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JOHN W. LICCIONE

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RON DESANTIS, *et al.*

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NHC Tropical Cyclone Report — Hurricane Helene (AL092024)

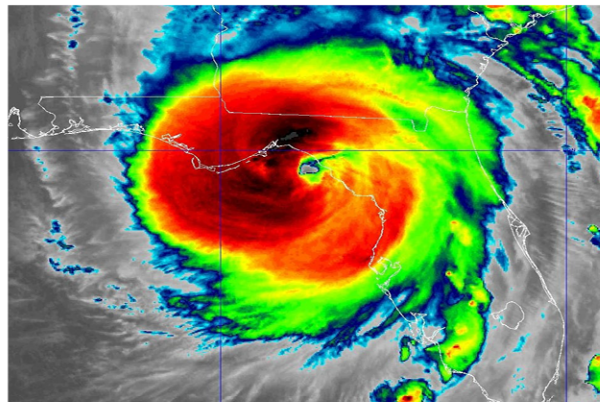


NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE HELENE (AL092024)

24–27 September 2024

Andrew B. Hagen, John P. Cangialosi, Marc Chenard¹,
Laura Alaka, and Sandy Delgado
National Hurricane Center
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GOES-16 INFRARED IMAGE OF HELENE AT 0200 UTC 27 SEPTEMBER 2024 PRIOR TO LANDFALL IN FLORIDA.
IMAGE COURTESY OF NOAA/NESDIS/STAR.

Helene made landfall in the Florida Big Bend region as a category 4 hurricane (on the Saffir-Simpson Hurricane Wind Scale). The storm brought catastrophic inland flooding, extreme winds, deadly storm surge, and numerous tornadoes that devastated portions of the southeastern United States and southern Appalachians. Helene is responsible for at least 250 fatalities in the United States (including at least 175 direct deaths), making it the deadliest hurricane in the contiguous U.S. since Katrina in 2005. Helene also produced tropical storm conditions and minor damage across portions of Mexico and Cuba.

¹ NOAA/NWS/NCEP Weather Prediction Center, College Park, MD

² This version updates the fatality count by removing one direct fatality that is no longer classified as associated with Helene, and also adds one indirect fatality. These changes are based on new data provided by North Carolina and are also reflected in that state's fatality count. Previous updates: 8 April 2025 to add a direct fatality in North Carolina and remove an erroneous rainfall observation in Tennessee (EMBT1), which resulted in a change to the highest rainfall amount in Tennessee; 21 March 2025 to update casualty statistics for North Carolina and remove an erroneous rainfall observation (BLAN7) in North Carolina. Original report dated 19 March 2025.

central Illinois, a wind observation of 37 kt and a gust to 57 kt was measured at Coles County Memorial Airport around 0200 UTC 28 September. Surface observations indicate that Helene's sustained winds dropped below gale force by 0600 UTC 28 September. See the table below for the highest measured wind gusts in each state related to Helene. The Ohio, Indiana and Illinois observations occurred after Helene became post-tropical.

Highest Measured Wind Gusts by State			
State	County	Location	Wind Gust (kt)
Virginia	Grayson	Grayson Highlands	57
West Virginia	Wayne	Huntington	61
Kentucky	Fayette	Lexington	56
Kentucky	Wolfe	Pine Ridge	56
Tennessee	Unicoi	Unicoi	52
Ohio	Clinton	Wilmington	59
Indiana	Marion	Indianapolis	59
Illinois	Coles	Mattoon	57

Storm Surge⁷

Helene produced a catastrophic storm surge with significant impacts to coastal communities along a large portion of Florida's Gulf Coast. Figure 10 shows the NHC storm surge analysis, which represents the maximum inundation during Helene. In the Big Bend region, storm surge inundation of 12 to 16 ft AGL occurred from just west of Keaton Beach through Steinhatchee, where small coastal communities were devastated. Significant storm surge and wave impacts extended as far south as Naples, bringing dangerous storm surge to densely populated areas such as Tampa Bay and Sarasota. The large size of Helene's wind field exacerbated the storm surge impacts over an extensive area.

