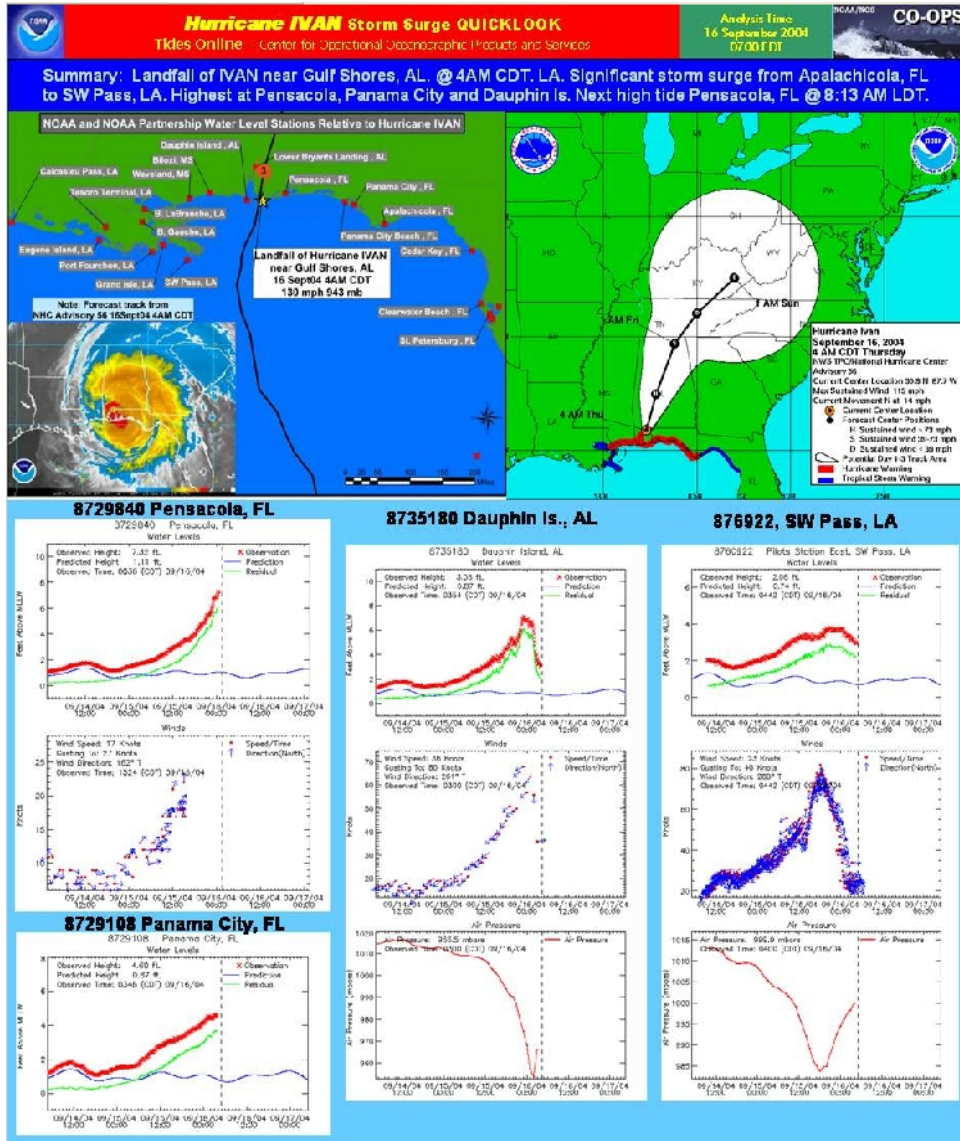


Hurricane IVAN

Preliminary Water Levels Report



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

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE

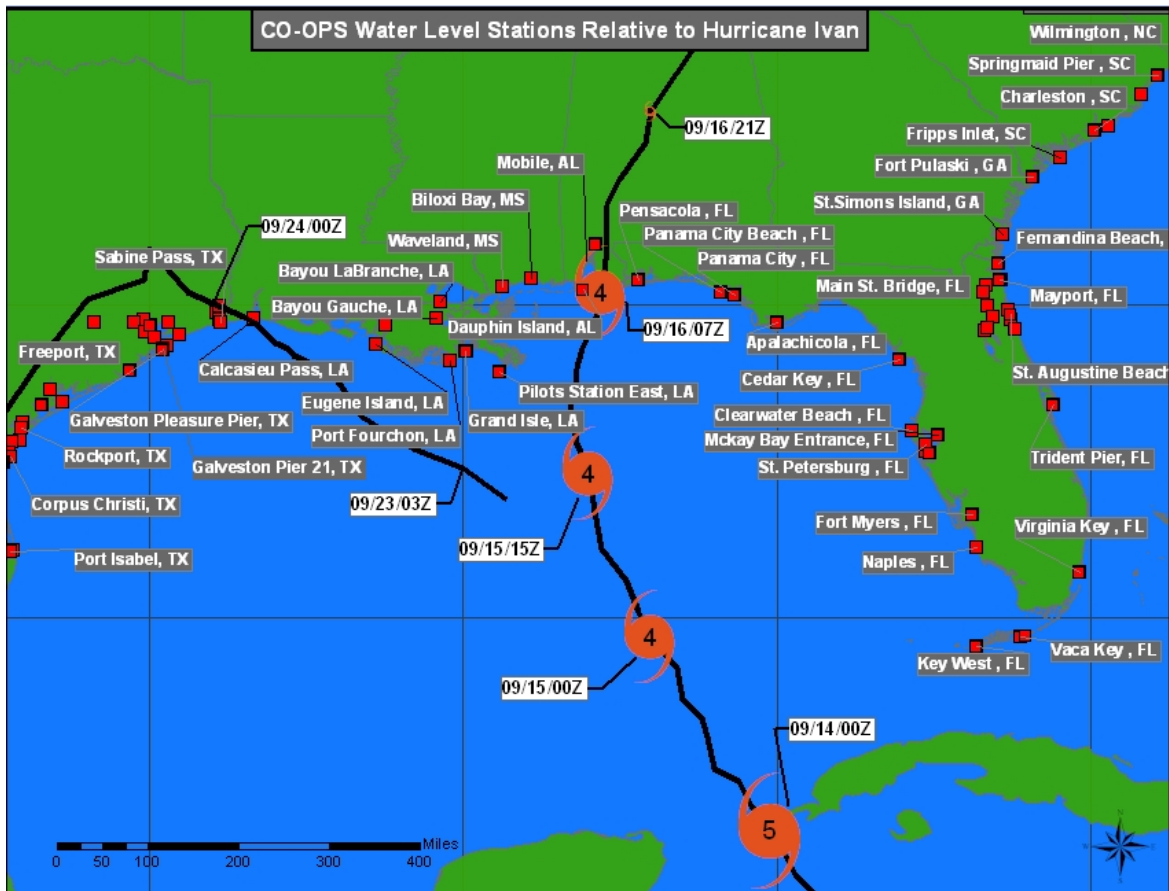
National Ocean Service

Center for Operational Oceanographic Products and Services

CO-OPS Water Level Data for Hurricane IVAN

NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) maintains a network of water level gauges along the Atlantic coast and in the Gulf of Mexico. During the hurricane season (June through November) CO-OPS personnel actively maintain and monitor these gauges during storm events. Data from these stations can be triggered for real-time monitoring in storm surge mode and accessed at Tides Online (www.tidesonline.nos.noaa.gov) or by accessing water level observations on the CO-OPS homepage at <http://www.co-ops.nos.noaa.gov>. There are approximately 86 water level stations from Wilmington, NC to Port Isabel, TX that are operated by CO-OPS and through a NOAA partnership with the Florida Department of Environmental Protection (FDEP), Bureau of Mapping and Surveying (www.dep.state.fl.us/lands/surv_map).

CO-OPS personnel actively maintained and monitored water level stations which provided valuable data from 30 water level stations during the 2004 passing of Hurricane IVAN. Hurricane IVAN made landfall as a 105 kt, Category 3 hurricane at approximately 0650 UTC 16 September near Gulf Shores, AL. After traveling north through Alabama and on into the midatlantic region remnants of IVAN turned south crossed back over Florida as an extra tropical low reentered the Gulf and made landfall as a tropical depression near Cameron, LA around 0200 UTC 24 September. IVAN impacted stations from Vaca Key on Florida's southern east coast to Port Isabel in southern Texas.



