Intermediate Scale Coastal Behaviour: Measurement, Modelling And Prediction.

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LONG TERM GOAL

Our overall goal is to achieve a better understanding and better predictions of coastal behaviour at intermediate (event/season/year/decade) scales. We aim to bring together researchers from Europe and North America to gain the best possible benefit from developments in field observation, theory and numerical modelling.

OBJECTIVES

We are following a four-pronged collaborative programme of objectives. Data on intermediate scale behaviour from both sides of the Atlantic are being studied and ways are being sought to project these observations onto a manageable number of descriptive parameters or basic patterns. Top-down modelling uses these data products to develop black-box (data extrapolation) and grey-box (behaviour-oriented) models for the observed behaviour. Bottom-up modelling investigates the predictive potential of process-based models, making best use of process results from US and European field campaigns, combined with existing modelling expertise. There is also a vital linking activity aimed at ensuring that the data, top-down modelling and bottom-up modelling activities interact fully, in order to bring together the most productive aspects of each into a predictive capability for intermediate-scale coastal change.

APPROACH

This project is designed to create interaction between European and North American scientists who are already involved in research related to intermediate scale coastal behaviour. Our approach to achieving this interaction is through workshops, exchanges, support for Research Fellows, and additional research support.

WORK COMPLETED

Workshops:

An ARGUS Workshop was held at Oregon State University in February 2000, and involved participants from five of the seven collaborating Institutions (Plymouth University, Dalhousie University, University of Twente, HR Wallingford and Oregon State University). Apart from continuing discussions to improve analysis techniques, considerable progress was made in the development of new methods to parameterise the highly complex digital images and also in relating the bathymetry to top-down models.

Our 6th Workshop was held in Plymouth in September 2000. All collaborators were represented and a total of 20 people attended. The overall aim of this Workshop was to identify and build on links between the component activities in the context of the need to improve prediction of intermediate scale coastal change. As in previous Workshops, an informal programme of talks and discussions took place. The opportunity for extensive and open discussions once again proved greatly stimulating and productive. Many important points were raised and although we cannot claim to have entirely resolved differences of interpretation of the linking activities, the discussions will form a valuable basis for further work and for the presentations to be made at the Final Workshop next year.

Plans were also laid for the Final Workshop, which we hope to hold on Sunday 10th June 2001, before the Coastal Dynamics 2001 Conference in Lund, Sweden. All CD2001 participants will be invited to a series of presentations summarising our achievements.

Exchanges:

Exchanges and visits supported by this NICOP project are listed in table 1.

Table 1: Table of exchanges and visits.

Name	Position	Home Institution	Location visited	Purpose	Dates
Tony Bowen	Professor	Dalhousie University	a) OSU b) Plymouth	Research and ARGUS Workshop 6th Workshop	Oct 99 – Jun 2000 Sept 00
Diane Foster	Assistant Professor	Ohio State U (ex Dal)	a) DHI b) Plymouth	Research Collaboration 6th Workshop	Aug 2000 Sept 2000
i) Ken Kingston ii) Cyril Mallet	PhD student Post-doctoral Fellow	U. Plymouth	OSU	ARGUS Workshop and further research	Feb – Mar 2000
Howard Southgate	Project Leader	WR Wallingford (on leave)	OSU	ARGUS Workshop	Feb 2000
i) Aart Kroon ii) Gerben Ruessink iii)Irene van Enckevort	Asst. Prof Research Fellow Research Student	Utrecht Uni (through Twente)	OSU	ARGUS Workshop	Feb 2000 Dec 99 – Feb 2000
i) Rolf Deigaard ii) Nils Droenen iii) Dorthe Petersen iv) Hakeem Johnson	Professor Research Assistant PhD student Researcher	DHI/ISVA	Plymouth	6th Workshop	Sept 2000
i) Rob Holman ii) Chris Chickadel	Professor PhD Student	OSU	Plymouth	6th Workshop	Sept 2000
Nathaniel Plant	Post-doctoral fellow	Twente	a) OSU b) Plymouth c) San Francisco, California	ARGUS Workshop 6th Workshop AGU	Feb 2000 Sept 2000 Dec 2000

