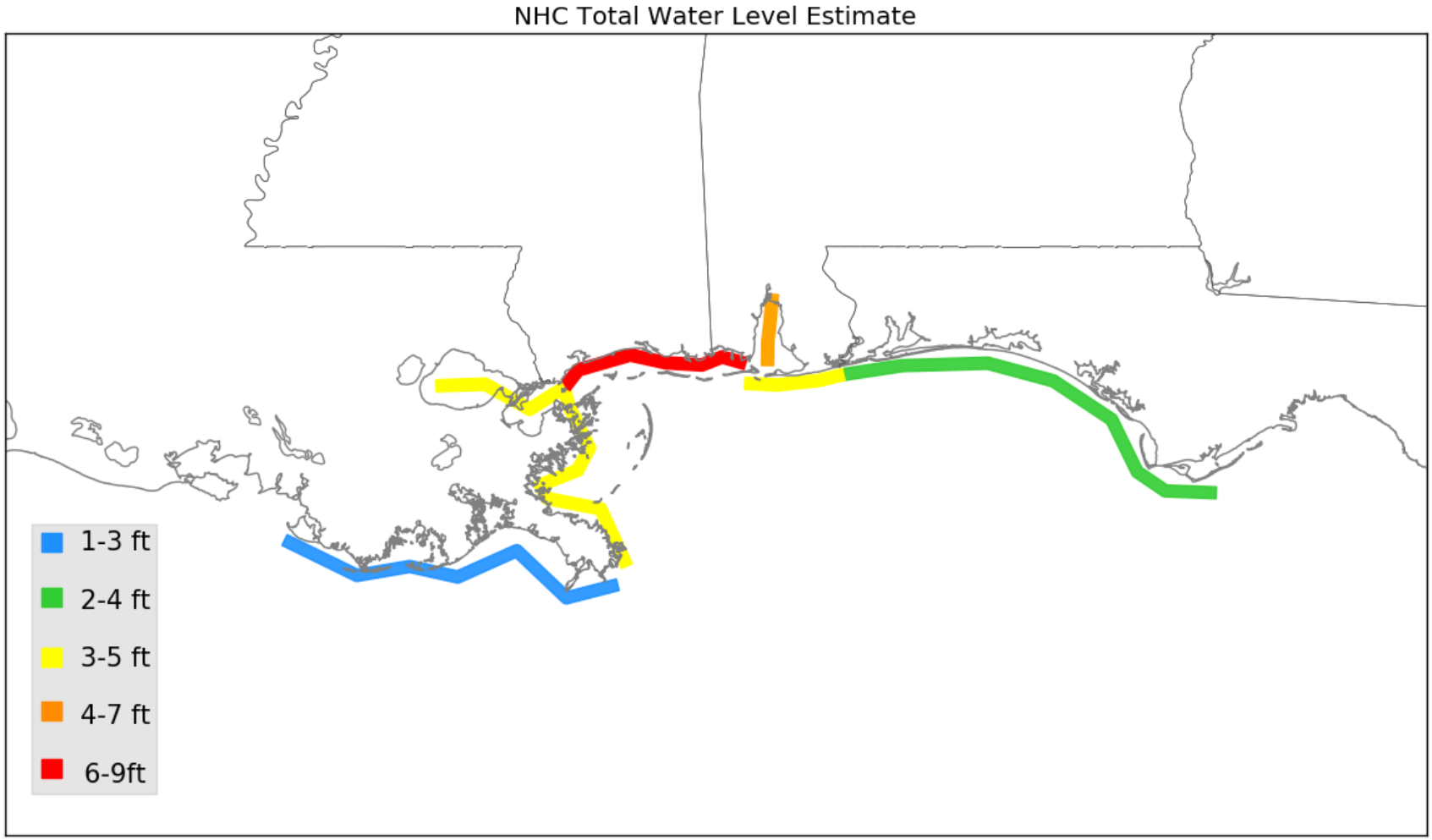

Figure 5. Analyzed storm surge inundation (feet above ground level) along the northern Gulf Coast from Hurricane Nate. Image courtesy of the NHC Storm Surge Unit.

