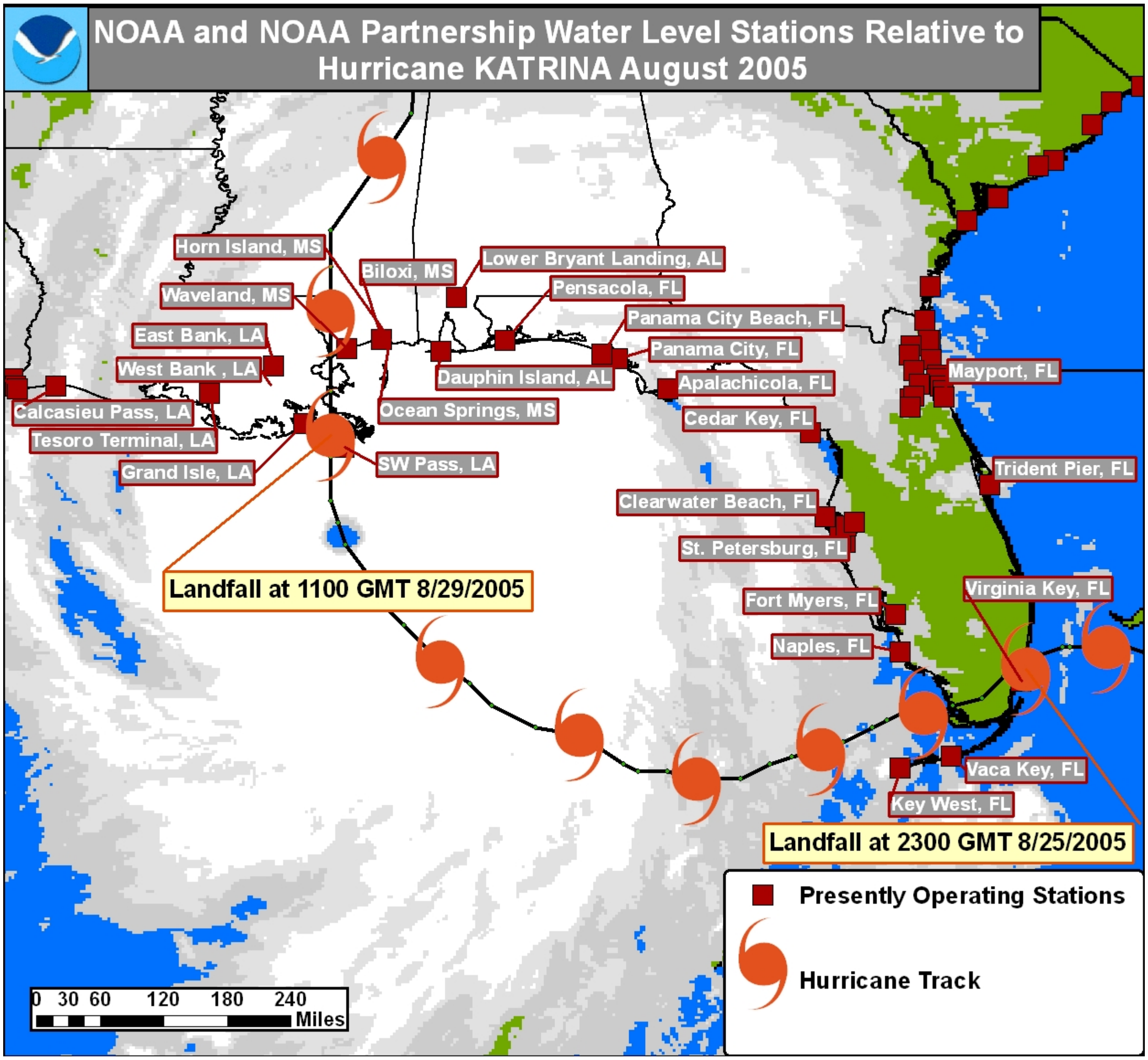
Preliminary Report

HURRICANE KATRINA STORM TIDE SUMMARY



*For the purpose of timely release, data contained within this report have undergone a “limited” NOS Quality Assurance/Control; however, the data have not yet undergone final verification. All data subject to NOS verification.

Revised September 15, 2005

noaa National Oceanic and Atmospheric Administration

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

SUMMARY

Hurricane KATRINA made the first landfall on **August 25th at 2300 GMT**, between Hallandale Beach and North Miami Beach, FL, and continued into the Gulf of Mexico (Coverpage). KATRINA increased in strength and curved northward, making the second landfall on **August 29th at 1110 GMT**, at Grand Isle, LA (Figure 1)**.** At the time of first landfall, water levels were near predictions at stations along eastern Florida (Figures 2-5). Water levels elevated after KATRINA had passed, on August 26th (Tables 1 & 2). At the time of the second landfall, KATRINA'S maximum sustained winds were between **135 - 145 mph,** with higher gusts. The minimum barometric pressures were between **918-923 mb.** The Center for Operational Oceanographic Products and Services (CO-OPS) stations recorded elevated water levels, primarily from Calcasieu Pass, LA to Apalachicola, FL (Figures 1-25). However, elevated water levels were also observed in Texas and along the Gulf coast of Florida (Tables 1 & 2). Station location information is in Appendix 1. All water level observations are measured in meters above the standard tidal charting datum, Mean Lower Low Water (MLLW) based on the National Tidal Datum Epoch 1983-2001 (See Appendix 2 for references and definitions of datums). The report summarizes the highest observed water levels, referred to as the storm tide, which is the sum of the storm surge and the astronomic tide. It also provides the difference between observed water levels and predicted astronomic tides.

Ocean Springs, MS, recorded the highest storm tide of **4.043 m (13.26 ft)** above MLLW. However, the sensor ceased transmissions at this point and did not record a maximum elevation (Table 1; Figure 14). This observed water level was 3.534 m above the predicted astronomical tide**.** Sensor transmission failure also occurred at the next highest storm tide station, Waveland, MS **(2.737 m, 8.98 ft; Figure 15)**. This observed water level was 2.233 m above the predicted astronomical tide. Pilots Station, SW Pass, LA **(2.362 m, 7.75 ft; Figure 20)** and Pensacola, FL **(2.038 m, 6.69 ft; Figure 11)** had the next highest storm tide, with successful sensor transmission during the Hurricane. The observed water levels were 1.880 and 1.579 m, respectively, above the predicted astronomical tide.

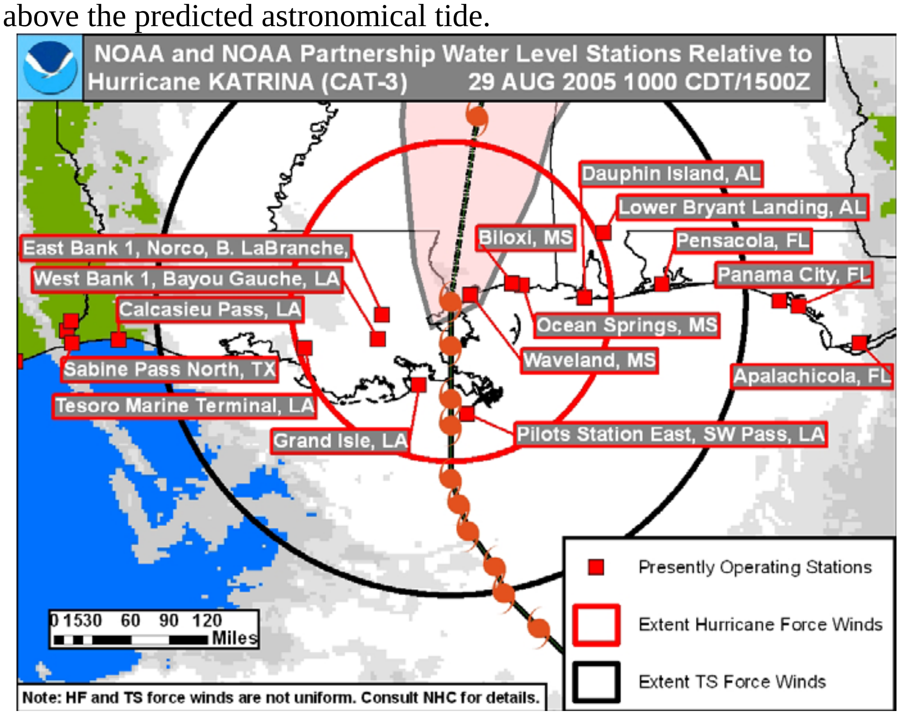


Figure 1: Map illustrating the locations of stations which recorded the highest observed water levels, primarily from Calcasieu Pass, LA to Apalachicola, FL.

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Table 1: **Maximum water levels** for Hurricane KATRINA, August 2005.

*For the purpose of timely release, data contained within this report have undergone a “limited” NOS Quality Assurance/Control; however, the data have not yet undergone final verification. All data subject to NOS verification.

Station Name	**Station ID**	**Date & Time** GMT	**Max Water Level** (Meters above MLLW)	**Predicted Water Levels** (m)	**Difference** (m)	**Max Water Level** (Feet above MLLW)	**Predicted Water Levels** (ft)	**Difference** (ft)
[1]Ocean Springs, MS	8743281	08-29-05 13:18	4.043	0.509	3.534	13.26	1.67	11.59
[1]Waveland, MS	8747766	08-29-05 09:12	2.737	0.504	2.233	8.98	1.65	7.33
Pilots Station, SW Pass, LA	8760922	08-29-05 09:30	2.362	0.482	1.880	7.75	1.58	6.17
Pensacola, FL	8729840	08-29-05 15:24	2.038	0.459	1.579	6.69	1.51	5.18
Dauphin Island , AL	8735180	08-29-05 17:00	1.942	0.297	1.645	6.37	0.97	5.40
[1]Horn Island, MS	8742221	08-29-05 04:48	1.898	0.262	1.636	6.23	0.86	5.37
[1]East Bank, LaBranche, LA	8762372	08-30-05 02:30	1.865	0.106	1.759	6.12	0.35	5.77
[2]Grand Isle, LA	8761724	08-29-05 12:42	1.739	0.442	1.297	5.71	1.45	4.26
Cedar Key, FL	8727520	08-28-05 13:30	1.659	1.089	0.570	5.44	3.57	1.87
Trident Pier, FL	8721604	08-26-05 17:48	1.500	1.209	0.291	4.92	3.97	0.95
Apalachicola, FL	8728690	08-28-05 14:12	1.357	0.555	0.802	4.45	1.82	2.63
Panama City Beach, FL	8729210	08-29-05 12:36	1.323	0.528	0.795	4.34	1.73	2.61
[1]Biloxi, MS	8744117	08-29-05 07:42	1.316	0.443	0.873	4.32	1.45	2.86
Clearwater Beach, FL	8726724	08-28-05 09:12	1.307	0.822	0.485	4.29	2.70	1.59
[2]Lower Bryant Landing, AL	8737373	08-29-05 14:06	1.186	0.582	0.604	3.89	1.91	1.98
Panama City, FL	8729108	08-29-05 13:54	1.168	0.484	0.684	3.83	1.59	2.24
Virginia Key, FL	8723214	08-26-05 06:24	0.979	0.670	0.309	3.21	2.20	1.01
Calcasieu, LA	8768094	08-29-05 07:18	0.938	0.684	0.254	3.08	2.24	0.83
Galveston Bay Entrance, TX	8771341	08-29-05 06:42	0.892	0.551	0.341	2.93	1.81	1.12
Vaca Key, FL	8723970	08-26-05 08:48	0.769	0.335	0.434	2.52	1.10	1.42
Sabine, TX	8770570	08-29-05 08:06	0.759	0.575	0.184	2.49	1.89	0.60
Key West, FL	8724580	08-26-05 07:00	0.694	0.609	0.085	2.28	2.00	0.28
Bayou Gauche, LA	8762482	08-29-05 15:36	0.482	0.042	0.440	1.58	0.14	1.44
Tesoro Terminal, LA	8764044	08-30-05 11:12	0.305	0.184	0.121	1.00	0.60	0.40

[1] Sensor ceased transmissions and did not record maximum water level.
[2] Sensor malfunction noted at elevated water levels.

