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Modelling the effect of climate change on coastal dunes

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Background

The size and shape of coastal dunes depends on the balance between accretion and erosion. Changes in this balance may have consequences for the direction and speed of dune development.

As both accretion and erosion are driven by climatic forces, our research question is: how does climate change influence dune development ?

Objective

The objective is to simulate effect of scenarios on resulting size and shape of foredunes. Model requirements:

- Simulate dune morphology on yearly-decadal timescale
- Sensitive to climatic parameters
- Only dry beach and foredune
- Cellular, rule-based approach
- Limited amount of parameters

Model description

The model is based on the sand transport algorithm by Baas (2002) and is extended for a coastal setting De Groot et al. (in prep). It simulates aeolian transport, vegetation development and dune erosion, with one iteration equivalent to 4 days. The model input consists of an initial profile, a map of initial vegetation cover and a time series of sea levels. The output is a series of topographies and vegetation maps.

Aeolian transport

Sand transport in cross-shore direction. Erosion and deposition probability depend on vegetation.

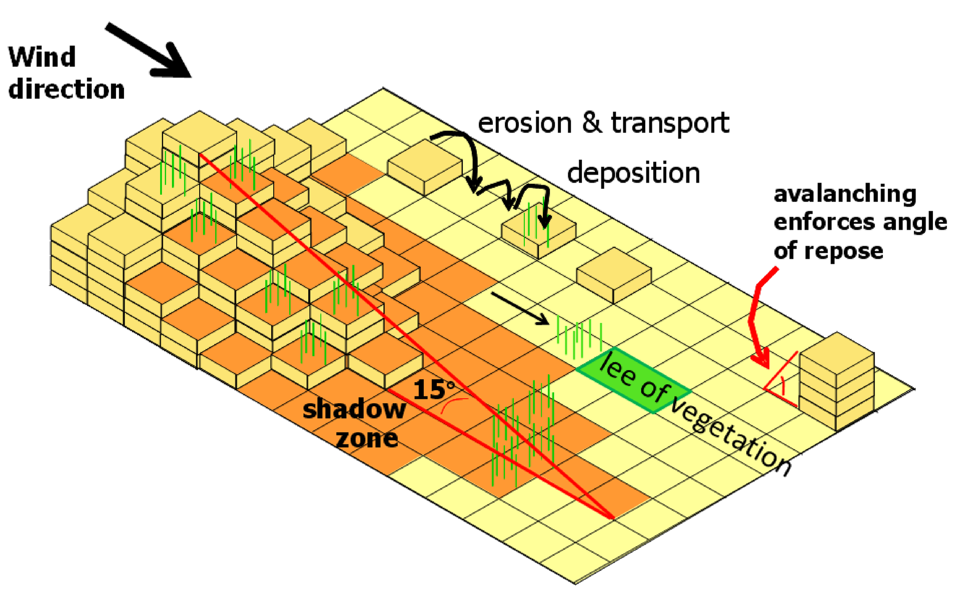

Figure 1. Aeolian transport and interaction with vegetation. Adapted from Baas (2002).

Vegetation

Positive growth response of vegetation to burial, representative of marram grass. Presence of vegetation in a cell stimulates deposition and limits erosion.

Dune erosion

Sea-level time series is converted to wave ‘energy’. Energy dissipation depends on the water depth. When enough energy remains, the topography is set back to the equilibrium profile.

