Southern Climate Impacts Planning Program

Preliminary Report Summary of Hurricane Barry

July 10th – 17th, 2019

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Some information contained within this summary report is preliminary and subject to change.

Times are discussed in EDT, CDT, UTC, and Z, and are specific to the time the figure was released, generated, or preference of the figure source.

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Introduction

Barry was unique in many ways, from where it originated to its complex structure. It was also slow to develop a defined storm center and once formed, it became detached from the mid-level circulation, making it difficult to initialize and forecast. The storm will be remembered for producing record-breaking tropical cyclone rainfall totals in Arkansas, knocking down power lines and trees, and its inability to live up to forecasted extreme precipitation totals in Louisiana. This document is a preliminary summary of the storm containing information on its development and tracking, precipitation forecasts and observed totals, and factors that limited Barry from becoming the extreme rainmaker (in Louisiana) many expected.

Development and Tracking

The National Hurricane Center (NHC) released the first outlook (Figure 1) on what would become Hurricane Barry on Saturday, July 6th 2019, at 2:00 pm EDT. Remarks from the Tropical Weather Outlook highlighted a trough, or an elongated area of relatively low atmospheric pressure, over Tennessee and northern Mississippi. At the time, the area of low pressure was only given a 20% chance of formation over the next five days, but was forecasted to track south and enter the Gulf of Mexico (GOM). On Sunday, July 7th 2019, at 8:00 am EDT, the NHC assigned a 40% probability of formation to the trough (over the next five days), highlighting favorable upper-level winds (lack of shear) and conducive GOM sea surface temperatures (SST) in the upper 80°F range (30–32.5°C). In fact, SST anomalies in the northeast sector of the GOM where the trough was tracking were in the 1–2°C range above normal (Figure 2).

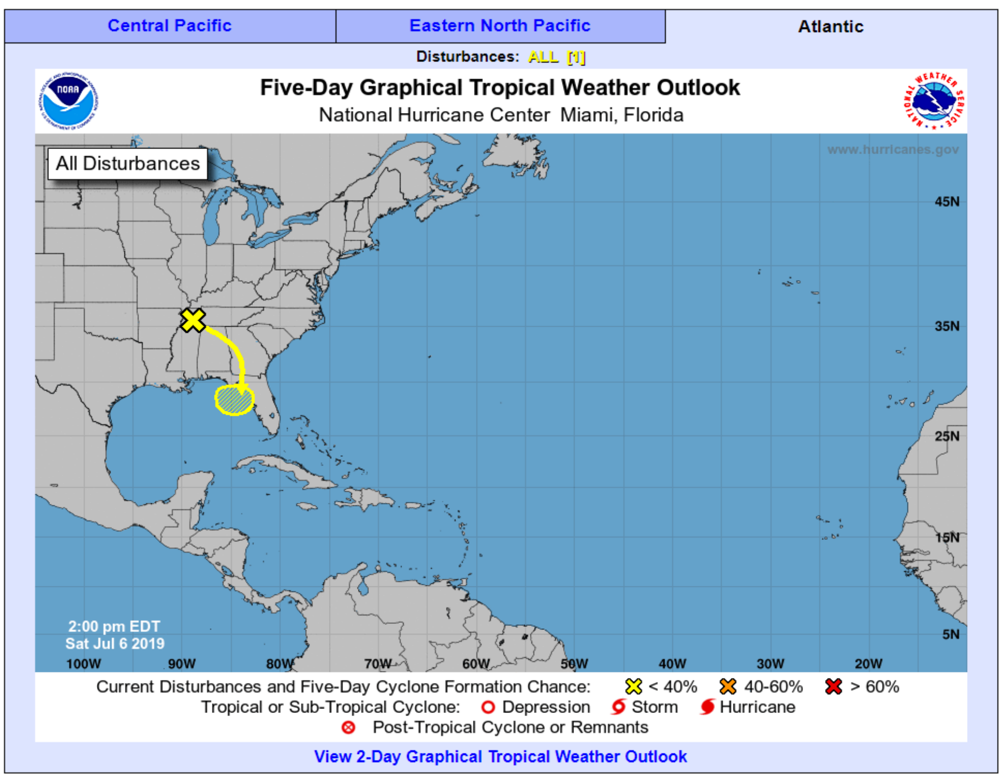

Figure 1. First Tropical Weather Outlook produced by the National Hurricane Center at 2:00 pm EDT, Saturday, July 6th 2019 concerning an elongated trough over Tennessee and northern Mississippi. This is the first sign of Hurricane Barry.

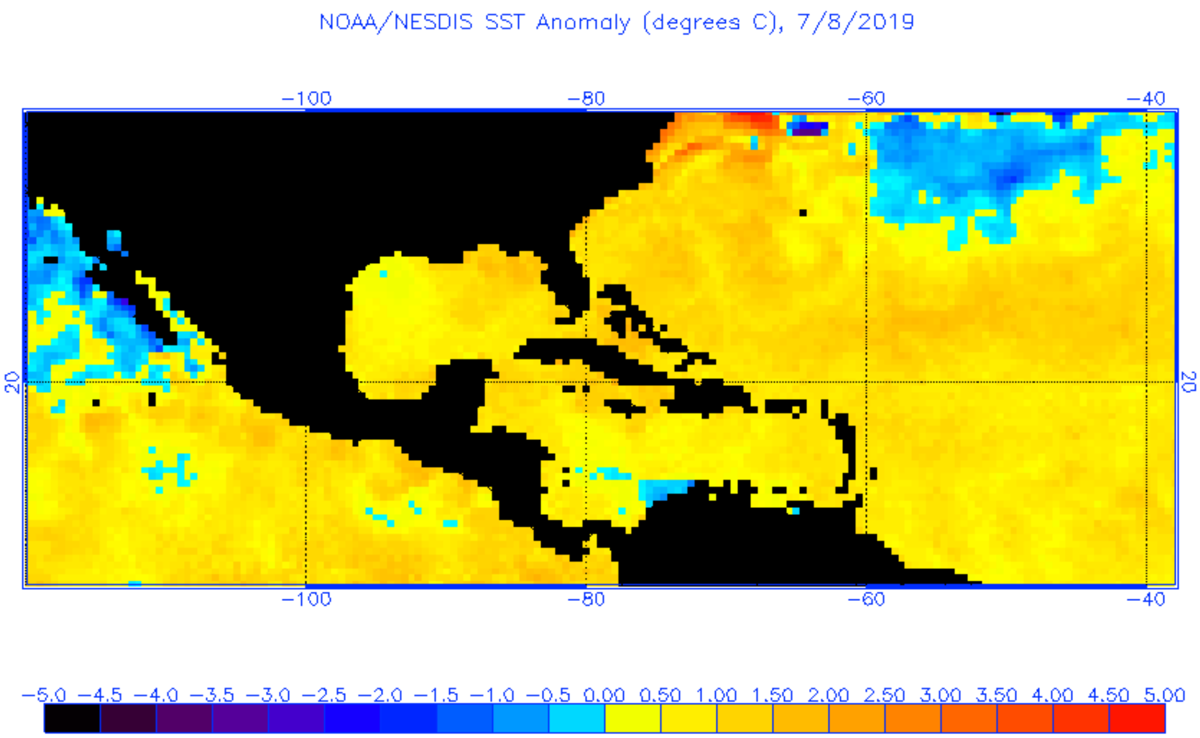

Figure 2. NOAA National Environmental Satellite, Data, and Information Service (NESDI) Sea Surface Temperature Anomaly (°C) for July 8th 2019 prior to the formation of Barry.

On Monday, July 8th 2019 at 2:00 am EDT the NHC increased the probability of formation to 70% in the eastern GOM (Figure 3) for the coming 5-days, stating a tropical depression could form by the end of the week. On the very next outlook at 8:00 am EDT, the probability of formation increased to 80%. On Tuesday, July 9th 2019, the broad area of low pressure was positioned over Apalachee Bay, just southeast of Tallahassee, Florida. At this point, the NHC became more confident a tropical cyclone would form over the coming days, as the formation probability over the coming two-days was up to 70% and the five-day remained at 80%. The NHC scheduled a reconnaissance aircraft to investigate the low on July 10th.

On Wednesday, July 10th 2019, at 8:00 am EDT, the NHC labeled the area of low pressure “Two” – or potential tropical cyclone two. It was located roughly 160-km (100 mi.) south of Apalachicola, Florida at 28.3N 86.7W and was moving west-southwest at roughly 7-knots. Storm “Two” had maximum sustained winds of 25-knots and a central pressure of 1011 millibars (mb). The NHC gave “Two” a 100% chance of formation over the next two and five-days. At the time, model guidance was confident of a landfall in Louisiana, but the spread was somewhat wide, ranging from Mississippi to the upper coast of Texas. Models showed bifurcation into a west or east landfall bin (Figure 4). Then, on Thursday, July 11th 2019, at 8:00 am EDT the NHC Outlook officially showed Tropical Storm Barry with a central pressure of 1005 mb and sustained winds of 35-knots, moving west at 4-knots.

