Netherlands Enterprise Agency

Webinar Wind Resource Assessment for Hollandse Kust (noord)

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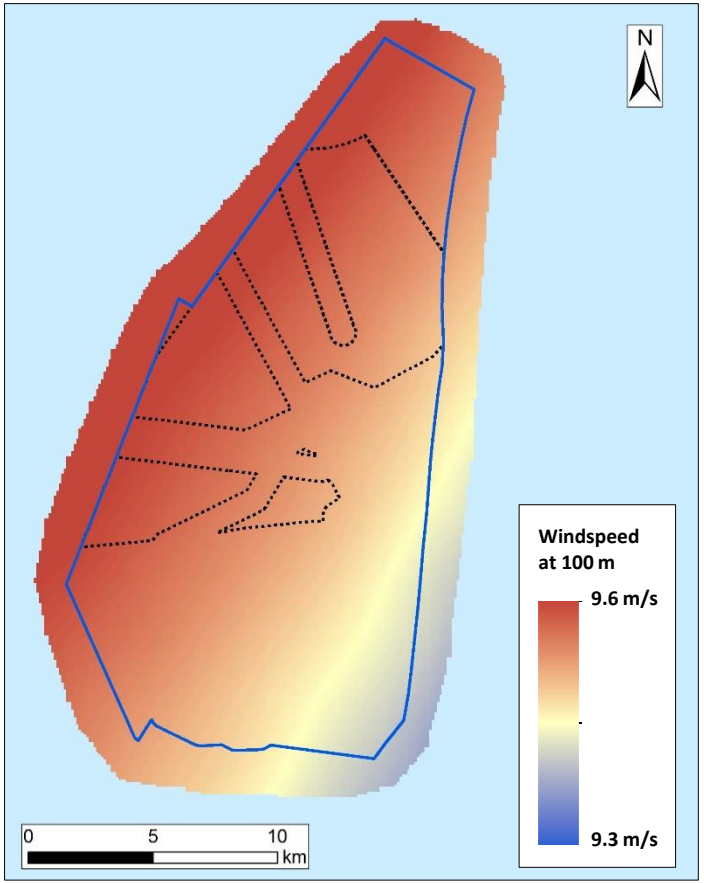
Welcome

- Introduction speaker and panel
- Goal of this webinar
- Agenda

Have a successful meeting!

Hollandse Kust (noord)
Wind resource assessment

16th of May 2019



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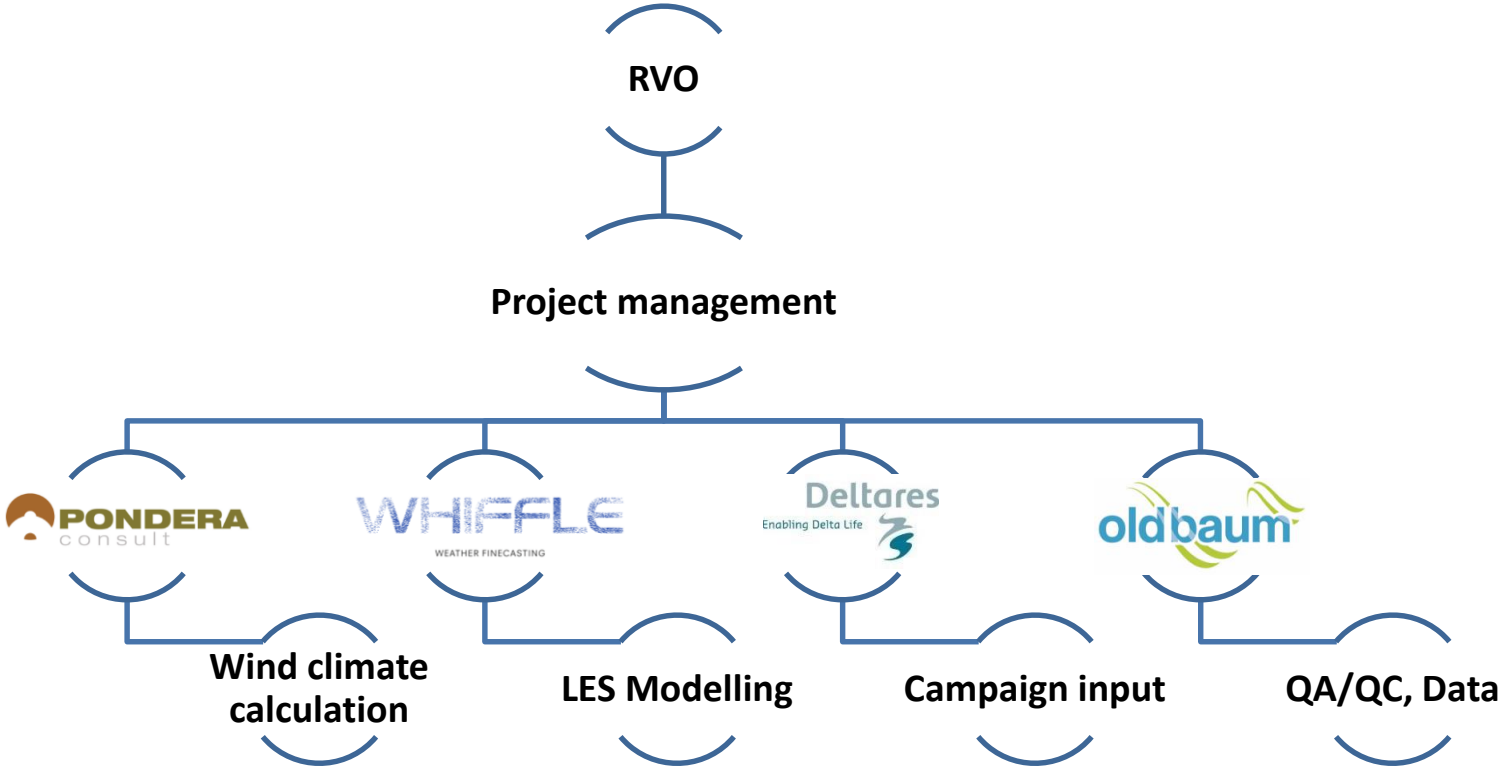


