Rapid tsunami warning by means of GPS

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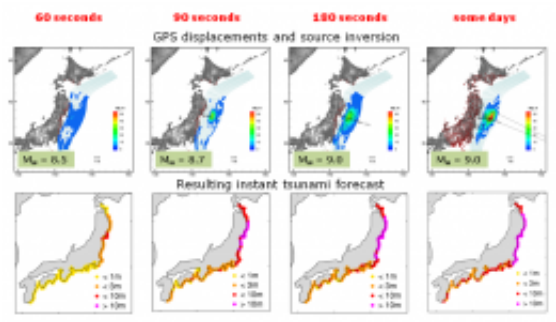

The figure shows the evolution of the rupture model based on real-time GPS data (top row) and corresponding tsunami forecasting (lower row) in time: 60, 90 and 180 seconds after beginning of the earthquake. The model after 3 minutes already is in good agreement with actual wave height observations at the coast. © A. Babeyko, GFZ

For submarine earthquakes that can generate tsunamis, the warning time for nearby coastal areas is very short. Using high-precision analysis of GPS data from the Fukushima earthquake of 11 March 2011, scientists at the German Research Centre for Geosciences GFZ showed that, in principle, the earthquake magnitude and the spatial distribution can be determined in just over three minutes, allowing for a rapid and detailed tsunami early warning.

One advantage of a GPS monitoring network in the vicinity of the epicentre is the availability of data shortly after the quake starts. Even as the earth shakes, the horizontal and vertical movements of the tectonic

plates are observed. Along with gradually incoming seismic data, this leads to an image of the rupture process while it is still in progress. This result was presented by GFZ scientist Dr. Andrey Babeyko at this year's assembly of the EGU (European Geosciences Union) in Vienna. "On the occasion of the Fukushima earthquake, we analysed data from more than 500 GPS stations and showed that a correct estimate of the magnitude of M = 9.0 and of the generated tsunami could have been possible in just three to four minutes after the earthquake," said Dr. Babeyko. The procedure consists of several steps: First, the raw GPS data is evaluated using high-precision satellite orbit data. The resulting displacements are inverted by means of a mathematical method to produce a spatial earthquake model. This allows to determine the deformation of the seabed, which is used as the source of the tsunami. Last step is the computation of the tsunami propagation in order to determine the warning levels for the coastal segments.

The so-called GPS shield concept was initially developed for the tsunami early warning system GITEWS that the Helmholtz Association developed under the leadership of GFZ on behalf of the German Federal Government for Indonesia. "The application on the data sets of the catastrophic earthquake of 11 March 2011 shows again what potential a GPS shield has in tsunami early warning systems, "said Babeyko."A GPS shield could be a useful tool for all regions with earthquake/tsunami risks."

There is an additional factor: a complete seismic evaluation takes time, which is not available in case of a potentially tsunamigenic event. Therefore, traditional seismic methods tend to underestimate the moment magnitude for very strong earthquakes in the beginning. GPS measurements of the horizontal and vertical displacements can correct this effect.