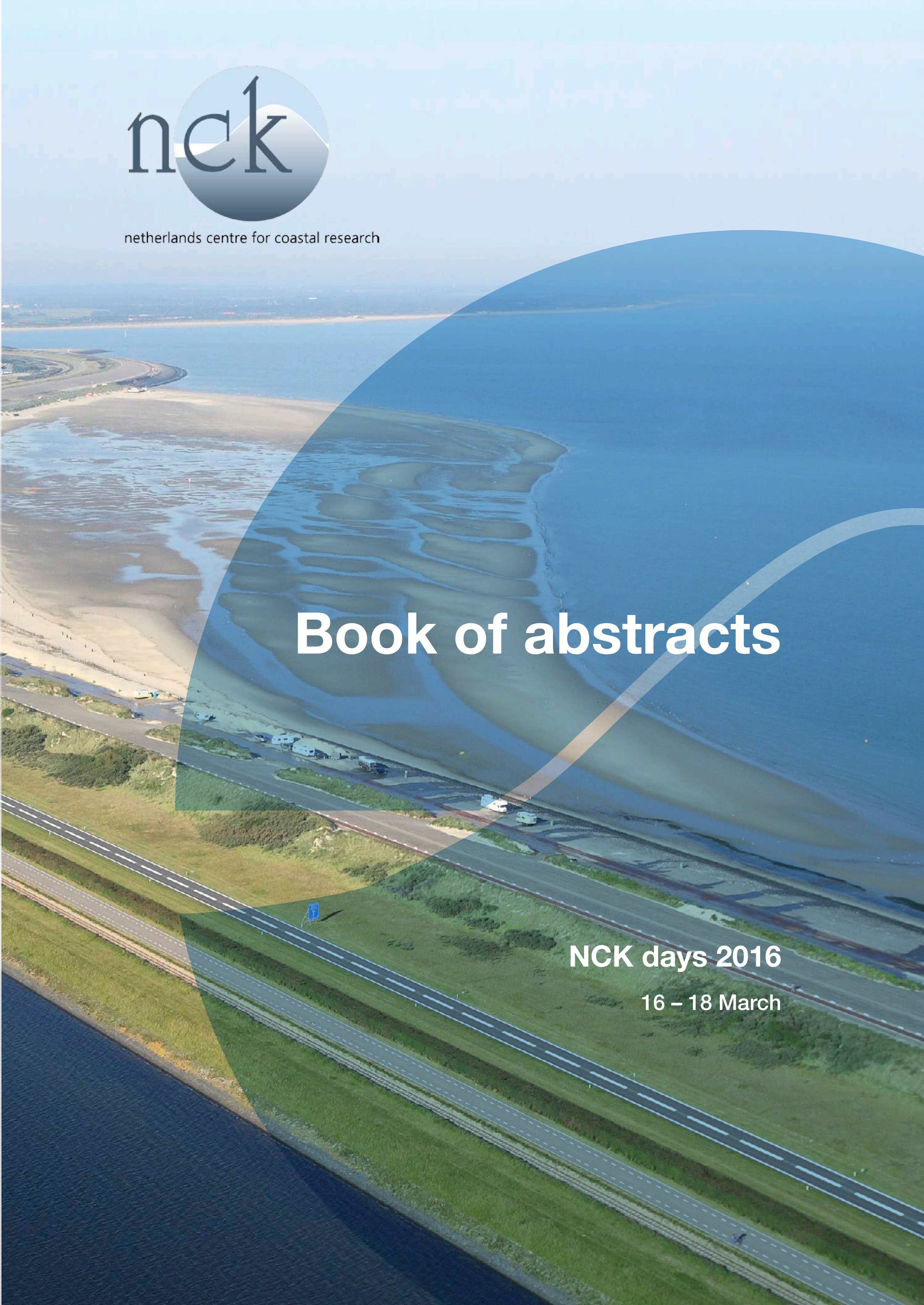
nck

netherlands centre for coastal research



Book of abstracts

NCK days 2016

16 – 18 March

Book of abstracts NCK days 2016

netherlands centre for coastal research

Book of abstracts

NCK days 2016

16 – 18 March

Inspiration Centre Grevelingen, Ouddorp

Sponsored by:

Netherlands Organisation for Scientific Research

Organised by:

Deltares
Enabling Delta Life

Preface

Dear NCK colleagues and guests,

Welcome to the NCK days 2016!

This year Deltares is organizing the symposium. We have been looking for an alternative venue since we have been convening in Delft a number of times before. After considering several options, and taking into account the ‘boundary conditions’ (“brilliant place but too expensive”; “convenient but boring”), we have chosen the Inspiration Center on the Brouwersdam. This place opened up in May 2015 and sits on the most southern end of the province of Zuid-Holland (yes, this is not Zeeland, that starts a 100 m further!). Situated on the Kabbelaarsbank, a shoal in the now closed-off Grevelingen estuary, it recalls the magnificence of a once powerful but now tamed natural system. When you climb the 126 stairs of the watchtower you will be 26 m above ground level and, weather permitting, you can have a splendid view over the ebb-tidal delta of the estuary. Since its closure in 1971, this area saw significant changes. The tidal channels rapidly filled in with predominantly mud, an extensive sand bar (the so-called Bollen van de Ooster) was formed on the seaward edge and over the years the ebb-tidal delta shrunk in size. An interesting detail is that the western part of Kabbelaarsbank, which was extending on the seaward side of the dam, has been completely eroded by waves. The sand was transported towards the dam where it formed a wide beach and the wind has been blowing part of the sand onto the dam, forming a real dune complex. As such, this part of Kabbelaarsbank worked as sand motor avant la lettre. Lately, the beach is eroding as well and had to be nourished. You can have a look at these dunes when visiting the ice breaker which will be organized on the seaward side of the dam, or you can walk there during one of the breaks.

Returning to the watchtower, looking east you will be overlooking the present Lake Grevelingen and get an impression of the extent of the former estuary. Our key-note speaker will further introduce this system to us.

All in all, we hope that this edition of the NCK days will live up to the reputation of being a meeting with interesting presentations, lively discussions, ample networking opportunities to bring back memories of former co-operation or start new ones, a worthwhile excursion and, most of all, a wonderful atmosphere!

We enjoyed preparing the meeting very much, we learned a lot doing so (okay, so most conferences have poster boards in landscape format; we will always remember that), we want to thank everyone who helped us getting things done and NWO for their sponsoring and we do hope that you will enjoy this edition of the NCK days.

Julia Vroom
Bas van Maren
Ad van der Spek

Delft, March 2016

Organisation

Netherlands Centre for Coastal Research
P.O. Box 177
2600 MH Delft
Boussinesqweg 1
2629 HV Delft
Tel +31 6 1560 9774
secretary@nck-web.org
www.nck-web.org

Programme NCK days 2016

Wednesday 16 March

16.00u Sprint session Open Earth

20.00u Icebreaker at Beach Pavilion Brouw

Thursday 17 March

08.30h Registration

09.00h Opening

09.10h **Keynote**: Paul Paulus - Programme Volkerak-Zoommeer

09.45h **Session 1: Building with Nature chaired by Bas Borsje**

Maria Barciela Rial	*The MarkerWadden: the influence of the sand fraction on the ripening behaviour of Markermeer sediment*
Astrid Kramer	*Building with Nature in practice: Brouwerseiland*

10.15h Poster pitches

10.30h Coffee/tea break

11.00h **Session 2: Aeolian transport chaired by Gerben Ruessink**

Marinka van Puijenbroek	*Embryo dune development is influenced by beach morphology and climatic factors*
Sytze van Heteren	*Two thousand years of eolian activity near the old Rhine estuary preceding and following its abandonment*
Winnie de Winter	*Measuring Aeolian Saltation Intensity On High Spatiotemporal Scales Using A Home-Built Saltation Detection System (Saldecs)*
Sierd de Vries	*An application of a new Aeolian sediment transport model at the sand motor*

12.00h Lunch

13.30h **Session 3: (Sand) Waves and storms chaired by Henk Steetzel**

John Damen	*Analysis of variation in sand waves superimposed on sand banks*
Floris de Wit	*Tide-Induced Currents In A Phase Resolving Wave Model*
Angels Fernandez Mora	*SINBAD project: modelling wave breaking effects on sediment transport*
Hao Wang	*Coupling area model to coastline and profile models: nice prospects for fast and long term computations*
Jasper Donker	*Dune recovery and development in the aftermath of the Sinterklaasstorm*
Jelmer Veenstra	*Operational storm early warning system in Morphan*

15.00h **Excursion**

Wear sturdy boots and protection against potential showers; the beach is very exposed!

18.15h Drinks & dinner

Friday 18 March

08.30h	Registration	
09.00h	**Session 4: Human impacts chaired by Thijs van Kessel**	
	Petra Dankers	*Effect of dredging on fine sediment dispersion along Dutch coastline*
	Lodewijk de Vet	*Human impact on intertidal flats in the Eastern and Western Scheldt*
	Yorick Broekema	*Observations of Flow and Turbulence at the Eastern Scheldt Storm Surge Barrier*
	Lynyrd de Wit	*Determination of backfill for sand placement near a trench*
10.00h	Poster pitches	
10.15h	Coffee/tea break	
10.45h	**Session 5: Innovative observational techniques chaired by Bram van Prooijen**	
	Janine Nauw	*Tidal energy extraction in the Marsdiep inlet: BlueTEC: world's 1st floating Tidal Energy Converter*
	Roeland de Zeeuw	*The future in coastal engineering is now: drone with LiDAR*
	Els Knaeps	*Water Quality Monitoring Using New Sentinel Satellite Data*
	Josh Friedman	*X-band radar derived high resolution bathymetry and hydrodynamics*
	Yvonne Smit	*Quantification of spatial variability in surface moisture on a sandy beach by using an infrared terrestrial laser scanner*
12.00h	Lunch	
13.30h	**Session 6: estuaries chaired by Mick van der Wegen**	
	Evelien Brand	*The driving mechanisms behind morphological changes in the Western Scheldt mouth area over the past two centuries – a data analysis*
	Jasper Leuven	*Bar dimensions and shapes in estuaries*
	H. Elmilady	*3D sediment dynamics in an estuarine strait*
	V. Marco Gatto	*Tide-Induced and Lag-Driven Sediment Transport In The Wadden Sea: Towards a Fully Eulerian Perspective*
	Maarten Kleinhans	*Turning the tide: effects of river inflow and tidal amplitude on sandy estuaries in the Metronome tidal laboratory facility*
14.45h	Coffee/tea break	
15.15h	**Session 7: Ecology chaired by Martin Baptist**	
	Barend van Maanen	*Modelling the effects of sea level rise on tidal channel networks and mangrove habitat evolution*
	Tisja Daggers	*A model to assess intertidal microphytobenthic primary production at the macro scale using satellite imagery*
	Sophie van Zanten	*Ecosystem service dynamics of the sand engine*
	Simeon Moons	*Shaping the coast(al community)*
16.15h	Closure	
	Best presentation and poster award	

Field excursion to the west coast of the Island of Schouwen

Photo by Bert van der Valk

Schedule:
15.00h Departure of busses from conference site
15.30h Arrival at Westenschouwen
15.30h-16.00h Walk along the beach
16.00h-17.00h Explanation at the sites
17.00h-17.45h Return walk along the beach
17.45h Departure of the buses back to conference site/hotel

Guides: Bert van der Valk (Deltares) and Frans Beekman (The Hague)

The west coast of Schouwen island is the scene of regular coastal sand nourishments along the landward side of a channel and on the beach (once in every four years). The intention is to skip one of these nourishments (in 2016) and use the sand elsewhere (Brouwersdam). Morphological effects of skipping this particular nourishment were reported (Deltares, 2013). Current conditions will be studied in the field during the excursion.

The site is also a show-case pilot for Dynamic Coastal Management (DCM; 'Dynamisch Kustbeheer'). Some 10 years ago, DCM started. One of the immediate consequences was that the Water Board stopped planting Marram grass and stopped fixing the blow outs in the coastal dunes. It took approximately 8 years before the coastal dune started to be active, i.e. accumulating blown sand at the back side of the coastal dune made available by erosion on the front side of the coastal dune. The activated coastal dune in this coastal area is one of the best known Dutch examples of increase of natural conditions at zero loss of safety levels.

Plans for large-scale rejuvenation of the dune landscape including coastal dune and more landward located dune systems were assessed in their potential. Two artificial excavations ('kerven') will be turning into 'wind gaps' for the transport of beach sand into the dune area, beyond the coastal dune. A large area will be at least partially stripped of existing vegetation in order to enable the dune sand to be mobile again. The Province of Zeeland is in charge of this project, while the area manager Staatsbosbeheer will be the chief executing agency.

List of Posters

M.P. Boersema	*Morphological development of the Perkpolder basin*
D. Boot	*Understanding the effect of permeable brushwood dams on the hydro- and sediment dynamics on a tropical mangrove mudflat*
L. Braat	*Effects of mud supply on large-scale estuarine morphology*
J. Brinkkemper	*San suspension by sea-swell waves in the shoaling and surf zone*
G.H.P. Campmans	*The influence of storms on sand wave dynamics: morphodynamics modeling using a linear stability approach*
I. Colosimo	*Sediment for Saltmarshes: Physical Aspects of a Mud Motor*
G. Dam	*Long-term sand-mud modeling of the Scheldt estuary*
L. Duarte Campos	*Laser particle counter validation for sand transport measurements using high speed camera*
A.V. de Groot	*Richel: the birth of an island*
T. de Haas	*Long-term planform evolution of estuaries and tidal basins: lessons from the Holocene evolution of the Dutch coast*
P.M. Hage	*Determining characteristics of sand strips on a narrow beach by using video monitoring*
M. Hayden-Hughes	*The dark knight rises, can the invasive bivalve Ensis directus save our coasts?*
S. van Heteren	*Response of wave-dominated and mixed-energy barriers to storms*
B. Hoonhout	*Aeolis: a new model for Aeolian sediment supply and transport*
B.J.A. Huisman	*Sediment sorting at the Sand Motor*
A.P. Iwantoro	*Morphodynamics of estuarine channel networks*
M. de Jong	*The ecological effects and potential of deep sand extraction on the Dutch continental shelf using ecosystem-based design*
M. Kroon	*Design of modelling sequence for the assessment of ecological value of artificial reefs in the near shore environment*
Q. Lodder	*Towards a new way of calculating the Dutch annual nourishment volume*
D.R. Mastbergen	*Flow Slide on the Tidal Flat of Walsoorden in the Western Scheldt*
J.J. Nauw	*Observations of Hydrodynamics and Suspended Sediment Dynamics in the Kimstergat near Harlingen*
J.J. Nauw	*Impact of interannual variability in hydrodynamic conditions on spawning ground-nursery ground connectivity in North Sea plaice Pleuronectes Platessa*
A. Nnafie	*Reproducing the morphology of the Scheldt mouth using an idealized process-based model*
C. Nolet	*Mapping coastal bio-geomorphic dune development with UAV-imaging*
T.D. Price	*Sandbar, beach and dune: how do they connect?*
M. Radermacher	*A numerical and field study of tidal flow separation at mega-nourishments*
G. Ramaekers	*Designing the nourishment of Brouwersdam*
B.G. Ruessink	*Observations of Beach-Dune Interaction in Man-Made Trough Blowouts*
J. Rutten	*Sandbar behaviour along a man-made, curved coast*
F.G. Silva	*Dune-systems near inlets, a first insight*
M.C. Verbeek	*Experimental and numerical assessment of flow interaction at storm surge barriers with hydro-turbines*
S. Vos	*Measuring beach responses due to storm cycles, preliminary results*
D. Wesselman	*The effect of tides and storm surges on the sediment transport during overwash events*
P.W.J.M. Willemsen	*Long-term biogeomorphological behavior of couples bare intertidal flats and vegetated foreshores*
J. van der Zanden	*Wave bottom boundary layer flow and turbulence under a plunging breaking wave over a rigid breaker bar*

Abstracts in alphabetical order

THE *MARKERWADDEN*: THE INFLUENCE OF THE SAND FRACTION ON THE RIPENING BEHAVIOUR OF MARKERMEER SEDIMENT

Maria Barciela Rial[1*], Johan C. Winterwerp[1,2], Leon A. van Paassen[1], Jasper Griffioen[3,4] and Thijs van Kessel[2]
[1] Delft University of Technology, Faculty of Civil Engineering and Geosciences -*m.barcielarial@tudelft.nl
[2] Deltares PO Box 177, 2600 MH Delft, The Netherlands
[3] Utrecht University, Department of Innovation, Environmental and Energy Sciences, Faculty of Geosciences.
[4] TNO P.O. Box 80015, 3508 TA Utrecht, The Netherlands

Description of research

The large and shallow Lake *Markermeer,* The Netherlands suffers from ecological problems. Its ecosystem has been affected by high turbidity levels, caused by the resuspension of the oxic and highly bioturbated uppermost layer of the bed. To improve its water quality, a broad and multidisciplinary consortium has been working together since 2013 on the *MarkerWadden*. This Building with Nature (BwN) project aims to improve the ecosystem in the lake by creating a wetland with sediments partly originating from the mud material of the bed of the lake itself. Part of the sediments which is placed above the water level will be exposed to evaporative conditions. Due to evaporation these sediments will consolidate. The deformation behaviour of ripening sediments is significantly affected by its composition. The sediment composition varies enormously in the *Markermeer,* in particular the sand content. In this research the behaviour of sediment while drying was carried out.

Figure 1 shows a fragment of the negative excess pore pressure development in time at the bottom probe of a Hyprop for a natural *Markemeer* Holocene clay sample (containing 10% of sand) and a sieved sample (without sand) during a desiccation test in a climate room with a constant temperature of 24°C.

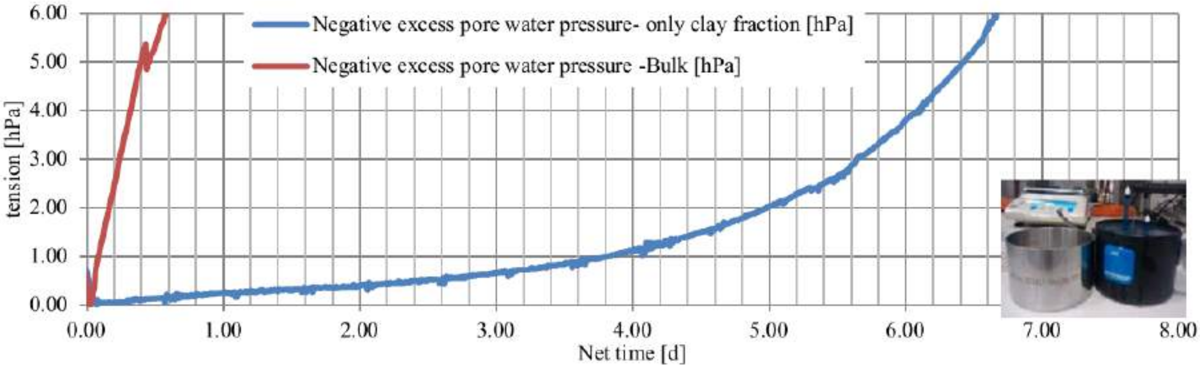


Figure 1. Negative excess pore pressure at the bottom probe corrected for the initial hydrostatic head and the hydrostatic head loss in time as a result of evaporation and shrinkage

From the water loss and measured pore pressures the water retention curves are determined (Figure 2a). The curves have a different starting point and clearly do not aline at higher suction values due to a difference in the initial liquidity and a different composition. Figure 2b shows that the undrained shear strength as a function of liquidity index of the remoulded natural sample clearly fits the empirical correlations available in literature.

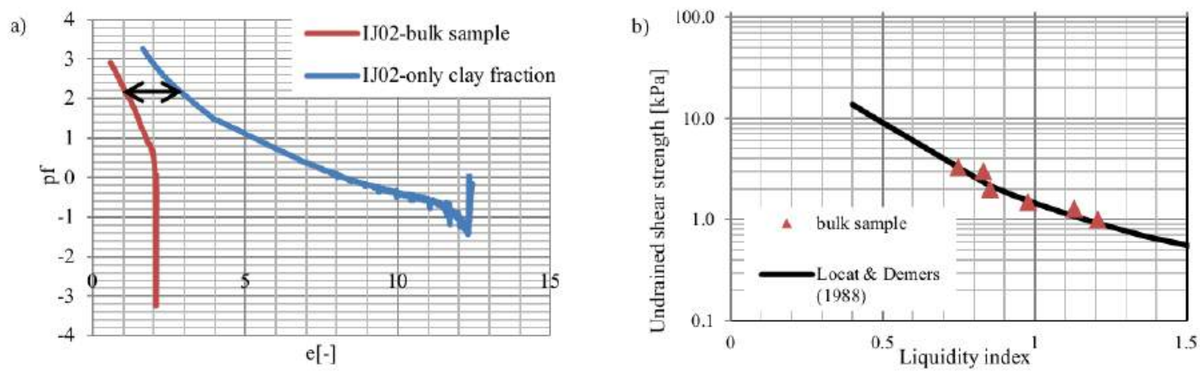


Figure 2. a) Water retention curve of a sieved and a natural sample of Markermeer Holocene clay. b) Correlation between the liquidity index and the undrained remoulded shear strength for a natural sample

MORPHOLOGICAL DEVELOPMENT OF THE PERKPOLDER BASIN

M.P. Boersema[1*], M.E. van Vliet[1] J.J. van der Werf[2], T.J. Bouma[1,3] and J. Stronkhorst[1,2]
[1] HZ University of Applied Sciences, matthijs.boersema@hz.nl, joost.stronkhorst@hz.nl
[2] Deltares, jebbe.vanderwerf@deltares.nl
[3] The Royal Netherlands Institute for Sea Research (NIOZ), tjeerd.bouma@nioz.nl

Introduction

Since 2003 the ferry between Kruiningen (Zuid-Beveland) and Perkpolder (Zeeuws-Vlaanderen) is out of service, which was also a starting point for regional development initiatives at Perkpolder. These initiatives combine housing, recreation and development of a salt water natural area. For the development of this area, Rijkswaterstaat made an opening in the original dyke of 400 m and constructed a new dyke around this new tidal basin with a surface of 75 ha. After the opening in June of 2015, the area gets flooded twice per day, which results in sediment import from the Western Scheldt (Figure 1). The potential sediment import, and the accumulation rate are important parameters in the development of salt marches, and the possibilities for recreational usage. In this study the morphological development of the Perkpolder basin is investigated and compared with reference basins in the vicinity. This research is part of three year monitoring and research program, executed by the partners of Centre of Expertise Delta Technology.

Methodology

For this study the basin hypsometry (Boon & Byrne, 1980) of the Perkpolder tidal basin is investigated and compared with other areas (Land van Saeftinghe and Sieperdaschor), to give an estimate of the sediment storage capacity of the newly created basin. In order to obtain a deeper understanding of the sediment accumulation rate, the elevation development of these additional areas is used as projection of the development at the Perkpolder tidal basin. In the coming years the sediment accumulation of the basin will also be monitored with the help of field measurement.

Findings

A comparison of the basin hypsometry of the different areas shows the large sediment storage potential of the Perkpolder basin. The basis has relatively low elevation compared to the present tidal range (MLW is -2.1 m NAP and MHW is 2.6 m NAP). This is due to the fact that the area was a part of a polder which was already embanked in the 13th century. The average elevation of the Perkpolder basis is -0.8 m NAP, as compared to the present average elevation of the Land van Saeftinghe, which is 2.0 m NAP.

References

Boon, J.D. and R.J. Byrne, 1981. On basin hypsometry and the morphodynamic response of coastal inlet systems, Mar. Geol. 40: 27-48

Figure 1. Overview of the Perkpolder basin, direction of photo is SE. Source: Rijkswaterstaat, Edwin Paree

UNDERSTANDING THE EFFECT OF PERMEABLE BRUSHWOOD DAMS ON THE HYDRO- AND SEDIMENT DYNAMICS ON A TROPICAL MANGROVE MUDFLAT

Dax Boot[1], Maarten van der Vegt[1], Marije Smit[2]
[1] Utrecht University, d.boot1@students.uu.nl, M.vanderVegt@uu.nl,
[2] Witteveen+Bos Consulting Engineers, marije.smit@witteveenbos.com

Introduction

Many tropical coastal regions around the globe experience enhanced erosion caused by the reduction in mangrove forest coverage by endured aquaculture and other anthropogenic influences. As a result, their function as natural wave attenuators disappeared. Consequently, waves are hitting the upper flat and coastline with more energy, eroding the coastline and shifting the bottom profile to a concave shape. A feedback loop is hypothesized to set in motion that will enhance erosion even further (Winterwerp et al., 2013).

To reverse this feedback loop, it is proposed to implement permeable brushwood dams according to the Dutch and German examples in the Waddensea. However, fundamental knowledge about the effects of such dams on hydro- and sediment dynamics on a tropical mudflat is lacking. The main aim of this study is to determine the effectiveness of such a dam as a function of water level, wave conditions and position of the dam.

Methodology

The effects are studied using a SWASH model in 2DV mode with a cross-shore distance of 3 km, at which the first 2 km are linearly sloping 1:1000 and the last km exponentially (both concave and convex). The dam is implemented as rigid vegetation that is emergent at all water levels. The dam's characteristics (i.e. horizontal density, height, stem diameter, drag coefficient) are set to result in a calibrated transmission coefficient according to the findings of Albers et al. (2011). The diurnal tidal amplitude is set to 1 m.

The hydrodynamics are studied for significant wave heights of 0.2 and 0.5 m where the dam location is varied between 100 m, 150 m, 200 m, and 300 m offshore from the shoreline for both a convex and concave upper intertidal flat. The sediment dynamics are limited to a significant wave height of 0.2 m and a dam location of 200 m offshore from the shoreline at a concave upper flat. Waves and tides are coupled through tidal induced, set water levels for the stationary wave runs (24 per cycle).

Results

It was found that the wave height (see Figure 1), orbital velocity, flow velocity, vertical viscosity and bed shear stress decrease as a consequence of the dam. The location influences the area of protection, relative energy transmission and wave height at breaking. The combined effect of the erosion on the foreshore and sediment being transport to the upper flat by the tides during rising water levels is in line with the existing literature and hypothesis of this study. Furthermore, the dam is increasingly effective for a lower water depth and larger energetic conditions.

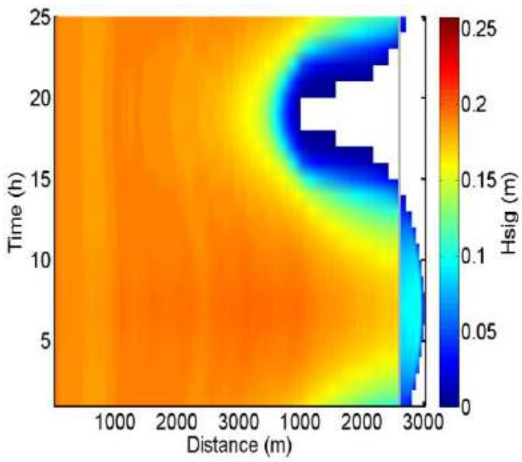


Figure 1: Wave height with dam during one tidal cycle with the dam indicated by the grey line. The x-axis shows the cross-shore distance with zero being the most offshore location. The y-axis indicates the time in hours at different water levels.

Conclusions

The results imply that the feedback will reverse over time if the sediment is deposited landward of the dam and the slope slowly changes to convex. Connecting the results to the 'windows of opportunity' set by Balke et al. (2013); it is recommended that the dam is progressively placed farther from the shoreline in discrete steps. Further research might focus on the longer-term morphological effects of permeable dams.

EFFECTS OF MUD SUPPLY ON LARGE-SCALE ESTUARINE MORPHOLOGY

L. Braat[1*], M.G. Kleinhans[1], T. Van Kessel[1,2], S. Wongsoredjo[1], L. Bergsma[1]
[1] Utrecht University, l.braat@uu.nl, m.g.kleinhans@uu.nl, s.wongsoredjo@student.uu.nl, l.s.m.bergsma@students.uu.nl
[2] Deltares, thijs.vankessel@deltares.nl

Sandy river estuaries have great economic and ecologic values, but a better understanding is required about the effect of mud on large-scale morphodynamics to optimise maintenance strategies. Very few studies actually include sand-mud interaction effects on morphodynamics on decadal and centennial timescales due to model limitations and lack of spatially and temporally dense data of mud in the bed. Here we study effects of cohesive sediment supply on equilibrium estuary shape, bar-channel patterns and dynamics, during formation from idealised initial conditions over a time scale of centuries and millennia.

On the basis of related modelling and experimentation of river and delta patterns we hypothesise that mud will settle into mud flats flanking the estuary that resist erosion and thus self-confine and narrow the estuary and reduce braiding index and channel-bar mobility.

We applied the process-based numerical model Delft3D in depth-averaged mode starting from idealised convergent estuaries (figure 1). Mixed sediment was modelled with an active layer and storage module with fluxes predicted by the Partheniades-Krone relations for the cohesive regime, and Engelund-Hansen for the non-cohesive regime depending on the fraction of mud. This was subjected to a range of different mud inputs from the river or from the sea and a range of river discharge and tidal amplitudes.

Our modelling results show that mud is predominantly stored in mudflats on the sides of the estuary (figure 1c). Higher mud concentration at the river inflow leads to narrower and shorter estuaries. Channels within the estuary also become narrower due to increased cohesion in the channel banks. This trend is confirmed in preliminary experiments. However, channels do not increase in depth; this is in contrast with what is observed in rivers and we do not yet fully understand this. Migration rates of channels and bars and bar splitting and merging also reduce with increasing mud concentration. For higher discharge channel avulsions occur further upstream and bars become more elongated. Consequently, estuaries become less convergent with larger discharge. The effects of waves and marine mud on morphology are still under investigation.

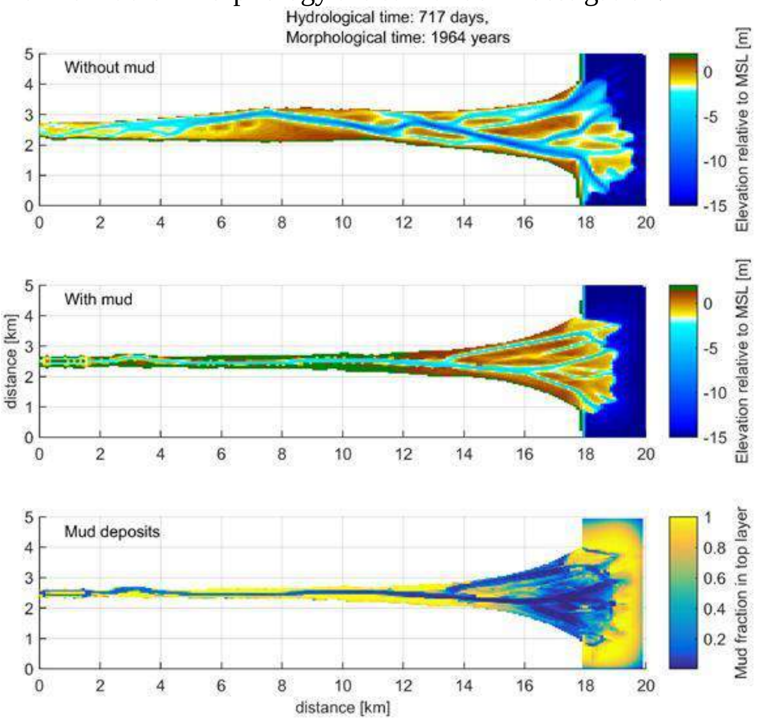


Figure 1 Modelling results of idealised estuaries with only sand (a) and with fluvial mud supply (b and c). Showing bathymetry maps after 1964 years (a and b) and mud fraction in the top layer (c).

The driving mechanisms behind morphological changes in the Western Scheldt mouth area over the past two centuries – a data analysis

E. Brand[1,2]*, T. van Oyen[1], A. Nnafie[1]
[1] Flanders Hydraulics Research, evelien.brand1@gmail.com, tomas.vanoyen@mow.vlaanderen.be, abdel.nnafie@mow.vlaanderen.be
[2] Utrecht University

Introduction

The Western Scheldt mouth area has shown significant changes in morphology over the past two centuries, but the driving mechanisms behind these changes are not yet fully understood. In this study, historical bathymetries of the mouth and the estuary, the external tidal forcing, and human interventions were analysed, to improve the understanding of the morphology of the mouth area.

Methods and results

First, the morphological changes were quantified, by digitizing historical bathymetrical maps (Figure 2) and calculating the orientations and cross-sectional areas of the channels. From this data, it appears that the most significant changes in the mouth are the growth of the Wielingen and the rotation and decrease in area of the Spleet and the Deurloo. In the estuary the most important changes are the decrease in area of two channels towards areas that are now reclaimed and a rotation of the main channel at the inlet.

