RVO.nl Metocean measurement campaign

Hollandse Kust Noord Offshore Wind Farm

Webinar 23 May 2019: Richard Davies, Eisse van den Oever, Vegar Neshaug (Fugro)

Contents

FUGRO

Introduction to the metocean campaign

Purpose, project overview, observations and comparison

Purpose of the measurements

Fugro carried out a metocean measurement campaign at the Hollandse Kust Noord Offshore wind farm (OWF) to support future wind farm developers.

The resulting dataset should allow developers to **reduce the uncertainties in the metocean conditions** and;

- Carry out more accurate calculations of the annual energy yield;
- Calibrate and/or validate metocean models available for the wind farm design.

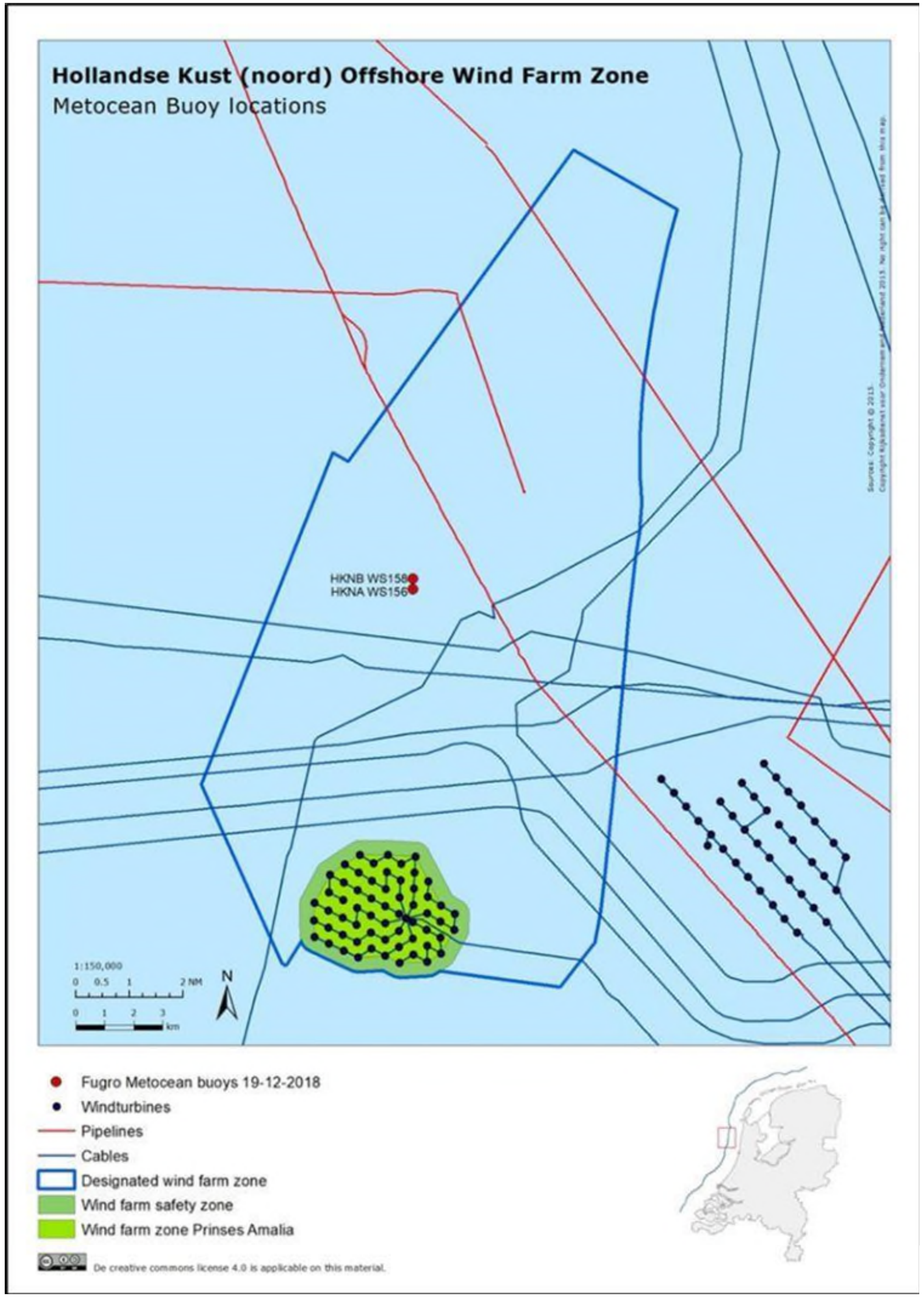
Project Location

2 Seawatch Wind LIDAR Buoys deployed: HKNA, HKNB

Data collected from April 2017 to April 2019

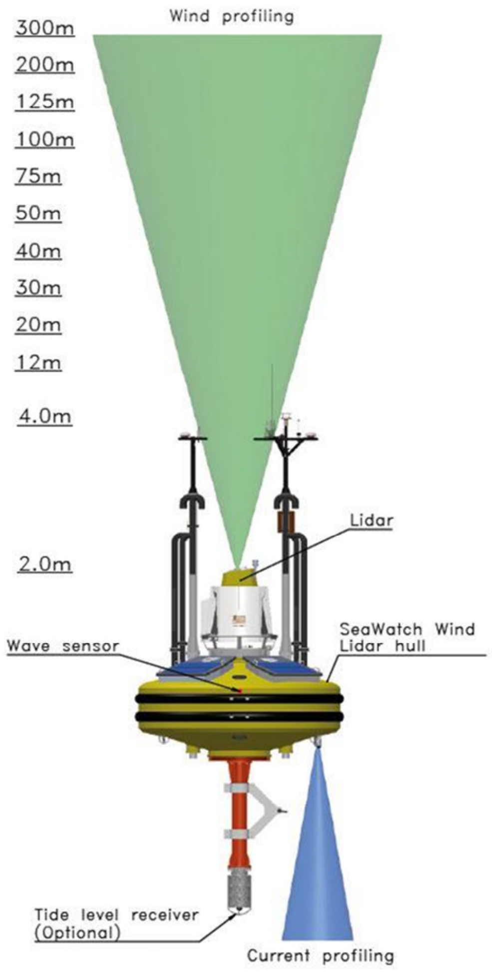
Buoys were deployed approximately 15 NM offshore

Water depths of 23 m at both buoys



Parameters observed

- Wind at 10 elevations to 200m
  - Speed
  - Direction
  - Turbulence intensity
  - Inflow angle
  - Wind shear/veer
- Wave
  - Height
  - Period
  - Direction
- Current profile down to 22 m
- Water temperature
- Atmosphere
  - Pressure
  - Humidity
  - Temperature
- Water level or relative tide



Borssele – RVO.nl – June 2015 - March 2017

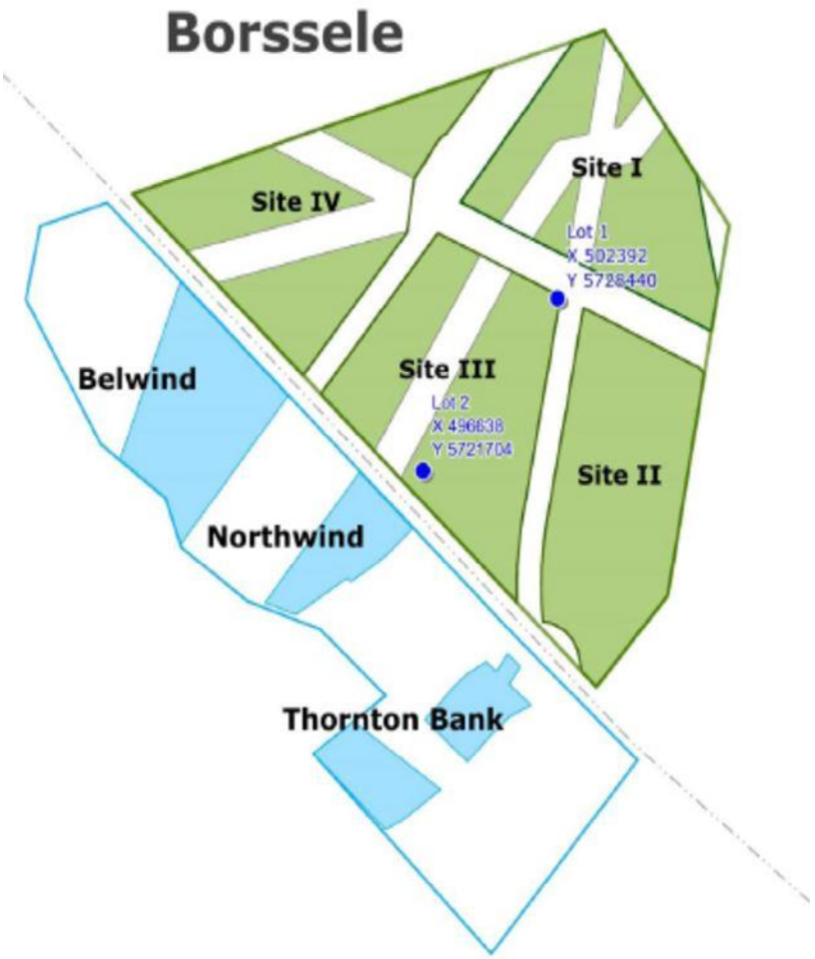
1 SeaWatch Wind LIDAR buoy deployed June 2015 and 1 SWLB buoy deployed February 2016

Parameters:

- Mooring at 30 m water depth
- Wave height, period and direction
- Current profile (28 m) and water temperature
- Wind speed and direction at 11 elevations
- Air pressure
- Air humidity and temperature
- Water level (tide)

Wind observations:

Wind speed and direction, turbulence intensity, inflow angle and wind shear/veer

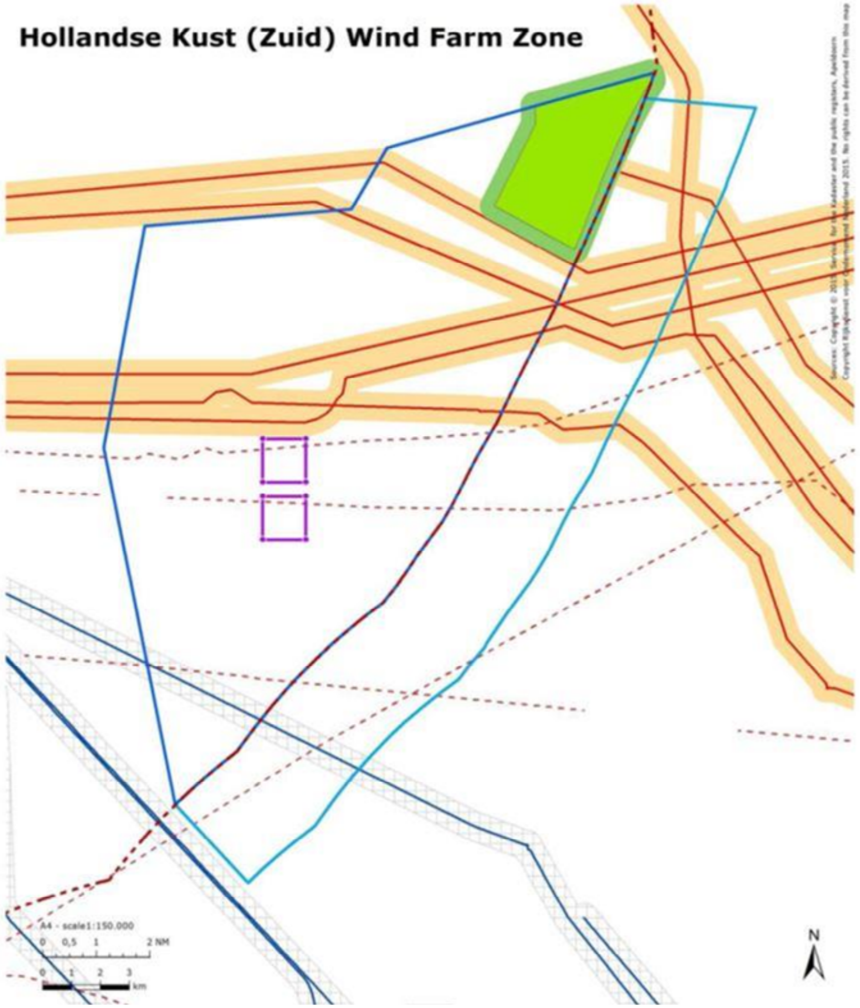


HKZ – RVO.nl - June 2016 – June 2018

2 SeaWatch Wind LIDAR buoys deployed

Parameters:

- Mooring at 23 m water depth
- Wave height, period and direction
- Current profile (22 m) and water temperature
- Wind speed and direction at 11 elevations
- Air pressure
- Air humidity and temperature
- Water level (tide)



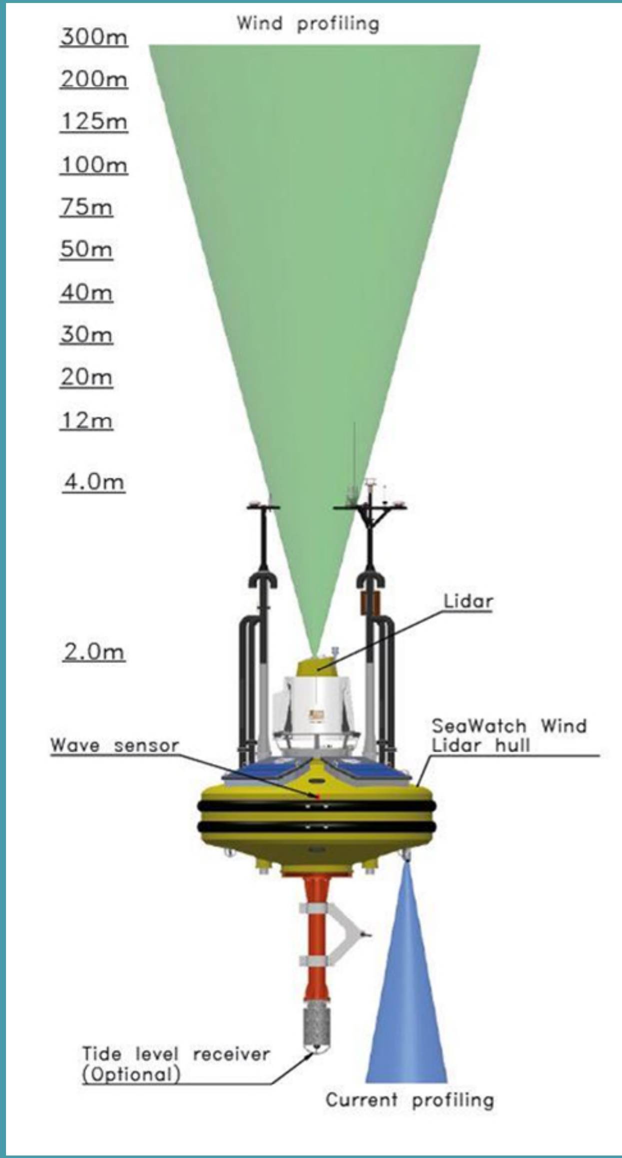
Wind observations

Wind speed and direction, turbulence intensity, inflow angle and wind shear/veer

Fugro SEAWATCH Wind LIDAR Buoy

Building upon proven technology:

A compact, proven measurement buoy that includes wind profile, waves, current profile, and meteorology

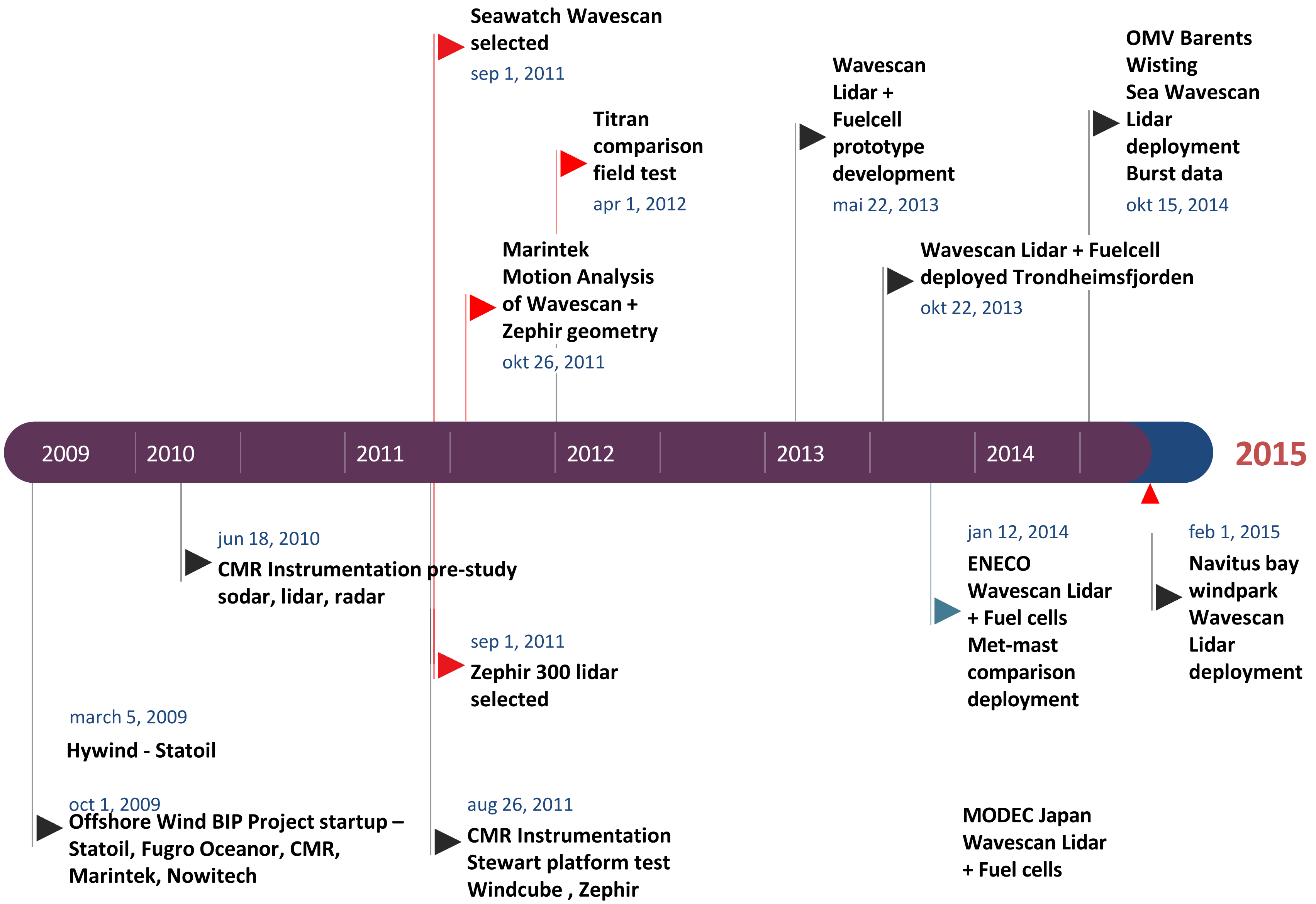


Replaces Conventional Met Masts

High reduction in:

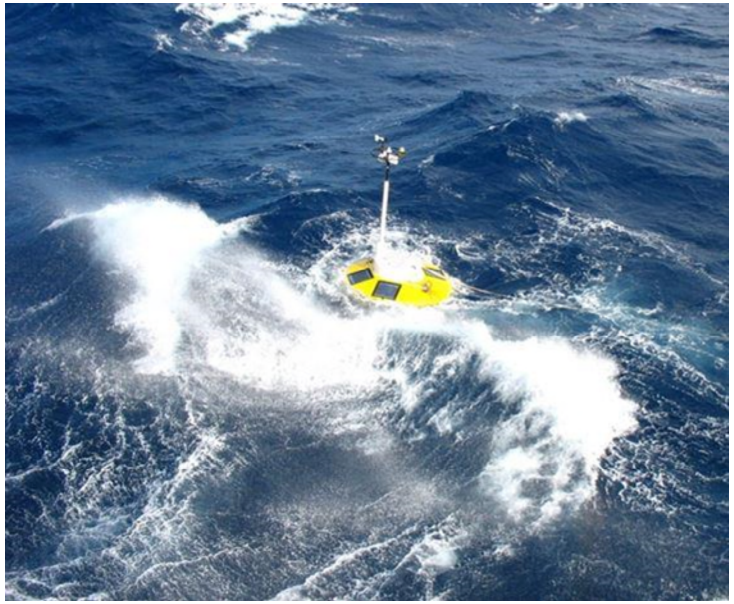
- Construction time before first data
- Foundations complexities
- Difficulties to access and crew transfer (safety)
- High cost of design, installation and maintenance

R&D Timeline


Seawatch Wavescan selected
sep 1, 2011
Titran comparison field test
apr 1, 2012
Marintek Motion Analysis of Wavescan + Zephir geometry
okt 26, 2011
Wavescan Lidar + Fuelcell prototype development
mai 22, 2013
Wavescan Lidar + Fuelcell deployed Trondheimsfjorden
okt 22, 2013
OMV Barents Wisting Sea Wavescan Lidar deployment Burst data
okt 15, 2014
2009
2010
2011
2012
2013
2014
2015
jun 18, 2010
CMR Instrumentation pre-study sodar, lidar, radar
sep 1, 2011
Zephir 300 lidar selected
march 5, 2009
Hywind - Statoil
oct 1, 2009
Offshore Wind BIP Project startup – Statoil, Fugro Oceanor, CMR, Marintek, Nowitech
aug 26, 2011
CMR Instrumentation Stewart platform test Windcube , Zephir
jan 12, 2014
ENECO Wavescan Lidar + Fuel cells Met-mast comparison deployment
feb 1, 2015
Navitus bay windpark Wavescan Lidar deployment
MODEC Japan Wavescan Lidar + Fuel cells

