EVENT BRIEFING

Event:	Hurricane Delta
Region:	Louisiana, Mexico

FAST Authors:	David Roueche, Auburn University (Lead FAST-1) Sabarethinam Kameshwar, Louisiana State University (Lead FAST-2) Justin D. Marshall, Auburn University Sai Aditya Bandaru, Louisiana State University (Graduate Student) Trung Do, University of Louisiana at Lafayette
VAST Authors:	Tracy Kijewski-Correa, University of Notre Dame (Lead) Maria D. Cortes Delgado, University of Puerto Rico at Mayaguez Shane Crawford, National Institute of Standards and Technology Sajad Javadinasab Hormozabad, University of Kentucky Stephen Strader, Villanova University
Editors:	David O. Prevatt, University of Florida

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Key Lessons

- ❏ Structural damage from Hurricane Delta was minimal based on public reports and direct observations by the FAST members. As peak wind gusts from Delta were well below design levels, this outcome was not unexpected.
- ❏ Roof cover damage was commonly observed across Delta's wind field, although preliminary observations by FAST did not indicate a well-defined damage gradient. The lack of a noticeable damage gradient may be a by-product of the joint hurricane impacts of Laura and Delta. As illustrated in Figure 4.1, the juxtaposition of Laura and Delta's wind fields created a large swath of 90-100 mph wind speeds within which damage patterns were more uniform. Economic impacts of roof cover loss in a hurricane are often severe and disproportionate to the level of structural damage observed.
- ❏ A few examples of Hurricane Delta causing additional damage beyond Laura were observed by the FAST members, but these instances did not appear widespread. However, many areas southeast of Lake Charles were not documented by StEER following Hurricane Laura, so it was difficult to separate damage by storm in these areas. Moreover, as field observations affirmed little to no progress in recovery of damaged properties, the dislodged tarps and additional water penetration from rainfall and flooding in Delta will only further delay the recovery and compound losses. The streetview data collected by Delta FASTs encompasses many of the same areas imaged in Laura, providing a valuable longitudinal dataset to explore recovery rates, debris evidence of interior losses in Laura,

and potential for compounding losses from these sequential hurricanes.

- The societal impacts of Hurricane Delta are likely severe, but will require additional research to document. For example, there are likely to be mental health impacts of two hurricane landfalls within weeks of each other, and additional health consequences resulting from widespread evacuation and disruption of testing and contact tracing during the COVID-19 pandemic. Critical supply chains like oil and gas production were also disrupted at the highest levels since Hurricane Katrina. Such questions are outside the scope of StEER, but worthy of investigation by other EER researchers.

1.0 Event Description

As the strongest hurricane on record named with a Greek letter, Hurricane Delta made landfall in Mexico near Puerto Morelos, Quintana Roo as a Category 2 hurricane on 7 October 2020, with a second landfall in the United States as a Category 2 hurricane on 9 October 2020 in Creole, LA. This U.S. landfall was approximately 10 miles east of the Hurricane Laura landfall location that occurred on 27 August 2020. In comparing the two hurricanes, reports suggest that Delta had a greater potential for damage by storm surge, whereas Laura's losses were driven by wind. Notably, Hurricane Delta is the 10th named storm to hit the continental United States this year.

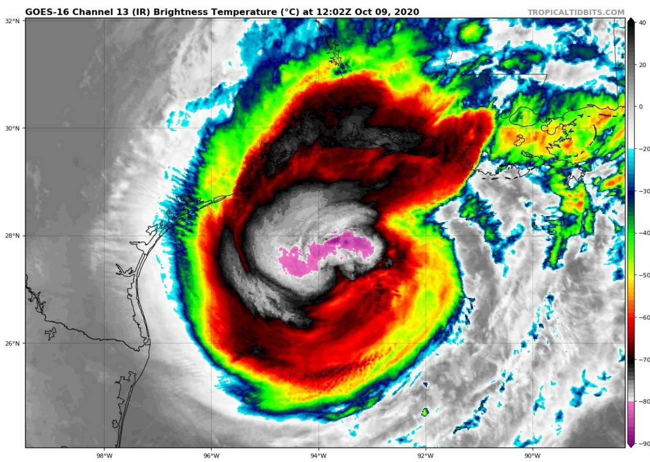
As of 12 October, four deaths have been attributed to Hurricane Delta: two in Louisiana were respectively traced to a generator fire and gas leak, the other two in Florida were drownings tied to rip currents/tides (McLaughlin et al., 2020). The damage caused by Hurricane Laura in Louisiana (Roueche et al., 2020) weakened the infrastructure in many of the communities exposed to Delta, leading to compounded losses (see thread for progressive satellite imagery after the storm in a number of communities).

This was most notable in Lake Charles, a community that suffered heavy damage in Hurricane Laura. Aerial imagery collected before Delta made landfall showed thousands of blue tarps on roofs in communities impacted by Hurricane Laura, which were then exposed to Delta's winds and heavy rainfall. Additionally, much of the debris created by Hurricane Laura had not been removed by the time Delta swept through Louisiana, which increased the potential for missile impacts. The mayor of Lake Charles further indicated that, despite being a Category 2, more residents evacuated for Hurricane Delta in contrast with Laura, potentially due to the number of compromised homes not suitable for sheltering through a second storm. Moreover, the psychological toll of a second strike on residents still recovering from Laura, cannot be underestimated.

