

# VALIDATION OF THE DUTCH OFFSHORE WIND ATLAS (DOWA) WITH OFFSHORE MAST AND LIDARS

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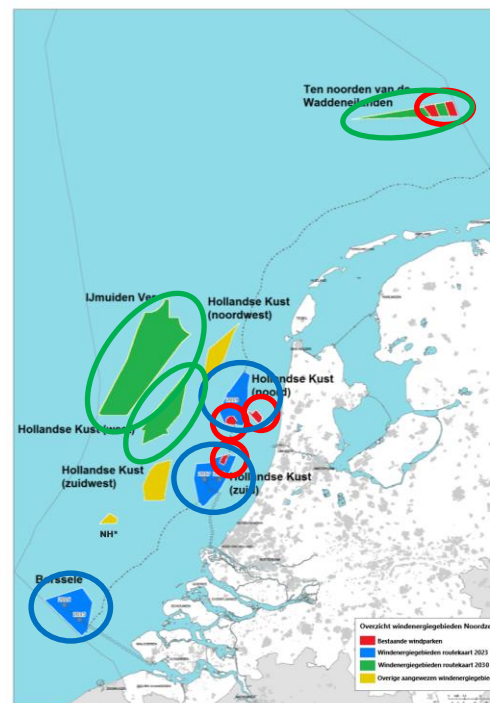


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    - › Hourly, diurnal seasonal and yearly
    - › Weibull distributions
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# BACKGROUND

- › **Operational (957MW)**
  - › OWEZ 2006 108MW
  - › Amalia 2008 120MW
  - › Luchterduinen 2015 129MW
  - › Gemini 2017 600MW
- › **Tender (3.5GW)**
  - › Borssele 2016 1400MW
  - › HKZ 2017/18 1400MW
  - › HKN 2019 700MW
- › **Roadmap 2030 (6.1GW)**
  - › HKW 1400MW
  - › Fryslan Islands 700MW
  - › IJmuiden ver 4000MW



Source: Letter of minister to House of Representatives

# INTRO

## WHAT IS DOWA

DOWA is short for Dutch Offshore Wind Atlas

- ✓ KNMI released the KNW, KNMI North Sea Wind Atlas in 2013
  - based on global reanalysis ERA-interim and downscaled for 1979-2013 with KNMI's Harmony model (extended in DOWA to 2019)
  - Validated, in 2015, against scatterometer (satellite) winds and several (offshore) mast measurements: climatological accuracy (long term averages/extremes) at hub height comparable to climatology based on measurements
  - Uniform wind shear correction required

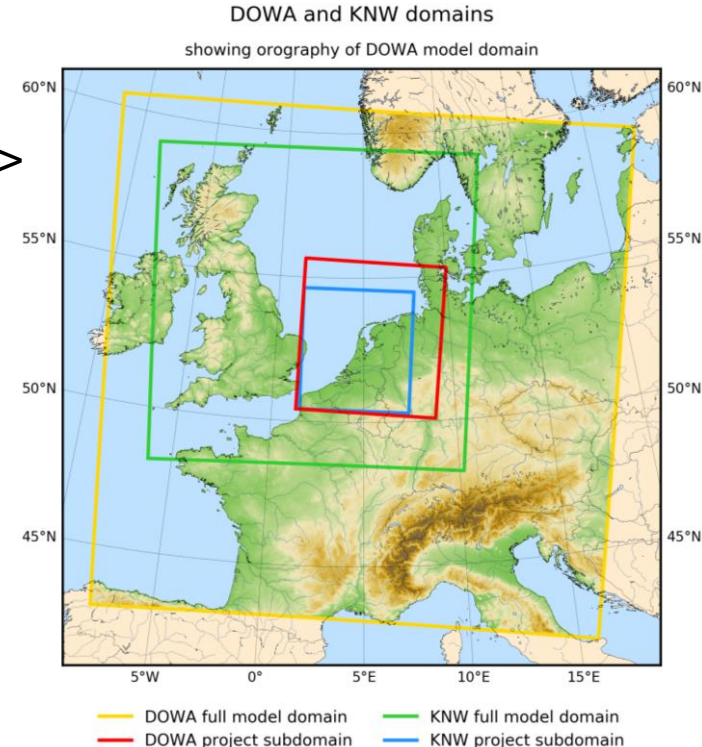
In order to improve the short term, hourly, prediction accuracy and improve the wind shear representation, a new model was made. DOWA is based on:

- ✓ ERA5, improvement on ERA-interim, with higher resolution in time and
- ✓ Applied a new version of Harmony with a better turbulence scheme, resulting in a better representation of wind shear
- ✓ DOWA includes the information to make further LES downscaling possible

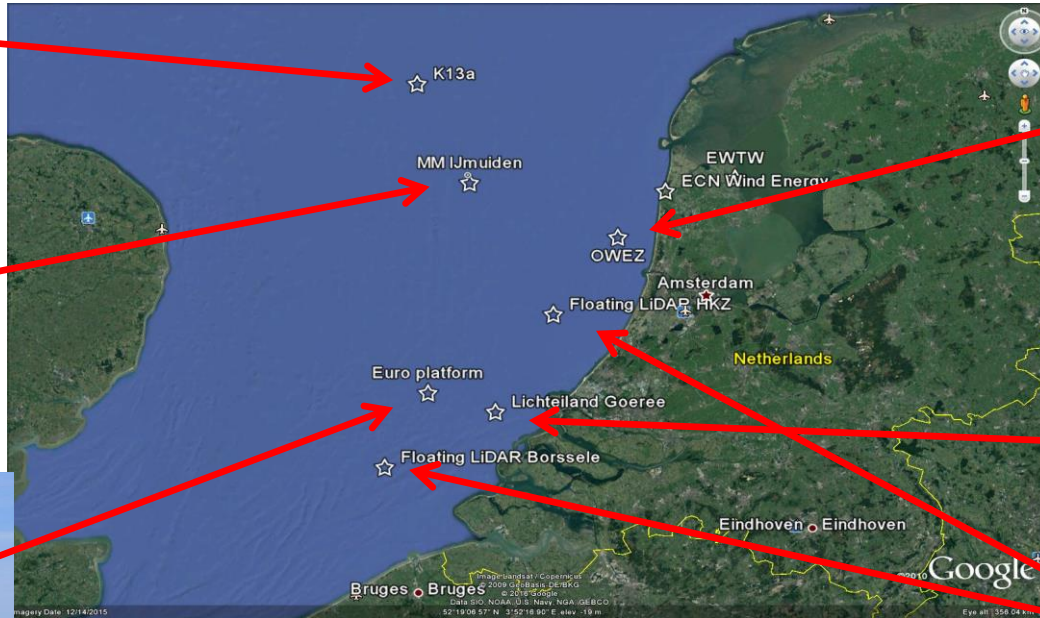
# IMPROVEMENTS OF DOWA COMPARED TO KNW

## DOWA compared to KNW

- + larger domain, including German offshore windfarms =>
  - + improved hourly correlation
  - + improved wind information at higher altitudes (600M)
  - + DOWA includes info for further LES downscaling
- 
- DOWA “only” 10+ years, so can not improve climatological accuracy (KNW 40 years)



# OVERVIEW MEASUREMENT PLATFORMS



# VALIDATION DATA

DOWA validated with measurements of 9 sites:

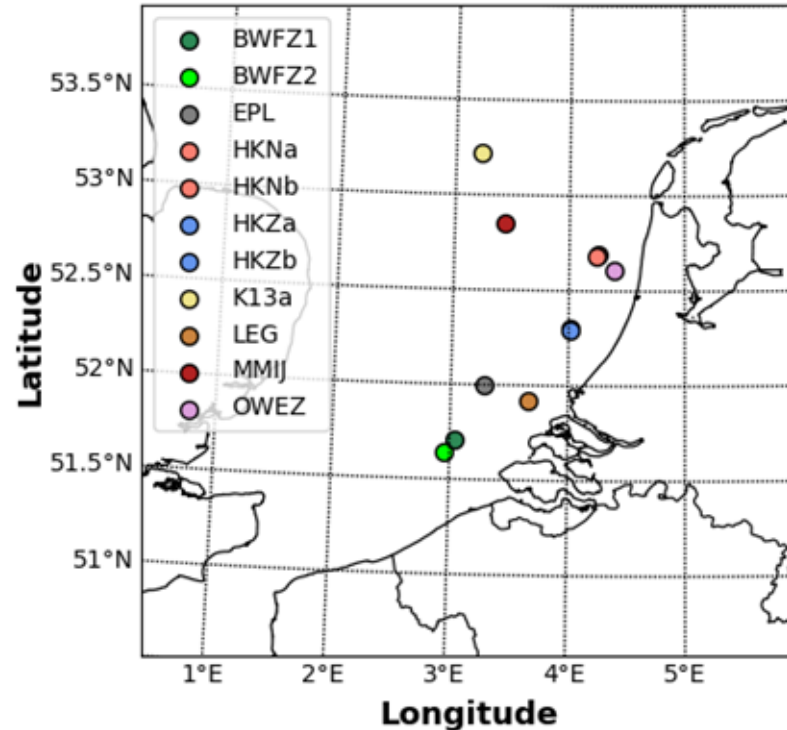
- ✓ Offshore met mast measurements
- ✓ LiDAR measurements (floating and mounted on platform)
- ✓ advanced SCATterometer (ASCAT)
- ✓ Compared to EMD ConWx

