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14. ABSTRACT

Currently, there are a number of models capable of predicting hydrodynamic and bathymetric evolution across the nearshore profile. These models encompass horizontally 1-dimensional and 2-dimensional evolution. Also, there are a number of hydrodynamic and bathymetric data sets, which span time periods of days [e.g., Birkemeier and Thornton, 1994] to decades [e.g., Wijnberg, 1995]. Yet, the skill of existing nearshore process models at predicting observed nearshore bathymetric change over a range of time-scales has not been well described.

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EVALUATION OF NEARSHORE PROFILE PREDICTIONS

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1. INTRODUCTION

Currently, there are a number of models capable of predicting hydrodynamic and bathymetric evolution across the nearshore profile. These models encompass horizontally 1-dimensional and 2-dimensional evolution. Also, there are a number of hydrodynamic and bathymetric data sets, which span time periods of days [e.g., *Birkemeier and Thornton*, 1994] to decades [e.g., *Wijnberg*, 1995]. Yet, the skill of existing nearshore process models at predicting observed nearshore bathymetric change over a range of time-scales has not been well described.

2. FORWARD MODELING

We compared the predictions obtained from a simplified process-based, 1-D-horizontal profile evolution model [*Plant et al.*, 2001] to parts of a 20-year long data set of observed profile evolution from Duck, NC, USA (Figure 1). The model formulation included a wave height transformation and a sediment transport formulation:

$$\frac{\partial}{\partial x} H = F(H, h, \text{ parameters}), \qquad (1)$$

where H is the rms wave height, and h is the water depth, and the parameterization is that of Thornton and Guza [1983].

The transport parameterization was

$$Q = \left(c H^3 h^{-3/2}\right) \left\{ \left(\frac{\partial}{\partial x} h\right) - \left(r_1 \frac{H}{h}\right) + \left(r_2 \frac{H}{h}\right)^2 \right\}. \qquad (2)$$

The term in parentheses is a wave stirring term, and the terms in braces form a rectification function (Figure 2)

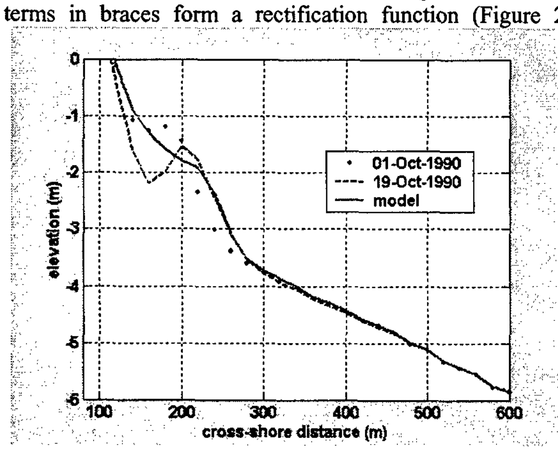

Figure 1. Initial observed profile (dots), final observed profile (dashed), and final predicted profile (solid) corresponding to the DELILAH experiment.

representing the influences of downslope transport, onshore transport due to weak wave nonlinearity (e.g., wave skewness), and offshore transport due to strong nonlinearity (e.g., undertow). Three free parameters are c, r_1, and r_2, which are expected to be O(10-3- 10-4), O(1), O(1).

Finally, sediment continuity was invoked:

$$\frac{\partial}{\partial t}(-z_b) = \frac{\partial}{\partial x} Q, \qquad (3)$$

where Z_b is the bed elevation relative to a fixed datum.

The model was initialized with an observed (alongshore-averaged) profile and forced at the seaward boundary with observed wave heights and tides. Hydrodynamic data were linearly interpolated to computation times. Wave angle and alongshore currents were ignored.

The bathymetric evolution was computed using an Adams-Bashforth scheme with a spatial step, Δx, of 20 m and a time step, Δt, of 3 hours.

3. INVERSE MODELING

Using an initial guess of the parameter values {c=1e-3, r_1=0.5, r_2 =1}, the sensitivity of a run of the forward model results with respect to the parameters was estimated using the adjoint model (equations not presented here). The sensitivity estimates and the deviations between all model predictions and all observations (18 days of beach surveys in the case of the DELILAH test) were used to estimate improved model parameters. The procedure was repeated iteratively to minimize the sum of the squared error.

