Modeling the M_2 and O_1 Baroclinic Tides in the Gulf of Mexico using the HYbrid Coordinate Ocean Model (HYCOM)

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This study focuses on modeling the baroclinic tidal dynamic in the Gulf of Mexico. In particular, the study addresses the importance of tidal energy conversion in the interior of this basin. A recent paper by *Gouillon et al.* (in review, 2009) computed new estimates of tidal energetics in the Gulf of Mexico using a high resolution model of a barotropic ocean, thus assuming that the bottom friction was the only mechanism for tidal dissipation. Here, we investigate the importance of the tidal conversion process as a contributor to the dissipation of the barotropic tide by considering a baroclinic ocean.

Numerical experiments are conducted with the HYbrid Coordinate Ocean Model (HYCOM) (*Bleck*, 2002) with high horizontal resolution (1/25°). HYCOM is run in a fully isopycnal mode. There is no bottom friction to isolate the tidal conversion process and no diapycnal mixing is prescribed. The initial stratification is the monthly mean of August (summer) when the stratification is the strongest in the GOM. The tides are the only forcing present in the model runs. The tidal forcing is implemented by setting elevations and depth-independent velocities along the open boundaries of the model (Caribbean Sea and Florida Keys) obtained by the North Atlantic 2D model of *Egbert et al.* (*Egbert and Erofeeva*, 2002). Here we considered 2 tidal constituents: M_2 and O_1 tide (12.421 hr and 25.81 hr, tidal period respectively). In the GOM, the K_1 tide is similar to the O_1 tide and the S_2 tidal constituent signal is negligible.

Figure 1 shows the tidal amplitudes and tidal phases in the domain for a) the M_2 tide and b) the O_1 tide. A qualitative evaluation of these results shows that they are in good agreement with previous studies such as *Reid and Whitaker* (1981), and more recently *He and Weisberg* (2002) and *Kantha* (2005). A qualitative validation of the simulated baroclinic tides is made by comparing the results against 62 tidal gauges located around the Gulf of Mexico. The Figure 2 shows: a) the histogram of the difference between observed and modeled tidal amplitudes and b) the histogram of the directional distance. It is clear that both tidal amplitude and phase are well represented in HYCOM.

Estimates of the tidal baroclinic energy are computed in the basin. The depth integrated baroclinic energy densities are computed following *Martini et al.* (2007):

$E = \frac{\rho_0}{2}\int_{-H}^{0}\left\langle u^2 + v^2 \right\rangle_t dz + \frac{\rho_0}{2}\int_{-H}^{0}\left\langle N^2\zeta^2 \right\rangle_t dz$, where, u and v are the eastward and the northward velocities, respectively, ζ the vertical displacement, N the buoyancy frequency spatially averaged over the domain, ρ_0 the average density and H the bottom depth. Figure 3a shows that most of the baroclinic energy is in the vicinity of the West Florida Shelf (WFS) and that most of this energy is trapped in the eastern basin. As the internal waves propagate away from their generation site (WFS), they quickly dissipate as the cross vertical section in Figure 3b shows.

Since the Gulf of Mexico is considered a flat basin, we expect negligible baroclinic tidal energy in the GOM. This is confirmed by the above findings although strong baroclinic tidal energy exists near the Yucatan Shelf and the WFS.