Floating LiDAR measurements are:

- ✓ Borssele Wind Farm zone 1 and 2
- ✓ Hollandse Kust Zuid WFz 1 and 2
- ✓ Hollandse Kust Noord WFz 1 and 2

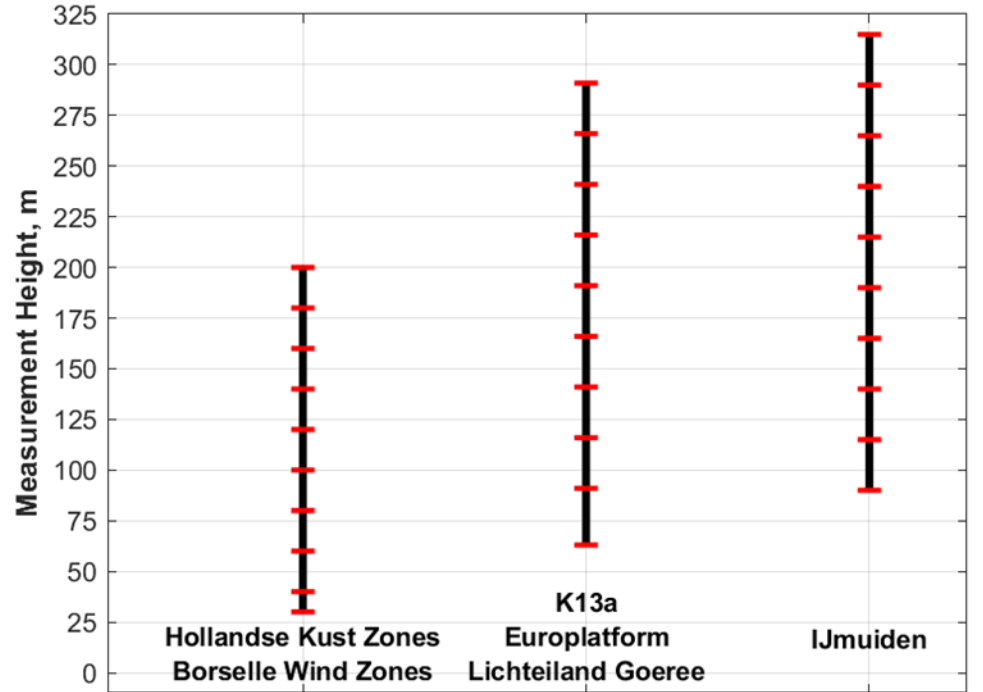
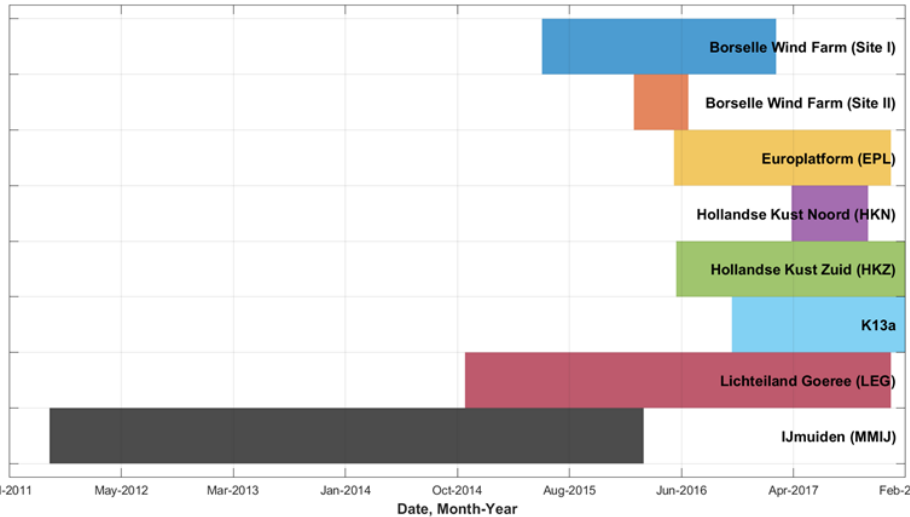
Platform mounted LiDAR are:

