netherlands centre for coastal research

NCK - Days 2015

Book of abstracts

March 18 - 20, 2015

Co-sponsored:

Rijkswaterstaat
Ministerie van Infrastructuur en Milieu

netherlands centre for coastal research

NWO
Netherlands Organisation for Scientific Research
Earth and Life Sciences

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NCK – Days

March 18th to 20th, 2015

Strandpaviljoen STRUIN, Camperduin

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NCK Secretariat:

Claire van Oeveren – Theeuwes MSc

P.O. Box 177

2600 MH Delft

Rotterdamseweg 185

2629 HD Delft

The Netherlands

Tel. +31 (0)6 15 005 417

e-mail: claire.vanoeveren@deltares.nl

www.nck-web.org

Content

1. Preface

Dear NCK colleagues and guests,

It is a great pleasure for Rijkswaterstaat to welcome you all at this annual NCK symposium. The theme of NCK 2015 is *Coastal maintenance: Bringing Science, Policy and Practice together*. A theme that highly reflects the work of Rijkswaterstaat.

As the executive body of the Ministry of Infrastructure and the Environment, Rijkswaterstaat manages the main highway and waterway network in the Netherlands. Rijkswaterstaat is responsible for the technical condition of the infrastructure and for its user-friendliness, such as a safe and clean national waterway system, smooth and safe traffic flows and flood control. Our daily work also consists of the national monitoring for water quantity, water quality and morphology.

Our monitoring program gives us insight in the development of our natural system over time. In the nineteen seventies and eighties we saw a continued loss of dune area. The Dutch government decided to put a stop to this structural coastal erosion in 1990. In order to do this, a reference coastline was defined, based on our monitoring data and general coastal knowledge, a yearly test procedure was designed and the Dynamic Preservation policy was introduced. This policy stated that coastal erosion should be compensated predominantly with sand nourishments, under the motto 'soft measures where possible, hard structures where necessary'. In the Netherlands we now have over 20 years of experience with maintaining the coast with sand nourishments. By adding sand to the coast we are able to largely satisfy the sand demand of our coastal system to keep up with sea level rise and remain protected against flooding. The measure of using sand has proven successful; our monitoring data shows that structural erosion is largely controlled, therefore the loss of coastal area has been put to a stop.

Our coastal policy is based on the use of sand and natural dynamics (*Building with Nature*). The location of this meeting is right at the reinforcement of the Hondsbossche and Pettemer sea defence. A project that embodies this idea. In collaboration with Hoogheemraadschap Hollands Noorderkwartier we bring the coastal defence back to strength for years to come.

Building with Nature, in collaboration with others is something Rijkswaterstaat highly values. To perform our daily and future tasks we need (up to date) scientific knowledge. Therefore, Rijkswaterstaat works closely with knowledge institutes on questions related to e.g. modelling, hydrodynamics, morphodynamics, sedimentology, biology, system behaviour and flood risk management. The participation of Rijkswaterstaat in NCK is covered by the colleagues of the Department of Water, Traffic and Environment (WVL). They help to develop the vision of Rijkswaterstaat, by bringing in and gathering the scientific knowledge that is required to perform the tasks of Rijkswaterstaat. Not only for its current but also its future tasks.

We are happy to see that a large amount of abstracts (~70) have been handed in and by the number of participants (> 100) we may conclude that the NCK coastal research community is thriving. We hope that the presentations, posters and informal contacts during these NCK Days will strengthen our collaboration and scientific knowledge and enhances the benefits of this network for all of us.

Enjoy the NCK Days of 2015!

On behalf of Roeland Allewijn (Director Rijkswaterstaat – WVL Safety and Water usage) and the organizing committee, Rena Hoogland and Quirijn Lodder,

Gemma Ramaekers

2. The Netherlands Centre for Coastal Research (NCK)

"Our network stimulates the cooperation and exchange of wisdom between coastal researchers from various research themes and institutes, making us all better."

The Netherlands Centre for Coastal Research is a cooperative network of private, governmental and independent research institutes and universities, all working in the field of coastal research. The NCK links the strongest expertise of its partners, forming a true centre of excellence in coastal research in The Netherlands.

The NCK was established with the objectives:

- To increase the quality and continuity of the coastal research in the Netherlands. The NCK stimulates the cooperation between various research themes and institutes. This cooperation leads to the exchange of expertise, methods and theories between the participating institutes.
- To maintain fundamental coastal research in The Netherlands at a sufficient high level and enhance the exchange of this fundamental knowledge to the applied research community.
- To reinforce coastal research and education capacities at Dutch universities;
- To strengthen the position of Dutch coastal research in a United Europe and beyond.

2.1 History

In 1992, the successful multidisciplinary collaboration that initiated during a large scale research project, Coastal Genesis, was institutionalized by the founding of the Netherlands Centre for Coastal Research. The NCK was initiated by the coastal research groups of Delft University of Technology, Utrecht University, WL | Delft Hydraulics and Rijkswaterstaat RIKZ. Since then, the official partnership of the NCK has expanded with the University of Twente (since 1996), the Royal Netherlands Institute for Sea Research (NIOZ, since 1999), UNESCO-IHE Institute for Water Education (since 2004) and Wageningen IMARES (since 2008).

For more than 20 years, the NCK collaboration continues to stimulate the interaction between coastal research groups, which in the past had often worked more isolated. It facilitates a strong embedding of coastal research in the academic programmes and courses, attracting young and enthusiastic scientists to the field of coastal dynamics. Several times a year, the NCK organises workshops and/or seminars that are aimed at promoting cooperation and mutual exchange of information and knowledge. NCK is open to researchers from abroad and encourages the exchange of young researchers. Among the active participants are often a lot of people from other institutes and companies.

2.2 The NCK Programme Committee

The NCK Programme Committee establishes the framework for the activities to be organised by NCK. These include for instance the annual coastal symposium ("The NCK Days") and the topics for the seminars ("Theme days"). The Programme Committee gathers twice a year.

As of March, 2014, the NCK Programme Committee consists of:

- A.J.F. van der Spek PhD. (Chairman, c/o Deltares)
- M.C. van Oeveren - Theeuwes MSc. (Programme Secretary NCK, c/o Deltares)
- B.C. van Prooijen PhD. (Delft University of Technology)
- K.M. Wijnberg PhD. (University of Twente)
- G. Ramaekers MSc. (Rijkswaterstaat-WVL)
- prof. H. Winterwerp PhD. (Deltares / Delft University of Technology)
- T. Gerkema PhD. (Royal Netherlands Institute for Sea Research, NIOZ)
- prof. P. Herman PhD. (Royal Netherlands Institute for Sea Research, NIOZ)
- prof. J.A. Roelvink PhD. (UNESCO-IHE)
- M.J. Baptist PhD. (Wageningen IMARES)
- M. van der Vegt PhD. (Utrecht University – IMAU)

2.3 The NCK Directory Board

The NCK Programme Committee and the Programme Secretary are supervised by the NCK Directory Board. As of January 2015, the Directory Board consists of:

- prof. J. Kwadijk PhD. (Deltares, Chairman)
- M.C. van Oeveren - Theeuwes MSc. (Programme Secretary NCK, c/o Deltares)
- R. Allewijn PhD. (Rijkswaterstaat-WVL)
- prof. M.J.F. Stive PhD. (Delft University of Technology)
- prof. P. Hoekstra (Utrecht University - IMAU)
- prof. S.J.M.H. Hulscher PhD. (University of Twente)
- prof. H. Brinkhuis PhD. (Royal Netherlands Institute of Sea Research NIOZ)
- prof. A. Mynett ScD. (UNESCO-IHE)
- prof. H. Lindeboom PhD. (Wageningen IMARES)

2.4 The NCK Partners

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, with a particularly important role for the Department of Hydraulic Engineering. This department 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. Mathematical, numerical modelling and experimental validation of these processes is at the forefront internationally, while recently the additional focus is on the development of field expertise.

More information
http://www.citg.tudelft.nl/over-faculteit/afdelingen/hydraulic-engineering/

Representatives
Representative in the NCK Directory Board: prof. M.J.F. Stive PhD.
Representative in the NCK Programme Committee: B.C. van Prooijen PhD.

Deltares

Applied research in water, subsurface and infrastructure

WL | Delft Hydraulics, GeoDelft, the Soil and Groundwater unit of TNO and parts of Rijkswaterstaat have joined forces on 1 January 2008 in a new independent institute for delta technology, Deltares.

Deltares is an independent, institute for applied research in the field of water, subsurface and infrastructure. Throughout the world, we work on smart solutions, innovations and applications for people, environment and society. Our main focus is on deltas, coastal regions and river basins. Managing these densely populated and vulnerable areas is complex, which is why we work closely with governments, businesses, other research institutes and universities at home and abroad.

Enabling Delta Life

Our motto is Enabling Delta Life. As an applied research institute, the success of Deltares can be measured in the extent to which our expert knowledge can be used in and for society. For Deltares the quality of our expertise and advice is foremost. Knowledge is our core business.

All contracts and projects, whether financed privately or from strategic research budgets, contribute to the consolidation of our knowledge base. Furthermore, we believe in openness and transparency, as is evident from the free availability of our software and models. Open source works, is our firm conviction. Deltares employs over 800 people and is based in Delft and Utrecht.

More information
http://www.deltares.nl/en

Representatives
Representative in the NCK Board of Supervisors: prof. J. Kwadijk PhD
Representative in the NCK Programme Committee: prof. H Winterwerp PhD

Imares

Institute for Marine Resources and Ecosystem Studies

Wageningen IMARES (Institute for Marine Resources and Ecosystem Studies) is the Netherlands research institute established to provide the scientific support that is essential to developing policies and innovation in respect of the marine environment, fishery activities, aquaculture and the maritime sector. Wageningen IMARES is

- an independent, objective and authoritative institute whose aim is to find the right equilibrium between marine ecology, seafood production and maritime economy;
- a key, proactive player in national and international marine research networks (including ICES and EFARO).

We carry out research for both national authorities and specific research programmes (50%), international RTD programmes (30%) and contract research for private, public and NGO partners (20%). Our key focal research areas cover ecology, environmental conservation and protection, fisheries, aquaculture, ecosystem based marine economy, coastal zone management and marine governance.

Wageningen IMARES has some two hundred people active in field surveys, experimental studies, from laboratory to mesocosm scale, modelling and assessment, scientific advice and consultancy. Our work is supported by unique in-house facilities that include specialist marine analysis labs, experimental halls, outdoor mesocoms, specific field-sampling devices, databases and models. The Wageningen IMARES quality system is ISO 9001 certified while special chemical analysis and ecotoxicological studies are performed according to RVA, ISO 17025 accreditation and GLP standards. We collaborate with fellow research specialists where necessary and where such collaboration generates clear added value. Our research is regularly published in international peer reviewed publications. As part of the Wageningen UR, Wageningen IMARES has close ties with Wageningen University and the Van Hall Larenstein professional University. Both universities cater for Bachelor, professional Master and academic Master education programmes. The institute runs a PhD programme together with Wageningen University.

More information

http://www.wageningenur.nl/en/Expertise-Services/Research-Institutes/imares/About-IMARES.htm

Representatives

Representative in the NCK Board of Supervisors: prof. H. Lindeboom PhD
Representative in the NCK Programme Committee: M. Baptist PhD

NIOZ

Royal Netherlands Institute for Sea Research

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.

More information
www.nioz.nl/home_en.html

Representatives
Representative in the NCK Board of Supervisors: prof. H. Ridderinkhof PhD
Representative in the NCK Programme Committee: T. Gerkema PhD, prof. P. Herman PhD

Rijkswaterstaat

Water, Traffic and Environment

As the executive body of the Ministry of Infrastructure and Environment, Rijkswaterstaat manages the Netherlands' main highway and waterway network. Rijkswaterstaat is responsible not only for the technical condition of the infrastructure but also for its user-friendliness. Smooth and safe traffic flows, a safe, clean and user-friendly national waterway system and protection from flooding: that is what Rijkswaterstaat is about.

Participation in NCK

Rijkswaterstaat's participation in NCK is covered bij the service Water, Traffic and Environment (WVL). Within Rijkswaterstaat, WVL develops Rijkswaterstaat's vision on the main highway and waterway network, as well as the interaction with our living environment. WVL is also repsonsible for the scientific knowledge that is required for Rijkswaterstaat to perform its tasks, now and in the future.

As such, WVL works closely with knowledge institutes and acts as their principal within Rijkswaterstaat. By participating in joint ventures and forming strategic alliances with partners from the scientific world, WVL stimulates the development of knowledge and innovation with and for commercial parties.

More information
http://www.rijkswaterstaat.nl/en/

Representatives
Representative in the NCK Board of Supervisors: R. Allewijn PhD
Representative in the NCK Programme Committee: G. Ramaekers MSc

UNESCO-IHE

Institute for Water Education

UNESCO-IHE is an 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.

More information
https://www.unesco-ihe.org/

Representatives
Representative in the NCK Board of Supervisors: Prof. A. Mynett ScD
Representative in the NCK Programme Committee: Prof. D. Roelvink PhD

University of Twente

Civil Engineering & Management

Since 1992, the University of Twente has an educational and research programme in Civil Engineering, 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. Research of the section Water Engineering and Management (WEM) focuses on i) physics of large, natural, surface water systems, such as rivers, estuaries and seas and ii) analysis the management of these systems. Within the first research line WEM aims to improve the understanding of 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 management 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, biogeomorphology and ecomorphodynamics have been awarded to this section.

More information
http://www.utwente.nl/ctw/wem/

Representatives
Representative in the NCK Board of Supervisors: prof. S. Hulscher PhD
Representative in the NCK Programme Committee: K. Wijnberg PhD

Utrecht University

Institute for Marine and Atmospheric Research Utrecht (IMAU)

The Institute for Marine and Atmospheric research Utrecht (IMAU) is hosted partly at the Faculty of Science and partly at 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 Climate Dynamics and Physical Geography and Oceanography of the coastal zone, by integrating theoretical studies and extensive field studies. IMAU focuses on the hydrodynamics and morphodynamics of beaches and surf zones, shoreface and shelf, as well as on the dynamics of river deltas, estuarine systems and barrier islands.

More information
|http://www.uu.nl/faculty/geosciences/EN/Pages/default.aspx
http://imau.nl/

Representatives
Representative in the NCK Board of Supervisors: prof. P. Hoekstra PhD
Representative in the NCK Programme Committee: M. van der Vegt PhD

3. Programme NCK-Days, Strandpaviljoen STRUIN, 2015

Wednesday March 18th		
18:30 – 21:30	Icebreaker (Ijgenweis, Schoorl)	

Thursday March 19th		
08:30	Registration	
09:00	Opening	
09:05	Welcome by Rijkswaterstaat – Koen van der Werff	
Session 1	**Coastal Zone Management – Rena Hoogland - Rijkswaterstaat**	
09:20	Quirijn Lodder –	Dutch Coastal Zone Management, a review of nourishment types and their morphological behaviour
	Paul Olijslagers –	Design and maintenance of Hondsbossche and Pettemer new sea defence
	Marije Smit –	ZSNH: aeolian processes in dune design
	Alma de Groot –	Tales of Island Tails: development under natural and influenced conditions
	Tommer Vermaas –	Sedimentation rate, patterns and dredging effects in Rotterdam harbour access channel, the Maasgeul
	Thijs van Kessel –	Mud in Dutch estuaries and in the Wadden Sea: a value proposition
11:00	Poster Pitches (20x45 seconds) & Poster Session (incl. coffee & tea)	
Session 2	**Natural Systems; Beaches, Estuaries and Tidal Inlets. Part I – Timothy Price – Utrecht University**	
11:45	Jantien Rutten –	Sandbar behaviour at the Sand Motor: three years of observations
	Laura Brakenhoff –	Interaction of tides, groundwater levels and surface moisture on a sandy beach
	Filip Galiforni Silva –	Space-time beach variability in an exposed barrier island: the case of Ilha Comprida (SP), Brazil
	Wim Ridderinkhof –	Periodic migration of sandy shoals on the ebb-tidal deltas of the Wadden Sea
12:50	Lunch	
Session 3	**Natural Systems; Beaches, Estuaries and Tidal Inlets. Part II –Timothy Price – Utrecht University**	
14:00	Marc Hijma –	Mississippi River diversions and their influence on the evolution of the Chenier Plain (Louisiana, USA)
	Vincent Vuik –	Wave attenuation by vegetated foreshores under storm conditions: evidence from the field
	Maria Ibanez Sanz –	Assessment of flocculation and settling of cohesive sediments using zeta potential measurements
14:50	Poster Session (incl. coffee & tea)	
15:30	Kees Stam –	Introduction to the weak link: Hondsbossche Pettemer Sea Defence
16:00	Excursion: Hondsbossche Pettemer Sea Defence (circa 1 hour)	
18:30	Dinner	

Friday March 20th		
08:30	Registration	
09:00	Opening	
Session 4	**Hydrodynamics and (aeolian) Sediment Transport – Martijn Henriquez – Delft University of Technology**	
09:05	Giordano Lipari –	Not just in the wind: the Dutch Wadden Sea and its very own storm surges
	Max Radermacher –	Tidal flow separation at the Sand Motor
	Jurre de Vries –	Observations of turbulence in the periodically-stratified Marsdiep basin
	Joost Brinkkemper –	Turbulence and sand suspension events in the surf zone of a field-scale laboratory beach
	Joep van der Zande -	Bed-level motions and sheet-flow processes in the swash zone
	Bas Hoonhout –	The Influence of Spatially Varying Supply on Coastal Aeolian Transport: A Field Experiment
10:45	Poster Pitches (20x45 seconds) & Poster Session (incl. coffee & tea)	
Session 5	**Bio-Geomorphology – Tjeerd Bouma - Imares**	
11:30	Joep Keijsers –	Modelling the bio-geomorphological evolution of coastal dunes
	Marjolein Post –	Habitat Selection of Juvenile Sole: Consequences of Shoreface Nourishment
	Maarten de Jong –	Ecosystem-based design rules for sand extraction sites on the Dutch Continental Shelf
	Martin Baptist –	Constrasting spatiotemporal trends in salt-marsh development of the Mokbaai, Texel, the Netherlands
	Sil Nieuwhof –	Biogenic structures on intertidal flats enhance retention at local and landscape scale
	Zhengchang Zhu –	Physical forces and ecosystem engineers can act in synergy in displacing ‘living particles’: evidence from seed burial in tidal flats
13:00	Lunch	
Session 6	**Data Management & Modelling – Pieter Roos – University of Twente**	
14:30	Niels Kinneging –	Coastal morphological monitoring at Rijkswaterstaat
	Elena Vandebroek –	Monitoring the Sand Motor with TerraSAR-X satellite data
	Jurgen Klein –	Validation of the North Sea Storm Surge Atlas by hindcasting historical storms
	Abdel Nnafie –	On the sand exchanges between the Scheldt estuary and its ebb-tidal delta: An idealized model study
	Jianfeng Tao –	Morphodynamic evolution of large-scale radial sand ridges: a case study in Jiangsu coast, China
	Ype Attema –	Long-term bio-geomorphological modelling of the formation and succession of salt marshes
16:00	Poster Session & Handing in Poster- and Presentation Evaluations (coffee & tea)	
16:30	Closure	

4. Abstracts

4.1 Abstracts for presentations

Dutch Coastal Zone Management, a review of nourishment types and their morphological behaviour

Quirijn Lodder[1,2], Gemma Ramaekers[1], Rena Hoogland[1]

[1] Rijkswaterstaat, Quirijn.Lodder@rws.nl, Gemma.Ramaekers@rws.nl, Rena.Hoogland@rws.nl
[2] Delft University of Technology

1. Introduction

Rijkswaterstaat is responsible for the execution of the Dutch coastal zone management policy. This presentation gives an overview of the range of nourishment types that are placed along the Dutch coast and will give an overview of their morphological behaviour.

The current Dutch coastal zone policy has, in essence, been in effect since 1990. In 1990 the Netherlands started maintaining the coast by means of sand nourishments. Since 1990 the scale of the nourishments increased in volume, number and type. The annual nourishment budget has been increased from on average 7.5 to 12 million m^3.

2. Nourishment design parameters

Three types of nourishments are now common practice: beach, shore face and in tidal channels.. Since 2011 the experimental “Mega” nourishment, the Sandmotor has been added to the types of nourishments. Table 1 gives an overview of the key design parameters for the Dutch nourishments..

Type	Percentile	Beach	Shoreface	Channel	"Mega"
Volume (Mm3)	5%	0.2	0.5	1.5	8
	50%	0.5	1.5	3	15
	95%	2	4	6	25
Volume per m (m3/m)	5%	50	200	300	500
	50%	200	400	1000	1000
	95%	400	600	2000	3000
Length (km)	5%	1	2	0.5	2
	50%	1.5	4	1.5	4
	95%	6	10	6	8

Table 1: Key design parameters of Dutch nourishments. Note that the volumes given in table 1 are net in situ volumes. In general the gross volume is 1.15 times the net volume.

3. Morphological behaviour

The general behaviour of the different types of nourishments can be summarized as follows:

- Beach nourishments erode quite quickly. The nourished sand diffuses to cross- and alongshore.
- Shoreface nourishments tend to migrate cross-shore towards the beach. Although this seems not true for all shoreface nourishments.
- Channel nourishments generally tend to remain quite stable over the years. However this isn’t true for all locations.
- Mega nourishment the Sandmotor erodes at the most seaward parts. The sand is currently being deposited both alongshore (South and North) and cross shore.

In the presentation we will highlight similarities and differences in morphological behaviour since they provide leads for future evaluation, research and practice. Which remains needed to continually improved the way we maintain our coast.

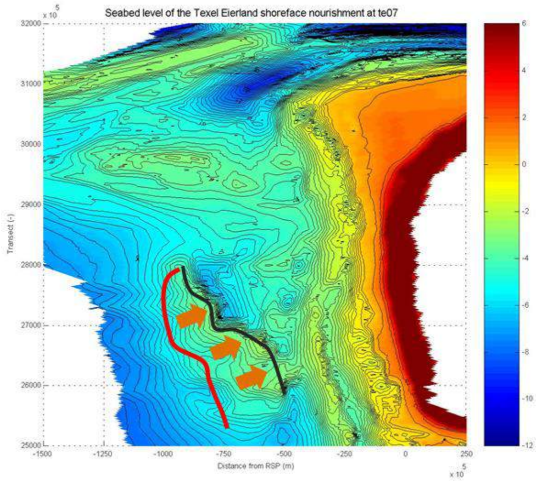

Figure 1: example of a shoreface nourishment at Texel. Red line: Location of the crest in the first survey after placement (2005). Black line location of the crest in 2007.

4. Innovation

In recent years Rijkswaterstaat implemented a new strategy for the execution of nourishments. We changed from an annual nourishment program to a four year program that is updated annually. This change resulted in an annual financial efficiency of about 20%.

Within the nourishment program 2012 – 2015 eight nourishments will be monitored extra in order to be able evaluate and learn from them. In the presentation we will highlight some of these nourishments.

Design and maintenance of Hondsbossche and Pettemer new sea defence

F.J.H. Olijslagers[1], P.G. Brandenburg[2]
[1] Royal Boskalis Westminster N.V. paul.olijslagers@boskalis.com
[2] Van Oord peter.brandenburg@vanoord.com

1. Introduction

After the periodic safety test, the Hondsbossche and Pettemer sea defence was designated as a ‘weak link’ in the Dutch coast. Temporary measures were taken in 2006 and in 2011 this weak link was addressed as an integral project within the high water protection program (HWBP) with a dual objective: improve the flood safety and improve spatial quality. The new sea defence will consist of a series of dunes with a sandy beach in front. In 2013 the joint venture of marine contractors Van Oord and Boskalis were assigned for the design, construction and 20 years maintenance of the new sea defence. This abstract deals with the design and maintenance strategy.

2. Design:

2.1 Requirements

The design had to meet the following product requirements:

- meet the safety requirements (1/10,000 year conditions) within project boundaries (seaward of NAP+5m, no residual strength of existing dike)
- design life: 50 years
- maximum dune height NAP+12m
- smooth coastline (< 3°/250m)
- take into account uncertainties.
- conditions for ecological development

2.2 Design philosophy

The design is based on a minimum profile needed to meet safety requirements and a buffer to compensate for losses until first maintenance campaign.

The minimum cross-shore profile for safety, see Figure 1, consists of: 1) closure depth 2) equilibrium profile 3) dune width based on dune erosion in design conditions

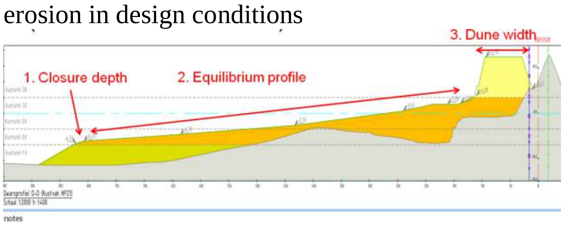

Figure 1: Typical cross-shore profile

The buffer consists of 1) hydraulic losses based on extensively validated process-based numerical model 2) sand losses by aeolian transport 3) sub-soil settlement.

The design is optimised to minimize the total volume of sand needed for safety and 20 years maintenance.

3. Maintenance:

3.1 Requirements

The trigger for maintenance is safety. After 18 years an advice will be prepared by the contractors for the BKL coastline position on the basis of the experiences during the preceding period.

3.2 Maintenance philosophy

Every year, the safety against flooding is assessed by analysing the trend of the residual strength of the dunes, see Figure 2. The residual strength is defined by a residual dune volume after the normative storm condition, taking into account uncertainties, see Figure 3.

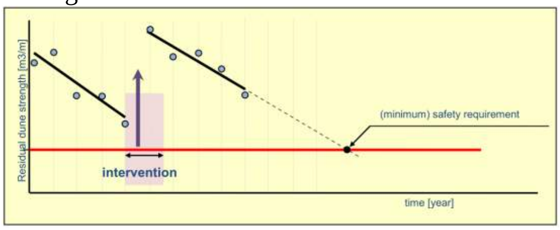

Figure 2: Linear trend of residual strength

Figure 3: definition of residual dune volume

4. Results

The design is obtained by successively optimising:
- coastline smoothness
- volume of sand for safety, maintenance and conditions for ecological development;

Above all the maintenance strategy is driven by safety against flooding.

5. Conclusions

Putting responsibility of design, construction and maintenance with the contractor, requirements are met at the lowest cost.

Acknowledgments

HHNK s gratefully acknowledged for the permission to present this article.

ZSNH: aeolian processes in dune design

M.W.J. Smit[1], D.C. van Kester[2] and F.J.H. Olijslagers[3]

[1] Witteveen + Bos, Marije.Smit@witteveenbos.com
[2] Van Oord, Dennis.vanKester@vanoord.com
[3] Boskalis, Paul.Olijslagers@boskalis.com

1. Introduction

The coastal defence between Petten and Camperduin was one of the final weak links of the Dutch coast and is currently being reinforced in the project Zwakke Schakels Noord-Holland (ZSNH, Figure 1). When reinforcing shores with dunes in the Netherlands, these dunes have generally been constructed as a straight dike and completely planted with beach grass to stabilize the sand, resulting in stable dunes with low ecological value. For ZSNH it was desired to create a safe and appealing coast. The dune area has therefore been designed aiming to stabilize the sand where it is necessary and to allow aeolian sand transport where it is possible. The first adheres to the demands for safety and having no nuisance of windblown sand. The second answers the demands on allowing an ecologically interesting area to develop and to create an appealing coastal stretch.

Figure 1: Dune design near Camperduin (www.kustopkracht.nl)

2.Methodology:

Dunes grow and are being profiled due to accumulating sand by aeolian transport. The knowledge of aeolian processes has been used in the design of the coastal defence for ZSNH. Existing knowledge and experience have been combined with the design requirements, resulting in a combination of measures. In general about 9 m^3/m/year sand accumulates in the dunes along the Dutch coast (e.g. De Vries et al. 2012, Van der Wal 2004). It is important that this sand accumulates in useful locations without nuisance. Experience from Maasvlakte II and results from fieldwork and field experience along the Dutch coast have been used to define where the sand is most likely to accumulate and what measures could help to stabilize the sand locally. These measures are applied to the cross shore profile of the designed dune.

3. Results

Combining knowledge and experience resulted in the choice of various measures at various cross shore and alongshore locations, specific for the local situation. There are three categories of measures: those based on the effect of 1. large geometric features, 2. Small geometric features and 3. plants and objects. Large elevations create shelter where sand will accumulate (Figure 2). Local small elevations will create a variation in deposition pattern, thus creating a variable and locally evolving dune. Plants will locally reduce wind speeds, resulting in settling and containing sand. Combining these measures with locally patches without vegetation will allow sand to move locally, stimulating ecological values to develop. The combination of measures results in a dune that is alongshore variable. During the realisation phase less sand than expected was moved by the wind. Most likely this is due to a combination of the effect of geometry (large dune) and extra temporary measures like adding paper pulp and brush wooden fences.

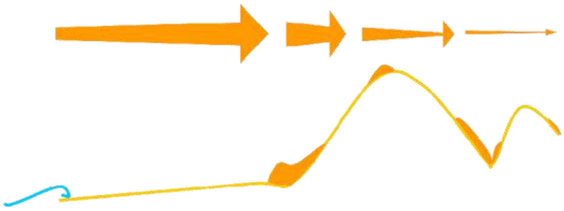

Figure 2: Example of effect of large geometry: the dune itself will reduce the wind velocities and thus allow sand to settle (orange: windblown sand).

4. Conclusions

Combining knowledge and experience of aeolian processes and demands in dune design lead to a design and realisation of a dune area which is both safe as well as appealing.

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Tales of Island Tails: development under natural and influenced conditions

Alma de Groot[1*], Albert Oost[2], Evert Jan Lammerts[3], Willem van Duin[1], Roos Veeneklaas[4], Bregje van Wesenbeeck[2], Elske Koppenaal[5]

[1] IMARES, P.O. Box 167, 1790 AD Den Burg, alma.degroot@wur.nl, willem.vanduin@wur.nl
[2] Deltares, P.O. Box 177, 2600 MH Delft, albert.oost@deltares.nl, bregje.van.wesenbeeck@deltares.nl
[3] Staatsbosbeheer Divisie Beheer & Ontwikkeling, P.O. Box 333, 9700 AH Groningen, e.lammerts@staatsbosbeheer.nl
[4] Bosgroep Noord-Oost Nederland, Balkerweg 48a, 7738 PB Witharen, r.veeneklaas@bosgroepen.nl
[5] Community and Conservation Ecology, P.O. Box 11103, 9700 CC Groningen, e.c.koppenaal@rug.nl

1. Introduction

Island tails are the downdrift parts of barrier islands and consist of salt marshes, dunes, beaches, beach plains and green beaches. Large parts of the tails of the Wadden-Sea island have lost dynamics and are ageing. This is largely caused by human influence. As an aid for managers to develop new strategies to rejuvenate island tails, a frame of reference was created for the development of island tails.

2.Methods

We made use of existing data, field visits and literature for the development of a conceptual model. The data consisted of (historic) topographic maps, aerial pictures, vegetation maps, and measurements of surface elevation and clay thickness on the salt marshes. The study focussed on Terschelling, Ameland, Schiermonnikoog (all NL) and Spiekeroog (D).

3. Results

All island tails in the Wadden Sea are unique, but all contain several recognizable elements. Their development follows the general pattern of biogeomorphic succession. At first the island tail consists of a bare beach plain (Figure 1). Secondly, biotic processes start to influence the morphology and embryonic dunes form. In the third phase, green beaches, dunes and salt marshes develop, including drainage such as creeks and washovers. Finally, the biotic processes dominate and the individual parts of the island tail undergo vegetation succession, stabilising the morphology.

Island tails may develop completely without any human interference (Figure 1). With human alterations (such as sand-drift dikes and embankments), natural dynamics generally decrease, increasing the speed of succession, and on the long run reducing the diversity in landforms, vegetation types and successional stages. Both for natural and human-influenced island tails, succession is the dominant process. Large-scale setbacks in succession most likely only occur when large-scale processes cause the erosion of part of the island tail.

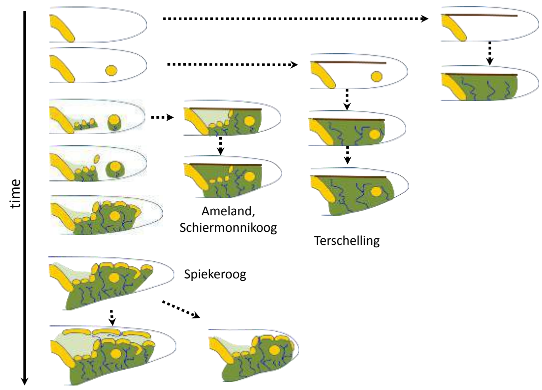

Figure 1: Island-tail development under undisturbed (left) and disturbed conditions, with examples of island tails. Yellow = dunes, dark green = salt marsh, light green = green beach, blue = creeks, brown = sand dike.

4. Conclusions

The current state of an island tail depends on its age, the presence of man-made sand-drift dikes, the time elapsed since their construction, and the occurrence of large-scale processes having affected the development of the island tail since.

In their current form, island tails are some of the most dynamic parts of the Dutch coast. This makes them very suitable for allowing natural processes to their full extent. It seems possible to introduce more dynamics through active management. There are however limits to the effects that can be expected, as the geomorphological processes from the initial phases, that cause landscape variation, cannot always be restored on a large scale in later phases of the succession.

