Numerical study of the formation process of sandy deposit formed by the 2011 Tohoku-oki tsunami

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For modeling of tsunami sediment transport, grain size is generally assumed as single grain size or multiple grain size. Although there are some studies that conducted modeling under the multiple grain size condition, most studies have been performed under the single grain size. However, in the single grain size condition, we cannot calculate lateral and horizontal variations of grain size distribution of tsunami deposits, so we cannot confirm whether the model can reproduce landward and upward fining features that are commonly observed in the tsunami deposits. In this study, we simulated the sediment transport during the 2011 Tohoku-oki tsunami in order to evaluate the reproducibility of the modeling and to clarify the sedimentation process of the tsunami deposit.

Our study area is around the right bank of the Nanakita River mouth in Sendai, Japan. In this area, a detailed field survey was carried out by Abe et al. (2012), and we set a transect along their transect B. Delft3D, which is developed by deltales, was used in this study. Based on the 2011 Tohoku-oki tsunami modeling results using a source model proposed by Imamura et al. (2012), we extracted a wave profile at 2 km offshore of the transect. Then, this wave pattern was set as an incident wave for the calculation. We assumed 5 m thick movable bed uniformly from the bottom of the sea to the Teizan canal as in Watanabe et al. (2018), while landward from the canal was assumed as fixed bed. Normal distribution was assumed as grain size distribution at the movable bed based on Takashimizu et al. (2012) and Szczuciński et al. (2012); then four particle size was chosen for the multiple grain size modeling. We carried out calculations under multiple and single grain conditions (sediment 1 to 4) plus single grain size at mode diameter (354 μm) and compared each result. Manning's roughness coefficient was assumed based on a distribution map of Sugawara et al. (2014). Modeling results showed that inundation distance, flow depth and distribution of the tsunami deposit were generally consistent with those measured by Abe et al. (2012), although there were some discrepancy in the flow depth near the shoreline. Fining landward trend was not changed to the coarsening trend through the calculation. Although landward coarsening trend was locally and temporally formed, it was then changed to the fining trend through time. As a whole, our modeling results reproduced landward thinning and fining trends. Actually, the modeling results using both single mode diameter and the multiple grain size were almost similar. This is probably because normal distribution of grain size was assumed in this study and the percentage of around mode diameter is high.

Keywords: tsunami numerical simulation, multiple grain size, the 2011 Tohoku-oki tsunami

