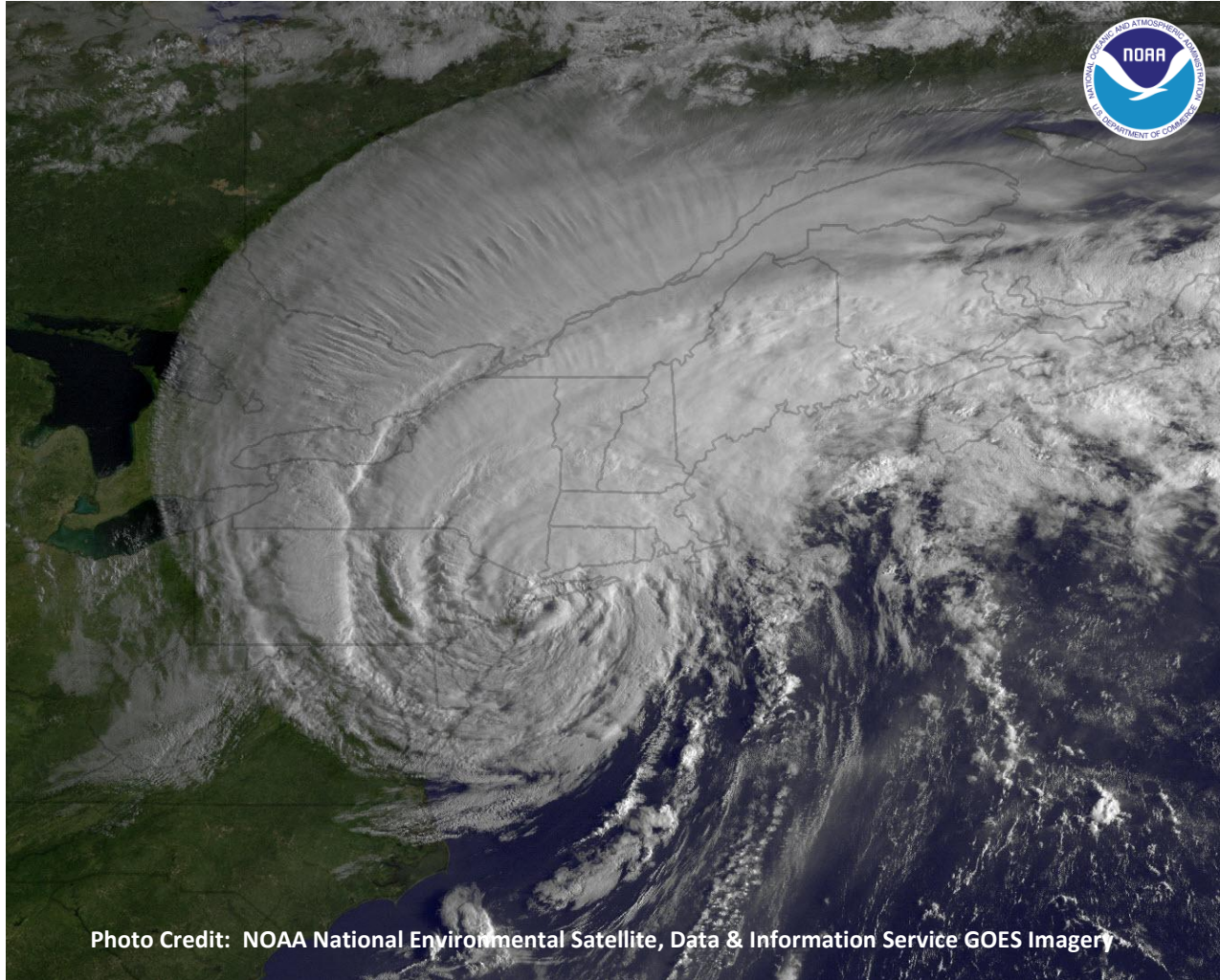


## HURRICANE IRENE



Silver Spring, Maryland  
October 14, 2011

**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

## HURRICANE IRENE

Colleen Fanelli, Paul Fanelli  
October 14, 2011

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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 operates stations in partnership with the National Estuarine Research Reserve (NERR) and the Puerto Rico Seismic Network (PRSN). This report documents the elevated water levels, high winds and reduced barometric pressures recorded at stations along the coast of Puerto Rico and the U.S. Virgin Islands as well as the east coast of the U.S. from Florida to Maine during Hurricane Irene.

Station information and locations are contained in Figures 1 & 2a-2d and Appendices 1 & 2. Tidal stations are referenced to the standard chart datum of Mean Lower Low Water (MLLW), based on the National Tidal Datum Epoch 1983-2001 (Appendix 3). In addition, at many locations along the East Coast of the U.S., water levels are provided relative to 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 for stations affected by Hurricane Irene by geographic region. Where available, water level elevations relative to NAVD88 are also presented, along with the residuals at the time of the maximum storm tides. Maximum storm surge levels are summarized in Table 3, ranked by amplitude. Storm tides are the maximum water level elevations during a storm passage. Residuals are the elevation differences between observed and predicted tides. Storm surge is the residual caused directly by the storm during its passage. Table 2 provides maximum wind speeds, wind gusts, and minimum barometric pressures observed at the stations during Hurricane Irene.

In addition, the report highlights stations which have exceeded historical recorded maximum water levels as a result of Irene (Figure 3). The historical recorded maximum water levels are the maximum water elevation measured by a water level station with a continuous time series throughout a high tide cycle for the entire historical period. 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 4 – 88). For comparison and context, the historical recorded maximum water levels are displayed on the graphs, where available. The Highest Astronomical Tide (HAT) datum is also displayed to illustrate the elevation of the highest predicted astronomical tide expected to occur at a specific tide station over the 1983-2001 National Tidal Datum Epoch.

## Summary

Irene initially struck eastern Puerto Rico as a strong Tropical Storm on August 22, 2011. A few hours following this landfall, Irene strengthened into the first hurricane of the 2011 Atlantic season. While passing to the north of Hispanola and over the Bahamas, Irene slowly strengthened, reaching Category 3 strength with winds of 104 knots (120 mph) on August 24, 2011. After this, Irene began to slowly weaken as it passed off the southeastern U.S. coast. The initial east coast landfall of Irene was near Cape Lookout, NC on August 27 at 1130 GMT as a category 1 hurricane with winds of 74 knots (85 mph). Irene re-emerged over the Atlantic Ocean on August 27 2300 GMT just to the southeast of Norfolk, VA and moved parallel to the mid-Atlantic coast before making a secondary landfall along the coast of New Jersey near Little Egg Inlet on August 28 0935 GMT as a weak Category 1 hurricane with winds of 65 knots (75 mph). After the second landfall, Irene continued on a rapid northeasterly track through New England, weakening to a tropical storm before moving into Canada near the intersection of New Hampshire and Maine.

As Irene passed over Puerto Rico, the maximum storm tide measured was 0.787 m (2.58 ft) at Fajardo, PR on August 22 0530 GMT. The maximum storm surge recorded was 0.495 m (1.62 ft) at Esperanza, Vieques Island, PR on August 22, 0506 GMT. Maximum storm surge/residuals along the coast of Puerto Rico and the U.S. Virgin Islands ranged from 0.12 to 0.50 m (0.4 to 1.6 ft).

Along the east coast of the U.S., a noticeable storm surge was observed from northern Florida to Maine. Storm surge residuals from Florida to South Carolina generally ranged from 0.30 to 1.02 m (1.0 to 3.3 ft). Along the North Carolina coast, storm surge/residuals ranged between 0.76 and 2.16 m (2.5 and 7.1 ft). The highest storm surge/residual measured along the Atlantic coast of the U.S. was 2.161 m (7.09 ft) at Oregon Inlet Marina, NC on August 28, 0354 GMT, several hours after Irene re-emerged over the Atlantic Ocean after traversing the Outer Banks of North Carolina. Along the southern Chesapeake Bay, storm surge residuals ranged between 0.75 and 1.48 m (2.5 and 4.9 ft) with higher values near the mouth of the bay. The northern half of Chesapeake Bay did not exhibit a significant storm surge from Hurricane Irene. Within the Delaware River and Bay, water level residuals included both storm surge and abnormally high river flow due to storm-induced runoff in the Delaware River Basin and ranged from 0.89 and 2.69 m (2.9 and 8.8 ft), with the highest residual of 2.694 m (8.84 ft) recorded at Newbold, PA on August 28, 1324 GMT. Along the mid-Atlantic coast from Virginia to New York City, storm surge residuals ranged between 1.00 and 1.44 m (3.2 and 4.7 ft). Along the coast of New England, storm surge residuals ranged between 0.42 and 1.45 m (1.4 and 4.8 ft) with the highest storm surge values along the southern New England coast bordering Long Island Sound.

The highest wind speed recorded at CO-OPS and partnership stations, corresponding to the initial landfall of Irene along the east coast of Puerto Rico was 50.5 knots (mph) at Esperanza, Vieques Island, PR on August 22, 0536 GMT. The highest wind gust of 65.9 kts (mph) occurred at the same location on August 22, 0506 GMT. The minimum barometric pressure corresponding to Puerto Rico landfall was 992.7 mb at San Juan, PR on August 22, 0742 GMT. At CO-OPS and partnership stations along the east coast of the U.S., the highest wind speed recorded as Irene moved up the coast was 60.8 knots (mph) at Duck, NC on August 27, 2106 GMT. The highest wind gust of 72.7 kts (mph) occurred at the same location on August 27, 2112 GMT. The minimum barometric pressure recorded along the east coast of the U.S. was 950.6 mb, also at Duck, NC on August 27, 2112 GMT.

More information, data and storm reports can be found at the CO-OPS website, <http://tidesandcurrents.noaa.gov>. Storm reports are located under the Publications section of the webpage.

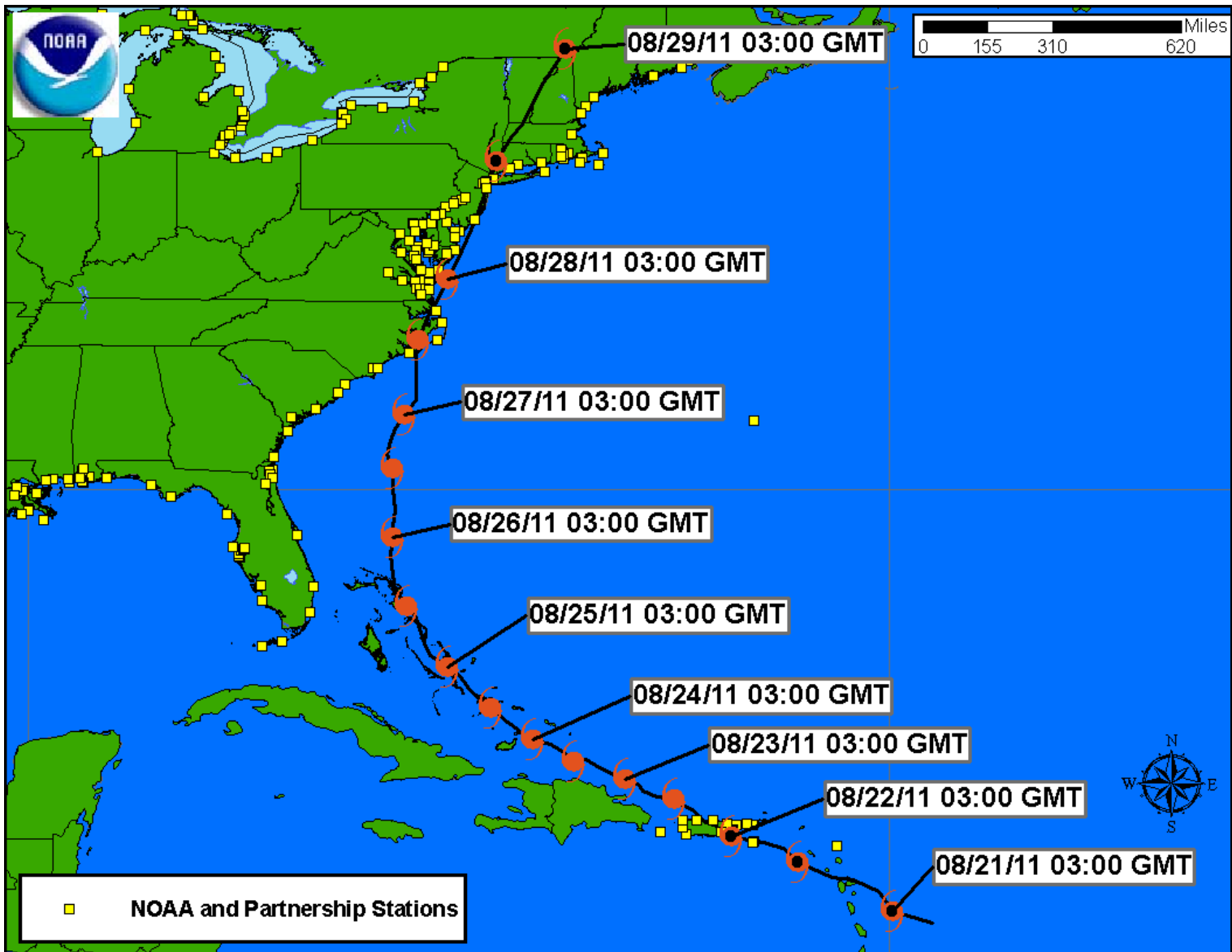
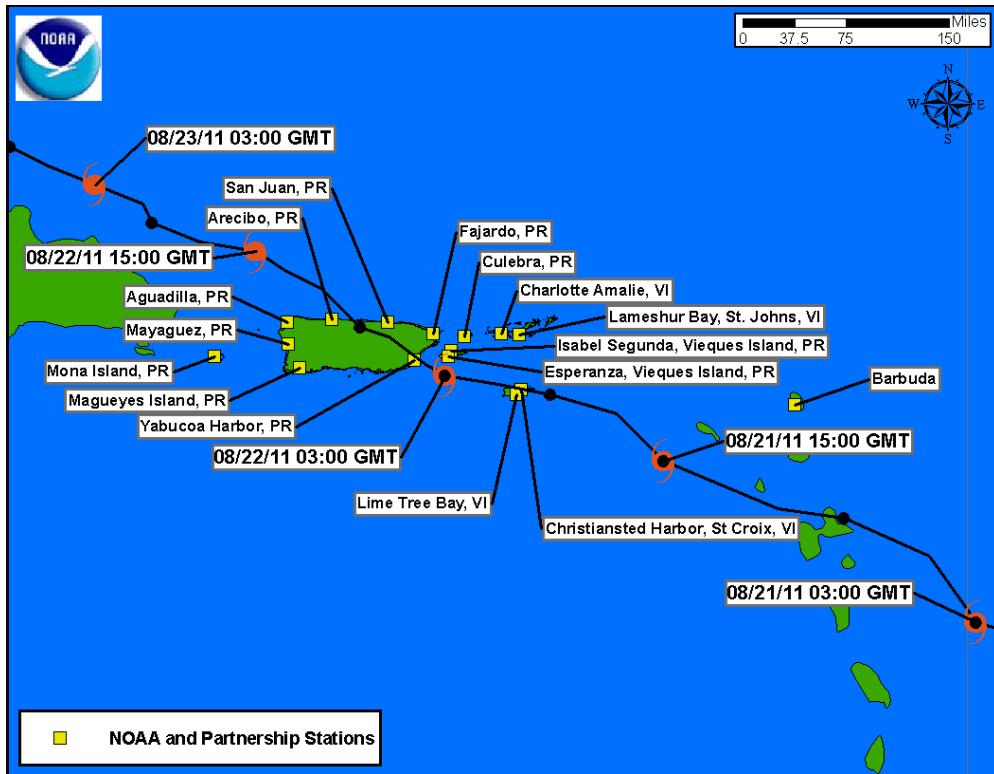
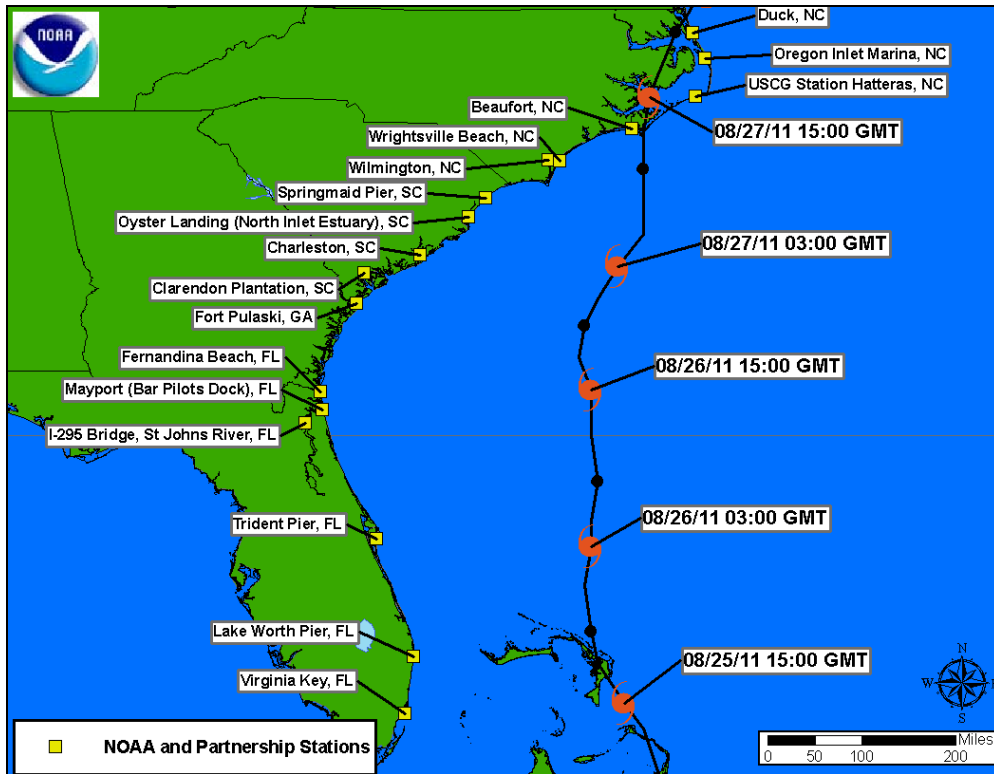
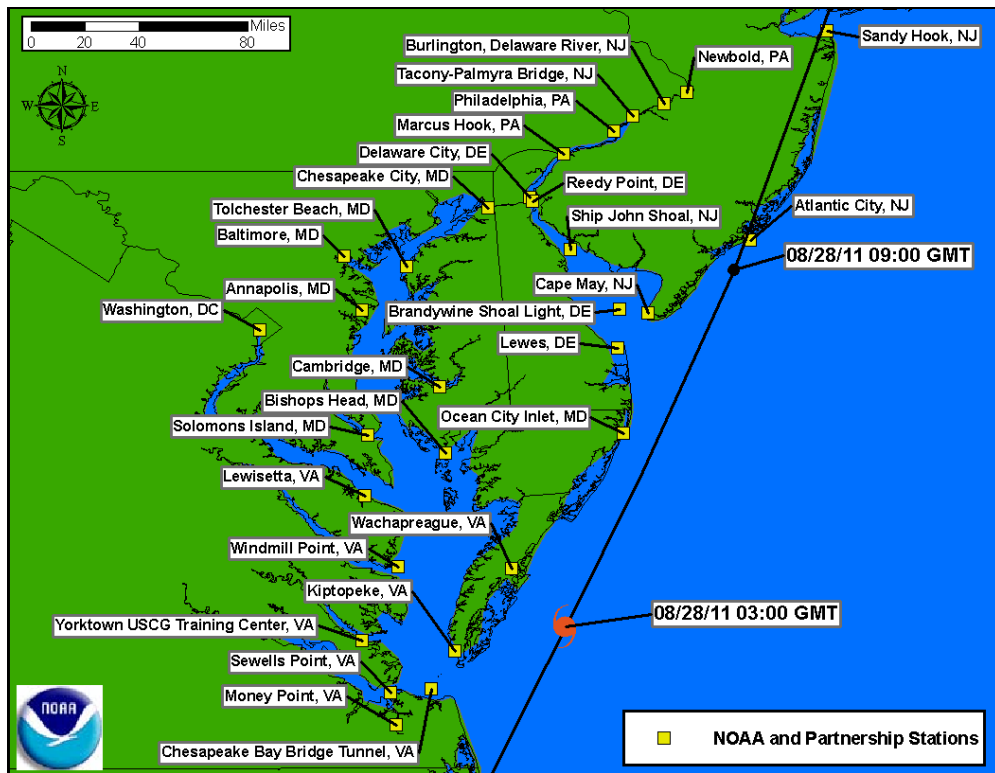
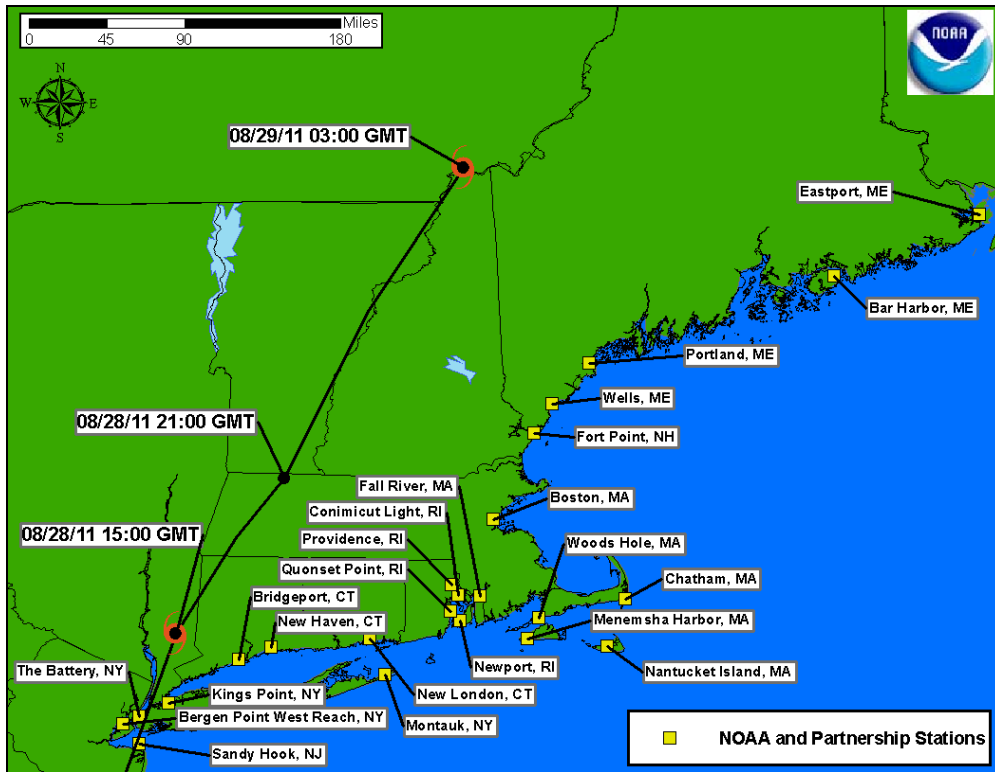


Figure 1: NOAA and Partnership stations relative to the Hurricane Irene storm track (track information courtesy of the NOAA National Hurricane Center).



Figures 2a and 2b: NOAA and Partnership stations located along the coast of a) Florida to North Carolina and (b) Puerto Rico, the U.S. Virgin Islands and Barbuda, relative to the Hurricane Irene storm track (track information courtesy of the NOAA National Hurricane Center).



Figures 2c and 2d: NOAA and Partnership stations located along the coast of c) northern New Jersey to Maine and d) Virginia to southern New Jersey, relative to the Hurricane Irene storm track (track information courtesy of the NOAA National Hurricane Center).

Table 1a: Maximum recorded water levels in geographic order for Hurricane Irene, August 2011. Referenced to Mean Lower Low Water (MLLW) and North American Vertical Datum of 1988 (NAVD88). Storm Tide includes both tidal and meteorological forces and storm surge represents the observed water level (storm tide) minus predicted astronomical tide levels.

Station Name	Station ID	Date & Time GMT	Storm Tide	Predicted	Storm Surge/ Residual (m)	Storm Tide	Storm Tide	Predicted	Storm Surge/ Residual (ft)	Storm Tide
			(m, MLLW)	(m, NAVD88)		(ft, MLLW)	(ft, NAVD88)			
Barbuda	9761115	08/21/2011 18:00	0.365	0.179	0.186	n/a	1.20	0.59	0.61	n/a
Christiansted Harbor, St Croix, VI	9751364	08/21/2011 21:48	0.496	0.181	0.315	n/a	1.63	0.59	1.03	n/a
Lameshur Bay, St. John, VI	9751381	08/21/2011 19:24	0.401	0.222	0.179	n/a	1.32	0.73	0.59	n/a
Lime Tree Bay, VI	9751401	08/22/2011 00:12	0.471	0.226	0.245	n/a	1.55	0.74	0.80	n/a
Charlotte Amalie, VI	9751639	08/22/2011 04:36	0.432	0.142	0.290	n/a	1.42	0.47	0.95	n/a
Culebra, PR	9752235	08/21/2011 19:18	0.488	0.294	0.194	n/a	1.60	0.96	0.64	n/a
Isabel Segunda, Vieques Island, PR	9752619	08/21/2011 19:42	0.511	0.331	0.180	n/a	1.68	1.09	0.59	n/a
<sup>3</sup> Esperanza, Vieques Island, PR	9752695	08/22/2011 05:06	0.596	0.101	0.495	n/a	1.96	0.33	1.62	n/a
Fajardo, PR	9753216	08/22/2011 05:30	0.787	0.299	0.488	n/a	2.58	0.98	1.60	n/a
Yabucoa Harbor, PR	9754228	08/22/2011 04:18	0.399	0.109	0.290	n/a	1.31	0.36	0.95	n/a
San Juan, PR	9755371	08/22/2011 06:48	0.550	0.289	0.261	n/a	1.80	0.95	0.86	n/a
Arecibo, PR	9757809	08/23/2011 20:48	0.658	0.488	0.170	n/a	2.16	1.60	0.56	n/a
Magueyes Island, PR	9759110	08/22/2011 23:06	0.323	0.250	0.073	n/a	1.06	0.82	0.24	n/a
Mayaguez, PR	9759394	08/23/2011 21:06	0.482	0.259	0.223	n/a	1.58	0.85	0.73	n/a
Aguadilla, PR	9759412	08/23/2011 20:30	0.501	0.380	0.121	n/a	1.64	1.25	0.40	n/a
Mona Island, PR	9759938	08/23/2011 00:18	0.391	0.257	0.134	n/a	1.28	0.84	0.44	n/a
<sup>2</sup> Virginia Key, FL	8723214	08/29/2011 13:54	1.043	0.812	0.231	0.441	3.42	2.66	0.76	1.45
<sup>2</sup> Lake Worth Pier, FL	8722670	08/28/2011 00:00	1.343	1.023	0.320	0.595	4.41	3.36	1.05	1.95
Trident Pier, FL	8721604	08/26/2011 22:42	1.803	1.296	0.507	0.930	5.92	4.25	1.66	3.05
I-295 Bridge, St Johns River, FL	8720357	08/27/2011 13:54	0.702	0.286	0.416	0.556	2.30	0.94	1.36	1.82
Mayport (Bar Pilots Dock), FL	8720218	08/26/2011 23:30	2.059	1.638	0.421	1.143	6.76	5.37	1.38	3.75
Fernandina Beach, FL	8720030	08/27/2011 00:00	2.651	2.088	0.563	1.486	8.70	6.85	1.85	4.88
Fort Pulaski, GA	8670870	08/26/2011 23:00	2.778	2.427	0.351	1.543	9.11	7.96	1.15	5.06
Clarendon Plantation, SC	8667633	08/27/2011 00:48	3.030	2.536	0.494	n/a	9.94	8.32	1.62	n/a
Charleston, SC	8665530	08/26/2011 22:54	2.329	1.890	0.439	1.372	7.64	6.20	1.44	4.50
Oyster Landing (N. Inlet Estuary), SC	8662245	08/26/2011 23:06	2.296	1.640	0.656	1.471	7.53	5.38	2.15	4.83
Springmaid Pier, SC	8661070	08/26/2011 22:00	2.334	1.831	0.503	1.372	7.66	6.01	1.65	4.50
Wrightsville Beach, NC	8658163	08/26/2011 21:48	2.088	1.444	0.644	1.316	6.85	4.74	2.11	4.32

<sup>1</sup> Sensor reached physical limit on measurements and did not record a maximum/minimum value.

<sup>2</sup> Station did not record a maximum storm tide and/or storm surge coinciding with the timing of Irene.

<sup>3</sup> Maximum recorded water level value exceeded historical maximum value.

<sup>4</sup> Maximum storm tide/storm surge includes likely effects from runoff.



Table 1b: Maximum recorded water levels in geographic order for Hurricane Irene, August 2011. Referenced to Mean Lower Low Water (MLLW) and North American Vertical Datum of 1988 (NAVD88). Storm Tide includes both tidal and meteorological forces and storm surge represents the observed water level (storm tide) minus predicted astronomical tide levels.

Station Name	Station ID	Date & Time GMT	Storm Tide	Predicted	Storm Surge/ Residual (m)	Storm Tide	Storm Tide	Predicted	Storm Surge/ Residual (ft)	Storm Tide
			(m, MLLW)			(m, NAVD88)	(ft, MLLW)	(ft, NAVD88)		
Wilmington, NC	8658120	08/30/2011 02:48	1.598	1.555	0.043	0.865	5.24	5.10	0.14	2.84
Beaufort, NC	8656483	08/27/2011 10:24	1.913	0.989	0.924	n/a	6.28	3.24	3.03	n/a
USCG Station Hatteras, NC	8654467	08/28/2011 02:54	1.250	0.134	1.116	n/a	4.10	0.44	3.66	n/a
<sup>3</sup> Oregon Inlet Marina, NC	8652587	08/28/2011 03:54	2.322	0.161	2.161	2.132	7.62	0.53	7.09	6.99
Duck, NC	8651370	08/27/2011 21:00	1.592	1.037	0.555	0.925	5.22	3.40	1.82	3.03
Money Point, VA	8639348	08/28/2011 00:48	2.585	1.117	1.468	2.024	8.48	3.66	4.82	6.64
Chesapeake Bay Bridge Tunnel, VA	8638863	08/27/2011 23:24	2.250	0.987	1.263	n/a	7.38	3.24	4.14	n/a
Sewells Point, VA	8638610	08/27/2011 23:54	2.302	0.917	1.385	1.801	7.55	3.01	4.54	5.91
Yorktown USCG Training Center, VA	8637689	08/28/2011 00:12	2.011	0.887	1.124	n/a	6.60	2.91	3.69	n/a
Windmill Point, VA	8636580	08/28/2011 01:42	1.441	0.520	0.921	1.152	4.73	1.71	3.02	3.78
Lewisetta, VA	8635750	08/28/2011 03:30	1.384	0.482	0.902	1.131	4.54	1.58	2.96	3.71
Kiptopeke, VA	8632200	08/27/2011 23:36	1.977	0.993	0.984	1.397	6.49	3.26	3.23	4.58
<sup>1</sup> Wachapreague, VA	8631044	08/27/2011 21:48	2.053	1.131	0.922	n/a	6.74	3.71	3.02	n/a
<sup>2</sup> Washington, DC	8594900	08/25/2011 09:06	1.181	0.936	0.245	0.756	3.87	3.07	0.80	2.48
Solomons Island, MD	8577330	08/28/2011 03:48	1.124	0.440	0.684	0.865	3.69	1.44	2.24	2.84
<sup>2</sup> Annapolis, MD	8575512	08/25/2011 07:24	0.778	0.506	0.272	0.543	2.55	1.66	0.89	1.78
<sup>2</sup> Baltimore, MD	8574680	08/25/2011 09:06	0.908	0.543	0.365	0.654	2.98	1.78	1.20	2.15
<sup>2</sup> Chesapeake City, MD	8573927	08/25/2011 11:54	1.315	0.986	0.329	n/a	4.31	3.23	1.08	n/a
<sup>2</sup> Tolchester Beach, MD	8573364	08/25/2011 08:24	0.945	0.627	0.318	n/a	3.10	2.06	1.04	n/a
Cambridge, MD	8571892	08/28/2011 07:06	0.945	0.700	0.245	0.608	3.10	2.30	0.80	1.99
Bishops Head, MD	8571421	08/28/2011 04:24	1.262	0.645	0.617	n/a	4.14	2.12	2.02	n/a
Ocean City Inlet, MD	8570283	08/27/2011 23:48	1.430	0.818	0.612	0.929	4.69	2.68	2.01	3.05
Lewes, DE	8557380	08/28/2011 00:06	2.499	1.592	0.907	1.698	8.20	5.22	2.98	5.57
<sup>3</sup> Brandywine Shoal Light, DE	8555889	08/28/2011 00:06	2.693	1.869	0.824	n/a	8.84	6.13	2.70	n/a
<sup>4</sup> Reedy Point, DE	8551910	08/28/2011 03:30	2.448	1.875	0.573	1.543	8.03	6.15	1.88	5.06
<sup>4</sup> Delaware City, DE	8551762	08/28/2011 03:48	2.689	1.746	0.943	n/a	8.82	5.73	3.09	n/a
<sup>4</sup> Newbold, PA	8548989	08/28/2011 06:54	3.651	2.625	1.026	n/a	11.98	8.61	3.37	n/a
<sup>4</sup> Philadelphia, PA	8545240	08/28/2011 05:48	3.026	2.182	0.844	2.074	9.93	7.16	2.77	6.80

<sup>1</sup> Sensor reached physical limit on measurements and did not record a maximum/minimum value.

<sup>2</sup> Station did not record a maximum storm tide and/or storm surge coinciding with the timing of Irene.

<sup>3</sup> Maximum recorded water level value exceeded historical maximum value.

<sup>4</sup> Maximum storm tide/storm surge includes likely effects from runoff.

Table 1c: Maximum recorded water levels in geographic order for Hurricane Irene, August 2011. Referenced to Mean Lower Low Water (MLLW) and North American Vertical Datum of 1988 (NAVD88). Storm Tide includes both tidal and meteorological forces and storm surge represents the observed water level (storm tide) minus predicted astronomical tide levels.

Station Name	Station ID	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)				(ft, MLLW)			
<sup>4</sup> Marcus Hook, PA	8540433	08/28/2011 04:36	2.755	1.963	0.792	n/a	9.04	6.44	2.60	n/a
<sup>4</sup> Burlington, Delaware River, NJ	8539094	08/28/2011 06:36	3.456	2.415	1.041	n/a	11.34	7.92	3.42	n/a
<sup>1,4</sup> Tacony-Palmyra Bridge, NJ	8538886	08/28/2011 07:06	3.030	1.983	1.047	n/a	9.94	6.51	3.44	n/a
<sup>3</sup> Ship John Shoal, NJ	8537121	08/28/2011 00:48	2.847	2.094	0.753	n/a	9.34	6.87	2.47	n/a
Cape May, NJ	8536110	08/28/2011 00:06	2.605	1.849	0.756	1.685	8.55	6.07	2.48	5.53
Atlantic City, NJ	8534720	08/28/2011 00:00	2.121	1.467	0.654	1.324	6.96	4.81	2.15	4.34
Sandy Hook, NJ	8531680	08/28/2011 12:36	2.971	1.559	1.412	2.113	9.75	5.11	4.63	6.93
<sup>3</sup> Bergen Point West Reach, NY	8519483	08/28/2011 12:42	3.114	1.724	1.390	2.214	10.22	5.66	4.56	7.26
The Battery, NY	8518750	08/28/2011 12:42	2.896	1.568	1.328	2.049	9.50	5.14	4.36	6.72
<sup>3</sup> Kings Point, NY	8516945	08/28/2011 14:00	3.758	2.399	1.359	n/a	12.33	7.87	4.46	n/a
Montauk, NY	8510560	08/28/2011 13:12	1.641	0.802	0.839	1.244	5.38	2.63	2.75	4.08
Bridgeport, CT	8467150	08/28/2011 15:06	3.683	2.329	1.354	2.512	12.08	7.64	4.44	8.24
<sup>3</sup> New Haven, CT	8465705	08/28/2011 14:36	3.528	2.111	1.417	n/a	11.57	6.93	4.65	n/a
New London, CT	8461490	08/28/2011 13:24	1.997	0.934	1.063	1.437	6.55	3.06	3.49	4.71
Quonset Point, RI	8454049	08/28/2011 12:06	2.097	1.372	0.725	n/a	6.88	4.50	2.38	n/a
Providence, RI	8454000	08/28/2011 13:54	2.516	1.100	1.416	1.762	8.25	3.61	4.65	5.78
Conimicut Light, RI	8452944	08/28/2011 11:54	2.313	1.560	0.753	n/a	7.59	5.12	2.47	n/a
Newport, RI	8452660	08/28/2011 11:54	1.994	1.291	0.703	1.372	6.54	4.24	2.31	4.50
Nantucket Island, MA	8449130	08/28/2011 16:00	1.381	0.991	0.390	n/a	4.53	3.25	1.28	n/a
Menemsha Harbor, MA	8448725	08/28/2011 13:12	1.611	0.869	0.742	n/a	5.29	2.85	2.43	n/a
Woods Hole, MA	8447930	08/28/2011 13:36	1.405	0.530	0.875	0.990	4.61	1.74	2.87	3.25
Chatham, MA	8447435	08/28/2011 16:12	2.271	1.787	0.484	1.241	7.45	5.86	1.59	4.07
Fall River, MA	8447386	08/28/2011 11:42	2.226	1.632	0.594	n/a	7.30	5.35	1.95	n/a
Boston, MA	8443970	08/28/2011 15:06	3.641	3.116	0.525	1.963	11.95	10.22	1.72	6.44
Fort Point, NH	8423898	08/29/2011 03:36	3.335	3.168	0.167	1.822	10.94	10.39	0.55	5.98
Wells, ME	8419317	08/29/2011 03:30	3.420	3.176	0.244	1.898	11.22	10.42	0.80	6.23
Portland, ME	8418150	08/29/2011 03:06	3.645	3.315	0.330	2.044	11.96	10.88	1.08	6.71
Bar Harbor, ME	8413320	08/29/2011 03:12	4.160	3.778	0.382	2.339	13.65	12.39	1.25	7.67
Eastport, ME	8410140	08/29/2011 03:06	6.711	6.380	0.331	3.682	22.02	20.93	1.09	12.08

<sup>1</sup> Sensor reached physical limit on measurements and did not record a maximum/minimum value.

<sup>2</sup> Station did not record a maximum storm tide and/or storm surge coinciding with the timing of Irene.

