The partitioning of coherent and incoherent tidal energy near the Hawaiian Ridge

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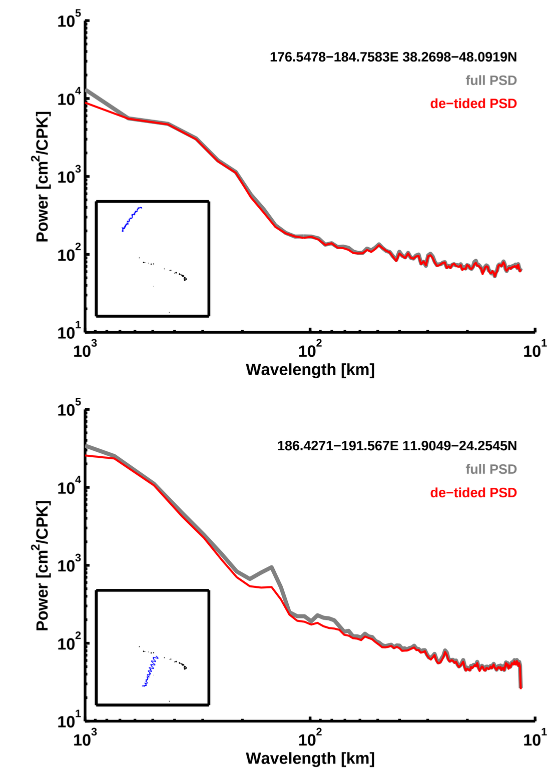
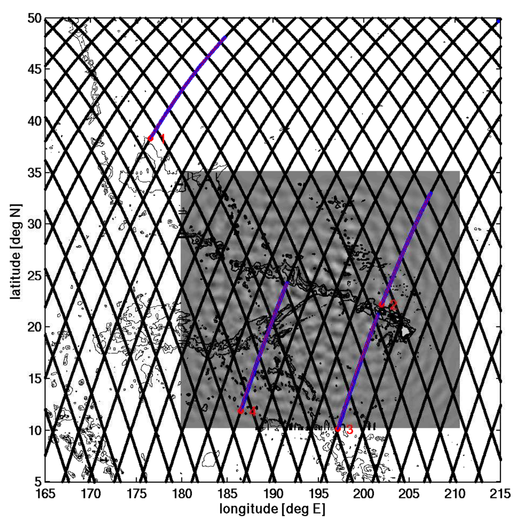
Introduction

The phase-coherent component of surface elevation associated with the tide can be identified by harmonic analysis of satellite SSH. After the coherent component of tidal variance is subtracted, excess variance in the along-track wavenumber spectra is sometimes evident near wave numbers of the mode-1 and mode-2 internal tide. These bumps in the spectra are attributed to the phase-incoherent internal tide.

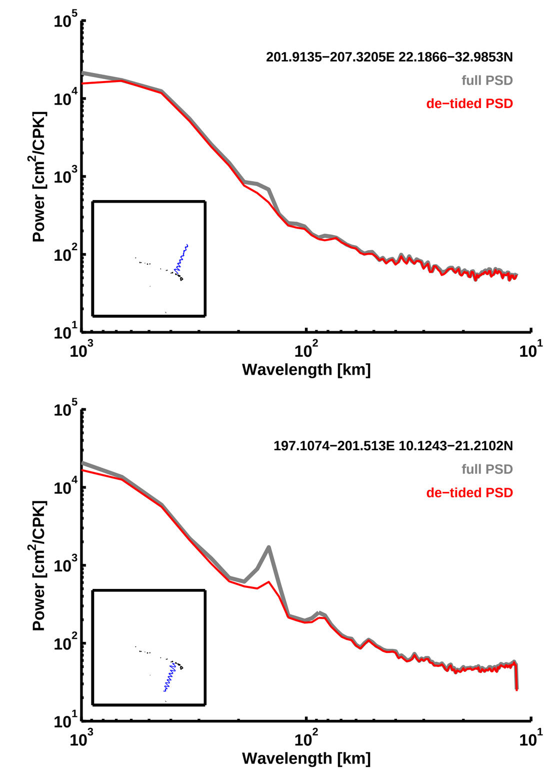
In order to quantify the amount of energy associated with the internal tide, it is necessary to first account for the non-tidal energy. This poster presents an analysis of SSH data in the region around the Hawaiian Ridge, an internal tide generation site, and a model spectrum is proposed for the non-tidal energy.