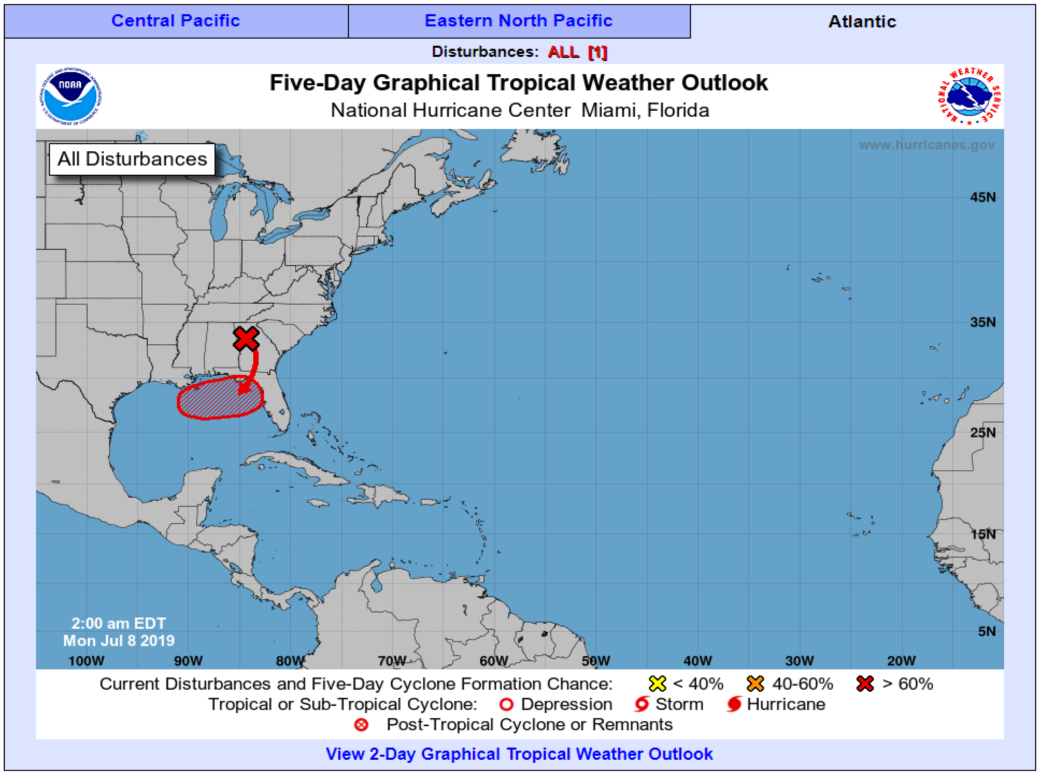

Figure 3. Tropical Weather Outlook produced by the National Hurricane Center at 2:00 am EDT, Monday, July 8th 2019, showing a 70% probability of formation over the next 5-days.

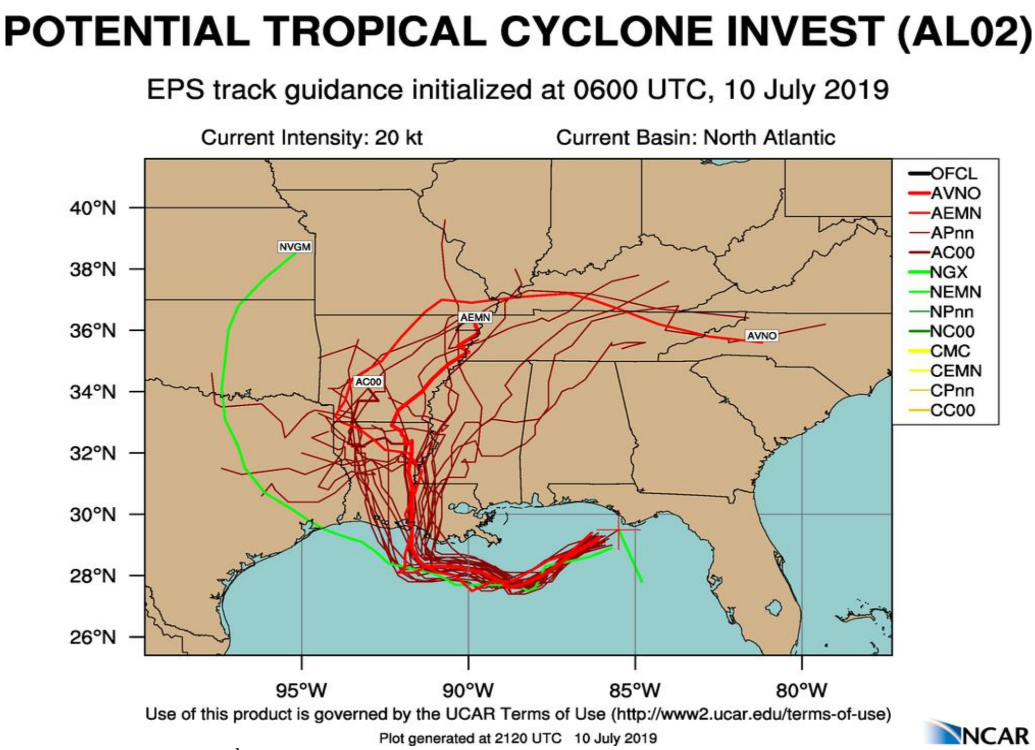

Figure 4. July 10th 2019, 6:00 UTC model guidance of Tropical Storm Barry produced by National Center for Atmospheric Research (NCAR). Models show a bifurcation between an east and west landfall. Nonetheless, most models show a landfall in Louisiana.

By Friday, July 12th at 8:00 am EDT, Tropical Storm Barry had intensified, with a central pressure of 998 mb and sustained winds of 55-knots. Located roughly 160-km (100 mi.) south of the Louisiana coast, models began to converge on the track and landfall location. Models at 18UTC on July 12th 2019, had Barry making landfall in southern Louisiana, but began to spread after landfall (Figure 5). The average of the ensembles (GFS) had a forecasted a track that made landfall near Vermillion Bay, LA. The NHC forecasted roughly the same thing (Figure 6).

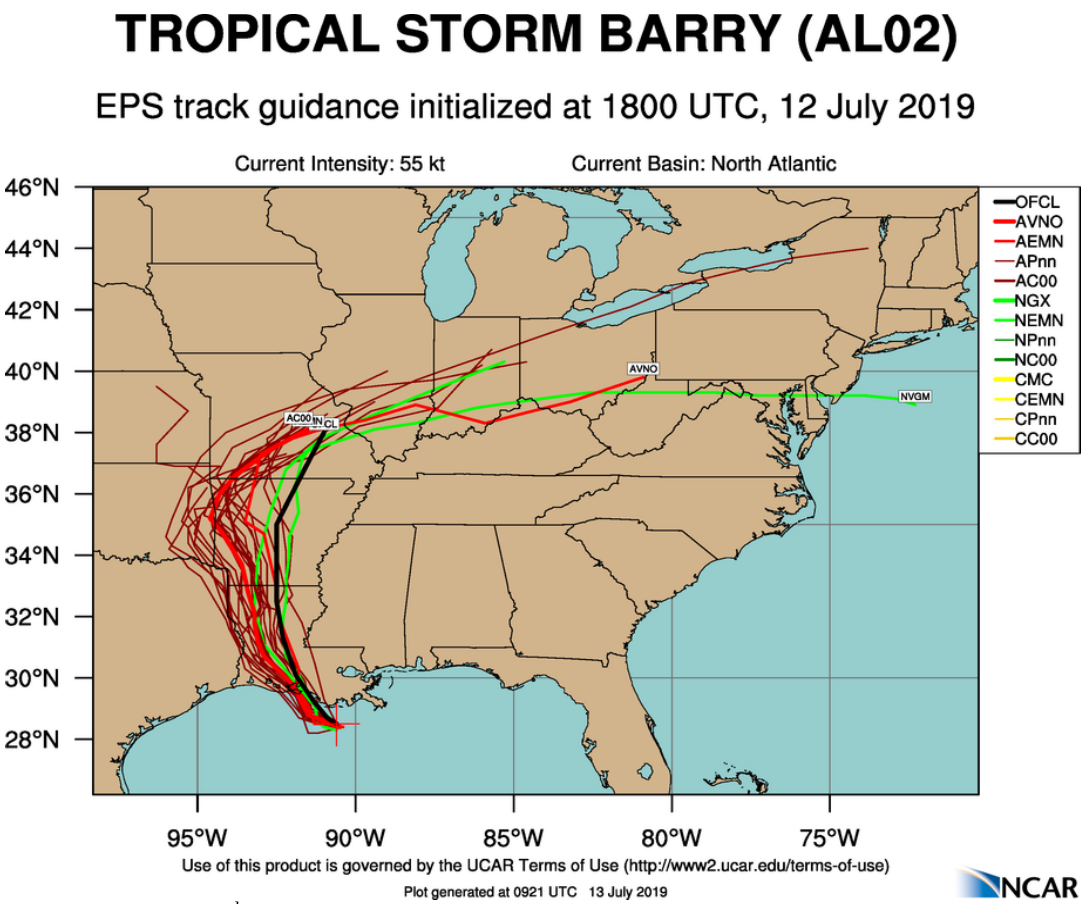

Figure 5. July 12th 2019, 18:00 UTC model guidance of Tropical Storm Barry produced by NCAR. Models show close agreement in track.