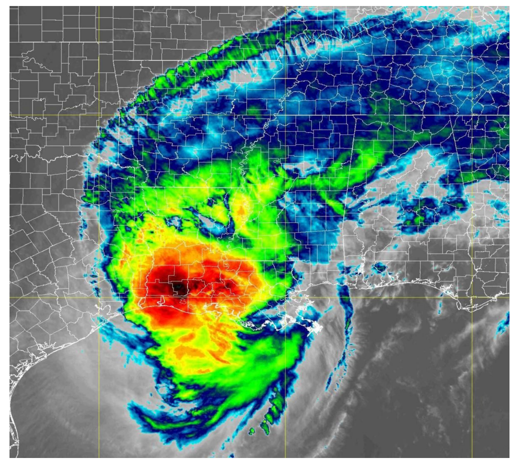
In response, StEER activated two Field Assessment Structural Teams (FAST-1, FAST-2) between 12-15 October 2020 to deploy streetview panorama imaging techniques, using the same teams and hardware that surveyed Hurricane Laura. The first team operated out of Auburn University, led by David Roueche with Justin Marshall, and collected data 12-13 October. The second team out of Louisiana State University was led by Sabarethinam Kameshwar and operated 14-15 October; FAST-2 liaised with other local researchers (Trung Do, University of Louisiana at Lafayette). Their combined data collection efforts emphasized a longitudinal data capture of areas previously documented for Hurricane Laura, as well as new clusters exposed to some of the Delta's highest wind speeds to the east of landfall. This event briefing includes a description of the hazards in Hurricane Delta and summaries of the impacts to buildings and other infrastructure as reported in public and social media, as well as through the observations of the FASTs.

2.0 Hazard Description

As typical of gulf coast hurricanes, Delta underwent rapid intensification in the Gulf, taking only 30 hours to move from tropical depression status to Category 4, including moving from Category 2 storm to a Category 4 storm in just two hours and 20 minutes. However, conditions near the coast reduced the storm's intensity before landfall (Fig. 2.1), resulting in a Category 2 storm with a predicted windfield with a maximum 3-second gust of 100 mph (at 10 m, in flat open terrain) near the landfall site at Creole (Fig 2.2). These wind speeds were considerably lower than the design winds in Hurricane Laura (Roueche et al, 2020). Note that a number of teams deployed equipment to measure Delta's windfield, as tracked through this Asset Map.



(a)



(b)

Figure 2.1. Hurricane Delta color infrared image Friday morning 9 October 2020 prior to landfall and near peak intensity (Source: TropicalTidbits.com); (b) NOAA GOES satellite imagery of Hurricane Delta just after landfall (NOAA GOES East Satellite).

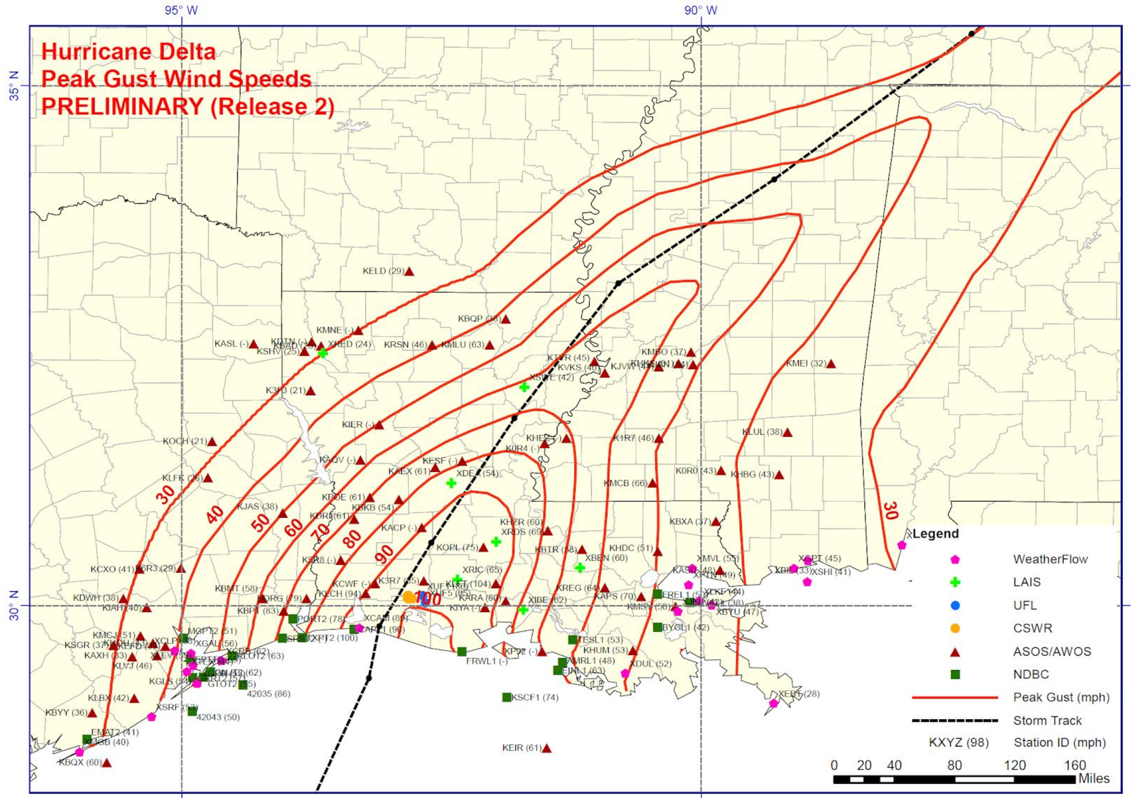


Figure 2.2. Preliminary estimate of 3-second wind gusts (Source: ARA, Release 2)

Figure 2.3 (a,b) illustrates the maximum water height associated with Hurricane Delta's storm surge. This preliminary data illustrates that the Calcasieu Pass, LA tidal gauge rose to 7.4 feet as Delta passed. The Freshwater Canal Locks, LA tidal gauge reached a maximum water level of 11 feet, which appears to be the upper limit of its measurement range. These measurements were quite consistent with the storm surge predictions (Fig. 2.3c).

