NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

TROPICAL STORM HAROLD

(AL092023)

21–23 August 2023

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National Hurricane Center
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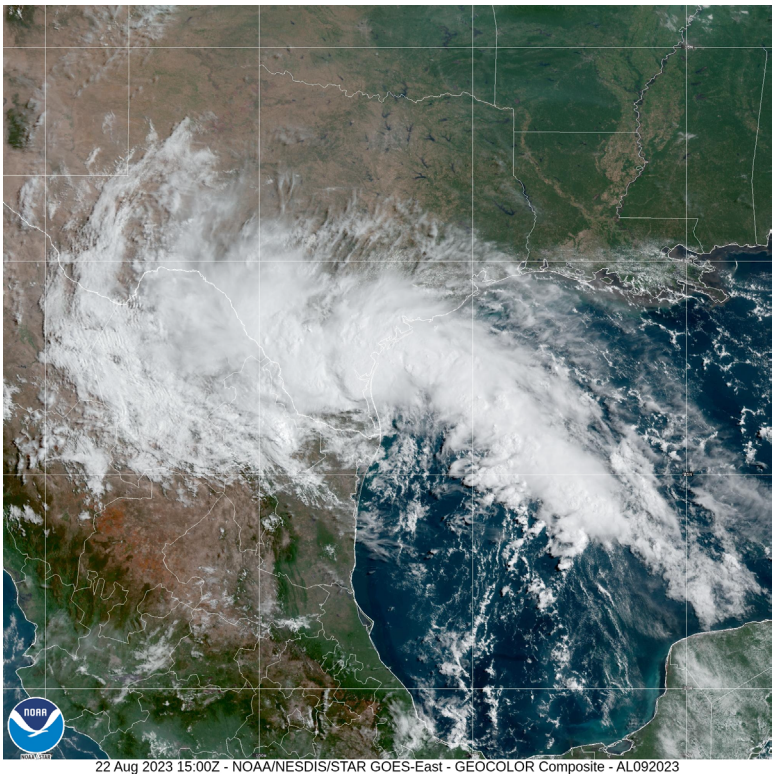

GOES-16 GEOCOLOR IMAGE OF TROPICAL STORM HAROLD NEAR LANDFALL IN SOUTH TEXAS AT 1500 UTC 22 AUGUST 2023. IMAGE COURTESY OF NOAA/NESDIS/STAR.

Harold was a tropical storm that made landfall in South Texas, where it caused generally minor damage.

Tropical Storm Harold

21–23 AUGUST 2023

SYNOPTIC HISTORY

Harold formed from a tropical wave that exited Africa around 8-10 August. The wave was difficult to track, but appeared to move uneventfully westward across the tropical Atlantic for the next week or so, and was near the Leeward Islands on 16 August. By 17 August, convection increased over the northern portion of the wave, to the north of the Dominican Republic. The area of disturbed weather moved over the Bahamas on 18-19 August, across the southern Florida peninsula and the Straits of Florida late on 19 August, and into the southeastern Gulf of Mexico by 20 August. The system's cloud pattern became better organized over the Gulf, and by 1800 UTC 21 August it had developed a closed low-level circulation and enough convective organization to be designated as a tropical depression while centered about 360 n mi east of Brownsville, Texas. The "best track" chart of the tropical cyclone's path is given in Fig. 1, with the wind and pressure histories shown in Figs. 2 and 3, respectively. The best track positions and intensities are listed in Table 1[1].

A well-developed mid-level ridge was situated to the north of the system, and the depression moved on a mostly west-northwestward track with increasing forward speed. The cyclone strengthened into a tropical storm around 0600 UTC 22 August. While it approached the coast of South Texas, the cyclone's center re-formed slightly to the north, but the system remained on a mainly west-northwestward heading. Harold strengthened a little more, and its center made landfall near Big Shell Beach on Padre Island, Texas around 1500 UTC 22 August with an intensity of 50 kt. The system was never a very well-organized tropical storm, as exemplified by the cover image, with a somewhat elongated cloud pattern. Later on the 22nd, Harold moved across extreme South Texas. It weakened to a tropical depression before moving over extreme northern Mexico on 23 August. The cyclone moved back into Texas later on the 23rd, and degenerated into a remnant low over the Big Bend region, dissipating shortly thereafter.

METEOROLOGICAL STATISTICS

Observations in Harold (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), objective Advanced Dvorak Technique (ADT) estimates and Satellite

[1] 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.

Consensus (SATCON) 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 flights of the 53rd Weather Reconnaissance Squadron of the U.S. Air Force Reserve Command (AFRC). There were 2 AFRC missions into Harold and its potential tropical cyclone predecessor. 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 Harold.

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

Winds and Pressure

The peak intensity of Harold, 50 kt at 1200 and 1500 UTC 22 September, i.e. near landfall in South Texas, is based on a blend of flight-level and SFMR winds from the Air Force aircraft along with surface observations over South Texas. Just before landfall, an Air Force reconnaissance aircraft reported SFMR-observed surface winds of 51 kt and flight-level adjusted surface winds of 44 kt. In Fig. 2, the analysis fix of an intensity of 50 kt at landfall is based on surface reports. The highest sustained wind reported from surface stations was 42 kt at Loyola Beach and Packery Channel, Texas, and the highest observed gust was 58 kt at Loyola Beach.

Harold's minimum pressure of 995 mb is based on an observation of 995.6 mb from NOAA data buoy 42020 just offshore of extreme South Texas. Harold's center passed near or over this buoy.