1 Introduction

The goal of the Study

- A wind resource assessment for the Hollandse Kust (noord) Wind Farm Zone, consisting of a single site.

- The scope of this study as defined by RVO.nl:
  - *The Wind Resource Assessment shall provide data that can be used for wind farm modelling, yield assessments and business case calculations for the offshore wind farm to be developed in the HKNWFZ.*

- Challenge: to reduce uncertainty compared to previous studies (e.g. Hollandse Kust (zuid))

2 Wind measurements & methodology

Overall approach: 1

1. Selection of highest-quality primary wind measurements
2. Selection and validation of data sources for long-term correction and horizontal extrapolation
3. Calculation of wind climates:
   - Vertical extrapolation
   - Long-term correction
   - Horizontal extrapolation

2 Wind measurements & methodology

Overall approach: 2

4. Combination of climatologies at site centre and to site nodes
5. Calculation of wake effects
6. Comparison to other site studies

2 Wind measurements & methodology

Primary wind measurements

- HKN floating LiDARs
- 116 m OWEZ met mast

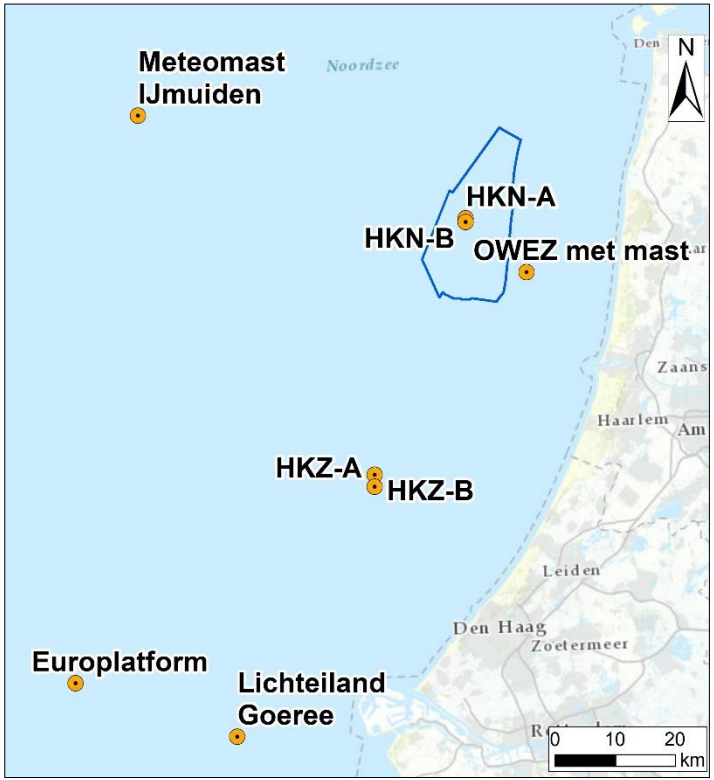
Other wind measurements

Met masts:

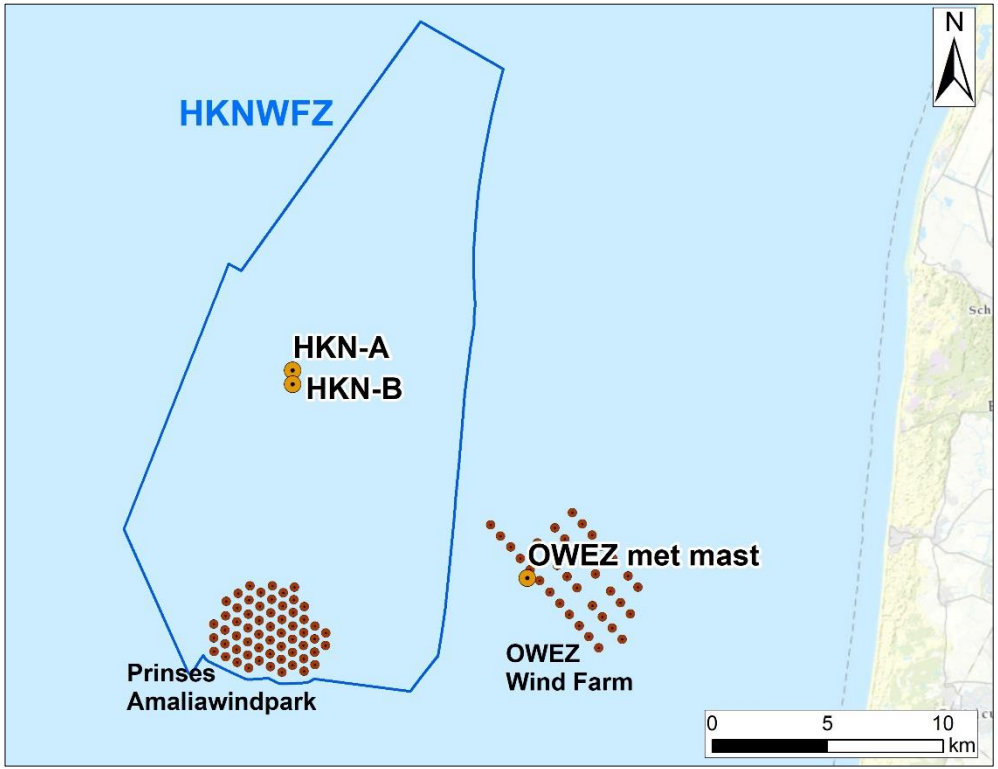
- 92 m Meteomast IJmuiden (MMIJ)
- 38 m Lichteiland Goeree (LEGO)
- 29 m Europlatform (EPL)

