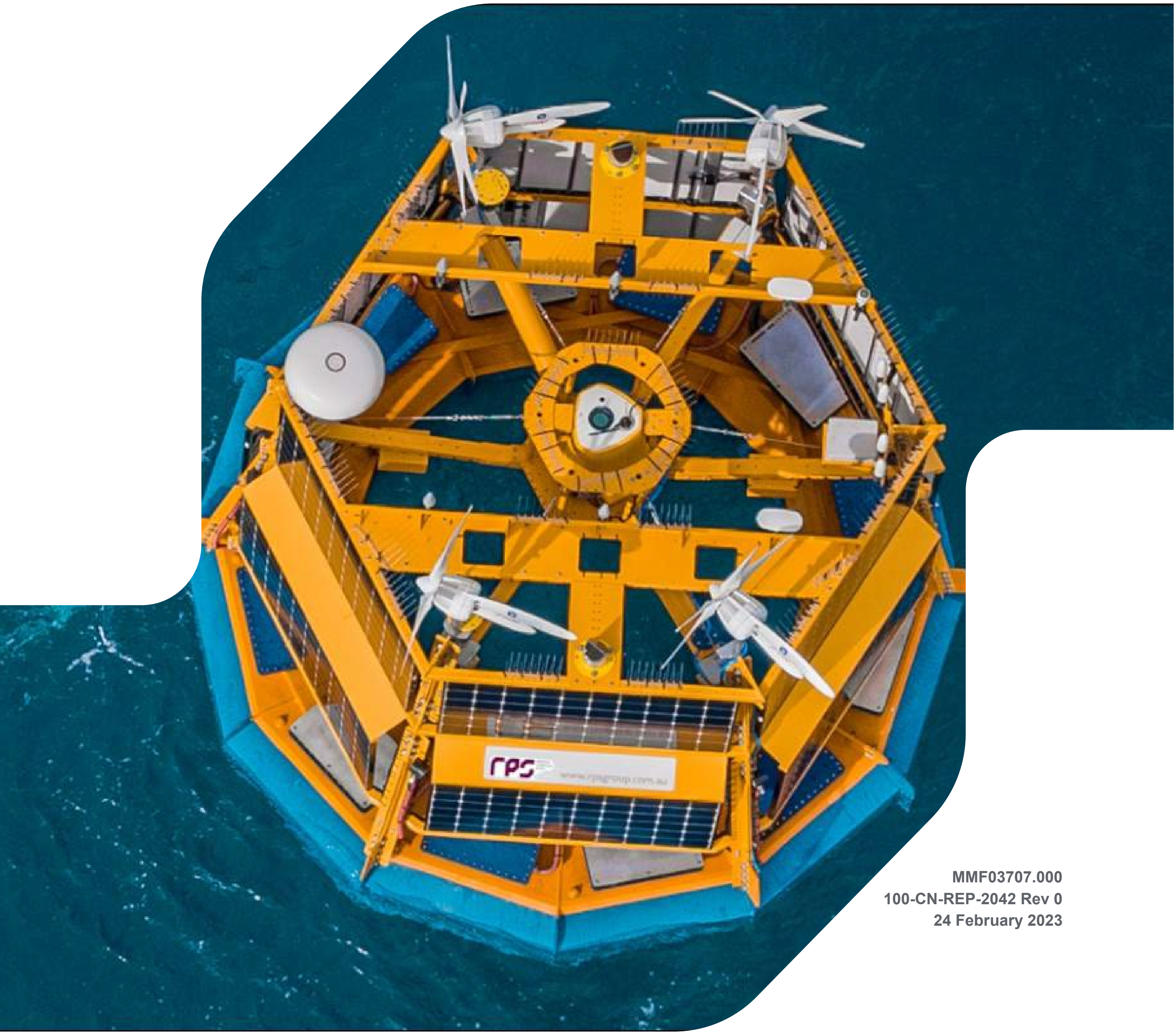
TN328326 SUPPLY OF METOCEAN DATA FOR NEDERWIEK WIND FARM ZONE

Monthly Measurement and Validation Report - December 2022



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Dear Behzad,

TN328326 Supply of Metocean Data for Nederwiek Wind Farm Zone – Monthly Measurement and Validation Report - December 2022

Herewith our report 100-CN-REP-2042 Revision 0, titled "TN328326 Supply of Metocean Data for Nederwiek Wind Farm Zone – Monthly Measurement and Validation Report – December 2022".

This report consists of 1 month of data from the ongoing 2-year measurement programme commencing on 1st June 2022. Observations of wind, wave, current, water-level, atmospheric pressure, and air temperature were made in connection with the development of offshore wind farms in the Netherlands. Validation of these measurements against independent observations at near-by sites are included in this report.

Should you have any queries regarding this report, or require further information, please advise.

Yours sincerely,
for RPS Australia West Pty Ltd

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EXECUTIVE SUMMARY

The Netherlands Enterprise Agency (RVO) has commissioned RPS to measure, validate and provide key meteorological and oceanographic (metocean) parameters in the Nederwiek Wind Farm Zone (NW WFZ) in the North Sea some 100 km west of Den Helder, the Netherlands. This report presents the data collected for the month of December 2022 by two RPS LiDAR Buoys deployed 1 km apart at the NW site.

System availability for NW B buoy was between 95 and 100% for all measured parameters and post processed data availability was similar with only minor data loss.

On the 13th of December, NW A buoy (serial number 107) drifted due to third party interference and was not able to be replaced during the remainder of December due to weather conditions that made the work unsafe. This has resulted in only the first ~13 days of data for NW A being available, resulting in system availability of only ~39%. The coastguard was notified by a fishing vessel that the buoy was drifting (and therefore a navigation hazard) following an incident the fishing vessel had with the mooring. The coastguard informed RPS of the incident and collected the buoy.

The NW B buoy (serial number 101) had been shown to have both wind generators failed whilst one is required for power budget in the winter, so this buoy was recovered and replaced with Lidar Buoy 106 on 11th December with no data gap resulting.

Where available, the data from the two buoys has been validated against each other using correlation plots that demonstrate excellent agreement. The efficacy of the data is further confirmed by validation against independent data sources, which eliminates the possibility of measurement errors common to the two buoys. The data below summarises the post processed data availability.

	NW A	Comment	NW B	Comment
Air Temperature	39.7		98.7	
Barometric Pressure	39.7	#1	98.7	#1
Current Profile	39.7		99.9	
Tides	36.5	#2	88.4	#2
Water Temperature	39.7		100	
Waves	39.8		100	
Wind Profile LiDAR	39.6	#3	98.3	#3

Notes:

#1 The BP loggers both experienced unreliable fluctuations and were flagged during QC.

#2 The GNSS tide gauge did not always return realistic values due to interference caused by the lengthy Rudics transmission message.

#3 The LiDAR occasionally fails to collect valid data due to rain or fog.

All other data losses were due to small transmission losses or quality control.

Contents

Tables

Figures

Appendices

Glossary

For ease of interpretation of the metocean parameters presented in the tables and/or discussed within the report or contained within the data files, a list of their symbols, parameter names and brief definitions are as follows:

Wind and Meteorological Parameters

Symbol	Name/Variable	Definition	Units
AT	AirTemp	Air Temperature	°C
BP	BP	Barometric Pressure	hPa
WS_g	GustSpd	3-second gust speed	m s^{-1}
Z	Height	measurement height above sea-level	m
ϕ	InflowAngle	Inflow Angle	° (from horizontal)
TI	TurbulenceIntensity	Turbulence Intensity	Dimensionless
α	WindShear	Wind Shear Exponent	Dimensionless
WS_Z	WindSpd	10-minute mean wind speed at a height *Z* m above sea-level	m s^{-1}
WS_H	WindSpd	horizontal component of wind speed	m s^{-1}
θ_Z	WindDirn	10-minute mean wind direction at a height Z m ASL	° True (from)
β	WindVeer	Wind veer between two heights above sea-level	° m^{-1}
WS_V	WindVertComp	vertical component of wind speed	m s^{-1}

Wave Parameters (Also refer to Appendix E for additional wave glossary and definitions)

Symbol	Name/Variable	Definition	Units
H_s	Hs	total significant wave height	m
H_{sSea}	HsSea	sea proportion of significant wave height	m
H_{sSwell}	HsSwell	swell proportion of significant wave height	m
T_p	Tp	spectral peak wave period	s
T_{pSea}	TpSea	sea proportion of spectral peak wave period	s
T_{pSwell}	TpSwell	swell proportion of spectral peak wave period	s
T_m	Tm	spectral mean wave period	s
T_{mSea}	TmSea	sea proportion of spectral mean wave period	s
T_{mSwell}	TmSwell	swell proportion of spectral mean wave period	s
T_{ss}	SeaSwellSep	sea-swell separation period	s
T_z	Tz	spectral average zero-crossing wave period	s
T_{zSea}	TzSea	sea proportion of spectral average zero-crossing wave period	s
T_{zSwell}	TzSwell	swell proportion of spectral average zero-crossing wave period	s
H_{max}	Hmax	maximum single wave height	m
T_{Hmax}	THmax	period of the maximum single wave	s
θ_p	ThetaP	spectral peak wave direction (from)	° (from)
θ_{pSea}	ThetaPSea	sea proportion of spectral peak wave direction (from)	° (from)
θ_{pSwell}	ThetaPSwell	swell proportion of spectral peak wave direction (from)	° (from)
θ_M	ThetaM	spectral mean wave direction (from)	° (from)

θ_{MSea}	ThetaMSea	sea proportion of spectral mean wave direction (from)	° (from)
θ_{MSwell}	ThetaMSwell	swell proportion of spectral mean wave direction (from)	° (from)
$\Delta\theta_p$	SpreadP	spread (standard deviation of peak wave direction)	°
$\Delta\theta_{pSea}$	SpreadPSea	spread of sea proportion (standard deviation of peak wave direction)	°
$\Delta\theta_{pSwell}$	SpreadPSwell	spread of swell proportion (standard deviation of peak wave direction)	°
$\Delta\theta_M$	SpreadM	spread (standard deviation of mean wave direction)	°
$\Delta\theta_{MSea}$	SpreadP	spread of sea proportion (standard deviation of mean wave direction)	°
$\Delta\theta_{MSwell}$	SpreadP	spread of swell proportion (standard deviation of mean wave direction)	°

Current Parameters

Symbol	Name/Variable	Definition	Units
-	CurSpd	Current Speed	m s^{-1}
-	CurDirn	Current Direction	° True (towards)
-	CurVertComp	vertical component of current speed	m s^{-1}
-	WaterTemp	Water temperature	°C

Tidal Parameters

Symbol	Name/Variable	Definition	Units
-	TideHeight	water-level above a specified datum	m
-	HAT	Highest Astronomical Tide	
-	LAT	Lowest Astronomical Tide	
-	MSL	Mean Sea Level	
-	MHWS	Mean High Water Spring	
-	MLWS	Mean Low Water Spring	
-	MHWN	Mean High Water Neap	
-	MLWN	Mean Low Water Neap	

Units

Symbol	Definition
°	degrees (0-359°)
°C	degrees celsius
° m^{-1}	degrees per metre
hPa	hectopascals (units of barometric pressure)
Hz	Hertz
m	metres
m s^{-1}	metres per second (Note: 1 m s^{-1} ~ 1.95 knots)
s	seconds

Abbreviations

The following abbreviations (in addition to those presented in the definitions above) may be used in this report:

ADCP	Acoustic Doppler Current Profiler
AMSL	Above Mean Sea Level (metres)
ASB	Above Seabed (metres)
ASL	Above Sea Level (metres)
BMSL	Below Mean Sea Level (metres)
CT&DO	Conductivity, Temperature and Dissolved Oxygen
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IA	Investigation Area
ID#	Unique identifier of netCDF files using deployment location and sequence.
IJV	IJmuiden Ver
ISO	International Organization for Standardization
MC	Measurement Campaign
Metocean	Meteorological and Oceanographic
MSL	Mean Sea Level (metres)
N	North (direction octant, others are NE, E, SE, S, SW, W and NW), referenced to True North
NM	Nautical Miles (1 NM ≈ 1.85 km)
NOAA	National Oceanic and Atmospheric Administration
NW	Nederwiek
NW WFZ	Nederwiek Wind Farm Zone
QC	Quality Control
RPS	RPS Australia West Pty Ltd
RVO	Client – Netherlands Enterprise Agency
TWC	Through Water Column
UTC	Universal Time Coordinated (UTC +0 hours for this report unless stated otherwise)
UXO	Unexploded Ordnance
WFZ	Wind Farm Zone
WGS84	World Geodetic System (revised in 1984)
WW3	WAVEWATCH-III wave model

1 INTRODUCTION

1.1 Project Description

The Netherlands Enterprise Agency (RVO) has commissioned RPS to measure, validate and provide key meteorological and oceanographic (metocean) parameters in the Nederwiek Wind Farm Zone (NW WFZ) in the North Sea some 100 km west of Den Helder, the Netherlands. This is a component of their offshore wind energy 2030 climate target to contribute 55 TWh/a of electricity from offshore wind power into the national grid. There are currently three sites within the NW WFZ under development. Figure 1.1 illustrates the Dutch Offshore Wind Energy Roadmap zones within the North Sea.

The field area is in ~30 m water depth within the Nederwiek Wind Farm Zone and is referred to as:

- Nederwiek (two sites, NW A and NW B): Measurements began on approximately 1st June 2022, and here December 2022 data are reported.

During the planned 24-month programme, metocean data will be obtained from these fields using instruments fixed on floating systems. Measurement parameters include wind, wave, current, water-level, atmospheric pressure, and air temperature.

Meteorological data obtained through the measurements within the NW WFZ are intended for use in wind resource assessments; while oceanographic measurements are intended for validation and calibration of the numerical metocean modelling studies performed by third parties. For this purpose, it is of particular importance that measurements capture the full spectrum from mild ambient conditions to severe episodic events, to facilitate reduced uncertainty - which is critical for design.

Additionally, metocean data will be used as reference for operations at sea during the various Netherlands Enterprise Agency (RVO) survey campaigns. For this purpose, it is a necessary requirement that data are available in (near) real-time through a web portal.

The site consists of two adjacent U-shaped mooring and buoy systems, the buoy being a RPS LiDAR 4.5 Buoy.

Figure 1.2 illustrates the location of both NW A and NW B within the metocean campaign investigation area.

1.2 Report Objective

This report covers the monthly measurements and validation of the metocean data for December 2022 from sites NW A and NW B.

1.3 Project Duration

The measurement program is planned for a period of 24 months from June 2022 with provision to extend to 36-months. Full data delivery and reporting is scheduled at 12-month intervals.

1.4 Related Reports

- “MRU 5 AND MOSE G-1000 WAVE COMPARISON New York RPS 4.5 Lidar Buoy and Wave-Met Buoy” – 100-CN-REP-1853 Rev A.
- “Validation of Floating LiDAR Measurements from RPS Buoy FLB-106” – C841/21/02.
- “Validation of Floating LiDAR Measurements from RPS Buoy FLB-101” – C841/18/01.
- “Validation of Floating LiDAR Measurements from RPS Buoy FLB-107” – C841/22/01.
- “Independent analysis and reporting of ZX Lidars performance verification executed by ZX Lidars at the UK Remote Sensing Test Site” – 10332408-R-29-A; 10332408-R-1-A; 10332408-R-46-A.
- “Classification of ZephIR 300 Lidar at the UK Remote Sensor Test Site” – ZephIR LiDARs, Nov 2014.

2 METHOD

2.1 Instrumentation

Each site consists of two RPS LiDAR 4.5 Buoys, positioned 1 km apart secured with U-shaped moorings. Each Buoy had the following sensors installed:

- 1 x ZX 300M LiDAR (wind profiles, turbulence intensity, barometric pressure and air temperature).
- 1 x Kongsberg MRU-5 Reference unit (directional waves and buoy motion).
- 1 x Wind Observer anemometer (fixed height near-surface wind speed and direction).
- 2 x GNSS Compass (buoy heading, GPS location, GPS clock).
- 1 x RPS Tide sensor (water level).
- 1 x Aanderaa Seaguard WLR 7 (water level).
- 1 x Signature 500 ADCP (through water column currents and water temperature).
- 1 x Teledyne RDI 600 kHz Workhorse ADCP (through water column currents and water temperature).

Additional sensors have been installed for redundancy which log data internally rather than transmit in real-time. These instruments will only be reported if needed following recovery of instrumentation.

2.2 Measurement Locations

The two measurement locations, NW A and NW B, were positioned 1000 m apart, approximately 60 NM to the northwest of Den Helder (see Figure 1.3). To allow the spare buoy to be deployed before recovering the existing buoy, both measurement locations consist of 2 sites 1000 m apart which are named NW A1 and A2, and NW B1 and B2.

Error! Reference source not found. documents the location of the LiDAR buoys along with deployment dates, instrument serial numbers, sensor heights and water depth.

2.2.1 Horizontal Positioning

The horizontal locations of the main anchors of the moorings were determined using the Global Positioning System (GPS), WGS84 Datum. The vessel GPS was used to position the vessel, and the positions recorded were verified by RPS using the handheld GPS on vessel stern. The coordinates of the two moorings are listed below.

Site	Latitude (N) (Main Anchor)	Longitude (E) (Main Anchor)	Nominal Water Depth (m LAT)	Comment
NW A 2	53° 23' 17" N	3° 07' 51" E	29.1	1-13 December 2022
NW B 1	53° 22' 45" N	3° 06' 57" E	29.6	1-11 December 2022
NW B 2	53° 23' 16" N	3° 06' 58" E	29.1	12-31 December 2022

The ADCP and Wave netCDF data files contain variables Latitude and Longitude (single value) of the anchor location as determined at the time of deployment, while the Wind and Tide netCDF data files contain the same information (variables RefLatitude and RefLongitude), as well as time varying GNSS Latitude and Longitude as the buoy moves on its mooring line about the anchor point.

2.2.2 Vertical Positioning

The RPS LiDAR 4.5 Buoy follows the ocean surface to position sensors at:

- ZX 300M LiDAR sensor at 3.3 m ASL.
- Anemometers at 3.7 m ASL.
- Air Temperature and Barometric Pressure at 3.6 m ASL.
- RPS Tide Sensor at 3.6m ASL.
- MRU at 0.0 m ASL.
- WLR 7 at 0.45 m ASB.
- Signature 500 ADCP at 1.8 m BSL.

- Workhorse ADCP at 3 m ASB

Instrument heights are presented in Table 2.1 and Table 2.2.

2.3 Field Visits

Field visits are scheduled for deployment, recovery, and servicing as required. Details of field visits to date are tabulated below. Further information can be found in the field logs in Appendix A.

Dates	Purpose
22 May - 3 June 2022	Deployment Trip – Site Visit #1 • Setup and deployment of NW A and NW B LiDAR Buoys. • NW A (Buoy 106 deployed 23/05/2022 05:55 UTC, ID# J3707:03:NW:A:01) and NW B (Buoy 101 deployed 02/06/2022 14:55 UTC, ID# J3707:04:NW:B:01).
2-4 November 2022	Buoy 106 drifted off NW A location late on the 2nd and was intercepted on the 4th November and towed ashore. Buoy 106 ID# J3707:03:NW:A:01.
28-30 November 2022	Deployment Trip – Site Visit #2 to replace drifted buoy. • Deployment of NW A LiDAR Buoy and recovery of the previous mooring including Workhorse ADCP and WLR 7 Tide gauge. • NW A (Buoy 107 deployed 29/11/2022 09:30 UTC, ID# J3707:06:NW:A:02).
10-12 December 2022	Deployment Trip – Site Visit #3 to replace buoy 101. • Deployment of NW B LiDAR Buoy and recovery of NW B LiDAR Buoy 101 due to failed wind generators. • NW B (Buoy 106 deployed 11/12/2022 10:00 UTC, ID# J3707:10:NW:B:02).
13-14 December 2022	Buoy 107 drifted off NW A location late on the 13th and was intercepted on the 14th December and brought ashore. Buoy 107 ID# J3707:06:NW:A:02.

2.4 Mooring Design

Two moorings were deployed at NW, with a fully equipped third mooring remaining onshore if a replacement is required. The mooring configurations are discussed below with schematics available in Appendix B. RPS performs site specific dynamic mooring performance calculations for expected extreme conditions to ensure survival of the buoy-mooring system. Further checks are made that the mooring does not impact any measurements by confirming the buoy follows the sea surface for wave measurements and no mean tilt is introduced on the buoy. Mooring design is reported separately.

2.4.1 NW A

The RPS LiDAR 4.5 Buoy is anchored with a U-shaped mooring design where the retrieval end is subsurface with acoustic releases for recovery. The nominal water depth at NW A is 29.1 m LAT.

2.4.2 NW B

The NW B mooring is identical to NW A and located 1000 m to the west. The nominal water depth at NW B is 29.6 m LAT.

2.5 Data Transmission

Data are retrieved from the measurement program in the following ways:

- Satellite Iridium Rudics messages sent every 30 minutes which include 3 x 10-minute values for all parameters (except waves, which is sampling every 30 minutes). The transmission includes all parameters except for currents where 5 levels are selected (Bins 7, 11, 15, 19 and 23 at respective depths of 9.3, 13.3, 17.3, 21.3, and 25.3 m BMSL), limited due to available band width and longer messages becoming less reliable. These data are used for:
    – real-time web display and data checking.

  - generation of monthly reports.

- 4G mobile network connection is used to download raw data files daily, which occasionally fails so is manually filled in as required at the end of each month. These data are provided monthly and used for the annual report.
- Satellite Iridium Pilot as an emergency back up or intervention due to the cost of data transmission.
- Direct recovery by physically visiting the buoy (Wi-Fi or manual download).

Resolution and range of transmitted data are presented in Table 2.3. Note that wave data resolution cannot be specified, as they are calculated from a 16-band compressed spectra in the frequency domain.

3 METEOROLOGICAL MEASUREMENTS

Meteorological measurements were conducted at both measurement sites NW A and NW B.

3.1 Instrumentation

All reported parameters are logged and stored by individual instruments with subsets transferred to the two, independent onboard RPS M200 data loggers for near real-time transmission.

3.1.1 M200

Each buoy contains a pair of independent RPS M200 data loggers.

The recorded data is stored to a 64 Gigabyte compact flash card at a sampling rate of 2 Hz, which provides a two-year storage capacity. The recorded 10-minute averaged data are also transmitted via iridium modem from the M200 data logger to RPS servers. Raw data can be collected via 4G (or Iridium Broadband) as required.

The buoy GPS information and buoy health status is also transmitted in the data, allowing the monitoring of the buoys' positions and health for proactive intervention if required.

The following data is logged by the M200:

- 10-minute data from the ZX 300M LiDAR.
- Raw and processed wave data from the MRU 5.
- Raw and processed data on buoy heading and water levels.
- 10-minute data from the Nortek Signature current profiler.

3.1.2 ZX 300M LiDAR

The RPS LiDAR Buoy uses the ZX 300M LiDAR. The buoy provides power for the LiDAR, plus backup memory and real-time data transmission.

The ZX 300M LiDAR measures wind from 10 to 300 m above sensor height in 10 user selectable height bins tabled below (with a fixed 11th reference bin measured at 38 m above sensor height), along with data from an Airmar 150WX at 3.7 m AMSL measuring barometric pressure, air temperature, and wind.

Measured parameters from the LiDAR are:

- Wind data measured at each of the 11 heights:
  - Horizontal wind speed (m s^{-1}).
  - Horizontal wind speed min (m s^{-1}).
  - Horizontal wind speed max (m s^{-1}).
  - Horizontal wind speed std. dev. (m s^{-1}).
  - Vertical wind speed (m s^{-1}).
  - Turbulence intensity.
- Met. parameters (air temperature, barometric pressure, near-surface wind).

The data comes direct from the ZX 300M LiDAR, with buoy heading measured separately by GPS to correct directions. There is no motion compensation required and the LiDAR unit quality flags the data automatically during measurements based on algorithms applied internally.

RPS quality control the data as per Section 7.1 and Appendix F, including post processing checks for potential 180-degree ambiguity in the wind directions.

The ZX 300M LiDAR was configured to measure at the following bin heights for both locations.

Configured height (m)	Bin height relative to MSL (m)
297	300^
247	250^
197	200
177	180
157	160
137	140
117	120
97	100
67	70
38*	41*
27	30

*Fixed reference height determined by manufacturer of ZX 300M LiDAR.

^Heights beyond limit of validated usage and excluded from availability calculation.

All instrument specifications are included in Appendix C.

3.1.2.1 ZX 300M LiDAR Directional Ambiguity

The ZX 300M LiDAR laser sensor has a 180° direction ambiguity. To resolve this, it utilises measurements from the Airmar 150WX to measure the wind direction near surface, then adheres to the closest observed wind direction for the LiDAR.

At times (usually during low winds), the Airmar 150WX can have difficulty resolving the correct direction, as it is inconsistent with the LiDAR and Wind Observer II anemometer, and the adjacent buoy. During these periods where the Airmar 150WX wind directions are suspect, the buoy Wind Observer II anemometer was used to identify and flag as bad any occurrences of directional ambiguity in the LiDAR wind directions.

3.1.2.2 Calculation of Derived Parameters

A few derived wind parameters are helpful in describing the motion of air packets and related forces on turbine blades. These include inflow angle, wind shear exponent and wind veer as described below.

Inflow Angle

Inflow angle (ϕ) is described as the angle between the wind vector and the horizontal plane. If the wind vector is purely horizontal (with no vertical component) then the inflow angle is zero. For a wind vector flowing downwards, the inflow angle is negative; and conversely, an upwards flowing wind vector will produce a positive inflow angle. This is calculated as:

$$\phi = \tan^{-1}\left(\frac{WS_V}{WS_H}\right)$$

Where WS_V is the vertical wind speed, and WS_H is the horizontal wind speed.

Wind Shear exponent

Near-surface boundary layer winds are influenced by friction and other surface properties. A measure of how a vertical wind profile varies with height due to these properties can be expressed in terms of vertical wind shear. This can be separated into shear (a change in wind speed with height), and veer (a change in direction with height). From the wind profile power law,

$$ws_U = ws_L \left(\frac{z_U}{z_L}\right)^{\alpha}$$

Where WS_U is the wind speed at the upper level (200 m ASL), WS_L is the wind speed at the lower level (100 m ASL), Z_U is the upper height above sea level, Z_L is the lower height above sea level, and α is the wind shear exponent.

Hence, the exponent (α), can be expressed as:

$$\alpha = \frac{\ln\left(\frac{WS_U}{WS_L}\right)}{\ln\left(\frac{Z_U}{Z_L}\right)}$$

Wind Veer

To calculate the difference in wind direction over a height range, the wind veer (β) can be determined by the equation:

$$\beta = \frac{\theta_U - \theta_L}{z_U - z_L}$$

With Z_U and Z_L as for wind shear, while θ_U and θ_L are the wind directions at the upper (200 m ASL) and lower levels (100 m ASL) respectively.

3.2 Equipment Validation

Each LiDAR buoy has been validated offshore following the OWA Roadmap for Commercialisation of Floating LiDAR Buoys and reported by an independent third party. These validation reports for all three buoys (including the spare) are listed in Related Reports Section 1.4.

Each RPS LiDAR Buoy validation meets the OWA Roadmap requirement for the occurrence of wind speed range. The maximum wind speed during all validations has been 28 m s^{-1}.

Prior to mobilisation, each LiDAR unit was validated at the onshore Met Mast maintained by ZX Lidars and the validation independently reported by DNV GL.

