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Book of Abstracts

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Royal Netherlands Naval College (KIM) – Den Helder

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Netherlands Organisation for Scientific Research

Organised by:

Wageningen University & Research

Contents

Preface

Welcome to the 25th NCK days!

Wageningen Marine Research is organizing this lustrum edition of the NCK days. We have chosen Den Helder as conference location since there is a perfect fit between this location and NCK for a number of reasons. Firstly, Den Helder is surrounded by the sea at three sides: to the west is the North Sea with its dunes and beaches, to the north is the impressive Marsdiep tidal inlet and to the east are the mudflats of the Wadden Sea. Secondly, since November 2015, Wageningen Marine Research has a new office in Den Helder in a building that very appropriately used to be a maritime academy. The building has a typical Amsterdamse School architecture and was opened in 1930. Thirdly, Den Helder has a large navy port and it hosts the Royal Netherlands Naval College, where 'adelborsten' are trained to become naval officers of the Royal Netherlands Navy. Furthermore, Den Helder's port is a perfect harbour for the offshore and fishing industry. Thus, Den Helder is intimately linked to the sea and coast in combination with education; perfect for the NCK!

This lustrum edition has a number of specials. We invited two interesting and surprising keynote lecturers. We will go out to explore on sea, on board of the TX44, and visit the port of Den Helder, the Wadden Sea mudflats and the Razende Bol, the latter for seal watching. And of course we have a lustrum photo competition, so bring your camera!

We thank NWO for sponsoring and we wish you interesting and fruitful NCK days 2017!

The organising committee
Martin Baptist, Alma de Groot & Marlies Baart.

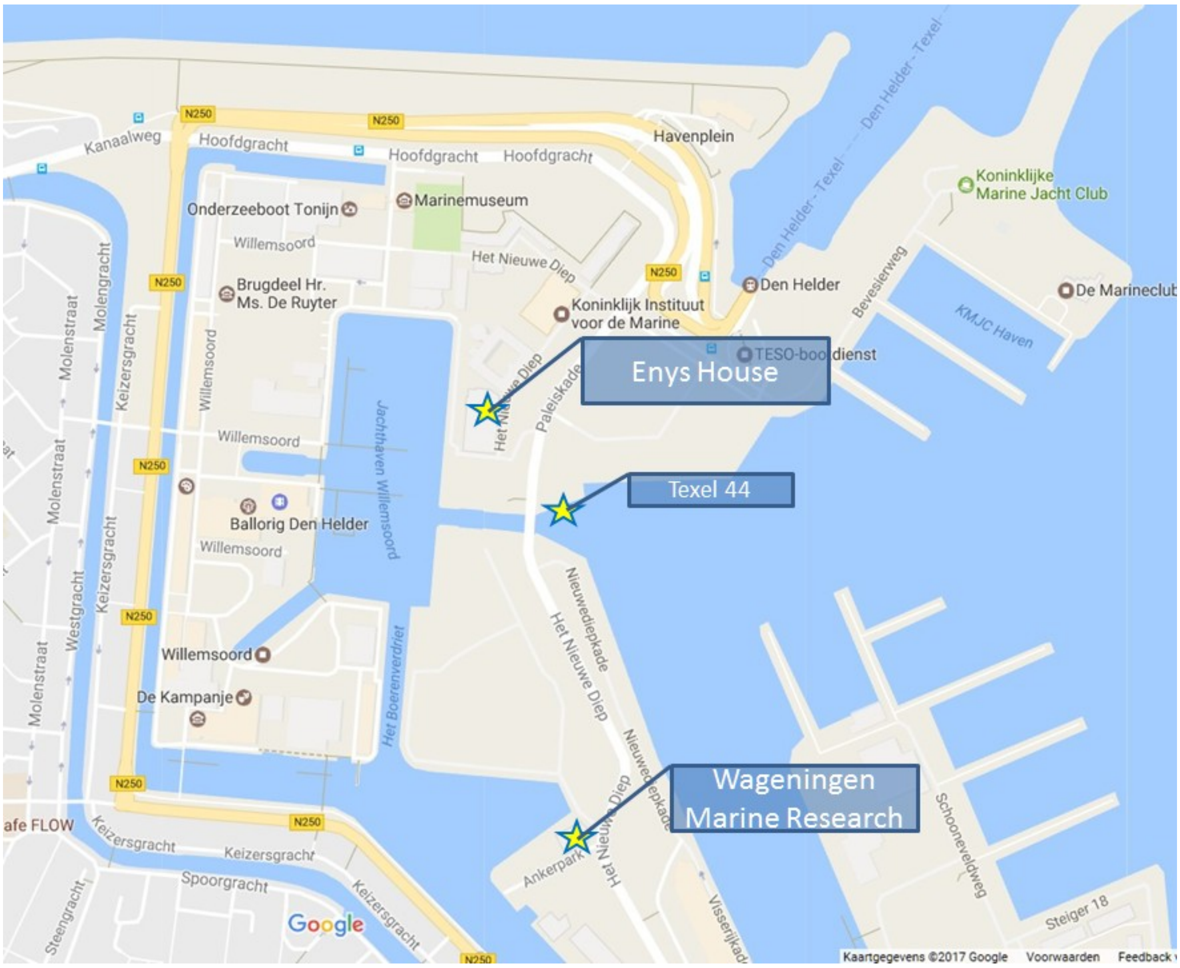
Conference locations

Important locations for this conference are shown on the map below.

We open on Wednesday evening, March 15, with an icebreaker reception at Wageningen Marine Research in the former “Zeevaartschool”.

The symposium is hosted at the Royal Netherlands Naval College at Den Helder, in the educational building “Enys House”.

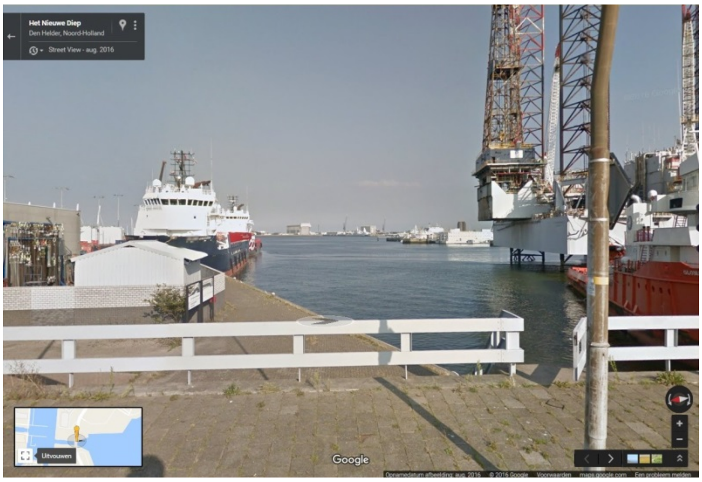
The excursion boat will be moored at the quay opposite of Enys House.



Boat tour

We will embark on the Texel 44 opposite the conference location Enys house at the outer side of the sluice near the drilling platform, see picture for the location of the quay.

On board we meet Kees Turnhout, director of the Port of Den Helder and former commander of the Royal Naval College. The boat will lead us through the Port of Den Helder and past the tidal flats of Balgzand while we explain about the Building with Nature plans in this port. We will then sail out to the Razende Bol where we go seal watching.



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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.

Objectives

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.

For more than 20 years, the NCK collaboration continues to stimulate the interaction between coastal research groups. It facilitates a strong embedding of coastal research in the academic programmes and courses, attracting young and enthusiastic scientists. Several times a year, the NCK organises workshops and/or seminars, aimed at promoting cooperation and mutual exchange of knowledge.

NCK is open to researchers from abroad and exchanges of young researchers are encouraged. Among the active participants we often find people from a lot of different institutes and companies.

Organisation NCK

Netherlands Centre for Coastal Research
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www.nck-web.org

The directory board of NCK consists of:

- prof. J. Kwadijk PhD. (Deltares, Chairman)
- J. Vroom MSc. (Programme Secretary NCK, c/o Deltares)
- K. van der Werff MSc. (Rijkswaterstaat)
- prof. S.G.J. Aarninkhof PhD. (Delft University of Technology)
- prof. P. Hoekstra PhD. (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. J.A. van Dijk PhD. (UNESCO-IHE)
- J. Asjes MSc. (Wageningen Marine Research)
- M. van der Meulen PhD. (TNO Geological Survey of the Netherlands)

The NCK Programme committee consists of:

- A.J.F. van der Spek PhD. (Deltares, Chairman)
- J. Vroom MSc. (Programme Secretary NCK, c/o Deltares)
- G. Ramaekers MSc. (Rijkswaterstaat)
- B.C. van Prooijen PhD. (Delft University of Technology)
- K.M. Wijnberg PhD. (University of Twente)
- D.S. van Maren PhD. (Deltares)
- T. Gerkema PhD. (Royal Netherlands Institute for Sea Research, NIOZ)
- prof. T.J. Bouma PhD. (Royal Netherlands Institute for Sea Research, NIOZ)
- prof. J.A. Roelvink PhD. (UNESCO-IHE)
- M.J. Baptist PhD. (Wageningen Marine Research)
- M. van der Vegt PhD. (Utrecht University – IMAU)
- S. van Heteren PhD. (TNO Geological Survey of the Netherlands)

Historical context

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

1920

An important step in the development of formalized knowledge was taken in the 1920s by the Nobel-prize laureate Hendrik Lorentz, who designed a computational scheme for assessing the tidal effects of the closure of the Zuyderzee. At the same time, with the founding of Delft Hydraulics, physical scale models became the favourite instrument for designing coastal engineering works. They remained so for a long time.

1953

The storm surge disaster of 1953 provided a strong incentive for coastal research in support of the Delta Project, which entailed a drastic shortening of the Dutch coastline. The Delta Project profoundly affected the morphodynamics of the Rhine-Meuse-Scheldt delta; large parts of the system were transformed into what one might call a life-size hydraulic laboratory.

1965

In the 1960s, a monitoring programme (JARKUS) was established to assess the evolution of the nearshore zone along the entire Dutch coast on a yearly basis. The resulting data base revealed not only short-term fluctuations of the shoreline, but also large-scale structural trends. The JARKUS data set represents a key source of coastal information, particularly in combination with historical observations of Dutch coastline evolution that date back to 1840-1850. With no equivalent data set available worldwide, the unique JARKUS data base has inspired a wealth of coastal research programmes throughout the years.

1985

The growing need for integrated coastal management led by the end of the 1980s to the development of a national coastal defence policy of 'Dynamic Preservation' (1990). This involved sustainable maintenance of the coast through 'soft' interventions (often nourishment of the beach and shoreface with sand taken from offshore) allowing for natural fluctuations. The basic principles were derived from a major research project for the systematic study of persistent trends in the evolution of the coastal system. This Coastal Genesis project - carried out by a multidisciplinary team of coastal engineers, physical and historical geographers and geologists - laid the ground for NCK.

1991

The successful multidisciplinary collaboration initiated during the Coastal Genesis project was institutionalized by means of the founding of the Netherlands Centre for Coastal Research (NCK). The NCK was initiated by the coastal research groups of Delft University of Technology, Utrecht University, WL | Delft Hydraulics and Rijkswaterstaat RIKZ. Early 1996, the University of Twente and the Geological Survey of The Netherlands (now the Netherlands Institute of Applied Geoscience TNO: TNO-NITG) joined NCK, followed by the Netherlands Institue for Sea Research (NIOZ, 1999), the Netherlands Institute for Ecology - Centre for Estuarine and Marine Ecology (NIOO-CEME, 2001), UNESCO-IHE Institute for Water Education (2004) and Wageningen IMARES (2008).

The NCK Partners

Wageningen Marine Research

Our mission

- To explore the potential of marine nature to improve the quality of life.

Wageningen Marine Research (WMR) is the Netherlands research institute established to provide the scientific support that is essential for developing policies and innovation in respect of the marine environment, fishery activities, aquaculture and the maritime sector. We conduct research with the aim of acquiring knowledge and offering advice on the sustainable management and use of marine and coastal areas. Wageningen Marine Research is an independent, leading scientific research institute

We carry out scientific support to policies (50%), strategic RTD programmes (30%) and contract research for private, public and NGO partners (20%). Our key focal research areas cover marine ecology, environmental conservation and protection, fisheries, aquaculture, ecosystem based economy, coastal zone management and marine governance. Wageningen Marine Research primarily focuses on the North Sea, the Wadden Sea and the Dutch Delta region. It is also involved in research in coastal zones, polar regions and marine tropical areas throughout the world and in specific fresh water research.

Wageningen Marine Research 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 state-of-the-art in-house facilities that include specialist marine analysis and quality labs, outdoor mesocoms, specific field-sampling devices, databases and models. The Wageningen Marine Research quality system is ISO 9001 certified.

More information
http://www.wur.nl/en/Expertise-Services/Research-Institutes/marine-research/about-us.htm

Representatives
Representative in the NCK Board of Supervisors: J.Asjes MSc
Representative in the NCK Programme Committee: M. Baptist PhD

WAGENINGEN
UNIVERSITY & RESEARCH

TNO

Geological Survey of the Netherlands

The government has assigned various tasks to TNO in respect of information on the Dutch subsurface. TNO acts (internationally) as the Geological Survey of the Netherlands and we manage data and information supplied by mining companies to the Minister of Economic Affairs, Agriculture and Innovation.

TNO has the legal task of making information on the Dutch subsurface available to Dutch society so as to enable the sustainable use and management of the subsurface and the mineral resources it contains. This information is needed to make comprehensive decisions concerning the organisation of the space above and below ground.

More information
https://www.tno.nl/en/

Representatives
Representative in the NCK Board of Supervisors: M. van der Meulen PhD
Representative in the NCK Programme Committee: S. van Heteren PhD

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. S.G.J. Aarninkhof 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
Representatives in the NCK Programme Committee: A.J.F. van der Spek PhD, D.S. van Maren PhD

Deltares
Enabling Delta Life

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. Brinkhuis PhD
Representatives in the NCK Programme Committee: T. Gerkema PhD, T.J. Bouma 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 takes care of the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands. They are 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
The participation of Rijkswaterstaat in NCK is covered by the service Water, Traffic and Environment (WVL). WVL develops the vision of Rijkswaterstaat 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 Rijkswaterstaat requires to perform its tasks, now and in the future.
As such, Rijkswaterstaat - WVL works closely with knowledge institutes. 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: K. van der Werff MSc
Representative in the NCK Programme Committee: G. Ramaekers MSc

Rijkswaterstaat
Ministerie van Infrastructuur en Milieu

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: J.A. van Dijk PhD
Representative in the NCK Programme Committee: Prof. D. Roelvink PhD

UNESCO-IHE
Institute for Water Education

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

UNIVERSITY OF TWENTE.

Utrecht University

Institute for Marine and Atmospheric Research Utrecht IMAU

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

Final Programme NCK days 2017

Wednesday 15 March

20:00 **Icebreaker reception** at Zeevaartschool, Ankerpark 27 Den Helder

Thursday 16 March

08:30 **Registration at Enys House, Koninklijk Instituut voor de Marine**

09:00 **Opening** by Kapitein der Zee Peter van den Berg, commandant van het KIM and Tammo Bult, director Wageningen Marine Research

09:30 **Keynote**: dr. Aart Kroon, Københavns Universitet
MORPHODYNAMICS OF A BARRIER ISLAND AND ADJACENT LAGOON IN SOUTHERN DENMARK

10:00 **Session 1: Mud**, chair: Han Winterwerp

L. Braat
COHESIVE SEDIMENT IN SCALE-EXPERIMENTS OF ESTUARIES

I. Colosimo
WIND EFFECTS ON INTERTIDAL FLAT SEDIMENT TRANSPORT

R.C. van de Vijsel
DO ALGAE BOOST LANDSCAPE FORMATION?

10:45 **Poster pitches**

11:00 **Coffee/tea break**

11:30 **Session 2: Sand nourishments**, chair: Gemma Ramaekers

C. van Gelder - COASTAL GENESIS 2.0

T.D. Price
OBSERVATIONS OF LANDWARD SAND MOVEMENT AT A NATURAL AND A NOURISHED BEACH

P. Rauwoens
THE FINANCIAL IMPACT OF BLOWN SAND: AN ASSESSMENT AT THE BELGIAN COAST

J. Cleveringa
THE INS AND OUTS OF SEDIMENT BUDGETS

D. Roelvink
COASTLINE MODELLING: THE NEXT GENERATION?

12:45 **Lunch**

14:00 **Session 3: Biogeomorphology in salt marshes**, chair: Bas Borsje

T.J. Bouma
SEDIMENT DYNAMICS AS DRIVER OF SALT MARSH DYNAMICS

P.W.J.M. Willemsen
SEASONALITY IN MORPHOLOGICAL BEHAVIOUR AT THE INTERFACE OF SALT MARSHES AND TIDAL FLATS USING HIGH TEMPORAL RESOLUTION FIELD DATA

Ü.S.N Best
MODELLING SEA LEVEL RISE IMPACT ON SALT MARSH/MANGROVE-MUDFLAT MORPHODYNAMICS

C. Schwarz
ARE PLANT LIFE-HISTORY STRATEGIES ABLE TO SHAPE BIO-GEOMORPHOLOGIC INTERACTIONS?

M. van Regteren
BIOGEOMORPHIC IMPACT OF OLIGOCHAETES (ANNELIDA) ON SEDIMENT PROPERTIES AND SALICORNIA SP. SEEDLING ESTABLISHMENT

15:15 **Boat tour Port of Den Helder, Balgzand and Razende Bol**

19:00 **Conference dinner at Enys House**

Friday 17 March

08:30 **Registration at Enys House, Koninklijk Instituut voor de Marine**

09:00 **Keynote**: dr. Mardik Leopold, Wageningen Marine Research
HIGHWAY TO HELGOLAND: ON SPERM WHALE STRANDINGS AND OCEANOGRAPHY

09:30 **Session 4: Aeolian transport & storms and waves**, chair: Kathelijne Wijnberg

S. de Vries
AEOLIAN SEDIMENT TRANSPORT PROCESSES IN THE INTERTIDAL ZONE

P.M. Hage
SAND-STRIP CHARACTERISTICS AND OCCURRENCE ON A NARROW BEACH USING VIDEO IMAGING

M. Jansen
AEOLIAN TRANSPORT AND DUNE DEVELOPMENT AT THE HONDSBOSSCHE AND PETTEMER DUNES: AN ECOSHAPE PROJECT

J. Rutten
CRESCENTIC SANDBARS ALONG CURVED COASTS IN A BIMODAL WAVE CLIMATE

M.B. Albernaz
MORPHOLOGICAL EVOLUTION OF ESTUARY MOUTHS WITH WAVE-CURRENT INTERACTIONS

10:45 **Poster pitches**

11:00 **Coffee/tea break**

11:30 **Session 5: Observational techniques**, chair: Matthieu de Schipper

S. Vos
MEASURING COASTAL CHANGES WITH A PERMANENT LASER SOLUTION

G. Hagenaars
ACCURACY OF COASTLINE DYNAMICS BASED ON SATELLITE IMAGES, A NOVEL APPROACH TO COASTLINE MONITORING

J.R.F.W. Leuven
EBB- AND FLOOD TIDAL CHANNELS IN SCALE-EXPERIMENTS OF ESTUARIES

I. van den Ende
ONSHORE SANDBAR MIGRATION: PROCESSING PIV MEASUREMENTS TO ANALYSE WAVE DRIVEN SEDIMENT TRANSPORT IN THE NEARSHORE

C.M. van der Hout
SEASONAL TO TIDAL VARIATIONS OF SPM AND CHLOROPHYLL-A IN A COASTAL TURBIDITY MAXIMUM ALONG THE DUTCH COAST

12:45 **Lunch**

14:00 **Session 6: Estuaries & Ebb-tidal deltas**, chair: Maarten van der Vegt

H.M. Elmilady
LONG TERM MORPHODYNAMIC MODELLING OF SEA-LEVEL RISE IN SAN PABLO BAY

W.M. van Dijk
SHOAL MARGIN COLLAPSES IN THE WESTERN SCHELDT ESTUARY

S.E. Poortman
MODELLING THE WESTERN SCHELDT NAVIGATION CHANNEL SPRING TIDE EDDY AT OSSENISSE

14:45 **Coffee/tea break**

15:15 **Session 6: - continued**

L.B. Brakenhoff
DYNAMICS OF SAW-TOOTH BARS ON EBB-TIDAL DELTAS

K.J.H. Lenstra
CYCLIC EVOLUTION OF EBB-TIDAL DELTA OF AMELAND RESULTS IN PERIODICALLY CHANGING IMPORT AND EXPORT IN THE INLET

M.R. Hiatt
TOPOLOGIC AND DYNAMIC CONNECTIVITY IN ESTUARY CHANNEL NETWORKS

T. Ysebaert
TIDAL FLAT NOURISHMENTS: A RARE AND UNEXPLORED ECO-ENGINEERING PRACTICE IN ESTUARINE MANAGEMENT

16:15 **Best presentation, best poster and best photo award**

16:30 **Closure**

List of Posters

Name	**Title**
Bergeijk et al	Modelling onshore sand transport in shallow water during low energy conditions
Boers et al	New functionality MorphAn Software
Brinkkemper et al	Onshore migration of an intertidal bar: The TASTI field experiment
Broekema et al	Hydro-morphodynamics at the Eastern Scheldt: A wide range of scales
Bruckner et al	Large-scale river and estuary modeling with mud and vegetation
Dam et al	Reconstructing the sediment budget of the western Scheldt 1860-1955
Damen et al	Analysis of spatial variations in sand wave shapes
De Groot et al	State of the art of aeolian and dune research on the Dutch and Belgian coast
De Schipper et al	Beach Scarp Behaviour at the Sand Engine
De Vet et al	Hydrodynamics on a large tidal flat surrounded by water: the Roggenplaat
De Winter et al	Spatial variability of wind flow over a bar-beach-foredune morphology
De Wit et al	Intra-wave modelling of sediment transport in presence of strong currents
De Zeeuw et al	Impact of dune growth promotion measures
Donker et al	Modelling of wind flow over a Beach-Dune System
Engelstad et al	How island slopes effect wave shape and transformation during island inundation
Gatto et al	Bed Composition: a Key Factor for the Channel-Flat Equilibrium?
Gerkema et al	Annual mean sea level and its sensitivityy to wind climate
Hanssen	Towards improving predictions of non-Newtonian settling slurries with Delft3D: theoretical development and validation in 1DV
Hendriks et al	Investigating the buffering of fines in a sandy seabed: planned field measurements along the Egmond aan Zee transect
Hepkema et al	What internal length scale determines the tidal bar length in estuaries?
Hoeks et al	Are dunes formed by Lévy walks?
Hoonhout & de Vries	Aeolian sediment supply from the sand motor mega nourishment
Huisman et al	Bed composition changes at large-scale coastal structures
Krewinkel et al	Sand wave migration reversal due to severe wind events
Kroon et al	Initial evolution of a large-scale sandy intervention
Lanckriet et al	Tackling marina inlet sedimentation in Blankenberge and coastal erosion at Wenduine
Lodder & Wilmink	Nature Based Solutions in the North Sea region
Lokhorst et al	Estuary scale experiments with saltmarsh vegetation
Moons et al	Bio-geomorphology of the Dutch shoreface: the American razor clam, Ensis directus
Nnafie & Van Oyen	Effects of extreme wave and wind events on morphodynamics of estuaries: An idealized model study
Onselen et al	Scale effects on wave-induced sediment mobility in the Metronome tidal facility
Pearson et al	The Influence of Grain Size on Sediment Transport Pathways at Ameland Inlet
Post & Baptist	Potential impact of the Sand Motor on juvenile plaice and sole abundance

Radermacher et al	Impact of the Sand Motor on alongshore bathymetric variability
Ramaekers & Lodder	Coastal Maintenance: Nourishments near Den Helder
Schrijvershof et al	Understanding sediment disposals on the Walsoorden tidal flat in the Western Scheldt
Schulz & Gerkema	An inversion of the estuarine circulation by sluice water discharge
Schulz et al	Slope-induced tidal straining: Analysis of rotational effects
Selaković et al	Effects of ecoengineering species in estuaries
Silva et al	Observation of storm surge flooding on dune topography in inlets
Slangen et al	The impact of uncertainties in ice sheet dynamics
Smits	Morphodynamic optimisation study of the design of semi-permeable dams for rehabilitation of a mangrove-mud coast: A case study of the Building-with-Nature project in Demak, Indonesia
Strypsteen & Rauwoens	Aeolian Sediment Flux Measurements at the Belgian Coast
Wesselman et al	The effect of the washover geometry on sediment transport during inundation events
Wijnberg et al	ShoreScape: sustainable co-evolution of the natural and built environment along sandy shores
Wijnberg et al	Visualization and measurements of flow around scaled beach houses
Williams et al	Detection of aeolian streamers in video images

Abstracts of oral presentations

in order of oral presentations at the conference programme

Cohesive sediment in scale-experiments of estuaries

L. Braat, J.R.F.W. Leuven & M.G. Kleinhans
Utrecht University, L.Braat@uu.nl, J.R.F.W.Leuven@uu.nl, M.G.Kleinhans@uu.nl

Introduction

Mud plays an important role in alluvial estuaries in relation to ecological restoration and harbour maintenance but is rarely considered in long-term models. Over the past years, substantial progress has been made in long-term, morphological, numerical modelling with mud (Braat et al., in prep), however, physical experiments of estuaries have proven to be difficult. Recently, a novel tidal facility, 'the Metronome', was built in which self-evolving estuaries can be studied (pilot: Kleinhans et al., 2015). After successful experiments with sand we continued with cohesive sediment. Our objective is to study the effects of cohesive sediment supply on the large-scale morphology of estuaries.

Method

The Metronome drives tidal flow by periodically tilting of the flume. By tilting the flume we exaggerate bed slope to create realistic sediment mobility on a small scale. To simulate the effects of cohesive mud we supplied nutshell grains (0.15 ml/s, diameter of 0.2 mm) with a river discharge of 0.1 l/s to a flat sand bed with an initial exponential channel. Nutshell has a low density and is therefore transported in suspension. Moreover it becomes slightly cohesive, but less then real mud that would fixate the bed (van de Lageweg et al., 2016). Bathymetry was collected every 500 to 1000 tidal cycles using Structure from Motion and time lapse images were taken every tidal cycle from which we could extract water depth by blueness. In total the experiments ran for 15000 tidal cycles.

Results and Discussion

Within the first 300 cycles morphological changes are fast: an alternate bar pattern develops, the initial shape starts widening and ebb-flood dominated channels develop (Fig. 1). The nutshell initially deposits on top of the bars but is later also found at the sides of the estuary and in abandoned channels. These deposition areas are generally near high water level and experience low flow velocities. Preliminary measurements suggest that due to nutshell deposition on bars, bars become higher (Fig. 1). At the start of the experiment nutshell is only deposited upstream and then spreads downstream, though the concentration remains larger upstream which might be representable for hyper turbid conditions in real estuaries. Due to the cohesiveness of the nutshell deposits, we observe the formation of steep banks and sides of bars that are subjected to undercutting. The cohesion increases the critical shear stress for erosion and influences the morphology. Widening of the estuary is less, or less rapid. Furthermore, overall dynamics of the estuary with cohesive sediment supply is lower than the experiment without supply. We observe less chutes and less migration.

Conclusion

The cohesive sediment was mainly deposited on bars and in smaller amounts along the sides of the estuary and in abandoned channels. The overall width decreased and bars became slightly higher compared to the run without nutshell. Furthermore, cohesive sediment decreased morphodynamics and caused steeper banks to form.

This research was funded by the Dutch Technology Foundation STW (grant Vici 016.140.316/13710 to MGK). Additionally, we would like to thank the technical staff of Physical Geography for their support.

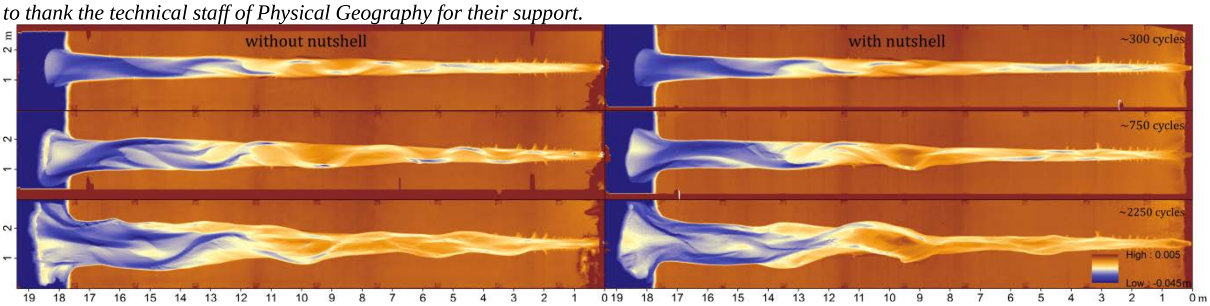

Figure 1: Bathymetry at three time steps of experiment with (right) and without (left) cohesive sediment supply.

Wind effects on intertidal flat sediment transport

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Introduction
Within the *MudMotor Project* sediment dredged in the Port of Harlingen (Friesland, the Netherlands) is relocated in the Kimstergat Channel to promote salt marsh development and reduce siltation in the harbour. Understanding the effect of the mud motor requires knowledge of the sediment exchange between the Kimstergat and the adjacent Koehool intertidal flat.

Method
In order to estimate the sediment fluxes between the channel and the mudflat, a 44 days field campaign was carried out in spring 2016. Six Wave Loggers and two frames, equipped with Acoustic Doppler Velocimeters (ADVs) and Optical Back Scatters (OBSs), were installed along a transect at Koehool. The data covers a variety of combinations of wind, waves and tidal conditions.

Results
Figure1 shows an example of the large variability in the sediment dynamics, even in two consecutive tidal cycles. The second tidal cycle shows a classical behaviour in water level, flow velocity and sediment concentration: a fast rising water level in combination with a flow from the channel towards the mudflat (positive flow velocity), and a slower falling tide with flow velocities towards the channel (negative flow velocity). High concentrations are found at the beginning and end of the cycle.
A totally different behaviour is found in the first tidal cycle, especially during the falling tide: due to the opposing wind, the flow is not directed towards the channel (velocity flow keeps positive during the entire tidal cycle), the water level lowering is postponed and the sediment concentrations is significantly higher. The water was almost clear at the rising tide, likely due to the wind from onshore.
The differences in sediment concentration results from the combinations of water depth, wave height, wave direction relative to the flow and flow magnitude and direction. It cannot be simply attributed to differences in wave height: a more detailed analysis of the data revealed a complex pattern of bed shear stress enhancement/reduction (and therefore the sediment erosion) by interacting waves, tides and wind-driven currents.

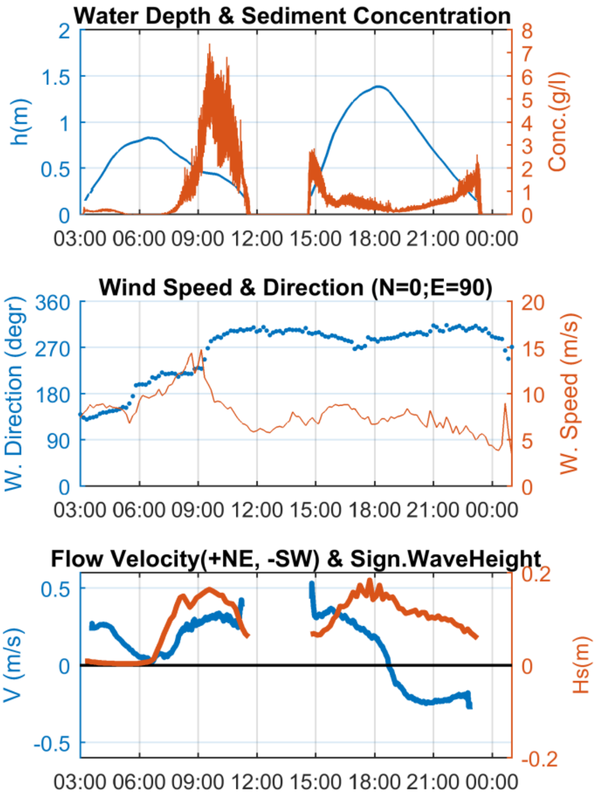

Figure1: two consecutive tidal cycles with different velocity and the concentration profiles, due to different wind directions.

Conclusions
The wind direction plays a major role on the tidal flat sediment transport. As the time scale of the variability of the wind speed and wind direction can be shorter than the tidal cycle, significant net transport rates can occur. Such relatively common events are expected to play an important role in the yearly averaged sediment transport and therefore on the effectiveness of a successful transport of the dredged sediment towards the mudflats.

Do algae boost landscape formation?

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Introduction

The development from intertidal mudflat towards salt marsh is characterised by strong positive feedbacks in which drainage, mud consolidation and benthic algae mat growth might play a central role. We suggest that bistability can arise between a fluidic mud state and a vegetated state. Once drainage channels have been formed, lateral drainage further enhances mud consolidation, promoting benthic algae growth, which again reinforces drainage structures. On the other hand, when mud is poorly consolidated ("fluid mud") any topography, essential for good drainage, is rapidly flattened out again. The resulting lack of drainage topography impedes algae growth, such that the system remains in a fluidic mud state. This raises the question how (drainage) bedforms can arise from initially very poorly consolidated, fluidic mud. We hypothesise that benthic algae can actively decrease the mud fluidity locally; this enables the formation of self-organised bedforms (Figure 1), facilitating the transition from poorly consolidated to well-drained mudflat state and setting the stage for further development towards a salt marsh.

Methods

We motivate our hypotheses with a simple numerical biogeomorphological model (Figure 2), coupling depth-averaged hydrodynamics to algae mat growth and a simplified bed evolution equation. Algae mats limit sediment erosion, whereas inundation reduces algal growth. A crucial, new assumption herein is that algae locally decrease the fluidity of deposited sediment. Model assumptions and results are compared to field measurements on an intertidal mudflat in the Schelde estuary on the Dutch-Belgian border. Field data comprises aerial photos (drone) to detect algae presence, bathymetric measurements (terrestrial laser scanner) to determine bedforms and sediment samples to quantify mud consolidation.

Conclusions

We show that benthic algae mats can, by locally reducing mud fluidity, trigger the formation of mudflat drainage structures and further development to a vegetated state. This mechanism might be especially relevant for initially poorly consolidated mudflats, e.g. after managed coastal realignments. Without the influence of benthic algae, development from such a fluidic mud state towards a well-drained vegetated state might be strongly impeded. This emphasises the importance of biotic processes for intertidal morphodynamics.

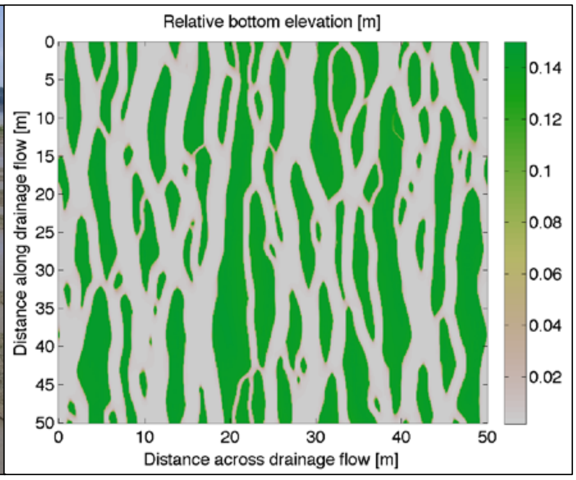

Figure 1 (left). Regular bedforms induced by benthic algae mats (Vaucheria) on an intertidal mudflat in the Schelde estuary, Dutch-Belgian border. Figure 2 (right). Numerically simulated bedforms (top view) formed by biogeomorphological interactions; drainage flow is oriented from top to bottom of the picture.

Coastal Genesis 2.0

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Introduction

Rijkswaterstaat maintains the coast by means of annual sand nourishment operations. Climate change and land subsidence mean that the long-term vision for the coastal policy requires re-assessment. To keep pace with sea-level rise structurally, we must now consider how we can continue to maintain our coast with a sustainable approach to sand nourishment.

The so called ‘Sand Decision’ in the Delta Programme -the national policy to keep our country safe from floods-, sets out principal choices for the long-term coastal policy:
1. A sustainable equilibrium must be maintained between the coastal foundation and sea-level rise.
2. Pilot programmes must be conducted to generate knowledge about the best approach to sustainable coastal maintenance. Knowledge about how to execute these choices is developed in de programme Coastal Genesis 2.0.