The NOAA Weather Prediction Center (WPC) called for heavy precipitation in the days leading up to Hurricane Delta's landfall. Many of the same regions that were heavily impacted by Hurricane Laura were projected to experience greater than seven inches of precipitation (e.g., interior Louisiana), causing further losses to damaged building inventories. Comparing the WPC quantitative precipitation forecast (QPF) to the observed Advanced Hydrologic Prediction Service (AHPS) precipitation totals (Fig. 2.4), the WPC QPF forecast handled the system well. In fact, many of the areas projected to receive greater than 10 inches of rainfall did. More than 3 million people and 1.7 million homes were exposed to greater than 2 inches of rainfall; whereas, as many as 1.4 million people and 730,000 homes were exposed to 5 inches of precipitation or greater. As noted in Section 1.0 of this briefing, those regions heavily impacted by Hurricane Laura experienced significant flooding.

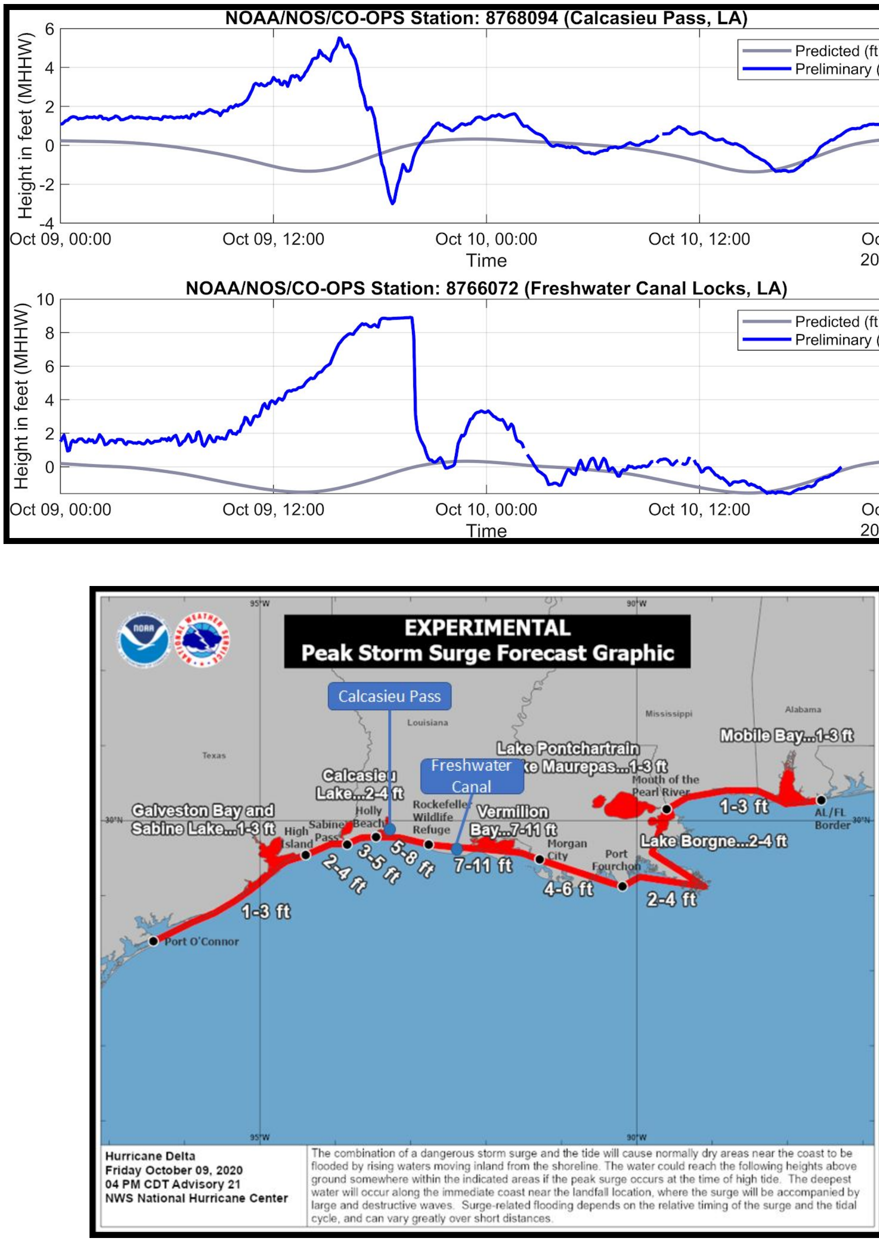
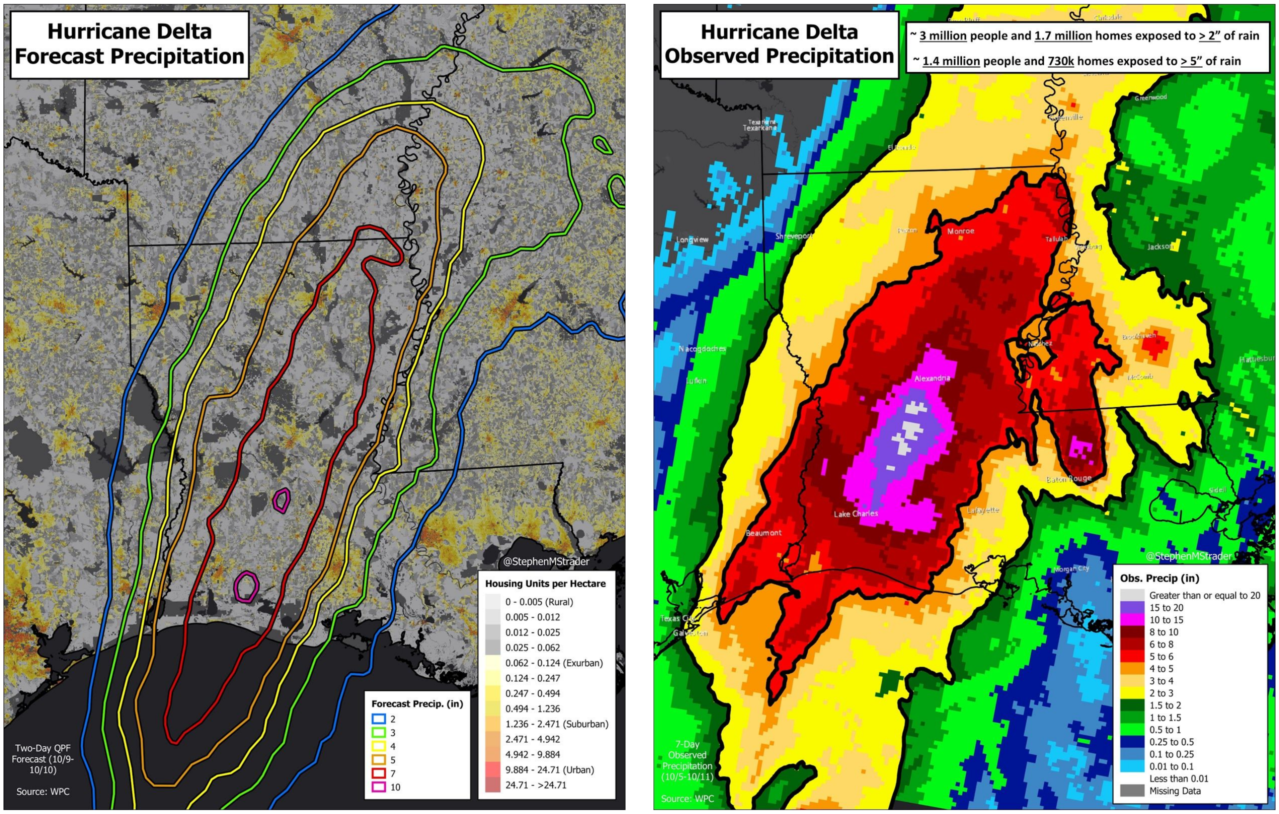