The SEAWATCH Wavescan Platform

Seawatch metocean buoys: servicing in Trondheim, Norway



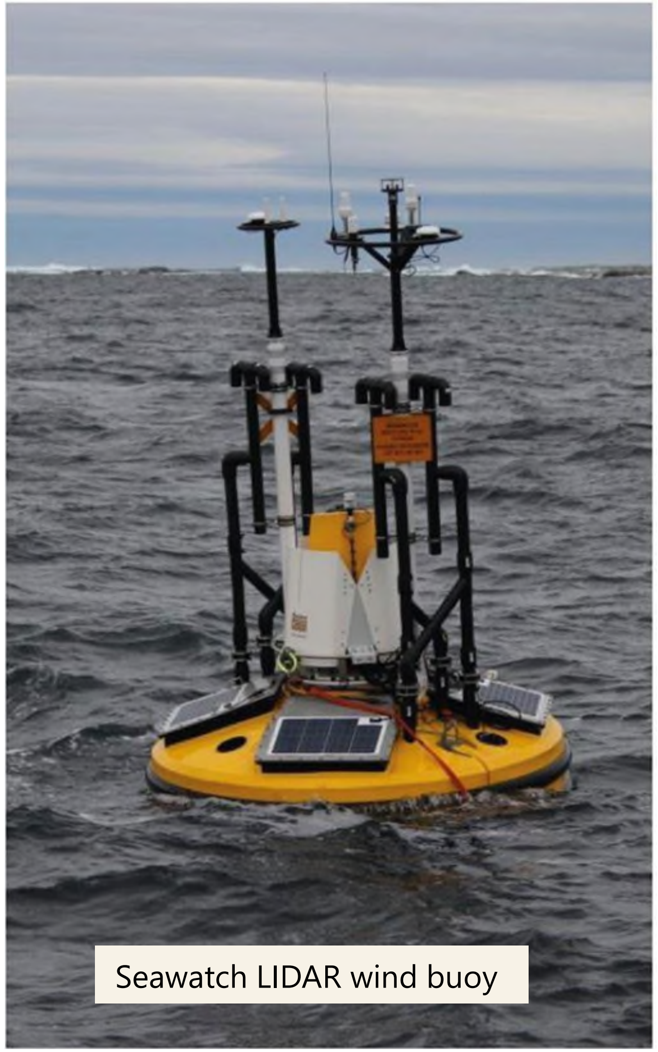
SEAWATCH Wavescan Platform

- Selected as the platform for the Lidar
- Successful track record world-wide since 1985
- Uniquely designed to optimise wave direction measurements
- Full onboard processing of all measured data
- Two-way communication link for data transfer and control
- Robust and reliable in temperature extremes and harsh environments
- Multi-parameter platform with mounting options for a wide range of oceanographic and meteorological instrumentation

The SEAWATCH Wind LiDAR Buoy

The ZephIR LIDAR selected from a comprehensive motion sensitivity analysis comparison of commercial alternatives

In collaboration between Fugro OCEANOR, NOWITECH, Christian Michelsen Research (CMR) and Statoil (now Equinor)

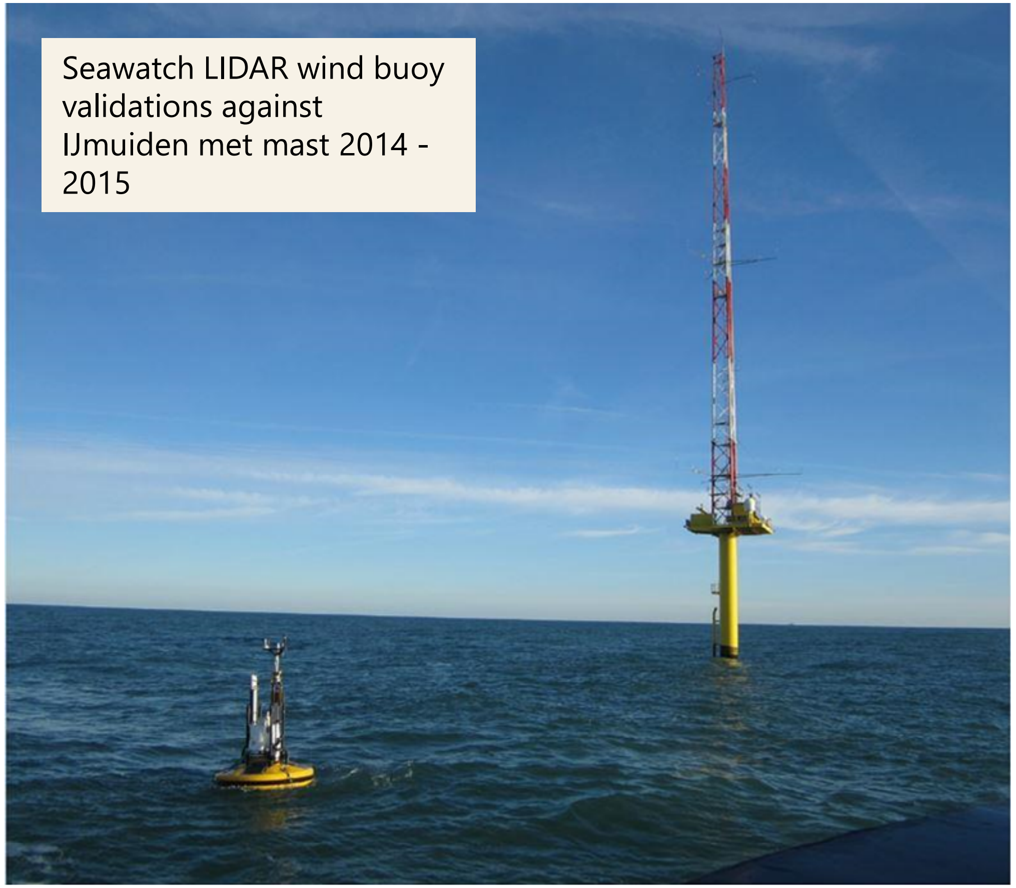


Seawatch LIDAR wind buoy

CarbonTrust OWA Roadmap Validation

IJmuiden offshore validation trial

- Conducted 2014-2015
- 6 months trial
- DNVGL issued independent performance verification
- Culminated in OWA Stage 2 Type Validation

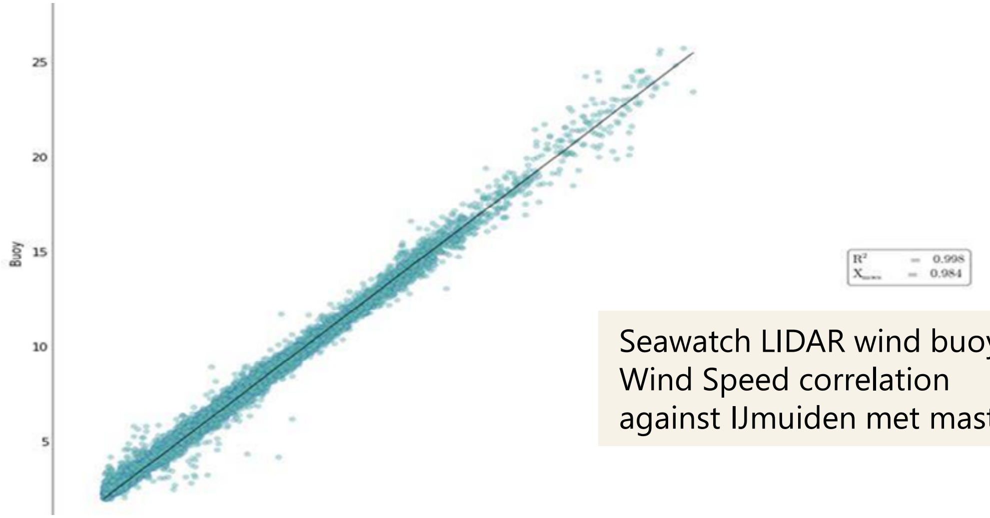


Seawatch LIDAR wind buoy validations against IJmuiden met mast 2014 - 2015

Pre-Commercial Wind Profile Data Comparison

Wind Speed

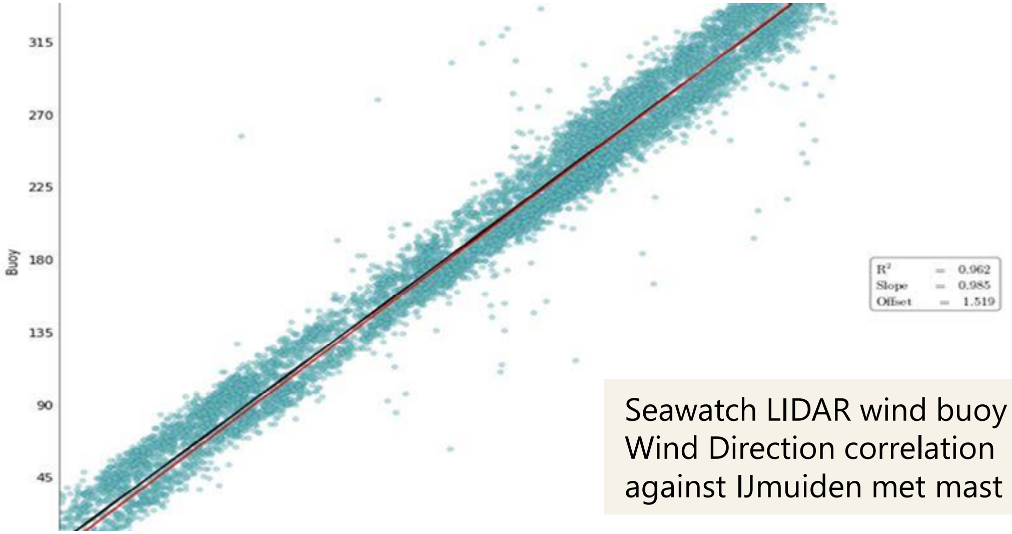
- **R2 = 0.99** (Best practice criteria > 0.98, minimum 0.97)
- **Slope = 0.98** (Best practice criteria 0.98-1.02, minimum 0.97-1.03)
- Mean offset between 0.11 m/s and 0.15 m/s



Seawatch LIDAR wind buoy Wind Speed correlation against IJmuiden met mast

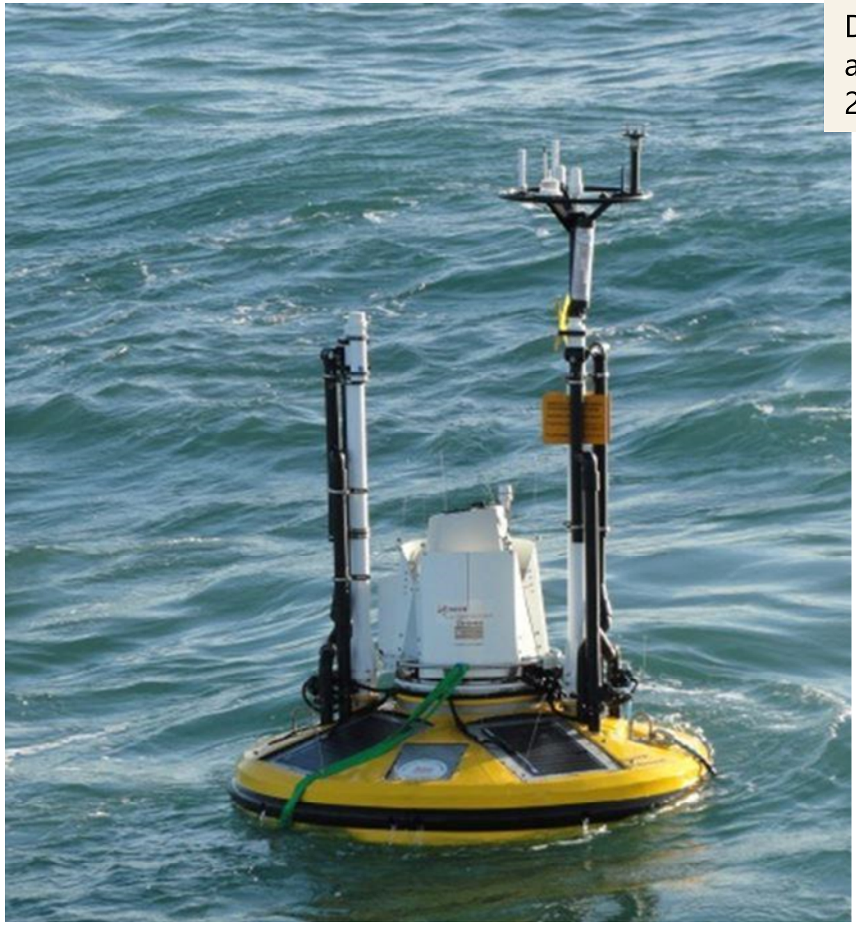
Wind Direction

- **R^2 = 0.96 - 0.97** (Best practice criteria >0.97, minimum >0.95)
- **Slope = 0.97 - 0.99** (Best practice criteria 0.97-1.03, minimum 0.95-1.05)
- **Mean offset between 1.5 and 5.8 degrees** (Best practice criteria <5 degrees, minimum <10 degrees)