The objective for this programme is: ‘To generate knowledge so that well-founded decisions can be made from 2020 onwards about the policy and management of the Dutch sandy coastal system.’
We will be engaging in research between 2015 and 2019 to determine how much sand will be needed in the long term, where and when the sand is needed, and how we can deposit the sand on the coast. Coastal functions and how will they develop are taken into account. We use existing data and we will collect new data along the coast. We will also carry out a pilot in the outer delta to see if is it possible and desirable to conduct pilot projects with larger sand nourishment quantities at this type of location in the future. Research lines include long-term coastal development, ecology, data management, sand extraction, spatial planning and economy.

Bird’s-eye view of the area between the Wadden Islands Terschelling (left) and Ameland (right). On this location a pilot project is planned for sand nourishment in the outer delta.

Observations of landward sand movement at a natural and a nourished beach

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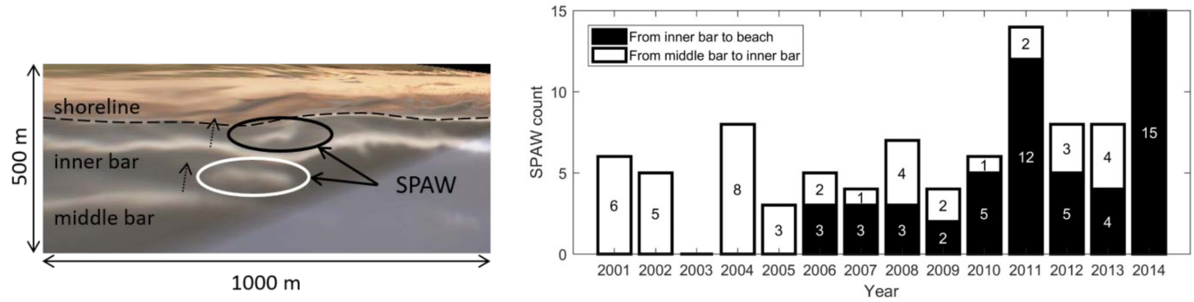
Motivation

At sandy coasts, wave- and wind-induced processes drive the cross-shore movement of sand between the (submerged) sandbars and the (emerged) beach-dune system. While the wave-driven beach and dune erosion during storms is reasonably well understood, the subsequent landward return of sand leading to the recovery of the beach-dune system remains unclear. On spatial scales from tens of meters to a few kilometres, intriguing, yet unexplained alongshore variations in the rate of recovery are often observed. Recent observations have shown that the landward-protruding shallower areas of sandbars –known as horns– regularly separate from the bar and subsequently migrate onshore towards the beach as an isolated morphological feature, termed *Shoreward Propagating Accretionary Wave*, or SPAW (Wijnberg and Holman, 2007; left Figure). It remains unclear what role this onshore migration of SPAWs plays in the recovery of the beach-dune system, and the development of alongshore-variable morphology. Moreover, it is unknown how natural SPAW dynamics are affected by shoreface nourishments, artificial placements of sand in the sandbar zone that, similar to SPAWs, are intended to be redistributed across the beach-bar system through natural processes. Accordingly, we used multi-year datasets of daily (Argus) video images to explore and compare SPAW characteristics at a natural, non-nourished beach (Coast3D station) and a regularly nourished beach (Jan van Speijk station), both near Egmond aan Zee, The Netherlands.



Example of a video image (left) and observations of SPAW occurrence (right) at the non-nourished beach near Egmond aan Zee, The Netherlands, showing SPAWs migrating from the middle bar to the inner bar (white ovals/rectangles)and from the inner bar to the beach (black ovals/rectangles).

Observations

Over the 14 (7.5) year study period we observed an average of 6.6 (7.6) SPAWs per year at the natural (nourished) study site. The average lifetime of a SPAW was approximately 40 days, with average lengths and widths of approximately 200 m and 30 m, respectively, migrating onshore at an average rate of ~1.3 m/day. Over the study period, the SPAWs increasingly emerged from the inner bar and to a lesser extent from the middle bar (right Figure), relating to the inter-annual net offshore migration (NOM) of the nearshore bars. Interestingly, at the natural site, the alongshore locations of SPAWs were more constant in time as the bar from which they originated was positioned further offshore. Shoreface nourishments were found to freeze the NOM and affect the bar morphology for several years after their placement, affecting both the probability and alongshore location of SPAW emergence. Our observations suggest that SPAWs play a significant role in the cross-shore sand exchange within the bar-beach-dune system and the development of alongshore variability, which may both be affected through the placement of shoreface nourishments.

Acknowledgements

This work is part of the project "Spawning sand from sea to land", awarded to the first author by the Netherlands Organisation for Scientific Research (NWO), under contract 016.Veni.171.101.

Reference

Wijnberg, K.M. and Holman, R.A., 2007. Video-observations of shoreward propagating accretionary waves. *Proceedings of the RCEM 2007*: 737-743.

The financial impact of blown sand: an assessment at the Belgian coast

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The 67km long Belgian coast runs through 10 municipalities. Approximately half of the coast consists of the natural system of beaches and dunes, the other half is densely built and consists of a beach, running into a dike. Although Aeolian sand transport is a necessary physical mechanism to increase the resilience of beaches (and dunes) after storms, it is mostly regarded as nuisance to many coastal towns. Sand blows into the streets, on railroads, promenades and squares, endangering pedestrians and cyclists and preventing safe car and tram traffic. It further causes obstruction in the sewerage system. Moreover, the accumulation of sand in the touristic centers leaves a filthy image. As a result, local authorities invest largely in keeping the sand out of the built environment, mostly by cleanup works.

In order to assess the actual cost of blown sand, we conducted interviews with all partners involved: the coastal communities and several Flemish agencies (Coastal Division, Public Transport De Lijn, Roads and Traffic Agency) to acquire information on

- The location of critical points
- The actual cost of cleanup works on an annual basis
- Measures done to decrease the amount of Aeolian sand transport towards the dike.

Mostly, no records are being held of the specific cost related to blown sand, and the actual volume of sand transported into the town is unknown. It was found that there is a large variation in cost over the coastal municipalities, which can be partly explained by the spread in natural and built environment over municipalities, and partly by the policy at which level they want to keep the streets clean.

Based on the interviews, the total annual cost for the entire Belgian coast is estimated to be almost 5M euro, which boils down to 150 euro per meter dike per year.
Over the years, this cost has increased, mostly due to the beach nourishments in the framework of masterplan coastal safety, increasing the dry beach both in height and width, and several measures have been implemented to decrease the sand transport rate. The placement of sand screens or the creation of a vegetated dune seawards of the dike, as is done in one spot, captures the Aeolian sand on the beach. Towns are experimenting in how to increase the obstructing capacity of the dike against blown sand by placing concrete blocks on top or making a ditch in the sand at the dike's foot during winter season.

Measures against the nuisance of blown sand: sand screens are placed at various locations (left), a dune in front of the dike (Nieuwpoort) and the creation of a ditch at the dike's foot (Ostend)

Acknowledgements
We thank all Belgian coastal municipalities and the divisions of the department of Mobility and Public Works of the Flemish Government for their kind cooperation during this investigation.
This research is done in the framework of the IWT-SBO project CREST (Climate Resilient Coast, www.crestproject.be)

The Ins and Outs of Sediment Budgets

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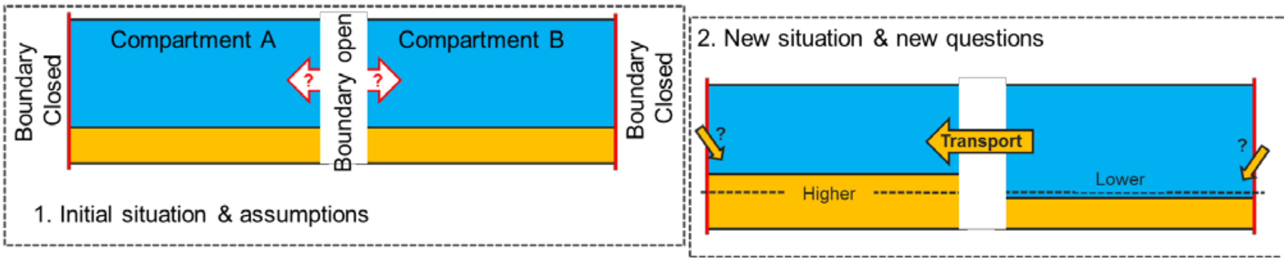
Introduction

Our understanding of coastal systems comes in part from studies of sediment budgets. In the Netherlands the national policy on the coast and the coastal management is founded on the sediment budget of its coastal system. The luxury of extensive datasets on the bathymetry of most parts of Netherlands coast allows for detailed analysis of sediment budgets. When unexpected spikes or curious developments give rise to discussions incidental studies focus on the quality of the bathymetric underlying the sediment budgets. Given the importance of sediment budgets for coastal research, policy and management a rudimentary framework is presented here with the major assumptions, intrinsic problems and their consequences.

What is a sediment budget?

A sediment or sedimentary budget describes the volumetric development of one or more compartments of a coast and the exchange of sediment over the boundaries of the compartments and between the compartments. There are various ways to construct a sediment budget. Here the focus is on sediment budgets based on bathymetric data. Others methods focus on the sources and sinks via data or through calculations on the sediment-transport mechanisms. And combinations of methods may be applied too.



Schematic demonstration of a sediment budget of two adjacent compartments A and B, with: 1. The initial situation with the assumptions on the boundaries; 2. After some time and new measurements of the bathymetry the transport direction can be assessed, and new questions arises on the origin of the surplus sediment in compartment A.

Points of concern for sediment budgets based om bathymetric data

- Truly closed coastal systems do not exists, open boundaries are the rule: A useful sediment budget requires a careful choice of its boundary or boundaries
- Not all sinks and sources can be accounted for, because the data-density of parts the compartment (harbours, marshes) differs and hidden sinks (subsidence) may be present.
- Bathymetric data is given in meters with reference to a datum, but the sediment budget is in cubic meters or tons. The calcutions require an assumption on the density, that is very often implicit.
- Systematic “errors” are of major importance for bathymetric data and are introduced via various routes, including changes in the measuremnet ans positioning techniques, revisions of the datum and human mistakes.
- Not all sediments in de the coastal system may be conservative: peat may vanish and shell and shellfragments can be produced within compartments.

Conclusions

A sediment budget is immensely useful to get a grip on the coastal dynamics. When bathymetric data is used to assess a sediment budget several points should be addressed. Ideally the consequences of these points should be incorporated in bandwidths on the sediment development and sinks and sources.

Coastline modelling: the next generation?

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Background

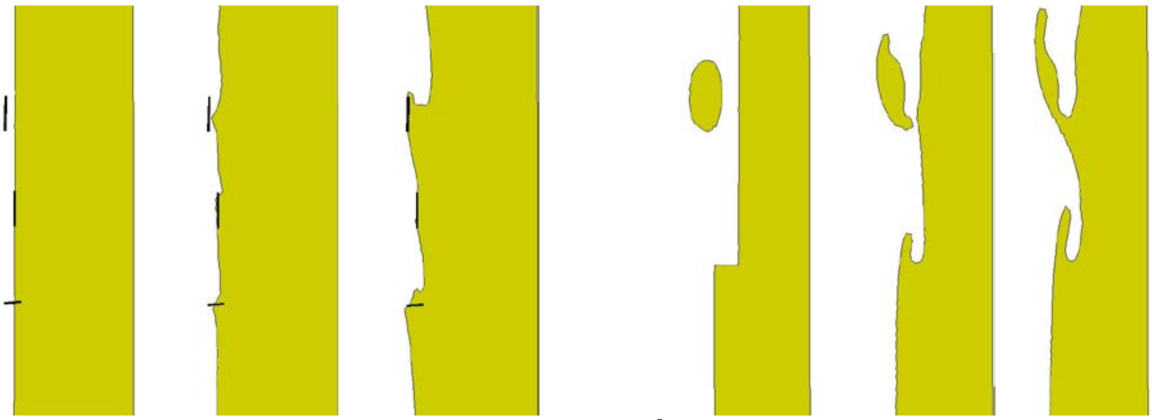
Coastline modelling is widely applied in engineering practice as a cheap and quick tool to predict planform changes over decades or more. However, present-day operational models such as UNIBEST-LT/CL, LITPACK, GENESIS are generally based on a coastline defined relative to a reference line that is either straight or curving. Such an approach does not allow for serious coastline instabilities or spits to form, and generally only can handle only one continuous coastline section. On the other hand, models showing more advanced behaviour such as instabilities and spit formation have been developed for very idealized cases since Ashton et al., 2011; their model is a mix of grid-based and coastline representation and though it shows solutions of great beauty and complexity it is not easily transferred to engineering practice. Recently, grid-free methods are starting to evolve, which have the potential to be more flexible and easily allow inclusion of additional processes such as splitting up and merging of coast sections, sand waves passing along sediment-starved coasts, soft cliff erosion etc.

Model development

We are developing a grid-free coastline model in Matlab, where the coastline is represented as an arbitrary number of free-form polylines, which can be open or closed (islands). The sediment transport along the coastlines is driven by a CERC-like transport formula based on deepwater conditions; the waves can be shielded by other parts of the same or other coast sections or by structures, also represented by polylines and coastline changes are computed based on the transport gradients, with modifications to deal with high-angle instabilities. Regridding takes place continuously to allow the growing of spits and other forms. A set of routines is called every time step to check whether overwashing takes place, spits get too narrow and break up, or sections merge. Hard structures block waves and when they cross any shoreline, they block the transport, until the coastline advances enough to allow bypassing. Initial coastlines and hard structures can be entered interactively or read from text files.

Examples and outlook

In the figure we show an application of three coastal structures with the initial coastal response and the long-term development with intermittent bypassing. On the right some advanced coastal features are shown. During the presentation we will outline the method and plans for the near future.



Sample of coastline simulations for a mean wave direction of 240 °N and uniform wave spreading of 90o.
Left three panels: coastline with groyne, revetment and offshore breakwater after 0, 3 and 20 years.
Right three: developing spit on coast discontinuity and island migrating onshore and merging with coastline.

References

Andrew Ashton, A. Brad Murray & Olivier Arnault (2001). Formation of coastline features by large-scale instabilities induced by high-angle waves. Nature, Vol. 414, Nov 15, 2001, pp. 296-300.

Sediment dynamics as driver of salt marsh dynamics

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Salt marshes are increasingly recognized for their coastal defence value (Temmerman et al 2013). Being able to actually apply them within coastal defence schemes requires that we are able to predict their long-term dynamics and understand how to create marshes at locations where they are needed (Bouma et al. 2014). Within this presentation, we will highlight recent findings (Bouma et al. 2016, Cao et al. submitted, in prep., Hu et al. 2015a, 2015b) on the role of sediment dynamics on salt-marsh establishment and their cyclic dynamics consisting of alternating lateral erosion and lateral expansion.

Whereas previous studies have mainly focussed on quantifying if a tidal system is accreting or eroding on the long-term, recent studies show that sediment levels may vary strongly from day to day (Hu et al. 2015a), with major ecological consequences (e.g. see Hu et al. 2015b, Suykerbuyk et al. 2016). We will explain how such short-term (i.e. day to day) sediment dynamics on the tidal flat both induces cliff formation as well as determines seedling survival, thereby making it the driver of the long-term (i.e. decadal) cyclic salt marsh dynamics (Bouma et al. 2016). As accretion and erosion trends and dynamics can differ greatly between locations at a local and global scale, we will show the effect of contrasting short-term sediment disturbance-regimes on the seedling establishment of two globally widely spread *Spartina* species. That is, we will show from mesocosm experiments how seedling survival after a contrasting disturbance free period (i.e., 2 & 9 days) respond to exposure to *i)* contrasting constant net accretion/erosion rates, *ii)* accretion/erosion events that differ in timing x amplitude but cumulatively cause an identical net change, and *iii)* regular fluctuations in sediment level, using contrasting amplitudes, but without causing any net accretion/erosion effect (Cao et al. submitted). Moreover we will show by a manipulative macro-marsh-organ field experiment, how seedling survival is affected by sediment properties like drainage (Cao et al. in prep.). Finally, we will show experimentally how marsh expansion is affected by cliff height (Cao et al. in prep.). Overall we aim to provide a comprehensive overview explaining how sediment dynamics and sediment types affect salt marsh establishment and their long-term cyclic dynamics.

Temmerman S, Meire P, Bouma TJ, Herman PMJ, Ysebaert T, De Vriend HJ (2013) Ecosystem-based coastal defence in face of global change. Nature 504: 79-83 (doi:10.1038/nature12859)

Bouma TJ, van Belzen J, Balke T, Zhu Z, Airoldi L, Blight AJ, Davies AJ, Galvan C, Hawkins SJ, Hoggart SPG, Lara JL, Losada IJ, Maza M, Ondiviela B, Skov MW, Strain EM, ThompsonRC, Yang SL, Zanuttigh B, Zhang L, Herman PMJ (2014) Identifying knowledge gaps hampering application of intertidal habitats in coastal protection: Opportunities & steps to take. Coastal Engineering 87: 147–157.

Bouma, T.J.; van Belzen, J.; Balke, T.; van Dalen, J.; KLaassen, P.; Hartog, A.M.; Callaghan, D.P.; Hu, Z.; Stive, M.J.F.; Temmerman, S.; Herman, P.M.J. (2016). Short-term mudflat dynamics drive long-term cyclic salt marsh dynamics. *Limnol. Oceanogr. 61(6)*: 2261–2275.

Hu Z, Lenting W, van der Wal D, Bouma TJ (2015a) Continuous monitoring bed-level dynamics on an intertidal flat: Introducing novel, stand-alone high-resolution SED-sensors. Geomorphology 245: 223-230

Hu Z, van Belzen J, van der Wal D, Balke T, Wang ZB, Stive, MJF, Bouma TJ (2015b) Windows of opportunity for salt marsh vegetation establishment on bare tidal flats: The importance of temporal and spatial variability in hydrodynamic forcing. J Geophysical Research – Biogeosciences 120: 1450-1469.

Suykerbuyk, W.; Bouma, T.J.; Govers, L.L.; Giesen, K.; de Jong, D.J.; Herman, P.M.J.; Hendriks, J.; van Katwijk, M.M. (2016). Surviving in Changing Seascapes: Sediment Dynamics as Bottleneck for Long-Term Seagrass Presence. Ecosystems 19(2): 296-310

Seasonality in morphological behaviour at the interface of salt marshes and tidal flats using high temporal resolution field data

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Sediment dynamics at tidal flats is a key parameter for driving ecosystem dynamics, connecting the long-term cyclic behaviour of the marsh to (changing) large-scale physical forcing (Bouma et al., 2016). Sediment dynamics plays an important role in seedling establishment in marshes (Silinski et al., 2016). However, we still need to quantify sediment dynamics to predict key ecological processes of seedling establishment and the initiation of cliff erosion (Bouma et al., 2016). This study shows long-term high temporal resolution time series of sediment dynamics and explains the dynamics using physical parameters.

Bed level changes were assessed using SED (Surface Elevation Dynamics) -sensors (Hu et al., 2015), located at the interface of the tidal flat and marsh. Transects with 4 to 7 SED-sensors were measured at 4 locations in the Westerschelde: Zuidgors and Zimmermanpolder (North coast) and Paulinapolder and Hellegatpolder (South coast). The time series, containing raw data at least every 30 minutes, were analysed using a recently developed autonomous script. This resulted in more than a year of bed level data for all locations (except for the Paulinapolder; 10 months). The results show a clear temporal (seasonal) and spatial pattern of bed level changes (Fig. 1). The variability decreases from the sea to the vegetation edge and increases a little going into the vegetation at all sites. The Northern sites show a more positive variability in Spring and Summer and more negative variability in Fall and Winter, while the southern sites show a more equally distributed variability. In general the most variability is shown in the Spring.

The (pre)dominant wind direction in the Westerschelde is approximately perpendicular to the vegetation edge of the Northern sites. This can be the driver of the high range of variability at those sites. The high variability in the Spring can be driven by the appearance of diatoms during this season (Le Hir et al., 2007). Quantifying the extent to which sediment dynamics occur, contributes to the understanding of thresholds of seedling establishment in space and time.

Bouma et al., (2016). Short-term mudflat dynamics drive long-term cyclic salt marsh dynamics. *Limnology and Oceanography*.

Hu et al., (2015). Continuous monitoring bed-level dynamics on an intertidal flat: Introducing novel, stand-alone high-resolution SED-sensors. *Geomorphology*.

Le Hir et al., (2007). Sediment erodability in sediment transport modelling: Can we account for biota effects? *Continental Shelf Research*.

Silinski et al., (2016). Quantifying critical conditions for seaward expansion of tidal marshes: A transplantation experiment. *Estuarine, Coastal and Shelf Science*.

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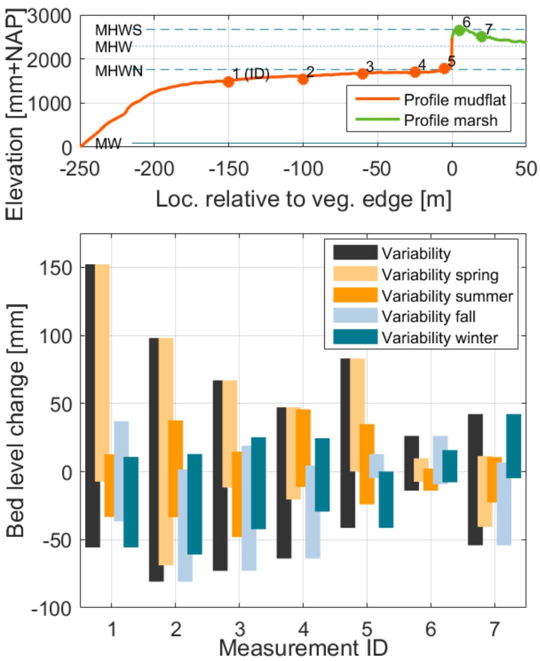

Figure 1. Seasonal sediment dynamics at the Zuidgors (Westerschelde, NL). A profile perpendicular to the coast with 7 measurement points including the mean water (MW), mean high water spring (MHWS), mean high water (MHW) and mean high water neap (MHWN) are showed (top panel). The total range of variability (max. and min.) and the seasonal range of variability relative to the first measurement of the period (total of season) are showed (bottom panel).

Modelling sea level rise impact on salt marsh/mangrove-mudflat morphodynamics

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Introduction

Over the past decade, strategies such as the Building with Nature have made coastal managers aware that only the combination of hard and soft techniques can ensure a sustainable and stable coastline. In many tropical and subtropical regions whose coast comprise of highly dynamic mudflats, the inclusion of vegetated foreshores within coastal protection strategies has been critical towards stabilizing the coastline. However in many of these countries, an effective understanding of the interaction between the vegetation and morphodynamics and the processes which result in the long term cyclic erosion-sedimentation patterns is limited by resources. Therefore the use of a schematized model, which couples the vegetation growth model with the morphodynamic modelling of Delft3D provides the framework for universal applicability and will enhance the knowledge on the triggers for the cyclic processes and the resilience of these coastlines to sea level rise.

Methodology

The vegetation growth model was developed using Matlab, which was then coupled with a 2DH depth averaged Delft3D model including wave action and tides. For the salt marsh species, Spartina and Salicornia, the growth model was based on that of Temmerman, et al. (2007) whereas the mangrove growth model is based on approach of van Maanen, et al. (2015). For both models the initial establishment is randomized over the grid cells, followed by the growth, diffusion and decay of the vegetation in areas of high stresses. The Spartina and Salicornia were coupled with the morphodynamics every three months and based on simplified conditions similar to the Western Scheldt whereas the mangroves were coupled every year with similar forcings to that of tropical countries whose coasts receive sediments from the Amazon Basin. The trachytope application of Delft3D Flow represented the change in bed roughness and the effect on flow well for the Spartina-Salicornia models.

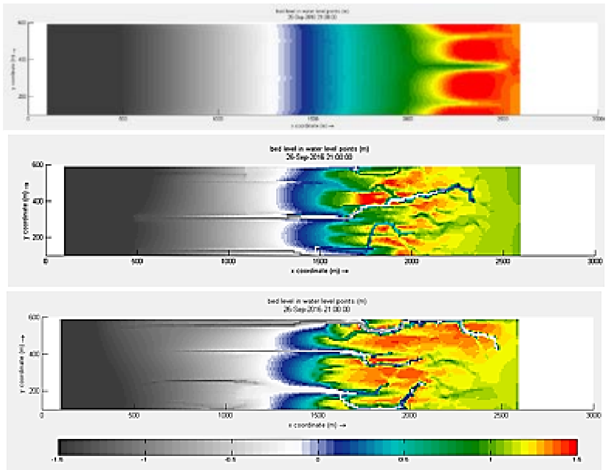

Figure 1: From the top, Bed Level without vegetation[i], with vegetation[ii], Sea level rise (SLR) with vegetation[iii]

Results, Discussion and Conclusions

The marsh-mudflat system develops towards equilibrium within 100 years. Model results even show a characteristic cliff at the mudflat-marsh interface. Imposing a gradual rise in sea level incises and widens the channels and eventually drowns the system. The cliff continues to shift landward as seen by the continuous deepening in front of the marsh. Without vegetation, the formation of levees is quite noticeable. Model results provide new insights into possible impacts of sea level rise essential to address vulnerability of mangrove and marsh coasts to sea level rise.

References

Temmerman S, Bouma T, Van de Koppel J, Van der Wal D, De Vries M, Herman P (2007) Vegetation causes channel erosion in a tidal landscape. Geology 35: 631-634
van Maanen B, Coco G, Bryan KR (2015) On the ecogeomorphological feedbacks that control tidal channel network evolution in a sandy mangrove setting. *Proc. R. Soc. A* 471: 20150115.

Are plant life-history strategies able to shape bio-geomorphologic interactions?

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Previous studies on interactions between vegetation and their abiotic environment underlined the importance of bio-geomorphologic feedbacks in shaping landscape structures in for instance intertidal channel networks. Nevertheless until now, the ability of vegetation to influence geomorphologic structures was linked to properties of their physical structures such as stem stiffness, stem diameter or stem density, interacting with hydrodynamics and sediment transport. Yet the role of life-history strategies, i.e. the mode of plant proliferation such as sexual reproduction from seeds, non-sexual lateral expansion or a combination of the former two in shaping bio-geomorphologic interactions was hitherto ignored.

This study presents numerical experiments based on a wetland ecosystem present in the Western Scheldt Estuary (SW, the Netherlands) showing the importance of life-history strategies shaping bio-geomorphologic interactions. We specifically compare two extremes in life-history strategies, (1) one species solely establishing from seeds and relying on their mass recruitment (*Salicornia europea*); And a second species (*Spartina anglica*) that relies on a mixed establishment strategy consisting of seed dispersal and clonal lateral expansion through tillering, with a very low seed recruitment success per year.

Based on conducted numerical experiments using the hydro-morphodynamic modelling suite TELEMAC2D we show that the *Spartina*-case facilitates relative low channel densities with pronounced channel networks, whereas the *Salicornia*-case favours high channel densities with less pronounced intertidal channels. The conducted numerical experiments are the first indication showing that plant proliferation strategies exert a major control on emerging patterns in bio-geomorphologic systems. This provides a deeper understanding in the constraining factors and dynamics shaping the emergence and resilience of bio-geomorphologic systems.

Biogeomorphic impact of *Oligochaetes* (Annelida) on sediment properties and *Salicornia sp.* seedling establishment

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Oligochaetes (Annelida) are active bioturbators that can be present in high densities in the transition zone between intertidal flats and salt marsh, though their occurrence and functional role remains understudied. Bioturbation can stimulate resource flows into the sediment and the upward conveyor belt feeding mechanism leads to substrate mixing. This study aims to clarify the biogeomorphic role of *Oligochaete* bioturbation in facilitating or hindering vegetation establishment. Two microcosm experiments were performed to assess the effect of *Oligochaete* bioturbation on sediment properties, oxygen availability, algal biomass, seed distribution and germination success of pioneer species *Salicornia spp*. *Oligochaetes* created tunnel networks in the sediment matrix. The increase in available surface area for solute exchange increased oxygen penetration depth (Fig. 1) but did not affect ammonium levels. Sediment properties such as dry bulk density, porosity and organic matter content remained similar in bioturbated and non-bioturbated microcosms. The bioturbation however significantly reduced algal biomass. Both substrate mixing and inhibition of algal biofilm development lead to increased erodibility. *Oligochaete* conveyor belt mixing buried *Salicornia spp.* seeds until below the critical germination depth, thus affecting *Salicornia spp*. germination and development. Our study indicates that small, though numerous, O*ligochaete* bioturbators may reduce lateral salt marsh expansion potential by hindering the establishment of pioneer vegetation in the transition zone.

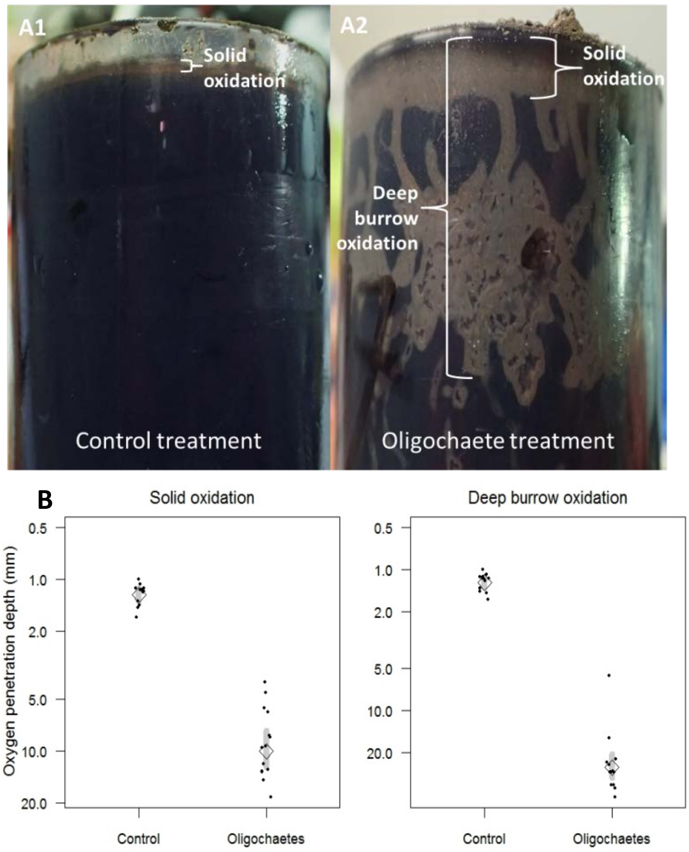

Figure 2 Effects of Oligochaete bioturbation on oxygen penetration in the sediment after 36 days; A1: without and A2: with Oligochaetes. B: Oxygen penetration depth (log-scale) after 36 days for solid oxidation (left) and deep burrow oxidation (right) (n=14 per treatment).

Aeolian Sediment Transport Processes in the Intertidal Zone

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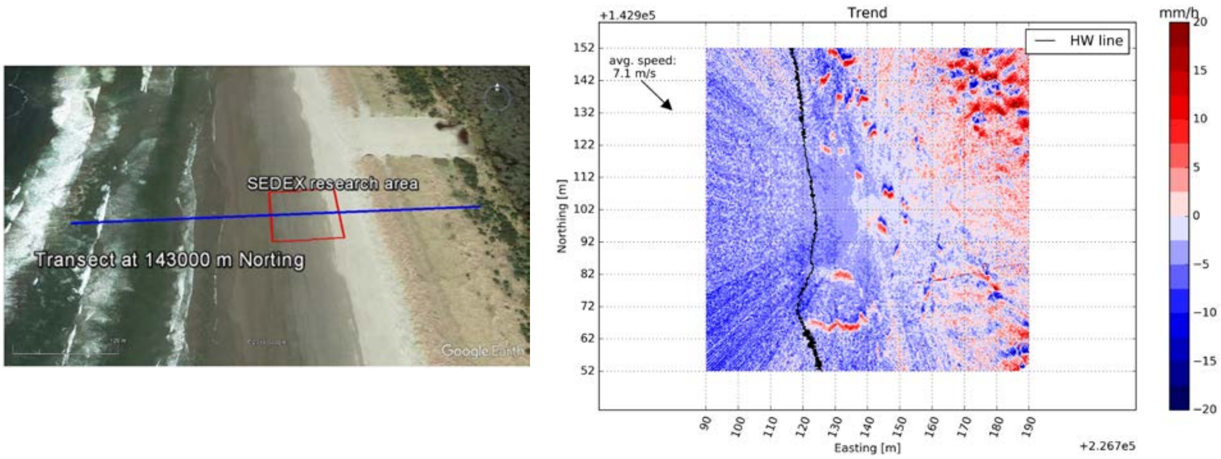
The growth of coastal dunes is thought to be primarily governed by aeolian sediment transport. Quantifying and predicting aeolian sediment transport processes is both a scientific and practical challenge because of the uncertainties in the relative importance of the transport capacity of the wind and the availability of sediment (or sediment supply). Although the transport capacity of the wind is reasonably well understood, quantification and prediction of sediment supply is still a challenge. Quantification of sediment supply is especially complicated by the inherent spatiotemporal variations. Recent studies have hypothesised that the intertidal zone plays a significant role supplying sediment to the system of aeolian sediment transport. However, the intertidal zone is a complex study area since alternating marine and aeolian processes on the tide timescale likely influences sediment availability.

In this study we use detailed measurements of aeolian erosion and sedimentation in the intertidal and supratidal coastal zone to quantify aeolian sediment supply and associated dune growth. Measurements were collected at Long Beach, Washington (USA), during the 6 week SEDEX[2] (**S**andbar-a**E**olian-**D**une **EX**change **Ex**periment) field campaign. A RIEGL VZ2000 laser scanner was used to collect high resolution topographic data with 15-minute intervals during several tidal cycles (see figure for an example). To our knowledge, these belong to the first observations of the small but significant erosion in the intertidal zone due to wind driven processes within a tidal cycle. At the same time the small but significant sedimentation at the dry beach and dunes is measured on the tidal timescale. These data support the hypothesis that the intertidal zone is a significant supply of sediment to the aeolian system. Moreover, these data are essential in future understanding and predicting sediment exchange between marine and aeolian zones, aeolian sediment transport on beaches and the growth of coastal dunes.



Left panel shows the measurement area in the red square at Long Beach, Washington (USA). Right panel shows a top view of the measured trends of sedimentation (red) and erosion (blue) during one low tide. Significant erosion is measured around the High Water line (HW line) and some sedimentation at the upper beach. Moreover, migrating ripples are present on the upper beach.

Sand-strip characteristics and occurrence on a narrow beach using video imaging

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Introduction

Wind is responsible for transporting sand from the beach towards the dunes. During transport events, the beach can become covered with patches of dry, light-coloured sand which move slowly over dark, moist sand. These patches can grow out to form patterns similar to zebra stripes, known as sand strips. They are common bedforms in wet aeolian systems during big transport events, but their dynamics and characteristics are not well understood. This study aims to relate sand strip occurrence and sand strip characteristics to wind conditions and beach state. These relations provide important insights into the conditions associated with major transport events and can be used to improve long term predictions of aeolian sediment fluxes through the beach dune interface. This is of particular interest for narrow beaches, where many potential transport events do not result in actual transport.

Study site

The study site is a mild sloping (~1:30) narrow beach (<100 m) located between Egmond aan Zee and Castricum in The Netherlands. An optical remote sensing system consisting of 5 RGB-colour cameras, known as ARGUS, monitors the site. Hourly snapshots of the beach made between 2005 and 2013 were used. An automatic weather station operated by the KNMI in IJmuiden, 15 km south of the study site, provided the corresponding hourly mean wind velocity and direction.

Methods and results

The ARGUS snapshots were searched for well-developed sand strips. Auto- and cross-correlation were used to determine the wavelength of the sand strips and their migration velocity, respectively. It was found that sand strips have an average wavelength of 17m and a migration speed of 3m/h. Both wavelength and migration velocity increase when the wind velocity goes up. Sand strips only occur when the beach is wide enough. They usually form first close to the foredune and spread seaward as beach width increases during falling tide. Snapshots showing various transport intensities were studied to find which wind conditions result in aeolian transport. The wind needs to surpass a threshold of 7 to 8 m/s to get transport, but to get well-developed sand strips, the wind has to blow (almost) alongshore as well. Sand strip orientation often differs from the regional wind direction, suggesting that the local (foredune) topography affects the local wind field on the beach.

Conclusion and discussion

Argus is a useful tool to study sand strips and their dependency on wind characteristics. It has provided an extensive sand strip database that will be used to examine which wind events determine the input of wind-blown beach sand into the dunes on a time scale of years.

