Rapid Determination of Earthquake Magnitude for Tsunami Warning Systems using GPS: An Opportunity for IGS to Make a Difference.

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The 26 December 2004 Sumatra earthquake (M_w 9.2-9.3) generated the most deadly tsunami in history. Yet within the first hour, the true danger of a major ocean wide tsunami was not indicated by seismic magnitude estimates, which were far too low (M_w 8.0-8.5). This problem relates to the inherent saturation of early seismic-wave methods. Here we show that the earthquake's true size and tsunami potential can be determined using Global Positioning System (GPS) data up to only 15 minutes after earthquake initiation, by tracking the mean displacement of the Earth's surface associated with the arrival of seismic waves. Within minutes, displacements of >10 mm are detectable as far away as India, consistent with results using weeks of data after the event. These displacements imply M_w 9.0 ± 0.1, indicating a high tsunami potential. This suggests existing GPS infrastructure could be developed into an effective component of tsunami warning systems.

IGS has an opportunity to contribute to future tsunami warning systems around the globe. An important aspect is real-time access to IGS data and precise GPS orbit and clock information, and software to analyze these data in real time. In this study we showed that current 30 second data from the existing IGS network would have been sufficient to identify the extreme tsunami danger. While it is likely that higher rate data would incrementally improve sensitivity, it is clear that densification of the IGS network around subduction zones would be more valuable. However the important message is that using the currently IGS network configuration can be much faster at accurately determining large earthquake magnitudes than using current seismological networks. To assess design requirements we show the effect of adding near-field stations, and the effect of orbit quality by comparing the use of real-time estimated orbits and clocks, ultra-rapid IGS orbits, and the Broadcast Ephemeris.