Linked VORTEX Model for Mine Burial Prediction

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LONG-TERM GOALS

Our long-term goal is to provide the Navy an updated process model applicable to Fleet needs for the prediction of mine scour and burial in nearshore waters, surf, very shallow water (VSW) and into the shallow water (SW) zone.

OBJECTIVES

We believe that the necessary tasks to achieve this long-term goal include:

1. Document the existing updated VORTEX model.
2. Exercise VORTEX model on additional field datasets.
3. Interface individual Fortran codes within a MATLAB architecture to better link the modules.
4. Write a User's Manual and tutorial to accompany the model.
5. Transfer documentation and source code to the Navy.
6. Evaluate how to integrate VORTEX with Mine Burial Expert System (MBES) models such as Rennie et al. (2005).

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APPROACH

Post-doctoral researcher Peter Adams joined our group 1 September 2005. He has a background in process geomorphology and numerical modeling. During his first month working with us, Peter has gained familiarity with the individual components of our numerical models that treat the many aspects of coastal processes. In particular, Peter has been working with the wave transformation component of the VORTEX model. This component is rooted in the well-known Ref/Dif model developed by Jim Kirby (Kirby and Dalrymple, 1983) and others, and has been applied to the complicated bathymetry of the Southern California Bight (O'Reilly and Guza, 1993). Peter has successfully run the Ref/Dif wave transformation model for the entire Southern California Bight for a number of different offshore wave climate conditions. This task is valuable as the sediment transport component of the VORTEX model relies on these computed nearshore wave and sediment conditions.

The VORTEX model consists of two coupled components: a farfield module that treats the offshore wave conditions and the transformation of waves as they enter shallow water, and a nearfield component that handles the computations associated with scour and burial (Figure 1). At present, VORTEX is poorly documented and difficult for others to use without personal instruction by its developers. Peter has begun writing a User's Manual that, when complete, will document the model architecture and provide a tutorial for its use.

