NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE HARVEY

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17 August – 1 September 2017

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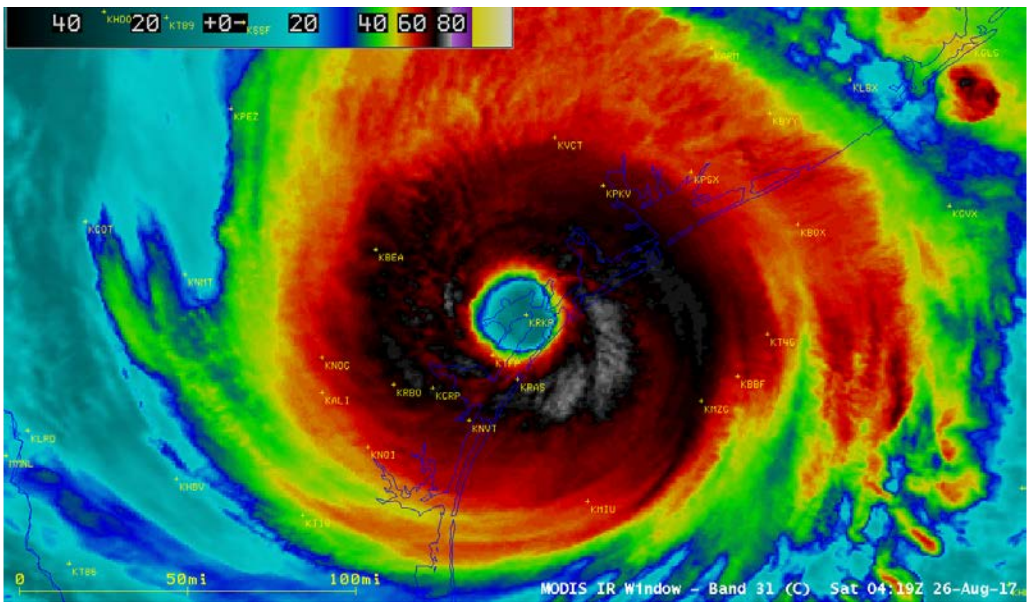

NASA TERRA MODIS INFRARED IMAGE OF HARVEY AT 0419 UTC 26 AUGUST 2017 JUST AFTER LANDFALL AS A CATEGORY 4 HURRICANE IN TEXAS. IMAGE COURTESY OF UW/CIMSS.

Harvey started as a typical weak August tropical storm that affected the Lesser Antilles and dissipated over the central Caribbean Sea. However, after re-forming over the Bay of Campeche, Harvey rapidly intensified into a category 4 hurricane (on the Saffir-Simpson Hurricane Wind Scale) before making landfall along the middle Texas coast. The storm then stalled, with its center over or near the Texas coast for four days, dropping historic amounts of rainfall of more than 60 inches over southeastern Texas. These rains caused catastrophic flooding, and Harvey is the second-most costly hurricane in U.S. history, after accounting for inflation, behind only Katrina (2005). At least 68 people died from the direct effects of the storm in Texas, the largest number of direct deaths from a tropical cyclone in that state since 1919.

[1] Original report date 23 January. Updated Montgomery county damage, tornado totals, corrected some typos, and added a picture of Nederland, Texas, rain gauge location.

Hurricane Harvey

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SYNOPTIC HISTORY

The wave that spawned Harvey moved off the west coast of Africa on 12 August with a large convective mass that had mostly dissipated by late the next day. Convection increased near the wave axis on 15 August, likely due to the passage of a convectively coupled Kelvin wave early that day (Fig. 1). A low pressure center formed early on 16 August, but easterly shear initially prevented any organization of the associated convection. The shear relaxed overnight, allowing deep convection to build near the center, and a tropical depression formed around 0600 UTC 17 August about 440 n mi east of Barbados. The depression became a tropical storm 12 h later. The "best track" chart of Harvey's path is given in Fig. 2, with the wind and pressure histories shown in Figs. 3 and 4, respectively. The best track positions and intensities are listed in Table 1[2].

Harvey moved quickly westward, south of a western Atlantic ridge, reaching an initial peak intensity of 40 kt early on 18 August. The storm's center passed over Barbados at 1000 UTC that day and St. Vincent five hours later, although most of the strong winds occurred away from those islands to the north of the center. Increasing northerly wind shear caused Harvey to gradually weaken back to a depression early on 19 August and to degenerate into a tropical wave by 1800 UTC that day over the central Caribbean Sea.

The remnants of Harvey moved rapidly to the west and west-northwest for the next couple of days, staying convectively active while they moved over the Yucatan Peninsula on 22 August. A low pressure area formed late that day in association with a short-lived burst of deep convection. The low moved west-northwestward into the Bay of Campeche early on 23 August and, shortly after 0600 UTC, more persistent deep convection increased near the low. By 1200 UTC, an Air Force Reserve reconnaissance aircraft found that the circulation of the low had become better-defined, indicating that Harvey had regenerated into a tropical depression when its center was located about 150 n mi west of Progreso, Mexico.

Initially, the depression was poorly organized with a large radius-of-maximum winds (RMW). This structure did not last for long as a smaller RMW formed, possibly due to concentrated deep convection near the center. Harvey began to rapidly intensify late on 23 August in an environment of light shear, very warm water and high mid-level moisture. The storm turned northward, steered around the western edge of the distant subtropical ridge, and the track gradually bent toward the northwest during the next day or two. The cyclone's rate of intensification increased early on 24 August as a large mass of deep convection formed over the center, and an eye was noted on reconnaissance observations by 1200 UTC that day. Harvey

[2] A digital record of the complete best track, including wind radii, can be found on line at ftp://ftp.nhc.noaa.gov/atcf. Data for the current year's storms are located in the *btk* directory, while previous years' data are located in the *archive* directory.

became a hurricane later on 24 August, and by that night a well-defined eye appeared in infrared satellite pictures. The hurricane reached category 3 status by midday on 25 August while it approached the middle Texas coast and intensified into a category 4 hurricane by 0000 UTC 26 August. Harvey's center made landfall on the northern end of San Jose Island about 5 n mi east of Rockport, Texas at 0300 UTC that day. Sustained winds of 115 kt and a minimum central pressure of 937 mb are estimated for that landfall. The hurricane then made a second landfall on the Texas mainland 3 h later, slightly weaker due to land interaction, with 105 kt winds and an estimated central pressure of 948 mb southeast of Refugio on the northeast coast of Copano Bay west of Holiday Beach. Harvey rapidly weakened over land to a tropical storm within 12 h after landfall and maintained a 35-kt intensity for the next day or so, aided by the sustaining effects of the southeastern portion of its circulation remaining over water.

The steady northwestward motion of the cyclone stopped as Harvey became embedded in light steering currents between one mid-tropospheric high over the Four Corners region and another high over the northern Gulf of Mexico. The storm made a slow loop late on 26 August into 27 August, and drifted eastward or southeastward for the next few days. Although the center passed well south of the Houston Metro and Golden Triangle (southeastern Texas between Beaumont, Port Arthur and Orange) areas, torrential rains fell in these locations near a stationary front on the north and east side of Harvey (see Figs. 12-15).

The storm center moved back offshore around 0300 UTC 28 August over Matagorda Bay, its winds slightly re-strengthening with deep convection reforming near and north of the center. However, the vertical wind shear was too strong for much intensification, and Harvey reached a final peak intensity of 45 kt late on 29 August. By that time, the storm turned to the north-northeast due to a strengthening ridge over the western Atlantic, its center never having moved more than 60 n mi offshore of the Texas Coast. Extremely heavy rains, however, continued on the north and northwest side of the tropical cyclone, most concentrated then near the Beaumont-Port Arthur area. Harvey made its final landfall in southwestern Louisiana at 0800 UTC 30 August near Cameron with 40-kt sustained winds. Thereafter, the cyclone slowly weakened over land, becoming a tropical depression late on 30 August. Harvey then moved northeastward over the southern United States while producing heavy rainfall, and it transformed into an extratropical cyclone by 0600 UTC 1 September over the Tennessee Valley. The cyclone dissipated over northern Kentucky late the next day.

METEOROLOGICAL STATISTICS

Observations in Harvey (Figs. 3 and 4) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), and objective Advanced Dvorak Technique (ADT) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Observations also include flight-level, stepped frequency microwave radiometer (SFMR), and dropwindsonde observations from 21 flights of the 53rd Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command and the NOAA Hurricane Hunters. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the

NASA Global Precipitation Mission (GPM), the European Space Agency's Advanced Scatterometer (ASCAT), and Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in constructing the best track of Harvey.

Ship reports of winds of tropical storm force associated with Harvey are given in Table 2, and selected surface observations from land stations and data buoys are given in Table 3.

Winds and Pressure

Harvey's maximum winds of 115 kt occurred during a several hour period concluding with its first Texas landfall. That intensity was based on a blend of peak SFMR measurements of 113 kt near 2122 UTC 25 August and maximum observed 700-mb flight-level winds of 129 kt at 2037 UTC and 2330 UTC 25 August. Both of those 700-mb winds support a surface wind of about 115 kt using a typical flight-level wind to surface wind reduction. Another SFMR measurement of 113 kt at 0419 UTC 26 August is thought to be unreliable due to shoaling. The highest *observed* sustained winds on land were 96 kt near Aransas Pass, with the highest *observed* gust being 126 kt near Rockport, Texas (Table 3). It should be noted, however, that the northeastern quadrant of the hurricane came ashore in an unpopulated and unmonitored area near San Jose Island and Matagorda Island, including Aransas National Wildlife Refuge, and the maximum winds were probably not sampled by any anemometer. An instrument near the entrance of Copano Bay failed before the highest winds arrived at that location.

The minimum pressure of Harvey is estimated to be 937 mb, based on a dropsonde measurement of 938 mb with 10 kt of surface wind at 0215 UTC 26 August. The lowest observed pressure on land was 940.8 mb reported by a storm chaser in Rockport at 0331 UTC 26 August. Another storm chaser reported a pressure of 932.8 mb in Rockport at about the same time, but this observation is questionable because other pressure readings in the area were several mb higher. It is also possible that this pressure was observed in an eyewall mesovortex, which would not be representative of the overall circulation.

Storm Surge[3]

The combined effect of the surge and tide produced maximum inundation levels of 6 to 10 ft above ground level to the north and east of Harvey's center landfalls in Texas in the back bays between Port Aransas and Matagorda, including Copano Bay, Aransas Bay, San Antonio Bay, and Matagorda Bay. Fig. 5 provides an analysis of maximum coastal inundation heights along the coasts of Texas and Louisiana from Harvey. The highest inundations (8 to 10 ft above ground level) likely occurred along the western shores of San Antonio Bay and adjacent Hynes Bay. The highest measured water level by a tide gauge was 6.7 ft above Mean Higher High Water (MHHW) at a Texas Coastal Ocean Observing Network (TCOON) site at Port Lavaca. Other notable TCOON tide gauge observations include 5.5 ft MHHW at Seadrift, 5.3 ft MHHW at Port Aransas, and 4.8 ft MHHW at the Aransas National Wildlife Refuge. Fig. 6 shows water levels relative to MHHW measured at tide gauges along the coasts of Texas and Louisiana.

Data from United States Geological Survey (USGS) storm tide pressure sensors and high water mark surveys from the back bays between Port Aransas and Matagorda provide evidence of inundations higher than those suggested solely by the National Ocean Service (NOS) or TCOON tide gauges. A sensor installed in Austwell, Texas, along the shore of Hynes Bay recorded a wave-filtered water level of 9.49 ft above the North American Vertical Datum of 1988 (NAVD88), which converts to 8.7 ft MHHW. In addition, a sensor installed in Port Lavaca recorded a water level of 8.82 ft NAVD88 (8.1 ft MHHW), while a sensor located in the upper reaches of Caranchua Bay measured a water level of 9.17 ft NAVD88 (8.4 ft MHHW). Various high water mark surveys conducted by the USGS and the National Weather Service (NWS) between Austwell and the Aransas National Wildlife Refuge suggested water levels as high as 11 to 12 ft MHHW, but these estimates likely contain the effects of wave runup and thus may be too high to represent actual inundation. The USGS storm tide sensor data, with considerations of sampling gaps, suggest that the highest inundations from Harvey were 8 to 10 ft above ground level.

Copano Bay, where Harvey made its second Texas landfall, also had significant storm surge flooding of 4 to 7 ft above ground level. A TCOON gauge near the entrance to Copano Bay recorded a maximum water level of 4.0 ft MHHW while a nearby USGS storm tide sensor measured a wave-filtered water level of 5.79 ft NAVD88 (5.1 ft MHHW). A survey conducted by the Corpus Christi NWS office also measured up to 7 ft of inundation above ground level at Holiday Beach on the northeastern side of Copano Bay.

Similar coastal flooding of 4 to 7 ft above ground level occurred in locations south of Port Aransas to the north entrance of the Padre Island National Seashore. In addition to the aforementioned Port Aransas gauge, which measured 5.3 ft MHHW, the TCOON gauge at

[3] 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).

Packery Channel measured a water level of 4.7 ft MHHW, and the USGS surveyed a high water mark of 6.4 ft above ground level near Port Aransas. Along the Gulf of Mexico side of the barrier island, a water level of 3.5 ft MHHW was measured at the Bob Hall Pier. Due to offshore winds on the west side of Harvey, less flooding (generally 1 to 3 ft above ground level) occurred in Corpus Christi Bay. A tide gauge at the USS Lexington in Corpus Christi measured a water level of 1.0 ft above MHHW. Less than 3 ft of inundation also occurred to the south in areas adjacent to Laguna Madre, including Padre Island.

Onshore winds to the east of Harvey's Texas landfall locations likely produced storm surge inundations of 4 to 7 ft above ground level along the barrier island from Port Aransas to Matagorda, however that area is unpopulated with no tide gauge observations. To the north and east, tide gauge observations indicate that water levels of 2 to 4 ft above ground level occurred from Matagorda through the upper Texas coast eastward to the central Louisiana coast due to storm surge. For example, the TCOON tide gauge at High Island recorded a peak water level of 4.1 ft MHHW while the gauge at San Luis pass measured a water level of 3.3 ft MHHW. In Louisiana, an NOS gauge at the Freshwater Canal Locks recorded a peak water level of 3.2 ft MHHW.

It must be noted that several tide gauges, particularly those in upper Galveston Bay near Houston and in Sabine Lake near Beaumont and Port Arthur, recorded peak water levels that were significantly affected by excessive rainfall runoff from Harvey's historic heavy rains. The most extreme cases were from two TCOON gauges on the east side of Houston: a station in Manchester measured a peak water level of 10.5 ft MHHW and a gauge at Lynchburg Landing recorded a peak water level of 7.3 ft MHHW. While these water levels are representative of the type of inundation that occurred in parts of the Houston area, the high values reported by these gauges were largely caused by excessive rainfall runoff and not storm surge.

Rainfall and Flooding

Harvey was the most significant tropical cyclone rainfall event in United States history, both in scope and peak rainfall amounts, since reliable rainfall records began around the 1880s. The highest storm total rainfall report from Harvey was 60.58 inches near Nederland, Texas (Fig. 7), with another report of 60.54 inches from near Groves, Texas. Both of these values (and from five other stations) exceed the previously accepted United States tropical cyclone storm total rainfall record of 52.00 inches at Kanalohuluhulu Ranger Station, Hawaii, in August of 1950 from Hurricane Hiki. A map of the storm-total rainfall associated with Harvey (or its post-tropical phase over the Ohio Valley) is given in Fig. 8.

For the continental United States, the previous tropical cyclone rainfall record was 48.00 inches in Medina, Texas from Tropical Storm Amelia in 1978. It is remarkable that during Harvey, eighteen values over 48 inches were recorded (Fig. 9) across southeastern Texas, with 36 to 48 inches recorded in the Houston metro area. These rains caused catastrophic flooding in Harris and Galveston counties, with 9 out of the 19 official river gauges in Harris County (which includes the city of Houston) recording all-time high flood stages. Table 3 shows selected heavy rain totals, and a full listing of rainfall reports can be found in a supplementary data file at: https://www.nhc.noaa.gov/data/tcr/supplemental/harvey_rain.xlsx.

Due to the severe limitations of measuring rainfall of this magnitude (e.g. many standard rain gauges filled up to a ~12 inch maximum and were unable to be emptied due the extreme rain rates), it is useful to look at the peak rain totals in other ways The multi-radar, multi-sensor quantitative precipitation estimation radar estimates (Fig. 10, for more details see: https://www.nssl.noaa.gov/about/events/review2015/science/files/Zhang_NSSLReview2015_MRMS-Hydro.pdf) were as high as 65-70 inches in southeastern Texas. Interestingly, there were few rainfall reports near the center of the radar-estimated maximum during Harvey in the vicinity of Port Arthur and the Lower Neches Wildlife Management Area (Fig. 10), and these radar estimates represent the highest rainfall that could have occurred (outside of the actual measurements).

While the peak rainfall amounts were exceptional over Texas, the areal extent of heavy rainfall is truly overwhelming, literally and figuratively. A comparison of historic United States tropical cyclone rainfall events is shown in Figs. 11a and b, with Harvey being compared to Allison (2001) and Beulah (1967). Large sections of southeastern Texas received 3 ft or more of rainfall in Harvey, whereas only very small portions of the Houston metro area had those totals in Allison. Beulah had one of the largest 10 inch or greater rain shields on record, similar to Harvey's. For any total above 15 inches, however, Harvey's area(s) are considerably larger. In fact, NOAA recently completed an analysis of annual exceedance probabilities for southeastern Texas (Fig. 12) after Harvey, with a large portion of that area experiencing a flood with less than a 1-in-1000 (0.1%) chance of occurring in any given year (e.g., a 1000-year or greater flood). While established records of this nature are not kept, given the exceptional exceedance probabilities, it is unlikely the United States has ever seen such a sizable area of excessive tropical cyclone rainfall totals as it did from Harvey.

The meteorological situation that caused Harvey to produce these extreme rains deserves additional explanation. While Harvey was very slow moving over Texas, not all drifting cyclones produce such torrential rain totals, and it is notable that the heaviest rainfall fell outside of the core of the cyclone. Harvey moved into a somewhat baroclinic environment over Texas, with slightly cooler and drier air over the southern United States behind a weak stationary front (Fig. 13). The weak front was situated across the Houston metro area from 26-27 August, enhancing surface convergence and lift within the very warm and humid air on the eastern side of Harvey, leading to several episodes of heavy rain. Upper-level divergence was also occurring near the front, further contributing to large and intense rain bands. The rain rates observed in these bands were exceptional, with 6.8 inches of rain in just one hour documented in southeastern Houston from extremely heavy rain bands training over the same location. The front hardly moved from 27-28 August (Figs. 14, 15), leading to the extreme rainfall totals in the Houston metro area since the main inflow band originated over the very warm waters of the northwestern Gulf of Mexico, which provided multiple influxes of warm and humid air. It should be noted that while the magnitude of this event was unprecedented, the synoptic situation was not, and previously has been associated with other tropical cyclone flood events near the coast.

By late on 28 August, the front was in the vicinity of the Beaumont/Port Arthur area, and Harvey's center had moved offshore. The cyclone had begun to lose some tropical characteristics with drier air wrapping around the core, but it still was advecting warm and moist air over the frontal boundary along the Texas/Louisiana coasts, producing abundant isentropic lift. The heaviest rainfall was occurring in a deformation zone on the north or northwest side of the cyclone, near the stationary front. While the rainfall was not as heavy as the 26 August event, 2-3 inches of rain per hour were still occurring in areas of Houston. The heaviest rain shifted eastward into Jefferson County on 28-30 August, which was located in the deformation zone and near the stationary front (Fig. 16), leading to the absolute rainfall maxima in that area.

Harvey also produced heavy rain over Louisiana, with a peak amount of 23.71 inches recorded west of Vinton. Radar data, however, suggests an estimate of about 40 inches for a maximum value, which is considered more representative of peak rainfall in that state since there were few observations over extreme southwestern Louisiana (e.g. Fig. 10). Lesser totals were measured as Harvey moved farther into the southern United States and Tennessee Valley on 31 August - 1 September, although there was a local maximum of about a foot of rain reported in Tennessee. These rains caused some significant flooding in Tennessee, especially in Robertson County.

Tornadoes

Harvey was a prolific tornado producer. There were 52 tornadoes preliminarily reported during Harvey (Fig. 17), about half of which occurred near and south of the Houston metro area. Over 150 tornado warnings were issued during the event. Tornadoes were also noted in Louisiana, Mississippi, Alabama and Tennessee as the cyclone moved near or over those states. Fortunately, almost all of the tornadoes were relatively weak, of EF-0 and EF-1 intensity, with generally minor damage, few injuries and no deaths attributed to them.

CASUALTY AND DAMAGE STATISTICS

Harvey is responsible for at least 68 direct deaths[4] in the United States, all in Texas. Over half of the deaths (36) were in Harris County in the Houston metro area. A county-by-county listing of the direct deaths is available in Table 4. All but three of the deaths were from freshwater flooding, and none of the deaths can be linked to the storm surge, which is quite remarkable for a category 4 hurricane landfall. Still, Harvey is the deadliest U.S. hurricane in terms of direct deaths since Sandy (2012) and is the deadliest hurricane to hit Texas since 1919. About 35 additional deaths are ascribed to indirect causes, such as electrocution, motor-vehicle crashes and isolation from necessary medical services. Four people were reported injured by a tornado north of Reform, Alabama.