Storm Surge[2]

Harold produced 1 to 3 ft of storm surge inundation above ground level (AGL) along the Texas Coast. Several National Ocean Service (NOS) tide gauges near Corpus Christi Bay, located north of the landfall location in Padre Island, Texas, recorded maximum water levels greater than 2 ft above Mean Higher High Water (MHHW). Peak water levels in these locations include 2.59 ft above MHHW in Nueces Bay, 2.43 ft above MHHW near Viola Turning Basin, and 2.01 ft above MHHW at the USS Lexington in Corpus Christi Bay. Farther to the north along the

[2] 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).

Texas coast, NOS tide gauges reported water levels of 1.99 ft MHHW, 1.97 ft MHHW, and 1.87 ft MHHW near Galveston Pier 21, San Luis Pass, and Port Lavaca, respectively.

Rainfall and Flooding

Harold produced a narrow swath of 5 to 7 inches of rain near its track over South Texas (Fig. 4) with a maximum measured total amount of 6.98 inches near Orange Grove, Texas. The rainfall was mostly beneficial, in that it partially alleviated drought conditions over the area.

Tornadoes

There were two EF0 tornadoes reported in Live Oak and Jim Wells Counties, TX, between 1600 and 1700 UTC 22 August. These caused mostly minor damage.

CASUALTY AND DAMAGE STATISTICS

There were no direct deaths[3] due to Harold. Damage in Texas appeared to be minor. More than 35,000 homes and businesses in South Texas reportedly lost power due to the storm. There was some tree damage in portions of South Texas. Damage figures, likely relatively low, are not available.

FORECAST AND WARNING CRITIQUE

Genesis

The genesis of Harold was fairly well forecast (Table 4), although its development in the 7-day time frame was somewhat less well anticipated than its formation in 2 days. It was first mentioned in the Tropical Weather Outlook that an area of low pressure could form over the central or western Gulf of Mexico 138 h prior to genesis, with a low chance (<40%) of formation within 7 days. The 7-day genesis probability was raised to the medium category (40-60%) 72 h before genesis, and the 7- and 2-day formation probabilities were both raised to high (>60%) 18 hours prior to genesis. The location of Harold's genesis was well forecast (Fig. 5), with all of the predicted genesis areas capturing the location where Harold formed.

[3] 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.

Track

A verification of NHC official track forecasts for Harold is given in Table 5a. There were only 3 cases to verify at 24 hours and just 1 case at 36 hours. A homogeneous comparison of the official track errors with selected guidance models is given in Table 5b. There were too few cases to draw meaningful conclusions from these statistics.

Intensity

A verification of NHC official intensity forecasts for Harold is given in Table 6a, and a homogeneous comparison of the official intensity errors with selected guidance models is given in Table 6b. As for track errors, there were too few cases to make meaningful conclusions, although it could be noted that the official 36-hour intensity error for the single case is zero.

Wind Watches and Warnings

Coastal wind watches and warnings associated with Tropical Storm Harold are given in Table 7. A Tropical Storm Warning was issued for portions of the South Texas coast when the system was designated as a Potential Tropical Cyclone, about 23 hours before the arrival of tropical storm force winds.

Storm Surge Watches and Warnings

No storm surge watches or warnings were issued for Harold. The peak storm surge forecast for the south Texas Coast was 1 to 3 ft AGL, which verified well with available observations.

Impact-based Decision Support Services (IDSS) and Public Communication

The NHC began communication with emergency managers on Monday, August 21 as Harold was forming in the Gulf of Mexico. Two decision support briefings were provided to emergency managers and coordinated through the FEMA Hurricane Liaison Team embedded at the NHC. The briefings were federal teleconferences with FEMA HQ and FEMA Region 6. These briefings continued through Tuesday, August 22, as Harold moved inland over Texas.

The Tropical Analysis and Forecast Branch of NHC provided one live briefing on Harold (while a Potential Tropical Cyclone) on 21 August to the U.S. Coast Guard District 8 in support of their life-saving mission.

ACKNOWLEDGEMENTS

Much of the observed data in this report came from Post Tropical Cyclone Reports issued by NWS Weather Forecast Offices in Brownsville, Corpus Christi, and Houston, Texas. Data were also provided by the NOAA National Data Buoy Center and the NOS Center for Operational Oceanographic Products and Services.

David Roth of the NOAA Weather Prediction Center produced the rainfall map (Fig. 4), and Philippe Papin of NHC made the track and predicted genesis area maps (Figs. 1 and 5). Matthew Green and Michael Spagnolo of FEMA and Chris Landsea of NHC provided the IDSS information.

Table 1. Best track for Tropical Storm Harold, 21–23 August 2023.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
21 / 1200	24.7	89.2	1008	25	disturbance
21 / 1800	25.0	90.8	1008	30	tropical depression
22 / 0000	25.4	92.4	1008	30	"
22 / 0600	25.8	94.3	1003	40	tropical storm
22 / 1200	26.8	96.4	996	50	"
22 / 1500	27.1	97.4	995	50	"
22 / 1800	27.3	98.3	997	40	"
23 / 0000	27.7	100.1	1002	30	tropical depression
23 / 0600	28.5	101.7	1007	25	"
23 / 1200	29.7	103.3	1011	20	low
23 / 1800					dissipated
22 / 1500	27.1	97.4	995	50	minimum pressure and maximum winds
22 / 1500	27.1	97.4	995	50	landfall over Padre Island, TX

Table 2. Selected ship reports with winds of at least 34 kt for Tropical Storm Harold, 21–23 August 2023.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/ speed (kt)	Pressure (mb)
22 / 0200	C6SE5	28.6	93.6	080 / 35	1010.6
22 / 0500	C6SE5	28.1	92.8	090 / 40	1010.6

Table 3. Selected surface observations for Tropical Storm Harold, 21–23 August 2023.

