

The Energy Budget of an Altimeter-Derived Baroclinic Tide Model

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Talk EGU21-7887, EGU General Assembly

Session OS4.1 “Tides in the past, present and future”, April 29, 2021

Motivation

- Dissipation of internal tides may drive mixing to sustain the global meridional overturning circulation.
- The dissipation must match the generation; can it be quantified?
- Data-constrained baroclinic tide models are useful for SSH prediction (Carrere et al 2021 *Ocean Sci.*, **17**, 147–180).
- To what extent can models of SSH be used to study tidal dynamics, including tidal energetics?

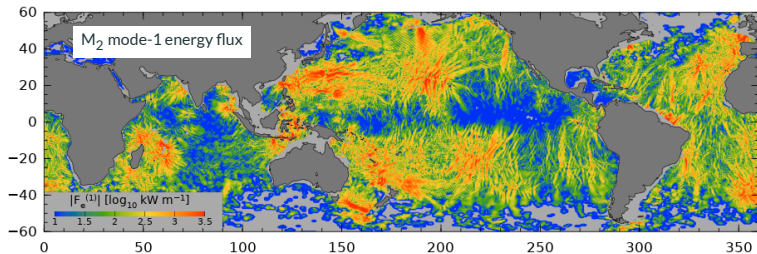
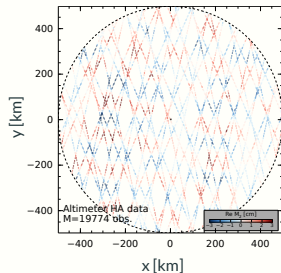
Use “High Resolution Empirical Tide” (HRET) model of baroclinic SSH to examine this question.

Outline of this talk

- HRET Model: What is it? How was it created?
- Baroclinic dynamics: What points of comparison with HRET can be made?
- Mode-1 baroclinic phase speed: observations vs. theory
- Energy flux divergence

Take-home message: Using coupled shallow water equation dynamics, HRET can be used to compute velocity, energy, and energy flux. While the energy flux divergence appears reasonable, it is about a factor of two smaller than independent estimates based on semi-analytical linear theory.

HRET: a kinematic model for baroclinic SSH



$$\eta(x, y) = \sum_{j=1}^N \sum_{k=0}^2 \sum_{l=0}^{2-k} (a_{klj} x^k y^l \cos(\mathbf{k}_j \cdot (x, y)) + i b_{klj} x^k y^l \sin(\mathbf{k}_j \cdot (x, y))), \quad (1)$$

Fit local solutions on overlapping domains, then interpolate η to uniform 0.05° resolution.

Interpreting Baroclinic SSH: Coupled Shallow Water Equations

Use coupled shallow water (CSW) equations of Kelly (2016), a projection of the linearized dynamics on locally-defined vertical modes.

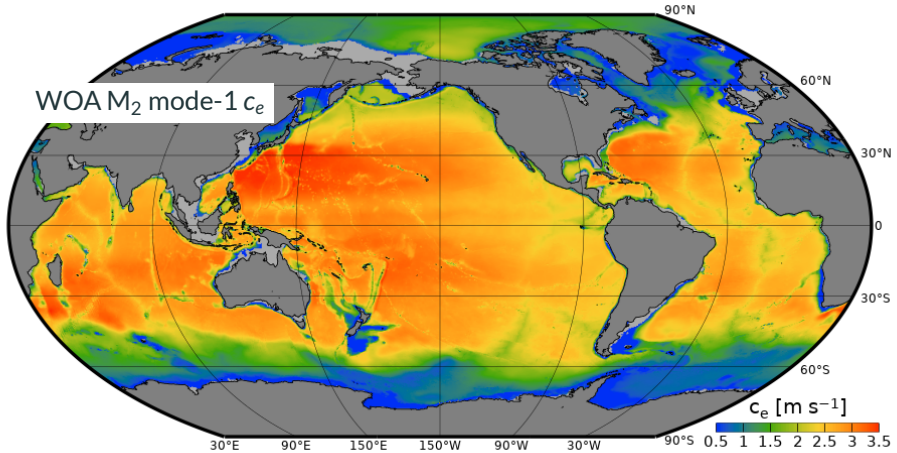
1. How well do the observed phase speeds compare with the predictions?
2. Which terms in CSW can be estimated from HRET SSH? Can one derive velocity?
3. Does energy flux, $\mathbf{F} = H\mathbf{u}p$, agree with $\mathbf{c}_g E$?
4. Is $D = \nabla \cdot \mathbf{F}$ usefully accurate?