Examples of ARGUS photos showing no, medium and high amounts of sand transport. Source: ARGUS Coast3D tower.

Aeolian transport and dune development at the Hondsbossche and Pettemer Dunes: an Ecoshape project

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1. Introduction

To reinforce the Hondsbossche and Pettemer Sea Defence dike a very large sand nourishment (Zwakke Schakels Noord-Holland: 40 Mm3) has been completed in 2015 incorporating a high coastal dune (now called Hondsbossche and Pettemer Dunes - HPD). Examination in 2004 demonstrated the unsuitability of the existing sea dike. A sandy solution was designed and constructed, employing Building with Nature methods. Current research questions of our group are (1) what is the accumulation/erosion volume (m3/yr) of sand in the dune sand (2) what are the local effects of design features such as dune profile shape, artificial relief features and brushwood screens on accumulation and erosion patterns of dune sand. To elaborate these questions Ecoshape and partners set up a monitoring programme which includes LiDAR topography measurements and aerial photographs of the zone above the waterline four times per year. After completion of the works eight LiDAR measurements have been carried out. The measurements give insight in alongshore variation of the morphological changes above NAP + 3.5 m, but also in local effects and dynamics of design features.

2. Methodology

The sand accretion and erosion volumes are determined between consecutive measurements on transects perpendicular to the NAP+3.5 m sea front dune foot. The local dynamics and effects are investigated by analysing the measurements on a smaller spatial scale.

3. Results

Volume changes in the dunes along the entire HPD show accumulation, especially in the southern and middle part (figure 1, profile type 3 and 4) which we understand well since the project started at its southern connection point to the old coast. The accumulation is highest in the first seven months (May 2015-Dec 2015) and tends to decrease and stabilise towards the end of 2016.

The evolution of artificially made pits on top of the dune shows that the deeper pits deform more than the shallower ones. At the upwind side of the pit accretion takes place while erosion is observed at the downwind side.

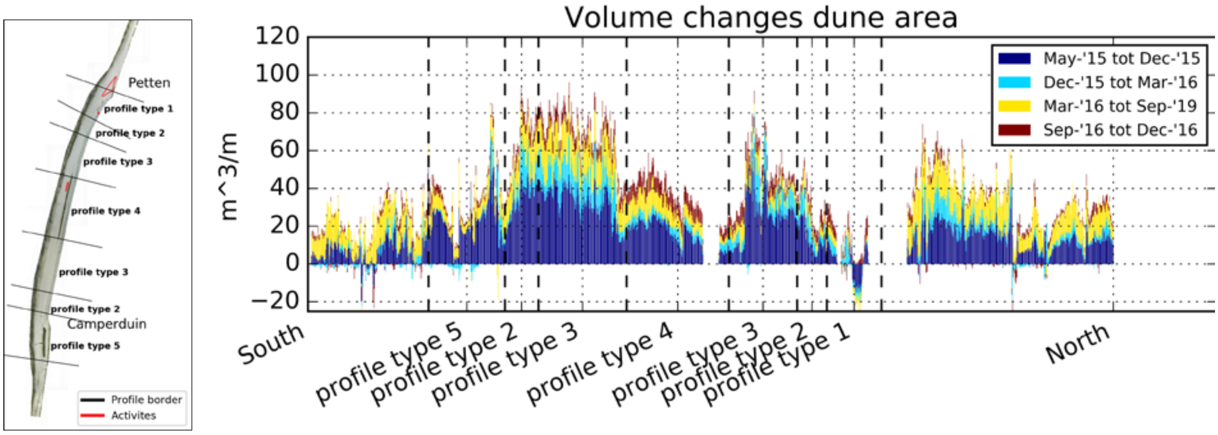

Figure 3. Accumulation volumes in the HPD dune area (>3.5 m+NAP), from south (left) to north (right).

4. Discussion

In the southern and middle part of the HPD higher dune sand accumulation rates were observed till now. It remains to be seen if this continues in the same way, or not. At the Northern and Southern end of the HPD the upper part of the beach eroded more. Due to these losses in beach width less sediment may be (-come) available for aeolian transport. The morphological changes in the deeper pits might be caused by the extra wind turbulence that is created there, while this effect is much weaker for the more shallow ones.

Crescentic sandbars along curved coasts in a bimodal wave climate

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Motivation, aim and set-up

Sandbars, ridges of sand parallel to the shore, can develop certain alongshore variability with deeper, seaward protruding bays and shallower, landward protruding horns. The dynamics of such crescentic bars along straight coasts are relatively well-understood: in general, near-normal waves are known to stimulate the growth of crescentic patterns while obliquely incident or high energetic waves may erase such patterns. In contrast, along curved coasts, little is known about the effect of the varying coastline orientation on crescentic patterning. Given the recent trend in coastal policy towards large-scale man-made perturbations in the coastline (e.g. Sand Motor, HPZ), better insight into the associated morphodynamics is desired, e.g. to predict the occurrence of hazardous rip currents. Our previous observations from the Sand Motor showed that, intriguingly, distinct differences existed between bar morphology at the western and northern flank of the curved coast. More specifically, crescentic patterns developed along the western side, while the bar straightened along the northern side under a series of storms. Based on this, we hypothesize that the local wave angle is key to the alongshore differences in bar morphology. Besides the spatial variation in coastline orientation, the prevailing bimodal wave climate at the Sand Motor further induces a spatiotemporal variability in wave angle. Using a nonlinear morphodynamic model, we aim to characterize the effect of the angle of wave incidence on sandbar behaviour along a curved coast. We used an idealized setup, based on our observations at the Sand Motor. The synthetic bathymetry, with a Gaussian-shaped coastline and an alongshore uniform sandbar, was forced with a bimodal wave climate, represented by an abruptly shifting angle between two directions every day. Model scenarios include variations on wave angle and coastline curvature.

Findings

Pronounced alongshore differences in bar morphology, i.e. crescentic versus straight, arose preferably under wave climates where the angles of wave incidence were similar or near-unimodal (Fig. 1a,b). Crescentic patterns were less pronounced or absent along both flanks (c,d) for scenarios with larger differences between the angles of wave incidence. Here, strong longshore currents induced by obliquely incident waves seem to explain the lack of crescentic patterns at one flank (a,b) for the near-unimodal scenarios, and at both flanks (c,d) for the increasingly bimodal scenarios. Correspondingly, alongshore differences in bar morphology were larger for more strongly curved coasts, since the local wave angle, and inherently the alongshore current, varied stronger alongshore. To conclude, our work suggests that both the curvature and the variation in wave angle determine the occurrence and positioning of crescentic patterns in nearshore sandbars along (man-made) curved coasts.

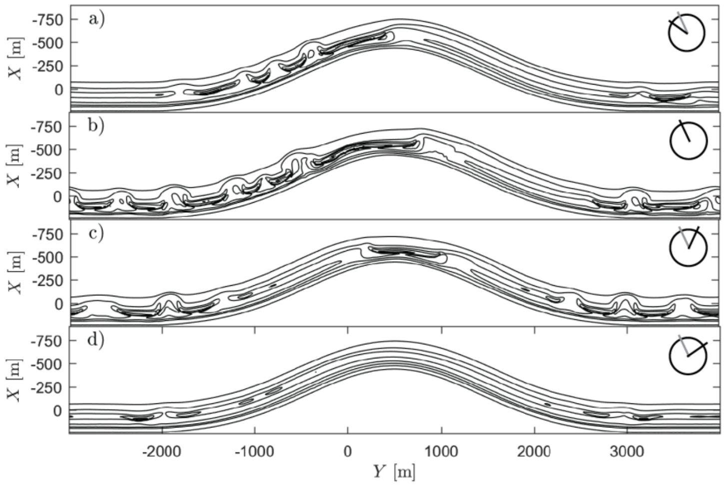

Figure 1. Bathymetric contours after 10-day simulations for unimodal (b) to bimodal (a, c, d) scenarios; the grey and black lines in the circles in the top right corners indicate the two angles of wave incidence used.

Morphological evolution of estuary mouths with wave-current interactions

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Introduction and Methods

Estuaries are formed and controlled by complex interactions between inherited geology, hydrodynamics, sediment supply and biota (Vos, 2015). However, long term modelling efforts have been performed under rather simplistic boundary conditions (*e.g.*, Van der Wegen and Roelvink, 2008). Thereafter, this study combined effects of river inflow, tidal currents and waves on large-scale evolution of estuaries and effects of initial valley and coastal plain morphology thereon.
Idealised Delft3D model scenarios were based on high-resolution geological reconstructions of Dutch estuaries (Figure 1) and their initial and boundary conditions (De Haas *et al., submitted*). Especial attention is devoted into the effects of wave-current related transport within the estuary. Model results will be compared with geological reconstructions and physical experiments performed on the Metronome, *i.e.* 20x3 m tilting flume where entire estuaries can be simulated.

Preliminary Results

The inclusion of waves creates a wave dominant zone on both estuary flanks. Within this zone, sediment was transported into the river mouth, which was not observed when only tides and river discharge were considered. Therefore, net flood sediment transport into the estuary appears to be highly controlled by wave action, as shown in Figure 2B. This behaviour corroborates from hypotheses derived from our geological reconstructions as well as from physical experiments. Sediment transported by alongshore littoral drift and onshore directed transport was observed inside the estuary due to wave action.
High resolution geological reconstructions, comprehensive numerical modelling and physical experiments were able to identify the effects of wave hydrodynamics and related transport that promotes flood directed net sediment transport. Combined with river discharge decline and sediment supply, this tentatively explains the closure of Holocene estuaries along the Dutch coast.

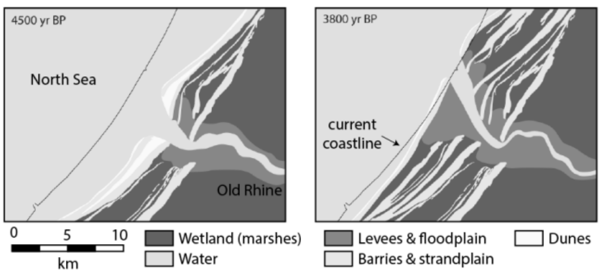

Figure 1. Geological reconstruction of Old Rhine river estuary (modified from De Haas et al., submitted).

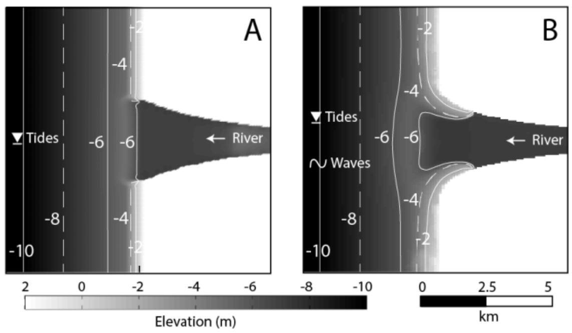

Figure 2. Preliminary numerical simulation of estuaries with tides and river discharge without waves (A) and with waves (B).

Acknowledgments

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References

De Haas, T., Pierik H.J., Van der Spek, A.J.F., Cohen, K.M., Hijma, M.P., Kleinhans, M.G. (submitted). Long-term evolution of tidal systems: effects of rivers, coastal boundary conditions, eco-engineering species, inherited relief and human interference. *Earth Science Reviews*, invited

Van der Wegen, M., Roelvink, J.A. (2008). Long-term morphodynamic evolution of a tidal embayment using a two-dimensional, process-based model. *J. Geophys. Res.*, 113, C03016, doi: 10.1029/2006JC003983

Vos, P., 2015. Origin of the dutch coastal landscape. *Ph.D. thesis*, Utrecht University.

Measuring coastal changes with a Permanent Laser Solution

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Introduction

About 44% of the world population live within 100 miles of the coast and are vulnerable to predicted climate changes such as sea level rise and weather extremes. Good predictions of coastal behaviour are important to maintain coastal functions (such as recreation, safety and ecology) and obtain maintenance strategies in the future. A lack of suitable height measurements over multiple spatio-temporal scales hinders the development of accurate coastal models. Especially the dry part of the coast lack suitable and accurate measurements.

Permanent Laser Solution

In order to obtain accurate height measurements over multiple spatio-temporal scales a permanent laser scan solution has been developed (figure 1). The setup obtains measurements automatically with a time range of 10 minutes up to a year and a spatial range of 30 cm up to 1.2 kilometres.

Figure 1: Permanent laser setup at Kijkduin.

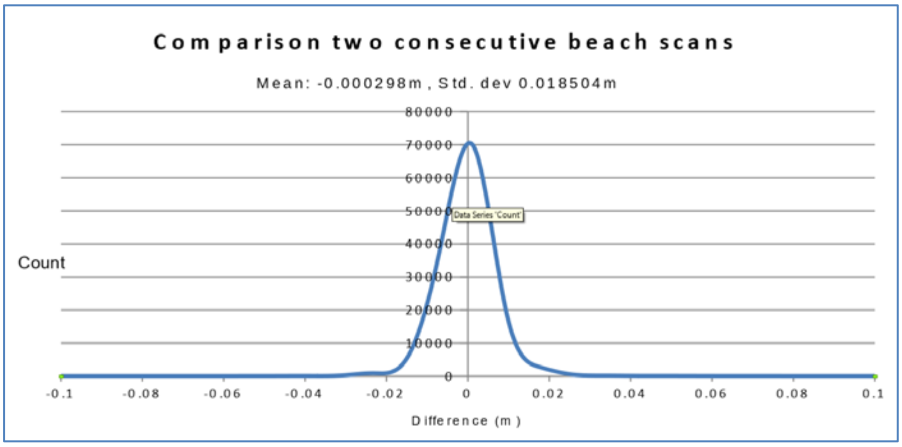

Figure 2: Histogram of the measured differences of two consecutive beach scans (14 January 2017) at Kijkduin, The Netherlands. The mean difference is 0.3 mm with a standard deviation of 1.9 cm.

Results

The first results show that it is possible to measure very small differences (average difference of two consecutive scans of less than a mm, see figure 2) far exceeding existing measuring techniques. Figure 3 shows a difference plot of 5 days (21 and 16 January 2017) showing small differences along the waterline indicating landward moving breaker bars.

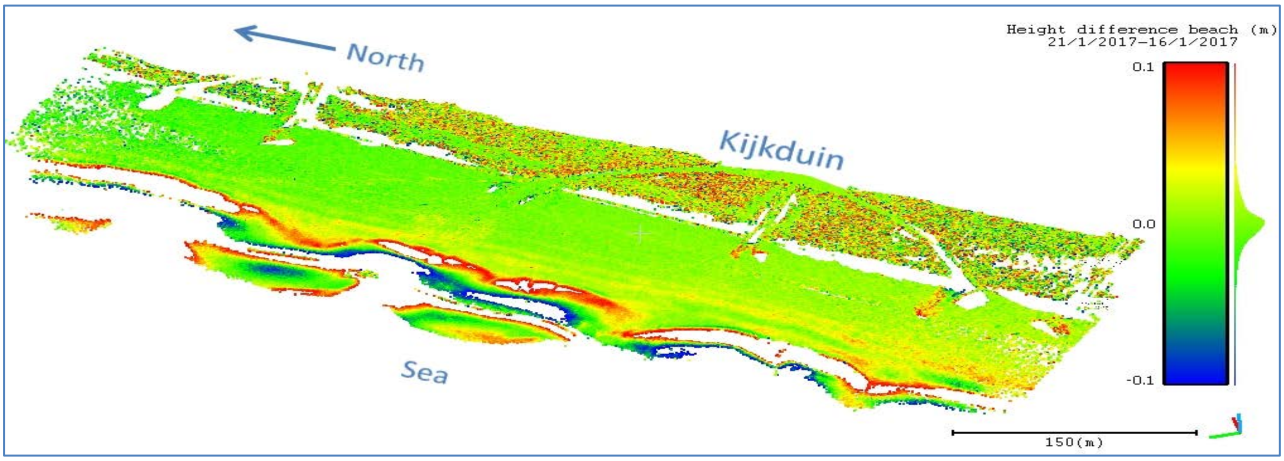

Figure 3: Difference plot of two beach scans from 21 and 16 January 2017 at Kijkduin, the Netherlands

Accuracy of coastline dynamics based on satellite images, a novel approach to coastline monitoring

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Introduction: Coastal areas fulfil important values for society. Erosion may harm these values and is often mitigated. Erosive trends should be captured in long term data on coastal indicators to be correctly managed.

Image processing techniques are able to make a distinction between pixels containing land (e.g. beaches) from pixels containing water (e.g. seas). The border separating water and land pixels comprises information on the waterline observed along a coastal stretch.

Since 1984, satellite imagery provides data on a global scale with a frequent revisit time (every 5-16 days) and a moderate spatial resolution (~10-30 m). Recently, Google launched the Google Earth Engine (GEE) platform with the purpose of removing the traditional computational limitations in satellite image processing. The GEE allows for the opportunity to use publicly available satellite images to their full extend, an example of which is the recently launched Aqua Monitor (Donchyts, et al., 2016).

Objective: The positional accuracy and applicability of the Satellite Detected Waterline (SDW) from all available satellite images by means of the novel GEE platform in relation to coastline monitoring practice is assessed in this research for the Holland coast.

Approach: To assess the accuracy and application range of SDW positions we take the following steps:
1. Detect waterline positions from optical satellite images using an automated, unsupervised waterline detection algorithm on the GEE platform.
2. Calculate the positional accuracy as the horizontal distance (in meters) between the detected waterline and concurrent in-situ measurements of the observed waterline location.
3. Analyse trends in positional shifts of the extracted waterline positions along the coast to assess coastline dynamics and (structural) erosion.

Results: The positional accuracy of the SDW is within half the image pixel resolution (~10 m) for all satellite images used in this study. In case all sources of inaccuracy are absent, the accuracy increases to an average value of 1 m, with a standard deviation of 5 m, indicating that the correct pixel edges are detected as the waterline.

Along very dynamic stretches (change rates of 10 – 60 meter/year, such as observed along the Sand Motor), trends are very similar to observed in-situ measurements. In case of less dynamic locations or locations with a strong periodicity, the trend has the same order of magnitude.

Conclusions: Waterline locations detected from satellite images are accurately positioned with respect to in-situ measurements.

With this efficient technique time series of coastline positions of the last 30 years can be produced in a matter of hours. Due to the frequent revisit time, large spatial coverage and historical extend of the data, satellite images provide a unique source of information, which can be used to study the evolution of the Dutch coast and deltas.

References

Donchyts, G., Baart, F., Winsemius, H., Gorelick, N., Kwadijk, J., & van de Giesen, N. (2016). Earth's surface water change over the past 30 years. Nature Climate Change (pp. 810–813). NATURE CLIMATE CHANGE.

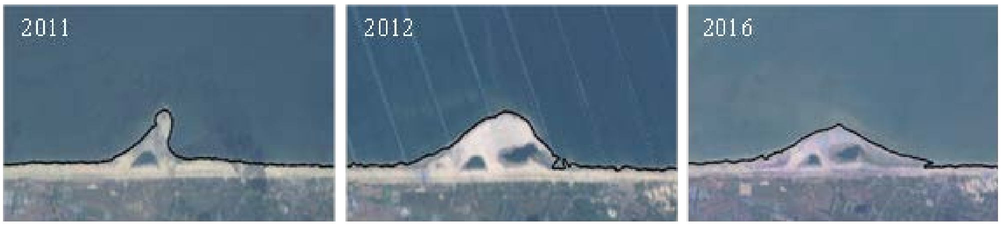

Figure 1: Evolution of the SDW position (black line) for the Sand Motor study area. From left to right: construction of the Sand Motor in 2011, the situation in 2012 and the present state in 2016.

Ebb- and flood tidal channels in scale-experiments of estuaries

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Introduction & methodology

The occurrence of mutually evasive ebb- and flood tidal channels is one of the most typical features in tidal basins and estuaries (Fig. 1). While Van Veen already observed and described these striking elements in the 1950s, their forming mechanism is still largely unknown because of the challenges in numerical modelling and physical models of tidal systems. Recently, it was shown that a periodically tilting flume can generate dynamic tidal morphology (Kleinhans et al., 2015). In this study we investigate the formation and evolution of mutually evasive ebb- and flood tidal channels with measurements of water levels and tidal currents. We define the confluences of ebb- and flood channels as nodes, for which we will show that they behave as asymmetric stable bifurcations.

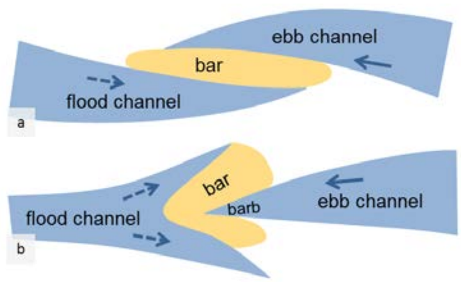

Fig. 1: Mutually evasive tidal channels.

We created estuaries in a tilting flume of 20 m long and 3 m wide. The maximum tilting slope was 0.004 m·m^{-1} with a period of 40 s. The typical amplitude of tidal flow velocity was 0.3 m·s^{-1} and water depths were 0.02-0.05 m. The experiment started with an initial converging channel at the centreline of the flume and was subsequently tilted for 15,000 tidal cycles. Detailed measurements of bathymetry, water levels and flow velocities were made during 12 stages of the experiment.

Bathymetry was created using Structure for Motion software (Agisoft) (Fig. 2a). Flow velocities were measured using Particle Image Velocimetry (PIV) and water levels were measured with echo sounders. Overhead cameras collected time-lapse imagery to monitor the evolution of the experiment. The water was dyed blue and the blueness was used as a proxy for water depth (Fig. 2b).

Results, discussion & conclusion

Dynamic channels and shoals evolved during the experiment. In the first 500 tidal cycles, an alternate bar pattern developed. This stage was followed by widening of the estuary, formation of flood tidal channels with a sill at their upstream end, and an increase in the number of channels and shoals (Braiding Index) in cross-section.

Water levels and tidal currents varied considerable in along-channel and cross-channel direction, creating cross-bar water level gradients. At these locations, cross-bar channels formed, because water levels and flow velocities in the ebb channel were generally larger than in the flood channel (Fig. 2). A growing cross-bar channel often reversed the role of the ebb- and flood channels.

Within 500 tidal cycles, mutually evasive ebb- and flood tidal channels formed in our experimental setup. Measurements of water level, bed level and flow velocities show that tidal bifurcations evolve into asymmetric stable bifurcations. After the formation of a flood tidal channel, gradients in water level generate cross-bar flow, which eventually cross-cuts the tidal bar that formed between the flood channel and the parallel ebb tidal channel.

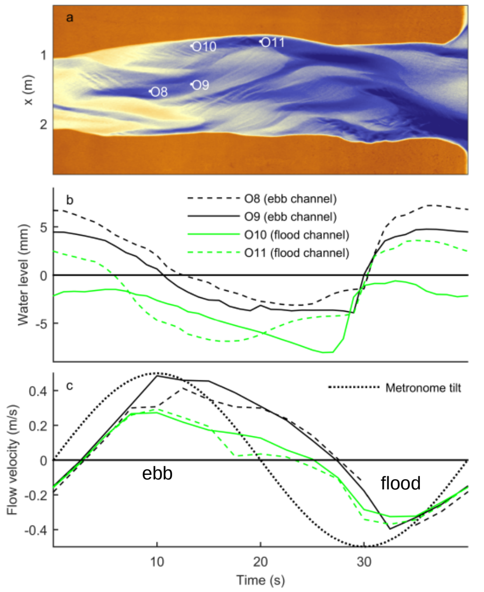

Fig. 2: Bathymetry (a) with measurements of water level (b) and tidal current (c) during the experiment.

Acknowledgments & references

We are grateful to C. Roosendaal, A. van Eijk, H. Markies and M. van Maarseveen for their technical support. This research was supported by the Dutch Technology Foundation STW (grant Vici 016.140.316/13710 to MGK).

Kleinhans et al., 2015. Turning the tide: growth and dynamics of a tidal basin and inlet in experiments. *J. Geophys. Res. Earth Surf., 120 (1):*, 95–119.

Van Veen, J. (1950). Ebb and flood channel systems in the Netherlands tidal waters, reprint of the original text. *J. the Royal Dutch Geogr. Society, 67*, 303-325.

Onshore sandbar migration: Processing PIV measurements to analyse wave driven sediment transport in the nearshore

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Introduction

This study investigates wave driven onshore sandbar migration. Observations show that sandbars move onshore during mild wave conditions. Literature describes different potential sediment mechanisms that cause this onshore migration, but the dominant cause is still under debate. The goal of the present study is to determine the dominant sediment mechanism in wave driven onshore sandbar migration.

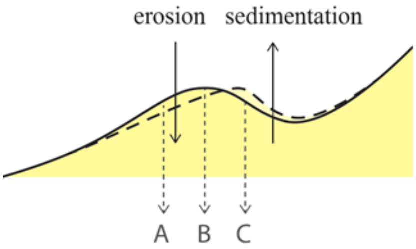


Figure 1: Measurement locations around the sandbar during onshore migration

Method

The study uses data collected in a mobile-bed wave flume [Henriquez, et al., 2009]. The study consists of two parts: (1) calculating sediment transport based on PIV data and (2) analysing wave driven sediment transport in the wave bottom boundary layer. The analysis distinguishes three transport mechanisms: current related, long wave related and short wave related sediment transport.

Results

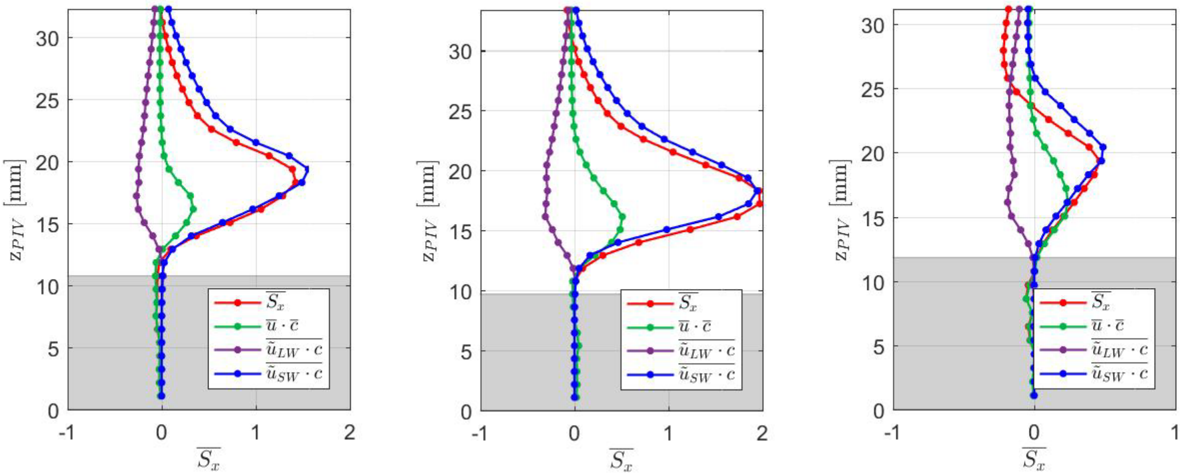
The findings show that short wave related sediment transport is dominant in onshore bar migration (Figure 1). In addition, sediment transport appears to depend on the wave shape close to the bottom at the elevation of maximum sediment transport. The wave shape changes towards the bottom: asymmetry is transformed into skewness, which results in strongly skewed and backward pitched waves close to the bottom.

In addition, the study shows that PIV data have potential to determine sediment transport without additional concentration measurements. Three essential steps in the method are: (1) placement of the PIV laser in front of the wave flume instead of the common position on top, (2) calibrate the intensity and concentration based on the mean bed and mean water intensity and (3) multiply the PIV sediment velocities with the concentration to obtain sediment transport.

The results of this study contribute to improve the accuracy of coastal morphology predictions and the efficiency of beach nourishments and other coastal protection measures.

References

Henriquez,M., Reniers, A., and Ruessink, B. G. (2009). On the scaling of sediment transport in the nearshore. Second International Conference on the Application of Physical Modelling to Port and Coastal Protection, January 2009).



(A) Offshore of the sandbar *(B) On top of the sandbar* *(C) Onshore of the sandbar*

Figure 4: Sediment transport mechanisms at the three locations A, B, C (Figure 1) at the sandbar during onshore movement. The lines display the total sediment transport (red), the current related transport (green), the time-average long wave (purple) and the time-averaged short wave related transport (blue).

Seasonal to tidal variations of SPM and chlorophyll-a in a coastal turbidity maximum along the Dutch coast

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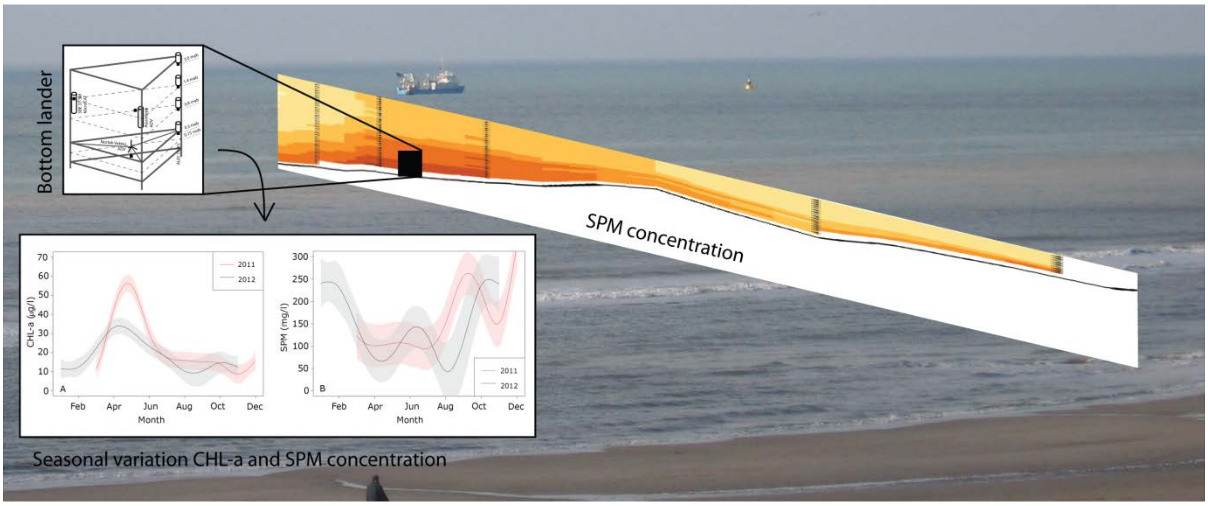
Large amounts of fine sediments are transported along the Dutch coast, but long-term monitoring covering their variability is scarce. We present results from lander measurements at the 10 m depth zone, near Egmond, where since 2010 multiple monitoring programs have taken place to understand the local dynamics of suspended matter and the effects on benthic life. In a broader sense, this information leads to a better understanding of the transport of SPM and related particles in the southern North Sea.

A comprehensive dataset of 2 years was acquired within the LaMer monitoring program near Egmond. The bottom lander was located in the turbidity maximum zone. We will focus on the local dynamics of both suspended particulate matter (SPM) and chlorophyll-a (CHL-a) concentrations on seasonal and tidal scales. The research area is characterized by strong tidal currents, non-breaking waves under normal conditions, breaking waves during storms and by density differences due to the fresh water in the Rhine ROFI. The SPM is a mixture of silt, mud and organic particles, while the seabed mainly consists of silt and sand. Near the bed, up to 30 cm above the seabed, accumulation of SPM occurs in a concentrated mud suspension where concentrations can exceed 1 g/l. In this suspension also CHL-a concentrations are high, which may explain the preferred settlement of the benthic bivalve *Ensis directus* in this zone. Profiles of SPM concentrations obtained within the Building with Nature program provide the vertical distribution of SPM over the water column on tidal and spatial scales. We will compare the equilibrium Rouse profile to these SPM distributions to analyze whether it is suitable as a practical approximation in this dynamic environment.



Graphical overview showing the overlap of the two monitoring programs with a cross-sectional SPM concentration and seasonal variations of chlorophyll-a and SPM concentrations.

Long term morphodynamic modelling of sea-level rise in San Pablo Bay

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Sea-Level rise is an evident threat and a growing concern worldwide. Current sea-level rise projections suggest a mean sea-level rise of 10-170 cm between 2000 and 2100, exceeding the rate of 15-20 cm/century observed past century in the San Francisco Bay area. This poses questions on to what extend we can predict morphodynamic developments under sea level rise scenarios.

This study investigates the long-term morphodynamic evolution of San Pablo Bay, a sub-embayment in San Francisco Bay, under different sea-level rise scenarios with the main focus on the survival of the intertidal flats. Bathymetric surveys are available between 1851 to 1983 on a 30 year interval and provide a unique validation opportunity for Delft3D morphodynamic modelling of the Northern San Francisco Bay and forecasting morphodynamic developments to 2100 under sea-level rise scenarios.

We show significant skill in hindcasting the volumes, areas (Figure 1) and shape (Figure 2) of the intertidal areas for both the depositional (1856-1953) and erosional (1953-onwards) periods. The model morphodynamic performance metrics showed good to excellent performance providing confidence in forecasts. The forecasts suggest inevitable loss of intertidal flats under different sea level rise scenarios, since flats inundate despite increased sediment trapping rates.

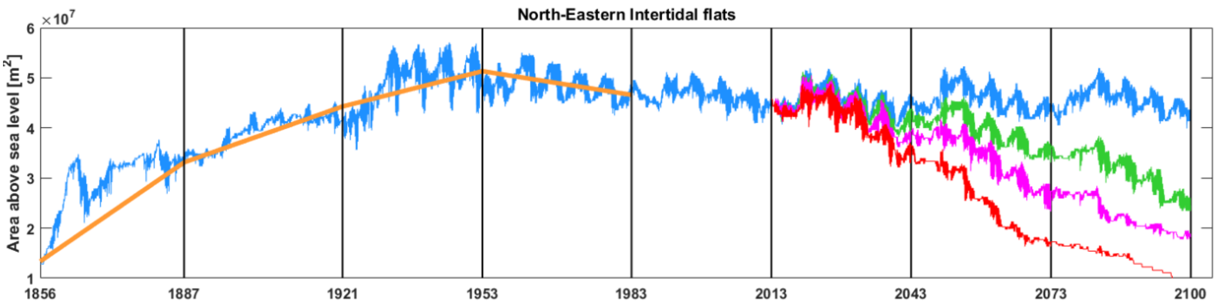

Figure 1, Development of intertidal areas (m^2) from 1856 to 2100. Orange line represents observations while blue, green, purple and red lines represent modelled sea-level rise scenarios 0, 42, 84 & 167 cm, respectively.

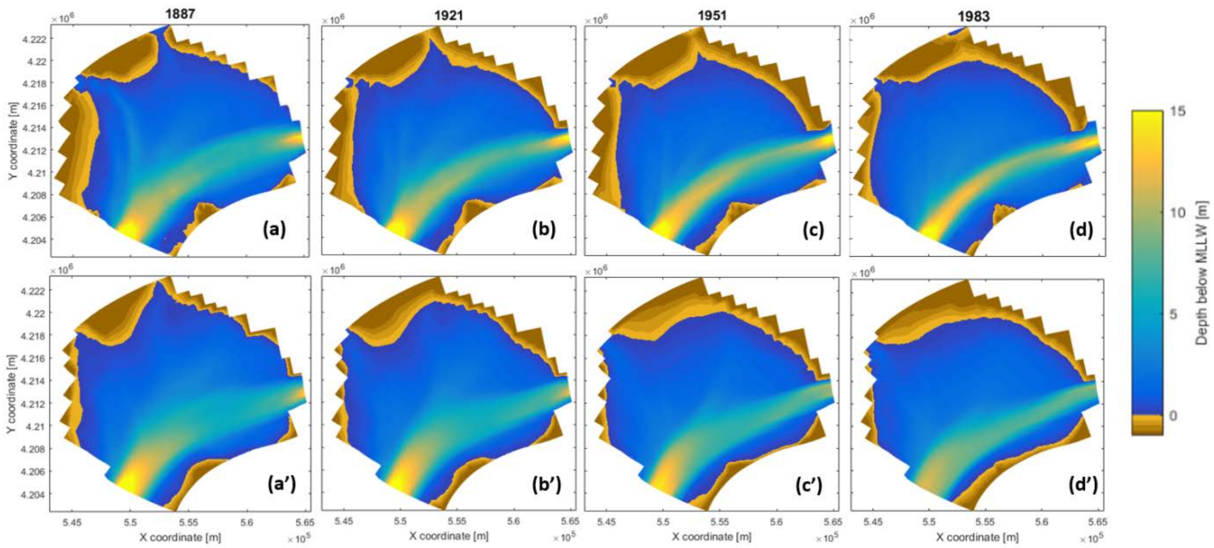

Figure 2, San Pablo Bay's observed (Top Row a,b,c,d) and modelled (Bottom Row a',b',c',d') bathymetry for the hindcast years 1887, 1921, 1953 & 1987, respectively.

