Numerical modeling of tsunami deposits: recent advances and future research

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This presentation reviews recent research on numerical modeling of tsunami sediment transport and discusses future research directions.
From the viewpoint of disaster science, recurrence intervals and magnitudes of paleotsunami events is a primary reason for studying tsunami deposits. Tsunami numerical modeling has been an important part of the research field since the 1990s. Numerical modeling provides supporting information for interpreting tsunami deposits and can help reconstruct inundation area and wave source. The 2011 Tohoku-oki earthquake tsunami provided an opportunity to improve coupled tsunami hydrodynamic and sediment transport models because of the quantity and quality of pre- and post-tsunami field data and real-time observations. For example, recent case studies of Oppa and Hirota Bays on the Sanriku Coast [1][2] and the coastal plain of Sendai Bay [3] demonstrated that changes in the coastal geomorphology, volumes of erosion and deposition, and distribution of the onshore tsunami deposit can be reproduced when the model inputs and boundary conditions, such as wave source, bathymetry and topography sediment source, and grain size are well constrained. Numerical modeling of tsunami sediment transport will benefit planning pre-tsunami countermeasures and post-tsunami recovery, improved estimation of tsunami inundation area and wave source, and assessing suitable sites for geological surveys of paleotsunami deposits.
A dearth of geological data and uncertainties in pre-existing geomorphology and other conditions are very common in paleotsunami research. In such circumstance, unequivocal estimation of tsunami inundation area and wave source is quite difficult. Hybrid modeling [4][5], which combines forward and inverse models of tsunami sediment transport and deposition, is a possible way to solve this problem. Flow parameters, such as flow velocity and shear velocity, are estimated based on the inverse modeling of tsunami deposit. Estimated flow parameters are used as boundary conditions of the forward modeling, which determines tsunami inundation area and wave source. In addition, forward modeling is used to assess whether the assumptions of the inverse model are satisfied. Although substantial investigation will be required, hybrid modeling can be a promising approach to extract more information from tsunami deposits.
The role of tsunamis in coastal geomorphology and stratigraphy, and the formation process of tsunami deposits are important topics for tsunami sedimentology. Few numerical studies [6][7] have investigated internal structures of tsunami deposits, for example sedimentary units and lamina, and horizontal and vertical variations of grain size. Tsunami deposits simulated by the forward modeling are not often compared with the observed deposits, in terms of structures. If numerical models acquire the ability to resolve the sedimentary structure of deposits, we can compare models not only to the commonly observed parameters such as deposit thickness and bulk grain size of deposit, but also can constrain the processes of tsunami sedimentation. A new model, the “stratum simulator” can be coupled with numerical models of tsunamis and other phenomena that create event layers. Such models may benefit improved identification of event deposits and interpretation of sedimentary records.

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