

## HURRICANE SANDY

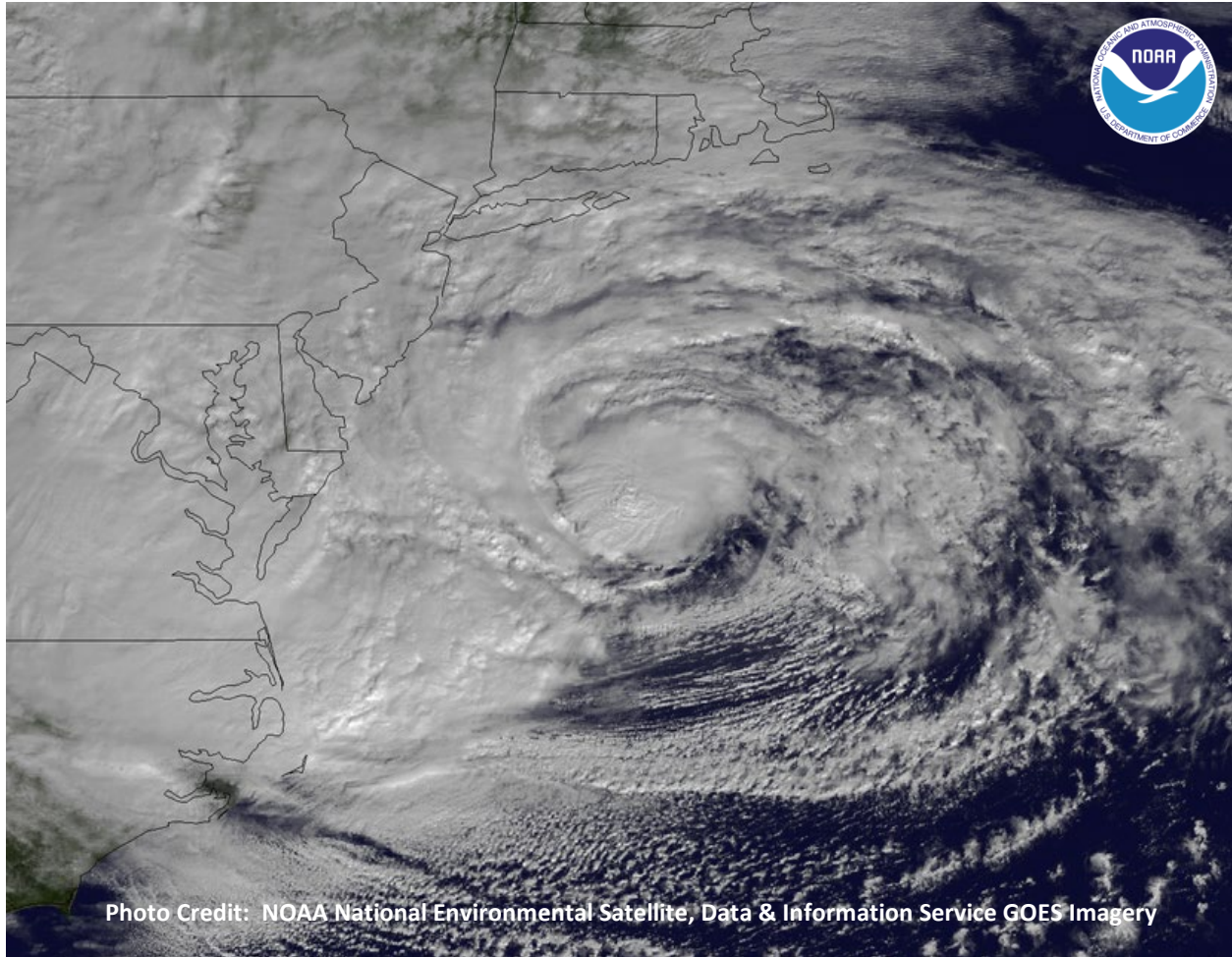


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Silver Spring, Maryland  
January 24, 2013

**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 SANDY

Colleen Fanelli, Paul Fanelli, David Wolcott  
January 24, 2013

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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. This report documents the elevated water levels, high winds and reduced barometric pressures recorded at stations along the East Coast of the U.S. from Florida to Maine during Hurricane Sandy.

Station information and locations are contained in Figures 1 & 2a-2c 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 several locations along the U.S. coast, 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 Sandy 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 Sandy.

In addition, the report highlights stations which have exceeded historical recorded maximum water levels as a result of Sandy (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 – 74). 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.

Within data reports that CO-OPS generates for significant tropical cyclones, storms are designated by the most significant classification obtained throughout the storm's duration. While Sandy was, at times, a tropical storm, a hurricane and a post-tropical cyclone prior to making landfall along the East Coast of the U.S., the storm will be referenced as Hurricane Sandy throughout this report.

## Summary

Sandy initially formed as a tropical depression in the southwestern Caribbean, about 320 miles south-southwest of the Kingston, Jamaica on October 22<sup>st</sup> 2012. Sandy followed a generally northward track over the coming days, moving over eastern Jamaica, eastern Cuba and the Bahamas (not shown). As Sandy moved over the Bahamas, the storm curved slightly to the west. While Sandy remained well offshore of Florida as a category 1 hurricane on October 26<sup>th</sup> (see Figure 2a), tropical storm force winds began to affect the U.S. Atlantic coast. Hurricane Sandy then began to take a more northeasterly track, following the coastline of North and South Carolina from October 27<sup>th</sup> to October 29<sup>th</sup> while remaining 250 to 300 miles offshore (see Figure 2a). Although Sandy remained a category 1 hurricane, the storm continued to grow in size. As Sandy moved offshore of the Outer Banks of North Carolina, the storm began to curve back to the northwest and head towards the mid-Atlantic coast as it picked up speed on October 29<sup>th</sup> (see Figures 2b and 2c). Despite the fact that Sandy had transitioned to a post-tropical cyclone just prior to making landfall near Atlantic City, NJ around 00:00 GMT on October 30<sup>th</sup> (October 29<sup>th</sup> 20:00 EDT), the storm still exhibited winds equivalent to a category 1 hurricane at landfall. Following landfall, the storm continued west-northwestward through Pennsylvania on October 30<sup>th</sup>, continuing to impact areas with tropical storm force winds and heavy rainfall before eventually curving northward into Canada the following day.

As Sandy passed offshore of Florida, Georgia and South Carolina, the maximum storm tide measured was 3.045 m (9.99 ft) above Mean Lower Low Water (MLLW) at Clarendon Plantation, SC on October 28 13:54 GMT. The maximum storm surge/residual across this region was also measured at Clarendon Plantation, SC and reached 1.082 m (3.55 ft) above tidal predictions on October 28 18:00 GMT. Maximum storm surge/residuals from Florida to South Carolina ranged from 0.28 to 1.08 m (0.9 to 3.6 ft) during Sandy. The highest wind speed and gust across this region were both measured at Lake Worth Pier, FL with a speed of 38.7 kts (44.5 mph) and a gust of 48.6 kts (55.9 mph). The minimum barometric pressure recorded from Florida to South Carolina was also at Lake Worth Pier, FL and measured 997.2 mb.

As Hurricane Sandy made a turn towards the mid-Atlantic coast and continued to grow in size, much more significant storm effects were observed from North Carolina northward to New England, especially across New Jersey, New York and Connecticut. The maximum observed storm tide along the coast from North Carolina to New Hampshire was 4.444 m (14.58 ft) above MLLW at Bergen Point West Reach, NY on October 30 01:24 GMT, shortly after landfall. The maximum storm surge/residual across this region was measured at Kings Point, NY and reached 3.856 m (12.65 ft) above tidal predictions on October 29 23:00 GMT, which was an hour prior to landfall. During Sandy, maximum storm surge/residuals along the mid-Atlantic coast from North Carolina to Delaware ranged from 0.63 to 1.63 m (1.8 to 5.3 ft). Within the Chesapeake Bay, maximum storm surge/residuals ranged from 0.75 to 1.46 m (2.5 to 4.9 ft). Within the Delaware Bay and River, maximum storm surge/residuals ranged from 1.62 to 1.96 m (5.3 to 6.4 ft). From New Jersey to Connecticut, maximum storm surge/residuals ranged from 1.57 to 4.44 m (5.2 to 12.7 ft). Along the New England coast from Rhode Island to Massachusetts, maximum storm surge/residuals ranged from 1.28 to 4.44 m (6.2 to 12.2 ft). Across the coast of New Hampshire and Maine, maximum storm surge/residuals ranged from 0.69 to 1.08 m (2.3 to 3.5 ft).

The highest wind speed recorded at CO-OPS and partnership stations from North Carolina to New England due to Hurricane Sandy was 51.9 kts (59.7 mph), at Cape May, NJ on October 30 00:00 GMT as Sandy made landfall. The highest wind gust also was recorded at Cape May, NJ and measured 65.3 kts (75.1 mph) on October 30 00:00 GMT. The minimum barometric pressure recorded from North Carolina to New England measured 945.5 mb at Atlantic City, NJ on October 29 22:24 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.

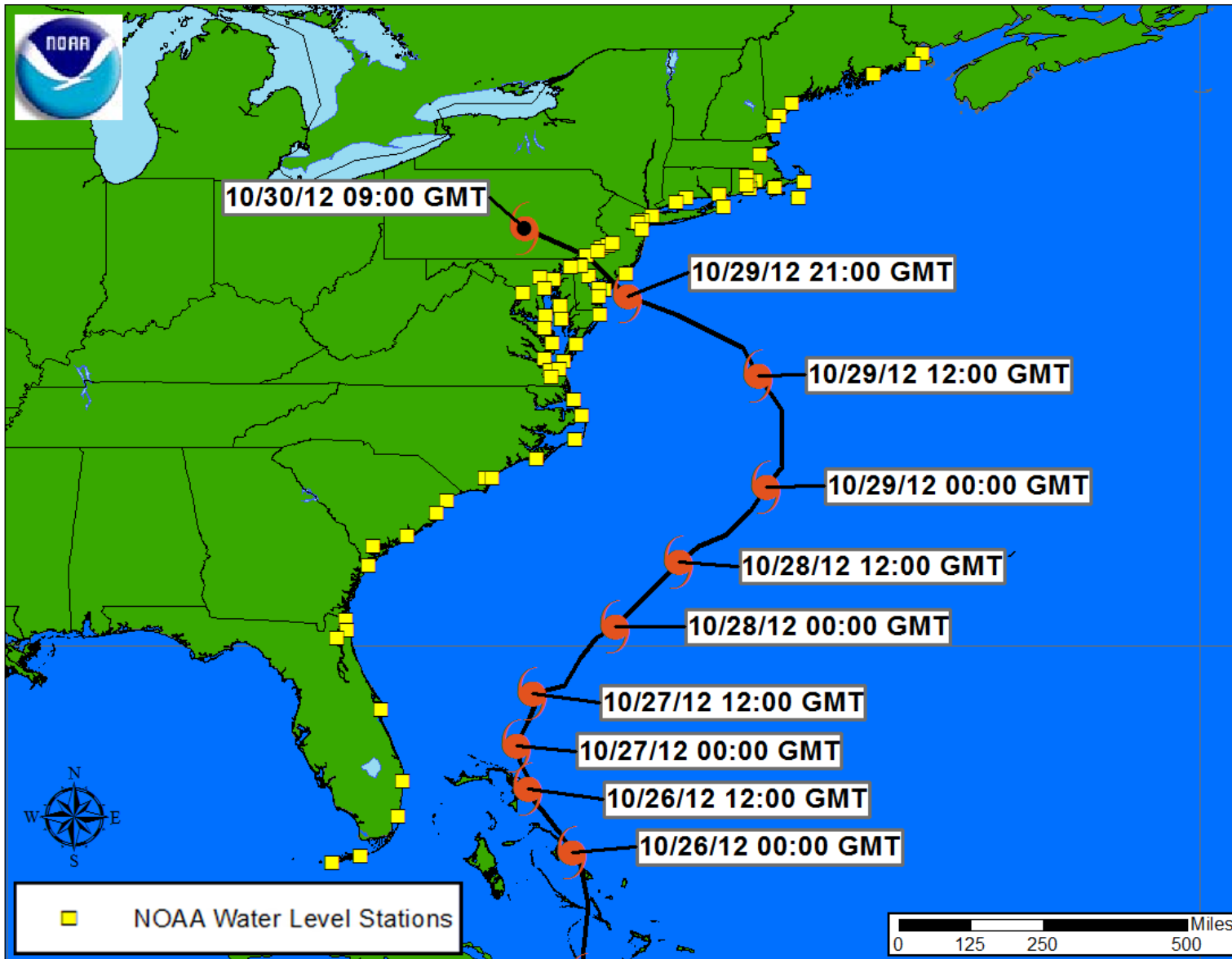
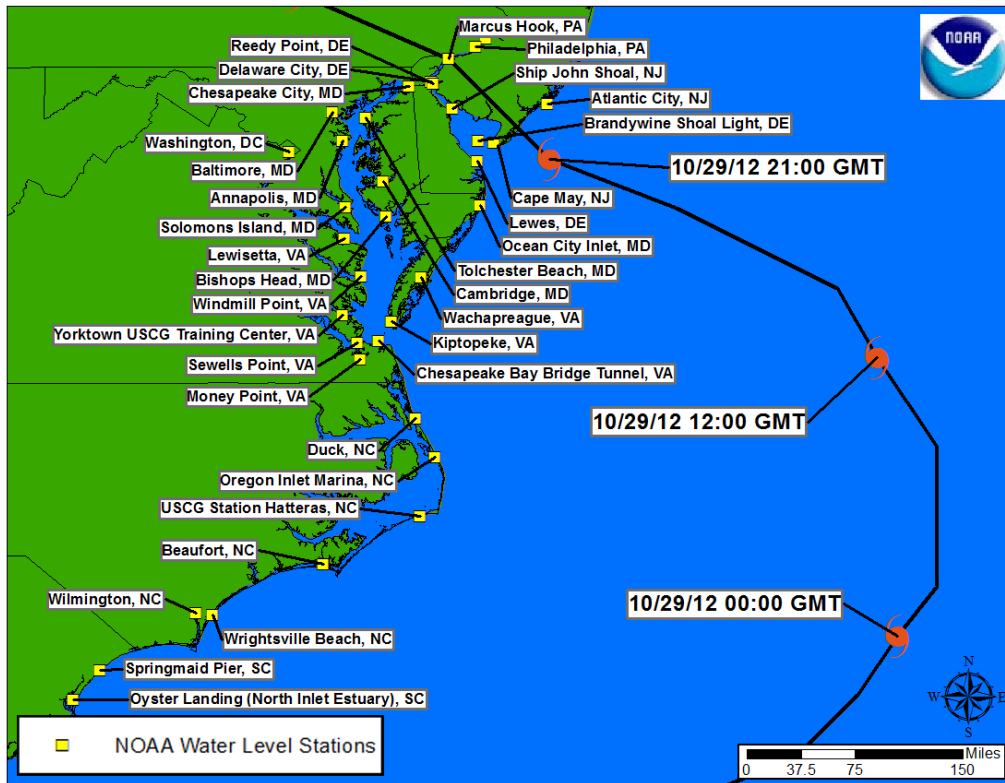
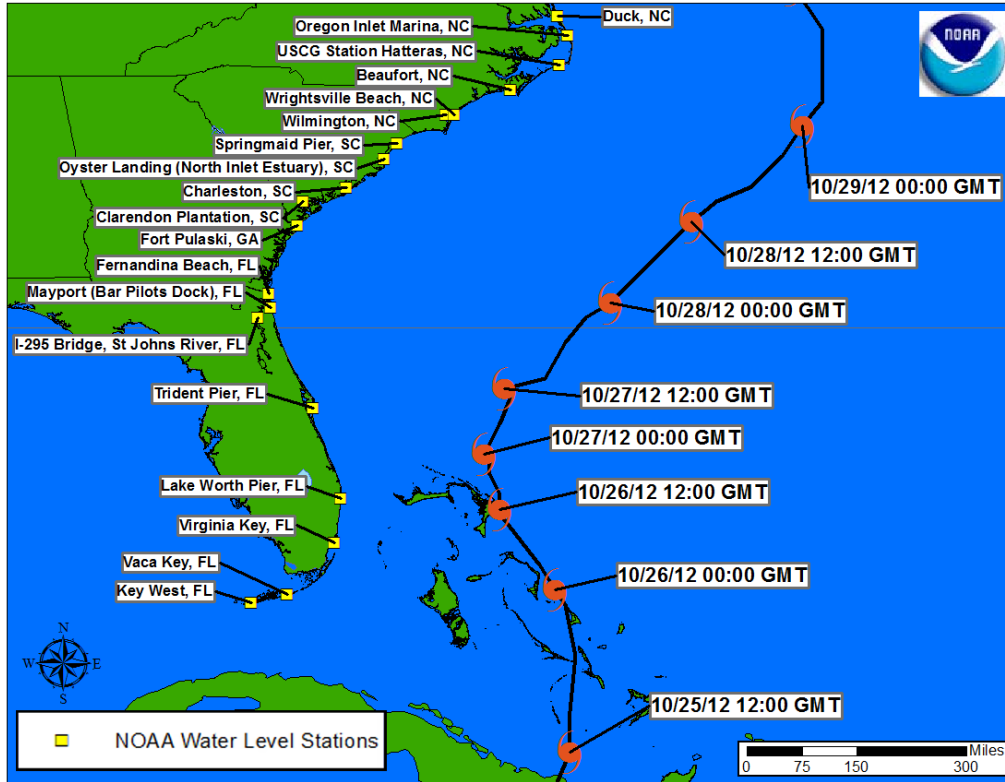


Figure 1: NOAA and partnership stations relative to the Hurricane Sandy storm track (track information courtesy of the NOAA National Hurricane Center).



Figures 2a and 2b: NOAA and partnership stations located along the coast of a) Florida to North Carolina and b) South Carolina to New Jersey, relative to the Hurricane Sandy storm track (track information courtesy of the NOAA National Hurricane Center).



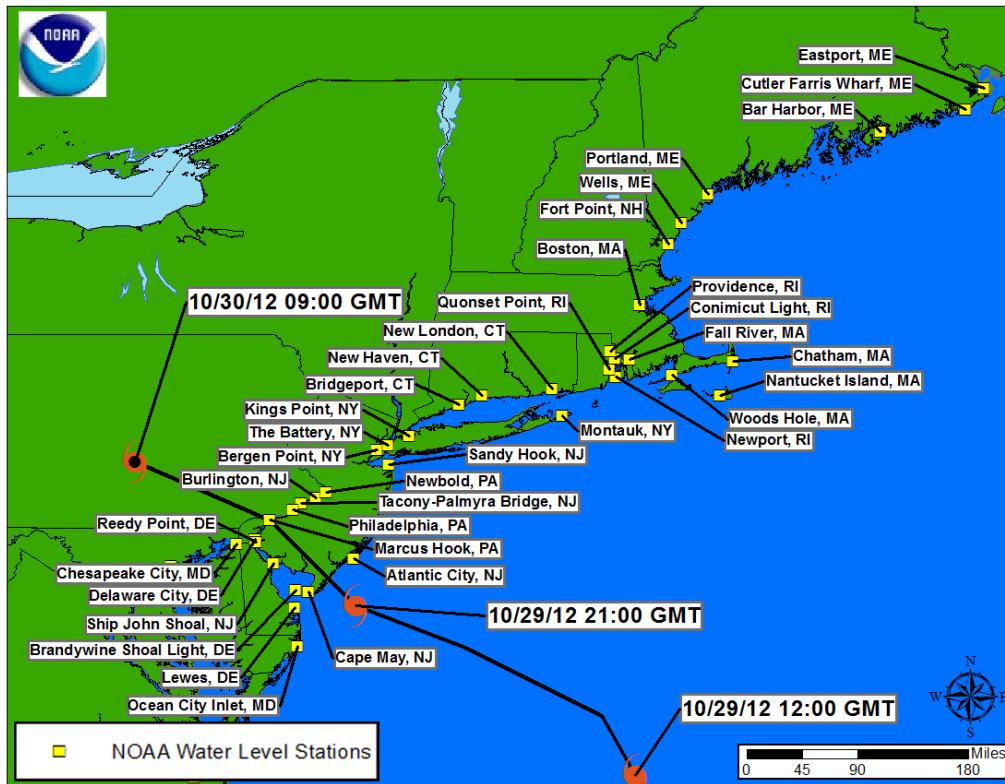


Figure 2c: NOAA and partnership stations located along the Atlantic Coast from Maryland to Maine, relative to the Hurricane Sandy storm track (track information courtesy of the NOAA National Hurricane Center).

Table 1a: Maximum recorded water levels in geographic order for Hurricane Sandy, October 2012, referenced to MLLW and NAVD88 (where available). Storm Tide includes both tidal and meteorological forces and storm surge represents the observed water level (storm tide) minus predicted astronomical tide. Stations where the historical maximum water level was exceeded are highlighted in gray.

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)			
Key West, FL	8724580	10/30/2012 02:24	0.930	0.675	0.255	0.392	3.05	2.21	0.84	1.29
Vaca Key, FL	8723970	10/30/2012 03:48	0.827	0.357	0.470	0.420	2.71	1.17	1.54	1.38
Virginia Key, FL	8723214	10/28/2012 12:48	1.264	0.826	0.438	0.662	4.15	2.71	1.44	2.17
<sup>3</sup> Lake Worth Pier, FL	8722670	10/28/2012 11:06	1.614	1.060	0.554	0.866	5.30	3.48	1.82	2.84
Trident Pier, FL	8721604	10/28/2012 10:54	2.022	1.338	0.684	1.149	6.63	4.39	2.24	3.77
I-295 Bridge, St Johns River, FL	8720357	10/28/2012 15:24	0.812	0.331	0.481	0.666	2.66	1.09	1.57	2.19
Mayport (Bar Pilots Dock), FL	8720218	10/28/2012 12:42	2.009	1.711	0.298	1.093	6.59	5.61	0.98	3.59
Fernandina Beach, FL	8720030	10/28/2012 13:06	2.456	2.142	0.314	1.291	8.06	7.03	1.03	4.24
Fort Pulaski, GA	8670870	10/28/2012 12:24	2.752	2.368	0.384	1.517	9.03	7.77	1.26	4.98
Clarendon Plantation, SC	8667633	10/28/2012 13:54	3.045	2.547	0.498	n/a	9.99	8.36	1.63	n/a
Charleston, SC	8665530	10/28/2012 12:06	2.238	1.866	0.372	1.281	7.34	6.12	1.22	4.20
Oyster Landing (N. Inlet Estuary), SC	8662245	10/28/2012 12:42	2.021	1.657	0.364	1.196	6.63	5.44	1.19	3.92
Springmaid Pier, SC	8661070	10/28/2012 12:00	2.166	1.717	0.449	1.204	7.11	5.63	1.48	3.95
Wrightsville Beach, NC	8658163	10/28/2012 11:48	1.947	1.394	0.553	1.175	6.39	4.57	1.82	3.85
Wilmington, NC	8658120	10/30/2012 15:00	1.802	1.488	0.314	n/a	5.91	4.88	1.03	n/a
Beaufort, NC	8656483	10/29/2012 12:30	1.633	1.162	0.471	n/a	5.36	3.81	1.55	n/a
<sup>3</sup> USCG Station Hatteras, NC	8654467	10/29/2012 03:00	1.441	0.222	1.219	n/a	4.73	0.73	4.00	n/a
Oregon Inlet Marina, NC	8652587	10/29/2012 14:42	1.309	0.262	1.047	1.094	4.29	0.86	3.43	3.59
<sup>2</sup> Duck, NC	8651370	10/28/2012 11:24	2.128	1.213	0.915	1.461	6.98	3.98	3.00	4.79
Money Point, VA	8639348	10/29/2012 14:00	2.223	1.035	1.188	n/a	7.29	3.40	3.89	n/a
Chesapeake Bay Bridge Tunnel, VA	8638863	10/29/2012 12:36	2.163	0.978	1.185	n/a	7.10	3.21	3.89	n/a
Sewells Point, VA	8638610	10/29/2012 13:18	2.076	0.919	1.157	1.575	6.81	3.02	3.79	5.17
Yorktown USCG Training Center, VA	8637689	10/29/2012 13:30	1.835	0.876	0.959	n/a	6.02	2.87	3.15	n/a
Windmill Point, VA	8636580	10/29/2012 14:30	1.336	0.494	0.842	n/a	4.38	1.62	2.76	n/a
Lewisetta, VA	8635750	10/28/2012 18:12	1.144	0.476	0.668	0.891	3.75	1.56	2.19	2.92
Kiptopeke, VA	8632200	10/29/2012 12:48	2.080	0.982	1.098	1.500	6.82	3.22	3.60	4.92
Wachapreague, VA	8631044	10/29/2012 12:12	2.558	1.497	1.061	n/a	8.39	4.91	3.48	n/a

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

<sup>2</sup> Sensor was damaged or destroyed and likely did not record a maximum water level

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

Table 1b: Maximum recorded water levels in geographic order for Hurricane Sandy, October 2012, referenced to MLLW and NAVD88 (where available). Storm Tide includes both tidal and meteorological forces and storm surge represents the observed water level (storm tide) minus predicted astronomical tide. Stations where the historical maximum water level was exceeded are highlighted in gray.

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)			
Washington, DC	8594900	10/31/2012 00:06	1.863	0.887	0.976	1.438	6.11	2.91	3.20	4.72
<sup>1</sup> Solomons Island, MD	8577330	10/30/2012 22:48	0.894	0.267	0.627	0.635	2.93	0.88	2.05	2.08
Annapolis, MD	8575512	10/30/2012 13:00	1.183	0.192	0.991	0.948	3.88	0.63	3.25	3.11
Baltimore, MD	8574680	10/30/2012 10:36	1.420	0.351	1.069	1.166	4.66	1.15	3.51	3.83
Chesapeake City, MD	8573927	10/30/2012 13:54	1.808	0.787	1.021	n/a	5.93	2.58	3.35	n/a
Tolchester Beach, MD	8573364	10/30/2012 11:24	1.460	0.410	1.050	n/a	4.79	1.35	3.44	n/a
Cambridge, MD	8571892	10/29/2012 21:30	1.386	0.633	0.753	1.049	4.55	2.08	2.47	3.44
<sup>3</sup> Bishops Head, MD	8571421	10/30/2012 18:36	1.310	0.661	0.649	0.930	4.30	2.17	2.13	3.05
Ocean City Inlet, MD	8570283	10/29/2012 13:42	1.847	0.707	1.140	1.348	6.06	2.32	3.74	4.42
Lewes, DE	8557380	10/29/2012 13:00	2.654	1.478	1.176	1.853	8.71	4.85	3.86	6.08
<sup>2</sup> Brandywine Shoal Light, DE	8555889	10/29/2012 12:00	2.470	1.682	0.788	n/a	8.10	5.52	2.58	n/a
Reedy Point, DE	8551910	10/30/2012 05:42	2.774	1.306	1.468	1.869	9.10	4.28	4.82	6.13
<sup>3</sup> Delaware City, DE	8551762	10/30/2012 05:54	2.968	1.332	1.636	n/a	9.74	4.37	5.37	n/a
Newbold, PA	8548989	10/30/2012 09:18	3.731	2.117	1.614	n/a	12.25	6.95	5.30	n/a
<sup>3</sup> Philadelphia, PA	8545240	10/30/2012 08:06	3.237	1.602	1.635	2.292	10.62	5.26	5.36	7.52
<sup>3</sup> Marcus Hook, PA	8540433	10/30/2012 06:48	3.100	1.450	1.650	n/a	10.17	4.76	5.41	n/a
Burlington, Delaware River, NJ	8539094	10/30/2012 09:12	3.563	1.882	1.681	n/a	11.69	6.17	5.52	n/a
Tacony-Palmyra Bridge, NJ	8538886	10/30/2012 08:36	3.324	1.707	1.617	n/a	10.91	5.60	5.31	n/a
<sup>3</sup> Ship John Shoal, NJ	8537121	10/30/2012 04:12	2.872	1.531	1.341	n/a	9.42	5.02	4.40	n/a
<sup>3</sup> Cape May, NJ	8536110	10/29/2012 13:42	2.717	1.645	1.072	1.797	8.91	5.40	3.51	5.89
Atlantic City, NJ	8534720	10/30/2012 00:24	2.712	1.242	1.470	1.915	8.90	4.07	4.83	6.28
<sup>2,3</sup> Sandy Hook, NJ	8531680	10/29/2012 23:36	4.033	1.422	2.611	3.175	13.23	4.67	8.56	10.42
<sup>3</sup> Bergen Point West Reach, NY	8519483	10/30/2012 01:24	4.443	1.571	2.872	n/a	14.58	5.15	9.43	n/a
<sup>3</sup> The Battery, NY	8518750	10/30/2012 01:24	4.284	1.418	2.866	3.438	14.06	4.65	9.41	11.28
<sup>3</sup> Kings Point, NY	8516945	10/30/2012 02:06	4.361	1.758	2.603	n/a	14.31	5.77	8.54	n/a
Montauk, NY	8510560	10/30/2012 00:12	2.169	0.574	1.595	1.691	7.12	1.88	5.24	5.55
<sup>3</sup> Bridgeport, CT	8467150	10/30/2012 02:06	4.007	1.617	2.390	2.836	13.15	5.31	7.84	9.30

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

<sup>2</sup> Sensor was damaged or destroyed and likely did not record a maximum water level

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

Table 1c: Maximum recorded water levels in geographic order for Hurricane Sandy, October 2012, referenced to MLLW and NAVD88 (where available). Storm Tide includes both tidal and meteorological forces and storm surge represents the observed water level (storm tide) minus predicted astronomical tide. Stations where the historical maximum water level was exceeded are highlighted in gray.

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>3</sup> New Haven, CT	8465705	10/30/2012 01:36	3.733	1.253	2.480	n/a	12.25	4.11	8.14	n/a
New London, CT	8461490	10/30/2012 00:12	2.436	0.634	1.802	1.876	7.99	2.08	5.91	6.16
<sup>1</sup> Quonset Point, RI	8454049	10/30/2012 01:12	2.045	1.098	0.947	n/a	6.71	3.60	3.11	n/a
Providence, RI	8454000	10/29/2012 23:30	2.854	1.215	1.639	2.100	9.37	3.99	5.38	6.89
<sup>3</sup> Conimicut Light, RI	8452944	10/29/2012 23:12	2.760	1.084	1.676	n/a	9.06	3.56	5.50	n/a
Newport, RI	8452660	10/29/2012 23:00	2.491	0.930	1.561	1.869	8.17	3.05	5.12	6.13
Nantucket Island, MA	8449130	10/29/2012 16:06	1.821	1.069	0.752	n/a	5.97	3.51	2.46	n/a
Woods Hole, MA	8447930	10/29/2012 22:18	1.769	0.243	1.526	1.354	5.81	0.80	5.01	4.44
Chatham, MA	8447435	10/29/2012 16:00	2.821	1.896	0.925	1.790	9.26	6.22	3.04	5.87
<sup>3</sup> Fall River, MA	8447386	10/29/2012 23:42	2.730	1.247	1.483	n/a	8.96	4.09	4.87	n/a
Boston, MA	8443970	10/29/2012 15:48	3.939	3.147	0.792	2.261	12.92	10.32	2.60	7.42
Fort Point, NH	8423898	10/29/2012 15:36	3.474	2.908	0.566	1.953	11.40	9.54	1.86	6.41
Wells, ME	8419317	10/29/2012 15:42	3.487	2.960	0.527	n/a	11.44	9.71	1.73	n/a
Portland, ME	8418150	10/29/2012 15:18	3.627	3.043	0.584	2.026	11.90	9.98	1.92	6.65
Bar Harbor, ME	8413320	10/29/2012 15:06	3.883	3.522	0.361	n/a	12.74	11.56	1.18	n/a
Cutler Farris Wharf, ME	8411060	10/31/2012 16:24	4.953	4.497	0.456	n/a	16.25	14.75	1.50	n/a
Eastport, ME	8410140	10/31/2012 16:18	6.293	5.925	0.368	3.264	20.65	19.44	1.21	10.71

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

<sup>2</sup> Sensor was damaged or destroyed and likely did not record a maximum water level

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

Table 2a: Maximum recorded wind speed, wind gusts and minimum barometric pressure in geographic order for Hurricane Sandy, October 2012.

