Performance of the Coastal Modeling System for Various Conditions in the Navigational Waters of the Texas Coastal Bend

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Introduction/Background

Corpus Christi Bay is primarily a shallow bay (~4 meters) located off the Gulf of Mexico in South Texas. **(Figure 2)** The main challenge in modeling this bay and the surrounding area originates from a deep ship channel (~14 meters) running across the bay. The Corpus Christi ship channel provides the main connection with the Gulf of Mexico and has a significant impact on water levels. Another important variable affecting water levels and circulation are strong winds, typically directed from the Southeast or North, directions that are perpendicular to the ship channel. The hydrodynamic model chosen for this study was the Coastal Modeling System (CMS) developed by the U.S. Army Corps of Engineers. The model was selected for its computational efficiency, ease of implementation and its emphasis on navigation channel performance. The model performance is evaluated based on its accuracy in predicting water levels and currents at four locations within the model area. Average performance based on hourly water levels during 2010 is better than 2.6 cm mean absolute error at all locations. Performance during periods which included several cold fronts is similar to the average yearly performance. Model performance during a two week period which included the passage of 2010 hurricane Alex and Tropical Depression 2 shows good performance as well with all water levels being within 2.8 cm of the measured values. The research further shows that wind forcing is not a major factor for water level accuracy and that the inclusion of a recent man made inlet, Packery Channel, only impacts the accuracy of the closest station to the inlet (Packery). Based on this research CMS is a good selection for the real-time nowcasting of water levels in the Texas Coastal Bend waterways.

Data and Methods

- National Oceanic and Atmospheric Administration (NOAA) Lat/Lon coastline data to define land boundaries
- NOAA digital elevation model to define bathymetry
- Texas Coastal Ocean Observation Network (TCOON) water level and wind measurements
- Surface-Water Modeling System (SMS) interface

1. The TCOON measurements were used to force and to analyze model performance
2. To analyze impact of wind on model performance, the model was run with and without wind forcing
3. To analyze the impact of Packery channel, the model ran with the channel and then with the channel removed
4. To conduct the analysis, mean absolute errors, root mean squared errors and biases were computed for each location
5. The currents were analyzed by comparing along channel TCOON current measurements at Port A to model predictions

Results:

2010 Full Year Analysis: (Refer to Table 1)

The overall 2010 mean absolute error for all the verification stations fell within 2.6 cm. The lowest mean absolute error of 1.6 cm occurred at the Rockport station and the highest mean absolute error of 2.5 cm occurred at the Port Aransas station. The yearly average predictions do not present a notable bias and the slight biases that were computed, average themselves out amongst the four stations.

2010 Tropical Storm and Cold Front Analysis: (Refer to Table 1)

The late June to mid July 2010 time period which includes hurricane Alex and Tropical Depression 2 shows an increase in mean absolute error for all the stations when compared to the yearly average. The most notable change occurs at Rockport with a 1 cm increase and Ingleside with a .6 cm increase in the mean absolute error. Unlike the yearly average, the tropical storm and the cold front periods present a bias (negative during storms and positive during cold fronts).

Packery Channel, Wind Impact and Current Analysis:

The removal of Packery channel from the model showed no effect on verification stations except for the one located along the channel where the mean absolute error increased by 1.2 cm. The removal of wind from the model run showed that wind does not significantly impact the predictions. Only Rockport and Packery stations were affected (~ 1 cm increase in MAE). The final analysis of the currents along the channel showed that the model follows the correct phase but constantly over-predicts or under-predicts the current velocities **(Figure 5)**.

Discussion:

The yearly average analysis shows that the model is successful at nowcasting with all the mean absolute errors falling within 2.6 cm. The analysis shows that there is no significant bias during the yearly average. The bias is negative for all the stations during the tropical storm time period from January through March and the opposite occurring during the two cold front time periods with positive bias. The wind is not a significant factor in model performance with mean absolute error only significantly increasing at two stations, Rockport and Packery. The small impact of wind on model performance is likely due to the lag between wind forcing and changes in water levels.