Ad Reniers	Post-doctoral Fellow	NPS, Monterey	Plymouth	6th Workshop	Sept 2000
Huib de Vriend	Professor	Twente	Plymouth	6th Workshop	Sept 2000
James Sutherland	Project Leader	HR Wallingford	Plymouth	6th Workshop	Sept 2000

Research Fellows supported:

Ken Kingston (Plymouth). PhD student. Appointed 1st October 1998. Genetic Algorithms and Neural Nets for the analysis of ARGUS images.

Brad Morris (Plymouth). Post-doctoral Fellow (25% NICOP: 75% EC INDIA Project). Video observations at Faro, Portugal.

Nils Dronen, and Erik Ostergaard Madsen (ISVA). Research Assistants. Funded by NICOP for February -March 2000 and June –August 2000 respectively, but with continuing collaboration. Process modelling.

Andy Peet (until Dec 99) and James Sutherland (from August 2000) (HR Wallingford). Research Fellows. Measures of predictive skill for coastal morphodynamic models.

Nathaniel Plant (U. Twente). Post-doctoral Fellow. Appointed May 1998 (after a PhD at OSU with Rob Holman). Analysis of field data and idealised morphologic models.

Additional Research Support.

The 5-camera ARGUS system established last year to overlook the COAST3D site at Teignmouth, UK. continues to provide excellent images of the remarkable estuarine sand banks in the region. The costs associated with maintaining this site, principally telephone bills, are funded by this grant.

Time series of wave data for the Teignmouth site have been identified from the archive of wave model output available from the UK Meteorological office, and relevant data has been ordered through HR Wallingford. These data will provide important input to the interpretation of imagery from the Teignmouth ARGUS system.

No satisfactory solution to the problem of measuring the wave climate at Perranporth has yet been found following the failure of in situ sensors last year. A brief but interesting discussion on this topic took place at the 6th Workshop and several promising leads are being followed. We plan to install a new system before the completion of this programme.

RESULTS

The level of interactions and the presentations at the Workshops this year indicate that a great deal of useful progress is being made on each of the aspects of the programme.

Process modelling at Dalhousie (Tony Bowen) and DHI (Diane Foster, Ken Haste Andersen, Jorgen Fredsoe) involves comparison between a 2DV model and observations of sand suspension in nearshore, wave-dominated conditions. The overall agreements are encouraging but there is still significant disagreement over the scale of the wave boundary layer which is requiring

reconsideration of the parameterisation of appropriate bed roughness. The ISVA group (Rolf Deigaard, Nils Droenen, Jurgen Fredsoe, Ken Haste Andersen) is also investigating process models for the evolution of barred coasts and the dynamics of wave ripples. Fully non-linear simulations are being undertaken of the development of irregularities in a bar on a straight coast, and the interactions between the mechanisms of instability and the mechanisms (cross-shore transport) that form and modify the bar profile are being investigated. The developing irregularities show quasi-periodic 'rip channels' which are unexpectedly oriented towards the oblique wave incident angle and are not directly associated with actual rip currents.

At DHI Hakeem Johnson is comparing observed nearshore wave spectra and bed level changes measured during the Sandy Duck experiments in 1997 with model predictions using the DHI parametric spectral model and coastal area morphological model. The work has involved extensive analysis of the field data. The model predictions of nearshore wave climate are in good agreement with observations. Predicted bed level changes are in general agreement with observations and the detailed comparisons are providing useful indications of the strengths and weaknesses of different modelling approaches.

At NPS Ad Reniers is investigating 2DH process models of the morphological development of a nearshore region under the influence of long period (wave group) motion. Realistic large-scale irregularities in bar shape are produced by the models.