[4] Deaths occurring as a direct result of the forces of the tropical cyclone are referred to as “direct” deaths. These would include those persons who drowned in storm surge, rough seas, rip currents, and freshwater floods. Direct deaths also include casualties resulting from lightning and wind-related events (e.g., collapsing structures). Deaths occurring from such factors as heart attacks, house fires, electrocutions from downed power lines, vehicle accidents on wet roads, etc., are considered “indirect” deaths.

The latest NOAA damage estimate from Harvey is $125 billion, with the 90% confidence interval ranging from $90 to $160 billion. The mid-point of the estimate would tie Katrina (2005) as the costliest United States tropical cyclone, which was also $125 billion (see https://www.ncdc.noaa.gov/billions/). However, the unadjusted costliest tropical cyclone list is not the most relevant record to examine because of inflation and other cost increases since 2005. A more reasonable comparison uses the Consumer Price Index (CPI)-adjusted technique, which modifies 2005 dollars to 2017. The adjustments make Katrina's total $161.3 billion in 2017 dollars, leading to Harvey being the 2nd costliest U.S. tropical cyclone. There is, however, still a large uncertainty in the total damage estimate (hence the large confidence interval). This is due to many factors, including that a majority of the residential flood loss claims are from outside the 500-year flood plain, where there is low National Flood Insurance Program (NFIP) participation, with tens of thousands of claims still outstanding.

The damage caused by Harvey's flooding was catastrophic over a large area of southeastern Texas. Over 300,000 structures in that region were flooded, with up to 500,000 cars reported flooded as well (e.g., Fig. 18). About 336,000 customers lost power during the hurricane. An estimated 40,000 flood victims were evacuated to or took refuge in shelters across Texas or Louisiana. FEMA reported that about 30,000 water rescues were conducted during Harvey.

The exceptional rainfall fell over some of the most densely populated areas of the U.S. Gulf Coast. Widespread flooding of homes and businesses occurred from the Houston metro area southward, and the floodwaters inundated major roads such as I-10, I-45, and US-59. Record water levels were observed on Buffalo Bayou, Clear Creek, Dickinson Bayou and Cypress Creek. Some of the hardest hit areas from flooding in the Houston metro area extended from Humble to Lake Houston, including the neighborhoods of Northshore, Bellaeu Woods, Riviera, Treasure Cove, Kings Lake Estates, Kings River, Kings Crown Estates, Kings River Estates, Atascocita Shores, Atascocita West, Ramblewood, Walden Subdivisions, and along the West Lake Houston Parkway, North Houston Ave., Thelma Road, Hamblen Road and Aqua Vista Drive. These were just some of the hundreds of subdivisions that suffered catastrophic flooding. During the height of the storm, controlled releases from Addicks and Barker Reservoirs were performed to prevent catastrophic dam failures, which further flooded some of the areas above. Record flooding along the east fork of the San Jacinto River led to flooded homes in Northwood Country Estates and River Terrace.

Farther south, catastrophic flooding was reported in League City, Friendswood and Dickinson in Galveston County, with extreme water levels leading to numerous water rescues across these areas and downtown Houston (Fig. 19). Primary and secondary roads in the area were inundated, including Bay Area Blvd., FM 528 and FM 518. At least 160,000 structures were flooded in Harris and Galveston counties.

Beyond the Houston metro area, the most serious flood damage was noted farther east in Texas over Jefferson, Orange, Hardin and Tyler counties, with about 110,000 structures (about one-third of the total structures damaged by Harvey) in those counties flooded. Flooding induced by widespread rainfall amounts of 40 inches resulted in several oil and gas refineries in the Golden Triangle area (southeastern Texas between Beaumont, Port Arthur and Orange) going offline for days, and consequently gas prices in the United States spiked to their highest levels in two years. Record water levels were seen on Pine Island Bayou, the Lower Neches River and Cow Bayou.

A bridge collapse occurred at the Highway 96 Bridge over Village Creek near Silsbee, and flood waters inundated parts of I-10 in Rose City, Vidor and near the city of Orange. Historic flooding was also reported in many cities across these counties, including Port Arthur, Lumberton, Warren, Groves, Bevil Oaks, Sour Lake, Hamshire, Fannett, China, Silsbee, Lakeview, Mauriceville and northeastern Beaumont.

Near the initial landfall location in Texas, wind damage was extreme in Aransas County, Nueces County, Refugio County and the eastern part of San Patricio County. Approximately 15,000 homes were destroyed in these areas, with another 25,000 damaged, and extensive tree damage was noted. Generally, the damage was most severe in the areas adjacent to Aransas Bay and Copano Bay, with the city of Rockport hit particularly hard. Coastal areas of the counties above and Calhoun County were inundated with storm surge, and many marinas reported serious damage or destruction of boats, docks and piers. This includes State Highway 361 which was inundated along the entire stretch of Mustang Island. The surge also damaged or destroyed many coastal structures in Port Aransas, Holiday Beach, Copano Village, Lamar, Seadrift, North Padre Island and Mustang Island. Erosion from surge near the Packery Channel caused an interruption to the primary water supply to Port Aransas for six days. Corpus Christi was spared the worst of the hurricane's effects, with widespread but mostly minor damage reported. At the peak, roughly 220,000 customers lost power.

In Fort Bend County, major flooding occurred with both the Brazos and San Bernard Rivers experiencing record floods. Major-to-record flooding occurred along the Brazos River from Richmond to Rosharon. Significant home flooding occurred in areas of Simonton, Richmond, Rosenburg, and Thompsons. Nearly 200,000 people were evacuated due to levee concerns and restrictions. Major-to-record flooding also occurred on the San Bernard River at both East Bernard and Boling, with the hardest hit area being Tierra Grande. At least 8,500 homes in this county were damaged by Harvey.

In Brazoria County, the Brazos and San Bernard Rivers experienced record water levels, which caused widespread floods across the county. The hardest hit communities were in Baileys Prairie, Richard and West Columbia. Widespread major flooding on the Brazos River and Oyster Creek led to numerous roads and homes flooding in Columbia Lakes, Mallard Lakes, Great Lakes, Riverside Estates and the Bar X Ranch subdivisions, as well as homes on CR 39. Flooding damaged the bridge over Cow Creek at CR 25, making it impassable. Major flooding also occurred along the San Bernard River at Sweeny with widespread inundation of the west floodplain. The Phillips 66 refinery took on water near Little Linville Bayou. Hanson Riverside Park was inundated, and water overtopped the Phillips Terminal, halting all vessel traffic. High flows from the Brazos and San Bernard Rivers caused navigation problems for several weeks. Over 9,000 homes experienced flood damage from the storm.

In Wharton County, widespread catastrophic flooding occurred from both the Colorado and San Bernard Rivers, causing Highway 59 to close between Hungerford and El Campo. The flooding inundated areas of Wharton, with hundreds of homes and businesses under water in many communities including Hobben Oaks, Bear Bottom, Elm Grove, River Valley and Pecan Valley. Other areas such as Glenflora, Peach Acres and the Orchard were hard hit. Major-to-record flooding also occurred on the San Bernard River at both East Bernard and Boling, with the hardest hits areas being El Lobo and New Gulf. Major lowland flooding occurred with many homes (including some on the second-story) and businesses being inundated, and the cotton crop was decimated. An estimated 2,000 homes were damaged or destroyed in the county.

Major lowland flooding occurred in Matagorda County along the Tres Palacios River. Many roadways were under water, and homes in the El Dorado Country, Oak Grove, and Tres Palacios Oaks subdivisions flooded. Major flooding also occurred on the Colorado River at Bay City as levees were overtopped by 2 ft of water. High flows from the Colorado and Tres Palacios Rivers impacted river navigation for several weeks. Roughly 2,900 homes were damaged in the county.

In San Jacinto County, major lowland flooding occurred on the Trinity River near Goodrich with damage and debris noted near the boat ramp and channel in proximity to the river gauge. Major flooding occurred upstream near Lake Livingston, with roads and many homes south of the lake being inundated. About 3,300 homes were damaged in the county.

In Montgomery County, widespread catastrophic flooding occurred along the San Jacinto River and its tributaries, and along Lake, Spring, Caney and Peach Creeks. Record pool elevations were observed at Lake Conroe, leading to a record water release which exacerbated flooding downstream. The flooding resulted in over 300 road closures and all major thoroughfares including SH 242, SH 105, US 59 and I-45. County first responders completed over 6000 high-water rescues. The hardest hit subdivisions included River Oaks, Mccade Park and Estates, Woodloch, Whispering Oaks, Chateau Woods, Benders Landing, Del Lago, Walden, Spring Forest, Clear Creek Forest, Shadow Bay, Timber Lakes, Timber Ridge and Fox Run. Over 4,100 houses were damaged or destroyed by the flooding.

Major-to-record flooding occurred in Liberty County along the Trinity River with numerous roads inundated including FM 787. Many homes and subdivisions were either cut off or inundated, specifically north of the city of Liberty and in the Grenada Lakes Estates subdivision. Significant damage occurred along the banks of the river due to high flows and several utility lines were severed due to the loss of poles in the vicinity of the Romayor gauge. Record river levels were also observed on the east fork of the San Jacinto River causing significant flooding in Cleveland, Williams and Plum Grove. High flows caused significant scouring of the state 105 (business) road; other roads were washed out as well, with bridge washouts or closures observed in many parts of the county. At least 1,000 homes were damaged in the county.

In Chambers County, record floods over the lowlands occurred along the Trinity River. Cedar Bayou was out of its banks in many locations, with significant flooding observed in Baytown. Numerous roads and homes were inundated across the county, including extensive flooding in the Milam Bend subdivision. High flows from the Trinity River impacted the navigation community for several weeks. An estimated 3,000 homes were damaged, and numerous businesses had significant damage.

In Jasper and Newton counties, an estimated 20 to 40 inches of rain fell across the area. This rainfall lead to major flooding, with over 4,000 homes flooded in Jasper County and about 2,000 in Newton County. The hardest hit areas were Kirbyville, Buna, Weiss Bluff, Trout Creek, Call and along the Sabine River. River gauges on the Neches and Sabine rivers had levels up to their second highest crests on record, and Big Cow Creek at Newton recorded its highest on record.

In Fayette County, a widespread area of 25 to 30 inches of rain produced major flooding along the Colorado River and produced the third highest crest ever at La Grange. Much of the city of La Grange below Waters Street was flooded. There were over 400 flooded homes and businesses flooded in La Grange and across the county. Two hundred of the homes sustained major flood damage including dozens of businesses that were flooded in downtown La Grange. Less severe flooding occurred in DeWitt County near Cuero from the Guadalupe River.

Louisiana received relatively minor damage compared to Texas. Still, roughly 2,000 homes flooded in Calcasieu, Beauregard, and Cameron Parishes, with many flooded roads and rivers noted. Many of these homes were located along the Sabine River, which recorded its second highest crest on record at Orange. Eastern sections of Lake Charles, Chennault eastward to Iowa and northward to Moss Bluff were hit with flooding late on 27 August.

Very heavy rain in Tennessee caused minor damage. The Memphis area had flooding and over 19,000 customers lost power, with winds gusting to 52 kt at the airport. More significant flooding was reported in Robertson County (Nashville area), with 13 residents in the Chestnut Flats Apartment near the Nashville Fairgrounds evacuated due to the high water. In addition, the downtown Nashville Goodwill Industries reported major flooding, and about 10,000 customers were out of power at one time in that city.

Much of the damage summaries in this section came from the Post Tropical Cyclone Reports from the Corpus Christi, San Antonio, Houston and Lake Charles NWS offices. Further local details are available in their summaries at: http://www.weather.gov/crp/hurricane_harvey, https://www.weather.gov/ewx/wxevent-2017harvey, http://www.weather.gov/hgx/hurricaneharvey and https://www.weather.gov/lch/2017harvey.

FORECAST AND WARNING CRITIQUE

NHC anticipated with limited lead time Harvey's formation to the east of the Caribbean Islands (Table 5a). NHC introduced the 5-day potential for tropical cyclone development into the Tropical Weather Outlook (TWO) in the low category (<40%) about 4 days before genesis occurred. It raised the probability to the medium (40-60%) category 3 days before formation, and the 2-day probability only reached the medium category 12 h before genesis occurred. In neither forecast time period did the probability reach the high category (>60%). The re-formation of Harvey was well-forecast by NHC (Table 5b), with the system re-entering the outlook 78 h before genesis occurred again with a medium chance of formation during the next 5 days. The remnants of Harvey in the Caribbean were given a high (>60%) chance of genesis in the 2-day outlook 42 h before reformation occurred — an excellent forecast by current standards.

A verification of NHC official track forecasts for Harvey is given in Table 6a. Official forecast track errors were much lower than the mean official errors for the previous 5-yr period, although the OCD5 (climatology) errors were also quite low, indicating that these forecasts were “easier” than average. A homogeneous comparison of the official track errors with selected guidance models is given in Table 6b. Generally the NHC official forecast (OFCL) beat much of the guidance except for the consensus aids (TVCN, TVCX). Among the individual deterministic models, the ECMWF (EMXI), UKMET (EGRI) and COAMPS (CTCI) models all did well at some of the forecast times, mostly centered in the middle range of the forecast period. Much of the GFS-based guidance (GFSI, AEMI and HWFI) did not have a particularly good performance for Harvey.

A verification of NHC official intensity forecasts for Harvey is given in Table 7a. Official forecast intensity errors were above the mean official errors for the previous 5-yr period through 48 hours, then considerably lower than average after that through 5 days. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 7b. The NHC intensity forecast performed better than all of the intensity model guidance at 12, 96 and 120 h but was worse than all of guidance at 36 and 48 h. This unusual dichotomy appears to be due to the cyclone weakening faster than expected over land at 36 and 48 h, but NHC correctly forecasting Harvey to stay a weak cyclone at long range, with almost every forecast point verifying over land. In general, the intensity model consensus (IVCN) was the best model aid, and was superior to any other forecast (including OFCL) from 24-48 h. The Decay-SHIPS (DSHP) and Florida State Superensemble (FSSE) models had relatively poor performances compared to the other guidance.

Initially, the rapid intensification (RI) of Harvey after its re-formation was not well-anticipated, but most of the guidance had Harvey near hurricane intensity before landfall in Texas (Fig. 20). The next day, however, most of the historically reliable guidance aids showed Harvey rapidly intensifying, although the guidance was still too low (Fig. 21). A NHC Special Advisory issued at 1800 UTC 24 August, 33 h before landfall (not shown), forecast RI and verified within 5 kt of the intensity near landfall, which was an outstanding forecast.

Watches and warnings for winds associated with Harvey are given in Table 8. A Hurricane Watch was first issued at 1500 UTC 23 August and a Hurricane Warning was first issued at 0900 UTC 24 August. These watches and warnings were issued about 48 and 36 hours, respectively, before tropical-storm-force winds affected the Texas coast, close to the desired lead times. The possibility of hurricane-force winds to affect the Texas coast was first mentioned in the Tropical Weather Outlook, over 72 hours before they occurred, which is believed to be a first for a system that had not yet (re)formed.

The NHC began providing direct support to emergency managers on 22 August, as Harvey was re-forming over the Yucatan Peninsula and continued through 30 August, when Harvey made its final landfall in SW Louisiana. This decision support included calls and briefings coordinated through the FEMA Hurricane Liaison Team, embedded at the NHC. The briefings included the states of Texas and Louisiana, FEMA Region 6 as well as Federal/State video-teleconferences. The NHC also collaborated with the affected NWS offices to ensure a consistent message, and NWS meteorologists provided Impact-based Decision Support Services (IDSS), for local and state emergency management offices during this event. In addition, the NHC director maintained direct communications with senior state emergency management officials to discuss the evolving threat to Texas. For the first part of Harvey's track, the NHC provided support to many government meteorological services for areas around the Caribbean Sea, including Barbados (which has responsibility for Dominica, St. Vincent and the Grenadines), France (for Martinque and Guadeloupe), St. Lucia, Aruba, Belize and Mexico.

At various points in time, the NWS issued storm surge warnings for portions of the Texas coast from Port Mansfield to High Island and for portions of the Louisiana coast from Holly Beach to Morgan City. The NWS issued storm surge watches for other portions of the Texas coast south of Port Mansfield to the mouth of the Rio Grande, east of High Island to Holly Beach, and for the coasts of Galveston Bay and Sabine Lake. The NWS issued the initial Storm Surge Watch for Harvey along the Texas coast from Port Mansfield to High Island at 1500 UTC 23 August (Table 9). The initial Storm Surge Warning was issued from Port Mansfield to San Luis Pass, Texas, at 0900 UTC 24 August. Water level observations indicate that at least 3 ft of inundation (which NHC uses as an initial threshold for the storm surge watch/warning) occurred in areas within the bounds of the storm surge warning area in Texas (see Fig. 6).

The NHC's first forecast for maximum storm surge heights (at 1500 UTC 23 August) was 4 to 6 ft above ground level within the storm surge watch area, and that forecast was gradually raised to 6 to 12 ft above ground level within the area between the north entrance of the Padre Island National Seashore to Sargent at 1800 UTC 24 August. Later that evening, maximum storm surge heights were increased to 9 to 13 ft above ground level in the area from Port Aransas to Port O'Connor. The maximum observed storm surge heights of 8 to 10 ft above ground level occurred within that outlined region in the back bays between Port Aransas and Port O'Connor.

Before the Louisiana landfall of Harvey, the NWS issued a Storm Surge Watch from Port Bolivar, Texas, to Morgan City, Louisiana, at 2100 UTC 28 August, and a portion of that area from Holly Beach to Morgan City was upgraded to a Storm Surge Warning at 2100 UTC 29 August for expected inundations of 2 to 4 ft above ground level, especially in Vermilion Bay. Although there were no tide gauges where the highest inundation occurred, storm surge simulation hindcasts indicate that 2 to 4 ft of inundation above ground level occurred in portions of Vermilion Bay.

The storm surge watches and warnings for Harvey were the first operational issuance of these products for the NWS, which have been in development for the past several years. It is hoped that this new capability, along with the storm surge inundation graphic and major outreach efforts during that time, were factors in there being no surge-related deaths from this category 4 hurricane. In addition, an NHC media pool was in full operation from 24-26 August to provide live briefings to national and local television outlets in both English and Spanish, and an additional 200 media phone interviews were conducted. NHC was also active on social media to keep the public informed in real-time on the latest NHC/NWS forecasts and warnings, with posts on Twitter generating 35 million impressions and Facebook posts reaching more than 5.5 million users and causing 2.9 million post engagements.

The rainfall forecasts for Harvey, issued by the Weather Prediction Center (WPC), were the highest on record for any U.S. tropical cyclone event and deserve some comment. When Harvey re-formed in the Gulf of Mexico, the initial maximum rainfall forecast was for 20" in southeastern Texas (Fig. 22). These rainfall forecasts were gradually increased to a peak of 40" several hours before Harvey made landfall in Texas, roughly 24-36 hours before the extreme rains began in the Houston metro area. These totals were further raised to 50" about a day before the center of Harvey left Texas.