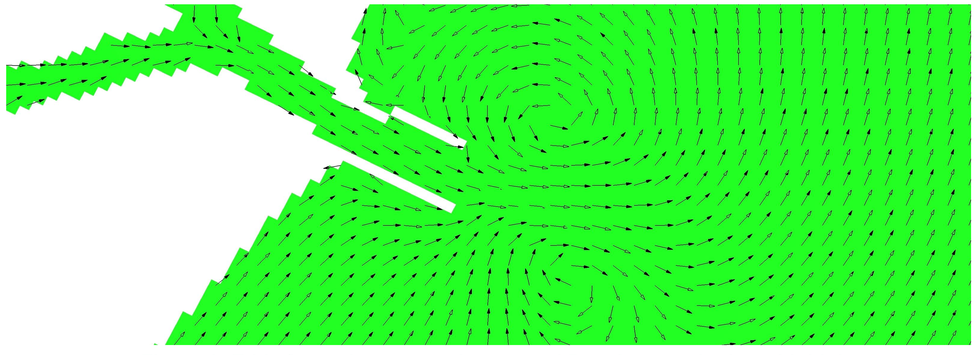

Figure 1: Eddy formations occurring around Port Aransas jetties with higher current speeds (1.4 m/s) occurring inside the ship channel during ebb

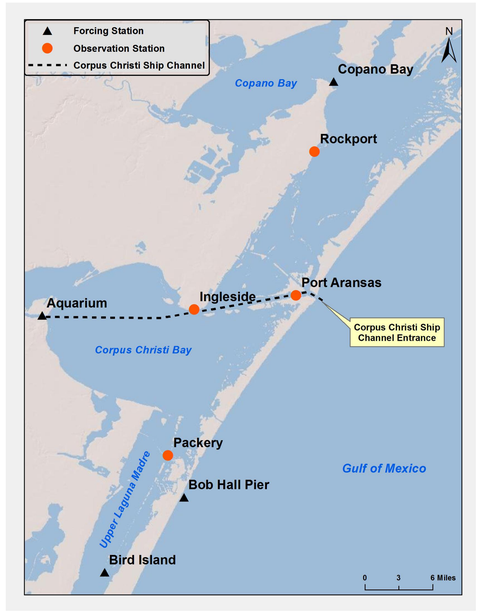

Figure 2: Study area map

	Packery	Ingleside	Port Aransas	Rockport
Full 2010 Analysis				
MAE (m)	0.020	0.021	0.025	0.016
RMSE(m)	0.143	0.146	0.157	0.128
Bias (m)	-0.003	0.004	0.006	-0.006
Tropical Storm Analysis (June 28 - July 14, 2010)				
MAE (m)	0.022	0.027	0.027	0.026
RMSE(m)	0.147	0.166	0.165	0.160
Bias (m)	-0.008	-0.009	-0.011	-0.023
Cold Front Analysis (January 1 - March 31, 2010)				
MAE (m)	0.022	0.024	0.028	0.013
RMSE(m)	0.149	0.155	0.169	0.115
Bias (m)	0.005	0.020	0.015	0.001
Cold Front Analysis (November 1 - December 31, 2010)				
MAE (m)	0.022	0.014	0.025	0.013
RMSE(m)	0.147	0.118	0.158	0.115
Bias (m)	0.000	0.005	0.009	0.008

Table 1: CMS water level performance analysis for 4 verification stations

References:

Hess, K., 2003. Standards for Evaluation of NOS Operational Nowcast and Forecast Hydrodynamic Model Systems. NOAA Technical Report. U.S. Department of Commerce, NOAA, Silver Spring, MD.

Adele M. Buttolph, Christopher W. Reed, Nicholas C. Kraus, Nobuyuki Ono, Magnus Larson, Benoit Camenen, Hans Hanson, Ty Wamsley, Alan K. Zundel. *Two-Dimensional Depth-Averaged Circulation Model CMS-M2D: Version 3.0, Report 2, Sediment Transport and Morphology Change*. Coastal and Hydraulics Laboratory. August 06. ERDC/CHL TR-06-9. 212 p. Sponsored by U.S. Army Corps of Engineers.

Acknowledgements:

NOAA Environmental Cooperative Science Center, Grant #:NA06OAR4810164
Alex Sanchez, U.S. Army Corps of Engineers, Engineer Research and Development Center, Coastal and Hydraulics Laboratory
Nicholas C. Kraus, U.S. Army Corps of Engineers, Coastal and Hydraulics Laboratory

Conclusions:

The 2010 yearly analysis shows that the model implementation was successful with all the stations having a small mean absolute error at no more than 2.5 cm and no significant bias. Small biases were observed during cold front and tropical storm passages. The research also shows that the inclusion of the recently dredged Packery channel only affects the Packery observation station. Furthermore, the analysis shows that wind does not play a significant role for the prediction of water levels. Given the model's success in nowcasting, the model will be tested for forecasting by forcing it with Artificial Neural Network predictions.