<sup>3</sup> Maximum recorded water level value exceeded historical maximum value.

<sup>4</sup> Maximum storm tide/storm surge includes likely effects from runoff.

Table 2a: Maximum recorded wind speed, wind gusts and minimum barometric pressure in geographic order for Hurricane Irene, August 2011.

Station Name	Station ID	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
Barbuda	9761115	08/21/2011 15:12	15.5	30.1	08/21/2011 15:12	16.7	32.5	08/21/2011 10:36	1007.1
Christiansted Harbor, St Croix, VI	9751364	08/21/2011 23:42	14.6	27.6	08/22/2011 01:36	32.6	44.7	08/21/2011 22:18	996.5
Lameshur Bay, St. John, VI	9751381	n/a	n/a	n/a	n/a	n/a	n/a	08/21/2011 21:42	1004.5
Lime Tree Bay, VI	9751401	08/22/2011 00:06	19.1	37.1	08/22/2011 00:12	25.3	49.2	08/21/2011 22:36	996.9
Charlotte Amalie, VI	9751639	n/a	n/a	n/a	n/a	n/a	n/a	08/21/2011 21:30	1003.7
Culebra, PR	9752235	08/22/2011 02:54	10.1	19.6	08/22/2011 03:06	22.7	44.1	08/22/2011 05:12	1004.5
Isabel Segunda, Vieques Island, PR	9752619	08/22/2011 05:36	14.6	28.4	08/22/2011 05:36	26.0	50.5	n/a	n/a
Esperanza, Vieques Island, PR	9752695	08/22/2011 04:48	26.0	50.5	08/22/2011 05:06	33.9	65.9	08/22/2011 04:12	996.0
Fajardo, PR	9753216	08/22/2011 04:06	17.8	34.6	08/22/2011 05:18	27.3	53.1	08/22/2011 05:30	998.4
Yabucoa Harbor, PR	9754228	08/22/2011 06:48	13.1	25.5	08/22/2011 06:54	22.4	43.5	n/a	n/a
San Juan, PR	9755371	08/22/2011 06:54	17.8	34.6	08/22/2011 07:06	24.6	47.8	08/22/2011 07:42	992.7
Arecibo, PR	9757809	08/22/2011 10:06	14.6	28.4	08/22/2011 09:18	19.1	37.1	08/22/2011 10:12	999.7
Magueyes Island, PR	9759110	08/22/2011 19:12	13.3	25.9	08/22/2011 19:12	17.2	33.4	08/22/2011 08:42	1003.8
Mayaguez, PR	9759394	08/22/2011 14:48	9.1	17.7	08/22/2011 15:12	13.7	26.6	08/22/2011 11:06	1007.4
Aguadilla, PR	9759412	n/a	n/a	n/a	n/a	n/a	n/a	08/22/2011 11:54	1002.9
Virginia Key, FL	8723214	08/27/2011 18:06	10.0	19.4	08/25/2011 10:48	15.0	29.2	08/25/2011 21:00	1001.7
Lake Worth Pier, FL	8722670	08/25/2011 20:24	19.5	37.9	08/25/2011 20:24	23.0	44.7	08/25/2011 22:54	1001.3
Trident Pier, FL	8721604	08/27/2011 19:00	14.3	27.8	08/27/2011 19:00	17.1	33.2	n/a	n/a
Mayport (Bar Pilots Dock), FL	8720218	08/26/2011 12:12	14.4	28.0	n/a	n/a	n/a	08/27/2011 22:48	1004.5
Fernandina Beach, FL	8720030	n/a	n/a	n/a	n/a	n/a	n/a	08/27/2011 22:48	1001.4
Fort Pulaski, GA	8670870	08/26/2011 18:36	13.4	26.0	08/26/2011 12:36	16.9	32.9	08/27/2011 20:42	1000.9
Charleston, SC	8665530	08/26/2011 16:48	15.3	29.7	08/26/2011 14:54	20.4	39.7	08/27/2011 07:24	998.6
Springmaid Pier, SC	8661070	08/26/2011 21:30	20.4	39.7	08/26/2011 21:12	27.7	53.8	08/27/2011 07:48	991.0
Wrightsville Beach, NC	8658163	08/27/2011 02:36	25.0	48.6	08/27/2011 09:48	32.8	63.8	08/27/2011 09:24	976.3
Wilmington, NC	8658120	n/a	n/a	n/a	n/a	n/a	n/a	08/27/2011 09:30	979.5
Beaufort, NC	8656483	08/27/2011 08:06	17.8	34.6	08/27/2011 10:12	29.9	58.1	08/27/2011 13:00	952.9

Table 2b: Maximum recorded wind speed, wind gusts and minimum barometric pressure in geographic order for Hurricane Irene, August 2011.

Station Name	Station ID	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
USCG Station Hatteras, NC	8654467	08/27/2011 09:42	25.5	49.6	08/27/2011 09:36	35.6	69.2	08/27/2011 17:36	968.6
Oregon Inlet Marina, NC	8652587	08/27/2011 20:42	26.3	51.1	08/27/2011 20:00	36.1	70.2	08/27/2011 19:54	965.5
Duck, NC	8651370	08/27/2011 21:06	31.3	60.8	08/27/2011 21:12	37.4	72.7	08/27/2011 21:12	950.6
Money Point, VA	8639348	08/28/2011 01:48	17.9	34.8	08/28/2011 01:48	27.5	53.5	08/27/2011 23:12	968.5
Chesapeake Bay Bridge Tunnel, VA	8638863	08/27/2011 16:00	26.2	50.9	08/27/2011 16:00	32.0	62.2	08/27/2011 23:48	967.3
Sewells Point, VA	8638610	n/a	n/a	n/a	n/a	n/a	n/a	08/27/2011 23:06	972.0
Yorktown USCG Training Center, VA	8637689	08/28/2011 03:42	23.5	45.7	08/28/2011 03:48	29.4	57.1	08/28/2011 00:12	974.7
Lewisetta, VA	8635750	08/28/2011 08:24	17.1	33.2	08/27/2011 22:48	25.5	49.6	08/28/2011 04:06	979.1
Kiptopeke, VA	8632200	08/28/2011 04:48	22.1	43.0	08/28/2011 06:54	28.2	54.8	n/a	n/a
Wachapreague, VA	8631044	08/27/2011 16:42	20.1	39.1	08/27/2011 16:48	29.3	57.0	08/28/2011 03:42	968.1
Washington, DC	8594900	08/28/2011 08:54	12.6	24.5	08/28/2011 04:42	22.1	43.0	08/28/2011 07:18	984.5
Solomons Island, MD	8577330	08/28/2011 03:36	20.7	40.2	08/28/2011 03:12	30.5	59.3	08/28/2011 06:18	979.5
Annapolis, MD	8575512	n/a	n/a	n/a	n/a	n/a	n/a	08/28/2011 07:24	980.3
Baltimore, MD	8574680	08/28/2011 07:12	16.9	32.9	08/28/2011 07:12	23.2	45.1	08/28/2011 07:12	981.9
Chesapeake City, MD	8573927	08/28/2011 15:30	11.8	22.9	08/28/2011 02:00	19.1	37.1	08/28/2011 09:00	976.8
Tolchester Beach, MD	8573364	08/28/2011 07:06	20.5	39.8	08/28/2011 12:06	26.8	52.1	08/28/2011 07:36	979.4
Cambridge, MD	8571892	08/27/2011 22:30	19.2	37.3	08/27/2011 22:30	26.9	52.3	08/28/2011 06:48	976.2
Bishops Head, MD	8571421	08/28/2011 10:24	20.7	40.2	08/28/2011 11:30	26.0	50.5	08/28/2011 05:42	975.8
Ocean City Inlet, MD	8570283	08/28/2011 12:36	15.0	29.2	08/27/2011 20:18	21.8	42.4	08/28/2011 06:24	964.4
Lewes, DE	8557380	08/27/2011 22:06	21.1	41.1	08/27/2011 22:06	29.4	57.2	08/28/2011 07:30	968.4
Brandywine Shoal Light, DE	8555889	08/28/2011 16:42	27.2	52.9	08/28/2011 16:42	34.3	66.7	08/28/2011 07:54	968.9
Reedy Point, DE	8551910	n/a	n/a	n/a	n/a	n/a	n/a	08/28/2011 09:24	975.2
Delaware City, DE	8551762	08/28/2011 01:54	17.3	33.6	08/28/2011 01:36	22.6	43.9	08/28/2011 09:42	975.2
Newbold, PA	8548989	08/28/2011 20:54	13.3	25.9	08/28/2011 21:24	19.3	37.5	08/28/2011 11:18	971.1
Philadelphia, PA	8545240	08/28/2011 02:12	10.1	19.7	08/28/2011 01:42	18.1	35.2	08/28/2011 10:12	973.3

Table 2c: Maximum recorded wind speed, wind gusts and minimum barometric pressure in geographic order for Hurricane Irene, August 2011.

Station Name	Station ID	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
Marcus Hook, PA	8540433	n/a	n/a	n/a	n/a	n/a	n/a	08/28/2011 10:00	974.6
Burlington, Delaware River, NJ	8539094	08/28/2011 06:36	16.7	32.5	08/28/2011 06:36	22.3	43.3	08/28/2011 11:00	972.1
Tacony-Palmyra Bridge, NJ	8538886	n/a	n/a	n/a	n/a	n/a	n/a	08/28/2011 10:42	973.5
Ship John Shoal, NJ	8537121	08/28/2011 00:00	21.1	41.0	08/28/2011 14:12	25.6	49.8	08/28/2011 09:06	971.9
Cape May, NJ	8536110	08/28/2011 16:48	26.1	50.7	08/28/2011 16:48	33.6	65.3	08/28/2011 08:06	967.1
Atlantic City, NJ	8534720	n/a	n/a	n/a	n/a	n/a	n/a	08/28/2011 09:30	960.1
Sandy Hook, NJ	8531680	08/28/2011 20:42	20.5	39.8	n/a	n/a	n/a	08/28/2011 12:36	962.9
Bergen Point West Reach, NY	8519483	08/28/2011 20:54	14.4	28.0	08/28/2011 20:54	20.8	40.4	08/28/2011 13:06	966.1
The Battery, NY	8518750	n/a	n/a	n/a	n/a	n/a	n/a	08/28/2011 13:12	964.6
Kings Point, NY	8516945	08/28/2011 23:06	17.1	33.2	08/28/2011 22:30	21.9	42.6	08/28/2011 13:42	968.2
Montauk, NY	8510560	n/a	n/a	n/a	n/a	n/a	n/a	08/28/2011 16:36	983.4
Bridgeport, CT	8467150	08/28/2011 14:36	19.1	37.1	08/28/2011 14:36	23.2	45.1	08/28/2011 15:00	975.4
New Haven, CT	8465705	08/28/2011 15:54	18.0	35.0	08/28/2011 16:30	23.1	44.9	08/28/2011 16:30	977.0
New London, CT	8461490	08/28/2011 14:42	18.9	36.7	08/28/2011 14:54	24.1	46.8	08/28/2011 17:48	983.5
Quonset Point, RI	8454049	08/28/2011 16:42	22.8	44.3	08/28/2011 17:30	28.8	56.0	08/28/2011 18:18	983.4
Providence, RI	8454000	08/28/2011 15:48	21.6	42.0	08/28/2011 12:42	30.0	58.3	08/28/2011 19:36	983.2
Conimicut Light, RI	8452944	08/28/2011 13:30	28.2	54.8	08/28/2011 13:36	36.8	71.5	08/28/2011 19:48	983.1
Newport, RI	8452660	08/28/2011 16:42	20.1	39.1	08/28/2011 15:24	26.4	51.3	08/28/2011 18:12	984.7
Nantucket Island, MA	8449130	08/28/2011 17:48	13.3	25.9	08/28/2011 22:06	21.4	41.6	08/28/2011 20:24	991.1
Woods Hole, MA	8447930	n/a	n/a	n/a	n/a	n/a	n/a	08/28/2011 20:48	988.9
Fall River, MA	8447386	n/a	n/a	n/a	n/a	n/a	n/a	08/28/2011 19:48	985.4
Boston, MA	8443970	n/a	n/a	n/a	n/a	n/a	n/a	08/28/2011 21:12	983.3
Wells, ME	8419317	08/28/2011 17:36	15.0	29.2	08/28/2011 20:18	19.4	37.7	08/29/2011 00:42	983.5
Portland, ME	8418150	n/a	n/a	n/a	n/a	n/a	n/a	08/29/2011 02:24	983.4
Bar Harbor, ME	8413320	08/29/2011 12:18	10.3	20.0	08/29/2011 01:36	19.1	37.1	08/29/2011 04:42	989.8
Eastport, ME	8410140	08/29/2011 00:36	18.3	35.6	08/29/2011 00:36	24.1	46.8	08/29/2011 07:24	991.9

Table 3a: Maximum recorded storm surge/residual levels ranked by amplitude for Hurricane Irene, August 2011. Storm Surge/Residual represents the observed water level (storm tide) minus predicted astronomical tide levels.

Station Name	Station ID	Date & Time GMT	Storm Surge/ Residual	
			(m)	(ft)
<sup>4</sup> Newbold, PA	8548989	08/28/2011 13:24	2.694	8.84
<sup>4</sup> Burlington, Delaware River, NJ	8539094	08/28/2011 13:18	2.370	7.78
<sup>3</sup> Oregon Inlet Marina, NC	8652587	08/28/2011 03:54	2.161	7.09
<sup>1,4</sup> Tacony-Palmyra Bridge, NJ	8538886	08/28/2011 12:30	1.867	6.13
<sup>4</sup> Philadelphia, PA	8545240	08/28/2011 11:54	1.596	5.24
Money Point, VA	8639348	08/28/2011 02:36	1.484	4.87
Providence, RI	8454000	08/28/2011 14:00	1.454	4.77
<sup>3</sup> Kings Point, NY	8516945	08/28/2011 13:24	1.441	4.73
Sandy Hook, NJ	8531680	08/28/2011 12:48	1.426	4.68
<sup>3</sup> New Haven, CT	8465705	08/28/2011 14:36	1.417	4.65
<sup>3</sup> Bergen Point West Reach, NY	8519483	08/28/2011 13:00	1.404	4.61
Sewells Point, VA	8638610	08/27/2011 23:48	1.390	4.56
The Battery, NY	8518750	08/28/2011 13:12	1.384	4.54
Bridgeport, CT	8467150	08/28/2011 14:12	1.373	4.50
Yorktown USCG Training Center, VA	8637689	08/27/2011 20:06	1.339	4.39
Chesapeake Bay Bridge Tunnel, VA	8638863	08/27/2011 23:24	1.263	4.14
Conimicut Light, RI	8452944	08/28/2011 14:24	1.239	4.06
Lewes, DE	8557380	08/28/2011 06:24	1.236	4.06
<sup>1</sup> Wachapreague, VA	8631044	08/28/2011 04:30	1.186	3.89
Fall River, MA	8447386	08/28/2011 14:48	1.171	3.84
Wrightsville Beach, NC	8658163	08/27/2011 02:36	1.166	3.83
<sup>4</sup> Delaware City, DE	8551762	08/28/2011 06:06	1.165	3.82
New London, CT	8461490	08/28/2011 16:00	1.139	3.74
USCG Station Hatteras, NC	8654467	08/28/2011 02:54	1.116	3.66
<sup>3</sup> Brandywine Shoal Light, DE	8555889	08/28/2011 06:36	1.106	3.63
<sup>4</sup> Marcus Hook, PA	8540433	08/28/2011 10:42	1.091	3.58
Cape May, NJ	8536110	08/28/2011 06:18	1.073	3.52
Quonset Point, RI	8454049	08/28/2011 14:30	1.071	3.51
<sup>3</sup> Ship John Shoal, NJ	8537121	08/28/2011 07:36	1.043	3.42

<sup>1</sup> Sensor reached physical limit on measurements and did not record a maximum/minimum value.

<sup>2</sup> Station did not record a maximum storm tide and/or storm surge coinciding with the timing of Irene.

<sup>3</sup> Maximum recorded water level value exceeded historical maximum value.

<sup>4</sup> Maximum storm tide/storm surge includes likely effects from runoff.

Table 3b: Maximum recorded storm surge/residual levels ranked by amplitude for Hurricane Irene, August 2011. Storm Surge/Residual represents the observed water level (storm tide) minus predicted astronomical tide levels.

Station Name	Station ID	Date & Time GMT	Storm Surge/ Residual	
			(m)	(ft)
Ocean City Inlet, MD	8570283	08/28/2011 04:06	1.029	3.38
Clarendon Plantation, SC	8667633	08/27/2011 05:00	1.020	3.35
Lewisetta, VA	8635750	08/28/2011 00:54	1.005	3.30
Kiptopeke, VA	8632200	08/27/2011 19:12	1.004	3.29
Atlantic City, NJ	8534720	08/28/2011 06:36	1.000	3.28
Windmill Point, VA	8636580	08/27/2011 21:36	0.974	3.20
Beaufort, NC	8656483	08/27/2011 11:54	0.968	3.18
Newport, RI	8452660	08/28/2011 14:24	0.960	3.15
Woods Hole, MA	8447930	08/28/2011 14:18	0.916	3.01
<sup>4</sup> Reedy Point, DE	8551910	08/28/2011 06:00	0.888	2.91
Fernandina Beach, FL	8720030	08/27/2011 03:42	0.877	2.88
Montauk, NY	8510560	08/28/2011 15:48	0.870	2.85
Oyster Landing (N. Inlet Estuary), SC	8662245	08/27/2011 04:24	0.862	2.83
Mayport (Bar Pilots Dock), FL	8720218	08/27/2011 03:30	0.785	2.58
Fort Pulaski, GA	8670870	08/27/2011 03:06	0.783	2.57
Menemsha Harbor, MA	8448725	08/28/2011 14:42	0.771	2.53
Duck, NC	8651370	08/27/2011 14:36	0.757	2.48
Solomons Island, MD	8577330	08/28/2011 01:48	0.747	2.45
Bishops Head, MD	8571421	08/28/2011 02:06	0.739	2.42
Wells, ME	8419317	08/28/2011 19:30	0.732	2.40
Springmaid Pier, SC	8661070	08/27/2011 01:48	0.699	2.29
Charleston, SC	8665530	08/27/2011 02:42	0.638	2.09
Portland, ME	8418150	08/28/2011 20:06	0.586	1.92
Fort Point, NH	8423898	08/28/2011 19:18	0.572	1.88
Cambridge, MD	8571892	08/28/2011 12:00	0.550	1.80
Trident Pier, FL	8721604	08/26/2011 03:18	0.539	1.77
Boston, MA	8443970	08/28/2011 17:48	0.534	1.75
Chatham, MA	8447435	08/28/2011 18:00	0.514	1.69

<sup>1</sup> Sensor reached physical limit on measurements and did not record a maximum/minimum value.

<sup>2</sup> Station did not record a maximum storm tide and/or storm surge coinciding with the timing of Irene.

<sup>3</sup> Maximum recorded water level value exceeded historical maximum value.

<sup>4</sup> Maximum storm tide/storm surge includes likely effects from runoff.

Table 3c: Maximum recorded storm surge/residual levels ranked by amplitude for Hurricane Irene, August 2011. Storm Surge/Residual represents the observed water level (storm tide) minus predicted astronomical tide levels.

Station Name	Station ID	Date & Time GMT	Storm Surge/ Residual	
			(m)	(ft)
<sup>3</sup> Esperanza, Vieques Island, PR	9752695	08/22/2011 05:06	0.495	1.62
Fajardo, PR	9753216	08/22/2011 05:30	0.488	1.60
Eastport, ME	8410140	08/29/2011 07:18	0.464	1.52
I-295 Bridge, St Johns River, FL	8720357	08/27/2011 05:30	0.464	1.52
<sup>2</sup> Lake Worth Pier, FL	8722670	08/26/2011 05:48	0.446	1.46
Bar Harbor, ME	8413320	08/28/2011 21:30	0.433	1.42
Nantucket Island, MA	8449130	08/28/2011 17:06	0.417	1.37
<sup>2</sup> Baltimore, MD	8574680	08/25/2011 09:30	0.373	1.22
<sup>2</sup> Washington, DC	8594900	08/27/2011 20:18	0.363	1.19
<sup>2</sup> Chesapeake City, MD	8573927	08/25/2011 08:42	0.356	1.17
<sup>2</sup> Tolchester Beach, MD	8573364	08/25/2011 13:42	0.347	1.14
<sup>2</sup> Annapolis, MD	8575512	08/25/2011 14:24	0.324	1.06
Christiansted Harbor, St Croix, VI	9751364	08/21/2011 21:48	0.315	1.03
Yabucoa Harbor, PR	9754228	08/22/2011 05:42	0.310	1.02
Isabel Segunda, Vieques Island, PR	9752619	08/22/2011 02:36	0.304	1.00
<sup>2</sup> Virginia Key, FL	8723214	08/27/2011 18:30	0.302	0.99
Charlotte Amalie, VI	9751639	08/22/2011 04:36	0.290	0.95
Mayaguez, PR	9759394	08/23/2011 15:36	0.279	0.92
San Juan, PR	9755371	08/22/2011 07:24	0.273	0.90
Wilmington, NC	8658120	08/27/2011 06:24	0.271	0.89
Culebra, PR	9752235	08/22/2011 04:30	0.265	0.87
Lameshur Bay, St. John, VI	9751381	08/22/2011 02:42	0.261	0.86
Lime Tree Bay, VI	9751401	08/22/2011 01:12	0.252	0.83
Arecibo, PR	9757809	08/22/2011 10:18	0.221	0.73
Barbuda	9761115	08/21/2011 11:12	0.201	0.66
Mona Island, PR	9759938	08/22/2011 16:00	0.192	0.63
Aguadilla, PR	9759412	08/22/2011 11:42	0.162	0.53
Magueyes Island, PR	9759110	08/23/2011 15:24	0.123	0.40

<sup>1</sup> Sensor reached physical limit on measurements and did not record a maximum/minimum value.

<sup>2</sup> Station did not record a maximum storm tide and/or storm surge coinciding with the timing of Irene.

<sup>3</sup> Maximum recorded water level value exceeded historical maximum value.

<sup>4</sup> Maximum storm tide/storm surge includes likely effects from runoff.



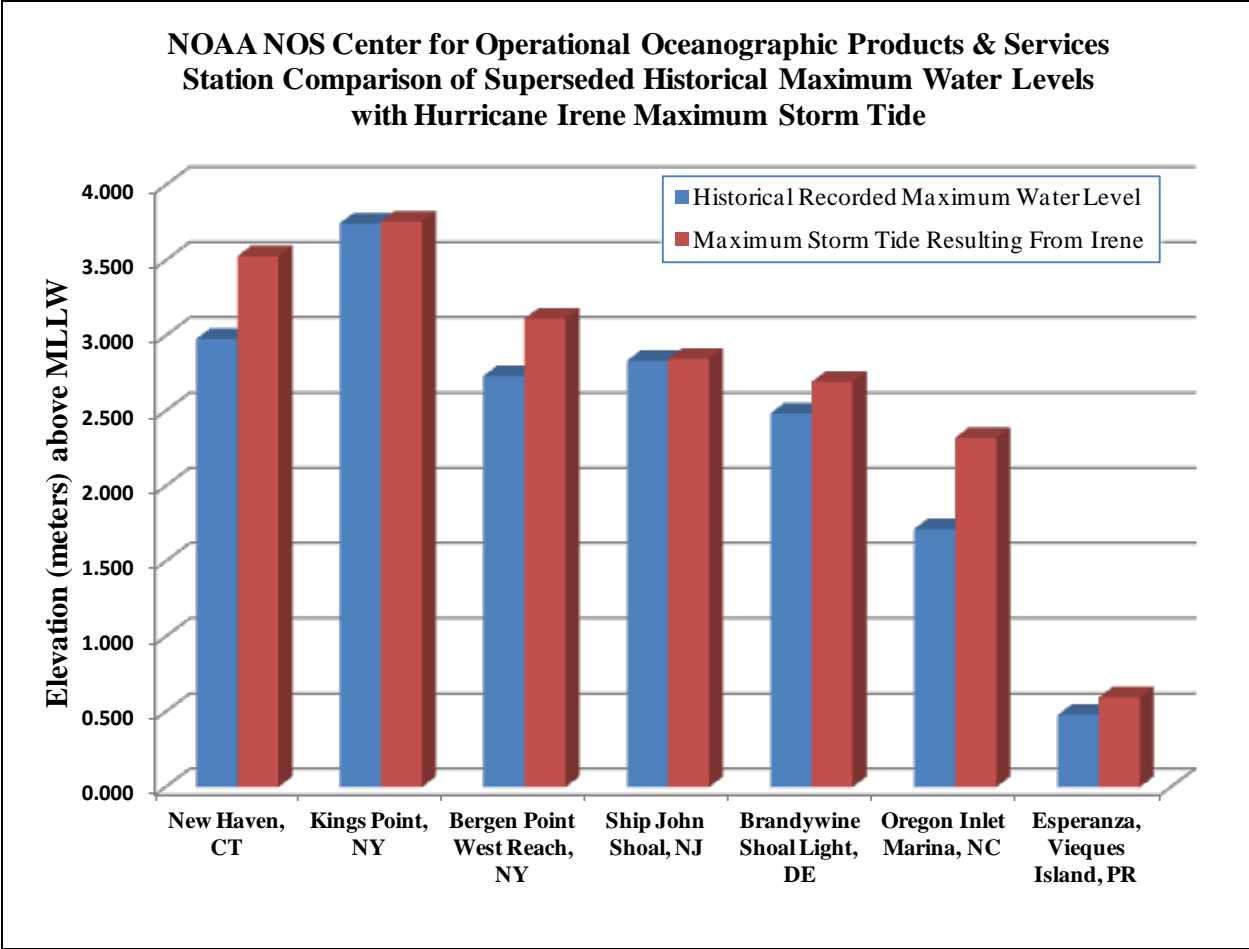


Figure 3: Stations that exceeded historical recorded maximum tide levels during Hurricane Irene.

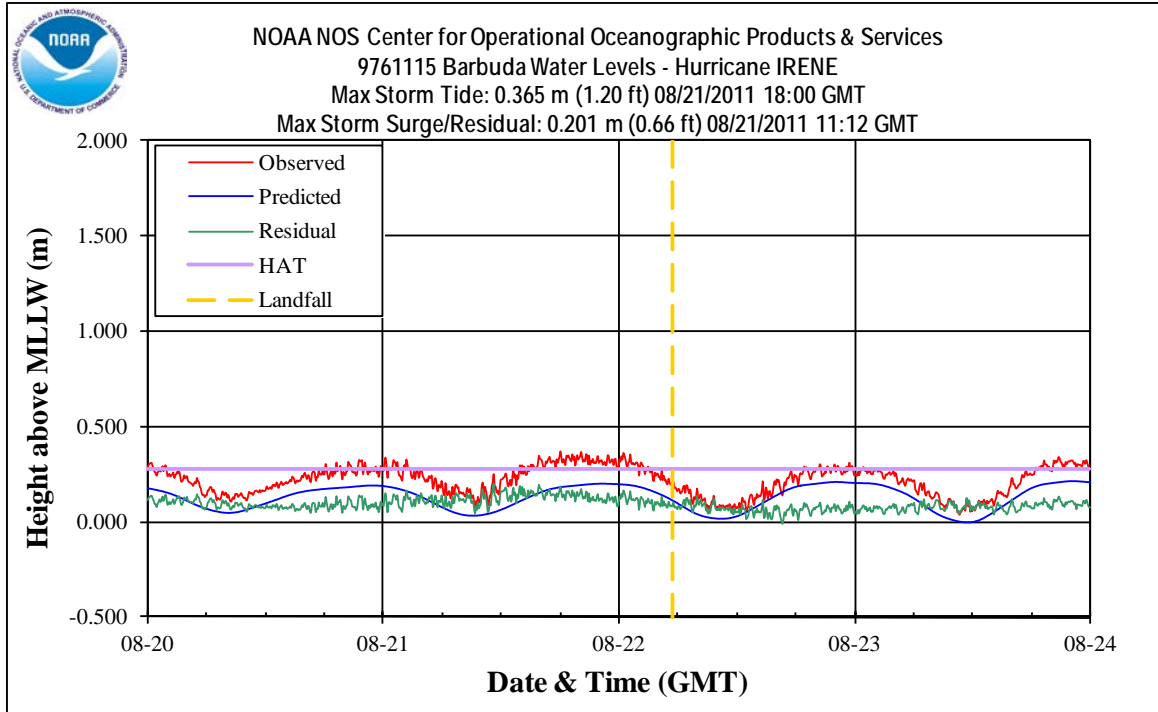


Figure 4: Water levels above Mean Lower Low Water (MLLW) at Barbuda. A line denoting Highest Astronomical Tide (HAT) is displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

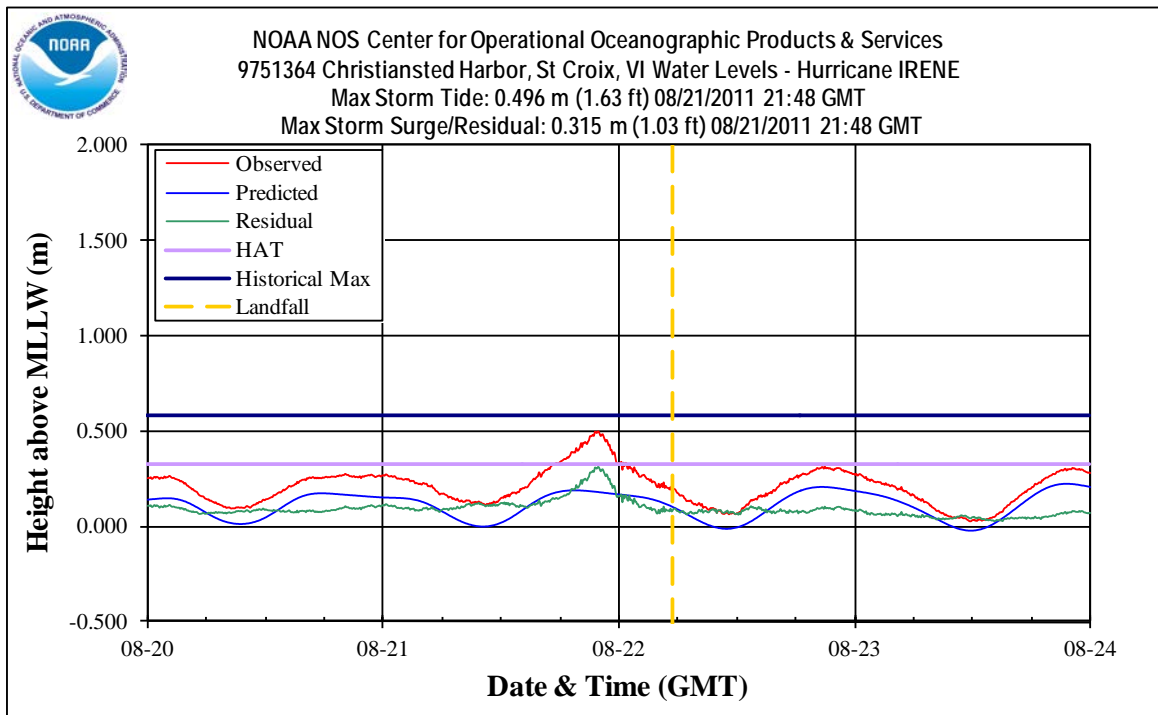


Figure 5: Water levels above Mean Lower Low Water (MLLW) at Christiansted Harbor, St. Croix, VI. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

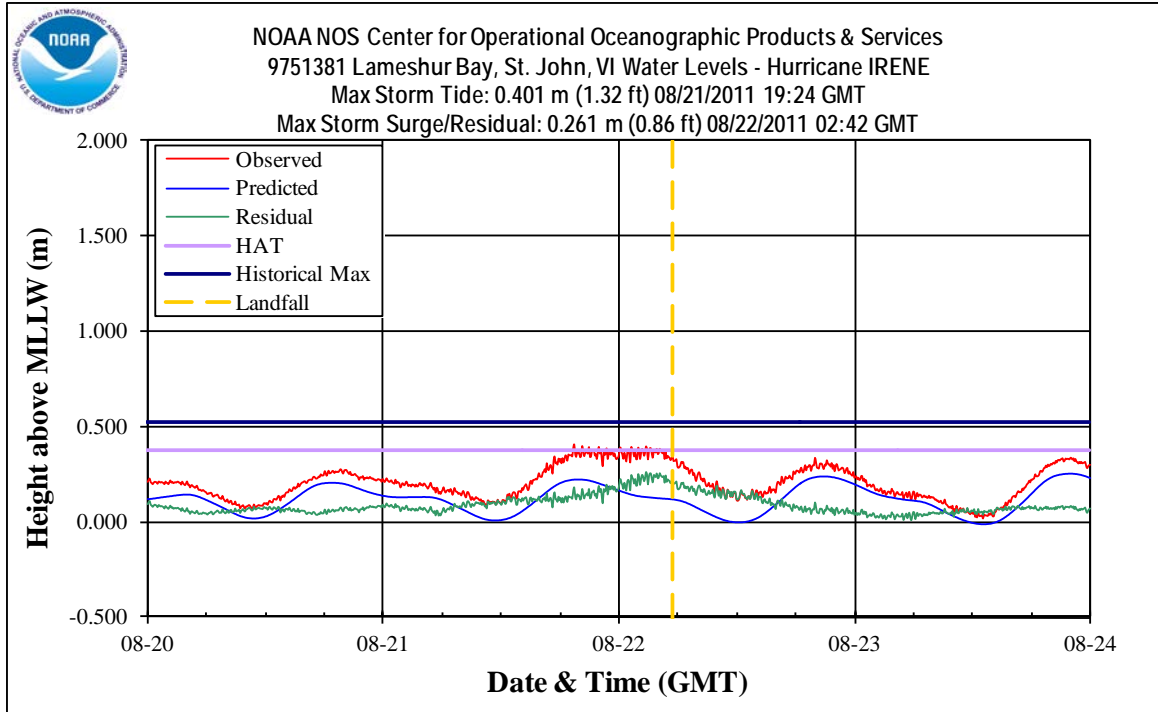


Figure 6: Water levels above Mean Lower Low Water (MLLW) at Lameshur Bay, St. John, VI. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

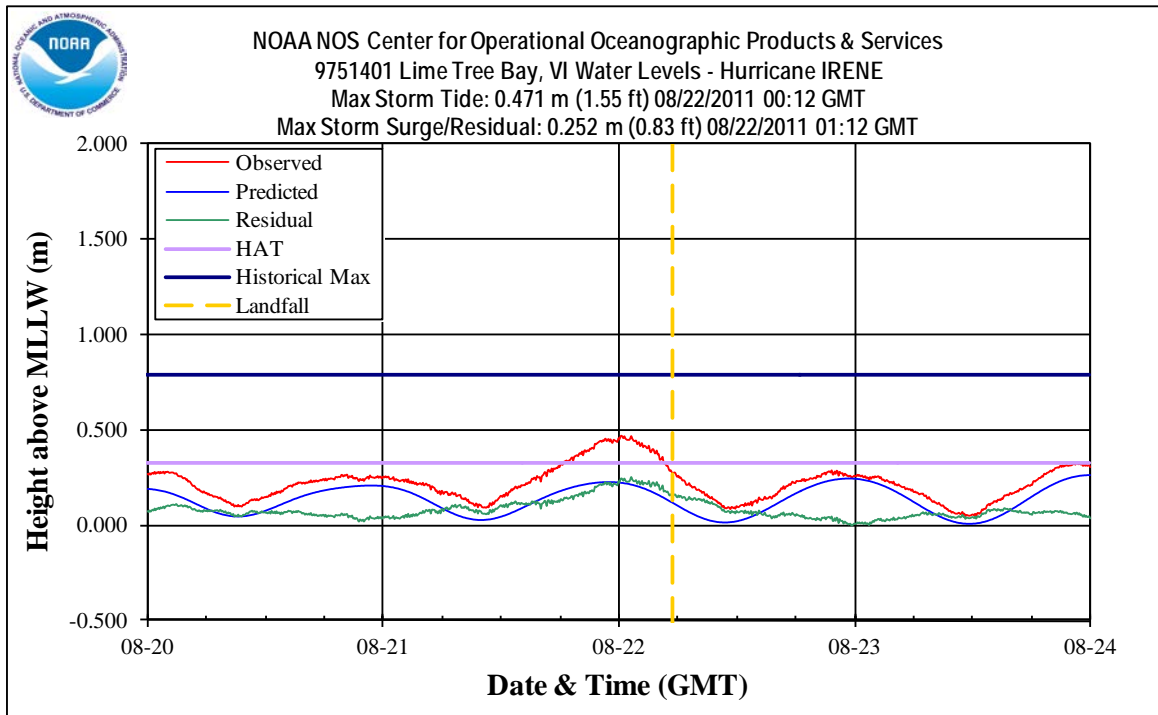


Figure 7: Water levels above Mean Lower Low Water (MLLW) at Lime Tree Bay, VI. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

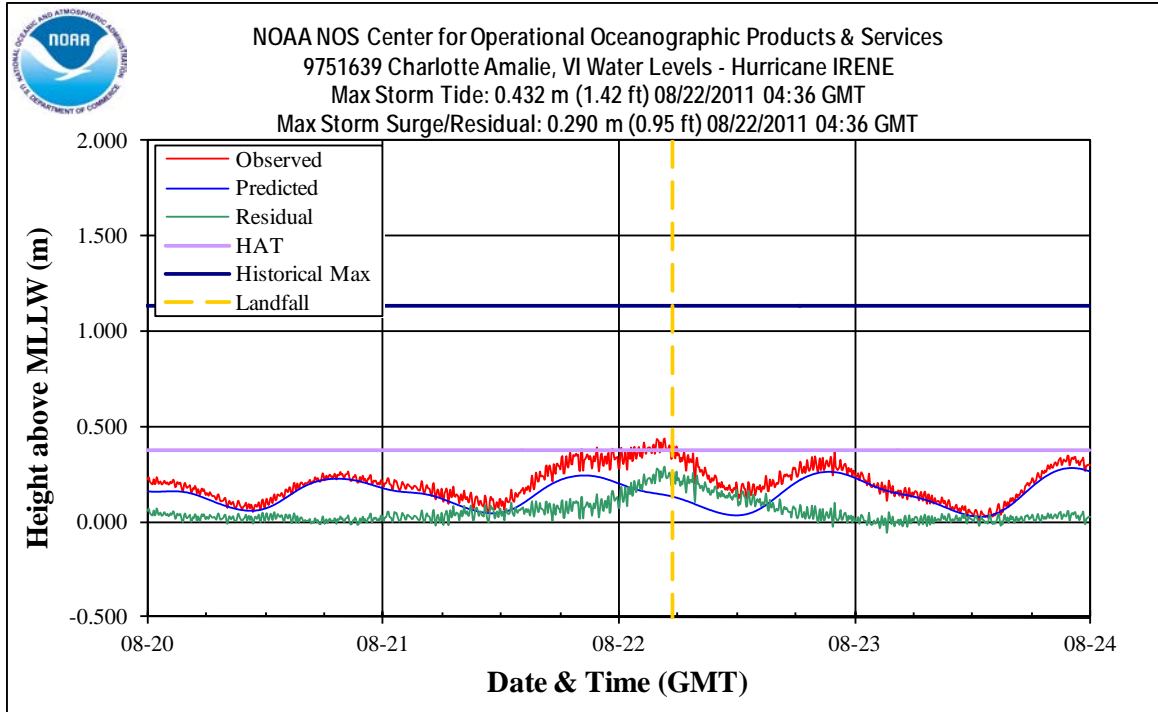


Figure 8: Water levels above Mean Lower Low Water (MLLW) at Charlotte Amalie, VI. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

