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Towards Reliable Real-time Prediction of Tsunami Heights Using "GPS-Shield" Arrays

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The 2004 catastrophic Indian-Ocean tsunami has strongly emphasized the need for reliable tsunami early- warning systems. Another giant tsunamigenic earthquake may occur west of Sumatra, close to the large city of Padang. We demonstrate that the presence of islands between the trench and the Sumatran coast makes earthquake-induced tsunamis especially sensitive to slip distribution on the rupture plane: wave heights at Padang may differ by more than a factor of 5 for earthquakes having the same seismic moment (magnitude) and rupture zone geometry but different slip distribution. Hence, reliable prediction of tsunami wave heights for Padang can not be provided using traditional, earthquake-magnitude-based methods. We show, however, that such prediction can be issued within less than 10 minutes of an earthquake by incorporating special types of near-field GPS arrays ('GPS Shield'). These arrays measure both vertical and horizontal displacements and can resolve higher order features of the slip distribution on the fault than seismic moment if placed above the rupture zone or less than some 100 km away of the rupture zone. Stations in the arrays are closely spaced (10-20 km) and aligned perpendicular to the trench, i.e., parallel to the expected gradient of surface coseismic displacement. In the case of Sumatra and Java, the GPS-Shield arrays should be placed at Mentawaii Islandes, located between the trench and Sumatra and directly at the Sumatra and Java western coasts where no islands are present. We demonstrate that the 'GPS Shield' can also be applied to northern Chile, where giant earthquake may also occur in the near future. Moreover, this concept may be applied globally, to many other tsunamigenic active margins where the land is located above or close to seismogenic zones.