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Interfacial waves in two-layer exchange flows downslope of a bottom sill

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An experimental study was conducted to examine the interfacial waves in two-layer exchange flows downslope of a bottom sill. The objective of the study was to understand the generation mechanisms of different interfacial waves and the generation conditions and development of Kelvin–Helmholtz (KH) instabilities in spatially varying flow field. During the flow regime of the steady maximal exchange, low-frequency oscillation of the density interface above the sill crest was observed, which resulted in periodic piling and releasing of the lower-layer fluid. This low-frequency oscillation led to the development of large-scale downslope waves that caused significant interfacial entrainment. The periodic time of those piling and releasing events was found to be inversely proportional to the square root of the reduced gravitational acceleration and to be related to the baroclinic forcing of the basin internal seiching. During late sub-maximal exchange, regular and frequent KH instabilities were generated at the interface down the slope at bulk Richardson number of approximately 0.07–0.21, which is considerably larger than previous theoretical predictions for parallel flows with a sharp density interface. Two different growth patterns of those KH instabilities were observed. Measurements of their initial growth rate and the wavelength were also obtained and compared to the theoretical predictions.

Key words: gravity currents, shear waves

1. Introduction

Exchange flows are observed when two water bodies of different densities are connected by a channel or strait. The amount of exchange flow and the induced mixing can have an important environmental impact, as seen in the exchange of the more saline Mediterranean water with the less saline Atlantic Ocean water through the Strait of Gibraltar (Armi & Farmer 1988; Baringer & Price 1997), the summer time exchange of warmer heavily polluted Hamilton Harbour water with cooler Lake Ontario water through the Burlington Ship Canal (Lawrence *et al.* 2004), and the exchange between Little Sodus Bay and Lake Ontario (Rueda & Cowen 2005), among others. The hydraulics of exchange flows was first studied by Armi & Farmer (1986). Some recent studies considered the effects of friction and non-hydrostatic forces (Zhu

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