# Numerical study of sediment particle trajectories under tidal bores

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## Abstract :

*The tidal bores occur in the shallow mouths of some rivers when high tides rise in the narrow funnel-shaped estuaries. There are two types of tidal bores. Low Froude numbers $Fr$ lead to low turbulences in the river flows, inducing undular tidal bores. High Froude numbers $Fr$ lead to high turbulences in the river flows, inducing breaking tidal bores. The study of sediment particle trajectories under tidal bores will help to understand the mechanisms of sediment transport in the river flows where the tidal bore phenomenon can appear. OpenFOAM, a CFD code, was used to simulate undular and breaking tidal bores by varying the Froude number $Fr$ between 0.99 and 1.66. The validation of numerical simulations was performed by means of Lemoine's theory. The analysis of wave amplitude $a_w$ and wavelength $L_w$ has allowed to define the transition between the hydraulic jump and the undular tidal bore, and the transition between the undular and breaking tidal bores. $L_w$ approaches the infinity when the undular tidal bore becomes a hydraulic jump. The decrease of wave amplitude $a_w$ is related to the presence of breaking tidal bores. The undular tidal bore appears for $Fr_1 > 1.04$. It becomes partially breaking for $Fr_2 > 1.43$ and totally breaking for $Fr_3 > 1.57$. A tracker method, based on solving of Maxey-Riley equations, was used to estimate the trajectory of sediment particles under tidal bores. The analysis of sediment particle trajectories was performed by means of modified Chen's model. The modications of Chen's model use three parameters denoted by $\beta_1$, $\beta_2$ and $\beta_3$. The relation between each parameter and the Froude number $Fr$ was established. $\beta_1$, related to the front celerity, decreases when $Fr$ increases. The undular tidal bores move faster than the breaking tidal bores. $\beta_2$ and $\beta_3$, related to the elevation and the attenuation, increase when $Fr$ increases. The train of undulations disappears with $Fr$. The wave breaking is responsible of the disappearance of undulations.*

**Keywords : Sediment transport, Maxey-Riley equations, tracker method, tidal bore, Froude number, OpenFoam.**