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)				
Offshore									
Buoy 42020 (27.0°N 96.7°W)	22/1320	995.6	22/1310	42	51				
Texas									
International Civil Aviation Organization (ICAO) Sites									
Falfurrias AWOS (KBKS)	22/1715	997.0	22/1735	32	53				2.35
Aransas County (KRKP)	22/1025	1009.4	22/1509	30	45				
Alice International	22/1800	1001.4	22/1737	34	45				3.83
Orange Grove NALF	22/1956	1007.6	22/1756	27	42				
Naval Air Station Kingsville	22/1756	1004.7	22/1638	30	48				2.46
Corpus Christi International	22/1835	1006.4	22/1541	37	54				4.74
Naval Air Station Corpus Christi	22/1452	1007.7	22/1627	41	55				4.41
Cameron County Airport (KPIL)	22/0110	1006.8	22/1740	22	32				
Hebbronville, Jim Hogg County Airport (KHBV)	22/1930	1003.7	22/1930	29	37				3.03
South Texas International Airport (KEBG)	22/1755	1007.7	22/1755	19	26				
Beeville Municipal Airport (KBEA)	22/1955	1010.1	22/1655	17	30				
Calhoun County Airport (KPKV)	22/1055	1011.8	22/1615	25	35				0.21
Mustang Beach (KRAS)	22/1815	1010.2	22/1615	31	38				2.04
Nueces County (KRBO)	22/1755	1008.4	22/1815	33	42				3.02
Victoria Regional (KVCT)	22/2000	1011.9	22/1909	28	45				0.30
Bay City Regional Airport (KBYY)			22/1655	23	35				
Texas Gulf Coast Regional Airport (KLBX)	22/0953	1013.0	22/2016	18	33				
Palacios Municipal Airport (KPSX)	22/1053	1012.0	22/1953	29	40				
Galveston Scholes Field (KGLS)	22/1052	1013.0	22/2200	26	35				
Conroe-North Houston Regional Airport (KCXO)	22/2053	1014.0	22/1853	15	36				
Hydrometeorological Automated Data System (HADS) Sites (NWS)									
Rio Grande NWR Edinburg 17 NNE TX US									0.49
Coastal-Marine Automated Network (C-MAN) Sites									
Aransas Pass Sentinel	22/1530	1007.8	22/1600	34	43			1.35	

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)				
Port Aransas (PTAT2)			22/1700	36	42				
National Ocean Service (NOS) Sites									
Port Isabel	22/1300	1006.4	22/0806	25	37	1.14	1.52	1.00	0.53
Realitos Peninsula	22/1342	1005.9	22/0030	27	32			1.10	
South Padre Island U.S. Coast Guard Station	22/1254	1006.4	22/1306	18	27	1.16	1.39	0.95	
SPI Brazos Santiago	22/1306	1006.1	22/0812	24	32	1.18	1.19	0.55	
Rockport	22/1042	1008.2	22/1600	29	38	1.28	2.51	1.21	1.38
Aransas Wildlife Refuge	22/1030	1009.9	22/1600	25	33	0.96	2.17	0.89	
Seadrift	22/1012	1009.9	22/2106	18	26	0.97	2.23	0.89	
Port O'Connor	22/1012	1010.6	22/1542	27	35	1.59	2.47	1.37	
Port Lavaca	22/2042	1010.7	22/1942	28	35			1.87	
Baffin Bay	22/1524	1004.7	22/1542	40	48		1.14	0.70	
South Bird Island	22/1518	1006.1	22/1518	37	49		1.56	0.99	
Port Aransas (RTAT2)	22/1430	1008.9	22/1448	32	42	1.69	2.28	1.39	
USS Lexington	22/1818	1006.0				2.32	3.04	2.01	
Packery Channel	22/1500	1007.1	22/1506	42	52	1.32	1.84	1.05	
Viola Turning Basin	22/1730	1007.7	22/1800	33	40			2.43	
MODA Ingleside	22/1648	1007.8	22/1700	29	40			1.33	
San Luis Pass						2.22	2.88	1.97	
Galveston Pier 21 (GTOT2)						2.19	3.09	1.99	
Galveston Bay Entrance (North Jetty)	22/0930	1012.0	22/1712	28.8	42	1.80	2.62	1.51	
Freeport SPIP	22/0930	1011.0	22/1948	31.1	40.8	1.93	2.51	1.49	
Nueces Bay						2.88	3.86	2.59	
La Quinta Channel						2.02	2.27	1.50	
Matagorda City						1.36	2.13	1.11	
Public/Other									
Sarita Station (Mesowest)	22/1110	1002.4	22/1610	28	41				
SPIW Park (WeatherFlow)			22/0755		43				
Laguna Vista (CWOP)	22/1300	1006.4	22/0944	14	32				0.89
Hellen Station (TWB75)	22/1925	1005.1	22/1815	25	40				2.82
Loyola Beach (WeatherFlow)	22/1630	1006.0	22/1530	42	58				
Corpus Christi HurrNet (WeatherFlow)	22/1456	1005.2	22/1626	40	51				