⁷ 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).

Figure 11 shows reflectivity data from the Tampa Bay (TBW) Doppler radar highlighting the storm structure near the time of landfall, overlaid with the available in situ maximum water level observations relative to Mean Higher High Water (MHHW, i.e. an approximation for inundation at the immediate coastline). Observations in Figure 11 include the NOAA tide gauges and U.S. Geological Survey (USGS) water level sensors that were deployed in the days prior to landfall. Note that the deployed USGS water level sensor data are wave-filtered (i.e., storm tide only) and measured relative to the North American Vertical Datum of 1988 (NAVD88) and then converted to MHHW using the vertical transformation tool (<https://vdatum.noaa.gov/>) provided by the National Geodetic Survey (NGS) Office of Coast Survey (OCS) and Operational Oceanographic Products and Services (CO-OPS) of NOAA.

Peak storm surge inundation levels of 12 to 16 ft AGL occurred from just west of Keaton Beach to south of Steinhatchee (Fig. 10) as observed by the deployed USGS water level sensor network in this remote area. Three water level sensors were placed just south of Keaton Beach near Fish Creek; two of these sensors reported maximum water levels greater than 13.5 ft above MHHW (Fig. 11), while the third was mounted to a pavilion that was destroyed. Of the reporting sensors, one was placed on a dock along a wave-protected waterway, while the other was located on the immediate coast and recorded significant waves on top of the storm tide. Aerial imagery collected by the NOAA Remote Sensing Division shows that many homes were removed from foundations leaving only the slab and stilts where the elevated home once was. Entire homes appear to have been picked up by the storm surge and moved to remote wetlands⁸. On-the-ground National Weather Service (NWS) survey crews also found significant damages in Dekle and Keaton Beach and identified a high confidence stilled high water mark of 13.8 ft AGL inside a brick building displaced from the immediate coast. The mark was also recorded relative to NAVD88 (17.0 ft NAVD88) and converted to 15.3 ft above MHHW, slightly higher than the in situ USGS data.

In Steinhatchee, a USGS streamgage located approximately two miles from the mouth of the Steinhatchee River reported 9.6 ft above MHHW prior to failing (not shown in Figure 11). A post-storm survey by the USGS field crew found a high water mark of 14.25 ft above NAVD88 (converts to 12.6 ft above MHHW) near the sensor, approximately 4.5 ft higher than the maximum water level recorded during Hurricane Idalia in August 2023. Additionally, NWS survey crews found a high confidence stilled high water mark of 11.25 ft above the building slab in the second story of a condominium located downstream of the sensor. This high water mark measured 17.8 ft above NAVD88, which converts to 16.1 ft above MHHW. The immediate coastline between Keaton Beach and the mouth of the Steinhatchee River likely received some of the strongest onshore winds and highest storm surge due to the location and structure of the eyewall, and based on high water marks collected, storm surge inundation up to 16 ft AGL is estimated to have occurred (Fig. 10).

North and west of Keaton and Dekle Beach, NWS survey crews found a high water mark measuring 10.4 ft above the building slab in an elevated home in Spring Warrior Fish Camp (14.7 ft NAVD88/12.9 ft MHHW). A gradient of storm surge exists west of this location across the storm

⁸ <https://storms.ngs.noaa.gov/storms/helene/index.html#17.08/29.822441/-83.592399>