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
Key West, FL	8724580	n/a	n/a	n/a	n/a	n/a	n/a	10/26/2012 09:54	1002.6
Vaca Key, FL	8723970	10/25/2012 18:42	16.9	32.9	10/25/2012 18:42	21.0	40.8	10/26/2012 19:54	1002.0
Virginia Key, FL	8723214	10/25/2012 17:06	14.1	27.4	10/25/2012 19:12	21.9	42.6	10/26/2012 19:30	997.4
Lake Worth Pier, FL	8722670	10/26/2012 14:00	19.9	38.7	10/26/2012 09:30	25.0	48.6	10/27/2012 08:00	997.2
Trident Pier, FL	8721604	10/26/2012 14:24	12.8	24.9	10/26/2012 14:24	18.1	35.2	10/27/2012 19:48	1000.2
I-295 Bridge, St Johns River, FL	8720357	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Mayport (Bar Pilots Dock), FL	8720218	10/26/2012 16:24	13.7	26.6	10/26/2012 19:12	17.4	33.8	10/27/2012 10:00	1003.2
Fernandina Beach, FL	8720030	10/27/2012 11:48	11.8	22.9	10/30/2012 18:24	15.0	29.2	10/27/2012 09:54	1001.0
Fort Pulaski, GA	8670870	10/30/2012 02:06	14.7	28.6	10/29/2012 18:48	18.0	35.0	10/27/2012 19:24	1000.8
Clarendon Plantation, SC	8667633	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Charleston, SC	8665530	10/25/2012 19:06	11.2	21.8	10/28/2012 03:12	13.9	27.0	10/27/2012 19:54	999.2
Oyster Landing (N. Inlet Estuary), SC	8662245	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Springmaid Pier, SC	8661070	10/27/2012 17:30	10.9	21.2	10/27/2012 09:00	17.1	33.2	10/29/2012 20:24	997.9
Wrightsville Beach, NC	8658163	10/27/2012 22:54	16.3	31.7	10/27/2012 21:24	21.9	42.6	10/29/2012 21:00	994.6
Wilmington, NC	8658120	n/a	n/a	n/a	n/a	n/a	n/a	10/29/2012 20:48	995.6
Beaufort, NC	8656483	10/28/2012 10:48	17.2	33.4	10/28/2012 12:54	23.6	45.8	10/28/2012 19:12	991.4
USCG Station Hatteras, NC	8654467	10/29/2012 02:24	23.3	45.3	10/29/2012 02:12	28.9	56.2	10/29/2012 02:30	987.7
Oregon Inlet Marina, NC	8652587	10/28/2012 13:24	18.8	36.5	10/29/2012 04:36	26.2	50.9	10/29/2012 18:30	986.6
Duck, NC	8651370	10/28/2012 21:48	22.5	43.7	10/28/2012 21:24	27.0	52.5	10/29/2012 18:42	985.1
Money Point, VA	8639348	10/29/2012 21:54	10.5	20.4	10/29/2012 21:54	20.5	39.8	10/29/2012 21:54	983.4
Chesapeake Bay Bridge Tunnel, VA	8638863	10/29/2012 01:00	22.3	43.3	10/29/2012 01:00	26.8	52.1	10/29/2012 21:36	980.7
Sewells Point, VA	8638610	n/a	n/a	n/a	n/a	n/a	n/a	10/29/2012 21:54	982.3
Yorktown USCG Training Center, VA	8637689	10/29/2012 01:00	18.2	35.4	10/29/2012 15:48	21.8	42.4	10/29/2012 22:30	980.0
Windmill Point, VA	8636580	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Lewisetta, VA	8635750	10/29/2012 20:00	18.2	35.4	10/29/2012 21:24	23.5	45.7	10/30/2012 00:12	974.4
Kiptopeke, VA	8632200	10/30/2012 01:30	21.7	42.2	10/29/2012 21:54	26.8	52.1	n/a	n/a
Wachapreague, VA	8631044	10/27/2012 23:48	14.0	27.2	10/29/2012 21:30	19.6	38.1	10/29/2012 22:00	974.9
Washington, DC	8594900	10/30/2012 01:18	16.5	32.1	10/30/2012 01:36	27.0	52.5	10/30/2012 02:30	968.8

Table 2b: Maximum recorded wind speed, wind gusts and minimum barometric pressure in geographic order for Hurricane Sandy, October 2012.

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
Solomons Island, MD	8577330	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Annapolis, MD	8575512	n/a	n/a	n/a	n/a	n/a	n/a	10/30/2012 01:24	964.4
Baltimore, MD	8574680	10/29/2012 16:54	13.0	25.3	10/29/2012 21:12	24.0	46.7	10/30/2012 03:00	962.8
Chesapeake City, MD	8573927	10/29/2012 21:48	13.6	26.4	10/29/2012 22:36	21.3	41.4	10/30/2012 02:00	956.3
Tolchester Beach, MD	8573364	10/29/2012 23:24	21.1	41.0	10/29/2012 23:30	26.6	51.7	10/30/2012 02:18	960.9
Cambridge, MD	8571892	10/29/2012 18:18	17.0	33.0	10/29/2012 21:18	24.9	48.4	10/30/2012 01:06	967.6
Bishops Head, MD	8571421	10/29/2012 23:18	24.7	48.0	10/29/2012 20:24	30.2	58.7	10/30/2012 00:06	970.8
Ocean City Inlet, MD	8570283	10/30/2012 03:00	18.8	36.5	10/29/2012 18:06	26.1	50.7	10/29/2012 21:06	962.7
Lewes, DE	8557380	10/29/2012 21:12	23.6	45.9	10/29/2012 23:12	29.6	57.5	10/29/2012 22:06	959.0
Brandywine Shoal Light, DE	8555889	10/29/2012 10:12	22.7	44.1	10/29/2012 11:54	27.9	54.2	10/29/2012 12:00	988.5
Reedy Point, DE	8551910	n/a	n/a	n/a	n/a	n/a	n/a	10/30/2012 01:30	954.5
Delaware City, DE	8551762	10/29/2012 20:24	16.0	31.1	10/29/2012 21:00	22.9	44.5	10/30/2012 01:30	954.2
Newbold, PA	8548989	10/30/2012 02:30	17.6	34.2	10/30/2012 02:30	26.4	51.3	10/30/2012 00:18	955.3
Philadelphia, PA	8545240	n/a	n/a	n/a	n/a	n/a	n/a	10/30/2012 01:24	952.0
Marcus Hook, PA	8540433	n/a	n/a	n/a	n/a	n/a	n/a	10/30/2012 01:48	951.9
Burlington, Delaware River, NJ	8539094	10/30/2012 01:12	18.4	35.8	10/30/2012 01:12	25.7	50.0	10/30/2012 00:30	953.7
Tacony-Palmyra Bridge, NJ	8538886	n/a	n/a	n/a	n/a	n/a	n/a	10/30/2012 00:42	952.7
Ship John Shoal, NJ	8537121	10/30/2012 04:18	26.2	50.9	10/30/2012 04:00	29.6	57.5	10/29/2012 23:30	953.0
Cape May, NJ	8536110	10/30/2012 00:00	26.7	51.9	10/30/2012 00:00	33.6	65.3	10/29/2012 22:18	953.8
Atlantic City, NJ	8534720	n/a	n/a	n/a	n/a	n/a	n/a	10/29/2012 22:24	945.5
Sandy Hook, NJ	8531680	10/29/2012 22:18	20.0	38.9	10/29/2012 22:42	30.8	59.9	10/29/2012 22:12	961.0
Bergen Point West Reach, NY	8519483	10/29/2012 19:06	16.3	31.7	10/30/2012 00:36	24.5	47.6	10/29/2012 21:54	963.8
The Battery, NY	8518750	n/a	n/a	n/a	n/a	n/a	n/a	10/29/2012 21:42	964.1
Kings Point, NY	8516945	10/29/2012 21:06	12.8	24.9	10/29/2012 17:42	21.3	41.4	10/29/2012 22:00	965.7
Montauk, NY	8510560	n/a	n/a	n/a	n/a	n/a	n/a	10/29/2012 20:00	974.4
Bridgeport, CT	8467150	10/29/2012 21:06	18.9	36.7	10/29/2012 21:06	26.8	52.1	10/29/2012 20:54	972.5
New Haven, CT	8465705	10/29/2012 21:36	15.3	29.7	10/29/2012 21:48	26.2	50.9	10/29/2012 20:36	973.9
New London, CT	8461490	10/29/2012 20:42	16.8	32.7	10/29/2012 20:54	24.8	48.2	10/29/2012 20:12	976.9

Table 2c: Maximum recorded wind speed, wind gusts and minimum barometric pressure in geographic order for Hurricane Sandy, October 2012.

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
Quonset Point, RI	8454049	10/29/2012 20:48	22.1	43.0	10/29/2012 20:12	28.3	55.0	10/29/2012 20:06	981.8
Providence, RI	8454000	10/29/2012 20:30	17.7	34.4	10/29/2012 22:30	23.9	46.5	10/29/2012 20:12	983.1
Conimicut Light, RI	8452944	10/29/2012 20:42	23.8	46.3	10/29/2012 19:24	31.6	61.4	10/29/2012 20:12	982.0
Newport, RI	8452660	n/a	n/a	n/a	n/a	n/a	n/a	10/29/2012 20:18	981.6
Nantucket Island, MA	8449130	10/29/2012 19:36	20.5	39.8	10/29/2012 18:54	26.6	51.7	10/29/2012 19:06	984.0
Woods Hole, MA	8447930	n/a	n/a	n/a	n/a	n/a	n/a	10/29/2012 19:54	984.0
Chatham, MA	8447435	n/a	n/a	n/a	n/a	n/a	n/a		
Fall River, MA	8447386	n/a	n/a	n/a	n/a	n/a	n/a	10/29/2012 19:48	983.6
Boston, MA	8443970	n/a	n/a	n/a	n/a	n/a	n/a	10/30/2012 00:42	989.5
Fort Point, NH	8423898	n/a	n/a	n/a	n/a	n/a	n/a		
Wells, ME	8419317	10/29/2012 21:30	17.5	34.0	10/29/2012 20:30	24.1	46.8	10/30/2012 02:24	994.0
Portland, ME	8418150	n/a	n/a	n/a	n/a	n/a	n/a	10/30/2012 03:06	997.7
Bar Harbor, ME	8413320	10/30/2012 07:18	19.4	37.7	10/30/2012 06:30	24.7	48.0	10/31/2012 20:36	999.7
Cutler Farris Wharf, ME	8411060	10/29/2012 19:36	8.5	16.5	10/29/2012 18:42	14.8	28.8	10/31/2012 21:30	1000.1
Eastport, ME	8410140	10/29/2012 20:30	15.0	29.2	10/29/2012 23:12	20.0	38.9	10/31/2012 22:30	1000.0

Table 3a: Maximum recorded storm surge/residual levels ranked by amplitude for Hurricane Sandy, October 2012. Storm Surge/Residual represents the observed water level (storm tide) minus predicted astronomical tide levels.

Station Name	Station ID	Date & Time GMT	Residual	
			in Meters	in Feet
<sup>3</sup> Kings Point, NY	8516945	10/29/2012 23:00	3.855	12.65
<sup>3</sup> Bridgeport, CT	8467150	10/30/2012 00:18	2.997	9.83
<sup>3</sup> Bergen Point West Reach, NY	8519483	10/30/2012 01:48	2.913	9.56
<sup>3</sup> The Battery, NY	8518750	10/30/2012 01:24	2.866	9.40
<sup>3</sup> New Haven, CT	8465705	10/30/2012 00:06	2.786	9.14
<sup>2,3</sup> Sandy Hook, NJ	8531680	10/29/2012 23:36	2.611	8.57
New London, CT	8461490	10/29/2012 22:54	1.982	6.50
Newbold, PA	8548989	10/30/2012 10:42	1.956	6.42
Burlington, Delaware River, NJ	8539094	10/30/2012 10:24	1.917	6.29
<sup>3</sup> Marcus Hook, PA	8540433	10/30/2012 08:00	1.907	6.26
Providence, RI	8454000	10/29/2012 22:12	1.888	6.20
Tacony-Palmyra Bridge, NJ	8538886	10/30/2012 09:48	1.861	6.11
<sup>3</sup> Delaware City, DE	8551762	10/30/2012 06:54	1.826	5.99
<sup>3</sup> Conimicut Light, RI	8452944	10/29/2012 22:12	1.795	5.89
Montauk, NY	8510560	10/29/2012 22:12	1.794	5.89
<sup>3</sup> Philadelphia, PA	8545240	10/30/2012 09:18	1.777	5.83
Atlantic City, NJ	8534720	10/29/2012 20:42	1.773	5.82
Reedy Point, DE	8551910	10/30/2012 07:06	1.769	5.80
<sup>3</sup> Fall River, MA	8447386	10/29/2012 22:30	1.677	5.50
Lewes, DE	8557380	10/29/2012 17:30	1.627	5.34
Newport, RI	8452660	10/29/2012 22:18	1.627	5.34
<sup>3</sup> Ship John Shoal, NJ	8537121	10/30/2012 05:42	1.615	5.30
<sup>3</sup> Cape May, NJ	8536110	10/29/2012 18:00	1.574	5.16
<sup>1</sup> Quonset Point, RI	8454049	10/29/2012 20:48	1.572	5.16
Woods Hole, MA	8447930	10/29/2012 22:06	1.545	5.07
Wachapreague, VA	8631044	10/29/2012 05:54	1.508	4.95
Chesapeake City, MD	8573927	10/30/2012 10:18	1.486	4.88
Money Point, VA	8639348	10/29/2012 07:54	1.460	4.79
Sewells Point, VA	8638610	10/29/2012 07:24	1.394	4.57
Boston, MA	8443970	10/29/2012 21:00	1.394	4.57
Chesapeake Bay Bridge Tunnel, VA	8638863	10/29/2012 06:54	1.330	4.36
Ocean City Inlet, MD	8570283	10/29/2012 16:48	1.321	4.33

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

<sup>2</sup> Sensor was damaged or destroyed and likely did not record a maximum water level.

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



Table 3b: Maximum recorded storm surge/residual levels ranked by amplitude for Hurricane Sandy, October 2012. Storm Surge/Residual represents the observed water level (storm tide) minus predicted astronomical tide levels.

Station Name	Station ID	Date & Time GMT	Residual	
			in Meters	in Feet
<sup>2</sup> Brandywine Shoal Light, DE	8555889	10/29/2012 05:54	1.285	4.22
Chatham, MA	8447435	10/29/2012 22:42	1.280	4.20
<sup>2</sup> Duck, NC	8651370	10/29/2012 06:24	1.269	4.16
Washington, DC	8594900	10/30/2012 21:42	1.228	4.03
<sup>3</sup> USCG Station Hatteras, NC	8654467	10/29/2012 03:00	1.219	4.00
Nantucket Island, MA	8449130	10/29/2012 22:42	1.188	3.90
Yorktown USCG Training Center, VA	8637689	10/29/2012 07:54	1.176	3.86
Kiptopeke, VA	8632200	10/29/2012 07:42	1.146	3.76
Baltimore, MD	8574680	10/30/2012 14:18	1.124	3.69
Oregon Inlet Marina, NC	8652587	10/29/2012 20:30	1.103	3.62
Clarendon Plantation, SC	8667633	10/28/2012 18:00	1.083	3.55
Tolchester Beach, MD	8573364	10/30/2012 09:48	1.078	3.54
Wells, ME	8419317	10/29/2012 21:24	1.076	3.53
Annapolis, MD	8575512	10/30/2012 14:18	1.021	3.35
Fort Point, NH	8423898	10/29/2012 21:42	1.013	3.32
Portland, ME	8418150	10/29/2012 22:06	0.996	3.27
Cambridge, MD	8571892	10/30/2012 15:54	0.987	3.24
<sup>3</sup> Bishops Head, MD	8571421	10/30/2012 01:54	0.944	3.10
Fernandina Beach, FL	8720030	10/27/2012 16:18	0.900	2.95
Oyster Landing (N. Inlet Estuary), SC	8662245	10/28/2012 04:48	0.887	2.91
Fort Pulaski, GA	8670870	10/28/2012 03:42	0.882	2.89
Windmill Point, VA	8636580	10/29/2012 14:00	0.844	2.77
<sup>1</sup> Solomons Island, MD	8577330	10/30/2012 13:48	0.784	2.57
Mayport (Bar Pilots Dock), FL	8720218	10/28/2012 04:12	0.772	2.53
Cutler Farris Wharf, ME	8411060	10/29/2012 22:42	0.761	2.50
Trident Pier, FL	8721604	10/28/2012 07:12	0.760	2.49
Lewisetta, VA	8635750	10/29/2012 10:54	0.751	2.46
Charleston, SC	8665530	10/28/2012 03:48	0.729	2.39
<sup>3</sup> Lake Worth Pier, FL	8722670	10/28/2012 06:36	0.697	2.29
Bar Harbor, ME	8413320	10/29/2012 22:36	0.688	2.26
Wrightsville Beach, NC	8658163	10/28/2012 02:36	0.687	2.25
Eastport, ME	8410140	10/30/2012 00:00	0.673	2.21

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

<sup>2</sup> Sensor was damaged or destroyed and likely did not record a maximum water level.

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

Table 3c: Maximum recorded storm surge/residual levels ranked by amplitude for Hurricane Sandy, October 2012. Storm Surge/Residual represents the observed water level (storm tide) minus predicted astronomical tide levels.

Station Name	Station ID	Date & Time GMT	Residual	
			in Meters	in Feet
Springmaid Pier, SC	8661070	10/28/2012 02:54	0.616	2.02
Beaufort, NC	8656483	10/29/2012 17:48	0.580	1.90
I-295 Bridge, St Johns River, FL	8720357	10/28/2012 05:48	0.568	1.86
Wilmington, NC	8658120	10/30/2012 10:42	0.561	1.84
Vaca Key, FL	8723970	10/26/2012 13:36	0.518	1.70
Virginia Key, FL	8723214	10/29/2012 22:18	0.491	1.61
Key West, FL	8724580	10/30/2012 08:00	0.283	0.93

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

<sup>2</sup> Sensor was damaged or destroyed and likely did not record a maximum water level.

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

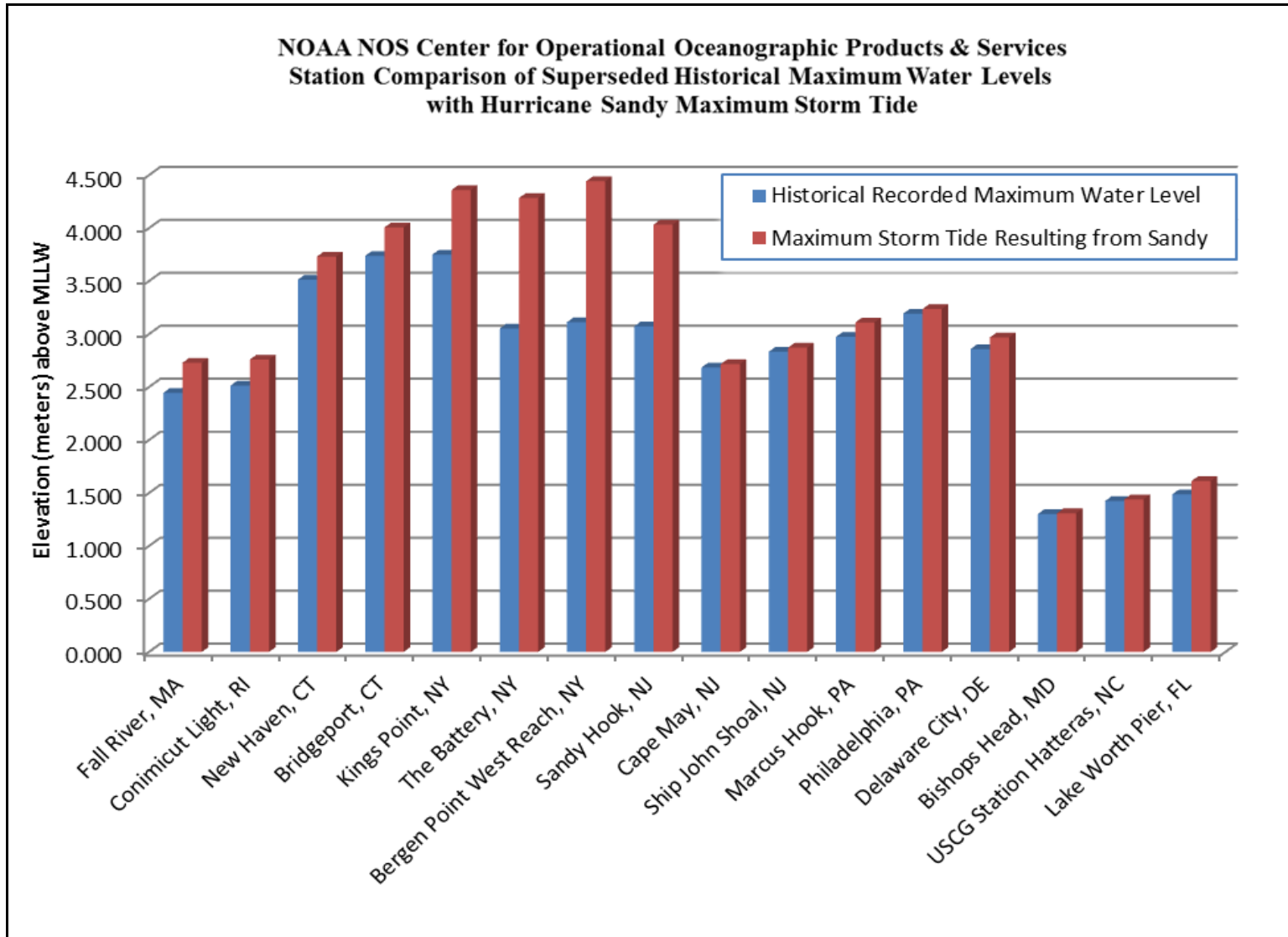


Figure 3: Stations that exceeded historical recorded maximum water levels during Hurricane Sandy. The station at Sandy Hook, NJ was destroyed before recording a maximum water level, therefore the maximum water level of record will remain unchanged. While the station at USCG Station Hatteras, NC recorded a higher water level during Hurricane Irene in 2011 than during Sandy, the historical maximum water level was not superseded following Irene because the station did not record a full tide.

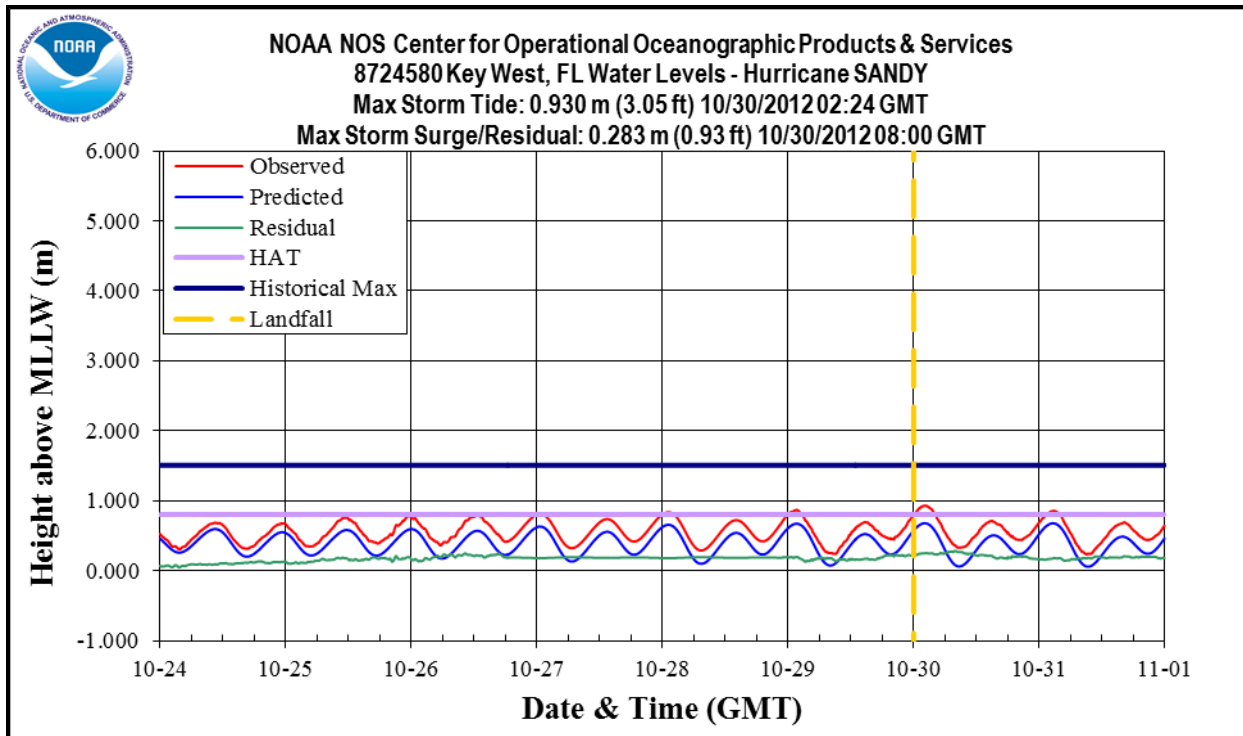


Figure 4: Water levels above Mean Lower Low Water (MLLW) at Key West, FL. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

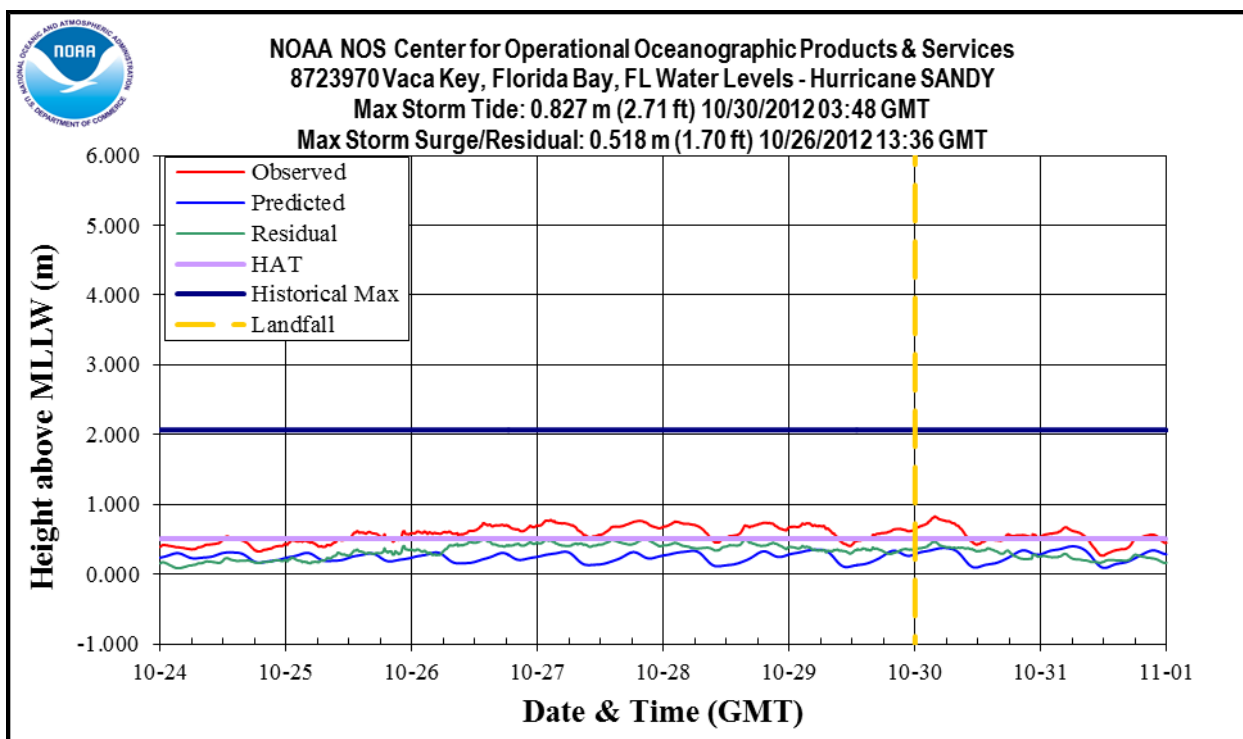


Figure 5: Water levels above Mean Lower Low Water (MLLW) at Vaca Key, FL. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

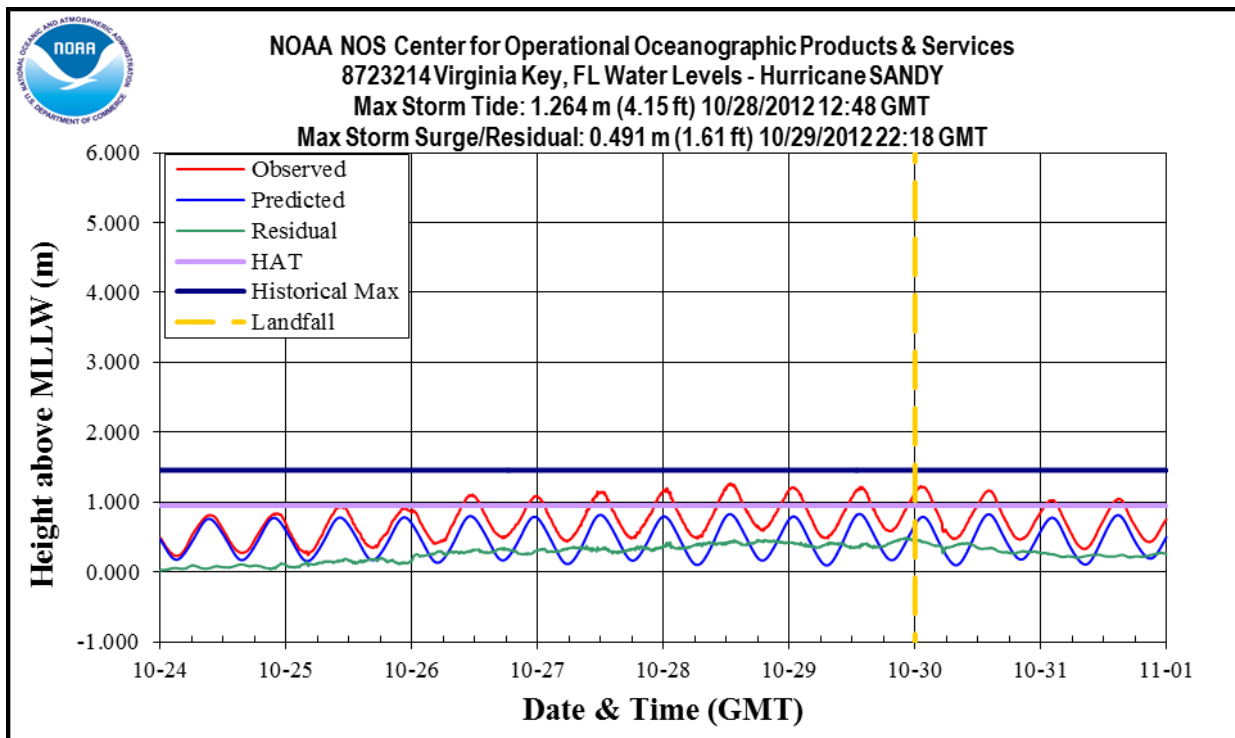


Figure 6: Water levels above Mean Lower Low Water (MLLW) at Virginia Key, FL. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

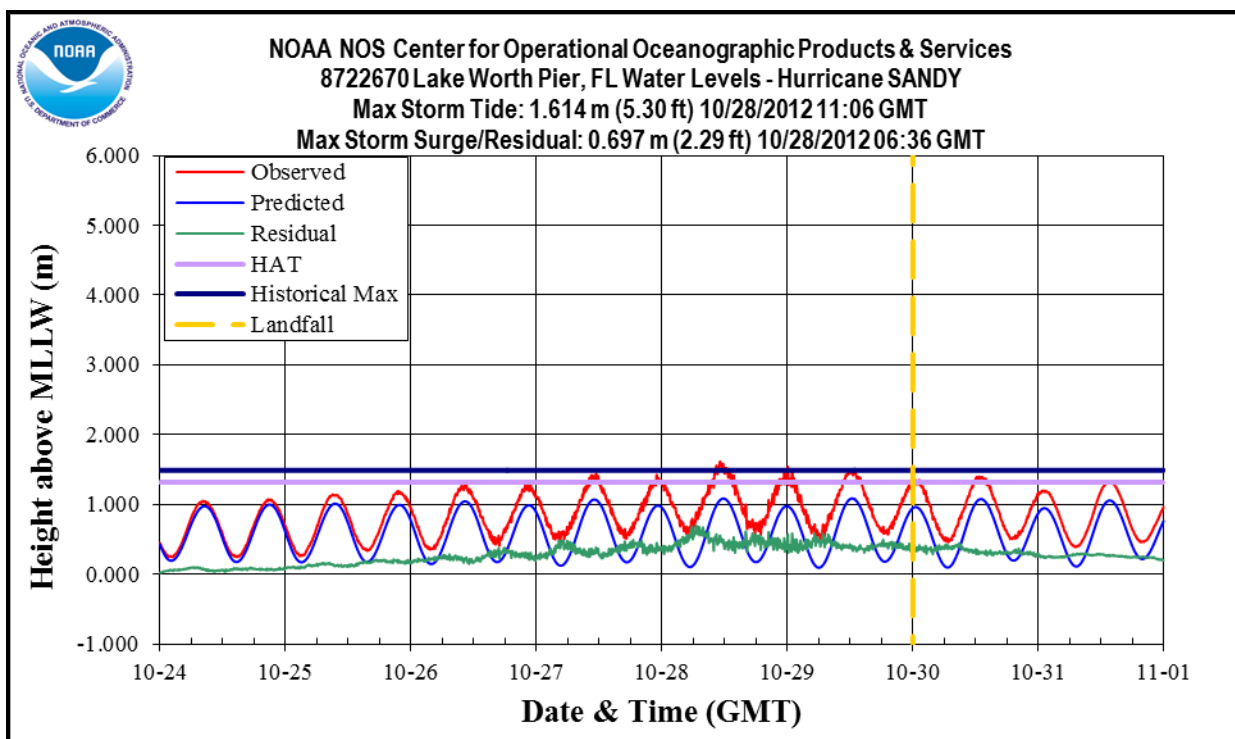


Figure 7: Water levels above Mean Lower Low Water (MLLW) at Lake Worth Pier, FL. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

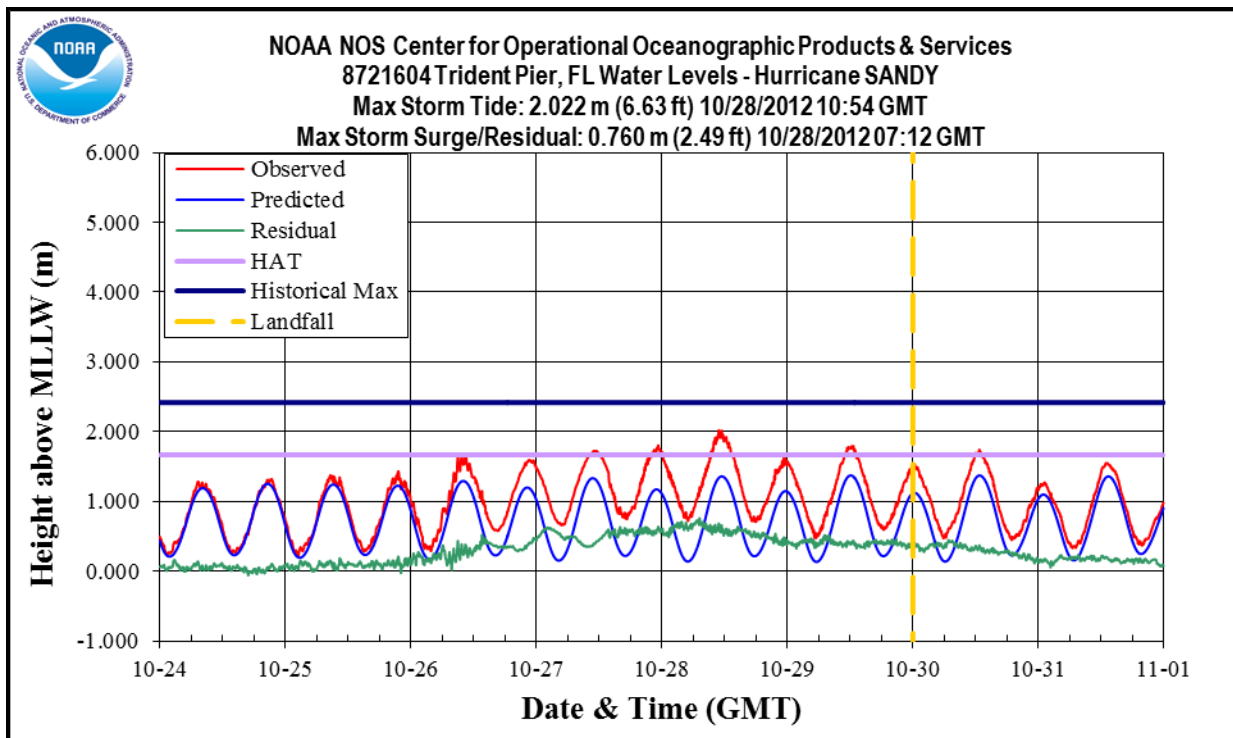


Figure 8: Water levels above Mean Lower Low Water (MLLW) at Trident Pier, FL. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

