Modeling studies of internal tide generation at the Hawaiian Ridge: Comparison to inferences from altimetry

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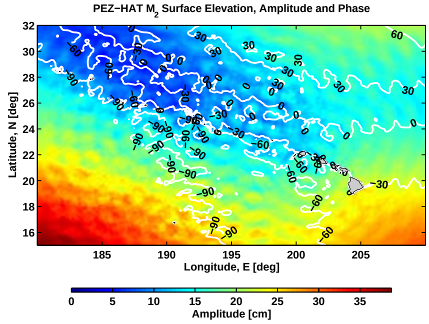
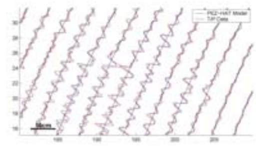
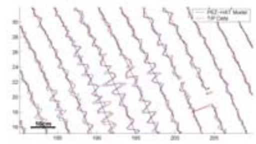
PEZ-HAT: A 3D primitive equations model for internal tide modeling and assimilation

- Z coordinates in vertical, split time step; numerics based on MOM
- partial cells in vertical
- Resolution: 1/30 degree, 50 levels in vertical (variable)
- Normal component of barotropic (M_2) transport specified; radiation of baroclinic velocity and tracers + sponge layer
- Vertical mixing: $K_v = 5$ cm^2/s; $K_\rho = 0.5$ cm^2/s; Horizontal mixing: $A_v = A_\rho = 12.5$ m^2/2
- unsmoothed bathymetry from Smith and Sandwell
- Forward integration for 28 M_2 periods; harmonic analysis for last 2 periods

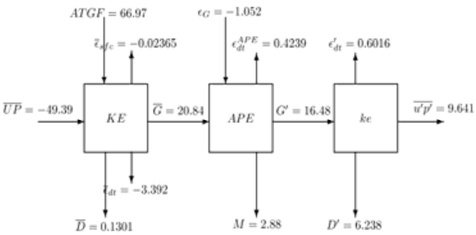




High-passed surface elevation amplitudes: model vs. T/P

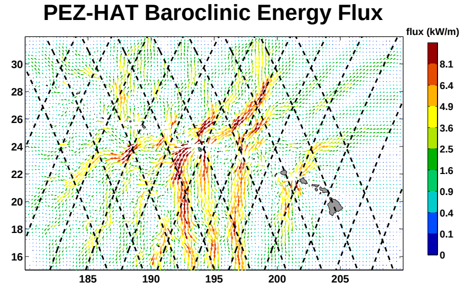


PEZ-HAT Energy Budget



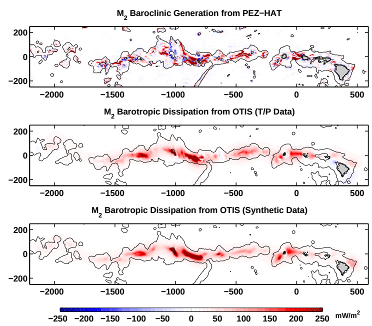
- **Block diagram of PEZ energy budget (in GW) for the Hawaiian ridge domain, including truncation error (left); KE, ke, and APE represent reservoirs of barotropic kinetic energy, baroclinic kinetic energy, and available potential energy**
- **Validated against 2D analytical solution of Petrellis and Young (2004)**
- **Model baroclinic energy flux is concentrated in relatively narrow streams (right, with T/P-Jason ground tracks overlain)**

PEZ-HAT Baroclinic Energy Flux



Synthetic Data Experiment I: Validation of barotropic energy "dissipation" estimates from altimetry

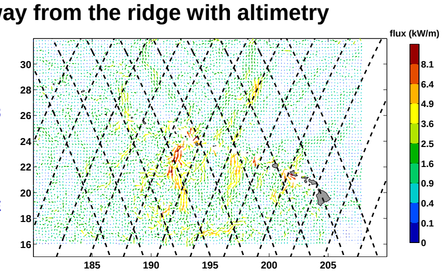
- **Sample model surface elevation along T/P-Jason track**
- **Assimilate synthetic data into shallow water equations model, estimate barotropic energy loss as in Egbert & Ray (2000, 2001) (lower panel)**
- **Compare to actual conversion from KE to APE (top panel)**
- **Inferences from shallow water inversion of synthetic altimetry data are quite accurate, and also agree well with estimates from actual T/P data (middle panel)**