Acknowledgments

This study was commissioned by O+BN, funded by VBNE, Deltaprogramma Waddengebied (Ministry of EZ) and Programma naar een Rijke Waddenzee.

Sedimentation rate, patterns and dredging effects in Rotterdam harbour access channel, the Maasgeul

Tommer Vermaas[1], Marc Hijma[1], Thaiënne van Dijk[1,2] and Niels Kinneging[3]

[1] Deltares, tommer.vermaas@deltares.nl, marc.hijma@deltares.nl, thaienne.vandijk@deltares.nl
[2] University of Twente, t.a.g.p.vandijk@ctw.utwente.nl
[3] Rijkswaterstaat, niels.kinneging@rws.nl

1. Introduction

Access channels to harbours have to be dredged regularly to keep the required navigation depth. Therefore, knowledge of the sedimentation rates in the channel is important to design efficient monitoring and dredging policies. Several theoretical models on the sedimentation of (dredged) channels have been designed in the past (e.g. Galvin, 1982; Van Rijn, 1986). However, field studies are still limited in number (e.g. Gosh et al., 2001).

The Maasgeul is the offshore access channel to Rotterdam harbour and is kept at a depth of -24 m LAT. To keep the channel floor at depth, the Maasgeul is being dredged several times a year up to an annual volume of about 1 million m^3. In this study we used bathymetrical measurements to determine 1) the natural sedimentation rate and patterns in the channel and 2) the effect of dredging activity on the sedimentation rate.

2. Methodology

Analyses were based on monthly bathymetrical grids from 2008-2013 with a 1x1m resolution. For each pixel, trends of bed level in time were calculated in three different ways. Dredging events were determined to be any bed level change ≤ -25 cm in one month. Two aspects are used to quantify the effect of dredging: 1) the 'recovery period' - the time until exceedance of the pre-dredging bed level and 2) the 'recovery effect' - the increased sedimentation rate directly after dredging. The recovery effect is studied by comparing average bed level changes in the subsequent months after a dredging event and related to the depth of dredging.

3. Results

Two of the applied methods to calculate the trend in bed level yielded good results, showing natural spatial patterns (Fig. 1). The southern part of the channel shows higher sedimentation rates as an effect of a dominant northward residual current. Trends calculated between dredging events were averaged to yearly sedimentation rates. These show a clear change

in spatial pattern that can be correlated to the seaward harbour extension 'Maasvlakte II' from 2009-2013.

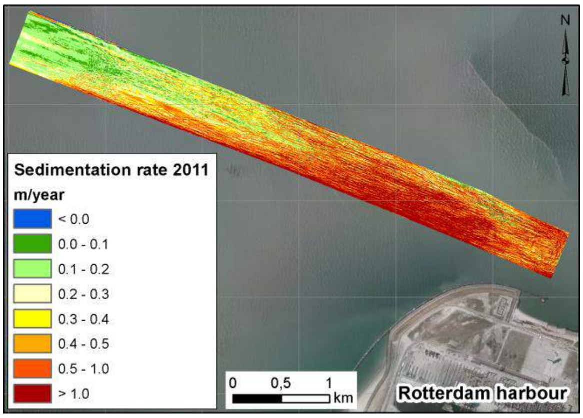

Figure 1: Average sedimentation rate in 2011

The recovery effect is visible in the sedimentation rates that are higher in the first two months after a dredging event. The recovery effect is depended on the dredging depth: the deeper the dredging, the higher the sedimentation rate. This is also expressed in the recovery period: deep dredging results in a relatively shorter recovery period. The average recovery periods are ca. 5 months after 40 cm dredging and ca. 7 months after 1 m dredging, indicating that smaller dredging events are more efficient.

4. Conclusions

The developed methods to determine the natural sedimentation rates in the Maasgeul show clear spatial patterns that can be explained by physical and environmental conditions. In the first two months after dredging, dredging affects the sedimentation rate the most. Smaller dredging events are relatively more effective in terms of recovery period.

The results of this study can be used to optimize dredging and monitoring activities.

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Mud in Dutch estuaries and in the Wadden Sea: a value proposition

Thijs van Kessel[1], Marcel Taal[1]

[1] Deltares, thijs.vankessel@deltares.nl
[2] Deltares, marcel.taal@deltares.nl

1. Introduction

Mud is an integral part of the sediment dynamics along the Dutch coast, next to sand, most notably in estuaries such as the Scheldt and Ems and in the Wadden Sea.

In pre-industrial times, the suspended sediment concentration was likely close to a natural level, although small-scale land reclamation works and dike construction may have affected it locally. Mud deposition was perceived as a benefit, as fertile agricultural land could be created from it.

This perception changed during industrialisation. Steam power facilitated larger ships requiring deeper navigation channels. Steam also provided the power to dig deeper channels and to maintain them. The construction of the New Waterway contributed much to the rise of the Dutch dredging industry. At the same time, population growth increased pressure on land use for harbours, industries, housing and agriculture, resulting in an accelerating confinement of estuaries by land reclamation. The combination of deeper but narrower estuaries resulted in more mud import from sea, more dredging in navigation channels and harbours, less deposition on intertidal flats (their area was reduced) and a higher turbidity. This again worsened the light climate for the growth of algae, being the basis of the food-chain. Last but not least, industrialisation also caused a rise of pollution levels, contaminating the mud and reducing the options for beneficial use. More and more, mud started to be perceived as a costly problem. Suddenly the Netherlands experienced a mud excess.

Time has come to reverse this trend. Stricter emission regulations combined with a significant relocation of industrial activities outside the Netherlands and Europe has led to cleaner muds that can be used more widely. Progress in safety thinking reversed the trend from even higher dikes along even narrower estuaries towards estuaries with more accommodation space for tidal energy and wider intertidal flats that may grow with sea level rise, thus protecting dikes and providing extra safety. Slowly but gradually, we tend to move back from highly engineered estuaries towards more natural estuaries, although still restrained by man, to provide a societally acceptable balance between safety, accessibility and nature.

To make such development possible, sufficient mud should be available to allow the tidal flats to grow with (increasing) high water levels and land subsidence. At this moment, more than sufficient mud is available for small-scale setbacks such as the Hedwigepolder in the Scheldt estuary. Some even worry that the new intertidal area will grow too fast, leaving too little time between setback and supra-tidal saltmarsh development. Is it possible that, when many more plans are made for the beneficial use of mud, we change from a mud excess to a mud shortage in several decades from now in the Netherlands? It is now unclear how much of these plans can be realised concurrently without compromising each other from the point of view of mud supply. Doubling a tidal area from 1 to 2 m^2 also doubles the deposited volume, but does this also hold for doubling from 1 to 2 km^2, or much more? Beyond a certain limit the mud supply will become a limiting factor, a further increase in scale will just reduce the sedimentation rate, maybe even below a critical level to make this approach viable. What is this limit and how much mud may we tap from our estuarine and coastal system to serve our needs? And how do we value this compared to the ecological gains of a better light climate?
These questions will be discussed in more detail and with more context during the presentation. Also some first answers will be provided, but no final answers. The objective of the presentation is to create awareness and as to provide an input to the discus-sion on the long-term sediment management of the Dutch coast. For the sandy coastline this discussion has evolved substantially over the past decade and conclusions have been implemented in coastline management policy, but for mud the discussion and resulting best policy is still less evolved.

Sandbar behaviour at the Sand Motor: three years of observations

Jantien Rutten[1], Gerben Ruessink[1]
[1] Utrecht University, Department of Physical Geography, j.rutten@uu.nl

1. Introduction

Along the Dutch coast, the Sand Motor, a hooked-shaped 21 Mm^3 mega-nourishment, was constructed as coastal protection measure on decadal scales. The nourished sands are aimed to be distributed along the adjacent coast by waves and currents in a natural way over several years, known as diffusion. On top of the slowly changing large-scale morphology, variability in depth was observed on meso scales, i.e. over hundreds of meters and from a few days to several months. Here sandbars are the dominant meso-scale subtidal morphology, elongated alongshore ridges of sand. We examine the spatiotemporal variability of meso-scale morphology, using a combination of bed elevation measurements by jet-ski's and remote sensing observations.

2.Material and methods

2.1 Bed elevation measurements

Subtidal bed elevation has been measured every two months since August 2011, using a jet-ski equipped with an echosounder. The raw measurements were interpolated to a grid using a Loess filter[2].

2.2 Video-derived morphology

Eight Argus video cameras, mounted on a 40 m tower and looking alongshore, have been collecting imagery of the Sand Motor since March 2013. Sandbar and shoreline position were estimated from time-averaged images by feature tracking of white elongated lines of wave dissipation (Figure 1). The dissipation lines, induced by the foam of preferential wave breaking, served as a proxy for sandbar and shoreline location.

2.2 Hydrodynamic forcing

Offshore wave height and wave direction were obtained from a wave buoy. Spatial patterns in wave forcing are derived from video time series of pixel intensity. Wavelength and wave angle were extracted from wave phase maps, which were produced by cross-correlation of pixels in the spectral domain[3].

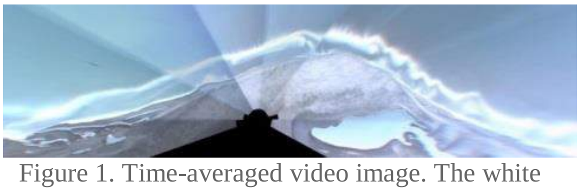

Figure 1. Time-averaged video image. The white patterns depict the subtidal sandbars.

3. Observations on meso-scale morphology

The subtidal bar system varies alongshore from a straight elongated longshore bar in the south to transverse and terrace-shaped bars in the north (Figure 1). Argus imagery reveals that the longshore bar has a rather steady position, at a distance of ~180 m from the shoreline in winter. During summer, the bar migrates 20-30 m onshore. Sinuosity in the bar, and co-sinuosity in the shoreline, has been observed for two periods (month(s)) during the winter of 2013-2014. The patterns were removed by high waves. Such elongated longshore bars, potentially with rhythmic patterns, are typically found in the Netherlands. The transverse bars and terrace-shaped bars, however, are not that common for the Dutch coast. Minor changes were observed in position of both the transverse and terrace-shaped bars during summer, while during autumn and winter storms the rhythmic patterns were removed and the bars were reset seaward and straightened.

4. Discussion and conclusion

- Meso-scale (100 m) morphology of the Sand Motor, i.e. a subtidal sandbar system, varies from a summer to a winter state
- Alongshore differences are observed in meso-scale morphology, e.g. bar type and bar behaviour, and its storm response
- Alongshore variability in meso-scale morphology can potentially be explained by alongshore differences in cross-shore slope and hydrodynamic forcing.

Acknowledgments

This PhD project, part of Nature Coast, was funded by Stichting Toegepaste Wetenschap (STW).

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Interaction of tides, groundwater levels and surface moisture on a sandy beach

Laura Brakenhoff[1] and Gerben Ruessink

[1] Utrecht University, Department of Physical Geography; laurabrakenhoff@gmail.com

1. Introduction

Wind-driven (aeolian) sand transport from the beach is of prime importance to coastal dune formation and growth, as well as dune recovery after a severe storm. The amount of aeolian sand transport is not only determined by wind speed, but also by beach surface characteristics, predominantly moisture content.

The surface moisture content is determined by processes in the atmosphere (evaporation and precipitation) and in the groundwater (via capillary transport). The groundwater level in the beach is governed mostly by the tide.

In this contribution we aim to quantify the relation between tidal water level, groundwater level and surface moisture content based on field observations. We expect this work to contribute to a better understanding of spatial and temporal patterns in aeolian sand transport.

2. Methodology

A six-week field campaign was performed at the Sand Motor, near The Hague (NL) in fall 2014. Here, tidal water level was measured with a pressure transducer at the low-water line, while 8 dipwells were deployed to measure groundwater levels in a 80-m long cross-shore array. A Delta T Theta probe was used to measure surface moisture content along the same array. The height of the capillary fringe above the ground water level was estimated, using a grain size of 400µm, to be about 0.2m.

3. Results

3.1 Overheight

Figure 1 shows the groundwater level at a representative low tide during neap and spring tide. It can be seen that the inland groundwater level is in both cases higher than mean sea level. This overheight is approximately 0.25m larger during spring than during neap tide.

3.2 Effects of groundwater on surface moisture

During spring tide, the capillary fringe was estimated to reach the beach surface longer throughout the day than during neap tide. Yet, the surface moisture content is relatively high in both cases (Figure 2). The beach slope is found to be essential: the overheight rises constantly in landward direction, so when the beach surface slope decreases, the water table gets closer to the surface, thereby increasing the surface moisture content. This happens at 40m during spring tide and at 30m during neap tide (Figure 2).

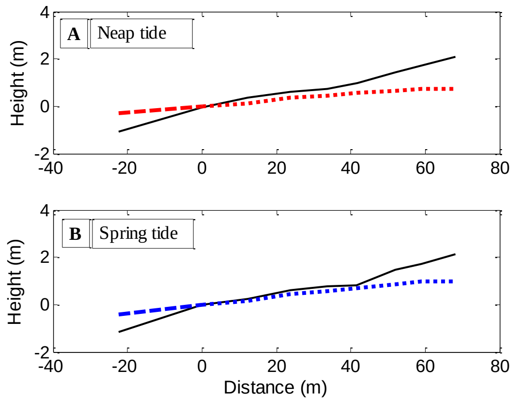

Figure 1: groundwater levels (dashed lines) and bed profiles (solid lines) at neap (A) and spring (B) tide

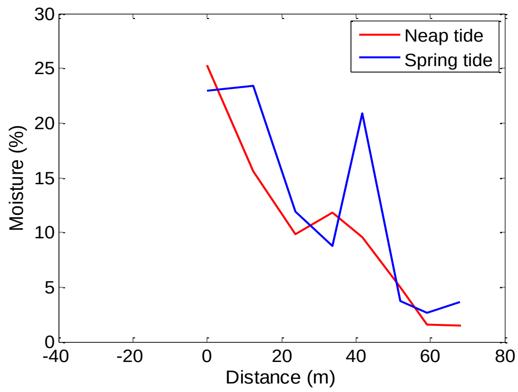

Figure 2: The surface moisture content at spring and neap tide

4. Discussion and Conclusions

The tide and the bed profile control the spatial and temporal surface moisture content. Especially when the beach has a low slope, the overheight causes the capillary fringe to rise to the surface, increasing the surface moisture content and thus decreasing the potential for aeolian transport. Spring-neap tide variations in overheight and hence moisture content might cause a spring-neap tidal variation in the potential for aeolian transport, assuming the same wind conditions.

Space-time beach variability in an exposed barrier island: the case of Ilha Comprida (SP), Brazil.

Silva, F. G.[1], Sousa, P. H. G. O.[2] Siegle, E.[3]

[1] Water Engineering and Management, University of Twente, P.O. Box 217, 7500 AE Enschede, Netherlands.
[1, 2, 3] Oceanographic Institute, University of São Paulo, São Paulo, Brazil
f.galifornisilva@utwente.nl[1]; sousaph@usp.br[2] ; esiegle@usp.br[3]

1. Introduction

The aim of this study is to evaluate the space-time variations of wave processes along the beach system of Ilha Comprida (SP). These results are then related to morpho-sedimentary characteristics and variability. Hence, potential longshore drift estimates, as well as wave power and elevation data were used to evaluate the beach system.

2.Methodology:

2.1 Wave data and numerical modelling:

The MIKE21 SW wave propagation model was applied to provide nearshore wave characteristics for the potential longshore drift and wave power estimates. Due to the lack of long-term wave data, the 30 year wave reanalysis database from the global wave generation model WAVEWATCH III (NOAA/NCEP) was used to define specific wave scenarios (wave occurrence above 5%) to be defined as boundary conditions. From each simulated wave, its nearshore characteristics have been extracted at depths of around 5 m. The potential longshore drift has been estimated using the approach exposed in Bittencourt et al (2005), whilst the wave power has been estimated through linear wave theory

2.2 Field data

Morpho-sedimentary characteristics were surveyed at five locations (Figure 1). During one year, five repeated elevation surveys were conducted at each location using a DGPS system, followed by sediment sample collection. These data were used for beach volume estimates, altimetry maps and assessment of grain size variation and distribution.

3. Results

In a long-term perspective, the longshore drift estimates show a transport trend towards NE. Moreover, it presents two positive gradient spots, located on the central-southern and northern portions. During the most energetic periods, the central-southern spot becomes bigger and reach more southern regions, whilst the northern spot maintains its position throughout the year. High values of wave power have been found approximately at the same positive spots (Figure 1). These results are consistent with observed trends in the field, where the positive gradient spots were located at regions which experience erosion problems. The presence of the Bom Abrigo Island and the azimuth variation could give insights about both the transport trends and the wave power distribution.

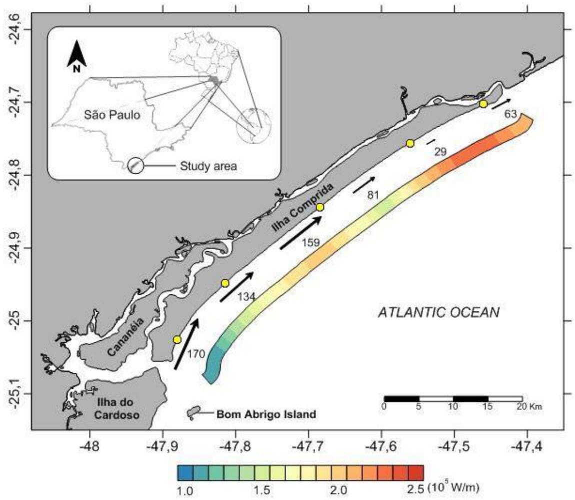

Figure 1: Study area location, the transport trends and the wave power distribution. The yellow circles represent the locations of the elevation surveys.

4. Conclusions

Along this wide open stretch of coastline, exposed to the same offshore wave regime, the local bathymetry and the presence of natural features induce a nearshore varying wave regime, resulting in areas with either negative or positive sediment balance at different locations throughout the same period.

Acknowledgments

We would like to acknowledge the Brazilian National Council for Scientific and Technological Development (CNPq) for the funding.

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Periodic migration of sandy shoals on the ebb-tidal deltas of the Wadden Sea

Wim Ridderinkhof[1], Huib E. de Swart[1], M. van der Vegt[1] and P. Hoekstra[1]

[1] IMAU, Utrecht University - W.Ridderinkhof@uu.nl

1. Introduction

The Frisian and Danish Islands form the border between the Wadden Sea and the North Sea. Seaward of the tidal inlets that separated them, ebb-tidal deltas are formed by the local interaction of waves and tides. It has been observed that on some of these deltas shoals periodically migrate from the sea towards the shore. For instance, at the Ameland Inlet large shoals that originate from the ebb-tidal delta attach to the shore every 50 – 60 years (*Israel and Dunsbergen*, 1999). At the Texel Inlet, a similar shoal supplied **O**(10^7) m^3 of sand to the coast in 1908 (*Sha*, 1989). A better understanding of these periodically migrating shoals is important, since they play an important role in the sediment balance of the nearshore zone and many of the Wadden Islands are subject to erosion.

The period between successive shoals that migrate to the coast varies among different inlets. *Gaudiano and Kana* [2001], analyzed the morphologic evolution at nine inlets in South Carolina, and found that this period is larger at inlets with a larger tidal prism.

In this study, it is investigated if the periodic migration of shoals can be observed at all inlets of the Wadden Sea. Regional differences will be examined. Furthermore, it will be discussed if the relationship found by *Gaudiano and Kana* [2001] is applicable to the shoals migrating on the ebb-tidal deltas of the Wadden Sea.

2.Methodology:

Three different sources are used to analyze the shoals at the West Frisian Islands. 1) The position of the mean low water line (source: *KNMI*). 2) Bathymetric profiles along cross-shore transects (source: *Rijkswaterstaat*) 3) Bathymetric profiles covering the entire Dutch coast (source: *Rijkswaterstaat*). The migration of shoals on the ebb-tidal deltas of the East and North Frisian Islands, and the Danish Islands, is monitored using satellite observations. For this, in total 45 Landsat satellite images of the period between 1973 and 2014 (available through *http://earthexplorer.usgs.gov/*) are used.

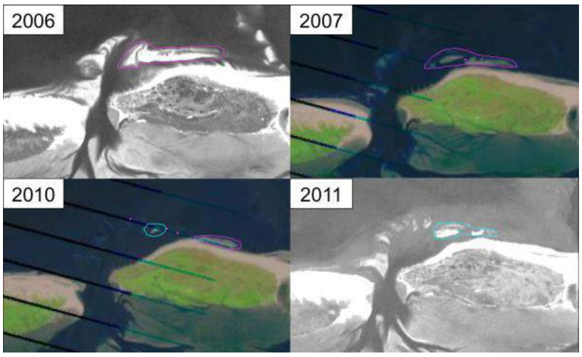

Figure 1: Two successive shoals that migrate from the ebb-tidal delta of the Wichter Ee to Baltrum

3. Results

At all ebb-tidal deltas of the West and East Frisian Islands, migrating shoals are observed. Interestingly, the period between successive shoals varies strongly by location. For example, based upon 3 successive shoals observed at the Wichter Ee (Figure 1), it is estimated that there shoals attach to the island every 4,3 years. While at the Amelander Inlet shoals attach to the coast approximately every 60 years.

4. Conclusions

Migrating shoals are observed at all inlets of the West and East Frisian Islands, but not at all inlets of the North Frisian and Danish Islands. This is related to differences in alongshore sediment transport and tidal prism.

There is a tendency of larger periods between successive shoals at inlets with a larger tidal prism. But, wide inlets with multiple channels deviate from this relationship and have a relatively short period.

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Mississippi River diversions and their influence on the evolution of the Chenier Plain (Louisiana, USA)

Marc Hijma[1,2], Torbjörn Törnqvist[2] and Zhixiong Shen[2,3]

[1] Deltares, marc.hijma@deltares.nl
[2] Tulane University, tor@tulane.edu,
[3] Coastal Carolina University, zshen@coastal.edu

1. Introduction and problem definition

In the past, the Mississippi River has shifted its course frequently, resulting in distribution of sediments along the coast and 'healing' of scars in the coastline. The current fixed position of the Mississippi River results in large, sediment-starved sections that erode rapidly. Controlled Mississippi River diversions to such sections constitute a key element to coastal restoration with the goal to achieve sediment accretion rates that keep pace with future relative sea-level rise in strategically selected areas. Geological information of past river-mouth switching can provide insights as to whether rapidly subsiding areas can be saved by river diversions and how fast this process can be. The existing time-control of these shifts is still predominantly based on research from the 1940-1960s and there is a need for new, high-resolution chronological data, in order to better understand the natural behavior of the Mississippi River and the Chenier Plain that lies to the west of the Delta. As there is a westward directed offshore current, sediments from the Mississippi reaching the Gulf of Mexico can be partly transported towards the Chenier Plain that lies more than 200 km westward of the delta (Figure 1). The latter consists of alternations of muddy, marshy areas with sandy ridges (cheniers) in between and is currently strongly eroding. The chronological work on Chenier Plain development also stems from decades ago (1950s) and ridge formation was dated using reworked shells, dating the oldest chenier to ~3,000 cal yr Before Present (BP). Ever since that time, Chenier Plain development has been linked to Mississippi River development. The hypothesis is that when the mouth of the Mississippi is situated close to the Chenier Plain, the abundance of muddy sediments will lead to seaward growth of the coastline. When the Mississippi shifts to a more easterly position, mud delivery is reduced and waves erode mudflats and form cheniers. However, current chronologies for Mississippi River-mouth shifting and Chenier Plain development do not show a clear 1:1 relationship and therefore it has been suggested that local river systems have a strong influence on Chenier Plain development as well. This paper presents new insights on the link between the river and the coastal plain. This is important because when planning man-made diversions, it will be essential to understand the natural system in order to anticipate future coastal response to these diversions.

2.Methodology

We gathered new data to improve the chronologies with the aim to better understand the evolution of the Missisippi Delta and the Chenier Plain. We have used both radiocarbon and Optically Stimulated Luminescence (OSL) dating. With the latter technique the age of sandy cheniers, and also of sandy Mississippi River deposits can be determined directly. Each sampling site was chosen after extensive fieldwork to obtain a detailed stratigraphic framework. We will discuss and compare the chronologies of the Mississippi Delta and the Chenier Plain in order to answer the question: do they match?

Figure 1: Location of the Mississippi Delta and the Chenier Plain

4. Conclusions

The new chronology for the Chenier Plain shows that this plain formed in the last 3000 years. In that time four major Mississippi Delta lobes have been active. We can directly link major changes in Chenier Plain evolution to changes in the position of the Mississippi River mouth. Smaller changes cannot always be linked to the river. This will partly be the result of local evolution of the Chenier Plain, but most likely also of unresolved changes in the outline of the Mississippi Delta in that time. The conclusion that changes in the position of the river mouth directly influences the evolution of the Chenier Plain, means that when making a diversion, this will not only benefit the area near the diversion, but also the areas westward along the coast.

Wave attenuation by vegetated foreshores under storm conditions: evidence from the field

Vincent Vuik[1], Isabella Kratzer[2], Bas Jonkman[3] and Bas Borsje[4]

[1] Delft University of Technology and HKV Consultants, V.Vuik@tudelft.nl
[2] NIOZ Yerseke, isabella.kratzer@nioz.nl
[3] Delft University of Technology, S.N.Jonkman@tudelft.nl
[4] Twente University and Deltares, Bas.Borsje@deltares.nl

1. Introduction

It is recognized that vegetated foreshores like salt marshes can reduce hydraulic loads on coastal dikes, potentially allowing for more slender dike designs. However, quantitative field evidence of the load reduction during severe storm conditions is lacking. Existing models that relate quantities like the two-percent wave run-up height to flotsam levels (e.g. IJnsen, 1983) are based on the assumption of a Rayleigh distribution for the wave height. On shallow foreshores, wave height distributions deviate from the Rayleigh distribution (Battjes & Groenendijk, 2000). We will show a new model, based on the current unique combination of measured incident wave conditions and measured flotsam levels.

Figure 1: Two lines of flotsam ('veekranden') on the dike at the transition from a mudflat to a salt marsh

2. Methodology

Starting from November 2014, wave gauges have been deployed at five transects in the Western Scheldt (2), the Wadden Sea, Nieuwe Maas and Zwarte Meer, to quantify wave attenuation by *Spartina*, *Scirpus, Elytrigia* and *Phragmites* vegetation.

On January 11th, a heavy storm has hit the Dutch coast, with water levels reaching 3.3 m+NAP at Eemshaven. After this storm, the position of the flotsam – mostly organic debris, transported towards the dike by waves– has been measured on the outer slope of the Wadden dike between Eemshaven and Lauwersoog (Figure 1). The flotsam level corresponds to the highest wave run-up during the highest still water level during the storm surge.

During the same storm, wave sensors have been deployed, five perpendicular to the dike to investigate the wave transformation over the salt marsh, and four parallel to the dike, to quantify the wave height distribution near the dike for different foreshore types: tidal flats, pioneer salt marsh and mature salt marsh.

3. Results

The flotsam levels were considerably lower behind the salt marshes than behind the mudflats (Figure 1).

Based on our measurements, we will present the wave attenuation capability of different plant species.

4. Conclusions

- Salt marshes bordering coastal dikes contribute significantly to the reduction of wave loads on the dike, compared to bare mudflats.
- The reduction of wave loads primarily depends on the geometry of the vegetated foreshore, and on the vegetation species present.
- Flotsam levels are a useful indicator for wave run-up, provided that sufficient insight is available about the wave height distribution.

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Assessment of flocculation and settling of cohesive sediments using zeta potential measurements

Ibanez, Maria[1], Chassagne, Claire[1], Winterwerp, Johan C[1,2]
[1]Delft University of Technology, Civil Engineering and Geosciences, Section of Environmental Fluid Mechanics, PO Box 5048, 2600 GA, Delft, The Netherlands
Email: M.E.IbanezSanz-16@tudelft.nl
[2]Deltares, Marine and Coastal Management, PO Box 177, 2600 MH, Delft, The Netherlands

Flocs in estuaries are formed principally by the aggregation of clays and polymers (organic matter, EPS…) in the presence of ions [8]. Due to electrostatic interactions (Coulomb, van der Waals, …) bridging between polymers and particles occurs. The anchoring of polymers to clay particles can be evaluated through the study of the interfacial properties of the clay-polymer system by electrophoretic mobility measurements (Zeta Potential). An estimation for the surface charge of the clay is obtained in terms of the zeta potential. The zeta potential has proven to be a good indicator for predicting the changes (changes in particle size, density and floc strength) of clayey materials as a function of the fluid properties (changes in salinity, pH, shear stresses) ([1],[2],[3],[7]). These changes can in turn be related to changes in settling and consolidation behavior ([4],[5],[6]).

2.Methodology

The Zeta potential of a river clay sample was analyzed as function of polymer concentration with a Zeta Nano Malvern devise. Some settling columns experiments were done. The interface of the clay was analyzed on time, giving the settling rate as function of polymer concentration.

3. Results

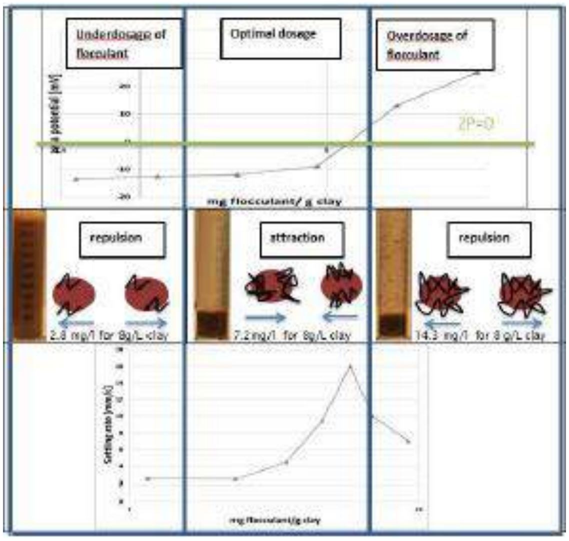

Figure 1: zeta potential and settling rate of river clay with cationic flocculant.

4. Conclusions

Three regions can be defined:

1) Underdosage of flocculant: low dose, the repulsive forces between particles do not allow flocculation, and hence settling does not occur. (|ZP| large)

2) Optimal dosage: Cationic polymers attach to the negatively charged particles, neutralizing their electrokinetic charge and making aggregation possible. At neutral zeta potential, flocculation is optimal and the supernatant is clear(optimal polymer coverage and the settling velocity is the highest). (|ZP|≈0)

3) Overdosage of flocculant: the optimum dose is exceeded, flocculation still occurs, but at a lower rate ("excess" of positive charges at the clay surface, which increase the time for positive particles to encounter a negatively charged zone). When the flocculant dose is further increased, all particles become too positively charged, resulting in mutual steric repulsion, and a decrease in the settling velocity. (|ZP| large)

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Not just in the wind: the Dutch Wadden Sea and its very own storm surges

Giordano Lipari
Waterbeweging.nl | Watermotion.eu glnl@ymail.com

1. Introduction

When raging winds threateningly raise the water against the coast, it is generally taken as ground truth that the higher the peak wind speed, the higher the peak water level. The surge records in the Dutch Wadden Sea (DWS), however, defeat this intuition, since some severe surges, such as that of November 2006 in Delfzijl, were not caused by the most severe winds in the same control period.

New understanding on the hydrodynamics of storm surge generation in the DWS has been gained in Lipari *et al.* (2008) and Lipari and van Vledder (2009). These insights then led to a reconsideration of the regulatory hydraulic boundary conditions for the coastal safety assessment (see Credits). They are also being commented with comparable detail for a public audience for the first time.

2. Methodology

To unravel the specificity of surge generation in the DWS, those investigations considered [a] a statistical analysis of the year records in the DWS in the 1930- 2005 period; [b] the analysis of the water level signal for six severe events from 1981 through 2007; [c] the hindcast of the storm surges of 1/11/06 (Figure 1), 12/1/07, 18/1/07 and 9/11/07; [d] pseudo-hindcasts with simplified storm patterns to verify that the surges under item c were unsteady and spatially non-uniform in nature; [e] numerical experiments to identify storm patterns that could work out as a template for a larger class of surge-generating storms.

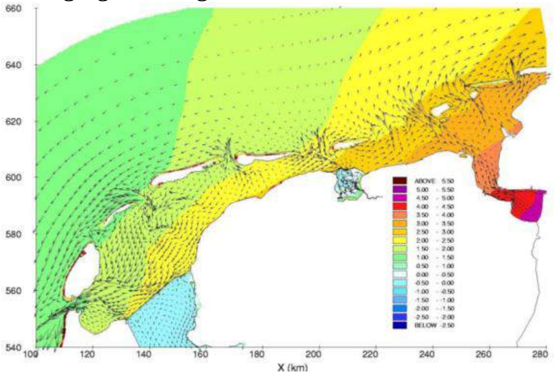

Figure 1: Hindcast of the surge of 1/11/2006. Time of peak water level in Delfzijl (Lipari *et al.*, 2008)

3. Results

Two noteworthy circumstances were recognised to be at play in the severe event of 1 Nov 2006 (Figure 1). Firstly, the unlimited presence of water is self-evident on a shore squarely facing the ocean's expanse. In contrast, the water volume contained in the Wadden Sea depends on the history of the flow exchange across its several tidal inlets. During a storm the accumulation of large enough *amounts of water* to create surges of concern is promoted by a 'match' between the storm, seen as an evolving atmospheric pattern, and the geography of the DWS itself. Secondly, the *water motion* inside the DWS is constrained by the available space in terms of both shorelines and bed depths. Thereby, as soon as the slope of the water levels permits, the water moves alongshore across the wind, again in contrast with the behaviour of a storm surge from an open sea.

