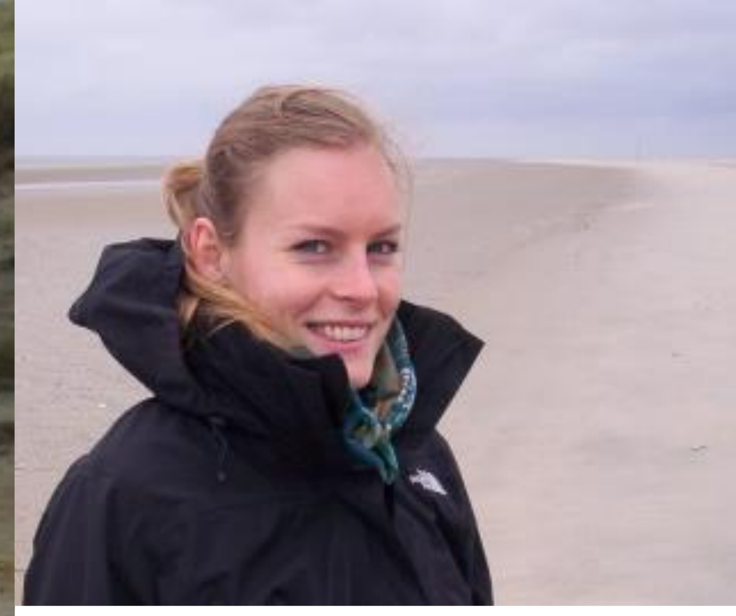

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The influence of beach-foredune morphology on local wind characteristics

Introduction

Aeolian transport from the (intertidal) beach is the primary source of foredune sand supply. Models that aim to predict this supply often use regional wind characteristics. The presence of a high and steep foredune can, however, cause the local wind characteristics on the beach to deviate substantially from the overall regional values. **Our objective** is to study the spatial variability in wind characteristics (mean speed, turbulence and direction) on a beach using (local) field data and regional wind data. This study serves as an initial step towards a more realistic aeolian transport model incorporating local wind conditions.

How do wind characteristics evolve over a beach profile with a foredune?

1) Mean wind speed ($\bar{u}$)
2) Turbulent Kinetic Energy (TKE)
3) Wind steering

Methodology

Field experiment

- 6-week field campaign
- Autumn 2015 and 2017
- Beach south of Egmond aan Zee
- cross-shore ultrasonic anemometer array (*Fig. 1*)
- 4-6 devices at 90 cm above the bed.

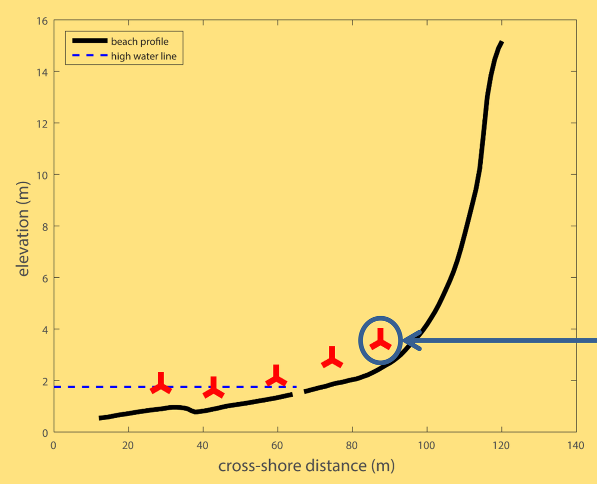
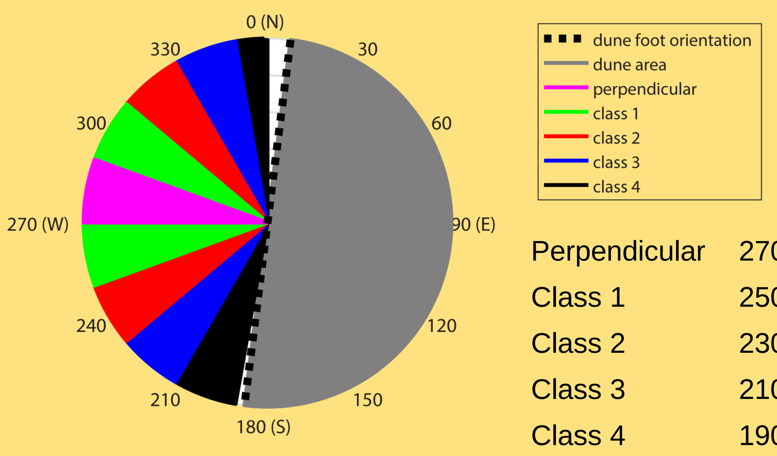


Fig 1: Field setup. Cross-shore array (left) with 4-6 ultrasonic anemometers (right).