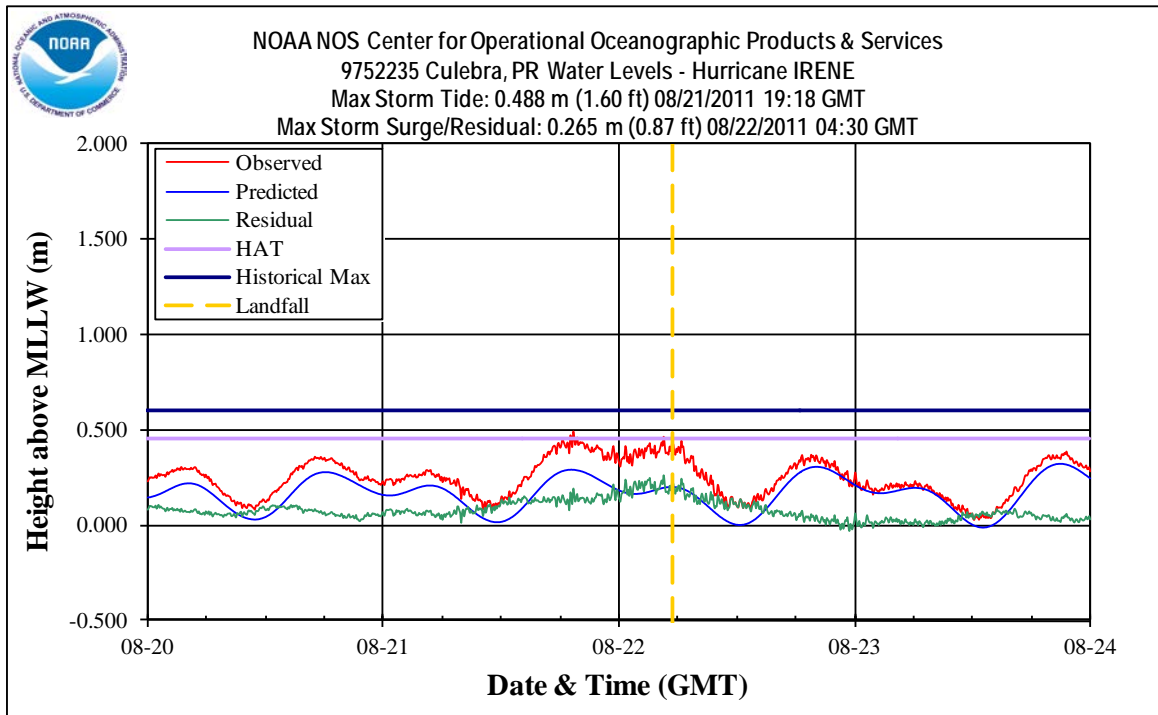


Figure 9: Water levels above Mean Lower Low Water (MLLW) at Culebra, PR. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

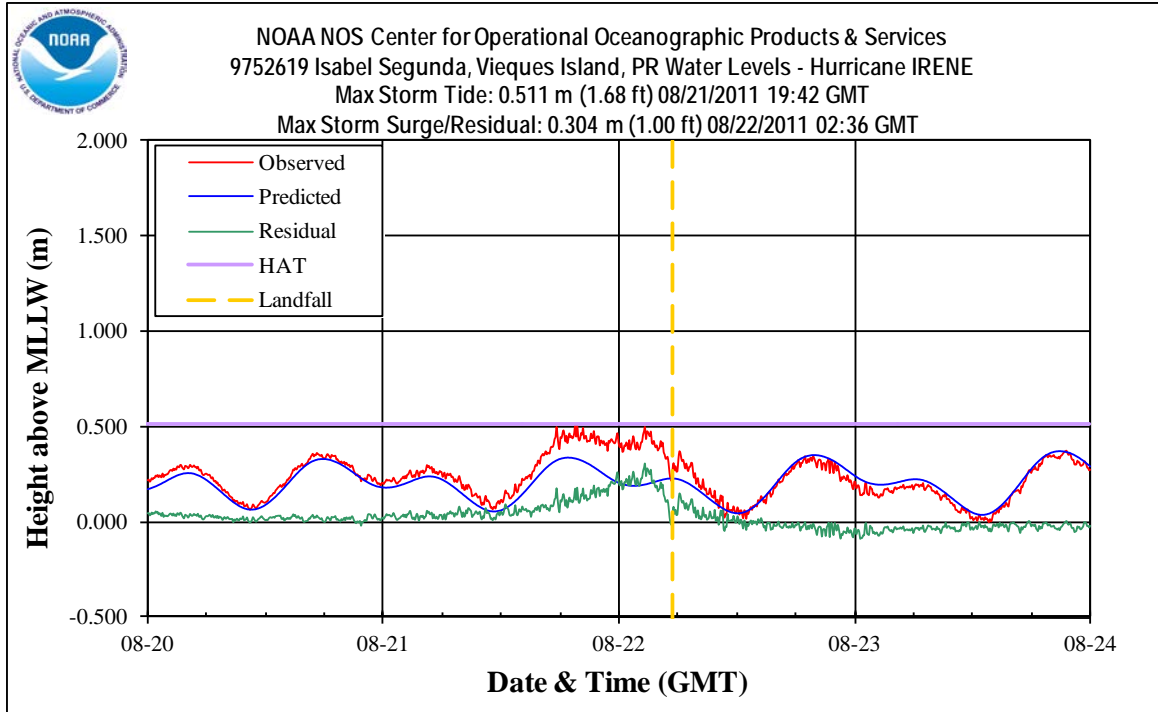


Figure 10: Water levels above Mean Lower Low Water (MLLW) at Isabel Segunda, Vieques Island, PR. A line denoting Highest Astronomical Tide (HAT) is displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

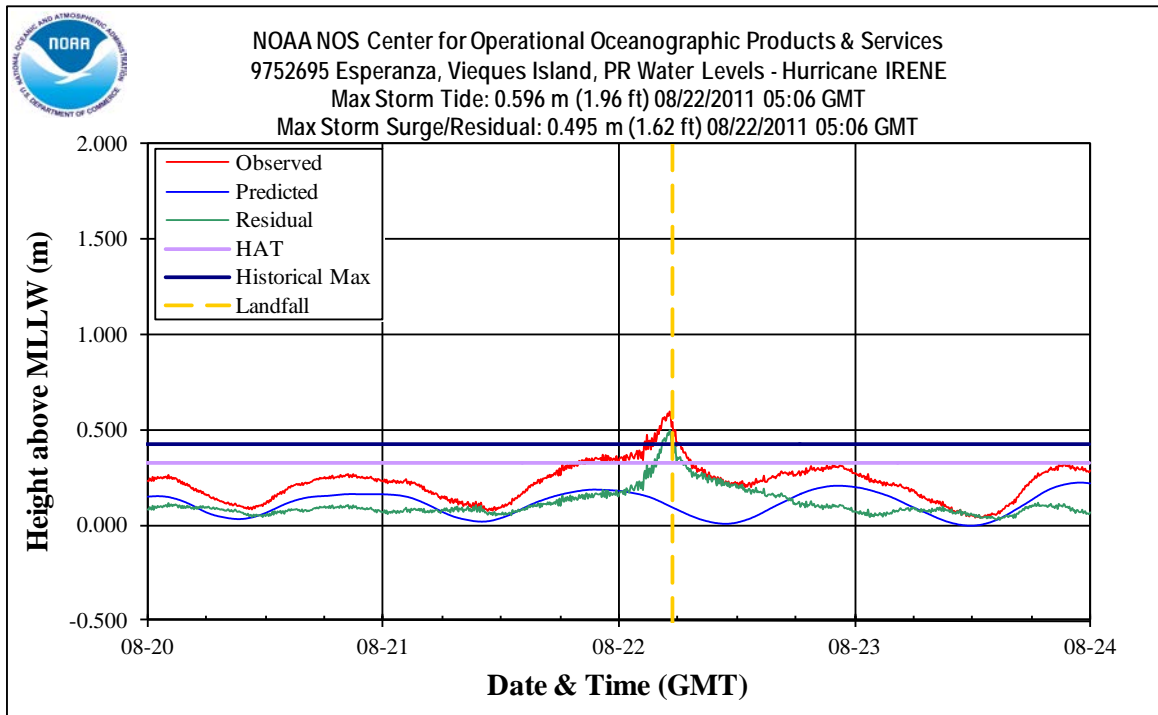


Figure 11: Water levels above Mean Lower Low Water (MLLW) at Esperanza, Vieques Island, PR. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded historical recorded maximum tide level. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

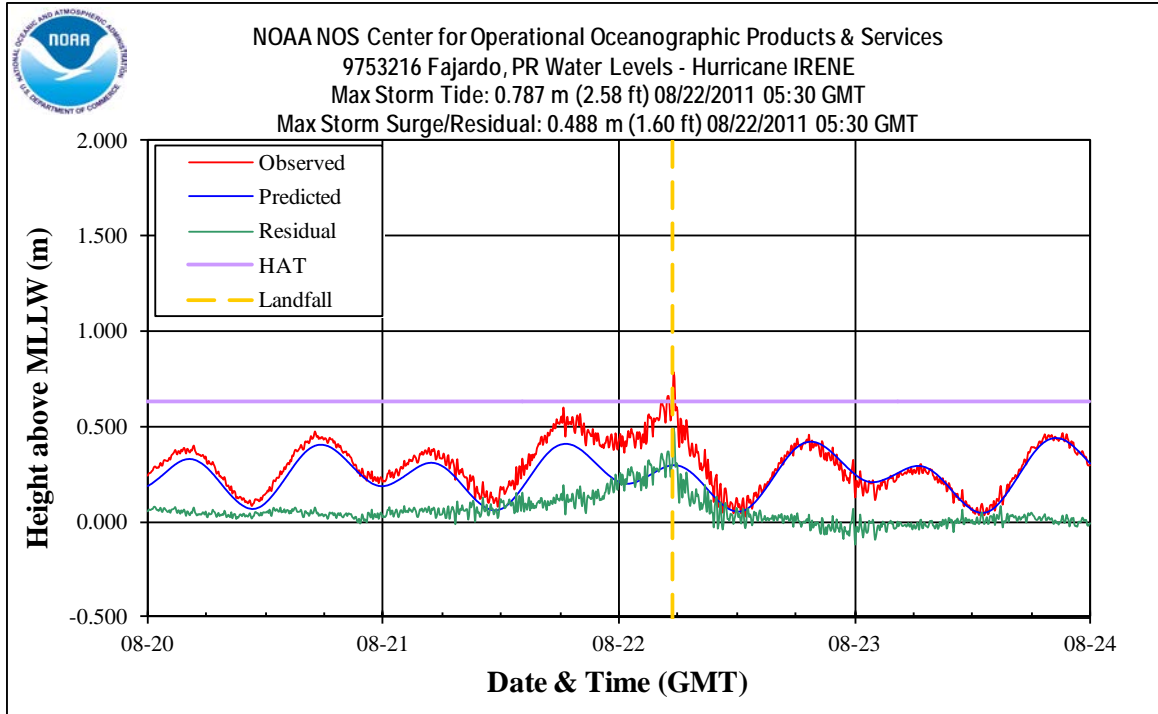


Figure 12: Water levels above Mean Lower Low Water (MLLW) at Fajardo, PR. A line denoting Highest Astronomical Tide (HAT) is displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

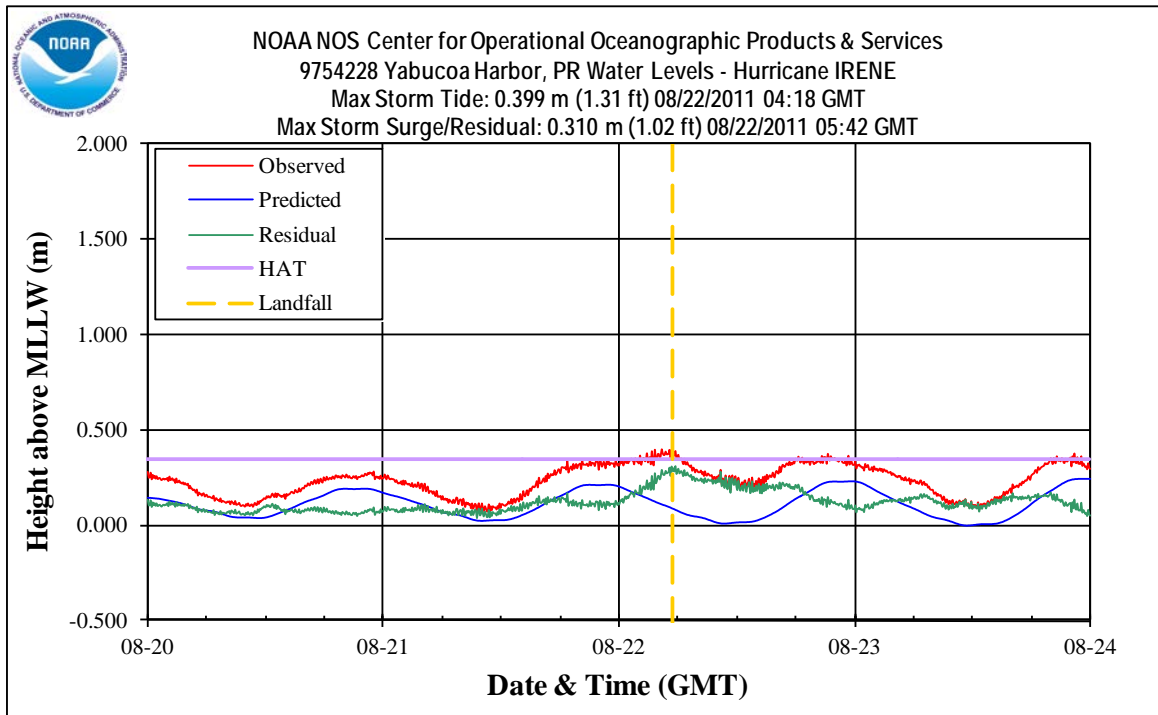


Figure 13: Water levels above Mean Lower Low Water (MLLW) at Yabucoa Harbor, PR. A line denoting Highest Astronomical Tide (HAT) is displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

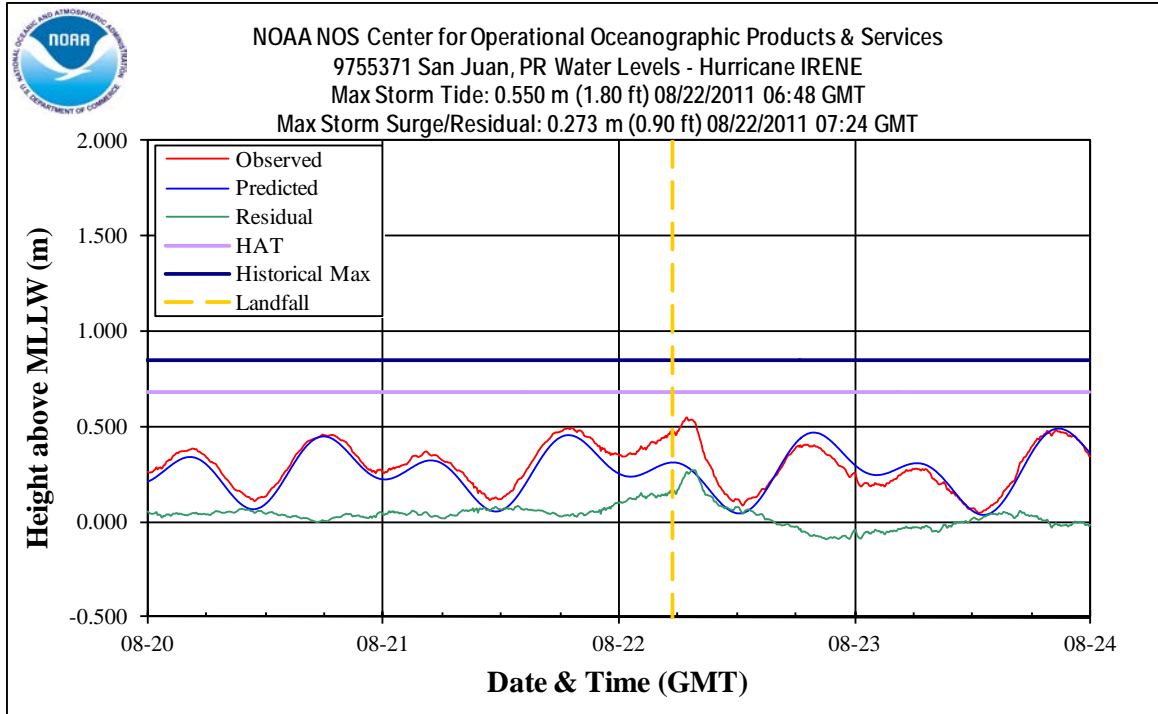


Figure 14: Water levels above Mean Lower Low Water (MLLW) at San Juan, PR. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

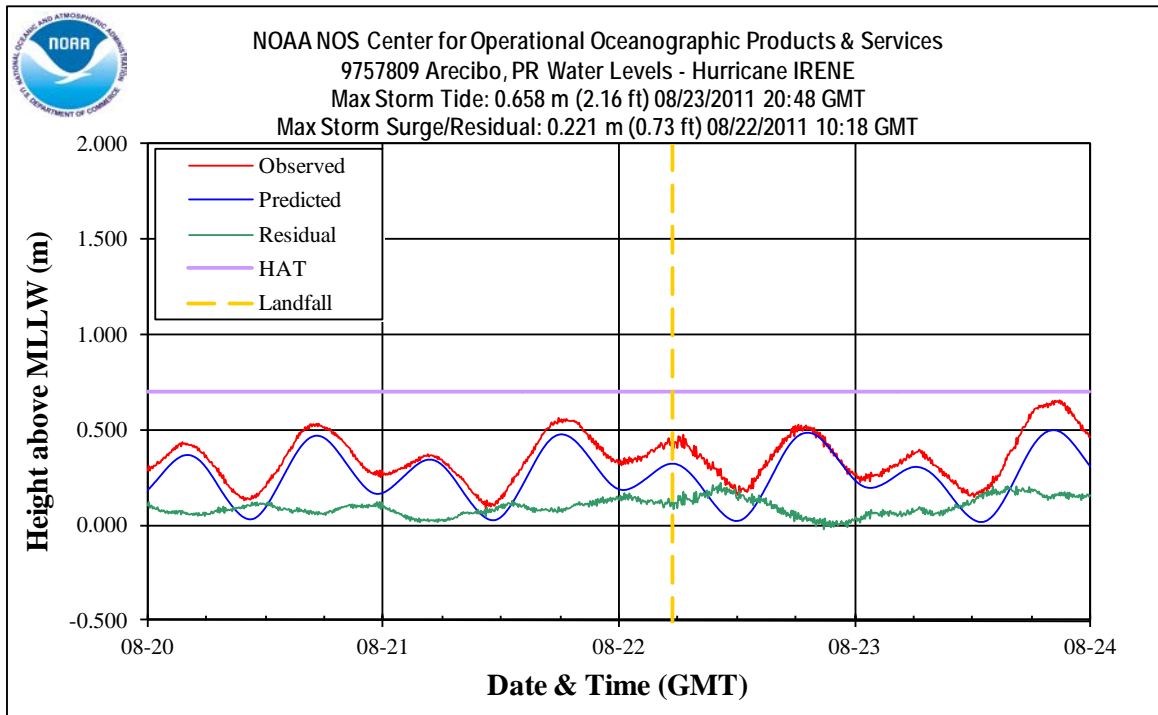


Figure 15: Water levels above Mean Lower Low Water (MLLW) at Arecibo, PR. A line denoting Highest Astronomical Tide (HAT) is displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

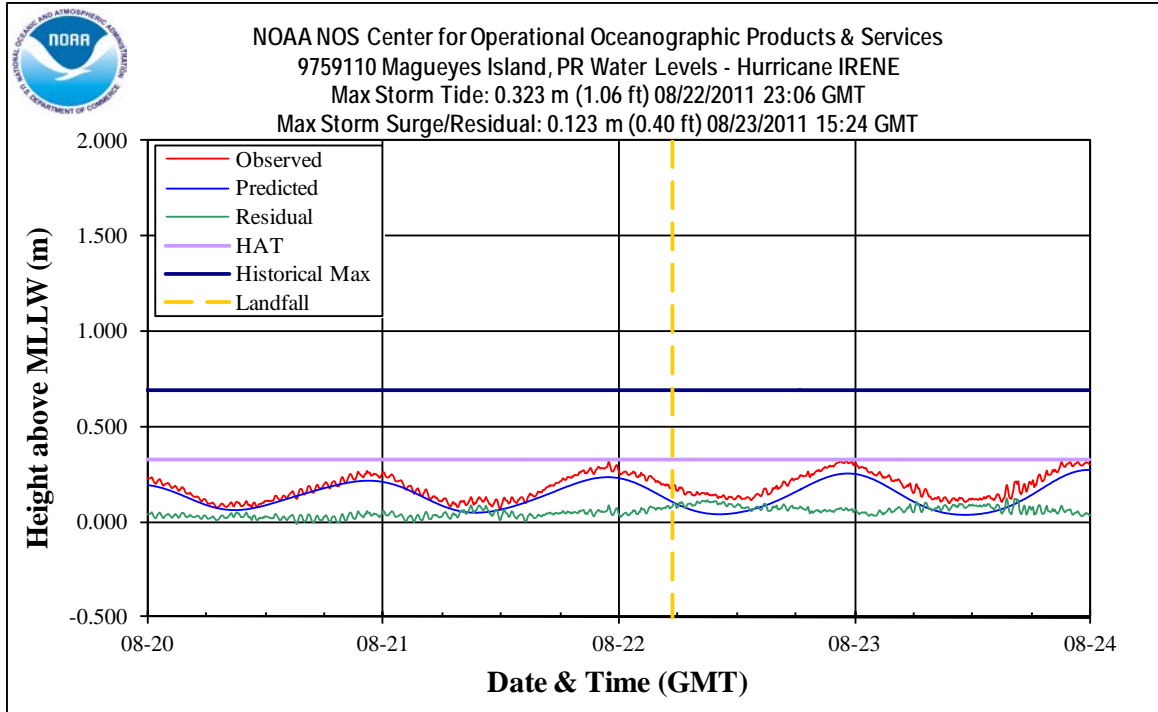


Figure 16: Water levels above Mean Lower Low Water (MLLW) at Magueyes Island, PR. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

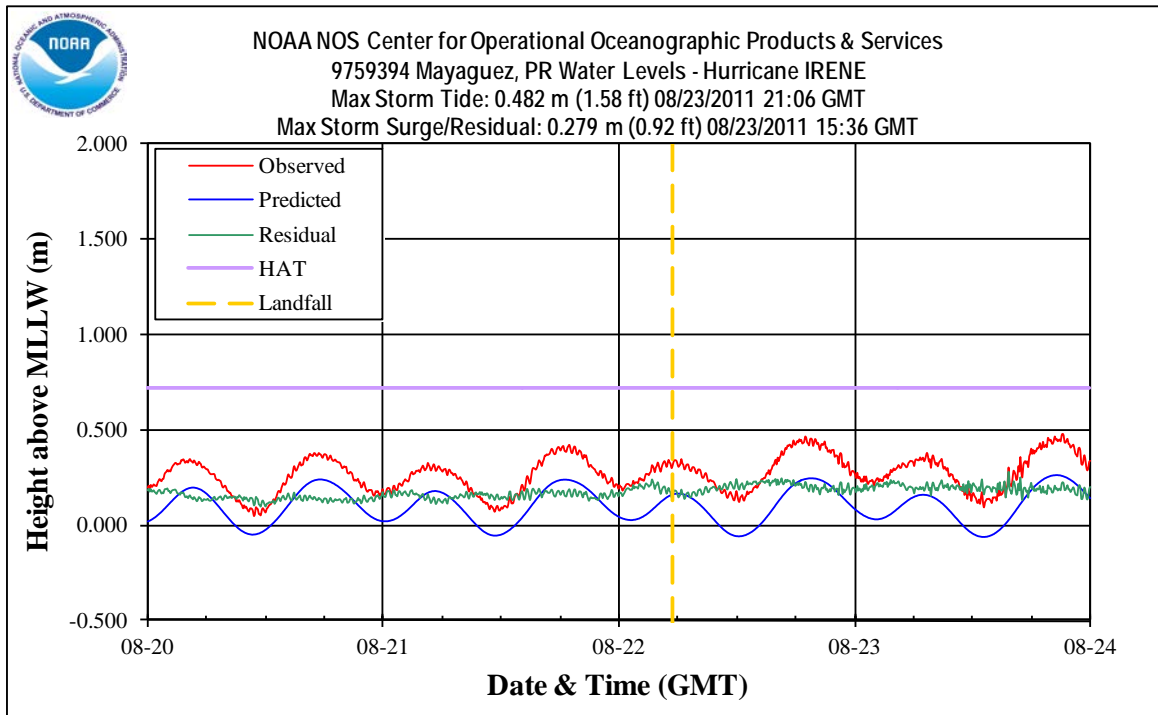


Figure 17: Water levels above Mean Lower Low Water (MLLW) at Mayaguez, PR. A line denoting Highest Astronomical Tide (HAT) is displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.



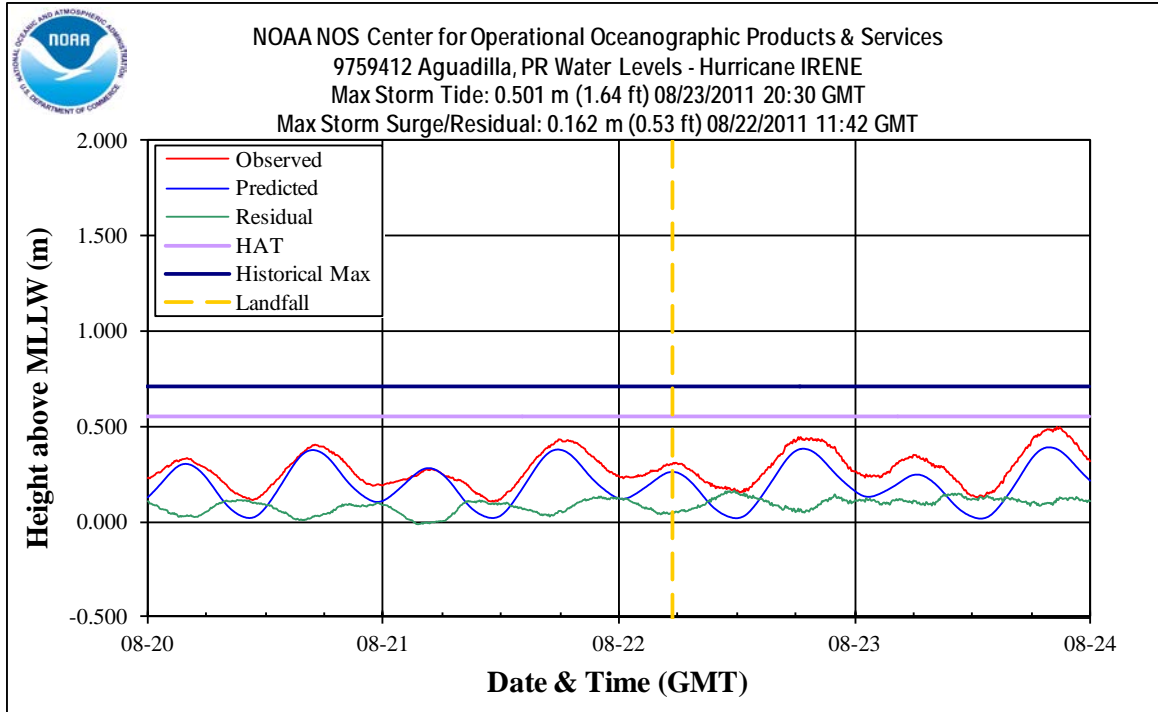


Figure 18: Water levels above Mean Lower Low Water (MLLW) at Aguadilla, PR. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

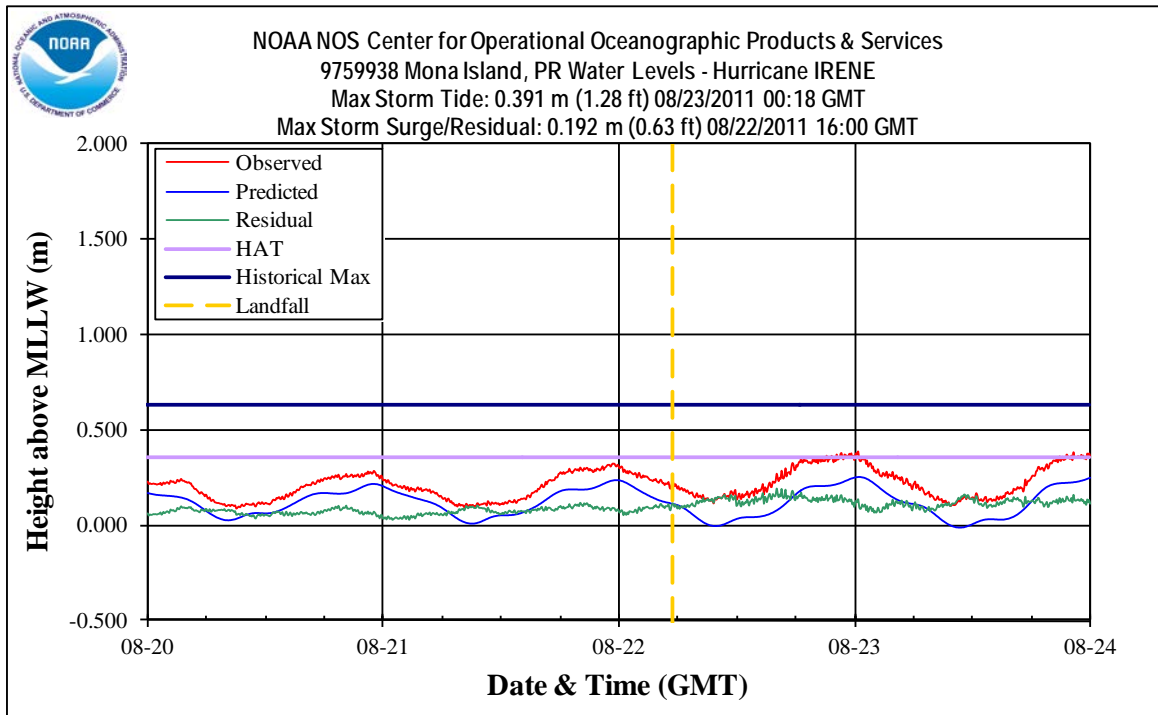


Figure 19: Water levels above Mean Lower Low Water (MLLW) at Mona Island, PR. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall along the east coast of Puerto Rico on 8/22/2011 05:25 GMT.

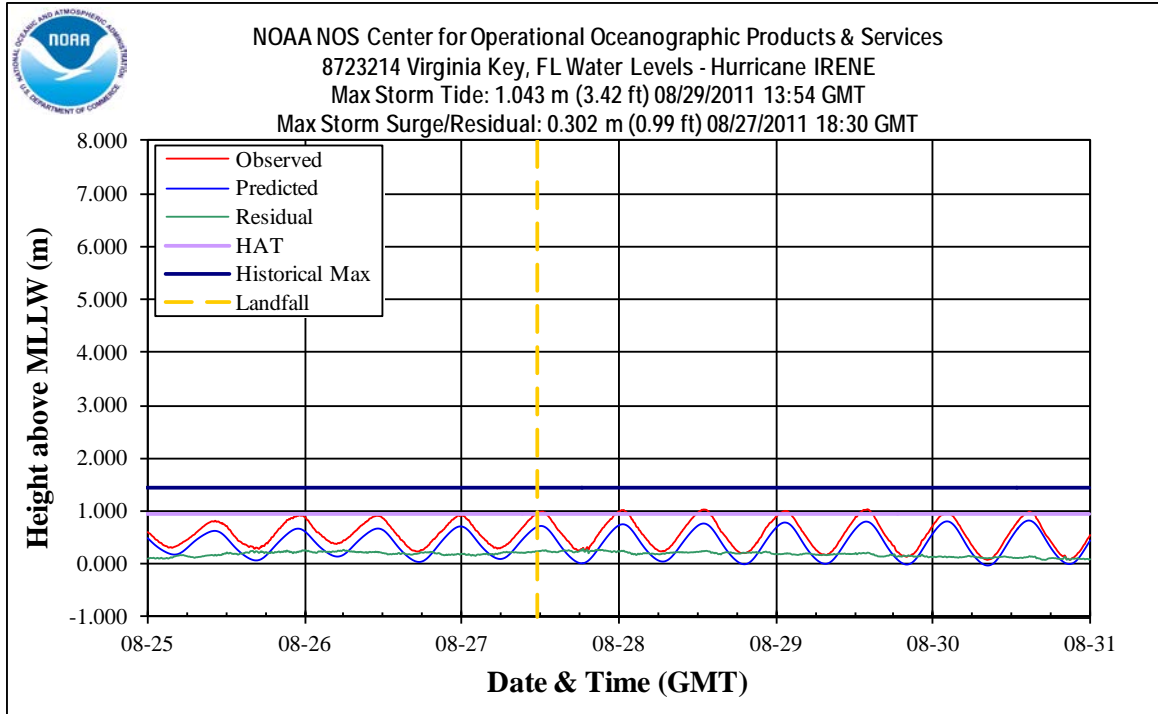


Figure 20: Water levels above Mean Lower Low Water (MLLW) at Virginia Key, FL. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. The maximum storm tide and/or storm surge did not coincide with the timing of Irene. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

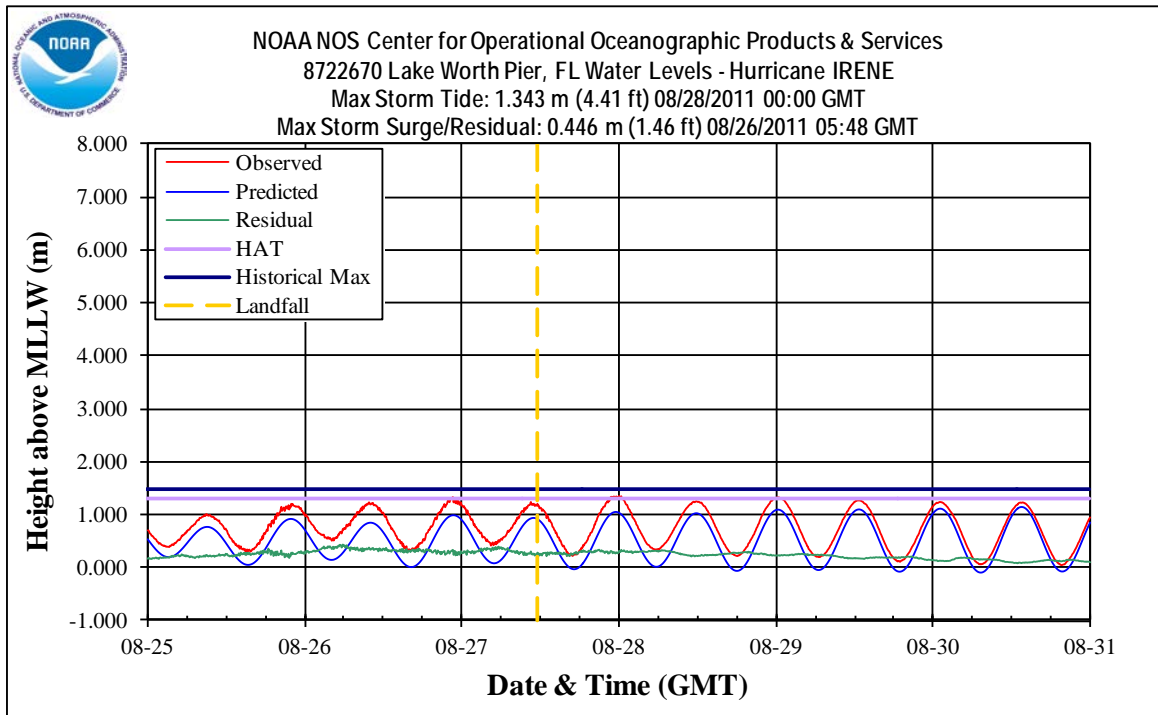


Figure 21: Water levels above Mean Lower Low Water (MLLW) at Lake Worth Pier, FL. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. The maximum storm tide and/or storm surge did not coincide with the timing of Irene. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

