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Numerical study of sheared mobile polydisperse sediment beds with a coupled lattice Boltzmann - discrete element method

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With the increasing computational power of today's supercomputers, geometrically fully resolved simulations of particle-laden flows are becoming a viable alternative to laboratory experiments. Such simulations enable detailed investigations of transport phenomena in various multiphysics scenarios, such as the coupled interaction of sediment beds with a shearing fluid flow. There, the majority of available simulations as well as experimental studies focuses on setups of monodisperse particles. In reality, however, polydisperse configurations are much more common and feature unique effects like vertical size segregation.

In this talk, we will present numerical studies of mobile polydisperse sediment beds in a laminar shear flow, with a ratio of maximum to minimum diameter up to 10. The lattice Boltzmann method is applied to represent the fluid dynamics through and above the sediment bed efficiently. We model particle interactions by a discrete element method and explicitly account for lubrication forces. The fluid-particle coupling mechanism is based on the geometrically fully resolved momentum transfer between the fluid and the particulate phase. We will highlight algorithmic aspects and communication schemes essential for massively parallel execution.

Utilizing these capabilities allows us to achieve large-scale simulations with more than 26.000 densely-packed polydisperse particles interacting with the fluid. With this, we are able to reproduce effects like size segregation and to study the rheological behavior of such systems in great detail. We will evaluate and discuss the influence of polydispersity on these processes. These insights will be used to improve and extend existing macroscopic models.