

## **HURRICANE IKE**



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Silver Spring, Maryland  
July 2, 2009

**noaa** National Oceanic and Atmospheric Administration

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**U.S. DEPARTMENT OF COMMERCE**  
**National Ocean Service**  
**Center for Operational Oceanographic Products and Services**

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National Ocean Service  
National Oceanic and Atmospheric Administration  
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The National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) collects and distributes observations and predictions of water levels and currents to ensure safe, efficient and environmentally sound maritime commerce. The Center provides the set of water level and coastal current products required to support NOS' Strategic Plan mission requirements, and assists in providing operational oceanographic data/products required by NOAA's other Strategic Plan themes. For example, CO-OPS provides data and products required by the National Weather Service to meet its flood and tsunami warning responsibilities. The Center manages the National Water Level Observation Network (NWLON), and a national network of Physical Oceanographic Real-Time Systems (PORTS) in major U.S. harbors. The Center establishes standards for the collection and processing of water level and current data; collects and documents user requirements which serve as the foundation for all resulting program activities; designs new and/or improved oceanographic observing systems; designs software to improve CO-OPS' data processing capabilities; maintains and operates oceanographic observing systems; performs operational data analysis/quality control; and produces/disseminates oceanographic products.

## **HURRICANE IKE**

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OF COMMERCE  
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## Overview

The National Oceanic and Atmospheric Administration (NOAA) Center for Operational Oceanographic Products and Services (CO-OPS) maintains a network of oceanographic and meteorological stations along the United States coastlines and Great Lakes to monitor water levels, winds (speed, direction and gusts), barometric pressure, and air/water temperature. CO-OPS also displays observations from partnership organizations that meet National Ocean Service (NOS) station installation standards, such as the Texas Coastal Ocean Observing System (TCOON; NOAA, 2008; Appendix 1). Utilizing these observations and tidal predictions, CO-OPS produces a real-time Storm QuickLook synopsis product for tropical cyclones impacting the United States and technical storm reports for select storms.

This report documents the elevated water levels, high winds and reduced barometric pressures recorded at stations along the Gulf Coast from southern Florida to Texas during Hurricane Ike. The timing and amplitude of the maximum observed water level elevations, referred to as storm tides, as well as simultaneous information on meteorological parameters, are used to evaluate storm forecasts, characterize the intensity and movement of the hurricane, and to assess post-storm damage.

Station information and locations are contained in Figure 1 and Appendices 1 & 2. Tidal stations are referenced to the standard chart datum of Mean Lower Low Water (MLLW) and non-tidal stations are referenced to Mean Sea Level (MSL), based on the National Tidal Datum Epoch 1983-2001 or Modified 5-Year Epoch (Appendix 3). In addition, water levels are provided on a geodetic reference datum, the North American Vertical Datum of 1988 (NAVD88), to assist in relating water levels to coastal inundation estimates.

Table 1 provides storm tide elevations and predicted tide elevations (in feet and meters) relative to MLLW or MSL for all stations affected by Hurricane Ike by geographic region. Where available, water level elevations relative to NAVD88 are also presented, along with the storm surges/residuals at the time of the maximum storm tides. Please note that the storm surges/residuals are not the maximum recorded during Hurricane Ike, unless footnoted (See Table 4 for maximum storm surges/residuals). Table 2 contains the same information, with stations ranked by amplitude of storm tide.

The observed maximum water levels are the result of the effects of high wind stress, low atmospheric pressure and the geographic orientation of the coastline, in addition to the timing and strength of the normal astronomical tide when the storm reaches its peak. If a storm occurs at a high tide and/or during a period of spring tides, the maximum water level can be significantly higher than when a storm occurs during a low tide and/or during a period of neap tides (Appendix 3). Notations are included on stations where the timing of the high or low tides are relevant to the maximum water levels reached.

Table 3 provides maximum wind speeds, wind gusts, and minimum barometric pressures observed at the stations during Hurricane Ike. Maximum storm surge/residual water levels are summarized in Table 4, ranked by amplitude. Storm surge/residual water levels are calculated by subtracting the difference between the observed storm tide and the predicted astronomical tide. The storm surge/residual will include storm surge and potentially other pre-storm baseline

oceanographic conditions and/or riverine input. The effects of waves are not included (Appendix 3). Where footnoted, the maximum storm surge coincided with maximum storm tide.

In addition, the report includes information on which stations have exceeded historical recorded maximum tide levels as a result of Ike (Figure 2). The historical recorded maximum tide levels are the maximum tide elevation measured by a water level station with a continuous time series throughout a high tide cycle. A complete cycle is required to calculate the maximum tide elevation, applying a best fit curve to the observations. These historical records may not have included the highest water levels measured at a station during an event if a complete high tide cycle was not measured due to station/sensor damage (Appendix 3).

Individual time series graphs are provided for each station (Figures 3 – 47). For comparison and context, the historical recorded maximum tide levels are displayed on the graphs, where available. The Mean Higher High Water (MHHW) datum is also displayed to illustrate the average height of the higher high waters at a particular station, providing an indication of a station's normal tidal range. The timing of Ike's landfall is delineated to correlate the water level response to the storm's progression across the Gulf of Mexico. Lastly, using geographically representative stations, Ike's progression is illustrated with simultaneous storm surge/residual series in Figure 48.

## Summary

Hurricane Ike initially struck eastern Cuba as a Category 4 storm on the Saffir-Simpson Scale (Appendix 4) on September 8, 2008. By the time the storm emerged over the southern Gulf of Mexico late September 9, it had weakened to a Category 1 storm. Ike gradually increased in size and strength as it moved west-northwestward across the Gulf of Mexico on September 10-12.

Water levels were slightly elevated along the Florida Keys as Hurricane Ike passed offshore to the south and west. As Ike approached the western Gulf Coast, storm tides rose from the Florida panhandle to Texas (Figure 48). The storm made landfall on September 13 at 0710 GMT near Galveston, Texas as a Category 2, with maximum sustained winds of 95 knots (110 mph). At many Galveston Bay stations, the sensors reached their physical high limits on measurements and/or were damaged before the highest observations were recorded. Even though these stations did not record the actual maximum storm surge and storm tides, multiple station maximums still exceeded historical recorded maximums tide levels (Table 2; Figures 2, 30-38).

In close proximity to the storm path, Eagle Point, TX recorded throughout the storm and recorded a storm tide of 3.641 m (11.95 ft) above MLLW at 06:24 GMT, which was 3.500 m (11.48 ft) above the predicted tide (see storm surge/residual in Table 3a and Figure 35). Maximum wind speed was over 59 knots, with a gust of 78 knots (90 mph) recorded at 06:12 GMT (Table 2). Water levels continued to rise as the storm moved inland, with a recorded storm tide near Houston at Manchester, Houston Ship Channel, TX (3.742 m (12.28 ft) above MLLW, Figure 32) just before the sensor maximum was reached.

The water level sensors at the stations along the outer coast at Galveston Pleasure Pier and Galveston Bay Entrance were damaged or malfunctioned during the storm, but still recorded the highest storm tides of record at each station just prior to the sensor malfunction. The Galveston Pier 21 station recorded a maximum storm tide of 3.299 m (10.82 ft) above MLLW just prior to sensor malfunction and recorded lowest barometric pressure (951.5 mbar; Tables 1 & 2; Figure 37).

The maximum recorded water levels and wind speeds/gusts were to the east of landfall, especially in Sabine Lake and associated waterways. After landfall, at 07:54 GMT Sabine Pass North, TX recorded the highest storm tide (for stations included in this report) of 4.362 m (14.31 ft) above MLLW, within an hour of the predicted high tide (Figure 28). This nearly coincided with the maximum recorded storm surge/residual of 3.839 m (12.60 ft), recorded 6 minutes earlier. Sabine Pass also recorded the highest maximum wind speeds (>61 knots) and gust (83 knots; 96 mph) during the 05:00 GMT hour (Table 2). In Louisiana, at 07:42 GMT Calcasieu Pass had a storm tide of 3.628 m (11.90 ft) above MLLW occurring within one hour of high tide (Table 1; Figure 26). Maximum wind speed was also over 61 knots, with a gust of 75 knots (86 mph) recorded at 07:30 GMT (Table 2). The Freshwater Locks, LA station had the only maximum water level which occurred at a low tide, yet still exceeded the historical recorded maximums tide level at that station (3.096 m (10.16 ft) above MLLW; Table 1; Figures 2 & 24).

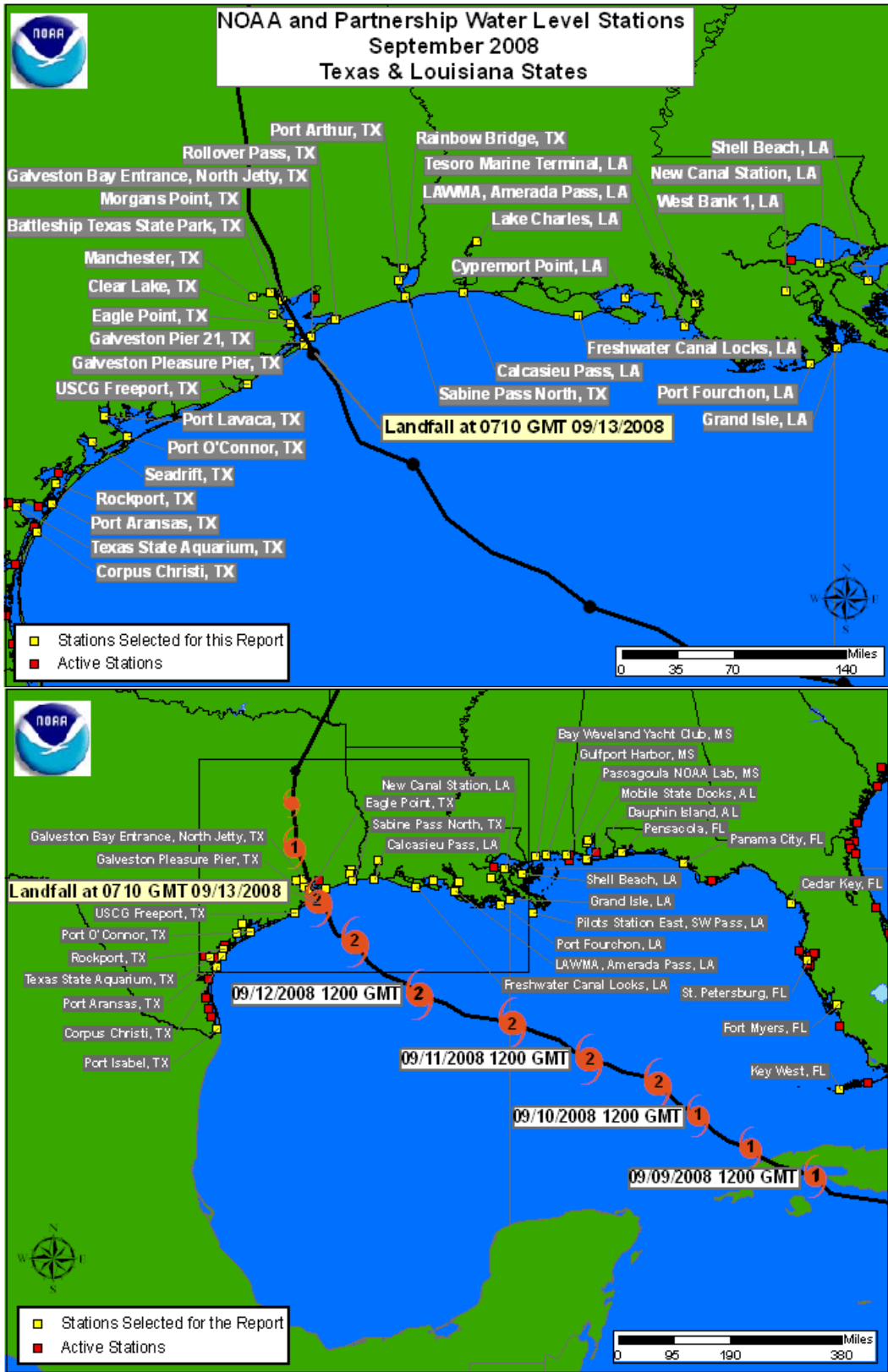
US Coast Guard Freeport station recorded a new historical maximum water level of 2.262 m (7.42 ft) above MLLW (Table 1; Figures 2 & 39). Wind speeds were over 50 knots, with a gust over 76 knots (87 mph) and minimum pressure less than 972 millibars (Table 2). Impacts from the

storm were felt as far south as the station at Corpus Christi, which superseded the historical recorded maximum tide level, with water levels at 1.804 m (5.92 ft) above MLLW (Figures 2 & 46).

After landfall, Ike quickly weakened as it moved northward over eastern Texas before turning to the northeast through the Midwestern states. Southern Texas stations, such as Seadrift and Port Isabel, and inland Louisiana stations of West Bank 1, Bayou Gauche and Tesoro Marine Terminal, finally reached the maximum storm tides after the storm had moved inland (Table 1, Figure 48).

In summary, to the right of Ike's track and landfall, from eastern Texas to the Florida panhandle, storm surge/residuals recorded at stations ranged from 0.507 to 3.839 m (1.66 to 12.60 ft; Table 2). Storm surge/residuals recorded at stations within Galveston Bay, Texas and associated waterways, ranged from 2.424 to 3.839 m (7.95 to 12.60 ft; Table 2). Storm surges/residuals recorded at stations to the left of Ike's landfall, along the southwestern Texas coast ranged between 0.782 and 2.705 m (2.57 to 8.87 ft; Table 2).

More information, data and storm reports can be found at the CO-OPS website, [www.tidesandcurrents.noaa.gov](http://www.tidesandcurrents.noaa.gov). Storm reports are located under the Publications section of the webpage. Information about the Storm QuickLook product can be found at <http://tidesandcurrents.noaa.gov/quicklook.shtml> or [tide.predictions@noaa.gov](mailto:tide.predictions@noaa.gov).



Figures 1a and 1b: NOAA and Partnership stations relative to the Hurricane Ike storm track (track information courtesy of the NOAA National Hurricane Center). Due to map scale, not all stations are labeled.

Table 1a: Maximum recorded water levels in geographic order for Hurricane Ike, September 2008. Referenced to Mean Lower Low Water (MLLW) or Mean Sea Level (MSL) and North American Vertical Datum of 1988 (NAVD88).

Station Name	Date & Time (GMT)	Storm Tide	Predicted	Storm Surge/Residual (m)	Storm Tide (m, NAVD88)	Storm Tide	Predicted	Storm Surge/Residual (ft)	Storm Tide (ft, NAVD88)
		(m, MLLW or **MSL)				(ft, MLLW or **MSL)			
<sup>5</sup> Key West, FL	09/10/2008 10:30	0.937	0.583	0.354	0.399	3.07	1.91	1.16	1.31
<sup>3</sup> Fort Myers, FL	09/10/2008 17:18	0.991	0.425	0.566	0.673	3.25	1.39	1.86	2.21
<sup>5</sup> St. Petersburg, FL	09/10/2008 14:18	1.290	0.740	0.550	n/a	4.23	2.43	1.80	n/a
Cedar Key, FL	09/11/2008 14:48	1.769	1.136	0.633	1.082	5.80	3.73	2.08	3.55
<sup>5</sup> Panama City, FL	09/11/2008 12:48	1.246	0.516	0.730	1.076	4.09	1.69	2.40	3.53
Pensacola, FL	09/11/2008 16:42	1.324	0.449	0.875	1.226	4.34	1.47	2.87	4.02
Dauphin Island, AL	09/11/2008 15:48	1.373	0.420	0.953	1.303	4.50	1.38	3.13	4.27
<sup>5</sup> Coast Guard Sector Mobile, AL	09/12/2008 15:36	1.599	0.435	1.164	n/a	5.25	1.43	3.82	n/a
<sup>5</sup> Mobile State Docks, AL	09/12/2008 15:54	1.471	0.528	0.943	1.409	4.83	1.73	3.09	4.62
<sup>5</sup> Pascagoula NOAA Lab, MS	09/12/2008 14:24	1.655	0.447	1.208	n/a	5.43	1.47	3.96	n/a
<sup>2</sup> Gulfport Harbor, MS	09/12/2008 20:42	1.376	0.264	1.112	1.283	4.51	0.87	3.65	4.21
<sup>4,5</sup> Bay Waveland Yacht Club, MS	09/12/2008 13:42	2.322	0.552	1.770	2.222	7.62	1.81	5.81	7.29
<sup>5</sup> Pilots Station East, LA	09/12/2008 11:48	1.382	0.472	0.910	n/a	4.53	1.55	2.99	n/a
<sup>5</sup> Shell Beach, LA	09/12/2008 15:06	2.283	0.448	1.835	n/a	7.49	1.47	6.02	n/a
<sup>3,5</sup> Grand Isle, LA	09/12/2008 12:06	1.590	0.419	1.171	n/a	5.22	1.37	3.84	n/a
<sup>4,5</sup> New Canal Station, LA	09/12/2008 23:30	1.674	0.124	1.550	n/a	5.49	0.41	5.09	n/a
<sup>2,3,4</sup> Port Fourchon, LA	09/12/2008 08:36	1.700	0.430	1.270	n/a	5.58	1.41	4.17	n/a
West Bank 1, LA	09/14/2008 06:00	**0.972	**0.058	0.914	n/a	**3.19	**0.19	3.00	n/a
<sup>1</sup> Tesoro Marine Terminal, LA	09/13/2008 19:30	1.413	0.102	1.311	n/a	4.64	0.33	4.30	n/a
LAWMA, Amerada Pass, LA	09/12/2008 19:48	2.380	0.382	1.998	n/a	7.81	1.25	6.56	n/a
<sup>2,5</sup> Cypremort Point, LA	09/11/2008 11:42	0.973	0.442	0.531	n/a	3.19	1.45	1.74	n/a
<sup>4,6</sup> Freshwater Canal Locks, LA	09/12/2008 23:48	3.096	0.049	3.047	n/a	10.16	0.16	10.00	n/a
<sup>1,3,5</sup> Lake Charles, LA	09/12/2008 14:00	1.037	0.325	0.712	n/a	3.40	1.07	2.34	n/a

\*This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control.

<sup>1</sup> Station/Sensor was damaged and did not record a maximum/minimum value.

<sup>2</sup> Sensor reached the physical limit on measurements and did not record a maximum/minimum value.

<sup>3</sup> Maximum recorded water level value and maximum storm surge/residual occur at the same time.

<sup>4</sup> Maximum recorded water level value exceeded historical recorded maximum tide level at that station.

<sup>5</sup> Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides.

<sup>6</sup> Maximum recorded water level coincided within an hour of a low tide, resulting in lower storm tides.

Table 1b: Maximum recorded water levels in geographic order for Hurricane Ike, September 2008. Referenced to Mean Lower Low Water (MLLW) or Mean Sea Level (MSL) and North American Vertical Datum of 1988 (NAVD88).

Station Name	Date & Time (GMT)	Storm Tide	Predicted	Storm Surge/Residual (m)	Storm Tide (m, NAVD88)	Storm Tide	Predicted	Storm Surge/Residual (ft)	Storm Tide
		(m, MLLW or **MSL)				(ft, MLLW or **MSL)	(ft, NAVD88)		
<sup>5</sup> Calcasieu Pass, LA	09/13/2008 07:42	3.628	0.611	3.017	n/a	11.90	2.00	9.90	n/a
*Port Arthur, TX	09/13/2008 09:12	3.635	0.279	3.356	n/a	11.93	0.92	11.01	n/a
* <sup>2,3</sup> Rainbow Bridge, TX	09/13/2008 09:12	2.946	0.154	2.792	n/a	9.67	0.51	9.16	n/a
<sup>3,4,5</sup> Sabine Pass North, TX	09/13/2008 07:54	4.362	0.525	3.837	n/a	14.31	1.72	12.59	n/a
<sup>1,3,4</sup> Morgans Point, TX	09/13/2008 07:06	2.746	0.058	2.688	n/a	9.01	0.19	8.82	n/a
* <sup>1,3</sup> Battleship Texas, TX	09/13/2008 06:54	2.406	0.179	2.227	n/a	7.89	0.59	7.31	n/a
* <sup>2,4</sup> Manchester, TX	09/13/2008 17:24	3.742	0.453	3.289	n/a	12.28	1.49	10.79	n/a
* <sup>1,4</sup> Clear Lake, TX	09/13/2008 05:42	2.495	0.077	2.418	n/a	8.19	0.25	7.93	n/a
* <sup>1,3</sup> Rollover Pass, TX	09/13/2008 05:48	3.423	0.051	3.372	n/a	11.23	0.17	11.06	n/a
<sup>3,4</sup> Eagle Point, TX	09/13/2008 06:24	3.641	0.141	3.500	n/a	11.95	0.46	11.48	n/a
<sup>1,3,4</sup> Galveston Bay Entrance, TX	09/13/2008 01:12	2.972	0.103	2.869	n/a	9.75	0.34	9.41	n/a
<sup>1,5</sup> Galveston Pier 21, TX	09/13/2008 09:00	3.299	0.465	2.834	3.256	10.82	1.53	9.30	10.68
<sup>1,4</sup> Galveston Pleasure Pier, TX	09/13/2008 04:06	2.981	0.277	2.704	2.795	9.78	0.91	8.87	9.17
<sup>4</sup> USCG Freeport, TX	09/12/2008 20:00	2.262	0.361	1.901	n/a	7.42	1.18	6.24	n/a
*Seadrift, TX	09/14/2008 00:42	1.002	0.124	0.878	n/a	3.29	0.41	2.88	n/a
* <sup>3,5</sup> Port Lavaca, TX	09/13/2008 14:54	1.176	0.274	0.902	n/a	3.86	0.90	2.96	n/a
*Port O'Connor, TX	09/12/2008 22:18	1.291	0.239	1.052	n/a	4.24	0.78	3.45	n/a
Rockport, TX	09/13/2008 15:42	0.923	0.146	0.777	1.206	3.03	0.48	2.55	3.96
* <sup>5</sup> Port Aransas, TX	09/13/2008 10:24	1.375	0.314	1.061	n/a	4.51	1.03	3.48	n/a
*Texas State Aquarium, TX	09/13/2008 15:54	1.128	0.214	0.914	n/a	3.70	0.70	3.00	n/a
<sup>4,5</sup> Corpus Christi, TX	09/13/2008 07:48	1.804	0.522	1.282	1.668	5.92	1.71	4.21	5.47
Port Isabel, TX	09/13/2008 16:12	1.263	0.401	0.862	1.003	4.14	1.32	2.83	3.29

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Table 2a: Maximum recorded water levels ranked by amplitude of storm tide for Hurricane Ike, September 2008. Referenced to Mean Lower Low Water (MLLW) or Mean Sea Level (MSL) and North American Vertical Datum of 1988 (NAVD88).