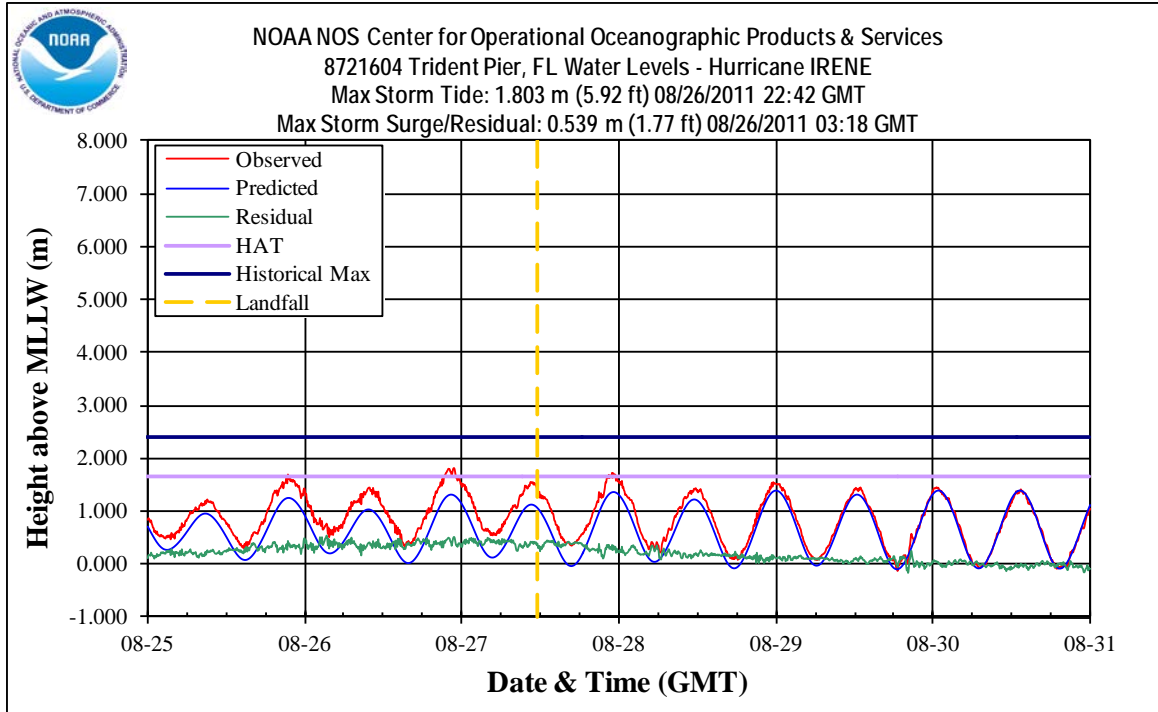


Figure 22: Water levels above Mean Lower Low Water (MLLW) at Trident Pier, FL. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

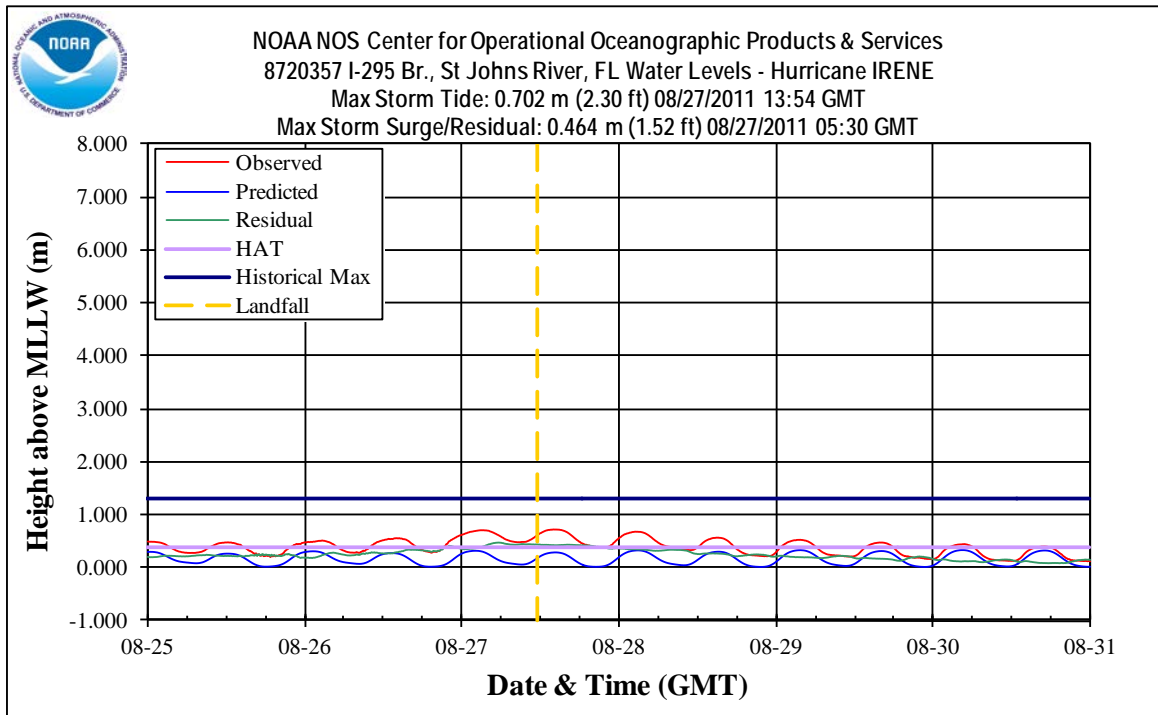


Figure 23: Water levels above Mean Lower Low Water (MLLW) at I-295 Bridge, St. Johns River, FL. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

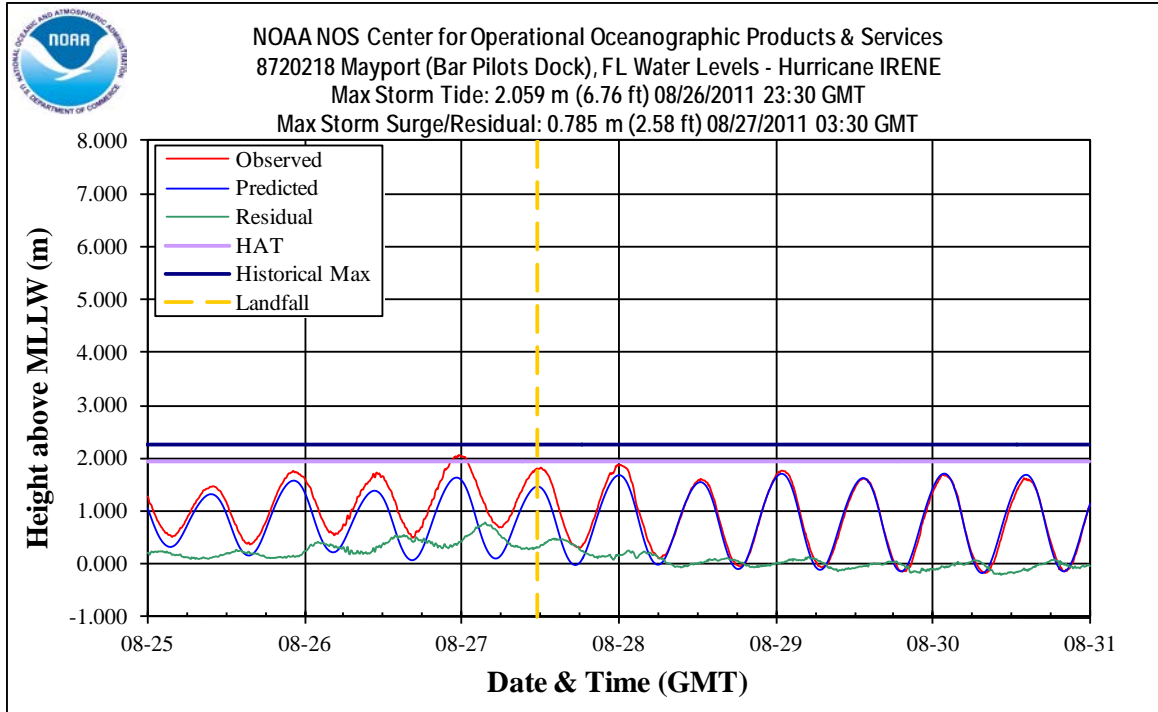


Figure 24: Water levels above Mean Lower Low Water (MLLW) at Maypor (Bar Pilots Dock), FL. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

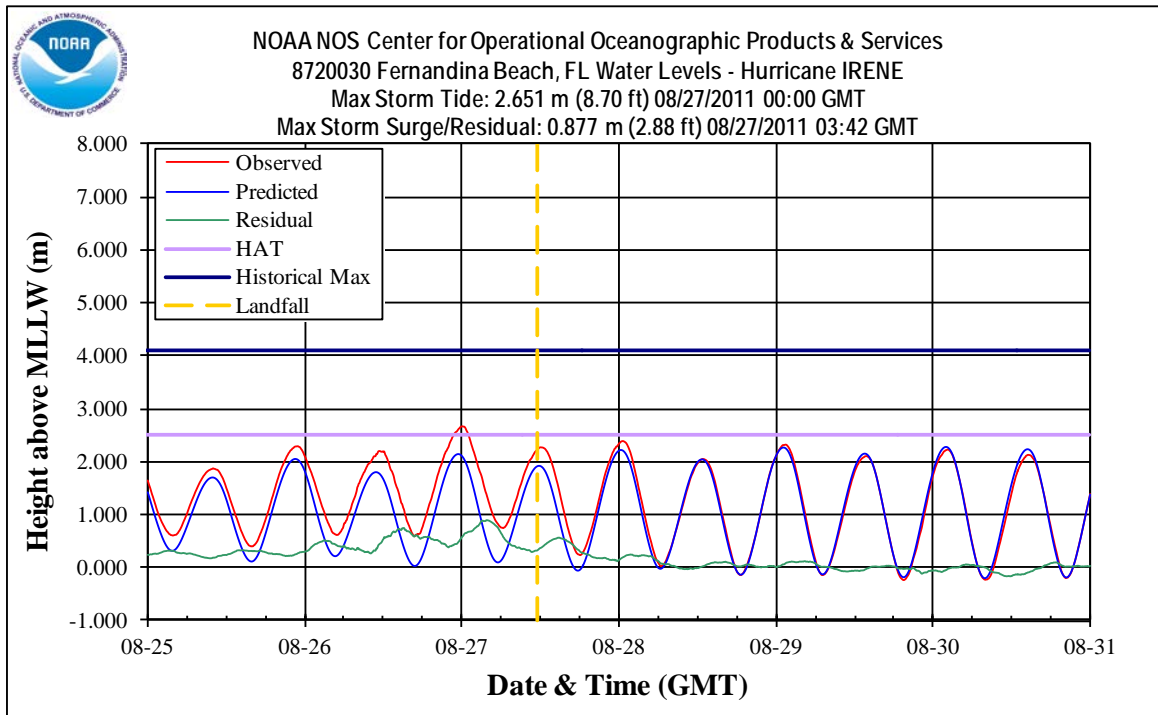


Figure 25: Water levels above Mean Lower Low Water (MLLW) at Fernandina Beach, FL. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

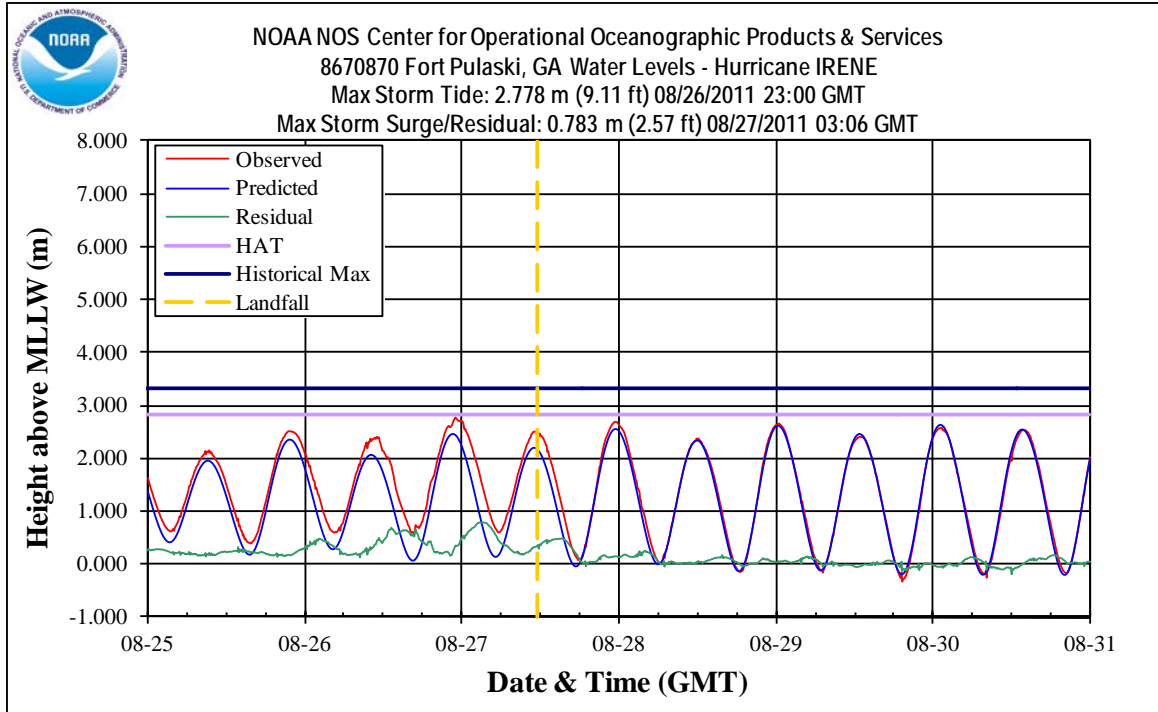


Figure 26: Water levels above Mean Lower Low Water (MLLW) at Fort Pulaski, GA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

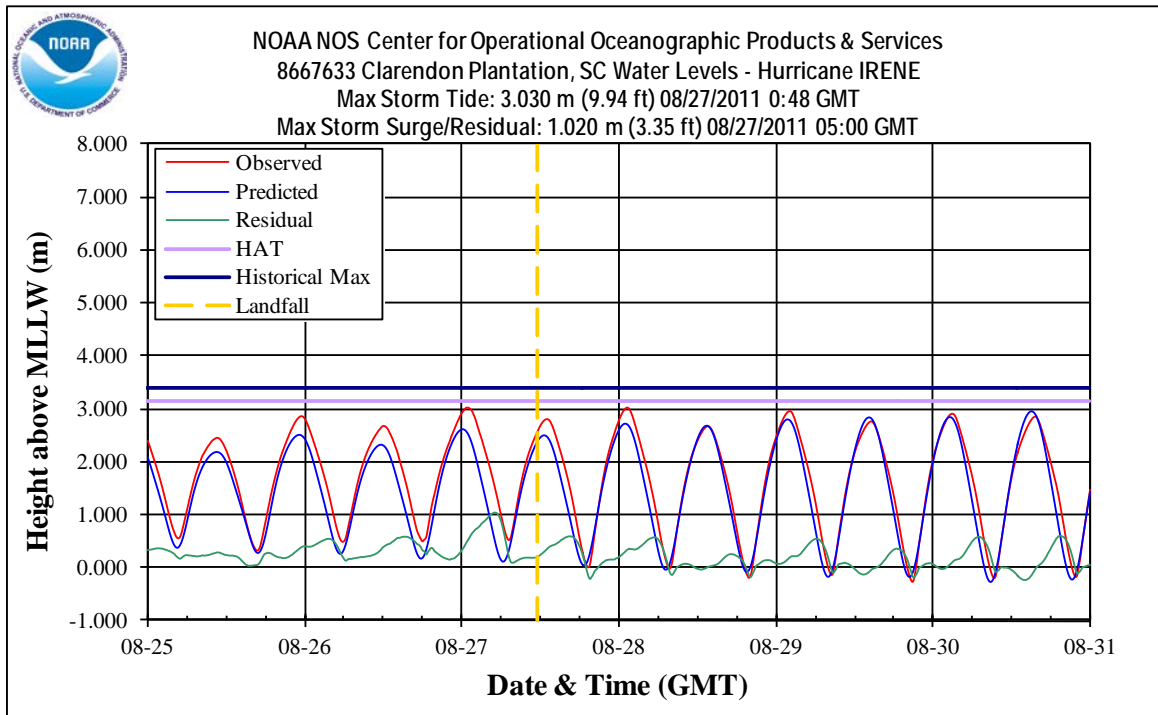


Figure 27: Water levels above Mean Lower Low Water (MLLW) at Clarendon Plantation, SC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

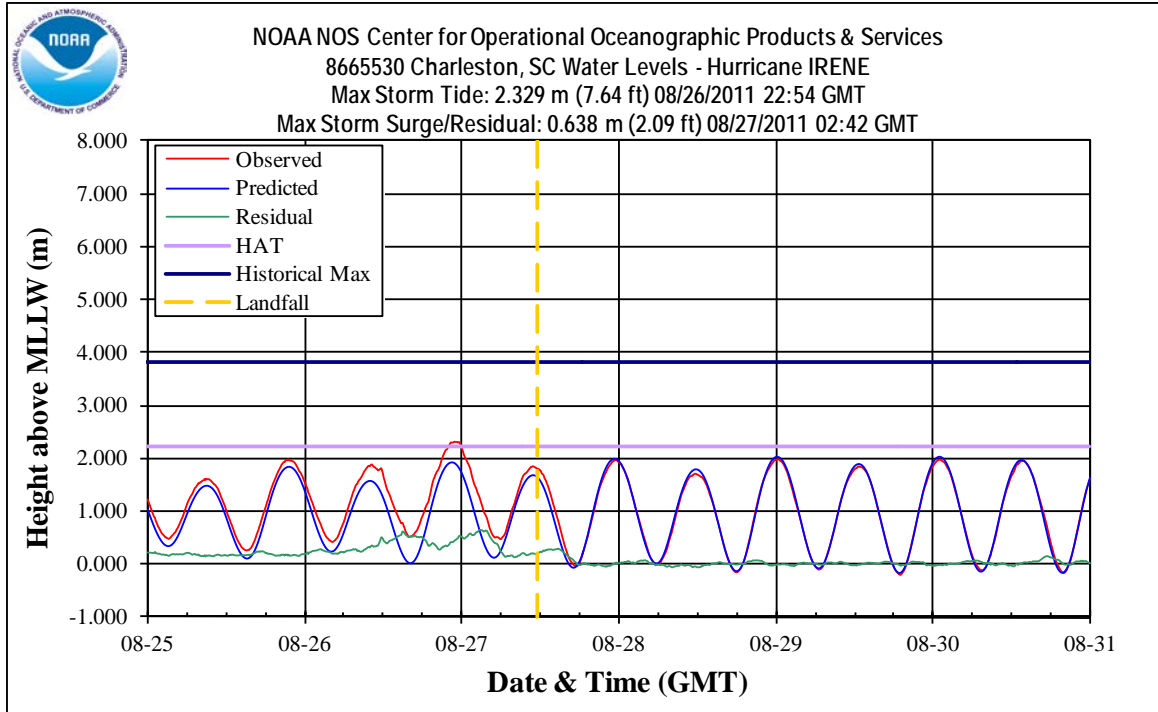


Figure 28: Water levels above Mean Lower Low Water (MLLW) at Charleston, SC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

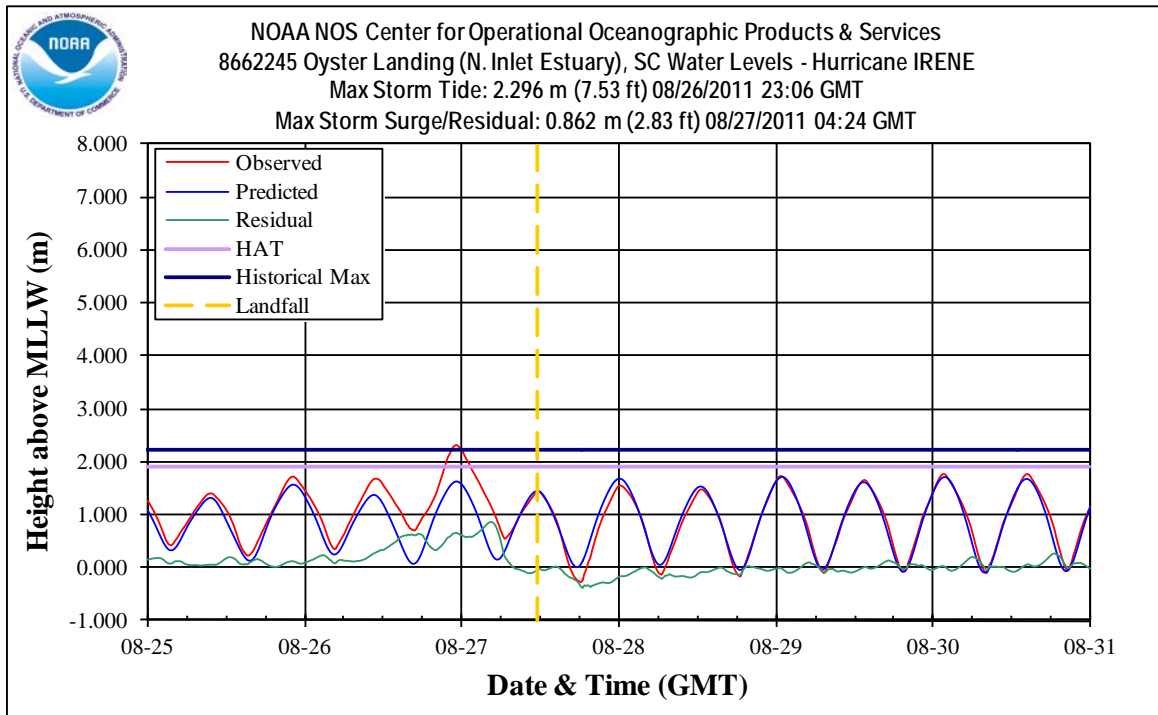


Figure 29: Water levels above Mean Lower Low Water (MLLW) at Oyster Landing (N. Inlet Estuary), SC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded historical recorded maximum tide level. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

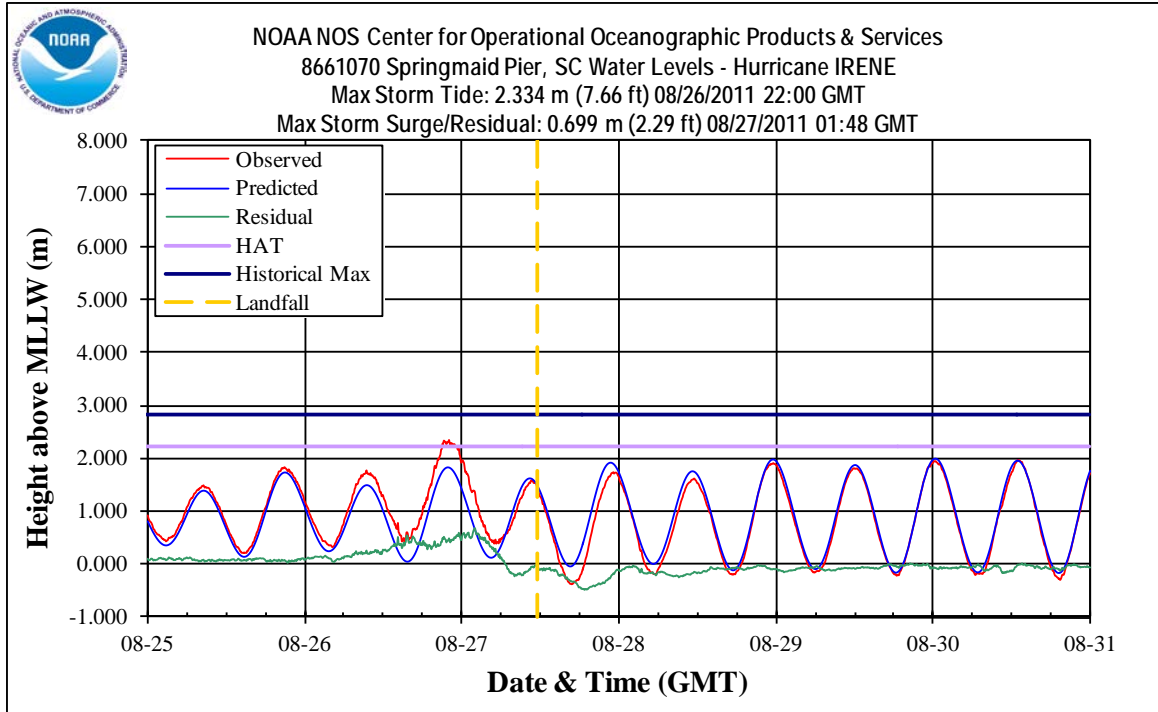


Figure 30: Water levels above Mean Lower Low Water (MLLW) at Springmaid Pier, SC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

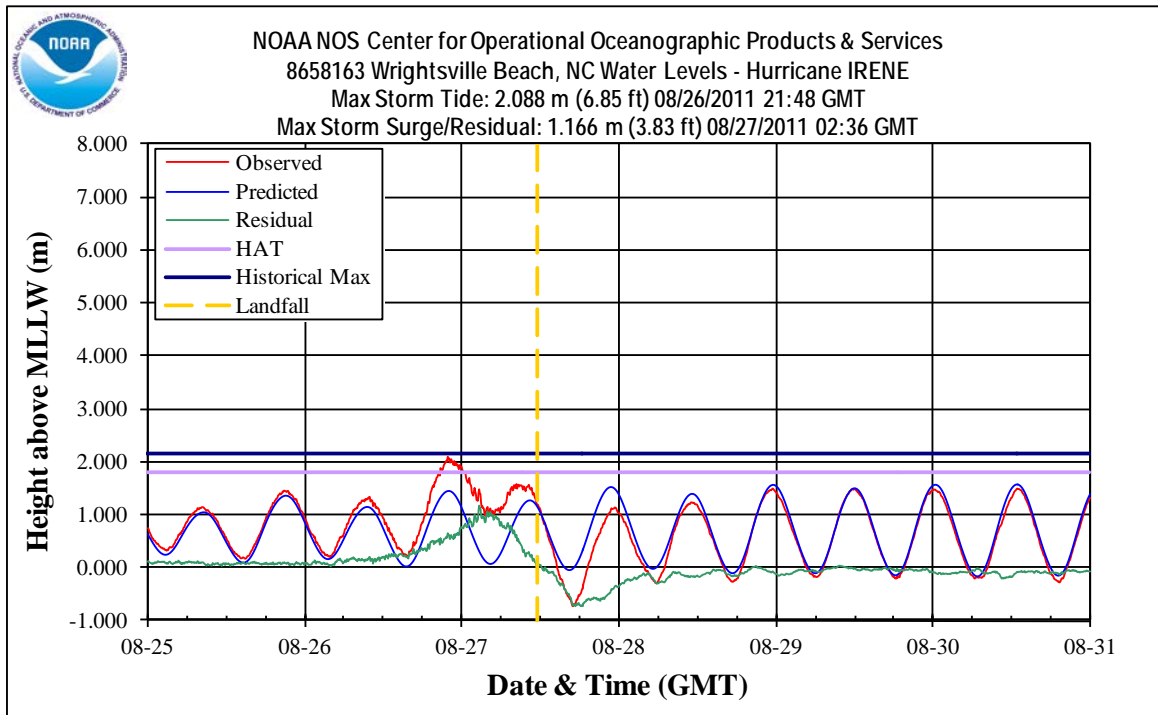


Figure 31: Water levels above Mean Lower Low Water (MLLW) at Wrightsville Beach, NC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

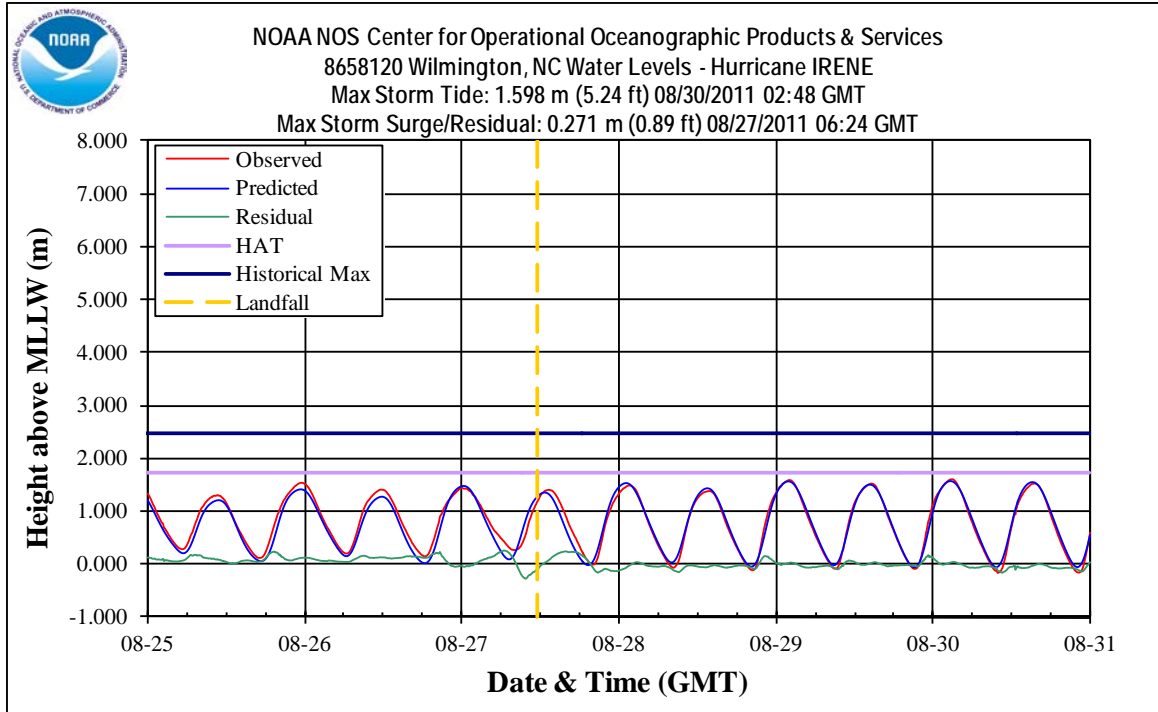


Figure 32: Water levels above Mean Lower Low Water (MLLW) at Wilmington NC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

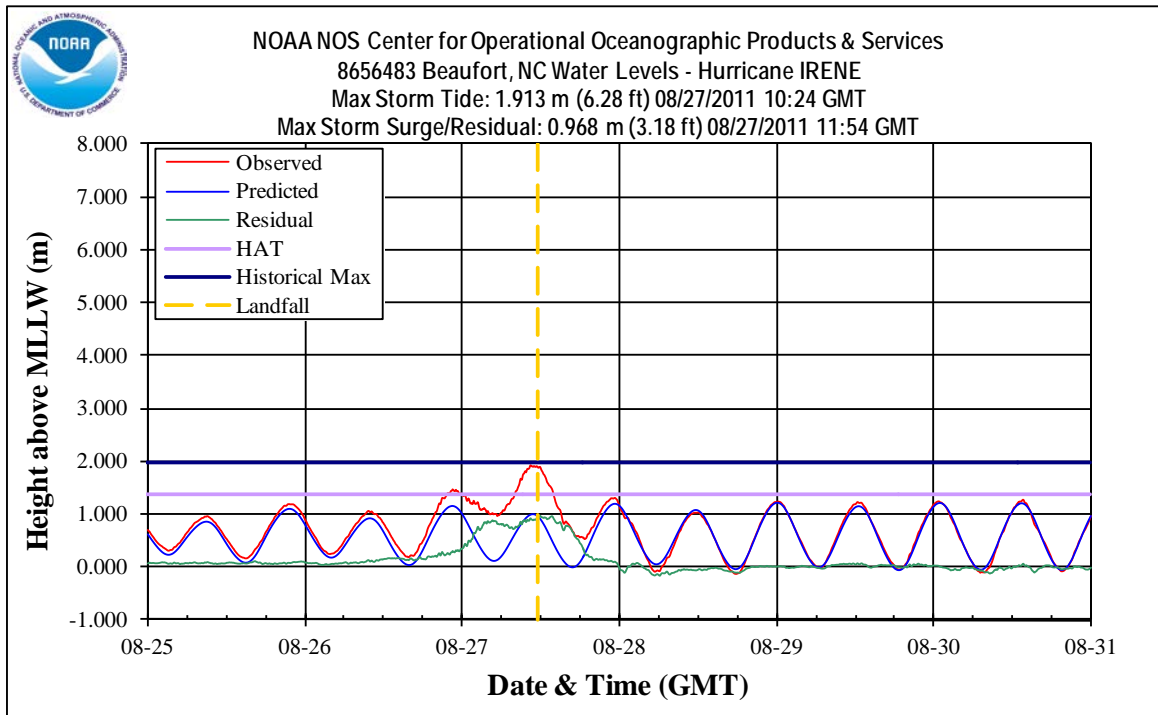


Figure 33: Water levels above Mean Lower Low Water (MLLW) at Beaufort, NC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.



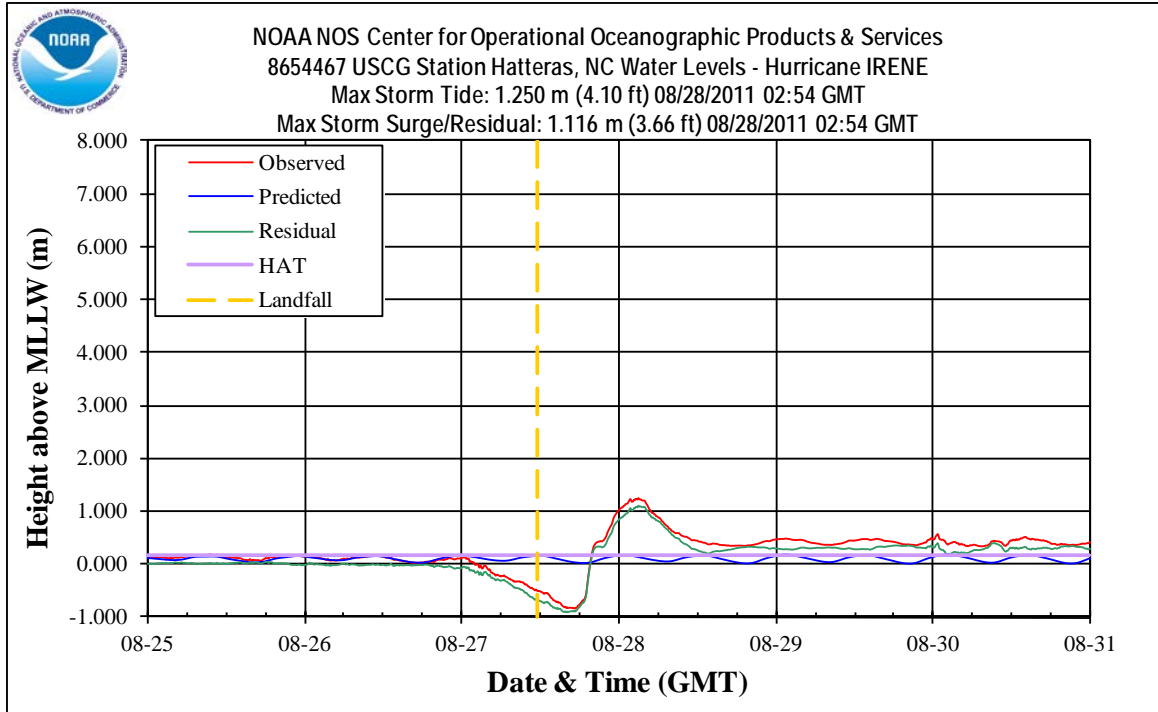


Figure 34: Water levels above Mean Lower Low Water (MLLW) at USCG Station Hatteras, NC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

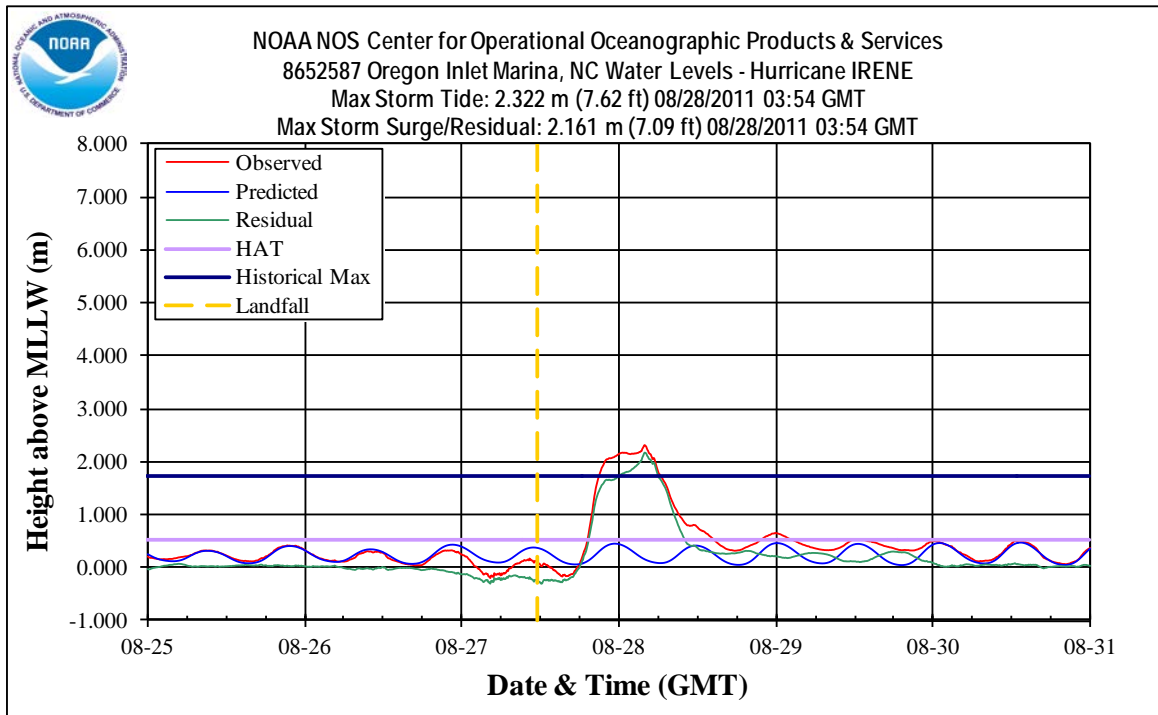


Figure 35: Water levels above Mean Lower Low Water (MLLW) at Oregon Inlet Marina, NC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded historical recorded maximum tide level. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

