NCK-days 2008

Book of abstracts

Netherlands centre for Coastal Research

NCK-days 2008

Book of abstracts

Netherlands centre for Coastal Research

Report

March 2008

1 Preface

Dear NCK members, guests, speakers and participants,

On behalf of the organizing committee and the Board of NCK it is my pleasure to welcome you all at our annual NCK symposium 2008 in Delft. After our successful 15th Anniversary symposium in IJmuiden and a year with other special activities, 2008 will be a year in which we will further work on the consolidation and expansion of our organisation. This year, new members will become part of the NCK community.

For the first time this NCK symposium is now hosted by Deltares. This new research institute for delta technology unites the former NCK partners WL Delft Hydraulics, TNO Bouw en Ondergrond and RWS-RIKZ (together with GeoDelft). To mark this special occasion, the place of venue is Delft instead of our common sea-side resort.

We are pleased again to offer you an attractive program that clearly demonstrates our NCK trademark. Well-known subjects related to sandy coasts, tidal inlets and estuaries will alternate with presentations on the transport and deposition of sand-mud mixtures, the interdisciplinary work within biogeomorphology and the development of shelf sea morphology.

I wish you all a productive and most enjoyable meeting !

March 2008

Prof. dr. Piet Hoekstra
Chairman Programme Committee NCK

Contents

2 The Netherlands Centre for Coastal Research (NCK)

2.1 Historical context

Coastal research in The Netherlands has a long history. For many centuries, experience gained from the country's successes and failures in the struggle against the sea has been the major source of innovation. A more formal and systematic approach has developed over the last hundred years:

- 1920: An important step in the development of formalized knowledge was taken in the 1920s by the Nobel-prize laureate Hendrik Lorentz, who designed a computational scheme for assessing the tidal effects of the closure of the Zuyderzee. At the same time, with the founding of Delft Hydraulics, physical scale models became the favourite instrument for designing coastal engineering works. They remained so for a long time.
- 1953: The storm surge disaster of 1953 provided a strong incentive for coastal research in support of the Delta Project, which entailed a drastic shortening of the Dutch coastline. The Delta Project profoundly affected the morphodynamics of the Rhine-Meuse-Scheldt delta; large parts of the system were transformed into what one might call a life-size hydraulic laboratory.
- 1965: In the 1960s, a monitoring programme (JARKUS) was established to assess the evolution of the nearshore zone along the entire Dutch coast on a yearly basis. The resulting data base revealed not only short-term fluctuations of the shoreline, but also large-scale structural trends. The JARKUS data set represents a key source of coastal information, particularly in combination with historical observations of Dutch coastline evolution that date back to 1840-1850. With no equivalent data set available worldwide, the unique JARKUS data base has inspired a wealth of coastal research programmes throughout the years.
- 1985: The growing need for integrated coastal management led by the end of the 1980s to the development of a national coastal defence policy of 'Dynamic Preservation' (1990). This involved sustainable maintenance of the coast through 'soft' interventions (often nourishment of the beach and shoreface with sand taken from offshore) allowing for natural fluctuations. The basic principles were derived from a major research project for the systematic study of persistent trends in the evolution of the coastal system. This Coastal Genesis project – carried out by a multidisciplinary team of coastal engineers, physical and historical geographers and geologists – laid the ground for NCK.
- 1992: The successful multidisciplinary collaboration initiated during the Coastal Genesis project was institutionalized by means of the formal founding of the Netherlands Centre for Coastal Research (NCK).

The NCK was initiated by the coastal research groups of Delft University of Technology, Utrecht University, WL | Delft Hydraulics and Rijkswaterstaat RIKZ. Early 1996, the University of Twente and the Geological Survey of The Netherlands (now the Netherlands Institute of Applied Geoscience TNO: TNO-NITG) joined NCK, followed by the Netherlands Institue for Sea Research (NIOZ, 1999), the Netherlands Institute for Ecology – Centre for Estuarine and Marine Ecology (NIOO-CEME, 2001) and UNESCO-IHE Institute for Water Education (2004).

2.2 NCK Objectives

The NCK was established with the objectives of:

- increasing the quality of the coastal research in the Netherlands by enhancing cooperation between the various research streams and guaranteeing the continuity of coastal research in the Netherlands by exchange of expertise, methods and theories between the participating institutes;
- maintaining fundamental coastal research in The Netherlands at a sufficient high level and enhancing the exchange of knowledge to the applied research community;
- reinforcement of coastal research and education capacities at Dutch universities;
- strengthening the position of Dutch coastal research in a United Europe and beyond.

15 years of NCK collaboration particularly stimulated scientific interaction between – originally often isolated – coastal research groups, facilitated a strong embedding of coastal research in the academic programmes and courses and attracted young scientists to the field of coastal dynamics.

2.3 NCK Research Themes

The NCK research programme is not limited to the Dutch coast, but emphasises the development of generic knowledge that is applicable to a variety of coastal systems. An important role is reserved for large scale dynamics and upscaling approaches. Basic knowledge of the dynamics of the system (substance transport, morphological development and their interactions) is translated into diagnostic and predictive mathematical models. Using these models, concentration distributions of relevant substances and the morphodynamic behaviour of coastal zones can be examined. This includes the interaction between processes at various temporal and spatial scales, such as swell, storm-induced oscillations, tides, spring and neap tidal cycles, seasonality, sedimentation-resuspension cycles, long term cycles in the hydrology and in the chemical and biological water quality characteristics. Special attention is paid to the impacts of extreme conditions (storms, surges) and the probability of their occurrence. NCK research (interaction) is concentrated within five themes, three of which focus on characteristic coastal sedimentary environments and two have a more disciplinary approach.

2.3.1 Seabed and Self

A major proportion of the sediments deposited in the Dutch coastal zone during the Holocene transgression originated from the Southern North Sea. Recent research has shown that the seabed of the southern Bight has been profoundly reworked and that large amounts of sediment have been transported, partly in coastal direction. These long-term, large-scale morphodynamics are closely related to sea level rise. The forces driving large-scale morphodynamics are produced by tides and meteorological influences, and thus act on a much smaller time scale. The same forces also generate a variety of morphological structures on much smaller scales. These include sandbanks, sand waves and ripples. The current and transport patterns on the shelf that generate morphological change are in turn themselves influenced by these morphological structures. This feedback results both from large and smaller-scale structures. The seabed behaves, therefore, as a cascade system with self-organizing properties.

Research activities on the theme of Seabed and Shelf comprise sediment transport dynamics, numerical morphodynamic modelling, morphodynamic analysis of finite amplitude perturbations on the sea bottom using idealized models, and mapping of both the top layer and the deeper sediment layers of the sea floor. The resultant understandings are relevant to many practical issues. These include: improving the stability of navigation channels, locating sand mining pits, preventing destruction of cables and conduits on the sea floor, optimizing sea-floor monitoring programmes, predicting coastal response to sea level rise on geological time scales, and the construction of artificial islands.

2.3.2 Beach Barrier Coast

The beach barrier coast of Holland protects a large portion of The Netherlands lying below mean sea level. Without proper maintenance of this coastal system, coastal towns such as Egmond aan Zee would long ago have turned into Egmond in Zee. Beach barrier coasts show a wide variety of morphodynamic processes, including tide-, wave- and wind-driven transport of sediment. The combined effect of these processes yields trends as well as (quasi-) rhythmic fluctuations in the position of the coastline and other coastal phenomema. It is important to assess trends in natural dynamics to identify any structural sediment deficit. Since the fluctuations are often of large magnitude, they may easily obscure the overall trends in coastal behaviour.

Fluctuations may be of standing or propagating nature and may have periodicities on time scales ranging from the very small (connected to the variations in wave conditions) to the very large (connect to overall sediment availability). Effective and efficient management of coastal zones benefits from a sound understanding of trends and fluctuations and the ability to predict them.

Because of the variety of spatial and temporal scales involved in coastal evolution, NCK chooses to structure its research on beach barrier coasts on the basis of three scales. Starting point is the concept of a scale cascade, which assumes that it is possible to distinguish a spatially and temporally bounded domain existing within the boundary conditions established by larger scales and governed by smaller-scale intrinsic dynamics which may be either ignored or captured by aggregation assumptions. The theme seeks to formulate dynamic models for such domains, using both theoretical and observational information. This concept of ‘appropriate modelling’ aims to make models both as simple as possible and yet as complex as necessary.

The theme identifies three evolutionary scales, while noting that it is yet uncertain whether these scales may indeed be distinguished as bounded scale domains. These are:

- Beach state and seasonal scale (time scales ranging from the duration of wave events to seasons);
- Management and intervention scale (time scales ranging from years to decades, in the order of the life time of hard and soft interventions in the coastal system);
- Historic and recent Holocene scale (time scales ranging from a century to thousands of years).

On the beach state and seasonal scale, research activities are based on the use of process-based modelling approaches, supported by high-resolution in-situ and remote sensing observations. On the historic and recent Holocene scale, where process-based models become inaccurate, behaviour-oriented, empirical models are used, supported by historic and geological data. On the management and intervention scale, research activities aim at furthering the prediction horizon of morphological simulations through combined use of process-based models, empirical models and data-driven approaches. Long-term data sets such as the JARKUS data set of annually-surveyed coastal profiles are an important asset in this respect.

2.3.3 Tidal Inlet Systems and Estuaries

Unlike the central Holland coast, the north (Wadden Sea) and south-west (Delta region) coast can be characterized as tidal basins/inlets and estuarine systems. They are highly dynamic systems with tidal shoals, channels and sometimes entire islands migrating at time scales of only a few decades.

The morphological evolution of the Wadden Sea on this timescale is driven by both tides and waves. More sheltered embayments and estuaries are found in the south-west (Eastern and Western Scheldt) and to the north-east (Ems estuary). In all these areas, strong interactions are observed between the water motion and the erodible bed, resulting in large sediment transport rates and highly dynamic morphological patterns (channels and shoals) exhibiting complex behaviour in both time and space. This yields – even more than in the case of the beach barrier coastal system – a large variety of morphodynamic evolutions over a cascade of spatio-temporal scales. Resarch on coastal inlet and tidal basin systems is therefore likewise structured on the basis of a cascade of scales.

Because of the important economic and ecological functions of tidal inlet systems and estuaries, there is an increasing need to develop reliable simulation models for water motion, transport processes and morphological changes in such areas. Despite the significant progress that has been made in this area over recent decades, many processes are still poorly understood. Issues include:

identification of the dominant hydrodynamic and morphodynamic phenomena that occur in tidal inlet systems and estuaries and of their main characteristics;
- development of appropriate descriptions to quantify net sediment fluxes in such systems, due to tides, waves and three-dimensional water motion;
- devising ways of modelling feedback from the morphology to the water motion where it takes place on a time scale much longer than the hydrodynamic time scales;
- identification of the relevant feedback between morphology and ecology and devising ways to model it.

Research efforts focus on the modelling of long-term morphological changes (time scales of months to years, spatial scales of 100 m and more) and the interaction between ecological and abiotic processes.

2.3.4 Sand and Mud

The scientific sediment world is renowned for its segregation: cohesives and non-cohesives are entirely separate fields of study. The various formulae commonly used for water/bed exchange, settling velocity, etc. are applicable to the transport and fate of either cohesive or non-cohesive sediment. However, nature is generally less discriminating and natural sediment suspensions and deposits often consist of a mixture of cohesive and non-cohesive sediments. Such mixtures may behave entirely differently from their components in isolation; for instance, a small addition of fines to a sandy bed may considerably increase its erosion resistance. Hence, progress in our understanding of natural sediments and in our ability to model them requires studies on the behaviour of the entire mixture.

Sediments mixtures also need to be studied from an ecological point of view. Sediment composition, especially the sand-mud ratio, is an important parameter in the characterization of marine habitats and the evaluation of the health and productivity of natural environments. To further complicate the issue, sediment composition is controlled not only by physical (abiotic) processes, but also by chemical and biological processes. This makes it essential that the study of sand-mud mixtures be undertaken within a multi-disciplinary framework, such as offered by the NCK.

Research within the Sand and Mud theme consists of theoretical studies, laboratory experiments, field surveys, and mathematical modelling. Research activities cover processes in the water column, within the bed and at the bed-water interface, and include subjects such as flocculation, segregation, consolidation and swell, erosion and liquefaction, adsorption and desorption, etc. With respect to the behaviour of sand-mud mixtures, three scales can be distinguished within the micro- and meso-scale ranges:

- on the micro-scale, the erodibility of the bed as a function of the bed composition (sand-mud ratio, stratification, etc) plays a role. The skin friction is also determined on this scale;
- also on the micro-scale, the bed forms (flat bed, ripples, dunes, etc) determine the effective hydraulic resistance of the flow, thus affecting velocity profiles and even flow rates;
- on an intermediate-scale, horizontal sorting effect play an important role; settling times, flow velocity and transport path determine the fate of the various sediment fractions;
- and finally, on an seasonal scale the composition of the bed will vary considerably: in the winter/storm season mud will be eroded and transported, sometimes being exported from the system, while in the summer period the mud content of the tidal flats will be build up again; biological effects increase this process considerably.

It is evident that processes on these various scales are strongly interrelated: erodibility plays a role in the availability of the various sediments, but is itself governed by the sediment fractions depositing at the particular location. Erodibility also governs bed formation, and the bed forms affect the large-scale transport of the various sediment fractions. The gaps in our knowledge occur in particular on the micro- and meso-scale, i.e. in relation to bed formation and erodibility, and the interaction of the various scales. Sand and mud processes are closely related to the morphological development of estuaries and coastal systems. Such development is a function of bed forms and sediment availability, and hence of bed composition. In this way, the scales identified above are closely related to morphodynamic scales, though the time scales may differ.

2.3.5 Hydrodynamics

The subject of hydrodynamics inevitably plays a key role in NCK research. Indeed, like the previous theme, it cuts across all other NCK programmes. Many activities in the area of hydrodynamics take place in the context of morphodynamic and ecological models.

Hydrodynamics is a ‘cascade’ item avant la lettre: not only in the scheduling of the hydrodynamic processes (from 1D to 3D modelling), but also in the procedures used (e.g. multiple scale expansions) and, of course, in the physical processes that are studied. These include turbulence, waves (sea and swell, long waves), tidal flows and residual long-term currents. Significant effort is directed at 3D numerical modelling of unsteady, turbulent, free-surface flows including salinity and/or temperature induced density variations and suspended sediment. Research issues are the appropriate subgrid (non-isotropic) modelling of turbulence, including buoyancy effects, and the further development of suitable numerical schemes. The development towards inclusion of nonhydrostatic effects is pursued further, even into the domain of relatively short surface waves including breaking waves. This appears to have great potential for studies of wave-current interactions and interaction with sedimentary beds.

In recent years, large effort has been invested in the modelling of water motion in the coastal zone on the temporal and spatial scales of wave groups (‘low-frequency’ motions, also collectively referred to as ‘surf beat’). This work is ongoing. The resulting velocity patterns are used as input for a sediment transport model, which is capable of simulating the initial development and evolution of rip current systems.

Finally, work is being done on the improved modelling of wind-generated waves within the class of phase- and group-averaged spectral wave energy models, particularly through the SWAN model. At the moment, special attention is being paid to the propagation of waves in shallow water.

2.3.6 Bio-geomorphology

One of the initiatives of NCK is the setup of the theme bio-geomorphology. Bio-geomorphology is the study of the interaction between geomorphological features and organisms. It is a relatively new discipline within the study of water systems combining ecology and geomorphology. Geomorphology is the study of landforms and their formation. Ecology is the study of the relationships between organisms and their environment. The environment can be defined as factors that affect organisms. These factors can be a-biotic (physical, chemical), biotic (other organisms) or anthropogenic (humans). Related terms are ecomorphology, eco-morphology, ecogeomorphology or biomorphology. A related field of research is biogeology.
In the Netherlands bio-geomorphology related research is executed in the field, in laboratory facilities and includes development of mathematical models. Main areas of research are:

- Modelling-, field- and experimental study on bio-geomorphology of river floodplains.
- Fieldwork in the Western Scheldt on interaction of salt marshes with currents, waves and sediment transport.
- Fieldwork in the North Sea on relations between organisms and seabed.
- Flume experiments on interactions of waves and currents with plants.
- Process-based model development on flow, wave patterns affected by vegetation.
- Process-based model development on sediment transport and sediment composition in relation to vegetation and biological (de)stabilizers of the sediment.

The platform bio-geomorphology (www.biogeomorphology.org) has been founded in December 2003 as an initiative of Delft University of Technology. The platform consists at present of members of many Netherlands research institutes and end-users. The platform is not per definition limited to Dutch organizations and welcomes input of other interested parties.

Goal of the platform is to provide networking and stimulate interaction between researchers in the field of bio-geomorphology. Within the platform ongoing and new research issues will be discussed with from the viewpoint of potential co-operation in joint projects and sharing of knowledge and resources. The platform will furthermore discuss issues related to student teaching and training.

2.4 Organization

NCK is a cooperative effort between private, governmental and independent research institutes and universities and carries out a research programme that is compatible with the needs mentioned above. Within this framework, the Centre offers the opportunity to conduct innovative research as a member of a team.

A programme committee establishes the framework for the research to be carried out by NCK. Based on this framework, researchers prepare proposals, which NCK submits for funding to national and international agencies.

Since 1998, following the evaluation of the previous report, a part time programme secretary has been appointed. His tasks are amongst others:

- drafting and keeping up to date of the research programme in cooperation with the Programming Committee;
- stimulating joint NCK research projects;
- increasing the visibility of NCK, both inside the NCK partner organisations and external (national and international).

The NCK Programming Committee and the Programme Secretary are supervised by the NCK Directory Board. During the period 1998-2003, ir. Ad van Os fulfilled the role of NCK Programme Secretary. As of January 1st, 2004, he was succeeded by dr.ir. Stefan Aarninkhof. As of June 1st 2006 he in turn was succeeded by dr.ir. Mark van Koningsveld. Secretarial support is provided by Mrs. Jolien Mans.

Several times a year, the Centre organises workshops and/or seminars that are aimed at promoting cooperation and mutual exchange of information. NCK is open to researchers from abroad. Exchanges of young researchers are encouraged and possibilities for sabbaticals are pursued.

Through the participating institutes, researchers have access to several facilities. The universities offer computing facilities. Field data can be accessed from data banks at Rijkswaterstaat and Deltares. The researchers of NCK may use numerical model systems developed at Deltares and Rijkswaterstaat. Deltares and Delft University of Technology offer various hydraulic laboratory facilities. Advanced equipment for field measurements is available at Utrecht University and at Rijkswaterstaat. Rijkswaterstaat and the Netherlands Institute for Sea Research can provide research vessel support. Through access to these facilities the necessary opportunities to advance the frontiers of knowledge of coastal processes are provided.

2.5 The NCK Partners

The NCK links the strongest expertise of its partners, forming a true centre of excellence in coastal research in The Netherlands. The nine partners are briefly introduced in this section. All individuals participating to the NCK activities as of early 2005 are listed in Appendix B, including their contact details.

Delft University of Technology, Faculty of Civil Engineering and Geosciences

The Faculty of Civil Engineering and Geosciences is recognised as one of the best in Europe. The Department of Hydraulic and Geotechnical Engineering encompasses the Sections Fluid Mechanics and Hydraulic Engineering. Both have gained over the years an internationally established reputation, in fluid dynamics in general, in coastal dynamics, in the fields of coastal sediment transport, morphology, wind waves, coastal currents and the mathematical, numerical modelling of these processes.

Netherlands Ministry of Transport, Public Works and Watermanagement, Directorate General Rijkswaterstaat

Rijkswaterstaat (RWS) is part of the Ministry of Transport, Public Works and Water Management of the Netherlands. The National Institute for Coastal and Marine Management (RIKZ) is part of Rijkswaterstaat. It provides advice and information on coastal flood protection and on the sustainable use of estuaries, coasts and seas. For this purpose, RIKZ develops and maintains a knowledge and information infrastructure. As a knowledge and data bank, RIKZ is also at the service of other parts of the national government, and it collaborates with various agencies and organizations at an international level. RWS manages a large data base of monitoring data on hydrodynamics, morphology, water quality and ecology of the North Sea and coastal zone. The JARKUS set of yearly bathymetric surveys of the Dutch coastal zone, and extensive survey data on the response of the coastal zone, estuaries and Wadden Sea to a number of major human interferences, are examples.

Deltares

Deltares is the result of a merger of WL|Delft Hydraulics, GeoDelft, a parts of TNO Built Environment and the research parts of Rijkswaterstaat RIKZ, RIZA and DWW. Deltares, which started its activities on 01-01-2008, is an independent non-profit organisation for consultancy, research and development in the field of hydrodynamics, hydrology and water resources management. It has some 80 years of world-wide experience in physical scale modelling, mathematical modelling, field work and transfer of knowledge and know-how in these areas. The relevant experience of Deltares as far as NCK is concerned lies in research, development and application of models concerning hydrodynamics, sediment transport and morphodynamics in the coastal zone. A close link between research and practical advisory work warrants a strong interaction with potential end users. Offshore and coastal activities concentrate on seabed and coastal infrastructure and resources, seabed mapping and surveying, geo-hazard and environmental assessment, marine and coastal research and marine and coastal information systems.Deltares has a unique set of experimental facilities to its disposal, recognised by the EU as “Large Installations”. Another important class of facilities is formed by the wide range of numerical modelling software for coastal dynamics, at various levels of sophistication.

University of Utrecht, Institute for Marine and Atmospheric Research Utrecht IMAU

Institute for Marine and Atmospheric research Utrecht (IMAU) is composed of the Meteorology and Physical Oceanography Department of the Faculty of Physics and Astronomy and the Coastal Research Section of the Physical Geography Department of the Faculty of Geosciences. The Institute’s main objective is to offer an optimal, stimulating and internationally oriented environment for top quality fundamental research in Meteorology, Physical Oceanography and Physical Geography, by integrating theoretical studies and extensive field studies. IMAU focusses on the morphodynamics of beaches and surf zones, shoreface and shelf and the dynamics of river deltas (especially in the tropics) and estuarine systems.

