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Investigation of the Dynamics of 3-D Flocs with Complex Morphology via Stokesian Dynamics Simulations

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Understanding the transport behaviors of suspended particulate matter (SPM) is crucial for analyzing the impact and the flux of sediment in natural aquatic environment. SPM usually exists in form of flocs which are fragile and loosely bound aggregates characterized by highly irregular 3D shape, low effective densities and high porosity [1]. Previous studies of the physical characteristics of flocs are often based on simplified 2-D geometries of complex 3-D shapes. With the availability of 3-D sampling data of flocs, we employ Stokesian dynamics simulations to investigate the vertical or horizontal transport behaviors of flocs, e.g. settling under gravity or movement under shear flows. The correlations between the floc shapes, the transport behaviors and the floc internal stresses imposed by surrounding fluid are investigated.
3-D voxel-based datasets of the flocs are generated by conducting non-destructive 3-D X-ray computed tomography imaging on the stabilized floc samples, following the preparation protocol described in Wheatland et al. [2]. Based on the resulting voxel-based images of the flocs, the structure of each individual floc is modelled as an assembly of identical solid spheres and the velocity of the assembly is solved via Stokesian dynamics [3,4].
An automated process of predicting the dynamics of a floc in liquid environment from its voxel image is established. The entire modelling approach can serve as a powerful tool for analyzing the parameters determining the flocs transport behaviors and possibly provide inputs for modelling sediment bed growth rate at macro scales.

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