There was some debate at this time if Tropical Storm Barry would make landfall as a Hurricane. The 7:00 am CDT discussion on July 13th 2019, highlighted sustained winds of 70-mph with higher gusts and an estimated central pressure of 991 mb. The wind field was impressive, with tropical-storm-force winds extending outwards roughly 280-km (175 mi.) from the poorly defined center. However, Barry was not well organized and dry air combined with wind shear were observed, especially in the northern half of the storm, sparking debate over whether Barry could reach hurricane status at landfall, even with the storm showing 65-knot winds (on 7:00 am July 13th 2019). By 7:00 am CDT (12:00 UTC) model guidance showed agreement and the storm was set to make landfall somewhere in southern Louisiana (Figure 7). The debate was of its strength at landfall.

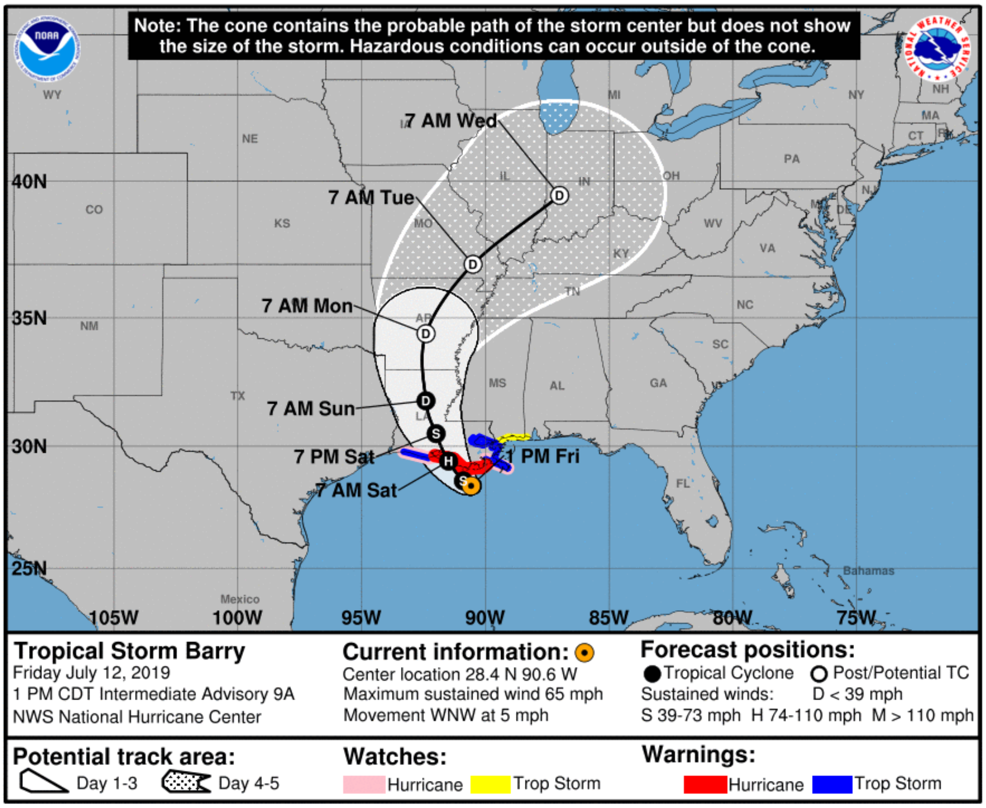

Figure 6. National Hurricane Center 1:00 CDT Intermediate Advisory forecasting Tropical Storm Barry to become a hurricane at landfall in southern Louisiana.

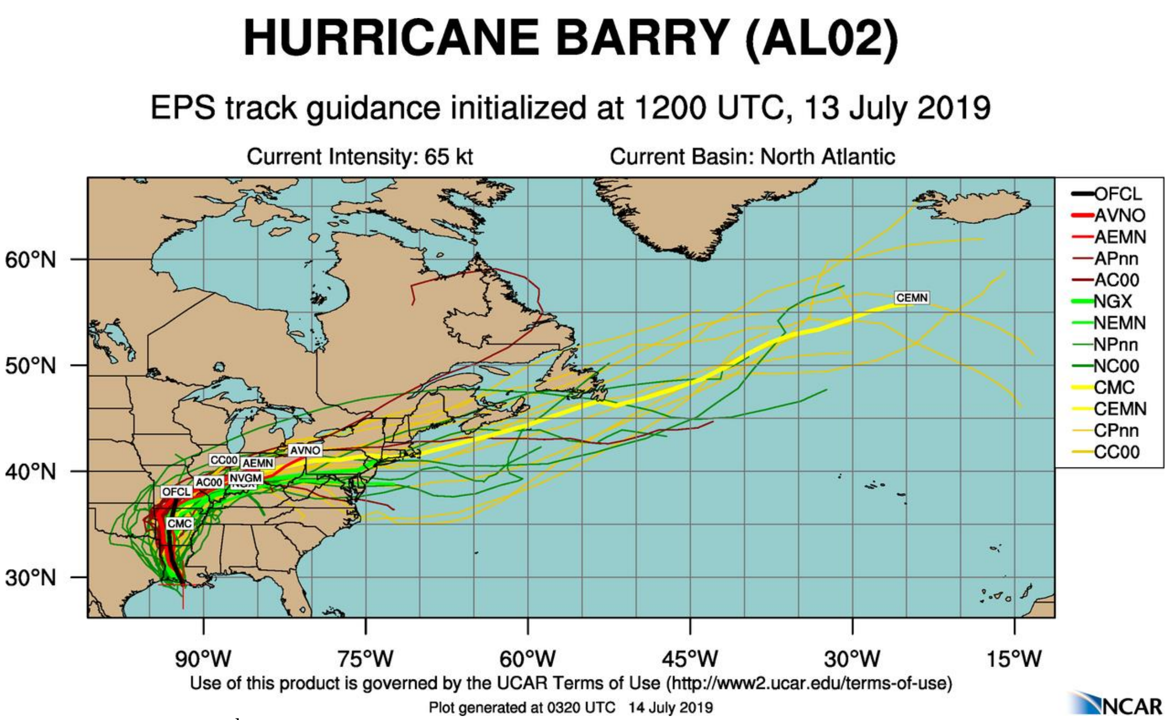

Figure 7. July 13th 2019, 12:00 UTC model guidance for Hurricane Barry. Barry had reached hurricane strength and was expected to make landfall within the next 6-hours.

Then, sometime between 7:00 am – 1:00 pm CDT on Saturday, July 13th 2019, Hurricane Barry (officially upgraded to a hurricane) made landfall near the Vermillion Bay and Marsh Island area in Louisiana, as a category one (≥ 74 mph winds) hurricane according to the NHC's discussion released on 4:00 pm CDT. However, the lack of a clearly defined center made pinpointing the exact location and time of landfall difficult, but the NHC has stated they will eventually determine the time and location in post-analysis of the storm.

Storm surge across southern Louisiana was relatively minimal, with stations like Shell Beach and Grand Isle (Figure 8) seeing a surge of roughly 0.91–1.07 m (3–3.5 ft.) prior to landfall (wind-driven) then decreasing once the storm moved inland (due to the counterclockwise rotation and wind pushing water away from these locations). At the tidal gauge on the Atchafalaya River, west of Shell Beach and Grand Isle, and closer to where Hurricane Barry made landfall, storm surge values ≥ 1.98 m (6.5 ft.) were recorded. The peak surges occurred later in the day on July 13th because Barry took some time working its way along the Louisiana coast. According to preliminary information from the National Weather Service (NWS), the top two surges occurred in Louisiana at Caillou Lake (Caillou Lake NR Dulac) and Caillou Bay (Cocodrie) in Terrebonne Parish, with surges of 2.78 m (9.11 ft.) and 1.99 m (6.55 ft.), respectively.

