Hydrodynamic Model Comparison for Corpus Christi Bay

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Introduction/Background

Water level predictions are used for navigation, emergency management and coastal projects. Oceanic and atmospheric data is important for accurate current and water level predictions and is used to drive hydrodynamic models at various locations. The main purpose of this project was to select a hydrodynamic model capable of providing accurate results for the project area while simultaneously being computationally efficient. Two hydrodynamic models (CMS & FVCOM) have been implemented for Corpus Christi Bay and were compared by their accuracy and computational time to determine which model is best suitable for the project location. The study was implemented using a specific twelve day early November case with water level and wind forcings from observation stations located in the Bay and along the Gulf coast **(Figure 3)**. Model implementation was were kept as simple and similar as possible for comparison purposes. The models' performance accuracy was checked using observation stations located throughout the bay. The long term goal is to have a hydrodynamic predictive model running real time for the Coastal Bend area using Artificial Neural Network (ANN) model predictions as the hydrodynamic model's forcings.

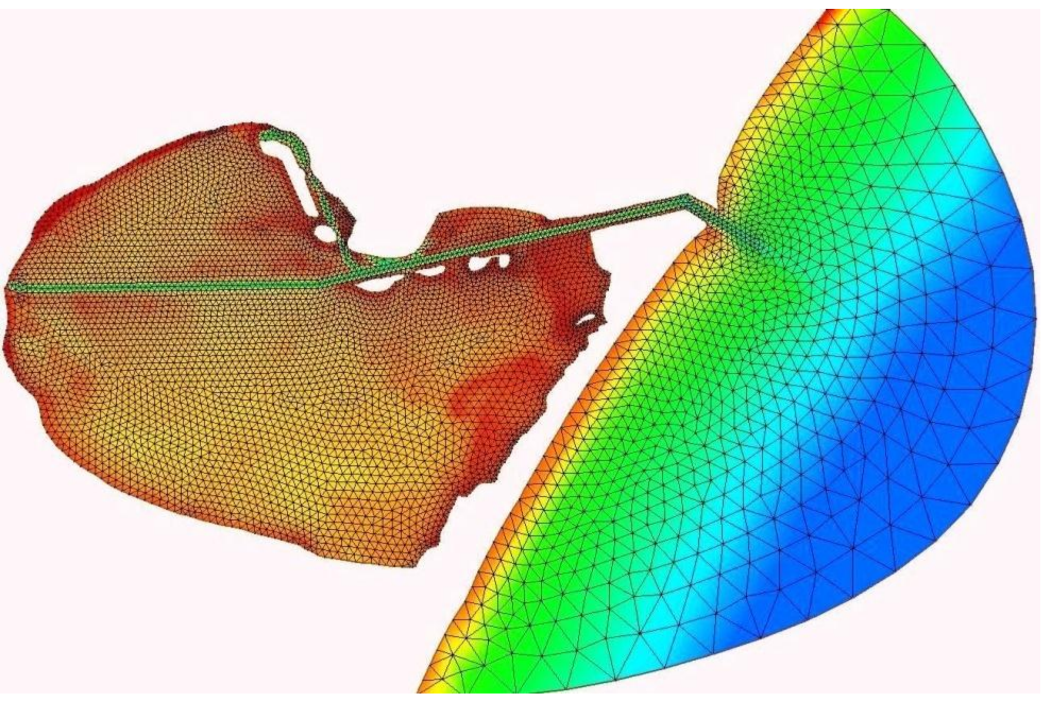

Figure 1: FVCOM Modeling Grid for CC Bay

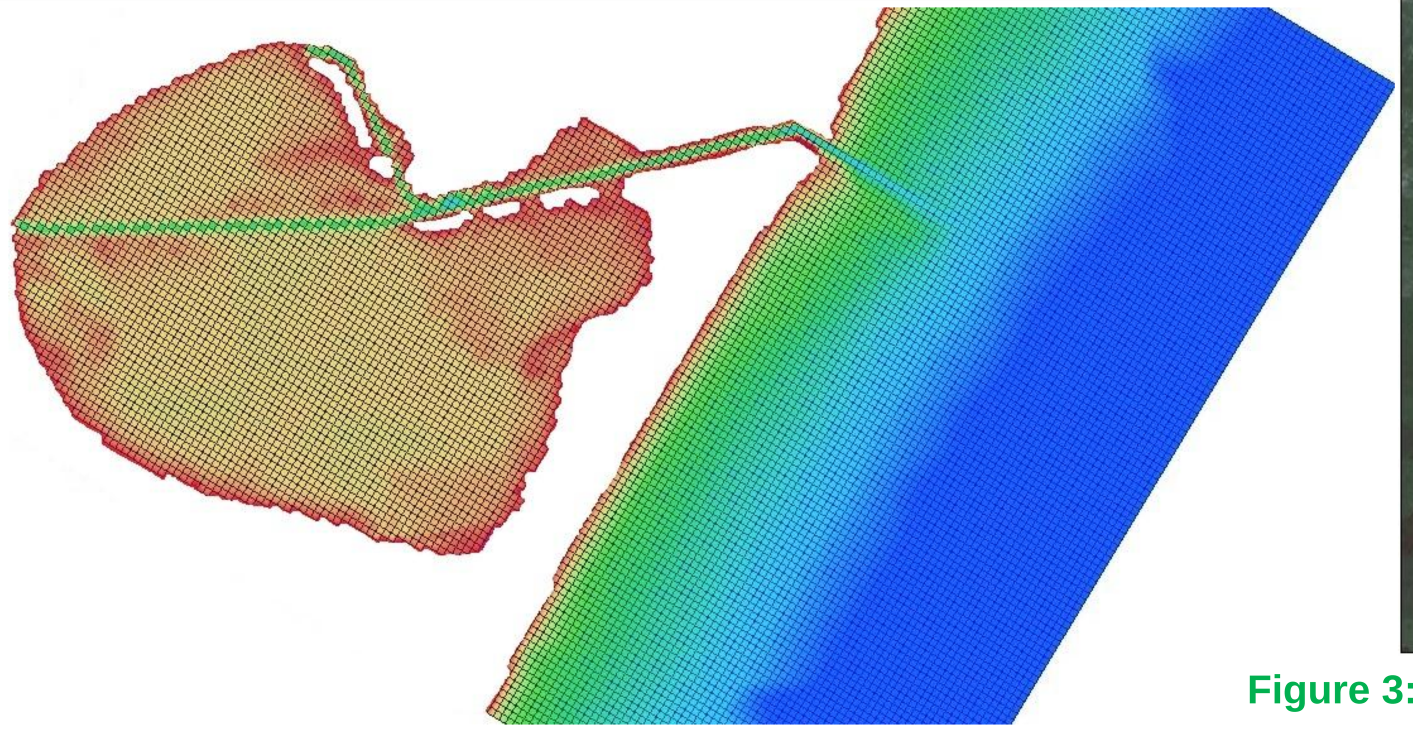

Figure 2: CMS Modeling Grid for CC Bay

Figure 3: Corpus Christi Bay, Texas 27˚ 47′ 0″ N, 97˚ 18′ 0″ W

Materials