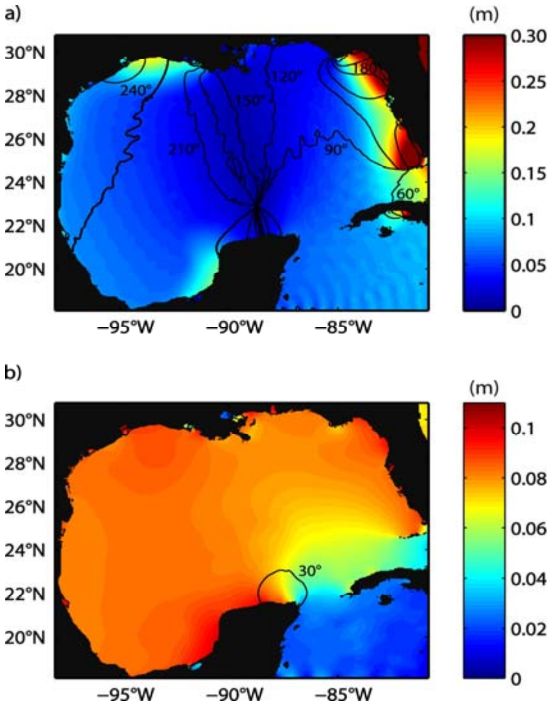

Figure 1: Tidal amplitudes and phases for a) M2 and b) O1

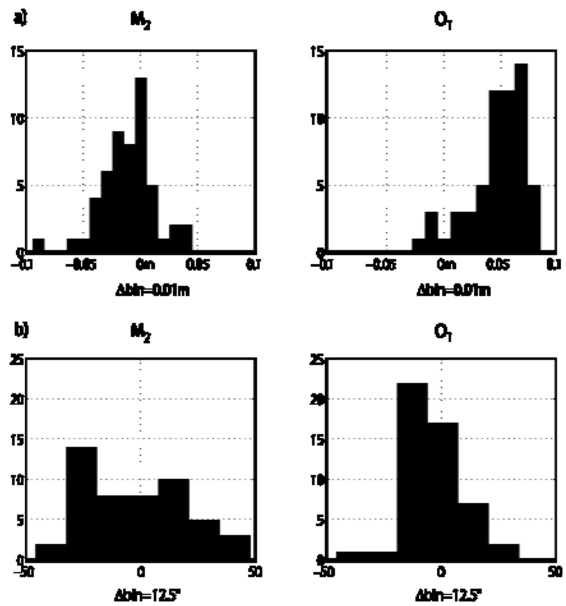

Figure2: M2 and O1 histograms of a) difference between observation and model and b) directional distance

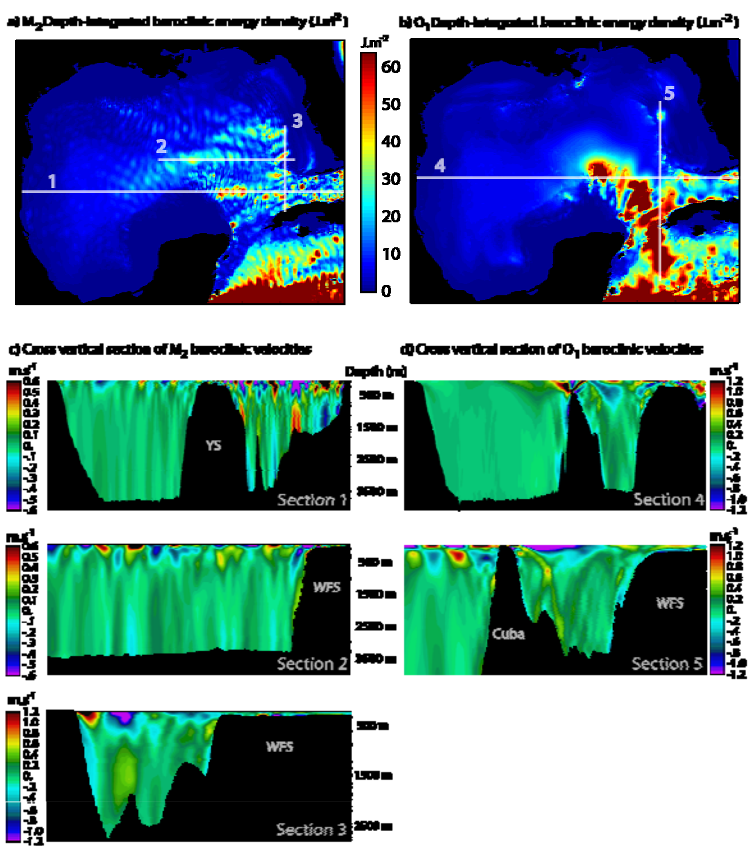

Figure 3