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論　文　内　容　の　要　旨

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The sediment and ice can be considered solid substances in fluid flows and are active research fields having rich contents to be studied. In order to enhance numerical modeling knowledges for such problems, this thesis compiles the research works for the macro and mesoscopic numerical modeling for the sediment and ice problem in two parts, respectively. Before the parts, Chapter 1 outlines an introduction including research objectives, motivations, descriptions of fluid flows in different scales and an outline for the thesis. The descriptions of fluid flows provide a brief introduction to macro and mesoscopic modeling.

Part 1 of this thesis comprises Chapter 2 to 4 devoted to macroscopic numerical modeling for sediment transports at an estuary the Ohkouzu diversion channel of the Shinano River to the Sea of Japan. In Chapter 2, the numerical models for an estuarine flow and sediment transports are developed as a numerical framework in the 2 and 3D space. The contributions in this chapter are a representative particle tracking method (PTM) with the simple model for a flocculation process motivated on the traditional solution for the sediment transport with the advection-diffusion equation (ADE). In Chapter 3, the detailed numerical techniques for the macroscopic models can be found. In Chapter 4, discussions of a lab-scale lock-exchange problem for the validation of the newly proposed PTM against the ADE are followed by the application of the numerical models for the sediment transport problem in the estuary. A proposed simple flocculation model is enriched by the experimental parameters. The results with numerical modeling give more understanding of the interaction between sediment transports and estuarine flow dynamics including the density current. In particular, the PTM yields the comprehensive descriptions about particle distribution in space and time depending on the estuary flow and sediment particle sizes. The overall results confirmed the in-situ observations and measurements.

Part 2 documents mesoscopic modeling, precisely lattice Boltzmann modeling, for ice problems in an open channel flow in Chapter 5 to 9. Chapter 5 describes lattice Boltzmann models for free surface flows, scalar (heat) transports, liquid-solid phase transitions and fluid–solid interactions in order to comport the ice in open channel flows. Many of them have been coupled first time. Chapter 6 presents the implementations for the described models with the pseudo-potential codes containing new procedures, e.g., the coupling of free surface-liquid solid phase transition-immersed boundary algorithms. After Chapter 7 that gives extensive validations for each particular phenomenon hidden in ice in flows, the numerical models are applied to the fixed or freely moving ice in open channel flows. A substantial application in an outlet channel of a small hydropower plant results the description of the open water forming mechanism and shows a potential of the models for the ice problem in open channel flows as well as for the complex physics. Finally, the improvement of the numerical code to a parallel computation is slightly discussed in Chapter 9.

Nevertheless, each part is followed by a summary, the general conclusion and future recommendations are detailed in Chapter 10.