track, however, the western portion of the Big Bend still experienced a dangerous storm surge due to Helene's large wind field and the concave coastline despite mostly offshore winds. Maximum storm surge inundation of 6 to 9 ft AGL occurred west of Spring Warrior Creek to the Econfina River (Fig. 10), where the region is mostly remote evergreen forests/wetlands lacking structures to identify high water marks. Storm surge inundation of 5 to 7 ft AGL occurred from the Econfina River westward to the Ochlockonee River, where a deployed USGS water level sensor at Shell Point Beach in Wakulla County measured 6.53 ft above MHHW. The storm surge penetrated well inland, and NWS survey crews collected high water marks of 2 to 3 ft AGL in St. Marks. Farther to the west, 3 to 5 ft AGL of storm surge inundation occurred from Ochlockonee River to Indian Pass (Fig. 10), where the NOS tide gauge at Apalachicola measured 4.33 ft above MHHW. West of Indian Pass, water levels were elevated to 1 to 3 ft AGL, with the NOS tide gauges at Panama City and Panama City Beach measuring 3.02 and 3.26 ft above MHHW, respectively.

East of the landfall location, significant storm surge impacts extended well away from the storm center. Maximum storm surge inundation of 8 to 12 ft AGL occurred from south of Steinhatchee through Cedar Key, including Horseshoe Beach (Fig. 10). A deployed USGS water level sensor at Suwannee River measured 12.18 ft above MHHW (Fig. 11). Moreover, the NOS tide gauge at Cedar Key⁹ measured 9.30 ft above MHHW, the highest recorded water level since the station started reporting in 1914. This measurement also breaks the previous record held by Hurricane Idalia in August 2023 (6.89 ft above MHHW). A nearby deployed USGS water level sensor reported a similar water level of 8.84 ft above MHHW.

Maximum storm surge inundation of 6 to 9 ft AGL occurred from south of Cedar Key to the Anclote River. USGS deployed water level sensors at the mouth of the Crystal River and on Pine Island (Hernando County) measured 9.0 ft and 8.84 ft above MHHW, respectively (Fig. 11). In Pasco County, a deployed USGS water level sensor measured 7.60 ft above MHHW, and was a protected sensor, with minimal wave impacts. NWS survey crews found significant impacts to communities along the rivers such as Homosassa Springs, Yankeetown, and Crystal River.

Maximum storm surge inundation of 5 to 7 ft AGL occurred from the Anclote River southward to Longboat Key (Fig. 10). In Pinellas County, deployed USGS water sensors located along exposed barrier islands measured water levels of 7.23 ft (Fred Howard Park), 6.75 ft (Clearwater Bach), and 7.26 ft (Madeira Beach) above MHHW, with significant waves on top. Nearby, the NOS tide gauge at Clearwater¹⁰ (station record back to 1973) measured 6.67 ft above MHHW (Fig. 11), surpassing the previous record from the Superstorm of March 1993. Farther south in Manatee County, a deployed USGS water sensor located on Longboat Key measured a wave-filtered storm tide of 6.68 ft above MHHW. Widespread high water marks were observed by NWS survey crews along this very populated region of the Florida coast, with stilled waterlines inside many homes.

⁹ Data courtesy of NOAA's National Ocean Service (NOS) Center for Operational Oceanographic Products & Services (CO-OPS)

¹⁰ Data courtesy of NOAA's National Ocean Service (NOS) Center for Operational Oceanographic Products & Services (CO-OPS)

A USGS Hydrologic Imagery Visualization and Information System (HIVIS) camera captured the dangerous storm surge at Madeira Beach in coastal Pinellas County. Figure 12 shows the evolution of beach images: A) the beach a day prior to the landfall, B), C) and D) show the evolution in the afternoon and evening prior to landfall. The storm surge continued as darkness fell, and the last image E) shows the scene days after landfall when water levels subsided and the camera provided a clear picture. Image E) highlights the significant beach erosion that occurred, exposing a groin that is in place to maintain and trap sand. Significant erosion and sediment transfer occurred along a large portion of the Florida Peninsula, and communities were forced to dig roads and structures out of the sand.