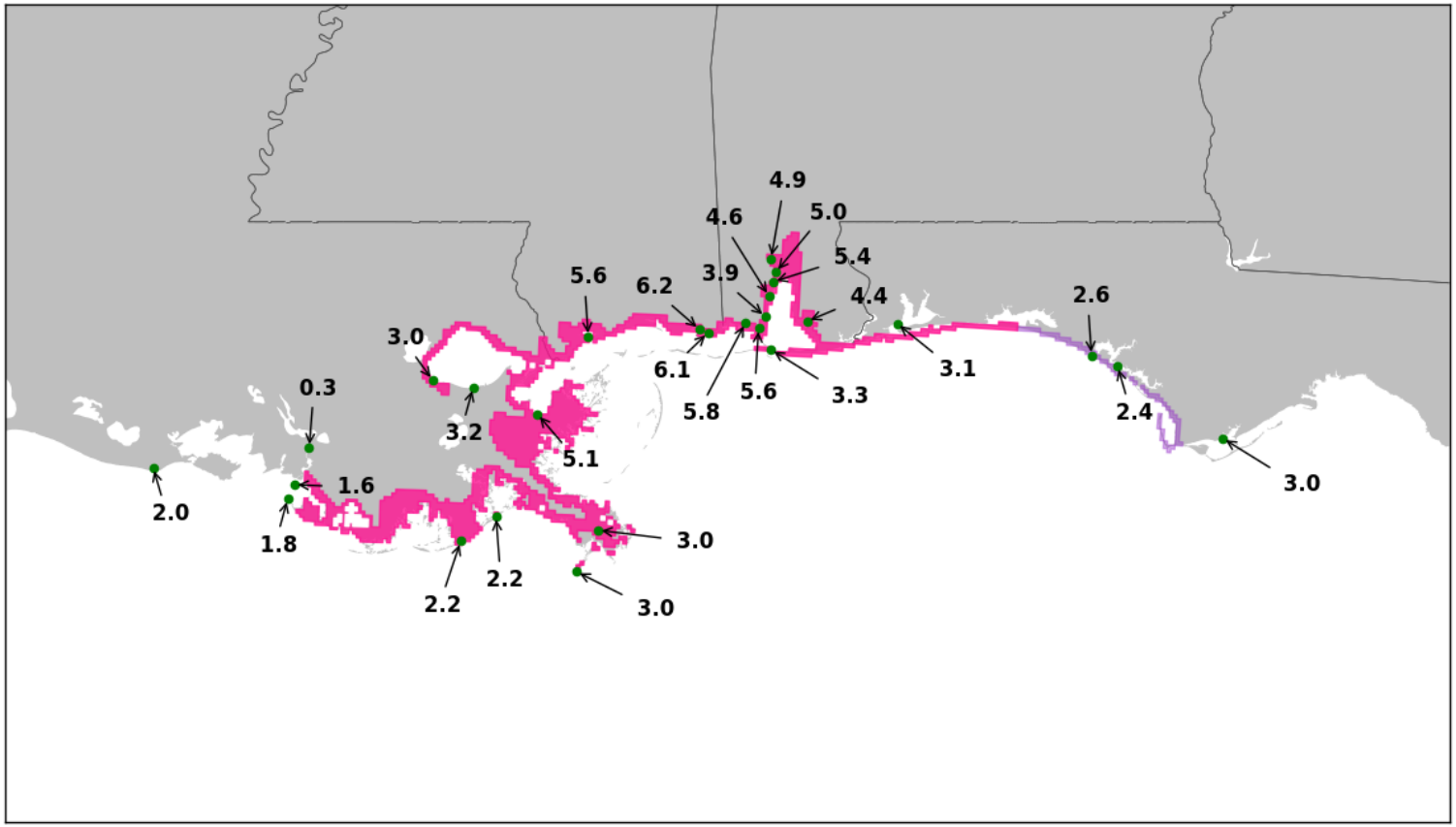

Figure 6. Maximum water levels (feet) measured from tide gauges along the northern Gulf Coast during Hurricane Nate and areas covered by storm surge warnings (magenta) and watches (lavender). Water levels are referenced above Mean Higher High Water (MHHW), which is used as a proxy for inundation (above ground level) on normally dry ground along the immediate coastline. Image courtesy of the NHC Storm Surge Unit.

