

Vegetated dune and swale formation on barrier islands



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Background

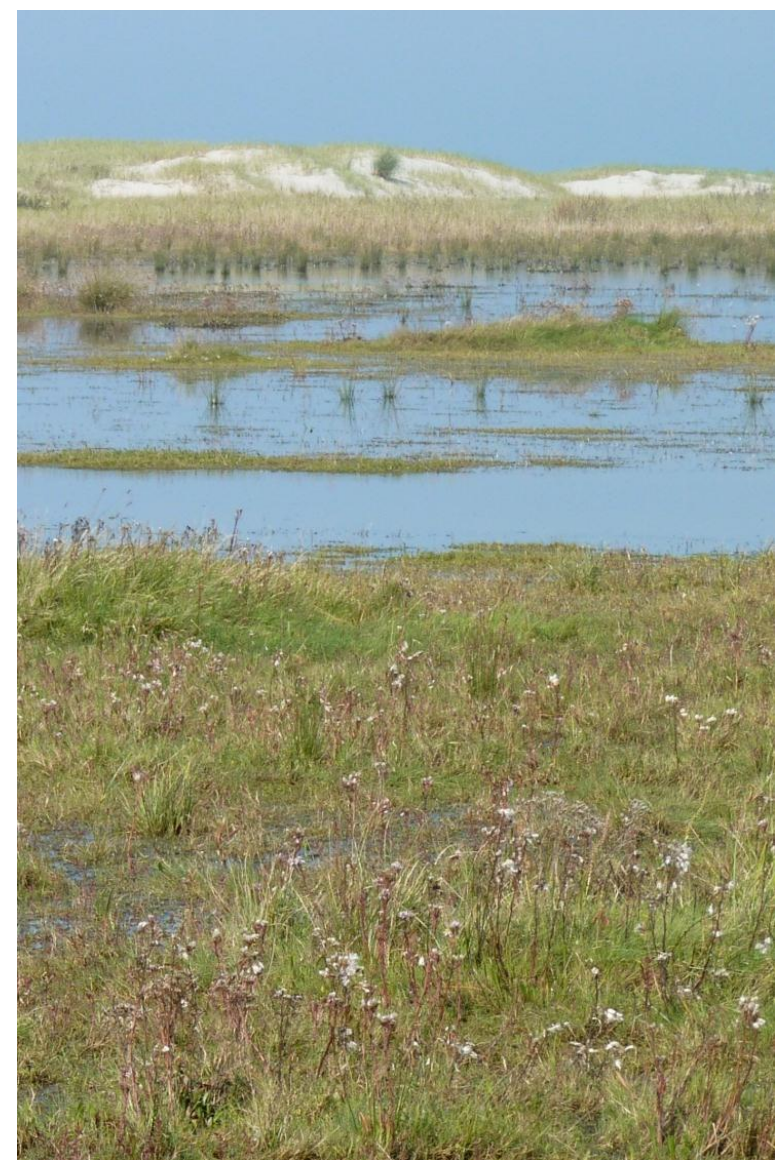


Figure 1. New dunes and swale on Schiermonnikoog.

Occasionally, new dunes and swales (primary dune slacks) develop on the Wadden islands (Fig 1). Often, this is related to sand banks welding to the shore.

The formation of these dune areas affects biodiversity, sediment exchange, and coastal defence by acting as buffer during storms. Relatively little is known about:

- which factors are decisive for such dunes and swales to develop, and
- how stable such dune areas are through time.

A model study was performed to obtain more insight into these matters.

Model

- **Dune formation** is simulated by moving slabs of sand according to simple (nature-based) behavioural rules (Fig. 2).
- Topography, time-varying water levels and vegetation determine which parts of the topography are reworked by the **sea**.