MAXIMUM OBSERVED WATER LEVELS

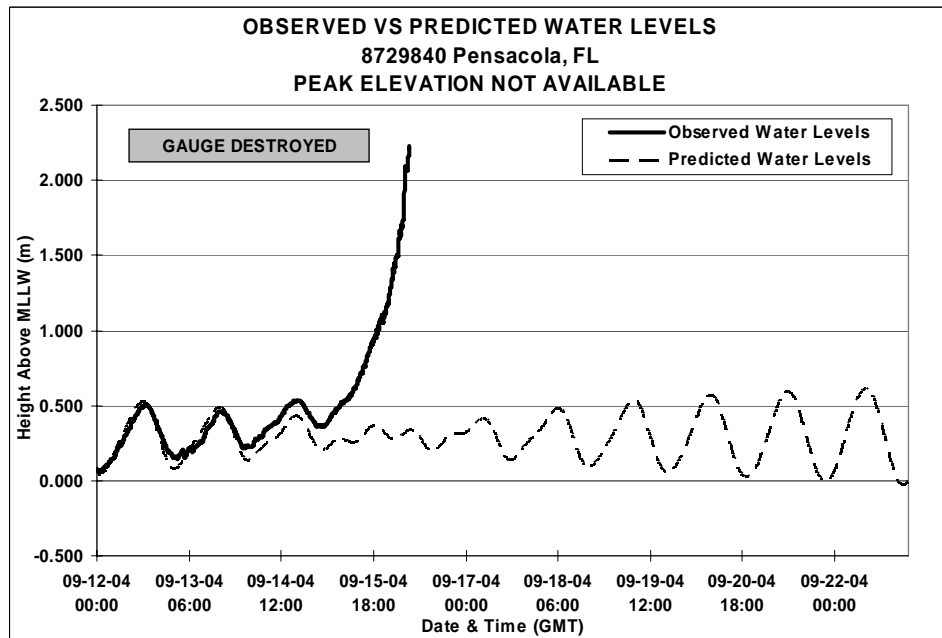
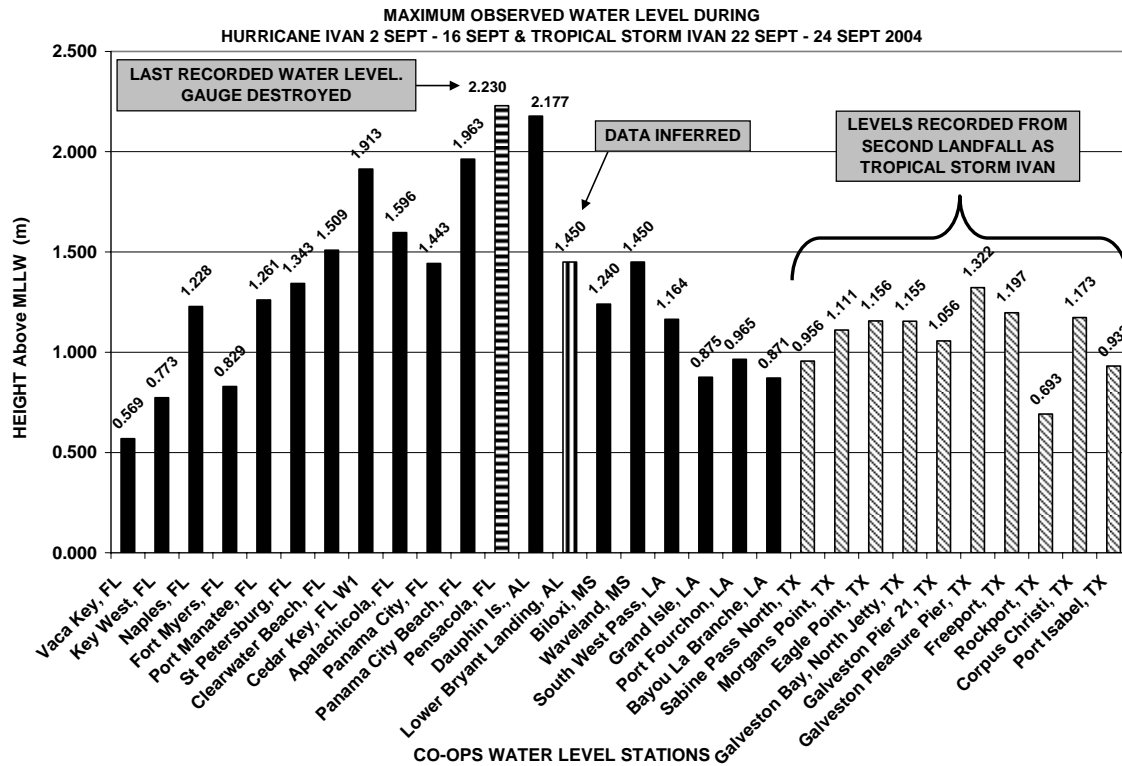
Hurricane IVAN which made initial landfall as a Category 3 hurricane on 16 September near Gulf Shores, AL was the strongest storm of the season reaching Category 5 strength after it passed over Grenada in the Caribbean. The highest maximum observed water level recorded was at Pensacola, FL (2.230 m) though this gauge was destroyed by the storm and an exact water level cannot be recovered. The next three highest observed water levels were at Dauphin Island (2.177 m), Panama City Beach (1.963 m), and Cedar Key (1.913 m) (Table 1). Water levels at Apalachicola and Panama City were slightly less at 1.596 m and 1.443 m respectively. The remainder of the stations to the east and west of landfall recorded water levels of approximately 0.800 m to 1.400 m. IVAN reformed into a tropical depression on 22 September in the Gulf of Mexico after travelling in a circular motion through the southeastern United States and made landfall near Cameron, LA. The highest observed water level during this event was recorded at Galveston Pleasure Pier (1.322 m). Freeport and Corpus Christi, TX recorded the second and third highest with 1.197 m and 1.173 m respectively.

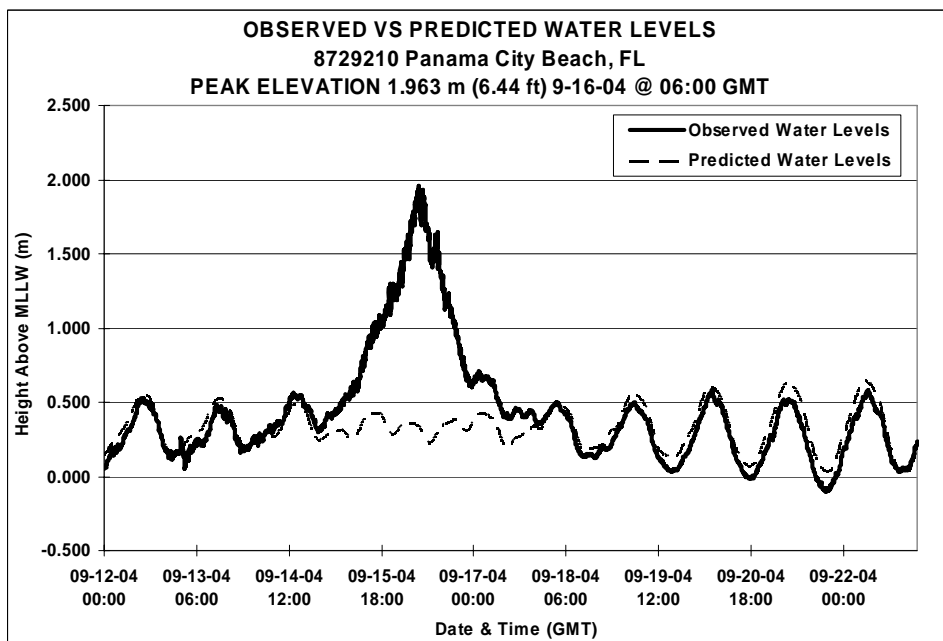
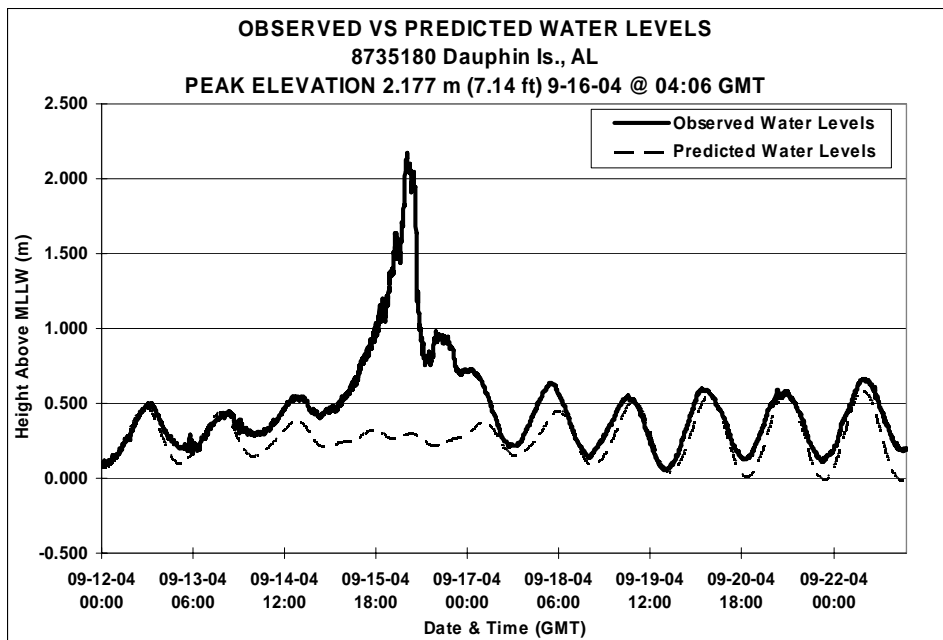
Table 1. Maximum observed water levels during hurricane IVAN.