Nathaniel Plant and collaborators in the Netherlands and the US are developing top-down (empirical) models to predict nearshore morphological evolution. A simple bar migration model (Plant et al., 1999; Plant and Wijnberg, 1999) has proved remarkably successful at predicting the changing offshore location of bars at Duck and Katwijk (Netherlands), as shown in figure 1. More than 80% of the variance in bar position was explained by the model, even when the dominant long-term trends were removed, indicating that the same basic dynamics explains much of the intra-annual as well as the inter-annual behaviour. These results are inspiring an ongoing exploration of bottom-up (process) models which might explain the source of the dynamics revealed by the top-down approach.

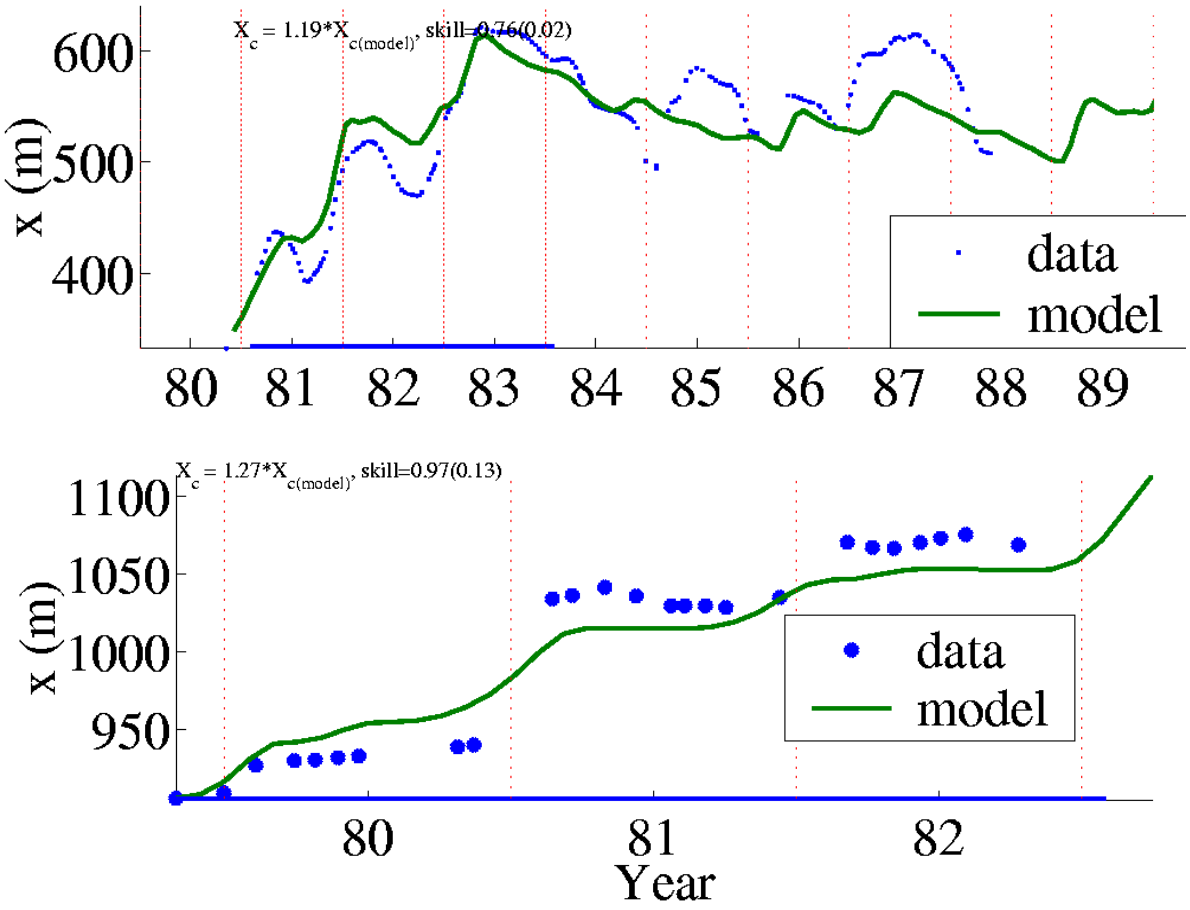

Figure 1. Prediction of outer bar migration at Duck (top) and Katwijk (bottom) using the model of Plant et al, 1999. Predition skills over the 7 and 3 year time series were 0.76 and 0.97, respectively. Characteristic time scales of the two systems were 1 and 5 years. In both systems, the bars migrated towards the time-varying wave break point.

The productive collaboration between OSU (Rob Holman, Chris Chickadel) and Plymouth (Mark Davidson, Ken Kingston, Cyril Mallet, David Huntley), developing analysis and interpretation techniques for ARGUS and related images, has continued apace this year. New techniques based on the neural net approach have been developed to determine the shoreline, and as a result the detailed intertidal topography of the highly mobile sand banks at Teignmouth can be mapped. Neural nets are also being used to parameterise the form of nearshore sand banks, and can successfully describe banks on an open shoreline using 10 parameters. Ongoing work is investigating links between the variation of these parameters and the forcing factors such as wave parameters and tidal currents. The INDIA project, linked to this programme through Plymouth post-doctoral fellow Brad Morris, has also produced excellent ARGUS-type images of a rapidly evolving tidal inlet on the Portugese coast.