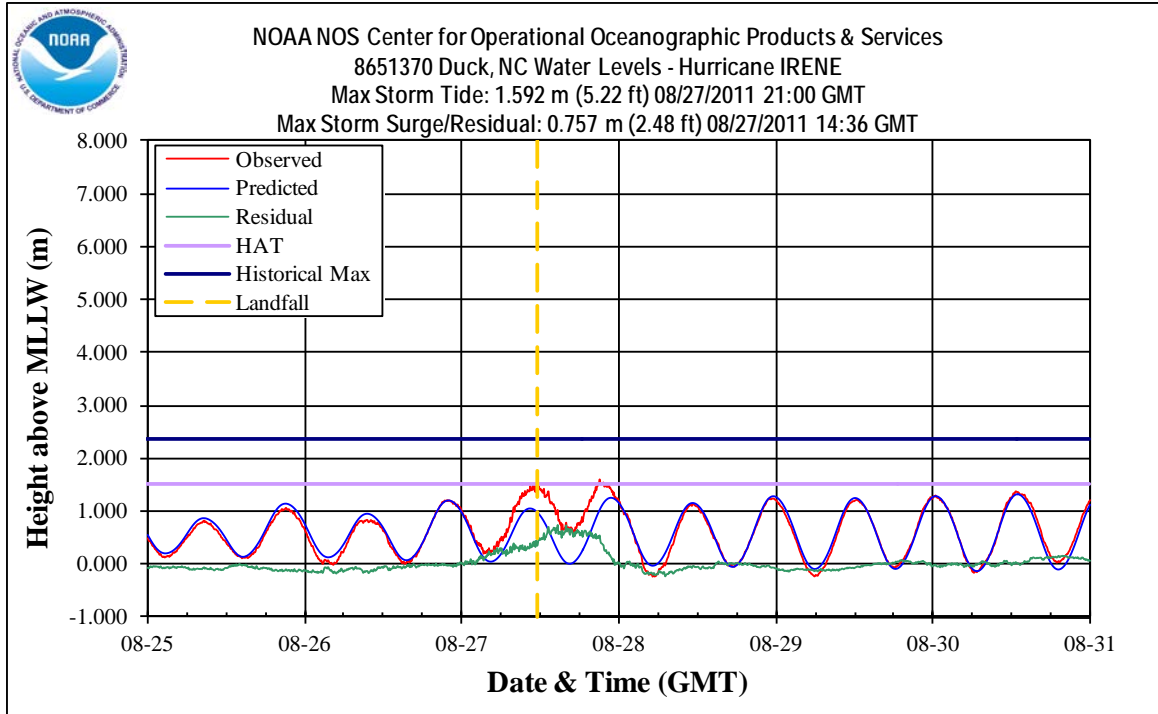


Figure 36: Water levels above Mean Lower Low Water (MLLW) at Duck, NC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

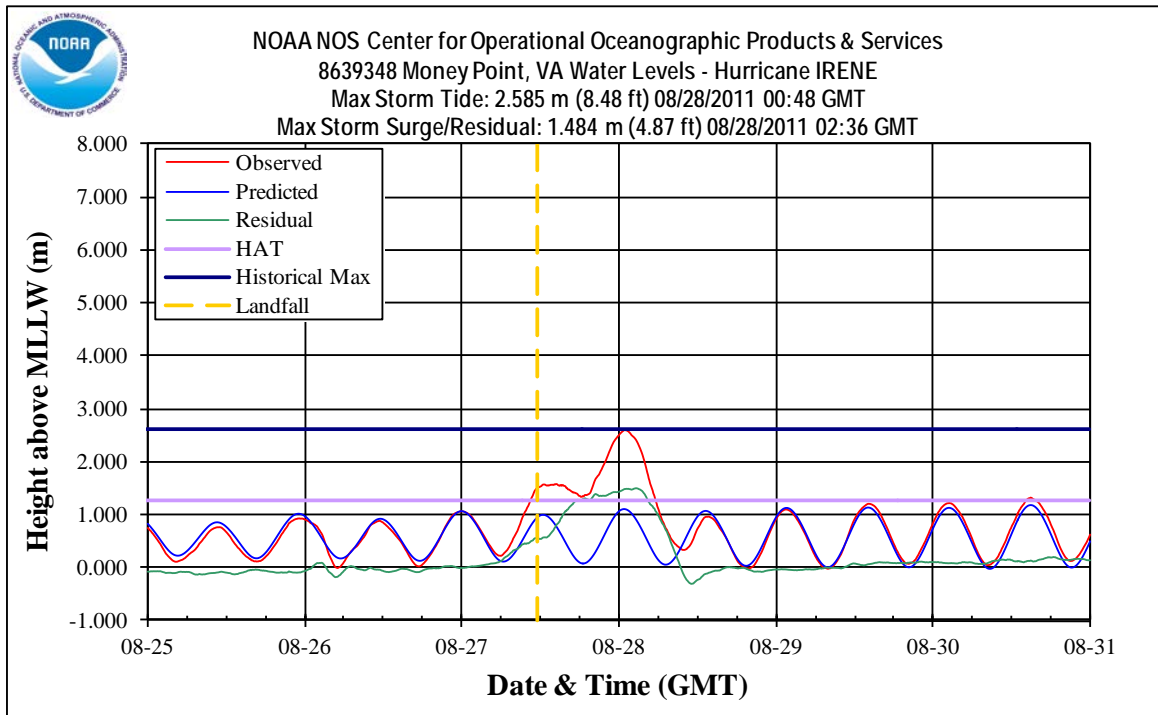


Figure 37: Water levels above Mean Lower Low Water (MLLW) at Money Point, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

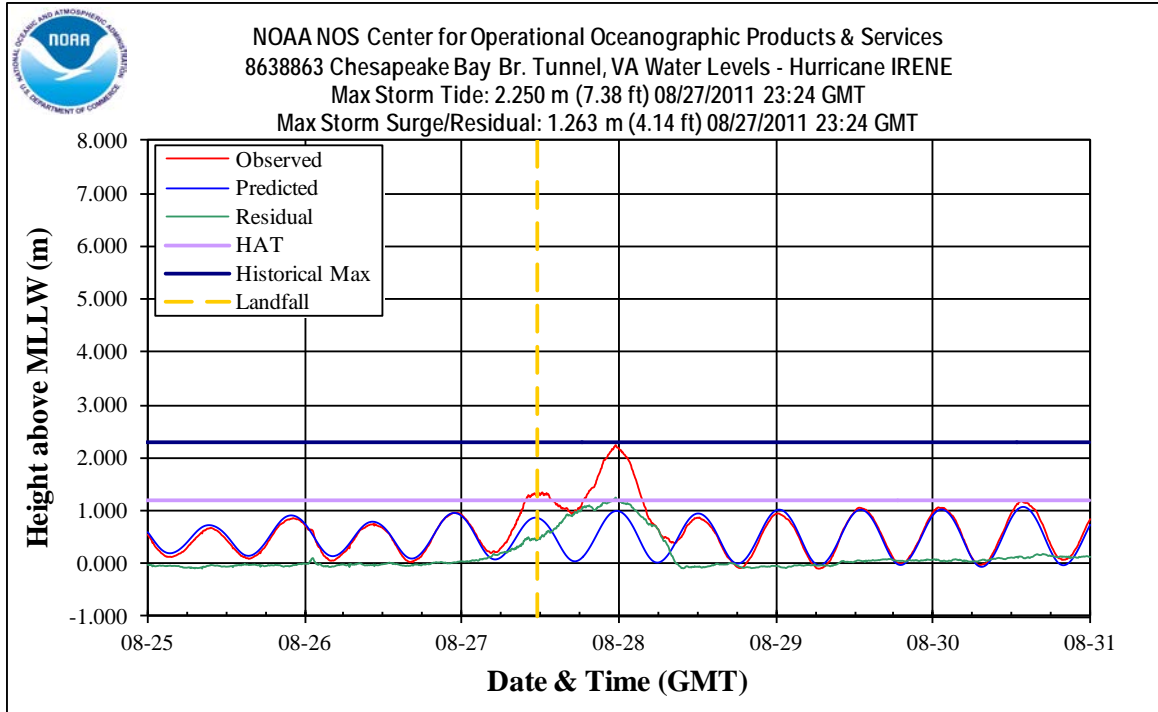


Figure 38: Water levels above Mean Lower Low Water (MLLW) at Chesapeake Bay Bridge Tunnel, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded historical recorded maximum tide level. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

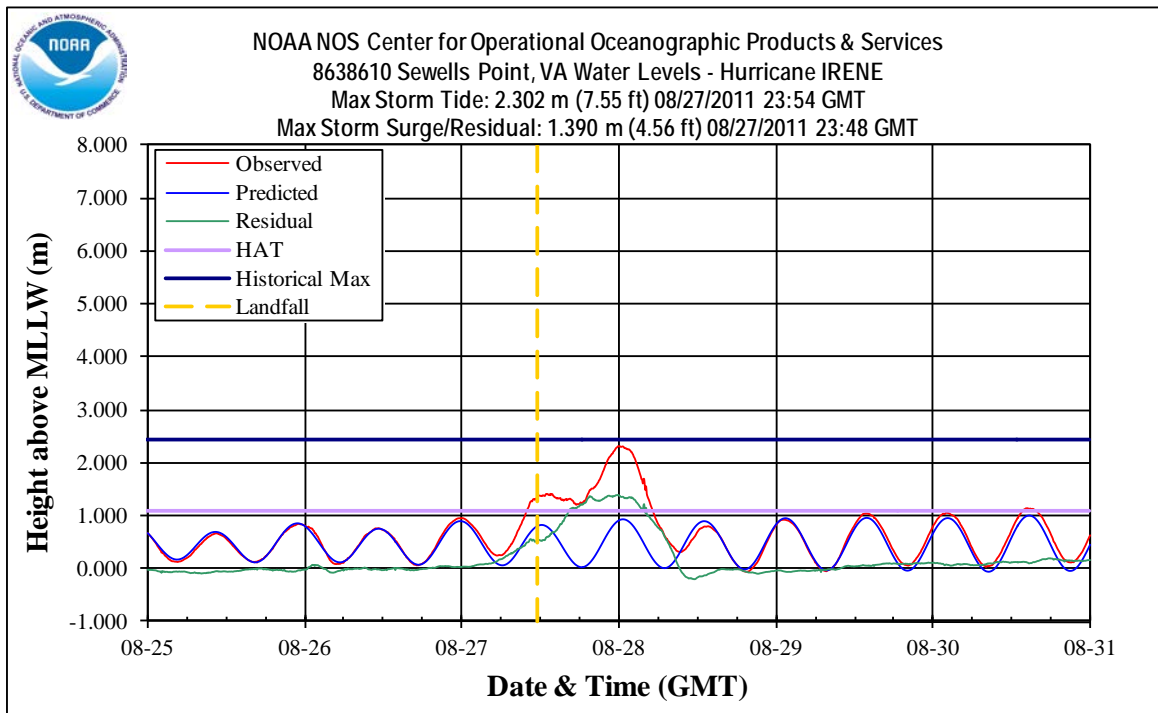


Figure 39: Water levels above Mean Lower Low Water (MLLW) at Sewells Point, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

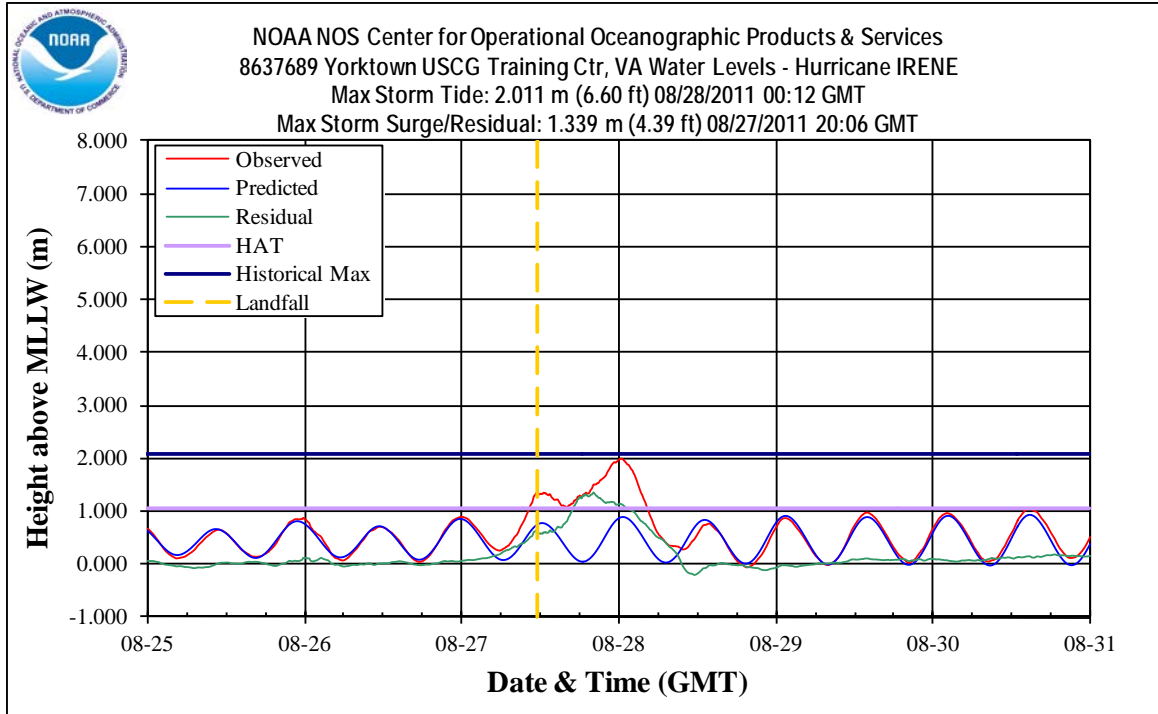


Figure 40: Water levels above Mean Lower Low Water (MLLW) at Yorktown USCG Training Center, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

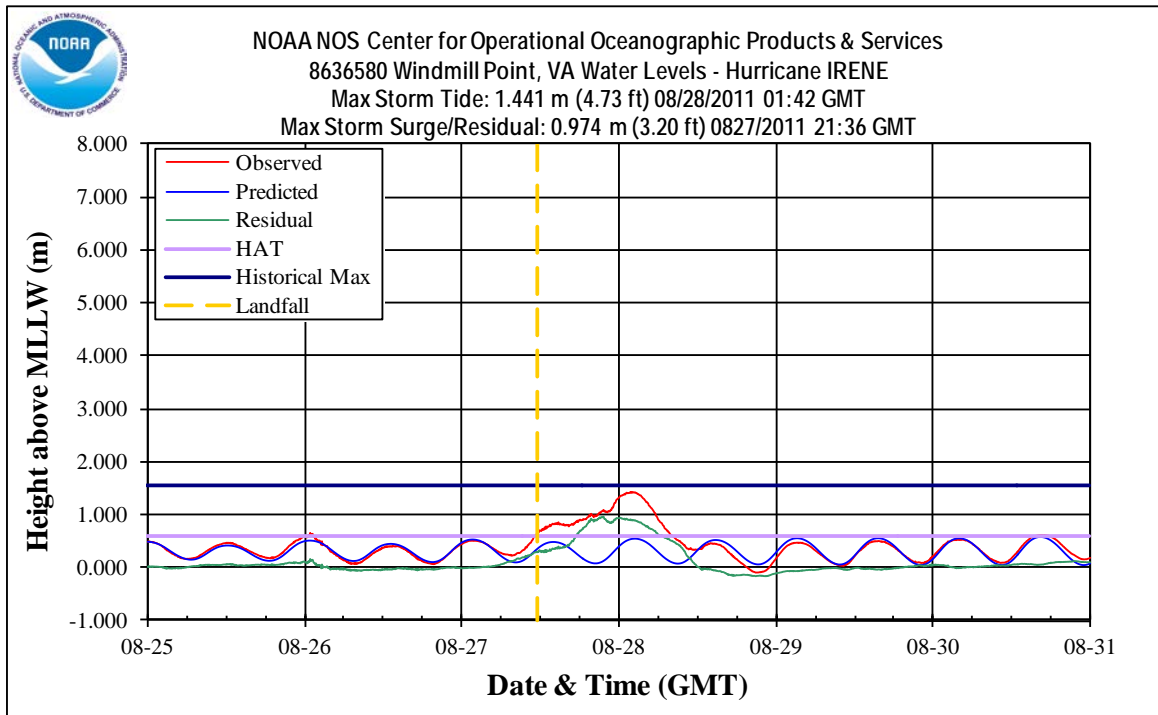


Figure 41: Water levels above Mean Lower Low Water (MLLW) at Windmill Point, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

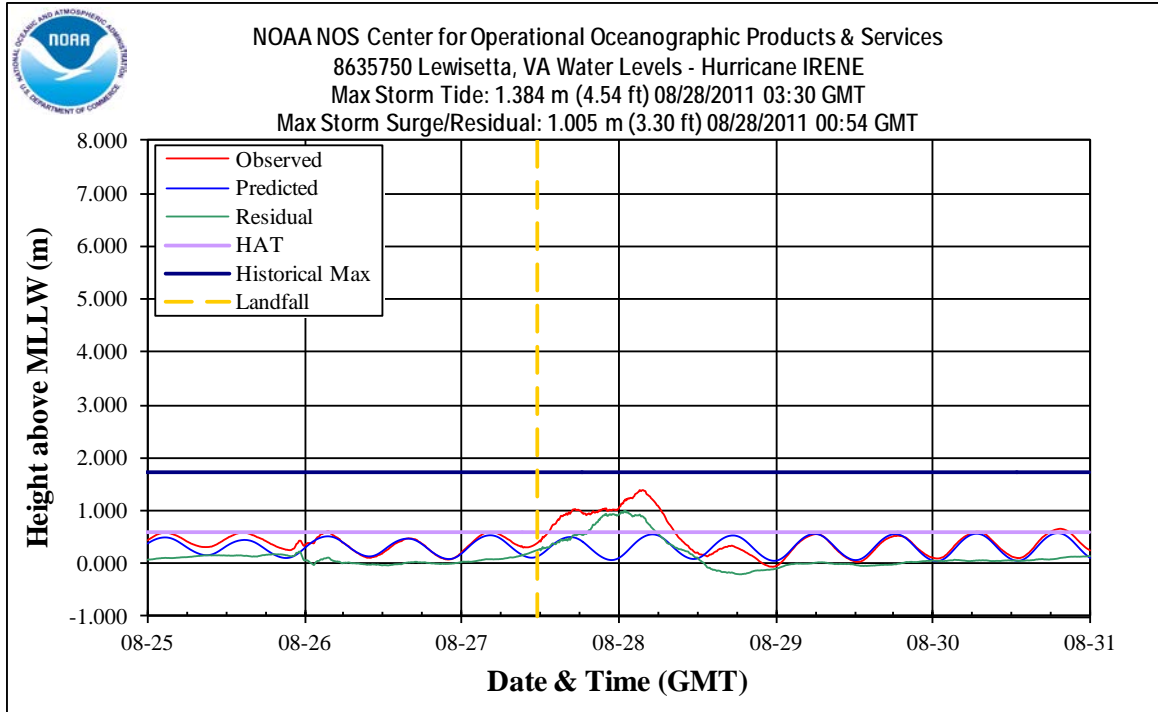


Figure 42: Water levels above Mean Lower Low Water (MLLW) at Lewisetta, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded historical recorded maximum tide level. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

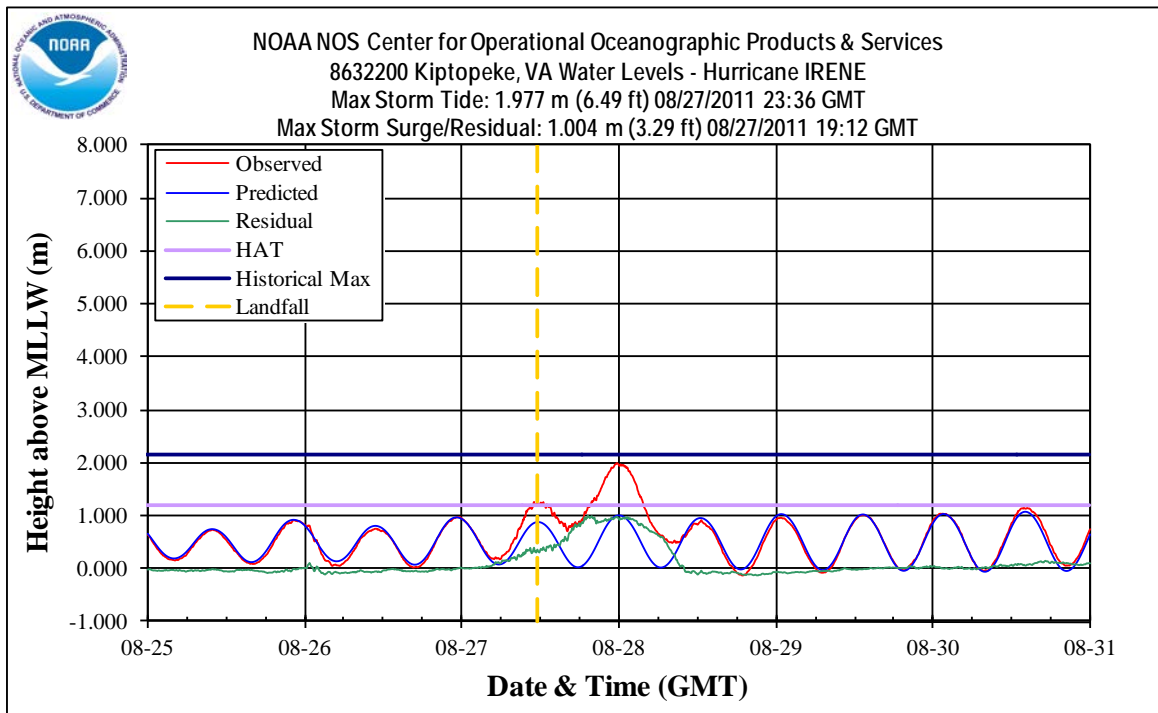


Figure 43: Water levels above Mean Lower Low Water (MLLW) at Kiptopeke, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

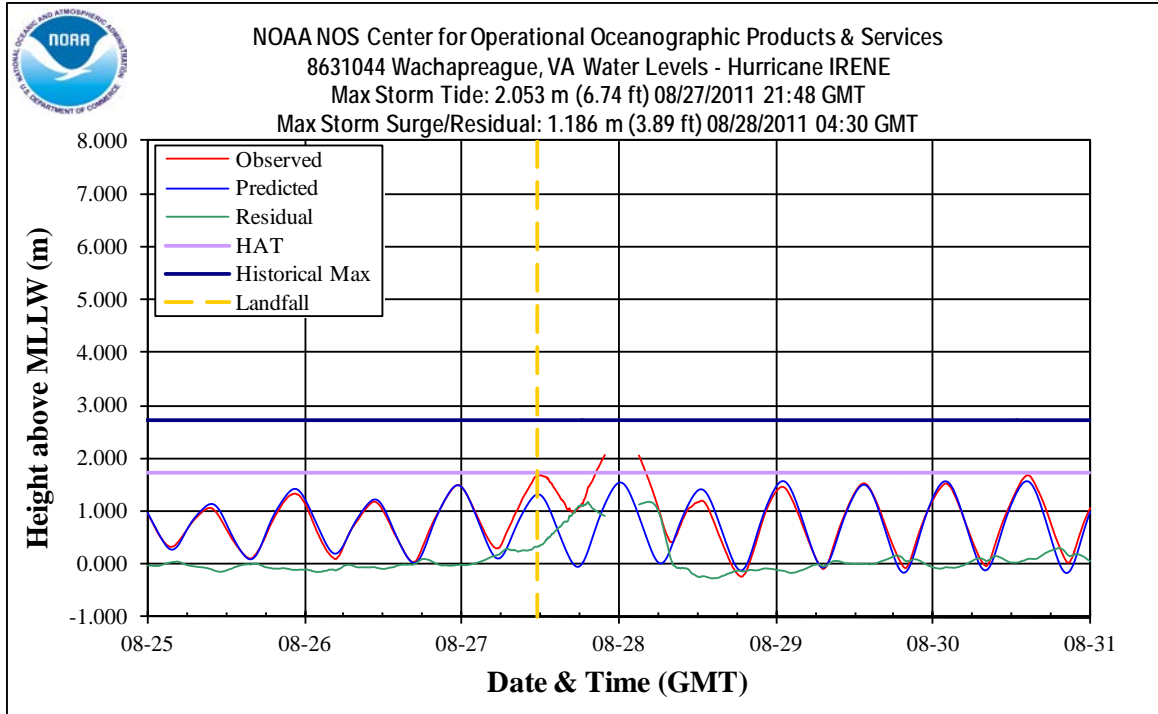


Figure 44: Water levels above Mean Lower Low Water (MLLW) at Wachapreague, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sensor reached the physical limit on measurements and did not record a maximum value. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

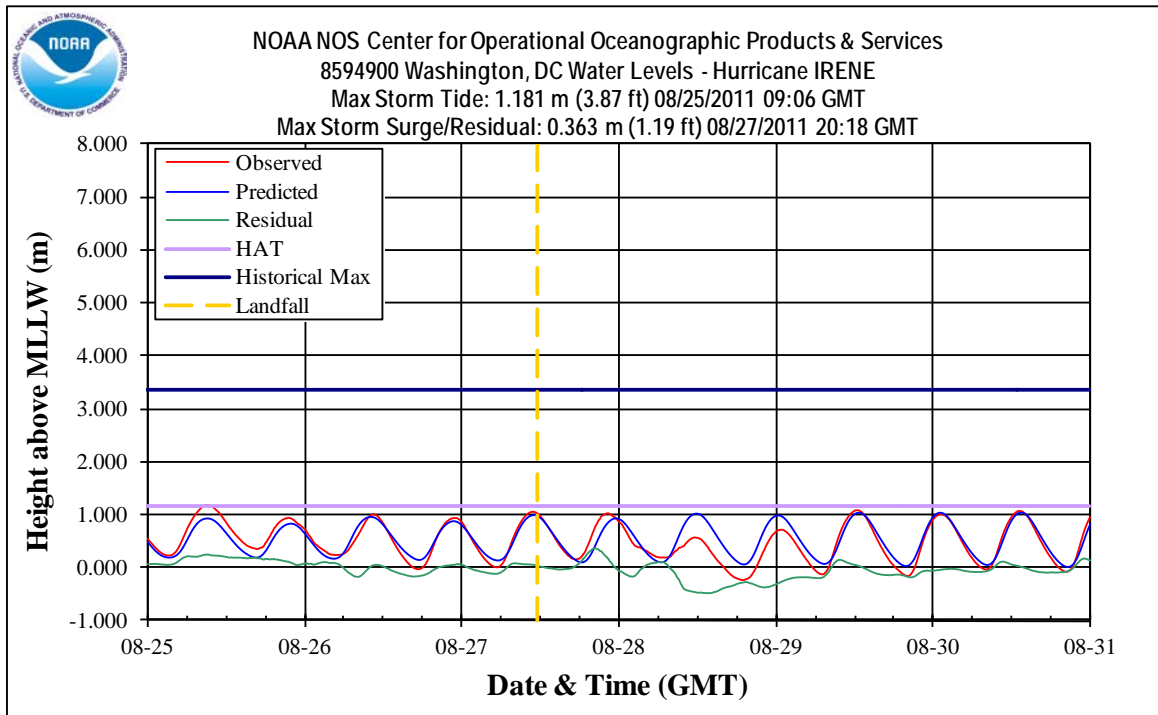


Figure 45: Water levels above Mean Lower Low Water (MLLW) at Washington, DC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. The maximum storm tide and/or storm surge did not coincide with the timing of Irene. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

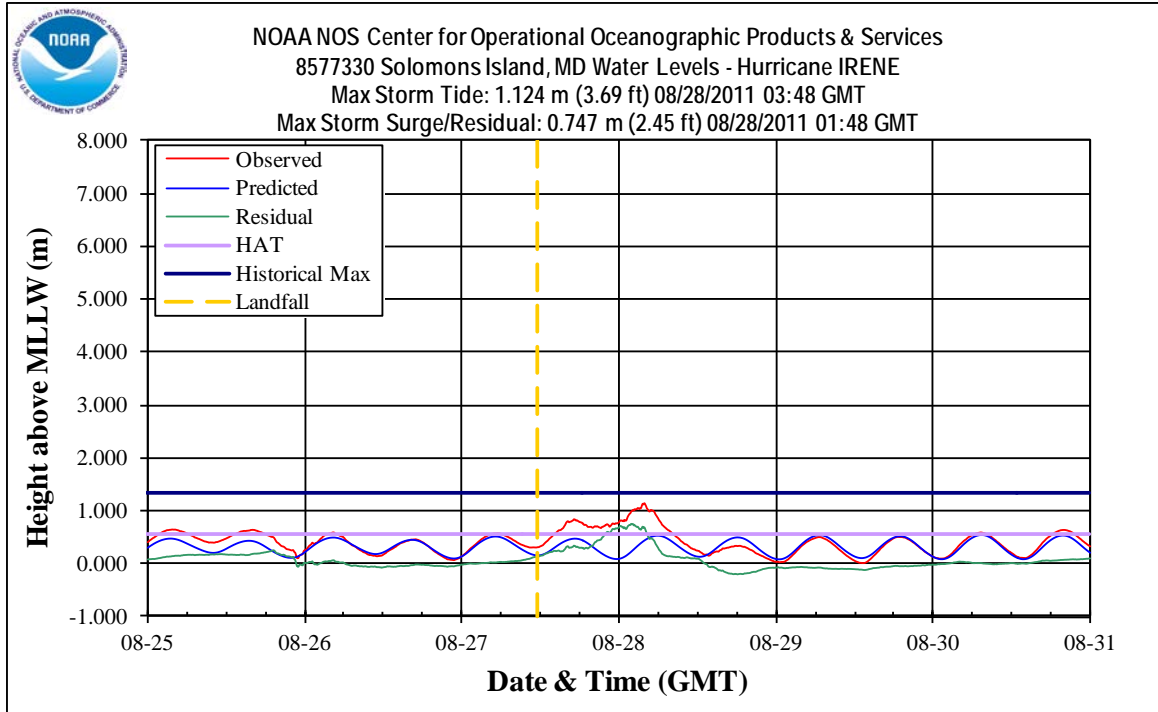


Figure 46: Water levels above Mean Lower Low Water (MLLW) at Solomons Island, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

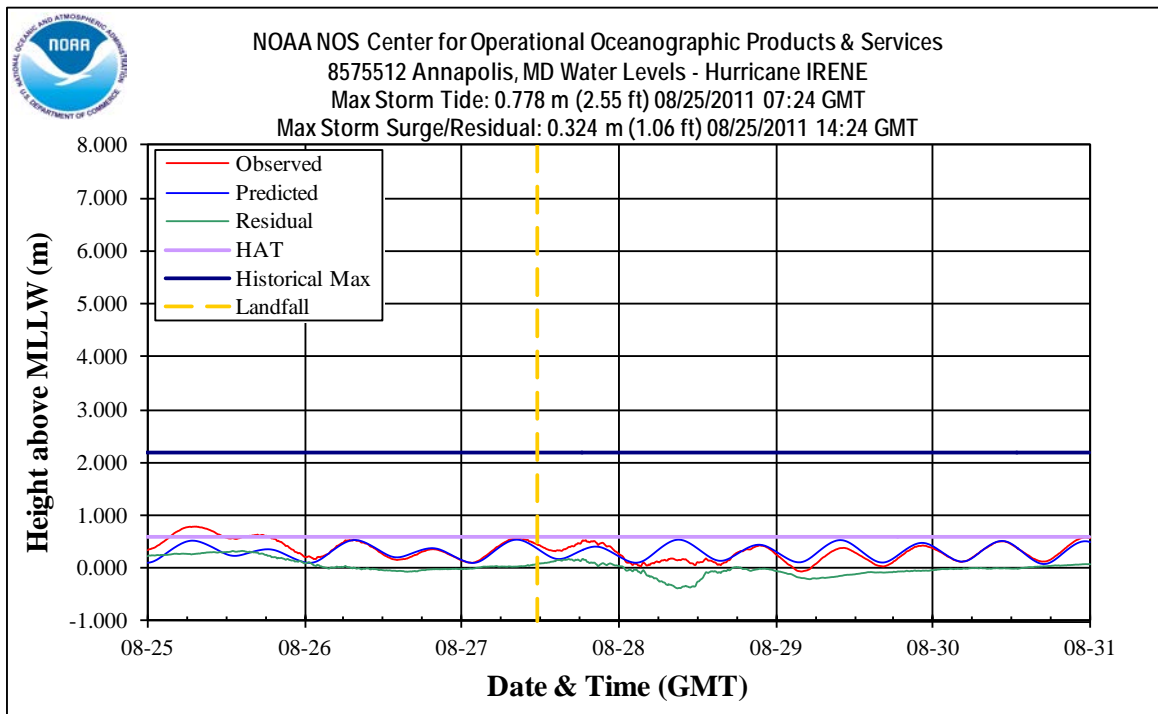


Figure 47: Water levels above Mean Lower Low Water (MLLW) at Annapolis, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. The maximum storm tide and/or storm surge did not coincide with the timing of Irene. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

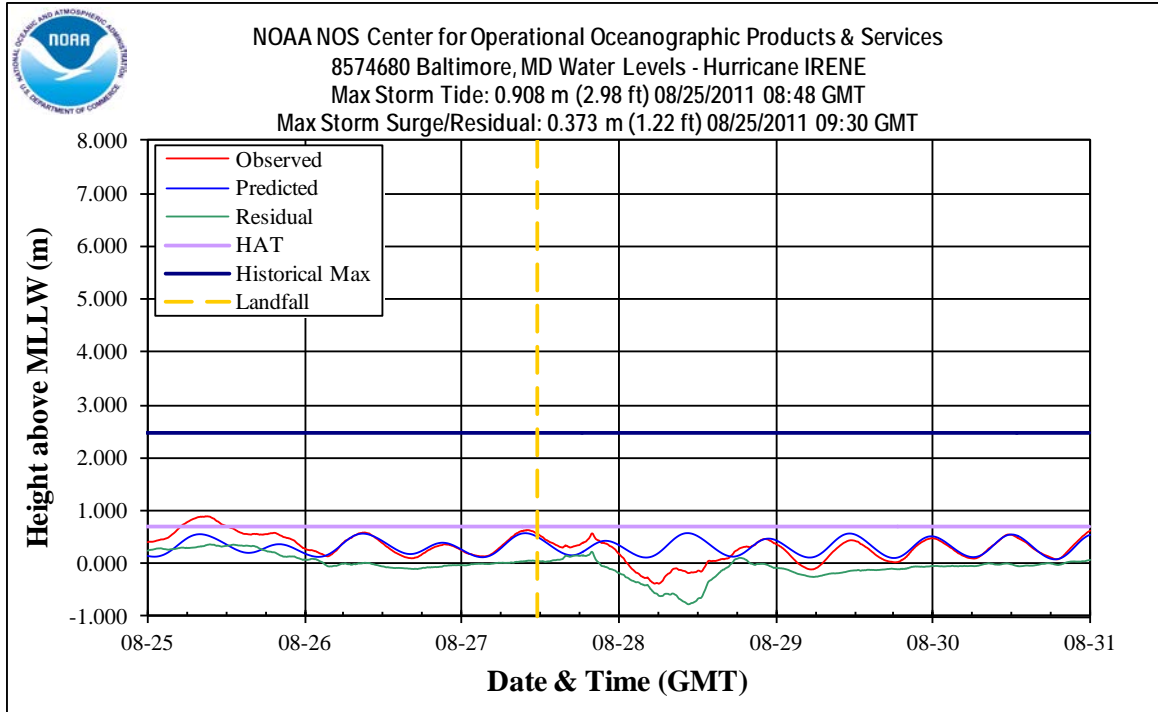


Figure 48: Water levels above Mean Lower Low Water (MLLW) at Baltimore, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. The maximum storm tide and/or storm surge did not coincide with the timing of Irene. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

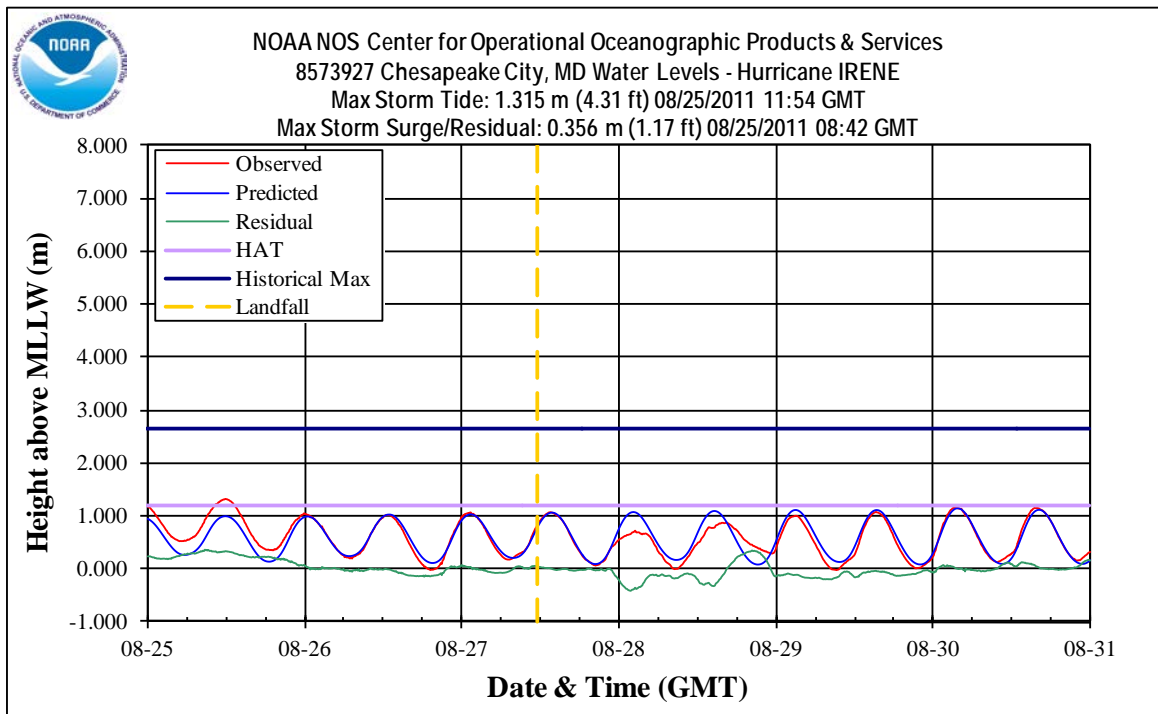


Figure 49: Water levels above Mean Lower Low Water (MLLW) at Chesapeake City, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. The maximum storm tide and/or storm surge did not coincide with the timing of Irene. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.