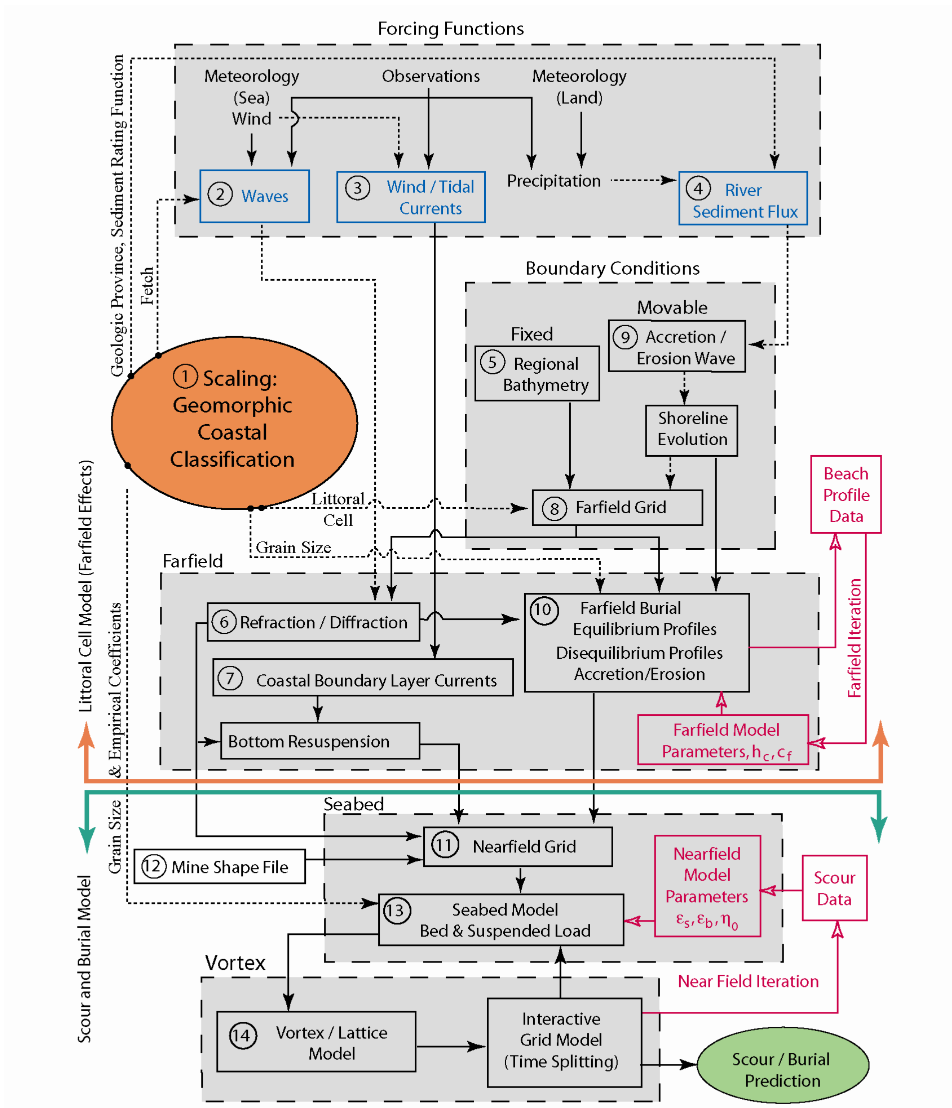

Figure 1. VORTEX architecture consisting of a coupled farfield (littoral cell) model and a nearfield scour and burial model.

In tandem with the development of the User's Manual, Peter will assemble the components of VORTEX into a MATLAB-based architecture that allows users to isolate and apply individual model components for specific research needs. As some of the individual components are computationally demanding, we plan to keep them as FORTRAN codes. The linking together of individual components and the management of input/output files, however, will be moved to the MATLAB environment, making the overall architecture more user-friendly and allowing the users to run individual components to suit their research needs.

It is noteworthy that the farfield portion of VORTEX incorporates several field-tested modules that have direct application to ONR Broad Agency Announcement (BAA) #05-026 Topic 4A, An Open Source Community Model for Coastal Sediment Transport. The overall goal of this announcement is a numerical model coupling hydrodynamics, sediment transport and morphodynamics suitable for diagnostic simulations of coastal processes. Farfield modules in VORTEX now incorporate code for wave refraction/diffraction, longshore transport of sand forced by these waves, and the shape of the beach profile resulting from differing wave heights along the beach. When these modules are placed in a user-friendly format such as MATLAB, they should qualify as end-products for BAA#05-026 Topic 4A.

WORK COMPLETED

FY 2005 has been a no-cost-extension year, but as detailed in our 2004 annual report, VORTEX has been subjected to field testing with a variety of mine types along four different coastal locations: the vicinity of Scripps Pier, La Jolla, CA; at Silver Strand Beach off the Naval Amphibious Base, San Diego, CA; at Indian Rocks Beach, FL; and offshore of Martha's Vineyard, MA. In all cases, VORTEX predictions were compared with the diver observations of mine scour and burial. At Indian Rocks and Martha's Vineyard, blind tests were conducted among diverse models and VORTEX performed well. VORTEX is the only model that can predict the physical silhouette of mine and bedform.

A paper on VORTEX has been written and submitted to the *Journal of Oceanic Engineering*, IEEE (Jenkins and Inman, submitted 15 April 2005b).

A summary of our VORTEX research was presented at the 5th Annual ONR Workshop on Mine Burial Prediction, 31 January 2005, in Hawaii. The ongoing and potential applications of the model were discussed: a) providing quantitative input for expert systems modeling (ESM), b) optimizing VSW Marker for Navy marine mammal program (SPAWAR), c) predicting UXO burial, exposure and transport (NFESC).

