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Flood deposition and Storm resuspension of sediments in front of a deltaic wave- influenced river mouth: Insights from 14 years of measurements and numerical modelling

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River Mouth Bars (RMBs) are key morphological units for the future of deltas in nowadays rapidly changing natural and anthropogenic conditions, due to their sensitivity to river and environmental transformations. RMBs may bypass or disturb longshore currents by modulating the wave dissipation patterns, favor sediment sequestration, and develop morphological and stratigraphical asymmetries on coasts evolving in prevalent unidirectional longshore circulation environment such is the case of the Danube delta.

We report annual and seasonal bathymetric changes based on surveys of the Sf. Gheorghe river mouth area in the Danube Delta between 2004 and 2017, and examine the processes driving these changes with numerical modelling. On the long term, the overall negative sediment budgets recorded in front of Sf. Gheorghe mouth indicate that the present sediment supplied by the Danube, decreased by upstream dam construction, is insufficient to maintain a long term stable river mouth bar configuration.

Nevertheless, RMB sediment budgets show clear inter-annual variability modulated by the timing of storms and floods. During the exceptional river flood interval (2005-2006), when two floods with a 17-yr recurrence period occurred, and water discharge reached a maximum of 3500 m^3/s compared to an average of 1500 m^3/s, the RMB crest was pushed offshore by 250m and the RMB experienced a positive budget of 9 x 10^6 m^3down to -16 m (3.2 x 10^6 m^3 down to -8 m). Ca. 65% of this sediment volume gain was removed in just two years (2006-2008) in the absence of severe storms, whilst later, a similar sediment volume with that recorded post-floods, of 7.4 x 10^6 m^3down to -16 m (3.1 x 10^6 m^3 down to -8 m) was swept away in just one year between 2011 May and May 2012, mostly due to an extreme storm (February 2012) with offshore waves reaching 6 m in height. We simulated this event with Mike 21/3, a coupled hydrodynamic, wave and sediment transport model. The model simulates longshore currents exceeding 3 m/s on the seaward side of the mouth bar crest and intense wave breaking, and is able to reproduce the erosion patterns during the extreme storm only if cohesive sediments (silts/muds) are simulated. Sedimentological data based on shallow cores and surface samples shows that cohesive sediments are dominant below -4m, -6m depth in front of the river mouth showing the contribution of cohesive sediments in deltaic river mouth architecture.

Finally, we integrated field data with the Mike 21/3 model results to derive a conceptual hydro-morphodynamic model of an asymmetric wave influenced river mouth bar during the two antagonistic phases: (1) Flood dominated during which jet spreading and deceleration, plume expansion and extensive sediment deposition occurs and (2) Storm dominated during which the river jet is deflected downdrift, seaward of the mouth bar crest, wave breaking and the longshore current channelizes along the bar crest, possible wave supported gravity flows may occur and sediment resuspension induced by wave orbital velocities transports cohesive sediments at greater depths, showing the contribution of the silts and clays to RMB dynamics.