NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

TROPICAL STORM WANDA

(AL212021)

30 October–7 November 2021

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National Hurricane Center
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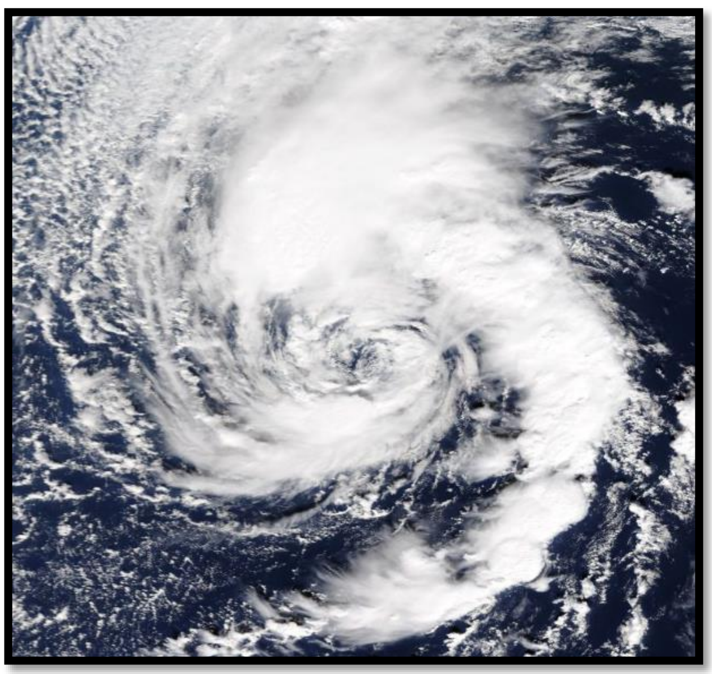

NASA/TERRA MODERATE RESOLUTION IMAGING SPECTRORADIOMETER (MODIS) IMAGERY OF SUBTROPICAL STORM WANDA AT PEAK INTENSITY AROUND 1313 UTC 31 OCTOBER 2021. IMAGE COURTESY NASA EOSDIS WORLDVIEW.

Wanda originated from a powerful nor'easter that brought hurricane-force wind gusts, heavy rainfall, and flooding to portions of New England in late October. The system became a subtropical cyclone a few days after moving away from the United States and underwent tropical transition while it meandered over the open waters of the north Atlantic Ocean.

Tropical Storm Wanda

30 OCTOBER–7 NOVEMBER 2021

SYNOPTIC HISTORY

Wanda's origins were non-tropical. On 24–25 October, a mid-level shortwave trough moved over the southeastern United States and emerged off the Atlantic coast. The associated upper-level diffluence on the east side of this trough over the warm Gulf Stream waters induced the development of a well-defined surface low pressure area by 1800 UTC 25 October, about 120 n mi southeast of Cape Fear, North Carolina. Buoy observations and scatterometer data indicate that a warm front extended east-northeastward from the gale-force low center, and some deep convection that was concentrated to the northeast of the low that evening coincided with this frontal feature. The low deepened and developed a more baroclinic satellite appearance as it raced northeastward on 26 October ahead of a deep-layer trough moving across the Great Lakes region and Mid-Atlantic states. The storm-force surface low occluded later that day, and the system continued to strengthen as it absorbed another baroclinic low that was moving off the U.S. Mid-Atlantic coast. The extratropical cyclone continued deepening and reached a peak intensity of 60 kt by 0000 UTC 27 October, when it was centered about 110 n mi east-southeast of Nantucket, Massachusetts.

The powerful cyclone completed a cyclonic loop just offshore Nantucket early on 27 October. Later that day, the system's peak winds gradually decreased as it began moving away from the United States. During this time, the system's asymmetric wind field greatly expanded, with gale-force winds extending up to 540 n mi away from its center in the northeastern quadrant. The cyclone moved quickly eastward across the western Atlantic on 28–29 October while embedded within a deep-layer trough. The low possessed an expansive wind field with a radius of maximum winds (RMW) greater than 100 n mi during this period. A brief flare-up of convection occurred to the north of the cyclone late on 29 October, but it was collocated with the weakening baroclinic zone still connected to the low. A series of scatterometer passes on 29–30 October showed that the wind field significantly contracted and the RMW decreased, which signaled subtropical transition was underway. Early on 30 October, the low turned southeastward and completely separated from its fronts. Soon after, the cyclone produced fragmented bands of convection to the south and east of its center. Because the system was still collocated with an upper-level trough, the low was designated a subtropical storm at 1200 UTC 30 October, when it was centered about 515 n mi south-southeast of Cape Race, Newfoundland. The "best track" chart of Wanda'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].

[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.

Wanda's eastward to east-southeastward motion abruptly stopped on 31 October as it moved underneath a cutoff upper-level low. This orientation reduced the deep-layer shear over the surface cyclone and increased the instability aloft. As a result, Wanda's convection became more organized in bands that wrapped around the northern and eastern sides of its circulation (Fig. 4), despite marginal 23°C sea-surface temperatures (SSTs). Wanda reached a peak intensity of 50 kt by 0600 UTC 31 October, when it was located about 825 n mi west of the Azores. The cyclone meandered over the central Atlantic later that day, then briefly moved southward to southeastward early on 1 November. Although this brought Wanda over slightly warmer SSTs of 23.5–24°C, increasing deep-layer shear and intrusions of dry mid-level air steadily weakened the cyclone that day. By this time, Wanda began to assume the appearance of a sheared tropical cyclone in satellite images. Scatterometer data revealed that the cyclone's surface wind field contracted, and the RMW decreased to 30–40 n mi. It is estimated that Wanda transitioned to a tropical cyclone by 1200 UTC 1 November, when it was located about 825 n mi west-southwest of the Azores.

The sheared tropical cyclone turned eastward late that day and northeastward on 2 November as it moved between an upper-level low to its north and a distant ridge to its southeast. A large convective burst developed early on 2 November, but this convection was eroded later that day by a significant intrusion of dry air. Some convection returned early on 3 November as the cyclone moved northward around a building mid-level ridge to its east. This northward motion brought Wanda over cooler 20–21°C SSTs, but the cyclone was able to maintain bands of shallow to moderate convection near its center (Fig. 5) while its intensity fluctuated between 40–45 kt. Wanda reached a weakness in the steering flow late on 4 November, and it gradually turned southeastward and then southward on 5 November as a narrow ridge built to the northwest of the system. This steering flow eventually brought the storm back over slightly warmer SSTs, but the convection remained limited due to entrainment of dry and stable mid-level air surrounding the cyclone. A general southward to south-southwestward motion continued until late on 6 November, when Wanda became caught in the southwesterly flow ahead of an approaching mid-level trough over the northern Atlantic. This pattern caused the cyclone to turn northeastward, and the associated wind shear stripped away its remaining convection shortly after 0600 UTC 7 November. Wanda degenerated to a 35-kt post-tropical cyclone by 1200 UTC that day, when it was located about 375 n mi west-northwest of the Azores. The post-tropical cyclone accelerated northeastward ahead of an approaching frontal system, and it merged with the front and dissipated over the northeastern Atlantic Ocean shortly after 0000 UTC 8 November.

METEOROLOGICAL STATISTICS

Observations in Wanda (Figs. 2 and 3) include subjective satellite-based Hebert-Poteat subtropical technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB), Dvorak technique intensity estimates from 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. 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 Wanda.

There were no ship reports of winds of tropical storm force associated with Wanda as a subtropical or tropical cyclone. During the extratropical low phase (Figs. 6 and 7), the system affected the northeastern United States and adjacent waters of the western Atlantic Ocean, and selected surface observations during this phase are given in Table 3.