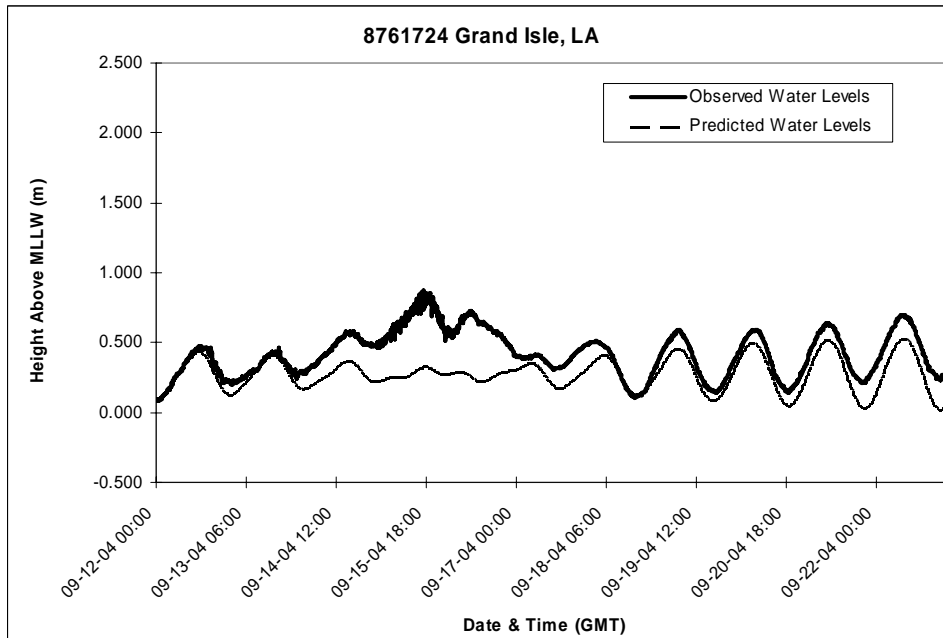
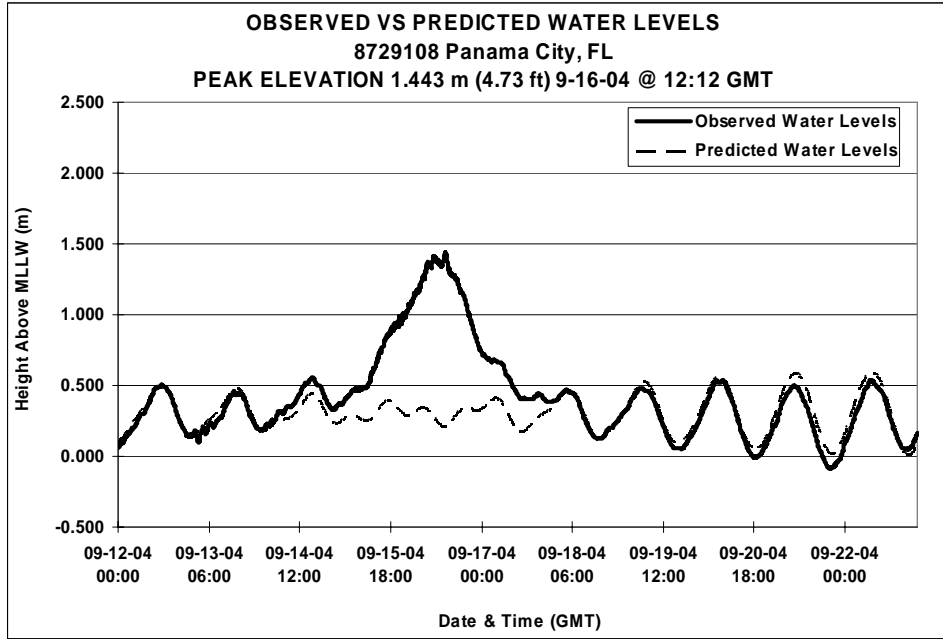
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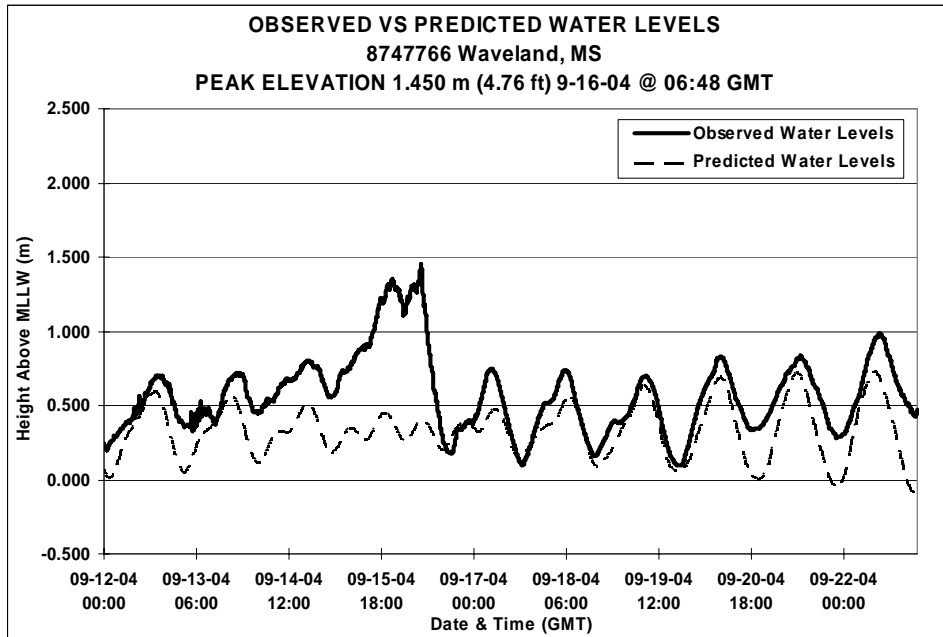
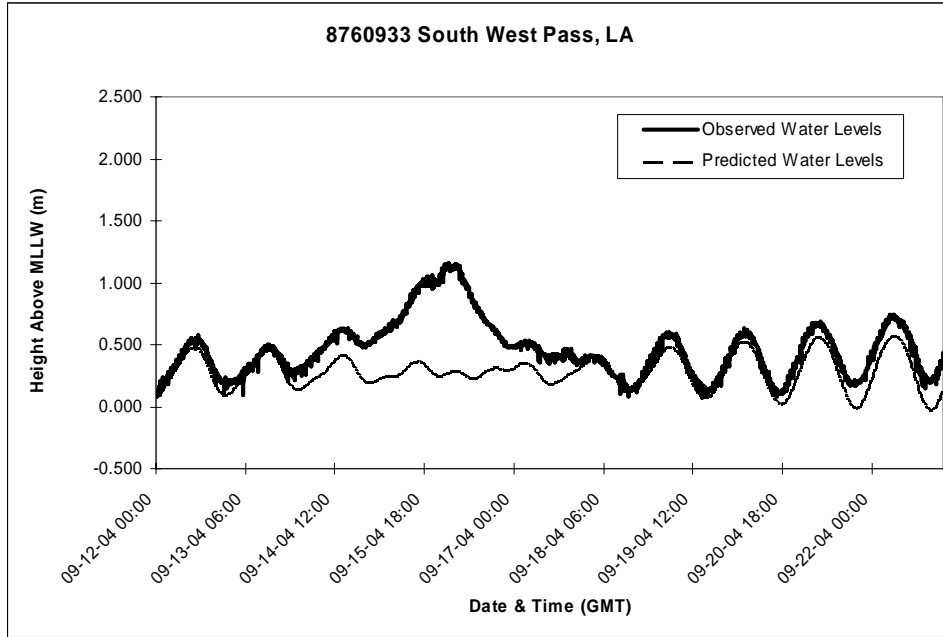
Maximum Observed Water Levels Referred to MLLW, NAVD 88 and NGVD29					
Station ID	Station Name	Date-Time	Maximum Observed Water Level Above MLLW (m)	Maximum Observed Water Level Above NAVD 88 (m)	Maximum Observed Water Level Above NGVD 29 (m)
8723970	Vaca Key, FL	09-22-04 10:06	0.569	0.162	0.589
8724580	Key West, FL	09-14-04 14:24	0.773	0.235	0.644
8725110	Naples, FL	09-15-04 17:18	1.228	0.532	0.955
8725520	Fort Myers, FL	09-15-04 20:42	0.829	0.511	0.869
8726384	Port Manatee, FL	09-15-04 18:42	1.261	-0.147	0.122
8726520	St Petersburg, FL	09-15-04 19:00	1.343	2.371	2.371
8726724	Clearwater Beach, FL	09-15-04 17:54	1.509	0.964	1.227
8727520	Cedar Key, FL W1	09-15-04 19:42	1.913	1.226	1.437
8728690	Apalachicola, FL	09-16-04 06:54	1.596	1.364	1.537
8729108	Panama City, FL	09-16-04 12:12	1.443	1.273	1.417
8729210	Panama City Beach, FL	09-16-04 06:00	1.963	N/A	N/A
8729840	*Pensacola, FL	09-16-04 05:36	*2.230	2.132	N/A
8735180	Dauphin Is., AL	09-16-04 04:06	2.177	2.107	2.066
8737373	**Lower Bryant Landing, AL	09-16-04 19:18	**1.450	1.450	1.450
8744117	Biloxi, MS	09-16-04 03:30	1.240	1.240	1.240
8747766	Waveland, MS	09-16-04 06:48	1.450	1.384	1.339
8760922	South West Pass, LA	09-16-04 02:00	1.164	1.164	1.164
8761724	Grand Isle, LA	09-15-04 17:06	0.875	1.041	0.948
8762075	Port Fourchon, LA	09-16-04 06:54	0.965	N/A	N/A
8762372	Bayou La Branche, LA	09-16-04 04:24	0.871	N/A	N/A
8770570	Sabine Pass North, TX	09-22-04 05:54	0.956	N/A	N/A
8770613	Morgans Point, TX	09-22-04 14:00	1.111	N/A	1.106
8771013	Eagle Point, TX	09-22-04 14:00	1.156	N/A	N/A
8771341	Galveston Bay, North Jetty, TX	09-22-04 09:42	1.155	N/A	N/A
8771450	Galveston Pier 21, TX	09-22-04 11:54	1.056	1.013	1.010
8771510	Galveston Pleasure Pier, TX	09-22-04 09:18	1.322	1.136	1.184
8772440	Freeport, TX	09-22-04 09:42	1.197	N/A	N/A
8774770	Rockport, TX	09-23-04 13:54	0.693	0.864	N/A
8775870	Corpus Christi, TX	09-23-04 06:24	1.173	1.037	0.691
8779770	Port Isabel, TX	09-23-04 08:30	0.932	0.672	N/A

