Tsunami Data Assimilation of S-net Pressure Gauge Records

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The 2016 Fukushima Earthquake (M7.4) generated a moderate tsunami, which was recorded by the offshore pressure gauges of the Seafloor Observation Network for Earthquakes and Tsunamis (S-net). The S-net has a very short distance between two neighboring stations (~30 km), and records the water pressure and transmits the data to land in real time. Hence, it enables us to forecast the tsunami by data assimilation. Tsunami data assimilation is an early warning approach based on offshore observed data. It does not need the source information (Maeda et al., 2015 *GRL*). In this study, we used the S-net pressure gauge records for data assimilation, and retroactively forecasted the tsunami waveforms at three coastal tide gauges (Ofunato, Kamaishi and Miyako) to validate our method.

We processed the S-net raw records by two methods. In the first method, we removed the tidal components by polynomial interpolation, and applied a low-pass filter. This method is widely used in retrospective studies for waveform post-processing. However, the acausal digital filters require future data to filter the past data. So this method is not applicable in real-time operation. In the second method, we used the Ensemble Empirical Mode Decomposition (EEMD) real-time tsunami detection algorithm to extract the tsunami signals (Wang et al., 2020 *SRL*). EEMD decomposes the input data into several Intrinsic Mode Functions (IMFs), and separates the tsunami signals, seismic waves and tidal components automatically. The IMF2 represents the tsunami signals that are detected in real time. Then, the processed waveforms at 28 S-net pressure gauges were used for data assimilation.

The waveforms forecasted by assimilation with digital filter and EEMD were both consistent with the real observations in the first tsunami peak at coastal tide gauges. Though the assimilation results with digital filter had a better performance in the following waveforms, we note that only the EEMD results can be obtained in real-time operation. In summary, the data assimilation of S-net pressure gauge records is able to forecast the tsunami waveforms accurately, and the tsunami data assimilation approach can be really put into practice with the help of EEMD real-time detection algorithm.