Winds and Pressure

The precursor extratropical cyclone reached an estimated peak intensity of 60 kt early on 27 October. This is supported by a 0030 UTC 27 October ASCAT-A pass that showed winds between 55–60 kt to the north of the cyclone's occluded front. NOAA buoy 44011 at Georges Bank reported a peak sustained wind of 51 kt at a 4 m elevation at 1859 UTC 26 October, which adjusts to a 10-m wind of 56 kt. Several land-based and buoy observations recorded sustained winds of 55 kt or greater early on 27 October as the nor'easter made its closest approach to land. Buoy 44020 in Nantucket Sound measured a peak wind of 51 kt at a 4 m elevation, which adjusts to a 10-m wind of 56 kt. A WeatherFlow station in Duxbury, Massachusetts, measured a sustained wind of 58 kt with a gust of 90 kt, and an elevated C-MAN station at Buzzards Bay reported a sustained wind of 58 kt and a gust of 73 kt. The lowest land-based pressure observations occurred on Nantucket as the nor'easter neared the island early on 27 October. A WeatherFlow station at Nantucket Harbor recorded a minimum pressure of 977.0 mb with 41-kt winds at 0748 UTC, and the Nantucket Memorial Airport (KACK) reported a minimum pressure of 977.4 mb with 46-kt winds at 0753 UTC. Both of these observations support an estimated minimum pressure of 973 mb during the extratropical phase as the low passed just offshore.

Wanda reached an estimated peak intensity of 50 kt as a subtropical storm from 0600 UTC to 1800 UTC 31 October. This intensity is supported by ST3.0 (45–50 kt) Hebert-Poteat subtropical classifications from TAFB and ADT estimates of 45–49 kt during this period. A couple of scatterometer passes just before and after peak intensity revealed 45-kt winds associated with Wanda, and it is assumed that some strengthening occurred between these two passes based on the storm's improved structure in satellite and microwave images. The estimated minimum pressure of 983 mb is based on a blend of SATCON and global model pressure estimates.

Storm Surge[2]

The extratropical low produced coastal flooding along portions of the New England coast. A storm surge of 3 to 4 ft above normal tide levels was measured at a few sites, and the National Ocean Service (NOS) tide gauges at Chatham and Nantucket, Massachusetts, each recorded peak water levels of 2.7 ft and 2.4 ft, respectively, above Mean Higher High Water (MHHW). A United States Geological Survey (USGS) gauge at Sesuit Harbor in Dennis, Massachusetts, also measured a peak water level of 2.7 ft MHHW.

Rainfall and Flooding

The extratropical low produced 2–5 inches of rainfall with maximum totals greater than 6 inches across portions of northern New Jersey, northeastern Pennsylvania, southern New York, and Connecticut. Peak rainfall totals by state are as follows: 6.82 inches near Ridge, New York; 6.63 inches near Warren Township, New Jersey; 6.50 inches near Beach Lake, Pennsylvania; and 6.06 inches near Ridgefield, Connecticut. The heavy rainfall broke daily precipitation records at several locations in New York, including Binghamton, Islip, New York City (John F. Kennedy Intl. Airport), and Syracuse. Bridgeport, Connecticut also set a new daily rainfall record. Elsewhere, 1–3 inches of rain with locally higher amounts fell over portions of upstate New York and coastal Massachusetts.

CASUALTY AND DAMAGE STATISTICS

There were no reports of damage or casualties associated with Wanda as a subtropical or tropical cyclone. Media reports indicate there was at least one fatality[3] related to the precursor extratropical cyclone that eventually became Wanda. In New Jersey, a driver was killed on the morning of 27 October when a falling tree branch (likely due to strong winds) struck a vehicle on Mendham Road in Morris Township.

The nor'easter produced damaging winds as well as coastal and freshwater flooding over portions of the northeastern United States. Over 600,000 customers lost power in New England as strong wind gusts downed trees and power lines. Hurricane-force wind gusts occurred in coastal Massachusetts, where some roads were blocked and numerous homes and vehicles were damaged by falling trees. Along the coast, large waves crashed onto some homes near the

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[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).

[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.

seawall, and several small boats became grounded. Heavy rainfall produced flash and river flooding that forced temporary road closures in portions of New Jersey, New York, and Pennsylvania. Some localized flooding was also reported in parts of Connecticut and Rhode Island. More than a dozen water rescues were performed in Union Beach, New Jersey, as some drivers became stranded in floodwaters. A flash flood emergency was issued in upstate New York for major flooding at Owasco Inlet near Moravia.

FORECAST AND WARNING CRITIQUE

The potential for the extratropical cyclone to transition to a subtropical or tropical cyclone was recognized well in advance, but the actual timing of Wanda's subtropical genesis was poorly forecast. Table 2 provides the number of hours in advance of formation associated with the first NHC Tropical Weather Outlook (TWO) forecast in each likelihood category. The system from which Wanda developed was introduced in the 5-day TWO with a low (<40%) chance of formation 150 h (6.25 days) before it became a subtropical storm. The 5-day chance was first raised to the medium (40–60%) category 126 h before formation, as the global models indicated some potential for the extratropical cyclone to gradually shed its frontal structure and acquire subtropical characteristics as it moved toward slightly warmer waters. But over the next couple of days, the GFS and ECMWF models became less bullish for subtropical development. In particular, forecasters noted trends in the simulated satellite imagery from both models that suggested the low would struggle to sustain enough organized convection to be classified as a subtropical storm once it completely separated from its fronts. As a result, the 5-day probabilities were reduced to the low category at 1800 UTC 27 October and remained in the low category through 29 October. The system's 5-day genesis probability was again raised to the medium category 12 h before genesis. For the 2-day TWO, a low formation chance was introduced 108 h before genesis. The 2-day genesis chance was raised to the medium category just 6 h before formation, as NHC forecasters believed hostile environmental conditions would delay subtropical transition. The genesis probabilities did not reach the high category in the 5-day or 2-day outlook before formation occurred.

A verification of NHC official track forecasts for Wanda is given in Table 4a. Official track forecast (OFCL) errors were comparable to or lower than the mean official errors for the previous 5-yr period at 24–72 h, but higher than the mean official errors at 12, 96, and especially at 120 h. A complex steering pattern over the northern Atlantic Ocean caused Wanda to meander for several days and take an unusual track across open waters, which made for a very challenging track forecast. This is reflected by the climatology-persistence (OCD5) track errors for Wanda, which were much higher than their 5-yr means from 12–96 h. A homogeneous comparison of the official track errors with selected guidance models is given in Table 4b. The ECMWF (EMXI) was the best-performing track model for Wanda, as it had lower errors than OFCL at all forecast periods. In fact, the ECMWF had the lowest track errors of any guidance at 96 and 120 h, outperforming the consensus aids by a wide margin.

A verification of NHC official intensity forecasts for Wanda is given in Table 5a. Official intensity forecast (OFCL) errors were lower than the mean official errors for the previous 5-yr period at all forecast times. The OCD5 intensity errors were also lower than their 5-yr means at all forecast times, which suggests that Wanda's intensity was easier to forecast than an average Atlantic tropical cyclone. NHC forecasters correctly predicted that marginal to occasionally hostile environmental conditions over the subtropical and northern Atlantic would only allow for small fluctuations in Wanda's intensity during its lifetime. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 5b. The ECMWF model was also a top performer for Wanda's intensity, having the lowest errors of any model from 12–60 h. Numerous global and regional models had slightly lower errors than OFCL at 12–48 h. At 72 h and beyond, OFCL outperformed almost all of the guidance including the consensus aids.

There were no land-based tropical or storm surge watches and warnings associated with Wanda. During the low's extratropical phase, the National Weather Service issued high wind and coastal flood warnings for portions of the northeastern United States to cover the threat from these hazards associated with the nor'easter.