Figure 2.3: (Top) Preliminary observed water levels for the Calcasieu Pass, LA and Freshwater Canal Locks, LA tidal gauges; (bottom) forecast peak storm surge for Hurricane Delta with locations of Calcasieu Pass and Freshwater Canal tidal gauges noted (Source: NOAA HPC).



(a) (b)

Figure 2.4. (a) NOAA Weather Prediction Center (WPC) two-day forecast quantitative precipitation forecast (QPF) from 10/9/20 through 10/10/20 and housing unit density (Credit: Stephen Strader); (b) NOAA Weather Prediction Center (WPC) Advanced Hydrologic Prediction Service (AHPS) 7-day observed precipitation from 10/5/20 through 10/11/20 (Credit: Stephen Strader).

Further evidence of inland flooding from Delta is illustrated by the hydrographs in Figure 2.5, where the Calcasieu River near Lake Charles, LA reached the major flood stage, cresting midweek. Further north, the Bayou Cocodrie stream gauge near Clearwater, LA crested early Sunday morning near record levels.

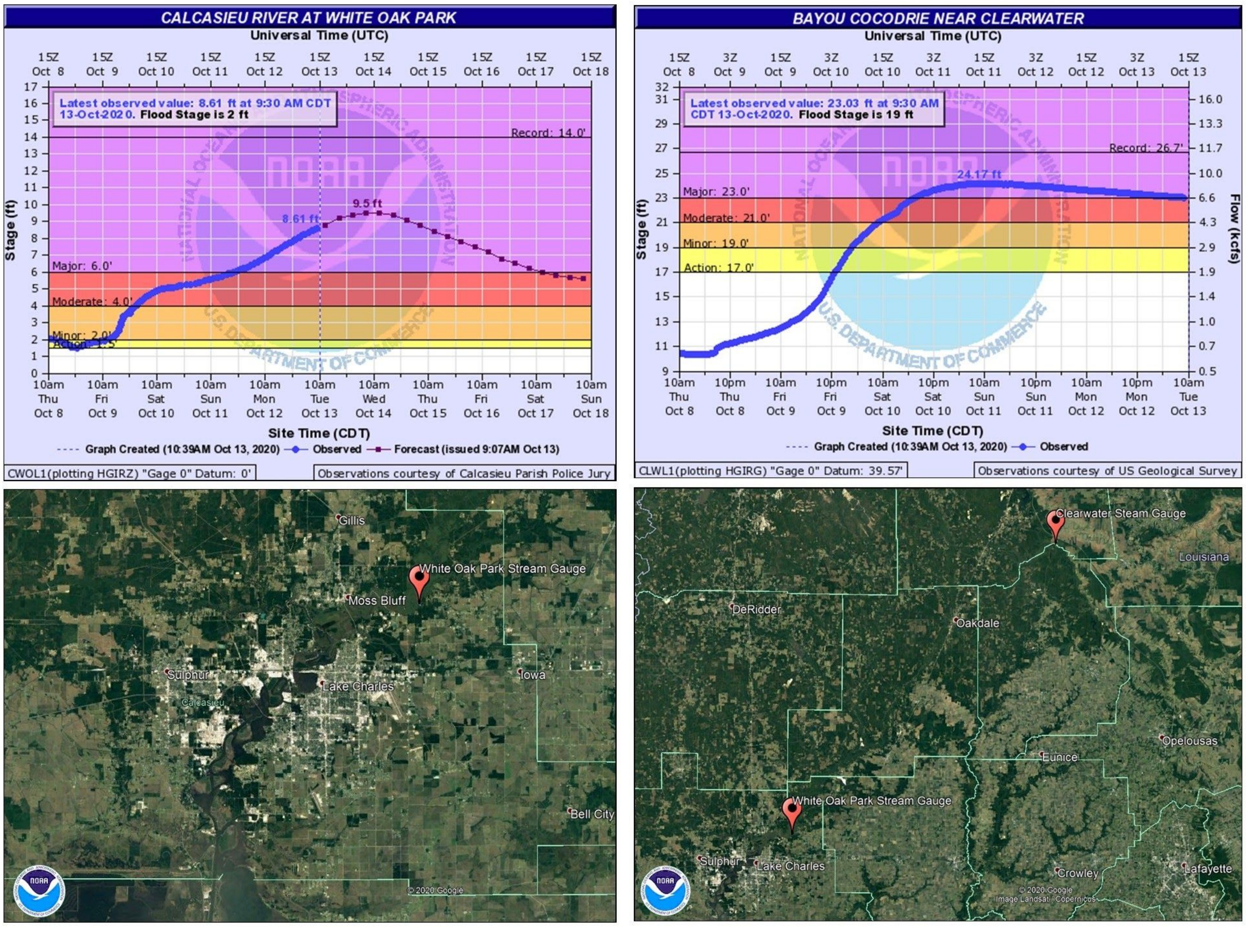


Figure 2.5. Hydrographs for the Calcasieu River at White Oak Park near Lake Charles, LA and the Bayou Cocodrie near Clearwater, LA (Source: NOAA).

3.0 Damage to Structures

The following sections summarize the preliminary reports of damage to structures from public and social media.

3.1 Wind Damage (Yucatán Peninsula)

Hurricane Delta primarily affected the areas/sectors of Playa del Carmen and Quintana Roo at the Yucatan Peninsula. The official Twitter page of the Mexican government stated that there were 40,000 people evacuated across the Yucatan Peninsula prior to the landfall of Hurricane Delta. The most impacted structures were from the hospitality and tourism industry reporting damages including broken storefront windows (Fig. 3.1a), damage to light structures (Fig. 3.1b), and failure of facade elements (Fig. 3.1c). Entire panes of glass were also dislodged at the Cancun airport (Fig. 3.1d). Power outages were reported at Playa del Carmen on 7 October, with widespread reports of damage to the power grid. A notable recurring failure was the hinging of reinforced concrete electrical poles at their base, as noted in Figure 3.2a (the video of the failure in Fig. 3.2a zooms in further on the hinging of these poles). Flooding also caused widespread disruptions (Fig. 3.2b). However, according to reports by the Mexican government, Playa del Carmen and Quintana Roo were already returning to normal operations as soon as 8 October, with ongoing collection of debris.

(a)

(b)

(c)

(d)