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<sup>5</sup> Coast Guard Sector Mobile, AL	09/12/2008 15:36	1.599	0.435	1.164	n/a	5.25	1.43	3.82	n/a
<sup>3,5</sup> Grand Isle, LA	09/12/2008 12:06	1.590	0.419	1.171	n/a	5.22	1.37	3.84	n/a
<sup>5</sup> Mobile State Docks, AL	09/12/2008 15:54	1.471	0.528	0.943	1.409	4.83	1.73	3.09	4.62
<sup>1</sup> Tesoro Marine Terminal, LA	09/13/2008 19:30	1.413	0.102	1.311	n/a	4.64	0.33	4.30	n/a
<sup>5</sup> Pilots Station East, LA	09/12/2008 11:48	1.382	0.472	0.910	n/a	4.53	1.55	2.99	n/a
<sup>2</sup> Gulfport Harbor, MS	09/12/2008 20:42	1.376	0.264	1.112	1.283	4.51	0.87	3.65	4.21
* <sup>5</sup> Port Aransas, TX	09/13/2008 10:24	1.375	0.314	1.061	n/a	4.51	1.03	3.48	n/a
Dauphin Island, AL	09/11/2008 15:48	1.373	0.420	0.953	1.303	4.50	1.38	3.13	4.27
Pensacola, FL	09/11/2008 16:42	1.324	0.449	0.875	1.226	4.34	1.47	2.87	4.02
*Port O'Connor, TX	09/12/2008 22:18	1.291	0.239	1.052	n/a	4.24	0.78	3.45	n/a
<sup>5</sup> St. Petersburg, FL	09/10/2008 14:18	1.290	0.740	0.550	n/a	4.23	2.43	1.80	n/a
Port Isabel, TX	09/13/2008 16:12	1.263	0.401	0.862	1.003	4.14	1.32	2.83	3.29
<sup>5</sup> Panama City, FL	09/11/2008 12:48	1.246	0.516	0.730	1.076	4.09	1.69	2.40	3.53
* <sup>3,5</sup> Port Lavaca, TX	09/13/2008 14:54	1.176	0.274	0.902	n/a	3.86	0.90	2.96	n/a
*Texas State Aquarium, TX	09/13/2008 15:54	1.128	0.214	0.914	n/a	3.70	0.70	3.00	n/a
<sup>1,3,5</sup> Lake Charles, LA	09/12/2008 14:00	1.037	0.325	0.712	n/a	3.40	1.07	2.34	n/a
*Seadrift, TX	09/14/2008 00:42	1.002	0.124	0.878	n/a	3.29	0.41	2.88	n/a
<sup>3</sup> Fort Myers, FL	09/10/2008 17:18	0.991	0.425	0.566	0.673	3.25	1.39	1.86	2.21
<sup>2,5</sup> Cypremort Point, LA	09/11/2008 11:42	0.973	0.442	0.531	n/a	3.19	1.45	1.74	n/a
West Bank 1, LA	09/14/2008 06:00	**0.972	**0.058	0.914	n/a	**3.19	**0.19	3.00	n/a
<sup>5</sup> Key West, FL	09/10/2008 10:30	0.937	0.583	0.354	0.399	3.07	1.91	1.16	1.31
Rockport, TX	09/13/2008 15:42	0.923	0.146	0.777	1.206	3.03	0.48	2.55	3.96

\*This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control.

<sup>1</sup> Station/Sensor was damaged and did not record a maximum/minimum value.

<sup>2</sup> Sensor reached the physical limit on measurements and did not record a maximum/minimum value.

<sup>3</sup> Maximum recorded water level value and maximum residual/storm surge occur at the same time.

<sup>4</sup> Maximum recorded water level value exceeded historical recorded maximum tide level at that station.

<sup>5</sup> Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides.

<sup>6</sup> Maximum recorded water level coincided within an hour of a low tide, resulting in lower storm tides.

Table 3a: Maximum recorded wind speed, wind gusts and minimum barometric pressure in geographic order for Hurricane Ike, September 2008.

Station Name	Maximum Wind Speed			Maximum Wind Gusts			Minimum Atmospheric Pressure	
	Date & Time (GMT)	m/sec	knots	Date & Time (GMT)	m/sec	knots	Date & Time (GMT)	mbar
Key West, FL	09/10/2008 07:18	9.8	19	09/10/2008 10:24	15.8	31	09/09/2008 20:36	1004.2
Fort Myers, FL	09/10/2008 09:36	8.4	16	09/10/2008 09:36	14.5	28	09/10/2008 07:18	1011.6
St. Petersburg, FL	09/11/2008 18:18	8.6	17	09/09/2008 20:42	13.5	26	09/09/2008 20:30	1010.3
Panama City, FL	09/12/2008 18:42	10.8	21	09/11/2008 18:36	14.5	28	09/10/2008 21:42	1011.8
Pensacola, FL	09/10/2008 21:30	5.2	10	09/15/2008 20:36	8.9	17	09/10/2008 20:42	1012.1
Dauphin Island, AL	09/11/2008 15:42	19.7	38	09/11/2008 15:42	27.6	54	09/12/2008 00:12	1010.7
Coast Guard Sector Mobile, AL	09/11/2008 20:36	13.0	25	09/11/2008 21:36	16.6	32	09/12/2008 22:06	1011.6
Bay Waveland Yacht Club, MS	09/11/2008 15:18	18.7	36	09/12/2008 12:12	22.6	44	09/12/2008 21:36	1008.4
Pilots Station East, SW Pass, LA	09/12/2008 08:36	24.9	48	09/11/2008 11:42	31.4	61	09/12/2008 09:24	1004.6
Shell Beach, LA	09/12/2008 10:12	23.0	45	09/12/2008 10:24	29.6	58	09/12/2008 09:48	1005.5
Grand Isle, LA	09/12/2008 06:48	15.0	29	09/11/2008 21:48	25.4	49	09/12/2008 09:24	1005.3
New Canal Station, LA	09/11/2008 21:12	16.6	32	09/11/2008 21:06	21.1	41	09/12/2008 09:48	1006.2
West Bank 1, Bayou Gauche, LA	09/12/2008 23:06	16.6	32	09/12/2008 18:30	22.6	44	09/12/2008 20:48	1003.8
LAWMA, Amerada Pass, LA	09/12/2008 14:24	18.2	35	09/12/2008 14:18	25.1	49	09/12/2008 21:00	999.2
Calcasieu Pass, LA	09/13/2008 08:18	31.4	61	09/13/2008 07:30	38.4	75	09/13/2008 09:36	989.5
*Port Arthur, TX	09/13/2008 06:00	21.4	42	09/13/2008 07:00	34.9	68	n/a	n/a
Sabine Pass North, TX	09/13/2008 05:48	31.5	61	09/13/2008 05:00	42.5	83	09/13/2008 07:18	983.8
<sup>1</sup> Morgans Point, TX	09/13/2008 06:12	23.7	46	09/13/2008 06:30	35.4	69	09/13/2008 07:12	963.2
* <sup>1</sup> Clear Lake, TX	09/13/2008 04:00	14.0	27	09/13/2008 06:00	24.0	47	09/13/2008 06:00	974.0
* <sup>1</sup> Rollover Pass, TX	09/13/2008 04:00	26.2	51	09/13/2008 01:00	32.8	64	n/a	n/a

\*This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control.

<sup>1</sup> Station/Sensor was damaged and did not record a maximum/minimum value.

Table 3b: Maximum recorded wind speed, wind gusts and minimum barometric pressure in geographic order for Hurricane Ike, September 2008.

Station Name	Maximum Wind Speed			Maximum Wind Gusts			Minimum Atmospheric Pressure	
	Date & Time (GMT)	m/sec	knots	Date & Time (GMT)	m/sec	knots	Date & Time (GMT)	mbar
Eagle Point, TX	09/13/2006 06:06	30.5	59	09/13/2006 06:12	39.9	78	09/13/2008 07:48	954.3
<sup>1</sup> Galveston Bay Entrance, TX	09/13/2008 02:18	26.2	51	09/13/2008 02:54	34.6	67	09/13/2008 03:30	978.8
Galveston Pier 21, TX	n/a	n/a	n/a	n/a	n/a	n/a	09/13/2008 07:48	951.5
<sup>1</sup> Galveston Pleasure Pier, TX	09/13/2008 04:48	26.8	52	09/13/2008 03:30	38.9	76	09/13/2008 07:54	951.7
USCG Freeport, TX	09/13/2008 05:24	26.2	51	09/13/2008 05:24	39.2	76	09/13/2008 06:42	971.7
*Seadrift, TX	09/14/2008 02:00	12.3	24	09/13/2008 03:00	16.8	33	n/a	n/a
*Port O'Connor, TX	09/13/2008 03:00	16.7	32	09/13/2008 03:00	20.3	39	n/a	n/a
Rockport, TX	09/14/2008 01:42	12.7	25	09/14/2008 01:36	15.3	30	09/13/2008 08:24	996.5
*Port Aransas, TX	09/15/2008 14:00	11.4	22	09/13/2008 06:00	15.4	30	n/a	n/a
Corpus Christi, TX	09/15/2008 07:54	14	27	09/15/2008 08:00	16.3	32	09/13/2008 00:42	996.7
Port Isabel, TX	09/15/2008 11:00	11.2	22	09/15/2008 11:00	13.7	27	09/13/2008 01:30	999.9

\*This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control.

<sup>1</sup> Station/Sensor was damaged and did not record a maximum/minimum value.

Table 4a: Maximum recorded storm surge/residual levels ranked by amplitude for Hurricane Ike, September 2008.

Station Name	Station ID	Date & Time GMT	Storm Surge/Residual	
			(m)	(ft)
<sup>3,4,5</sup> Sabine Pass North, TX	8770570	09/13/2008 07:48	3.839	12.60
* <sup>2,4</sup> Manchester, TX	8770777	09/13/2008 09:12	3.577	11.74
<sup>3,4</sup> Eagle Point, TX	8771013	09/13/2008 06:24	3.500	11.48
* <sup>1,3</sup> Rollover Pass, TX	8770971	09/13/2008 05:48	3.372	11.06
*Port Arthur, TX	8770475	09/13/2008 09:00	3.361	11.03
<sup>5</sup> Calcasieu Pass, LA	8768094	09/13/2008 02:48	3.158	10.36
<sup>1,5</sup> Galveston Pier 21, TX	8771450	09/13/2008 03:42	3.062	10.05
<sup>4,6</sup> Freshwater Canal Locks, LA	8766072	09/12/2008 23:54	3.050	10.01
* <sup>2,3</sup> Rainbow Bridge, TX	8770520	09/13/2008 09:12	2.792	9.16
<sup>1,3,4</sup> Galveston Bay Entrance, TX	8771341	09/13/2008 01:12	2.869	9.41
<sup>1,4</sup> Galveston Pleasure Pier, TX	8771510	09/13/2008 03:42	2.705	8.87
<sup>1,3,4</sup> Morgans Point, TX	8770613	09/13/2008 07:06	2.688	8.82
* <sup>1,4</sup> Clear Lake, TX	8770933	09/13/2008 06:00	2.424	7.95
* <sup>1,3</sup> Battleship Texas State Park, TX	8770743	09/13/2008 06:54	2.227	7.31
<sup>5</sup> Shell Beach, LA	8761305	09/12/2008 05:42	2.026	6.65
LAWMA, Amerada Pass, LA	8764227	09/12/2008 23:42	2.023	6.64
<sup>4</sup> USCG Freeport, TX	8772447	09/12/2008 20:42	1.905	6.25
<sup>4,5</sup> Bay Waveland Yacht Club, MS	8747437	09/12/2008 13:18	1.770	5.81
<sup>4,5</sup> New Canal Station, LA	8761927	09/13/2008 05:18	1.570	5.15
<sup>1</sup> Tesoro Marine Terminal, LA	8764044	09/13/2008 19:00	1.316	4.32
<sup>4,5</sup> Corpus Christi, TX	8775870	09/12/2008 23:30	1.288	4.23
<sup>2,3,4</sup> Port Fourchon, LA	8762075	09/12/2008 08:36	1.270	4.17
<sup>5</sup> Pascagoula NOAA Lab, MS	8741533	09/12/2008 00:18	1.240	4.07
<sup>3,5</sup> Grand Isle, LA	8761724	09/12/2008 12:06	1.171	3.84
<sup>5</sup> Coast Guard Sector Mobile, AL	8736897	09/12/2008 15:30	1.165	3.82
*Port O'Connor, TX	8773701	09/13/2008 02:42	1.132	3.71
<sup>2</sup> Gulfport Harbor, MS	8745557	09/12/2008 20:54	1.120	3.67
* <sup>5</sup> Port Aransas, TX	8775237	09/13/2008 04:12	1.072	3.52

\*This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control.

<sup>1</sup> Station/Sensor was damaged and did not record a maximum/minimum value.

<sup>2</sup> Sensor reached the physical limit on measurements and did not record a maximum/minimum value.

<sup>3</sup> Maximum recorded water level value and maximum storm surge/residual occur at the same time.

<sup>4</sup> Maximum recorded water level value exceeded historical recorded maximum tide level at that station.

<sup>5</sup> Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides.

<sup>6</sup> Maximum recorded water level coincided within an hour of a low tide, resulting in lower storm tides.

Table 4b: Maximum recorded storm surge/residual levels ranked by amplitude for Hurricane Ike, September 2008.

Station Name	Station ID	Date & Time GMT	Storm Surge/Residual	
			(m)	(ft)
Pensacola, FL	8729840	09/11/2008 23:48	1.020	3.35
<sup>5</sup> Mobile State Docks, AL	8737048	09/12/2008 02:54	1.006	3.30
Dauphin Island, AL	8735180	09/11/2008 21:06	0.997	3.27
*Texas State Aquarium, TX	8775296	09/13/2008 09:12	0.970	3.18
<sup>5</sup> Pilots Station East, SW Pass, LA	8760922	09/12/2008 08:36	0.926	3.04
West Bank 1, Bayou Gauche, LA	8762482	09/14/2008 10:48	0.915	3.00
* <sup>3,5</sup> Port Lavaca, TX	8773259	09/13/2008 14:54	0.902	2.96
*Seadrift, TX	8773037	09/13/2008 17:06	0.897	2.94
Cedar Key, FL	8727520	09/11/2008 10:06	0.880	2.89
Port Isabel, TX	8779770	09/13/2008 15:30	0.865	2.84
Rockport, TX	8774770	09/13/2008 13:36	0.782	2.57
<sup>5</sup> Panama City, FL	8729108	09/11/2008 19:54	0.778	2.55
<sup>5</sup> St. Petersburg, FL	8726520	09/10/2008 23:06	0.750	2.46
<sup>1,3,5</sup> Lake Charles, LA	8767816	09/12/2008 14:00	0.712	2.34
<sup>3</sup> Fort Myers, FL	8725520	09/10/2008 17:18	0.566	1.86
<sup>2,5</sup> Cypremort Point, LA	8765251	09/15/2008 00:36	0.556	1.82
<sup>5</sup> Key West, FL	8724580	09/09/2008 16:30	0.507	1.66

\*This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control.

<sup>1</sup> Station/Sensor was damaged and did not record a maximum/minimum value.

<sup>2</sup> Sensor reached the physical limit on measurements and did not record a maximum/minimum value.

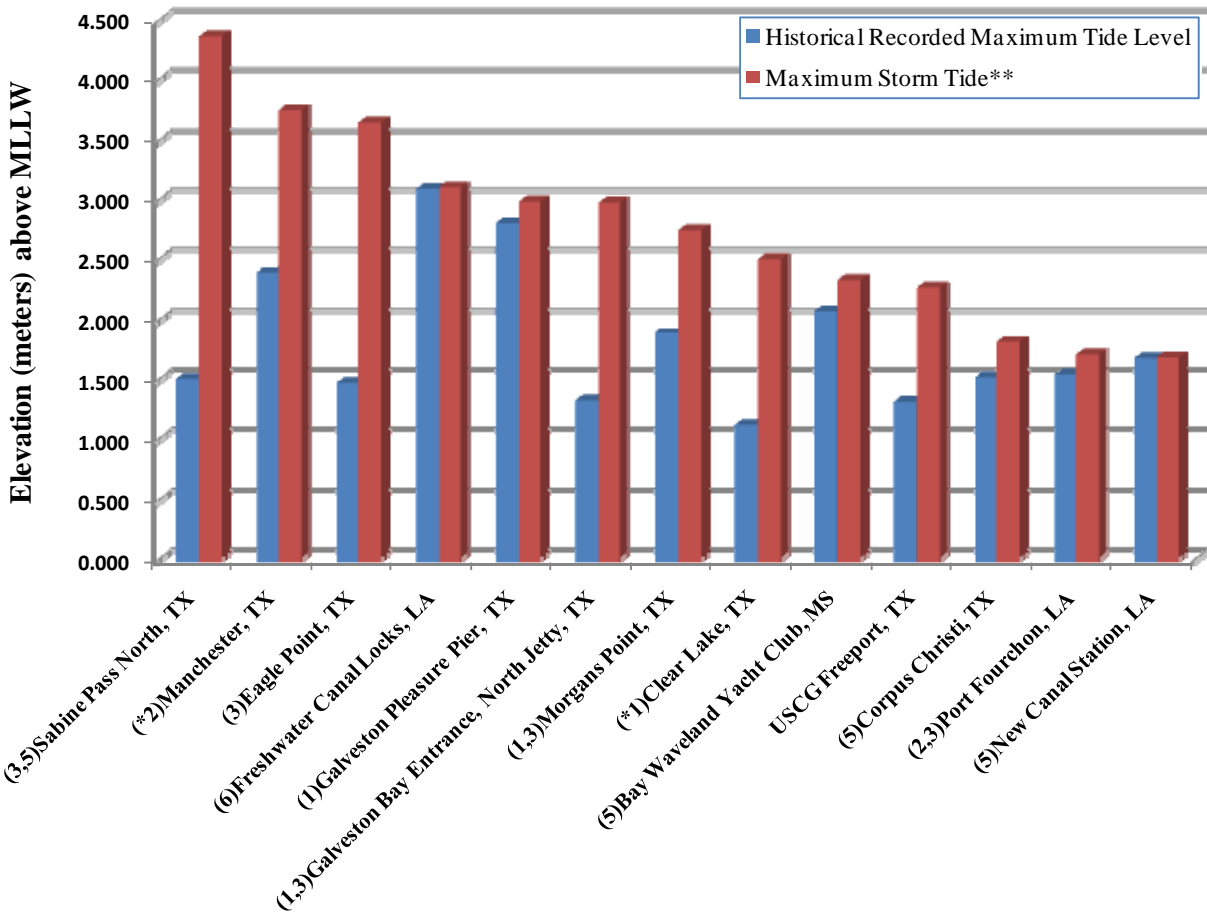
<sup>3</sup> Maximum recorded water level value and maximum storm surge/residual occur at the same time.

<sup>4</sup> Maximum recorded water level value exceeded historical recorded maximum tide level at that station.

<sup>5</sup> Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides.

<sup>6</sup> Maximum recorded water level coincided within an hour of a low tide, resulting in lower storm tides.

## Station Comparison of Historical Recorded Maximum Tide Levels with Hurricane Ike Maximum Storm Tides



\*\* Includes stations/sensors that were damaged or reached the physical limit on measurements and did not record a maximum value- see numerical footnotes.

Figure 2: Stations that exceeded historical recorded maximum tide levels during Hurricane Ike. Stations are denoted with an (\*) when operated by the Texas Coastal Ocean Observing System (TCOON) and data does not undergo post-processing NOS Quality Assurance / Control; (1) station/sensor was damaged and did not record a maximum value; (2) Sensor reached the physical limit on measurements and did not record a maximum value; (3) stations where the maximum storm tide and maximum storm surge/residual occur at the same time; (5) stations where the maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides; and (6) stations where the maximum recorded water level coincided within an hour of a low tide, resulting in lower storm tides.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8724580 Key West, FL Water Levels - Hurricane IKE  
 Max Storm Tide: 0.937 m (3.07 ft) 09/10/2008 10:30 GMT  
 Max Storm Surge/Residual: 0.507 m (1.66 ft) 09/09/2008 16:30 GMT

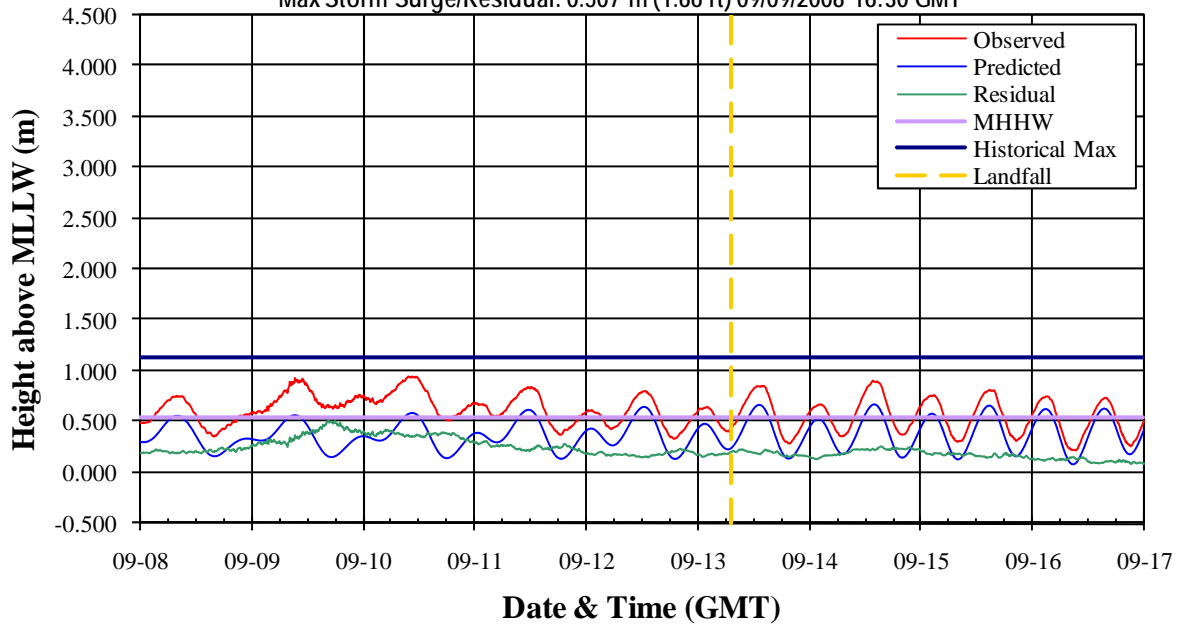


Figure 3: Water levels above Mean Lower Low Water (MLLW) at Key West, FL. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8725520 Fort Myers, FL Water Levels - Hurricane IKE  
 Max Storm Tide: 0.991 m (3.25 ft) 09/10/2008 17:18 GMT  
 Max Storm Surge/Residual: 0.566 m (1.86 ft) 09/10/2008 17:18 GMT