ACKNOWLEDGEMENTS

Data in Table 3 were compiled from reports issued by the Weather Prediction Center and the NWS Weather Forecast Offices in Mount Holly, New Jersey; Albany, Binghamton, and Upton, New York; Norton, Massachusetts; and Gray, Maine. John Cangialosi created the Wanda "best track" map (Fig. 1).

Table 1. Best track for Tropical Storm Wanda, 30 October–7 November 2021.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
25 / 1800	32.5	76.3	1006	35	extratropical
26 / 0000	34.2	74.1	1002	45	"
26 / 0600	35.9	71.3	996	45	"
26 / 1200	37.7	69.1	992	50	"
26 / 1800	39.5	68.2	984	55	"
27 / 0000	40.8	67.6	979	60	"
27 / 0600	41.4	69.4	973	60	"
27 / 1200	39.9	70.1	976	55	"
27 / 1800	38.7	68.5	980	50	"
28 / 0000	39.0	65.9	981	45	"
28 / 0600	39.4	63.9	982	45	"
28 / 1200	39.8	61.9	982	45	"
28 / 1800	40.2	59.8	982	45	"
29 / 0000	40.6	58.1	982	45	"
29 / 0600	40.7	56.8	982	45	"
29 / 1200	40.6	55.5	981	45	"
29 / 1800	40.4	54.0	981	45	"
30 / 0000	40.1	52.4	982	45	"
30 / 0600	39.4	51.2	984	40	"
30 / 1200	38.5	49.6	986	40	subtropical storm
30 / 1800	37.5	47.8	988	40	"
31 / 0000	36.5	46.0	987	45	"
31 / 0600	36.6	44.2	985	50	"
31 / 1200	36.5	43.4	983	50	"
31 / 1800	36.4	43.5	985	50	"
01 / 0000	35.8	44.0	989	45	"
01 / 0600	34.8	44.2	991	40	"
01 / 1200	34.1	43.4	993	40	tropical storm

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
01 / 1800	34.1	42.6	997	35	"
02 / 0000	34.4	41.9	997	35	"
02 / 0600	34.9	41.3	996	40	"
02 / 1200	35.5	40.7	996	40	"
02 / 1800	36.2	40.5	996	40	"
03 / 0000	36.9	40.4	996	40	"
03 / 0600	37.6	40.2	995	40	"
03 / 1200	38.4	39.9	994	40	"
03 / 1800	39.3	39.7	992	45	"
04 / 0000	40.2	39.7	992	45	"
04 / 0600	41.0	39.7	992	45	"
04 / 1200	41.7	39.7	994	40	"
04 / 1800	42.1	39.6	994	40	"
05 / 0000	42.3	39.0	992	45	"
05 / 0600	42.0	38.3	992	45	"
05 / 1200	41.1	37.8	993	45	"
05 / 1800	39.6	37.5	996	45	"
06 / 0000	38.4	38.0	999	45	"
06 / 0600	37.6	38.3	1000	45	"
06 / 1200	37.2	38.4	1001	40	"
06 / 1800	37.1	38.0	1002	35	"
07 / 0000	37.4	37.4	1003	35	"
07 / 0600	38.1	36.4	1004	35	"
07 / 1200	39.2	34.9	1006	35	low
07 / 1800	40.9	32.8	1006	40	"
08 / 0000	43.2	29.7	1006	40	"
08 / 0600					dissipated
31 / 1200	36.5	43.4	983	50	minimum pressure and maximum wind

Table 2. Number of hours in advance of Wanda's formation associated with the first NHC Tropical Weather Outlook forecast in the indicated likelihood category. Note that the timings for the "Low" category do not include forecasts of a 0% chance of genesis. Numbers in parentheses ( ) indicate the number of hours in advance that the system was first mentioned in the outlook before the category was lowered.

	Hours Before Genesis	
	48-Hour Outlook	**120-Hour Outlook**
Low (<40%)	108	150
Medium (40%-60%)	6	(126) 12
High (>60%)	-	-

Table 3. Selected surface observations for the extratropical phase, several days before the low transitioned into Subtropical Storm Wanda.

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)				
Offshore									
NOAA Buoys									
44011 – Georges Bank (41.09N 66.56W)	27/0000	983.4	26/1859	51 (4 m, 1 min)	56				
44020 – Nantucket Sound (41.49N 70.28W)	27/0840	981.0	27/0649	51 (4 m, 1 min)	60				
44005 – Gulf of Maine (43.20N 69.13W)	27/0550	993.4	27/0611	49 (5 m, 1 min)	52				
44008 – Nantucket (40.50N 69.25W)	27/0740	978.6	26/2109	47 (4 m, 1 min)	52				
44013 – Boston (42.35N 70.65W)	27/0710	993.1	27/0847	47 (3 m, 1 min)	56				
44017 – Montauk Point (40.69N 72.05W)	27/0950	991.5	27/1229	47 (4 m, 1 min)	52				
44027 – Jonesport (44.28N 67.30W)	27/0650	1002.1	27/0743	43 (5 m, 1 min)	52				
44007 – Portland (43.53N 70.14W)	27/0650	998.9	27/0652	41 (4 m, 1 min)	47				
44025 – Long Island (40.25N 73.16W)	26/1330	993.2	27/1304	39 (4 m, 1 min)	45				
44066 – Texas Tower #4 (39.62N 72.64W)	27/0410	992.9	27/1332	39 (4 m, 1 min)	45				
41002 – South Hatteras (31.76N 74.95W)	26/1930	1002.4	25/1917	35 (4 m, 1 min)	41				
44009 – Delaware Bay (38.45N 74.68W)	26/1900	996.1	27/0402	35 (4 m, 1 min)	39				
41013 – Frying Pan Shoals (33.44N 77.76W)	26/0740	1003.7	26/0713	33 (4 m, 1 min)	37				
44014 – Virginia Beach (36.61N 74.84W)	26/0720	997.0	26/0631	33 (3 m, 1 min)	39				
44065 – New York Harbor (40.37N 73.70W)	26/1410	993.3	26/1058	33 (4 m, 1 min)	39				
Ocean Observatories Initiative (OOI) Buoys									
44075 – Inshore (40.36N 70.88W)	27/1040	979.6	27/1420	37 (5 m)					
44077 – Offshore (39.94N 70.88W)	27/1110	980.4	27/1800	36 (5 m)					
University of New Hampshire Buoys									
44073 – Gulf of Maine (43.02N 70.54W)			27/0704	37 (3 m)	47				
Northeastern Regional Association of Coastal Ocean Observing Systems Buoys									

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)				
44032 – Central Maine Shelf (43.72N 69.36W)			27/0604		49				
44030 – Western Maine Shelf (43.18N 70.43W)			27/0804		47				
44033 – Penobscot Bay (44.05N 69.00W)			27/1104		43				
Environment and Climate Change Canada (ECCC) Buoys									
44150 – La Have Bank (42.50N 64.02W)	27/1620	992.9	27/0020	39 (5 m)	57				
44137 – East Scotia Slope (42.26N 62.03W)	28/0520	992.6	27/0120	36 (5 m)	44				
Delaware									
Community Collaborative Rain, Hail, & Snow (CoCoRaHS) Sites									
Long Neck 6.5 NW (DE-SS-76) (38.68N 75.24W)									2.12
New Jersey									
CoCoRaHS Sites									
Warren Twp 1.3 W (NJ-SM-82) (40.63N 74.54W)									6.63
Citizen Weather Observer Program (CWOP) / Public									
Waldwick (CW2073) (41.02N 74.12W)									6.49
Westwood (40.99N 74.03W)									6.10
Pennsylvania									
CWOP/Public									
Beach Lake (41.60N 75.15W)									6.50
Vandling (41.63N 75.47W)									5.89
Shohola (41.47N 74.92W)									4.64
New York									
WeatherFlow Sites									
Great Gull Island (XGUL) (41.20N 72.12W)			27/1130	42 (16 m)	57				

