Experimental data of The effect of building geometry on the size of aeolian deposition patterns: scale model experiments at the beach

Authors: Daan W. Poppema, Kathelijne M. Wijnberg, Jan P.M. Mulder, Sander E. Vos & Suzanne J.M.H. Hulscher

Date: Oktober 2022

This repository contains the data of scale experiments performed at the beach to determine how the size of aeolian deposition and erosion patterns around beach buildings depends on building geometry.

Two series of experiments were performed, each with cuboid scale models of various sizes.

- Series A consisted of cuboid scale models of buildings, placed at the beach for approximately 1 day. These scale models ranged in size from 0.3x0.5x0.3 m (*w* x *l* x *h*) to 1x2x0.6 m.
- Series B consisted of a shipping container (2.5x12x2.5 m) and a small scale model (0.5x2x0.5 m), placed simultaneously at the beach for more than 2 months.

In Poppema et al. (2019), series A is used to study the shape and type of the initial deposition and erosion patterns that develop around a building. In Poppema et al. (2021), series A and B are used to determine the dependency of the deposition size on building geometry; determine the effect of wind speed on deposition size; and compare initial deposition size to longer-term (weekly to monthly) deposition development.

References:

Poppema, D.W., Wijnberg, K.M., Mulder, J.P.M., & Hulscher, S.J.M.H. (2019). Scale experiments on aeolian deposition and erosion patterns created by buildings on the beach. Coastal Sediments 2019 proceedings. Doi: 10.1142/9789811204487_0146.

Poppema, D.W., Wijnberg, K.M., Mulder, J.P.M., Vos, S.E., & Hulscher, S.J.M.H. (2021). The effect of building geometry on the size of aeolian deposition patterns: Scale model experiments at the beach. Coastal Engineering. Doi: 10.1016/j.coastaleng.2021.103866.

1. Configuration of experiment A

The scale models of series A consisted of cuboid stacks of cardboard boxes. To examine the effect that building size and shape have on the size of deposition patterns, the scale model size and shape were varied. The model length, width, and height ranged between 1 and 4 boxes, with individual boxes being 33x50x35 cm (*w* x *l* x *h*). Scale models were placed at the beach in the morning, and the resulting deposition patterns were recorded at the end of the day, so that patterns could develop for one day. For each experiment, the orientation of the boxes was tuned to the dominant wind direction during placement of the scale models.

In total experiment A consisted of seven days (A1-A7). Six to ten models (i.e. six to ten stacks of different dimensions) were placed on the beach every day (see Fig. 1, Fig. 2). During the first 4 days, sedimentation and erosion patterns around models were successfully recorded. During the last 3 days, lower sediment transport due to weaker wind and some mixing of deposition patterns from (more closely spaced) neighbouring scale models lead to results that were less developed and more chaotic. Nonetheless, some development was usually visible, especially in erosion around the upwind corners and/or upwind deposition. The set-up of the experiments is described in table 1 and sketched in figure 1 and 2.

Table 1: A concise overview of the conducted experiments in series A. Adapted from Poppema et al. (2019), Table 1.

Date	Location	Number of scale models	Wind speed [m/s]	Remarks
29-05-2018	Terschelling	6	6.8	
11-10-2108	Sand Motor	9	5.9	Bed moist, less erodible
12-10-2018	Sand Motor	8	6.9	Bed moist, less erodible
23-10-2018	Sand Motor	10	9.5	
24-10-2018	Sand Motor	8	6.5	Light rain
19-11-2018	Sand Motor	9	7.6	
20-11-2018	Sand Motor	9	7.0	