University of Twente, Civil Engineering & Management

Since 1992, the University of Twente is providing the education and research programme Civil Engineering (previously called Civil Engineering & Management), which aims at embedding (geo)physical and technical knowledge related to infrastructural systems into its societal and environmental context. The combination of engineering and societal faculties makes this university particularly well equipped to run this programme. Early 2002, the two sections Water Resources Management and Modelling of Integrated Civil Engineering Systems formed the new section Water Engineering and Management (WEM). The research of WEM focuses on i) physics of large, natural, surface water systems, such as rivers, estuaries and seas and ii) analysis of the management of such systems. Within the first research line WEM aims to improve understanding of the physical processes and to model their behaviour appropriately, which means as simple as possible but accurate enough for the water management problems that are considered. Dealing with uncertainty plays an important role here. An integrated approach is central to the water management analysis, in which not only (bio)physical aspects of water systems are considered, but also the variety of functions these systems have for the users, the way in which decisions on their usage are taken, and how these are turned into practical applications. Various national and international research projects related to coastal zone management, sediment transport processes, offshore morphology and eco-morphodynamics have been awarded to this section.

Netherlands Institute for Sea Research NIOZ

The Netherlands Institute for Sea Research (NIOZ) aspires to perform top level curiosity-driven and society-inspired research of marine systems that integrates the natural sciences of relevance to oceanology. NIOZ supports high-quality marine research and education at universities by initiating and facilitating multidisciplinary and sea-going research embedded in national and international programmes

Netherlands Institute for Ecology, Centre for Estuarine and Marine Ecology NIOO-CEME

The Netherlands Institute of Ecology (NIOO-KNAW) focusses on basic and strategic research into individual organisms, populations, ecological communities and ecosystems. The NIOO-KNAW employs more than 250 people at three research centres and its headquarters. The Centre for Estuarine and Marine Ecology (NIOO-CEME) in Yerseke concentrates on ecosystems in brackish and salt water. It conducts research in estuaries and coastal waters in Europe, Africa, Asia, and the Polar Regions. It also participates in several deep-sea projects. The centre originally started as the Delta Institute for Hydrobiological Research in 1957. CEME consists of three departments: Ecosystem Studies, Marine Microbiology and Spatial Ecology.

UNESCO-IHE Institute for Water Education

UNESCO-IHE is a UNESCO Category 1 institute for water education and research. Based in Delft, it comprises a total of 140 staff members, 70 of whom are responsible for the education, training, research and capacity building programmes both in Delft and abroad. It is hosting a student population of approximately 300 MSc students and some 60 PhD candidates. Although in existence for more than 50 years, it was officially established as a UNESCO institute on 5 November 2001 during UNESCO's 31st

General Conference. UNESCO-IHE is offering a host of postgraduate courses and tailor-made training programmes in the fields of water science and engineering, environmental resources management, water management and institutions and municipal water supply and urban infrastructure. UNESCO-IHE, together with the International Hydrological Programme, is the main UNESCO vehicle for applied research, institutional capacity building and human resources development in the water sector world-wide.

3 Symposium programme

Wednesday, March 26th

	20:00	guided tour in the Prinsehof Museum	
	21:00	reception at the Prinsehof Museum, location: kamer van Charitate	

Thursday, March 27th

	09:00	registration	
	09:30	welcome *scientific director Deltares*	*Huib de Vriend*
	09:50	opening *president programme committee Netherlands centre for coastal Research*	*Piet Hoekstra*
	session 1 beach barrier coasts		
	10:20	sedimentary signature of a storm-surge unit in the western Netherlands coastal dunes	*Sytze van Heteren*
	10:40	environmentally controlled transgressive "younger" coastal dunes along the Holland coast	*Bert van der Valk*
11:00	**cofee break**		
	11:30	why shoreface nourishments work: a physical experiment study	*Dirk Jan Walstra*
	11:50	automated extraction of beach bathymetries from video images	*Laura Uunk*
	12:10	prediction of dune erosion due to storms	*Leo van Rijn*
	12:30	probabilistic sensitivity analysis of dune erosion computation	*Kees den Heijer*
	12:50	5 minutes presentation posters	
13:00	**lunch** + postersession		
	session 2 bio-geomorphology		
	14:30	interaction between young mussel beds and fine sediment on a Wadden sea intertidal flat	*Bas van Leeuwen*
	14:50	modelling sand/mud segregation by benthos	*Fransesc Montserrat*
	15:10	plant growth strategies directly affect biogeomorphology of estuaries	*Tjeerd Bouma*
15:30	**cofee break**		
	session 3 sand/mud		
	16:00	shear induced flocculation of mud in different physico-chemical environments	*Franscesca Mietta*
	16:20	modelling wave damping by fluid mud	*Wouter Kranenburg*
	16:40	erosion threshold of sand/mud mixtures	*Walter Jacobs*
20:00	**dinner**		

Friday, March 28th

	session 3 sand/mud (continued)		
	09:00	a generic morphological model for unstructured grid	*Ye Qinghua*
	09:20	minimising harbour sedimentation through optimal dock length design	*Bas van Maren*
	09:40	on SPM entrapment in the Rotterdam Waterway	*Michel de Nijs*
	10:00	predicting suspended sediment concentration at Noordwijk	*Biswa Bhattacharia*
10:20	**cofee break**		
	session 4 tidal inlets and estuaries		
	11:00	analytical description of tidal dynamics in convergent estuaries	*Huub Savenije*
	11:20	solving the taylor problem with horizontal viscosity	*Pieter Roos*
	11:40	using a process based model to re-producing escoffier closure curve	*Ali Dastgheib*
	12:00	the Rhine region of fresh water influence	*Gerben de Boer*
	12:20	effect of tidal asymmetry and sea level rise on inlet morphology	*Pushpa Dissanayake*
12:40	**lunch** + postersession		
	14:15	Encora session	*Nicky Villars, Job Dronkers*
15:00	**cofee break**		
	session 5 seabed and shelf		
	15:30	limited predictability properties of modelled sand ridges on the inner shelf	*Nicolette Vis-Star*
	15:50	effects of large-scale human activities on the North sea seabed	*Henriette van der Veen*
	16:10	new high resolution flow and sand transport measurements under full-scale surface waves	*Jolanthe Schretlen*
	16:30	the sediment budget of the Delta coast (south-west Netherlands)	*Jelmer Cleveringa*
	16:50	closure	*Mark van Koningsveld, Piet Hoekstra*

Saturday, March 29th

	10:00	hands on experimenting in the experimental facilities of TU Delft	
	15:00	the end	

4 Abstracts

4.1 Abstracts for presentations

SEDIMENTARY SIGNATURE OF A STORM-SURGE UNIT IN THE WESTERN NETHERLANDS COASTAL DUNES

Sytze van Heteren, Marcel Bakker, Albert Oost, Ad van der Spek and Bert van der Valk

Deltares

A northwesterly storm on November 9, 2007 created a moderate storm surge that eroded about 10 m of the coastal dunes along a 1-km-long stretch near Heemskerk in the western Netherlands. The resulting dune scarp provided a unique exposure of beach and eolian sediments. In the months following the storm, we studied this exposure, with particular emphasis on a storm-surge unit that reaches an elevation of almost 6.5 m above mean sea level. The storm-surge unit consists of one or more shell-rich layers that are characterized by convolute bedding, vertical air-escape structures, large shells that are mostly oriented convex side up, and sets of parallel laminae that thin and dip in a landward direction. The shell-rich layers were deposited by storm waves that flooded a coastline fronted by undulating dunes, overtopping the lowest parts of the frontal dunes. The landward-dipping parallel laminae were deposited in washovers behind these lows. In the exposure, the storm-surge unit shows considerable relief, with local evidence of scouring. Multiple layers of convolute bedding may point to deposition during one storm surge spanning several high tides or to deposition during separate storm surges. The approximate age of the storm-surge unit, 1650 to 1850 AD, is provided by preliminary OSL ages of sand and a ^{14}C age of an articulated cockle, and by the presence of coal and brick fragments. During this time span, major storm surges flooded the western Netherlands coastal area in 1717, 1741 and 1825, as known from historical records. The present study extends the 115-year-long monitoring series of storm-surge levels in the western Netherlands, providing much-needed information for coastal managers to predict 1:10,000-year flooding levels for coastal-safety purposes. The new data also shed light on wave-runup during extreme storm surges, which is poorly understood at present.

Figure 1: Convolute bedding and slump structure at Heemskerk exposure. Euro for scale.

ENVIRONMENTALLY CONTROLLED TRANSGRESSIVE "YOUNGER" COASTAL DUNES ALONG THE HOLLAND COAST

Bert van der Valk[1)] and Ad van der Spek[1,2)]

[1)]Deltares and [2)]Delft University of Technology and NCK

Along the Holland coast, the formation of the Younger Dunes is the culmination of a long-term process of coastal straightening that coincides with the closure of the majority of coastal inlets through the Holland coastline. The process of inlet closure started already during the pre-roman Iron Age. Dune formation continued during the Roman period locally, and more prominently around the coastal inlets both due to inhabitation and more strong erosional coastal processes providing sand supply to the dunes. Reworking large quantities of coastal sand made available by the re-arrangement of the sand volume stored previously in ebb-tidal delta´s and estuary mouths, along with the general slower (when compared to a few thousands of years earlier) positive and negative movements of the coastline, caused these large volumes of sand to drift longshore and onshore and worked into transgressive coastal dune formations, a process well-known from other coastal dune and barrier areas in NW Europe.

These scarcely vegetated parabolic dune formations started to move landinward earlier (pre-roman iron age) along already longer erosional parts of the coastline, and somewhat later (early medieval period) along less erosional coastlines in between the (former) coastal inlets. Based on (unfortunately) scarce dating information, the volumes of sand passing the coastline could either be 30 to 50 m3/m/yr that seem very large volumes when compared to the maximum values experienced today, which are 9-14 m3/m/yr maximum.

However it is known that a larger availability of sand on the beach potentially moves up the transportable volume of sand considerably above the figures of 9-14 m3/m/yr even nowadays. What is definitively different is the influence of vegetation. It is very likely that the Holland coast before the enforcement of strong coastal defense policies e.g. on marram planting, showed a totally different density and distribution of general vegetation patterns; hence eolian transportation and sedimentation processes had a high degree of free reign. In part these processes were still active recently in more remote areas such as the Schouwen dunes in Zeeland. The knowledge on these past processes is of importance for current policy on a more dynamic type of coastal management.

Current stabilized dune vegetation is a man-made pattern mostly brought about by consecutive and combined actions such as:

- Enforced marram planting from the 15th century onwards
- Protection for hunting wild animals on (noble) private properties
- The start of extracting drinking water from the dunes, restricting access and until then common and widespread use and extraction of dune vegetation products for fodder, housing and fuel
- The formation of nature reserves at provincial, local and European levels, severely restricting any persistent and solid form of disturbance in the dunes.
- Increased yearly precipitation laden with NOx and other fertilizing substances

All factors contributed to the same result, i.e. the fixation of dune surfaces. On their own not one of these factors would be able to effectively stabilize a dune surface. The natural dune system of the Western Netherlands presently being subjected to the pressure of man would be still as active as it was in the prehistory as in the Middle Ages.

In conclusion, the main cause for the large-scale early medieval transgressive dune formation was however, consecutive closure of a number of coastal inlets, and large-scale re-arrangement of large volumes of sand leading to wide-spread transgressive dune sheet formation that could not be contained, let alone stopped until well into historical times, when the organization of coastal defense had increased sizable levels, and population increase enabled such more intensive forms of conservationist landscape management.

WHY SHOREFACE NOURISHMENTS WORK: A PHYSICAL EXPERIMENT STUDY

Dirk-Jan Walstra[1,2] and Claartje Hoyng[1,2], Pieter Koen Tonnon[1] and John de Ronde[1]

[1]Deltares, [2]Delft University of Technology

Within the VOP project (joint RWS-WL | Delft Hydraulics research program), experiments were conducted to investigate the effect of two shoreface nourishment designs (Figure 1). They are located at different depths in the profile but have identical volumes (approx. *400 m^3/m* on prototype scale). The experiments were carried out in the *50 m* long Scheldt Flume for an averaged and a storm wave condition using sand with a D_{50} of *130 μm*. Besides regular profile measurements, detailed measurements of wave height, velocities and sediment concentrations were carried out at several cross-shore positions. The research is aimed at establishing and quantifying the dominant physical processes that are affected by the presence of a shoreface nourishment. To that end detailed comparisons are made between the results for the nourishment designs and a reference profile using the temporal profile development and process measurements.

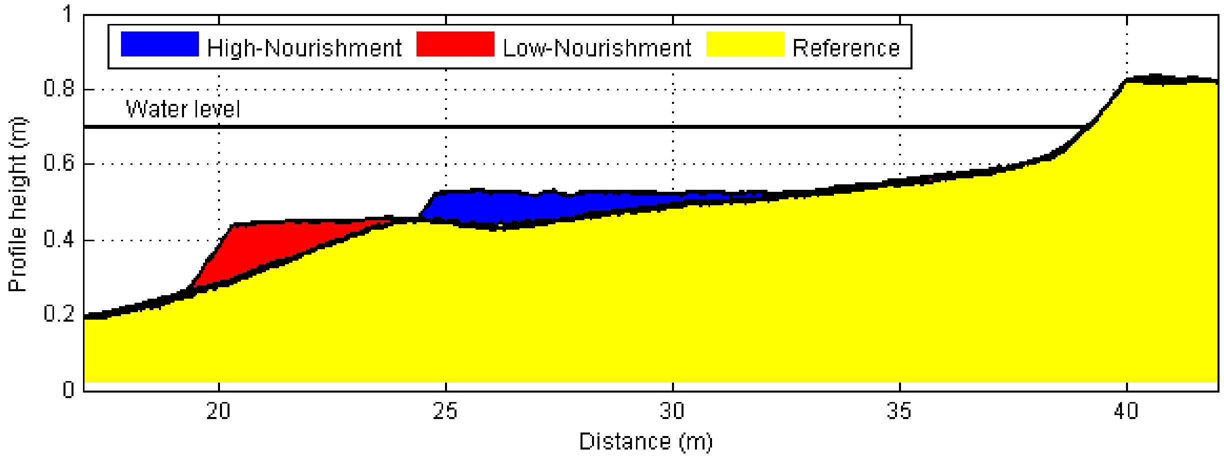


Figure 1: Initial profiles for the reference case and both nourishment designs.

As an example the temporal development of the sand volume (relative to the reference case) in the upper part of the profile is shown in Figure 2. The effect of the shoreface nourishment designs is clearly visible. The high nourishment results in the largest relative increase of sand volume, *60%* for both wave conditions, compared to *20%* (average waves) and *40%* (storm waves) for the low nourishment design at end of the experiments. During the presentation, results from the process measurements will be linked to the observed profile development.

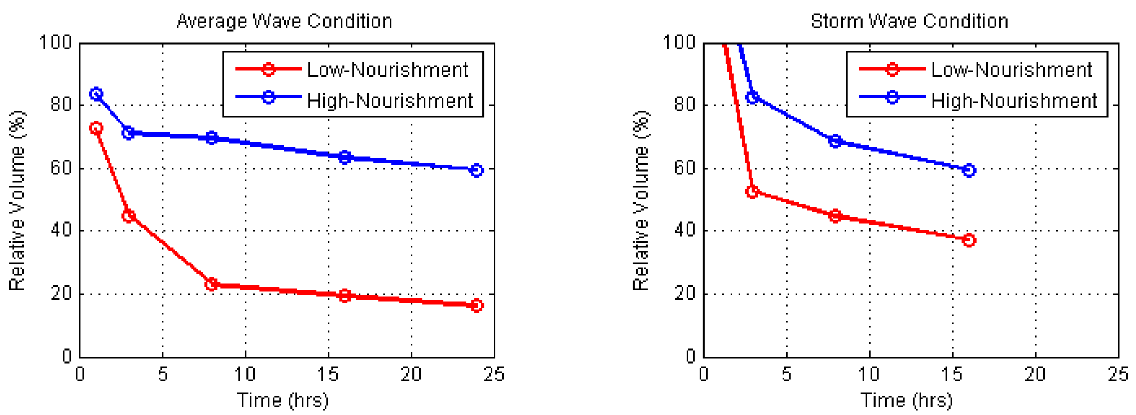


Figure 2: Relative temporal development of sand volumes for upper part of profile (landward of *x=32 m*).

AUTOMATED EXTRACTION OF BEACH BATHYMETRIES FROM VIDEO IMAGES

Laura Uunk[1)], Robin Morelissen[2)], Kathelijne Wijnberg[1)], Suzanne Hulscher[1)]

[1)] Twente University, [2)] Deltares

Knowledge of the beach behaviour is required from both a coastal management as well as a scientific point of view. The little information that is currently available on the smaller spatiotemporal scales limits our understanding of the beach behaviour. An easy and relatively cheap way of collecting bathymetric data is offered by the use of Argus video images. From these images information on the beach can be derived, such as the position of subtidal bars or the bathymetry of the intertidal beach. The latter is subject of this research.

The bathymetry of the intertidal beach can be derived from Argus video images by detecting the shoreline on the image and combining its location with its calculated elevation, based on tide, wave setup and swash. In this way shorelines detected throughout the tidal cycle provide elevation contours of the intertidal beach. Currently, detection of the shoreline and calculation of the elevation are automated, but acceptance of the correct shoreline points (i.e. quality control) is still an action that requires human control. As manual quality control is very time-consuming, only monthly bathymetries have been derived from Argus images so far. The advantage that the hourly-collected Argus images could provide is thus not yet used to its fullest extent.

A completely automated shoreline detection and quality control algorithm was developed by N.P. Plant: the Auto Shoreline Mapper (ASM). This tool was later on improved by A. Cerezo and M. Harley for the Dutch beach. Its performance however was not satisfactory, because after mapping only a few bathymetries the ASM generally quitted because, in time, it ran out of shoreline data. It appeared this depended largely on the automated acceptance procedure of shoreline points. For each image all detected shoreline points are compared to a benchmark bathymetry, which is interpolated from shoreline points detected on previous images within a certain timeframe. A user-defined, spatially non-varying maximum vertical difference between the shoreline point and the benchmark bathymetry determines whether a shoreline point is accepted or rejected (see Figure 1). This benchmark bathymetry, in combination with the vertical difference criterion, takes over the human quality control.

Two problems encountered with the automated quality control are that sometimes a) wrongly detected shoreline points are accepted and b) correctly detected shoreline points are rejected. If the vertical acceptance criterion is set very loose, many points, including the wrongly detected ones, will be accepted on low-sloping beaches like the Dutch ones. In case of a very strict criterion, elevation changes that could naturally occur within one tidal cycle are not accounted for, leading to the rejection of many good points. The setting of the criterion is therefore a trade-off between accepting wrong shoreline points in case of a larger value or rejecting good points in case of a smaller value.

Currently tests are carried out with different acceptance criteria to study the impact on the performance of the ASM. Also the influence of accepting many wrong points or rejecting many good points on the quality of the obtained bathymetry is studied. This will hopefully result in an understanding of which spatiotemporal scales of beach processes can be studied using ASM derived shoreline points.

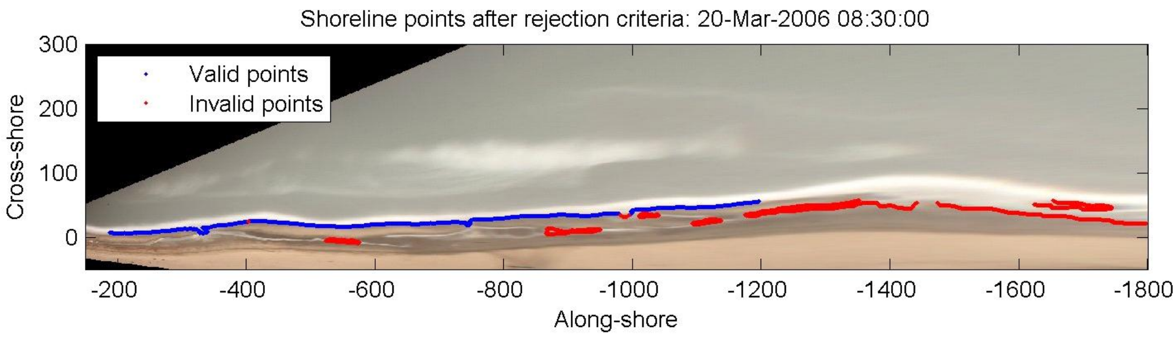


Figure 1: Accepted and rejected shoreline points by the ASM on a plan view image of the Egmond beach

PREDICTION OF DUNE EROSION DUE TO STORMS

Leo van Rijn[1,2)]

[1)]Deltares and [2)]University of Utrecht

This presentation presents results of experimental and mathematical modelling of beach and dune erosion under storm events.

Re-analysis of the experimental results on dune erosion in small-scale and large-scale flumes show that the dune erosion for extreme conditions is somewhat smaller (250 m^3/m) than that based on earlier analysis results (300 m^3/m).