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)				
Napeague (XNAP) (41.01N 72.06W)	27/0944	991.2	27/1254	40 (10 m)	61				
CWOP Stations									
Stony Brook (EW5678) (40.91N 73.12W)			27/1131	41	63				
Ridge (EW4748) (40.88N 72.92W)									6.82
Saint James (CW9244) (40.88N 73.15W)									6.45
CoCoRaHS Sites									
Centereach (NY-SF-84) (40.89N 73.07W)									6.45
Connecticut									
International Civil Aviation Organization (ICAO) Sites									
Groton – New London Airport (KGON) (41.33N 72.05W)	27/0556	992.4	27/1147		47				
WeatherFlow Sites									
Stonington Outer Breakwater 4 (XSTO) (41.32N 71.91W)	27/0805	989.9	27/1135	38 (11 m)	56				
USCG Academy (XCGA) (41.37N 72.09W)	27/0838	990.4	27/1048	37 (17 m)	61				
CoCoRaHS Sites									
Ridgefield 3.7 NNE (CT-FR-24) (41.32N 73.48W)									6.06
Wilton 1.9 NW (CT-FR-63) (41.21N 73.47W)									5.41
CWOP Stations									
Armonk (41.09N 73.70W)									4.83
Rhode Island									
NOS Sites									
Quonset Point (QPTR1) (41.59N 71.41W)	27/0918	990.3	27/1106	43 (7 m)	56				
Newport (NWPR1) (41.50N 71.33W)	27/0912	989.9	27/0948	34 (8 m)	48				
WeatherFlow 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)				
Block Island Jetty (XBLK) (41.20N 71.59W)	27/0912	987.8	27/1047	51 (11 m)	74				
Bristol Harbor (XCAS) (41.65N 71.29W)	27/0834	987.1	27/1019	43 (9 m)	69				
Point Judith (XJUD) (41.36N 71.50W)	27/0919	987.4	27/1104	42 (16 m)	67				
Public/Other									
Hope Valley (41.51N 71.72W)									2.11
Massachusetts									
ICAO Sites									
Nantucket Mem. AP (KACK) (41.25N 70.06W)	27/0753	977.4 [I]	27/0753	46 [I]	61 [I]				
Coastal Marine Automated Network (C-MAN) Stations									
BUZM3 – Buzzards Bay (41.40N 71.03W)	27/0900	984.6	27/0940	58 (25 m)	73				
National Ocean Service (NOS) Sites									
Chatham (CHTM3) (41.69N 69.95W)	27/0806	981.7	27/0600	54 (7.5 m)	68	3.78	5.36	2.7	
Nantucket Island (NTKM3) (41.29N 70.10W)	27/0800	978.2	27/0748	39 (8.5 m)	56	3.93		2.4	
WeatherFlow Sites									
Duxbury (XDUX) (42.06N 70.65W)	27/0845	983.8	27/0925	58 (12 m)	90				
Scituate (XSIT) (42.20N 70.72W)	27/0722	989.2	27/0842	49 (10 m)	85				
Wellfleet (XWEL) (41.93N 69.98W)	27/0810	979.1	27/0855	52 (33 m)	80				
Vineyard Haven (XVIN) (41.46N 70.59W)	27/0857	980.2	27/0907	51 (10 m)	76				
Nantucket Harbor (XNAN) (41.31N 70.06W)	27/0748	977.0	27/0743	43 (10 m)	63				
Mesonet Stations									
Edgartown (41.38N 70.53W)			27/0831		82				
CoCoRaHS Sites									
Falmouth 0.6 NNW (MA-BA-13) (41.55N 70.61W)									3.94
Falmouth 3.1 NNW (MA-BA-2) (41.59N 70.63W)									3.79
CWOP Stations									

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)				
Chilmark (FW5264) (41.38N 70.68W)									3.43
United States Geological Survey (USGS) Sites									
Sesuit Harbor at Dennis (SESM3) (41.75N 70.15W)							7.40	2.7	
Vermont									
CoCoRaHS Sites									
Wilmington 0.6 WNW (VT-WH-16) (42.87N 72.88W)									2.20
New Hampshire									
C-MAN Stations									
IOSN3 – Isle of Shoals (42.97N 70.62W)	27/0700	995.6	27/0850	49 (19 m)	63				
CoCoRaHS Sites									
Hampstead 1.6 NNE (NH-RC-33) (42.90N 71.17W)									2.21
Maine									
C-MAN Stations									
MDRM1 – Mt. Desert Rock (43.97N 68.13W)	27/0700	999.7	27/0510	51 (23 m)	60				
CoCoRaHS Sites									
York 4.7 NNW (ME-YK-63) (43.22N 70.69W)									2.30

[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] 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 NOS tide gauges, the height of the water above Mean Higher High Water (MHHW) is used as a proxy for inundation.
[I] Incomplete

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Wanda, 30 October–7 November 2021. 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	27.8	36.9	**34.4**	**42.1**	**57.4**	**68.3**	188.2	405.3
OCD5	85.9	188.4	272.1	377.5	434.4	454.0	452.5	364.8
Forecasts	28	26	24	22	20	18	14	10
OFCL (2016-20)	23.9	36.3	49.1	63.9	79.0	94.1	128.1	169.7
OCD5 (2016-20)	45.1	97.2	157.2	216.7	271.1	325.4	414.4	490.0

Table 4b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Tropical Storm Wanda, 30 October–7 November 2021. 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	60	72	96	120
OFCL	27.4	37.0	36.3	42.6	58.4	71.5	194.7	417.1
OCD5	82.5	184.4	271.9	385.3	446.3	465.8	478.9	**363.7**
GFSI	**22.9**	**36.7**	43.6	48.1	63.2	82.2	**179.4**	**240.7**
HWFI	**24.9**	39.6	60.5	82.0	93.6	99.6	209.8	**341.7**
HMNI	29.1	54.1	80.9	97.9	101.1	95.4	**192.5**	**327.9**
EGRI	**23.8**	**33.2**	40.5	51.6	64.2	87.9	240.2	**196.6**
EMXI	**18.2**	**24.5**	**25.1**	**30.5**	**43.9**	**50.6**	**97.6**	**191.9**
NVGI	33.1	57.0	61.9	61.4	87.9	155.9	494.2	684.5
CMCI	**21.9**	**28.8**	**31.8**	43.4	70.0	108.3	273.3	552.1
CTCI	**25.9**	46.7	64.1	91.3	141.8	209.1	433.4	462.3
GFEX	**20.3**	**29.9**	**29.8**	**29.6**	**45.5**	**53.4**	**123.9**	**207.5**
TVCA	**22.0**	**32.2**	37.2	42.9	**56.4**	72.3	197.6	**268.6**
TVDG	**21.8**	**31.0**	**35.9**	**37.6**	**48.6**	**61.1**	**172.3**	**228.9**
HCCA	**21.0**	**28.8**	**29.5**	**34.6**	**47.2**	**64.1**	**187.8**	**347.8**
FSSE	**20.5**	**27.7**	37.1	46.4	60.5	91.7	212.4	**245.2**
AEMI	**22.8**	39.8	48.8	51.0	70.4	90.6	227.9	**337.1**
TABS	43.4	95.9	159.2	201.5	218.2	242.0	342.6	**234.9**
TABM	46.9	105.5	193.1	287.6	376.4	481.3	862.5	458.8
TABD	58.8	142.7	295.9	483.9	690.7	924.2	1534.2	1264.7
Forecasts	26	24	22	20	18	16	12	4

