Final Report for the Project:

Adaptation of the ELCIRC model to Texas bays and estuaries

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Summary

Over the past 3 years, we have helped install the ELCIRC (Eulerian-Lagrangian Circulation) and SELFE (Semi-implicit Eulerian-Lagrangian Finite Elements) models at TWDB. We have provided technical support to TWDB staff as they have evaluated and tested the models. The models have since evolved rapidly towards maturity via algorithmic improvement and benchmarking with a variety of coastal margin/estuarine baroclinic circulations in US, Canada and Europe.

Some early work was done with ELCIRC at TWDB. Through applications to other benchmark applications, we have demonstrated that the newer model SELFE is generally superior to ELCIRC, at moderately higher computational cost, because of more formal higher-order numerics therein. The physical quantities SELFE simulates include tidal elevation, velocity, temperature and salinity.

Recently we have applied the newest SELFE model to the Sabine and Keith Lake region. The results are shown below.

Model set-up for Sabine/Keith Lake

TWDB modelers developed a first version of the unstructured grid for this region (Fig. 1), which has a number of very narrow channels; the small element size is about 10m. We have edited some parts of the horizontal grid to increase the minimum element size to about 80m to alleviate the Courant number restriction on the internal waves, and to eliminate excessively skew elements. Both the old and new grids have problem in properly representing some small channels, and this needs to be addressed in future work (see "Lessons learnt"). The final grid has 15409 nodes and 23913 triangular elements. The system is shallow, and includes some dry land. The model capability of ELCIRC and

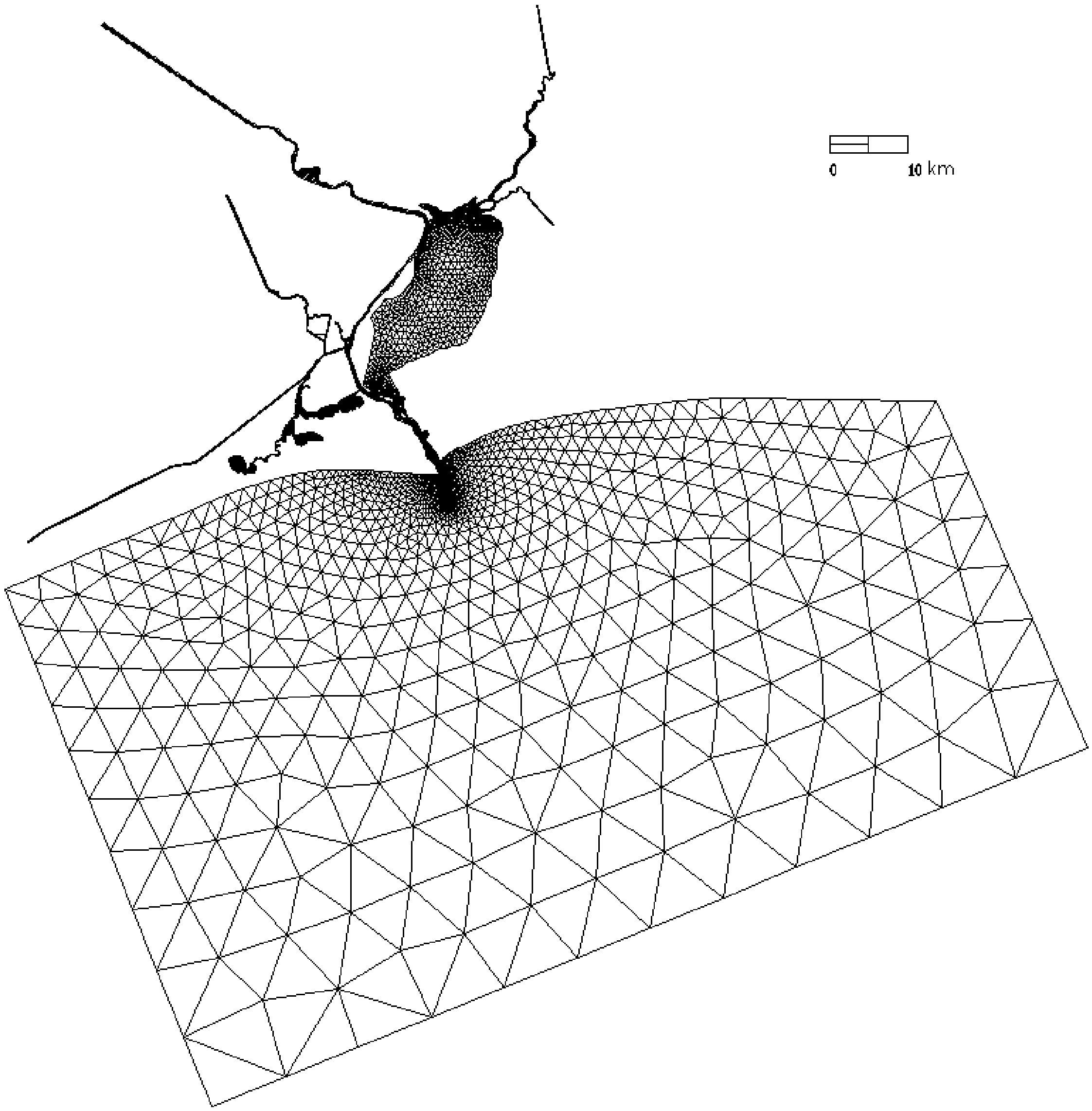
SELFE is well suited for this type of applications. For the SELFE simulation we did, 11 terrain-following *S* levels were employed in the vertical direction.

