Internal Tides in a Global Ocean Circulation Model: Generation and Propagation into the Coastal Ocean

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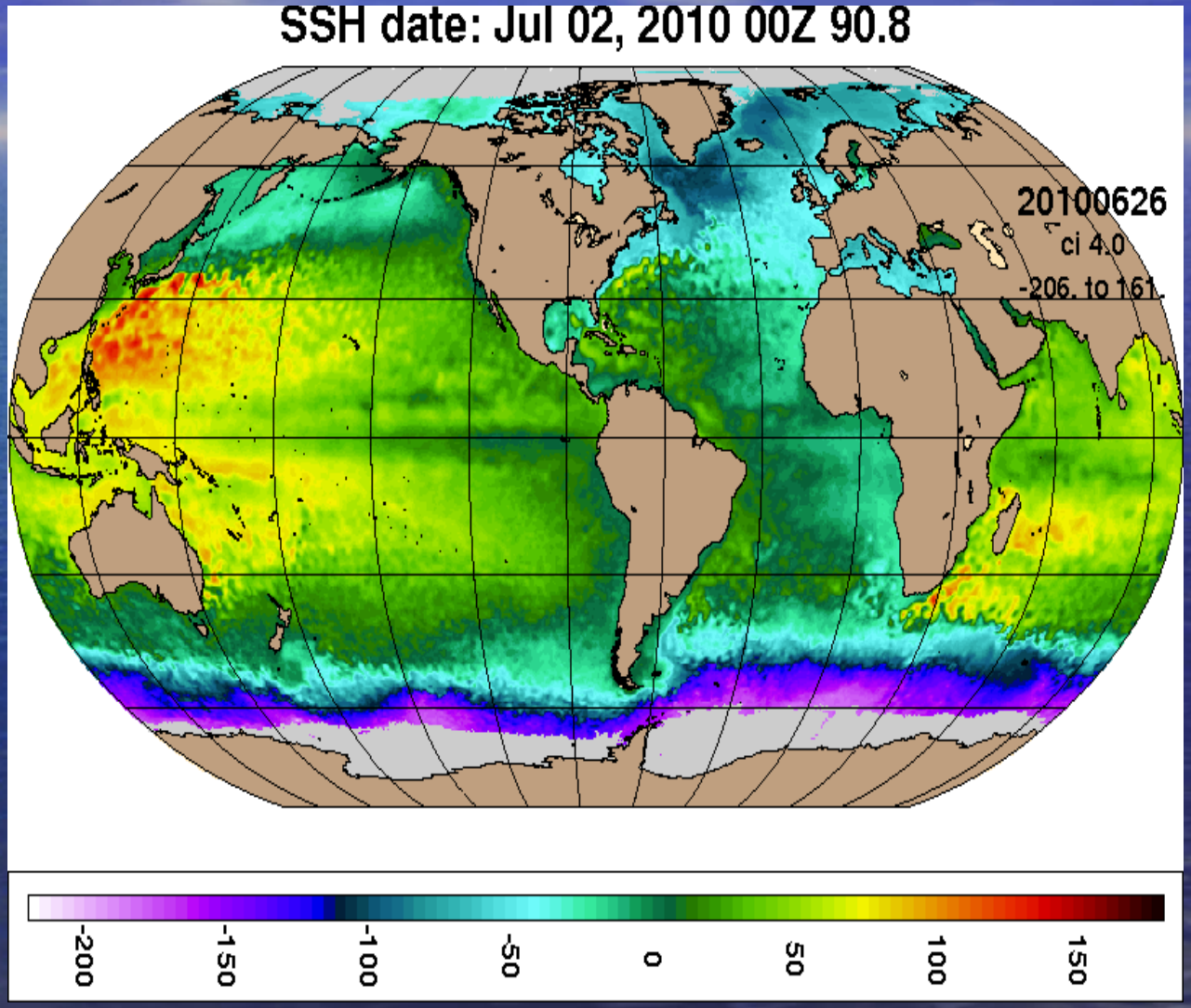
Internal Tides in a Global Ocean Circulation Model

- Today I will briefly describe the NRL effort to include tidal forcing in the global ocean forecast system
  - We have a long simulation with forcing by the tidal geopotential and realistic wind stress and buoyancy forcing with an equatorial resolution of 9 km
- I present preliminary comparisons to the TPXO7.2 barotropic tidal model, Richard Ray's along-track altimetric tidal analyses and historical current meter moorings
- The model drag is tuned to give good agreement with the pelagic tide gauges
- The model shows localized generation of the internal tide and propagation for 1000's of km as seen by Ray, Alford and others
- The comparison with the current meter moorings is problematic due to the difficulty in recovering the barotropic tide, intermittency of the internal tide and deep intensification of the tidal flow in the model
- A caveat from the Ph.D work of Sam Kelly at Oregon State shows that shoaling internal tides can impact the tides on the shelf

Global HYCOM Ocean Forecast Model

- NRL runs a global ocean forecast system
- Uses the Hybrid Coordinate Ocean Model
- 1/12° horizontal resolution
- 32 vertical layers

