NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

TROPICAL STORM NADINE

(AL152024)

19–20 October 2024

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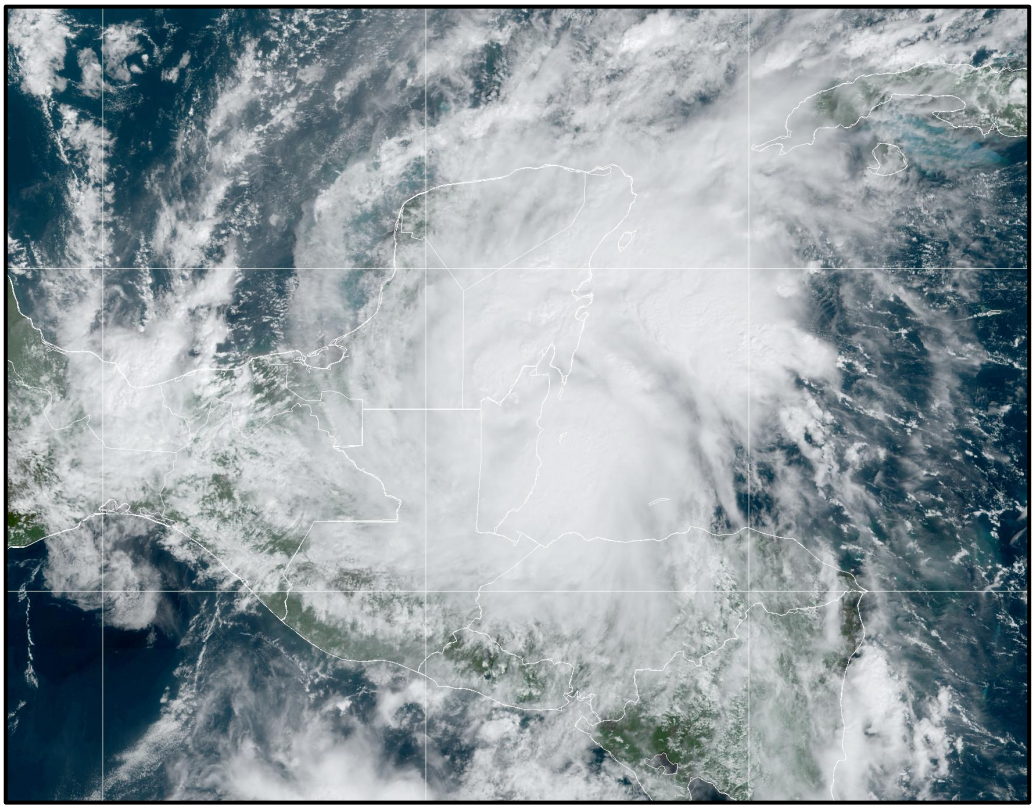
National Hurricane Center
8 January 2025



GOES-EAST GEOCOLOR VISIBLE SATELLITE IMAGE OF TROPICAL STORM NADINE AT 1600 UTC 19 OCTOBER 2024, NEAR THE TIME OF LANDFALL ALONG THE COAST OF BELIZE. IMAGE COURTESY NOAA/NESDIS/STAR.

Short-lived Nadine made landfall as a tropical storm in Belize, bringing heavy rainfall and flooding to portions of Central America and southeastern Mexico that resulted in at least 7 direct fatalities.

Tropical Storm Nadine

19–20 OCTOBER 2024

SYNOPTIC HISTORY

Nadine appears to have originated from a broad area of low pressure that formed over the southwestern Caribbean Sea on 15 October. The system remained broad and weak while producing disorganized showers and thunderstorms over the next couple of days as it moved slowly northwestward, passing offshore of the east coast of Nicaragua. Shower and thunderstorm activity increased later on 17 October, and surface observations showed falling surface pressures over the western Caribbean Sea that day. On 18 October, showers and thunderstorms began showing increased signs of organization, and satellite-derived wind data that evening revealed that a well-defined area of low pressure had formed with 30–35-kt winds to the north of the center. This marked the formation of Tropical Storm Nadine by 0000 UTC 19 October, about 160 n mi east of Belize City, Belize. The "best track" chart of Nadine'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].

Nadine moved westward on 19 October while being steered by a well-established low- to mid-level ridge over the eastern United States. Initially, the sprawling system had a large radius of maximum wind with convective bands confined to the northern and eastern portions of its circulation (Fig. 4a). However, Nadine was able to become better organized and intensify later that day over the very warm waters of the northwestern Caribbean Sea in a low shear and highly divergent upper-level environment. Convection began to wrap around the center of the storm (Fig. 4b), and aircraft data indicated the radius of maximum wind contracted as Nadine approached the coast of Belize. It is estimated that Nadine made landfall as a 50-kt tropical storm near Belize City at 1600 UTC 19 October (Fig. 5).

After landfall, Nadine moved westward across northern portions of Belize and Guatemala and weakened to a 30-kt tropical depression by 0000 UTC 20 October, when it was located about 25 n mi north-northwest of Flores, Guatemala. Continued land interaction induced further weakening while the associated convection diminished and the surface circulation became less defined. As a result, Nadine degenerated to a remnant low and then dissipated over southern Mexico early on 20 October. However, remnant mid-level vorticity and moisture from Nadine moved into the eastern Pacific basin later that day and contributed to the formation of Tropical Storm Kristy[2] on 21 October.

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[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.

[2] https://www.nhc.noaa.gov/data/tcr/index.php?season=2024&basin=epac

METEOROLOGICAL STATISTICS

Observations in Nadine (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), objective Advanced Dvorak Technique (ADT) estimates and Satellite Consensus (SATCON) 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 one flight 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 Global Precipitation Mission (GPM), the European Space Agency's Advanced Scatterometer (ASCAT), the Defense Meteorological Satellite Program (DMSP) satellites, and the Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats (TROPICS) satellites, among others, were also useful in constructing the best track of Nadine.

There were no credible ship reports of tropical-storm-force winds associated with Nadine. Selected surface observations from land stations and data buoys are given in Table 2.

Winds and Pressure

The estimated peak intensity of 50 kt at landfall near 1600 UTC 19 October is based on aircraft data from the Air Force Reserve Hurricane Hunters. The aircraft recorded peak 850-mb flight-level winds of 62 kt at 1612 UTC that day offshore in the northeast quadrant of Nadine, shortly after the center made landfall. Applying a standard 80% adjustment factor to the peak flight-level winds supports a surface intensity of about 50 kt. Radar and satellite images suggest the storm was becoming better organized and likely strengthening through its landfall in Belize, and a blend of the peak ADT (55 kt) and SATCON (46 kt) estimates also supports the 50-kt landfall intensity.

The strongest winds associated with Nadine occurred to the north of its center. There were no official reports of sustained tropical-storm-force winds in Belize, but several stations measured tropical-storm-force gusts on 19 October. A peak gust of 42 kt was reported on Caye Caulker, and 39-kt gusts were recorded at Little Belize, San Pedro, and Half Moon Caye. In Mexico, several stations along the coast of the Yucatán Peninsula of Mexico in the state of Quintana Roo reported sustained tropical storm conditions early on 19 October. A WeatherFlow station in Cancún (XCCN) reported a sustained wind of 36 kt at 0831 UTC 19 October and a peak gust of 44 kt. A weather station at Arrecifes de Xcalak (XCLX4) reported a sustained wind of 34 kt and a peak gust of 45 kt at 1030 UTC that day.