LiDARs:

- HKZ LiDARs
- Meteomast IJmuiden LiDAR
- Lichteiland Goeree LiDAR
- Europlatform LiDAR



2 Wind measurements & methodology



2 Wind measurements & methodology

WRA 1: Floating LiDAR

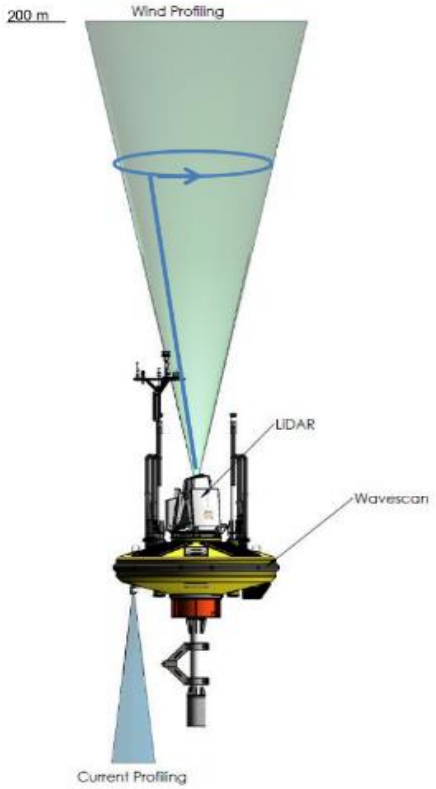
Used 1st year of HKNB-wind measurements from 100m, without gap-filling

1. High data availability (96.5 %) & good traceability
2. No vertical extrapolation needed
3. Long-term correction from 1 year of measurements to a 15-year period (2003-2018), based on MCP with ERA5 model data

2 Wind measurements & methodology

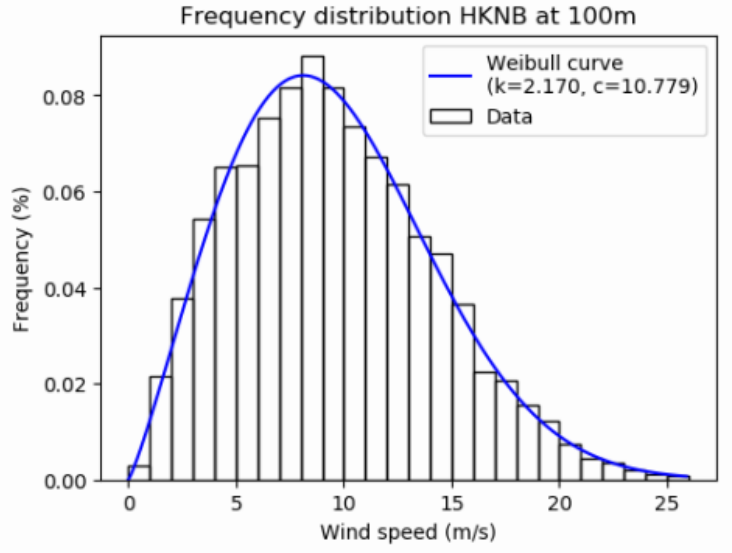
Campaign results HKNB floating LiDAR:
9.63 m/s (1 yr)

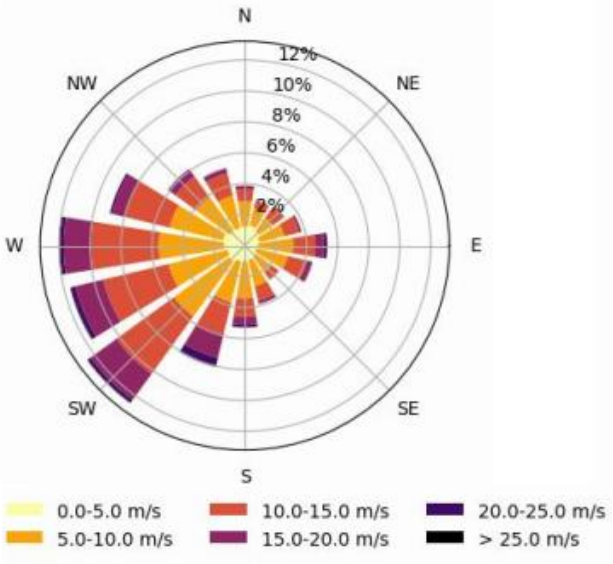
Category	HKNB Details
Measurement type	ZephIR 300s LiDAR
Measurement heights (m MSL)	30, 40, 60, 80, 100, 120, 140, 160, 180, 200
Measurement period	10/04/2017-09/04/2017
ZephIR Measurement averaging period	10-minute