Table 2: **Maximum water levels in geographic order** for Hurricane KATRINA, August 2005.

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Station Name	**Station ID**	**Date & Time** GMT	**Max Water Level** (Meters above MLLW)	**Predicted Water Levels** (m)	**Difference** (m)	**Max Water Level** (Feet above MLLW)	**Predicted Water Levels** (ft)	**Difference** (ft)
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Virginia Key, FL	8723214	08-26-05 06:24	0.979	0.670	0.309	3.21	2.20	1.01
Vaca Key, FL	8723970	08-26-05 08:48	0.769	0.335	0.434	2.52	1.10	1.42
Key West, FL	8724580	08-26-05 07:00	0.694	0.609	0.085	2.28	2.00	0.28
Clearwater Beach, FL	8726724	08-28-05 09:12	1.307	0.822	0.485	4.29	2.70	1.59
Cedar Key, FL	8727520	08-28-05 13:30	1.659	1.089	0.570	5.44	3.57	1.87
Apalachicola, FL	8728690	08-28-05 14:12	1.357	0.555	0.802	4.45	1.82	2.63
Panama City, FL	8729108	08-29-05 13:54	1.168	0.484	0.684	3.83	1.59	2.24
Panama City Beach, FL	8729210	08-29-05 12:36	1.323	0.528	0.795	4.34	1.73	2.61
Pensacola, FL	8729840	08-29-05 15:24	2.038	0.459	1.579	6.69	1.51	5.18
[2]Lower Bryant Landing, AL	8737373	08-29-05 14:06	1.186	0.582	0.604	3.89	1.91	1.98
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Tesoro Terminal, LA	8764044	08-30-05 11:12	0.305	0.184	0.121	1.00	0.60	0.40
Calcasieu, LA	8768094	08-29-05 07:18	0.938	0.684	0.254	3.08	2.24	0.83
Sabine, TX	8770570	08-29-05 08:06	0.759	0.575	0.184	2.49	1.89	0.60
Galveston Bay Entrance, TX	8771341	08-29-05 06:42	0.892	0.551	0.341	2.93	1.81	1.12

[1] Sensor ceased transmissions and did not record maximum water level.
[2] Sensor malfunction noted at elevated water levels.

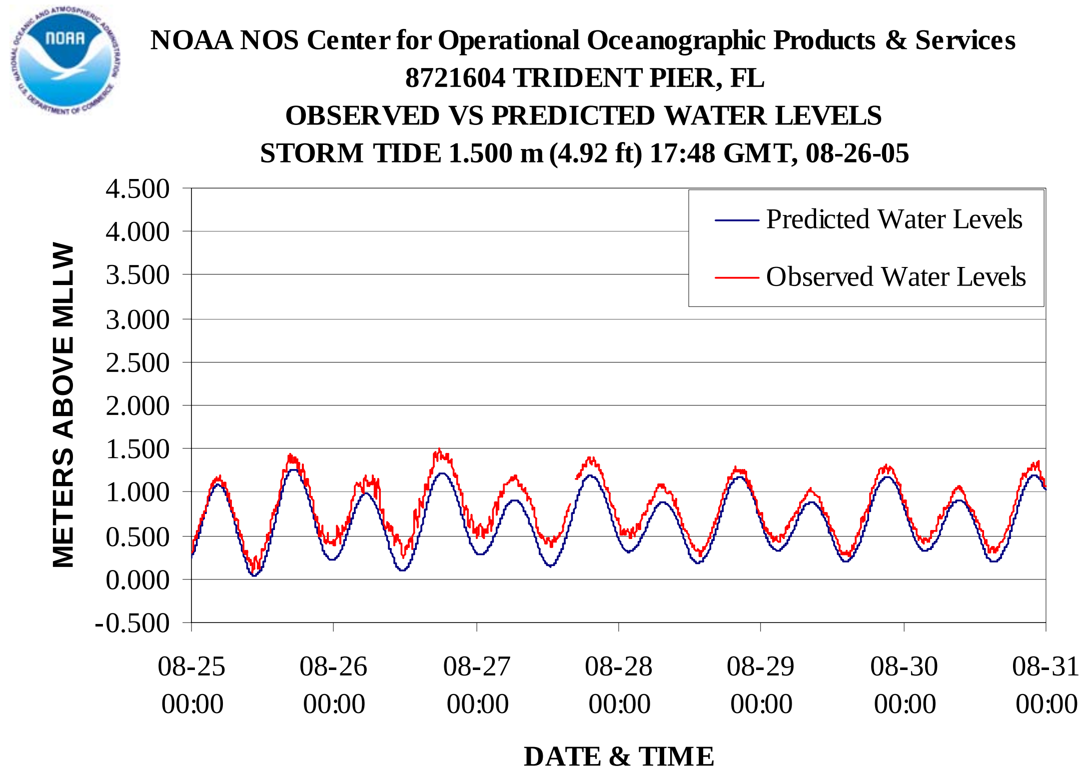

Figure 2: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Trident Pier, FL, before, during, and after Hurricane KATRINA.

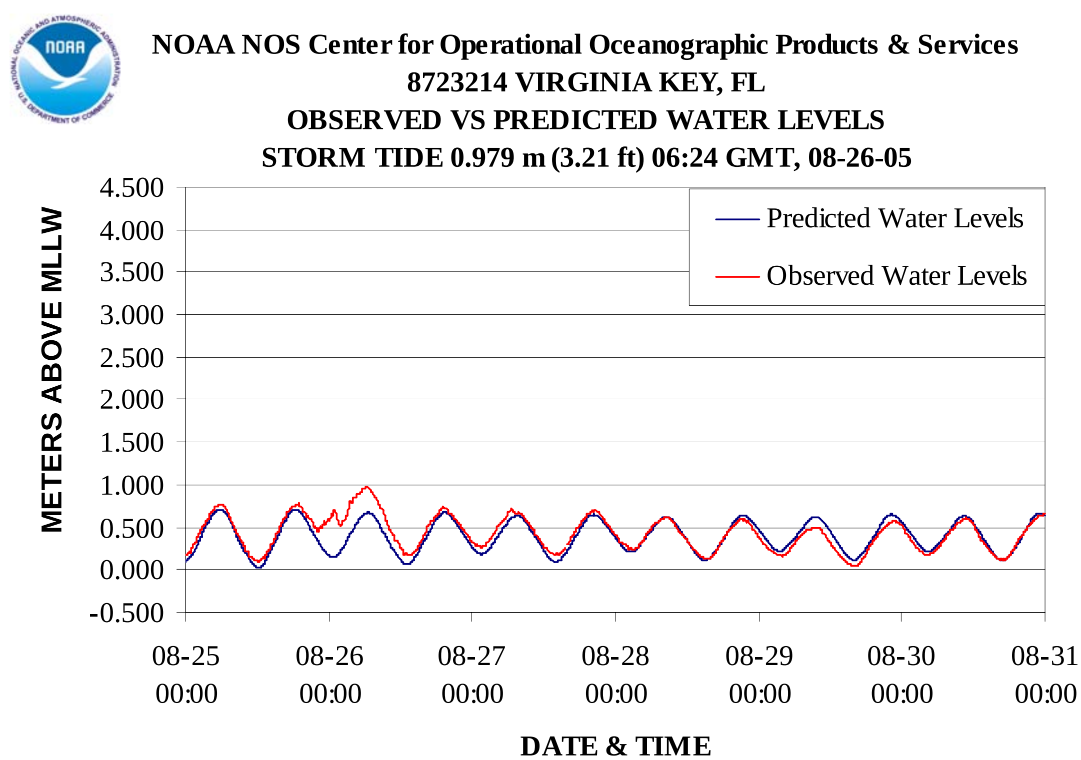

Figure 3: Time series of observed and predicted water above tidal datum, Mean Lower Low Water (MLLW) at Virginia Key, FL, before, during, and after Hurricane KATRINA.

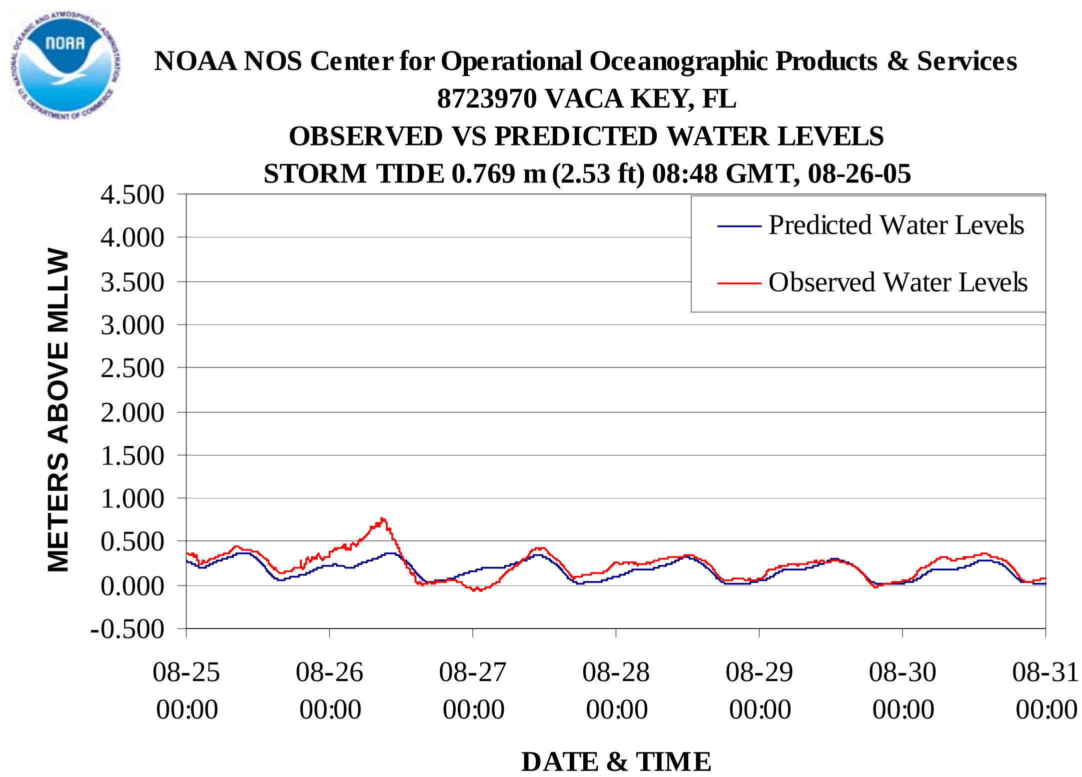

Figure 4: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Vaca Key, FL, before, during, and after Hurricane KATRINA.

