Computer Simulation of Sand Ripple Growth and Migration.

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LONG-TERM GOALS

The long-term goals of this study are to improve our understanding and ability to predict sand ripple size and migration under conditions relevant for active mine burial. This will assist in the quantification of how sand ripple growth and migration contribute to subsequent mine burial under waves and currents. In fine to medium sand scour-type bedforms grow to meter scale horizontal dimensions and 0.1-0.4 meter scale vertical dimensions under storm waves (Clifton 1976, Hay and Wilson, 1994, Traykovski et al. 2000). There are many potentially dominant variables controlling bedform size, shape, and migration rate, including wave orbital diameter, period, current strength, bed sediment size, size distribution, and compaction. Computer simulation has the potential to assist in understanding which of these variables are dominant under a variety of conditions. The potential improvement in the understanding of the fundamental mechanisms of sand bedform formation from this study will be a significant contribution to the quantification of bedform processes related to the burial of mines in sandy coastal environments.

OBJECTIVES

The objectives of this project are to modify, calibrate, and combine recently developed computer simulations of sand ripple growth and movement to make them applicable to the computer simulation of mine burial. The computer simulation work includes modifying and expanding the computer model of Wilson 1996 and combining it with the models of Wiberg and Smith 1985 and Rubin and Hunter 1987. The Wilson model is a highly nonlinear coarse-grid simulation that captures the relevant sediment transport physics in semi-empirical parameterizations from the Coastal Engineering and wave-flume literature. The Wiberg-Smith model calculates individual trajectories, and is needed to determine the transport effects of bed slopes, and the Rubin-Hunter model incorporates directionality in the forcing and it's result on the migration of the ripples (but requires other bedform characteristics such as height as inputs).

APPROACH

The approach can be summarized in the following list of tasks as follows:

1. Add a Bagnold-type gravitational settling term to the Wilson model to enhance prediction capability. The model currently has an oversimplified gravitational term, a more realistic version

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14. ABSTRACT
The long-term goals of this study are to improve our understanding and ability to predict sand ripple size and migration under conditions relevant for active mine burial. This will assist in the quantification of how sand ripple growth and migration contribute to subsequent mine burial under waves and currents. In fine to medium sand scour-type bedforms grow to meter scale horizontal dimensions and 0.1-0.4 meter scale vertical dimensions under storm waves (Clifton 1976, Hay and Wilson, 1994, Traykovski et al. 2000). There are many potentially dominant variables controlling bedform size, shape, and migration rate, including wave orbital diameter, period, current strength, bed sediment size, size distribution, and compaction. Computer simulation has the potential to assist in understanding which of these variables are dominant under a variety of conditions. The potential improvement in the understanding of the fundamental mechanisms of sand bedform formation from this study will be a significant contribution to the quantification of bedform processes related to the burial of mines in sandy coastal environments.

15. SUBJECT TERMS

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will lead to the model converging more quickly and possibly stabilizing on a more accurate bedform size.

2. Enhance the Wilson model to include grain size effects. This task involves recalculating mobility and gravitational settling parameters for a variety of sand sizes. The model will then be run through a range of wave and current conditions for each sand grain size.

3. Perform computer model sensitivity studies to identify parameters that need further measurement. Several terms in the model are poorly characterized in either flume or field experiments, their sensitivity in the model must be checked over a range of forcing conditions and sand grain sizes.

4. Interface this improved model to the Wiberg-Smith model and Rubin-Hunter model. One way to enhance trust in the model is to demonstrate that it produces the same results as other models in similar parameter ranges if these ranges can overlap.

WORK COMPLETED

This project was funded in April of this year, so there is little to report in the way of completed work. Task 1, addition of a Bagnold-type gravitational settling term to the model has been started, and task 3, the model sensitivity analysis to this addition is underway.

RESULTS

Example runs of the model with and without the gravitational settling terms are shown in Figures 1 and 2. A general overview of the model is provided in Wilson 1996. This work also carries on from previous work done for the US Geological Survey. The wave forcing is asymmetrical, and the grid is 107 by 109 centimeters and the model runs forward in time, moving sand from grid point to grid point depending upon bed slope, lee sheltering, and small scale avalanching. In previous work, the model has been tested for independence of the results from the gridding scheme employed by running the model with different angles of the wave forcing. Further model verification runs (not shown) have been made to test the effects of grid size and the periodic boundary conditions (in both x and y directions) used. These runs show no significant difference from the standard grid size (107 by 109 point array) employed.

The new results shown here demonstrate that the model generates a significantly more realistic ripple profile (lower graph) when a simple gravitational settling algorithm is added. The ripples in this model grow from sand-grain size roughness due to positive reinforcement of initial instabilities. The preferred ripple size and shape depend on interactions of the ripples with each other, the orbital diameter, and timing of the forcing. These results need further verification for the wide range of forcing encountered in the field. The model without the gravitational settling generates all the observed ripple types (including cross-ripples and lunate mega-ripples as observed by Clifton 1976) and the gravitational settling is not expected to change the general results of the model.

