Wave transformation on the mangrove-mud coast of Demak, Indonesia

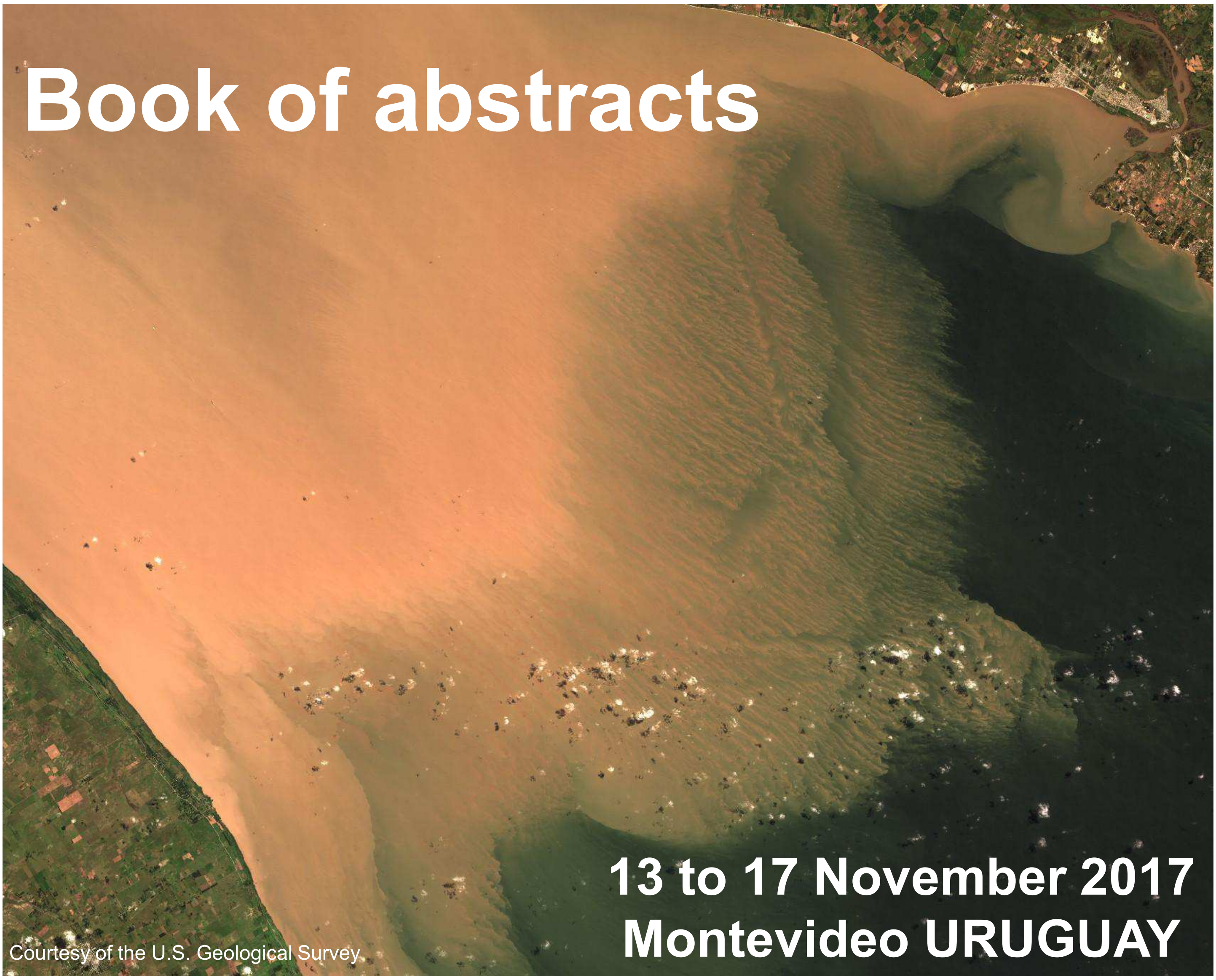
Tas, Silke; Gijón Mancheño, Alejandra; Herman, Peter; Reniers, Ad; Uijttewaal, Wim; Winterwerp, Han

Publication date
2017

Citation (APA)
Tas, S., Gijón Mancheño, A., Herman, P., Reniers, A., Uijttewaal, W., & Winterwerp, H. (2017). *Wave transformation on the mangrove-mud coast of Demak, Indonesia*. 39-40. Abstract from INTERCOH 2017, Montevideo, Uruguay.