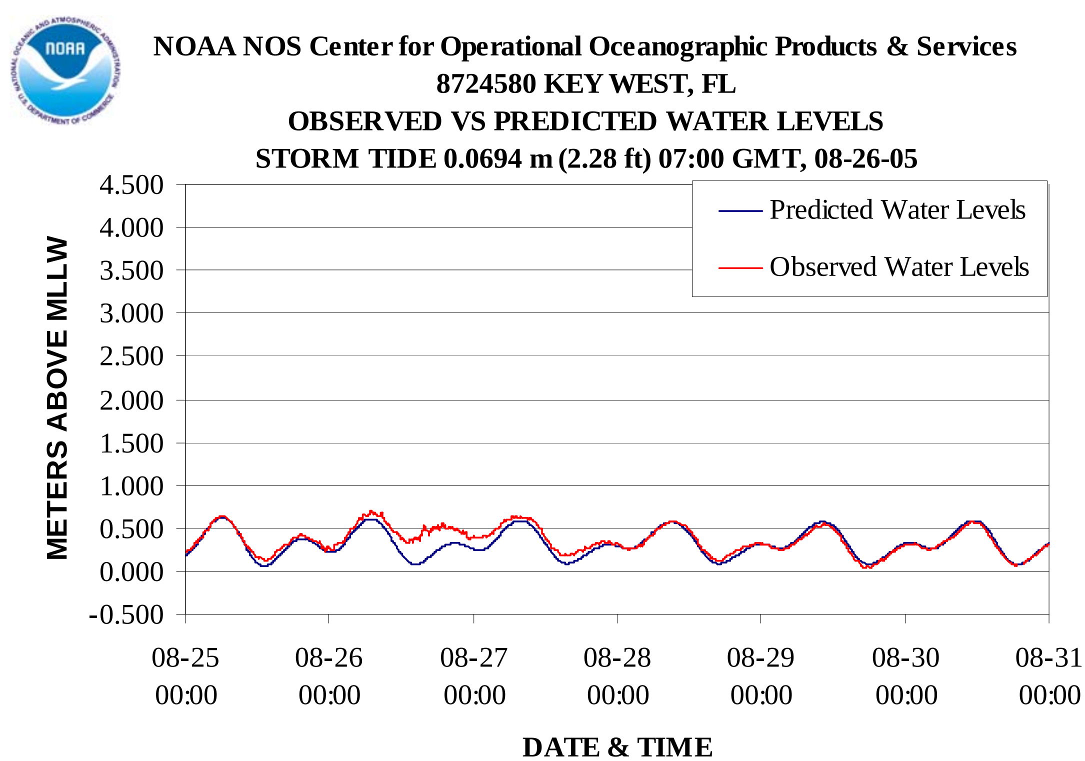

Figure 5: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Key West, FL, before, during, and after Hurricane KATRINA.

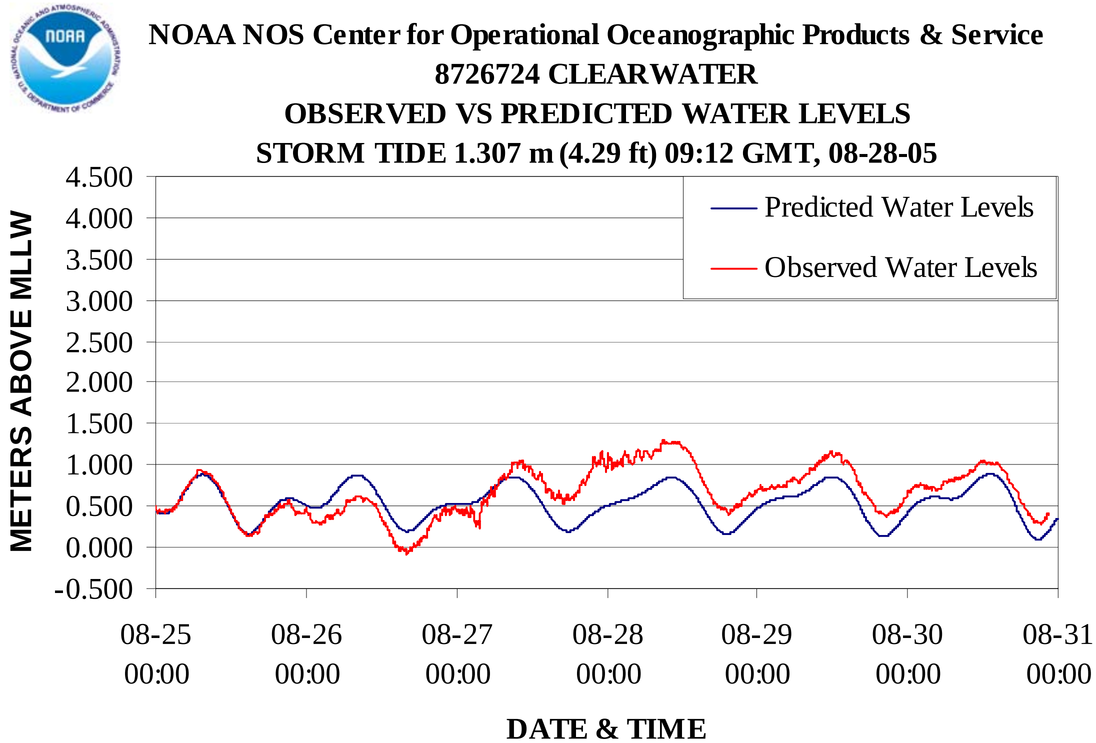

Figure 6: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Clearwater, FL, before, during, and after Hurricane KATRINA.

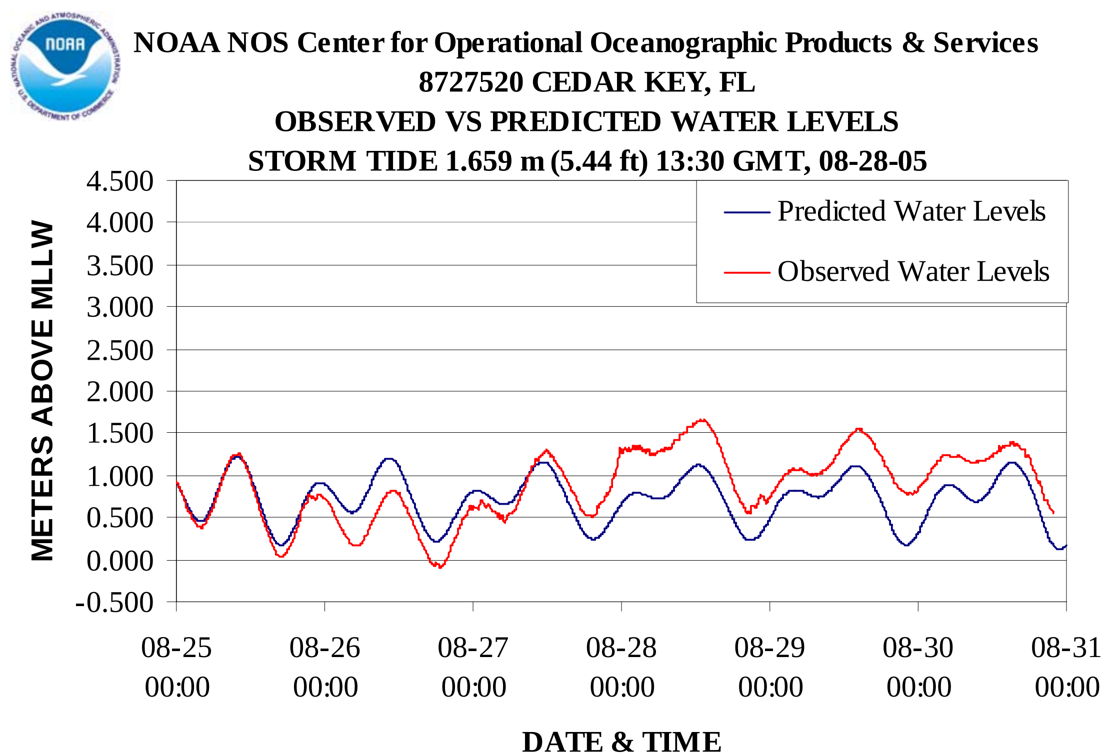

Figure 7: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Cedar Key, FL, before, during, and after Hurricane KATRINA.

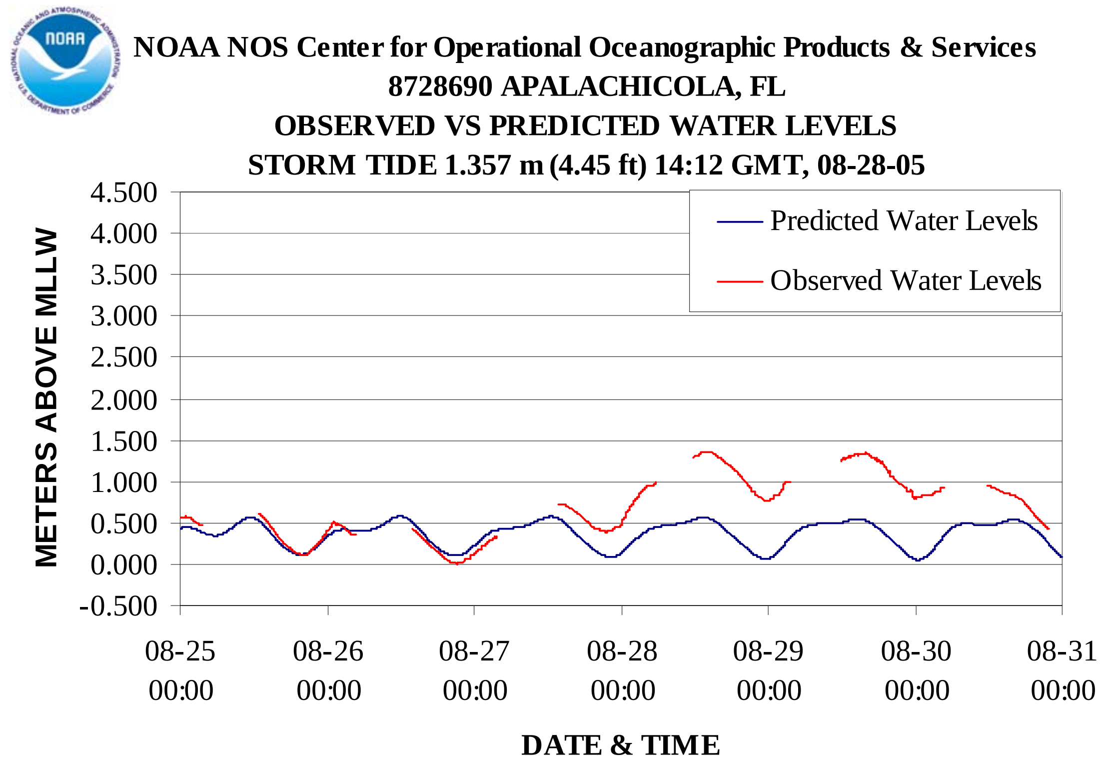

Figure 8: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Apalachicola, FL, before, during, and after Hurricane KATRINA.