Table 1. Best track for Hurricane Harvey, 17 August – 1 September 2017.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
16 / 0600	13.7	45.8	1013	25	low
16 / 1200	13.7	47.4	1010	25	"
16 / 1800	13.6	49.0	1009	25	"
17 / 0000	13.6	50.6	1010	25	"
17 / 0600	13.4	52.0	1008	25	tropical depression
17 / 1200	13.1	53.4	1008	30	"
17 / 1800	13.0	55.0	1004	35	tropical storm
18 / 0000	13.0	56.6	1003	40	"
18 / 0600	13.0	58.4	1004	40	"
18 / 1000	13.1	59.6	1004	40	"
18 / 1200	13.1	60.3	1004	40	"
18 / 1500	13.2	61.2	1004	40	"
18 / 1800	13.2	62.2	1005	35	"
19 / 0000	13.4	64.0	1005	35	"
19 / 0600	13.5	65.7	1005	35	"
19 / 1200	13.7	67.5	1006	30	tropical depression
19 / 1800	13.8	69.2	1007	30	tropical wave
20 / 0000	14.0	71.0	1007	30	"
20 / 0600	14.2	72.9	1007	30	"
20 / 1200	14.4	75.0	1006	30	"
20 / 1800	14.7	76.8	1007	30	"
21 / 0000	15.1	78.6	1007	25	"
21 / 0600	15.7	80.5	1008	25	"
21 / 1200	16.4	82.5	1008	25	"
21 / 1800	17.3	84.6	1008	25	"
22 / 0000	18.0	86.4	1008	25	"

22 / 0600	18.6	87.8	1009	25	"
22 / 1200	19.4	88.8	1010	25	"
22 / 1800	20.0	89.7	1010	25	low
23 / 0000	20.5	90.7	1009	25	"
23 / 0600	20.9	91.6	1008	25	"
23 / 1200	21.4	92.3	1006	30	tropical depression
23 / 1800	21.6	92.4	1005	35	tropical storm
24 / 0000	22.0	92.5	1003	40	"
24 / 0600	22.8	92.6	997	50	"
24 / 1200	23.7	93.1	986	60	"
24 / 1800	24.4	93.6	978	70	hurricane
25 / 0000	25.0	94.4	973	80	"
25 / 0600	25.6	95.1	966	90	"
25 / 1200	26.3	95.8	949	95	"
25 / 1800	27.1	96.3	943	105	"
26 / 0000	27.8	96.8	941	115	"
26 / 0300	28.0	96.9	937	115	"
26 / 0600	28.2	97.1	948	105	"
26 / 1200	28.7	97.3	978	65	"
26 / 1800	29.0	97.5	991	50	tropical storm
27 / 0000	29.2	97.4	995	45	"
27 / 0600	29.3	97.6	998	40	"
27 / 1200	29.1	97.5	998	35	"
27 / 1800	29.0	97.2	998	35	"
28 / 0000	28.8	96.8	997	35	"
28 / 0600	28.6	96.5	997	40	"
28 / 1200	28.5	96.2	997	40	"
28 / 1800	28.4	95.9	997	40	"
29 / 0000	28.2	95.4	996	40	"
29 / 0600	28.1	95.0	996	40	"

29 / 1200	28.2	94.6	995	40	"
29 / 1800	28.5	94.2	993	45	"
30 / 0000	28.9	93.8	994	45	"
30 / 0600	29.4	93.6	990	40	"
30 / 0800	29.8	93.5	991	40	"
30 / 1200	30.1	93.4	992	40	"
30 / 1800	30.6	93.1	996	35	"
31 / 0000	31.3	92.6	998	30	tropical depression
31 / 0600	31.9	92.2	999	25	"
31 / 1200	32.5	91.7	1001	20	"
31 / 1800	33.4	90.9	1001	25	"
01 / 0000	34.1	89.6	1000	30	"
01 / 0600	34.9	88.2	1002	30	extratropical
01 / 1200	36.0	87.1	1002	25	"
01 / 1800	36.5	86.4	1004	20	"
02 / 0000	37.2	85.6	1007	20	"
02 / 0600	37.9	84.9	1009	20	"
02 / 1200	38.2	84.7	1013	15	"
02 / 1800					dissipated
18 / 1000	13.1	59.6	1004	40	landfall on the southern end of Barbados
18 / 1500	13.2	61.2	1004	40	landfall on St. Vincent
26 / 0300	28.0	96.9	937	115	minimum pressure, maximum winds and landfall on San Jose Island, TX
26 / 0600	28.2	97.1	948	105	landfall on the northeast end of Copano Bay, west of Holiday Beach, TX
30 / 0800	29.8	93.5	991	40	landfall near Cameron, LA

Table 2. Selected ship reports with winds of at least 34 kt for Harvey.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
25 / 0600	WDE958	27.0	91.7	080 / 40	1006.7
25 / 0600	A8PQ7	27.4	91.9	130 / 35	1008.0
25 / 0600	WBYQ	27.6	91.8	090 / 37	1010.1
25 / 0600	WDF476	28.0	92.7	140 / 55	1009.4
25 / 0700	A8PQ7	27.3	91.8	130 / 35	1008.0
25 / 0900	WLMQ	22.1	92.0	230 / 45	1007.2
25 / 1100	C6FN5	25.9	88.6	020 / 35	1008.1
25 / 1200	WNFQ	28.0	92.7	120 / 35	1008.3
25 / 1500	LAIG7	28.5	93.3	140 / 42	1012.0
26 / 0500	3FMK7	28.9	93.2	130 / 38	1012.0
28 / 1200	WGAX	28.3	93.0	190 / 45	1006.8
28 / 2000	2CWB5	28.1	92.7	330 / 46	1006.0
29 / 2300	WFAF	27.7	87.6	130 / 41	1013.2
30 / 0300	WFAF	28.3	88.5	110 / 36	1016.1
30 / 1100	3FNZ5	29.9	93.9	340 / 40	995.3
30 / 1500	LAIG7	27.5	91.7	250 / 37	1010.0

Table 3. Selected surface observations for Harvey, 17 August – 1 September 2017.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Martinique									
International Civil Aviation Organization (ICAO) Sites									
Martinique Aimé Césaire International Airport (TFFF) (14.59N 61.00W)			18/1400	29	44				
St. Lucia									
International Civil Aviation Organization (ICAO) Sites									
Hewanorra International Airport (TLPL) (13.73N 60.95W)			18/1318	23	43				
George F.L. Charles Airport (TLPC) (14.02N 60.99W)			18/1400	18	39				
Offshore Sites									
NOAA Buoys									
Corpus Christi, TX (42020)[G] (26.97N 96.69W)	25/1850	980.6	25/1850	52[F] (5 m, 10 min)	64				
Freeport, TX (42019) (27.91N 95.35W)	28/2350	997	25/1930	35 (5 m, 10 min)	47				
Galveston, TX (42035) (29.23N 94.41W)	29/2000	995.5	29/2230	38 (5 m, 10 min)	52				
TGLO TABS Buoy J (42044) (26.19N 97.05W)	25/1100	1000.2	25/1130	27 (3.4 m, 10 min)	34				
TGLO TABS Buoy K (42045) (26.22N 96.50W)	25/1330	990.6	25/1400	37 (3.4 m, 10 min)	49				
Oil Platforms									

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Eugene Island 215 (KEIR) (26.19N 97.05W)	30/0948	1002.5	30/1230	34 (24.7 m)	41	3.1	4.68		
Mississippi Canyon 311a (KMDJ) (26.22N 96.50W)			30/0535	36 (90 m)	48				
United States									
Alabama									
International Civil Aviation Organization (ICAO) Sites									
Lowe Army Heliport (KLOR) (31.33N 85.75W)									4.39
Mobile Downtown Airport (KBFM) (30.63N 88.07W)									4.73
Mobile Regional Airport (KMOB) (30.69N 88.24W)									6.22
Weatherflow Sites									
Orange Beach/Mill Point (XMLP) (30.30N 87.51W)			30/0902	23 (5.5 m, 5 min)	35				
Other Sites									
Ariton 4 W (ARTA1) (31.59N 85.78W)									5.28
Atmore 12 N (ATMA1) (31.17N 87.44W)									4.50
Daleville 2 W (DALA1) (31.34N 85.75W)									5.40
Sellerville 1 E (SLLA1) (31.13N 85.98W)									4.40
Semmes 5 SW (BCDA1) (30.72N 88.30W)									8.04

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Silverhill 3 W (FSHA1) (30.55N 87.8W)									6.20
Skipperville 3 ENE (SKPA1) (31.58N 85.50W)									4.72
Arkansas									
International Civil Aviation Organization (ICAO) Sites									
Monticello Municipal Airport (KLLQ) (33.64N 91.75W)									3.20
Stuttgart Municipal Airport (KSGT) (34.60N 91.57W)									4.31
Other Sites									
Beedeville 4 NE (BDVA4) (35.47N 91.05W)									4.40
Florida									
International Civil Aviation Organization (ICAO) Sites									
Bob Sikes Airport (KCEW) (30.78N 86.52W)									5.69
Destin Executive Airport (KDTS) (30.40N 86.47W)									4.53
Pensacola International Airport (KPNS) (30.47N 87.19W)									7.99
Other Sites									
Chipley (CHPF1) (30.78N 85.48W)									3.55
Geneva 5 ESE (GNEF1) (28.72N 81.04W)									3.57
Milton 7 ESE (MLYF1) (30.57N 86.92W)									4.18

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)C	Storm tide (ft)D	Estimated Inundation (ft)E	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)A	Sustained (kt)B	Gust (kt)				
Oldsmar 2 W (TBFF1) (28.05N 82.71W)									4.99
Georgia									
Other Sites									
Adel 7 W (31.16N 83.54W)									3.02
Donalsonville (DNVG1) (31.03N 84.89W)									3.17
Kentucky									
International Civil Aviation Organization (ICAO) Sites									
Campbell Army Airfield/Fort Campbell (KHOP) (36.67N 87.49W)			01/0725	29 (10 m, 2 min)	41				4.40
Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) Sites									
Auburn 0.3 SW (KY-LG-4) (36.86N 86.72W)									8.55
Auburn 2.6 SSW (KY-LG-5) (36.83N 86.74W)									8.76
Bowling Green 1.6 SW (KY-WR-26) (36.98N 86.46W)									8.23
Guthrie 0.8 WNW (KY-WR-28) (36.65N 87.18W)									7.80
Hodgenville 0.1 SSW (KY-AL-17) (37.57N 85.74W)									6.89
Russellville 1.3 NNE (KY-LG-3) (36.86N 86.89W)									8.02
Scottsville 4.9 NE (KY-AL-11) (36.88N 86.17W)									7.65

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Smiths Grove 0.3 SE (KY-WR-26) (37.05N 86.20W)									8.19
Valley Station 1.6 NNE (KY-JF-21) (38.13N 85.85W)									6.52
Other Sites									
Alvaton (ALVK2) (36.90N 86.38W)									10.68
Bowling Green (BWGK2) (37.00N 86.43W)									11.22
Finney (BRRK2) (36.90N 86.13W)									7.58
Louisiana									
International Civil Aviation Organization (ICAO) Sites									
Abbeville/Chris Crusta Memorial Airport (KIYA) (29.98N 92.08W)	30/1035	1001	30/2055	25 (10 m, 2 min)	34				
Belle Chasse Naval Air Station (KNBG) (29.82N 90.03W)	30/1055	1006.6	30/1955	26 (10 m, 2 min)	36				
Boothville (KBVE) (29.33N 89.40W)	30/1159	1007.8	30/1422	31 (10 m, 2 min)	42				0.46
Cameron (KCVW) (29.78N 93.30W)	30/0805	992.9	30/0735	30 (10 m, 2 min)	42				
De Quincy Industrial Air Park (K5R8) (30.44N 93.47W)	30/1015	994.2	30/2035	22 (10 m, 2 min)	34				
Fort Polk (KPOE) (31.04N 93.19W)	30/1333	998.6	26/2020	25 (10 m, 2 min)	36				15.04
Galliano (KGAO) (29.44N 90.26W)			30/1855	24 (10 m, 2 min)	35				

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Lafayette Regional Airport (KLFT) (30.21N 91.98W)	30/1054	1001	30/2148	26 (10 m, 2 min)	36				7.90
Lake Charles Regional Airport (KLCH) (30.13N 93.23W)	30/0905	993.9	30/0932	25 (10 m, 2 min)	39				14.52
New Iberia/Acadiana Regional Airport (KARA) (30.03N 91.88W)	30/1053	1001.7	30/2100	24 (10 m, 2 min)	35				9.12
New Orleans Lakefront Airport (KNEW) (30.04N 90.03W)	30/1008	1005.8	30/1551	35 (10 m, 2 min)	49				5.33
Port Fourchon (KXPY)			30/1915	26 (10 m, 2 min)	41				
Sulphur/Southland Field Airport (KUXL) (30.13N 93.38W)	30/0145	1001.3	28/1235	22 (10 m, 2 min)	34				
Louisiana State University Coastal Studies Institute Sites									
South Pelto Block (SPLL1) (29.20N 89.43W)			30/1700	34 (10 m, 8 min)	41				
National Ocean Service (NOS) Sites									
Amerada Pass (AMRL1 / 8764227) (29.45N 91.34W)	30/0942	1003.2	29/0812	18 (11m)	25	3.09	3.74	2.9	
Berwick (TESL1 / 8764044) (29.67N 91.24W)	30/0948	1003.5	30/1206	25 (12.5m)	33	2.40		1.5	
Bulk Terminal (8767961) (30.19N 93.30W)						3.56		3.2	
Calcasieu Pass (CAPL1 / 8768094) (29.77N 93.34W)	30/0748	992.0	28/0554	34 (12.3m)	44	2.94		2.8	
Eugene Island (8764314) (29.37N 91.38W)	30/0948	1002.5	30/1230	35	42	3.12		2.8	

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Freshwater Canal Locks (FRWL1 / 8766072) (29.55N 92.31W)	30/0930	999.6	30/0912	31 (19.5m)	40	3.99		3.2	
Grand Isle (GISL1 / 8761724) (29.26N 89.96W)	30/0848	1006.7	30/1542	23	34 (9.3m)	1.22		1.3	
Lake Charles (LCLL1 / 8767816) (30.22N 93.22W)	30/0942	994.3				3.73		3.6	
Port Fourchon, Belle Pass (8762075) (29.11N 90.20W)						1.28		1.3	
United States Geological Survey Sites									
Bayou Grand Caillou (29.38N 90.72W)						1.8[H]	3.01		
Grand Isle (29.27N 89.95W)						1.8[H]	3.05		
Lafitte (29.48N 90.01W)						1.6[H]	2.65		
United States Army Corps of Engineers Sites									
Houma Navigation Canal (29.39N 90.73W)						1.5[H]	2.81		
Mandeville (30.37N,90.09W)						2.5[H]	3.49		
Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) Sites									
Goldonna 1.5 N (LA-NT-5) (32.04N 92.91W)									12.76
Iowa 0.9 ESE (LA-CC-3) (30.23N 93.00W)									16.66
Iowa 9.7 NNW (LA-CC-9) (30.37N 93.07W)									17.44

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Natchitoches 4.8 WNW (LA-NT-3) (31.79N 93.17W)									12.82
Noble 1.8 ESE (LA-SN-7) (31.68N93.32W)									13.10
Pleasant Hill 10.2 SE (LA-SN-3) (31.70N 93.41W)									15.05
Ragley 5 SE (LA-BG-2) (30.47N 93.16W)									16.16
Sulphur 2.2 E (LA-CC-6) (30.23N 93.32W)									13.23
Weatherflow Sites									
Cameron (XCAM) (29.78N 93.29W)			30/1250	36 (10.4 m, 1 min)	43				
Dulac (XDUL) (30.04N 90.02W)	30/0804	1003.8	30/1639	27 (10.4 m, 1 min)	36				
Kenner Pontchartrain Causeway (XPTN) (30.20N 90.12W)			30/2007	33 (12.5 m, 1 min)	37				
Mandeville (XMVL) (30.36N 90.09W)			30/1854	30 (10.4 m, 1 min)	35				
New Orleans Lakefront (XLKF) (29.34N 90.73W)			30/1926	28 (10.4 m, 1 min)	49				
Venice East Bay – Tower (XEBT) (29.06N 89.30W)			30/1717	29 (15.2 m, 5 min)	40				
Waggaman Jefferson Parish (XJEF) (29.94N 90.23W)			30/1817	22 (10.4m , 1 min)	35				
Remote Automated Weather Station (RAWS) Sites									
Hackberry (HAKL1) (29.89N 93.40W)			30/1249	27	42				

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Lacassine (30.00N 92.89W)			30/2056	27	38				
Natchitoches (NATL1) (31.29N 93.11W)									13.04
Other Sites									
Bell City 13 SW (BELL1) (29.97N 93.09W)									22.04
Grand Chenier 9 ESE (GCHL1) (29.73N 92.82W)									15.98
Hackberry 8 SSW (HCKL1) (29.88N 93.42W)									20.71
Lake Arthur (LWRL1) (30.07N 92.68W)									13.30
Lake Charles (LCHL1) (30.25N 93.22W)									17.28
Leesville (LEEL1) (31.13N 93.25W)									16.60
Moss Bluff (MBFL1) (30.30N 93.22W)									18.97
Moss Bluff (MBLL1) (30.30N 93.20W)									20.81
Old Town Bay 6 NE (OTBL1) (30.28N 93.13W)									22.19
Vinton 5 W (NBFL1) (30.18N 93.63W)									23.71
Mississippi									
International Civil Aviation Organization (ICAO) Sites									
Keesler Air Force Base (KBIX) (30.40N 88.92W)									3.69

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
M. Graham Clark Downtown Airport (KPLK) (30.46N 88.53W)									4.58
Natchez-Adams County Airport (KHEZ) (31.61N 91.30W)									4.63
Weatherflow Sites									
Gulfport (XGPT) (30.36N 89.11W)			30/1921	32 (10.4 m, 1 min)	35				
Gulfport/Ship Island (XSHI) (30.23N 88.98W)			30/1854	28 (11.9 m, 5 min)	39				
Other Sites									
Booneville (BOOM6) (34.67N 88.57W)									3.87
Gautier 6 NNW (SHCM6) (30.45N 88.66W)									8.06
Gloster (GLOM6) (31.20N 91.02W)									3.67
Holcut (HCTM6) (34.73N 88.30W)									3.69
Independence 1 W (INDM6) (34.70N 89.82W)									4.77
Necaise 1 N (NNHM6) (30.62N 89.41W)									4.55
New Albany (NABM6) (34.47N 89.00W)									4.76
North Carolina									
International Civil Aviation Organization (ICAO) Sites									

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Fayetteville Regional Airport (KFAY) (34.99N 78.88W)									3.02
Other Sites									
Barber 3 S (BBRN7) (35.68N 80.61W)									3.34
Charlotte (MYSN7) (35.46N 80.81W)									3.65
Charlotte 12 N (GILN7) (35.41N 80.85W)									3.36
Clayton (CYNN7) (35.64N 78.46W)									4.31
Davidson 8 SW (CWAN7) (35.43N 80.96W)									3.27
Goldsboro 2 N (GOLN7) (35.42N 77.99W									3.66
Huntersville (COKN7) (35.42N 80.90W)									4.18
Shallote 7 NE (NATN7) (34.05N 78.29W)									3.18
Tennessee									
International Civil Aviation Organization (ICAO) Sites									
Memphis International Airport (KMEM) (35.04N 89.98W)			31/2238	32 (10 m, 2 min)	52				4.06
Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) Sites									
Adams 2.9 WSW (TN-RB-18) (36.57N 87.06W)									8.73
Cedar Hill 2.6 N (TN-RB-16) (36.59N 87.00W)									10.67

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Cedar Hill 4.4 NNE (TN-RB-38) (36.61N 86.98W)									9.45
Clarksville 14.4 WSW (TN-MT-73) (36.46N 87.57W)									8.67
Finger 4.1 ENE (TN-MN-3) (35.38N 88.55W)									8.67
Greenbrier 1.4 N (TN-RB-15) (36.44N 86.80W)									10.93
Nashville 4.1 SSW (TN-DV-152) (36.11N 86.81W)									18.20
Pleasant View 2.8 ESE (TN-RB-35) (36.38N 86.99W)									9.18
Sommerville 1.3 E (TN-FY-5) (35.24N 89.33W)									8.63
Springfield 2.9 NNW (TN-RB-6) (36.54N 86.90W)									10.17
Springfield 4.4 SSW (TN-RB-31) (36.44N 86.98W									9.30
Other Sites									
Henderson 1 N (HENT1) (35.45N 88.68W)									11.04
Texas									
ICAO Sites									
Alice International Airport (KALI) (27.74N 98.03W)	26/0653	1000.7	26/0853	29 (10 m, 2 min)	41				0.33
Angleton/Brazoria County Airport (KLBX) (29.12N 95.47W)	28/1545	1000.3	29/1953	29 (10 m, 2 min)	41				18.49
Aransas County Airport (KRKP) (28.09N 97.04W)	26/0153	969.8	25/2202	44 (10 m, 2 min)	60				

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Austin Bergstrom International Airport (KAUS) (30.18N 97.68W)	27/0753	1003.6	27/0302	39 (10 m, 2 min)	47				10.07
Austin/Camp Mabry (30.32N 97.77W)	27/0751	1005.7	27/1729	20 (10 m, 2 min)	39				7.97
Bay City Municipal Airport (KBYY) (28.97N 95.86W)	28/2355	999.0	28/2355	31 (10 m, 2 min)	40				
Beeville Municipal Airport (KBEA) (28.36N 97.79W)			26/0015	30 (10 m, 2 min)	38				
Brazos 451 Oil Platform (KBQX) (28.49N 95.72W)	29/0155	997.3	26/0635	46 (24.7 m, 2 min)	61				
Burnet Municipal Airport (KBMQ) (30.74N 98.23W)	27/0953	1008.9	26/1823	23 (10 m, 2 min)	34				
Calhoun County Airport (KPKV) (28.65N 96.68W)			26/0058	34 (10 m, 2 min)	43				
Cleveland Municipal Airport (K6R3) (30.35N 95.01W)	30/1415	1004.1	30/1615	17 (10 m, 2 min)	47				25.76
College Station/Easterwood Field (KCLL) (30.58N 96.37W)	28/1410	1006.4	27/2210	26 (10 m, 2 min)	37				15.74
Corpus Christi International Airport (KCRP) (27.77N 97.50W)	25/2351	994.5	25/2251	36 (10 m, 2 min)	55				1.46
Eagle Lake Airport (KELA) (29.60N 96.32W)	28/0435	1001.7	26/1115	25 (10 m, 2 min)	36				
Fredericksburg (KT82) (30.24N 98.91W)	27/0815	1008.2	26/2315	27 (10 m, 2 min)	35				0.73
Galveston Scholes Field (KGLS) (29.27N 94.87W)	29/1535	1000.7	29/2355	39 (10 m, 2 min)	49				22.87