- ✓ Euro platform
- ✓ K13
- ✓ Licht Eiland Goeree
- ✓ Met mast IJmuiden



# VALIDATION DATA

LiDAR measurements  
Measurement period and heights



Measurement site LiDAR sampling heights (horizontal red lines)



# VALIDATION WHAT AND HOW

The validation is performed on several quantities or valuations

- › Wind Speed
- › Wind shear
- › Daily, Monthly and Seasonal averages
- › Correlations at different heights and periods like hourly, seasonal and diurnal averages
- › Weibull fit

Bias with measurements is determined by,  $WS_{meas} - WS_{dowa}$   
 or  $WD_{meas} - WD_{dowa}$

Correlation is determined by,  $WS_{dowa} = slope * WS_{meas} + y_{intercept}$   
 where the slope should go to 1 and the  $y_{intercept}$  to 0.

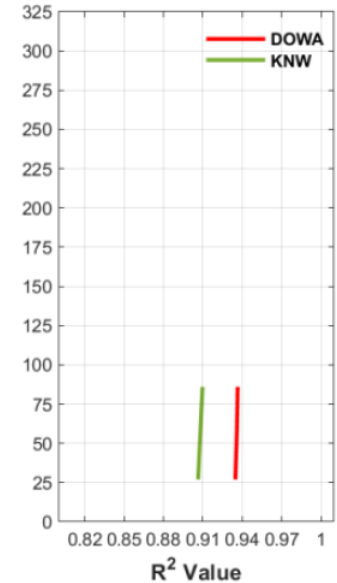
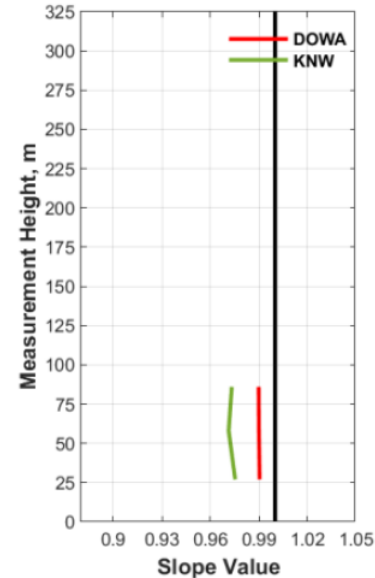
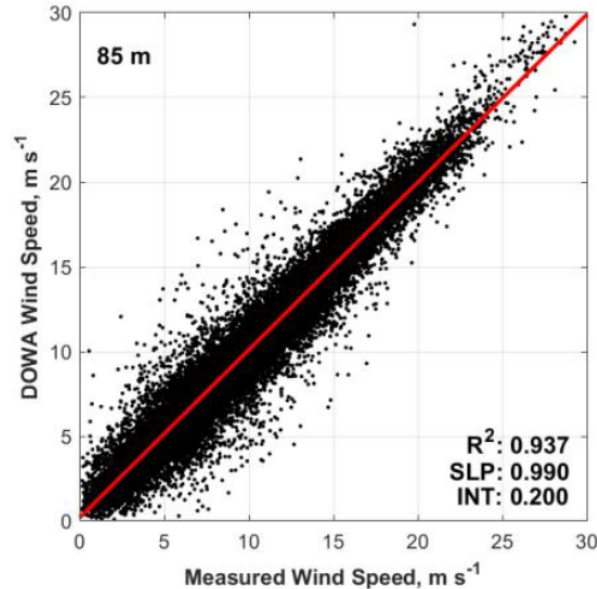
The correlation coefficient  $R^2$  should go to 1 indicating less scatter

# RESULTS – WIND SPEED – MET MAST

## Results MMIJ

Total uncertainty of the measurements assumed to be ~ 2.5% – 3.1%

MMij (85)	KNW	DOWA
Slope	0.97	0.99
Y-intercept	0.28	0.20
R <sup>2</sup>	0.91	0.94