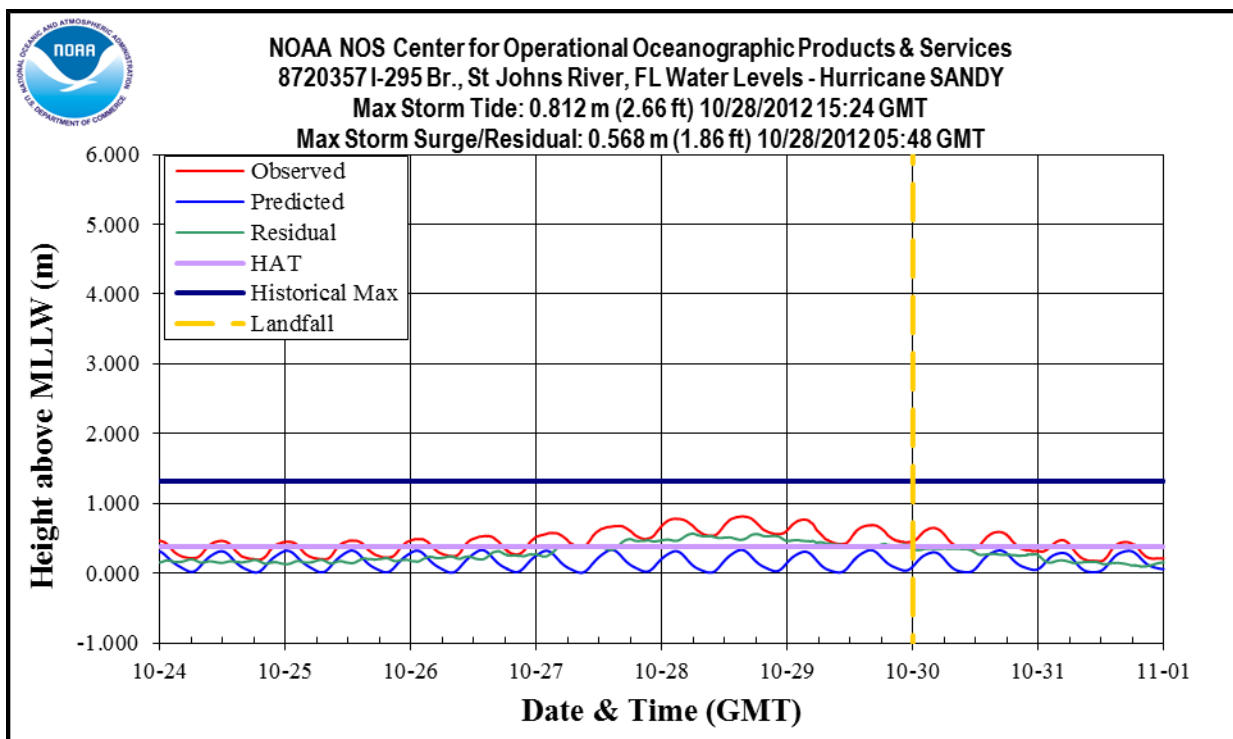


Figure 9: Water levels above Mean Lower Low Water (MLLW) at I-295 Bridge, St. Johns River, FL. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

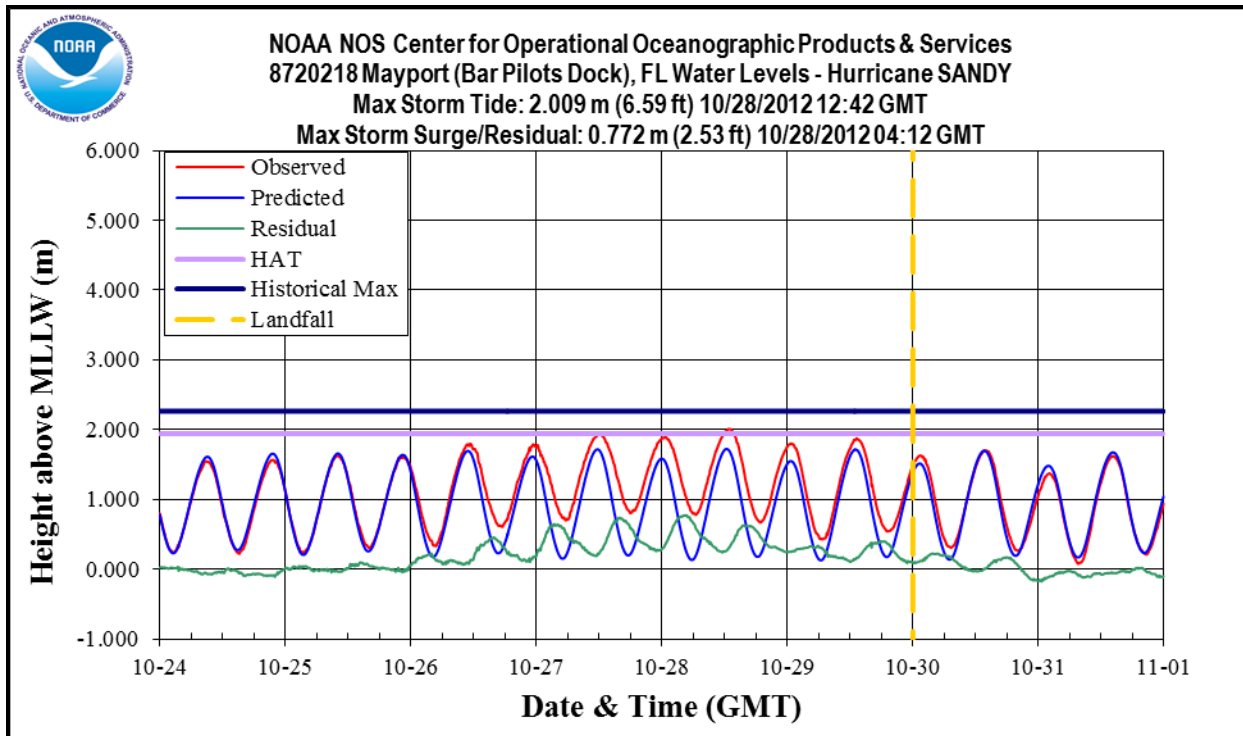


Figure 10: Water levels above Mean Lower Low Water (MLLW) at Mayport (Bar Pilots Dock), FL. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

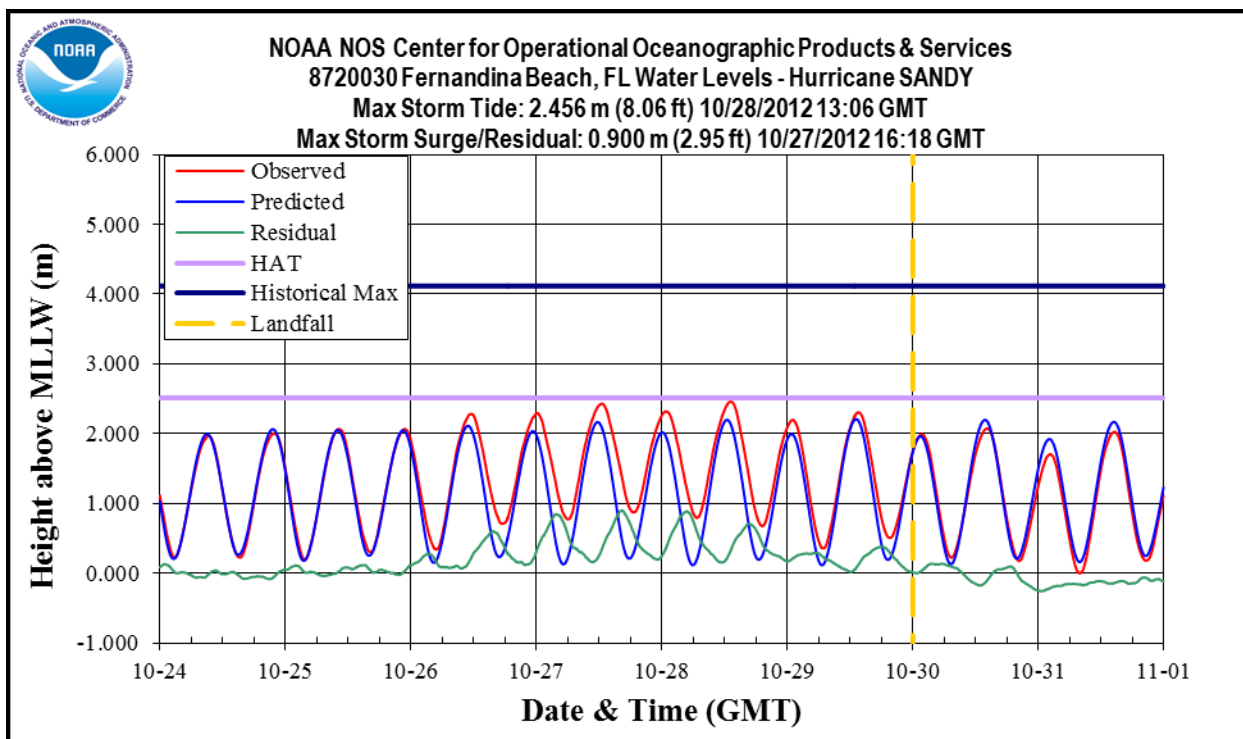


Figure 11: Water levels above Mean Lower Low Water (MLLW) at Fernandina Beach, FL. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

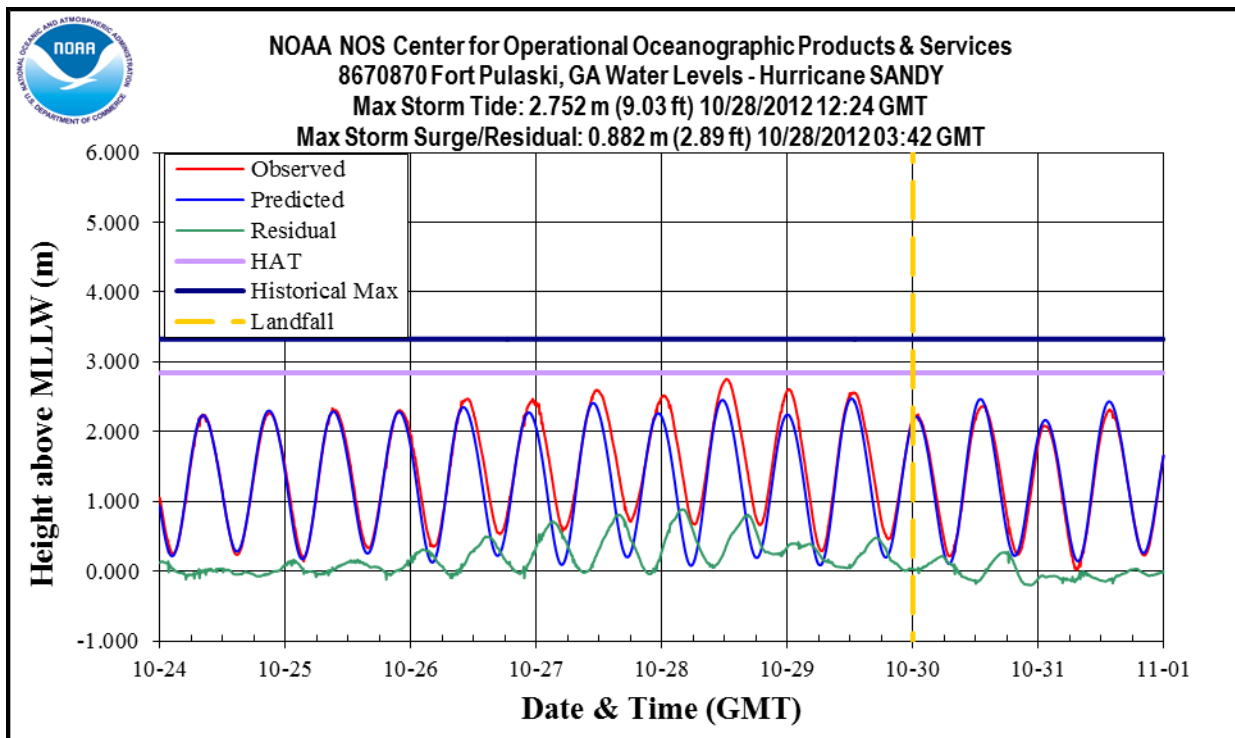


Figure 12: Water levels above Mean Lower Low Water (MLLW) at Fort Pulaski, GA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

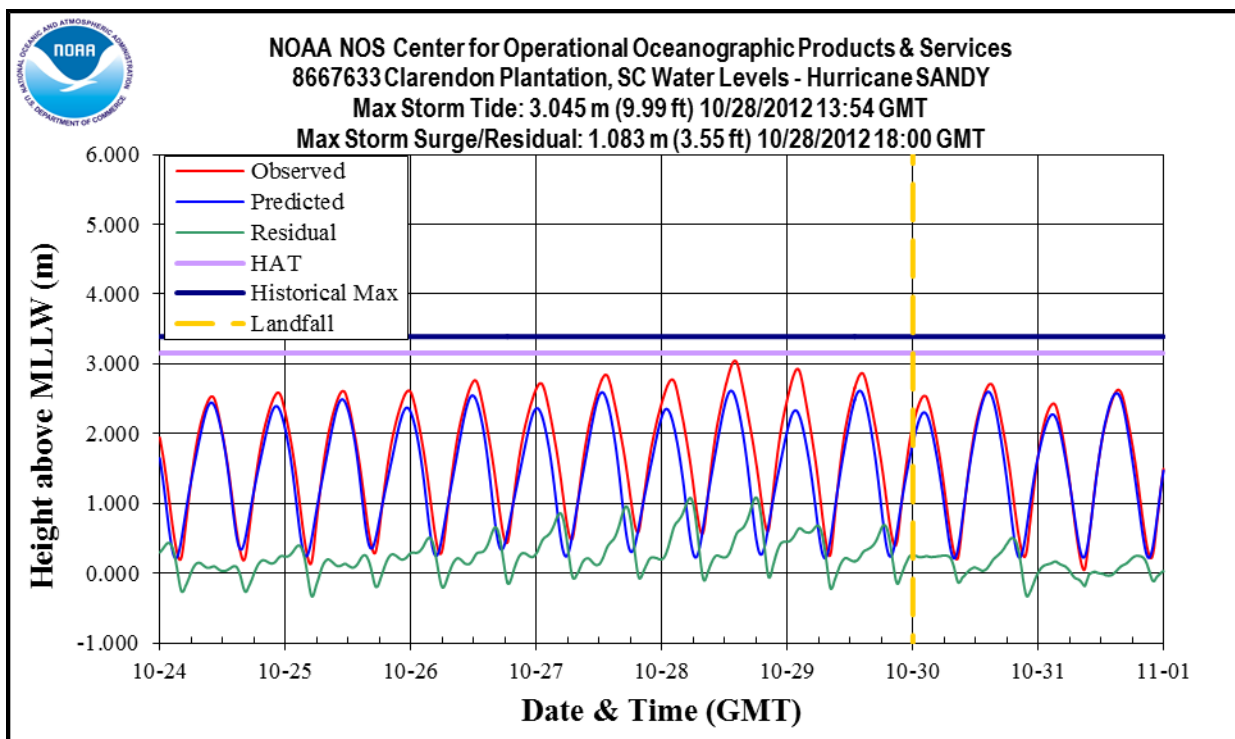


Figure 13: Water levels above Mean Lower Low Water (MLLW) at Clarendon Plantation, SC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.



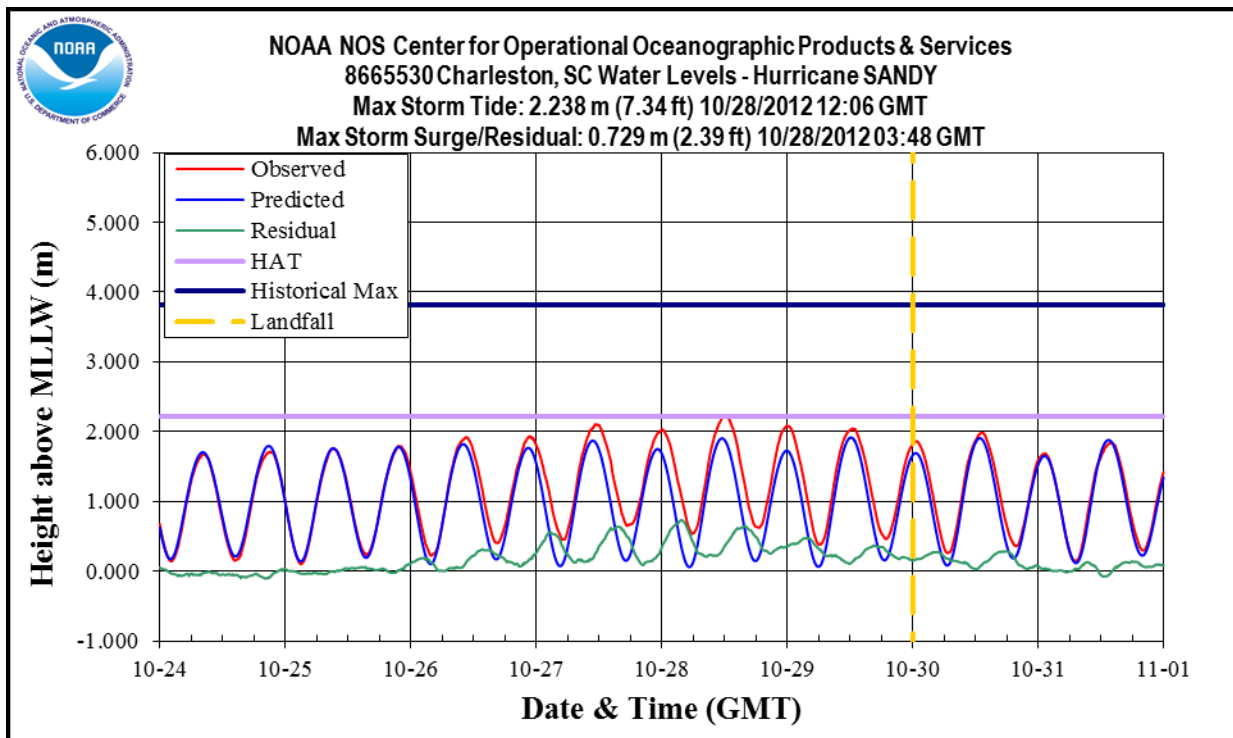


Figure 14: Water levels above Mean Lower Low Water (MLLW) at Charleston, SC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

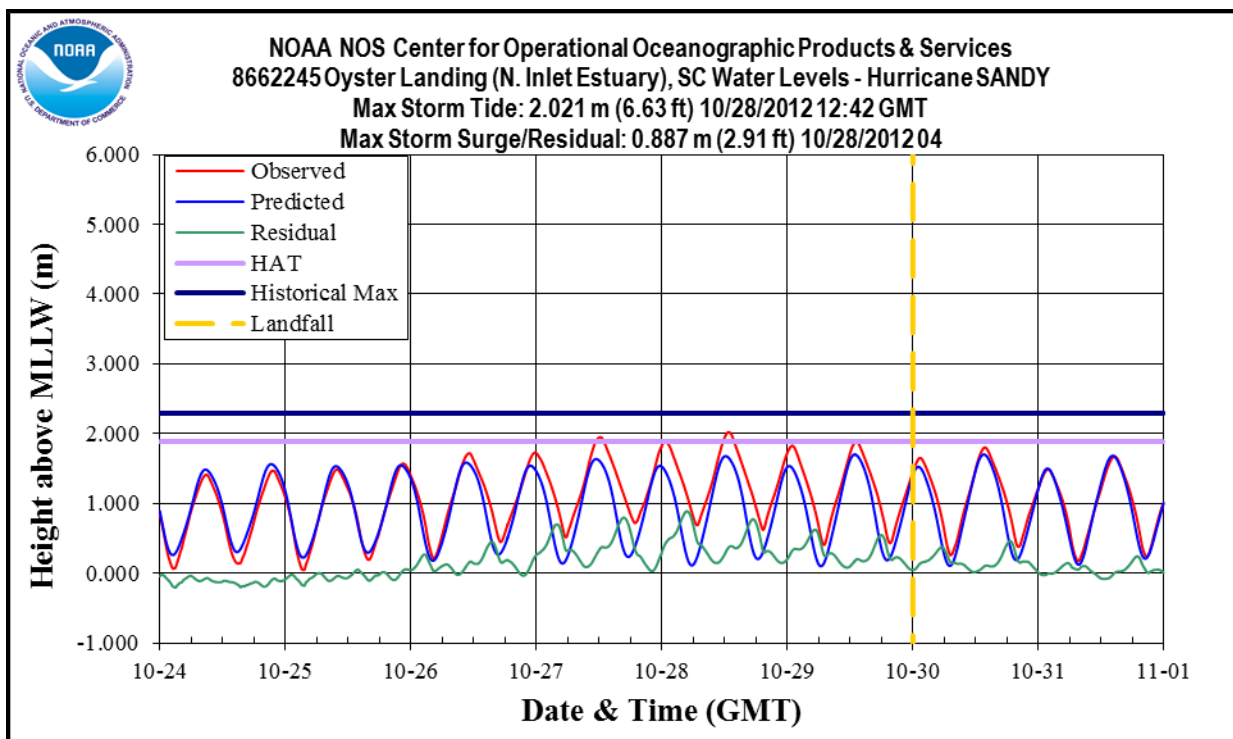


Figure 15: Water levels above Mean Lower Low Water (MLLW) at Oyster Landing (N. Inlet Estuary), SC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

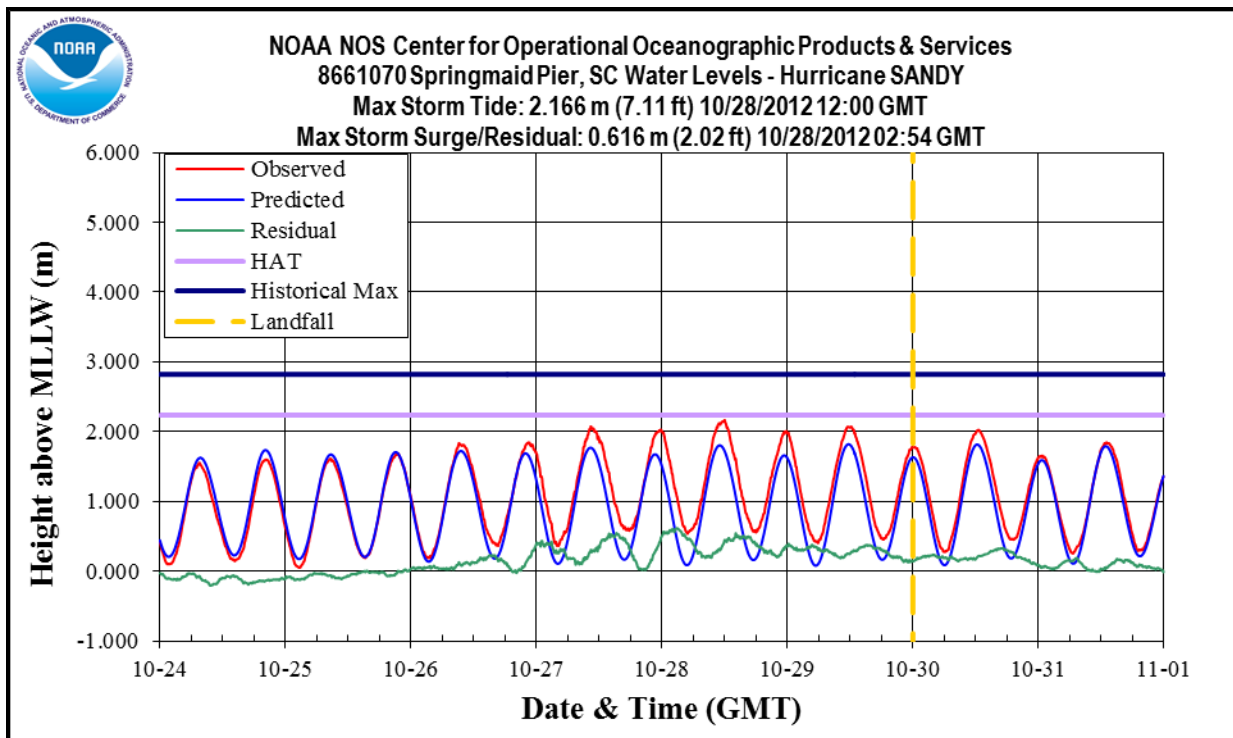


Figure 16: Water levels above Mean Lower Low Water (MLLW) at Springmaid Pier, SC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

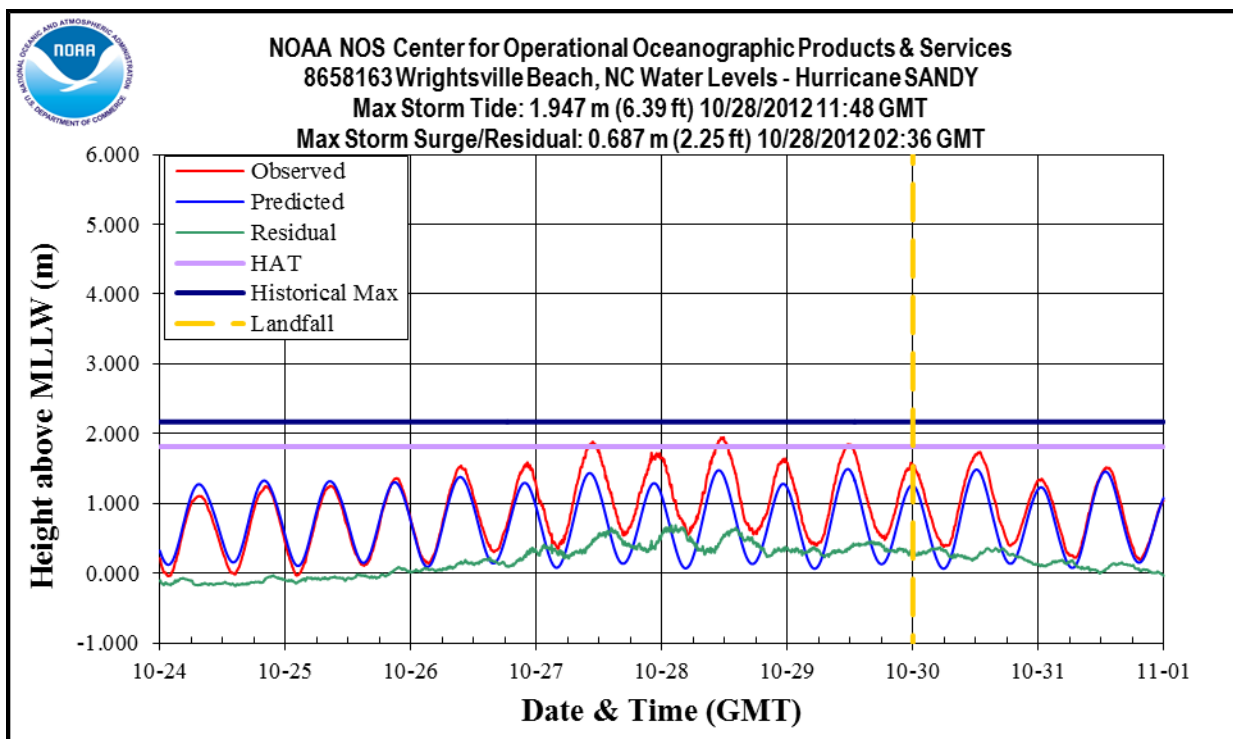


Figure 17: Water levels above Mean Lower Low Water (MLLW) at Wrightsville Beach, NC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

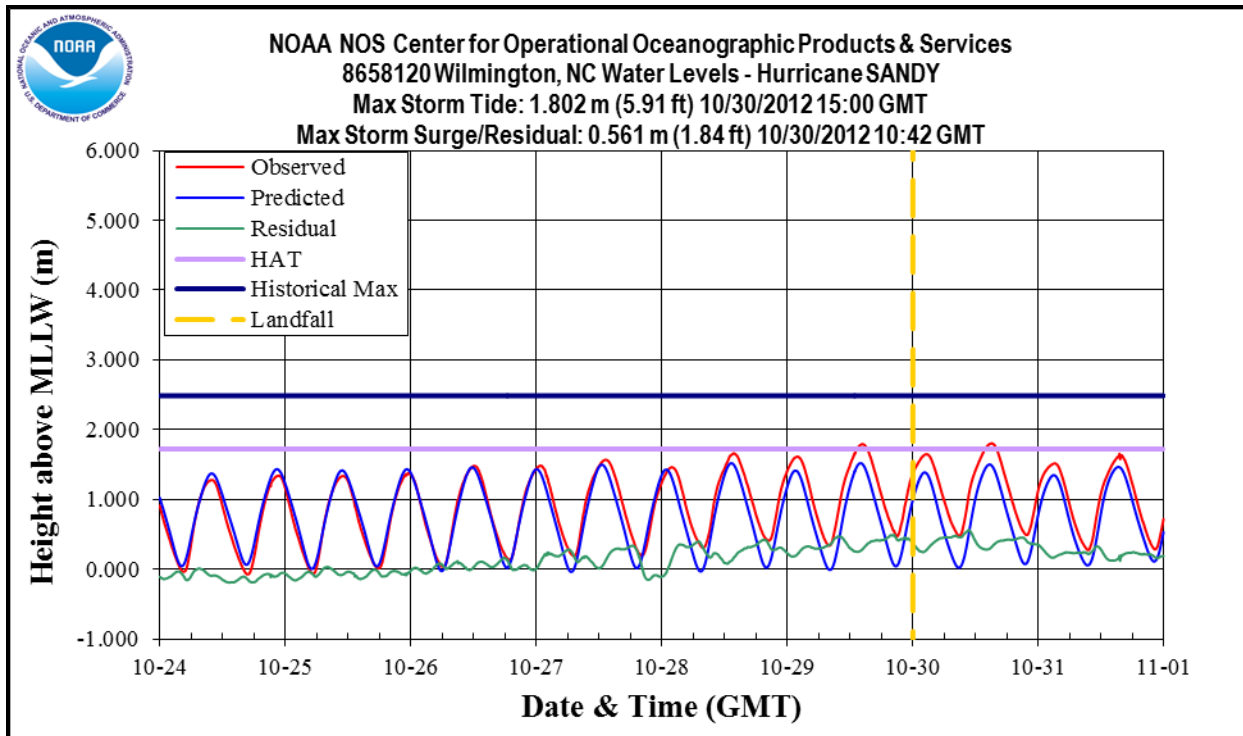


Figure 18: Water levels above Mean Lower Low Water (MLLW) at Wilmington, NC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

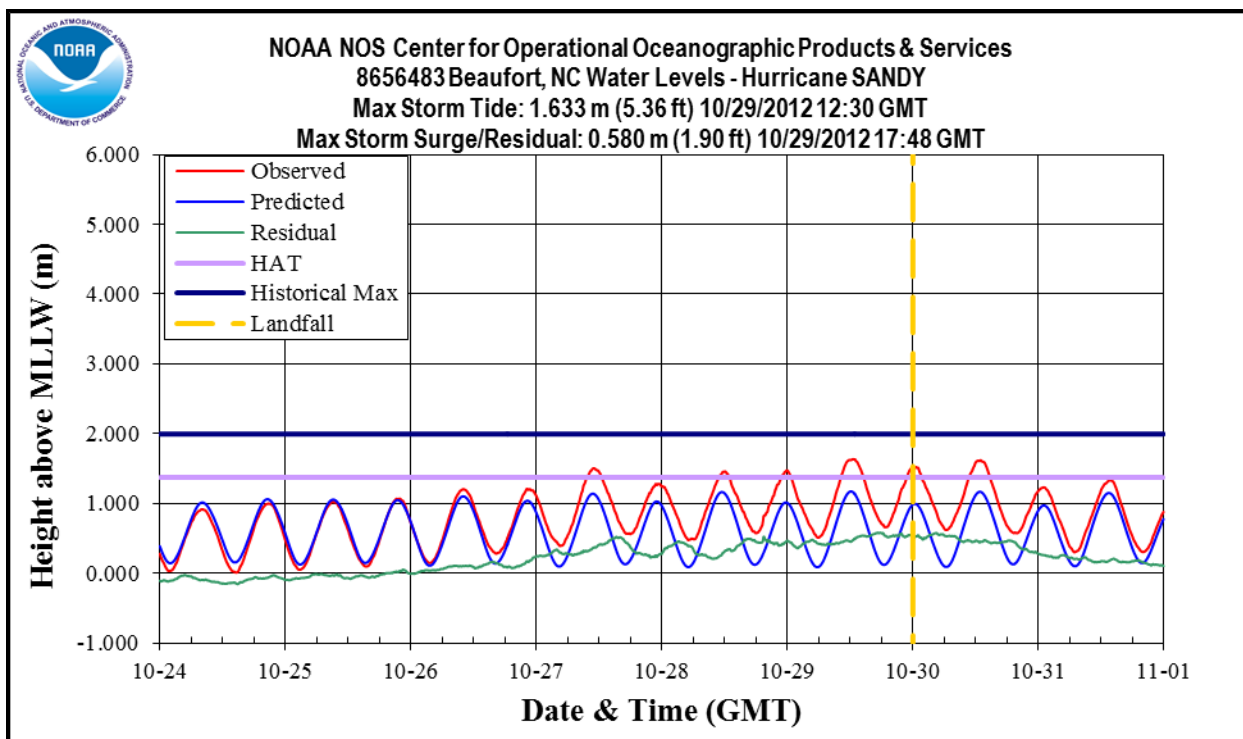


Figure 19: Water levels above Mean Lower Low Water (MLLW) at Beaufort, NC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

