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# Video monitoring of meso-scale aeolian activity on a narrow beach

## I. Introduction

The morphologic evolution of coastal dunes is inextricably linked to the neighbouring beach through the incessant exchange of sand (Figure 1). Intense storm-wave processes erode the foredune within a few hours and transport its sand seaward, while aeolian processes return the eroded sand from the beach into the dune system, although at a much lower pace (months to years, or meso scale). While we have extensive knowledge of the wave processes that erode dunes, our current understanding of meso-scale beach sand supply to the dunes is, in sharp contrast, largely qualitative and conceptual. Our ultimate aim is to develop a robust, efficient and accurate predictive model, applicable in both scientific and applied studies, of meso-scale sand supply to dunes. Here, as a first step, we aim to examine which factors affect aeolian sand delivery into the dunes based on meso-scale video monitoring of aeolian activity on a natural beach.


**Figure 1**: Beach-dune sand exchange by (a) wave-induced and (b) aeolian processes

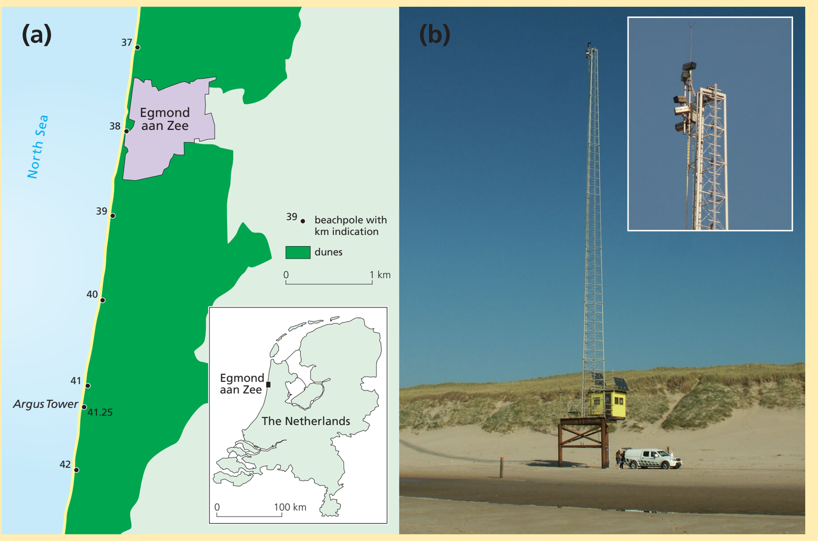
## II. Available data

**Field site** (Figure 2a)
Egmond aan Zee

- North-south oriented, facing the North Sea
- Wave-dominated, with micro- to mesotidal conditions
- Narrow beach (< 100 m) with mild slope (typically, 1:30)
- Quartz sand, with median diameter of 300 μm

**Video monitoring** (Figure 2b)

- 50-m high, Argus video tower
- Operational since 1998
- Half-hourly snapshots overlooking the beach
- Aeolian activity is clearly visible as sand streamers and, in particular, sand strips (Figure 3)
- Concurrent meteorological (wind speed and direction, rainfall) and water level data