The estimated minimum pressure of 1002 mb at landfall is based on aircraft data. A 1452 UTC 19 October center dropsonde reported a surface pressure of 1004 mb with 18-kt surface winds, and a subsequent dropsonde at 1535 UTC measured a 1004-mb surface pressure with 23-kt surface winds. The lowest land-based pressure observation was 1004.6 mb at Sir Barry Bowen Municipal Airport (MZBE) in Belize City.

Rainfall and Flooding

Heavy rainfall associated with Nadine affected portions of Central America and southeastern Mexico. In Belize (Fig. 6), a storm-total rainfall maximum of 9.47 inches (240.6 mm) was reported in Ranchito, and 8.76 inches (222.4 mm) of rain fell in Yo Creek. Nadine generally produced 4–8 inches (100–200 mm) of rainfall over northern and central portions of the country, which resulted in some flooding in these areas. Rainfall totals in Guatemala (Fig. 7) generally ranged from 2–4 inches (50–100 mm), with 4.80 inches (121.9 mm) reported in Esquipulas and 3.89 inches (98.7 mm) farther north in Poptún.

In Mexico (Fig. 8), torrential rainfall resulted from the interaction of tropical moisture from Nadine with a slow-moving front over the Yucatán Peninsula (Fig. 9). The highest rainfall totals from 18–20 October were reported in the state of Veracruz, with a storm total maximum of 19.07 inches (484.5 mm) of rain in Ángel Rosario Cabada. Elsewhere, areal average rainfall amounts of 3–6 inches (75–150 mm) with peak totals greater than 10 inches (250 mm) were recorded over portions of the states of Chiapas, Oaxaca, Quintana Roo, and Tabasco. The heavy rainfall resulted in flash and river flooding and landslides.

Maximum reported storm-total rainfall in Mexico by state:

Campeche: 6.77 inches (172.0 mm) in Xpujil
Chiapas: 13.26 inches (336.8 mm) in El Escalón
Quintana Roo: 10.27 inches (260.8 mm) in Nicolás Bravo
Tabasco: 12.74 inches (323.5 mm) in Tapijulapa
Veracruz: 19.07 inches (484.5 mm) in Ángel Rosario Cabada

CASUALTY AND DAMAGE STATISTICS

Reports from the National Meteorological Service of Mexico and the media indicate that Nadine caused 13 fatalities, including at least 7 direct[3] deaths. Four of these deaths occurred in the state of Chiapas. Two people died in the Tila municipality near Carrizal after a home was severely damaged by a landslide. One person drowned in the Chamula municipality near Tierra Colorada after being swept away by floodwaters while trying to cross a flooded stream in a vehicle, and another person died in the Ocosingo municipality after being swept away by floodwaters. In the state of Veracruz, two people died due to flooding in Catemaco, and one person died after a home collapsed in the municipality of Tequila. Six other fatalities were reported in the state (2 each in Santiago Tuxtla and Uxpanapa, and 1 each in Hidalgotitlán and Playa Vicente). Media reports suggest one of the fatalities in Santiago Tuxtla was an indirect death due to electrocution, but the causes of the others are unknown at the time of this report. Note that some of these

[3] 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.

fatalities may have been from flooding caused by the combined influence of Nadine and the stalled front over southeastern Mexico.

There are currently no monetary damage estimates available for Nadine.

Central America

There was no major damage reported, but some flooding impacts occurred in northern and central portions of Belize and northern Guatemala. In Belize, several roads and bridges were made impassable by floodwaters, and a pedestrian bridge in San Ignacio was destroyed. Some minor beach erosion was reported in San Pedro Town on Ambergris Caye.

Mexico

The most significant impacts were the result of flash and river flooding that inundated homes, damaged infrastructure, and triggered landslides across southeastern Mexico. Over 30,000 homes and 60 schools were damaged across 84 municipalities in the state of Veracruz, and 72 people were rescued. Several dozen downed trees and landslides were reported across the state, along with some road collapses and damaged bridges. Some of the most affected locations included the cities of Minatitlán and Coatzacoalcos. In the state of Chiapas, 40 municipalities were affected with more than 6,900 homes damaged. There were also reports of downed trees and damaged roads, bridges, and schools. About 1,800 homes were affected in the state of Tabasco, along with some flooded roads and a few landslides. Roadway flooding also occurred in the states of Campeche and Quintana Roo, including the cities of Chetumal, Cancún, Tulum, and José María Morelos. Some minor wind damage and power outages were reported in the states of Campeche and Quintana Roo, including a downed tree on a home in Chetumal. Figure 10 shows some of the damage caused by Nadine.

FORECAST AND WARNING CRITIQUE

Genesis

The genesis of Nadine was not well anticipated (Table 3). Although the disturbance from which Nadine developed was introduced in the Tropical Weather Outlook (TWO) 108 h prior to genesis, the system reached the medium and high categories in both the 2-day and 7-day TWO only 24 h and 6 h before genesis, respectively. Because the disturbance formed relatively close to land, it was difficult to predict whether the feature would remain over water long enough for tropical cyclone formation to occur. This uncertainty contributed to the poor near-term genesis forecasts. Figure 11 shows composites of 7-day Graphical TWO (GTWO) genesis areas for each category prior to the formation of Nadine. All of the GTWO formation areas captured the location of genesis over the northwestern Caribbean Sea.

Track and Intensity

A verification of NHC official track forecasts for Nadine is given in Table 4. Official track forecast errors were lower than the mean official errors for the previous 5-yr period at 12 h and 24 h, albeit for a small number of forecasts. A verification of NHC official intensity forecasts for Nadine is given in Table 5. For the three verifying 12-h forecasts, the official intensity forecast errors were greater than the mean official errors for the previous 5-yr period. No meaningful comparisons can be made with the models due to Nadine's brief existence as a tropical cyclone and the small number of forecasts issued.

Wind Watches and Warnings

Coastal wind watches and warnings associated with Nadine are given in Table 6. The NHC initiated potential tropical cyclone advisories at 2100 UTC 18 October on the precursor disturbance, enabling Belize and Mexico to issue Tropical Storm Watches for portions of their coastlines.

ACKNOWLEDGEMENTS

The national meteorological services of Belize, Guatemala, and Mexico provided data, observations, and rainfall maps used in this report. Dr. Philippe Papin (NHC) created the Graphical TWO verification figure.