All sensors were originally supplied calibrated by the manufacturer.

In addition, pre-deployment sensor “bench-checks” were performed at the RPS workshops in Perth Western Australia and prior to installation.

The relevant ZX LiDAR performance verification reports are listed in section 1.4.

3.3 Sampling Regimes

The sampling regimes of the instrumentation for both buoys are identical and presented below:

Instrument	Sensor Height (m) ASL	Parameter(s)	Sampling Rate	Sub-sampling
ZX 300M LiDAR	3.3	Wind Speed Wind Direction Turbulence Intensity	10-minute	~16 s to collect entire height range means ~37.5 samples are taken over the 10-minute period.
Airmar 150WX	3.7	Air Temperature Barometric Pressure	10-minute	
WO II	3.7	Wind Speed Gust Speed Wind Direction	10-minute	1 Hz
M200	0.0	MRU Compass WO II	2 Hz MRU 1 Hz Winds 1-minute 10-minute	The M200 samples at 4Hz, and logs 1Hz winds, 2Hz MRU. The data is averaged to produce 1-minute and 10-minute data.
Vaisala WXT534	3.6	Air Temperature Barometric Pressure	10-minute	1 Hz

3.4 Data Accuracy

Parameter	Range	Accuracy*	Resolution
Wind Speed (ZX 300M LiDAR)	0 to 80 m s^{-1}	0.1 m s^{-1}	-
Wind Direction (ZX 300M LiDAR)	0 to 359°	< 0.5°	-
Wind Speed (Wind Observer II)	0 to 65 m s^{-1}	± 2%	0.01 m s^{-1}
Wind Direction (Wind Observer II)	0 to 359°	± 2°	1°
Air Temperature (Airmar 150WX)	-40 to 80°C	1.1°C at 20°C	0.1°C
Barometric Pressure (Airmar 150WX)	300 to 1100 hPa	±0.5 hPa at 25°C	0.1 hPa
Air Temperature (Vaisala WXT534)	-52 to 60°C	±0.3 °C at 20°C	0.1°C
Barometric Pressure (Vaisala WXT534)	500 to 1100 hPa	±1 hPa at -52° to <0° ±0.5 hPa at >0° to <30°C ±1 hPa at >30° to 60°	0.1 hPa

* As per Original Equipment Manufacturer (OEM) specifications.

Please note that in the monthly transmitted data the wind speeds are compressed to a range of 0 to 131.07 m s^{-1}. Data errors generated by the LiDAR are given values 9998 (rain/fog) or 9999 (instrument error), and in the compression these become the maximum value that is then flagged bad. Annual reporting will recover the 9998 and 9999 data distinction.

4 WAVE MEASUREMENTS

Wave parameters were recorded at both buoy sites NW A and NW B.

4.1 Instrumentation

All reported parameters are logged and stored by individual instruments with subsets transferred to the two, independent onboard M200 data loggers for near real-time transmission, as outlined in section 3.1.1.

4.1.1 MRU 5

The RPS LiDAR 4.5 Buoy hosts a Kongsberg MRU 5 inertial motion sensor mounted at water level in the buoy hull. The MRU 5 records heave, pitch and roll (HPR) measurements with high accuracy during rotations. The MRU 5 maintains its specified accuracy aboard any surface vessel or subsea vehicle. The following wave parameters are derived from the HPR:

- H_{max} Maximum wave height (metres).
- T_{Hmax} Period of maximum wave height (seconds).
- H_s Significant wave height (metres).
- T_m Mean wave period (seconds).
- T_p Peak wave period (seconds).
- T_z Average zero crossing period (seconds).
- θ_p Peak wave direction (degrees).
- θ_m Mean wave direction (degrees).
- $\Delta\theta_p$ Spread of peak wave period (degrees).
- $\Delta\theta_m$ Spread of mean wave period (degrees).
- Directional frequency spectrum.

The above parameters are available in monthly time series data files, all will be quality controlled except for the direction frequency spectra which will be provided quality controlled in the annual data set.

Error! Reference source not found. lists MRU deployment locations, times, and depths for the reporting period. Instrument specifications are included in Appendix C. For a review of the MRU-5 as a wave sensor, see Section 1.4.

4.1.2 Spectral Partitioning Method

For the purposes of real-time data provision, validation, and monthly reporting, RVO have requested the determination of a varying sea-swell ($_{ss}$) separation frequency (f_{ss}) from the total wave spectra using:

$$T_{ss} = 5.5\sqrt{H_s}$$

Where T_{ss} is the sea-swell separation period and H_s is significant wave height. Giving a sea-swell separation frequency (f_{ss}) for a given spectra as:

$$f_{ss} = \frac{1}{T_{ss}}$$

This sea-swell separation frequency was used to define the separation of total spectral energy into wind sea or swell. Characteristic spectral parameters were then calculated and presented.

Full details on the wave analysis, can both be found in Appendix E.

4.2 Calibration

All sensors were originally supplied calibrated by the manufacturer.

In addition, pre-deployment sensor “bench-checks” were performed at the RPS workshops in Perth Western Australia prior to installation.

MRU 5 calibration certificates are provided in Appendix D.

4.3 Sampling Regime

The sampling regime of the MRU 5 for both buoys are identical and presented below.

Instrument	Sampling Rate	Sub-sampling
MRU 5	10-minute	2 Hz
M200	1-minute	4 Hz

4.4 Data Accuracy

Parameter	Range	Accuracy	Resolution
MRU Pitch and Roll	± 180 °	0.02 ° RMS	0.001 °
MRU Gyro	± 149 ° s^{-1}	0.08 ° s^{-1}	0.001 ° s^{-1}
MRU Acceleration	± 30 m s^{-2}	0.01 m s^{-2} RMS	0.001 m s^{-2}
MRU Heave	± 50 m	5 cm or 5%, whichever is greater	0.01 m

4.5 Surface Following Buoy

Derivation of wave measurements from the buoy motion requires the assumption that the buoy follows the sea surface even through the passage of extreme waves. RPS has performed dynamic mooring simulation during 100-year extreme conditions to ensure the buoy response follows the sea surface during very severe sea-states.

5 CURRENT MEASUREMENTS

Through water column currents were measured at both sites NW A and NW B.

5.1 Instrumentation

Current profile is measured by a Nortek Signature 500 kHz mounted downward looking from 1.8 m below the sea surface in the keel of the buoy. All reported parameters are logged and stored by individual instruments with subsets transferred to the two, independent onboard M200 data loggers for near real-time transmission, as outlined in section 3.1.1.

5.1.1 Nortek Signature 500 kHz

The Signature measures the current velocity profile (including vertical velocity) at intervals defined by the user (1 m was selected) and water temperature at the instrument level. The Signature uses five acoustic transducers, four are slanted at 25° to the vertical, and one is vertical (not enabled). The instrument logs echo intensity for each active acoustic beam and has an internal compass and tilt sensor.

The Signatures used in the RPS LiDAR 4.5 Buoy include Attitude and Heading Reference Systems (AHRS) option to better measure the pitch and roll in the presence of buoy motion, for improved bin mapping, and therefore better-quality current data.

Radial current velocity components are sensed along each of the four slanted acoustic beams, by measuring the Doppler shift of acoustic reflections from particles (volume scatterers) which are advected by the currents. These are then computationally rotated to a north-south, east-west, and vertical coordinate system, and converted to velocities using the instrument's internal processor, compass, and tilt sensors. This computation assumes the current is uniform across 4 beams.

Current profile measurements (pings) are averaged over the sampling period to improve the accuracy and to provide a vector-average; however, the timing between pings is user-specified, and a burst of pings is sometimes used instead of spacing the pings evenly over the ensemble period, to avoid aliasing by wave orbital velocities. See Section 5.3 for the setup used on this program.

The speed of sound is assumed to be constant through the water column and is calculated from the water temperature sensed by the ADCP (at the instrument level) with an assumed water salinity entered during instrument setup (in this case 35 PSU).

Table 2.1 and Table 2.2 lists Signature 500 deployment locations, times, and depths for the reporting period.

The instrument specifications for the Signature 500 have been included in Appendix C.

5.2 Calibration

The sensor of the Signature 500 was supplied calibrated by the manufacturer, but it should be kept in mind that the velocity measurement of the ADCP is very difficult to calibrate and not normally done. In addition, pre-deployment sensor calibrations, or "bench-checks" were performed by RPS prior to installation.

Operational checks were conducted on the velocity transducers to confirm they were functioning correctly as part of the pre-deployment process (no workshop calibrations were possible).

The Signature compass was found to be slightly affected by the magnetic influence of the buoy, so current directions have been corrected to the heading of the buoy recorded by the GNSS compass. Current directions are referenced to True North.

Pitch and roll were similarly confirmed on a purpose designed tilt jig. This was to ensure that the maximum tilt error was less than 1º.

Spot checks were performed on the temperature sensor against a calibrated thermometer. This was to ensure that the maximum temperature error was less than 1 ºC.

Data-logging checks were finally undertaken to ensure that the instrument was correctly storing the data.

Calibration certificates are provided in Appendix D.

5.3 Sampling Regime

The sampling regime of the Signature 500 for both buoys are identical and presented below:

Sampling Schemes	
Blanking Distance	0.5 m
Cell size	1 m
Number of cells	30
Measurement Interval	10 minutes
Average Interval	3 minutes
Assumed salinity	35 PSU
Recorded coordinate system	BEAM
Horizonal precision	0.75 cm/s
Vertical precision	0.25 cm/s

5.4 Data Accuracy

5.4.1 Nortek Signature 500 kHz

Parameter	Range	Accuracy	Resolution
Current Speed	0.5 – 4 m s^{-1}	0.3%	0.1 cm s^{-1}
Current Direction	0 – 359°	± 2°	0.1°
Water Temperature	-4 to +40 °C	0.1 °C	0.01 °C

5.5 Valid Bins and Echo Interference

Acoustic Profiling Current Meters that detect a Doppler shift signal in volume backscatter from the water column do not obtain valid data when side lobe energy from the transducers contaminates the received signal in the time gate corresponding to the measurement bin. Please see the table below for a summary of the valid measurement depths.

Near the Seabed

Current Profiler data very near the seabed from the Nortek Signature are corrupted by the direct side-lobe reflection from the seabed. The expected corruption zone for a 25° head as used in the Nortek Signature is 9% of the range plus one bin. In 30 m of water, no valid data are obtained within 3.5 m of the seabed. This assumes a flat seabed and vertical orientation of the instrument. The interference may be higher in sloping or uneven topography, or when the instrument is tilted. More valid bins are obtained at high tide because the buoy is floating.

Near the Sea Surface

The Nortek Signature was positioned at 1.8 m below sea level downward looking from within the buoys' keel structure with a 0.5 m blank and 1 m bin resolution, so Bin 1 is at 3.3 m BSL. It was expected that bins that measure from the keel area (extends to 5 m depth) cannot produce valid data as the keel disturbs the current flow and there will be some contamination from sidelobe echoes off the keel. We note that the echo contamination contains no Doppler shift translating to zero current speed and can be a subtle portion of the total echo that is difficult to detect, so caution is required.

There was sidelobe echo of beam 3 of the Signature from the keel, that arrived back at the instrument directly. Then echo amplitude is observed to remain high for longer (more bins) than expected, which timing is consistent with a double reflection of the sidelobe energy off the sea surface and back to the instrument a second time. Data quality checking determined the first valid bin was Bin 7 at a depth of 9.3 m.

On the 29th of August 2022, RPS used the remote satellite connection to the NW B buoy Signature to switch off Beam 3, so that the interference of the side lobe double echo path is eliminated, resulting in three additional bins near the sea surface for each buoy to pass QC. From this time, the Signature has operated on 3 beams and data quality checks have confirmed the quality of the data has not been degraded.

Location	Nominal Water Depth (LAT)	Highest Valid Bin Number	Highest Valid Bin Depth (Below Sea Surface)	Lowest Valid Bin Number	Lowest Valid Bin Depth (Below Sea Surface)
NW A	29.1 m	Bin 4	6.3 m	Bin 23	25.3 m
NW B	29.6 m	Bin 4	6.3 m	Bin 23	25.3 m

6 TIDE MEASUREMENTS

Water level measurements were made with a GNSS sensor, referenced to LAT.

6.1 Instrumentation

All reported parameters are logged and stored by individual instruments with subsets transferred to the two, independent onboard M200 data loggers for near real-time transmission, as outlined in section 3.1.1.

6.1.1 RPS Tide Sensor

RPS has developed a system which measures water level in real-time that has been fitted to the RPS LiDAR 4.5 Buoy. The RPS Tide Sensor utilises a GPS aided inertial navigation system and AHRS (altitude and heading reference systems) that provides accurate position, velocity, acceleration, and orientation under the most demanding conditions. It combines temperature calibrated accelerometers, gyroscopes, magnetometers, and a pressure sensor with a dual antenna GNSS (Global Navigation Satellite System) receiver. These are coupled within a sophisticated algorithm and Trimble RTX correction service to provide accurate and reliable orientation data, including correction for buoy layover.

Water level had a final check onsite against the Den Helder tide gauge once the FLS was deployed for towing. https://www.psmsl.org/data/obtaining/stations/23.php

Data is logged using a purpose built M200 RPS data logger at 1 minute (average of 1 Hz data), with 1-minute averaged data point transmitted via an Iridium message every 10-minutes.

Instrument specifications for the RPS Tide Sensor have been included in Appendix C.

6.2 Calibration

The GNSS tide system is set at a known ellipsoid height at an established survey benchmark to record data during factory acceptance testing to confirm accuracy and correct operation. The vertical datum has not been accurately set yet as this can be more accurately done as the data available from site becomes longer for harmonic analysis. Final adjustment of the datum will be done after a year of data is available.

6.3 Sampling Regime

The sampling regime of the RPS Tide Sensor for both buoys are identical and presented below:

Sampling Schemes	
Logged Data	1Hz
Transmitted Data	10 minutes

6.4 Data Accuracy

The accuracy of the RPS GNSS tide sensor is:

Parameter	Range	Accuracy (RMS)	Resolution
Horizontal	No range limit	0.03 (m)	0.1 mm
Vertical	No range limit	0.05 (m)	0.1 mm

7 DATA QUALITY, RELIABILITY AND AVAILABITY

7.1 Data Quality Control

RPS quality control includes rigorous pre-deployment checks and calibrations to ensure sensors are working correctly. During data processing, the results of the calibrations are applied, with full audit trail so that results can be verified.

The performance of the instruments is monitored closely, including detailed checks of real-time data during deployment to determine possible sensor drift and outages. Instrument details (metadata) are logged and signed off as checked in a quality-controlled process. Once instruments are recovered, first and last logged samples are compared against time from a reliable source (such as GPS time) to allow calculation of instrument time drift. Significant timing errors are corrected in post processing.

Once the quality control is completed, it is reviewed by a Senior Metocean scientist or other suitably qualified person. This includes visual inspection of time series to check for instrument faults, sensor drift, spurious data, timing errors and overall data quality. Related parameters are overlayed, or stack plotted to inspect for consistency. The resulting data files contain quality variables associated with each parameter which, for every time step, will have an associated quality index from 0 to 3, where 0=unknown, 1=good, 2=suspect and 3=bad.

Suspect or erroneous data were flagged as bad and excluded from further analysis. Refer to Appendix F for further breakdown of the data processing chain and QC procedures.

7.2 Data Reliability

All sensors satisfactorily passed all pre-deployment checks and calibrations. Any spurious and erroneous data points have been flagged (or removed) using RPS quality control methodology.

7.2.1 Data Cataloguing and Storage

The quality-controlled data presented in the report are stored in standard netCDF format files that are held by RPS on backup tape written to industry standards. The backup tape is stored in-house, and a copy is similarly held off-site.

For ease of handling by end users, the netCDF files contain a deployment ID attribute which serves as a unique identifier. The ID# is created using RPS reference numbers followed by location and deployment sequence numbers. For example, "*J3707:03:NW:A:01*", *J3707* is an RPS project code, *03* is RPS assigned data number, *NW* is location, *A* is location reference, and *01* is the first deployment.

7.3 Data Availability

Metocean Survey is often conducted by leaving instruments unattended in remote locations for long durations. There is always the potential for instrument failure causing some data gaps which cannot be filled. The engineering application of the data is often statistically based or supported by long term modelling, so not adversely affected by small data gaps provided the occurrence is not biased towards extreme conditions. The true project impact of any data gaps depends on the duration, the parameter measured and the application of the data, and should be assessed by an expert. Whilst some data gaps are unavoidable the industry continues to strive for 100% data availability.

System availability is described as the moment the measurement systems are powered and operating correctly and includes times when the sensor may record data that does not pass QC. The System availability percentage is calculated based on the number of measured records relative to the number of expected records over the reporting period.

The post-processed data availability is based on the number of records after QC, relative to the expected number of records. For example, the LiDAR is well known to self QC data bad when affected by rain or fog which can range from 1 to 10% data loss in any given month.

To guide the reader on the expected data availability the following subjective values are provided.

	System Data Availability %	Post-processed Data Availability %
Excellent	>95%	>90%
Good	90 - 95%	85 - 90%
Acceptable	80 - 90%	75 - 85%
Limited	60 - 80%	60 - 75%
Poor	<60%	<60%

7.3.1 System Availability

As described in Section 2.5, data are retrieved from the buoy in several ways, and the most frequent is by Iridium Rudics every 30 minutes. This main data source is used for the monthly reporting to facilitate timely reporting, with the exception of the wave, current and water temperature data that are recovered from the data logger by 4G. Note that the Iridium Rudics data transmission occasionally failed causing missing data from the real-time web display.

On the 13th of December, NW A buoy (serial number 107) drifted due to third party interference and was not able to be replaced during the remainder of December due to weather conditions that made the work unsafe. This has resulted in only the first ~13 days of data for NW A being available. The coastguard was notified by a fishing vessel that the buoy was drifting (and therefore a navigation hazard) following an incident the fishing vessel had with the mooring. The coastguard informed RPS of the incident and collected the buoy.

The NW B buoy (serial number 101) had been shown to have both wind generators failed whilst one is required for power budget in the winter, so this buoy was recovered and replaced with Lidar Buoy 106 on 11th December with no data gap resulting.

For the RPS LiDAR 4.5 Buoy deployed at NW B, and for all sensors, the system availability was between 98 and 100%, with the only unavailability caused by Iridium transmission gaps, for which data are available from the 4G download. The missing data will be provided in the annual data.

Iridium Rudics transmission data were amalgamated from systems A and B to achieve a data recovery via Rudics of:

- 39.7% on NW A
- and 98.8% on NW B.

7.3.2 Post QC Data Availability

Post QC data availability is summarised in the table below for each data type. Detailed percentages are available in Table 7.4 for NW A and NW B, while cumulative availability percentages for each data type are presented in Table 7.5 and Table 7.6. Visual representation of the post-processed availability % for each parameter are available as bar charts in the relevant Appendices G to J.

Parameter	System Data Availability %		Post-processed Data Availability %	
	NW A	**NW B**	**NW A**	**NW B**
Air Temperature	39.7	98.8	39.7	98.7
Barometric Pressure	39.7	98.8	39.7	98.7
Currents*	39.7	100	39.7	99.9
Tides	39.7	98.7	36.5	88.4
Water Temperature	39.7	100	39.7	100
Waves	39.8	100	39.8	100
Wind**	39.7	98.8	39.6	98.3

* Average data availability % of current speed and direction was calculated for the valid bins from 6 m BSL to 4 m above seabed.

** Average data availability % of Wind Speed and Direction from 9 heights (30 to 200 m AMSL). Heights above 200 m are beyond the LiDAR's certified range and excluded from data availability calculations.

Gaps in the QC'd dataset can be from:

1. No Data - the instrument has not recorded data.
2. Flagged bad in QC - Data has been removed after quality checking of the data.

In the event of no data, all gaps of greater than 6 hours are listed below. Whether the data resides still on the buoy and can be recovered with the buoy, as well as the reason for the gap, will be investigated and reported on a month-by-month basis.

In the event of data removal via a QC process, if for any reason on any given day 10% or greater of the expected data level is removed for any instrument, the occurrence will be recorded in the table below with the reason for removal noted in the table.

In both cases, a full campaign log will be presented in the end of campaign report, and the instrument will be monitored for any sign of performance deterioration.

Significant data outages are listed below.

Location	Parameter	Date	Period	Comment
NW A	All	13/12/22	~18 days	Drifted off location

Other issues that have contributed to data being marked bad during QC were:

- The LiDAR wind data does not pass internal quality checks or produces an unrealistic value. The occurrence increases with the range of the wind measurement and is often associated with unfavourable atmospheric conditions such as rain or fog.
- The near surface anemometer at 3.7 m ASL measured obstructed flow when the buoy does not face bow to the wind, usually caused by the current drag on the buoy exceeding the wind drag with the two in opposing directions.
- The GNSS tide gauge did not always return realistic values due to interference from the Rudics transmitter. Data loss were typically not at the same time from the buoys at NW A and B.

8 DATA ANALYSIS AND PRESENTATIONS

8.1 Meteorological Measurements

Standard analysis of the processed data was undertaken to produce the following presentations:

- Monthly time history overlay plots of wind speed, wind direction, turbulence intensity, inflow angle, wind shear, wind veer, air temperature and barometric pressure for each site.
- NW A versus NW B monthly time history overlay plots of air temperature, barometric pressure and wind speed and direction at representative heights of 3.7, 30, 100, and 200 m AMSL.
- Monthly data availability bar charts for each parameter at each site.
- Statistics tables of wind speed, wind direction, turbulence intensity, inflow angle, wind shear, wind veer, air temperature and barometric pressure for each site.
- Monthly rose plots and histograms of wind speed and direction accompanied by relevant statistical parameters (maximum, minimum, mean, and standard deviation values) at each height, for each site.
- NW A versus NW B monthly correlation plots of wind speed and direction (at representative heights of 3.7, 30, 100, and 200 m AMSL), and near-surface air temperature and barometric pressure.

Meteorological measurement presentations are available in Appendix G.

8.2 Wave Measurements

Standard analysis of the processed data was undertaken to produce the following presentations:

- NW A versus NW B monthly time history overlay plots of H_s, T_p, T_z, T_m, θ_p, $\Delta\theta_p$, H_{max}, and T_{Hmax}.
- Monthly data availability bar charts for each parameter at each site.
- Statistics tables of H_s with θ_p, T_p with θ_p, H_{max} with θ_p, T_{Hmax} with θ_p, and T_z for each site.
- Monthly rose plots and histograms of H_s with θ_p, and T_p with θ_p accompanied by relevant statistical parameters (maximum, minimum, mean, and standard deviation values) for each site.
- NW A versus NW B monthly correlation plots of H_s, T_m, θ_p, θ_m, and T_z.

Wave measurement presentations are available in Appendix H.

8.3 Current Measurements

To keep the volume of presentations succinct and relevant, only measurements from 5 levels are presented (Bins 7, 11, 15, 19, and 23 for the Signature), rather than 17+ levels (which are all contained within the monthly data files). Standard analysis of the processed data was undertaken to produce the following presentations:

- Monthly time history overlay plots of current speed, current direction, and water temperature for each site.
- NW A versus NW B monthly time history overlay stack plots of current speed, current direction, and water temperature.
- Monthly data availability bar charts for each parameter at each site.
- Statistics tables of water temperature, current speed and current direction for each site.
- Monthly rose plots and histograms of current speed and direction accompanied by relevant statistical parameters (maximum, minimum, mean, and standard deviation values) for each site.
- NW A versus NW B monthly correlation plots of water temperature, current speed and current direction.

Current measurement presentations are available in Appendix I.

8.4 Tide Measurements

Standard analysis of the processed data was undertaken to produce the following presentations:

- NW A versus NW B monthly time history overlay plots of measured water levels.
- Monthly data availability bar charts for water level at each site.
- Statistics tables of tide height for each site.
- NW A versus NW B monthly correlation plots of water levels.

Tide measurement presentations are available in Appendix J.

9 RESULTS

Summary statistics of measured parameters for the reporting period of December 2022, are presented in this section for both NW A and NW B. As a result of NW A buoy (serial number 107) drifting, only the first ~13 days of data is available for that location. The measurements from the two sites are then compared using overlay plots and correlations in order to validate the results. Presentations are in Appendices G through to J. Further validation of the measurements from the two sites against third party sources data are presented in Section 10.

9.1 Meteorological Measurements

Summary statistics of wind observations and near-surface meteorological parameters for both sites for this reporting period are listed below. Further presentations can be found in Appendix G.

Site	Parameter (units)	Height (m) AMSL	Minimum	Maximum	Mean	Standard Deviation	Main Direction/s^ (from)
NW A	Air Temperature	3.7	2.65	10.50	6.41	1.3835	-
	Barometric Pressure	3.7	1005.10	1030.20	1016.43	7.9695	-
	Wind Speed (m s^{-1})	300	0.73	17.99	8.79	4.0979	ENE E NNW
		250	0.87	17.86	8.72	4.0176	ENE E NNW
		200	1.06	18.08	8.64	3.9576	ENE E NNW
		180	1.01	17.97	8.61	3.9275	ENE E NNW
		160	1.07	17.74	8.58	3.9039	ENE E NNW
		140	1.15	17.75	8.55	3.8823	ENE E NNW
		120	1.00	17.57	8.51	3.8493	ENE E NNW
		100	1.06	17.31	8.46	3.8275	ENE E NNW
		70	0.78	17.18	8.40	3.7762	ENE E NNW
		41	0.87	16.77	8.25	3.6921	ENE E NNW
		30	1.01	16.64	8.16	3.6421	ENE E NNW
		3.7	0.72	14.23	7.00	3.1916	ENE E NNW
NW B	Air Temperature	3.7	2.65	11.25	7.20	1.7109	-
	Barometric Pressure	3.7	987.40	1032.70	1010.94	9.7201	-
	Wind Speed (m s^{-1})	300	0.80	30.31	12.31	6.4491	SSW SW WSW
		250	0.81	29.04	12.12	6.2637	SSW SW
		200	0.90	28.07	11.85	6.0252	SSW SW
		180	0.95	27.52	11.72	5.8952	SSW SW
		160	0.69	27.40	11.59	5.7447	SSW SW
		140	0.84	26.33	11.43	5.5711	SSW SW
		120	0.81	25.17	11.25	5.3872	SSW SW
		100	0.87	24.18	11.05	5.2015	SSW SW
		70	0.77	23.46	10.75	4.9238	SSW SW
		41	0.86	22.17	10.34	4.5875	SSW SW
		30	0.80	22.10	10.12	4.4332	SSW SW
		3.7	0.54	16.59	8.06	3.6342	SSW SW

^ Main directions are where occurrence is greater than 10%.

9.1.1 Validation of NW A with NW B

Correlation analysis statistics of wind observations and near-surface meteorological parameters between the sites A and B for this reporting period can be found in Appendix G. Ordinate Intercept for Wind Speeds are forced through the origin, Wind Direction slopes are set to 1, while Line of Best Fit are calculated using perpendicular least squares.

As a subjective guide to the reader, we set the following KPIs.

Parameter (Units)	Slope	Coefficient of Determination (R^2)
Air Temperature (°C)	0.98-1.02 excellent 0.97-1.03 good	>0.98 excellent >0.97 good
Barometric Pressure (hPa)	0.98-1.02 excellent 0.97-1.03 good	>0.98 excellent >0.97 good
Wind Speed (m s^{-1})	0.98-1.02 excellent 0.97-1.03 good	>0.98 excellent >0.97 good
Wind Direction (° from)	Offset < 5º excellent Offset < 10º good	>0.97 excellent >0.95 good

The results of the correlation analysis are summarised below.

