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Forcing of gravity waves by potential vorticity in a shallow water model

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Improvements in observational and numerical resolution of the ocean have led to a greater interest in the role of large-scale coherent internal waves, particularly those generated by tidal forcing over topography. Analysis of the global energy budget of the ocean has also identified tidal forcing as a major energy input and has suggested internal wave breaking as a primary mechanism for abyssal mixing. As a result, there has been a renewed interest in these long scale waves and their transfer of energy to smaller scales, ultimately leading to overturning and mixing. Recent observational and numerical studies have shown that the majority of internal wave energy from generation sites have wavelengths on the order of the deformation radius and can propagate across hundreds and possibly even thousands of kilometers. Additionally, there is strong numerical evidence that such waves are unstable in latitudes near 29°, where this coherence contributes to an accelerated nonlinear cascade to smaller scales and increased abyssal mixing.

One aspect of this problem which has not yet been addressed is the role of the geostrophic mesoscale. Coherent internal waves propagating across the open ocean are likely to encounter regions of vigorous geostrophic turbulence. We present numerical evidence showing that the potential vorticity (PV) anomalies contained in large scale geostrophic currents are responsible for the transfer of energy between different waves. In this way, a single coherent signal propagating through geostrophic turbulence will tend to lose most of its energy to a broad spectrum of gravity waves propagating in different directions, producing a more isotropic and incoherent wavefield. Furthermore, this forcing is dominated by resonant triad interactions within the nonlinear advection terms, where the PV modes are essentially unchanged but act as catalysts for the redistribution of energy within the wave spectrum. These results place constraints on the lifetime of these tidally forced internal waves and the relative importance of their role in the ocean.