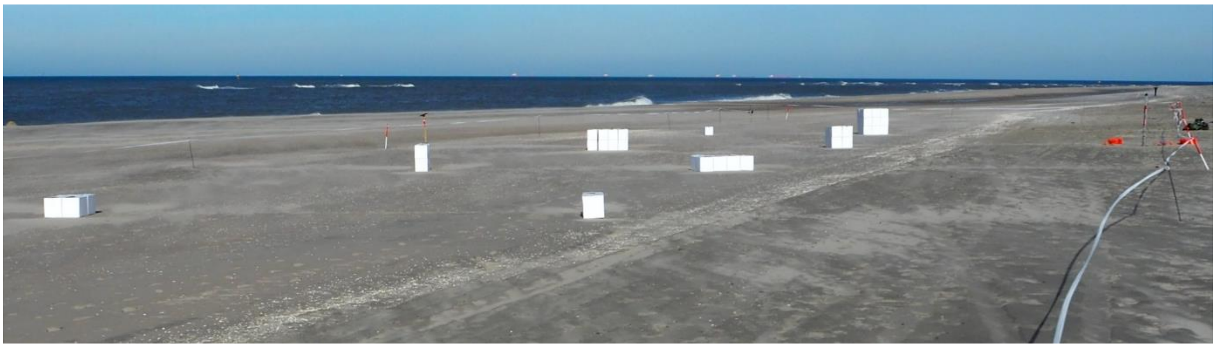

Figure 1: The set-up at one of the days (12-10-2018), testing the effect of building width and height. Note: scale model configuration, orientation and location changed between all experiments. Identical to Figure 3 in Poppema et al. (2021)

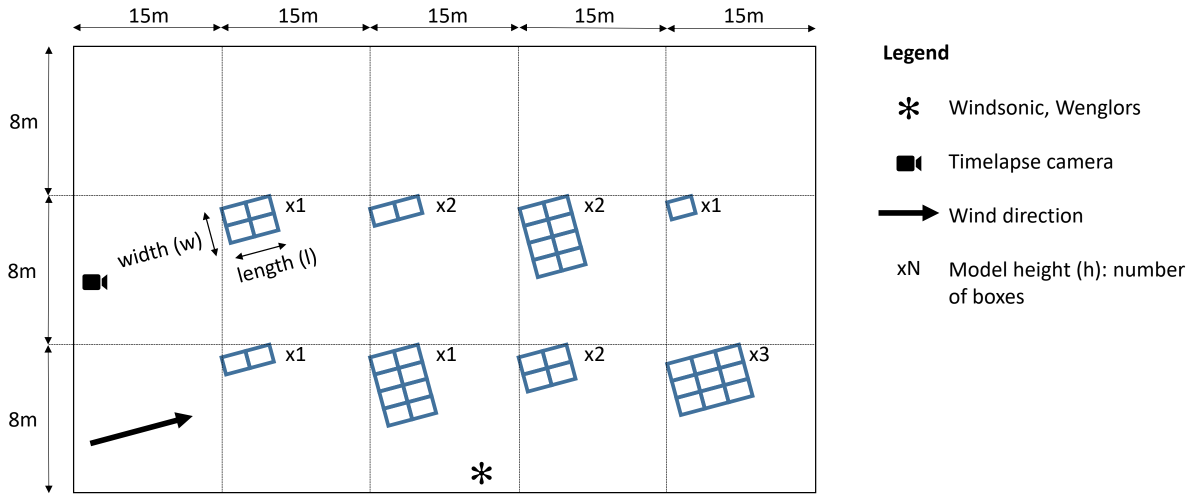

Figure 2: A sketch (distance between scale models not to scale) of the specific set-up shown in Figure 1. Identical to Figure 4 in Poppema et al. (2021)

The bed around scale models is measured using structure-from motion (SfM) photogrammetry to determine deposition and erosion. This results in orthophotos and DEM's of the experimental results. The orthophoto is used by an edge detection algorithm to determine the location of deposition areas, aided by manual interpretation of both the orthophoto and DEM (see Poppema et al. (2021).

In addition, wind speed and direction are measured using a windsonic wind station; the occurrence of sediment transport at various elevations above the bed is measured using Wenglor laser particle counters; and timelapses of the experiments are recorded.

Below, in section 3, the origin and measurement methods of the data in the repository are described in more detail. At the end of the ReadMe, some photos follow to illustrate the experimental configurations and results. Further details can be found in Poppema et al. (2021).

