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A New Modeling Approach to Hindcast Marine Turbidity Currents

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The bulk of the sediment found on the abyssal plain is transported from the shelf to the deep ocean by marine turbidity currents. They consecutively erode, transfer and deposit large amounts of sediment determining the characteristics of the marine environment. Further, their destructive nature is evidenced by several failures of subsea infrastructures that have been associated with their passage. Many numerical models have been developed to study field-scale turbidity currents. However, these models do not include sediment transport processes typical of coastal settings. As such they currently require the prescription of boundary conditions usually difficult to assess. Here we present a new modeling approach to hindcast marine turbidity currents that is based on a three-dimensional application of the process-based model Delft3D capable of predicting the initiation of sediment gravity flows driven by wind- and wave-induced processes. Detailed numerical simulations were carried out to investigate the nature of a turbidity current that impacted upon a submarine pipeline offshore Philippines after the nearby landfall of a tropical cyclone. Our simulations predict the triggering of a severe turbidity current only after the passage of the aforementioned tropical cyclone and the absence of any significant undercurrent associated with the other most relevant cyclones that passed near the study area during the lifespan of the pipeline, matching field observations in the form of pipeline shifting. Numerical results describe the development of rip currents that flush out water and sediment in cross-shore direction, ultimately triggering a turbidity current into the submarine canyon that cross the pipeline where its displacement was detected. Collapse of similarity profiles of the predicted undercurrent with experimental measurements and field observations demonstrates the reliability of the model in capturing the vertical structure of turbidity currents. As Delft3D has been demonstrated to accurately reproduce sediment transport processes associated with different environmental pressures in various geomorphological settings, the proposed modelling approach will allow for a deeper understanding of the mechanisms involved in the initiation of marine turbidity currents and their potential forecast.