- Coastal Modeling System (CMS) Hydrodynamic Model
  - Finite volume, 2D (calculations based on a single layer water column), structured grid
  - Developed by the U.S. Army Corps of Engineers
- Finite Volume Coastal Ocean Model (FVCOM)
  - Finite volume, 3D (calculations based on a multi layer water column (10 sigma layers)), unstructured grid
  - Developed by Marine Ecosystem Dynamics Modeling Laboratory
- Wind speed, wind direction, water levels and currents as input data
  - Provided by the Texas Coastal Ocean Observation Network
- Coastline XY dataset
  - Provided by NOAA's National Geophysical Data Center
- Bathymetric XYZ scatter dataset
  - Provided by the Texas Water Development Board

Methods

- Create two separate grids for the models using coastline & bathymetry data using SMS software.
  - The process involves creating individual grids from the coastline data and then interpolating the bathymetry scatter data to add depth to the model.
- Find a significant data set to use as oceanic and atmospheric forcings (also will be used to check the models).
  - The forcings are applied at the grid's boundaries (the main forcing is the Gulf of Mexico boundary).
- Analyze and compare the two models by running them simultaneously under similar conditions
  - Similar conditions include: same wind and water level forcing, same bathymetry and similar grid structures.
  - The analysis includes comparing the models' predictions to actual observations using mean absolute error for water levels and currents and comparing the computation time for each model.
- Determine the model which best fits Corpus Christi Bay

