A new numerical model of turbidity currents considering the vertical flow structure: Development of the two-layer depth-averaged model based on numerical experiments using 2-D RANS model

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This study proposes a new numerical model of turbidity currents, which allows us to perform numerical experiments of natural-scale turbidity currents.

Turbidity currents run out long distances and deposit vast amounts of sediments on submarine fans of deep-sea floors. The length of submarine channels created by turbidity currents exceeds tens of kilometers and reaches up to thousands of kilometers. However, the existing numerical models of turbidity currents have difficulties to reproduce the natural-scale turbidity currents because its computational load is high or computed flow parameters are unrealistic. Recently, a numerical study of turbidity currents at an equilibrium state using depth-resolving 1-D Raynolds-averaged Navier–Stokes (RANS) model implied that a turbidity current could separate itself into two layers. This result suggests that a turbidity current can run out long distances without dissipating because the flow is driven by its lower layer which does not get diluted.

This study proposes a two-layer depth-averaged model, which is composed of the lower driving and upper diluting layers, to reproduce the behavior of the natural turbidity currents that potentially travel very long distances. This model includes the equations of conservation for the momentum, fluid mass, and sediment mass of each layer. This study conducted the two-dimensional numerical experiments using depth-resolving 2-D RANS model with the aims of (i) parameterization of the fluid and suspended sediment fluxes at the boundary between two layers, and (ii) providing the reference data for verification of the newly proposed model. We obtained spatial and temporal changes of flow properties of turbidity currents in both vertical and flow-parallel directions by RANS model. As a result, it was suggested that the fluxes of fluid and suspended sediment can be estimated from other flow parameters. The spatial development of flow parameters computed by the depth-averaged two-layer model shows good agreement with those results of RANS model. Finally, we conducted numerical experiments of field-scale turbidity currents with the two-layer model, and the model predicted reasonable values of flow parameters. As future studies, further numerical experiments under various topographic and flow initial conditions are required for more accurate parameterization of the newly proposed model of turbidity currents. Also, it is necessary to verify the model by physical laboratory experiments and field data.

キーワード：混濁流、数値実験、深さ平均モデル、レイノルズ平均ナビエストークスモデル
Keywords: turbidity current, numerical experiments, depth-averaged model, Raynolds-averaged Navier–Stokes model

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