

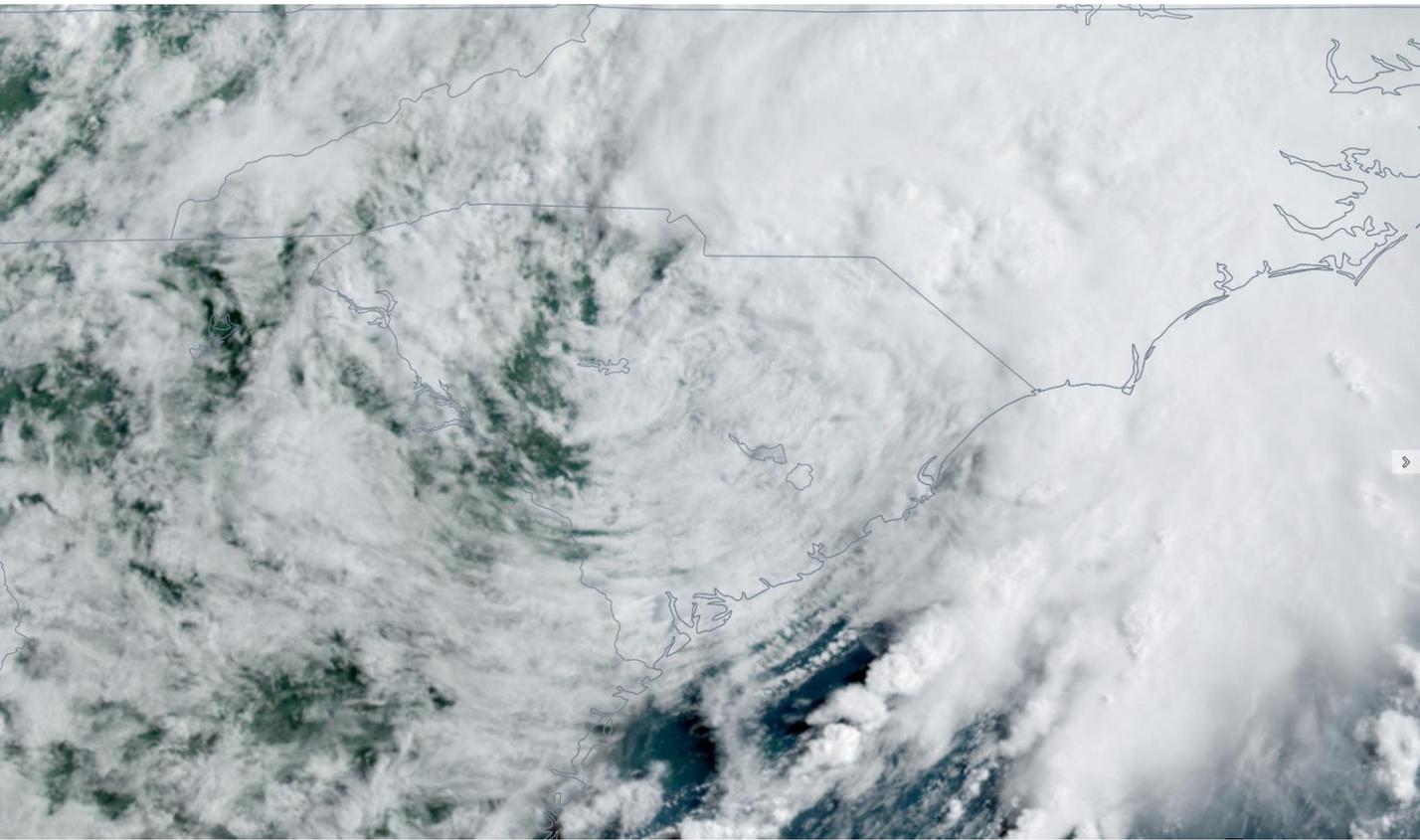


Tropical Storm Elsa – Open File Report

South Carolina State Climatology Office

Report Date: July 15, 2021

Website: <http://www.dnr.sc.gov/climate/sco>



PRELIMINARY

Storm History and Impacts Report

June 7-8, 2021

Synoptic Analysis 3
Rainfall Reports 7
Storm Surge. 9
Wind Reports 10
Tornadoes 11

THIS REPORT SERVES AS A PRELIMINARY DISSEMINATION OF INFORMATION ON THE IMPACTS OF TROPICAL STORM ELSA ON THE STATE OF SOUTH CAROLINA.

FOR MORE DETAILED DATA, PLEASE CONTACT:

Dr. Hope Mizzell
State Climatologist
MizzellH@dnr.sc.gov

Mr. Frank Strait
Severe Weather Liaison
StraitF@dnr.sc.gov

Ms. Melissa Griffin
Asst. State Climatologist
GriffinM@dnr.sc.gov

Cover Picture Credit
This is True Color RGB imagery generated by the University of Wisconsin’s RealEarth website from GOES-16 satellite data of Tropical Storm Elsa at 9:30 a.m. on July 8, 2021, while the storm was centered over or near Richland County. Additional figures and pictures used throughout this report were retrieved from the National Hurricane Center, University of Wisconsin, National Weather Service Damage Assessment Tool and WeatherBELL Analytics, LLC.

Synoptic Analysis

On June 29, 2021, the National Hurricane Center (NHC) began to highlight in their outlook products that a tropical wave, at the time 800 miles southwest of Cabo Verde and unusually strong for June, was generating widespread thunderstorms and that this feature could become a tropical cyclone. By 5 p.m. AST on June 30, it was designated Potential Tropical Cyclone Five by NHC, and they began to issue advisory products for it. By 11 p.m. AST, an area of low pressure associated with this tropical wave had become defined well enough for it to be classified as a tropical cyclone and NHC designated it as Tropical Depression Five. By 5 a.m. on June 30, NHC, using satellite intensity estimation techniques, determined that winds had increased to tropical storm strength and named it Tropical Storm Elsa. Elsa then intensified while approaching the northern Windward Islands, becoming a hurricane while passing over the island of Barbados. Elsa weakened to a tropical storm over the Caribbean Sea before skirting the Tiburon Peninsula of Haiti on July 3 and then making landfall in Cuba on July 5. Elsa's center then passed by just to the west of South and West-Central Florida before making landfall Cedar Key, Florida. At the same time, Elsa strengthened into a hurricane briefly while over the western Gulf of Mexico; it weakened again before making landfall. From there, Elsa drifted slowly northeastward through northern Florida and southern Georgia. Elsa began to affect South Carolina late on July 7 as it began to accelerate northeastward. The storm's center entered South Carolina during the early morning of July 8 as . By 11 a.m. on July 8, Elsa's center exited South Carolina into North Carolina, continuing a northeastward path from eastern North Carolina to New England. It became extratropical on the evening of July 9 while southeast of Portland, Maine.