Figure 3.1. Damage in Cancún, Mexico: (a) storefront glass damage (Source: Washington Post); (b) light structure damage (information kiosk) (Source: CNN); (c) facade damage to resort (Source: @RadarOmega_WX Reed Timmer, Oct. 7 Twitter); (d) shattered windows at Cancun Airport (Source: @RadarOmega_WX Reed Timmer, Oct. 7 Twitter)

(a) (b)

Figure 3.2. (a) Concrete electrical poles failed by hinge at base in Cancún, Mexico (Source: @MirandaMonaco,Camila Miranda, Oct. 8 Twitter) and (b) flooding in Cozumel (@vivecozumel, Cozumel, Oct 7).

3.2 Oil Industry (Gulf of Mexico)

Previously disrupted by Hurricane Laura (Roueche et al., 2020), the oil industry was again forced to halt approximately oil production due to Hurricane Delta. Delta's track cross cut through the heart of deepwater oil and gas activities, causing more significant supply disruptions than Laura and halted the highest percentage of Gulf crude output since Hurricane Katrina in 2005 (van Mossener, 2020). Reports suggest that the approach of Delta suspended 92% of offshore crude oil and 62% of natural gas production in the U.S.-regulated northern Gulf of Mexico. Workers were evacuated from 279 offshore facilities and producers moved 15 drilling rigs away from Delta's large wind fields (Goldman, 2020).

3.3 Wind Damage (Louisiana)

As noted in Section 1, the comparatively lower wind speeds in Hurricane Delta would normally not pose a significant risk of widespread structural damage, though in this unique instance, structures already damaged by Hurricane Laura had enhanced vulnerability to: (i) additional loss of weakened elements, (ii) the removal of tarps protecting unrepaired damage from Laura (Fig. 3.3a), (iii) impacts of Laura-debis mobilized by Delta's wind field, and (iv) additional interior losses resulting from heavy rainfall and flooding penetrating previously compromised building envelopes (Fig. 3.3b). The fact that many already damaged areas were re-exposed in Delta made it difficult to differentiate what damage, if any, could be directly attributed to Delta. Tree fall instigated by the heavy rainfall remained a driver of damage (Fig. 3.4a). Downtown Lafayette did report more substantive damage, including damage to windows and masonry walls (Potter, 2020). Some damage to agricultural facilities was also reported, see Figure 3.4b. (KATC, 2020). Wind was also a major driver of damage to the power grid: as of 1:30 pm ET 10/11/2020, over 324,000 buildings in Louisiana were without power, while over 58,000 buildings in Texas and over 14,000 buildings in Mississippi were without power (poweroutage.us).