Dune erosion caused by wave impact has been modelled by a cross-shore profile model (CROSMOR-model), which is based on a 'wave by wave' modelling approach solving the wave energy equation for each individual wave. The model has been applied to the recent Deltaflume experiments on dune erosion. The three main processes affecting dune erosion have been taken into account: the generation of low-frequency effects, the production of extra turbulence due to wave breaking and wave collision and the sliding of the dune face due to wave impact. The calibrated model can very well simulate the observed dune erosion above the storm surge level during storm events in small-scale facilities, large-scale facilities (see Figure 1) and in the protoype (1953 storm in The Netherlands) using the same model settings.
Application of the CROSMOR-model to the prototype Reference Case as defined by Vellinga (1986) yields a dune erosion volume of about 170 m^3/m, which is considerably smaller than the value of about 250 to 300 m^3/m based on scale model results**.** This discrepancy may be caused by upscaling errors (using available scaling laws) of laboratory test results to prototype conditions and by mathematical modelling errors. As regards scaling errors, the mathematical model is more reliable. The model has been verified using field data. For example, the CROSMOR-model has been used to simulate the 1975 hurricane Eloise in the USA and the 1953 storm in The Netherlands (Van Rijn, 2008). In both cases the model over-estimates the observed erosion. Hence, the model seems to produce conservative rather than optimistic results for field conditions.

The mathematical model results have been used to develop a new dune erosion rule.

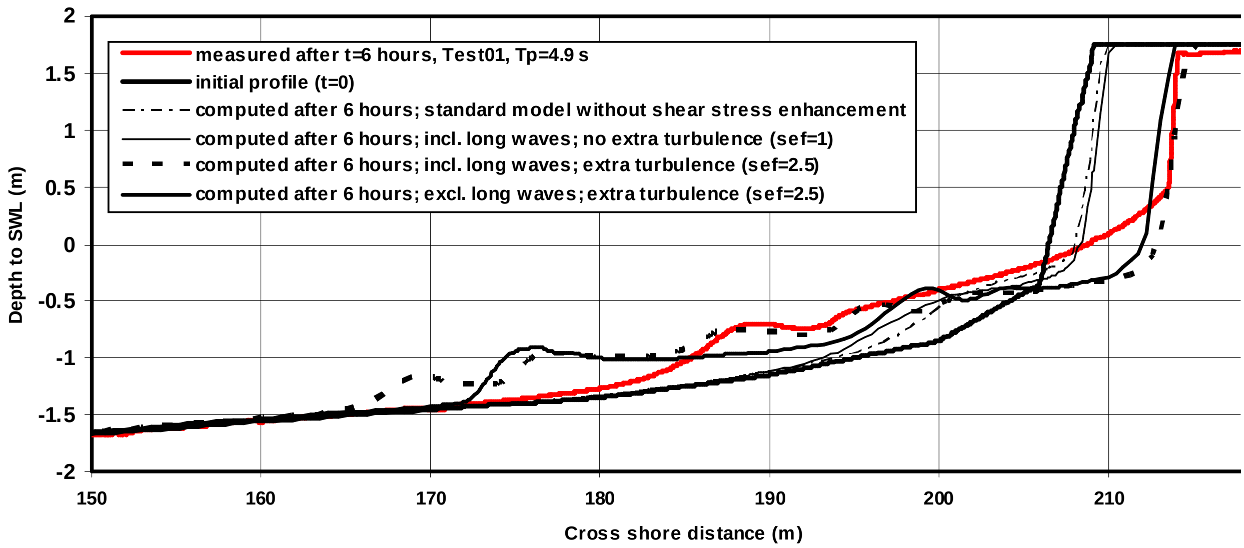


Figure 1: Computed and measured bed profiles of dune erosion after 6 hours for Test T01 (Delta flume)

PROBABILISTIC SENSITIVITY ANALYSIS OF DUNE EROSION COMPUTATION

Kees den Heijer[1,2)]

[1)]Delft University of Technology, [2)]Deltares and NCK

Introduction

Coastal dunes often constitute the final sea defence of low laying coastal areas. If the dunes are breached by a severe storm, serious damage due to flooding and direct wave attack could occur, resulting in loss of life and property. Therefore, it is essential to be able to properly predict the impact of a storm on a dune coast. The safety assessment method for dune coasts used in The Netherlands is being updated to account for recent insights concerning extreme conditions. Various aspects which play a role in the dune erosion process are not (optimally) included in the current safety assessment method. These aspects include wave period, storm characteristics, foreshore bathymetry, variability in bathymetry, longshore variability, higher probabilities of occurrence, structures and other special cases as well as the time dependent process modelling of dune erosion. In short, it is not clear whether the Dutch dune coast is safe enough. If the current safety assessment method is too conservative, the costs for coastal maintenance can be reduced. But otherwise, if the dune coast is less safe than assumed so far, strengthening measures might be urgently needed. A revised safety assessment method for dune coasts is being developed which accounts for all aspects currently considered as relevant, in a holistic way.

Description of research

The study presented here concerns a probabilistic sensitivity analysis of various parameters that are included in the current Dutch safety assessment method. The core of this method is the DUROS-plus model (WL | Delft Hydraulics, 2006). Although for the actual assessment a semi-deterministic method is used, the design values of the parameters are based on a probabilistic investigation (WL | Delft Hydraulics, 2007). Using this probabilistic investigation as a reference, the various distribution functions have been varied in order to get more insight in the influence of each of these parameters.
The generic probabilistic toolbox ‘Prob2B’ (former Probox), developed by TNO Built Environment and Geosciences has been applied for this investigation, and coupled with the MATLAB-based dune erosion routines of McTools (Marine and Coastal Tools).

References

WL | Delft Hydraulics, 2006. Dune erosion; Product 1 – Deterministic dune erosion prediction methods. WL | Delft Hydraulics report H4357.

WL | Delft Hydraulics, 2007. Dune erosion; Product 3 – Probabilistic dune erosion method. WL | Delft Hydraulics report H4357.

Courage, W.M.G. & H.M.G.M. Steenbergen, 2007. Prob2B™: variables, expressions and Excel®. Installation and Getting Started. TNO-report 2007-D-R0887/A, TNO Built Environment and Geosciences, Delft. August 2007.

INTERACTION BETWEEN YOUNG MUSSEL BEDS AND FINE SEDIMENT ON A WADDEN SEA INTERTIDAL FLAT

Bas van Leeuwen[1,2], Suzanne J.M.H Hulscher[2], Denie C.M. Augustijn[2],
Mindert B. de Vries[2,3,4] and Bregje K. van Wesenbeeck[3]

[1] Svašek Hydraulics, [2]University of Twente, [3]Deltares and [4]Delft University of Technology

Large aggregations of mussels (Mytilus edulis), so called mussel beds, live in the Dutch Wadden Sea and the Eastern Scheldt estuary. Mussel beds range in size from small beds of a few tens of square meters, to very large beds measuring in the square kilometers. Mussel beds are recognized as an important factor influencing biogeomorphological processes and it is thought that mussel beds may influence the fine sediment dynamics of an estuarine system. Until now, no successful attempts at modeling this influence exist. Therefore, the objective of this research is to model mussel bed-sediment interaction to study the influence of mussel beds on the deposition and erosion of fine sediment on an intertidal flat in the Wadden Sea.

Mussels experience sedimentation inside the bed. This sedimentation is the result of both the active filtration of suspended sediment resulting in (pseudo-)faecal pellet production and the passive settling of material during slack tide. Young mussels are highly mobile and respond to this sedimentation by climbing on top of the sediment and covering it. In this way they capture and protect thick layers of mud, causing rapid elevation of the bed, ensuring access to suspended algae for food. Older mussels lose their ability to move and may be buried by sediment or younger mussels. The maximum growth of mussel beds is restricted by the submergence (and feeding) time and will hardly exceed mean sea level.

To model the interaction between fine sediments and a young mussel bed the process-based Delft3D-FLOW model was used. Roughness and erosion behavior were implemented using an adjusted vegetation model. As an extra feature, active capture of suspended fine sediment by mussel feeding was added to the Delft3D model. The properties of sediment (including pseudo-faecal matter) deposited in between mussels were taken into account by adjusting the sediment characteristics in the mussel bed. The mussel bed implementation was tested in a model of a Wadden Sea intertidal mudflat area south of Ameland, which is suitable mussel habitat. The model simulated two current dominated summer months. A sensitivity analysis was conducted on the parameters of the mussel bed implementation. Finally, different patterns, known to occur in young mussel beds, were imposed.

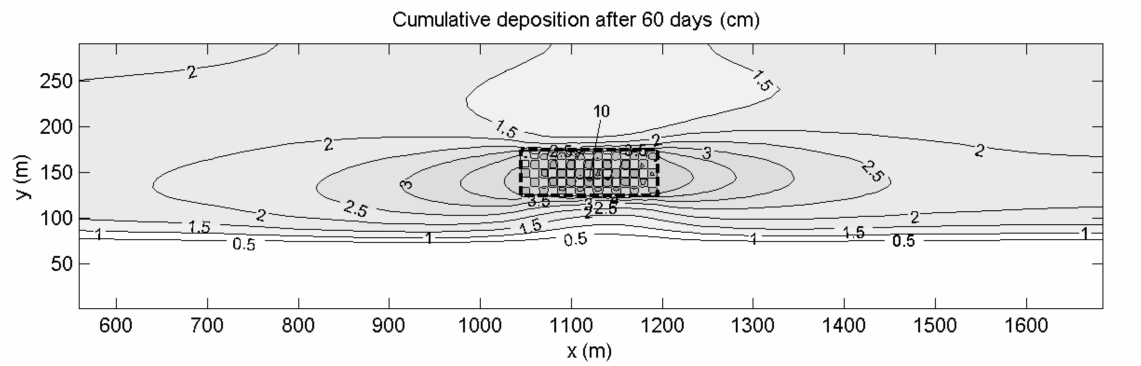


Figure 1: Accretion of fine sediment in and around a patchy young mussel bed (outline depicted as dotted line) as computed by the Delft3D model. At y < 50 m the intertidal flat is bordered by a channel.

The model simulated the large amount of sediment that is captured by young mussel beds (up to 10 cm in two months, see Figure 1) correctly. It has further been concluded that roughness and filtration rate of mussel beds are important factors in mussel bed influence on fine sediment. A combination of active deposition via filtration and slowdown of the flow leads to high cumulative deposition in the mussel bed. In the surrounding area deposition is also high because of a reduction of flow velocities caused by the rough mussel bed. Patchiness causes mussel beds to experience less sedimentation than uniformly covered beds of the same size. This supports the hypothesis that mussel beds exhibit patchy structures to keep free of smothering by sediment. This is especially relevant for more mature mussels, which do not have the ability to climb on top of the sediment.

MODELLING SAND-MUD SEGREGATION BY BENTHOS

F. Montserrat[1,2], P. Provoost[2], C. Van Colen[3], M. Ponti[4], K. vanden Meersche[2,3], T. Ysebaert[2] and P.M.J. Herman[2]

[1] Delft University of Technology, [2] Netherlands Institute of Ecology - Centre for Estuarine and Marine Ecology, [3] Marine Biology dept. - Ghent University and [4] CIRSA Ravenna - University of Bologna

Sediments dominated by a muddy skeleton tend to display a more cohesive character and are less sensitive for erosion than those with a sand-dominated matrix. The erosive behaviour of such sediments can change abruptly from cohesive to non-cohesive as the mud:sand ratio decreases and passes a threshold value (Jacobs, 2006). The activity of fauna living in/on the sediment can influence the mud:sand ratio actively (selective feeding), but also passively (movement). We used UV-fluorescent sediment mimics to track both sediment fractions through the bed in the case of a natural benthic community and one that has been removed completely and was allowed to gradually recolonise (Montserrat *et al.*, subm.). We then used an image analysis method to obtain a continuous vertical distribution of the mimics in the sediment. In concert with these analyses we performed analyses on macrobenthos and sediment variables, as well as lab-experiments, in order to obtain a sound understanding of biogenically mediated sediment processes. The investigated tidal flat was dominated by sediment-diffusing bivalves and both our results and modeling efforts showed that their activity brought fine particles to the sediment-water interface where they are easily transported away.

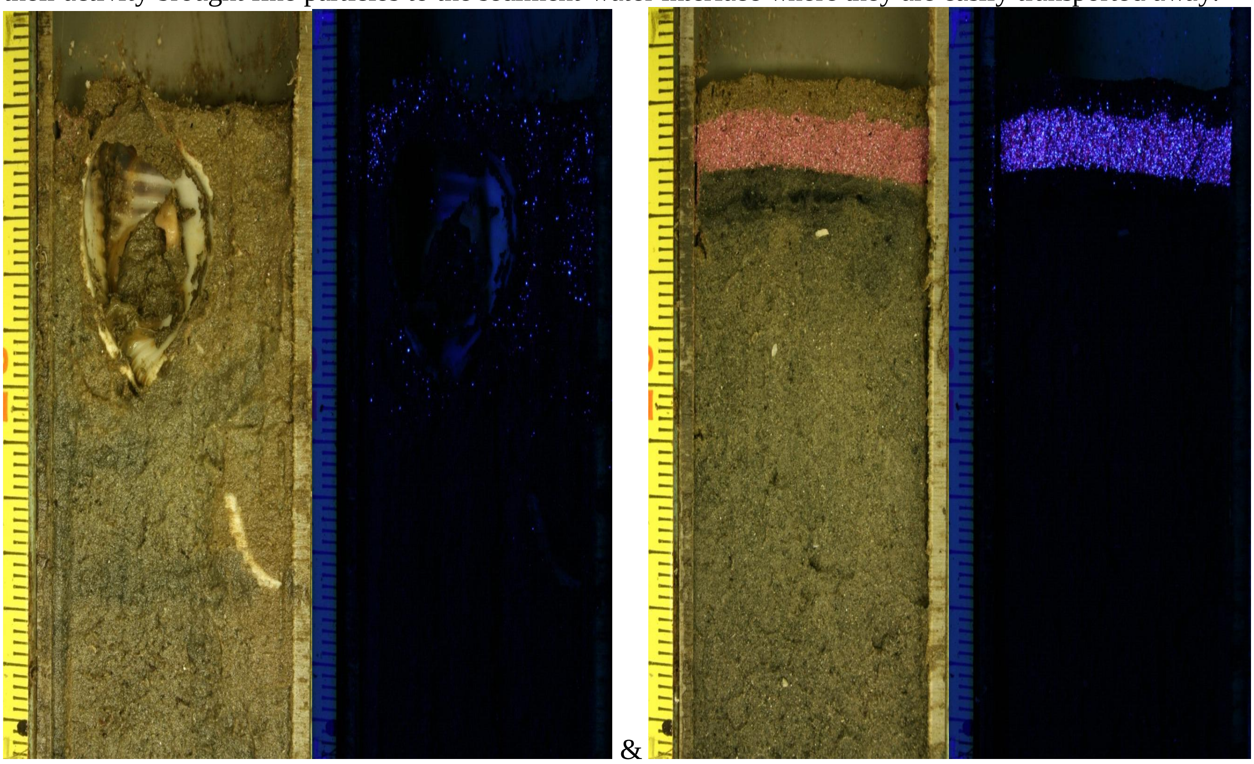


Figure 1: A longitudinal section of sediment cores containing sediment mimics of a coarse and a fine sediment fraction. The left light/dark-UV pair is taken in undisturbed sediment with macrofauna, while the right pair is taken from sediment devoid of macrofaunal activity. The absence of macrofauna even yields a net deposition, as can be seen from the layer of sediment on top of the luminophore layer.

f.montserrat@nioo.knaw.nl

Montserrat, F., van Colen, C., Ysebaert, T., and Herman, P.M.J. (*subm.*) Changing sediment properties with the (dis)appearance of a intertidal benthic community

Jacobs, W. (2006) Eco-morphology of estuaries and tidal lagoons: literature review and experiments on sand-mud mixtures. TU Delft report no. 1-06

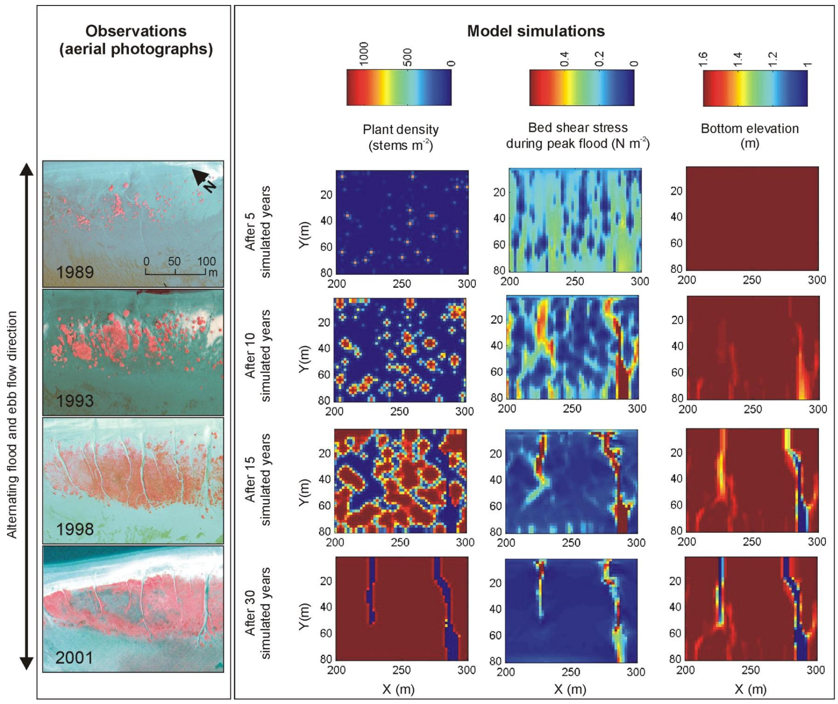
PLANT GROWTH STRATEGIES DIRECTLY AFFECT BIOGEOMORPHOLOGY OF ESTUARIES

Tjeerd J. Bouma[1)], S. Temmerman[2)], M. Friedrichs[3)], B.K. van Wesenbeeck[1,4)], F.G. Brun[1)], J.T. Dijkstra[5)], M.B de Vries[4)], G. Graf[3)], P.M.J. Herman[1)]

[1)] NIOO-CEME, [2)] Universiteit Antwerpen, [3)] University of Rostock, [4)] Deltares, [5)] Delft University of Technology

Questions? Please sent e-mail to t.bouma@nioo.knaw.nl

Biophysical interactions between organisms and hydrodynamic forces are a main determinant of geomorphology of intertidal areas. Especially vascular plants have striking effects on intertidal geomorphology. Seagrasses and salt-marsh plants that inhabit intertidal areas are known to have strongly contrasting morphologies. The interaction between hydrodynamic forces and plant morphology determines how, and how much, plants influence sediment dynamics. To assess the geomorphological effect of different vegetation types, we carried out a series of studies in flumes with unidirectional flow and extrapolated these flume results by hydrodynamic modeling with Delft-3D.
We will present results for contrasting vegetation types to demonstrate that differences in organism traits do give profound differences in landscape formation. Our model simulations are backed-up by detailed flume observations on sedimentation and erosion patterns, for four contrasting vegetation types. Our results show that both shoot stiffness and vegetation density are highly important for long-term large-scale landscape evolution.



Single example of landscape evolution by the stiff salt marsh species *Spartina anglica*. (Left panels) Aerial photographs showing the patterns of plant colonization by *Spartina anglica* (red colour) and channel formation on a tidal flat (Plaat van Valkenisse, SW Netherlands). (Right panels) Selected time steps during simulation of plant colonization and channel formation on a tidal flat. For each time step, a map of plant density, bed shear stress during peak flood, and bottom elevation is shown for a selected part of the model grid. Simulations started from an initially bare, flat area with a spatially uniform flow field. (Modified from Temmerman et al. 2007. Geology 35: 631-634.

SHEAR INDUCED FLOCCULATION OF MUD IN DIFFERENT PHYSICO-CHEMICAL ENVIRONMENTS.

Francesca Mietta[1)], Claire Chassagne[1)], and Johan C. Winterwerp[1,2)]

[1)] Delft University of Technology, [2)] Deltares

The fine fraction of suspended matter differs from coarser fractions because its size and settling velocity vary with the environmental conditions as a consequence of flocculation processes. The rate at which flocs form and the size they attain depends on the hydrodynamic conditions, the residence time, the sediment type and the properties of the water suspension such as pH and salinity. Estuaries are highly dynamic environments with ever changing conditions where sediment is transported by currents and advection. This implies that it is extremely difficult to understand the mechanisms leading to flocculation by means of *in situ* observations. Laboratory experiments allow a wider analysis of the phenomena.

This work aims at the understanding of the relation between shear rate and mud flocculation by means of jar test experiments. The physico-chemical conditions of the suspension influence this relation by affecting the strength of flocs and the flocculation rate. Flocculation tests with different pH and salinity are done varying the shear rate. The sediment used is natural mud from the Western Scheldt estuary. The flocculation experiments are coupled with the study of sediment properties such as ζ-potential, primary particles size distribution and organic matter content. The ζ-potential is a measure of the surface charge of the particles.

Both a decrease of pH and an increase of salt concentration lead to the formation of larger flocs, because in both cases the ζ-potential decreases. This leads to an increase of the probability of particles to stick together after collision and therefore an increase of the mean size of particles and a decrease of the flocculation time. An example of time evolution of the floc size distribution is plotted in Figure 1.

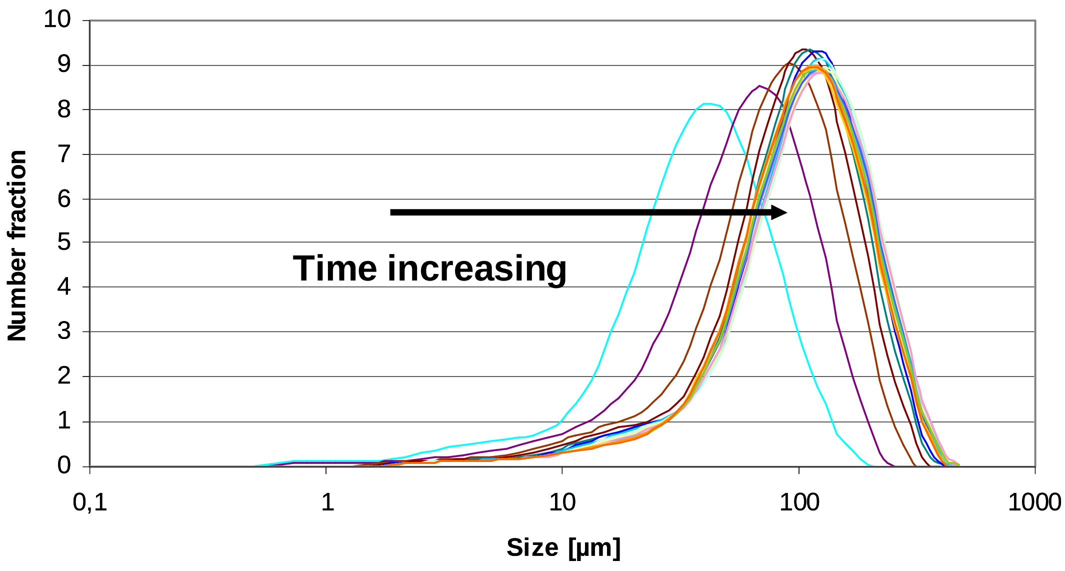


Figure 1: Time evolution of the floc size distribution of mud.