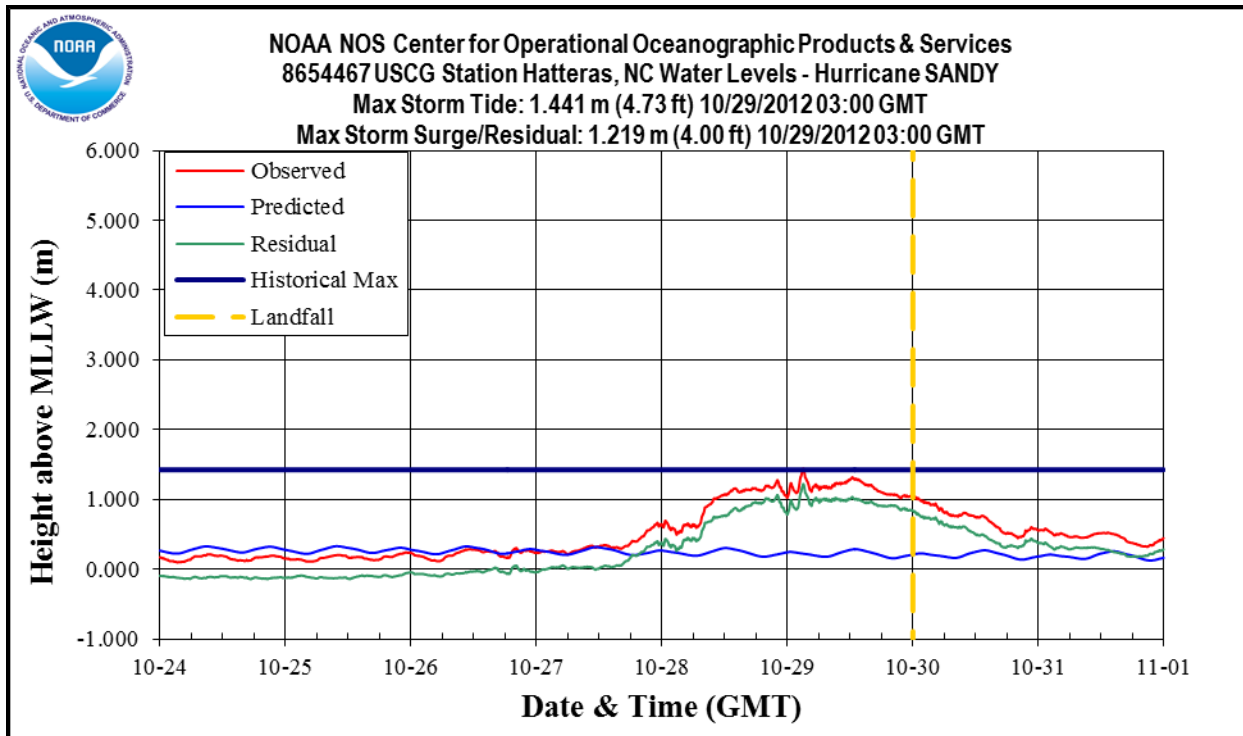


Figure 20: Water levels above Mean Lower Low Water (MLLW) at USCG Station Hatteras, NC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

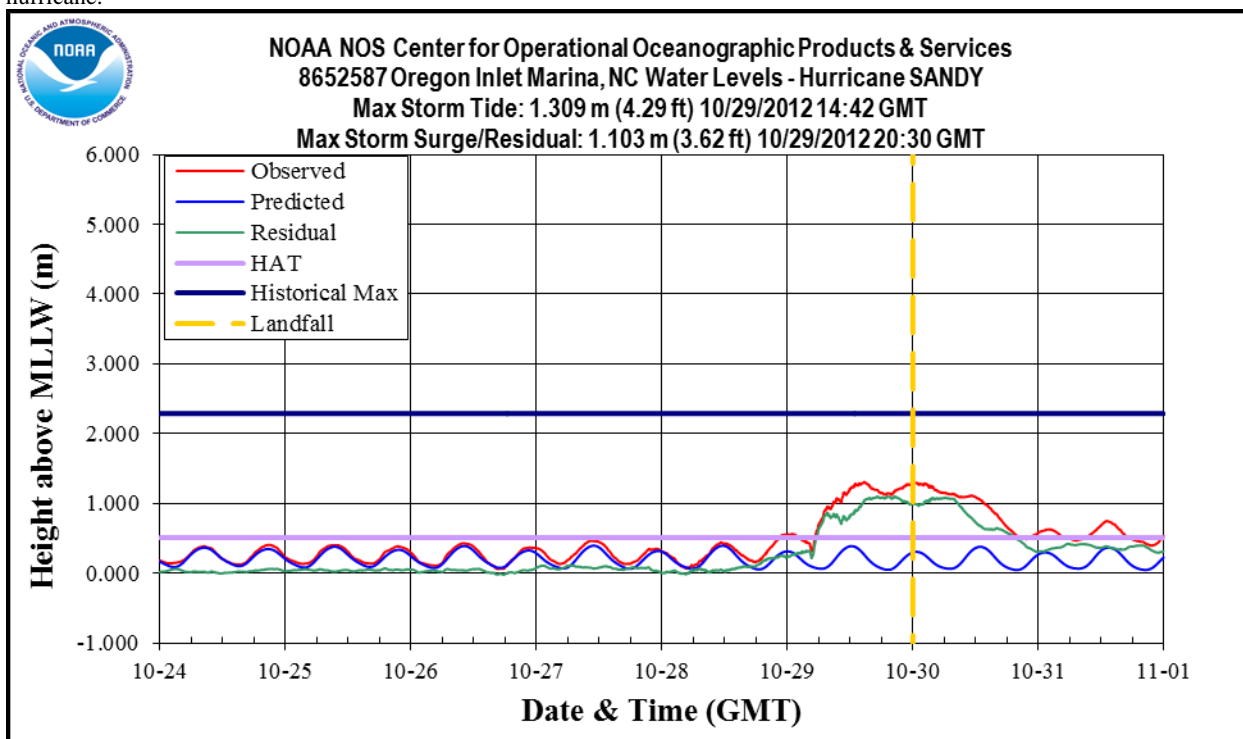


Figure 21: Water levels above Mean Lower Low Water (MLLW) at Oregon Inlet Marina, NC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

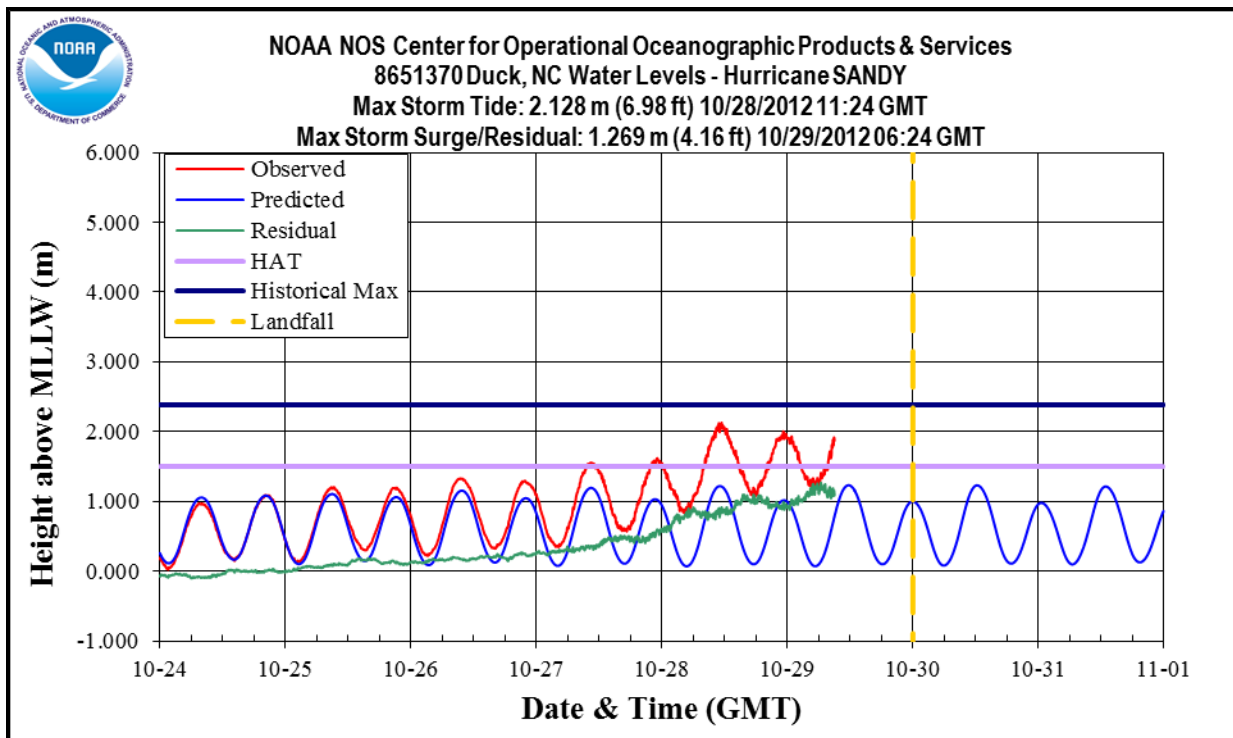


Figure 22: Water levels above Mean Lower Low Water (MLLW) at Duck, NC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane. The sensor was damaged by the storm and likely did not record the maximum water level.

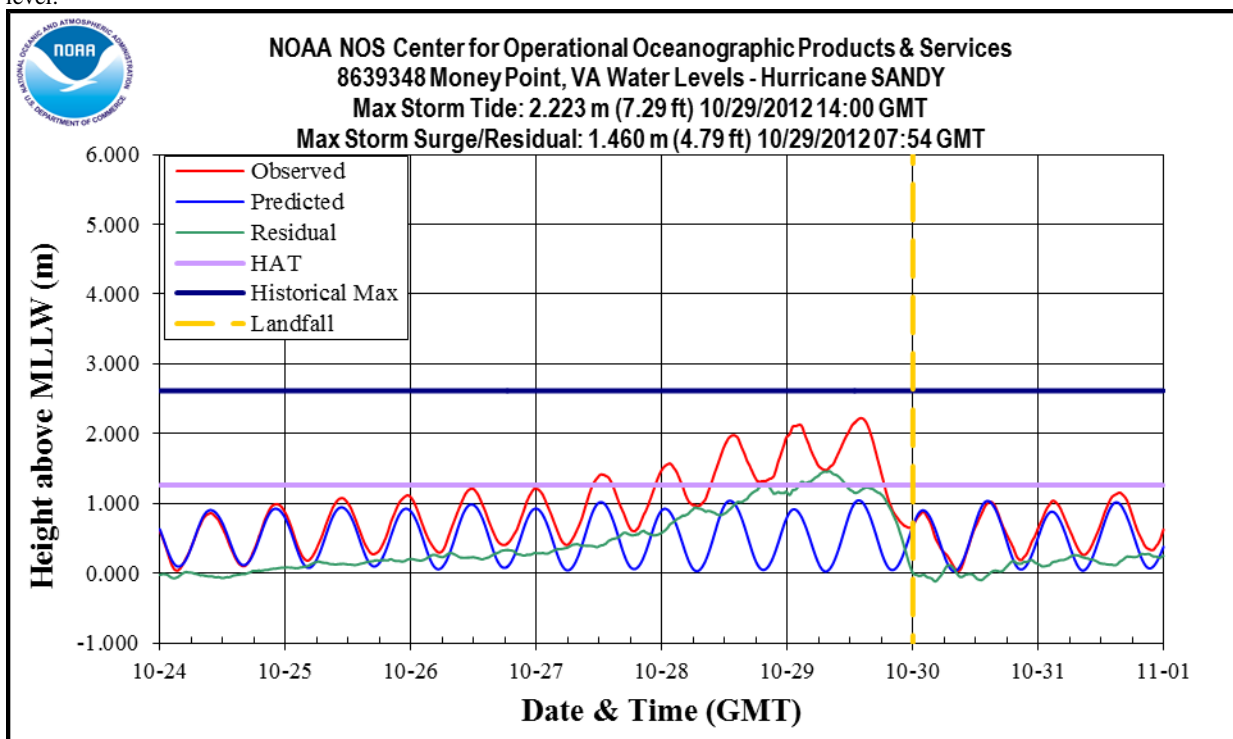


Figure 23: Water levels above Mean Lower Low Water (MLLW) at Money Point, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

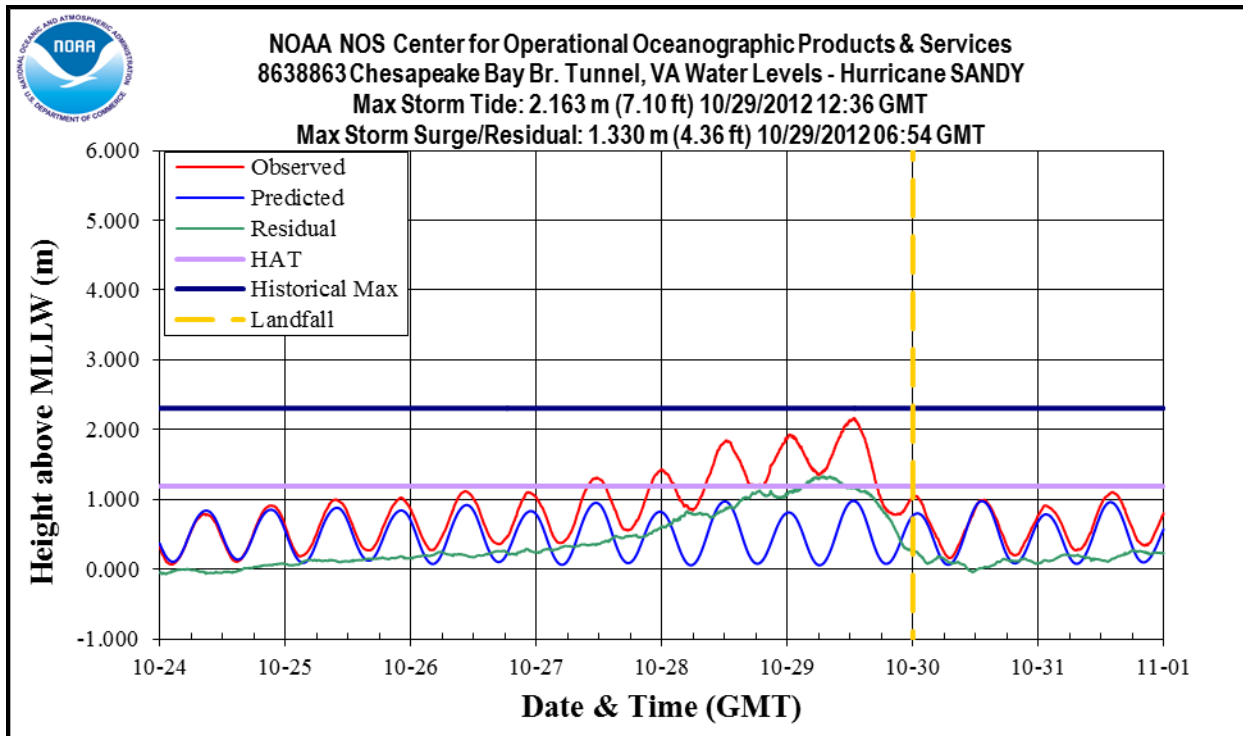


Figure 24: Water levels above Mean Lower Low Water (MLLW) at Chesapeake Bay Bridge Tunnel, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

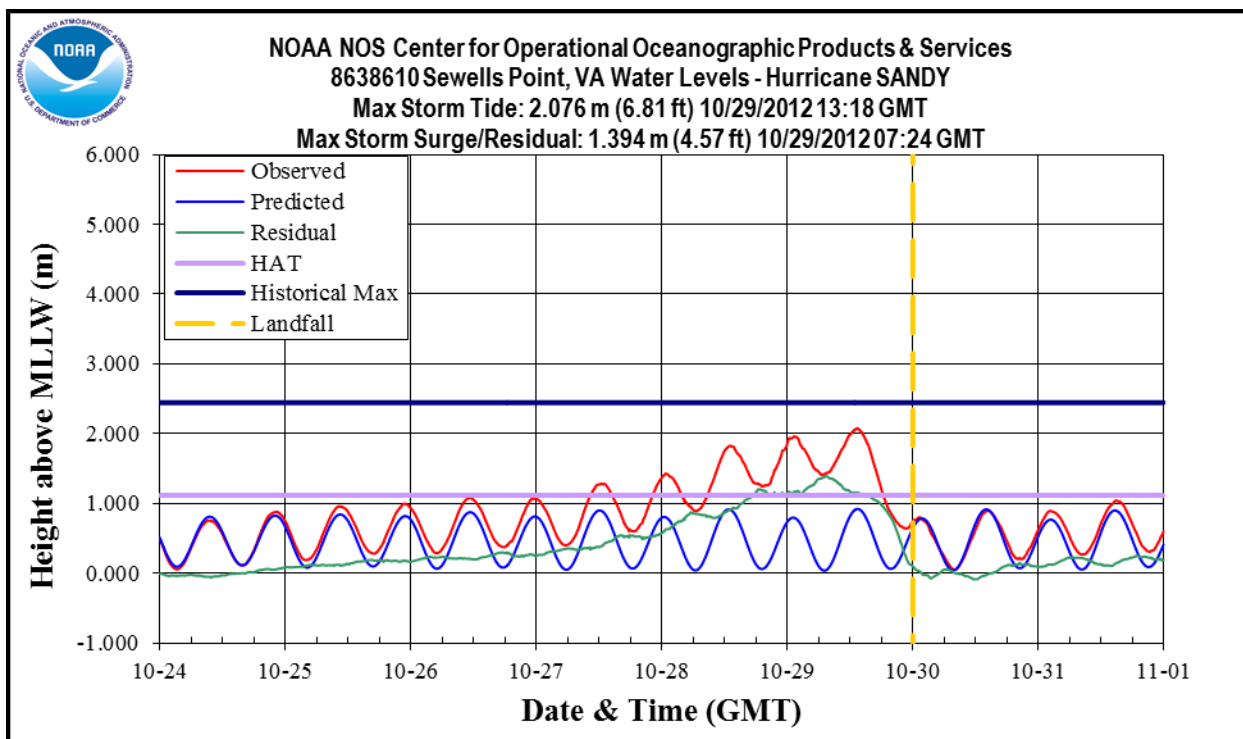


Figure 25: Water levels above Mean Lower Low Water (MLLW) at Sewells Point, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

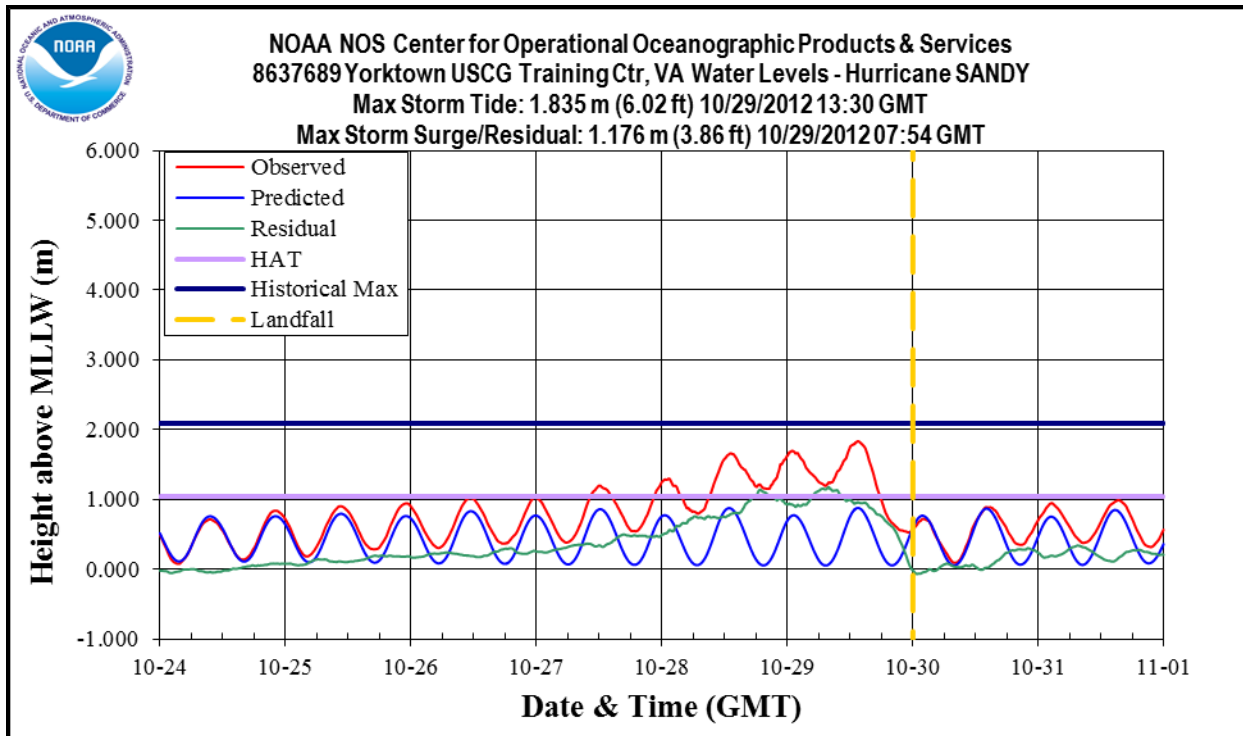


Figure 26: Water levels above Mean Lower Low Water (MLLW) at Yorktown USCG Training Center, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

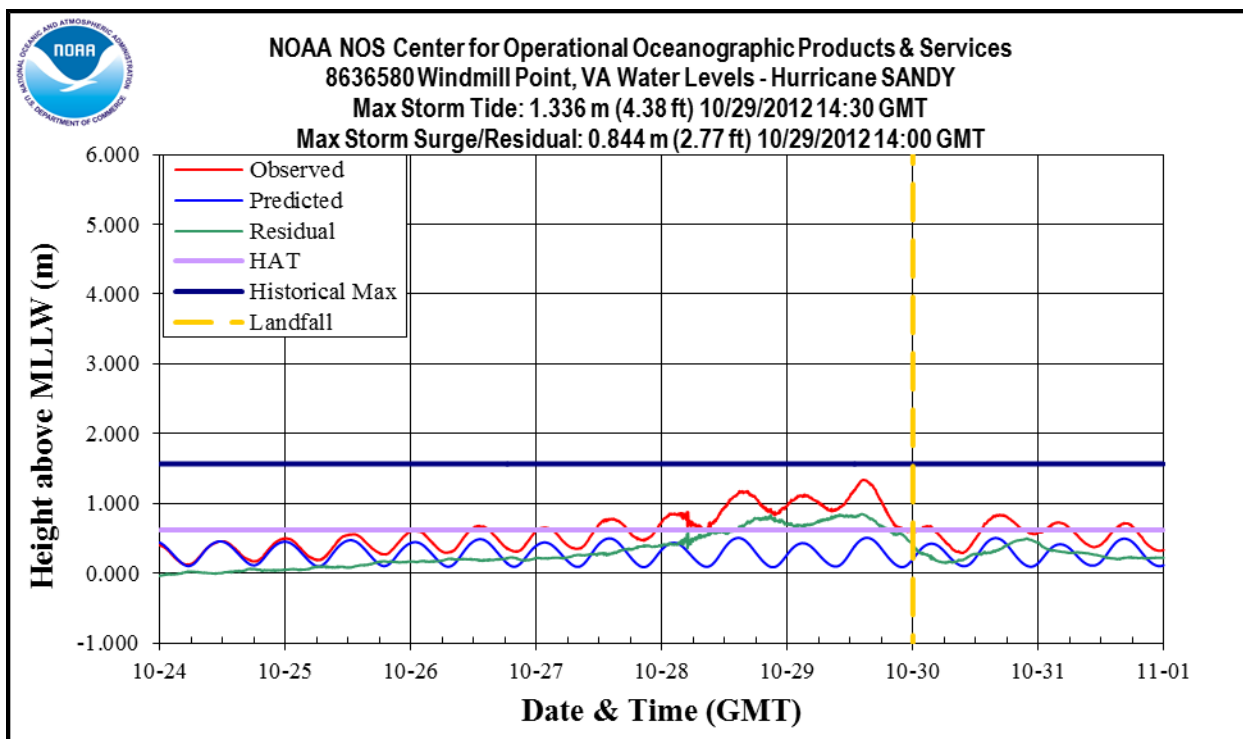


Figure 27: Water levels above Mean Lower Low Water (MLLW) at Windmill Point, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

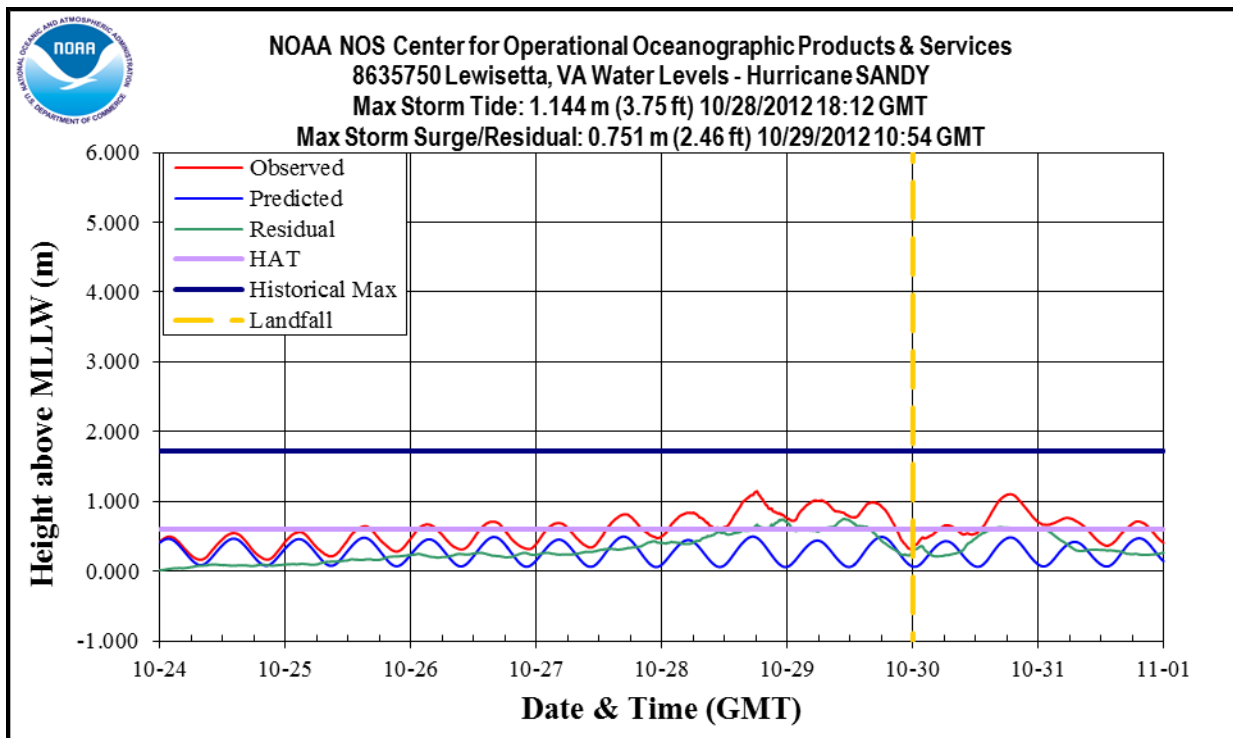


Figure 28: Water levels above Mean Lower Low Water (MLLW) at Lewisetta, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

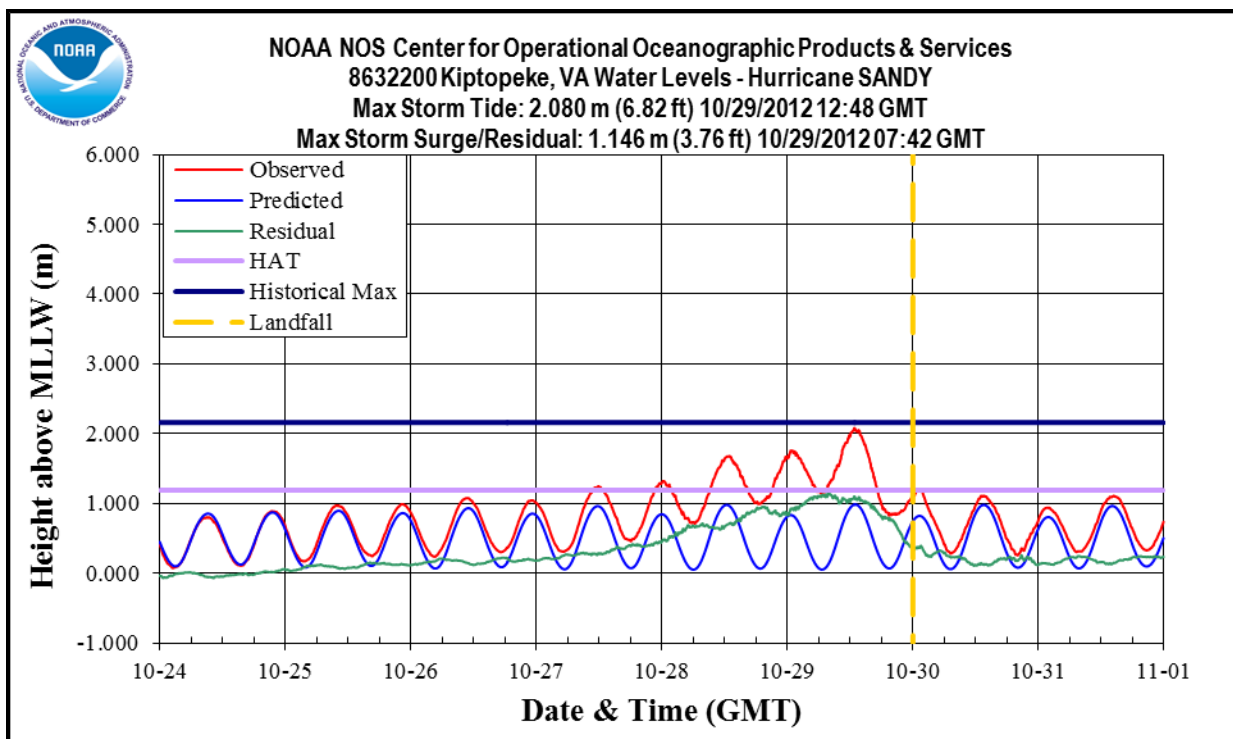


Figure 29: Water levels above Mean Lower Low Water (MLLW) at Kiptopeke, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.