Thus, the DWS surges are significantly modulated by the physical geography of the basin. Only the storms causing a substantial net gain of water behind the barrier islands can create severe surges there. Under the rotating wind fields of westward-moving depressions, the timely alignment of wind direction and tidal inlets is one key to piling-up considerable volumes of water against the coast.

4. Conclusions

The surge severity in the DWS is not solely a response of the water mass to shearing winds. High wind speeds alone are neither necessary nor sufficient to cause, or expect, record-breaking surges.

The DWS itself drives both water storage and motion, thus effectively conditioning which storms result in a surge with a certain level of flood hazard, with possibly counter-intuitive outcomes.

Acknowledgements/Credits

This knowledge was gained during the preparative studies for the WTI (*Wettelijk Toetsinstrumentarium*) 2011 carried out by Deltares on behalf of Rijkswaterstaat. Alkyon Hydraulic Consultancy & Research BV prepared the assignments Lipari *et al.* (2008) and Lipari and van Vledder (2009) under the supervision of Jacco Groeneweg of Deltares. Since 2010 Alkyon HC&R is a trading name of Arcadis Nederland BV.

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Tidal flow separation at the Sand Motor

Max Radermacher[1], Matthieu de Schipper[1], Wilmar Zeelenberg[1] and Ad Reniers[1,2]

[1] Faculty of Civil Engineering and Geosciences, Delft University of Technology, M.Radermacher@TUDelft.nl
[2] Department of Marine and Coastal Systems, Deltares

1. Introduction

The Sand Motor mega-nourishment at the Delfland coast in the Netherlands acts as a large coastline perturbation, which has an impact on waves and currents. The alongshore tidal flow contracts around the protrusive shape of the nourishment, which might give rise to flow separation and the creation of eddies in the lee of the Sand Motor. Shallowness, unsteady tidal flow (Signell and Geyer, 1991) and the presence of spatial density gradients (Souza and Simpson, 1997) constitute a complex flow field.

As part of the MegaPEX2014 field campaign, numerous measurements of the tidal flow field were obtained, using in-situ as well as remote sensing techniques. This study presents a subset of these measurements, showing the presence of tidal flow separation north of the Sand Motor during the flood phase of the tide.

2. Methodology

A set of GPS-tracked drifters was deployed around the tip of the Sand Motor. Furthermore, a nearshore grid of Acoustic Doppler Current Profilers (ADCP's) was deployed (stations A5 and B3 indicated in Figure 1) and combined with data obtained from two long-running ADCP stations further north (stations E and F).

Next to these in-situ measurements, remote sensing data were obtained from an X-band radar station at Kijkduin, just north of the Sand Motor.

3. Results

Drifters deployed near the tip of the Sand Motor during the flood period of the tide are found to be transported off-shore with the main flow, indicative of a large recirculation zone (see Figure 2). This view is supported by oppositely directed alongshore flow velocities at ADCP stations A5 and B3. Also at stations E and F, recorded flow velocities show signs of disturbance of the flood flow by the presence of the Sand Motor. Time-averaged backscatter values obtained with the radar, although of a qualitative character, are of great help in interpreting the in-situ observations and coupling them to the flow separation process occurring at a larger scale.

At the conference we will also show that the freshwater lens, discharged from the river Rhine and transported with the flood current, interacts with the separating flow field.

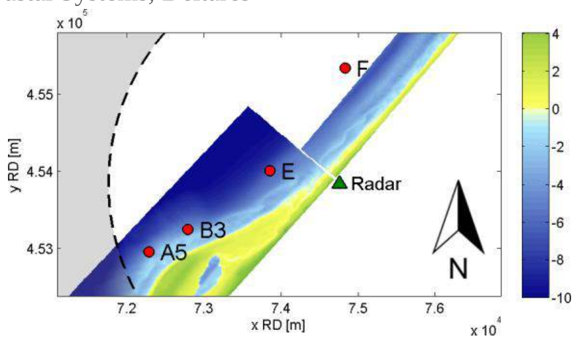

Figure 1: ADCP stations (red dots) and radar station (green triangle; range indicated with dotted line), which were deployed during the MegaPEX2014 field campaign. Colors represent bed level in m with respect to N.A.P.

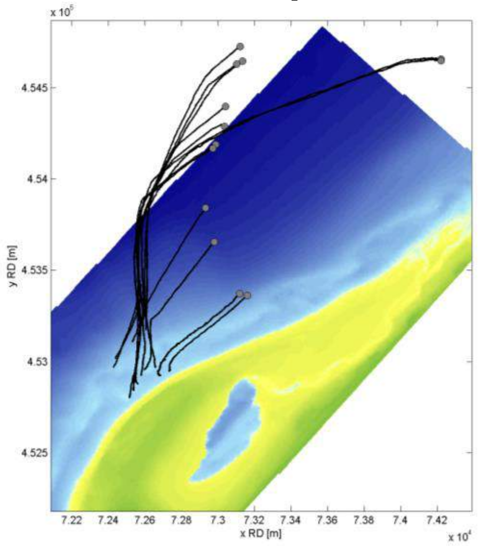

Figure 2: Drifter tracks recorded during the flood period on October 1st, 2014.

Acknowledgements

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Observations of turbulence in the periodically-stratified Marsdiep basin

Jurre J. de Vries[1], Herman Ridderinkhof[1] and Hendrik. M. van Aken[1]

[1] Royal Netherlands Institute for Sea Research, jurre.de.vries@nioz.n

1. Introduction

Turbulence is an important factor in estuarine hydrodynamics, because it impacts the shape of the vertical profiles of velocity, which is important for the residual current structure. Furthermore, it determines the vertical distribution of suspended matter and thereby contributes to their net transport. In estuaries, tidal currents and density gradients are connected to turbulence through several complicated feedback mechanisms, illustrating the diverse role turbulence plays in estuarine dynamics (*Stacey et al., 2011* and references therein).

In this study, observations of turbulence production and dissipation, collected during neap and spring tide conditions, are presented and linked to the estuarine circulation dynamics. *De Vries et al.* (2015) observed flood stratification at the study site, which might alter the turbulence and estuarine circulation dynamics.

2.Methodology:

A bottom frame, equipped with an Acoustic Doppler Current Profiler and a Temperature, Conductivity, Depth sensor, is deployed in the main channel of the Marsdiep basin during a neap and a spring tide.

A variance method is used to estimate the Reynolds stresses which, in combination with the vertical shear in velocity, yields the turbulence production. Furthermore, the turbulence dissipation rate is estimated with a structure function method.

3. Results

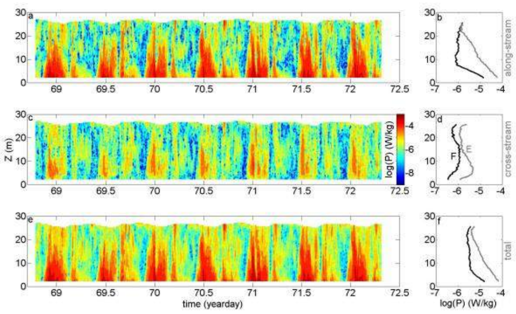

Figure 1: Along-stream, cross-stream and total turbulence production (upper, middle and lower row, resp.) during spring tide conditions. The right column indicates flood(F)- and ebb(E)-averaged profiles.

Figure 1 shows the turbulence production during spring tide conditions. Turbulence production is greatest in along-stream direction during ebb, due to the presence of the largest currents. However, a large contribution of the cross-stream component is evident during late flood and peak ebb, demonstrating that cross-stream production is also important.

Figure 2 shows average profiles of total turbulence production and dissipation, illustrating a balance between both. Production and dissipation only balance each other when cross-stream production is included, which accounts for 30 to 50 percent of the total turbulence production.

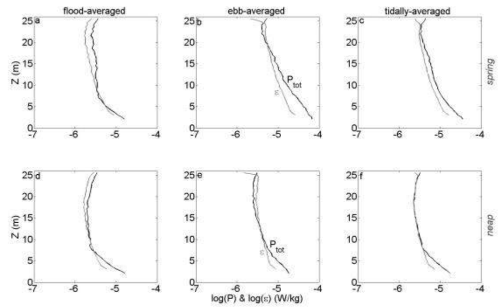

Figure 2: Flood-, ebb- and tidally-averaged profiles of total turbulence production, P_{tot}, and dissipation, ε, (left, middle and right column, resp.) during spring and neap tide (upper and lower row).

4. Conclusions

The observations show that turbulence production in the Marsdiep basin is not only generated by near-bed vertical shears in along-stream velocity, but also by internally-generated cross-stream shears in velocity. A balance between production and dissipation rate is only present when the cross-stream production is included, which accounts for 30 to 50 % of the total. Despite the presence of an ebb-dominant asymmetry in vertical mixing, a classical estuarine circulation is observed which increases towards spring tide. The generation of estuarine circulation is hypothesized to occur predominantly during the long period of weak mixing during late flood.

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Turbulence and sand suspension events in the surf zone of a field-scale laboratory beach

Joost Brinkkemper[1] and Gerben Ruessink[1]

[1] Department of Physical Geography, Utrecht University, j.a.brinkkemper@uu.nl

1. Introduction

The surf zone is characterized by the presence of breaking waves and bores, generating turbulent vortices travelling from the surface downwards. These vortices can reach the bed and suspend sand intermittently (Nadaoka et al., 1988). The timing of these suspension events in the wave phase, for both short-waves and infragravity-waves, determines whether they enhance onshore or offshore transport of sand. In this study, the coherence between turbulence and suspension events, as well as their coupling with wave orbital motions, is investigated using field-scale laboratory measurements collected during BARDEXII.

2.Methodology:

The BARDEXII experiment was conducted in the Delta flume in 2012. The experimental set-up consisted of a 4.5m high and 75m wide sandy barrier, with a beach slope of 1:15. This study focuses on the data collected by four rigs located across the surf zone, including measurements of turbulence, sand suspension, flow velocities and ripple characteristics. The location of wave breaking was estimated from images recorded by an Argus style camera. A wide range of hydrodynamic conditions and water levels during the experiment resulted in a breaking wave fraction between 0 and 0.5 at the location of the turbulence rig.

Figure 1: Wave breaking on the location of the turbulence rig during BARDEXII.

3. Results

Both turbulence intensities and sediment concentrations are phase-coupled with the short-wave and the infragravity-wave orbital motion. The highest values in the short-wave phase are found while the wave motion is in the onshore direction. This in contrast to the coupling with the infragravity-wave phase, for which highest values are found while the orbital motion is in the offshore direction (Figure 2). Wave-by-wave analyses show more intense suspension and turbulence events beneath broken waves than beneath non-broken waves, but the intensity of these events is not correlated, i.e. higher turbulence events do not consistently result in higher suspension events.

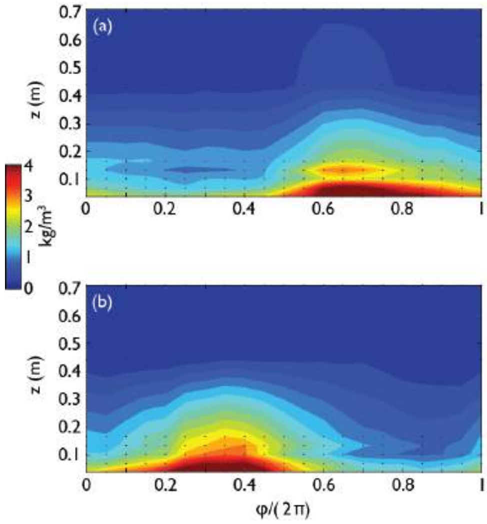

Figure 2: Phase-coupling of the sediment concentration with (a) short-wave and (b) infragravity-wave cross-shore motion. In both panels, 0.25 represents the maximum in offshore and 0.75 the maximum in onshore velocity.

4. Conclusions

Although turbulence and suspension events are on average occurring in the same wave phase, no coherence between the intensity of individual events was found in the collected data. This does not implicate that this coherence is non-existent, but rather that wave-averaged studies of sand transport are more suitable for field and field-like measurements.

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Bed-level motions and sheet-flow processes in the swash zone

Joep van der Zanden[1], José M. Alsina[2], Iván Cáceres[3] and Jan S. Ribberink[1]

[1] University of Twente, j.vanderzanden@utwente.nl; j.s.ribberink@utwente.nl
[2] Imperial College, j.alsina@imperial.ac.uk
[3] Universitat Politècnica de Catalunya (UPC), i.caceres@upc.edu

1. Introduction

The swash-zone is a highly dynamic area with large sediment fluxes within a shallow, transient water layer. Connecting the surf zone to the beach, the swash is a relevant area for coastal morphology. Obtaining high-quality measurements in the swash has been proven challenging. Therefore, the complex physical processes driving sediment transport in the swash are poorly understood. We present results of recent large-scale wave-flume experiments, focusing on sheet-flow sediment transport in the swash zone.

2.Methodology:

Experiments were done in the CIEM wave flume at UPC, Barcelona. The campaign focused on the role of grouping period on near-shore morphology and sediment transport processes. Here we present results for one erosive condition, involving a bichromatic group (period T_{gr}=15 s) propagating from a water depth of 2.48 m towards a constantly sloping (1:15) beach built with medium sand (D_{50}=0.25 mm).

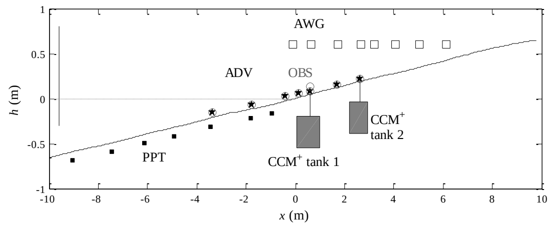

Figure 1: Overview of instrumental set-up.

Figure 1 shows the instrumental set-up close to the shoreline. Along the surf and swash zone, the evolution of the wave groups (water levels) is measured through a series of Pore Pressure Transducers (PPTs) and Acoustic Wave Gauges (AWGs). Water velocities (ADVs) and sediment concentrations (OBSs) measure sediment fluxes. Of particular notice are two recently developed CCM$^+$ tanks, that can be used to measure bed-levels and sediment concentrations in the sheet-flow layer.

3. Results

Figure 2 shows the ensemble-mean results for two characteristic wave groups in the lower swash. The intra-wave bed-level varies, with net erosion during uprush and net accretion during the backwash. Despite hydrodynamics being largely similar, the groups show substantial differences in terms of magnitudes of the bed-level changes. Sheet-flow transport can be identified during uprush and backwash. The time-variant bed-level and absence of upper sheet-flow layer mark clear differences from oscillatory sheet-flow studies.

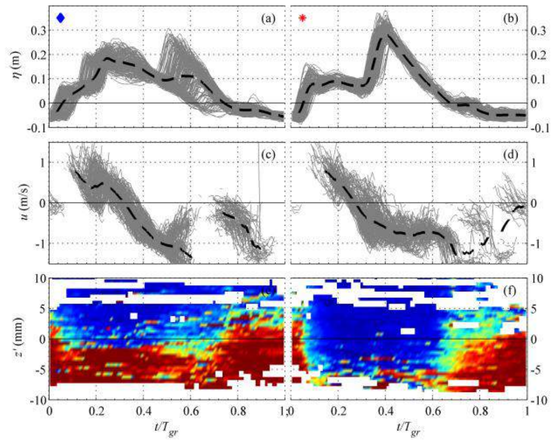

Figure 2: Ensemble-mean results for two characteristic wave groups (left & right). (a,b) Water surface levels η; (c,d) horizontal water velocities u; (e,f) time-varying concentrations in the sheet-flow layer at heights z' w.r.t. group-averaged bed-level.

4. Conclusions

We present for the first time simultaneous bed-level and sheet-flow measurements for a continuous swash cycle. Sheet-flow dynamics in the swash differ from oscillatory flow conditions, with (i) a time-variant intra-group bed-level and (ii) absence of typical upper sheet-flow behaviour. Both observations are likely due to the strong flow non-uniformity in the swash, as a result of which horizontal advective processes dominate local sheet-flow layer dynamics.

Acknowledgments

The experiments were funded by the EU through the HydraLab IV access program. The CCM$^+$ instrumentation was developed within the SINBAD project, funded by STW and EPSRC.

The Influence of Spatially Varying Supply on Coastal Aeolian Transport: A Field Experiment

Bas Hoonhout[1,2], Sierd de Vries[1] and Nickolas Cohn[3]

[1] *Department of Hydraulic Engineering, Delft University of Technology, Stevinweg 1, 2628CN Delft, The Netherlands. b.m.hoonhout@tudelft.nl*

[2] *Unit of Hydraulic Engineering, Deltares, Boussinesqweg 1, 2629CN Delft, The Netherlands.*

[3] *College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, 104 CEOAS Admin Building, OR 97331, Corvallis, USA. cohnn@geo.oregonstate.edu*

1. Introduction

Supply-limiting factors, like moisture content and sediment armoring, influence coastal aeolian sediment transport and subsequently dune evolution significantly. We organized a 6-week field experiment on the influence of spatiotemporal variations in supply on coastal aeolian sediment transport at the Sand Motor, The Netherlands. Due to the presence of a strongly curved coastline and complex intertidal bathymetries, a large spatial variation in supply is to be expected at the Sand Motor, which makes the area particularly suitable for a field experiment on this subject.

2. Hypotheses and objectives

The objective of the field experiment is to validate assumed relations between the spatiotemporal gradients in wind-driven sediment fluxes, sediment size distribution of the top layer of the beach, moisture content, topography and wind velocity and direction. The main hypothesis we formulated reads:

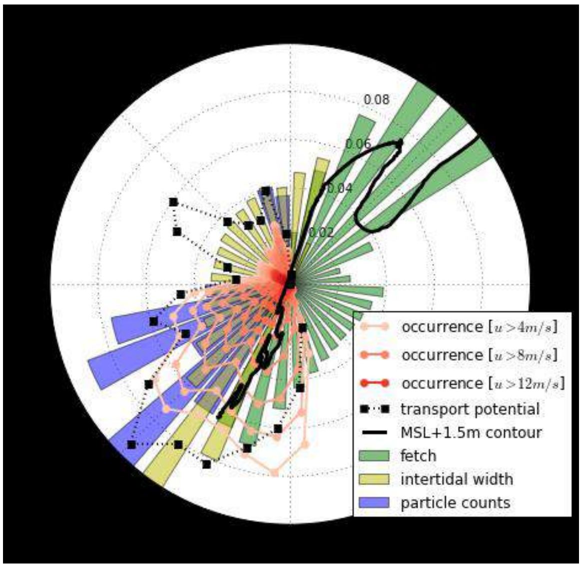

Figure 1: Distribution of wind and potential aeolian sediment transport. Particle counts coincide with directions where potential transport and intertidal beach width are significant. Note that bar plots are not to scale.

"*The intertidal beach is the most important source of sediment for coastal aeolian transport and subsequently dune growth*."

3. Equipment and deployments

A flexible measurement set-up was used consisting of 8 masts with battery power and data loggers. Each mast could be equipped with a Gill 2D WindSonic ultrasonic wind speed and direction sensor at a height of 1.8m above the bed, a Trime PICO32 soil moisture sensor buried in the soil horizontally and multiple Wenglor laser sensors for saltation measurements at variable heights. The Wenglor laser sensors registered passing particles of 50 µm and larger with a frequency of 10 kHz using a laser beam of 0.6 mm.

4. Results

Figure 1 shows the distribution of the wind over the directions and the resulting potential sediment transport based on the generally assumed relation between sediment transport (q) and wind velocity (u) q~u!. The peaks in potential transport only partially coincide with the particle counts near the high water mark, namely in those directions where the source area consists largely of intertidal beach. Furthermore, the northwesterly storm event that caused a significant maximum in wind velocity and potential transport did not result in a maximum in particle counts due to flooding of the intertidal beach and hence a significant decrease of supply. These preliminary results show that not the largest surface area of sand, nor the biggest fetch or the most severe storm result in significant aeolian sediment transport events, but persistent moderate winds over large intertidal beaches are the key to coastal Aeolian sediment transport. These results support the hypothesis that the intertidal beach is the most important source for aeolian sediment transport.

Acknowledgments

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Modelling the bio-geomorphological evolution of coastal dunes

Joep Keijsers[1], Alma de Groot[2], Michel Riksen[1]

[1] Soil Physics and Land Management group, Wageningen UR (joep.keijsers@wur.nl)
[2] IMARES, Wageningen UR (alma.degroot@wur.nl)

1. Introduction

Coastal dunes are dynamic features, rapidly evolving in response to a host of bio-geomorphological processes acting at different scales. This complexity limits our ability to predict effects of management interventions or environmental change on dunes. As a first step towards a predictive model, we (1) investigated historical fluctuations in dune size; (2) studied interactions between vegetation and sedimentation patterns on foredunes and (3) used these results to improve and test a cellular dune-beach-vegetation model (DUBEVEG).

2.Methodology

The study is focused on the barrier islands in the North of The Netherlands. The JARKUS database and aerial photographs were used to construct a detailed view of foredune topography and vegetation cover. Rijkswaterstaat's Waterbase and KNMI repositories were used to obtain information on tides, meteorology and climate scenarios.

3. Results

3.1 Fluctuations in dune size

Fluctuations in dune size are largely related to storm surge events. Dune erosion is more severe and more frequent where fronting beaches are narrow and steep and less frequent where wide beaches absorb the wave energy. When major storms are absent, there is much unexplained alongshore variance in the levels of sand input towards the dunes (Keijsers et al, 2014).

3.2 Sedimentation and vegetation patterns

The distribution of aeolian sand over the foredune is strongly related to the vegetation pattern (Figure 1).

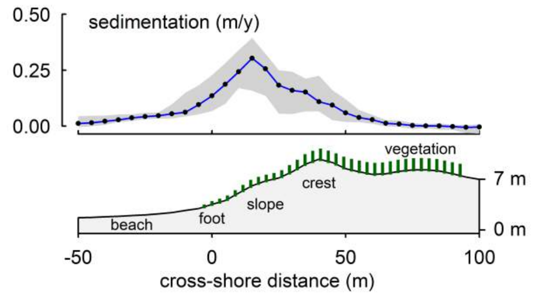

Figure 1. Sedimentation profile across foredunes on Ameland, 2002 to 2011. Average of 17 profiles.

Higher vegetation cover is able to trap a larger fraction of the passing sand, although even a full cover is not able to trap all of it. Maximum sedimentation generally occurs within 20 m of the vegetation's seaward limit. In turn, vegetation patterns were found to evolve slowly in two dominant modes: (1) establishment of new patches near the dunefoot; and (2) lateral expansion of existing patches. We could not identify a clear correlation between the level of sedimentation and the degree of vegetation expansion (Keijsers et al, 2015).

3.3 Modelling dune evolution

The results were used to improve and calibrate the Wageningen beach-dune model DUBEVEG. The dune evolution trajectory depends strongly on the timing of storm surge events. After simulating many possible storm-recovery sequences, we found that a dune develops towards an equilibrium cross-shore position, where storm erosion and recovery are roughly balanced. Nevertheless, at any time, the momentary dune-foot position may strongly deviate from this equilibrium.

Simulations with KNMI climate scenarios over the 2000-2050 period indicate that dunes respond by gradually retreating landward. For extreme scenarios of sea-level rise and increased drought, outside the KNMI ranges, rapid transitions occur from stable, vegetated dune ridges to mobile transgressive ridges.

4. Conclusions

Although dune evolution is a result of complex bio-geomorphological interactions, the limited set of rules in the DUBEVEG model performs well in reproducing the decadal scale dynamics of foredunes.

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Habitat Selection of Juvenile Sole: Consequences of Shoreface Nourishment

Marjolein H.M. Post[1], Martin J. Baptist[1], Ewout Blom[1], Loes Bolle[1]
[1] Institute for Marine Resources and Ecosystem Studies (IMARES), The Netherlands. Marjolein.Post@wur.nl

1. Introduction

The coastal sea of the Netherlands is a highly productive environment that provides nursery grounds for many flatfish species, such as plaice and sole (Teal and Van Keeken, 2011). The necessary increase in shoreface nourishment frequency and volumes in this area is likely to affect this nursery function (Baptist et al., 2012). Important habitat conditions can be altered, including coarsening of the sediment, thereby affecting the burial ability and habitat preference of flatfish. This study will analyse sediment type preference by juvenile sole in order to understand the effects of shoreface nourishment on their presence in the shallow coastal zone.

2.Methodology:

2.1 Species

Juvenile sole were reared in captivity at 17°C without the presence of sediment to avoid familiarization with grain size in an early stage. Juvenile length ranged from 42-89 mm representing settlement size of sole.

2.2 Laboratory setup

Sediment preference was determined in a circular preference chamber, following the design by Myrick et al. (2004). The preference chamber assured constant water conditions with a temperature of 11°C; the temperature in the Dutch shallow zone during settlement in early May. Four different sediment classes were distributed in a gradient over 8 compartments of equal size. To account for any spatial preference caused by external environmental conditions, the distribution of sediment classes was rotated every 24 hours with a full dark-light cycle. Each trial was repeated with 80 sole. Sediment preference was assessed by the final numbers of sole present in very fine (63-125 µm), fine (125-250 µm), medium (250-500 µm) or coarse (500-1000 µm) sand compartments. Their lengths were measured to account for any length-dependent sediment selection.

3. Results

Preliminary results show a preference for finer sediment (63-125, 125-250 µm) by juvenile sole (Figure 1). There was no apparent size-dependent preference for grain size (42-89 mm TL).

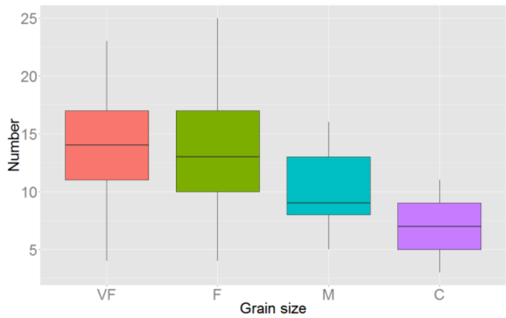

Figure 1: Sediment preference of juvenile sole

4. Conclusions

The study shows that juvenile sole have a preference for finer sediment types. This grain size preference might result in changes in their spatial distribution, but will also depend on other habitat conditions. The findings of this study will be used in habitat models. Habitat models are necessary to determine factors of importance for the settlement, growth and abundance of juvenile flatfish. These will offer an understanding of the effects of nourishments and will contribute to the development of nourishment strategies that enable the preservation of the shallow coastal sea nursery function.

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This project is funded by STW and the Nature Coast consortium.

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Ecosystem-based design rules for sand extraction sites on the Dutch Continental Shelf

Maarten F. de Jong[1], Martin J. Baptist[2], Bas W. Borsje[3]
[1]IMARES Wageningen UR, maarten.dejong@wur.nl
[2]IMARES Wageningen UR, martin.baptist@wur.nl
[3]Deltares, Bas.Borsje@deltares.nl

1. Introduction

The Dutch authorities promote extraction depths over 2 m to guarantee sufficient supply of sand. We investigated short-term ecological impact of deep (-20 m) sand extraction and ecological landscaping in the Maasvlakte 2 borrow pit.

2. Results

Macrozoobenthic biomass increased 5-fold in the deepest areas compared to reference areas and species composition changed to white furrow shell (*Abra alba*). Macrozoobenthos correlates with sediment characteristics and bed shear stress [1,2,3]. Demersal fish biomass increased 20-fold and plaice (*Pleuronectes platessa*) became dominant instead of Dab (*Limanda limanda*) [2].

3 Eco-based design rules

Based on τ, distinctions can be made between macrozoobenthic assemblages [1,2,3]. For future borrow pits, sediment characteristics are lacking but τ can be calculated (Equation 1 or Delft 3D approach). Based on the bed shear stress, two main assemblages can be distinguished (the *Abra alba* assemblage and the *Eteone sp. - S. bombyx* assemblage). The first assemblage occurs at $\tau <$ 0.37 Nm^{-2} and the second at $\tau >$ 0.49 Nm^{-2} [4]. We developed eco-system based design rules to reach a bed shear stress of 0.35 Nm^{-2} using equation 1 and a certain current velocity (U) and pre-dredged water depth in order to give space to both macrozoobenthic assemblages [1,5].

$\tau_{b\ no\ pit} = \rho_{seawater} * g * \frac{U^2}{C^2}$ (Equation 1)

It is recommended to use 3D in later design phases for more accurate τ values.

4. Conclusions

Borrow pits with τ ~0.35 Nm^{-2} can enhance biodiversity and alleviate adverse effects compared to maximum extraction depths. Ecological landscaped sand waves can be used to influence τ and enhance habitat heterogeneity. Below τ = 0.35 Nm^{-2}, an increasing dominance of brittlestars (Ophiuroids) may be expected [3]. Demersal fish composition and biomass returned to pre-dredged levels in the deepest parts (44 m) which coincided with a local high sedimentation rate (0.75 m y^{-1}) and high abundance of brittlestars [4].

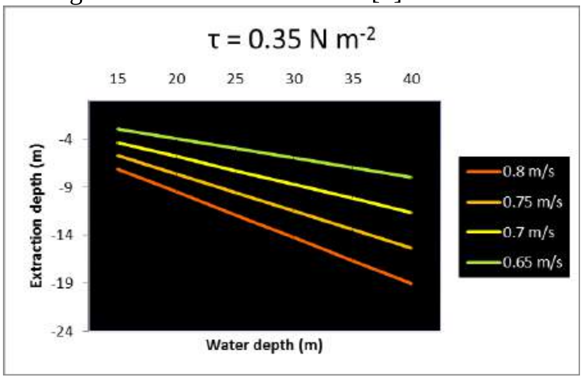

Fig. 1: Eco-system based design rule to reach 0.35 Nm^{-2} under different water depth and current velocity scenarios.

Acknowledgments

We wish to thank Building with Nature, Ad Stolk (Rijkswaterstaat), Boskalis and Van Oord, Port of Rotterdam, NIOZ, IMARES, fieldworkers and GO29.

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Contrasting spatiotemporal trends in salt-marsh development of the Mokbaai, Texel, The Netherlands

Martin J. Baptist[1,2*], Willem E. van Duin[1], Alma V. de Groot[1], Sjors E.A. Treffers[2] and Cor J. Smit[1]

[1] Institute for Marine Resources and Ecosystem Studies (IMARES), The Netherlands. Martin.Baptist@wur.nl
[2] Van Hall Larenstein University of Applied Science

1. Introduction

Salt marshes have profound biogeomorphic feedback processes (Baptist 2005). The objective of this study is to determine the spatiotemporal developments in the Mokbaai salt marsh over a 30 year period, and to explore possible causes for change.

2.Methodology

2.1 Salt-marsh vegetation

Salt-marsh vegetation was mapped approximately every six years as part of the VEGWAD monitoring programme of Rijkswaterstaat. The maps are based on 1:50,000 aerial photographs and vegetation recordings that serve as ground truth. Vegetation maps of the study area are available from 1985, 1994, 1999, 2005 and 2011 (Pranger & Tolman 2013).

2.2 Surface elevation

Surface elevation was derived from a number of sources. In 1983 bathymetric measurements of the intertidal area of the Mokbaai were carried out by Rijkswaterstaat. High-resolution elevation data were obtained in 2010 through LiDAR by Rijkswaterstaat. The depth of the navigation channel was surveyed in 2010 by Shore monitoring for (NIOZ). Additional elevation measurements were done in April 2013 on the intertidal flats and salt marsh.

3. Results

The salt marsh showed mainly succession in the 1990s. From 1999 onwards two contrasting trends occurred. The central low marsh zone showed regression to pioneer zone and even to pre-pioneer zone. Simultaneously, the south-western edge showed a succession to high and brackish marsh zone and then to climax vegetation with reed (Figure 1).

Over the past 30 years an erosion of 15-25 cm occurred in the intertidal area in front of the salt marsh. This explains why the pioneer zone has given way to the development of a pre-pioneer zone. Based on a simple sediment balance of the Mokbaai, it is likely that the trapping of sediment in the channel and harbour basin, combined with the maintenance dredging, resulted in a reduced availability of sediment in the back of the bay.

The succession into a climax vegetation with *Phragmites australis* that occurred in large parts along the south-western edge of the marsh was associated with increasing freshwater seepage from the bordering dunes.

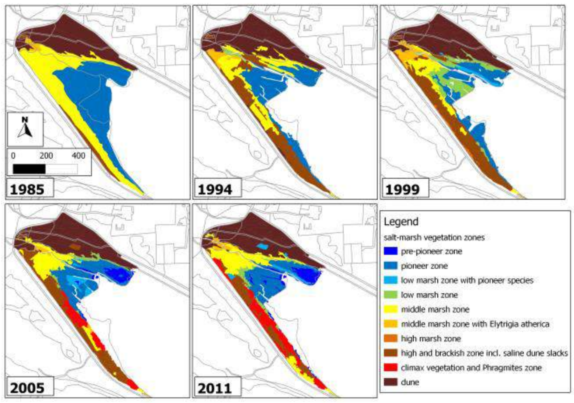

Figure 1: Salt-marsh vegetation zones from 1985 to 2011. Data from Rijkswaterstaat.