Van der Wegen, M., B. E. Jaffe, J. A. Roelvink (2011)."Process-based, morphodynamic hindcast of decadal deposition patterns in San Pablo Bay, California, 1856–1887. J. of Geoph. Res. Vol 116 (F02008).

Shoal margin collapses in the Western Scheldt Estuary

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Channel bank failure and collapses of shoal margins (flow slides) have been recorded systematically in Dutch estuaries for the past 200 years. Between 1800 and 1978 more than 1000 large failures with sediment volumes up to a million cubic meters were documented in soundings of the Eastern and Western Scheldt estuaries (Wilderom, 1979). In many locations collapses reoccur at intervals of several years to decades. Flow slides are subdivided theoretically into two different types of underwater failure processes: rapid flow slides due to liquefaction and slow due to retrogressive breaching. The objective of this study is to investigate where shoal margin collapses occur, what shoal margin collapses volume are, and predict shoal margin collapse locations in the Western Scheldt.

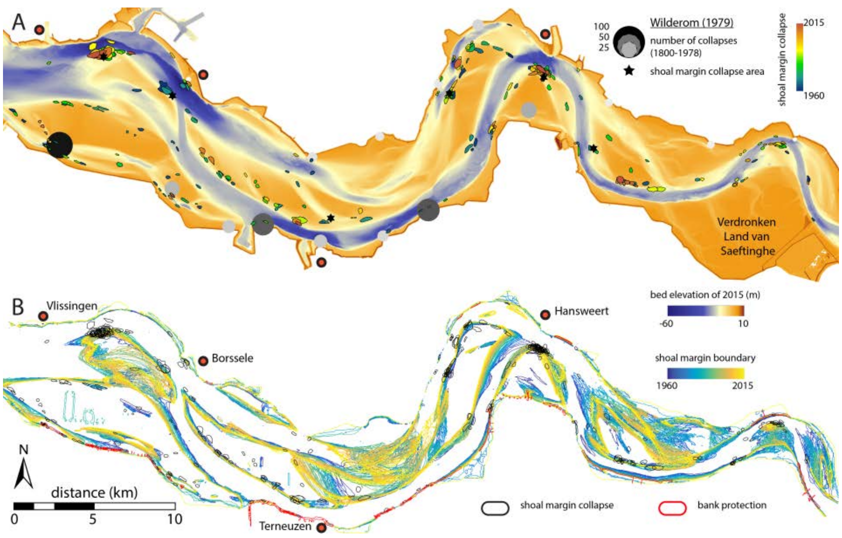
We identified shoal margin collapses from existing Digital Elevation Models (DEMs) by analysing DEMs of Difference (DoD) of the Western Scheldt for the period 1959-2015. We determined the area, volume and geometries of the shoal margin collapses, and analysed the location of the shoal margin collapses with a bar-to-excess width ratio. Furthermore, we analysed the shoal margin locations to a probability of occurrence formula $P(FS) = 1 - e^{-F(FS)}$. The frequency (*F(FS)*) used for bank safety assessment in the Netherlands (WBI, 2017) reads as follows

$$F(FS) = \left(\frac{5}{cot\alpha_r}\right)^5 \cdot \left(0.5 \cdot \left(\frac{H_R}{24}\right)^{2.5} \cdot \left(\frac{1}{10}\right)^{-10\,(0.05+\psi)} + 0.5 \cdot \left(\frac{H_C}{24}\right)^5 \cdot Fr_{mud}\right) \cdot \frac{\#SM}{L_{SM}} per\ km, yr$$

where α_r = relative slope gradient, H_R = relative slope height, ψ = state parameter, H_C = channel depth, Fr_{mud} = mud layers fraction, #SM = number of shoal margin collapses per year, and L_{SM} = shoal margin boundary length. Afterwards, we identified the accuracy of the prediction by plotting the true positive rate against the false positive rate.

We identified 292 shoal margin collapses along a 300 km long shoal margin boundary. Shoal margin collapses occur at locations where the bar-to-excess width ratio is greater than 1 and where shoal margin migration is low (in the Netherlands often defined by bank protection works, Wilderom 1961-1973), whereas no collapses occur at locations where shoal margin migration is high (see Figure). The average shoal margin collapse area is about 34,000 m^2 and has an average volume of 100,000 m^3, meaning that the average thickness is about 3 m. The shoal margin collapse geometry is best represented by a ¼ ellipsoid. The probability of occurrence formula identified low probabilities for the shoal margin collapses as the average relative slope height was only 11 m and the average relative slope gradient only 6^o for the collapsed shoal margins. Nonetheless, by applying various threshold values for the probability of occurrence, we found that the true positive rate was 2.5 times higher than the false positive rate when 50% of all the shoal margin collapse locations were predicted. So, we assume that a flow slide is predicted, if the calculated probability is 10^{-7}%.

We conclude that on average 5.3 shoal margin collapses per year occur in the Western Scheldt, and that the location of the shoal margin collapse can be predicted by mainly the variation in relative slope height and gradient within the Western Scheldt Estuary.



***A**. DEM of the Western Scheldt Estuary of 2015 with channel/ shoal margin collapses according to Wilderom (1800-1978) and new identified shoal margin collapses from 1959-2015. **B**. Shoal margin boundaries over time showing locations of high and low migration, where collapses mainly occur around low/no migration of the shoal.*

Modelling the Western Scheldt navigation channel spring tide eddy at Ossenisse

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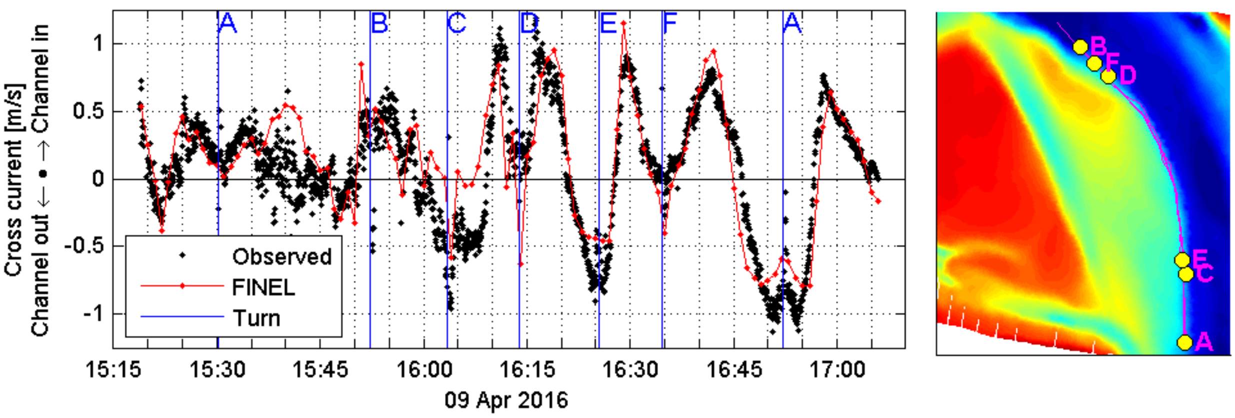
Abstract

During strong spring tides, east of Ossenisse an eddy is present in the Western Scheldt navigation channel, causing cross currents up to 2.5 m/s in the navigation channel (Royal Netherlands Navy, 2015). The cross current is troublesome for shipping and has in the past even led to ships running aground, for example the Fowairet in 2005. This accident has led to research on the cross current, consisting of several measurement campaigns and modelling efforts. The measurements in the area provided insight in the eddy behaviour and the circumstances in which the eddy arises, and since then warnings are issued when strong cross currents are to be expected.

Modelling the spring tide eddy however proved difficult. Settings of several available numerical flow model schematisations of the Western Scheldt have been adjusted in order to model the spring tide eddy near Ossenisse. Results have improved and a spring tide eddy is produced, but the location of the eddy and the timing of generation still deviate from reality (Deltares, 2013; LTV, 2013).

Recently, it is investigated whether it is possible to reproduce the Ossenisse spring tide eddy with the FINEL model package. By locally refining the triangular mesh and reducing the Nikuradse bed roughness, modelling the Ossenisse spring tide eddy with FINEL has succeeded. The model results are compared to several current measurements performed by Rijkswaterstaat, see an example on April 9th, 2016 below. The location of the eddy and the cross current are modelled well, although some deviations in the peak velocities are still visible. With FINEL now predictions of the Ossenisse eddy can be provided as well as better understanding of the driving mechanisms. It can also be used to develop local measures which reduce the hindering influence of the eddy on navigation.



Observed and modelled cross current in the navigation channel near Ossenisse. Note that the observations are sailed current measurement, and the location of the vessel varies in time. The moments the vessel turns around and the vessel track are indicated as well.

References

Royal Netherlands Navy (2015). Netherlands Notice to Mariners, volume 17, BAZ 189-207, April 23rd, ISSN 0166-932X.

Deltares (2013). Stroming in de Westerschelde. Inventarisatie van de informatiebehoefte en informatievoorziening. December 13th, reference: 1207729-002-ZKS-0002 (Dutch)

LTV – Consortium Deltares, IMDC, Svasek, Arcadis (2013). Mitigatie dwarsstroming Zuidergat (B-25). October 10th, reference: I/RA/11387/13.070/GLI/GLI (Dutch)

Dynamics of saw-tooth bars on ebb-tidal deltas

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Introduction

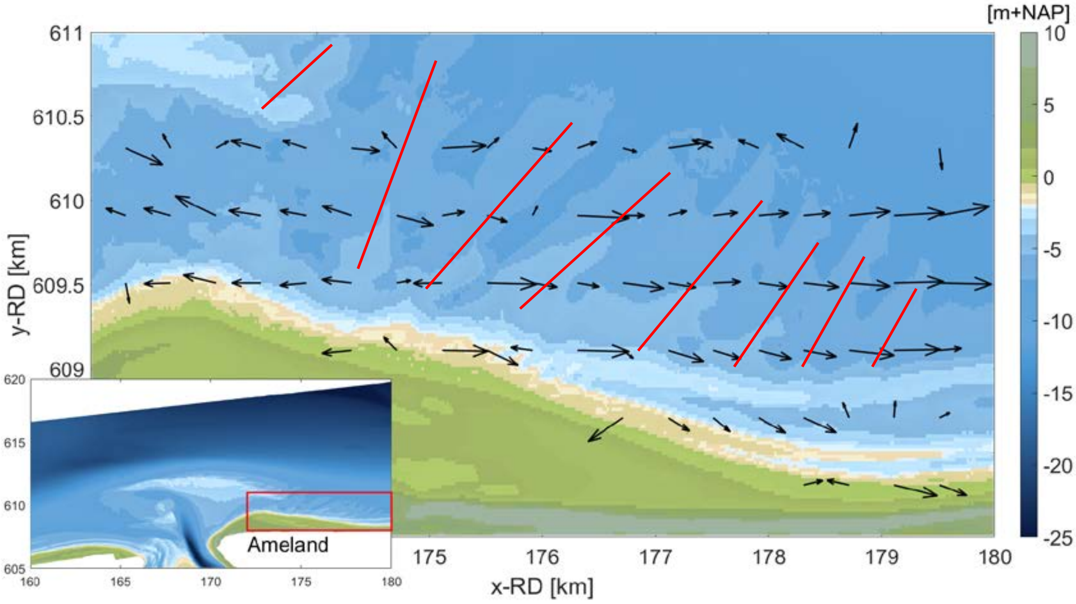
Ebb-tidal deltas are important parts of barrier coasts, but sediment transport patterns across these deltas are poorly understood. Usually, ebb-tidal deltas feature many bedforms like swash bars (occurring on the swash platform) and saw-tooth bars (which can be found on the terminal lobe). While swash bar complexes have received quite some scientific attention, the behaviour of saw-tooth bars has not been studied as extensively. The goal of this study is to quantify the migration rate and direction of saw-tooth bars, from which the total sediment transport directions and magnitudes along the outer parts of the ebb-tidal delta will be revealed.

Methods

To get a first estimation of bedform migration, a time series (1989-2014) of bathymetries of the Ameland ebb-tidal delta are compared with each other through spatial correlation (following the method of Buijsman and Ridderinkhof, 2008). Using the bedform migration rate and the estimated amount of sediment per bedform, sediment transport volumes can be calculated. Eventually, these volumes will be compared to transport volumes across other ebb-tidal deltas in the Wadden Sea.

Results

The figure below shows results of the spatial correlation between 2007 and 2008 in an area with saw-tooth bars, indicating transport magnitudes and directions. It is visible that the bars travel alongshore, towards the east. On average, the migration speed is 93 m/y, with a maximum of 189 m/y. These are typical values, which are also found for other years. Using an average width of 1500 m and a height of about 2 m, the average amount of sand transported by saw-tooth bars is 83,500 m^3/y. This is about 10% of the total longshore sand transport at Ameland, which is $1.0 \cdot 10^6$ m^3/y (Ridderinkhof et al., 2016).



Bedform-induced sediment transport magnitudes and directions between 2007 and 2008 (black arrows), projected on the 2008 bathymetry. Bar crests are indicated by red lines. Bottom left: overview of the 2008 bathymetry of the Ameland ebb-tidal delta, with the location of the larger picture denoted by the red rectangle.

References

Buijsman MC, Ridderinkhof H. 2008. Long-term evolution of sand waves in the Marsdiep inlet. I: High-resolution observations. *Continental Shelf Research* **28**: 1190-1201.

Ridderinkhof W, Hoekstra P, Van der Vegt M, De Swart HE. 2016. Cyclic behaviour of sandy shoals on the ebb-tidal deltas of the Wadden Sea. *Continental Shelf Research* **115**: 14-26.

Cyclic evolution of ebb-tidal delta of Ameland results in periodically changing import and export in the inlet

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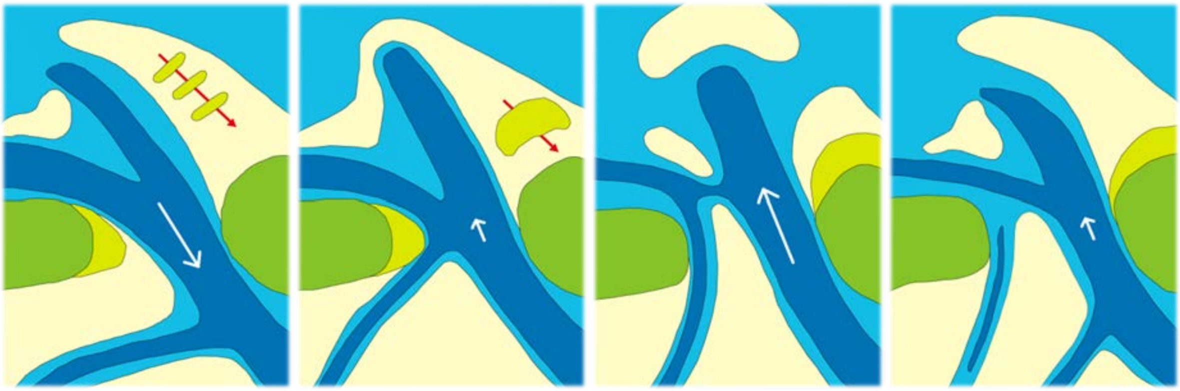
Introduction

Ebb-tidal deltas are shallow sandy features located seaward of tidal inlets and are important for coastal safety in barrier systems. They act as a shield for incoming (storm) wave energy and they are a source of sediment for the barrier islands and the back-barrier basin. This 'feeder' function is often related to the observed cyclic behavior of shoal formation, migration and attachment to the downdrift island. The main objective of this study is to study how the cyclic behavior of an ebb-tidal delta influences the wave, tide and sediment transport patterns.

Methods

The area of this study is the ebb-tidal delta of the Ameland inlet (see Figure), which is considered to be the most natural system of the Dutch Wadden Sea. The Delft3D/SWAN model is run with realistic (i.e., measured) bathymetries from 1971, 1989, 1999 and 2011 in a high spatial and temporal resolution. Hydrodynamic forcing consists of a combination of tides and waves, where different wave classes represent dominant wave conditions (direction and wave height).



Schematic representation of Ameland inlet, cyclic channel-shoal dynamics and sediment exchange between basin and sea (white arrows). From left to right: 1971, 1989, 1999 and 2011.

Results

The results indicate that the system can change from a sediment exporting system (transport directed from Wadden Sea to North Sea) to a sediment importing system (transport directed from North Sea to Wadden Sea) during different stages of the cyclic behavior (see Figure). During storms, the system imports sediment for all bathymetries. However, the magnitude and even direction of the sediment flux during more tidally dominated conditions changes with bathymetry. These changes in import/export of sediment near the inlet seem to be caused by changes in the position of tidal residual circulation cells.

Topologic and dynamic connectivity in estuary channel networks

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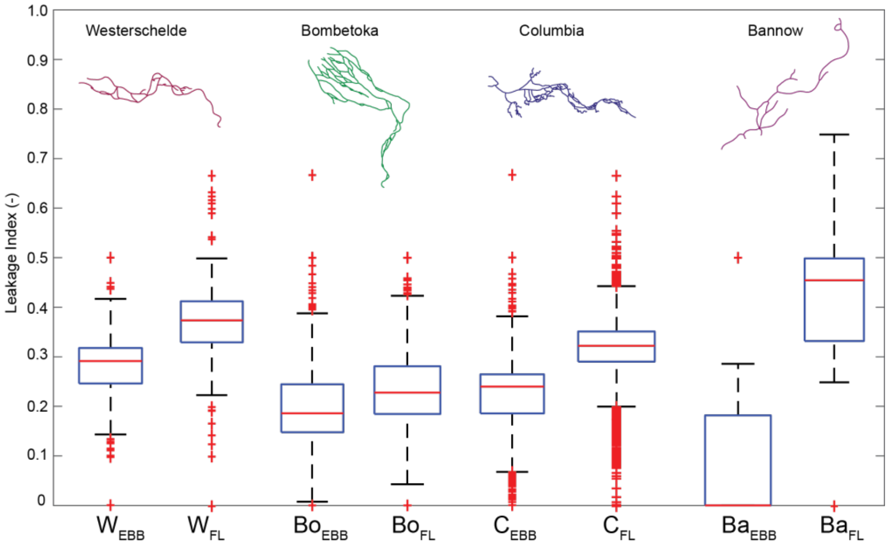
Estuaries are coastal water bodies that are subject to both fluvial and marine forcings, and can host highly dynamic and variable networks of channels and bars. Estuarine environments are among the most productive in the world, provide a range of ecosystem services, and support economic activity. The channel networks of estuaries range significantly in complexity, from single thread straight channels to multi-channel systems that bifurcate and recombine. Analysing estuary channel connectivity can provide insight into estuarine dynamics, as has been done for tributary networks (Rodríguez-Iturbe and Rinaldo, 1997), deltas (Tejedor et al., 2015a,b), and braided rivers (Marra et al., 2014), but no formal analysis of estuary topologic and dynamic connectivity exists. In this study, we extract channel networks for estuaries around the world and apply spectral graph theory (Tejedor et al., 2015a,b) to characterise their topologic and dynamic connectivity. We implement a semi-automatic method for the extraction of estuarine channel network topology and geometry using singularity analysis (Isikdogan et al., 2015) and geoprocessing tools. Networks are analysed considering two directions: one representing flow in the landward "flood" direction and the other in the seaward "ebb" direction. Spectral graph theory techniques developed for unidirectional deltaic channel networks (Tejedor et al., 2015a,b) are adapted and applied to the bidirectional estuarine channel networks, and we examine the differences and similarities in topologic and dynamic connectivity in the flood and ebb directions using a suite of metrics. The steady state flux, a measure of how information passes through a network, is calculated and related to known and modeled dynamics in the Westerschelde. The leakage index, a measure of dynamic connectivity that indicates the proportion of flux distributed among different links, has significantly different distributions in the flood and ebb directions (see figure), and the magnitude of difference seems to be related to the degree of topologic connectivity. Estuaries tend to have a higher leakage index in the flood versus ebb direction, which indicates the fluxes in the flood direction are more widely distributed and that more material is allocated to bars, tidal flats, and marshes than in the ebb direction. We use a set of metrics to describe topologic and dynamic connectivity for estuary channel networks around the world and provide a novel characterisation of estuaries.



The leakage index for the Western Schelde (W), Bombetoka (Bo), Columbia River (C), and Bannow (Ba) estuaries in the ebb (subscript EBB) and flood (subscript FL) directions.

References
Isikdogan et al. (2015), *IEEE Geosci. Remote Sens. Letters*, 12, 11, 2218-2221
Marra et al., (2014), *Earth Surf. Process. Landforms*, 39, 766-778
Rodríguez-Iturbe, I., *and* A. Rinaldo *(1997), Cambridge Univ.Press,* New York.
Tejedor, A. *et al. (*2015a*), Water Resour. Res.,* 51, 3998–4018
Tejedor, A. et al. (2015b), *Water Resour. Res.,* 51, 4019–4045

Tidal flat nourishments: a rare and unexplored eco-engineering practice in estuarine management

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Introduction

Tidal flats are worldwide at risk due to coastal development and climate change. Tidal flats are valuable coastal habitats that sustain coastal food webs, and provide essential ecosystem services such as coastal protection, nutrient cycling and food production. Degradation of these habitats can have consequences on a global scale as they are important feeding grounds for migratory bird populations along world's major flyways. Their conservation and restoration is a major coastal management issue.

Tidal flat nourishments in the Oosterschelde

In the Oosterschelde estuary (SW Netherlands), tidal flats are eroding rapidly due to large-scale infrastructural works in het 1980's. To mitigate this erosion, large-scale pilots with sand nourishments on tidal flats are tested, a rare and unexplored practice in estuarine management. The nourishment replaces sediment that has been eroded away over time. Dredged material comes from channels and dumping techniques are adopted from beach nourishment projects.

Nourishing tidal flats have major eco-morphological impacts as it changes the topography, elevation and grain size, and it buries and kills benthic communities. Recolonization however, takes place in a relative short time frame. Though, as the physical and chemical characteristics of the tidal flat are altered by the nourishment, the benthic community structure may not reflect the previous setting and alterations may become permanent. Furthermore, there is a risk that non-native species might be able to take advantage of the unoccupied niche just after the nourishment.

Lessons learned

We will discuss lessons learned from two tidal flat nourishments (Galgeplaat: 140.000 m^3 of sand in 2008; and Oesterdam: 500.000 m^3 of sand in 2013) in the Oosterschelde estuary and how those lessons are incorporated in designing a new nourishment (Roggenplaat planned in 2017). To this purpose, we will present data from a multidisciplinary, multiannual monitoring programme looking at ecology (benthos, birds), hydrodynamics, and morphodynamics and their interactions.

The Oesterdam tidal flat nourishment in the Oosterschelde (Photo: Edwin Paree).

Abstracts of poster presentations

in alphabetical order by last name

Modelling onshore sand transport in shallow water during low energy conditions

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Introduction

Beaches generally erode during high energy conditions, while they accrete during the subsequent low energy conditions. The processes resulting in offshore sand transport and beach erosion are well understood, but this is not the case for the onshore transport during low energy conditions. To investigate which processes dominate the onshore transport, model simulations of the sand transport Q as function of the hydrodynamic conditions and the bed profile were conducted using a coupling of the SWASH model and the sand transport formulations of Fernández-Mora et al (2015). The model was set-up based on data collected during the TASTI field campaign at Vejers beach (Denmark) in the autumn of 2016 (Brinkkemper et al, 2017).

SWASH model results: Hydrodynamics

A 1-D computational domain was used with 4 vertical layers. At the offshore boundary, a JONSWAP spectrum was prescribed using the significant wave height and the peak period from a wave buoy located 15 km offshore. Flow velocities (output frequency of 4 Hz) and significant wave height H_s were based on the last 20 minutes of the simulation time. As can be seen in the Figure, the SWASH model is able to simulate the observed behaviour of a decrease in H_s above the sand bars and close to the shore where waves break. Also, the undertow (negative velocity) is observed at the locations of wave breaking. Validation of the hydrodynamical model results in shallow water with TASTI data is part of ongoing work.

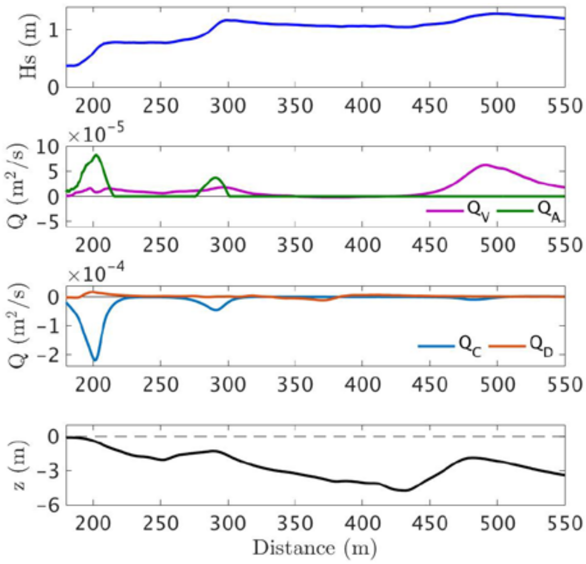

Figure 5: The significant wave height H_s and the transport terms as function of cross-shore distance. The bottom panel shows the bathymetry of Vejers beach.

Sand transport model

The sand transport model accounts for the transport by velocity skewness Q_V, acceleration skewness Q_A, currents Q_C and diffusion Q_D. The equations are based on the near-bed velocity, so the velocity of the bottom layer of the SWASH model was used. Using the calibration constants of Fernández-Mora et al (2015) results in the predictions seen in Figure 1, based on Hs = 1 m and Tp = 8 s. The skewness and acceleration transport are both onshore directed and largest above the sandbars and near the shoreline, with the acceleration transport increasing in importance closer to the shore. The transport due to currents is offshore at these locations, while the diffusive transport is positive as the seaward side and negative at the landward side of the bars. Future work will also involve a comparison of the model predictions against observed sand transport fluxes.

References

Brinkkemper, J.A. et al (2017). Onshore migration of an intertidal bar: The TASTI field experiment. NCK abstract 2017

Fernández-Mora, A., Calvete, D., Falqués, A., & Swart, H. E. (2015). Onshore sandbar migration in the surf zone: New insights into the wave-induced sediment transport mechanisms. *Geophysical research letters*, *42*(8), 2869-2877.

Zijlema, M., Stelling, G., & Smit, P. (2011). SWASH: An operational public domain code for simulating wave fields and rapidly varied flows in coastal waters. *Coastal Engineering*, *58*(10), 992-1012.

New functionality MorphAn Software

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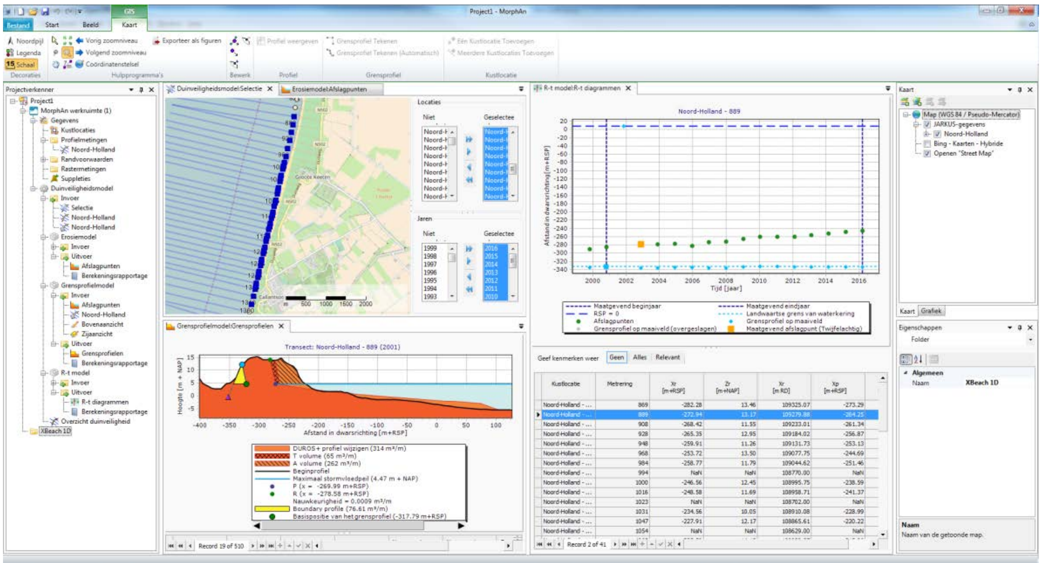
Poster presentation MorphAn 1.5

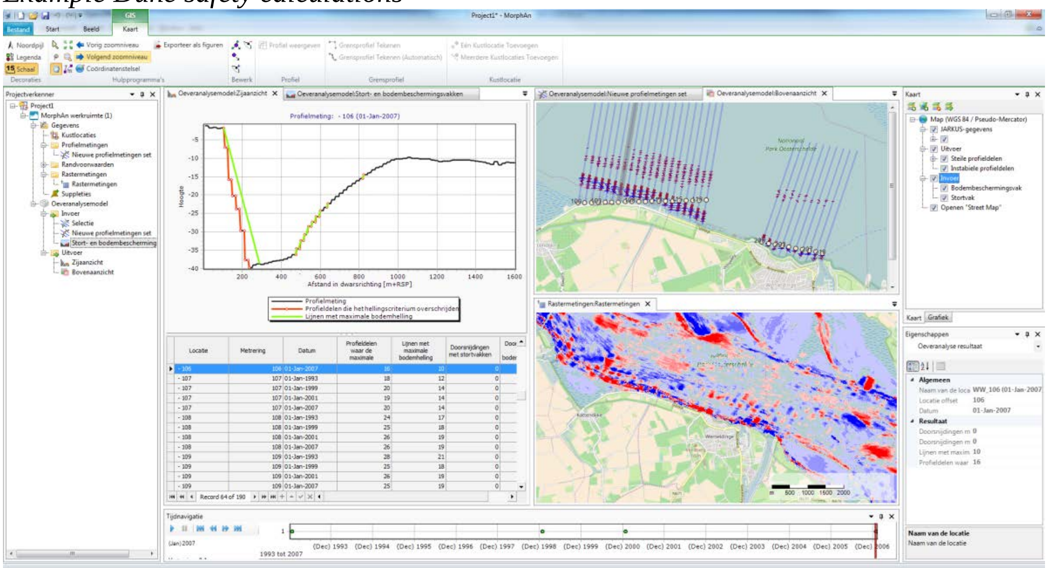
MorphAn is a software program which enables coastal zone managers, flood defence specialists, consultants and researchers to thoroughly assess the safety of the sandy Dutch coast against flooding. It can also be used to to analyse the morphological behaviour of the coast and coastal zone, e.g. trend and volume analyses.

The models DUROS+, D++ and XBeach1D constitute the heart of MorphAn's safety module and allow a safety assessment as prescribed by Dutch law. The morphological analyses that are carried out by MorphAn, too, are based on formats and indicators detailed in Dutch regulations.

The use of MorphAn is free. Morphan provides easy access to coastal data. The many graphs and maps within MorphAn allow detailed safety and morphological analyses to be carried out in a user friendly, intuitive way.



Example Dune safety calculations



Example Morphological analysis of foreshore development

Onshore migration of an intertidal bar: The TASTI field experiment

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Introduction

The onshore transport of sand during fair weather conditions is essential for beach recovery between storms. Our current knowledge, however, is not sufficient to properly predict the onshore movement of nearshore sandbars using morphological models. We aim to improve our understanding of the morphodynamics during these conditions and more specifically to determine which mechanisms are responsible for the onshore directed sand transport. To this end, the field experiment TASTI (Turbulence And Sand Transport Initiative) was conducted at the beach of Vejers, Denmark in September/October 2016. The experiment resulted in a unique dataset containing both onshore and offshore directed migration of the intertidal bar.

Field campaign

Measurements were collected during four weeks in the intertidal zone, between -1 to +1 m above mean sea level, along a cross-shore and 400-m alongshore array. The cross-shore array consisted of four rigs, of which two were equipped with acoustic current meters to measure unidirectional flow and turbulence, optical backscatter sensors for sand concentrations, ripple profilers and a pressure sensor to estimate the sea surface elevation. The two smaller rigs were equipped with three optical backscatter sensors, an electromagnetic flow meter and a pressure sensor. Together, these rigs allow us to determine sand transport gradients and to study the mechanisms responsible for the onshore directed sand transport. The alongshore array consisted of five additional pressure transducers to measure alongshore differences in the wave field over the intertidal beach. Furthermore, DGPS surveys were conducted every day to monitor morphological changes in the intertidal zone and daily time-exposure images were created from the top of the primary foredune, using a GoPro camera during low-tide, to get qualitative data on the position and alongshore variability of subtidal sandbars.

Morphodynamics

The intertidal bar present at the start of the campaign steepened and moved in the onshore direction during the first ten days, which were characterized by low energy conditions (H_0 = 0.4-0.8 m). The cross-shore array was located landward of an embayment in the crescentic subtidal bar. Subsequently, during day 11, 12 and 13, energetic conditions (H_0 up to 4.0 m) resulted in a flattening of the beach profile and a straightening of the subtidal bar, although the alongshore variability, both in bar and beach morphology, remained. Low-energetic swell (H_0 < 1 m) during day 14 to 23, resulted in the reformation of an intertidal bar, which gradually steepened and moved onshore again, but at different rates alongshore. During the NCK days we will show the first results from this unique dataset.

Cross-shore instrument array during low tide in the first week of the campaign.

Hydro-morphodynamics at the Eastern Scheldt: A wide range of scales

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Introduction

The Eastern Scheldt estuary has witnessed large transformations in its recent history. In response to the flooding of 1953, the estuary was partly closed by a storm surge barrier consisting of artificial islands and sluice gates. The impact of human interventions at the Eastern Scheldt basin is not straightforward, because estuarine processes involve a wide range of spatial scales.

Hydro-morphodynamic processes at the Eastern Scheldt estuary

Figure 1 shows a conceptual sketch of the different relevant processes at the Eastern Scheldt. A direct result of the storm surge barrier is a significant contraction of the flow (1) as it approaches the barrier and enters the basin, leading to very high local velocities. Furthermore, as the flow enters the basin, the barrier piers induce considerable turbulence (2). Downstream of the applied bed protection large scour holes have formed (3). Another direct result of the barrier is a reduction of the tidal prism. Therefore, since the construction of the barrier, the intertidal flats have faced substantial morphological changes (4), which can be related to the change in the large-scale hydrodynamics.
Five tidal stream turbines (B) were recently installed in one of the openings of the barrier by Tocardo International BV. The turbines interact with the complex hydro-morphodynamics of the Eastern Scheldt estuary (5). They may add smaller-scale turbulence to the barrier induced turbulence and influence the tidal exchange and flow velocities. In this way the turbines possibly affect the large-scale hydro-morphodynamics in the Eastern Scheldt.

Towards a multi-scale understanding of the Eastern Scheldt estuary

Currently, at the TU Delft researchers from different projects investigate the multi-scale hydro-morphodynamics of the Eastern Scheldt. Additional effort is put in the understanding of the complex interactions between processes having different time- and length scales. Ultimately this will provide the knowledge necessary to understand and predict the effect of human interventions (like the storm surge barrier or turbines) on the hydro-morphodynamics of the Eastern Scheldt. This requires the development of numerical modelling techniques coupling multiple spatial scales.