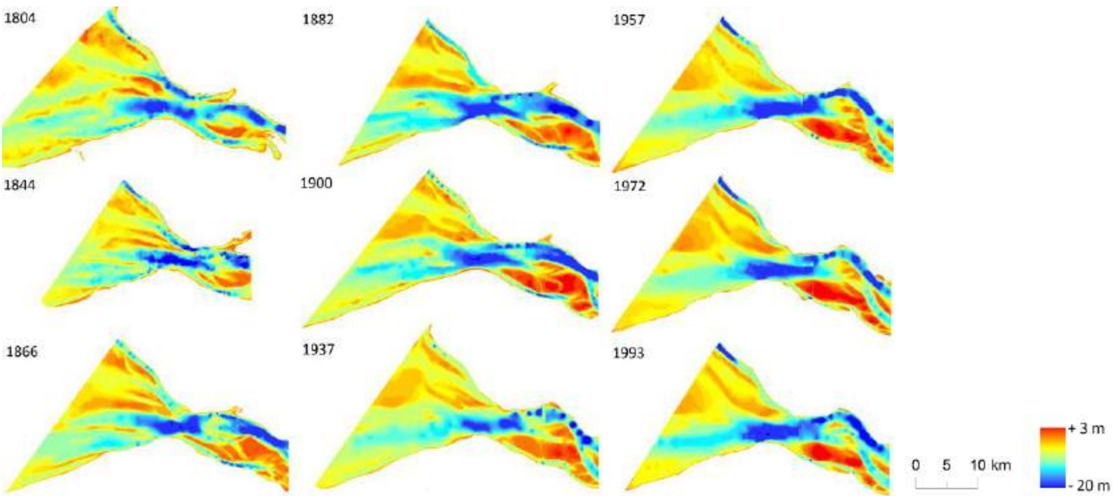


Figure 2. Digitized bathymetries of the Western Scheldt (mouth) from the past two centuries

Second, we studied the evolution of the external tidal forcing over the last two centuries, revealing that the M_2 tidal amplitude has increased due to sea level rise. The M_4 amplitude has also increased, but this could also be due to local changes in geometry. As a result of this, the tide at Vlissingen has become less flood dominant since 1900. A Delft3D model was used to study the effects of the changes in the hydrodynamic forcing on the sediment transport. From the model results, it appears that the changes in the incoming tide, resulted in an increase in sediment transport out of the estuary.
Third, the influence of human interventions is studied by evaluating the temporal correlation between the morphological changes with the taken measures. From this effort, it appears that only the land reclamations in the estuary seem to have influenced the long-term, large-scale morphology.

Conclusions

Over the past two centuries, the Wielingen has grown significantly. Previously, it was thought that this was most likely due to the preferred channel location in combination with the delaying effects of the geology. However, this study shows that the growth of the Wielingen might as well be due to the changing orientation of the channel at the inlet. Moreover, this study shows that sea level rise might have influenced the Western Scheldt mouth area significantly.

SAND SUSPENSION BY SEA-SWELL WAVES IN THE SHOALING AND SURF ZONE

J.A. Brinkkemper[1] and B.G. Ruessink[1]
[1] Utrecht University, j.a.brinkkemper@uu.nl, b.g.ruessink@uu.nl

While the sand transport by breaking-induced currents (undertow) is reasonably well understood and embedded in morphodynamics models, this is not the case for the sea-swell sand transport, especially under breaking asymmetric waves. In this study, the sand suspension and transport by sea-swell waves in shallow water was investigated with measurements collected during a field-scale laboratory experiment.

The Barrier Dynamic Experiment II (BARDEXII) was conducted in the Deltaflume in Vollenhove, the Netherlands, in 2012. The initial bed profile consisted of a 4.5 m high, 5 m wide and 75 m long sandy (d_{50} = 0.42 mm) barrier with a beach slope of 1:15. This profile was subjected to different random wave conditions (Hs = 0.55-0.90 m and Tp = 8-12 s) and water levels. We here focus on measurements collected with five vertically spaced (z = 0.04-0.17 m) sand concentration sensors at one cross-shore location, where the fraction of breaking waves varied between 0 and 0.5 and the ripple steepness between 0.12 (vortex ripples during low Hs/h) and 0.02 (strongly subdued ripples during high Hs/h).

We found that the phase-coupling between the orbital motion and sand concentration depends on the relative wave height. Under non-breaking waves and vortex ripples (Hs/h < 0.45) the phase-lag between sand concentration and the wave-orbital motion is positive (i.e., the concentration lags orbital velocity, see Figure 1a,c), indicating that vortex shedding is the main suspension mechanism. For breaking (plunging) waves (Hs/h > 0.65) a negative phase-lag is found (i.e., the maximum in concentration precedes the maximum onshore orbital velocity, see Figure 1b,d), this indicates that the suspension is caused by surface-induced turbulence. During intermediate conditions (0.45 < Hs/h < 0.65) both suspension mechanisms seem to counteract, as no phase-coupling was found. Future work will look at the implications of these findings for the magnitude and the direction of the wave-induced sand transport.

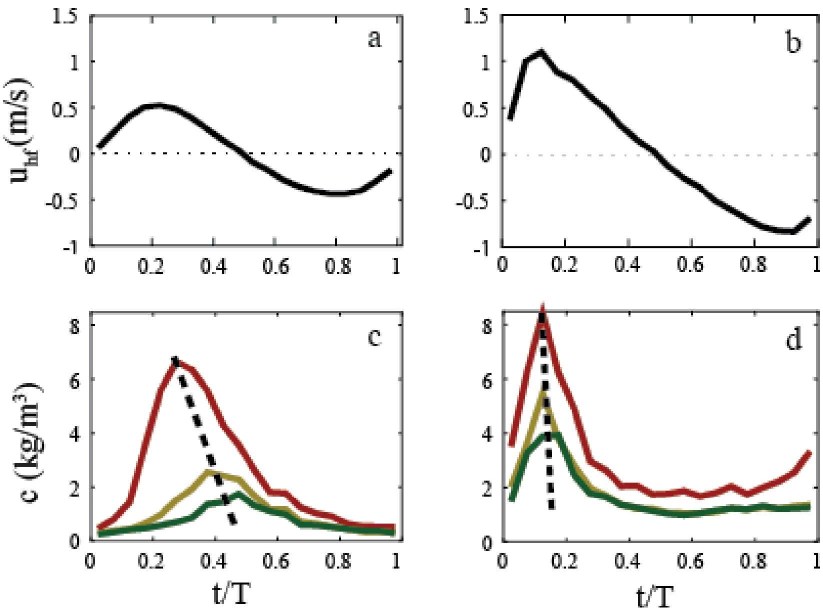


Figure 1. Two examples of phase-averaged cross-shore velocity and sand concentrations in the shoaling (a,c) and surf (b,d) zone. The phase-averaged concentrations are shown for z=0.04 (red), z = 0.10 (brown) and z = 0.17m (green). The dashed line connects the maximum phase-averaged concentrations in the vertical.

Observations of Flow and Turbulence at the Eastern Scheldt Storm Surge Barrier

Y.B. Broekema[1*], R.J. Labeur[1], W.S.J. Uijttewaal[1]
[1] Delft University of Technology, Y.B.Broekema@tudelft.nl

Introduction

Recent investigations have shown that on both sides of the Eastern Scheldt storm surge barrier, downstream of the applied bed protection, large scour holes have developed. These may compromise the stability of the bed protection. The ongoing erosion is only partly understood, making future development hard to predict. For an effective approach to mitigate erosion, it is necessary to determine the cause at a more fundamental level. As a first step, new field data of the flow was analysed.

Methodology

Rijkswaterstaat collected velocity data at the barrier between 01-2014 and 04-2015. ADCP's were mounted on a measurement frame and placed on the bed. For all inlets, on both the sea- and basin side of the barrier, a transect of 4 ADCP's was placed. These were located on top of the bed protection, the sloping part, the deepest part and the far end of the scour hole, respectively. The ADCP's collected data during roughly one spring-neap tidal cycle. In the same period, velocity data was also obtained using an ADCP mounted on a boat. This data was collected for one falling or rising tide, such that the scour hole was always at the downstream side of the barrier with respect to the flow.

Results

Approaching the barrier, there is a considerable contraction of the flow, especially on the sea-side. The barrier distorts the flow, leading to a large turbulent wake with characteristics of grid turbulence. By interpolating the boat data, a 2D depth averaged flow field was reconstructed downstream of the barrier (Figure 1). Large, horizontal differences in flow velocity are observed, accompanied by large circulation zones. Similar flow features were found in scale-model tests during the design phase of the barrier. By using the stationary ADCP's, turbulence intensities over the depth were determined. These show that there is quite some variation over the depth, with largest intensities found inside the scour hole. The vertical variations indicate the importance of the three-dimensional character of the flow. Summarizing, a first look at the data shows that a large part of the flow features around the barrier can be described by (Quasi) 2D processes, but that three dimensionality cannot be disregarded.

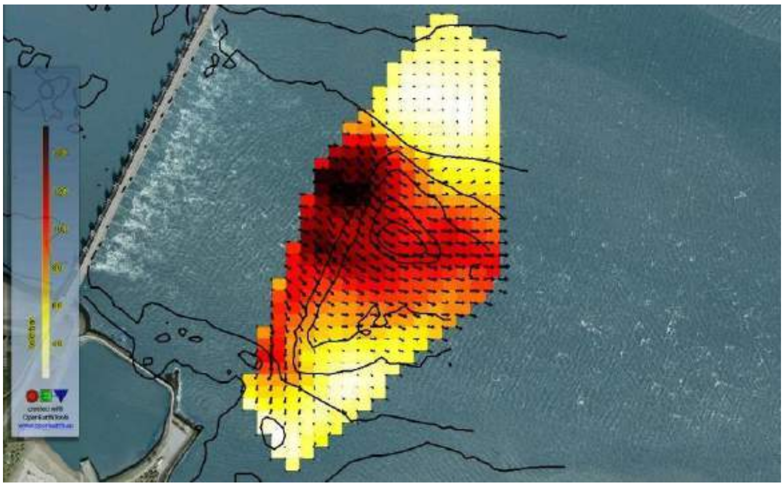


Figure 1 Measured 2D flow field at the Schaar entrance, colormap shows the magnitude of the flow velocity. Black contour-lines indicate the bathymetry.

Acknowledgements

Rijkswaterstaat is gratefully acknowledged for financing this project, and for collecting the data and making it available for analysis.

THE INFLUENCE OF STORMS ON SAND WAVE DYNAMICS: MORPHODYNAMIC MODELING USING A LINEAR STABILITY APPROACH

G.H.P. Campmans[1*], P.C. Roos[1], S.J.M.H. Hulscher[1]
[1] University of Twente, g.h.p.campmans@utwente.nl, p.c.roos@utwente.nl, s.j.m.h.hulscher@utwente.nl

Tidal sand waves are large-scale rhythmic bed forms observed in many tide-dominated shallow seas that have a sandy seabed. They have typical wavelength of hundreds of meters and are several meters in height. The behaviour of sand waves is of practical interest because they tend to interfere with navigation, pipelines, cables and windfarms. Process-based morphodynamic models have been developed to increase our understanding of sand wave dynamics (e.g. see the review by: Besio et al., 2008). In particular, sand waves have been explained as free instabilities of the system (Hulscher, 1996) using a linear stability analysis.

Observations show that storms play a significant role in sand wave dynamics. In this research we qualitatively investigate the influences of storm-related processes on sand wave dynamics. These storm processes, such as wind waves and wind-driven flow, enhanced turbulent conditions and suspended load sediment transport act on top of the fair weather processes such as tidal currents and bed load sediment transport.

An idealized sand wave model, based on linear stability analysis, is developed to obtain preferred sand wave characteristics for given storm conditions. The obtained characteristics are wavelength, orientation, migration rate and growth rate associated with the so called fasted growing mode. For example, the influence of wind wave amplitude and direction on the preferred wavelength of bed forms is shown in Figure 1. The preferred wavelength increases for increasing wind wave amplitudes, and in particular for waves coming in approximately perpendicular to the tidal current. Other results show the influence of wind direction and magnitude on sand wave migration, and that wind waves can enhance migration.

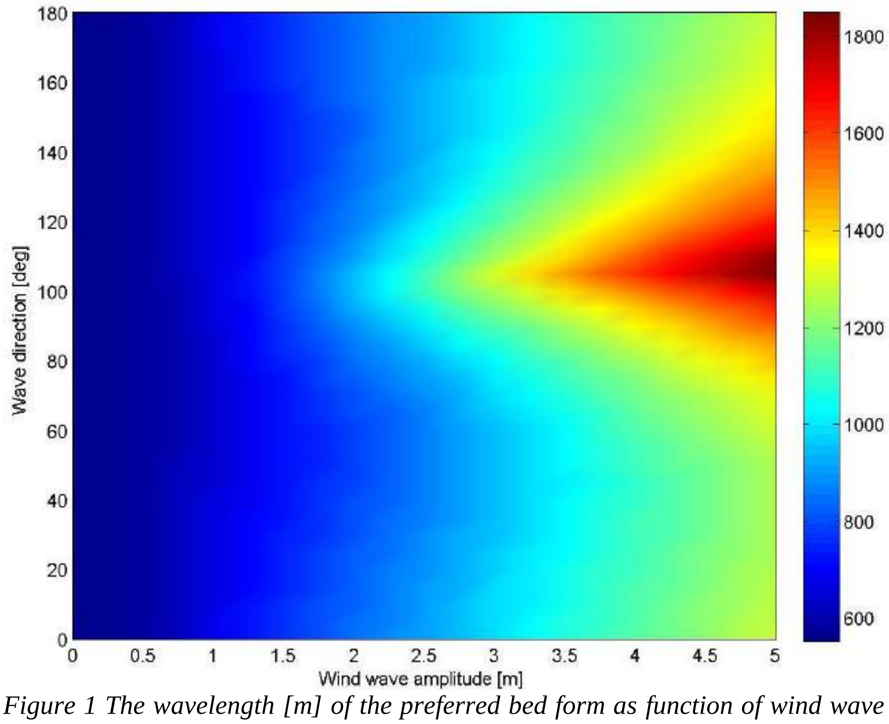


Figure 1 The wavelength [m] of the preferred bed form as function of wind wave amplitude and direction. The wind wave direction is with respect to tidal direction. The wind wave period is 6 seconds.

Besio, G., Blondeaux, P., Brocchini, M., Hulscher, S., Idier, D., Knaapen, M.A.F., Németh, A.A., Roos, P.C., Vittori, G., 2008. The morphodynamics of tidal sand waves: a model overview. Coastal Engineering 55, 657–670.

Hulscher, S.J.M.H., 1996. Tidal-induced large-scale regular bed form patterns in a three-dimensional shallow water model. Journal of Geophysical Research 101, 20727–20744.

SEDIMENT FOR SALTMARSHES: PHYSICAL ASPECTS OF A MUD MOTOR

I.Colosimo[1], B.C. van Prooijen[1], D.S. van Maren[1,2], J.C. Winterwerp[1,2], A.J.H.M. Reniers[1]
[1] Delft University of Technology – Civil Engineering and Geoscience, The Netherlands
[2] Deltares - PO Box 177, 2600 MH Delft, The Netherlands

The *Mud Motor* is a *Building With Nature* initiative with the aim to re-use dredged material for ecological purposes. The pilot project envisages the disposal of sediments, dredged in the Port of Harlingen, at strategic locations along the Kimstergat Channel. This extra supply of sediment is expected to promote the growth and stability of salt marshes, improving the efficiency of the Wadden Sea ecosystem services and the coastal protection from flooding. The likely reduction of sediment recirculation into the harbour area will be an additional benefit, leading to a reduction in dredging costs.

Preliminary analyses of bathymetric data, indicated net accretion in the area over time (see Figure 1). The Kimstergat Channel during the same period has migrated towards the coast and has extended in the northeast direction. The transect at the envisioned location Koehool shows a significant accretion (around 2 meters) in the last century (see Figure 2). However, the deposition rates decreased in the last decades. Furthermore, in proximity of the coastline, the bed levels are not growing above the 0m NAP, but there is a seaward progradation of the tidal flat.

Identification and quantification of the processes responsible for these morphological changes will be the first part of this project. This implies the unravelling of the interaction between wind-waves and tidal-currents and its effect on the transport of cohesive sediments onto an intertidal mudflat. Based on this knowledge, the transport mechanisms that bring sediments from the disposal site to the salt-marshes will be determined.
Special attention will be given to the bed shear stress enhancement due to the wave-current interaction. Moreover, the assessment of sediment transport arising from event-driven processes will be fundamental for the design of the *multi-year semi-continuous nourishment of muddy sediments.*

Field measurements will be conducted to obtain high resolution time-series of the bed shear stresses and sediment concentrations during various conditions, ranging from mild to stormy weather. These data will be used to improve the modelling of the combined wave- and current- induced bed shear stress in order to analyse the effect of the Mud Motor.

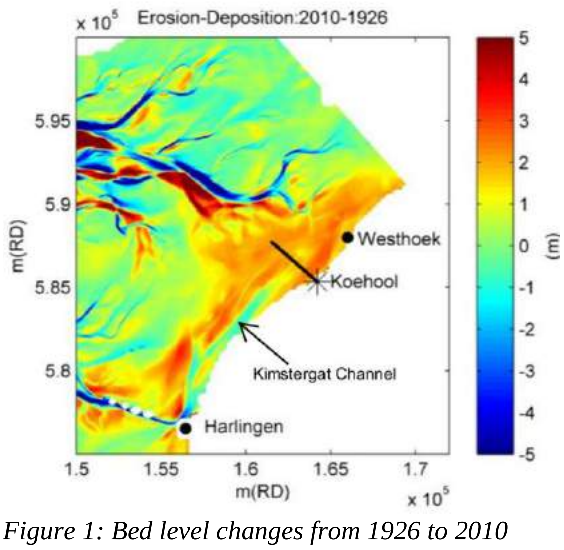


Figure 1: Bed level changes from 1926 to 2010

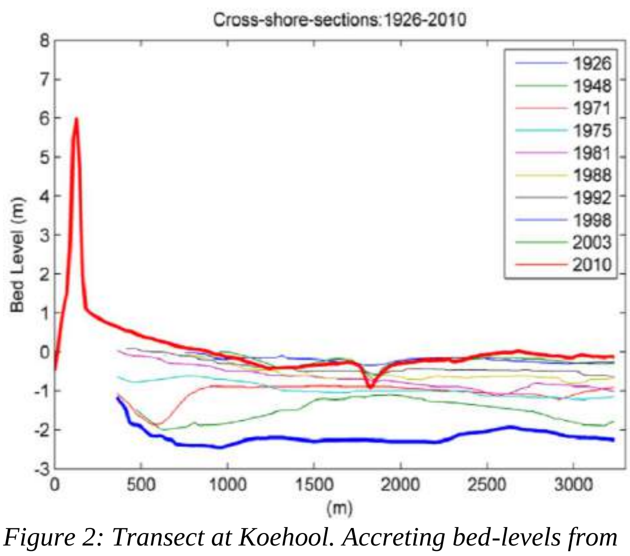


Figure 2: Transect at Koehool. Accreting bed-levels from 1926 to 2010.

A MODEL TO ASSESS INTERTIDAL MICROPHYTOBENTHIC PRIMARY PRODUCTION AT THE MACRO SCALE USING SATELLITE IMAGERY

T.D. Daggers[1]*, J. Kromkamp[1], P. Herman[1,2], D. van der Wal[1]
[1] Royal Netherlands Institute for Sea Research, Tisja.Daggers@nioz.nl, Jacco.Kromkamp@nioz.nl, Daphne.van.der.Wal@nioz.nl
[2] Deltares, Peter.Herman@deltares.nl

Quantifying large scale spatial variability in intertidal microphytobenthic productivity is necessary to better understand the amount of benthic organic carbon available for grazing, burial and transport to the pelagic zone, and to improve global estimates of carbon sequestration in intertidal areas. However, there is no general method to routinely assess intertidal benthic primary production at the macro scale.

Several 1D-models have been developed to calculate microphytobenthic primary production in intertidal areas, but none of these models are adapted to be used on larger spatial scales, e.g. in combination with satellite remote sensing. In this study, we adapted the 1D sediment-optical model from Forster et al. (2006) to a 2D-model, using information on microphytobenthic biomass and silt content retrieved from Landsat 8. Photosynthetic parameters were measured on several locations in the Eastern and Western Scheldt with a PAM fluorometer. The photosynthetic capacity (maximum photosynthetic rate) could be linked to ambient temperature. The method is validated on nine intertidal flats in the Eastern and Western Scheldt in the Netherlands.

The model provides a means to obtain information on steady state microphytobenthic primary production rates of an entire estuary with relatively little effort and may be applied to other estuaries, although calibration at the estuary of interest is needed. Furthermore, using multiple images temporal variability in microphytobenthic production may be assessed.

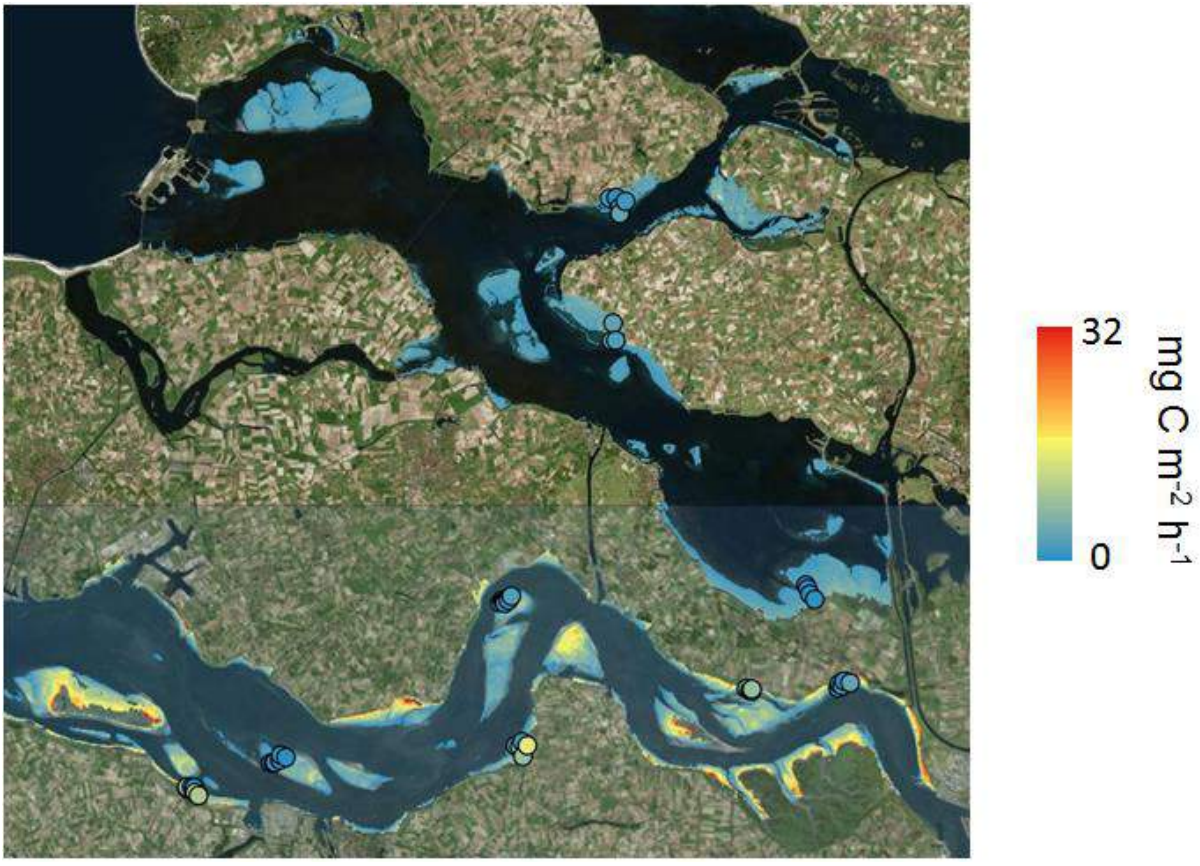


Figure 3 Average intertidal microphytobenthic production rates in the Eastern and Western Scheldt in March 2015.

LONG-TERM SAND-MUD MODELING OF THE SCHELDT ESTUARY

G. Dam[1,2,3]*, M. Van der Wegen[1,4], A.J. Bliek[2], J. Cleveringa[5]
[1] UNESCO-IHE, dam@svasek.com, m.vanderwegen@unesco-ihe.org, bliek@svasek.com
[2] Svašek Hydraulics
[3] Dam Engineering
[4] Deltares
[5] ARCADIS

A long-term morphological simulation of the Scheldt estuary is carried out using FINEL2d and using both the sand and mud fraction. The 1860 bathymetry and outline of the estuary is used as a starting point with a completely sandy bed. Land reclamations are simulated by closing off areas at the exact moment of embankment. Mud is imposed on the sea and river boundary and at a constant concentration. Initially there is sand export at the mouth (negligible sand transport at the river) and mud import from both the sea and the river, see figure 1. As a consequence the total sediment amount in the estuary is initially increasing over time because the mud import is higher than the sand export. The mud is stored in quiet areas, such as salt marshes and side branches, see figure 2. After around 100 years the mud import from the sea becomes less because the storage areas are getting full. As a consequence the mud from the river (which still continues) starts flowing to the sea because it cannot be stored. The initial mud import at the mouth becomes a mud export over time. The total sediment amount in the estuary is now decreasing because the sand export still continues and there is no more permanent settlement of mud. Nowadays it is thought that the estuary is still importing mud (and exporting sand), but as storage capacity decreases a change in net sediment direction of mud is possible in the future!

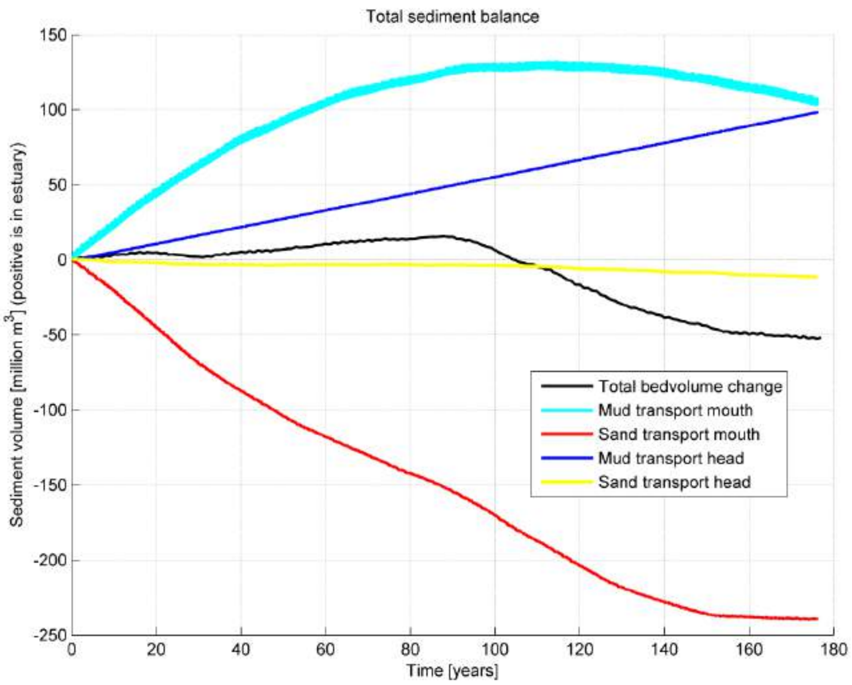


Figure 4 Net sediment transport over time.

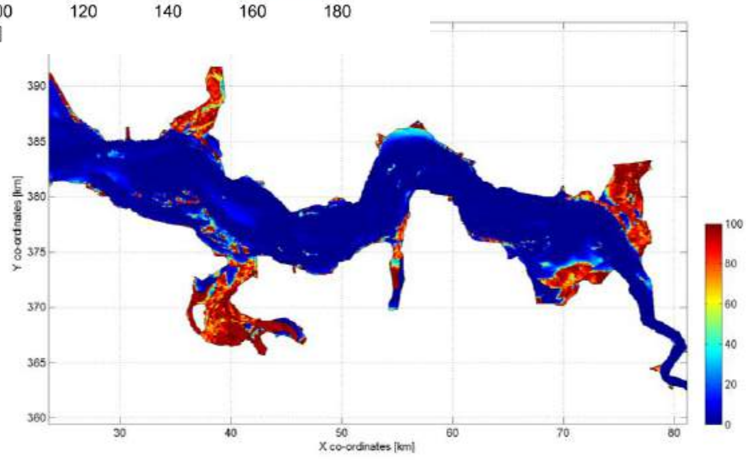


Figure 2 Mud content in bed after 175 years (1860 layout).

ANALYSIS OF VARIATION IN SAND WAVES SUPERIMPOSED ON SAND BANKS

J.M. Damen[1], T.A.G.P. van Dijk[1,2], S.J.M.H. Hulscher[1]
[1] University of Twente, j.m.damen@utwente.nl,
[2] Deltares

Introduction

Sand waves are rhythmic bed forms with lengths between 100 and 1000 metres (Ashley, 1990) that occur in various shelf seas around the world, including on the Netherlands Continental Shelf (NCS). Sand banks have wavelengths of several kilometres and heights larger than 10 metres. The orientation of sand bank crests is almost parallel to the tidal flow, whereas sand wave crests are perpendicular to the tidal flow axis. Sand waves superimposed on sand banks may vary in shape due to variations in local conditions (e.g. Lanckneus et al., 1994; Franzetti et al., 2013). However, a systematic analysis of shape variations over sand banks remains to be performed.

For safe navigation and offshore engineering projects it is important to have a solid understanding of processes controlling bed form shape variations. The aim of this study is therefore to explain the variations in sand wave shapes related to their relative position on a sand bank.

Methods and results

At four sites on the NCS (figure 1A), shapes of all individual sand waves were quantified and coupled to their relative location on a sand bank based on relative depth and slope (figure 1B). Large differences were found between the northern areas (1 and 2) compared to the southern areas (3 and 4). The data revealed that sand wave asymmetries on both sand bank flanks have an opposite direction for the southern areas, whereas a similar effect was not identified for the northern areas. Sand wave lengths for the northern areas were found to increase towards the crests. For southern areas 3 and 4 a decrease in length was found towards the sand wave crests. A comparison to tidal flow ellipses will be made to possibly explain these differences.

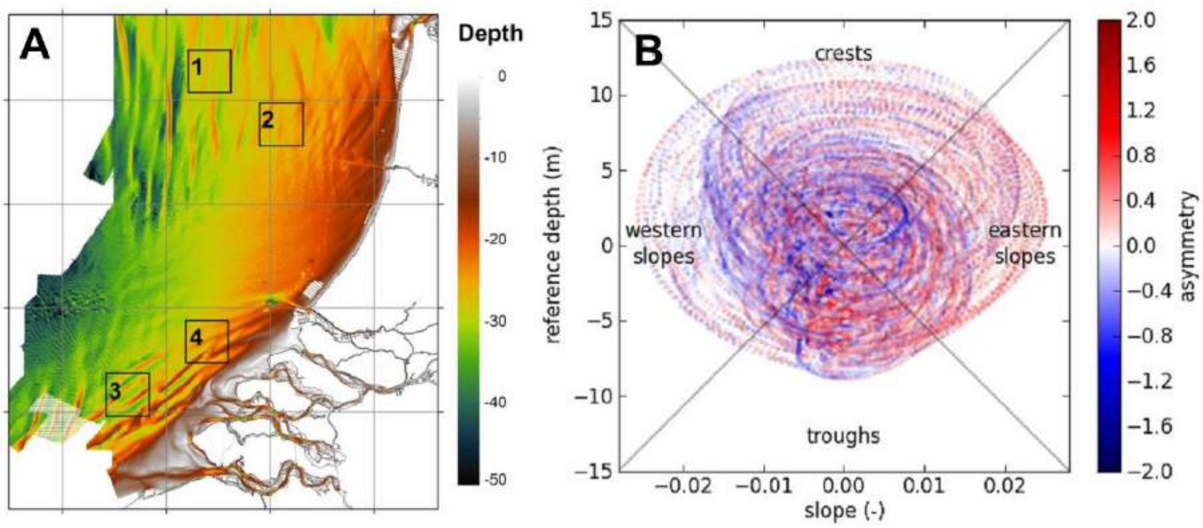


Figure 1 Study areas for sand waves superimposed on sand banks (A), sand wave asymmetry in study area 3 (B).

References

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

Lanckneus, J., De Moor, G., and Stolk, A. (1994). Environmental setting, morphology and volumetric evolution of the Middelkerke Bank (southern North Sea). Marine Geology, 121(1):1–21.

Franzetti, M., Le Roy, P., Delacourt, C., Garlan, T., Cancouët, R., Sukhovich, A., and Deschamps, A. (2013). Giant dune morphologies and dynamics in a deep continental shelf environment: Example of the banc du four (Western Brittany, France). Marine Geology, 346:17–30.

EFFECT OF DREDGING ON FINE SEDIMENT DISPERSION ALONG DUTCH COASTLINE

P.J.T. Dankers[1]*, T. Vijverberg[2]
[1] Royal HaskoningDHV, petra.dankers@rhdhv.com
[2] Royal HaskoningDHV, Thomas.vijverberg@rhdhv.com, now at Hydronamic, Boskalis

Description of research

Harbour basins and fairways around Rotterdam are dredged almost continuously. The dredged material consists of sand and mud. Dredged sandy materials are used elsewhere and contaminated (muddy) sediments are disposed in designated contained areas. The dredged muddy sediments are deposited at allocated dispersion sites in the North Sea. In general, maintenance dredging material is dispersed at a location called “Verdiepte Loswallen” (deep dispersion sites), while capital dredging material is often dispersed at the “Loswal Noordwest” (dispersion site). In total on average 10 Mm^3 of mud is dispersed yearly at the “Verdiepte Loswallen”. A large part of this material does not stay for ever at the dispersion sites but spreads from the dispersion sites along the North Sea coast and towards the Wadden Sea.

