Universiteit Utrecht

Faculty of Geosciences
Physical Geography

Gerben Ruessink

Aeolus meets Poseidon

a Vici project on wind-blown sand transport on wave-dominated beaches

Introduction

Coastal dunes serve as a natural safety barrier against marine flooding and possess high ecological value with many environmental transitions (wet/dry, salt/fresh). The societal need for safe coasts has resulted in over-stabilized dunes that can withstand the impact of fierce storm waves, but have impoverished natural values and undesirably reduced biodiversity. We now face the challenge of combining coastal safety objectives with nature development to maintain sustainable and climate-proof dunes. This demands profound quantitative understanding of aeolian (wind-blown) processes, rather than of storm-wave processes alone. Wind-blown beach sand allows dunes to grow vertically with sea-level rise, thereby ensuring long-term coastal safety, and is crucial to sustain the dunes' biodiversity by resetting ecological succession locally and temporally.

The **overarching aim** is to develop a robust, efficient and accurate predictive model, applicable in both scientific and applied studies, of meso-scale (several years) aeolian sand supply to dunes. The focus is on natural, long (>1 km) and relatively narrow (<100 m) sandy beaches backed by managed dunes.

The foredune often resembles an over-stabilized sand dike that has lost its natural dynamics

Research projects

Aeolian transport on beaches is influenced strongly by the ***moisture*** of the top few millimetres of sand. Moisture and sand transport ***interact*** to create fascinating aeolian bedforms that, in turn, lead to complex spatial and temporal variability in ***transport***. These challenging interactions and feedbacks, coupled to scale issues, currently defy accurate ***meso-scale predictions*** of aeolian sand supply to the dunes.

Moisture dynamics (PhD 1)

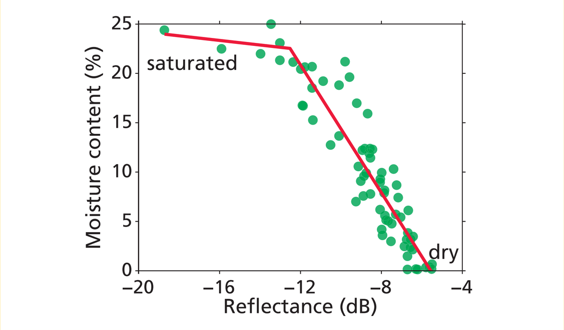
Aims

- to identify temporal and spatial dynamics in surface moisture,
- to elucidate their key controls,
- to develop a realistic model to predict these dynamics.

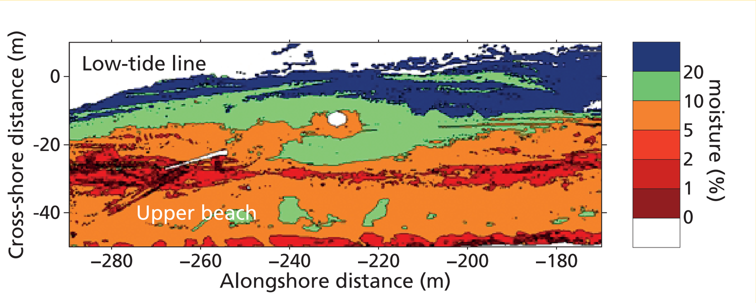
Approach

- *field measurements* of surface moisture using infrared terrestrial laser scanning, extended with measurements of phreatic groundwater levels, vertical moisture profiles, and precipitation and various atmospheric parameters,
- *numerical modelling* of beach hydrology.

Infrared terrestrial laser scanner; time-of-flight principle; point cloud: x, y, z, R; 122.000 points/s; 360°/100° scan in 5 – 20 minutes; 5 – 25 x 10^6 points in single cloud.



The moisture content is well related to the reflectance of the terrestrial laser scanner.



Moisture map

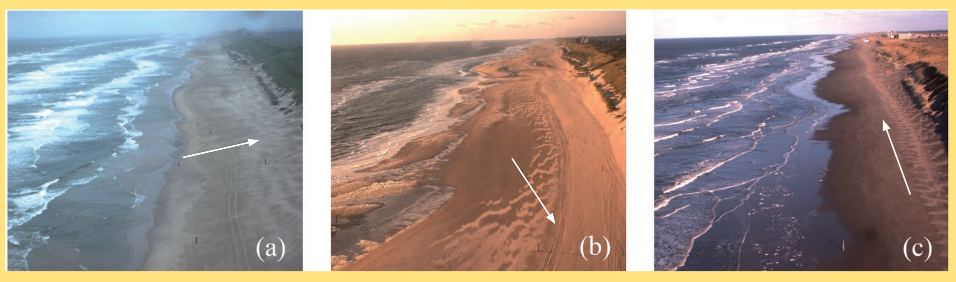
Moisture-transport feedback (PhD 2)

Aims

- to characterize the frequency, timing and relative magnitude of aeolian transport events,
- to understand better which key parameters control meso-scale sand supply from narrow beaches.

