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Internal Hydraulic Jumps in Shallow Flows over Topography

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A barotropically forced stratified flow over topography can generate an internal hydraulic jump with upstream shear. The structure and mixing of these jumps are investigated theoretically and numerically. The effect of upstream shear on simplified jumps in two-layer flows without topography results in jump types such as undular bores, smooth front turbulent jumps, and fully turbulent jumps (Ogden and Helfrich, 2016). Increased shear results in entrainment across the jump with jump structures that resemble expanding shear layers. The addition of topography increases the number of qualitative jump types. Idealized simulations are conducted to characterize the types of jumps that can occur under various parameter regimes. The effect of parameters such as the volume flow rate and topographic height are considered. Flow structures including first-mode jumps with wave overturning and higher-mode jumps with wedges of homogeneous stagnant fluid are found. The degree of mixing and the mass budget of the developing stagnant wedge illuminate the important physical characteristics of each jump type. Existing hydraulic jumps in the environment are compared to the parameter regimes the identified jump types. The applicability of two-layered theories for studying these jumps is also considered.