TSUNAMI WARNING IN THE NEAR FIELD: THE APPROACH IN HAWAI'I

Gerard J. Fryer, Barry Hirshorn,
Charles S. McCreery, Robert K. Cessaro, and Stuart A. Weinstein
RHH Pacific Tsunami Warning Center
Honolulu, Hawaii, USA

ABSTRACT

Tsunami warnings must always be made from imperfect and limited data, but uncertainties become especially acute in the near field, where a tsunami reaches its target coastline in a half-hour or less. In the absence of a warning (either because there is no warning system or because the system responds too slowly) the usual advice is "When the ground shakes so severely that it's difficult to stand, move away from the ocean." The severe shaking criterion reduces the chance of unnecessary evacuation (rapid evacuation has its own considerable perils, and must be avoided unless absolutely necessary), but what if shaking is not severe? There is no guarantee that tsunami hazard will be restricted to the meizoseismal region. Worse, if the earthquake has slow rupture (large displacement but mild shaking) the "severe" criterion will be tragically misleading: in Nicaragua, 1992, for example, hundreds were injured and 179 killed by a tsunami from an offshore earthquake that few onshore even felt. Where such potential failures of the usual near-field advice are suspected, we must attempt to issue useful (i.e. rapid) warnings. Local warning systems, however, must be tailored to the local conditions.

The difficulties of local warning are well demonstrated by the Hawaiian Islands, where deep water close offshore means rapid tsunami propagation out of the region of extreme shaking. An earthquake on the Kona (west) coast of the Island of Hawai'i should warn residents there that a damaging tsunami is likely within ten minutes, but the gentler shaking at Kihei on Maui (the next island to the west) would provide little clue of the tsunami to come 18 minutes later. In Honolulu, almost 300 km from the source, many would not even be aware of the earthquake, but the tsunami would arrive 30 minutes later. Even more troubling is the possibility of a tsunami earthquake: the slow rupture of the Kalapana Earthquake of 1975, together with "silent" earthquakes detected by GPS, suggest that Hawai'i could suffer an earthquake so slow that, like Nicaragua 1992, not even residents on the immediate coast near the epicenter would be alarmed.

With so little time for warning, we cannot wait for water-level confirmation of a tsunami. All shallow (<20 km) Hawaiian earthquakes larger than M_W=6.5 are thrust events on or near a volcano's basal decollement. These will be tsunamigenic if close to the shoreline. If we assume a thrust mechanism, tsunami warning will require only epicenter and magnitude information and a crude depth determination (is the hypocenter shallower or deeper than 20 km?). By far the most reliable rapid magnitude measurement is M_{WP}, made from the initial few tens of seconds of the P-arrival on broadband seismographs. For a large Kona earthquake, however, the sole broadband station on Hawai'i will be clipped, forcing us to measure M_{WP} from the severely restricted range

perspective provided by the only other broadband stations: on ‘Oahu. To rectify this situation, broadband seismometers are being installed on all the major islands. With the new network, warnings (initially made assuming shallow depth) will be possible within two minutes of earthquake origin time. By combining information from co-located accelerometers and an expanding short-period network, our goal is to reduce the time-to-warning to 90 seconds for any earthquake within the Hawaiian Islands. With Mauna Loa slowly awakening and the possibility that volcano inflation might drive a great basal-slip earthquake, our target is to achieve 90-second warning within two years.