# Simulation of medium to long-term dune evoloution with interacting marine and aeolian sediment transport processes

Hallin, Caroline; Huisman, Bas; Krijnen, Ine; de Vries, Sierd

**DOI**
10.48470/28

**Publication date**
2022

**Document Version**
Final published version

**Published in**
Book of abstracts Building Coastal Resilience 2022

**Citation (APA)**
Hallin, C., Huisman, B., Krijnen, I., & de Vries, S. (2022). Simulation of medium to long-term dune evoloution with interacting marine and aeolian sediment transport processes. In G. Strypsteen, B. Roest, D. Bonte, & P. Rauwoens (Eds.), *Book of abstracts Building Coastal Resilience 2022 : Dune in front of a dike* (pp. 22-24). (VLIZ Special Publication; Vol. 89). Vlaams Instituut voor de Zee. https://doi.org/10.48470/28

# Simulation of medium to long-term dune evoloution with interacting marine and aeolian sediment transport processes

Caroline Hallin[1], Bas Huisman[2], Ine Krijnen[3] and Sierd de Vries[1]

[1] Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands
E-mail: e.c.hallin@tudelft.nl, sierd.devries@tudelft.nl
[2] Department of Applied Morphodynamics, Deltares, Delft, The Netherlands
E-mail: bas.huisman@deltares.nl
[3] E-mail: inelottekrijnen@gmail.com

## 1. INTRODUCTION

In recent years, dune-in-front-of-dike projects have been carried out at several locations, e.g. at Raversijde and Oosteroever in Belgium and the Hondsbossche dunes in the Netherlands. In the near future, many coastal defence systems require reinforcement to adapt to rising sea levels, and often, natural values along the coasts may also be enhanced. Therefore, it is anticipated that this type of hybrid coastal protection – a mix of grey and green solutions – will become more common in the future. Contrary to grey defence structures, such as earth dikes and rock or concrete structures, dunes are dynamic features. Their level of flood protection depends on their morphological evolution due to aeolian and marine transport processes, vegetation dynamics, and anthropogenic impact.

Numerical models are commonly used tools to assess the safety level of dunes and predict their future evolution. In addition to event timescales (storms), the decadal timescale is typically of interest from a coastal management perspective, especially when considering sea level rise. On this timescale, dune build-up through aeolian transport depends on the wind's transport capacity, and the availability of sediment of the appropriate size exposed to the wind is an important process. Sediment availability for aeolian transport is controlled by other sediment transport processes, such as dune erosion and longshore sediment transport, nourishments, and limiting factors, such as surface moisture and armour layers.

Simulation of dune evolution at the decadal timescale requires an integrated model approach that accounts for the non-linear interactions between marine and aeolian transport processes in the longshore and cross-shore direction. Reduced complexity approaches are required when these models are applied to large temporal (decades) and spatial scales (kilometres).

This study aims to predict medium to long-term dune evolution by developing a new coupled long- term beach and dune evolution model, coDaC (**co**upled **D**unes **a**nd **C**oasts ). The new model combines a semi-empirical cross-shore transport model, the CS-model (Hallin *et al.* 2019a), with a longshore transport and coastline evolution model, Unibest CL+ (Figure 1). The coupled model is applied to simulate 22 years of morphological dune evolution along an 8 km-long coastal stretch at the Kennemer Dunes in the Netherlands.

## 2. THE coDaC MODEL

During simulation, a model coupler exchanges sediment transport rates between the submodels, the CS-model and Unibest CL+. The CS-model is applied to several cross-shore (CS) transects distributed alongshore on the Unibest CL+ coastline grid. The CS-model computes the volume of sediment stored in the dune and a simplified dune morphology based on a triangular or trapezoidal shape. It simulates aeolian transport from the beach towards the dune, $q_w$ [m$^3$/m/s], dune erosion, $q_d$, and overwash, and a Bruun-type morphological compensation for sea level rise, $q_S$. These transports are exchanged with the Unibest CL+ model as sources or sinks that influence the shoreline location. In return, Unibest CL+ exchanges gradients in the longshore transport influenced by beach and shoreface nourishments, $dQ/dy$.

In the CS-model, changes to sediment availability, $dV/dt$ [$m^3/m/s$], is computed based on the sediment transport rates at the transects,

$$\frac{dV}{dt} = q_d - q_w - a \cdot (q_s + \frac{dQ}{dy})$$

where $a$ is an empirical coefficient.

The aeolian sediment transport cannot exceed the available volume, $V$. It becomes supply limited in CS-transects where the potential aeolian transport rates exceed the storage and influx of transportable sediment.