There are three open boundaries in the system: outer ocean boundary, Sabine and Neches Rivers. The latter two are the only freshwater sources included in the model (although there are some other minor sources that haven't been incorporated). Precipitation and evaporation have not been implemented in the models and therefore were not considered. However, air-water heat exchanges were enabled. The boundary conditions for river temperature as well as the initial conditions for salinity and temperature were calculated from NCOM simulation for the same period (Jan 29 to Feb 26 2006). The tidal amplitudes and phases were calculated from a package that has not been well tested (although the results shown below partially validated it). The discharges at the two rivers were downloaded from a USGS web site, and the velocity at the outer ocean boundary was not imposed but indirectly specified via backtracking in the model.

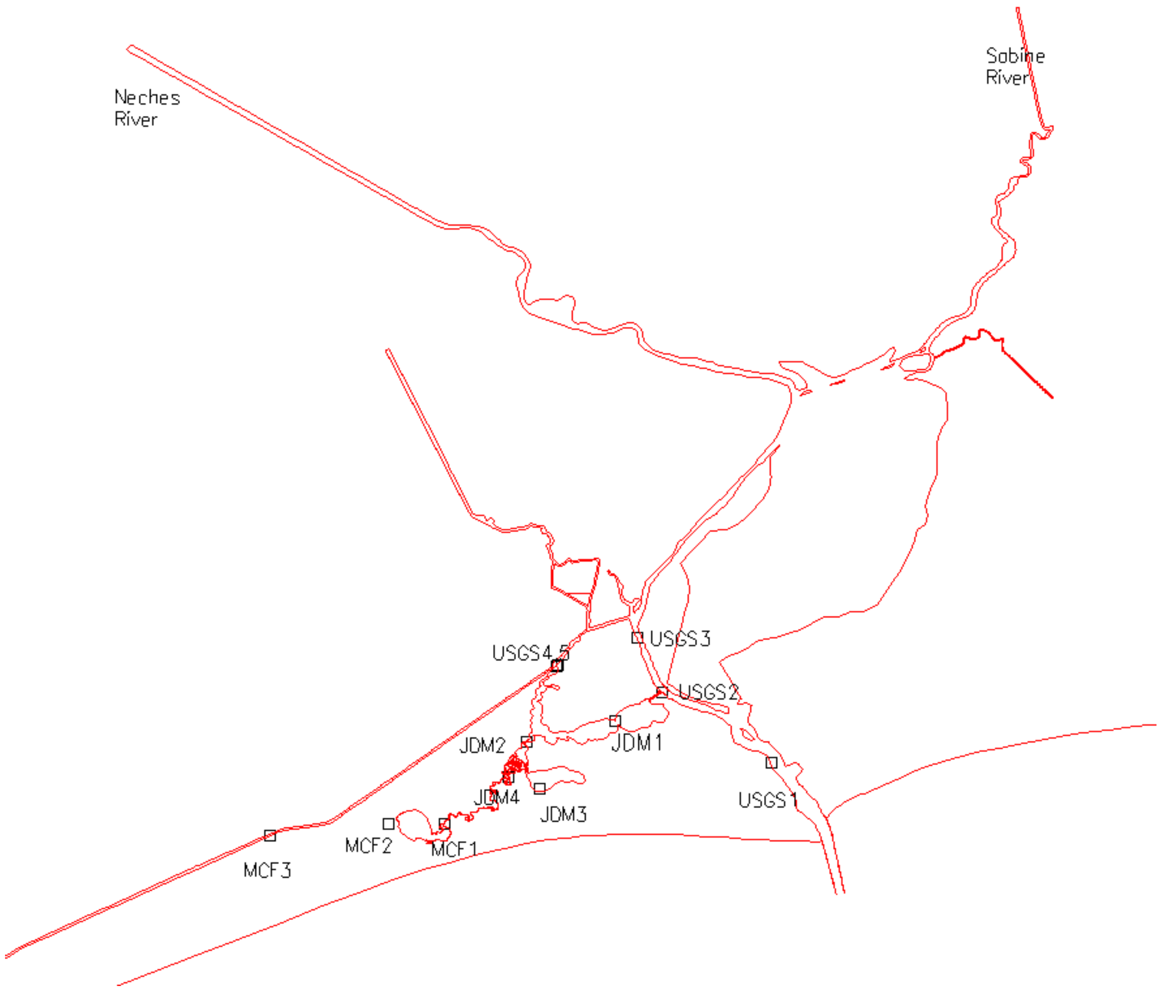
The model results were compared to field observations from in-situ monitoring equipment deployed in the system by the TWDB. It should be noted that the field data used in the comparisons is the raw data and has not been yet been through TWDB's QA/QC procedures.

Some preliminary results are shown below. The 4-week run took about 5 days on an Intel Xeon x86 with 2.4GHz CPU.