MODELLING WAVE DAMPING BY FLUID MUD

Wouter Kranenburg[1], Han Winterwerp[1,2] and Gerben de Boer[2]

[1]Delft University of Technology, [2]Deltares

On numerous locations in the world mud occurs in front of the coast close to river mouths. This mud can be transported to these places in fluid state or can become fluid under certain wave conditions. Fluid mud may have a strong damping effect on surface waves. Dissipation of up to 90% of the wave energy within a few kilometers has been measured. In this study, the wave model SWAN is modified to enable the modelling of dissipation of energy during the propagation of a wave field over fluid mud.

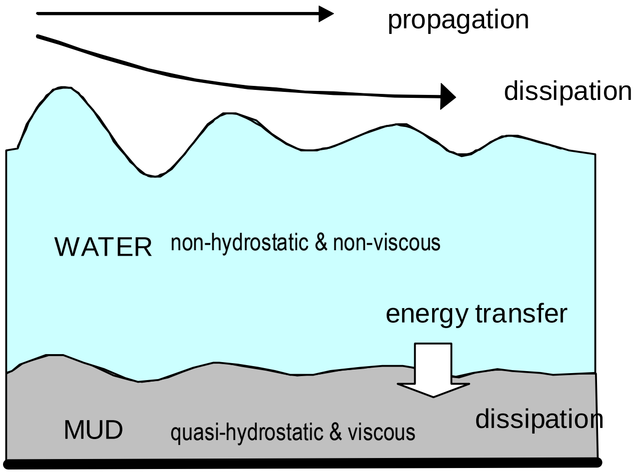


Figure 1: viscous two-layer model

A two-layer model (fig.1) is used to describe the water-mud-system. The upper layer represents the water and is non-hydrostatic and non-viscous. The lower layer represents the fluid mud and is quasi-hydrostatic and viscous. Based on this schematization a complex dispersion equation is derived and compared with other dispersion equations from literature. A numerical solving procedure is formulated to solve this implicit complex dispersion equation for the wave number. When the wave number is known, information on the damping is given by the imaginary part, while the real part is associated with the wave length and the propagation velocity of energy.

To compute wave damping for situations in practice (fig.2), the influence of mud is incorporated in the wave model SWAN. First, the energy dissipation term consistent with the dispersion equation is derived and added as a sink term to the energy balance in SWAN. By making the mud-adjusted wave number available through the whole code, also influence of fluid mud on energy propagation is included in the model. The performance of the model for both energy dissipation and energy propagation is validated and compared to analytical solutions for some simple cases.

Result

The final result of this study is a modified version of SWAN which allows to model the decrease of energy during the propagation of a wave field over fluid mud. The model is ready for use in engineering applications by specialists.

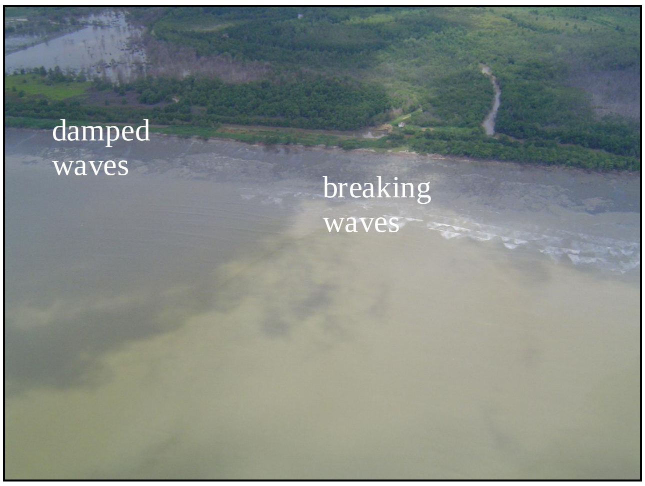


Figure 2: Aerial photograph of wave breaking and wave damping at the Demerara coast, Guyana

EROSION THRESHOLD OF SAND-MUD MIXTURES

Walter Jacobs[1)], Philippe Cann [2)], Pierre Le Hir[2)], and Walther van Kesteren[3)]

[1)] Delft University of Technology, [2)] IFREMER, [3)] Deltares

This study deals with the measurements of the erosion threshold and undrained shear strength of sand-silt-clay mixtures. It is part of a systematic research into the erosion behaviour of mixed sediments in intertidal areas, including the effect of biological, chemical and physical influences. A large number of erosion tests is executed using a re-circulating small-scale flume (see figure 1), which is very practical to use. Artificial samples were generated using a specific experimental set-up in order to obtain homogenously mixed and 100% saturated samples.

The sample compositions are varied concerning clay-silt ratio, clay mineralogy and sand-silt ratio. The data are discussed following a geotechnical approach. A strong relation with the plasticity index in combination with the water content is found. Besides, a clear transition in behaviour exists for samples with a dominant sand-silt skeleton and a clay-water matrix. This transition is explained by considering the granular porosity, which is the space between sand and silt grains. This space is either filled with water, or with a mixture of water and clay.

A comparison between the results for the erosion threshold and the undrained shear strength shows that both observed transitions occur for a similar relation between water content and plasticity index. It is also indicated that the role of the permeability in the erosion behaviour of soils is important. This agrees with a newly proposed erosion formulation, which will be compared with the results of this study in future research. Finally, the study provides a valuable data set that can be used as a reference for following stages of this research concerning (the erosion behaviour of) more natural sediments.

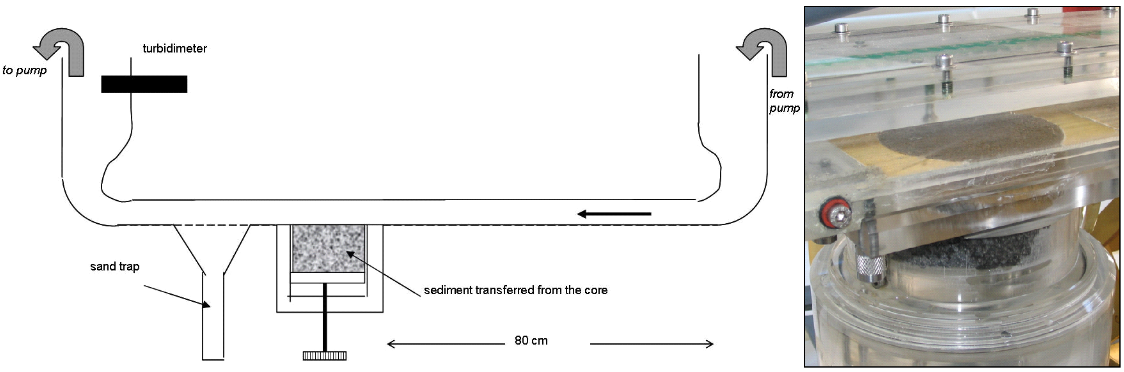


Figure 1: Re-circulating flume (‘*Erodimetre*’) as applied in this study (after le Hir *et al*., 2005, 2006). At left, the flow direction is indicated by the arrow. The hatched area is a sediment sample. Downstream of the sample the sand trap and turbidity meter are plotted. At right, a detail of an inserted sample is shown.

A GENERIC MORPHOLOGICAL MODEL FOR UNSTRUCTURED GRID

Qinghua, YE[1,2], J. A. Roelvink[1,2], H. R. A. Jagers[1,2], Leo Postma[1,2], J. K. L. Van Beek [1)]

[1)] UNESCO-IHE Institute for Water Education
[2)]Deltares and NCK

Processes based morphological modeling is one of the advanced tools to assess the evolution of the coastal system. In the last decades, many built-in morphological modules have been developed within hydrodynamic software packages. As a result, these morphological modules also inherited the advantages and disadvantages of the hydrodynamic models.

A generic morphological model is set up independent of the coupled hydrodynamic model within the Delft3D-WAQ framework. The model is generic in two senses. i) the model can be coupled with different types of hydrodynamic module, using structured or unstructured grid; integrated using finite volume method, finite difference, or finite element method; ii) the model is applicable to various typical morphological problems, such as, 1D, 2D or 3D problems in river network or coastal area.

The model includes 4 modules (Fig. 1), i.e., bed state description module, sediment transport module, geomorphologic bed level update module, and hydrodynamic module. The prior 3 modules are developed using the Open Process Library (OPL) to couple with the current module of Delft3D-FLOW.

The model is validated with two preliminary applications: i) developing of the equilibrium bed slope; ii) sand hump migration along a horizon channel. The results from the generic model are comparable to the analytical solution and the results from the Delft3D-FLOW online MOR model.

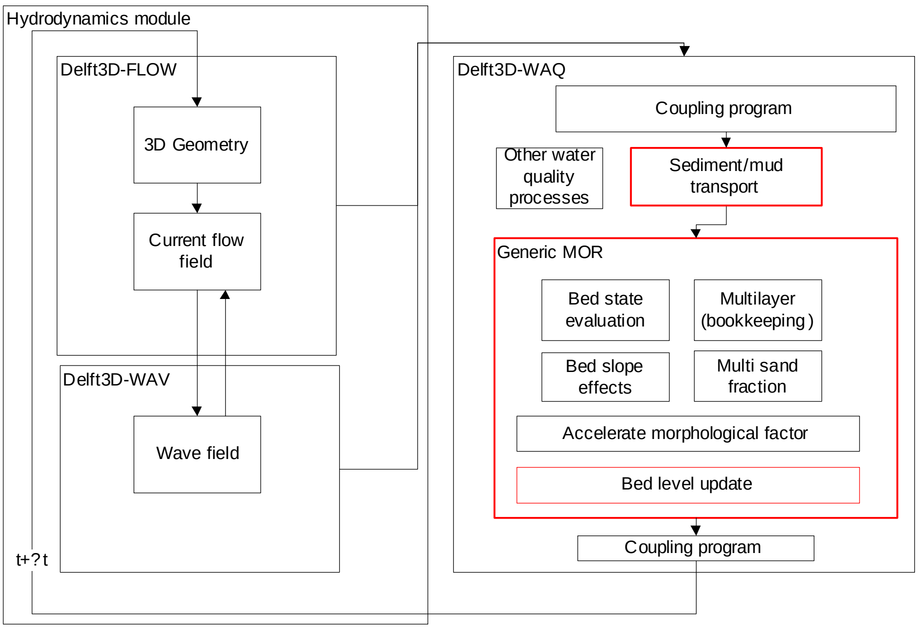


Figure 1: Structure of the generic morphological model

MINIMISING HARBOUR SEDIMENTATION THROUGH OPTIMAL DOCK LENGTH DESIGN

Bas van Maren[1,2], Han Winterwerp[1,2], Marc Sas[3], Joris Vanlede[4],

[1] Deltares, [2] Delft Technical University, [3] IMDC, [4] Waterbouwkundig Laboratorium Borgerhout

A new harbour dock, the Deurganckdok, was created recently along the Scheldt River, to extent the capacity of the Antwerp harbour. In contrast with existing harbour docks, in which ships enter through locks, the entrance of the Deurganckdok is connected with the Scheldt River over its full width. Although such an entrance is effective for ship traffic, it will most likely lead to high sedimentation rates in the dock, and therefore to high dredging maintenance costs. To minimize siltation rates in the dock, a physical scale model, a numerical model, and several measurement campaigns were setup, which aimed at designing strategies to minimize sediment import into the dock.

One of the outcomes of the numerical model study was that the density-driven exchange flows in the Deurganckdok are influenced by the length of the dock. Low-salinity surface plumes that enter the dock reflect at the landward end, and propagate back. Therefore the surface salinity in the dock depends on the length of the dock. The surface salinity, in turn, influences the near-bed hydrostatic pressure. A lowering of the hydrostatic pressure inside the dock, resulting in increased inflow from the Scheldt into the dock, leads to increased import rates when this coincides with a period of a high sediment supply (Figure 1). The results are generically valid for all harbour docks in an estuarine setting with a sufficiently high salinity range, as long as they are fully opened (i.e. without a lock), and sufficiently long. With a low tidal density variation (around 0.5 kg/m^3), the dock length probably influences exchange flows at small dock lengths (approximately 1 km) whereas the dock length should be much higher (4 km) when the tidal density variation is higher (around 5 kg/m^3). Whether these changing exchange flow result in a lowering or increase of sediment import, depends on the phase difference between sediment concentration peaks on the adjacent river/estuary and the salinity variation, and on the vertical distribution of sediment. Sediment import is unaffected by the vertical distribution of exchange flows when sediment is fully vertically mixed.

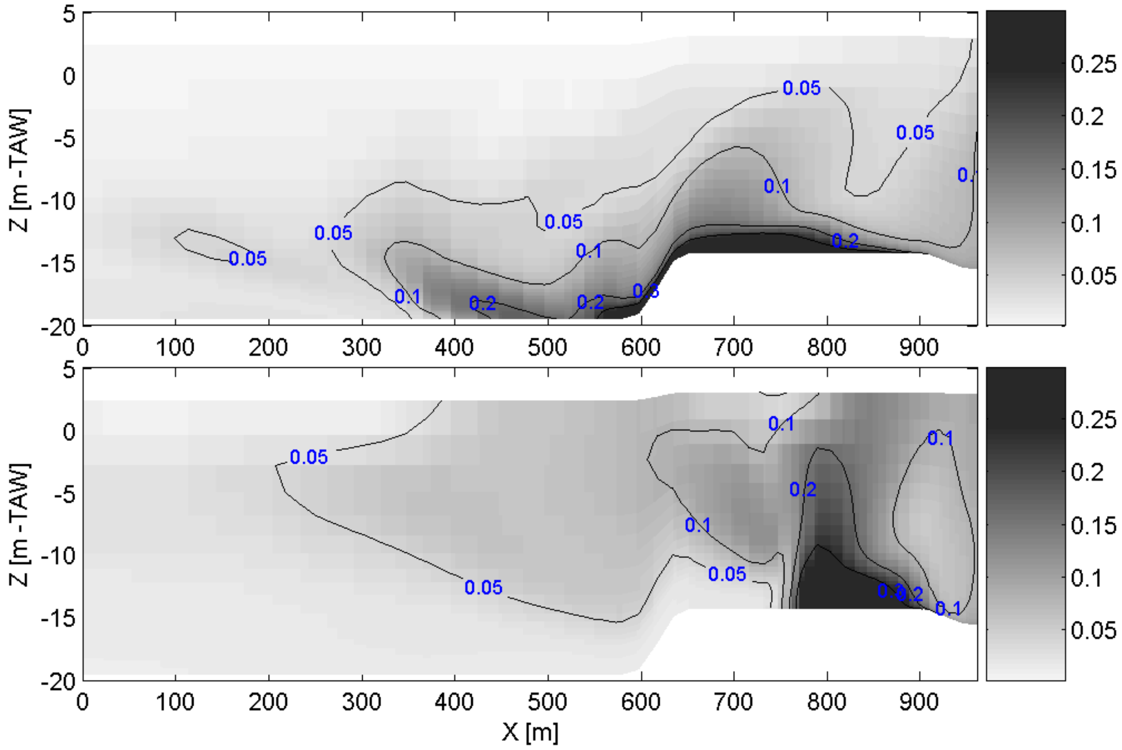


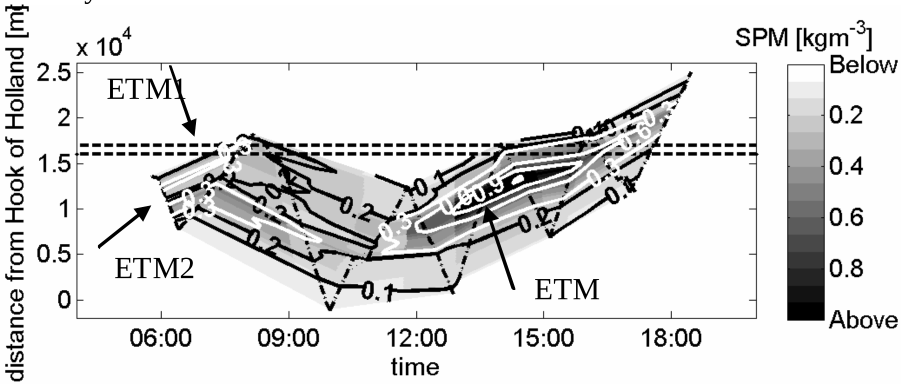
Figure 1: Sediment concentration in the Deurganckdok with half length (top) and full length (bottom)

ON SPM ENTRAPMENT IN THE ROTTERDAM WATERWAY

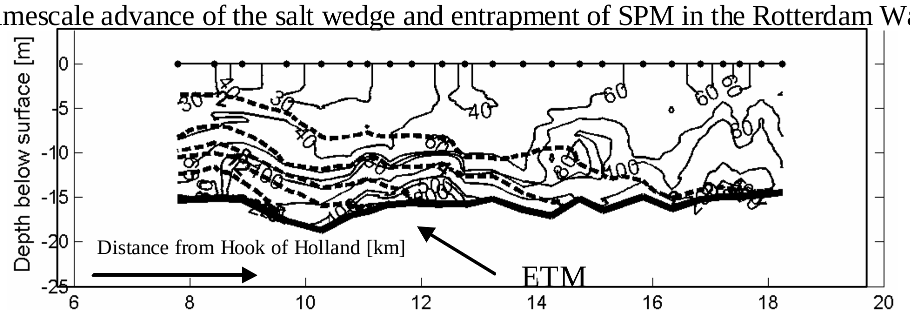
Michel A.J. de Nijs[1], Johan C. Winterwerp[1,2] and J.D. Pietrzak[1]

[1] Delft University of Technology, [2]Deltares

In this study the presence of an ETM in the Rotterdam Waterway has been quantified and its relation to harbor siltation (Botlek Harbor) established. In the Rotterdam Waterway the internal structure (baroclinic and buoyancy) keeps a SPM balance (ETM) against the river discharge. The ETM at the tip of the salt wedge is a key factor in supplying SPM to Botlek Harbor. Salinity induced density currents therefore dominate the exchange of SPM in the mouth of Botlek Harbor and the trapping of SPM in the basin. Viewed over large timescales, the ETM may consequently control the supply of SPM to various harbor basins on the estuary due to (frequent) advection and exchange driven excursions in response to changes of the boundary conditions. It can therefore be stated that one of the most important engineering applications of the knowledge of processes that determine accumulation of sediment arises from their influence on the large scale and long term suspended sediment budget of ports. This includes knowledge of the origin of the sediment, the type of sediment, the direction and magnitude of the sediment transport and the trapping efficiency of the estuary.



A better understanding of the mud transport processes (ETM) in the Rotterdam Waterway will increase insight into the variability of the siltation rates in harbor basins. In turn, knowledge of the variability of the dredging data and origin of the dredged mud provides information on the transport of mud. Sediment budget, mineral, isotope and contaminant metal tracer analyses indicate that fluvial sediment mainly contributes to siltation. Furthermore, the down-estuary boundary the Maasmond is not a 100% marine sediment boundary. This means that the effects of the salinity induced baroclinic and buoyancy structure on the tidal flow and turbulence keep SPM trapped in the Rotterdam Waterway. It can therefore be argued that over large timescales the length of the salt water intrusion and fresh-water discharge (supply of fluvial SPM) determine the magnitude of the ETM, and not the strength of the gravitational flow and/or tidal pumping, which import marine sediments. Down-estuary and up-estuary excursions of salt water determine the trapping probability of fluvial SPM. The prediction of the siltation rates in the harbor basins therefore requires a proper quantification of the along channel distribution of salinity and sediment in the Rotterdam Waterway. A 3D modeling approach is needed because the salt water intrusion limit and ETM represent 3D balances. Proper (reliable) boundary conditions over sufficient period of time are required to allow quantitative comparisons between numerical models and measurements. In many estuaries the boundary conditions are measured only for the duration of the survey, or not at all, which hampers a quantitative comparison. This presentation deals with the tidal timescale advance of the salt wedge and entrapment of SPM in the Rotterdam Waterway.



Figures: The first graph shows the along channel distribution of near-bed SPM concentration constructed from successive passages through the head of the salt wedge (second graph). The dashed lines respectively depict the Botlek Harbor and the junction Rotterdam Waterway-Old Meuse-New Meuse. The second graphs shows the vertical and along channel distribution of salinity (dashed lines) and SPM concentration (continuous lines).

PREDICTING SUSPENDED SEDIMENT CONCENTRATION AT NOORDWIJK

B. Bhattacharya

UNESCO-IHE Institute for Water Education

The prediction of the concentration of suspended particulate matter (SPM) is important for a better understanding of the coastal processes. SPM concentration is commonly predicted using a numerical model. In the Delft Cluster research project *Morphodynamics of the North Sea and Coastal Defences* an alternative approach using an Artificial Neural Networks (ANN) is adopted for predicting SPM. If a sufficiently long time series data of SPM is available then ANN can be used to build a reliable model to predict SPM concentration. ANN do not need much of a detailed description of the underlying process, which is needed in a process modelling. ANN are presently known as universal function approximators due to their ability to emulate complex processes expressed through sets of input and output observations. However, its application to the sediment transport domain is limited.