3. CASE STUDY

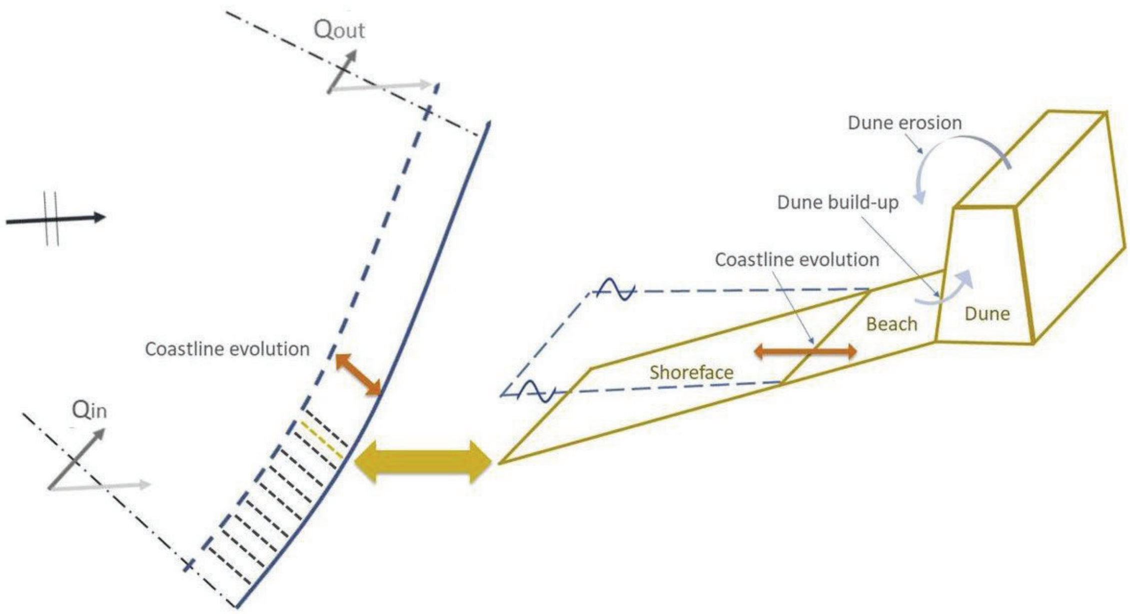


*Figure 1: Schematic picture of the coupling between Unibest CL+ and the CS-model in coDaC*

The coDaC model was applied to an 8 km-long coastal stretch at the Kennemer dunes with a mix of transport and supply-limited dune evolution. The model was calibrated and validated against yearly observations of topography and bathymetry in 26 transects from the JARKUS data set (Figure 2). The result was compared to a previous application of the CS-model (Hallin *et al.* 2019b). Compared to the application of the non-coupled CS-model, the results improved due to the longshore spreading of nourishments, which previously only were accounted for in the nourished transects (Figure 2). In conclusion, the coupled model requires long data sets for calibration but is a promising tool for predicting long-term dune evolution in areas with abundant data on the historical evolution.

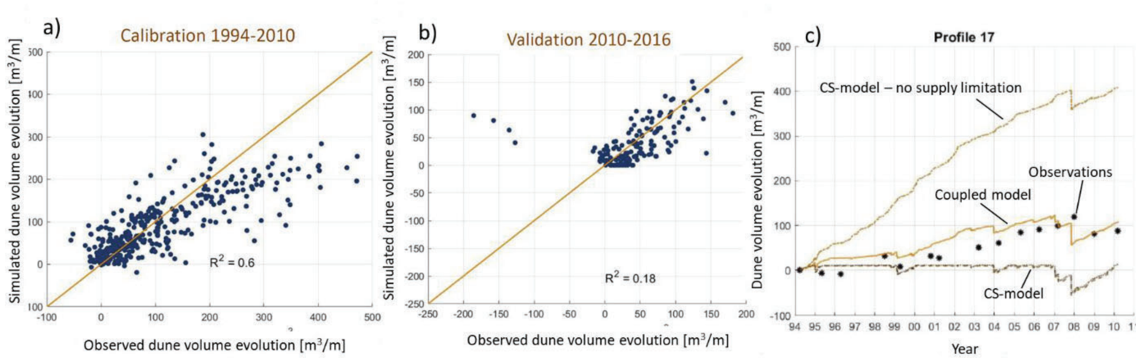


*Figure 2: a) Result of calibration coupled model b) Result of validation coupled model c) Result of calibration profile 17 compared to CS-model simulations with and without supply limitation*

4. REFERENCES


- Hallin, C., Larson, M., Hanson, H. 2019a. Simulating beach and dune evolution at decadal to centennial scale under rising sea levels, PLoS ONE 14(4): e0215651, 1-30
- Hallin, C., Huisman, B., Larson, M., Walstra, D-J., Hanson, H. 2019b The impact of sediment supply on decadal-scale dune evolution – Analysis and modelling of the Kennemer dunes in the Netherlands, Geomorphology, 337, 94-110