Inverse analysis of turbidity currents using two dimensional shallow water model

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Quantitative reconstruction of flow properties from turbidites is a long-standing problem in deep-sea sedimentology. If this is realized, magnitudes of past hazardous events may be estimated from geologic records containing seismo-(tsunami-)generated turbidites. Also, entire geometry of turbidite reservoir can be inferred by flow reconstruction. Thus, inverse analysis of turbidity currents contributes to disaster-risk assessment, and is of economic importance. Here we propose a new methodology to reconstruct flow properties of turbidity currents from three-dimensional geometry of deposits. In this method, a two-dimensional shallow-water model of turbidity currents was employed as the forward model. Numerical simulation was repeated to obtain horizontal distribution of thickness of turbidites under various initial conditions, and then this synthetic data set was used for supervised training of a deep-learning neural network (DNN). After the training phase finished, DNN properly estimated initial conditions of turbidity currents (e.g. initial flow height, velocity, etc.) from artificial test data set that was also produced from the forward model. To summarize, the machine learning produced the inverse model of turbidity currents that can estimate paleo-hydraulic conditions from synthetic or ancient turbidites. In previous methods, the computational cost of two dimensional model was too high to be employed as the forward model for turbidite inversion. On the other hand, our methodology can reconstruct initial conditions of turbidity currents instantaneously. Although production of the training data set requires 1000s times repetition of calculation, the problem of calculation efficiency can be easily solved by using PC cluster. In future study, it is expected to apply the new methodology to actual turbidites measured in 3D seismic profiles or by high-resolution sampling on modern sea floor.

Keywords: sediment gravity flow, turbidite, inverse analysis, machine learning