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Runup of solitary waves on a circular island

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This is a study of the interactions of solitary waves climbing up a circular island. A series of large-scale laboratory experiments with waves of different incident height-to-depth ratios and different crest lengths is described. Detailed two-dimensional run-up height measurements and time histories of surface elevations around the island are presented. A numerical model based on the two-dimensional shallow-water wave equations including runup calculations was developed. Numerical model predictions agreed very well with the laboratory data and the model was used to study wave trapping and the effect of slope. Under certain conditions, enhanced runup and wave trapping on the lee side of the island were observed, suggesting a possible explanation for the devastation reported by field surveys in Babi Island off Flores, Indonesia, and in Okushiri Island, Japan.

1. Introduction

From 1992 to 1994, submarine earthquakes around the Pacific basin generated six large tsunamis: the Nicaragua tsunami on September 2, 1992; the Flores Island tsunami on December 12, 1992; the Hokkaido Island tsunami on July 12, 1993; the East Java tsunami of June 2, 1994; the Kuril Islands tsunami of October 4, 1994; and the Mindoro Island tsunami of November 15, 1994. They all caused extensive property damage and deaths of at least 1640 people (Satake *et al.* 1993; Yeh *et al.* 1993; Hokkaido Tsunami Survey Group 1993; Yeh *et al.* 1995; Synolakis *et al.* 1995; Imamura *et al.* 1995). In the Flores Island and Okushiri events, unexpectedly large tsunami runup heights in the lee of small islands were observed. During the Flores event, two villages located on the southern side of the circular Babi Island, whose diameter is approximately 2 km, were washed away by the tsunami, attacking from the north (see figure 1). Similar phenomena occurred on the pear-shaped Okushiri Island, which is approximately 20 km long and 10 km wide (see figure 2). The southern region of the island suffered extensive damage from the tsunami attack, which approached the island from the northwestern direction. Maximum runup height at the marked location in figure 2 was about 20 m. These phenomena are apparently not entirely uncommon and have also been reported by Bascom (1990): "We discovered that, except for headlands pointing into the (tsunami) wave, embayments facing exactly opposite to the wave direction were likely to be most affected."