Results:

Comparison/Runs	FVCOM	CMS
Number of Grid Cells	~ 11,000	~ 12,000
Single Processor Run (hrs.)	17	2
Multi Processor Run (hrs.)	2	~
Aquarium Water Levels MAE (m)	0.065	0.058
Ingleside Water Levels MAE (m)	0.048	0.066
Bob Hall Pier Water Levels MAE (m)	0.047	0.021
Port Aransas Water Levels MAE (m)	0.110	0.054
Packery Water Levels MAE (m)	0.018	0.008
Ingleside Currents (Along Channel) (m/s)	0.090	0.083
Port Aransas Currents (Along Channel) (m/s)	0.340	0.190

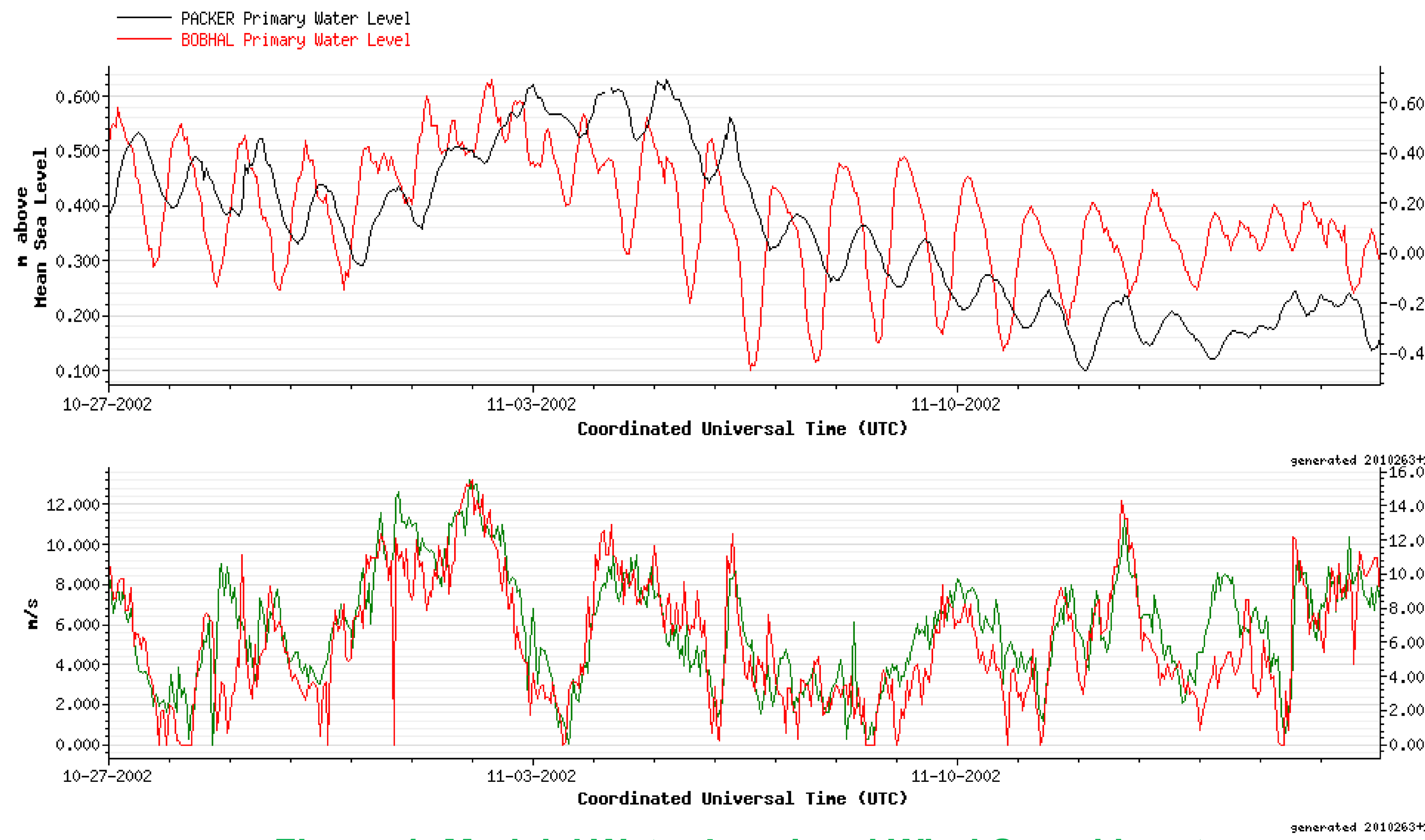

Figure 4: Models' Water Level and Wind Speed input

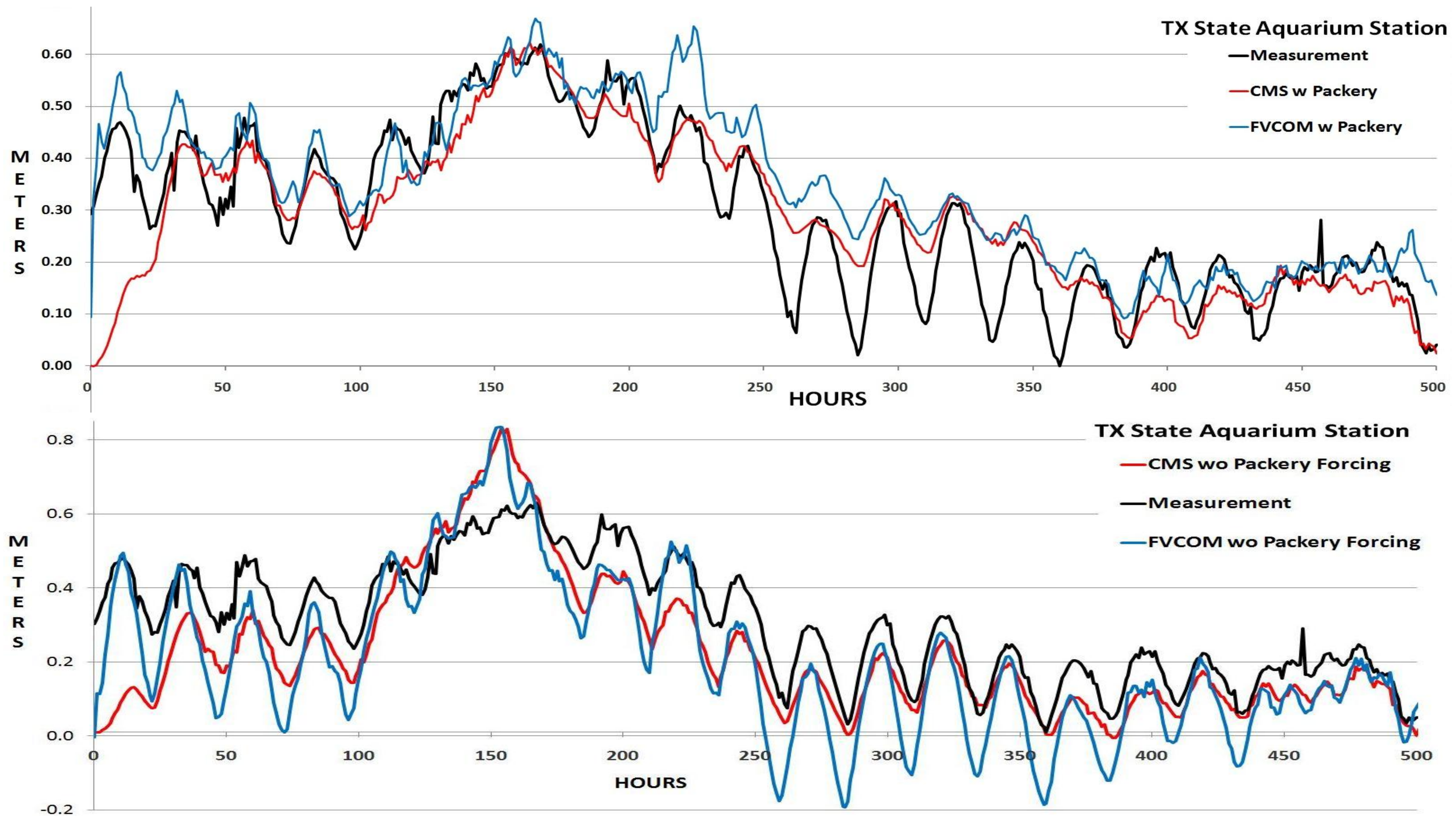

Figure 5: Models' Water Level Performance Analysis at Aquarium Station

Discussion:

The two models ran for the same location and the same time period. The models were both forced from the Gulf using Bob Hall Pier measurements and from the southwestern edge of the bay using Packery station measurements. Both models overall display similar results, under predicting currents in the ship channel and water level range in the bay. At four out of five locations, CMS's accuracy was better for water levels. CMS also performed better at predicting current velocity. Both models were lacking in current velocity predictions with errors reaching 30% for FVCOM. Implementation of both models was however course for initial comparison. Because of its performance, computational efficiency and user friendly interface CMS was selected for this project. For comparison's sake, the models were kept as simple and similar as possible. Future projects include adjusting the CMS model and its parameters to provide better predictions.