4. Conclusions

We found contrasting trends in spatiotemporal developments of the Mokbaai salt marsh over a 30 year period. Both trends could be linked to two independent processes.

Acknowledgments

We thank the National Park Service of the Dunes of Texel, Rijkswaterstaat, the Water Board Hollands Noorderkwartier and the Ministry of Defence. Many thanks go to students of the 2013 Summer School of the Netherlands Centre for Coastal Research (NCK) Maria Ibanez, Giorgio Santinelli, Rooney Mathew and Saulo Meirelles for explorative data analyses.

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Biogenic structures on intertidal flats enhance retention at local and landscape scale

Sil Nieuwhof, Jim van Belzen, Bas Oteman, Johan van de Koppel, Peter Herman, Daphne van der Wal

Spatial Ecology Department, Royal Netherlands Institute for Sea Research (NIOZ Yerseke), sil.nieuwhof@nioz.nl

1. Introduction

Mussels and oysters are ecosystem engineers, in that these species are able to build hard biogenic structures on otherwise soft bottom sediments. Such structural change has important consequences for ecosystem services, such as wave attenuation and the retention of water, nutrients and fine sediments. Retention of e.g. water and fine sediments is important for the functioning of coastal systems, because it drives community composition by creating different habitats. Yet, little is known about how large the footprint of biogenic structures is on retention.

2. Methodology

We used a combination of remote sensing techniques and generic modeling to understand how the interplay of added biogenic structure and the underlying landscape determines the retention capacity at multiple spatial scales.

2.1 Local effects

We scanned 3 intertidal shellfish reefs and the surrounding mudflats using a terrestrial laser scanner. An algorithm (Knecht et al., 2012; Schrenk et al., 2014) was used on the rasterized data to determine the potential water retention relative to surface area for bare mudflat and shellfish patches (see Fig 1.).

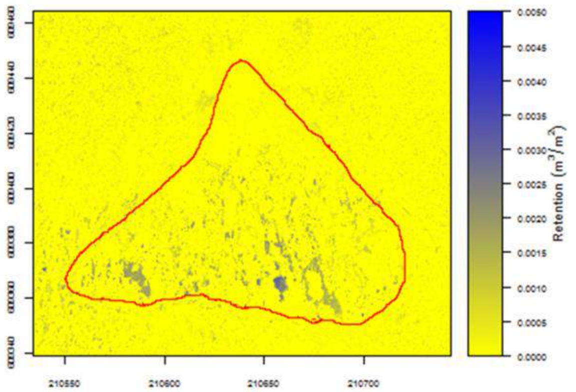

Figure 1: Potential retention pools inside and outside a musselbed (delineated by a red line)

2.2 Large scale effects

Shellfish areas were located using Synthetic Aperture Radar satellite imagery. LIDAR bathymetry maps were used to study potential retention at basin scale, both for bare mudflat and for shellfish dominated areas. A generic retention model was constructed to see how retention depends on both landscape characteristics and different configurations of biogenic structure added by ecosystem engineering shellfish.

3. Results

The terrestrial laser data showed higher water retention capacity on shellfish beds compared to bare mudflat. This was also reflected by remote sensing data, at a larger scale (Fig 2.).

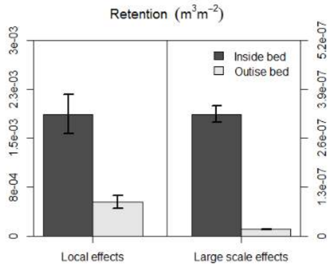

Figure 2: Retention differences between shellfish dominated zones and bare mudflat at local scale (left panel) and basin scale (right panel)

4. Conclusions

On intertidal flats the potential for water retention is greatly enhanced by reef building shellfish, locally as well as at the basin scale. Strikingly, shellfish reefs enhance retention even at low densities, and this effect is largest on relatively flat landscapes. Our results provide valuable new insights into the importance and context dependence of biogenic structure to landscapes.

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Physical forces and ecosystem engineers can act in synergy in displacing 'living particles': evidence from seed burial in tidal flats

Zhenchang Zhu[1], Francesco Cozzoli[2], Tom Ysebaert[1], Peter M.J. Herman[1] and Tjeerd J. Bouma[1]

1 Spatial Ecology Department, Royal Netherlands Institute for Sea Research (NIOZ), Yerseke 4400AC, The Netherland, zhenchang.zhu@nioz.nl

2 Department of Biological and environmental Sciences and technologies, University of Salento, 73100, Lecce, Italy

1. Introduction

Physical processes e.g. hydrodynamics are known to be tightly coupled with ecosystem engineering in shaping sediment dynamics in coastal landscape (Corenblit et al,. 2011). Yet it is unclear whether and how biophysical coupling drives the movement of particles of a biological signature such as seeds. We address this question by investigating the interactive effects of currents and ecosystem engineers on seed burial of a common salt marsh pioneer in tidal flats.

2.Methodology:

Manipulative experiments: annular flume and mesocosm experiments (Figure.1).

Target ecosystem engineers: four common benthic animals in the NW European tidal flats with different engineering modalities were employed.

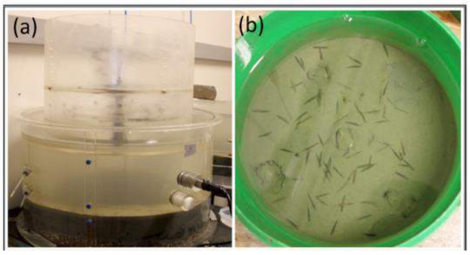

Figure.1. Experiment units: (a) annular flume, (b) bucket in the mesocosm

3. Results

Our results showed that water flow can be of equal or higher importance than ecosystem engineers for seed burial (Figure. 2). For passive seed-burying engineers (PSE), their coupling with currents produced synergistic seed burial effect, while it was additive for active seed-burying engineers (ASE). Quantity of biophysical burial differed between PSE species due to species-specific variability on sediment reworking ability and was affected by total biomass of the PSE species considered.

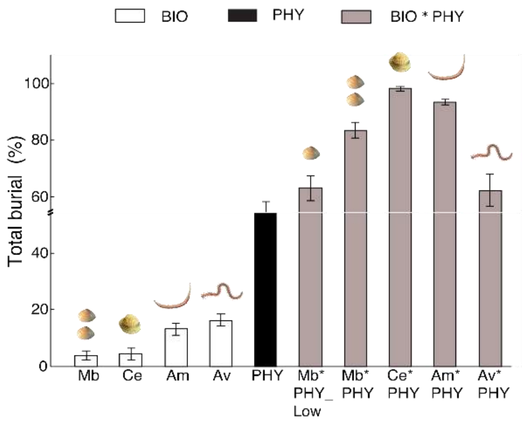

Figure. 2: Proportions of seeds (Mean ± SE, n=4) that were buried for all the treatments of BIO (animals only), PHY (currents only) and BIO * PHY (coupling between animals and currents)

4. Conclusions

Physical forces and ecosystem engineers can act in synergy in driving the vertical movement of the living particles 'seeds', depending on the functional properties of the ecosystem engineers. This study highlights the role of biophysical interaction in shaping ecological process in coastal systems.

Acknowledgments

We thank J. Soelen, L. van IJzerloo, J. van Dalen, H. Cheng, T. Hong and Q. Zhu for field assistance, and thank THESUES project and China Scholarship Council for funding.

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Coastal morphological monitoring at Rijkswaterstaat

Niels Kinneging and Albert Mulder[1]

[1] Rijkswaterstaat WVL
niels.kinneging@rws.nl, albert.mulder@rws.nl

1. Introduction

Rijkswaterstaat is responsible for the national monitoring programme for water management. This programme involves monitoring for water quantity, water quality and morphology. This abstract focusses on the morphological monitoring.

2.Monitoring strategy

Rijkswaterstaat has organised its monitoring according to the monitoring cycle. Various needs for information need to be supported by the programme. For the monitoring of elevation in total 28 information needs were identified (see Mansholt et al, 2011). For the coastal data these were:

- maintenance of the basic coast line
- input for models for storm search warnings
- assessment of coastal defense
- morphological research

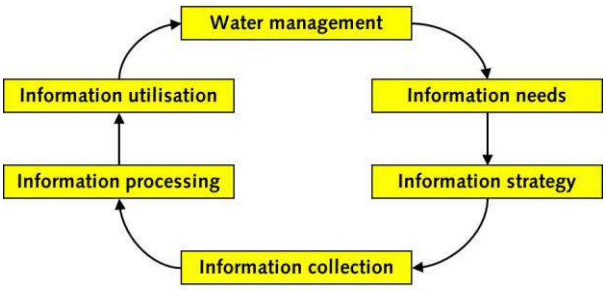

Figure 1: Monitoring **cycle.**

3. Monitoring programme

The monitoring programme for the coastal zone consists of two major components, the Jarkus programma and the 'vaklodingen'.

In the Jarkus programme the near coast zone, the beach and the first line of dunes are measured yearly. From a trend analysis on the profiles the sand nourishment for the coming years derived.

In the 'vaklodingen' the coastal system is measured up to the -20m NAP line. The deeper area of the NCP is measured by the Hydrographic Office of the Ministry of Defense. The monitoring frequency of the 'vaklodingen' varies from once every 3 years for dynamic areas like the Eastern Scheldt to once every 6 years for the Wadden Sea.

In figure 2 the coastal monitoring programme is depicted.

Figure 2: Schematic overview of coastal monitoring by Rijkswaterstaat.

4. Techniques

Monitoring the shallow coastal zone, including dry zones like plates and beaches, require a combination of different techniques.

Rijkswaterstaat makes use of single and multibeam echosounders for the submerged areas and LIDAR for dry areas. The planning of the activities is carefully tuned to the local tide. In that way an overlap in the data from echosounders and LIDAR can be obtained.

4. Conclusions

The data from the Rijkswaterstaat monitoring programme prove to be very valuable for various application.

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Monitoring the Sand Motor with TerraSAR-X satellite data

Elena Vandebroek[1], Roderik Lindenbergh[2], Freek van Leijen[2], and Matthieu de Schipper[2]
[1] U.S. Fulbright Fellow and Environmental Science Associates; elena.vandebroek@gmail.com
[2]Delft University of Technology; r.c.lindenbergh@tudelft.nl, f.j.vanLeijen@tudelft.nl,
m.a.deschipper@tudelft.nl

1. Introduction

The Sand Motor is a massive (~1 km^2) beach nourishment project on the coast of South Holland. Completed in 2011, it is an innovative and economical approach to shore protection. Natural processes, like waves, wind, and tides, distribute the sand to adjacent beaches, with less beach habitat impacted during construction. The dynamic nature of the Sand Engine requires that it be closely monitored to understand its evolution. Currently, a variety of expensive and time-consuming monitoring techniques are implemented on a monthly basis. Meanwhile, a radar satellite, TerraSAR-X, collects a high-resolution (3x3m) and cloud-penetrating SAR image of the Sand Motor every 11 days. This study investigates whether waterlines detected in TerraSAR-X imagery are accurate enough to monitor the Sand Motor and its influence on adjacent beaches.

2. Research Questions

Is it possible to accurately detect the waterline in TerraSAR-X imagery? Does the quality/success of waterline detection correlate with environmental factors (wave conditions, precipitation)? This study examines ~200 radar images, while previous studies analyze, at most, a few images. This enables us to examine the quality of the waterline extraction under a wide range of environmental conditions. Previous studies (Rijkswaterstaat 2006, Robinson 2011) propose methods to detect the waterline in radar imagery, but none identify what waterline is being detected. Is it the current water level, mean high waterline, extent of wave run-up, or a previous high tide? Are the image resolution and detection algorithm accurate enough to answer this question?

3. Methods

Various image filtering, classification, region growing, and georectification techniques are used to extract waterlines from a time series of TerraSAR-X images (2011 to 2014). At the Sand Motor, extensive monitoring makes it possible to quantify waterline accuracy using bi-monthly RTK-GPS topography surveys and nearby wave and tide measurements.
Comparison with survey data allows excellent validation of SAR waterlines (Figure 1).

4. Results

It is possible to extract waterlines from TerraSAR-X imagery using a series of image processing steps. These radar-derived waterlines align well with contour lines extracted from GPS survey data at the tide elevation during image acquisition. Quality of the detected waterlines depends on environmental conditions, especially wind speed and wave height.

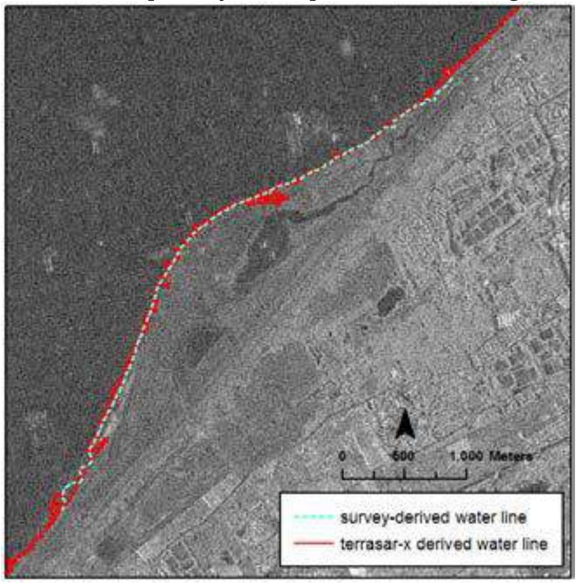

Figure 1: Comparison of surveyed waterline and a waterline derived from a TerraSAR-X image

5. Conclusions

While TerraSAR-X data does not yet provide the same level of detail as GPS surveys, it may be a more affordable monitoring approach for locations where similarly frequent/extensive monitoring is not feasible. The restrictions, level of accuracy and the shoreline dynamics for the Sand Motor will be discussed in detail at the conference.

Acknowledgments

This work is supported by the Netherlands America Foundation and the Fulbright U.S. Student Program.

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Validation of the North Sea Storm Surge Atlas by hindcasting historical storms

J. Klein BSc[1], dr. ir. M. van Ledden[2,3], dr. ir. H.W. van den Brink[4], ir. N.J.F. van den Berg[2], dr. ir. P.C. Roos[1] and prof. dr. S.J.M.H. Hulscher[1]

[1] University of Twente, j.klein-1@student.utwente.nl
[2] Royal HaskoningDHV
[3] Delft University of Technology
[4] Royal Dutch Meteorological Institute

1. Introduction

Current storm surge forecasting is often carried out with detailed real-time computer modelling. These models are accurate, but also computer intensive with long calculation times. Also, the forecast horizon is short and the possibilities for scenario assessment are limited.

In 2013 a North Sea Storm Surge Atlas was developed by Royal HaskoningDHV, KNMI and Deltares, which uses a new and innovative method to predict storm surges in the North Sea area. As such, it provides quick insight of storm surges for five to ten days ahead, based on a large offline database of predefined and precalculated storms, rather than performing all calculations real-time.

This research focuses on the validation and uncertainty identification of two possible algorithms for the Storm Surge Atlas. This is done by hindcasting 33 historical storms and comparing these simulations to observed water levels.

2. Methodology

The Storm Surge Atlas uses a weather forecast consisting of pressure fields. A large database of predefined storms with precalculated storm surges is used for the forecasting of storm surges.

At this moment two possible algorithms exist to use this database for prediction of storm surges. The first method (A) is based on finding a best matching pressure field in the database and using the precalculated surge as surge prediction. The second method (B) uses a linear regression model. The direct correlation between spatial patterns in the pressure fields in the database and the precalculated surges are used to calculate the predicted surge from the forecasted pressure fields.

To assess the performance of both Storm Atlas methods, 33 historical storms have been selected and hindcasted. The performance assessment is done for 11 locations, of which 5 are located at the North Sea coast of the United Kingdom and 6 at the Dutch coast. A comparison between method A and B is then made for the performance on peak water level, duration of the storm water level and timing of the peak.

Furthermore, sources of uncertainty are identified and classified in order to focus the improvement of the Storm Surge Atlas.

3. Results

Table 1 shows an overview of the performance of both Storm Atlas methods. In general, the results show that method A performs slightly better. When looking more in-depth to the results of peak water levels, we see that method A has a more structural underestimation with less variability, whereas method B has a larger variability in under- and overestimation.

	Method A	**Method B**
Peak water level [m]	0.46	0.50
Duration [hours]	1.10	1.70
Timing [hours]	9.87	10.07

Table 1: Root mean squared errors of the simulated and observed water levels

The size of the database and the quality of the pressure fields as input data have been identified as major sources of uncertainty and therefore as focus points for improvement of the Storm Surge Atlas.

4. Conclusions

It can be concluded that the North Sea Storm Surge Atlas is a tool which is able to reproduce historical storm surges quite well, with large time savings compared to real-time modelling. The North Sea Storm Surge Atlas can be a valuable addition in the field of storm surge forecasting, e.g. for scenario analysis, quick assessments of possible developments of a storm.

It is recommended to work further with the Storm Atlas method A, based on finding a matching pressure field.

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On the sand exchanges between the Scheldt estuary and its ebb-tidal delta: An idealized model study

Abdel Nnafie[1], Tomas Van Oyen[1], Bart De Maerschalck[1], Toon Verwaest[1], Jebbe van der Werf [2], Mick van der Wegen[2], Julia Vroom[2] and Marcel Taal[2]

[1] Flanders Hydraulics Research, Berchemlei 115, B-2140 Antwerp, Belgium, E-mail: abdel.nnafie@mow.vlaanderen.be

[2] Deltares, P.O. Box 177, 2600 MH Delft, The Netherlands

1. Introduction

The morphology of the Scheldt mouth is characterised by an extensive shallow area, which is flanked by two deeper (shipping) channels (Dumon et al. 2006, Kornman *et al.*, 2000). As such, the morphology of this region echoes the characteristics of an ebb-tidal delta.

The Scheldt ebb-tidal delta has a great ecological and economical value. Knowledge about the physical mechanisms that control its morphodynamic development and how it interacts with the estuary is still lacking. As a first step towards a better understanding of these mechanisms, this contribution focuses on the residual sediment exchange between the Scheldt estuary and its mouth.

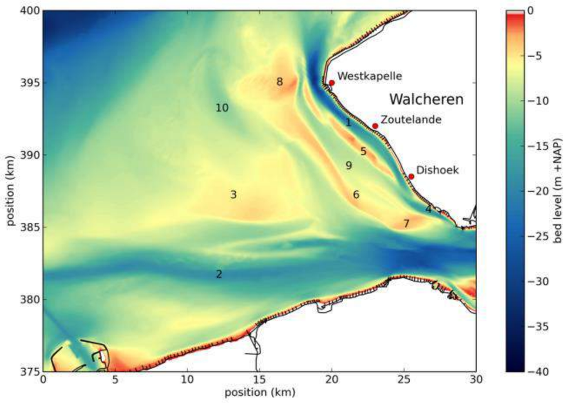


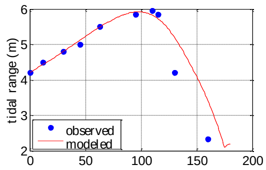
Figure 1: Bathymetric map of the Scheldt mouth.

2.Methodology:

An idealized 2DH numerical model is used for this study. The geometry of the estuary is that of an estuary with a converging width. In the default setting, the water motion is forced by prescribing an M_2 tidal component. First, the model is calibrated by comparing the amplitudes and phases of the tidal elevation and velocity with observations. Second, the tidally averaged residual sediment transport is computed for different parameters settings (geometry, bottom profiles, adding M_4 component..)

3. Results

…are presented here.



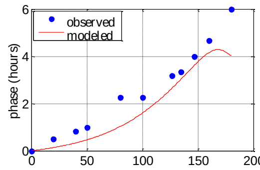


Figure 2: Left: Tidal range (m) vs. long-channel distance. Right: As in Left, but for the phase (hours).

- Tidal amplification/asymmetry occurs in the estuary in agreement with observations.
- Prescribing an M_4 component affects asymmetry of tidal velocity: net sediment exchange changes.

4. Conclusions

Preliminary results show that prescribing an M_4 tidal component has a great impact on the net sediment exchange.

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Morphodynamic evolution of large-scale radial sand ridges: a case study in Jiangsu coast, China

Jianfeng Tao[1], Zhengbing Wang[2] and Changkuan Zhang[1]
[1] State Key Laboratory of Hydrology-Water Resources and Hydraulic Engineering, Hohai University, Nanjing, 210098, China. Emaill: aoetao@hhu.edu.cn, ckzhang@hhu.edu.cn
[2] Deltares, Delft, 2600 MH, The Netherlands. Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, 2600 GA. Email: Zheng.Wang@deltares.nl

1. Introduction

As the largest-scale sand ridge systems along the Chinese coast, the radial sand ridges (RSRs) (Figure 1a) is located on the seabed of the southern Yellow Sea with a radiative fan-shaped channel-ridge pattern with a central angle of about 150° (Wang et al., 2012).

In this study, using a state-of-the-art morphodynamic model, we try to address what are the factors determining the sizes and shapes of the RSRs and how do the large-scale sand ridges behave under different tidal forcing?

2. Methodology

In this study, the morphodynamic model Delft3D is employed. A total sediment transport formula developed by Engelund and Hansen (1967) is used. The configuration of the model is schematized as a fan-shaped domain with an angle of 150°, which has only an open boundary at seaward side. An orthogonal curvilinear coordinate is applied and the grid cell size ranges from 3.5 km × 4 km along open boundary to 150 m × 200 m at convergence side. The mean grain size of bottom sediment is 0.125 mm. The open boundary at the seaward side was imposed by M_2 tide, which is derived from the TPXO 7.2 (Egbert et al., 1994). Six cases are simulated to explore the sensitivity of model results to different tidal force of M_2 tidal constituent. Three cases are simulated to explore the influence by the Coriolis effect.

3. Results

Figure 1b shows the result of simulation morphology which is similar to the morphology of RSRs (Figure 1a). The tidal wave system changes obviously due to different tidal force, resulting in different morphologies. It seems that characteristics of the tidal system are the main factor determining the pattern of the sand ridges. Spatial variations of the phase and the amplitude are important, although the variation of the phase seems to be more important. The evolution of the channel-ridge patterns is different in different stages. The whole channel-ridges pattern evolves rapidly during the first 100 years. From 100 years to 400 years, the root-mean-square height increase slow down with an average growth rate of about 3.3×10^{-3} m/yr (i.e., about 1 m for 300 years). After 400 years, a slight increase in growth is observed. Noticeably, the magnitude of root-mean-square height increases just for 0.5 m from 400 years to 2000 years. The co-tidal map of M_2 constituent and the morphological evolution are very sensitive to the Coriolis force. The anticlockwise amphidromic moves northwest and the radial fan-shape channel-ridge pattern disappears as the Coriolis effect decreases.

4. Conclusions

In this study, the main features of the morphology of RSRs are well reproduced numerically. Tidal wave systems are the primary governing force for the morphology of RSRs. For large-scale and long-term simulations, the Coriolis' effect is important.

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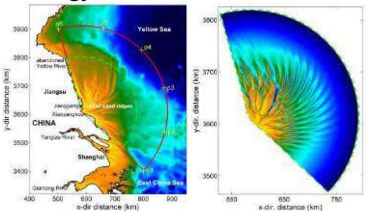

Figure 1: (a) Bathymetry of radial sand ridges; (b) Simulation morphology after 2000 years

Long-term bio-geomorphological modelling of the formation and succession of salt marshes

Ype Attema[1], Gerard Dam[2], Bram van Prooijen[3], Robert-Jan Labeur[4], Dano Roelvink[5],

[1] TU-Delft, Svasek Hydraulics; y_h_attema@hotmail.com
[2]Svasek Hydraulics, UNESCO-IHE, Dam Enginering; gerard.dam@damengineering.no
[3]TU-Delft; b.c.van.prooijen@tudelft.nl
[4]TU-Delft; r.j.labeur@tudelft.nl
[5]TU-Delft, UNESCO-IHE, Deltares; d.roelvink@unesco-ihe.org

1. Introduction

The interaction between vegetation and the morphodynamics is considered to be an important process in salt marsh formation and succession. Therefore, the inclusion of vegetation modelling on the long-term morphological development of salt marshes is assessed by implementing a vegetation growth model in the morphodynamic modelling software FINEL2d.

2. Approach

The vegetation growth model as proposed in Temmerman et al (2007) was implemented in the package FINEL2d. This allows for the simulation of the interaction between vegetation, hydrodynamics, sediment transport and morphology. The vegetation growth model of Temmerman is based on an increase of vegetation stem density by means of a random possibility of establishment in combination with reduction of stem density for severe flow conditions or too much inundation. A modification of this concept was made, following the Windows-of-Opportunity concept as proposed in Balke et al. (2011). By this modification, the establishment of vegetation depends on the inundation time and maximum bed shear stress.

The vegetation-growth models have been tested on a simplified small tidal basin to assess the performance and the sensitivity. Subsequently, these models have been employed to hindcast the formation and succession of "The drowned land of Saeftinghe".

The Saeftinghe case study results demonstrate that the proposed method can reproduce the development of channels, tidal creeks and tidal flats over a 100 year period, see Figure 1.

3. Conclusions

Two types of systems have been identified: In Type 1 vegetation is leading and morphological development follow, whereas in Type 2 the morphological development is leading and the vegetation follows. For Type 1, the exact development of vegetation growth is essential. In this type of system the vegetation growth determines the tidal creek pattern. On the other hand, for Type 2, as in the 'Saeftinghe' case, the contribution is less significant. This is reflected in the fact that there are minor differences in channel and tidal creek patterns between the bio-geomorphological simulations and the purely morphological model results.

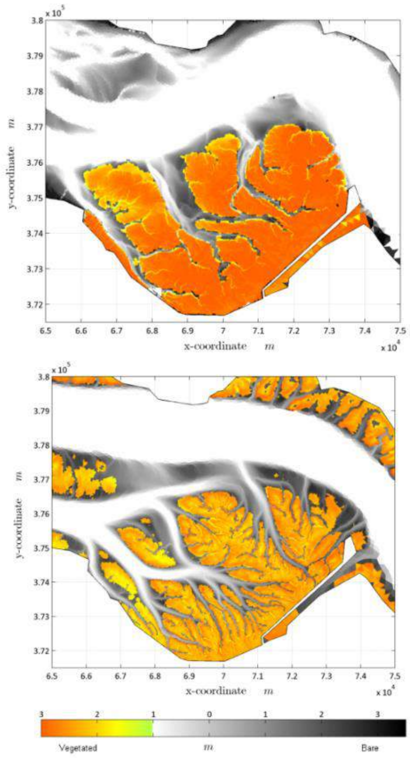

Figure 1: Bed level elevation and vegetation patterns for "Saeftinghe". *Upper:* Measured *Lower:* Modelled

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Division of net sediment discharge over bifurcations in tidal networks

N.C. Alebregtse[1, 2], and H.E. de Swart[1]

[1] Institute for Marine and Atmospheric research, Utrecht University, 3584 CC Utrecht
[2] E-mail: n.c.alebregtse@uu.nl

1. Introduction

Many tidal environments display bifurcations of the main channel near the ocean. The combination of river and tidal flow distributes sediment over the different branches. Knowledge on the distribution of sediment is important to assess the stability of the branches, as is well known from river bifurcations. However, due to the bi-directional tidal flow, it is not clear how the net sediment discharge is divided, and thus whether a branch will be stable.

Modeling morphodynamics on long timescales to assess channel stability is mostly done using idealized models, such as 1D network models. However, such models require a formulation for the distribution of sediment at a bifurcation, which have only been established for unidirectional flow (e.g. Wang et al., 1995). The aim of this study is to make the first steps towards such a formulation by investigating the division of net sediment discharge over a single bifurcation. This is done for a range of parameter settings (i.e. varying depth and settling velocity) using the numerical model Delft3D.

2. Domain

The left panel of Fig. 1 shows a top view of the bifurcation. The tidal network consists of one upstream branch, which represents the river, and two downstream branches connected to the sea. The geometry is the same as considered by Buschman et al. (2010), who studied the division of net water discharge at a tidally influenced bifurcation.

3. Results

The right panel of Fig. 1 shows the results of a scenario where the depth of branch 2 has been changed. It shows the net sediment discharge in branch 1 (solid line), 2 (dashed-dotted line), and 3 (dashed line) as a function of the depth in branch 2 for a settling velocity of 0.01 mm s^{-1}.

For a depth of 5 m the system is symmetric and branch 2 and 3 both transport half of the net sediment transport from upstream. However, for different depths in branch 2 this distribution becomes asymmetric.

Acknowledgments

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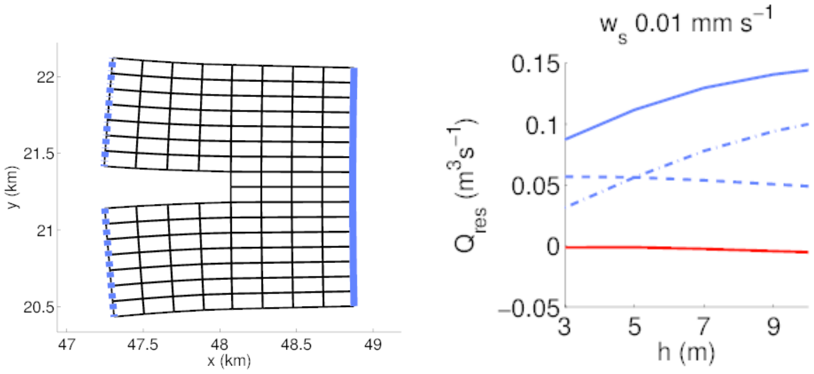

Figure 1: Left panel: top view of a bifurcation. Blue lines indicate cross-sections through which transports are computed. Upstream of the bifurcation is branch 1; downstream are branches 2 and 3. Right panel: Cross-sectionally integrated net sediment discharge in branch 1 (solid line), 2 (dashed-dotted line), and 3 (dashed line). The red line shows the net transport towards the vertex.

The influence of the beach profile on nonlinear infragravity-wave interactions

Anouk de Bakker[1], Marion Tissier[2] and Gerben Ruessink[1]

[1] Utrecht University, a.t.m.debakker@uu.nl and b.g.ruessink@uu.nl

[2] TU Delft, m.f.s.tissier@tudelft.nl

1. Introduction

Nonlinear triad interactions redistribute energy over the spectrum which transforms the shape of sea-swell waves (SS, f = 0.05 - 2 Hz) and generates energy at infragravity frequencies (IG, f = 0.005 - 0.05 Hz). IG waves are found to be important in the erosion of beaches and dunes during storms. Recently, it has been suggested that IG waves may lose energy by transferring it back to (former) SS spectral peak or by IG-IG transfers that cause IG waves to steepen and eventually break.

Here, we investigate energy transfer patterns for different types of beaches, using the model SWASH.

2.1 Model validation

Governing equations of SWASH are the non-linear shallow water equations and account for non-hydrostatic pressure (Zijlema et al. 2011). We validated SWASH using the high-resolution, small-scale, Globex laboratory dataset with a 1:80 sloping beach (Ruessink et al. 2013). The onset and amount of SS wave breaking are captured well. The IG-wave growth and arrest are well captured too, however their dissipation is slightly overestimated.

2.2 Nonlinear energy transfers

The bispectrum detects phase-coupling between the three frequency components in a triad. The imaginary part of the bispectrum shows the direction and relative strength of the energy transfers between the three frequencies. The nonlinear source term $\boldsymbol{S_{nl}}$ accounts for energy transfers to and from a frequency. $\boldsymbol{S_{nl}}$ is estimated by integrating the product of the imaginary part of the bispectrum and a coupling coefficient following Herbers et al. 2000.

To obtain insight in the different triad interactions, four bispectral zones are defined, with triads including either one, two or three IG-frequency components, and triad interactions solely between SS frequencies. For these four zones, nonlinear energy transfers are calculated and are compared for varying beach profiles, to study the effects of profile steepness and shape.

3. Results

Figure 1 shows the energy transfer patterns for a 1/50 uniform slope, separated into the four zones. Seaward, and in the outer part of the surf zone, transfers are dominated by SS-SS-SS interactions. Transfers involving IG waves (IG-SS-SS) cause growth of IG energy and broadening of the spectrum. Within the inner part of the surf zone, transfers involving two or more IG frequencies start to dominate and the energy transfers from low to high IG frequencies (IG-IG-IG).

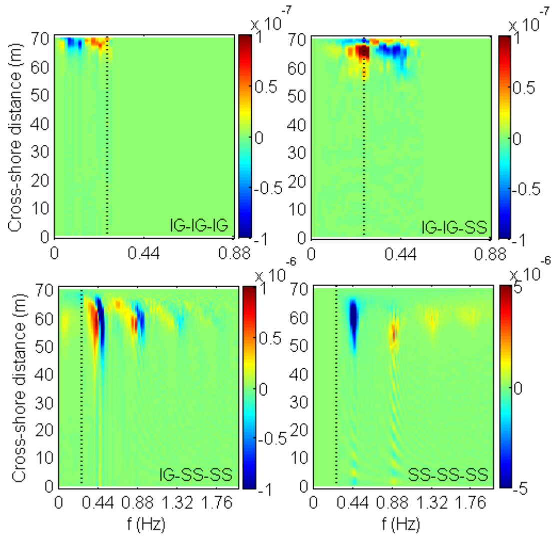

Figure 1: *Snl* plotted versus frequency *f* and cross-shore position *x*. With (a) IG frequencies only, (b) two IG and one SS frequency, (c) two SS and one IG frequency and (d) SS frequencies only. The dashed line indicates the boundary between IG and SS.