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)				
Laguna Shores (WeatherFlow)	22/1528	1004.1	22/1547	40	51				
Wildcat (WeatherFlow)	22/1118	1006.1	22/1623	31	41				
Surfside Beach (Mesonet)	22/2003	1011.0	22/1853	30	44				
Galveston Fishing Pier (Mesonet)	22/1048	1013.0	22/1023	26	37				
Matagorda Bay (Mesonet)	22/0929	1012.0	22/1129	27	33				
Clear Lake Park (Mesonet)	22/1121	1014.0	22/1806	22	34				
8.5 N Katy (Mesonet)									1.09
Fulshear (Mesonet)									2.25
NWS Cooperative Observer Program (COOP) Sites									
Corpus Christi National Weather Service									4.90
Robstown									4.85
Corpus Christi Botanical Gardens									4.62
Padre Island at Corpus Christi									3.92
Port Aransas 11 SSW									3.50
Kingsville									3.35
Armstrong 4SE									2.96
0.7 NE Port Mansfield									2.55
Port Aransas									2.43
Port Isabel									1.46
South Padre Island									1.20
Beeville 5 NE									1.01
San Manuel									0.68
McCook									0.50
Remote Automated Weather Stations (RAWS)									
Hebbronville			22/1946	27	41				2.61
Laguna Atascosa									2.00
Linn-San Manuel									0.43
Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) Sites									
Orange Grove 4.5 SE									6.98
Robstown 4.9 NNW									6.53
Orange Grove 8.1 WNW									6.34

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)				
Robstown 6.2 ENE									5.89
Corpus Christi 7.3 W									5.49
Orange Grove 3.3 NW									5.41
Corpus Christi 3.4 WSW									5.40
Corpus Christi 4.8 W									5.28
Corpus Christi 4.8 SSE									5.25
Corpus Christi 9.0 SSE									4.88
Corpus Christi 6.9 SE									4.68
Corpus Christi 8.3 SSE									4.61
Corpus Christi 7.5 SSE									4.55
Corpus Christi 5.1 WNW									4.28
Corpus Christi 3.1 WNW									4.17
Corpus Christi 8.7 SSE									3.94
Portland 1.2 NW									3.78
Hebbronville 0.7 ENE									3.72
Falfurrias 8.9 SSW									3.62
Premont 5.0 SSW									3.50
Alice 7.9 W									3.30
Premont 0.9 WSW									3.15
Corpus Christi 9.1 NW									3.06
Hebbronville 4.3 SSE									2.85
Skidmore 6.9 W									2.82
Kingsville 6.5 SSE									2.65
Port Mansfield 1.1 SE									2.55
Hebbronville 14.8 SSE (Sugar Camp)									2.50
Hebbronville 32.4 S (Borregos Ranch)									2.15
Port Aransas 4.0 SSW									1.87
Laguna Vista 1.8 NW									1.48
Rockport 0.8 WNW									1.42
Rockport 8.0 NNE									1.32
Goliad 5.6 NNE									1.13
Goliad 8.7 NNW									1.11

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)				
Hebbronville 21.2 SSE (Jones Ranch)									1.10
Rockport 4.4 SW									1.09
Hebbronville 32.3 SSW									0.95
Laguna Vista 0.3 N									0.85

[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). Storm tide is water height above Mean Lower Low Water (MLLW) for NOS stations in Puerto Rico, the U.S. Virgin Islands, and Barbados.
[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.

Table 4. Number of hours in advance of formation 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	**168-Hour Outlook**
Low (<40%)	48	138
Medium (40%-60%)	24	72
High (>60%)	18	18

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Harold, 21–23 August 2023. 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	60	72	96	120
OFCL	34.4	41.0	**24.6**					
OCD5	61.6	157.3	265.3					
Forecasts	5	3	1					
OFCL (2018-22)	23.8	35.7	47.8	61.4	76.1	90.5	125.7	172.1
OCD5 (2018-22)	46.4	99.2	157.4	215.0	254.9	321.2	405.1	486.6

Table 5b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Tropical Storm Harold, 21–23 August 2023. Errors smaller than the NHC official forecast are shown in boldface type.

Model ID	Forecast Period (h)							
	12	24	36	48	60	72	96	120
OFCL	34.4	41.0	24.6					
OCD5	61.6	157.3	265.3					
GFSI	**32.0**	**34.1**	96.8					
NVGI	50.6	105.6	79.4					
HWFI	**26.3**	**36.6**	**21.1**					
HMNI	35.1	78.5	60.1					
HFAI	47.2	92.8	72.2					
HFBI	40.9	67.3	66.2					
CTCI	**30.3**	**39.6**	31.8					
HCCA	37.4	51.1	31.8					
AEMI	**33.1**	43.4	**21.9**					
TVCA	34.7	60.3	55.0					
TVCX	34.7	57.6	55.0					
TVDG	35.1	57.6	60.9					
TABD	**33.2**	**17.6**	27.7					
TABM	34.5	49.3	55.0					
TABS	45.7	101.9	141.3					
Forecasts	5	3	1					

Table 6a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Harold, 21–23 August 2023. 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	60	72	96	120
OFCL	**3.0**	**1.7**	**0.0**					
OCD5	5.0	6.7	14.0					
Forecasts	5	3	1					
OFCL (2018-22)	5.1	7.6	8.9	10.1	10.7	11.5	13.3	15.5
OCD5 (2018-22)	6.8	10.7	13.9	16.5	18.3	20.2	22.9	23.4

Table 6b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Tropical Storm Harold, 21–23 August 2023. Errors smaller than the NHC official forecast are shown in boldface type.