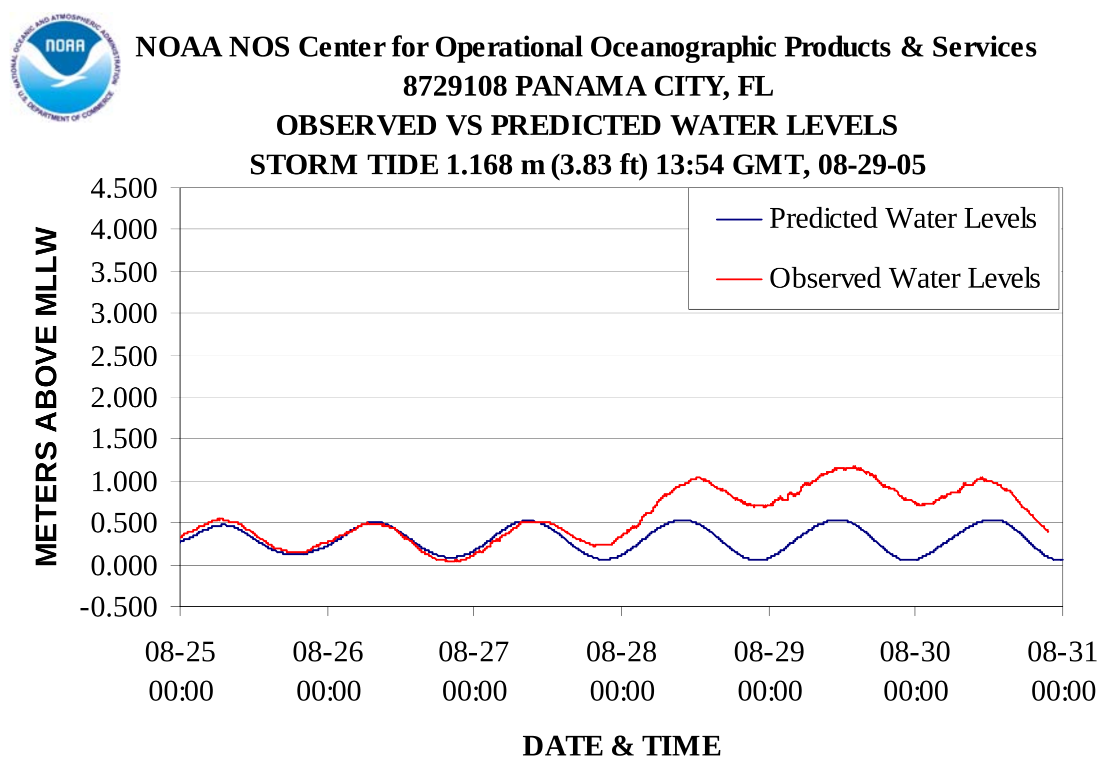

Figure 9: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Panama City, FL, before, during, and after Hurricane KATRINA.

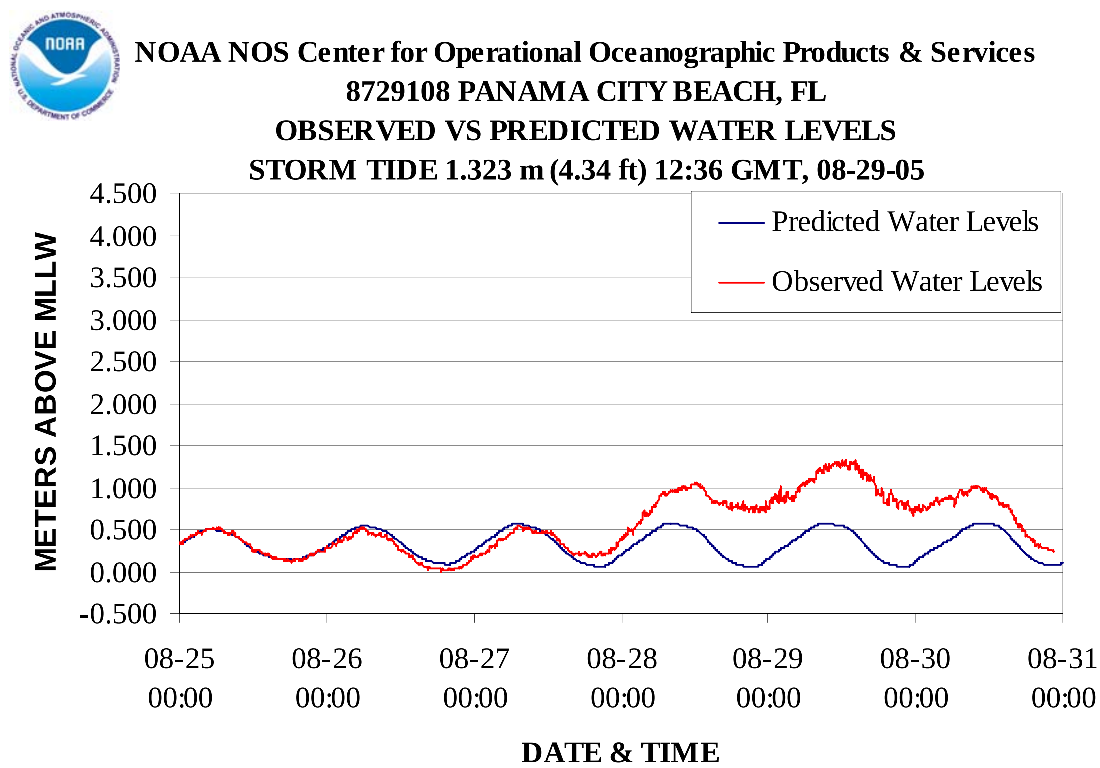

Figure 10: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Panama City Beach, FL, before, during, and after Hurricane KATRINA.

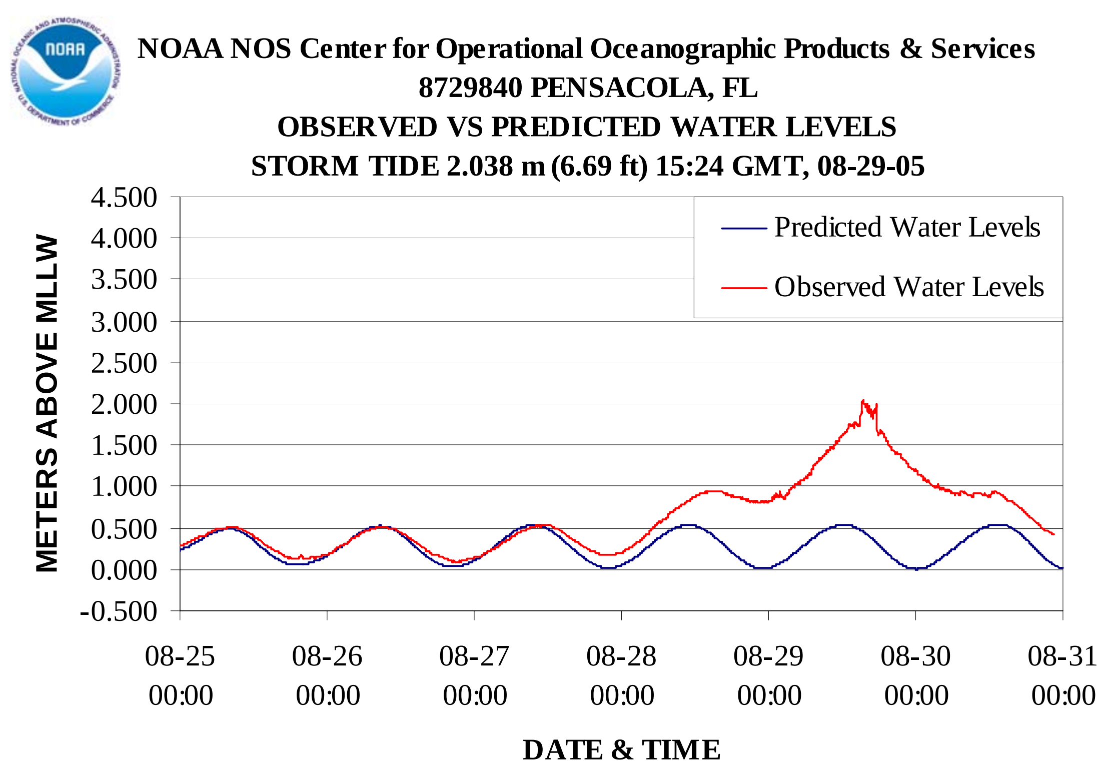

Figure 11: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Pensacola, FL, before, during, and after Hurricane KATRINA.