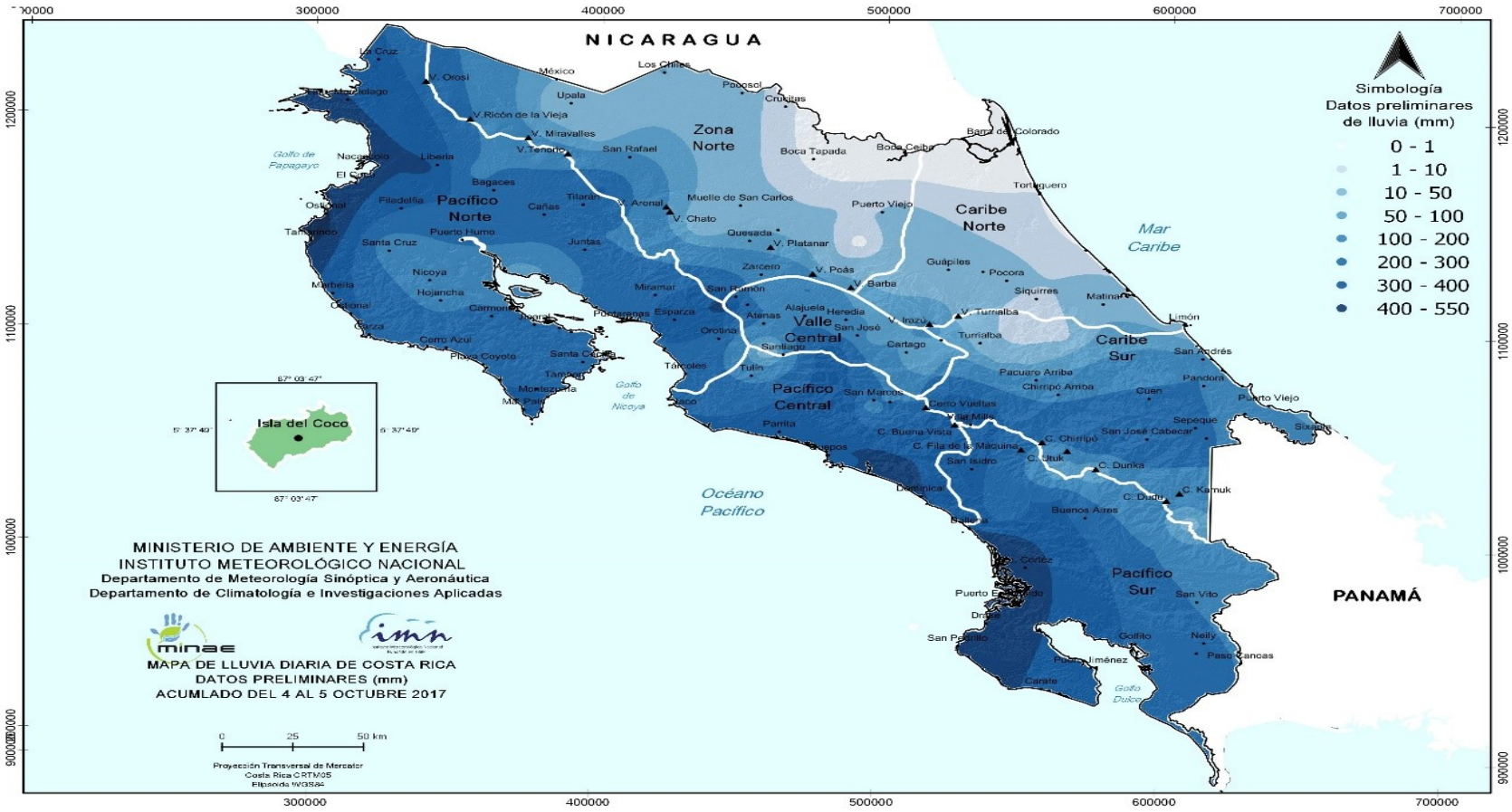

Figure 7. Rainfall distribution (mm) in Costa Rica for Hurricane Nate, 4–8 October 2017. Image courtesy of the Instituto Meteorológico Nacional of Costa Rica.