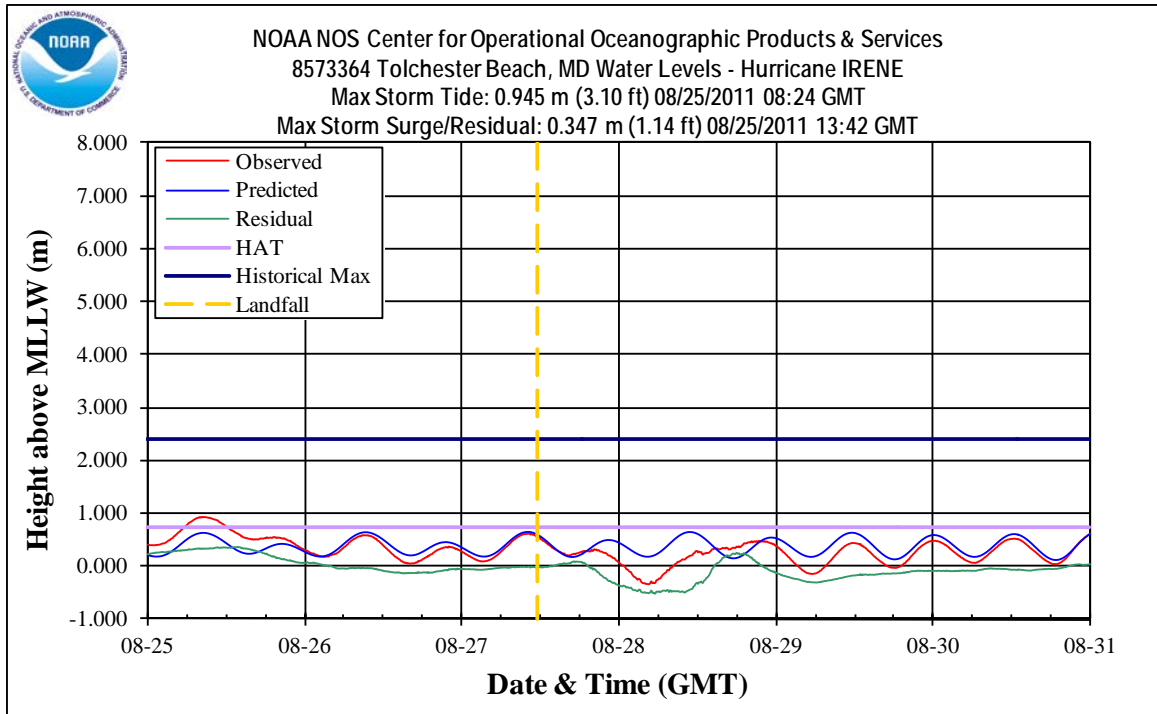


Figure 50: Water levels above Mean Lower Low Water (MLLW) at Tolchester Beach, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. The maximum storm tide and/or storm surge did not coincide with the timing of Irene. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

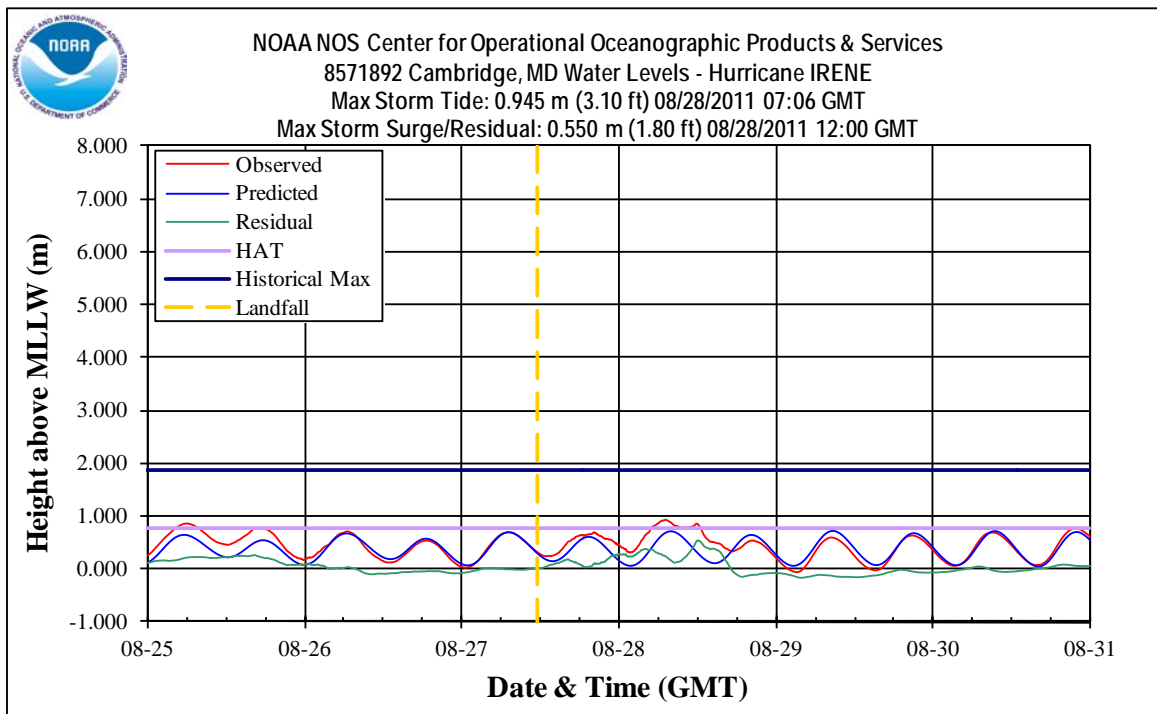


Figure 51: Water levels above Mean Lower Low Water (MLLW) at Cambridge, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

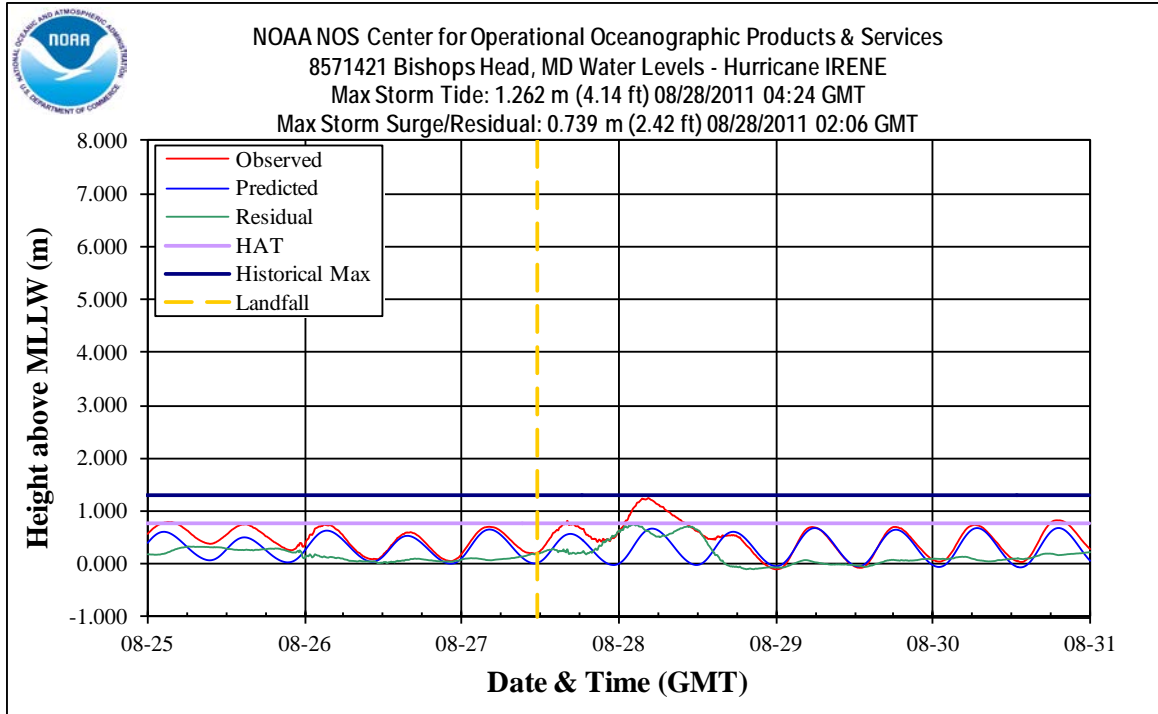


Figure 52: Water levels above Mean Lower Low Water (MLLW) at Bishops Head, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

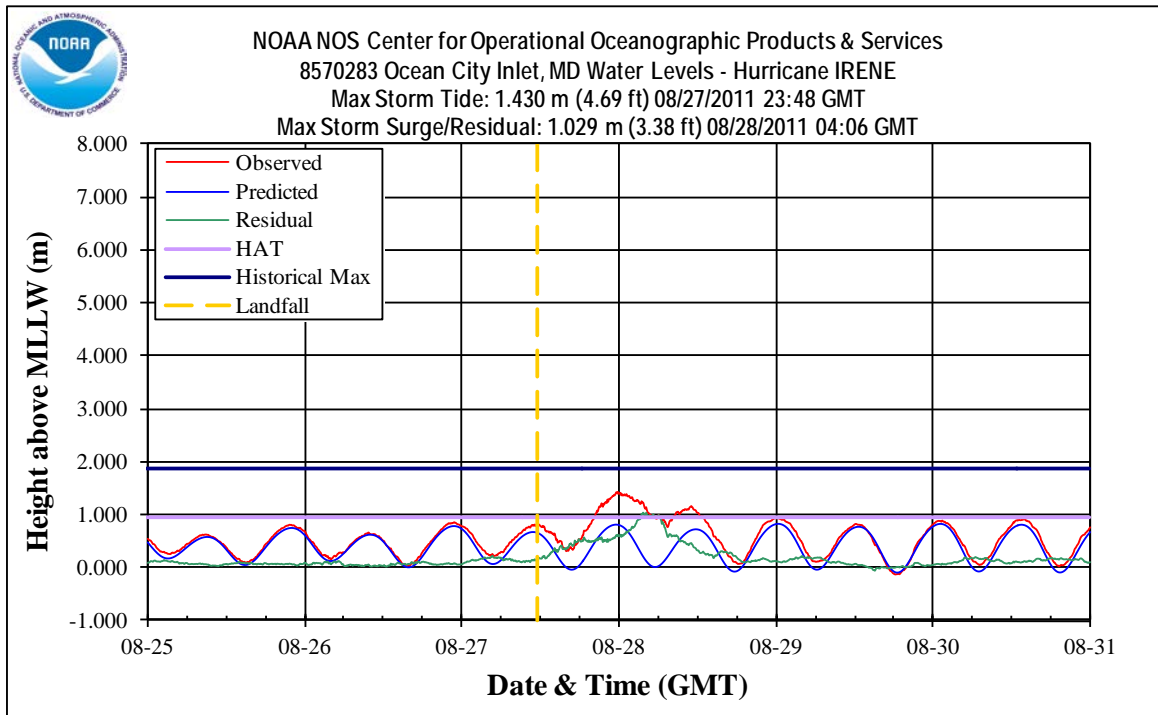


Figure 53: Water levels above Mean Lower Low Water (MLLW) at Ocean City Inlet, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made landfall near Cape Lookout, NC on 8/27/2011 11:30 GMT.

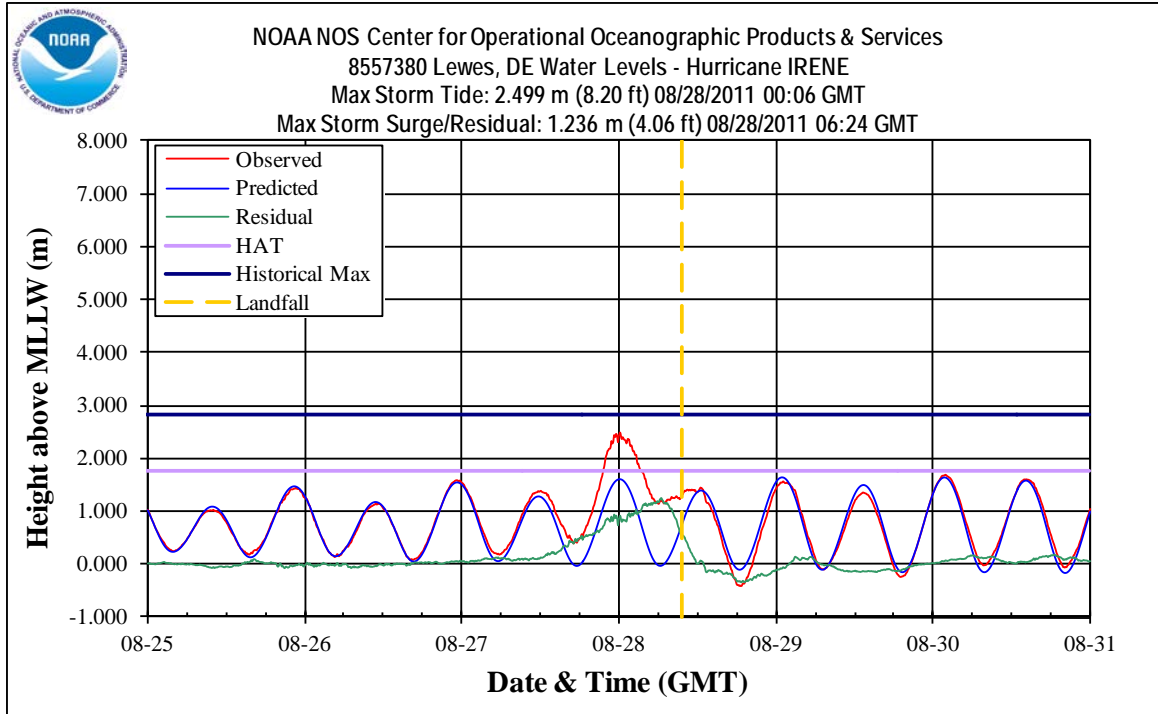


Figure 54: Water levels above Mean Lower Low Water (MLLW) at Lewes, DE. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

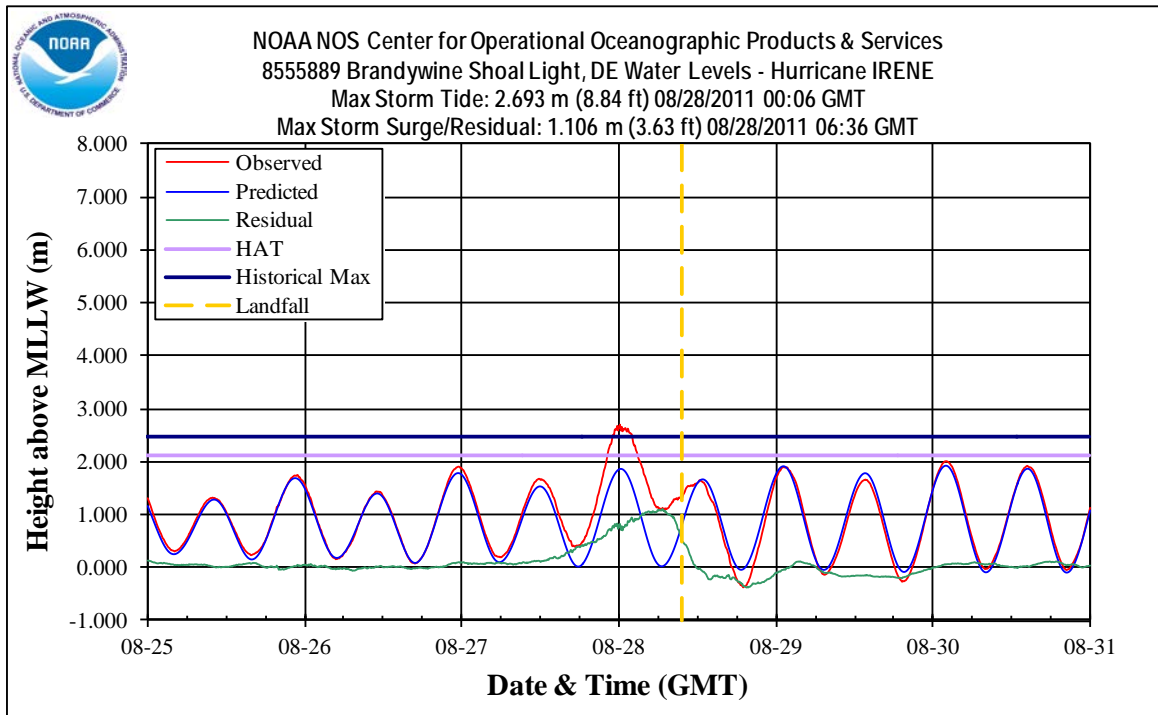


Figure 55: Water levels above Mean Lower Low Water (MLLW) at Brandywine Shoal Light, DE. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded historical recorded maximum tide level. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

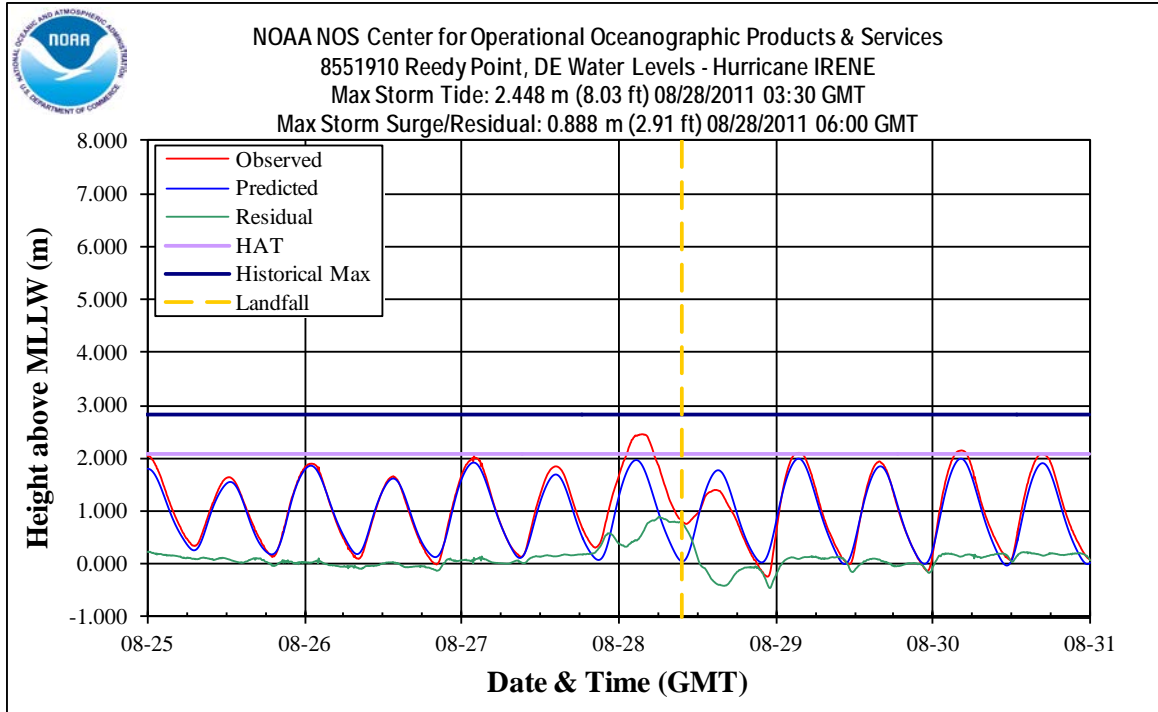


Figure 56: Water levels above Mean Lower Low Water (MLLW) at Reedy Point, DE. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum storm tide/storm surge includes likely effects from runoff. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

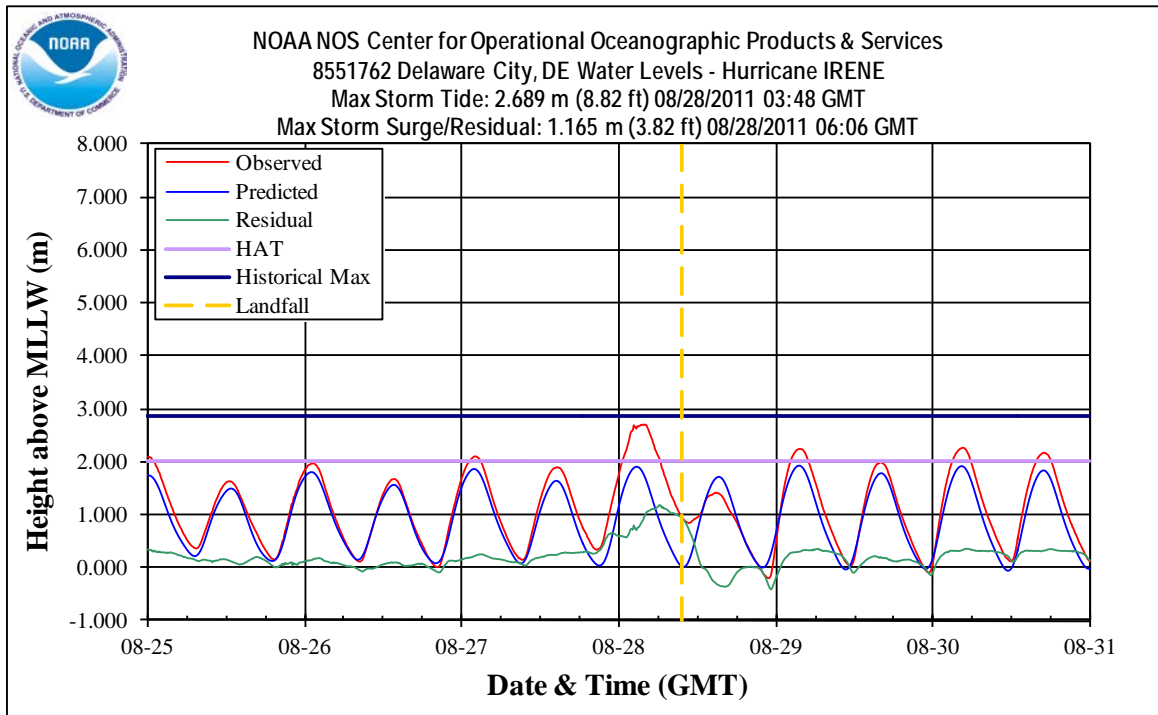


Figure 57: Water levels above Mean Lower Low Water (MLLW) at Delaware City, DE. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum storm tide/storm surge includes likely effects from runoff. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

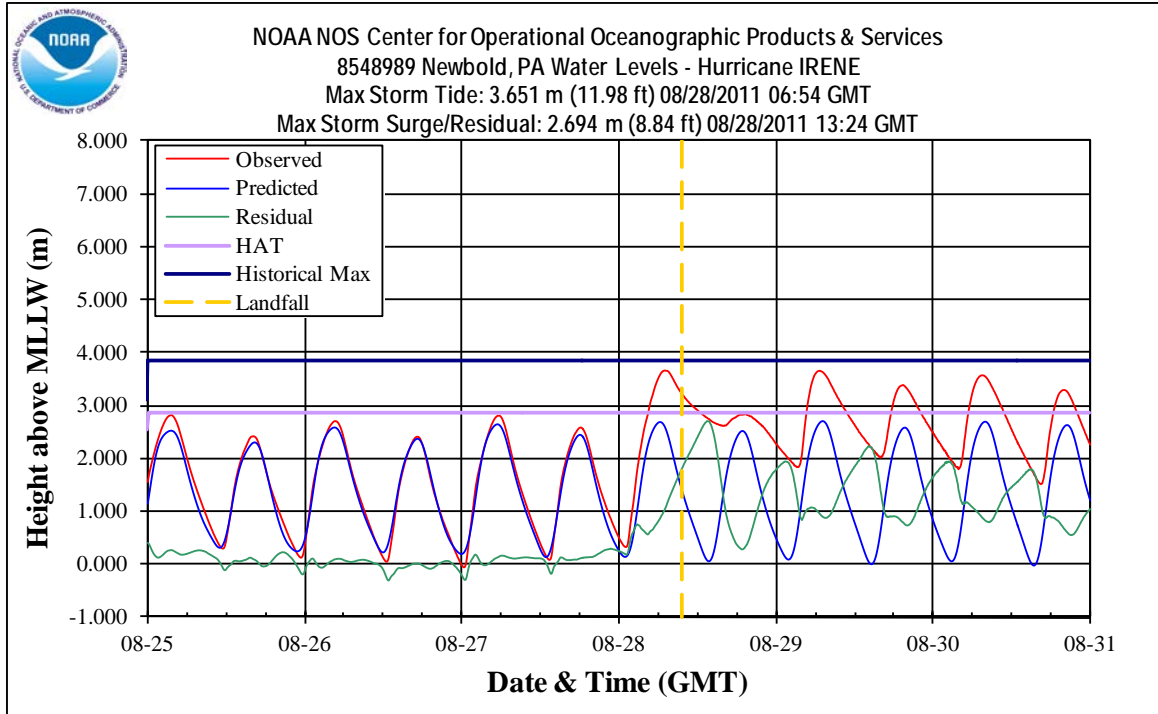


Figure 58: Water levels above Mean Lower Low Water (MLLW) at Newbold, PA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum storm tide/storm surge includes likely effects from runoff. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

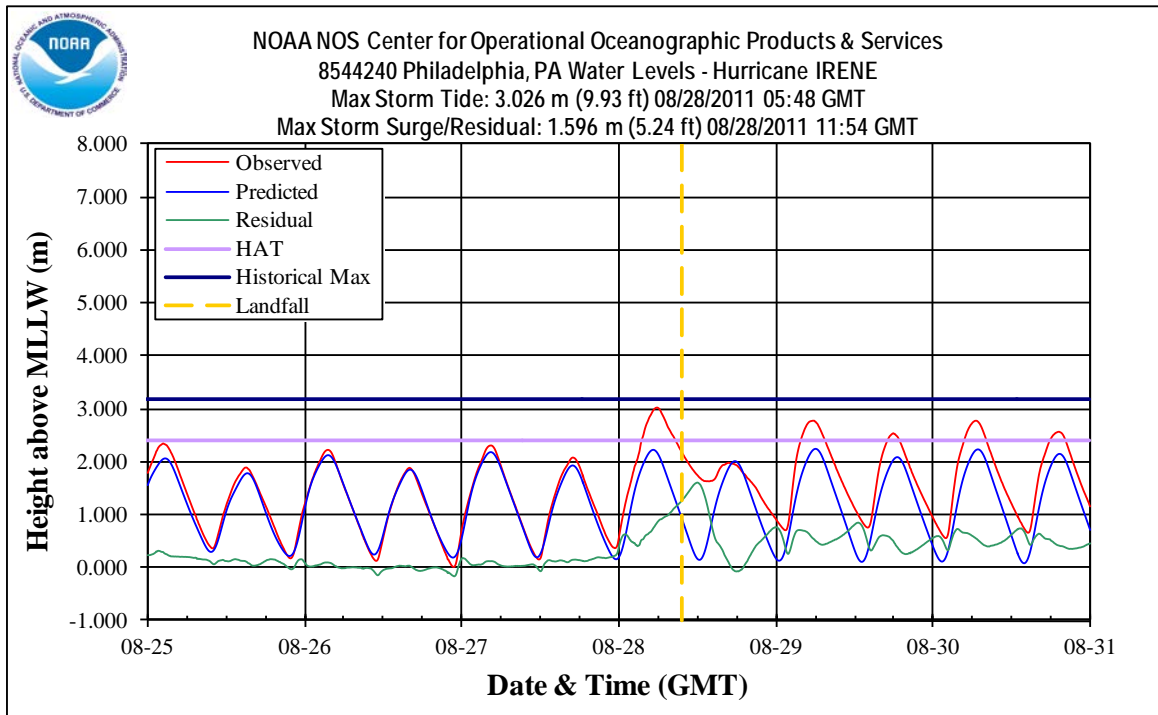


Figure 59: Water levels above Mean Lower Low Water (MLLW) at Philadelphia, PA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum storm tide/storm surge includes likely effects from runoff. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

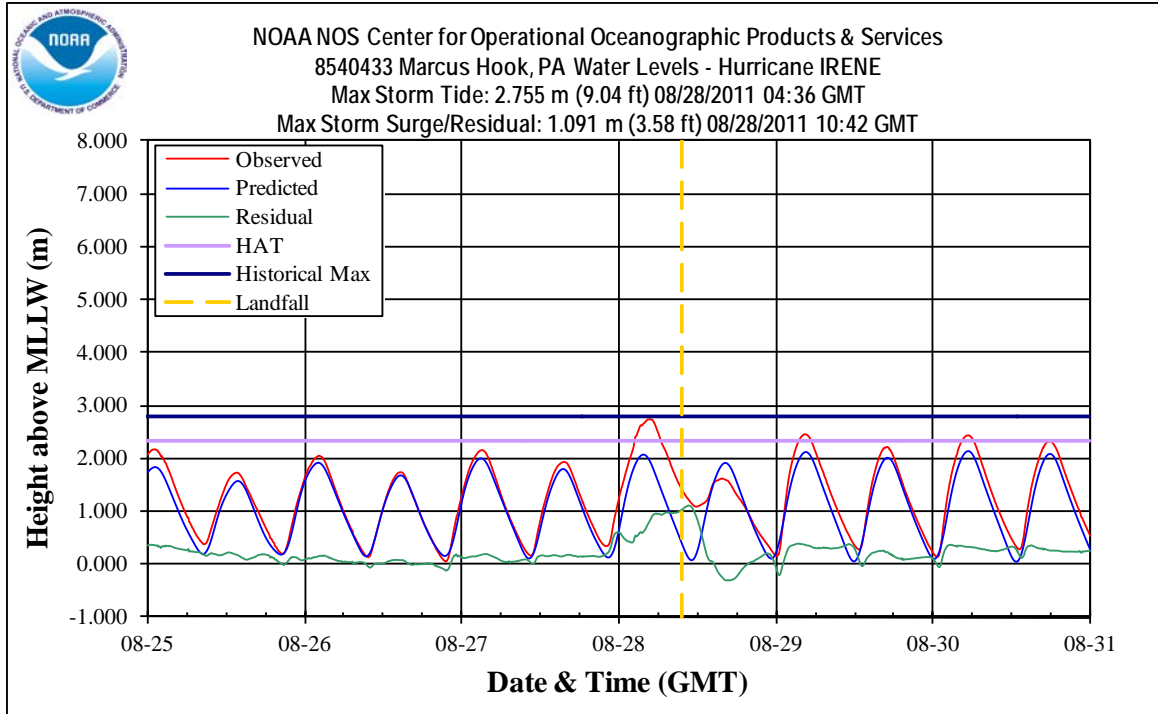


Figure 60: Water levels above Mean Lower Low Water (MLLW) at Marcus Hook, PA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum storm tide/storm surge includes likely effects from runoff. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

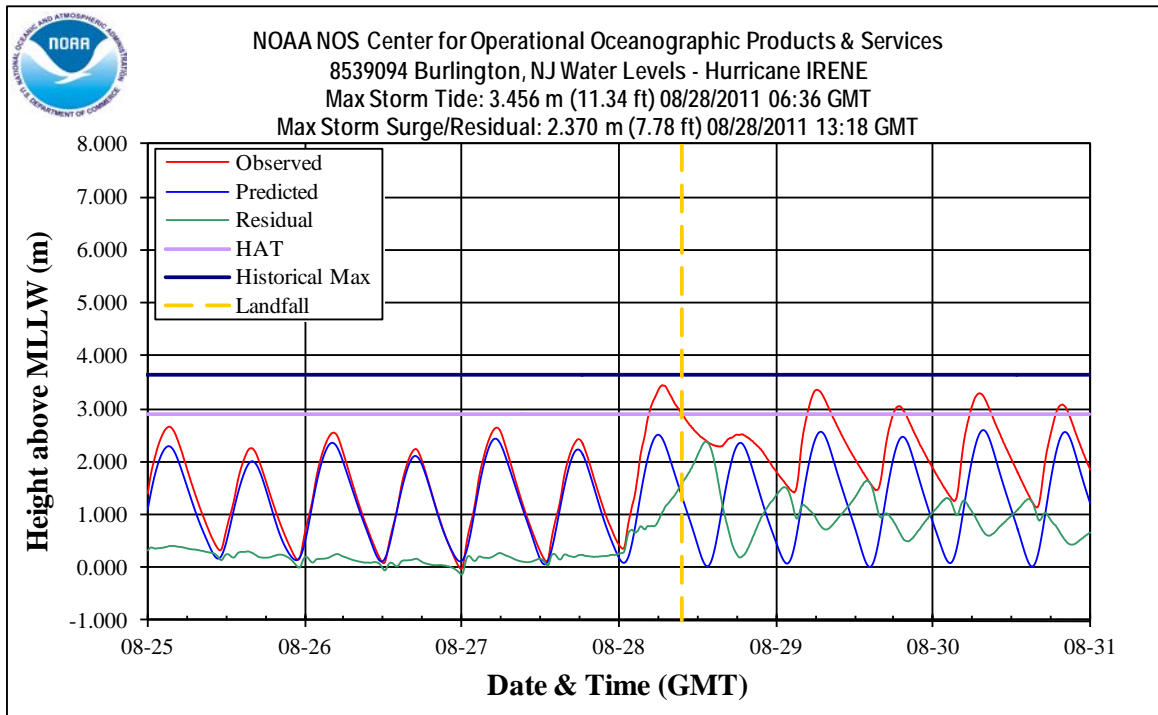


Figure 61: Water levels above Mean Lower Low Water (MLLW) at Burlington, NJ. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum storm tide/storm surge includes likely effects from runoff. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

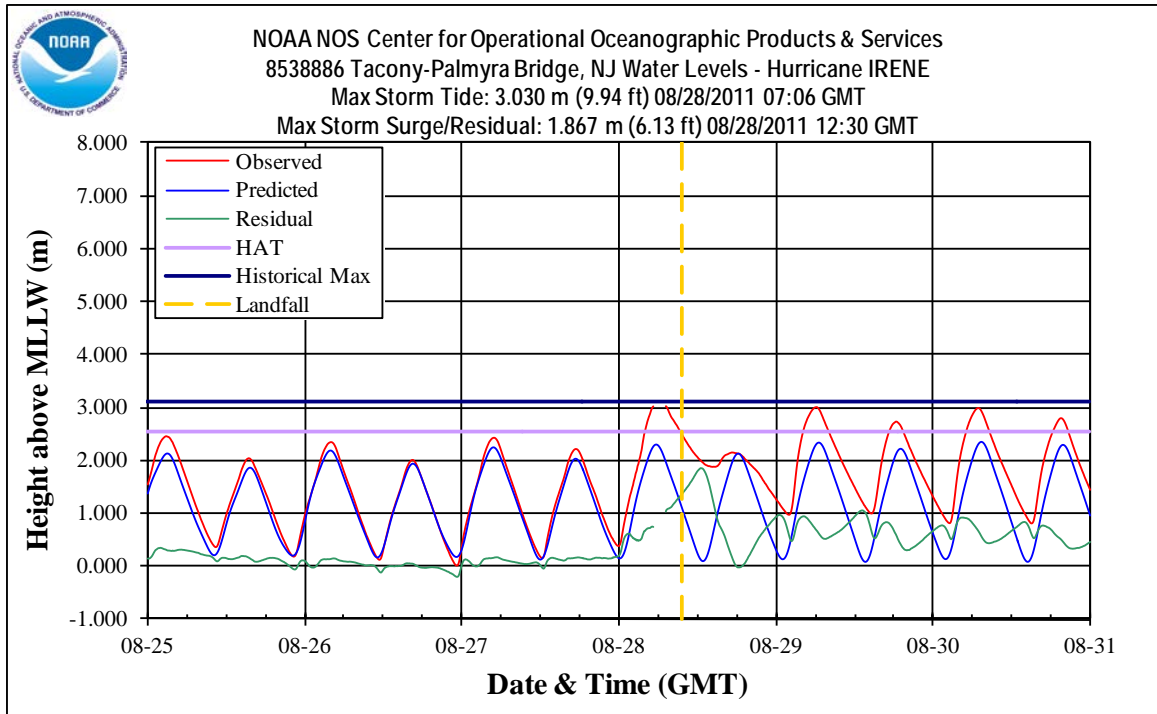


Figure 62: Water levels above Mean Lower Low Water (MLLW) at Tacony-Palmyra Bridge, NJ. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sensor reached the physical limit on measurements and did not record a maximum value. Maximum storm tide/storm surge includes likely effects from runoff. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

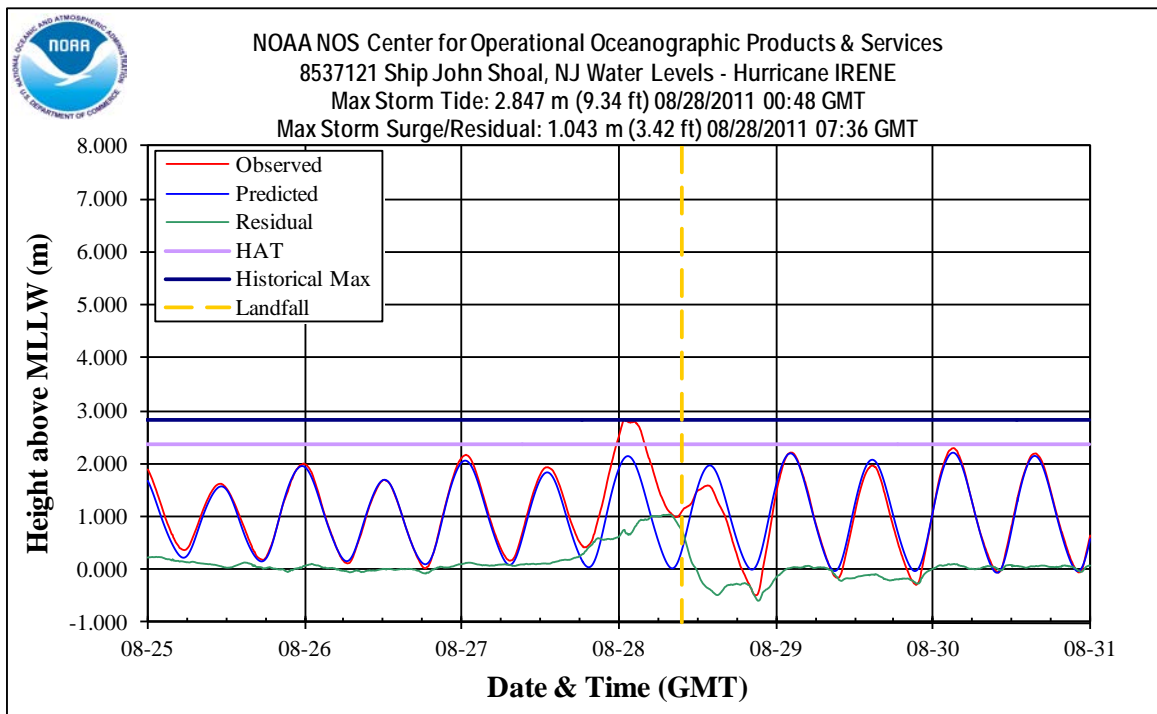


Figure 63: Water levels above Mean Lower Low Water (MLLW) at Ship John Shoal, NJ. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded historical recorded maximum tide level. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

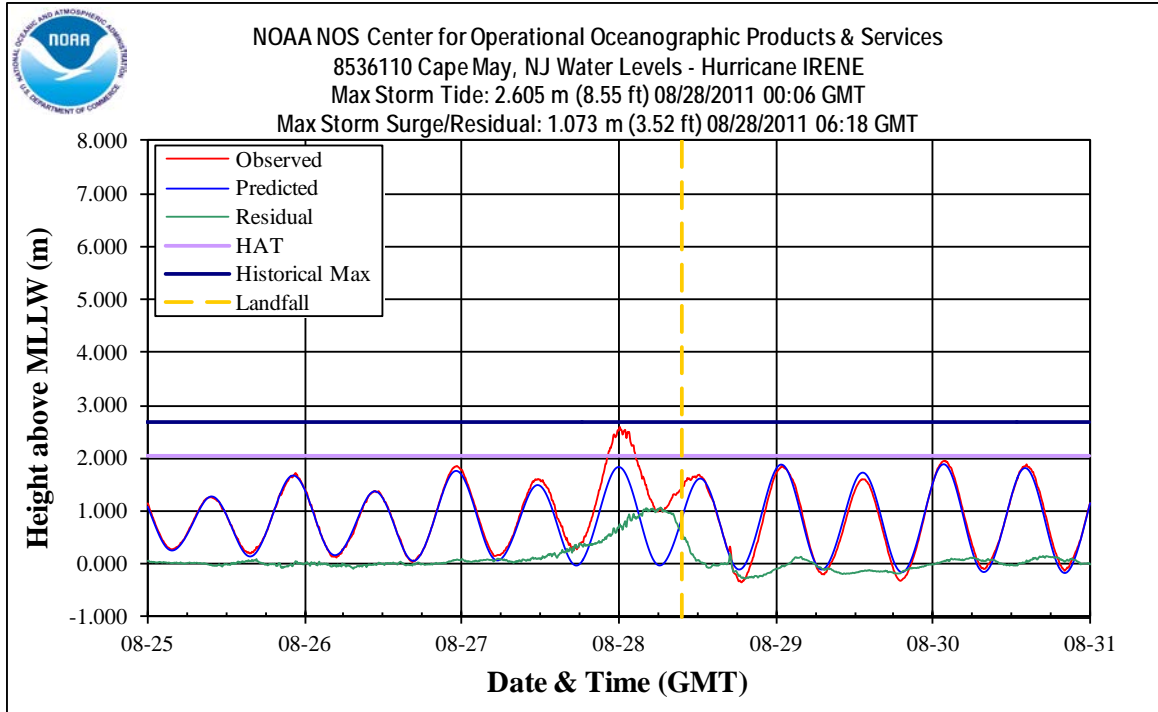


Figure 64: Water levels above Mean Lower Low Water (MLLW) at Cape May, NJ. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

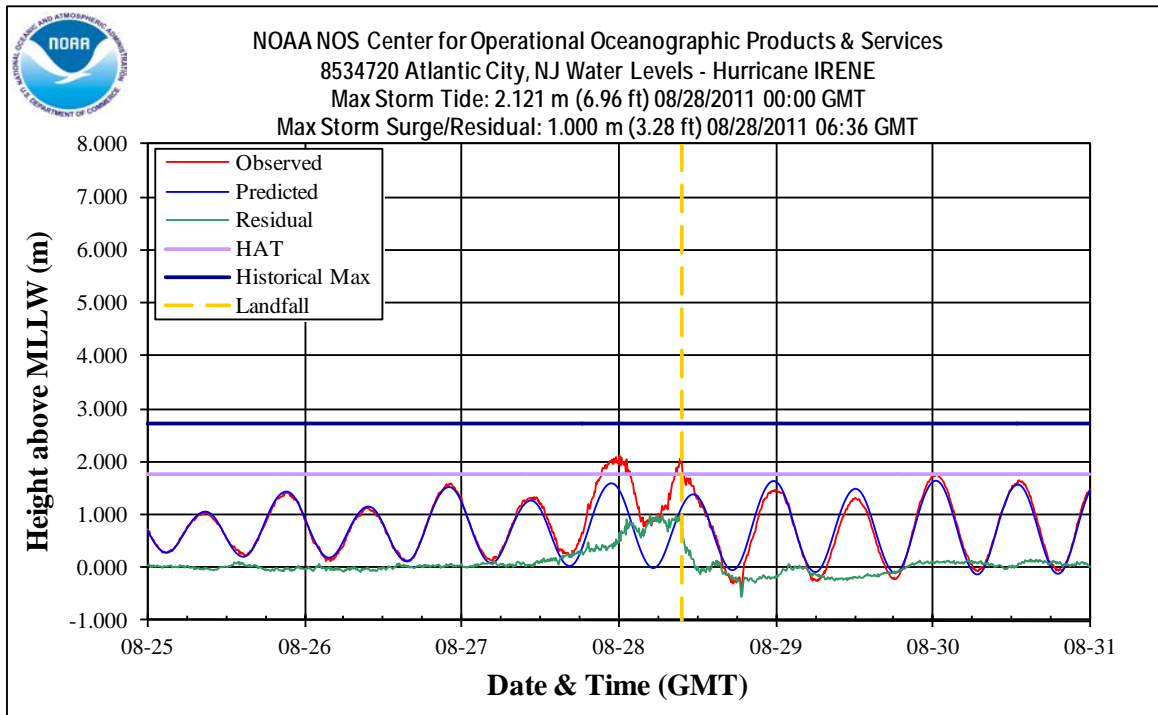


Figure 65: Water levels above Mean Lower Low Water (MLLW) at Atlantic City, NJ. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.