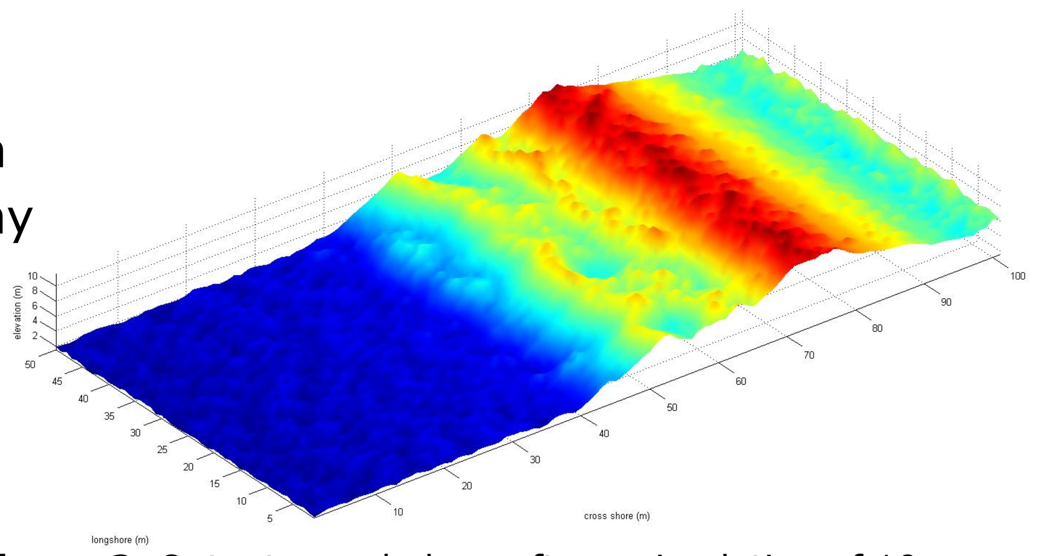

Figure 2. Output morphology after a simulation of 10 years.

Results

Simulations are compared with developments in JARKUS profiles. Success rate is determined by comparing trend in dune volume and the longshore-averaged change in elevation.