Perpendicular	270°- 290°	
Class 1	250°- 270°	290°- 310°
Class 2	230°- 250°	310°- 330°
Class 3	210°- 230°	330°- 350°
Class 4	190°- 210°	350°- 360°

Fig 2: Wind direction classes.

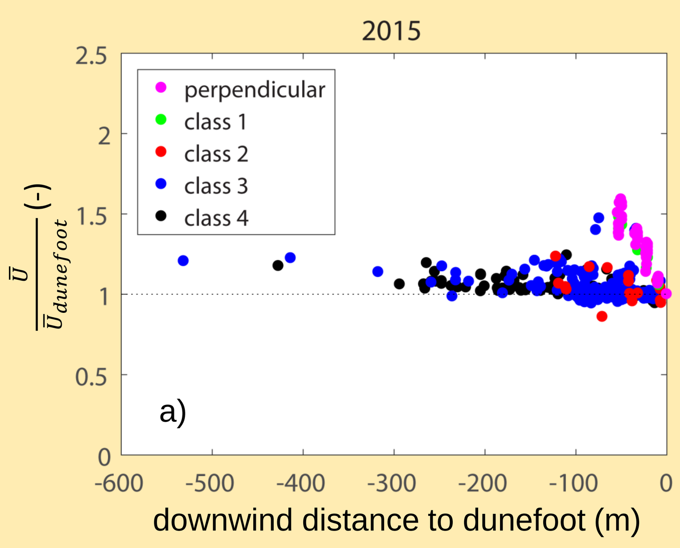
Data analysis

- Data are 10 Hz, three-dimensional velocities
- Processed into 5-minute mean wind characteristics
- Regional winds: IJmuiden weather station
- subdivision of onshore winds in bins of 20˚ (Fig. 2)

Results

1. Wind speed

- $\bar{u}$ decreases in downwind direction
- $\bar{u}$ at the dune foot can be 1.5 times smaller compared to values at the waterline
- Downwind decrease in velocity is less pronounced for the more alongshore wind conditions (class 3 and 4, Fig 3).
- In 2017, during the more alonshore conditions (class 2 and 3, Fig 3b), $\bar{u}$ is larger on the beach compared to the dunefoot due to the presence of embryo dunes.



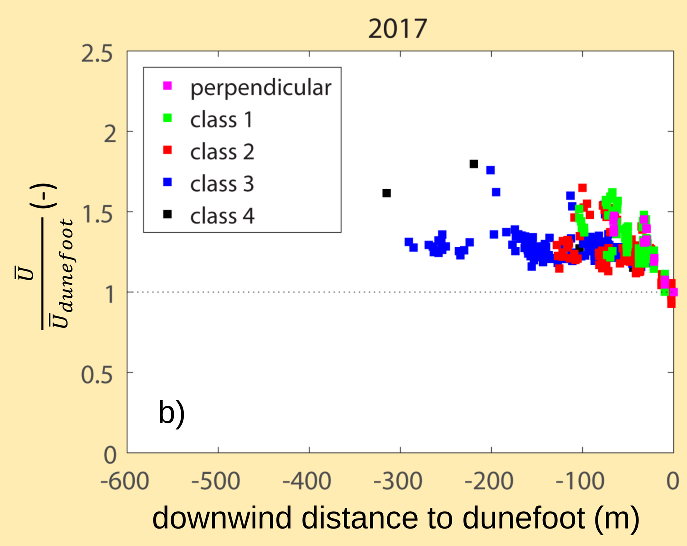
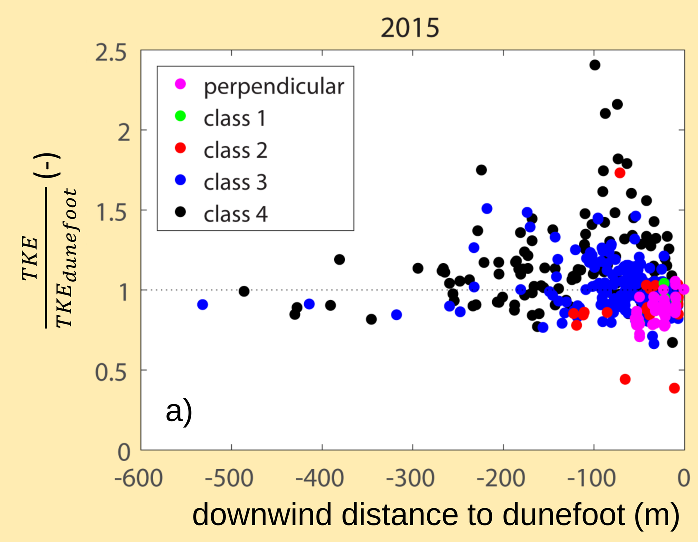