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Georgetown (KGTU) (30.69N 97.69W)	27/1340	1009.2	27/1340	24 (10 m, 2 min)	35				4.59
Giddings (KGYB) (30.17N 96.98W)	26/2335	1001.9	27/0455	26 (10 m, 2 min)	38				15.77
Gonzales (KT20) (29.52N 97.46W)	26/1715	996.2	26/1715	30 (10 m, 2 min)	45				13.46
Hondo Municipal Airport (KHDO) (29.36N 99.16W)	27/0851	1005.8	27/1559	33 (10 m, 2 min)	44				
Houston Executive Airport (KTME) 29.81N 95.90W)	28/1335	1002.7	28/2155	29 (10 m, 2 min)	40				
Houston Hobby Airport (KHOU) (29.65N 95.28W)	28/1315	1002.4	29/1853	29 (10 m, 2 min)	42				37.01
Houston Sw Airport (KAXH) (29.51N 95.48W)	28/1335	1002	26/0615	26 (10 m, 2 min)	37				
Houston/Bush Intercontinental Airport (KIAH) (29.97N 95.35W)	28/1435	1003.4	26/1807	31 (10 m, 2 min)	41				31.26
Houston/Ellington Field (KEFD) (29.62N 95.17W)	29/1650	1003.3	26/1750	27 (10 m, 2 min)	36				
La Grange/Fayette Regional Airport (K3T5) (29.91N 96.95W)	26/1615	1001.8	26/1802	20 (10 m, 2 min)	35				18.98
Mustang Beach Airport (KRAS) (27.81N 97.09W)			25/1955	47 (10 m, 2 min)	59				3.95
Naval Air Station Corpus Christi (KNGP) (27.69N 97.29W)		986.1	25/2149	54 (10 m, 2 min)	77				0
Naval Air Station Kingsville (KNQI) (27.51N 97.81W)	26/0056	999.0	25/1956	31 (10 m, 2 min)	42				1.93

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
New Braunfels Municipal Airport (29.70N 98.05W)	26/2251	1000.8	27/0025	38 (10 m, 2 min)	50				7.03
Nueces County Airport (KRBO) (27.78N 97.69W)			26/0315	39 (10 m, 2 min)	51				
Orange County Airport (KORG) (30.07N 93.80W)	30/0925	994.2	30/0855	26 (10 m, 2 min)	43				36.47
Palacios Municipal Airport (KPSX) (28.72N 96.25W)	26/0653	1000	26/1420	43 (10 m, 2 min)	60				7.84
Pearland/Clover Field (KLVJ) (29.52N 95.24W)	28/1320	1002.7	26/1430	29 (10 m, 2 min)	44				34.43
Pleasanton (KPEZ) (28.95N 98.52W)	27/0955	1002.9	26/1715	26 (10 m, 2 min)	37				0.85
Port Isabel Arpt (KPIL) (26.15N 97.23W)	25/1253	1001.9	25/1553	24 (10 m, 2 min)	34				0.48
Port San Antonio (KSKF) (29.38N 98.58W)	27/0730	1002.7	26/1258	26 (10 m, 2 min)	42				0.91
Randolph Air Force Base (KRND) (29.54N 98.28W)	27/0756	1001.3	26/1652	28 (10 m, 2 min)	50				4.23
Robert Wells Airport (K66R) (29.64N 96.51W)	28/0255	1002.4	26/1335	24 (10 m, 2 min)	34				
San Antonio International Airport (KSAT) (29.54N 98.47W)	27/0751	1001.8	26/1744	30 (10 m, 2 min)	46				1.94
San Antonio Stinson Municipal Airport (KSSF) (29.33N 98.47W)	27/0753	1001.4	26/1802	26 (10 m, 2 min)	39				1.49
San Marcos (KHYI) (29.90N 97.87W)	26/2256	1002	27/0132	36 (10 m, 2 min)	48				

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Southeast Texas Regional Airport (KBPT) (29.95N 94.03W)	30/1053	996.5	30/1030	30 (10 m, 2 min)	43				47.52
Sugarland Regional Airport (KSGR) (29.62N 95.65W)	28/1320	1001.7	26/1150	38 (10 m, 2 min)	50				22.67
Victoria Regional Airport (KVCT) (28.85N 96.92W)	26/0451	998.3	26/0451	37 (10 m, 2 min)	51				1.06
Coastal-Marine Automated Network (C-MAN) Sites									
Port Aransas (PTAT2) (27.82N 97.05W)	26/0200	961.7	26/0220	83 (14.9 m)	108				
Sabine Pass (SRST2) (29.68N 94.03W)	30/0800	998.3	30/0700	33 (9.1 m)	40				
National Estuarine Research Reserve System Sites									
Aransas Ship Channel (MIST2) (27.83N 97.05W)	26/0115	967	25/2200	57[F] (9.1 m)					
Copano East (MAXT2) (27.13N 97.03W)	26/0200	972	26/0200	73[F] (7.5 m)					
National Ocean Service (NOS) Sites									
Bob Hall Pier (MQTT2 / 8775870) (27.58N 97.22W)	26/0112	986.3	25/2242	50 (12.7 m)	66	4.24	4.72	3.5	
Eagle Point (EPTT2 / 8771013) (29.48N 94.92W)	29/1106	1002.0	26/0354	36	45	4.18		3.7	
Freeport (FCGT2 / 8772447) (28.94N 95.30W)	28/2106	999.3	26/0930	44	53	3.19		2.5	
Galveston Bay Entrance/North Jetty (GNJT2 / 8771341) (29.68N 94.03W)	29/1900	998.3	26/1348	46	54	2.73		2.6	
Galveston Pier 21 (GTOT2 / 8771450) (29.36N 94.72W)	29/1854	998.6				2.87	3.96	2.7	

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Matagorda Bay Entrance Channel (MBET2 / 8773767) (28.643N 96.33W)	26/0130	993.9	26/0224	58	68	2.76		2.3	
Morgans Point (MGPT2 / 8770613) (29.68N 94.98W)	29/1054	1002.3	26/0048	29	40	4.06	4.74	3.5	
Port Isabel TX (PTIT2 / 8779770) (26.06N 97.21W)	25/1154	1001.2	25/1130	21 (11.6 m)	31	1.64	1.93	1.4	
Rainbow Bridge (8770520) (29.98N 93.88W)						3.38		2.9	
Rockport (RCPT2 / 8774770) (28.02N 97.05W)	26/0336	941.8	26/0154	59 [F] (7.5 m)	94	1.97 [I]	3.16		
Sabine Pass North (SBPT2 / 8770570) (29.73N 93.87W)	30/0848	998.2	26/1812	33 (7.9 m)	47	3.44	4.78	3.2	
SPI Brazos Santiago (BZST2 / 8779749) (26.07N 97.15W)	25/1254	1000.1	25/1548	33	40	1.67		1.4	
Texas Point (TXPT2 / 8770822) (29.69N 93.84W)	30/0848	995.5	29/0800	43 (12.5 m)	53	3.26		3.1	
Remote Automated Weather Station (RAWS) Sites									
Aransas Wildlife Refuge (AFWT2) (28.30N 96.82W)			25/2259	45	94				
Matagorda Island (MIRT2) (28.12N 96.80W)			25/2312	44 [F]	72				
McFadden National Wildlife Refuge (FADT2) (29.71N 94.12W)			29/2035	23	38				
Victoria (VCRT2) (28.86N 96.92W)			26/1204	50	72				
Woodville (WVLT2) (30.75N 94.40W)	30/1104	989.8	30/1804	17	34				

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Texas Coastal Observing Network Sites									
Aransas Wildlife Refuge (AWRT2 / 8774230) (28.23N 96.80W)	26/0424	970.5	26/0112	69	92	4.80		4.8	
Baffin Bay (BABT2) (27.30N 97.40W)	25/2306	995.5	25/2230	44 (10 m)	55				
Copano Bay (CPNT2 / 8774513) (28.11N 97.02W)	26/0400	944.0	26/0306	79	103	4.12		4.0	
Galveston Railroad Bridge (GRRT2 / 8771486) (29.30N 94.90W)	29/1106	1000.3	29/0254	38	52	3.15	3.73	2.8	
High Island (HIST2 / 8770808) (29.59N 94.39W)	29/1842	999.8	29/1848	33	41	5.13		4.1	
Lynchburg Landing (LYBT2 / 8770733) (29.76N 95.08W)	28/1042	1003.2	27/1918	26	37	7.75	8.85	7.3[J]	
Manchester (NCHT2 / 8770777) (29.73N 95.27W)	28/0900	1001.6	26/0706	24	31	11.52		10.5[J]	
Matagorda City (EMAT2 / 8773146) (28.71N 95.91W)	28/1718	997.3	26/0300	37	48	3.33		3.2	
Nueces Bay (NUET2 / 8775244) (27.83N 97.49W)	26/0254	989.3	26/0324	51	65				
Packery Channel (PACT2 / 8775792) (27.63N 97.24W)	26/0136	986.1	25/2318	58 (10.7 m)	72	4.77	5.51	4.7	
Port Aransas (RTAT2 / 8775237) (27.84N 97.07W)	26/0224	959.3	25/2242	50[F] (10.7 m)	69	5.65	6.17	5.3	
Port Aransas Sentinel (ANPT2 / 8775241) (27.84N 97.04W)	26/0202	964	26/0142	96[F] (14.2 m)	115	1.63[I]			
Port Arthur (PORT2 / 8770475) (27.84N 97.04W)	30/0936	996.1	30/0124	26 (10.7 m)	36	4.20		3.7	

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Port Lavaca (VCAT2 / 8773259) (28.64N 96.61W)	26/0942	993.3	26/0806	53	67	7.06		6.7	
Port O'Connor (PCNT2 / 8773701) (28.45N 96.40W)	26/0354	994.2	26/1054	54 (9 m)	70	3.25		3.0	
Realitos Peninsula (RLIT2 / 8779280) (26.26N 97.28W)	25/1412	1001.6	25/1542	28	36				
Rincon del San Jose (RSJT2 / 8777812) (26.80N 97.47W)	25/1836	999.6	25/1836	34 (10 m)	41				
Rollover Pass (RLOT2 / 8770971) (29.52N 94.51W)	29/1806	999.6	28/0454	37	44	3.87		3.2	
S Bird Island (IRDT2 / 8776139) (27.48N 97.32W)	25/2306	991.7	26/0142	47 (4.3 m)	62				
San Luis Pass (LUIT2 / 8771972) (29.08N 95.12W)	29/1018	1002.9	26/0130	38	59	3.22		3.3	
Sargent (SGNT2 / 8772985) (28.77N 95.62W)	28/2024	998.3	26/0742	43	55	3.19		3.0	
Seadrift (SDRT2 / 8773037) (28.41N 96.71W)	26/0606	985.5	26/0630	54 (10.1 m)	74	5.77		5.5	
South Padre Island Coast Guard Station (PCGT2 / 8779748) (26.07N 97.17W)	25/1300	1000.9	25/1518	32	40	1.77		1.4	
USS Lexington (TAQT2 / 8775296) (27.82N 97.39W)	26/0242	987.8				1.18	2.06	1.0	
Weatherflow Sites									
Clear Lake Park (XCLP) (29.56N 95.07W)			26/0420	29 (9.8 m)	46				
Corpus Christi (XCRP) (27.59N 97.30W)	26/0132	986	26/0304	47 (10 m, 1 min)	65				

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Crab Lake (XCRB) (29.46N 94.62W)			29/1843	47 (19.8 m)	53				
Galveston Bay (XGAL) (29.54N 94.91W)			26/0401	35 (5.2 m)	42				
Galveston Fishing Pier (XGPR) (29.24N 94.85W)			25/1836	43 (11.6 m)	50				
Laguna Shores (XLAG) (27.63N 97.29W)	26/206	985.4	25/2217	52 (10 m, 1 min)	71				
Levee (XLEV) (29.42N 94.89W)			25/2320	38 (8.2 m)	45				
Matagorda Bay (XMGB) (28.59N 95.98W)			26/0458	48 (6.1 m)	56				
Poenisch Park (XPOE) (27.72N 97.34W)	26/0220	988.4	26/0115	49 (10 m, 1 min)	64				
Portland Wildcat (XWLD) (27.86N 97.32W)	26/0335	984.7	26/0355	48[F] (5 m, 5 min)	64				
Seabrook (XSBK) (29.55N 95.02W)			26/0315	34 (9.1 m)	41				
South Padre Island (XPAD) (26.08N 97.17W)			25/1030	30 (12.2 m, 5 min)	38				
South Padre Island SPIW Park (XSPP) (26.16N 97.17W)			25/1120	29 (5.5 m, 5 min)	37				
Surfside Beach (XSRF) (28.92N 95.29W)			25/2206	37 (7.6 m)	50				
Texas City (XTEX) (29.36N 94.95W)			26/0226	42 (19.8 m)	48				
Texas Tech University Hurricane Research Team StickNet									
0102A (27.88N 97.29W)				50 (2.25 m, 1 min)	66				

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
0103A (27.91N 97.13W)				69 (2.25 m, 1 min)	94				
0104A (28.11N 97.03W)				69 [F] (2.25 m, 1 min)	88				
0105A (28.34N 96.93W)				71 (2.25 m, 1 min)	90				
0106A (28.44N 96.73W)				57 (2.25 m, 1 min)	76				
0108A (28.03N 97.24W)				73 (2.25 m, 1 min)	86				
0110A (28.41N 96.87W)				68 (2.25 m, 1 min)	89				
0111A (28.66N 96.42W)				69 (2.25 m, 1 min)	53				
0112A (28.59N 96.63W)				44 (2.25 m, 1 min)	58				
0213A (27.70N 97.15W)				66 (2.25 m, 1 min)	80				
0214A (27.59N 97.22W)				53 (2.25 m, 1 min)	68				
0220A (28.16N 97.21W)				74 [F] (2.25 m, 1 min)	86				
Other Sites									
Beaumont 4 S (JZHT2) (30.02N 94.14W)									49.06
Beaumont 4 WSW (JZLT2) (30.06N 94.21W)									46.54
Beaumont 4 WSW (JZNT2) (30.04N 94.08W)									46.38

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Bevil Oaks 5 ENE (JYOT2) (30.18N 94.19W)									47.28
Brazos Santiago Pass (BRZT2) (26.07N 97.15W)	25/1254	1000.1	25/1548	32 (10 m, 6 min)	38				
Central Gardens 5 NW (JZJT2) (30.06N 94.21W)									46.54
China 2 S (JZTT2) (30.02N 94.33W)									47.44
Clear Lake (29.56N 95.14W)									48.14
Coleto Creek (CKDT2) (28.73N 97.17W)					77				9.42
Copano Bay Causeway Park	26/0356	944.7							
Ellington Field 2 E (29.60N 95.12W)									52.00
Fannet 5 WNW (JZVT2) (29.95N 94.33W)									45.00
Fannett 1 NE (JZPT2) (29.93N 94.24W)									49.25
Friendswood (29.05N 95.20W)									56.00
Friendswood (29.74N 95.57W)									54.00
Friendswood 2 E (29.50N 95.16W)									47.40
Friendswood 2 NNW (29.54N 95.22W)									50.04

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Goliad 10 S (KTXGOLIA4) (28.52N 97.41W)					54[F]				22.68
GWRT2 (28.36N 98.12W)			26/1406	21	35				
Hamshire 5 SSW (JYST2) (29.79N 94.34W)									45.79
Highlands 2 SSE (BATT2) (29.79N 95.04W)									45.10
Horsepen Creek @ Bay Area Boulevard (29.58N 95.10W)									45.68
Johnson Space Center Building B30 (29.55N 95.09W)			26/2355	(12.2 m)	47				
KTXCUERO1 (29.15N 97.30W)	26/1435	992.6	26/1415	23	36				
KTXCUERO3 (29.15N 97.30W)	26/1540	989.2							
KTXSMILE2 (29.29N 97.57W)				40	50				
KTXSMILE3 (29.12N 97.62W)			26/1516	27	44				
KTXYORK4 (29.03N 97.53W)	26/1647	991.2	26/1500	21	35				
KTXYORK6 (28.91N 97.50W)				40	42				
League City (DW6282) (29.50N 95.10W)									45.66
League City 3 S (29.43N 95.11W)									52.87

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
League City 3 W (29.48W 95.16W)									45.34
League City 4 S (29.42N 95.11W)									51.62
Liberty 2 WSW (LBYT2) (30.06N 94.82W)									49.39
Nassau Bay 2 SSE (29.51N 95.08W)									47.86
Port Arthur 18 WSW (JYHT2) (29.79N 94.21W)									47.99
Port Lavaca U. Florida Research Tower (FCMP T3) (28.61N 96.63W)			26/0438	43 (10 m, 1 min)	44				
Rockport (iCyclone) (28.058N 97.041W)	26/0331	940.8							
Rockport Doppler on Wheels Anemometer (NSFDOW) (28.08N 97.04W)				93 (adjusted to 10 m, 1 min)	122				
Rockport U. Florida Research Tower (FCMP T2) (28.08N 97.05W)	26/0402	941.3	26/0252	88 (10 m, 1 min)	122				
Santa Fe 3 ENE (29.39N 95.05W)									54.77
South Padre Island (SPIT2) (26.06N 97.17W)	25/1300	1000.9	25/1518	32 (10 m, 6 min)	40				2.40
Texas A&M Corpus Christi (27.71N 97.32W)	26/0153	985			75				
Victoria (TXVC-4) (28.52N 97.41W)	26/1203	984.4			74				14.29

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Webster 2 NW (29.55N 95.14W)									52.30
Webster 2 S (29.51N 95.12W)									48.20
Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) Sites									
Beaumont 4.6 S (TX-JJ-11) (30.02N 94.16W)									45.50
Dayton 0.2 E (TX-LR-14) (30.05N 94.89W)									49.31
Pasadena 4.4 WSW (TX-HRR-93) (29.68N 95.22W)									45.74
Santa Fe 0.7 S (TX-GV-60) (29.37N 95.10W)									46.70
National Severe Storms Laboratory (NSSL) Probes									
Taft (NSSL Probe) (28.04N 97.33W)			26/0410	65 (3.4 m, 1 min)	82				
Woodsboro (NSSL Probe) (28.22N 97.35W)			26/0641	60 (3.4 m, 1 min)	76				
Center for Severe Weather Research (CWSR) Probes									
Rockport (Pod B) (28.08N 97.04W)			26/0227	50[F] (1 m, 1 min)	68				
Rockport (Pod C) (28.09N 97.04W)			26/0139	48[F] (1 m, 1 min)	67				
Rockport (Pod D) (28.11N 97.03W)			26/0138	64[F] (1 m, 1 min)	86				
Jefferson County Drainage District Rain Gauges									
Boondocks Road @ Taylors Bayou, South Fork (6400) (29.85N 94.23W)									47.99

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
Craigen Road @ Taylors Bayou D-500 (5620) (29.88N 94.26W)									47.28
East Bay Bayou @ Skillern Tract (5050) (29.63N 94.41W)									47.44
Frint Road Willow Marsh Bayou (2900) (30.00N 94.16W)									46.38
Glenbrook Drive @ Green Acres / Ditch 407 (3200) (29.94N 94.23W)									49.25
Groves 1.3 N (8906) (29.96N 93.92W)									60.54
Highland Ave @ Ditch 104 (2500) (30.03N 94.08W)									46.50
Landis Drive @ Ditch 202B (2700) (30.07N 94.20W)									46.57
Mayhaw Bayou @ Englin Road (7200) (29.79N 94.34W)									45.79
Nederland 1.5 SW (8920) (29.95N 94.01W)									60.58[K]
Pine Tree Ditch 601 South China Road (6200) (29.97N 94.34W)									45.00
Pipkin Ranch @ Willow Slough Ditch 550 (6720) (29.77N 94.20W)									45.12
Port Arthur 6.4 WNW (8918) (29.93N 94.03W)									45.26
Rush Ditch @ Hwy 1663 (6350) (29.86N 94.45W)									45.20

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[C]	Storm tide (ft)[D]	Estimated Inundation (ft)[E]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[A]	Sustained (kt)[B]	Gust (kt)				
South China Road Ditch 608 (5200) (30.03N 94.33W)									47.44
State Highway 124 @ Hillebrandt Bayou (2300) (30.04N 94.15W)									49.06
State Hwy 365 @ Green Pond Gully (5400) (29.94N 94.33W)									45.00
Winne Wetlands @ Mayhaw Bayou (5250) (29.80N 94.36W)									47.52
Earth Networks Mesonet Sites									
Corpus Christi KRIS TV (KRIST) (27.79N 97.40W)			26/0255	32 [F] (10.6 m, 2 min)	63				
Rockport Texas Maritime Museum (RCKPR) (28.03N 97.05W)			26/2335	41 [F] (7.9 m, 2 min)	67				
Seadrift DOW Chemical (SDRFT) (28.52N 96.77)			26/1125	46 [F] (10.6 m, 2 min)	78				

[A] Date/time is for sustained wind when both sustained and gust are listed.
[B] Except as noted, sustained wind averaging periods for C-MAN and land-based reports are 2 min; buoy averaging periods are 8 min.
[C] Storm surge is water height above normal astronomical tide level.
[D] For most locations, storm tide is water height above the North American Vertical Datum of 1988 (NAVD88).
[E] Estimated inundation is the maximum height of water above ground. For NOS tide gauges, the height of the water above Mean Higher High Water (MHHW) is used as a proxy for inundation.
[E] Estimated inundation is the maximum height of water above ground. For NOS tide gauges, the height of the water above Mean Higher High Water (MHHW) is used as a proxy for inundation.
[F] Anemometer damaged or data recording otherwise interrupted and likely did not record maximum winds.
[G] Station 42020 went adrift on 8/25 around 1800 UTC and stopped reporting at that time.
[H] Surge is estimated using a pre-storm baseline for USCOE and USGS gauges
[I] Sensor damaged or destroyed and likely did not record maximum water level
[J] Significantly affected by excessive fresh water rainfall runoff
[K] Preliminary highest tropical cyclone storm total rainfall in U.S. history

Table 4. Direct deaths by county in Texas associated with Harvey.