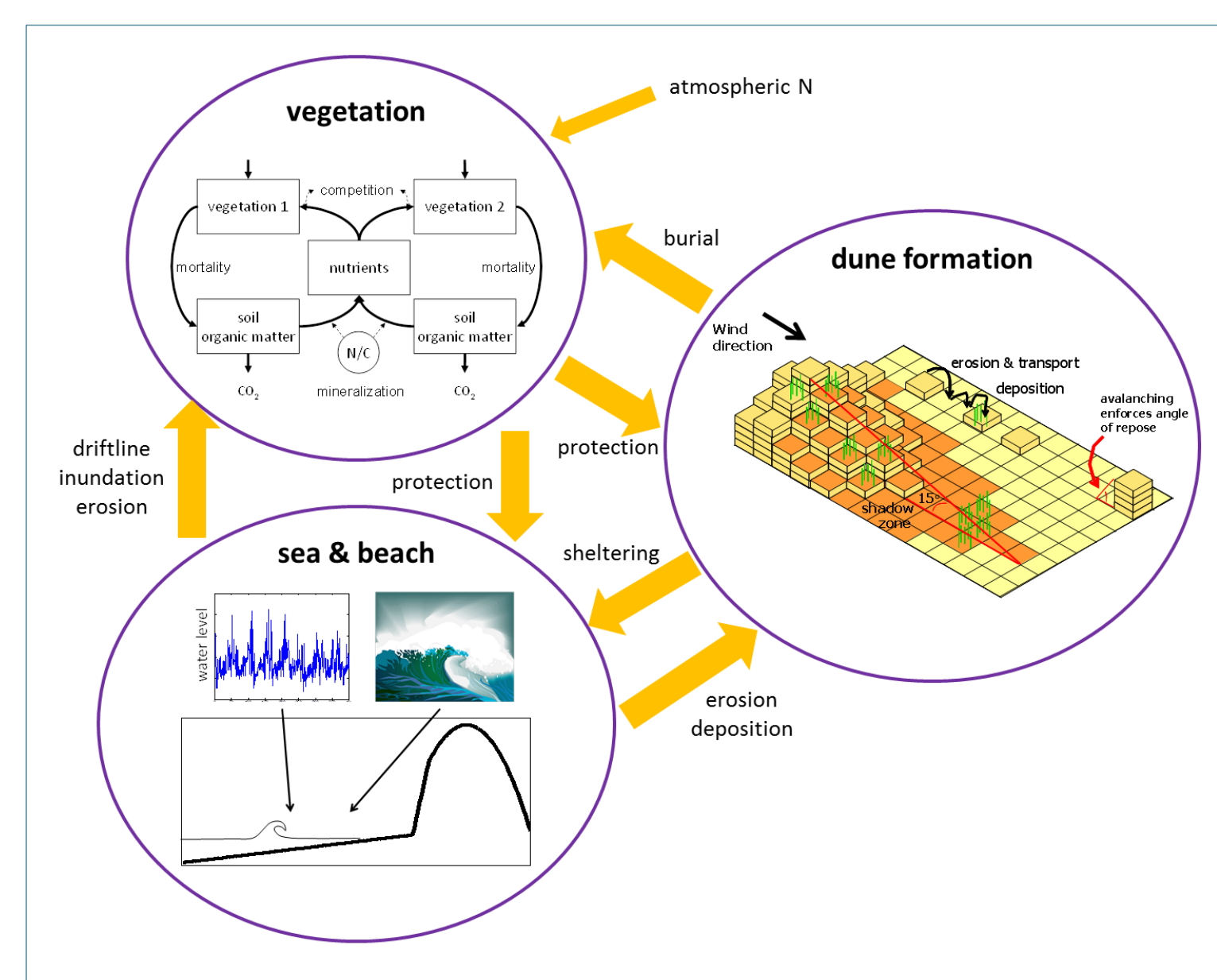


Figure 2. Model outline.

- The **vegetation** consists of dune grass (e.g. *Ammophila arenaria*) and dune-slack vegetation (a mixture of several species). The two vegetation types compete for nitrogen. Their growth is further affected by several factors (Fig. 2).

Results

Model validation

Starting from a bare beach with a single foredune, the simulations were run for 15 model years. Model results are reasonable similar in dune shape, height, and vegetation patterns, compared to recent dune formation on Schiermonnikoog (NL) (Fig. 3).