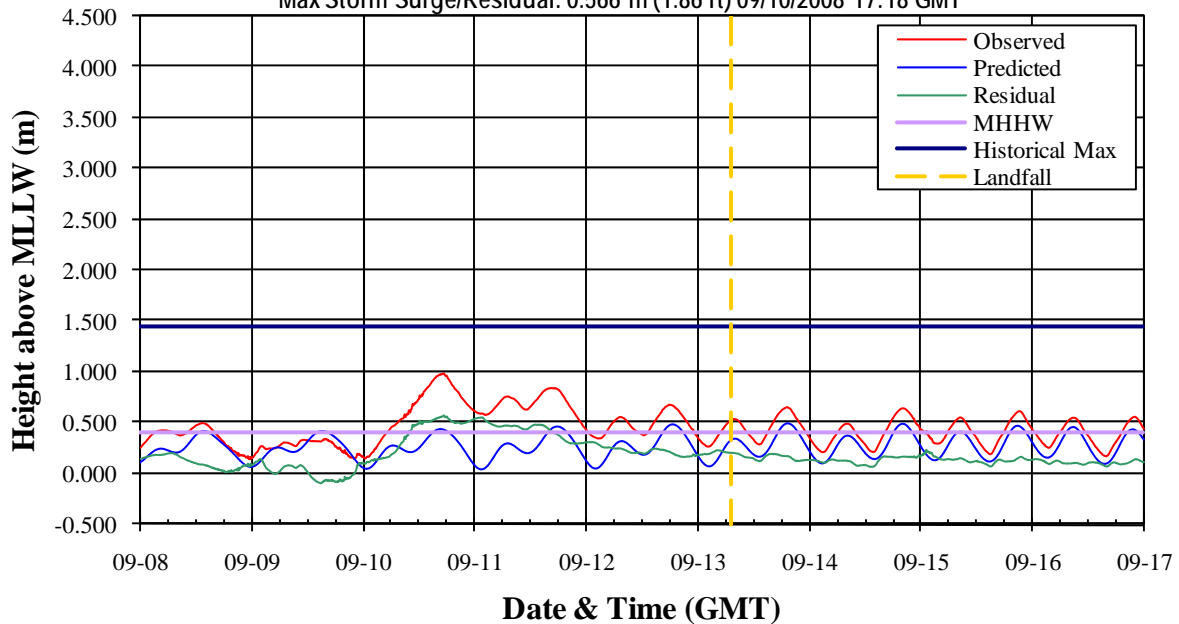


Figure 4: Water levels above Mean Lower Low Water (MLLW) at Fort Myers, FL. Maximum recorded water level value and maximum storm surge/residual occur at the same time. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8726520 St. Petersburg, FL Water Levels - Hurricane IKE  
 Max Storm Tide: 1.290 m (4.23 ft) 09/10/2008 14:18 GMT  
 Max Storm Surge/Residual: 0.750 m (2.46 ft) 09/10/2008 23:06 GMT

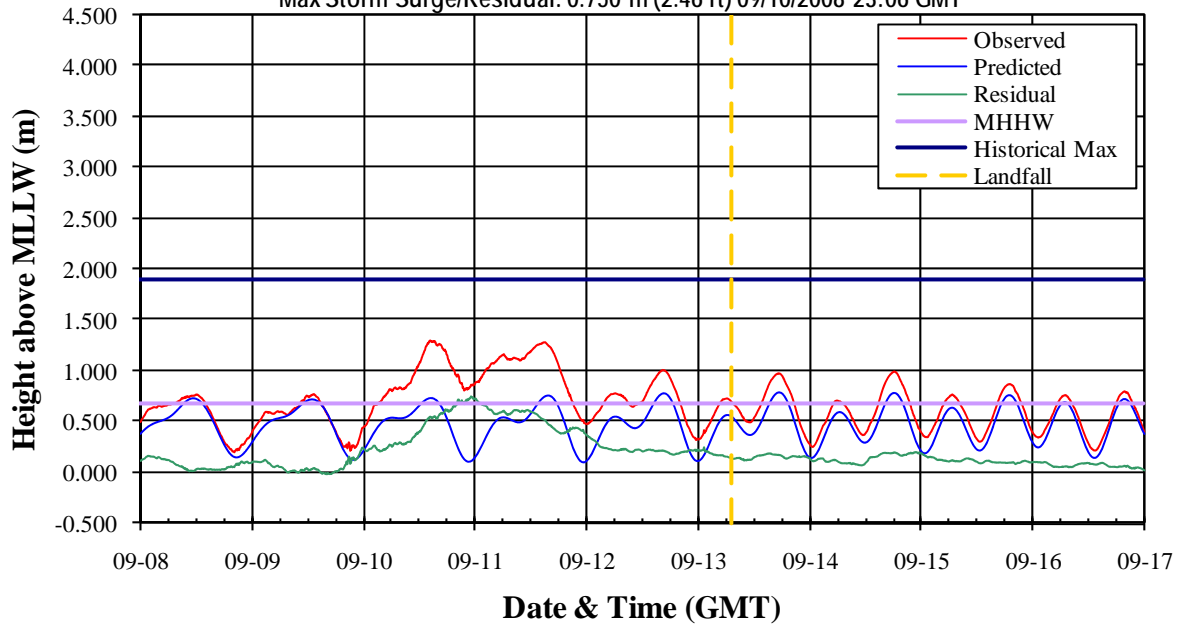


Figure 5: Water levels above Mean Lower Low Water (MLLW) at St. Petersburg, FL. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8727520 Cedar Key, FL Water Levels - Hurricane IKE  
 Max Storm Tide: 1.769 m (5.80 ft) 09/11/2008 14:48 GMT  
 Max Storm Surge/Residual: 0.880 m (2.89 ft) 09/11/2008 10:06 GMT

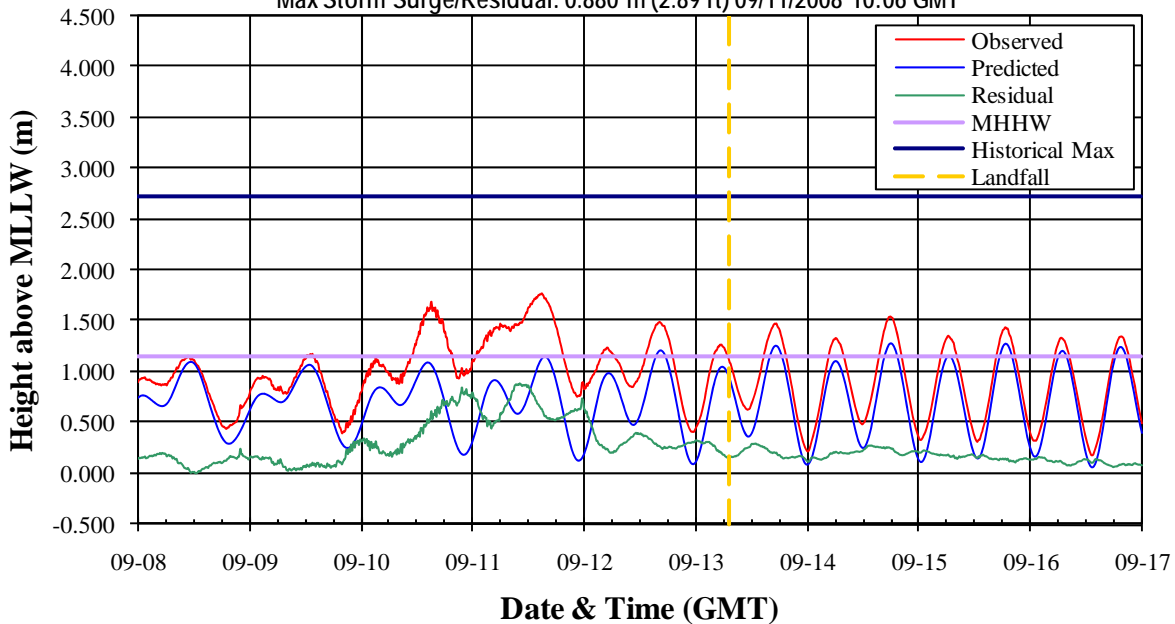


Figure 6: Water levels above Mean Lower Low Water (MLLW) at Cedar Key, FL. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.





NOAA NOS Center for Operational Oceanographic Products & Services  
8729108 Panama City, FL Water Levels - Hurricane IKE  
Max Storm Tide: 1.246 m (4.09 ft) 09/11/2008 12:48 GMT  
Max Storm Surge/Residual: 0.778 m (2.55 ft) 09/11/2008 19:54 GMT

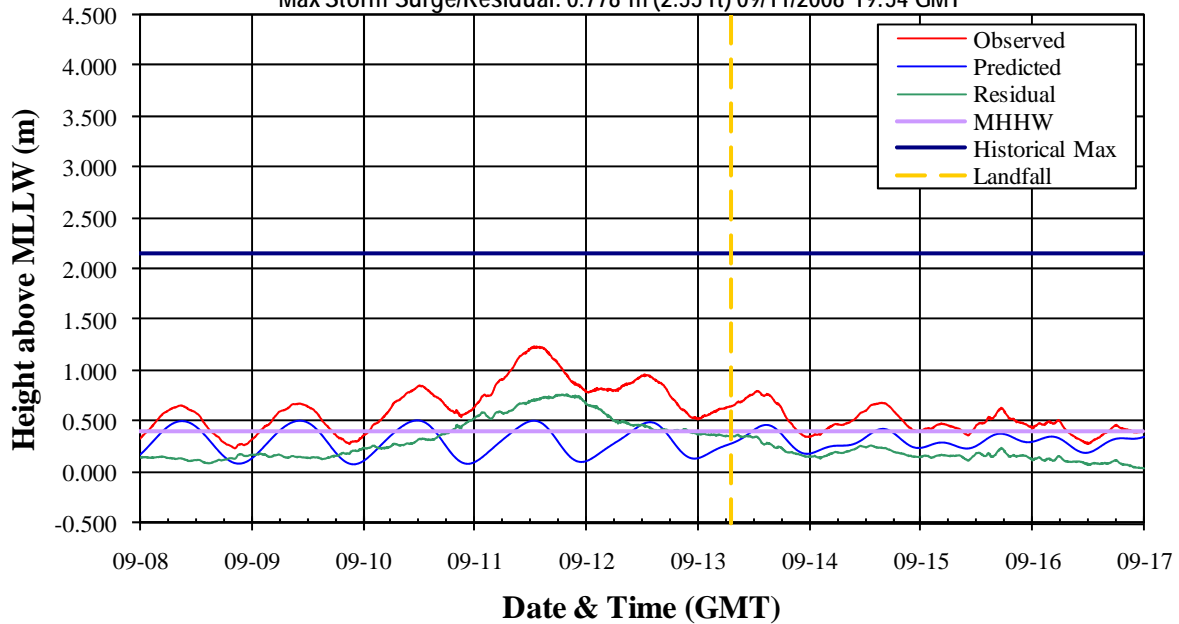


Figure 7: Water levels above Mean Lower Low Water (MLLW) at Panama City, FL. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
8729840 Pensacola, FL Water Levels - Hurricane IKE  
Max Storm Tide: 1.324 m (4.34 ft) 09/11/2008 16:42 GMT  
Max Storm Surge/Residual: 1.020 m (3.35 ft) 09/11/2008 23:48 GMT

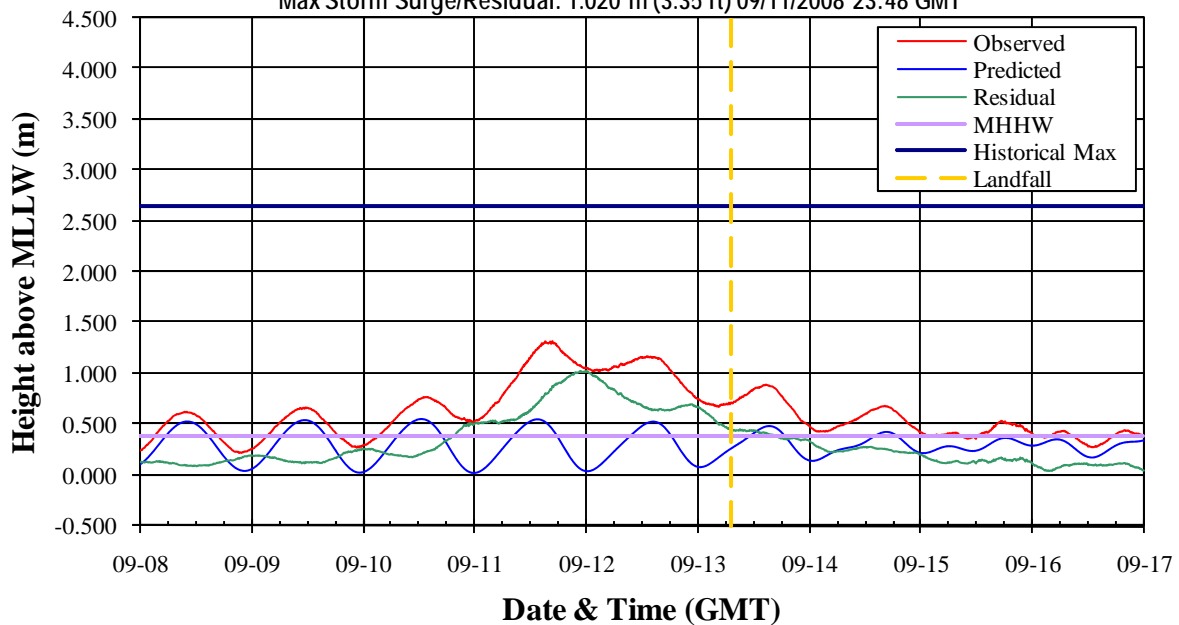


Figure 8: Water levels above Mean Lower Low Water (MLLW) at Pensacola, FL. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
8735180 Dauphin Island, AL Water Levels - Hurricane IKE  
Max Storm Tide: 1.373 m (4.50 ft) 09/11/2008 15:48 GMT  
Max Storm Surge/Residual: 0.997 m (3.27 ft) 09/11/2008 21:06 GMT

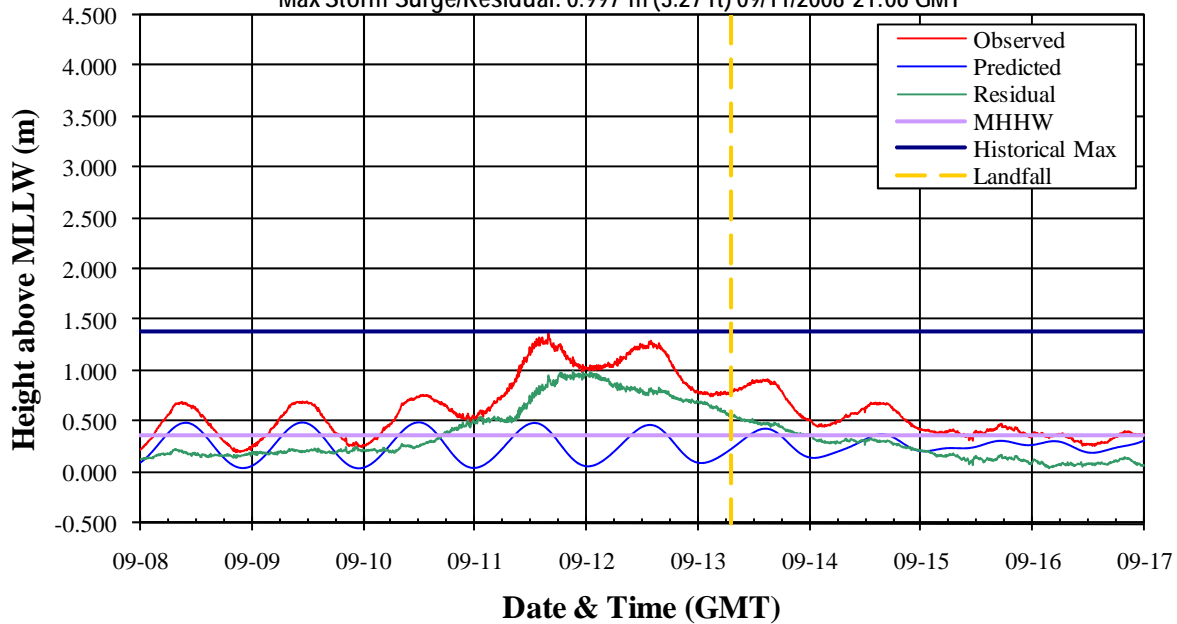


Figure 9: Water levels above Mean Lower Low Water (MLLW) at Dauphin Island, AL. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
8736897 Coast Guard Sector, Mobile, AL Water Levels - Hurricane IKE  
Max Storm Tide: 1.599 m (5.25 ft) 09/12/2008 15:36 GMT  
Max Storm Surge/Residual: 1.165 m (3.82 ft) 09/12/2008 15:30 GMT

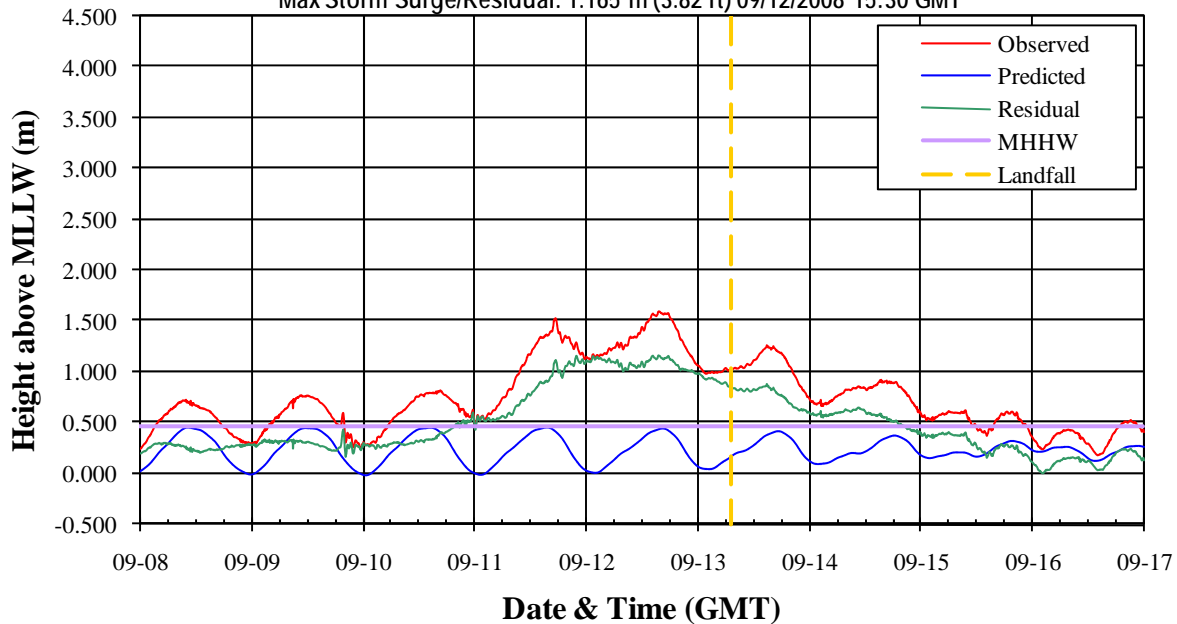


Figure 10: Water levels above Mean Lower Low Water (MLLW) at Coast Guard Sector Mobile, AL. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8737048 Mobile State Docks, AL Water Levels - Hurricane IKE  
 Max Storm Tide: 1.471 m (4.83 ft) 09/12/2008 15:54 GMT  
 Max Storm Surge/Residual: 1.006 m (3.30 ft) 09/12/2008 02:54 GMT

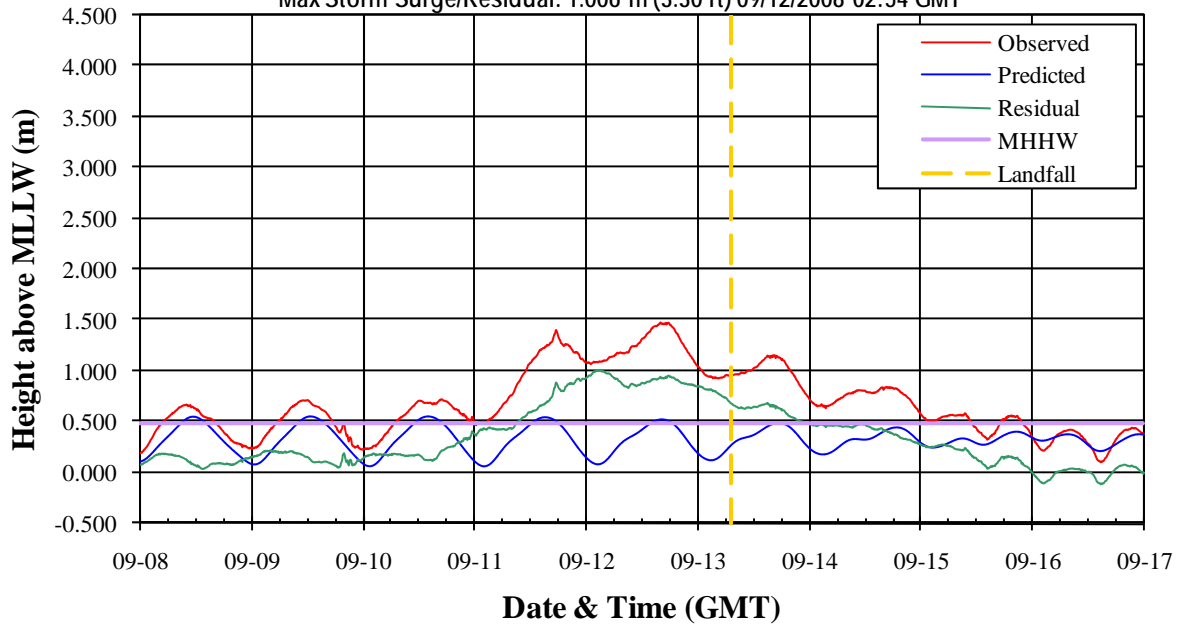


Figure 11: Water levels above Mean Lower Low Water (MLLW) at Mobile State Docks, AL. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8741533 Pascagoula NOAA Lab, MS Water Levels - Hurricane IKE  
 Max Storm Tide: 1.655 m (5.43 ft) 09/12/2008 14:24 GMT  
 Max Storm Surge/Residual: 1.240 m (4.07 ft) 09/12/2008 00:18 GMT