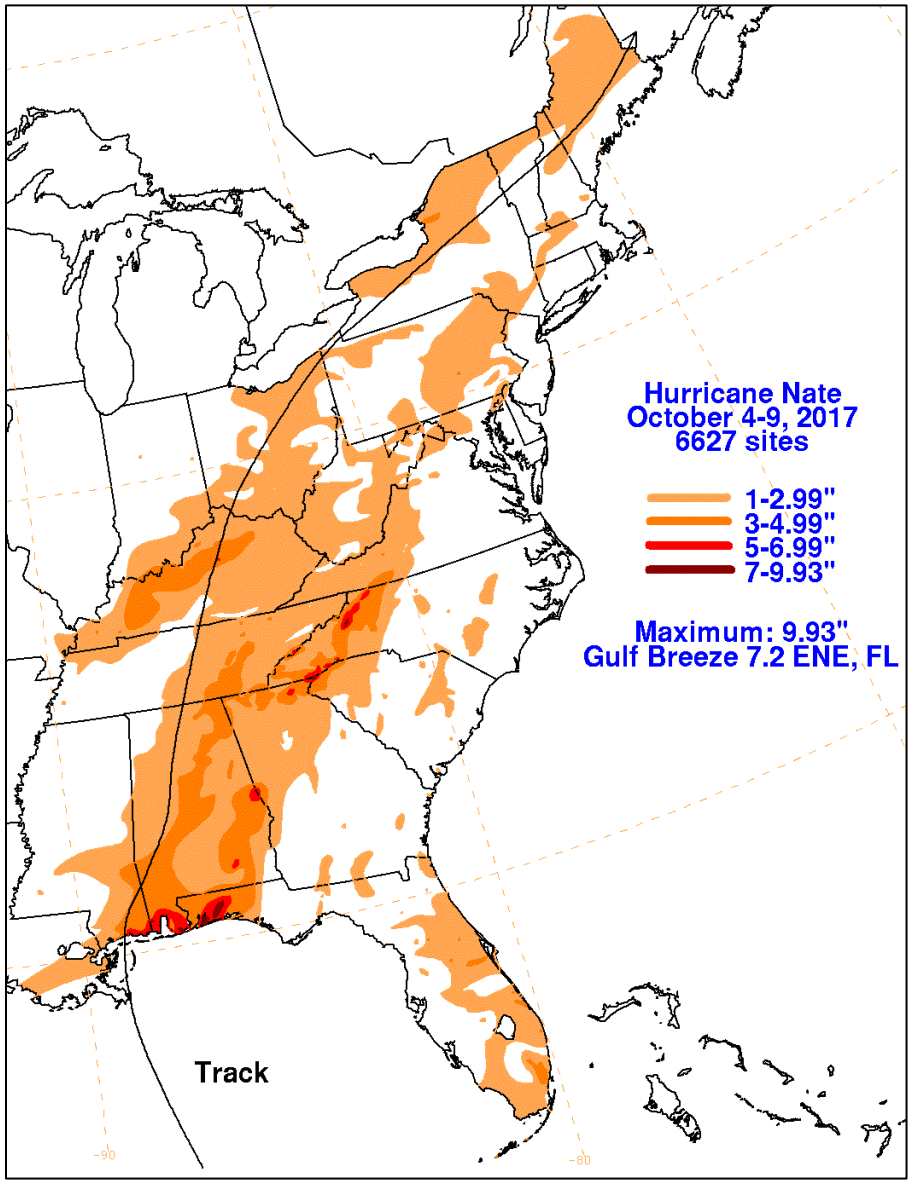

Figure 8. Rainfall distribution (inches) in the United States for Hurricane Nate, 4–8 October 2017. Image courtesy of David Roth at the Weather Prediction Center, College Park, Maryland.