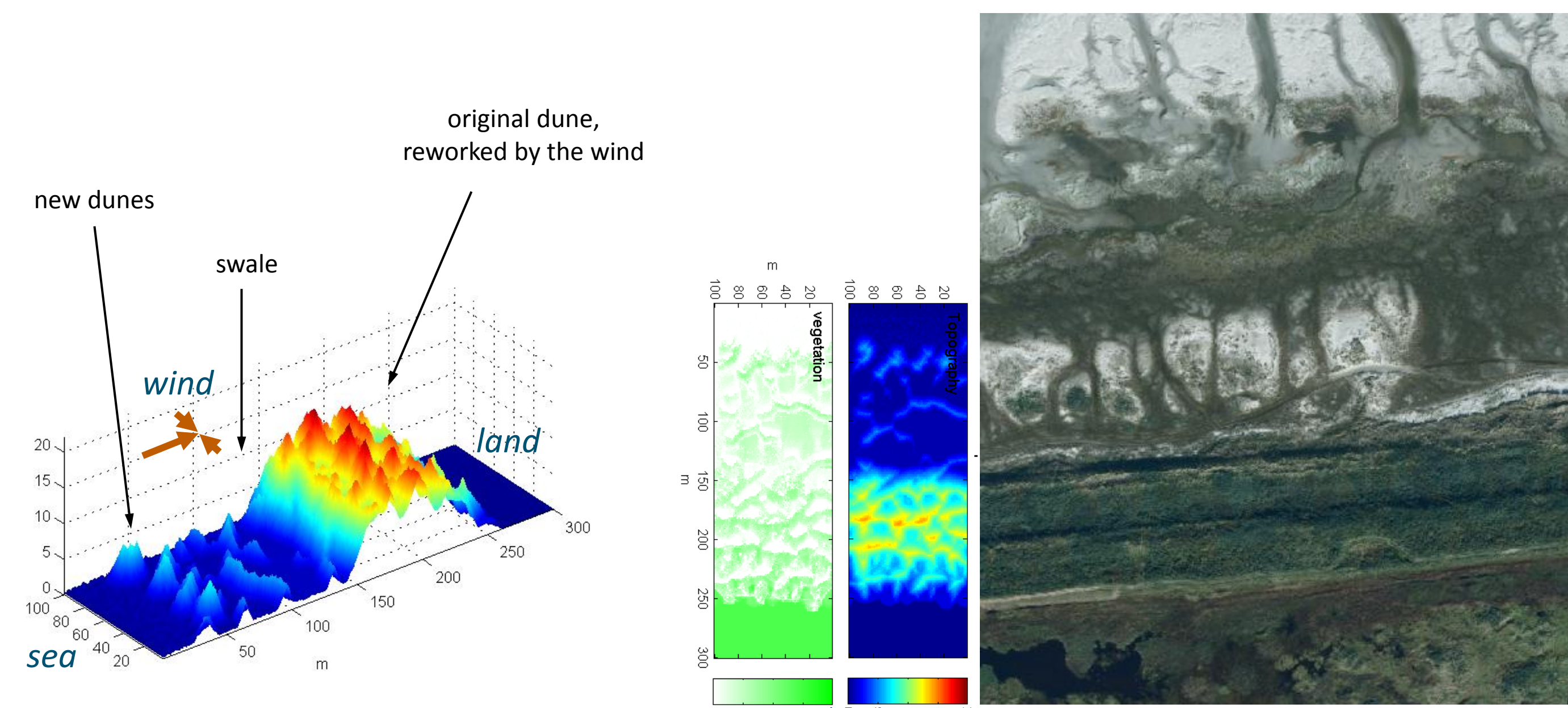
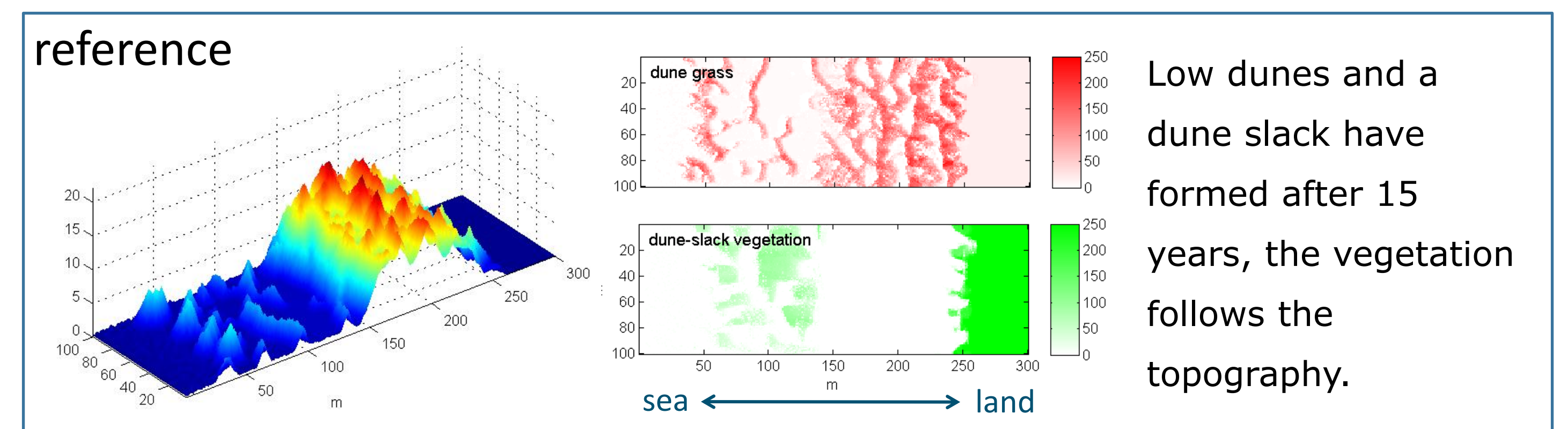