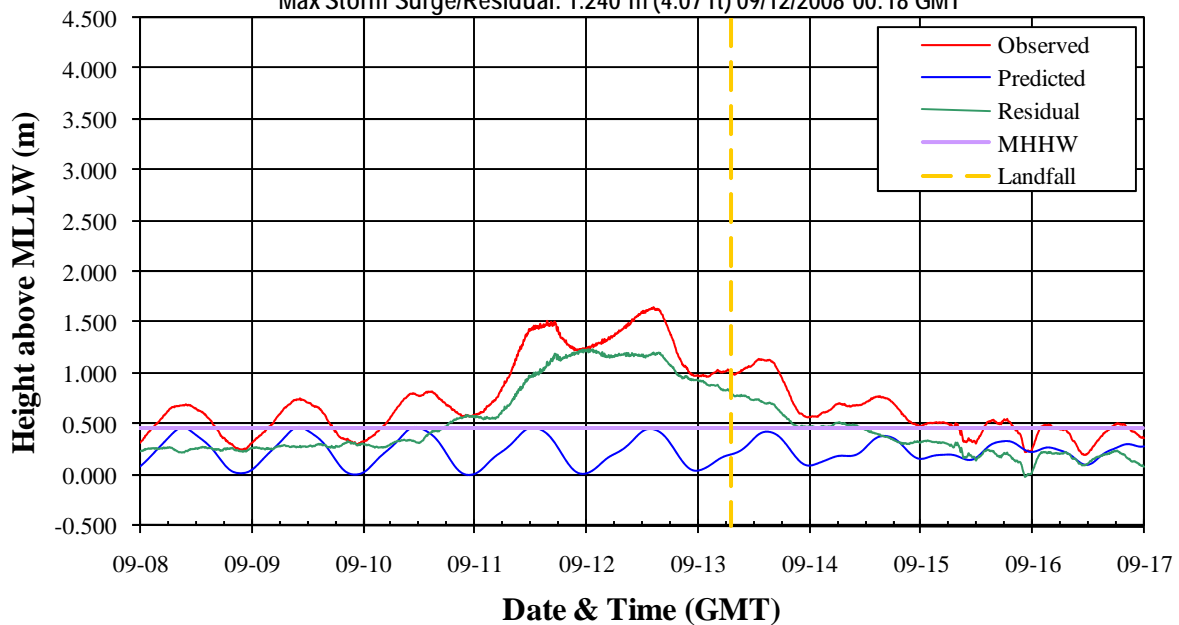


Figure 12: Water levels above Mean Lower Low Water (MLLW) at Pascagoula NOAA Lab, MS. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
8745557 Gulfport, MS Water Levels - Hurricane IKE  
Max Storm Tide: 1.376 m (4.51 ft) 09/12/2008 20:42 GMT  
Max Storm Surge/Residual: 1.12 m (3.67 ft) 09/12/2008 20:54 GMT

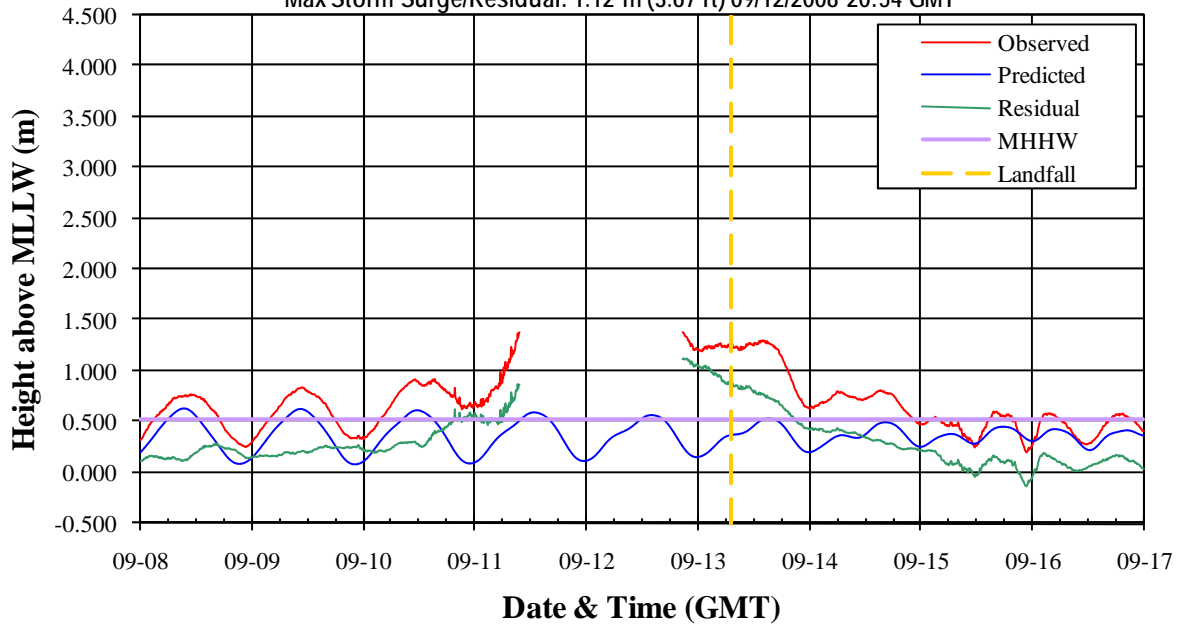


Figure 13: Water levels above Mean Lower Low Water (MLLW) at Gulfport Harbor, MS. Sensor reached the physical limit on measurements and did not record a maximum value. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
8747437 Bay Waveland Yacht Club, MS Water Levels - Hurricane IKE  
Max Storm Tide: 2.322 m (7.62 ft) 09/12/2008 13:42 GMT  
Max Storm Surge/Residual: 1.770 m (5.81 ft) 09/12/2008 13:18 GMT

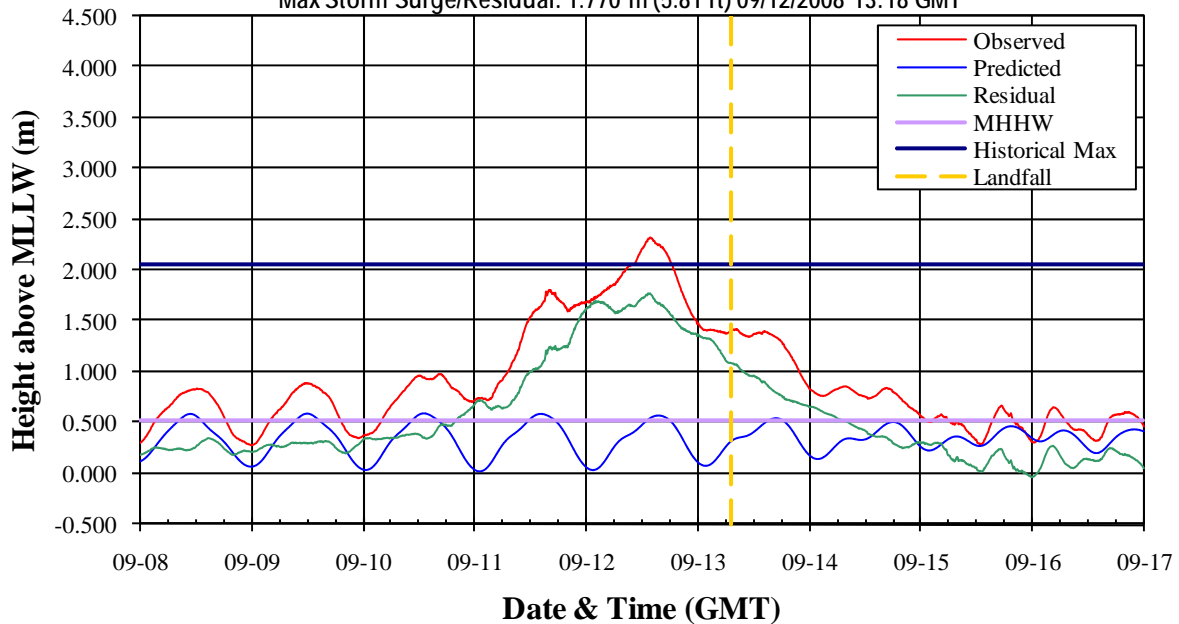


Figure 14: Water levels above Mean Lower Low Water (MLLW) at Bay Waveland Yacht Club, MS. Maximum recorded water level value exceeded historical recorded maximum tide level. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
8760922 Pilots Station East, SW Pass, LA Water Levels - Hurricane IKE  
Max Storm Tide: 1.382 m (4.53 ft) 09/12/2008 11:48 GMT  
Max Storm Surge/Residual: 0.926 m (3.04 ft) 09/12/2008 08:36 GMT

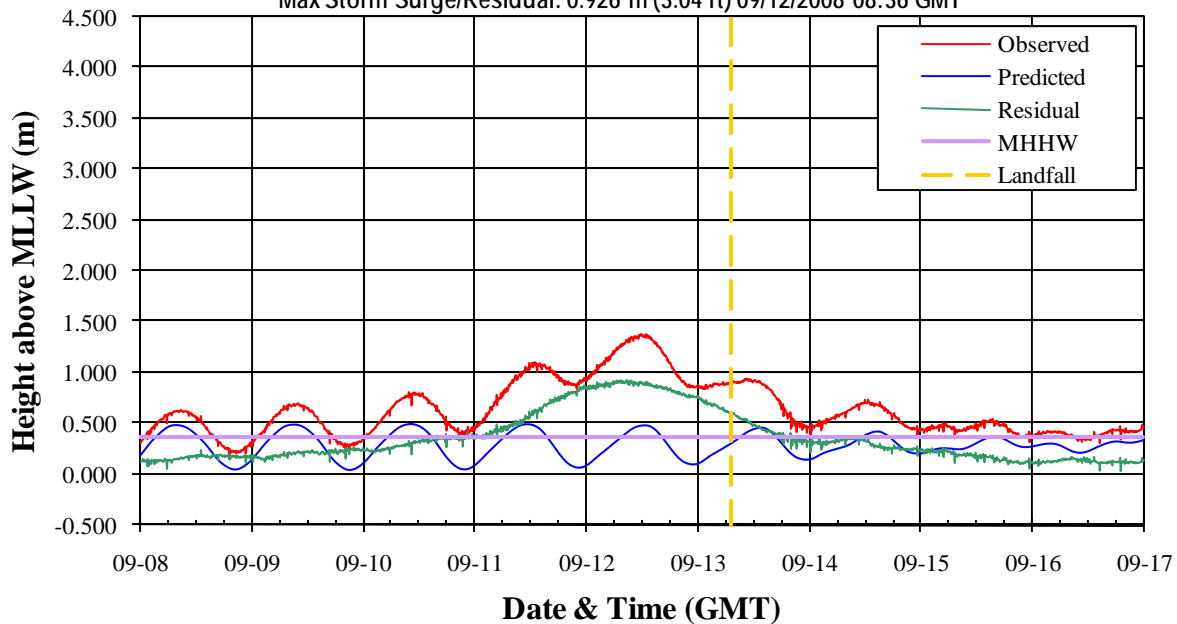


Figure 15: Water levels above Mean Lower Low Water (MLLW) at Pilots Station East, SW Pass, LA. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
8761305 Shell Beach, LA Water Levels - Hurricane IKE  
Max Storm Tide: 2.283 m (7.49 ft) 09/12/2008 15:06 GMT  
Max Storm Surge/Residual: 2.026 m (6.65 ft) 09/12/2008 05:42 GMT

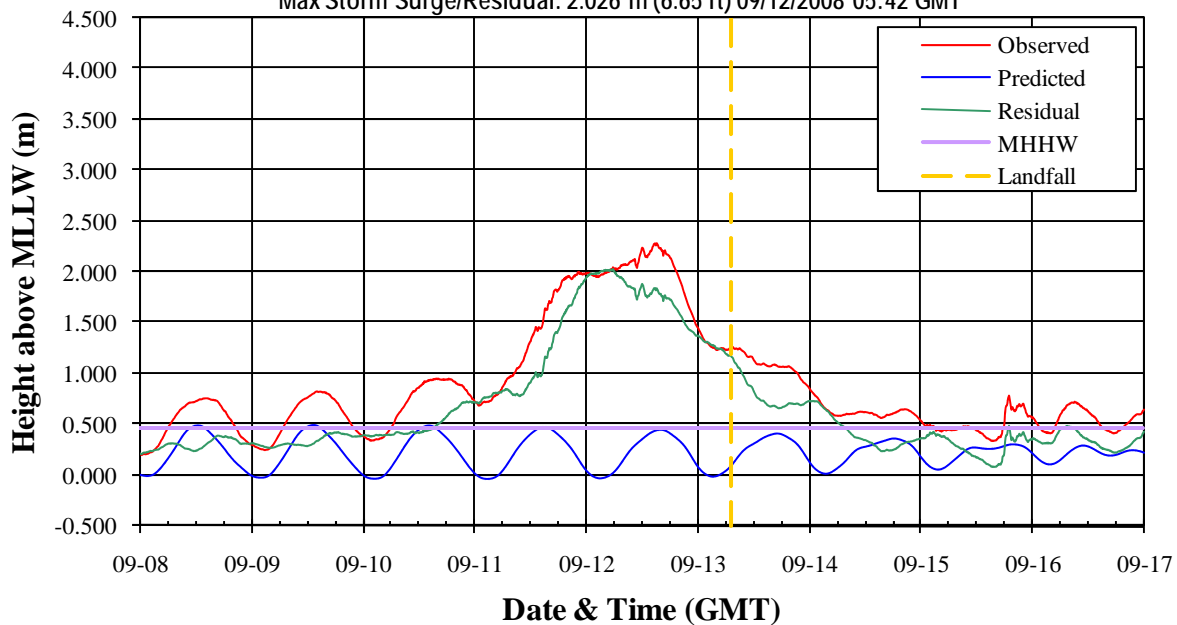


Figure 16: Water levels above Mean Lower Low Water (MLLW) at Shell Beach, LA. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services

8761724 Grand Isle, LA Water Levels - Hurricane IKE

Max Storm Tide: 1.590 m (5.22 ft) 09/12/2008 12:06 GMT

Max Storm Surge/Residual: 1.171 m (3.84 ft) 09/12/2008 12:06 GMT

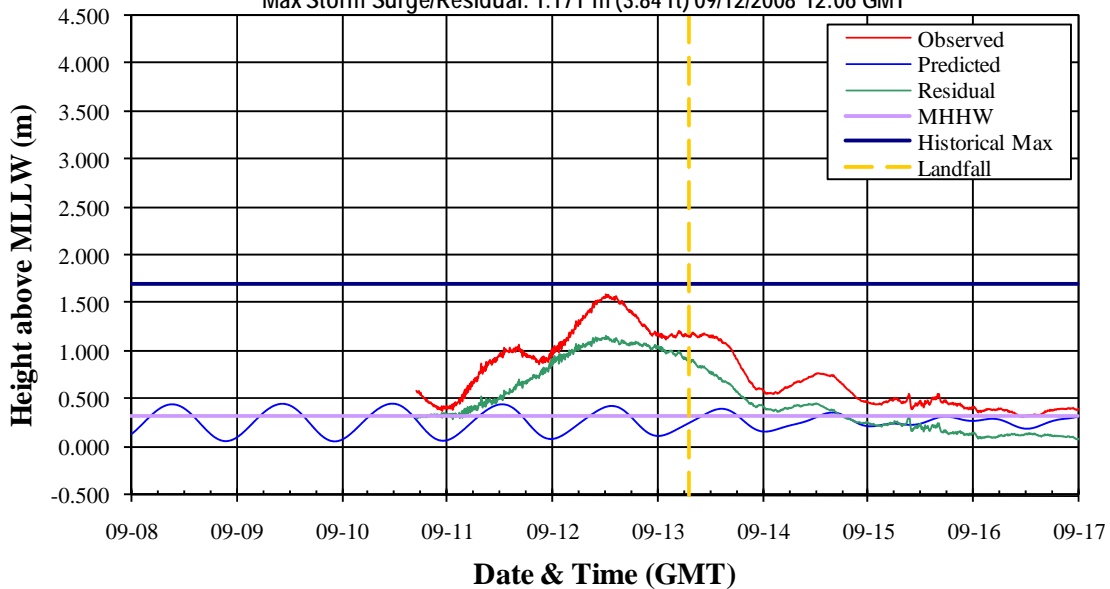


Figure 17: Water levels above Mean Lower Low Water (MLLW) at Grand Isle, LA. Station was repaired after Hurricane Gustav on September 10, 2008. Maximum recorded water level value and maximum storm surge/residual occur at the same time. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services

8761927 New Canal Station, LA Water Levels - Hurricane IKE

Max Storm Tide: 1.700 m (5.49 ft) 09/12/2008 23:30 GMT

Max Storm Surge/Residual: 1.57 m (5.15 ft) 09/13/2008 05:18 GMT

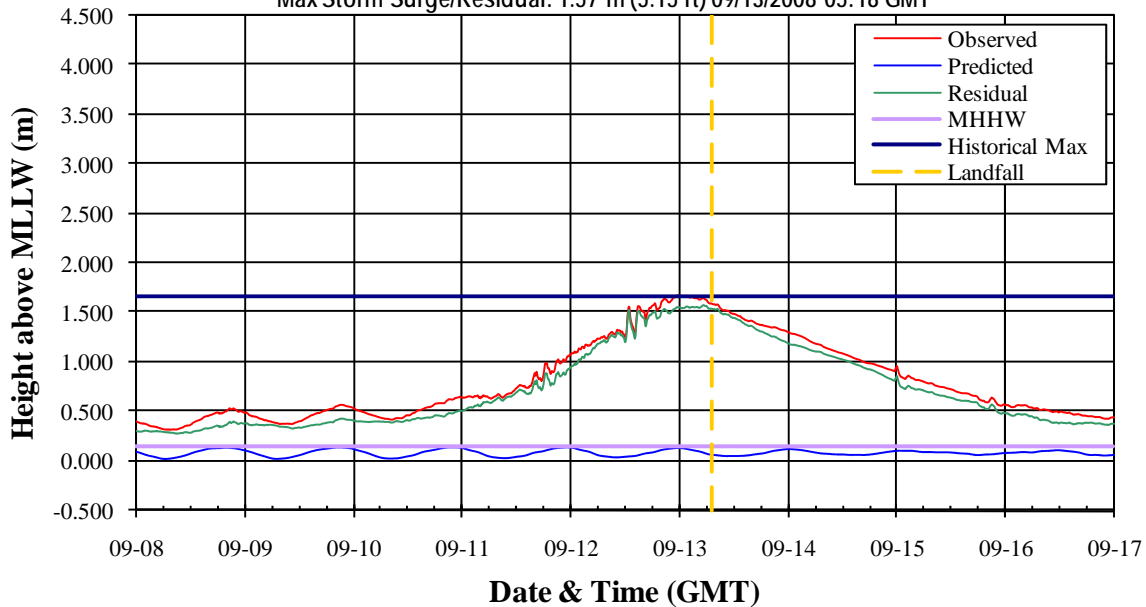


Figure 18: Water levels above Mean Lower Low Water (MLLW) at New Canal, LA. Maximum recorded water level value exceeded historical recorded maximum tide level. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8762075 Port Fourchon, LA Water Levels - Hurricane IKE  
 Max Storm Tide: 1.700 m (5.58 ft) 09/12/2008 08:36 GMT  
 Max Storm Surge/Residual: 1.270 m (4.17 ft) 09/12/2008 08:36 GMT

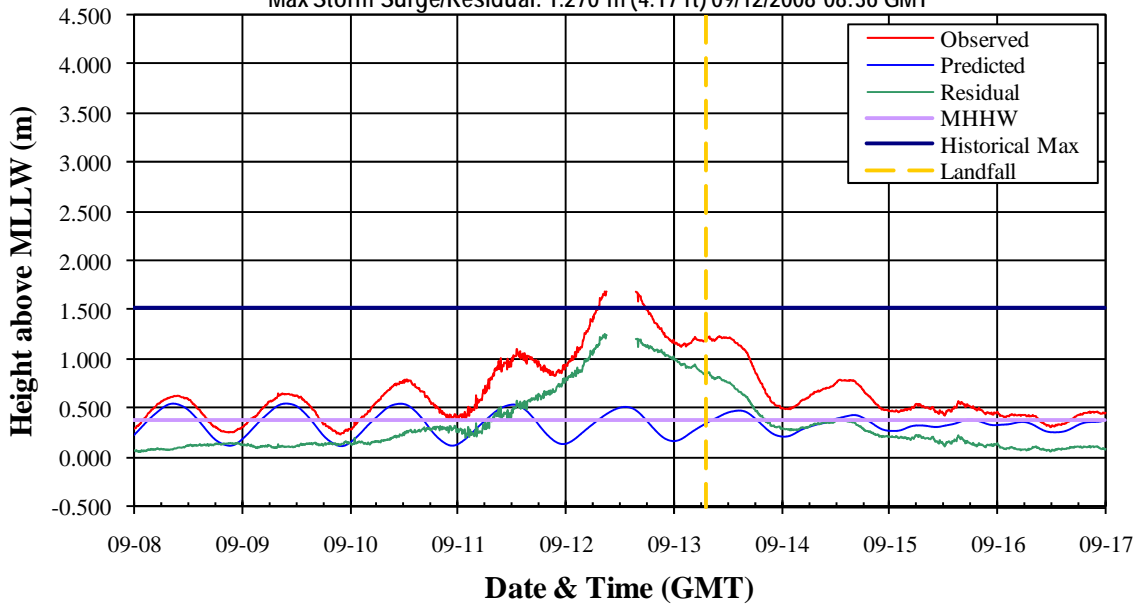


Figure 19: Water levels above Mean Lower Low Water (MLLW) at Port Fourchon, LA. Sensor reached the physical limit on measurements and did not record a maximum value. Maximum recorded water level value and maximum storm surge/residual occur at the same time. Maximum recorded water level value exceeded historical recorded maximum tide level. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8762482 West Bank 1, Bayou Gauche, LA Water Levels - Hurricane IKE  
 Max Storm Tide: 0.920 m (3.02 ft) 09/14/2008 06:00 GMT  
 Max Storm Surge/Residual: 0.915 m (3.00 ft) 09/14/2008 10:48 GMT

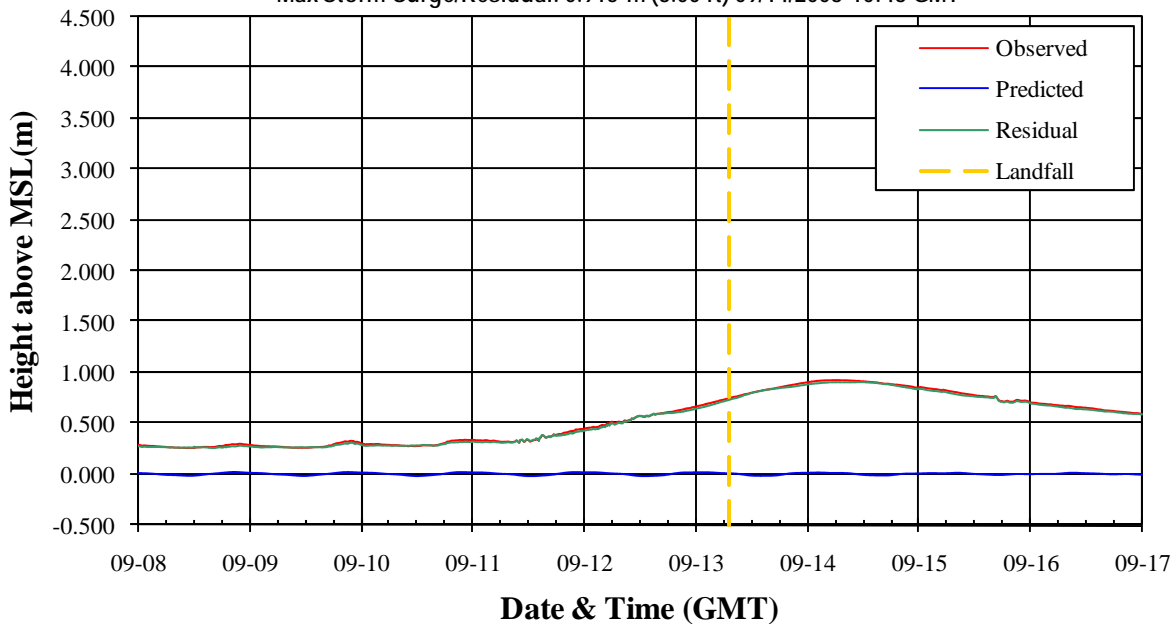


Figure 20: Water levels above Mean Sea Level (MSL) at West Bank 1, Bayou Gauche, LA, a primarily non-tidal station. During this time period, the predicted water levels have a very small tidal range (0.038-0.064 m above MSL) and are not visible at this scale.