HR Wallingford continues to provide the focus of links between this programme and the EC COAST3D project, which is entering its final year. Recent work has shown the applicability of longshore averaging of bathymetry for use with coastal profile models (eg COSMOS or UNIBEST) for Egmond-aan-Zee (NL), a quasi-uniform beach characterised by two offshore bars broken by rip channels. Morphological developments over periods of 6 to 10 days, totalling 30 days altogether, were used to look at the performance of the models. In addition error bars on the driving parameters have been used to derive standard deviations on the predictions. These developments help to clarify

the value of coastal profile models in situations with longshore non-uniformities and will aid our understanding of the limitations of our predictions. COAST3D data is also being used to assess the value of the Brier Skill Score (BSS), which has already been identified by the NICOP group as the best overall indicator of agreement between observed and predicted morphology. For example, BSS has been used to tune the COSMOS model using data from the Egmond main experiment. Optimised use of the model, for example through choice of an appropriate cross-shore averaging length, has been demonstrated. A journal paper on skill scores for bathymetry is in preparation.

IMPACT/APPLICATIONS

This NICOP project aims to assess prospects for the understanding and prediction of intermediate and large-scale coastal change. This will be the theme of the final workshop, planned for June 2001. Progress made so far, in process understanding, in linking simple models and observations, in developing methods for making best use of remote video imagery, and in assessment methods for model performance, is already of practical as well as research value.

TRANSITIONS

The interlinking of a number of US and European projects, in modelling and fieldwork, is central to this NICOP project.

RELATED PROJECTS

Examples are given above of the way in which the NICOP funds are creating collaborative links between US programmes, particularly the Sandy Duck field work, and European projects COAST3D, INDIA, SASME, SEDMOC and SWAMIEE..

All four of the European collaborating institutions on this programme are involved in a new EC-funded project entitled HUMOR, which is expected to start before the end of the year. The overall aim of the HUMOR project is 'to develop reliable assessment and forecasting techniques to better understand, model and predict the physical and geomorphological processes governing medium and long-term natural changes of the coastal zone, including the impact of anthropogenic activities'. The total value of the 3-year project is 2.6 MEuros.