Parameter (units)	Height (m) AMSL	Ordinate Intercept	Slope	Correlation Coefficient (R)	Coefficient of Determination (R^2)
Air Temperature (°C)	3.7	-0.011	1.017	0.988	0.976
Barometric Pressure (hPa)	3.7	-49.587	1.050	0.994	0.988
Wind Speed (m s^{-1})	200	0.000	1.003	0.994	0.989
	100	0.000	1.003	0.993	0.986
	30	0.000	1.002	0.992	0.984
	3.7	0.000	0.977	0.982	0.964
Wind Direction (° from)	200	-0.007	1.000	0.996	0.993
	100	0.118	1.000	0.997	0.995
	30	0.035	1.000	0.998	0.995
	3.7	-0.889	1.000	0.998	0.995

The time series overlay plots of the meteorological parameters show excellent agreement.

The temperature measured by the two buoys agree very well with a standard error of 0.2°C, compared to the specified accuracy of 1.1°C. The Correlation Coefficient of 0.99 is better than expected given the instrument accuracy.

The Barometric Pressure measured by the two buoys agree very well with a standard error of 0.633 hPa, compared to the specified accuracy of 0.5 hPa. The Correlation Coefficient is 0.99 and the slope close to unity confirming the excellent agreement.

The correlation plots of wind speed (excluding speeds < 2 m s^{-1}) at the four levels selected all produce a slope within 0.3% and a Coefficient of Determination above 0.98. These comparisons are within the best practice KPIs set by the OWA Roadmap for LiDAR Buoy validation trials.

The correlation plots of wind direction (excluding directions when speeds < 2 m s^{-1}) at the three LiDAR levels selected all produce an intercept less than 1° and a Coefficient of Determination above 0.99. The offset is less than the specified accuracy of the ZX 300M LiDAR of 2°.

9.2 Wave Measurements

Summary statistics of wave parameters for both sites for this reporting period are listed below. Further presentations can be found in Appendix H.

Site	Parameter (units)		Minimum	Maximum	Mean	Standard Deviation	Main Direction/s^ (from)
NW A	Significant Wave Height (m)	Total	0.55	2.78	1.63	0.6702	NNE NE
		Sea	0.32	2.67	1.33	0.7349	NE NNW
		Swell	0.21	1.64	0.81	0.355	NNE NE
	Peak Period (s)	Total	3.94	15.06	7.72	1.8183	NNE NE
		Sea	2.98	8.85	6.25	1.4245	NE NNW
		Swell	4.92	15.06	8.28	1.907	NNE NE
	Zero-crossing Period (s)	Total	3.69	7.05	5.35	0.7543	-
		Sea	2.95	5.87	4.50	0.8153	-
		Swell	5.23	12.25	8.31	1.5797	-
	Maximum Wave Height (m)		0.91	5.00	2.62	1.1106	NNE NE
	Period of Maximum Wave Height		3.51	13.41	6.77	1.5645	NNE NE
NW B	Significant Wave Height (m)	Total	0.55	4.19	1.82	0.7803	SSW NNW
		Sea	0.29	4.18	1.6	0.8615	S SSW
		Swell	0.21	1.96	0.7	0.3483	NNW
	Peak Period (s)	Total	3.88	17.07	7.52	2.0255	SSW NNW
		Sea	3.05	9.21	6.3	1.3727	S SSW
		Swell	4.82	18.29	8.92	2.2698	NNW
	Zero-crossing Period (s)	Total	3.65	7.08	5.31	0.7089	-
		Sea	2.98	6.87	4.69	0.8413	-
		Swell	5.27	13.98	8.99	1.6877	-
	Maximum Wave Height (m)		0.79	8.05	2.96	1.3121	SSW NNW
	Period of Maximum Wave Height		3.62	15.25	6.59	1.5224	SSW NNW

^ Main directions are where occurrence is greater than 15%.

9.2.1 Validation of NW A with NW B

Correlation analysis was performed for key wave parameters using Line of Best Fit calculated using perpendicular least squares. For heights and periods, the ordinate intercept was forced through the origin, and for directions, the slopes were set to one. Time history overlays and correlation plots can be found in Appendix H.

As a subjective guide to the reader, we set the following KPIs.

Parameter (Units)	Slope	Coefficient of Determination (R^2)
Significant Wave Height (m)	0.98-1.02 excellent 0.97-1.03 good	>0.95 excellent >0.90 good
Mean Period (s)	0.98-1.02 excellent 0.97-1.03 good	>0.95 excellent >0.90 good
Mean Direction (°)	Offset < 5° excellent Offset < 10° good	>0.95 excellent >0.90 good
Zero-crossing Period (s)	0.98-1.02 excellent 0.97-1.03 good	>0.95 excellent >0.90 good

Correlation analysis statistics of wave parameters between the 2 sites at NW for this reporting period are listed below.

Parameter (units)	Ordinate Intercept	Slope	Correlation Coefficient (R)	Coefficient of Determination (R^2)
Significant Wave Height (m)	0.000	1.015	0.993	0.986
Mean Period (s)	0.000	1.007	0.989	0.978
Zero-crossing Period (s)	0.000	1.007	0.985	0.970
Peak Direction (°)	1.697	1.000	0.993	0.986
Mean Direction (°)	1.445	1.000	0.999	0.997

The time series overlay plots of the wave parameters show good agreement.

The Significant Wave Height measured by the two buoys agree very well with a standard error of 0.06 m, within the specified accuracy of 5 cm or 5%. The slope was 1.02 equivalent to a 2% difference, and the Coefficient of Determination was high at 0.99.

The Mean Period measured by the two buoys agree well with a standard error of 0.09 seconds. The slope was 1.01 equivalent to a 1% difference, and the Coefficient of Determination was 0.98.

The Mean Direction measured by the two buoys agree well with an Ordinate Intercept 1.45º and the Coefficient of Determination was 0.999. The Peak Direction does not compare as well with more outliers existing due to the nature of the parameter, especially in bi-modal sea states, so is not of concern.

9.3 Current Measurements

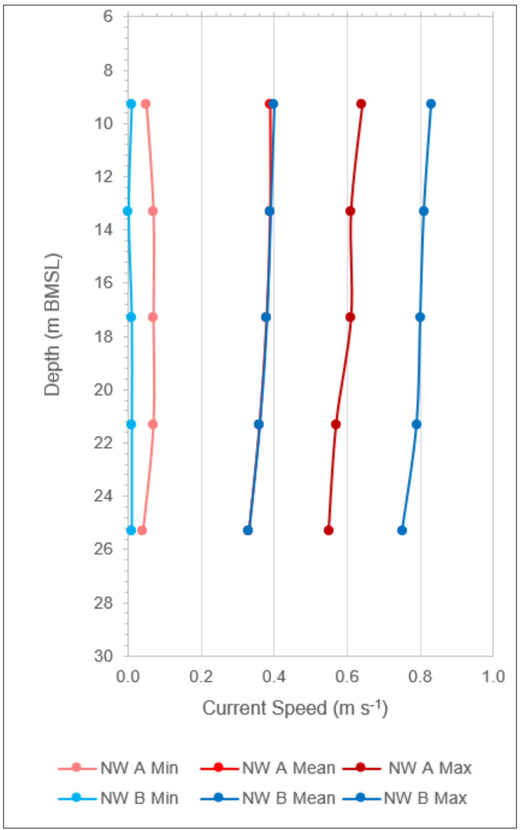
Due to the high number of levels measured in the current profile that are very similar in results, only 5 bins are presented, being bins 7, 11, 15, 19 and 23.

Summary statistics of surface, mid-level, and near-bed current observations for both sites for this reporting period are listed below. Further presentations can be found in Appendix I.

Site	Parameter (units)	Depth (m) BMSL	Minimum	Maximum	Mean	Standard Deviation	Main Direction/s^ (towards)
NW A (29.1 m LAT)	Water Temperature (°C)	1.8	10.83	13.09	11.87	0.5787	-
	Current Speed (m s^{-1})	9.3	0.05	0.64	0.39	0.1036	N S
		13.3	0.07	0.61	0.39	0.1001	N S
		17.3	0.07	0.61	0.38	0.0981	N S
		21.3	0.07	0.57	0.36	0.0956	N S
		25.3	0.04	0.55	0.33	0.0904	N S
NW B (29.6 m LAT)	Water Temperature (°C)	1.8	8.46	13.17	10.64	1.2410	-
	Current Speed (m s^{-1})	9.3	0.01	0.83	0.40	0.1355	N SE S
		13.3	0.00	0.81	0.39	0.1303	N SE S
		17.3	0.01	0.80	0.38	0.1253	N SE S
		21.3	0.01	0.79	0.36	0.1201	N SE S
		25.3	0.01	0.75	0.33	0.1120	N SE S

^ Main directions are where occurrence is greater than 15%.

The above statistics are presented in the profile plots below for NW A and NW B showing minimum, mean and maximum current speeds for the reported levels at both sites. Maximum current speeds are consistently stronger through the water column at NW B due to lack of current data later in the month during maximum speeds.



9.3.1 Validation of NW A with NW B

Correlation analysis was performed for current speed and direction using Line of Best Fit calculated using perpendicular least squares. For speed, the ordinate intercept was forced through the origin, and for directions the slope was set to one. Time history overlays and correlation plots can be found in Appendix I.

As a subjective guide to the reader, we set the following KPIs.

Parameter (Units)	Slope	Coefficient of Determination (R^2)
Water Temperature (°C)	0.98-1.02 excellent 0.97-1.03 good	>0.97 excellent >0.95 good
Current Speed (m s^{-1})	Not applicable as the locations are affected by seabed friction	>0.95 excellent >0.90 good
Current Direction (° from)	Offset < 5º excellent Offset < 10º good	>0.95 excellent >0.90 good

Correlation analysis statistics between the 2 sites at NW for this reporting period are listed below.

Parameter (units)	Depth (m) BMSL	Ordinate Intercept	Slope	Correlation Coefficient (R)	Coefficient of Determination (R^2)
Water Temperature (°C)	1.8	-0.329	1.034	0.990	0.980
Current Speed (m s^{-1})	9.3	0.000	1.022	0.945	0.893
	13.3	0.000	1.017	0.938	0.880
	17.3	0.000	1.015	0.932	0.869
	21.3	0.000	1.012	0.928	0.861
	25.3	0.000	1.009	0.905	0.819
Current Direction (° from)	9.3	-1.401	1.000	0.998	0.996
	13.3	-1.381	1.000	0.998	0.996
	17.3	-1.277	1.000	0.997	0.994
	21.3	-1.220	1.000	0.997	0.994
	25.3	-1.066	1.000	0.997	0.994

The water temperature measured by the two buoys agree very well with a standard error of 0.06°C, compared to the specified accuracy of 0.1°C. The slope is 1.028, within 1% of unity. The Correlation Coefficient of 0.989 is very good given the instrument specified accuracy.

Current speeds measured by the two buoys show good agreement, with the 3 upper bins analysed showing a slope of within 5% of unity and correlation coefficient greater than 0.93. This agreement is within the instruments specified accuracy, and there is scope for some real differences between the two locations 1000 m apart with slightly different water depths. For the lowest 2 bins analysed, the 0.5 m difference in water depth at the two locations (29.1 and 29.6 m) means the height ASB is also 0.5 m different, which is expected to introduce real differences due to seabed friction. The correlation plot shows good agreement with a correlation coefficient around 0.91, although the NW A ADCP reads 5-10% lower than the NW B ADCP.

The current direction scatter plot and time series show excellent agreement with the Coefficient of Determination above 0.99.

9.4 Tide Measurements

Summary statistics of water level observations for both sites for this reporting period are listed below. Harmonic analysis of tide data was conducted from previous months of measurements to determine LAT at NW is 1.22 m below MSL. Further presentations can be found in Appendix J.

Site	Parameter (units)	Minimum	Maximum	Mean	Standard Deviation
NW A	Surface Elevation (m) LAT	0.36	2.26	1.21	0.4693
NW B	Surface Elevation (m) LAT	0.05	2.51	1.28	0.4898

9.4.1 Validation of NW A with NW B

Time history overlays and correlation plots can be found in Appendix J.

As a subjective guide to the reader, we set the following KPIs. The difference in actual water levels for the 2 locations is expected to be negligible.

Parameter (Units)	Slope	Coefficient of Determination (R^2)
Surface Elevation (m) LAT	0.98-1.02 excellent 0.97-1.03 good	>0.97 excellent >0.95 good

Correlation analysis statistics of water level observations between the 2 sites for this reporting period are listed below.

Parameter (units)	Ordinate Intercept	Slope	Correlation Coefficient (R)	Coefficient of Determination (R^2)
Surface Elevation (m) LAT	0.026	0.998	0.995	0.990

The timeseries shows good general agreement in the measured surface elevation at NW A and NW B.

The correlation plot demonstrates good agreement with a slope of 0.998, intercept close to zero and a correlation coefficient of 0.995. The differences in the two instruments are less than the specified accuracy.

10 INDEPENDENT VALIDATION

This section provides validation of measured parameters from NW A and NW B against independent data in order to confirm the reliability of these observations. The first check was NW A against NW B data, presented in Section 9, and this section provides an independent check against systematic errors that might apply to both those measurement systems (e.g., common software error). Usually, the independent data comes from a near-by location and sampled differently, so the purpose is not to quantify the accuracy of the measured data, but rather a sensibility check to show good general agreement. Time series overlays have been generated and presented in full in Appendix K.

10.1 Reference Data

Depending on availability, RPS may use any of the following sources of independent data for the monthly validation of NW measurements. Sources used in this report are documented in sections 10.2 to 10.5.

Source Name	Distance from NW	Sample Interval	Reference Parameters	Description and Comments
NDBC Buoy (62145)	20 NM to the southwest	10 min	• significant wave height • zero-crossing wave period • air temperature equivalent 2 m AGL • barometric pressure sea level	• Realtime measurements from oil-rig helideck and buoy • Currently being received in NRT by RPS datafeeds/data-access. • Historical measurement data also available via NCDC/NCEI
Hoorn-A Platform (EHQE)	46 NM to the southeast	10 min	• wind speed and direction 50 m AMSL • air temperature 50 m AMSL • barometric pressure 50 m AMSL	• Measurements from oil-rig helideck and buoy • Historical measurement data also available via NCDC/NCEI
K13-A (06252 EHJR)	10 NM to the south. Water Depth ~28 m MSL	10 min	• wind speed and direction • air temperature • barometric pressure • significant wave height • mean wave direction • zero crossing period	• Realtime measurements from offshore platform helideck and buoy • Data available by KNMI data portal and API.
K14-FA-1C (06204 EHKV)	20 NM to the southeast	10 min	• wind speed and direction scaled to 10 m AMSL	• Realtime measurements from offshore platform helideck • Data available by KNMI data portal and API.
NWS Ocean current model*	Grid point Latitude: 53°22'42" N Longitude: 3°07'16" E Water Depth: 30.9 m MSL	60 min 15 min^	• current velocities at 10 and 20 m BMSL • sea surface temperature • sea surface height^	• UKMO Atlantic-European North West Shelf – Ocean Physics Analysis. Detailed description here • Gridded observations, satellite, and other assimilated data is available via Copernicus-Marine

* NORTHWESTSHELF_ANALYSIS_FORECAST_PHY_004_013: Spatial resolution 0.014° × 0.03°; coordinate reference system WSG 84 (EPSG 4326); 33 vertical depth levels available (surface, 10, 20 m levels used in this report).

^ The sea surface height data from the NWS model is available as sea surface height above geoid (m). An offset of 0.4 m has been applied to these heights to align with the measured data for ease of comparison.

A map for the data source locations is shown below.

The offshore helideck systems are CAP437 certified, and instruments are rigorously QA/QC'd and undergo regular calibration and maintenance to ensure consistent and reliable data quality.

10.2 Meteorological Validation

Reference data from K13 platform were used for wind, air temperature, and barometric pressure data. Time series are plotted in Appendix K with observations recorded at NW B. As there was only a few days of good wind and wave data for NW A, NW B was used for validation instead.

For the temperature, there's a good agreement excluding occasional events which can be caused by the location difference for temperature. As shown in the time series, there is little variation in the temperature during the month so the validation for correlation is not well tested, although still achieved a correlation coefficient of 0.87.

For the Barometric pressure the correlation is 1.00 confirming the data.

The wind speed and direction show good agreement with a correlation coefficient for wind speed of 0.93 and for direction 0.97. The wind speed measured at the K13 platform is typically 10% less than the LiDARs which has been consistently observed from IJV location as well.

The trends (moments of high measurements, pattern of increase and decrease) are similar in the measured and reference data sets, showing that no systematic errors seem to be present in the measured data.

10.2.1 Wind Speed Events > 10.8 m s^{-1}

To inspect wind events greater than 10.8 m s^{-1} in greater detail, in Appendix K weekly plots are provided of wind speed with a horizontal line depicting the threshold. Note the threshold applies to surface winds however the wind speeds from ~50 m are plotted due to the availability of the reference.

The wind threshold was exceeded for about half the month including the following days:

- 2-8 December
- 15 December
- 17-20 December
- 21 December
- 24-31 December

The time series demonstrates similar behaviour during wind events with excellent agreement between the 2 buoys (for the period of data overlap 1-13 December) and good agreement with the reference located further away, causing no concern for measurement error.

10.3 Wave Validation

Reference wave height, period and direction data were acquired from the K13 Buoy and compared to observations recorded at NW A and B. Time series are plotted in Appendix K, and show good agreement at all times and against NW B:

H_s had a correlation slope of 0.97 and coefficient of 0.98.

Tz had a correlation slope of 1.02 and coefficient of 0.95.

The mean direction had an intercept of 0.7º and correlation of 0.98.

10.3.1 Wave Events H_s > 4 m

H_s exceeded 4 m on the 30th December when only NW B was on site, and showed good agreement with the reference buoy at K13.

Maximum H_s for the month of December was recorded during this period at 4.2 m.

10.4 Current Validation

Reference data from the NWS Model (10 and 20 m depths) were used for current validation. Time series are plotted in Appendix K with observations recorded at NW A and B.

The agreement in sea surface temperature is very good with the same trends and a correlation coefficient of 0.98.

The agreement in current speed and direction is good with a correlation slope for NW against the reference being 0.98 and correlation coefficient 0.99. The model data fit close to the two-measurement data sets. Since the trends in the reference model and measured data are the same, no systematic errors seem to be present in the measured data.

10.5 Tide Validation

Reference data from the NWS Model were used for tide validation. Time series are plotted in Appendix K with observations recorded at NW A and B.

The sea surface height data from the NWS model is available as sea surface height above geoid (m). An offset of 0.4 m was applied to the reference data for ease of comparison to the measured data to align the vertical heights. The agreement in water levels is good with the same trends at the same time indicating no systematic errors are present in the measured data. The model shows slightly more tidal range, within the errors expected from modelling.

11 CONCLUSION

Measurements at NW have been completed for the month of December 2022 by two RPS LiDAR Buoys deployed 1 km apart at the NW site with the following results:

- On the 13th of December, NW A buoy (serial number 107) drifted due to third party interference and was not able to be replaced during the remainder of December due to weather conditions that made the work unsafe. This has resulted in only the first ~13 days of data for NW A being available. The coastguard was notified by a fishing vessel that the buoy was drifting (and therefore a navigation hazard) following an incident the fishing vessel had with the mooring. The coastguard informed RPS of the incident and collected the buoy.
- The NW B buoy (serial number 101) had been shown to have both wind generators failed whilst one is required for power budget in the winter, so this buoy was recovered and replaced with Lidar Buoy 106 on 11th December with no data gap resulting.
- System availability for the NW B buoy was 98 to 100% for all parameters, with NW A only ~39% due to drifting off location.
- Post QC data availability > 95% from NW B and buoy, and ~39% for NW A.
- Measurements validate well for the RPS LiDAR buoys against each other when available, such that it can concluded the sensors have worked well with no indication of malfunction. Accuracy levels claimed by the sensor manufacturers are substantiated by the validations.
- Measurements have been validated against independent sources, which eliminates the possibility of measurement errors common to the two buoys.
- Although for the second half of December there was only one buoy on site, the earlier validation for two LiDAR buoys at the same site, and the month-long validation against the reference data set remain conclusive about the good quality of the data collected for the whole month,

There was one storm events during the month of December 2022 where significant wave height was close to 4.2 m, and wind speed to 25 ms^{-1} at height.

12 REFERENCES

1. Carbon Trust Offshore Wind Accelerator: Roadmap for the Commercial Acceptance of Floating LiDAR Technology (Version 2.0, 9th October 2018)

TABLES

Location Name	Latitude (WGS84)	Longitude (WGS84)	Nominal Water Depth (m LAT)	Deployment Period (UTC)	Buoy Serial Number / Mooring	Deployment ID#	Instrument Type	Instrument Model	Instrument Serial Number	Sensor Height (m AMSL)
NW A	53°22'44"N	3°07'51"E	29.1	23/05/2022 08:55 - 02/11/2022 23:00	106	J3707:03:NW:A:01	LiDAR	300M	876	3.3
							LiDAR Met.	Airmar 150WX	60008017	3.7
							Anemometer	WOII	1922004	3.7
							ADCP	Signature 500	103012	1.8 (m BMSL)
							MRU	MRU-5	26004	0.0
							GNSS Tide	OEM7700	BMHR 19190043R	3.6
							AT/BP	Vaisala WTX534	T3633913	3.6
				23/05/2022 08:55 - 29/11/2022 13:40	Independent	J3707:08:NW:A:01	Tide	WLR 7	1538	0.45 (m ASB)
					Mooring	J3707:07:NW:A:01	ADCP	Workhorse 600 kHz	24466	3.0 (m ASB)
NW A	53°23'28"N	3°07'87"E	29.1	29/11/2022 09:30 – 12/12/2022 07:30	107	J3707:06:NW:A:02	LiDAR	300M	925	3.3
							LiDAR Met.	Airmar 150WX	60663334	3.7
							Anemometer	WOII	1922006	3.7
							ADCP	Signature 500	103318	1.8 (m BMSL)
							MRU	MRU-5	26017	0.0
							GNSS Tide	OEM7700	DMMU 21200157D	3.6
							AT/BP	Vaisala WTX534	T3633943	3.6

Table 2.1 Cumulative LiDAR buoy deployment locations and dates with instrument serial numbers and heights for NW A from May 2022.

Location Name	Latitude (WGS84)	Longitude (WGS84)	Nominal Water Depth (m LAT)	Deployment Period (UTC)	Buoy Serial Number / Mooring	Deployment ID#	Instrument Type	Instrument Model	Instrument Serial Number	Sensor Height (m AMSL)
NW B	53°22'44"N	3°06'57"E	29.6	03/06/2022 14:55 – 11/12/2022 11:47	101	J3707:04:NW:B:01	LiDAR	300M	1174	3.3
							LiDAR Met.	Airmar 150WX	60667571	3.7
							Anemometer	WOII	2137002	3.7
							ADCP	Signature 500	103000	1.8 (m BMSL)
							MRU	MRU-5	25081	0.0
							GNSS Tide	OEM7700	BMHR 21420112P	3.6
							AT/BP	Vaisala WTX534	T3633920	3.6
NW B	53°23'16"N	3°06'58"E	29.1	12/12/2022 09:00 – present	106	J3707:10:NW:B:02	LiDAR	300M	876	3.3
							LiDAR Met.	Airmar 150WX	60008017	3.7
							Anemometer	WOII	1922004	3.7
							ADCP	Signature 500	103012	1.8 (m BMSL)
							MRU	MRU-5	26004	0.0
							GNSS Tide	OEM7700	BMHR 19190043R	3.6
							AT/BP	Vaisala WTX534	T3633913	3.6

Table 2.2 Cumulative LiDAR buoy deployment locations and dates with instrument serial numbers and heights for NW B from June 2022.

Instrument Type	Transmitted Parameter	Min	Max	Resolution
LiDAR Data	Tilt RMS	0	25.4	0.2
	Tilt Max	0	50.8	0.4
	Pitch	-25.5	25.5	0.1
	Roll	-25.5	25.5	0.1
	Compass #1	0	359	1
	M200 Wind Speed	0	81.91	0.01
	M200 Wind Gust	0	81.91	0.01
	M200 Wind Dirn	0	359	1
	M200 Wind Sigma Theta	0	255	1
	Lidar Met Wind Speed	0	81.91	0.01
	Lidar Met Wind Dirn	0	359	1
	Lidar Met Air Temp	-30	72.35	0.05
	Lidar Met BP	860	1064.7	0.1
	Lidar Met RH	0	100	1
	Lidar Compass	0	359	1
	Lidar max tilt	0	63	1
	Lidar wind speed 1 to 11	0	131.071	0.001
	Lidar wind dirn 1 to 11	0	359	1
	Lidar TI 1 to 11	0	3.3554431	0.0000001
	Lidar wind vert comp 1 to 11	-32.767	32.767	0.001
Tide Data	Tide Height	32-bit floating point	32-bit floating point	32-bit floating point
	Height Sigma	0	0.51	0.002
	differential age	0	31	1
	solution age	0	31	1
	SVs	0	31	1
	solutions SVs	0	31	1
	VDOP	0	6.2	0.2
Signature Data	heading	0	359	1
	pitch	-90	165	1
	roll	-90	165	1
	temperature	-30	72.35	0.05
	speed of sound	1400	1655	1
	blank	0	163.83	0.01
	cell	0	163.83	0.01
	east/north/vert/err comp 1 to 5	-4.095	4.095	0.002
	beams 1 to 4 for bins 1 to 5	0	255	1
Wave Data*	Latitude	-90	90	0.0001
	Longitude	-180	180	0.0001
	Sea Swell Sep	0	25.5	0.1
	Hs total, sea, swell (recalculated)	0	12.7	0.1
	Tp total, sea, swell (recalculated)	0	31.75	0.25
	Theta peak total, sea, swell (recalculated)	0	359	1
	Hmax	0	25.4	0.2
	THmax	0	31.75	0.25

Table 2.3 Data transmission range and resolution.

* Spectra is compressed from 128 bins to 31 (Seatex) and floating-point numbers are adjusted to dynamic range (0 to max) before being transmitted as 7 bits with one extra sign bit.

Site	Parameter	Sample Height (m AMSL)	Post-processed Data Availability %	
			NW A	NW B
Met.	AT	3.7	39.7	98.7
	BP	3.7	39.7	98.7
	WindSpd	200	39.6	98.1
		180	39.6	98.4
		160	39.6	98.3
		140	39.7	98.4
		120	39.7	98.4
		100	39.7	98.6
		70	39.7	98.6
		41	39.7	98.5
		30	39.7	98.6
	WindDirn	200	39.4	97.9
		180	39.4	98.2
		160	39.4	98.1
		140	39.5	98.2
		120	39.5	98.2
		100	39.5	98.4
		70	39.5	98.4
		41	39.5	98.4
		30	39.5	98.4
Waves	Hs	0	39.8	100
	HsSea	0	39.8	100
	HsSwell	0	39.8	100
	SpreadP	0	39.8	100
	ThetaM	0	39.8	100
	ThetaMSea	0	39.8	100
	ThetaMSwell	0	39.8	100
	ThetaP	0	39.8	100
	Tm	0	39.8	100
	TmSea	0	39.8	100
	TmSwell	0	39.8	100
	Tp	0	39.8	100
Currents	WaterTemp	-1.8	39.7	100
	CurSpd	-9.3	39.7	100
		-13.3	39.7	100
		-17.3	39.7	100
		-21.3	39.7	100
		-25.3	39.7	100
	CurDirn	-9.3	39.7	100
		-13.3	39.7	100
		-17.3	39.7	100
		-21.3	39.7	100
		-25.3	39.7	100
Tides	Tide	0	36.5	88.4

Table 7.4 NW A and NW B post-processed availability for reporting month of December 2022 for each parameter.