Seawatch LIDAR wind buoy Wind Direction correlation against IJmuiden met mast

SEAWATCH Wind LiDAR Buoy - Approval Pre-commercial



DNV GL Pre-commercial approval certificate for 2014-2015 validations

Project name:	Fugro/Oceanor Seawatch Wind LiDAR Buoy	DNV GL / GL Garrad Hassan
Report title:	ASSESSMENT OF THE FUGRO/OCEANOR SEAWATCH FLOATING LIDAR VERIFICATION AT RWE IJMUIDEN MET MAST	Deutschland GmbH Section Offshore Germany Brooktorkai 18
Customer:	Fugro/OCEANOR AS, Trondheim, Norway	20457 Hamburg
Contact person:	Lasse Lonseth, Olaf Sveggen	Germany
Date of issue:	2015-01-30	Tel: +49 40 36149 2748
Project No.:	4257 13 10378	DE 118 606 038
Report No.:	GLGH-4257 13 10378-R-0003, Rev. B	

Task and objective: 3rd Party Assessment of an Offshore Performance Verificaton of the Fugro/Oceanor SEAWATCH Wind LiDAR Buoy at RWE IJmuiden Met Mast in the Dutch Northsea Sector

Prepared by:	Verified by:	Approved by:
A. D.Stein Deputy Head of Section Offshore, Hamburg	D. Fagkari, A. Beeken, P. Schwenk Senior and Project Engineers	A. D. Stein Deputy Head of Section Offshore, Hamburg

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☒ Client's Discretion
☐ Published

Keywords:
LiDAR, Floating Lidar Device,

Reference to part of this report which may lead to misinterpretation is not permissible.

Rev. No.	Date	Reason for Issue	Prepared by	Verified by	Approved by
A	2014-12-19	Draft issue, for clients comments, only	DeSte	AnBee	DeSte
B	2015-01-30	Final isue (electronic only)	DeSte	DarIF, AnBee, Pasch	DeSte

"An evaluation of the Fugro/Oceanor SWL Buoy floating LiDAR system was completed by comparing its measurements against data from the IEC-compliant IJmuiden met mast. Sufficient data were collected to allow an assessment in line with the Roadmap. In the IJmuiden offshore trial very encouraging results were indeed obtained. DNV GL concludes that the FO SWL Buoy system has demonstrated its capability to produce accurate wind speed and direction data across the range of sea states and meteorological conditions experienced in this trial (i.e. up to about 5.8 m significant wave height and 9.8 m maximum wave height and 10 min averaged wind speeds up to 26 m/s). Furthermore, it has recorded excellent availability throughout the 6 month period and demonstrated structural survivability in the met-ocean conditions present from early spring."

Seawatch Wind Lidar buoy – Sensors

Parameter	Manufacturer and Model
Wave height, period and direction:	Fugro WaveSense 3
Current profile and water temperature:	Nortek Aquadopp Profiler 600 kHz
Wind speed and direction:	Gill Windsonic
Wind speed and direction profile:	ZephIR 300 Lidar
Air pressure:	Vaisala PTB330
Air humidity and temperature:	Vaisala HMP155
Water level (Tide):	Thelma Water Level Sensor

Seawatch Wind Lidar buoy – Redundancy & backup

Power

- 4 independent fuel cells and compartments
- 3 different sources (fuel cells, solar panels, lithium batteries)
- 5-9 months autonomy (most recent version is 9 months)

Equipment/Sensors

- 3 different compasses
- 2 Met stations (1 on the LIDAR + 1 in the mast)

Data Collection

- Raw wind data (10 min average + scanning frequency/pattern of Zephir LiDAR (1 Hz)) stored internally in the LiDAR
- Raw current data stored internally in the current meter
- Raw wave data stored internally in the wave sensor
- Raw and processed wind data (10 min average + 1 Hz) stored in the datalogger
- All other data stored in the datalogger
- Raw All 10 min data transmitted to shore, in some cases also 1 Hz data

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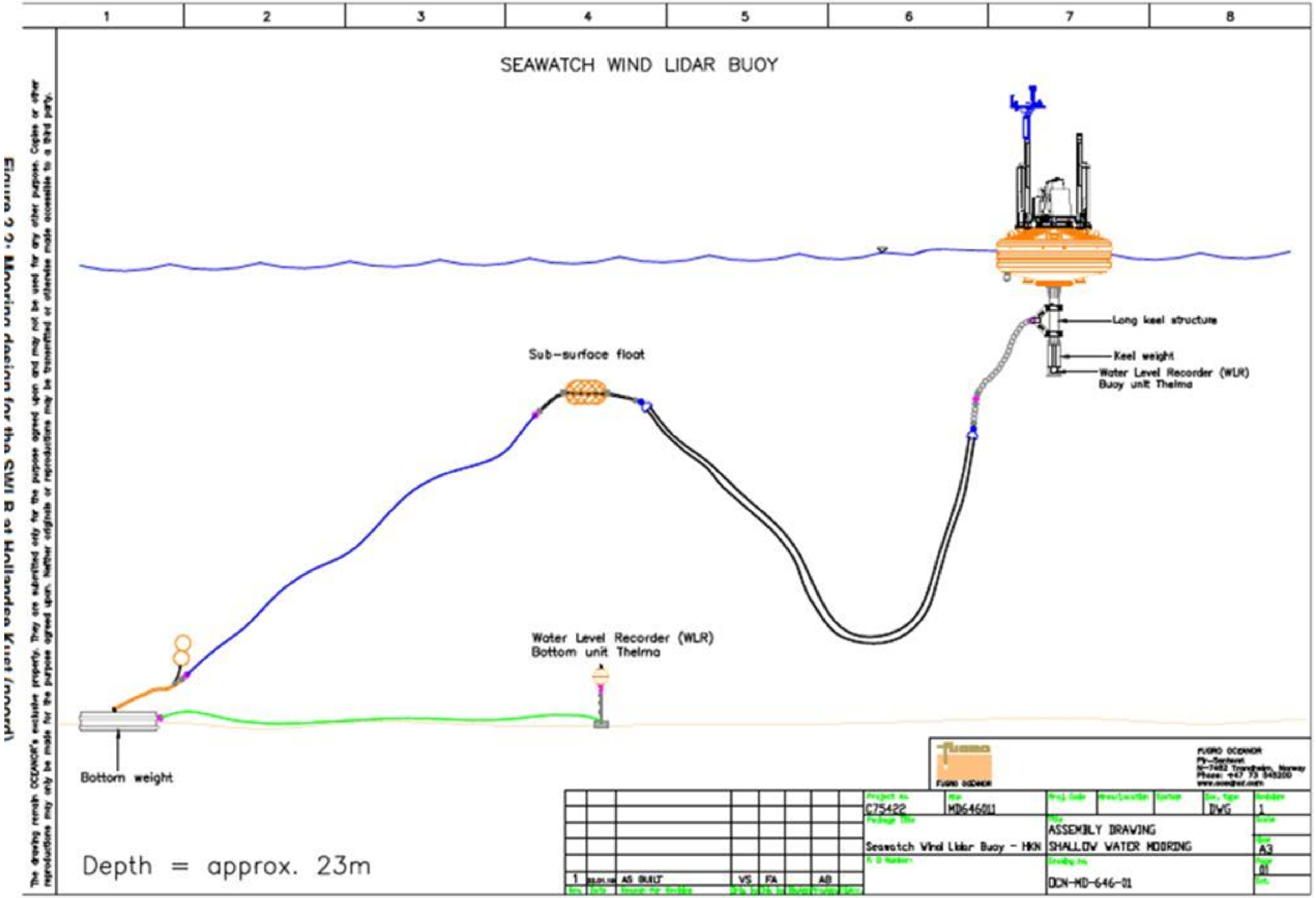
Seawatch Wind Lidar buoy – Mooring



Quality Assurance

Of the system and collected metocean data

Quality Assurance

Measurement System Quality

- Offshore Wind Accelerator (Carbon Trust - OWA) Type Validated Pre-commercial stage system according to OWA roadmap
- Manufacturing according to ISO standard ISO9001 compliance since 1985, ISO9001:2008
- Factory calibrated sensors - LiDAR onshore validated against UK met mast
- Factory Acceptance Test
- OWA Unit Validated Pre-deployment system validation – min 40 measurements in each wind class

Data Validation

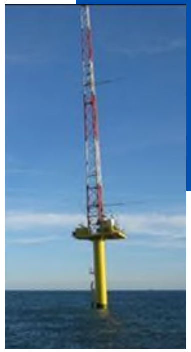
- Comparison with nearby similar measurements (wind and waves) performed by Deltares

Double Measurements

- Comparison between two SWLB as one redundant system

SeaWatch Wind LIDAR Buoy - Validation process

Pre-Commercialisation validation	LIDAR Supplier validation	Project validation	Project validation
OWA Type Validation Approval by DNV GL: (RWE) IJmuiden IEC-compliant met mast comparison 2014 (5.8m Hs 9.8m Hmax)	Pre-supply Approved by DNV GL: Pershore IEC met mast comparison, UK Each unit Completed	OWA Pre-Deployment Approved by DNV GL: Titran, Frøya 2017 Completed	Met, wave and current validations Deltares independent validation reports 2017-2019



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Pre/Post - deployment validation site: Titran, Frøya

Positions of SEAWATCH Wind LIDAR Buoy and Land LIDAR at the Island Frøya

Pre/Post - deployment validation – Titran, Frøya

- Pre- and post validation site approved by DNVGL
- Onshore LIDAR reference at Stabben Fort is established; standard anemometry reference masts (NTNU [Norwegian University of Science & Technology]) available
- More than ten SWLB successfully validated at site since March 2015

Pre-deployment validation location (Seawatch LIDAR wind buoy in background)

Wind Lidar buoys – pre-deployment validation results

Buoy no	Validation period	No of days	Max WS
WS149	11/3 - 25/3/2015	14 days	25.5 - 31.5 m/s
WS156	1/7 - 29/9/2015	90 days	17.5 - 22.4 m/s
WS157	11/12/2015 - 4/1/2016	24 days	27.6 - 32.2 m/s
WS158	5/4 - 3/5/2016	28 days	18.5 - 23.4 m/s
WS170	2/3 – 21/3/2017	19 days	23.3 – 27.48 m/s

Tabulated results of Pre-deployment validations for all buoys deployed in the measurement programme

WIND SPEED ACCURACY

Overview of linear regression analysis results for wind speed comparisons between the SWL Buoy and the reference Lidar for height 100 m

Buoy no	WS149	WS156	WS157	WS158	WS170
Slope (X_{mws})	1.011	1.008	1.014	1.010	1.015
Regr.coeff. (R^2_{mws})	0.994	0.987	0.974	0.985	0.98

