APPLYING XBEACH ON 7,300 KM COASTLINE: DETERMINING COASTAL CLIFF RETREAT DURING A STORM

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MOTIVATION

Denmark has more than 7,000 km soft coastline of which most is exposed to storm erosion. The presence of more than 13,000 groins, shore parallel breakwaters and revetments clarify the need of protecting infrastructure and property against coastal erosion in a changing climate. The Danish Coastal Authority is responsible for carrying out a national risk assessment evaluating the risk level of storm erosion today, and in 2065 and 2115.
This abstract focusses on the methodology for the calibration and validation of the numerical model XBeach to calculate the cliff retreat during storm using measured storm data. It is of highest priority to set up a model, which can perform on a national scale. In this work, it is shown that a single model setup is able to estimate the cliff retreat for all types of Danish coastlines.

METHODOLOGY

The risk of storm erosion is defined by the product of the probability of a retreat (in meters) of a coastal cliff during one storm and the value of the assets lost from the retreat. The retreat of sandy cliffs in Denmark is estimated by applying the Open Source Software XBeach. The retreat of moraine cliffs in Denmark has previously been studied by Frederiksen (2018) contributing to common literature on the subject by Halcrow (2007) and Earkie et. al (2014). In conclusion, moraine cliffs do not erode during single storm events, hence they are neglected in this project.

The hydrodynamic input for XBeach constitutes of hindcast storm data from 60 hydrographic locations in deep Danish waters from 1995 to 2017 (DHI, 2019a) from a coupled hydrodynamic and spectral wave model (DHI, 2019b). Based on the highest peak water levels, the five severest storms are selected. The water levels are adjusted so the peak corresponds to the water level of a statistical storm for a 100-, 1,000-, and 10,000-year return period. Corresponding waves are not adjusted. The storm duration is set to 48 hours prior to and after the peak water level. The storm causing the largest cliff retreat is chosen. Effects of climate change is calculated by adding expected sea level rise from RCP8.5 scenario.

The pathway is constructed by combining a terrain model and a bathymetric model. The XBeach model grid is gradually refined towards the coast. As a conservative approach, the effect of shore parallel breakwaters on wave breaking are neglected. However, standardized revetments based on a national analysis are included as non-erodible layers in the model.

MODEL CALIBRATION

Due to the national wide approach and a strict project time plan, a less computationally demanding 1D setup is selected since only cross-shore sediment transport is considered during a single storm. The XBeach model is calibrated at Vedersø, exposed to the North Sea, to a severe storm measured in 2005. Model parameters were analyzed in order to find the best model calibration results. Based on these analyses, the most applicable values of the investigated parameters were gamma = 0.55, D50 = 0.0004 m, morfac = 5, dryslp = 0.8 and facua = 0.3.

The model is subsequently validated with historic storm data at three other coasts with different wave exposure. In total, the model is validated using seven different coastal profiles.

VALIDATION RESULTS

The calculated coastal cliff retreat rates and the measured retreat during a storm are shown in table 1 for all calibration and validation cases. Vedersø 1 is the calibration run.

Table 1 – Measured and calculated cliff retreat [m].

Location	Measured	Calcu-lated
Vedersø 1, high exposure	16	16
Vedersø 2 , high exposure	4	4
Heatherhill , medium exposure	0	1
Havstokken medium exposure	8	8
Gedesby 1 , low exposure	2	2
Gedesby 2 , low exposure	2	2
Gedesby 3 , low exposure	2	3
Gedesby 4 , low exposure	4	4

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