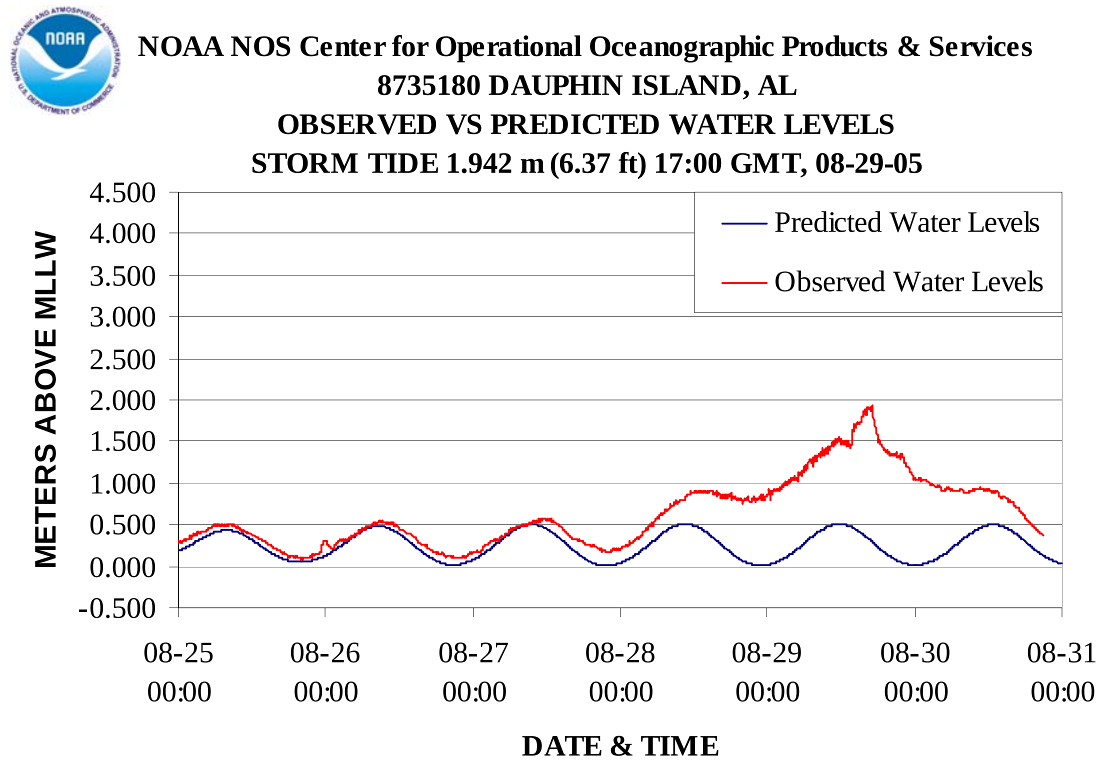

Figure 12: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Dauphin Island, AL, before, during and after Hurricane KATRINA.

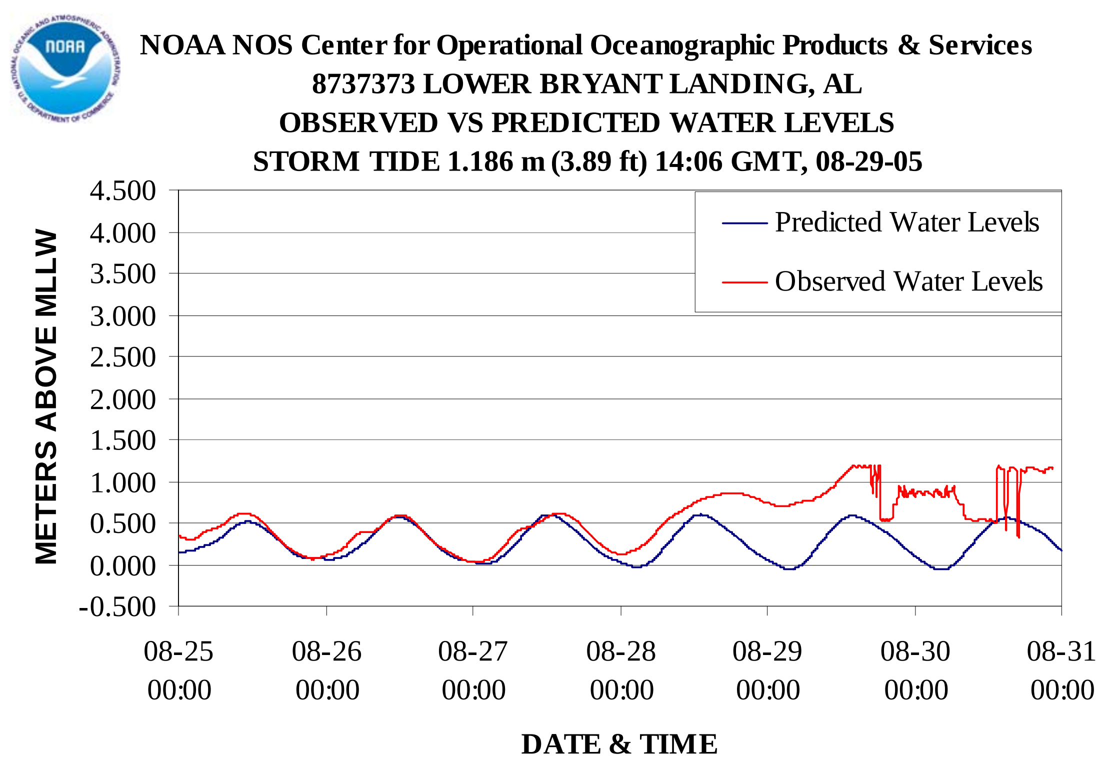

Figure 13: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Lower Bryant Landing, AL, before, during, and after Hurricane KATRINA. Sensor malfunction noted at elevated water levels.

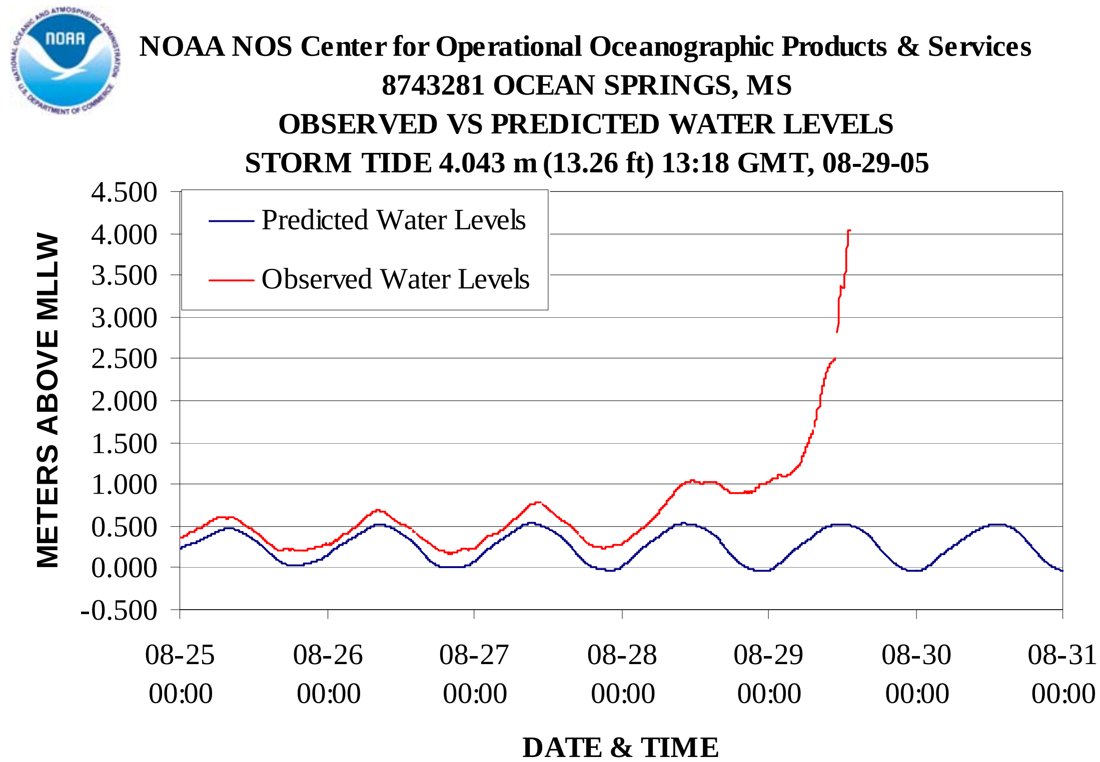

Figure 14: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Ocean Spring, MS, before, during, and after Hurricane KATRINA. Station ceased transmissions and did not record a maximum elevation.

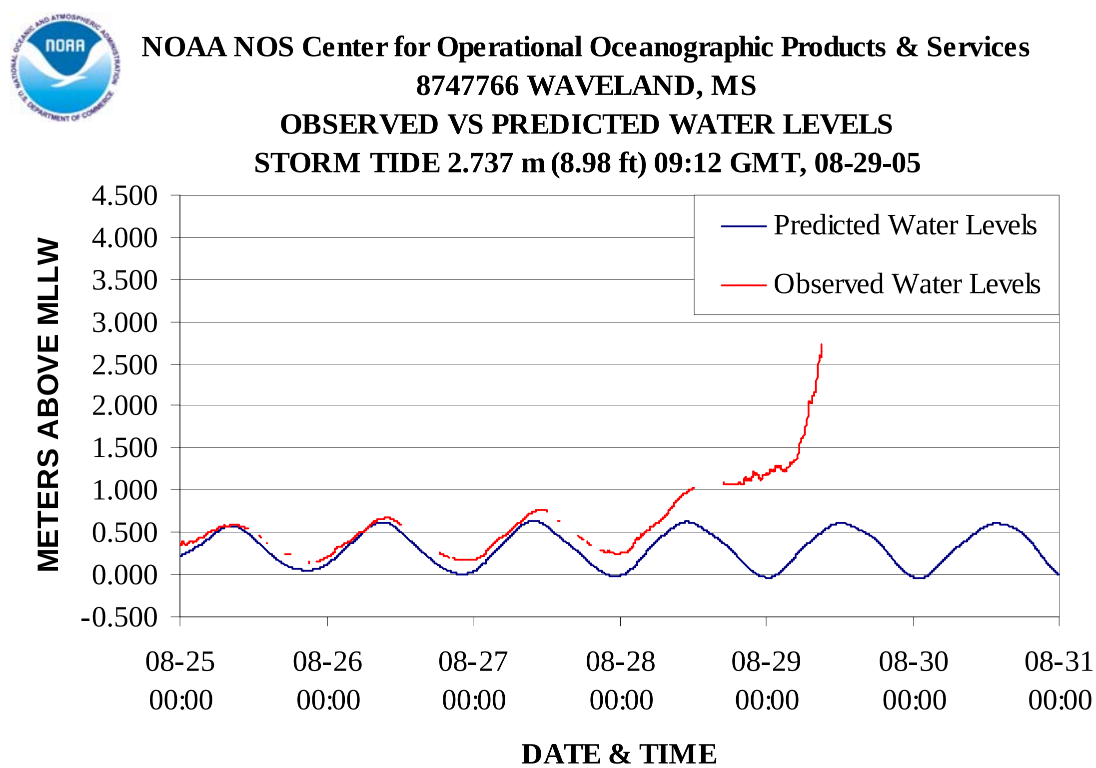

Figure 15: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Waveland, MS, before, during, and after Hurricane KATRINA. Station ceased transmissions and did not record a maximum elevation.

