Geophysical Research Abstracts, Vol. 9, 01726, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-01726

Predictability Experiments of Nearshore Bathymetry using a Process-based Numerical Model

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Nearshore sandbars are common morphological features in 2 to 10-m water depth, protecting beaches from wave attack. Predictions of sandbar behaviour, based on nonlinear, deterministic waves-currents-bathymetric evolution models, are necessarily uncertain: the model formulations are incomplete and hence uncertain; also, the nonlinearity in the governing equations may result in predictive uncertainty because of a sensitive dependence on initial conditions. Both uncertainty sources impose a temporal limit to the predictability, beyond which the difference between the predicted and observed state is as large as the difference between two random states. The value of this limit as well as its dominant source are unknown.

Here, a calibrated waves-currents-bathymetric evolution model and an 8-year data set of daily measured cross-shore depth profiles of the Hasaki coast, Japan are used to examine the predictability limit and its dominant source for cross-shore oriented nearshore sandbar behaviour. The core of the methodology is an ensemble technique known as lagged-average forecasting. At a specific verification time t_V, the ensemble not only contains the forecast started from the initial conditions observed at some control time t_C but also forecasts for the same t_V started one or more days earlier than t_C. The temporal evolution of the spread in the ensemble members with in an increase in t_V indicates the sensitivity of the predictions to small differences in the initial conditions, while the temporal evolution of the difference between the ensemble mean and the observed depth profiles ('model skill') indicates the building up of errors owing to model flaws.

Results based on approximately 400 ensembles with 8 members each indicate that the error growth due to variability in the initial conditions and model uncertainty is

not a simple function of the forecasting time ($t_V - t_C$), but depends on the nature of the initial variability and the type of wave conditions. In general, the sensitivity of the predictions to variability in the initial conditions is limited, although storms tend to diversity the ensemble members somewhat. Situations with 'no model-skill' are reached at specific storm events, independent of the variability in the initial conditions, the spread in the ensembles just before these events, and the forecasting time. This suggests that the limit to the predictability of cross-shore oriented nearshore sandbar behaviour is primarily model-induced.