PROGRESS ON USER'S MANUAL AND MODEL DEVELOPMENT

During the month of September 2005, Peter Adams wrote a preliminary User's Manual to accompany the Ref/Dif component of the VORTEX model, and it was tested by a colleague who was able to reproduce model output of wave heights and directions for the Southern California Bight. In addition to the User's Manual, Peter has run the Ref/Dif model component on the Goleta coast for several different wave conditions. The next step is to run the Ref/Dif component on coastal stretches where existing field data are available in preparation for testing the complete VORTEX model against new field data.

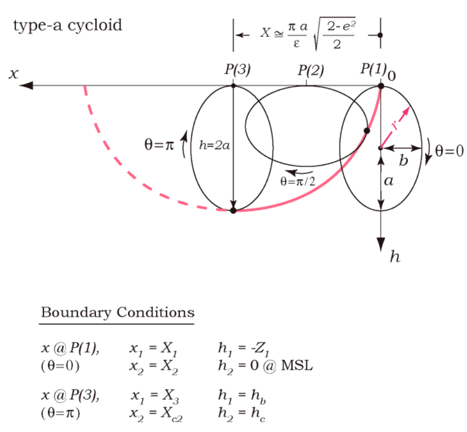

Figure 2. Elliptic cycloid solution (red line) for the equilibrium beach profile traced by a point on a rolling ellipse with semimajor and semiminor axis a, b, eccentricity $e = \sqrt{1-(b^2/a^2)}$, ***polar coordinate vector r, angle of rotation*** θ, **and** $\varepsilon = 1.0$.

IMPACT/APPLICATIONS

Acceptance (with revisions) by the *Journal of Geophysical Research* of our paper, "Thermodynamic solutions for equilibrium beach profiles," (Jenkins and Inman, resubmitted 2005a) places the VORTEX Model in a more rigorous position by providing an exact theoretical solution for equilibrium beaches. It was found that the equilibrium profile, consists of conjoined bar-berm and shorerise portions, and that each portion follows the trace of a type-a elliptic cycloid (Figure 2). The detailed profile of an equilibrium beach can now be described in terms of the incident wave height, period, and the sand sizes of the bar-berm and shorerise beach. Further, the envelop of successive wave heights from the low waves of summer through the high storm waves of winter provide a measure of the critical mass (volume) of sand necessary above the bedrock platform to maintain the perennial beach (Figure 3). Higher waves than those for the winter waves will cause a disequilibrium beach (Inman et al., 1993), exposure of the bedrock, and objects such as mines will reside on the rock surface where they are more easily moved by waves and currents.

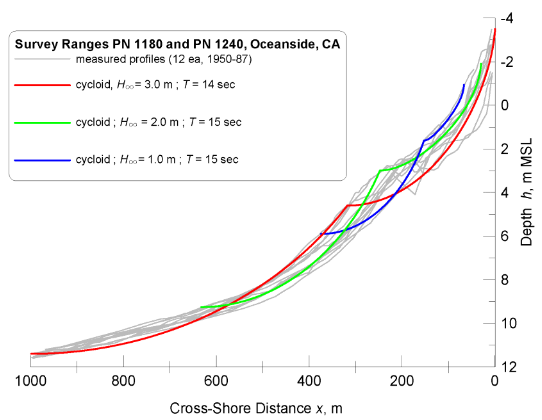

Figure 3. Envelope of variability of measured beach profiles(1950-87) at Oceanside, CA (gray) compared to the ensemble of elliptic cycloid solutions (colored) for selected incident wave heights and periods with $D_1 = 200\mu m$ **sand,** $D_2 = 100\mu m$, $N = 10$, $\gamma = 0.8$, **and** $\Lambda = 0.81$.

RELATED PROJECTS

With funding from the Kavli Institute, we have worked to improve process modeling of coasts, emphasizing the shorezone on cliffed coasts. This collaborative effort enabled us to update modules in our ONR- supported farfield littoral cell model (LCM) and add a bedrock exposure and cutting model (BCM) that is gridded for subbottom exposure and sea cliff changes. The updated LCM now includes elliptic cycloid analyses for the equilibrium beach profile. In another collaborative effort with the Kavli Institute, we have built the web site, http://coastalchange.ucsd.edu . It provides students, researchers, and public agencies with a general reader's introduction to coastal processes and the erosion challenges faced by coastlines in California and elsewhere.