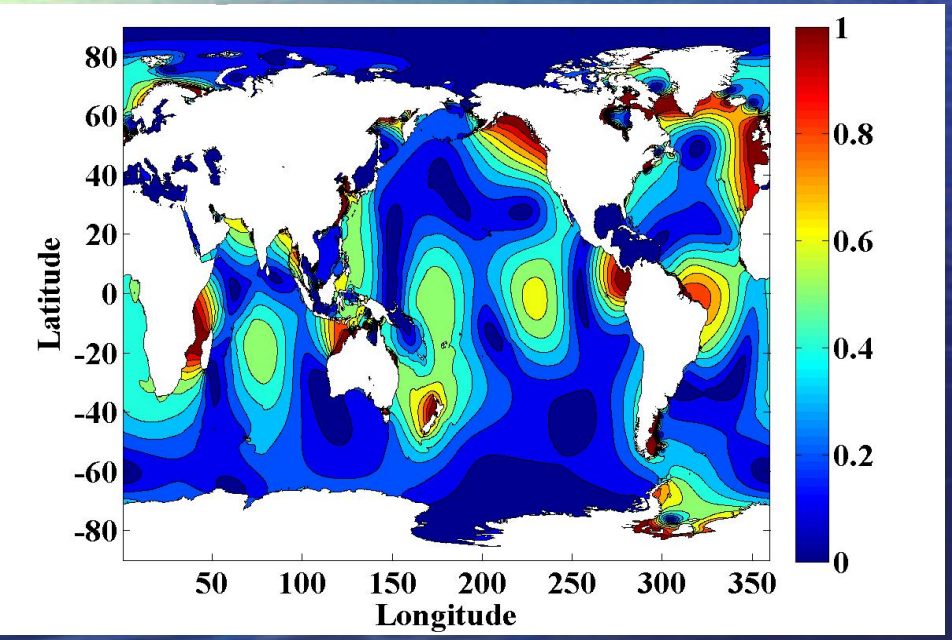


Modeling tides in the global model

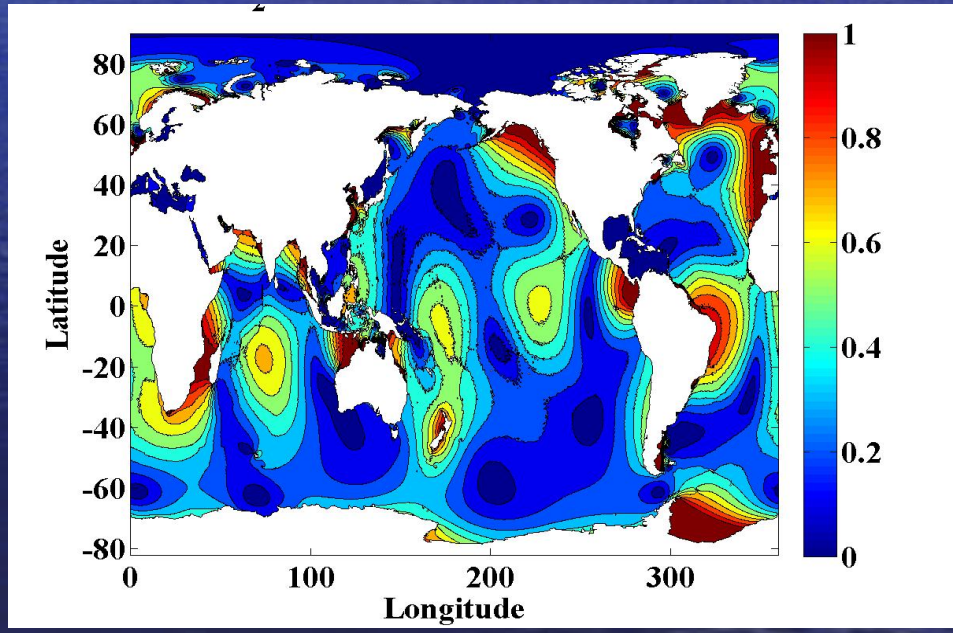
- In the global model, the body forces due to the tidal potential, self attraction and loading have been added
- Tidal Forcing with 8 constituents:
  - Semidiurnal M_2, S_2, N_2 and K_2
  - Diurnal O_1, P_1, Q_1 and K_1
- Topographic wave drag is applied to the tidal motions
  - The form of the drag is generalized from the linear topographic wave drag, but tuned to minimize the difference with the 103 pelagic tide gauges using a barotropic version of the model