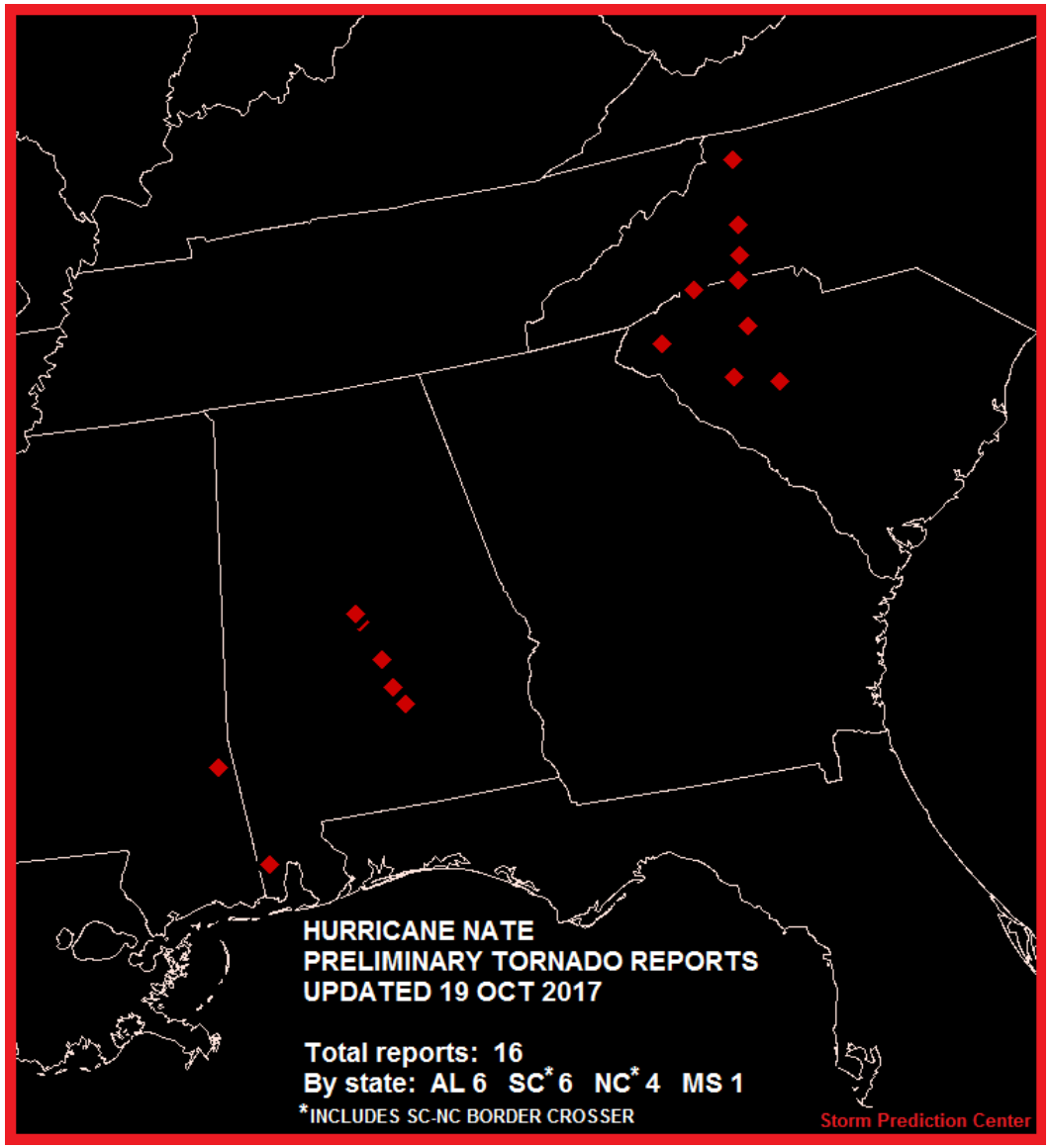

Figure 9. Map of the tornadoes associated with Hurricane Nate, courtesy of Roger Edwards at the Storm Prediction Center, Norman, Oklahoma.