RIKZ and CEFAS (Centre for Environment, Fisheries and Aquaculture Sciences, UK) collected hourly SPM data at Noordwijk (10 km offshore) during 2000-2001 using *SmartBuoy*. The SPM time series shows a high variability. The time series is filtered with a low pass filter with a time window of 25 hours so as to remove all short-term fluctuations in the time series. This resulted in a modified SPM time series, which follows the trend of the SPM time series with a sediment mass over 90% of the unfiltered series in daily or weekly terms. The high pass filter, which is complementary to the low pass filter, contains only short-term fluctuations mainly due to tides. It is decided to model the low pass filtered SPM time series only.

During data analysis it is observed that bed shear stress has the strongest relationship to SPM variations, which corroborates the physical understating of the process. Similar to the SPM time series, low pass filtered time series of bed shear stress is computed. Bed shear stress of the current time step and two previous time steps are used as inputs. South-Westerly wind component is taken as another input, as it is instrumental in bringing sediments in the Dutch coastal area. Moving average of significant wave heights of past seven days is chosen as the fifth input. The output of the ANN model is low pass filtered SPM. It may be noted that using SPM at the previous time step as an input would have improved the modelling results. However, it is not done so that this model can be used at other places where SPM data is not measured regularly.

The ANN model is trained using the back-propagation algorithm (a specialized version of the gradient-based optimisation algorithm). One hidden layer with seven (found by optimisation) nodes is used. Tangent hyperbolic activation function at the hidden layer and a linear function at the output layer are used. The network's performance in training and testing for some storm periods can be seen in Fig. 1.

Conclusions: From the testing results it can be concluded that though there are errors in predicting SPM still the general trend is predicted well. It is concluded that the ANN model has learned to predict the SPM concentrations at Noordwijk.

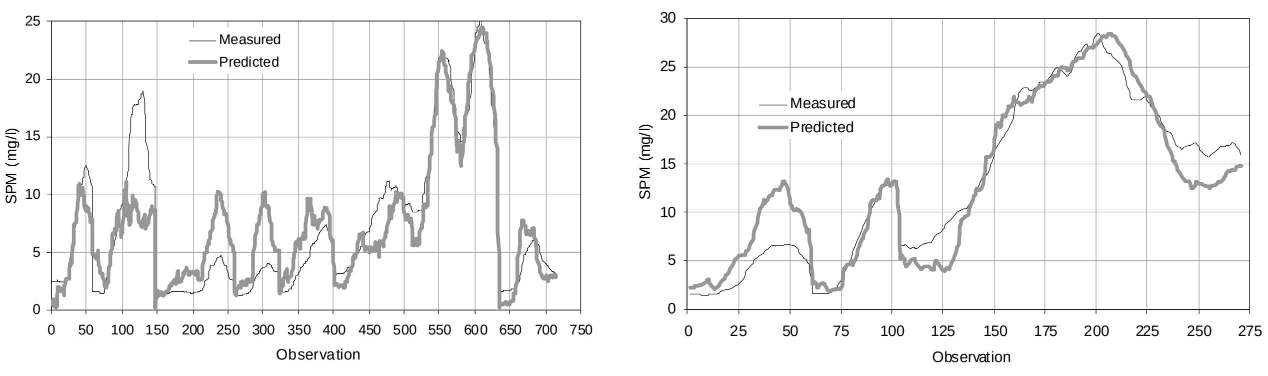


Figure 1. (a) Predicted SPM concentrations on the training dataset; (b) Predicted SPM concentrations on the testing dataset.

Acknowledgement: The research is funded by Delft Cluster research project Morphodynamics of the North Sea and Coastal Defences.

ANALYTICAL DESCRIPTION OF TIDAL DYNAMICS IN CONVERGENT ESTUARIES

Huub Savenije[1,2], Jennifer Haas [1] and Marco Toffolon[3]

[1]Delft University of Technology [2]UNESCO-IHE, [3]University of Trento, Italy

Analytical solutions of the one-dimensional hydrodynamic equations for tidal wave propagation are now available and, in this paper, presented in explicit equations. For given topography, friction and tidal amplitude at the downstream boundary, the velocity amplitude, the wave celerity, the tidal damping and the phase lag between High Water (HW) and High Water Slack (HWS) (see Fig. 1) can be computed. The simple harmonic solution is based on the full non-linearised set of St. Venant equations applied to an exponentially converging channel, which may have a bottom slope. Two families of solutions exist. The first family consists of mixed tidal waves, which have a phase lag between zero and π/2, which occur in alluvial coastal-plane estuaries with almost no bottom slope; the second family consists of standing waves, which develop in short estuaries with a steep topography. Special cases are presented for progressive waves, frictionless waves, waves in channels with constant cross-section, and waves in ideal estuaries where there is no damping or amplification. The analytical method is accurate in the downstream, marine, part of estuaries and particularly useful in combination with ecological or salt intrusion models. The solutions are compared with observations in the Schelde, Elbe and Hau estuaries.

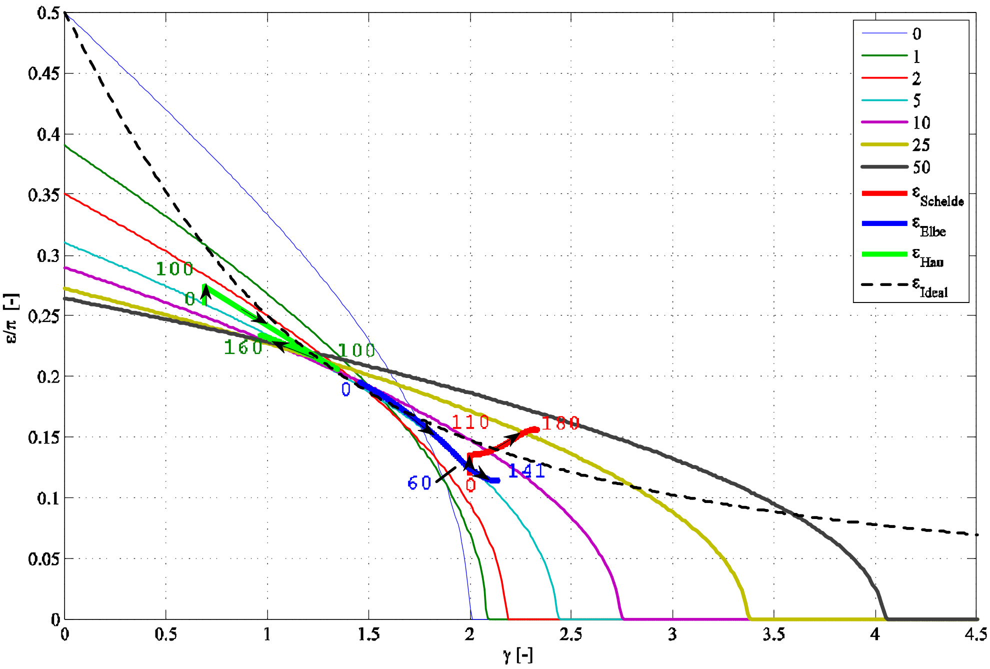


Figure 1: Analytical solutions for the phase lag between HW and HWS as a function of the convergence number γ and the friction number χ (lines with different colours). The thin blue line corresponds with the subset of frictionless estuaries (χ=0). The dashed line corresponds with the subset of ideal estuaries, obeying the equation $\chi = \gamma\left(\gamma^2 + 1\right)$. Also presented are three real estuaries: the Hau (Mekong), the Elbe and Schelde, which drape themselves around the subset of ideal estuaries.

SOLVING THE TAYLOR PROBLEM WITH HORIZONTAL VISCOSITY

Pieter C. Roos[1] and Henk M. Schuttelaars[2]

[1]University of Twente, [2]Delft University of Technology

Intricate patterns of residual flow and tidally driven sediment transport are observed in tidal basins such as the Wadden Sea. To analyse the physical mechanisms resulting in these patterns in detail, an analytical process--base model is developed. To obtain a smooth flow field for complex basin geometries, it is essential to include horizontal viscosity. As a first step towards such a model, we extend the classical Taylor problem to account for horizontally viscous effects.

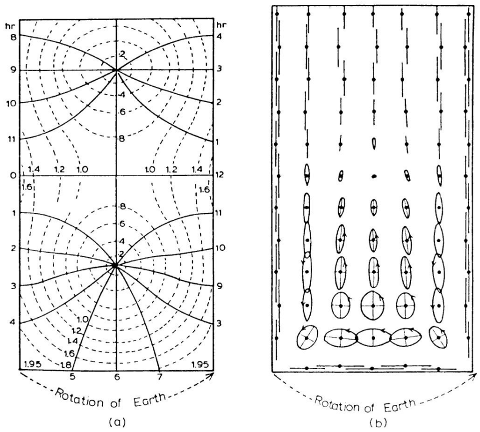


Figure 1: Taylor (1921) solution, with closed boundary at bottom end: (a) co-tidal lines (solid) and co-range lines (dashed), (b) tidal current ellipses, satisfying the kinematic boundary condition at the close boundaries.

In his classic paper, Taylor (1921) solved the inviscid, linearized shallow water equations in a semi-enclosed basin of uniform depth on an *f*-plane, requiring no-normal flow at the closed boundaries. The solution was written as the superposition of typical wave solutions: incoming and reflected Kelvin waves as well as reflected Poincaré modes, generated at the landward boundary.
As shown by our analysis, the inclusion of a horizontal viscosity ν has the following implications:

- The no-normal flow condition at the closed basin boundaries is extended to a no-slip condition.
- The wave numbers of the Kelvin and Poincaré modes are slightly modified. The Kelvin wavelength decreases slightly, and so does the e-folding decay distance of the (evanescent) Poincare modes. Due to viscous dissipation, the wave amplitudes furthermore display decay in the direction of propagation.
- The cross-channel structure of the Kelvin and Poincaré modes is modified, now displaying boundary layers in which the flow velocities become zero.
- Finally, a new type of mode arises, with a cross-channel structure strongly resembling that of the Poincaré modes and an along-channel decay distance governed by viscous effects.

To solve the viscous Taylor problem, a collocation method is employed to satisfy the no-slip condition at the landward boundary. As it turns out, the new modes are required to build up the viscous boundary layer at this boundary. Results are compared to the classical Taylor solution. The next step is to extend the geometry towards arbitrary, box-type of basin shapes.

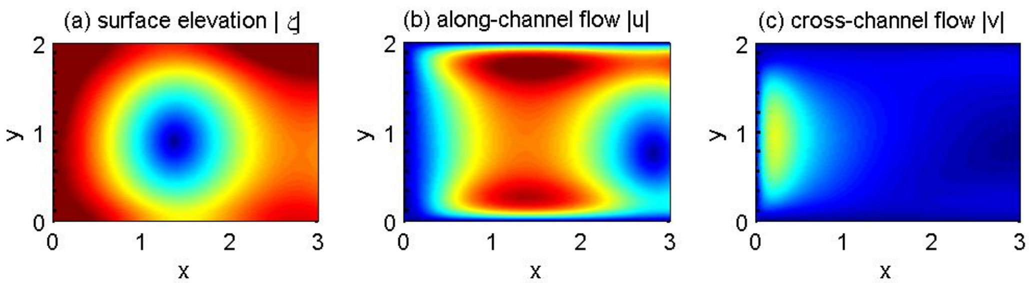


Figure 2: Solution to Taylor problem with horizontal viscosity. The closed boundary is on the left (at x=0), where the Kelvin wave incoming from the right is reflected. The presence of a boundary layer is visible by the low amplitudes of the flow field (in blue) near the closed basin boundaries x=0, y=0 and y=B=2.

USING A PROCESS BASED MODEL TO RE-PRODUCING ESCOFFIER CLOSURE CURVE

Ali Dastgheib[1)], Mick van der Wegen[1)] and Dano Roelvink[1,2)]

[1)]UNESCO-IHE Institute for water education [2)]Deltares

One of the well-known approaches to investigate the stability of a tidal inlet, is the relationship between the maximum averaged velocity through the inlet, V_m, and the inlet cross-sectional area, A_C first introduced by Escoffier (1940) as closure curve concept. Analytical descriptions of the closure curve are proposed by Brown (1928) , Keulegan's (1951), or DiLorenzo (1988). Comparison with a real inlet is provided by a.o. Van de Kreeke (2004). A so-called equilibrium velocity is suggested in the closure curve which indicates an assumed equilibrium cross sectional area of the inlet.

In this study a very simplified model of a tidal basin is used to reproduce the closure curve by deploying a numerical, process-based model (Delft3D) which includes morphological bed level updates and the assumed equilibrium conditions is investigated. The model result is compared with the analytical methods.

Model results show that in the case of no littoral drift or wave driven sediment into the inlet no specific equilibrium conditions exist. However in the presence of an additional sediment source in the inlet like wave-induced transport, the equilibrium velocity can be simulated.

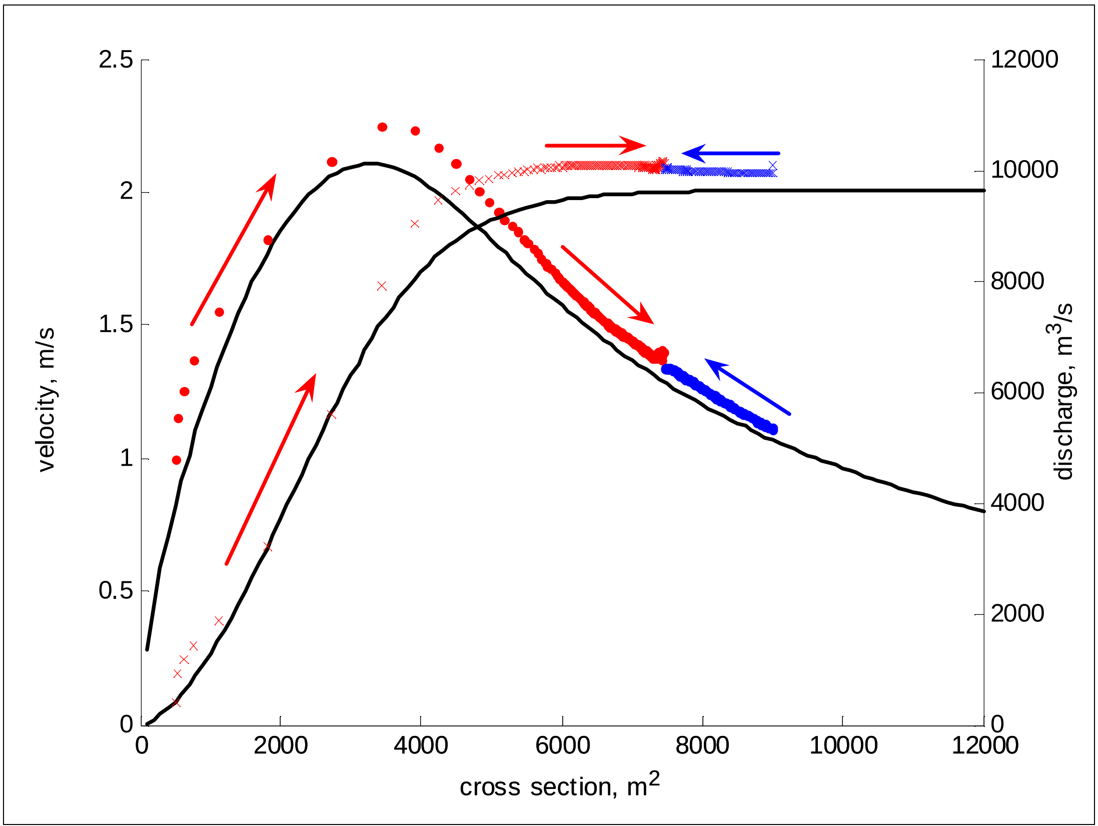


Figure 1: Escoffier Closure Curve based on the harmonic solution compared with the Curve produced according to the result of the model

THE RHINE REGION OF FRESHWATER INFLUENCE

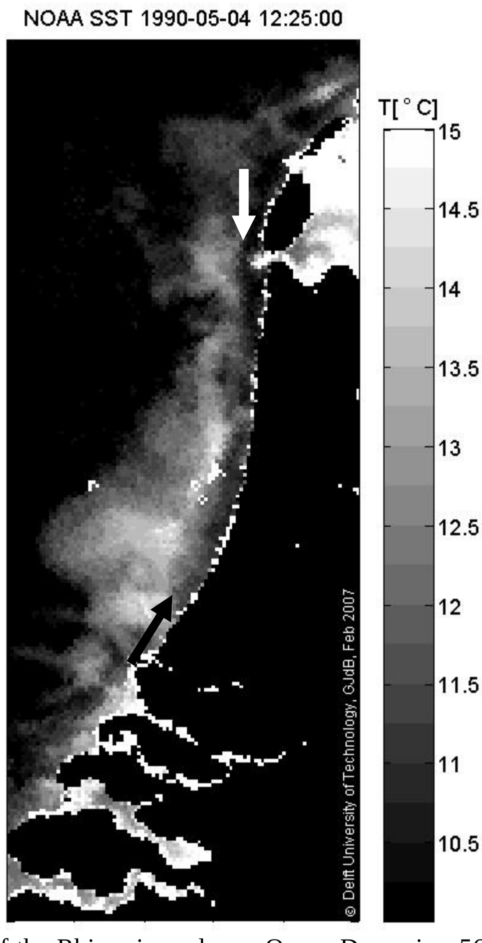
Gerben J. de Boer[1,2] and Julie D. Pietrzak[1] and Johan C. Winterwerp[1,2]

[1] Delft University of Technology, [2]Deltares

The objective of my PhD research has been to understand and quantify the influence of the Rhine river plume acting as a narrow coastal conduit for the transport of less saline water and SPM.

Tidal straining

During periods of vertical stratification (neap tide, low energy winds) a strong semi-diurnal variation is present in the cross-shore velocities (Simpson et al. 1993, OA; Visser et al, 1994, OA), whereas normally the tidal currents are directed along the coast over the entire water depth. However, when the coastal zone is stratified, the bottom and surface layer start to behave differently. Reduced mixing between the surface and bottom layer allows the two layers to behave partly independently. Due to Earth rotation the surface layer is deflected towards the right. Consequently, after flood the surface currents are redirected towards the coast, instead of dropping to zero at slack. In contrast, after ebb the surface current are redirected offshore, instead of dropping to zero at slack. Due to continuity requirements at the coast, the bottom layer can only respond to the cross shore surface velocities with a cross shore component in the opposite direction. Therefore, when the surface currents are onshore, the bottom currents are directed offshore. Of course, earth rotation also tries to deflect the bottom currents to the right. However, the effect of Coriolis on the surface layers is stronger because they flow faster. (This resembles the spiraling flow in river bends where the centrifugal force on the surface layers deflects the surface velocities outwards and as such forces the bottom velocities to be deflected inwards.) Hence the cross-shore bottom and surface velocities are opposite in a stratified coastal zone. The alongshore surface and bottom velocities are still in phase though. The resulting surface and bottom velocities can be described with counter-rotating tidal ellipses. The resulting cross shore velocity shear can be up to 70 cm/s and interacts with the cross shore density gradient. This leads to periodic stratification (Simpson and Souza, 1995, JGR) From LW to HW the surface currents are directed offshore. They advect fresher coastal water offshore. Meanwhile, the bottom currents are directed onshore and advect saltier water onshore. Due to this differential advection the region is stratified at HW. From HW to LW the process reversed. The fresh surface waters are advected back towards the coast, while the saltier bottom waters are advected back seawards. Consequently, at LW the water column is close to uniform again.



Upwelling induced by tidal straining

The tidal straining mechanism should lead to upwelling (UW) and downwelling (DW) at the coast. The presence of UW of colder water has indeed been observed in Sea Surface Temperature satellite images from NOAA/KNMI in May. When the coastal zone is stratified, solar heating causes the surface waters to heat faster then the surrounding well-mixed waters. In these circumstances upwelling can clearly be observed (De Boer et al, 2007). An excellent series of images in May 1990 shows a 5 to 10 km wide and 100 km long band of cold water reappearing every HW. Between the HWs the band disappears. This shows the large spatial scale of tidal straining in the DCZ.

Publications

G.J. de Boer, J.D. Pietrzak & J.C. Winterwerp, 2007. Using the potential energy anomaly equation to investigate tidal straining and advection of stratification in a region of freshwater influence. Accepted for publication in to Ocean Modelling.

G.J. de Boer, J.D. Pietrzak & J.C. Winterwerp, 2007. SST observations of upwelling induced by tidal straining in the Rhine ROFI. Continental shelf research. Accepted, special issue PECS 2006 (in press).

G.J. de Boer, J.D. Pietrzak & J.C. Winterwerp, The vertical structure of the Rhine river plume, Ocean Dynamics, 56, 198-216, special issue PECS 2004.