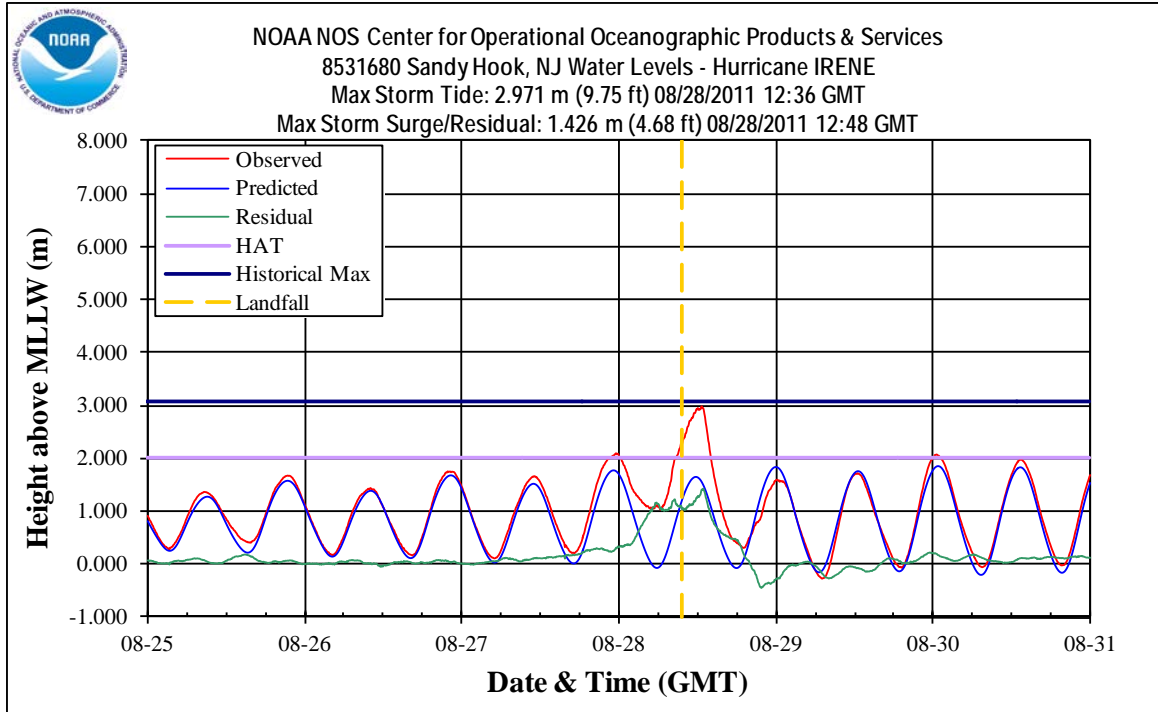


Figure 66: Water levels above Mean Lower Low Water (MLLW) at Sandy Hook, NJ. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

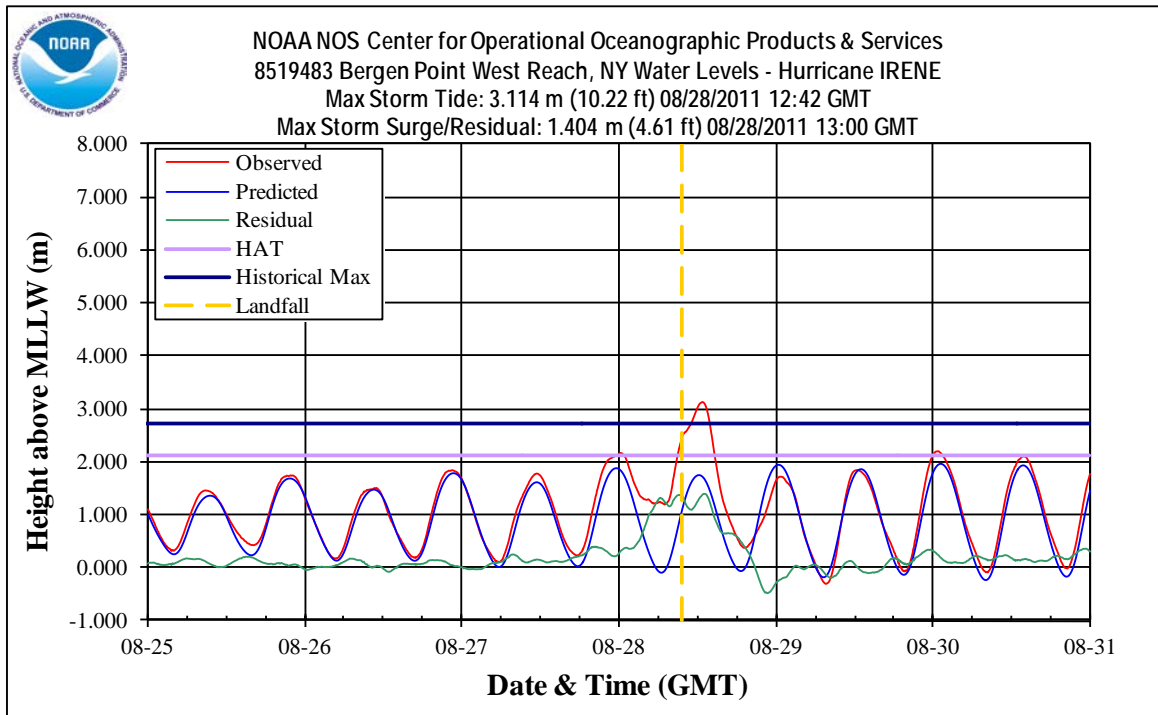


Figure 67: Water levels above Mean Lower Low Water (MLLW) at Bergen Point West Reach, NY. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded historical recorded maximum tide level. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

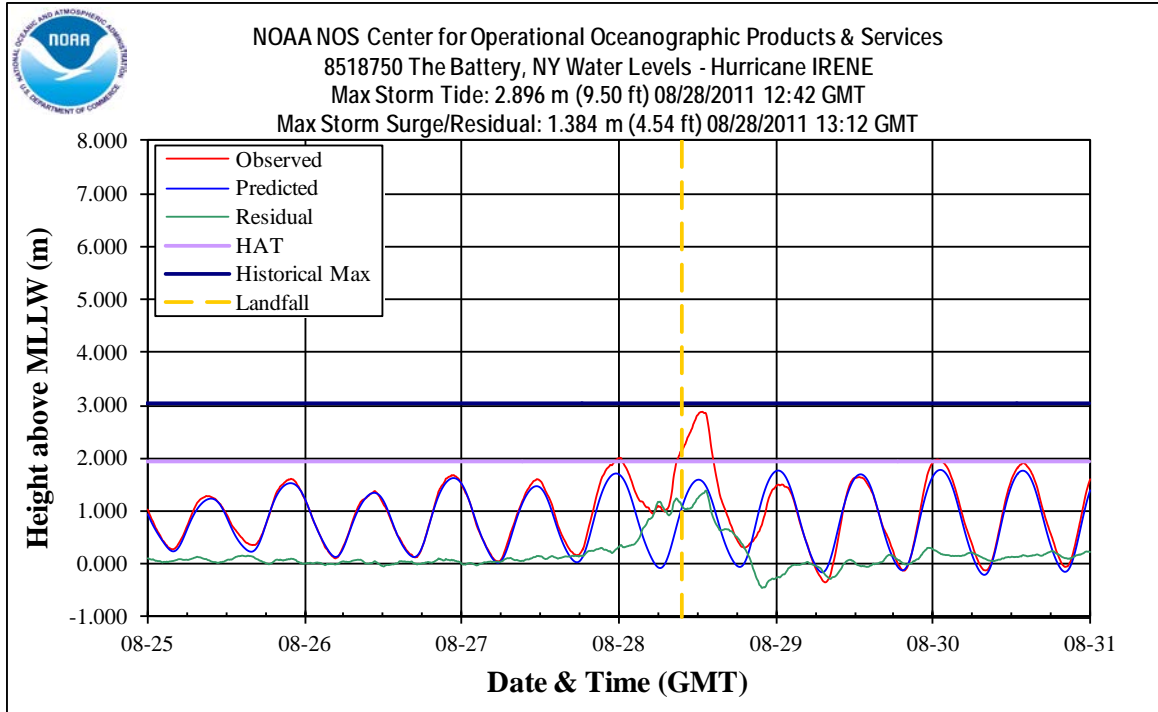


Figure 68: Water levels above Mean Lower Low Water (MLLW) at The Battery, NY. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

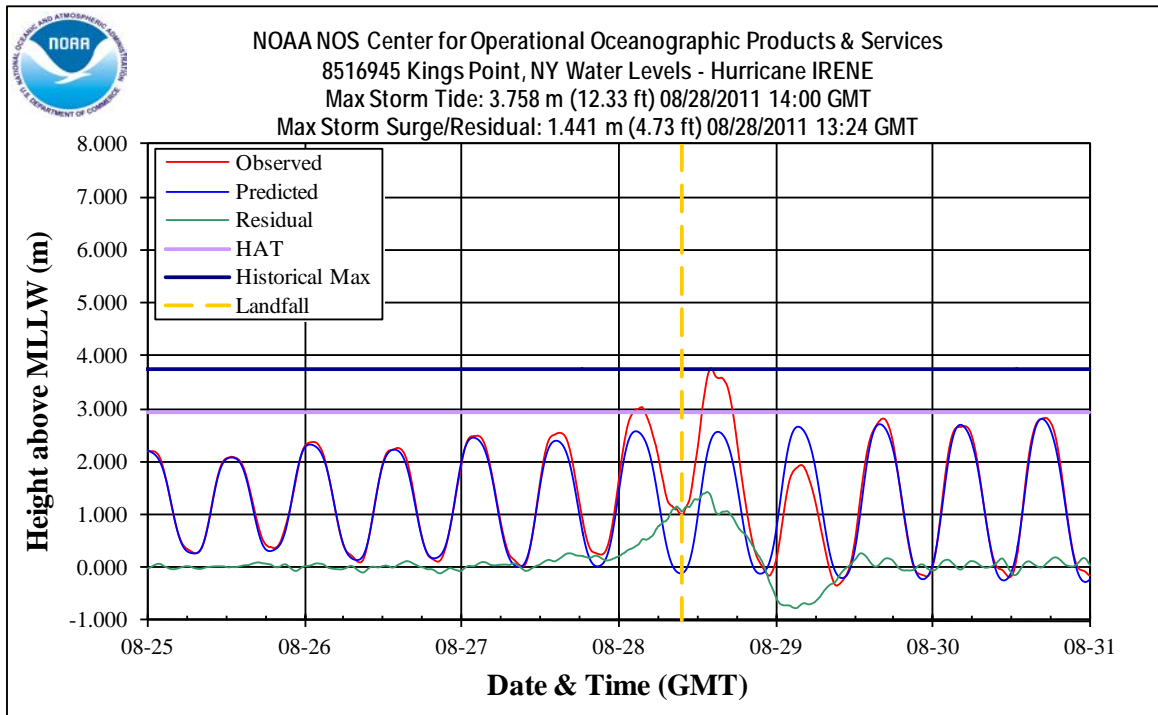


Figure 69: Water levels above Mean Lower Low Water (MLLW) at Kings Point, NY. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded historical recorded maximum tide level. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

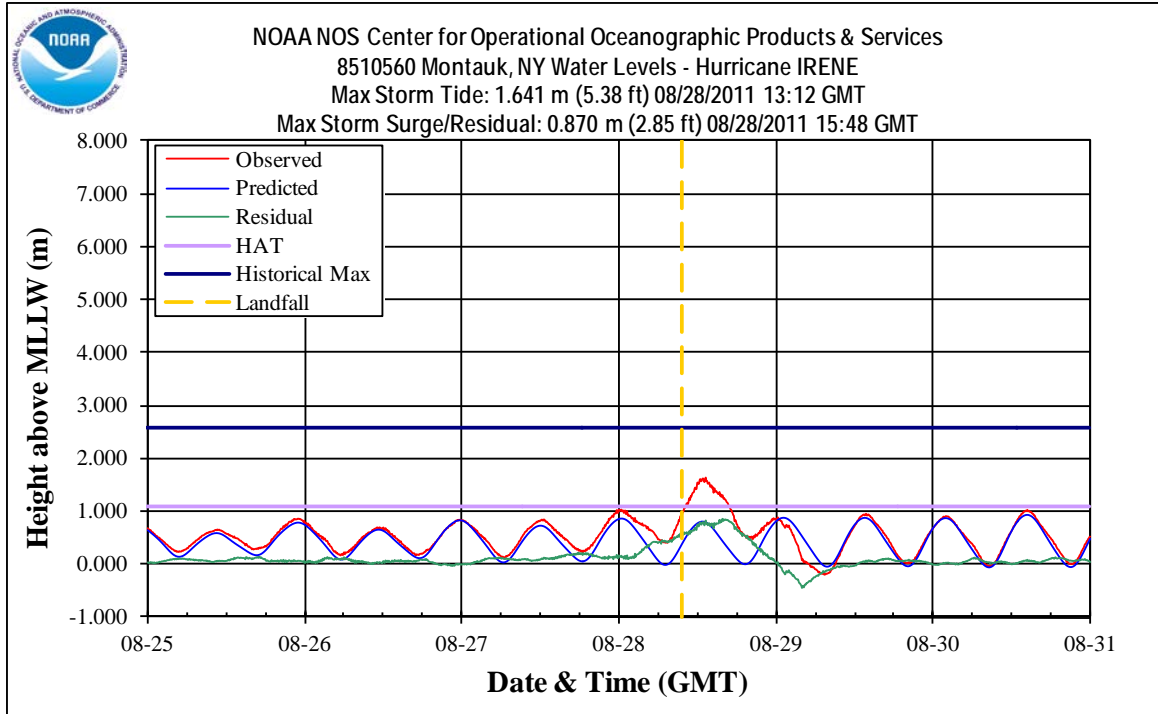


Figure 70: Water levels above Mean Lower Low Water (MLLW) at Montauk, NY. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

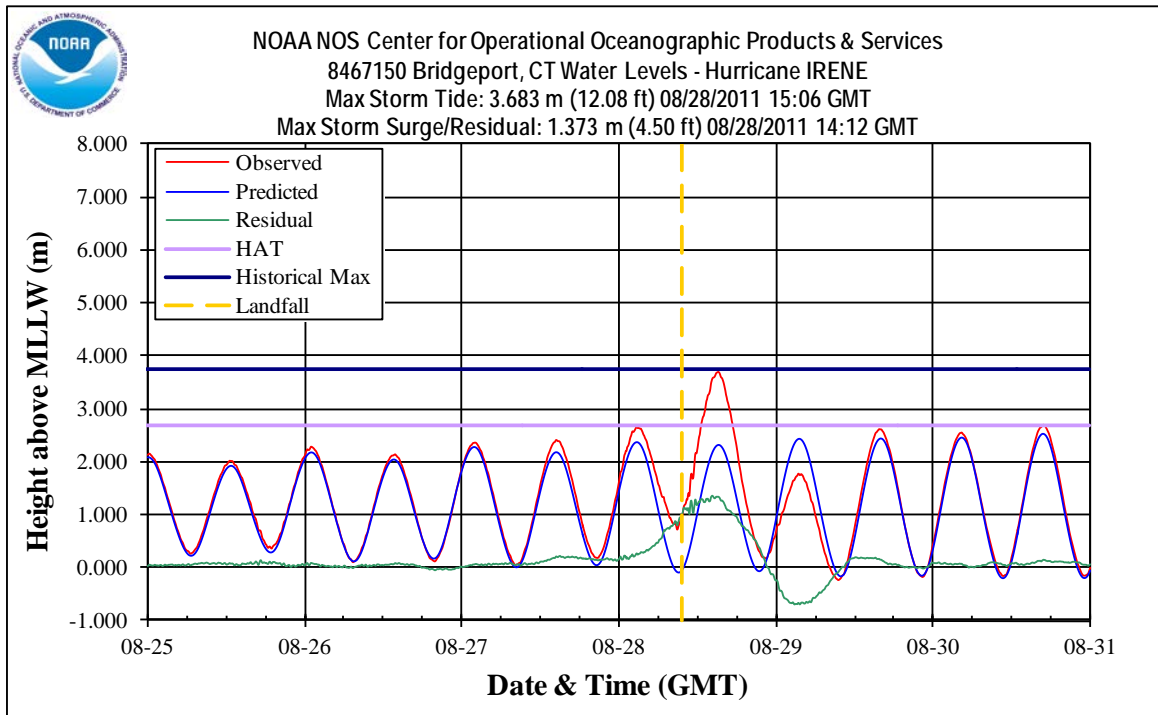


Figure 71: Water levels above Mean Lower Low Water (MLLW) at Bridgeport, CT. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

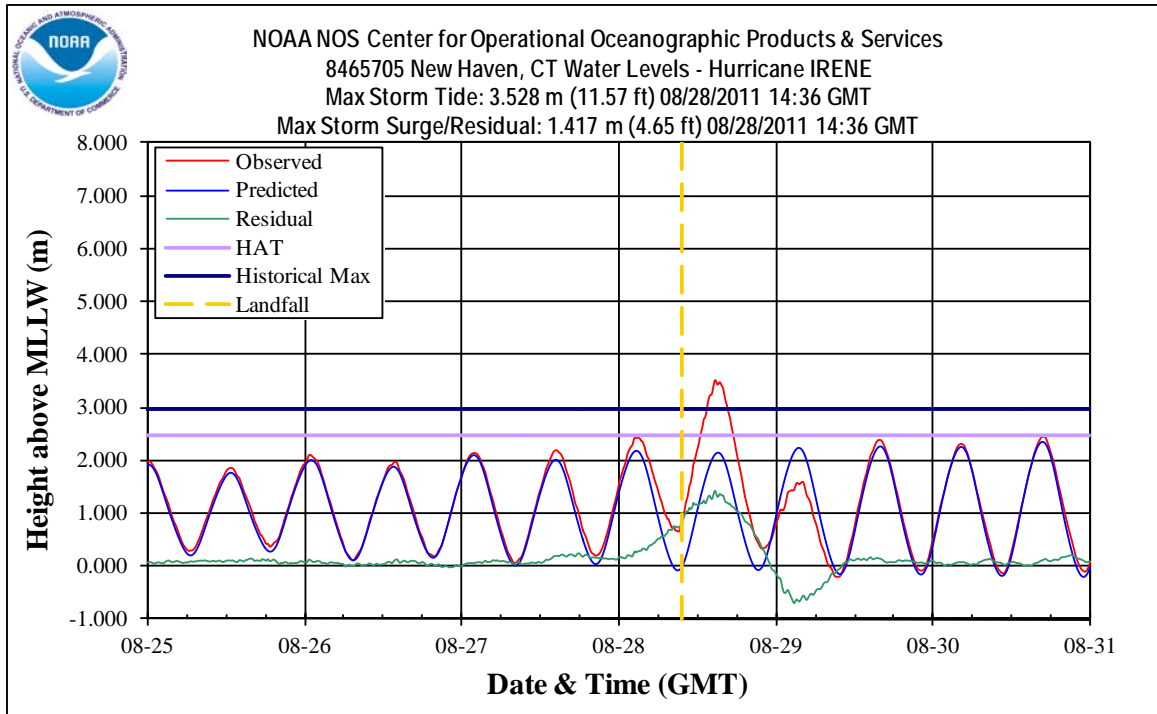


Figure 72: Water levels above Mean Lower Low Water (MLLW) at New Haven, CT. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded historical recorded maximum tide level. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

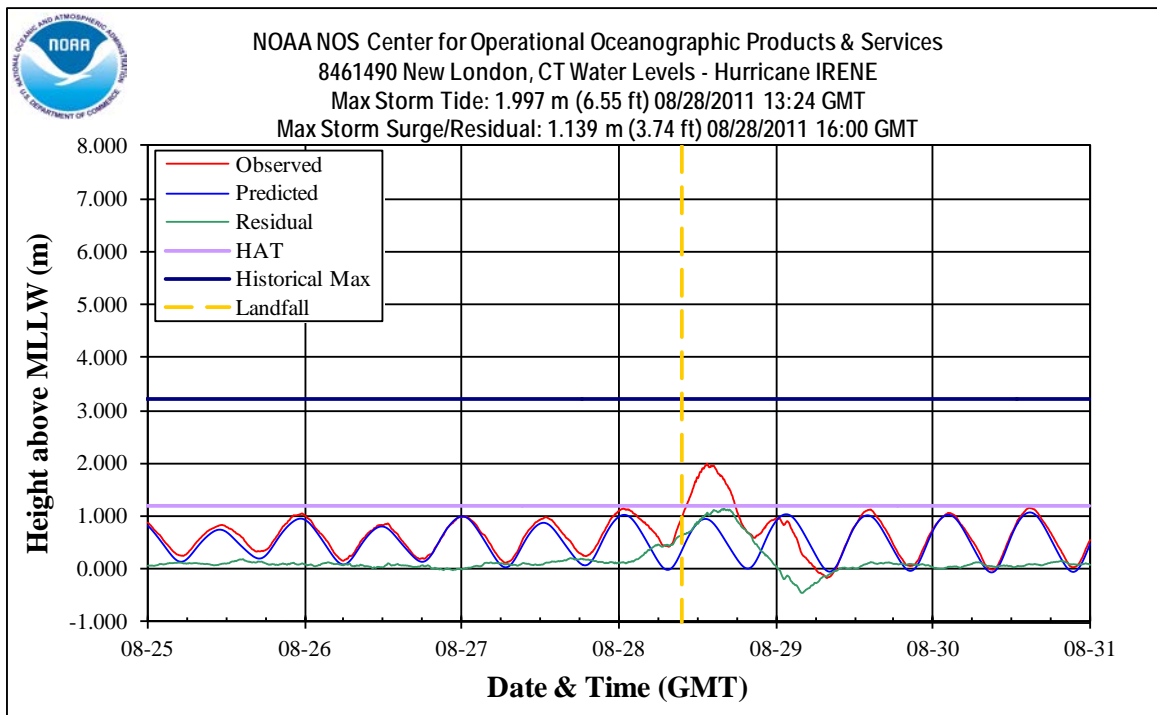


Figure 73: Water levels above Mean Lower Low Water (MLLW) at New London, CT. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

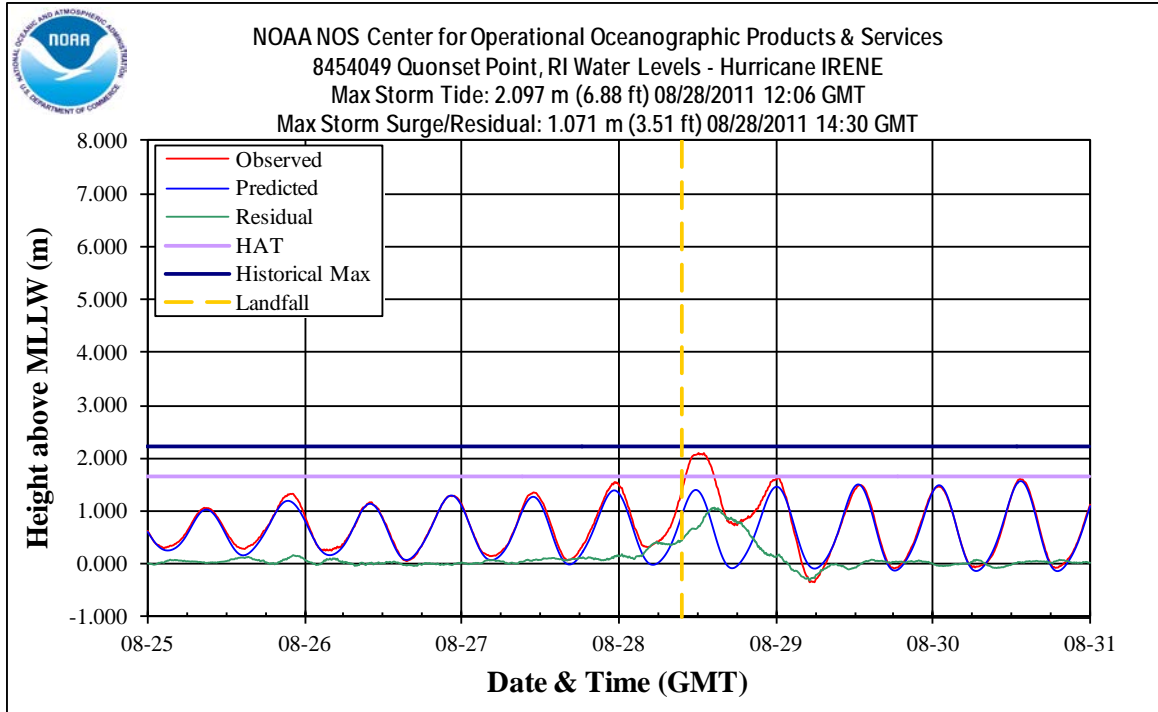


Figure 74: Water levels above Mean Lower Low Water (MLLW) at Quonset Point, RI. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

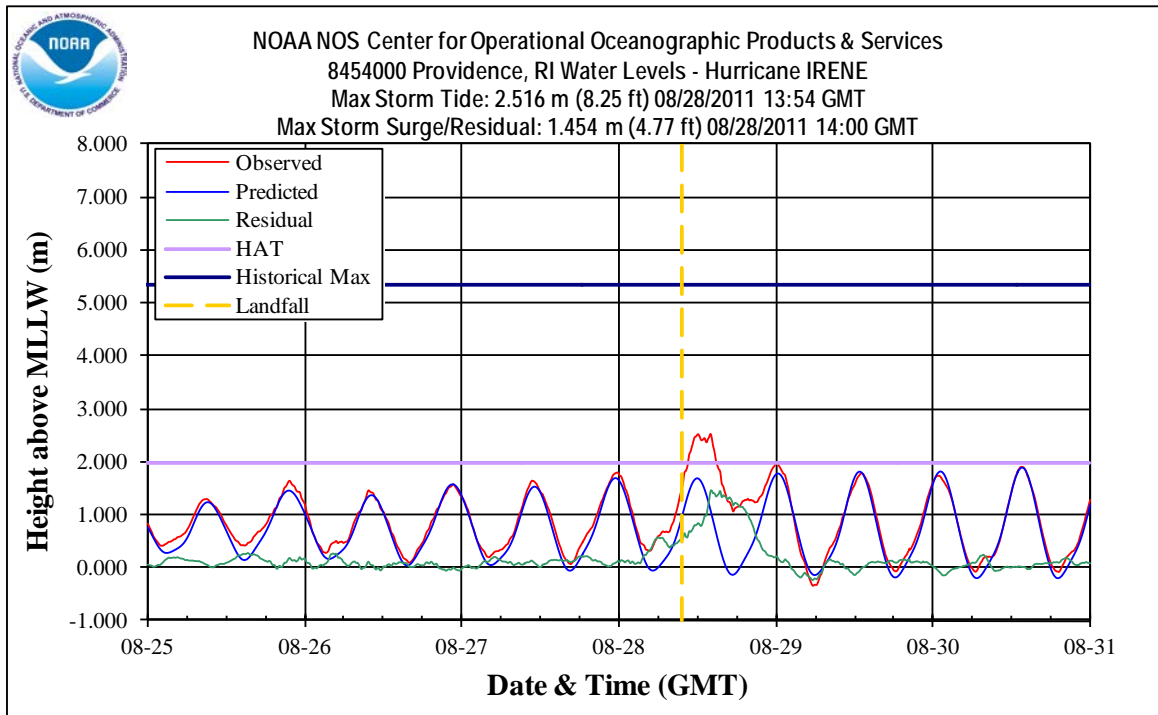


Figure 75: Water levels above Mean Lower Low Water (MLLW) at Providence, RI. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

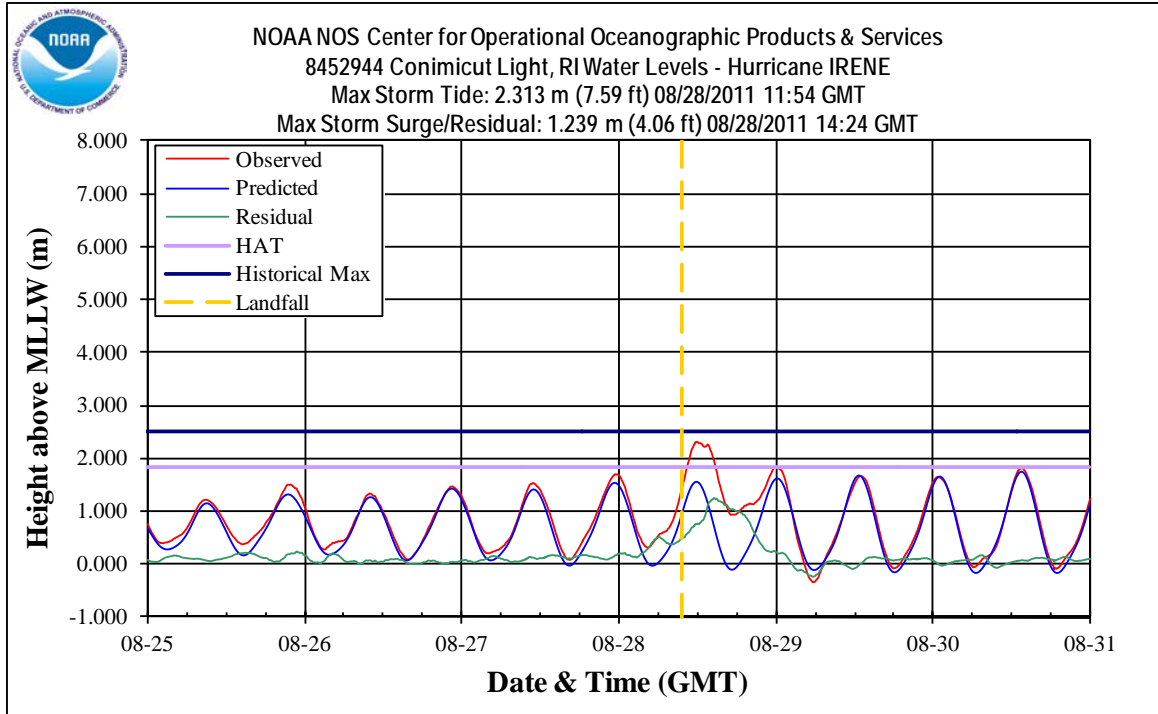


Figure 76: Water levels above Mean Lower Low Water (MLLW) at Conimicut Light, RI. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

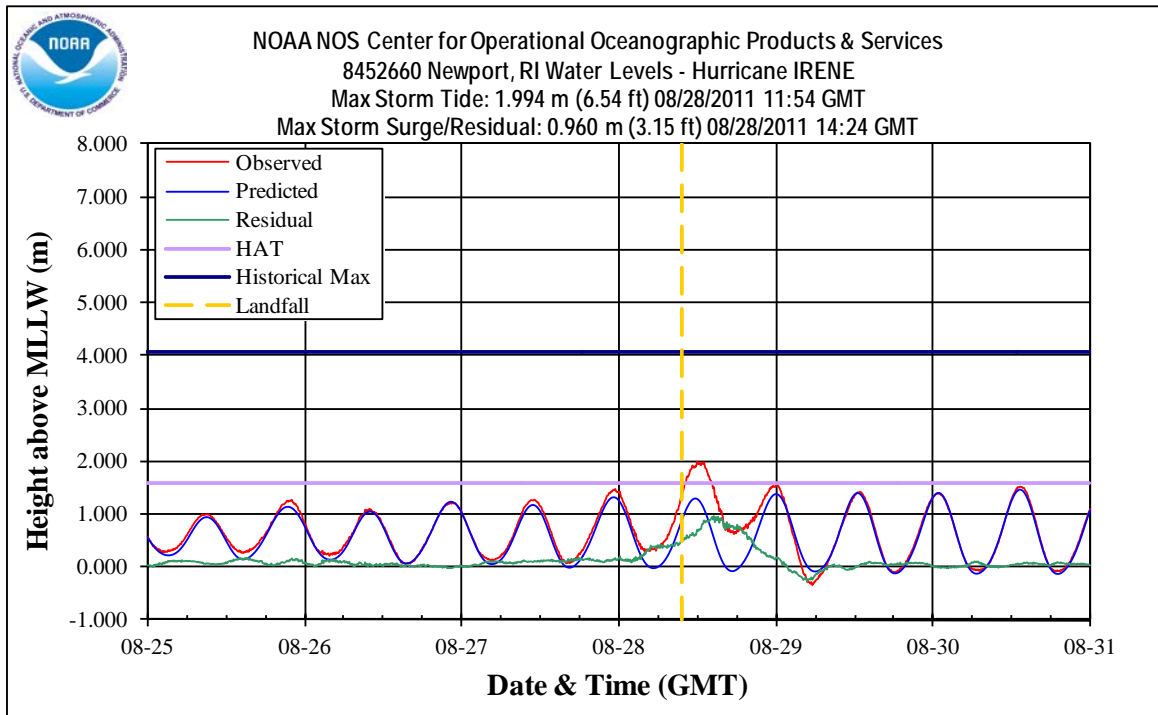


Figure 77: Water levels above Mean Lower Low Water (MLLW) at Newport, RI. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