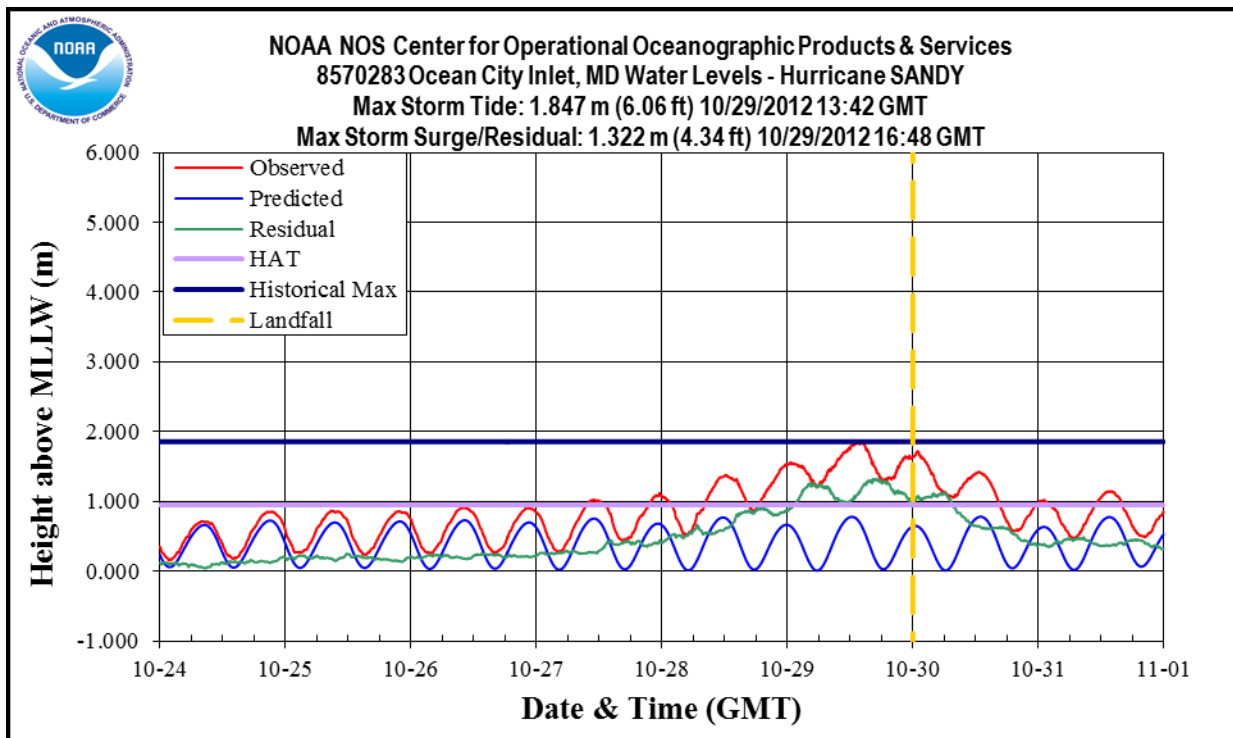


Figure 30: Water levels above Mean Lower Low Water (MLLW) at Wachapreague, VA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

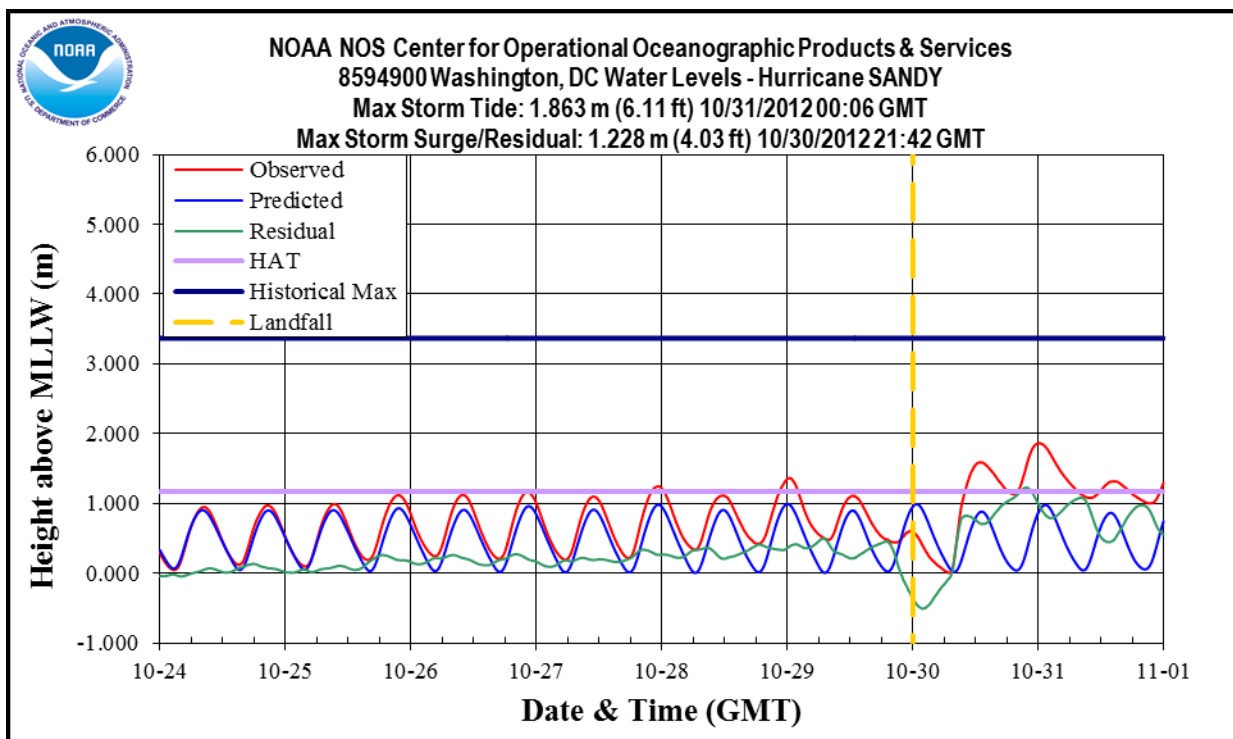


Figure 31: Water levels above Mean Lower Low Water (MLLW) at Washington, DC. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

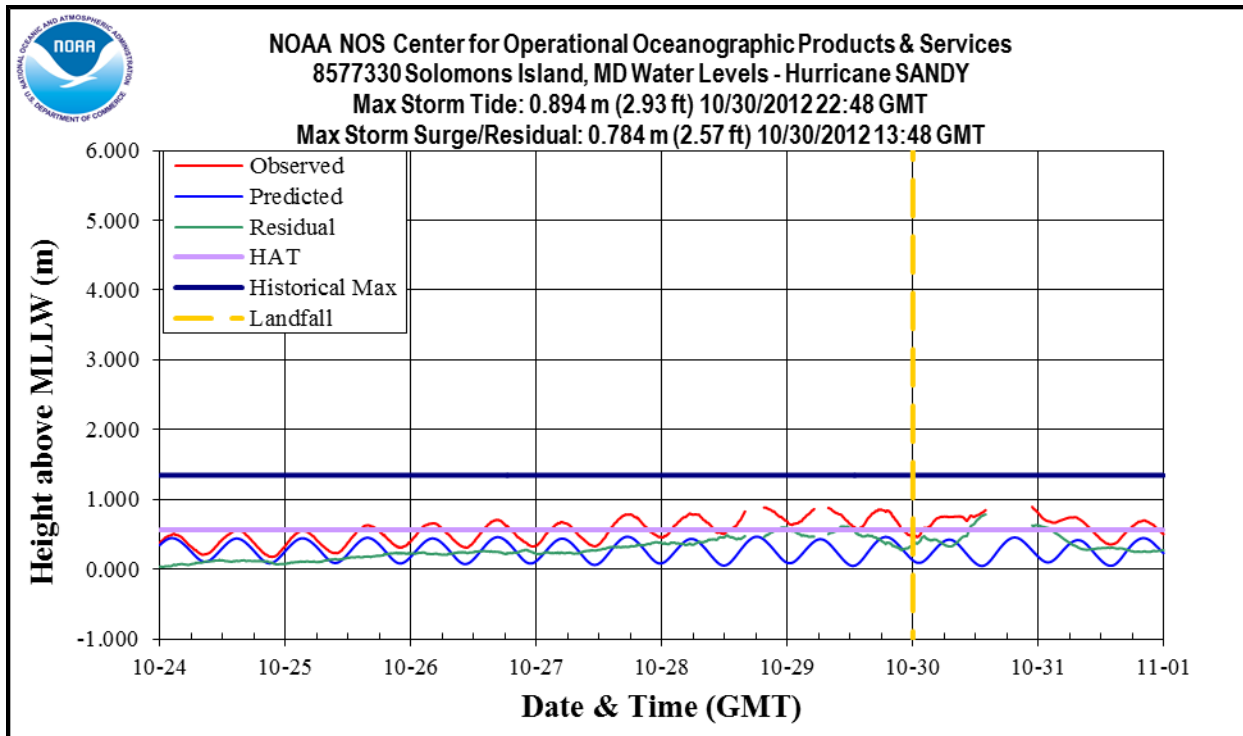


Figure 32: Water levels above Mean Lower Low Water (MLLW) at Solomons Island, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane. On multiple high tides, the sensor reached its physical limit and did not record a maximum water level.

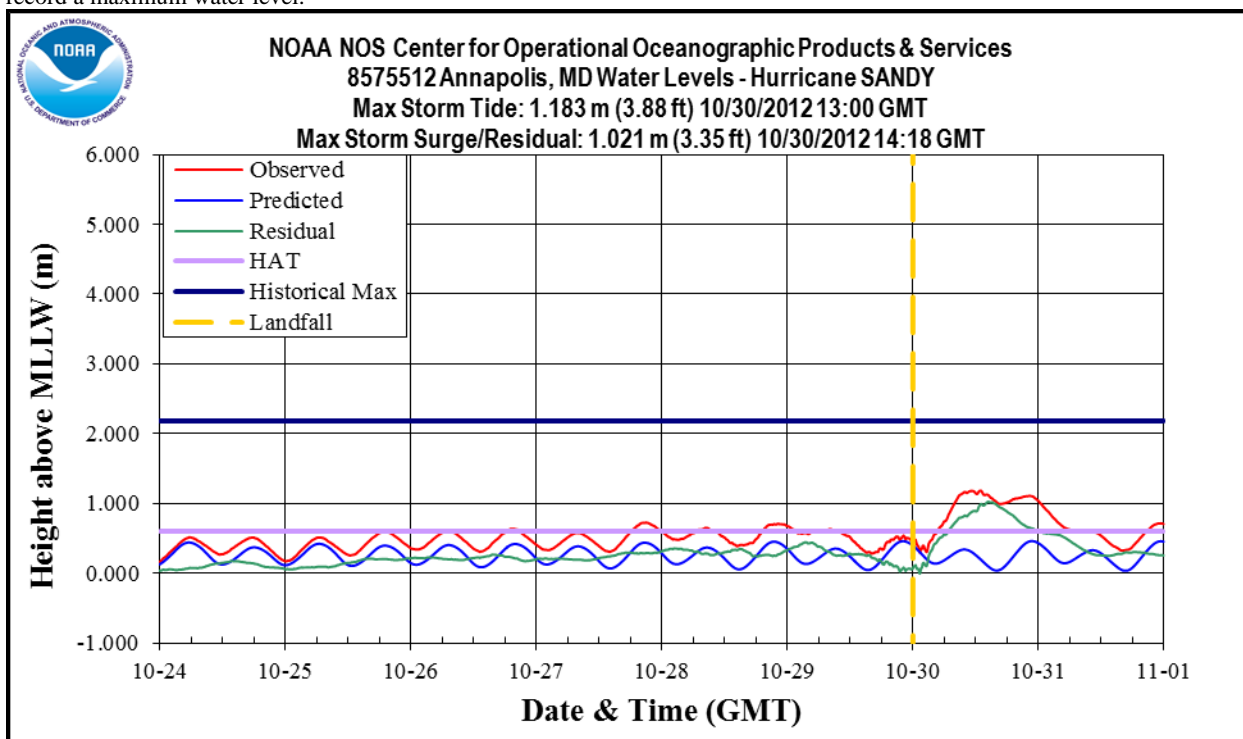


Figure 33: Water levels above Mean Lower Low Water (MLLW) at Annapolis, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

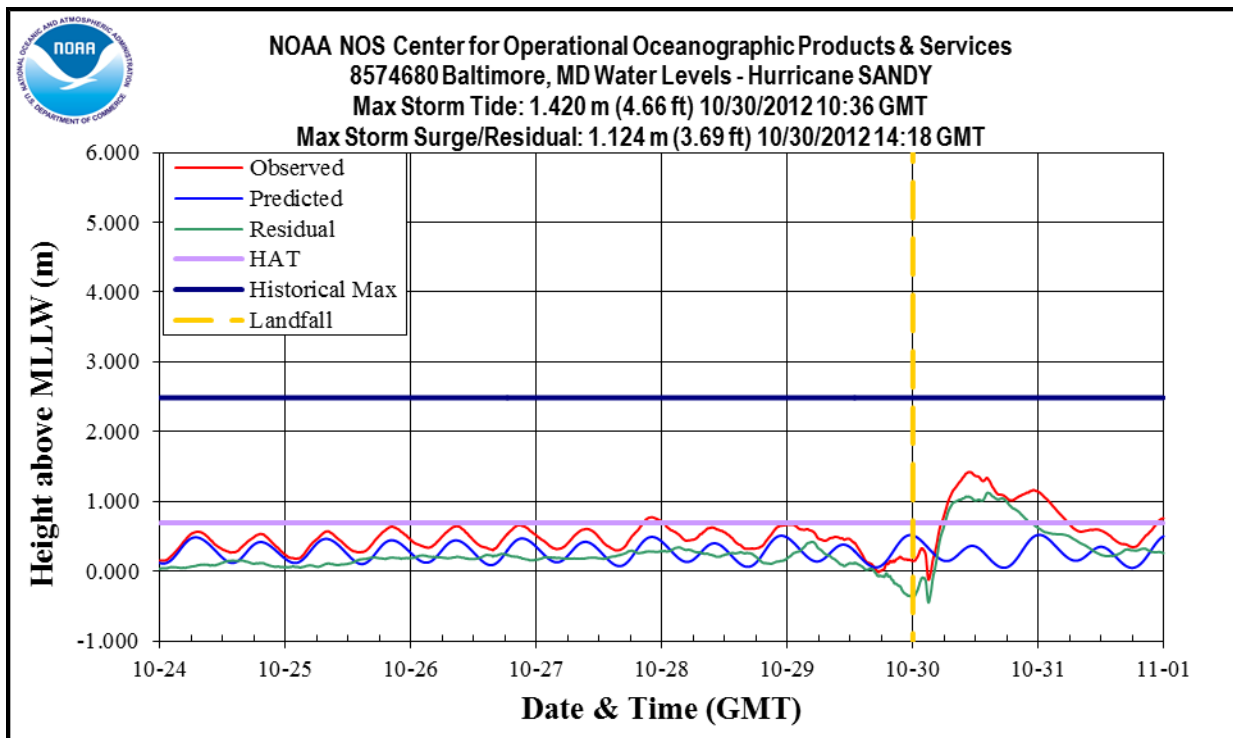


Figure 34: Water levels above Mean Lower Low Water (MLLW) at Baltimore, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

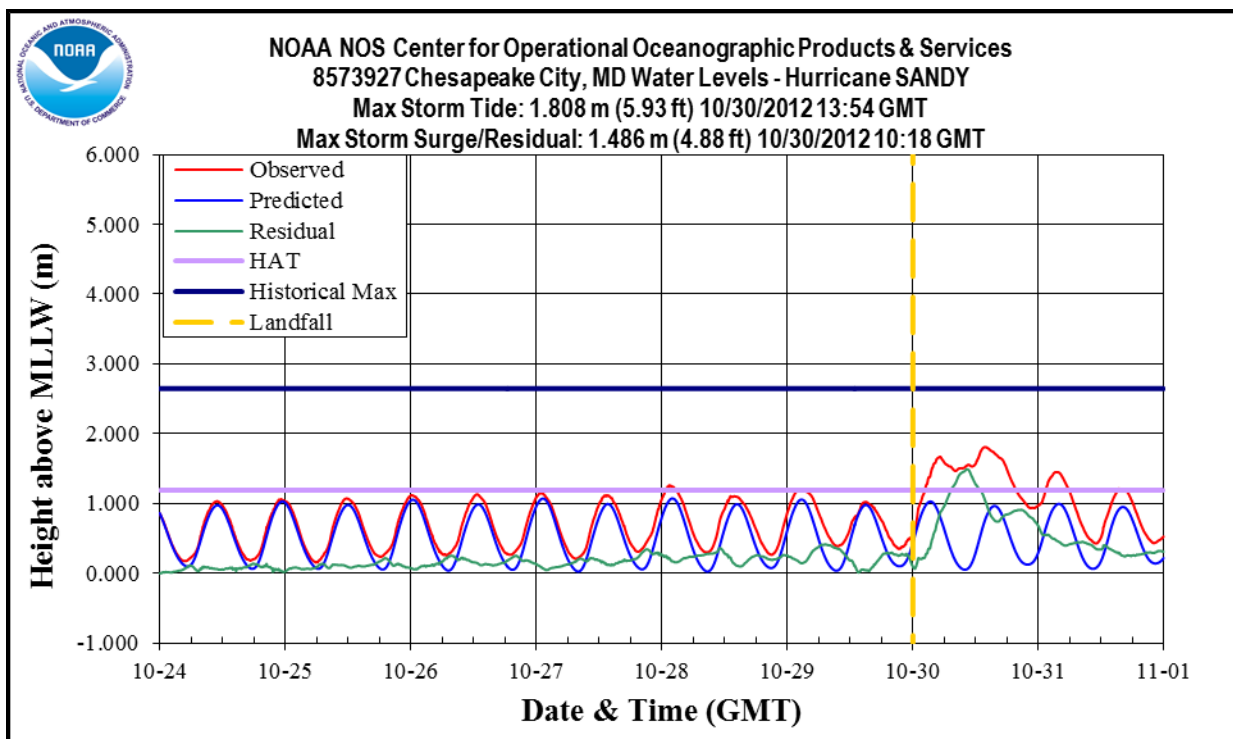


Figure 35: Water levels above Mean Lower Low Water (MLLW) at Chesapeake City, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

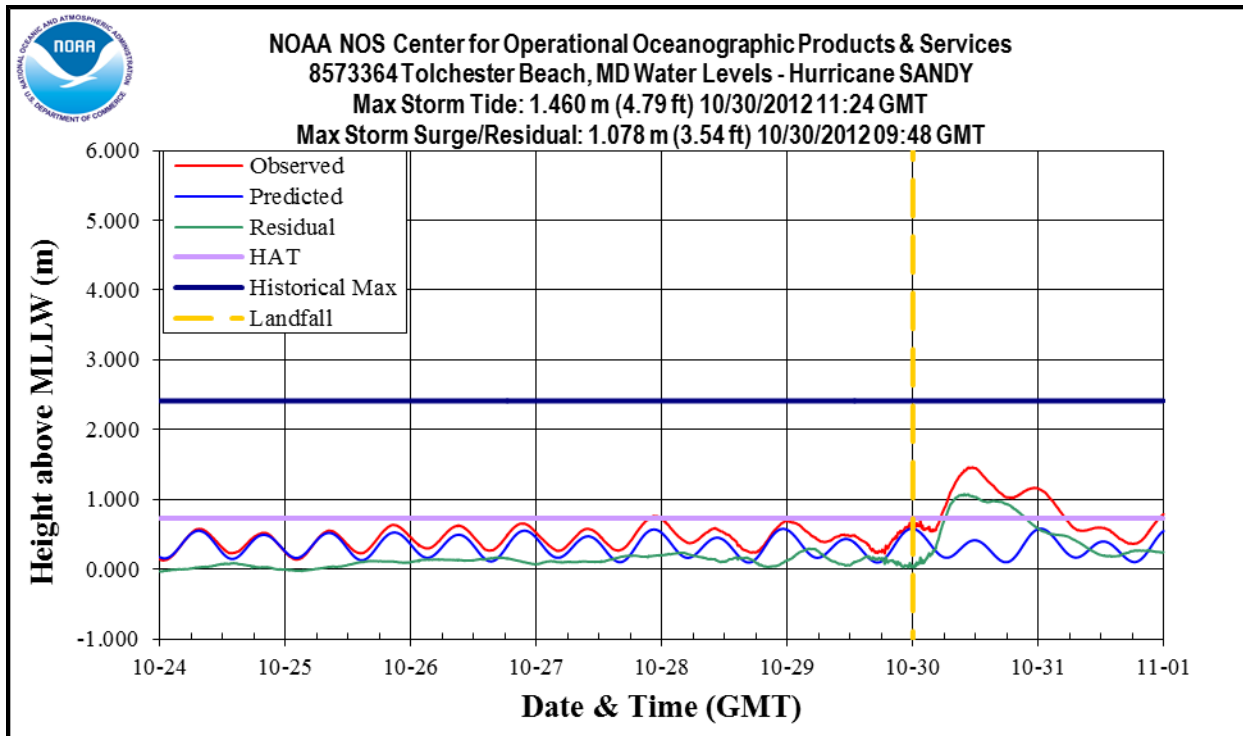


Figure 36: Water levels above Mean Lower Low Water (MLLW) at Tolchester Beach, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

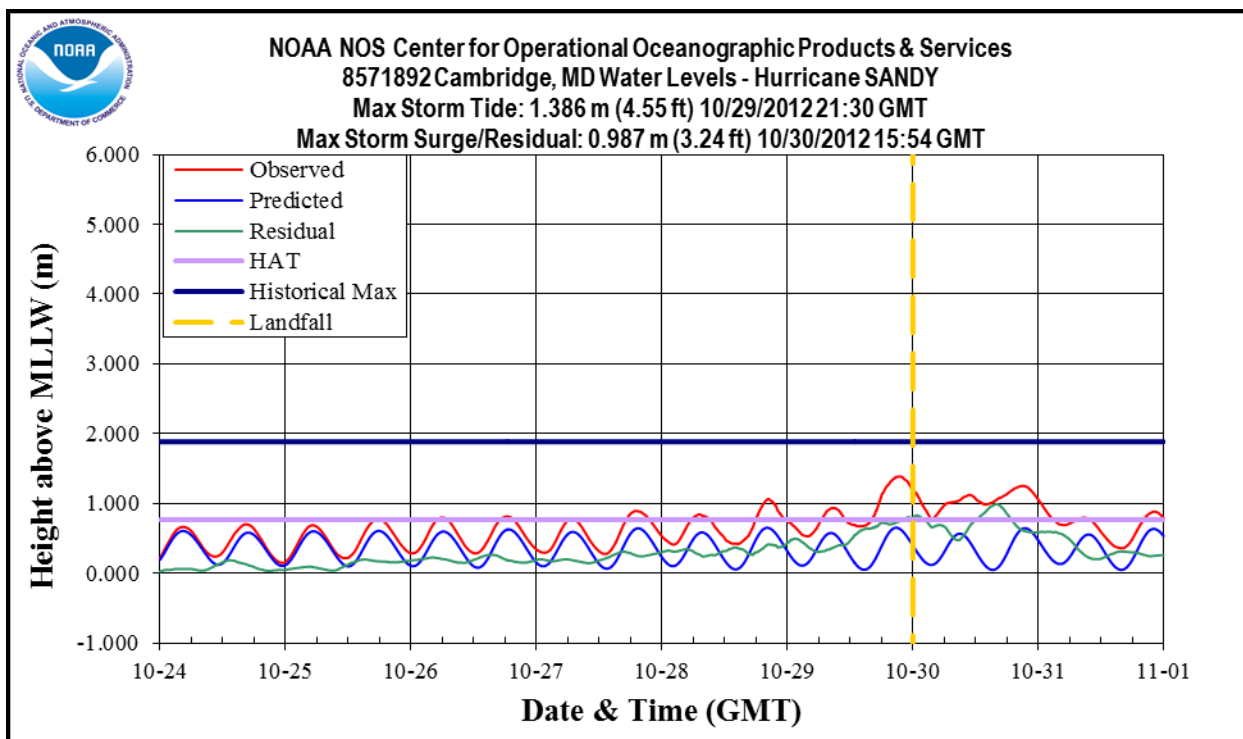


Figure 37: Water levels above Mean Lower Low Water (MLLW) at Cambridge, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

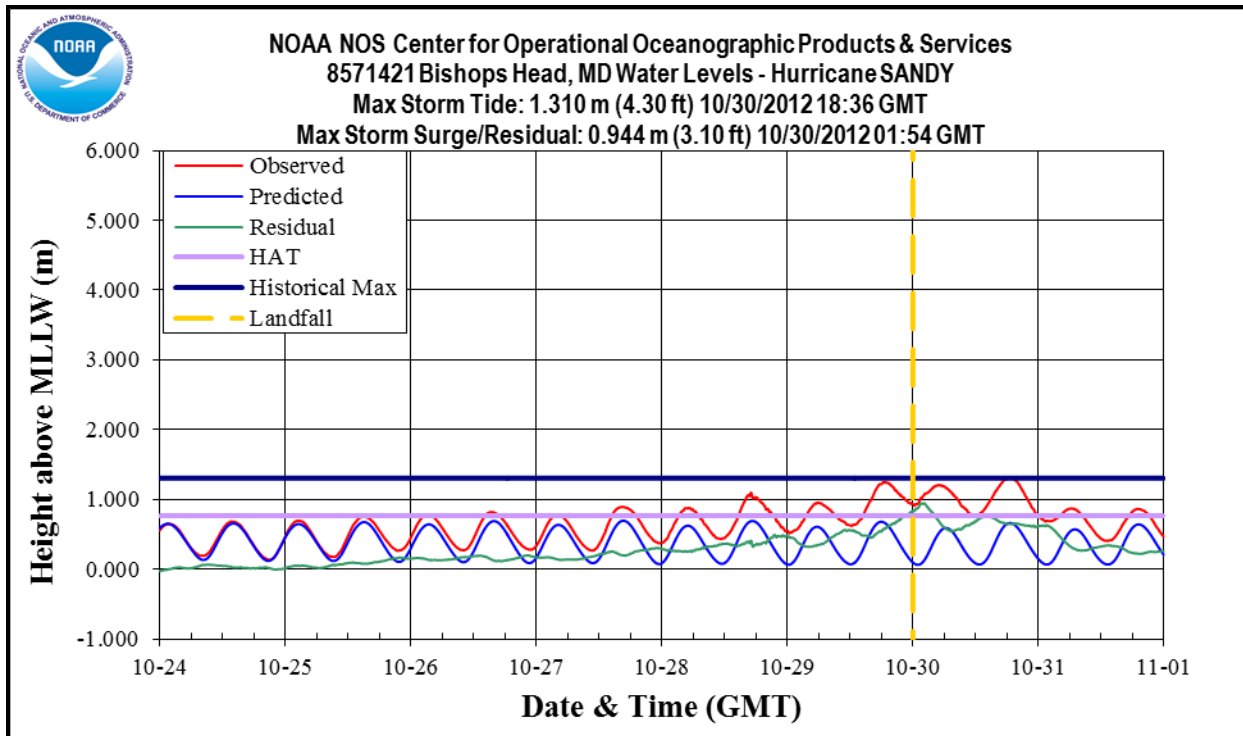


Figure 38: Water levels above Mean Lower Low Water (MLLW) at Bishops Head, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

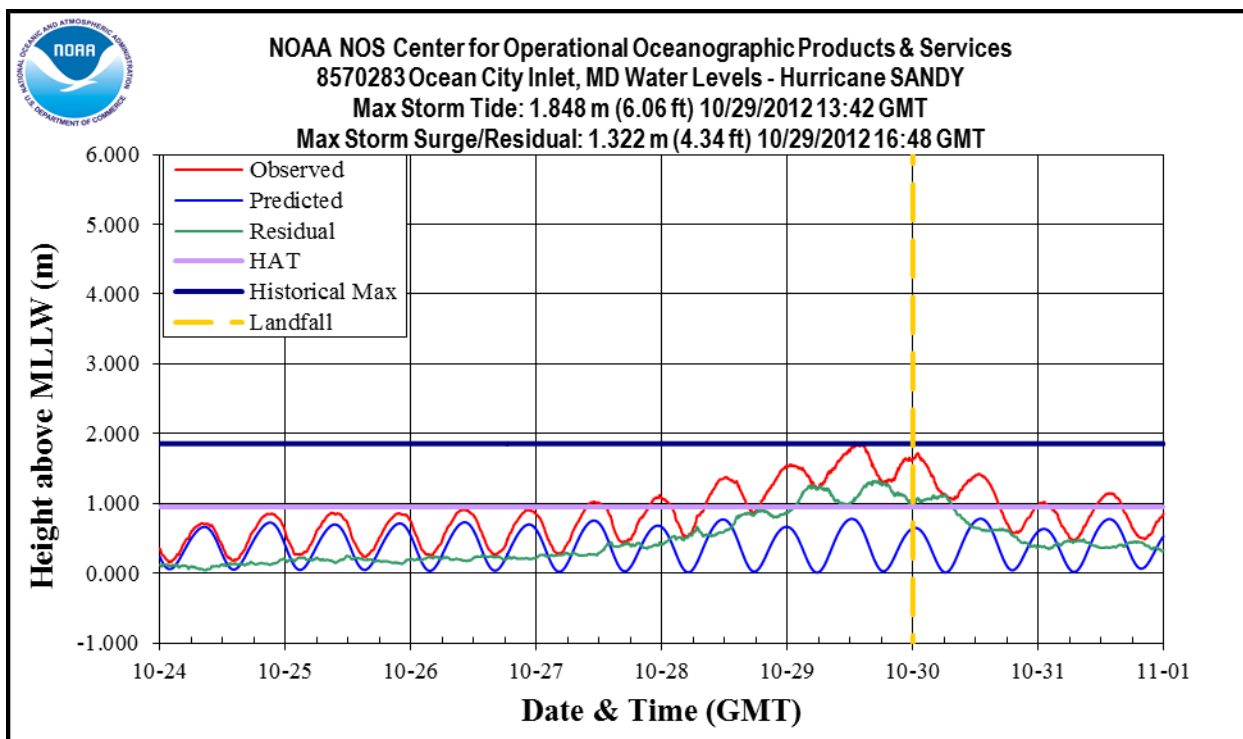


Figure 39: Water levels above Mean Lower Low Water (MLLW) at Ocean City Inlet, MD. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

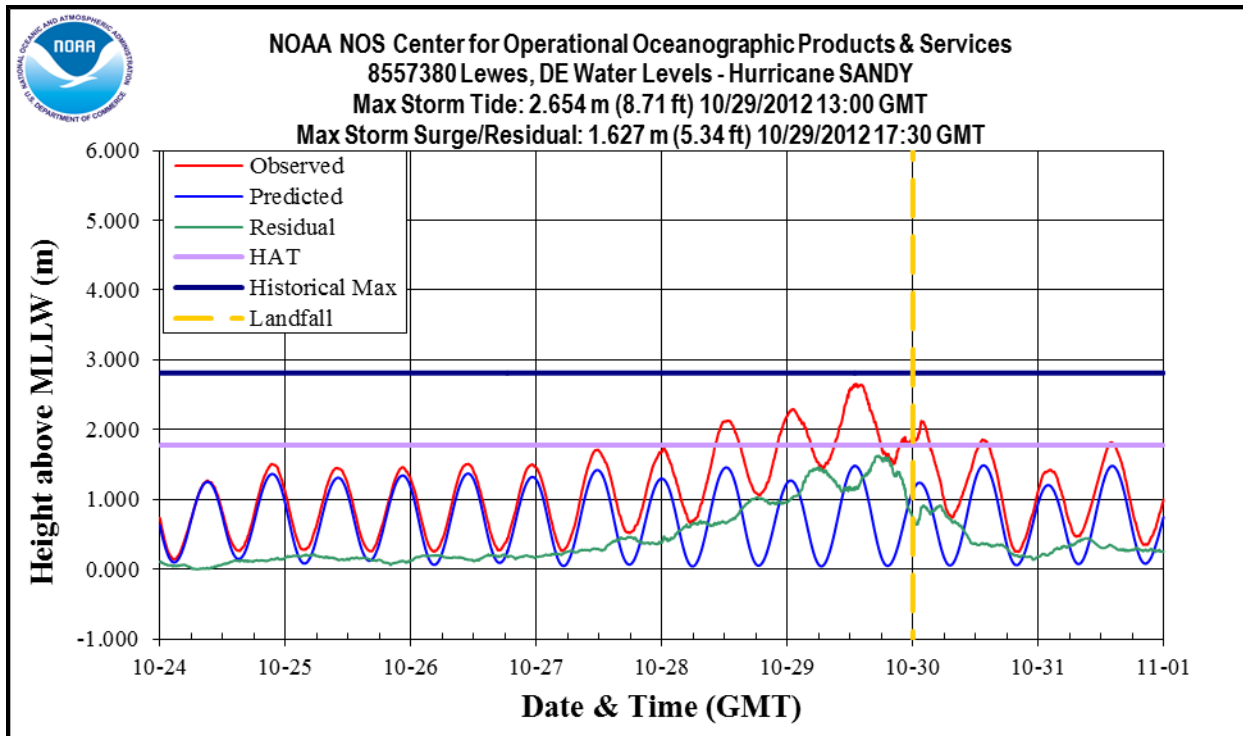


Figure 40: Water levels above Mean Lower Low Water (MLLW) at Lewes, DE. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

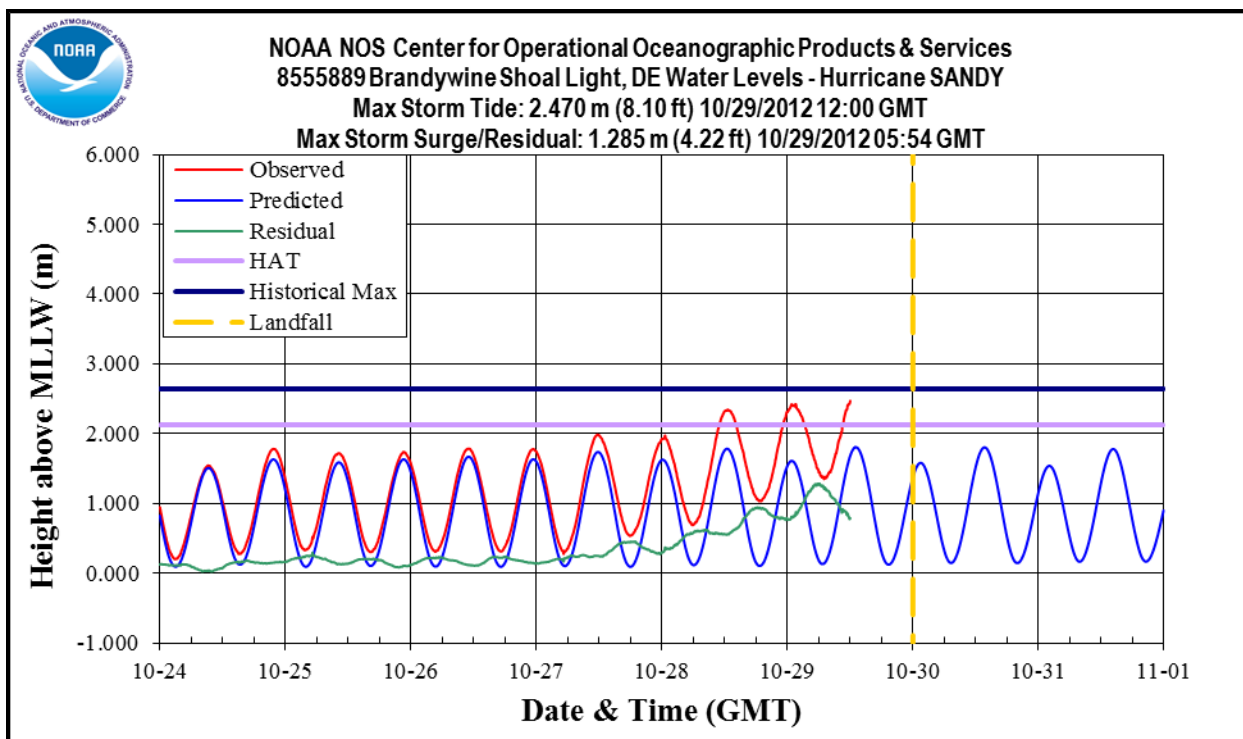


Figure 41: Water levels above Mean Lower Low Water (MLLW) at Brandywine Shoal Light, DE. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane. The sensor was damaged by the storm and did not record the maximum water level.