(a) (b)

Figure 3.3. Damage in Lake Charles: (a) tarped roofs in a residential area (Source: CNN); (b) flooding in neighborhood where homes have unrepaired roof damage sustained in Hurricane Laura (Gerald Herbert/AP)

(a) (b)

Figure 3.4. Damage in Lafayette: (a) tree falls causing significant structural damage, (b) CGI roof on agricultural building (Source: KATC)

4.0 Field Observations

Figure 4.1 illustrates the routes captured by the FASTs along with the joint maximum wind hazard intensity that resulted from Laura and Delta. Note that Delta's wind field was previously presented in Figure 2.2 and Laura's wind field was reported in Roueche et al. (2020). Their observations are organized below by region.

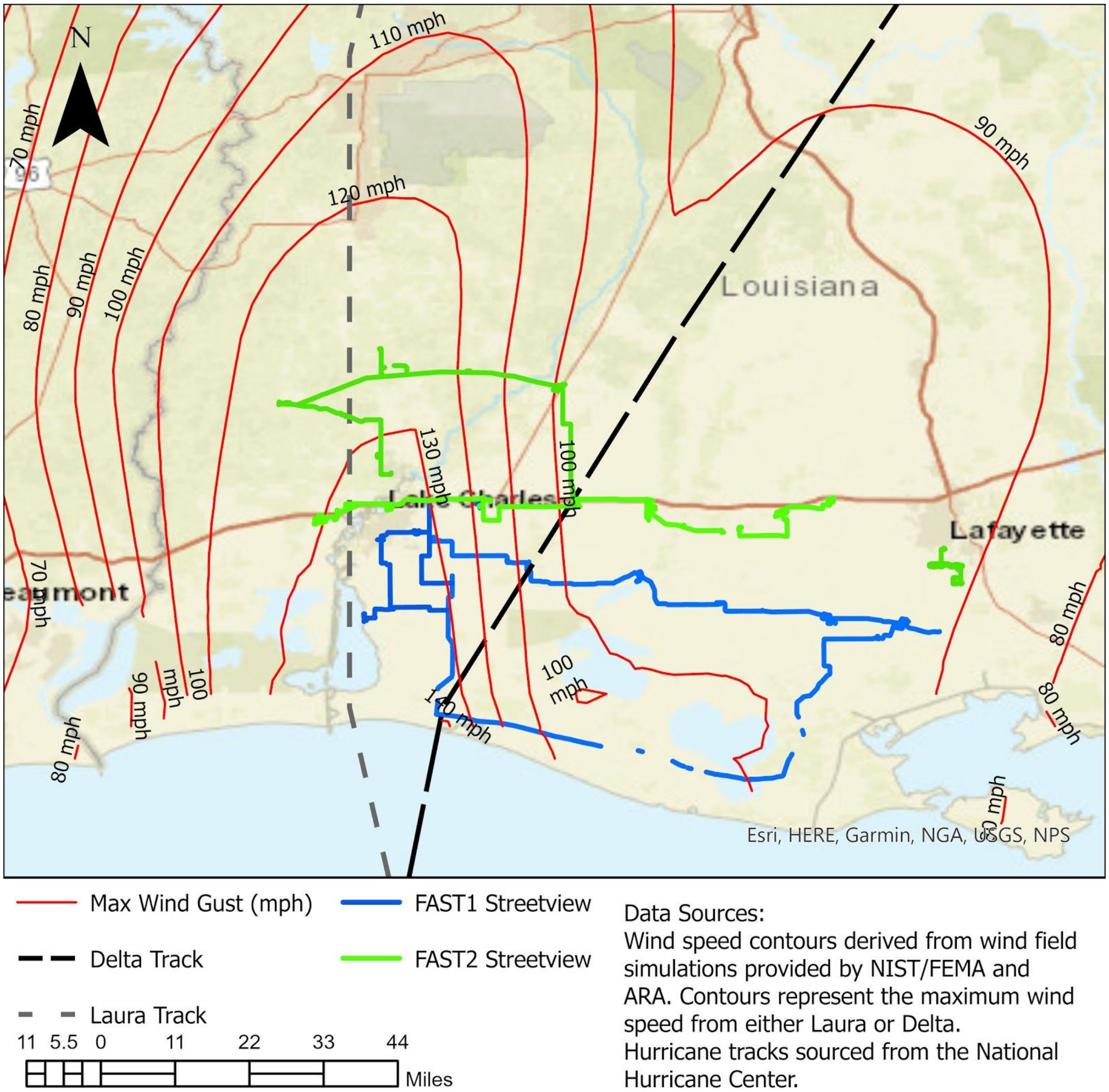


Figure 4.1. Streetview routes by FAST-1 and FAST-2 within context of maximum gust wind speeds from both Laura and Delta.