Table 1. Best track for Tropical Storm Nadine, 19–20 October 2024.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
18 / 1800	17.2	84.8	1005	30	disturbance
19 / 0000	17.3	85.5	1004	35	tropical storm
19 / 0600	17.4	86.4	1004	40	"
19 / 1200	17.4	87.5	1003	45	"
19 / 1600	17.5	88.2	1002	50	"
19 / 1800	17.5	88.7	1004	45	"
20 / 0000	17.3	90.0	1005	30	tropical depression
20 / 0600	17.1	91.2	1006	25	low
20 / 1200					dissipated
19 / 1600	17.5	88.2	1002	50	maximum wind, minimum pressure, and landfall near Belize City, Belize

Table 2. Selected surface observations for Tropical Storm Nadine, 19–20 October 2024.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)	Gust (kt)	
Belize						
Caye Caulker (17.73N 88.03W)			19/1615		42	
Little Belize (18.18N 88.31W)					39	
San Pedro (17.91N 87.97W)					39	
Half Moon Caye (17.21N 87.53W)					39	
Middle Caye (16.74N 87.81W)					38	
Mauger Caye (17.61N 87.77W)					36	
Santa Martha (17.98N 88.37W)					35	
Belize City – Sir Barry Bowen Municipal AP (MZBE) (17.52N 88.20W)	19/1615	1004.6			32	4.17
Ranchito (18.38N 88.41W)						9.47
Yo Creek (18.09N 88.63W)						8.76
Yo Chen (18.38N 88.49W)						8.68
Mexico						
Isla Mujeres (IMUX4) (21.25N 86.74W)			19/0950	35	43	
Arrecifes Xcalak (XCLX4) (18.27N 87.83W)	19/1030	1006.0	19/1030	34	45	
Punta Allen (19.80N 87.46W)			19/1130	26	37	
Banco Chinchorro (BCHX4) (18.76N 87.30W)			19/0745	23	37	
Ángel Rosario Cabada (18.58N 95.44W)						19.07
Los Tuxtlas II (TXLV4) (elev. 915 m) (18.37N 94.93W)			19/2130		37	18.28
Tres Zapotes (18.47N 95.42W)						15.88
WeatherFlow Sites						
Cancun (XCCN) (21.06N 86.78W)			19/0831	36 (11 m)	44	
Xcaret Park (XPDC) (20.58N 87.12W)			19/0519	33 (11 m)	44	

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)	Gust (kt)	
Puerto Morelos (XPRM) (20.83N 86.89W)			19/0645	30 (10 m)	37	
Tulum (XTUL) (20.32N 87.36W)			19/0328	28 (10 m)	36	
Guatemala						
Esquipulas (14.56N 89.34W)						4.80
Concepción (14.32N 90.79W)						4.41
Poptún (16.32N 89.41W)						3.89
Offshore						
42056 – Yucatan Basin (19.82N 84.95W)	18/0900	1008.6	18/2342	37 (4 m, 1 min)	41	
42057 – Western Caribbean (16.97N 81.57W)	17/2250	1005.2				

[a] Date/time is for sustained wind when both sustained and gust are listed.

Table 3. Number of hours in advance of formation of Nadine 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	**168-Hour Outlook**
Low (<40%)	78	102
Medium (40%-60%)	24	24
High (>60%)	6	6

Table 4. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Nadine, 19–20 October 2024. 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	60	72	96	120
OFCL	**17.5**	**0.0**						
OCD5	61.2	126.4						
Forecasts	3	1						
OFCL (2019-23)	23.9	36.5	49.3	63.4	79.2	93.4	132.9	190.4
OCD5 (2019-23)	45.7	97.1	153.0	205.4	254.9	297.8	372.7	439.1

Table 5. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Nadine, 19–20 October 2024. 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	60	72	96	120
OFCL	6.7	**0.0**						
OCD5	7.0	8.0						
Forecasts	3	1						
OFCL (2019-23)	5.0	7.3	8.5	9.7	10.4	10.9	12.9	15.5
OCD5 (2019-23)	6.6	10.2	13.1	15.6	17.2	18.6	21.8	22.6

Table 6. Watch and warning summary for Tropical Storm Nadine, 19–20 October 2024.

Date/Time (UTC)	Action	Location
18 / 2100	Tropical Storm Watch issued	Belize City, Belize to Tulum, Mexico
19 / 0600	Tropical Storm Watch upgraded to Tropical Storm Warning	Belize City, Belize to Tulum, Mexico
19 / 0900	Tropical Storm Warning modified to	Belize City, Belize to Cancun, Mexico
20 / 0000	Tropical Storm Warning discontinued	All

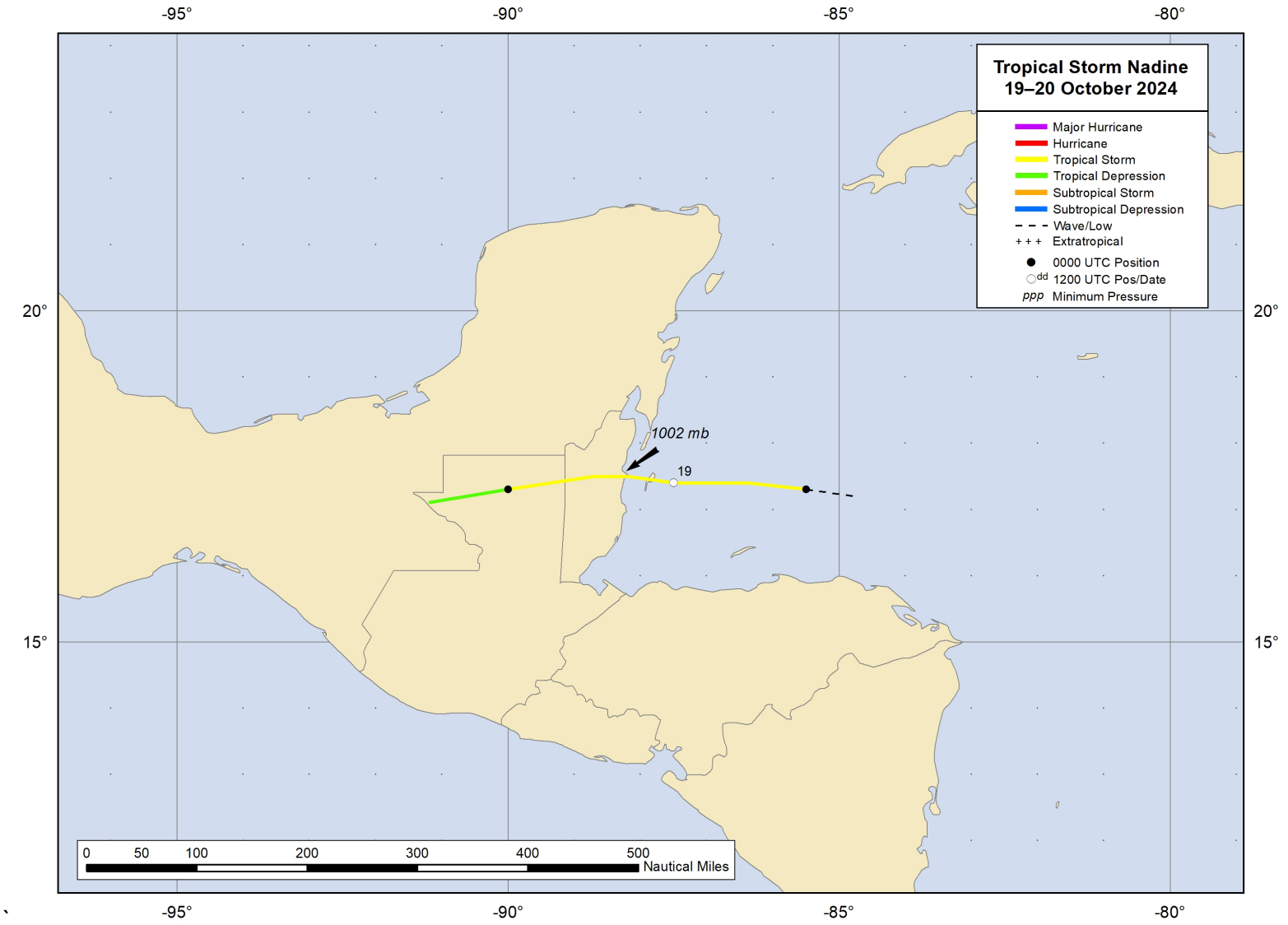

Figure 1. Best track positions for Tropical Storm Nadine, 19–20 October 2024.