Approach

- 15-year long *Argus* data set. Moisture-transport feedback is visible as beautiful aeolian bedforms, known as sand strips,
- *modelling* of sand-strip dynamics through a cellular automaton model.



Examples of sand strips during low tide

Growth of sand strips after a high tide

Transport magnitude (PhD 3)

Aim

- to improve predictions of the aeolian transport rate, including its variation in downwind direction from the location of no transport to the beach-dune transition.

Approach

- *field measurements* using spatially extensive network of high-frequency saltation sensors, extended with sonic anemometers, sand catchers, a high-speed video camera and a terrestrial laser scanner.

Aeolian transport is often organized into snake-like streamers

Sand catchers

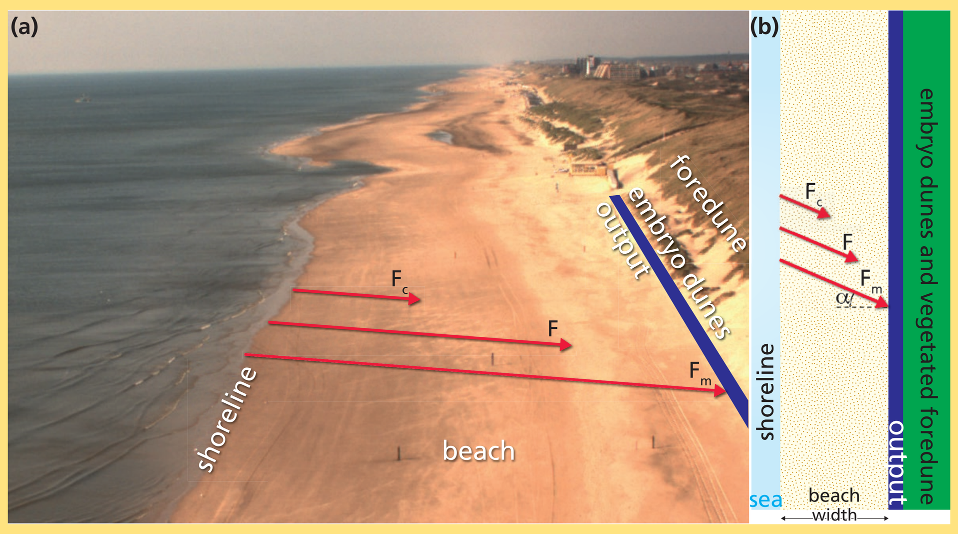
Meso-scale modelling (postdoc)

Aims

- to develop the meso-scale sand supply model,
- to quantify uncertainties inherent to the model predictions.

Approach

- *translate* detailed results of PhD projects 1-3 into parameterizations inherent to the critical fetch model of Bauer and Davidson-Arnott (2002),
- *Monte-Carlo* simulations.



Schematic (a) oblique and (b) top view of the meso-scale framework

Application

Seasonal surveys of aeolian sand supply and model application in two case studies

- dune-biodiversity: Noordwest Natuurkern (Bloemendaal)
- coastal safety: Kust op Kracht (Hondsbossche Zeewering)

(a) Panoramic view of the 5 trenches through the foredune in National Park Zuid-Kennemerland (Noordwest Natuurkern); (b) landward view through trench 4; and (c) vegetation clearance on the parabolic dune landward of trench 4.

Stakeholders:

PWN, Hoogheemraadschap Hollands Noorderkwartier, ARCADIS, Vereniging Natuurmonumenten, Witteveen+Bos, Royal Boskalis Westminster N.V., Arens Bureau voor Strand- en Duinonderzoek, Deltares, Rijkswaterstaat (Water, Verkeer en Leefomgeving)

Funded by the Technology Foundation STW of the Netherlands Organisation for Scientific Research, project# 13709

STW Enabling new technology