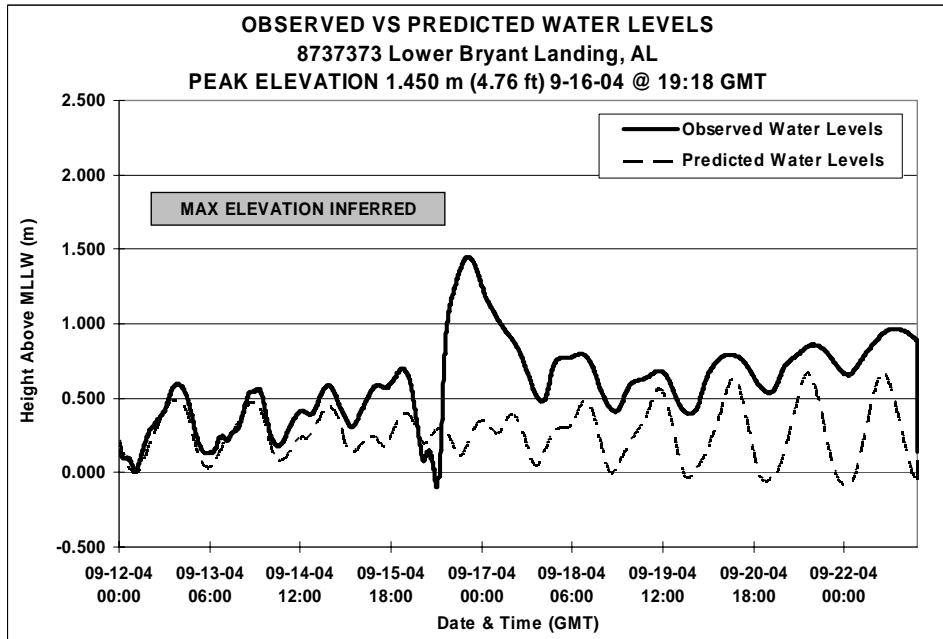
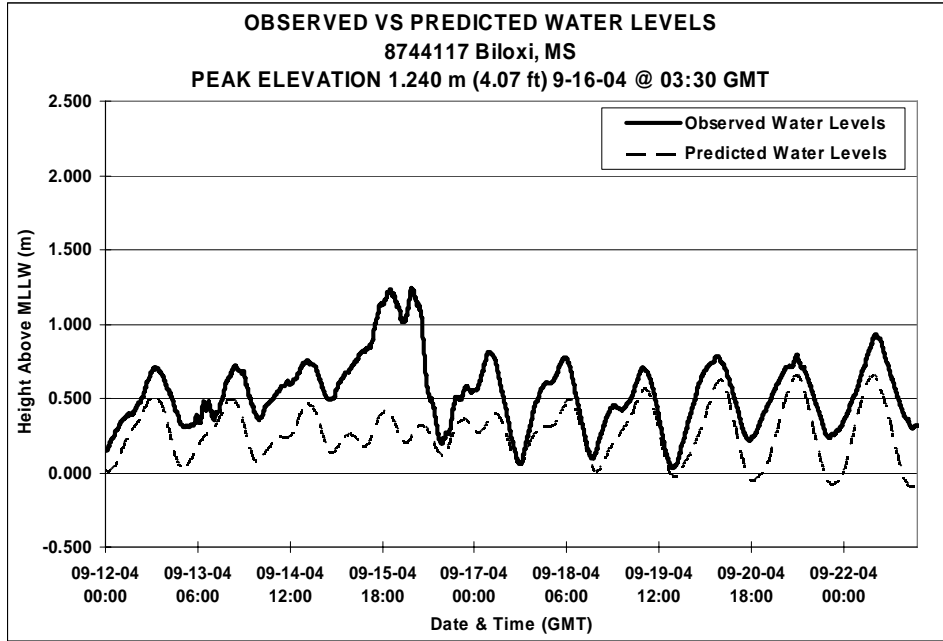
* Gauge destroyed **Data Inferred