Results for Sabine/Keith Lake

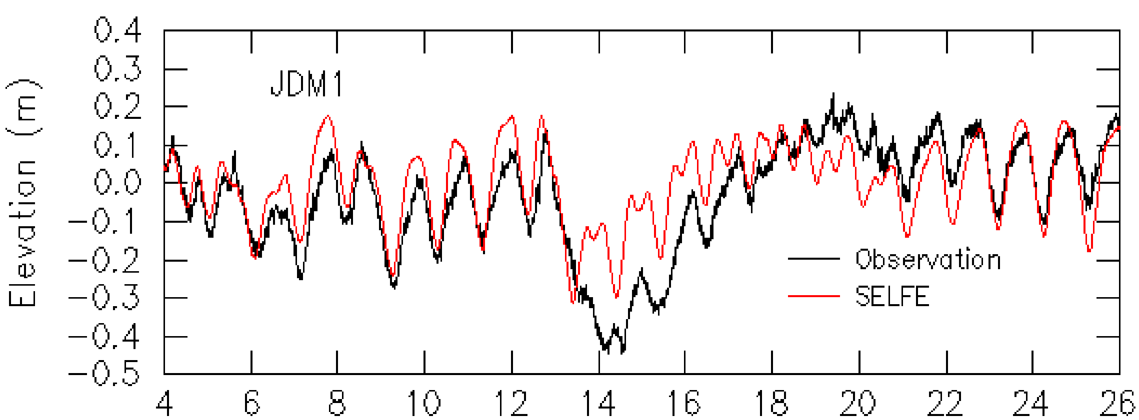


(a)



(b)

Figure 1. (a) Computational grid; (b) location of observational stations.