2. Configuration of experiment B

Experiment B was a longer-term experiment, where two scale models were placed on the beach for more than two months: a small scale model and a full-scale model (see Figure 3). The small scale model was a box of 0.5x2x0.5 m, so comparable in size to the one-day experiments of series A, but more elongated in shape. The full-scale model, consisting of two shipping containers, measured 2.5x12x2.5 m, so with comparable proportions as the small scale model, but in size comparable to a real beach hut. The goals of this experiment were to determine whether the results from the small-scale one-day experiments also apply on the scale of a beach hut, and to examine morphological development over a longer period.

Both scale models were placed parallel to the coast, 20 m from each other and the dune foot. The dominant wind direction was alongshore to slightly onshore, so approximately facing the short side of the scale models. Multiple storms occurred, including a heavy storm 2 days after the experiment started. Results were measured at three different days (table 2): after 1 and 3 storms days to examine the initial development, and after 5 weeks to examine the longer-term effects.

The bed around scale models is measured using structure-from motion (SfM) photogrammetry at various moments in time to measure morphological development. In addition, wind measurements are available.

Figure 3: The full-size model of experiment B

Table 2: An overview of the measurements taken at the 5-week experiment conducted at Noordwijk.

Date	Name in files	Measurement of	Remarks
06-02-2020	Day 0	Only small model	T0: Models placed
08-02-2020	Day 1	Only small model	Barely any development: smoothing of footsteps
09-02-2020	Day 2	Both models	after 1 storm day Small scale model: clear development Full-size model: only upwind deposition measurable
11-02-2020	Day 3	Both models	after 3 storm days Deposition tails of full-scale model end up in dune
11-03-2020	Day 4	Both models	Period with strong wind, relatively constant direction Small scale model located in tail of full-size model
28-04-2020	Day 5	Both models	Change in wind direction, patterns partly reverted

3. Data in repository

The following data is available in the data repository

- Raw data: Agisoft Metashape photogrammetry files + photos used for photogrammetry
- Raw data: wind speed, wind direction, sand transport data
- Timelapse, detail photos of experiments
- Processed data: digital elevation models, orthophotos of set-ups
- Processed data of edge detection for automatic deposition detection: binarized orthophoto, shapefile with detected edges of areas
- Processed data: horizontal size of deposition pattern

Table 3 and 4 describe the data available for experiment A and B:

Table 3: Data availability per experiment of series A

Experiment	Raw data: photos, photo-grammetry files	Processed data: DEM, orthophoto	Processed data: edge detection	Processed data: depo-sition size	Wind, sand transport data	Timelapse	Detail photos
A1	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A2	Yes	Yes	Yes	Yes	Yes	No	Yes
A3	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A4	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A5	Yes	Yes	Partial[1]	No	Yes	Yes	Yes
A6	Yes	Yes	Partial[1]	No	Yes	Yes	No
A7	Yes	Yes	Partial[1]	No	Yes	Yes	Yes

[1] The binarized orthophoto is not available online, but the resulting shapefile of the deposition edge is available.

Table 4: Data available for experiment B.

Date	Name in files	Raw data: photos, photo-grammetry files	Processed data: DEM, orthophoto	Processed data: deposition size	Wind data	Detail photos
06-02-2020	Day 0	Yes	Yes	No		Yes
08-02-2020	Day 1	Yes	Yes	No	Yes[1]	No
09-02-2020	Day 2	Yes	Yes	Yes	Yes[1]	No
11-02-2020	Day 3	Yes	Yes	Yes		Yes
11-03-2020	Day 4	Yes	Yes	Yes		Yes
28-04-2020	Day 5	Yes	Yes	No		Yes

[1]There is a detailed WindSonic wind measurement of 3 days, from 7 feb until 9 feb. This file is included in the folder of Day1. In addition, there is winddata from a nearby WindGuru measurement station, from February 7 until March 23.

The data and the methods used to obtain the data are further described below. More details on the methods used can be found in Poppema et al. (2021).