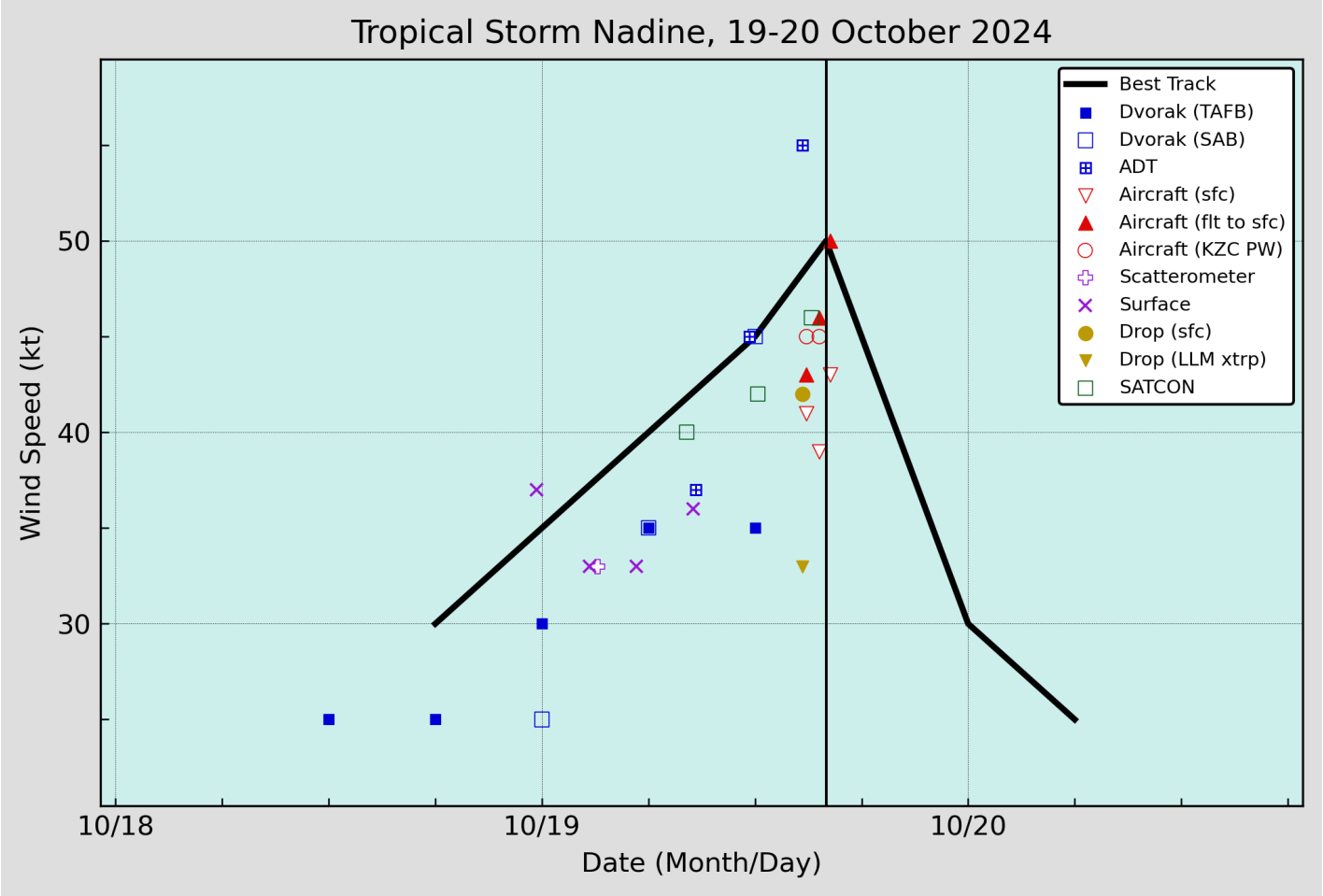

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Nadine, 19–20 October 2024. Aircraft observations have been adjusted for elevation using an 80% adjustment factor for observations from 850 mb. Dropwindsonde observations include actual 10 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. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC, and the solid vertical line corresponds to landfall.

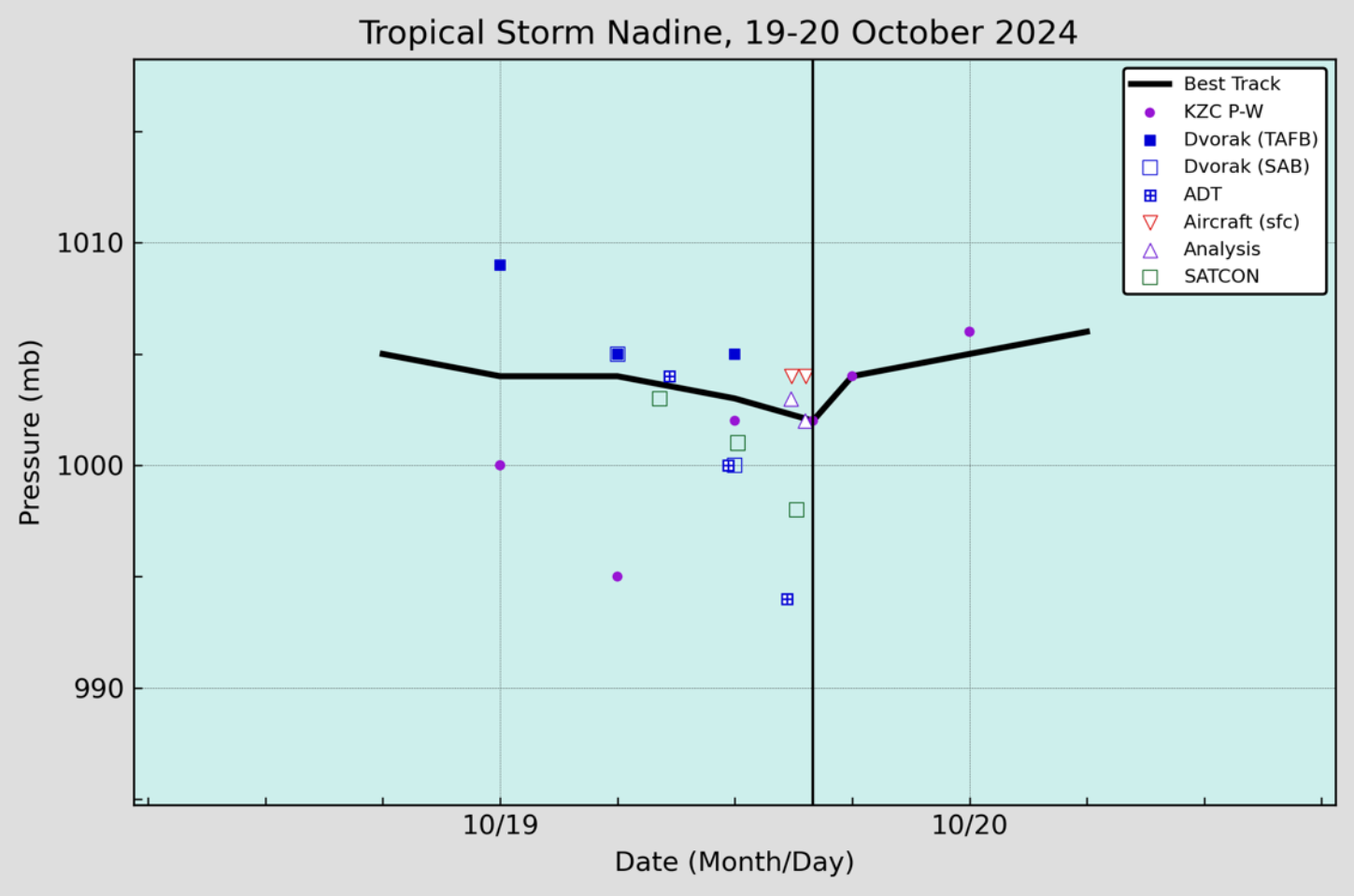

Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Nadine, 19–20 October 2024. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC, and the solid vertical line corresponds to landfall.