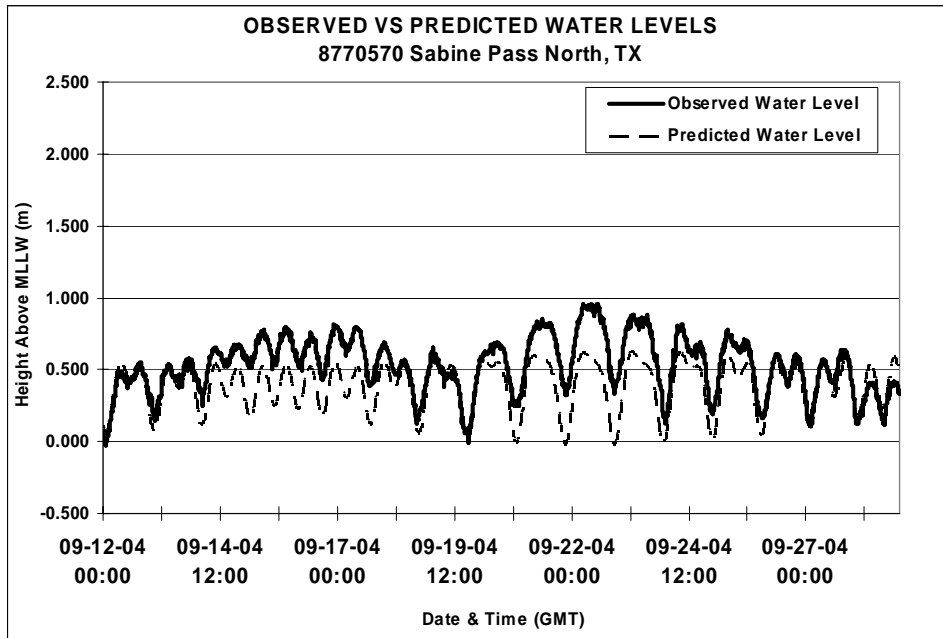
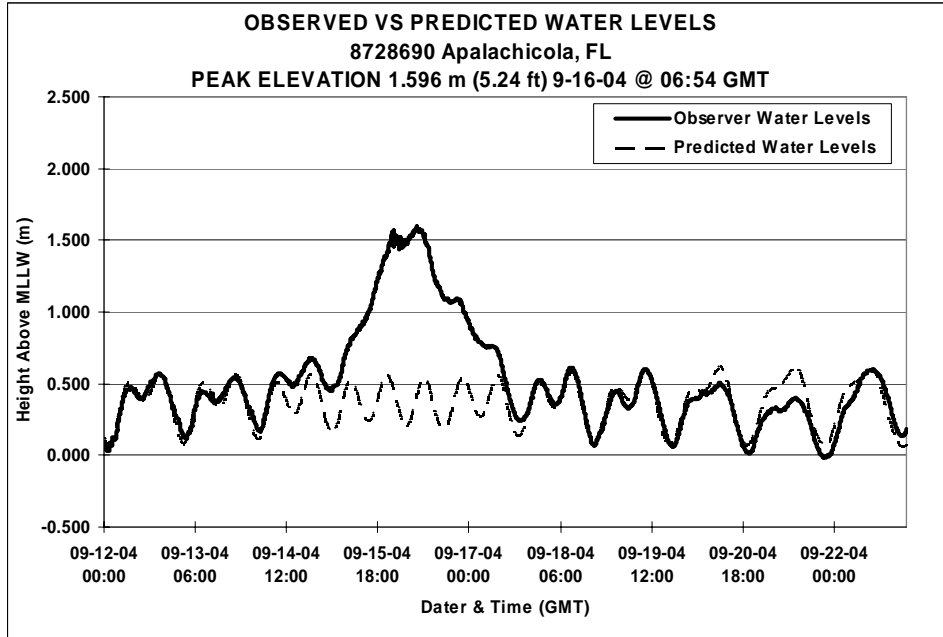


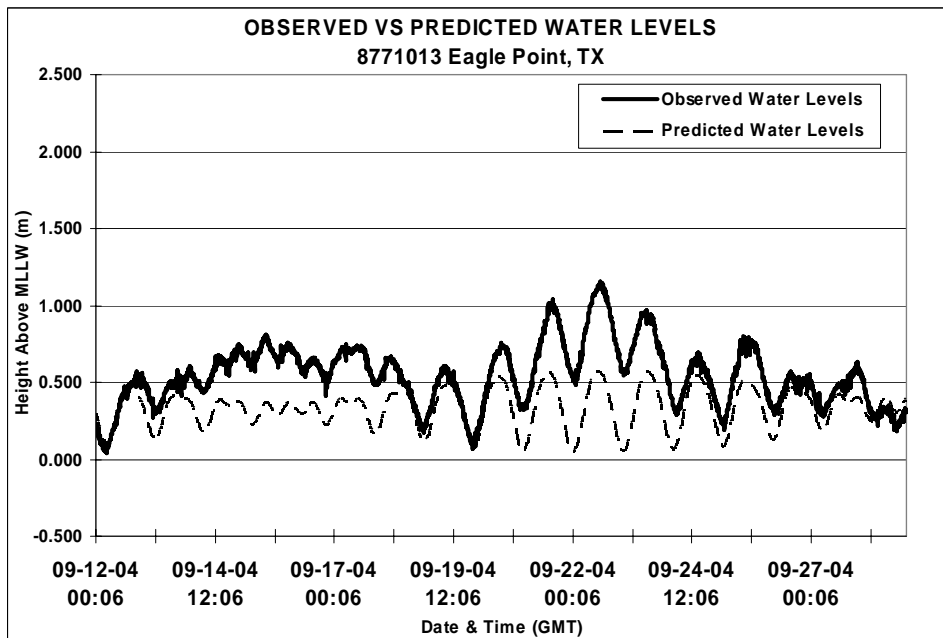
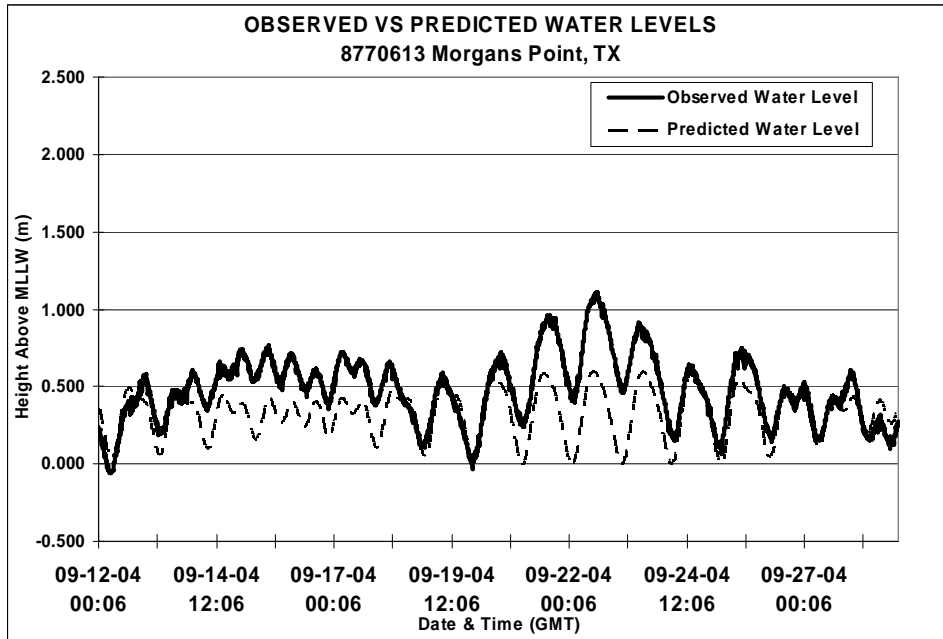