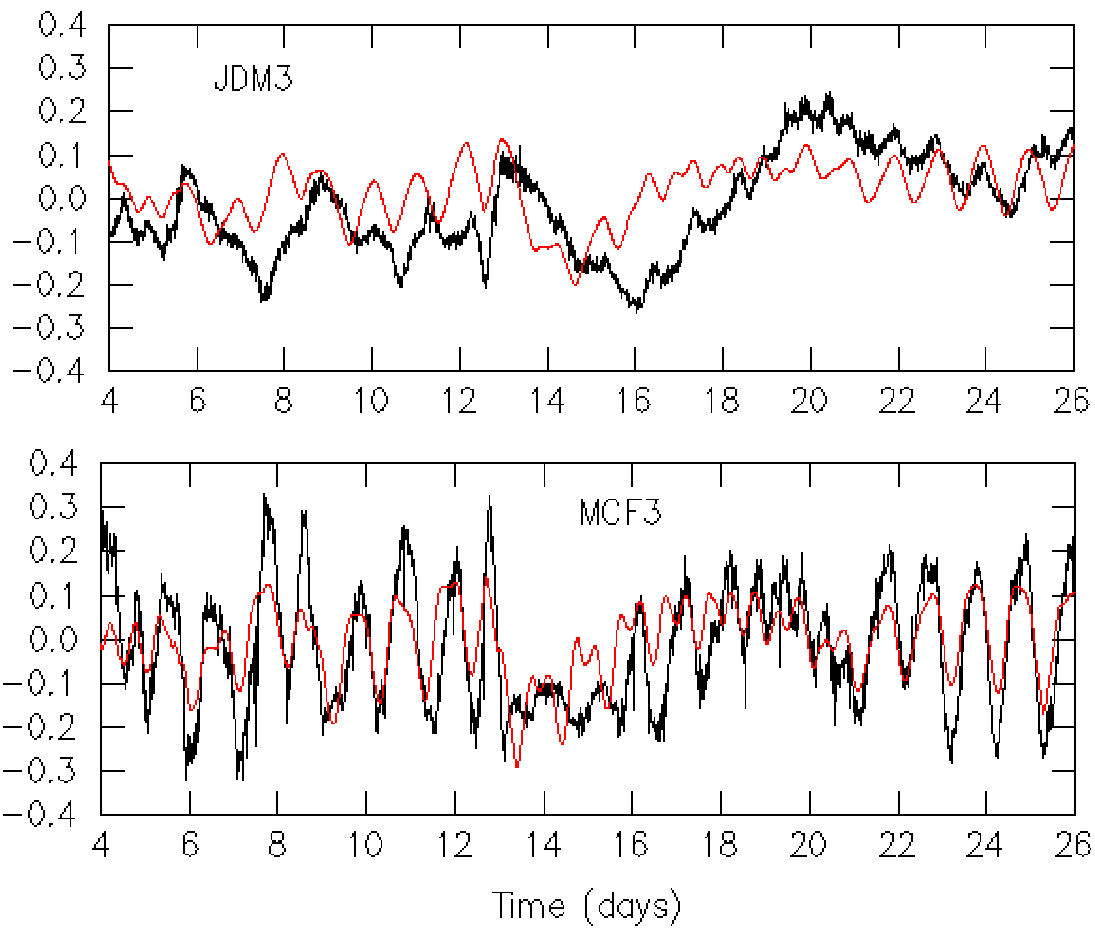
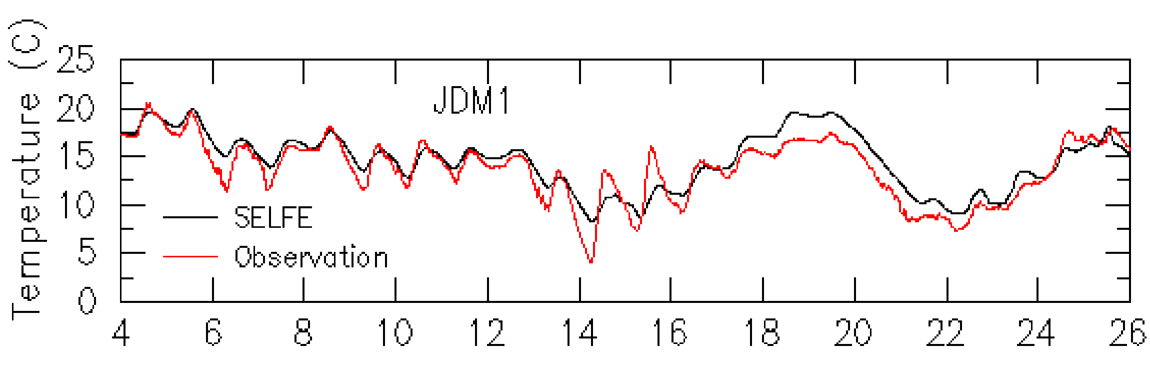
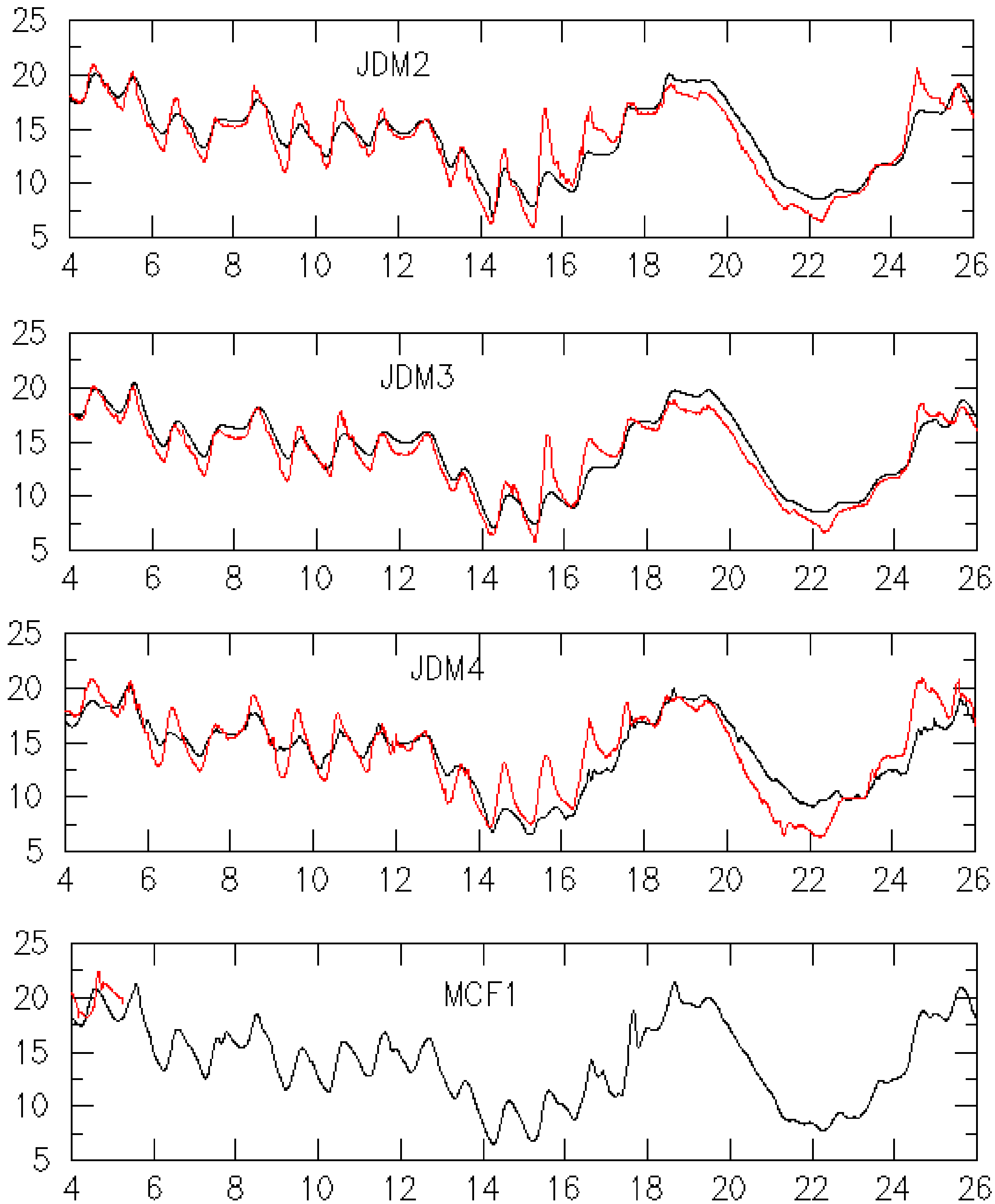


Figure 2. Comparison of tidal elevations at JDM1, JDM3 and MCF3. MCF2 is outside the current grid. Observational data at other stations is either unavailable or questionable. The data has been de-meaned as the vertical datum is uncertain. The starting time, Day 4 corresponds to 00:00PST on Feb. 02, 2006.