Legend	
KPI	failed
KPI	passed minimum
KPI	passed best practice

WIND DIRECTION ACCURACY

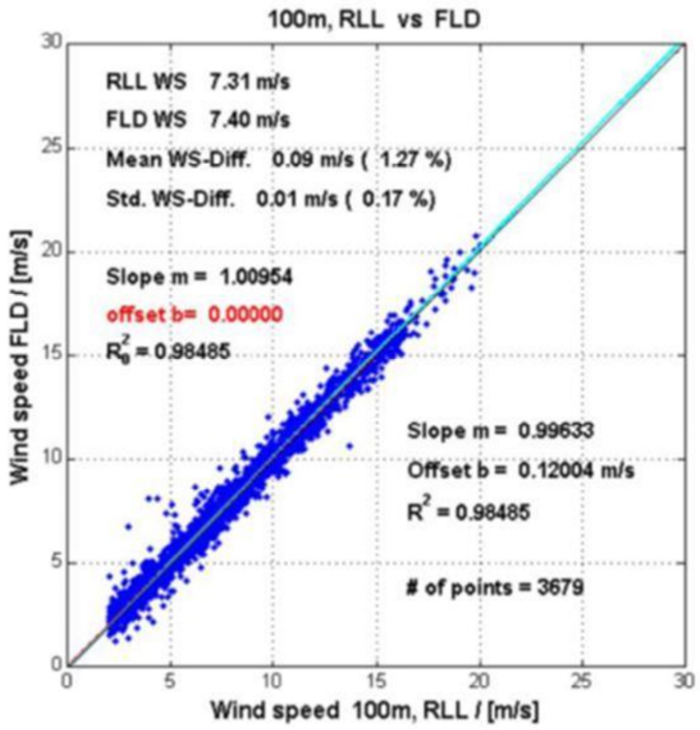
Overview of linear regression analysis results for wind direction comparisons between the SWL Buoy and the reference Lidar for height 100 m

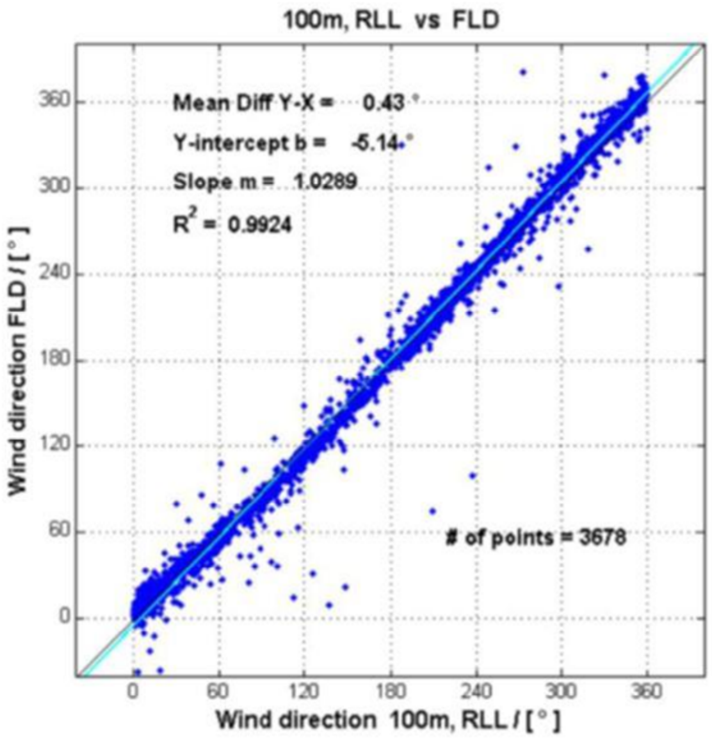
Buoy no	WS149	WS156	WS157	WS158	WS170
Slope (X_{MWd})	0.976	0.958	1.005	1.029	0.994
Regr.coeff. (R^2_{mwd})	0.981	0.987	0.981	0.992	0.993
Mean offset (OFF_{mwd})	-4.93	-6.82	-3.07	0.43	-1.42

Legend	
KPI	failed
KPI	passed minimum
KPI	passed best practice

Wind Lidar buoys – pre-deployment validation results

Mean Offset (OFF_{mwd}) accuracy for wind direction (WD) has been a significantly improved from Borssele & HKZ campaigns. Achieved by using a compass of better quality.





Correlation of LIDAR buoy and Land LIDAR for 100 m height (buoy WS158): Wind Speed (left) and Wind Direction (right)

Data reports

https://offshorewind.rvo.nl/windwaternh

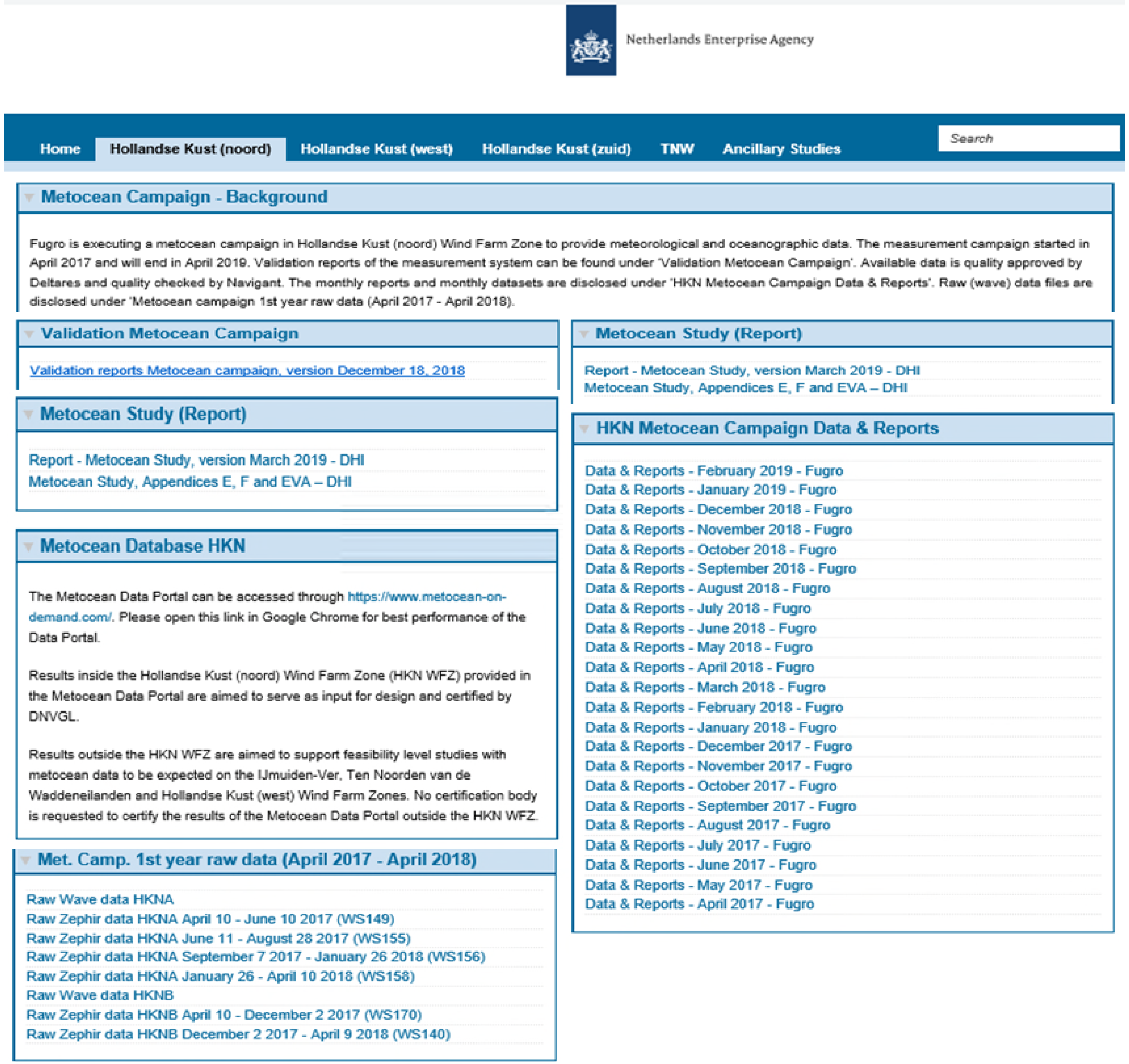
Data Set types

By month, by location

- Deltares validation reports (PDF)
- Data & descriptive reports (PDF)
- Raw data files (Excel)
- RVO Statement of Compliance

Outstanding

- Concatenated report for full measurement campaign
- Final validation reports and acceptance



Netherlands Enterprise Agency

Home | Hollandse Kust (noord) | Hollandse Kust (west) | Hollandse Kust (zuid) | TNW | Ancillary Studies | Search

Metocean Campaign - Background

Fugro is executing a metocean campaign in Hollandse Kust (noord) Wind Farm Zone to provide meteorological and oceanographic data. The measurement campaign started in April 2017 and will end in April 2019. Validation reports of the measurement system can be found under 'Validation Metocean Campaign'. Available data is quality approved by Deltares and quality checked by Navigant. The monthly reports and monthly datasets are disclosed under 'HKN Metocean Campaign Data & Reports'. Raw (wave) data files are disclosed under 'Metocean campaign 1st year raw data (April 2017 - April 2018).

Validation Metocean Campaign

Validation reports Metocean campaign, version December 18, 2018

Metocean Study (Report)

Report - Metocean Study, version March 2019 - DHI
Metocean Study, Appendices E, F and EVA – DHI

Metocean Database HKN

The Metocean Data Portal can be accessed through https://www.metocean-on-demand.com/. Please open this link in Google Chrome for best performance of the Data Portal.

Results inside the Hollandse Kust (noord) Wind Farm Zone (HKN WFZ) provided in the Metocean Data Portal are aimed to serve as input for design and certified by DNVGL.

Results outside the HKN WFZ are aimed to support feasibility level studies with metocean data to be expected on the IJmuiden-Ver, Ten Noorden van de Waddeneilanden and Hollandse Kust (west) Wind Farm Zones. No certification body is requested to certify the results of the Metocean Data Portal outside the HKN WFZ.

Met. Camp. 1st year raw data (April 2017 - April 2018)

Raw Wave data HKNA
Raw Zephir data HKNA April 10 - June 10 2017 (WS149)
Raw Zephir data HKNA June 11 - August 28 2017 (WS155)
Raw Zephir data HKNA September 7 2017 - January 26 2018 (WS156)
Raw Zephir data HKNA January 26 - April 10 2018 (WS158)
Raw Wave data HKNB
Raw Zephir data HKNB April 10 - December 2 2017 (WS170)
Raw Zephir data HKNB December 2 2017 - April 9 2018 (WS140)

Metocean Study (Report)

Report - Metocean Study, version March 2019 - DHI
Metocean Study, Appendices E, F and EVA – DHI

HKN Metocean Campaign Data & Reports

Data & Reports - February 2019 - Fugro
Data & Reports - January 2019 - Fugro
Data & Reports - December 2018 - Fugro
Data & Reports - November 2018 - Fugro
Data & Reports - October 2018 - Fugro
Data & Reports - September 2018 - Fugro
Data & Reports - August 2018 - Fugro
Data & Reports - July 2018 - Fugro
Data & Reports - June 2018 - Fugro
Data & Reports - May 2018 - Fugro
Data & Reports - April 2018 - Fugro
Data & Reports - March 2018 - Fugro
Data & Reports - February 2018 - Fugro
Data & Reports - January 2018 - Fugro
Data & Reports - December 2017 - Fugro
Data & Reports - November 2017 - Fugro
Data & Reports - October 2017 - Fugro
Data & Reports - September 2017 - Fugro
Data & Reports - August 2017 - Fugro
Data & Reports - July 2017 - Fugro
Data & Reports - June 2017 - Fugro
Data & Reports - May 2017 - Fugro
Data & Reports - April 2017 - Fugro

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HKN Measurement Summary

Note: Final report and data submission outstanding:

Preliminary discussion only

HKN Wind Farm Zone

HKN wind farm survey and Northwind wake effects study

- Two stations HKNA and HKNB established and maintained throughout the project 2017-2019
- An operational backup system kept ready on shore
- High availability ensured by swapping the operational backup system with an active offshore station
- The active buoy then serviced on-shore and prepared as operational backup ('leap frogging')