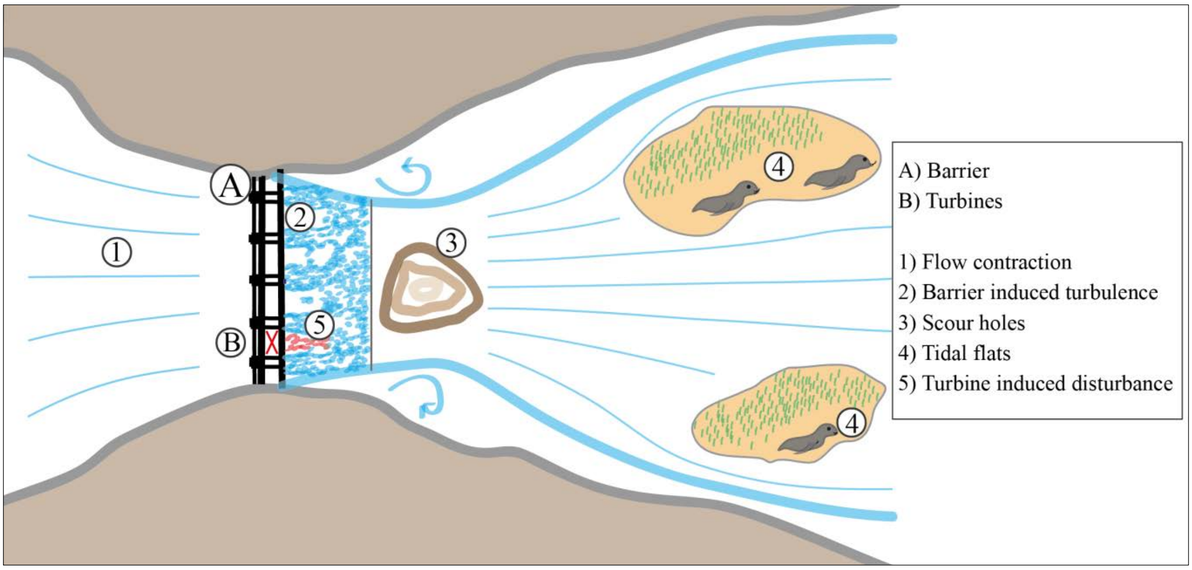

Figure 6: Schematic overview of the Eastern Scheldt estuary and relevant multi-scale processes.

Acknowledgements

This work is financially supported through different projects by: Rijkswaterstaat, NWO (Emergo project: 850.13.021 and The New Delta project: 869.15.008)

Large-scale river and estuary modeling with mud and vegetation

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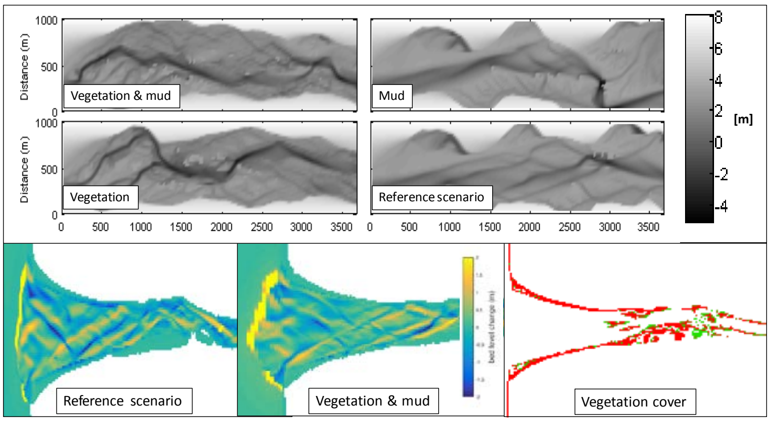
Introduction

We hypothesise that large-scale planform shape and development of estuaries are, like rivers, partly determined by stabilizing and destabilizing effects induced by mud and eco-engineering species (Kleinhans, 2010). We investigate those effects on planform geometry and bar patterns along the river-estuary continuum to enhance understanding of morphological long-term development.

Methods

We combined a morphological depth-averaged 2D model within the software Delft3D with a dynamic vegetation model coupled to flow resistance (Oorschot et al., 2015). The vegetation model represents species-specific settling, growth, and mortality which allow analysis of their impact on flow and sediment patterns as well as effects vice versa. The model was set up for the main fluvial and estuarine species with stabilizing eco-engineering effects in the Scheldt system. We investigated the role of mud, and its interaction with vegetation through active layer modelling and excess shear-stress relations for erosion and sedimentation.

Results



Vegetation focusses flow into channels and stabilizes bars and banks in rivers and estuaries. Mud enhances stabilization and modifies morphology. However, mud mostly settles where vegetation settles, whereas mud in isolation only deposits on the higher floodplains. In estuaries, mud does not settle on mid-estuary bars. For a combination of both factors we showed a further enhancement of the mud fraction with mud accumulation in areas where the vegetation is located.

Upper part: Bathymetry of an idealized river with different combinations of mud and vegetation after 300 years. Lower part: Bathymetry of an idealized estuary after 80 years. Blue areas are scour, yellow areas sedimentation. Right picture represents vegetation cover per cell.

Conclusions

The numerical model allows a quantitative representation of hydraulic and morphological processes in the fluvial and estuarine zone including the role of biomorphodynamics and mud. In comparison with the long-term development of the Scheldt system, the inclusion of several eco-engineering types and their interaction with mud and vegetation will allow determination of processes induced by typical eco-engineering species.

Acknowledgements

This research is funded by the ERC Consolidator grant and the NWO Vici grant, both to M.G. Kleinhans, with contributions by Deltares.

References

Kleinhans, M. G. (2010). Sorting out river channel patterns. *Progress in Physical Geography*, *34*(3), 287-326.

Meire, P., Ysebaert, T., Damme, S. V., Bergh, E. V. D., Maris, T., & Struyf, E. (2005). The Scheldt estuary: a description of a changing ecosystem. *Hydrobiologia*, *540*(1), 1-11.

Oorschot, M. V., Kleinhans, M., Geerling, G., & Middelkoop, H. (2015). Distinct patterns of interaction between vegetation and morphodynamics. *Earth Surface Processes and Landforms*.

Reconstructing the sediment budget of the western Scheldt 1860-1955

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Management of the Scheldt estuary requires understanding of the long-term sediment fluxes. Many policy related questions are directly or indirectly linked to this subject. Examples are: dredging and disposal strategy, sand mining issues and the observed increase in tidal range with negative impacts on many user functions. Until recently, data analyses suggested that the Scheldt was a sand importing estuary. In this research we investigate the period 1860-1955 using available topographic data and a 3D subsurface model of TNO–Geological Survey of The Netherlands, called GeoTop. We could reconstruct which type of sediment was deposited in this period, including the side branches that were reclaimed in this period. Based on all information we conclude that the estuary in fact has been a sand exporting estuary for the last two centuries. The sand export is mainly related to expanding channels in the western part of the estuary, which seem not to be equilibrium yet (Figure 1) with the hydrodynamics. Furthermore, we conclude that there has been a mud import in the estuary, which was deposited in bars and the side branches (Figure 2).
In order to understand the processes better, a process-based morphological sand-mud model was set up for this period based on Dam et al. (2016) and Dam & Bliek (2013). The model simulates the 1860-1955 period and confirms the sand export and mud import.

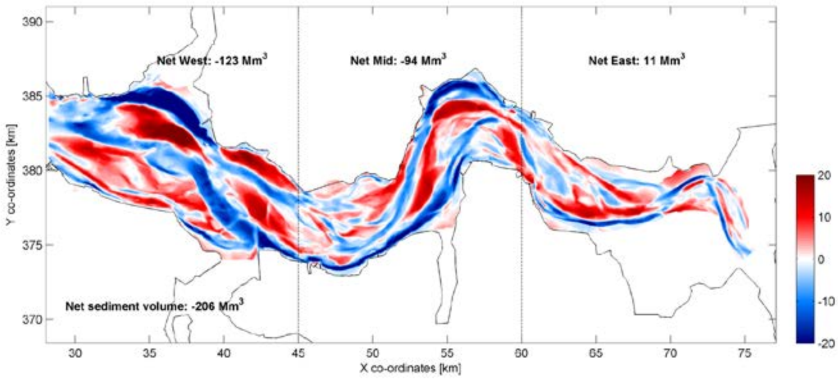

Figure 1: Erosion/sedimentation (meters) and net volume per section 1860-1955 based on measurements

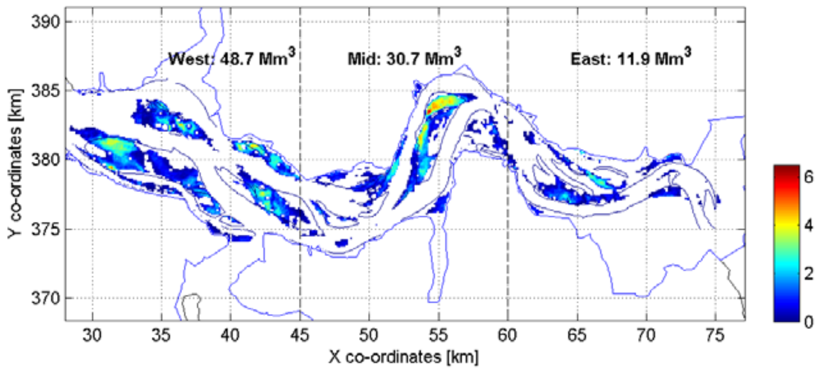

Figure 2: Clay deposition (meters) and total volume per section 1860-1955 based on GeoTop data.

References

Dam, G., Van der Wegen, M. Labeur, R.J. and Roelvink, D. (2016). Modeling centuries of estuarine morphodynamics in the Western Scheldt estuary. Geophysical Research Letters, Volume 43, Issue 8, pp. 3839-3847, doi:10.1002/2015GL066725.
Dam, G., Bliek, A.J. (2013) Using a sand-mud model to hindcast the morphology near Waarde, The Netherlands, Maritime Engineering, Vol. 166, pp. 63-75, doi: 10.1680/maen.2011.43.

Analysis of spatial variations in sand wave shapes

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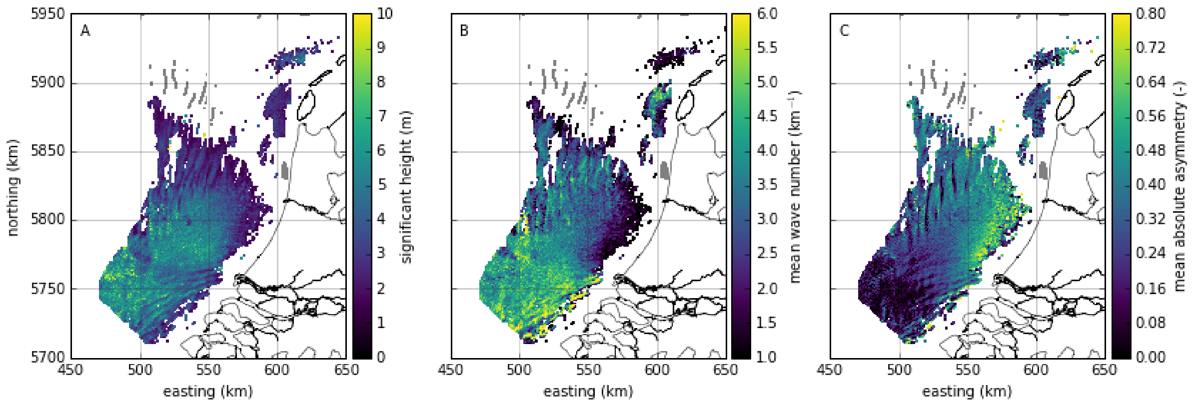
Introduction

Sand waves are rhythmic bed forms with lengths between 100 and 1000 metres (Ashley, 1990) with varying shapes depending on environmental properties, such as water depth, grain size, tidal characteristics and surface waves. The relation between these environmental properties and sand wave shape characteristics has mainly been investigated using models or case studies of local observations, but no large-scale analysis of these features is available. In this study, all sand waves on the Netherlands Continental Shelf are analysed to determine length, height and asymmetry. This dataset is compared to the impact of tidal flow, surface waves and sediment transport approximations. The aim of this study is to better understand the processes that control sand wave shape characteristics over a large area.

Methods and results

Sand wave properties are extracted by locating crests and troughs of the sand waves per transect. The impact of tides and surface waves is described using Shields parameters for the tidal flow and wave orbital motion at the bed. Rouse numbers are used to describe the dominant mode of transport due to waves and tides and the bed load transport is calculated. The sand wave properties are compared to these process descriptors by selecting locations where only one descriptor varies and all other descriptors are more or less constant (Van Santen, 2011).

The results show both small- and large-scale spatial variations in sand wave shapes on the NCS with generally steeper sand waves to the south and more asymmetrical sand waves to the northeast. Of the process descriptors, the mode of transport seems the dominant factor in the spatial variation in sand wave shapes.



Sand wave shapes on the Netherlands Continental Shelf with (A) height, (B) wavenumber and (C) asymmetry

Acknowledgements

The Dutch ministry of public works and Netherlands Hydrographic Office provided the multibeam data in time series and the data was interpolated by Deltares. This research is supported by the Netherlands Organisation for Scientific Research (NWO), which is partly funded by the Ministry of Economic Affairs.

Ashley, G. M. (1990). Classification of large-scale subaqueous bedforms: A new look at an old problem. Journal of Sedimentary Research, 60(1).

Van Santen, R. B., De Swart, H. E. &Van Dijk, T. A. G. P. (2011). Sensitivity of tidal sand wavelength to environmental parameters: A combined data analysis and modelling approach Continental Shelf Research, 31, 966-978.

State of the art of aeolian and dune research on the Dutch and Belgian coast

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Five years ago, at the previous anniversary of the NCK days, an overview was presented of the state of the art of “Measuring and modelling coastal dune development in the Netherlands” (De Groot et al., 2012). At that moment, new coastal-dune research had sprung up in the Netherlands after a relatively quiet period of about two decades, and the individual research projects were just starting to interconnect.

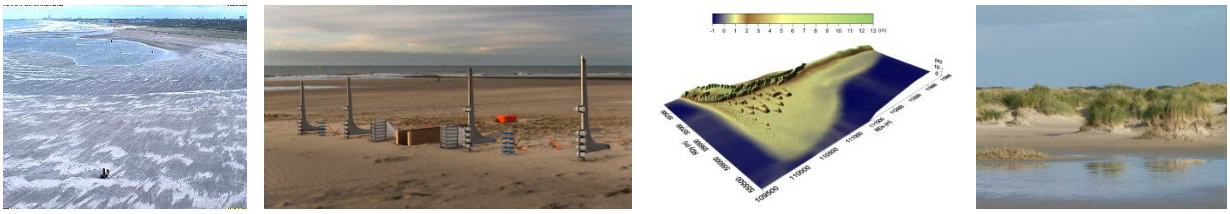
Since then, research has blossomed. A large number of PhD students, postdocs and staff of many institutes are involved, and coastal aeolian processes have become a permanent topic of recent NCK days. Young researchers are meeting a couple of times per year to discuss their work informally, and several PhD theses were defended.

The main current topics are:

- Sediment fluxes between the beach and dunes;
- Formation, erosion, and morphology of embryonic dunes and foredunes;
- Effects of human interventions on dune systems.
- Long-term development of dune systems.

These topics are studied from several angles and with various techniques:

- **Interdisciplinary approach:** the ongoing research takes place on various spatial and temporal scales, and takes both the fundamental and applied approach. Ecology has become an integral part of the studies, and often the studies are embedded in larger projects that consider the broader surroundings, ranging from underwater morphology to societal aspects.
- **Monitoring techniques:** recent developments in laser scanning and drone-based measurements have increased the amount of topographic data that can be gathered. New sand transport sensors are being applied. In addition, the ongoing monitoring programs by Rijkswaterstaat continue to be a vital basis for understanding the coastal system .
- **Field sites:** the number of study sites has increased strongly, so that almost all types of Dutch and Belgian beach-dune systems are being covered. Those include both artificial and natural locations.
- **Numerical models:** applied models range from the simple to the complex and include various model types (CA, process-based, CFD). The newest challenge is to couple models above and under water.



Examples of current Dutch and Belgian dune research.

De Groot, A.V., Vries de, S., Keijsers, J.G.S., Riksen, M.J.P.M., Ye, Q., Poortinga, A., Arens, S.M., Bochev-Van der Burgh, L.M., Wijnberg, K.M., Schretlen, J.L., Thiel de Vries van, J.S.M., 2012. Measuring and modeling coastal dune development in the Netherlands. In: NCK-days 2012 : Crossing borders in coastal research., 13 March 2012 - 16 March 2012, Enschede, the Netherlands.

Beach Scarp Behaviour at the Sand Engine

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Beach scarps are near vertical cliffs that can be present on the subaerial beach. In contrast to the more common dune cliffs, these scarps are not vegetated and are lower on the beach. The height of these scarps can be well over 1.5 m and they are observed especially at beaches with recent nourishments. To date it is however difficult to predict if (or when) scarps are likely to occur at (nourished) beaches. The main objective of this study is therefore to investigate when scarps exist and persist and how this may vary in space. Ultimately, we would like to be able to predict when scarps occur and, if possible, to be able to adjust nourishment designs to avoid these features.


Beach scarps along the perimeter of the Sand Engine mega-nourishment, the Netherlands

This research is based on nearly 5 years of topographic data in which scarps emerge, persist and get destructed at various locations along the curved coastline of the Sand Engine. The data was processed to reveal the scarp statistics for cross-shore transects along the most seaward section, with transects spaced ~40 m apart in alongshore direction. Concurrent hydrodynamic data were available from an offshore wave and water level station.

Results of the analyses show that scarp existence varies widely from month to month. Large scarps emerged for the first time a year after construction. Surprisingly, scarps were totally removed several times in the investigated period, just to reappear in a few months time. This complete removal of the scarps is observed in autumn (Oct-Dec) of 2012, 2013 and 2014 and these removals follow periods with high storm surges and waves. Scarp existence is also found to vary spatially along the perimeter.

We hypothesized that the framework for dune erosion based on run-up and crest level (Sallenger, 2000) can be adopted to predict the fate of existing beach scarps, based on the observed synchronicity between high wave events and the removal of scarps:

- The scarp will retreat (i.e. the collision regime) in case maximum wave run-up is below the scarp crest level but above the scarp toe.
- If run-up occasionally exceeds the scarp crest level the scarp will be removed (i.e. the overwash regime).

A first order comparison of the data with this adapted Sallenger framework revealed that indeed the framework can be used to understand storm impact on scarps. These results also suggest that the crest level of a nourishment platform is crucial in the existence and persistence of the scarps.

Sallenger Jr, A. H., 2000. Storm impact scale for barrier islands. *Journal of Coastal Research,* 890-895.

Hydrodynamics on a large tidal flat surrounded by water: the Roggenplaat

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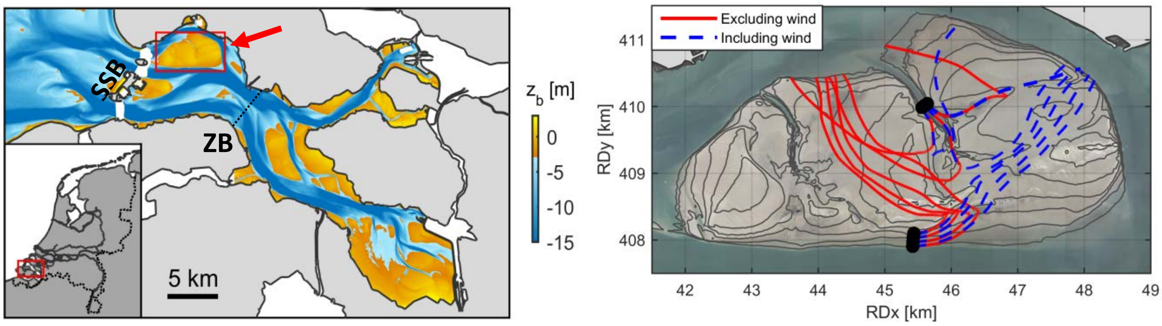
Introduction

In both the Eastern and Western Scheldt (the Netherlands), the intertidal flats are facing morphological changes induced by human interventions (de Vet et al., 2017). Various nourishments and dumping strategies are designed to mitigate the decay in ecological value as a consequence of these changes. The Roggenplaat tidal flat in the Eastern Scheldt will be nourished later this year (2017-2018). This study focusses on the processes driving the flow on the present-day geometry of the Roggenplaat. Our insights contributed to an efficient design of the nourishment but are also relevant for a general understanding of tidal flats surrounded by water.

Approach

Our approach was two-fold. First, we measured the spatial and temporal distribution of the flow on top of the flat by 16 mutually employed ADCPs. Secondly, we developed a high-resolution (10 m grid size) Delft3D model, to extend the insights of the ADCP measurements with various model scenarios.



Left: Bed level (w.r.t. MSL) of the Eastern Scheldt with the arrow pointing at the Roggenplaat, Right: aerial picture (courtesy Cyclomedia) with modelled tracks of drogues released at MWL during rising water in a single-tide simulation with and without the inclusion of wind stresses (contour lines indicate the bathymetry).

Results

With various model scenarios we identified the relative importance of the tidal signal, the storm surge and the wind stresses on the flow patterns on top of the flat. This flow is driven during mild conditions net in NW direction. While under the impact of wind stresses, the direction of the net flow can be completely different, see the right figure. Our modelled observations are well in line with the insights from the extensive ADCP measurements.

Discussion and Conclusions

For a large tidal flat surrounded by channels, there are many degrees of freedom for the flow. The net flow on the tidal flat is related to the geometry of the channels around the tidal flat. However, the large dimensions of such tidal flats cause wind stresses to have a relatively large impact on the net flow patterns. Because wind events are related to higher energetic waves, this is an important aspect for morphological features affected by those events. Contradictory, the orientations of the major tidal creeks are in line with the net flow during mild wind, indicating these are less affected by such events.

References

De Vet P.L.M., Van Prooijen B.C., Wang Z.B. (2017) The differences in morphological development between the intertidal flats of the Eastern and Western Scheldt. *Geomorphology*. doi: 10.1016/j.geomorph.2016.12.031

Spatial variability of wind flow over a bar-beach-foredune morphology

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Introduction

In many Dutch coastal regions, dunes act as a primary defence against flooding of the low-lying hinterland by storm surges from the sea. Nowadays, we can use advanced numerical models in scientific projects and policy-making to predict dune erosion by wave action. In between storms coastal foredunes recover by aeolian sediment transport from the (intertidal) beach. Models capable of predicting this recovery are still in their infancy because of, among a number of aspects, the potentially strong spatial variability in wind characteristics on the beach. Mean wind characteristics are likely to vary due to the presence of an intertidal bar-trough system and the often steep and tall foredune front. Additionally, the strong intermittent character in aeolian transport points to the need of understanding wind turbulence to improve sediment transport rate predictions. Here, we examine mean wind velocity and turbulence characteristics across a bar-beach-foredune morphology at Egmond Beach in The Netherlands.

Methods

Three-dimensional wind velocities were measured at a height of 0.90 m and a frequency of 10 Hz in a cross-shore array. We used 4 to 6 ultrasonic anemometers (figure 1) between the waterline and the dune foot, depending on the beach width. During a 6-week field campaign in autumn 2015, measurements were performed nearly every day during daytime. This resulted in an extensive dataset with mean wind speeds over the full range of no wind up to 10 m/s. The velocity data were processed into a 5-minute mean turbulent kinetic energy (TKE) and mean velocity ($\bar{u}$).

Figure 1: Ultrasonic anemometer installed, as a part of a cross-shore array, at the beach south of Egmond aan Zee. The tall and steep foredune front is visible in the background.

Results

Preliminary analysis shows a positive dependence of the TKE on $\bar{u}$during onshore winds (figure 2), indicating an increasing gustiness (up to 1.5 m^2/s^2) with increasing mean wind velocity. In contrast, during offshore winds the TKE-values reach up to 4 m^2/s^2 during mean wind speeds smaller than 6 m/s that are unrelated to $\bar{u}$. During onshore winds the relation of TKE to $\bar{u}$ is spatially varying: at distances of about 50 m seaward from the dune foot, mean wind velocities can be 1.5 times higher than at the dune foot with identical TKE values.

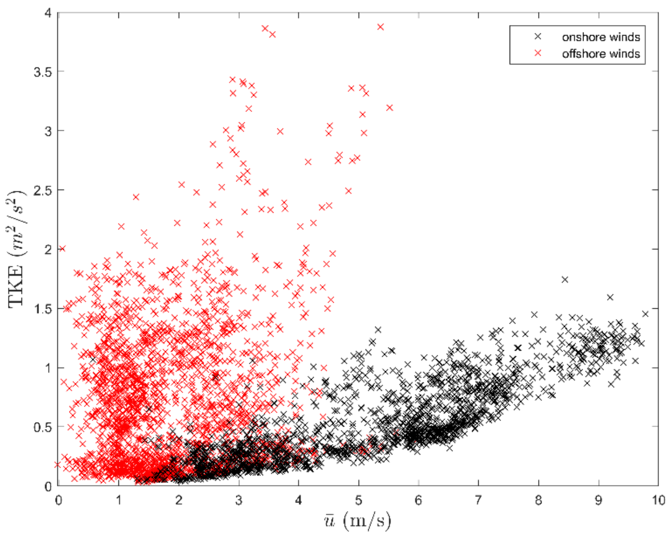

Figure 2: Turbulent kinetic energy versus mean wind speed. The turbulent kinetic energy of onshore winds (black) is related to the mean wind speed, while during offshore winds (red) these are unrelated.

Ongoing research

Future work will focus on the influence of beach width (tide), wind direction and bar-trough morphology on the relation between turbulence and mean wind velocity across the beach.

Intra-wave modelling of sediment transport in presence of strong currents

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SEAWAD is an acronym for SEdiment supply At the WAdden sea ebb-tidal Delta. In the present situation the ebb-tidal deltas are eroding due to a loss of sediment towards the tidal basins and adjacent coasts. Predicted sea-level rise will exacerbate this situation. Large-scale nourishments, in line with the Sand Engine, are proposed at the ebb-tidal deltas. The aim of the SEAWAD project is to investigate the feasibility, efficiency and design of a mega-nourishment on the ebb-tidal delta.

Strong currents are present in the vicinity of a tidal inlet. It is known that wave shapes significantly transform when encountering a current, influencing wave skewness and asymmetry. Sediment transport formulae in phase-averaging models (like DELFT3D) are a function of near-bed velocity skewness and asymmetry. However, these models do not take into account the influence of currents on the wave skewness and asymmetry. Therefore, it is presently impossible to correctly predict the wave-related sediment transport when strong currents are present. This project aims to improve sediment transport formulations to include the effect of currents on waves. This is essential for the SEAWAD project as at the ebb-tidal delta, where the mega-nourishment is proposed, waves can be highly nonlinear due to the tidal currents.

A field campaign is included in this project to investigate hydrodynamic and morphological conditions in the Amelander Zeegat (tidal inlet between Wadden Islands Terschelling and Ameland). Obtained data, potentially extended with other available data where both waves and currents are present, will be used to find a better representation of near-bed velocity skewness and asymmetry. Furthermore, the detailed phase-resolving wave-flow model SWASH will be used to investigate intra-wave sediment transport. To use SWASH, first tidal currents have to be implemented in the model. Preliminary results of SWASH simulations including waves and currents will be presented in this poster presentation. The influence of currents on the free-surface wave skewness and asymmetry will be discussed.

Amelander Zeegat [source: beeldbank.rws.nl]

Impact of dune growth promotion measures

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Context & objective

To promote aeolian sediment deposition more inland, a pilot project was initiated with Hoogheemraadschap Hollands Noorderkwartier and PWN in the winter of 2015/2016. The goal of the project was to reinforce the seaward dunes for safety reasons. Several incisions were made in the first dune row and vegetation was removed in a study area near Kieftenvlak, North Holland. To examine the impact and effectiveness of the measures a small monitoring program was executed with five photogrammetry surveys from drones in spring of 2016.

Left: Photogrammetry drone at Kieftenvlak. Middle: Large deposition inland of an incision in the first dune row, Right: Transect over the deposition zone (red line in middle panel) for Jan. 2016 (grey) and May 2016 (green).

Observations & results

The consecutive bed level measurements in spring 2016 show different impact for the various measures used. Locations where dune vegetation is removed often display erosional behaviour, especially if these are aligned with wind direction. Deposition of sand is often found at the edges of the bare sediment in the first vegetation. Also the downwind slopes of the dunes, facing landward, experience accretion where the vegetation was removed. Further inland, leeward of the large incisions in the first dune row, sedimentation can be up to 2 m (see also figure above). The impact of small incisions was mostly very local.

Changes in bed level and dune volumes coincide with periods of large oblique winds. Up to 10 meters of horizontal expansion of the sedimentation was found in the period Jan 17th – Feb 15th, a relative normal period with few minor storms from southwest directions. This period resulted in 90% of all the accreted volumes in the full domain over the spring.
The photogrammetry measurements were repeated in the end of Jan 2017 with a photogrammetry/LiDAR survey, results of which will be also presented at the conference.
Photogrammetry surveys work well in bare dunes. Vegetated dunes and larger areas will be measured by LiDAR surveys.

Modelling of wind flow over a Beach-Dune System

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Introduction

Coastal dune systems are formed by aeolian (wind driven) processes. Similar to water, the flow of wind is influenced by topography. Advanced 3d models for water flow are used to predict sediment behaviour and morphologic change. Predictions of aeolian morphologic change in dunes are far less advanced. For example, often a regional wind speed and direction are used as input for aeolian transport models, neglecting the strong effect of foredune topography on the local (i.e., on the beach) wind field. Moreover, the intermittent character of aeolian sand transport (e.g., streamers) suggests that taking into account wind turbulence is important for accurate predictions of aeolian dune growth. Here, we study the effect of beach and coastal-foredune topography on near-bed wind characteristics using the open source Computational Fluid Dynamics (CFD) package OpenFOAM.

Methods

OpenFOAM incorporates a broad range of solving algorithms and turbulence parametrisations for the Navier-Stokes equations and includes tools for mesh generation. A 3D mesh of the bottom 100~m of the atmosphere was generated around a detailed digital terrain model of the beach and foredune at Egmond aan Zee, the Netherlands. The mesh density increased from 10x10 m near the atmospheric boundary up to 0.5x0.5 m near the terrain. A constant wind speed was applied at the seaward boundary (i.e. cross-shore wind). The steady state solving algorithm SimpleFOAM was used to model incompressible wind flow over the foredune. Turbulence was parametrised with the renormalized group k-epsilon method.

Results

Preliminary results (Figure 1) show that the model predicts a decrease in wind speed (Figure 1) near the dune foot. The model also predicts an increase in wind speed on top of the approximately 20-m high foredune. Further landward, the wind flow detaches from the surface, resulting in lower velocities near the bed.

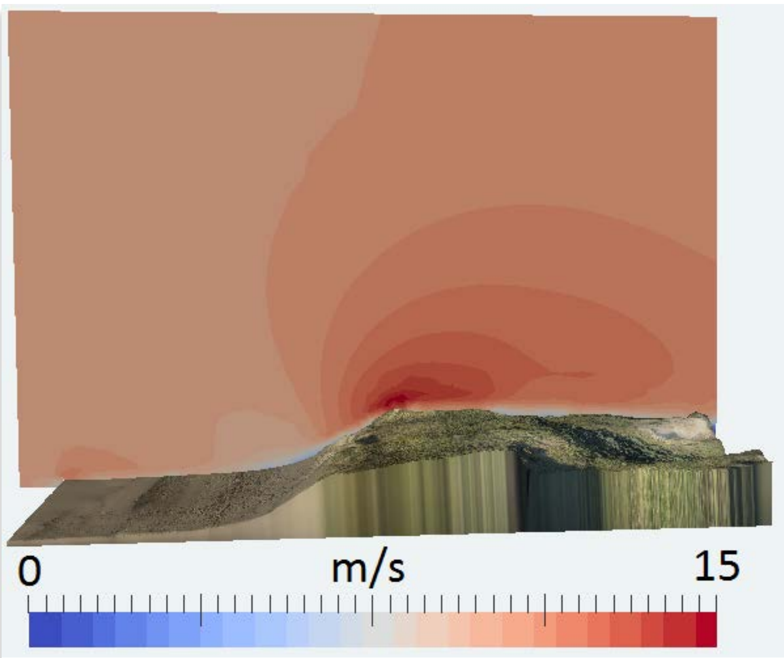

Figure 7: Cross-section (cross-shore – z plane) of wind speed over a coastal foredune near Egmond aan Zee, the Netherlands.

Ongoing research

The next step will be to validate the model with wind measurements carried out during the 2015 Aeolex experiment and to examine changes in wind direction in front of the steep foredune. Our end goal is to find simple relations between regional and local wind characteristics, needed to drive an aeolian transport model to predict dune growth.

How island slopes effect wave shape and transformation during island inundation

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1. Introduction

The vertical growth of barrier islands is important for their survival in times of sea level rise. During overwash and island inundation sediment is transported onshore and can potentially lead to island growth. Dunes and dikes are protecting the barrier islands, but are also cutting off the sand supply to the area landwards of the protection. However, to evaluate the feasibility of restoring these natural processes by re-opening dikes and dunes, and to be able to determine design criteria for openings, the effect of regional aspects such as the steepness of the beach slopes on wave transformation and wave shapes (which effect sediment transport) during inundation need to be known.

2. Methods

To simulate the transformation of low-frequency (LF, ~0.005-0.05 Hz) and high-frequency (HF, ~0.05-1 Hz) waves on varying beach slopes and island shapes during inundation, the non-hydrostatic wave-flow model SWASH (Zijlema et al., 2011) was run with 2 vertical layers out of 12m depth in profile mode. The wave shape is described by both asymmetry (forward leaning pitch) and skewness (long, shallow troughs and narrow, high crests). An increase in asymmetry and skewness is described by higher negative and positive numbers, respectively.

3. Results

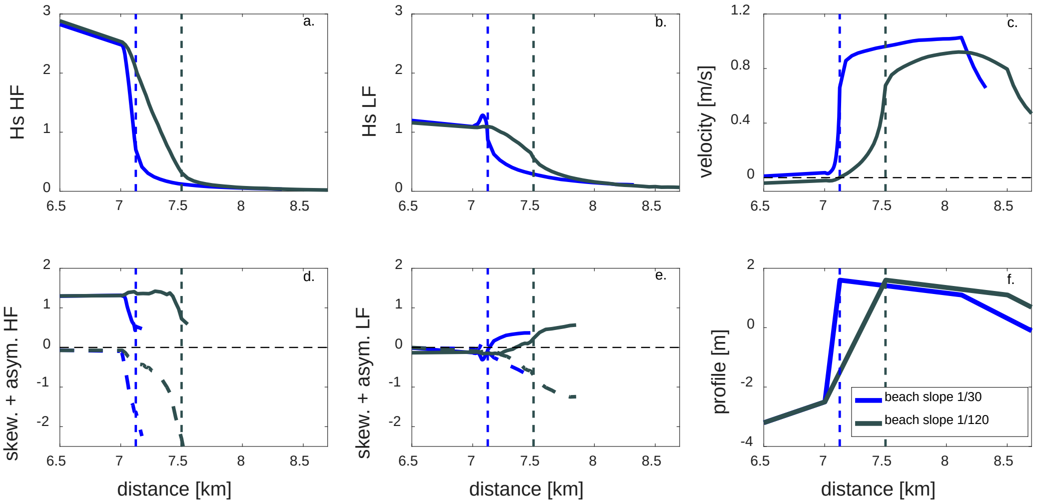

Figure 1. High (HF) and low frequency (LF) significant wave height (a. and b.), current velocity (c.), HF (d.) and LF (e.) wave asymmetry (dashed curves) and skewness (solid curves) and the profile (f.). Asymmetry and skewness are only shown for wave heights > 0.2 m. The blue and grey vertical lines show the profile crests.

Results suggest that waves remain higher on the steep sloping beach and also on the adjacent island flat when compared to a gentle slope. Due to higher wave set-up (not shown), velocities are increased on the island flat for the steep slope. HF and LF waves are more forward pitched and the skewness is increased for the gentle slope. We will investigate next how this affects onshore sand transport rates on the washover flat.

References

Zijlema, M., Stelling, G., Smit, P., 2011. *Coastal Engineering*, 58 (10), 992-1012.

Bed Composition: a Key Factor for the Channel-Flat Equilibrium?

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A Missing Piece in the Sediment Puzzle

Several hydrodynamic mechanisms are responsible for residual sediment transport in tidal basins. *Lag effects* and *tidal asymmetries* are the dominant ones. If waves are not considered, these two mechanisms always import sediments into the "shallow" region (a few meters below MSL). Thereby the intertidal area should continuously accrete with sediment coming from adjacent channels, whereas a balance is observed. Resuspension by small-amplitude waves is the main counter-mechanism acting on the tidal flats, but those waves cannot reach out to the bed in deeper areas. Furthermore, baroclinic circulation scarcely affects sediment transport in many inlet systems, such as the Wadden Sea. However, those systems have stayed close to dynamic equilibrium for the last decades. Since the hydrodynamics alone does not explain a balance in the channels, we hypothesize that the counter-mechanism has a *sedimentological* origin instead, arising from the progressive landward fining of the bed composition.

