Nonlinear energy transfer across the oceanic internal wave spectrum down to turbulent dissipation scales

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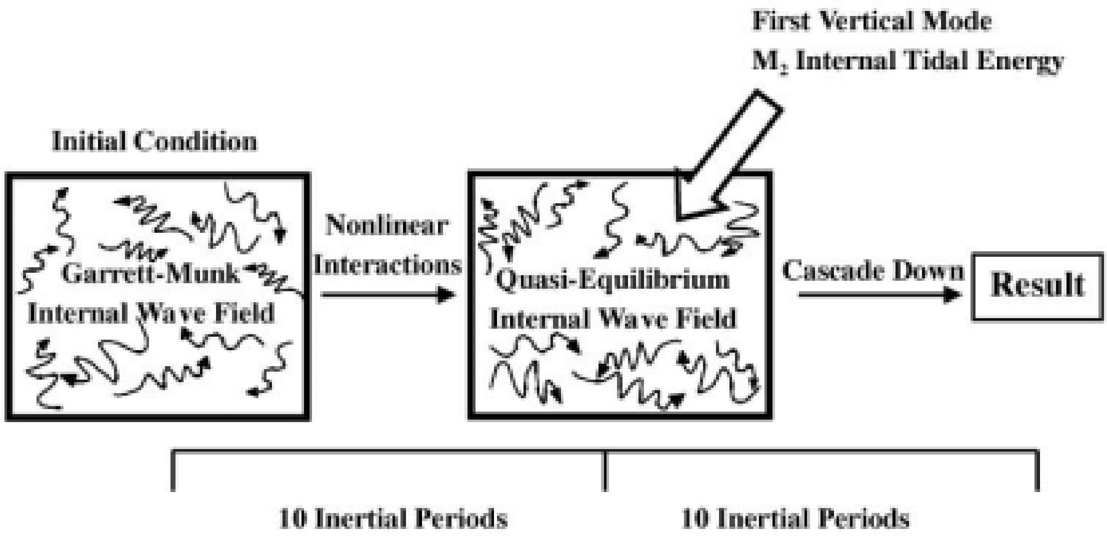
Global mapping of diapycnal mixing rates at depth is crucial to accurate modeling of the abyssal ocean general circulation. Diapycnal mixing in the stratified ocean interior is considered to be associated with sporadic overturning and breaking of internal waves.

The energy for diapycnal mixing processes in the deep ocean is originally supplied by wind stress fluctuations and tide-topography interactions, and then transferred across the local internal wave spectrum down to dissipation scales by nonlinear interactions among internal waves. This implies that, in addition to the spatial distributions of tidally generated internal waves and wind-induced near-inertial waves, nonlinear energy transfer processes within the internal wave spectrum should be examined before the global distribution of diapycnal mixing rates in the deep ocean can be clarified.

In the present study, in order to examine how the energy supplied by M2 internal tides cascades through the local internal wave spectrum down to dissipation scales, two sets of numerical experiments are carried out where the Garrett-Munk-like quasi-stationary internal wave spectra at 49N (experiment I) and 28N (experiment II), respectively, are first reproduced and then perturbed instantaneously in the form of an energy spike at the lowest vertical wavenumber and M2 tidal frequency. These experiments attempt to simulate the nonlinear energy transfer within the quasi-stationary internal wave fields near the Aleutian Ridge and the Hawaiian Ridge, respectively, both of which are generation regions of large amplitude M2 internal tides.

In experiment I, the energy spike stays at the lowest wavenumber where it is embedded and the spectrum remains quasi-stationary after the energy spike is injected. In experiment II, in contrast, the energy level at high horizontal and vertical wavenumbers rapidly increases after the injection of the energy spike, exhibiting strong correlation with the enhancement of high vertical wavenumber, near-inertial current shear. This implies that, as the high vertical wavenumber, near-inertial current shear is intensified, high horizontal wavenumber internal waves are efficiently Doppler shifted so that the vertical wavenumber rapidly increases and enhanced turbulent dissipation takes place. The elevated spectral density in the high vertical wavenumber, near-inertial frequency band, which plays the key role in cascading energy to dissipation scales, is thought to be caused by parametric subharmonic instability. In experiment I, in contrast, the M2 tidal frequency is 1.2 times the inertial frequency at 49N so that M2 internal tide is free from parametric subharmonic instability. Accordingly, even though significant M2 internal tidal energy may be generated, it is not available to support local deep water mixing.


First Vertical Mode
M_2 Internal Tidal Energy
Initial Condition
Garrett-Munk
Internal Wave Field
Nonlinear
Interactions
Quasi-Equilibrium
Internal Wave Field
Cascade Down
Result
10 Inertial Periods
10 Inertial Periods