JDM2
JDM3
JDM4
MCF1
25
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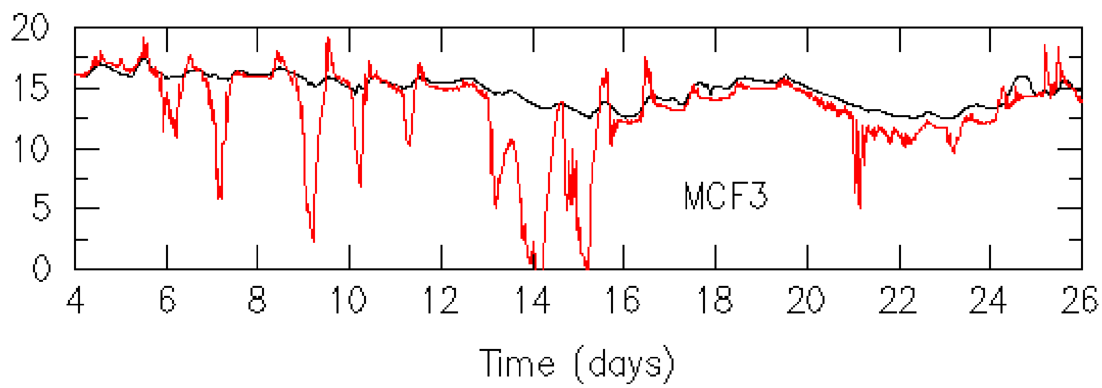
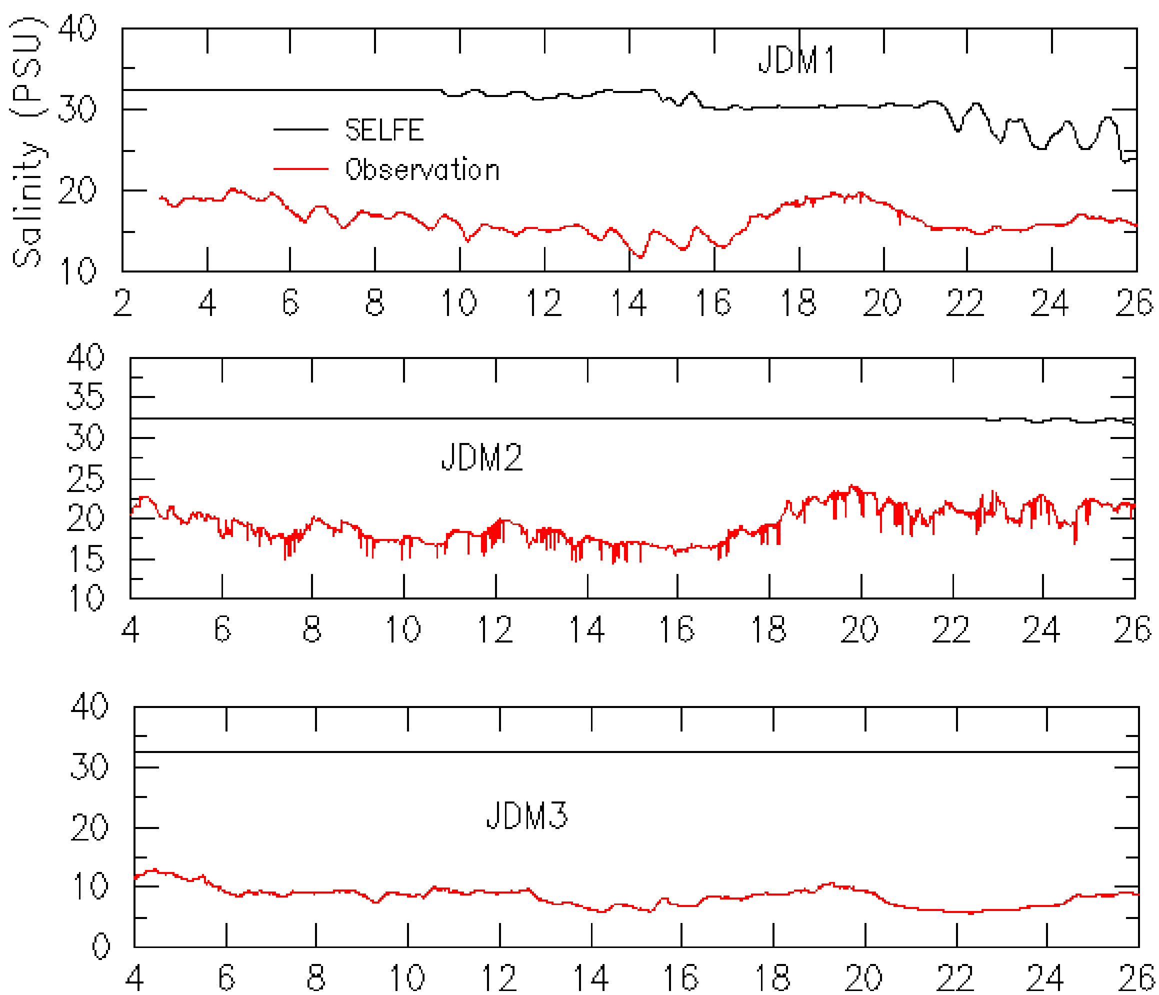


Figure 3. Comparison of surface water temperature at JDM1-4, MCF1 and MCF3. Note the strange spikes present in observational data at MCF3.