EFFECT OF TIDAL ASYMMETRY AND SEA LEVEL RISE ON INLET MORPHOLOGY

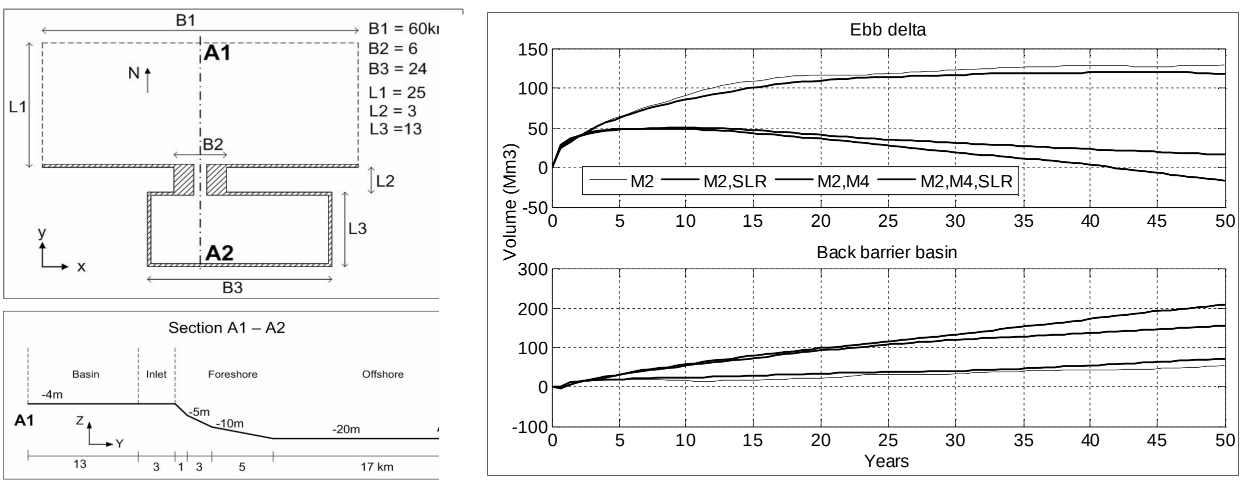
D.M.P.K. Dissanayake[1)] and J.A. Roelvink[1,2,3)]

[1)]UNESCO-IHE Institute for Water Education, [2)]Deltares, [3)]Delft University of Technology

This paper presents the preliminary work carried out on the influence of sea level rise and tidal asymmetry on inlet morphological changes. The long-term aim of this study is to understand and model the behaviour of such inlets and to address the possible mitigation measures in case of negative impacts. The present schematized approach is focused on the morphological changes of Ameland Inlet, which is relatively undisturbed inlet located between Ameland and Terschelling barrier islands in the Dutch Wadden sea. This study uses a process-based 2D numerical model, Delft3D, as a tool in this analysis. Van Rijn (1993) sediment transport formulas are employed in this model. The model is simulated by applying M2 and M4 tidal force. Morphological evolution is accelerated after each time step by multiplying a morphological scale factor (235) to model 50-year morphological changes. Different sea level rise rates are used for the model. This work presents the effect of sea level rise (10 mm/year) and tidal asymmetry on morphological evolution.

The results are analyzed in both qualitative and quantitative sense. Resulting 50-year morphological changes in all models are producing westward oriented main ebb channel and eastward favoured back barrier basin channel pattern, which are typical morphological features for the Ameland inlet. Figure 1 clearly shows that the sea level rise causes to increase the sediment import into the basin, which is accelerated by including the tidal asymmetry. The ebb delta volume shows quasi-equilibrium state after two decades if the model does not include tidal asymmetry. In contrast, the ebb delta is disappearing in the last decade of the model which has tidal asymmetry and sea level rise. All models import sediment into the basin throughout the period with different rates. Moreover, the results are compared with empirical relations (Jarret, 1976; Wang et al., 1999). The end results fit remarkably well with the Jarret's relation. In fact, they are located away from the equilibrium line in the flood-dominant region in the second relation.

Results of this simple approach are in agreement with the basic knowledge on the influence of sea level rise and tidal asymmetry on the inlet morphological changes. According to the present results, the tidal flats can not follow the rate of sea level rise. Therefore, we are working to include other important mechanisms such as wave effects to get a better insight in the behaviour.



(a) (b)

Figure 1: The schematized bathymetry (a), sediment volume change in ebb delta and back barrier basin based on the initial flat bathymetry (b)

LIMITED PREDICTABILITY PROPERTIES OF MODELLED SAND RIDGES ON THE INNER SHELF

N.C. Vis-Star [1)] and H.E. de Swart [1)] and D. Calvete [2)]

[1)] Institute for Marine and Atmospheric Research, Utrecht University [2)] UPC Barcelona, Spain

A nonlinear morphodynamic model is discussed that simulates feedbacks between a storm-driven current, waves and the sandy bottom of the inner shelf (depths between 10 and 20 m). The currents are governed by shallow water equations, the wave properties are described by phase-averaged equations, the bed level follows from sediment mass conservation and a Bailard-type of sediment transport is employed. The model describes the time evolution of amplitudes of known linear eigenmodes of the system, which resemble observed shoreface-connected sand ridges. Here, the sensitivity of the characteristics of finite-amplitude ridges to changes in the number N of modelled subharmonics (of the initially fastest growing mode) is investigated. It turns out that for any choice of N the model shows the growth and subsequent saturation of the height of the ridges. The migration speed of the ridges and the average spacings between successive ridges in the saturated state differ from those in the initial state. The overall characteristics of the bed forms (saturation time, final height, average spacing, migration speed) hardly vary with N and they appear to agree fairly well with field data. However, individual time series of modal amplitudes and bottom patterns strongly depend on the choice for N. As the latter parameter is not well known the model results suggest that the detailed evolution of ridges can not be predicted.

EFFECTS OF LARGE-SCALE HUMAN ACTIVITIES ON THE NORTH SEA SEABED

H.H. van der Veen[1)] and S.J.M.H. Hulscher[1)]

[1)] University of Twente

There are many plans to utilize the North Sea environment, e.g. large-scale sand mining for large infrastructural projects and the placement of offshore wind farms. We investigate the effects of these activities on the North Sea seabed. To do this, we set up a GIS (Geographical Information System) containing data on the North Sea and embedded idealized morphodynamic models to calculate the large-scale morphodynamics due to sand mining (based on Roos et al. (2008)) and offshore wind farms in the GIS (Van der Veen et al., 2007). We focus on these two activities because in the coming years, large-scale sand mining is planned in the North Sea (e.g. due to the expansion of the Rotterdam harbour, extracting 365 Mm^3 sand from the seabed) and numerous plans exist to build large wind farms in the North Sea.

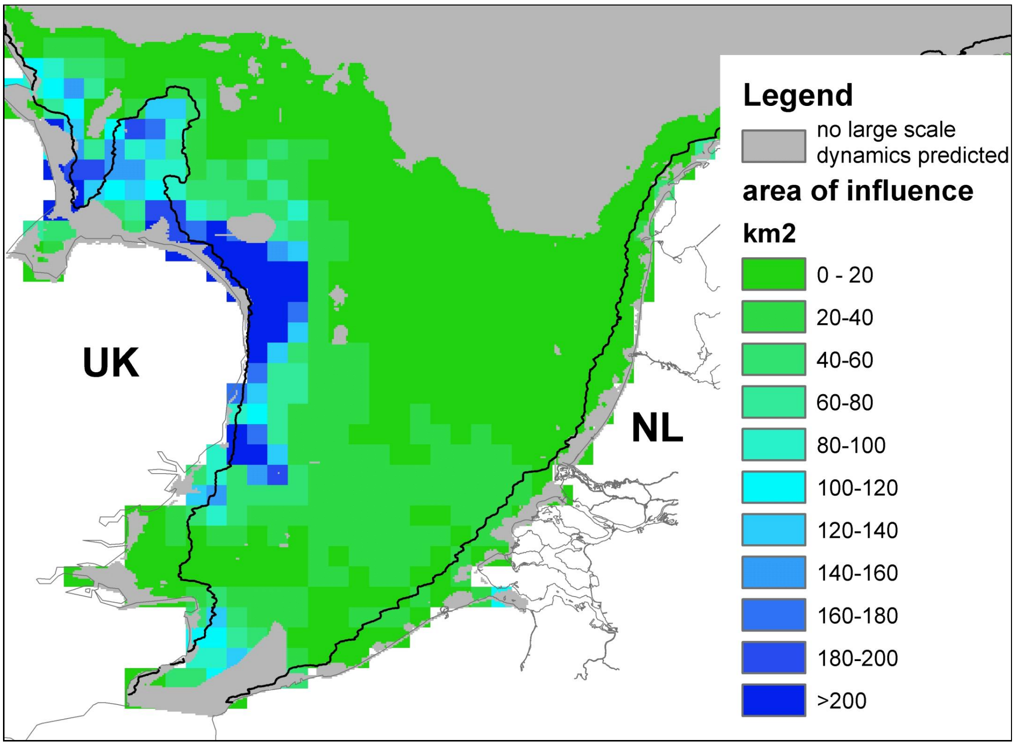


Figure 1: Overview of the area of influence (where the seabed change due to the sand pit is more than 10 cm) of a sand pit (3 x 2km wide, depth 2m, angle with respect to the flow 45°) with site-specific input parameters (water depth and flow velocity), situated at different locations in the North Sea. The black line denotes the 20 meter depth contour.

The results (e.g. figure 1) show that sand mining and wind farms have a large impact on the morphodynamics of the seabed. Furthermore, the inclusion of the morphodynamic models in the GIS allows a rapid calculation of the morphological effects of these activities at a certain location in the North Sea, thus providing a rapid assessment tool regarding the large-scale morphological effects of sand mining and offshore wind farms. Also, the GIS and the connected models form a flexible system that can be updated with new data sources and other models if these become available. These properties make the system both generic as flexible as it allows the use of the system when new data or models become available.

Roos, P. C., et al. (2008). *Modelling the morphodynamic impact of offshore sandpit geometries.* Coastal Engineering **submitted**.

Van der Veen, H. H., et al. (2007). *Seabed morphodynamics due to offshore wind farms*. Proceedings of the 5th IAHR symposium on River, Coastal and Estuarine Morphodynamics (RCEM2007), Enschede, The Netherlands.

NEW HIGH RESOLUTION FLOW AND SAND TRANSPORT MEASUREMENTS UNDER FULL-SCALE SURFACE WAVES.

Jolanthe J.L.M. Schretlen[1)], Jebbe J. van der Werf [1)], Maarten Kleinhans [2)], Joris P.C. Eekhout[1)], W. Michel Zuijderwijk [2)], Jan. S. Ribberink [1)] and Tom O'Donoghue [3)]

[1)] University of Twente, [2)] University of Utrecht, [3)]University of Aberdeen, UK

Introduction

Existing models used to portray upper shore-face sand transport processes, are primarily based on data from oscillatory flow tunnel experiments. Although large similarities exist between the transport processes in tunnels and under surface waves, former experiments indicate that flow differences between them may have a substantial effect on the net transport rate (e.g. Ribberink et al., 2000). We present new experiments in which (near-bed) flow and wave-related sand transport processes under full-scale surface waves are measured in more detail than before.

Description of the experiments

The experiments were performed in the 280 m long, 5 m wide and 7 m deep Großer WellenKanal (GWK) in Hannover, Germany. A 1 m thick horizontal bed (D_{50} = 0.26 mm) was placed in the flume, with a 1:20 beach slope at the far end. To capture the bed-surface processes under the waves, measurements were done on a range of scales: from flow velocities inside the sheet-flow layer up to bed level changes along the whole flume. Instruments used in these experiments include UVP, Vectrino, CCM, EMF, UHCM, TSS, ABS, pressure sensor, wave gauges and bed profilers. The majority of the measurements were carried out under regular wave conditions (height 0.7 to 1.6 m, period 5.0 to 9.1 s) in both the sheet-flow and ripple regime.

Results

Figure 1 shows UVP flow velocity measurements inside the wave boundary layer for a sheet-flow experiment with regular asymmetric waves with a height of 1.5 m and period of 6.5 s. Graph a shows the time-dependent horizontal velocities at 9 different levels and Graph b shows the velocity profiles at 12 different phases during one wave.

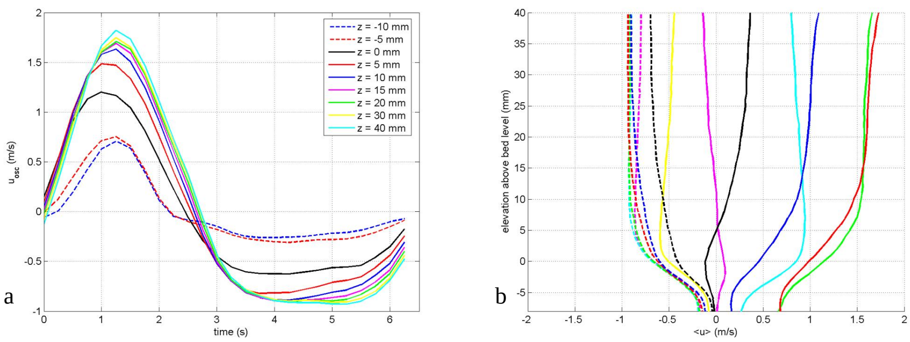


Figure 1 Time dependent velocities at 9 different levels (a) and velocity profiles at 12 different wave phases (b)

In combination with other flow velocity, sediment concentration and net sand transport measurements, these results provide new insights into flow and sand dynamics under full-scale surface waves. The results will be used to verify and further develop sand transport and morphological models.

Acknowledgements

The experiments in the GWK are performed in the framework of Integrated Infrastructure Initiative Hydralab-III of the European Community's Sixth Framework Programme (022441). The data processing and analysis is carried out within the Dutch/UK project SANTOSS, funded by the Dutch Technology Foundation STW, applied science division of NWO and the technology program of the Ministry of Economic Affairs (TCB 6586) and by the UK's Engineering and Physical Research Council EPSRC (GR/T28089/01).

References

Ribberink, J.S., C.M. Dohmen-Janssen, D.M. Hanes, S.R. McLean & C.E. Vincent (2000), Near-bed sand transport mechanisms under waves, a large flume experiment (Sistex99), *In: Proc. 27th Int. Conf. Coast. Eng., 3263-3276, Sydney, Australia.*

THE SEDIMENT BUDGET OF THE DELTA COAST (SOUTH-WEST NETHERLANDS)

Jelmer Cleveringa[1)] , Bert van der Valk[2)], Ben de Sonneville[2)], John de Ronde[2)], and Rob Steijn[1)],

[1)]Alkyon Hydraulic Consultancy and Research, [2)]Deltares

Introduction

The coastal zone policy for the Netherlands aims at the long-term (tens to hundreds of years) sustainable stabilization of the Dutch coastal zone through the maintenance of a neutral sediment budget. We have reanalyzed the sediment budget of the Delta coast on basis of the bathymetric data from 1964 to 2004. Three questions regarding the morphodynamics of Delta Coast have been addressed: 1. What are the persistent morphological changes and how do these relate to the sediment budget? 2. Which sediment-transport processes account for the observed changes; and 3. How do errors in the bathymetric data influence the estimates of the sediment budget of the (former) ebb-tidal deltas? In this presentation we focus on the third aspect of the study

Method, results and discussion

To assess the influence of the problems in the bathymetric data (that result from errors in the soundings and from the data handling) we assume that in areas without large-scale morphological changes the trend in the development is consistent over the entire period from 1964 to 2004. Flip-flop shifts from erosion to deposition in areas like: 1. The Vlakte van de Raan; 2. The area in between the ebb-tidal deltas of the Oosterschelde and Westerschelde; and 3. The area in between the former ebb-tidal deltas of the Haringvliet Grevelingen, are regarded as the result of data problems. In area 2 the period of 1972 –1976 shows over +35 Mm^3 of sedimentation and that changes into over -10 Mm^3 of erosion in the period from 1976-1980. These changes are almost completely the results of sedimentation and erosion that does not exceed +/- 1 m. Because these small changes occur over a large surface area the total volume involved is large.

We have extended our assumptions to the entire Delta coast and applied four different corrections to account for the data problems. Depending on the type of correction the sediment volume that is used to correct for the data problems can exceed 80% of the total volume of erosion and deposition for certain time periods. The result of the corrections is that much of the spikiness of the original data is smoothed out. Furthermore the maximum value for the (total) cumulative sediment volume decreases, as do the trends in the erosion or deposition (figure 1).

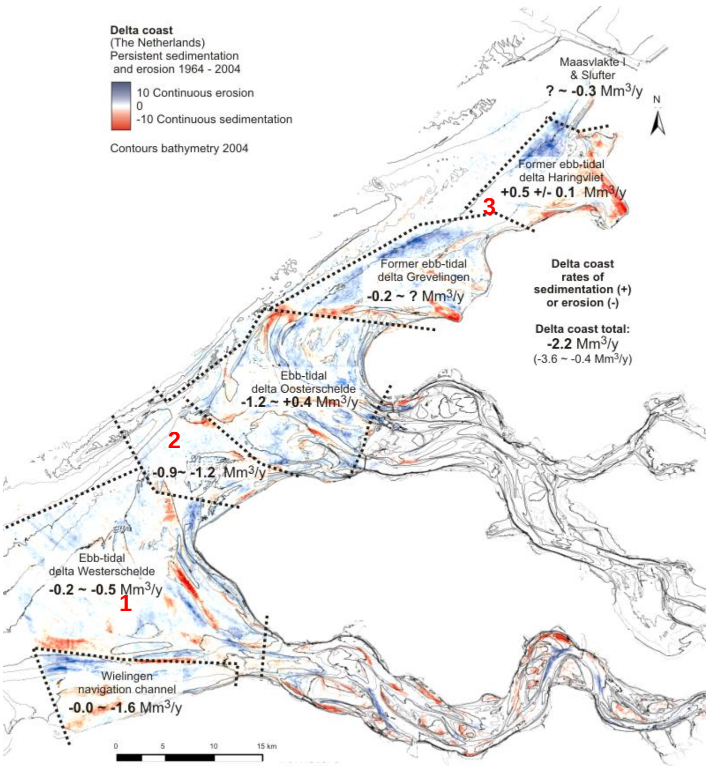


Figure 1: Rates of erosion or deposition in the period from 1976/1980 to 2004 for areas of the Delta coast segment (on a map of the persistent erosion (blue) and sedimentation (red) in the period from 1964 to 2004).

Conclusions

Problems in the data do indeed influence the estimates of the sediment budget of the Delta coast. Several approached can be used to correct for the effect of the dataproblems. Based on the corrections we have applied, our best estimate is that the sediment volume of the complete Delta coast from 1980 to 2004 has decreased on average with –2.2 Mm^3 per year, with an upper limit of –3.6 Mm^3 and a lower limit of –0.4 Mm^3.

4.2 Abstracts for posters

LONG-TERM SAFETY OF DUNE-PROTECTED COASTS

L.M. Bochev-van der Burgh[1)], K.M. Wijnberg[1)], S.J.M.H. Hulscher [1)]and J.P.M. Mulder[1,2)]

[1)] University of Twente, [2)] Deltares

Long-term coastal safety, over time periods of up to 200 years, is an important coastal management objective in the Netherlands.
Assessing the long-term safety of a dune-protected coastal area requires different model approaches, i.e. a model to forecast long-term coastal evolution and an ‘event-scale’ dune erosion model to compute the amount and extent of erosion due to the occurrence of a super storm.
Dune erosion models appear to be quite sensitive to cross-shore beach and dune morphology. However, in long-term model forecasts detailed cross-shore morphological information is lost.
We thus need to find an approach to bring back morphological information in long-term model forecasts, which can then be used as input for the dune erosion model. We propose empirical orthogonal function analysis (EOF analysis) to account for this lost morphological information.
The work approach is shown in Figure 1.

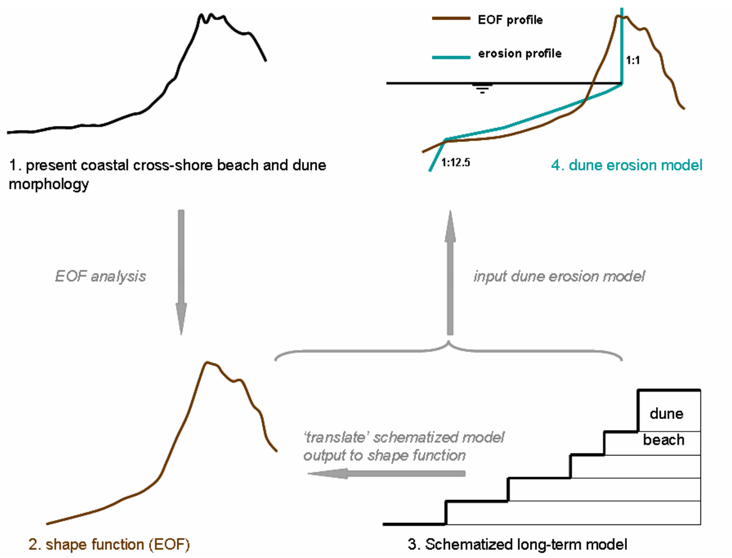


Figure 1: Work approach: from schematized long-term model output to EOF-derived shape functions, which are used as input for the dune erosion model

References

TAW (1995), Basisrapport Zandige Kust, Technische Adviescommissie voor de Waterkeringen, 507 pp.

Steetzel, H. and Wang, Z.B. (2003), Development and application of a large-scale morphological model of the Dutch coast, phase 2: Formulation and application of the PONTOS-model version 1.4, Tech. Rep. Alkyon and WL|delft hydraulics.