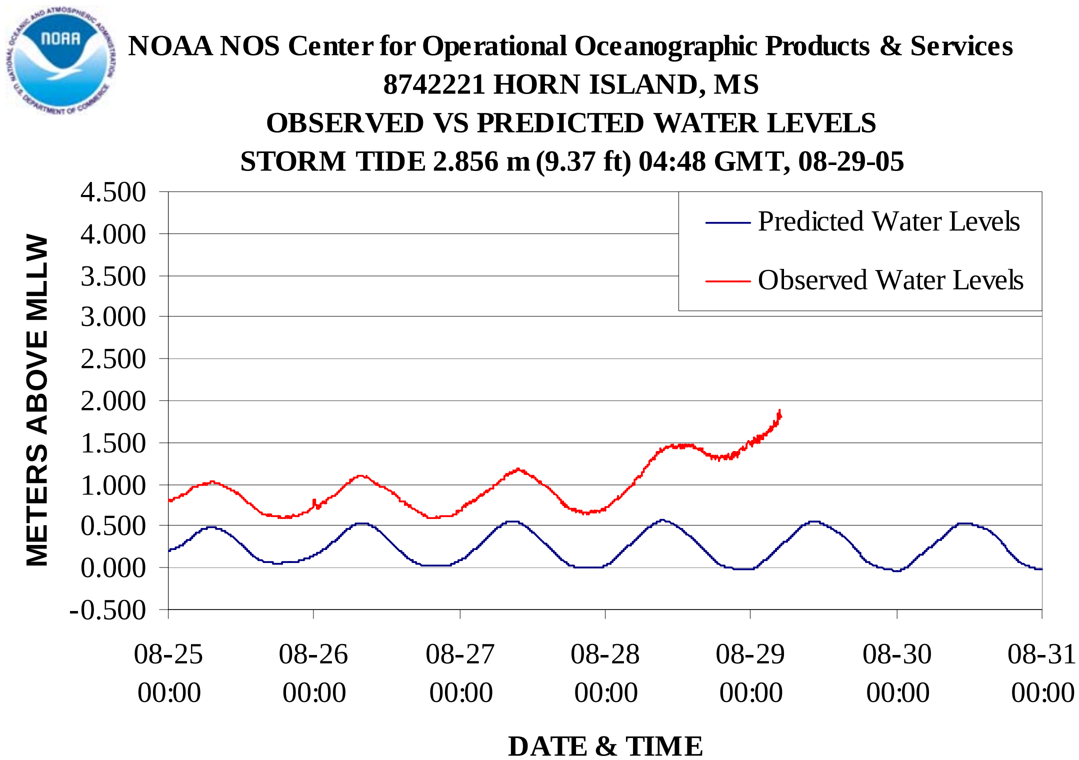

Figure 16: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Horn Island, MS, before, during, and after Hurricane KATRINA. Station ceased transmissions and did not record a maximum elevation.

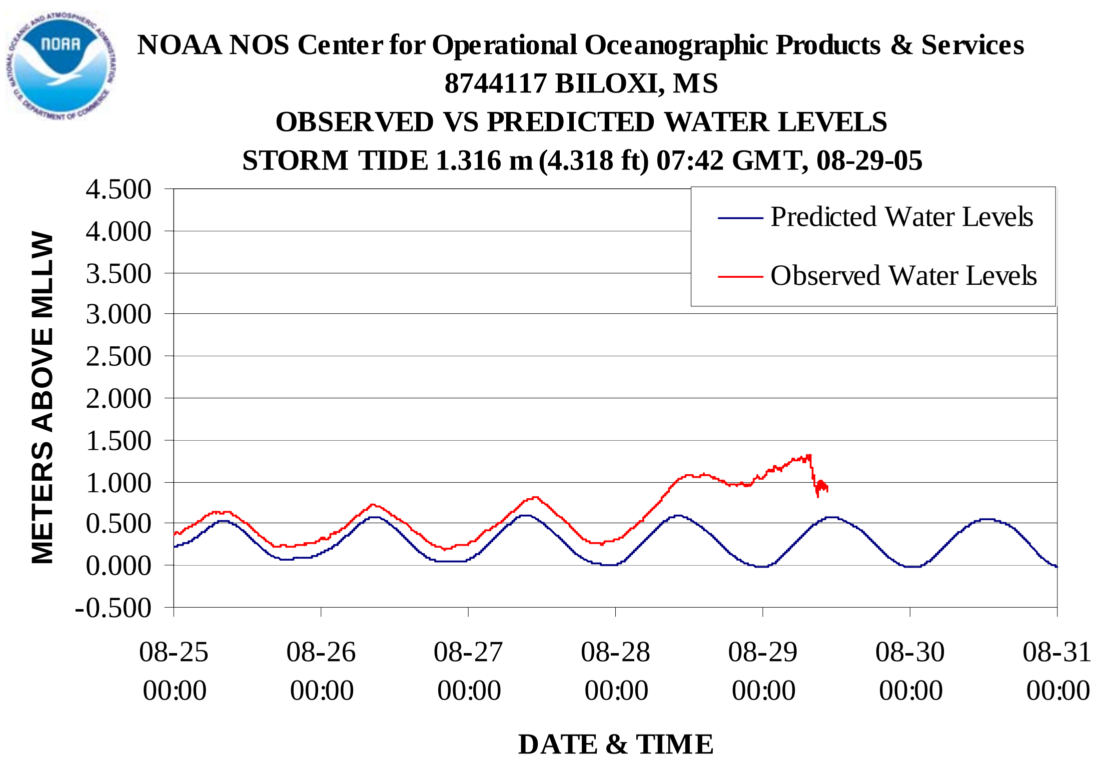

Figure 17: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Ocean Spring, MS, before, during, and after Hurricane KATRINA. Station ceased transmissions and did not record a maximum elevation.

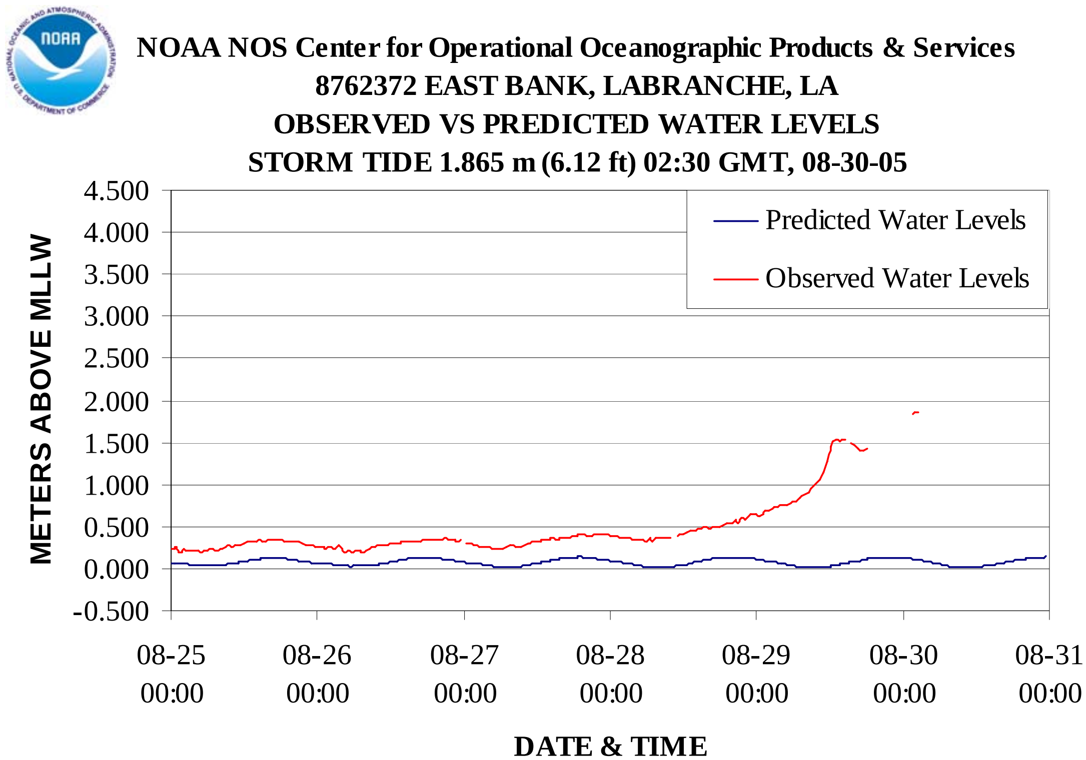

Figure 18: Time series of backup sensor data and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at East Bank, LaBranche, LA, before, during, and after Hurricane KATRINA. Station ceased transmissions and did not record a maximum elevation.

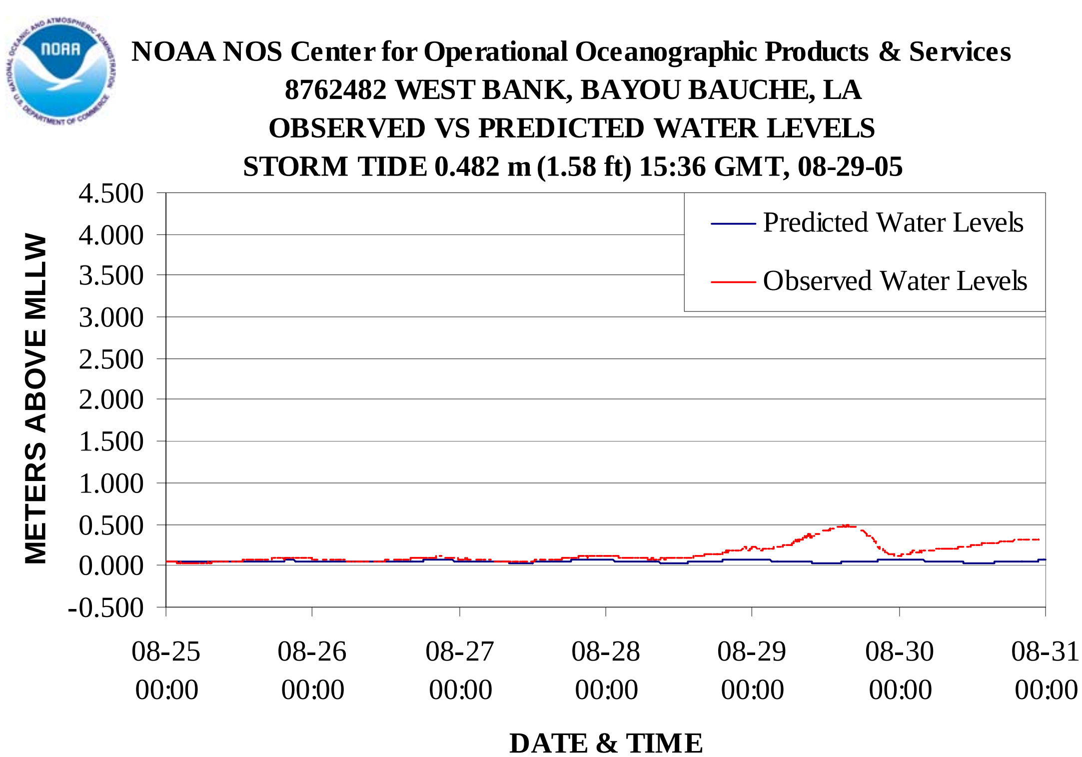

Figure 19: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at West Bank, Bayou Bauche, LA, before, during, and after Hurricane KATRINA.