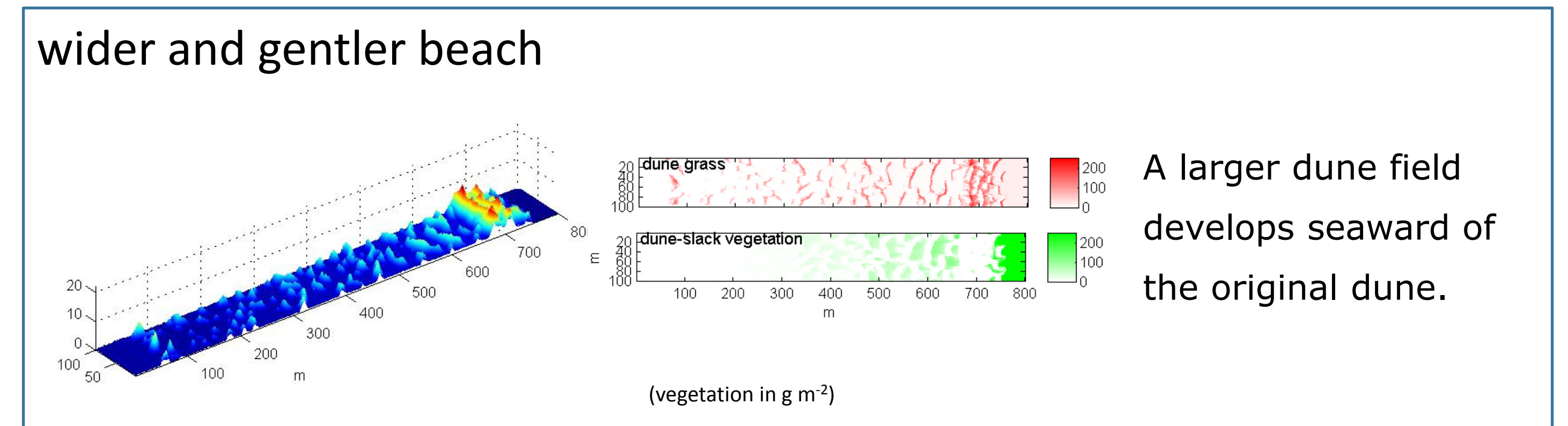
Figure 3. Left: topography after 15 years. Right: comparison between maps of vegetation and topography, and an aerial photograph of newly-developed dunes and swale at Schiermonnikoog (NL), at the same scale.