NOAA NOS Center for Operational Oceanographic Products & Services  
8764044 Tesoro Marine Terminal, LA Water Levels - Hurricane IKE  
Max Storm Tide: 1.413 m (4.64 ft) 09/13/2008 19:30 GMT  
Max Storm Surge/Residual: 1.316 m (4.32 ft) 09/13/2008 19:00 GMT

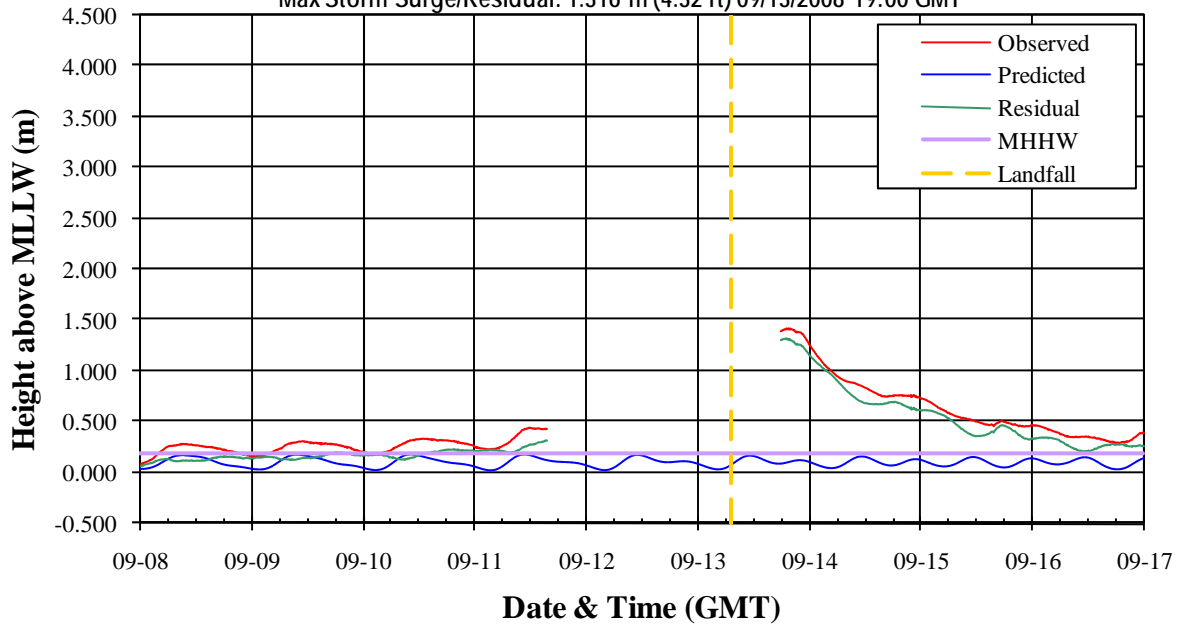


Figure 21: Water levels above Mean Lower Low Water (MLLW) at Tesoro Marine Terminal, LA. Station/Sensor was damaged and did not record a maximum/minimum value. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
8764227 LAWMA, Amerada Pass, LA Water Levels - Hurricane IKE  
Max Storm Tide: 2.38 m (7.81 ft) 09/12/2008 19:48 GMT  
Max Storm Surge/Residual: 2.023 m (6.64 ft) 09/12/2008 23:42 GMT

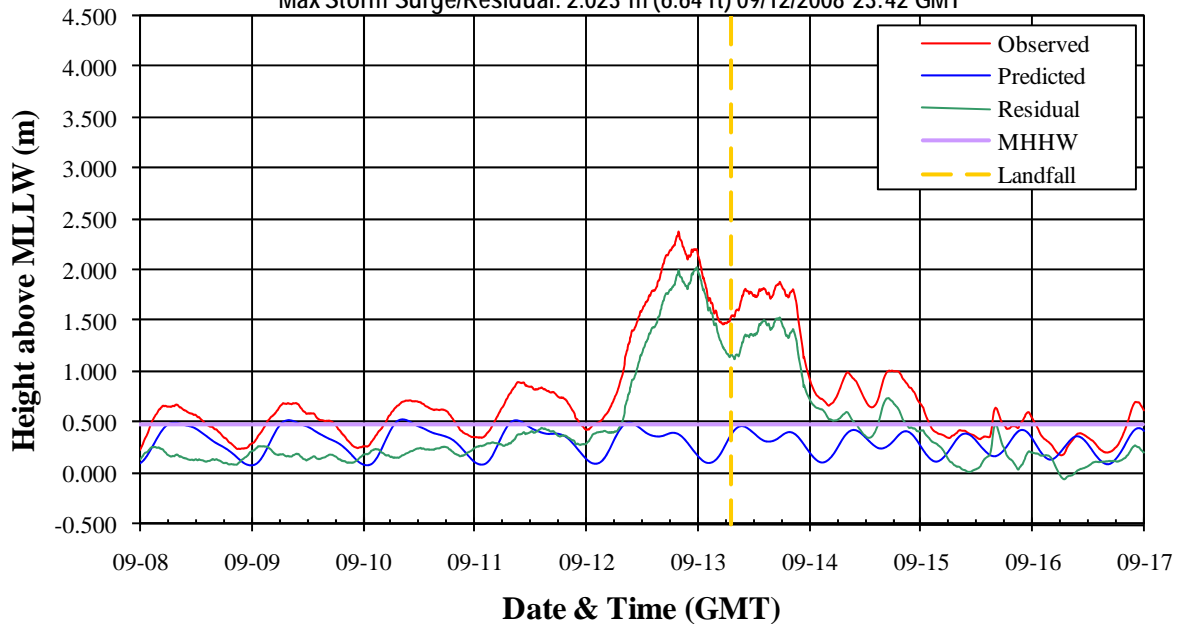


Figure 22: Water levels above Mean Lower Low Water (MLLW) at LAWMA, Amerada Pass, LA. A line denoting Mean Higher High Water (MHHW) is displayed.





NOAA NOS Center for Operational Oceanographic Products & Services  
 8765251 Cypremort Point, LA Water Levels - Hurricane IKE  
 Max Storm Tide: 0.973 m (3.19 ft) 09/11/2008 11:42 GMT  
 Max Storm Surge/Residual: 0.556 m (1.82 ft) 09/15/2008 00:36 GMT

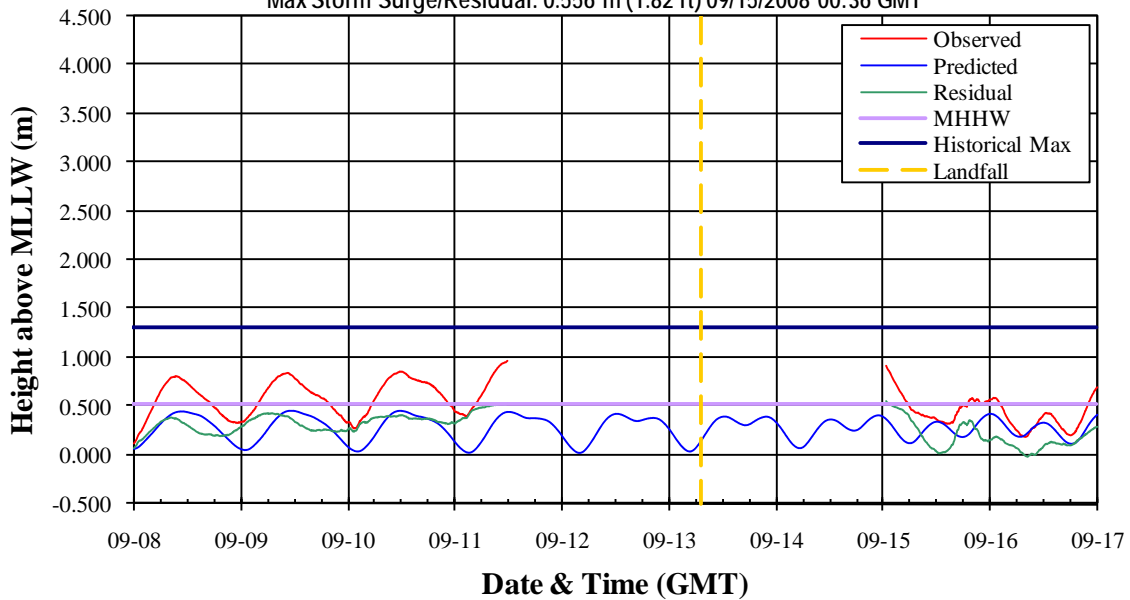


Figure 23: Water levels above Mean Lower Low Water (MLLW) at Cypremort Point, LA. Sensor reached the physical limit on measurements and did not record a maximum value. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8766072 Freshwater Canal Locks, LA Water Levels - Hurricane IKE  
 Max Storm Tide: 3.096 m (10.16 ft) 09/12/2008 23:48 GMT  
 Max Storm Surge/Residual: 3.05 m (10.01 ft) 09/12/2008 23:54 GMT

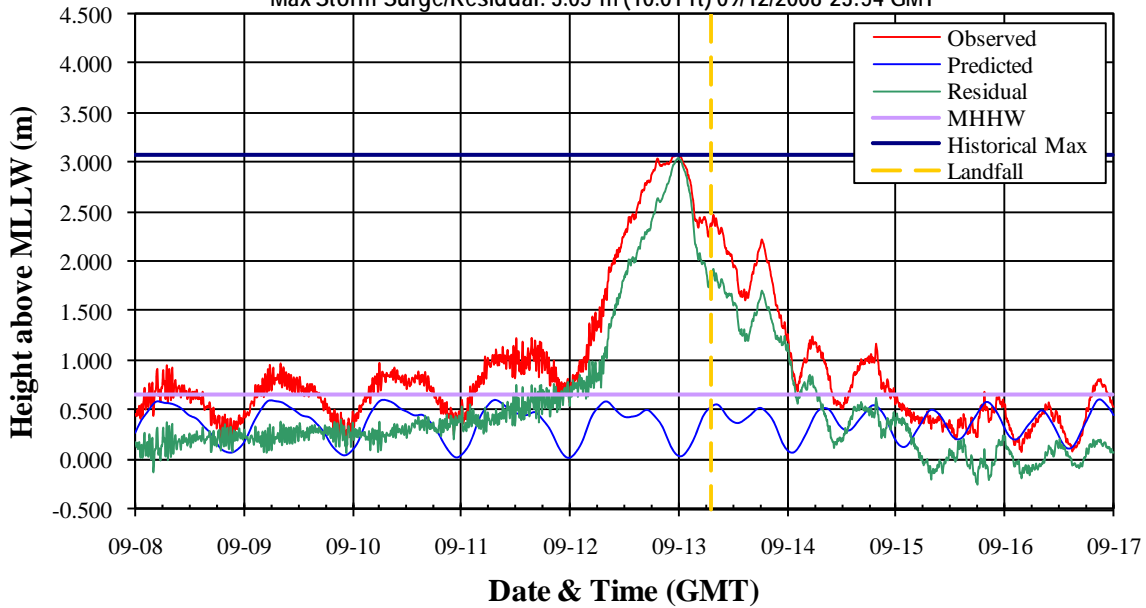


Figure 24: Water levels above Mean Lower Low Water (MLLW) at Freshwater Canal Locks, LA. Maximum recorded water level value exceeded historical recorded maximum tide level. Maximum recorded water level coincided within an hour of a low tide, resulting in lower storm tides. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services

8767816 Lake Charles, LA Water Levels - Hurricane IKE

Max Storm Tide: 1.037 m (3.20 ft) 09/12/2008 14:00 GMT

Max Storm Surge/Residual: 0.712 m (2.34 ft) 09/12/2008 14:00 GMT

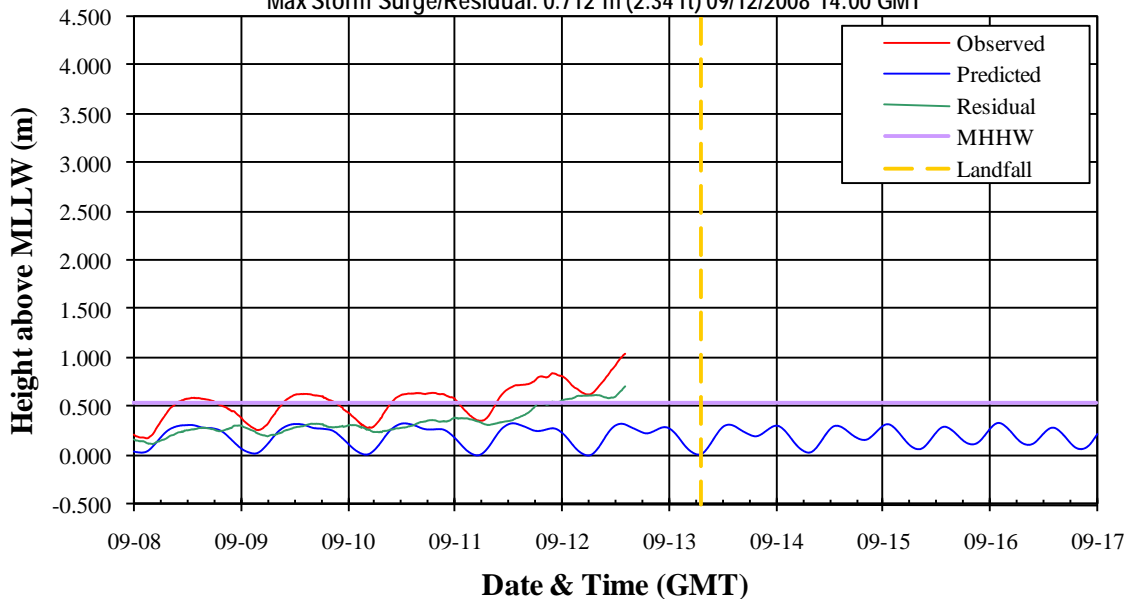


Figure 25: Water levels above Mean Lower Low Water (MLLW) at Lake Charles, LA. Station/Sensor was damaged and did not record a maximum/minimum value. Maximum recorded water level value and maximum storm surge/residual occur at the same time. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services

8768094 Calcasieu Pass, LA Water Levels - Hurricane IKE

Max Storm Tide: 3.640 m (11.9 ft) 09/13/2008 07:42 GMT

Max Storm Surge/Residual: 3.170 m (10.40 ft) 09/13/2008 02:48 GMT

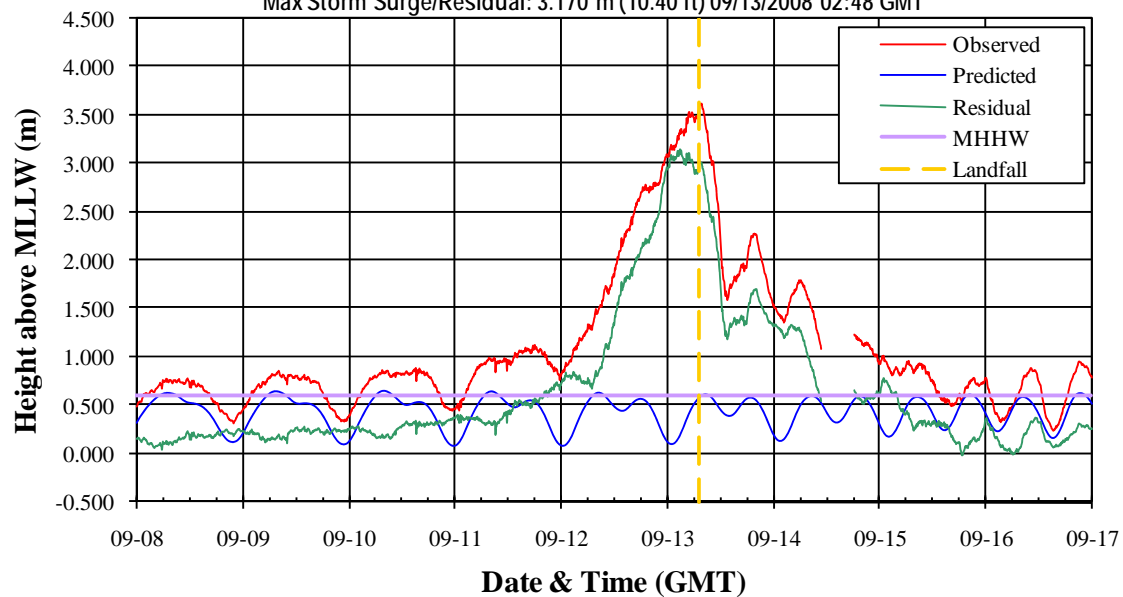


Figure 26: Water levels above Mean Lower Low Water (MLLW) at Calcasieu Pass, LA. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8770475 Port Arthur, TX Water Levels - Hurricane IKE  
 Max Storm Tide: 3.635 m (11.93 ft) 09/13/2008 09:12 GMT  
 Max Storm Surge/Residual: 3.361 m (11.03 ft) 09/13/2008 09:00 GMT

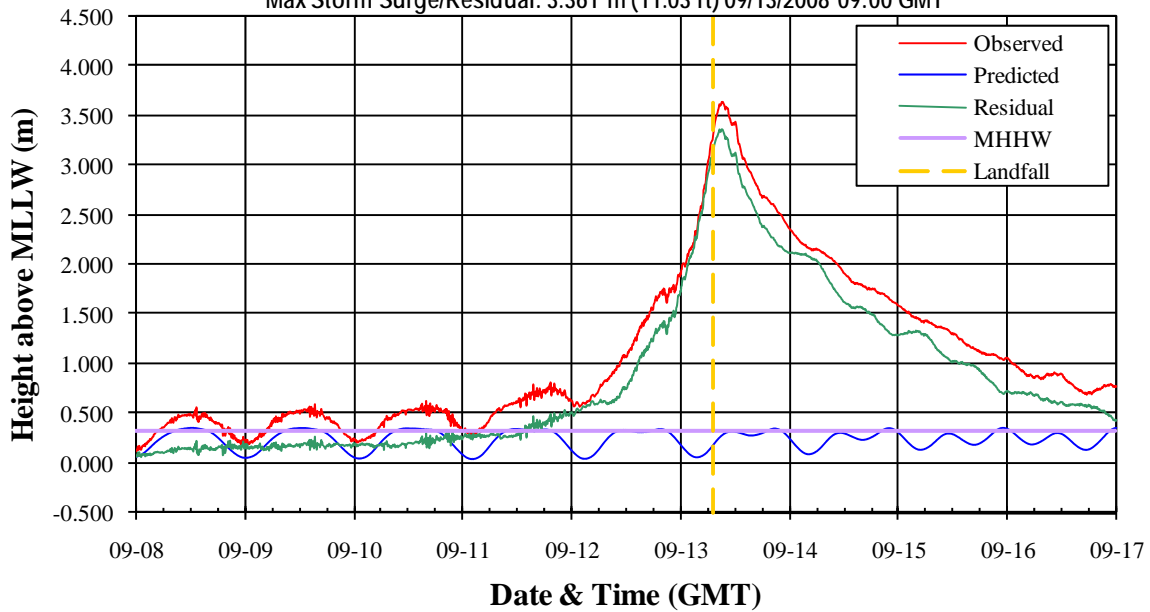


Figure 27: Water levels above Mean Lower Low Water (MLLW) at Port Arthur, TX. This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8770520 Rainbow Bridge, Neches River, TX Water Levels - Hurricane IKE  
 Max Storm Tide: 2.946 m (9.67 ft) 09/13/2008 09:12 GMT  
 Max Storm Surge/Residual: 2.792 m (9.16 ft) 09/13/2008 09:12 GMT

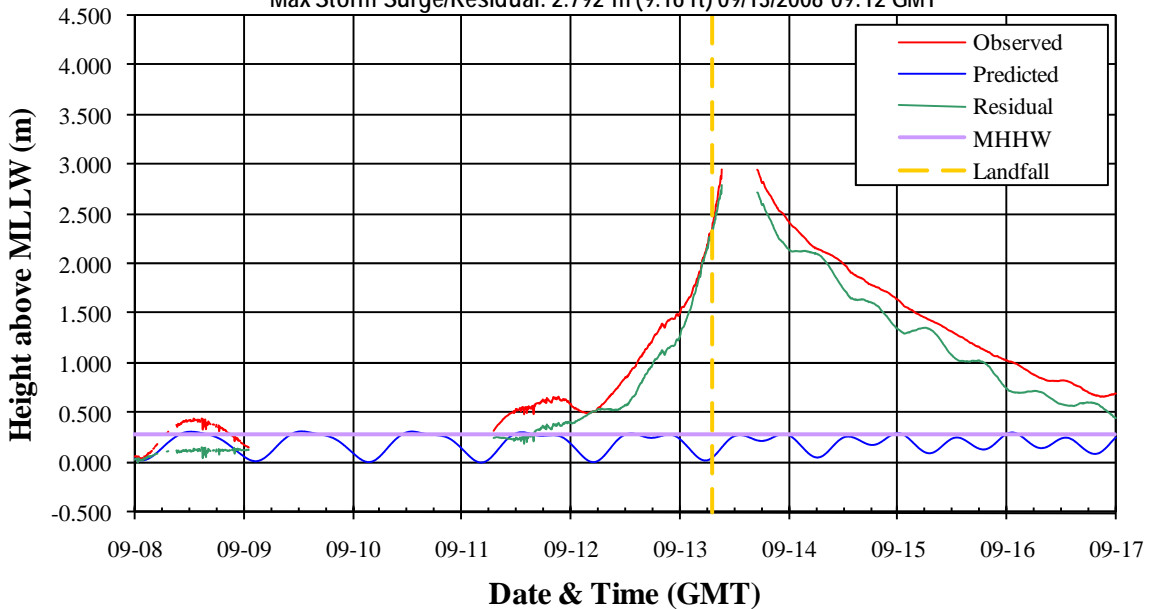


Figure 28: Water levels above Mean Lower Low Water (MLLW) at Rainbow Bridge, Neches River, TX. . This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control. Sensor reached the physical limit on measurements and did not record a maximum/minimum value. Maximum recorded water level value and maximum storm surge/residual occur at the same time. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8770570 Sabine Pass North, TX Water Levels - Hurricane IKE  
 Max Storm Tide: 4.362 m (14.31 ft) 09/13/2008 07:54 GMT  
 Max Storm Surge/Residual: 3.839 m (12.6 ft) 09/13/2008 07:48 GMT

