Fluid Dynamics Seminar

Jared Penney,
University of Waterloo

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Salt Finger Instabilities near Gravity Currents and Topography

Abstract:

Double-diffusive instabilities are a classical problem in fluid dynamics, and as such have been extensively researched. Due to the prevalence of double-diffusive instabilities in the open ocean, they are frequently modeled in open domains, away from solid boundaries. The interaction of double-diffusive effects and solid boundaries yields interesting results, however, that are worth examining. This research studies the formation of salt fingers near Gaussian hills from a shallow layer of hot, salty water over a layer of cooler, fresh water. These instabilities are numerically simulated using a pseudospectral code with mapped coordinates to account for the effects of topography. Several numerical experiments were performed that modify the slope of the hill, the position of the water layer interface, and the temperature gradient between water layers to determine the effects on the resulting instabilities. The angle of the interface is observed to distort so that the curves of the scalar fields become nearly perpendicular to the hill, in order to satisfy the no flux conditions at the boundary. This results in a near wall finger-like instability that develops more quickly than the free salt fingers. The slope of the hill appears to have almost no effect on the formation of fingers away from the hill, although it does have a significant effect on the near wall instability. Narrower hills with steeper slopes cause the formation of near wall salt fingers at earlier times. These fingers decrease in size as the width of the hill increases and the slope becomes shallower. Near wall fingers are absent for hills with shallow slopes until later times, however, a narrow layer of fresh water does form above the salt water-fresh water interface and creeps slowly up the hill. In all cases, there are fresh water fingers that grow upward near the top of the hill that increase in salinity with hill width. Smaller differences in temperature between the two layers of water result in fewer, wider salt fingers that develop more quickly than for larger temperature differences between water layers. Three-dimensional effects are also examined by allowing two-dimensional instabilities to develop, then perturbing them in the spanwise direction. Additionally, gravity currents caused by streamwise thermohaline stratification are simulated in two-dimensions. Tilted finger-like structures are observed to form from the leading edge of the high-salinity gravity current front.