Raw data: photos, photogrammetry files

The photos of the experiments were taken from a height of 5m, using a Phantom 4 Pro drone and an Olympus E-PL7 camera on a telescopic stick. Drone photos are of a 20 megapixel resolution, taken in jpeg with a fixed 8.8mm lens (74° horizontal angle of view). Photos taken with the Olympus camera are of 16-megapixel resolution, taken in raw with a 20 mm lens (47° horizontal angle of view). The typical pixel footprint size was approximately 1 mm for individual photos.

The structure-from-motion (SfM) photogrammetry is performed with Agisoft Metascan, version 1.5.3 to 1.6. Photogrammetry project files of experiment A contain DEM's, orthophotos, binarized orthophotos, and shape files with the detected edges of deposition areas. Photogrammetry project files of experiment B contain cameras, tie points, markers (GCP's and scale bars), a dense point cloud for day 5, digital elevation models (DEMs) and orthophotos.

For experiment A, the photogrammetry files are georeferenced using wooden scale bars (sets of points with a known distance between them) of 60 cm. For experiment B, both ground control points (individual points with a known location) and scale bars were used. These are based on markers that can be recognized automatically by Agisoft. Ground control point locations were measured using an RTK GPS, with an accuracy of approximately 2cm. For each day of experiment B, three files are uploaded for the markers. The first contains the location of ground control points. The second contains a Python script to load the scalebars into Agisoft (runnable from within Agisoft). The third contains a list with the distance between all markers that form scalebars, to be loaded with the Python script. Not all markers in the list were employed during the experiments, unused markers are ignored upon loading the list.

Note that for experiment B only the measurements of day 4 and 5 are properly georeferenced with RTK-GPS markers throughout the domain. Of the other days there are no GPS measurements. Scale bar markers were present, so they are properly scaled using scale bars. But subsequent georeferencing is based on the marker coordinates on the small scale model of day 4. These are only three very local markers, so the rest of the domain is most likely somewhat rotated and distorted! This means local measurements (distances) are reliable, but extreme care should be taken in subtracting DEMs and interpreting absolute elevation measurements.

Processed data: DEM, orthophoto

The DEMs and orthophotos are available separately, as georeferenced tiff files. Orthophotos are additionally available as down-sampled jpg files. To distinguish deposition and erosion more easily, DEMs are filtered. The original DEMs contain the elevation approximately relative to the scale bars (experiment A) or relative to NAP (Amsterdam ordinance datum, for experiment B). The filtered DEM contain the elevation relative to a fitted surface, to remove general trends of the sloping beach and focus on local deviations from this trend, i.e. deposition, erosion and natural bedforms. This fitted surface is a linear surface ($z=a+bx+cy$) for DEMs with 'linearly filtered' in the name. The surface is quadratic ($z=a+bx+fy+dx^2+ey^2+fxy$) for DEMs with with 'quadratically filtered' in the name.

Processed data: deposition size

Based on the DEM, orthophoto and binarized orthophotos, the horizontal dimensions of the deposition patterns were measured. The figure below shows for which deposition features these dimensions were measured.

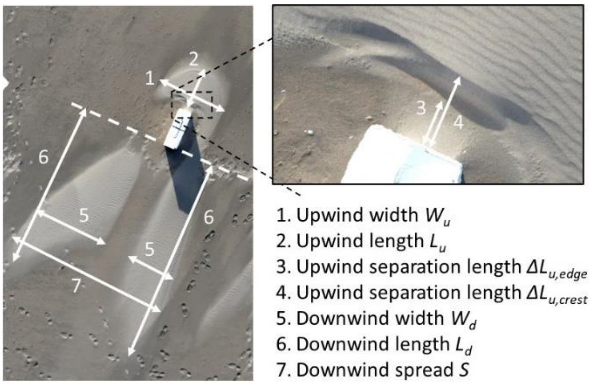

Figure 4:The definition of the deposition size features. Equal to Figure 8 in Poppema et al. (2021).

Wind, Wenglor data

For experiment A, The wind speed and direction were measured using a 2D Windsonic ultrasonic anemometer, at 1.8 m height and using a sampling frequency of 0.2 to 1Hz. The height of the saltation layer was measured by a vertical array of 10 Wenglor laser particle counters. The Wenglors were positioned between 5 and 120 cm above the bed. By comparing the observed particle flux at different elevations above the bed, the height of the saltation layer can be determined, and compared to the scale model height (0.5m).