2 Wind measurements & methodology

Campaign results HKNB floating LiDAR





2 Wind measurements & methodology

WRA 2: OWEZ met mast

Used: 1 year of OWEZ-met mast measurements at 70m

1. High data availability (95.3 %) & good traceability
2. Extrapolation from measurement height to 100 m, based on direction & time-of-day measured shear profile
3. Long-term correction from 1 year of measurements to a 15-year period (2003-2018), based on MCP with ERA5 model data

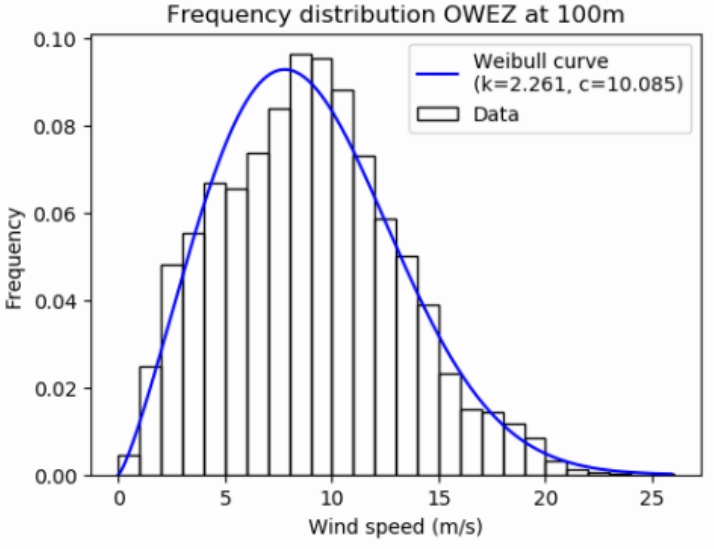
2 Wind measurements & methodology

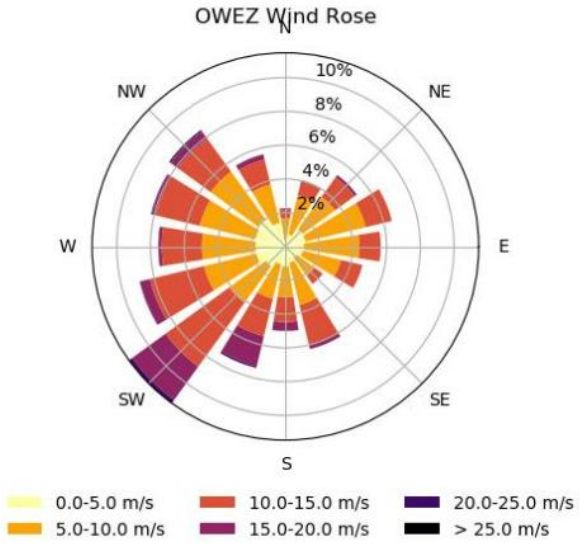
Campaign results OWEZ met mast:
8.96 m/s (1yr) interpolated to 100 m

Category	OWEZ met mast
Instruments	Cup anemometers (9x) – Mierij Meteo 018 Wind vanes (9x) – Mierij Meteo 524 Sonic anemometer (3x) – Gill 1086M
Measurement heights (m MSL)	21, 70, 116
Measurement period	01/07/2005 – 30/06/2006
Measurement averaging period	10 minute

2 Wind measurements & methodology

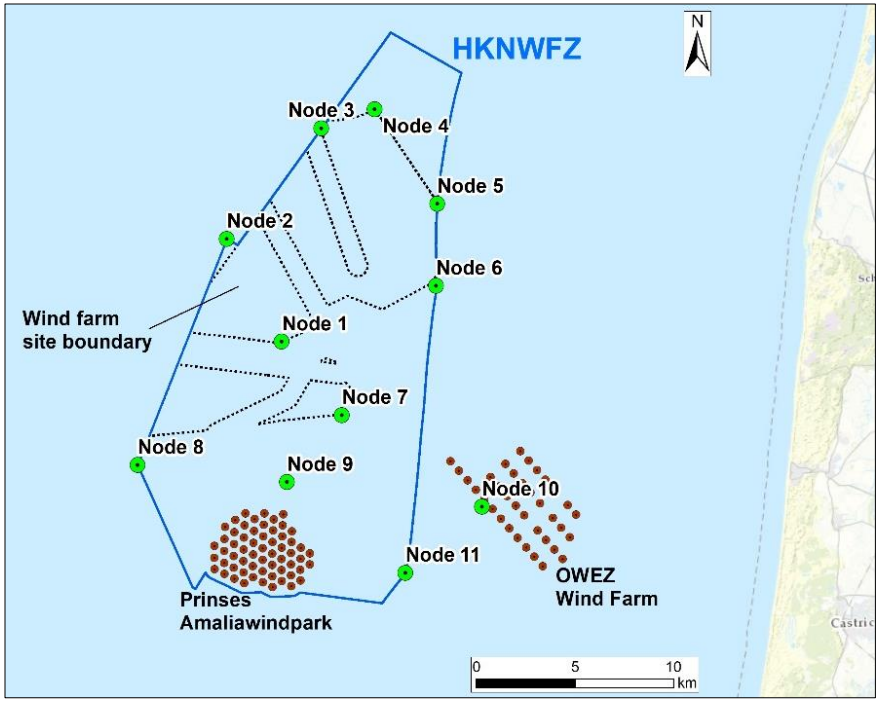
Campaign results OWEZ met mast





2 Wind measurements & methodology

- HKNWFZ nodes presented in study
- Selected for representation of wind climate & wake modelling