INTERCOH 2017
Montevideo - Uruguay
November 13 - 17

14th International Conference on Cohesive Sediment Transport Processes



Book of abstracts

13 to 17 November 2017
Montevideo URUGUAY

Courtesy of the U.S. Geological Survey

imfia

FACULTAD DE INGENIERIA

UNIVERSIDAD DE LA REPÚBLICA URUGUAY

Fundación Julio Ricaldoni
INGENIERÍA EN EL URUGUAY

Wave transformation on the mangrove-mud coast of Demak, Indonesia

S.A.J. Tas[1], A. Gijón Mancheño[1], P.M.J. Herman[12], A.J.H.M. Reniers[1], W.S.J. Uijttewaal[1], J.C. Winterwerp[12]

[1] Department of Hydraulic Engineering, Faculty of Civil Engineering and Geosciences
Delft University of Technology, PO-box 5048, 2600 GA Delft, The Netherlands
E-mail: s.a.j.tas@tudelft.nl

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

Abstract
In this paper the typical hydrodynamics on mangrove-mud coasts are studied. Worldwide, these coasts experience serious erosion problems, and while the importance of mangrove ecosystems is becoming widely recognised, mangrove restoration projects frequently fail due to poor understanding of the system, especially the hydrodynamics. Therefore, a landscape model of the eroding coastline of the Demak district in Indonesia is developed to analyse the typical hydrodynamics associated to mangrove-mud coasts. Owing to the fine sediment, these coastlines are characterised by gentle slopes, in the order of 1:1000 or less. Both the theoretical and numerical wave transformation have to be re-evaluated on such slopes, which is done by combining models with field measurements. Also the current patterns and density effects are studied in detail to generate a full understanding of the hydrodynamics on mangrove-mud coasts.

Introduction
The erosion of mangrove-mud coasts is a serious problem worldwide, affecting millions of people in their daily life. For example, income drops of 60-80% and halving of commercial sea fishing over the last 5-10 years have been reported in eroding areas of Java, Indonesia, largely attributed to the loss of mangrove spawning and sheltering grounds (Manumono, 2008).
The objective of the current research project is to develop a bio-morphodynamic landscape model for mangrove-mud coasts. The algorithms for the physical and biological processes will be developed based on laboratory and field work, the latter carried out at the extremely eroding Demak coastline, Java, Indonesia.
The focus of this paper is the hydrodynamics on these muddy coasts. Due to the fine sediment, muddy coastlines are characterised by extremely gentle slopes, in the order of 1:1000 or less. On such slopes, the subtle balance between dispersion and shoaling of waves has to be re-established, and numerical models such as SWAN have experienced issues with quadruplet wave-wave interactions (Tas, 2016). Long waves are known to be less affected by these mild slopes, resulting in a lower peak frequency nearshore (Phan Khanh Linh et al., 2015). Also the effect of viscous wave damping by the soft muds on the seabed, and the effect of stratification due to river outflow is investigated.
A retreating coastline, such as the Demak coastline, is the net response to an imbalance in sediment transports. The sediment balance of muddy coasts typically consists of two huge gross fluxes, erosion and sedimentation, and results in a significantly smaller net effect. We hypothesise that the relatively weak effect of vegetation on the sediment may stabilise this inherently unstable system. One of the main drivers of sediment transport is the hydrodynamics nearshore. Therefore, the first step towards protection and/or restoration of mangrove coasts is a thorough understanding of the hydrodynamics of the system.

Methods
In order to understand the hydrodynamics at the Demak coastline, a numerical landscape model has been set up. For this, Delft3D is used, a 3D modelling suite to investigate hydrodynamics, sediment transport and morphology and water quality for fluvial, estuarine and coastal environments (Deltares, 2016). The modelled hydrodynamics are compared with currently available data (summarised below) and data taken from the field campaign which is scheduled in the Summer of 2017.
The domain is chosen sufficiently large, to prevent interaction between possible river plumes and boundary effects. This domain is illustrated in Figure 1. For the waves, an even larger domain is used in order to prevent that shadow zones induced by the boundaries affect the region of interest, i.e. the Demak coastline.