Left column, scatterplot of the DOWA and wind speeds @ MMIJ  
right column, vertical differences in the value of the linear least-squares regression slope and R<sup>2</sup>

# RESULTS – WIND SPEED - LIDAR

## Results LiDAR

Total measurement uncertainty assumed to be ~2%-3.4%

MMij (90)	KNW	DOWA
Slope	0.97	0.98
Y-intercept	0.30	0.20
R <sup>2</sup>	0.91	0.93

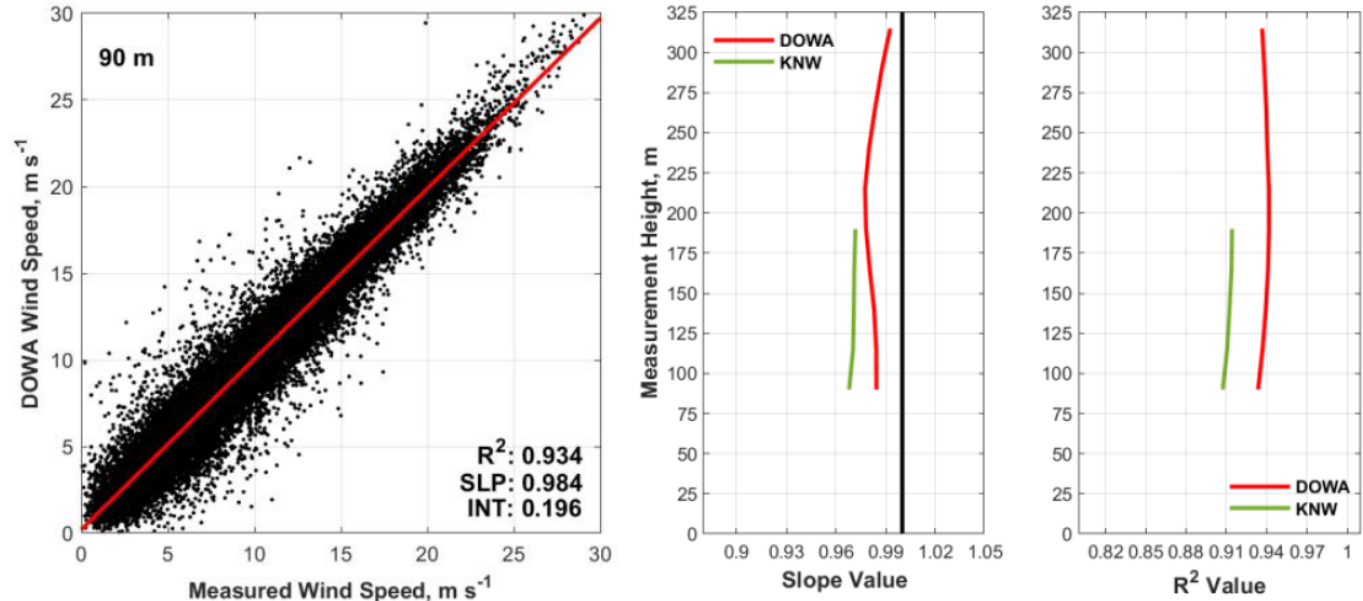
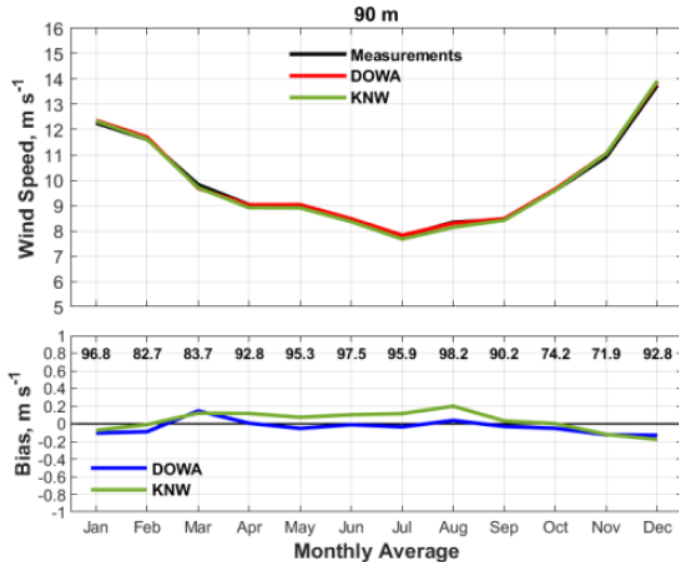


Figure 8 (Left column) Scatterplot of the DOWA and LiDAR wind speeds at MMIJ. (Right column) Vertical differences in the value of the linear least-squares regression slope and R<sup>2</sup>.