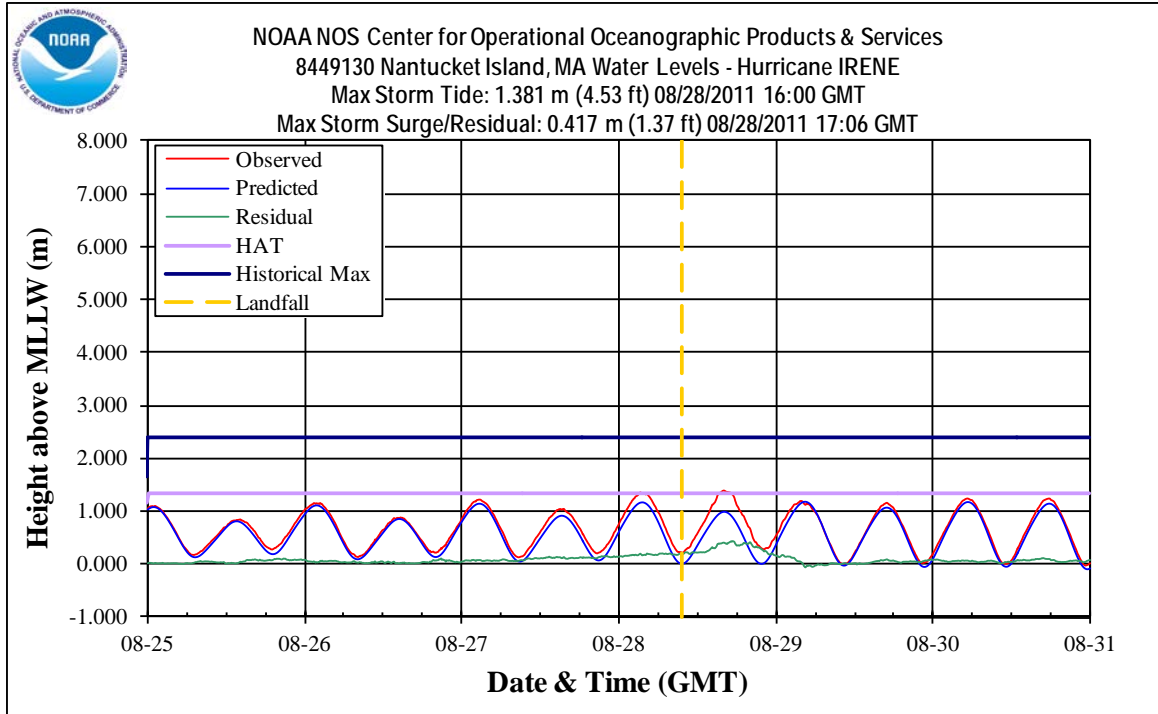


Figure 78: Water levels above Mean Lower Low Water (MLLW) at Nantucket Island, MA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

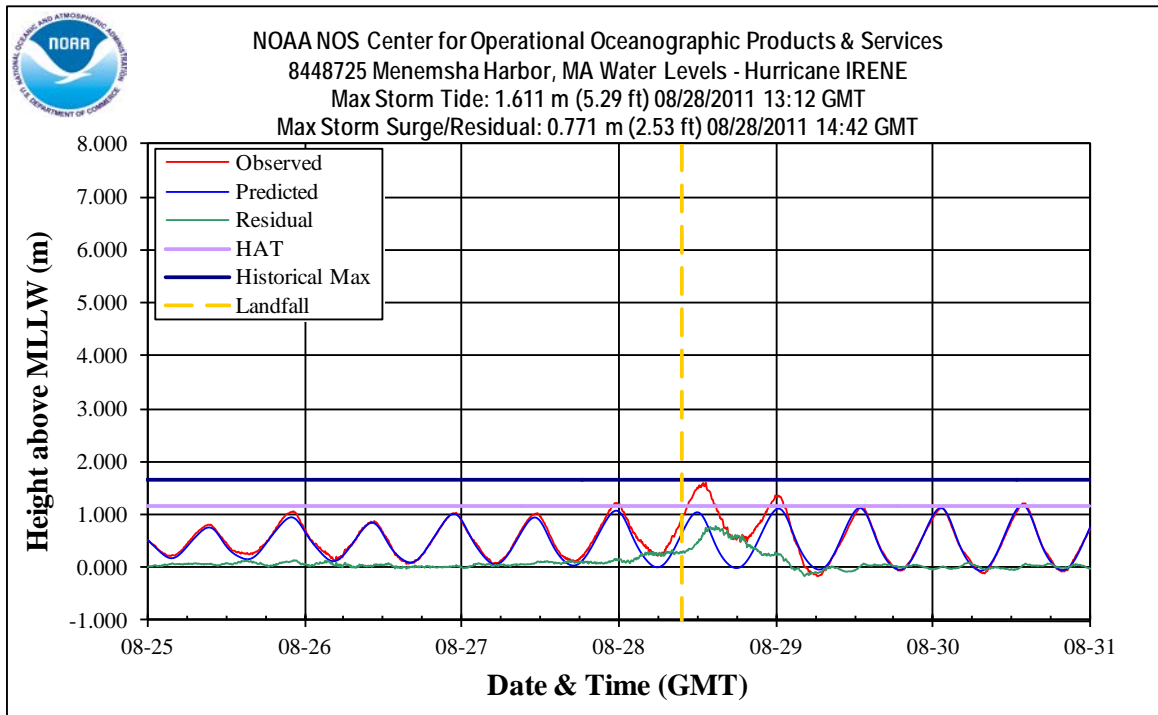


Figure 79: Water levels above Mean Lower Low Water (MLLW) at Menemsha Harbor, MA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

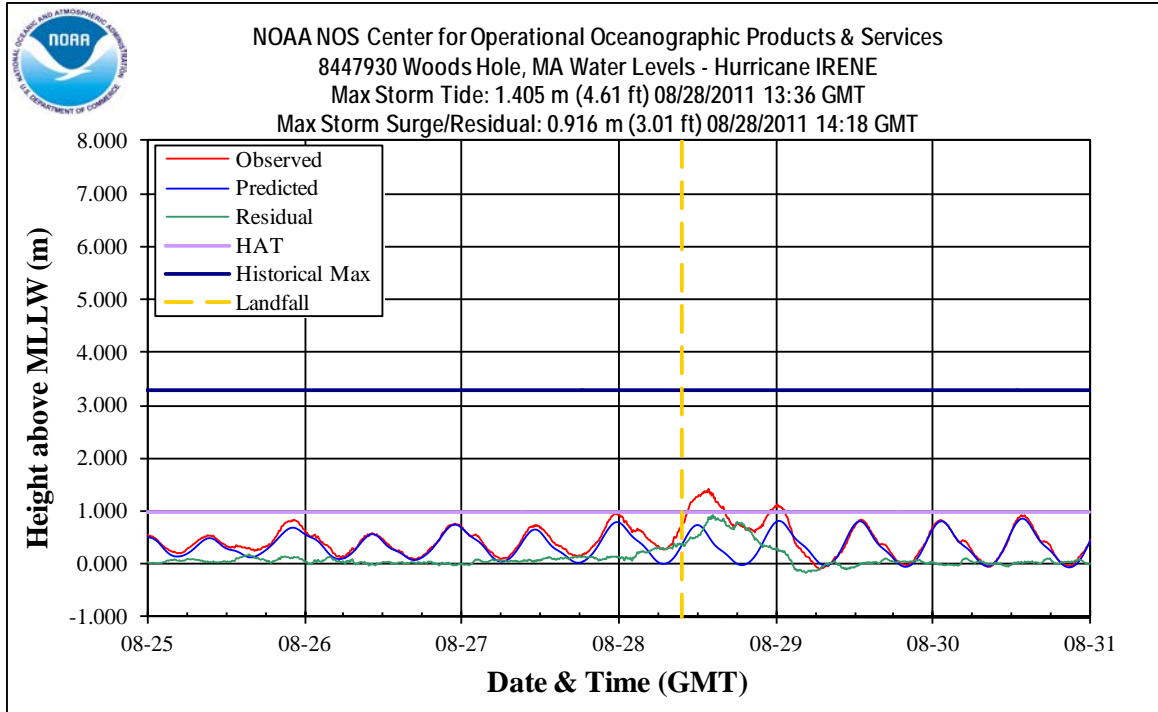


Figure 80: Water levels above Mean Lower Low Water (MLLW) at Woods Hole, MA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

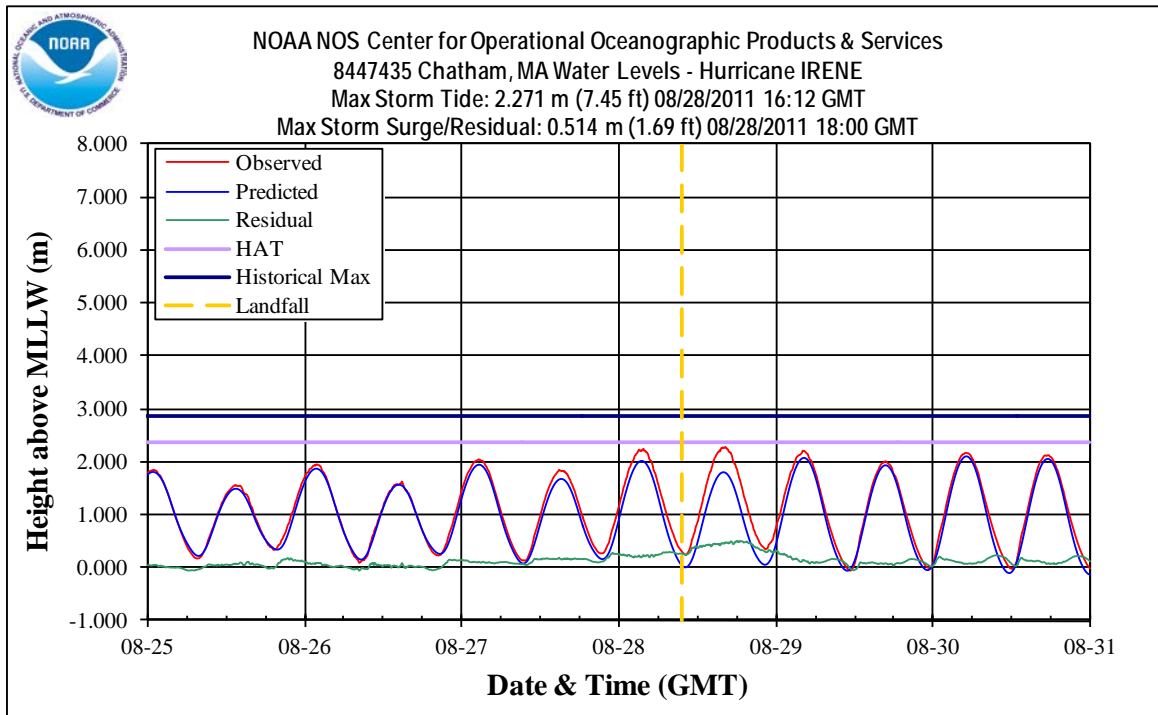


Figure 81: Water levels above Mean Lower Low Water (MLLW) at Chatham, MA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.



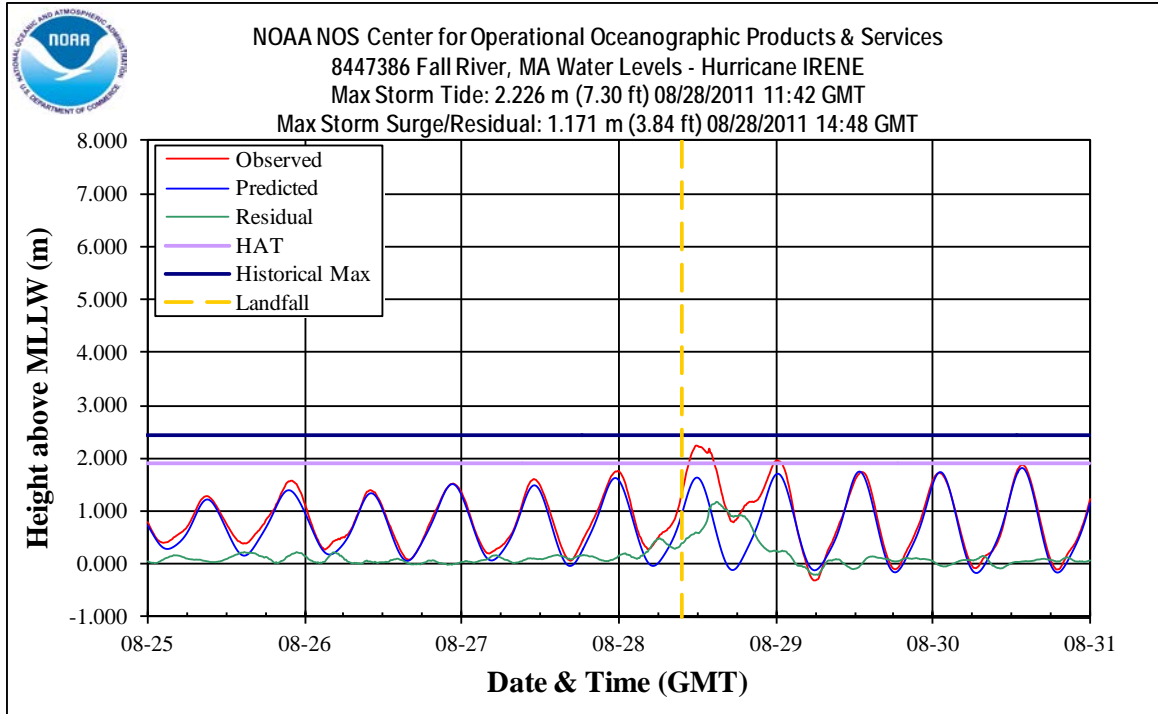


Figure 82: Water levels above Mean Lower Low Water (MLLW) at Fall River, MA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

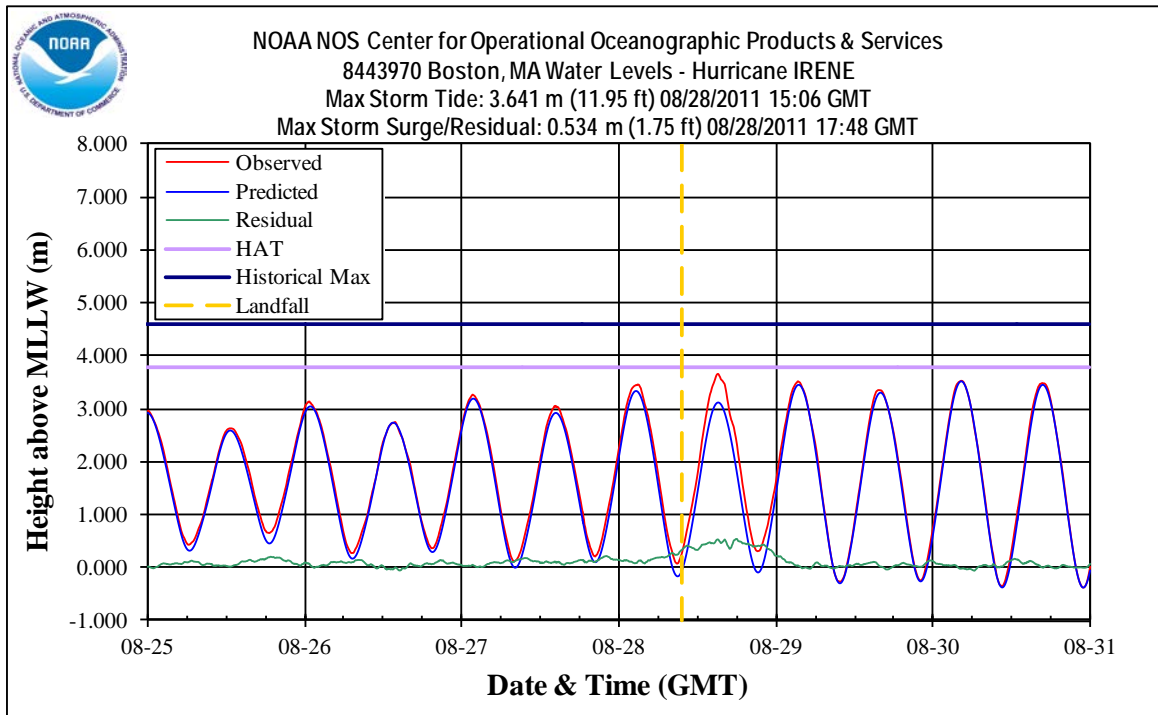


Figure 83: Water levels above Mean Lower Low Water (MLLW) at Boston, MA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

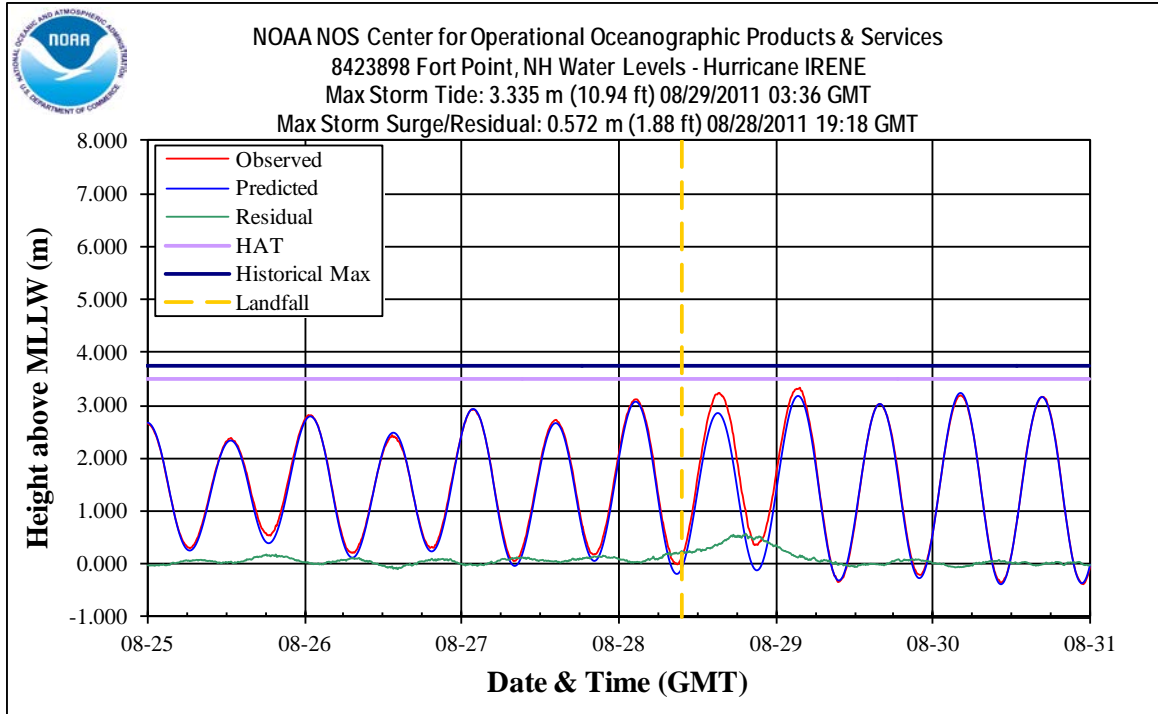


Figure 84: Water levels above Mean Lower Low Water (MLLW) at Fort Point, NH. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

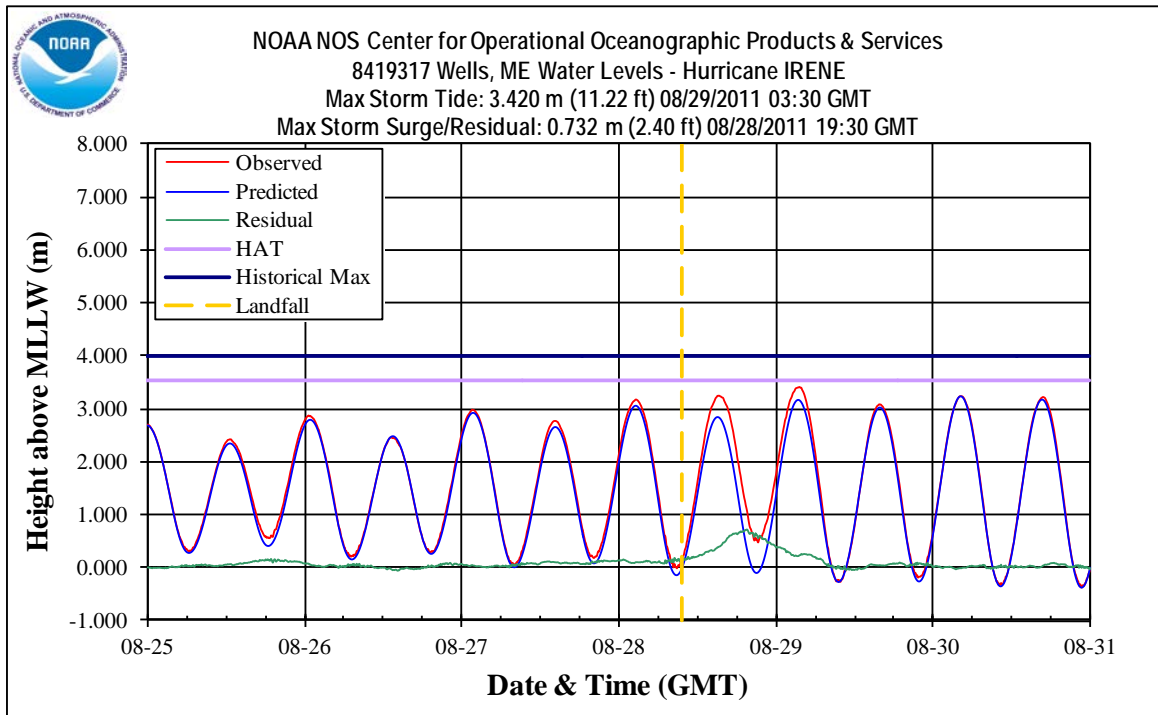


Figure 85: Water levels above Mean Lower Low Water (MLLW) at Wells, ME. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

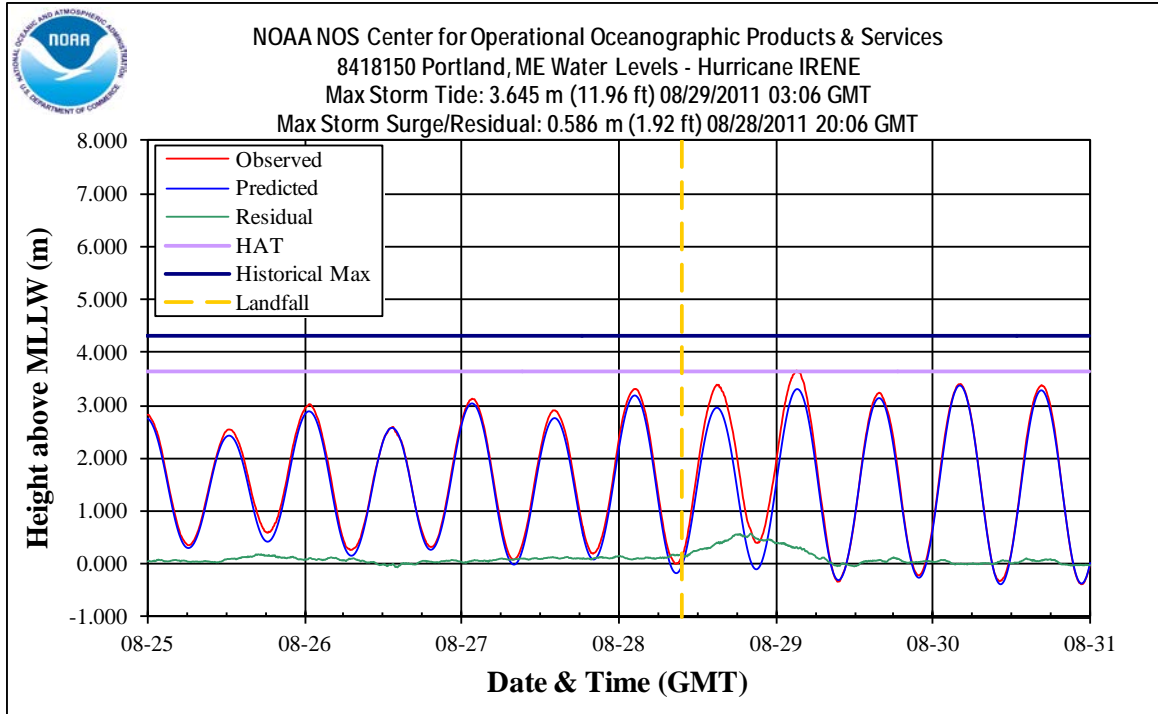


Figure 86: Water levels above Mean Lower Low Water (MLLW) at Portland, ME. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

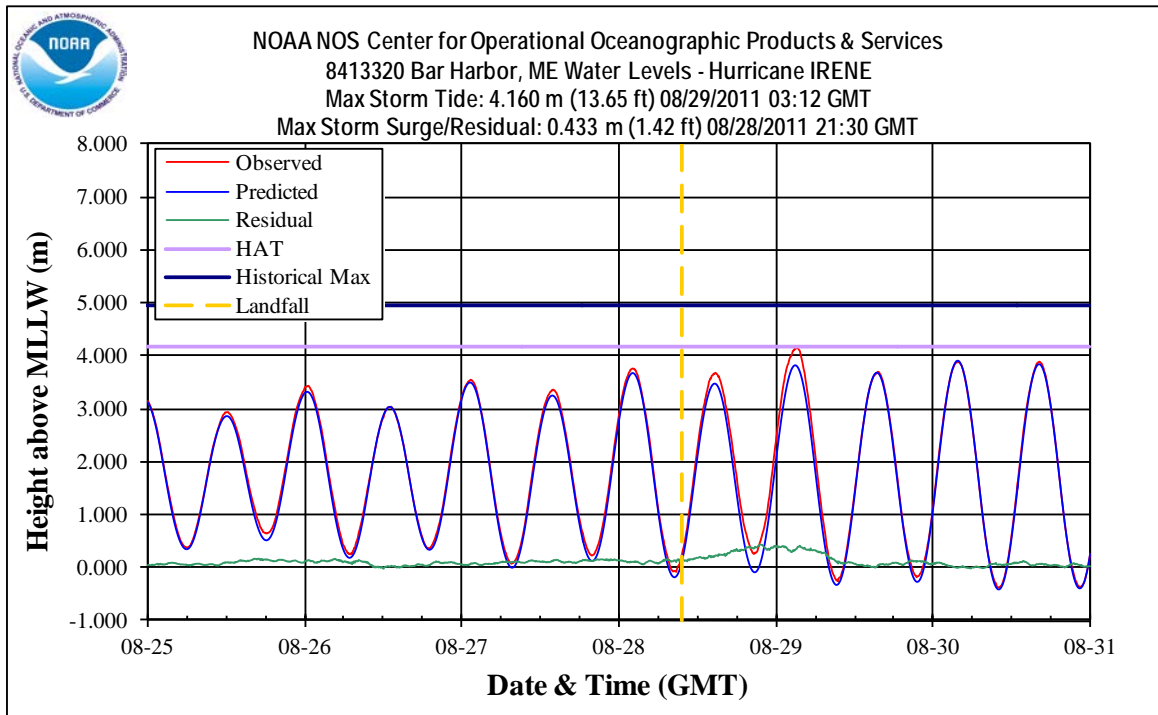


Figure 87: Water levels above Mean Lower Low Water (MLLW) at Bar Harbor, ME. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

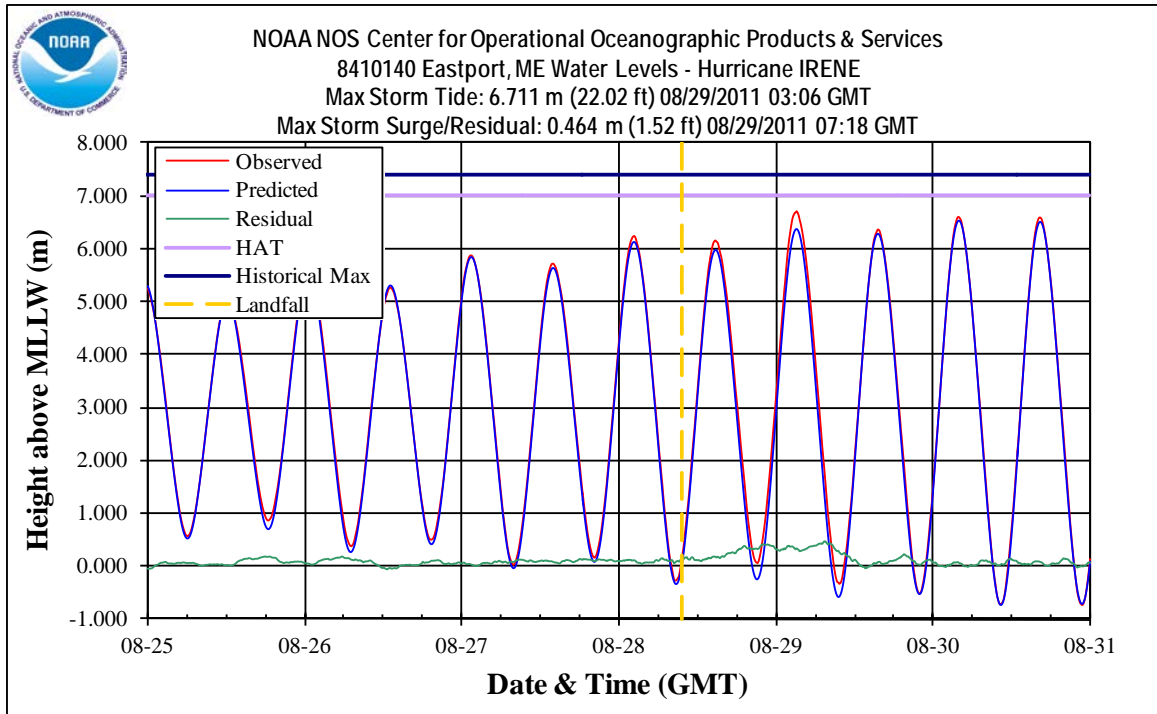


Figure 88: Water levels above Mean Lower Low Water (MLLW) at Eastport, ME. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Irene made final landfall near Little Egg Inlet, NJ on 8/28/2011 09:35 GMT.

## **Appendix 1: References and Contact Information**

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) 713-2877 ext. 211  
Fax: (301) 713-4437  
E-mail: Storm QuickLook ([tide.predictions@noaa.gov](mailto:tide.predictions@noaa.gov))

## Appendix 2: Station Locations

Station Name	Station ID	Latitude °N	Longitude °W
Barbuda	9761115	17.59069	-61.82056
Christiansted Harbor, St Croix, VI	9751364	17.75000	-64.70500
Lameshur Bay, St. John, VI	9751381	18.31825	-64.72422
Lime Tree Bay, VI	9751401	17.69472	-64.75381
Charlotte Amalie, VI	9751639	18.33583	-64.92000
Culebra, PR	9752235	18.30086	-65.30247
Isabel Segunda, Vieques Island, PR	9752619	18.15253	-65.44381
Esperanza, Vieques Island, PR	9752695	18.09386	-65.47136
Fajardo, PR	9753216	18.33522	-65.63111
Yabucoa Harbor, PR	9754228	18.05508	-65.83300
San Juan, PR	9755371	18.45894	-66.11642
Arecibo, PR	9757809	18.48053	-66.70236
Magueyes Island, PR	9759110	17.97008	-67.04642
Mayaguez, PR	9759394	18.22000	-67.16000
Aguadilla, PR	9759412	18.45664	-67.16458
Mona Island, PR	9759938	18.09000	-67.93833
Virginia Key, FL	8723214	25.73140	-80.16180
Lake Worth Pier, FL	8722670	26.61170	-80.03330
Trident Pier, FL	8721604	28.41580	-80.59310
I-295 Bridge, St Johns River, FL	8720357	30.19170	-81.69170
Mayport (Bar Pilots Dock), FL	8720218	30.39670	-81.43000
Fernandina Beach, FL	8720030	30.67170	-81.46500
Fort Pulaski, GA	8670870	32.03330	-80.90170
Clarendon Plantation, SC	8667633	32.33570	-80.78410
Charleston, SC	8665530	32.78170	-79.92500
Oyster Landing (N. Inlet Estuary), SC	8662245	33.35170	-79.18670
Springmaid Pier, SC	8661070	33.65500	-78.91830
Wrightsville Beach, NC	8658163	34.21330	-77.78670
Wilmington, NC	8658120	34.22670	-77.95330
Beaufort, NC	8656483	34.72000	-76.67000
USCG Station Hatteras, NC	8654467	35.20864	-75.70417
Oregon Inlet Marina, NC	8652587	35.79500	-75.54830
Duck, NC	8651370	36.18333	-75.74667
Money Point, VA	8639348	36.77830	-76.30170
Chesapeake Bay Bridge Tunnel, VA	8638863	36.96667	-76.11333
Sewells Point, VA	8638610	36.94667	-76.33000
Yorktown USCG Training Center, VA	8637689	37.22667	-76.47833
Windmill Point, VA	8636580	37.61620	-76.29000

## Appendix 2: Station Locations (continued)

Station Name	Station ID	Latitude °N	Longitude °W
Lewisetta, VA	8635750	37.99611	-76.46444
Kiptopeke, VA	8632200	37.16519	-75.98844
Wachapreague, VA	8631044	37.60778	-75.68583
Washington, DC	8594900	38.87333	-77.02167
Solomons Island, MD	8577330	38.31667	-76.45167
Annapolis, MD	8575512	38.98328	-76.48156
Baltimore, MD	8574680	39.26667	-76.57833
Chesapeake City, MD	8573927	39.52670	-75.81000
Tolchester Beach, MD	8573364	39.21333	-76.24500
Cambridge, MD	8571892	38.57330	-76.06830
Bishops Head, MD	8571421	38.22000	-76.03830
Ocean City Inlet, MD	8570283	38.32833	-75.09167
Lewes, DE	8557380	38.78169	-75.12000
Brandywine Shoal Light, DE	8555889	38.98667	-75.11333
Reedy Point, DE	8551910	39.55831	-75.57331
Delaware City, DE	8551762	39.58170	-75.58830
Newbold, PA	8548989	40.13670	-74.75170
Philadelphia, PA	8545240	39.93333	-75.14167
Marcus Hook, PA	8540433	39.81170	-75.41000
Burlington, Delaware River, NJ	8539094	40.08170	-74.86970
Tacony-Palmyra Bridge, NJ	8538886	40.01194	-75.04300
Ship John Shoal, NJ	8537121	39.30500	-75.37500
Cape May, NJ	8536110	38.96833	-74.96000
Atlantic City, NJ	8534720	39.35500	-74.41830
Sandy Hook, NJ	8531680	40.46690	-74.00940
Bergen Point West Reach, NY	8519483	40.63670	-74.14170
The Battery, NY	8518750	40.70060	-74.01420
Kings Point, NY	8516945	40.81030	-73.76490
Montauk, NY	8510560	41.04830	-71.96000
Bridgeport, CT	8467150	41.17330	-73.18170
New Haven, CT	8465705	41.28330	-72.90830
New London, CT	8461490	41.36139	-72.08997
Quonset Point, RI	8454049	41.58680	-71.41100
Providence, RI	8454000	41.80710	-71.40120
Conimicut Light, RI	8452944	41.71670	-71.34330
Newport, RI	8452660	41.50500	-71.32670
Nantucket Island, MA	8449130	41.28500	-70.09670
Menemsha Harbor, MA	8448725	41.35444	-70.76783

**Appendix 2: Station Locations (continued)**

Station Name	Station ID	Latitude °N	Longitude °W
Woods Hole, MA	8447930	41.52330	-70.67170
Chatham, MA	8447435	41.68847	-69.95108
Fall River, MA	8447386	41.70430	-71.16410
Boston, MA	8443970	42.35480	-71.05340
Fort Point, NH	8423898	43.07170	-70.71170
Wells, ME	8419317	43.32000	-70.56331
Portland, ME	8418150	43.65670	-70.24670
Bar Harbor, ME	8413320	44.39170	-68.20500
Eastport, ME	8410140	44.90460	-66.98290



### 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.

**Highest Astronomical Tide (HAT):** The elevation of the highest predicted astronomical tide expected to occur at a specific tide station over the National Tidal Datum Epoch.

**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.

**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 National Tidal Datum Epoch is 1983 through 2001. It is reviewed annually for possible revision and must be actively considered for revision every 25 years.

**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.

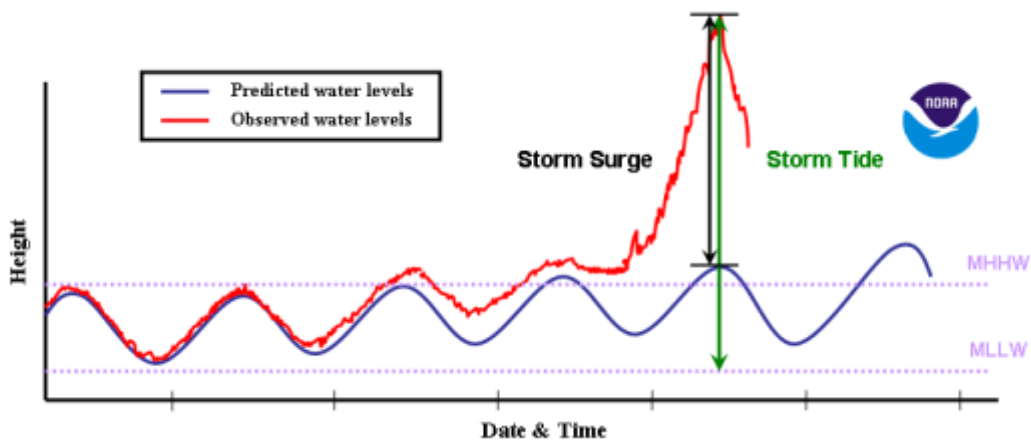
**Tide:** The periodic rise and fall of a body of water resulting from gravitational interactions between Sun, Moon, and Earth. The vertical component of the particulate motion of a tidal wave. Same as astronomic tide.

**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 Hurricane Wind Scale 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 Wind Scale is a 1-5 rating based on the hurricane's present intensity (<http://www.nhc.noaa.gov/aboutshs.shtml>). The scale does not address the potential for other hurricane-related impacts, such as storm surge, rainfall-induced floods, and tornadoes. Note that all winds are using 1-minute averaged wind speeds at a 10-meter elevation with an unobstructed exposure.