PUBLICATIONS

SASME Web page: http://www.wldelft.nl/sasme/sasme.htm
COAST3D Web page: http://www.hrwallingford.co.uk/projects/COAST3D
INDIA Web Page: http://www.pol.ac.uk/jjw/INDIA.html
SEDMOC Web Page: http://hydr.ct.tudelft.nl/wbk/public/sedmoc/index.HTM

BALDOCK, T.E., HUNTLEY, D.A., BIRD, P.A.D., O'HARE, T.J. and BULLOCK, G.N., 1999. Breakpoint generated surf beat induced by bichromatic wave groups. *Coastal Engineering,* **39,** 213-242.

COCO, G., HUNTLEY, D.A. and O'HARE, T.J., 1999. Beach cusp formation: analysis of a self-organisation model. Proceedings Coastal Sediments '99, Long Island, New York. *New York, American Society of Civil Engineers.*

COCO, G., HUNTLEY, D.A. and O'HARE, T.J. 2000. Investigation of a self-organisation model for beach cusp formation and development. *J. Geophys. Res.* (in press)

DAVIDSON, M.A., KINGSTON, K.S. and HUNTLEY, D.A., 2000. New solution for directional wave analysis in reflective wave fields. *J. Waterway, Port, Coastal and Ocean Engineering,* **126 (4),** 173-181.

DROENEN, N. and DEIGAARD, R. Three-dimensional near-shore bar morphology. Abstract for the *27th Int. Conf. on Coastal Engineering*, Sydney, Australia, 2pp.

FALQUES, A., COCO, G. and HUNTLEY, D.A., 2000. A mechanism for the generation of wave-driven rhythmic patterns on the surf zone. *J. Geophys. Res.* (in press).

KINGSTON, K.S., RUESSINK, B.G, VAN ENKEVORT, I.J.M., and DAVIDSON, M.A., Artificial neural network correction of remotely sensed sandbar location, Marine Geology (169)1-2 (2000) pp. 137-160

HANSON, H., S. AARNINKHOF, M. CAPOBIANCO, J.A. JIMENEZ, M. LARSON, R.J. NICHOLLS, N.G. PLANT, H.N. SOUTHGATE, H.J. STEETZEL, M.J.F. STIVE, and H.J.d. VRIEND. Modelling of coastal evolution on yearly to decadal time scales, *Journal of Coastal Research*, in review.

MADSEN, A.J., and N.G. PLANT. Intertidal beach slope predictions compared to field data, *Marine Geology*, in review.

MILES, J.R., RUSSELL, P.E. and HUNTLEY, D.A., 2000. Field measurements of sediment dynamics in front of a seawall. *J. Coastal Res.* (in press).

PLANT, N.G., and S.J.M. HULSCHER. Nonlinear interaction of nearshore morphology, in *Proc. ICCE 2000*, edited by B. Edge, ASCE, Sydney, in review.

PLANT, N.G., B.G. RUESSINK, and K.M. WIJNBERG. Morphologic properties derived from a simple cross-shore sediment transport model, *Journal of Geophysical Research*, in press.

PLANT, N.G., M.H. FREILICH, and R.A. HOLMAN. The role of morphologic feedback in surf zone sand bar response, *Journal of Geophysical Research*, in press.

PLANT, N.G., and S.J.M. HULSCHER. Nonlinear interaction of nearshore morphology, 2000, in *Book of Abstracts. ICCE 2000*, ASCE, Sydney.

PLANT, N.G., and R.A. HOLMAN, 1999. Extracting morphologic information from field data, in *Proceedings 26th International Conference Coastal Engineering*, edited by B.E. Edge, pp. 2773-2784, ASCE, Copenhagen.

RUESSINK, B.G.,VAN ENKEVORT, I.J.M., KINGSTON, K.S. and DAVIDSON, M.A., Analysis of observed two- and three-dimensional nearshore bar behaviour, Marine Geology (169)1-2 (2000) pp. 161-183

RUGIERO, P., G. KAMINSKY, and N.G. PLANT, 1999. Coastal morphologic variability of high energy dissipative beaches, in *Proceedings 26th International Conference Coastal Engineering*, edited by B.E. Edge, pp. 3238-3251, ASCE, Copenhagen.