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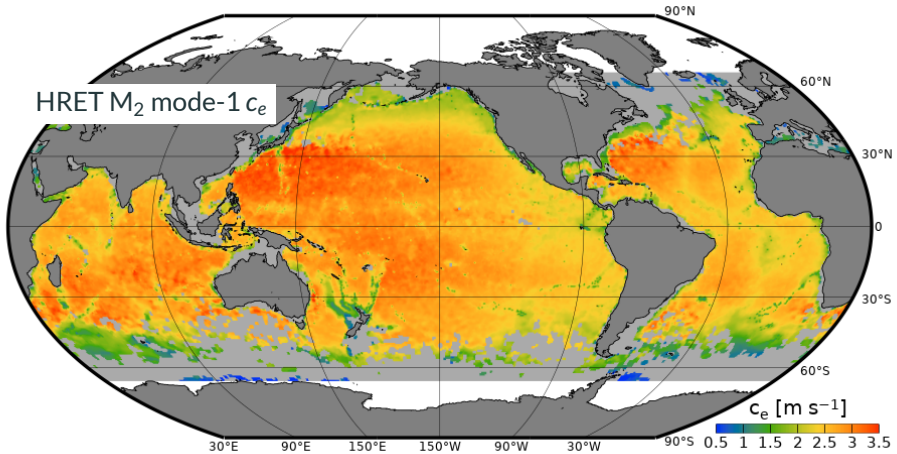
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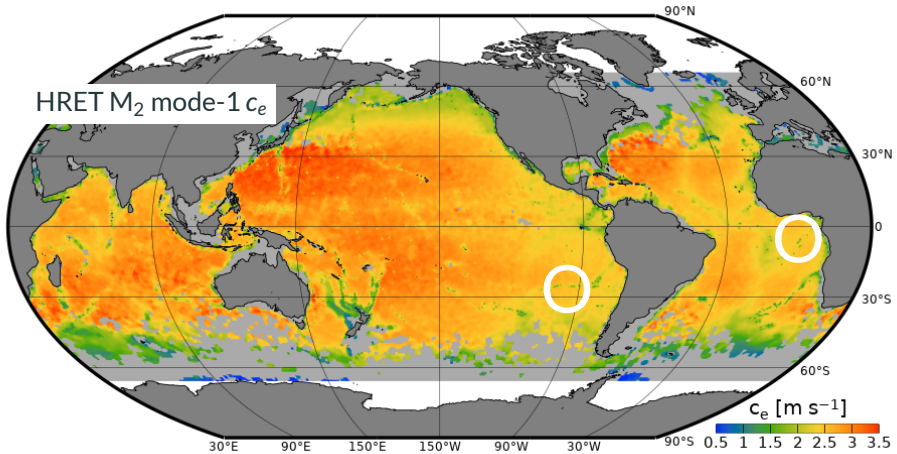
Theoretical vs. observed eigenspeed