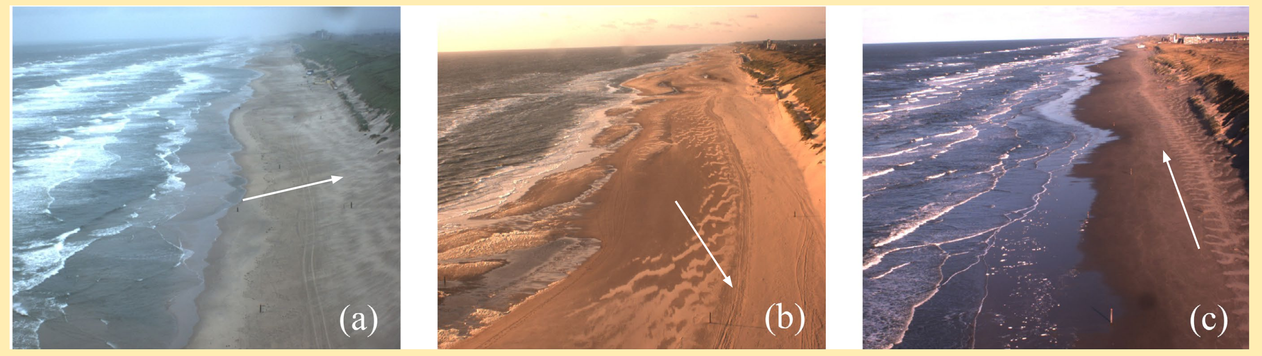




**Figure 3**: Examples of sand strips during low tide. Sand strips are low-amplitude, large-wavelength and slipfaceless deposits that migrate slowly in the wind direction and, depending on wind direction, can have orientations from almost shore-normal (a) to shore-parallel (c).

## III. Potential transport

**Approach**

- Wind events: sustained wind speeds above 8 m/s for at least 4 hours
- Potential transport during an event based on Hsu (1974):

$$Q = 1.16 \times 10^{-5} u^3 3600 \cos\theta$$

where $Q$ is potential transport rate in kg/m/hour, $u$ is wind speed in m/s, and $\theta$ is angle between shore-normal and wind direction.

- Classification of wind events as (using maximum $u$ during an event):

**Table 1**: Description of wind-based transport classes

| Wind class | Description | Aeolian transport rate (kg/m/hour) |
|---|---|---|
| 1 | very small | < 30 |
| 2 | smal | 30 – 60 |
| 3 | medium | 60 – 90 |
| 4 | large | 90 – 120 |
| 5 | very large | > 120 |

**Results**

- Estimated potential transport rate varies between 2.5 and $6.6 \times 10^4$ kg/m/year and is strongly affected by cos θ term. In other words, most wind events are shore oblique (here, from the southwest, see Figure 4)
- Most wind events are classified as 'very small' or 'small', especially when the cos θ term is considered (Figure 5)

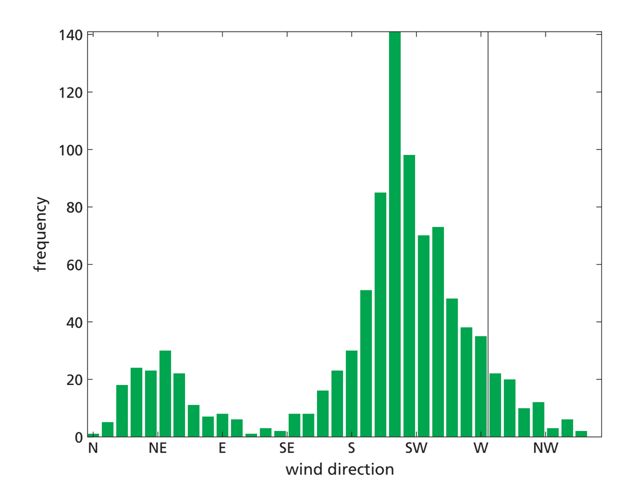



**Figure 4**: Number of wind events (in 2005-2012) versus wind direction. Vertical line indicates (onshore) shore normal wind.

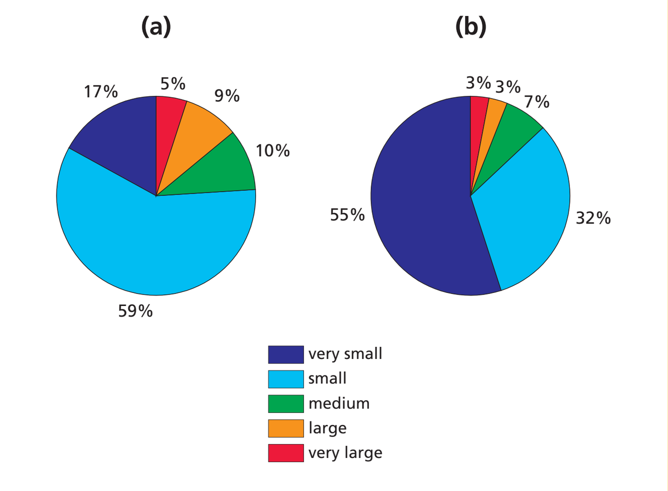



**Figure 5**: Percentage of wind event classes (in 2005-2012), without (a) and with (b) the cosine effect

## IV. Video-based transport events

**Approach**

- Images of all wind events were examined and classified (Table 2 and Figure 6)