Methodology

In order to test our hypothesis, two steps are undertaken using the *Vlie* basin in the Wadden Sea as case study. (1) Sediment data analysis: a statistical model will assess the variability of the bed composition with respect to hydro-morphological properties of the basin. (2) Morphodynamic modelling: an exploratory model will simulate the channel-flat exchange as a 1D process, accounting for multiple sediment fractions and implementing a non-directional wave parametrization (Young & Verhagen, 1996) into the package *Delft3D.*

Preliminary Analysis

In Fig. 1, the dense (1-2 per km^2) samples of the *SedimentAtlas Waddenzee* (RWS, 1989-1997) are binned into discrete intervals ($\Delta x = 2.5$ *km*) of their distance from the inlet. The coarse-fraction content of the bed ($D \geq 250\ \mu m$) is largest near the inlet and decreases inside the basin. Fine sand is nearly equally present. Finer fractions ($D < 125\ \mu m$) are hardly present in the deeper channels, but they increase steadily shorewards. Morphodynamic simulations with a single grain size and without waves confirm that lag effects and tidal asymmetry lead to continuous sedimentation on the tidal flats at the expense of the shallow channels (Fig. 2), with the low-water line approximately marking the transition between accretion and degradation. The planned simulations will allow for the influence of waves and of spatial gradients in the bed composition. The anticipated outcome is that residual transport can vanish once those two factors are considered. If verified, future investigations in estuarine morphodynamics should consider the joint effects of tidal forcing, wave forcing and bed composition.

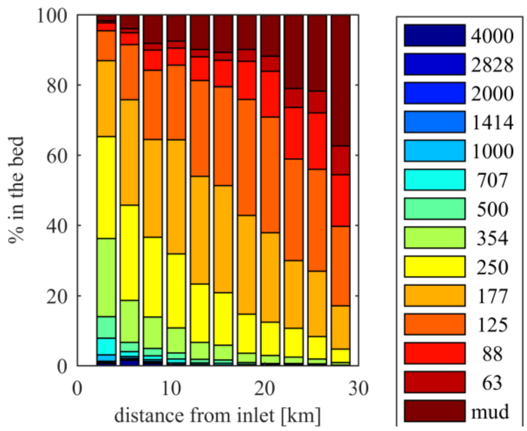

Fig.1: Variability of the Vlie basin's surficial bed composition with distance from the inlet. The legend indicates the grain sizes in μm.

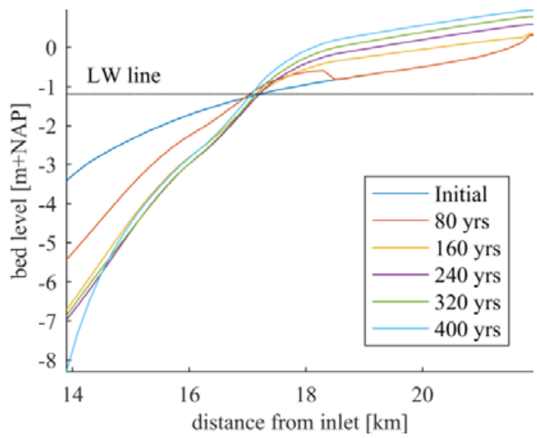

Fig.2: Bed-level evolution of a morphodynamic simulation with single-sediment fraction (125 μm) and only tidal forcing.

Annual mean sea level and its sensitivity to wind climate

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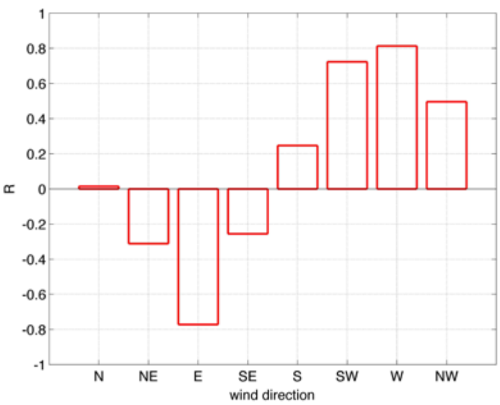
Changes in relative mean sea level affect coastal areas in various ways, such as the risk of flooding, the evolution of barrier island systems, or the development of salt marshes. Long-term trends in these changes are partly masked by variability on shorter time scales. Some of this variability, for instance due to wind waves and tides (with the exception of long-period tides), is easily averaged out. In contrast, inter-annual variability is found to be irregular and large, of the order of several decimeters, as is evident from tide gauge records. This is why the climatic trend, typically of a few millimeters per year, can only be reliably identified by examining a record that is long enough to outweigh the inter-annual and decadal variabilities.

In this presentation we examine the relation between the annual wind conditions from meteorological records and annual mean sea level along the Dutch coast. To do this, we need reliable and consistent long-term wind records. Some wind records from weather stations in the Netherlands date back to the 19th century, but they are unsuitable for trend analysis because of changes in location, height, surroundings, instrument type or protocol. For this reason, we will use only more recent, homogeneous wind records, from the past two decades. The question then is whether such a relatively short record is sufficient to find a convincing relation with annual mean sea level. It is the purpose of this work to demonstrate that the answer is positive and to suggest methods to find and exploit such a relation.

We find that at the Dutch coast, southwesterly winds are dominant in the wind climate, but the west-east direction stands out as having the highest correlation with annual mean sea level. For different stations in the Dutch Wadden Sea and along the coast, we find a qualitatively similar pattern, although the precise values of the correlations vary. The inter-annual variability of mean sea level can already be largely explained by the west-east component of the net wind energy vector, with some further improvement if one also includes the south-north component and annual mean atmospheric pressure. Knowledge of these local correlations can then be used to correct values of annual mean sea for these atmospheric effects. This halves the margin of error (expressed as 95%-confidence interval) for linear trends in a 20-year sea level record.

The sensitivity on wind direction has a regional variability, even on a small scale like the Dutch Wadden Sea. Model results illustrate the detailed spatial patterns in inter-annual variability of annual mean sea level.



Correlation of annual mean sea level (Den Helder) and annual mean wind energy (Vlieland), for 1996-2015.

Towards improving predictions of non-Newtonian settling slurries with Delft3D: theoretical development and validation in 1DV

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To date there is limited knowledge about the flow behaviour of non-Newtonian slurry and tailings flows. In hydraulic engineering and the mining industry numerous questions and uncertainties still exist. Different numerical and analytical models have been developed attempting to meet this demand. For the larger part they describe the rheological properties of the flow and are commonly developed for the mining industry. Delft3D is a widely used and proven numerical modelling suite to predict flow behaviour of different water bodies including physical processes e.g. the transport of sediments and stratifications. This thesis contributes to embedding the rheological characterizations for mud-sand-water mixtures and settling of granular material in Delft3D in three steps.

1. Analysis of three different rheological formulas

Rheological functions describe the relation between the shear rate and the shear stress and provide information on the resistance to flowing if a mixture is deformed. In literature three different formulas, developed in different fields of work, are found. In these models the rheology depends on the material properties and concentrations. From comparison to experimental data it appears that the three models predicted the rheological behaviour.

2. Shear induced hindered settling

A concentrated static non-Newtonian fluid with shear strength above a few Pascals is able to keep coarser silt or sand solid particles in suspension thanks to the yield stress. This phenomenon is expressed in the shear induced settling formula. The presence of many coarse particles within the carrier fluid hinders to settling of each single particle. Therefor the settling formula is expanded to a shear induced hindered settling formula.

3. Implementation into Delft3D

The rheology, settling and hydraulics interact with each other. The rheology of the mixture determines the flow velocity profile. Velocity variations over the vertical introduce a shear. Shear rate influence coarse particles segregation or settling. The sand concentration (at each layer) and the shear rate influences the apparent viscosity, which in return influences the rheology.

The rheology and settling formulas are implemented in a 1DV model analogous to Delft3D taken into account the coupled features.

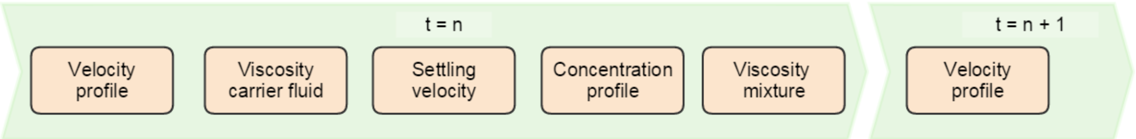

Figure 1 Calculation sequence of 1DV model

The study is completed by model verification on theoretical relations, and simple validation.
The present model is able to simulate non-Newtonian laminar flows and the segregation of granular material in the carrier fluid in 1DV.

Investigating the buffering of fines in a sandy seabed: planned field measurements along the Egmond aan Zee transect

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Introduction

The seabed in the Dutch Coastal Zone of the North Sea mainly consists of sand. However, the relatively small faction of fines that is present, already has an important effect on the behaviour of the seabed, the benthic and the pelagic system. Temporal variations in Suspended Particulate Matter (SPM) have a large effect on the timing and rate of primary production, thereby also affecting higher trophic levels. Field measurements along the Dutch coast indicate significant seasonal variations in concentrations of SPM. These seasonal variations originate from a marked seasonality in wind climate and the occurrence of storms. During storms, increases in SPM occur simultaneously in large parts of the Dutch coastal zone of the North Sea. This demonstrates that on short timescales, the vertical exchange of fines between the mostly sandy sea bed and the water column is dominant. However, the underlying physical and biological processes resulting in the water-bed exchange of fines are still largely unknown. These processes are studied in the SANDBOX research project, as a part of which field measurements are conducted along the Dutch coast.

Methodology & goals

During a measurement cruise with the RV Pelagia, measurements are made along a transect perpendicular to the Dutch coast, at Egmond aan Zee. The study site is shown in the left panel of Figure 1. Firstly, the bathymetry and small-scale bedforms along the transect will be mapped out precisely with side scan sonar measurements. Secondly, Sediment Profile Imaging (SPI) is utilized to obtain a qualitative image of the upper 15-20cm of the seabed. An example of such a SPI image is shown in the right panel of Figure 1. Analysis of these images provides information on physical and chemical parameters of the seabed. Additionally, it can be assessed whether the fines that are present in the seabed are well-mixed or occur as well-defined layers. To quantify the grain size and mud content of the seabed, boxcores and multicores will be taken at a regular interval. The boxcore samples will also be used to characterize the benthic macrofauna population along the transect. The overall goal of these field measurements is to study the structure and mud content of the seabed on the Dutch shoreface, enabling to focus on spatial gradients in the cross-shore direction. The aim is to assess these seabed characteristics in relation to occurrence of small-scale bedforms and benthic macrofauna.

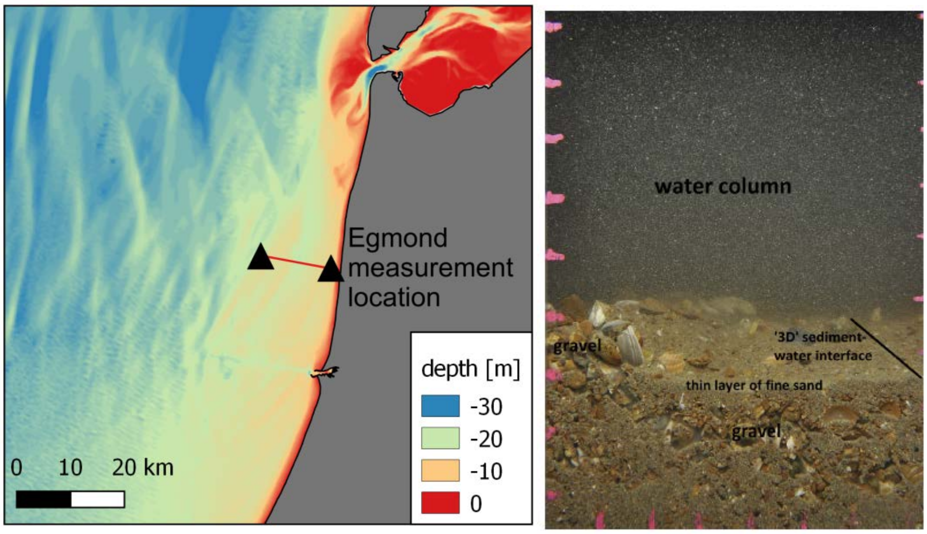

Figure 1: Proposed field work location to study the seabed characteristics, perpendicular to the Dutch coast at Egmond (left). Image obtained with SPI imagery, after de Backer et al.(2014) (right)

Acknowledgements

This work is part of the SANDBOX project, funded by NWO-ALW. The additional funding by Boskalis is also appreciated.

What internal length scale determines the tidal bar length in estuaries?

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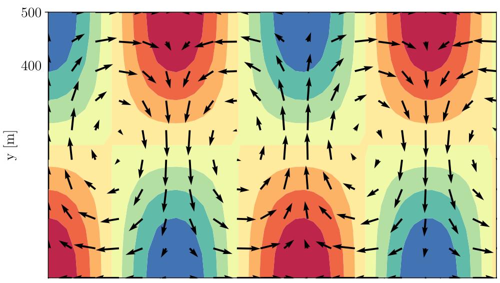
Introduction

The dynamics of bottom patterns in estuaries have been a subject of study since some time. Tidal bars in estuaries influence possible shipping routes to large harbors that are often located upstream the estuary. Furthermore, tidal bars are important for in the ecosystem of the estuary. This study is concerned with the question: ‘what internal length scale determines the tidal bar length?’. The motivation is that comparing previous studies (Dalrymple and Rhodes (1995), Seminara & Tubino (2001), Schramkowski et al. (2002), Hibma et al. (2004) and Leuven et al. (2016)) does not yet yield a clear answer to this question. Therefore, trying to bridge the gap between different models and observations, we build on, and extend the work of Schramkowski et al. (2002).

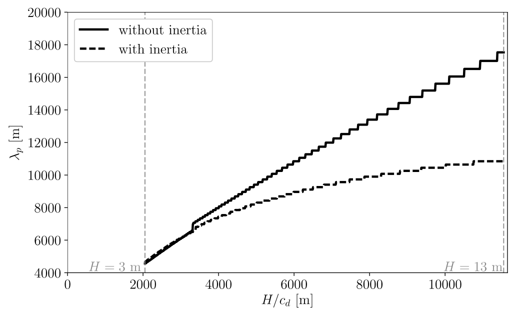
Internal length scales

Schramkowski et al. (2002) uses a linear stability analysis to investigate the bottom patterns in a straight channel where water motion is forced by an imposed pressure gradient force. This yields the wavelength of the preferred bottom mode that has the largest growth rate and that will dominate the bottom pattern after some time.

In this study the sensitivity of internal length scales on the preferred wavelength (that is, the bar length) is investigated. The internal length scales are the estuary width, the tidal excursion length, and the friction length scale. In narrow channels Seminara & Tubino (2001) show that inertia can be neglected. The scaling arguments suggest that this is not true in wider channels. Therefore, also the effect of inertia is investigated. The figure below shows the residual current perturbation on an alternating bar pattern and the relation between the preferred wave length and the friction length scale.



Residual cells of the current velocity perturbation (arrows) in an estary with an alternating bar pattern. The colors indicate the bottom height (red is bar, blue is through). The estuary width is 500 m, the imposed pressure gradient amplitude is such that velocities are around 0.7 m/s and the undisturbed depth, H, is 10 m ($H/c_d \approx 8500$ m). Inertia is included.



Preferred wavelength, λ_p, versus the friction length scale, H/c_d. The undisturbed depth, H, is varied between 3 m and 13 m and the drag coefficient, c_d, depends on H. The estuary width is again 500 m and the current velocity amplitudes are around 0.7 m/s.

References

Dalrymple, R. W. and Rhodes, R. M. (1995). Estuarine dunes and bars. *Geomorphology and Sedimentology of Estuaries. Developments in Sedimentology*, vol. 53, p359.
Hibma, A., Schuttelaars, H. M., and de Vriend, H. J. (2004). Initial formation and long-term evolution of channel-shoal patterns. *Cont. Shelf Res.*, vol. 24, p1637.
Leuven, J. R. F. W., Kleinhans, M. G., Weisscher, S. A. H., and van der Vegt, M. (2016). Tidal sand bar dimensions and shapes in estuaries. *Earth-Science Reviews*, vol. 161, p204.
Schramkowski, G. P., Schuttelaars, H. M., and de Swart, H. E. (2002). The effect of geometry and bottom friction on local bed forms in a tidal embayment. *Continental Shelf Research*, vol. 22, p1821.
Seminara, G. and Tubino, M. (2001). Sand bars in tidal channels. Part 1. Free bars. J. Fluid Mech., vol. 440 p49.

Are dunes formed by Lévy walks?

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Introduction

Coastal dunes play a vital role in protection of the shoreline. They arise from the interaction between vegetation and aeolian processes. Depending on its density, vegetation can locally reduce the wind velocity below the transportation threshold, thereby promoting the settlement of sand particles. In turn sand deposition protects the plants from the detrimental effects of flooding. The two dominant dune grasses of the North-Atlantic coasts are: *Ammophila arenaria* and *Elytrigia juncea.* These two species differ in growth form, which results in contrasting vegetation patterns. However, the relationship between the spatial patterning of dune grasses and their sand trapping efficiency is poorly understood. With the use of an individual based model we aim to further understand the biophysical feedback leading to dune formation.

Methodology

An individual based model was constructed to determine the optimal movement strategy that maximizes sand deposition while taking costs for the plant (above and belowground vegetation) into account. The random walk theory was used to model clonal dispersal. Preliminary field data suggests that the movement strategy of *A. arenaria* follows the Lévy walk principle, which results in a spatial vegetation pattern that consists of multiple small patches with a relative high shoot density. In contrast *E. juncea* grows in single larger patches, which resembles a Brownian walk.
The step length between two plants was randomly selected from a power law distribution. By varying the exponent (μ), either an Lévy walk ($\mu \approx 2$), Brownian walk ($\mu \approx 3$) or ballistic movement ($\mu \approx 1$) could be simulated. Field data was used to parameterize the degree of rhizome branching and the minimal and maximal step length. The density dependent positive feedback of vegetation on sand deposition was modeled using convolution matrices. The convolution matrix that simulates the effect of a single plant on wind velocity consisted of a Gaussian curve around a single grid cell (omnidirectional wind).

Preliminary results

When using the same number of shoots in the model (n=300) an exponent of $\mu \approx 2$ appeared to impact the threshold wind shear velocity to the greatest extent, making the area below the critical threshold at which sand deposition takes place the largest (figure 1C and 1D). This was not the case for $\mu \approx 3$ (figure 1A and 1B). From these preliminary results we can, for the time being, concluded that: 1) spatial patterns are important for maximizing the area at which sand deposition takes place, and 2) patterns resulting from a Lévy walk seem to be to most effective in maximizing sand deposition.

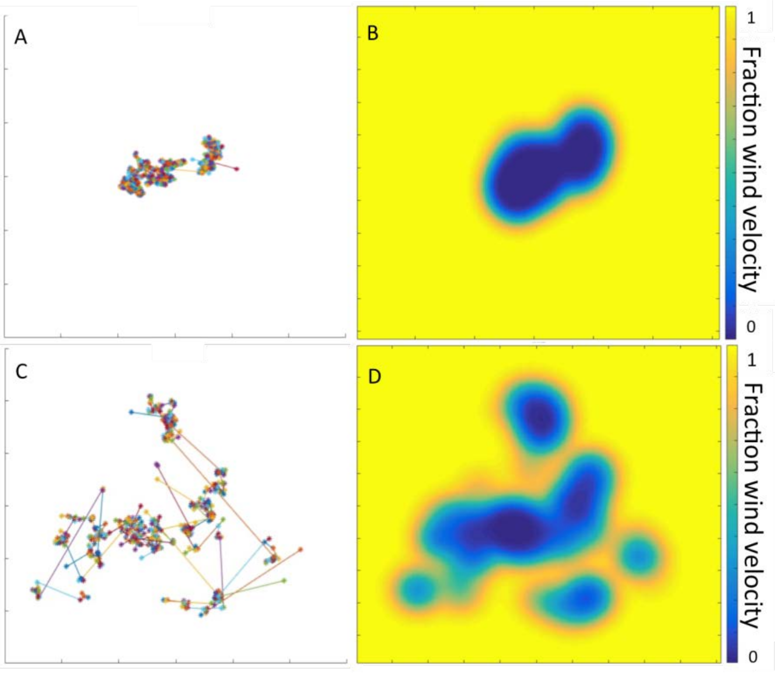

Figure 1: Preliminary model results. **(A)** Model output for simulating a Brownian Walk ($\mu \approx 3$). **(B)** The amount of grid cells in which the wind velocity has been altered due to a Brownian walk (in a 140x140 grid). **(C)** Model output of an Lévy walk ($\mu \approx 2$). **(D)** Impact of a spatial pattern resulted from an Lévy walk on the wind velocity (in a 140x140 grid).

Aeolian Sediment Supply from the Sand Motor Mega Nourishment

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The Sand Motor mega nourishment is intended to enhance growth and resilience of coastal dunes on medium to long time scales by stimulation of natural sediment transport processes. The Sand Motor is intended to nourish the entire Holland coasts over a period of two decades. In addition, the local dune area is anticipated to increase with about 30 ha in the same period. The growth and resilience of coastal dunes largely depends on the presence of a continuous supply of aeolian sediment.

This study gains insight in the spatiotemporal variations in aeolian sediment supply in the Sand Motor domain by using an aeolian sediment budget analysis (Hoonhout and de Vries, 2017) based on four years of bi-monthly topographic measurements of the Sand Motor domain. It is estimated that the Sand Motor is a supply-limited system as aeolian sediment supply accumulates to only 25% of the wind transport capacity. Aeolian sediment supply from the higher beach areas diminished after half a year after construction of the Sand Motor, due to the formation of deflation lag deposits that constitute a beach armor layer. More than 58% of all aeolian sediment deposits originate from the low-lying beaches that are regularly reworked by waves and hence do not develop a beach armor layer. The compartmentalization of the Sand Motor in armored and unarmored surfaces suggests that the construction height is an important design criterion that influences the lifetime and region of influence for any mega nourishment.

The remarkable subaerial topographic development of the Sand Motor is further investigated using the two-dimensional (2DH) aeolian sediment availability and transport model AeoLiS (Hoonhout and de Vries, 2016). The model describes both spatial and temporal variations in aeolian sediment availability and supply induced by the combined influence of sediment sorting, beach armoring and soil moisture content. The influence of spatiotemporal variations in aeolian sediment availability and the model performance are illustrated by a comparison between model results and the sediment budgets analysis to identify and quantify the main sources (intertidal and supratidal beach) and sinks (dunes, dune lake and lagoon) for aeolian sediment in the coastal system (Figure 1).

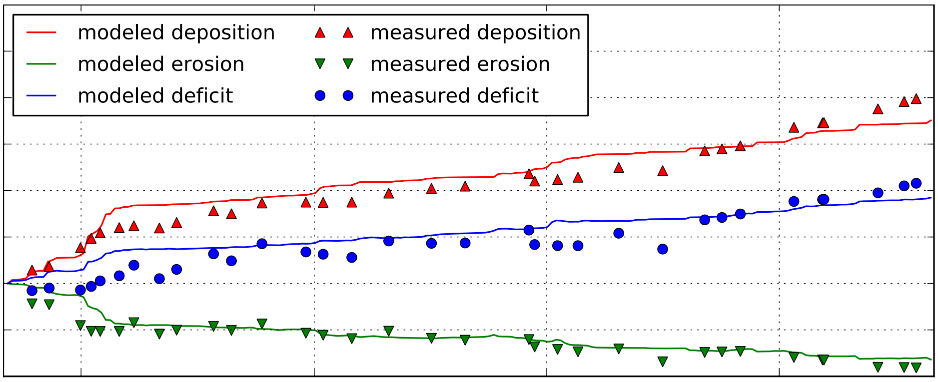

Figure 8 Measured vs. modelled sediment volumes: deposition in dunes, dune lake and lagoon, erosion from the dry beach area and derived erosion (deficit) from low-lying and intertidal beaches.

References

Hoonhout, B. M. and de Vries, S. (2016). A process-based model for aeolian sediment transport and spatiotemporal varying sediment availability. Journal of Geophysical Research: Earth Surface. doi:10.1002/2015JF003692. 2015JF003692.

Hoonhout, B. M. and de Vries, S. (2017). Aeolian sediment supply at a mega nourishment. Coastal Engineering. Submitted.

Bed composition changes at large-scale coastal structures

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Introduction

Heterogeneity in bed sediment composition has been found to be of relevance for various coastal processes (e.g. transport of bi-modal sediment) and marine ecology. The field is, however, still unexplored and a clear view on the impact of large scale coastal interventions is missing. For this reason, extensive monitoring of the bed composition has taken place at large scale 'Sand Motor' nourishment (21 million m^3). These bed composition changes consisted of a 150 μm coarsening of the D_{50} in front of the Sand Motor peninsula and a fining at the adjacent coast. Aim of the current research was to evaluate the relevance of hydrodynamic conditions for the development of heterogeneity in D_{50} at large-scale nourishments and the underlying sorting mechanisms.

Methodology

The current studies applied a Delft3D numerical model with five sediment size fractions and a multi-layer administration of the bed composition to assess the relevance of different hydrodynamic conditions on the spatial and temporal changes in D_{50}. A good representation of the redistribution of non-uniform sediment (i.e. the observed spatial pattern of D_{50}) was obtained independent of the initial condition for the D_{50} of the bed (R^2 of 0.84 to 0.94).

Forcing conditions and mechanisms

The extent and magnitude of the coarsening of the bed in front of the peninsula is related to the velocity of the horizontal tide (Fig. 1a) and also present for moderate wave conditions (Fig. 1b), but far less pronounced during energetic conditions (i.e. H_{m0}>3 m; see Fig. 1c). This relates to a mechanism of preferential transport of fine sand from the Sand Motor to the adjacent coast during moderate conditions, which is due to the locally enhanced bed shear stresses and more frequent suspension of the finer sand fractions in front of the Sand Motor. Storm conditions, on the other hand, induce a partial removal of the coarse top-layer due to mobilization of all of the size fractions and mixing with the relatively fine substrate material. Especially, the enhanced bed shear stresses due to contraction of the tide affect the D_{50} changes at the Sand Motor (e.g. less impact for smaller Sand Motor configuration, Fig. 1d), which means that large-scale D_{50} changes can occur at any large-scale coastal structure (e.g. port breakwater). An investigation of bed composition changes is therefore considered essential for environmental impact assessments of future large-scale coastal structures.

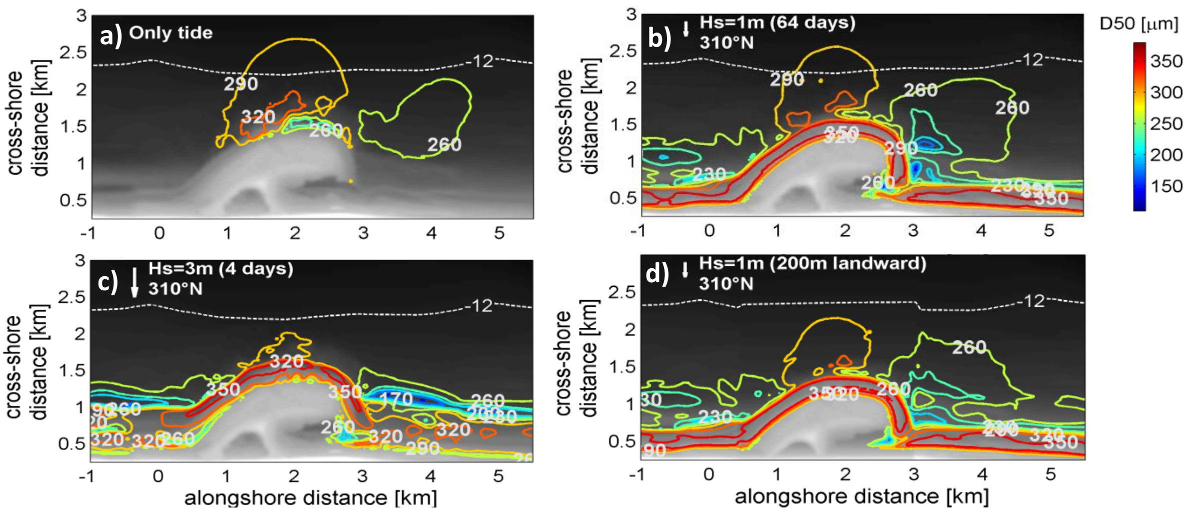

Figure 1: Modelled bed composition (D_{50}) at the Sand Motor for different combinations of tidal and wave forcing conditions (panel a to c) and nourishment configuration (panel d).

Sand wave migration reversal due to severe wind events

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Migrating sand waves may pose risks to subsea pipelines. As a result of migrating sand waves free spans may occur (Németh, Hulscher, & de Vriend, 2002). Free spans may initiate vibrations resulting in pipe fatigue damage (Gao et al., 2006). Therefore, it is vital to understand the behaviour of these sand waves for pipe maintenance. In the present study we investigate an irregular and dynamic sand wave field, indicated in Figure 1, which covers part of the BBL-pipeline. The BBL (installed in 2006) is a 230 km long natural gas pipeline from Balgzand (NETHERLANDS) to Bacton (UK). Since 2008, regular high resolution batymetric surveys along the BBL have been performed, which show sand waves migrating in various spatial directions over the years. This indicates that sand wave migration may be caused by both the regular tide as well as (severe) wind events, making the migration difficult to predict. However, investigating why this variation occurs is relevant in understanding the physical processes. This increased understanding will help us to make a sustainable design for offshore structures such as wind farms and pipelines, which often cross (dynamic) sandwave fields.

We analysed field data to uncover the sand waves dynamics and found that in space, over the years, storms may have a significant effect on sand wave crest migration. This is presented for the three highest sand waves in the field in Figure 2, showing the location of the crests indicating an opposite migration direction (westwards) during the years 2013 and 2015. During these years the wind statistics showed extremer wind conditions, compared to the default migration direction (eastwards).

Next, we apply a validated Delft3D-FLOW model to assess the influence of storm events on the dynamics of the bottom topography. Comparing the model outcomes with found sand wave migration over the years, we conclude whether the meteorological conditions support the reversal of sand wave migration direction.

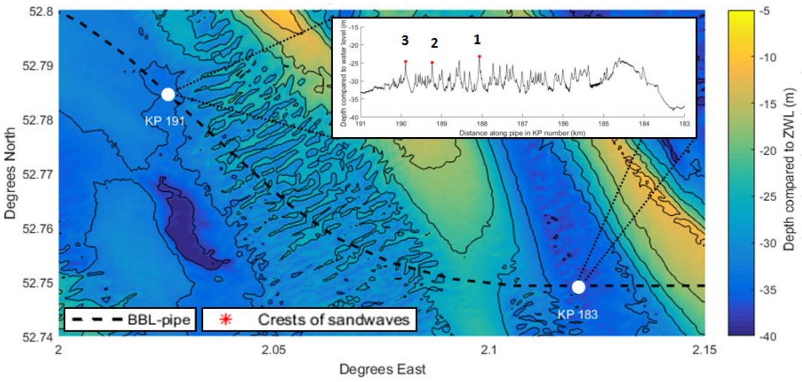

Figure 9: Top view of sand wave. Sand wave crests 1,2 and 3 are indicated.

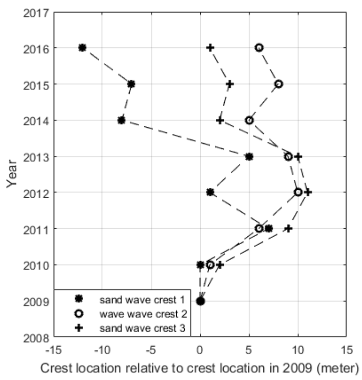

Figure 10: Crest migration of sand waves 1,2 and 3.

References

Gao, F., Yang, B., Wu, Y., & Yan, S. (2006). Steady current induced seabed scour around a vibrating pipeline. *Applied Ocean Research , 28* (5), 291–298.

Németh, A., Hulscher, S., & de Vriend, H. (2002). Modelling sand wave migration in shallow shelf seas. *Continental Shelf Research , 22* (18-19), 2795–2806.

Initial evolution of a large-scale sandy intervention

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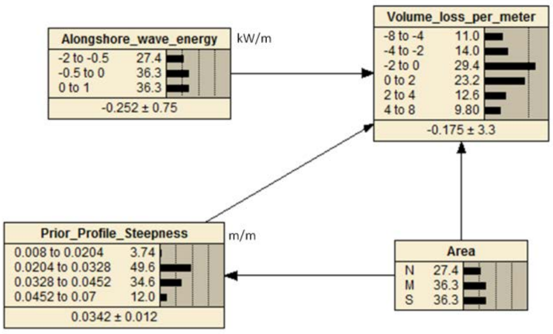
The recent adaptation of the Building with Nature paradigm of using natural dynamics to our benefit challenges our knowledge and prediction capability of the evolution of large scale sandy interventions. The initial dynamics of these nourishments are very high because of a.o. large initial gradients in coastline orientation, sorting of sediments and adaptation of the slope towards equilibrium. Whereas especially these initial dynamics are not yet fully understood.

An example of such a large scale nourishment is the Sandmotor which is extensively monitored and researched. A more recent example is the reinforcement of the Hondsbossche and Pettemer Sea Defence, called the Hondsbossche Dunes (HBD), a mega nourishment of 35 million m3 situated along the Dutch North-Holland coast, see left figure. The first year after installation the HBD was monitored along 11 transects with a monthly interval.

To investigate the governing processes that dominate the initial sub-aqueous development a conventional data analysis was extended with a Bayesian Network (BN). The BN was trained with the observational data and used to reveal correlations between several coastal indicators.

The observation data shows that the steepness of the cross-shore profile is initially high and reduced after a period of high wave energy to values similar to the long-term average. The conventional data analysis shows that there is a weak correlation (r^2=0.3) between wave power and volume loss. In addition, the BN shows that high volume losses are 15% more likely to occur with high waves from the south. Whereas sedimentation is 15% more likely to occur with waves from the north.

The early results suggest that a BN is a useful interpolation tool in data analysis. Findings based on the BN are however highly dependent on the amount of data. The BN could be extended to examine the effects of extreme events, if a large(r) data set is present.



Left an aerial picture of the HBD just after installation. Right: The Bayesian Network with first year of observations.

Marina inlet sedimentation in Blankenberge and beach erosion in Wenduine, Belgium

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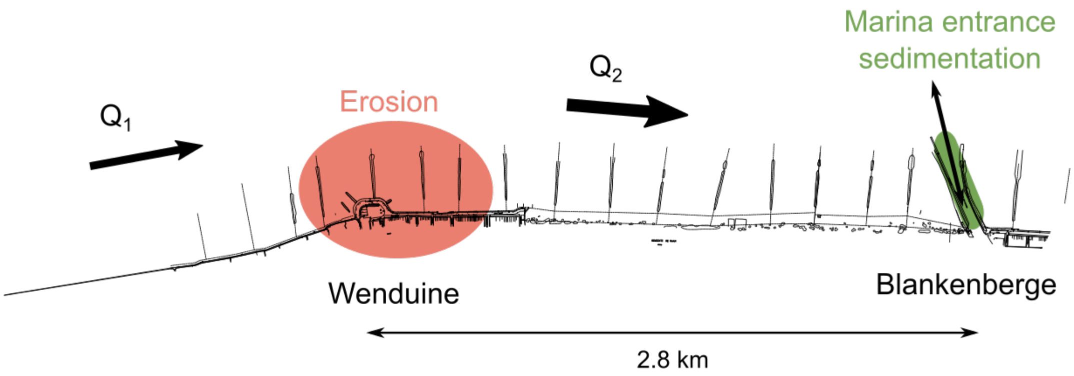
Problem statement

Blankenberge and Wenduine are two neighbouring Belgian coastal towns that are each experiencing specific morphological issues. The access channel to the Blankenberge marina is constrained by two low jetties and experiences sedimentation due to littoral drift. Authorities aim to restrict dredging activities in the access channel to winter months only, and avoid dredging works during the summer tourist season. However, channel sedimentation rates are currently too high and summer dredging is sometimes needed after storm events. Less than three kilometres to the west, Wenduine is located at a breakpoint in coastline orientation and experiences structural erosion. Beach nourishments are regularly performed to mitigate the erosion but typically have a short lifespan.



Schematic overview of the Wenduine-Blankenberge area.

Toward a smart solution

In 2017, a design study will be performed to develop structural solutions for both Blankenberge and Wenduine. The study will compare several different options, including raising and extending the marina jetties and setting up a buffer zone updrift of the Blankenberge inlet, raising or extending groynes between Wenduine and Blankenberge, and performing a (mega-)nourishment. Numerical simulations with XBeach and MIKE21-BW (among others) will be performed in order to find the optimal solution.

