Investigation of lutocline dynamics in a turbulent Couette flow: a simplified model for muddy tidal inlets

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ABSTRACT:

The formation of a lutocline, i.e. a zone of sharp vertical gradient in suspended sediment concentration, can play an important role in rapid change in channel geomorphology of estuarine channels with strong tidal currents and relatively high concentrations of fine-grained suspended sediment. Understanding the mechanisms responsible for the stability and breakdown of muddy lutoclines is a crucial aspect for a more accurate prediction of the suspension profiles, and also of short-and long-term morphodynamic change in tidal channels. In this study we numerically analyze lutocline dynamics by modeling the response of the vertical concentration profile to a turbulent Couette flow, using the turbulence k-epsilon closure. Couette flow addresses an idealized one dimensional flow in which the motion starts through the application of a given shear stress on the upper plate. The model allows the study the propagation of the applied shear stress through the entire water column, so capturing the effects on turbulence and mud morphodynamics. First, we analyze the behavior of suspension profiles in the case steady state, unidirectional flow; second, we show how the model can be used to analyze the time scale of breakdown of the lutocline, in order to investigate the condition for which it can be stable, persisting throughout the tidal cycle (~12h) and thus affecting channel morphodynamics, or be transient and ephemeral.