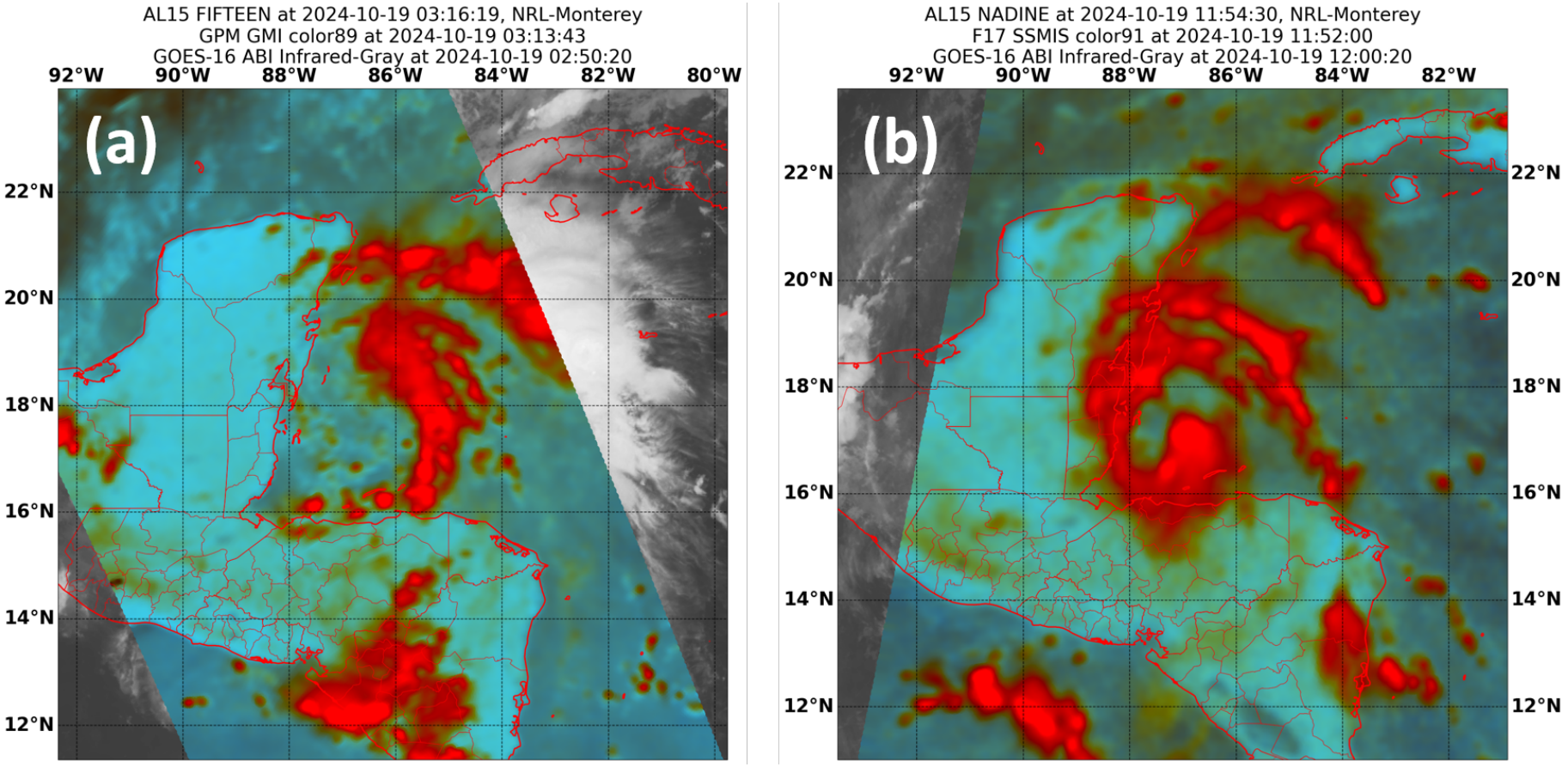

Figure 4. (a) GMI 89-GHz color composite image of Tropical Storm Nadine at 0313 UTC 19 October, with curved banding over the northern and eastern portions of the circulation. (b) SSMIS 91-GHz color composite image of Tropical Storm Nadine at 1152 UTC 19 October, with improved signs of organization and a curved band wrapping around the center.