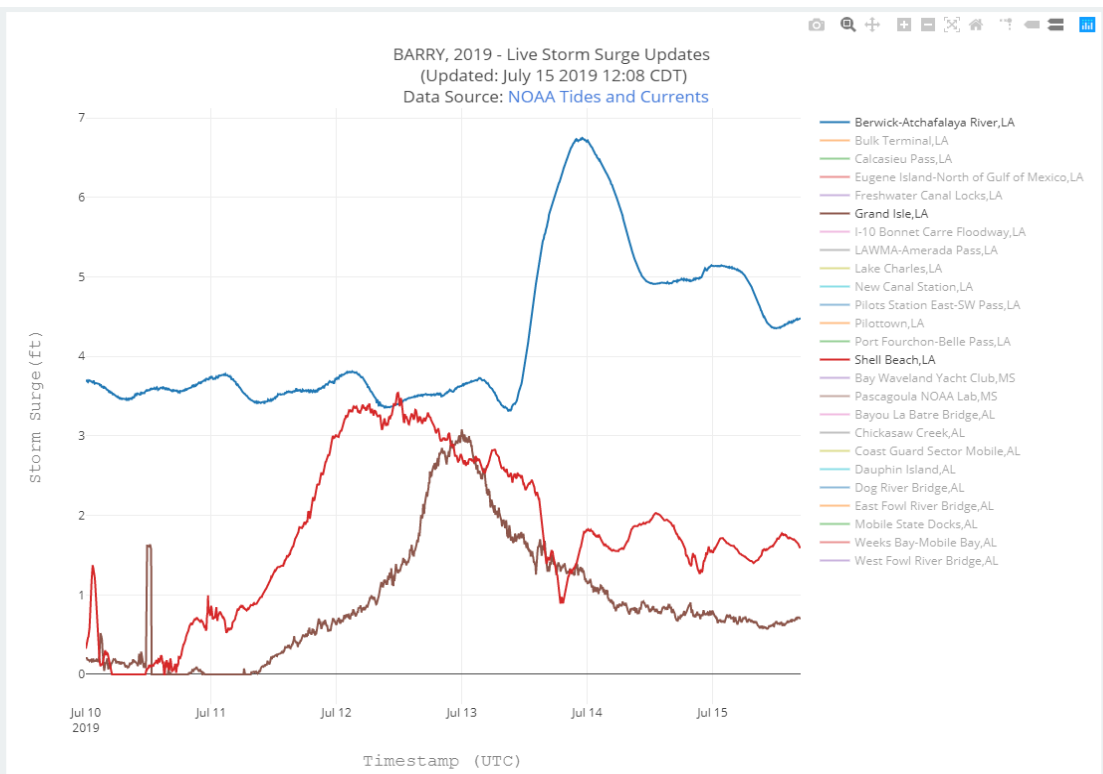

Figure 8. Live Storm Surge Tracker produced by the Southern Regional Climate Center (SRCC) and the Southern Climate Impacts Planning Program (SCIPP) for Hurricane Barry from July 10–15. Surge strikes and peaks at Shell Beach, LA and Grand Isle, LA before reaching the Atchafalaya River, LA. http://surge.srcc.lsu.edu/ from SURGEDAT.

By 10:00 pm Saturday, July 13th 2019, Barry was well into Louisiana and located at 31.0N 93W, moving north-northwest at roughly 7-knots (8-mph) (slightly faster than some models had anticipated). Most models forecasted Barry further weakening, as most storms do post-landfall; however, Barry was still producing winds around 40-knots and maintaining its tropical storm status. By 1:00 pm CDT on Sunday, July 14th 2019, Barry was still (barely) a tropical storm with sustained winds of 40-mph, but by 4:00 pm, became a tropical depression and continued to track north-northwest into Arkansas at roughly 8-knots (Figure 9).

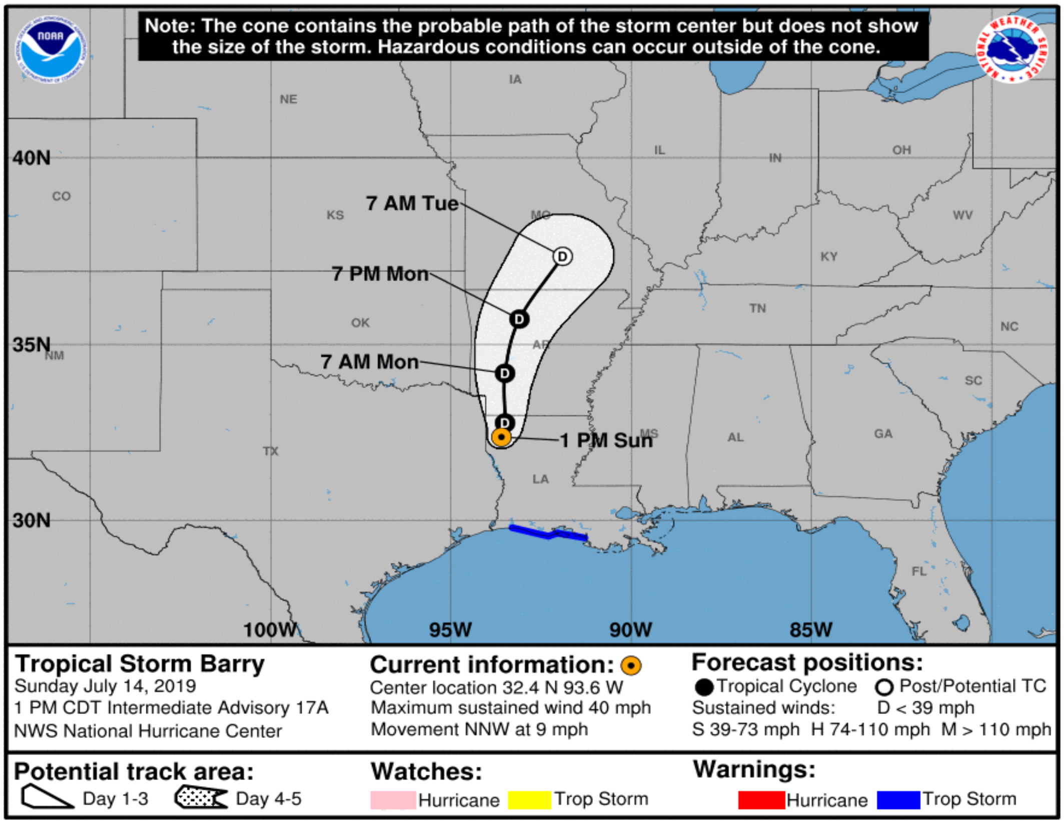

Figure 9. July 14th 2019, 1:00 pm CDT Intermediate Advisory showing the last moments of Tropical Storm Barry before it weakens to a tropical depression and enters Arkansas.

Overall, the forecasting of Hurricane Barry's initialization and track were quite impressive. The NHC detected and monitored a broad area of low pressure over the central United States, migrating south into the GOM, 5-days in advance of it becoming a tropical storm. This type of early forecasting – the detection of disturbed weather inland in the southeastern United States turning into a Hurricane and making landfall in Louisiana –might just be unprecedented. Models showed slight disagreement from July 10th–11th regarding the landfall zone but came to agreement quickly thereafter. Most issues regarding the diverging tracks were related to the disorganization of the system, making it difficult to accurately initialize the models without an accurate storm center. Forecasting is particularly challenging under these circumstances. Overall, we feel that the tracking of the storm is considered a huge success, while the precipitation forecast is a different story.

Precipitation Forecast

To help convey forecasted rainfall totals, mostly from model output, the NHC releases Key Messages. These messages contain information on likely arrival time of tropical-storm-force winds and estimated rainfall totals. All rainfall total estimates are 168-hour or 7-day estimates. Hereafter, all discussed rainfall estimates will be at this 168-hr duration. Some figures and map produced by the NHC are generated before the release of the Key Messages or statements. In this report, the figures will be aligned with the time the message(s) were released.

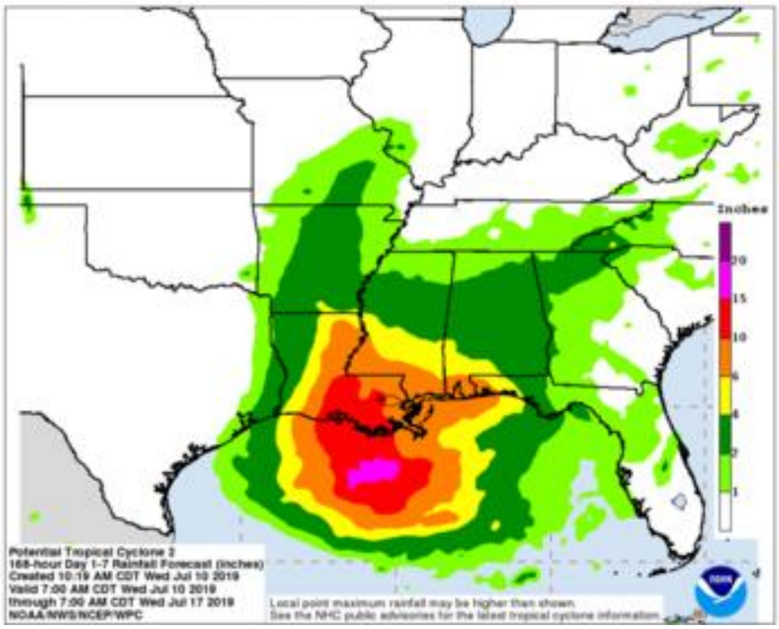

Figure 10. Key Message for Potential Tropical Cyclone "Two", 10:00 am CDT Wednesday, July 10th 2019 showing estimated 7-day rainfall totals (Advisory 1).

The first 'Key Message' produced by the NHC for, at the time Tropical Cyclone "Two" (10:00 am CDT Wednesday, July 10th 2019), contained rainfall estimates of 254–381 mm (10–15 in.) for parts of southeastern Louisiana and 152–254 mm (6–10 in.) for much of the rest of the state (Figure 10). 30-hrs later, at 4:00 pm CDT on Thursday, July 11th 2019, the sixth advisory was released (Figure 11a). This update showed a large pocket of rainfall estimates in the 381–508 mm range (15–20 in.) encompassing areas such as Baton Rouge and New Orleans, with a smaller envelope of +508 mm (+20 in.) estimates, just east of Lafayette. This release, along with other models showing high rainfall totals, induced fear in many residents across the state, particularly in southern Louisiana, where roughly 3-years ago the historic August 2016 event produced a peak 48-hr rainfall total of 797 mm (31.39 in.) with an extensive region of over 250 mm (10 in.).