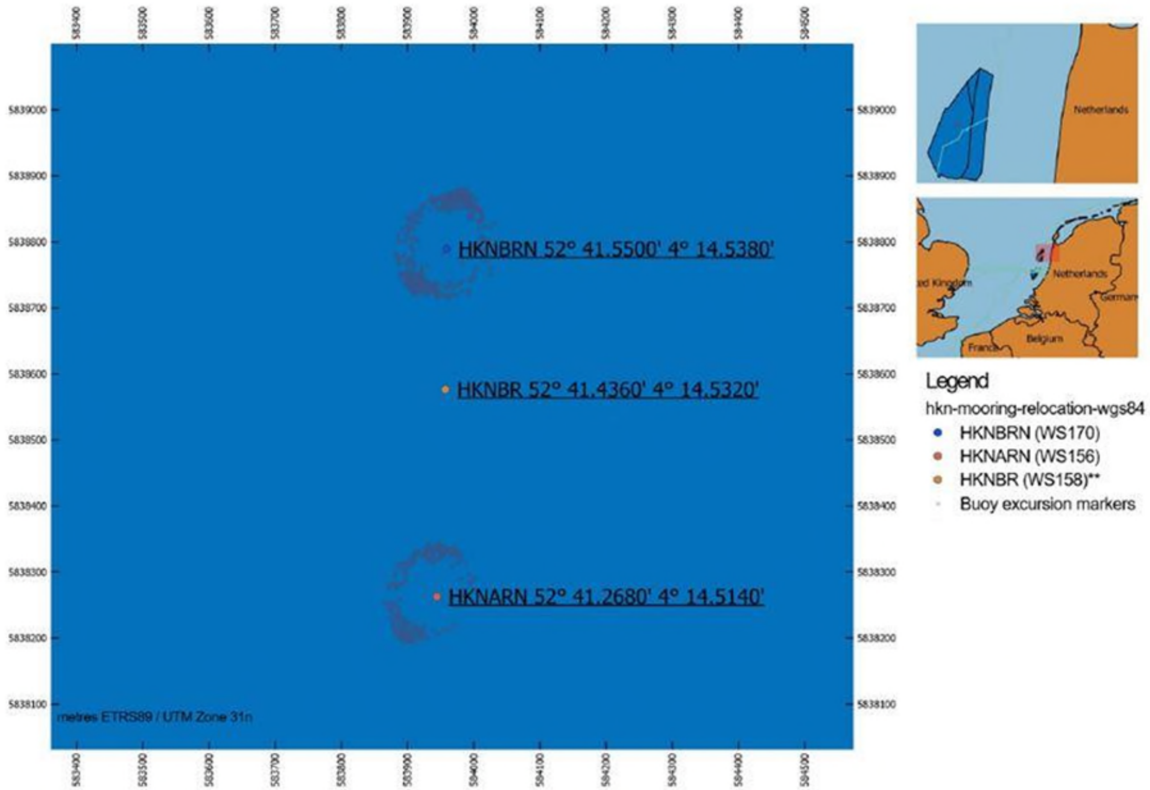
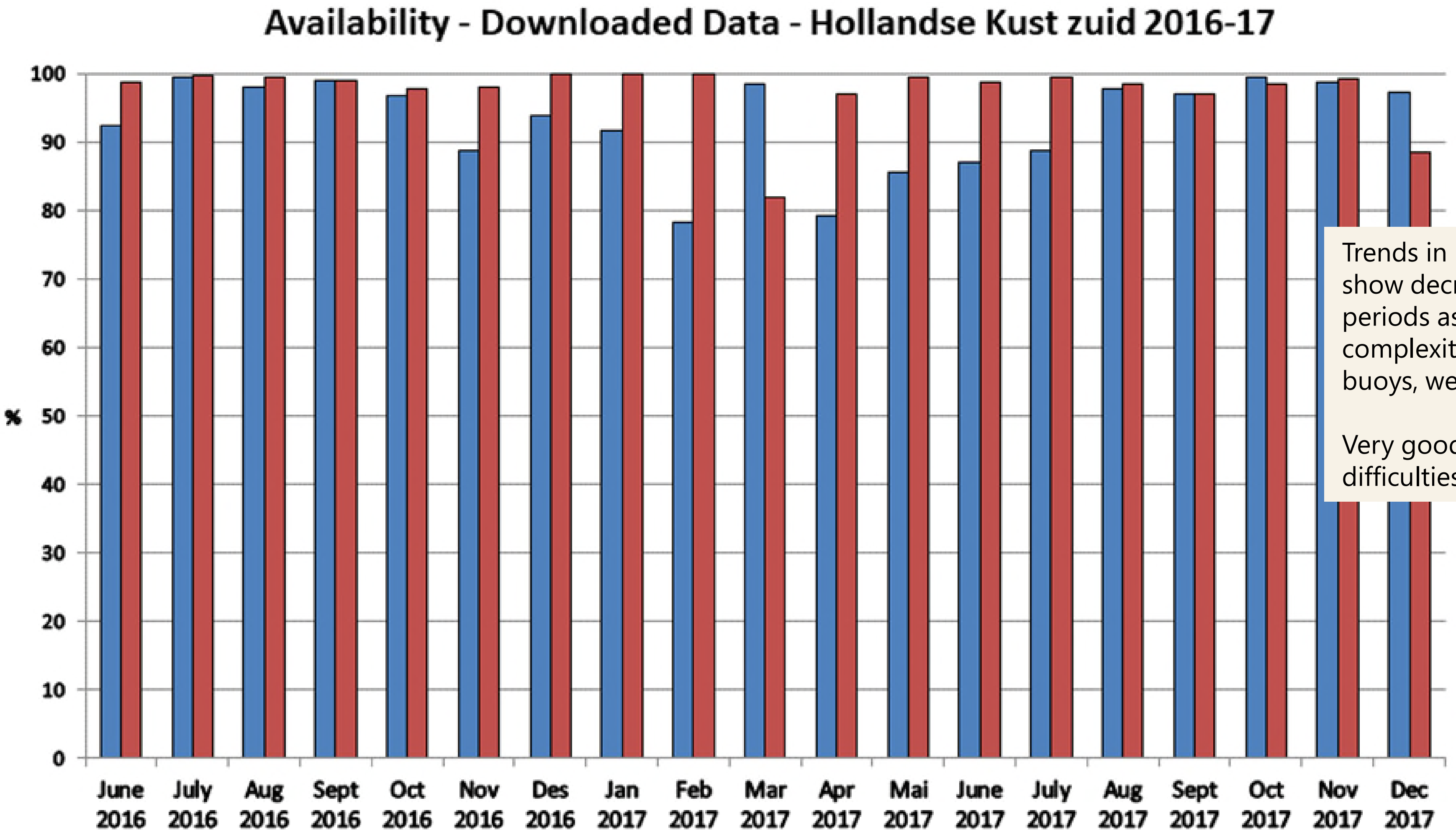


Figure 1.3: Map of the buoy mooring positions January 2019.

HKN Wind Farm Zone – Preliminary Results

Availability – Downloaded Data (wind speed and direction): comparable with HKZ



Trends in Borssele, HKZ and HKN data show decreased data return in winter periods associated with operational complexities (harsh weather, drifting buoys, weather delays in redeployment):

Very good data return in spite of these difficulties

HKN Wind Farm Zone – RVO.nl 2017-2019 Preliminary Results

Environmental conditions experienced at HKN Wind farm

Parameter		Value	Date	(HKZ Comparison)
Highest Significant Wave height	m	7.20	Dec 2017	(6.48)
Max wave height	m	10.8	Dec 2017	(10.6)
Highest 10 min Average Wind speed (30 m)	m/s	24.5	Dec 2017	(28.9)
Highest 10 min Average Wind speed (200 m)	m/s	32.8	Dec 2017	(32.3)

HKN total data maxima not yet collated and presented.
HKZ data shown to illustrate measurement regime capabilities

Operational Experience

Reasons for operations

All deployed buoys had their scheduled service visits for refueling but there were a number of occasions we had to perform some emergency response operations.

Monday the 5th of December 2017 we received a drift alert that on of our buoys was gone adrift. The buoy was recovered and the spare deployed. Original buoy was serviced and made ready for redeployment.

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Operational Challenges

Vessels and their challenges

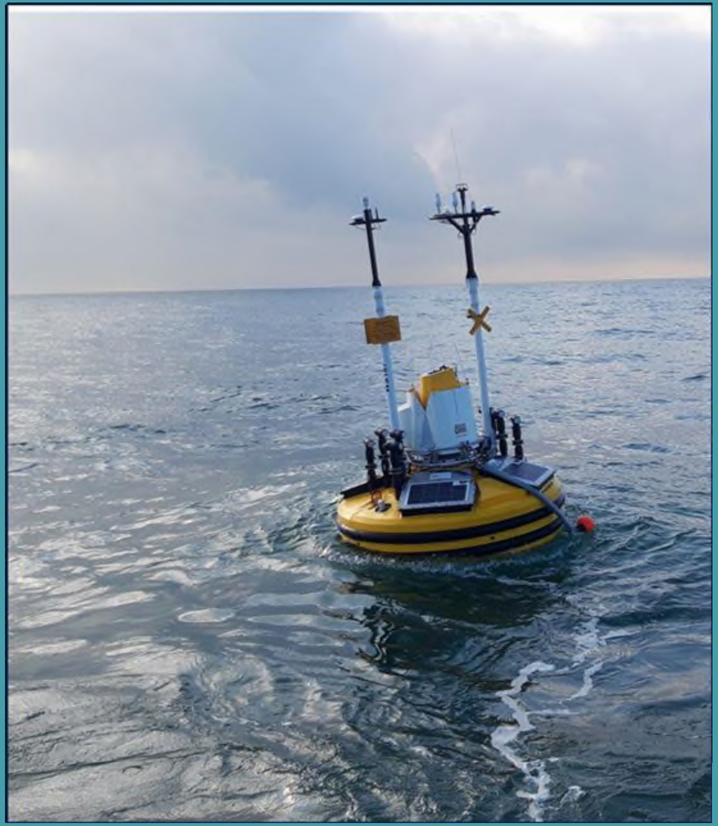
- 16 third party vessel hired
- On average vessels were on hire for 2 days
- Spot market vessel availability is not always guaranteed
- Suitability of vessel equipment was not always guaranteed
- Crew was sometimes unfamiliar with equipment and intended operations

Operational Challenges

Maintenance & emergency response operations

- Weather windows were usually narrow (max. 1m wave and 20 knt windspeed)
- Fast-track mobilisation
- Fast-track familiarisation with Fugro HSSE principles
- Fast-track introduction to project specifics
- Lifting operations and guidelines
- Availability of safety equipment on the vessels

Operational challenges overcome



Results

- 16 successful operational site visits
  - Suitable vessels available
  - Goals achieved
  - Safe operations: No injuries
  - No or only minor damage to equipment

- Numerous improvements on;
  - Crew safety
  - Equipment
  - Procedures
  - Fast-track of third party hire
  - Communication with authorities

Data evaluation - Deltares

HKN evaluation outstanding: Comments based upon HKZ review

HKN – Deltares Field Data Validation

HKNA and HKNB observations validated

Wind, waves, air and water temperature, air pressure, water levels and currents validated with reliable sources in the North Sea (anemometer, LiDAR, hydrodynamic model, etc).