County	Direct Deaths
Harris	36
Orange	9
Jefferson	5
Galveston	3
Montgomery	3
San Jacinto	3
Ft. Bend	3
Jasper	2
Newton	2
Hardin	1
Walker	1
Total	68

Table 5a. Number of hours in advance of formation of Harvey east of the Lesser Antilles associated with the first NHC Tropical Weather Outlook forecast in the indicated likelihood category. Note that the timings for the “Low” category do not include forecasts of a 0% chance of genesis.

	Hours Before Genesis	
	48-Hour Outlook	120-Hour Outlook
Low (<40%)	84	96
Medium (40%-60%)	12	72
High (>60%)		

Table 5b. Number of hours in advance of reformation of Harvey in the Gulf of Mexico with the first NHC Tropical Weather Outlook forecast in the indicated likelihood category. Note that the timings for the “Low” category do not include forecasts of a 0% chance of genesis.

	Hours Before Genesis	
	48-Hour Outlook	120-Hour Outlook
Low (<40%)	78	78
Medium (40%-60%)	72	78
High (>60%)	42	66

Table 6a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Harvey. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**18.8**	**28.8**	**38.9**	**49.7**	**81.2**	**124.5**	**168.7**
OCD5	35.6	68.8	112.1	157.1	239.5	305.3	350.8
Forecasts	38	36	32	28	23	20	20
OFCL (2012-16)	24.9	39.6	54.0	71.3	105.8	155.4	208.9
OCD5 (2012-16)	47.3	103.9	167.8	230.3	343.1	442.6	531.0

Table 6b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Harvey. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 6a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	16.7	26.8	39.5	49.3	87.3	139.2	186.1
OCD5	33.9	65.6	104.4	148.1	238.9	325.5	370.5
GFSI	21.9	36.7	55.7	74.0	131.5	216.7	266.8
AEMI	22.2	37.4	57.5	73.0	124.2	175.8	224.1
HWFI	17.7	32.2	52.5	76.4	130.2	194.5	226.1
EGRI	19.3	28.0	**35.3**	**41.8**	**76.0**	147.2	244.3
EMXI	22.3	35.3	47.3	56.0	**82.4**	**133.1**	212.4
CMCI	22.8	35.8	54.8	70.1	94.5	**132.4**	**157.8**
NVGI	27.9	47.4	66.7	90.2	131.3	169.1	199.8
CTCI	17.4	**26.0**	40.3	51.5	**71.8**	**122.9**	193.1
TVCN	**16.4**	**23.8**	**35.0**	**43.2**	**79.2**	**135.1**	**179.4**
TVCX	17.0	**24.7**	**36.7**	**43.5**	**77.7**	**131.8**	**181.2**
HCCA	17.4	28.1	42.2	53.3	97.3	**138.3**	**178.7**
GFEX	21.1	33.8	50.0	61.3	102.0	169.7	226.3
FSSE	19.8	31.2	46.2	57.2	95.4	147.5	207.4
TABD	33.9	69.3	100.4	129.6	152.0	259.1	341.4
TABM	26.3	54.0	78.8	83.0	148.6	233.2	303.0
TABS	42.2	84.5	87.6	69.8	169.3	211.4	293.2
Forecasts	28	26	24	23	19	17	16

Table 7a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Harvey. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	5.8	8.9	12.0	15.0	**6.5**	**3.5**	**6.3**
OCD5	6.7	11.5	14.9	16.9	11.5	10.2	13.8
Forecasts	38	36	32	28	23	20	20
OFCL (2012-16)	5.5	8.2	10.5	12.0	13.4	14.0	14.5
OCD5 (2012-16)	7.1	10.5	13.0	15.1	17.4	18.2	20.6

Table 7b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Harvey. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 7a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	5.0	7.2	9.8	11.7	6.3	4.1	5.9
OCD5	5.6	10.1	12.1	12.5	10.8	9.6	14.6
HWFI	6.3	8.0	**8.8**	**7.5**	7.3	8.7	11.6
DSHP	5.1	7.5	**8.9**	**7.8**	9.6	10.2	8.8
LGEM	5.1	7.2	**9.1**	**8.9**	9.1	9.2	7.9
ICON	5.1	**6.3**	**7.9**	**7.6**	8.4	9.2	8.1
IVCN	5.2	**6.1**	**7.0**	**6.7**	6.7	7.6	7.4
HCCA	5.1	**6.0**	**7.6**	**7.7**	8.5	9.4	8.8
FSSE	5.5	**6.6**	**8.1**	**8.5**	11.5	10.9	7.6
GFSI	7.4	8.6	**7.9**	**8.9**	**5.6**	5.6	10.4
EMXI	8.5	12.6	16.7	18.6	23.2	27.9	32.1
Forecasts	32	30	27	23	19	17	16

Table 8. Wind watch and warning summary for Harvey, 17 August – 1 September 2017.

Date/Time (UTC)	Action	Location
17 / 1500	Tropical Storm Watch issued	Dominica
17 / 1500	Tropical Storm Warning issued	Martinique, St. Lucia, Barbados, St. Vincent and the Grenadines
18 / 1200	Tropical Storm Warning discontinued	Barbados
18 / 1800	Tropical Storm Watch discontinued	All
18 / 1800	Tropical Storm Warning discontinued	All
23 / 1500	Tropical Storm Watch issued	Mouth of the Rio Grande to Port Mansfield Texas
23 / 1500	Tropical Storm Watch issued	San Luis Pass Texas to High Island
23 / 1500	Tropical Storm Watch issued	Boca de Catan Mexico to Mouth of the Rio Grande
23 / 1500	Hurricane Watch issued	Port Mansfield to San Luis Pass Texas
24 / 0900	Tropical Storm Watch changed to Tropical Storm Warning	Mouth of the Rio Grande to Port Mansfield
24 / 0900	Hurricane Watch issued	Mouth of the Rio Grande to Port Mansfield
24 / 0900	Tropical Storm Watch discontinued	San Luis Pass to High Island
24 / 0900	Tropical Storm Warning issued	Matagorda to High Island
24 / 0900	Hurricane Warning issued	Port Mansfield to Matagorda
24 / 2100	Tropical Storm Warning modified to	Sargent to High Island

24 / 2100	Hurricane Warning modified to	Port Mansfield to Sargent
25 / 1500	Hurricane Watch changed to Tropical Storm Warning	Mouth of the Rio Grande to Port Mansfield
25 / 2100	Tropical Storm Watch discontinued	All
25 / 2100	Tropical Storm Warning discontinued	Mouth of the Rio Grande to Port Mansfield
26 / 0900	Tropical Storm Warning modified to	Port O'Connor to High Island
26 / 0900	Hurricane Warning discontinued	Port Mansfield to Sargent
26 / 1500	Tropical Storm Warning modified to	Baffin Bay to High Island
26 / 1500	Hurricane Warning discontinued	All
27 / 0300	Tropical Storm Warning modified to	Baffin Bay to Sargent
27 / 0900	Tropical Storm Warning modified to	Port O'Connor to Sargent
27 / 2100	Tropical Storm Watch issued	Sargent to San Luis Pass
28 / 0300	Tropical Storm Watch discontinued	All
28 / 0300	Tropical Storm Warning discontinued	Port O'Connor to Sargent
28 / 0300	Tropical Storm Warning issued	Mesquite Bay to High Island
28 / 1500	Tropical Storm Watch issued	Cameron to Intracoastal City Louisiana
28 / 1500	Tropical Storm Warning modified to	Mesquite Bay to Cameron
28 / 2100	Tropical Storm Watch discontinued	All
28 / 2100	Tropical Storm Warning modified to	Mesquite Bay to Intracoastal City
29 / 1500	Tropical Storm Watch issued	Morgan City to Grand Isle

29 / 1500	Tropical Storm Warning discontinued	Mesquite Bay to Intracoastal City
29 / 1500	Tropical Storm Warning modified to	Port O'Connor to Morgan City
30 / 0300	Tropical Storm Watch discontinued	All
30 / 0300	Tropical Storm Warning discontinued	Port O'Connor to Morgan City
30 / 0300	Tropical Storm Warning modified to	Freeport to Grand Isle
30 / 0900	Tropical Storm Warning modified to	High Island to Grand Isle
30 / 1200	Tropical Storm Warning modified to	Freeport to Grand Isle
30 / 1800	Tropical Storm Warning modified to	Sabine Pass to Grand Isle
31 / 0000	Tropical Storm Warning discontinued	All

Table 9. United States Storm Surge Watch and Warning summary for Harvey.

Date/Time (UTC)	Action	Location
23 / 1500	Storm Surge Watch issued	Port Mansfield to High Island, Texas
24 / 0900	Storm Surge Warning issued	Port Mansfield to San Luis Pass
24 / 0900	Storm Surge Watch issued	South of Port Mansfield to the Mouth of the Rio Grande
24 / 1800	Storm Surge Warning issued	North San Luis Pass to High Island
25 / 2100	Storm Surge Watch discontinued	South of Port Mansfield to the Mouth of the Rio Grande
26 / 0900	Storm Surge Warning discontinued	South of Baffin Bay to Port Mansfield
26 / 1500	Storm Surge Warning discontinued	South of Port Aransas to Baffin Bay
27 / 0300	Storm Surge Warning discontinued	All
28 / 2100	Storm Surge Watch issued	Port Bolivar Texas to Morgan City Louisiana
29 / 2100	Storm Surge Warning issued	Holly Beach to Morgan City
30 / 0900	Storm Surge Watch discontinued	West of High Island to Port Bolivar
30 / 1500	Storm Surge Watch discontinued	West of Sabine Pass to High Island
30 / 2100	Storm Surge Watch / Warning discontinued	All

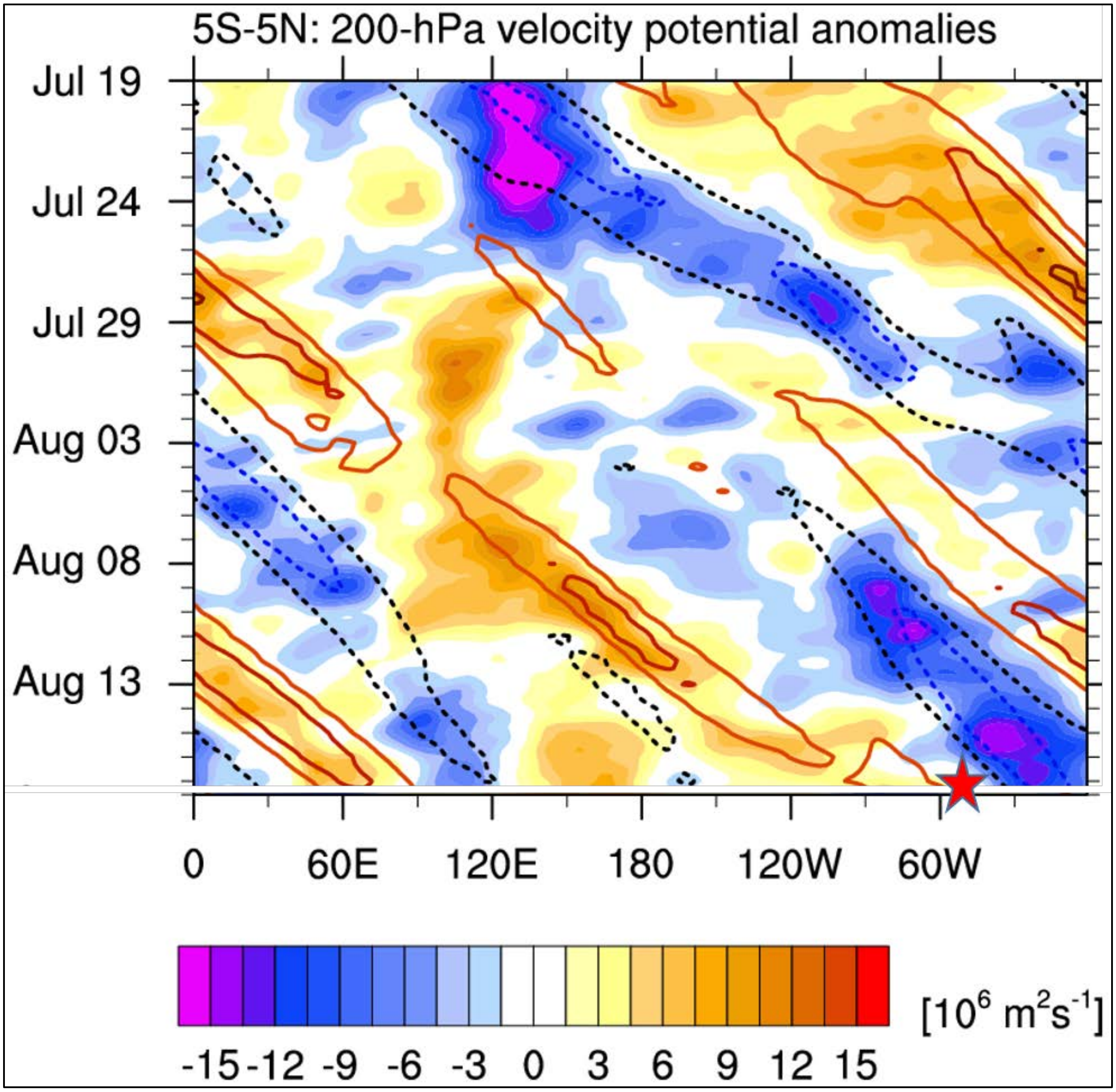

Figure 1. Velocity potential anomalies at 200 mb (VP200) from 5°N-5°S (shaded, x 10^6 m^2 s^{-1}). The shading shows unfiltered VP200 anomalies where negative (positive) values represent mass divergence (convergence). Red contours show CCKW-filtered VP200 anomalies; dashed lines represent upper-level divergence (convectively active). The contour interval begins at 1 standard deviation and contours indicate a 0.5 standard deviation increment thereafter. The red star is the genesis point of Harvey. Figure adapted from Michael Ventrice, IBM/The Weather Channel in collaboration with the University of Albany, Albany NY.

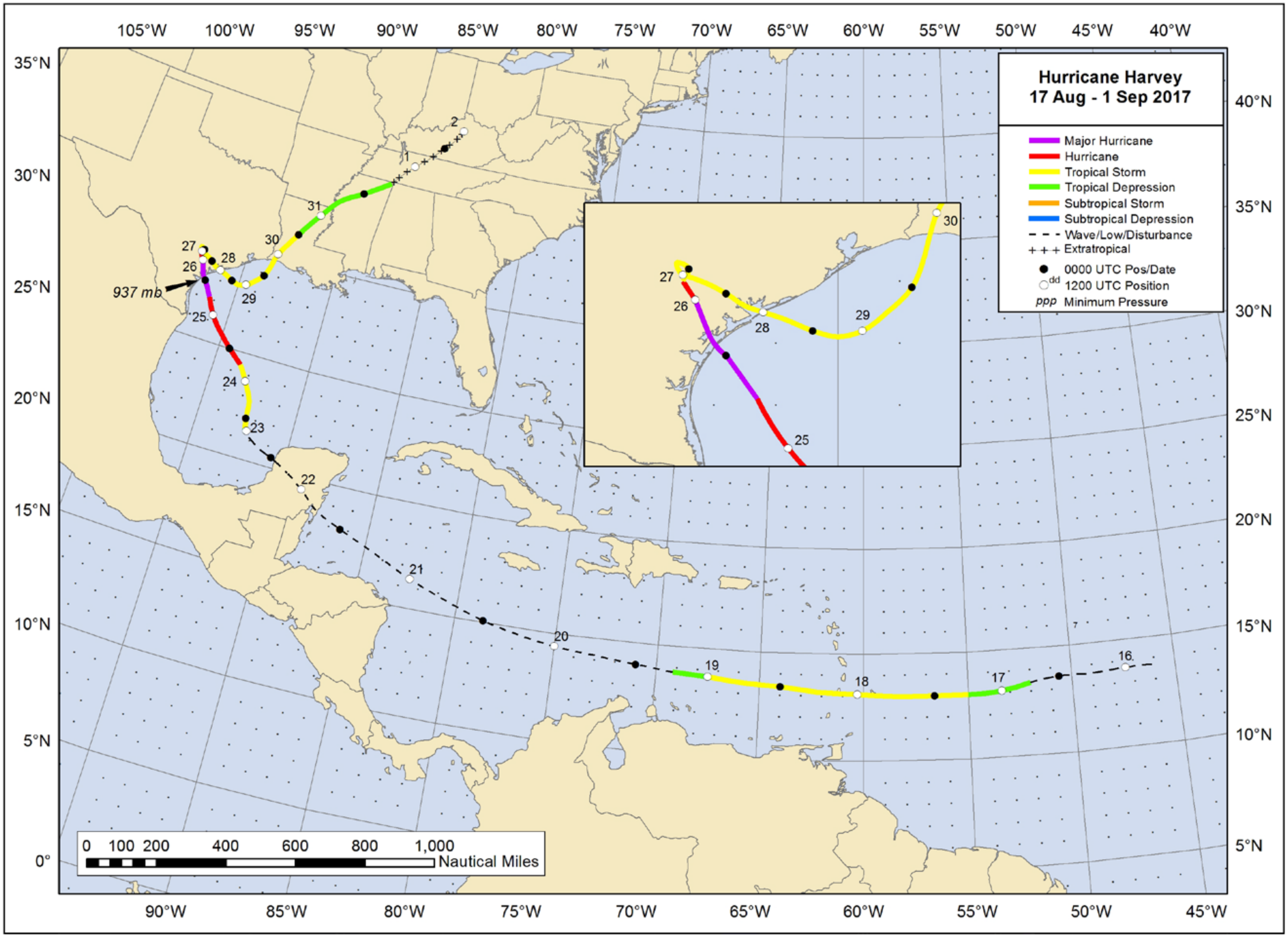

Figure 2. Best track positions for Hurricane Harvey, 17 August – 1 September 2017.

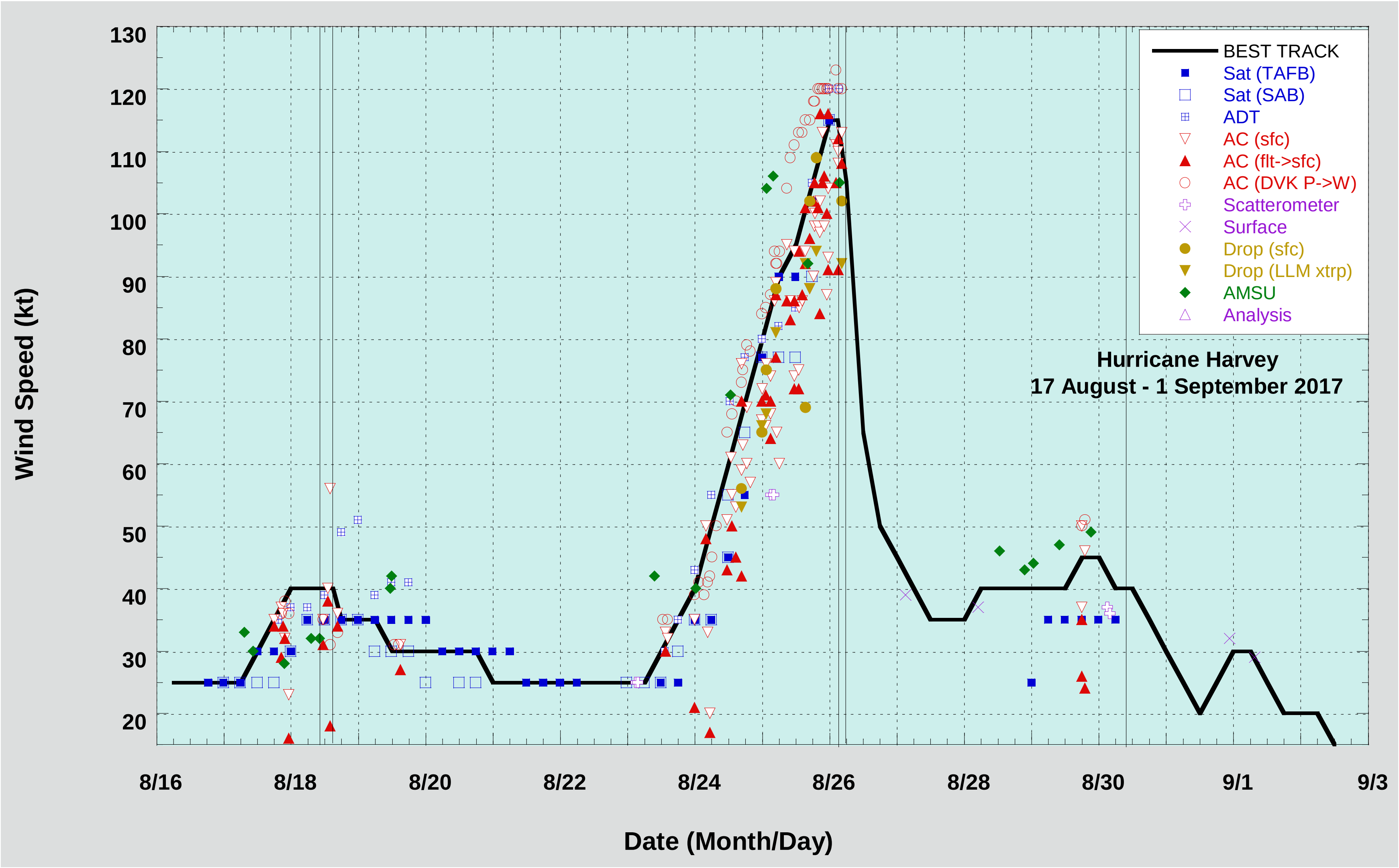

Figure 3. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Harvey, 17 August – 1 September. Dropwindsonde observations include actual 10 m winds (sfc), as well as surface estimates derived from the mean wind over the lowest 150 m of the wind sounding (LLM). Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC, and solid vertical lines correspond to landfall.