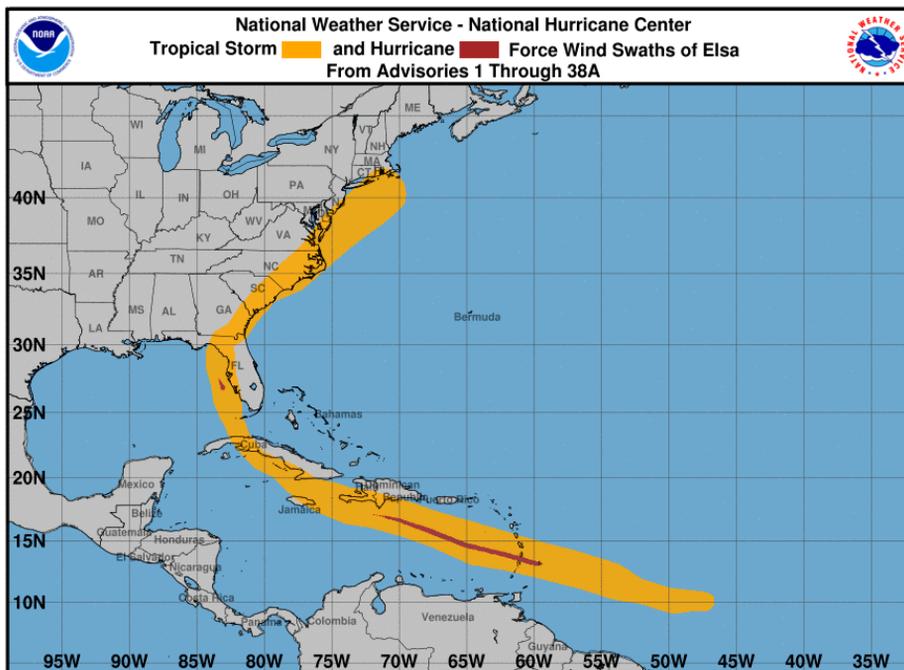


Figure 1: Wind history for Elsa from NHC showing areas of tropical storm and hurricane force winds along Elsa's path though the Atlantic, Caribbean Sea

Synoptic Analysis

Several factors influenced Elsa during its life as a tropical cyclone. A strong upper-level ridge predominantly steered Elsa over the western Atlantic ocean, which kept it on a southerly track through the Caribbean and the Greater Antilles. An unseasonably strong and deep upper trough was present over the eastern part of the United States as Elsa formed and moved into the Caribbean. This feature weakened and lifted out ahead of Elsa's arrival in the Greater Antilles but left enough of a weakness in the upper ridge behind for Elsa to track more northward as it approached Cuba and then moved into the eastern Gulf of Mexico. A new upper trough arrived in the Midwestern United States and around the Great Lakes on July 6, which caused Elsa to turn more northeastward after landfall in northern Florida, then carried Elsa northeastward across South Carolina and then toward New England.

