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Fundamental study for 2-D numerical simulation of channel changes in large rivers dominated by fine sediment

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Summary

Numerous barrage structures have been constructed on the Indus River for irrigation and water distribution. These structures affect the flow and sediment continuity of the river during high flows, and have led to channel changes and embankment failures in the past. The 2-D numerical modeling of flow and sediment is a viable tool to predict channel changes in large rivers. However, it is not easy to verify such numerical models in a large river dominated by fine sediment. In the current numerical model, e.g., the one developed by Takebayashi and Egashira (2001), sediment is transported by the flow based on the transport equation. The non-equilibrium transport of fine sediment is modelled using erosion and deposition, as source and sink terms, respectively, which control the bed elevation change in rivers dominated by fine sediment. The objectives of this study are twofold: to verify the current numerical models governing fine sediment transport based on field measurements and satellite-based observations; and to propose modifications where observed physical processes could not be adequately explained using the current model. Subsequently, the proposed numerical method can be used to predict channel changes in a large, fine sediment-dominated river, such as the Indus, which can be used

propose changes in channel management or countermeasures to river managers and policy makers.

To elucidate the sediment transport processes and verify the current numerical models in a large river, field measurements are conducted in the Brahmaputra River using an Acoustic Doppler Current Profiler (ADCP), turbidity meter, water sampler and bed material sampler. Acoustic Backscatter Turbidity (ABT) is used as a surrogate for fine sediment concentrations. Furthermore, satellite-based NIR observation is employed to obtain a spatial distribution of turbidity near the water surface. The ABT, and the satellite-based NIR are proven to be robust methods to monitor fine sediment. Boils are also observed in areas of the river where velocity differences exist due to bedform or river bed shape. It is found that the force generated by boils lifts larger particles into suspension, and that the vertical sediment concentration profile is controlled by the vertical flow velocity, in addition to the turbulent-diffusion process. Thereafter, using dense measurements by the ADCP, the transport of fine sediment is discussed for different flow conditions. ABT is used to estimate vertical profiles of non-uniform sediment concentrations implying the Rousean distribution. In an area where the flat-bed condition exists, no boils are observed, and nearly equilibrium condition is observed. In the areas where the vertical velocity exists due to influence of bedform or boils, the vertical distribution of sediment concentrations can be represented using the Rouse equation by including the influence of vertical velocity. To model boils in a 2-D numerical model, the occurrence of boils is predicted using bedform roughness.

The final part of the study outlines policy implications in light of the findings of the present study. In particular, the requirements and constraints of the proposed method for

numerical modelling in large, fine sediment-dominated rivers are discussed. As a number of new methods based on the field measurements and satellite data are used to verify the current numerical model in fine sediment-dominated river. Practical applications of the present study towards improving river management and policy are also discussed.