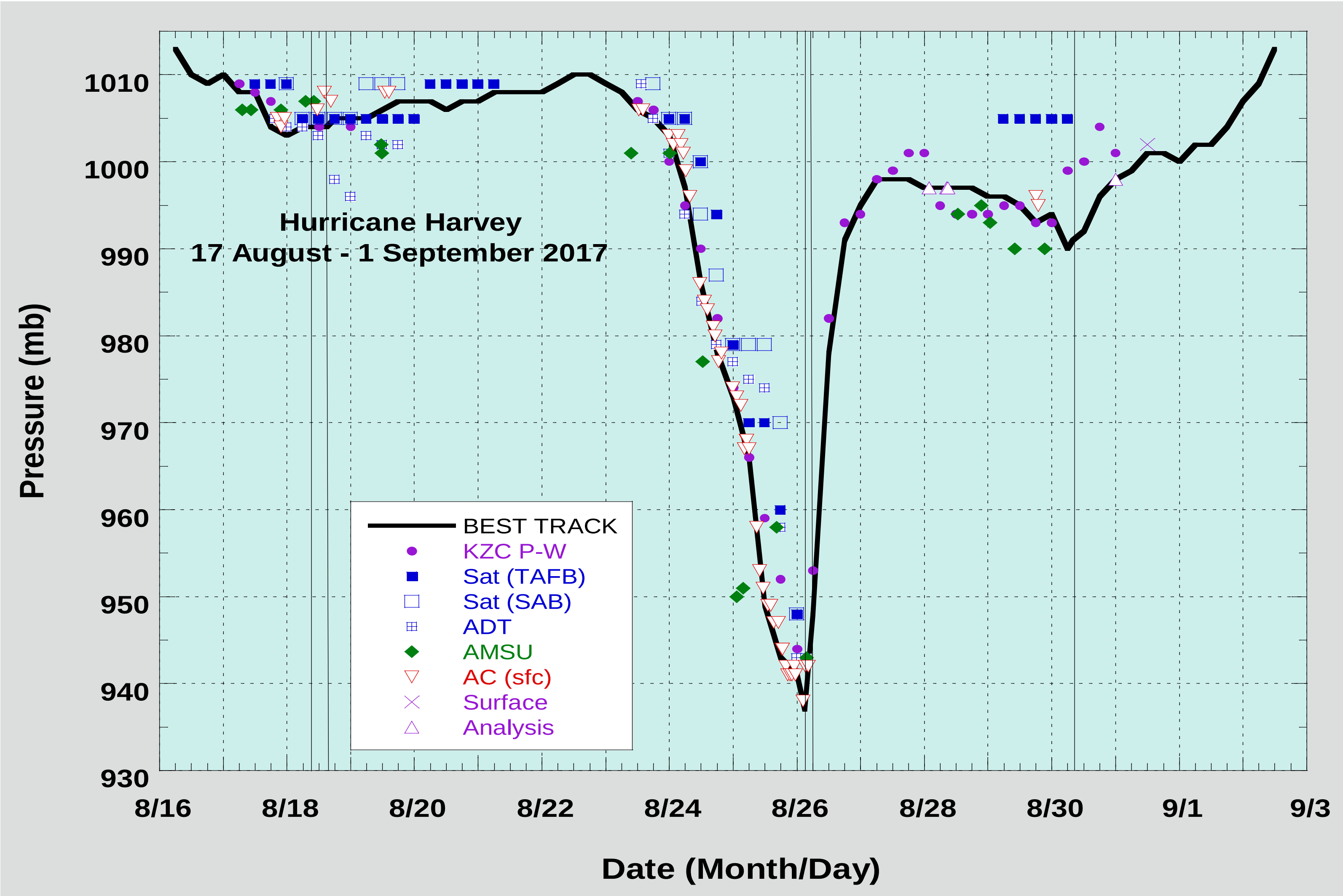

Figure 4. Selected pressure observations and best track minimum central pressure curve for Hurricane Harvey, 17 August – 1 September. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC, and solid vertical lines correspond to landfall.

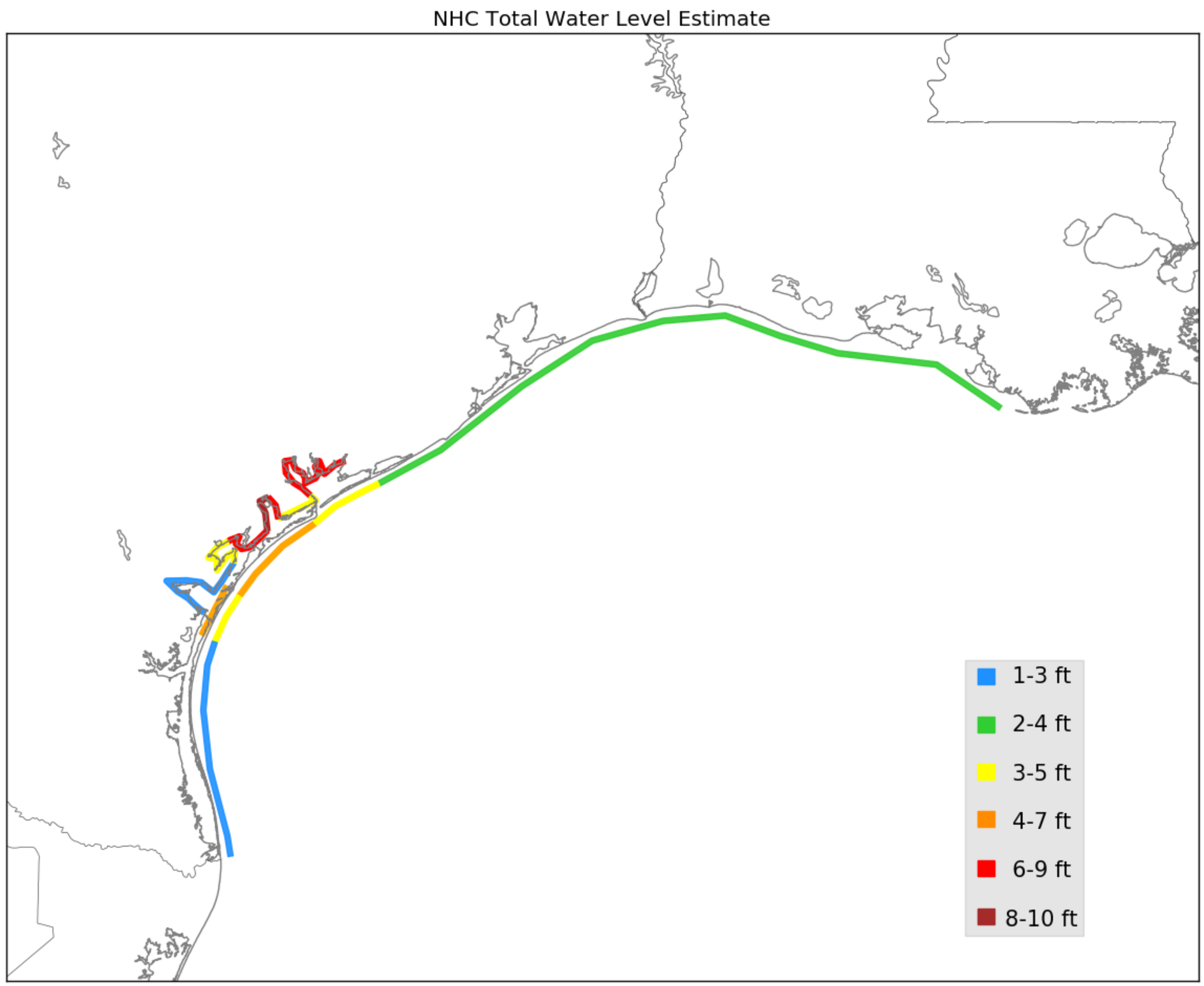

Figure 5. Analyzed storm surge inundation (feet above ground level) along the coast of Texas and Louisiana from Hurricane Harvey. Image courtesy NHC Storm Surge Unit.

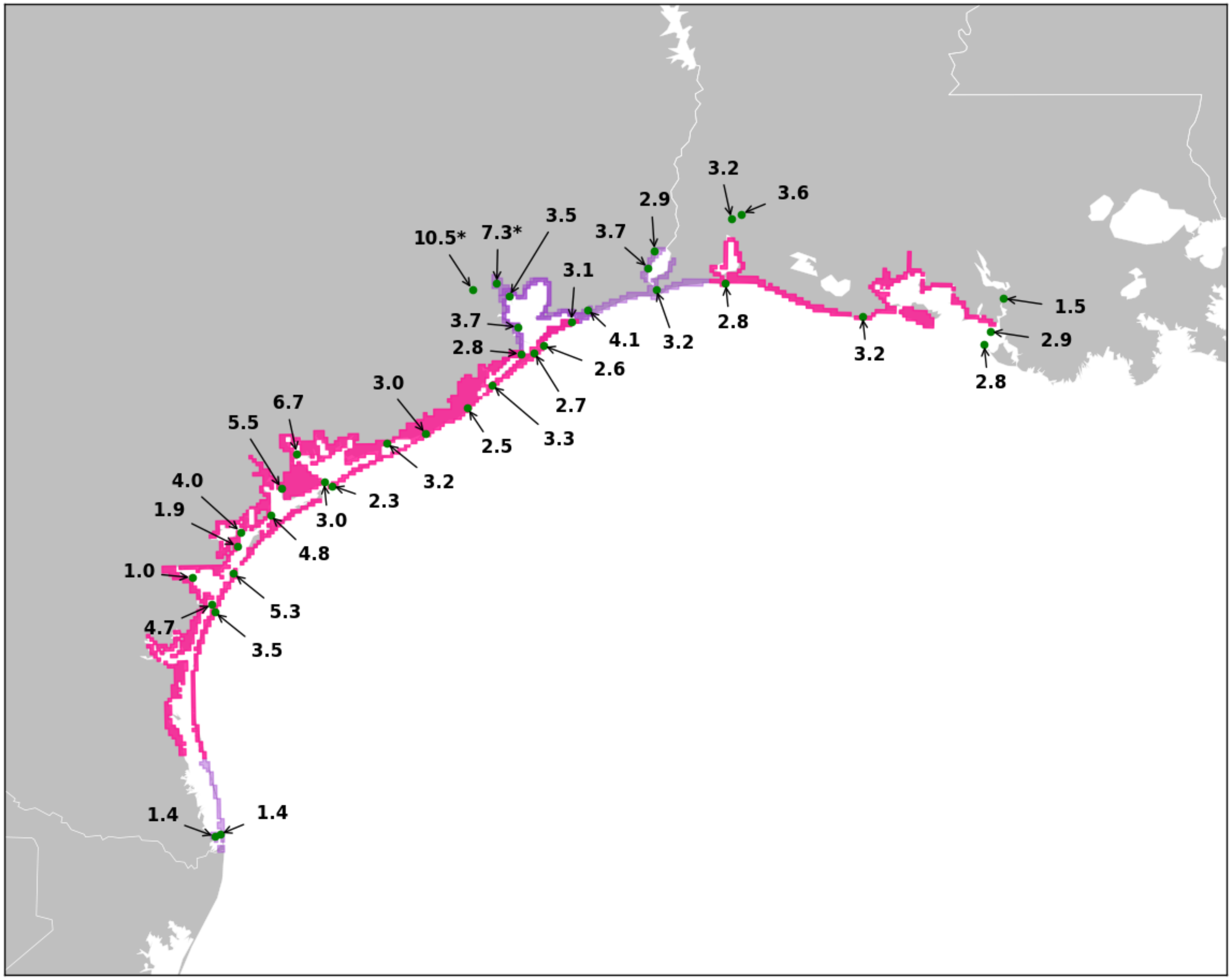

Figure 6. Maximum water levels (feet) measured from tide gauges along the coasts of Texas and Louisiana during Hurricane Harvey and areas covered by storm surge warnings (magenta) and watches (lavender). Water levels are referenced above Mean Higher High Water (MHHW), which is used as a proxy for inundation (above ground level) on normally dry ground along the immediate coastline. Image courtesy of the NHC Storm Surge Unit. Note starred values are contaminated by excessive flood runoff.

Figure 7. Picture of Jefferson County Drainage District rain gauge in Nederland, Texas, where the U.S. tropical cyclone rainfall record of 60.58 inches was set during Harvey.

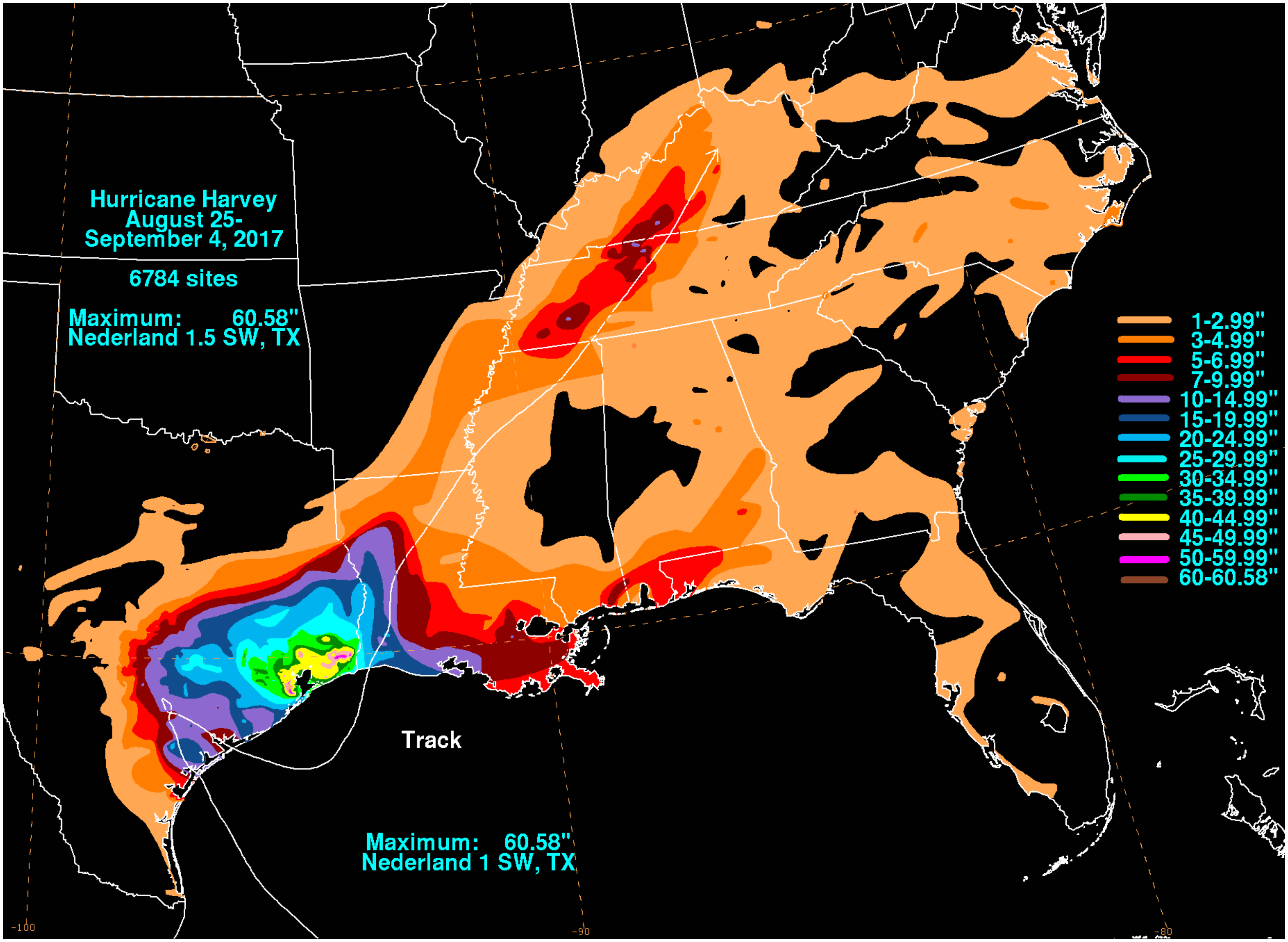

Figure 8. Observed rainfall totals (inches) in association with Harvey and its remnants. Figure courtesy David Roth (WPC).

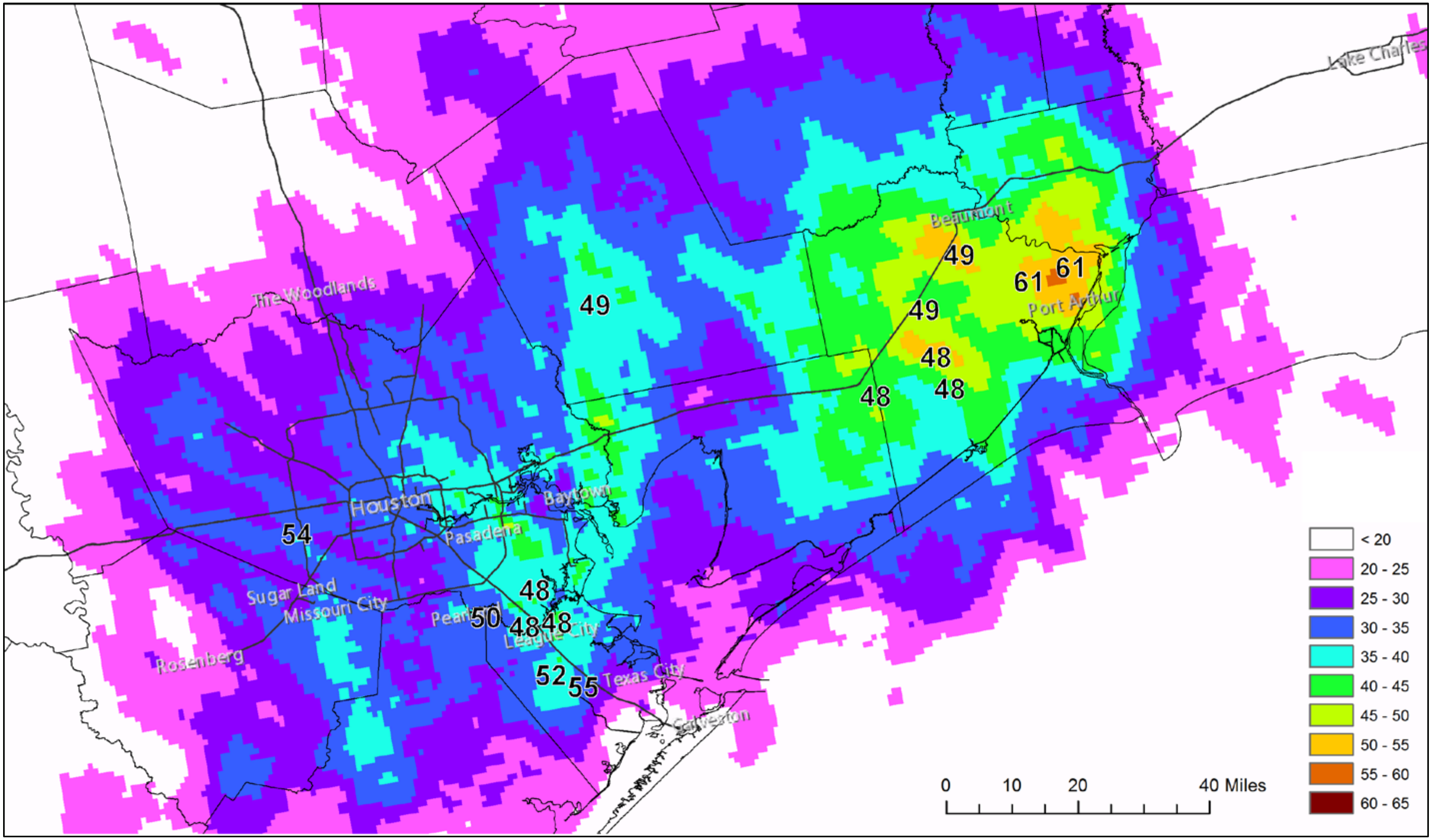

Figure 9. NOAA gauge-corrected, multi-radar multi-sensor quantitative precipitation estimates for Harvey (inches), 25 August-1 September 2017. The black numbers are actual rain gauge values, all of which exceed the previous U.S. continental rainfall record for a tropical cyclone.