IMPORTANCE OF TOPOGRAPHICALLY INDUCED SEDIMENT FLUXES ON EQUILIBRIUM BED PROFILES AND THEIR LINEAR STABILITY IN TIDAL EMBAYMENTS

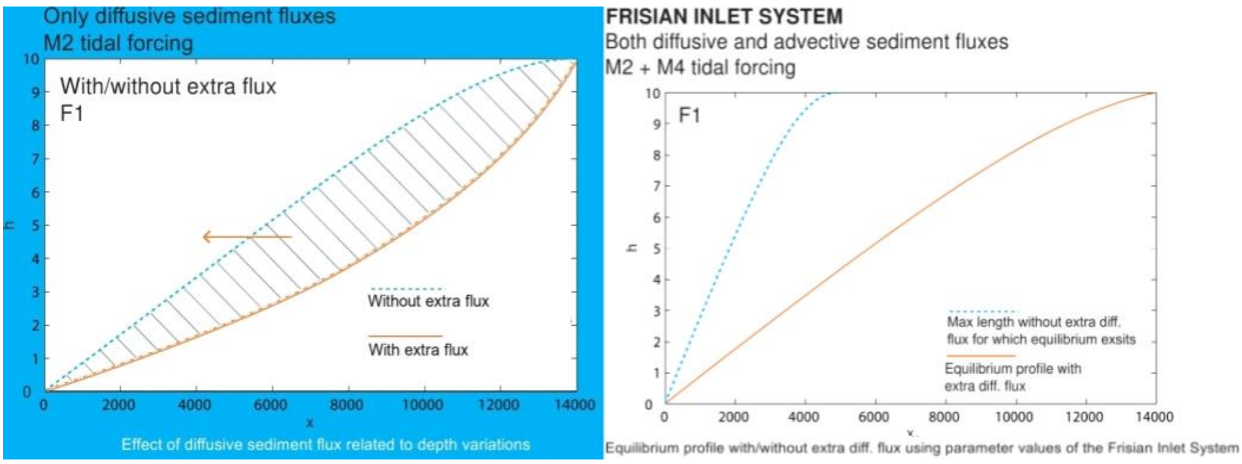
Miriam ter Brake[1)] and Henk Schuttelaars[1)]

[1)]Delft University of Technology

To study the spatial and temporal behaviour of bottom patterns observed in many tidal embayments, an idealized morphodynamic model is developed and analyzed.

The geometry of the model domain consists of a semi-enclosed, rectangular basin. We force the water motion at the entrance of the embayment by prescribing sea surface elevation that consists of a leading tidal constituent (M2 tide) and its first overtide (M4 tide). To describe the water motion, we solve the depth averaged shallow water equations. Sediment is only transported as suspended load. Contrary to many other models that use a depth-averaged suspended load description, the suspended sediment fluxes induced by topographic variations are included. The bed changes due to convergences and divergences of the suspended sediment flux.

This system of equations allows for morphodynamic equilibrium solutions that only depend on the along-channel position (i.e. are uniform in the cross-sectional direction). By comparing model results (for realistic forcing) with observations in the Wadden Sea, we show and explain that it is essential to include the suspended sediment fluxes induced by topographic variations: observed embayment lengths are in the order of 15-20 km, if we neglect the topographically induced suspended sediment flux, maximum embayment lengths in the order of 3-5 km are found. Inclusion of these fluxes results in morphodynamic equilibrium profiles that resemble the width averaged profiles as observed in inlets in the Wadden Sea.



Apart from influencing the underlying one-dimensional equilibrium profile, the topographically induced fluxes influence the linear stability of these equilibria as well. We will discuss this influence for both one-dimensional (a decrease of stability compared with the case without the topographically induced flux) and two-dimensional perturbations and explain this physically.

STATISTICAL UNCERTAINTY ANALYSIS OF COASTAL STATE INDICATORS – EVALUATION OF THE ECOBEACH TECHNIQUE APPLIED AT EGMOND-AAN-ZEE (THE NETHERLANDS)

Christophe Brière[1], Bas Arens[2], Henk F.P. van den Boogaard[1], Anna Cohen[1] , Sander van Rooij[1] and Kees van Ruiten[1]

[1] Deltares, [2] Arens Bureau voor Strand- en Duinonderzoek

Beach evolution can vary over a wide range of different temporal and/or spatial scales. Our capability to understand and especially predict this variability is however still limited. The objective of this communication is to provide an objective insight into the variability of the COAST3D beach of Egmond setting up a regression type of statistical models. Besides, the analysis of results enables the evaluation of the efficiency of the Ecobeach technique which consists of vertical, passive drainage pipes that are regularly spaced on the Egmond beach.

To get an overview over the huge amount of information available along the cross-shore direction (Jarkus data, Argus-based images, dGPS data and AHN data have been used in this study), Coastal State Indicators (e.g. MCL, Intertidal MCL, beach volume, dune volume) which are relevant to describe the morphological features that change in time and space, have been defined. Due to large spatial variations of the Coastal State Indicators, spatial aggregation by longshore averaging has been performed in order to improve the confidence and the predictability of models.

For the modelling of a time series of a Coastal State Indicator, parameterised regression models, including harmonic components for the description of seasonal and decadal cyclic patterns, have been used. On the basis of measurements, the model parameters have been identified. The quantitative assessment of uncertainties in the model parameters and model predictions is an important issue in the present work.

In order to protect the Dutch coast in an innovative way, the Ecobeach technique has been installed in Egmond. Statistical regression models have been set-up using data available before the installation of the drainage system. Comparison between model outputs and observations enables the identification of potential effects of the Ecobeach technique.

For most of the applications, a linear regression model has been set-up including a harmonic function with a period of about 15 years, as the Fourier analysis of residuals showed the possible presence of a cyclic pattern corresponding to the coastal bar reappearance. The long-term evolution of the dune volume displays for example such a cyclic behavior, showing that the beach is acting as a transferring zone between the dunes and the deeper waters. Regarding the influence of the Ecobeach technique on the evolution of the Coastal State Indicators, no significant trend break has been noticed in general. However, such statistical analysis requires long-term datasets, to identify potential effects of the drainage system respective to the natural evolution. It means that answering to research questions related to the efficiency of the Ecobeach technique should not be given right away based only on a few observations obtained after the installation of the system.

Collecting and describing observations of beach variability is one way to support coastal management (e.g. design and implementation of soft engineering interventions). Trends of the evolution of Coastal State Indicators have been therefore described using data monitored at different time and spatial scales, providing good insight on the morphological changes which occur at the beach of Egmond.

THE EFFECT OF DEEPENING THE EMS ESTUARY ON TIDAL DYNAMICS AND RESIDUAL CIRCULATION PATTERNS

Alex Chernetsky[1)] and Henk Schuttelaars[1)]

[1)]Delft University of Technology

Over the past 20 years, successive deepening of the Ems estuary from 4-5 m to 7.3 m in the brackish water zone has significantly altered the tidal dynamics. Between 1980 and 2005, the tidal range has increased by 1.5 in the upstream reaches. Furthermore, the surface sediment concentration has increased from 400 mg/l to as much as 4-5 g/l and the position of the turbidity zone has shifted upstream as far as the tidal weir.

To investigate the observed changes, an analytical 2DV model approach is employed. Two distinctive bathymetries are considered which represent the 1980 and 2005 situation, respectively. The water motion equation is solved analytically by making a regular expansion of the various physical variables in a small parameter (the ratio of the tidal amplitude over the water depth). Model results are calibrated to water level and velocity data for both the 1980 and 2005 case.

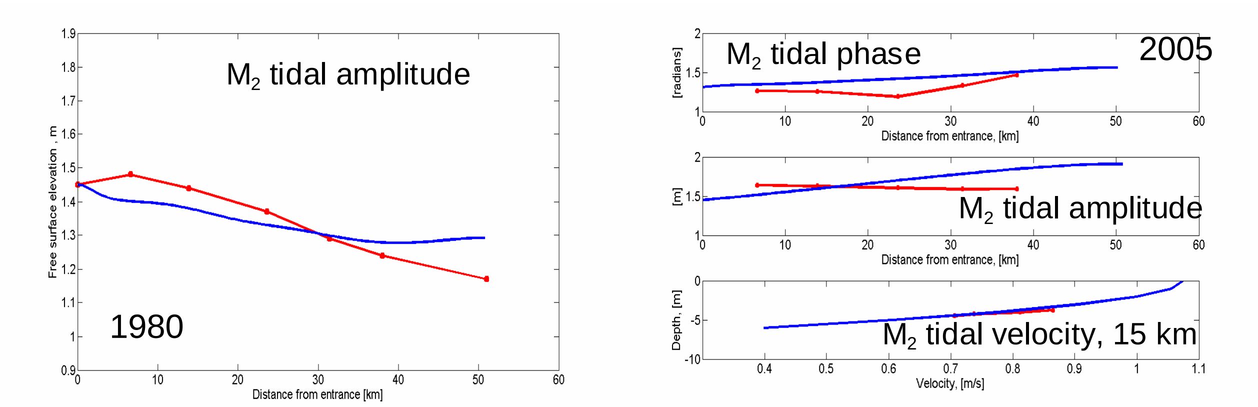


Figure 1: Results of calibration of the model

Model results suggest that changes to tidal magnitude and asymmetry between 1980 and 2005 are mainly caused by a factor 3x decrease in hydraulic roughness. The residual current patterns have mainly changed due to changes in gravitational circulation and tidal return flow (Stokes Drift).

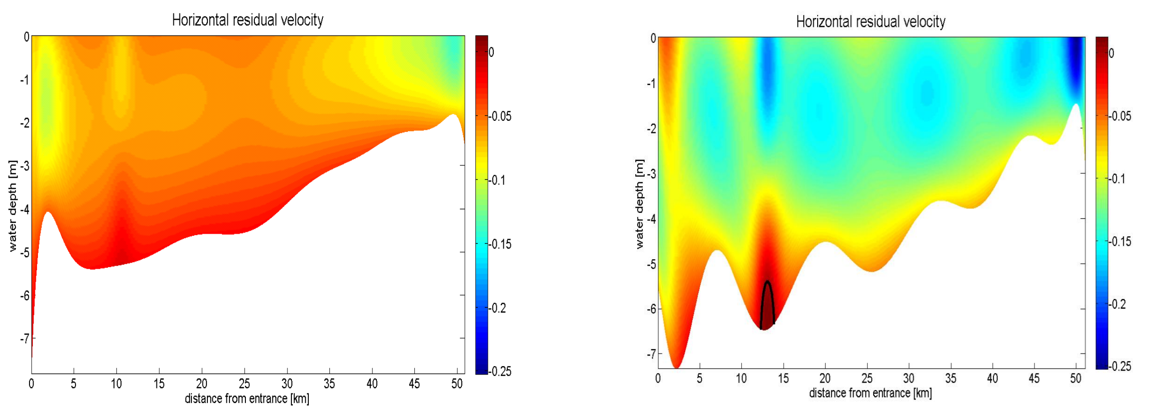


Figure 2: Comparison of the residual circulation patterns between 1980 and 2005

1980 2005

SAND ENGINE: AN INNOVATIVE SOLUTION FOR COASTAL SAFETY, RECREATION AND NATURE DEVELOPMENT?

Anna Cohen[1)], Martin Baptist[2)], Stefan Aarninkhof[3)], Ankie Bruens[1)] and Jan Mulder[1)]

[1)]Deltares, [2)]IMARES, [3)]VBKO

Introduction

Sea level rise is the main cause of a continuous decrease in the available amount of active sands in the Dutch coastal zone. Considering sand as the carrier of all functions, present Dutch coastal policy compensates this decrease in order to guarantee sustainable safety and functions in the dune area..This is a reactive approach based on an observed rate of sea level rise. The 'sand engine' concept presently is widely proposed as a pro-active approach: i.e. adding an amount of sand in excess to the reactive approach.. A variety of aims goes with these proposals, from increase in safety level to increase in natural area. To support discussion on a political level, a study was carried out to feed the discussion with concrete information. A wide range of schematic sand engine lay-outs has been selected (figure 1).

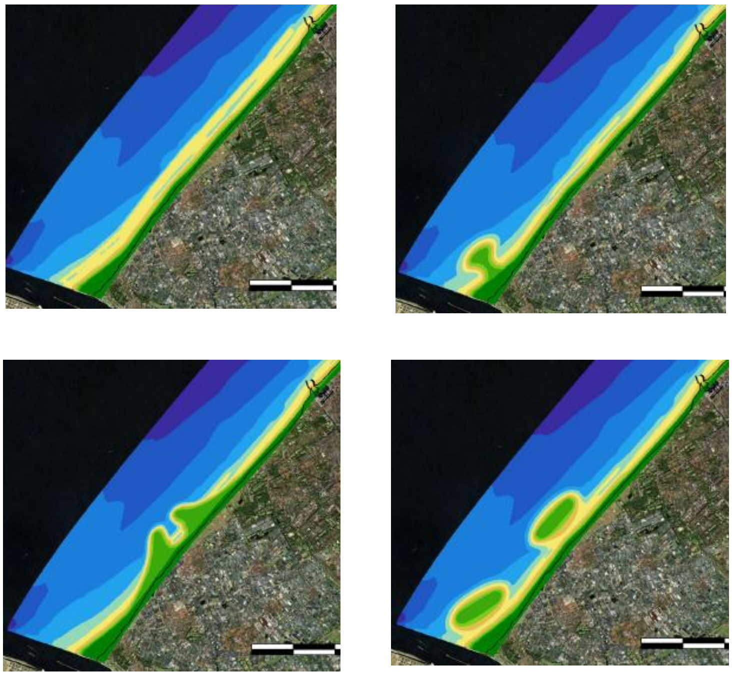


Figure 1 A selection of the schematic sand engine lay-outs studied in this research

A preliminary evaluation framework has been developed to map the potentials and risks of various lay-outs. The framework consists of the following aspects:

- Technical and financial feasibility
- User functions:
  1. Nature development
  2. Recreation
  3. Safety and coastal maintenance
- Innovative character and possible 'grandeur' of approach

Conclusions

Cost are primarily dependent on total volume and secondly on height and position of the sand engine. Main benefits are (1) the creation of extra dune area along the coast, (2) an increase in safety levels and (3) a reduction in coastal maintenance efforts.

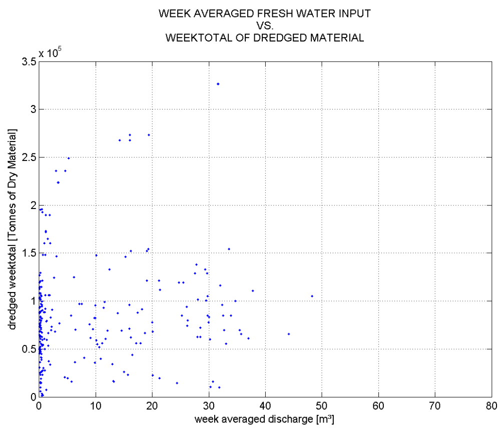
HUMAN AND ENVIRONMENTAL EFFECTS ON THE TOP OF THE MUD LAYER IN THE ENTRANCE OF THE ZEEBRUGGE HARBOUR

Arvid Dujardin[1,2], Joris Vanlede[1] and Youri Meersschaut[3]

[1]Vlaamse Overheid – Departement Mobiliteit en Openbare Werken – Waterbouwkundig Laboratorium, [2]Soresma, Business Unit Water and [3]Vlaamse Overheid – Departement Mobiliteit en Openbare Werken – afdeling Maritieme Toegang

Navigation in the port of Zeebrugge can be hindered by the presence of a high concentrated benthic suspension (hcbs). Depth averaged suspended sediment concentrations (including the hcbs layer) range from 10mg.l^{-1} up to 4,000mg.l^{-1}. The suspended sediment concentration within the benthic layer can reach several tens of grams per litre (IMDC 2007). The top of this hcbs layer is identified by the 210kHz acoustic reflection surface. The Nautical Bottom, a site-specific upper limit for the bulk density, above which navigation is concerned to be safe, is defined at 1,200kg.m^{-3}. A better understanding of the human and environmental effects on the hcbs layer could result in countermeasures reducing siltation and maintenance dredging.

A statistical analysis of parameters such as weekly dredging intensity, location of the top of the mud layer, growth rate of the mud layer, fresh water input from the Leie by-pass channel, wind force and wave height in the period from 1999 till 2005 resulted in poor correlation coefficients (figures 1 and 2). Three interpretations are given. Week averaged hydro-meteo data masks the occurrence of short-time events such as storms. The mud layers calculated growth rate can be levelled out due to the variable time span between soundings. Finally, dredging works are not planned solely based on the level of nautical depth, which reduces the correlation between environmental conditions and dredged volumes. However, seasonally trends are clearly visible in both human and environmental effects (Dujardin et al. 2007).



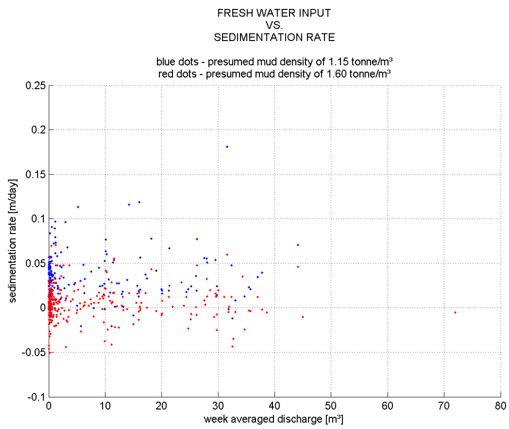


Figure 1 (left): a scatter plot of fresh water input from the Leie by-pass channel and dredged quantity shows no clear correlation. Figure 2 (right): a scatter plot of fresh water input from the Leie by-pass channel and the calculated sedimentation rate shows only poor correlation. To calculate the sedimentation rate an estimate of the dredged materials density was needed; 1.15 tonne/m³ is a lower limit (pre-2005 definition of nautical depth in Zeebrugge), 1.60 tonne/m³ is an upper limit (density of a muddy sand mixture).

References:

Dujardin A.; Vanlede J.; De Mulder T. and Mostaert F. 2007. Haven van Zeebrugge – Invloedsfactoren op de ligging van de top van de sliblaag in het CDNB. *WL Rapporten, 643-10*. Waterbouwkundig Laboratorium: Borgerhout, België.

IMDC 2007. Langdurige monitoring van zout/zoet-verdeling in de haven van Zeebrugge en monitoring van zout, slib en hooggeconcentreerde slibsuspensies in de Belgische kustzone. Deelrapport 3.1: Through Tide SiltProfiler & CTD-OBS Measurements – Autumn 2006. (I/RA/11292/07.023/JME).

FLOW INTERACTIONS OVER PLANT AND ANIMAL ASSEMBLAGES: IS THE OVERALL EFFECT EQUAL TO THE SUM OF THE CONSTITUENTS?

Luca A. van Duren[1)], Iris E. Hendriks[2)], Tjeerd J. Bouma[3)], Andrew Folkard[4)], Gareth E. Johnston[5)]; Ed P. Morris[6)], Nick Pope[7)], Jennifer Verduin[8)]

[1)]Deltarres, [2)]IMEDEA [3)]NIOO-CEME, [4)]Lancaster university [5)]School of Ocean Sciences, Bangor, [6)]University of Cadiz, [7)]Plymouth Marine Laboratory, [8)]Murdoch University

Benthic organisms vary widely in flexibility, protrusion height, shape and size. Rough, hard structures create turbulence in the boundary layer. Filter feeding bivalves can add to this by the effect of the interaction of their exhalent jets with the boundary layer flow. Aquatic plants severely reduce flow speeds inside the plant canopy. Although turbulence intensity inside the canopy is increased, the flow reduction is large enough to create a relatively calm environment. Most studies to date have been devoted to the interaction of individual species and flow. Most natural systems consist of communities of species. E.g. in the Mediterranean, bivalves (*Pinna nobilis*) grow inside seagrass meadows, creating a substrate of large, rough elements submerged inside a flexible canopy. In the Oosterschelde lawns of tube worms (*Lanice conchilega*) can be invaded by clumps of Pacific Oysters, creating a bed surface with elements of different orders of magnitude. Within the framework of the EU marine biodiversity network MarBEF, we studied the effects of different individual species on boundary layer flow, as well as the cumulative effect of mixes of these species.

THE POTENTIAL USE OF *CRASSOSTREA GIGAS* IN COASTAL MANAGEMENT

Cornelia Faust[1], Tjeerd J. Bouma[1], Mindert B. de Vries[2], Marieke M. van Katwijk[3] Bregje K. van Wesenbeeck[1,2]

[1)] NIOO CEME, Yerseke [2)]DELTARES, [3)]Radboud University Nijmegen

Innovative ideas need to be found to protect coastal zones in times of sea level rise and increasing storm frequencies. Salt- marsh forming and sediment accreting ecosystem engineers like *Spartina anglica* are useful in coastal protection to attenuate hydrodynamics and thereby unburden the dikes. Oyster banks (*Crassostrea gigas*), situated seawards of salt marshes, may facilitate *Spartina anglica* stands by dissipating hydrodynamic energy and increasing sediment availability. Due to increased roughness to flow and production of faeces, oyster banks may also enhance sediment accretion on intertidal flats.
Hydrodynamic modeling indeed confirmed that Oyster banks may facilitate *Spartina anglica* stands and enhance sediment accretion on intertidal flats. However, the question remains to which extent oysters can survive in highly exposed areas.

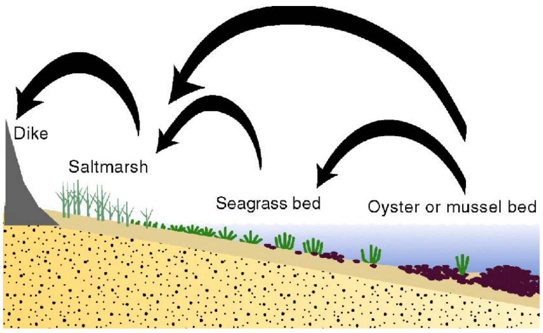


Figure 1:
The three-stage coastal defense construction with oyster bank, seagrass beds and salt marsh plants.

As a first step we focus on the tolerance of oysters to the exposure to hydrodynamic energy. Therefore, an artificial oyster bank was established on an intertidal flat as part of a WINN pilot project and hydrodynamic impact was measured during the severe storm on January 18th 2007. We observed oyster loss. Based on a hydrodynamic habitat analysis with the Delft-3D model, this loss of oysters was in agreement with the drag and bed shearstress calculated from local wave and current measurements. Present study reveals that (A) it is complicated to construct oyster banks in highly exposed areas, (B) that the Delft-3D model is a helpful support to identify those locations, which require special methods to construct sustainable oyster banks.