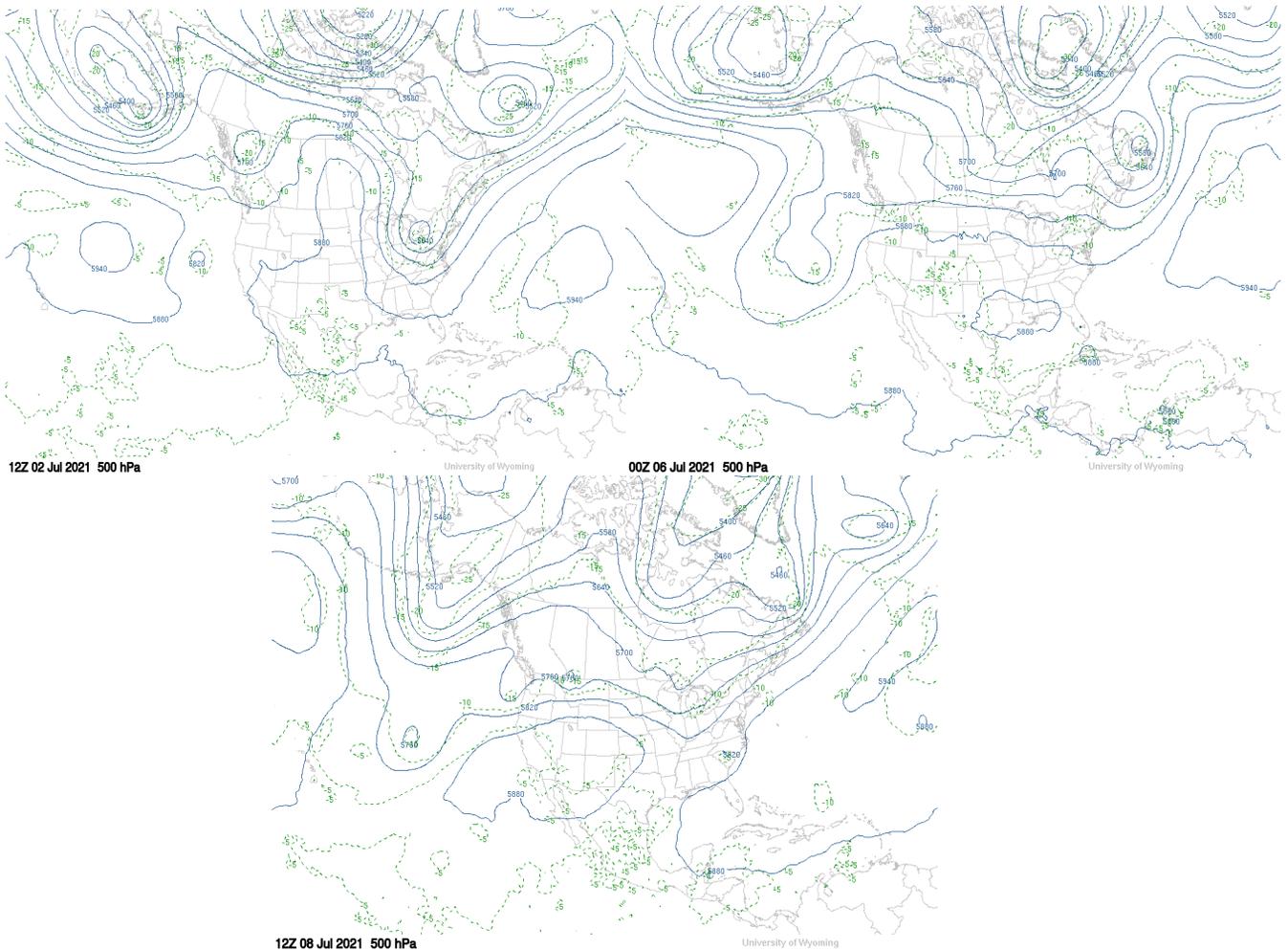


Figure 2, top left: 500 millibar height analysis for 12Z July 2 showing the upper ridge steering Elsa (at the time near Barbados) westward and the unusually deep upper trough over the eastern United States.

Figure 3, top right: 500 millibar height analysis for 0Z July 6 (when Elsa was centered near western Cuba) showing a weakness in the upper ridge left behind by the departing trough.

Figure 4, bottom: 500 millibar height analysis for 12Z July 8 showing the new upper trough over the Great Lakes causing Elsa (at the time centered over South Carolina) to accelerate northeastward.

Synoptic Analysis

Elsa tracked across very warm waters along its entire path through the Atlantic, the Caribbean Sea, and the Gulf of Mexico. Sea surface temperatures over the northern half of the eastern and central Caribbean were near 28°C (82.4°F). Over the northwestern Caribbean, the sea surface temperatures were around 29.5°C (85.1°F). Water temperatures were near 29°C (84.2°F) in the southeastern Gulf of Mexico, but slightly cooler over the northeastern Gulf of Mexico, near 28°C.

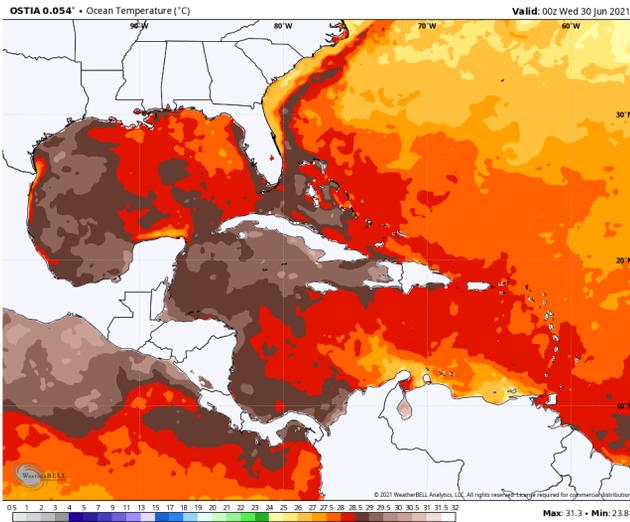


Figure 5, left: OSTIA sea surface temperature plot for 0Z June 30 (image from WeatherBELL)

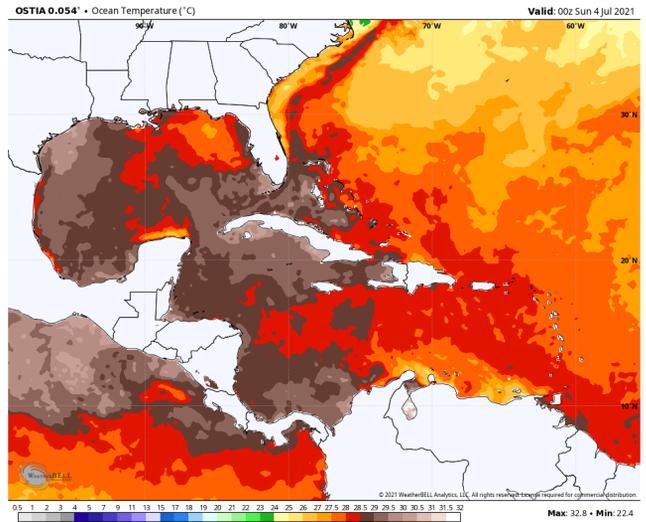


Figure 6, right: OSTIA sea surface temperature plot for 0Z July 4 (image from WeatherBELL)

Elsa was in a low-shear environment when it traveled across the tropical Atlantic and the Caribbean Sea. However, its rapid forward motion, 25-30 mph, hindered it from gaining strength over the warm Caribbean waters. Shear increased as Elsa reached the southeastern Gulf of Mexico due to strong westerly winds aloft in that area and this shear was present until Elsa made landfall in Florida.

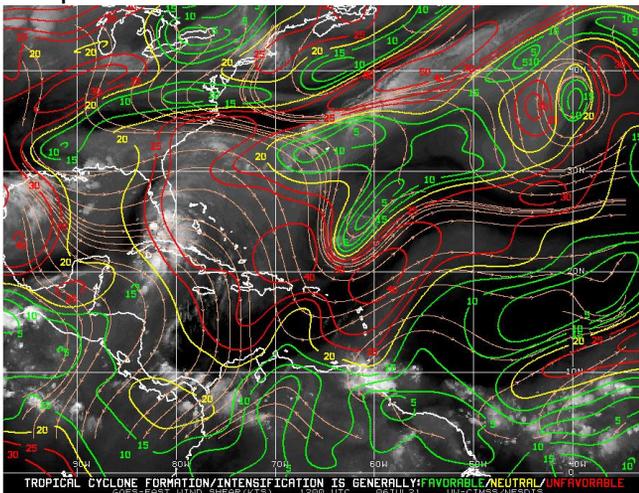


Figure 7, left: Shear analysis from 12Z July 6 (image from University of Wisconsin CIMSS)