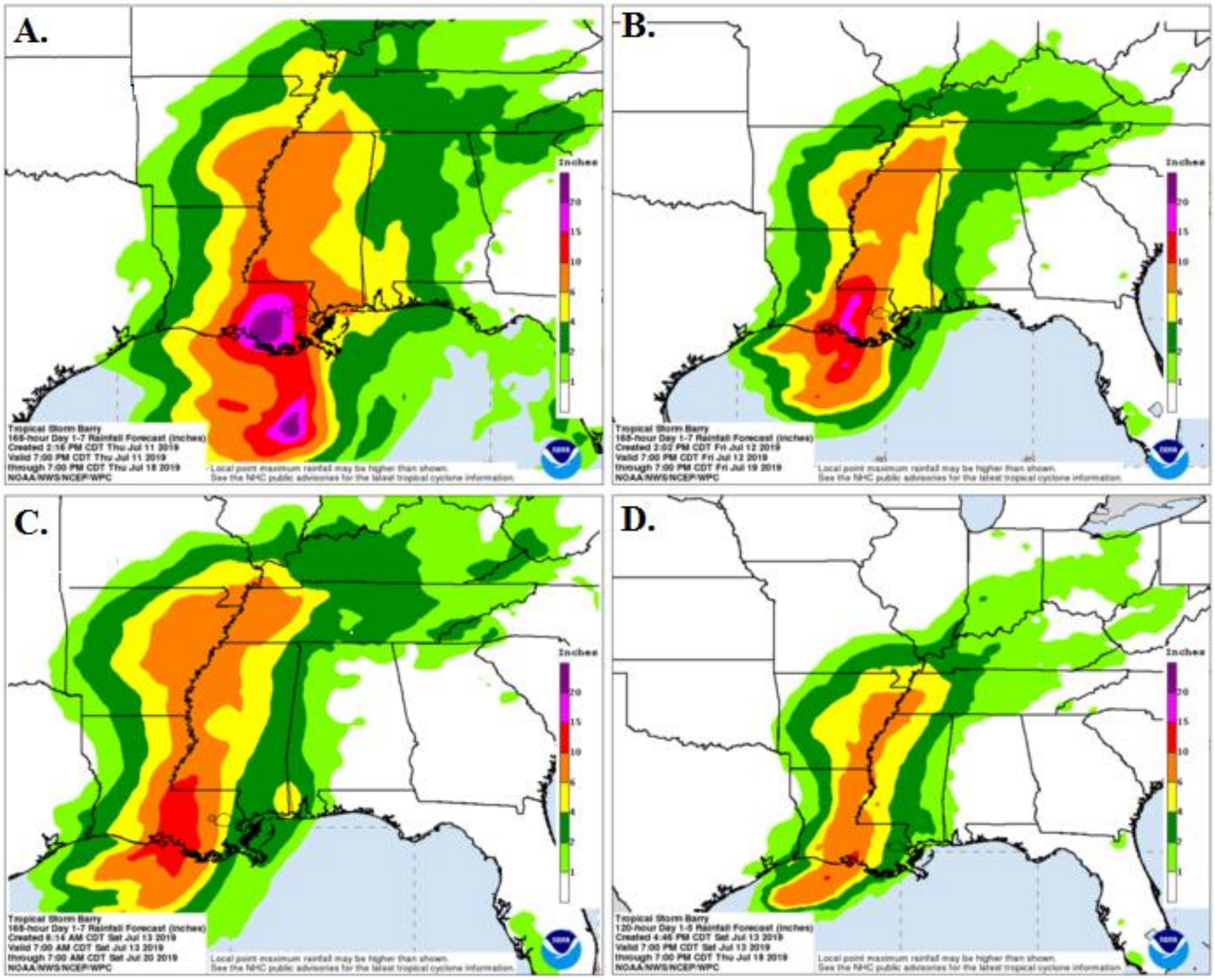

Figure 11. **A –** Key Message for Tropical Storm Barry, released 4:00 pm CDT Thursday, July 11th 2019 showing estimated 7-day rainfall totals (Advisory 6). Rainfall estimates increased significantly from the first advisory. **B –** Released 4:00 pm CDT Friday, July 12th 2019 showing estimated 7-day rainfall totals (Advisory 10). Rainfall estimates had decreased from the sixth advisory but still showed extreme totals. **C –** Released 10:00 am CDT Saturday, July 13th 2019 showing estimated 7-day rainfall totals (Advisory 13). Rainfall estimates had decreased from the tenth advisory but 254–381 mm (10–15 in.) totals were still expected. **D –** Released 10:00 pm CDT Saturday, July 13th 2019 showing estimated 7-day rainfall totals (Advisory 15). Rainfall estimates had decreased significantly from the thirteenth advisory. *Please note the spatial scales and extent differ in the panels, which may bias interpretation.*

The seventh update was very similar in totals as the sixth, but estimates decreased in magnitude and spatial extent thereafter. The tenth update (Figure 11b), which was released at 4:00 pm CDT on Friday, July 12th 2019, calmed the nerves of many in New Orleans, mainly because estimates had dropped to 152–254 mm (6–10 in.). Baton Rouge, on the other hand, was still on high alert, as the capital city was still surrounded by 254–381 mm (10–15 in.) estimates with embedded 381–508 mm estimates (15–20 in.). At this point, most citizens had heard the latest forecasts and had gone home or were already off work and hunkered down. In fact, most stores around Baton Rouge were running low or completely sold out of water and bread by Thursday, July 11th. So, this precipitation forecast was likely the last one processed before the weekend and arrival of the storm.

Advisories 10–12 were similar, but when advisory 13 was issued at 10:00 am CDT Saturday, July 13th 2019, rainfall estimates shifted westward and the 381–508 mm (15–20 in.) estimates were no longer present (Figure 11c). By the 15th advisory, released at 10:00 pm CDT on Saturday, July 13th 2019, the estimated totals had significantly dropped and Baton Rouge was located between the 102–152 mm (4–6 in.) and 152–254 mm (6–10 in.) estimated range (Figure 11d). Finally, by the 16th advisory released at 4:00 am CDT on Sunday, July 14th 2019, most of Louisiana was in the 51–102 mm (2–4 in.) range, with slightly higher totals (102–152 mm to 152–254 mm) estimated for areas around Lake Charles and Lafayette.

Observed Rainfall Totals

According to the NWS Advanced Hydrologic Prediction Service (https://water.weather.gov/precip/), quantitative precipitation estimates for the 7-day period of July 9–16th show a small swath of 508 mm (+20 in.) near Ragley, LA, just north of Lake Charles (Figure 12). According to The Weather Prediction Center (WPC) Preliminary Storm Summary updated at 11:00 am CDT, July 17, 2019, a station in Ragley, LA (Ragley 4 S) recorded 598.93 mm (23.58 in.) for the duration of the storm (Table 1). Sixteen preliminary storm total amounts across Louisiana can be seen in Table 1. Some other notable totals include a station in Oberlin (Oberlin 1 SSW) that recorded 461.26 mm (18.16 in.) and Denham Springs (Denham Springs 6.8N) that recorded 293.62 mm (11.56 in.).

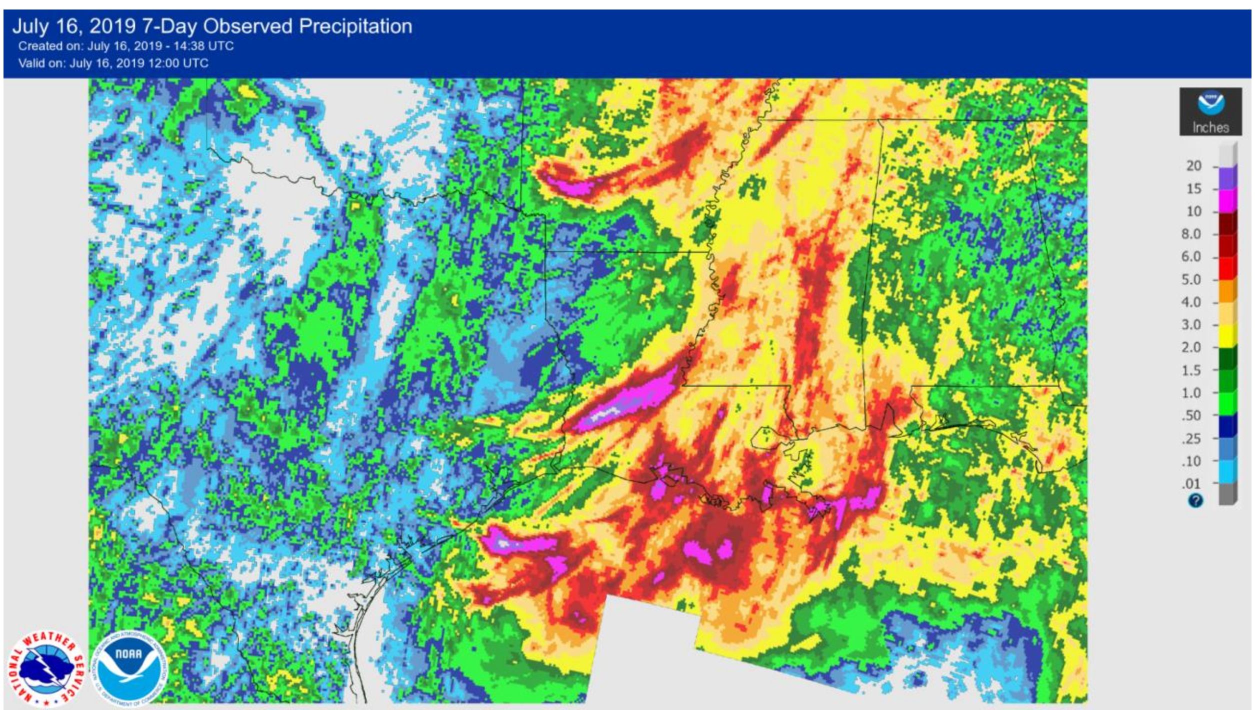

Figure 12. National Weather Service's Advanced Hydrologic Prediction Service 7-day (7/9–716) Quantitative Precipitation Estimates. https://water.weather.gov/precip/

Table 1. The Weather Prediction Center (College Park, MD) Storm Summary Message containing selected (7/17/19) preliminary storm total rainfall where the event has ended. www.wpc.ncep.noaa.gov.