**Table 2**: Description of video-based transport classes

| Transport class | Description |
|---|---|
| 0 | No aeolian transport |
| 1 | Very small – wind is just strong enough to transport sand. Sand strips are poorly developed or absent; streamers appear at various places on the beach. |
| 2 | Small – sand strips appear more often, but the sand strips and streamers do not occur along the entire beach. |
| 3 | Medium – sand strips are visible along the beach, but they are relatively small and/or not completely developed and move slowly. |
| 4 | Large – both sand strips and streamers are visible along the entire beach, but the strips do not migrate very fast. |
| 5 | Very large – as 4, but sand strips migrate faster. |

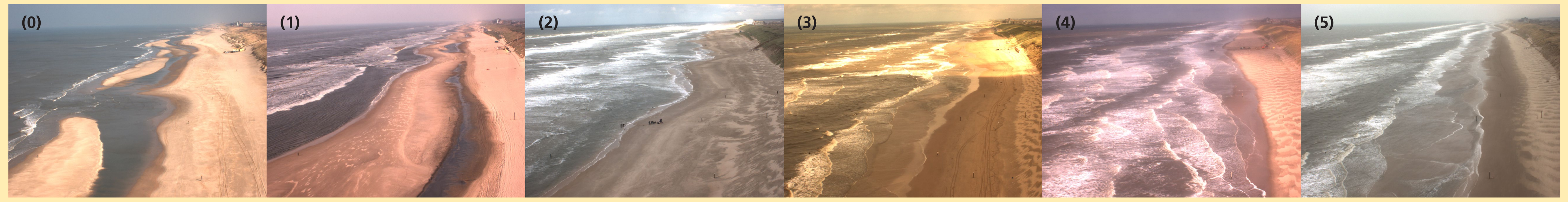



**Figure 6**: Example images of 6 Argus images showing the transport classes, from 0 to 5.

**Results**

Wind-based and video-based classifications do not necessarily match, see Table 3.

- Most events with pronounced sand strips (transport classes 2-5) were observed during moderate winds (wind classes 1 and 2). Under these conditions the wind is shore oblique.
- Most strong wind events (wind classes 4 and 5) did not have traces of aeolian transport (transport classes 0 and 1) because of beach inundation by a storm surge.
- Rain was seen to shut-down the aeolian system when sand strips were not well developed (low wind speeds, 8-12 m/s), but not so during substantially stronger winds.

**Table 3**: Video-based transport classes versus wind-based potential-transport classes

| | Transport class | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Wind class** | no data | 0 | 1 | 2 | 3 | 4 | 5 | *sum* |
| 1 | 239 | 59 | 95 | 37 | 44 | 61 | 29 | 564 |
| 2 | 88 | 37 | 74 | 23 | 30 | 18 | 19 | 289 |
| 3 | 9 | 7 | 13 | 14 | 4 | 5 | 6 | 58 |
| 4 | 9 | 6 | 9 | 3 | 0 | 1 | 0 | 28 |
| 5 | 7 | 8 | 4 | 0 | 0 | 0 | 2 | 21 |
| *sum* | 352 | 117 | 195 | 77 | 78 | 85 | 56 | 960 |

## V. Conclusions

(1) There may be a substantial mismatch between the relative importance of potential and actual aeolian transport events on a narrow beach as studied here.
(2) This mismatch is governed strongly by wind direction and beach width. Moderate shore-oblique winds result in far more pronounced aeolian activity than strong shore-normal winds. Whether shore-oblique wind events actually supply sand to the dune system, is an open question that we will study next.