Month Year	Parameter	System Data Availability %		Post-processed Data Availability %	
		NW A	NW B	NW A	NW B
December 2022	Air Temperature	39.7	98.8	39.7	98.7
	Barometric Pressure	39.7	98.8	39.7	98.7
	Currents*	39.7	100	39.7	99.9
	Tides	39.7	98.7	36.5	88.4
	Water Temperature	39.7	100	39.7	100
	Waves	39.8	100	39.8	100
	Wind**	39.7	98.8	39.6	98.3
November 2022	Air Temperature	99.9	95.7	99.8	95.7
	Barometric Pressure	99.9	95.7	99.8	95.7
	Currents*	100	100	97.1	99.9
	Tides	99.9	95.7	99.5	94.7
	Water Temperature	100	100	100	100
	Waves	11.9	100	11.9	100
	Wind**	11.9	95.7	11.6	95.3
October 2022	Air Temperature	99.0	96.6	98.9	96.6
	Barometric Pressure	99.0	96.6	97.2	96.6
	Currents*	100	100	99.4	99.3
	Tides	99.0	96.6	91.9	94.8
	Water Temperature	100	100	100	>99.9
	Waves	100	100	>99.9	>99.9
	Wind**	99.0	96.6	98.7	96.4
September 2022	Air Temperature	98.1	95.6	98.1	95.6
	Barometric Pressure	98.1	95.6	96.7	94.7
	Currents*	100	100	99.9	99.9
	Tides	98.1	95.6	87.4	91.1
	Water Temperature	100	100	100	100
	Waves	100	100	100	100
	Wind**	98.1	95.6	97.3	94.8
August 2022	Air Temperature	97.6	97.7	97.6	96.8
	Barometric Pressure	97.6	97.7	97.6	96.1
	Currents*	100	99.1	86.2	85.4
	Tides	97.6	97.7	89.9	92.0
	Water Temperature	100	99.1	100	99.1
	Waves	97.4	97.7	97.4	97.7
	Wind**	97.6	97.7	96.6	95.9
July 2022	Air Temperature	99.3	98.5	99.3	95.2
	Barometric Pressure	99.3	98.5	99.3	95.2
	Currents*	100	100	85.0	85.0
	Tides	99.3	98.5	89.8	92.1
	Water Temperature	100	100	100	100
	Waves	99.3	98.5	99.3	98.5
	Wind**	99.3	98.5	98.8	94.7

Table 7.5 Historic monthly system availability and post-processed availability percentages for NW A and NW B for each parameter group from June 2022.

* Average data availability % of current speed and direction was calculated for the valid bins from 6 m BSL to 4 m above seabed.

** Average data availability % of Wind Speed and Direction from 9 heights (30 to 200 m AMSL). Heights above 200 m are beyond the LiDAR's certified range and excluded from data availability calculations.

Month Year	Parameter	System Data Availability %		Post-processed Data Availability %	
		NW A	NW B	NW A	NW B
June 2022	Air Temperature	98.8	98.6	98.5	98.6
	Barometric Pressure	98.8	98.6	98.4	98.5
	Currents*	100	100	85.0	85.0
	Tides	98.8	98.6	89.1	91.6
	Water Temperature	100	100	100	100
	Waves	98.8	98.6	98.8	98.5
	Wind**	98.8	98.6	97.2	97.3

Table 7.6 Historic monthly system availability and post-processed availability percentages for NW A and NW B for each parameter group from June 2022.

* Average data availability % of current speed and direction was calculated for the valid bins from 6 m BSL to 4 m above seabed.

** Average data availability % of Wind Speed and Direction from 9 heights (30 to 200 m AMSL). Heights above 200 m are beyond the LiDAR’s certified range and excluded from data availability calculations.

FIGURES

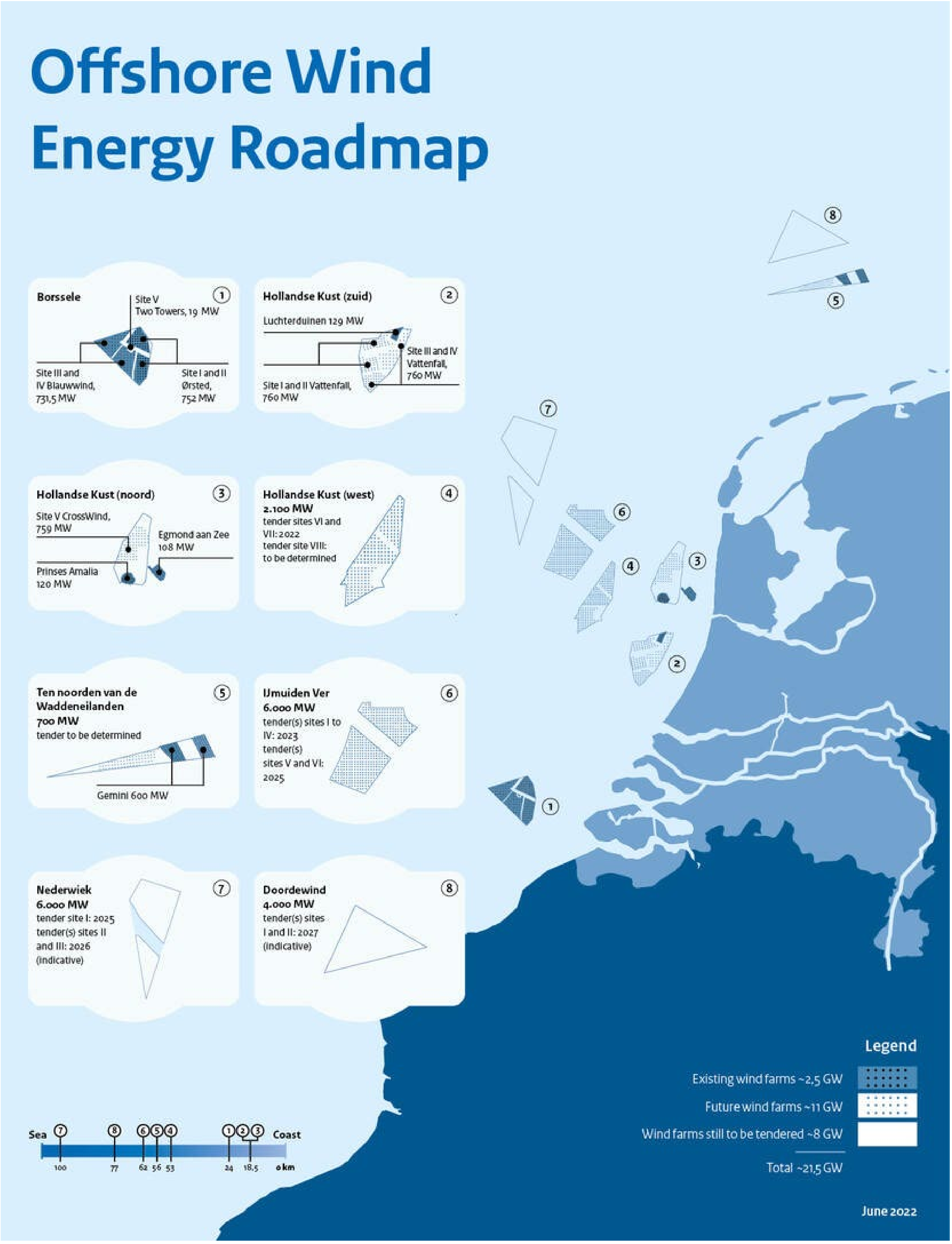


Figure 1.1 Dutch Offshore Wind Energy Roadmap.

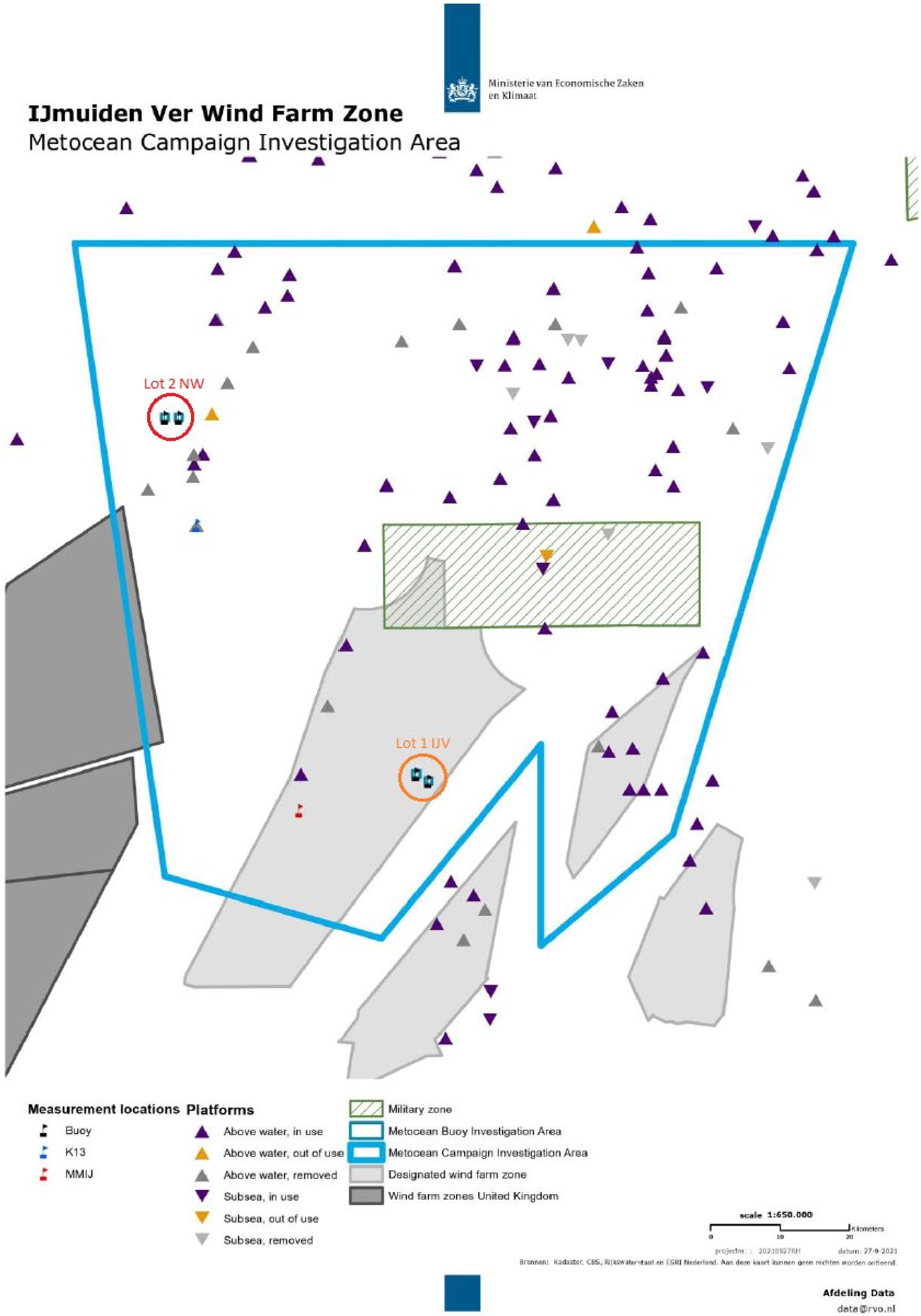


Figure 1.2 Location map of NW within the metocean campaign investigation area.

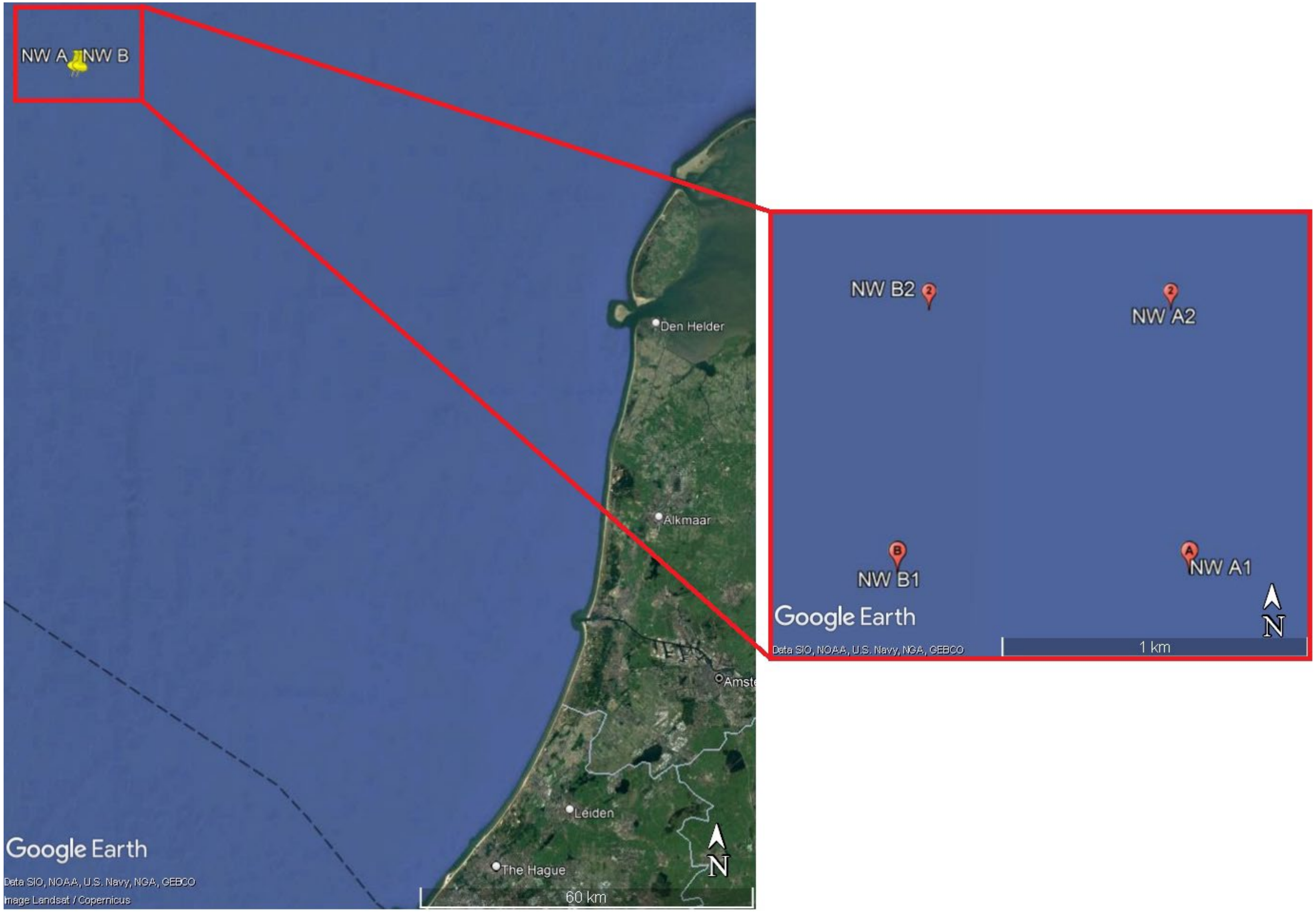


Figure 1.3 Location map of NW A and NW B relative to Den Helder.

Appendix A
Field Logs

DAILY FIELD LOG - SUMMARY

MAKING COMPLEX EASY

CLIENT:	Netherlands Enterprise Agency	**DATE OF VISIT:**	22/05/2022 – 03/06/2022
LOCATION:	Den Helder	**PROJECT NO:**	MMF03707
OPERATION:	NW Lidar Installation	**VESSEL NAME:**	Voe Earl, Teddy
PERSONNEL:	Kingsley Greville, Sharif Bruce, Iain Carr, Haseeb Seeni, Maan Bruce.	**# VESSEL CREW:**	4 and 4

Time Zone Details:	(UTC+2)
Time	**Details of Work Undertaken**
	Sunday 22/05/2022
	Load Vessel and prepare mooring at port of Den Helder.
12:00	Depart Den Helder Port for NW_A1 Location.
	Monday 23/05/2022
09:40	Commence deployment of NW_A1 Lidar Buoy Mooring.
10:45	Deployment complete.
11:00	Depart for Port of Den Helder.
	Tuesday 24/05/2022 – 01/06/2022 = Weather Standby
	Wednesday 1/6/2022
	Load Vessel and prepare mooring at port of Den Helder.
17:00	Depart port for NW B1 location.
	Thursday 2/6/2022
16:10	Commence deployment of NW_B1 Lidar Buoy Mooring.
16:55	Deployment complete.
17:00	Depart for Port of Den Helder.
	Friday 3/6/2022
07:30	Arrive at Port of Den Helder, vessel demobilised.

DAILY FIELD LOG

Deployment:

Mooring	Latitude Longitude (WGS84)	Instrument	Water Depth (LAT)	Deployed (UTC+2)
NW_A1 *RPS LiDAR 4.5 Buoy*	53° 22.745'N 3° 07.856'E	RPS Lidar 4.5 Buoy - 106	29.1m	1055 23/05/2022
NW_A1 *Recovery Clump*	53° 22.857'N 3° 07.933'E		29.1m	1055 23/05/2022
NW_B1 *RPS LiDAR 4.5 Buoy*	53° 22.744'N 3° 06.951'E	RPS Lidar 4.5 Buoy - 101	29.6m	1655 02/06/2022
NW_B1 *Recovery Clump*	53° 22.837'N 3° 07.809'E		29.6m	1655 02/06/2022

Spare Buoy Details	Instrument
RPS LiDAR 4.5 Buoy	RPS Lidar 4.5 Buoy - 107

RPS Personnel:
Kingsley Greville
Sharif Bruce
Iain Car
Maan Bruce

Client Representative:
Wim Zuijderduijn

Voe Earl Vessel Crew:
Michael Henderson
Mark Fullard
Mark Furgason
Peter Bates

Teddy Vessel Crew:
Dennis Vanjersel
Marcel Epema
Ryan Balesteros
Ranel Layderos

Field Log Prepared by: Kingsley Greville

Field Log Checked by: Michael Wiegele

DAILY FIELD LOG

CLIENT:	Netherlands Enterprise Agency	**DATE OF VISIT:**	28 - 30/11/2022
LOCATION:	Den Helder	**PROJECT NO:**	MMF03707
OPERATION:	NW_A2 Buoy deployment and NW_A1 broken mooring recovery	**VESSEL NAME:**	Coastal Vanguard
PERSONNEL:	Jack Stanton, Anthony Gaffney	**# VESSEL CREW:**	4 and 2

Time Zone Details:	(UTC+1)
Time	**Details of Work Undertaken**
Monday 28th November	
08:00	RPS board Coastal Vanguard.
11:20	Begin towing buoy Heading for NW A2.
Tuesday 29th November	
08:45	Commence deployment operations.
9:50	Deployment complete
10:40	Commence recovery.
14:40	Recovery complete.
17:00	Commence ADCP mooring deployment.
17:25	ADCP mooring deployed
17:35	Clean up of deck and prepare to steam to Den Helder
Wednesday 30th November	
5:15	Arrive port of Den Helder and demobilise vessel.

DAILY FIELD LOG

Deployment:

Mooring	Latitude Longitude (WGS84)	Instrument	Water Depth (LAT)	Deployed (UTC+2)
NW_A2 *RPS LiDAR 4.5 Buoy*	53° 23.276'N 3° 7.866'E	RPS Lidar 4.5 Buoy - 107	30.2m	09:30 UTC+1 29/11/2022
NW_A2 *Recovery Clump*	53° 23.314'N 3° 8.067'E		30.2m	09:50 UTC+1 29/11/2022
NW_A1_ADCP	53°22.603'N 03°08.090'E	ADCP – 9832	30.6m	17:25 UTC+1 29/11/2022

Recovery:

Mooring	Latitude Longitude (WGS84)	Instrument	Water Depth (LAT)	Deployed (UTC+2)
NW_A1 *RPS LiDAR 4.5 Buoy*	53° 23.276'N 3° 7.866'E	Buoy had broken the mooring and drifted.	29.1m	14:40 UTC+1 29/11/2022
NW_A1 *Recovery Clump*	53° 23.314'N 3° 8.067'E		29.1m	14:00 UTC+1 29/11/2022

Spare Buoy Details	Instrument
RPS LiDAR 4.5 Buoy	RPS Lidar 4.5 Buoy - 106

DAILY FIELD LOG

RPS Personnel:
Jack Stanton
Anthony Gaffney

Client Representative:
Not Present Offshore

Voe Earl Vessel Crew:
J.J. Rotgans
C.Lyashchenko
H Visser
V. Koel
A.Ysbrandy

Spare buoy was not out of service for this campaign.

Field Log Prepared by: Jack Stanton

Field Log Checked by: Kingsley Greville

DAILY FIELD LOG

CLIENT:	Netherlands Enterprise Agency	**DATE OF VISIT:**	10/12/2022 – 12/12/2022
LOCATION:	Den Helder	**PROJECT NO:**	MMF03707
OPERATION:	NW_B2 (106) Lidar Buoy Deployment NW_B1 (101) Lidar Buoy Recovery	**VESSEL NAME:**	Coastal Vanguard
PERSONNEL:	Iain Carr	**# VESSEL CREW:**	5

Time Zone Details:	(UTC+1)
Time	**Details of Work Undertaken**
	Saturday 10th December
08:30	Project induction, vessel loading JHA with crew.
09:00	Load and prepare equipment on back deck of Coastal Vanguard.
10:30	Lift buoy 106 into water and secure towing ropes.
13:00	Buoy towing JHA with crew.
13:45	Depart for NW B2.
	Sunday 11th December
08:45	Daily start brief, JHA and Toolbox talk for deployment
09:00	Pass over deployment location, 32m deep 1.5m tide
09:33	Buoy 106 2.4T anchor deployed
09:55	Buoy 106 700kg recovery anchor deployed
10:40	JHA and Toolbox talk for recovery
11:00	Acoustic release opened, small float on surface, recovery commence
12:47	Buoy 101 recovered, proceed to Den Helder
	Monday 12th December
1200	Arrive back at Den Helder and demobilse Coastal Vanguard.

DAILY FIELD LOG

Deployment:

Mooring	Latitude Longitude (WGS84)	Instrument	Water Depth (Echo Sounder)	Deployed (UTC+1)
NW_B2 *RPS LiDAR 4.5 Buoy*	53° 23.279'N 3° 06.980'E	RPS Lidar 4.5 Buoy - 106	32m	10:00 11/12/2022
NW_B2 *Recovery Clump*	53° 23.194'N 3° 7.081'E		32m	10:00 11/12/2022

Recovery:

Mooring	Latitude Longitude (WGS84)	Instrument	Water Depth (Echo Sounder)	Recovered (UTC+1)
NW_B1 *RPS LiDAR 4.5 Buoy*	53° 22.744'N 3° 06.951'E	RPS Lidar 4.5 Buoy - 101	29.6m on deployment	12:47 11/12/2022
NW_B1 *Recovery Clump*	53° 22.837'N 3° 06.809'E		29.6m on deployment	12:47 11/12/2022

Spare Buoy:

Spare Buoy Details	Instrument
RPS LiDAR 4.5 Buoy	RPS Lidar 4.5 Buoy - 101

RPS Personnel:
Iain Carr

Client Representative:
Jan van Houten

Vessel Crew:
C.Ijsbrandij
V Popovs
H Visser
V Koel
J Rotgans

Comments:
Lidar Buoy 101 was continually working and was recovered due to low battery power. On return to Den Helder Buoy 101 had 2 wind generators replaced. The buoy and spare mooring were available as a working spare by end of day 13/12/2022.

DAILY FIELD LOG

Field Log Prepared by: Iain Carr

Field Log Checked by: Kingsley Greville

DAILY FIELD LOG

CLIENT:	Netherlands Enterprise Agency	**DATE OF VISIT:**	13/12/2022 – 14/12/2022
LOCATION:	Den Helder	**PROJECT NO:**	MMF03707
OPERATION:	NW_A2 Buoy (107) Drifting Buoy Recovery	**VESSEL NAME:**	Terschelling
PERSONNEL:	No RPS Personnel Present on Vessel	**# VESSEL CREW:**	

Time Zone Details:	(UTC+1)
Time	**Details of Work Undertaken**
Tuesday 13th December	
08:30	NW_A2 Lidar buoy 107 has incident with fishing vessel causing it to break away from mooring (approximate time from transmitted data. Fishing interference notified by the coastguard).
17:30	Vessel Terschelling is mobilised by the Coastguard to retrieve the buoy.
Wednesday 14th November	
01:43	Buoy is retrieved by vessel Terschelling, lifted on board for return to Den Helder.
09:30	Vessel alongside Den Helder Wharf. Buoy demobilised from vessel.

Recovery (Off location):

Mooring	Latitude Longitude (WGS84)	Instrument	Water Depth (LAT)	Recovered (UTC+1)
NW_A2 *RPS LiDAR 4.5 Buoy*	53°25.884'N 03°06.752'E	RPS Lidar 4.5 Buoy - 107	Unknown	01:43 UTC+1 14/12/2022

Notes:

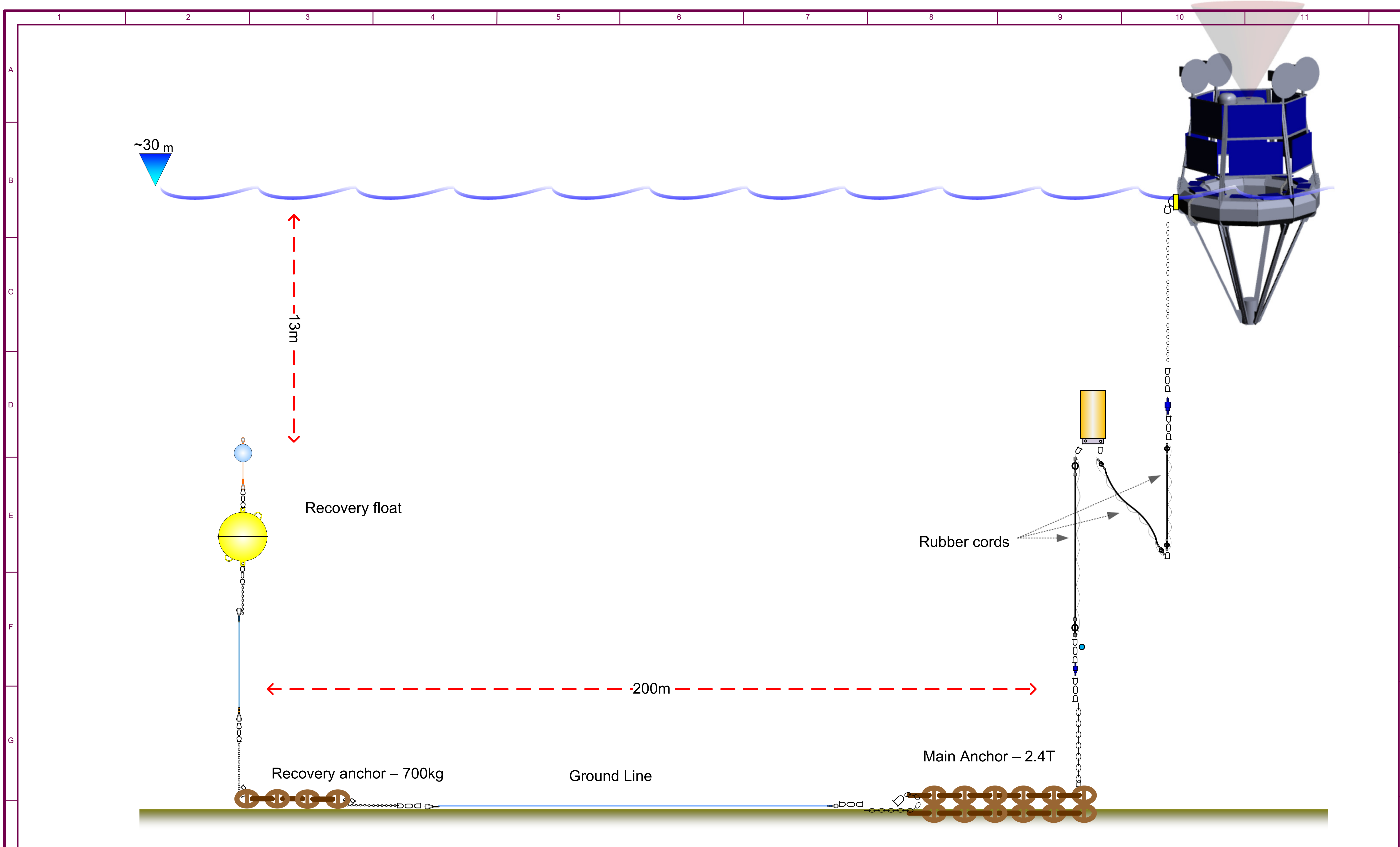
The coastguard was contacted by a fishing vessel following the incident with the buoy and mooring. The coastguard informed RPS that the fishing vessel reported the buoy drifted away from the mooring following the incident.