Station	Total (mm)	Total (in.)
RAGLEY 4 S	598.93	23.58
OBERLIN 1 SSW	461.26	18.16
MARKSVILLE 4 SSW	408.43	16.08
GILLIS 3 WNW	379.98	14.96
MOSS BLUFF 5 WNW	348.49	13.72
BUHLER 2 E	340.36	13.4
BORDELONVILLE 1 NE	328.68	12.94
DE QUINCY ENE	326.64	12.86
BUNKIE 0.3 WSW	299.72	11.8
DENHAM SPRINGS 6.8 N	293.62	11.56
GRAND PRARIE 3 NW	269.24	10.6
KINDER 4 WNW	246.38	9.7
VILLE PLATTE 3 ESE	229.87	9.05
ATCHAFALAYA RIVER AT SIMMESPORT	214.12	8.43
MONTICELLO 3 ENE	199.14	7.84
BATON ROUGE	168.15	7.39

Outside of Louisiana, particularly in Arkansas, Barry produced substantial rainfall totals. Preliminary reports by the NWS describe a potential state record for maximum rainfall caused by a tropical cyclone. Arkansas's state record for maximum rainfall caused by a tropical cyclone or its remnants (dating back to 1950) is currently 353.31 mm (13.91 in.) from June 28–July 2, 1989 (Ashley County). Preliminary (Cooperative Observer) observations from gauges in Dierks (Dierks 3 S) and Murfreesboro (Murfreesboro 1 W) have Barry storm totals of 421.39 mm (16.59 in.) and 370.33 mm (14.58 in.), respectively. While the preliminary information is subject to change or revision, it is plausible to expect a new record for the state.

Perhaps, the most interesting and important storm totals are located in and around Baton Rouge, Hammond, and New Orleans (Figure 13). As estimated by the NWS (NWS New Orleans, rainfall ending 7/16/19), these totals are derived by NWS River Forecast Centers using observed rainfall from gauges, radar-based estimates, and forecaster quality control (NWS 2019, source: water.weather.gov). Estimated totals for most of East Baton Rouge Parish are in the 76.2–152.4 mm (3–6 in.) range, with embedded areas of 152.4–203.2 mm (6–8 in.). In Livingston Parish (just east of Baton Rouge), where Denham Springs is located, a small area with 254–304.8 mm (10–12 in.) estimated totals is present due to the training of storms in that vicinity. In the preliminary report by the WPC, a station in Baton Rouge recorded 187.71 mm (7.39 in.) during the same period.

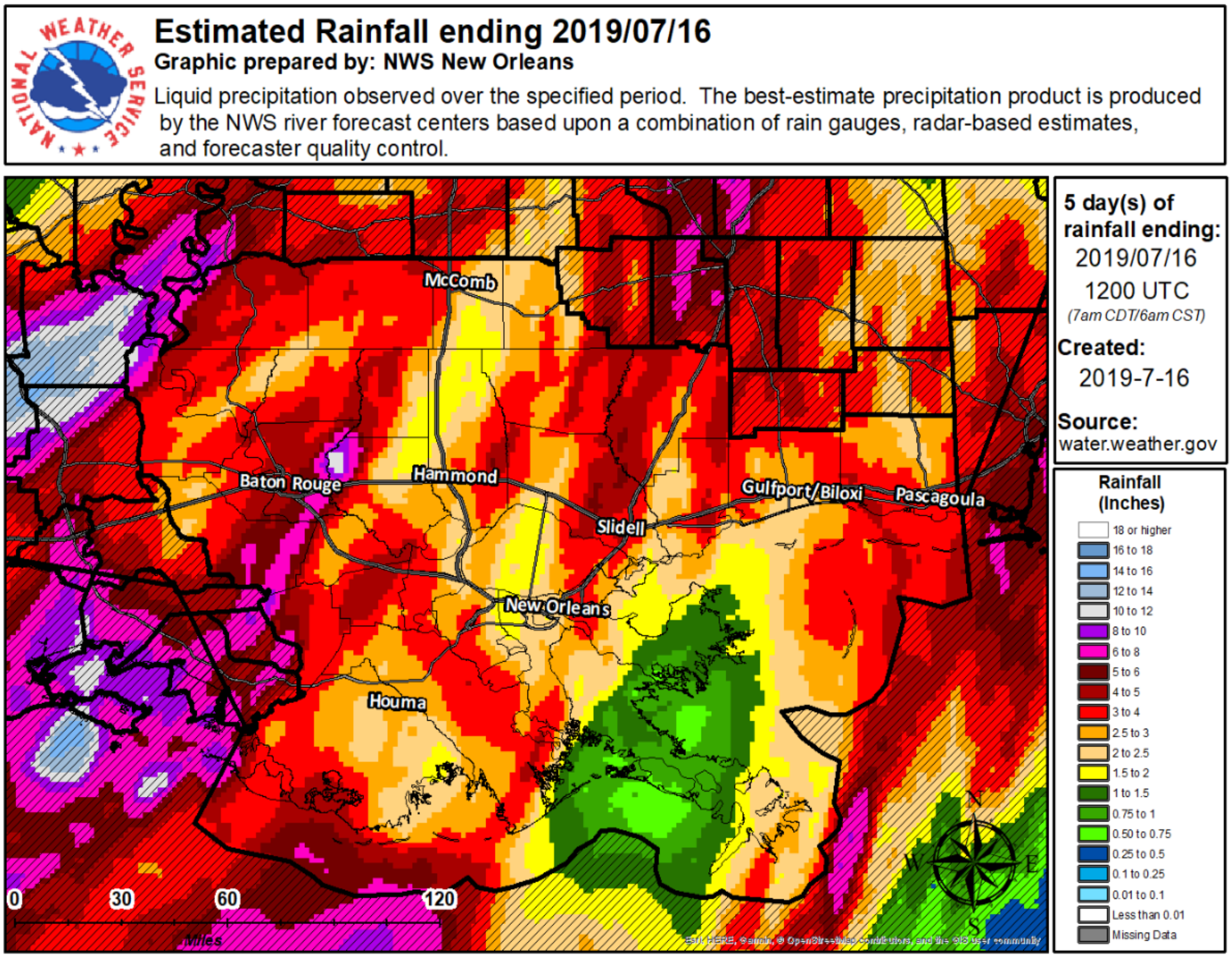

Figure 13. National Weather Service estimated storm total rainfall ending July 16th 2019 at 12:00 UTC for southeastern Louisiana.

The biggest surprise exists in New Orleans where estimated totals are a scant 38.1–76.2 mm (1.5–3 in.) (Figure 13). These totals pale in comparison to the 203.2–254 mm (8–10 in.) observed on Wednesday, July 10th 2019, produced by thunderstorms that were loosely affiliated with the low pressure in the GOM, fueled by high precipitable water values. The WPC preliminary storm total report states the New Orleans Naval Air Station only received 61.47 mm (2.42 in.) during Barry. To the west of New Orleans and Baton Rouge, in the south-central part of the state (near Ragley), totals were higher and align well with what was expected. However, the question remains, why did models forecast extreme precipitation totals over such a vast area? Why did we not experience extreme precipitation during the storm?

Constraints on Barry's Development

To completely explain the multiple and intricate details as to why models incorrectly forecasted extreme precipitation during Barry is beyond the scope of this summary report; however, a few obvious factors can be discussed briefly. First, Barry was an asymmetric storm (lopsided), with strong convection and moisture in its southern half and dry air in the northern sector. This is very different from the classical circular (symmetrical) convective pattern common in many hurricanes. The asymmetrical nature limited the ability for Barry to become organized or stacked with rotation around a well-defined center. Barry was spread out and disorganized, but because it was so dispersed, it was able to absorb and make use of extensive water vapor (precipitable water), caused mainly by warm GOM SST's. The combination of warm SST's in the GOM (see Figure 2), slow movement (between 2.5–5 knots before landfall), and abundant precipitable water likely drove the models to forecast high precipitation totals for many areas in and around Barry's path. However, the presence of dry air and wind shear were able to mitigate the effect of the conducive rainfall ingredients listed above, and these factors were obviously not handled well by the models.