2 Wind measurements & methodology

- Long term correction using ERA5 for each dataset
- In WRA2, translation of OWEZ results to site center to obtain 2nd wind climate using KNW-atlas
- Results at site center (Node 1):
  - WRA1: HKNB + ERA5. Result 9.56 ± 0.43 m/s
  - WRA2: OWEZ + ERA5. Result 9.55 ± 0.50 m/s
- Results align, trust in KNW-atlas for representing wind speed gradient

3 Resulting long term wind climate

Uncertainty components	WRA1 Comments	WRA2 Comments	WRA1 (HKNB) [%]	WRA2 (OWEZ) [%]
Instrument accuracy	LiDAR	Met mast	3.3	2.0
Instrument mounting	LiDAR	Cup anemometer	0.5	2.5
Data quality	LiDAR	Met mast	1.0	0.5
Data processing	LiDAR	Met mast	1.0	1.0
Wake effect due to nearby wind farms	Calculated	n/a	0.1	0.0
Vertical extrapolation	n/a	From 70 m	0.0	0.3
Horizontal extrapolation to HKNWFZ centre (Node 1)	n/a	From met mast	0.0	1.0
Horizontal extrapolation to HKNWFZ nodes	KNW-atlas	KNW-atlas	1.0	1.0
Long-term representation (=6/sqrt(n))	15 years ERA5	15 years ERA5	1.6	1.6
MCP uncertainty	15 years ERA5	15 years ERA5	0.7	1.3
KS-test derived wind speed distribution uncertainty	15 years ERA5	15 years ERA5	1.7	3.1
Total	-	-	**4.5%**	**5.2%**

3 Resulting long term wind climate

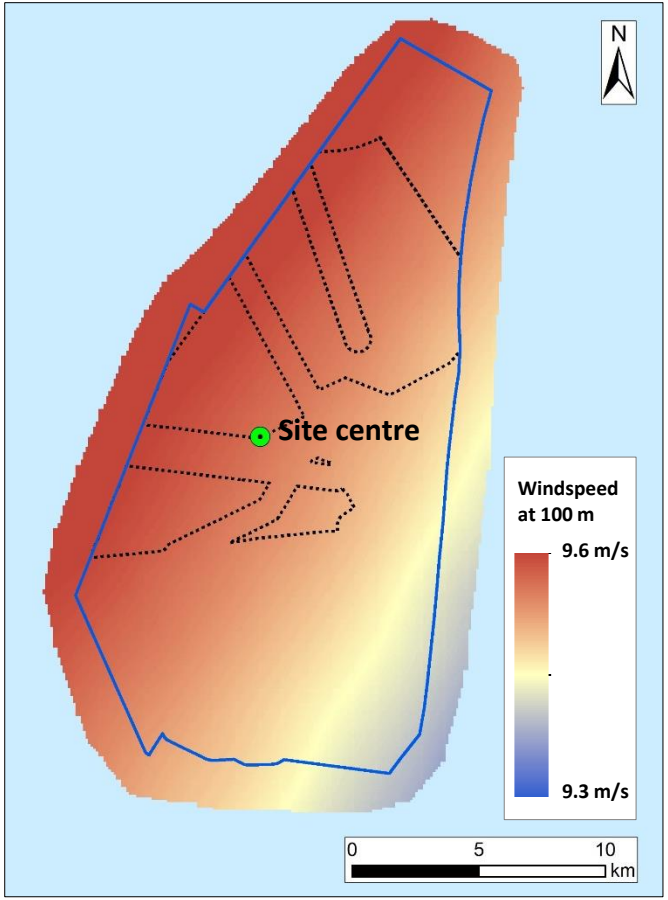
Focus: Top-3 uncertainty components

- WRA 1: HKNB LiDAR buoy based
  - Instrument accuracy 3.3%
  - KS-Test statistic 1.7%
  - Long term representation 1.6%

- WRA 2: OWEZ based
  - KS-Test statistic 3.1%
  - Instrument mounting 2.5%
  - Instrument accuracy 2.0%

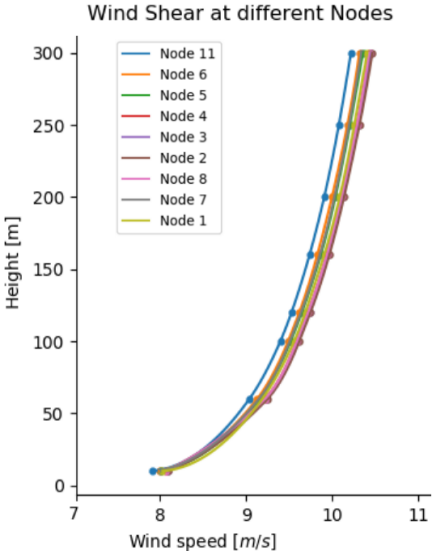
3 Resulting long term wind climate

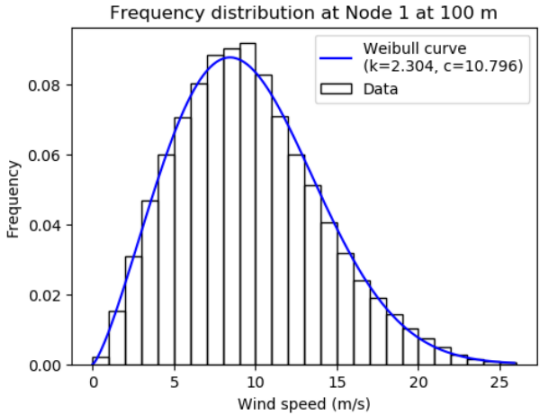
Resulting wind speed at site centre:
9.56 m/s ± 0.39 m/s (uncertainty = 4.1 %)