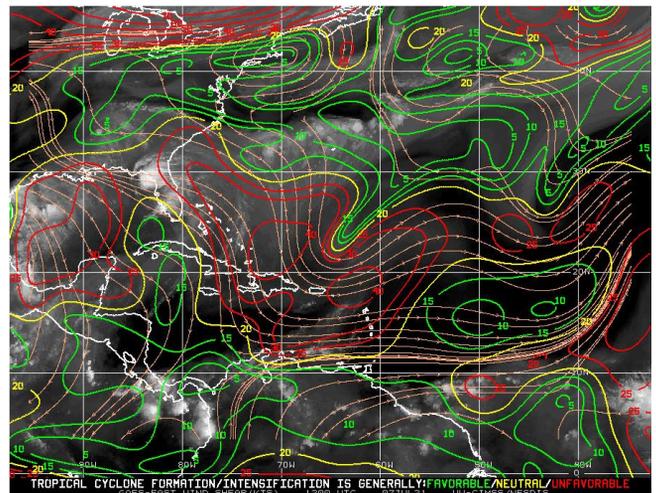


Figure 8, right: Shear analysis from 12Z July 7 (image from University of Wisconsin CIMSS)

Synoptic Analysis

The Madden-Julian Oscillation (MJO), discovered in 1971 by researchers at the National Center for Atmospheric Research, is well-known to modulate thunderstorms and tropical cyclone activity in the world's tropics. The location and intensity of the MJO's wave pattern have proven to be useful in forecasting tropical cyclones. The pattern produces a dipole of upward and downward motion which both cover large portions of the equatorial regions, sometimes extending into the midlatitudes. This dipole typically drifts eastward at 15-20 mph. The MJO's cycle is divided into eight phases defined by the area of the world's tropics where upward motion, favorable for widespread thunderstorm activity, is located. The Atlantic basin is under favorable conditions for tropical thunderstorm activity and potential tropical cyclone formation when the MJO is in Phases 8, 1, and 2.

When the tropical wave which gave rise to Elsa was crossing the Atlantic, the MJO was in Phase 2 and close to reaching Phase 3. The intensity of the MJO pattern was also not particularly strong at the time. The result was favorable conditions in the area where Elsa formed and along the first part of Elsa's track. However, an unfavorable downward motion area was encroaching on the western Caribbean Sea and the Gulf of Mexico at the time, and Elsa moved into this area as it reached the central Caribbean Sea. This general area of sinking air likely played a role in weakening Elsa as it passed south of Hispaniola and helped to keep it from gaining much intensity as it crossed the Gulf of Mexico.

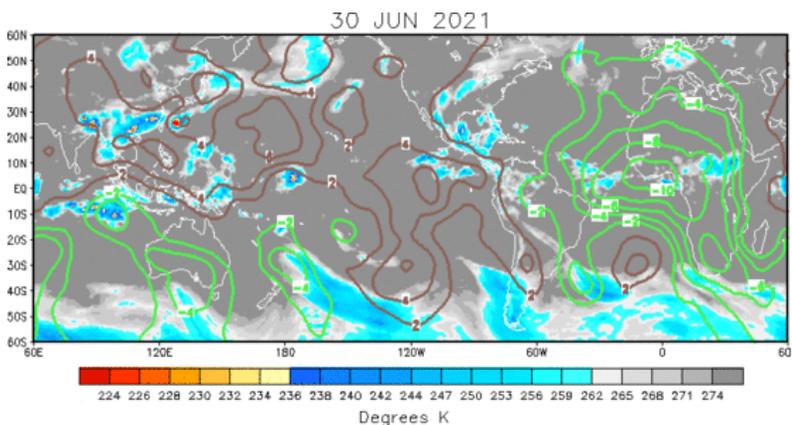


Figure 9: 200 hPa (millibar) level Velocity Potential Anomaly plotted by the Climate Prediction Center on June 30, showing upper divergence (green contours), corresponding to general rising motion, over Africa and much of the Atlantic Ocean. Elsa at the time was developing midway between Africa and the Lesser Antilles.

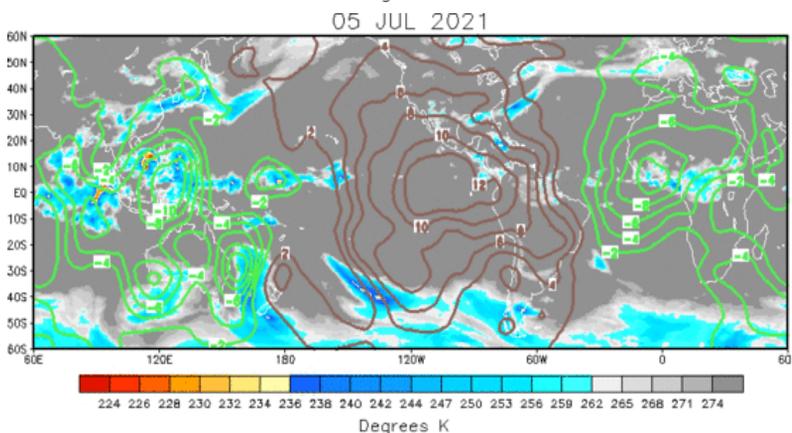


Figure 10: 200 hPa (millibar) level Velocity Potential Anomaly plotted by the Climate Prediction Center on July 5, showing upper convergence (brown contours), corresponding to general downward motion, over the Americas, Gulf of Mexico and Caribbean Sea. Elsa at the time was located just south of Cuba.

Rainfall Reports

The most significant impact from Elsa on South Carolina was heavy rainfall. The Lowcountry saw the heaviest rainfall, with parts of Beaufort, Charleston, and Colleton Counties receiving more than six inches of rain. Three-inch or greater rainfall was widespread over much of the state's Coastal Plain. Rainfall from Elsa was much less over the Midlands and spotty over the Upstate. While Elsa's rain set no records, minor flooding was reported over parts of the Lowcountry and Pee Dee.