The WindSonic and the top five Wenglors were connected to the same datalogger. The lowest five Wenglors were connected to a second datalogger. For the uploaded files, observations are split in three separate files: the wind data; the lowest wenglors; and the highest wenglors.

For experiment B, there is one detailed WindSonic wind measurement of 3 days, from 7 feb until 9 feb. This file is included in the folder of Day1. In addition, there is winddata from a nearby WindGuru measurement station. (WindGuru is a wind forecast website.) This station is located 100m from the experiments, at 10m high and supplies 10-minute averaged data from February 7 until March 23.

Timelapses

Timelapse photos are taken of experiment A with an SJCAM SJ7Star action camera, from a height of approximately 5m and with a 10-second sampling interval. Photos are edited to increase contrast and then combined into a timelapse movie. This timelapse movie is uploaded.

Drone photos; detail photos

To illustrate the set-up and results of the experiments, several photos are available. Depending on the experiment, there are an overview photos of the entire experiment (taken by drone), top view photos per scale model/scale model group (taken by drone) and photos with details of the experiment (handheld photos).

4. Photo impression of experiments

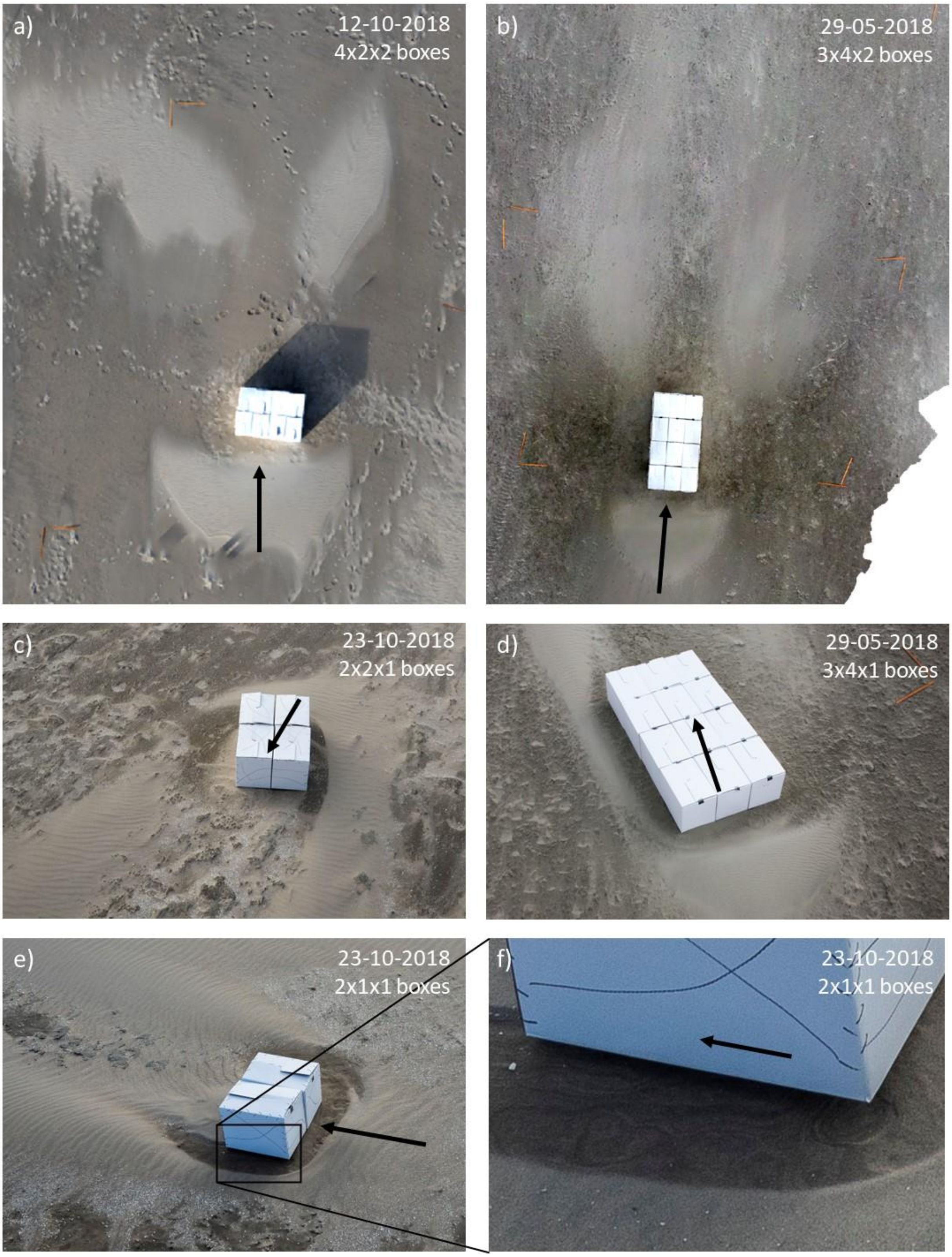

Figure 5: Photos of experiment A, showing set-ups and notable erosion and sedimentation structures around scale models, with arrows indicating the wind direction. 5a) Orthophoto showing a large distance between the model and the start of the downwind horseshoe deposition. 5b) Orthophoto showing lateral inner and outer erosion and downwind inner erosion. 5c) Photo of a model oriented obliquely to the wind, showing lateral inner deposition 5d) Photo of a model oriented obliquely to the wind, showing upwind inner deposition and asymmetric lateral deposition. 5e) Photo showing continuous lateral deposition. 5f) Zoom of 5e, showing erosion around model and under model corners. Adapted from figure 6 in Poppema et al. (2019)