Fig 3: Relative mean wind speed as a function of downwind distance to the dunefoot, for field campaigns in a) autumn 2015, and b) autumn 2017.

2. TKE

- TKE is not variable across the beach, but slightly larger at the dune foot (Fig 4).
- In 2017, the TKE is larger at the dune foot compared to the 2015 measurements. This can be caused by the presence of developed embryo dunes.



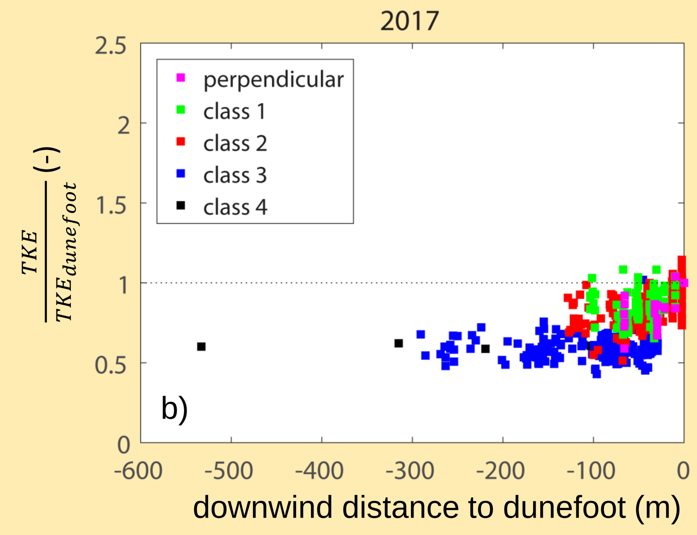
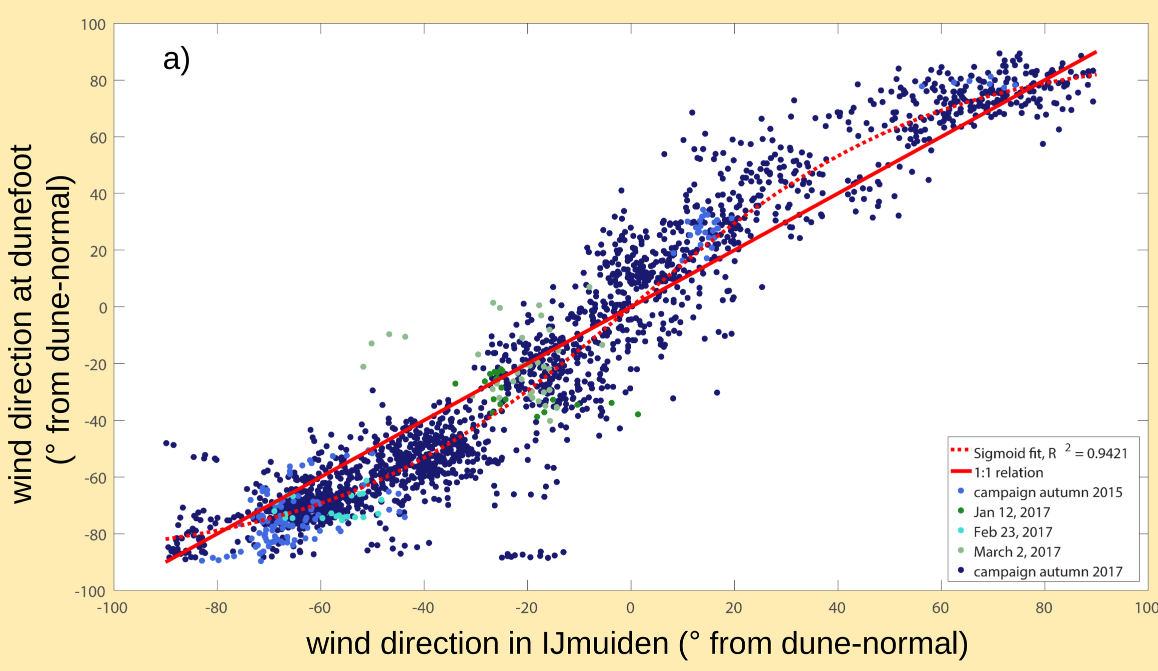