Model ID	Forecast Period (h)							
	12	24	36	48	60	72	96	120
OFCL	3.0	1.7	0.0					
OCD5	5.0	6.7	14.0					
DSHP	5.2	4.7	4.0					
LGEM	5.6	4.7	3.0					
HWFI	5.0	3.3	4.0					
HMNI	5.8	5.7	2.0					
HFAI	5.0	6.3	2.0					
HFBI	4.8	3.3	5.0					
CTCI	4.0	7.0	2.0					
GFSI	5.0	2.7	2.0					
IVCN	5.0	4.3	2.0					
ICON	5.4	4.7	3.0					
HCCA	4.0	3.0	0.0					
Forecasts	5	3	1					

Table 7. Watch and warning summary for Tropical Storm Harold, 21–23 August 2023.

Date/Time (UTC)	Action	Location
21 / 1500	Tropical Storm Watch issued	Port O'Connor to Sargent
21 / 1500	Tropical Storm Warning issued	TX/MEX Border to Port O'Connor
22 / 2100	Tropical Storm Watch discontinued	All
22 / 2100	Tropical Storm Warning discontinued	All

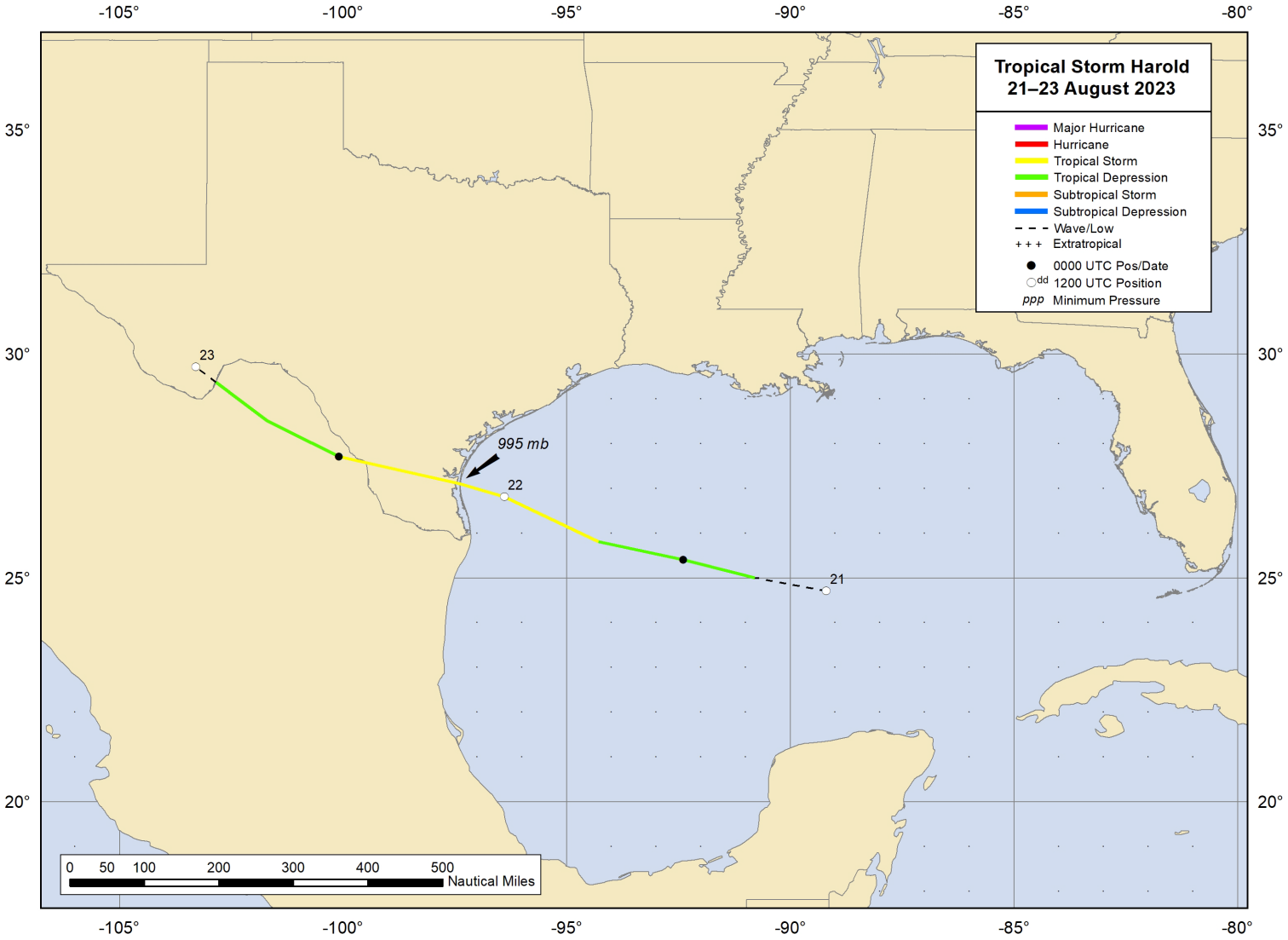

Figure 1. Best track positions for Tropical Storm Harold, 21–23 August 2023.

