Development of tsunami damage reduction technologies by linking oceanographic radar with numerical simulations

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1. Background and purpose of the research

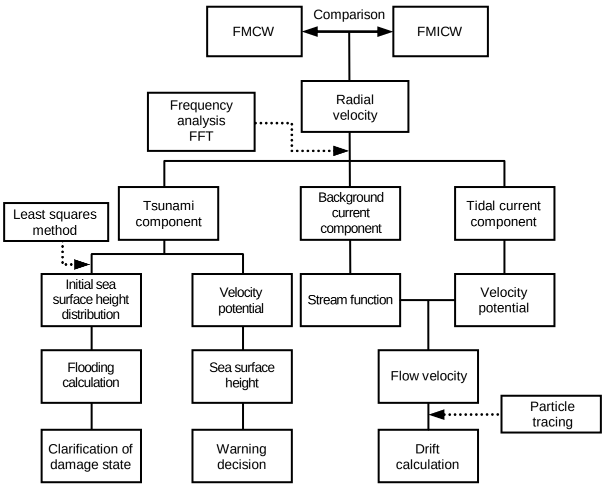
The Great East Japan Earthquake clarified two major problems concerning the reduction of tsunami damage: [1] underestimation of tsunami height, and [2] delayed identification of regions that will be severely damaged. [1] was a result of technical limits of present tsunami warning system based only on analysis of seismic waves and [2] was caused by slow clarification of the state of damage by prefectures as a result of catastrophic damage to administrative organs of cities, towns, and villages by the Great East Japan Earthquake. In the event of a giant earthquake such as the predicted Nankai Trough Earthquake, these problems could recur.

Oceanographic radar is land-based remote sensing equipment that measures flow on the ocean surface up to 100km offshore. We developed technology to resolve the above two problems by linking oceanographic radar with numerical simulations. To overcome challenge [1], we developed a method of calculating the sea surface height (SSH) distribution based on tsunami flow velocities offshore measured by the radar, and to deal with challenge [2], we developed a method of estimating tsunami initial SSH distribution with high precision by taking advantage of the characteristics of the radar, specifically its ability to obtain spatial distribution of a flow field. If it is possible to predict initial SSH distribution with high precision, it is also possible to clarify the state of damage over a wide area using existing tsunami models.

2. Analysis procedure

The figure shows the observed data processing flow chart. The double lines indicate technologies already developed, including existing technologies. The oceanographic radar transmits radio waves to the sea surface and receives the backscattered signals from the ocean surface. Frequency analysis (FFT) of the signal can obtain the velocity component caused by the tsunami (tsunami component) and the background current component unrelated to the tsunami (wind-induced current, density-driven current and tidal current components). Based on knowledge of fluid mechanics, the tsunami component is converted to water level distribution, and compared with tsunami warnings (resolving challenge [1]). This tsunami component and the least squares method are used to estimate the initial tsunami water level distribution[1]. In other words, it statistically estimated the degree of SSH that ought to be formed in the hypocenter region to create the tsunami distribution measured by the radar. Then the SSH is applied to the tsunami model to perform flooding calculation and to clarify the state of wide-area damage (resolving challenge [2]). The background current component will be used to calculate drift of heavy oil etc. discharged into the ocean.

Figure. Measured Data Processing Flow Chart



3. Future challenges

A weakness of our present radar system (FMICW) is that it is susceptible to the impacts of various kinds of noise resulting in weakening tsunami signals. To improve this, our research group is now developing radar that uses another transmission/reception system (FMCW). comparative tests of the present radar and the new radar system will be performed in the next fiscal year.

[Sources]
Fuji et al. doron, Journal of JSCE, Ser. B2 (Coastal Engineering) NO. 69, I_436-I_440, 2013