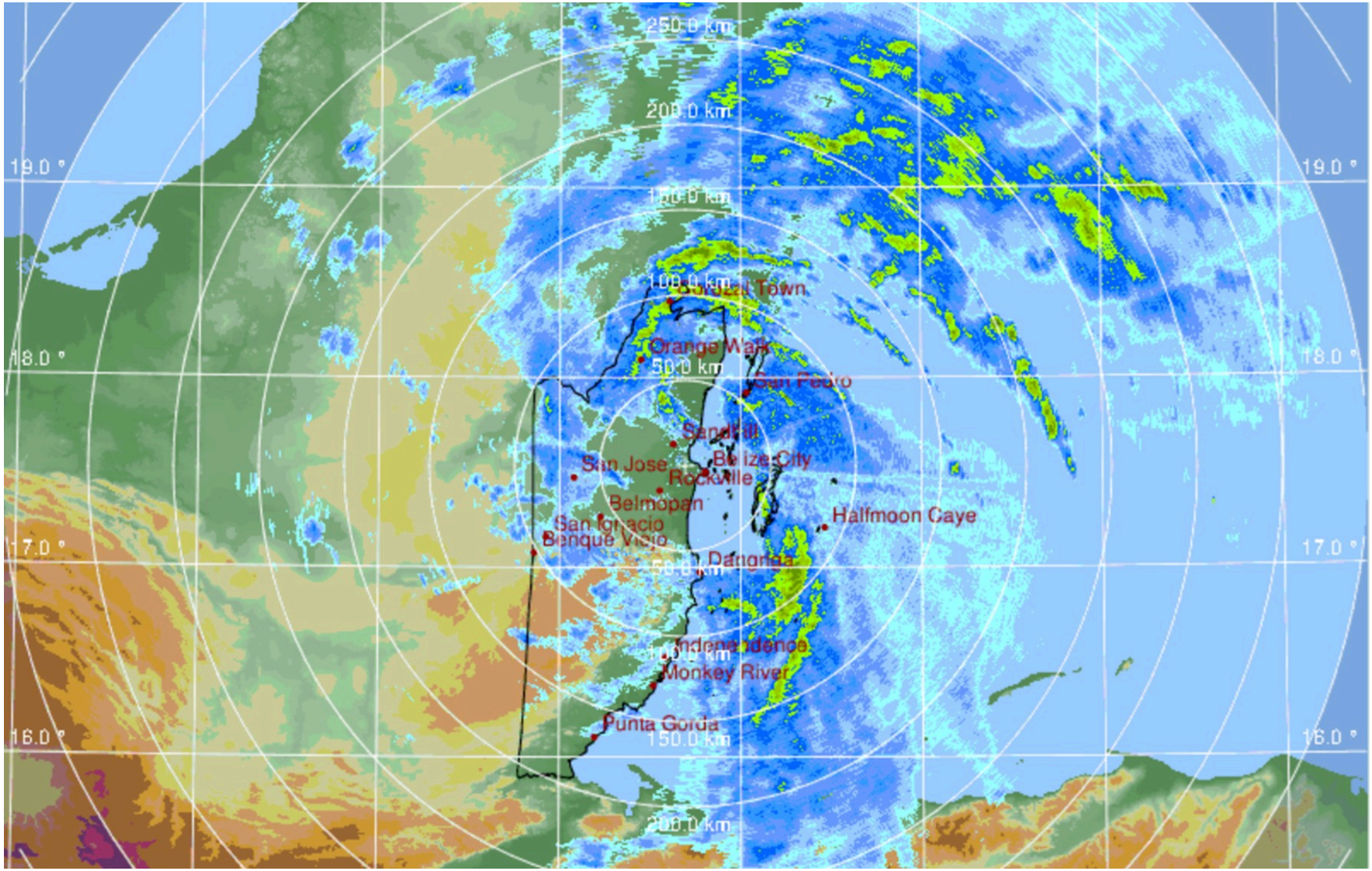

Figure 5. Belize radar image from around the time that Tropical Storm Nadine made landfall on 19 October near Belize City. Image courtesy of the National Meteorological Service of Belize.

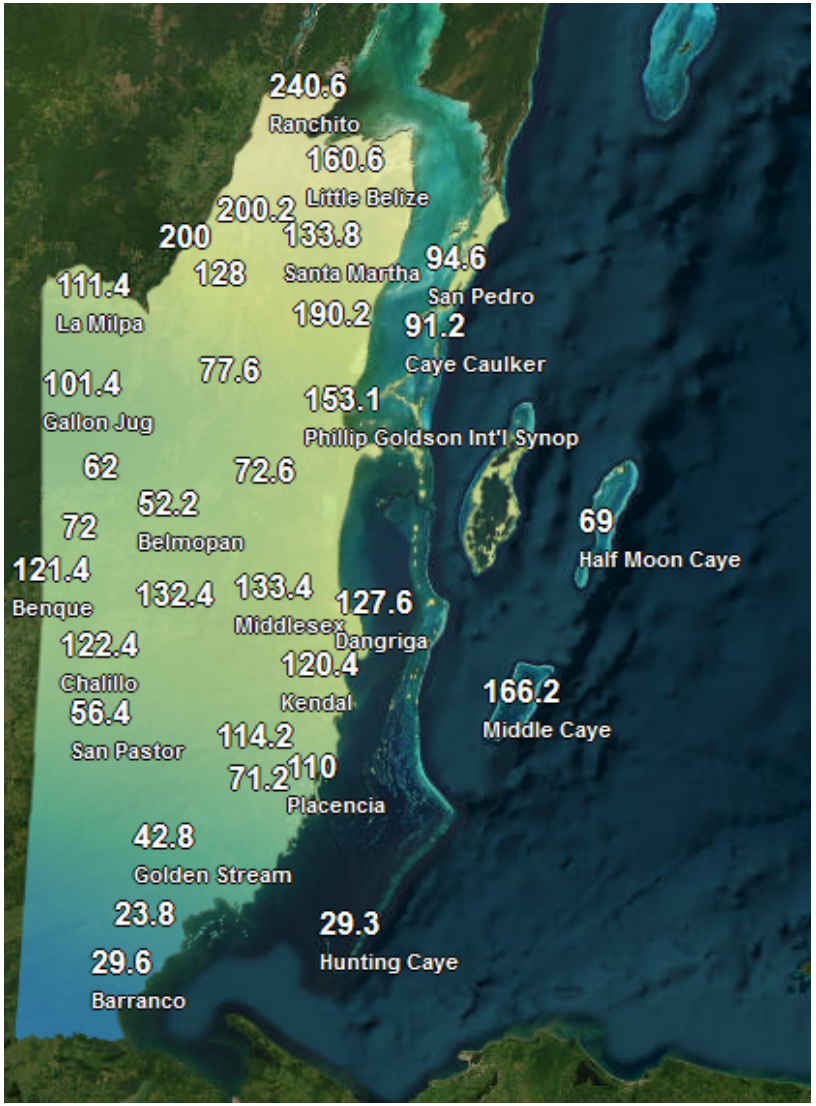

Figure 6. Rainfall accumulations (mm) in Belize from 1800 UTC 18 October – 1800 UTC 20 October 2024. Data and image courtesy of the National Meteorological Service of Belize.