The goal of our research was to determine the effect of the present dredging and disposal strategy on the suspended sediment concentrations along the Dutch coast. Furthermore, we investigated the effect of the proposed deepening of the Nieuwe Waterweg on sediment concentrations along the coast. An advanced Delft3D-WAQ model of the southern North Sea was used to assess the large scale fine sediment transport. Several scenarios were run to determine the relative effect of dredging and disposal of fine material. Our results served as a base for the ecological evaluation of the effects of turbidity along the North Sea coast and towards the Wadden Sea.

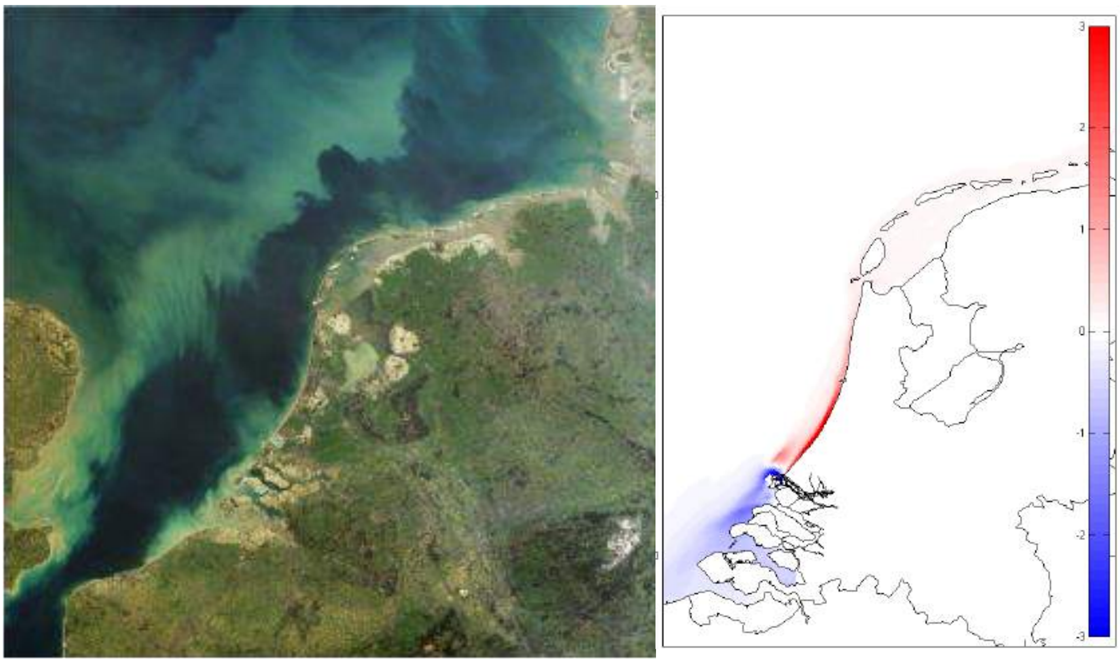


Figure 5: a) Satellite view of the North Sea. Source: MODIS rapid response project NASA/GSFC; b) Modelled spreading of fine sediment from dispersion site in the North Sea.

Acknowledgements

This work was conducted in close cooperation with Thijs van Kessel and Katherine Cronin from Deltares. This work was performed for the Port of Rotterdam

DUNE RECOVERY AND DEVELOPMENT IN THE AFTERMATH OF THE SINTERKLAASSTORM

J.J.A. Donker[1]*, P.M. Hage[1], B.G. Ruessink[1]
[1] Utrecht University, j.j.a.donker@uu.nl, p.m.hage@uu.nl, b.g.ruessink@uu.nl

Introduction

On December 5, 2013 the highest storm surge since 1990 hit the Dutch coastal zone. Dunes along the Holland coast eroded severely, locally up to 40 m^3/m. The impact of such storm surges on dune erosion has been studied intensively and the processes are well understood, leading to reasonably accurate predictive erosion models. To make predictions of long-term (> years) dune development, more knowledge is required on the aeolian processes that govern dune recovery and growth. It is expected that the long-term aeolian input depends on beach width because of the fetch effect[1]. To study this, topographic data of the beach and foredune are required at both high spatial and temporal resolution. Here, the applicability of mobile laser scanning (MLS) to monitor dune growth and erosion is studied and the relation between dune activity and beach width is investigated.

Method

A MLS system attached to an internal navigation system with RTK-GPS was used to carry out 10 surveys of a 3 km beach stretch between Castricum and Egmond aan Zee, the Netherlands. The system typically obtains 300-1000 height measurement points per m^2 depending on surface slope and distance from the system. The first survey was performed on December 10, 2013, 5 days after the aforementioned storm. Survey frequency then increased from bi-annually in 2014 to bimonthly in 2015 to allow linking of erosion, and growth to specific wave and wind events. The height observations were mapped into 1x1 m DEMs. Foredune and beach activity were determined by calculating the standard deviation of the height per grid cell over all surveys.

Figure 6: Part of the monitored foredune, aeolian transport is visible on the beach.

Results

The quality of the MLS generated DEM was assessed by comparing the DEMs with simultaneously performed manual RTK-GPS measurements. The measurement error was found to increase with distance from the car; however remained well within the specified accuracy of 0.2 m at 100 m from the car. Foredune activity was largest where beach width was smallest. Here, most activity was caused by erosion during storm surges. At the wider beaches, the area in front of the foredune was the most active. This is related to the formation and erosion of embryo dunes in front of the foredune. Dune volume increased in periods without storm surges and volume changes were positively related to beach width.

Discussion and conclusions

While at narrow beaches erosion results in an active foredune, on wide beaches the formation and erosion of embryo dunes makes the beach in front of the dune the most active. Embryo dunes limit the impact of storm surges on dune erosion[2]. Both the formation of these embryo dunes and the positive correlation between beach width and dune volume change confirm that the limitation of the fetch[1] has a substantial influence on long-term dune development.

References

1. R.C. de Winter, F. G. (2015). Observations and modeling of alongshore variability in dune erosion at Egmond aan Zee, the Netherlands. *Coastal Engineering, 99*, 167-175.

LASER PARTICLE COUNTER VALIDATION FOR SAND TRANSPORT MEASUREMENTS USING HIGH SPEED CAMERA

L. Duarte Campos[1], K. Wijnberg[1], L. Oyarte Gálvez[2], S. Hulscher[1]
l.a.duartecampos@utwente.nl, k.m.wijnberg@utwente.nl, l.a.oyartegalvez@utwente.nl, s.j.h.m.hulscher@utwente.nl
[1] Water Engineering & Management, [2] Physics of Fluids.
University of Twente

During the last decade, optical particle counters (Wenglor laser sensor, Figure 1, left hand panel) have been used in various studies to obtain rates of aeolian sand transport in the beach-dune environment. These sensors have been tested in wind tunnels [1] and generally seemed to record aeolian transport properly, and field applications of the sensor reported in literature seemed to provide realistic results. A transport sensor comparison field study exists, however, in which the Wenglor sensor strongly underestimated transport compared to other sensors [2]. Some strongly deviating results in our own transport measurements by a co-located sand trap and Wenglor sensor array urged us to further look into the detectability of various grain sizes by the Wenglor sensor.

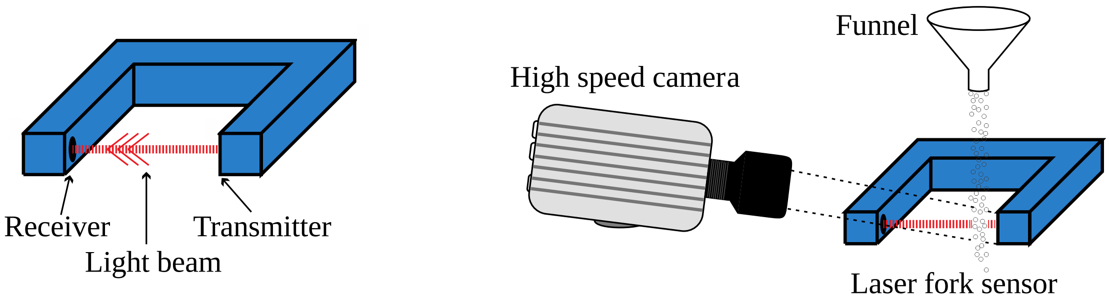


Figure 7 Experimental setup in the laboratory: Left side shows a Wenglor and its laser, and on the right side an example of a typical experiment developed.

In this study we present the results of laboratory experiments to determine the capability of the Wenglor sensor to count sand particles of various grain sizes. The experimental setup (Figure 1) consists of a Wenglor sensor that counts the grains, falling from a funnel. As the grains drop, a high-speed camera records the grains as they cross the laser beam (Figure 2), such that independent measurement of grain counts can be collected from the image data. Grain counts missed by the Wenglor can now be identified and its cause may be determined. Tests have been done with both polydisperse sand grains and monodisperse stainless steel beads.

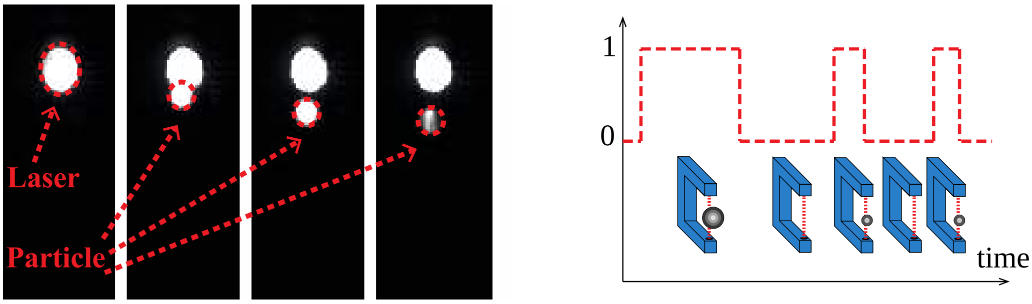


Figure 2 Left side shows a sequence of images when a particle is crossing the laser beam and on the right side a schematized version of the signal obtained from the Wenglor as a grain crosses the laser beam.

References

[1] Barchyn, T.E., Hugenholtz, C.H., Li, B., and MacKenna Neuman, C. (2014). From particle counts to flux: Wind tunnel testing and calibration of the 'Wenglor' aeolian sediment transport sensor. Aeolian Research. v.15 pages 311–318.
[2] Hugenholtz, C.H., and T.E. Barchyn (2011). Laboratory and field performance of a laser particle counter for measuring aeolian sand transport. Journal of Geophysical Research. Vol 116, F01010.

3D SEDIMENT DYNAMICS IN AN ESTUARINE STRAIT

H. M. Elmilady[1,2], M. van der Wegen[1,2], D. Roelvink[1,2] , T. van Kessel[2] , F. M. Achete[1]
[1] UNESCO-IHE, elmil1@unesco-ihe.org, m.vanderwegen@unesco-ihe.org, f.achete@unesco-ihe.org
[2] Deltares, Dano.Roelvink@deltares.nl, Thijs.vanKessel@deltares.nl

This study investigates the sediment dynamics in Carquinez Strait within the Northern San Francisco Bay (Figure 1). The area is known for pronounced and seasonally varying (river flow induced) salinity and temperature gradients along with its associated density currents. The availability of a large data set from temporary and continuous monitoring stations provides a unique opportunity for validating a 3D numerical model.
Our research applies Delft3D for modelling the 3D dynamics (both Z-layers and sigma layers) including wind waves, salinity, temperature and sediment transport. The model calibration and validation was performed using salinity, temperature and suspended sediment concentration (SSC) observations from WY 2004 and 2012, respectively. In addition, a sensitivity analysis determines the effect of the various uncertainties.
We show significant skill in predicting the salinity (Figure 2) and temperature fields. However, the sigma layer model required a lower roughness than the Z-layers model to compensate for the higher numerical diffusion. Changing the model roughness had a minor effect on the model hydrodynamics. On the other side, the Z-layer model showed some inconsistences in predicting the SSC. Our model results confirmed the observed presence of an ETM in Carquinez Strait. The sigma layer model showed that high river flows caused sediment pulses extending seaward of Carquinez Strait and that gravitational circulation induced landward sediment transport during low river flow conditions. Furthermore, the high contribution of freshly deposited, easily erodible sediment to local SSC has been observed.

Figure 1, Left figure represents the Model Grid on a Google Earth satellite image, Right figure shows an aerial view of Carquinez Strait, Source: Wikipedia.

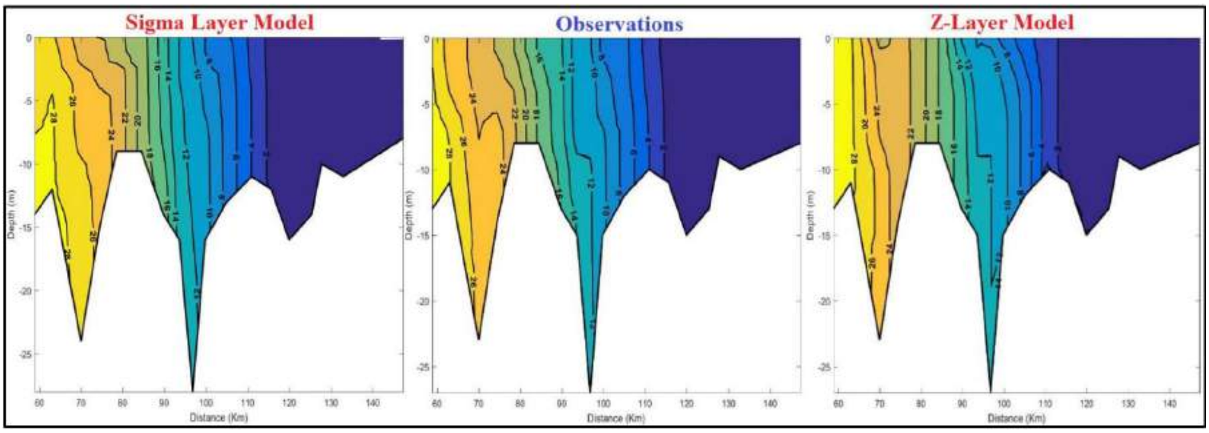


Figure 2, represents longitudinal salinity transects across the model domain for dry conditions (5-18-2004), Left figure (Sigma Layers Model), Middle figure (Observations) and Right figure (Z-layers Model).

SINBAD PROJECT: MODELLING WAVE BREAKING EFFECTS ON SEDIMENT TRANSPORT

A. Fernandez-Mora[1], J. Ribberink[1], J. van der Zanden[1], J. van der Werf[1,2] and N. G. Jacobsen[3]
[1] CTW-WEM University of Twente, m.fernandezmora@utwente.nl, j.s.ribberink@utwente.nl, j.vanderzanden@utwente.nl
[2] Sediment Transport and Coastal Morphology, Deltares, Jebbe.vanderWerf@deltares.nl
[3] Coastal Structures and Waves, Deltares, Niels.Jacobsen@deltares.nl

Introduction

An accurate prediction of sediment transport is essential to properly simulate near-shore morphodynamics. At present, despite that sediment transport formulas account for the main processes that drive sediment transport, they lack on the prediction of transport rates and bottom changes under breaking waves. In fact, there is a general lack on the understanding of the effects of wave breaking hydrodynamics and turbulence on the sediment transport, particularly, their effects in the wave boundary layer.

The SINBAD project (held in collaboration between the University of Twente, the University of Aberdeen and the University of Liverpool) is focused in to get more insight on the effects of wave breaking in sediment transport. During the project, large flume experiments have been performed, paying special attention in the detailed measurement of the surface elevation, the vertical and horizontal velocities, the boundary layer processes and the sediment transport. The second part of the project stands for the simulation of the flume experiments in terms of hydrodynamics, turbulence and sediment transport in order to get more insight of the processes involved on sediment transport induced by plunging breaking waves.

Numerical modelling and preliminary results

The numerical simulations are performed by using the waves2foam+sediMorph model, based in the open- source platform OpenFoam. The hydrodynamic model (Jacobsen et al., 2012), solves the RANS equations complemented with the $k - \omega$ SST model for the turbulence closure problem. The sediment transport accounts for the contribution of both bed-load and suspended-load transport modes. The bottom changes are computed through the Exner equation and it is updated at each time step to account for the morphodynamic feedback.

The good agreement of the hydrodynamic simulations with measurements and the successful results of the model in previous works in terms of sediment transport and morphodynamics are encouraging to continue with the sediment transport simulations for the experiment and analyse the effects of wave breaking induced fluxes and turbulence in the boundary layer and in the sediment transport.

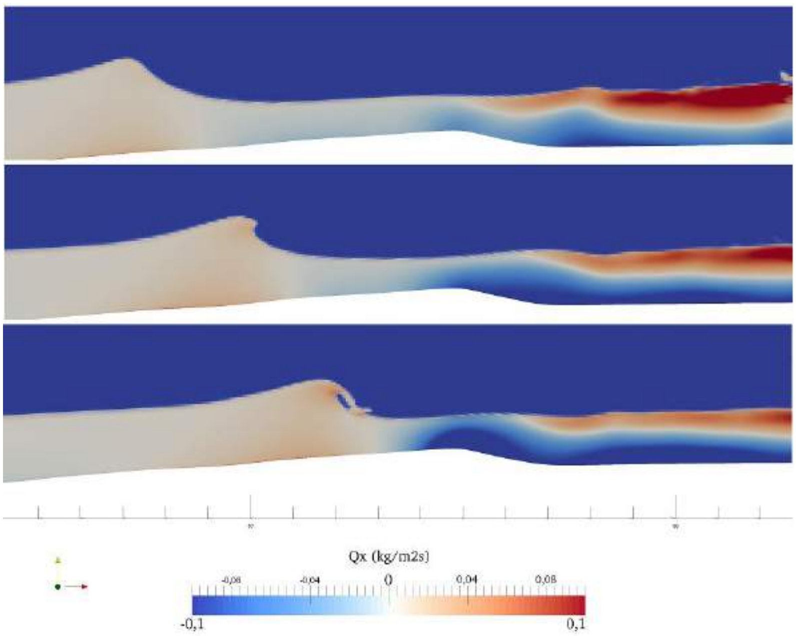


Figure 1 Snapshots of the simulated transport flux Qx during the wave breaking.

X-BAND RADAR DERIVED HIGH RESOLUTION BATHYMETRY AND HYDRODYNAMICS

J. Friedman[1]*, C. Swinkels[1], R. Hoekstra[1,2], M. Radermacher[2]
[1] Deltares, Josh.Friedman@deltares.nl, Cilia.Swinkels@deltares.nl, Roderik.Hoekstra@deltares.nl
[2] Delft University of Technology, M.Radermacher@tudelft.nl

Introduction

In 2011, the *Sand Motor*, a large scale beach nourishment, was realized on the south-western Dutch coast. An extensive multi-year monitoring campaign was launched to track its morphological development. A radar station was also included to support monitoring. Its application is highly lucrative in the coastal environment since it avoids the common *in situ* measuring problems – laborious setup, ideal conditions, limited resolution, and high cost. This work focuses on the development of X-band radar software at the *Sand Motor* to investigate remote sensing as an accurate alternative for deriving nearshore bathymetry and hydrodynamics.

Radar data can be processed into hydrodynamic parameters such as waves, currents and bathymetry information using a 3D Fast Fourier Transform (FFT). The resulting wave components (k_x, k_y, ω) from the image spectra are necessary inputs for inverting the Doppler-shifted linear dispersion relation. The newly developed **XM**Fit software includes this algorithm, which is able to simultaneously extract depth, surface currents and wave parameters.

High Resolution Bathymetry and Hydrodynamics

XMFit high resolution nearshore bathymetry based on a 25m grid for a single high water is presented in Figure 1. The individual scatter points are from **XM**Fit and the contours represent measured survey data. The two datasets have a correlation coefficient of 0.97 and a bias of 0.30m. **XM**Fit is capable of detecting nearshore sandbars and the correct bathymetric gradient at the *Sand Motor* (Figure 1 inlay).

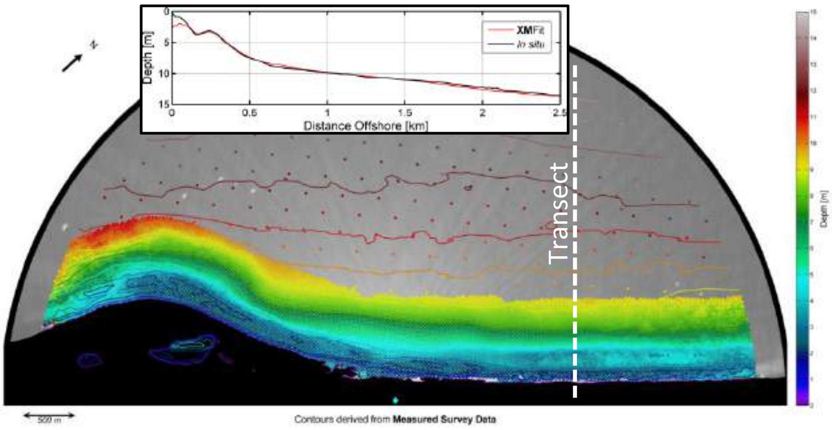


*Figure 1 - **XM**Fit derived bathymetry (scatter) with measured survey data (contours) for Oct. 23rd, 2014*

XMFit high resolution surface currents align well with the Acoustic Doppler Current Profilers (ADCPs) deployed within the radar domain (Figure 2). Currents in the lee of the *Sand Motor* are represented by **XM**Fit despite the complexity of large scale eddies and density fronts.

Conclusions

XMFit is an in-house developed product with the ability to derive accurate high resolution bathymetry and current fields in the complex *Sand Motor* environment. This makes **XM**Fit an extremely promising remote sensing tool that can be potentially applied to any existing X-band radar system.

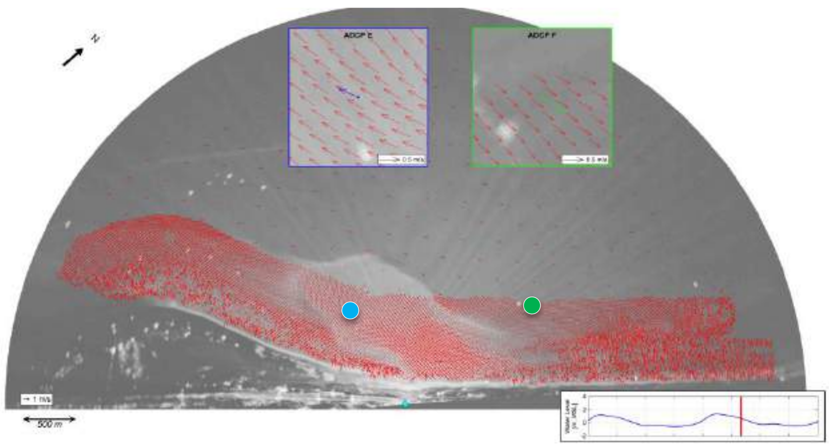


*Figure 2 - **XM**Fit derived surface currents (red) with measured ADCPs (blue and green) at 16:00 on Oct. 23rd, 2014*

TIDE-INDUCED AND LAG-DRIVEN SEDIMENT TRANSPORT IN THE WADDEN SEA: TOWARDS A FULLY EULERIAN PERSPECTIVE

V.M. Gatto[1], B.C. van Prooijen[1], Z.B. Wang[1,2]
[1] Delft University of Technology, v.m.gatto@tudelft.nl, [2]Deltares

Background

Quantifying the transport mechanisms underlying the sediment import/export between the Wadden Sea and the North Sea is crucial in order to understand the response to past anthropogenic interferences and cope with future sea-level rise. The *lag effects* (e.g. *settling and scour lag*) are regarded to be among the main drivers of sediment import. However, a quantification of the sediment fluxes due to the lag effects is missing as well as a comparison with the other tidal mechanisms of barotropic origin, e.g. *tidal asymmetry* and *Stokes' drift.* The classic descriptions of the lag effects are Lagrangian and do not account for wind waves; process-based modelling needs such assumptions to be removed.

Methodology

Isolating the individual effects in an Eulerian framework is not straightforward. We propose an approach in which their aggregated bearing is defined by the difference between fluxes based on the full sediment balance equation and fluxes based on the equilibrium concentration. An observation-based, one-dimensional model for the Vlie basin is adopted. We investigate the relative contribution of the 3 mechanisms to the residual transport of silt and fine sand over the semidiurnal timescale. The influence of short wind waves on the mechanisms is considered.

Results and Conclusions

A distinct spatial difference is found. In absence of waves, lag effects are dominant in the whole subtidal area; tidal asymmetry leads in the intertidal part. Here, lag effects lose their exclusively sediment-importing character. Still, sediment import is found in all locations. When including wave forcing, the deeper region (below –2 m NAP) is unaffected. However, the residual seaward velocity compensating Stokes' Drift becomes the main mechanism in shallow channels, resulting in export. Onto the tidal flats, higher concentrations due to wave resuspension coupled to strongly flood-dominant tidal asymmetry enhance landward transport instead. Since "classic" no-waves dynamics of the 3 mechanisms is already altered for very mild weather conditions, the outcome points out the interaction between wind waves and tidal flow is key to understand the channel/flat sediment exchange.

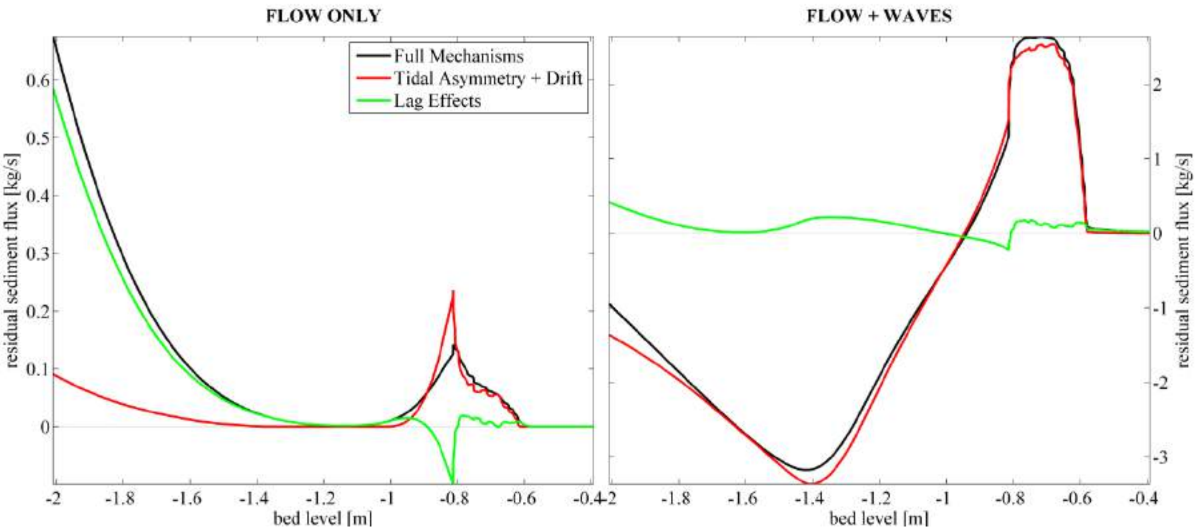


Figure 1: net semidiurnal transport of silt (D = 63 µm) in the Vlie basin, without (left) and with (right) wind waves. Positive (negative) values means import (export).

RICHEL: THE BIRTH OF AN ISLAND?

A.V. de Groot*, S. Brasseur, G. Aarts, E. Dijkman, R. Kirkwood
IMARES Wageningen UR, alma.degroot@wur.nl, sophie.brasseur@wur.nl, geert.aarts@wur.nl, elze.dijkman@wur.nl, roger.kirkwood@wur.nl

New island development is not very often observed in the Dutch Wadden Sea. Richel had long been an unvegetated sand bar, located on the Wadden Sea side of Vlieland. The past ten years, vegetation has established and an embryonic dune field has developed. The dune field is dominated by Sand Couch (*Elytrigia juncea*), and was in 2014 home to at least 18 other plant species. The outline of the dune field was more or less stable between 2011 and 2014. The groundwater is brackish to fresh, creating conditions that allow further growth into a white dune field. The area is intensively used by breeding birds and is the most important pupping site for Grey Seal (*Halichoerus grypus grypus*) in the Netherlands. Depending on the number and intensity of storms, and the sand budget of Richel, the area is expected to develop into a full ‘small island’ with dunes and salt marsh, or be eroded to become a bare sandflat once again.

Figure 8 Richel in 2014, looking in South-easterly direction. Photo: IMARES.

LONG-TERM PLANFORM EVOLUTION OF ESTUARIES AND TIDAL BASINS: LESSONS FROM THE HOLOCENE EVOLUTION OF THE DUTCH COAST

T. de Haas[1]*, H.J. Pierik[1], M.G. Kleinhans[1]
[1] Utrecht University, Faculty of Geosciences, t.dehaas@uu.nl

Estuaries are partly enclosed coastal bodies of water with one or more rivers flowing into them and with a free connection to the open sea. They have embayed or seaward widening planforms with coastal inlets and are partly filled with intricate patterns of shoals, tidal sand bars, mud flats and marshes and banks. These form on inherited topography and substrate under changing relative sea level, fluvial and coastal sediment inputs by tidal currents, local wind waves and density driven circulation.

How estuaries respond to changing conditions critically depends on the degree to which their perimeters are fixed by inherited surface geometry, substrate and dikes, or to what extent internal bio-geomorphological processes adapt the perimeters to externally imposed, changing fluvial and coastal boundary conditions. To date, there is no consensus on which processes dominantly determine the planform shape of estuaries. As a result, current understanding and predictive capabilities of large-scale estuary planform shape have critical gaps regarding effects of a) large-scale effects of internal biomorphodynamics of tidal flats, bars, marshes and banks, and b) externally imposed effects: geometry of the drowned valley or sedimentary coastal plain, size of rivers feeding freshwater and sediments, sealevel change and human interference.

We aim to pinpoint the main processes that determine estuary planform, by analysing the long-term planform evolution of estuaries and tidal basin along the Dutch coast during the Holocene. Temporal variations in basin size and channel area, intertidal and supratidal area will be quantified from existing paleogeographical reconstructions, and associated sediment budgets will be quantified. Temporal variations in estuarine planform will be correlated to external forcings such as sea level rise, fluvial input of fresh water and sediment and coastal input of sediment. Subquestions that we aim to answer with this analysis include: (1) how does river inflow influence estuarine planform and (2) how does fluvial mud supply influence the relative contribution of supratidal marshes to the total estuarine planform?

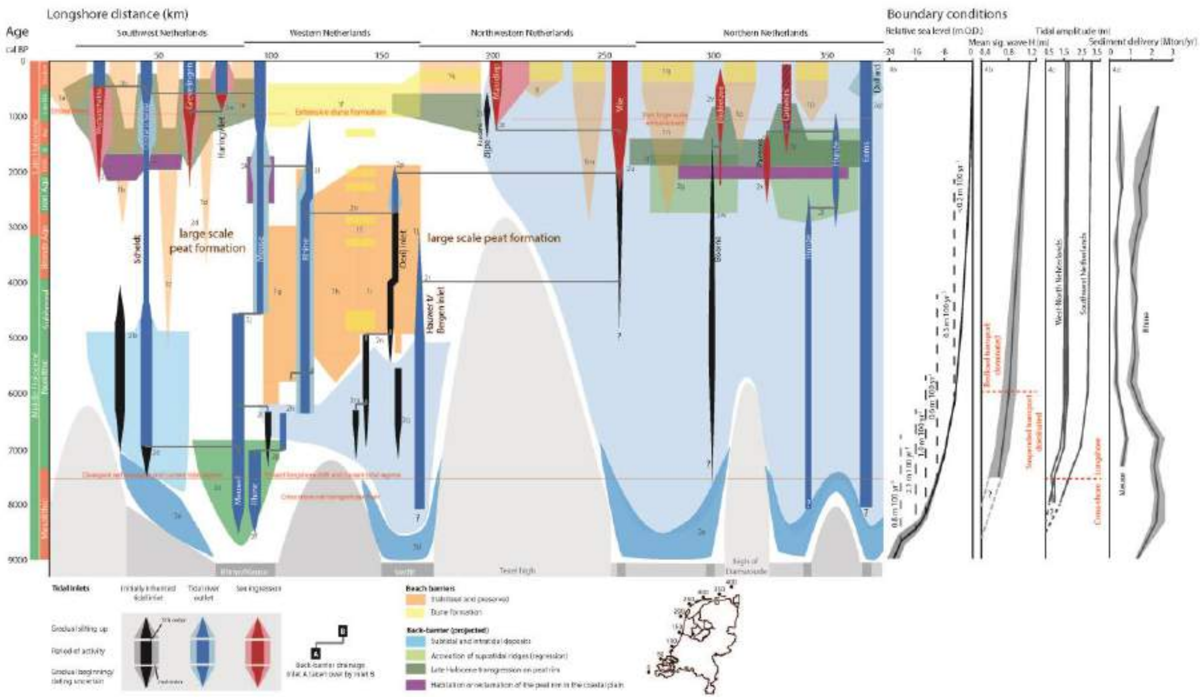


Figure 9: Longshore diagram on coastal plain development, showing the long-term temporal and spatial evolution of estuaries and tidal basins.