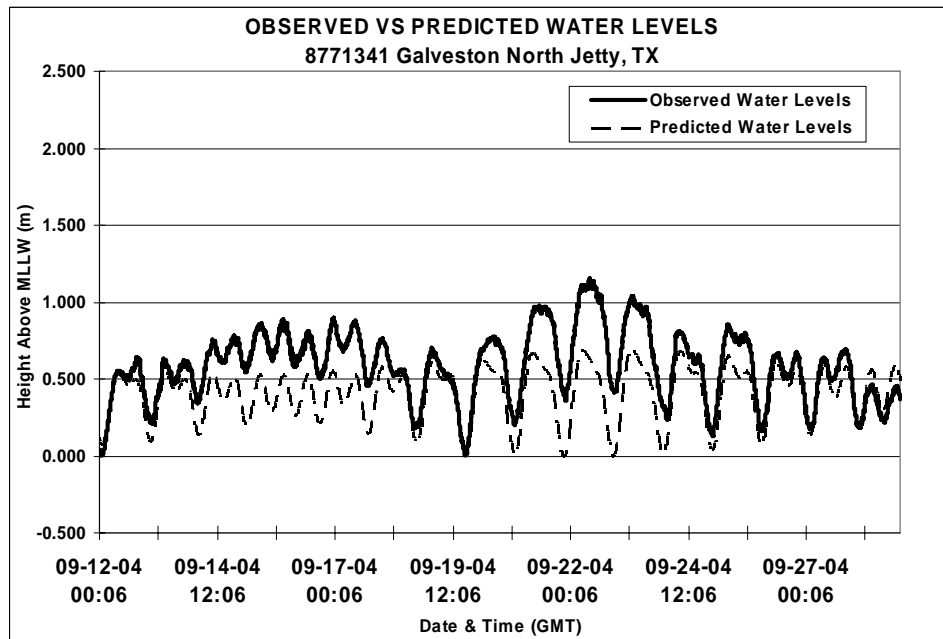












STORM SURGE

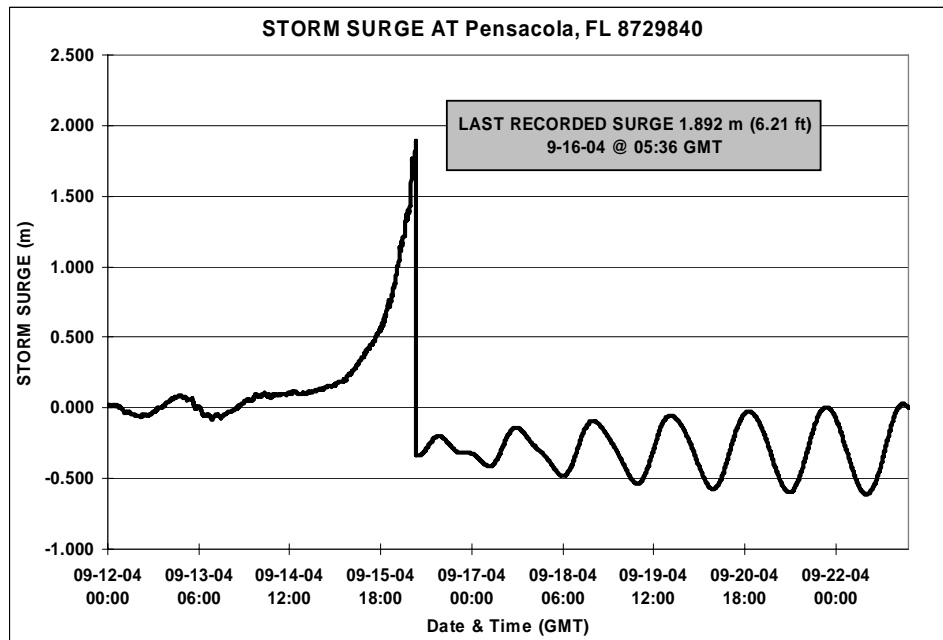
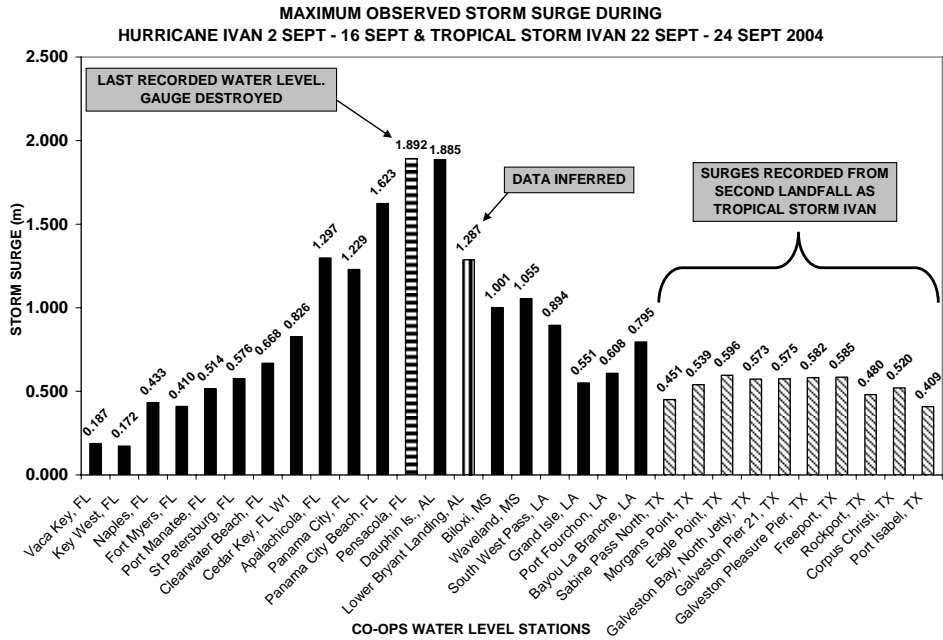
Storm surge resulting from hurricane IVAN was greatest at Pensacola (1.892 m) though as stated above this value is only a partial record (Table 2). Fifteen miles to the west Dauphin Island recorded a surge of 1.885 m (Figure 8). Stations in the region to the west of the storms track such as Biloxi, MS, Waveland, MS and South West Pass, LA recorded storm surges of 1.001 m, 1.055 m, and 0.894 m, respectively. To the east Panama City Beach recorded a surge of 1.623 m, and Panama City recorded a surge of 1.229 m. During IVAN's second landfall Eagle Point, TX recorded the highest surge at 0.596 m. The rest of the stations along the Texas coastline recorded similar levels that averaged approximate 0.5 m.

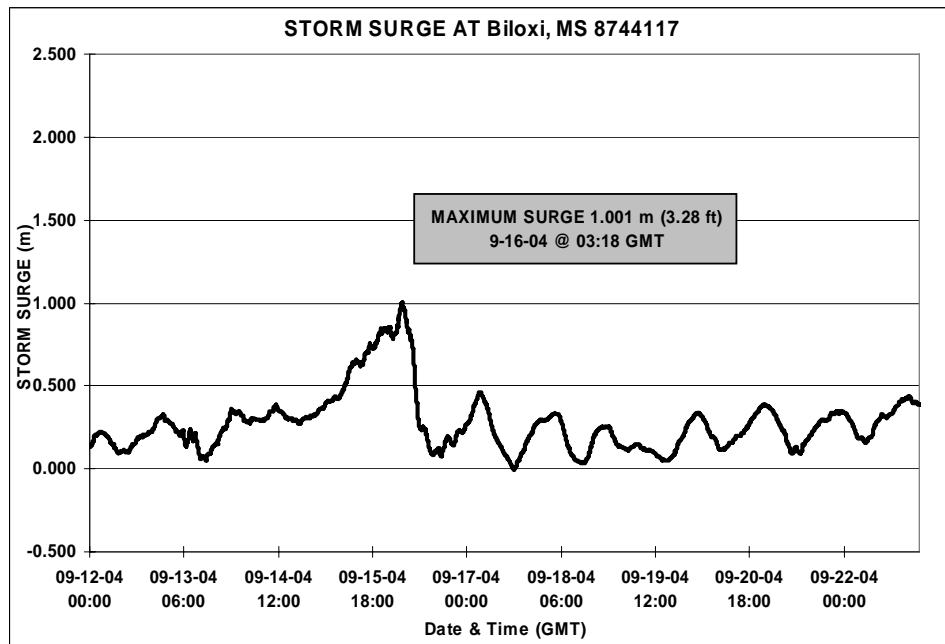
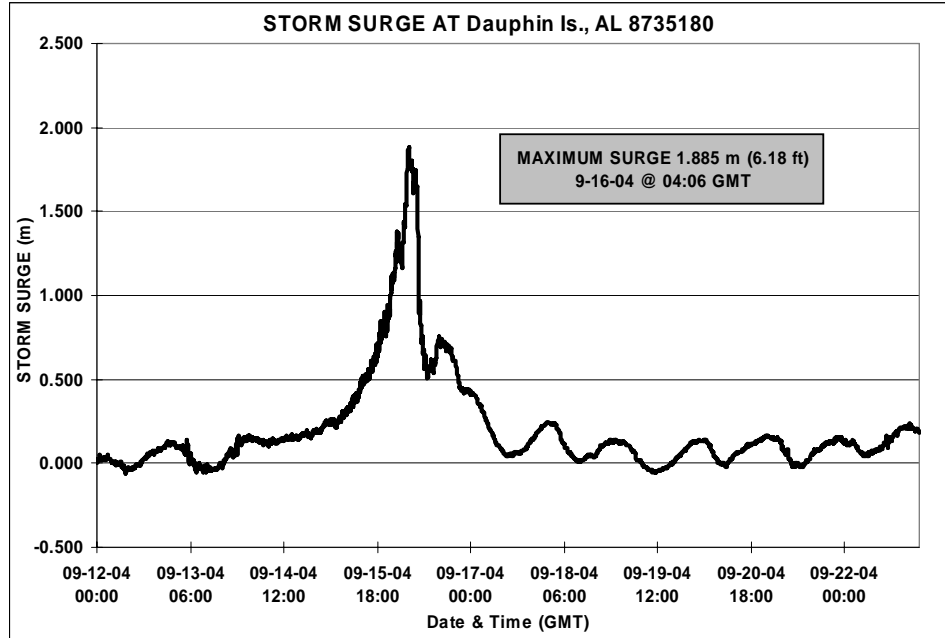
Table 2. Maximum observed storm surge during hurricane IVAN.