Lidar buoy 107 had 1 broken solar panel which was replaced immediately when buoy was lifted on to Den Helder wharf. Buoy and mooring were available for redeployment from 14/12/2022.

Field Log Prepared by: Kingsley Greville

Field Log Checked by: Kingsley Greville

Appendix B
Mooring Diagrams



* Note: Drawing not to scale

rps MAKING COMPLEX EASY

TITLE	PROJECT	CLIENT
Lidar Buoy Mooring Design	Lidar Buoy (30m)	RVO

JOB No.	
DRAWING No.	
DATE:	17/01/2022
DESIGNED	GMB
CHECKED	GKW
DRAWN	MCW
CLIENT	

Appendix C
Instrument Specifications

RPS LIDAR 4.5 BUOY

The RPS LIDAR 4.5 Buoy is designed for reliability with redundancy in the power, data logging and communication systems.

Overview

Our buoy has Level 2 accreditation from DNV-GL in the context of the Carbon Trust Offshore Wind Accelerator Roadmap for the Commercial Acceptance of Floating Lidar Technology.

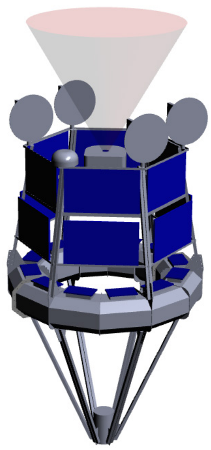
RPS has build and validated 2 LiDAR 4.5 Buoys, with another 2 built and due to be validated by the end of 2019.

Data Security

Two-way satellite communication methods including Iridium Pilot and 4G ensure all raw data are transmitted from the buoy daily.

On-board high capacity data logging using the RPS M200 data loggers allows for raw data to be stored on two loggers on the buoy.

Antitheft measures include security bolts that require specialized tooling.



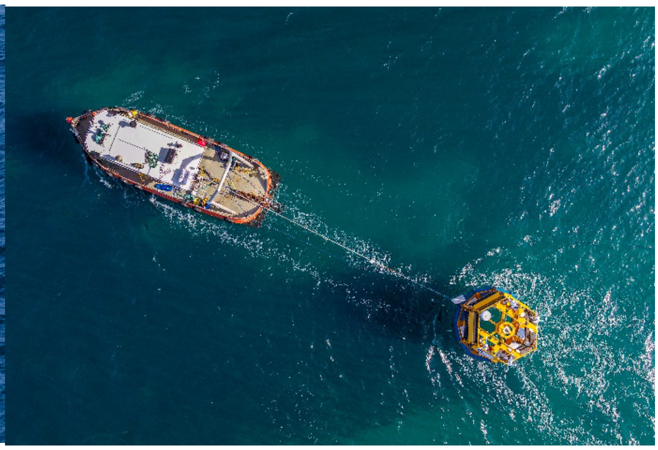
We offer:

- Weight 4800 kg, with 2780 kg of excess buoyancy
- The dodecagon hull diameter is 4.65 m
- Supports a Zephyr 300M LiDAR
- Buoy motion data is captured using data from a KONGSBERG MRU 5 Motion Reference Unit and GNSS Compass.
- Dual redundant logging and transmission systems to minimise risk of costly data loss or site repair visit.
- Stable platform for wind measurements and communications.
- Main data transmission is on 4G modem or Iridium Pilot with raw data transmitted daily.
- Additional dual Iridium transmission systems for 10 minute mean data in real time.
- Electronics and batteries are sunken into the buoy hull for protection.
- Dual satellite location tracking beacons.
- Large capacity solar and wind power supply charging batteries.
- A zero emission buoy

Specifications

Standard parameters are included in the following table.

Parameter	Range	Accuracy	Resolution
GNSS heading	0 to 360°	±0.2°	0.001°
MRU pitch and roll	±180°	0.02° RMS	0.001°
MRU Gryo	±149°/s	0.08% RMS	0.001°/s
MRU acceleration	±30m/s^2	0.01 m/s^2 RMS	0.001 m/s^2
MRU heave	±50m	5 cm or 5%, whichever is greater	0.01m
LiDAR - 10 to 200m profile			
LiDAR wind speed	1 to 70 m/s	0.1m/s	0.001 ms-1
LiDAR wind direction	0 to 360°	±0.5°	0.0001°
Wind Observer /wind speed	1 to 60 m/s	±2%	0.01 ms^{-1}
Wind Observer/wind dir	0 to 360°	±2%	1°



Contact:

RPS

31 Bishop Street
Jolimont

Western Australia 6014

+61 8 9387 7955

metocean@rpsgroup.com

www.rpsgroup.com/mst

OUR WIND LIDARS

THE ORIGINAL AND MOST VALIDATED LIDAR SENSORS

ZephIR 300M

THE INDUSTRY-STANDARD OFFSHORE WIND LIDAR.

ZephIR 300M

FULLY-MARINISED AND DESIGNED SPECIFICALLY FOR USE OFFSHORE.

10 to 200+ metre wind measurements from deck.

Extensive 3 year service life ensuring the lowest cost of ownership of any offshore lidar available.

A complement, replacement or substitute for offshore masts.

Has been installed and proven for use on all market-ready floating lidar platforms.

Validated across multiple pre-commercial floating deployments and mast replacements on fixed platforms.

PRODUCT SPECIFICATIONS

ZephIR 300

MEASUREMENTS

RANGE	0 - 10m (Onboard MET Weather Station) 10 - 200m (Lidar measurement)
PROBE LENGTH @10m @100m	± 0.07 metres 100m ± 7.70 metres
HEIGHTS MEASURED	10 User Configurable 1 additional MET Weather Station measurement
SAMPLING RATE	50Hz (Up to 50 measurement points every second)
AVERAGING RATE	True 1-second averaging 10 minute averaging
ACCURACY Wind speed Direction variation Range	0.1m/s ‹ 0.5° ‹ 1 m/s to 70 m/s

PRODUCT

SERVICE INTERVAL	36 Months from new
SIZE WEIGHT	900 x 900 x 1001mm 55kg
IP RATING	IP 67
POWER CONSUMPTION POWER INPUT	69W 12V
TEMPERATURE RANGE	-40 + 50°C
WARRANTY MAINTENANCE	3 Years No annual maintenance or calibration in this period

ZephIR DM

MEASUREMENTS

RANGE	At Installati on (Onboard MET Weather Station) 10 - 300m (Lidar measurement)
PROBE LENGTH @10m @100m	± 0.07 metr es 100m ± 7.70 metres
RANGES MEASURED	10 User Con figurable 1 additional MET Weather Station measurement
VERTICAL SLICES MEASURED	True Hub Height (motion compensated) Up to 12 ad ditional slices
SAMPLING RATE	50Hz (Up to 50 measurement points every second)
AVERAGING RATE	True 1-seco nd averaging 10 minute a veraging
ACCURACY Wind speed Direction variation Range	0.1m/s ‹ 0.5° ‹ 1 m/s to 7 0 m/s

PRODUCT

SERVICE INTERVAL	24 Months f rom new
SIZE OF POD WEIGHT OF POD	534 x 544 x 846mm (Legs tailored to deployment) 45kg
IP RATING	IP 67
POWER CONSUMPTION POWER INPUT	85W 12V
TEMPERATURE RANGE	-25 + 50°C
WARRANTY MAINTENANCE	2 Years No annual maintenance or calibration in this period

ZephIR 300M

MEASUREMENTS

RANGE	0 - 10m (Onboard MET Weather Station) 10 - 200m (Lidar measurement)
PROBE LENGTH @10m @100m	± 0.07 metres 100m ± 7.70 metres
HEIGHTS MEASURED	10 User Configurable 1 additional MET Weather Station measurement
SAMPLING RATE	50Hz (Up to 50 measurement points every second)
AVERAGING RATE	True 1-second averaging 10 minute averaging
ACCURACY Wind speed Direction variation Range	0.1m/s ‹ 0.5° ‹ 1 m/s to 70 m/s

PRODUCT

SERVICE INTERVAL	36 Months from new
SIZE WEIGHT	900 x 900 x 1001mm 55kg
IP RATING	IP 67
POWER CONSUMPTION POWER INPUT	69W 12V
TEMPERATURE RANGE	-40 + 50°C
WARRANTY MAINTENANCE	3 Years No annual maintenance or calibration in this period

Power consumptions provided subject to ZephIR Power Guide available on request.
Largest single component weight / size shown - for transport weight and dimensions please contact us.

CURRENT PROFILER

Signature500

Mean currents and turbulence, plus wave height, direction and ice tracking

The Signature500 ADCP is designed for flexibility. It measures current profiles at up to 8 Hz sampling frequency. It can also measure direct vertical velocity profiles, wave height and direction, and acoustic ranging to ice. The center beam also functions as a biological echosounder, enabling high-resolution measurements of biomass in the water column. All these features can be combined using Nortek's patented concurrent mode technology.

CURRENT PROFILER

Signature500

Highlights

- Five beams for mean currents and turbulence
- Wave height and direction
- Acoustic ranging to ice

Applications

- Turbulence studies
- Tidal turbine operations
- Studies of tidal currents
- Sediment transport studies
- Ice drift and draft studies
- Vessel-mounted coastal surveying
- Plankton migration studies
- Biomass measurements
- Directional wave measurements
- Suitable for wave buoys

CURRENT PROFILER

Signature500

Technical specifications

→ Water velocity measurements	
Maximum profiling range1)	60 m (burst mode), 70 m (average mode)
Cell size	0.5-4 m
Minimum blanking	0.5 m
Maximum number of cells	256 (burst)/200 (average)
Velocity range (along beam)	User-selectable 2.5 or 5.0 m/s
Minimum accuracy	0.3% of measured value ± 0.3 cm/s
Velocity precision	Broadband processing, consult instrument software
Velocity resolution	0.1 cm/s
Max sampling rate	8 Hz (4 Hz using 5 beams)
→ HR option (on 5th beam only)	
Velocity range	N/A
Cell size	N/A
Profiling range	N/A
Range velocity limitations	N/A
→ AD2CP measurement modes	
Single	Burst or average
Concurrent	Burst and average
Alternate	Single and/or concurrent
→ Echo intensity (along slanted beams)	
Sampling	Same as velocity
Resolution/ dynamic range	0.5 dB / 70 dB
Transducer acoustic frequency	500 kHz
Number of beams	5; 4 slanted at 25°, 1 vertical
Beam width	2.9°
→ Echo sounder option	
Resolution	6 mm - 0.5 m
Number of bins	11,000
Transmit pulse length	32 ?s - 1 ms
Transmit pulse	Monochromatic or pulse compressed (25% BW)
Resolution / dynamic range	0.01 dB / 70 dB
→ Wave measurement option	
AST frequency	500 kHz
AST max distance	75 m

Signature500

NORTEK

Wave measurement option	
Maximum wave measurement depth	60 m
Height range	-15 to +15 m
Accuracy/resolution (Hs)	< 1% of measured value / 2 cm
Accuracy/resolution (Dir)	2° / 0.1°
Period range	1-50 s
Cut-off period (Hs)	5 m depth; 0.6 sec, 20 m depth; 1.1 sec, 60 m depth; 1.9 sec
Cut-off period (dir)	5 m depth; 1.5 sec, 20 m depth; 3.1 sec, 60 m depth; 5.5 sec
Sampling rate (velocity and AST)	4 Hz
Ice measurement option	
Parameters	Acoustic ranging to ice, speed and direction, echo sounder data
Sensors	
Temperature:	Thermistor in head (sampled at meas. rate)
Temp. range	-4 to +40 °C
Temp. accuracy/resolution	0.1 °C/0.01 °C
Temp. time response	2 min
Compass:	Solid State magnetometer (max 1 Hz samplerate)
Accuracy/resolution	2° for tilt < 30°/0.01°
Tilt:	Solid State accelerometer (max 1 Hz sample rate)
Accuracy/resolution	0.2° for tilt < 30°/0.01°
Maximum tilt	Full 3D
Up or Down	Automatic detect
Pressure:	Piezoresistive (sampled at meas. rate)
Standard range	0-100 m (inquire for options)
Accuracy/precision	0.1% FS / Better than 0.002% of full scale
AHRS option	
Accelerometer dynamic range	± 2 g
Gyro dynamic range	± 250°/sec
Magnetometer dynamic range	± 1.3 Gauss
Pitch and roll range /resolution	± 90° (pitch) ± 180° (roll) /0.01°
Pitch and roll accuracy	± 2° (dynamic)4), ± 0.5° (static, ±30°)
Heading range / resolution	360°, all axis /0.01°
Heading accuracy	± 3° (dynamic)4), ± 2° (static, tilt < 20°)
Sampling rate	Same as measurement rate (up to 8 Hz)
Data recording	
Capacity	16 GB, 64 GB or 128 GB (inquire for larger capacity)
Data record	Consult instrument software

CURRENT PROFILER

Signature500

Data recording	
Mode	Stop when full
Real-time clock	
Accuracy	± 1 min/year
Clock retention in absence of external power	1 year. Rechargeable backup battery.
Data communications	
Ethernet	10/100 Mbits Auto MDI-X, TCP/IP, UDP/IP, HTTP protocols, Fixed IP / DHCP client /Auto IP address assignment, UPnP and Nortek proprietary instrument discovery over Ethernet
Serial	Configurable RS-232/RS-422 300-1250000 bps
Recorder download baud rate	20 Mbit/s (Ethernet only) - 1 GB in 6 minutes
Controller interface	ASCII command interface over Telnet and serial
Connectors	
Depending on configuration	MCBH6F (Ethernet), MCBH8F (serial), MCBH2F-G2 (pwr), optional Souriau M-series metal connector for online use (10M)
Software	
Functions	Deployment planning, instrument configuration, data retrieval and conversion (for Windows®)
Power	
DC input	12-48 V DC
Maximum peak current	1.5 A
Max. average consumption at 1 Hz	8 W at 1 Hz, Ethernet adds 0.75 W
Typical average consumption	25 mW
Sleep consumption	100 ?A, power depending on supply voltage
Transmit power per beam	0.3-30 W, adjustable levels
Ping sequence	Parallel
Batteries	
Internal	180 Wh alkaline, 540 or 1800 Wh with long canister
Duration	Depending on configuration, consult software
Environmental	
Operating temperature	-4 to +40 °C
Storage temperature	-20 to +60 °C
Vibration	IEC60068-2-64
EMC approval	IEC/EN 61000-6-2, 61000-6-3
Depth rating	300 m (for 6000 m version, contact Nortek for specifications)

Signature500

Materials	
Standard model	POM with titanium fasteners
Dimensions	
Maximum diameter	228 mm
Maximum length with room for internal batteries	274 mm (180 Wh), 464 mm (540 Wh or 1800 Wh Li)
Maximum length without room for internal batteries	184 mm
Weight	
In air, no battery	6.4 kg (5.2 kg short)
In water, no battery	-0.35 kg (0.6 kg short)
Battery	1.8 kg

RPS TIDE SENSOR

RPS has developed a system which can measure water level in real-time that can be fitted to any RPS MetOcean Buoy including the 1.2 m Mini MetBuoy, 2.4 m MetOcean Buoy and the 4.5 m LiDAR Buoy.

Buoy Overview

The toroidal hull design has been used by RPS for over 20 years as the basis for many metocean measurements in shallow to very deep waters.

RPS has a range of toroidal shaped hulls (1.2 m to 4.5 m), which can be customised to carry large payloads. It provides a stable platform for measurements while maintaining a high level of reserve buoyancy. The hull design has continually proven itself in extreme cyclonic conditions over extended deployments, often spanning several years.

Measuring Water Levels

The RPS Tide Sensor utilises a GPS aided inertial navigation system and AHRS that provides accurate position, velocity, acceleration and orientation under the most demanding conditions. It combines temperature calibrated accelerometers, gyroscopes, magnetometers and a pressure sensor with a dual antenna GNSS receiver.

These are coupled with in a sophisticated algorithm and Trimble RTX correction service to provide accurate and reliable orientation data, including correction for buoy layover.

Data is logged using a purpose built RPS data logger at 1 Hz, with 1-minute averaged data transmitted via an Iridium message every 30 minutes.

History

The toroidal buoys have been deployed in water depths ranging from less than 5 m to in excess of 3000 m. Most deployments have been for extended periods of time, usually between 12 to 24 months, however some have also been permanently deployed.

While the hull design has only changed slightly, the superstructure and mooring design have evolved into its present advanced design. Design focus has always been performance and reliability.

Key features:

- Small and stable platform for water level measurements and communications.
- Uses the Trimble RTX correction service with coordinates computed in ITRF2014, current epoch.
- Large canisters for electronics and batteries.
- Solar power supply or battery powered (6 months) in certain applications where solar panels may be at risk of theft.
- Proven record of survivability through extreme conditions.
- Each GNSS buoy can be easily customised to suit the application and client's needs, including additional meteorological, wave and current sensors plus custom logging and telemetry options.
- GNSS receiver can track current and upcoming GNSS constellations including GPS, GLONASS, Galileo, and BeiDou.

Specifications

Using a correction service, the accuracies for horizontal and vertical measurements are:

Performance	Accuracy (RMS)*
Horizontal Accuracy	3 cm
Vertical Accuracy	5 cm

**Calculated from 7-day static data. Accuracy will vary with observing conditions*

Mean Sea Surface to an International Terrestrial Reference Frame (ITRF)

Coordinates and ellipsoid heights are computed in ITRF2014, current epoch to allow transformation to GDA2020. Elevation data can be converted to heights relative to Australian Height Datum (AHD). User specified datums can be utilised upon request. In defining the mean sea surface (MSS) RPS use innovative and proven techniques to isolate tidal and seasonal signals to give an accurate solution for the mean sea surface relative to a datum.

Tidal Analysis

For tidal analysis, RPS designed software uses the versatile harmonic analysis methods of Foreman (2008), Foreman (1972) and Godin (1972) to solve tidal constituent amplitudes and phases to give residual water levels, tidal predictions and solving long term (18.6 years) statistics (e.g. HAT, LAT, MHWS, MHWN).

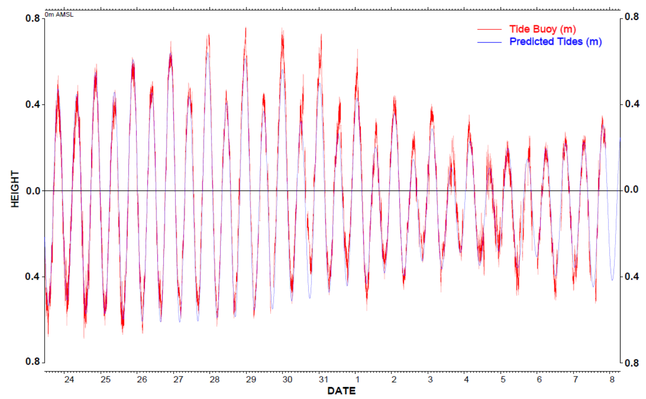
Real time data delivery

The default is for transmission every 30 minutes using an Iridium message, with other transmit intervals available.

Each message contains an overall status message of time, horizontal location and battery voltage, then following on is 30 x 1-minute height values, with associated QA parameters.

30 x 1-minute average messages with

Description	Units	Transmitted range	Comments
ht (height rel WGS84)	m	single precision float	Height relative to WGS84
ht_sigma	m	0 to 255	Range 0 to 0.51 m. Resolution 0.002 m
diff_age	s	0 to 31	Differential age: 0 to 31 s. Average count over the minute, rounded to integer
sol_age	s	0 to 31	Solution age: 0 to 31 s. Average count over the minute, rounded to integer
SVs		0 to 31	Number satellites tracked: 0 to 31. Average count over the minute, rounded to integer
solnSVs		0 to 31	Number satellite vehicles used in solution: 0 to 31. Average count over the minute, rounded to integer
vdop		0 to 31	Vertical dilution of precision VDOP. Range 0 to 6.2 Resolution 0.2. Average over the minute.



Contact us

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VAISALA

Weather Transmitter WXT530 Series

Features

- Right parameter combination
- Easy to use and integrate
- Weather parameter hub
- Analog sensors can be added
- Compact, lightweight
- Low power consumption
- mA output suitable for industrial applications
- Cost-effective
- DNV GL Type Examination

Vaisala Weather Transmitter WXT530 is a unique series of sensors with parameter combinations that allow you to choose what is right for your application. WXT530 is a flexible, integrated building block for weather applications. WXT530 series improves your grip on weather.

Flexibility

WXT530 is a series of weather instruments that provides 6 of the most important weather parameters: air pressure, temperature, humidity, rainfall, wind speed and direction through various combinations. You can select the transmitter with the needed parameter(s) into your weather application, with a large variety of digital communication modes and wide range of voltages. A heated option is available. Low power consumption enables solar panel applications. WXT530 Series focuses on maintenance-free operations in a cost-effective manner.

Integration

The series offers analog input options for additional third-party analog sensors. With the help of the built-in analog-to-digital converters, you can turn WXT530 into a small, cost-effective weather parameter hub.

Additional parameters include solar radiation and external temperature sensor. Further, the analog mA output for wind speed and wind direction enables a wide variety of industrial applications. WXT530 exceeds IEC60945 maritime standard.

Solid performance

WXT530 Series has a unique Vaisala solid-state sensor technology. To measure wind, Vaisala WINDCAP® ultrasonic wind sensors are applied to determine horizontal wind speed and direction. Barometric pressure, temperature, and humidity measurements are combined in the PTU module. The PTU module is easy to change without any contact with the sensors. The precipitation measurement is based on the unique acoustic Vaisala RAINCAP® Sensor without flooding, clogging, wetting, and evaporation losses.

Option	Rain	Wind	PTU 1)
WXT531	✔		
WXT532		✔	
WXT533	✔	✔	
WXT534			✔
WXT535	✔		✔
WXT536	✔	✔	✔

1) *PTU is a compact changeable module. Vaisala recommends changing it every 2 years.*

TYPE APPROVED PRODUCT
DNV·GL
DNVGL.COM/AF

DNV GL TYPE EXAMINATION CERTIFICATE No. TAA00000VF

Technical data

Barometric pressure measurement performance

Observation range	500 ... 1100 hPa
Accuracy (for sensor element) at 600 ... 1100 hPa	±0.5 hPa at 0 ... +30 °C (+32 ... +86 °F) ±1 hPa at −52 ... +60 °C (−60 ... +140 °F)
Output resolution	0.1 hPa / 10 Pa / 0.001 bar / 0.1 mmHg / 0.01 inHg

Air temperature measurement performance

Observation range	−52 ... +60 °C (−60 ... +140 °F)
Accuracy (for sensor element) at +20 °C (+68 °F)	±0.3 °C (±0.54 °F)
Output resolution	0.1 °C (0.1 °F)

Relative humidity measurement performance

Observation range	0 ... 100 %RH
Accuracy (for sensor element)	±3 %RH at 0 ... 90 %RH ±5 %RH at 90 ... 100 %RH
Output resolution	0.1 %RH

Wind measurement performance

Wind speed	
Observation range	0 ... 60 m/s (134 mph)
Reporting range	0 ... 75 m/s (168 mph)
Response time	0.25 s
Available variables	Average, maximum, and minimum
Accuracy	±3 % at 10 m/s (22 mph)
Output resolution	0.1 m/s (km/h, mph, knots)
Wind direction	
Azimuth	0 ... 360°
Response time	0.25 s
Available variables	Average, maximum, and minimum
Accuracy	±3.0° at 10 m/s (22 mph)
Output resolution	1°
Averaging time	1 ... 3600 s, sample rate 1, 2, or 4 Hz (configurable)

Mechanical specifications

Weight	
WXT534, WXT535, WXT536	0.7 kg (1.54 lb)
WXT531, WXT532, WXT533	0.5 kg (1.1 lb)

Operating environment

Operating environment	Outdoor use
Operating temperature	−52 ... +60 °C (−60 ... +140 °F)
Storage temperature	−60 ... +70 °C (−76 ... +158 °F)
Operating humidity	0 ... 100 %RH
Operating pressure	500 ... 1100 hPa
Wind [1)]	0 ... 60 m/s (0 ... 134 mph)
IP rating	Without mounting kit: IP65 With mounting kit: IP66

1) *Due to the measurement frequency used in the sonic transducers, RF interference in the 200 ... 400 kHz range can disturb wind measurement.*

Precipitation measurement performance

Collecting area	60 cm^2 (9.3 in^2)
Rainfall [1)]	
Output resolution	0.01 mm (0.001 in)
Field accuracy for daily accumulation	Better than 5 %, weather-dependent
Duration	Counting each 10-second increment whenever droplet detected
Duration output resolution	10 s
Intensity	Running 1-minute average, 10 s steps
Intensity observation range	0 ... 200 mm/h (0 ... 7.87 in/h) (broader with reduced accuracy)
Intensity output resolution	0.1 mm/h (0.01 in/h)
Hail [2)]	
Output resolution	0.1 hits/cm^2 (1 hits/in^2), 1 hit
Intensity output resolution	0.1 hits/cm^2h (1 hits/in^2h), 1 hit/h

1) *Cumulative accumulation after the latest automatic or manual reset.*
2) *Cumulative number of hits against collecting surface.*

Inputs and outputs

Operating voltage	6 ... 24 V DC (−10 ... +30 %)
Average power consumption	Minimum: 0.1 mA at 12 V DC (SDI-12 standby) Typical: 3.5 mA at 12 V DC (typical measuring intervals) Maximum: 15 mA at 6 V DC (constant measurement of all parameters)
Heating voltage	DC, AC, or full-wave rectified AC 12 ... 24 V DC (−10 ... +30 %) 12 ... 17 V AC_{rms} (−10 ... +30 %)
Typical heating current	12 V DC: 800 mA, 24 V DC: 400 mA
Digital outputs	SDI-12, RS-232, RS-485, RS-422
Communication protocols	SDI-12 v1.3, Modbus RTU, ASCII automatic and polled, NMEA 0183 v3.0 with query option

WXT536 analog input options

Solar radiation	0 ... 25 mV
Voltage input	0 ... 2.5 V , 0 ... 5 V, 0 ... 10 V
Tipping bucket rain gauge	0 ... 100 Hz
Temperature (Pt1000)	800 ... 1330 Ω

WXT532 analog mA output options

When the analog output option is applied, digital communication is not available.