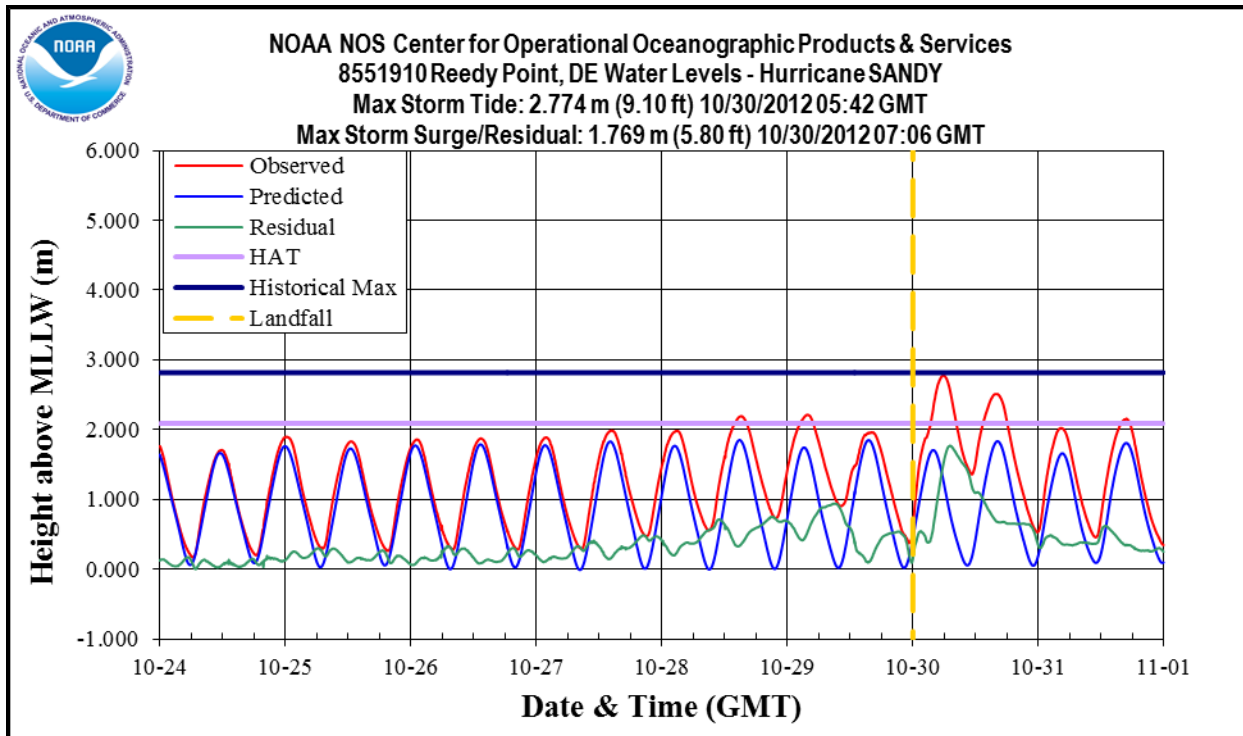


Figure 42: Water levels above Mean Lower Low Water (MLLW) at Reedy Point, DE. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

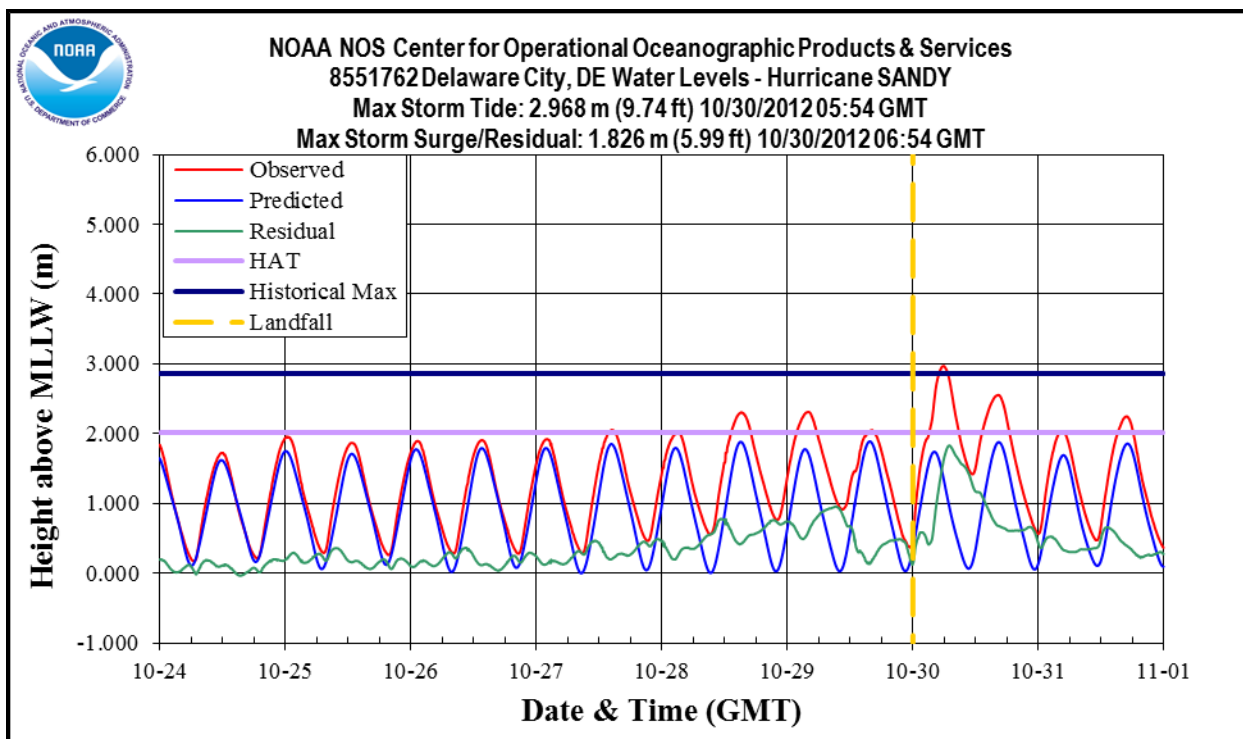


Figure 43: Water levels above Mean Lower Low Water (MLLW) at Delaware City, DE. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

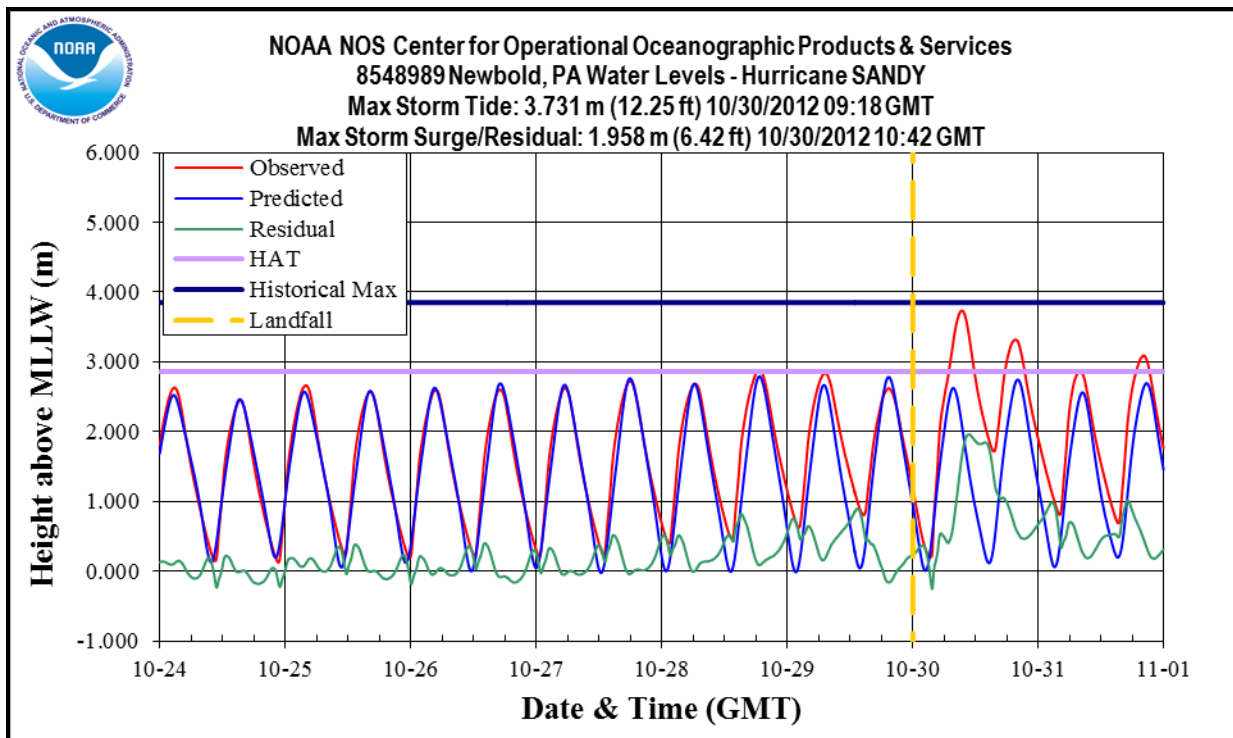


Figure 44: Water levels above Mean Lower Low Water (MLLW) at Newbold, PA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

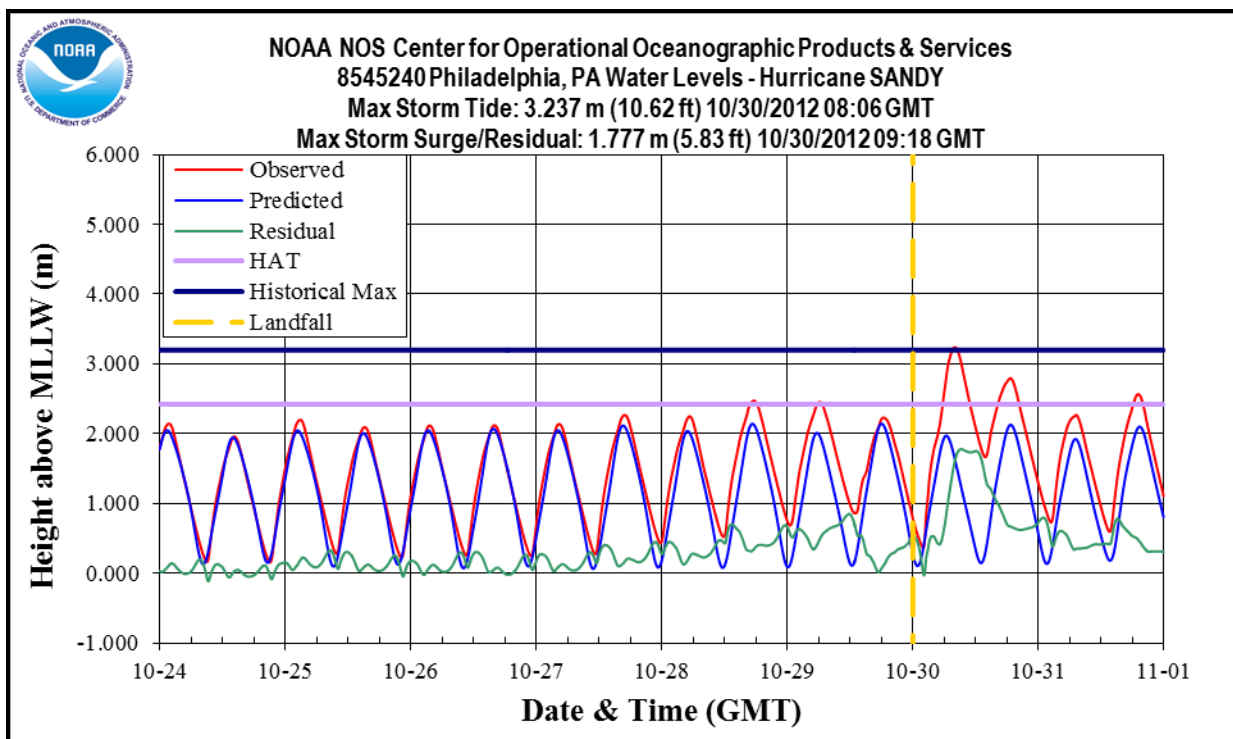


Figure 45: Water levels above Mean Lower Low Water (MLLW) at Philadelphia, PA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.



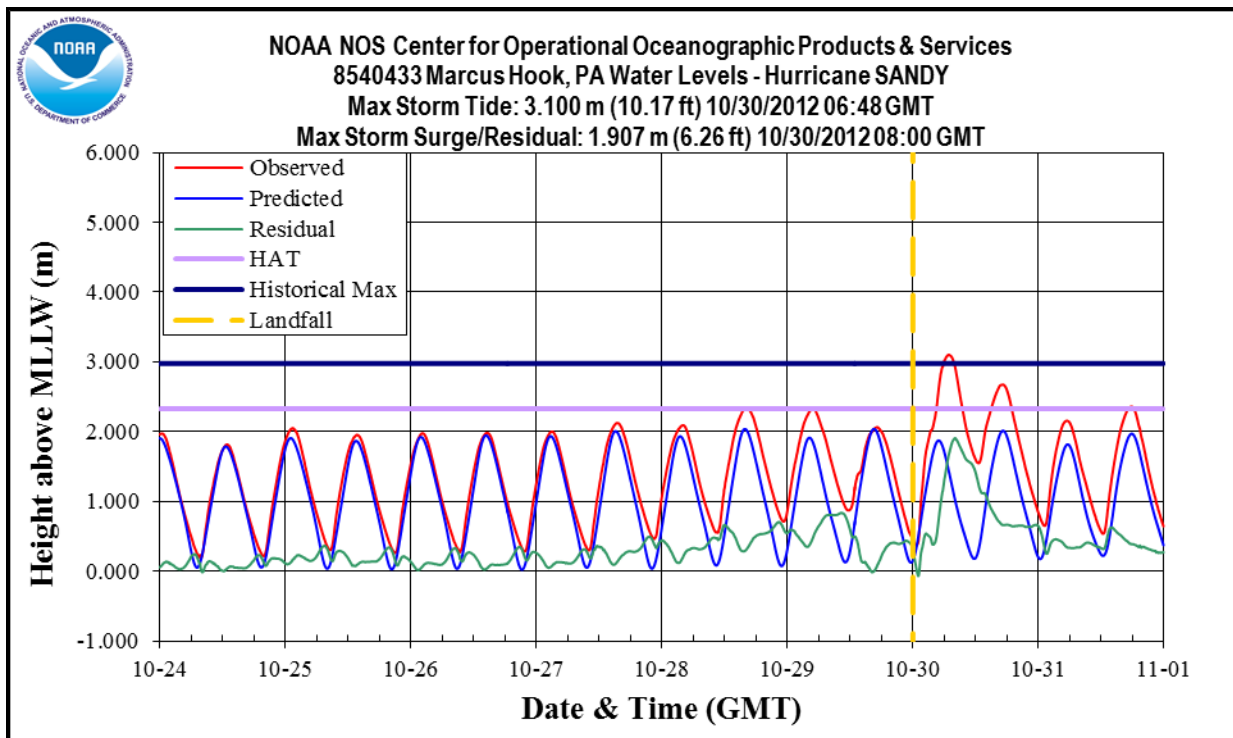


Figure 46: Water levels above Mean Lower Low Water (MLLW) at Marcus Hook, PA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

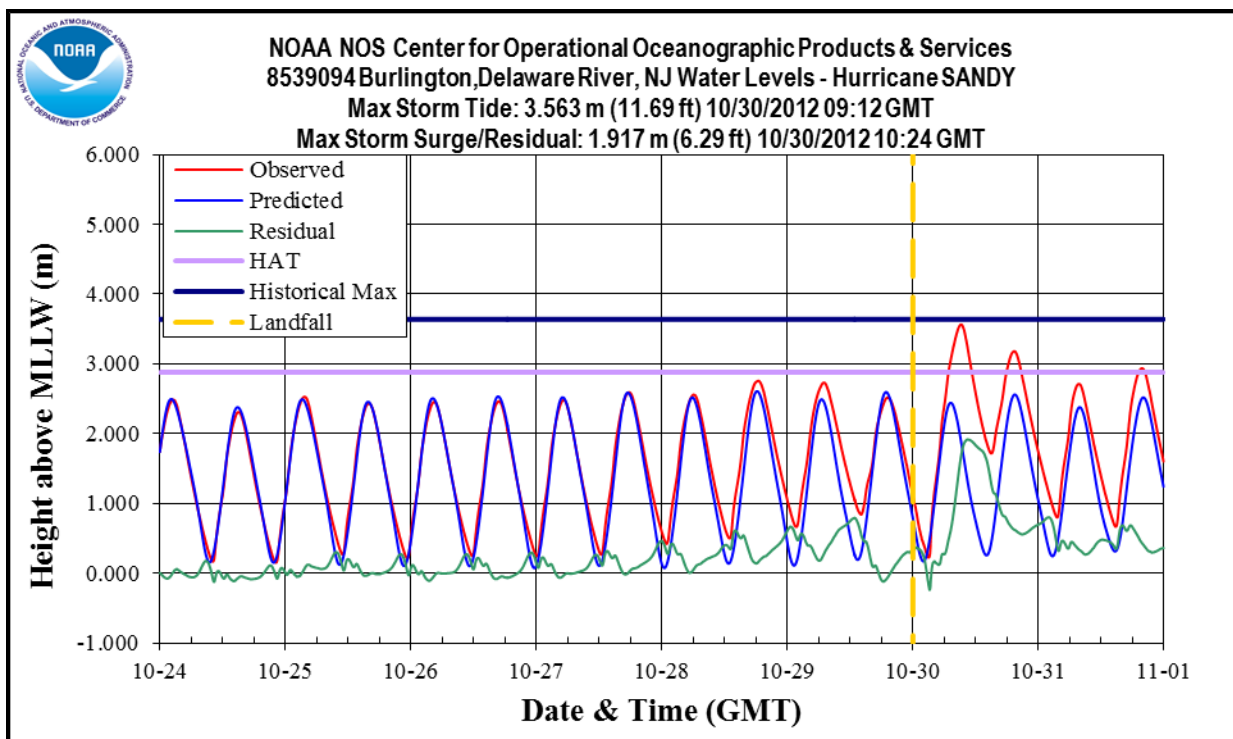


Figure 47: Water levels above Mean Lower Low Water (MLLW) at Burlington, Delaware River, NJ. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

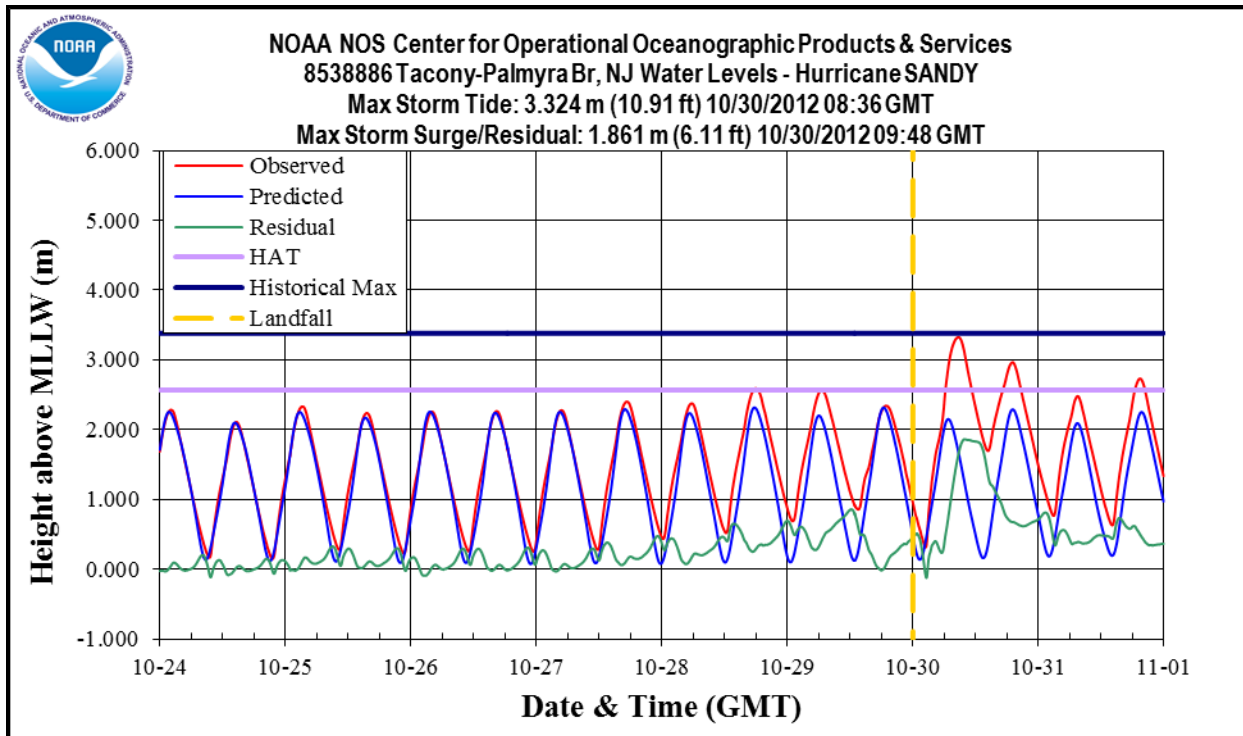


Figure 48: Water levels above Mean Lower Low Water (MLLW) at Tacony-Palmyra Bridge, NJ. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

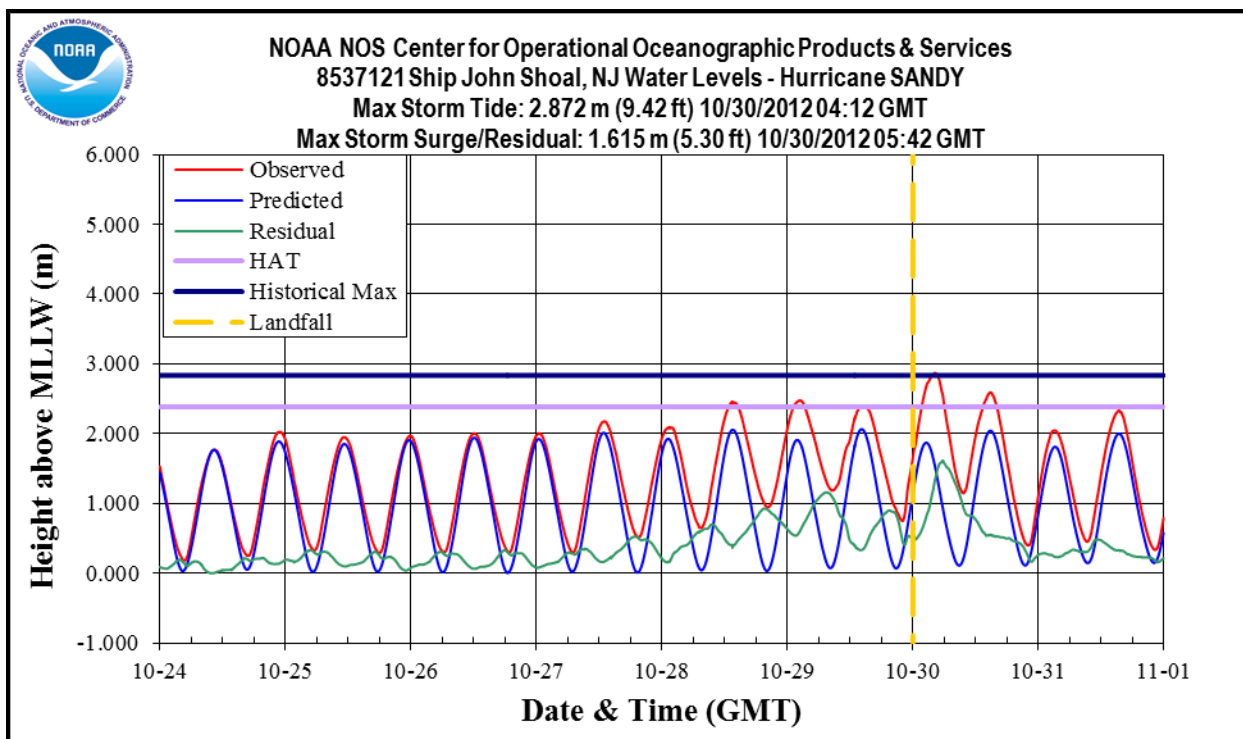


Figure 49: Water levels above Mean Lower Low Water (MLLW) at Ship John Shoal, NJ. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

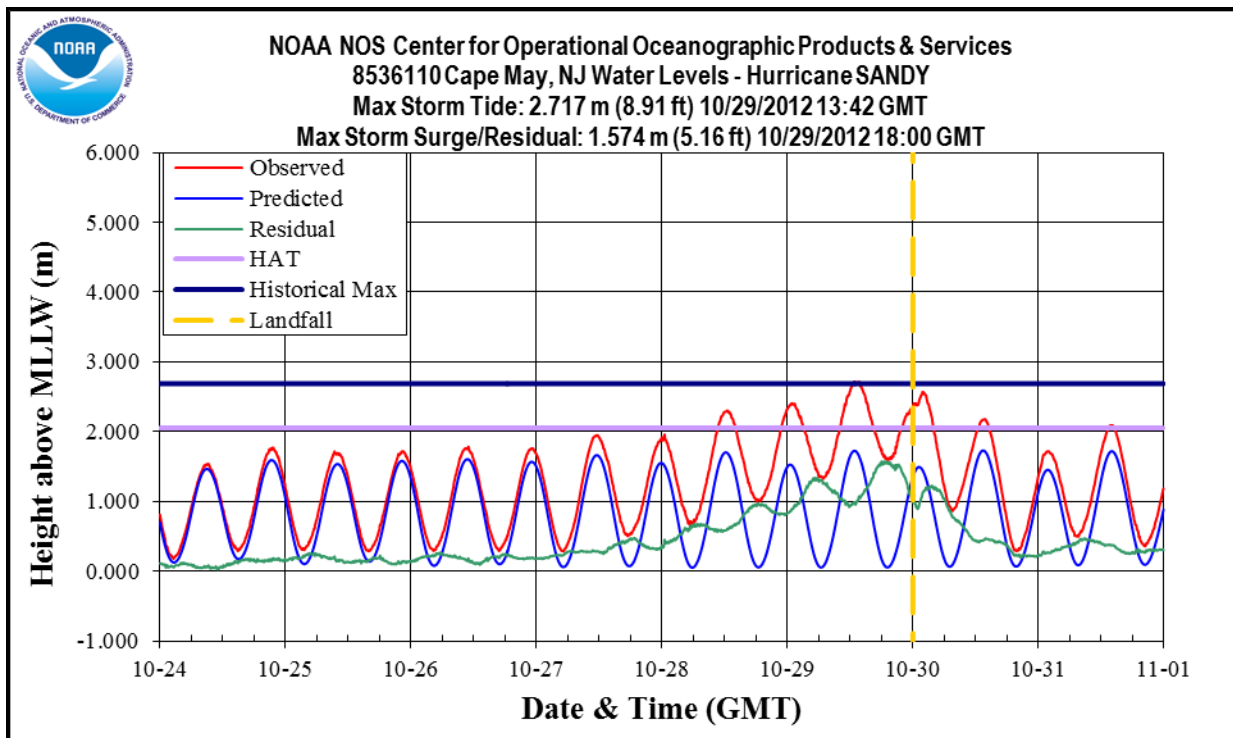


Figure 50: Water levels above Mean Lower Low Water (MLLW) at Cape May, NJ. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

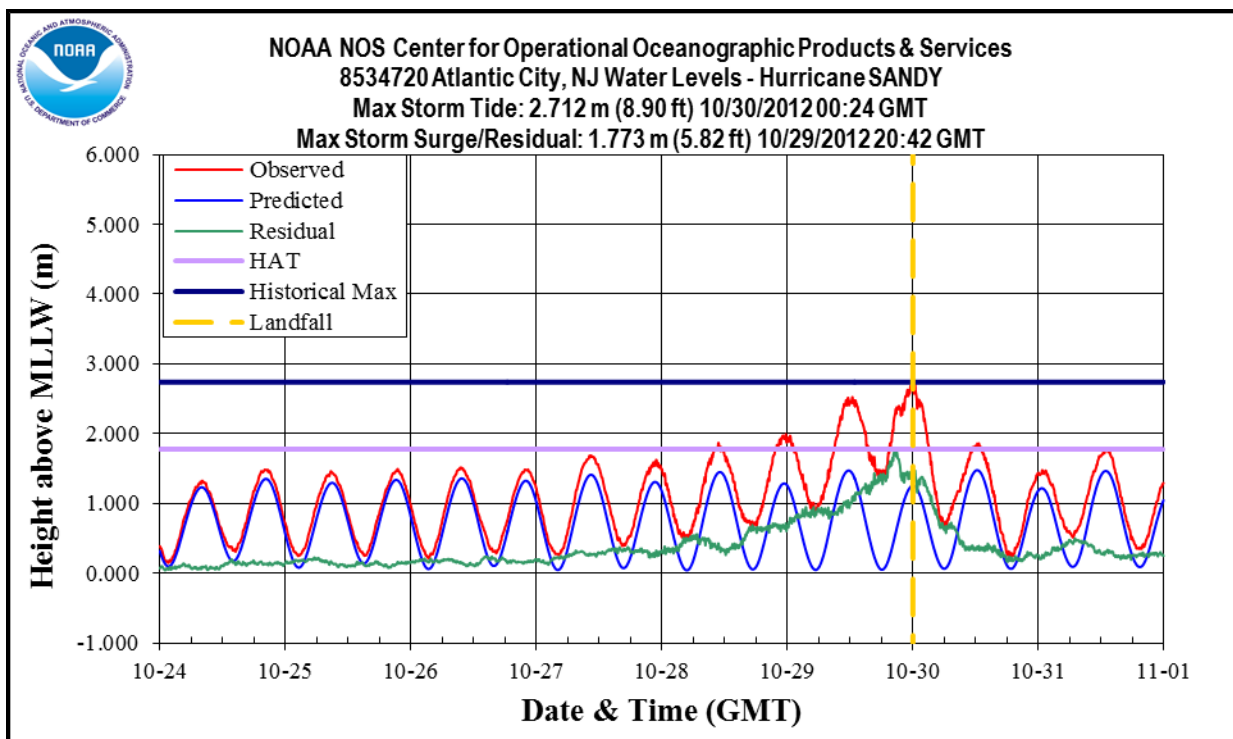


Figure 51: Water levels above Mean Lower Low Water (MLLW) at Burlington, Atlantic City, NJ. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

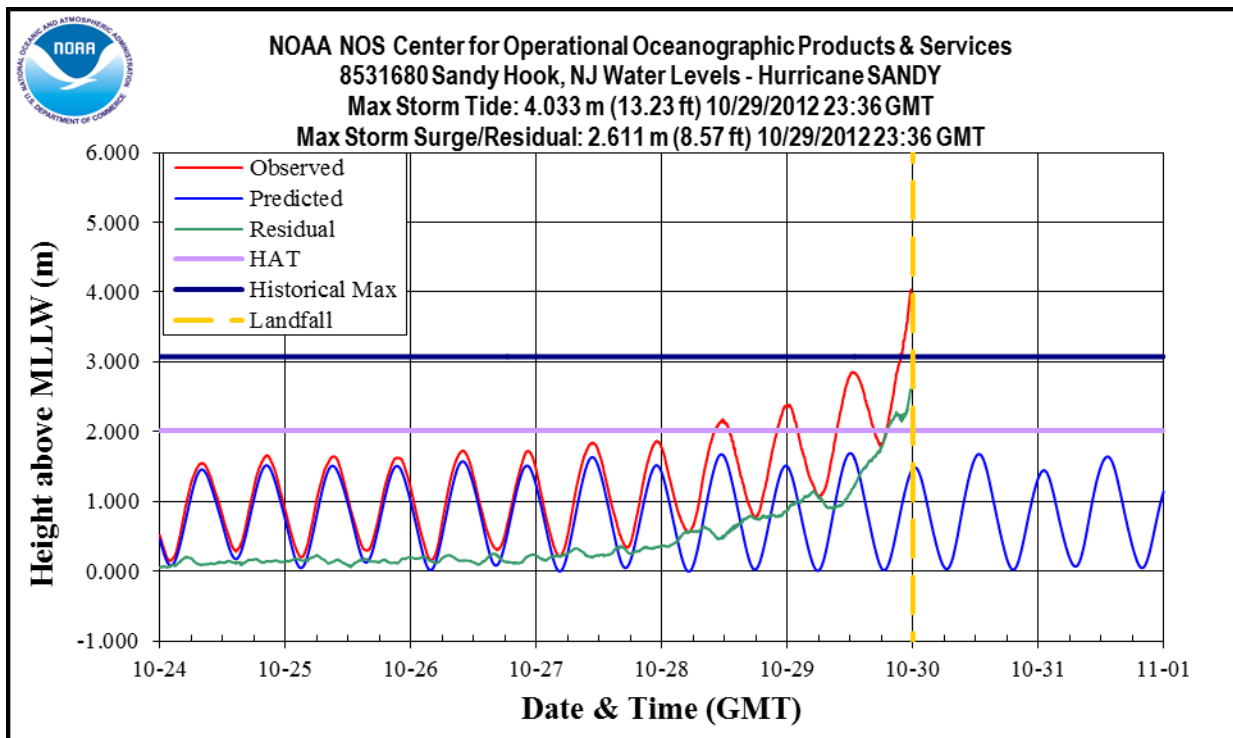


Figure 52: Water levels above Mean Lower Low Water (MLLW) at Sandy Hook, NJ. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane. The sensor was damaged by the storm and likely did not record the maximum water level during Sandy. Because the sensor did not record a full tide while exceeding the historical maximum water level, the record will not be superseded.

