ABSTRACT

A numerical model to predict long-term coastal morphological behaviour in the Caribbean

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A numerical model was developed for use in the prediction of coastal morphology, due to natural processes, relevant to sites in the Caribbean. This research integrated the mathematical formalism and empirical bases required to delineate a probabilistic predictive model, which consists of four predictive phases designed for processes associated with 1) the hydrodynamic forcing of a random wave climate; 2) wave transformation in the nearshore zone; 3) sediment response to the hydrodynamic forces; and 4) the morphological response. The model employed a time-averaged, depth-integrated approach to those processes, which are prevalent within the nearshore region from the deep-water limit to the shoreline. The hydrodynamic forcing was primarily related to the probabilistic description of deep-water wave conditions, which included hurricane-generated seas. These deep-water conditions provided the input to the wave transformation phase.

The wave transformation stage involved the shoaling, refraction, breaking and decay of waves in the nearshore region, including the shallow water zone. The hydrodynamic phase also included the determination of undertow velocities and nearbed wave orbital velocities, which were required for sediment transport predictions. Sediment transport was based on the "Energetics" approach, which provides estimates of bedload and suspended load that are dependent on the efficiency of the energy processes in the fluid stream. This type of approach requires the calculation of velocity moments, and the establishment of levels of efficiencies of the sediment transport processes. Resulting sediment transport rates in the coastal area were used to determine bed level changes through exploitation of the principle of conservation of sediment mass.

Shoreline bed level changes are affected by swash zone processes. This highly complex area of the nearshore zone is the dynamic interface between the sediment stored on land, and the sediment in transition in the nearshore zone. This research proposed a new method to predict sediment movement in the swash zone, for use in the predictive model.

Validation exercises at various stages of the predictive model, demonstrate that the model is capable of adequately simulating nearshore wave heights, the breaking process, undertow currents, swash velocities and beach morphology. Deficiencies in the predictive capability of the model are identified, and further refinements are recommended to improve the accuracy and the range of applicability of the morphological model.

Keywords: beach morphology; storm waves, shallow water waves; undertow velocity; sediment transport; swash zone; wave breaking; energy dissipation.