Effects of environmental factors

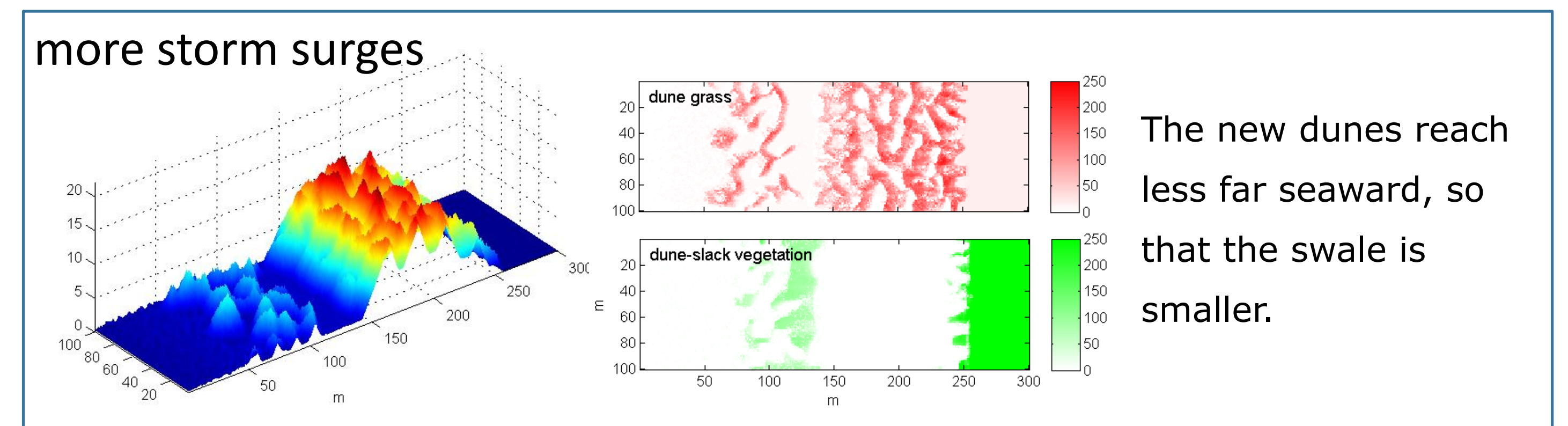
Simulations were done for various environmental factors. The 3D topography and vegetation maps are shown below.



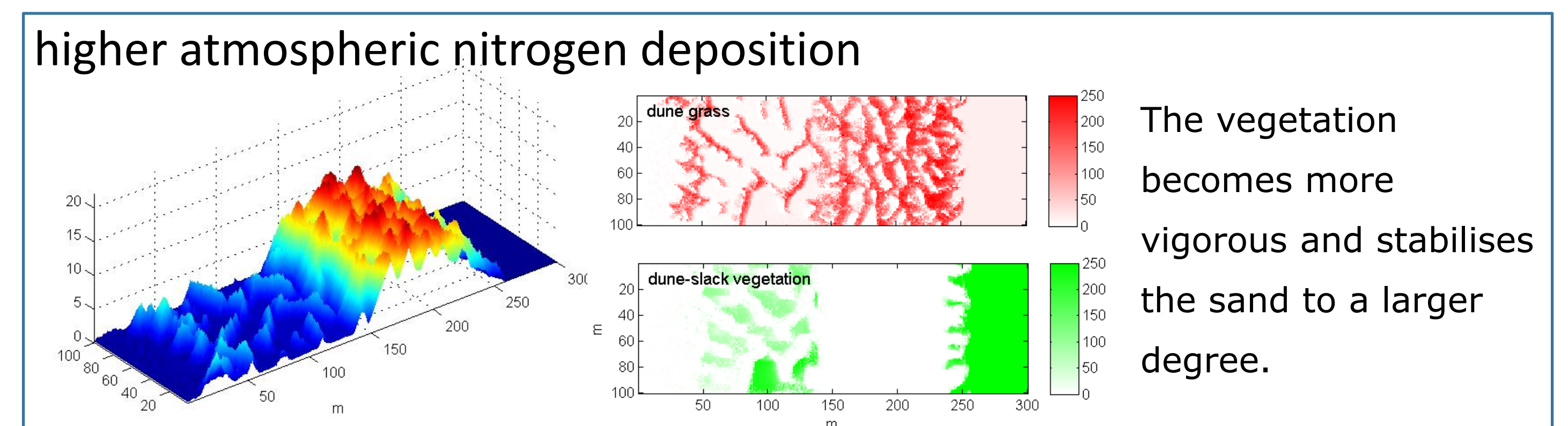
Low dunes and a dune slack have formed after 15 years, the vegetation follows the topography.