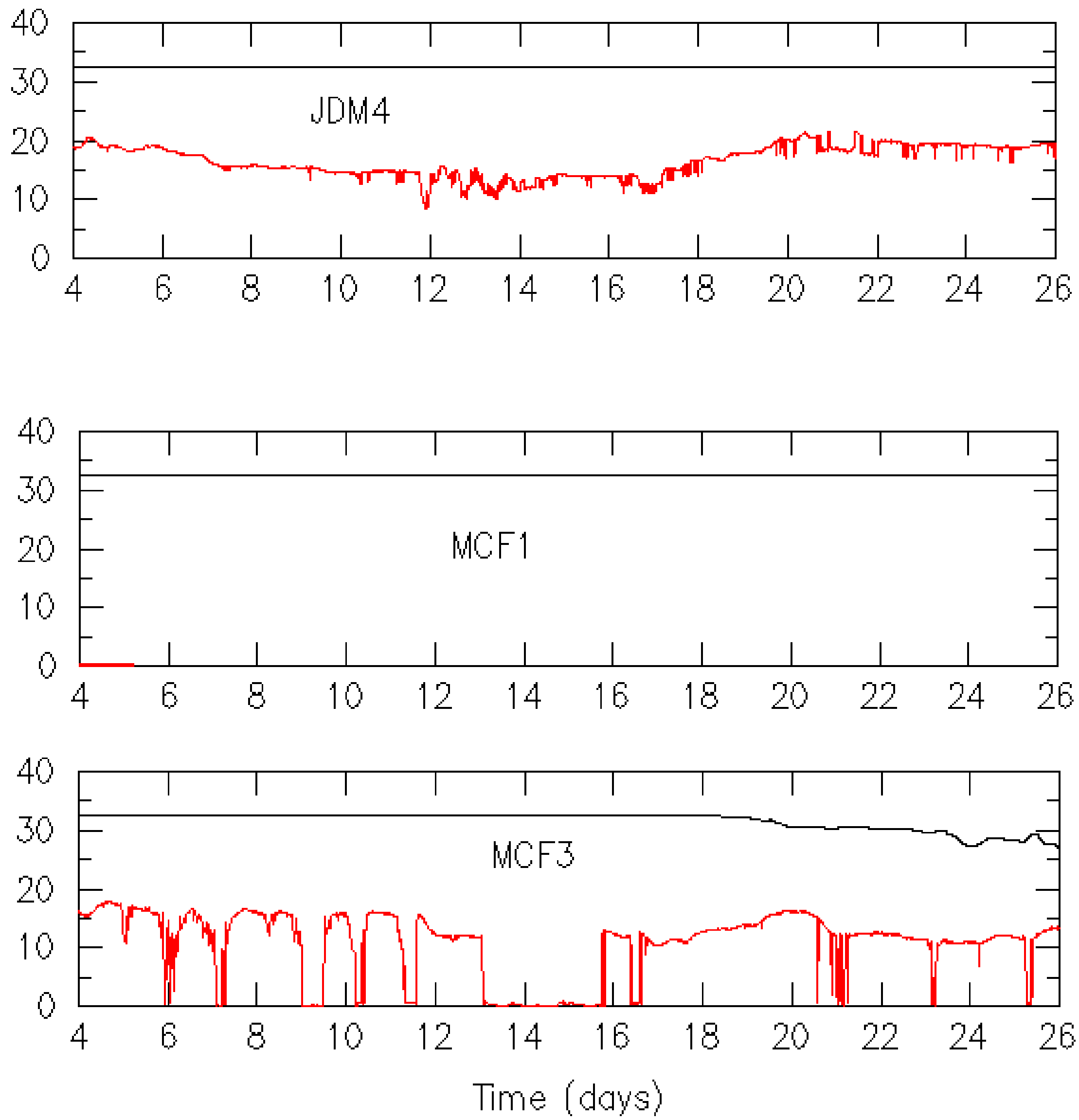


Figure 4. Comparison of surface water salinity at JDM1-4, MCF1 and MCF3. Note the strange spikes present in observational data at MCF3. Data at MCF1 looks questionable.