References

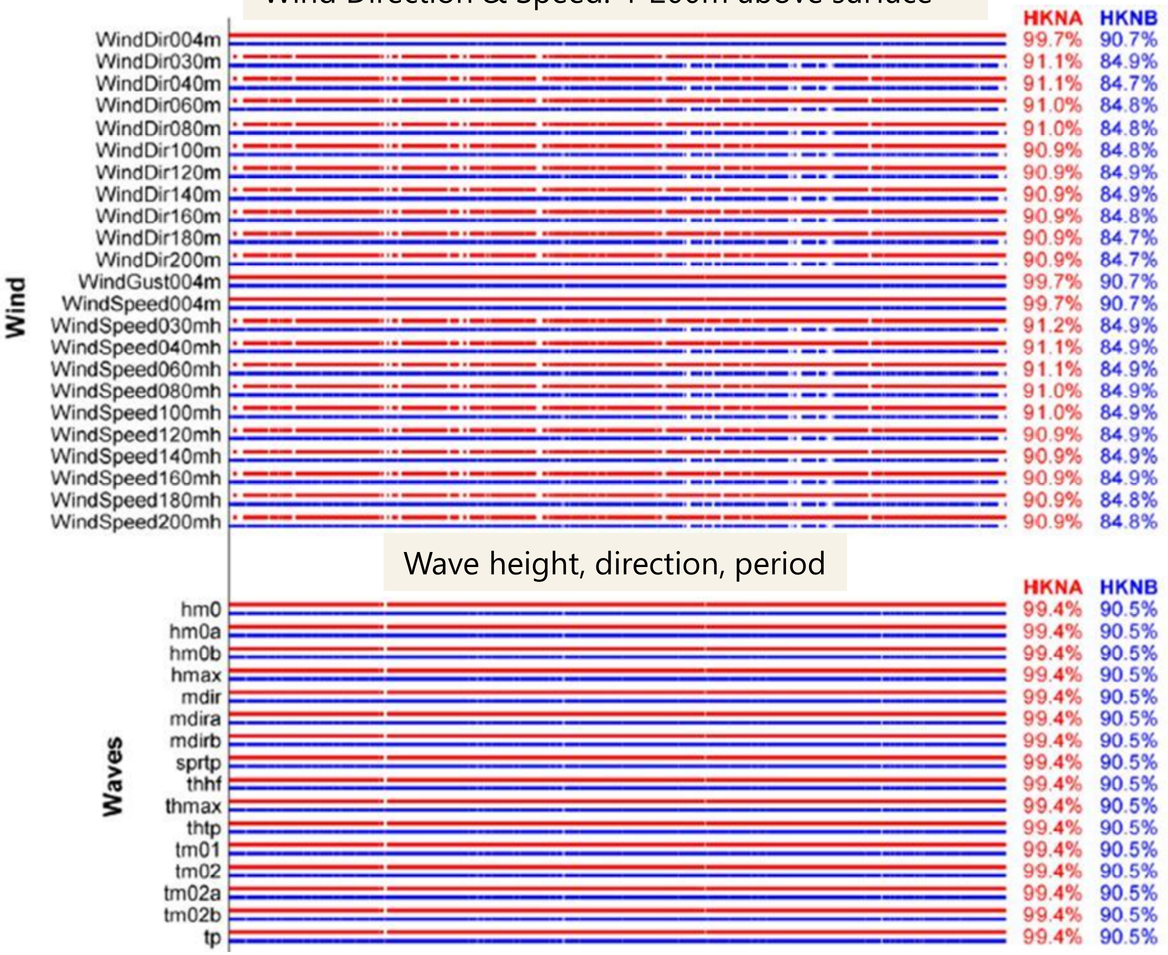
Seawatch LIDAR buoy Intercomparison with LEG, IJmuiden, EPL, K13 and Q11.

Assessed quantitatively

General characteristics — eg: the vertical profiles of the wind and current speeds — are also qualitatively assessed.

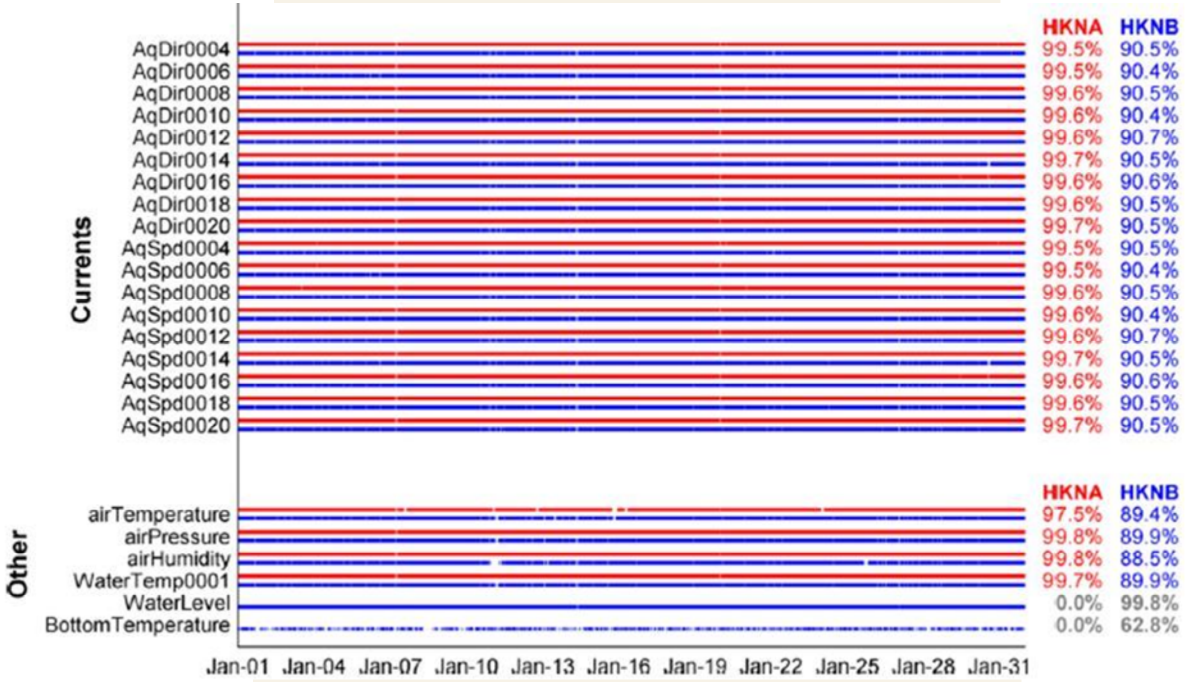
HKN – Field Data Validation - Parameters

Wind Direction & Speed: 4-200m above surface



Wave height, direction, period

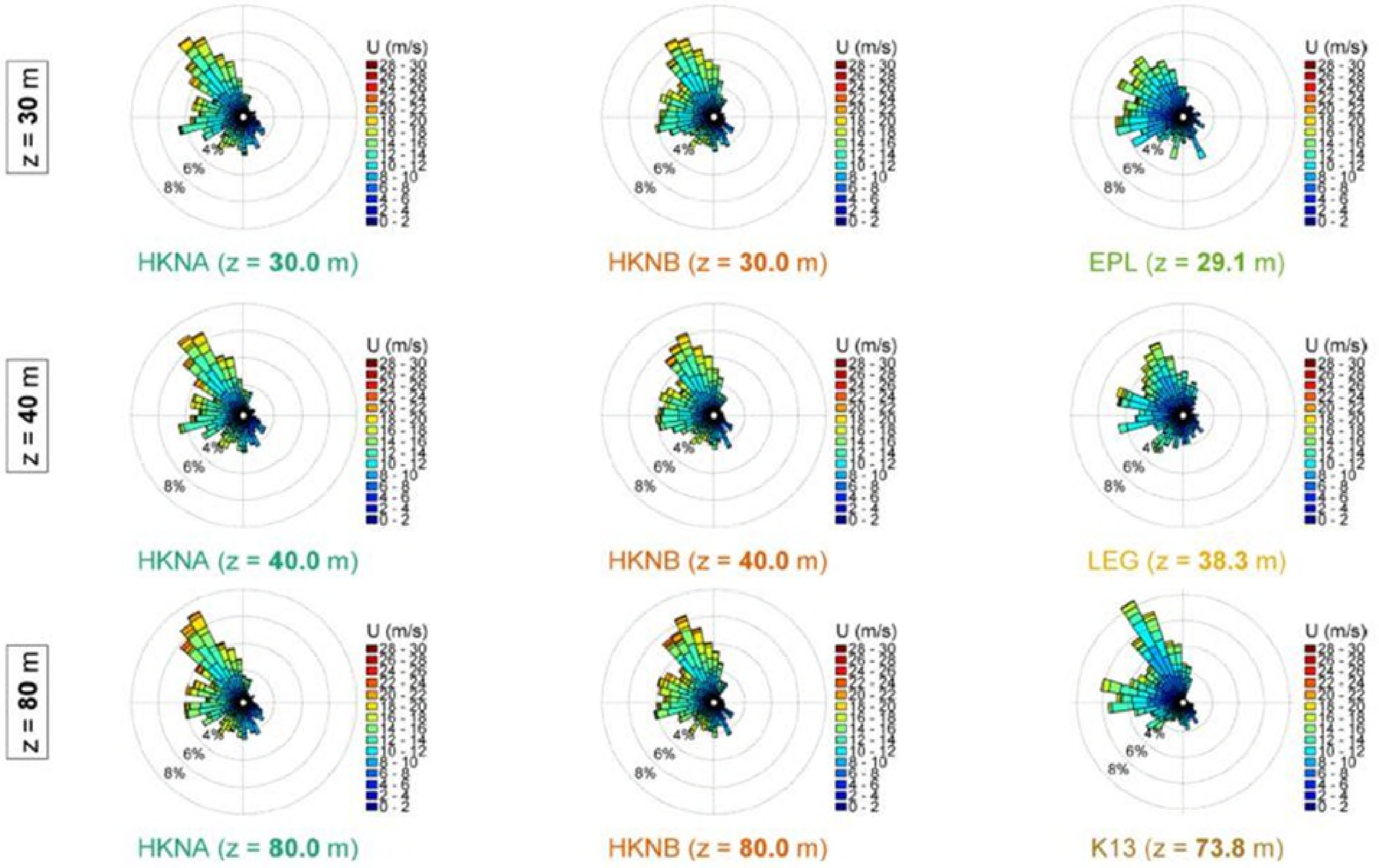
Current speed & direction: 4-20m below surface



Air temp, pressure, humidity; water temp, level; seabed temp

Example parameter list and transmitted availability - January 2019
Credit: Deltares

HKN – Field Data Validation - Wind



HKNA, HKNB Wind Speed & Direction vs reference stations: EPL, LEG, K13.

