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Internal solitary waves control offshore extension of mud depocenters on the NW Iberian shelf

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Hydrodynamic conditions and near-bottom sediment transport on the NW Iberian shelf associated with a 5-day storm in September 2014 were monitored. Analysis of the field data in combination with high-resolution 3D modeling revealed that mesoscale (downwelling, coastal jet) and submesoscale processes (density front, secondary circulation and gravity-driven turbidity flow) induced by the storm play a major role in transporting fine-grained sediment from shallow waters toward mid-shelf mud depocenters. In the post-storm relaxation period, a rapid offshore dispersal of artificially (by lander deployment) resuspended mud was observed along an isopycnal surface with a mean transport speed of 0.5 m/s. To unravel a possible relationship between such rapid material dispersal and internal waves, we apply a weakly nonlinear model based on the variable-coefficient Gardner-Ostrovskii equation to estimate the flow fields and bottom shear stress induced by shoaling of mode-1 long internal solitary waves (ISW). Observed amplitudes and periods of these waves above the continental rise are used to provide model boundary conditions. Shoreward propagation of the ISW in three representative periods (pre-, during- and post-storm) is simulated, respectively. Simulation results show a good agreement with the backscatter signals from the eco sounder. Shoaling and transformation of the internal wave, from a single Gaussian-shape wave characterized by negative polarity and small amplitude to a dispersive trailing wave packet with varying amplitude and inverse polarity, are satisfactorily reproduced. Model results indicate that the maximum orbital velocity of the ISW increases during and after the storm, along with an offshore shift of the critical point where the leading ISW become unstable due to a drastic increase of high order nonlinearity. Bottom shear stress resulting from the wave deformation becomes strong enough (>=0.1 Pa) to winnow unconsolidated sediment from the mid-shelf mud depocenter and thus constrains the offshore extension of the depocenter. This provides a sound explanation for the observed coarsening of sediment grain size from the mid-shelf toward the shelf edge. An enhancement of the bottom orbital velocity and the asymmetry in the excursion direction of mode-1 long ISW in the post-storm period prove to be an efficient mechanism for cross-shelf transport of fine-grained sediment.