(a) Segments 1 (top) and 4 (bottom)



(b) Selected Ground Tracks

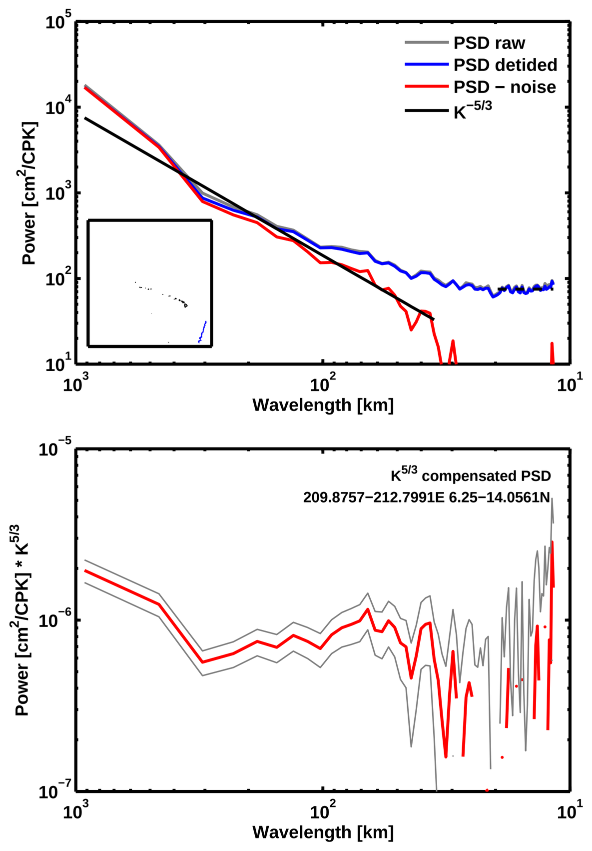


(c) Segments 2 (top) and 3 (bottom)

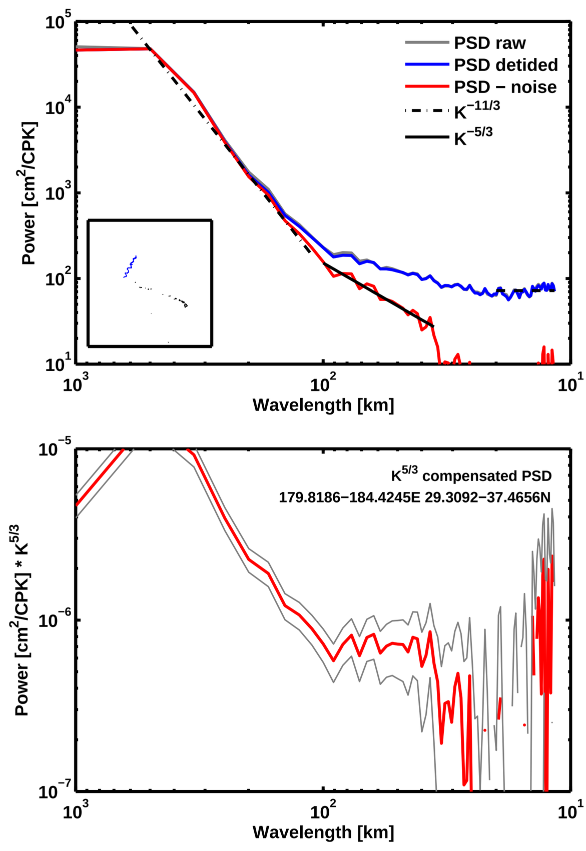
Figure 1: Representative Along-Track Wavenumber Spectra