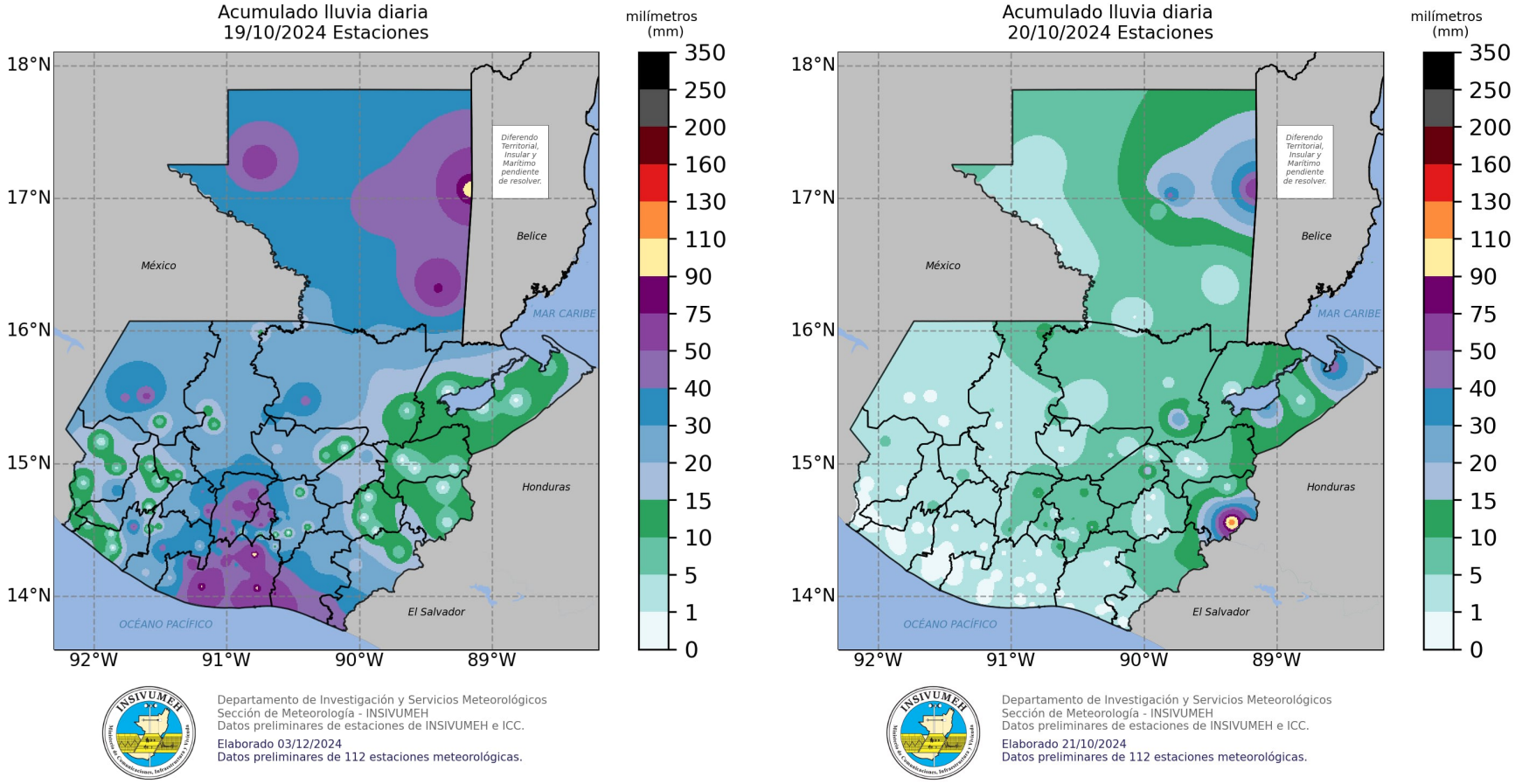

Figure 7. Rainfall accumulations (mm) in Guatemala on 19 October (left) and 20 October (right) 2024. Images courtesy of the National Meteorological Service of Guatemala (INSIVUMEH).

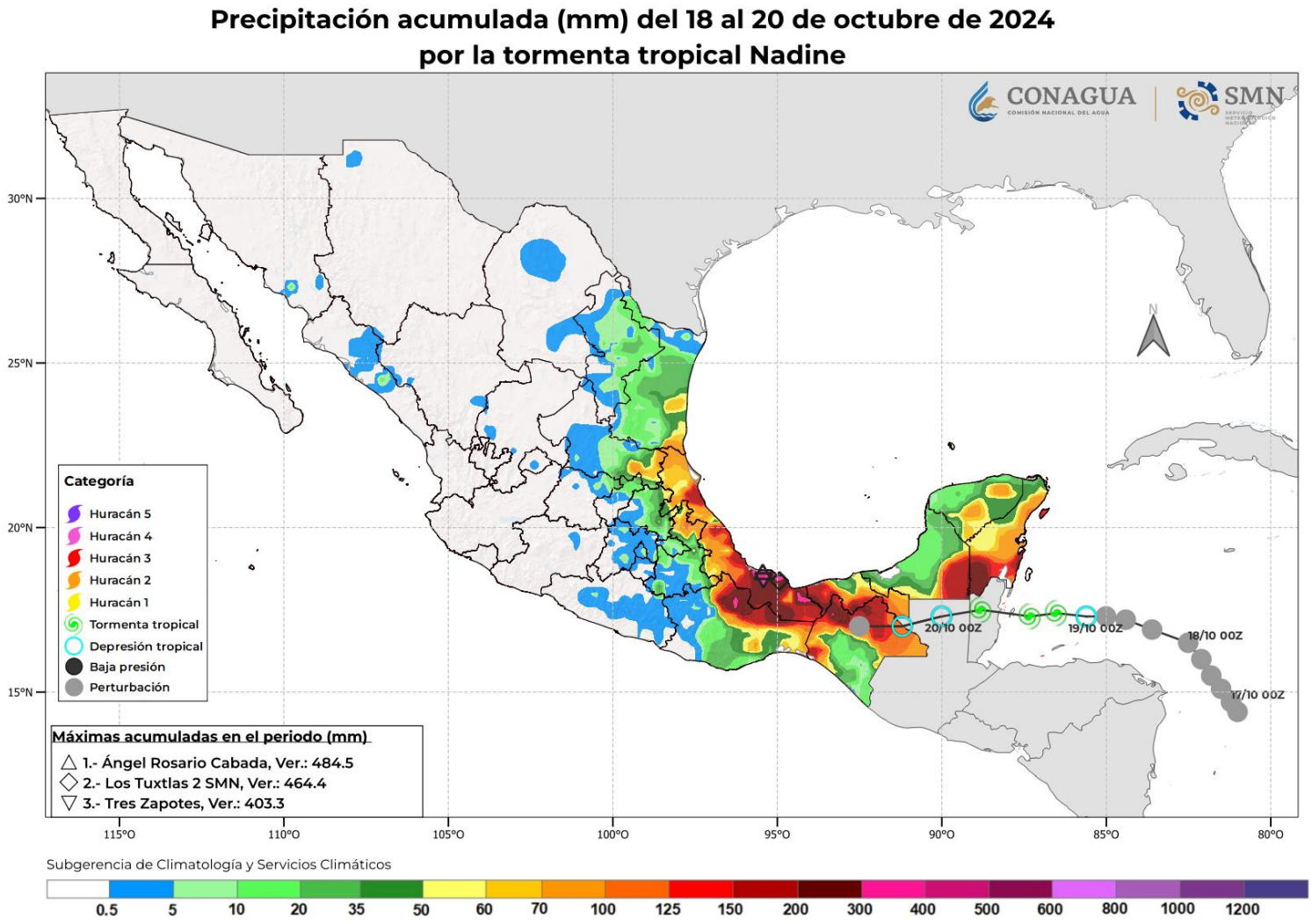

Figure 8. Rainfall accumulations (mm) in Mexico from 18–20 October 2024. Track and intensity are based on the operational NHC assessment. Not all of the rainfall depicted here is related to Nadine. Image courtesy of CONAGUA and the National Meteorological Service of Mexico.