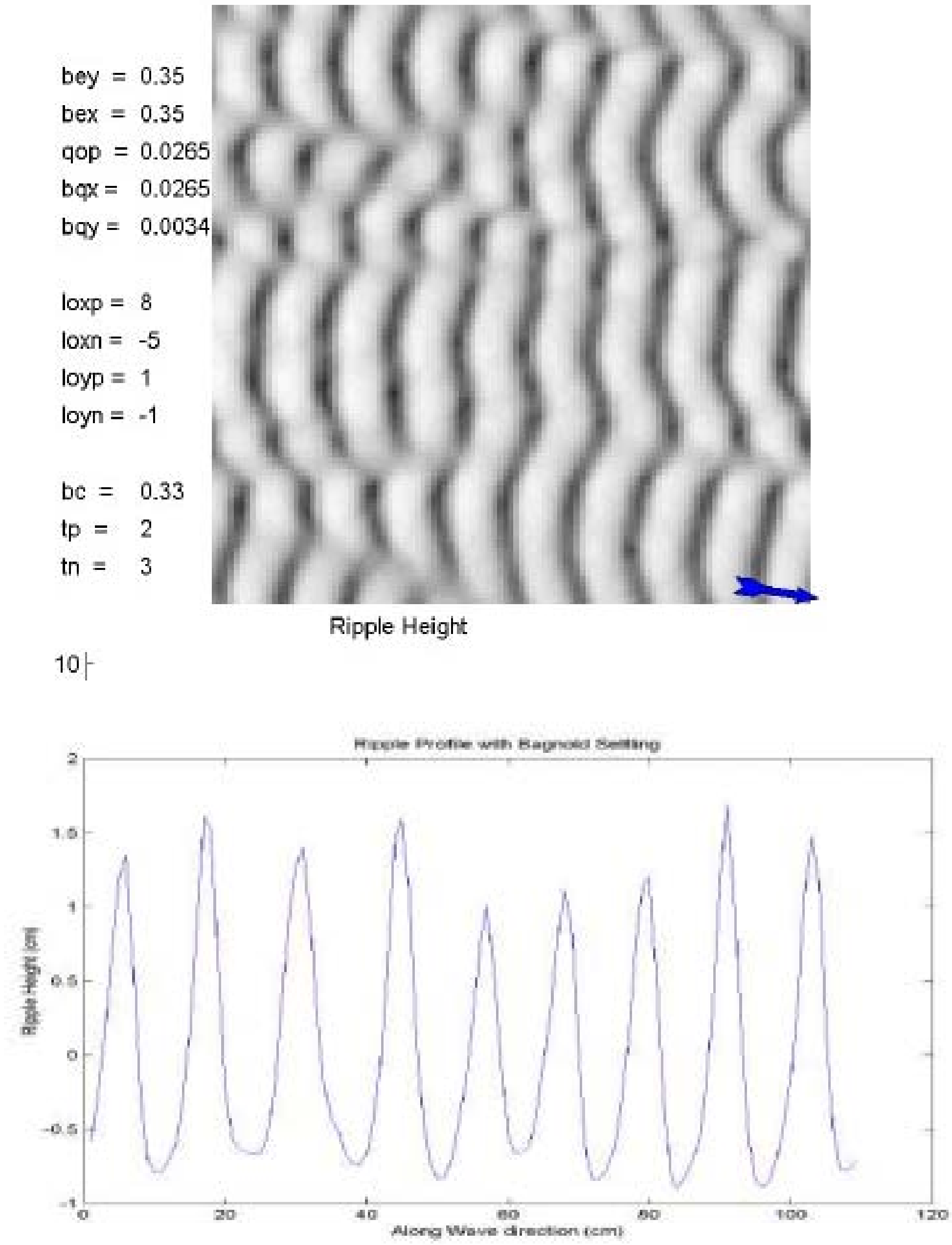

Figure 1: Computer simulation of sand ripples under waves.

[The upper graph is a gray scale map of the ripple elevation, with darker gray on the crests of the ripples. The arrow denotes the wave direction, the numbers on the left side of the image are model settings. The lower graph shows a cross-section of values across the domain at 30 cells down. The model was started with sand-grain size roughness, then stopped after 250 time steps (roughly equal to 250 seconds). Ripple height has stabilized in the domain at time step 250, but the ripples continue to migrate and change due to the asymmetric forcing, and periodic boundary conditions.]

