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A computationally efficient two-phase hydro-sediment-morphdynamic model and its preliminary field applications

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While fluvial flows carrying relatively coarse sediments involve strong two-phase interactions, existing numerical modeling in the field-scale is mostly based on quasi-single phase flow model. Here a computationally efficient two-phase hydro-sediment-morphodynamic model is developed with a special focus on field applications. The hybrid LTS/GMaTS method originally developed for quasi-single flow model is extended to the present two-phase flow model, of which the achieved reduction in the computational cost facilitates the present field applications in the Taipingkou Waterway, Middle Yangtze River. To overcome numerical instabilities arising from the relatively large spatial and time steps in field case that lead to an issue of stiff source term, the following numerical treatments are proposed: implementation of theoretically-derived lower and upper limits for the inter-phase interactive forces. Moreover, to improve the numerical accuracy, the HLLC approximate Riemann solver is used for the water phase, whereas the FORCE solver is used for the sediment phase. Both the present two-phase flow model and the existing quasi-single-phase flow model are applied to a series of typical cases, including refilling of a dredged trench, a full dam-break flow in an abruptly widening channel and reproduction of the Taipingkou waterway, Middle Yangtze River. Compared with the quasi-single-phase flow model, the two-phase flow model has better performance as compared to the measure data and has more profound physical significance.