Simulating Tides in the Gulf of Mexico using the HYbrid Coordinates Ocean Model

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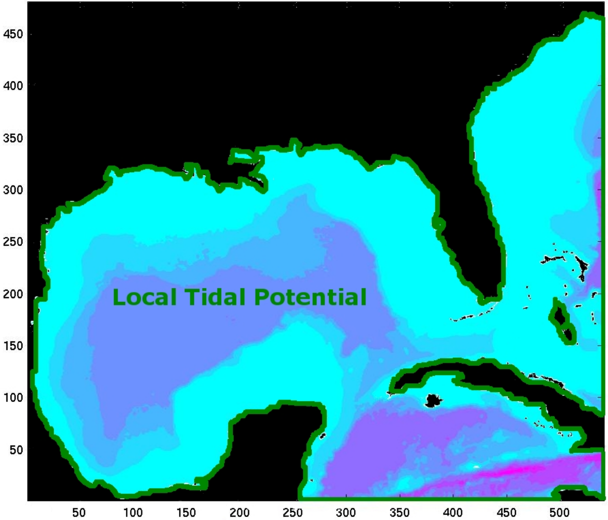
Implementation of tides in a numerical model

In order to implement tides in a semi-enclosed basin one needs to prescribe :

- in the whole domain, a Local Tidal Potential forcing
- at the limits of the domain, an Open Boundaries forcing, which represents the tidal flow coming from outside the domain.

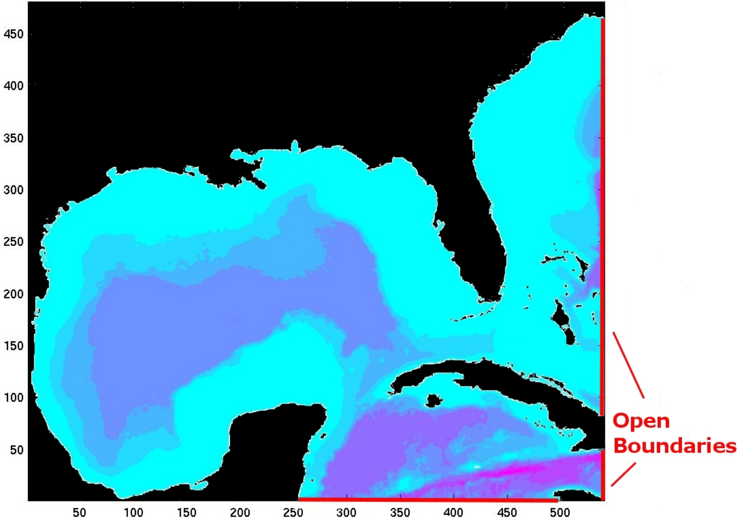
Introduction : Local Tidal Potential (Astronomical Forcing)

The Local Tidal Potential forcing is applied to the whole domain



Introduction : Open Boundaries (Remote Forcings)

The Open Boundaries forcing is applied locally



Introduction

Gouillon et al., 2008

- Simulation of tides in the Gulf of Mexico (GOM) assuming a barotropic ocean and using the Navy Coastal Ocean Model
- Tides are best described when Open Boundaries and Local Tidal Potential forcings are combined
- Bottom friction is the only mechanism of energy dissipation taken into account

Goals of the present study

1. to validate the simulation of barotropic tides in the GOM with HYCOM
2. to consider an additional mechanism of energy dissipation : the conversion from *barotropic* to *baroclinic* modes
3. to quantify the loss of energy due to the internal wave mixing

Proposed work

1. run HYCOM with a barotropic ocean configuration and assess its ability to model barotropic tides. Comparison against :
   - previous numerical experiment with a barotropic ocean using NCOM
   - data assimilative tidal model in the Gulf of Mexico (Kantha's, 2000)
2. run HYCOM with a baroclinic ocean (realistic stratification) and evaluate the loss of energy by tidal conversion process. This should be done with or without bottom friction to isolate the conversion process

Methods : HYCOM

- Vertical coordinate system combines : isopycnal, pressure level (z), terrain following (σ) coordinates
- discretization along isopycnal surfaces provides physically more realistic flows and prevents spurious diapycnal mixing
- η is assumed to be null in the pressure gradient $\Rightarrow$ limitation in the coastal areas

Methods

Model configuration

- domain : Gulf of Mexico + Atlantic
- resolution : 1/25°, i.e. 541×481 grid points
- barotropic configuration $\Rightarrow$ 3 layers, $O(\Delta\rho) \approx 10^{-3} kg.m^{-3}$
- full isopycnal coordinates
- model is run for 15 days (spin-up is reached after 4 days)
- the last 4 days are used to compute tidal amplitudes and phases

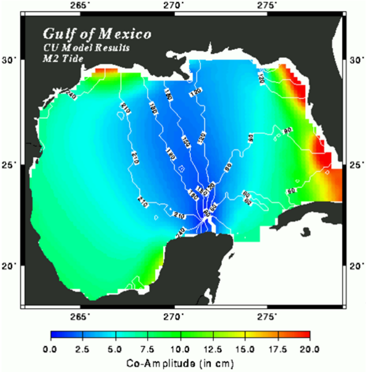
Boundaries conditions :

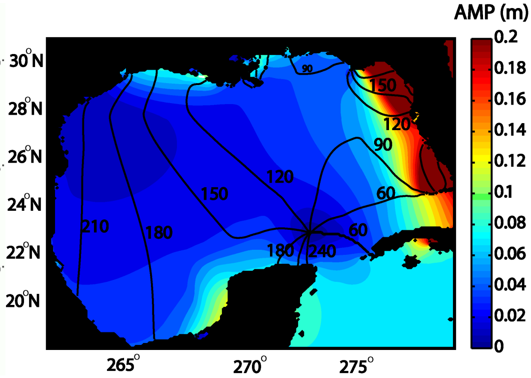
- Tidal forcing at Open Boundaries obtained with an inverse global model (Egbert's TPX06.2 model)
- Flather condition at Open Boundaries
- Bottom friction