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Wanda, 30 October–7 November 2021. 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	**5.2**	**6.2**	**5.8**	**6.4**	**4.5**	**3.3**	**3.2**	**4.0**
OCD5	3.9	4.7	6.3	8.1	9.5	11.6	18.9	7.4
Forecasts	28	26	24	22	20	18	14	10
OFCL (2016-20)	5.4	8.0	9.6	10.9	11.5	12.1	13.3	14.5
OCD5 (2016-20)	7.0	11.0	14.3	16.8	18.3	19.7	21.7	23.0

Table 5b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Tropical Storm Wanda, 30 October–7 November 2021. 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	60	72	96	120
OFCL	5.2	6.2	5.7	6.2	4.7	3.1	3.8	5.0
OCD5	**4.0**	**4.8**	6.4	8.1	9.7	11.6	19.3	**4.2**
HWFI	**3.5**	**4.5**	**4.7**	**3.2**	5.2	5.4	6.6	6.2
HMNI	**4.7**	**5.7**	**5.5**	**5.1**	5.0	4.1	6.9	10.8
DSHP	**4.8**	7.3	8.5	8.6	9.2	9.1	7.8	13.0
LGEM	**4.6**	6.9	8.1	8.6	9.7	10.6	11.8	**3.5**
ICON	**3.9**	**5.0**	**5.6**	**4.8**	5.3	5.4	6.3	5.2
IVCN	**4.0**	**5.1**	5.7	**4.8**	5.2	4.9	7.1	5.8
IVDR	**4.0**	**4.9**	**5.3**	**4.1**	**4.5**	4.2	6.9	6.5
CTCI	**5.1**	**5.7**	6.4	**5.8**	6.7	6.7	11.3	7.2
GFSI	**3.9**	**4.9**	**5.2**	**5.2**	**3.6**	3.2	5.1	11.0
EMXI	**2.8**	**2.6**	**2.7**	**2.8**	**3.2**	4.8	5.7	5.8
EGRI	**3.8**	**5.2**	5.9	**5.9**	5.8	5.1	7.3	**3.5**
CMCI	**3.2**	**3.8**	**3.5**	**3.7**	**4.1**	**2.9**	**3.4**	**2.2**
NVGI	**3.0**	**3.0**	**3.0**	**2.8**	**3.4**	4.2	**2.7**	5.8
AEMI	**3.7**	**3.9**	**4.5**	**4.7**	4.8	4.2	5.5	**0.8**
HCCA	**4.3**	**5.9**	6.8	**5.8**	5.8	4.9	5.6	**1.5**
FSSE	**4.2**	**5.5**	6.5	**5.8**	5.2	5.2	8.0	5.2
Forecasts	26	24	22	20	18	16	12	4

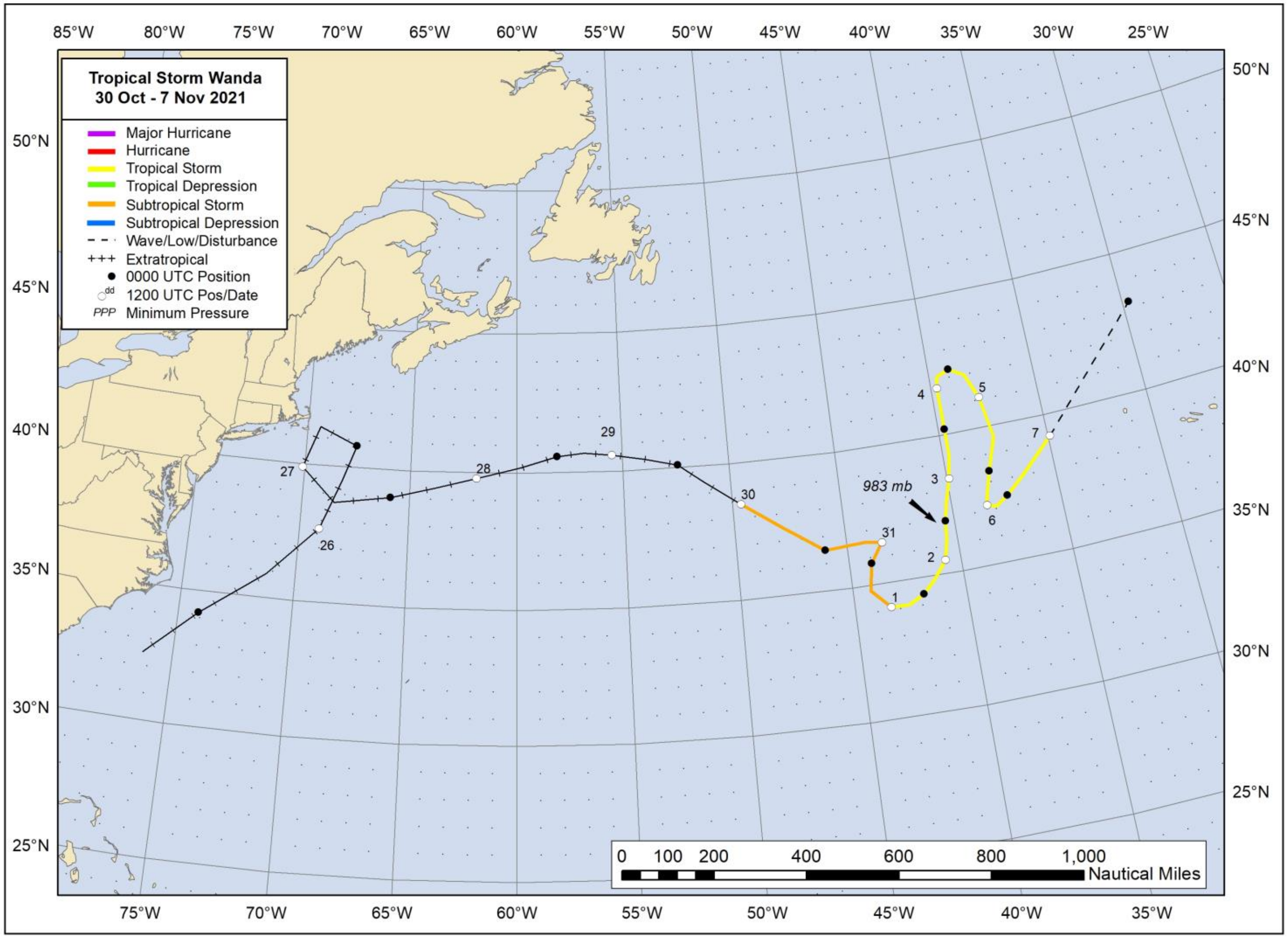

Figure 1. Best track positions for Wanda, 30 October–7 November 2021. Tracks during the extratropical stage are partially based on analyses from the NOAA Ocean Prediction Center and the NOAA Weather Prediction Center.