Comparison of M_2 tide from Inverse Model (TPXO7.2) and HYCOM Simulation

TPXO7.2 M_2 Tidal Model

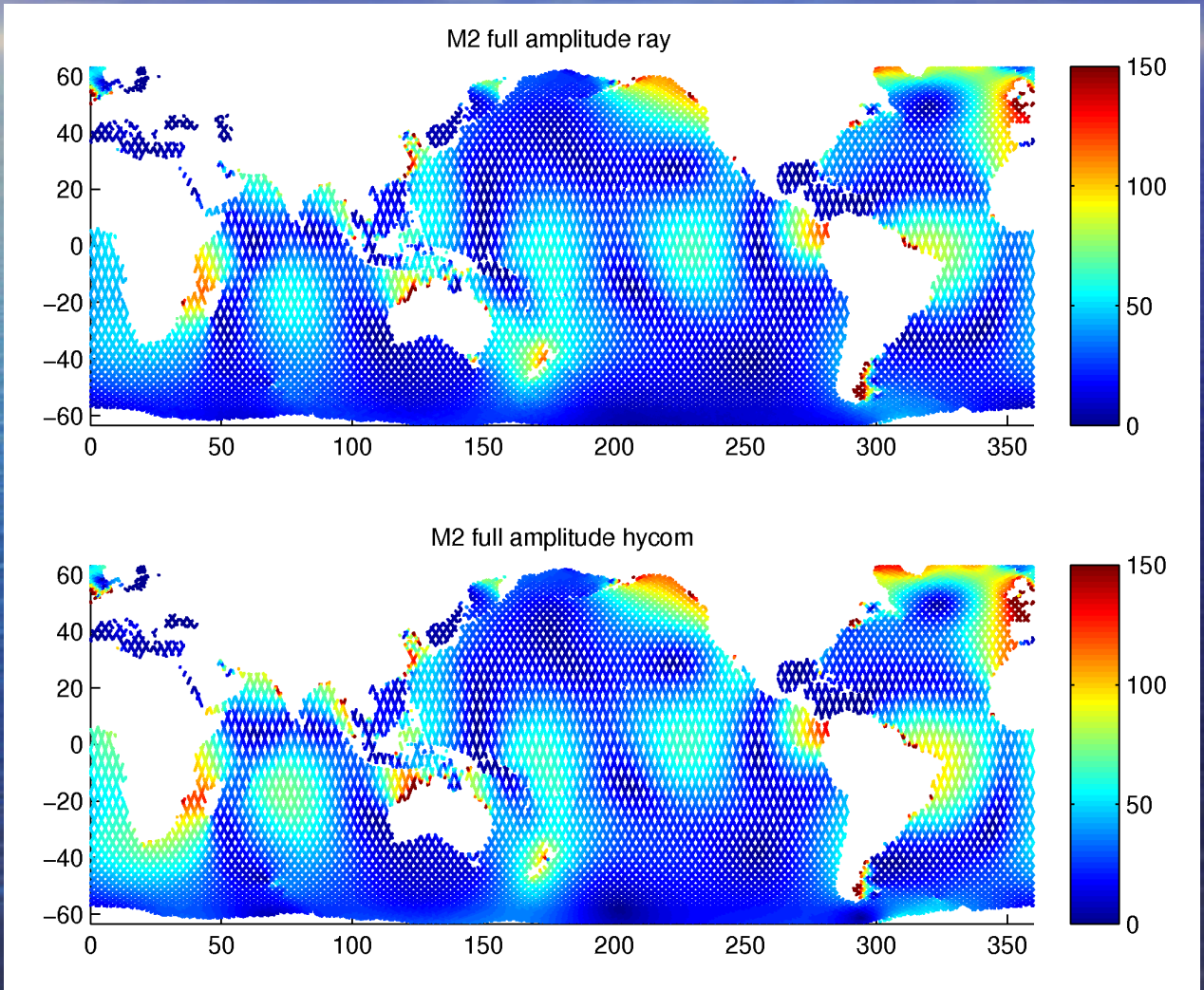


HYCOM M_2 Tide

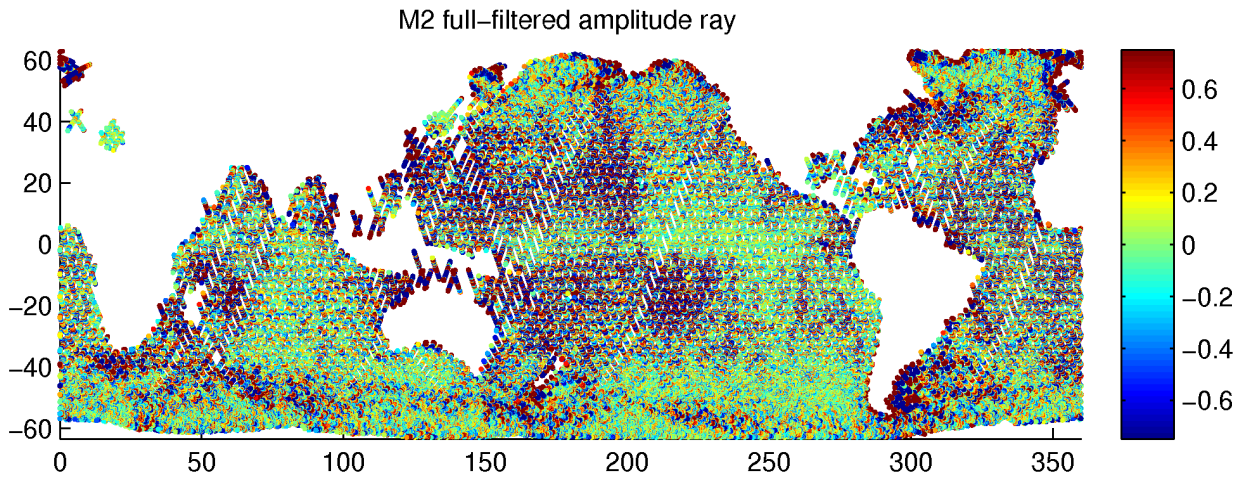


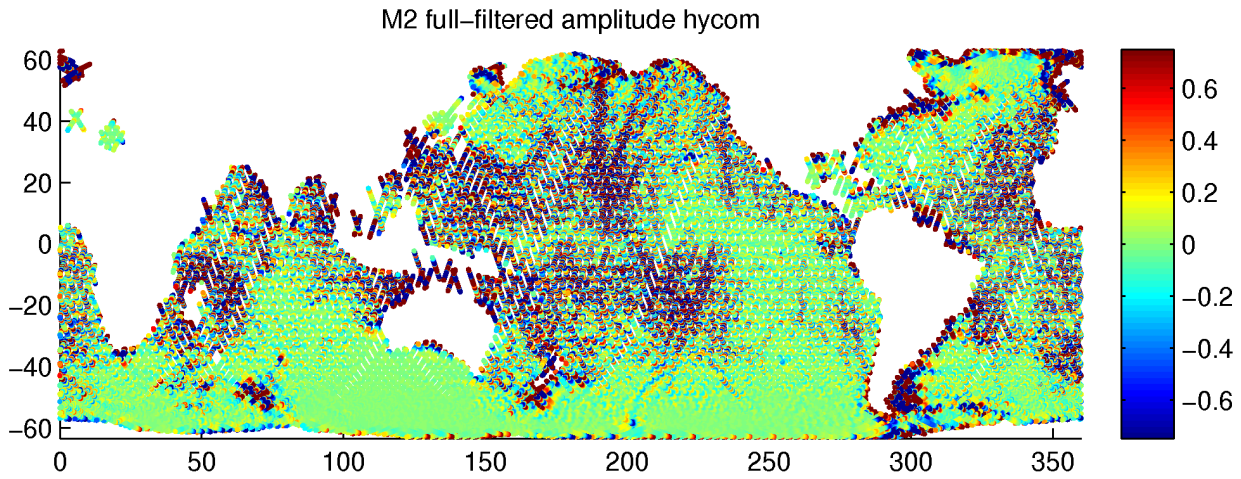
Difference with 102 pelagic tide gauges 7.8 cm rms
Difference with TPXO7.2 model 5.4 cm rms

