TSUNAMI SOFTWARE

Introduction

In the open ocean, a tsunami has a low height, an extremely long wavelength and travels at great speed. It can be detected in real time only by bottom-mounted pressure sensors. However, a tsunami slows down as it moves into shallower water, allowing it to be detected by shore-based HF radar systems well before its arrival. Although the wave period remains invariant, the height and the orbital velocity increase and the wavelength decreases.

A single HF radar system produces maps of the radial component of the ocean surface current velocity using radar echoes from short wind-driven waves. The tsunami produces surface velocities that superimpose on the slowly varying ambient current velocity background. They have a characteristic signature due to their coherence over large distances, allowing them to be detected when they arrive in the radar coverage area.

Simulation of radial current maps in the presence of a tsunami

A sinusoidal tsunami wave appears as a periodic surface current. Its wave orbital velocity at the surface transports the much shorter waves seen by the radar, adding to the ambient current field and producing a signature detectable by the radar. The equations of motion and continuity form the basis for tsunami modeling and provide equations for tsunami properties. These equations will apply over most of the radar coverage area, until the first surge is only moments away from the shore. As the wave moves into shore and the water depth decreases from this threshold value, the water velocity seen by the radar will increase as the group/phase velocity decreases. We assume that the water depth over the radar coverage area can be adequately represented by depth contours parallel to shore. A tsunami will move perpendicular to these contours. We calculate tsunami velocities using parameters of the 2004 Indian Ocean tsunami. Radial components of these velocities are added to the measured radial velocities.

Detection algorithm

(1) As the tsunami approaches shore, most variation in the composite velocity field is produced by the changing tsunami currents. To reduce the effect of

the varying ambient current field over this time period, we subtract the short-term radial velocities from time-averaged background values. These differenced velocities are then normalized to give the component perpendicular to the depth contours.

(2) The radar coverage area is then divided into narrow bands parallel to the depth contours, the normalized radial velocities in a given band are averaged and the standard deviation calculated.

(3) We define a correlation parameter for each band as the absolute value of the average radial velocity normalized by the standard deviation. When the current velocity field is dominated by tsunami velocities, which are typically coherent over bands parallel to the depth contours, the value of the correlation parameter will increase sharply, indicating the presence of a tsunami in a given band.

(4) The time it will take for the tsunami to strike the shore is calculated versus range. This depends to a large degree on the water depth over the radar coverage area. It takes hours for the tsunami to traverse a wide continental shelf, but only minutes when the shelf is narrow. In order for the tsunami show up on several simulated radar velocity maps when the shelf is narrow, it is necessary to artificially reduce its velocity by an input factor.