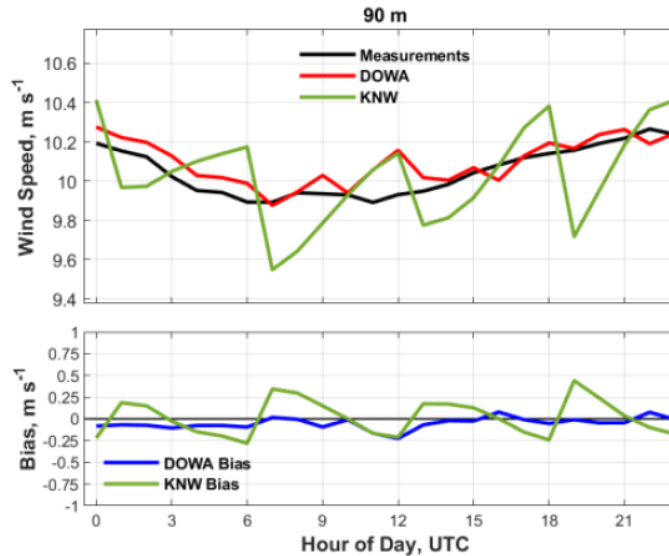
# RESULTS WIND SPEED – DIURNAL & SEASONAL

MMIJ (90) LiDAR

› Monthly mean values



› Hourly mean values



› Hourly bias

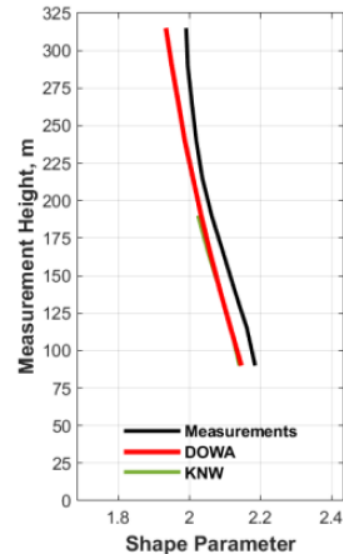
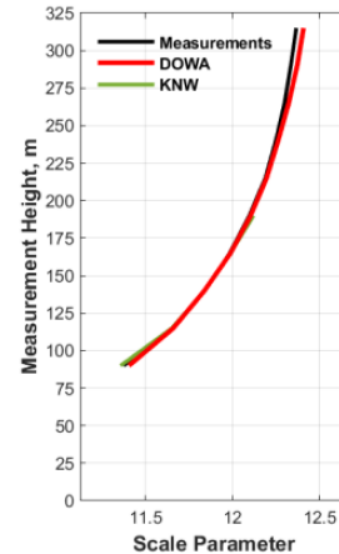
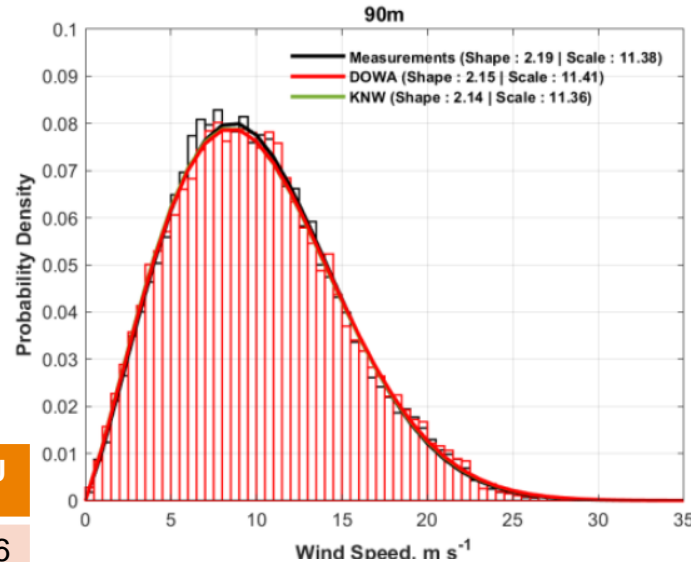
	MMIJ (90)	KNW	DOWA
$\mu$ bias			
@ 00hr		-0.22	-0.08
@ 06 hr		-0.28	-0.10
@ 12 hr		-0.21	-0.23
@ 18 hr		-0.24	-0.05
$\sigma$ bias			
@ 00 hr		1.57	1.24
@ 06 hr		1.49	1.25
@ 12 hr		1.52	1.23
@ 18 hr		1.67	1.30