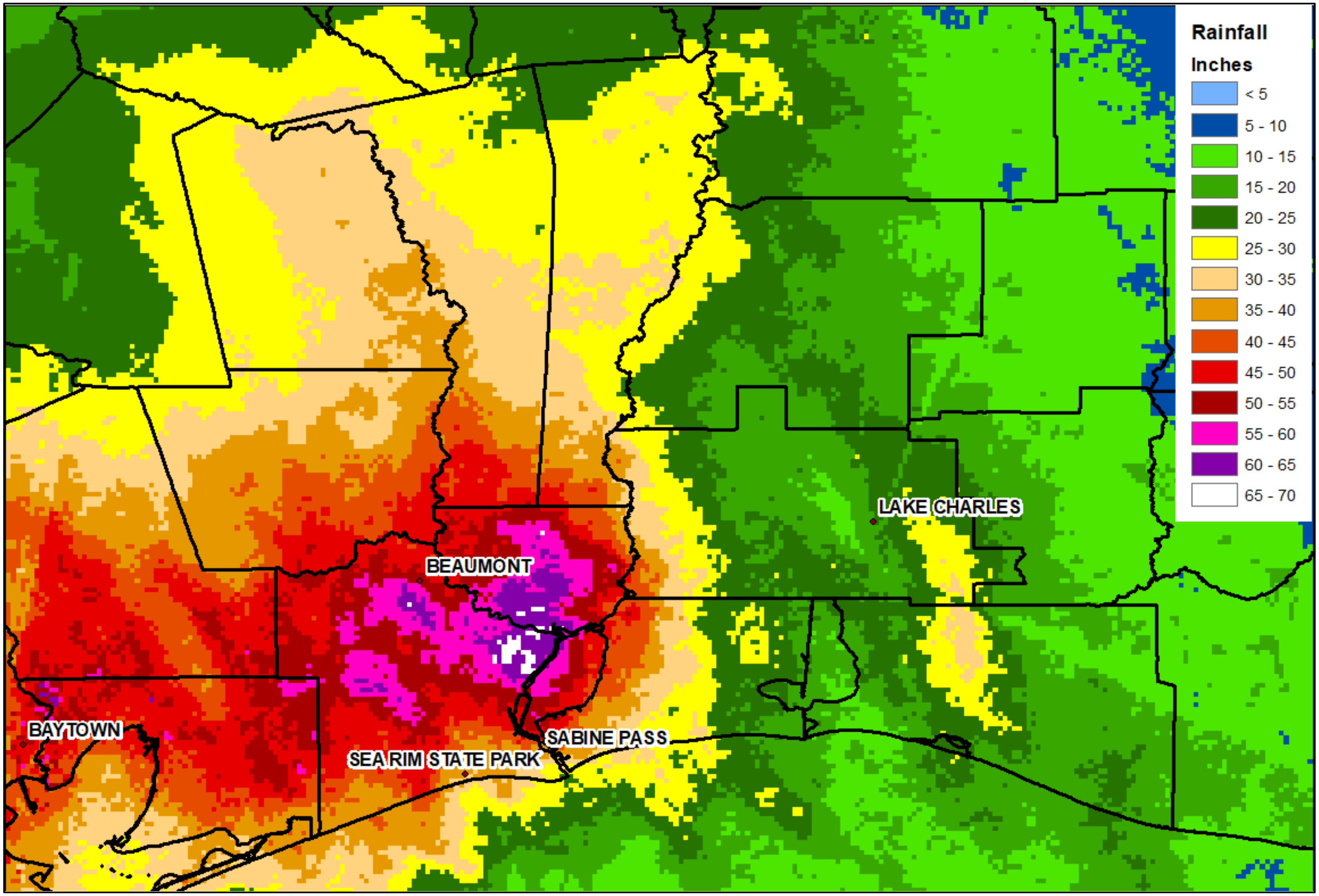

Figure 10. Raw NOAA Multi-radar multi-sensor quantitative precipitation estimation (inches) for Harvey in southeastern Texas from 25 August to 1 September 2017. Figure courtesy Jonathan Brazzell of NWS Lake Charles.

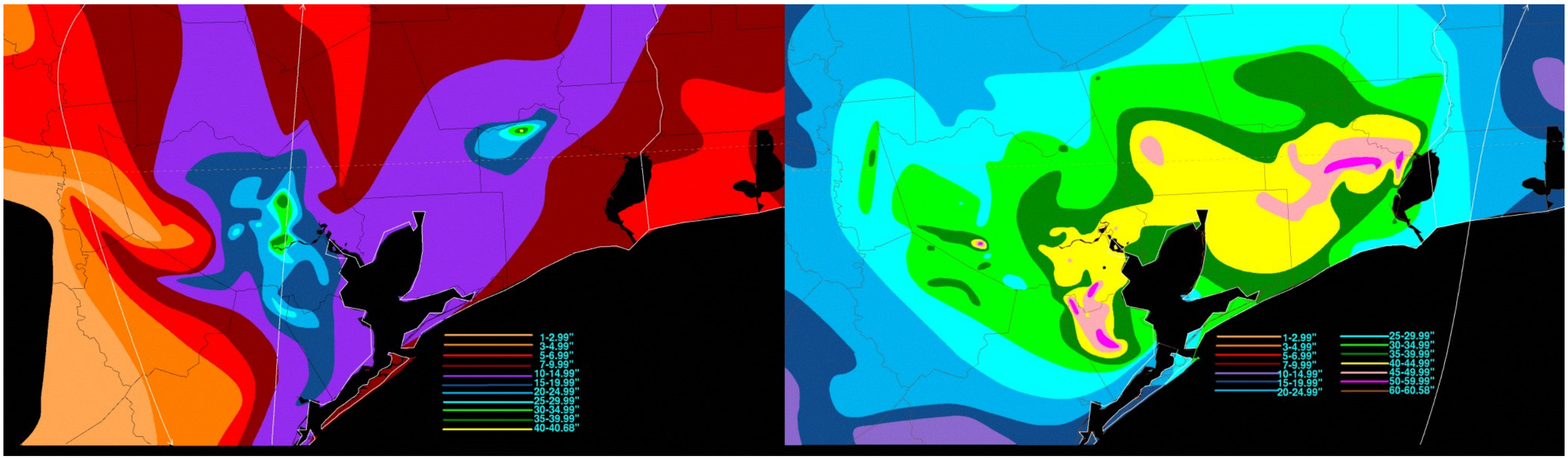

Figure 11a. Allison (2001) rainfall totals (left) vs Harvey rainfall totals (right) in inches for southeastern Texas with the same color and map scale. Note almost every location in SE Texas had considerably more rainfall during Harvey. Figure courtesy David Roth (WPC).

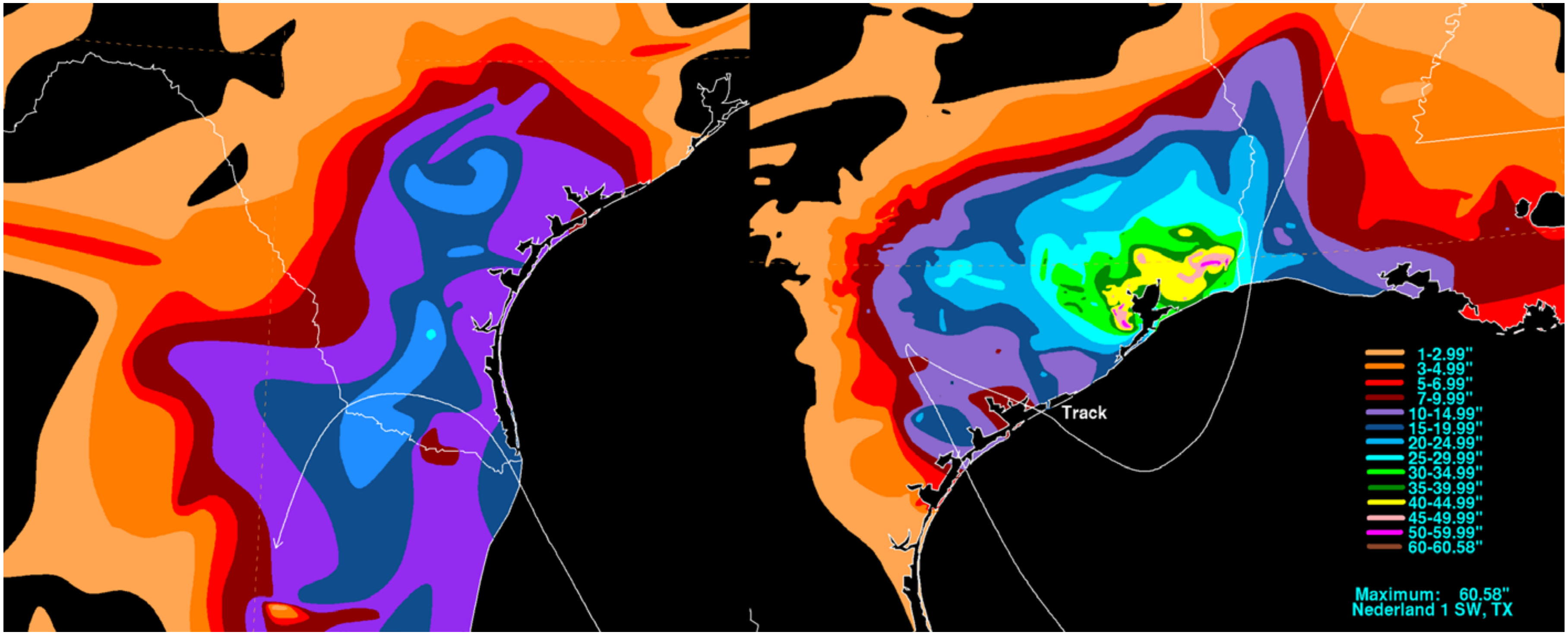

Figure 11b. As in Figure 11a except for Beulah (1967) rainfall (left).

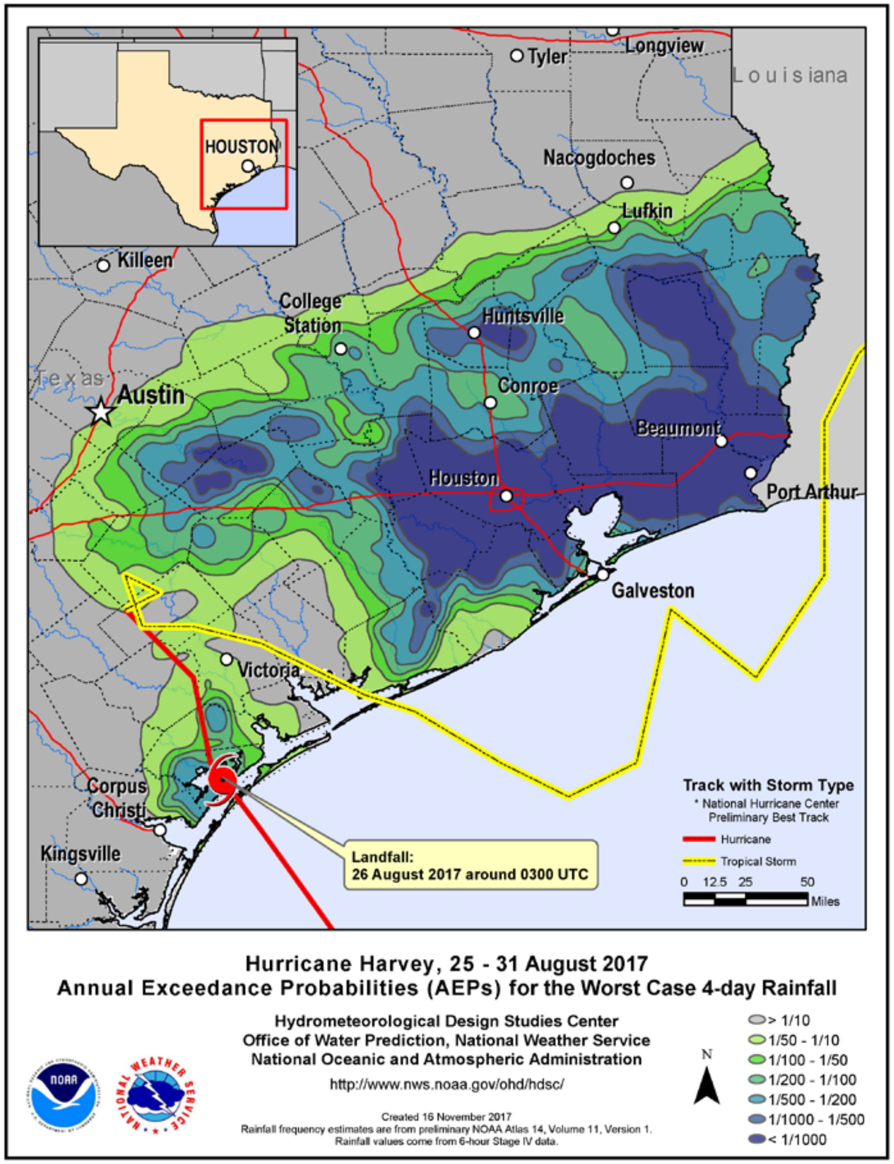

Figure 12. Annual 4-day rainfall exceedance probabilities for Harvey. Image courtesy NOAA Office of Water Prediction. Note that the track shown on the graphic was preliminary and does not reflect the final NHC best track.

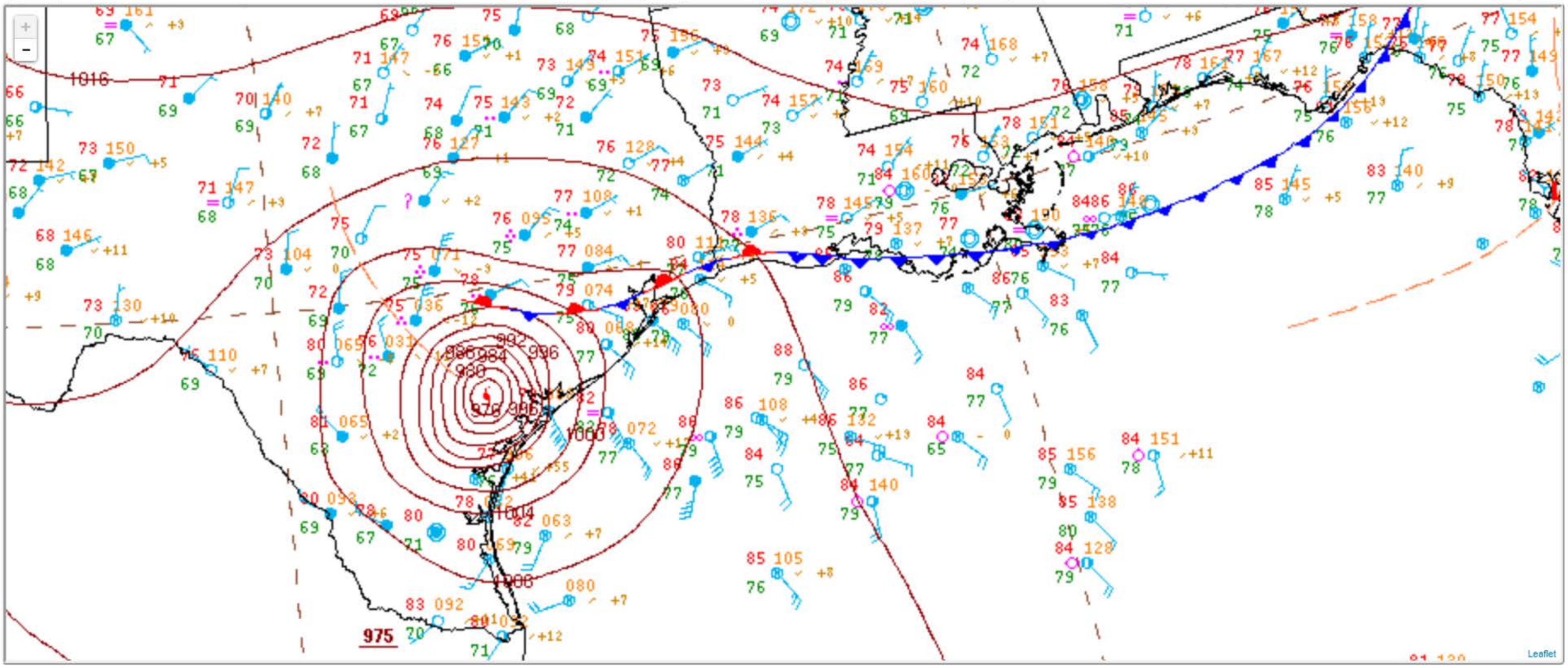

Figure 13. NCEP unified surface analysis at 1200 UTC 26 August 2017.

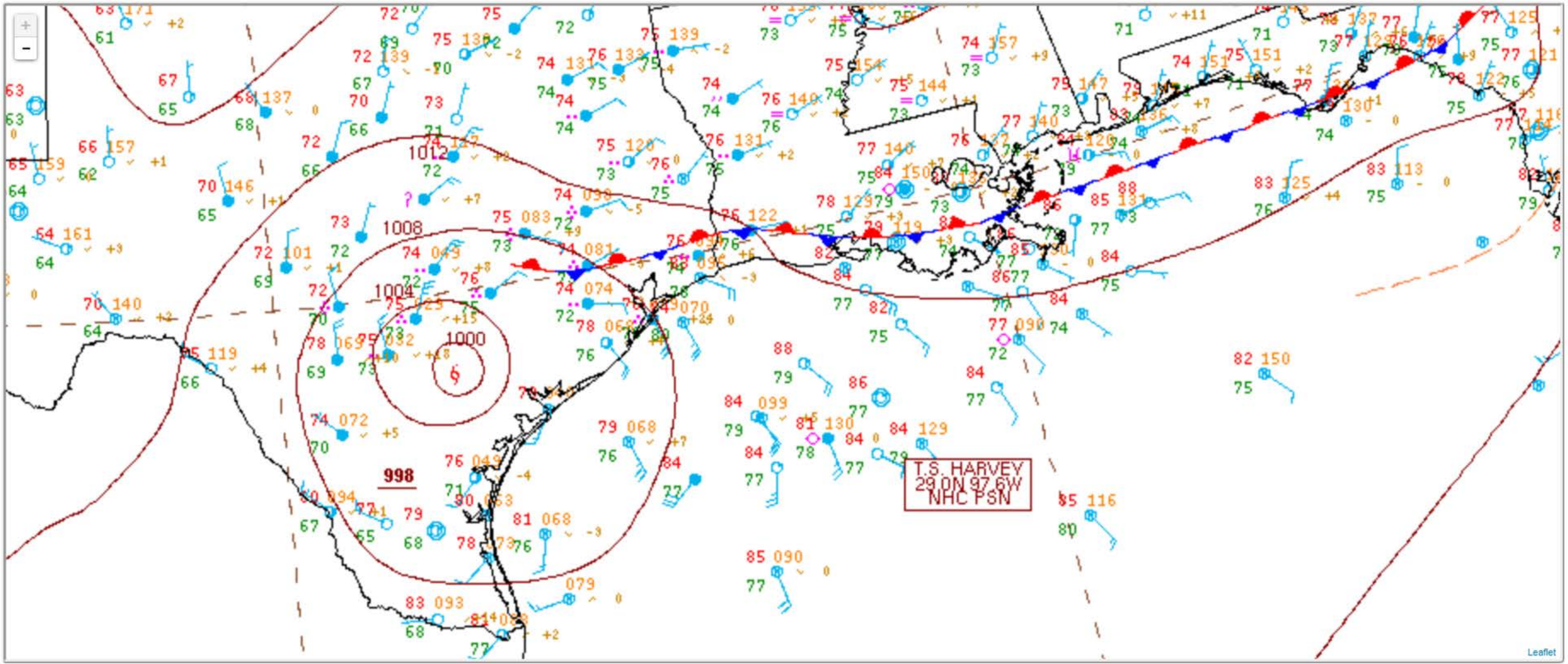

Figure 14. NCEP unified surface analysis at 1200 UTC 27 August 2017.