Within Tampa Bay, maximum storm surge inundation of 5 to 7 ft AGL occurred. The NOS tide gauge at East Bay measured 7.2 ft above MHHW. Elsewhere, NOS tide gauges measured water levels relative to MHHW of 6.83 ft at Old Port Tampa, 6.31 ft at St. Petersburg, and 6.04 ft at Port Manatee. The St. Petersburg tide station has the longest record in Tampa Bay, dating back to 1947. The maximum water level of 6.31 ft above MHHW during Helene surpassed the previous record of 3.97 ft during Hurricane Elena (1985)¹¹. Additionally, 4 to 6 ft AGL occurred from Venice to south of Englewood where a deployed USGS water level sensor measured 5.71 ft above MHHW near the Venice Fishing Pier.

Maximum storm surge inundation of 3 to 5 ft AGL occurred from south of Englewood to Bonita Beach including Charlotte Harbor. The NOS tide gauge on the Calossahatchee River in Fort Myers measured 5.12 ft above MHHW. South of Bonita Beach, maximum storm surge inundation of 2 to 4 ft AGL occurred in areas such as Naples, Marco Island, and Everglades City. The NOS tide gauge in Naples Bay measured 4.02 ft above MHHW. In the Florida Keys 1 to 2 ft of storm surge inundation occurred as NOS tide gauges at Key West and Vaca Key reported 1.57 and 1.40 ft above MHHW, respectively.

Elsewhere, Helene produced minor elevated water levels along the U.S. East Coast, where the NOS tide gauges at Fort Pulaski, Georgia and Charleston, South Carolina, reported water levels of 2.34 and 2.26 ft above MHHW, respectively. In Mexico, Helene produced water levels of 1 to 2 ft above normal tides along the east coast of the Yucatan Peninsula as supported by the tide gauge measurements at Isla Mujeres.

Rainfall and Flooding

United States

Helene, combined with its interaction with the baroclinic cut-off low over the southeastern United States, produced a prolonged period of heavy rainfall from 25–27 September, spanning from the Florida Panhandle northward into the southern Appalachians, where historic rainfall totals resulted in catastrophic flooding and widespread landslides. The large-scale weather

¹¹ Data courtesy of NOAA's National Ocean Service (NOS) Center for Operational Oceanographic Products & Services (CO-OPS)

EF-1 tornado in Sumter County, South Carolina, that occurred around 0932 UTC 27 September had a path width of about 1,000 yards. In North Carolina, one EF-3 tornado occurred around 1730 UTC 27 September in Nash County.

After Helene became post-tropical, an EF-1 tornado occurred in Rockingham County, North Carolina and an EF-2 tornado occurred in Pittsylvania County, Virginia.

CASUALTY AND DAMAGE STATISTICS

Reports from official state government sources as well as media reports indicate that Helene is responsible for at least 175 direct¹³ deaths in the United States. Storm surge caused 14 of those fatalities - all in Florida. Helene's winds are responsible for 65 of the direct deaths - the most direct wind deaths from any tropical cyclone in the continental United States going back to at least 1963¹⁴, according to data from Rappaport (2014) that covered the 1963–2012 period, and reports on U.S. hurricanes since that time available at NHC. Of the 65 direct wind fatalities, 61 were caused by falling trees during the storm. A breakdown of direct wind fatalities by state are as follows: Georgia (26), South Carolina (24), North Carolina (8), Florida (4), Virginia (2) and Indiana (1). Freshwater flooding, which includes landslides and debris flows, was responsible for at least 94 of the direct deaths: 77 in North Carolina, 15 in Tennessee and 2 in South Carolina. There were also 2 deaths caused by a tornado in Georgia that was associated with Helene, mentioned above. As of this writing there are at least 5 individuals listed as missing from western North Carolina and eastern Tennessee. A breakdown of direct deaths sorted by type and state is listed in the table below.

Direct Deaths by State and Type					
State	Wind	Storm Surge	Freshwater Flooding	Tornado	TOTAL
Florida	4	14			18
Georgia	26			2	28
South Carolina	24		2		26
North Carolina	8		77		85

¹³ 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 powerlines, vehicle accidents on wet roads, etc., are considered "indirect" deaths.