DETERMINING CHARACTERISTICS OF SAND STRIPS ON A NARROW BEACH BY USING VIDEO MONITORING

P.M. Hage[1]*, B.G. Ruessink[1], J.J.A. Donker[1]
[1] Utrecht University, P.M.Hage@uu.nl, B.G.Ruessink@uu.nl, J.J.A.Donker@uu.nl

Introduction

Wind can transport sand from the beach towards the dunes. The beach can become covered with patches of light-coloured dry sand that move over dark moist sand when this happens. These patches can form zebra-like stripes, which are known as sand strips. However, their characteristics and dynamics are not well understood, despite being common bedforms in wet aeolian systems. Research is needed to get insight about which wind conditions and beach characteristics result in high aeolian transport rates. This is especially important for narrow beaches, where many potential transport events do not always result in actual events, even though the wind velocity is high enough for it.
The first goal of this research is to characterise sand-strips from a multi-annual dataset of video imagery, focussing on their wavelength and migration velocity. The second goal is to study the dependence of these characteristics on wind velocity and direction.

Study site

The study site, located between Egmond aan Zee and Castricum in The Netherlands, is relatively narrow (100 m maximum at spring low tide), a N-S oriented, mildly sloping (~1:30) beach and consists of quartz sand with a median diameter of about 250µm. An ARGUS video system monitors the site. ARGUS is an optical remote sensing system, which consists at this site of five RGB-colour cameras that offer an 180^{O} beach view. The snapshots made between 2005 and 2013 were used. An automatic weather station in De Kooy, 35 km north of the study site, measured the corresponding hourly mean wind velocity and direction.

Methods and results

Firstly, the ARGUS images that did not show any signs of aeolian transport were excluded. Auto- and cross-correlation were used to determine the wavelength of sand-strips and their migration velocity.
Formation of sand strips starts at wind velocities around 8 m/s or higher, but only if the beach is broad enough. They occur more often during low tide because of this. The area just in front of the dunefoot is where they appear first most often. From there, they can spread seaward with the falling tide. This depends on the wind direction; during rare offshore winds, sand strips can form close to the water line. Winds from the southwest are most common though. Sand strips move alongshore from south to north under those wind conditions. They travel with a velocity of a few metres per hour, while their wavelength varies between 5 and 30m.

Conclusion and discussion

Argus has turned out to be a useful tool to study sand-strips, when they are numerous and clearly visible. 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.

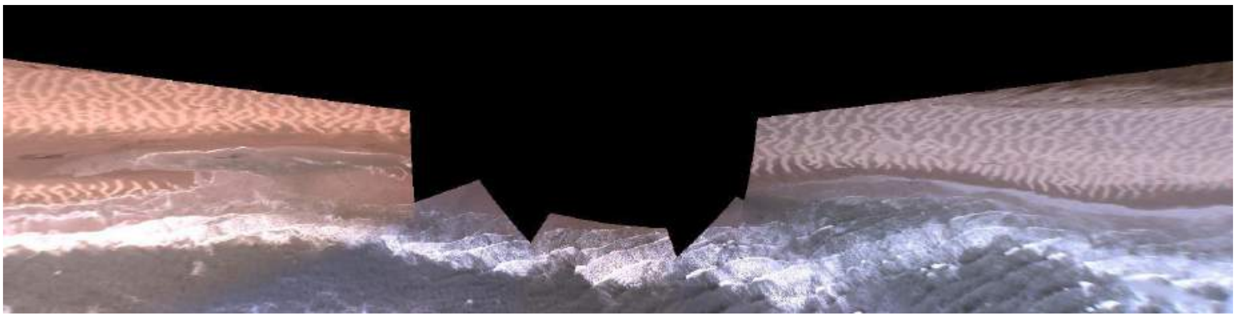


Figure 10 Plan view of the study site, showing a beach covered with sand strips. Source: ARGUS Coast3D tower.

THE DARK KNIGHT RISES

Can the invasive bivalve *Ensis directus* save our coasts?

Maria Hayden-Hughes, Simeon Moons, Tjeerd Bouma, Tom Ysebaert, Peter Herman

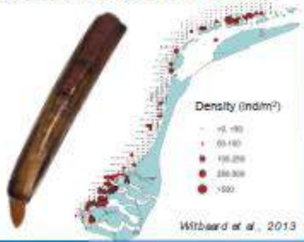
maria.h.h@btinternet.com simeon.moons@nioz.nl

The Dutch shore is threatened by erosion and invasive species. Can one problem solve the other?
Ensis directus **could be the hero the Netherlands deserves!**

1) *Ensis directus* is invading the Dutch coasts!

- Our dark knight, the American razor clam, invaded in 1977
- Now, it is the most abundant bivalve
- However, it occupies a unique hydrodynamic niche

Habitat and abundance of *E. directus* make it likely to influence erosion



2) Will *E. directus* act as natural sea defence?

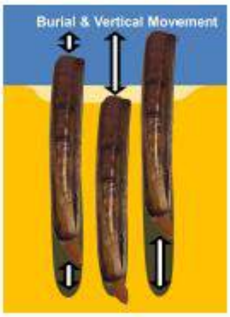
2 types of benthic behaviour affecting erosion

Biostabilization: protruding sessile organism
e.g. *tube building worms*

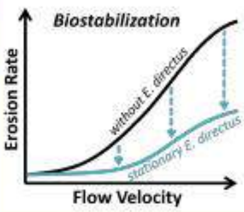
Bioturbation: burrowing activity
e.g. *amphipods*

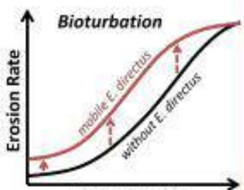
E. directus can do both

Stationary = Accretion

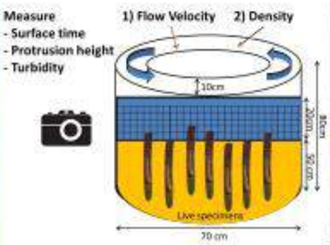


Mobile = Erosion





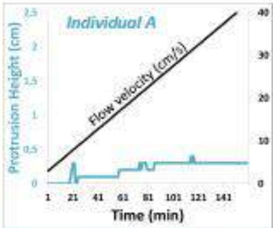
3) Behavioural Experiment in Annular Flume

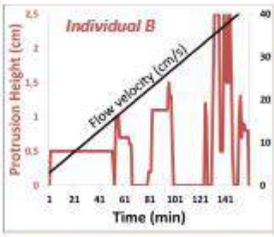


4) Preliminary results

"It's not who I am underneath, but what I do that defines me."

- Wide variety of vertical movement behaviour
- Vertical movement increases with flow velocity





5) What are the consequences for our coastline?

- Vertical movement behaviour of *E. directus* could be altering the stability of the coastline
- Spatial experiment is needed to determine when bioturbation exceeds stabilization

To be continued...

References:
Witbaard, R., Duineveld, G., & Bergman, M. (2013). *The Final Report on the Growth and Dynamics of Ensis Directus in the Near Coastal Zone Off Egmond, in Relation to Enviromental Conditions in 2011-2012.* NIOZ, Royal Netherlands Institute for Sea Research.

- Royal Netherlands Institute of Sea Research (NIOZ), Yerseke 4400AC, The Netherlands
- School of Ocean Sciences, Bangor University, Menai Bridge, Anglesey, LL59 5AB, UK

RESPONSE OF WAVE-DOMINATED AND MIXED-ENERGY BARRIERS TO STORMS

S. van Heteren[1], G. Masselink[2]
[1] TNO – Geological Survey of the Netherlands, sytze.vanheteren@tno.nl
[2] Plymouth University

The behaviour of coastal barriers is driven by a multitude of processes, including sub-annual fluctuations related to storm and post-storm conditions, and century-to-millennium-scale sea-level change. The response of barriers to storms, one of the main drivers of coastal change, is mainly a function of maximum storm runup and barrier morphology. Bar and berm flattening, beach lowering, dune scarping and scouring, channel incision, and barrier destruction, important erosive effects, are partly counterbalanced by depositional storm berms and beach ridges, localised vertical beach and barrier accretion, and washover formation. Site-specific factors such as storm type, duration and track, longshore sediment supply, shore-perpendicular currents, coastal setting and inner-shelf topography explain the differential nature of barrier response. This response can only be understood when barrier behaviour is assessed in a temporal context that does not just involve the extreme event under consideration, but also the morphological preconditioning due to antecedent hydrodynamics. For a proper understanding, a strong focus on thresholds, feedbacks, resilience and vulnerability is indispensable. The ‘resilience trajectory’ visualises and conceptualises non-linear barrier behaviour and long-term barrier vulnerability, showing changing barrier geometry over various time scales. A trajectory can be reconstructed using decadal records of barrier behaviour, and is key to understanding the influence of climate change on natural and developed coasts alike.

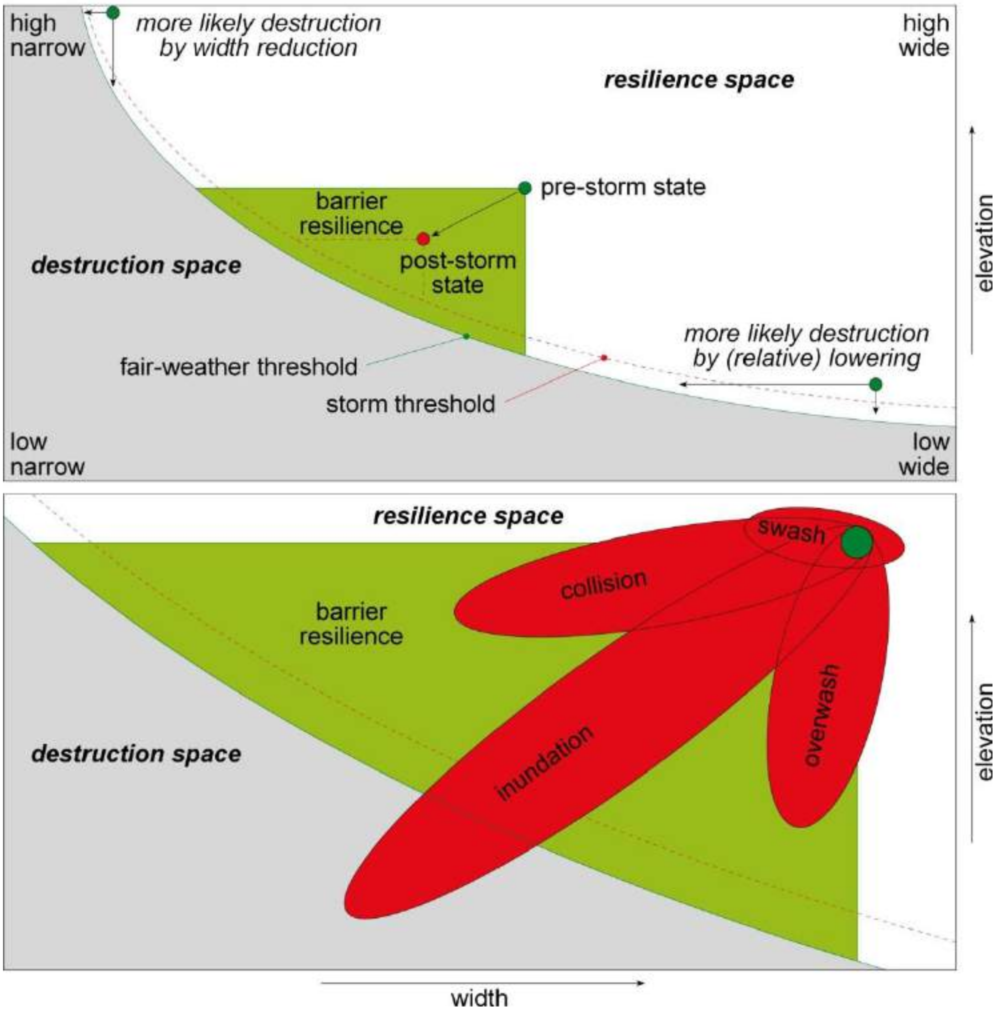


Figure 11 Concept of resilience and destruction space as a function of barrier width and elevation, which jointly determine its volume.

TWO THOUSAND YEARS OF EOLIAN ACTIVITY NEAR THE OLD RHINE ESTUARY PRECEDING AND FOLLOWING ITS ABANDONMENT

A.J.F. van der Spek[1], S. van Heteren[2]
[1] Deltares, ad.vanderspek@deltares.nl
[2] TNO – Geological Survey of the Netherlands

Seventeen recently acquired OSL ages shed new light on a 10-m-thick succession of dune sand intercalated with soil horizons at Groot Berkheijde near Wassenaar (western Netherlands). They provide the time control needed to reconstruct and understand phase-wise dune formation at the margin of an estuary in transition. This estuary of the Old Rhine river functioned as the main Rhine distributary between 5000 and 3000 years ago, started to deteriorate and fill up with mud after about 2000 years ago, and lost its function altogether in 1122 AD. In providing a changing paleogeographic context, it is considered to be one of the potential drivers of fluctuations in regional eolian activity. The OSL record obtained spans more than 2000 years, starting with the formation of an incipient cover of wind-blown sand on Subboreal cohesive clay and peat. In being pre-Roman, this first eolian phase commenced remarkably early. A humic unit, marked by a well-developed soil profile that formed shortly before 750 AD, is the most prominent of a series of discontinuities in eolian sedimentation, both pre- and post-dating estuary abandonment. When considered from a longer, century-scale perspective, sedimentation rates were fairly constant, averaging slightly less than 0.5 m per 100 years. Apparently, the supply of sand did not vary consistently as a function of estuarine state. Sand may have been provided in part through marine reworking of the Old Rhine delta, which had formed between 5000 and 3000 years ago. Remnants of this delta are located just offshore in an area of about 30 km^2 subject to shoreface erosion. The regional relevance of the long-term sedimentation constancy, observed at a single point located some 4 km from the former main Old Rhine channel, can only be established following additional dating of cores taken closer to the former river mouth. All dating results should be integrated in still-rudimentary long-term coastal sediment budgets to improve their accuracy and resolution. At present, time control on sand fluxes is still far from perfect; there is a strong need to increase the number of locations for which an accumulation chronology is available.

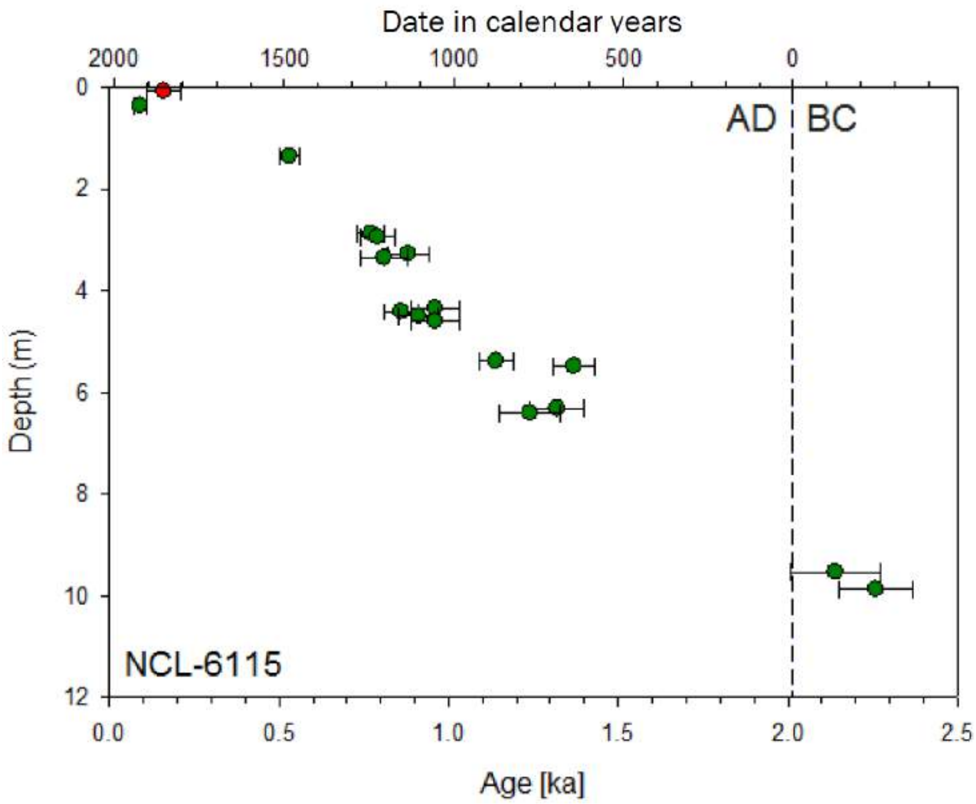


Figure 1 OSL ages of eolian succession at Groot-Berkheijde.

AEOLIS: A NEW MODEL FOR AEOLIAN SEDIMENT SUPPLY AND TRANSPORT

Bas Hoonhout[1,2], Sierd de Vries[1]
[1] Delft University of Technology, B.M.Hoonhout@tudelft.nl
[2] Deltares, Bas.Hoonhout@deltares.nl

AEOLIS (AEOlian transport LImited Supply) is a new numerical model for aeolian sediment transport that is first to account for spatiotemporal variations in aeolian sediment supply. Aeolian sediment supply can vary due to sorting of sediment and the development of beach armor layers. The model simulates the development of beach armor layers through multi-fraction aeolian sediment transport under variable wind speed and direction in a 2D horizontal domain.

AEOLIS also simulates tidal motions, wave stirring, infiltration and evaporation. High soil moisture contents tend to reduce aeolian sediment transport. Marine processes, such as tides and waves, tend to influence aeolian sediment supply by stirring of the top layer of the beach and breaking beach armor layers.

AEOLIS is applied to a series of four prototype cases (Figure 1) and two wind tunnel experiments showing how aeolian sediment transport can vary under constant wind conditions. The prototype cases show continuous sediment transport in case sediment sorting is not taken into account (P1). Sediment transport diminishes over time in case multiple sediment fractions are introduced and beach armoring occurs (P2). Combined with marine processes the model predicts a reduced sediment transport rate that originates primarily from the intertidal beach and depends on the tidal phase (P3). Finally, the important of high-energy wind events that (partially) reset the beach armor layer is illustrated (P4). The wind tunnel experiments show how the emergence of roughness elements (e.g. shells, cobbles) reduces aeolian sediment supply and how saltating sediment passes a patch of nonerodible gravel.

AEOLIS is the first aeolian sediment transport model that crosses the shoreline divide by simulating both sediment supply and marine processes. Currently, the model is applied in studies on the morphological development of the Sand Motor and the influence of (subtidal) bar welding on Aeolian sediment transport.

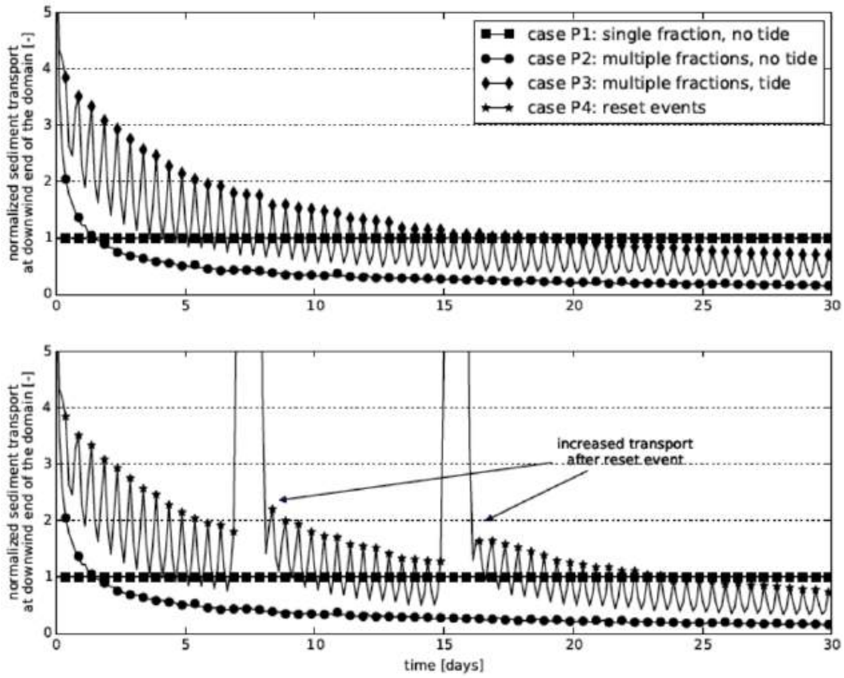


Figure 1. Top panel shows aeolian sediment transport time series for prototype cases P1, P2 and P3. Bottom panel shows the time series for prototype cases P1, P2 and P4.

SEDIMENT SORTING AT THE SAND MOTOR

B.J.A. Huisman[1,2], M.A. de Schipper[2], M.J.F. Stive[2], B.G.Ruessink[3]
[1] Deltares, Bas.Huisman@deltares.nl
[2] Delft University of Technology, M.A.deSchipper@tudelft.nl, M.J.F.Stive@tudelft.nl
[3] Utrecht University, B.G.Ruessink@uu.nl

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 the Sand Motor. Aim of the research was to assess the potential sorting at large scale nourishments and the underlying mechanisms.

Alongshore sorting

The bed composition at the Sand Motor was sampled (half-)yearly over a period of three years, which clearly showed alongshore sorting of the sediment (Figure 12). The median grain diameter (w.r.t. situation before construction) was up to 150μm coarser at the Sand Motor head and 50 μm finer at the adjacent coastal sections. It is envisaged that the sorting has consequences for the transport pathways of size fractions and the heterogeneity of the marine habitat for fish and benthic species.

Mechanisms

A Delft3D model was applied to assess the bed shear stresses and bed composition changes as a result of tide and waves. Increased tidal flow velocities at the head of the Sand Motor result in an increase of the time-averaged bed shear stresses (Figure 13). Consequently, the critical shear stress for erosion is exceeded more often here, which is especially relevant for the finer sediment fractions. The computed bed composition for a situation with only tide (Figure 3) showed similar alongshore sorting patterns as observed in the field, while wave conditions were far less relevant.

Conclusions

Current studies have shown that significant alongshore sediment sorting can take place at large scale coastal interventions, which is related to an increase of the tidal forces.

For the assessment of the environmental impact of future large scale coastal interventions it is highly recommended to assess the potential for alongshore sorting of sediment.

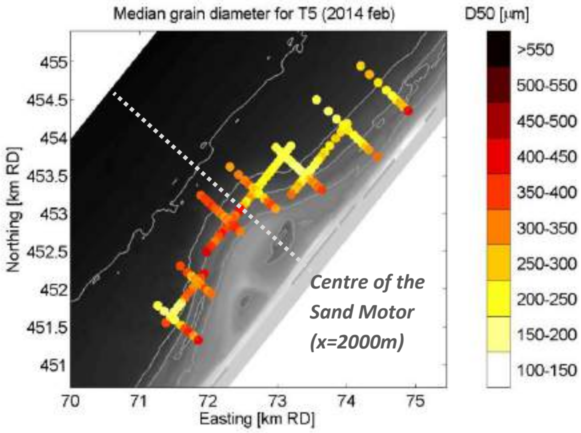


Figure 12 Measured median grain diameter at the Sand Motor (February 2014 survey)

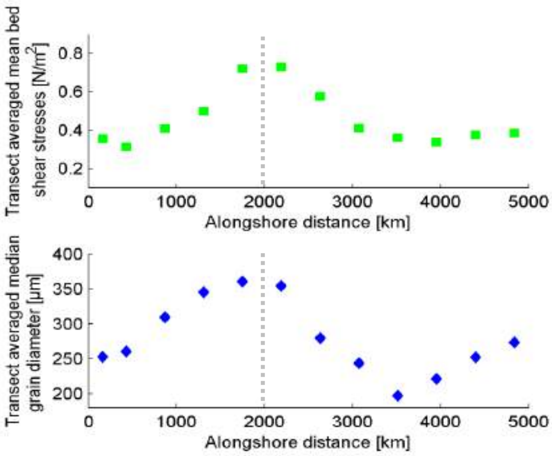


Figure 13 Inter-relation between time-averaged bed shear stress (for a month) and transect averaged D50

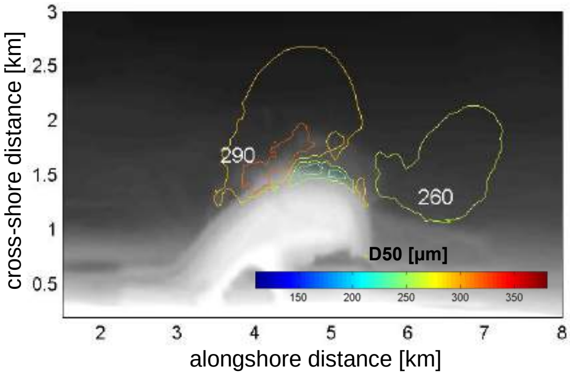


Figure 14 Modelled bed composition (D50) at the Sand Motor for a tide only situation (Delft3D)

MORPHODYNAMICS OF ESTUARINE CHANNEL NETWORKS

A.P. Iwantoro[1]*, M. van der Vegt[1]
[1] Utrecht University, a.pamungkas@students.uu.nl, M.vanderVegt@uu.nl

Description of research

The effects of tides on the morphodynamics of estuarine channel networks is still poorly understood. Bifurcations in rivers are often morphologically instable where one branch would be abandoned during avulsion. However, in more tide-dominated systems, the bifurcations seem to be more stable and both two branches keep open. The main aim of this study was to understand the effects of tides on the morphological evolution of an idealized estuarine channel network. It consisted of an upstream river that bifurcates into two downstream channels that are connected to the sea. By analysing the results obtained with a 2DH Delft3D model, we first identified the tidal propagation and sediment transport patterns in the system and subsequently examined the morphological development of the tidally-influenced junction. We analysed four different scenarios. First, the branches of the junction were set up to be different in depth. Second, the branches of the junction were set to be different in length. In both scenarios, the tide at the mouth of both branches was equal. The effect of the tide on the stability of the junction was examined by varying the tidal amplitude. Third, the configuration of both branches was set to be equal but the branches were forced with different tidal amplitude at the mouth. Fourth, a different tidal phase at the seaward of the branches is combined with the similar configuration of the branches. For the first and second scenario, the unequal geometry causes differences in tidal deformation along the channel, so the transport capacity in the branches becomes more unequal. As a result, the tides enhanced the morphological evolution that would occur in the absence of tides. For the third and fourth scenario, the different tidal forcing induces the tidal propagation from one branch to another. This propagation causes the erosion at the junction that maintains the two branches to keep open except for the tidal phase difference on both branches is below 45 degrees. These results indicate that equal tidal forcing enhances the morphological instability that would occur in a river-only situation while the different tidal forcing can cause the junction to be more stable.

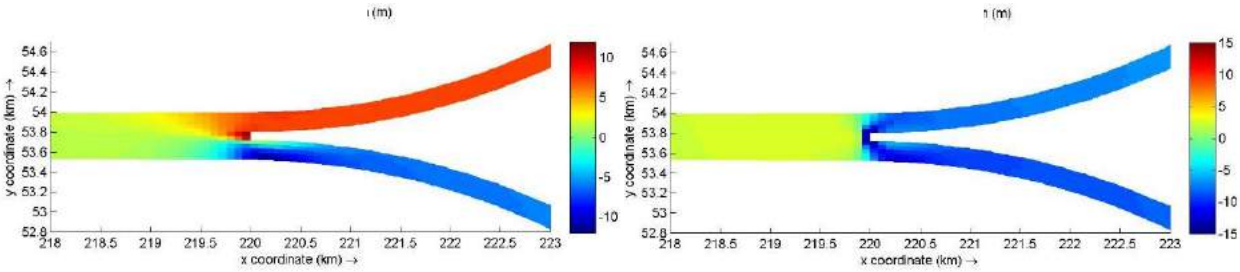


Figure 15. The left panel: the erosion and deposition pattern after 100 years simulation of bifurcation with the different length branches (the bottom branch has a shorter length (15 km) and the top branch is longer (30 km)) and imposed by an equal tidal forcing at the entrance of the two branches. The right panel: the 100 years morphological evolution of bifurcation with equal branches configuration and different tidal amplitude between branches (the tidal amplitude in the bottom branch is 0.25 m and in the top branch is 1 m).

THE ECOLOGICAL EFFECTS AND POTENTIAL OF DEEP SAND EXTRACTION ON THE DUTCH CONTINENTAL SHELF USING ECOSYSTEM-BASED DESIGN

Maarten de Jong[1]
[1] Arcadis

Sand extraction on the Dutch continental shelf is still increasing and reached volumes of 12 million m^3 of sand for nourishments and 9 million m^3 for construction. During the construction of Maasvlakte 2 (MV2), a 20 km^2 seaward expansion of the Port of Rotterdam, the Dutch authorities permitted sand extraction deeper than the regular 2 m, primarily to decrease the surface area of direct impact. Between 2009 and 2013, approximately 220 million m^3 sand was extracted from the MV2 borrow pit with an average extraction depth of 20 m under the seabed.. To counter the effects of sea-level rise, an increase up to 85 million m^3 is foreseen. The Dutch authorities now allow deep sand extraction to guarantee sufficient supply of marine sand in the intensively used coastal zone. Although the effects of nourishment received considerable attention, knowledge on deep sand extraction is only recently collected.

Wise application of sand extraction depths beyond 2 m can help to maximize sand yields and simultaneously decrease the surface area of direct impact. Furthermore, ‘new’ seabeds in borrow pits can be enriched with ecosystem-based sand bars or other configurations to increase habitat heterogeneity. A first pilot study revealed the applicability and efficiency of ecological landscaping. Sediment characteristics, biomass and species composition of organisms living in and on the seabed and demersal fish changed significantly.

Ecological data is needed for intermediate sand extraction depths (e.g. Euromaasgeul, Sand engine and HPZ) next to long-term data of the effects of deep sand extraction (MV2). For inter-comparison between sand extraction case studies, 2DH tide-averaged bed shear stress was used as a generic proxy for changed environmental conditions and related ecological effects. More sophisticated 3D models can reveal more realistic values and include more complex hydrodynamic phenomena such as flow channeling which may arise when the large number of solitary borrow pits become interconnected. Ecosystem-based design rules for future borrow pit can be designed based on bed shear stress values and ecological data.

TURNING THE TIDE: EFFECTS OF RIVER INFLOW AND TIDAL AMPLITUDE ON SANDY ESTUARIES IN THE METRONOME TIDAL LABORATORY FACILITY

Maarten Kleinhans, Lisanne Braat, Jasper Leuven, Anne Baar, Maarten van der Vegt, Marcel van Maarseveen, Henk Markies, Chris Roosendaal, Arjan van Eijk
Universiteit Utrecht, Faculty of Geosciences, m.g.kleinhans@uu.nl

Description of research

Many estuaries formed over the Holocene through a combination of fluvial and coastal influxes, but how estuary planform shape and size depend on tides, wave climate and river influxes remains unclear. Here we use a novel tidal flume setup of 20 m length by 3 m width, the Metronome (http://www.uu.nl/metronome), to create estuaries and explore a parameter space for the simple initial condition of a straight river in sandy substrate. Tidal currents capable of transporting sediment in both the ebb and flood phase because they are caused by periodic tilting of the flume rather than the classic method of water level fluctuation. Particle imaging velocimetry and a 1D shallow flow model demonstrate that this principle leads to similar sediment mobility as in nature. Ten landscape experiments recorded by timelapse overhead imaging and AGIsoft DEMs of the final bed elevation show that absence of river inflow leads to short tidal basins whereas even a minor discharge leads to long convergent estuaries. Estuary width and length as well as morphological time scale over thousands of tidal cycles strongly depend on tidal current amplitude. Paddle-generated waves subdue the ebb delta causing stronger tidal currents in the basin. Bar length-width ratios in estuaries are slightly larger to those in braided rivers in experiments and nature. Mutually evasive ebb- and flood-dominated channels are ubiquitous and appear to be formed by an instability mechanism with growing bar and bifurcation asymmetry. Future experiments will include mud flats and live vegetation.