Developing a Model Spectrum

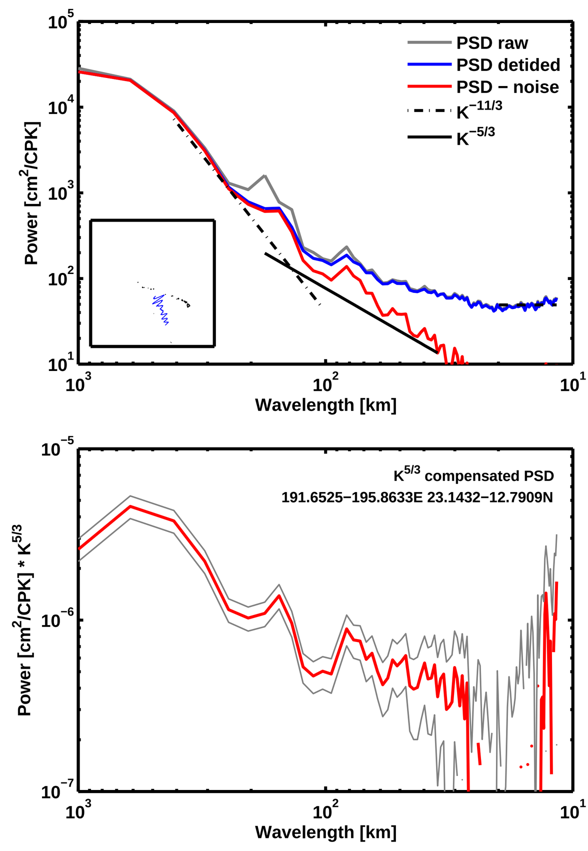
Both empirical mapping and numerical models of the internal tide have shown that the low-mode internal tide propagates over long distances in the ocean, with energy confined in relatively narrow beams. Spectra along ground tracks crossing the beams are quite different from spectra in other regions.