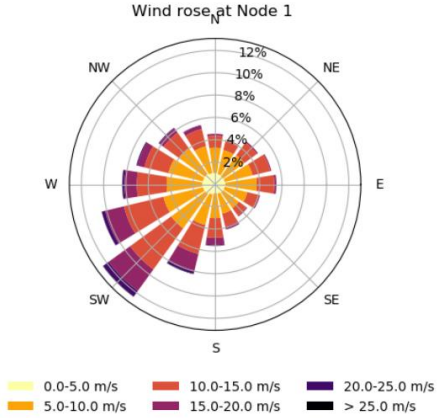


3 Resulting long term wind climate

Combined wind climate characteristics

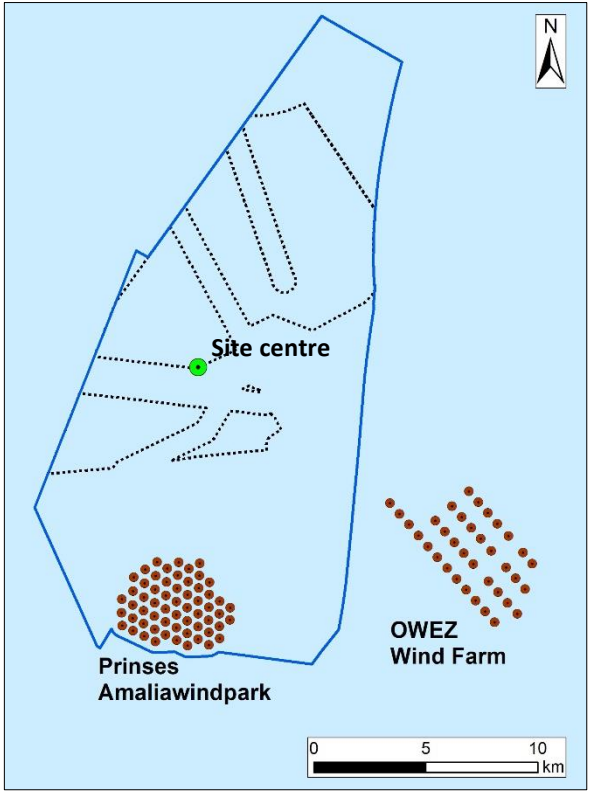






4 Wakes & site conditions

- Determine the effect of wakes of wind farms PAWP and OWEZ on floating LiDAR measurements
- Determine the effect of wakes on future HKN wind farm
- Defined 2 indicative wind farm layouts, based on 10 and 12 MW wind turbine
- Ran industry standard models (NO Jensen, Fuga) and innovative LES model GRASP



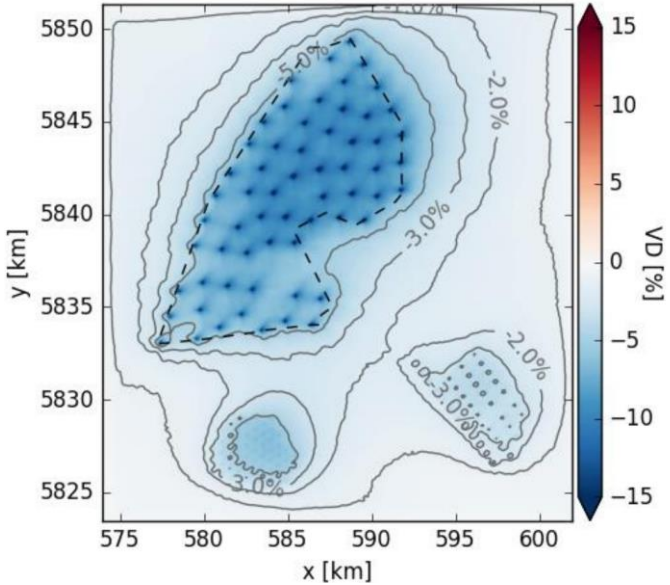
4 Wakes & site conditions

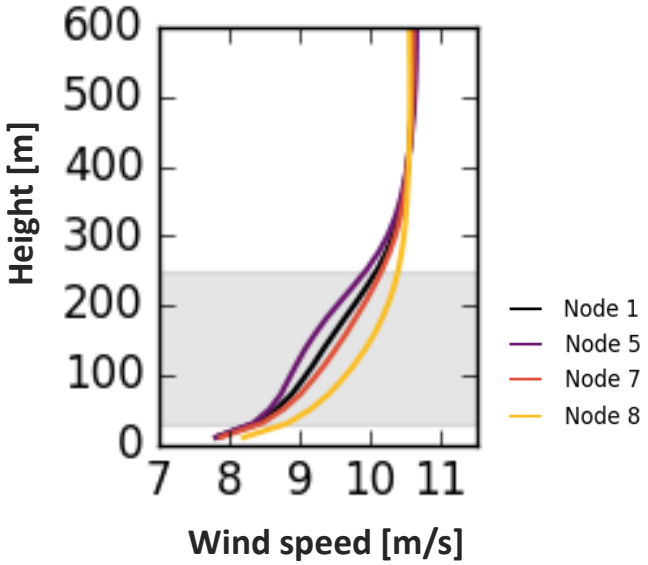
- Effect of current wind farms on LiDAR measurements: 0.1 – 0.2 % (m/s)
- Modelled effect of current wind farms on potential layouts: 0.2 – 0.3 % (AEP, average)