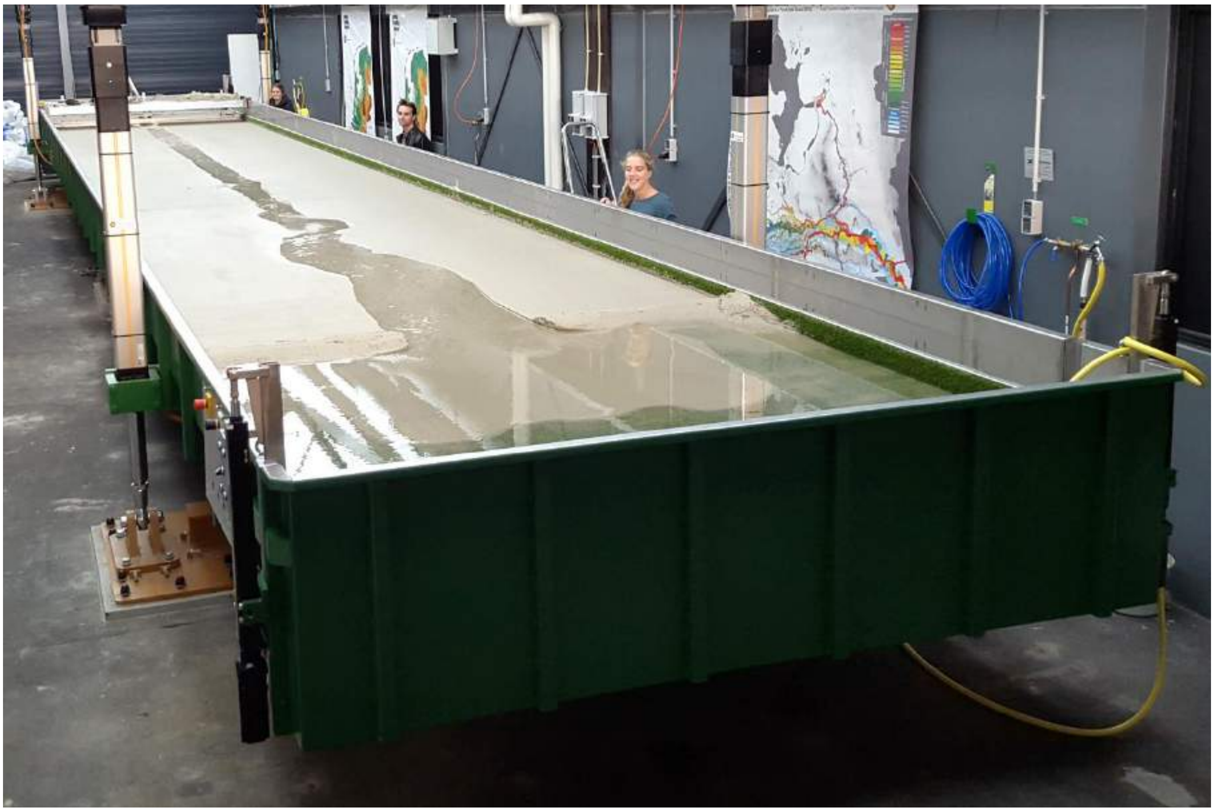


Figure 16 A first experimental estuary in the Metronome with river inflow and tidal tilting, but no waves (yet). Lisanne, Jasper and Anne for scale from back to front.

WATER QUALITY MONITORING USING NEW SENTINEL SATELLITE DATA

E. Knaeps[1,]*, L. De Keukelaere[1], R. Van De Kerchove[1], R. Raymaekers[1], S. Sterckx[1], I. Reusen[1]
[1] VITO, els.knaeps@vio.be

In June 2015 the new Sentinel -2A satellite from the Copernicus program was launched. The data, which is now freely available, provides a wealth of information for studying the coastal zone. Although it was designed as a land mission, with specific characteristics to study the vegetation on land, it has already proven to provide high quality data over the coastal waters. In February this year another satellite from the Copernicus program will be launched: Sentinel-3. Sentinel-3 will provide daily observations of our coastal areas but has a lower spatial resolution than Sentinel-2.
Here we show how these satellites can be used to study the water quality in our coastal waters and provide valuable information to support large scale construction works. Whereas Sentinel 3 can provide an overall view of the site, Sentinel-2 allows to derive more detailed information in the harbours, rivers and estuaries. We show the variety of parameters that can be derived and the pre-processing steps needed to come to high quality end products.

The research presented here is undertaken in the framework of two European FP7 projects (INFORM and Highroc).

Figure 17 True colour image of the Scheldt imaged by the Sentinel-2sensor.

BUILDING WITH NATURE IN PRACTICE: BROUWERSEILAND

A. Kramer[1],
[1] Royal Boskalis Westminster, astrid.kramer@boskalis.com

The Building with Nature (BwN) program officially started in 2007. Since then many pilot experiments in which the principle of BwN was applied have been carried out. This principle consists of working with the natural system as to meet society's infrastructural needs and stakeholders interests, while creating new opportunities for nature. A full scale application of Building with Nature outside Ecoshape can be found in the project Brouwerseiland (Figure 1).

Figure 18: Project location (left) and artist impression Brouwerseiland (right). Sources: Google Earth and Zeelenberg Architecture.

Located along the Brouwersdam in the most western part of the Grevelingen the work harbour Middelplaathaven will be reconstructed into an archipelago of islands dedicated to recreational housing, development of natural habitat and employment opportunities in the province of Zeeland and beyond.

Environmental studies of the project area and consultation with stakeholders resulted in a design aiming to enhance the marine and terrestrial system. The current flora and fauna in the Middelplaathaven is strongly determined by limited currents, limited variety in 3-dimensional structures and slightly contaminated sediment. Through facilitation of the boundary conditions for oyster habitat, placement of complex artificial reefs, re-use of overgrown hard substrate, capping of the contaminated sediment in combination with an optimized current profile (reduction of water depth) a significant increase of the marine bio-diversity hence ecological value is expected. Onshore, the islands will be constructed in such a way as to stimulate development of (wet) dune vegetation as to form a link with the Natura 2000 habitats in the Grevelingen.

Although the application of the Building with Nature principle has resulted in an improved ecological design approved by many stakeholders, the project is also subject to discussion owing to different interests between stakeholders and project developers. Additionally, the uncertainties in the translation of a conceptual idea into a practical design result in a discrepancy between species requirements and practical design parameters. Insight on the latter will be generated from in-situ monitoring and evaluation. Overall, we believe application of the concept of Building with Nature will add ecological and societal benefits to the Brouwerseiland project as well as beyond, and facilitates decision making processes towards project realization.

DESIGN OF MODELLING SEQUENCE FOR THE ASSESSMENT OF ECOLOGICAL VALUE OF ARTIFICIAL REEFS IN THE NEAR SHORE ENVIRONMENT

M. E. N. Kroon
Delft University of Technology, m.e.n.kroon@student.tudelft.nl

Introduction

Natural reefs are important habitats for a wide range of species. Furthermore, they attenuate waves and thereby protect the leeside, functioning as coastal protection. Many reefs are however eroding or degraded, leading to a loss of these ecosystem services. Artificial reefs can reverse this negative trend. The artificial reefs in this context are meant to restore or complement rocky reef environments in temperate to sub-tropical coastal waters. Such reefs can be created by 3D printers, providing a variety of possible shapes and local topographies. The design of a successful artificial reef is however not straightforward. The interaction between the complex topography and the flow is an important physical property of a reef, determining the success of habitability for certain species. In this study, we aim to develop tools/guidelines to design the artificial reefs in order to increase the success rate of artificial reefs.

Methodology

From literature study it was established that velocity profiles over potential habitat is an important physical property of a reef which determines the success of habitability for certain species.
A modelling sequence is developed to translate offshore wave data to detailed velocity profiles near the face of the structure, for a given design. Modelling is done in a 2DV environment. MET-ocean wave data is used as input for the SWAN wave model, to translate offshore wave conditions to a near shore wave climate. SWAN output is analysed by means of an extreme value analysis, creating input for large-scale computations with XBeach. In XBeach a first order approximation of location and dimensions of the reef, taking into account wave attenuation. SWASH is used to model the reef setup in detail. The model is calibrated with data collected in an experimental setup, shown in Figure 1. The 3D printed structure has been simplified to a steel plating with fixated rock, which resembles the porosity and cavity size of the 3D printed surface.

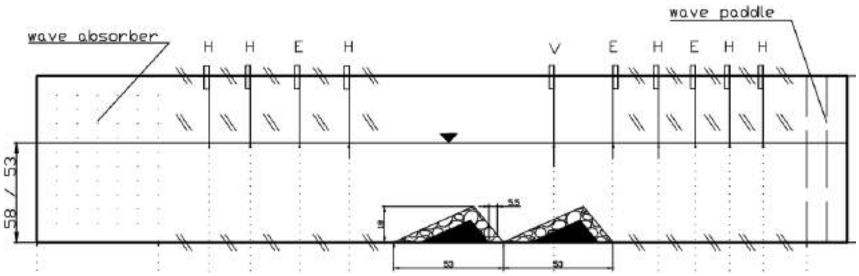


Figure 1-Physical model setup in flume

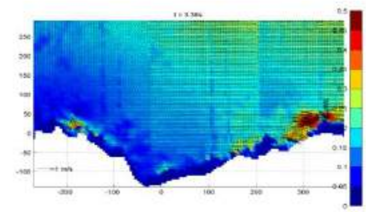


Figure 2 - PIV measurement of velocity in depression between modules

Results & Discussion

Figure 2 shows velocity measurements in the laboratory setup. This data is used for calibration of the SWASH model. In addition it gives insight in turbulent eddies that develop over the structure. This is not elaborated on in this research, only the mean velocity fluctuations are analysed. Analysis of wave height measurements proved the test setup to be of insufficient impact to attenuate the waves. Therefore an increase of units in the cross shore direction is advised.
Reefs printed as monolithic structures provide that habitat can be designed and printed in great detail. Applied in a staggered field, units collectively functions as a low crested structure.
It is expected that the prototype scale SWASH model is sufficiently accurate to predict ecological value by means of velocity profiles for the given target species and case study location. Preliminary results show a correlation R^2 between measurements and SWASH computations of water level between 0.85 -0.99 and velocities *u* and *v* of 0.8 – 0.95.
Other physical aspects influence ecological value, for example turbidity, turbulence and longshore currents. These should be accounted for in a later stage.

BAR DIMENSIONS AND SHAPES IN ESTUARIES

J.R.F.W. Leuven, M. van der Vegt, S.A.H. Weisscher, M.G. Kleinhans
[1] Utrecht University, j.r.f.w.leuven@uu.nl

Estuaries comprise fascinating patterns of dynamic channels and bars. Intertidal sandbars are valuable habitats, whilst channels provide access to harbours. We still lack a full explanation and classification scheme for the shapes and dimensions of bars in natural estuaries, in contrast with bars in rivers. Analytical physics-based models suggest that bar length in estuaries increases with flow velocity, tidal excursion length or estuary width, depending on the model. However, these hypotheses have never been validated due to a lack of data and experiments. We present a large dataset and determine the controls on bar shapes and dimensions in estuaries, with bar lengths spanning from centimetres (experiments) to tens of kilometres. To do so, we visually identified and classified 190 bars in real world estuaries, measured their dimensions (width, length, height) and local braiding index. For the estuaries used, data on estuarine geometry and tidal characteristics were obtained from governmental databases and literature on case studies. We found that many complex bars can be seen as simple elongated bars partly cut by mutually evasive ebb- and flood-dominated channels. Data analysis shows that bar dimensions scale with estuary dimensions, in particular with estuary width. Breaking up the complex bars in simple bars greatly reduces scatter. Analytical bar theory overpredicts bar dimensions by an order of magnitude in case of relatively small estuarine systems. Likewise, braiding index depends on local width-to-depth ratio, as was previously found for river systems. Our results suggest that estuary dimensions determine the order of magnitude of bar dimensions, while tidal characteristics modify this. We will continue to model bars numerically and experimentally. Our dataset on tidal bars enables future studies on the sedimentary architecture of geologically complex tidal deposits and enables studying effects of man-induced perturbations such as dredging and dumping on bar and channel patterns and ecological habitats.

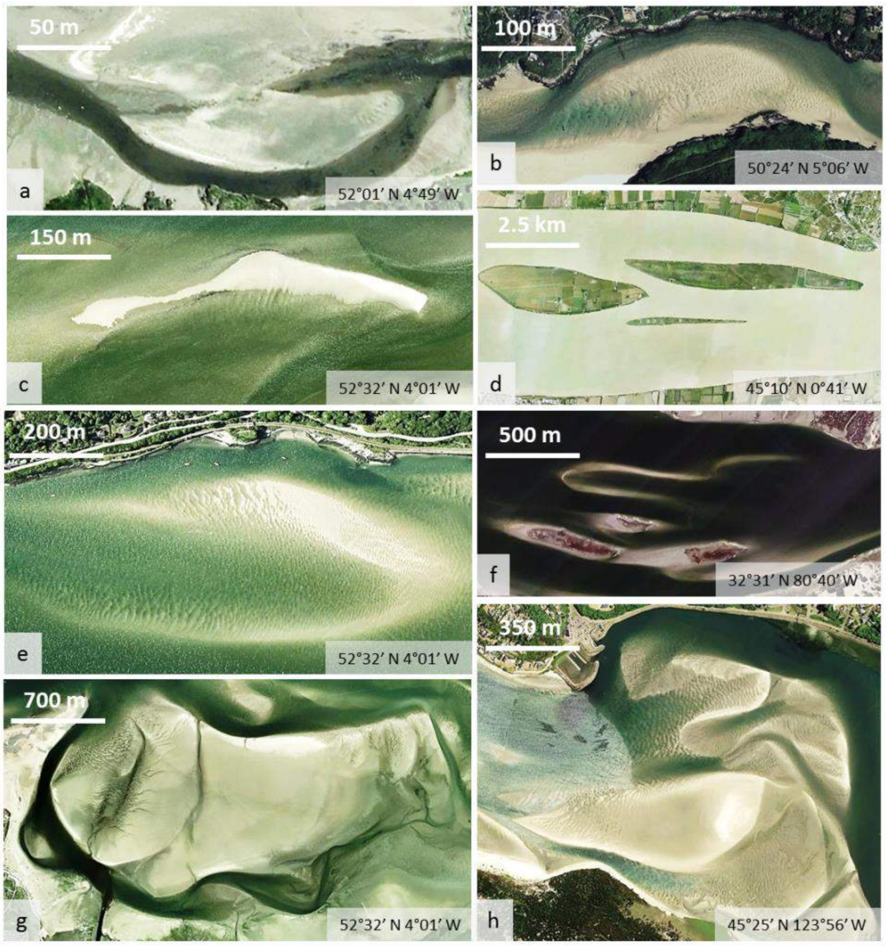


Figure 1: Aerial photographs of estuarine bars. Sidebar in the (a) Nyfer estuary (UK) and (b) Gannel estuary (UK); elongated bar in the (c) Dovey estuary (UK) and (d) Gironde estuary (Fr); u-shaped bar in the (e) Dovey estuary (UK) and (f) St. Helena estuary (USA); complex bar in the (g) Dovey estuary (UK) and (h) Netarts Bay (USA). In all cases flood flow is from left to right. Google Earth, accessed May-September 2015. Coordinates are in degrees longitude and latitude.

TOWARDS A NEW WAY OF CALCULATING THE DUTCH ANNUAL NOURISHMENT VOLUME

Quirijn. J. Lodder[1,2]
[1] Rijkswaterstaat, Quirijn.Lodder@rws.nl
[2] Delft University of Technology

1. Introduction

Rijkswaterstaat is responsible for the execution of the Dutch coastal zone management policy. This presentation gives an overview of the development of the total Dutch nourishment volume and will propose a new way of calculating the annual nourishment volume.

2. Nourishment volume

The current Dutch coastal zone policy of dynamic preservation of the coastline has, in essence, been in effect since 1990. In 1990 the Netherlands started maintaining the coast by means of sand nourishments. Since 1990 the scale of the nourishments increased in volume, number and type. With the start of the dynamic preservation policy an annual nourishment volume of 6 million m^3 was expected. However as shown in figure 1 the average annual nourishment volume was 7.5 million m^3 from 1991 to 2000. From 2001 the average annual nourishment volume has been increased to 12 million m^3 on average to compensate for sediment losses in deeper water. Figure 1 shows that the actual placed nourishment volume is slightly lower than 12 million m^3 namely 11 million m^3. This average is expected to increase in 2016 and 2017 due to upcoming already tendered nourishments.

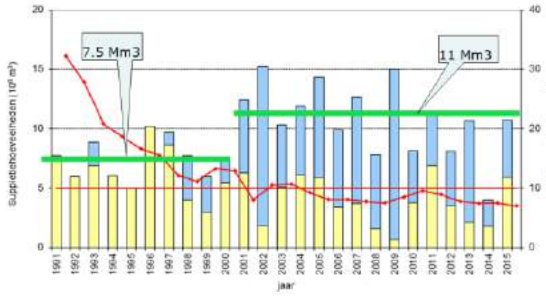


Figure 1: Average nourishment volume for coastal maintenance 1991 - 2015. In yellow beach nourishment, in blue shore face nourishment, red line with dots percentage of BKL exceedance.

Besides the annual nourishment volume for coastal maintenance over 100 million m^3 of sand has been added to the coast for coastal reclamations and reinforcements of the primary flood defences.

3. Current calculation of the annual nourishment volume

An overarching goal of the dynamic preservation is to add the same volume of sediment to the coastal system as is needed to keep the coastal system in balance with sea level rise. The total nourishment volume is calculated based on the schematisation of the coast as given in figure 2. This schematisation of the coast is based on the assumption that sediment losses occur in the active coastal system (Kustfundament = KF) due to sea level rise and sediment losses to the Western Scheldt (Ws) and the Wadden Sea (Wz). The sediment losses in both the active coastal system and towards the basins are thought to be equal to the basin area times the occuring sea level rise.

Following these assumptions the average annual nourishment volume is calculated as follows:

Vnour = (Akf+Awz+Aws)*SLRact = 12Mm^3 per year

With A= Area; SLRact = actual sea level rise.

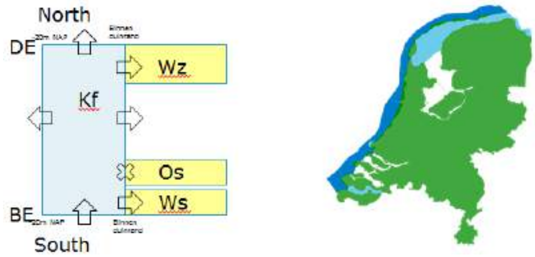


Figure 2: Schematisation of the Dutch coast.

4. Towards a new way of calculating the nourishment volume

In recent years Rijkswaterstaat has executed multiple research projects which provide evidence that the underlying assumptions of the annual nourishment volume might need to be revised. In this presentation these we will summarize this research, present a possible alternative for calculating the annual nourishment volume and outline the upcoming additional research needed implement a final new calculation method and nourishment volume.

MODELLING THE EFFECTS OF SEA LEVEL RISE ON TIDAL CHANNEL NETWORKS AND MANGROVE HABITAT EVOLUTION

B. van Maanen[1]*, G. Coco[2], K.R. Bryan[3]
[1] Utrecht University, The Netherlands, b.vanmaanen@uu.nl
[2] University of Auckland, New Zealand
[3] University of Waikato, New Zealand

The evolution of tidal basins and estuaries in tropical and subtropical regions is often influenced by the presence of mangrove forests. These environments are amongst the most productive systems in the world and are characterized by striking landscape patterns (fig. 1). However, these intertidal habitats are also extremely vulnerable and are threatened by climate change impacts such as sea level rise. It is therefore of key importance to improve our understanding of how tidal systems occupied by mangrove vegetation respond to rising water levels.

An ecomorphodynamic model was developed that simulates morphological change and mangrove forest evolution as a result of mutual feedbacks between physical and biological processes. The model accounts for the effects of mangrove trees on tidal flow patterns and sediment dynamics. Mangrove growth is in turn controlled by hydrodynamic conditions. Under stable water levels, model results indicate that mangrove trees enhance the initiation and branching of tidal channels, partly because the extra flow resistance in mangrove forests favours flow concentration, and thus sediment erosion in between vegetated areas. The landward expansion of the channels, on the other hand, is reduced.

Model simulations including sea level rise suggest that mangroves can potentially enhance the ability of the soil surface to maintain an elevation within the upper portion of the intertidal zone. While the sea level is rising, mangroves are migrating landward and the channel network tends to expand landward too. The presence of mangrove trees, however, was found to hinder both the branching and headward erosion of the landward expanding channels. Changes in the properties of the tidal channel networks are examined as well. Overall, model results highlight the role of mangroves in driving the morphological evolution of tidal systems and emphasize the need to account for ecomorphodynamic feedback mechanisms when assessing sea level rise impacts.

Figure 19 Tidal channel network and mangroves in the Rangaunu Harbour, North Island, New Zealand. Photo courtesy of the Department of Conservation, NZ.

FLOW SLIDE ON THE TIDAL FLAT OF WALSOORDEN IN THE WESTERN SCHELDT

D.R. Mastbergen[1], S.J. van Schaick[2], J.J. van der Werf[1], R.A. Schrijvershof[1]
[1] Deltares, Dick.Mastbergen@deltares.nl, Jebbe.vanderWerf@deltares.nl, Reinier.Schrijvershof@deltares.nl
[2] Delft University of Technology

Flow slides are a common phenomenon in tidal flat margins in estuaries and along river banks and coasts where fine sands and deep channels are present. Along the Eastern- and Western Scheldt, flow slides are reported since 1800. Before the Delta works were completed in 1987 and stone protection was applied on many vulnerable fore shores, dike collapse due to flow slides was a severe flood threat. On the 22nd of July 2014 a shipper reported that he saw a 'slide' with 'cracks' taking place on the southern bank of the tidal flat of Walsoorden. A week later multibeam bathymetry measurements were performed. A large gap had opened (Figure 1) and 850 000 m^3 of sediment was deposited in the channel. The navigational depth turned out to be reduced by over 7 m and additional dredging was commissioned by the Port of Antwerp. In the framework of the Dutch-Belgium 'Flexibel Storten' policy, monthly measurements are being performed on several dumping locations and it was decided to extend the survey area to the location of the slide.
Meanwhile, the location was selected to perform the IJkdijk / Flood Protection validation test. A flow slide was initiated by dredging and continuously surveyed with three vessels. Vibrocore boreholes and bottom samples were analysed. Several steep 6 m high breaches developed and slowly retrogressed into the shoreline, but eventually stopped. The involved volumes remained only small compared to the 22 July flow slide.

Figure 1 Aerial view of the gap created by the 22 July 2014 flow slide on the tidal flat of Walsoorden, Zuidergat and in the distance Perkpolder (E. Paree, September 2014).

The detailed and frequent bathymetry surveying combined with the soil investigation gives us a unique database of the geomorphological recovery of the system on meso-scale after a large event. The transport and erosion of the sand deposited in the tidal channel was analysed and compared with numerical computations (Delft3D). The sedimentation patterns in the gap and the composition of the sediment structures were analysed in more detail. This results in some new insights in transport patterns of sand by migrating dunes in the channel and along the tidal flat margins and the development of mud and clay layers.

Shaping the coast(-al community)

J. J. S. Moons[1]*, T. Ysebaert[1], P. M. J. Herman[2]
[1] NIOZ, Simeon.Moons@nioz.nl, Tom.Ysebaert@nioz.nl
[2] Deltares, Peter.Herman@deltares.nl

Ecosystem under pressure

More than 70% of the world's beaches is experiencing erosion. The coastal zone is squeezed in between the rising sea level and the urban growth. To protect urban areas from flooding many beaches are nourished. An immediate consequence is death by burial of the local macrozoobenthos, a key player in coastal ecosystems. The frequent disturbance of the shoreline by nourishments can have a cumulative and long lasting effect on the ecosystem. Future climate conditions and coastal urban growth will even increase this pressure. Now is the time to study the design of a sustainable coastline.

Figure 20 Macrozoobenthos found at the Dutch shoreface. Source: JJS Moons

Is bigger better?

The present study investigates the long-term effects of shoreface nourishments on the macrobenthos and the impact of a novel nourishment design, the Sand Motor. The Sand Motor is a mega-nourishment pilot that started in 2011 at the Dutch coast, the area has been monitored since then. A chronosequence of regular shoreface nourishments was constructed by sampling 14 previously nourished areas along the Dutch coast, as well as 4 unnourished areas.

Nourishment design matters

Results clearly show a change of the macrobenthic community over time after disturbance. Biodiversity is distinctly lower after recent shoreface nourishment activities, it increases over the course of 10 years but it does not reach the biodiversity found at unnourished areas. Furthermore, sediment grain sizes appear to increase at recently nourished sites, affecting the community composition. In contrast, the Sand Motor increases environmental heterogeneity, thereby increasing biodiversity along the coastline, though it is still evolving. Nourishment design thus seems to make a big difference on the community response and should be considered carefully in making long-term predictions.

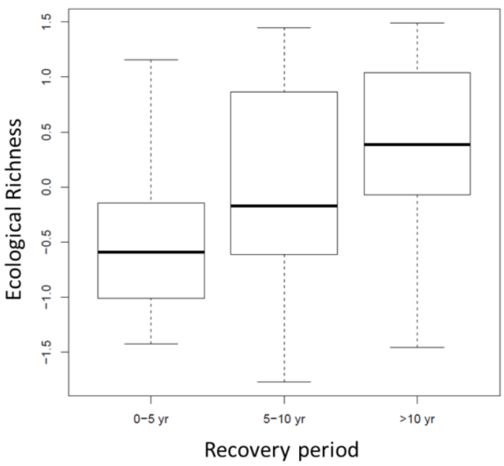


Figure 2 Macrobenthic Ecological Richness (comprises species richness, abundance and biomass) after 0-5, 5-10, or over 10 years of recovery since last shoreface nourishment.

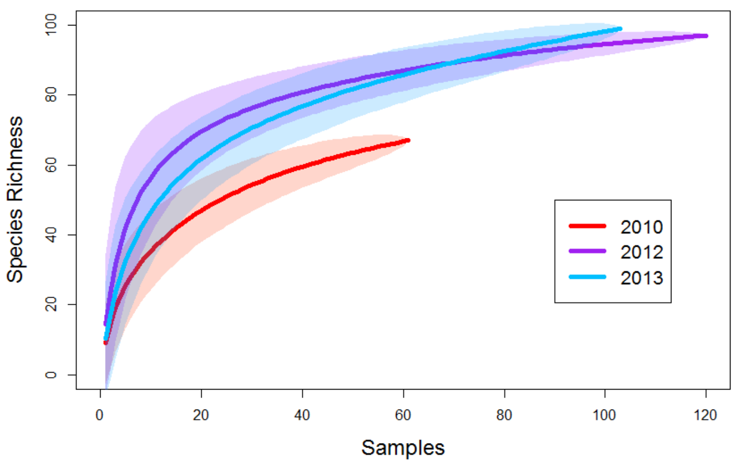


Figure 3 Species accumulation curve showing the number of macrobenthic species or higher taxa found at the Sand Motor, before construction in 2010, and after construction in 2012 and 2013. Average (hard line) and standard deviation (transparent band) are calculated by randomly adding samples (1000 permutations).

TIDAL ENERGY EXTRACTION IN THE MARSDIEP INLET
BLUETEC: WORLD'S 1ST FLOATING TIDAL ENERGY CONVERTER

J.J. Nauw[1]*, W. Lenting[1], M.G. Smit[1]
[1] NIOZ, janine.nauw@nioz.nl, walther.lenting@nioz.nl, marck.smit@nioz.nl

Abstract
Since 11 May of last year, the world's first floating tidal energy power plant BlueTEC Texel tidal energy platform is placed in the Marsdiep inlet, just south of the NIOZ. The unique cooperation between Bluewater, Damen, Van Oord/Acta Marine, Tocardo, Schottel Hydro, TKF, Vryhof, NIOZ, Nylacast and Tidal Test Centre bundles extensive experience in the maritime and offshore industry, in the field of design and operation of mooring platforms, shipbuilding, offshore dredging and installation, tidal turbines, power cables, anchors, research at sea and synthetic materials. The platform went from the drawing board to a grid-connected operating reality in just 6 months. The BlueTEC platform serves as a demonstrator model. Beneath the platform a tidal stream turbine is placed; at first with the T1 from Tocardo, which has recently been replaced by a T2 turbine, which has a larger rated capacity. A combined current & optic fiber cable connects the BlueTEC to the island of Texel; the power generated is put into the net of NIOZ and data can be transmitted through the cable instantaneously. In the years prior to the placement of the BlueTEC, necessary research has been performed. First of all, the optimal location was determined with in-situ observations, followed by long-term measurements to estimate the annual power output, a detailed investigation of the local current variability and tests have been performed with the free stream tidal turbine. Currently, a benchmark monitoring plan is in operation using Acoustic Doppler Current Profilers (ADCPs); one on either end of the platform to monitor in- and outflow conditions and one nearby on the sea floor to determine the local wave conditions. In the current study, the effect is of extracting energy at the BlueTEC on the physical environment, in terms of currents, suspended sediments and the bathymetric effects will be investigated. Moreover, the effects of the environmental factors on the stability of the platform and the efficiency of the turbine, e.g. (sheared) currents, waves and the wind will also be examined.

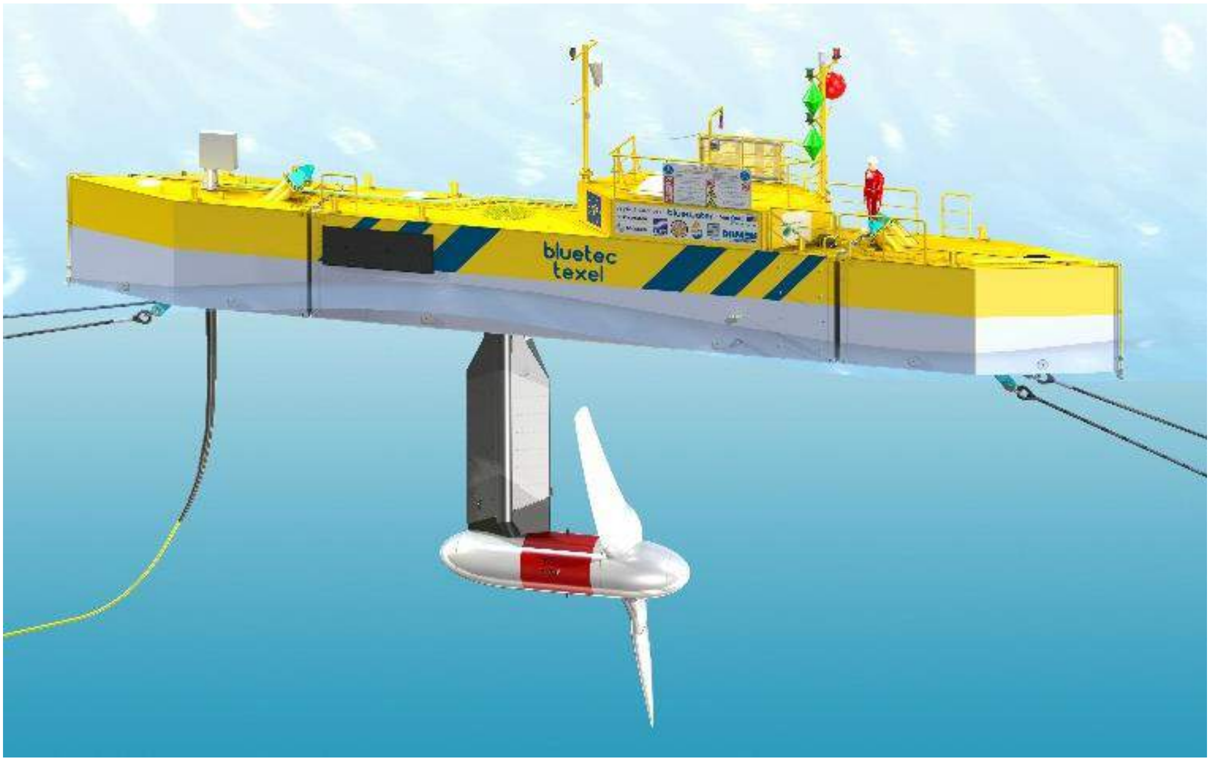


Figure 21: Schematic of the BlueTEC Texel. The world's first floating tidal energy converter.

OBSERVATIONS OF HYDRODYNAMICS AND SUSPENDED SEDIMENT DYNAMICS IN THE KIMSTERGAT NEAR HARLINGEN

J.J.Nauw[1], T. Gerkema[1]
[1] NIOZ Netherlands Institute for Sea Research, and Utrecht University, janine.nauw@nioz.nl, theo.gerkema@nioz.nl

To safeguard navigation, about 1.3 million m3 of mainly fine sediments are dredged in the harbour basins of the Port of Harlingen. The dredged sediment is dumped in the Wadden Sea, in the vicinity of the harbour. The present study forms part of the STW WATER2014 "mud motor" project. The idea is to spread part of the dredged sediments further north of Harlingen in the Kimstergat, as a semi-continuous source of sediment. The dumped sediment is expected to be transported by natural processes further into the area around Westhoek/Koehoal, as this is currently already a salt-marsh arean area with net sedimentation. The extra input of sediment is expected to lead to the formation and extension of salt marshes. This would yield less recirculation of dredged material back towards the harbour, hence less maintenance dredging, the promotion of the growth and stability of salt marshes, and improving the Wadden Sea ecosystem.

In a pilot study in the Kimstergat on 16 & 17 June of 2015, in-situ observations were performed to determine the local hydrodynamic conditions and the sediment transport in absence of the mud motor. The data suggests that locally hydrodynamics resemble those of an inverse estuary, e.g. the tidally averaged flow displayed a fresher inflow near the surface in the flood direction and more saline outflow near the bottom in the ebb direction, typical for arid regions. This is due to the location of the two sources of fresh water, which are in the downstream direction during the flood phase: the sluice near Kornwerderzand and (much smaller) the harbour of Harlingen. The spreading location for the dredged material was upstream from our measurement locations, during the late ebb phase of the tide. Besides the natural suspended sediment transport, the dredging plume was also observed on several occasions.