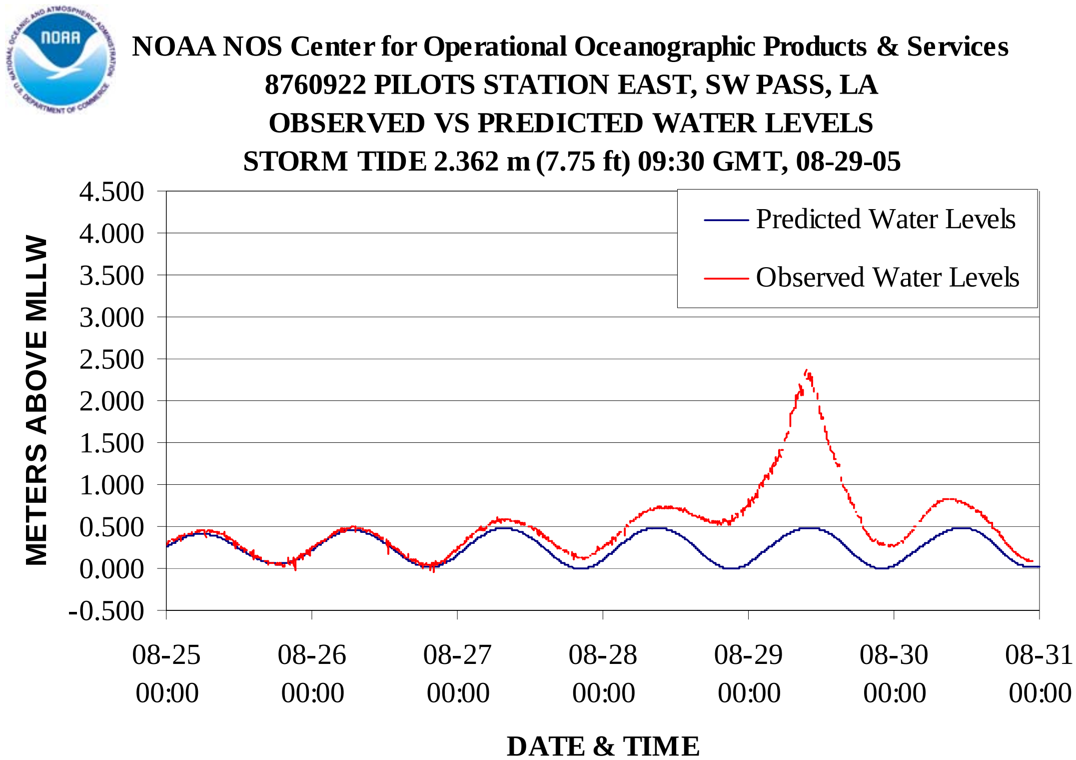

Figure 20: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at SW Pass, LA, before, during, and after Hurricane KATRINA.

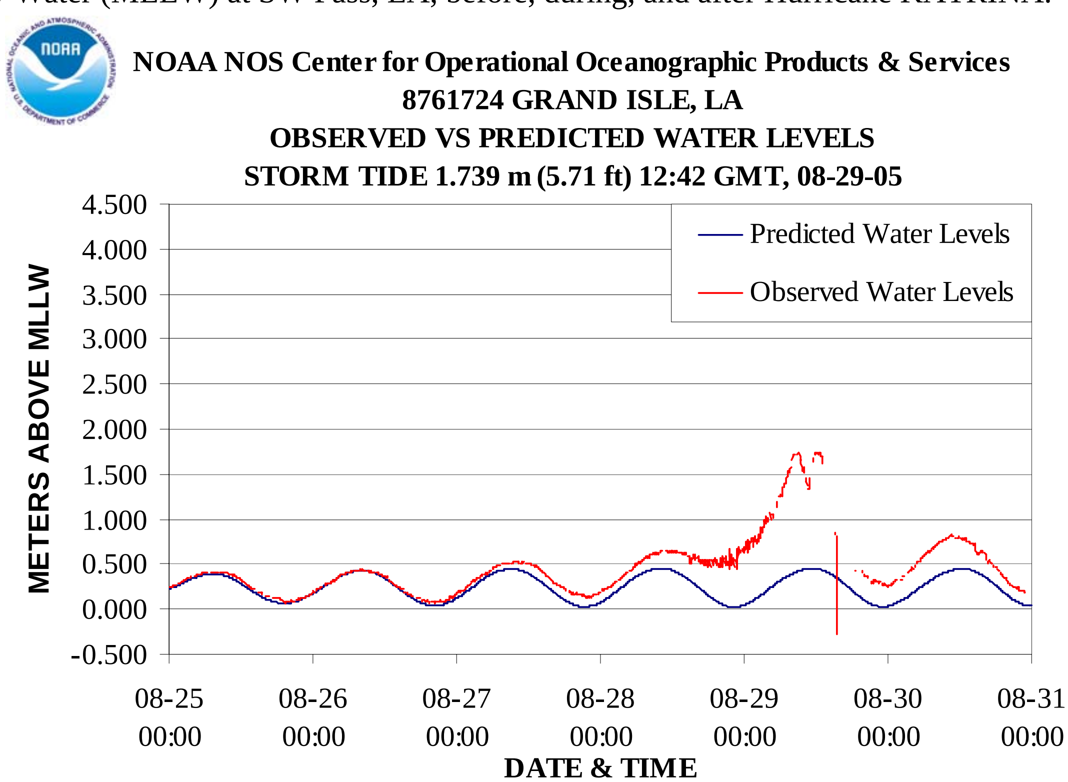

Figure 21: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Grand Isle, LA, before, during, and after Hurricane KATRINA. Sensor malfunction noted at elevated water levels.

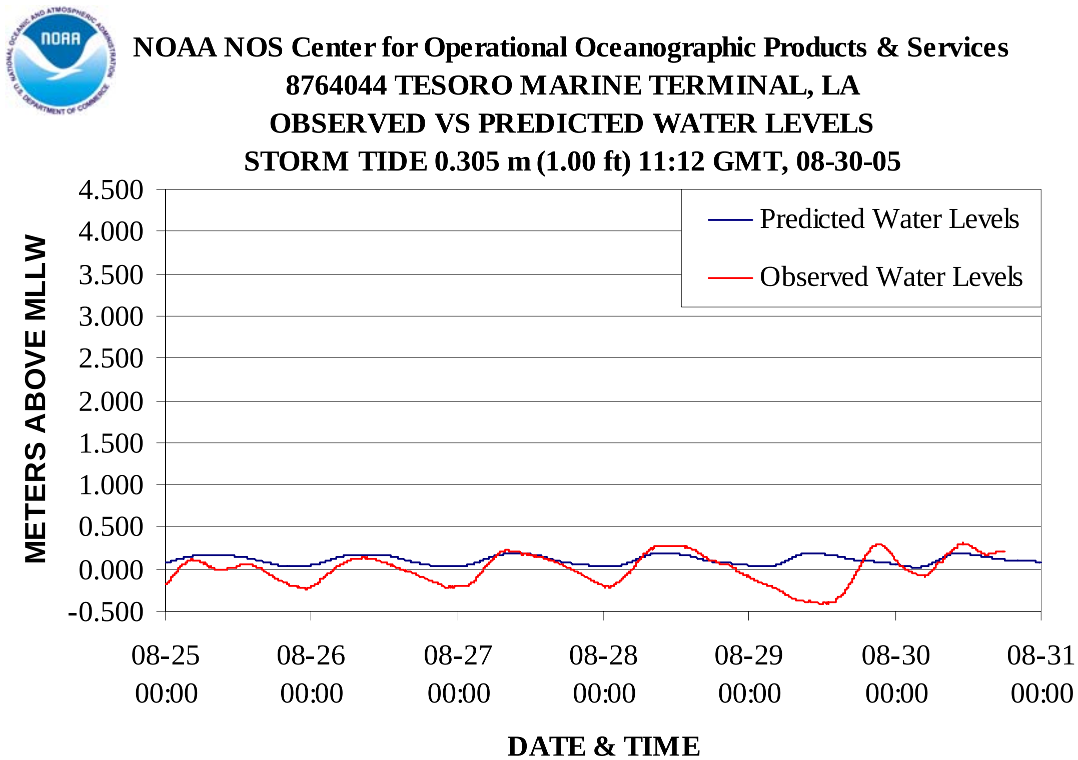

Figure 22: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Tesoro Marine Terminal, LA, before, during, and after Hurricane KATRINA.

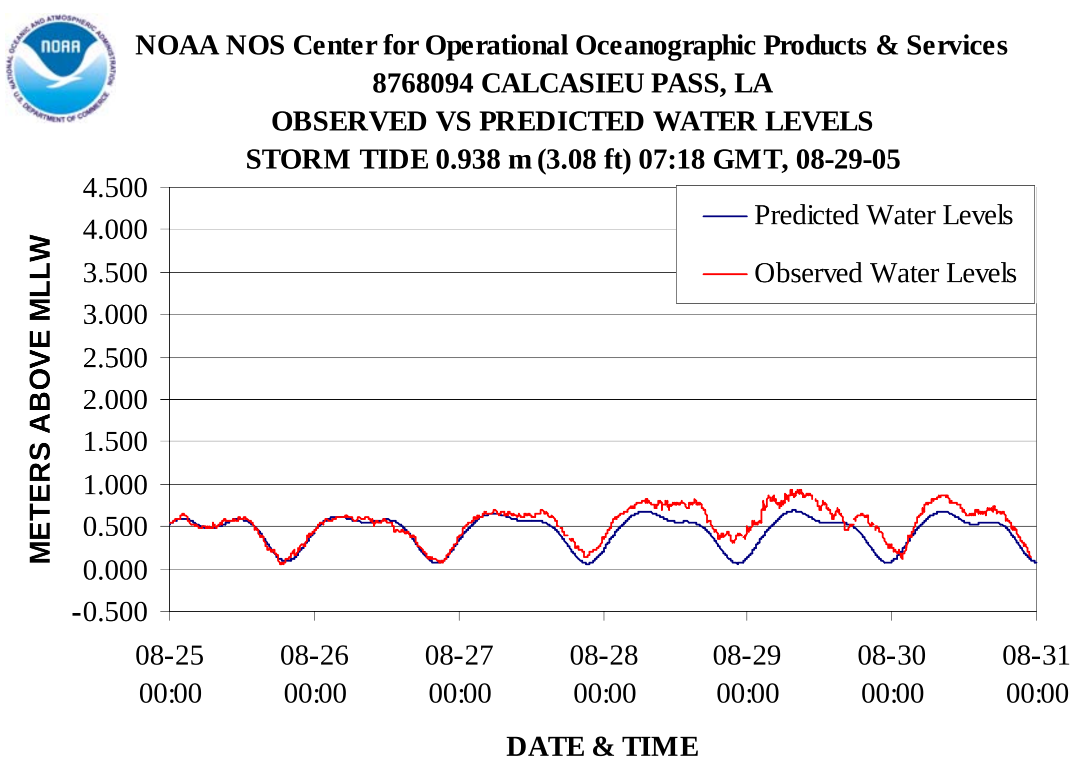

Figure 23: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Calcasieu Pass, LA, before, during, and after Hurricane KATRINA.