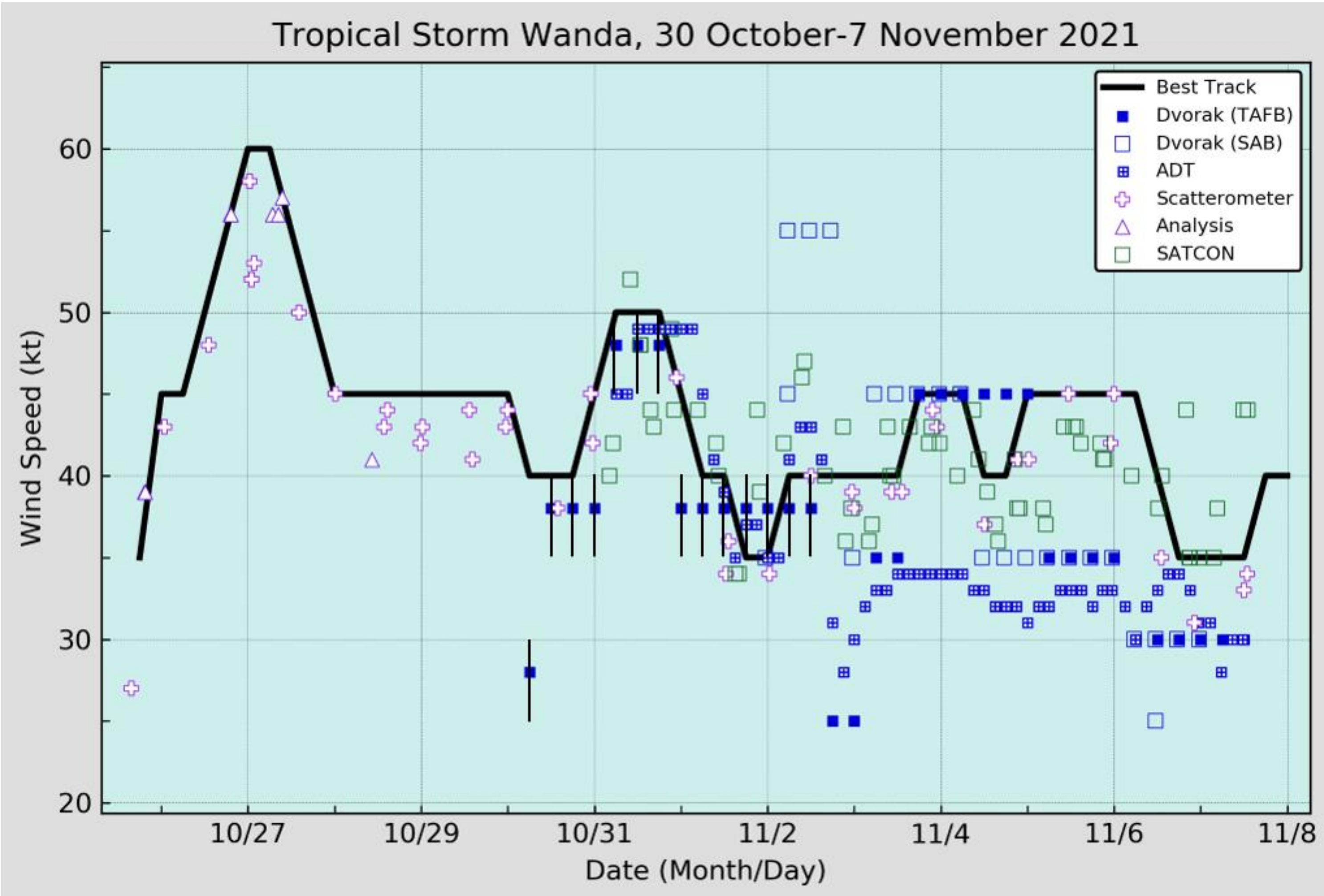

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Wanda, 30 October–7 November 2021. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC. Solid vertical lines depict intensity ranges associated with Hebert-Poteat subtropical satellite classifications.

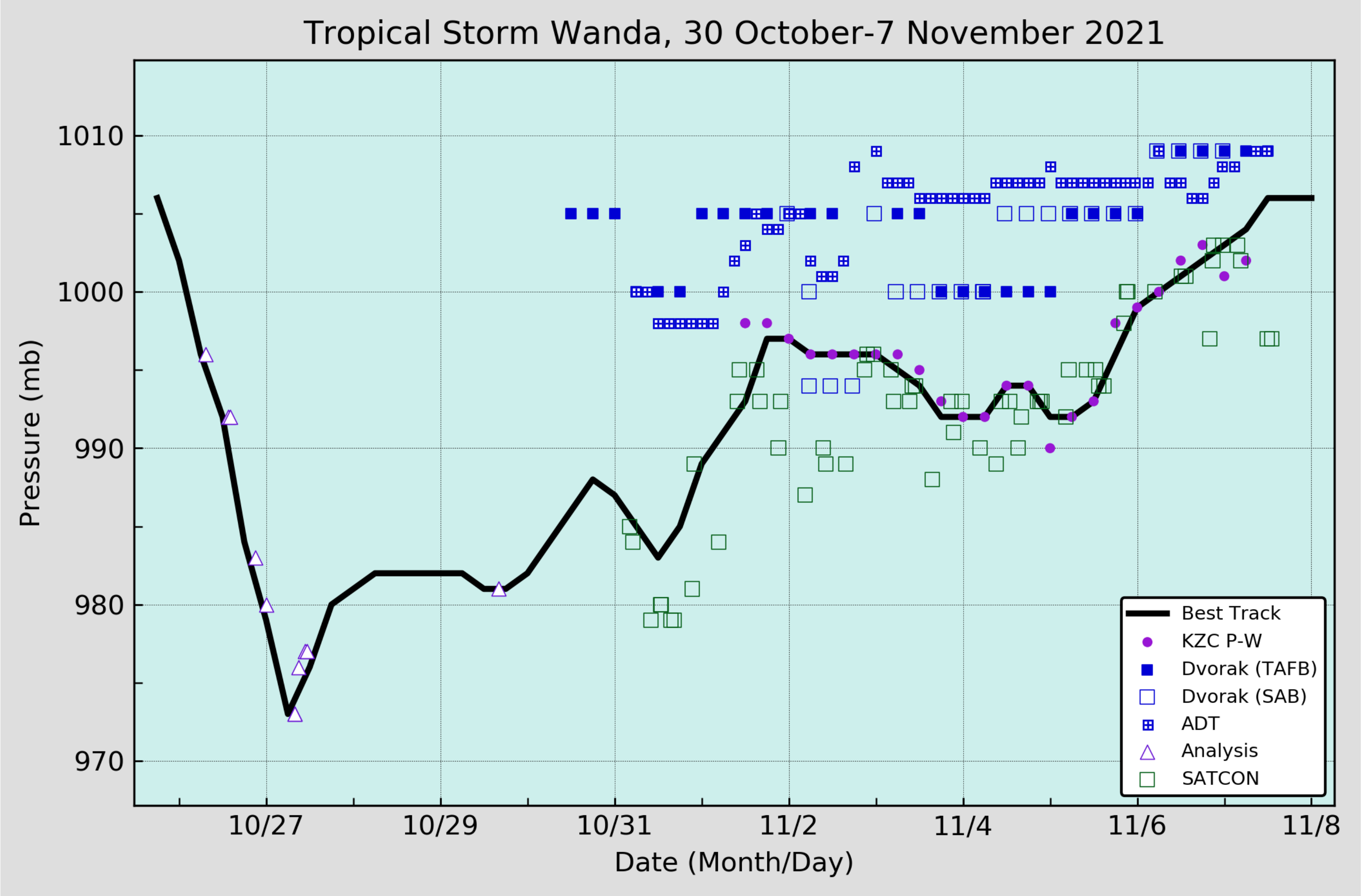

Figure 3. Selected pressure observations and best track minimum central pressure curve for Wanda, 30 October–7 November 2021. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological 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.