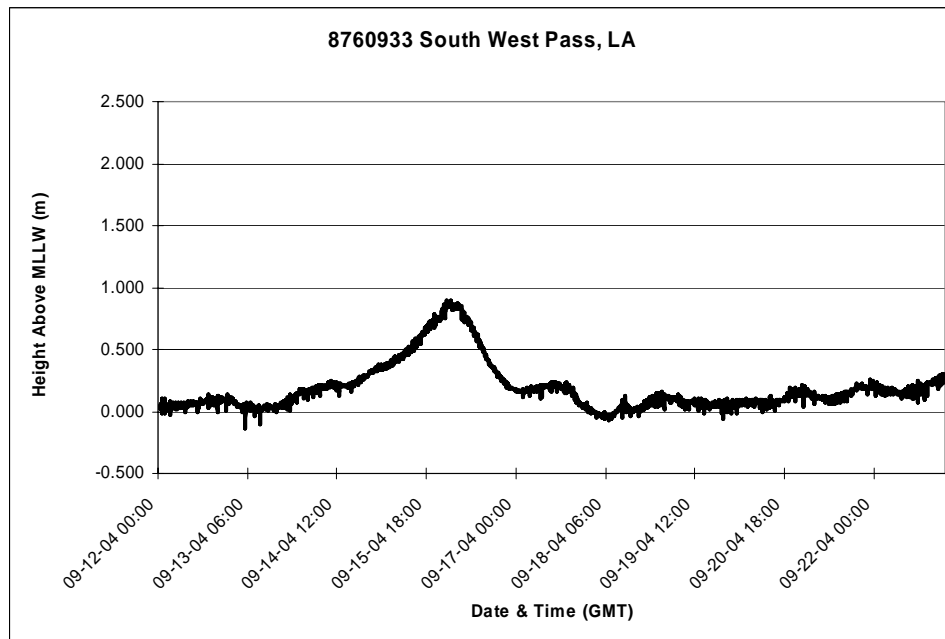
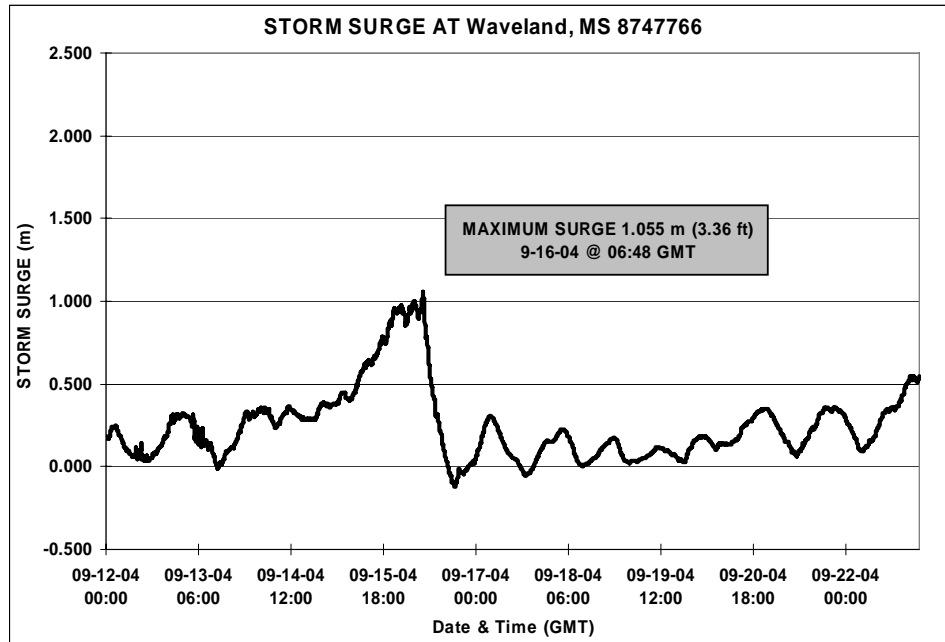
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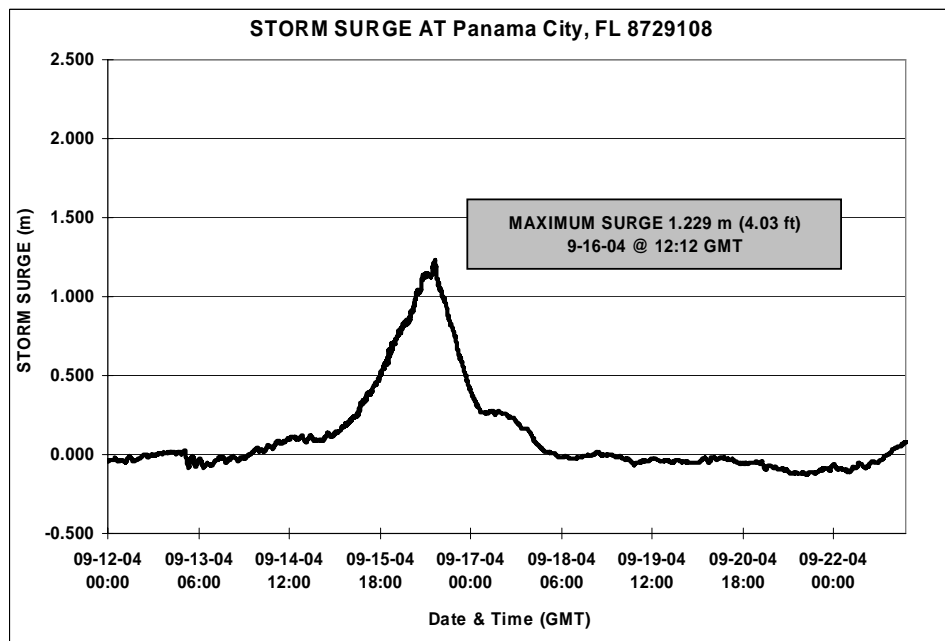
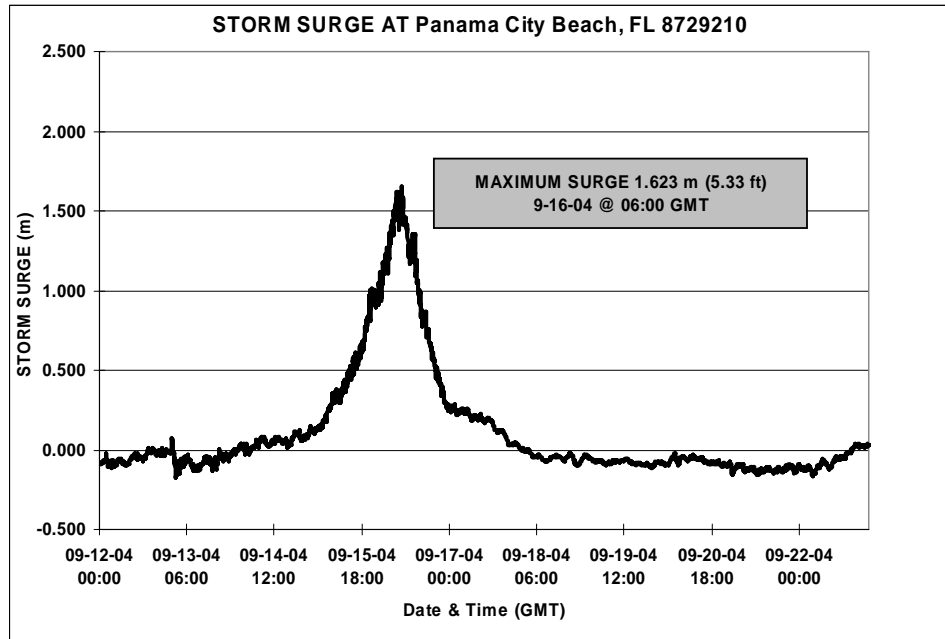
Maximum Storm Surge (Greatest Difference Between Observed and Predicted)					
Station ID	Station Name	Date-Time	Observed Water Level Above MLLW (m)	Predicted Water Levels (m)	Maximum Surge (m)
8723970	Vaca Key, FL	09-21-04 23:54	0.366	0.179	0.187
8724580	Key West, FL	09-14-04 09:18	0.409	0.237	0.172
8725110	Naples, FL	09-15-04 10:24	0.682	0.249	0.433
8725520	Fort Myers, FL	09-15-04 17:24	0.629	0.219	0.410
8726384	Port Manatee, FL	09-15-04 19:00	1.259	0.745	0.514
8726520	St Petersburg, FL	09-15-04 19:00	1.343	0.767	0.576
8726724	Clearwater Beach, FL	09-15-04 10:42	0.861	0.193	0.668
8727520	Cedar Key, FL W1	09-15-04 23:48	1.183	0.357	0.826
8728690	Apalachicola, FL	09-16-04 03:12	1.507	0.210	1.297
8729108	Panama City, FL	09-16-04 12:12	1.443	0.214	1.229
8729210	Panama City Beach, FL	09-16-04 06:00	1.963	0.340	1.623
8729840	Pensacola, FL	09-16-04 05:36	2.230	0.338	*1.892
8735180	Dauphin Is., AL	09-16-04 04:06	2.177	0.292	1.885
8737373	Lower Bryant Landing, AL	09-16-04 18:30	1.442	0.155	**1.287
8744117	Biloxi, MS	09-16-04 03:18	1.234	0.233	1.001
8747766	Waveland, MS	09-16-04 06:48	1.450	0.395	1.055
8760922	South West Pass, LA	09-16-04 00:54	1.153	0.259	0.894
8761724	Grand Isle, LA	09-15-04 17:06	0.875	0.324	0.551
8762075	Port Fourchon, LA	09-16-04 09:18	0.931	0.323	0.608
8762372	Bayou La Branche, LA	09-16-04 04:24	0.871	0.076	0.795
8770570	Sabine Pass North, TX	09-22-04 17:54	0.742	0.291	0.451
8770613	Morgans Point, TX	09-23-04 00:24	0.621	0.082	0.539
8771013	Eagle Point, TX	09-22-04 16:36	1.093	0.497	0.596
8771341	Galveston Bay, North Jetty, TX	09-22-04 15:42	1.036	0.463	0.573
8771450	Galveston Pier 21, TX	09-22-04 15:54	1.005	0.430	0.575
8771510	Galveston Pleasure Pier, TX	09-22-04 09:18	1.322	0.740	0.582
8772440	Freeport, TX	09-22-04 09:42	1.197	0.612	0.585
8774770	Rockport, TX	09-23-04 06:06	0.607	0.127	0.480
8775870	Corpus Christi, TX	09-15-04 18:36	0.951	0.431	0.520
8779770	Port Isabel, TX	09-23-04 20:06	0.532	0.123	0.409