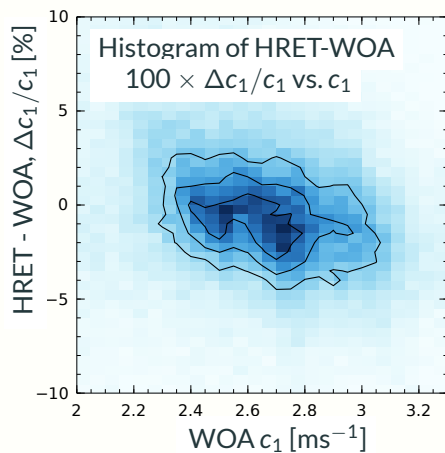
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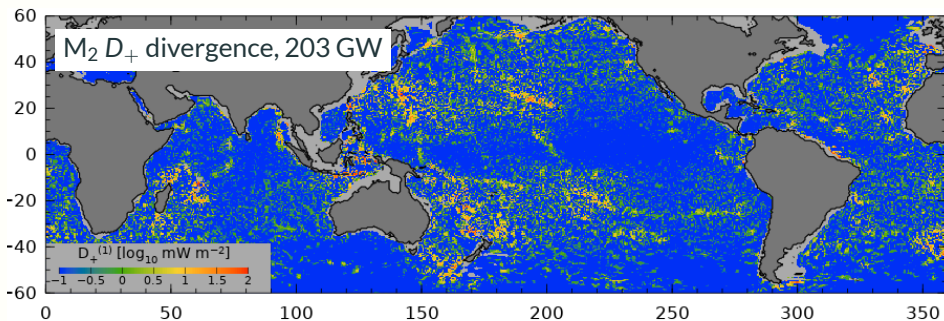
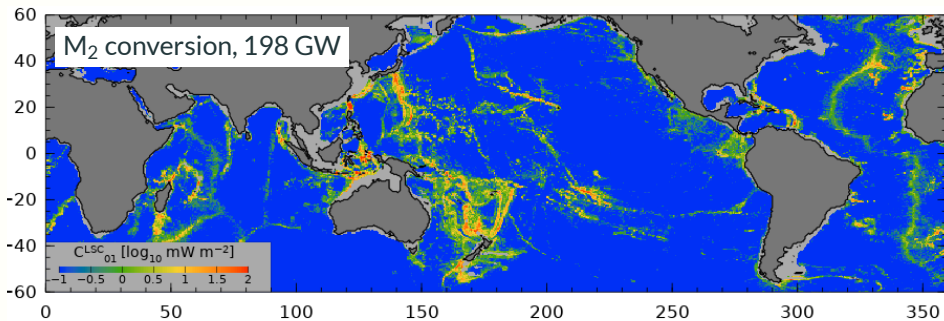
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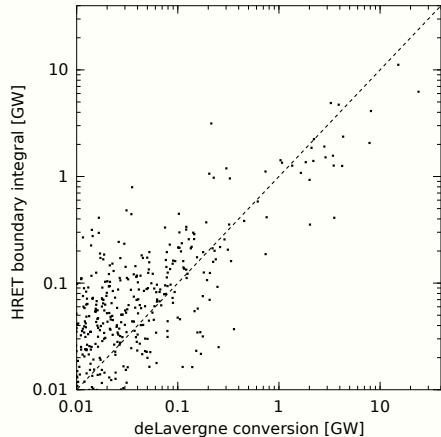
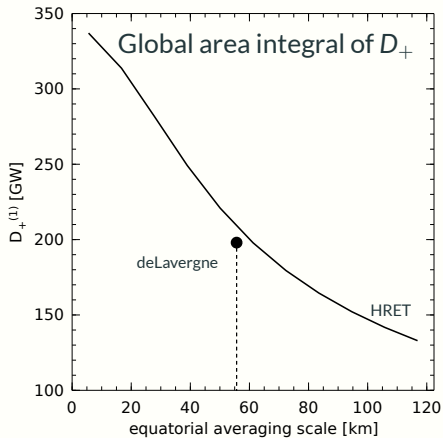
HRET Energy Flux Divergence

Compare HRET-derived $D = \nabla \cdot H\mathbf{u}_1 p_1$ with an independent estimate of the mode-1 generation from deLavergne et al (2018).

1. The divergence is a noisy field!
2. Previous publications considered D_+ , the area-integral of positive values of D .
3. Here we compare the contour integral of the normal flux of outbound waves with the area-integrated generation of deLavergne et al (2018).



HRET Energy Flux Divergence



Contour integrals are along boundaries of patches exceeding 1 mW/m^2 generation, based on deLavergne.

Conclusions

1. HRET-derived eigenspeeds agree well with theory, which provides confidence in using CSW to interpret dynamics.
2. The CSW term balances make sense insofar as they can be diagnosed.
3. Velocity, energy, and energy fluxes appear reasonable for mode-1 M_2 , K_1 , O_1 .
4. Mode-1 M_2 energy flux divergence is comparable to the independent estimate of barotropic-to-baroclinic generation of deLavergne et al (2018).