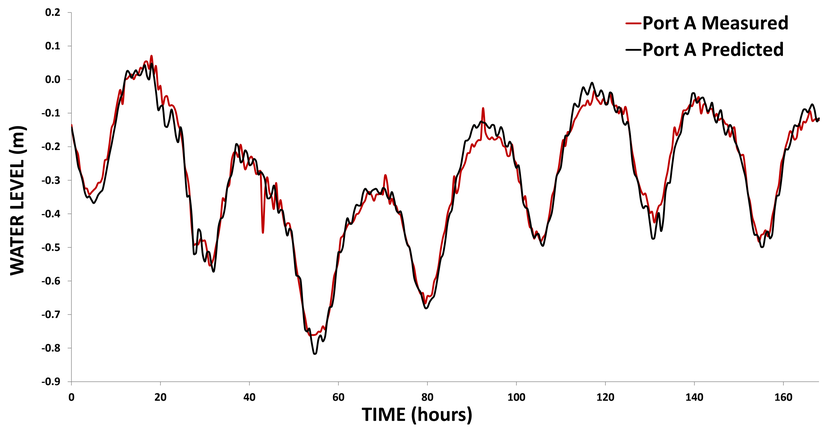

Figure 3: Model performance during cold front passage (March 20-26, 2010)

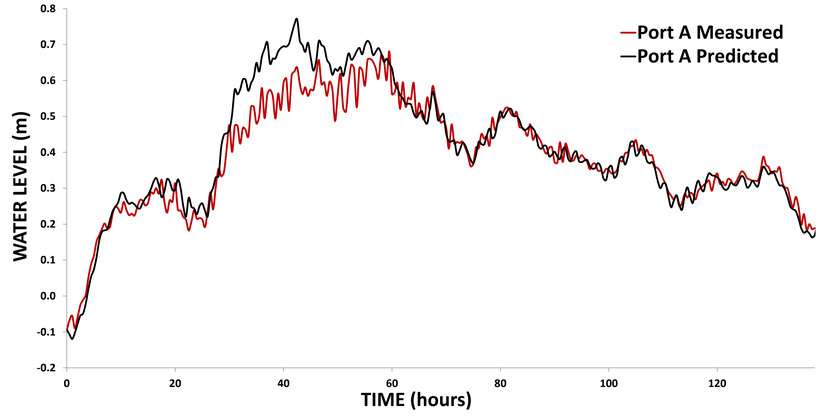

Figure 4: Model performance during Hurricane Alex (June 2010)

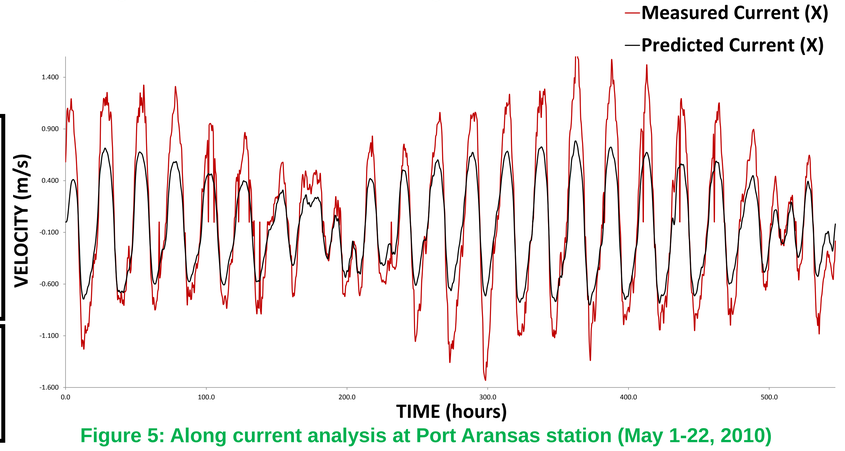

Figure 5: Along current analysis at Port Aransas station (May 1-22, 2010)