Station	Station Type	Rainfall Total (in)
Beaufort 1.6 SSW	CoCoRaHS	7.15
Green Pond 1.3 S	CoCoRaHS	6.74
Bluffton 6.2 WNW	CoCoRaHS	6.64
Beaufort 4.2 WSW	CoCoRaHS	6.64
Bluffton 7.2 WNW	CoCoRaHS	6.39
Bluffton 7.0 W	CoCoRaHS	6.34
Charleston 2.5 WNW	CoCoRaHS	6.18

Tropical Storm Elsa Precipitation Totals (July 7th - 9th, 2021)

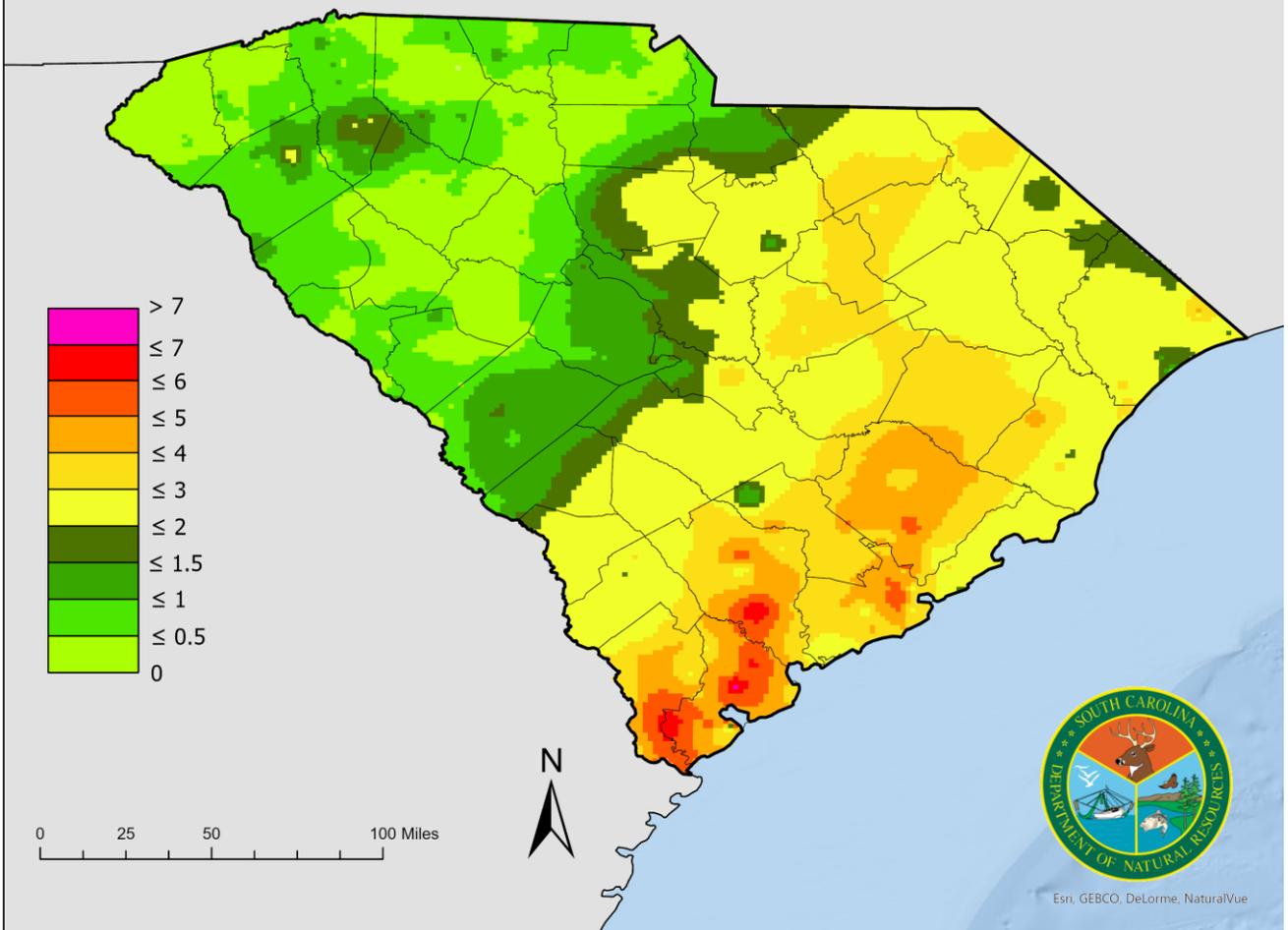
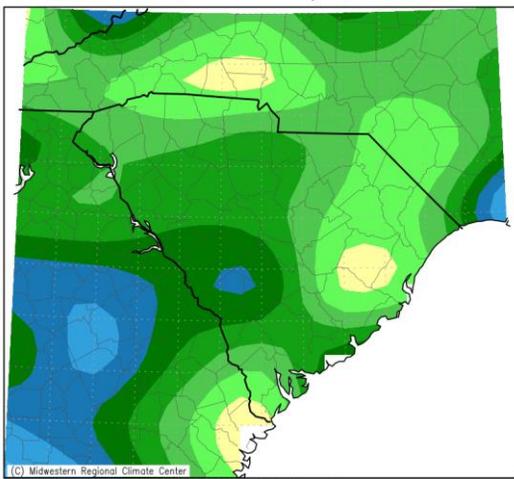


Figure 11: Rainfall totals for July 7-9 across South Carolina, showing that the heaviest rainfall occurred over the Lowcountry and that widespread heavy rainfall of two inches or more occurred along the Coastal Plain.

Rainfall Reports

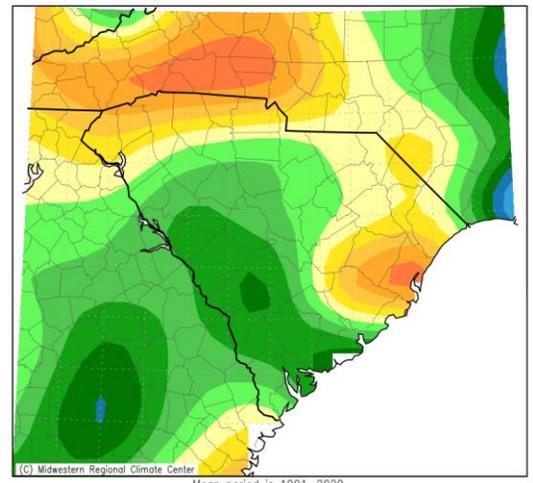
While Elsa's rainfall caused flooding in some areas, particularly along the coast, where it coincided with high tide and the highest storm surge, some areas found the rain beneficial. Parts of the state had been unusually dry in the weeks leading up to Elsa's arrival, and much of the Pee Dee was still in a mild to moderate drought. The rain from Elsa was beneficial from a drought standpoint in this area. Rainfall could also be considered helpful in the northern Midlands and in the Upstate, which had also seen below-average rainfall in the preceding 90 days leading up to Elsa's arrival.