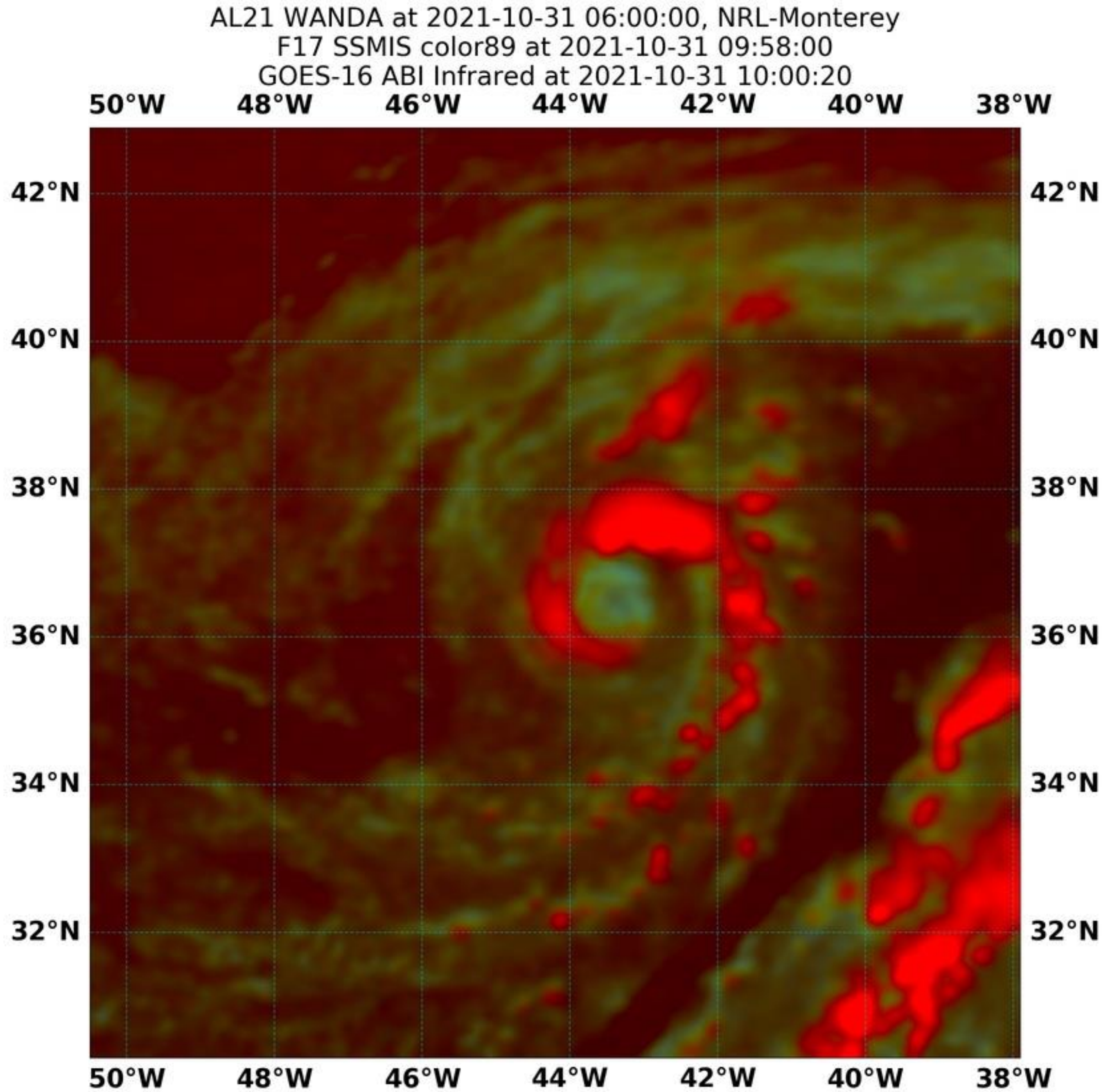

Figure 4. 91-GHz SSMIS color composite image of Subtropical Storm Wanda at 0958 UTC 31 October during its peak intensity over the north-central Atlantic Ocean. Image courtesy NRL Monterey.

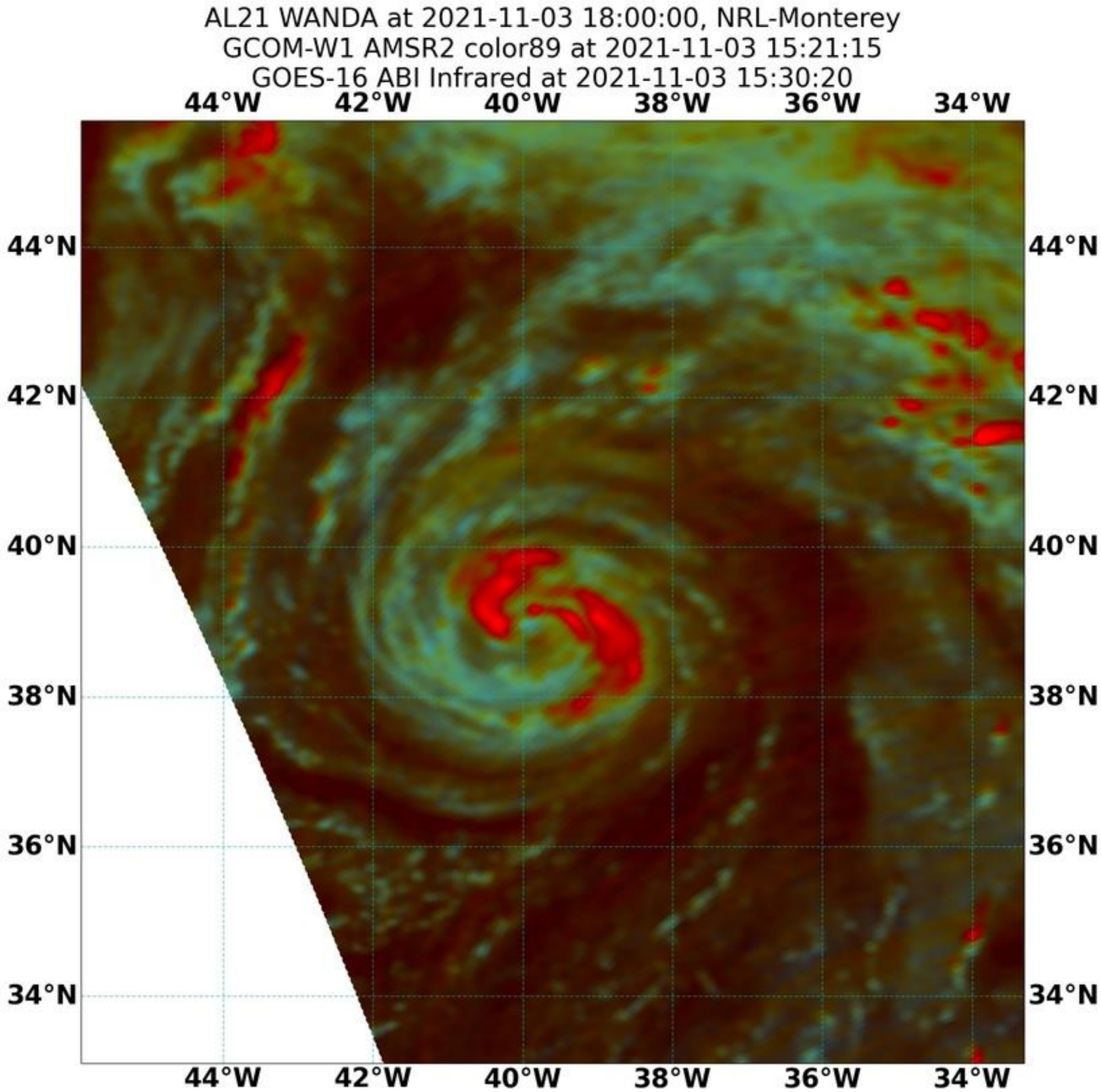

Figure 5. 89-GHz AMSR2 color composite image of Tropical Storm Wanda at 1521 UTC 3 November. Image courtesy NRL Monterey.