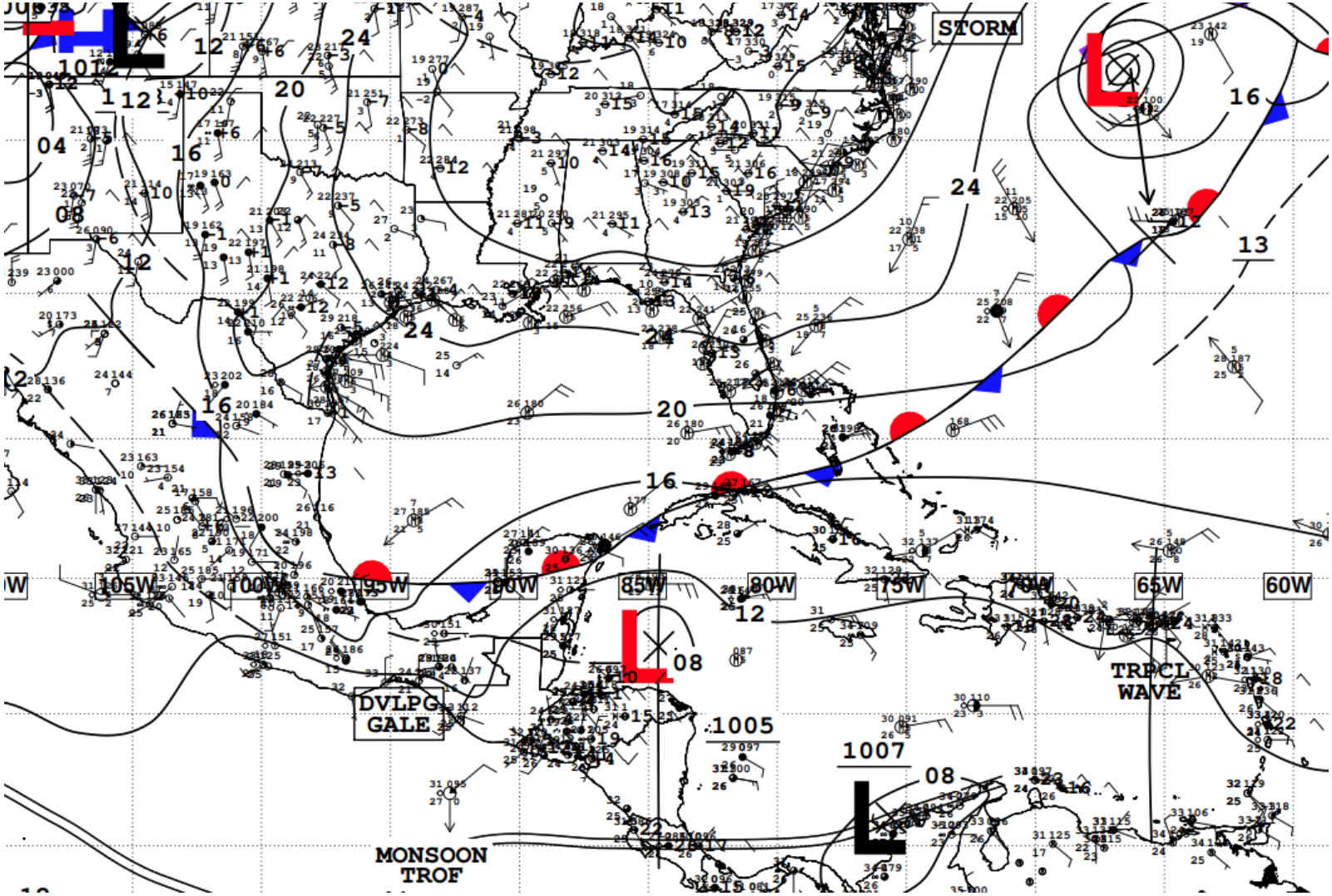

Figure 9. National Weather Service unified surface analysis at 1800 UTC 18 October 2024, showing an area of low pressure (soon to be Tropical Storm Nadine) in close proximity to a stalled front draped across the Yucatán Peninsula and the southwestern Gulf of Mexico. This front served as a focus for heavy rainfall over southeastern Mexico during the event.

Figure 10. Heavy rainfall associated with Nadine caused damage across portions of southeastern Mexico. (Left) Damage caused by a landslide in Carrizal, Chiapas. Photo credit: Chiapas Civil Protection (via X/@pcivilchiapas). (Right) Floodwaters inundate streets and buildings in the town of Tapijulapa, Tabasco. Photo credit: La Jornada.

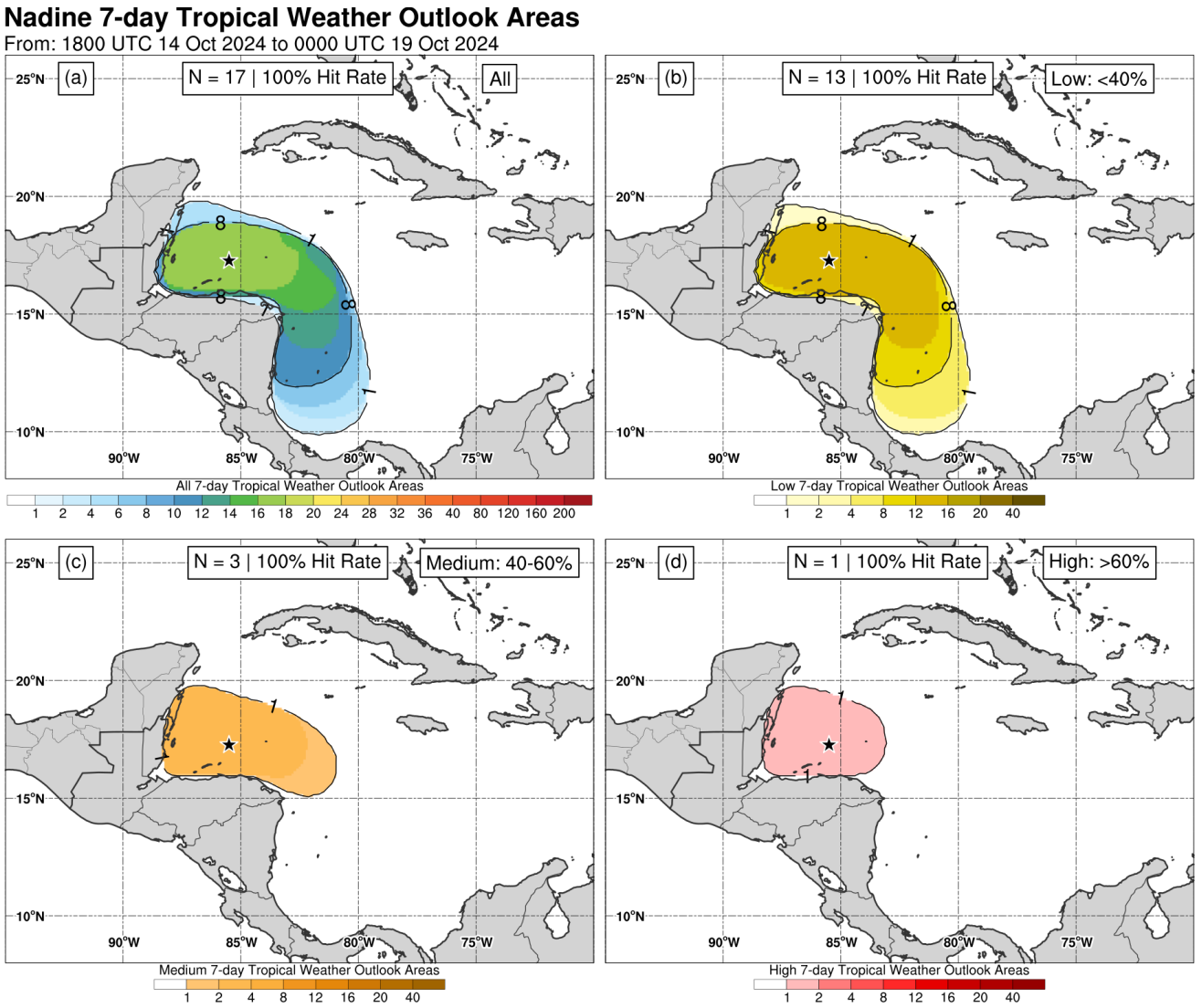

Figure 11. Composites of 7-day tropical cyclone genesis areas depicted in NHC's Tropical Weather Outlooks prior to the formation of Nadine for (a) all probabilistic genesis categories, (b) the low (<40%) category, (c) medium (40–60%) category, and (d) high (>60%) category. The location of genesis is indicated by the black star.