When comparing the above trend to other profiles, (steeper / gentler / convex / concave / sandbar) the steepness as well as the shape of the profiles is seen to influence the growth of the IG wave, and thereby also the trends and strengths of the triad interactions. For example, on steep beaches, SS waves dominate the entire surf zone, and IG interactions are relatively unimportant, whereas on gentle beaches the IG wave height grows considerably and dominates close to the shoreline, creating strong triad interactions involving IG frequencies.

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Turning the tide: Formation and behavior of tidal channels and bars in experimental estuaries

Bartels, P.C.J.[1], Kleinhans, M.G.[2]
[1] Utrecht University, P.C.J.Bartels@students.uu.nl
[2] Utrecht University, M.G.Kleinhans@uu.nl

1. Introduction

Ever since Van Veen (1950) described the different tidal channels in the Western Scheld, people have known of their existence. Ebb and flood use different tidal channels in an estuary, and form certain patterns to lead these different tides through. Ever since these patterns have been described it has been a mystery how these channels and bars form. Previously it was not possible for scientists to research this formation with something different than modelling, but with the introduction of the 'tilting flume' it has become possible to imitate tidal behaviour on an experimental scale. This research was done to try to find the factors determining the formation of tidal channels and whether they form an equilibrium or not.

Figure 1: Sketches of flanking (left) and forking tidal channel systems (right). Van Veen (1950)

2.Methodology: To mimic the tides in an experimental setup, a basin on a moving axis was used. By means of an extracting pole on one side of the basin it could tilt in a controlled way. The basin is filled with 4 cm layer of sediment (either sand or plastic) and two 'seas' on both ends of the basin. These ends also have the recharge and discharge of water into the basin, so that when the basin tilts to one side, it will be recharged from the other. This way a more or less constant water level is insured. Tidal amplitude and duration can be altered to research the effect of these tidal characteristics on the formation of tidal channels. In the layer of sediment an initial channel of varying width and depth is dug to channel the water through. Furthermore, this channel can be altered with a soft or hard perturbation.

3. Results

Figure 2 shows an example of a typical tidal experiment. Contrary to the sketches of Van Veen (1950) (figure 1) no clear singular patterns are seen. Experiments often displayed complex patterns with channels influencing the formation of others through the whole length of the estuary, something that is not unheard of in nature (Dalrymple and Rhodes, 1995). Particle tracking experiments did show though that tides preferred certain channels, where ebb chose different channels than flood. This already happens at the start of the experiments, where one tidal flow will create bars that obstruct and lead the other tide into other channels. Perturbing a channel may force a system to form channels, but the most natural ones form only when tidal amplitudes and initial width/depth ratios are right. Trying to predict the formation of well-developed channels proved to be a failure though. While shear stress and tidal amplitude play a large role in the formation of developed systems, both too large and too small magnitudes of the factors can prevent channels from forming.

Figure 1: End state of a tidal experiment done in sand.

4. Conclusions

Tidal amplitude is a most important factor in both the formation as the destruction of tidal channels.
Tidal bars form like river bars, only with different tides taking different channels.
Flanking and forking systems do not stand for certain characteristics: both systems can develop and disappear during the development of the estuary.
Prediction of the amount of channel formation still is something that need more research.

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Morphological monitoring of a swell-dominated coast in Ada, Ghana.

Annelies Bolle, Luciana Das Neves, Joris Rooseleer and Gijsbert Van Holland

[1] International marine and dredging consultants (IMDC nv) annelies.bolle@imdc.be, luciana.das.neves@imdc.be, joris.rooseleer@imdc.be and gijsbert.van.holland@imdc.be

1. Introduction

In 2010, the Ghanaian government decided to protect the coast in Ada, where the average rate of coastal retreat is locally more than 6 m/year. In total, a stretch of about 16 km will be defended with a combination of groynes and a beach nourishment. The project is split into two phases: first the groynes in the most critical stretch are built (finished in summer of 2013), then the remaining groynes and the beach nourishment are executed (currently ongoing). During the execution of this project extensive monitoring took place of coastal zone, in order to allow for detailed morphological studies. This paper discusses the main findings of this monitoring.

2. Environmental conditions

At Ada the average tidal range is about 1.0 m and almost no wind induced (storm) surge. The wave climate is swell dominated with occasionally a minor wind sea component. The longshore ocean-, wind- and tidal currents are relatively weak compared to the wave-induced longshore currents.

Figure 1 – Ada beach erosion and coastal protection

2. Morphological monitoring

2.2 Aim

The objective of the extensive ongoing monitoring campaign is to study the natural evolution and the governing coastal processes and to evaluate the effect of the groynes and the nourishment.

2.2 Measurements

Data for the morphological analysis come from different sources: classic topography and nearshore bathymetry, but also surf zone bathymetry from jetski surveys and aerial pictures from an unmanned aerial system are available. Wave heights are measured nearshore with a wave rider buoy. The big advantage of this dataset is the large period covered and the frequency of the measurements: basic data (topography and bathymetry, coastlines) are available for more than 5 years, whereas detailed data (such as a couple of jetski surveys, monthly or weekly beach profiles, 3-monthly aerial surveys and continuous wave data) are available for the last 2,5 years.

2.2 Analysis

The analysis is done on two levels: a general evolution of the coastline and morphology and a detailed evolution of beach profiles. The general evolution is based on analysing the changes in elevation, the volumetric changes and the coastline evolution. The profile analysis is based on analysing the evolution of a set of relevant parameters for the 120 profiles, monitored on a frequent basis.

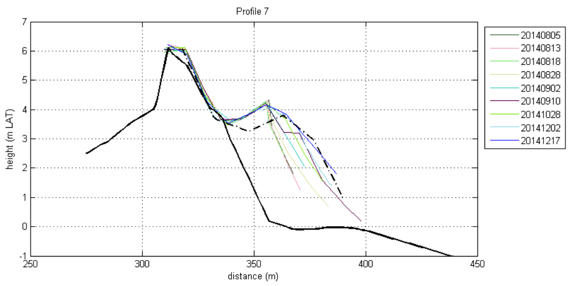

Figure 2 – Beach profile evolution after nourishment

4. Conclusions

The detailed dataset provided a valuable insight in the coastal processes and the beach profile behaviour under various conditions and different seasons. Beach erosion and restoration has been observed (and reproduced in for instance XBeach models (Gruwez et al, 2014; Verheyen et al., 2014), as well as the presence and impact of rip currents and nearshore bathymetric features on the coastline evolution. Moreover, the data now allow us evaluate the functioning of the new coastal protection system.

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Short-term mudflat dynamics drive long-term cyclic salt marsh dynamics: underlying mechanisms & implications for coastal defense

T.J. Bouma[1], J. van Belzen[1], T. Balke[2], Z. Hu[3], D.P. Callaghan[4], S. Temmerman[5], M.J.F Sitive[3], P.M.J. Herman[1]

[1] Royal NIOZ, The Netherlands – Tjeerd.bouma@nioz.nl, Jim.van.Belzen@nioz.nl, Peter.Herman@nioz.nl
[2] Oldenburg University, Germany – thorsten.balke@uni-oldenburg.de
[3] T. U. Delft, The Netherlands – zhan.hu@tudelft.nl, m.j.f.stive@tudelft.nl
[4] University of Queensland, Australia – dave.callaghan@uq.edu.au
[5] University of Antwerp, Belgium – stijn.temmerman@uantwerpen.be

1. Introduction

Coastal ecosystems may offer a valuable contribution to coastal defense (Temmerman et al. 2013). Recent flume measurements show that salt-marshes are even effective in attenuating wave energy under extreme conditions (Moller et al. 2014). However, in order to be able to use salt-marshes for coastal defense requires understanding their long-term persistence (Bouma et al. 2014).

An important threat of sea level rise to salt marshes may be posed by lateral erosion. We still lack mechanistic understanding of the processes controlling marsh edge dynamics: i.e., the on a decadal time-scale alternation between lateral marsh expansion onto the mudflat and lateral marsh retreat by cliff erosion. Our study aims to identify the mechanisms that control these marsh dynamics

2.Methodology:

By combining experimental field studies and mesocosm experiments, we identified the mechanisms underlying *i)* cliff formation on a previously lateral expanding marsh, and *ii)* seedling establishment in front of a retreating marsh-cliff

3. Results

In our presentation, we will elucidate how the short-term sediment dynamics at the mudflat (i.e., seasonal and shorter) is the mechanisms *i)* that initiate cliff formation on a previously lateral expanding marsh, and the mechanisms *ii)* that control seedling establishment in front of a retreating marsh-cliff.

4. Conclusions

Overall, present results imply that short-term (i.e., seasonal and shorter) sediment dynamics on the tidal flat determine the long-term (decadal and longer) cyclic behavior of the marsh edge. These findings have important implications for the best way of creating marshes for coastal defense purpose, and defining the most effective marsh management strategies and monitoring techniques.

Acknowledgments

We gratefully acknowledge financial support of STW-NWO grant 07324 and the EU-funded THESEUS project for funding our research to the application of salt marsh in coastal defense, which includes the unravelling of natural marsh dynamics.

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Turning the tide:
dynamics of channels and shoals in estuaries with sand and mud

L. Braat[1], J. R. F. W. Leuven[2], A. W. Baar[3] and M. G. Kleinhans[4]

Utrecht University, Faculty of Geosciences, Department Physical Geography
[1]L.Braat@uu.nl, [2]J.R.F.W.Leuven@uu.nl, [3]A.W.Baar@uu.nl, [4]M.G.Kleinhans@uu.nl

1. Introduction

Tidal systems such as the Ems and Scheldt estuaries and the Wadden Sea have perpetually changing and interacting channels and shoals of sand and mud, formed by ebb and flood currents. These morphologies have contradicting functions: Shoals that dry and flood daily are ecological valuable habitats, whilst channels have a multi-billion Euro impact as shipping fairways that provide access to harbours and urban areas. Currently worldwide sea level rise and dredging/dumping activities reduce the ecological important surface area of shoals, whilst increasing the risk of urban flooding.

Presently, models fail to adequately predict natural dynamics and the effects of human interference, making optimisation of management for the combined functions precarious. Furthermore, experimental scale models are controversial and rare for tidal systems and could, until now, not reproduce natural dynamics.

A large, unique, tidal facility is built based on a pilot setup that was the first to ever form dynamical channel-shoal systems (figure 1).

The main *objective* is to generate understanding of natural dynamics and response to human interference of channels and shoals in estuaries, and subsequently produce improved forecasting tools.

The *hypothesis* is that the natural dynamics are caused by sudden collapses of steep shoal and channel margins and sand transport processes on gentler slopes. These shoal breakdown processes are balanced by shoal build-up with a layer-cake of sand and mud. Together these processes govern the response to human interference.

2.Methodology:

For this study a research team is assembled that will do complementary *scale experiments* and *numerical modelling* (Figure 2).

The effects of sediment deflection on sloping beds will be studied by testing variations in flow velocity, helical flow and particle size. This is done by the use of experiments in an annular flume and numerical modelling. During modelling a transverse bed slope submodel will be tested in Delft3D.

A morphological model will be set up in which the effect of mud layers will be tested by implementing a sand-mud bed module in a Delft3D morphological model. Additionally, experiments will be performed in the tidal facility with and without mud to observe differences.

Experiments in the tidal facility will also be performed to test the effects of disturbances and their propagation in the system. Disturbances that are studied in particular are upstream river variations and dredging and dumping scenarios. These disturbances will also be modelled in the previous mentioned morphological model and analysis tools will be developed.

Throughout the study validated concepts from past river studies will be used and provide new insights in estuarine research. Furthermore, field data from Dutch and UK estuaries will be used to validate experimental and numerical model results.

Work on bank and shoal margin collapses and stratification for the petroleum industry will be done by two postdocs, positions that have not yet been filled.

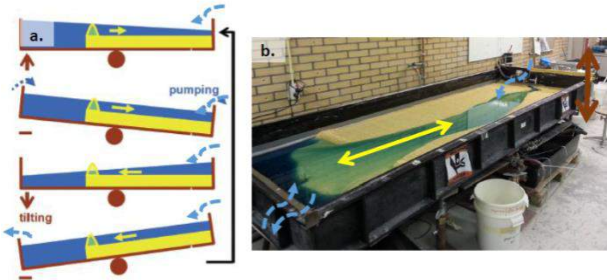

Figure 1: Pilot setup experimental tidal facility. a) schematic principle, b) experiment in progress.

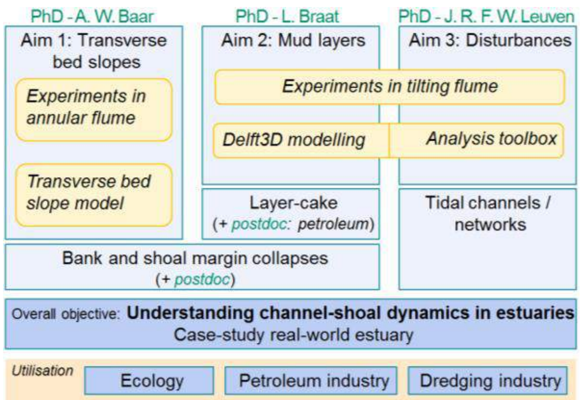

Figure 2: Organization chart

Assessment of hydrodynamics around permeable pile groins

Carolin Briele[1], Marije Smit[2], Daniël Dusseljee[2] and Marcel Zijlema[3]

[1] Formerly at Delft University of Technology, now at Fugro GeoServices B.V., C.Briele@Fugro.nl
[2] Witteveen+Bos Consulting Engineers, Marije.Smit@WitteveenBos.com/ Daniel.Dusseljee@WitteveenBos.com
[3] Delft University of Technology, M.Zijlema@tudelft.nl

1. Introduction

Permeable wooden pile groins have a long tradition as being part of the coastal protection in the Netherlands. They are generally built to protect beaches from eroding by reducing the (longshore) current velocity and thus the transport of sediments. However, scientific research is limited. This study (Briele, 2014) gives a range of boundaries under which these groins are applicable and their con-sequent effect on the flow field based on simplified generic cases. This is done by means of an inter-comparison of an analytical approach, the numerical wave-flow model SWASH (Simulating WAves till SHore) and laboratory experiments by Trampenau (2000). SWASH is being developed as a time-domain model and able to include various intra-wave transformations and wave interactions with amongst others currents and vegetation in coastal waters.

2. Methodology

The characteristics of the flow are investigated for scenarios on laboratory scale with current velocities in the order of 0.20 m/s, water levels around 0.10 m, piles with a diameter of 0.01 m and a groin permeability of 50 %.

Two different types of forcing are considered to study the impact of permeable pile groins on the hydrodynamics: The first forcing mechanism is a constant current that represents a realistic tide. A set of equations is derived based on the open channel flow equations with an additional resistance term based on Morison et al. (1950), and compared with the laboratory experiments and the SWASH model. The second forcing mechanism consists of breaking waves inducing a longshore current. The imposed regular, monochromatic waves are defined by a wave height of 0.05 m and a period of 1.23 s. SWASH results are compared to the laboratory experiments. Various scenarios of groin and wave characteristics not available as measurements are analysed numerically on the importance of the parameters.

3. Results

Permeable pile groins reduce current velocities in leeward direction of the groin while not altering the flow field significantly (Figure 1). Negative side-effects such as rip-currents windward of groins and an increased velocity in current direction just at the groin heads are less severe than in the presence of impermeable groins.

Good consistency is found between the results ob-tained in this study and the existing laboratory study by Trampenau (2000). The present study is able to provide insight into the flow field on a more detailed level than found in existing

literature. The numerical study further shows the importance of the relation of groin and wave characteristics. An important finding herein is the suitability of one groin setting for a wide range of approaching wave angles making this type of groin applicable for wider wave spectra. The results of all scenarios and further analyses will be presented at the NCK Conference.

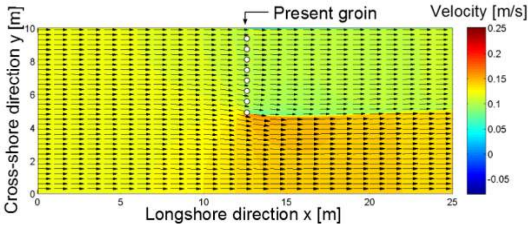

Figure 1: Flow field for a groin under current forcing (left to right).

4. Conclusions

Hydrodynamics around permeable pile groins can be computed with SWASH. Results based on the generic scenarios suggest that the usage of these groins can be favourable over impermeable groins and recommend further studies.

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Modelling of Grain Sorting Mechanisms for Natural and Nourished Beaches

Y. B. Broekema[1,2], A. Giardino[2], J.J. van der Werf[2], A.A. van Rooijen[1,2], B.C. van Prooijen[1] and M.J.F. Stive[1]
[1] Delft University of Technology, Delft, The Netherlands. yorick.broekema@gmail.com
[2] Deltares, Delft, The Netherlands

1. Introduction

Although sediment grain size in the nearshore area is known to be non-uniform, a uniform grain size is generally assumed in the implementation of coastal models (e.g. Delft3D) for predicting beach and shoreline evolution. Implementing non-uniformity may be relevant for the modelling of shoreface and beach nourishments, which generally consist of coarser material than the native beach sand. In this study a modelling approach was set-up to assess the effect of using multiple fractions on the simulated morphodynamics and to investigate sorting processes in the nearshore area.

2.Methodology

Experiments were performed in a large-scale wave flume in Hannover by the Joint Research Centre (JRC) of the European Union. This data was used to calibrate and validate a 2DV version of the process based Delft3D model, representing the wave flume. The model takes into account the effect of wave grouping and the accompanying long wave motion. Sediment was either represented by one single fraction or by 8 fractions, and spatial and temporal changes in bed composition were tracked with a multi-layered bed stratigraphy. The validated model of the wave flume was extended with different nourishment designs, based on studies of Vousdoukas et al. (2013) and Walstra et al. (2011).

3. Results

The model showed promising results, both in predicting morphological development over time and accurately computing sorting processes.

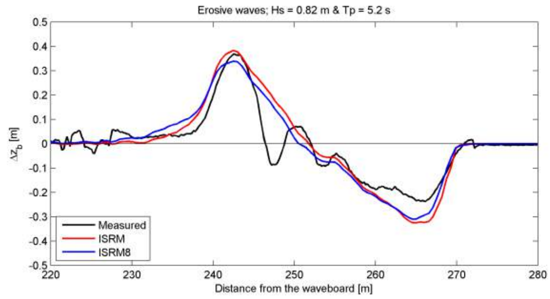

Figure 1: Measured (black) and computed change in bed level for a single fraction (red) and multi-fraction approach (blue).

Figure 1 shows that the effect of including multiple fractions is small. Both modelling approaches perform ‘good’ to ‘excellent’ in terms of Brier Skill Score, used to quantify the accuracy in bed level prediction. Figure 2 shows the corresponding change in median grain size. Modelled grain sorting at nourishments has also been confirmed by lab data.

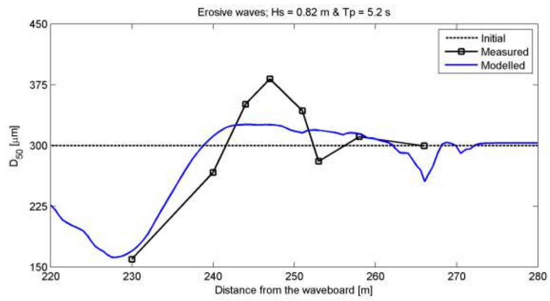

Figure 2: Measured (black) and modelled (blue) median grain size.

4. Conclusions

The study has shown consistency between model results, physical experiments and literature in terms of sorting processes. Based on the results from this study, the use of a multiple fraction approach has a limited effect on the morphological development. However, this approach can be relevant to assess the development of nourishments with a different grain size as well as the effects on other functions.

Acknowledgments

The authors would like to thank Michalis Vousdouskas (JRC) for the availability of the experimental data for this study and WVL (Rijkswaterstaat) for partly financing this work.

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The Bright Side of Mud

Jelmer Cleveringa[1]

[1] ARCADIS +31 6 5073 6850 Jelmer.cleveringa@arcadis.nl

1. Introduction

Safeguarding the shoreline of the Netherlands is the key element of the Dutch coastal policy. The preferred management strategy to achieve this goal is to maintain the sediment volume of the dunes, beach and shoreface with respect to the sea level through sand nourishments. This strategy is rooted in our understanding of the physics of the coast and adjacent tidal basins and estuaries. An essential element of that understanding is that the long term development of the coast is governed by the flux of sand from the coast to the tidal basins and estuaries.

2.Sediment budgets

Sediment budgets and calculations of sink and source terms are used to determine the sediment fluxes in and out of the compartments of the coast. Incorporating accelerated sea-level rise in sink and source calculations and numerical models give insight in the changes of the fluxes. The changes of theses fluxes are translated into the additional nourishments needed to maintain the sediment volume.

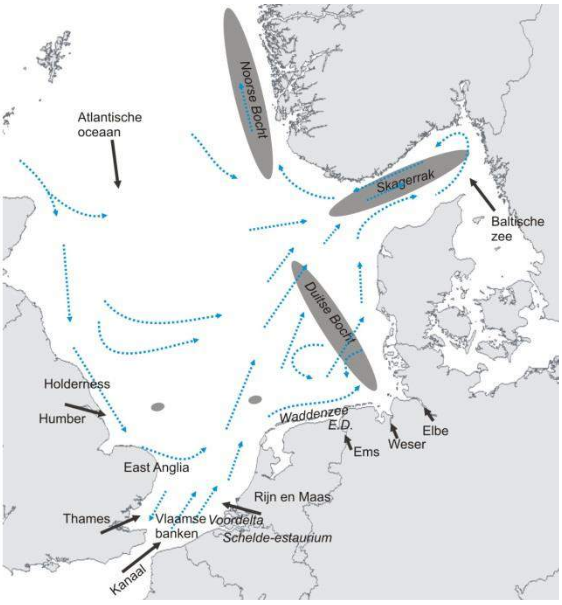

Figure 1: Sources, *sinks* and pathways for fine sediment along the North Sea Basin (after Eisma, 1981 and de Haas, 1997).

3. Lost in Translation

In the translation of the sediment fluxes to nourishment volumes the mud is often lost, resulting in the equation:

Sediment flux = Sand nourishment.

However, the mud that is deposited within the coastal system originates for the larger part from sources outside the coast (figure 1). This contrasts to the sand that originates from within the coastal system. The redistribution of the sand results in structural coastal retreat and is therefore the reason for nourishments.
The mud that is deposited within the coastal system does not require those nourishments. Incorporation of mud in the equation gives

Sediment flux = Mud deposition + Sand nourishment.

Rewriting the equation towards the management strategy results in:

Sand nourishment = Sediment flux – Mud deposition.

4. Conclusion

Mud is often a nuisance that hinders navigation, requires dredging and results in turbid conditions. Much time and effort is spend on the dark side of mud. On the bright side: nett sinks for mud are present in the Western Scheldt, Voordelta, Wadden Sea and the Eems-Dollard. The deposition of mud in these sinks may be more appreciated when its value of several million euros per year is regarded.

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A general model to assess benthic primary production in intertidal ecosystems

Tisja Daggers[1], Daphne van der Wal[1] and Jacco Kromkamp[1]

[1] Netherlands Institute of Sea Research (NIOZ), P.B. 140, 4400 AC Yerseke, The Netherlands

1. Introduction

Quantifying spatial variability in intertidal benthic primary production is necessary to guide management of estuaries. However, there is no general method to routinely assess intertidal benthic primary production at the macro scale. We expanded the 1D-model of Barranguet et al. (1998) to calculate intertidal benthic primary production rates using microphytobenthic biomass and mud content as input, which can be derived from satellite remote sensing.

Here, we present in situ measurements of the used model parameters and application of the model on a site in the Western Scheldt. Currently, we are working on upscaling of the model to the entire estuary, using algae biomass and mud content derived from satellite imagery.

2.Methodology

Microphytobenthic production mainly occurs in the upper 2 mm of the sediment. We divided the upper 2 mm into 200 sub layers and calculated primary production rates using the formula of Barranguet et al. (1998). Light attenuation was estimated using stepwise linear regression from grain size and chlorophyll-a concentrations (Jacco Kromkamp, unpublished data). Parameters of photosynthetic activity ($P_{\max}$, α) were derived from the fluorescence signal of the algae (rapid light curves, PAM fluorimetry).

To gain insight in spatial variability of photosynthetic parameters, we made rapid light curves (PAM) on four grids in the Scheldt delta. In addition, we studied temporal variation in photosynthetic parameters by measuring photosynthetic activity during one tidal cycle on two sites in the Western Scheldt.

2.3 Equations

Carbon fixation in each layer was calculated according to the formula of Barranguet et al. (1998): to which we added a respiration rate (Forster and Kromkamp 2006):

$$P = \left[P_{\max} * \tanh^{\alpha * \frac{E_{(\mathrm{PAR})}}{P_{\max}}} - \mathrm{RES}\right] * Chl \quad (1)$$

P = net hourly carbon fixation rate (mg C m^{-2} h^{-1})
$P_{\max}$ = photosynthetic capacity (mg C mg^{-1} chl *a* h^{-1})
α = photosynthetic efficiency (mg C mg^{-1} chl *a* h^{-1} [µmol photon m^{-2} s^{-1}]$^{-1}$)
RES = respiration rate (mg C mg^{-1} chl *a* h^{-1})
E(PAR) = photosynthetically active irradiance (µmol photon m^{-2} s^{-1})

Vertical chlorophyll-a distributions were calculated as a function of sediment type (Jesus et al. 2006):

$$\mathrm{Chl}\ a_{(\mathrm{accumulated})} = \frac{d}{d_{max}} + \mathrm{mud}\left(1 - \frac{d}{d_{max}} - e^{-2ed/d_{max}}\right)$$

d = layer depth (mm)
d_{max} = maximum depth (mm)
mud = percentage of < 63 µm particles

3. Results

Photosynthetic parameters were highly variable within grids (figure not shown). The observed variability was not related to elevation, sediment type, light intensity or algae biomass. Time series measurements showed that photosynthetic parameters do not vary as a function of emersion duration, but high variability within replicates was observed (figure not shown). Modelled primary production rates did not change significantly over time (Figure 1).

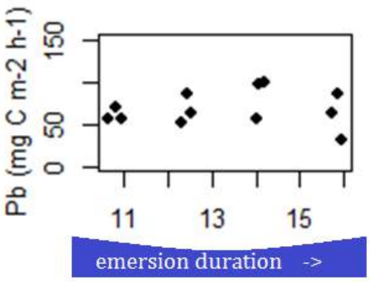

Figure 1: Modelled primary production rates in time based on PAM measurements at a site on the Biezelingse-Ham (Western Scheldt).

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Erosion of the Lower Sea Scheldt explained

Gerard Dam[1], Tim van Dam[2] and Bram Bliek[1]

[1] Dam Engineering, UNESCO-IHE; gerard.dam@damengineering.no
[2] Hogeschool Rotterdam; timvandam.92@gmail.com
Svašek Hydraulics; bliek@svasek.com

1. Introduction

The Lower Sea Scheldt upstream of Antwerp is part of the Scheldt estuary. In the past 5 decades significant erosion up to 7m has occurred in this part of the Lower Sea Scheldt. In the same period the tidal range has increased significantly. No maintenance dredging takes place in this part of the Lower Sea Scheldt, however in this research the hypothesis is investigated that human activities downstream of Antwerp are the cause of this erosion.

2.Methodology

The 2D process-based morphodynamic model FINEL2d is used to investigate the hypothesis. The model first needs to be set-up and calibrated. The model includes part of the North Sea, the Western Scheldt and the tidal rivers in Belgium and is driven by tidal boundary conditions. For the calibration the observed erosion from 1960 – 2010 is hindcasted. The model is calibrated on (observed changes in) tidal waterlevels, morphodynamic changes, and dredging volumes (The model has a dredging module).

Figure 1 shows the modelled and the observed erosion pattern for the 1960-2010 period. The model has a Brier-Skill Score of 0.58 for the morphological developments, which means that the model scores very well to calculate the observed erosion. Erosion volumes are predicted very well by the model as well as dredging volumes in the downstream part of Antwerp. The increase in tidal range of several dm over this 50 years is predicted well by the model.

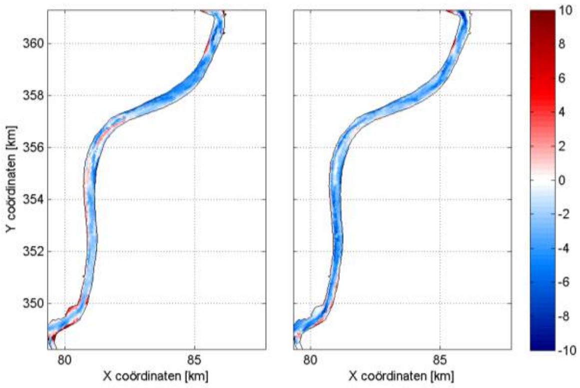

Figure 1: Erosion from 1960- 2010 in meters. Left: FINEL2d model; Right: observed erosion.

3. Scenarios.

Using the calibrated morphological model 3 extra scenarios have been defined, see Table 1. The T0 scenario is the calibrated run of the model in which human impacts have been carried out like reality. The T1 run is without any human activity, The T2 scenario is an extreme sand mining scenario, in which maintenance dredging is not dumped back into the system. Finally in the T3 scenario no deepenings of the navigational channel have been carried out (in reality in the '70's , the '90's and recently in 2011).

Scenario	Description
T0	Current situation, human impacts as reality
T1	As T0, but without any human impact
T2	As T0, but no dumping of maintenance dredging
T3	As T0, no deepenings; maintain 1960's depth

Table 1: Scenario definition

The scenarios show that human activities are clearly responsible for the increased tidal range in the Lower Sea Scheldt: the more human activities (dredging, deepening and sand mining) the more the tidal range increases. The net sand transport at Antwerp is also clearly affected by human activities: the more human activities downstream of Antwerp, the more net sand transport is directed downstream. This 'pulling' of the sand transport however is also felt upstream of the area of interest, so that the gradient of the sand transport (which causes the erosion) remains more or less the same. This makes that for all scenarios more or less the same erosion in the Lower Sea Scheldt (upstream of Antwerp) occurs, even for the scenario without any human activities. The erosion therefore cannot be contributed to human activities, but is a natural phenomenon of the system itself.

Towards a classification of the morphological development of intertidal flats: a comparison between the Eastern and Western Scheldt.

Lodewijk de Vet[1,2], Bram van Prooijen[1] and Zheng Bing Wang[1,2]

[1] Delft University of Technology; p.l.m.devet@tudelft.nl, b.c.vanprooijen@tudelft.nl.
[2] Deltares; zheng.wang@deltares.nl.

1. Introduction

The Eastern and Western Scheldt are two adjacent estuaries, which are both strongly affected by human interventions, see Figure 1. In the Eastern Scheldt, the storm surge barrier led to a substantial reduction of the tidal range. In the Western Scheldt, dredging works cause an ongoing deepening of the navigation channels. In this research, morphological data of both estuaries is studied to get to a morphological classification of the response of intertidal areas to these interventions. To obtain a better fundamental understanding of the system, a comparison of data to existing conceptual theories is made.

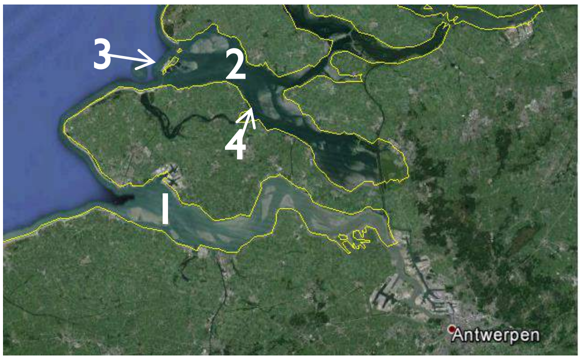

Figure 1: Location of the Western Scheldt [1], the Eastern Scheldt [2], the storm surge barrier [3] and the Galgeplaat [4] (Source: Google Earth).

2. Results

A clear change in shape of some of the intertidal flats is observed after the Eastern Scheldt was closed by the storm surge barrier in 1986. Figure 2 shows the morphological evolution of the northern section of the Galgeplaat. The profile evolves clearly from a convex-up profile towards a concave-up profile. Friedrichs (2011) states that a concave-up equilibrium profile is associated with a relatively large wave forcing. By the presence of the storm surge barrier, the wave forcing did indeed increase relatively to the tidal forcing, as the tidal amplitude was reduced. Also other features mentioned by Friedrichs are observed in the Eastern Scheldt estuary: by the relatively large importance of waves, some profiles are retreating (e.g. near the Anna Jacoba Polder).

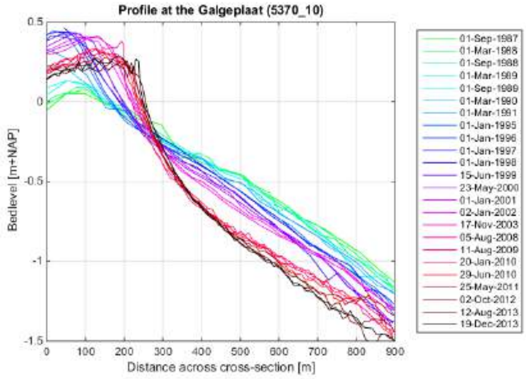

Figure 2: Profile evolution at the northern face of the Galgeplaat, measured with RTK gps (Source data: personal communication, Rijkswaterstaat, 2014).