¹⁴ Rappaport, E. N. 2014: Fatalities in the United States from Atlantic Tropical Cyclones. *Bull. Amer. Meteor. Soc.*, **95**, 341-346.

Direct Deaths by State and Type					
State	Wind	Storm Surge	Freshwater Flooding	Tornado	TOTAL
Tennessee			15		15
Virginia	2				2
Indiana	1				1
TOTAL	65	14	94	2	175

At least 72 indirect fatalities are linked to Helene: 23 in South Carolina, 22 in North Carolina, 16 in Florida, 9 in Georgia, 1 in Tennessee and 1 in Virginia. Many of the indirect fatalities were from medical issues, heart attacks, car accidents and incidents during post-storm cleanup. In addition to the 175 direct and 72 indirect fatalities, 3 people died of unknown causes related to Helene, which brings the total number of Helene-related fatalities in the United States to 250. Figure 23 shows a map depicting the locations of all known fatalities associated with Helene. A breakdown of direct fatalities by type is depicted in Figure 24. This figure shows that all the direct deaths occurred to the right of the path of Helene's center. The freshwater flooding fatalities were clustered in western North Carolina, eastern Tennessee and northwestern South Carolina. The wind fatalities were more spread out, with the largest number occurring in Georgia and South Carolina within 150 n mi to the right of the path of Helene's center. A breakdown of the total deaths by state is shown in the table below.

Total Deaths by State				
State	Direct Deaths	Indirect Deaths	Unknown	TOTAL
Florida	18	16		34
Georgia	28	9		37
South Carolina	26	23	1	50
North Carolina	85	22		107
Tennessee	15	1	2	18
Virginia	2	1		3
Indiana	1			1
Total	175	72	3	250

Across the Southeast U.S., Helene caused at least 117 injuries, and at least 2700 people were rescued from high water. About half of the rescues occurred due to storm surge along the west coast of Florida, and more than 1000 were due to freshwater flooding in western North Carolina.

According to the NOAA National Centers for Environmental Information (NCEI)¹⁵, Helene caused an estimated \$78.7 billion in damage in the United States. This makes Helene the 7th costliest U.S. hurricane (adjusted to 2024 values)¹⁶ behind Katrina, Harvey, Ian, Maria, Sandy, and Ida. Most of this damage occurred in Florida, Georgia, South Carolina, North Carolina, eastern Tennessee and southwestern Virginia.

An estimated 7.4 million customers¹⁷ (about 16.2 million people) lost power in the United States due to Helene between 26–28 September. The maximum outage count at any given moment in time was about 4.79 million customers (Fig. 25). Florida experienced the largest loss of power with ~1.69 million customers losing power. South Carolina, Georgia and North Carolina experienced an estimated 1.59 million, 1.28 million and 1.18 million outages, respectively.

More detailed information about the impacts and damage for each region affected by Helene are given below. Maps showing U.S. counties by state can be found at: <https://www.census.gov/geographies/reference-maps/2000/geo/state-county-outline-2000.html>

Florida

Helene produced significant storm surge damage along Florida's Gulf Coast from Taylor County southward to Collier County. Near where the landfall occurred, Helene's peak storm surge, estimated at 12–16 ft AGL, destroyed about 80 percent of the buildings in Keaton Beach and Steinhatchee (Fig. 26). In Horseshoe Beach, storm surge destroyed roughly 70 percent of the town. Notably, high evacuation rates in those areas resulted in no reported storm surge deaths. In coastal Levy County, the towns of Cedar Key and Yankeetown were devastated by record-breaking storm surge. Media reports¹⁸ indicate that about 25 percent of the homes in Cedar Key were destroyed, along with numerous businesses. In Yankeetown, 20 people were rescued from their rooftops. In Citrus County, storm surge inundated at least 300 homes in Crystal River and Homosassa Springs with water up to 5 ft deep inside homes, and crews rescued 85 people and pets from the floodwaters.