4.1 Newly Exposed Areas

FAST-2 surveyed areas to the east of those impacted by Laura on 15 October, noting Insignificant damage on the way from Lafayette to Youngsville, with no considerable damage in residential communities in Lafayette. However, in Youngsville, which was impacted primarily by Hurricane Delta, some houses (approximately 2-5%) had tarps on the roofs; damaged fences were also observed. Notably, in several residential communities, houses at the end of blocks and thus not shielded by other properties had more frequent and substantial loss of roof cover and/or chimney damage (Fig. 4.2-4.3). This trend was mainly observed in developments bounded by open terrain, and it did not seem to be affected by the age of the buildings (both new and established communities exhibited this trend). Even within suburban developments (such as Sugar Mill Pond), a similar trend was observed: houses adjacent to large open areas were damaged more frequently than houses in the interior of the subdivision.

Figure 4.2. Example of roof damage to house at end of block in Youngsville (Coordinates: 30.102928, -92.056204) (Credit: FAST-2).

4.2 LA-14 Gradient (East of Landfall)

In communities impacted primarily by Hurricane Delta, FAST-1 rarely observed structural damage and those cases were confined to very old structures. Roof cover loss was common, though a damage gradient was not evident, with similar frequency and severity of damage across LA-14 communities (including Abbeville, Kaplan, Gueydan, Lake Arthur, and Bell City). Roughly 30% of buildings had observable wind damage to roof cover, and severity was generally less than 20% (see example in Fig. 4.4). Wall cladding damage was more isolated (~5% of buildings with wall cladding damage, skewed by the frequent use of brick veneer, which in only a few cases had observed damage). Notably many older buildings (approximate vintage 1940s) sat on concrete piers with no positive attachment (gravity connection only) but FAST1 did not observe any shifted off foundations (Fig. 4.5). As a proxy for the intensity of the wind field, most power poles in that area were still intact, with some leaning.

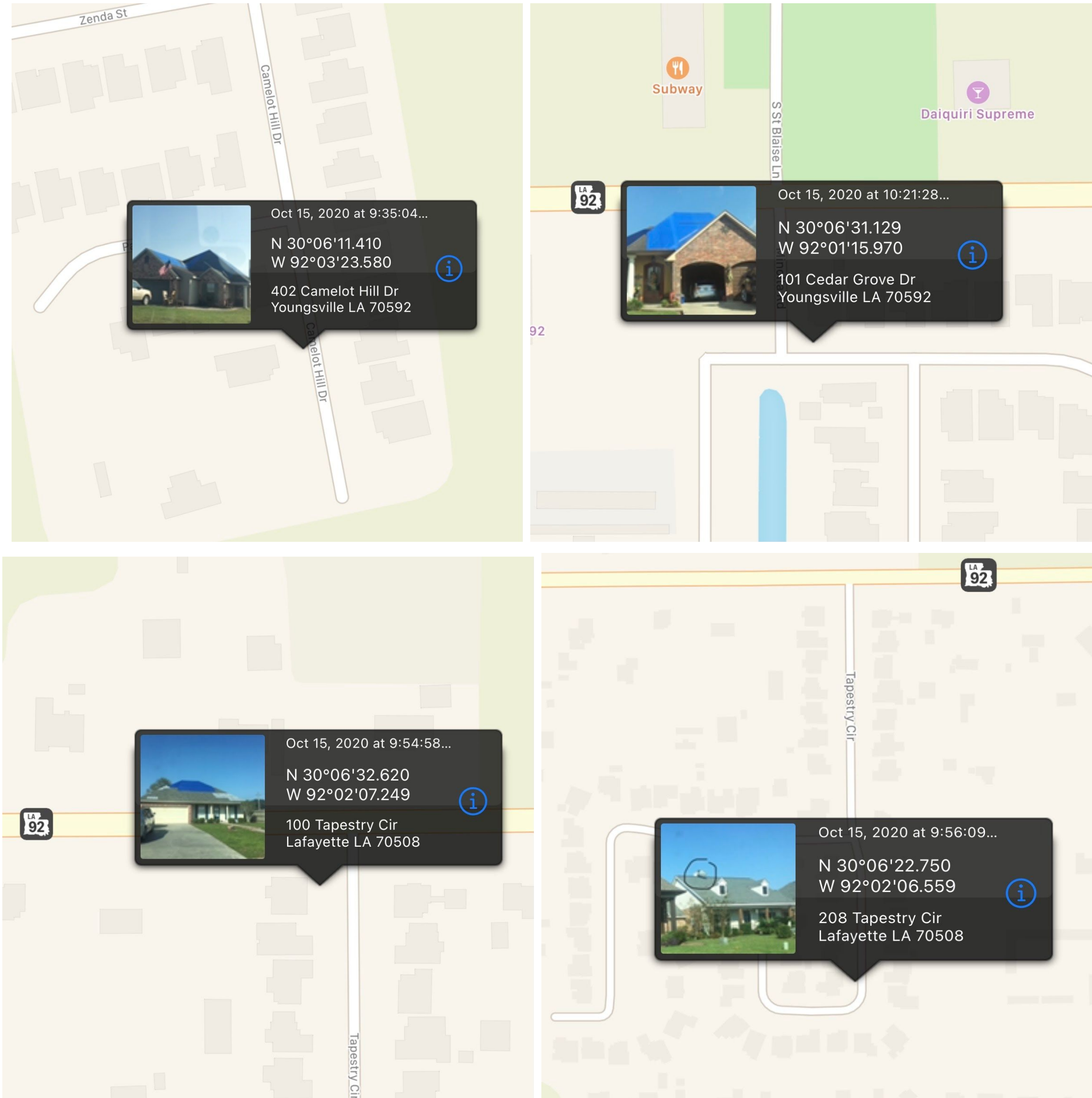


Figure 4.3. Locations of houses with roof cover loss or chimney damage at end of blocks in Youngsville (Credit: FAST-2).

