Modeling of grain size distribution of tsunami sand deposits in V-shaped valley of Numanohama during the 2011 Tohoku tsunami

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We propose a numerical method of tsunami sediment transportation that can simulate grain size distribution of deposited sand. In the numerical model, the sediment transportation is computed in the suspended load layer and bed load layer (Takahashi et al., 2000; Gusman et al., 2012, EPS). We introduce two sub layers in the bed load layer, which are the active layer and the parent layer. These sub layers contain grain size distribution information. The coefficients for the suspended transport (alpha) and bed load transport (beta) for grain sizes of 0.166, 0.267, and 0.394 mm are obtained by a hydraulic experiment conducted by Takahashi et al. (2011, Coastal Engineering). In this study, the coefficients for grain sizes outside the above range (0.166 –0.394 mm) are extrapolated and for those within the range are interpolated. We simulated sediment transportation of multiple grain sizes ranged from 0.063 (4 phi) to 5.657 mm (-2.5 phi) with an interval of 0.5 phi.
We apply the model to simulate the sedimentation process during the 2011 Tohoku earthquake in Numanohama, Iwate prefecture, Japan. Samples of tsunami sediment deposits in Numanohama coast have been collected after the 2011 Tohoku earthquake (Goto et al., 2015, Marine Geology). The grain size distributions at 15 sample points along a 500 m transect from the beach are used to validate the tsunami sediment transport model.
For the tsunami source model, we use the one estimated by Satake et al. (2013, BSSA). This source model can well reproduce the observed tsunami run-ups that are ranged from 16 –34 m along the steep valley in Numanohama. For the sediment source, the parent layer (sediment source) is unlimited anywhere in the modeling domain and the grain size distribution of the parent layer is assumed to be the same as that found at the beach. The 200 m long and 50 m wide beach in Numanohama is dominated by rounded sand particles with d_{50} (the grain size at which the sample are 50% finer than) of 1 mm and located in front of coastal marsh.
The shapes of the simulated grain size distributions at many sample points located within 300 m from the shoreline are similar to the observations with the difference between observation and simulation peak of grain size of less than 1 phi (Goto et al., 2015, Marine Geology). The thicknesses of the observed sand deposits are also compared with the simulated ones. The simulated sand thickness distribution is consistent with the observation. The model is also capable of showing the sediment transport process of how the grain size distribution of the sand deposit changes over time. This kind of simulation result may be compared with the observed vertical change of grain size distribution.

Keywords: Simulation of grain size distribution of tsunami sand deposits, Tsunami sediment transportation process, The 2011 Tohoku tsunami sand deposits, Spatial distribution of deposit thickness, Suspended load and bed load transports, Coastal morphology change