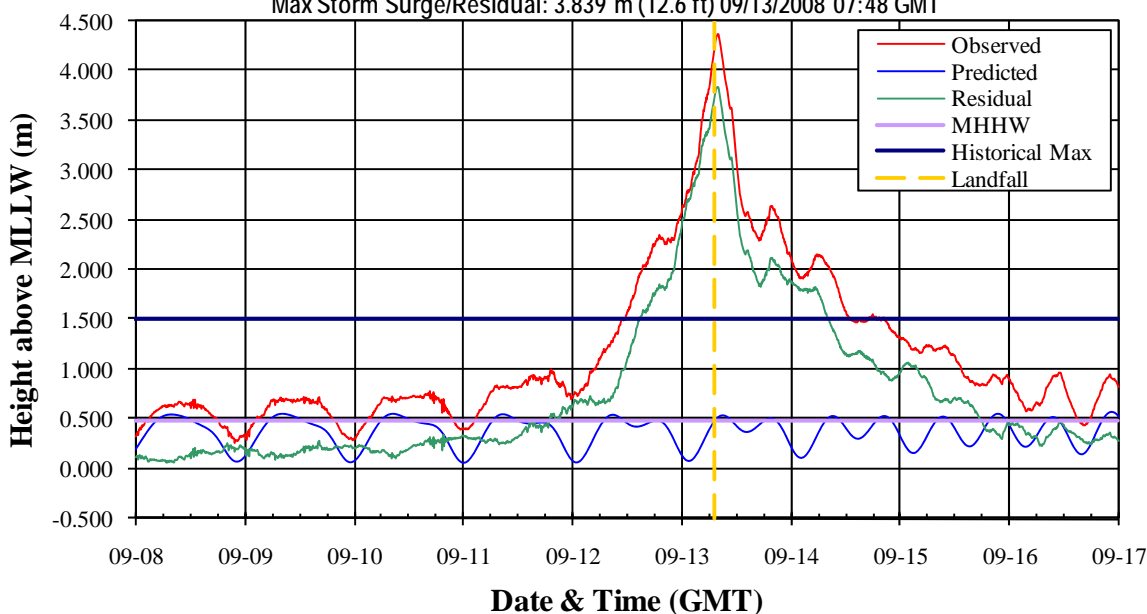


Figure 29: Water levels above Mean Lower Low Water (MLLW) at Sabine Pass North, TX. Maximum recorded water level value and maximum storm surge/residual occur at the same time. Maximum recorded water level value exceeded historical recorded maximum tide level. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8770613 Morgans Point, TX Water Levels - Hurricane IKE  
 Max Storm Tide: 2.746 m (9.01 ft) 09/13/2008 07:06 GMT  
 Max Storm Surge/Residual: 2.688 m (8.82 ft) 09/13/2008 07:06 GMT

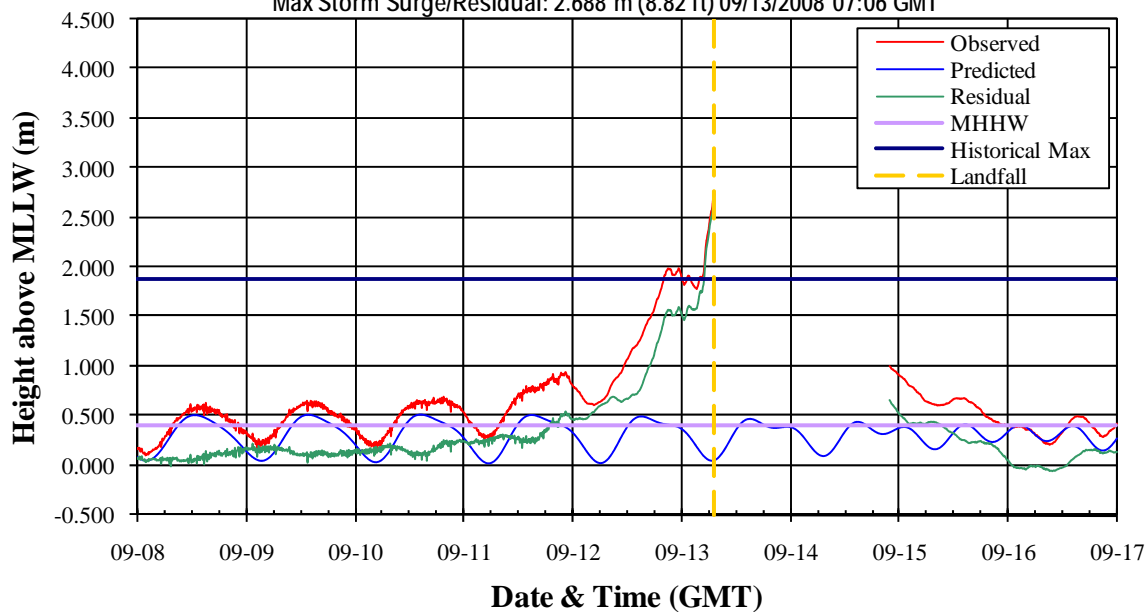


Figure 30: Water levels above Mean Lower Low Water (MLLW) at Morgans Point, TX. Station/Sensor was damaged and did not record a maximum/minimum value. Maximum recorded water level value and maximum storm surge/residual occur at the same time. Maximum recorded water level value exceeded historical recorded maximum

tide level. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8770743 Battleship Texas State Park, TX Water Levels - Hurricane IKE  
 Max Storm Tide: 2.406 m (7.89 ft) 09/13/2008 06:54 GMT  
 Max Storm Surge/Residual: 2.227 m (7.31 ft) 09/13/2008 06:54 GMT

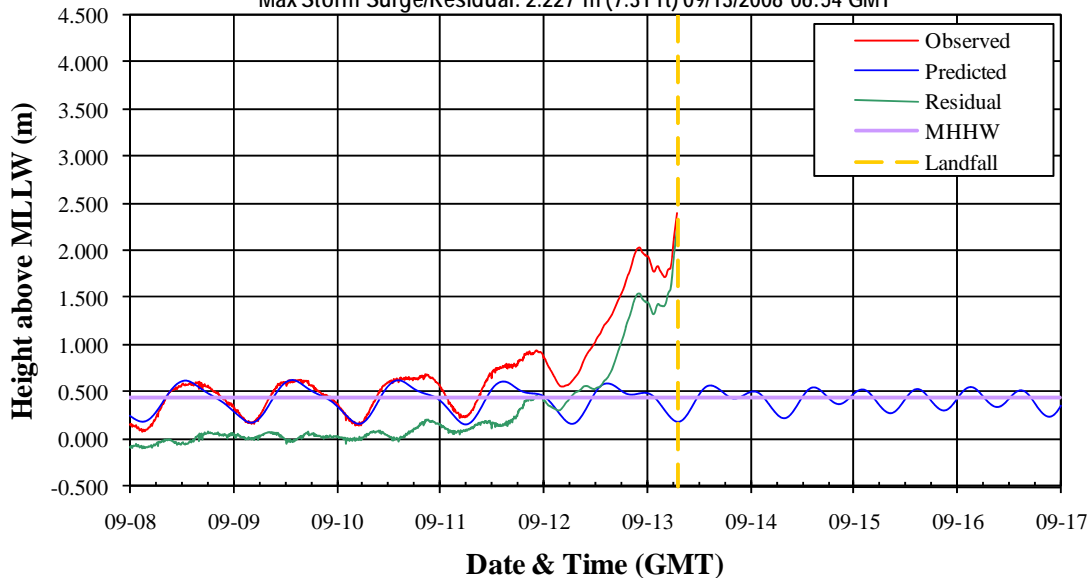


Figure 31: Water levels above Mean Lower Low Water (MLLW) at Battleship Texas State Park, TX. This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control. Station/Sensor was damaged and did not record a maximum/minimum value. Maximum recorded water level value and maximum storm surge/residual occur at the same time. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8770777 Manchester, TX Water Levels - Hurricane IKE  
 Max Storm Tide: 3.742 m (12.28 ft) 09/13/2008 17:24 GMT  
 Max Storm Surge/Residual: 3.577 m (11.74 ft) 09/13/2008 09:12 GMT

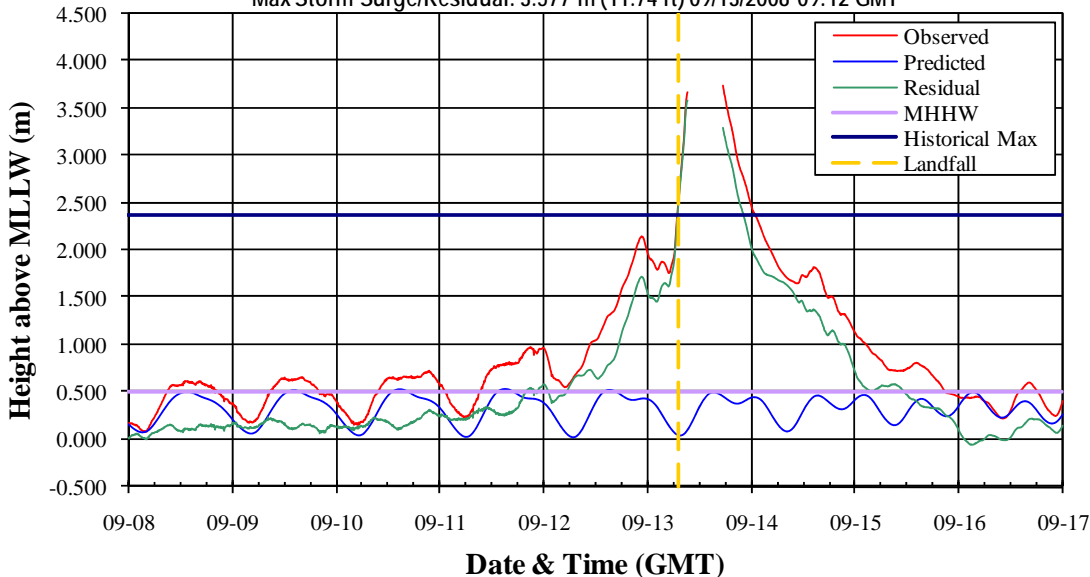


Figure 32: Water levels above Mean Lower Low Water (MLLW) at Manchester, TX. This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control. Sensor reached the physical limit on measurements and did not record a maximum value. Maximum recorded water level value exceeded historical recorded maximum tide level. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services

8770933 Clear Lake, TX Water Levels - Hurricane IKE

Max Storm Tide: 2.495 m (8.19 ft) 09/13/2008 05:42 GMT

Max Storm Surge/Residual: 2.424 m (7.95 ft) 09/13/2008 06:00 GMT

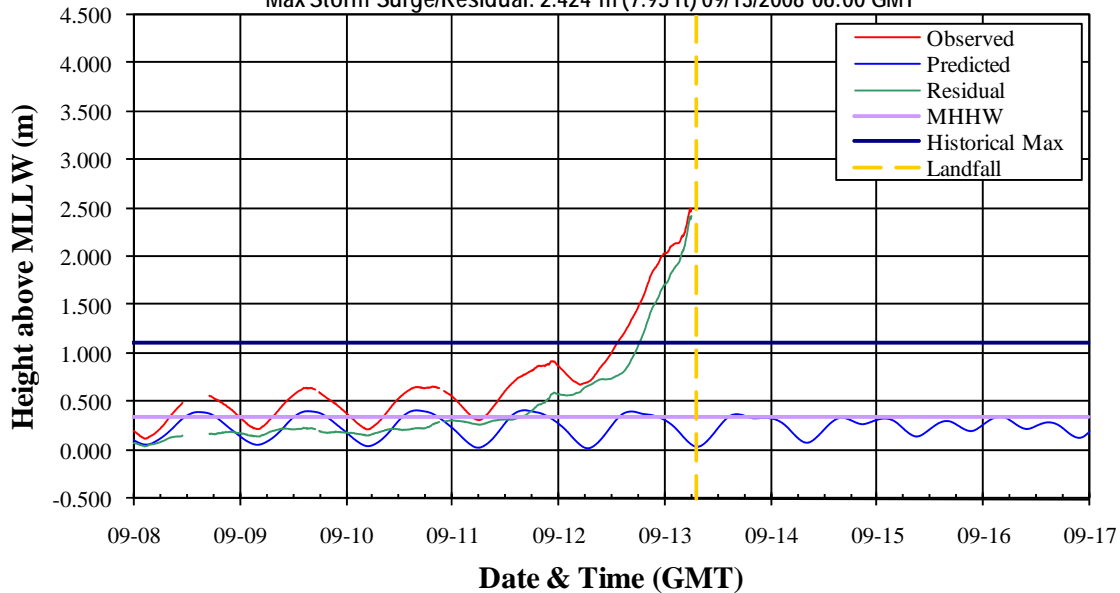


Figure 33: Water levels above Mean Lower Low Water (MLLW) at Clear Lake, TX. This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control. Station/Sensor was damaged and did not record a maximum/minimum value. Maximum recorded water level value exceeded historical recorded maximum tide level. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services

8770971 Rollover Pass, TX Water Levels - Hurricane IKE

Max Storm Tide: 3.423 m (11.23 ft) 09/13/2008 05:48 GMT

Max Storm Surge/Residual: 3.372 m (11.06 ft) 09/13/2008 05:48 GMT

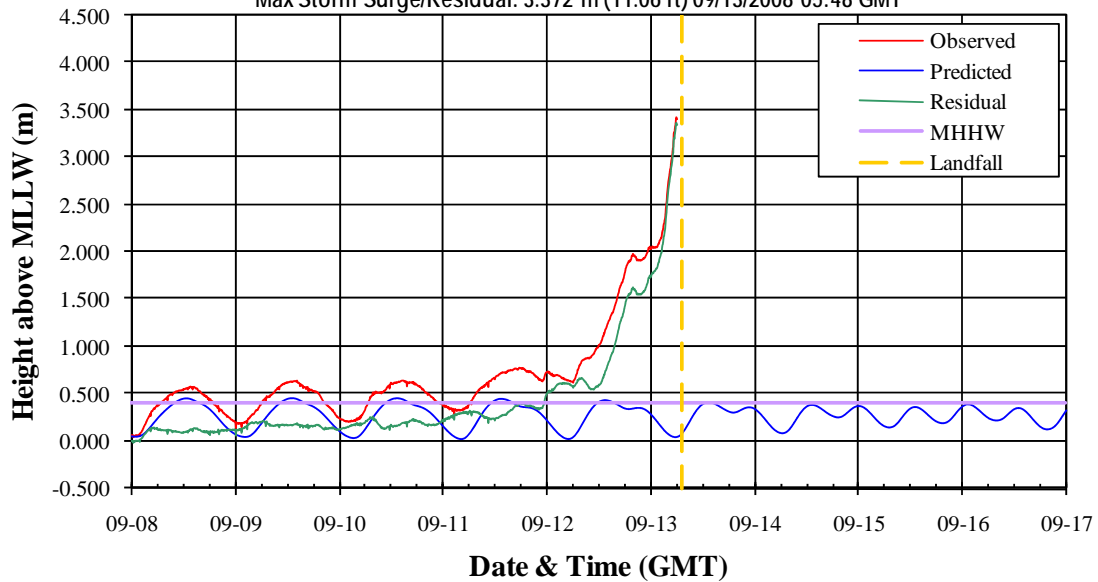


Figure 34: Water levels above Mean Lower Low Water (MLLW) at Rollover Pass, TX. This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control. Station/Sensor was damaged and did not record a maximum/minimum value. Maximum recorded water level value and maximum storm surge/residual occur at the same time. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services

8771013 Eagle Point, TX Water Levels - Hurricane IKE

Max Storm Tide: 3.641 m (11.95 ft) 09/13/2008 06:24 GMT

Max Storm Surge/Residual: 3.500 m (11.48 ft) 09/13/2008 06:24 GMT

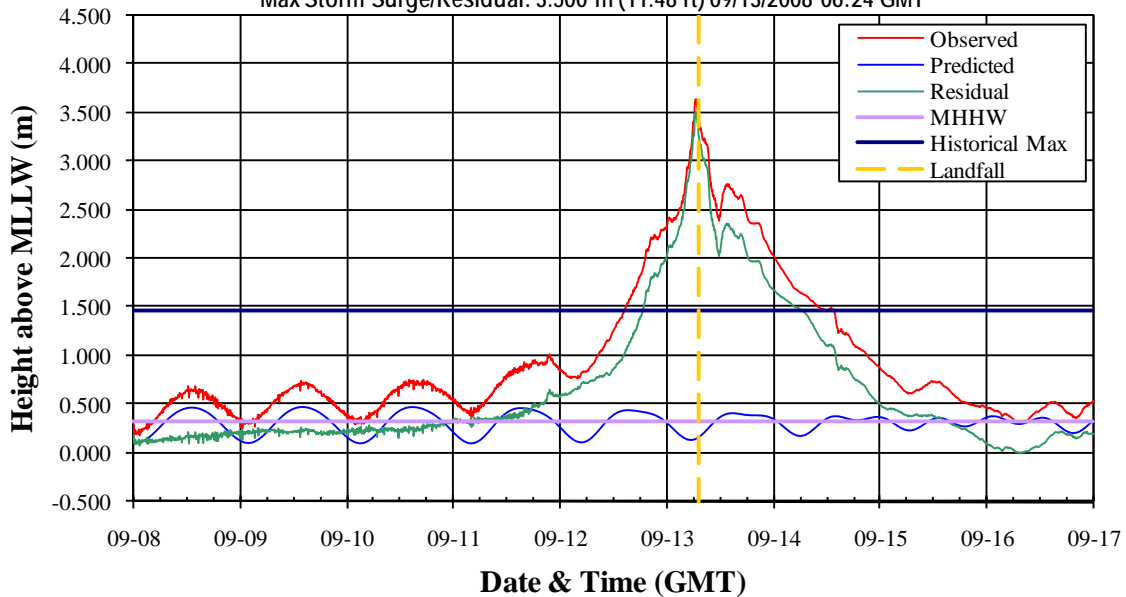


Figure 35: Water levels above Mean Lower Low Water (MLLW) at Eagle Point, TX. Maximum recorded water level value and maximum storm surge/residual occur at the same time. Maximum recorded water level value exceeded historical recorded maximum tide level. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services

8771341 Galveston Bay Entrance, North Jetty, TX Water Levels - Hurricane IKE

Max Storm Tide: 2.972 m (9.75 ft) 09/13/2008 01:12 GMT

Max Storm Surge/Residual: 2.869 m (9.41 ft) 09/13/2008 01

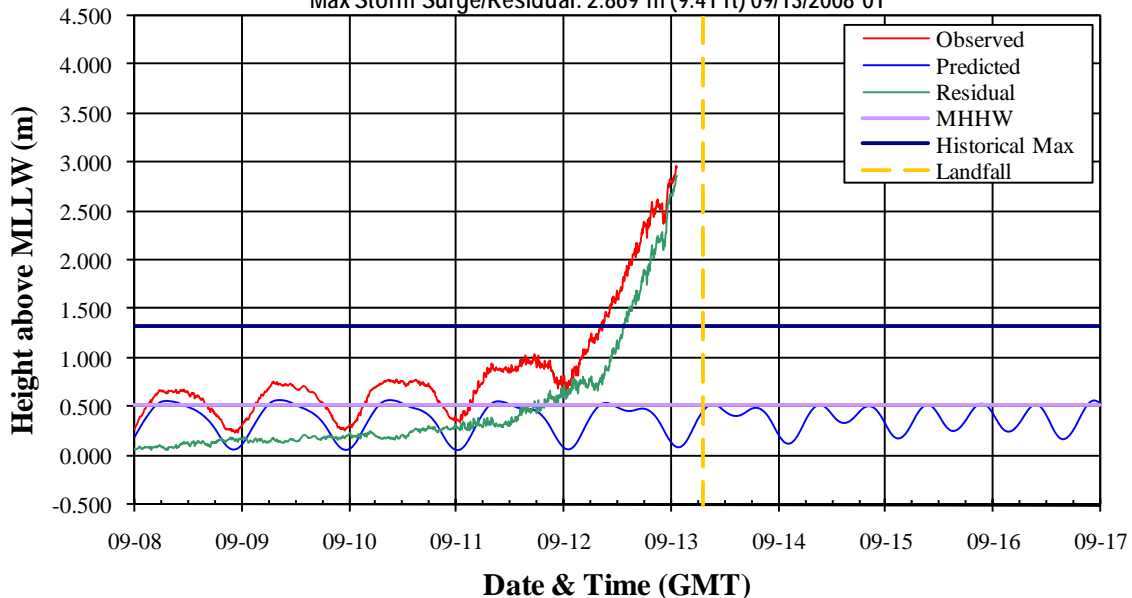


Figure 36: Water levels above Mean Lower Low Water (MLLW) at Galveston Bay Entrance, North Jetty, TX. Station/Sensor was damaged and did not record a maximum/minimum value. Maximum recorded water level value and maximum storm surge/residual occur at the same time. Maximum recorded water level value exceeded historical recorded maximum tide level. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.