- Conclusions:
  - Considered within uncertainty of calculations, no need to correct HKNB measurements
  - AEP deficit found to be minimal but is recommended to be calculated for final layouts

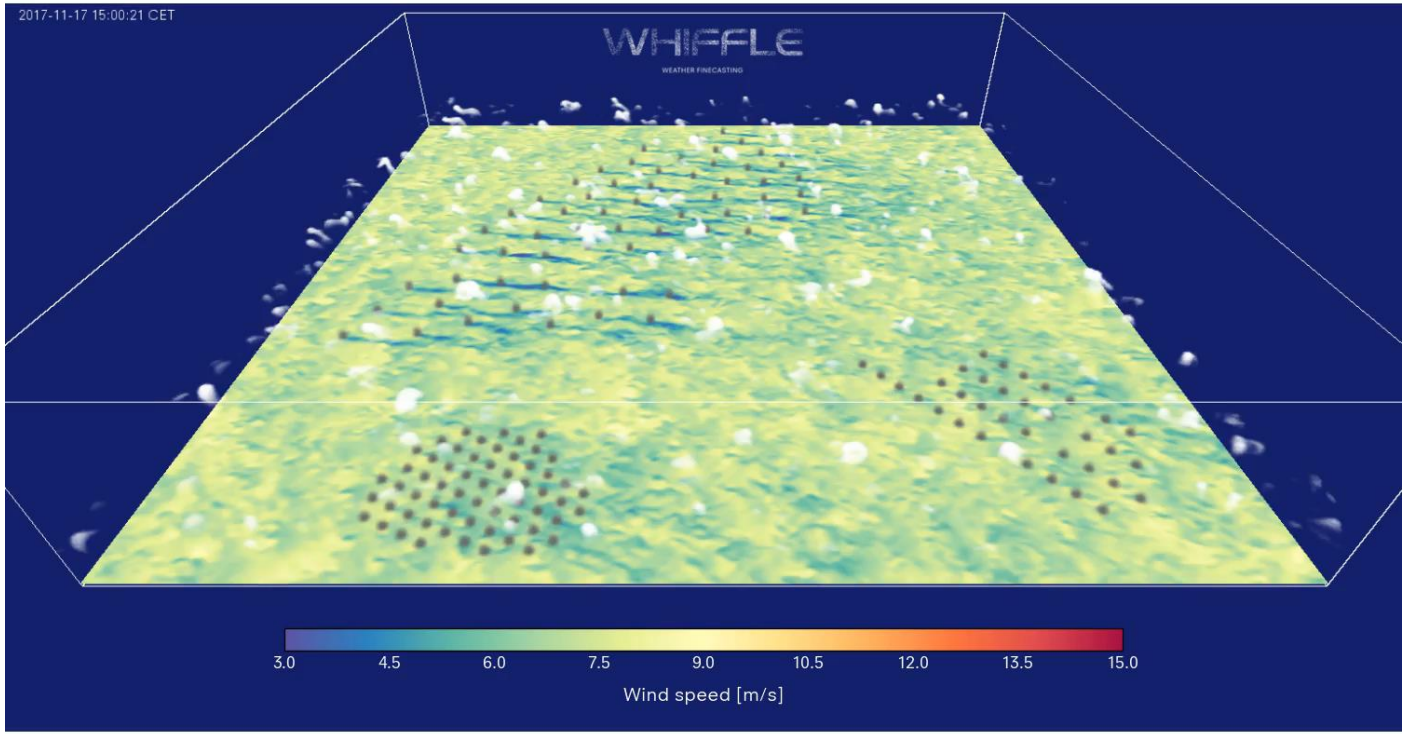
4 Wakes & site conditions

Results





4 Wake & site conditions



4 Wakes & site conditions

- Main parameters presented in report:
  - Mean wind speed & shear
  - Diurnal & monthly variation
  - Frequency distribution
  - Weibull parameters & wind rose
  - Temperature, pressure, humidity
  - Air density
- Conclusion: findings in line with known climatology for Dutch North Sea

5 Comparison

Meteocean desk study by DHI

- RVO.nl has in parallel commissioned DHI to perform a metocean desk study for the HKN wind farm zone, with a different scope:
  - *The DHI report and metocean database (are to) describe the normal and extreme wind conditions. This includes turbulence intensity, extreme wind speeds and wind shear. This information is intended for wind farm design.*