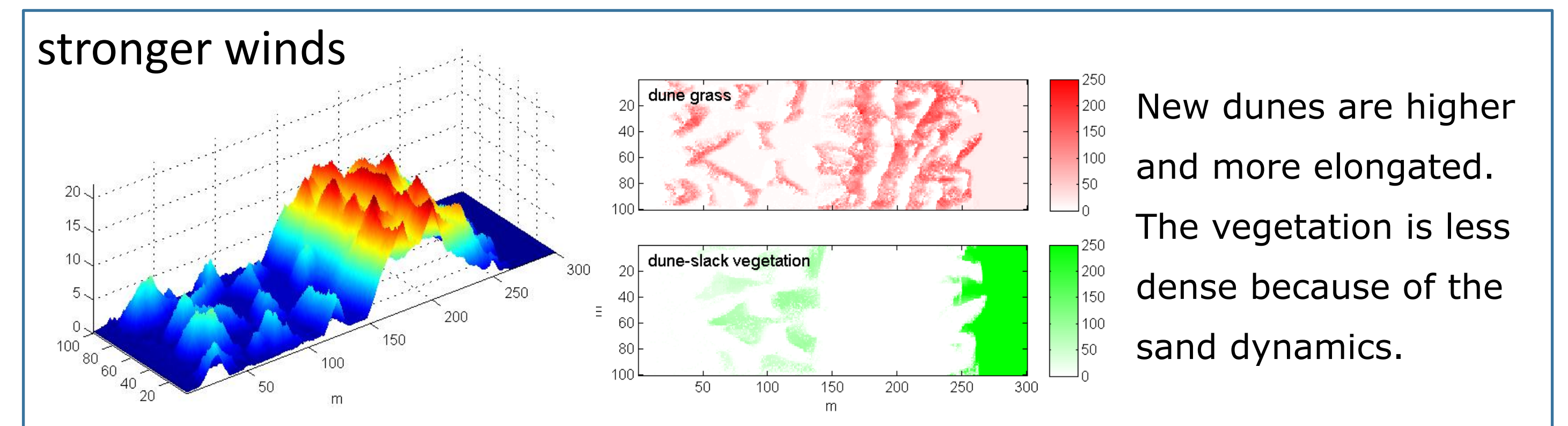
A larger dune field develops seaward of the original dune.



The new dunes reach less far seaward, so that the swale is smaller.



The vegetation becomes more vigorous and stabilises the sand to a larger degree.



New dunes are higher and more elongated. The vegetation is less dense because of the sand dynamics.

Conclusions

- The most important factor for dune and swale development is increasing beach width: bar welding or beach nourishments.
- The relative strength of vegetation growth, erosion by the sea, and sand transport by the wind further shape the dunes and swales.
- Vegetated dunes persist unless the beach reverts to structural erosion.
- Vegetation establishment is an important process, that needs more study.
- The model can be used for estimating the effects of climate change, sea-level rise, and sand nourishments.

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