Wind speed	0 ... 20 mA or 4 ... 20 mA
Wind direction	0 ... 20 mA or 4 ... 20 mA

Compliance

EU directives and regulations	EMC, RoHS
EMC compatibility	EN 61326-1, industrial environment CISPR 32 / EN 55032, Class B
Environmental	IEC 60068-2-1, 2, 6, 14, 30, 31, 78 IEC 60529, VDA 621-415
Maritime	IEC 60945 (Exposed) DNV GL Type Examination Certificate No. TAA00000VF
Compliance marks	CE, RCM, RoHS, China RoHS, UKCA

VAISALA

www.vaisala.com

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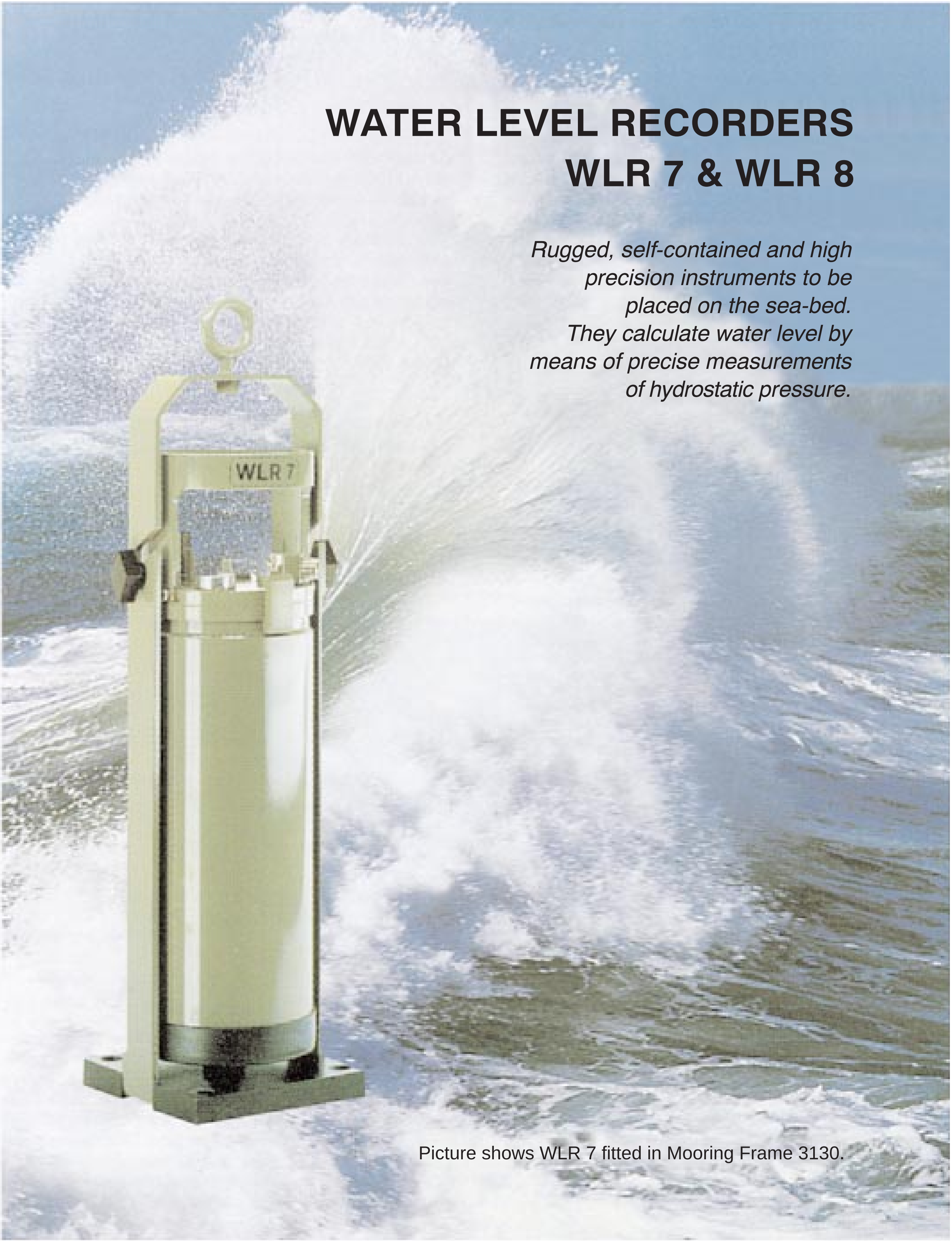
AANDERAA INSTRUMENTS

DATA COLLECTING INSTRUMENTS FOR LAND SEA AND AIR

WATER LEVEL RECORDERS
WLR 7 & WLR 8

Rugged, self-contained and high precision instruments to be placed on the sea-bed. They calculate water level by means of precise measurements of hydrostatic pressure.



Picture shows WLR 7 fitted in Mooring Frame 3130.

The Water Level Recorder WLR 7 is specially designed to measure ocean water levels. Placed on the seabed, the instrument records pressure, temperature and conductivity at regular intervals. On the basis of these data, precise variations in water level can be calculated.

The instrument consists of a high precision quartz pressure transducer, an electronic board, a Data Storage Unit, wiring and hardware, all fastened to the top end plate and housed in a cylindrical pressure case.

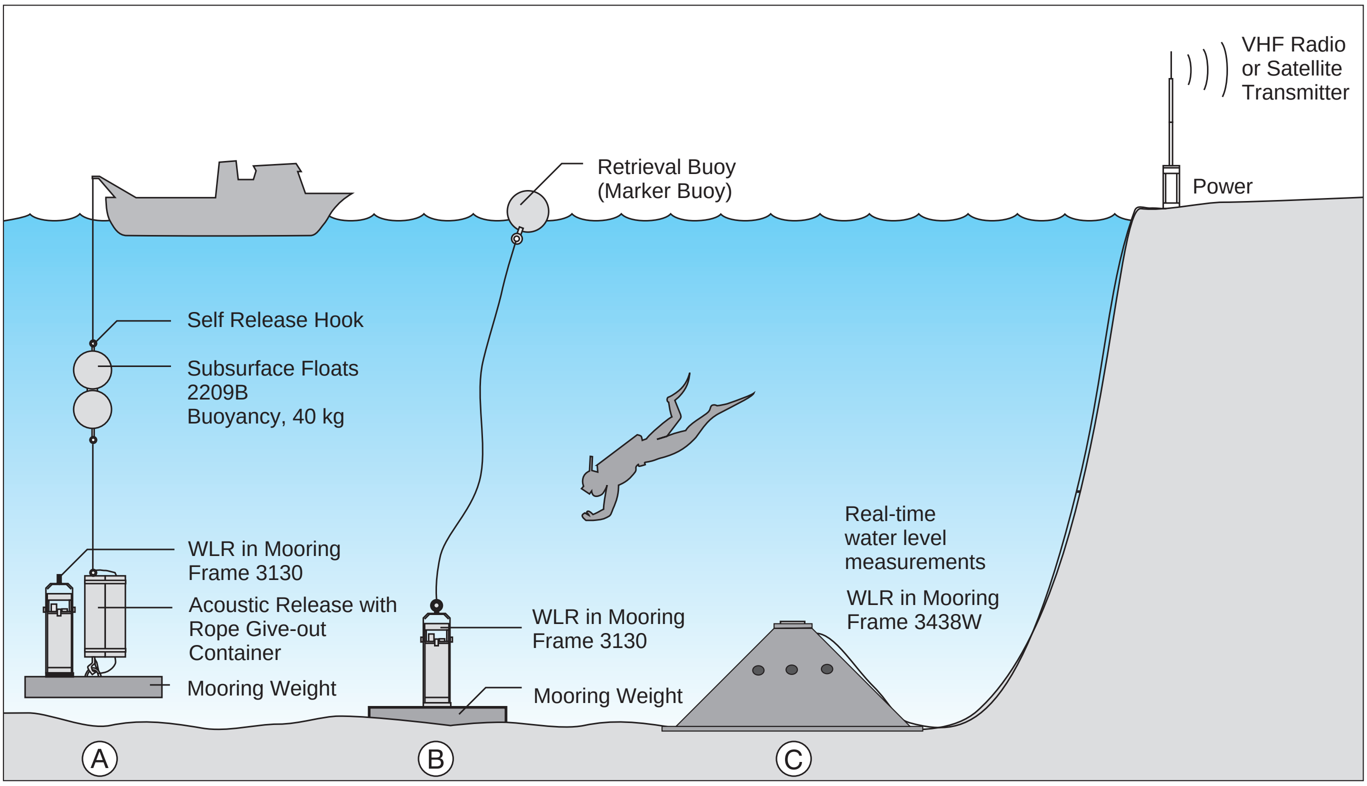
A measurement cycle, triggered by a high precision clock, starts with a forty seconds integration time of the pressure measurements. This eliminates pressure fluctuations due to waves. When the integration is completed, the data words are recorded. The first data word is a fixed reference reading followed by the temperature of the ambient water. The pressure is recorded as two ten-bit words and finally a ten-bit word for the water conductivity (optional sensor).

The data is stored in the Data Storage Unit (DSU) 2990 or 2990E which also records the time of the first measurement and subsequently the time of every first measurement after midnight. The data is simultaneously transmitted acoustically into the sea by keying on and off a 16.384 kHz carrier. These acoustic signals can be monitored at the surface using a Hydrophone Receiver 3079. The acoustic transducer is standard on the WLR 7 model but optional on the WLR 8 model.

On the high seas, the influence of barometric pressure on water level measurements is negligible. A depression or elevation of the sea surface relative to the pressure will compensate for changes in the measurement due to air pressure.

A deep sea version, designated WLR 8, has a pressure case able to operate down to 6000 meters depth. The WLR belongs to a family of instruments that utilize the same recording format and the same data reading system. Other members of this family are Recording Current Meter RCM 7, Temperature Profile Recorder TR 7 and Automatic Weather Station 2700.

TYPICAL MOORINGS



Drawing A shows deployment of the WLR mounted in Mooring Frame 3130 and an acoustic release device which makes instrument retrieval possible from all depths. The device will respond to an acoustic signal from the surface. The installation is lowered onto the seabed by means of a winch with a self-releasing hook. This system is recommended for areas with heavy sea traffic.

Drawing B shows the WLR placed on the seabed. A diver can retrieve the WLR by loosening two fastening knobs on the mooring frame. This allows repeated measurements from the same location since the frame remains in place and only the WLR is brought to the surface for data retrieval.

Drawing C shows an arrangement used in shallow waters that permits real-time telemetry of data brought ashore by a cable. The same cable can also power the WLR from batteries or mains from land. Data can be transmitted further via VHF/UHF radio, satellite or telephone communication.

SPECIFICATIONS FOR WLR 7 and WLR 8

Measuring system:
A digital system based on counting pulses from a sensor with frequency output. Five channels are measured in sequence and a ten-bit binary word is produced for each channel.
The channels are:

Ch.1. Reference. A fixed reading obtained by hard wiring a shift register inside the electronic board to check the WLR's performance and to identify individual instruments

Ch.2. Temperature.

Sensor type:	The sensor is based on a thermistor controlled oscillator with frequency 2.048–4.096 kHz
Thermistor:	Fenwall GB32JM19
Range:	–3 to +35°C
Resolution:	0.04°C
Accuracy:	±0.1°C
Response time:	30 seconds

Ch.3. and 4. Pressure (10 + 10 bits)

Sensor type:	The sensor is based on a pressure controlled oscillator with frequency 36–40 kHz
Ranges WLR 7:	0 – 700 kPa (60 m) (standard) 0 – 3500 kPa (340 m) (standard)
Ranges WLR 8:	0 – 14MPa (1370 m) (standard) Other ranges on request
Resolution:	0.001% of range
Repeatability:	±0.01% of full scale
Calibration Accuracy:	0.02% of full scale
Integration Time:	40 seconds

The pressure inlet port is 341 mm above the bottom of the instrument for the WLR 7 and 360 mm for the WLR 8
The instrument is calibrated in upright position.

Ch.5. Conductivity (optional)

Sensor Type:	Conductivity Cell 3094 for WLR 7 Conductivity Cell 4094 for WLR 8
Ranges:	0 – 77 mmho/cm (standard) 0 – 42 mmho/cm (on request)
Resolution:	0.1% of range
Accuracy:	±0.25 mmho/cm

Sampling Intervals

Selectable:	MS(ManualStart),1, 2, 5, 10, 15,20, 30, 60 or 120 min.
Accuracy:	Better than ±2 s/day within 0 to 20°C
External Triggering:	A 6 volt pulse to the signal output terminal activates the instrument

Recording System Aanderaa standard type Data Storage Unit 2990 or 2990E

Data Format:	PDC-4. (Pulse Duration Code 4 s.)
Storage Capacity:	
DSU 2990:	65500 10 bit words
DSU 2990E:	262000 10 bit words

Telemetry Acoustic Transducer

Acoustically:	Acoustic carrier keyed on and off
Frequency:	16.384 KHz ±5 Hz
Detection Range:	Up to 800 m with Hydrophone 3079

Note!
On the WLR 8 the Acoustic Transducer is optional.

Battery
High cap.Bat.3382: 7.2V, 14 Ah, sufficient for 343 days recording of all five channels at 10 minute intervals

Materials and Finish Nickel plated bronze and stainless acid proof steel. Durable epoxy coating

Weight (kg)

	WLR 7		WLR 8	
	Net	Gross	Net	Gross
in air:	13.7	19.1	15.2	20.5
in water:	9.2		10.9	

Dimensions (mm)
WLR 7: 432 x OD128
WLR 8: 450 x OD128

Accessories (included)

WLR 7:	Mooring Frame 3130
WLR 8:	Mooring Frame 3371 Weight: In air 3.2 kg, in water 2.7kg Pyramidical Mooring Frame 3438W for WRL 7 (optional)

Packing
Plywood case: 190 x 250 x 600 mm

Spares A set of recommended spares and accessories is included with the instrument

Warranty Two years against faulty materials and workmanship

CONVERSION FORMULA:

General formula for converting raw data into engineering units: $A + BN + CN^2 + DN^3$. (A, B, C and D are the calibration coefficients).

Pressure: The depth of water may be calculated from: Depth (m) = 0.001 · (P – AP) · (1/d) · (1/g) where P is the total pressure and AP is the atmospheric pressure both in Pascal. d is the density of water and g the earth's gravity in m/s^2 at the actual site of measurement. The N is derived from the readings in channels 3 and 4 (N_3 and N_4):
$N = N_3 \cdot 1024 + N_4$.

DECK UNIT 3127

This battery or mains powered unit is recommended to users for checking instrument performance as well as for calibrating purposes. An LCD display shows the decimal number corresponding to the ten bit binary output signal. The unit has an RS-232C output and is furnished with a push button that will trigger one measuring cycle of the instrument.

HYDROPHONE RECEIVER 3079

The hydrophone receiver is used to monitor the acoustic signals transmitted by a moored instrument. The Hydrophone is connected to and powered by Deck Unit 3127 which displays the acoustic signals as a decimal reading. Sensitivity to echoes has been reduced by an echo discriminator and to noise by a noise suppression circuit.

DATA STORAGE UNIT (DSU) 2990.

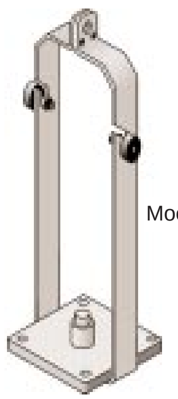
is the standard data storage unit for all Aanderaa recording instruments. This portable, watertight unit stores up to 65 500 ten bit, PDC-4 coded words in a set of EEPROMs. The data stored in the DSU is transferred to a computer via a DSU Reader 2995. The real-time clock and LCD display are powered by a built-in battery when the unit is removed from the instrument. An extended version, designated 2990E, storing up to 262000 datawords is also available.

DSU READER 2995

This unit provides a full duplex communication between a computer and the Data Storage Unit 2990. It converts the 0 to –5 volt serial signals associated with the DSU to dual-polarity signals in accordance the RS-232C standard. It also supplies the control voltage for powering the DSU during the read-out process.

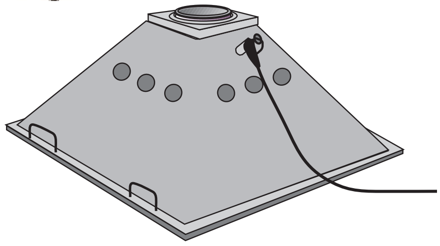
DATA READING PROGRAM 5059

is a new software program that may be used to download DSU 2990 data to a Personal Computer. The program is based on the latest software technology and is designed to be used with Windows 95, Windows 98 and Windows NT.
In addition to enable for downloading and exporting DSU data, it may also be used for data analysis. The 5059 include extensive charting and analysis facilities, and the resulting analysis graphs may be exported for use with other program such as Microsoft Word and Microsoft Excel.
The modern user interface, including drag & drop facilities combined with an extensive built-in Help system makes the 5059 easy to use. A sensor, station and instrument library allows you to build up a library holding configuration and calibration sets for all your instruments. A limited version is supplied free of charge. The full version is available at a moderate cost. Please contact the factory or visit our web site to obtain a 30 day fully functional trial version.


Mooring Frame 3130

MOORING FRAMES P/N 3130 and 3438W (for WLR 7) and P/N 3371 (for WLR 8)

Rugged frames for mooring the Water Level Recorders to the ocean floor which permits vertical stability as well as easy deployment and retrieval. The frames can be mounted on an anchor bar or other structures using four 1/2" bolts. The WLRs are easily installed and removed from the mooring frames.


Mooring Frame 3438W

Representative's Stamp

PO BOX 160, NESTTUN
5852 BERGEN, NORWAY
FANAVEIEN 13B
5221 NESTTUN, NORWAY
TEL. +47 55 109900
FAX. +47 55 109910
E-MAIL: info@aanderaa.no
WEB: http://www.aanderaa.com

Workhorse Sentinel ADCP

Self-Contained 1200, 600 or 300 kHz

Our most popular instrument. Over 1000 Workhorse Sentinel ADCPs are profiling currents in 50 countries. Our customers choose it for its unbeatable precision in shallow waters, for its 175-meter profiling range and for an unmatched low power consumption that makes it ideal for year-long deployments.

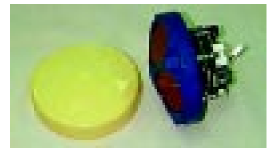
Customers tell us they like it because it's light and easy to deploy on buoys, boats or on the bottom. Links to shore are by cable or modem and Sentinel is easily upgraded to measure pressure, to undertake bottom-tracking tasks or to be used as a directional wave gauge.

			Long Range Mode	
Frequency	Range	Cell Size	Range	Cell Size
1200 kHz	14m	1m	19m	2m
600 kHz	47m	2m	67m	4m
300 kHz	126m	8m	165m	8m

RD Instruments
Tel: (858) 693-1178
sales@rdinstruments.com

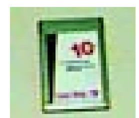
RD Instruments
www.rdinstruments.com

Included in a complete system:



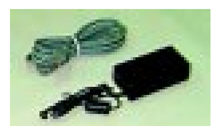
Transducer and electronics: molded composite plastic transducer head with four beams at 20° from vertical in a convex configuration, temperature sensor, electronics assemblies, fluxgate compass, pitch and roll sensors.

Batteries: one 28-D cell alkaline battery pack (factory degaussed).



Memory: 10 MB PC card internal memory (upgradeable to 440Mb).

Pressure case: composite plastic, 200m rated. End cap with wet-mateable connector and dummy plug.



Power supply for laboratory testing: 110-220V AC/24V DC power converter.

Input/output cable: 5 meter cable for communications and power.

Manuals and software: users guide; operation manual and easy-to-use Windows software package.

Spares parts and tool kit for maintenance.

Ship case: ruggedized compact case.

Workhorse Sentinel ADCP 1200, 600 or 300 kHz

Water Profiling

Depth Cell Size[a]	Typical range 12m[b] 1200kHz		Typical range 50m[b] 600kHz		Typical range 110m[b] 300kHz	
Vertical Resolution	Range (m)	Std. Dev.[c] (mm/s)	Range (m)	Std. Dev.[c] (mm/s)	Range (m)	Std. Dev.[c] (mm/s)
0.25m	11	182				
0.50m	12	66	36	182	see (a)	
1.0m	14	30	41	66	86	182
2.0m	15[b]	18	47	30	99	66
4.0m	see (a)		52[b]	18	112	30
8.0m					126[b]	18

Notes: a) user's choice of depth cell size is not limited to the typical values specified, b) longer ranges available, c) BroadBand mode single-ping standard deviation (Std.Dev.)

Long Range Mode

	Range (m)	Depth Cell Size (m)	Std. Dev. (mm/s)
1200kHz	19	2	35
600kHz	67	4	38
300kHz	165	8	38

Profile Parameters

Velocity accuracy:
- 1200, 600: ±0.25% of the water velocity relative to the ADCP ±2.5mm/s
- 300: ±0.5% of the water velocity relative to the ADCP ±5 mm/s

Velocity resolution: 1mm/s
Velocity range: ±5m/s (default):
±20m/s (maximum)
Number of depth cells: 1-128
Ping rate: 2 Hz (typical)

Echo Intensity Profile

Vertical resolution: depth cell size
Dynamic range: 80 dB
Precision: ±1.5dB (relative measure)

Transducer and Hardware

Beam angle: 20°
Configuration: 4 beam, convex
Internal memory: Unit comes with 10Mb card, standard. Two PCMCIA card slots available (10-220Mb each).
Communications: Serial port selectable by switch for RS-232 or RS-422. ASCII or binary output at 1200-115,400 baud.

Standard Sensors

Temperature (mounted on transducer)
- Range: -5° to 45°C
- Precision: ±0.4°C
- Resolution: 0.01°

Tilt
- Range: ±15°
- Accuracy : ±0.5°
- Precision: ±0.5°
- Resolution: 0.01°

Compass (fluxgate type, includes built-in field calibration feature)
- Accuracy: ±2° [e]
- Precision: ±0.5° [e]
- Resolution: 0.01°
- Maximum tilt: ±15°

Note: e) @ 60° magnetic dip angle, 0.5G total field

Power

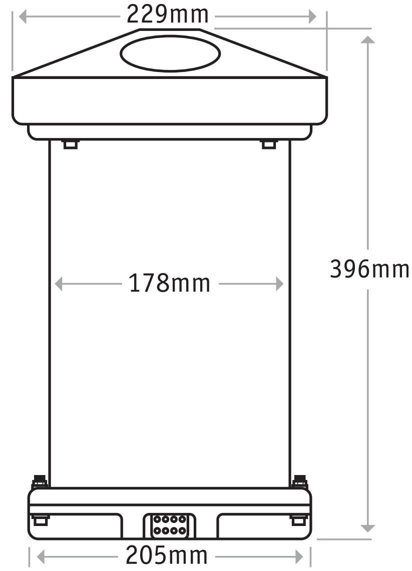
DC input: 20-60V DC. Internal battery pack, external battery pack or external power supply.
Voltage: 42V DC (new)
28V DC (depleted)
Capacity: @ 0°C: 400 watt hours

Transmit
- 16W @ 35V (1200kHz)
- 37W @ 35V (600kHz)
- 115W @ 35V (300kHz)

Environmental

Standard depth rating: 200m. Optional to 6000m.
Operating temperature: -5° to 45°C
Storage temperature: -30° to 75°C
Weight in air: 13.0kg
Weight in water: 4.5kg

Dimensions



Software

Use RDI's Windows™-based software for the best results:
- WinSC — Data Acquisition
- WinADCP — Data Display and Export

Upgrades Available

- Memory - 10-220Mb PCMCIA cards
- Pressure sensor
- External battery case
- High resolution water profiling modes
- Bottom tracking
- AC/DC power converter, 48V DC output
- Pressure cases for depths up to 6000m

For More Information

Call, e-mail or visit our web page. Ask for our Primer about ADCPs.

Internet: www.rdinstruments.com

RD Instruments
9855 Businesspark Avenue
San Diego, CA 92131 USA
Tel: (858) 693-1178 Fax: (858) 695-1459
E-mail: sales@rdinstruments.com

Specifications subject to change Rev 2.12

Appendix D
Calibrations

Seatex MRU Calibration Certificate

Seatex MRU model number:	5	5.generation
Serial number:	25081	
Calibration certificate number:	20180104-25081	

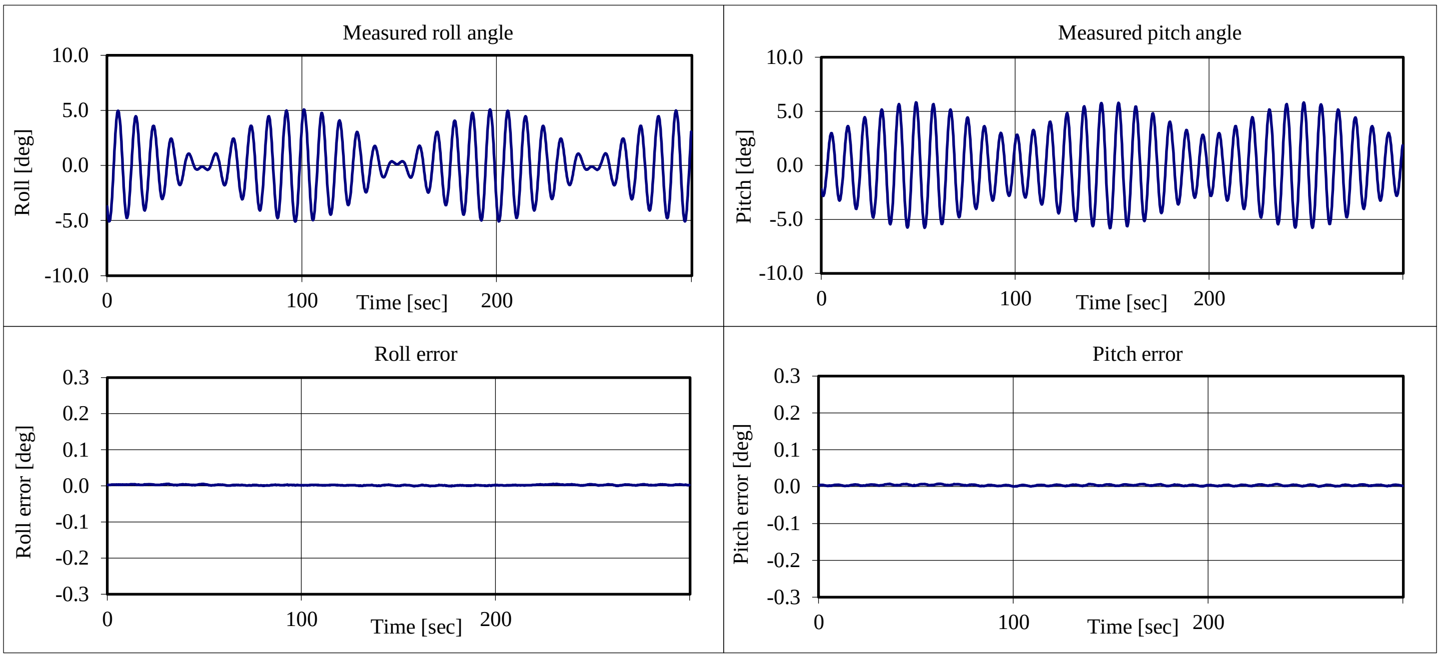
KONGSBERG

1. Roll and Pitch Accuracy Tests

Roll and pitch accuracy	Test requirement	Roll	Pitch
RMS static roll and pitch [deg]	0.02	Passed	Passed
RMS dynamic roll and pitch [deg]	0.02	Passed	Passed

The static accuracy was measured by sampling at 4 Hz for 30 minutes, when the Seatex MRU is stationary.
The dynamic accuracy was measured in a rate table test with simultaneous sinusoidal exitation in two axes for 10 minutes.