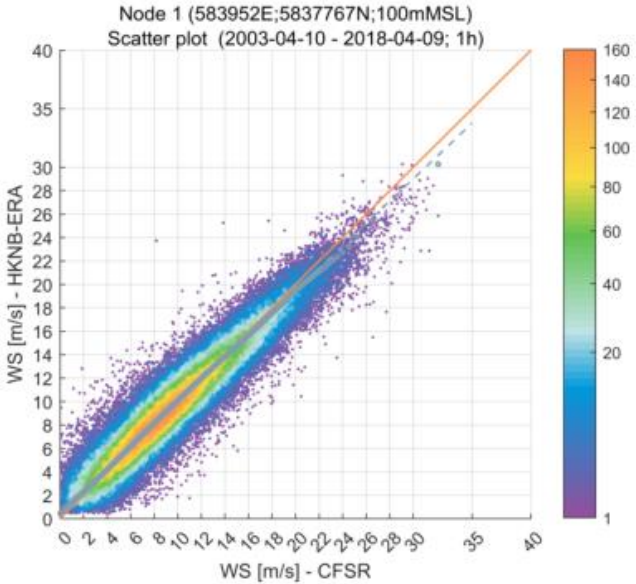
5 Comparison

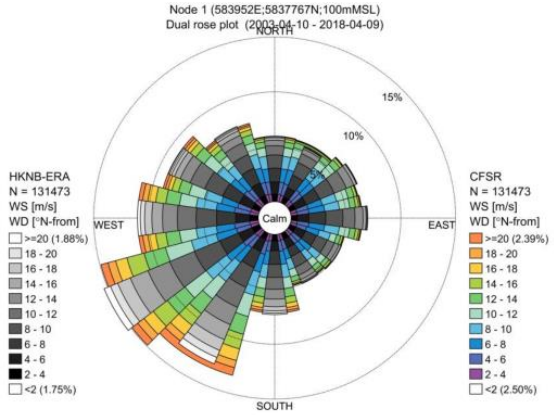
- Both studies align very well at all nodes
- The long-term mean wind speed at HKNWFZ site centre (Node 1):
  - *DHI report = 9.52 m/s*
  - *WRA report = 9.56 m/s*
- At site centre, the wind speed aligns within 0.04 m/s

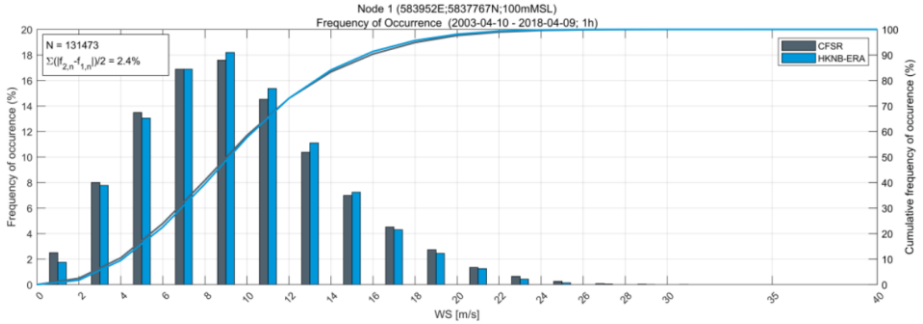
- At all four comparison nodes, the wind speeds are within 0.08 m/s

5 Comparison

Results for site centre





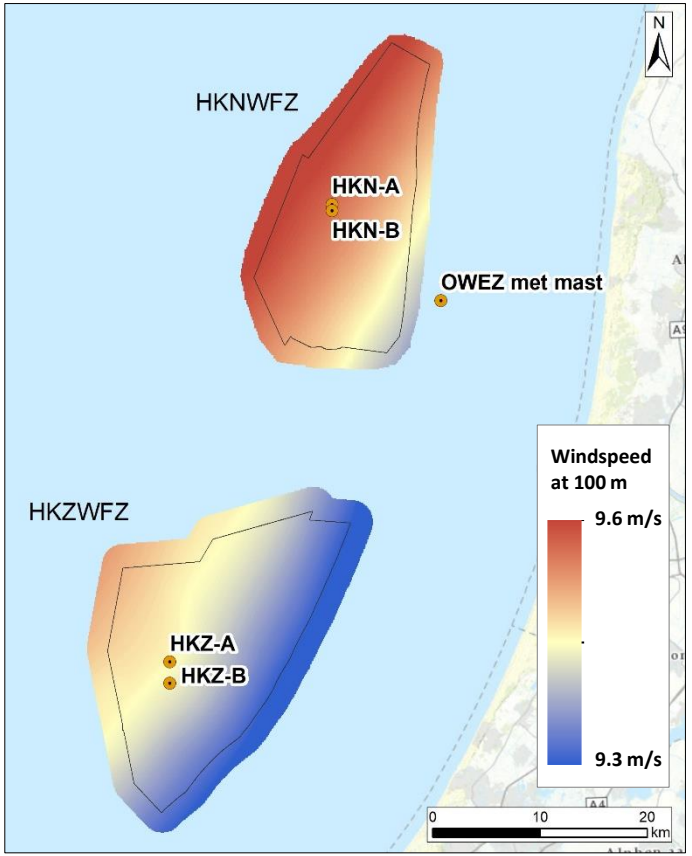


5 Comparison

Comparing HKNWFZ WRA w HKZWFZ WRA

- HKZWFZ mean long-term wind speed at 100 m:
  9.44 m/s ± 0.38 m/s
- HKNWFZ mean long-term wind speed at 100 m:
  9.56 m/s ± 0.39 m/s
- Both studies find a wind speed gradient across the sites of 2.2%

- Conclusion: both studies are aligned



6 Summary

- Confidence in measured datasets and resulting wind climates
- Mean long term wind speed: 9.56 m/s ± 0.39 m/s
- Wake effects limited
- Good alignment with DHI study and HKZ WRA
- Study certified by DNVGL

Thank you !

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http://www.oldbaumservices.co.uk/
https://ponderaconsult.com/uk/

Closing

- Questionnaire
- Lessons learned
- Availability panel
- Communications
  - https://offshorewind.rvo.nl
  - woz@rvo.nl

Thank you very much!