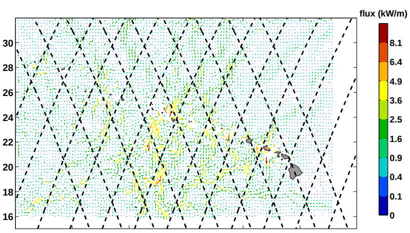
Synthetic Data Experiment II: Mapping baroclinic flux away from the ridge with altimetry

Reduced gravity Inversion:

- **Express surface elevation as a sum of 2-3 flat bottom modes**
- **Assimilate along track HC using modified shallow water equations**
- **Each mode satisfies LTE with reduced gravity**
- **Apply RG inversion to PEZ-HAT surface elevations measured on T/P tracks**



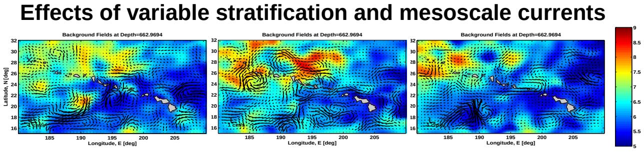
estimated flux significantly less than actual for synthetic data



- **Application to T/P-Jason data also results in significantly weaker fluxes than seen in PEZ-HAT**

Spatial structure of baroclinic flux is poorly sampled by T/P-Jason; some previous estimates of flux away from the ridge based on altimetry are almost certainly biased low

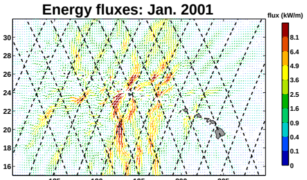
Effects of variable stratification and mesoscale currents



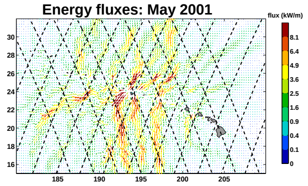
PEZ-HAT : linearized runs with spatially variable (steady) background fields

- **Stratification and currents from SODA-POP (J. Carton; examples above)**
- **Ensemble of runs: every 2 months for 10 years**
- **Analyze variability of harmonic constants to calibrate altimetric estimates of (phase locked) internal tide surface elevations**

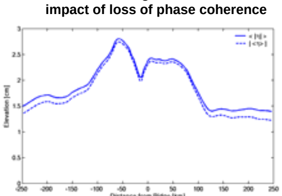
Energy fluxes: Jan. 2001



Energy fluxes: May 2001



Decay of surface elevation amplitude with distance from ridge: an estimate of the impact of loss of phase coherence

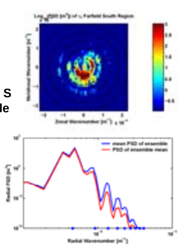


Right: wavenumber power spectrum for an area 250 km S of Oahu, comparing ensemble average PSD to PSD of ensemble average:

Mode 1: 87% coherent

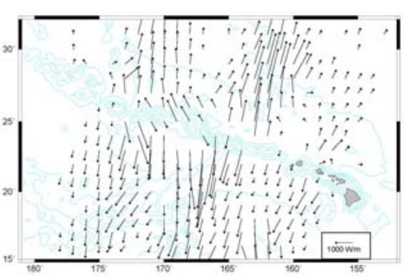
Mode 2: 40% coherent

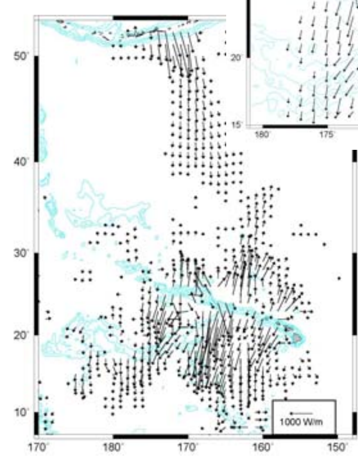
Mode 3: 20% coherent



Fitting altimetry to plane waves locally: Ray and Cartwright (2001)

Right: application to synthetic altimetry data





Left: application to T/P data (Ray and Cartwright. 2001)

- **Altimetry data in a 2x3 degree box is fit to plane wave model.**
- **Flux computed in each box (overlapping, offset by 1 degree)**
- **Amplitudes are similar for synthetic, real data**
- **Peak fluxes are much smaller and less focused, as with reduced gravity inversion**