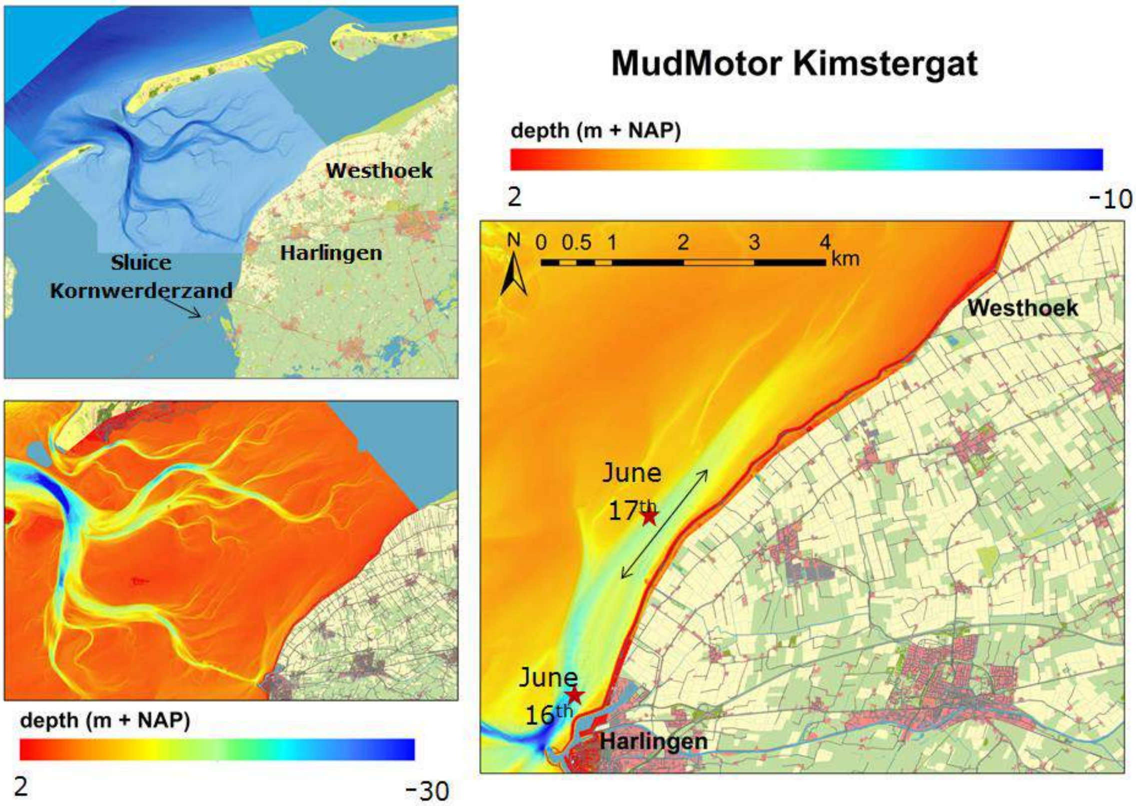


Figure 22 Bathymetry of the Western Dutch Wadden Sea (top left), the Vlie inlet (bottom left) and the Kimstergat orientated North-eastward near Harlingen (right).

IMPACT OF INTERANNUAL VARIABILITY IN HYDRODYNAMIC CONDITIONS ON SPAWNING GROUND-NURSERY GROUND CONNECTIVITY IN NORTH SEA PLAICE PLEURONECTES PLATESSA

J.J. Nauw[1]*, P. Ruardij[1], M. Tiessen[2] T. Gerkema[1], H.W. van der Veer[1]
[1] NIOZ, janine.nauw@nioz.nl, piet.ruardij@nioz.nl, theo.gerkema@nioz.nl, henk.van.der.veer@nioz.nl
[2]Deltares, meinard.tiessen@gmail.com

Abstract
A three-dimensional hydrodynamic model (GETM) was coupled to a particle tracking routine (GITM) to study the inter-annual variability in transport paths of particles in the North Sea and English Channel. Particles are distributed randomly in space and time in the entire North Sea. At their initial position, these particles represent newly spawned plaice eggs. Besides passive transport by the local hydrodynamics, many processes influence connectivity between the spawning areas and their nurseries. These processes include temperature dependent growth and mortality, the timing of the spawning and its initial distribution, passive demersal transport (DEM) and selective tidal stream transport (STST). The latter two processes occur in the later larval and early juvenile stages. There is still a lot of debate on the relative importance of these processes. In this study, we show that the initial spawning area and timing is of vital importance to simulate the connectivity well and that an accurate representation of the temperature dependent growth and mortality is essential to reproduce the timing and height of the peak in just-settled plaice larvae in Balgzand nursery ground in the Dutch Western Wadden Sea.

REPRODUCING THE MORPHOLOGY OF THE SCHELDT MOUTH USING AN IDEALIZED PROCESS-BASED MODEL

Abdel Nnafie, Tomas Van Oyen, Bart De Maerschalck
abdel.nnafie@mow.vlaanderen.be; abnnafie@gmail.com
Flanders Hydraulics Research, Antwerp, Belgium

Description of research

The morphology of the Scheldt mouth is characterised by an extensive shallow area (Vlakte van de Raan), which is flanked by two deeper (shipping) channels (Wielingen and Oostgat). The latter channels provide access to the port of Antwerp (see Fig. 1). On the one hand, the morphology of the Scheldt mouth echoes the characteristics of ebb-tidal deltas, which usually occur offshore of tidal inlets. On the other hand, however, the northern part of this area features presence of elongated tidal sand bars, which have a different formation mechanism.

Both natural processes and human interventions have influenced the morphological evolution of the estuary and its mouth area over the past two centuries (Kornman et al., 2000). Initially, these human interventions mainly consisted of land reclamations, which resulted in loss of intertidal areas and a fixation of the alignment of the estuary. In the 20th century, human interventions shifted from land reclamation to sand extraction and dredging and dumping activities to maintain the navigation route to the Antwerp harbour. Recently, the Flemish government announced new large-scale measures in the Belgium coastal region in support of safety, navigation and ecology. These measures, which are formulated in the so-called Master Plan Vlaamse Baaien, aim at adapting the coastal region (including the mouth area) by creating new offshore dune islands to the east of harbour of Zeebrugge and constructing a new navigation channel across the Vlakte van de Raan. Implementation of this master plan, however, rises the question of how these interventions would affect hydro- and morphodynamics in this area.

The main objective of this research is to obtain a better understanding of the morphodynamic response of the mouth area to the human interventions formulated in the Master Plan Vlaamse Baaien. For this, an idealized model approach is adopted, as the focus is on getting fundamental insight into this response rather than understanding all quantitative details. As a first step in achieving the research objective, we will present an idealized depth-averaged morphodynamic model (Delft3D), which is able to reproduce the main characteristics of the observed bottom patterns in the mouth area and the estuary.

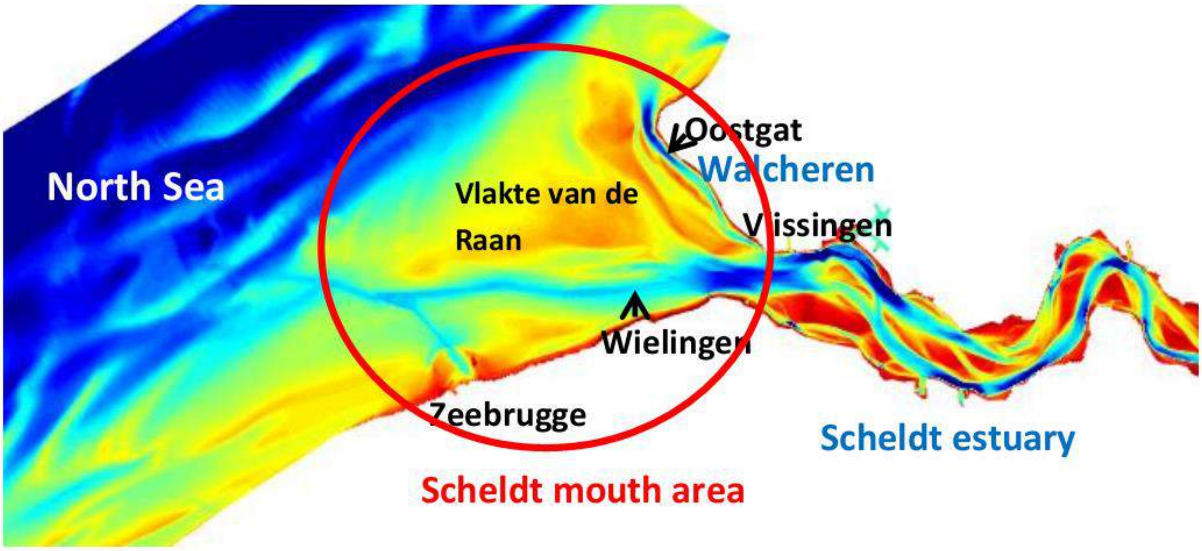


Figure 1 Bathymetric map of the Scheldt mouth area.

References

Kornman, B.; Arends, A.; Dunsbergen, D. (2000) Westerscheldemond 1970 – 2020: een morfologische blik op de toekomst. Ministerie van Verkeer en Waterstaat, Directoraat-Generaal Rijkswaterstaat, Rijksinstituut voor Kust en Zee/RIKZ.

Mapping coastal bio-geomorphic dune development with UAV-imaging

Corjan Nolet[1]*, Marinka van Puijenbroek[1], Juha Suomalainen[2], Juul Limpens[1], Michel Riksen[1]
[1] Soil Physics and Land Management group, Wageningen University (corjan.nolet@wur.nl)
[2] Laboratory of Geo-Information Science and Remote Sensing, Wageningen University

Introduction

Coastal dunes in the Netherlands develop by a mutually reinforcing interaction between aeolian sand deposition and dune-building grass species. Sand Couch (*E. juncea*) and Marram Grass (*A. arenaria*), in particular, not only act to trap sand but positively thrive under certain conditions of sand burial (Hesp 1989, Maun 2009). This introduces a positive bio-geomorphic feedback, where adequate levels of sand trapping encourage the plants to grow, in turn enhancing the plant's capacity to trap sand.
However, even though these processes are understood, little quantitative information is available on how these physical-biological feedbacks control dune morphology (Keijsers et al. 2014b). Therefore, in order to help elucidate how reinforcing feedbacks between plant growth and sand trapping promote dune growth, coastal bio-geomorphic dune development has been extensively mapped using an unmanned aerial vehicle (UAV).

Methodology

Over the course of a year, working within the WUR Unmanned Aerial Remote Sensing Facility (www.wageningenur.nl/uarsf), a high spatial-temporal resolution topographic and ecologic dataset has been constructed of a developing fore dune adjacent to the Sand Motor (www.zandmotor.nl). UAV-imaging was done using a camera modified for indicating a Normalized Difference Vegetation Index (red channel = near infrared 680-800 nm), ensuring enriched applicability for ecological monitoring.
Analysis of the data focuses on relationships between differences in vegetation densities and changes in dune height, as well as rates of aeolian deposition and changes in vegetation cover & vitality (i.e. greenness of the plant). The latter may serve as an indicator of plant response to burial and/or optimal burial levels.

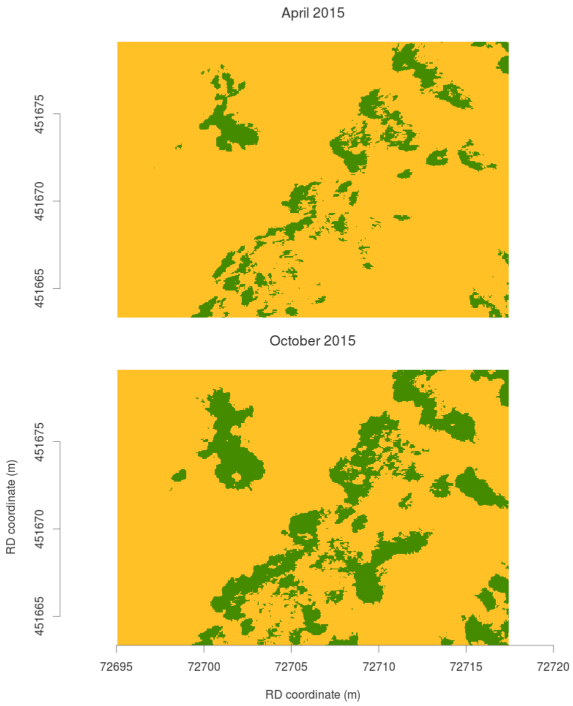


Figure 23. Detecting (change in) fore dune vegetation cover on the Sand Motor using k-means classification

Outlook

Current effort is directed at establishing a predictive relationship between vegetation density (pixels grass per m^2) and changes in dune height. This would, hypothetically, enable predicting dune development based on vegetation properties.

References

Hesp PA, 1989. A review of biological and geomorphological processes involved in the initiation and development of incipient foredunes. Proceedings of the Royal Society of Edinburgh Section B: Biological Sciences 96: 181–201.
Maun MA, 1998. Adaptations of plants to burial in coastal sand dunes. Canadian Journal of Botany 76: 713–738.
Keijsers JGS, Poortinga A, Riksen MJPM and Maroulis J, 2014b. Spatio-Temporal Variability in Accretion and Erosion of Coastal Foredunes in the Netherlands: Regional Climate and Local Topography. PLoS ONE 9(3): 91115

SANDBAR, BEACH AND DUNE: HOW DO THEY CONNECT?

T.D.Price[1], B.G. Ruessink[1], K.M. Wijnberg[2]
[1] Utrecht University, t.d.price@uu.nl, b.g.ruessink@uu.nl
[2] Twente University, k.m.wijnberg@utwente.nl

Introduction: alongshore-variable morphology

Seemingly straight sandy coasts, such as those of the Holland coast, may exhibit variations in beach width and dune morphology, often with a striking alongshore rhythmicity. The origin of this alongshore variability stretching across the sandbar-beach-dune system is not reflected in our current understanding of the underlying processes. On the one hand, alongshore variable dune erosion has been attributed to alongshore variable wave attack during storms with high surge levels[1]. On the other hand, this alongshore variability has been suggested to arise from alongshore differences in beach-dune recovery in between storms[2], during which wave-driven sand transport returns the eroded sand landward onto the intertidal beach, where it is picked up by the wind and returned into the dune system. The nearshore beach and dunes are thus clearly linked through the constant exchange of sand. In our work, we aim to connect sandbar morphodynamics to beach-dune recovery in particular, based on observations from different field sites.

Video observations of bar-beach-dune interaction

Our visual inspection of several datasets of time-exposure images (Figure 1a) from coasts worldwide reveal that nearshore sandbars regularly shed onshore-migrating isolated morphological features, called Shoreward Propagating Accretionary Waves (SPAWs)[3]. We hypothesize that the onshore welding of these SPAWs results in alongshore variations in intertidal beach width that, in turn, provide alongshore variations in the magnitude of wind-induced transport and, thus, dune recovery. In a 15-year dataset of video images from Egmond aan Zee, The Netherlands, for example, the growth of embryo dunes was particularly strong at locations where SPAWs welded ashore (Figure 1). We observe similar cycles of SPAW generation, onshore migration, and merging with the beach at the other study sites, which cover a range of wave climates and sandbar morphodynamics. Accordingly, our exploratory observations suggest that SPAWs may prove to play a crucial role in linking the nearshore to beach-dune system.

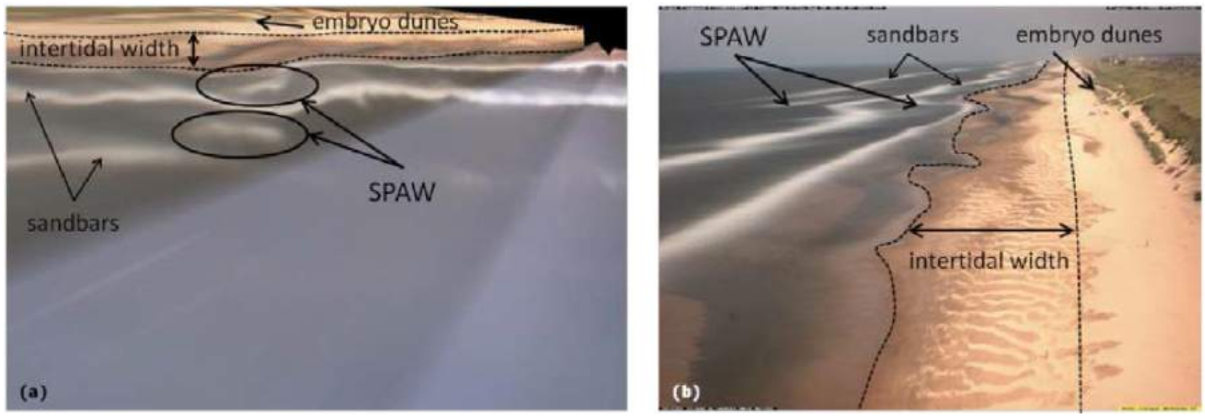


Figure 1 A (a) planview and (b) oblique time-exposure video image (Argus) from Egmond aan Zee, showing sandbars, SPAWs, intertidal beach width, and areas with embryo dune development.

1. Castelle, B., Marieu, V., Bujan, S., Splinter, K.D., Robinet, A., Sénéchal, N., Ferreira, S., 2015. Impact of the winter 2013-2014 series of severe Western Europe storms on a double-barred sandy coast: Beach and dune erosion and megacusp embayments. Geomorphology 238, 135-148.
2. De Winter, R.C., Gongriep, F., Ruessink, B.G., 2015. Observations and modeling of alongshore variability in dune erosion at Egmond aan Zee, the Netherlands. Coastal Engineering 99, 167-175.
3. Wijnberg, K.M., Holman, R.A., 2007.Video-observations of shoreward propagating accretionary waves. In: River, Coastal and Estuarine Morphodynamics: RCEM 2007 - Proceedings of the 5th IAHR Symposium on River, Coastal and Estuarine Morphodynamics, 737-743.

EMBRYO DUNE DEVELOPMENT IS INFLUENCED BY BEACH MORPHOLOGY AND CLIMATIC FACTORS

Marinka E.B. van Puijenbroek[1], Juul Limpens[1], Alma V. de Groot[2], Michel J.P.M. Riksen[3], Maurits Gleichman[1], Pieter A. Slim[4], Han F. van Dobben[4], Frank Berendse[1]
[1]Plant Ecology and Nature conservation Group, Wageningen University, marinka.vanpuijenbroek@wur.nl, juul.limpens@wur.nl, jm.gleichman@hetnet.nl, frank.berendse@wur.nl; [2]Imares Wageningen UR, alma.degroot@wur.nl; [3]Soil Physics and Land Management Group, Wageningen University, michel.riksen@wur.nl; [4] Alterra, Wageningen UR, pieter.slim@wur.nl, han.vandobben@wur.nl

Description of research

Introduction Rising sea levels threaten coastal safety by increasing risk of flooding. Coastal dunes provide a natural form of coastal protection, that may keep pace with sea-level rise. In this study we explored boundary conditions for early dune development to better predict natural dune expansion.

Methods We assessed how beach morphology, storm characteristics and other climatic factors influence early dune development, using a 30 year time-series of aerial photographs of 33 sites along the Dutch coast. We extracted presence and area of embryo dunes and related these to beach width and tidal range. In addition we analysed the effects of sand supply, storms, and weather conditions on the change in embryo dune area.

Results Area of embryo dunes was positively correlated with beach width, whereas the change in embryo dune area over time was correlated with storm intensity, growing season precipitation and sand nourishment. Embryo dune area increased over time periods with low storm frequency and wet summers and decreased over time periods with high storm frequency or intensity. Sand nourishment further improved dune development.

Conclusion We conclude that beach morphology determines the potential for new dune development, with wide beaches enabling development of large embryo dune fields. Sand nourishments stimulate dune development by increasing beach width. In addition, our results suggest that progressive dune development depends on weather and non-interrupted sequences of years without heavy storms.

Figure 1. A. Embryo dune development on Vlieland. B. Eroded embryo dune by storms.

A NUMERICAL AND FIELD STUDY OF TIDAL FLOW SEPARATION AT MEGA-NOURISHMENTS

M. Radermacher[1], M.A. de Schipper[1], C. Swinkels[2], A.J.H.M. Reniers[1,2]
[1] Delft University of Technology, m.radermacher@tudelft.nl, m.a.deschipper@tudelft.nl
[2] Deltares, cilia.swinkels@deltares.nl, ad.reniers@deltares.nl

Introduction

Large beach nourishments, like the Sand Motor, can cause strong interactions between the nourishment and the tidal flow field. Separation of shore-parallel periodic tidal flow and the associated formation of tidal eddies can have consequences for the morphological and ecological development of the coast and the nourishment. Furthermore, if the nourishment represents a significant recreational value, concerns about the impact of tidal flow separation on swimmer safety might arise.

This study is aimed at examining the characteristics of the tidal flow field around large-scale beach nourishments under varying nourishment geometry and tidal conditions. A numerical model is presented and validated against an extensive field dataset, which was obtained at the Sand Motor. Subsequently this model is employed to perform a parameter sensitivity study, examining the behaviour of the tidal flow field (occurrence of flow separation and eddy formation) as a function of nourishment geometry and tidal flow characteristics.

Results

The 2D-horizontal model is validated against the field dataset. The existence of large-scale tidal eddies as measured in the field is explained using the numerical model results. From 30 numerical simulations with varying nourishment geometry, a synoptic view of the disturbance of the tidal flow field by beach nourishments is created. Simulations are characterized based on their Keulegan-Carpenter number (K_C, which represents the ratio of tidal excursion length over alongshore nourishment size) and nourishment aspect ratio (α, cross-shore nourishment size over alongshore nourishment size). Five different types of behaviour are discerned (Figure 1), ranging from no flow separation to tidal eddies with varying characteristics.

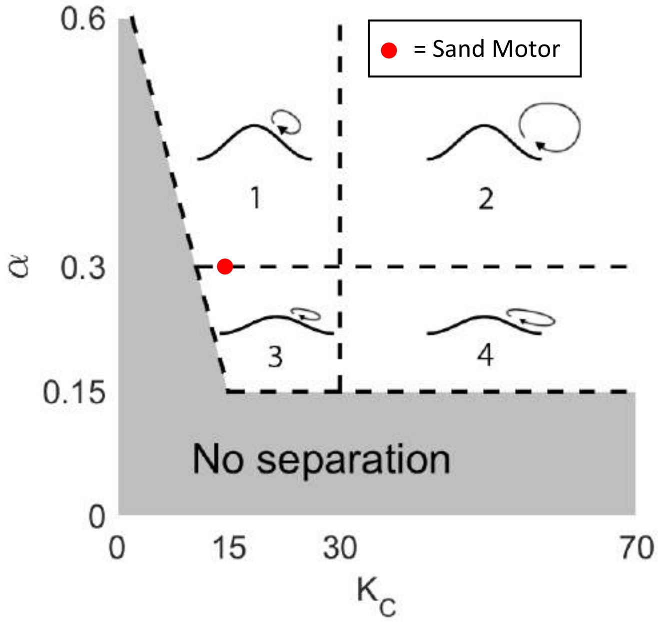


Figure 24 Overview of tidal eddy behaviour as a function of K_C and α. Flow separation does not occur for low values of KC and α, as these nourishments are too big and/or not pronounced enough. For larger parameter values, four different types of flow behaviour are identified. Region 1 in the figure is characterized by a relatively strong, spatially limited, circular tidal eddy. In region 2, tidal eddies can move further downstream and expand into the lee zone behind the nourishment, which leads to a weaker, but larger eddy. In region 3 and 4, more elliptical eddies develop, with their core closer to the nourishment tip (region 3) or further downstream (region 4).

These findings allow for a better control on the influence of planned (mega-)nourishments on the tidal flow field. Furthermore, they form a solid basis for further research into the implications of tidal flow separation for morphological, ecological and recreational aspects of the Sand Motor.

DESIGNING THE NOURISHMENT OF BROUWERSDAM

G. Ramaekers[1], .M. Lazar[1], Q.J. Lodder[1,2]
[1] Rijkswaterstaat gemma.ramaekers@rws.nl, marian.lazar@rws.nl, quirijn.lodder@rws.nl
[2] Delft University of Technology

Introduction

This year the NCK days are held at the partly new beach of Brouwersdam. Rijkswaterstaat nourished the first sand in 2015 and the work will finish in 2016. This particular nourishment was completed due to an exceptional chain of events: a) part of the sand needed to maintain the *reference coastline*[1] at the neighboring project on Schouwen was excluded for ecological reasons and became available for the Brouwersdam, b) co-financing from local governments, and c) special permission from the Ministry of Infrastructure and the Environment because the policy states that a stretch of coast is not considered for a beach nourishment if there is no reference coastline defined [1]. This beach nourishment is therefore a unique and presumably a one-off nourishment at this location.

The design of the nourishment of Brouwersdam

The sand was much needed for recreational purposes at Brouwersdam to compensate for the beach losses in the last 10 years. Due to the co-financing, this nourishment became reality and regional wishes were incorporated in the nourishment design. The main goal was to retrieve the coastline of 2005 as much as possible, creating maximum beach area for recreational purposes, including the return of a former beach pavilion (see Figure). Furthermore, the new beach surface needed to be moist and hard so it would be suitable for beachsports such as blowkarting.

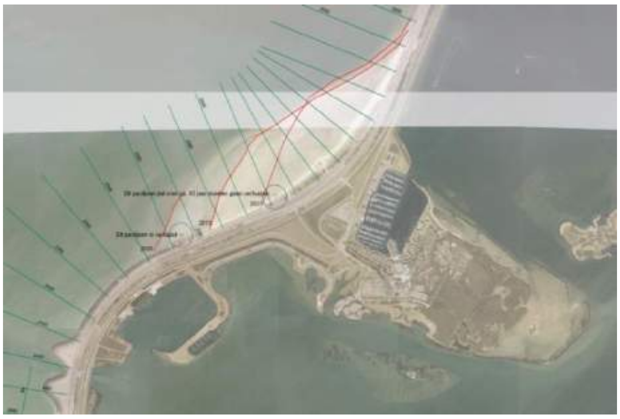


Figure: Aerial photograph of Brouwersdam. The red line in the left is the shoreline position in 2005.

In order to fulfill these local wishes the beach slope was made slightly steeper than usual (1:20 instead of 1:30) and the maximum height was lowered (~2 m NAP instead of 3 m NAP). Furthermore, to protect the adjacent road from aeolian sand deposition, sand was pushed against the dam to create a sandy slope where marram grass or sandtraps will be placed later.

Lessons learned

Although we do not yet know for how long the nourishment design will withstand the natural processes of erosion and northward migration of sand and fulfill the local needs, Rijkswaterstaat learned a lot about the process of co-financing a project and designing an unconventional nourishment.

References

[1] Rijkswaterstaat (2015). Programma Kustlijnzorg: Uitganspunten totstandkoming programma. www.rijkswaterstaat.nl; ZD0315VH2248 (in Dutch).

[1] The reference coastline acts as the norm for the sand volume in the shoreface and on the beach for each cross-shore transect (circa 250m in length) defined along the entire Dutch coast.

OBSERVATIONS OF BEACH-DUNE INTERACTION IN MAN-MADE TROUGH BLOWOUTS

B.G. Ruessink[1], J. Donker[1], S.M. Arens[2] and M. Kuipers[3]
[1]Utrecht University, b.g.ruessink@uu.nl; [2]Bureau for Beach and Dune Research; [3]PWN

Introduction

Most foredunes along the Dutch coast have been stabilized for improved coastal safety by centuries of marram grass planting. The lack of foredune dynamics implies that the beach and dunes are no longer a sand-sharing system, which negatively affects the variety of plant and animal species found in dune ecosystems. Stabilized foredunes are nowadays increasingly reactivated by digging notches (Figure 1), resembling natural trough blowouts, to stimulate aeolian dynamics and to improve biodiversity. Crucially, such large-scale measures see the beach-dune system as an integrated landscape, reconnecting the beach, foredune and backdunes through aeolian transport. This type of foredune restoration, however, has a high 'learning-by-doing' character, as the evolution of man-made notches and their long-term (years) effectiveness are not understood. The aim of this contribution is to analyse the evolution of five notches that, in 2012/2013 winter, were dug through a 750-m long stretch of the 20-m high foredune at the Dutch National Park Zuid-Kennemerland (Noordwest natuurkern project).

Methodology and Results

Since 2012 the region has been surveyed with airborne laser scanning and UAV photography, resulting in a multi-temporal data set of 10 Digital Terrain Models with a 1x1 m resolution. The initial width of the notches was 50-100 m, their cross-section dune length was 60-100 m, and the highest part of the valley floor was 9 m above MSL. Topographic difference maps show that the sidewalls of the five notches have steepened, causing the notches to become more U-shaped. The width and depth of the notches have, however, remained approximately the same. Landward of the notches large depositional lobes have developed (Figure 1), which with time have grown both laterally and vertically. Locally, lobe thickness now exceeds 7 m and lobe length 50 m. In total, 24,000 m3 of sand has eroded from the five notches after 2 years, and 44,000 m3 of sand has deposited further landward. This implies that about half of the deposited sand was eroded from the notches, with the second half presumably originating from the beach. The latter would equate to roughly 12.5 m3/m/year of windblown beach sand. The Noordwest natuurkern project illustrates that foredune restoration can result in unprecedented new dynamics on the time scale of a few years. Continued monitoring is required to establish whether foredune notches are self-sustaining on the long run.

Figure 1 View (in the seaward direction) of one of the notches, with a clear depositional lobe on its landward side. The sea is just visible through the notch. The lobe is covering buckthorn bushes.

SANDBAR BEHAVIOUR ALONG A MAN-MADE, CURVED COAST

J. Rutten[1]*, T.D. Price[1], B.G. Ruessink[1]
[1] Utrecht University, j.rutten@uu.nl, t.d.price@uu.nl, b.g.ruessink@uu.nl

The alongshore patterning (e.g. formation of rip channels) of nearshore sandbars is relatively well-understood along straight coasts. However, the effect of a curved coast on sandbar behaviour is relatively unknown. Given the expected increase in large-scale O(10 Mm^3) nourishments, e.g. Sand Engine, we foresee a marked increase in man-made, curved coastlines. Natural analogues of man-made curved coasts exist in the form of shoreline sandwaves, cuspate forelands and embayed beaches. Here, sandbar behaviour may show stunning alongshore variability that is possibly driven by alongshore changes in wave forcing (e.g., height and angle of incidence). The aim of our study is to quantify such alongshore variable sandbar behaviour using a 2.5 year dataset of daily low-tide video images from the convex coast of the Sand Engine (Fig. 1).

High-intensity breaker lines in ten-minute averaged video images served as proxies for the position of the sandbar and shoreline. The sandbar line and shoreline were extracted from the images using an alongshore automated tracking algorithm. Subsequently, we computed two morphometric parameters, over two boxes, north and west of the Sand Engine's tip: 1) the standard deviation, S_{bar} and S_{shore}, as a measure of alongshore variability, and 2) the lagged cross-correlation as a measure of coupling between patterns in the sandbar and shoreline.

We found both differences and similarities in sandbar behaviour between the northern and western coast. Strongly different patterning can be observed in the images, that is alongshore variable at either the northern side (Fig. 1a), or the western side (Fig. 1c). However, also patterning at both sides can be observed (Fig 1b). Asynchronous change in S_{bar} and S_{shore} for the northern and western side further support our observed timing differences in the growth and decay of alongshore variability. Furthermore, S_{bar} demonstrates that alongshore variability was most pronounced at the western side, promoting the coupling (Fig. 1b-c) between sandbar and shoreline (W: 16% observations; N: 6% observations).
Alongshore differences in timing and strength of sandbar patterning suggest that the local orientation of the coast plays a role. Despite the same offshore wave forcing, the predominant wave angle is shore-normal at the northern side, but oblique at the western side due to the convex coastline (Fig. 1d).