NOAA NOS Center for Operational Oceanographic Products & Services  
8771450 Galveston Pier 21, TX Water Levels - Hurricane IKE  
Max Storm Tide: 3.299 m (10.82 ft) 09/13/2008 09:00 GMT  
Max Storm Surge/Residual: 3.062 m (10.05 ft) 09/13/2008 03:42 GMT

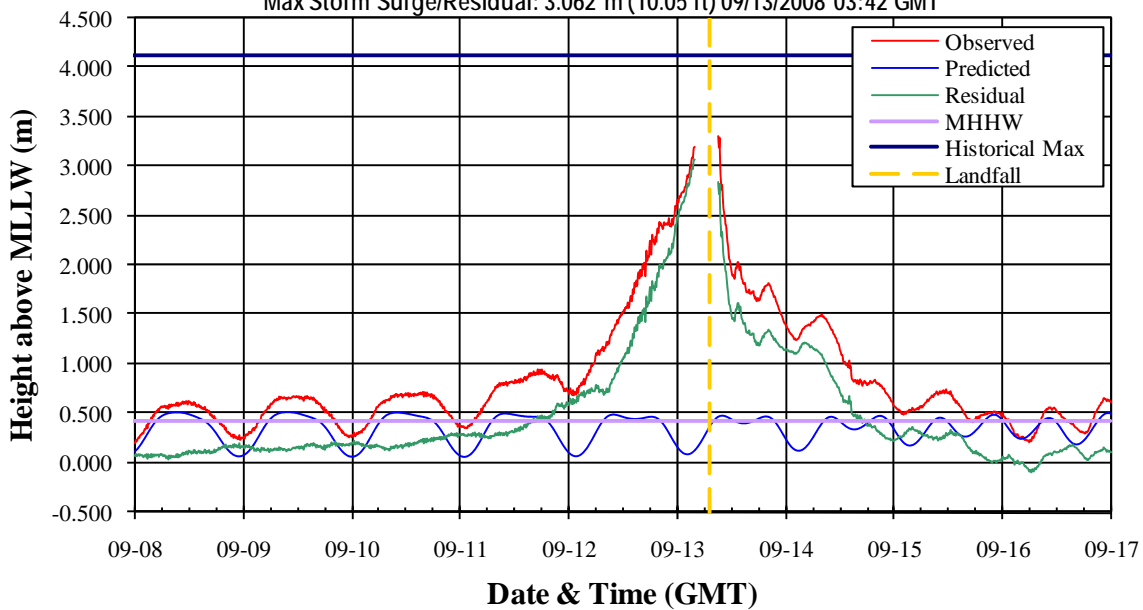


Figure 37: Water levels above Mean Lower Low Water (MLLW) at Galveston Pier 21, TX. Station/Sensor was damaged and did not record a maximum/minimum value. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
8771510 Galveston Pleasure Pier, TX Water Levels - Hurricane IKE  
Max Storm Tide: 2.981 m (9.78 ft) 09/13/2008 04:06 GMT  
Max Storm Surge/Residual: 2.705 m (8.87 ft) 09/13/2008 03:42 GMT

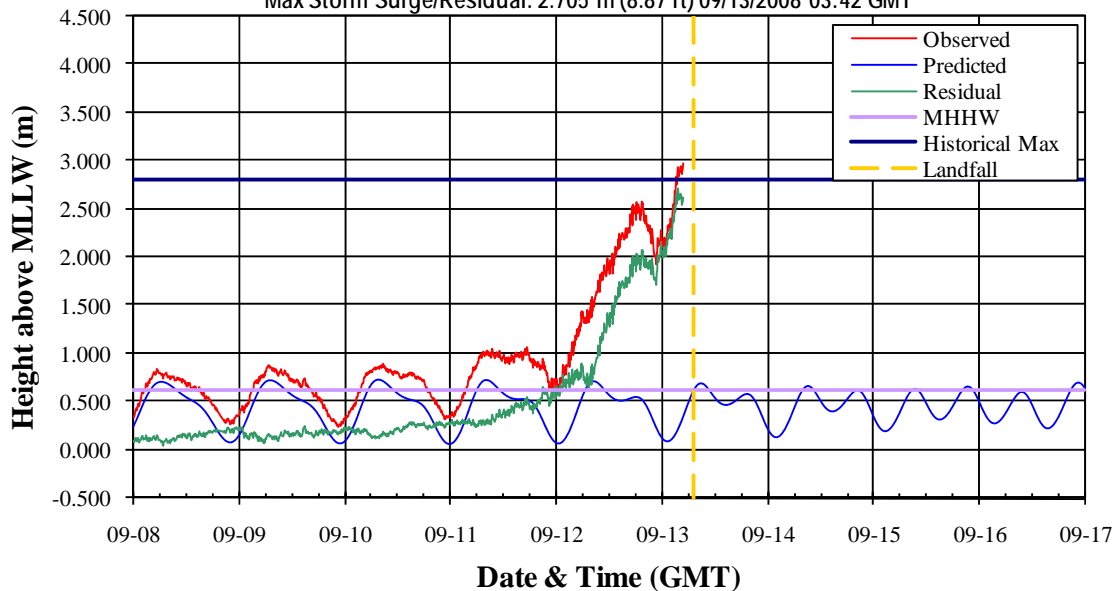


Figure 38: Water levels above Mean Lower Low Water (MLLW) at Galveston Pleasure Pier, TX. Station/Sensor was damaged and did not record a maximum/minimum value. Maximum recorded water level value and maximum storm surge/residual occur at the same time. Maximum recorded water level value exceeded historical recorded maximum tide level. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8772447 USCG Freeport, TX Water Levels - Hurricane IKE  
 Max Storm Tide: 2.262 m (7.42 ft) 09/12/2008 20:00 GMT  
 Max Storm Surge/Residual: 1.905 m (6.25 ft) 09/12/2008 20:42 GMT

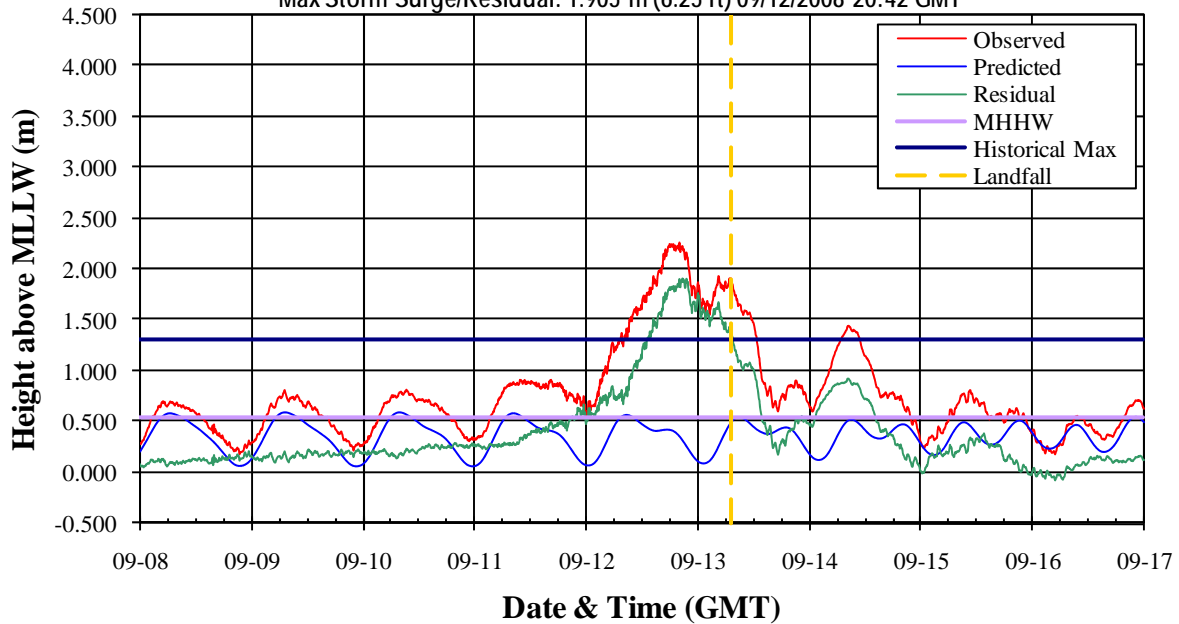


Figure 39: Water levels above Mean Lower Low Water (MLLW) at USCG Freeport, TX. Maximum recorded water level value exceeded historical recorded maximum tide level. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8773037 Seadrift, TX Water Levels - Hurricane IKE  
 Max Storm Tide: 1.002 m (3.29 ft) 09/14/2008 00:42 GMT  
 Max Storm Surge/Residual: 0.897 m (2.94 ft) 09/13/2008 17:06 GMT

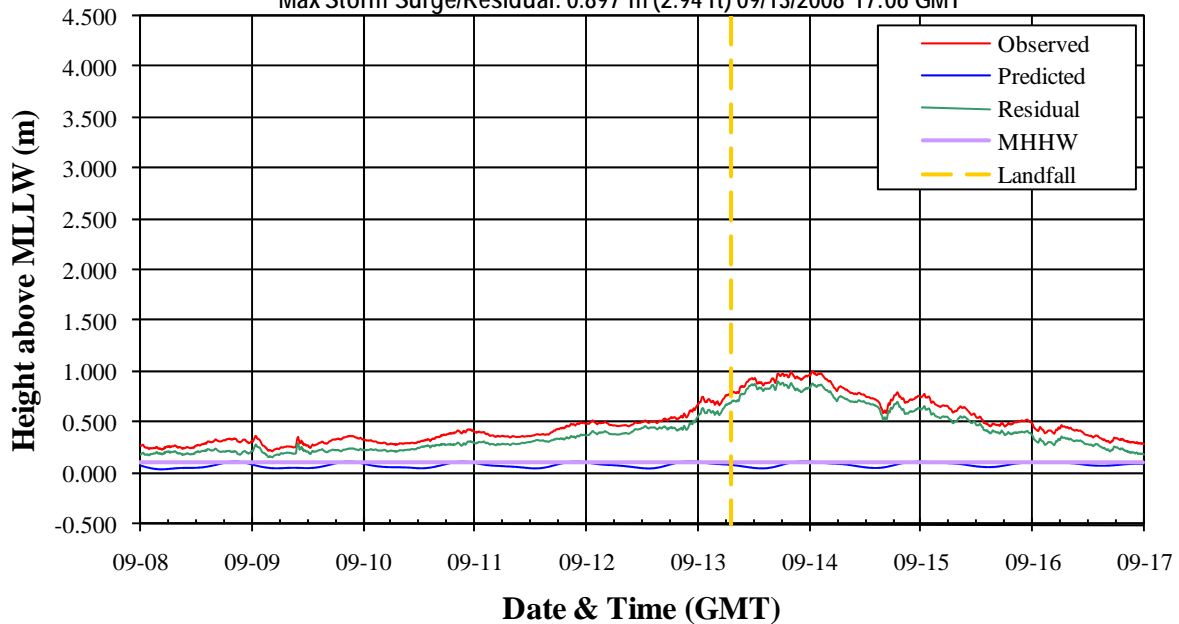


Figure 40: Water levels above Mean Lower Low Water (MLLW) at Seadrift, TX. This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8773259 Port Lavaca, TX Water Levels - Hurricane IKE  
 Max Storm Tide: 1.176 m (3.86 ft) 09/13/2008 14:54 GMT  
 Max Storm Surge/Residual: 0.902 m (2.96 ft) 09/13/2008 14:54 GMT

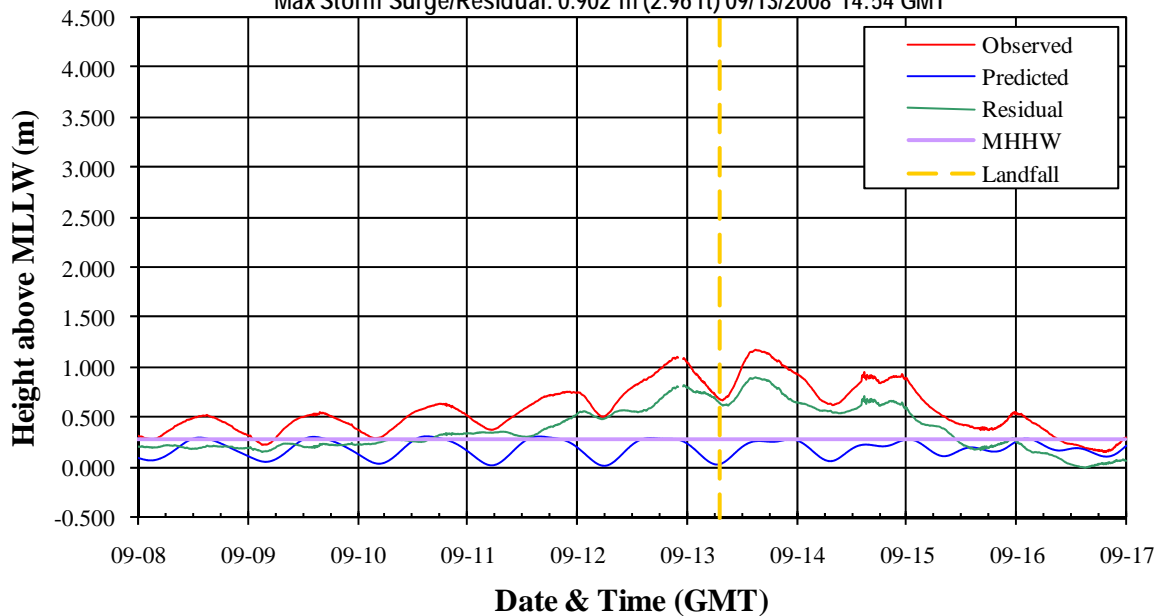


Figure 41: Water levels above Mean Lower Low Water (MLLW) at Port Lavaca, TX. This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control. Maximum recorded water level value and maximum storm surge/residual occur at the same time. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 8773701 Port O'Connor, TX Water Levels - Hurricane IKE  
 Max Storm Tide: 1.291 m (4.24 ft) 09/12/2008 22:18 GMT  
 Max Storm Surge/Residual: 1.132 m (3.71 ft) 09/13/2008 02:42 GMT

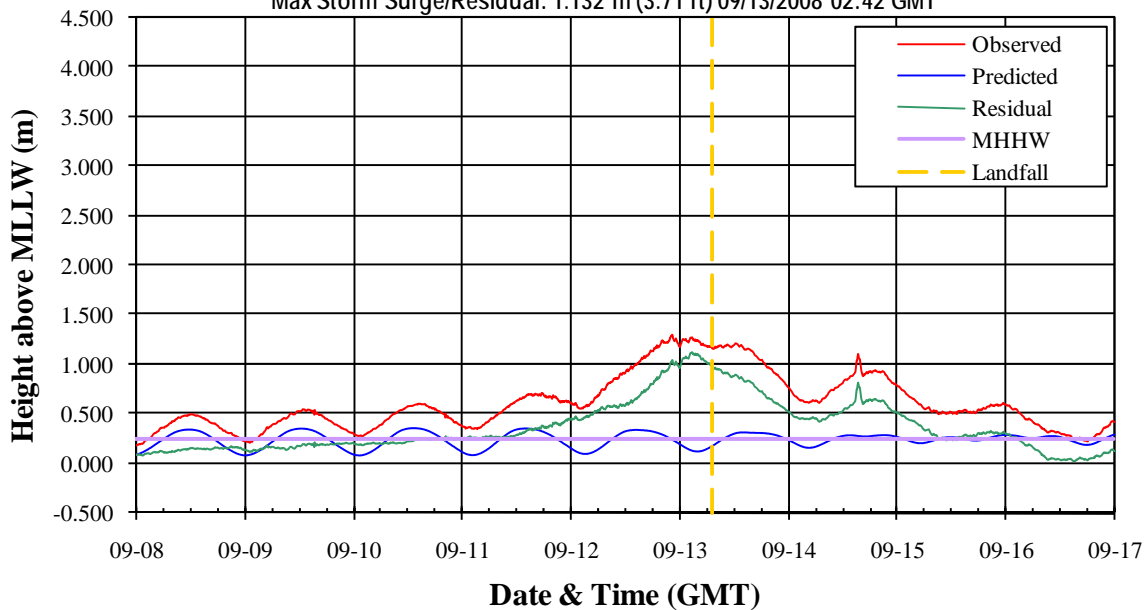


Figure 42: Water levels above Mean Lower Low Water (MLLW) at Port O'Connor, TX. This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services

8774770 Rockport, TX Water Levels - Hurricane IKE

Max Storm Tide: 0.923 m (3.03 ft) 09/13/2008 15:42 GMT

Max Storm Surge/Residual: 0.782 m (2.57 ft) 09/13/2008 13:36 GMT

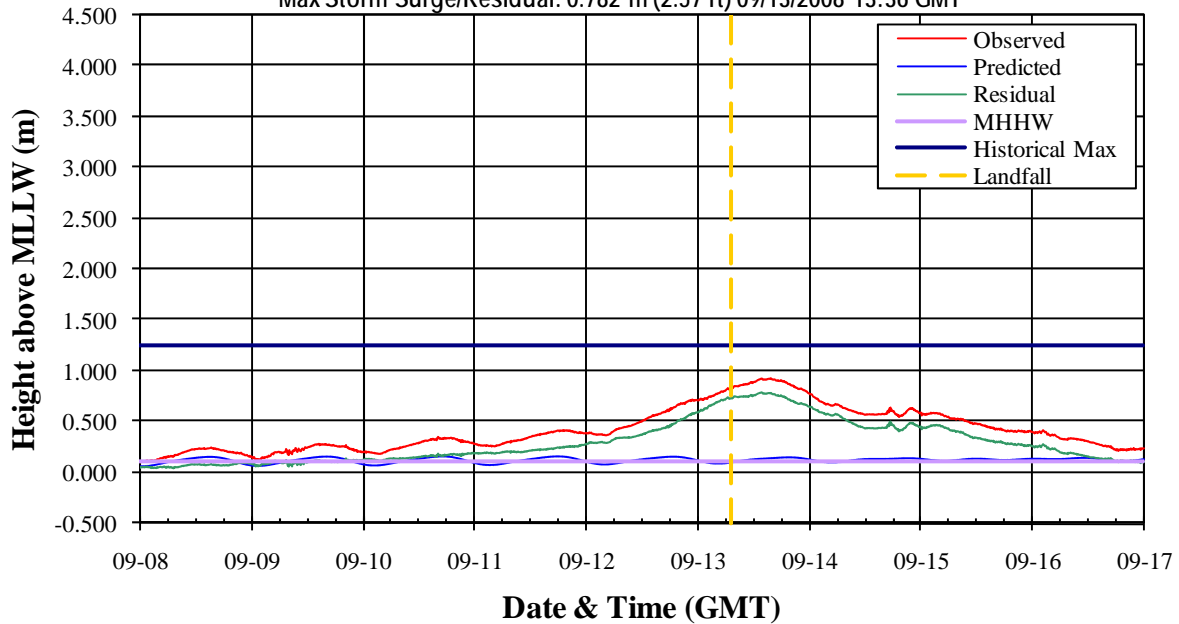


Figure 43: Water levels above Mean Lower Low Water (MLLW) at Rockport, TX. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services

8775237 Port Aransas, TX Water Levels - Hurricane IKE

Max Storm Tide: 1.375 m (4.51 ft) 09/13/2008 10:24 GMT

Max Storm Surge/Residual: 1.072 m (3.52 ft) 09/13/2008 04:12 GMT

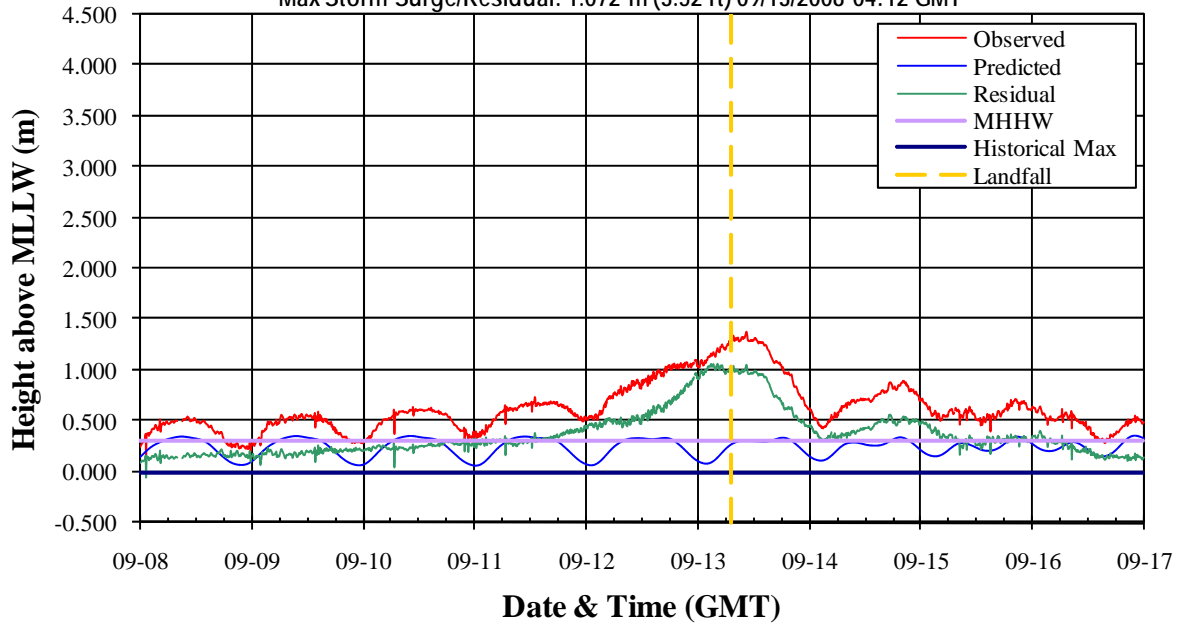


Figure 44: Water levels above Mean Lower Low Water (MLLW) at Port Aransas, TX. This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
8775296 Texas State Aquarium, TX Water Levels - Hurricane IKE  
Max Storm Tide: 1.128 m (3.70 ft) 09/13/2008 15:54 GMT  
Max Storm Surge/Residual: 0.970 m (3.18 ft) 09/13/2008 09:12 GMT

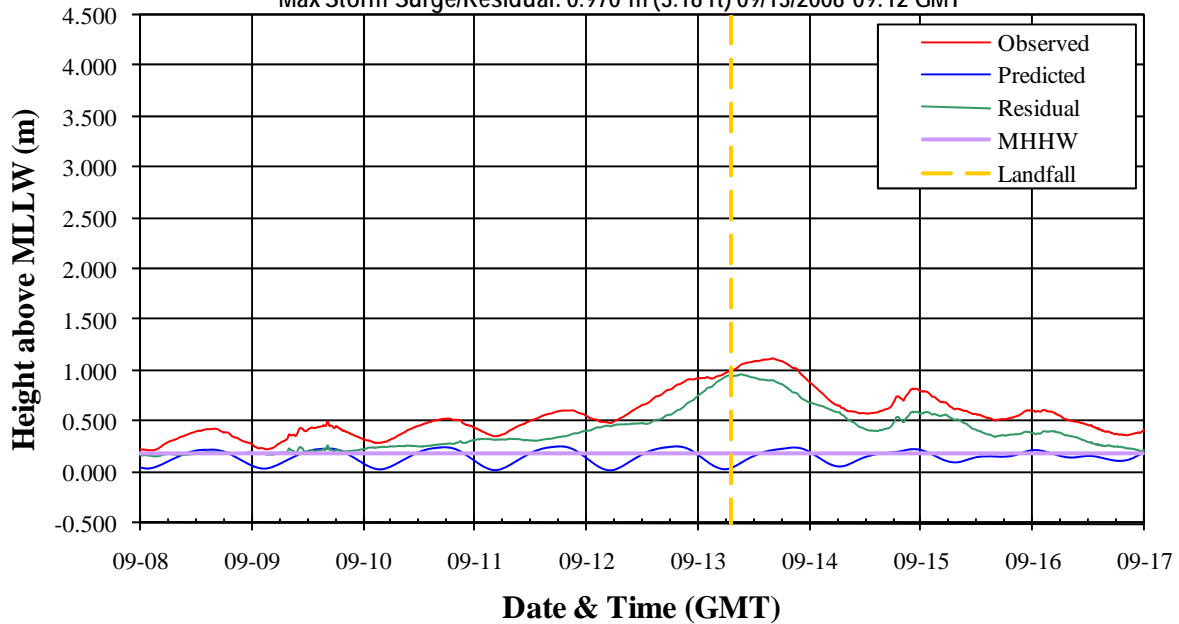


Figure 45: Water levels above Mean Lower Low Water (MLLW) at Texas State Aquarium, TX. This partnership station is operated by the Texas Coastal Ocean Observing System; data does not undergo post-processing NOS Quality Assurance / Control. A line denoting Mean Higher High Water (MHHW) is displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
8775870 Corpus Christi, TX Water Levels - Hurricane IKE  
Max Storm Tide: 1.804 m (5.92 ft) 09/13/2008 07:48 GMT  
Max Storm Surge/Residual: 1.288 m (4.23 ft) 09/12/2008 23:30 GMT