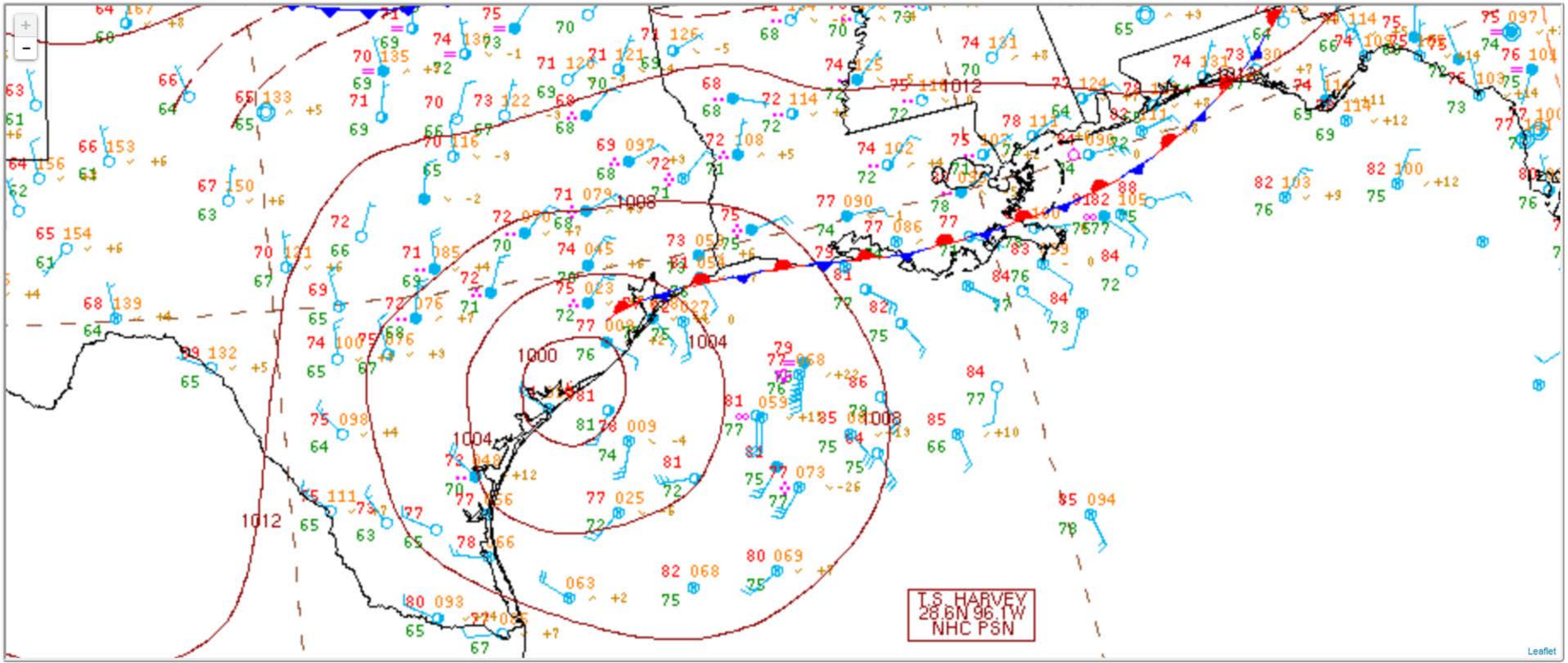

Figure 15. NCEP unified surface analysis at 1200 UTC 28 August 2017.

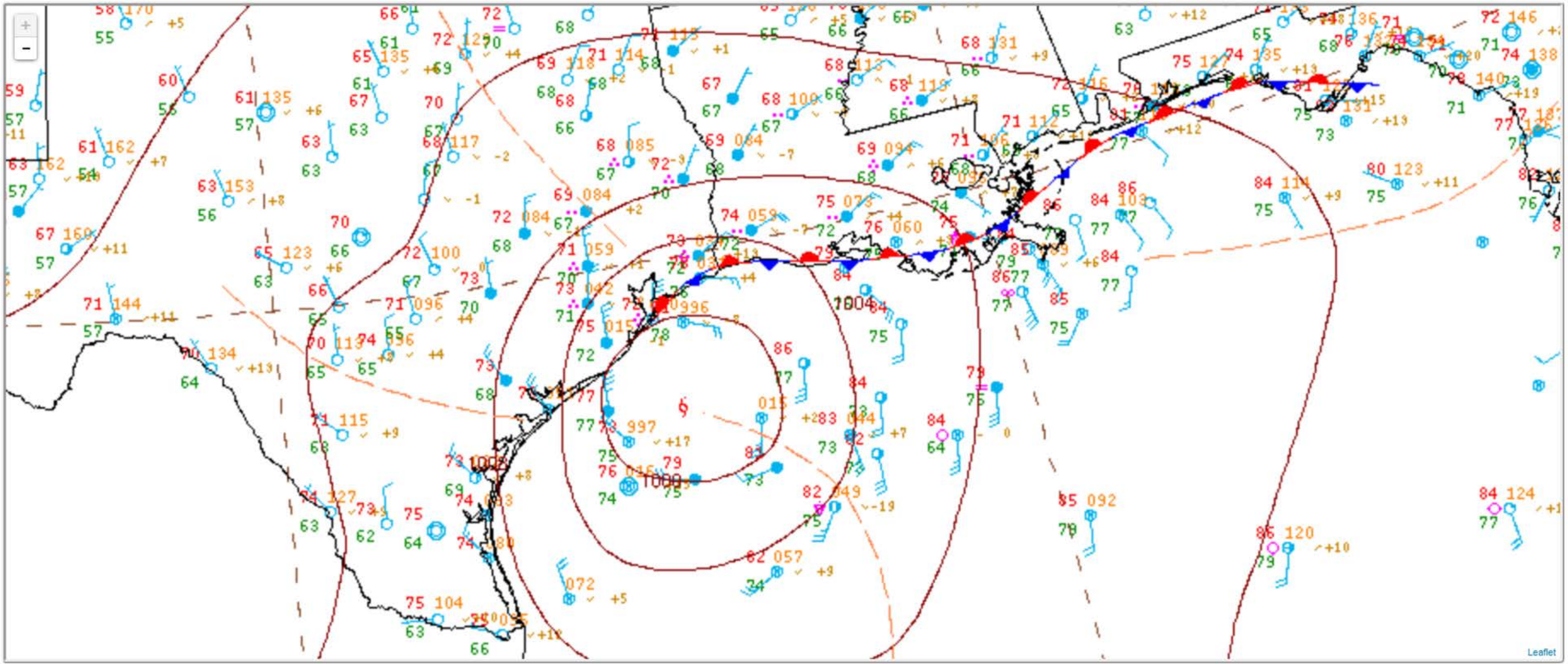

Figure 16. NCEP unified surface analysis at 1200 UTC 29 August 2017.

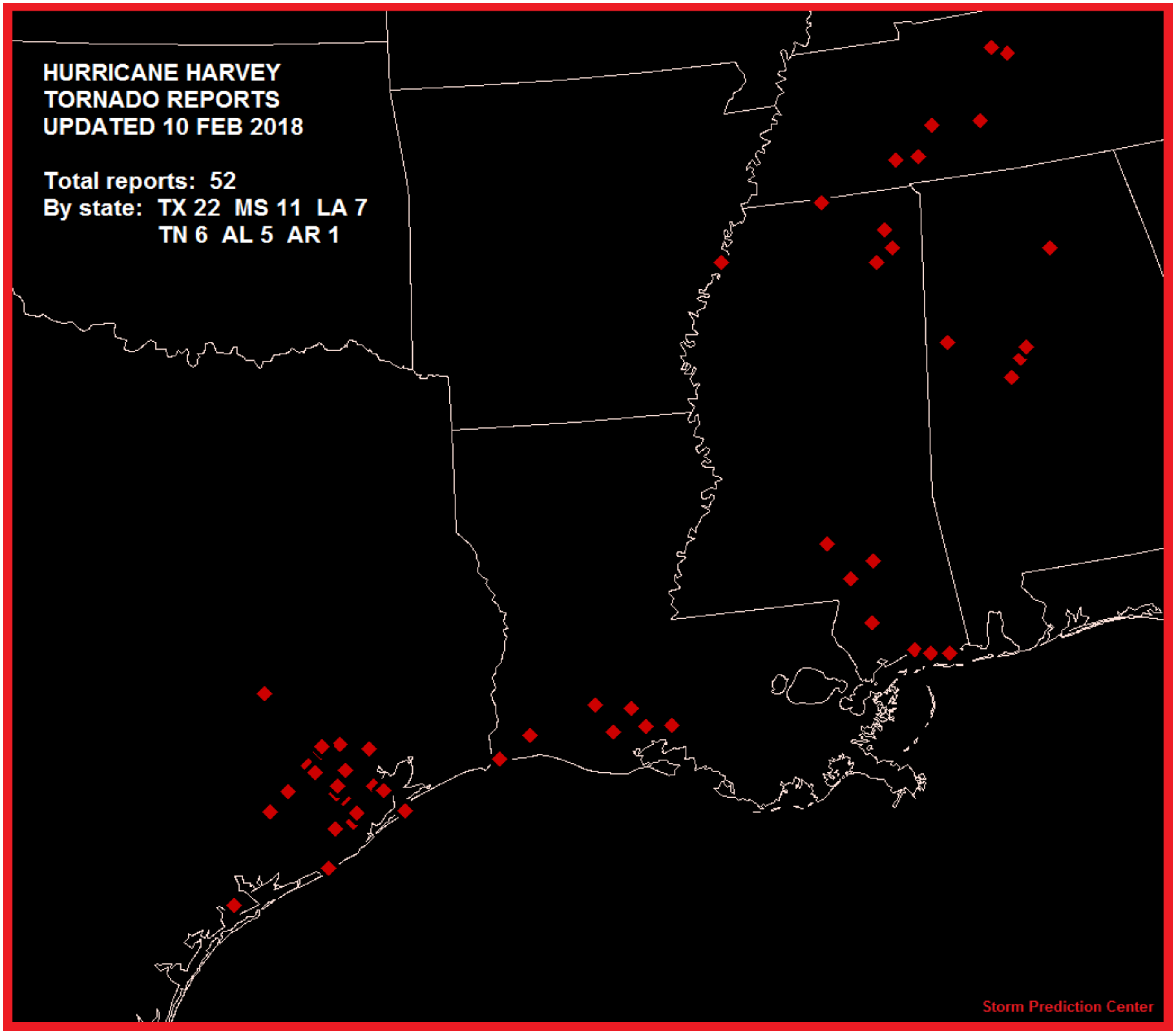

Figure 17. Tornado reports from Harvey. Figure courtesy Roger Edwards of the Storm Prediction Center.

Figure 18. Texas World Speedway after Harvey being used to store flooded cars. Photo credit Brazos Drones.

Figure 19. An example of the water rescues that were ongoing during Harvey in Houston on 27 August 2017. Photo credit David J. Phillip (Associated Press).

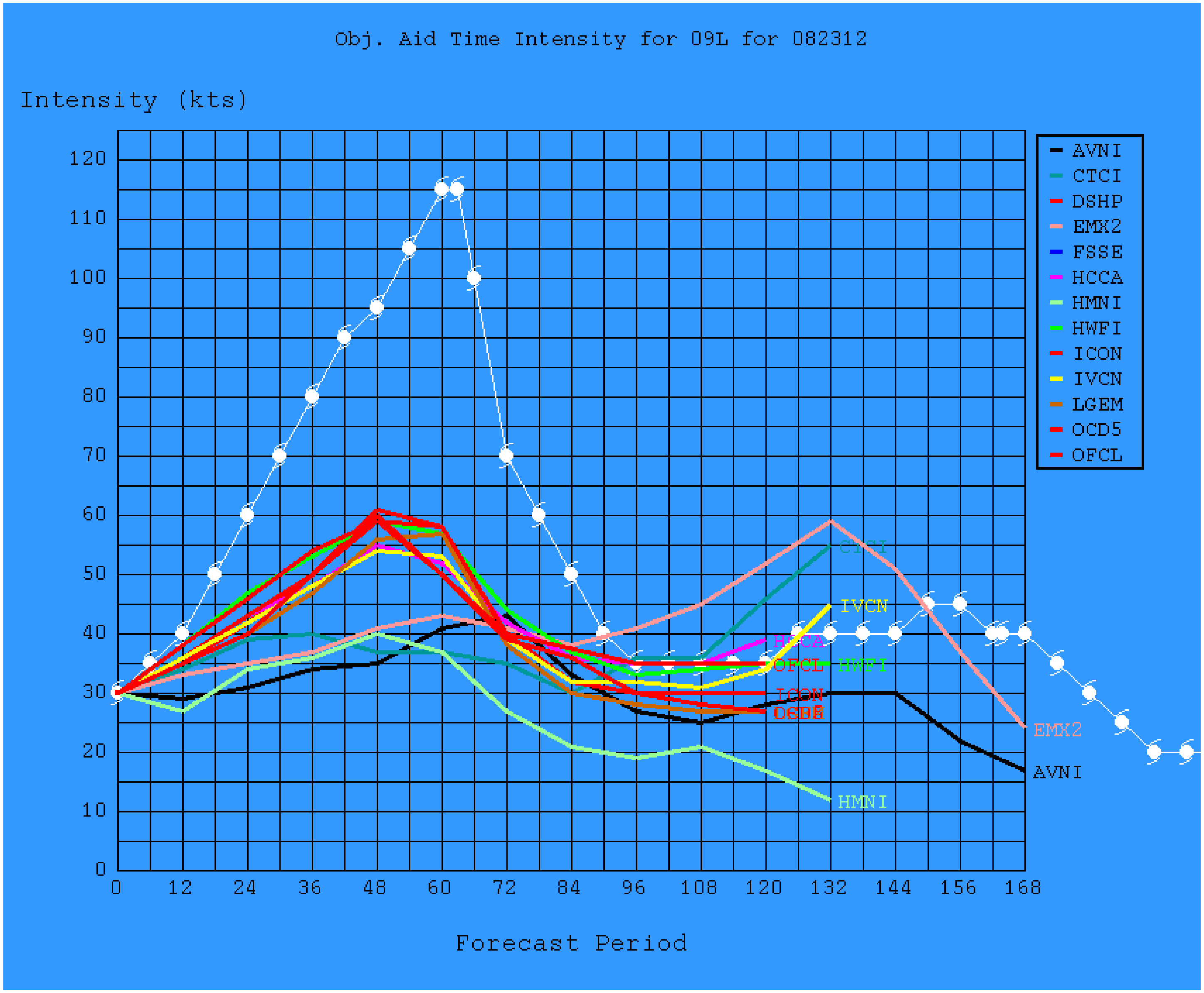

Figure 20. NHC intensity aids (knots, colored lines) for the 1200 UTC 23 August 2017 forecast cycle for Harvey (verifying points in white). Note the guidance was much too low for the intensity at landfall, which occurred near the 60-h point.

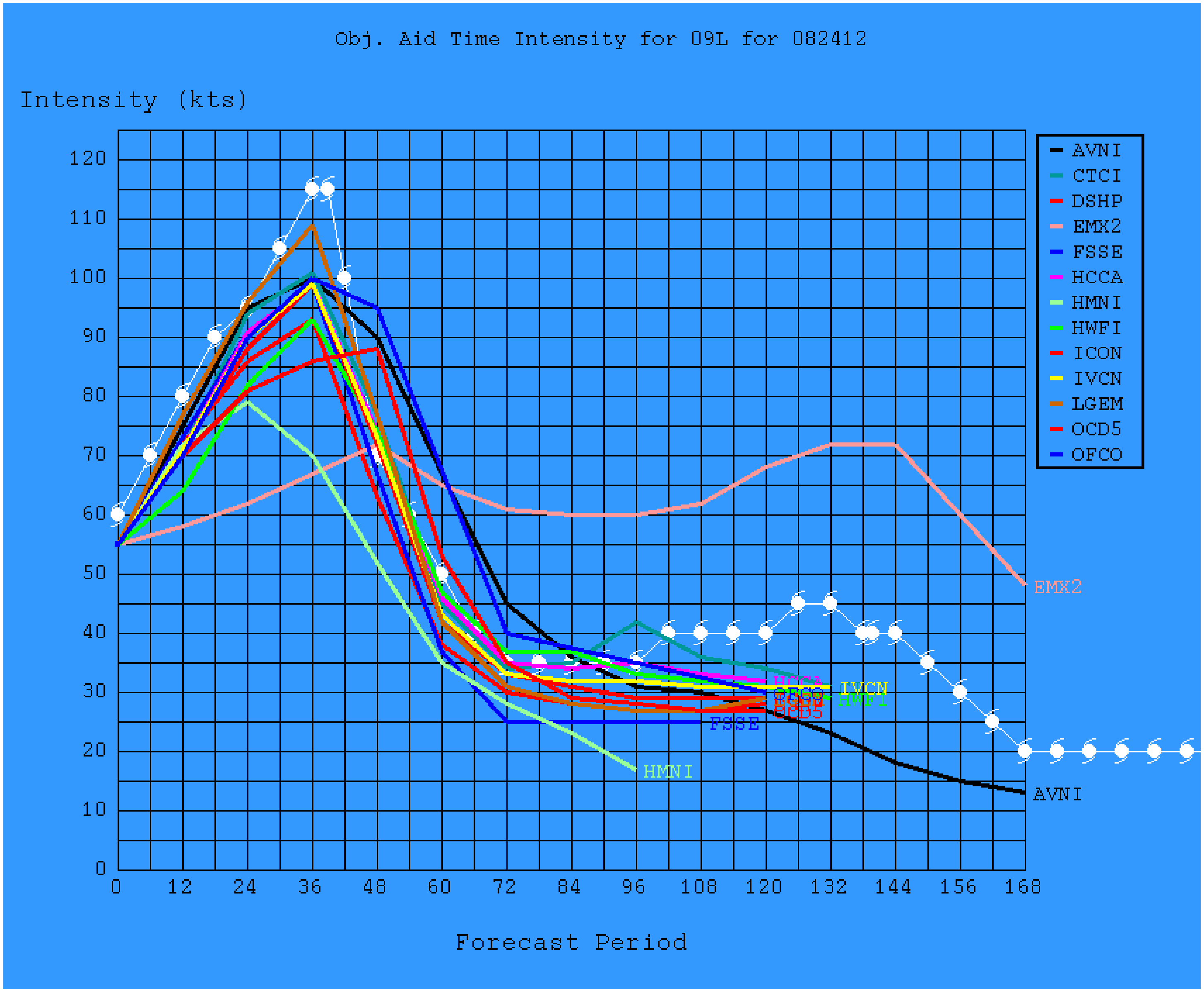

Figure 21. Same as Figure 20 but for 1200 UTC 24 August 2017. Note that much of the guidance showed rapid intensification before landfall, which occurred near the 36-h forecast point.

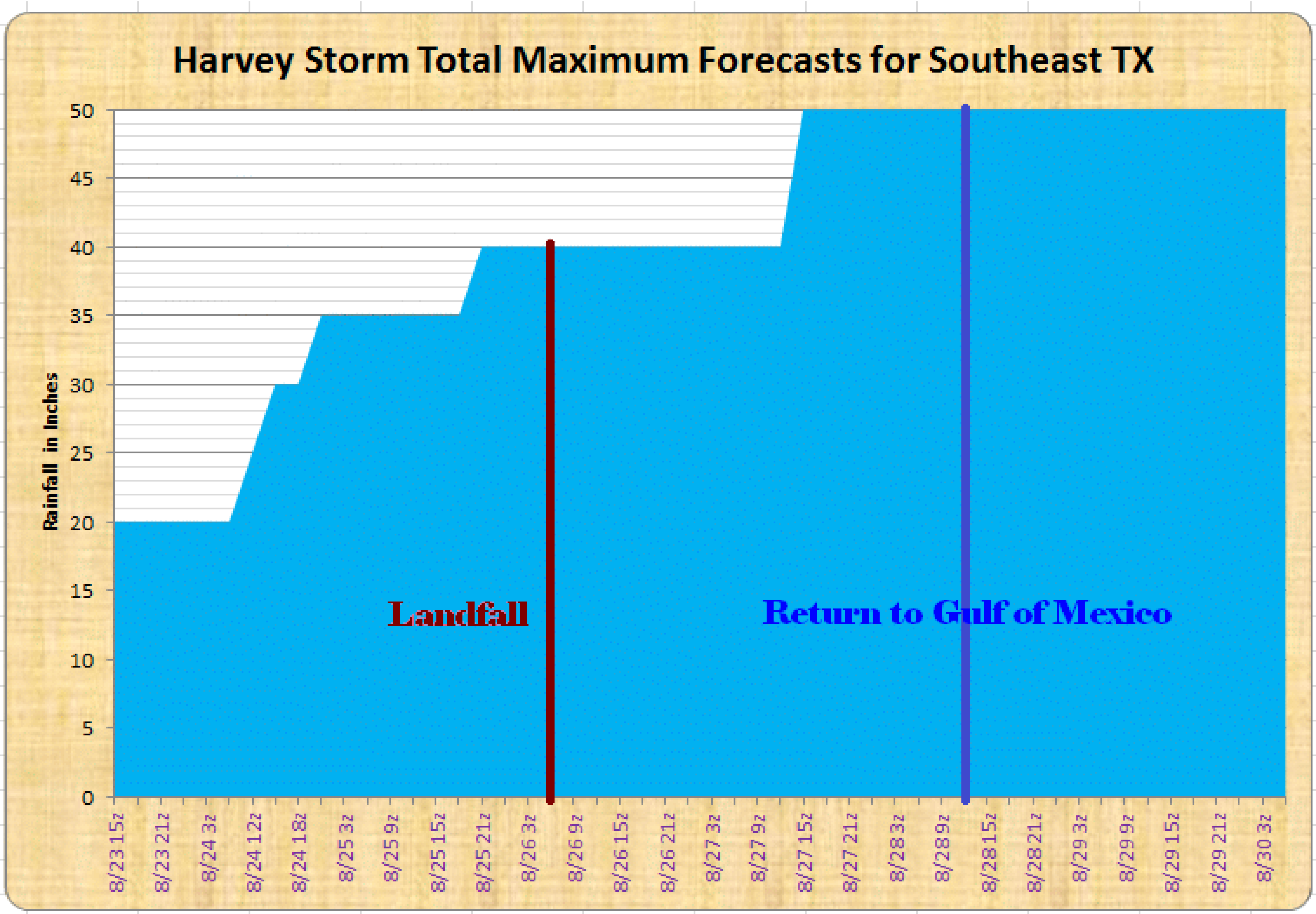

Figure 22. Time series of maximum rainfall forecasts for Harvey in southeastern Texas. Figure courtesy David Roth (WPC)