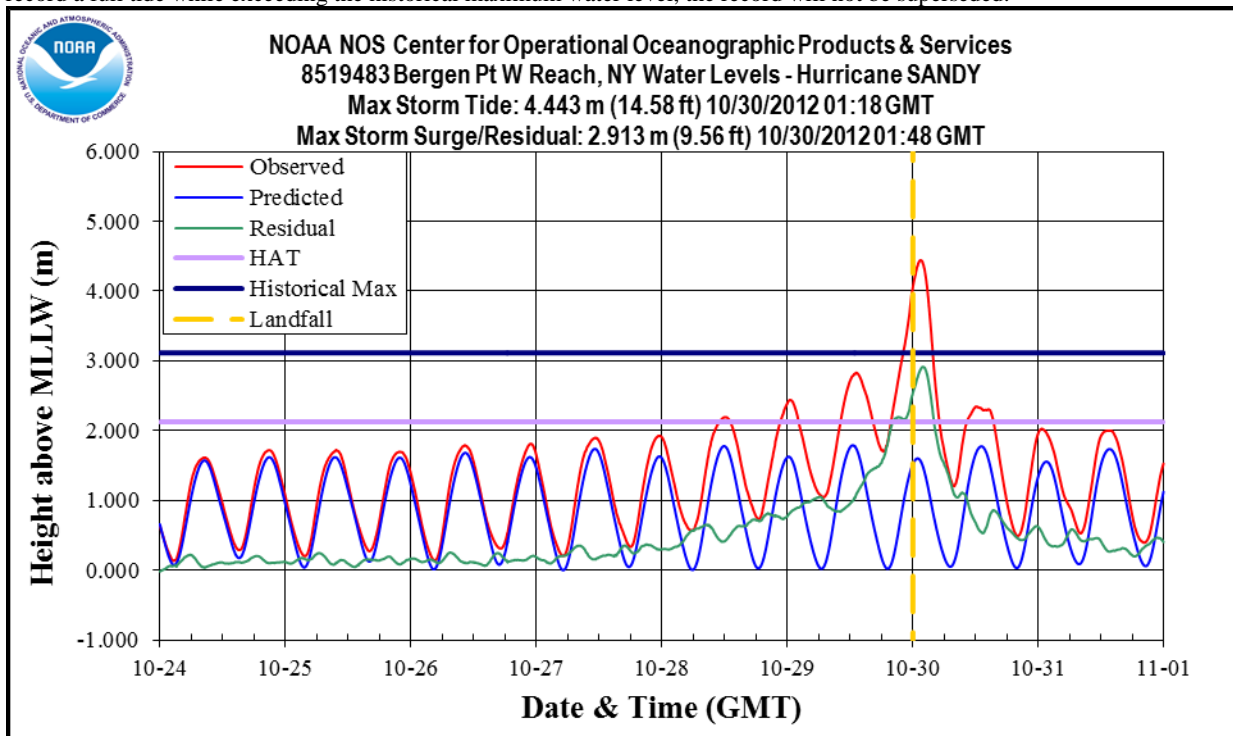


Figure 53: Water levels above Mean Lower Low Water (MLLW) at Bergen Point West Reach, NY. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

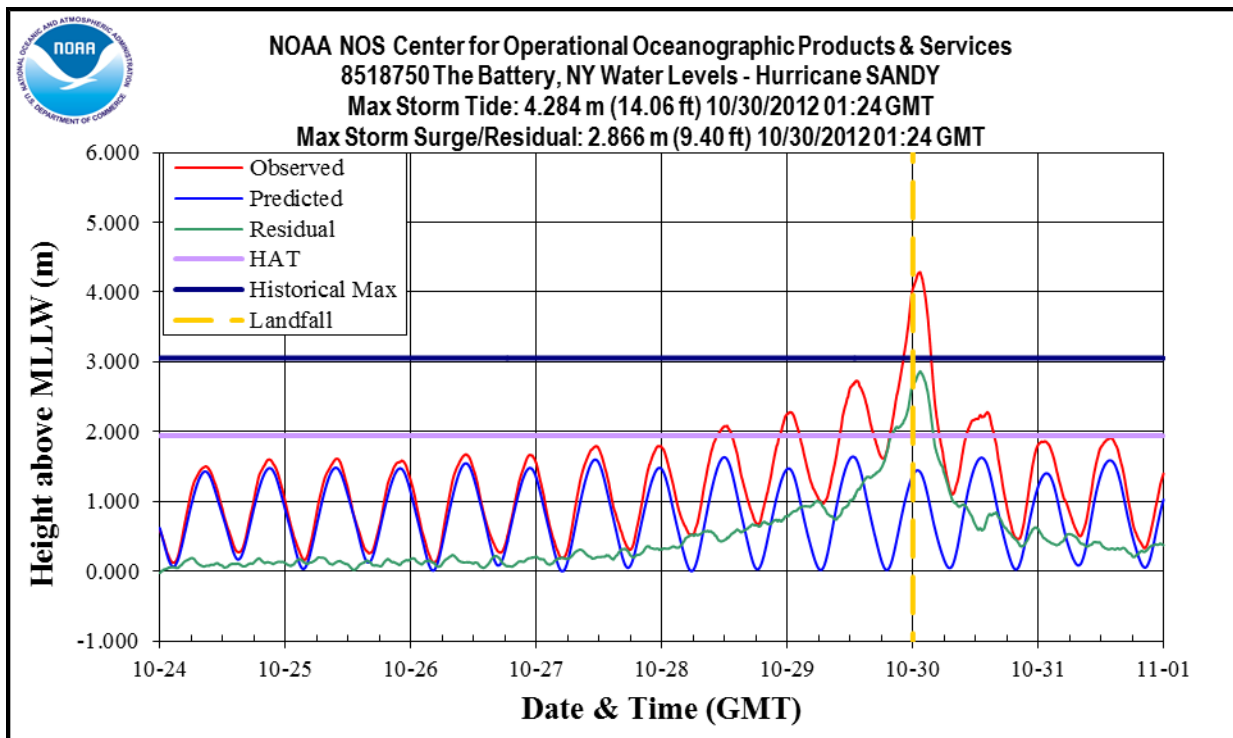


Figure 54: Water levels above Mean Lower Low Water (MLLW) at The Battery, NY. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

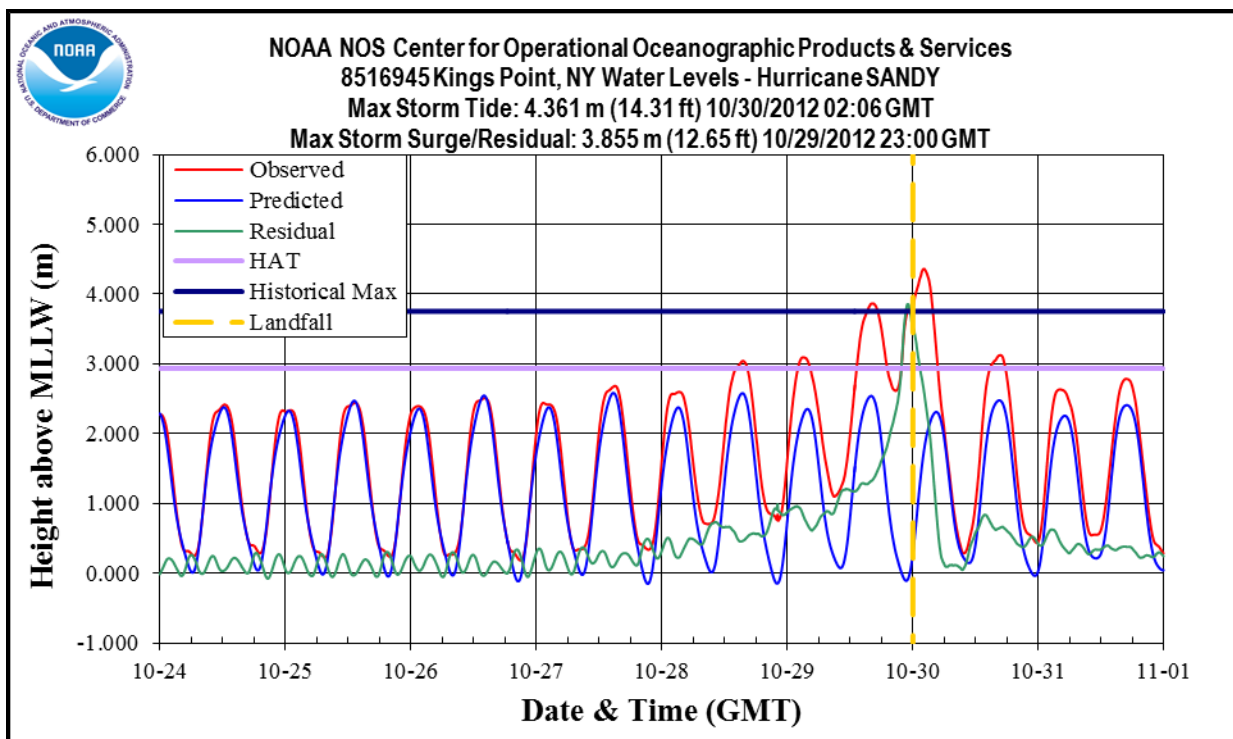


Figure 55: Water levels above Mean Lower Low Water (MLLW) at Kings Point, NY. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

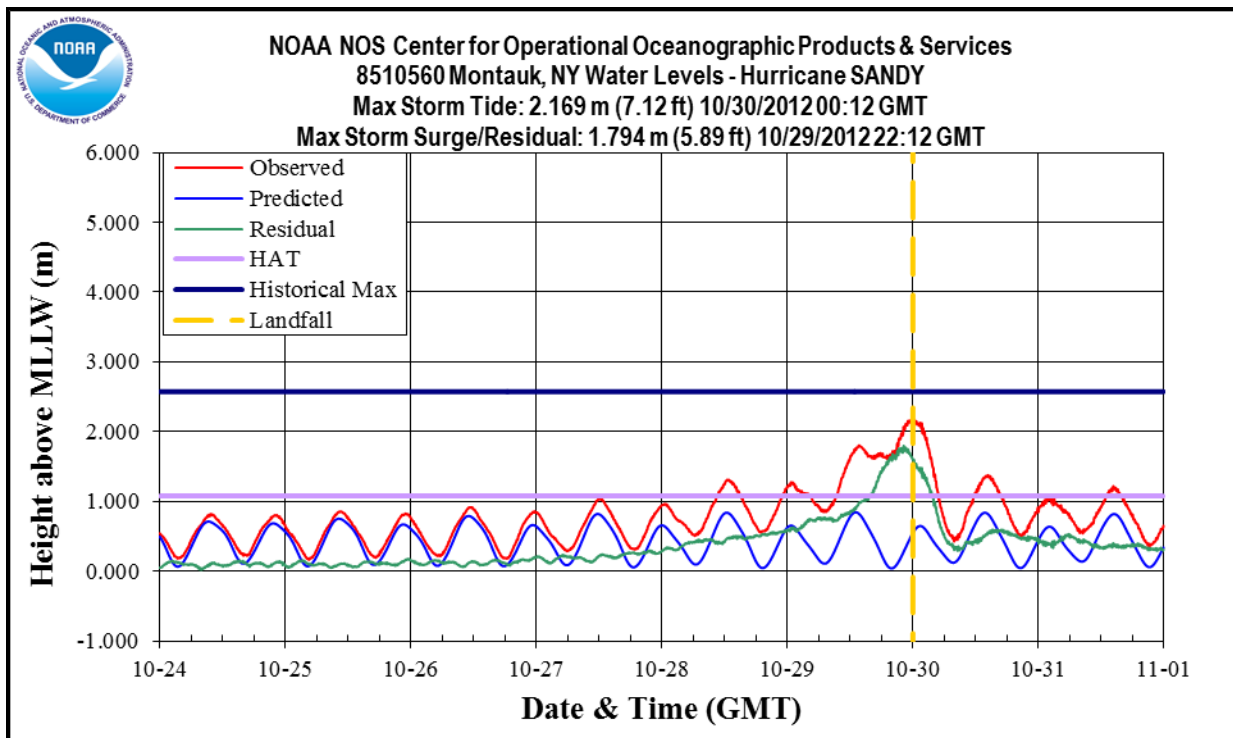


Figure 56: Water levels above Mean Lower Low Water (MLLW) at Montauk, NY. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

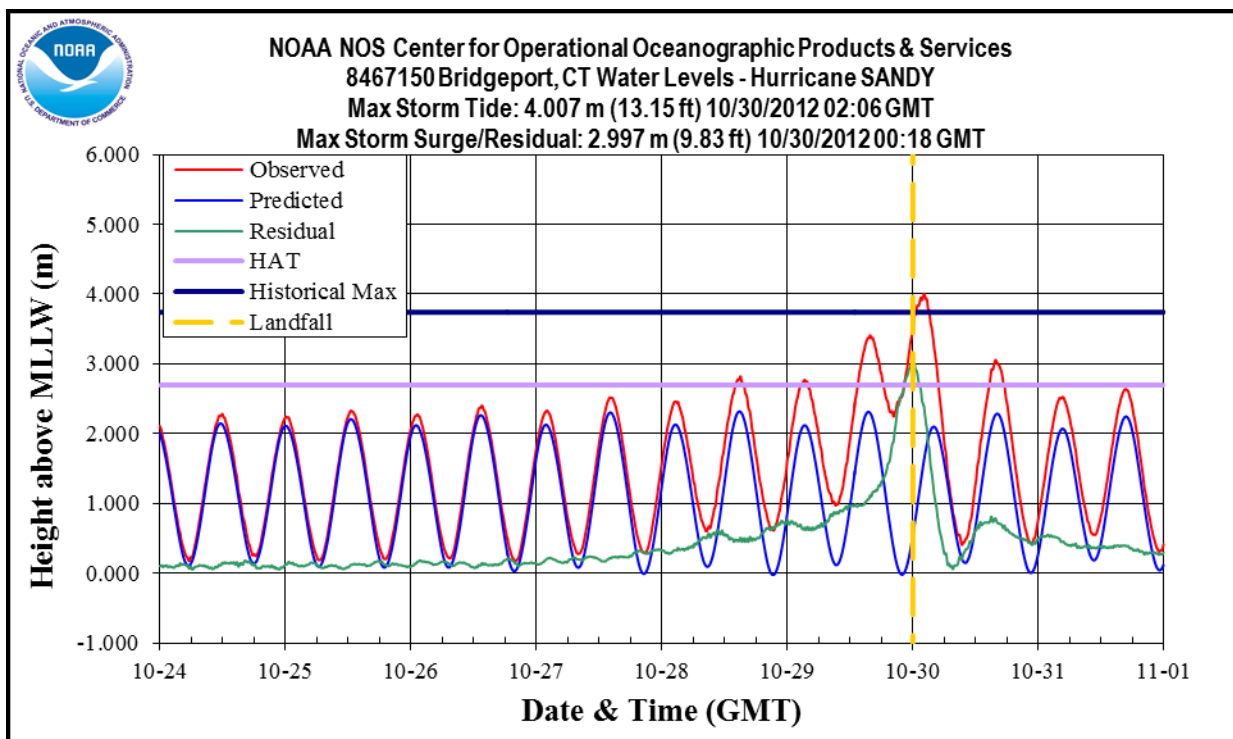


Figure 57: Water levels above Mean Lower Low Water (MLLW) at Bridgeport, CT. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

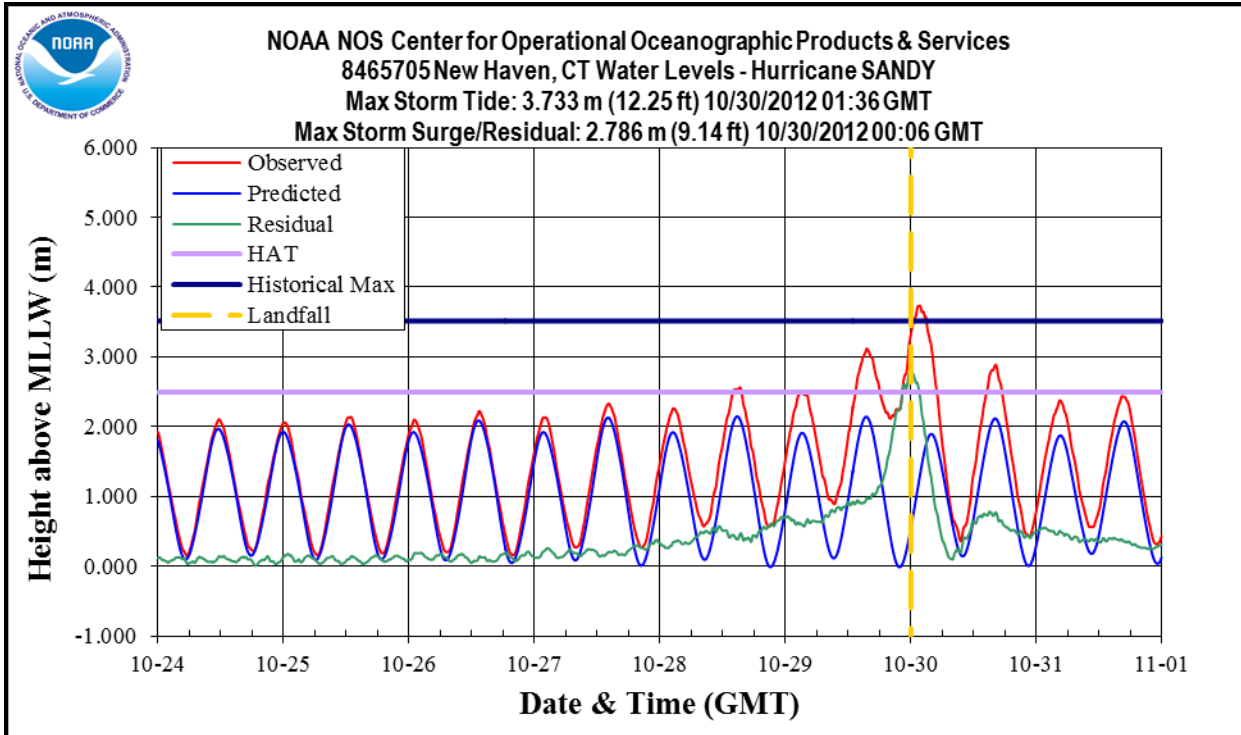


Figure 58: Water levels above Mean Lower Low Water (MLLW) at New Haven, CT. Lines denoting Highest Astronomical tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

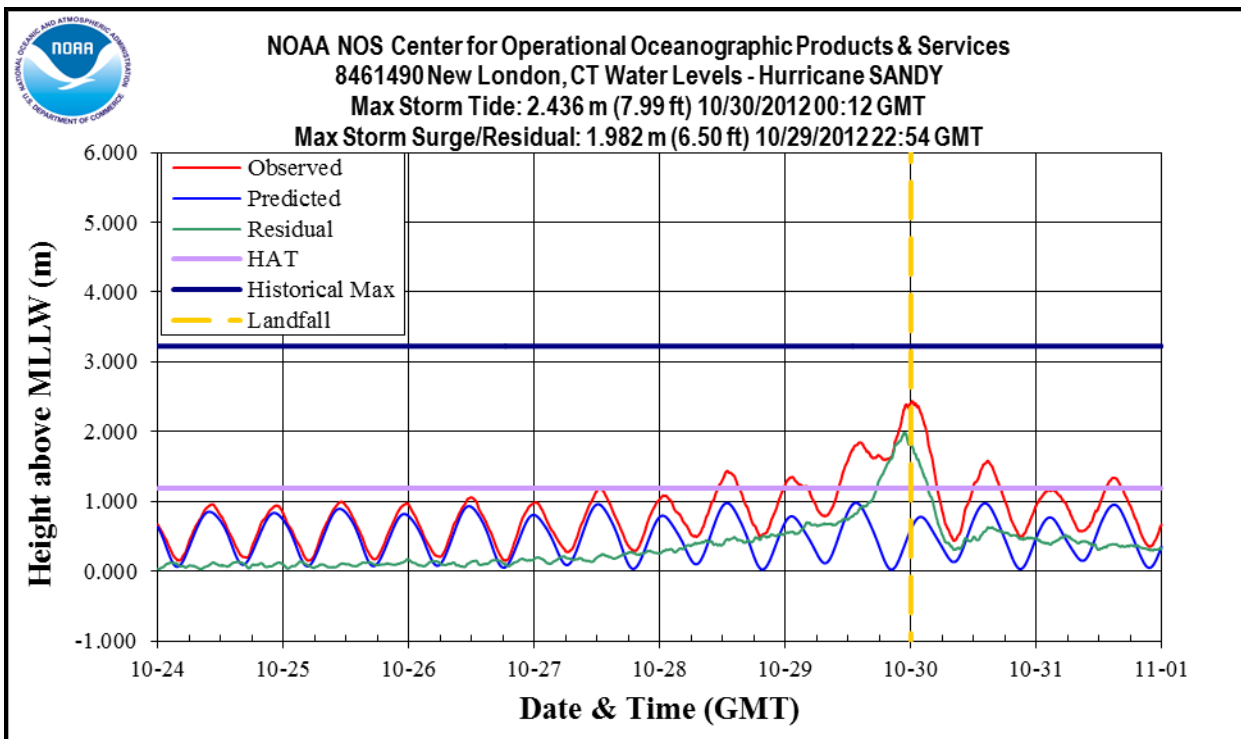


Figure 59: Water levels above Mean Lower Low Water (MLLW) at New London, CT. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

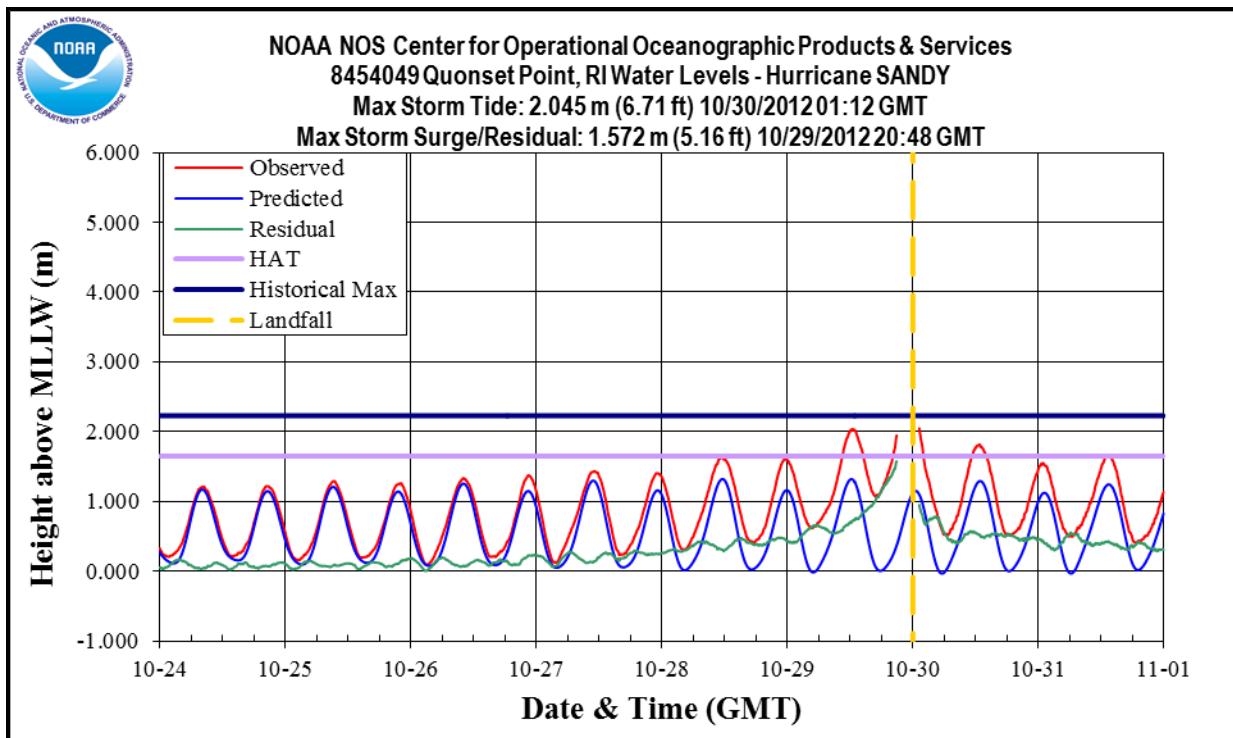


Figure 60: Water levels above Mean Lower Low Water (MLLW) at Quonset Point, RI. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane. Around the time of landfall, the sensor reached its physical limit and did not record a maximum water level.

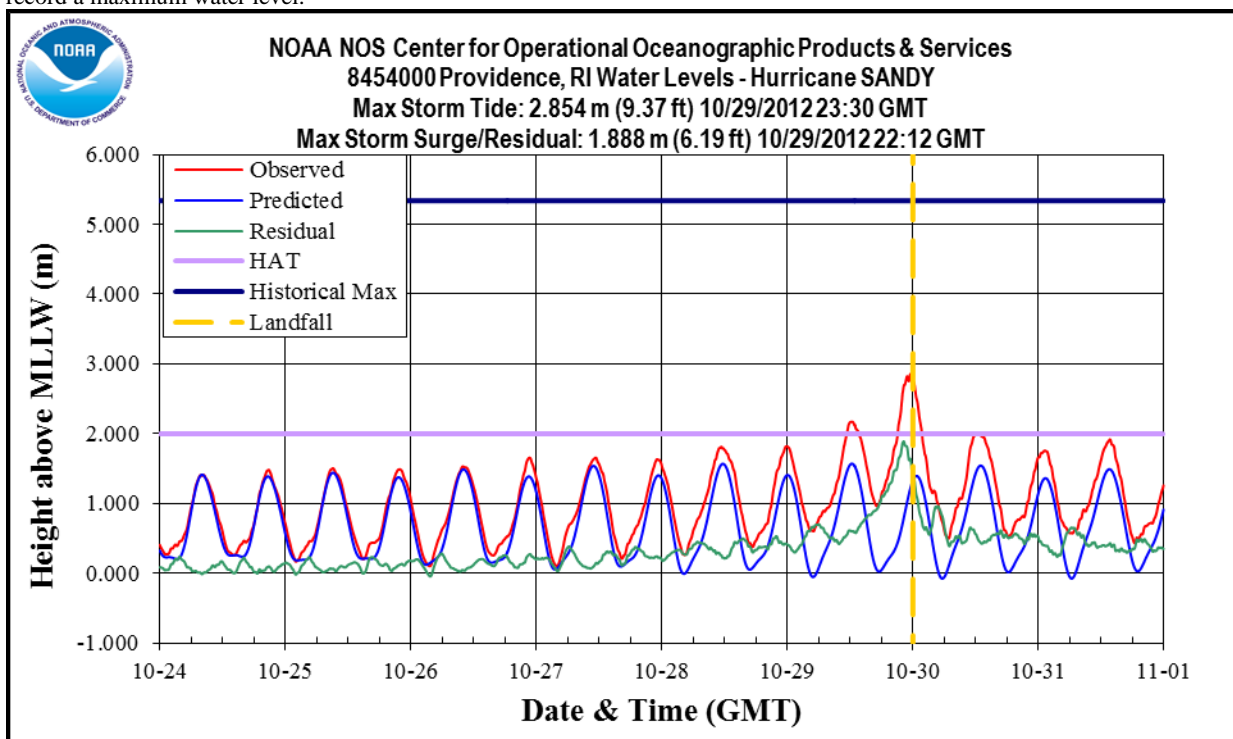


Figure 61: Water levels above Mean Lower Low Water (MLLW) at Providence, RI. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.



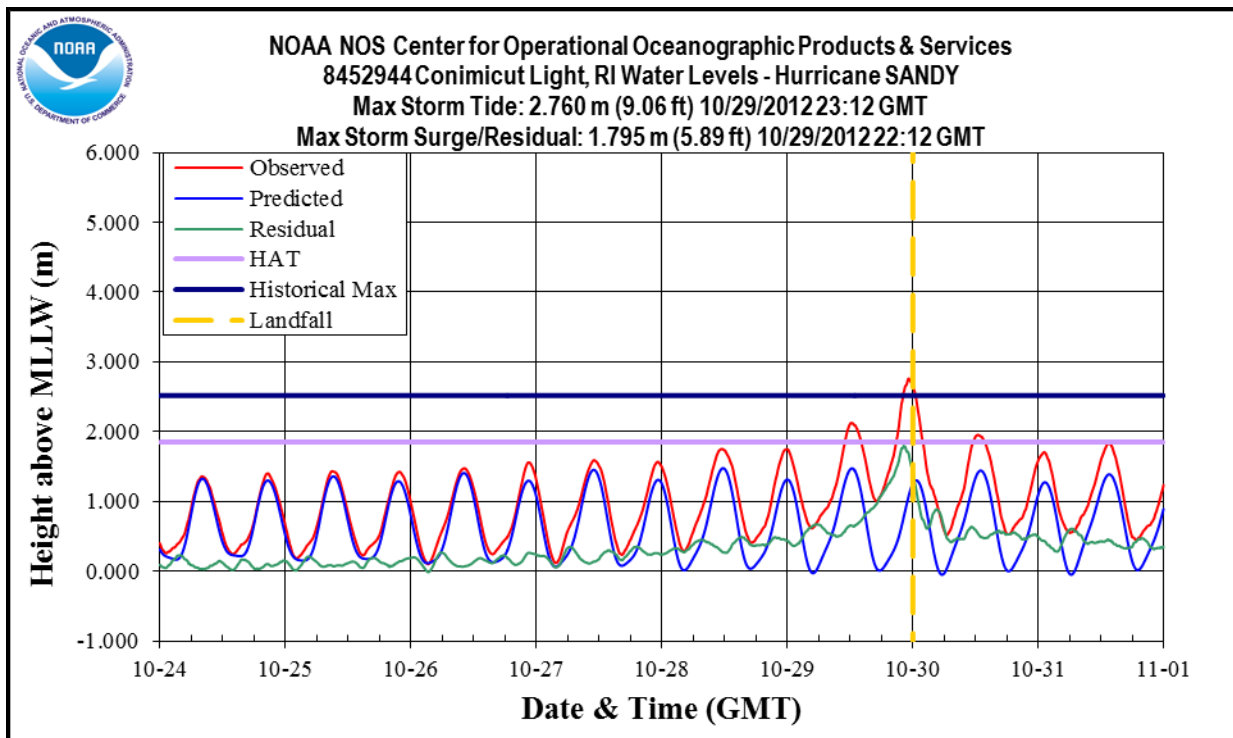


Figure 62: Water levels above Mean Lower Low Water (MLLW) at Conimicut Light, RI. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

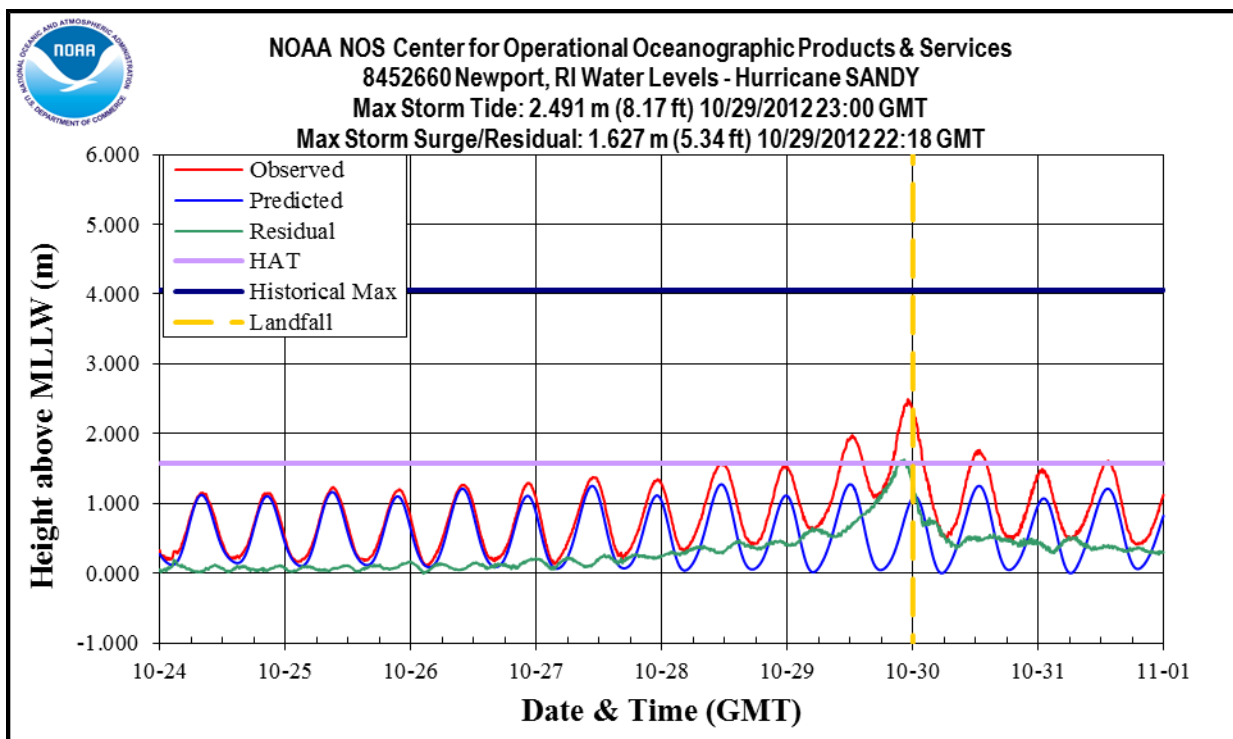


Figure 63: Water levels above Mean Lower Low Water (MLLW) at Newport, RI. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