Conclusions:

- Computationally, CMS is significantly faster than FVCOM (2D vs. 3D)
- CMS presented better predictions in most cases
- CMS is easier to implement and optimize
- Selection of CMS for this application
- Updating CMS: extended the grid, updated bathymetry, additional forcings, manning's coefficient changed in channel
- Future work includes extending the CMS grid northward and southward, testing the model under broader conditions and implementing it for real-time operation

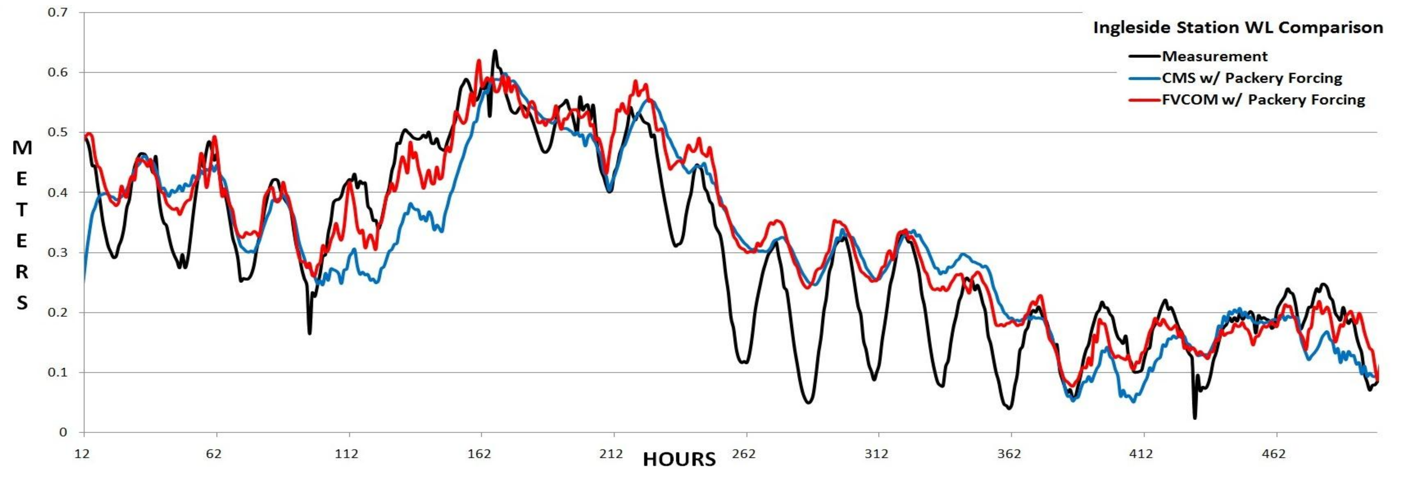