Fig 4: Relative TKE as a function of downwind distance to the dunefoot, for field campaigns in a) autumn 2015, and b) autumn 2017.

3. Wind steering

- Wind direction at IJmuiden and the dune foot are not equal (Fig 5a), the wind is steering over the beach.
- Net wind steering is equal during both northerly and southerly onshore winds (Fig 5b), with a maximum of 13˚ steering during incoming winds with a 40˚ angle.



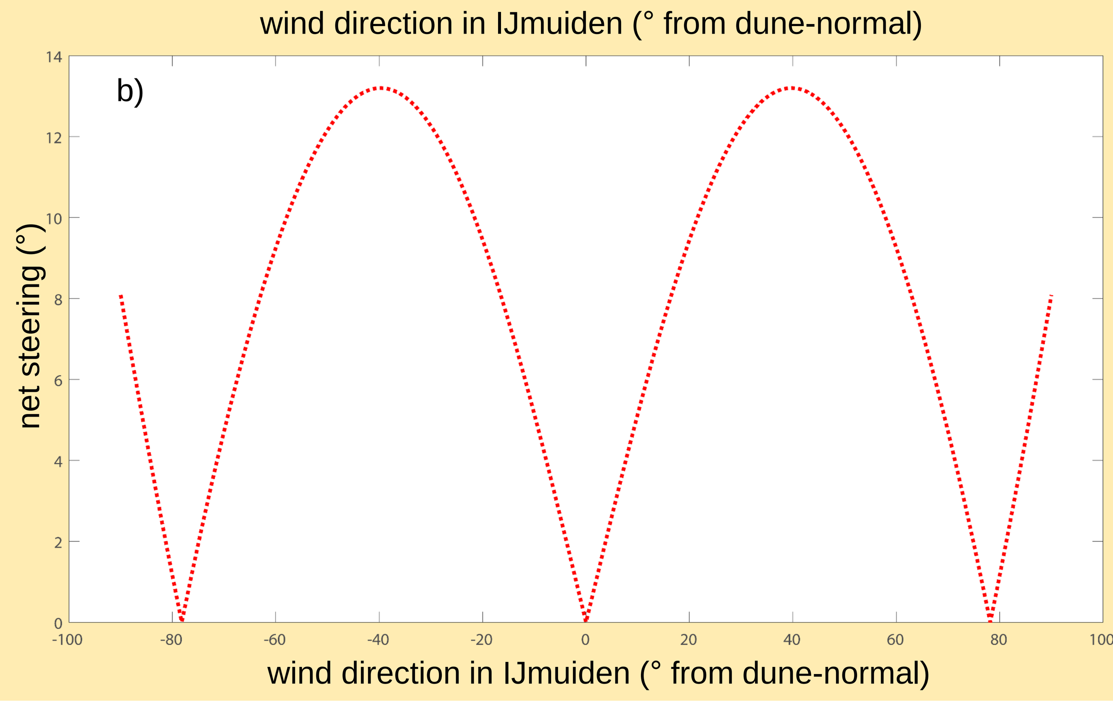


Fig 5: Wind steering. a) wind direction at dunefoot vs. wind direction in IJmuiden, and b) net steering over the beach.

Conclusions

1) The mean wind speed decreases in downwind direction for obliquely onshore winds. Alongshore windspeeds are more constant over the beach and only show a drop in velocity near the dune foot. Developed embryo dunes in front of the foredune also cause a decrease in wind speed.
2) During onshore winds the TKE is constant across the beach, with a slight increase at the dune foot (2015). The presence of embryo dunes result in more turbulence at the dune foot (2017).
3) Wind steering is the largest with oblique winds of 40-44˚, and the smallest (no steering) during perpendicular and nearly shore-paralell incoming winds.