REFERENCES

Inman, D. L., M. H. S. Elwany, and S. A. Jenkins, 1993, Shorerise and bar-berm profiles on ocean beaches, *Jour. Geophysical Res.*, v. 98, n. C10, p. 18,181-18,199.

Jenkins, S. A. and D. L. Inman, resubmitted 2005a, Thermodynamic solutions for equilibrium beach profiles, *Journal Geophysical Research (Oceans).*

Jenkins, S. A. and D. L. Inman, submitted 2005b, Scour and burial mechanics of objects in the nearshore, *Jour. Ocean Engineering*, IEEE (R. H. Wilkens and M. Richardson guest editors).

Kirby, J. T. and R. A. Dalrymple, 1983, A parabolic equation for the combined refraction-diffraction of Stokes waves by mildly varying topography, *Jour. Fluid Mech.*, v. 136, p. 453-466

O'Reilly, W. C. and R. T. Guza, 1993, A comparison of two spectral wave models in the Southern California Bight, *Coastal Engineering*, v. 19, p. 263-282.

Rennie, S. E., A. Brandt and N. Plant, submitted 2005, Mine Burial Expert System, *The Johns Hopkins University, Applied Physics Laboratory*, NSTD-05-021.

2005 PUBLICATIONS

Inman, D. L., 2005, Littoral cells, p. 594-599 in M. Schwartz, ed., *Encyclopedia of Coastal Science*, Springer, Dordrecht, Netherlands, 1211 pp. http://repositories.cdlib.org/sio/cmg/4/

Inman, D. L. and S. A. Jenkins, 2005a, Accretion and erosion waves on beaches, p. 1-4 in M. Schwartz, ed., *Encyclopedia of Coastal Science*, Springer, Dordrecht, Netherlands, 1211 pp. http://repositories.cdlib.org/sio/cmg/6/

Inman, D. L. and S. A. Jenkins, 2005b, Climate patterns in the coastal zone, p. 243-246 in M. Schwartz, ed., *Encyclopedia of Coastal Science*, Springer, Dordrecht, Netherlands, 1211 pp. http://repositories.cdlib.org/sio/cmg/3/

Inman, D. L. and S. A. Jenkins, 2005c, Energy and sediment budgets of the global coastal zone, p. 408-415 in M. Schwartz, ed., *Encyclopedia of Coastal Science*, Springer, Dordrecht, Netherlands, 1211 pp. http://repositories.cdlib.org/sio/cmg/5/

Inman, D. L. and S. A. Jenkins, 2005d, Scour and burial of objects in shallow water, p. 825-830 in M. Schwartz, ed., *Encyclopedia of Coastal Science*, Springer, Dordrecht, Netherlands, 1211 pp.

Inman, D. L., P. M. Masters and S. A. Jenkins, 2005a, Facing the coastal challenge: Modeling coastal erosion in southern California, p. 38-52 in O. T. Magoon et al., eds., *California and the World Ocean '02*, Amer. Society of Civil Engin., Reston, VA, 1431 pp. http://repositories.cdlib.org/sio/cmg/12/

Inman, D. L., S. A. Jenkins and P. M. Masters, 2005b, Modeling platforms, terraces, and coastal evolution, p. 647-651 in M. Schwartz, ed., Encyclopedia of Coastal Science, Springer, Dordrecht, Netherlands, 1211 pp. http://repositories.cdlib.org/sio/cmg/7/

PUBLICATIONS SUBMITTED

Jenkins, S. A. and D. L. Inman, resubmitted 2005a, Thermodynamic solutions for equilibrium beach profiles, *Journal Geophysical Research (Oceans).*

Jenkins, S. A. and D. L. Inman, submitted 2005b, Scour and burial mechanics of objects in the nearshore, *Jour. Ocean Engineering*, IEEE (R. H. Wilkens and M. Richardson guest editors).