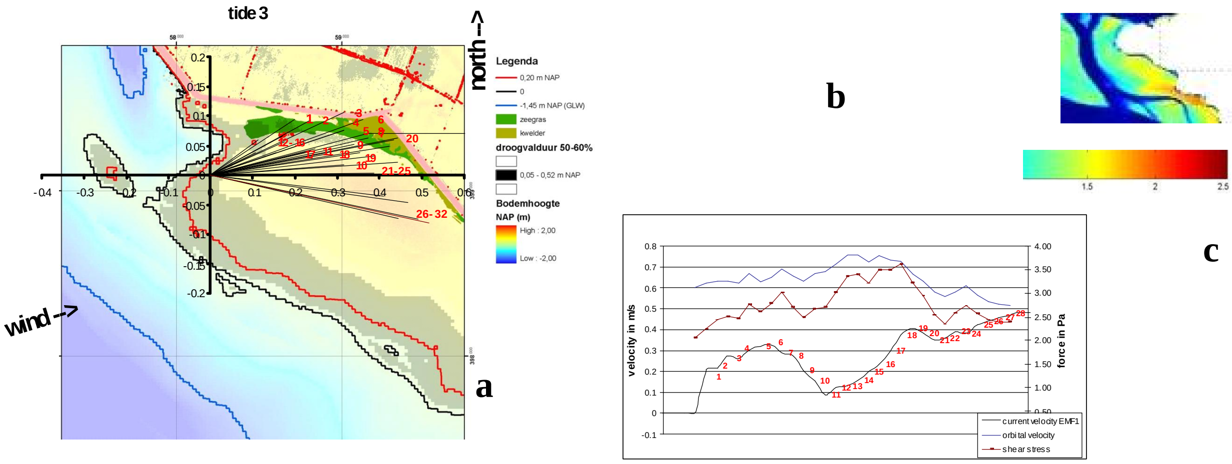


Figure 2:
The strong hydrodynamic impact during the severe storm *Kyrill* on 18th January is illustrated. Current direction (**a**), shear stress, current & orbital velocity distribution (**b**) have been measured during one tide at an intertidal flat. The shear stress originated during the storm hinders the oyster bank to persist, which was also predicted by the Delft model (**c**).

ASSESSING THE STORM VULNERABILITY OF THE BELGIAN COASTLINE

Reyns Johan[1,3)], Philippe Vanpoucke[2,3)], Toon Verwaest[3)], Katrien Van der Biest[3)], Paul Vanderkimpen[3,4)], Patrik Peeters[3)], Wouter Vanneuville[3)], Katrijn Holvoet[3)]

[1)] Universiteit Gent, Vakgroep Geografie, [2)] Universiteit Gent, Vakgroep Civiele Techniek, [3)] Vlaamse Overheid, Departement Mobiliteit en Openbare Werken, Waterbouwkundig Laboratorium, [4)] Soresma-Haecon NV

Climate change is likely to induce increased sea level and storm frequency. As such, assessing the strength of the Belgian coastal defence infrastructure against natural hazards is of primordial importance to reduce inundation consequences to properties and nature. This study presents an integrated methodology to estimate damage risks from a hypothetical storm with a surge level of +8m TAW and a duration of 45 hours along the entire coastline. After translation of deep water hydrometeorological conditions to the nearshore, several failure modes of the defence infrastructure are modelled: beach and dune erosion, collapse of dikes due to wave impact and overtopping, and subsequent breach forming and flooding of the low-lying coastal plain. Attention was paid to the various model uncertainties, by adopting a “+1,2 sigma” approach. Damage of infrastructure, properties and human casualties are calculated using a raster-based GIS model. Multiplication of the results with a rate factor based on prognoses of the evolution of socio-economic parameters allows projection of the results to 2050. All this will provide a tool for an optimized coastal zone management in Belgium.

5 Deltares

5.1 Deltares

A Dutch institute for Delta Technology

Delft Hydraulics, GeoDelft, the Subsurface and Groundwater unit of TNO and parts of Rijkswaterstaat have joined forces in an independent institute for delta technology, Deltares. Deltares combines knowledge and experience in the field of water, soil and the subsurface. It is frontrunner in the development, distribution and application of knowledge for meeting the challenges in the physical planning, design and management of vulnerable deltas, coastal areas and river basins.

Deltares works for and cooperates with Dutch government, provinces and water boards, international governments, knowlegde institutes and market parties. The institute employs more than 800 people. The institute is located in two cities: Delft and Utrecht.

5.2 Delta technology

Interventions in water and earth interact. That is why water and the subsurface in deltas cannot be viewed separately.

There is growing pressure on delta systems: economic development and demographic changes make the management of deltas increasingly complex. Shortage of space means that we are moving out more and more into areas that are less suitable for living in. Extreme fluctuations in water levels require us to focus more on management and safety. Falling land and rising sea levels accentuate that process. It is not enough to concentrate solely on coastlines or rivers. We need to look at catchment areas in their entirety.

We tackle safety issues by assessing risks in advance using models and other research methods. Questions about water and the subsurface involve not only technological issues, but also natural processes, spatial planning and administrative/legal processes. We apply knowledge about those processes in an integrated way to develop and improve the habitability of deltas, coastal areas and river basins. The integrated approach allows us to come up with innovative solutions. We call this approach ‘delta technology’.

5.3 'Enabling Delta Life'

Nowadays, more than 50% of the world's population live, work, and spend their leisure time in deltas, coastal areas and river basins. Delta areas have major economic potential because of their strategic location close to the sea and waterways. The ground is fertile and rich in minerals and raw materials. However, delta areas are also vulnerable: soft soil subsides, the sea level is rising, rivers show extreme levels and pressure on space and the environment is on the increase.

The Netherlands is renowned for its struggle against the water. We know how to make the most of the available space in densely populated deltas with soft soils and, at the same time, provide protection against the dangers of the water. As a result of that experience, Dutch experts are very much in demand, both at home and far beyond their own borders.

There is increasing global demand for knowledge and technology in the area of water and the subsurface in relation to delta issues. Deltares provides innovative solutions to make living and working in deltas, coastal areas and river basins safe, clean and sustainable.
This intrinsic commitment is expressed in Deltares' strategic principle - 'Enabling Delta Life.'

5.4 Widely applicable consultancy and research

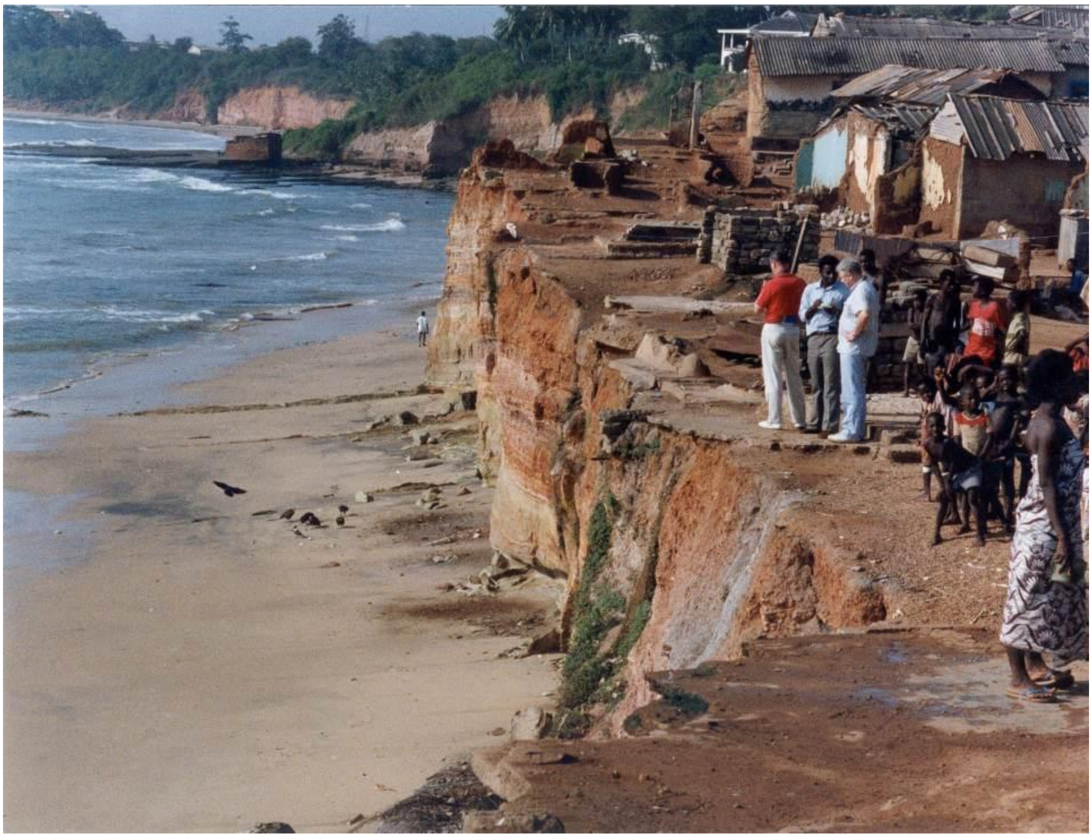
Deltares stands for the right balance between consultancy and research at both the national and international levels. Problems concering water and soil can be found all over the world. Taking part in these international cases and thus dealing with different circumstances enables Deltares to gain more indepth knowledge and to expand its knowledge base.

We are concerned with areas where economic development and population pressure are high, where space and natural resources – both above and below the surface – have to be used and managed in multi-functional and intensive ways.

5.5 Background of the participating institutes

WL | Delft Hydraulics is actively involved with water-related issues worldwide, whilst GeoDelft focuses on issues in the field of geo-engineering. The Subsurface and Groundwater unit of TNO is active in groundwater management, subsurface/soil remediation and the management and use of the subsurface domain. The Department of Transport, Public Works and Water Management (Rijkswaterstaat) is engaged in providing flood protection and safeguarding adequate supplies of clean water for all users. Rijkswaterstaat has transferred knowledge development for delta issues to Deltares.

For more information: www.deltares.nl



Key areas

Multiple spatial use
- Construction and soft soils

Living with water
- Water safety and design
- Water management and use
- Healthy water systems
- Hydraulic Engineering

Environmental surroundings
- Subsurface, water, and space
- Healthy soil systems and materials

Systems, processes, materials
- Measuring, modelling, predicting, providing information
- Product innovation

Knowledge as capital
  - Experimental observatories and test sites
- Strengthening the knowledge base

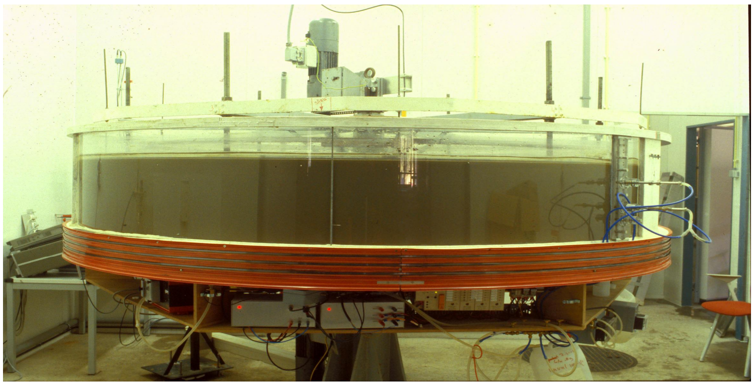
Facilities as capital
- Physical laboratory facilities (experimental analyses)
- Software facilities

6 Experimental facilities of Deltares

More information www.deltares.nl

geo/hydro facilities

rotating annular flume
The carousel consists of a rotating annular channel with a closed rotating lid at the water surface in opposite direction. The operational speed of the lid and the channel are experimentally determined using small spheres and an electromagnetic current meter. Data is collected using a PC mounted on the caroussel lid, wirelessly connected to the ground station. The annular flume is located inside a climate controlled room.



wave/current flume
Multiple purpose facility in which experiments can be carried out ranging from oil spill break-up to erosion and sedimentation of a deposited mud bed under wave and fow attack. The flume is equipped with a wave generator and a water circulation system. If required wave damping structures are available.

oscillating water tunnel
Constructed to study sediment transport phenomena and related problems under controlled simulated wave conditions and current at full scale. Problems like boundary layer flows, bed-loaded transport, suspended sediment transport, bed shear-stress, incipient motion and ripple formation can be studied. Tests can be performed both under random and periodic wave conditions.

large-scale geo/hydro flume
The socalled Dredging Flume is a research facility for complex soil/water interactions. It comprises a large concrete research-flume and a self propelled dredging module consisting of a multi purpose dredging installation complete with data-acquisition and data processing systems. The dredging module is mounted on top of the flume-walls. A glass wall can be installed to form a flume that enables visualisation of the processes.

hydro/structure facilities
wave/current flume
The socalled Scheldt flume is a glass-walled facility and is used to study a wide range of coastal related issues, viz. stability of all kinds of breakwaters, scour and scour protection, stability of beaches and studying wave run-up or wave overtopping. The model scale applied in this facility is usually between 1:10 and 1:50. The wave board is equipped with Active reflection Compensation (ARC). This technique is developed to minimise re-reflections off the wave board towards the model. The wave generator is able to generate 2nd order waves according to standard or prescribed wave density spectra.

large scale wave flume

The socalled Delta flume can be used for physical model studies in which scale effects are to be expected, like testing breakwaters and revetments, wave forces on structures or dune erosion testing. This facility enables testing on a scale close to prototype. The wave board is equipped with Active Reflection Compensation (ARC). This technique is developed to minimise re-reflections off the wave board towards the model. The wave generator is able to generate 2nd order waves according to all standard or prescribed wave density spectra.

wave/current basin

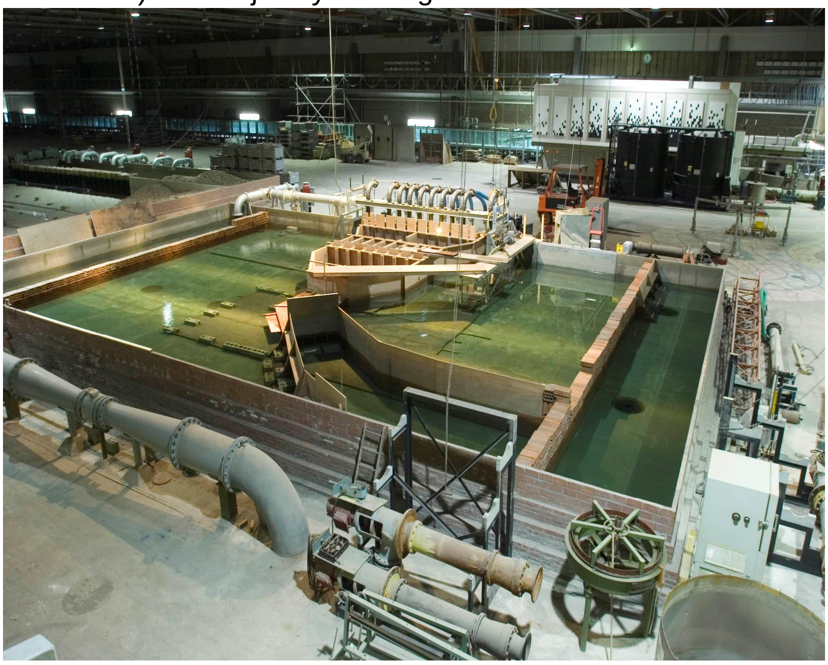
The socalled Scheldt basin has been designed to study the influence of combined wave-current loads (45-90 degrees angle) on typical scales 1:10 to 1:50. Typical projects for the Scheldt basin are related to scour and scour protection around offshore structures or stability testing for instance of breakwater heads. The wave generator of the Scheldt basin is able to generate long-crested 2nd order waves according to all standard or prescribed wave density spectra.

multi-directional wave basin

The socalled Vinjé basin is equipped with a programmable wave generator with 80 independently controlled paddles. The length of the wave front is 26.4 m. The paddles enables simulation of real sea conditions for both long-crested and short-crested waves, including directional spreading. This basin is perfectly suitable to perform 3D experiments to study breakwater roundheads, moored ship at (open) berths, wave forces on jetties, harbour wave agitation, etc. The model scale applied in this facility are usually between 1:30 and 1:75. The wave board is equipped with Active Reflection Compensation (ARC). This technique is developed to minimise re-reflections off the wave board towards the model. The wave generator is able to generate 2nd order waves according to all standard or prescribed wave density spectra.

intake/outfall facility

Civil works such as pump sumps can be investigated in this specific facility to verify and improve proper pump working under all operation and design/emergency conditions. Pump sumps with up to 20 individual pump compartments (with typical 1:10 scale) can be jointly investigated.



two-phase and dynamic flow test facility
Facility for testing pipeline components under two-phase (water-air) or dynamic flow conditions. The facility is used for the dynamic testing of check valves, air valves, pressure relief valves, as well as the steady, two-phase flow testing of control valves, separators and mixers.

valve test facility (water)
Testing of Cv, Kv or noise characteristic of any valve type up to 800 mm diameter takes place according to international standards (ISA, IEC, VDMA). The flow is supplied by eight speed-controlled pumps (maximum flow capacity 1.9 m^3/s). The pressure in the closed loop rig is controlled and maintained constant with an air vessel.

air flow test facility
Testing of valves and air valves takes place according to international standards (ISA, ISO, IEC, EN, VDMA). The flow is supplied by a large air vessel (capacity 70 m3), pressurized by a compressor. An active gas control valve allows for a constant pressure and flow in the test section. For a high accuracy over a wide flow range the main line or a bypass is available. The actual flow conditions are converted to standard conditions, according to the standards.

calibration rig for certified calibrations of flow meters
The calibration is based upon the “weighing method” according to standard ISO 4185. The flow is supplied by a constant head reservoir (at a height of 24 m). Rig specifications: maximum flow is 1.9 m3/s, maximum flow meter diameter is 2 m, accuracy is 0.05 %. During a specified period water is collected in one of the weighing tanks, which mass is measured with calibrated load cells. From the mass increase, filling time and water density, the volumetric flow rate is determined.

long pipeline test loop for dynamic experiments
The test loop has a length of 650 m and an internal diameter of 235 mm. Dynamic experiments can be carried out in single phase (water), or multi-phase (water-air-solid). Transport phenomena of water-air or water-air and sand at stationary and dynamic test conditions can be studied, as well as leak detection, pipe friction, flushing, etc.

Flume 4
This is a wide flume for investigations related to flow forces, discharge coefficients, specific design details, bed protection and morphological impact of hydraulic structures. The flume has a zig-zag formed overflow gate at the upstream side and a vertical lifting gate at the downstream side so that water levels can be controlled easily and accurately. A sediment sieve is constructed at the downstream side for the collection of lightweight material in morphological tests. The flume has a maximum discharge of 1000 l/s. The electrically driven measurement bridge can also be used for drag tests.

Kolkman flume
The Kolkman flume is used for investigations related to design details of hydraulic structures, forces on and vibrations of hydraulic structures. The flume has side walls made of glass. The wave generator is capable of generating both regular (periodic) and irregular (random) waves. It is equipped with online Active Reflection Compensation and activated either by a sinus generator or PC-steering signal.

Geo-engineering facilities

Geocentrifuge
Modelling plays an important part in geotechnical engineering, especially testing in a centrifuge. For physical modelling, the correct replication of the processes that might take place in reality is of concern. To do so the prototype situation is usually reduced in scale and tested. Modelling asks for the appropriate scaling laws. In geotechnical modelling, the major soil parameters to reproduce are the strength and stiffness.

1-g Model Facilities
Several 1-g model testing facilities are available at Deltares:

Large testing container surnamed 'Bak-van-Smits' (dim. 4m x 2.5mx 1.5m) has been constructed with a nozzle network on the bottom. Through these nozzles water can be injected with high pressures breaking the compacity of the sand block. Sand gets fluidized. Mounted steel grids can be used to densify the sand model. By this technique saturated sand models can be prepared with a wanted relative density of loose to dense (Dr(n)~80%). Capillary sand can also be prepared.

Testing domains: (cone) penetration tests, testing of field push-away techniques, compaction tests, trench tests, etc.

Medium testing container surnamed 'Brutusbak' (dim. 2m x 1m x1m). The 'Brutusbak' is provided with two parallel glass window making possible visual observations along the sand model profile. It has the same fluidization system as the large testing container. Sand models is compacted using shock waves. Obtained sand densities vary from loose to dense (Dr(n)~80%).

Testing domains: Soil deformations around a vibrating sheet-pile, arching effects, scaled geocontainers, etc.

Table centrifuge
A small and a large centrifuge stand side by side. The large geocentrifuge is generally used to investigate geotechnical problems related to the interactions between foundations and soils while the small table centrifuge can be used to determine soil properties. This makes a table centrifuge useful in necessary studies prior to large centrifuge tests.

Originally dedicated to clinical applications, a standard table centrifuge has been adapted to fit the needs of geotechnical investigations. In addition to its 4 modified cups diametrially located, sliprings have be mounted in the rotor to make possible the use of sensors in the cup and the transfer of data to the fixed world. Sensors like pressure gauges, electrodes, a displacement sensor could be used successfully in these conditions. It can rotate in a range of 500 to 1800 rpm corresponding to acceleration varying from 50 - 600 times the Earth's gravity.

Large triaxial cell

The large triaxial cell (dim. 0.4m in diameter & 0.8m high) is convenient to characterize the mechanical properties of coarse materials or large soil samples (for example: asfalt, cement, heterogeneous samples...) . Measurements are treated and presented in the same way than standard triaxial tests.

7 Acknowledgements

Organising Committee NCK-days 2008

Deltares:	Dr. Ankie Bruens
	Ms. Astrid van Bragt
Program Secretary NCK:	Dr.ir. Mark van Koningsveld
Overall coördinator NCK/NCR:	Ir. Ad van Os
Secretarial support NCK/NCR:	Mrs. Jolien Mans
Graphics:	Mr. Hans Roode

Additional organisation excursion *Hands on experimenting in the experimental facilities of TU Delft*

TU-Delft:	Dr. ir. Wim Uijttewaal

Sponsoring

Special thanks goes to the financial support by:

- Deltares
- NWO- Netherlands Organisation for Scientific Research