The theory of Friedrichs (2011) does not explain all morphological changes in the system, partially because it only considers equilibrium profiles. For example: the steepening and heightening of the intertidal flats in the Western Scheldt cannot be understood entirely with this theory. Further research aims at a better understanding of the estuaries by extending theories, like the one of Friedrichs, to the conditions in the Eastern and Western Scheldt.

3. Conclusions

As observed in the data, there are locations in the estuaries for which the intertidal areas respond in line with the theory of Friedrichs (2011) to human works. However, there are also tidal flats for which the morphological changes cannot be understood with the theory of Friedrichs and other insights are required.

Acknowledgments

This study is part of the EMERGO project (NWO). We thank Rijkswaterstaat for providing the datasets.

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Preliminary observations at the Heemskerk nourishment

Roeland de Zeeuw[1], Matthieu de Schipper[1,2], Laura Vonhögen-Peeters[3] and Gemma Ramaekers[4]

[1] Shore Monitoring & Research roeland@shoremonitoring.nl

[2] TU Delft, section of Hydraulic Engineering.

[3] Deltares

[4] Rijkswaterstaat, Water, Verkeer en Leefomgeving

1. Introduction

An average of 12 million m^3 of sand is nourished annually over the last decade at the Dutch coast (Rijkwaterstaat, 2015). The majority of this volume is installed as shoreface nourishments. However, the impact of the design parameters (i.e. shape, depth) of shoreface nourishments on the coastal response is not fully understood and varies from one location to another. In this contribution we show the first observations of an experimental shoreface nourishment study, which was executed near Heemskerk, the Netherlands.

2. The Heemskerk Nourishment

The differentiated nourishment installed in 2011-2012 near Heemskerk was a combination of two innovative nourishment types: 1) nourishing in deeper waters and 2) a gap between nourishment sections (so called “bollensuppletie”).

Ahead of the execution of the nourishment a model study was performed by Deltares to investigate the effects and the risks of this nourishment on the morphology and swimming safety.

The measurements performed are necessary to answer the two major research questions: 1) How does the coastline and the edges of the nourishment develop? 2) Does the shape of the nourishment result in more or faster sedimentation high in the profile?

Besides answering the questions above the measurements will also be used to validate the model outcomes.

2.1 Design

The nourishment at Heemskerk was installed in 2 sections, with a total of approximately 1.6 million m^3 of sediment. The southern section has a crest level of ~ -5 m NAP and was completed in August 2012, the northern side has a crest level of ~-6 m NAP and was completed in November 2012. A gap of 500 m was present between the two sections.

Figure 1: The planned design of the nourishment at Heemskerk. The cyan rectangles show the northern and southern nourishment sections. Red lines show the annual Jarkus transects; Yellow and green lines show the high-density survey lines of the ‘Jarkus verdicht’ surveys and the Shore jetski surveys near the end sections.

3. Observations

The first observations on the development of the nourishment show the evolution of the nourishment just after completion. A series of winter storms redistributed the sand and removed the irregularities of the construction. These consecutive surveys also show a small shoreward migration of the nourishment and a slope adjustment on the seaward flank. Remarkably the measurement just after a large storm in the winter of 2012 showed the presence of two rip channels, just shoreward of the nourishment ends.

These and other preliminary observations on the behaviour of the shoreline and the coastal state indicators over time will be presented at the conference.

The evaluation of this nourishment and the model validation will continue in the coming years.

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Rijkswaterstaat (2015) *Kustlijnkaartenboek 2015*, ed. G. Ramaekers (*in Dutch)*.

Cross-shore sediment dynamics in the intertidal zone of the Sand Motor

Marieke Dirksen[1], Florian van der Steen[1] , Anouk de Bakker[1], Joost Brinkkemper[1] and Gerben Ruessink[1]

[1] Department of Physical Geography, Utrecht University

1. Introduction

Coastal evolution models have substantial difficulties predicting morphological changes in shallow water. In this region, sand transport results from a complex mix of processes, including turbulence, short waves, infragravity waves and mean currents. Here, we focus more specifically on the role of infragravity waves and small-scale bedforms in the suspension of sand and resulting transport in the intertidal zone. These processes are studied using measurements collected during the MegaPEX field campaign on the Sand Motor.

2.Methodology

The MegaPEX field campaign was conducted in the fall of 2014 in collaboration with the STW NatureCoast project. Here we present measurements collected with a cross-shore instrument array deployed in the intertidal zone. The array included pressure sensors on 13 locations, which were on 3 locations collocated with an EMF and 3 STM's and on one location with an EMF, 3 ADV's, 7 STM's and a 3D sonar. Changes in the intertidal morphology were monitored using a DGPS.

3. Results

Offshore wave conditions were generally mild during the campaign (mean H_{m0} ~ 0.65 m, T_p ~ 4 s), but also higher energetic events were measured, including a storm with a surge level of 1.7 m, H_{m0} ~ 4.3 m and T_p ~ 7 s. Corresponding infragravity-wave heights over the array were in general around H_{ig} ~ 0.1-0.15 m and reached up to H_{ig} ~ 0.45 m during the storm.

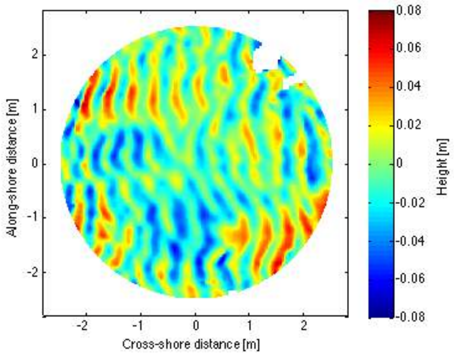

Figure 1: An example of a rippled bed derived from measurements by the 3D sonar, with the y-axis positive to the north and the x-axis positive to shore. The mean bed slope is removed from the image.

Measurements of the small-scale morphology at the seaward flank of the intertidal sandbar show the presence of bed forms during each measured (the 3D sonar could not record measurements during high energetic conditions) high tide. These bedforms were formed and wiped out within one high tide, as a flat bed was observed at this location during each low tide. From the 3D sonar image (Figure 1) ripple characteristics, such as length and orientation, were derived. Preliminary results show the increase of the nearbed sediment suspension when ripples are present, further analysis must provide more insight in the effect on sediment transport.

During both a representative low-, as well as a high-energetic tide, sand transport by infragravity waves was in the same order of magnitude as the transport by short waves, but the mean transport dominated (Figure 2). The transport is predominantly onshore directed for sea-swell waves (q_{hf}) for both low- and high-energetic conditions, and predominantly offshore (onshore) directed for infragravity waves during low (high) energetic conditions (q_{ig}). This might be explained by the location of the measurement rigs relative to the breakpoint of the waves.

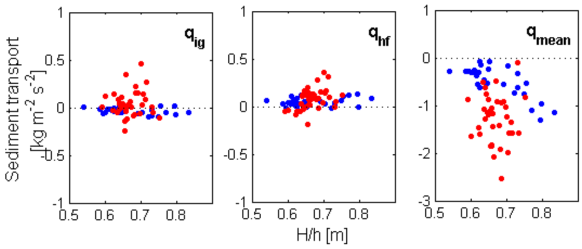

Figure 2: Measured suspended sediment transport during low-energetic conditions (blue) and high-energetic conditions (red).

4. Conclusions

The collected dataset offers a wide range of conditions for both ripples and infragravity wave heights to come closer to the understanding of sediment suspension and transport by both bedforms and infragravity waves.

Acknowledgments

The authors would like to thank Jantien Rutten, Laura Brakenhoff and our technicians for their assistance in the field.

Wave forcing in the Dutch Wadden Sea and the effects on mussel habitats

Jasper Donker[1], Maarten van der Vegt[1] and Piet Hoekstra[1]

[1] Utrecht University (j.j.a.donker@uu.nl, m.vandervegt@uu.nl, p.hoekstra@uu.nl)

1. Introduction

Mussel beds are an important part of the ecosystem in the Dutch Wadden Sea. Over the past decades intertidal mussel cover has declined, especially in the Western Wadden Sea (WWS). Wave forcing is an important process in limiting mussel bed survival in intertidal areas. The main objectives of this study are (1) to determine the spatial distribution in wave forcing in the Dutch Wadden Sea; (2) to relate wave forcing to the occurrence of intertidal mussel beds; (3) to study the differences in wave forcing and mussel bed occurrence between the Eastern Wadden Sea (EWS) and WWS

2. Methodology

SWAN (booij etal, 1999) was used in steady state to calculate the spatial distribution of wave forcing in the Dutch Wadden Sea for many environmental scenarios (30 different water levels, 6 different wind speeds, 8 wind directions). Obtained model results were subsequently linked to observed water levels, wind velocities en wind directions to create statistically representative estimates of wave exposure in the Dutch Wadden Sea for the period 1990 - 2013. Using contours of intertidal mussel beds from the years 1995-2011 the relation between modeled wave forcing and mussel bed cover is studied.

3. Results

Results reveal differences between basins up to 50% in the average wave forcing; wave forcing is largest in the Western basins. Mussel beds cover a relative smaller portion of the intertidal area in the more exposed basins.

Moreover, the average wave forcing on mussel beds in terms of the 95th percentile near bed orbital velocity is 0.20 ms^{-1}. This value is slightly larger in the West than in the East. As shown in Figure 1, in the Western Wadden Sea wave exposure at mussel beds is much smaller

(14%) than the average wave forcing on the intertidal area in the basins. In the East there is little difference between average intertidal and average mussel bed exposure.

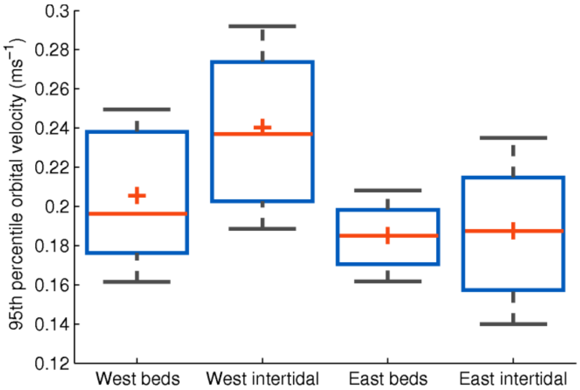

Figure 1: Wave exposure of mussel beds and all intertidal area for the WWS and EWS respectively. (median=redline, average=red cross, 25-75 percentile= blue box, standard deviation= black bars)

4. Conclusions

We conclude that in the WWS less area is suitable for mussel bed settlement as the area is limited by wave forcing, and that therefore habitat suitability in WWS is more sensitive to changes in the wave climate.

Acknowledgments

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Recording aeolian sand transport using laser particle counters

Leonardo Duarte Campos[1], Kathelijne Wijnberg[1], Lianne van der Weerd[1] and Gerben Bakker[2]
[1] University of Twente
l.a.duartecampos@utwente.nl
k.m.wijnberg@utwente.nl
a.j.vanderweerd@utwente.nl
[2] Wageningen UR
gerben.bakker@wur.nl

1. Introduction

Quantitative prediction of aeolian transport rates on beaches is still a difficult task, an important reason being the large spatio-temporal variability inherent to this type of transport. In order to validate new approaches to calculate aeolian transport, in situ field measurements are needed, combined with the knowledge on how to interpret point measurements in this spatio-temporal varying transport field.
In this contribution we present the first results of field experiments that aimed at exploring the effects of sensor positioning on the recording of Aeolian transport, including possible sensor related influences.

2. Methodology

The data on rates of aeolian sand transport were collected at the Zandmotor (fall 2014) using laser particle counting sensors with fork widths of 8 and 3 cm (Wenglor YH08PCT8 and Wenglor YH03PCT8 respectively). These sensors were mounted in arrays, in a mast and at surface level, to study the variation in counts in a horizontal and vertical direction. In the horizontal array, also the influence of the angle of the fork sensor relative to the mean wind direction was tested. Wind speed and direction were measured using a Gill Windsonic anemometer at 1.8 m elevation. The average wind speed during the experiments ranged from 5 to 15 m/s.

3. Preliminary Results

During the test with sensors in a vertical array most of the transport occurred in the lower 30 cm. Figure 1b shows that a large part of this transport is counted by the sensor that was positioned at 4 cm from the surface.
In the horizontal array we observed large (yet unexplained) variation in counts (Figure 2b). Possible explanations include physical causes such as large gradients in concentration (Tan et al. 2014) or a varying sensor height due to bed level changes of micro topography (i.e. ripples). It can also be due to sensor properties, because at very high concentration sensor saturation may occur (Barchyn et al. 2014).

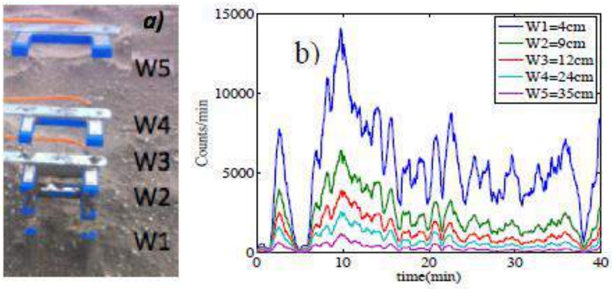

Figure 1: Sensors of 8cm fork width in a vertical array (a) and grains counted per minute (b).

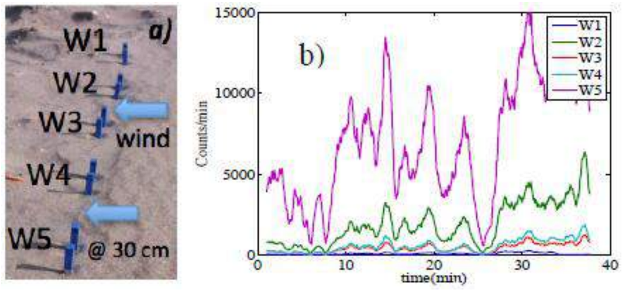

Figure 2: Sensors of 8cm fork width in a horizontal array (a) and grains counted per minute (b).

Future work

Follow-up experiments are planned at the Zandmotor as well as on a natural beach near Egmond aan Zee.

Acknowledgments

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Granular-bed patterns under an oscillating swirl flow: results from laboratory experiments

Matias Duran-Matute[1*], Alfredo Ranaldi[1,2] and GertJan van Heijst[1]

[1] Dept. of Applied Physics, Eindhoven University of Technology, Eindhoven, The Netherlands
[2] Mechanical Engineering, Universidad Simón Bolivar, Valle de Sartenejas, Venezuela
* e-mail: m.duran.matute@tue.nl

1. Introduction

It is well known that the flow above a granular bed is responsible for the formation of patterns. Examples of this are sand ripples and waves in coastal areas that result from the oscillating behaviour of tides and waves.

We present results of laboratory experiments on the patters formed in a granular bed under the action of an oscillating swirl flow. This flow can be considered as an idealization of the core of certain vortices or eddies that form along the coast due to the interaction of the tide with the bathymetry. In the experiments, we vary systematically three parameters: the frequency of the oscillation, the magnitude of the oscillation, and the magnitude of background rotation. The latter parameter serves to simulate the possible influence of the earth's rotation.

2. Experimental setup

The experiments were carried out inside a transparent cylindrical tank (with dimensions radius R=24.5 cm, height H=50 cm) placed inside a square tank and on top of a rotating table. The tank was filled with transparent Perspex particles (typical size of 2-3 mm and density ρ_f = 1.18 g/cm^3) up to a height of 5 cm. Then salt water with density ρ_p = 1.10 g/cm^3 was added up to a depth of 30 cm. To create the oscillating swirling motion of the fluid, the table was set to rotate at a rate

$$\Omega = \Omega_0 + \Omega_1 \sin(\omega t),$$

where Ω_0 is the background rotation rate, Ω_1 is the amplitude of the oscillation, and ω is the frequency of oscillation.

To measure the evolution of the bed, we used the "light attenuation technique" developed by Munro and Dalziel (2005). For its implementation, a light bank was placed under the tank, and a diffuser was located in between the light bank and the tank. The measuring technique is based on the principle that the light passing through the bed depends on the thickness of the bed at a certain point in the horizontal plane. A camera on top of the tank was employed to record the light intensity through the bed. The conversion of light intensity to bed thickness can be done after calibration.

3. Results

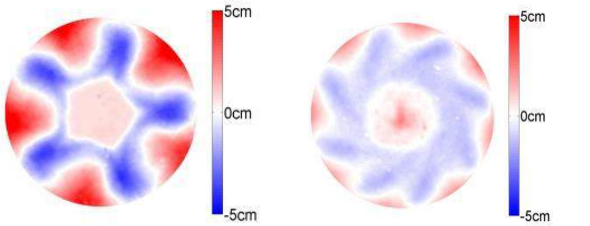

Fig. 1. Examples of final steady patterns obtained for Ω_0 = 0, Ω_1 = 0.8 rad/s, ω = 0.04 Hz (left) and Ω_0 = 0.8 rad/s, Ω_1 = 0.5 rad/s, ω = 0.04 Hz (right).

We found that the bed organizes itself into a pattern composed of a central undisturbed region, and an outer region composed of ripples (Fig. 1). For the case without background rotation, the ripples are radial (Fig. 1, left). In contrast, the ripples acquire an oblique direction when background rotation is added (Fig. 1, right). The number of ripples highly depends on the parameters of the problem

The measurements also allowed us to measure the erosion and transport efficiency of the flow as a function of the parameters of the problem.

4. Conclusions

The patterns formed in a granular bed under an oscillating swirl flow subjected to background rotation are highly dependent on all the parameters of the problem. We have observed that background rotation both increases the transport efficiency of the flow and limits the ripple height.

Acknowledgements

The authors would like to acknowledge the financial support of NWO (The Netherlands) through the VENI grant (#863.13.022) of M. Duran-Matute.

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Overwash observations on a Dutch barrier island

Anita Engelstad[1], Maarten van der Vegt[1] and Piet Hoekstra[1]
[1] Universiteit Utrecht, email: A.C.Engelstad@UU.nl

1. Introduction

Storm conditions increase water levels along barrier islands and coasts. If water levels are elevated during high astronomical tides and wave run-up exceeds a certain threshold (depending on the topography), overwash or even inundation of barrier islands is possible. Overwash and inundation are able to cause large-scale coastal changes that can range from the breaching of islands to vertical accretion of sediments (Donelly et al., 2006). Vertical accretion might aid in mitigating the effects of sea level rise and subsidence (Oost et al., 2012). However, not much is known about the hydrodynamic forcing during overwash and the accompanying morphological changes on high and broad barrier islands in a mesotidal mixed-energy system. In addition, due to the infrequent and energetic nature of overwash events, not much hydrodynamic field data exist.

2.Methodology

From the beginning of November 2014 until the end of January 2015, instruments were deployed on the low-lying (maximum height ~ 1.70m, relative to the Dutch Ordnance Datum, NAP) eastern end of the Dutch barrier island Schiermonnikoog. The instruments (Figure 1) were aligned cross-island, from the North Sea to the Wadden Sea, measuring water depths, wave parameters, flow velocities and suspended sediment concentrations during overwash and inundation events. In addition, the island cross-profile was measured at the beginning and the end of the deployment using dGPS to measure the changes in topography.

Figure 1: The instrument array on Schiermonnikoog consisted of 3 frames (blue squares) equipped with Accoustic Doppler Velocimeter (ADVs), pressure sensors and Optical Backscatter Sensors (OBS), and 9 stand-alone pressure sensors (orange squares).

3. Results

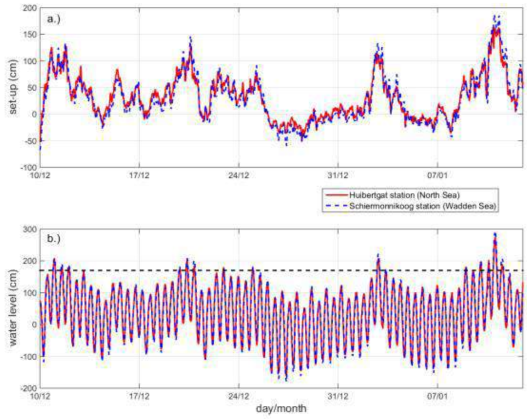

Figure 2: Set-up (a) and water levels (b) for the Huibertgat station (red curve) and the Schiermonnikoog station (blue dashed curve). The maximum height at the field site is ~1.70m, relative to NAP (black dashed line in b.)

4. Conclusions

Several storms during the observational period lead to surge levels in excess of one meter (Figure 2), causing the field site to flood at least four times. New and exciting wave and current data for these events will be shown at the time of the NCK days.

Acknowledgments

We couldn't have done it without the technical support of Marcel van Maarseveen, Henk Markies and Chris Roosendaal. We would also like to thank Natuurmonumenten for their assistance during the field work. This work is supported by NWO.

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BAROTROPIC PROCESSES OF SEDIMENT TRANSPORT IN TIDAL BASINS: A 1D MODEL FOR THE WADDEN SEA

V. M. GATTO[1], B.C. VAN PROOIJEN[1] Z.B. WANG[1,2]

[1] Delft University of Technology – v.m.gatto@tudelft.nl, b.c.vanprooijen@tudelft.nl
[2] Deltares – zheng.wang@deltares.nl

1. Introduction

Several sediment transport mechanisms determine the Wadden Sea's morphodynamics, but a ranking of their relative impact has not yet been established. 3D process-based models are not feasible for such purpose, while idealized models suffer from oversimplifications. In order to bridge the two, we propose an intermediate approach that is particularly suited to investigate the barotropic mechanisms recognized in literature as possibly dominant: *settling lag*, *scour lag*, *tidal asymmetry, tidal Stokes' Drift.*

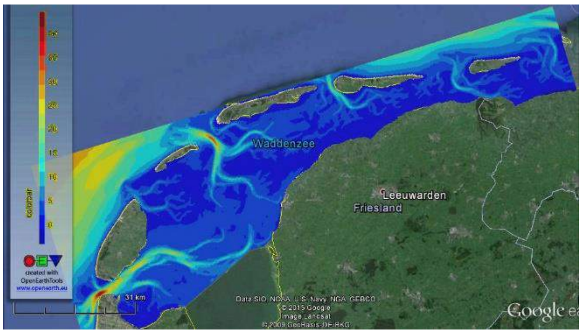

Figure 2: the western Wadden Sea (Google Earth).

2.Methodology

The 1DH numerical model by Van Prooijen & Wang (2013) is improved and recalibrated with data of Duran-Matute et al. (2014). With respect to similar approaches, novelties are brought by comprising wind forcing and hypsometry-based geometries. This is standardly applicable to short basins with dendritic structures and let us include more realistic hypsometrical effects. A versatile formulation for suspended sediment transport allows mimicking different grain sizes and resistances of the seabed to erosion (presence of cohesive material, biota activity) by controlling 2 parameters in the governing equation: critical bed-shear stress and settling velocity.

3. Results

The residual fluxes of fine and medium sand in the Vlie basin are simulated over a semidiurnal timescale by forcing the model with constant wind speed and either a symmetrical (*M2*) or slightly ebb-dominant (*M2+M4*) boundary tide (Fig. 2). In the former case, lag effects and internally-generated transition to flood dominance can hardly counterbalance estuarine drift and ebb dominance near the inlet: the system mostly exports sediment. Conversely, in the latter case the transition happens more seaward and sediment dynamics becomes governed by slack water asymmetries: the system imports all fractions with settling velocities below 1 cm/s.

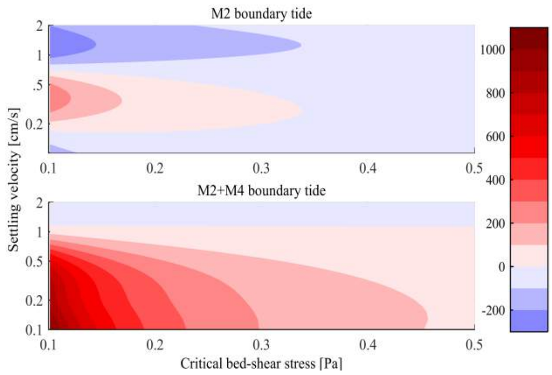

Figure 3: variability of semidiurnal sand balance (ton) for the Vlie inlet. Y-axis in logarithmic scale.

4. Conclusions

A state of residual, grain-size-selective transport may exist, on which the critical bed-shear stress exerts only a weak control. Under schematized forcing and average wind speed, tidal asymmetry is the main responsible mechanism. However, waves are absolutely necessary to mobilize the tidal flats. Differences between the fluxes observed at the inlet and in the intertidal area comply with the landward fining of mean grain sizes commonly observed in the Wadden Sea.

Acknowledgments

University Campus Fryslan for financial support; Drs. M. Duran-Mature and T. Gerkema for sharing data; Dr. H.M. Schuttelaars for consultancy.

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Tales of Island Tails: development under natural and influenced conditions

Alma de Groot[1*], Albert Oost[2], Evert Jan Lammerts[3], Willem van Duin[1], Roos Veeneklaas[4], Bregje van Wesenbeeck[2], Elske Koppenaal[5]

[1] IMARES, P.O. Box 167, 1790 AD Den Burg, alma.degroot@wur.nl, willem.vanduin@wur.nl
[2] Deltares, P.O. Box 177, 2600 MH Delft, albert.oost@deltares.nl, bregje.van.wesenbeeck@deltares.nl
[3] Staatsbosbeheer Divisie Beheer & Ontwikkeling, P.O. Box 333, 9700 AH Groningen, e.lammerts@staatsbosbeheer.nl
[4] Bosgroep Noord-Oost Nederland, Balkerweg 48a, 7738 PB Witharen, r.veeneklaas@bosgroepen.nl
[5] Community and Conservation Ecology, P.O. Box 11103, 9700 CC Groningen, e.c.koppenaal@rug.nl

1. Introduction

Island tails are the downdrift parts of barrier islands and consist of salt marshes, dunes, beaches, beach plains and green beaches. Large parts of the tails of the Wadden-Sea island have lost dynamics and are ageing. This is largely caused by human influence. As an aid for managers to develop new strategies to rejuvenate island tails, a frame of reference was created for the development of island tails.

2.Methods

We made use of existing data, field visits and literature for the development of a conceptual model. The data consisted of (historic) topographic maps, aerial pictures, vegetation maps, and measurements of surface elevation and clay thickness on the salt marshes. The study focussed on Terschelling, Ameland, Schiermonnikoog (all NL) and Spiekeroog (D).

3. Results

All island tails in the Wadden Sea are unique, but all contain several recognizable elements. Their development follows the general pattern of biogeomorphic succession. At first the island tail consists of a bare beach plain (Figure 1). Secondly, biotic processes start to influence the morphology and embryonic dunes form. In the third phase, green beaches, dunes and salt marshes develop, including drainage such as creeks and washovers. Finally, the biotic processes dominate and the individual parts of the island tail undergo vegetation succession, stabilising the morphology.

Island tails may develop completely without any human interference (Figure 1). With human alterations (such as sand-drift dikes and embankments), natural dynamics generally decrease, increasing the speed of succession, and on the long run reducing the diversity in landforms, vegetation types and successional stages. Both for natural and human-influenced island tails, succession is the dominant process. Large-scale setbacks in succession most likely only occur when large-scale processes cause the erosion of part of the island tail.

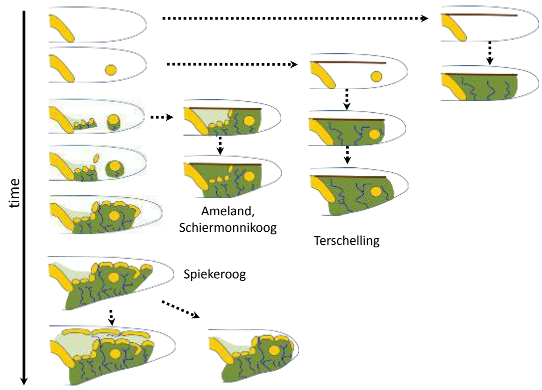

Figure 1: Island-tail development under undisturbed (left) and disturbed conditions, with examples of island tails. Yellow = dunes, dark green = salt marsh, light green = green beach, blue = creeks, brown = sand dike.

4. Conclusions

The current state of an island tail depends on its age, the presence of man-made sand-drift dikes, the time elapsed since their construction, and the occurrence of large-scale processes having affected the development of the island tail since.

In their current form, island tails are some of the most dynamic parts of the Dutch coast. This makes them very suitable for allowing natural processes to their full extent. It seems possible to introduce more dynamics through active management. There are however limits to the effects that can be expected, as the geomorphological processes from the initial phases, that cause landscape variation, cannot always be restored on a large scale in later phases of the succession.

Acknowledgments

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Video monitoring of aeolian activity on a narrow beach

P.M. Hage, MSc[1] and B.G. Ruessink[1]
[1] Department of Physical Geography, Utrecht University, P.M.Hage@uu.nl and B.G.Ruessink@uu.nl

1. Introduction

Dunes need sediment to grow and recover from storms. This sediment comes from the beach and is transported towards the dunes by the wind. It is therefore important to understand the process of aeolian transport. High aeolian transport rates are expected to happen during high wind velocities, but this is not always the case for narrow beaches (with a width of tens of meters). Weather conditions that seem quite favourable for aeolian transport do not always result in actual transport, thus something must limit the aeolian transport rate.
This MSc research focuses on aeolian transport on a narrow beach at Egmond aan Zee, the Netherlands, to explore which conditions create aeolian transport towards the dunes and which factors may limit aeolian transport.

2. Methodology

Data from the KNMI were used to find wind events (moments with potential sediment transport) and to calculate their potential transport rates. These wind events were then classified on a scale from 1 to 5, according to their potential transport rate (Table 1). The potential sediment transport was calculated with $Q = 1.16 * 10^{-5} * u^3 * 3600$, where u is the wind velocity (Hsu, 1974).
Argus images from the Coast3D tower were used to search for traces of aeolian transport in the form of sand strips and streamers. These images were visually classified, based on the amount and behaviour of these traces (Figure 1). This was done for the images that were collected at the same time as the wind events. The classified Argus images are called transport events. The classes of the wind events and the ones from the transport events were then compared to each other.

Wind class	Potential aeolian transport rate (kg/m/hour)
1	very small: < 30
2	small: 30 – 60
3	medium: 60 – 90
4	large: 90-120
5	very large: > 120

Table 1: Wind Classes.

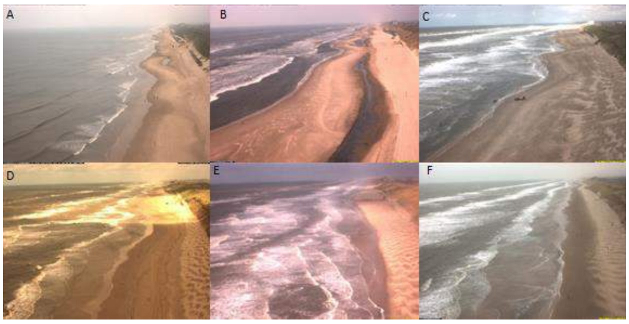

Figure 1: Visual classification of Argus images, ranging from no transport (A) to very high transport rates (F) (Argus Coast3D Tower).

3. Results

A long fetch, a strong wind and an onshore wind direction are generally assumed to lead to optimal dune growth, but these conditions lead to no or minimal sand transport on Egmond beach. Instead, alongshore winds result in substantial aeolian activity, but it is unknown how much this wind-blown sand actually ends up in the dune.
An event has a limited transport rate if it has a high potential transport rate (a high wind class), but a much lower rate in reality (a low transport class). The imagery suggests that a short fetch length is the most important limiting factor. Transport often happens only during low tide, because the beach becomes too narrow during high tide. Other limiting factors are moisture, the location of the bar and snow, but the first two seem to be more important for events with a low wind velocity.

4. Conclusions

Both strong and weaker winds can cover the beach with sand strips, as long as the wind direction is alongshore. Strong winds with a predominantly onshore direction do not result in transport; they sometimes lead to erosion instead. Four major transport limiting factors were found: a short fetch, moisture, the location of the bar and snow and/or ice.

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The controlling effect of hydrodynamic forcing on saltmarsh establishment: refine Windows of Opportunity concept

Zhan Hu[1,2], Jim van Belzen [1] Daphne van der Wal [1], Thorsten Balke [1,3], Zhengbing Wang [2,4], Marcel Stive [2], Tjeerd J Bouma [1]

[1] Spatial Ecology Department, Royal Netherlands Institute for Sea Research, Yerseke, The Netherlands (Zhan.hu@nioz.nl; Jim.van.Belzen@nioz.nl; Daphne.van.der.Wal@nioz.nl; Tjeerd.Bouma@nioz.nl)
[2] Hydraulic Engineering Department, Delft University of Technology, Delft, the Netherlands (M.J.F.Stive@tudelft.nl)
[3] Institute for Biology and Environmental Science, Carl von Ossietzky University Oldenburg, Oldenburg, Germany (thorsten.balke@uni-oldenburg.de)
[4] Deltares, Delft, The Netherlands (Zheng.Wang@deltares.nl)

1. Introduction

Understanding the mechanisms limiting and facilitating saltmarsh vegetation initial establishment is of widespread importance due to the many valuable services saltmarsh ecosystems offer. However, knowledge on where and when saltmarshes can establish is largely empirical and insights of the governing processes are lacking. Recently, the 'Windows of opportunity' (WoO) concept has been proposed as a framework providing an explanation for the initial establishment of biogeomorphic ecosystems and the role of physical disturbance herein [*Balke et al.*, 2011, 2014]. A WoO is a sufficiently long disturbance-free period following seedling dispersal, which enables successful establishment. By quantifying the occurrence of WoO, vegetation establishment pattern can be predicted. For simplicity sake and as prove of concept, the original WoO framework considers tidal inundation as the only physical disturbance to marsh establishment, whereas the known disturbance from hydrodynamic forcing is ignored. In this study, we incorporate hydrodynamic forcing in the WoO framework. Its spatial and temporal variability is considered explicitly in a saltmarsh establishment model.