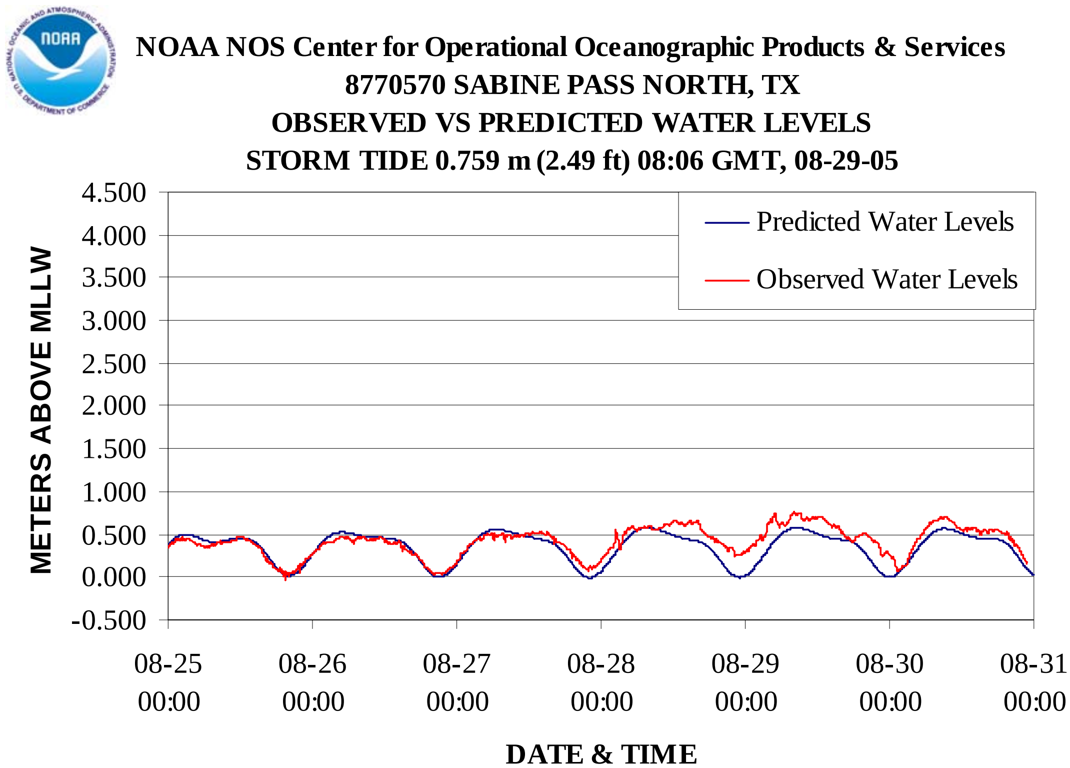

Figure 24: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Sabine Pass, North, TX, before, during, and after Hurricane KATRINA.

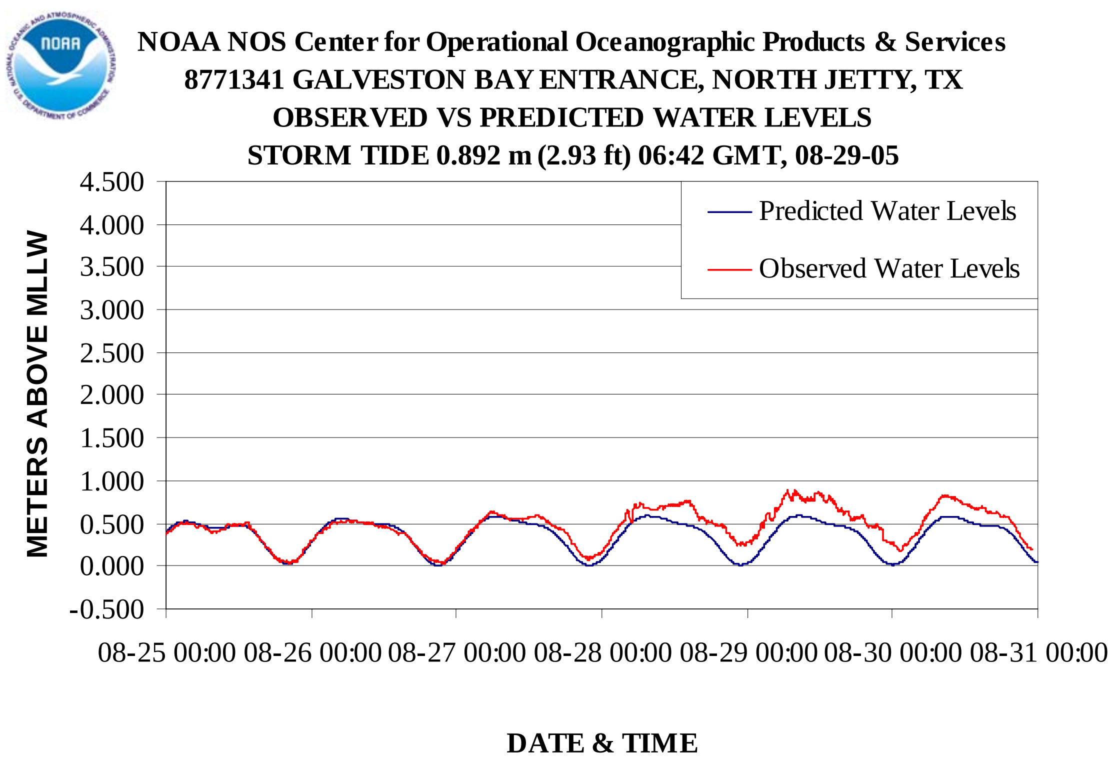

Figure 25: Time series of observed and predicted water levels above tidal datum, Mean Lower Low Water (MLLW) at Galveston Bay Entrance, TX, before, during, and after Hurricane KATRINA.

Appendix 1

Station Name	Station ID	Latitude	Longitude
Trident Pier, FL	8721604	28° 24.9' N	80° 35.6' W
Virginia Key, FL	8723214	25° 43.9' N	80° 09.7' W
Vaca Key, FL	8723970	24° 42.7' N	81° 06.3' W
Key West, FL	8724580	24° 33.2' N	81° 48.5' W
Clearwater Beach, FL	8726724	27° 58.6' N	82° 49.9' W
Cedar Key, FL	8727520	29° 08.1' N	83° 01.9' W
Apalachicola, FL	8728690	29° 43.6' N	84° 58.9' W
Panama City, FL	8729108	30° 09.1' N	85° 40.0' W
Panama City Beach, FL	8729210	30° 12.8' N	85° 52.8' W
Pensacola, FL	8729840	30° 24.2' N	87° 12.7' W
Lower Bryant Landing, AL	8737373	30° 58.7' N	87° 52.4' W
Dauphin Island , AL	8735180	30° 15.0' N	88° 04.5' W
Horn Island, MS	8742221	30° 14.3' N	88° 40.0' W
Ocean Springs, MS	8743281	30° 23.5' N	88° 47.9' W
Biloxi, MS	8744117	30° 24.7' N	88° 54.2' W
Waveland, MS	8747766	30° 16.9' N	88° 22.0' W
East Bank, LaBranche, LA	8762372	30° 03.0' N	90° 21.1' W
West Bank, Bayou Gauche, LA	8762482	29° 46.6' N	90° 25.1' W
Pilots Station, SW Pass, LA	8760922	30° 55.9' N	88° 24.4' W
Grand Isle, LA	8761724	30° 15.8' N	88° 57.4 W
Tesoro Marine Terminal, LA	8764044	29° 40.0' N	91° 14.2' W
Calcasieu, LA	8768094	29° 45.9' N	93° 20.6' W
Sabine, TX	8770570	29° 43.8' N	93° 52.2' W
Galveston Bay Entrance, TX	8771341	29° 21.5' N	94° 43.5' W

Appendix 2

Excerpt From:

Tide and Current Glossary, NOAA National Ocean Service, Silver Spring, MD, 2000.

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. Although the accompanying horizontal movement of the water is part of the same phenomenon, it is preferable to designate this motion as tidal current. Same as astronomic tide.

tide (water level) gauge: An instrument for measuring the rise and fall of the tide (water level).

storm tide: As used by the National Weather Service, NOAA, the sum of the storm surge and astronomic tide. See storm surge and tide.

storm surge: The local change in the elevation of the ocean along a shore due to a storm. The storm surge is measured by subtracting the astronomic tidal elevation from the total elevation. It typically has a duration of a few hours. 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 astronomic tide. It is potentially catastrophic, especially on low lying coasts with gently sloping offshore topography. See storm tide.

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.

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.

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_o. 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. See datum and National Tidal Datum Convention of 1980.

geodetic datum: See National Geodetic Vertical Datum of 1929 (NGVD 1929) and North American Vertical Datum of 1988 (NAVD 1988).

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.

National Tidal Datum Epoch: The specific l9-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 1960 through 1978. It is reviewed annually for possible revision and must be actively considered for revision every 25 years.

National Tidal Datum Convention of 1980: Effective November 28, 1980, the Convention: (1) establishes one uniform, continuous tidal datum system for all marine waters of the United States, its territories, Commonwealth of Puerto Rico, and Trust Territory of the Pacific Islands, for the first time in history; (2) provides a tidal datum system independent of computations based on type of tide; (3) lowers chart datum from mean low water to mean lower low water along the Atlantic coast of the United States; (4) updates the National Tidal Datum Epoch from 1941 through 1959, to 1960 through 1978; (5) changes the name Gulf Coast Low Water Datum to mean lower low water; (6) introduces the tidal datum of mean higher high water in areas of predominantly diurnal tides; and (7) lowers mean high water in areas of predominantly diurnal tides. See chart datum.

National Geodetic Vertical Datum of 1929 [NGVD 1929]: A fixed reference adopted as a standard geodetic datum for elevations determined by leveling. The datum was derived for surveys from a general adjustment of the first-order leveling nets of both the United States and Canada. In the adjustment, mean sea level was held fixed as observed at 21 tide stations in the United States and 5 in Canada. The year indicates the time of the general adjustment. A synonym for Sea-level Datum of 1929. The geodetic datum is fixed and does not take into account the changing stands of sea level. Because there are many variables affecting sea level, and because the geodetic datum represents a best fit over a broad area, the relationship between the geodetic datum and local mean sea level is not consistent from one location to another in either time or space. For this reason, the National Geodetic Vertical Datum should not be confused with mean sea level. See North American Vertical Datum of 1988 (NAVD 1988).

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. See International Great Lakes Datum of 1985, National Geodetic Vertical Datum of 1929, and geopotential difference.

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.

For further information on tides, tidal predictions, tidal datums and related publications, contact:

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