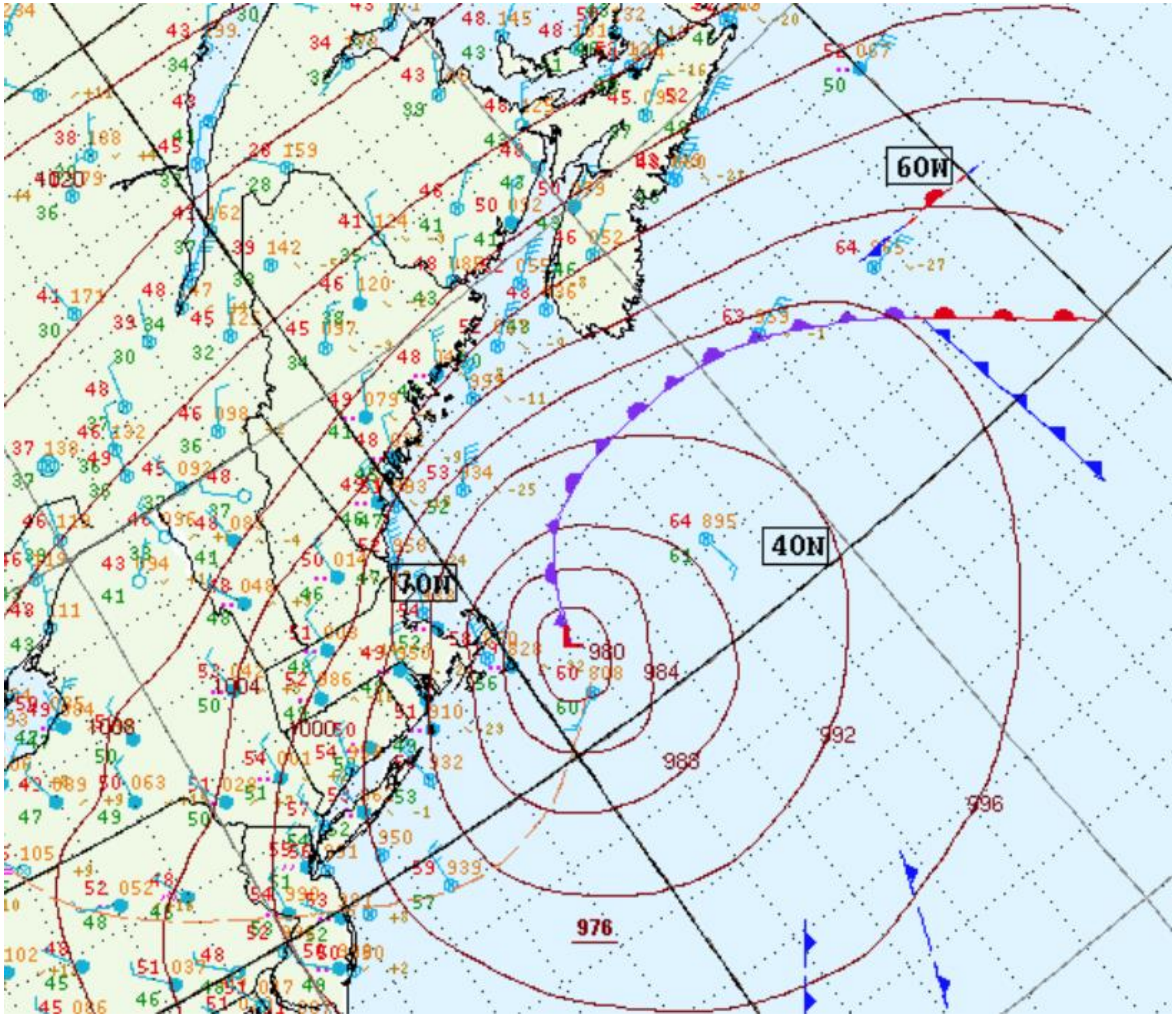

Figure 6. NOAA/NWS unified surface analysis map produced by the Ocean Prediction Center and Weather Prediction Center at 0600 UTC 27 October. Image courtesy WPC surface analysis archive.

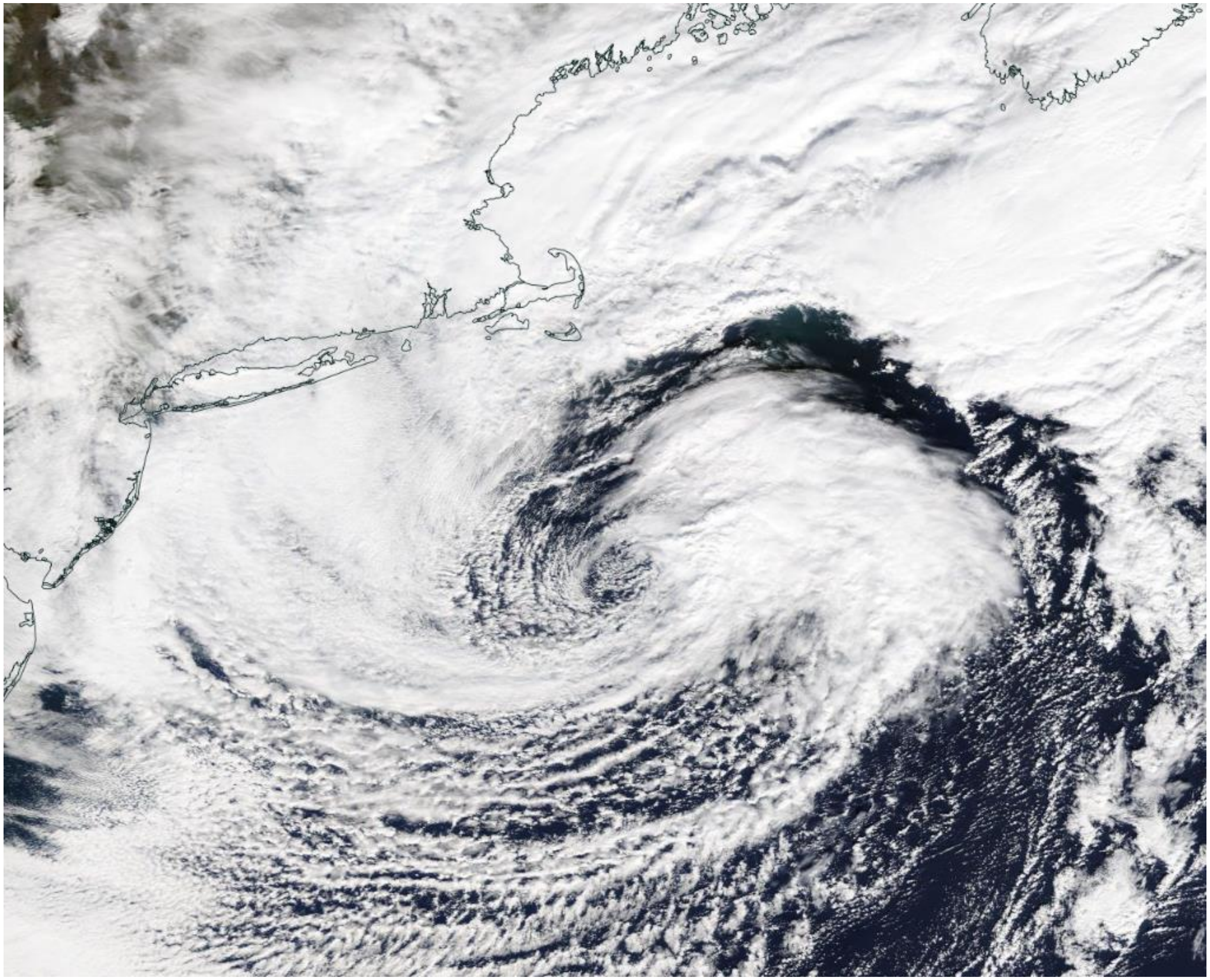

Figure 7. NASA Terra/MODIS true color image of the extratropical cyclone at 1516 UTC 27 October, shortly after it reached its peak intensity off the coast of Massachusetts. Several days later, this system transitioned into Subtropical Storm Wanda. Image courtesy NASA EOSDIS Worldview.