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Can New Information on Suspended Sediment Floc Characteristics Improve Understanding of Cohesive Sediment Behaviour?

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Within aquatic environments cohesive fine-grained sediments and mixed sediments are transported as loosely bound aggregates, or flocs, with low density, high porosity and irregular, fragile structures. Their transport behaviour, particularly settling velocity, is largely controlled by their physical characteristics including floc size, shape, porosity and density. Current measurement techniques, such as optical microscopy, floc cameras and electron microscopy, either measure these characteristics as 2-dimensional simplifications of 3-dimensional structures or estimate parameters using assumptions of e.g., spherical shape or fractal mathematics. Yet the accuracy of these techniques is questionable given their reliance on 2D imagery which cannot be used to accurately reconstruct the 3D geometries of irregularly shaped structures. Here, we present new data on the novel 3D quantification of these characteristics using 3D micro-computed tomography (3D micro-CT). Comparing these results against 2D measurements for the same floc samples enables the validity of traditional 2D imaging methods as a means of describing floc geometries to be tested.

The 2D and 3D geometries of flocs with different organic matter (OM) concentrations were investigated. Three ‘synthetic’ floc populations were generated consisting of bentonite clay with concentrations of OM (xanthan gum) at 0.1%, 2% and 5%. In addition, a ‘natural’ floc population was generated from natural estuarine sediment containing intrinsic OM. To measure 2D floc geometries, flocs were settled in a floc camera system, equipped with a modified settling column to facilitate floc capture. Captured flocs were subsequently stabilised in agarose gel and transferred for 3D analysis via micro-CT.

3D quantification of floc size, shape, porosity and density at resolution c. 10 microns indicates that floc shapes are highly irregular and non-fractal with up to 5 orders of aggregation. Comparison between 2D and 3D physical characteristics (variables quantifying size, shape and density) indicate floc properties estimated from 2D representations are highly misleading and are skewed in a systematic way that appears to related to the orientation of the floc particles when imaged in the water column.