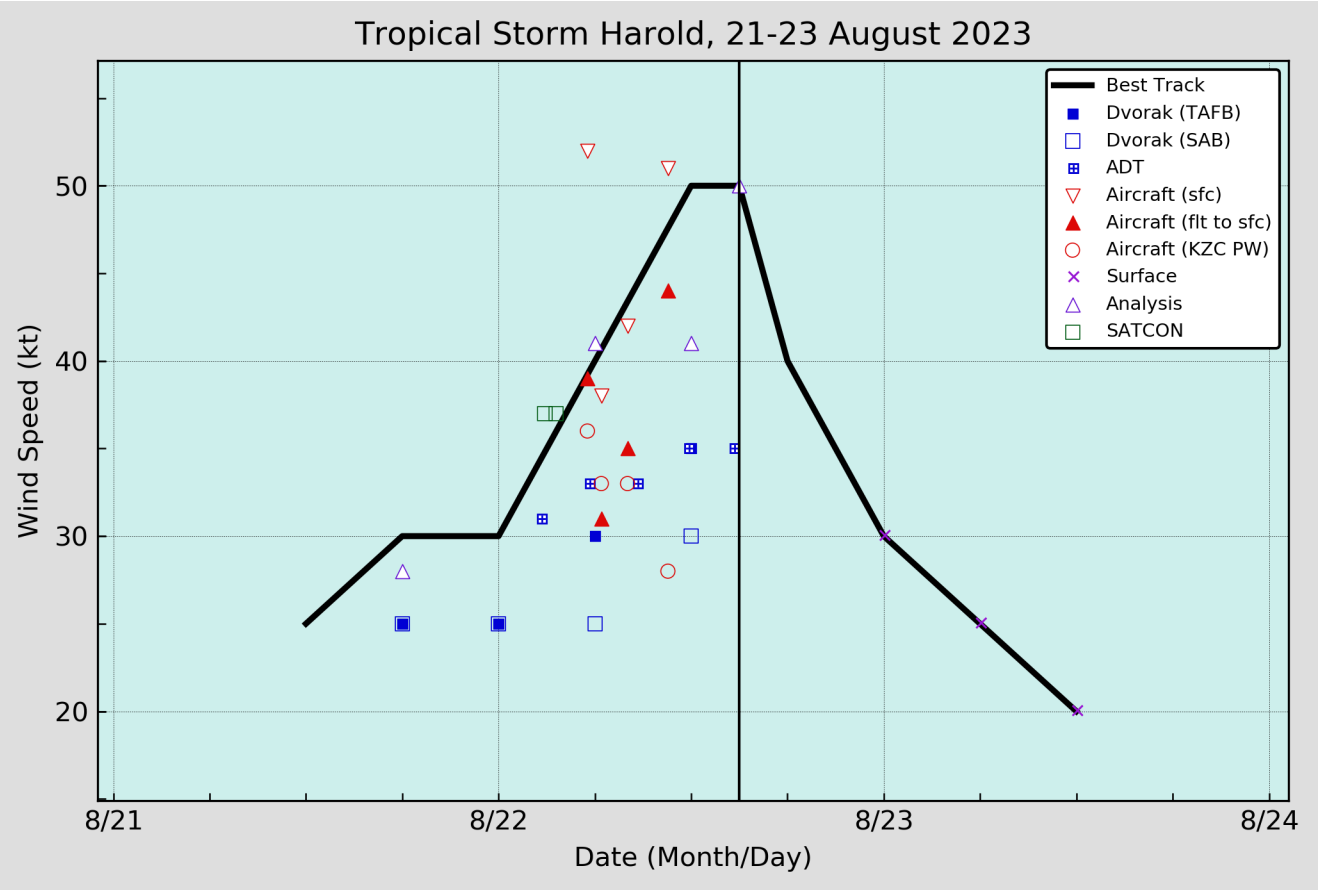

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Harold, 21–23 August 2023. Aircraft observations have been adjusted for elevation using 80% and 75% adjustment factors for observations from 850 mb, and 925 mb, respectively. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC, and solid vertical lines correspond to landfalls.