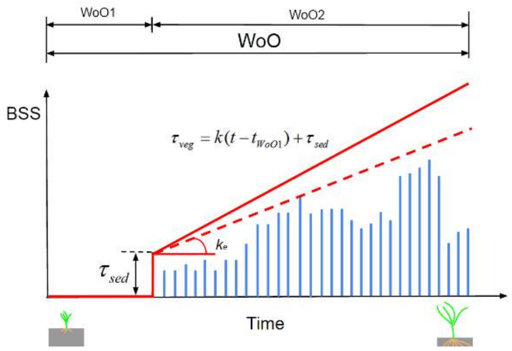

Figure 1. Schematization of the WoO1&WoO2 model. WoO1 is an inundation-free period with a critical minimum duration (BSS is zero); WoO2 is a period following WoO1, when the seedlings are experiencing bed shear stress disturbance (the blue line). The red soild line is the critical BSS for vegetation establishment (τ_{veg}). The red dash line is the highest slope in BSS time series.

We used this model to explain the observed episodic marsh recruitment in the Westerschelde Estuary, the Netherlands.

2.Methodology:

We propose a WoO1&WoO2 model for vegetation establishment prediction (Figure 1), which is compared with the original WoO model considering only WoO1.

3. Results

The predictions of the WoO1 model and WoO1&WoO2 model were evaluated based on the overall vegetation cover dynamics in 2004 and 2012 at the study site near Ellewoutsdijk. Our results reveal that this model can significantly increase the spatial prediction accuracy of marsh establishment compared to a model excludes the hydrodynamic disturbance.

4. Conclusions

The refined WoO model offers a valuable tool to understand and predict bottlenecks of saltmarsh restoration and consequences of changing environmental conditions due to climate change.

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Evaluation of the impact of high-angle waves on nourishments

B.J.A. Huisman[1,2], V. Curto[1,2], R. Hoekstra[2] and M. De Schipper[1]
[1]Delft University of Technology, B.J.A.Huisman@tudelft.nl, M.A.deSchipper@tudelft.nl
[2] Deltares, victoriacurto1@gmail.com, Roderik.hoekstra@deltares.nl

1. Introduction

Various researchers have been investigating the impacts of high-angle wave conditions (i.e. very oblique to the coast) on sandy coasts (e.g. Ashton et al., 2001). This research indicated that high-angle waves can explain coastline instabilities such as flying spits and alongshore sand waves. It was even argued that nourishments can impact the coast in such a way that instabilities may be generated (Van den Berg et al., 2011). The assumptions used in these studies do, however, focus on coasts with predominant wave incidence from high-angles which is only valid for a few places in the world. The aim of this research is therefore to investigate whether the instability phenomena may occur for beaches with realistic nourishments and time-varying wave-angle.

2. Methodology

The impact of high angle wave conditions is assessed for two schematic nourishments with a Gaussian shape (2km length and 250 or 1000m in cross-shore) with the Delft3D model.

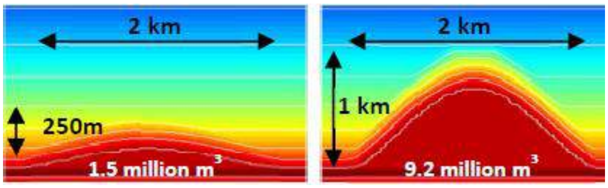

Figure 1: Nourishment configurations

High and low angle wave conditions are used in the simulation (either 0° and 65° w.r.t. coast normal) with varying persistence.

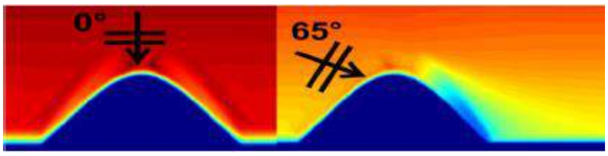

Figure 2: Example of applied wave conditions (Hm0)

3. Results

The morphology after 2.5 years for four typical simulations with different persistence of the 0° and 65° conditions is shown in Figure 3. The 0° situation shows rather symmetrical redistribution of sediment, while the 65° wave conditions generated some alongshore migration and leeward erosion.

The situations with alternating wave angle do experience alongshore migration (but to a lesser extent). Noticeable is that no leeward erosion is observed for the simulation with a small period of shore-normal waves (see lower right plot in Figure 3).

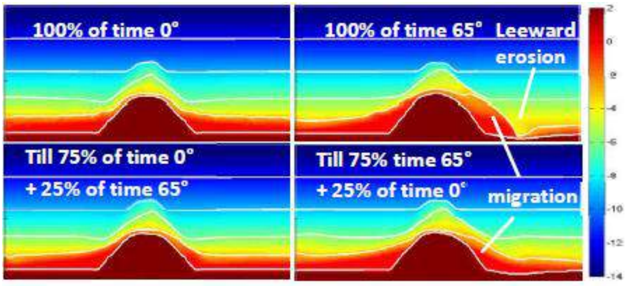

Figure 3: Morphology after 2.5 years with constant or time varying wave conditions

4. Conclusions

Results of this study indicated that typical nourishments are not likely to lead to instabilities as described in literature, but for the larger scale features some secondary effects as a result of prolonged periods of high-angle waves may be present. These effects concern potential migration of the feature and leeward erosion. However, a short period with low-angle waves can wipe out the impacts of preceding high-angle wave conditions. Consequently, the longer term impact of high-angle waves is considered to be minor for the Holland coast, where low-angle wave conditions occur frequently. Sections of coastline with more oblique wave incidence may, however, be affected by the high-angle instabilities.

Acknowledgments

The European Research Council of the European Union is acknowledged for the funding provided for this research by the ERC-advanced Grant 291206-NEMO.

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The effect of wave directional spreading in morphological models: hindcast of the impact of the Saint Nicholas storm on the Belgian coast

Thijs Lanckriet[1], Koen Trouw[2], Nicolas Zimmermann[1], Bart De Maerschalck[3], Tomohiro Suzuki[3]

[1] International Marine and Dredging Consultants, thijs.lanckriet@imdc.be, nicolas.zimmerman@imdc.be
[2] Fides Engineering, koen.trouw@fidesengineering.be
[3] Flanders Hydraulics Research, bart.demaerschalck@mow.vlaanderen.be, tomohiro.suzuki@mow.vlaanderen.be

1. Introduction

The morphological response of beach and dune systems to coastal storms often shows significant alongshore variability (De Winter et al., submitted) and modelling is increasingly performed in 2D mode. However, 1D cross-shore models are still commonly used, e.g. for larger timescales. The 1D approach neglects alongshore variability in sediment transport due to alongshore differences in the bathymetry, but also due to alongshore variation in wave run-up due to wave directional spreading.

2. The Saint Nicholas storm

A storm occurred in the North Sea on 5 and 6 December 2013 and is also known as "Xaver" or "Sinterklaasstorm". Along the Belgian coast, this storm resulted in high surge levels (highest recorded water levels since 1953) combined with significant wave heights of up to 2.7 m, which have a return period on the order of 1 year on the Belgian coast.

122 cross-shore profiles were surveyed using GPS three days before the storm. These were compared to an airborne lidar survey executed 4 days after the storm to provide a dataset of beach profile change along the entire Belgian coastline (~67 km).

3. Model results

Profiles were modelled in XBeach v1.21.3657 (Roelvink et al., 2009) using the standard settings in both 1D and 2D. The 2D configuration used an alongshore uniform bathymetry based on the pre-storm survey profiles. Erosion volumes were generally overestimated by the model, which is likely due to the use of the default calibration coefficients. For several profiles, the 1D model displays significant deviations from the 2D model results. Since both the 1D and 2D model use an alongshore uniform bathymetry, this is attributed to the directional spreading effect, which is not fully resolved in the 1D model.

Judging by the erosion volumes, a small number of alongshore grid rows (ny = 5 or ny = 8) appear to be sufficient to capture most of the 2D effect of directional spreading.

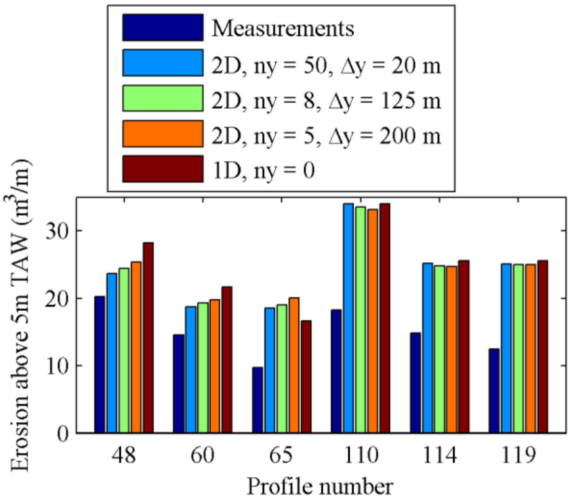

Figure 1: Beach erosion volume for 6 profiles using different model configurations.

4. Conclusions

The impact of the Saint Nicholas storm on the Belgian coast was modelled using XBeach in 1D and 2D. The 1D model does not resolve directional spreading, leading to differences in sediment transport predictions. A 2D model with a small number of alongshore grid rows reproduces the effect of directional spreading at a computational cost that is lower than a full 2D model configuration.

Acknowledgments

The authors wish to thank the Coastal Division of the Flemish Government for providing the measurement data and financial support, Rik Houthuys for assembling the data, and Dano Roelvink and Jaak Monbaliu for assistance with the numerical models.

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Bed morphology on the shoreface of the Zuid-Holland coast, the Netherlands

Saulo Meirelles[1], Martijn Henriquez[1], Alejandro J. Souza[2], Julie Pietrzak[1], Alexander R. Horner-Devine[3], Marcel Stive[1]
[1] Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands.
s.meirellesnunesdarocha@tudelft.nl, m.henriquez@tudelft.nl, j.d.pietrzak@tudelft.nl, m.j.f.stive@tudelft.nl
[2]National Oceanographic Center, Joseph Proudman Building, Liverpool, UK. ajso@noc.ac.uk.
[3]Civil and Environmental Engineering, University of Washington, Seattle, USA. arhdi@uwashington.edu.

1. Introduction

This study aims to use field observations to investigate the dynamics of small-scale bed forms under different hydrodynamics conditions and how this affects the bed roughness on the shoreface of the Zuid-Holland coast.

Small-scale bed forms undergo a feedback relation with the near bed hydrodynamics and impact the sediment transport. The measurement of the bed roughness in the field is still limited (Kleihans et. al, 2005) hence models usually rely on parameterized values to estimate the magnitude of the sediment transport. This can be critical, for example, for long-term morphological modelling

Regarding the hydrodynamic aspects, the shoreface of the
Zuid-Holland coast, the Netherlands, is affected by the action of waves, tides, wind-driven currents and the coastal plume from the Rhine river. These agents act in concert dictating the sediment mobility and are intrinsically dependent on the bed roughness. This parameter is crucial for fine-tuned sediment transport modelling.

Results from a previous oceanographic campaign showed discrepancies on the calculation of the shear velocity due to current. The lack of information about bed roughness is a plausible reason for the differences found since the roughness length considered in the models was a function only of the mean grain size.

2. MegaPEX (shoreface) / STRAINS II

The field observations were made during a joint experiment between MegaPEX (Mega Perturbation EXperiment) and STRAINS II (STRAtification Impacts in the Nearshore Sediment transport). Those two campaigns combined efforts to deploy measurement devices from the surfzone until 18 m depth. The site is located 10 km northward of the Rotterdam Waterway. The study area also encompasses the Sand Motor, a hook-shaped nourishment of 21.5Mm3 (Stive et al., 2013).
A frame (mini STABLE) was deployed at -12 m depth together with a suit of instruments meant to collect information about the near bed hydrodynamics, sediment concentration and bed forms. Also, sediment sampling will be carried out along a transect in front of the Sand Engine. This dataset will integrate a larger data base as part of the MegaPEX / STRAINS II.

3.Expected outcomes

Within the big picture, the new dataset is envisioned to give new insights about the morphodynamics of the shoreface in the Zuid-Holland coast. In the context of the MegaPEX / STRAINS II, it is hypothesized that the shoreface also responds to the coastal discontinuity caused by the Sand Motor so that the natural sand transport pathways are likely to be dramatically disturbed in the vicinity of such perturbation. Special attention will be paid to how the ripple geometry was affected by changes in hydrodynamic due to tidal straining which results from the interaction between the Rhine river plume and the tidal shear. Previous dataset showed that the front of the river plume hits the tip of the Sand Engine periodically.

Acknowledgements

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Is an ‘Abrupt’ rise of sea level likely in the 21st Century?

Robbert Misdorp, RWS (rtd), climecoast@gmail.com

Introduction:

The three main components contributing to global mean sea level rise (GMSLR) are the thermal expansion of oceans, the melting of glaciers, and the melting of land ice masses. These components vary over time. The melting of two large land ice masses contributed 33% to the global GMSLR during the last five years.

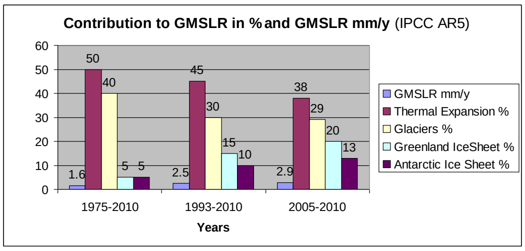

Figure 1: GMSLR and its contributing components

The Greenland Ice Sheet (GrIS) is highly susceptible to melting. The GrIS melting includes two processes, thinning and calving, each with its own observed melting rate. The dynamics of GrIS melting are, to a largely unknown part determined by the draining of supra-glacial lakes through vertical ‘moulins’, which may increase the lubrication of the ice masses slipping on the bedrock (PROMICE). These highly dynamic melting processes are difficult to model mathematically!

The net melting of GrIS strongly accelerated during the last decade, reaching levels of 500 km3/year and contributing 1.3 mm/year to the global MSLR.

Results:

A black-box process sum of the ’abrupt’ melting by thinning and calving of the GrIS over a century is presented. A four to five-fold increase in the recently observed *velocity rates* of thinning and calving would be needed to melt one seventh of the GrIS volume. Such an increase could very well occur over the 21st century in view of the observed acceleration of melting during the last two decades. Taking into account the two other contributing components – Antarctic melting and the thermal expansion of oceans - one can state that a SLR of 1.5m during the 21st Century is not unlikely.

If we take an output-based approach and look at the *quantity of ice to be melted* as a function of the air temperature, we see a possible start of an interesting trend.

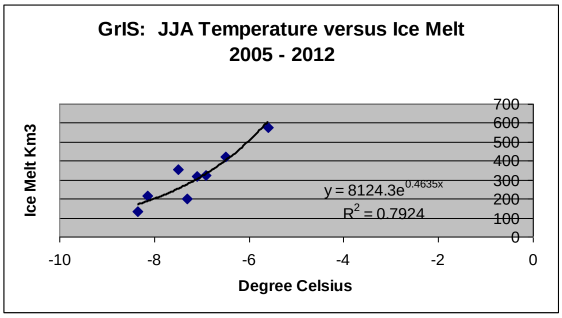

Figure 2: Exponential relation between Greenland annual JJA Air Temperature and annual net Ice Melt in km^3, 2005 - 2012 (source: R.Misdorp based on Tedesco 2013 and Zwally 2011)

Two agents of future change have not been taken into account here:
1) Antarctica: if the ‘sleeping giant’ West Antarctic Ice Sheet melts, it would lead to a 5 m GMSLR;
2) Permafrost thawing: recent Alaskan research indicates large potential releases of the potent GHG: CH_4.

Conclusion:

An ‘abrupt’ increase of GMSLR may not be unlikely in our century. This is a vital message for low-lying coastal nations worldwide. Examples of sustainable coastal adaptation applied in Europe and Asia are available at: www.coastalcooperation.net

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Shifting the paradigm in morphodynamic model validation: from pointwise errors to sediment redistribution

M.Mol[1], J. Bosboom[1], A.J.H.M. Reniers[1,2], C.F. de Valk[3]
[1] Delft University of Technology, M.Mol@student.tudelft.nl, J.Bosboom@tudelft.nl
[2] Deltares, [3] CentER, Tilburg University

1. Introduction

In this study, an improved error metric for morphodynamic models is introduced. The idea is to apply a penalty for the fundamental difference between predicted and observed bathymetries: a net sediment displacement.
Current error metrics, like the classical (Root) Mean Squared Error (*RMSE*), assume that predictions can be properly validated against observations by regarding the point-wise difference in bottom level. This analysis inherently has the problem that phase differences of bottom features are not recognized, such that a misplaced feature is penalised twice, the so called double penalty effect. To reduce the double penalty effect, Bosboom and Reniers (2014) formulated errors metrics based on an optimal smooth displacement field between predictions and observations. Since the employed image warping technique moves pixels rather than sand, sediment continuity is not guaranteed. To overcome this limitation, this study presents an error metric based on an optimal net sediment transport field: the Root Mean Squared Transport Error (*RMSTE*).

2.Methodology: To find a net transport (vector) field *q(x)* between a predicted bathymetry $h_1(x)$ and observed bathymetry $h_2(x)$, the following volume balance needs to be solved:

$$\nabla \cdot q(x) + h_2(x) - h_1(x) = 0 \qquad (1)$$

where x is the location of the points in domain Ω. If the transport field is found, the *RMSTE* can be defined as:

$$RMSTE = \left(\frac{1}{n} \cdot \sum_{i=1}^{n} \left(q(x_i) \right)^2 \right)^{\frac{1}{2}} \qquad (2)$$

with n the number of grid points and $q(x_i)$ the transport at grid point x_i, assuming evenly spaced grid points.
If Ω is two-dimensional, the transport directions are unknown and an additional assumption is required to find an unique transport field from Equation 1. We assume that the transport field is irrotational, such that q can be written as the gradient of a scalar (potential) field $\psi(x)$. Then Equation 1 becomes:

$$\nabla^2 \cdot \psi(x) + h_2(x) - h_1(x) = 0 \qquad (3)$$

Now Equation 3 can readily be solved, after which from Equation 2 the smallest possible *RMSTE* is obtained.

3. Example

Figure 1 shows a schematic observed bathymetry (O) with four predictions: P1, P2, P3 and a flat bottom P0 (dashed line). The domain-averaged bed-level is the same for all predictions. Table 1 gives the *RMSE* and *RMSTE* between each prediction and the observation.

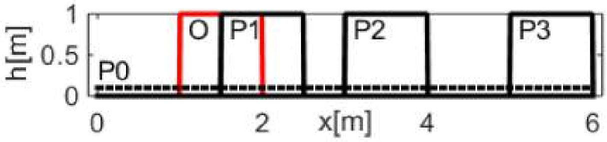

Figure 1: Predicted and observed bathymetries

Prediction	Phase err.	RMSE	RMSTE
P0	-	0.38 m	0.53 m2
P1	0.5 m	0.41 m	0.19 m2
P2	2 m	0.58 m	0.53 m2
P3	4 m	0.58 m	0.78 m2

Table 1: Error values

The *RMSE* can be seen to favour the flat bottom. The *RMSE* increases with increasing phase error until the feature is displaced more than its size. For larger displacements the *RMSE* remains constant. The *RMSTE*, on the contrary, is monotonically increasing for increasing feature displacement and the flat bottom is not necessarily favoured.

4. Conclusions

The *RMSTE* better agrees with morphologist's intuition than the *RMSE*, because it increases with increasing feature displacement and does not give the double penalty effect as occurring with the *RMSE*. Currently this method is being validated for two-dimensional cases.

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Sand, Water, Waves and Iron Worms

Simeon Moons[1], Tom Ysebaert[1,2] and Peter Herman[1,3]

[1] NIOZ-Yerseke, simeon.moons@nioz.nl
[2] IMARES
[3] Radboud University Nijmegen

1. Introduction

Coastal morphology is strongly influenced by ecosystem engineers. Well known examples are saltmarshes, dunes and coral reefs. But what about high-energy sandy shores in temperate regions? Models indicate that the common tube building worm *Lanice conchilega* can create hummocks of sand if the density is high enough (Borsje et al. 2014). Under what physical conditions can such a spatial pattern arise in the field? Do we find Lanice under these conditions? We designed a field experiment to find out.

2. Methodology

Artificial Lanice beds were placed in the intertidal zone and sediment elevation was measured at low tide (Figure 1). The frames consist of vertical steel pins (0.5 cm diameter, 14 cm long), positioned in a circle (1 m diameter) with a density of 1000/m^2, to resemble a natural bed. The frames were placed under different environmental conditions at the Sand Motor (Kijkduin, The Netherlands) for 2-3 days, which was repeated several times throughout September and October 2014.

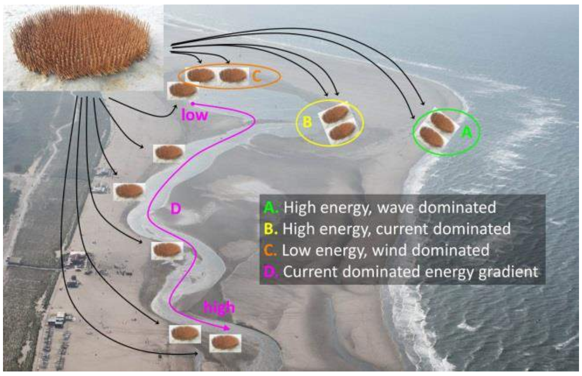

Figure 1: Artificial Lanice bed (upper left, photo: Simeon Moons) and deployment sites at the Sand Motor (Photo: RWS)

3. Results

Spatial patterns were dependent on physical conditions (Figure 2). At wave dominated sites sediment dynamics were very high, but no spatial patterns were observed. At current dominated sites hummocks were often formed. No spatial patterns were observed at low-energy sites. Hummock size increased with flow velocity to the point that erosion rates were so high that the frame was displaced.

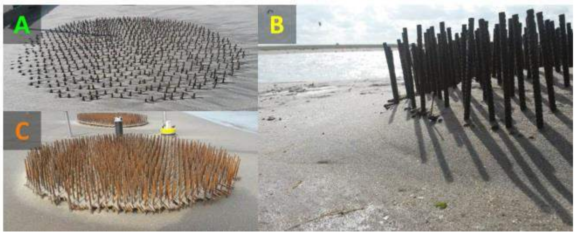

Figure 2: Observed spatial patterns after one day at (A) wave dominated, (B) current dominated and (C) low-energy sites. (Photos: Simeon Moons)

4. Conclusions

The spatial effect of the artificial Lanice bed increases with environmental energy. However, it is limited by its stability, just like natural Lanice tubes would wash away at high erosion rates. A recent study of the Scheldt Estuary showed Lanice densities to increase with decreasing flow velocities (Cozzoli et al. 2014). Sand Motor monitoring data also reveals that high densities have only been found at lower depths, where wave energy decreases. The effect of *Lanice conchilega* on the coastal morphology will thus be highest at relatively low energy areas.

Acknowledgments

We would like to thank STW, NIOZ, Tjeerd Bouma and the participants of MEGAPEX2014 for their support.

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EROSION AND RECOVERY OF THE BED AT MUDFLAT KAPELLEBANK - WESTERSCHELDE

BRAM C. VAN PROOIJEN[1] Q. ZHU
[1] Delft University of Technology – b.c.vanprooijen@tudelft.nl
[2] State Key Laboratory for Estuarine and Coastal Research, East China Normal University, Shanghai, China

1. Kapellebank - Westerschelde

We consider the Kapellebank, a semi-enclosed tidal flat along the north bank of the Westerschelde Estuary near Hansweert. A range of measurements with in situ instruments on frames, tracking path lines with GPS-drifters and visualization by areal pictures made with a UAV (drone). Here, we focus on the results of the instruments at the three frames (A1–A3, see Figure 1) along a cross shore transect. At these frames, waves, currents, SSC, and bed level changes were measured to get insights in the exchange of sediment between channel and mud flat.

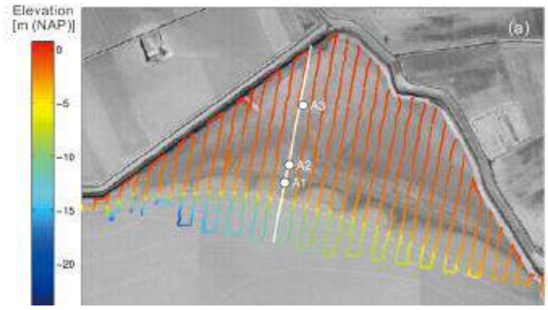

Figure 1: (top) Location of the Kapellebank in the Westerschelde. (bottom) position of the frames A1-A3.

2. Measurement Results

Timeseries were obtained over a period of 1 month at three locations. A period with high wind speeds coincided with neap tide. During this period, Location A1 was always flooded, resulting in high orbital velocities due to large wave heights during low tide. Subsequently erosion events occur during low water. Within several days a degradation of 10cm was found at location A1. Recovery of the bed took place in the weeks after. Approximately 2 weeks are needed for recovery of the bed. The other two locations (A2 and A3) hardly show bed level variations.

3. Interpretation

High waves are not sufficient to obtain high orbital velocities and associated erosion. Maximum near bed velocities are found at shallow water conditions, leading to erosion events. A storm is therefore most effective at the locations just below low water, as for these locations the period with waves in combination with shallow water is longest.

No significant bed level changes are found further on the flat, as erosion takes place when this part is dry. It is expected that the sediment has been transported into the channel. There, the bed shear stresses due to tidal currents are too high for sedimentation. The sediment concentration in the channel therefore increases. Deposition will subsequently take place again on the tidal flat. Recovery of the bed level is therefore relatively fast (weeks).

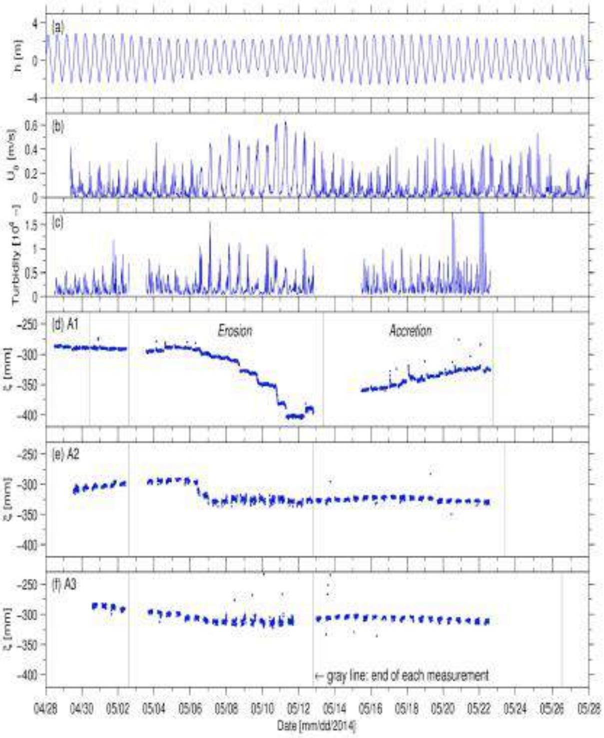

Fig. 1. Time series of
(a) water level (b) orbital velocity at site A1, (c) turbidity obtained by OBS attached on Vector, and (d)–(f) bed level changes measured by ADV at site A1, A2 and A3.

Optimization of offshore wind farm power cable routing

T.J. Roetert[1,2], R.W. Hasselaar[2], B.W. Borsje[1,2], S.J.M.H. Hulscher[1]

[1]Water Engineering and Management, University of Twente, Enschede, The Netherlands. t.roetert@gmail.com
[2]Deltares, Harbour Coastal and Offshore, Delft, The Netherlands

1. Introduction

Up to now methods to optimize cable route layout are only based on a flat seabed and do not take the seabed dynamics into account (Jenkins et al., 2013; Morelissen et al., 2003). The result of this approach is that power cable coverage is not guaranteed over wind farm design lifetime. Cable optimization is mainly executed based on shortest routes instead of cost reduction over the entire design lifespan. The aim of this research is to develop a Matlab based tool, which optimizes power cable route design based on expected morphological behaviour in the design lifetime of an offshore wind farm.

2. Methodology

To find the optimized cable layout a tool is developed including the optimization under a flat, static and dynamic seabed. These three steps help to identify the impact of bedforms on cable positions.

2.1 Flat and static bed optimization

First, the cable layout is determined based on a flat and static seabed. Found layouts show large similarities with the original layout in terms of total length. Thereby, the original layout is used during the optimization under a dynamic seabed.

2.2 Dynamic bed optimization

All connections in the original layout are optimized in vertical and horizontal direction. The aim for this step is to minimize weights of all connections. Cable weights are determined based on the cost function incorporating risk of failure and costs of failure, cables and monitoring.

3. Results

In section 3 the results of the research are presented.

3.1 Horizontal optimization

Figure 1 displays the optimized horizontal cable position. Combining all optimized connections shows that all vertical optimizations lead to a decrease in costs. Results of the horizontal optimization depend on the fixed burial depth and bed level change. Combined with an option to include case-specific information, it can be assumed that the tool is general applicable.

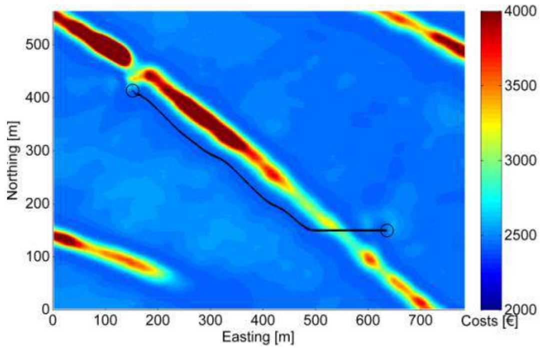

Figure 4: Horizontal (r) optimization of connection between two wind turbines

3.2 Sensitivity analysis

Parameters used in the vertical and horizontal optimization were all fixed. To show the influence of the different parameters, a rough sensitivity analysis is executed. A parameter from all four cost function parts is analysed. Main conclusions are that the parameter magnitude, amount of turbines affected and dynamics of the crossed area form the greatest influence on total costs.

3.3 Survey prediction

Since the tool is designed to find the optimized cable layout over the wind farm design lifetime, also parameter sensitivity after survey prediction is analysed. Results show that survey prediction only has influence on parameter sensitivity during the horizontal optimization. In addition, only connections interfering with sand waves were affected.

4. Conclusions

The results of this research make a contribution towards renewable energy targets. With the aid of this tool, cable coverage can be guaranteed, reliability increases and project costs and risk of cable failure decreases.

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INITIAL VOLUME LOSSES AT NOURISHED BEACHES AND THE EFFECT OF SURFZONE SLOPE

Matthieu de Schipper[1,2], Sierd de Vries[1], Joao Mil Homens[1], Ad Reniers[1,3], Rosh Ranasinghe[3,4] and Marcel Stive[1]

[1] TUDelft, M.A.deSchipper@tudelft.nl[2] Shore Monitoring & Research
[3] Deltares
[4] Unesco-IHE

1. Introduction

Nourishment projects often experience a period of large initial losses just after completion of the project (Fig. 1). A better understanding of these losses would improve the design of nourishment strategies. There are various reasons for this large initial erosion rate; e.g. lateral dispersion by feeding of adjacent coastline (coastline curvature), cross-shore transport beyond the depth of survey, washing out of finer particles and the increased wave and current attack by the beach protruding further into the sea.

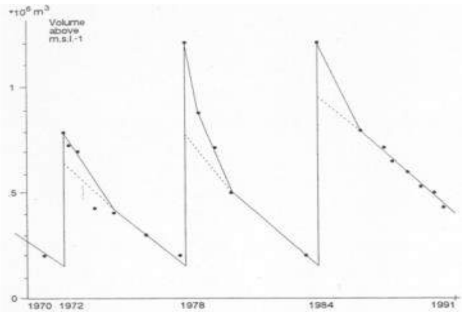

Figure 1: Sediment volumes at Sylt (Germany) in a coastal section with regular nourishments. Dashed lines indicate the background erosional trend, dots are annual measurements (from: Verhagen, 1992).

The effect of the change in the cross-shore slope by the nourishment on the initial erosion rate is however often not (explicitly) discussed. Generally, the shape of the profile at recently nourished sites is steeper than the pre-nourishment dynamic equilibrium profile. We propose that the large initial losses after installation of a nourishment could partly originate from this change in the cross-shore slope.

2. Estimating of the effect of cross-shore slope.

An increase in slope is likely to increase the alongshore sediment transport fluxes along the coast. For instance, if the common Kamphuis formula is used to predict the bulk sediment transport, a 100 % increase in the slope yields a 70 % increase in the cross-shore integrated alongshore sediment transport Qy. Consequently, for this topography with a steeper surf zone slope and larger alongshore sediment fluxes, the alongshore gradient in transport is increased as is the background erosion rate (Fig. 2).