Accumulated Precipitation (in): Departure from Mean
June 7, 2021 to July 6, 2021



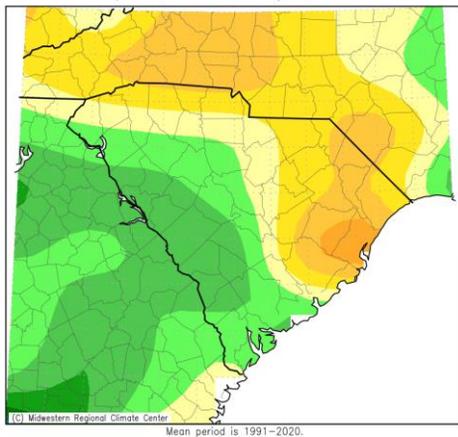
Midwestern Regional Climate Center
cli-MATE: MRCC Application Tools Environment
Generated at: 7/13/2021 2:04:27 PM CDT

Accumulated Precipitation (in): Departure from Mean
May 8, 2021 to July 6, 2021



Midwestern Regional Climate Center
cli-MATE: MRCC Application Tools Environment
Generated at: 7/13/2021 2:05:17 PM CDT

Accumulated Precipitation (in): Departure from Mean
April 8, 2021 to July 6, 2021



Midwestern Regional Climate Center
cli-MATE: MRCC Application Tools Environment
Generated at: 7/13/2021 2:05:58 PM CDT

Figure 12, top left: Rainfall departure for the previous 30-days ending July 6, 2021

Figure 13, top right: Rainfall departure for the previous 60-days ending July 6, 2021

Figure 14, bottom: Rainfall departure for the previous 90-days ending July 6, 2021

Storm Surge

Storm surge peaked at near 2 feet along the South Carolina coast. The small storm surge combined with its occurrence near low tide in the Lowcountry resulted in few impacts along the coast of the Lowcountry. The surge occurred near high tide along the Horry County coast; however, the net effect was typical high astronomical high tide. There were numerous reports of minor coastal flooding, but no significant coastal flooding was reported.

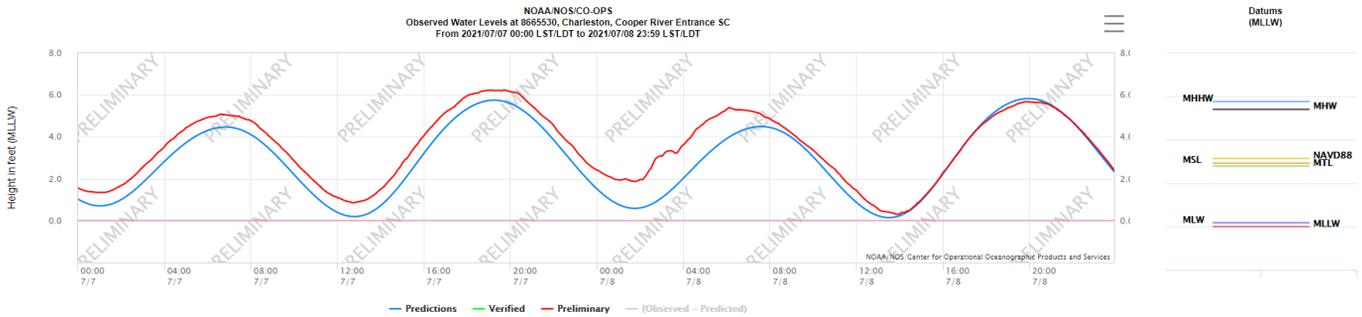


Figure 15: Observed (red) and predicted (blue) water levels at NOAA Tide Gauge 8665530, Charleston Cooper River Entrance, for July 7-8 (from NOAA Tides and Currents). Action Stage is 6.5 feet MLLW. Minor Flood Stage is 7.0 ft MLLW.

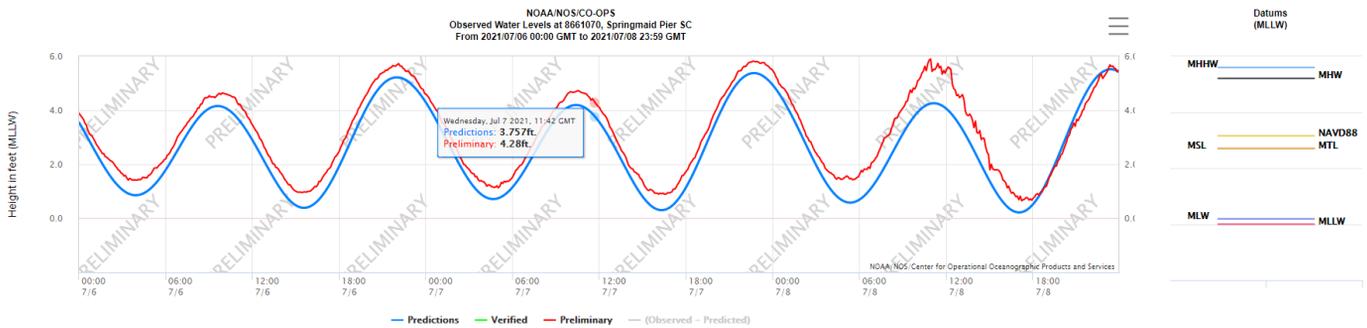


Figure 16: Observed (red) and predicted (blue) water levels at NOAA Tide Gauge 8661070, Springmaid Pier, for July 7-8 (from NOAA Tides and Currents). Action Stage is 7.0 feet MLLW and Minor Flood Stage is 7.5 feet MLLW.

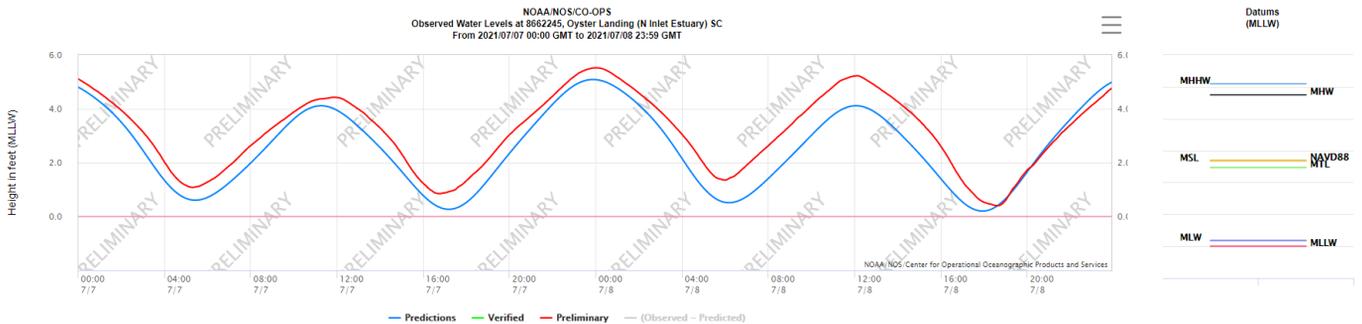


Figure 17: Observed (red) and predicted (blue) water levels at NOAA Tide Gauge 8662245, North Inlet Estuary, for July 7-8 (from NOAA Tides and Currents). Action Stage is 7 feet MLLW.