Comparison to the Altimetric tidal solution of Richard Ray

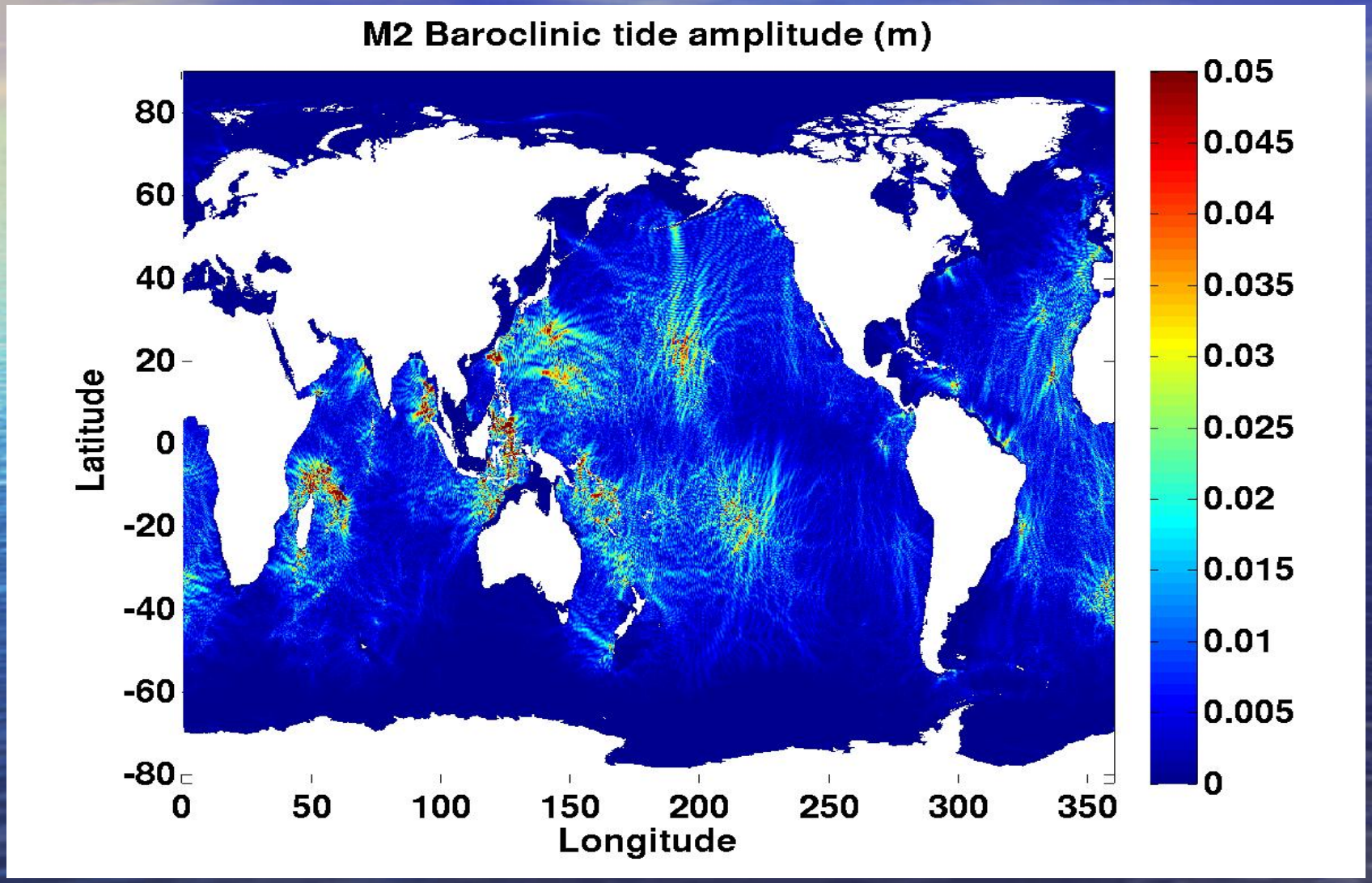


Internal Tides in the Altimetric and model SSH via filtering



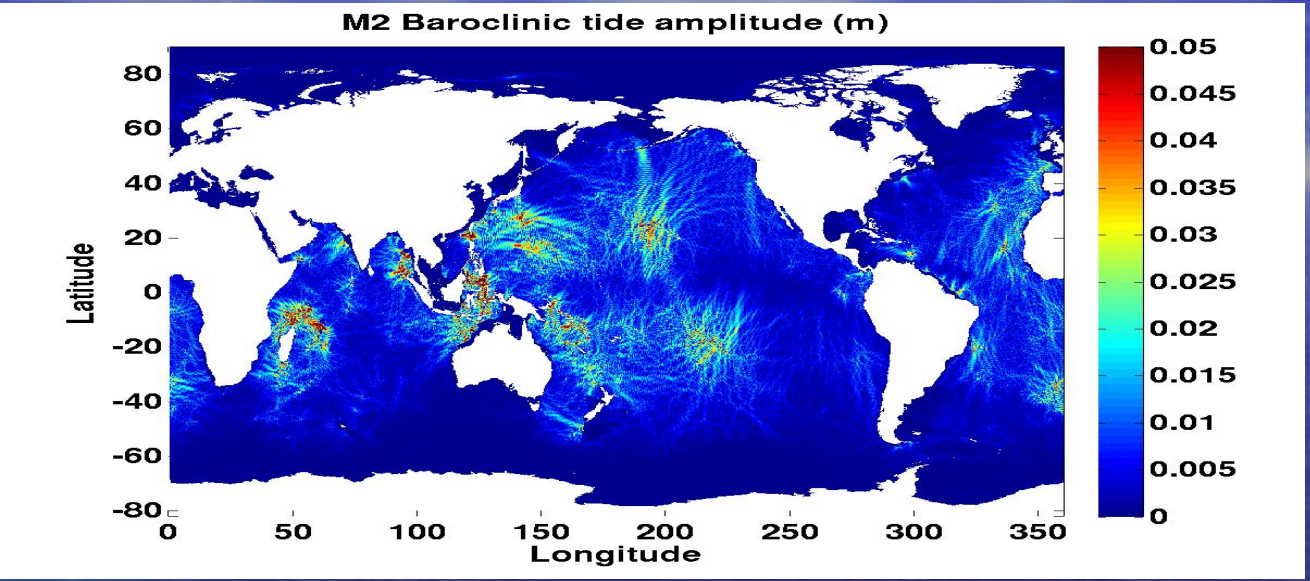


M_2 tidal amplitude from global model steric sea surface height



Baroclinic tides in models

HYCOM 18.5 with variable stratification and circulation



Two layer model with uniform stratification and no circulation

Simmons et al 2008

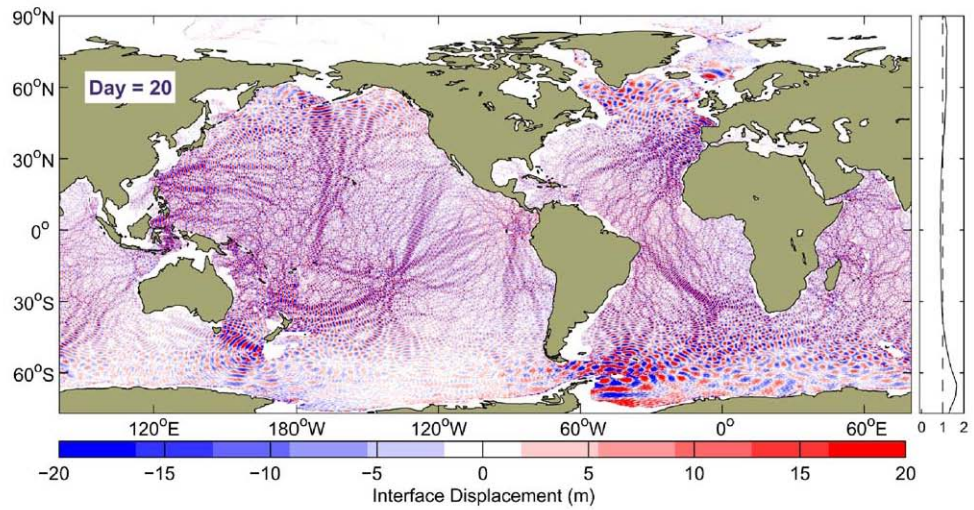