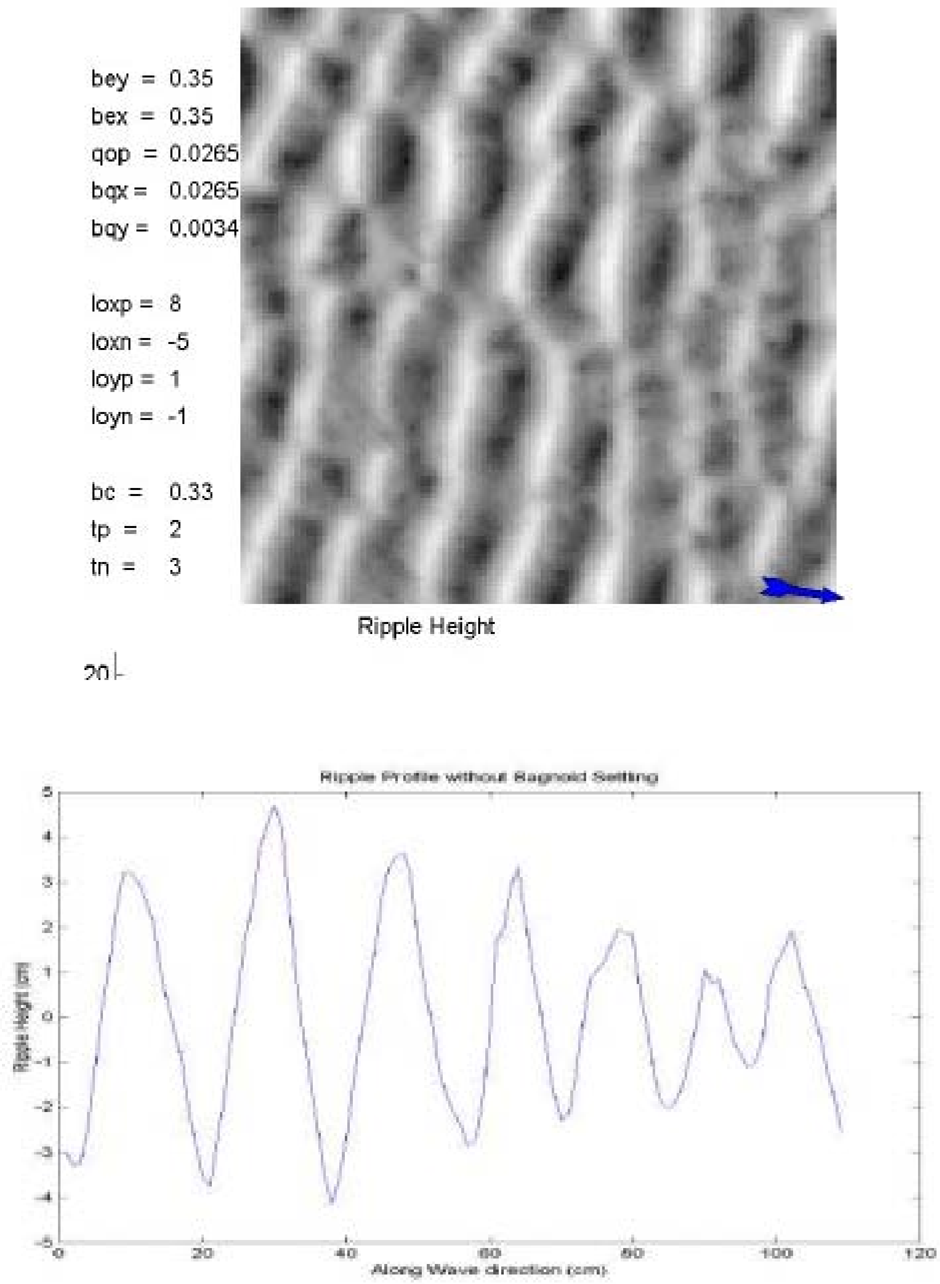

Figure 2: Computer simulation of sand ripples under waves.

[This run is similar to that of Figure 1, but the gravitational settling effect has been removed in order to demonstrate that the model generates steeper ripples that are sharper in profile, and without rounded troughs. Once again the arrow in the lower right side of the ripple image represents the direction of the wave forcing. The lower graph shows a cross-section of the values across the domain, 30 cells down from the top of the domain.]

MPACT/APPLICATIONS

The potential improvement in the understanding of the fundamental mechanisms of sand bedform formation from this study will be a significant contribution to the quantification of bedform processes related to the burial of mines in sandy coastal environments. Though this model is still under development, it demonstrates a capability to generate predictions of bedform size, shape and migration.

TRANSITIONS

This effort is still in the initial stages, so there are no tangible transition products yet.

RELATED PROJECTS

This project is closely related to the mine burial initiative field experiment of Dr. Peter Howd. This field experiment will provide important ground truth and calibration data.

REFERENCES

Clifton, H.E. Wave-Formed Sedimentary Structures-A Conceptual Model, in *Beach and Nearshore Sedimentation*}, R.A.Davis, Jr. and R.L. Ethington, eds. SEPM, Special Pub. No. 24, pp. 126-148, 1976.

Hay, A.E, and D.J. Wilson, 1994, Marine Geology, 119: 57.

Rubin, D.M. and R.E. Hunter, 1987, Science, 237: 276.

Traykovski, P., A.E. Hay, and J. Irish, 2000, J. Geophys. Res, 108 10380.

Wiberg, P.L., and J.D. Smith, 1985, J Geophys Res, 90, No C4: 7341.

Wilson, D.J., Ph.D. thesis, December 1996, Memorial Univ. of Newfoundland.