* Gauge Destroyed **Data Inferred









STORM SURGE DURING HURRICANE IVAN

Hurricane IVAN's initial landfall was made near Gulf Shores, AL with winds of 105 kts and barometric pressure of 946 mb (Table 11). The second landfall occurred as a tropical storm near Cameron, LA with winds of 30 kts and barometric pressure of 1004 mb. IVAN was the strongest storm of the season reaching Category 5 strength after passing over Grenada in the Caribbean. IVAN made landfall as a Category-3 hurricane producing surge throughout the Gulf. Maximum surge occurred from Naples to Cedar Key, FL on 15 September while the storm was 300 miles offshore in the Gulf. As IVAN approached the Alabama coast on 9/16 SW Pass, LA was the first station to reach peak surge levels followed by Apalachicola, Biloxi and Dauphin Island. Surge at Pensacola, Panama City Beach and Waveland, MS followed just before landfall. Surge at Pensacola rapidly increased and though the station was destroyed probably would have stayed elevated for several tidal cycles. The surge at Pensacola also coincided with landfall and was accompanied by 50 kt winds out of the northwest (126 degrees). Maximum surge at Dauphin Island coincided with predicted high tide and remained elevated for two tidal cycles. The surge at Dauphin, though relatively high, may not be completely reflective of surge for the affected coastal region given its distance from landfall (17 mi) and its location approximately five miles off the actual mainland. Dauphin Island surge was accompanied by 68 kt winds out of the northeast (60 degrees) which may have also retarded surge levels at the location. Greater mainland storm surges would have been recorded had the storm track taken it directly into Mobile Bay or farther to the west along the Mississippi Delta into the vicinity of New Orleans. Surge levels at stations to the east and west of Pensacola (see Figure 7 shown previously) illustrate that surge levels to the east of the storm, in the panhandle of Florida, tended to be higher than their counterparts to the west of landfall. This emphasizes the importance of both wind speed and direction in determining levels of storm surge during hurricanes. Ivan reformed into a tropical depression on 22 September in the Gulf of Mexico after travelling in a circular motion through the southeastern United States. During IVAN's second landfall near Cameron, LA storm surges were significantly less than surge near Gulf Shores, AL and averaged approximate 0.5 m. Surge was marginally higher at Eagle Point, TX than closer to the site of landfall near Sabine Pass, TX and can probably be attributed to local geography more than wind speed (19 kts) or direction (73 degrees).

Table 3. Meteorological factors affecting storm surge during hurricane IVAN.

STATION LOCATION	MAX WIND (kts)	MIN PRESSURE (mb)	PREDICTED HIGH TIDE	MAX LEVEL (m)	MAX SURGE (m)
**Pensacola, FL	50.0	980	NA	2.330	1.892
	9/16/04 5:00 *(126)	09-16-04 05:24	NA	09-16-04 05:36	09-16-04 05:36
Dauphin Is, AL	68.0	954	NA	2.177	1.885
	9/16/04 4:00 *(60)	09-16-04 07:00	09-16-04 05:36	09-16-04 04:06	09-16-04 04:06
Eagle Point, TX	25.0	1006	NA	1.156	0.596
	9/22/04 8:24 *(92)	09-15-05 23:18	09-22-02 12:26	09-22-04 14:00	09-22-04 16:36
(*) Wind direction "from" which the wind was blowing					
** Station Destroyed					
LANDFALL LOCATION	DATE & TIME (UTC)	WIND (kts)	PPRESSURE (mb)	Distance from water level station(s) (mi)	
Gulf Shores, AL	09-16-04 06:50	105	946	17 (Dauphin Is), 36 (Pensacola)	
Cameron, LA	09-24-04 02:00	30	1004	90 (Eagle Point), 28 (Sabine Pass)	
STATION LOCATION	MAX SURGE (m)	Pressure, Wind Speed & Direction at Water Level Station During Max Surge			
**Pensacola, FL	1.892	39 kts, 79 degrees, 979 mb			
	09-16-04 05:36	09-16-04 05:36			
Dauphin Is, AL	1.885	68 kts, 60 degrees, 974 mb			
	09-16-04 04:06	09-16-04 04:06			
Eagle Point, TX	0.596	19 kts, 73 degrees, 1017 mb			
	09-22-04 16:36	09-22-04 16:36			