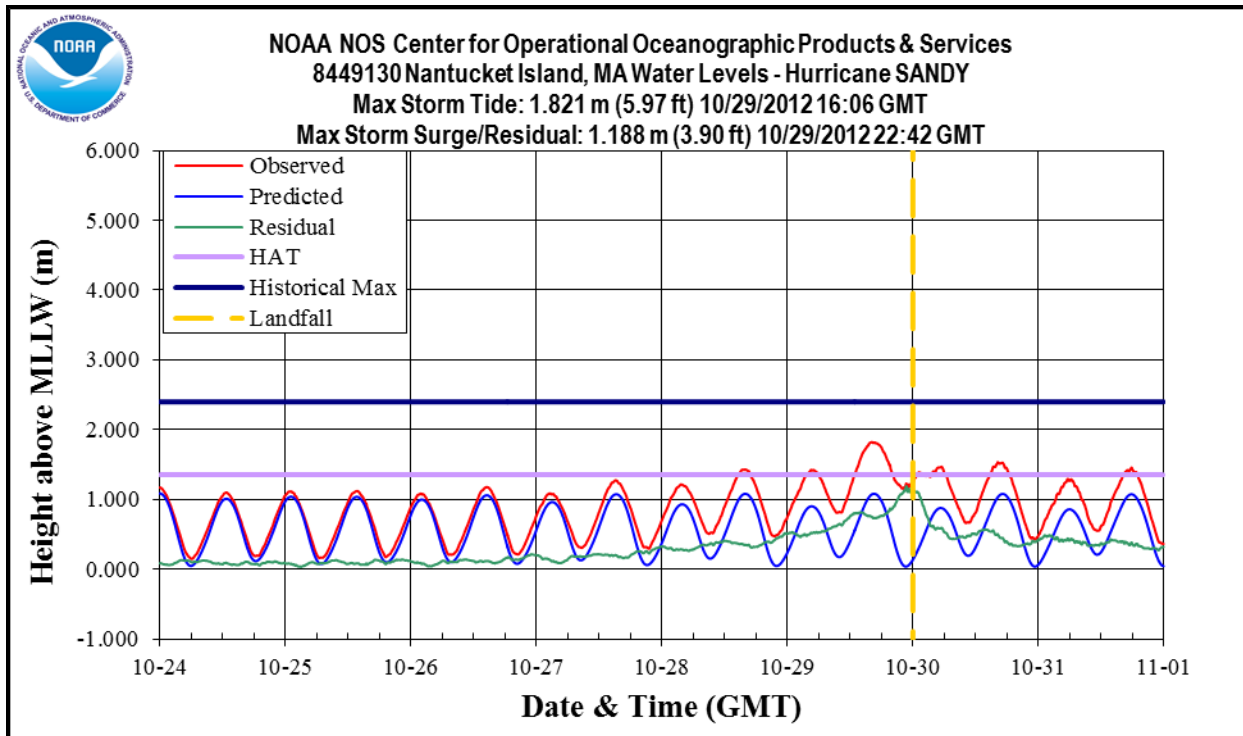


Figure 64: Water levels above Mean Lower Low Water (MLLW) at Nantucket Island, MA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

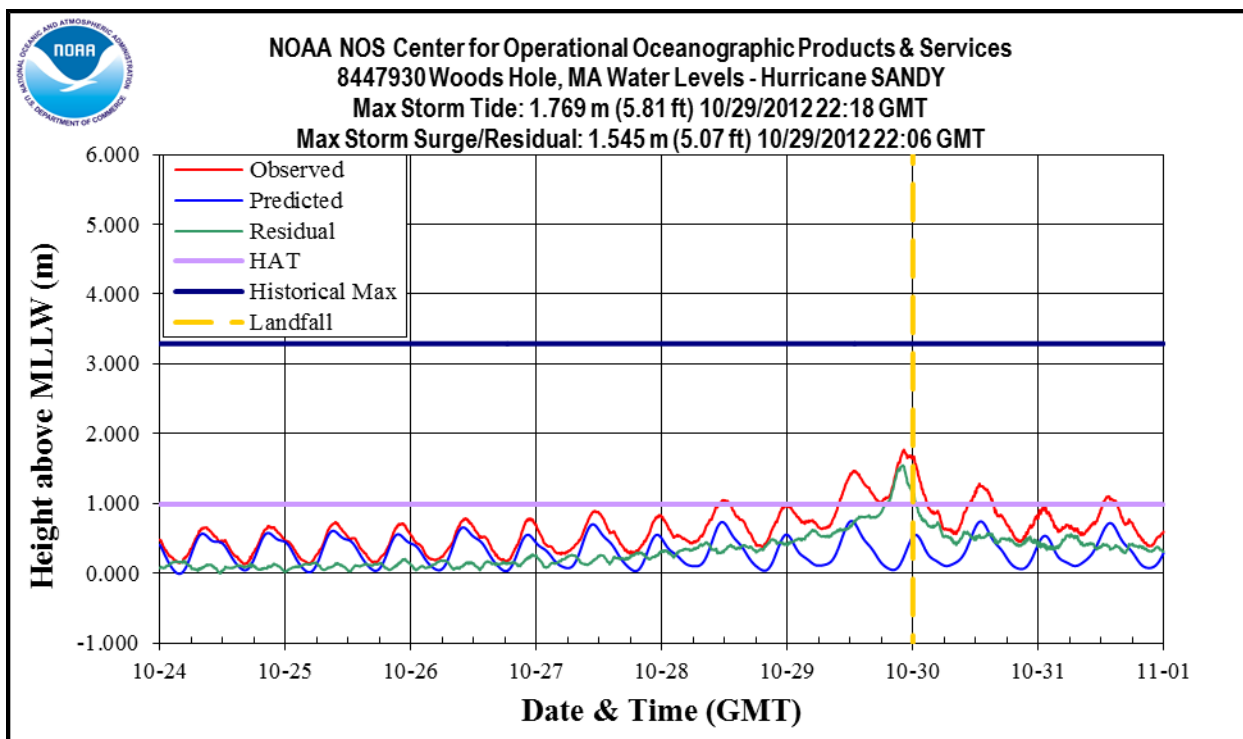


Figure 65: Water levels above Mean Lower Low Water (MLLW) at Woods Hole, MA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

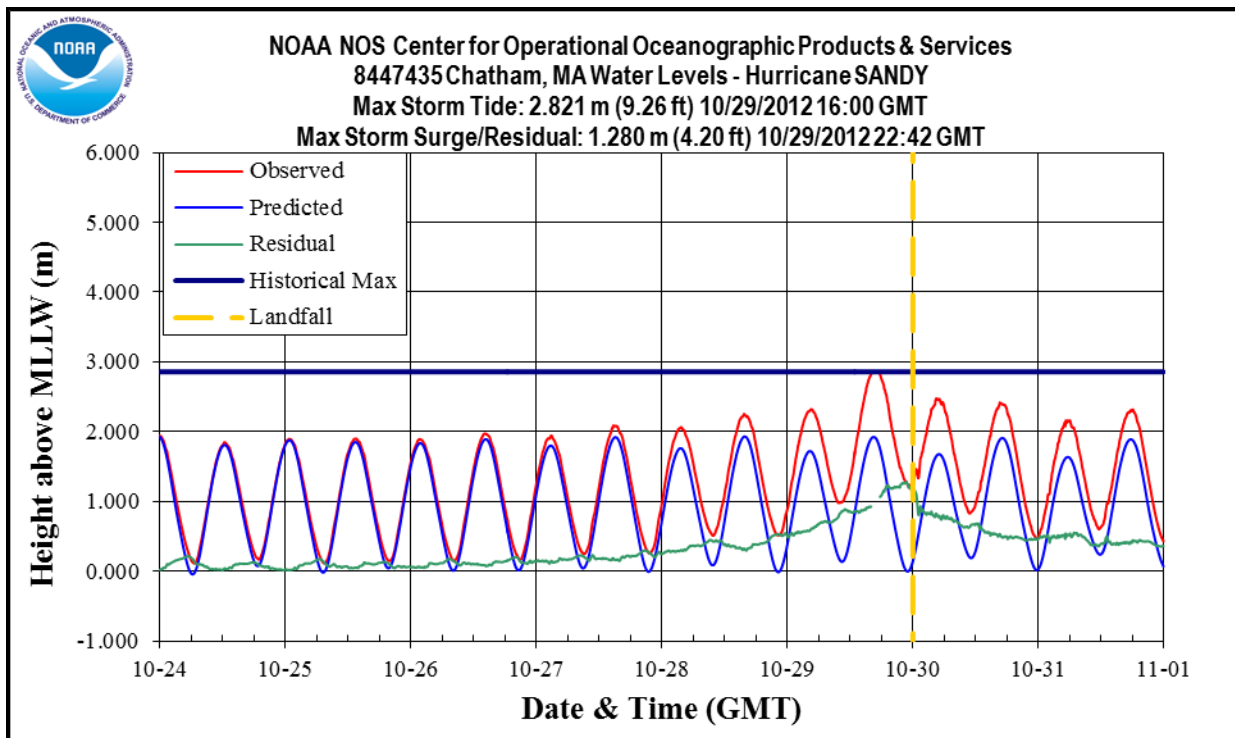


Figure 66: Water levels above Mean Lower Low Water (MLLW) at Chatham, MA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

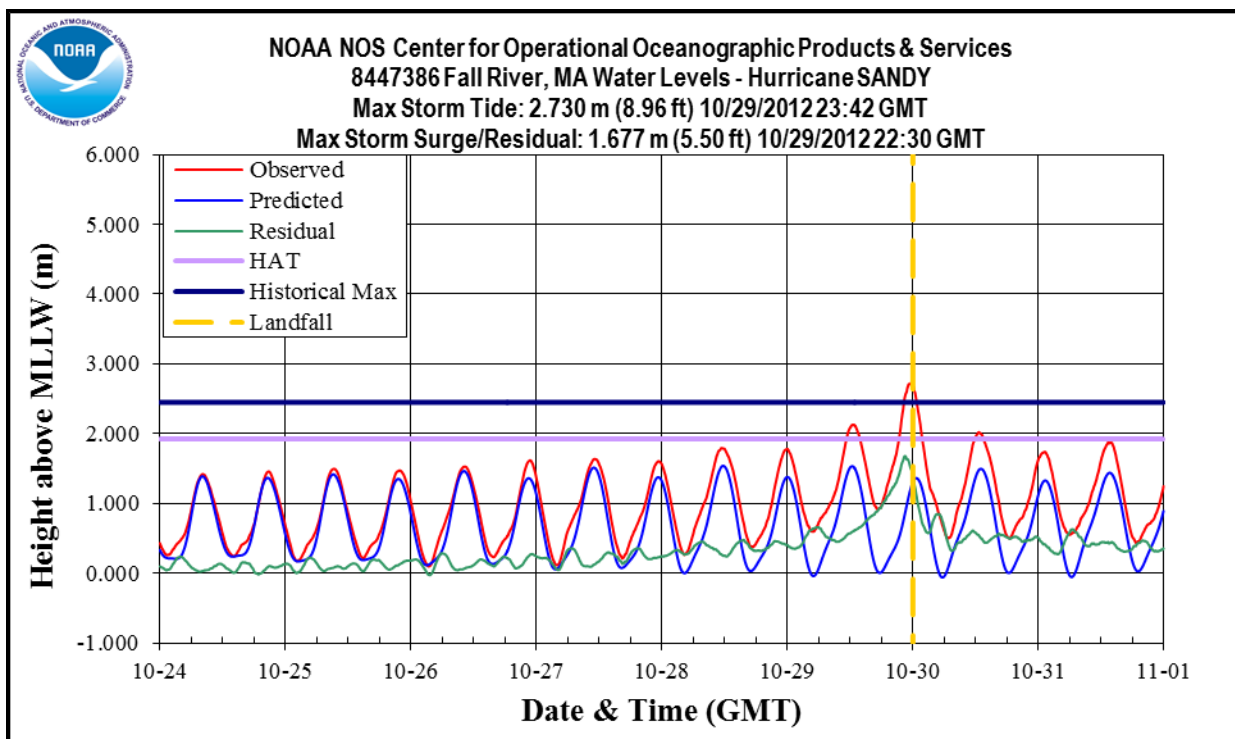


Figure 67: Water levels above Mean Lower Low Water (MLLW) at Fall River, MA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Maximum recorded water level value exceeded the historical maximum value. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

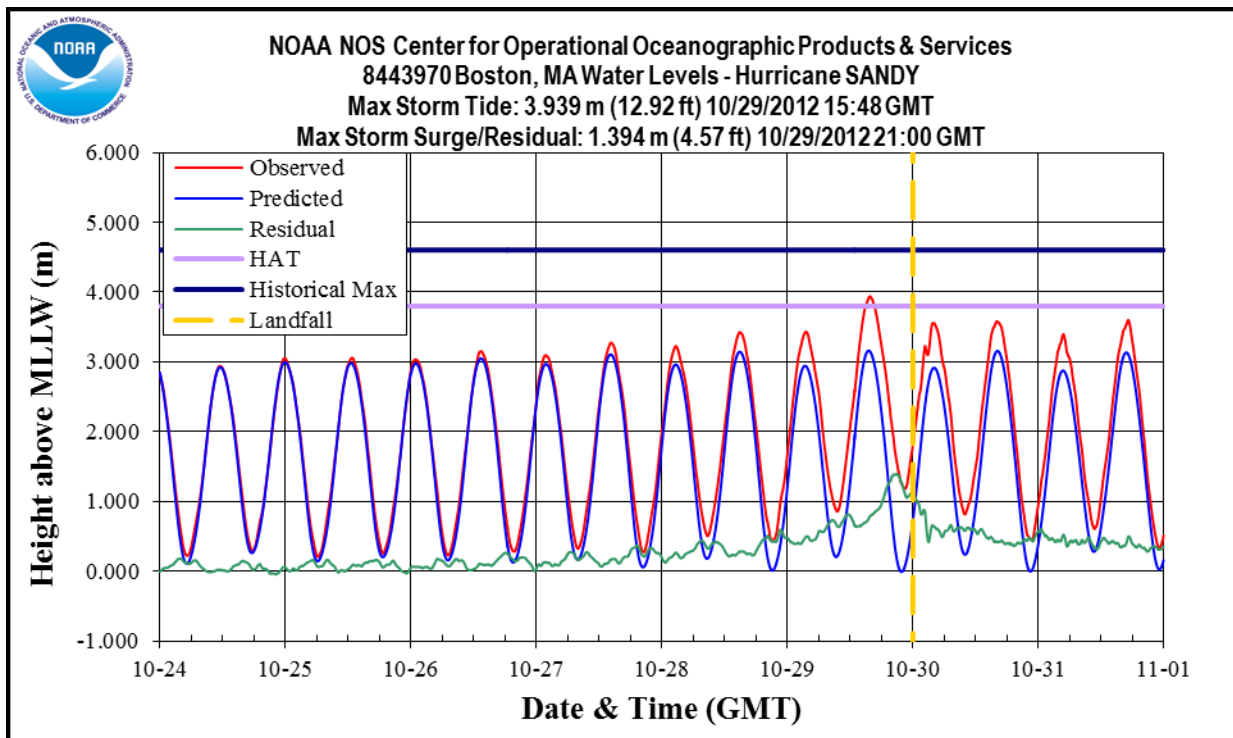


Figure 68: Water levels above Mean Lower Low Water (MLLW) at Boston, MA. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

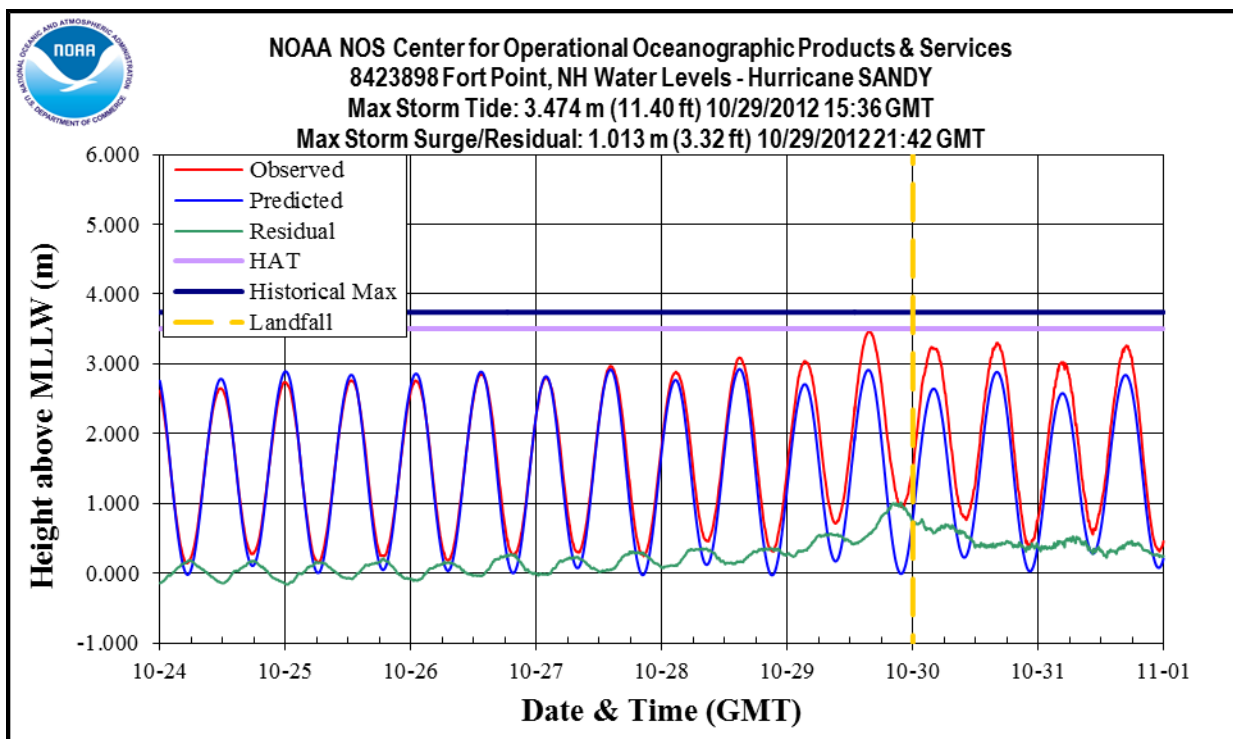


Figure 69: Water levels above Mean Lower Low Water (MLLW) at Fort Point, NH. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

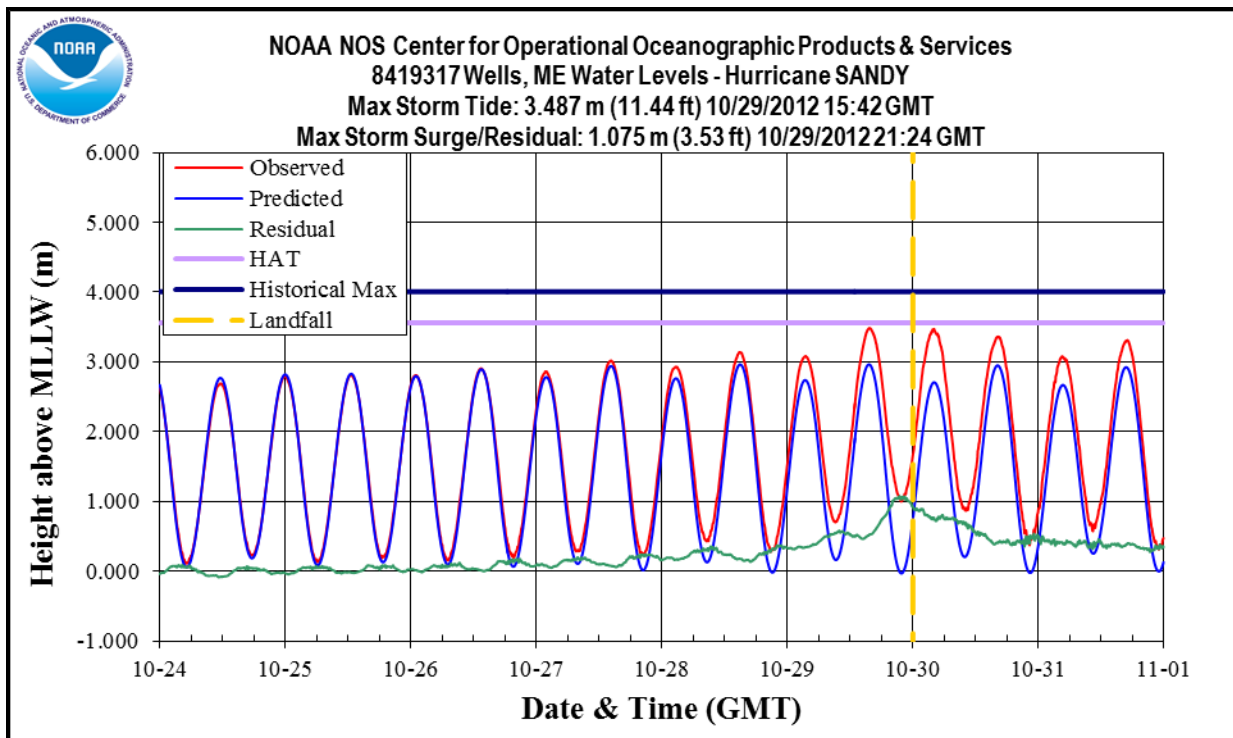


Figure 70: Water levels above Mean Lower Low Water (MLLW) at Wells, ME. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

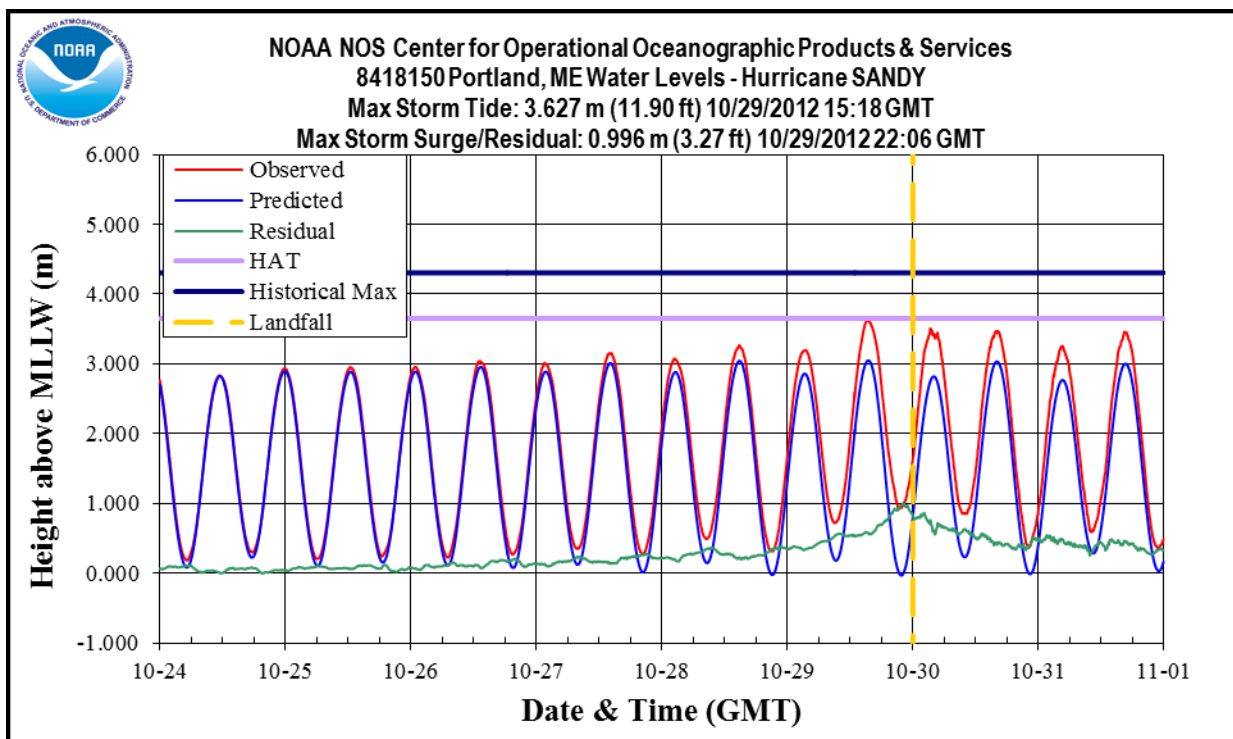


Figure 71: Water levels above Mean Lower Low Water (MLLW) at Portland, ME. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

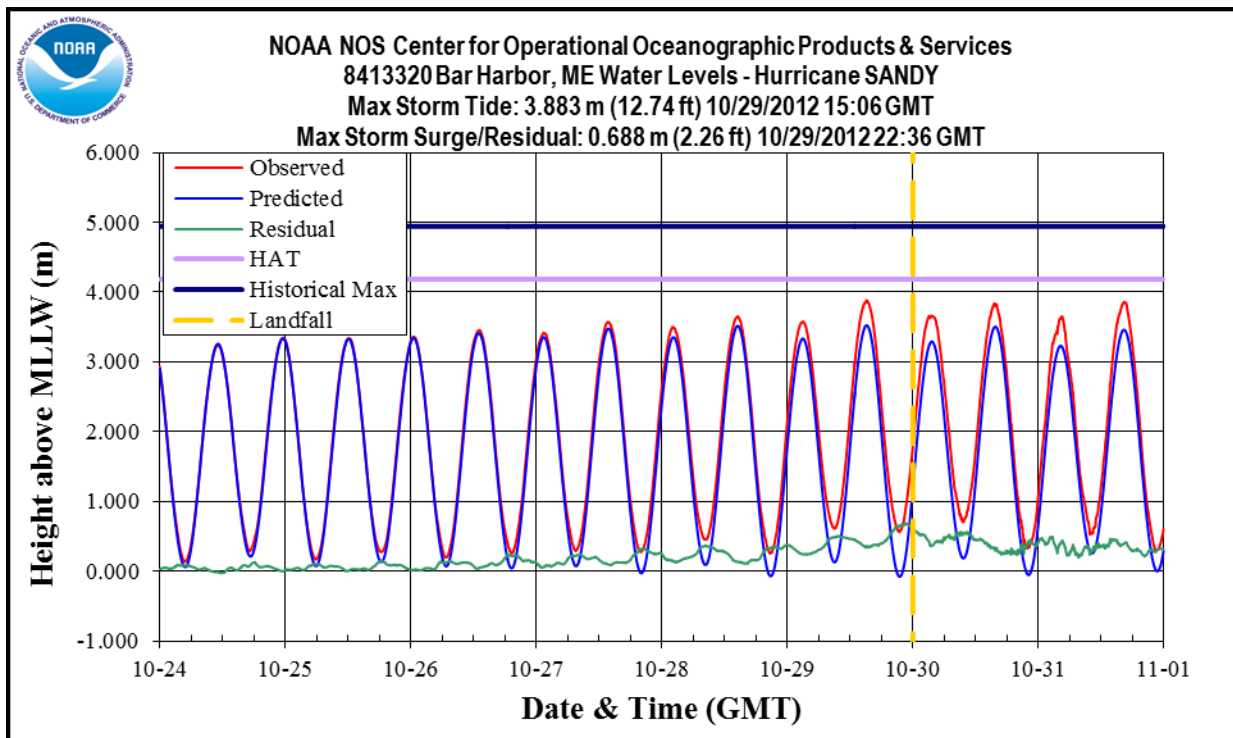


Figure 72: Water levels above Mean Lower Low Water (MLLW) at Bar Harbor, ME. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

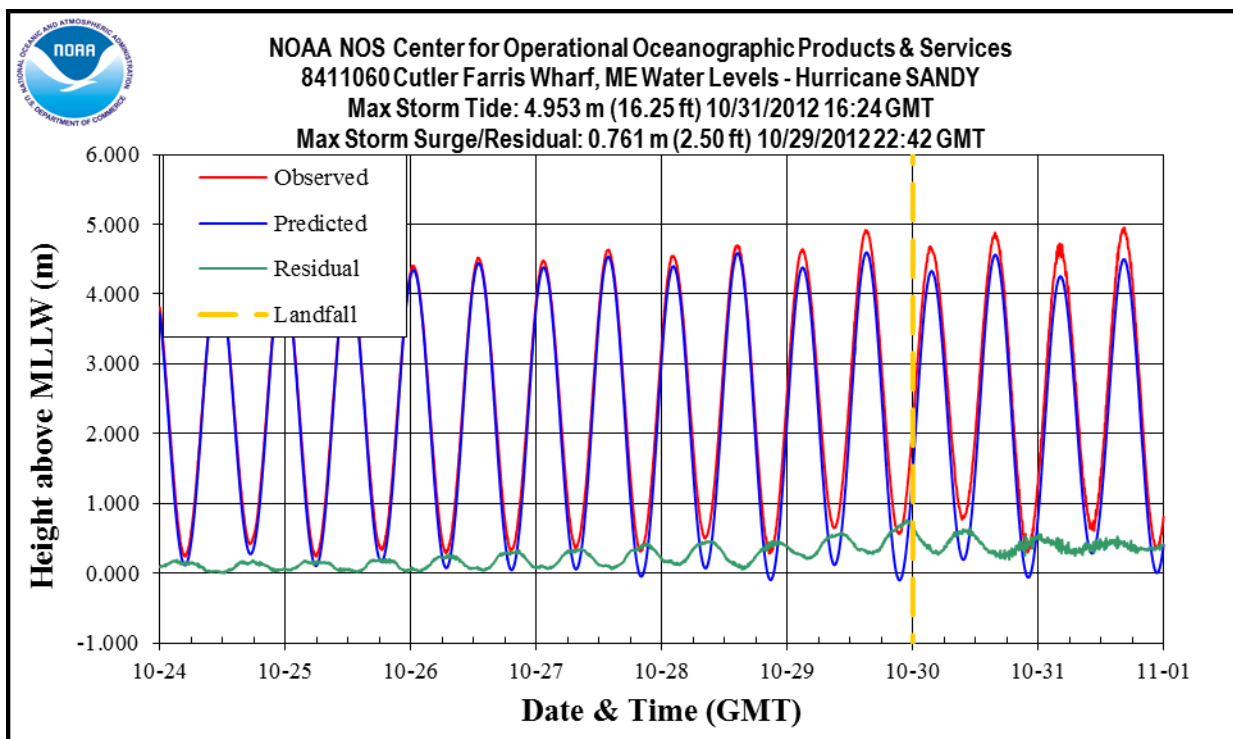


Figure 73: Water levels above Mean Lower Low Water (MLLW) at Cutler Farris Wharf, ME. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

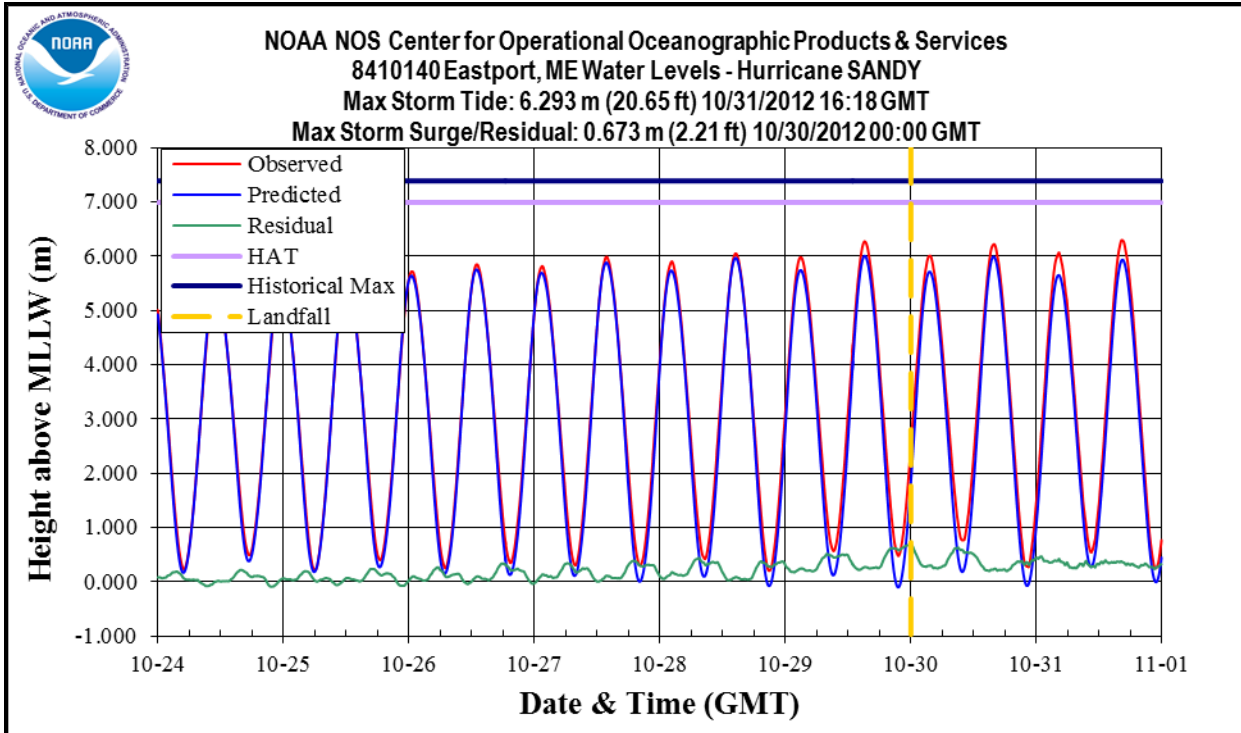


Figure 74: Water levels above Mean Lower Low Water (MLLW) at Eastport, ME. Lines denoting Highest Astronomical Tide (HAT) and Historical Maximum Water Level are displayed. Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane.

## **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
Key West, FL	8724580	24.55570	-81.80790
Vaca Key, FL	8723970	24.71170	-81.10500
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
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

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

<b>Station Name</b>	<b>Station ID</b>	<b>Latitude N</b>	<b>Longitude W</b>
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
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
Cutler Farris Wharf, ME	8411060	44.65670	-67.21000
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.

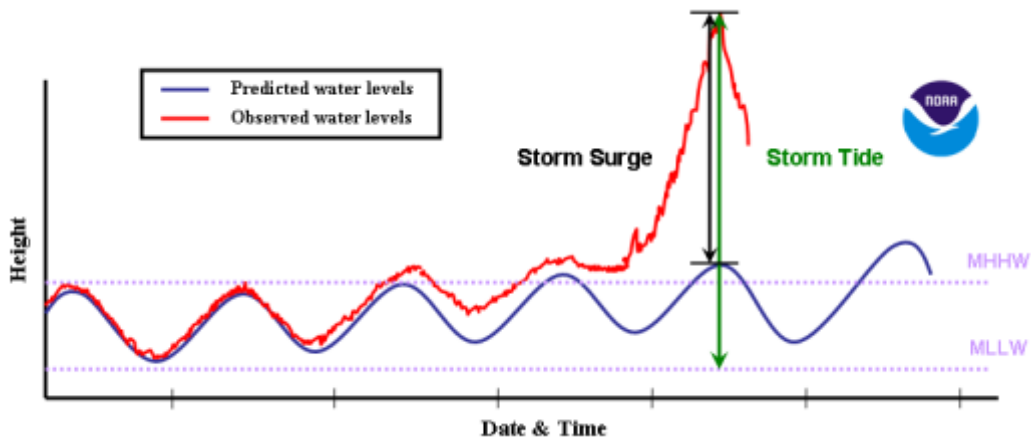
**Tide:** The periodic rise and fall of a body of water resulting from gravitational interactions between Sun, Moon, and Earth. The vertical component of the particulate motion of a tidal wave. Same as astronomic tide.

**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 (kt)	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.