Global modeling of internal tides and the internal gravity wave continuum

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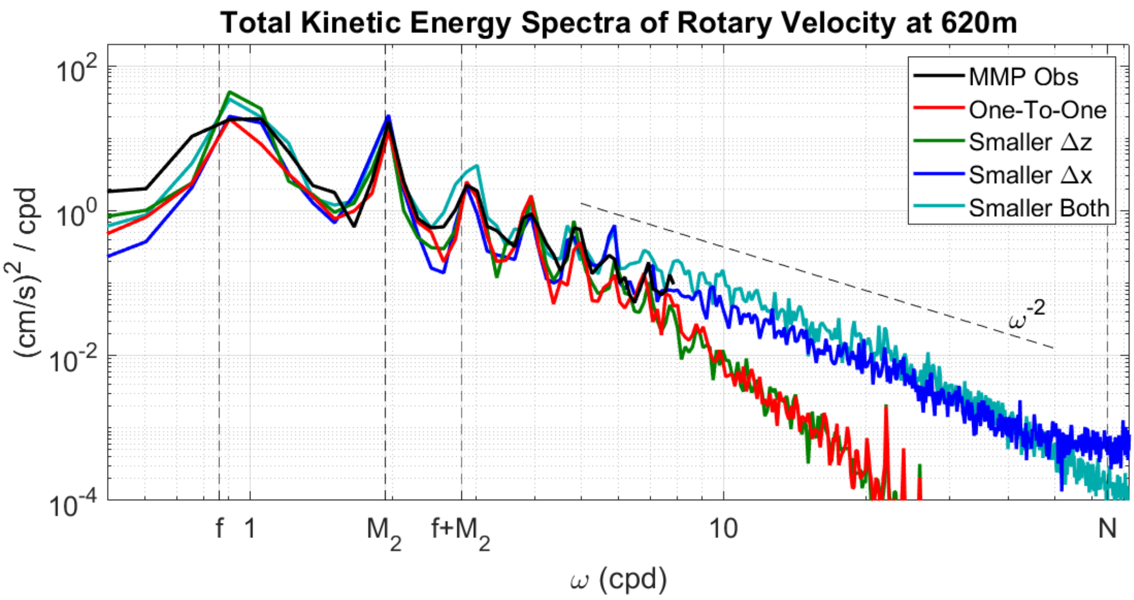
I will describe work that I have done with many collaborators, over the last decade, on global modeling of internal tides and the internal gravity wave continuum. I will show results from the US Navy HYCOM operational model, and simulations of the MITgcm run on NASA supercomputers, and discuss related efforts at other ocean modeling centers in the US and Europe. Starting with the Navy model, several groups have implemented simultaneous atmospheric and tidal forcing in high-resolution (eddying) global ocean models. This work in turn builds upon earlier work in basin- and global-scale modeling of internal tides, done with tidal forcing only, by Niwa and Hibiya, Furiuchi et al., and others including the author. High-resolution simulations with simultaneous tidal and atmospheric forcing carry mesoscale eddies, near-inertial motions, and internal tides all at once. If the horizontal and vertical resolutions are sufficiently high, they also carry a partial internal gravity wave continuum, or Garrett-Munk spectrum. I will discuss several aspects of these simulations, including comparisons to in-situ and remotely sensed observations, the utility of such simulations to planning for the Surface Water Ocean Topography (SWOT) wide-swath altimeter mission, and first results with regional simulations, run at even higher resolutions, with lateral boundary conditions taken from the global models. I believe that these simulations have opened up a new frontier of ocean models that can be more meaningfully compared with oceanic observations, and used for improved regional ocean modeling studies, in regards to a more fully developed spectrum of high-frequency internal wave motions. As noted, such simulations are also very useful for planning future altimeter missions. As an example of our work, the attached figure displays the frequency spectrum in observations from moored McLane Profilers (MMPs), and in four different simulations of a regional MITgcm simulation in a 6 by 8 degree patch near Hawai'i. The "one-to-one" simulation has the same resolution as the parent global simulation. The "Smaller delta z" simulation has three times as many levels in the vertical direction, the "Smaller delta x" simulation has eight times as many gridpoints in each horizontal direction, and the "Smaller Both" simulation has finer grid spacings in both the horizontal and vertical directions. The latter simulation, with the highest resolutions, follows the expected frequency^-2 spectrum most closely, out to frequencies as high as N, the buoyancy frequency. This result shows that if regional models are forced at their boundaries by global models that carry the low-mode internal waves, and have very high resolutions--in this case, 250 m grid spacing in the horizontal and 300 vertical levels--they display an improved internal gravity wave spectrum.

Keywords: internal waves, tides, ocean modeling


Total Kinetic Energy Spectra of Rotary Velocity at 620m
MMP Obs
One-To-One
Smaller Δz
Smaller Δx
Smaller Both
ω^{-2}
10^{2}
10^{0}
10^{-2}
10^{-4}
(cm/s)^2 / cpd
f
1
M_2
f+M_2
10
N
ω (cpd)