Revisiting fine-scale parameterizations for enhanced tidal mixing over a rough ocean bottom

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Although an accurate representation of ocean mixing processes into global circulation models is essential for accurate climate predictions,, existing parameterizations of mixing over rough bathymetry have plenty of room for improvement. For example, they do not take into account the fact that, as tide-topography interactions strengthen ($k_H U_0/\Omega$ >1), the generated internal waves transform from linear internal tides to quasi-steady internal lee waves where U_0 is the amplitude of the tidal flow dominating the background flow in the Garrett-Munk (GM) internal wave field, k_H is the horizontal wavenumber of the bottom topography, and $\Omega$is the semidiurnal tidal frequency.

In the present study, using a fixed value of the buoyancy frequency, we perform a series of eikonal calculations to examine the energy transfer from upward propagating quasi-steady internal lee waves to dissipation through nonlinear interactions with the background GM internal waves in a vertical two-dimensional plane. It is shown that the vertical structure of the mixing hotspot becomes dominated by U_0 rather than k_H; as U_0 increases, the fraction of energy dissipated at the ocean bottom decreases and the energy dissipation region extends vertically upward off the ocean bottom. These calculated results can be interpreted in terms of the vertical group velocity, C_{gz}, and the life time, τ, of the upward propagating quasi-steady lee wave packet. For a fixed density stratification, as k_H increases while keeping U_0 constant, C_{gz} becomes larger but becomes smaller so that the vertical decay scale of the energy dissipation rate remains nearly constant, whereas C_{gz} becomes larger but remains unchanged as U_0 increases while keeping k_H constant so that the vertical decay scale of the energy dissipation rate rapidly increases. This means that the resulting mixing hotspot extends further upward as U_0 increases, independent of k_H. This is in contrast to the result of the previous study by *Iwamae et al.* [2009] and *Iwamae and Hibiya* [2012] who showed that the concentration of the mixing hotspot becomes more focused nearer the ocean bottom as k_H increases, independent of U_0, although a trade-off relationship is found between the fraction of energy dissipated at the ocean bottom and the vertical extent of the energy dissipation region off the ocean bottom. A possible explanation for this difference is that C_{gz} and τ are both inversely proportional to k_H for linear internal tides.

The results of this study should be reflected in the parameterization of mixing over rough bathymetry to improve the accuracy of ocean general circulation models.

Keywords: Bottom-intensified turbulent mixing, Quasi-steady lee waves, Vertical group velocity, Nonlinear interaction time, Tidal flow amplitude, Ocean bottom roughness