Most tropical cyclones can tolerate some mild to moderate dry air and vertical wind shear, but Barry could not because of its disorganized and asymmetric nature. Once Barry encountered these headwinds, it was unable to reorganize and produce the forecasted extreme precipitation totals in Louisiana. First, a brief discussion on the wind shear that developed in conjunction with Barry that limited its ability to become organized.

Wind Shear

Wind shear is defined as the change in wind velocity (speed or direction) with height. The most important type of shear for tropical cyclones is in the vertical direction and its presence or absence can greatly influence the development and strength of a cyclone. The most conducive environmental conditions are those with little to no vertical wind shear because it enables tropical cyclones to "stack" or organize and spin counterclockwise (in the northern hemisphere), allowing for a vertically aligned and tight set up (conducive to strengthening), while also allowing the storm to vent at the top of the storm. When vertical wind shear is prevalent in the atmosphere around or near the tropical cyclone the vertically stacked nature deteriorates and the center of the storm becomes tilted (imagine the Leaning Tower of Pisa). Titled storms have problems strengthening because the currents of air cannot efficiently pump moisture and heat (energy) into the storm compared to a vertically stacked storm. This is equivalent to having a leaky fuel line in your car, while some of the fuel (energy) makes its way to the engine and propels you forward, some energy is lost and your ability to accelerate is severely limited.

Hurricane Barry was a victim of vertical wind shear. Using a wind shear derived (GOES-East) product from the Cooperative Institute for Meteorological Satellite Studies (CIMSS), it is possible to see how wind shear weakened Barry (Figure 14). In the images, areas with black, blue, and green colors represent areas with little to no wind shear (conducive environments) and areas with yellow, red, and white colors (not including contour lines) represent areas with moderate to high vertical wind shear (non-conducive environments). According to CIMSS, any shear below 20-knots (green colors and below on Figure 13) is conducive for tropical cyclones.

For more information on CIMSS shear product see… http://tropic.ssec.wisc.edu/misc/winds/info.winds.shr.html.

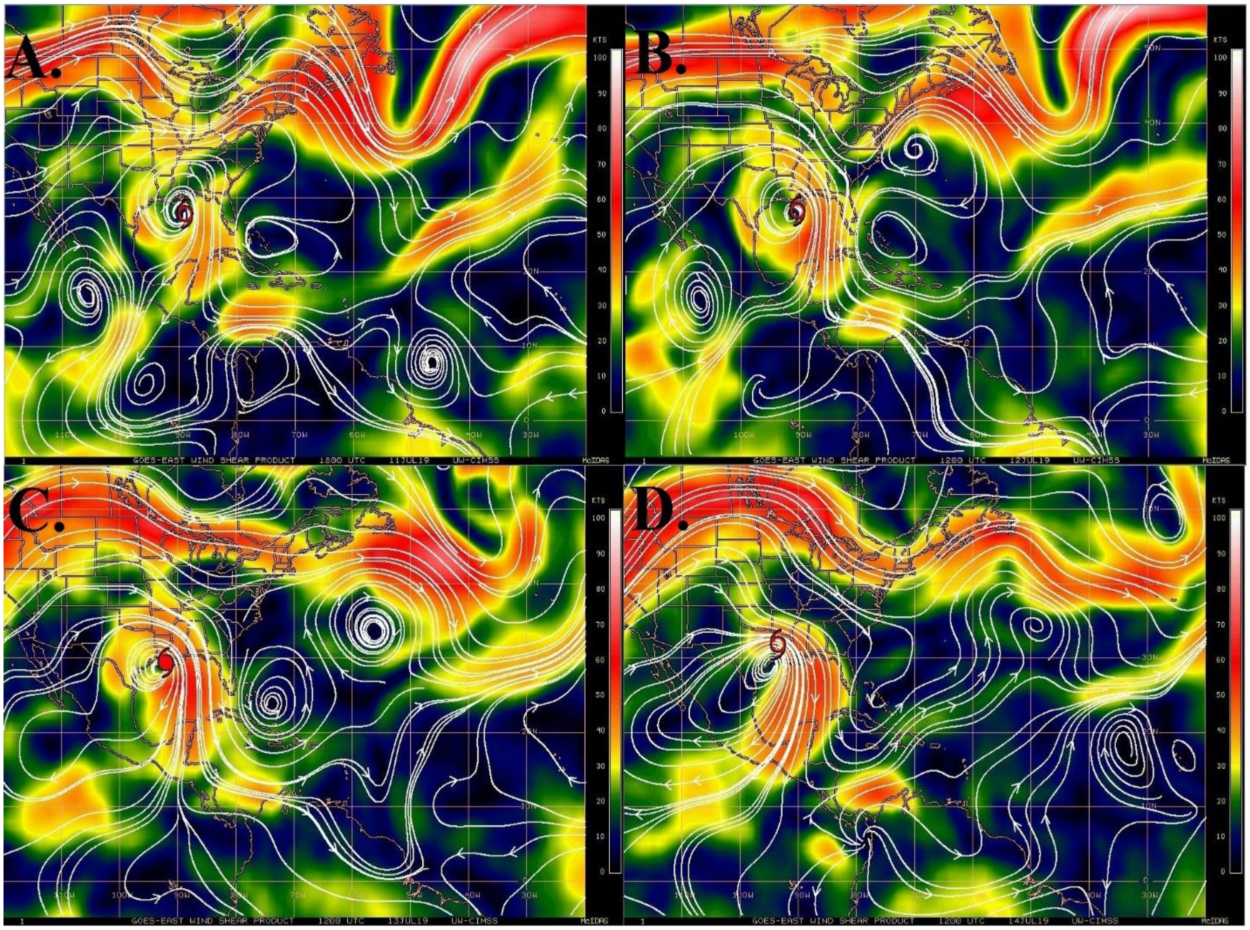

Figure 14. Wind shear derived from GOES-East wind shear product. **A** – 18:00UTC July 11th, **B** – 12:00UTC July 12th, **C** – 12:00UTC July 13th, **D** – 12:00UTC July 14th. Source: Cooperative Institute for Meteorological Satellite Studies (CIMSS), Space Science and Engineering Center (SSEC) / University of Wisconsin-Madison. http://tropic.ssec.wisc.edu/. Accessed 7/16/19.

At 1800 UTC (1:00 pm CDT) on July 11th 2019, Barry was just off the Louisiana coast and situated in an environment with mild wind shear (Figure 14a). As the day progressed, Barry stayed in a low shear environment favorable for continued strengthening and intensification. By 12 UTC (7:00 am CDT), on July 12th 2019, Barry was still somewhat stacked but was beginning to encounter some shear (northerly), that started to separate the lower and upper levels of the storm (Figure 14b). At 12 UTC (7:00 am CDT) on July 13th 2019, Hurricane Barry was located in a high shear environment, with shear from the north (Figure 14c). As the lower-level circulation propagated north-northwest into Louisiana the southern portion of the storm, containing intense convection and impressive rainfall rates, stayed offshore and became separated from the storm. The following day (12 UTC on July 14th 2019), Barry was still experiencing high shear that ripped the storm apart, separating the quadrants of the storm and circulation (Figure 14d). Heavy rainfall bands that were expected Saturday (July 13th, 2019) never arrived in many locations and the storm became extremely disorganized, which continued in the following days. Overall, Hurricane Barry is a great example of what wind shear can do to a storm. Barry never formed the well-defined eye and circulation expected with most hurricanes; however, Barry only spent a limited period in a low shear environment. Once Barry started to form and tried to intensify, the shear in the environment was too much for the storm to overcome, causing a disorganized and vertically separated storm that was unable to effectively circulate heavy rain bands into southeastern Louisiana.

Dry Air

Another factor that restricted Hurricane Barry's ability to produce extreme rainfall was the presence of dry air. Dry air can induce evaporation of liquid water in tropical cyclones, thus removing a critical ingredient needed for strengthening. Tropical cyclones also contain a warm core and evaporation is a cooling process that can reduce vertical motions (convection) within the storm. Dry air is also less dense than moist air (water vapor) at a constant temperature and will tend to sink (descend) and warm adiabatically producing layers of warm stable air that can also limit convection.

Water vapor images show how dry air impacted Barry during its lifecycle (Figure 15). On these images, dark orange and orange colors represent higher (warm) temperatures in the effective layer (highest layer with appreciable water vapor), meaning there is a lack of moisture (dry) in the troposphere in those areas. Gray and white to blue, green, red and encapsulated yellow colors show areas of lower (cold) temperatures in the effective layer demonstrating the presence of moisture.

On July 11th, 2019 at 20 UTC (3:00 pm CDT) the convection and moisture surrounding Barry is evident, with abundant water vapor just offshore of Louisiana (Figure 15a). Drier air is present to the northeast and west but not towards the direction Barry is traveling. The next day (July 12th 2019 at 20 UTC (3:00 pm CDT)) dry air is positioned over Arkansas, northern Louisiana, and northern Mississippi (Figure 15b). This air becomes critical in weakening Barry as it slowly advances north-northwest towards to coast. The following day (July 13th 2019 at 20 UTC (3:00 pm CDT)), the dry air pushed further south and Barry had already made landfall (Figure 15c). As Barry continued to track north-northwest at roughly 4–5 knots it encountered even more dry air that caused deterioration of the storm. The dry air-restricted the flow of warm moist tropical air from penetrating inland, which kept the deep convection offshore (wind shear also a factor) while Barry continued to ingest dry air that suppressed convection. Finally, by 3:00 pm CDT, July 14th, 2019, Barry was surrounded by dry air and the offshore convection had significantly weakened (Figure 15d).

