Modeling Tides in a Semi-Enclosed Basin
A Case study of the Gulf of Mexico

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Tides are a well known process but a better understanding on how to implement them in a numerical model is needed. The main objective of this study is to seek the behavior of these tides in a semi-enclosed basin, in particular the Gulf of Mexico (GoM). The Navy Coastal Ocean Model (NCOM), a three-dimensional, hydrostatic, primitive equation model developed at the U.S. Naval Research Laboratory (Martin, 2000), is used to implement and seek the behavior of tides in the GoM. After a 30 day run to adjust the baroclinic model to initial fields, three experiments are conducted. The first one considers only the local tidal potential (LTP) on each node of the grid. This LTP is considered like an atmopheric pressure and is directly derived from the tidal equilibrium theory. The second method specifies barotropic transport and elevation of the tidal signal at open boundaries. The third one combines both previous methods of forcing tides. The t_tide Matlab© program (Pawlowiscz, 2002) is used to extract tidal constituents from surface elevation, with phase and signal-to-noise ratios. A spectral analysis is performed to see which frequencies are dominant in the Basin (Form ratio).

Results show that semi-diurnal tides in the GoM are dominantly forced by the local tidal potential whereas diurnal tides in the basin are driven at the boundaries. Combining both methods leads to a very realistic model of tides. In some specific areas, the surface elevation is amplified or de-amplified when the local tidal potential forcing is combined with the tidal signal propagating from the open boundaries. So the process of combining both methods is locally non linear. Ray tracing, by calculating the gradient of the phase in the basin, and integration of the local tidal potential along the rays (1) show some constructive and destructive interferences that can explain the tidal amplification and de-amplification. The impact of local tidal potential on altering the propagating tidal signal is calculated by integrating:

$$\frac{\partial \eta}{\partial t} = -K_{M2}(\omega_{M2} + \frac{2\pi}{T_{M2}})\cos^2\Phi\sin(\omega_{M2}\chi T_{M2} + \chi + 2\lambda) \qquad (1)$$

along the rays. Here, η is the surface elevation, K_{M2} general amplitude of M_2 constituent, ω_{M2} frequency of M_2 constituent, T_{M2} period of M_2, Φ is the latitude and λ is the longitude, χ is the phase of M_2 constituent at time t.

Figure 1 shows the surface elevation difference between the free propagating waves coming through the open boundaries and the LTP forced propagating waves on the

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Florida West shelf. The Florida Big Bend ray is also shown. Integration along this path gives a difference of 0.017m and the net difference is 0.036m.

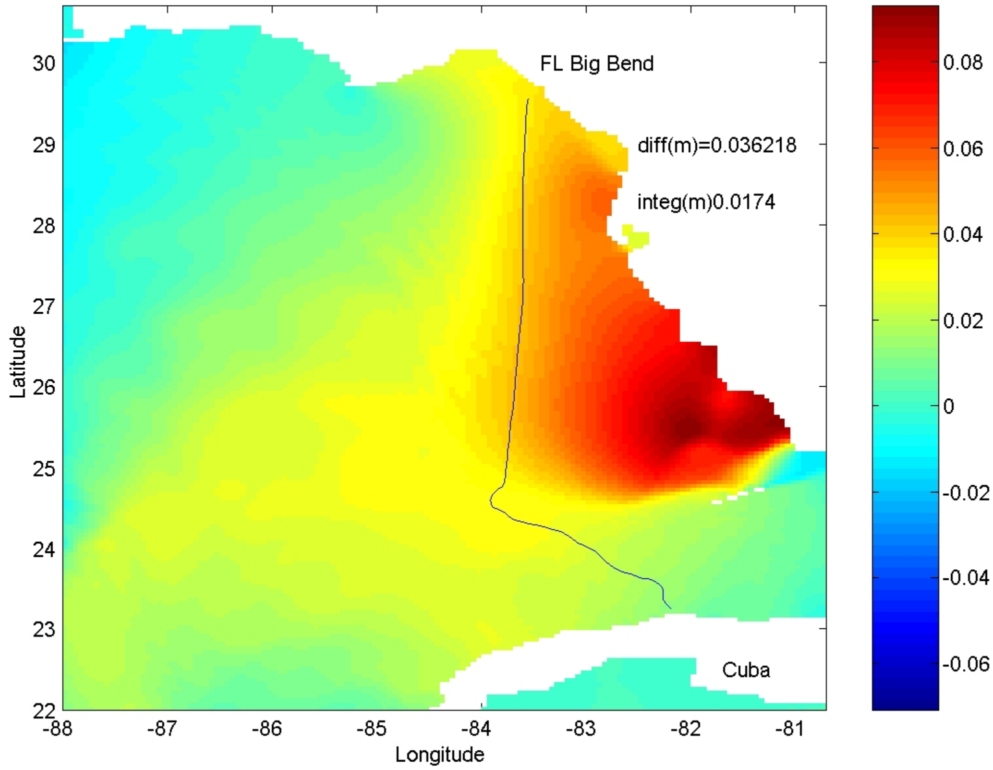

Figure 1: Surface elevation anomaly between free and LTP forced propagating wave (diff in meters) and ray tracing for the Florida Big Bend, integration of the LTP along the ray gives a constructive interference as the free propagating wave surface elevation is amplified by 0.0174 meter.

Numerical models of the GoM need to be accurately forced by the tidal signal at their open boundaries as it is the dominant forcing to get realistic tidal pattern. The LTP appears to be important in bays where the signal is easily amplified or de-amplified. It is clear that LTP is forcing the propagating waves in such a way that constructive interferences are possible in the West Florida Shelf. The work needs to be extended to the west part of the basin, particularly near the Bay of Campeche, where de-amplification is seen.

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