# WEIBULL DISTRIBUTIONS A SEVERAL HEIGHTS

MMIJ LiDAR compared to KNW & DOWA

KNW only to < 200 m

DOWA up to 600 m, however validation up to 325 m

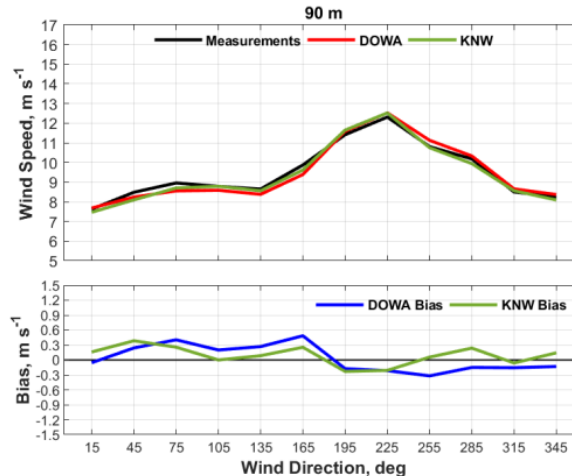
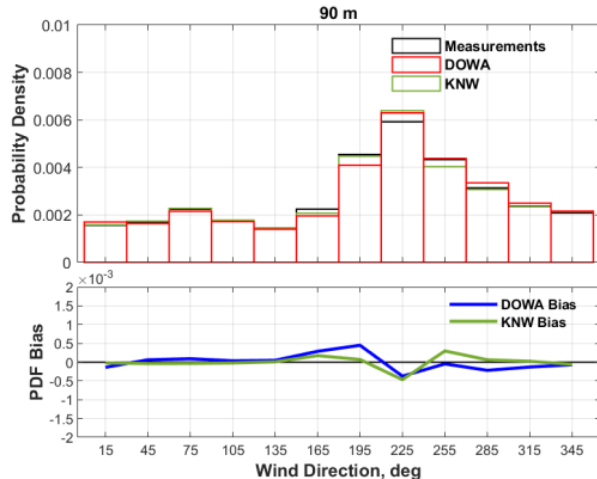


MMIJ (85)	KNW	DOWA	MMIJ
Weibull A	11.39	11.46	11.36
Weibull k	2.26	2.18	2.21

No significant difference between KNW and DOWA (as expected)

# RESULTS - WIND DIRECTION

- › Wind direction data is binned per 30° sector bins
- › Before binning a wind speed filter was applied removing 10 min average wind speeds below 4 m/s
- › Measurements were corrected for sectors where a wind farm disturbed measurements (not MMIJ)
- › Example MMIJ LiDAR



# CONCLUSIONS

- › DOWA provides a reliable data set of windspeeds and wind directions up to 600 m and for a period of more than 10 years up to 600 m height including information for further LES downscaling
- › DOWA improved the hourly wind speed correlation compared to KNW-atlas and also compared to e.g. EMD ConWx data
- › The new Harmony model improved the vertical wind shear results
- › DOWA produces identical seasonal (monthly) averages as KNW-atlas
- › DOWA and KNW-atlas time series result in good correlation Weibull shape (k) and scale (A) parameters
- › DOWA has better representation of the diurnal cycle, significantly improved upon KNW-atlas
- › **The differences between DOWA and the measurements are all within the accuracy of the measurements!**

# DOWA WEBSITE & QUESTIONS

At the DOWA website <https://www.dutchoffshorewindatlas.nl/> all results, including the validation reports, and a link to the KNMI Data Centre (KDC), to download the DOWA data, can be found

## Questions

The DOWA project is a joint effort between ECN, TNO, Whiffle and KNMI and is supported by the Topsector Energy from the Ministry of Economic Affairs and Climate Policy.



› **THANK YOU FOR YOUR  
ATTENTION**

**TNO.NL/ECNPARTOFTNO**



**ECN** ›

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