# The internal gravity wave spectrum: A new frontier in global ocean modeling

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## BACKGROUND

•High-resolution global ocean models forced by both atmospheric fields and tides are beginning to display realistic internal gravity-wave (IGW) spectra, as we demonstrated in Müller et al. (2015, GRL).

•We show IGW frequency spectra and frequency-horizontal wavenumber spectra computed from 1/12.5° and 1/25° global simulations of the HYbrid Coordinate Ocean Model (HYCOM), which is used by the US Navy as an ocean forecast model. The HYCOM frequency spectra are compared to frequency spectra computed from moored current meters.

•Nonlinear spectral kinetic energy transfers T(K,ω)--see Muller et. al. 2015 for details—are also computed and displayed.

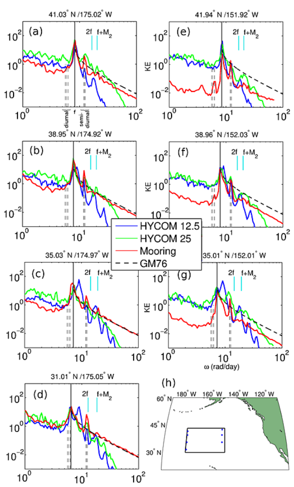


**Figure 1.** Frequency spectra in 1/12.5° (HYCOM12; blue) and 1/25° (HYCOM25; green) global HYCOM simulations and moored current meter data (red), at seven locations shown as blue stars in (h). The GM76 fit is shown in black. Spectra are logarithmically smoothed for display purposes. Vertical lines are drawn at the frequencies of the eight largest tidal constituents, and of f, 2f, and f+$M_2$. Spectral units are $(m/s)^2$/(radian/day).

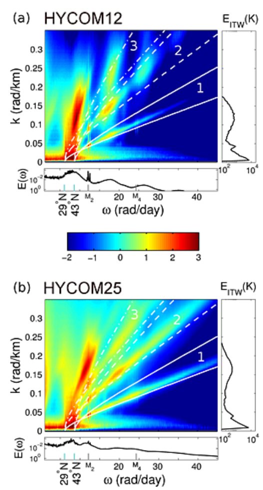


**Figure 2.** The horizontal wavenumber-frequency (K-ω) spectrum of kinetic energy in 1/12.5° (HYCOM12; top) and 1/25° (HYCOM25; bottom) global HYCOM simulations, for the region shown in Fig. 1h. Bands of vertical modes, computed from the IGW Sturm-Liouville problem along the northern and southern boundaries of the region, are labeled inside the panels with white lettering. Below (to the right), frequency (wavenumber) spectra computed over all wavenumbers (frequencies) are shown. Spectral units are $(m/s)^2$/[(radian/day)(radian/km)], shown on a $\log_{10}$ scale.

## MOTIVATION

Global modeling of oceanic internal gravity waves (IGWs) is important because:

•Breaking IGWs underlie much of the mixing in the subsurface ocean.

•IGWs impact acoustics, and hence, US Navy operations.

•IGWs will be both an important signal and an important source of noise in the NASA/CNES SWOT wide-swath satellite altimeter mission, currently planned for launch in 2020.

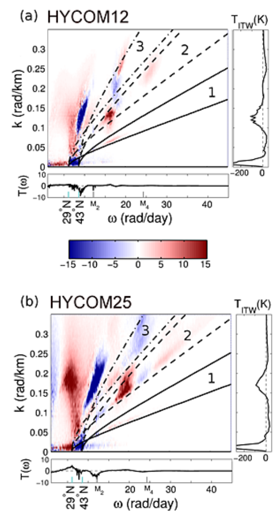


**Figure 3.** As in Figure 2 but for nonlinear spectral kinetic energy transfers T(K,ω). Dispersion curves and mode band numbers shown in black. Energy is taken out of the blue regions and added to the red regions. Spectral transfer units are $10^{-9}$ W/kg/[(radian/day)(radian/km)].

## CONCLUSIONS AND FUTURE WORK

•The IGW horizontal wavenumber-frequency spectrum of high-resolution HYCOM simulations that are forced by both atmospheric fields and astronomical tides fill out along the predicted linear dispersion curves, and fill out more completely when the model horizontal resolution is increased.

•The nonlinear spectral transfers T(K,ω) participate in filling out the IGW spectrum, and are more vigorous in the higher-resolution 1/25° HYCOM simulations.

•The frequency spectra in the higher-resolution 1/25° HYCOM simulations lie closer to the observed frequency spectra than do the spectra in the 1/12.5° simulations.

•In follow-up work, already underway, we will (a) examine several oceanic regions, not just one, (b) examine vertical wavenumber-frequency spectra in addition to the spectra shown here, and (c) compute results from 1/12°, 1/24°, and 1/48° global simulations of the MITgcm, in collaboration with Dimitris Menemenlis, as well as from 1/12.5° and 1/25° HYCOM simulations.