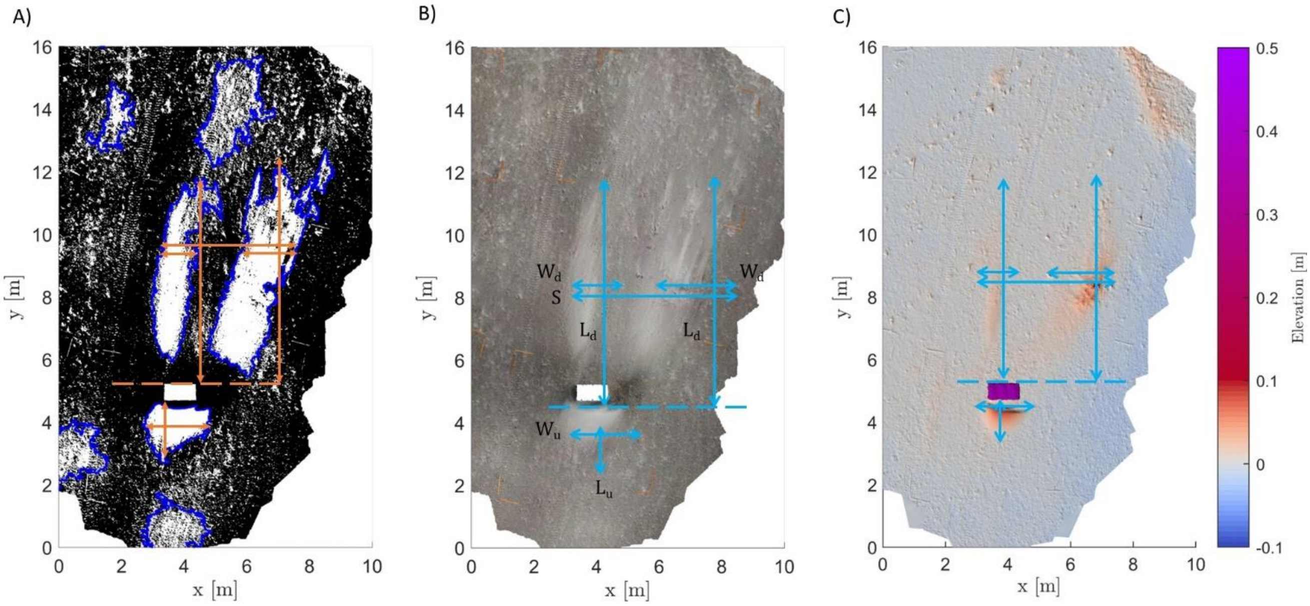

Figure 6: Example of the binarized orthophoto (A), original orthophoto (B) and DEM (C) of a set-up and their use for determining the deposition size (Experiment A, 29-05-2018, model of 1×0.5×0.35 m). Elevations of the DEM are relative to a fitted quadratic surface, to highlight local differences caused by erosion and deposition. Adapted from Figure 10 in Poppema et al (2021).

Figure 7: Experiment B. Left: the small and full-scale model upon placement Day0, 06-02-2020). Right, the full-scale model after