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Rapid tsunami early warning using real-time GPS: Reviewing the 2011 Tohoku event

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Nowadays, tsunami early warning is mostly based on seismological sensors and methods, even though there are some restrictions related to it. In case of the Tohoku earthquake on March 11, 2011, the official magnitude, which is a basis for tsunami warning, was Mw=7.9 in the beginning, and revised to Mw=8.4 after more than one hour, whereas the final value was found to be Mw=9.0. So the earthquake was dramatically underestimated, being more than 30 times more powerful than reported in the beginning. The use of additional sensor types could help to reduce these discrepancies immediately after the earthquake. GPS data can be processed in a real-time manner, resulting in accuracies of coseismic surface displacements of a few cm, which is enough to derive slip distribution at the fault. This allows to compute the sea floor deformation field, which is used as initial condition for the simulation of tsunami propagation and impact. In earlier studies, we demonstrated the power of the so called 'GPS Shield' concept based on synthetic GPS data. Here, we present a complete processing chain starting from actual GPS raw data of the Tohoku earthquake. We fully simulate the situation as it would be in a warning center. The chain includes processing of GPS observations with predicted orbits, inversion for slip and GPU based computation of the tsunami propagation and coastal warning levels. We show that it is possible to provide accurate tsunami warning as soon as 3 minutes after the beginning of the earthquake.