Plots of results from dynamic test of Seatex MRU with serial number 25081



2. Rate Gyro Accuracy Tests

Angular rate accuracy	Test requirement	R-axis	P-axis	Y-axis
RMS rate sensor noise [deg/s]	0.025	Passed	Passed	Passed
RMS rate sensor scale factor error [%]	0.08	Passed	Passed	Passed

The angular rate sensor noise level was measured by sampling at 4 Hz for 30 minutes, when the Seatex MRU is stationary.
The rate gyro scale factor error was tested by single-axis rotations on a rate table at ±30°/s and at ±50°/s.

3. Accelerometer Accuracy Tests

Linear acceleration accuracy	Test requirement	R-axis	P-axis	Y-axis
STD acceleration sensor noise [m/s^2]	0.002	Passed	Passed	Passed
RMS acceleration sensor scale factor error [%]	0.02	Passed	Passed	Passed

The acceleration sensor noise level was measured by sampling at 4 Hz for 30 minutes, when the Seatex MRU is stationary.
The accelerometer scale factor was measured by tilting the Seatex MRU in steps of 90° around a circle.

The Calibration Certificate test requirements are the technical specification limits in the MRU User Manual
A two-axis rate table with temperature chamber (DC 2267-TCM from Acutronic AG, 2007) was used to test the unit.
All tests were performed at room temperature according to test procedures in the MRU Production Manual

KONGSBERG SEATEX AS

Date of calibration: *2018-01-04*

Certificate of Calibrations and Tests

Instrument Information

Customer Reference No.	47284-650
Instrument Type	Signature500
Instrument Frequency	500 kHz
Instrument S/N	103000
Head S/N	D-3000
Interface Board S/N	3712
Interface Board Mfr. S/N	4MO0954280069
Digital Board Mfr. S/N	4MO0995940059
Analog Board Mfr. S/N	4MO1003470017
Sensor Board Mfr. S/N	4MO0933370022
Interface Board Rev.	H-4
Digital Board Rev.	I-3
Analog Board Rev.	G-1
Sensor Board Rev.	D-1(AHRS)

Calibrations and tests performed

Pressure	Passed
Tilt and Compass	Passed

All the tested values are within Nortek AS specifications

June 17, 2022
Date

Reviewed and approved (sign.)

Pressure Report

Details

Instrument Type	Signature500
Instrument S/N	103000
Pressure Range	300 dBar
Date	February 24, 2022
Operator	Faramarz Torkzad
Location	Nortek Factory Norway
Result	Passed

Description

Verification is performed in an automated pressure chamber. Fixed-point measurements are collected to verify the sensor.

Criteria of acceptance is ± 0.1% of full scale.

Reference: Paroscientific, Inc. - Digiquartz 9000-1K-242. Accuracy 0.01% of 689dBar.

Verification Results

Reference (dBar)	Pressure Diff. (dBar)	Pressure Diff. (% of FS)
0.62	0.08	0.03
31.73	0.05	0.02
59.04	0.03	0.01
91.30	0.01	0.00
121.35	-0.01	0.00
148.91	-0.02	-0.01
181.82	-0.02	-0.01
209.94	-0.04	-0.01
239.81	-0.05	-0.02
270.12	-0.06	-0.02
301.78	-0.08	-0.03

Tilt and Compass Report

Details

Instrument Type	Signature500
Instrument S/N	103000
Date	February 24, 2022
Operator	Kim Dunserudhagen
Location	Nortek Factory Norway
Result	Passed

Description

Calibration and verification is performed in a two axis automated jig. Continuous and fixed-point measurements are collected to calibrate and verify the sensor.

Criteria of acceptance for tilt sensor is ±0.5º.

Criteria of acceptance for compass sensor is ±2º.

Reference: Generic - Digital Protractor Series 950 Pro 3600. Accuracy ±0.05º.

Tilt Verification Results

	Diff. Up		Diff. Down	
Reference (°)	**Pitch (°)**	**Roll (°)**	**Pitch (°)**	**Roll (°)**
-30.00	0.01	0.04	0.03	-0.13
-15.00	-0.26	-0.13	-0.21	0.20
0.00	-0.01	0.15	0.07	-0.12
15.00	-0.10	-0.24	-0.25	0.24
30.00	0.05	0.00	0.00	-0.07

Compass Verification Results

Reference (°)	Heading Diff. Up (°)	Heading Diff. Down (°)
0.00	1.10	-0.38
45.00	0.74	-0.40
90.00	-0.14	-0.11
135.00	-0.61	0.09
180.00	-0.69	0.22
225.00	-0.36	0.10
270.00	0.63	-0.08
315.00	0.89	-0.15

AIRMAR®
TECHNOLOGY CORPORATION

Sensing Technology

WeatherStation® Instrument Calibration Certificate

Model: 200WX
ID: 60667571
Calibration Date: 1/20/2022
Manufacturer: Airmar Technology Corporation, Milford NH USA
Test Procedure: 96-154-02

The WeatherStation® Instrument passes testing for IPX-6 heavy seas water standards (excepting units equipped with RH sensors, which meet IPX4) and the IEC 60945 standards for exposed units(1). All units are calibrated in an onsite wind tunnel-2(2).

Unit Test Results:

Test Performed	Logged Value	Test Requirement
0 Knot Wind	0.1	Less than 1 Knot Max
Wind Cal(4)	PASS	Within ±2 Knots
Humidity	N/A	Within ±5 % RH
Temperature(5)	22.6	Within ±1.1 °C
Pressure	1006.0	Within ±2 mBar
Rate Gyro - Dynamic(6)	N/A	Under 4 deg/sec average error
Rate Gyro - Static	N/A	Within ±40 Deg/min
Pitch	0.2	Within 1°
Roll	0.0	Within 1°

Ambient (Local) Test Conditions(3):

Humidity: 20.5 %RH
Temperature: 22.9 Deg C
Pressure: 1005.8 mBars

Equipment List:

* **Wind Tunnel Calibration**
    - **Dwyer Pitot Tube**
    - **MKS Instruments Pressure Sensor: 220DD-00010A2B**
    - **BK Precision® 5491A Multimeter**
* **Ambient Temperature Readings (Temperature, humidity and pressure)**
    - **Vaisala® PTU200**
* **Rate Gyro Testing**
    - **SEI A2 Absolute encoder**
    - **US Digital R256 Motor Controller**

1 - After multiple heat cycles above 65° C (149°F) wind anemometer performance may require recalibration to remain within specifications at wind speeds above 50 knots (92.6 km/h).
2 - The on site wind tunnel is calibrated with a pitot tube, which in turn was calibrated with a NIST traceable pitot tube.
3 - Ambient conditions measured with a Vaisala® PTU200. Temperature, humidity and pressure readings compared to Vaisala® PTU200. The temperature, pressure and humidity readings from the Vaisala® instruments were calibrated by Vaisala® against instruments calibrated to NIST traceable instruments.
4 - Units are calibrated at 20 knots with a full circle multipoint calibration.
5 - Unit temperature and humidity recorded with 4+ knots of wind present.
6 - Test conducted at 70 degrees per second.

Seatex MRU Calibration Certificate

Seatex MRU model number:	5	5.generation
Serial number:	26004	
Calibration certificate number:	20191009-26004	

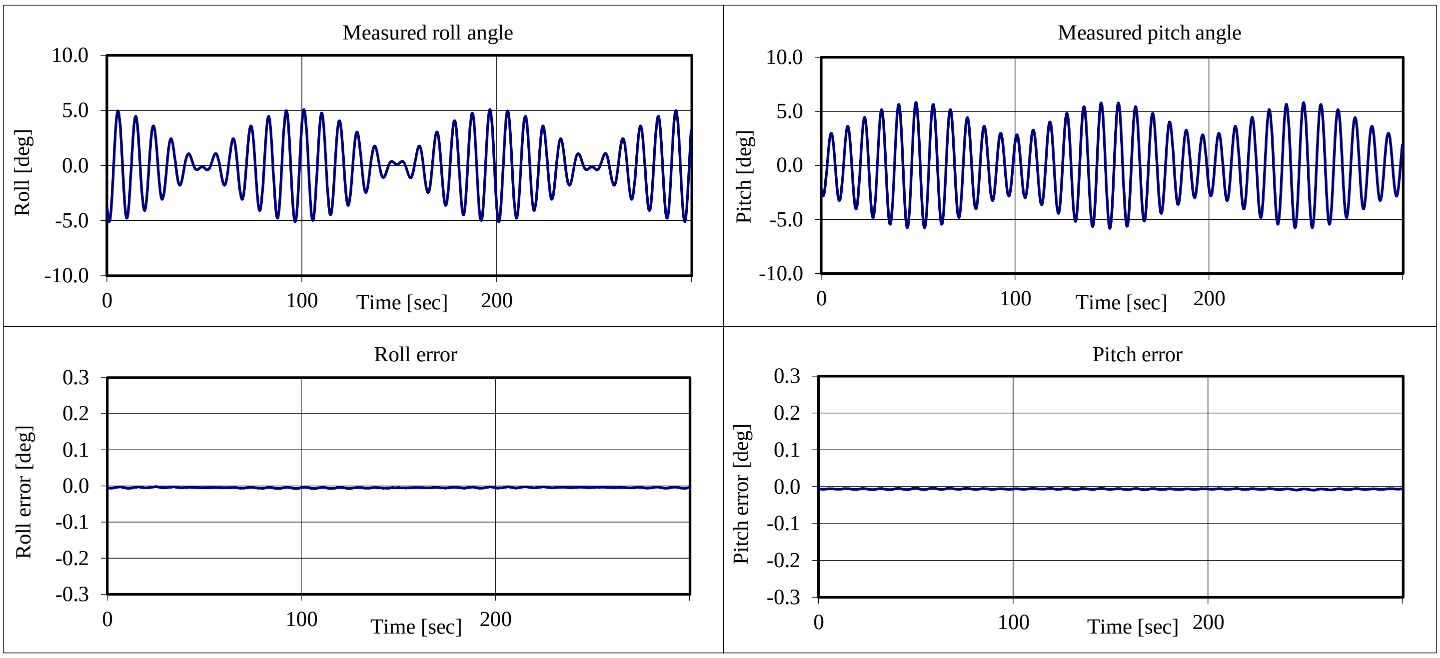
KONGSBERG

1. Roll and Pitch Accuracy Tests

Roll and pitch accuracy	Test requirement	Roll	Pitch
RMS static roll and pitch [deg]	0.02	Passed	Passed
RMS dynamic roll and pitch [deg]	0.02	Passed	Passed

The static accuracy was measured by sampling at 4 Hz for 30 minutes, when the Seatex MRU is stationary.
The dynamic accuracy was measured in a rate table test with simultaneous sinusoidal exitation in two axes for 10 minutes.

Plots of results from dynamic test of Seatex MRU with serial number 26004



2. Rate Gyro Accuracy Tests

Angular rate accuracy	Test requirement	R-axis	P-axis	Y-axis
RMS rate sensor noise [deg/s]	0.025	Passed	Passed	Passed
RMS rate sensor scale factor error [%]	0.08	Passed	Passed	Passed

The angular rate sensor noise level was measured by sampling at 4 Hz for 30 minutes, when the Seatex MRU is stationary.
The rate gyro scale factor error was tested by single-axis rotations on a rate table at ±30°/s and at ±50°/s.

3. Accelerometer Accuracy Tests

Linear acceleration accuracy	Test requirement	R-axis	P-axis	Y-axis
STD acceleration sensor noise [m/s^2]	0.002	Passed	Passed	Passed
RMS acceleration sensor scale factor error [%]	0.02	Passed	Passed	Passed

The acceleration sensor noise level was measured by sampling at 4 Hz for 30 minutes, when the Seatex MRU is stationary.
The accelerometer scale factor was measured by tilting the Seatex MRU in steps of 90° around a circle.

The Calibration Certificate test requirements are the technical specification limits in the MRU User Manual
A two-axis rate table with temperature chamber (AC 2267-TCM from Acutronic AG, 2011) was used to test the unit.
All tests were performed at room temperature according to test procedures in the MRU Production Manual

KONGSBERG SEATEX AS

Date of calibration: *2019-10-09*

Certificate of Calibrations and Tests

Instrument Information

Customer Reference No.	47284-652
Instrument Type	Signature500
Instrument Frequency	500 kHz
Instrument S/N	103012
Head S/N	D-3012
Interface Board S/N	3708
Interface Board Mfr. S/N	4MO0954280068
Digital Board Mfr. S/N	4MO0995940055
Analog Board Mfr. S/N	4MO1003450011
Sensor Board Mfr. S/N	4MO0971830013
Interface Board Rev.	H-4
Digital Board Rev.	I-3
Analog Board Rev.	G-1
Sensor Board Rev.	D-1(AHRS)

Calibrations and tests performed

Pressure	Passed
Tilt and Compass	Passed

All the tested values are within Nortek AS specifications

June 17, 2022

Date

Reviewed and approved (sign.)

Pressure Report

Details

Instrument Type	Signature500
Instrument S/N	103012
Pressure Range	300 dBar
Date	February 28, 2022
Operator	Faramarz Torkzad
Location	Nortek Factory Norway
Result	Passed

Description

Verification is performed in an automated pressure chamber. Fixed-point measurements are collected to verify the sensor.

Criteria of acceptance is ± 0.1% of full scale.

Reference: Paroscientific, Inc. - Digiquartz 9000-1K-242. Accuracy 0.01% of 689dBar.

Verification Results

Reference (dBar)	Pressure Diff. (dBar)	Pressure Diff. (% of FS)
3.47	0.12	0.04
39.99	0.09	0.03
58.54	0.06	0.02
91.83	0.03	0.01
121.84	0.01	0.00
142.44	0.00	0.00
180.26	-0.01	0.00
210.60	-0.04	-0.01
240.96	-0.06	-0.02
271.45	-0.10	-0.03
301.23	-0.12	-0.04

Tilt and Compass Report

Details

Instrument Type	Signature500
Instrument S/N	103012
Date	February 28, 2022
Operator	Faramarz Torkzad
Location	Nortek Factory Norway
Result	Passed

Description

Calibration and verification is performed in a two axis automated jig. Continuous and fixed-point measurements are collected to calibrate and verify the sensor.

Criteria of acceptance for tilt sensor is ±0.5º.

Criteria of acceptance for compass sensor is ±2º.

Reference: Generic - Digital Protractor Series 950 Pro 3600. Accuracy ±0.05º.

Tilt Verification Results

	Diff. Up		Diff. Down	
Reference (°)	**Pitch (°)**	**Roll (°)**	**Pitch (°)**	**Roll (°)**
-30.00	0.04	0.11	-0.02	-0.17
-15.00	-0.12	-0.08	-0.11	0.24
0.00	-0.03	0.06	0.14	-0.11
15.00	-0.15	-0.14	-0.31	0.15
30.00	0.09	0.14	0.21	-0.06

Compass Verification Results

Reference (°)	Heading Diff. Up (°)	Heading Diff. Down (°)
0.00	0.97	-0.14
45.00	1.01	-0.78
90.00	0.69	-0.27
135.00	0.01	0.30
180.00	-0.21	0.53
225.00	-0.31	0.97
270.00	0.35	0.63
315.00	0.86	0.32

AIRMAR® TECHNOLOGY CORPORATION

Sensing Technology

WeatherStation® Instrument Calibration Certificate

Model: 150WX
ID: 60008017
Calibration Date: 12/17/2018
Manufacturer: Airmar Technology Corporation, Milford NH USA
Test Procedure: 96-154-02

The WeatherStation® Instrument passes testing for IPX-6 heavy seas water standards (excepting units equipped with RH sensors, which meet IPX4) and the IEC 60945 standards for exposed units(1). All units are calibrated in an onsite wind tunnel-2(2).

Unit Test Results:

Test Performed	Logged Value	Test Requirement
0 Knot Wind	0.3	Less than 1 Knot Max
Wind Cal(4)	PASS	Within ±2 Knots
Humidity	20.3	Within ±5 % RH
Temperature(5)	21.2	Within ±1.1 °C
Pressure	989.4	Within ±2 mBar
Rate Gyro - Dynamic(6)	N/A	Under 4 deg/sec average error
Rate Gyro - Static	N/A	Within ±40 Deg/min
Pitch	0.0	Within 1°
Roll	0.0	Within 1°

Ambient (Local) Test Conditions(3):

Humidity: 24.9 %RH
Temperature: 21.2 Deg C
Pressure: 989.3 mBars

Equipment List:

* **Wind Tunnel Calibration**
  - **Dwyer Pitot Tube**
  - **MKS Instruments Pressure Sensor: 220DD-00010A2B**
  - **BK Precision® 5491A Multimeter**
* **Ambient Temperature Readings (Temperature, humidity and pressure)**
  - **Vaisala® PTU200**
* **Rate Gyro Testing**
  - **SEI A2 Absolute encoder**
  - **US Digital R256 Motor Controller**

1 - After multiple heat cycles above 65° C (149°F) wind anemometer performance may require recalibration to remain within specifications at wind speeds above 50 knots (92.6 km/h).

2 - The on site wind tunnel is calibrated with a pitot tube, which in turn was calibrated with a NIST traceable pitot tube.

3 - Ambient conditions measured with a Vaisala® PTU200. Temperature, humidity and pressure readings compared to Vaisala® PTU200. The temperature, pressure and humidity readings from the Vaisala® instruments were calibrated by Vaisala® against instruments calibrated to NIST traceable instruments.

4 - Units are calibrated at 20 knots with a full circle multipoint calibration.

5 - Unit temperature and humidity recorded with 4+ knots of wind present.

6 - Test conducted at 70 degrees per second.

Seatex MRU Calibration Certificate

Seatex MRU model number:	5	5.generation
Serial number:	26017	
Calibration certificate number:	20191017-26017	

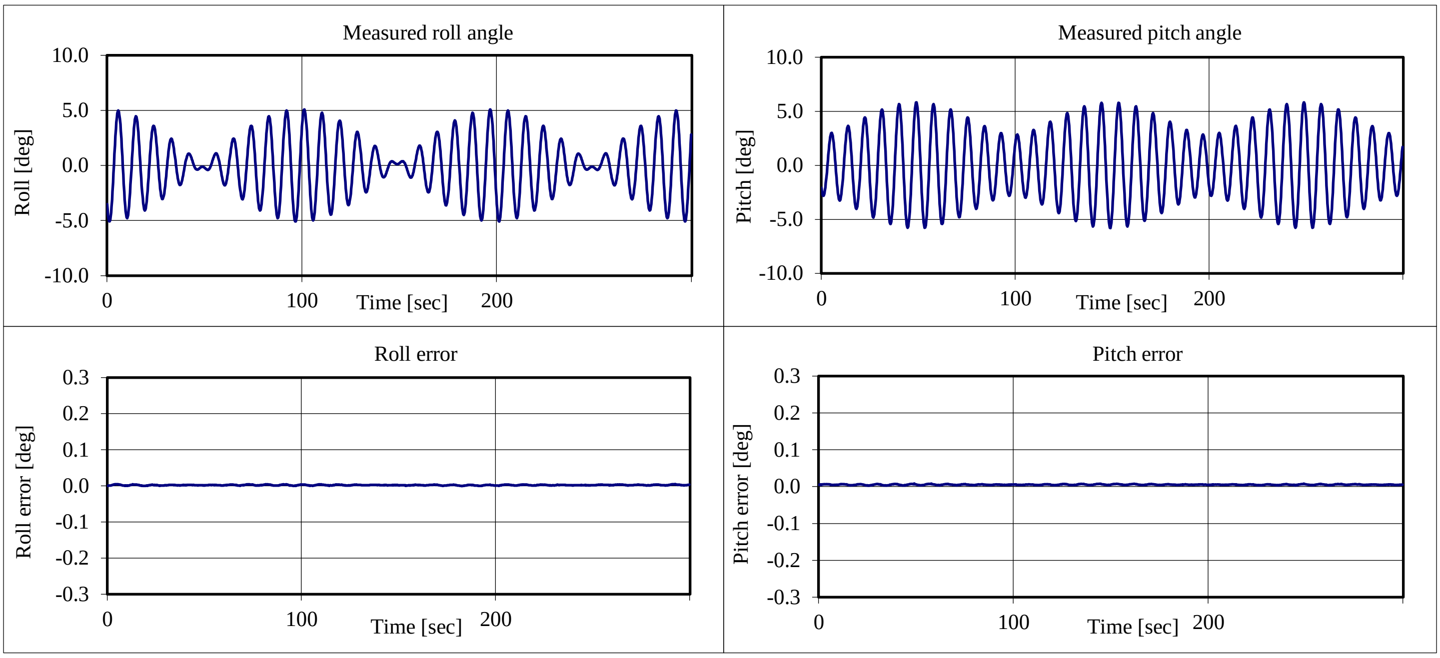
KONGSBERG

1. Roll and Pitch Accuracy Tests

Roll and pitch accuracy	Test requirement	Roll	Pitch
RMS static roll and pitch [deg]	0.02	Passed	Passed
RMS dynamic roll and pitch [deg]	0.02	Passed	Passed

The static accuracy was measured by sampling at 4 Hz for 30 minutes, when the Seatex MRU is stationary.
The dynamic accuracy was measured in a rate table test with simultaneous sinusoidal exitation in two axes for 10 minutes.

Plots of results from dynamic test of Seatex MRU with serial number 26017



2. Rate Gyro Accuracy Tests

Angular rate accuracy	Test requirement	R-axis	P-axis	Y-axis
RMS rate sensor noise [deg/s]	0.025	Passed	Passed	Passed
RMS rate sensor scale factor error [%]	0.08	Passed	Passed	Passed

The angular rate sensor noise level was measured by sampling at 4 Hz for 30 minutes, when the Seatex MRU is stationary.
The rate gyro scale factor error was tested by single-axis rotations on a rate table at ±30°/s and at ±50°/s.

3. Accelerometer Accuracy Tests

Linear acceleration accuracy	Test requirement	R-axis	P-axis	Y-axis
STD acceleration sensor noise [m/s^2]	0.002	Passed	Passed	Passed
RMS acceleration sensor scale factor error [%]	0.02	Passed	Passed	Passed

The acceleration sensor noise level was measured by sampling at 4 Hz for 30 minutes, when the Seatex MRU is stationary.
The accelerometer scale factor was measured by tilting the Seatex MRU in steps of 90° around a circle.

The Calibration Certificate test requirements are the technical specification limits in the MRU User Manual
A two-axis rate table with temperature chamber (DC 2267-TCM from Acutronic AG, 2007) was used to test the unit.
All tests were performed at room temperature according to test procedures in the MRU Production Manual

KONGSBERG SEATEX AS

Date of calibration: *2019-10-17*

Certificate of Calibrations and Tests

Instrument Information

Customer Reference No.	47283-648
Instrument Type	Signature500
Instrument Frequency	500 kHz
Instrument S/N	103318
Head S/N	D-3318
Interface Board S/N	3574
Interface Board Mfr. S/N	4MO0964460088
Digital Board Mfr. S/N	4MO0928940036
Analog Board Mfr. S/N	4MO0959280014
Sensor Board Mfr. S/N	4MO0933370018
Interface Board Rev.	H-4
Digital Board Rev.	I-3
Analog Board Rev.	G-1
Sensor Board Rev.	D-1(AHRS)

Calibrations and tests performed

Pressure	Passed
Tilt and Compass	Passed

All the tested values are within Nortek AS specifications

June 17, 2022

Date

Reviewed and approved (sign.)

Pressure Report

Details

Instrument Type	Signature500
Instrument S/N	103318
Pressure Range	300 dBar
Date	January 11, 2022
Operator	Faramarz Torkzad
Location	Nortek Factory Norway
Result	Passed

Description

Verification is performed in an automated pressure chamber. Fixed-point measurements are collected to verify the sensor.

Criteria of acceptance is ± 0.1% of full scale.

Reference: Paroscientific, Inc. - Digiquartz 9000-1K-242. Accuracy 0.01% of 689dBar.

Verification Results

Reference (dBar)	Pressure Diff. (dBar)	Pressure Diff. (% of FS)
0.61	0.14	0.05
30.54	0.11	0.04
59.38	0.09	0.03
91.38	0.06	0.02
120.38	0.03	0.01
147.60	0.02	0.01
179.71	-0.02	-0.01
211.02	-0.04	-0.01
240.86	-0.06	-0.02
269.98	-0.10	-0.03
300.80	-0.14	-0.05

Tilt and Compass Report

Details

Instrument Type	Signature500
Instrument S/N	103318
Date	January 11, 2022
Operator	Faramarz Torkzad
Location	Nortek Factory Norway
Result	Passed

Description

Calibration and verification is performed in a two axis automated jig. Continuous and fixed-point measurements are collected to calibrate and verify the sensor.

Criteria of acceptance for tilt sensor is ±0.5º.

Criteria of acceptance for compass sensor is ±2º.

Reference: Generic - Digital Protractor Series 950 Pro 3600. Accuracy ±0.05º.

Tilt Verification Results

	Diff. Up		Diff. Down	
Reference (°)	**Pitch (°)**	**Roll (°)**	**Pitch (°)**	**Roll (°)**
-30.00	0.16	0.06	0.11	-0.16
-15.00	-0.04	-0.06	-0.29	0.03
0.00	0.11	0.13	0.08	-0.07
15.00	-0.25	-0.22	0.06	0.23
30.00	0.06	0.07	0.05	-0.21

Compass Verification Results

Reference (°)	Heading Diff. Up (°)	Heading Diff. Down (°)
0.00	0.94	0.72
45.00	0.74	0.67
90.00	0.40	0.98
135.00	-0.05	1.20
180.00	0.26	0.52
225.00	0.71	0.40
270.00	1.03	0.19
315.00	1.01	0.14

AIRMAR®
TECHNOLOGY CORPORATION
Sensing Technology

WeatherStation® Instrument Calibration Certificate

Model: 200WX
ID: 60663334
Calibration Date: 1/15/2022
Manufacturer: Airmar Technology Corporation, Milford NH USA
Test Procedure: 96-154-02

The WeatherStation® Instrument passes testing for IPX-6 heavy seas water standards (excepting units equipped with RH sensors, which meet IPX4) and the IEC 60945 standards for exposed units(1). All units are calibrated in an onsite wind tunnel-2(2).

