LONG-TERM GOALS

Our objective is to develop a generic, process-based model to simulate the behavior of sand-mud mixtures in marine waters. This model will be particularly suited to study and simulate the effects of estuarine cohesive sediment discharges in a wave-dominated coastal environment.

OBJECTIVES

Our short-term objective is to develop a model to simulate the transport of layers of soft mud in the fore-shore by flow and waves and to simulate mud-induced wave-damping.

APPROACH

The near-shore of alluvial coastal areas is often sandy because of the high-energy wave impact. However, when rivers discharge in these areas, cohesive sediments are brought into the system, the dynamics of which are governed to a large extent by estuarine circulations. In that case, some coastal areas may be very muddy, whereas in other coastal areas the fine cohesive sediment settles and accumulates on the inner shelf, in calm water outside the breaker zone. The accumulated mud may liquefy under the influence of long waves, as a result of which a complicated three-way interaction between flow, waves and sediment suspension occurs.

We propose to implement the physical processes governing these interactions in the DELFT3D-system. We continue on the sand-mud research version recently finalized (e.g. point b. of this proposal). We propose to integrate this sand-mud model with the two-layer fluid module and the SWAN-wave module, including flow-wave interaction, which are both incorporated in the standard, operational DELFT3D code.

This new model will be set up in a generic way and will allow for the simulation of the behavior and development of sandy coastal areas with spatial and temporal variations in mud content: mud patches may come and go and these mud patches may be either in a consolidated or in a liquefied state. This implies that we will implement the following driving forces and physical processes:

- sediment dynamics governed by tide, wind-induced flow, estuarine circulation (density currents) and waves,
- erosion and deposition of sand-mud mixtures as a function of the sediment composition,
- formation of stratified and/or mixed sediment deposits,
- generation of fluid mud with Bingham non-Newtonian properties, either through rapid deposition in still water or by liquefaction of mud deposits,
- entrainment and consolidation of, deposition on and erosion of the sub-soil by the fluid mud layer,
- pressure- and gravity-driven movement of the fluid mud layer,
- buoyancy-induced damping of turbulence in the flow above the fluid mud layer,
- damping of incident waves by viscous dissipation in the fluid mud layer.

WORK COMPLETED

The processes of wave damping by fluid mud have been implemented in SWAN and tested against laboratory measurements and field observations. This implementation has been incorporated in the standard SWAN version that can be downloaded from the internet. The new implementation has been tested further against data from literature, in particular against the work of Gade, Dalrymple-Liu and Ng.

We have also completed and submitted to Coastal Engineering a manuscript on this work, which is currently in press.

We have started with the set-up of the hydrodynamic and sediment transport model of Patos Lagoon and Cassino Bay and the modeling of wave damping and wave-driven transport of fluid mud in coastal zone of Cassino Beach. The work is still according to the original schedule.

We have derived formulations for:
- wave-induced fluid mud transport,
- wave-induced liquefaction of a consolidated mud bed,
- strength recovery of a liquefied mud after passage of the waves.

A note on these formulations is enclosed to this progress report.

The formulations for wave-induced fluid mud transport have been implemented in DELFT3D and are being tested.

RESULTS

The computed hydrodynamics in terms of water level and salinity distributions and time series in the Patos lagoon – Cassino Beach coastal area compare favorably with limited set of data available. Also the computed siltation rates and patterns of fine cohesive sediment in the Cassino coastal area have a realistic pattern.

Observations on wave height could be reproduced. However, it is not yet clear whether the data contain measurements on fluid mud induced wave damping. This is still being investigated.
The new SWAN model compares favorably with data presented in the literature, in particular with the model results presented by Gade, Dalrymple-Liu and Ng.

**IMPACT/APPLICATIONS**

The new model allows prediction of wave height in coastal areas affected by layers of soft mud.

**TRANSITIONS**

The new routine has been developed in a generic way and is therefore applicable to many other sites.

The new routine has been implemented in the standard SWAN-software, becoming available to the scientific community.

The new formulations on wave-induced mud transport will be implemented in the standard DELFT3D system, which will be made available to the client in due time.

We have contributed to the organization of the final workshop on the Cassino Beach project in Brazil, which will be held in November 2006 in Porto Alegre, Brazil. We have prepared four joint presentations, which will be published in a special issue of Continental Shelf Research on the workshop proceedings.

**RELATED PROJECTS**

This project has close relations to the MURI project from a technical-scientific point of view.

**REFERENCES**


Gade, H.G., 1958, Effects of a non-rigid, impermeable bottom on plane surface waves in shallow water, Journal of Marine Research, 16 (2) 61-82.


**PUBLICATIONS**


Publications in preparation:

Raphael Nogueira, Gerben de Boer, Han Winterwerp, Susana Vinzon, Modeling of mud deposition on the open coast of the larger Patos Lagoon – Cassino Beach system.
Gerben de Boer, Han Winterwerp, Debora Cuchiara, Susana Vinzon, João Luiz Carvalho and Todd Holland, Modeling of the fluid mud induced wave damping in Cassino Beach coastal area.

Lauro Calliari, Susana Vinzon, Elisa Fernandes, Han Winterwerp, and Todd Holland, On the fine-sediment dynamics in the Patos Lagoon – Cassino Beach system.

Han Winterwerp, Gerben de Boer, Susana Vinzon, João Luiz Carvalho and Todd Holland, A two-layer model for wave-driven fluid mud migration in Cassino Beach coastal area.