Wind Reports

Elsa generated tropical storm force winds along most of the South Carolina coast. The table below summarizes the strongest wind gusts reported in South Carolina of 40 mph or greater.

Location	Peak Wind Gust (mph)	Date and Time (EDT)	Station Type
Calibogue Sound	81	11:13 p.m. July 7	WeatherFlow
Capers Nearshore Buoy	60	6:23 a.m. July 8	National Data Buoy Center
Myrtle Beach	54	6:24 a.m. July 8	National Weather Service
North Myrtle Beach	51	11:23 a.m. July 8	National Weather Service
MCAS Beaufort	51	2:47 a.m. July 8	National Weather Service
Beaufort	50	2:40 a.m. July 8	WeatherFlow
Fort Sumter	49	4:51 a.m. July 8	WeatherFlow
Fripp Nearshore Buoy	49	4:08 a.m. July 8	National Data Buoy Center
Murrells Inlet	49	9:23 a.m. July 8	WeatherFlow
Isle of Palms	48	5:41 a.m. July 8	WeatherFlow
Arthur Ravenel Bridge	48	5:15 a.m. July 8	SCDOT, MesoWest
Buoy 41008	47	10:50 p.m. July 7	National Weather Service
Charleston International Airport	47	2:03 a.m. July 8	National Weather Service
Florence Regional Airport	45	5:45 a.m. July 8	National Weather Service
Beaufort Executive Airport	44	3:15 a.m. July 8	National Weather Service
Hilton Head Island Airport	44	11:55 p.m. July 7	National Weather Service
Mount Pleasant Regional Airport	44	5:35 a.m. July 8	National Weather Service
Folly Island CMAN	43	5:00 a.m. July 8	National Data Buoy Center
Charleston Executive Airport	43	4:55 a.m. July 8	National Weather Service
Battery Point	42	4:24 a.m. July 8	WeatherFlow

The Calibogue Sound WeatherFlow station is situated on a channel marker located in the entrance to Calibogue Sound. The Capers Nearshore Buoy is moored in a location about 5.5 miles southeast of Capers Island. The Fripp Nearshore Buoy is moored about 5.2 miles southeast of Fripp Island. The Murrell's Inlet WeatherFlow station is situated on a channel marker located near the entrance to Murrell's Inlet. All other wind reports are from land stations.

Tornadoes

A total of five tornadoes spawned by Elsa were confirmed to have touched down in South Carolina by National Weather Service storm survey teams on July 8. There was one in Beaufort County, two in Charleston County, and one in Clarendon County. All the tornadoes were relatively weak; there were four rated at EF-1 and one rated at EF-0.

The first tornado was an EF-1 tornado on Parris Island starting at 11:44 p.m. on July 7, lasting for about one minute. It caused damage on a path approximately 50 yards wide and 0.1344 miles long. Peak wind speed was estimated by the National Weather Service to be 97 mph. This tornado caused no injuries or deaths. Many softwood and pine trees were snapped in this area, directly adjacent to the old Page Field runway complex.



Figure 18, left: Damage path (green line) of the Parris Island tornado of July 7, 2021.

Figure 19, right: An NWS photo of tree damage caused by this tornado.

The second tornado occurred in nearby Port Royal a short while later at 11:50 a.m. This tornado was rated an EF-1 by the NWS with maximum winds near 95 mph and lasted for about 2 minutes. The damage path was as much as 75 yards wide and 0.6259 miles long. The same storm which spawned this tornado is likely the same storm that had caused the tornado on Parris Island a few minutes earlier. There were no injuries nor fatalities reported. Damage reported included several trees being snapped, some leading to power line damage. A tree fell on a home on 11th Street. Some of the trees fell on homes and buildings along Paris Avenue West as well.

Tornadoes

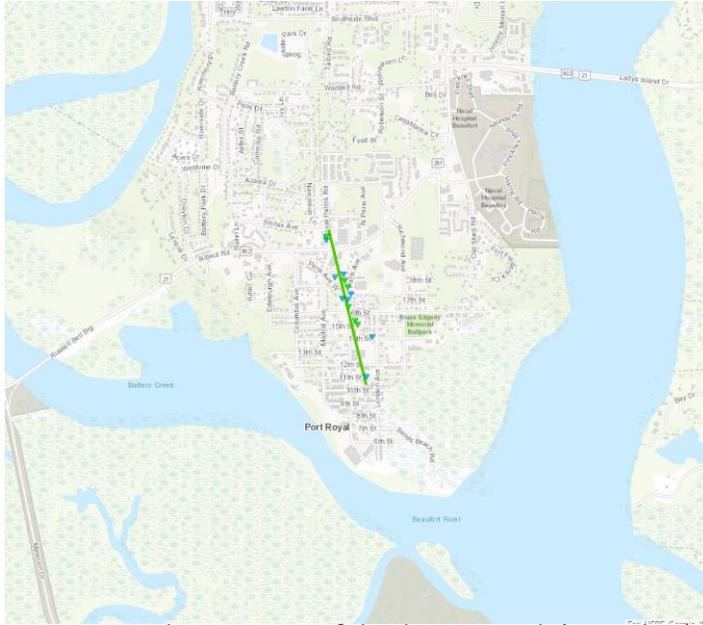


Figure 20, above: A map of the damage path (green line) of the Port Royal tornado of July 7, 2021.

Figure 21, right: An NWS photo of a tree which had fallen on a home in Port Royal.