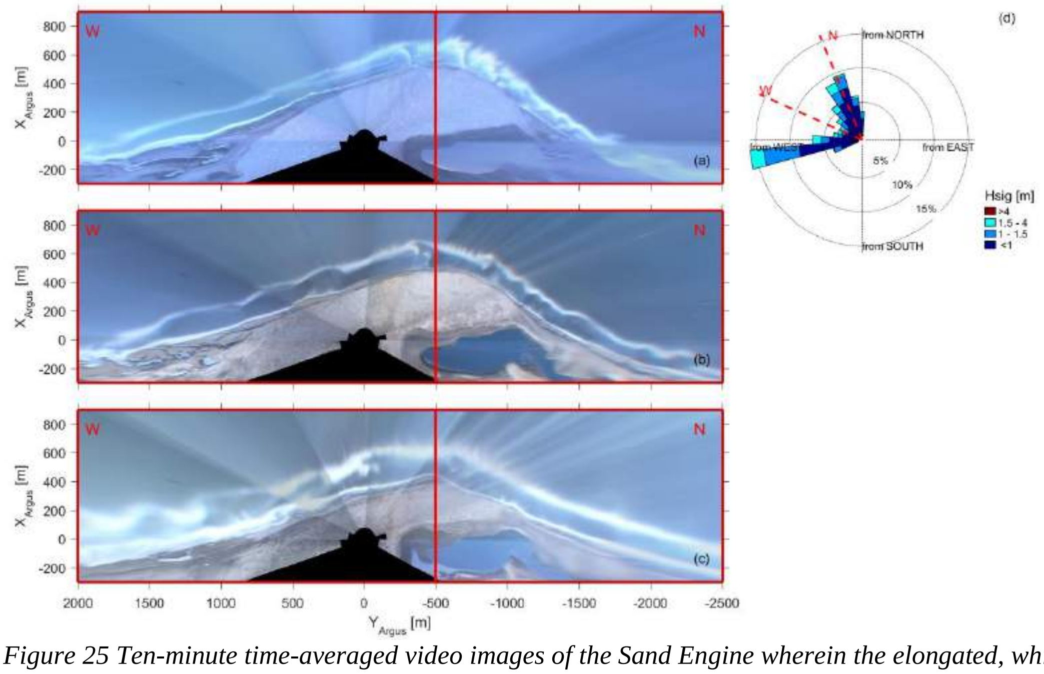


Figure 25 Ten-minute time-averaged video images of the Sand Engine wherein the elongated, white breaker lines indicate the sandbar (outer) and shoreline (inner). The red lines in the wave rose indicate the shore-normal at the northern and western side of the Sand Engine.

DUNE-SYSTEMS NEAR INLETS, A FIRST INSIGHT

Silva, F. G.[1], Wijnberg, K. M.[2]; Hulscher, S. J. H. M.[3]
1, 2, 3 Water Engineering and Management, University of Twente, P.O. Box 217, 7500 AE Enschede.
f.galifornisilva@utwente.nl[1]; k.m.wijnberg@utwente.nl[2]; s.j.m.h.hulscher@utwente.nl[3]

Introduction

Dune systems that emerge close to inlet systems are particular in the sense that processes from both beach and inlet are present and affect its development and dynamics. Little is known about the evolution of dunes in these areas, and even a descriptive research is missing. In that sense, the island of Texel (NL) presents a particular interesting case of dunes emerging close to inlets in the southern region of the island, where a beach plain (de Hors) of roughly 3 km² is located. Therefore, the aim of this research is to analyse the dune evolution on the area and assess whether a spatial dependence in the dune height variability exists or not.

Methodology

Detailed topographic data (5X5 meter grid) was used to evaluate the topographic evolution of the Hors area. The data has been acquired annually by Rijkswaterstaat using LIDAR technology, starting from 1997 until 2015. Digital elevation models were built from this data and used to obtain elevation statistics, as well as volume estimates for the area were the dunes were growing. Furthermore, to get insight in the dune development in the years before 1997, beach profiles in the area available from the JARKUS dataset were analysed.

Results and discussion

Figure 1 shows the mean elevation and the respective variance at the Hors. The dune area presented an accretion pattern, although different growing patterns can be recognized along the area. Besides changes in the shoreline position in the west area of the beach plain, the higher values of variance are located at the dune region, with higher values located at the west part (closer to the sea) and the central inner portion. The western sector presents a pattern of dune development similar to open coastlines, with long marked incipient dune rows growing in front of an established dune row. The central region presents a distinct pattern, with dunes growing in a nebkha-like shape along a bigger area. The eastern portion, which is more protected, exhibits a similar development as the western portion, though with smaller growing rates. The whole dune area accreted on average by 10^5 m³/year, which leads to an increase in elevation of approximately 9 cm/year, with the central portion contributing to approximately 40% of the volume increase. The results suggest that, with a positive net sediment supply, dunes near inlets present varying development patterns within the area.

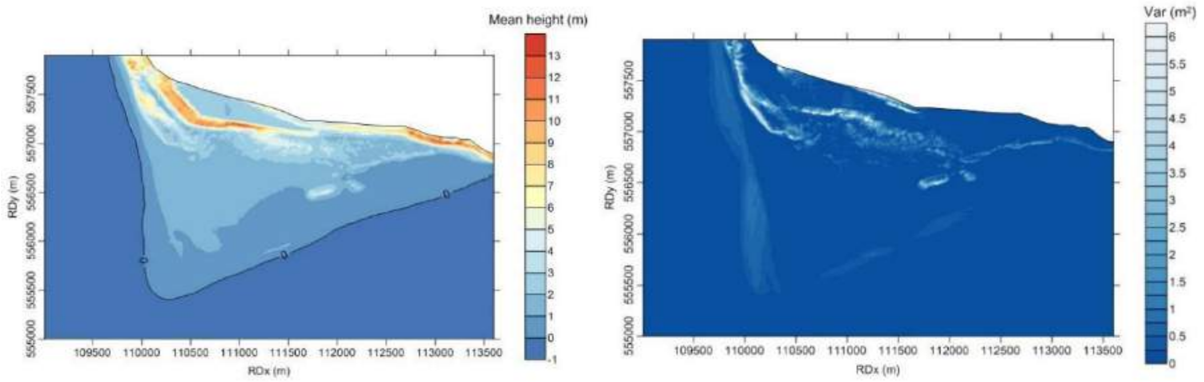


Figure 1: Left panel, mean elevation of the Hors. Right panel: variance of the elevation over 19 years.

Conclusion

The dunes at the Hors present an overall evolution and accretion pattern that have a spatial dependence. Different types of dune evolution, as well as elevation variability, are present over different portions of the beach plain. Further research is required to understand what are the relations between inlets and beach processes for the dune development at these areas.

QUANTIFICATION OF SPATIAL VARIABILITY IN SURFACE MOISTURE ON A SANDY BEACH BY USING AN INFRARED TERRESTRIAL LASER SCANNER

Yvonne Smit[1] (y.smit@uu.nl), Jasper Donker[1] and Gerben Ruessink[1]
[1] Department of Physical Geography, Faculty of Geosciences, Utrecht University, PO Box 80.115, 3508 TC, The Netherlands

1. Introduction

Accurate quantification of surface moisture in coastal environments is vital because surface moisture is believed to be important for aeolian sand transport. It limits the amount of sand transport by increasing the shear velocity threshold required to entrain sediment (*Bauer and Davidson-Arnott*, *2002*). Conventional measurement techniques (e.g. soil moisture probes) cannot adequately characterize the spatial and temporal distribution of surface moisture content (*Nield et al., 2014*). Here we present a new method for detecting surface moisture at high temporal and spatial resolution using the RIEGL VZ-400 terrestrial laser scanner (TLS).

Figure 26 The RIEGL VZ-400 Terrestrial Laser Scanner

2. Methodology

The TLS operates at a wavelength near a water absorption band (1550 nm). Hence, TLS reflectance is sensitive for detecting surface moisture over its entire range. Three days of intensive laser scanning were performed during fieldwork at Egmond aan Zee (The Netherlands) to investigate the applicability of the TLS. Moreover, gravimetric surface moisture samples were collected to calibrate the relation between TLS reflectance and surface moisture.

3. Results

The TLS typically produces O(10^6-10^7) data points, which we averaged into surface moisture maps with a grid size of 0.25 m. This grid size largely eliminates small moisture disturbances induced by, e.g. footprints or tire tracks, while retaining larger scale trends. Furthermore, the surface moisture maps reveal that within a radius of 80 m from the TLS, reflectance measurements are robust and repeatable and an accurate calibration curve between reflectance and the full range of surface moisture contents (0% - 25%) can be produced.

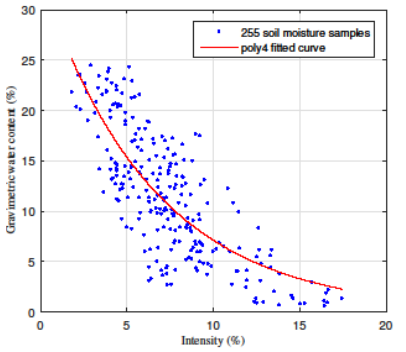


Figure 2 Calibration curve of intensity versus surface moisture, made with 255 surface moisture samples and converting the TLS reflectance output to intensity

4. Conclusion

The RIEGL-VZ-400 TLS is a state-of-the-art measurement device to produce robust and accurate measurements of surface moisture at the very thin upper layer of the beach. As a next step in our research, we will analyze the obtained maps to determine the spatial and temporal surface moisture variability and which processes affect this variability.

References

Bauer, B. O., and R. G. Davidson-Arnott (2002), A general framework for modeling sediment supply to coastal dunes including wind angle, beach geometry, and fetch effects, *Geomorphology, 49*, 89-108.

Nield, J. M., J. King, and B. Jacobs (2014), Detecting surface moisture in aeolian environments using terrestrial laser scanning, *Aeolian Research*, *12*, 9-17.

OPERATIONAL STORM EARLY WARNING SYSTEM IN MORPHAN

J. Veenstra [1,2]*, M. Boers[2], P.F.C. van Geer[2], J.M. Damen[1], J. Rietdijk[3], K.M. Wijnberg[1]
[1] University of Twente [2] Deltares [3] Hoogheemraadschap van Delfland
*contact address: j.veenstra-3@student.utwente.nl

Description of the research

Dunes protect a large part of the Dutch coast against flooding from the sea. Although most storms will not cause failure of this sea defence, they may still cause a threat to for instance seaside towns because of dune erosion and overtopping. Also, high waves and current velocities near the shore may cause damage to coastal structures or property on the beach.

Currently, weather, water level and wave forecasts provide coastal managers with timely information about the severity of an approaching storm, but the damaging effects to be expected of that particular storm are usually unclear. Despite ongoing research about calamity assessment, no early warning tool for storms is currently available at water authorities. In this study, an operational, quick, flexible and easy to use calamity assessment tool is designed, implemented in MorphAn and evaluated. MorphAn is a computer program that is already used by coastal water authorities and Rijkswaterstaat, for dune assessment and other coastal related analyses. MorphAn provides the additional possibility to use Python scripting to access a wide range of advanced functions to expand the standard functions.

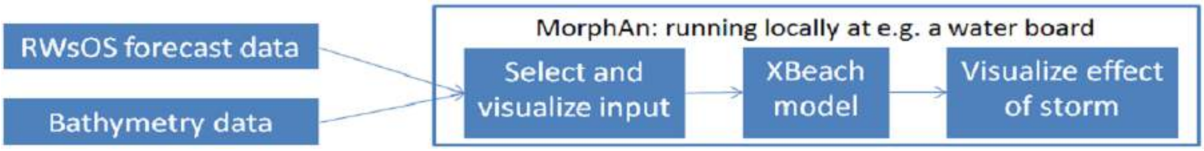


Figure 1. Schematization of the calamity tool

The calamity assessment tool in MorphAn provides a Graphical User Interface (GUI) where several steps from Figure 1 are taken, in order to provide a result which coastal managers can directly use. Jarkus transect bathymetry data from MorphAn or alternative 1D transect or 2D grid sources can be selected and are automatically downloaded, for instance recent bathymetry derived from Argus cameras. Real-time water level and wave 48-hour forecast data from RWsOS i is retrieved for the location of the bathymetry data. Using this data from remote servers eliminates local computational time of large and complicated water level and wave models, so the calamity assessment tool can be used on a normal laptop. The bathymetry and RWsOS data is automatically fed into the XBeach model, which calculates the hydrodynamic and morphologic processes of the storm. Figure 2 shows a 1D model results. It provides an early warning of the storm effects on the coast. These effects are for instance dune erosion or breaching, damage of property, high current velocities near the shore and overtopping of dunes or structures. Coastal managers can directly use this result for communication purposes, as well as for decisions about evacuation or protecting measures of levees or dunes.

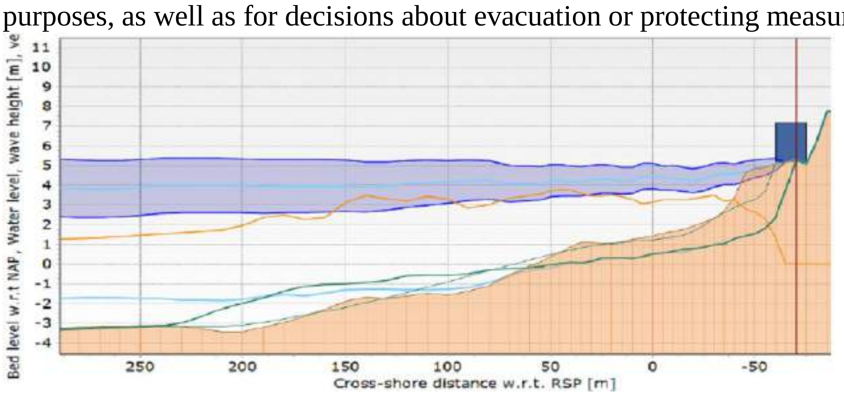


Figure 2. XBeach result with min/max water levels (light blue), a wave height band (blue area), max current velocities (orange), bed level (initial: brown area, several time steps: thin line(s), resulting: wide green line), water run-up (red vertical line) and buildings (dark blue square, and in this case affected by the water)

The uncertainties of the different bathymetry sources, water level and wave forecasts as well as the XBeach model are currently assessed. A sensitivity analysis of these uncertainties provides information about their effect on the result, to be taken into account in decision making. This way, an operational calamity assessment tool is provided to water authorities, with accuracy information about the result.

EXPERIMENTAL AND NUMERICAL ASSESSMENT OF FLOW INTERACTION AT STORM SURGE BARRIERS WITH HYDRO-TURBINES

M.C. Verbeek[1]*, R.J. Labeur[1]
[1] Delft University of Technology, m.c.verbeek@tudelft.nl

Introduction

Renewable sources of energy become increasingly important in a world with a growing energy demand. Hydro-turbines could play a role in the energy issue delivering a constant and substantial amount of energy. The turbine configuration turns out to be of great importance for the power budget of turbines. The determination of an optimum configuration is difficult because of the complex flow interactions between turbines and the support structures. Recently a pilot Horizontal Axis Tidal Turbine (HATT) project started in the Eastern Scheldt, where five turbines are implemented in the storm surge barrier. In this PhD project we will investigate the near- and far-wake dynamics resulting from the turbines and their support structures in both an experimental set-up and field survey near the Eastern Scheldt storm surge barrier. In the last phase of the research the local flow at the barrier will be embedded in a validated numerical model covering the regional water system. Such models are urgently needed to develop and sustain basins as the Eastern Scheldt. The ultimate challenge of this project is, to understand and integrate far- and near-wake dynamics through a numerical model.

Method

The envisaged laboratory experiments will focus on the near-wake dynamics and comprise different gate-sill configurations (Figure 1) with non-dimensional parameters, chosen to match closely those at the Eastern Scheldt barrier. Laser Doppler Anemometry (LDA) will be used to investigate the velocity fields and turbulence properties. Furthermore, the rotational character of the wakes will be identified using surface Particle Image Velocimetry (PIV). An extensive field survey in the Eastern Scheldt provides information on the far-wake dynamics of the turbines. An inventory and selection will be made of numerical models able to reproduce barrier-induced flow as observed in the laboratory experiments and in the field.

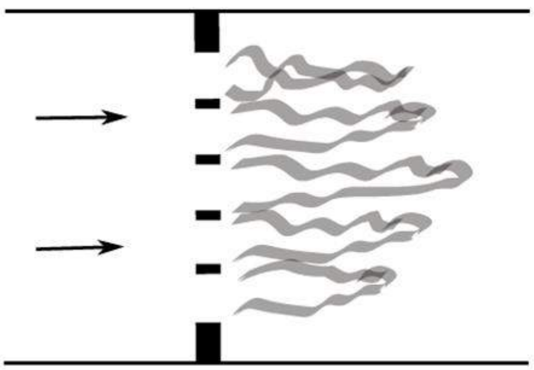


Figure 27 An artist impression of an example flume experimental set-up of a barrier opening including turbines.

Figure 2 A Barrier opening of the Eastern Scheldt storm surge barrier (source: Beeldbank RWS).

Acknowledgements

This project is funded by The Netherlands Organisation for Scientific Research (NWO).

HUMAN IMPACT ON INTERTIDAL FLATS IN THE EASTERN AND WESTERN SCHELDT

P.L.M. de Vet[1,2]*, B.C. van Prooijen[1], Z.B. Wang[1,2]
[1] Delft University of Technology, P.L.M.deVet@tudelft.nl, B.C.vanProoijen@tudelft.nl, Z.B.Wang@tudelft.nl
[2] Deltares

Introduction

The Eastern Scheldt (ES) and Western Scheldt (WS), as shown in Figure 1A, have been exposed to human activities over the past decades (e.g., dredging works and the construction of barriers). The WS showed mainly a tendency of heightening flats (Cleveringa, 2013), whereas the ES flats eroded severely after the construction of the storm surge barrier in 1986 (Louters, 1998). In this research, we compare the morphological evolution of the intertidal flats between both systems and further analyse the response to human interventions.

Methodology

We focus on the major intertidal flats which are surrounded by water (see Figure 1A), each vertically limited by their local MLW and MHW lines. Robust bulk-indicators for the morphology are formulated (average height, area and volume), together with average bed slope profiles for each flat derived from local hypsometric curves. With this method, the morphological response of individual flats can be studied, and an objective inter-comparison between flats is possible. Apart from DEM maps (Vaklodingen & LiDAR), also more frequently measured RTK cross-sections are consulted.

Results

We found the WS flats to be substantially steeper compared to the flats of the ES (e.g., Figure 1B). Although a net steepening and heightening of the WS flats and a net flattening and lowering of the ES flats are observed, these trends were not necessarily monotone in time or consistent for all flats. A relation between the height and the steepness of a flat is found when comparing the various intertidal flats, but also when analysing the development of individual flats over time. Furthermore, confidence is gained that the erosion of the intertidal flats in the ES might have decreased over the recent years.

Summary and conclusion

We developed a method to objectively compare various intertidal flats. We conclude that the observed morphological changes in both systems were driven for a substantial part by human interventions, which enforced differences in hydrodynamics between both systems.

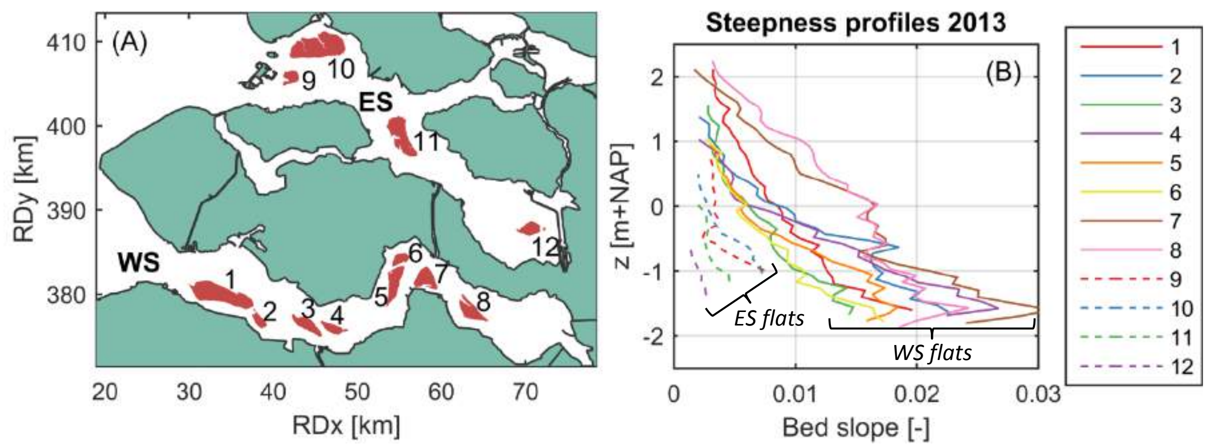


Figure 28 (A): overview studied intertidal flats, (B): average bed slope profiles over depth for all the considered flats (2013 LiDAR data), indicating substantially milder flats in the ES compared to the WS.

References

Cleveringa, J. (2013). Ontwikkeling mesoschaal Westerschelde: factsheets. Technical Report.
Louters, T., van den Berg, J. H., & Mulder, J. P. M. (1998). Geomorphological changes of the Oosterschelde tidal system during and after the implementation of the delta project. Journal of CR.

Measuring beach responses due to storm cycles
Preliminary results

S. Vos[1]
[1] Delft University of Technology, s.e.vos@tudelft.nl

Introduction

Storms cycles have a strong influence on the evolution of beaches. During storms (with high waves, strong currents and floods) the coast is attacked and sand is transported seaward while during intermediate “quiet” periods the sand is transported dune ward. Together with divergences in the alongshore sand transport, the netto sand transport determines the development of the coast in the sea- or dune ward direction.

This research project focuses on the beach responses due to storm cycles, i.e. the storm and the intermediate “quiet” period. In the past many aspects of the coastal response have been studied and have provided much information and tools (from hazard and flooding mapping/modelling tools to risk communication and strategic planning). However many studies focus on the attacking and hydrodynamic part of the coastal evolution and not so much on the restorative part. This is partly because the attacking part is more profound and visible and can more easily be measured. After a storm vertical changes of the beach (per 24 hours) can in be in the order of a meter or more (duo too changing bars or changes in the dunes) while vertical changes in the intermediate time can be in the centimetre scale per 24 hours. Especially the dry part of the coast ranging from the waterline to the dunes exhibits small changes.

Measuring these small changes are challenging. Several techniques (like GPS, photogrammetry or satellite/laser altimetry) are available but don't provide the detail in both space and time. Recent improvements in laser measurement techniques have made it possible to measure dry coastal changes in more detail in both space and time. This provides opportunities to measure the relative small changes in the intermediate period and provide valuable information for model development.

Figure 29: Laser measurement test on top of the Huis ter duin Hotel in Noordwijk.

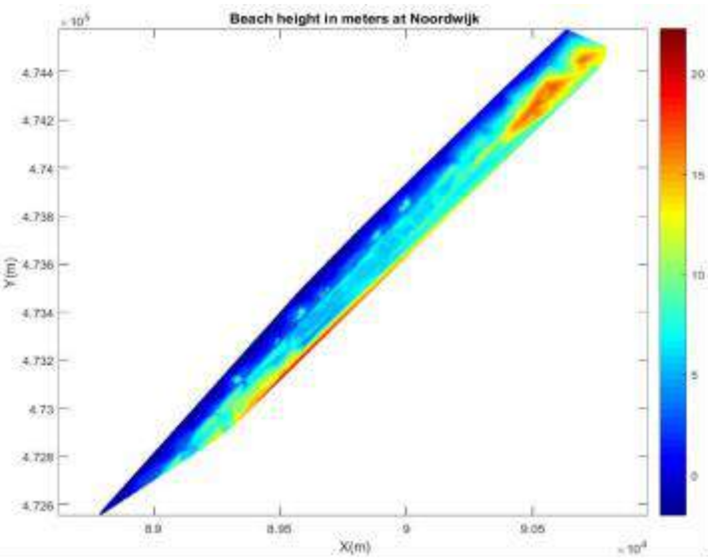


Figure 2: Measured beach height at Noordwijk.

In the end of 2015 several tests have been conducted with two laser systems (Leica MS50 and Riegl VZ2000) to test the usability of the lasersystems. The tests were conducted in Kijkduin (atop Hotel NH Atlantic) and Noordwijk (atop Hotel Huis ter Duin) [See figure 1].

The Riegl VZ 2000 gives the most promising results (see figure 2) and will be deployed in the near future to continuously measure the beach changes at two sites along the Dutch coast.

AN APPLICATION OF A NEW AEOLIAN SEDIMENT TRANSPORT MODEL AT THE SAND MOTOR

S. de Vries[1], B. Hoonhout[1,2]
[1] Delft University of Technology, Sierd.deVries@tudelft.nl
[2] Deltares, B.M.Hoonhout@tudelft.nl

This contribution shows an application of the new AEOLIS model (AEOlian transport LImited Supply) at the Sand Motor location. AEOLIS is the first numerical model to predict aeolian sediment transport rates that explicitly accounts for supply limited aeolian sediment transport next to capacity driven aeolian sediment transport. The main process that limits sediment supply to aeolian sediment transport is in the model is sediment sorting. The model can handle variable wind speed and direction in a 2D horizontal domain. Moreover, the model accounts for sediment sorting due to wind but also due to marine processes, such as tides and waves. The Sand Motor is chosen to showcase the current model capability.

The Sand Motor is an artificial sandy peninsula extruding from the Dutch coast about 1 kilometer into the North Sea (Stive et al., 2013). The Sand Motor is virtually permanently exposed to tides, waves and wind and its morphology is consequently very dynamic. About 70% of the Sand Motor area is located above 2m+MSL and is therefore only influenced by subaerial processes. Morphological measurements show that erosion due to wind at the dry areas of the sand engine has been limited. A coarse sand armour layer that was naturally established over time possibly prevents erosion. However, significant aeolian transport is observed at the Sand Motor.

Early model results predict that aeolian sediment in transport mostly originates from the intertidal beaches surrounding the Sand Motor. This might be explained by the periodic flooding which prevents an armour layer to be formed in the intertidal zone. Consequently, subtidal processes might significantly influence the subaerial morphology and especially the dune area at the sand engine location.

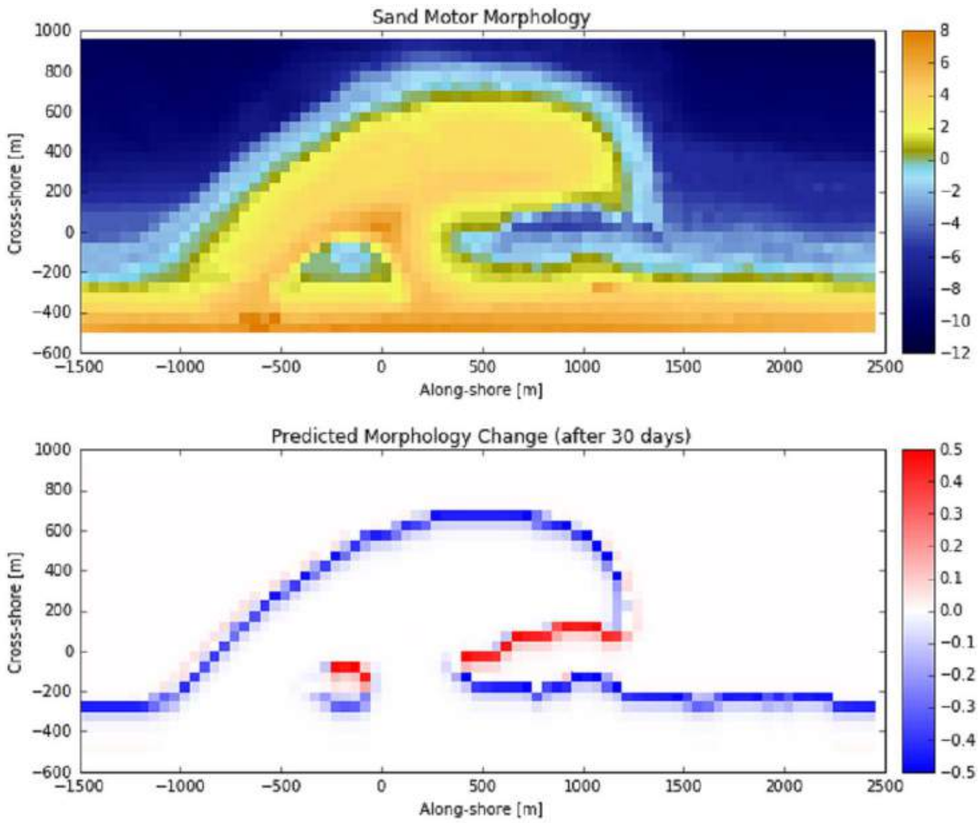


Figure 1. Top panel shows the Sand engine initial morphology, the colorbar indicates [m] above NAP. Bottom panel shows sedimentation and erosion [m]. Erosion is mostly concentrated in the intertidal area of the sand engine. Sedimentation occurs in the dune lake and lagoon lee side.

COUPLING AREA MODEL TO COASTLINE AND PROFILE MODELS:
NICE PROSPECTS FOR FAST AND LONG TERM COMPUTATIONS

Hao Wang[1], Mick van der Wegen[1,2], Dano Roelvink[1,2,3]
[1] UNESCO-IHE, h.wang@unesco-ihe.org, m.vanderwegen@unesco-ihe.org, d.roelvink@unesco-ihe.org
[2] Deltares, Mick.vanderWegen@deltares.nl, Dano.Roelvink@deltares.nl
[3] TU Delft, J.A.Roelvink@tudelft.nl

1. Introduction

Coastal morphodynamics involves multiple time and space scales. Area models covering tidal inlets applying a process-based approach typically have a spatial resolution of 100 m, whereas surf zone dynamics requires a much higher resolution. However, in a decadal-scaled simulation, the surf zone location varies over time, requiring high resolution throughout the domain. This increases computational time. In order to optimize the efficiency, an innovative approach is put forward coupling a 2DH area model with a 1D coastline model.

This approach consists of three sub-modules: an Area Model (Delft3D, Mike21, Xbeach etc.), a Coastline Model, and a Profile Model. It allows the computation of new coastlines and bathymetric feed back to the area model.

2. Results

In this study, a series of test cases are applied to evaluate the initial performance of the coastline model. The basic configuration of the domain is a straight coastline, with a groin or a hump lying in the middle.

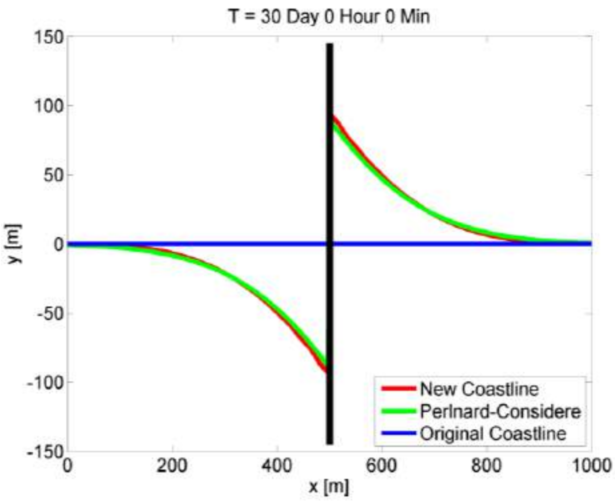


Figure 30 The Pelnard-Considere's analytical solution and the Coastline coupled Snell's Law Model result of the groin case. The angle of the incident wave is 30°, coming from northeast.

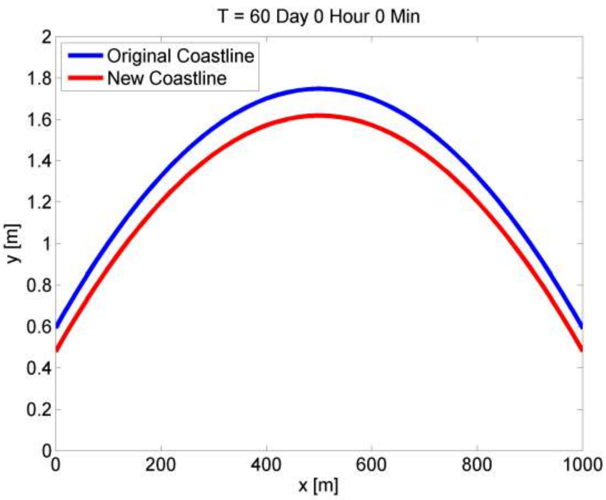


Figure 2 The result of the hump case shows a very symmetrical shape. The initial hump is generated by an analytical solution for alongshore dispersion of a beach nourishment (Rijkswaterstaat 1988).

Preliminary results are generated by coupling the coastline module with a simple wave model, which estimates breaking waves by Snell's Law. The result of the Groin case gains a stable and similar shape to the Pelnard-Considere's solution. For the hump case, by applying a northwest incident wave of 30 °, the new coastline shows a very symmetrical shape due small angles along the coastline.

3. Conclusion

These test cases give a positive feedback to the coupled-model approach. It is able to generate reasonable coastline curve and numerically stable with smaller incident angles (<43°). Efforts are ongoing to investigate larger wave angles and more complex cases.

THE EFFECT OF TIDES AND STORM SURGES ON THE SEDIMENT TRANSPORT DURING OVERWASH EVENTS

D. Wesselman[1], M. van der Vegt[1], A. Engelstad[1], R. de Winter[1], A. van Dongeren[2], R. McCall[2]
[1] Utrecht University
[2] Deltares

Description of research

Storm events generally result in elevated water levels at the meso-tidal Wadden Sea coast, the Netherlands. This can lead to overwash and inundation of parts of the barrier islands. We hypothesize that the cross-shore sediment transport, caused by such events, can on the long term contribute to the vertical accretion of the barriers. Currently, large parts of the Dutch barriers are closed off by artificial dunes which prevent overwash, but the partial re-opening of dunes is considered by the Dutch management authorities. It is therefore important to identify the dominant cross-shore hydrodynamic and sediment transport processes during an overwash event and to study the potential long-term sediment transport. In addition, we focus on the role of the back-barrier basin on overwash dynamics.

Methods

An XBeach model was set-up and validated against field data collected during overwash on East-Schiermonnikoog, the non-vegetated tip of the barrier. The simulated wave heights, periods, water levels and flow velocities agree well with the field data. Next, the model was run for a wide variety of storm and tidal characteristics. Based on water level data from 1990 to 2014, different storm classes are identified. Storms are sorted based on their peak water level during a tidal cycle and range from 1.5 meter to maximum 3 meter, with a separation of 0.25 meter per class.