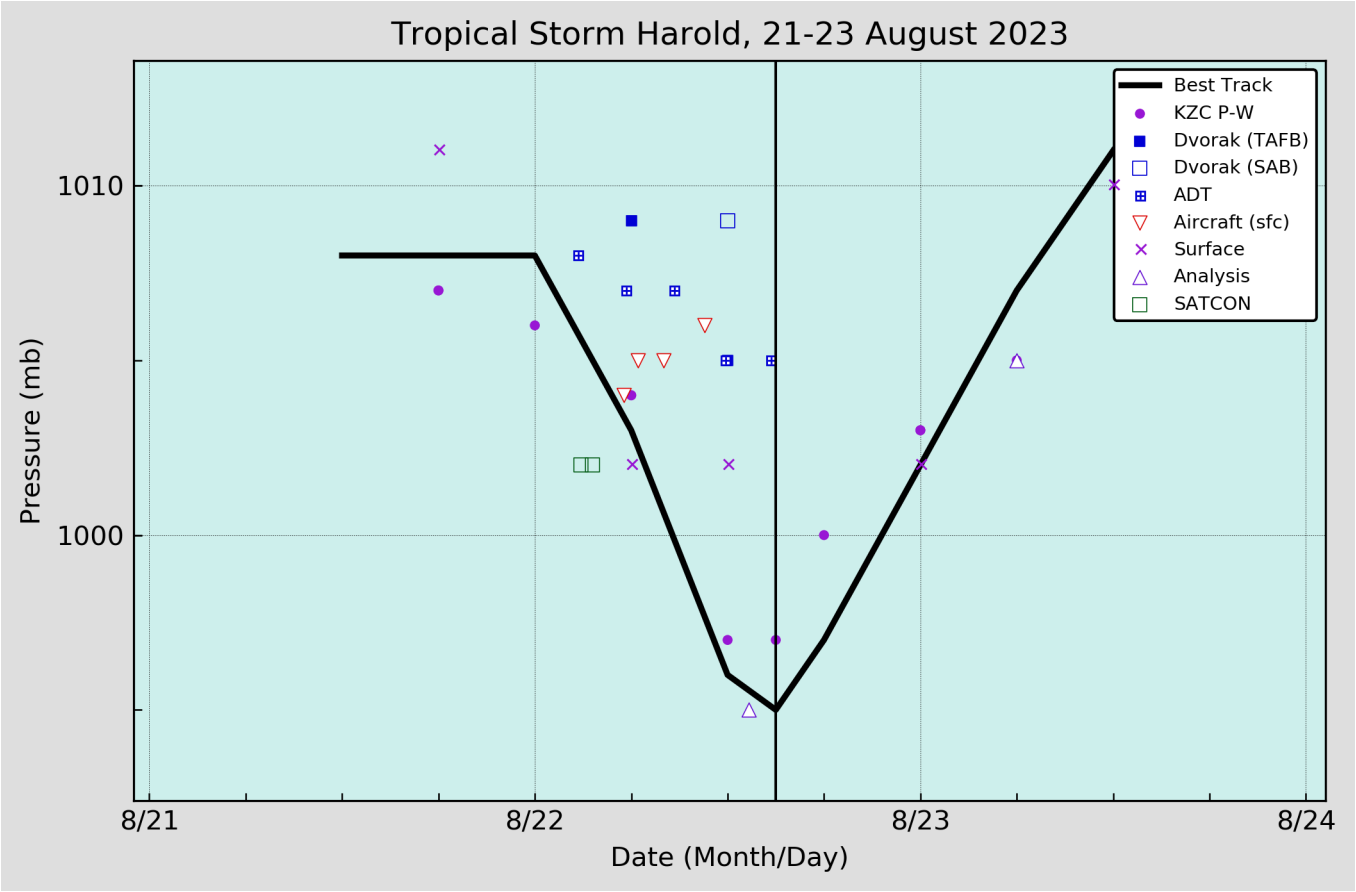

Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Harold, 21–23 August 2023. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. 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 landfalls.

