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Andreas Acrivos Dissertation Award Talk: Turbulence and Internal Waves in Tidal Flow over Topography

BISHAKHDATTA GAYEN, The Australian National University

Energetic internal waves, commonly known as internal tides, are generated in the ocean by tidal flow interactions with bottom topography like seamounts, ridges, slopes and canyons. In my talk, I will highlight the dynamical processes underlying the turbulence formed during the generation of internal tides at topography and their subsequent interaction with a realistically-stratified upper ocean. The processes have been investigated and quantified using Direct Numerical Simulation (DNS) and Large Eddy Simulation (LES). The focus of the talk will be on ocean topography where, despite gentle barotropic tides, strong near-bottom turbulence has been observed at certain locations. I will present the hypothesis that hotspots of turbulence occur at near-critical locations where the slope angle is nearly equal to the propagation angle. The simulations show transition to turbulence along the entire extent of the near-critical region of the slope when the Reynolds number is of the order 150. The transition is found to be initiated by a convective instability which is closely followed by shear instability. The peak value of the near-bottom velocity is found to increase with increasing length of the critical region of the topography. The scaling law that is observed to link the near-bottom peak velocity to slope length could be explained by a turbulent boundary layer analysis. Maximum turbulent kinetic energy and dissipation rate are found just after the zero velocity point when flow reverses from downslope to upslope motion and the local mean shear is almost zero. The phasing and other characteristics of the turbulent mixing in the present simulations show remarkable similarity with those observed off Kaena Ridge in Hawaii taken during the Hawaiian Ocean Mixing Experiment (HOME), and may be explained by the beam-scale convective overturns found here. In the last part of my talk, I will discuss the interaction between an internal wave beam that is launched from bottom topography and an upper ocean pycnocline, and I will also present the characterization of the cascade to small scales in the context of internal wave beam degradation that is observed in the ocean.