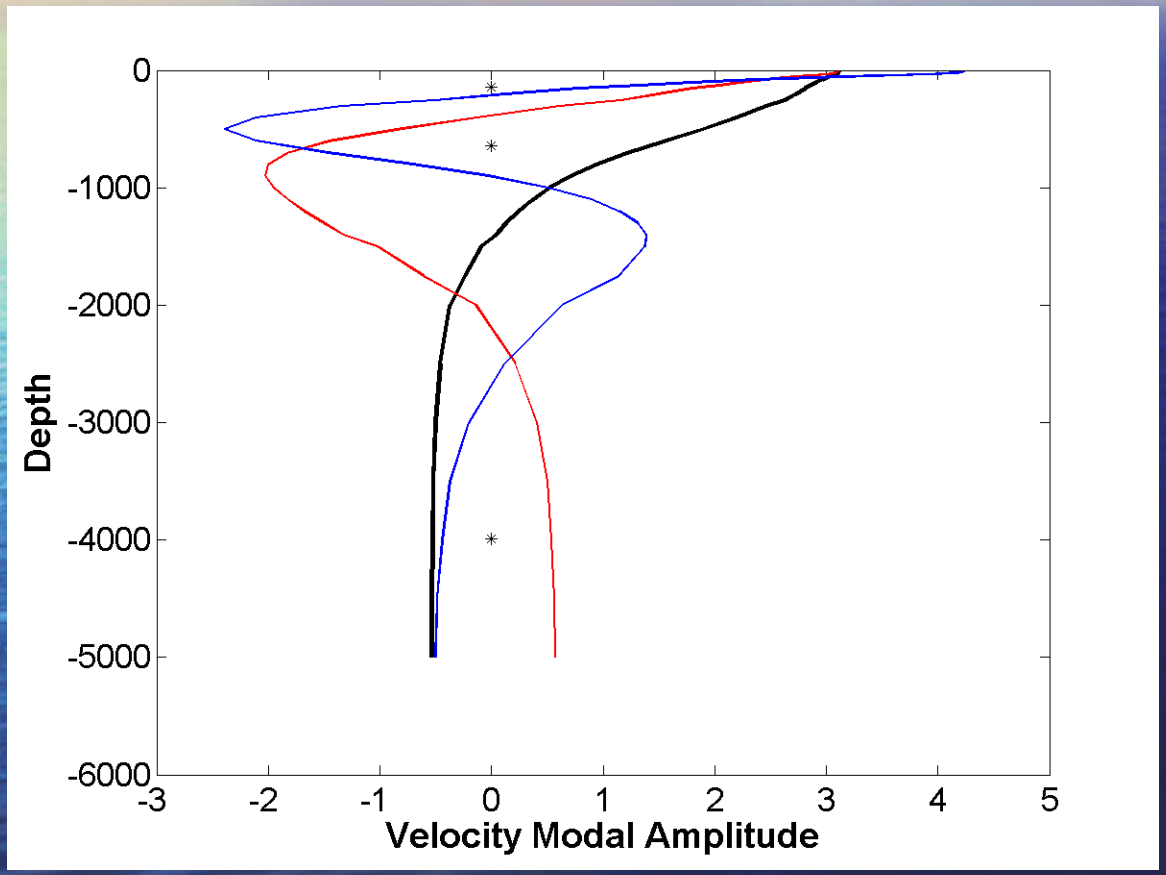
Fig. 8. Interface displacement, $\hat{\eta}$, normalized according to Eq. (15), on day 20 of spinup of the two-layer M_2 simulation. The resting depth of the interface is at 1100 m. The zonal mean of the normalization factor is shown on the right side of the plot.

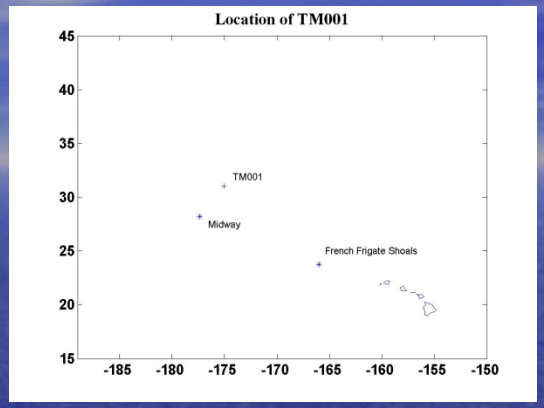
Current Meter Database

- Collection of approx 9000 current meter records accumulated by R.B. Scott:
  - OSU Buoy Group Archive
  - OSU Deep Water Archive
  - WHOI data
  - Additional moorings from other sources
- Existing records have lengths ~10 days to 2 years
- Records cover about 35 years ~1970-present
- Additional current meter records are continually being added to the database
- Record selection criteria:
  - Moorings with at least 3 instruments
    - One instrument above 800m and one instrument below 2000m
  - Observation interval:
    - Prefer hourly or shorter sampling
  - Length of Record:
    - Minimum of 180 days

