Hydrodynamics and sediments of the Bay of Buenaventura, Colombia – A 2D modeling study

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The Bay of Buenaventura, in the Pacific Ocean, is home of approximately 390.000 inhabitants, and one of the main trade hubs of Colombia. However, its shallow depths make it difficult for large ships to enter the Bay's port, holding up trade growth. National authorities, willing to sustain the port's economic dynamism, have dredged the bay's navigation canal over the last 26 years. Nevertheless, there remain important vacuums in the understanding of the morphodynamics of the bay, and there are no documented attempts to model its mixed sand and mud sediments dynamics.

During this work, a 2D depth averaged hydrodynamic, waves and sediment model of the Bay of Buenaventura was implemented using the TELEMAC modelling system. Moreover, three scenario simulations were performed, to assess the effect of deepening the bay's navigation canal. The scenarios represent the bathymetry as it was at the end of the last century (1997), and the bathymetries for a prospective depth of 14m and 16m respectively, along the Bay's navigation canal. Despite a persistent lack of data, the model was evaluated to be sufficiently accurate for simulating hydrodynamics, acceptable for mixed sediment dynamics, and limited for waves. The Bay's navigation canal, specifically the area between the open sea and the bay's entrance was revealed the main source and sink of sediments. This is the transition between deep and shallow waters, and also a horizontal contraction of the flow. Such geometry, plus a large tidal range (approximately 4m), caused a great deal of turbulence, erosion and re-suspension of bed particles during spring tides, reaching total sediment concentrations (bed load plus suspended load) above 135mg/l for sand and 18mg/l for clay. Conversely, during neap tides, sediments settled around this area and concentrations declined (<45mg/l for sand and <8mg/l clay).

Scenario simulations suggest that deepening the navigation canal leads to less erosion and lower sediment concentrations at its surroundings. This likely occurs because by deepening the canal, flow velocities are locally decreased, enhancing the sediment trapping capacity of the canal. It implies lower turbulent shear stresses at the sediment–water interface, and a decreased availability of sediments for re-suspension.

Finally, further research is proposed in the near future to reinforce this model and overcome simplifications caused by the lack of data. More specifically, the next step is to improve the wave model, as its ability to simulate the wave spectrum within the domain is still limited. Another step is to include the dumped volume of dredged material at the disposal location, which might provide a source of easily erodible material to the system.

Keywords: sediment morphodynamics; sand-mud mixtures; 2D depth-averaged numerical model; dredging