Geophysical Research Abstracts,
Vol. 11, EGU2009-11299, 2009
EGU General Assembly 2009

A fingerprint method for the rapid determination of earthquake displacement fields in support of tsunami early warning

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Low latency knowledge of the displacement field associated with a large earthquake is invaluable for estimates of the tsunami potential, the prediction of tsunami propagation, and ultimately reliable early warning. We have developed a fingerprint method for the near-real time determination of the displacement field of earthquakes observed by GPS networks. The fingerprint module is designed as a part of a prototype system for tsunami early warning, and in this system, the output of the fingerprint module feeds into a module for tsunami propagation modeling.

In a fault database, fault systems are parameterized and represented by reasonably large elements (order 200 km). For each element, the displacement fields are computed for unit slips and these a priori "fingerprints" are stored in the fault datebase. In general, the slip during an earthquake will have both a normal and a strike-slip component. Therefore, the fingerprints are computed for normal slip and strike slip separately. After a large earthquake, the set of elements participating in the rupture and the slip vector for each element can be determined in a rapid search through the database, in which a large number of reasonable combinations of fingerprints are fitted to low-latency high-resolution GPS time series. Different statistical measures for the fit quality are applied to determine the best-fitting set of elements. The weighted sum of the fingerprints for the identified active elements gives the total displacement field. We have previously validated the method for the 2004 Sumatran earthquake using the data of a sparse GPS network and shown that estimates of the displacement field could be made available within 12 minutes after the start of the rupture. In a time-delayed study, we use this method to investigate the relation between network geometry and minimum magnitude of earthquakes for which reliable determination of the displacement field can be achieved. This study utilizes GPS networks of variable density around several subduction zones, including the Sumatran and Cascadian faults. We also investigate the false-alarm rate as function of earthquake magnitude and network geometry.