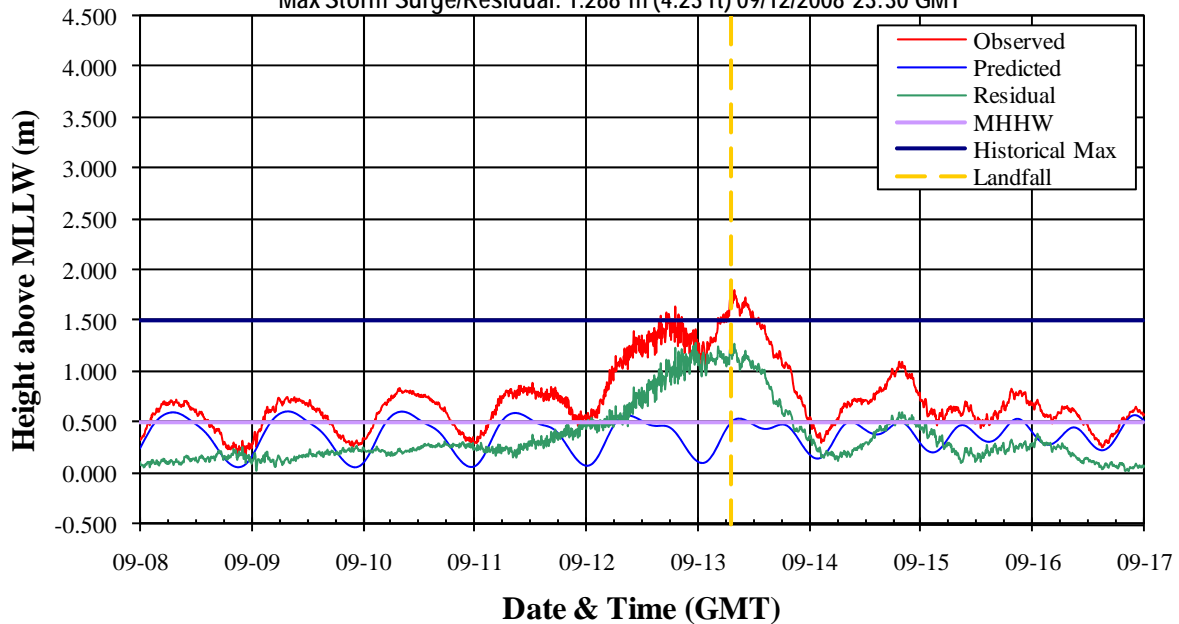


Figure 46: Water levels above Mean Lower Low Water (MLLW) at Corpus Christi, TX. Maximum recorded water level value exceeded historical recorded maximum tide level. Maximum recorded water level coincided within an hour of a high tide, resulting in higher storm tides. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services

8779770 Port Isabel, TX Water Levels - Hurricane IKE

Max Storm Tide: 1.263 m (4.14 ft) 09/13/2008 16:12 GMT

Max Storm Surge/Residual: 0.865 m (2.84 ft) 09/13/2008 15:30 GMT

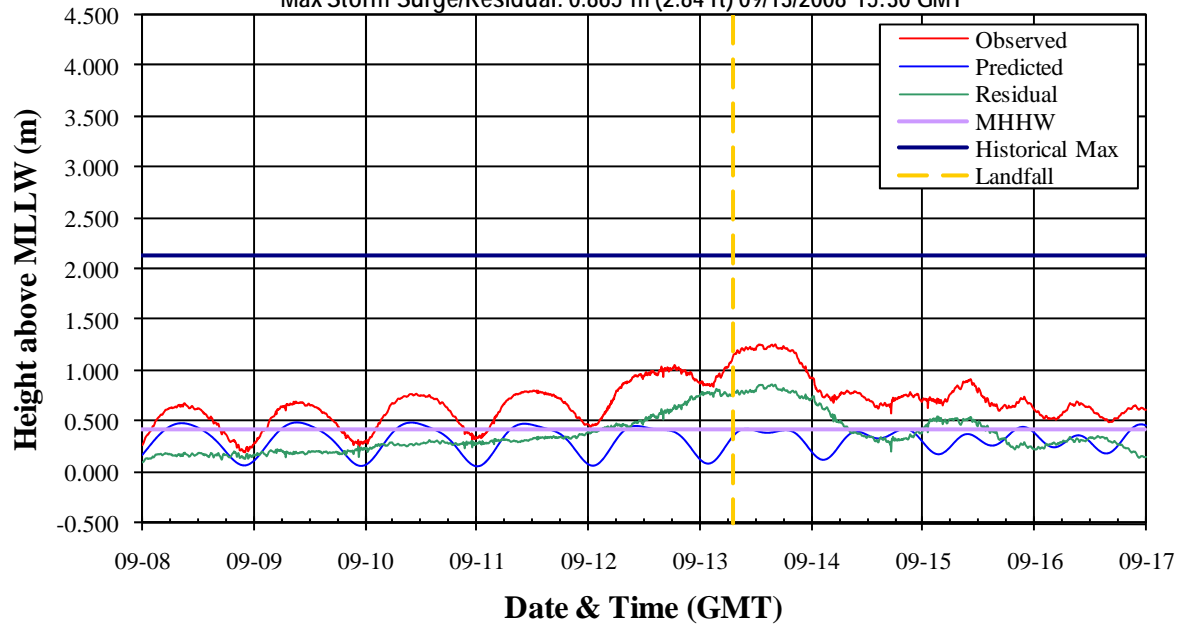


Figure 47: Water levels above Mean Lower Low Water (MLLW) at Port Isabel, TX. Lines denoting Mean Higher High Water (MHHW) and historical recorded maximum tide level are displayed.



NOAA NOS Center for Operational Oceanographic Products & Services  
 Select Maximum Residual/Storm Surge Levels Recorded During Hurricane Ike September 2008

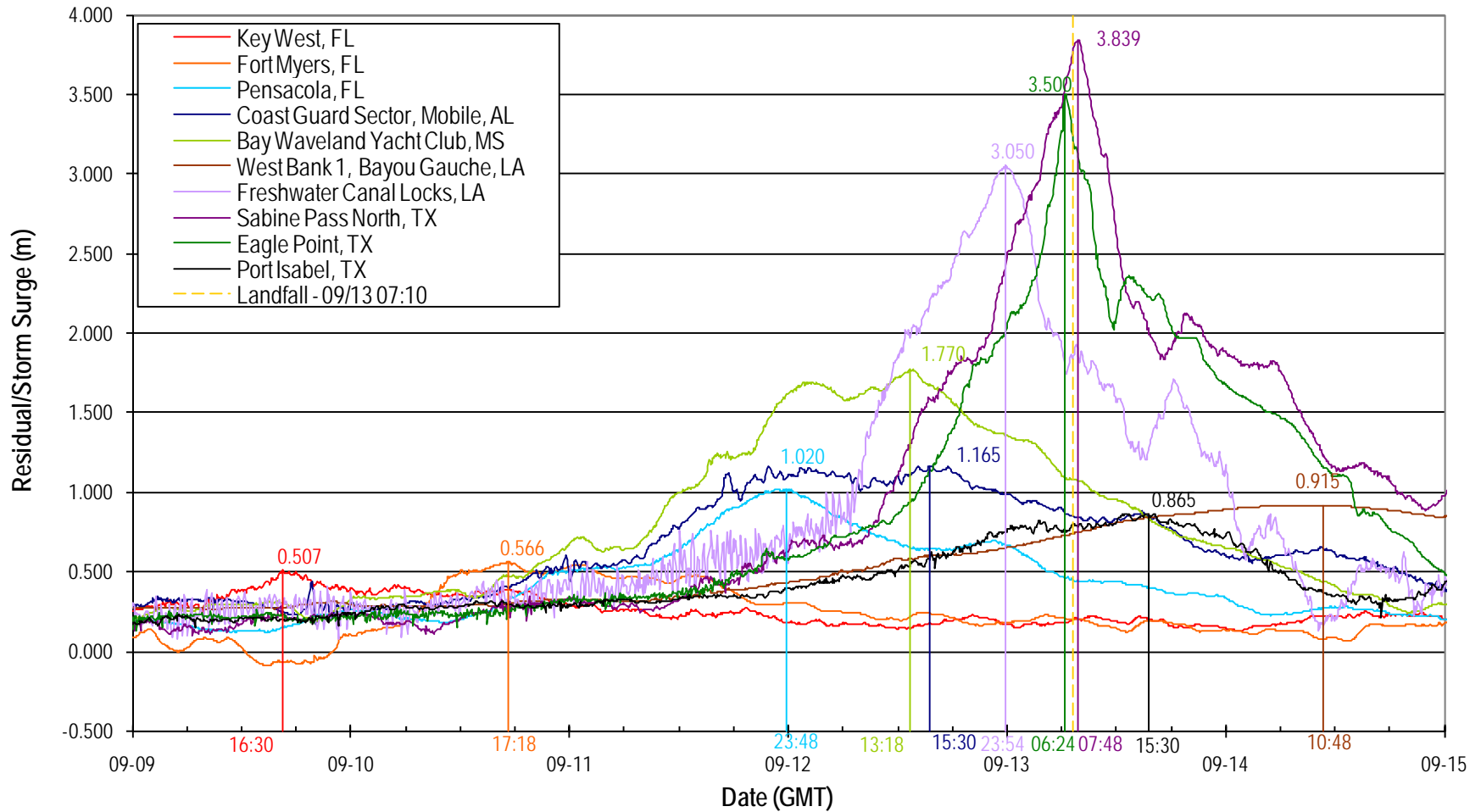


Figure 48: A synopsis of the progression of storm surge/residuals associated with Hurricane Ike across the Gulf of Mexico using geographically representative stations. Time and magnitude of the maximum storm surge/residuals are denoted on the graph.

## **Acknowledgments**

This report represents the cumulative efforts of personnel of the Center for Operational Oceanographic Products and Services. We would like to thank the Oceanographic Division personnel who are responsible for the processing, analysis and verification of the data incorporated into this report. We would like to thank the Continuous Operational Real-Time Monitoring System (CORMS) personnel who perform 24 hour, 7 days/week thorough QA/QC on all real-time data and the Field Operations Division personnel who operated and maintain all stations, both ensuring that a reliable and robust source of real-time data is readily available. We would also like to thank Peter Stone, Diana Perfect and Chris Zervas for their reviews which helped to improve this report. Special thanks is given to Stephen Gill for his numerous technical suggestions.



## **Appendix 1:**

NOAA, 2008. Center For Operational Oceanographic Products & Services Specifications and Deliverables for Installation, Operation, and Removal of Water Level Stations, NOAA/NOS, March 2008.

NOAA, 1991. Next Generation Water Level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual, NOAA/NOS, January 1991.

Center for Operational Oceanographic Products & Services Environmental Measurement Systems Sensor Specifications and Measurement Algorithm, NOAA/NOS.

For further information or updates on the Storm Technical Reports and Storm QuickLook product, contact:

Storm QuickLook  
Center for Operational Oceanographic Products and Services (CO-OPS)  
1305 East-West Highway  
Silver Spring, MD 20910-3281  
Phone: (301) 713-2890 ext. 110  
Fax: (301) 713-4437  
E-mail: Storm QuickLook ([tide.predictions@noaa.gov](mailto:tide.predictions@noaa.gov))

The Texas Coastal Ocean Observing System (TCOON) station installations meet National Ocean Service (NOS) standards (NOAA, 2008). However, the TCOON data does not undergo post-processing by CO-OPS and for the purpose of this report, questionable data have been removed. For further information on TCOON, see:

<http://lighthouse.tamucc.edu/TCOON/HomePage>

## Appendix 2: Station Locations

Station Name	Station ID	Latitude °N	Longitude °W
Key West, FL	8724580	24.55333	81.80833
Fort Myers, FL	8725520	26.64667	81.87167
St. Petersburg, FL	8726520	27.76000	82.62667
Cedar Key, FL	8727520	29.13500	83.03167
Panama City, FL	8729108	30.15167	85.66667
Pensacola, FL	8729840	30.40333	87.21167
Dauphin Island, AL	8735180	30.25000	88.07500
Coast Guard Sector Mobile, AL	8736897	30.64833	88.05833
Mobile State Docks, AL	8737048	30.70833	88.04333
Pascagoula NOAA Lab, MS	8741533	30.35833	88.56667
Gulfport Harbor, MS	8745557	30.36000	89.08167
Bay Waveland Yacht Club, MS	8747437	30.32500	89.32500
Pilots Station East, SW Pass, LA	8760922	28.93167	89.40667
Shell Beach, LA	8761305	29.86833	89.67333
Grand Isle, LA	8761724	29.26333	89.95667
New Canal Station, LA	8761927	30.02667	90.11333
Port Fourchon, LA	8762075	29.11500	90.20000
West Bank 1, Bayou Gauche, LA	8762482	29.77667	90.41833
Tesoro Marine Terminal, LA	8764044	29.66667	91.23667
LAWMA, Amerada Pass, LA	8764227	29.45000	91.34000
Cypremort Point, LA	8765251	29.71333	91.88000
Freshwater Canal Locks, LA	8766072	29.55500	92.30500
Lake Charles, LA	8767816	30.22500	93.22167
Calcasieu Pass, LA	8768094	29.76500	93.34333
*Port Arthur, TX	8770475	29.86667	93.93000
*Rainbow Bridge, Neches River, TX	8770520	29.98000	93.88167
Sabine Pass North, TX	8770570	29.73000	93.87000
Morgans Point, TX	8770613	29.68167	94.98500
*Battleship Texas State Park, TX	8770743	29.75667	95.09000
*Manchester, TX	8770777	29.71833	95.25167
*Clear Lake, TX	8770933	29.56333	95.06667
*Rollover Pass, TX	8770971	29.51500	94.51333
Eagle Point, TX	8771013	29.48000	94.91833
Galveston Bay Entrance, North Jetty, TX	8771341	29.35833	94.72500
Galveston Pier 21, TX	8771450	29.31000	94.79333
Galveston Pleasure Pier, TX	8771510	29.28500	94.78833
USCG Freeport, TX	8772447	28.93333	95.30000
*Seadrift, TX	8773037	28.40833	96.71167
*Port Lavaca, TX	8773259	28.64000	96.59500
*Port O'Connor, TX	8773701	28.45167	96.38833
Rockport, TX	8774770	28.02167	97.04667
*Port Aransas, TX	8775237	27.83833	97.07333
*Texas State Aquarium, TX	8775296	27.81167	97.39000
Corpus Christi, TX	8775870	27.58000	97.21667
Port Isabel, TX	8779770	26.06000	97.21500

\*This partnership station is operated by the Texas Coastal Ocean Observing System.

### Appendix 3: Definitions

**EXCERPTS FROM:** *Tide and Current Glossary*, NOAA National Ocean Service, Silver Spring, MD, 2000 (<http://www.tidesandcurrents.noaa.gov/publications/glossary2.pdf>), *Tidal Datums homepage* ([http://www.tidesandcurrents.noaa.gov/datum\\_options.html](http://www.tidesandcurrents.noaa.gov/datum_options.html)) and the *Storm QuickLook Frequently Asked Questions homepage* ([http://www.tidesandcurrents.noaa.gov/quicklook\\_faqs.shtml](http://www.tidesandcurrents.noaa.gov/quicklook_faqs.shtml))

**Bench mark (BM):** A fixed physical object or mark used as reference for a horizontal or vertical datum. A tidal bench mark is one near a tide station to which the tide staff and tidal datums are referred. A primary bench mark is the principal mark of a group of tidal bench marks to which the tide staff and tidal datums are referred.

**Chart datum:** The datum to which soundings on a chart are referred. It is usually taken to correspond to a low-water elevation, and its depression below mean sea level is represented by the symbol Z. Since 1980, chart datum has been implemented to mean lower low water for all marine waters of the United States, its territories, Commonwealth of Puerto Rico, and Trust Territory of the Pacific Islands.

**Datum (vertical):** For marine applications, a base elevation used as a reference from which to reckon heights or depths. It is called a tidal datum when defined in terms of a certain phase of the tide. Tidal datums are local datums and should not be extended into areas which have differing hydrographic characteristics without substantiating measurements. In order that they may be recovered when needed, such datums are referenced to fixed points known as bench marks. See chart datum and bench marks.

**Geodetic datum:** The NOAA National Geodetic Survey defines a geodetic datum as: "A set of constants used for calculating the coordinates of points on the Earth." In surveying and geodesy, a datum is a reference point on the earth's surface against which position measurements are made, and an associated model of the shape of the earth for computing positions. Horizontal datums are used for describing a point on the earth's surface, in latitude and longitude. Vertical datums are used to measure elevations or underwater depths.

**Historical Recorded Maximum Tide Level:** The maximum tide elevation measured by a water level station with a continuous time series throughout a high tide cycle. A complete cycle is required to calculate the maximum tide elevation, using a best fit curve of the observations. These historical records may not have included the highest water levels measured at a station during an event if a complete high tide cycle was not measured due to station/sensor damage. See storm tides.

**Mean Lower Low Water (MLLW):** A tidal datum. The average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch. See National Tidal Datum Epoch. For stations with shorter series, comparison of simultaneous observations with a control tide station is made in order to derive the equivalent datum of the National Tidal Datum Epoch.

**Mean Higher High Water (MHHW):** A tidal datum. The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch. For stations with shorter series, comparison of simultaneous observations with a control tide station is made in order to derive the equivalent datum of the National Tidal Datum Epoch.

**Mean Sea Level (MSL):** A tidal datum. The arithmetic mean of hourly heights observed over the National Tidal Datum Epoch. Shorter series are specified in the name; e.g. monthly mean sea level and yearly mean sea level.

**North American Vertical Datum of 1988 (NAVD 1988):** A fixed reference for elevations determined by geodetic leveling. The datum was derived from a general adjustment of the first-order terrestrial leveling nets of the United States, Canada, and Mexico. In the adjustment, only the height of the primary tidal bench mark, referenced to the International Great Lakes Datum of 1985 (IGLD 1985) local mean sea level height value, at Father Point, Rimouski, Quebec, Canada was held fixed, thus providing minimum constraint. NAVD 1988 and IGLD 1985 are identical. However, NAVD 1988 bench mark values are given in Helmert orthometric height units while IGLD 1985 values are in dynamic heights.

**National Tidal Datum Epoch:** The specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values (e.g., mean lower low water, etc.) for tidal datums. It is necessary for standardization because of periodic and apparent secular trends in sea level. The present NTDE is 1983 through 2001 and is actively considered for revision every 20-25 years. Tidal datums in certain regions with anomalous sea level changes (Alaska, Gulf of Mexico) are calculated on a Modified 5-Year Epoch.

**National Water Level Observation Network (NWLON):** The network of tide and water level stations operated by the National Ocean Service along the marine and Great Lakes coasts and islands of the United States.

**Neap tides:** Tides of decreased range occurring semimonthly as the result of the Moon being in quadrature (first or last quarters).

**Non-tidal:** Water levels may be classified as tidal or non-tidal. Water bodies with little or no range in tide and where the rise and fall of the water surface can no longer be practically measured in a predictable rhythm due to masking of the tide by hydrologic, wind, or other effects are non-tidal.

**Range of tide:** The difference in height between consecutive high and low waters. The mean range is the difference in height between mean high water and mean low water. The great diurnal range or diurnal range is the difference in height between mean higher high water and mean lower low water. For other ranges see spring, neap, perigean, apogean, and tropic tides; and tropic ranges.

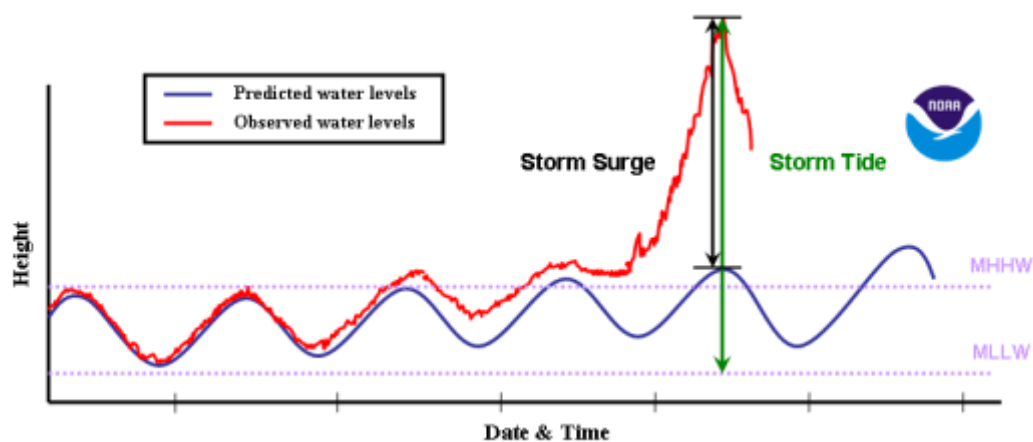
**Tide:** The periodic rise and fall of a body of water resulting from gravitational interactions between Sun, Moon, and Earth. The vertical component of the particulate motion of a tidal wave. Same as astronomic tide.

**Tide (water level) gauge:** An instrument for measuring the rise and fall of the tide (water level). Water levels may be classified as tidal and non-tidal.

**Spring tides:** Tides of increased range occurring semimonthly as the result of the Moon being new or full.

**Storm Surge/Residual:** The onshore rush of sea or lake water caused by the high wind and the low pressure centers associated with a landfalling hurricane or other intense storm. The amplitude of the storm surge at any given location is dependent upon the orientation of the coast line with the storm track, the intensity, size and speed of the storm, and the local bathymetry. In practice, storm surge is usually estimated by subtracting the normal or astronomical tide from the observed storm tide at tide stations. This difference between observed storm tides and astronomical tide can have other components such as regional elevated mean sea levels in the Gulf of Mexico due to the Loop Current, elevated sea levels on the West Coast due to El Niño Southern Oscillation (ENSO), or local elevated sea levels due to river runoff in tidal rivers.

**Storm Tide:** The maximum water level elevation measured by a water level station during storm events. Depending on location, the storm tide is the potential combination of storm surge, local astronomical tide, regional sea level variations and river runoff during storm events. Since wind generated waves ride on top of the storm surge (and are not included in the definition), the total instantaneous elevation may greatly exceed the predicted storm surge plus astronomical tide. It is potentially catastrophic, especially on low lying coasts with gently sloping offshore topography.



#### Appendix 4: Saffir-Simpson Scale Hurricane Classification

Category	Wind speed (kn)	Wind speed (mph)	Pressure (mb)
Tropical Depression	20-34	23-38	n/a
Tropical Storm	35-63	39-73	n/a
Category 1	64-82	74-95	> 980
Category 2	83-95	96-110	965-979
Category 3	96-113	111-130	945-964
Category 4	114-135	131-155	920-944
Category 5	> 135	> 155	< 920

National Hurricane Center: The Saffir-Simpson Hurricane Scale is a 1-5 rating based on the hurricane's present intensity (<http://www.nhc.noaa.gov/aboutsshs.shtml>). This is used to give an estimate of the potential property damage and flooding expected along the coast from a hurricane landfall. Wind speed is the determining factor in the scale, as storm surge values are highly dependent on the slope of the continental shelf and the shape of the coastline, in the landfall region. Note that all winds are using the U.S. the 1-minute averaged wind at the 10-meter elevation with an unobstructed exposure.