Since the Wenduine-Blankenberge case forms a textbook example of coastal morphology and how it affects coastal communities, we will host an interactive poster presentation. First, we will sketch the problem, including the current morphological system functioning and the causes for the problems at hand. We will also highlight the different aspects that are to be considered, such as coastal flooding protection, swimmer safety, nautical accessibility, ecological value, executability, and cost-effectiveness, and describe the currently proposed solutions. Then, we will host an interactive discussion in which all NCK participants, from students to experts, can test their coastal skills by proposing practical solutions and weighing them against existing ideas.

Nature Based Solutions in the North Sea region

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Introduction

Nature-Based solutions also known as Building with Nature (BwN) solutions are implemented to make coasts more resilient to climate change effects, primarily sea level rise. A common type of BwN solutions are beach and/or shoreface nourishments to counteract erosion, stabilize coasts, facilitate other functions and ensure protection to flooding. A preliminary cross country analysis of the design and behaviour of Dutch and Danish shoreface nourishments has been made by Lodder & Sørensen (2015). Lodder & Sørensen conclude that the observed behaviour of the studied nourishments can be partly explained by the local coastal dynamics and the nourishment design.

The observed behavioural differences of nourishments with respect to local coastal dynamics is one of the main themes in a new granted EU Interreg project. This Building with Nature project has been granted by the European Union Interreg VB North Sea Region (NSR) and will last from 2016 up to 2020. The project aims to generate key knowledge needed to make the sandy coasts of the NSR more adaptable and resilient to the effects of climate change. This knowledge is gathered through assessment of the dynamics of nourishments executed by the project partners: the responsible organisations for coastal management in South Sweden, Denmark, Schleswig-Holstein, Lower Saxony, the Netherlands and Flanders.

In this poster we introduce the outline of the project, present current practices in the design and monitoring of nourishments and give first insights in behaviour of nourishments in relation to the local coastal dynamics.

First results

In Table 1, a comparison of current practices of all project partners is shown. All projects partners do have a flood risk reduction goal in coastal management. The underlying policy goals however are deviating as well as the choice to include NBS / BwN solutions. Full compensation of erosional losses is not common. In addition, the choice of which nourishment type will be applied is diverse and partly depends on the observed coastal behaviour. All partners have experience in applying beach nourishments. Shoreface nourishments are not commonly applied yet.

	Flood risk reduction goal	Policy goals (criteria)	Compensate erosion goal	NBS/BwN in policy	Nourishment type (Beach / shoreface)
1. DCA (DK, central North Sea coast)	Yes	$P(f){:}\frac{1}{100}$, exceptional $P(f){:}\frac{1}{1000}$ (Hold the line)	Yes*	Yes	Both
2. LKN.SH (DE)	Yes	(Hold the line)	Partly	Yes	Both
3. NLWKN (DE)	Yes	Protect other functions (Hold the line and dune safety)	No	Yes	Beach
4. RWS (NL)	Yes	1) $P(f){:}\frac{1}{300}$ $up\ to$ $P(f){:}\frac{1}{100.000}$ 2) Protect coastal functions (Hold the line)	Yes	Yes	Both
5. MDK (BE)	Yes	1) $P(f){:}\frac{1}{1000}$ 2) No fatal casualties allowed (Hold the line)	No	Yes	Beach and experimental shoreface
6. LST (SE)	No	Shoreline protection (Building prohibited within range coastal zone)	No	No	Beach and experimental shore face

*Table 1 - Snapshot overview comparison current practices. P(f) indicates the flood risk reduction standard expressed as an annual probability of an extreme event that a flood defence should be able to withstand. * Budget restricted.*

References

Lodder, Q., & Sørensen, P. (2015). Comparing the morphological behaviour of Dutch-Danish shoreface nourishments. *Coastal Management: Changing coast, changing climate, changing mind*, DOI: 10.1680/cm.61149.397.

Interreg North Sea Region Building with Nature

Estuary scale experiments with saltmarsh vegetation

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1. Introduction

Large-scale planform shape and development of estuaries are partly determined by saltmarsh and riparian vegetation. Thus far the biogeomorphological interactions have been studied mainly on marsh scale and rarely on the scale of entire estuaries for lack of suitable models and scale experiments. Here we develop the first-ever analogue models of entire estuaries with mud and eco-engineering species to form mudflats and saltmarshes to investigate large-scale morphological effects.

2. Methods

The Metronome, a tilting flume of 20x3x0.3 m was developed to simulate tidal motions and river flow. By tilting the flume we created realistic sediment mobility through increased bed slopes. Crushed walnut shell was used to simulate mud because it is transported in suspension due to its low density but due to its smaller cohesion it does not entirely fixate the bed as real mud would.

Several plant species were distributed in the upstream river flow to recreate natural vegetation settlement, growth, mortality and eco-engineering effects of hydraulic resistance and apparent sediment cohesion. We used multiple vegetation species to represent different natural vegetation types and environments: *Veronica beccabunga*, *Rumex hydrolapathum*, *Sorghum bicolor*, and the often used *Medicago sativa* (van Dijk et al. 2013).

3. Results

Seeds released at the upstream boundary spread over the estuary and ended up on bars, shoals and the estuary margins. The outer part of the estuary was too hydrodynamically active for vegetation settlement. Vegetation species colonized different parts of the estuary: Veronica beccabunga germinated mainly in the lower intertidal area while Sorghum bicolor emerged only in the drier areas on the highest parts of bars and shoals. Addition of walnut created patterns similar to mudflats on the bars and shoals. Areas with vegetation also captured walnut similar to the enhanced deposition of fines by marshes in nature. Van Dijk et al., 2013 reported successful river experiments with species settling, on which we now build in our experiments with bidirectional flow and multiple species.

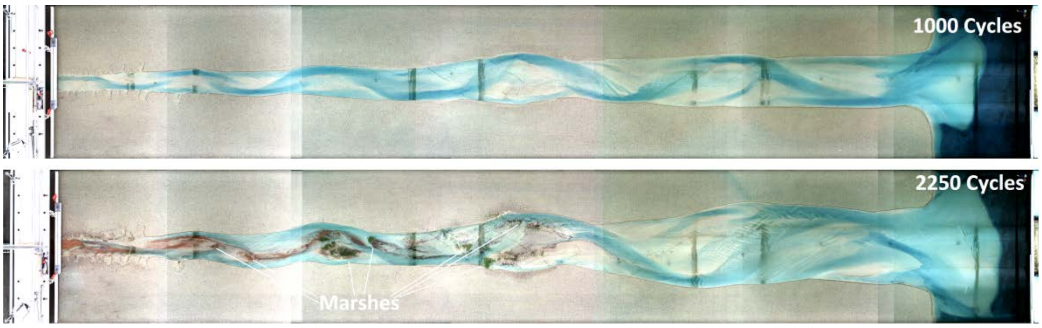

Figure 1. *The estuary after 1000 and 2250 tidal cycles, seeding took place after 1000 cycles*

4. Conclusions

Different vegetation species spread with the water flow offer the possibility to realistically simulate estuary biomorphodynamics. Determining which species represents which habitat in nature will allow us to reproduce patterns and study vegetation effects on the estuary scale.

Acknowledgments

This research is part of the ERC Consolidator grant of Prof. Doc. Maarten Kleinhans.

References

Dijk, W. M., Teske, R., Lageweg, W. I., & Kleinhans, M. G. (2013). Effects of vegetation distribution on experimental river channel dynamics. *Water Resources Research*, *49*(11), 7558-7574.

Bio-geomorphology of the Dutch shoreface: the American razor clam, Ensis directus

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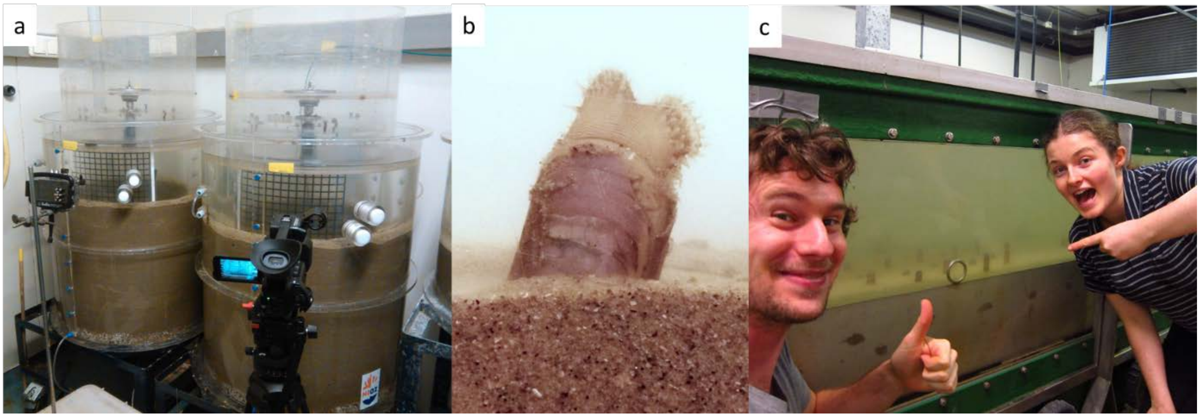
The American razor clam, *Ensis directus*, is by far the most abundant macrozoobenthic organism in the Dutch shoreface, yet we know very little about it. Recent monitoring of the Delftland coast found 85% of the total macrobenthic biomass consisting of *E. directus* (Moons *et al*., in prep.). *E. directus* is a non-indigenous species that was first recorded in 1977 and since then spread rapidly along the Dutch shore. The absurdly high abundance of *E. directus* is very likely to have an effect on its surroundings. *E. directus* inhabits a vertical burrow in the sand and can move up and down easily, therefore it might act as a bioturbator or bioirrigator, promoting the particle exchange between water and soil. On the other hand, it can also act as a biostabilizer: It needs to protrude slightly from the seabed in order to feed, obstructing the water flow and possibly creating skimming flow, similar to tubeworms. Since it is most abundant in the morphologically dynamic shoreface, a stabilizing effect would have the most impact. In this study we experimentally investigated the bio-geomorphological impact of *Ensis directus*.

We conducted 3 experiments: First, we placed living specimens of *E. directus* in a small annular flume and measured their protrusion height, surface time and the turbidity with varying densities and flow velocities. Second, we placed mimics in a big racetrack flume and measured the bed level changes and turbidity with varying densities and protrusion heights. Third, we repeated the second experiment with a high density of living specimens.

Our data nicely illustrate how the protrusion height and density of the *E. directus* can affect water flow and increase local sediment stability when studying mimics. However, the same cannot be said for living specimens. Surprisingly, we observed hardly any changes in the bed level or turbidity. The reason for this was explained by the behavioural observations. Though the specimens protrude most of the time, they limit their protrusion height and thereby minimize flow obstruction. They are very immobile under calm conditions, thus minimizing bioturbation. But, when the flow velocity is increased to the point that sand ripples form, they swiftly move up and down the ripples and keep their protrusion height stable. In conclusion, it seems that *Ensis directus* is neither a biostabilizer nor a bioturbator, but very well adapted to dynamic conditions. Our findings might explain why *Ensis directus* is so incredibly abundant in the dynamic shoreface, where other species have such a difficult time to survive.



The key players in this study: The small annular flumes (a), Ensis directus (b) and the large racetrack flume with Maria and Simeon (c).

Effects of extreme wave and wind events on morphodynamics of estuaries: An idealized model study

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Introduction

Estuaries are often situated in very densely populated areas with high economic activities that often strongly conflict with their ecological values. Understanding of the long-term (order decades to centuries) morphodynamic evolution in estuaries is of great importance to successfully manage these areas, such as maintaining shipping routes and preserving ecosystems. Climate scenarios generally predict an increased storminess in the future, where extreme wave and wind events are expected to occur more often. Little is known about the impact of these events on morphodynamics of estuaries, and particularly, how tidal channels and shoals will respond to these events.

The overall aim of this study is to improve fundamental understanding of how an increased storminess affect estuarine morphodynamics on medium and long time scales. Specifically, first, impact of extreme wave and wind events on the evolution of tidal channels and shoals is examined. Second, sensitivity of model results to intensity of extreme events as well as to their strength and chronology of their occurrence is investigated. The Scheldt estuary is used as a case study (Figure 1).

Methodology

In this study the coupled SWAN-Delft3D numerical model is used, which accounts for both flow, waves and wind. This model has been successfully applied to morphodynamic modeling of estuaries and other coastal systems. A curvilinear grid is created, which extends from Ghent to 30 km seaward (Figure 1). Size of grid cells ranges between 100 m and 300 m in the area of interest (Western Scheldt and its mouth area) and it increases to ~ 2.5 km at the offshore boundaries. Model experiments start from an idealized bathymetry, which is obtained by averaging the measured bedlevel over the width of the domain. As boundary conditions, the model is forced by a tidal wave with three harmonic constituents M2, M4 and M6 at the seaward boundaries (southern, western and northern boundaries in Figure 2).

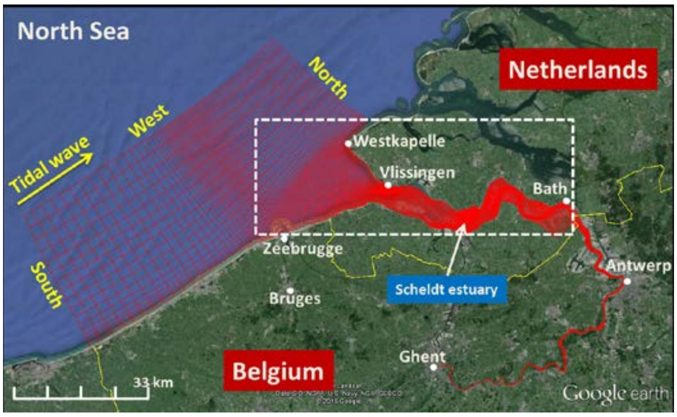

Figure 11 Delft3D computational grid (red), which covers entire Scheldt estuary and part of the North Sea. Focus area of present study (Western Scheldt and its mouth area) is indicated by white rectangle. The white arrow indicates direction of the propagating tidal wave in the North Sea (south-north).

Scale effects on wave-induced sediment mobility in the Metronome tidal facility

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In the recently developed Metronome tidal facility in Utrecht, patterns associated with estuaries can be recreated in a twenty-by-three meter tilting flume. In addition to the tilting mechanism, a wave generator that produces monochromatic waves was installed close to the seaward boundary of the flume. It appeared that wave reworking leads to an overall downdrift migration of the ebb delta and the formation of barrier islands on its terminal lobe. The addition of waves raise questions about scaling difficulties associated with the generated waves and their potential to mobilize sediment. In this research I aim to quantify scale effects and satisfy the requirements for sediment mobility similitude. This was done for a number of coastal profiles by combining results from measured time series with a 1:1 and 1:500 (prototype) scale 2D SWASH (Simulating Waves till Shore) model[1]. It appeared that all the conditions for Froude scaling are easily met while maintaining *Re >> 1000* at all locations, regardless of length scale or geometric distortion (Fig.1a). Wave energy loss in the near-shore is in similitude as expected based on the momentum balance[2]. In addition, scale effects due to surface tension, internal friction and viscous boundary layer friction are negligible at model scale, which followed from both theoretical predictions and modelled results. Since sediment size in the Metronome model is of similar size and density (medium coarse sand) as in nature, the scale ratio of shear stress (n_τ) must equal 1. SWASH model results confirm that it is impossible to maintain flow characteristics through Froude similitude while satisfying the conditions for shear stress similitude. Shear stress in the undistorted Froude up scaled prototype is in the order of 20-40 times larger than in the Metronome. If the coastal profile in the Metronome is regarded as a geometrically distorted representation of reality and a distortion factor of $(n_h/n_l) = 0.75$ is used, shear stress in the prototype can be brought back by about 40%. Further reduction of the distortion factor leads to unrealistic wave shapes and offshore wave energy loss in the prototype. Further scaling could potentially be done by lowering the prototype input wave height or increasing wave period, but at the expense of Froude similitude. In order to find Shields similitude while maintaining flow characteristics, the prototype sediment size must be increased following principles behind traditional scaling laws for sediment size[3],[4]. With $(n_h/n_l) = 0.75$ and using $n_{D50} = (n_h)^{0.55}$ leads to a ~2x overestimation of the prototype Shields parameter (Fig.1b). Further discrepancy between scale model and prototype could be explained by enhanced mobility on the scale model's steep slopes of the ebb delta terminal lobe.

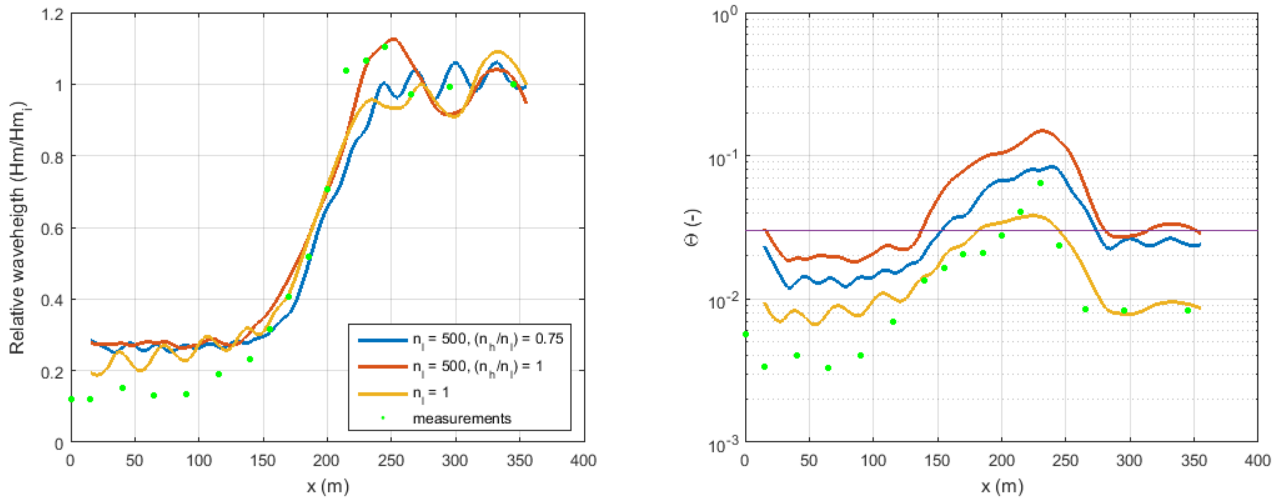

Figure 1. *Example of (a) Relative wave height as a function of cross-shore position and (b) Shields' parameter over an experimental ebb-delta. Horizontal line $\vartheta = 0.03$ indicates the beginning of motion. Wave height loss is in similitude, while Shields stress is overestimated at a length scale of 500.*

[1] Zijlema, M., Stelling, G., & Smit, P. (2011). SWASH: An operational public domain code for simulating wave fields and rapidly varied flows in coastal waters. *Coastal Engineering*, *58*(10), 992-1012. [2] Le Mehaute, B. (1976). Similitude in coastal engineering. *Journal of the waterways, harbors and coastal engineering division*, *102*(3), 317-335. [3] Noda, E. K. (1972). EQUILIBRIUM BEACH PROFILE SCALE-MODEL. *Journal of Waterways, Harbors & Coast Eng Div*, *98*(9367 Proceeding). [4] Van Rijn, L. C., Tonnon, P. K., Sánchez-Arcilla, A., Cáceres, I., & Grüne, J. (2011). Scaling laws for beach and dune erosion processes. *Coastal Engineering*, *58*(7), 623-636.

The Influence of Grain Size on Sediment Transport Pathways at Ameland Inlet

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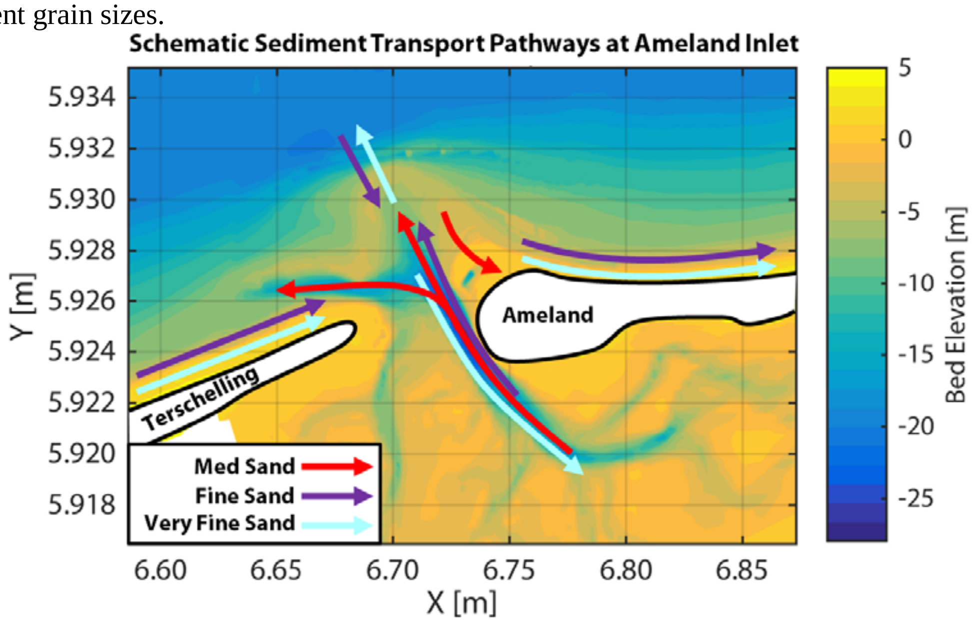
The future safety of islands in the Wadden Sea is closely related to the sediment contained in adjacent ebb-tidal deltas, since the deltas dissipate wave energy in storms and may supply or demand sediment to/from the coast and tidal basins. An acceleration of sea level rise would exacerbate sediment demand from the basins and may require large-scale nourishments to maintain the required level of safety. The SEAWAD and KUSTGENESE2 programs aim to determine if these nourishments are necessary and how to design them. The fate of sediment from a specific source (e.g. nourishments or the ebb-tidal delta) can be determined by mapping potential transport pathways and receptors.

Sediment transport pathways are highly dependent on the grain size, especially in complex environments like ebb-tidal deltas where the interactions between waves and currents are important. Furthermore, the net sediment fluxes that drive long-term morphological change are small compared to the gross fluxes over a single tidal cycle, and may vary between different sediment fractions. As part of this study, we aim to determine sediment transport pathways around Ameland Inlet in order to establish baseline conditions for planning future nourishment strategies and climate change adaptations.

The first goal of this study is to build a robust description of sediment transport pathways at Ameland Inlet using multiple lines of evidence, including grain size trend analysis (Le Roux & Rojas, 2007), field measurements of waves, currents, and bathymetry. We adopt a similar approach to Barnard et al (2013) for describing transport patterns. To supplement the observed measurements, particle tracking and sediment tracer techniques are used in a numerical model (Delft3D) to estimate transport pathways for different grain sizes.



Conceptual diagram of sediment transport pathways based on preliminary Delft3D model results. Arrows indicate direction but not magnitude of transport.

References

Barnard, P. L., et al. (2013), 'Integration of bed characteristics, geochemical tracers, current measurements, and numerical modeling for assessing the provenance of beach sand in the San Francisco Bay Coastal System', *Marine Geology* 345, 181–206.

Le Roux, J. P. and Rojas, E. M. (2007), 'Sediment transport patterns determined from grain size parameters: Overview and state of the art', *Sedimentary Geology* 202(3), 473–488.

Potential impact of the Sand Motor on juvenile plaice (Pleuronectes platessa) and sole (Solea solea) abundance

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1. Introduction

The Sand Motor is the world's first pilot project on mega nourishments and is expected to nourish the Dutch coast for the next 20 years (Stive et al., 2013). This project offers the opportunity to study the potential effects of mega nourishments for juvenile fish that use the shallow coastal sea as a nursery area. Nourishments are likely to alter this nursery function by changing important habitat conditions. The objective of this study is to identify these habitat conditions for juvenile sole and plaice. This could offer an insight in whether the Sand Motor has affected their nursery habitat in the nearby shallow coastal zone. This knowledge will contribute to the development of future nourishment strategies by identifying the key variables for juvenile flatfish abundance in valuable nursery grounds.

2. Methodology

Fish samples were taken on 9 transects perpendicular to the coast with the addition of benthos and sediment samples on 12 transects (Figure 1). The benthos/sediment samples were combined with fish samples based on their proximity. Total biomass of prey species, percentage of medium sand (250 – 500 µm), depth and visibility were related to fish abundance using negative binomial glmm's.

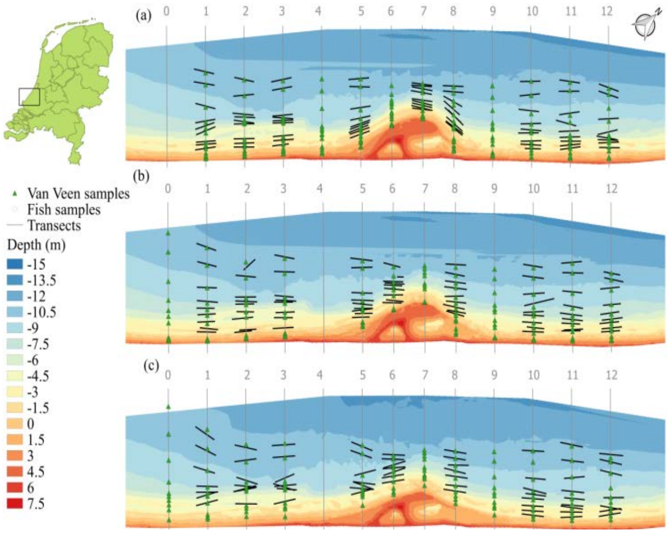

Figure 1. Sample locations for sediment and benthos (triangles) and fish track lines in 2012(a), 2013(b) and 2015(c).

3. Results

After construction, considerable variations in median grain size composition were visible in addition to the development of distinct coarse patches. The biomass of prey did not show a clear relationship to sediment but was significantly related to depth. Prey biomass showed an increase after the construction of the Sand Motor with a small decrease after 4 years. For both plaice and sole, their numbers decreased with an increase in the percentage of medium sand. However, only the presence of juvenile plaice was significantly explained by the percentage of medium sand. Water visibility did not explain fish abundance. Our analysis indicated that prey biomass was a key variable in explaining the abundance for both plaice and sole. The number of juveniles increased when prey biomass increases.

4. Conclusions

The study shows that the response to changes in habitat conditions were species specific. Sediment changes were visible around the Sand Motor but were only related to the presence of juvenile plaice. The biomass of benthic prey species increased overall after the construction of the Sand Motor. Our analysis indicated that for juvenile plaice and sole this will have a positive effect on their presence. The large variety and abundance of prey species can be beneficial for their growth. However, all habitat alterations should be carefully monitored together with possible cumulative effects of repeated nourishments.

Acknowledgments

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

References

Stive et al. (2013). A new alternative to saving our beaches from sea-level rise: The Sand Engine. Journal of Coastal Research 29(5): 1001-1008

Impact of the Sand Motor on alongshore bathymetric variability

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Introduction

Pronounced alongshore variability in nearshore bars, due to the presence of e.g. crescentic bars or rip channels, causes significant alongshore variability in the nearshore wave and flow fields. In turn, this may have an impact on recreational safety, large-scale mixing processes and coastal sediment transport.

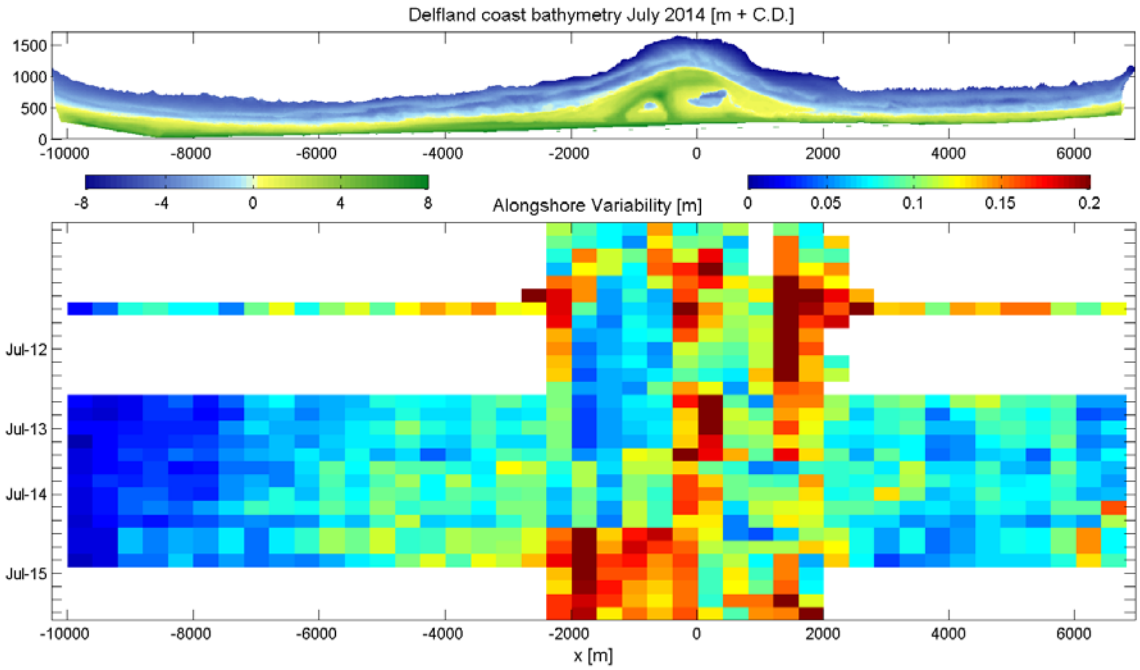
This study examines the impact of the Sand Motor on alongshore bathymetric variability, both at the nourishment itself and along the adjacent coastline. The analysis is based on a unique dataset of 30 consecutive topographic surveys covering the full Delfland coastal cell. Amongst others, this will shed new light on the ongoing discussion whether soft coastal engineering works can influence recreational safety.

Analysis

Alongshore bathymetric variability was computed by assessing the difference between the actual bathymetry and an alongshore averaged bathymetry. To account for the slowly-varying cross-shore beach slope of the Delfland coast, the alongshore averaged bathymetry is not computed over the full coastline length, but based on a running averaged beach profile over an alongshore stretch of 400 m. Subsequently, the alongshore bathymetric variability was averaged over blocks of 400 m in alongshore direction. The result is shown in the figure below.

Discussion

Strong spatio-temporal differences are observed in alongshore bathymetric variability. The Sand Motor is clearly more variable than the adjacent coastline. A more detailed analysis of these trends and their relation with wave forcing is subject of further research.



Spatio-temporal evolution of alongshore bathymetric variability at the Delfland coast.

Coastal Maintenance: Nourishments near Den Helder

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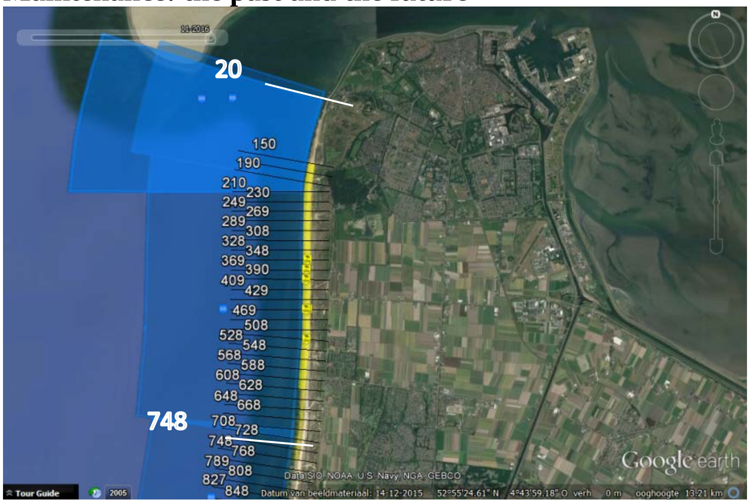
Introduction

This year the NCK days are held near the highly eroding northern part of the coast of North Holland. The Dutch government decided to put a stop to the occurring structural coastal erosion in 1990 by introducing the Dynamic Preservation policy. This policy stated that coastal erosion should be compensated predominantly with sand nourishments. Since 1991 Rijkswaterstaat is maintaining the coast near Den Helder intensively with three types of nourishments; beach, shoreface and channel nourishments. A summary of the maintenance history and insight into the near future are given below.

Maintenance: the past and the future



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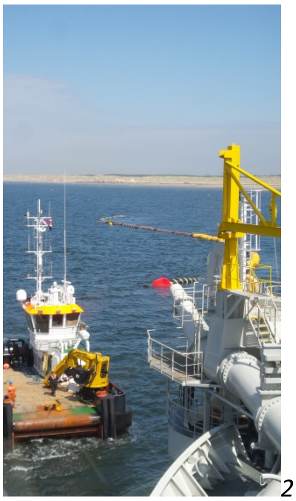
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Figure 1. The coast of the northern part of North Holland with JarKus transects (white numbers) and executed nourishments (yellow: beach, blue: shoreface and channel). Source: Kustviewer (Google Earth).
Figure 2. The Julianadorp beach nourishment (2015). Photo: G. Ramaekers

Since 1990 the area between transect 20 and 748 (Figure 1) has been nourished every 3 to 4 years on average. This was and still is necessary because it is one of the most eroding parts of the Dutch coast due to the vicinity of the Texel inlet system in which the development of the channels and shoals highly influence the development of the adjacent coastline[1]. Large amounts of sand are transported into the Waddensea through this inlet.
The two upcoming nourishments in this area will be 1) a channel nourishment of 3.5 Mm3 between transects 20 and 308 and 2) a shoreface nourishment of 1.8 Mm3 between transects 328 and 708 which will be placed relatively high in the profile (-3.5 m NAP instead of -5 m NAP for regular shoreface nourishments). Both nourishments are planned in 2019/2020. [2]

Lessons (to be) learned

Based on the local morphology and behavior of the previous nourishments we know that a combination of all three of nourishment types will be necessary to maintain this part of the coast in the future. Extra bathymetric monitoring and a final evaluation of the two upcoming nourishments will give us new insights into the feasibility of these approaches for maintaining the coast near Den Helder, given the return periods for nourishing.

References

[1] E. Elias & A. Bruens, Deltares (2012). De beheerbibliotheek Noord Holland (in Dutch).
[2] Rijkswaterstaat (2016). Toelichting op het suppletieprogramma voor de jaren 2016-2019. www.helpdeskwater.nl (in Dutch).

Understanding sediment disposals on the Walsoorden tidal flat in the Western Scheldt

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Introduction

The deepening and expansion of the Western Scheldt navigational channel in 2007-2010 demanded alternative disposal locations. One of these was the seaward tip of the intertidal shoal 'Plaat van Walsoorden' (Figure 1). This tip has been subject to a continuous trend of erosion in the second half of the last century. Disposing the sediment here is aimed to: (1) counteract erosion; (2) increase low-dynamic intertidal area, creating ecologically valuable habitat; and (3) increase the divergence of discharge between the main and secondary channel to strengthen the stability of the multiple channel system.

The morphological behaviour of the sediment disposals is well monitored and detailed measurements show that the disposed sediment migrates predominantly in flood direction, replenishing the intertidal area of the shoal. It is, however, not well understood why the sediment moves in this direction, what the more large-scale hydro- and morphodynamic effects of the disposal are, and what the controlling physical processes are. Such a comprehensive understanding of the morphodynamics of the sediment disposals enables managing authorities to optimise their sediment dumping strategy.

Methods

A high-resolution depth-averaged model (Delft3D) was set-up to simulate the morphological development of the sediment disposals, forced by tide, wind and waves. The hydrodynamics of the model were validated with velocity measurements collected during two campaigns in 2013. A representative morphological period was used to simulate the morphological development of the migration of the disposed sediment.

Results

First modelling results show that the model is well capable of reproducing the morphological development between September 2010 and October 2011, after the first disposal period (Figure 1). The disposal decreases the maximum current velocities locally, in line with the second aim of the sediment disposal.

