Numerical modeling of cohesive sediment transport along a mud dominated coast

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Introduction

Mud banks are a coastal morphological feature along the 1600 km long Amazon-Orinoco coastline. They migrate by (dominantly wave-induced) erosion of their trailing edge (i.e. the eastern side) and deposition on their leading edge (i.e. the western side) at an average rate of the order of 1 km/yr. These mud banks mostly consist of cohesive sediment, that is relatively easy entrained by currents and waves. As a result the suspended cohesive sediment concentration increases above mud banks. Moreover, suspended cohesive sediment concentrations are also determined by residual transport from the sediment discharge from the Amazon river, where all the cohesive material originates from. It is estimated that about 20% of the sediment discharge by the Amazon river is transported along this coastline by the North Brazilian Current and the Guiana Current. Modeling these processes on the scale of the continental shelf requires boundary conditions that differ from the conditions set on a coastal scale. In this research a free surface gradient has been applied in two directions: 1) a gradient in the downstream direction to mimic the Guiana current, and 2) a gradient from the shelf boundary to the coastline. These free surface gradients combined with the tidal database of Le Provost *et al.* (1995) were implemented to model currents for the coast of Suriname in the TELEMAC-2D hydrodynamic modeling software. Waves were also simulated by using TOMAWAC modelling software. The wave simulations were done with the following wave characteristics: peak period of 8 seconds, and a significant wave height of 1.5 meters. The sediment transport modeling software SISYPHE was used together with the TELEMAC-2D and TOMAWAC software to model suspended cohesive sediment transport. The results generated with these free surface gradients produced results that reflect the qualitative descriptions of suspended cohesive sediment transport in literature.

Shore parallel littoral currents and suspended sediment transport

The free surface gradients in both downstream and cross-shore directions were imposed on the model boundary. In particular, the insight of the cross-shore surface gradient was adapted from the study of the North Brazilian rings by Fratantoni *et al.* (2006) and wind driven currents in large oceans (Segar, 2012). Instead of implementing equations to model the North Brazilian rings and wind driven currents, a log-distributed water level gradient, perpendicular to the coast, of on average $1{:}5.10^{-6}$ was imposed on the cross-shore boundaries. In this way the model calculated a shoreward directed current in agreement with computed patterns within the domain and with observations. In addition, the imposed eastward surface gradient was about $1{:}4.10^{-7}$. Implementing both free surface gradients together with the new friction law proposed by Bi and Toorman (2015) in the TELEMAC-2D hydrodynamic modeling software, resulted in a dominant westward flowing littoral current (Figure 1).

The sediment transport modeling software SISYPHE was internally coupled to both the TELEMAC 2D and TOMAWAC modelling software to simulate cohesive sediment transport. An influx of cohesive suspended sediment was imposed on the upstream cross-shore boundary; this influx was set to a concentration of 0.02 g/l for only ten boundary nodes on the upstream cross-shore boundary. Furthermore, mud banks were implemented as erodible layers which could be eroded by bed shear stresses larger than 0.1 N/m^2. The model result of these implementations is illustrated in Figure 2.

The simulated littoral and tidal currents, and waves kept the suspended sediment transport parallel to the coastline.

Implementing these water level gradients on the boundary illustrate one successful way of simulating large scale littoral currents and suspended cohesive sediment transport.

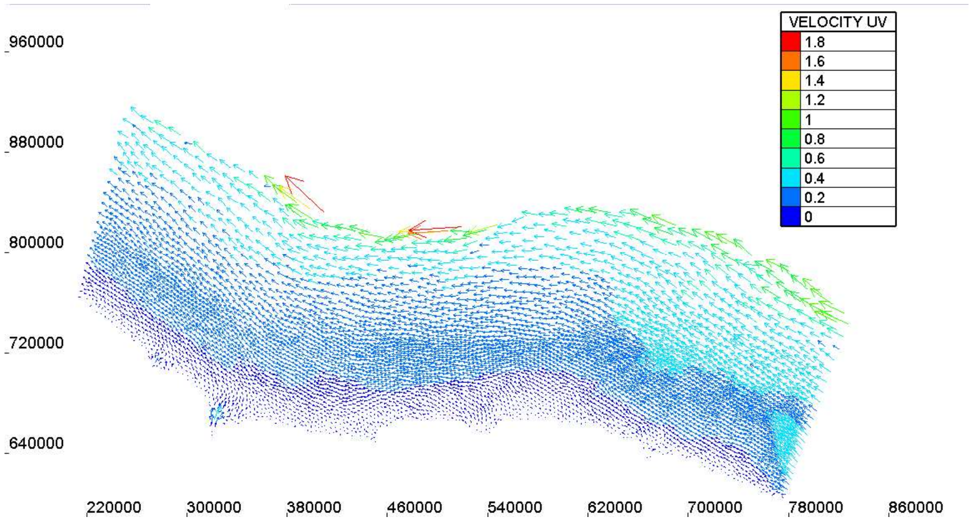

Figure 1: Modeled velocity vectors for large scale coastal model (after 92 simulated days).

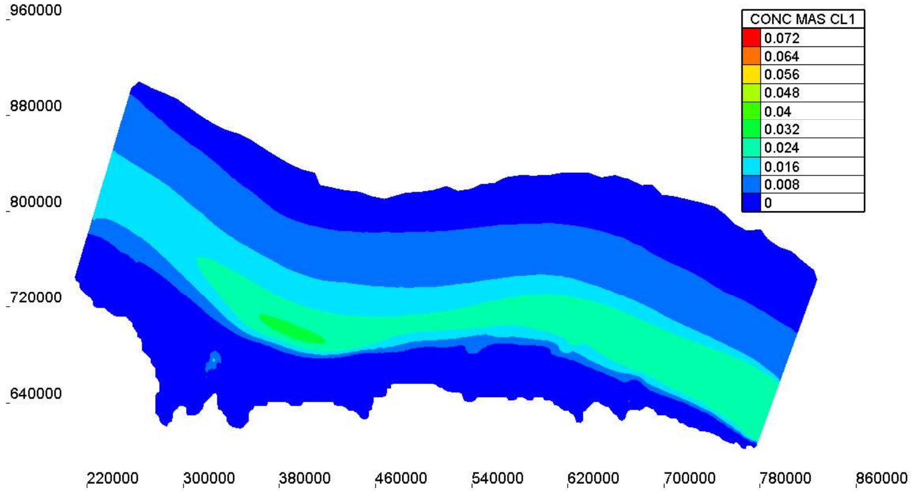

Figure 2: Simulated suspended cohesive sediment concentration (after 92 simulated days).

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