Preliminary results :

Comparison of phases and amplitudes for M_2 and O_1 tides between HYCOM, NCOM and observed tides

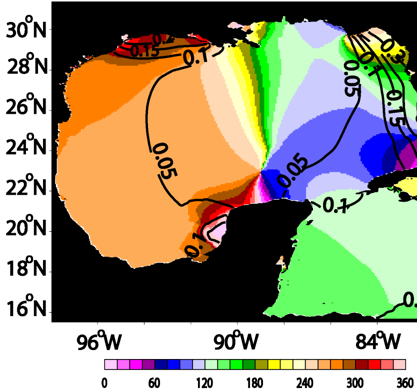
Kantha's model for M_2 tides **HYCOM simulation for M_2 tides**



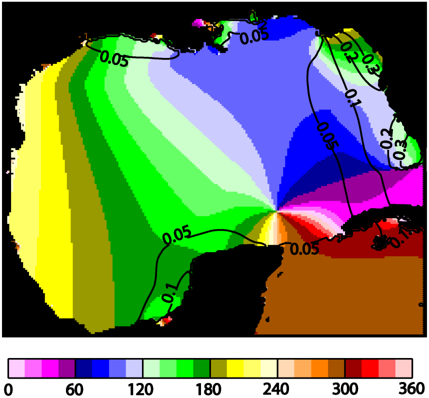


- In HYCOM the near-coast amplitudes are too weak in the West part of the basin
- The position of the amphidromic point is slightly shifted to the east

NCOM simulation for M_2 tides

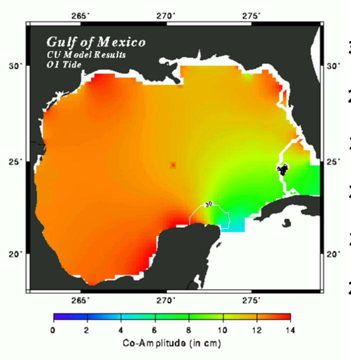


HYCOM simulation for M_2 tides

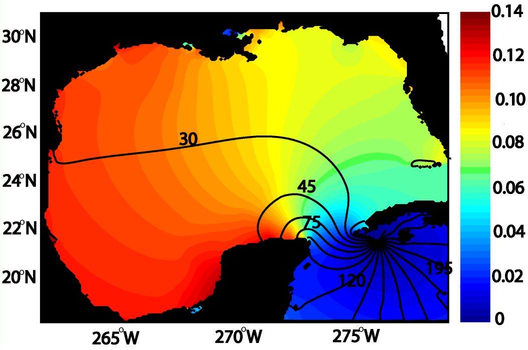


- A differente shape of the coamplitude lines 0.05 m in the middle of the basin (Yucatan Channel Mexico coast)
- General phase lag in the basin and absence of reflection pattern in the Louisiana bay

Kantha's model for O_1 tides

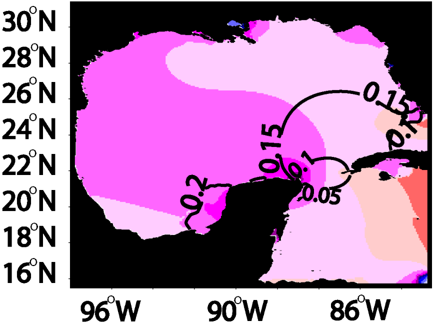


HYCOM simulation for O_1 tides

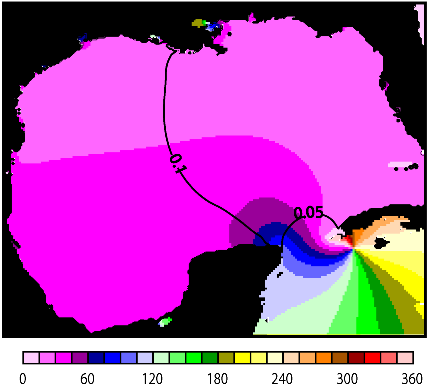


- Good agreement of tidal amplitudes in the main part of the domain

NCOM simulation for O_1 tides

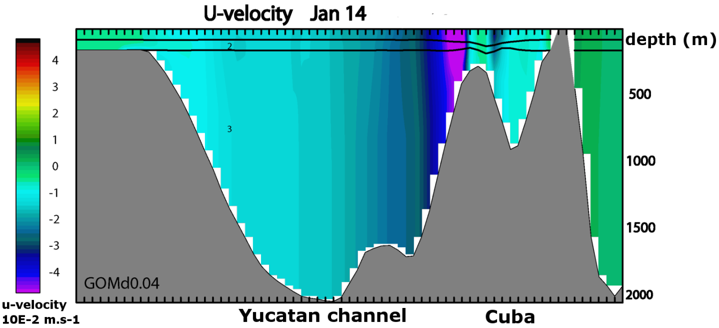


HYCOM simulation for O_1 tides



- The amphidromic point is shifted to the S-E
- NCOM has higher tidal amplitudes

Preliminary results : Limits of our barotropic approximation



- No propagation of internal tides because of the barotropic ocean configuration
- A realistic density gradient would generate internal gravity waves on steep topography

Conclusion

So far the simulation is promising. However more exploration on tidal phases and local tidal potential implementation need to be done. Some of the differences could be explained by :

- bathymetry smoothing and resolution (too coarse)
- geometry of the basin