In Hernando County, at least 500 homes suffered major damage, mostly from storm surge flooding along the barrier islands and immediate coast, and 18 people were rescued from the floodwaters. In Pasco County, first responders had to make 200 high water rescues from coastal areas due to storm surge, and at least 9,900 structures suffered damage, the majority of which were due to storm surge flooding in coastal parts of the county. In Pinellas County, 12 people drowned in the surge. Media reports indicate that 9 of these 12 victims were located on the barrier

¹⁵ <https://www.ncei.noaa.gov/access/billions/events>

¹⁶ <https://www.ncei.noaa.gov/access/billions/dcmi.pdf>

¹⁷ Estimate is based on PowerOutage.US storm summary. <https://poweroutage.us/about/majorevents>

¹⁸ <https://www.palmbeachpost.com/story/news/2024/09/29/reality-of-hurricanes-devastation-setting-in-along-with-relief/75430622007/>

islands on Pinellas County's west coast from St. Pete Beach to Indian Rocks Beach, 2 were in St. Petersburg and 1 was in Dunedin. Two storm-surge related fatalities were reported in Hillsborough County. Helene destroyed at least 419 homes in Pinellas and Hillsborough Counties combined, and at least 18,512 structures suffered major damage, with at least 13,909 others reporting minor or moderate damage.

In Manatee County, Anna Maria Island was heavily damaged by storm surge. Media reports and estimates from emergency managers indicate that 90 to 95 percent of the structures on Bradenton Beach were destroyed by Helene's storm surge. At least 594 structures were destroyed in mainland Manatee County. An additional 1,699 homes and commercial buildings reported major damage with 2,177 more reporting minor or moderate damage. Helene's storm surge damaged numerous structures in Sarasota County's coastal areas, where dozens of rescues took place during the storm. In Charlotte County, 8 structures were destroyed, 1,900 others had major damage and 750 others had minor or moderate damage, and most of this was due to storm surge. In Ft. Myers, at least 102 structures were damaged, with 52 of these reporting major damage. To the left of Helene's track, in Wakulla, Franklin and Gulf Counties, storm surge, freshwater flooding and wind caused minor to moderate structural damage.

Helene's winds caused extensive damage across Taylor, Dixie, Lafayette, Suwannee, Hamilton and Madison Counties including the cities of Perry, Cross City, Mayo, Live Oak, Jasper, and Madison. Much of this area experienced the eastern eyewall of Helene, where the majority of structures suffered damage and numerous trees and powerlines were down, according to the emergency managers of those counties. The strong winds extended to Atlantic coastal areas of northeastern Florida, and one person was killed in Duval County by a falling tree. At least one home in Liberty County (where the highest rainfall total in Florida was recorded) had damage due to freshwater flooding, and many roads were flooded.

Georgia

Helene produced at least \$5.5 billion in agricultural and timber losses in Georgia¹⁹, most of which was wind damage across southern and eastern portions of the state. The most significant wind damage occurred over the counties along and to the east of the path of Helene's center including Lowndes, Echols, Lanier, Clinch, Ware, Atkinson, Coffee, Bacon, Jeff Davis, Telfair, Appling, Toombs, Montgomery, Wheeler, Treutlen, Laurens, Johnson and Washington. Within the aforementioned counties, Helene's winds were directly responsible for 12 fatalities, while a tornado in Wheeler County killed two additional people. At least 82 injuries were reported there (77 of those occurred in Lowndes County - in and around the city of Valdosta - mainly from trees falling on homes) (Fig. 27). Hundreds of homes and buildings were destroyed, with tens of thousands of others damaged. In Coffee County, where gusts to 80 kt were recorded, 80-85% of the homes in the county were damaged. In Echols County, many roofs were damaged by both high winds and fallen trees, and about 1,000 power poles were snapped. In Telfair County, large trees and powerlines were down on most streets. In Toombs County, the town of Lyons was heavily damaged.

¹⁹ <https://extension.uga.edu/topic-areas/timely-topics/helene-report.html>