Figure 4.4. Typical roof cover damage levels in older (~2005) residential cluster in Abbeville (Credit: FAST-1).

Figure 4.5. Typical older home (approximately 1940s construction) in communities along LA-14. Inset photo shows that such homes are elevated on concrete piers of various heights with no positive attachment (Credit: FAST-1).

4.3 Lake Charles Metro Area

FAST-1 and FAST-2 surveyed a few clusters within the Lake Charles metro, capturing additional damage from Delta and status of recovery efforts. Many tarps, covering damaged roofs from Laura, were damaged by Hurricane Delta, exposing the structure to additional water damage. Very little rebuilding efforts were evident and most properties still had large piles of interior contents outside from Hurricane Laura, some of it scattered by Hurricane Delta winds (Fig. 4.6). A few cases of additional damage caused by Hurricane Delta were observed (Fig. 4.7).

FAST-2 follow-up surveys in Sulphur and Lake Charles did not identify any notable new damage due to Delta. The Capital One Tower suffered minor additional damage due to Hurricane Delta, with a few new broken window panes and dislodged plywood panels (covering windows lost in Hurricane Laura) (Fig. 4.8).

Figure 4.6. Typical scene in regions of Lake Charles visited by FAST-1 (Credit: FAST-1).

Figure 4.7. Progression of garage door damage on a home near the Chennault International Airport between hurricanes: (left) undamaged following Hurricane Laura and (right) buckled following Hurricane Delta, also note interior damages from Hurricane Laura as evidenced by debris pile at curb (Credit: FAST-1).

4.4 Areas North of LakeCharles

Working along US 190 on 15 October across communities previously surveyed in Laura, FAST-2 noted very little evidence of damage from Delta. In Kinder, power lines were still not repaired, but the high school was in session, with little progress on construction since Laura. In Reeves, where power restoration was still active as of the FAST-2 survey on 15 October, FAST-2 confirmed that the high school roof was in fact damaged due to Laura (this was not documented during FAST-2's original post-Laura survey). The high school's roof was tarped and those tarps were dislodged by Delta. Along US-190 from Reeves to Ragley, power restoration was ongoing as of the survey on 15 October. All schools were in session. Tarp loss was the only notable impact from Delta, and garage door failures in a community near Beauregard High School, documented in the Laura reconnaissance (Roueche et al. 2020), were repaired. FAST-2 also noted that damage in Dequincy was underestimated during Laura FAST-2 (Roueche et al. 2020), with the streetview dataset collected post-Delta affirming higher rates of damage in Laura.

Moss Bluff, south of US 190 and directly north of Lake Charles, similarly had insignificant damage due to Delta and repairs to the high school had progressed significantly since Laura, with schools in session.

4.5 LA-82 (Creole, Grand Chenier)

As of the FAST-1 survey on 12 October, power infrastructure had been mostly restored throughout the region, although many replaced poles were severely leaning (Fig. 4.9), possibly due to Hurricane Delta impacts. There was very little evidence of repair/recovery activity, with most surviving buildings appearing untouched from their post-Laura condition. During this time, flooding was still notable along portions of LA-82 with up to 24 inches of standing water on the roadway (observed around 3 PM, 12 October).

Figure 4.9. Power poles installed after Hurricane Laura already leaning severely along LA-27 (Credit: FAST-1; GPS: 30.0722, -93.1192). This location was subjected to approximately 85 mph peak gust wind speeds and 15-20 inches of rainfall.

I-10 & LA-90 Gradients (East of Landfall)

FAST-2 surveyed the gradient from Hurricane Laura along I-10 and LA-90 both for impacts by Delta and as a longitudinal survey on Laura recovery. Outside of damage to the power grid, most observable damage in Welsh, Lacassine and Iowa appears to be from Laura. At some locations in Jennings, power was still out on 14 October, with a number of tarped roofs, but it could not be definitively stated that this new damage was caused by Delta. Tarped roofs were also observed between Rayne and Crowley, but again will need to be verified by time-lapsed aerial imagery. Areas further east of the original Laura surveys (Estherwood and Mermentau) also did not have significant damage.

FAST-1 also investigated several clusters in Iowa and spoke with one homeowner who indicated two homes on his street had roofs replaced after Laura yet were damaged again during Delta. FAST-1 was unable to verify this report, however, as the two homes that were indicated as having damage did not appear to show any shingle loss in the streetview imagery. It is unclear if the damage was minor loss of cover quickly repaired by the contractor prior to FAST-1's arrival or referring to interior losses resulting from water penetration through poor detailing of the new roof.

5.0 Recommendations for Further Study

Due to the challenges associated with the COVID-19 virus, and the minor structural damage observed overall by the FAST scout teams, StEER does not anticipate engaging a full FAST response for Hurricane Delta. Rather, StEER's present response takes the form of this Event Briefing, which shares with the community StEER's impressions of the event and implications for natural hazard research and practice and generates a valuable streetview dataset that will be available for ongoing investigation, particularly in longitudinal analyses against the streetview data from Hurricane Laura, both of which will be published in DesignSafe as projects PRJ-2933 and PRJ-2988, respectively. Alternatively, while Laura streetview data has been published to Google Maps, StEER will be transitioning its streetview collections to Mapillary. StEER will continue to monitor reports from this event and should the damage to structures warrant additional investigations, StEER will notify the community through its standard channels. StEER will also coordinate with any field assessment teams activated from other sources (e.g., FEMA, NIST, NSF RAPID grants, etc).

6.0 References

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