8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

SAND TRANSPORT IN SURFACE WATERS: AN UNCERTAINTY ANALYSIS

***André B. Fortunato, Lígia Pinto, P. Freire, Xavier Bertin and Anabela Oliveira**

Laboratório Nacional de Engenharia Civil
Av. do Brasil, 101
1799-066 Lisbon, Portugal
{afortunato, llpinto, pfreire, xbertin, aoliveira}@lnec.pt
www.dha.lnec.pt/nec

Key Words: *uncertainty, sensitivity analysis, sediment transport, morphodynamics, numerical model.*

ABSTRACT

There is a growing concern over sediment-related issues in coastal areas, such as beach erosion and harbour accretion. Numerical (process-based and empirical) models are increasingly used to evaluate sediment fluxes, in order to analyse trends and to predict the effect of human interventions. However, the quantification of these sand fluxes often involves errors of over 100% for current-driven transport, and much higher for wave-driven transport. Quantifying these errors, understanding their sources and determining their consequences for the outcome of morphodynamic modelling studies is therefore vital for the quality and credibility of many coastal engineering studies.

This paper summarizes the results of a two year research project that aimed at verifying the following hypothesis: in engineering applications, the errors in the evaluation of sediment fluxes are, to a large extent, determined by errors in the inputs. Input errors include errors from other models (e.g., velocities computed by a hydrodynamic model), model approximations (e.g., spatially constant sediment characteristics), lack of data (e.g., sediment diameters based on limited data), etc.

The various sources of uncertainty were first investigated individually, in order to sort out the key parameters that control the errors. The uncertainty in the prediction of sediment fluxes was evaluated for flows with increasing complexity. Monte-Carlo simulations for simple permanent flows showed that the main parameters that affect sediment fluxes are the sediment diameter and the velocity [1]. This analysis also highlighted the different robustness of the various sediment transport formulae. Then, a sensitivity analysis for wave-dominated transport concluded that, for fine sands, sediment spreading and density also play an important role in determining sediment fluxes [2]. An error propagation analysis showed that, in tidally-driven systems, errors in the evaluation of even tidal harmonics can also contribute significantly to the errors in the sediment fluxes [3].

The accumulation of the large errors involved in the evaluation of sediment fluxes could potentially lead to meaningless results in long-term morphodynamic simulations. Yet, some researchers had some success in simulating the evolution of coastal morphology at

century-long time scales [e.g., 4], suggesting that error compensation could, at least to some extent, offset the error accumulation. Considering the growing interest in predicting the long-term evolution of coastal systems, in particular due to climate change impacts, we analysed the effect of errors in the evaluation of sediment fluxes on the uncertainty in long-term simulations, using a depth-averaged morphodynamic modelling system [5-7] applied to a tidal inlet. Results showed that the uncertainty increases only linearly with time [8]. Attempts to reduce the uncertainty by integrating the results over increasing spatial scales only met with minor success.

ACKNOWLEDGEMENTS

This work was partially funded by the Fundação para a Ciência e a Tecnologia, and FEDER, projects "SATUrN – Sand Transport in Surface Waters: an Uncertainty Analysis", "EMERA – Estudo da Embocadura da Ria de Aveiro", and "G-Cast – Application of Grid Computing in a Coastal Morphodynamics Nowcast-Forecast System". The fourth author was funded by the European Commission through a Marie Curie postdoctoral fellowship (project IMMATIE-041171).

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