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Turbulent dynamics of breaking internal gravity waves on slopes

ROBERT ARTHUR, OLIVER FRINGER, Stanford University — The turbulent dynamics of breaking internal gravity waves on slopes are investigated using a high-resolution numerical model. A Navier-Stokes code is employed in an idealized, three-dimensional domain where an internal solitary wave of depression impinges upon a sloping bottom. A bottom-following curvilinear grid is used to capture the bathymetry accurately, and the vertical grid spacing $\Delta z^+ = O(1)$ near the bottom in the breaking region to resolve the near-wall flow. In order to understand the transition to turbulence as a result of wave breaking, flow variability is analyzed in the cross-stream dimension. In particular, streamwise vorticity, or secondary streamwise rolls that lead to the turbulent breakdown of the wave, is found to develop in regions of unstable stratification. Dissipation and irreversible mixing of the density field are analyzed as a function of time, and related to breaking dynamics; irreversible mixing is quantified in terms of the change in background potential energy inside the domain. The mixing efficiency is also calculated for various wave and slope conditions. These results have application to the nearshore coastal ocean, where breaking internal waves affect the distributions of ecologically important scalars such as temperature, oxygen, and nutrients.

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