(a) LOW KE, LOW TIDAL KE

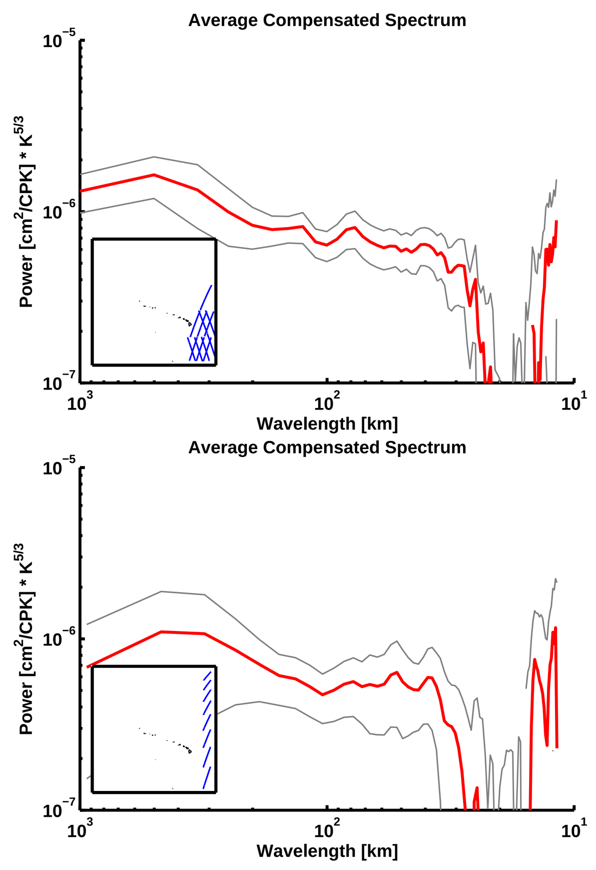


(b) HI KE, LOW TIDAL KE

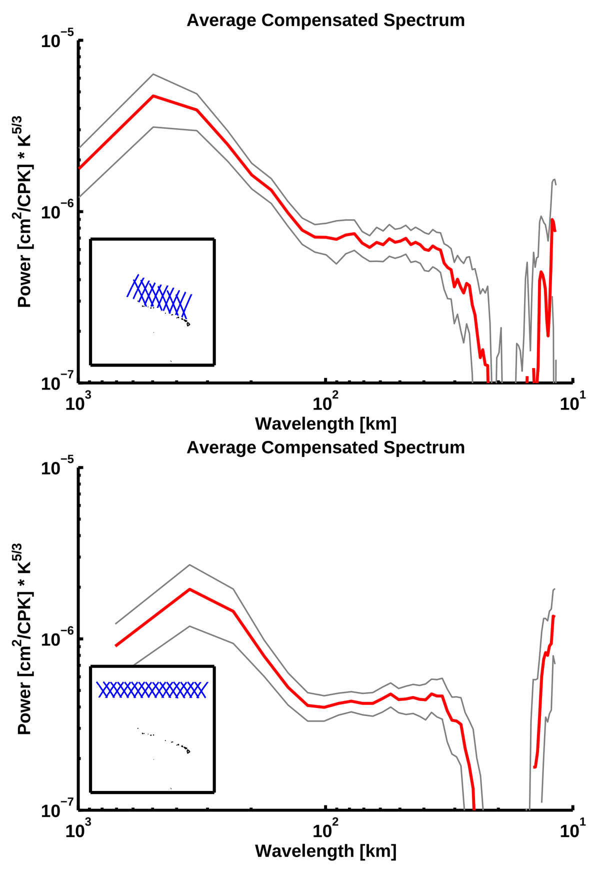


(c) HI KE, HI TIDAL KE

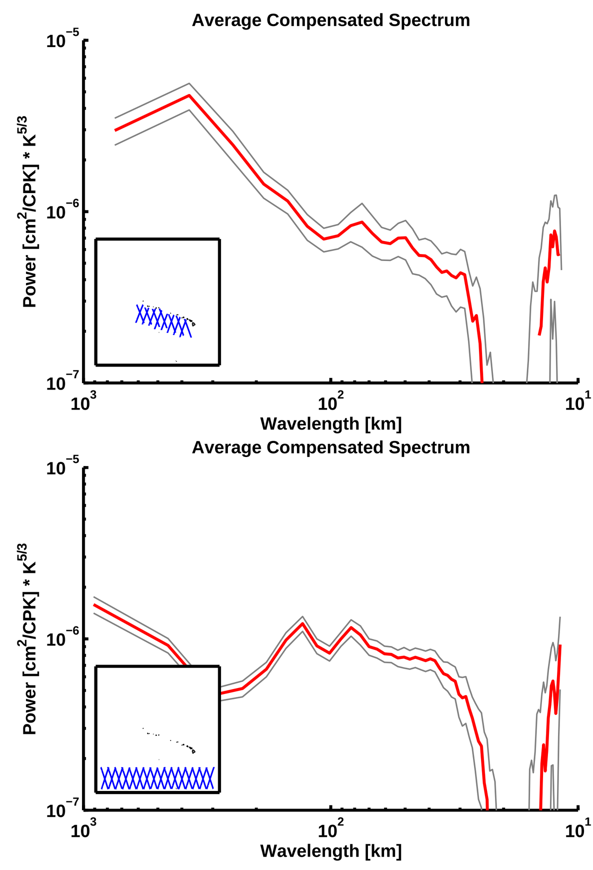
Figure 2: Raw, De-Tided, and De-Noised Spectra (Top); $k^{-5/3}$-Compensated Spectra (Bottom)



(a) LOW KE, LOW TIDAL KE



(b) HI KE, LOW TIDAL KE



(c) HI TIDAL KE

Figure 3: Spatially-Averaged $k^{-5/3}$-Compensated Spectra

Regions with little excess variance around the mode-1 and mode-2 internal tide wavelengths display $k^{-5/3}$ scaling in the $40-120$km wavelength range. Note that the high-wavenumber behavior of the spectrum is sensitive to the precise value of the estimated noise.

Speculations on the Origins and Significance of the $k^{-5/3}$ Subrange

Alternative hypotheses:

1. The $k^{-5/3}$ range is an artifact of altimeter data processing or environmental corrections.
2. The $k^{-5/3}$ range is caused by direct atmospheric forcing via an inverse barometer-like effect or surface winds.
3. A surface quasi-geostrophic (SQG) subrange exists at large scales, but the spectrum is dominated by ageostrophic SSH at smaller scales:

$$U_0 \cdot \nabla u_{SQG} = -g\nabla\eta \implies S_\eta(k) = \left(\frac{U_0}{g}\right)^2 S_{KE}(k). \qquad (1)$$

4. A non-SQG inertial subrange exists (e.g., stratified turbulence) which manifests as a $k^{-5/3}$ power law. Assuming a gravity-wave like balance, one obtains $S_\eta(k) = (\eta_0/g')S_{KE}(k)$ from kinematics.

In the latter two cases the transition between $k^{-11/3}$ and $k^{-5/3}$ behavior should be controlled by a critical Rossby number criterion, $L \sim U_0/f$.

Summary

- Along-track SSH spectra indicate the presence of coherent and incoherent mode-1 and mode-2 semidiurnal (M_2) internal tides around the Hawaiian Ridge,
- A model for the non-tidal wavenumber spectrum has been developed to assist in quantifying the ratio of incoherent to coherent tidal energy.
- The model non-tidal spectrum consists of the sum of a large-scale quasi-geostrophic component (k^{-5} QG, or $k^{-11/3}$ SQG), an intermediate-scale component ($k^{-5/3}$), and a noise component (k^0).

2010 Altimetry for Oceans and Hydrology
Lisbon, Portugal
October 18-22, 2010

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