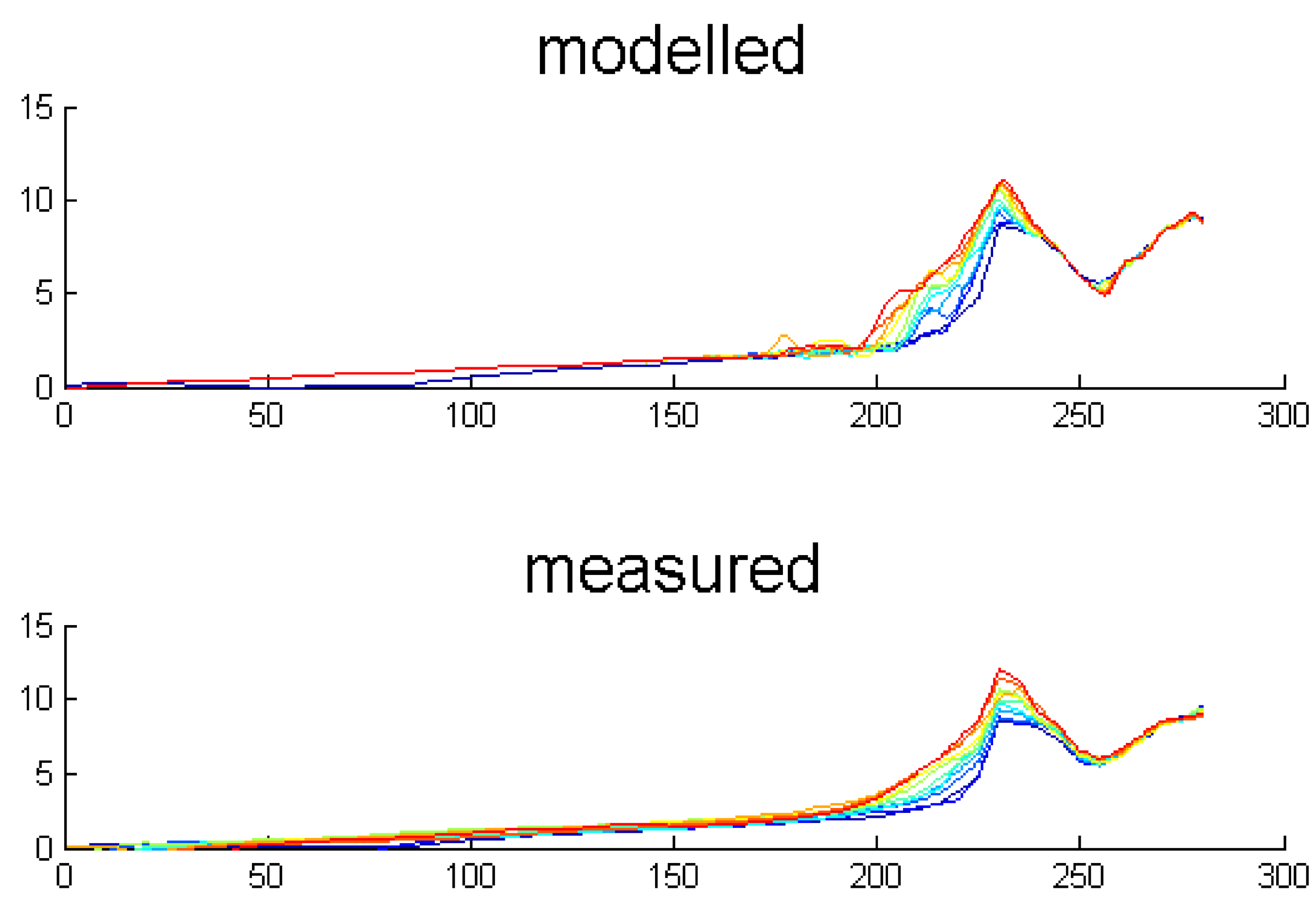

Figure 3. Profile development of model simulations and JARKUS profiles, both between 2000 and 2010 (r=0.87).

The trends in dune volume are most sensitive to sea level and storm frequency. Morphology is controlled by sea level and the effectiveness of vegetation.

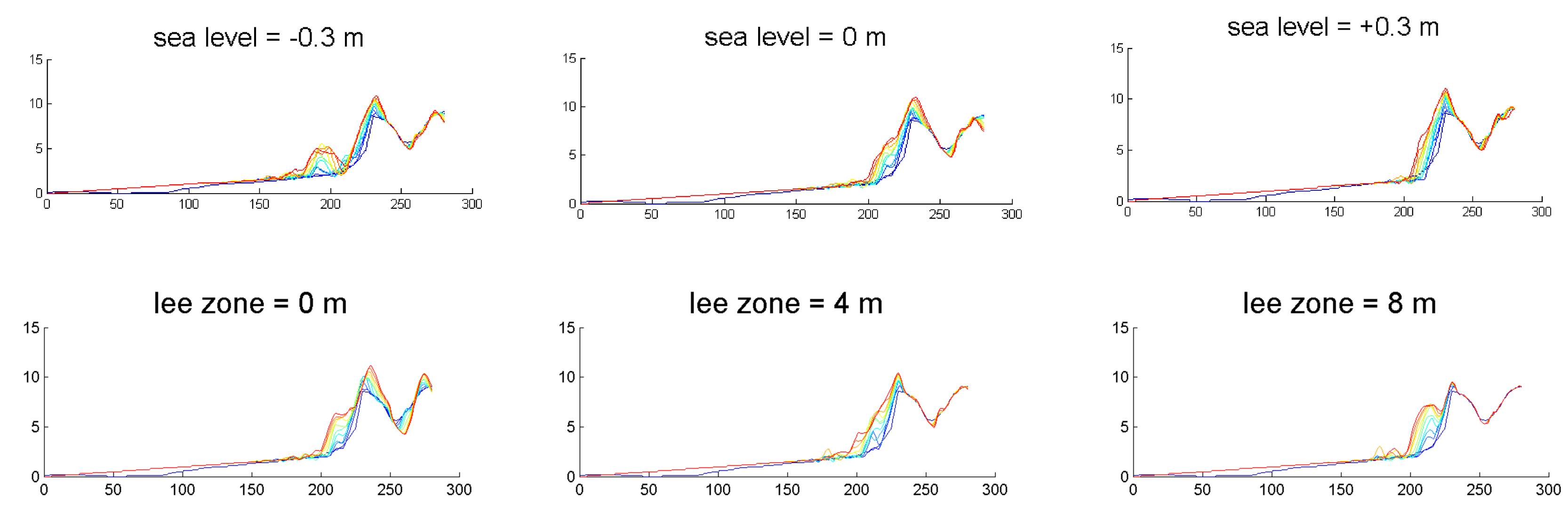

Figure 4. Morphology after 10 y with changing sea level (upper panels) or length of the vegetation lee zone (lower panels).

Conclusions

- Model effectively simulates dune development
- Morphological development in agreement with measurements
- Model is most sensitive to sea level and storm frequency
- Highly extendable

Future work

- Improve calibration of morphology
- Perform simulations for climate scenarios

References

Baas, A. C. W. (2002). "Chaos, fractals and self-organization in coastal geomorphology: Simulating dune landscapes in vegetated environments." Geomorphology **48**(1-3): 309-328.

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