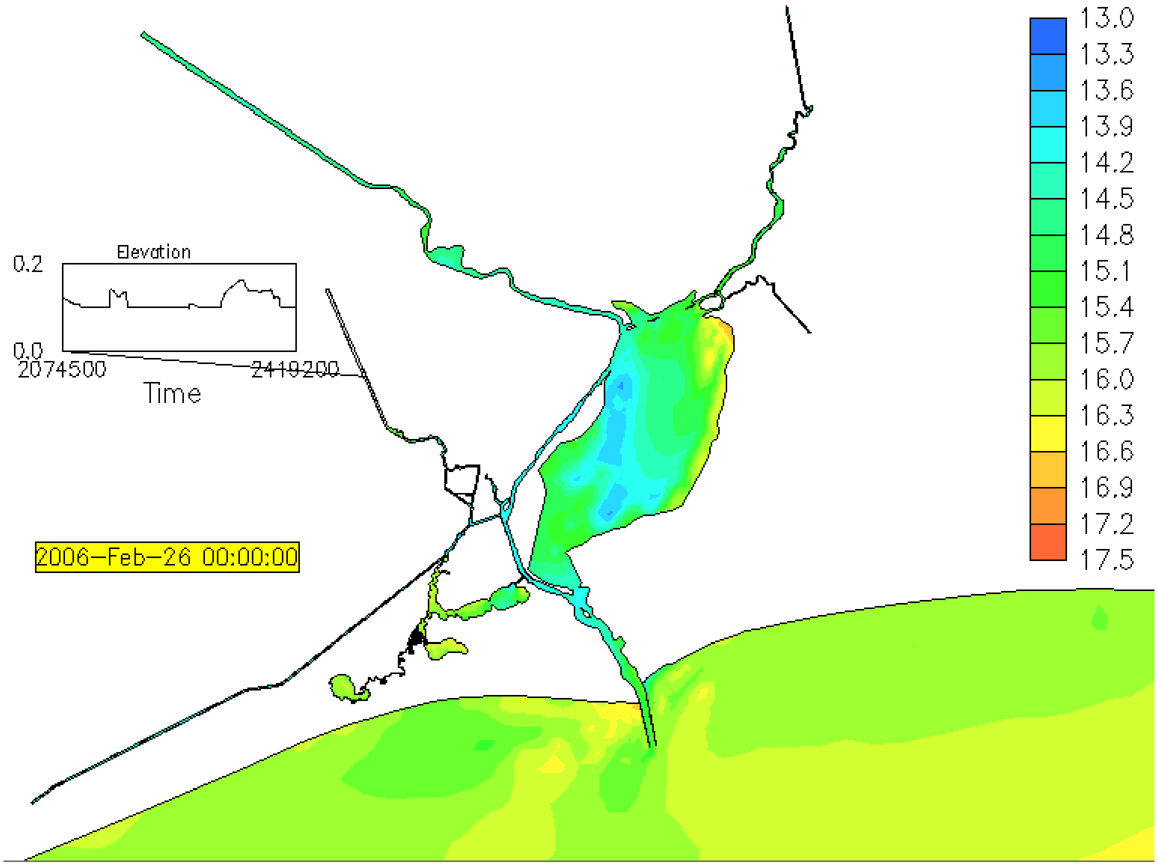


Figure 5. Surface temperature at the end of 28-day run. Also shown is the time history of elevation near a wetting and drying interface.

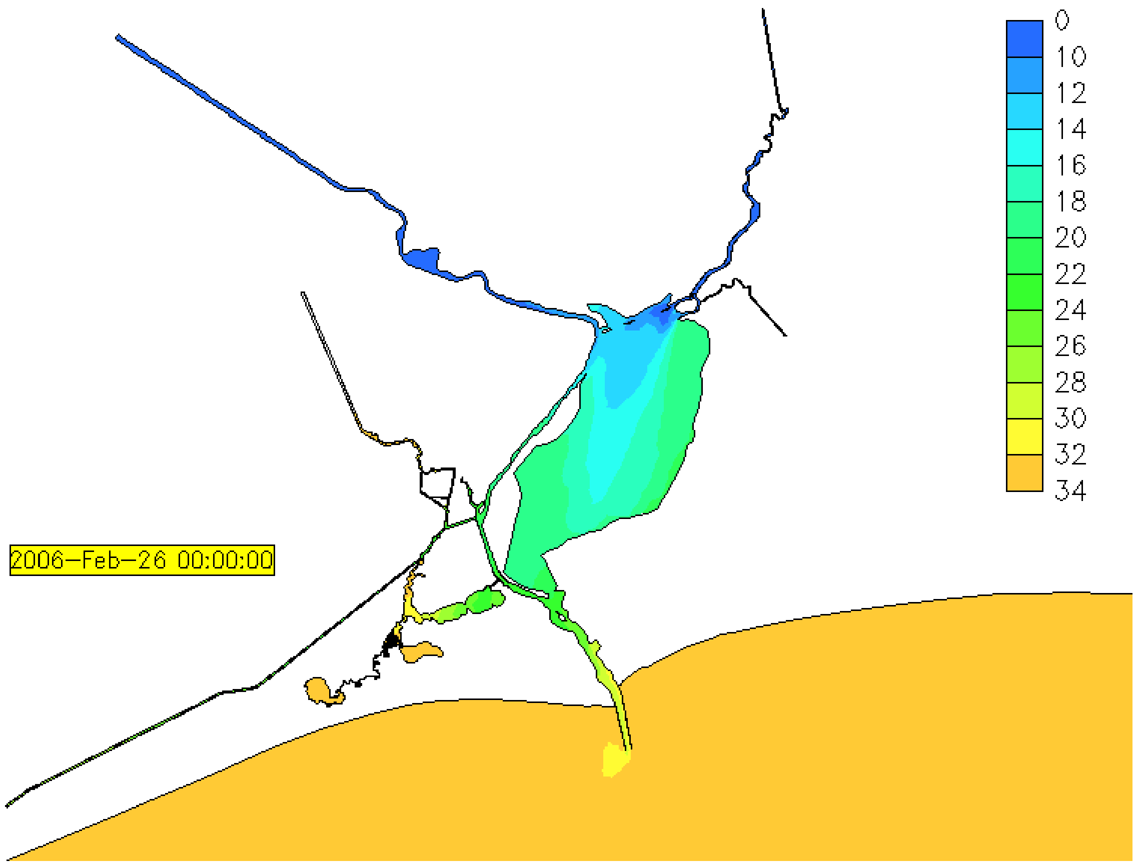


Figure 6. Surface salinity at the end of 28-day run.

