Tsunami Data Assimilation for the 2011 Tohoku Tsunami by a Single Ocean Radar in Ise Bay

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In previous study, tsunami forecasts in coastal area by data assimilation method using offshore tsunami observation was proposed (Maeda et al., 2015). This method forecasts tsunami wave height in coastal area directly without estimating the tsunami source, thus, this method is not affected by errors of the source estimation. However, when forecasting wave height on coastal areas using only offshore tsunami data, local topography effects such as in bays are difficult to consider (Wang et al., 2019).

For this problem, ocean radars can be a highly useful tool. Ocean radars observe surface current velocity where the spatial resolution is depending on the operational frequency. In this study, where 24.5 MHz is used, the observation range is approximately 30 km and the range increment is 1.5 km. Thus, dense observation in coastal areas by ocean radars enable us to consider local topography effects that are difficult to consider with only offshore observation alone, and have a possibility to forecast tsunamis more correctly. Moreover, because of land installation, the maintenance and the installation cost are inexpensive compared to the offshore tsunami observation tools.

In this research, we show that the 2011 Tohoku tsunami was successfully forecasted in Ise Bay by the data assimilation method using radial velocities of a single ocean radar. An optimal interpolation is used for the data assimilation. We quantified the forecast accuracy of the first tsunami wave and subsequent tsunami waves by the method of Aida (1978) and Variance Reduction (VR) respectively.

The results showed that at Nagoya, the tide gauge station located in the head of Ise Bay, the first wave was forecasted over 80% accuracy 60 min before the tsunami arrival. After the first tsunami wave, natural oscillation occurred in Ise Bay (Toguchi et al., 2018), however, at MATU, the tide gauge station at the radar site, VR was also over 80%. This indicates that the ocean radar successfully forecasted tsunami waves in the coastal region.

When forecasting tsunamis by data assimilation using a single ocean radar, the assimilation is performed by velocities that are projected onto the radial direction of the radar. Thus, the forecasting accuracy may differ depending on how the tsunami propagation directions match the radar radial directions. Therefore, when using a single ocean radar, it is possible to accurately forecast tsunamis by selecting optimal placement of the radar considering the topographical shape.

Keywords: Tsunami Data Assimilation, Ocean radar, Tohoku tsunami, Ise Bay