So why were the models so wrong with the precipitation totals? For starters, all for the correct ingredients were present (warm moist air, warm SST, low initial wind shear, etc.). With low-shear and high precipitable water, it seemed Barry would have no problem organizing and making use of an energy-packed environment (initially) to produce extreme precipitation. What the models did not anticipate were increases in vertical wind shear and dry air that caused Barry to fall apart. As Barry deteriorated, the forecasted rainfall totals fell as well and eventually synced with what was observed. Nonetheless, it is also important to note how difficult it is for both humans and models to forecast where tropically induced rain bands will occur. Some rain bands did arrive in parts of Louisiana, for example, isolated areas like Ragley received over 584 mm (23 in.), but overall, Barry's rainfall totals did not live up to the expectation.

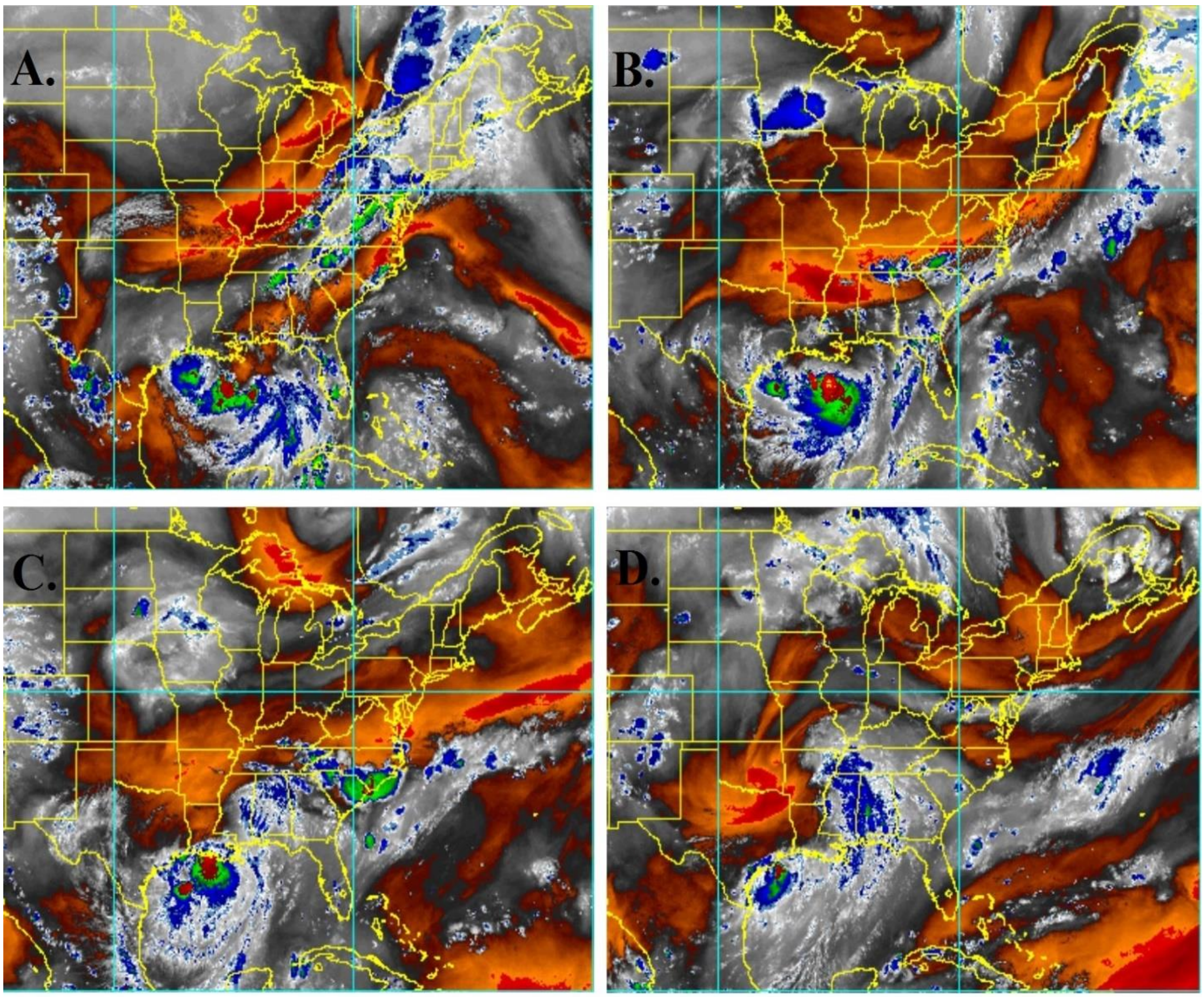

Figure 15. Water vapor imagery from GOES-East (14-km 6-hr). **A** – July 11th 20:00 UTC, **B** – July 12th 20:00 UTC, **C** – July 13th 20:00 UTC, and D – July 14th 20:00 UTC. Source Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University (CSU), National Oceanic and Atmospheric Administration (NOAA). Accessed July 17, 2019.

Conclusions

In Barry's wake were downed trees and power lines, cooler GOM SST's that show how efficient the storm was at removing energy (Figure 17), and rumblings from the public. As discussed, the initialization and tracking of Barry were done quite well, under the circumstances. Models did a great job showing storm development and movement; however, models did not do an adequate job forecasting precipitation totals. Post-storm chatter on talk radio on Monday, July 15th 2019, was highly critical of the forecasts and the "sensationalizaton" of the storm by media outlets. The aspersions being cast flooded the airwaves perhaps worse than the actual flooding produced by Barry, particularly in Baton Rouge and New Orleans. It is possible the heavy rainfall event observed on Wednesday, July 10th 2019 in New Orleans, that produced 203.2–254 mm (8–10 in.) in a matter of hours, set high expectations for Barry that never came to fruition.

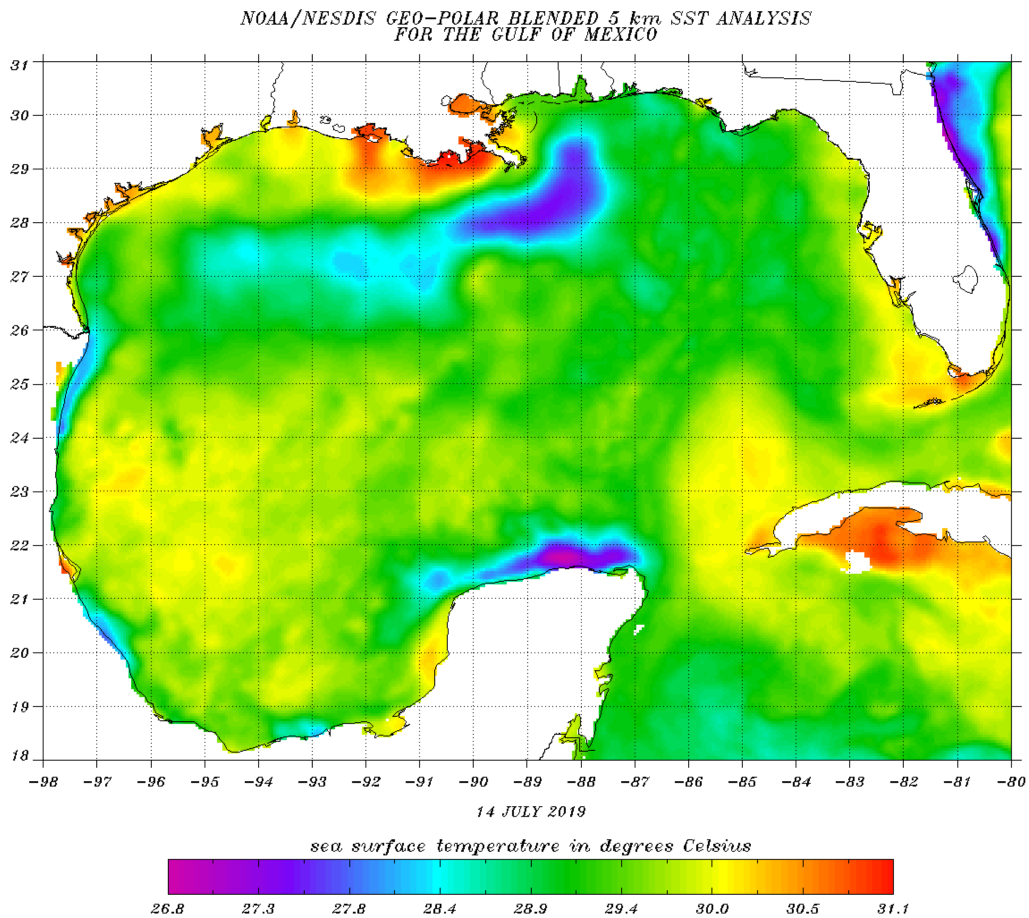

Figure 16. NOAA / NESDIS Geo-Blended 5-km SST Analysis for the GOMA post Hurricane Barry. Notice the sizeable pool of cool water produced behind Barry.