Results

From the model simulations we conclude that: (1) Maximum onshore transport occurs during more gentle storms instead of big storms (Figure 1). (2) The erosion and transport of sediment across the beach crest is mainly driven by the cross-shore current and short waves. Long waves are less important (3) For mixed-energy, meso-tidal barrier systems like the Wadden Sea, the dynamics of the back-barrier have to be taken into account. Water level gradients across the barrier are strongly influenced by the tidal phase propagation and the difference in storm surge height between the back-barrier basin and adjacent sea. The model simulations substantiate our hypothesis that overwash events can on the long term contribute to the vertical accretion of the Wadden Islands. Physical explanations about these conclusions will be given during the presentation.

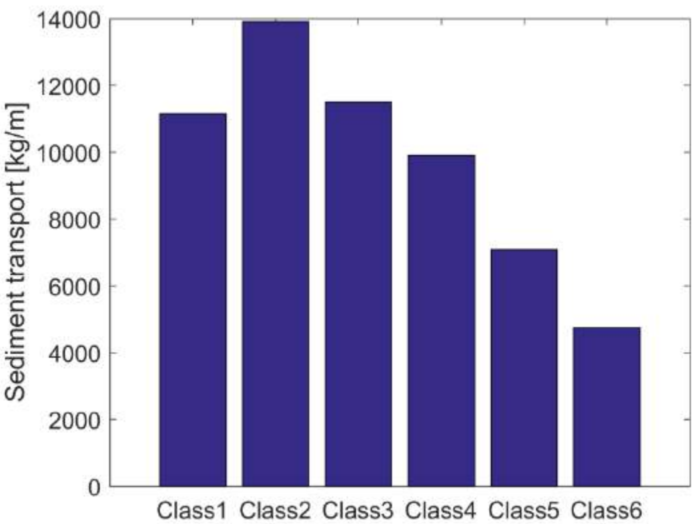


Figure 31 Sediment transport over the beach crest (= highest point of the cross-shore profile). Smaller storms that occur more often result in a larger net sediment transport. Class 1 has a peak water level between 1.75 and 2.00 meter. The water level increases with 25 cm. for every higher class

LONG-TERM BIOGEOMORPHOLOGICAL BEHAVIOR OF COUPLED BARE INTERTIDAL FLATS AND VEGETATED FORESHORES

P.W.J.M. Willemsen[1]*, B.W. Borsje[1,2], V. Vuik[3,4], S.K.H. Janssen[2,3], T.J. Bouma[5], S.J.M.H. Hulscher[1]
[1] University of Twente, p.willemsen@utwente.nl, [2] Deltares, [3] Delft University of Technology, [4] HKV, [5] NIOZ

Over the last decades, the development of coastal areas shows a growing paradox. The majority of the world population has settled in coastal areas, while coastal flood risks are likely to increase due to global and regional changes, including storm intensity, accelerating sea level rise (SLR) and land subsidence (Bouma et al., 2014 and references herein). Conventional coastal engineering solutions are increasingly challenged by these changes and become unsustainable. Ecological engineering can serve as an alternative or add-on to conventional coastal defences, such as groins, breakwaters, dams and revetments (Temmerman et al., 2013 and references herein). The main knowledge gap hampering application of intertidal ecosystems within coastal defense schemes is lack in ability to account quantitatively for long-term ecosystem dynamics (Bouma et al., 2014). Borsje et al. (2011) indicated that the dynamic foreshore can conceptually be related to SLR and that the bed level decreases after an extreme event. More recently Möller et al. (2014) showed a stable bed in the vegetated marsh during extreme weather events, while the tidal flat in front of the marsh is more dynamic and affecting the long-term sustainability of the intertidal ecosystem (e.g. Bouma et al., 2014; Hu et al., 2015).
The overall aim of this study is to quantify the long-term (50 – 100 year) biogeomorphological behavior of the coupled bare intertidal flat and vegetated foreshore. Hypothesized is that the long-term safety level of foreshore behaves within a cyclic pattern with short term fluctuations (fig. 1). In the presentation the research outline for the coming years will be presented, focusing on different aspects. The thriving processes for the dynamic behavior will be studied. The morphologic changes of study sites in the Dutch Southwest delta will be analyzed. These changes are collected since 2014, using SED sensors collecting point data of sedimentation and erosion. The behavior of the bare intertidal flat will be assessed using the line model (DET-ESTMORF) of Hu et al. (2015), calculating long-term morphodynamics using the dynamic equilibrium theory. The foreshore as a whole will be studied using a biogeomorphological landscape model (e.g. Delft3D, XBeach). Finally, an interactive design tool will be developed to increase the practical applicability of vegetated foreshores as natural coastal defence, by parameterizing and converting the applied models.

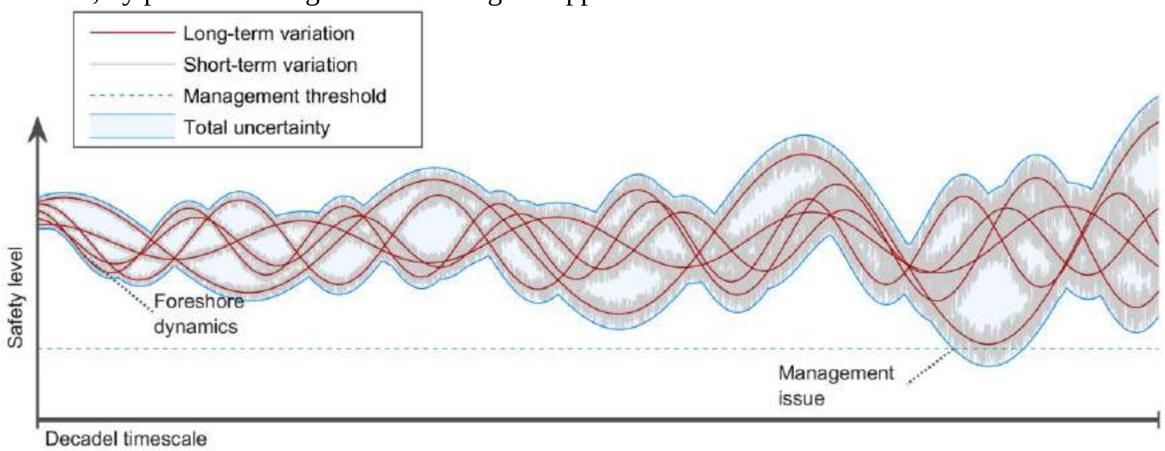


Figure 32. short- and long-term variability of the foreshore safety level (influenced by e.g. foreshore width, season, climate), that can contribute to the safety level of the dike at the back. Including a management threshold in case the ecosystem is functioning as natural coastal defence.

Borsje, B. W., van Wesenbeeck, B. K., Dekker, F., Paalvast, P., Bouma, T. J., van Katwijk, M. M., & de Vries, M. B. (2011). How ecological engineering can serve in coastal protection. *Ecological Engineering, 37*(2), 113-122.
Bouma, T. J., van Belzen, J., Balke, T., Zhu, Z., Airoldi, L., Blight, A. J., . . . Herman, P. M. J. (2014). Identifying knowledge gaps hampering application of intertidal habitats in coastal protection: Opportunities & steps to take. *Coastal Engineering, 87*, 147-157.
Hu, Z., Lenting, W., van der Wal, D., & Bouma, T. J. (2015). Continuous monitoring bed-level dynamics on an intertidal flat: Introducing novel, stand-alone high-resolution SED-sensors. *Geomorphology, 245*, 223-230.
Möller, I., Kudella, M., Rupprecht, F., Spencer, T., Paul, M., van Wesenbeeck, B. K., . . . Schimmels, S. (2014). Wave attenuation over coastal salt marshes under storm surge conditions. *Nature Geosci, 7*(10), 727-731.
Temmerman, S., Meire, P., Bouma, T. J., Herman, P. M. J., Ysebaert, T., & De Vriend, H. J. (2013). Ecosystem-based coastal defence in the face of global change. *Nature, 504*(7478), 79-83.

MEASURING AEOLIAN SALTATION INTENSITY ON HIGH SPATIOTEMPORAL SCALES USING A HOME-BUILT SALTATION DETECTION SYSTEM (SALDECS)

Winnie de Winter[1], Gerben Ruessink[1], Geert Sterk[1] and Bas van Dam[1]
[1] Utrecht University, w.dewinter@uu.nl, b.g.ruessink@uu.nl, g.sterk@uu.nl, d.b.vandam@uu.nl

1. Introduction
The occurrence of aeolian saltation is intermittent due to wind turbulence, which induces a non-continuous flow of sediment on small spatiotemporal scales (centimeters and seconds). The intermittency of saltation causes the transport to be confined to a smaller amount of time and consequently affects the time-averaged sediment transport rate (Davidson-Arnott and Bauer, 2009). High-frequent saltation sensors can be used to measure the intermittency of saltation. However, a large amount of sensors is needed to measure on a small-scale spatial variability. Previously used saltation sensors often show a mutual inequality in sensitivity or are designed such that it is impossible to use them on a high spatial resolution (centimeters). Here, we present the validation of the mutual equality of individual sensors in a home-built Saltation Detection System (SalDecS) (Figure 1) that can measure saltation intensity at a frequency of 10 Hz and at a spatial resolution of 0.10 m over a span of 3.10 m in wind-normal direction (Figure 2).

2. Methods
Wind tunnel experiments were carried out in 2015 at the International Centre for Eremology at Ghent University. During 5 different wind conditions, 10 individual sensors in the SalDecS were tested with sand from the field experiment site Egmond aan Zee, The Netherlands. In the field experiment we installed 4 SalDec systems, each of them containing 32 horizontally oriented sensors perpendicular to the prevailing wind direction to measure the wind-normal and temporal variability in saltation.

3. Results
Results reveal that in the wind tunnel saltation intensity is positively related to the mass flux. The saltation intensity variation among SalDec sensors varies between 12 %, for small mass fluxes and 3% for large mass fluxes. In the field, the sensors show a good mutual equality for both calm and intense saltation events.

4. Conclusions
Concludingly, the SalDecS can be used to qualitatively determine small-scale spatiotemporal variability in saltation intensity in the field. Saltation intensity variations along the wind-normal array smaller than 12% may represent the variation in sensitivity of the saltation sensors, whereas variations larger than 12% can be ascribed to variability in saltation transport intensity.

Figure 33: Saltation Detection System (SalDecS) installed at the beach south of Egmond aan Zee. The horizontal oriented array contains 32 sensors to measure small-scale spatiotemporal variability in saltation with a spatial resolution of 0.10 m and a frequency of 10 Hz.

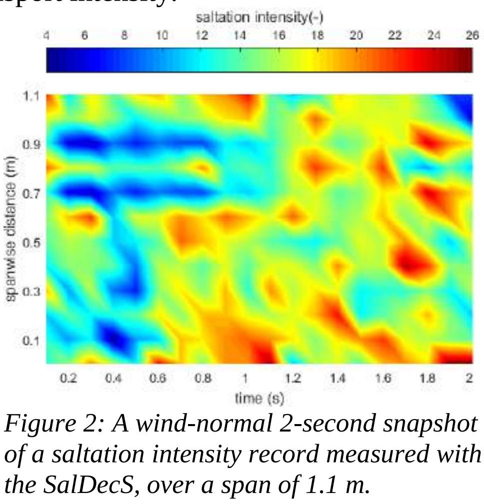


Figure 2: A wind-normal 2-second snapshot of a saltation intensity record measured with the SalDecS, over a span of 1.1 m.

References
Davidson-Arnott, R.G.D., Bauer, B.O. (2009). Aeolian sediment transport on a beach: Thresholds, intermittency, and high frequency variability. *Geomorphology, 105*, 117-126.

TIDE-INDUCED CURRENTS IN A PHASE-RESOLVING WAVE MODEL

F.P. de Wit[1], M.D. Klein[2], M. Zijlema[1], J. Bosboom[1], A.J.H.M. Reniers[1]
[1] dewit.fp@gmail.com
[1] Delft University of Technology, [2] Royal HaskoningDHV

Introduction

Alongshore currents are parallel to the coastline. In coastal areas they are often driven by a combination of wave and tidal forcing. In this study, the validity of the non-hydrostatic, wave-flow model SWASH to predict these currents is investigated. This is done by comparing model predictions with measurement observations. Observations were obtained from the COAST3D data-set at the gently sloping barred beach near Egmond. It contains six weeks of wave and velocity measurements for a wide range of conditions.

Model settings

An initial study was performed to investigate model settings and parameter sensitivity for correctly capturing wave dynamics. From this study, it can be concluded that two terrain-following layers and 75 grid cells per wave length lead to accurate results for surf zone wave modelling. Although some discrepancies in mean water level set-up were encountered, this is assumed not to affect alongshore current predictions.

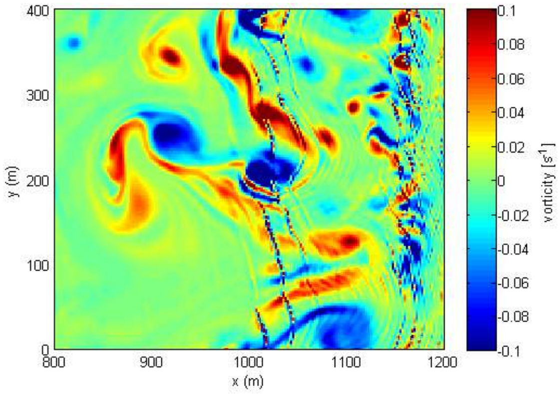


Figure 1: Snapshot of surf zone vorticity. Beach is to the right.

Implementation

The present SWASH model does not allow for the inclusion of alongshore tidal currents. Therefore, this study presents a method to include tidal forcing, which was implemented in the source code. This method enables the user to include the tide by imposing a water level gradient, which is assumed to be time averaged and spatially uniform. These assumptions are reasonable as spatial and temporal model scales are small compared to a tidal wave.

Conclusions

Validation results demonstrate the capability of SWASH to correctly represent wave transformation in a surf zone. Furthermore, modelled velocity predictions are in good agreement with observations for cases with waves from southwest and northward flood tidal currents, which were not disturbed by instabilities. Results were less well for cases with different forcing. Some discrepancies are observed between model and observations. Further study is required to evaluate whether this is caused by measurement inaccuracies, or whether other physical phenomena play a role in the mismatch. Inertia of a tidal wave and bottom friction are processes that could potentially be the cause of the discrepancies. It should be noted that conclusions are based on only five cases. Therefore, performing more simulations is underway.

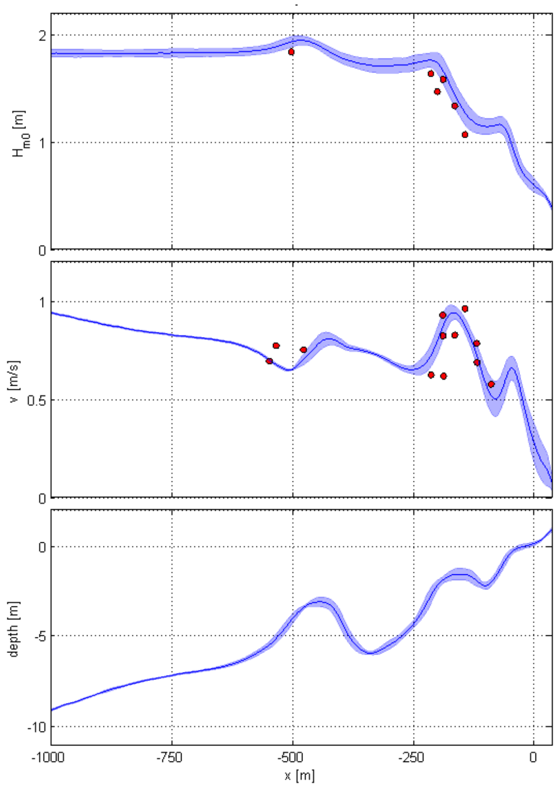


Figure 2: Modelled vs. measured H_{m0} and v

DETERMINATION OF BACKFILL FOR SAND PLACEMENT NEAR A TRENCH

L. de Wit[1], W. Snip[2]
[1] Svašek Hydraulics, Wit@svasek.nl
[2] Primo Marine, Wino.Snip@primo-marine.com

When sand is placed near a trench it is possible that part of the sediment will flow into the trench as a density current, especially when there is a bed slope towards the trench. This can be undesirable as it leads to an increase in dredging effort to achieve the desired trench depth. A detailed process based CFD (Computational Fluid Dynamics) model (De Wit 2015) is used to simulate the density current from sand placement near a trench for 2 cases: with and without ambient current towards the trench.

Placement of 4500 m^3 sand (200μm, w_s=2.3cm/s) from a hopper dredger sailing at 200 m distance along a trench with a bed slope of 1:20 towards the trench is simulated, see Figure 1. Placement takes 15 minutes and during this time the dredger has moved 900 m along the trench at 1 m/s. The CFD model uses 14 million fine grid cells of Δx,Δy,Δz=1.2x0.6x0.5m at outflow.

Figure 1 (left) shows a clear density current of 3-5m high with 10-100 g/l SSC for the case without ambient current. Maximum SSC at the free surface is 100-1000 mg/l. Due to deposition of sand at the sea bed the SSC inside the density current decreases at larger x distances from the dredger. Just when the density current has reached the trench at x=500m all sand has deposited. With a weak ambient current of 0.3 m/s the situation is completely different, see Figure 1 (right). The placed sand now behaves as a mixed plume with SSC of 1-10 g/l at the free surface.

For the investigated set of conditions there is no backfill without ambient cross flow, but 5% backfill can be expected when placing sand with 0.3 m/s ambient cross current towards the trench.

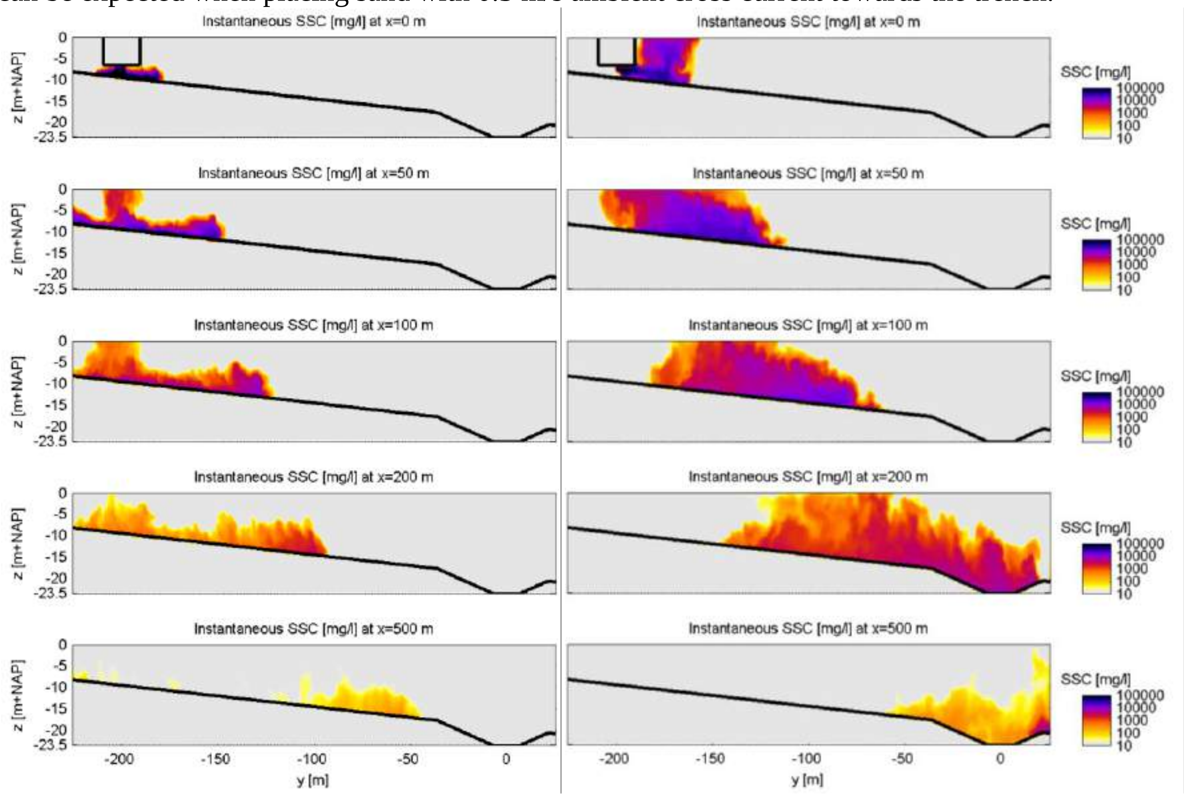


Figure 34 Illustration of the influence of the ambient current on a turbidity current near a trench: left without ambient flow at the turn of tides, right with 0.3 m/s ambient cross current in the trench

References

Wit L. de (2015), *3D CFD modelling of overflow dredging plumes*, Ph.D. thesis, Delft University of Technology.

WAVE BOTTOM BOUNDARY LAYER FLOW AND TURBULENCE UNDER A PLUNGING BREAKING WAVE OVER A RIGID BREAKER BAR

J. van der Zanden[1], D.A. van der A[1], T. O'Donoghue1, J.S. Ribberink[2]
[1] University of Aberdeen, joep.vanderzanden@abdn.ac.uk, d.a.vandera@abdn.ac.uk, t.odonoghue@abdn.ac.uk
[2] University of Twente, j.s.ribberink@utwente.nl

Motivation

Present understanding of hydrodynamic processes under breaking waves is primarily based on smallscale wave flume experiments. The few large-scale studies with breaking waves offered limited knowledge in particularly the temporal and spatial variation of breaking-induced turbulent kinetic energy (TKE) and its effect on the wave bottom boundary layer (WBBL). Such knowledge seems essential to improve morphodynamic modelling of the surf zone.

Experimental description

This motivated an international project (UK/NL, funded by EPSRC/STW) that included experiments in the large-scale CIEM wave flume (Barcelona), during which the outer and WBBL flow were measured using 0D2C Laser Doppler Anemometry and a 1D3C Acoustic Doppler Velocimetry Profiler with high temporal and spatial resolution (*Figure 1*). The experiments involved plunging breaking waves over a barred profile that was rigidized using an asphalt layer. Wave and bed profile conditions were consistent with a recent mobile-bed campaign (van der Zanden *et al., in prep.*), allowing detailed comparison between hydrodynamic and sediment transport processes along the outer and inner surf zone.

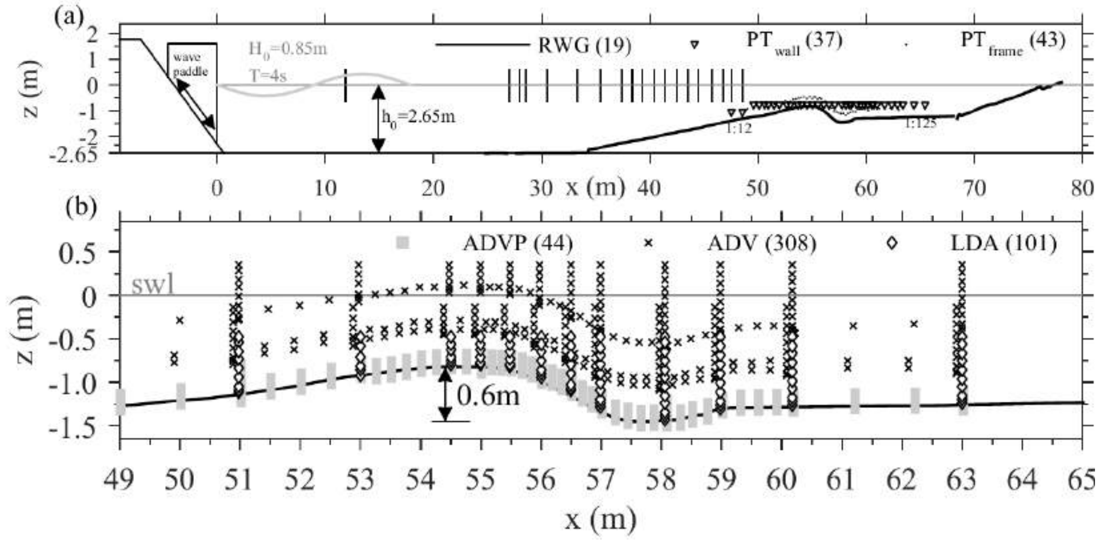


Figure 1 Experimental set-up. (a) Overview of wave flume and positions of water level measurements; (b) Close-up of test section and locations of velocity measurements.

Results

Analysis of the outer flow data revealed strong injection of TKE into the water column upon wave breaking (van der A *et al., in prep.*). Subsequently, TKE is transported downward due to advective (mean current and orbital flow) processes and increases near-bed (at 1 cm) TKE values in the breaking zone, relative to shoaling zone, by over a factor three. At the conference, the effects of TKE invasion on WBBL hydrodynamics will be presented.

References

van der Zanden, J., van der A, D.A. *et al.* (manuscript in preparation), *Near-bed hydrodynamics along a barred sand bed profile below a full-scale plunging breaking wave*.
van der A, D.A., O'Donoghue, T. *et al.* (manuscript in preparation), *Flow and turbulence under a largescale laboratory plunging wave over a fixed bar*.

ECOSYSTEM SERVICE DYNAMICS OF THE SAND ENGINE

S.C. van Zanten [1,2]* A.P. Luijendijk[1,2], A.P.E. van Oudenhoven[3]
[1]Delft University of Technology, Sophie.vanZanten@deltares.nl
[2] Deltares, Hydraulic Engineering
[3]Institute of Environmental Sciences CML, Leiden University

The Sand Engine (SE) is a unique and dynamic solution for coastal erosion, aimed at distributing the nourished sand along the Delfland coast. Besides enhancing coastal protection, the SE has been designed to also provide opportunities for recreation and nature development. The effectiveness of the SE's design can be evaluated following the ecosystem services approach. Typically, such an evaluation is made for one snapshot in time, usually at the initial state of the design. However, due to the dynamics of the SE, the ecosystem services are likely to change over time and across space. Future morphological behaviour of this intervention is being studied by process-based numerical models, which has resulted in morphological predictions up to 40 years ahead. Predicting the response of the ecosystem services of a nourishment by means of a process-based model could improve the decision-making regarding integrated coastal zone management.

The aim of this study is to assess the long-term development of the ecosystem services of the SE. In the study, the abiotic factors that describe the preconditions of the biotic system are specified and related to potential ecosystem service provision of the sandy shore. Subsequently, a quantitative method is set up for the assessment and validated using observations. The impact on the habitats is predicted using ecotopes: spatially defined ecological units, of which the abiotic characteristics are more or less homogeneous. In the habitat analysis the ecotopes are distinguished using the computed bed shear stresses (currents and waves) and evolving depth. The evolution of the ecotope areas is analysed over time and visualised in ecotope maps.

First results indicate a robust enhancement regarding coastline maintenance that holds beyond the envisaged lifetime of twenty years. Beach width available for recreation increases drastically along the entire Delfland coast. Regarding nature development, an extensive supratidal area develops increasing the space available for dune formation.

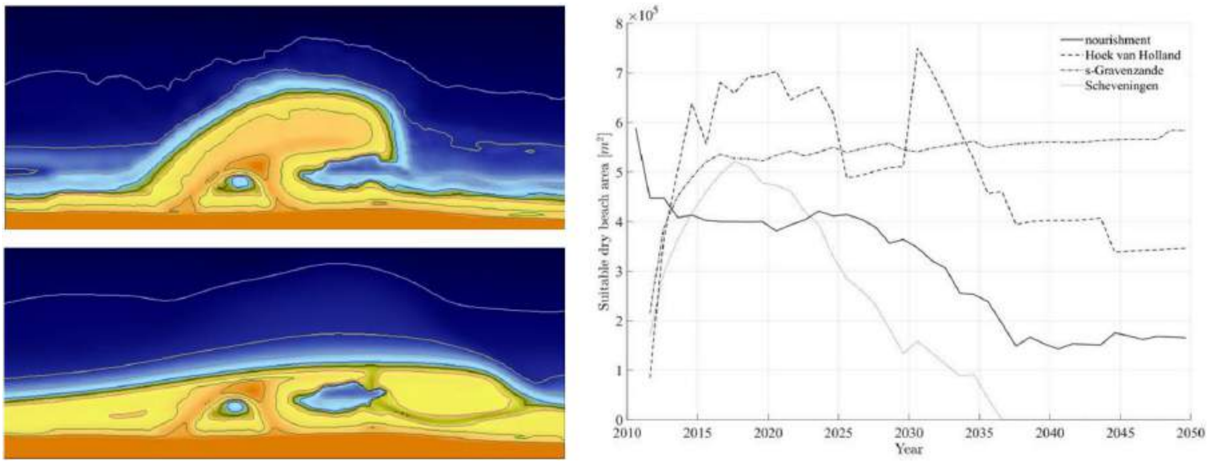


Figure 1 Initial bathymetry of the Sand Engine (top left), the predicted bathymetry in 2040 and the derived temporal development of the sunbathing surface area (ha) for four sections at the Delfland coast.

THE FUTURE IN COASTAL ENGINEERING IS NOW: DRONE WITH LIDAR

R.C. de Zeeuw[1]*, M.A. de Schipper [1, 3], E. Paree[2], R.C. Lindenbergh[3], C. Chatzikyriakou[3]
[1] Shore Monitoring & Research, roeland@shoremonitoring.nl
[2] Rijkswaterstaat CIV (*now at Hogeschool Zeeland*), edwin.paree@hz.nl
[3] Delft University of Technology, M.A.deSchipper@tudelft.nl

Over the last years the use of drones in coastal engineering and science has increased. Specifically when high resolution spatial coverage of the surface level elevation and vegetation coverage of a site is needed (e.g. dunes, intertidal flats). To date, drone photogrammetry is used in combination with manually placed and measured GPS ground control points, in order to get accurate georeferenced data. With respect to the limited spatial information obtained with GPS profile measurements, photogrammetry and drones yield an incomparable high resolution digital terrain model. Moreover, without extra acquisition effort an orthophoto can be produced, rendering multifunctional data from the same source: photographs. However, placing ground control points can be laborious (extensive dune fields) to near impossible on intertidal (mud)flats, which can take up as much as 75% of the total data acquisition time. Moreover, the photogrammetry technique has difficulties determining the bed surface levels on wet, gleaming surfaces or dense vegetation covers.
LiDAR (Light Detection And Ranging), a technique using laser pulses to determine the distance to an object or surface, can overcome some of these issues. Until recently LiDAR systems were very large, heavy and power demanding. In the last years smaller packages of integrated LiDAR, RTK-GNSS and INS systems are being developed, for mounting on unmanned aerial systems.

Figure 1. Left: the LiDAR drone. Right: LiDAR drone DTM in [m] RD NAP. Colours represent height and correspond to the colour bar in the legend. Height difference LiDAR-GPS indicated on DTM.

In this research we examined the use of a drone based LiDAR system for coastal purposes. A novel lightweight LiDAR (Velodyne HDL-32e), dual-frequency RTK-GPS/GLONASS receiver and IMU with fibre-optic gyro are integrated and mounted on a DJIS1000 multi-rotor UAV.

To test the applicability of such a LiDAR drone a first pilot was conducted at Schelphoek, Eastern Scheldt: a 40ha mudflat, currently monitored by RWS-CIV with conventional GPS profile measurements. The site is characterised by typical mudflat morphology: wet gleaming surfaces, channels and rubble mound sedimentation constructions.
During the test with the drone LiDAR data of the northern part (15ha) was acquired in 15 minutes flight time, rendering data on all but the inundated areas. The large number of points (>150 million) reveals many details of the site. A comparison of the LiDAR DTM (10 x 10 cm gridded) and RTK-GPS point measurements shows promising performance and accuracy with a mean difference (standard deviation) of 3 cm (6.7cm) between the two data sources.
The LiDAR drone technique and the results of the Schelphoek pilot will be discussed in more detail at the conference.

Notes

[illegible]
[illegible]
[illegible]
working in the field of coastal research. The NCK
[illegible]
[illegible]
The Netherlands. Founded in 1992, the NCK was
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
worldwide .

The NCK covers the following research themes: Seabed and Shelf, Beach Barrier Coasts. Tidal !niets
[illegible]
geomorphology, and Coastal Zone Management.

Several times a year, the NCK organizes workshops
[illegible]
and mutual exchange of knowledge. NCK is open
[illegible]
researchers is encouraged. Among the active participants we find people from various different institutes and companies. NCK activities help
[illegible]
management groups of NCK partners.
[illegible]
different backgrounds facilitates a multidisciplinary
[illegible]
[illegible]
end-user interests.

For more information, visit:

www.nck-web.org

[illegible]

NWO Netherlands Organisation for Scientific Research

[illegible]

Deltares Enabling Delta Life

TU Delft Delft University of Technology

UNESCO-IHE Institute for Water Education

Universiteit Utrecht

UNIVERSITY OF TWENTE.

WAGENINGEN UR For quality of life

NIOZ Royal Netherlands Institute for Sea Research

Rijkswaterstaat Ministerie van Infrastructuur en Milieu

Book of abstracts NCK days 2016