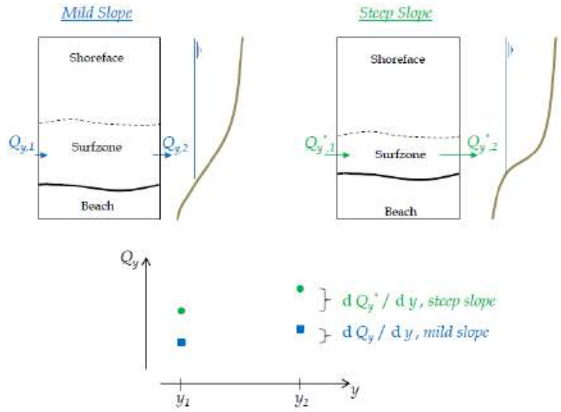

Figure 2: Plan view schematic of a coast with background erosion. Two cases are presented; with a mild profile slope in the surf zone (top left, blue) and the case after steepening of the profile (top right, green). The topography with a steep surf zone slope yields larger alongshore sediment fluxes Q_y and consequently a larger alongshore gradient in transport.

3. Field data

Morphological data from a nourishment at Vlugtenburg beach provide support for this hypothesis. At Vlugtenburg we observed a large difference in the erosion rates between the first years. Our measurements also showed that the slope adjusts on similar timescales as the timescales of initial losses, i.e. 1 to 2 years.

4. Conclusion

We conclude that the steepness of the man-made profile is an important parameter, which may be manipulated to influence the lifetime of the nourishment.

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Hydrodynamics of tidal waves in the Rhine-Meuse river delta network

Nynke Vellinga[1], Maarten van der Vegt[1] and Ton Hoitink[2]

[1] Department of Physical Geography, Utrecht University. Email n.e.vellinga@uu.nl and m.vandervegt@uu.nl
[2] Hydrology and Quantitative Water Management Group, Wageningen University. Email ton.hoitink@wur.nl

1. Introduction

The tidal propagation and discharge distribution through the Rhine-Meuse tidal river network strongly determines water levels and salinity intrusion. In this research we aim to gain insight in the propagation paths of the tidal wave through the network and the behaviour of the tidal wave at the junctions.

2.Methodology:

Measurements of flow velocity and salinity at twelve different junctions in the network have been analysed. Also, a three-dimensional model is used to improve spatial and temporal resolution with respect to the measurements. Modelled and observed water level and velocity data are in close agreement.

We analysed the model results by decomposing the hydrodynamics into an incoming and an outgoing wave. Water levels of the in- and outgoing waves are defined as $\eta_{in} = \frac{1}{2}(\eta + \sqrt{h/g}u)$ and $\eta_{out} = \frac{1}{2}(\eta - \sqrt{h/g}u)$, in which η is water level, h is water depth and u is flow velocity. A large outgoing wave indicates reflection or a 'backwards' propagating tidal wave. We also analysed the tidal energy fluxes in the network. As with the hydrodynamics, the tidal energy flux was split in an incoming and outgoing flux.

3. Results

In general, the incoming tidal wave amplitude decreases, while the phase increases when moving upstream. The outgoing wave characteristics strongly differ between branches. In some channels, a relatively large outgoing wave indicates tidal wave reflection. In others, the outgoing tidal wave is larger than the incoming one due to a circular propagation pattern in the network (Figure 1). The in- and outgoing wave phases support the results of the wave amplitudes and help to explain observed phase differences between branches at junctions.

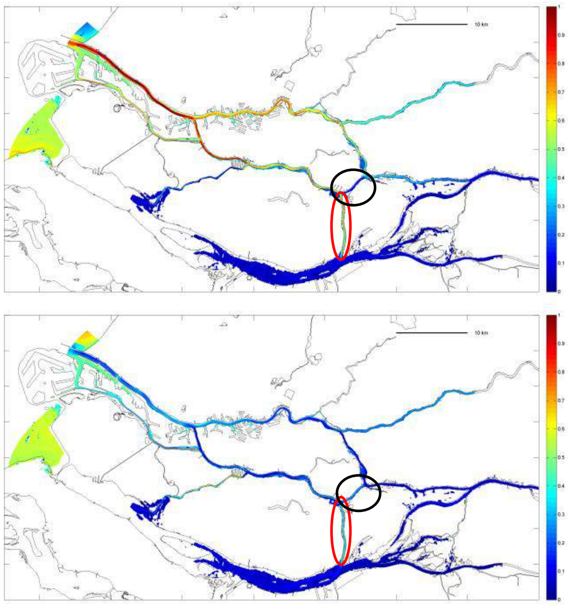

Figure 1: the tidal network with the amplitudes of the M_2 tidal constituent in meters. The top figure shows the amplitude of the incoming wave, the bottom figure the amplitude of the outgoing wave. In the red circled channel, the outgoing wave amplitude is large relative to the incoming wave amplitude. In the black circled channel, the outgoing wave amplitude is larger than the incoming wave amplitude.

The tidal energy flux shows a decreasing trend when moving upstream into the network. At junctions, the tidal energy flux is divided evenly among the different branches. This can result in decreasing energy fluxes while tidal amplitudes remain similar, as the energy flux is also dependent on (decreasing) channel width and depth.

4. Conclusions

Splitting the tidal wave in an incoming and outgoing wave elucidates the complex wave propagation paths and tidal wave reflection in the network. The results agree well with measurement data and explain observed phase differences between branches at junctions.

Dune growth due to aeolian sediment transport and the role of the beach and intertidal zone

Sierd de Vries[1], Matthieu de Schipper[1], Mitchell Harley[2], Gerben Ruessink[3]

[1] Delft University of Technology, Sierd.deVries@tudelf.nl; M.A.deSchipper@tudelft.nl
[2] Department of Physics and Earth Sciences, University of Ferrara, Italy, mitchell.harley@unife.it
[3] Utrecht University, B.G.Ruessink@uu.nl

Coastal dune systems are dynamic depending on their local conditions. During storms, dunes can erode due to marine processes. During calmer periods, dunes can recover and grow due to aeolian processes. The quantification of dune growth due to aeolian processes has received few attention. Increasing knowledge on the quantification of the growth of dunes is essential for predicting long term coastal evolution.

Recent studies on beaches and dunes along the Dutch coast have shown that annual accretion volumes in the dune area can be significant, in the order of 10 - 40 m^3/m/yr (de Vries et al. 2012). The source of the sediment which accumulates in the dunes is however unclear. We hypothesize that sand eroded from the upper beach is the main sediment supply for aeolian sediment transport governing dune growth.

To test this hypothesis we analyse cross-shore beach profiles collected on a monthly (seasonal) scale at three distinct locations. The data is collected at Vlugtenburg (by de Schipper et al., 2012) and Noordwijk (by Quartel et al., 2008) located in the Netherlands and Narrabeen located in Australia (by Harley et al., 2011).

Figure 1 shows an example of one of the analysed, cross shore, beach profiles. A gradual growing dune is present on the left hand side of Figure 1.The figure also shows some dominant signatures of stormy seasons at the lower beach areas where marine processes cause relatively large changes in the profile. In between the storm events, the upper beach areas are relatively stable. The high (and dry) part of the beach, which is not affected by marine processes (above the 3 m level) remains, relatively static during the full period.

Despite the significant changes in the morphology of the beach profile at this location, the growth of the dune is linear in time with a growth rate which is in the order of 30 m^3/m/yr. There is no significant erosion of the relatively stable upper/aeolian beach profile above 3 m NAP. Since there is no significant erosion due to aeolian processes at the upper beach, the deposited sediment in the dunes is unlikely to have originated from the upper part of the beach. It is unclear where this sediment originates but it is likely that the lower beach/intertidal area plays an important role. Since the intertidal zone is much more dynamic than the aeolian zone due to the influence of marine processes, it is however very difficult to analyse the volumes of erosion due to aeolian transport in the intertidal zone.

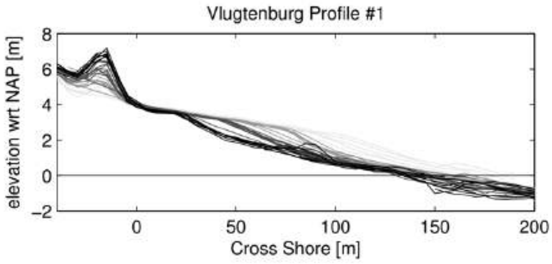

Figure 1. Profile measured at the Vlugtenburg location. The black and gray lines represent monthly measurements. The lightest colors show the earliest measurements. The darker colors represent the more recent measurements. Each year a darker color is used to stress the signature of the storm seasons.

We provide some evidence that supports the hypothesis that erosion in the *intertidal zone* accounts for a significant contribution to the sediment supply to the aeolian transport system but, the explicit role of the intertidal zone with respect to aeolian processes remains unclear. Process measurements could possibly supply valuable information on the specific role of the intertidal zone.

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Modeling the mud filling processes of tidal basins along the East China Sea coast

Yunwei Wang[1,2], Qian Yu[2] and Zheng Bing Wang[1,2]

[1] Deltares, the Netherlands ms.ywwang@gmail.com zheng.wang@deltares.nl
[2] Delft University of Technology, the Netherlands qianyu.nju@gmail.com

1. Introduction

Along the rocky coast of the East China Sea (Zhejiang and Fujian coast), a number of tidal basins formed in association with the early Holocene sea level rise. Fed by long-distance transported fine sediments from the Changjiang Estuary, these sheltered basins act as one of the important sinks of the large-scale Changjiang sedimentary system. The sedimentary and morphological patterns are characterized by: (1) thick muddy stratigraphy in the order of 10^1 m, (2) very fine sediments (typically silty clay), and (3) for long basins (e.g., Xiangshan Bay, Shacheng Bay), mud accumulate at the head of the bay, while a complex channel-flat morphology forms in wide basins (e.g. Sanmen Bay, LuoyuanBay). The understanding of the mud filling processes can help build a panoramic view of source-to-sink system of the Changjiang sediments.

2. Methods

In the present study, two-dimensional depth-averaged processes-based models (Delft3D) were used to simulate the long-term basin sedimentary and morphological processes associated with mud filling. Two types of idealized model domains were designed as abstractions of basin shapes (wide and long, respectively). Each domain consists of a tidal basin and a shelf area, connected through an inlet. Wave and tidal forces were involved, and the model was simulated for 300 years to allow the filling processes fully developed. From the initial uniform depth of 10m, the basin was filled quickly during the simulation period of 300 years.

3. Results

The supply of highly mobile fine sediments from the sea boundary can not settle down on the open shelf due to wave erosion, while in the sheltered basin, sediments carried by flood currents accumulated in the inner area where bed shear stresses are small. The final results show the channel-flat morphology and the mud deposition ca. 10 m thick on the flat area. The wide and long basins show quite different patterns of system developments (Figure 1, 2). These characters both agree with observations.

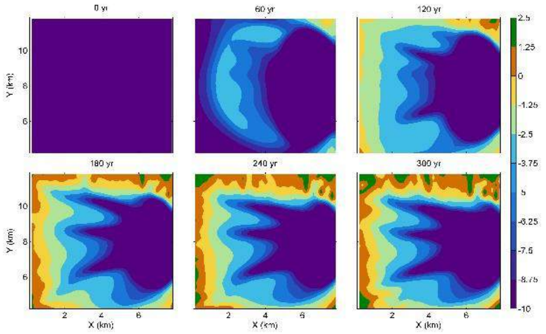

Figure 1: Bed elevation (m) to the MSL of wide tidal basins (every 60 yrs)

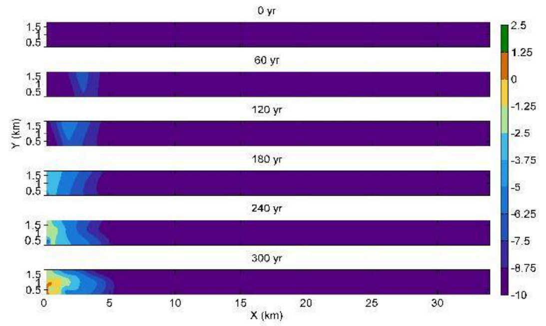

Figure 2: Bed elevation (m) to the MSL of long tidal basins (every 60 yrs)

These simulations suggest that the tidal basins can be filled very quickly (in the order of 10^2 yrs) compared with the Holocene high sea level period, and the main part of the stratigraphy records the information during the early stage when the Changjiang sediments reaching the adjacent shelf.

4. Conclusions

The mud filling processes of the sedimentary and morphological system were reproduced by numerical models. Tides, wind waves, boundary waves, sediments, and basin topography play important roles. The filling processes of wide and long basins are quite different: the former being associated with quick filling and then maintaining equilibrium, while the later being characterized by uniform filling with reduced rates. The stratigraphy within basins can record the environmental information of the Changjiang system, but the accumulation rates are dependent on spatial and temporal scales.

Salt dynamics in well-mixed estuaries: importance of advection by tides

Xiaoyan Wei[1], George P. Schramkowski[2] and Henk M. Schuttelaars[1]

[1] Applied Mathematics, Delft University of Technology
Email: x.wei-1@tudelft.nl; h.m.schuttelaars@ewi.tudelft.nl
[2] Flanders Hydraulics Research
Email: george.schramkowski@mow.vlaanderen.be

1. Introduction

Both the spatial and temporal distribution of salinity can significantly influence residual water motion through the gravitational and tidal straining, thus affecting the transport of sediment and pollutants, etc. In this work, we will investigate the salt transport mechanisms at the tidal time-scale, which is parameterized as an along-channel diffusivity in classical theories (Geyer & MacCready, 2014).

2. Methodology

To investigate the residual along-estuary salt transport, a width-averaged model is developed for estuaries that are tidally dominated and well-mixed. The water motion is solved using the same equations, boundary conditions and method as in Chernetsky et al (2010). The leading order water motion can be obtained without salinity information. To solve the residual flow, a width-averaged salinity equation has to be calculated. The salinity at the estuarine mouth is prescribed and the residual salt transport is required to vanish at the weir in the landward side. Furthermore, the salt flux through the sea surface and the bottom has to vanish. It is found that the temporal correlation between the velocity and salinity at the tidal time-scale results in a residual diffusive salt flux,
yielding a residual salt balance of

$$\left(K_x^{adv} + K_x\right)\frac{dS_0}{dx} = -\frac{R}{HB}. \qquad (1)$$

In Eq. (1), $K_x^{adv} = -\frac{1}{2}R\left\{\frac{1}{H}\int_{-H}^{0}\hat{S}_1\hat{u}_0^* dz\right\}\left(\frac{dS_0}{dx}\right)^{-1}$ measures the contribution of residual salt transport due to tidal advection. It is called the tidal advective diffusion, and can be calculated with the leading order water motion. Here S_0 is the leading order salinity, $\widehat{S}_1$ and $\hat{u}_0^*$ are the complex amplitude of the first order salinity and the conjugate complex amplitude of the leading order horizontal velocity. H and B are the depth and width of the estuary, and R is the river discharge prescribed at the weir. K_x is the horizontal diffusivity, parameterizing all unresolved processes of residual salt transport in the width-averaged model.

3. Results

Using observed residual salinity profile of the Delaware Estuary, the tidal advective diffusion K_X^{adv}, the total diffusivity $K_x^{total} = K_x + K_X^{adv}$, and the horizontal diffusivity K_x can be obtained. As shown in Fig. 1, K_X^{adv} is nearly constant with a value of 20 m^2/s, while K_x varies from 36 m^2/s at the mouth to 6 m^2/s in the middle region. This suggests that in the central region of the salt intrusion, tidal advection is the most significant process of residual salt transport.

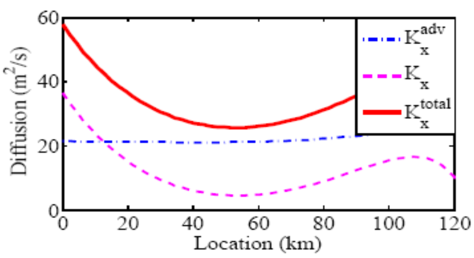

Figure 1: Diffusivity coefficients in the Delaware Estuary.

4. Conclusions

The contribution of tidal advective diffusion to residual salt transport is derived in a consistent way. It is the most significant residual salt transport mechanism in the middle region of the Delaware Estuary. The sensitivity of the tidal advectie diffusion to model parameters, together with some other applications will be presented during the NCK days.

Acknowledgments

This research was supported by the China Scholarship Council (CSC Program).

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The role of waves and currents on the sediment transport during overwash events

D.A. Wesselman[1], M. van der Vegt[1] and P. Hoekstra[1]
[1]Universiteit Utrecht, email: D.A.Wesselman@uu.nl

1. Introduction

Storm events generally result in increased water levels at the Wadden Sea coast. This can result in overwash and inundation (beach/dune crest is continuously flooded) of the beach/dune system (Sallenger, 2000). It is hypothesized that the cross-shore sediment transport, caused by such events, can on the long term contribute to the vertical accretion of the barriers. The Wadden Islands could in this way keep up with sea level rise. However, humans have turned the foredune system into a sand drift dike with a static and closed front. Presently, the re-opening of dunes is considered, creating a more natural dune system and making the barrier islands more resilient to sea level rise. The main goal of this presentation is to identify the dominant cross-shore hydrodynamic and sediment transport processes during an overwash event at a non-vegetated barrier (eastern tip of Wadden Sea island).

2.Methodology

2.1 XBEACH

The process-based model XBEACH (Roelvink et al., 2009) is used to simulate the dynamics of a low-lying barrier during an overwash event. The development of short- and long waves, currents, sediment transport and morphological change in a cross-shore transect was investigated. As a first step we studied the dynamics at an artificial barrier profile under different forcing conditions. We studied the sensitivity of the results to the wave forcing, water level and beach slope. The cross-shore profile represents a seaward boundary, where boundary conditions are prescribed, a non-vegetated spit, and a 2.5 km long low-lying basin at maximum 5 m depth. It represents a characteristic Wadden Sea profile. Next, we simulated storm events that occurred at the Eastern part of Schiermonnikoog (see abstract by Engelstad et al. for further information on the field campaign).

3. Results

The sensitivity of the cross-shore sediment flux over the top of a 2 m high barrier crest as a function of water level is illustrated in Figure 1. There is a maximum onshore (positive) sediment flux when mean water levels are 0.7 m above the crest height, for other parameters being constant. When changing the inundation depth both the waves (influencing the sediment resuspension) and the cross-shore currents
change. Due to wave breaking a mean set-up is generated. In contrast to what is observed near closed dune systems, in this case no offshore directed flow but a strong onshore directed flow is generated, because mean water levels are larger at the seaward side of the barrier than on the basin side. The results further suggest that largest onshore transport does not necessarily occur for the largest storms, but may occur for the milder storms that are present more frequently in the Wadden Sea area.

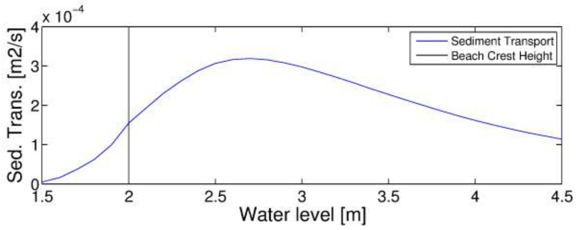

Figure 1: Mean sediment transport above the beach crest as function of water level. Positive means a landward flux. The beach crest height is 2 m.

4. Conclusions

We conclude that the largest flux of sediment over a spit/barrier occurs for relatively low water levels, representing mild storms. At present we are comparing observed inundation events at Schiermonnikoog with our model results. In the final phase we will investigate whether on the long term these fluxes are large enough to create aggradation of the barrier island and to compensate for sea level rise.

Acknowledgments

This project is funded by Climate-KIC.

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Regional uncertainties in sea level rise

Renske de Winter[1], Thomas Reerink[1] and Roderik van de Wal[1]

1 Utrecht University, Institute for Marine and Atmospheric research Utrecht (IMAU), r.c.dewinter@uu.nl

1. Introduction

Global sea level rise is not expected to be the same around the globe. This is related to different contributions of ocean dynamics, thermal expansion and gravitation effects due to mass redistribution. In the latest IPCC assessment report it is assumed that the uncertainties around these projects are gaussian distributed implying, that uncertainties are equally likely for both higher and lower probabilities. However, expect judgement (Bamber and Aspinall, 2013) shows that, as a result of ice sheet dynamics, the contribution of ice sheet melt to sea level rise SLR has large uncertainties towards high values. This would not only result in higher global average SLR as there is more water in the ocean, because as a result of the gravitational effect (mass attacks mass) the contribution of ice sheet melt varies regionally. Locally near a melted ice sheet it could even result in a sea level drop.

In this study we analyse how an asymmetric distribution influence the uncertainty in regional SLR.

2.Methodology

The different contributions to SLR are calculated by combining the probability density functions PDF from Bamber and Aspinall (2013) of Greenland, West Antarctica and East Antarctic and the global climate contribution to generate regional PDFs for sea level rise.

3. Results

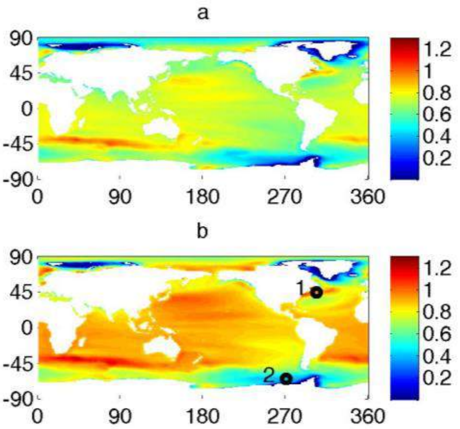

Figure 1: Mean SLR (m) for 2081-2100 a. Slangen et al. 2014, scenario B, b. with skewed estimated for ice sheet melt according to Bamber and Aspinall

There is a large variation in regional SLR (Figure 1a), as previous concluded by Slangen et al. (2014). The mass reduction of the ice sheets make that less water is attracted towards Greenland and West-Antarctica and hence a sea level drop is projected at these location.

If skewed PDFs for the ice sheets are taken into the mean SLR projection also changes for some locations, Figure 1b. However also the uncertainty ranges for SLR projections change. With a left skewed PDF for locations near the ice sheet (Figure 2c) and a right skewed PDF for location further away from the ice sheets (Figure 2a).

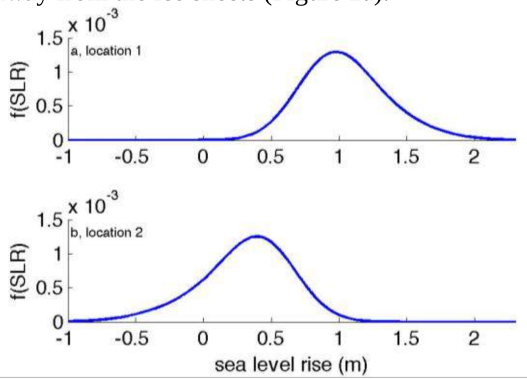

Figure 2: PDFs for sea level rise with skewed ice sheet contributions according to Bamber and Aspinall (2013) at locations 1(a) and 2(b) in Figure 1b.

4. Conclusions

The PDF for sea level rise near the ice sheets is expected to be skewed negative (for higher uncertainty levels the bandwidth towards lower values is large than the band width to higher values)

For most locations, the skewed uncertainties in ice sheet melt results in higher SLR estimates for the upper tail of the PDF.

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Wave and wind effects on the longterm morphodynamics of tidal-dominated back-barrier tidal basins, a modelling approach

Qian Yu[1], Yunwei Wang[2] and Zheng Bing Wang[3]

[1] Delft University of Technology, qianyu.nju@gmail.com
[2] Deltares & Delft University of Technology, ms.ywwang@gmail.com
[3] Deltares & Delft University of Technology, Zheng.Wang@deltares.nl

1. Introduction

In addition to the tidal forces, back-barrier tidal basin morphology is also possibly influenced by several other factors, including sea boundary wave conditions, wind-induced local waves, and wind-induced currents. How these factors and their combinations control the basin longterm morphodynamics can be investigated by the numerical experiments.

2. Methods

A 2DH process-based Delft3D model was utilized in the present study. The model domains are highly schematized to mimic the planimetric view of a back-barrier tidal inlet-basin system in the Wadden Sea region (Figure 1).

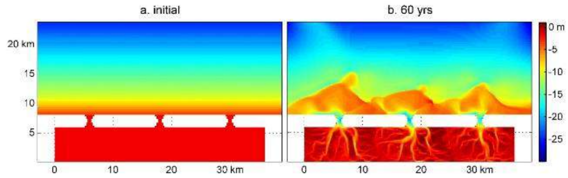


Figure 1: (a) The initial bathymetry of the modeling domain; (b) The bathymetry map of the reference case d1 after a 60 year simulation. Color bar denotes the bed elevation.

No.	Wind-current	Wind-wave	H_s (m)	W (m/s)
Case a1	N	N	0	0
Case a2	N	N	1.5	0
Case b1	Y	N	0	6
Case b2	Y	N	0	9
Case c1	N	Y	1.5	6
Case c2	N	Y	1.5	9
Case d1	Y	Y	1.5	6
Case d2	Y	Y	1.5	9

Table 1: Numerical modeling settings. H_s is sea boundary wave heights, and W is wind speed. Y (N) denotes that the related process is (not) involved.

Eight experiments were designed with the same tidal range of 3 m (Table 1). Case a1 and a2 only differ in sea boundary wave heights, wind-current and wind-wave effects are studied by Case b1 and b2 and Case c1 and c2, respectively, and Case d1 and d2 are to study the combined influences of wind-currents and wind-waves. All the cases were simulated for a 60-year period to make sure that the system reached equilibrium states.

3. Results

The equilibrium basin morphology can be presented by the area distribution (Figure 2). The sea boundary waves have limited influence on the distribution. The strong wind-currents increase the upper tidal flat area but reduce area of the low flat, while increasing wind-waves lead to opposite responses. The combination of these two processes leads to less low flat area but more area below the MLW in the basin.

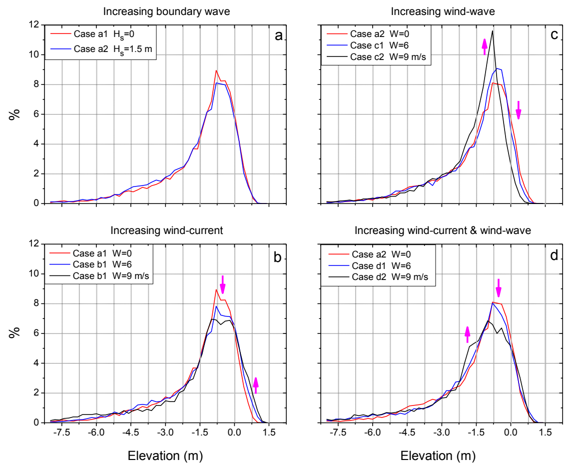


Figure 2: Distribution of areas within the tidal basins as a function of bed elevation. The arrows represent the variations of the curves with the increasing effects of the related processes. The light grey vertical lines denote the MLW (-1.5 m), MSL (0 m), and MHW (1.5 m), respectively.

4. Conclusions

Sea boundary waves can not modify the back-barrier basin morphology, but wind-current and wind-wave play an important role.

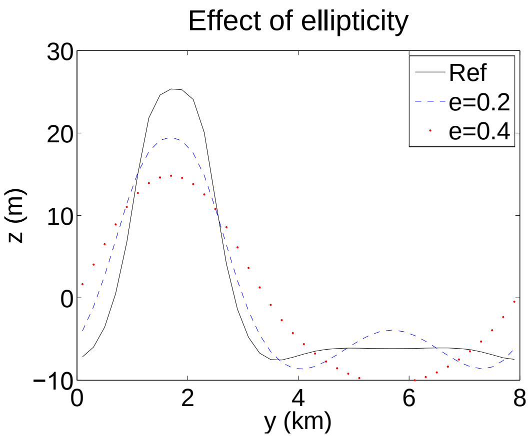
Finite height behaviour of offshore tidal sand ridges: a nonlinear model study

Bing Yuan[1], Huib de Swart[1] and Carles Panades[1]

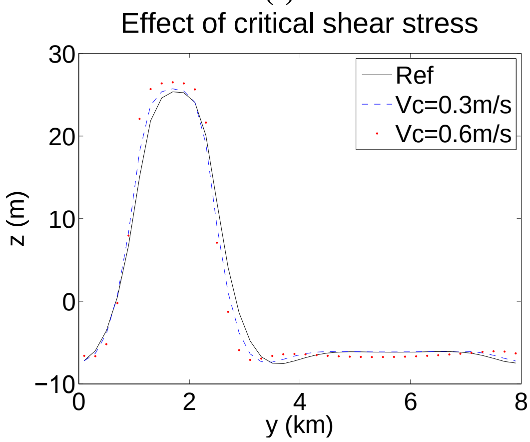
[1] Institute for Marine and Atmospheric Research Utrecht (IMAU), Utrecht University
b.yuan@uu.nl, h.e.deswart@uu.nl, C.PanadesGuinart@uu.nl

1. Abstract

Tidal sand ridges are large-scale bedforms on the continental shelves with sandy beds. These rhythmic seabed features have a typical wavelength of *O*(10) km and a height of *O*(10) m. Knowledge of these large-scale bedforms is important for navigation purposes, the health of the fishing industry and the stability of underwater structures, and also for making strategic planning of marine sand mining. In prior studies, highly simplified models (Huthnance, 1982; Roos et al., 2004) have been used to study the finite height behaviour of offshore tidal sand ridges, in which tidal currents are rectilinear, and the critical shear stress for sediment erosion is excluded. However, in reality tidal currents are generally elliptical, and the sediment would not be moved until the bed shear stress is large enough. In this work, an idealised nonlinear numerical model is used to study the finite height behaviour of these features. Specific aims are to quantify the effect of tidal characteristics and critical shear stress of sediment erosion on the nonlinear evolution of these bedforms. It is found out that if elliptical tides are imposed, the finite height of the ridges becomes lower, while if the critical shear stress is accounted for, the height of the ridges becomes higher and the crest becomes flatter (Figure 1).



(a)



(b)

Figure 1. Effect of tidal ellipticity and critical shear stress on equilibrium profiles for bed load. In the reference case (Ref), the undisturbed water depth is 30 m, the maximum current velocity is 1 m/s, without Coriolis force (the same setting as the case 0_b in Roos et al., 2004). Panel (a) shows the effect of including tidal ellipticity *e* (defined as the minor divided by the major of the tidal ellipse), and panel (b) shows the effect of including the critical shear stress/velocity *Vc* of sediment erosion.

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6. Notes

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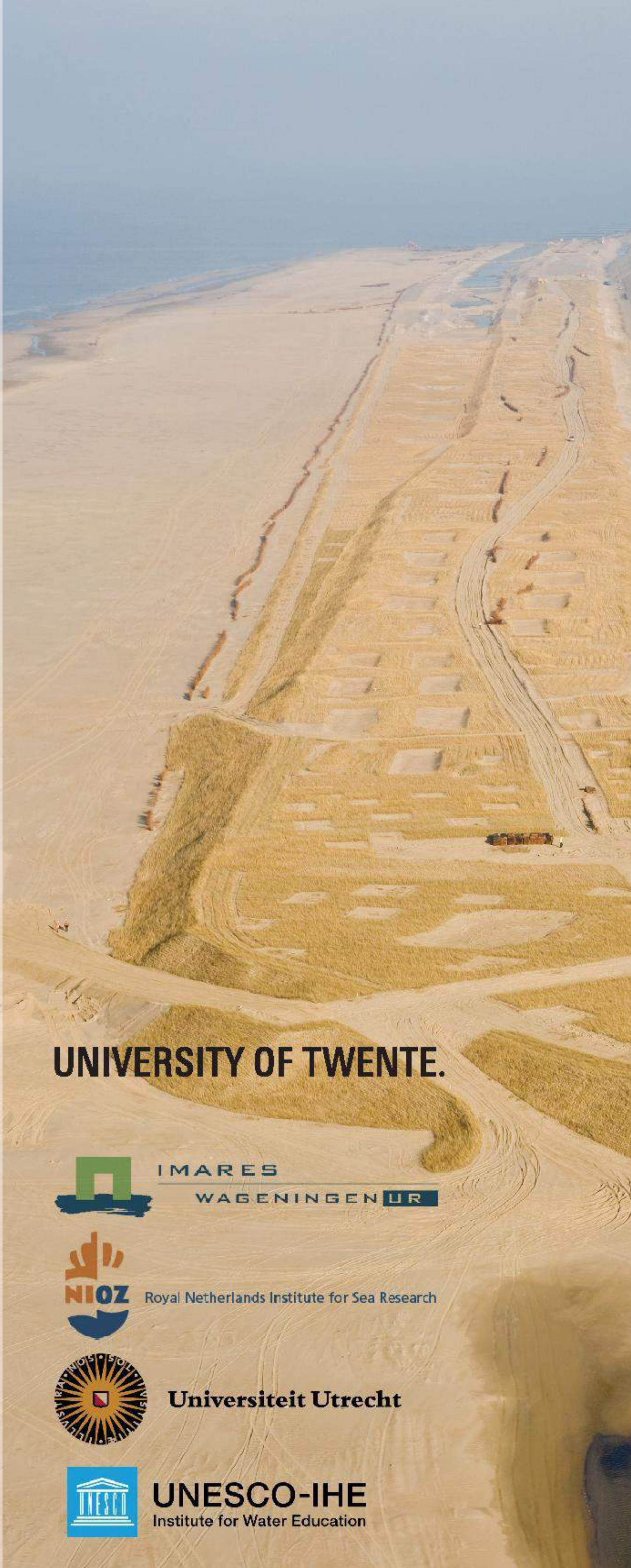

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