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A population balance model for multi-class floc size distributions of cohesive sediments in Belgian coastal zones

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To manage coastal and estuarine waters, it is critical to accurately predict the movements of cohesive and non-cohesive sediments. There are well-established methods to estimate the behavior of non-cohesive sediments; however, without extensive knowledge on flocculation processes it remains difficult to predict the behavior of cohesive sediments. Flocculation is one of the main processes (e.g., erosion, deposition, settling, consolidation and flocculation) in cohesive sediment dynamics. The study of flocculation is an interdisciplinary work since it relates to various physical (e.g., transport, settling and deposition), chemical (e.g., contaminant uptake and transformation) and biological (e.g., community structure activities and metabolism) activities. Nevertheless, a widely-accepted flocculation model that can quantitative simulating the Floc Size Distributions (FSDs) for a relatively large study domain has not yet been fully developed. In this study, a multi-class population balance flocculation model was developed to address the occurrence of suspended microflocs, macroflocs and megaflocs in Belgian coastal waters (southern North Sea). The floc size distributions were represented by the size and mass fraction of each particle group. The representative sizes of macroflocs and megaflocs are unfixed and migrated between classes mainly due to the effects of turbulent shear, differential settling and biofilm growth. Specifically, the growth of an aggregate because of biofilm attachment and extracellular polymeric substance glue is averaged to each elementary particle, with its growth rate response to various bio-activities. This simple bio-flocculation model has been successfully coupled in the open source TELEMAC modeling system with five passive tracers in a quasi-1D vertical case. It was validated by observation data at the station MOW1 close to Zeebrugge harbor during both peak algae bloom and low biomass periods. It shows that when the biomass is abundant the predictions of the mean settling velocities are largely underestimated when the biological effect is neglected. This model will enhance our knowledge of the dynamics of suspended particulate matters, especially the biophysical influences on the fate and transport of estuarine aggregates.