Reconstruction of flow depth and velocity of tsunamis by inverse analysis using thickness and grain-size distribution of tsunami deposits along 1D transect: Application to the 2011 Tohoku-oki tsunami and the 869 Jogan tsunami

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A new inversion model FITTNUSS (Framework of Inversion of Tsunami deposits considering Transport of Non-uniform Unsteady Suspension and Sediment entrainment) was proposed for estimation of tsunami hydrodynamic conditions from characteristic features of tsunami deposits along the transect. The forward model designed for the inverse analysis considers transport of non-uniform suspended load, and deposition from both run-up and stagnant phases of the tsunamis are calculated. The inversion model requires thickness and grain-size distribution of the tsunami deposit along 1D shore-normal transect as input data, and calculates flow depth, flow velocity and concentration of suspended sediments. Here, we applied this inversion model to the modern and the ancient tsunami deposits emplaced in the same region, and compare the reconstructed flow properties for understanding the behavior of the past tsunami. Firstly, the inversion model was applied to the 2011 Tohoku-oki tsunami deposit in the northern part of Sendai Plain. Thickness and grain-size distribution of the tsunami deposit were measured along the 4 km long transect from shoreline to the inundation limit. The run-up flow velocity observed by video footage was 4.2 m/s on average (Hayashi and Koshimura 2013), while the value estimated by the model was 4.15 m/s. The flow depths near shoreline obtained by the field survey and the inverse analysis were 4.9 m and 4.71 m, respectively. Secondly, the inversion model was applied to the 869 Jogan tsunami deposit in the northern part of Sendai Plain. Thickness and grain-size of the tsunami deposit were observed along the 3 km long transect from the paleo-shoreline to the estimated inundation limit. The run-up flow velocity and flow depth were estimated as 6.3-8.8 m/s in average and 5.3-7.8 m near shoreline. Although the 2011 Tohoku-Oki earthquake is often considered as the recurrence of the 869 Jogan Earthquake, the reconstructed values of flow velocity and depth of the 869 Jogan tsunami in the northern part of Sendai Plain were significantly high and deep in comparison with those of the 2011 Tohoku-oki tsunami, suggesting that there could be considerable differences in their generating mechanisms or topographic settings between these two tsunami events.

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