approximately 5 weeks (11-03-2020, referred to as 'Day4', because it is the fourth measurement day).

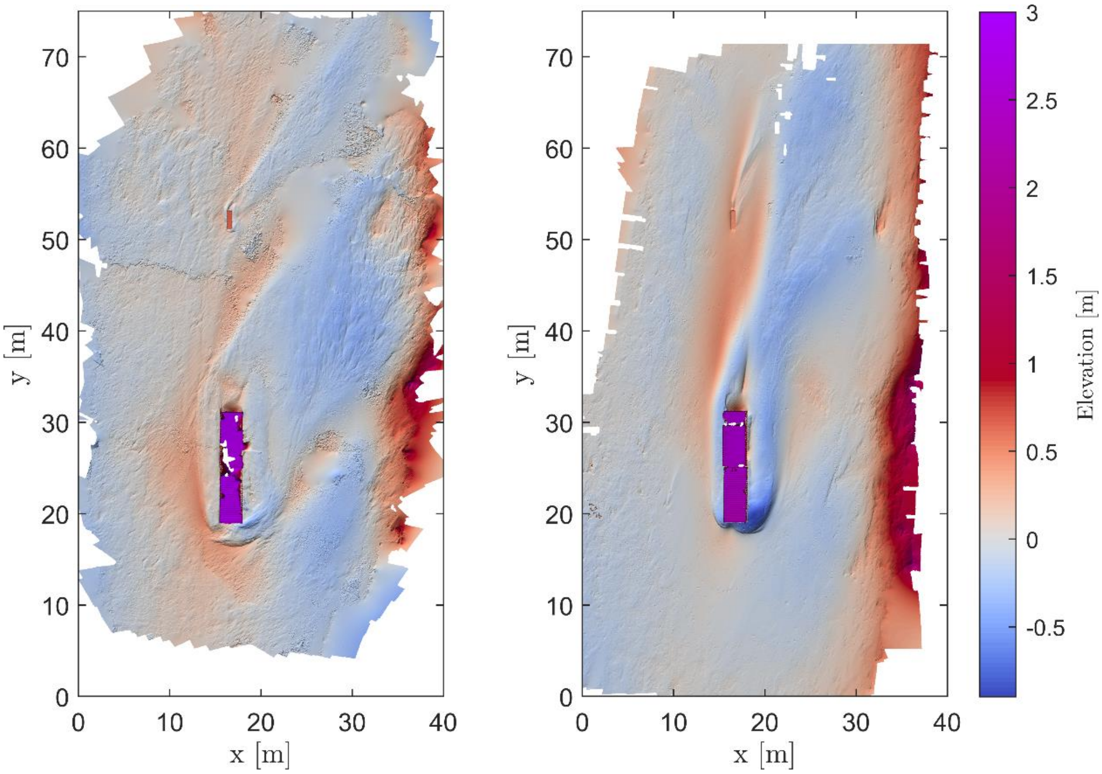

Figure 8: Example of the elevation maps of experiment B. The small scale model is located around x=15, y=50. The elevation is relative to a fitted quadratic surface to highlight local disturbances. Higher elevations at the right are the toe of the dune. Left: elevation map after 3 storm days ('Day3', 11-02-2020). Right: elevation map after 5 weeks ('Day4', 11-03-2020). Equal to Figure 14 in Poppema et al. (2021).