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Eddy-Internal wave decomposition and kinetic energy transfers in high-resolution turbulent channel flow with near-inertial waves

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Oceanic mesoscale eddies contain most of the kinetic energy (KE) in the ocean and therefore play an important role in determining the ocean's response to future climate scenarios. Oceanic wind-forced internal waves (IWs) are energetic fast motions that contribute substantially to the vertical mixing of water, thereby affecting biogeochemical and climate processes. We study the effects of wind-forced IWs on the KE pathways in high-resolution numerical simulations of an idealized wind-driven channel flow. Using spectral fluxes, we demonstrate that solutions with wind-forced IWs are characterized by a forward KE cascade, whereas solutions without exhibit an inverse KE cascade. We further decompose the flow field into 'eddy' and 'internal wave' motions using a Helmholtz decomposition and temporal filtering. This allows us to identify three key processes responsible for the reversal in the KE cascade: IW scattering, direct extraction, and stimulated cascade. Each process is quantified and discussed in detail.