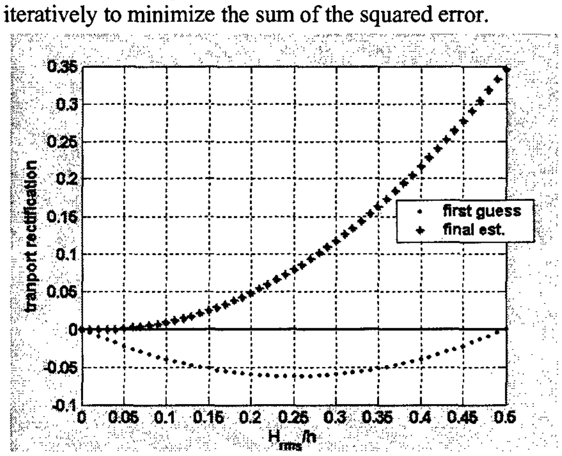

Figure 2. Sediment transport rectification function. The first guess represents the shape of the function initially used in the forward model. The final estimate corresponds to the parameters estimated via inverse modeling

4. RESULTS

Figure 1 shows a comparison to daily surveyed bathymetry from the DELILAH experiment. The tuned model predicted seaward sediment transport during the period of formation and seaward migration of a sandbar. However, the model did not predict a well developed trough, similar to the modeling results of Thornton et al. [1996].

The model predictions were more accurate than a prediction that there was no beach change over the study period (rms error = 0.24 m, Figure 3), and the no-change prediction error increased at twice the rate of the model prediction error (Figure 3). The modeling exercise was repeated with a 6-month time series of monthly bathymetric data, which had similar wave conditions to those during the DELILAH experiment. The model prediction error was 0.10 m, compared to 0.20 m for the no-change prediction. The model errors saturated rapidly (e-folding time of 30 days) at a value that was half the error of the corresponding no-change prediction errors (Figure 4). The no-change prediction was expected to saturate at a maximum value of 0.4 m in about 6-months, with an e-folding time of about 3.

5. CONCLUSIONS

We have chosen a simple parameterization of hydrodynamics and sediment transport along a cross-shore profile to predict bathymetric evolution. The predictions were compared to observations in order to tune the sediment transport parameterization and assess the model's predictive ability. Only sediment transport parameters were varied in order to fit the model to the data. This implies that, during the tuning process, errors in the hydrodynamic model were absorbed by the sediment transport parameterization.

In spite of many possible error sources, the tuned model predictions were better than a prediction that the beach was not evolving. This or perhaps any other nearshore profile evolution model could be used to make accurate (i.e., better than "no-change") forecasts as long as field observations are supplied at appropriate intervals (at least every 6 months in this case) to correct model prediction errors.

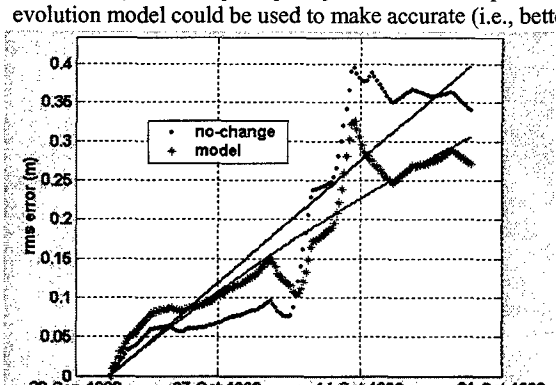

Figure 3. Time series of model errors (rms difference between observed and modeled profile at each time step) corresponding to the DELILAH experiment. The "no-change" error is the difference between the observed profile and the initial profile. Solid lines fit to data describe asymptotic error growth.

The parameter estimates from both 1-month and 6-month comparison periods yielded predictions that were dominated by offshore transport during periods of high waves. The bias of the tuned models toward offshore transport was similar to the bias reported by Thornton et al. [1996] and Gallagher et al. [1998], who used nearly perfect hydrodynamic inputs to drive sediment transport. This suggests that 1-dimensional horizontal, Bagnold-type sediment transport formulae systematically misrepresents onshore sediment transport, perhaps due to the neglect of alongshore variability.

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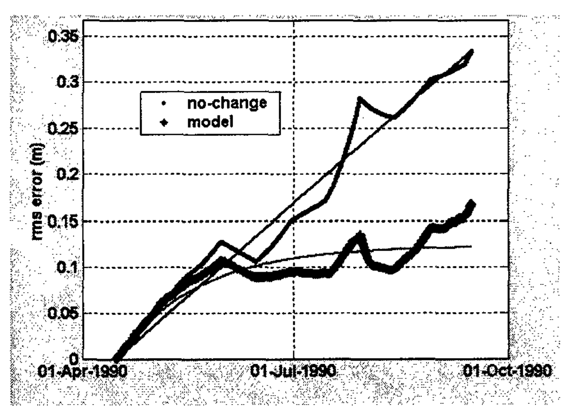

Figure 4. Time series of model errors corresponding to the 6-month experiment.