173 moorings meet these criteria

Normal Modes for mooring near Midway Island

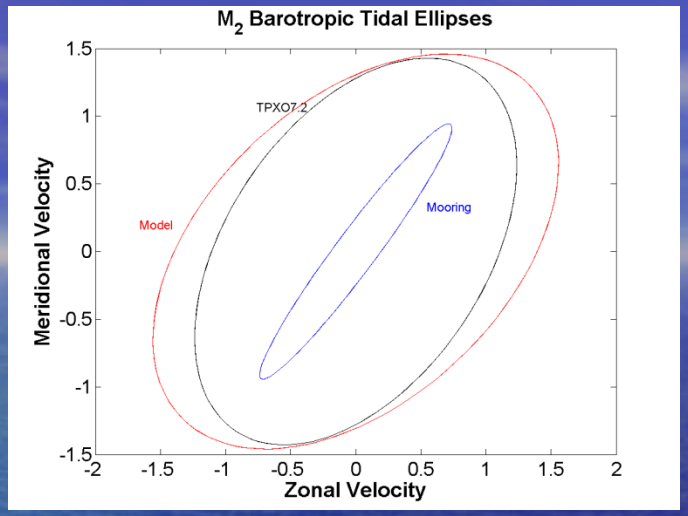


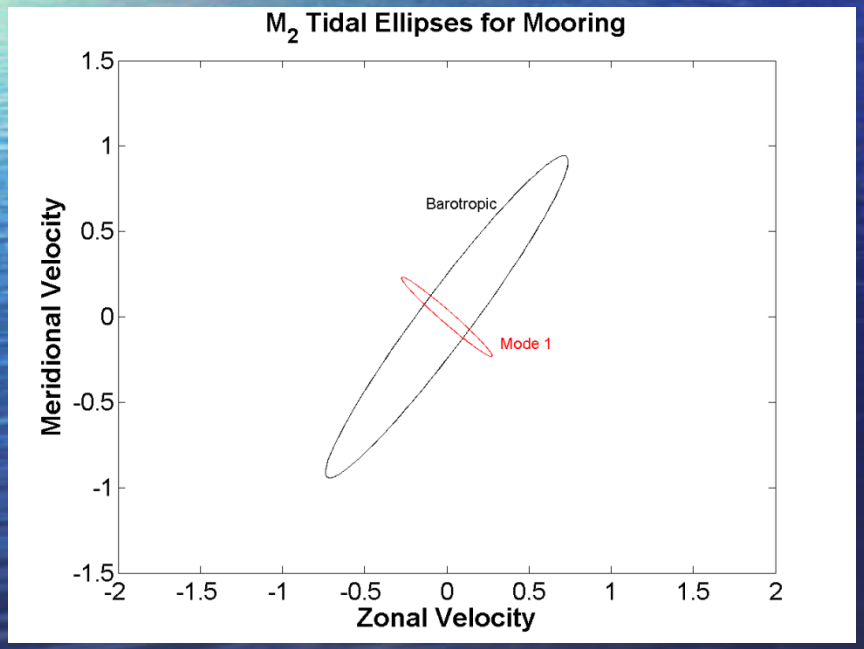


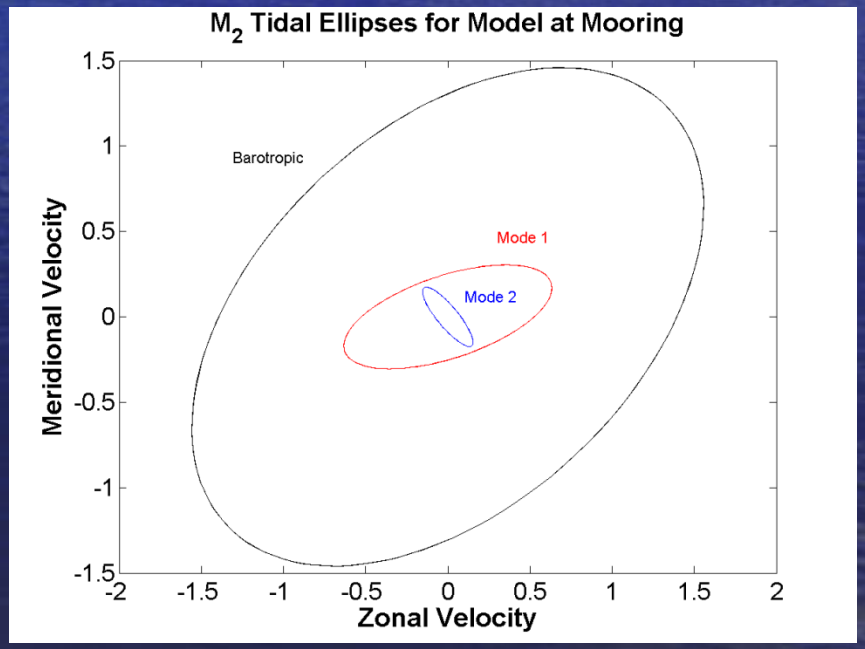
The distribution of current meters is marginal, barely able to resolve the first mode.