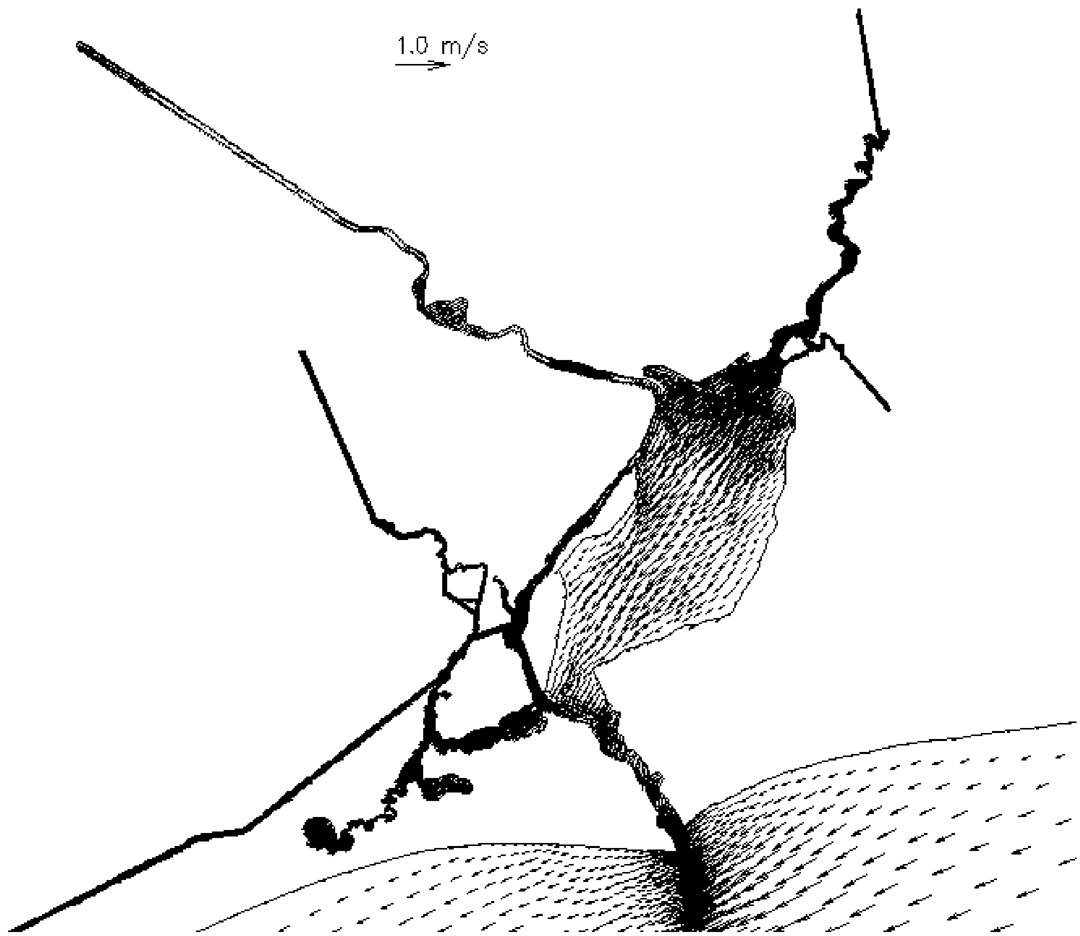


Figure 7. Surface residual velocity computed during the last 10 days.

Lessons learnt

Due to time constraints, we were only able to complete the first run for one particular domain of interest to TWDB. Nonetheless, the results for elevation and temperature were promising. The model salinity was clearly over-estimated. We haven't done any comparison for velocity yet.

During this process, we have identified the following areas for improvement. In order to better represent the delay in minimum water elevation from JDM1 to JDM3, the bottom friction needs to be looked at, and the horizontal grid clearly needs refinement/adjustment, especially around the narrow channels. Better tidal packages for the boundary conditions, and finer-scale atmospheric forcing (the coarse resolution global re-analysis data from NCEP was used in the study) should also improve the elevation results throughout the domain; the latter is particularly important if the sub-tidal components are to be accurately simulated. Finally, as far as the salinity is concerned, incorporating the evaporation and precipitation processes in the salt transport, and including more freshwater sources from smaller rivers/creeks (Neches and Sabine Rivers were the only freshwater sources in the study), and a better initial condition for salinity (the initial condition was derived from NCOM model that does not have adequate resolution in this area) should greatly improve the salinity results.

Further work on quality control of data is also warranted. The spikes in salinity and temperature data at MCF3 may suggest that that instrument was poorly located (maybe rising above the water surface), or it malfunctioned.

Knowledge transfer

Source code, user manual, and some benchmarks can be found in:
http://www.ccalmr.ogi.edu/CORIE/modeling/elcirc/
http://www.ccalmr.ogi.edu/CORIE/modeling/selfe/

In addition, the zipped input files for the SELFE run are also attached to this report.