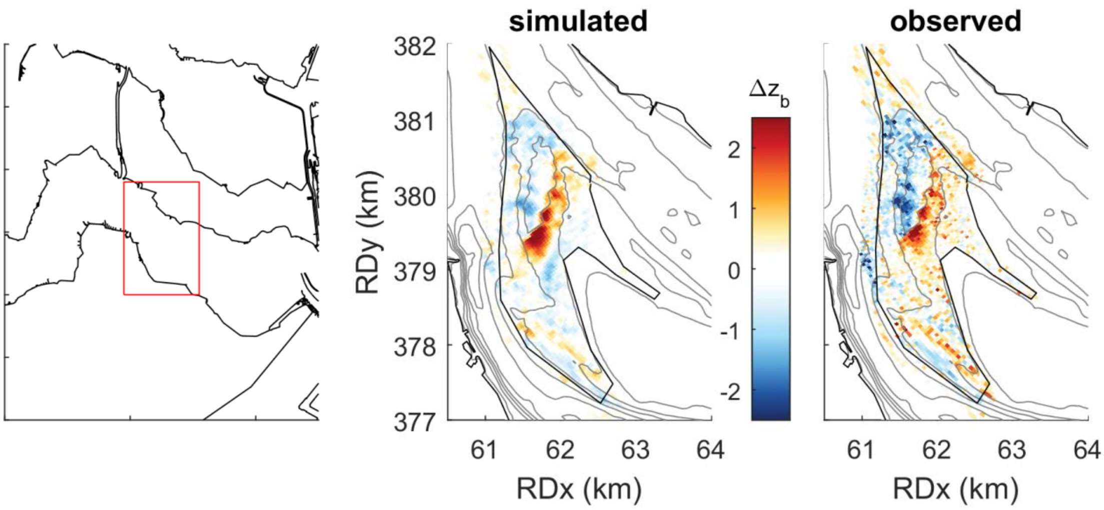

Figure 1: Location of the Walsoorden tidal flat in the Western Scheldt and erosion-sedimentation patterhn in the period September 2010 – October 2011; simulated (left) and observed (right).

Apart from reproducing the historical evolution we focus on identifying the physical (e.g. waves) and anthropogenic (e.g. dredging and dumping) processes that drive the morphological development of the sediment disposal. This new system understanding supports better sediment management in the Western Scheldt.

Slope-induced tidal straining: Analysis of rotational effects

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Slope-induced tidal straining

Tidal straining in estuaries is known to be a main driver of suspended sediment transport. For the generation of this process, a horizontal density gradient is required, typically caused by river discharge. Here we show that a purely vertical density stratification near sloping topography also induces a quasi-horizontal density gradient in cross-slope direction (i.e. up and down the slope). This density gradient, which does not require an external source, leads to similar tidal straining patterns as tidal straining in estuaries, and therefore causes a net sediment transport, mostly directed up the slope.

This process has been investigated with an idealized numerical model in Schulz and Umlauf, 2016. It was found that sediment can be transported over several kilometers during one tidal cycle, and that tidal pumping is the most important driver for this transport.

After observational evidence for the occurrence of slope-induced tidal straining have been found on a continental shelf in the East China Sea (Endoh et al., 2016), this idealized, one-dimensional model was extended to include the effect of Earth rotation.

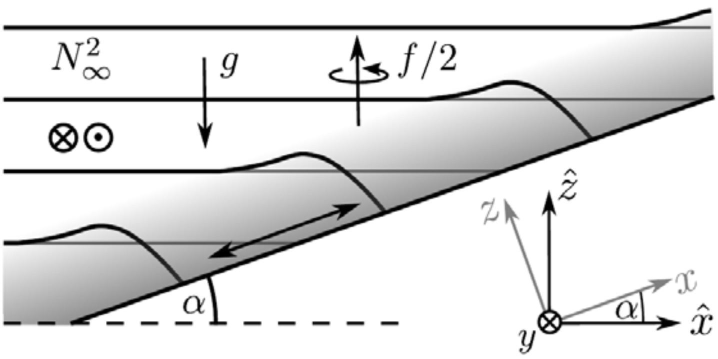

Fig. 1: Schematic view of the model geometry and density structure (black lines) near a uniform slope. Gray lines indicate isopycnal equilibrium levels. Upslope and slope-normal coordinate are denoted by x and z, respectively. Arrows symbolize the oscillating near bottom current.

Rotational effects on sediment transport

Besides reproducing the process of tidal straining visible in the observations, the model was used to investigate the influence of Earth rotation and varying latitude on slope-induced tidal straining, and especially the effects on sediment transport. Three main results are found in this study:

- This very simple model can correctly reproduce the most important features in the observations from the East China Sea, suggesting that slope-induced tidal straining is an important process on the continental shelf.
- Earth rotation induces a significant along-slope sediment transport that can exceed the magnitude of the cross-slope transport.
- SPM transport breaks down at high latitudes, where the tidal ellipse approaches a circular shape.

References

Schulz, K., Umlauf, L. (2016) “Residual transport of suspended material by tidal straining near sloping topography.” Journal of Physical Oceanography (2016).

Endoh, T., et al. (2016) ”Observational evidence for tidal straining over a sloping continental shelf.” Continental Shelf Research 117: 12-19.

Umlauf, L., Smyth, W. D., Moum, J. N. (2015). Energetics of Bottom Ekman Layers during Buoyancy Arrest. Journal of Physical Oceanography, 45(12), 3099-3117.

Umlauf, L., Burchard, H. (2011). Diapycnal transport and mixing efficiency in stratified boundary layers near sloping topography. Journal of Physical Oceanography, 41(2), 329-345.

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An inversion of the estuarine circulation by sluice water discharge

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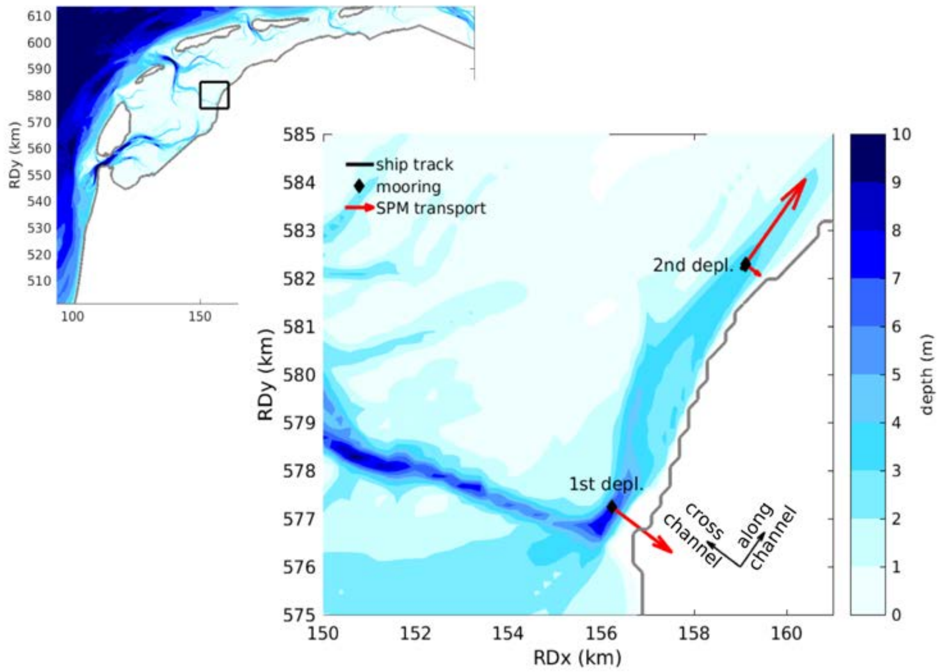

Fig.1: Map of the Dutch Wadden Sea and enlargement of the study area, the Kimstergat channel near the port of Harlingen. Indicated is the vertically and tidally integrated SPM transport in along- and cross-channel direction, calculated from two 13h observations in October 2016.

Classical estuarine circulation
Freshwater flowing into the ocean establishes a density gradient in horizontal direction. This typically leads to alternating density structures in the water column (stable stratification is established during ebb, well-mixed conditions during flood). This alternation can affect the tidal current and may cause a net landinward transport of SPM. This leads to sediment accumulation in habours and therefore an increased demand for dredging.

Inverted estuarine circulation
The study area near the port of Harlingen is directly affected from freshwater discharged through the Afsluitdijk in Kornwerderzand. As the sluice is only opened during low water, the incoming flood pushes a stratified water body into the channel, consisting of dense North Sea water near the bottom and fresh water from the sluice on top. During ebb, well-mixed water from the tidal flats enters the channel. These conditions are exactly opposite to the classical picture of stratification asymmetries in estuaries and could generally occur anywhere in the vicinity of a sluice. They suggest a possible inversion of the circulation with implications on SPM transport. We examined this with measurements of the current velocities, SPM concentration and temperature and salinity profiles during three cruises in the study area, an example of which is indicated in Fig. 1 and 2.

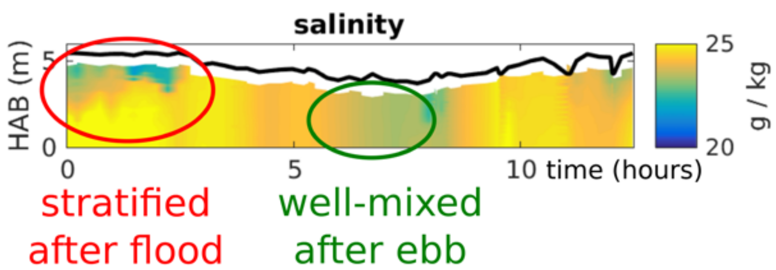

Fig.2: Temporal evolution of salinity over one tidal period during the first deployment indicated in Fig. 1.

Funded by the STW project "Sediment for salt marshes" (#13888)

Effects of ecoengineering species in estuaries

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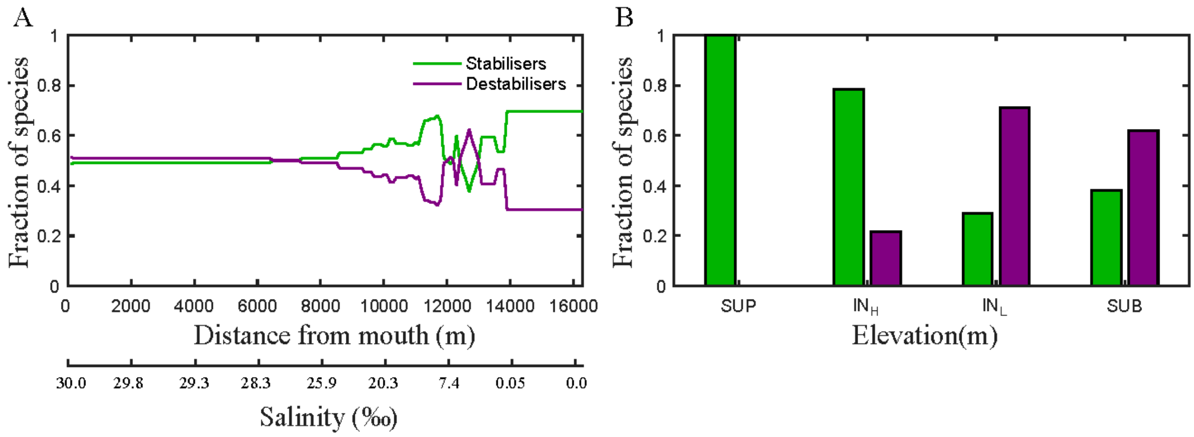
Introduction
Development of estuaries is a result of constant interaction between abiotic and biotic processes. Within these ecosystems there is significant habitat heterogeneity in terms of environmental predictors (e.g. salinity, temperature, depth, substrate and water velocity). These limiting factors are crucial for the distribution of organisms. Further, these organisms can affect the sediment dynamics, and we distinguish stabilising and destabilising species. We want to know if there is a correlation between the distribution of the stabilising and destabilising species and the morphology of estuaries.

Methodology
We collected literature data about salinity, elevation (depth), mud content and water velocity preference for more than 100 species of known ecosystem engineers of Western Scheldt estuary (The Netherlands). The data for minimum, optimum and maximum values for these factors were collected from the literature in combination with data base Encyclopedia of Life (http://eol.com). We used this data together with bathimetry and salinity function (Savenije, 1993) to model distribution of species in the gradient of Dovey estuary (UK) from its mouth to tidal limit with additional 10 meanders upstream (the location of last transect is Dyfi bridge).

Results
Estuaries support equal proportion of stabilising and destabilising species with an increase of stabilising species in the fresh water. Distribution of species in different elevation ranges show higher number of stabilizing species in supratidal and upper intertidal zones compared to higher number of destabilizing species in lower intertidal and subtidal zones.

Discussion
Stabilising and destabilising species are widespread in estuary gradient. However limiting environmental factors (salinity, elevation, mud content and water velocity) affect their distribution and effect on sediment dynamics. Our first results show proportion of stabilizing and destabilizing species in estuary gradient in terms of numbers of species. Next step is to include biomass of the species as well as proportion of elevation zones and quantify the stabilizing and destabilizing effects in different parts of the estuary.



Distribution of stabilising and destabilising species in A) gradient of estuary going from saline estuary mouth to freshwater river, B) different tidal zones (SUP-supratidal, IN_H-upper intertidal, IN_L- lower intertidal, SUB-subtidal).

Observation of storm surge flooding on dune topography in inlets

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Introduction

Dune systems located next to inlets will experience storm surge conditions differently from dunes in open coast settings, as dunes next to inlets will likely be more sheltered from waves, while potentially strong currents may occur in the inlet due to storm surge flooding, causing dunes to erode. Documentation on storm surge erosion of dune topography in inlets is however scarce. This study presents the first results of 6 field surveys carried out on the beach plain of De Hors (Texel, NL). The aim of these surveys is to get insight in the impact of storm surge on dune topography next to inlets in order to adapt a Cellular Automata type dune development model to be applicable near inlets.

Methodology

Topography was surveyed in three pre-selected areas using RTK-DGPS before and after a sequence of storm surge events between May/2015 and January/2017. From these, morphologic and volume changes were derived. The surveys of the January 2017 storm surge events also included placement of six rods with washers over the beach plain to evaluate sediment remobilization depth during the flooding. Measured water levels from nearby tide gauges were used for support information on each specific storm, together with wave and wind data.

Preliminary results and discussion

The monitored period was mild, as just two storm surges reached peak water levels over 2 meter +NAP.

Dune features located east on the beach plain showed slumping on the west side and deposition on the lee side (Figure 1). For the example shown, change in volume was small, with a cumulative loss of approximately 2 m³ of sand after the three last storms. Dune features located west on the beach plain were completely eroded. Although the vegetation resisted, no topographic sign of deposition was found in its surroundings. Expressive bed forms (Height: 15cm, Length: 50-100cm, approximately) developed on the west portion of the beach plain, gradually diminishing their size towards the east, where they disappeared, suggesting a decrease in the flow velocity from west to east (i.e. into the inlet) . The top layer of the beach plain was reworked at all rod locations to at least 20 cm depth.

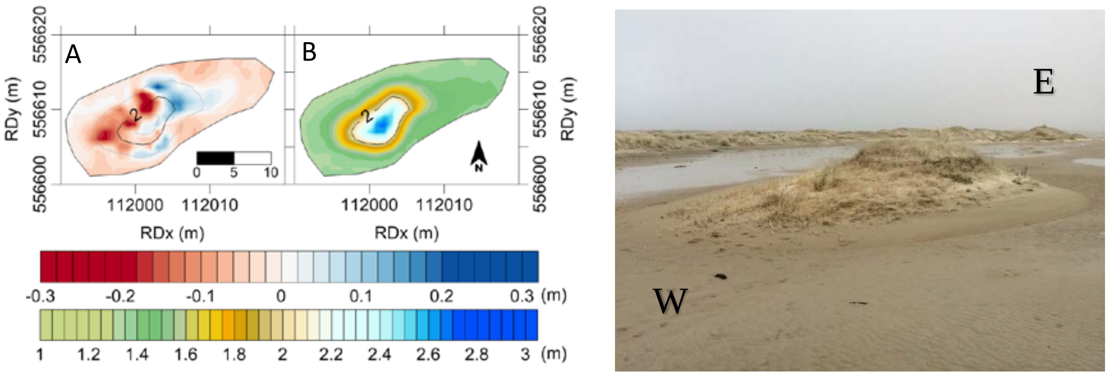

Figure 12: Left: A-Cumulative elevation change of a dune on the east part of the plain over the last three storms. Contours represent the elevation on the last survey (18-01-2017). B- Elevation map of the last survey (18-01-2017). Right: Picture of the dune after the last storm.

Conclusions

Preliminary results suggest that dunes experience different erosion depending on the location: stronger erosion on the west and sediment remobilization around the dune located east, suggesting a decrease on transport capacity. Reworking of the top sediment layer could be important as sediment supply for the dunes after the storm, since buried sediment become available for Aeolian transport. More event oriented data is necessary to drive more conclusions regarding dune erosion behaviour during storm surge events on these systems.

The impact of uncertainties in ice sheet dynamics on sea level allowances at tide gauge locations

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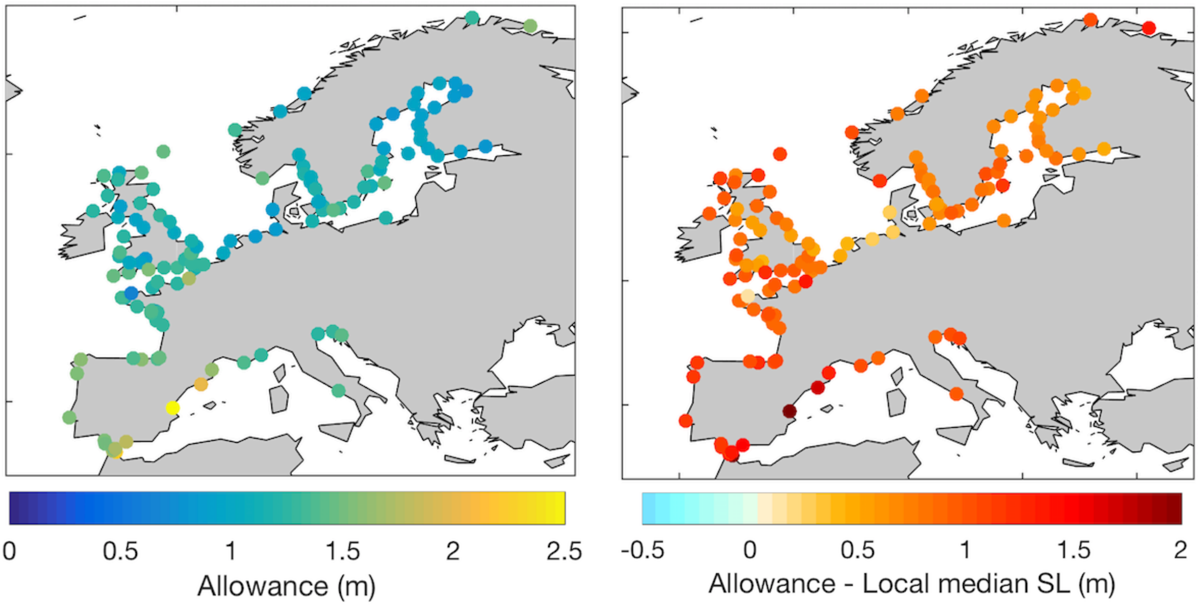
Sea-level is projected to rise in the coming centuries as a result of a changing climate. One of the major uncertainties is the projected contribution of the ice sheets, Greenland and Antarctica, to sea-level change. Here, we study the impact of different types of uncertainty distributions on so-called sea-level allowances. Allowances specify how much a coastal structure will need to be raised in order to keep the same risk of flooding when the mean sea-level rises. Allowances combine information on projected sea-level change with statistics of sea-level extremes at a certain location.

Our results show that allowances increase significantly for uncertainty distributions that are more skewed, due to the probability of much higher contributions from the ice sheets. Allowances are always larger than the median sea-level projected sea-level change (see figure). In a more skewed distribution, the allowances are also larger than the 95th percentile of the projected sea-level change, in contrast to distributions that have a Gaussian distribution, where the allowance is less than the 95th percentile sea-level change. The allowances are largest in regions where a relatively small observed variability in the extremes is paired with relatively large projected sea-level rise, typically around the equator.



(left) Allowances for the European region, based on statistics on extremes at tide gauge locations and projected sea-level changes between 2010 and 2100 with a high-emission scenario (RCP8.5) and a highly skewed ice sheet contribution (De Vries & Van de Wal, 2015); (right) Allowances minus the local median projected sea-level change, to show the additional height needed on top of the projected sea-level rise, to maintain the same flooding risks by 2100.

Morphodynamic optimisation study of the design of semi-permeable dams for rehabilitation of a mangrove-mud coast: A case study of the Building-with-Nature project in Demak, Indonesia

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Introduction
Due to the removal of mangrove forests, the coastal zone of Demak district has suffered from severe erosion. One of the proposed solutions to restore the sediment balance and encourage mangrove re-establishment, is the construction of semi-permeable dams.

Methods
A 2DH site-specific model was set up in Delft3D Flexible Mesh to simulate the large-scale morphodynamics of the area. As Demak coastal zone is a data poor environment, the model validation was largely based on qualitative observations and expert judgement.

System understanding
In order to capture sediment behind the dams, the system mainly depends on locally eroded sediment. Waves dominate the availability of sediment in the area. After waves have stirred up the sediment on the foreshore, the tidal current transports the suspended sediment towards the shore.

Results & discussion
The model results show that the dams successfully attenuate waves and capture sediment. Important design aspects were studied, aiming to formulate more generic guidelines for the design of such structures. New dams were found to have a negative influence on the sedimentation rate behind surrounding dams that are located further landward or sidewards. For comparable mangrove-mud coasts, single coast-parallel dams are expected to capture more sediment than closed off cells. It is recommended to use the model to test new dam configurations and to study other design aspects. More data should be gathered in order to fully validate the model.

Drone image of the project location in the coastal zone of Demak district in Indonesia. The dams on the left attenuate incoming waves, stimulating the deposition of sediment to ultimately encourage mangrove re-establishment.

Aeolian Sediment Flux Measurements at the Belgian Coast: Field Campaigns 2016

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Introduction

Since no accurate quantitative data on the amount of Aeolian sediment flux is available at the Belgian Coast, the impact of Aeolian processes in the overall sediment budget is unknown. Intensive studies on beach and dune erosion led to well-developed erosion models. In the recent years, consequently, there is a growing awareness for better prediction models for the equally important beach and dune accretion by wind. In order to derive quantitative relations between the amount of sand transported and parameters describing the hydro-meteorological state, monthly field campaigns are scheduled. Of the two-year field study planned, five field campaigns were conducted on the artificial beach of Mariakerke-Bad and the natural beach of Koksijde (West-Flanders, Belgium). These were conducted on May 13th 2016, September 29th 2016, November 21st 2016 respectively and on October 19th 2016 and November 24th 2016.

Methods

Depending of the study sites, weather conditions, wind conditions, topography and area of interest, each campaign, with a time span of one day, used a different experimental set-up. Two 3m-high meteorological stations, each with four anemometers, a wind vane and a temperature sensor, provided quantitative data of the wind flow at different locations on the beach. A CR800 Campbell Scientific datalogger recorded the data at 1Hz. The horizontal and vertical variability of the event scale Aeolian sediment transport was analyzed with a horizontal trap, 12 rotatable and 4 fixed MWAC sand traps. Two saltiphones registered the intensity and variations of grain impacts over time. Hourly measurements of the surficial moisture content were done with a ML3 Theta moisture probe. The topography measurements were typically done with laser and GPS techniques. Results of the data will be presented at the conference.

Part of the experimental set-up used on the beach of Mariakerke-Bad, November 21st 2016. As seen in the figure, it consisted of fixed MWAC sand traps, rotatable MWAC sand traps, vertical traps and a horizontal trap.

Acknowledgements

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The effect of the washover geometry on sediment transport during inundation events

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Introduction

Many Wadden Islands contain(ed) washover systems, with openings in the dunes that connect the North Sea to the Wadden Sea during storms (Figure 1a). We hypothesize that the sedimentation behind these openings during storms can on the long term contribute to the vertical accretion of the Wadden Islands. To find design criteria for the possible re-opening of (some of) the washovers, it is important to get more insight in the dominant hydrodynamic processes and the resulting sediment transport and deposition, and how this is influenced by local washover geometries such as the width and height of the washover opening, the width and slope of the beach and the presence of vegetation (Figure 1b). Furthermore, the interaction between two consecutive washover systems is investigated.

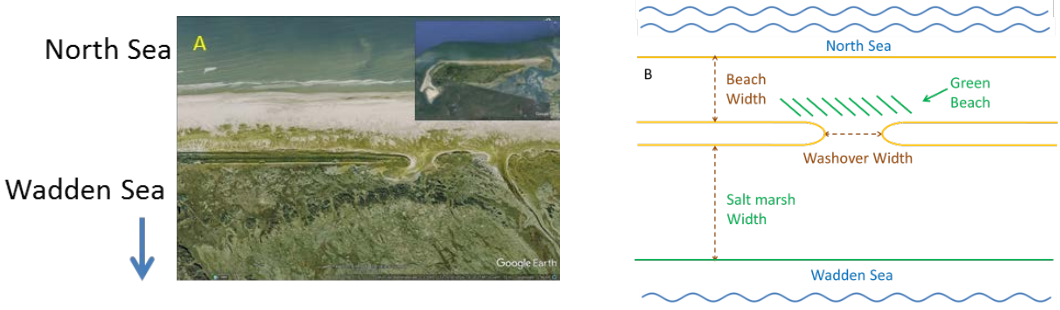

Figure 1. a) The first and second washover opening at Schiermonnikoog (the upper right figure). b) A schematic top-view of a natural Wadden Island, with several parameters that can be modified in the XBeach simulations.

Methods

For this study we use XBeach in area (2D), morphostatic mode. The default model geometry is based on the first washover opening of Schiermonnikoog, with a wide and gently sloping beach and a washover opening width of approximately 200 m. Both constant water levels and tidal curves are applied as boundary condition.

Results

For increasing washover width the flow velocity and sediment transport in the middle of the washover opening first increases, and then decreases. This is also reflected in the width-integrated sediment transport, which increases strongly until roughly 200 m. Wider openings than that contribute relatively less to the total sediment transport through a washover opening (Figure 2). Furthermore, the total transport strongly depends on the washover height: Lower washover berms lead to more transport during storms. The slope and width of the beach appear to have less influence. These and other results will be shown in more detail during the NCK days .

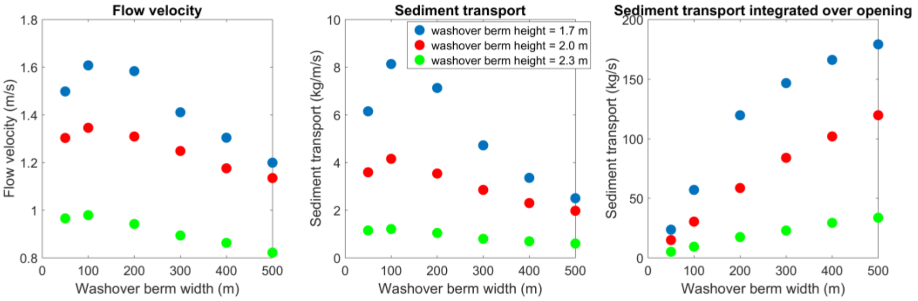

Figure 2. Flow velocity and sediment transport (per meter and through the whole opening) for several simulations that vary in washover opening width and height.

ShoreScape: sustainable co-evolution of the natural and built environment along sandy shores

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Introduction

The land-sea interface is a very attractive location for humans to settle. In the case of low lying, sedimentary coastlines this can be a risky location, as these shorelines are inherently dynamic in nature. Accelerating rates of relative sea level rise will increase coastal erosion, creating world-wide growing demands for coastal protection along urbanized shores. Starting point of this project is that the key to *sustainably* adapt to this situation is to be found in smart, pro-active sediment management using 'building-with-nature' (BwN) approaches, rather than in traditional reactive approaches involving expansion of static, hard coastal defense structures.

The ShoreScape project (2017-2022)

An element that has been overlooked so far in current BwN approaches, is the interaction with the built environment at the land-sea interface, creating new conditions for both sediment dynamics and settlement. Leaving this interaction unnoticed, these elements may be affecting each other adversely. A better understanding of their interaction offers the potential to create new 'coastal buffer zones' combining flood defense, urban development, and spatial quality (Figure 1).
The ShoreScape project (starting in 2017) aims to develop knowledge, tools and design principles for dynamic occupation of the land-sea interface, to enhance Building with Nature processes and exploit its potential for the spatial development of multi-functional coastal environments – *shorescapes*.
The sandy, dune-aligned west coast of the Netherlands is employed as a Living Lab to study interaction of sediment flows and building configurations in the beach-dune environment, both experimentally and through modelling (subproject A at University of Twente), and to develop design principles for dynamic occupation of the land-sea interface that support these natural dynamics (subproject B at TU Delft).

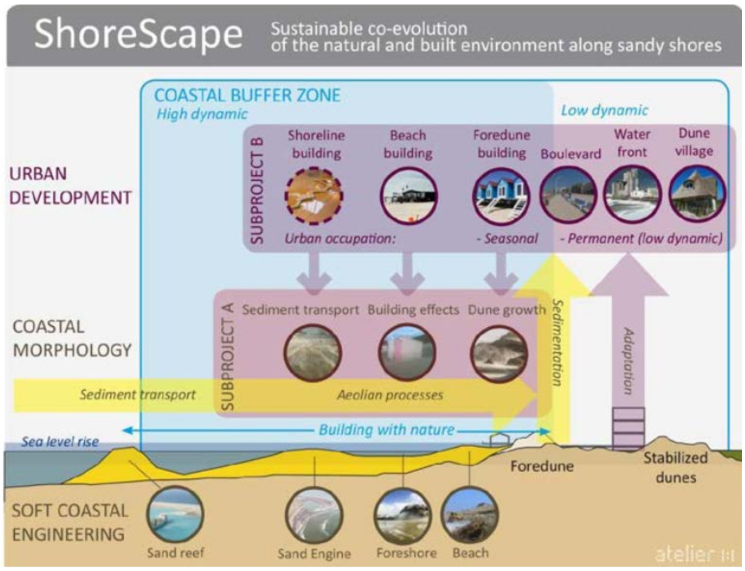

Figure 1: Illustration of the ShoreScape concept.

Project partners

Besides University of Twente (project co-ordinator K.M. Wijnberg) and TU Delft, project partners, are Deltares, Wageningen Marine Research, Hoogheemraadschap Hollands Noorderkwartier, Rijkswaterstaat, Witteveen&Bos, and H+N+S Landscape Architects.

Visualization and measurements of flow around scaled beach houses

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Introduction. Coastal dunes are crucial elements of the flood defense system of the Netherlands. Windblown sand transport plays a key role in their morphodynamics. Currently, arrays of beach houses are arising in front of the dunes act as obstacles in the flow field. It is not well understood how this affects the evolution of the dunes. As beach houses are bluff bodies (the opposite of streamlined bodies) the air flow around them is characterized by complex flow structures, such as vortices, which arise due to flow separation. In order to understand the effects of the beach houses on the evolution of the dunes it is necessary to first study the related flow topology. In this contribution we present our first steps in studying this topic.

Qualitative flow visualization in exploratory field experiments. In 2015, exploratory experiments were performed on the beach of Terschelling as part of the Oerol event (an annually recurring festival combining arts, nature, and science). Our four week experiments aimed at visualizing the air- and sediment flow around arrays of (scaled) beach houses, as illustrated in Figure 1 (top and middle panel).

Quantitative flow visualization technique for wind tunnel experiments. In 2016, an MSc project on quantitative air flow visualization around scaled beach houses was conducted in the EFD wind tunnel (Fig.1, bottom panel). As a first step we needed to develop a quantitative flow visualization setup using relatively simple devices to study flow topology around scaled beach houses.
A high speed imaging system using 2 moderate speed cameras and a special purpose control system was developed. The high speed imaging system is capable of capturing image pairs with a time interval between 1.5-80μs and illumination times can be varied between 800ns-80μs. Therefore it can be used for a wide velocity range. Also, the suitability was investigated of using smoke as a tracer particle for visualizing the flow field. The smoke was illuminated by a laser sheet. It was found that in a configuration where two cameras are used, smoke was not a suitable tracer particle. Some smoke outside the laser sheet was illuminated by stray light. As the two cameras view the scene from a different angle, both cameras see a different portion of the smoke outside the light sheet. This induced artefacts in the data that could not be removed. This problem does not exist for a single camera set-up. Hence an alternative single digital camera procedure has been suggested using a combination of red and blue laser sheets and a double exposed recording. This recording can then be separated into an image pair using the properties of the Bayer filter that arranges the color filter on the grid of photo sensors on the CCD or CMOS.

Figure 1: Impression of flow visualization experiments around scaled beach house on Terschelling beach and in the wind tunnel of the department of Engineering Fluid

Future work. The exploratory work presented here has provided useful input and inspiration to develop the ShoreScape project on sustainable co-evolution of the natural and built environment along sandy shores, starting this spring/summer. (See NCKdays-2017 abstract on the ShoreScape project).

Detection of aeolian streamers in video images

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Introduction

The growth of dunes requires the supply of sediment from the subaerial beach by wind-driven processes. Though recent approaches in coastal management try to utilize these processes to ensure that the dunes offer the desired level of coastal protection, the controls regulating longer-term sediment supply remain poorly constrained. In part this is due to the lack of datasets which permit studies at these timescales. To this end, video images provide a useful tool. Large-scale transport events are often characterized by the presence elongate regions of intense transport which are orientated parallel to the mean wind direction and are visually identifiable in images. Studies suggest that a few large-scale transport events may be responsible for the majority of the sediment supply towards the dunes at monthly to annual timescales (Delgado-Fernandez & Davidson-Arnott, 2010). Consequently, the identification of these features, which are termed streamers, may be pertinent in the evaluation of longer-term transport rates. The identification of streamers in video images remains a largely manual task, making the development of long-term datasets a time consuming task. Thus, the aim of the current research is to develop a (semi-) automated procedure in support of the identification of streamers in video images.

Methods and Results

The current procedure considers a series of points in an image corresponding to positions on the subaerial beach, within a given radial distance from the camera. Pixels surrounding each point are extracted and spectral analysis is conducted. A preferred orientation is estimated from the resulting spectra. Fig. 1 presents the results of one such analysis. Red/green dots denote positions where the orientation of the determined features are less/greater than 10º from the 10 minute averaged wind direction. Lines passing through the respective points illustrate the orientation of the features. The technique shows promise and appears to be particularly successful in estimating streamer orientation in the regions where they are most visually distinguishable. Further work is needed both to refine the technique and evaluate its the robustness and accuracy.

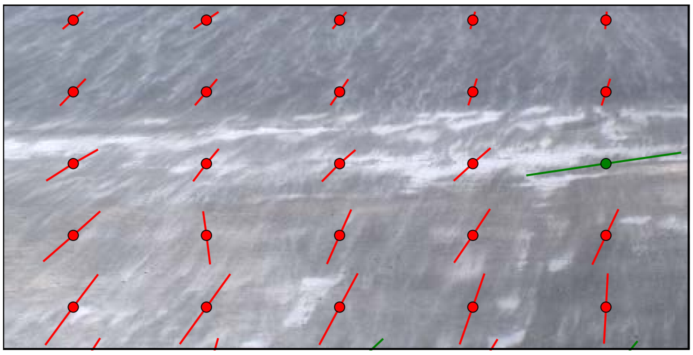

Fig. 1: An image exhibiting visible wind-driven sediment transport. Dots denote points in the image around which the orientation of features are estimated. The corresponding lines illustrate the estimated orientations. Red/green indicate orientations that are less/greater than 10º from the 10 minute averaged wind direction.

References

Delgado-Fernandez, I. and Davidson-Arnott, R. (2010). Mesoscale aeolian sediment input to coastal dunes: The nature of aeolian transport events. Geomorphology, 126(1):217-232

Notes

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. Founded in 1992, the NCK was established with the objectives: to increase the quality and continuity of the coastal research in the Netherlands; to enhance the exchange of knowledge to the applied research community; to reinforce coastal research and education capacities at Dutch universities and to strengthen the position of Dutch coastal research in a United Europe and beyond.

The NCK covers the following research themes: Seabed and Shelf; Beach Barrier Coasts; Tidal Inlets and Estuaries; Sand and Mud; Hydrodynamics; Biogeomorphology and Coastal Zone Management.

Several times a year, the NCK organises workshops and/or seminars, aimed at promoting cooperation and mutual exchange of knowledge. NCK is open to researchers from abroad and exchanges of young researchers are encouraged. Among the active participants we often find people from a lot of different institutes and companies. NCK Activities help establish strong relationships between research and management groups of NCK partners. The interaction between key-specialists from different backgrounds facilitates a multi-disciplinary approach towards coastal problems and improves the match between specialist knowledge and end-user interest.

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