The third tornado struck Edisto Island at 1:00 a.m. on July 8, lasting for about two minutes. The damage path was up to 100 yards wide and 1.1183 miles long. This tornado was also rated EF-1, with peak winds estimated by the NWS to be 95 mph. This tornado had a discontinuous path from Sunnyside Mills Road to Cypress Trees Lane near its intersection with S. C. Highway 174. Many hardwood and softwood trees were uprooted along the path, particularly near the end of the path.

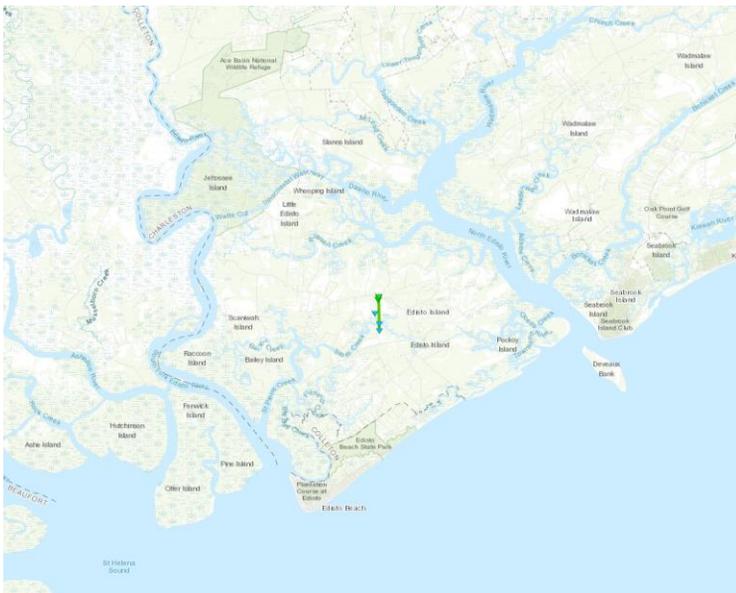


Figure 22, above: Damage path (green line) of the Edisto Island tornado of July 8, 2021.

Figure 23, right: An NWS photo of tree damage caused by the Edisto Island tornado.



Tornadoes

The fourth tornado hit the Awendaw area in Charleston County at 3:36 a.m. on July 8, lasting for two minutes. It was rated at EF-1 with estimated peak wind speeds of 95 mph. The damage path was 150 yards wide and 0.8195 miles long. Tree damage was reported in Wando Farms, and the winds blew in the front door of one resident's home. Several trees were uprooted or snapped near the path near the intersection of Ronlin Farm Road and Woodville Road.

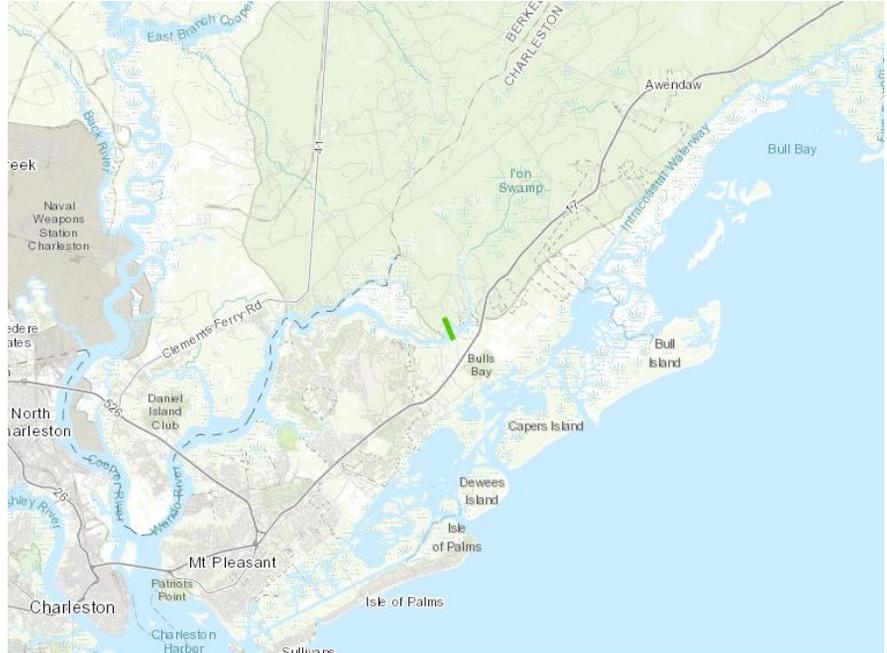
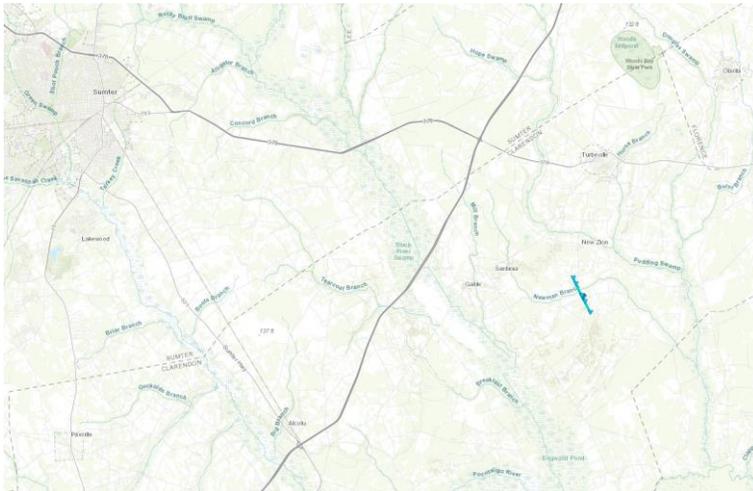


Figure 24: A map of the damage path (green line) of the Awendaw tornado of July 8, 2021.

The last tornado spawned by Elsa struck Clarendon County near New Zion at 4:12 a.m. on July 8 and lasted about two minutes. It was rated EF-0 with estimated peak winds of 85 mph. The path was up to 40 yards wide and 1.4926 miles long. No injuries nor fatalities were reported. It began in a field east of Old Manning Road just south of Knowlton Road and tracked along Old Manning Road, snapping numerous trees. An NWS survey team found damage to structures and farm equipment near the intersection of Old Manning Road and Newman Branch Road. A nearby cornfield sustained damage from the tornado.



*Figure 25, left: Damage path (blue line) of the Awendaw tornado of July 8, 2021.
Figure 26, right: An NWS photo of damage to a farm silo near New Zion.*