The poor resolution of the mooring data is a common and serious problem with leakage from high modes and poor estimates of the barotropic mode

Barotropic and Baroclinic tidal ellipses





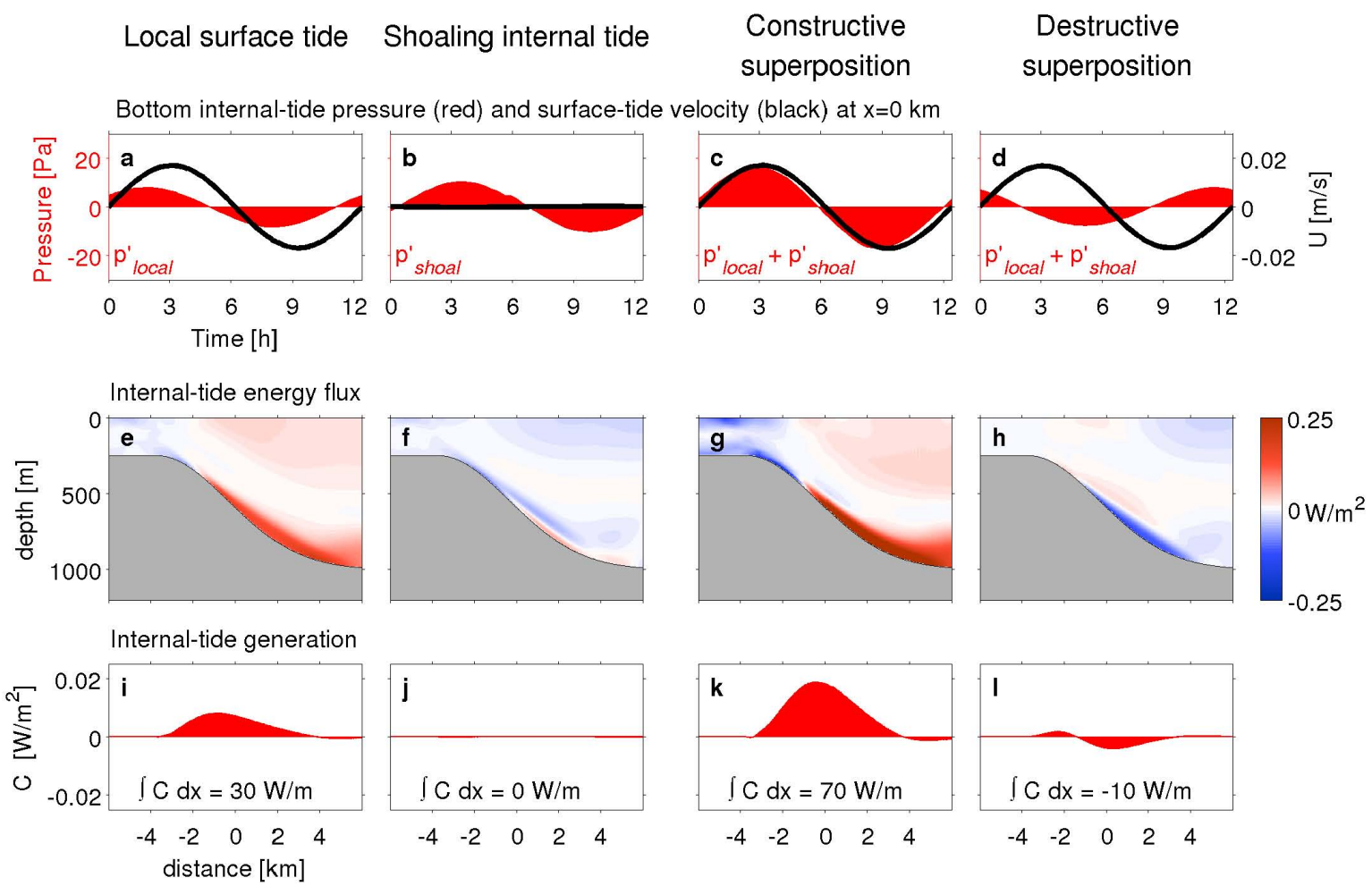


The barotropic tidal velocity is much weaker at the mooring and the orientation of the baroclinic ellipse is off by 90°. The model compares well with TPXO7.2

Are the remotely generated internal tides important to the coastal regions?

- Recent work by Sam Kelly at Oregon State University suggests the internal tides impinging upon the continental slope can impact the tides on the continental shelf
  - Neglect of the shoaling internal tide may lead to problems in local models
  - The phase of the shoaling tide is important

Impact of Shoaling Internal Tide



Kelly and Nash (submitted), *Geophys. Res. Lett.*