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Model predicted distribution of internal wave energy for diapycnal mixing processes in the deep waters of the North Pacific

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By using three-dimensional numerical models, we examine the distribution of internal wave energy for diapycnal mixing in the deep waters of the North Pacific. During winter, energetic near-inertial waves are excited in response to the midlatitude storms in the western-central North Pacific (30N-45N). Thus excited waves propagate southward down to 10N-15N where the frequencies become double the local inertial frequencies so that large amount of wave energy cascades down to dissipation scales under the parametric subharmonic instability. The low-vertical-wavenumber double-inertial frequency internal waves are, in contrast, very weak at the times and locations of the previous microscale measurements so that the observed diapycnal diffusivity of 0.1 cm2/s might not be representative.

The energy available for diapycnal mixing processes at depth is originally supplied at large scales by atmospheric forcing or tide-topography interactions and then transferred across the local internal wave spectrum down to small dissipation scales by nonlinear interactions amongst internal waves. This energy cascade is dominated by parametric subharmonic instability which transfers energy from low-vertical-wavenumber waves with frequencies over 2f (f is the local inertial frequency) to high-vertical-wavenumber near-inertial waves. An understanding of the sources and variability of low-vertical-wavenumber internal waves with frequencies over 2f is therefore a key factor in constructing a predictive model of the rates of diapycnal mixing associated with internal wave breaking in the stratified interior of the world oceans.

In the present study, we examine the generation and propagation of low-vertical-wavenumber low-frequency internal waves with the aid of three-dimensional multilevel numerical models to clarify the global mapping of diapycnal mixing rates in the abyssal ocean. The results of the numerical experiments show that energetic near-inertial waves are excited during winter in response to the intermittent passages of the midlatitude storms (30N-45N) in the western-central North Pacific. Thus excited near-inertial waves propagate southward down to the latitudes 10N-15N, where the frequencies of these internal waves become double the local inertial frequencies so that large amount of energy is expected to be available for diapycnal mixing processes.

Previous microscale measurements in the ocean interior have shown diapycnal diffusivity of the order of 0.1 cm2/s, which is one order of magnitude smaller than the value required by global and regional mass and heat balances. A possible explanation for this discrepancy is that the previous microstructure measurements have been carried out mostly in the eastern North Pacific or near the Equator during summer and fall, because the model predicted energy levels of the low-vertical-wavenumber double-inertial frequency internal waves are extremely low at the times and/or locations of these microstructure measurements.