Shows very strong correlation

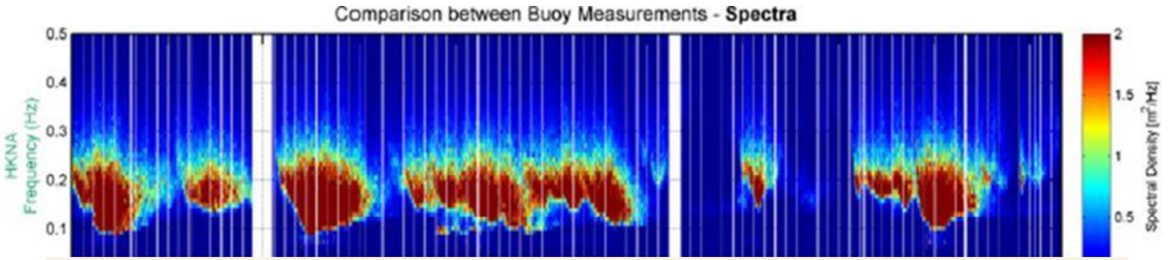
Wind roses January 2019
Credit: Deltares

HKN – SWLB Wind Intercomparison

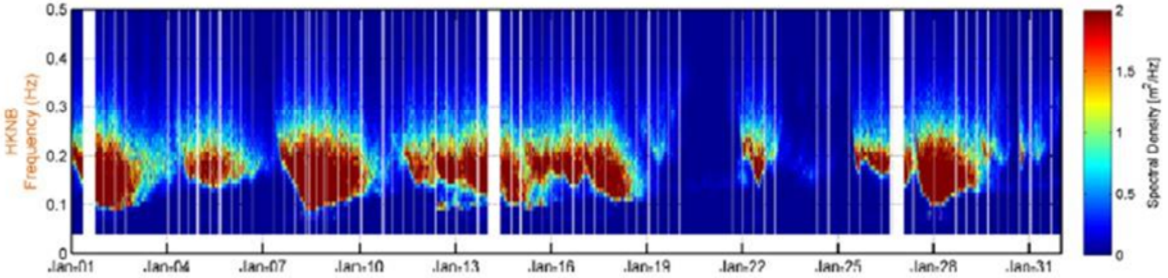
	Wind Speed					Wind Direction			
Elev. (m)	r^2 (-)	r (-)	Bias (m/s)	Sym. Slope (-)	n (-)	r^2 (-)	r (-)	Bias (°N)	n (-)
4	0.98	0.99	0.09	1.01	3944	0.98	0.99	-1.1	3944
30	0.99	0.99	0.04	1.00	3370	0.95	0.97	4.2	3368
40	0.99	1.00	0.04	1.00	3370	0.95	0.97	4.1	3362
60	0.99	1.00	0.03	1.00	3370	0.95	0.97	4.2	3364
80	0.99	1.00	0.02	1.00	3369	0.95	0.97	4.3	3366
100	0.99	1.00	0.04	1.00	3365	0.95	0.97	4.2	3363
120	0.99	1.00	0.04	1.00	3363	0.95	0.97	4.2	3361
140	0.99	1.00	0.03	1.00	3364	0.95	0.97	4.2	3361
160	0.99	1.00	0.03	1.00	3363	0.95	0.97	4.3	3360
180	0.99	1.00	0.03	1.00	3363	0.95	0.97	4.4	3357
200	0.99	1.00	0.05	1.00	3364	0.95	0.97	4.3	3362

Intercomparison HKNA vs HKNB January 2019
Credit: Deltares

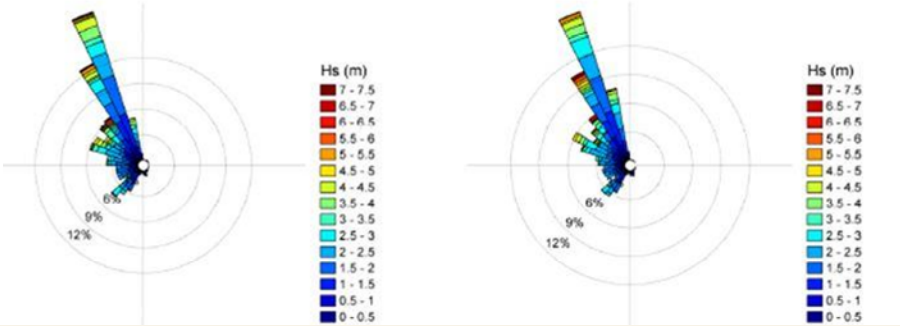
HKN – SWLB Wave Intercomparison



HKNA vs HKNB Wave frequency, spectral density: very strong correlation



Transmitted Wave Spectra January 2019
Credit: Deltares



HKNA vs HKNB Wave Height & Direction: very strong correlation

HKNA HKNB

Parameter	Unit	r^2 (-)	r (-)	Bias (unit)	Symmetrical Slope (-)	n (-)
hm0	m	0.99	0.99	0.01	1.00	4017
tp	s	0.69	0.83	-0.01	1.00	4017
mdir	°N	0.95	0.98	1.89	1.00	4017
hm0a	m	0.98	0.99	0.01	1.01	4017
hm0b	m	0.98	0.99	0.00	1.00	4017
hmax	m	0.92	0.96	-0.01	0.99	4017
mdira	°N	0.16	0.41	1.92	1.00	4017
mdirb	°N	0.95	0.98	1.62	1.00	4017
tm01	s	0.98	0.99	-0.01	1.00	4017
tm02	s	0.98	0.99	-0.01	1.00	4017
tm02a	s	0.78	0.89	-0.02	1.00	4017
tm02b	s	0.97	0.99	-0.01	1.00	4017

HKN –DCSMv6 Currents and tides validation

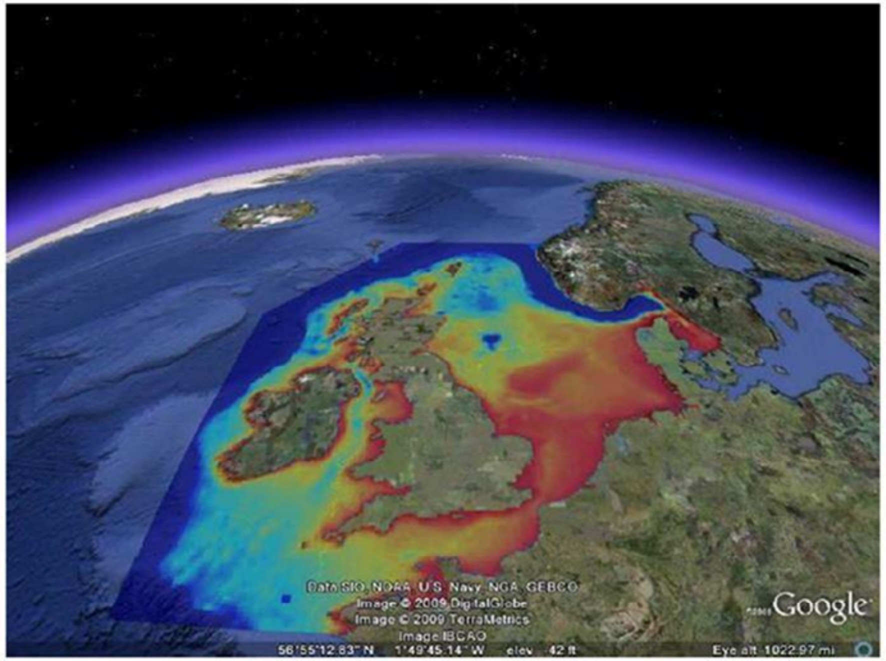
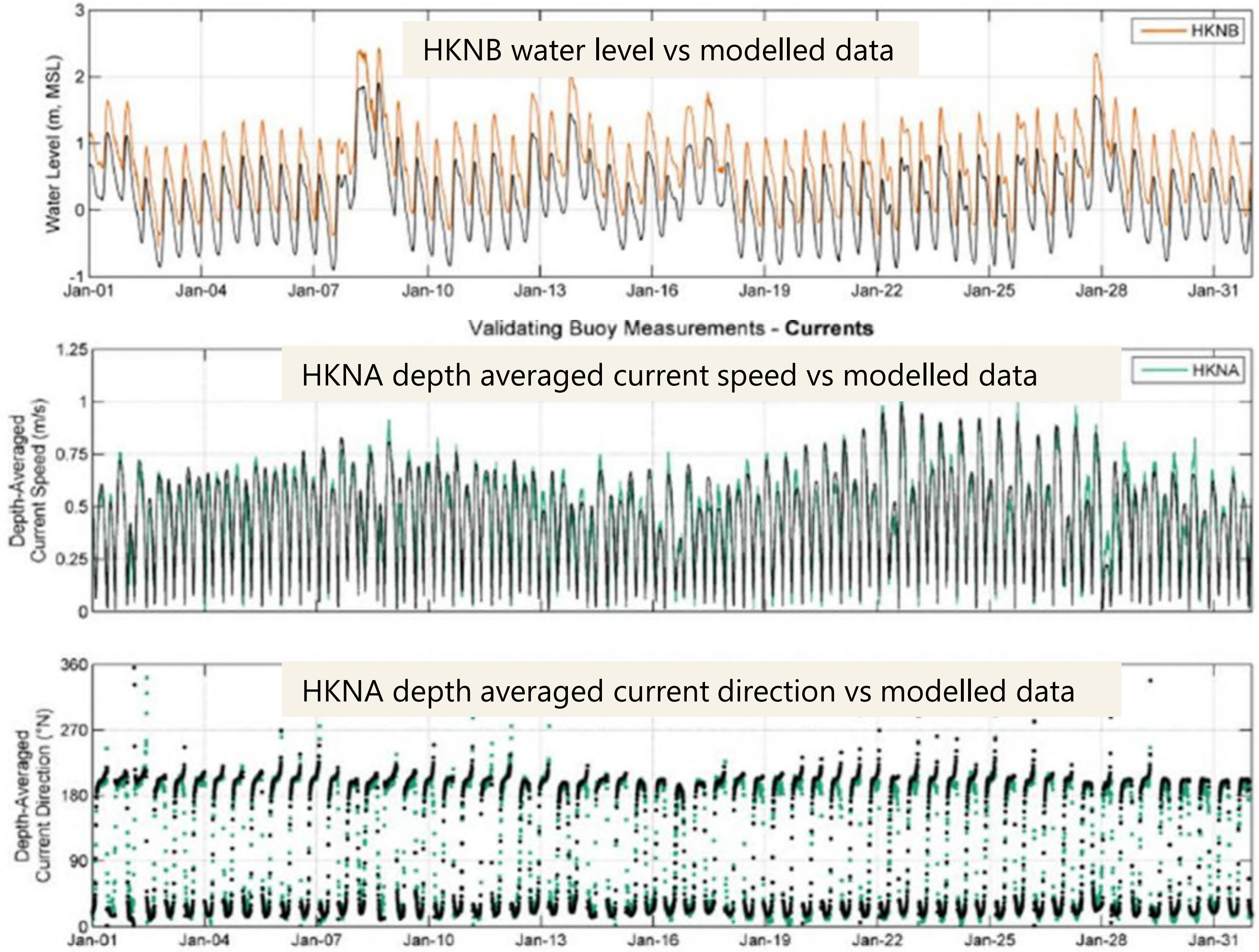


Figure 7.2: DCSMv6-ZUNOv4 model bathymetry (via Google Earth).



Credit: Deltares

Closing Remarks

HKN Deltares Validation Assessment

The overall conclusion of the validation is that the quality of the HKNA and HKNB data is high and the dataset trustworthy.

This makes the dataset, which is rather comprehensive, including vertical wind and current profiles and directional wave spectra, relatively useful and of interest for site study analyses.

For instance, for wind assessment studies, morphodynamics and metocean desk studies and in particular for the Hollandse Kust (noord) Wind Farm Zone.

HKZ Measurements (Deltares)

Not yet performaned for HKN Wind farm – pending final data submission

Summary:

- The agreement between the LiDAR buoys and the wind and wave observations from fixed platforms is relatively high, especially when considering the closest locations, LEG, EPL and IJmuiden.
- Comparisons between the HKZA and HKZB LiDAR wind velocities at all levels show low bias, good wind speed correlations and slopes close to 1
- wind direction correlations also close to 1 at the lower levels, but slightly lower at higher levels.
- The validation of the temperature, air pressure, water level and current data also show an excellent agreement between the HKZ observations and other observations,
- in the case of currents and water levels also excellent agreement with model results.

The overall conclusion of the validation is that the quality of the HKZA and HKZB data is high and the dataset trustworthy.

High confidence for the same conclusions for HKN Wind farm

FUGRO

Thank you for your time

Fugro Team

Webinar RVO
May 2019

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