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The investigation of form and processes in the coastal zone under extreme storm events - the case study of Rethymno, Greece

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Coastal zone is a significant geographical and particular region, since it gathers a wide range of social-human's activities and appears to be a complex as well as fragile system of natural variables. Coastal communities are increasingly at risk from serious coastal hazards, such as shoreline erosion and flooding related to extreme hydro-meteorological events: storm surges, heavy precipitation, tsunamis and tides. In order to investigate the impact of these extreme events on the coastal zone, it is necessary to describe the driving mechanisms which contribute to its destabilization and more precisely the interaction between the wave forces and the transport of sediment. The aim of the present study is to examine the capability of coastal zone processes simulation under extreme wave events, using numerical models, in the coastal area of Rethymno, Greece. Rethymno city is one of the eleven case study areas of PEARL (Preparing for Extreme And Rare events in coastal regions) project, an EU funded research project, which aims at developing adaptive risk management strategies for coastal communities focusing on extreme hydro-meteorological events, with a multidisciplinary approach integrating social, environmental and technical research and innovation so as to increase the resilience of coastal regions all over the world. Within this framework, three different numerical models have been used: the MIKE 21 - DHI, the XBeach model and a numerical formulation for sea bed evolution, developed by Afaf Bouharguane and Bijan Mohammadi (2013). For the determination of the wave and hydrodynamic conditions, as well as the assessment of the sediment transport components, the MIKE 21 SW and the MIKE 21 FM modules have been applied and the bathymetry of Rethymno is arranged into a 2D unstructured mesh. This method of digitalization was selected because of its ability to easily represent the complex geometry of the coastal zone. It allows smaller scale wave characteristics to be represented at a finer resolution, near of the shore and the shoreline structures, and the offshore respective characteristics at a coarser resolution. For the investigation of the morphological evolution of the sandy bed a new numerical model has been used. The proposed model is based on shallow water equations and on minimization principles in order to investigate the coupling between the flow and the sediment, considering the sea bed as a structure with low stiffness. Minimization principles have been used many times in the past to design defense structures against beach erosion. In previous works, the designed structures were independent of time and were built once for all. Hence, the present method goes one step further giving the possibility to the structure to change in time. The fundamental assumption of this method is the fact that bed adapts to the flow by some sort of optimal sand transport in order to minimize some energy expression, optimal transport is seen here as minimal change in the bed shape. Furthermore, in order to verify the accuracy of this formulation the output is compared with the results of the XBeach model, under the same simulation conditions.