Real-time forecasting of near-field tsunamis: current status of tsunami early warning and technology developments for future improvement

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Around Japan, many earthquakes and tsunamis occurred and damaged the near-field coastal communities. Since the source area is close to the Japanese coasts, the resulting tsunami comes in a short time, 5-30 min after an earthquake occurrence. One of the most effective countermeasures to mitigate the tsunami disasters is real-time tsunami forecasting. Rapid and accurate tsunami prediction and its appropriate dissemination to the residents of coastal region as tsunami early warning will help their decisions about evacuation. In this presentation, I will explain tsunami early warning issued by Japan Meteorological Agency (JMA) during the 2011 Tohoku earthquake (magnitude 9), and the improvements to overcome the shortages. Then, I will review tsunami-forecasting technologies that are developed in the seismology, coastal engineering, and geodesy fields.

Several geophysical observation data are available for real-time tsunami forecasting before tsunamis arrive at the near-field coasts. For example, seismic waves propagate much faster than tsunamis, and thus seismic magnitude based on the data is useful for issuance of tsunami warning soon after an earthquake. Another beneficial observation is offshore tsunami measurements, such as cabled ocean-bottom pressure sensors and GPS buoys. They can detect tsunamis directly, resulting in reliable update of tsunami warning. JMA, who has responsibility for issuing tsunami warnings in Japan, designed warning procedure by taking into account the strong points of those observation data. When the 2011 Tohoku earthquake occurred, JMA issued and updated tsunami warning promptly. However, a couple of shortages were highlighted, such as underestimation of tsunami-height prediction in the first warning due to magnitude saturation. To overcome the shortages, JMA has made several improvements and installed the new functions into the tsunami warning system.

In the research phase, tsunami monitoring and forecasting technologies are being developed and improved. One of the monitoring developments is large-scale and dense offshore seafloor earthquake and tsunami observation networks. Another monitoring development is improvement of GPS buoy in order to deploy it at more offshore region than the present limitation distance from the coastal line. In tsunami-forecasting technology development, several geophysical data are used. Real-time analysis methods of inland seismic and/or GNSS data are improved for estimating not only point source solution (magnitude and hypocenter location), but also finite source information (spatial size and slip distribution) that affects tsunami forecasting greatly. On the other hand, tsunami-forecasting methods that use offshore tsunami data are developed and improved by several kinds of approaches (e.g., tsunami source inversion or data assimilation technique). In addition, several researchers propose joint use of different kinds of geophysical data for compensating shortage of each data. Moreover, high-speed computing technology such as supercomputer and GPU are recently used for nonlinear tsunami simulations. Hybrid use of the real-time source estimation and the high-speed tsunami calculation will realize real-time tsunami inundation forecasting that will support not only tsunami evacuation behaviors, but also quick estimation of tsunami-damaged area resulting in support of early recovery from tsunami disasters.

As mentioned above, many technologies relating to real-time tsunami forecasting are developed and

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improved. I consider that we, people who experience the Great East Japan Earthquake, should continue the technology developments and conduct the careful performance tests towards the installation into tsunami warning system for the mitigation of future tsunami disasters.

Keywords: Tsunami early warning, Real-time tsunami forecasting, Offshore tsunami observation, Near-field tsunami, Disaster mitigation

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