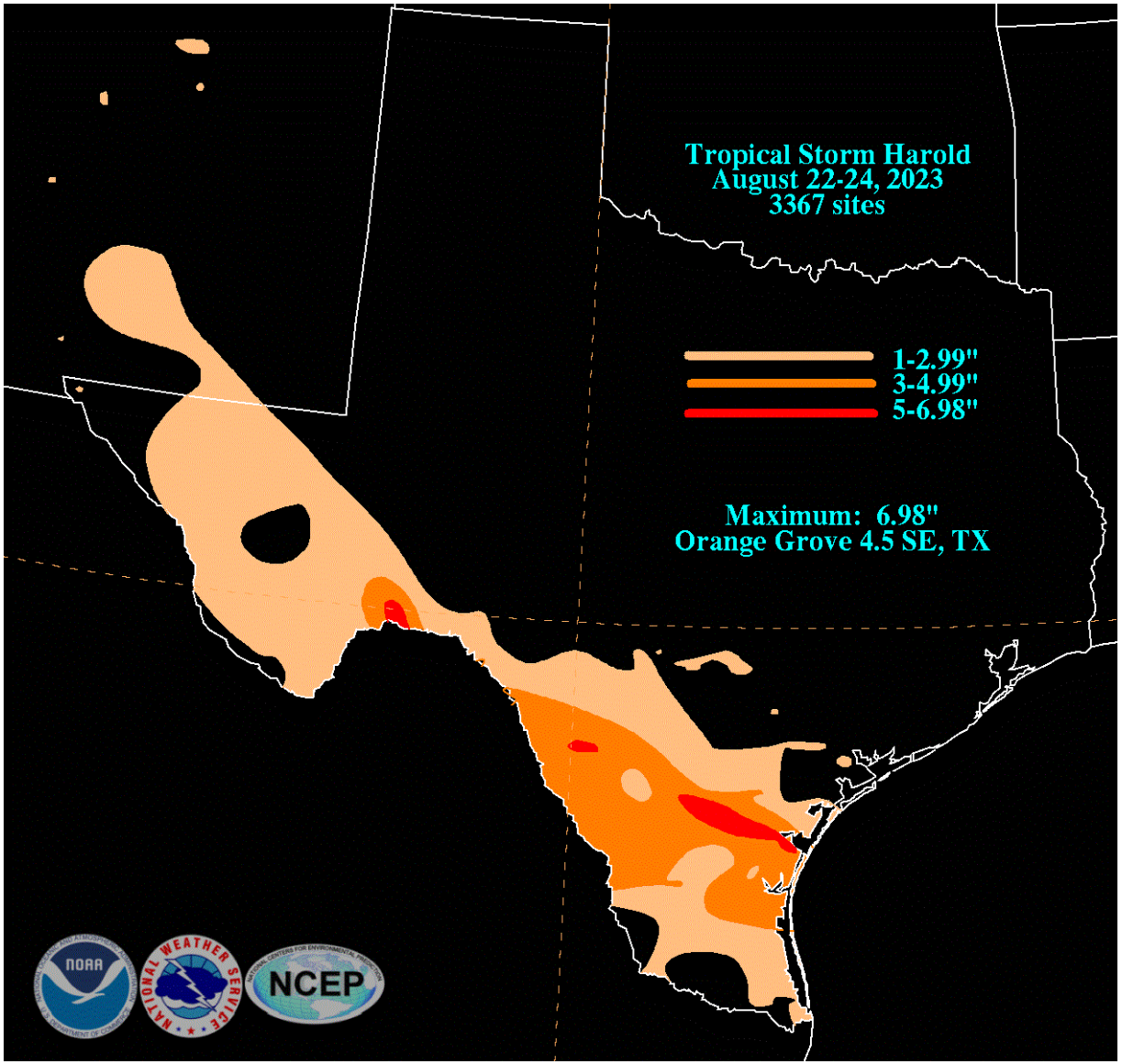

Figure 4. Rainfall totals for Tropical Storm Harold, August 2023. Analysis and map courtesy of David Roth, NOAA Weather Prediction Center.

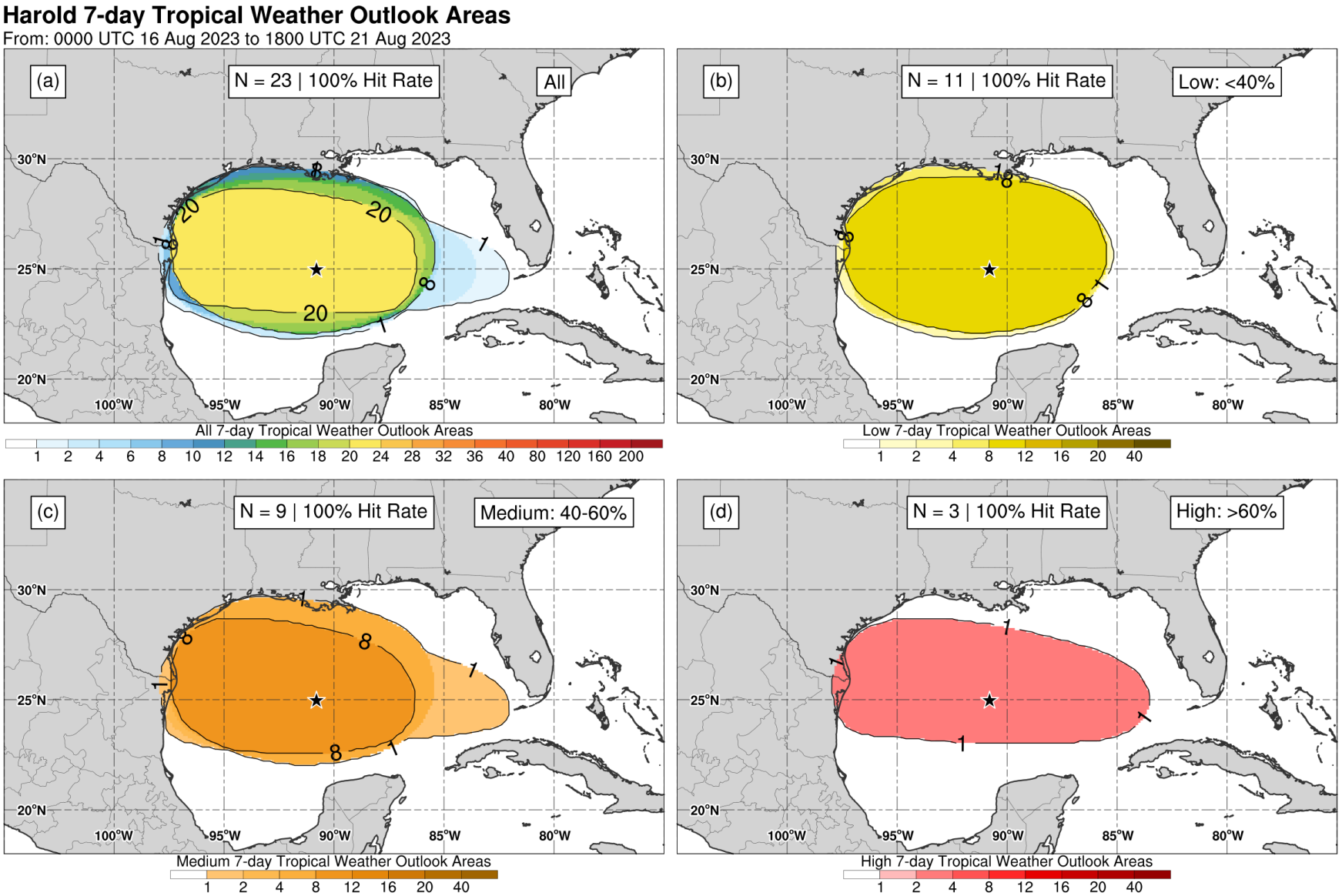

Figure 5. Composites of 7-day tropical cyclone genesis areas depicted in NHC's Tropical Weather Outlooks prior to the formation of Tropical Storm Harold for (a) all probabilistic genesis categories, (b) the low (<40%) category, (c) medium (40–60%) category, and (d) high (>60%) category. The location of genesis is indicated by the black star.