Since the Demak district has been a pilot site for coastal protection over the past years, there is already some information available, which is used to set up the boundary conditions of the model. A tidal station in Semarang, the city bordering the Demak district to the south, indicates the tide depicts a clear diurnal signal, with a small semi-diurnal component. The tidal range varies between 40cm and 60cm. There is a long-term average residual flow towards the east, resulting in a net fine sediment transport. Bed slopes are of the order of 1:1000 close to shore, further offshore steepening towards 1:500, all with a muddy substrate, although the thickness of the mud layers is unknown. Based on 14 years of wave data near Semarang, the mean wave height in the area is 0.46m and the maximum wave height lies between 2.6m and 3m. Due to the monsoon climate, all relevant waves have a direction between N and WNW. The wet season is from November to March. During this NW monsoon the river plumes are diverted to the east and pushed against the shoreline, inducing a gravitational circulation along large parts of the coast, keeping fine sediments close to the coastline. During the dry season, there are only local gravitational circulations (Winterwerp et al., 2014).

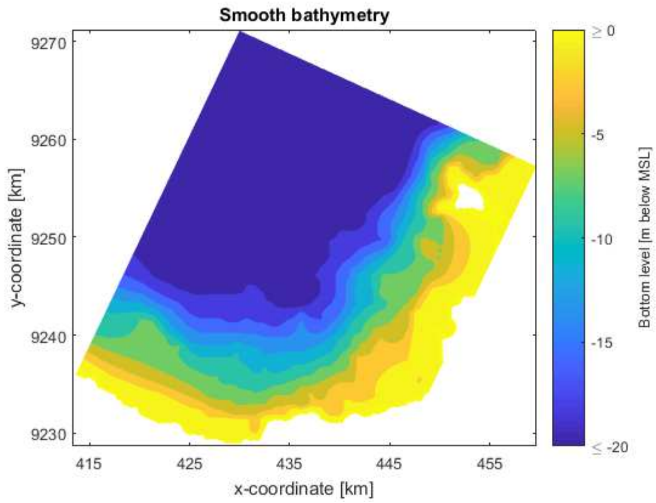


Figure 1: Domain with bathymetry of Delft3D model

Results

Wave transformation in the model is compared to wave measurements (wave height and period, orbital velocities) along transects in order to assess model performance. Non-linear wave-wave interactions (especially the quadruplets), dispersion, shoaling and wave damping by the soft muds on the seabed are analysed individually, in order to determine whether the wave transformation on these gentle slopes is modelled accurately.

Furthermore, current patterns (flow velocities and directions) are identified and analysed in order to identify the main driver(s) and to assess the presence of residual currents. Finally, density differences (salinity, temperature) are investigated over the seasons, to assess the presence of stratification.

Discussion

Understanding the hydrodynamics of the area is mandatory to gain insight in the causes of coastal erosion in Demak, moreover, it can be used to design successful coastal protection and restoration strategies. For example, by identifying the main processes driving wave transformation on gentle slopes, wave attenuating measures can be designed to tackle specific processes, and negative effects can be minimised.

Although the model is set up for the Demak area, several conclusions (such as the wave transformation on gentle slopes, the effect of stratification on sediment transport and specific protection and restoration measures) are applicable to many other mangrove coasts worldwide. However, it is important to note that, due to the sheltered character of the Java Sea, the Demak coastline is only exposed to wind waves. Therefore, the wave transformation and impact of swell waves on mangrove coasts will need to be analysed based on another case study.

References

Deltares. (2016). Delft3D Functional Specifications. Delft: Deltares.

Manumono, D. (2008). Perubahan Perilaku Masyarakat Kawasan pesisir Akibat Penurunan Pendapatan sebagai dampak abrasi dan rob di Kabupaten Demak/Behaviour change of coastal community as an impact of abration and rob in Demak Regency. In National Seminar of Dynamics of Agriculture and Rural Development.

Phan Khanh Linh, Van Thiel De Vries, J. S. M., & Stive, M. J. F. (2015). Coastal Mangrove Squeeze in the Mekong Delta. Journal of Coastal Research, 31(2), 233–243. http://doi.org/10.2112/JCOASTRES-D-14-00049.1

Tas, S. A. J. (2016). Coastal protection in the Mekong Delta. Wave load and overtopping of sea dikes as function of their location in the cross-section, for different foreshore geometries. Delft University of Technology.

Winterwerp, J. C., van Wesenbeeck, B. K., van Dalfsen, J., Tonneijck, F., Astra, A., Verschure, S., & van Eijk, P. (2014). A sustainable solution for massive coastal erosion in Central Java.