Figure 6: Models' Water Level Performance Analysis at Ingleside

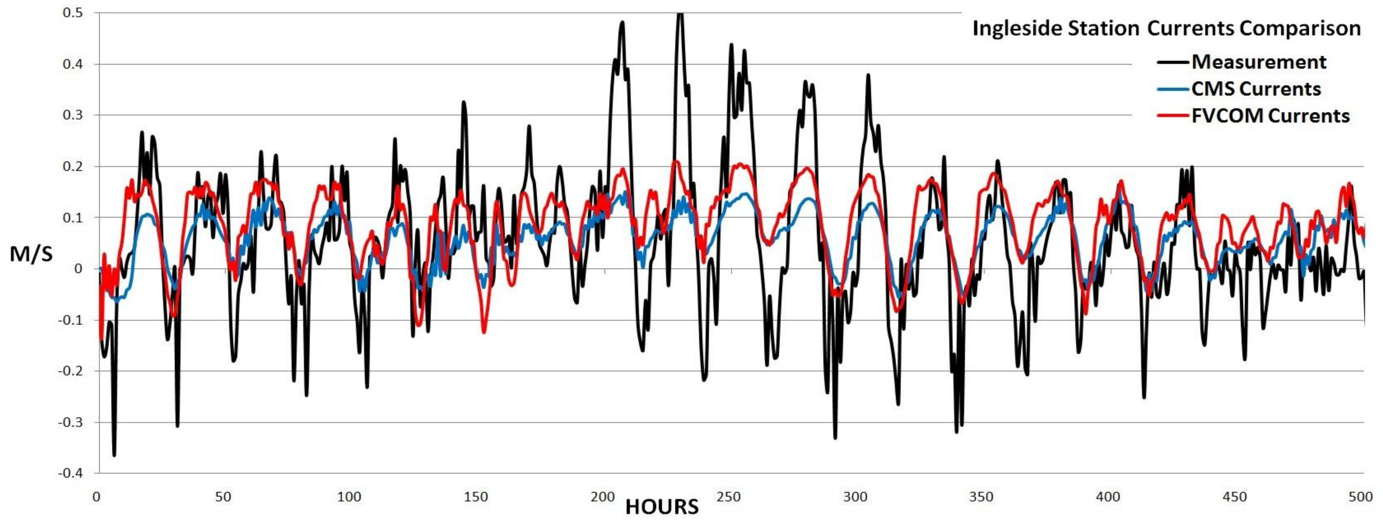

Figure 7: Models' Currents Performance Analysis at Ingleside

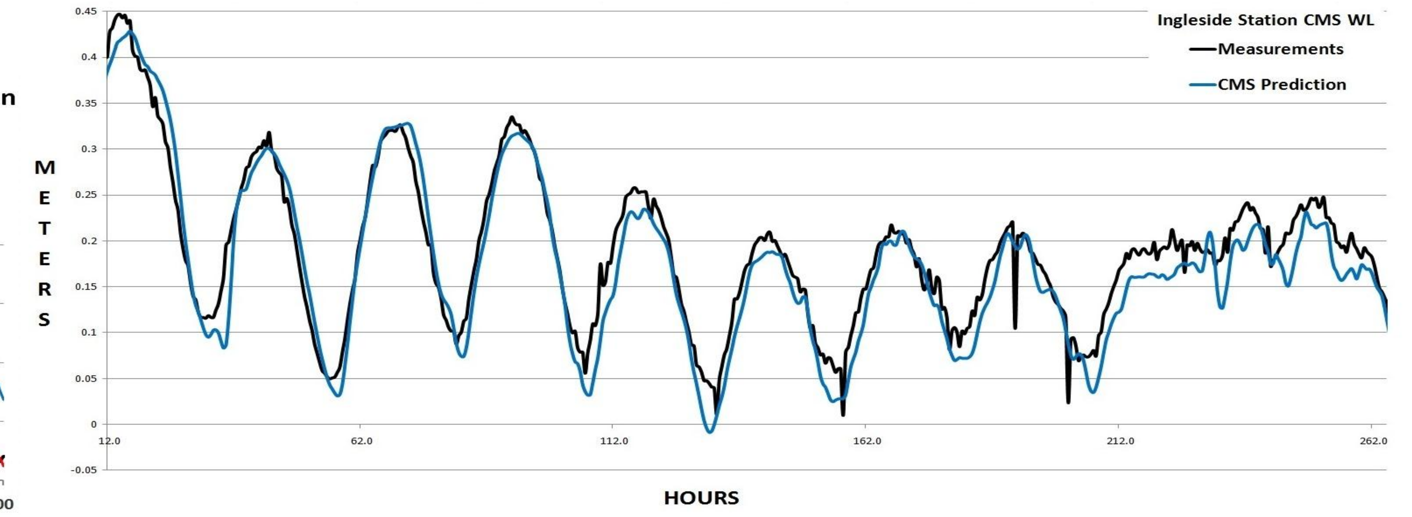

Figure 8: Models' Water Level Performance Analysis w/ Updated CMS

References:

Hicks, Steacy. *Understanding Tides.* U.S. Department of Commerce. December 2006.
Chen, Changsheng. *FVCOM User Manual*. University of Massachussetts-Dartmouth. July 2006.

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