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Tsunami simulation method initiated from waveforms observed by ocean bottom pressure sensors for real-time tsunami forecast; Applied for 2011 Tohoku Tsunami

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After tsunami disaster due to the 2011 Tohoku-oki great earthquake, improvement of the tsunami forecast has been an urgent issue in Japan. National Institute of Disaster Prevention is installing a cable network system of earthquake and tsunami observation (S-NET) at the ocean bottom along the Japan and Kurile trench. This cable system includes 125 pressure sensors (tsunami meters) which are separated by 30 km. Along the Nankai trough, JAMSTEC already installed and operated the cable network system of seismometers and pressure sensors (DONET and DONET2). Those systems are the most dense observation network systems on top of source areas of great underthrust earthquakes in the world.
Real-time tsunami forecast has depended on estimation of earthquake parameters, such as epicenter, depth, and magnitude of earthquakes. Recently, tsunami forecast method has been developed using the estimation of tsunami source from tsunami waveforms observed at the ocean bottom pressure sensors. However, when we have many pressure sensors separated by 30km on top of the source area, we do not need to estimate the tsunami source or earthquake source to compute tsunami. Instead, we can initiate a tsunami simulation from those dense tsunami observed data. Observed tsunami height differences with a time interval at the ocean bottom pressure sensors separated by 30 km were used to estimate tsunami height distribution at a particular time. In our new method, tsunami numerical simulation was initiated from those estimated tsunami height distribution.
In this paper, the above method is improved and applied for the tsunami generated by the 2011 Tohoku-oki great earthquake. Tsunami source model of the 2011 Tohoku-oki great earthquake estimated using observed tsunami waveforms, coseimic deformation observed by GPS and ocean bottom sensors by Gusman et al. (2012) is used in this study. The ocean surface deformation is computed from the source model and used as an initial condition of tsunami simulation. By assuming that this computed tsunami is a real tsunami and observed at ocean bottom sensors, new tsunami simulation is carried out using the above method. The station distribution (each station is separated by 15 min., about 30 km) observed tsunami waveforms which were actually computed from the source model. Tsunami height distributions are estimated from the above method at 40, 80, and 120 seconds after the origin time of the earthquake. The Near-field Tsunami Inundation forecast method (Gusman et al. 2014) was used to estimate the tsunami inundation along the Sanriku coast. The result shows that the observed tsunami inundation was well explained by those estimated inundation. This also shows that it takes about 10 minutes to estimate the tsunami inundation from the origin time of the earthquake. This new method developed in this paper is very effective for a real-time tsunami forecast.