Unit Test Results:

Test Performed	Logged Value	Test Requirement
0 Knot Wind	0.2	Less than 1 Knot Max
Wind Cal(4)	PASS	Within ±2 Knots
Humidity	N/A	Within ±5 % RH
Temperature(5)	21.8	Within ±1.1 °C
Pressure	1012.4	Within ±2 mBar
Rate Gyro - Dynamic(6)	N/A	Under 4 deg/sec average error
Rate Gyro - Static	N/A	Within ±40 Deg/min
Pitch	0.0	Within 1°
Roll	0.0	Within 1°

Ambient (Local) Test Conditions(3):
Humidity: 8.9 %RH
Temperature: 22.3 Deg C
Pressure: 1012.5 mBars

Equipment List:

* **Wind Tunnel Calibration**
  - o **Dwyer Pitot Tube**
  - o **MKS Instruments Pressure Sensor: 220DD-00010A2B**
  - o **BK Precision® 5491A Multimeter**
* **Ambient Temperature Readings (Temperature, humidity and pressure)**
  - o **Vaisala® PTU200**
* **Rate Gyro Testing**
  - o **SEI A2 Absolute encoder**
  - o **US Digital R256 Motor Controller**

1 - After multiple heat cycles above 65° C (149°F) wind anemometer performance may require recalibration to remain within specifications at wind speeds above 50 knots (92.6 km/h).
2 - The on site wind tunnel is calibrated with a pitot tube, which in turn was calibrated with a NIST traceable pitot tube.
3 - Ambient conditions measured with a Vaisala® PTU200. Temperature, humidity and pressure readings compared to Vaisala® PTU200. The temperature, pressure and humidity readings from the Vaisala® instruments were calibrated by Vaisala® against instruments calibrated to NIST traceable instruments.
4 - Units are calibrated at 20 knots with a full circle multipoint calibration.
5 - Unit temperature and humidity recorded with 4+ knots of wind present.
6 - Test conducted at 70 degrees per second.

Appendix E
Wave Analysis

WAVE GLOSSARY & DEFINITIONS

Wave Parameters

- H_s - total significant wave height
- T_p - spectral peak wave period
- T_m - spectral mean wave period
- T_z - spectral average zero-crossing wave period
- EH_{max} - expected maximum single wave height (often ~1.86 x H_s)
- TH_{max} - period of the maximum single wave (often ~1.15 x T_m)
- L/EH_{max} - inverse steepness of Maximum waves
- θ_p - direction of the peak spectral ordinate
- θ_m - direction of the mean spectral ordinate

JONSWAP Parameters

- α - Phillips parameter
- γ - peakedness parameter
- σ_A - low frequency width parameter
- σ_B - high frequency width parameter
- m_0 - zeroth moment of the spectrum

Spectral Wave Analysis

Directional Spectral Analysis of the wave profiles was conducted using Fast Fourier Transform (FFT) analysis as described in Appendix E. The first four Fourier Coefficients are used to determine a parametric cosine^{2s} spreading function description of the directional energy spectrum. This allows direct assessment of sharpness 's', and hence directional spread 'Δθ'.

The following wave parameters are typically derived from the directional wave spectra:

- zeroth, first, second and fourth spectral moments m_0, m_1, m_2 and m_4
- significant wave height, H_s (metres), from the spectral moment m_0, using

  $$H_s = 4(m_0)^{1/2}$$

- average zero crossing period T_z (seconds), from the spectral moments m_0 and m_2, using

  $$T_z = (m_0/m_2)^{1/2}$$

- mean wave period T_m (seconds), from the spectral moments m_0 and m_1, using

  $$T_m = (m_0/m_1)$$

- period of the peak spectral ordinate, T_p (seconds), where

  T_p = centre point of the frequency band containing maximum energy

- energy weighted mean direction, θ_m (degrees), is obtained by first calculating the energy weighted mean sine and cosine components as follows

$$\boldsymbol{S_{mean}} = \frac{\sum_i E_i \sin\theta}{\sum_i E_i} \qquad \boldsymbol{C_{mean}} = \frac{\sum_i E_i \cos\theta}{\sum_i E_i}$$

then the resulting energy weighted mean direction θ_m is

$$\boldsymbol{\theta_m} = \boldsymbol{arctan}\left(\frac{S_{mean}}{C_{mean}}\right)$$

- direction of the peak spectral ordinate, θ_p (degrees), where

θ_p= arctan (b_1/a_1)

and a_1 and b_1 are the first pair of Fourier components computed, in the case of θ_p, for the frequency band containing maximum energy

- the directional spread of the peak spectral ordinate, $\Delta\theta_p$ (degrees), where

$$\Delta\theta_p = \frac{180(2 - 2r)^{1/2}}{\pi}$$

$$\mathrm{r} = \sqrt{\left(a_1^2 + b_1^2\right)}$$

and a_1 and b_1 are defined above.

The first order estimates of the directional wave parameters were obtained from the x, y, z cospectra. Hence wave directions are estimated by way of an energy-weighted mean.

The above parameters were computed for the complete spectrum, and for the two portions of the split spectrum, the method used to split the spectrum is detailed in the report text.

An in-depth RPS document “Frequency Domain Analysis of Wave Data” is provided.

Time-Domain Wave Analysis

The raw heave displacement data were analysed in the time domain to identify and categorise individual waves within the data. The following wave parameters presented in this report were derived from time domain analysis

- H_{max} = the highest individual wave in the profile;
- TH_{max} = the zero up-crossing period associated with H_{max}.

Details on the analysis methodology are outlined in the “Time Domain Analysis” document.

General Definitions

Ambient conditions — Typical oceanographic conditions (waves & currents), represented by annual means and maxima.

Attenuation — See Wave attenuation.

Bathymetry — Sea floor topography.

Crest — See Wave Crest.

Design-wave — The most severe wave conditions a structure or vessel must be designed to withstand. Depends on the selected return period.

Diffraction — The phenomenon by which energy is transmitted laterally along a wave crest. When a part of a train of waves is interrupted by a barrier, such as an exposed reef, the effect of diffraction is manifested by propagation of waves into the sheltered region within the barrier's geometric shadow.

Expected maximum wave height (EHmax) — The height of the highest wave expected to occur in the period for which an extrapolated Hs value is considered to be representative (typically 3 to 6 hours).

Extreme conditions — Extreme oceanographic conditions (waves & currents), corresponding to a selected return period value.

Hindcast — Determination of previous wave conditions based on available wind information.

Isobath — A contour line connecting points of equal water depths on a chart.

Keulegan-Carpenter — A dimensionless parameter used to measure the importance of the drag force effect. It is equivalent to ratio of the particle orbit diameter to the structure diameter. KC = wave velocity x period/pipe diameter.

Liquefaction — As a result of wave induced cyclic loading, pore pressures in the soil build up to such an extent that the soil loses all shear strength due to loss of interlocking forces between grains.

Maximum wave height (Hmax) — The height of the highest wave in a record.

Morison's equations — Developed to describe the horizontal wave forces acting on solid bodies extending from the bottom through the free surface. The original equation was later adapted for used in the analysis of forces on pipelines. Morison's equations determine the drag, inertia and lift forces imposed on a pipeline. The coefficients within the equations vary with the Reynold's and Keulegan-Carpenter numbers.

Period of the highest wave (THmax) — The period of the highest wave in a record.

Refraction — The process by which the direction of a wave moving in shallow water at an angle to the depth contours is changed. The part of the wave in deeper water moves more rapidly than the part in shallower water, causing the crest to turn parallel to the bottom contours. The degree of refraction depends on the wave period and direction.

Return period The average time interval between successive events of the designwave (or current) being equalled or exceeded. Design of offshore structures is typically based on the 50-year or 100-year return period wave height and current speed.

Reynold's number A dimensionless parameter used to determine if a fluid flow is laminar or turbulent.
Re = velocity x length/kinematic viscosity.

Sand waves Formation in the seabed surface which has the appearance of waves, and consists of sandy material. May be characterised by a wave height and wave length.

Scour Erosion of sediment due to environmental conditions of waves and currents.

Sea Sea refers to waves which are under the influence of wind in a generating area.

Sea state A description of the sea surface with regard to wave action.

Shoaling Refers to a modification which waves undergo as they propagate from deep water to shallow water. The shoaling coefficient is the ratio of a wave in water of any depth to its height in deep water with the effects of refraction, friction, and percolation eliminated.

Significant wave height (Hs) The average height of the highest 1/3 of waves in a record.

Spectral mean wave period (Tm) The average period of the highest 1/3 of waves in a record.

Swell Waves which have moved out of the generating area and are no longer subjected to significant wind action

Wave attenuation A lessening of the height of a wave with distance from its origin.

Wave crest A point of maximum displacement of a wave above a mean value; the highest point of a wave. The term is also used to refer to a wave front, defined as a surface of constant phase of a propagating wave disturbance. Wave fronts may be approximated as plane surfaces oriented perpendicular to wave rays (which themselves are parallel to the direction of wave propagation).

Wave direction The direction from which waves are propagating.

Wave height The vertical distance between a wave crest (maximum point on the waveform) and the following wave trough (minimum point on the waveform).

Wave period The time taken for consecutive wave crests (or troughs) to pass a fixed point.

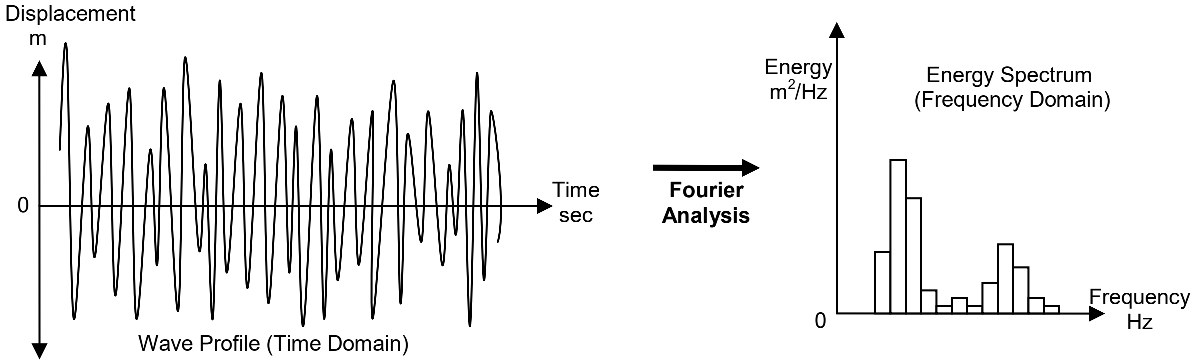
Wave-induced oscillatory currents The periodic backward-forward (orbital) flow of water particles in a wave.

Frequency Domain Analysis of Wave Data

1 INTRODUCTION

In wave processing, Fourier analysis methods can be used to convert the wave displacement profile in the time domain into an energy spectrum in the frequency domain.

In summary, the wave displacement is measured at discrete intervals in the time domain, giving a wave amplitude profile that shows how the wave height varies over time. Applying Fourier methods to this wave profile data set yields a histogram or periodogram of amplitude squared per unit of frequency at each one of a spectrum of frequencies. This is an estimate of the power contained in the original wave profile at each frequency band within the spectrum of frequencies. The general process is shown graphically as follows:



2 THE STANDARD FOURIER TRANSFORM

A physical process can be described in the time domain by some values *h* measured over a period of time *t*, giving a function in the time domain *h(t)*. It can also be equivalently described in the frequency domain as amplitude *H* (a complex number describing both amplitude and phase) as a function of frequency *f*, giving a function in the frequency domain *H(f)*. Converting between the time domain and frequency domain can be done using the standard Fourier transform equation:

$$H(f) = \int_{-\infty}^{\infty} h(t) e^{2\pi i f t} dt \qquad \text{where} \quad i = \sqrt{-1}$$

The functions *h(t)* and *H(f)* are essentially two different representations of the same function. Therefore converting from the frequency domain *H(f)* back to the time domain *h*(*t*) can be done using the inverse Fourier transform equation:

$$h(t) = \int_{-\infty}^{\infty} H(f) e^{-2\pi i f t} df$$

Converting from the time domain to the frequency domain using the standard Fourier transform produces a two-sided power spectral density that ranges from $f = -\infty$ to $f = \infty$.

For practical purposes, the range of frequencies of interest is usually positive, i.e. $0 \le f < \infty$ and a one-sided power spectral density *Ph(f)* can be obtained by:

$$Ph(f) \equiv |H(f)|^2 + |H(-f)|^2$$

When the function *h(t)* is real (as is the case for measuring physical processes such as waves), *H(f)* is symmetrical about zero (function is even) and the negative *f* is a mirror image of the positive *f*, so obtaining the one-sided power spectral density *Ph(f)* is then simplified to:

$$Ph(f) \equiv 2 \cdot |H(f)|^2$$

The total power in the sample data set is the same whether it is computed in the time domain or the frequency domain (Parseval's theorem):

$$\text{Total Power} \equiv \int_{-\infty}^{\infty} |h(t)|^2 dt = \int_{-\infty}^{\infty} |H(f)|^2 df$$

A **Fast Fourier Transform** (FFT) takes advantage of the relationship between the number of samples *N* and the number of matrix processing multiplications needed. For the general case of the discrete Fourier transform, N^2 complex number matrix multiplications are required.

If the number of input samples *N* is a power of 2, then a fast Fourier transform algorithm can be used that will compute the spectral results requiring only $N \log_2 N$ complex multiplications, which is significantly less than the N^2 complex multiplications required for the Discrete Fourier Transform (DFT). For example, with 256 input samples the DFT requires 65,536 multiplications while the FFT requires only 2,048. Otherwise, for all practical purposes the results are identical.

Note: To use an FFT, the number of input data samples to the FFT function must always be exactly a power of two, e.g. 256, 512, 1024 etc.

3 WINDOWING THE INPUT DATA SET

A Fourier transform inherently produces an infinitely wide frequency spectrum from an infinitely long series of measurements in the time domain.

In practical applications the data sample set cannot be infinite; in fact it is relatively very short, being only long enough to obtain a reasonable representation of the process, which is considered to continue indefinitely in the state represented by the samples taken.

However, the sample data sets that are taken from this supposedly continuous process start and end suddenly at some arbitrary points. The sampling process itself therefore applies a modulating function to the sampled data, in this case a square-ended window function. The discontinuities introduced by the square sampling window will appear as unwanted additional spectral components in the frequency domain after Fourier analysis.

To minimise the effects of the sampling window, there are a variety of different window functions that can be applied to the data set before performing the Fourier analysis. All have the object of minimising the discontinuities or sudden steps that occur at the start and end of the sampled data set.

A cosine taper window is commonly used, which applies a cosine taper to each end of the data set, gradually tapering the data values up from zero to full values in the first 10% of the samples, then down to zero again in the last 10% of the samples.

A 10% cosine taper window on a data set of *N* samples $h(t_k)$ is defined as:

For samples k = 0 to less than $\frac{N}{10}$, multiply by the factor $\frac{1}{2}\left[1-\frac{\cos 10\pi k}{N}\right]$

For samples k = $\frac{N}{10}$ through $\frac{N9}{10}$, multiply by the factor 1 (unchanged).

For samples k greater than $\frac{N9}{10}$, multiply by the factor $\frac{1}{2}\left[1-\frac{\cos 10\pi (N-k)}{N}\right]$

Note: Applying a window function to the data set reduces the total energy in the output spectrum because the input data is attenuated by the window. The spectral output of FFT needs to be multiplied by a correction factor to compensate for the window applied.

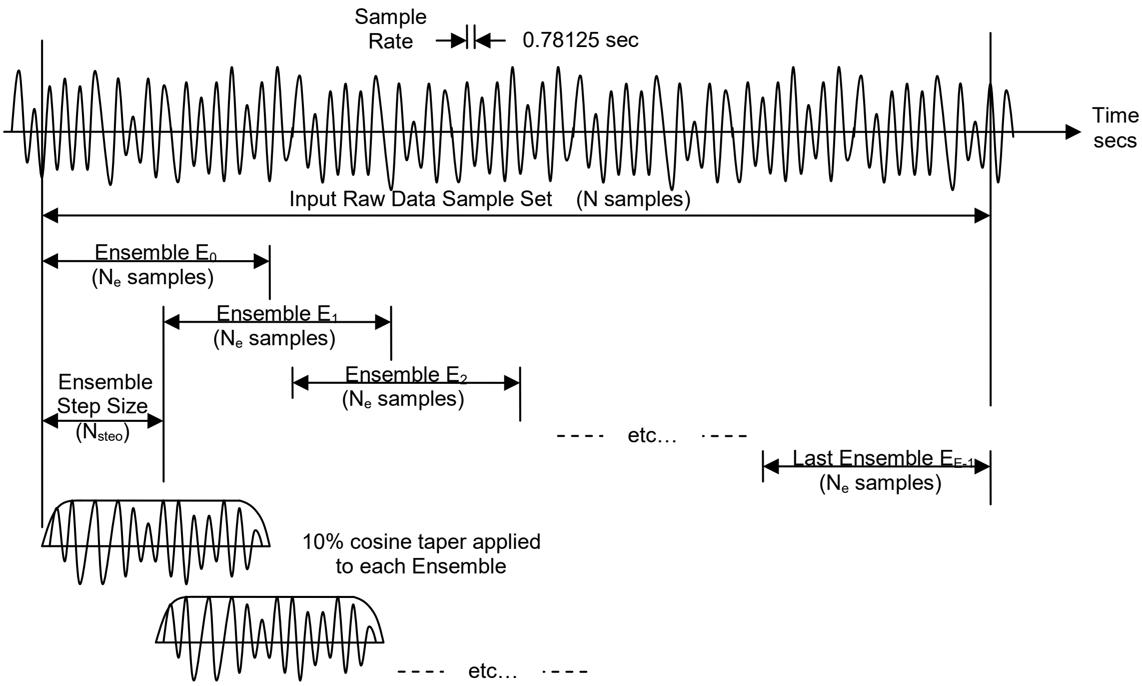
For a 10% cosine taper, the compensation factor is: $\frac{1}{0.8750}$ or 1.14286.

4 ENSEMBLE PROCESSING

The basis of the Ensemble Processing Method, is the use of the so-called Welch method which breaks the data set up into smaller, overlapping segments or ensembles of data. Fourier analysis is then performed on each ensemble and the spectral estimate or smoothed periodogram is obtained by averaging the spectral results from each ensemble. Overlapping ensembles are used to ‘smooth’ the results.

The ensemble averaging method reduces the overall variance of the resulting spectral estimates and is capable of producing more meaningful results from data that has missing or invalid samples, especially when selection criteria are applied to each ensemble to either include or reject that ensemble from the overall processing.

The following diagram shows the ensemble selection process graphically:



5 ENERGY DENSITY SPECTRUM

The energy density spectrum is calculated from the quality controlled heave displacement time series data set, ensemble by ensemble as detailed in the preceding sections.

To each ensemble a cosine taper window is applied, and then the one-sided power spectral density is obtained by applying a Fast Fourier Transform (FFT).

The energy density spectrum results obtained from applying an FFT to each ensemble are accumulated ordinate by ordinate and then divided by the number of good ensembles that were processed, in order to obtain the ensemble-averaged energy spectrum.

5.1 Calculating Total Summary Spectral Parameters

The first three order moments of the energy spectrum are calculated from *n* spectral ordinates:

Zeroth moment $M0 = \sum_{i=0}^{n} E_i \cdot f_{bw}$

First moment $M1 = \sum_{i=0}^{n} (E_i \cdot f_{bw}) f_n$ where $f_n = i \cdot f_{bw}$

Second moment $M2 = \sum_{i=0}^{n} (E_i \cdot f_{bw}) f_n{}^2$

From the spectral moments, the following summary parameters can be calculated for the whole of the energy density spectrum:

Significant Wave Height $Hs = 4\sqrt{M_0}$ (metres)

Spectral Mean Wave Period $Tm = \frac{M_0}{M_1}$ (seconds)

Average Zero-Crossing Period $Tz = \sqrt{\frac{M_0}{M_2}}$ (seconds)

The period of the peak spectral ordinate *Tp* can be calculated by locating the spectral ordinate containing the largest amount of energy, and multiplying the index of that ordinate by the spectral bandwidth f_{bw}.

Period of Peak Spectral Ordinate $$Tp = \frac{1}{i \cdot f_{bw}}$$

where *i* is the index of the highest ordinate.

The above summary parameters are calculated using the whole of the wave energy density spectrum, i.e. using spectral ordinates 0 through *n*. These provide the Total summary parameters for the whole of the frequency range.

5.2 Calculating Sea and Swell Summary Parameters

The wave energy density spectrum is then split into two parts at the frequency corresponding to the Sea-Swell Split, and summary spectral parameters are calculated separately for the low frequency part (Swell) and for the high frequency part (Sea) of the spectrum.
The spectral ordinates are split at the ordinate closest to that corresponding to the frequency represented by the Sea-Swell Split period, e.g. for a Sea-Swell Split of 9 seconds this gives an f_{split} of 0.11111Hz. The spectral ordinate index of the split *Ns* is obtained as follows:

$$Ns = \frac{f_{split}}{f_{bw}}$$ where *Ns* is rounded to the nearest integer.

The low frequency part (Swell) comprises spectral ordinates 0 through *Ns* inclusive.

The high frequency part (Sea) comprises spectral ordinates (*Ns* + 1) through *n* inclusive.

$$S_{total} = \{ 0, 1, \ldots n \}$$

$$S_{swell} = \{ 0, 1, \ldots Ns \}$$

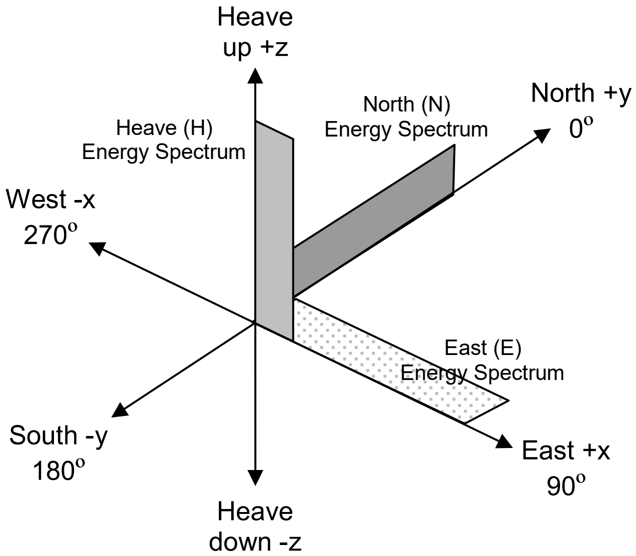
$$S_{sea} = \{ Ns+1, Ns+2, \ldots n \}$$

The zeroth, first and second moments of the energy spectrum are again calculated, but for the low frequency part only and then for the high frequency part only. The summary parameters are calculated from each set of the three moments, providing the Swell and Sea summary parameters respectively.

6 CALCULATING DIRECTIONAL SPECTRA

6.1 Power Density Spectra

For each of the three displacement time series (being heave, north and east displacement raw data sets), the spectral density can be calculated using Fourier analysis methods as previously described. This can now be visualised in three dimensions as:



POWER DENSITY SPECTRA

This gives three Fourier series, one for each primary axis. Each series consists of *n* Fourier coefficients corresponding to *n* frequency bands in the spectrum. Each spectral Fourier coefficient A_n is a vector consisting of a real and imaginary part:

$$A_n = \alpha_n + i\beta_n$$

The real part α_n is the magnitude of the energy component and the imaginary part $i\beta_n$ is the phase or direction of the energy component. For non-directional wave processing, and in the calculation of vertical wave energy (heave), the imaginary part is ignored and only the real part is used to obtain a one-sided energy density spectrum, the so-called auto spectrum.

6.2 Directional Spectra

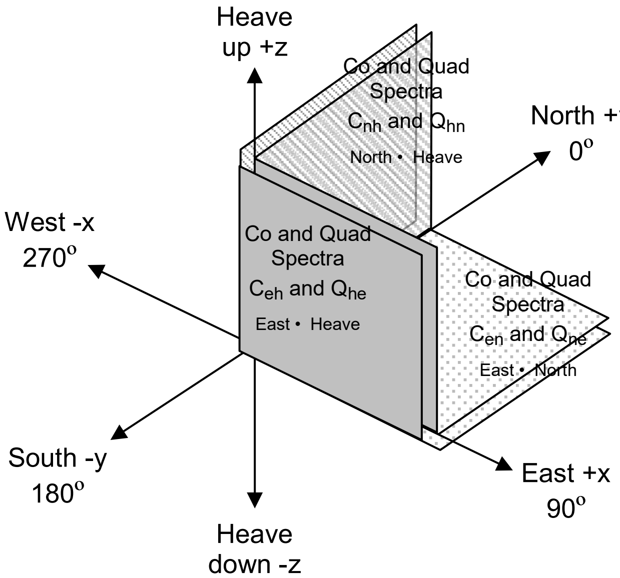
For directional wave processing, further information may be obtained by computing the cross-spectral components. This is done by matrix multiplication of the spectral Fourier coefficients between each pair of orthogonal axes. This results in two further spectra per pair of axes: a coincident spectrum (the magnitude or real part), and a quadrature spectrum (the phase or imaginary part).

For each of the *n* spectral Fourier coefficients in each pair of principal axes {east, north}, {east, heave} and {north, heave}, the coincident C_{xy} and quadrature Q_{xy} components can be calculated (note that C_{xy} and Q_{xy} are no longer complex numbers, but separately represent the real C_{xy} and imaginary Q_{xy} parts of the cross-spectrum calculation):

$$C_{xy} = \overline{A_x} \bullet \overline{A_y} = \alpha_x \alpha_y + \beta_x \beta_y$$

$$Q_{xy} = \overline{A_x} \times \overline{A_y} = \alpha_x \beta_y - \beta_x \alpha_y$$

This gives a total of 6 possible additional spectra, the so-called co-quad spectra, which can be visualised in three dimensions as:



CO-QUAD SPECTRA

6.3 Calculating Auto Spectra

For each valid, cleaned ensemble data set, a power spectrum is computed for each individual axis in turn, being {north}, {east} and {heave}. This provides three auto-spectra as detailed below.

The general power spectrum $P_{xx}(f)$ of the signal $x(t)$ is defined as:

$$P_{xx}(f) = X * X(f) \cdot X(f) = |X(f)|^2$$

where $X^*(f)$ is the complex conjugate of $X(f)$, and $X(f) = F\{x(t)\}$.

The auto power spectrum $P(f)$ is derived by dividing by n^2 where n is the number of samples:

$$P(f) = \frac{|X(f)|^2}{n^2}$$

This is equivalent to the real part of the cross-power spectrum described in the following section, and the same calculation method as for the co-quad spectra can be used, with x and y inputs being the same data set:

$$C_{ee}(k) = \frac{1}{n^2} \cdot E * E(k) \cdot E(k) \qquad \{\text{east}\}$$

$$C_{nn}(k) = \frac{1}{n^2} \cdot N * N(k) \cdot N(k) \qquad \{\text{north}\}$$

$$C_{hh}(k) = \frac{1}{n^2} \cdot H * H(k) \cdot H(k) \qquad \{\text{heave}\}$$

The heave auto power spectrum $Chh(k)$ is equivalent to the power density spectrum as calculated for non-directional waves and can be used for the wave height calculations rather than making a separate calculation for that purpose. Only $Chh(k)$ is required for calculation of wave height and other non-directional parameters. Other co-quad spectra are required for directional calculations, and these are derived as described in the following section.

Note: For the auto spectra, there is no rotation and therefore the quadrature or imaginary part is always zero:

$$Q_{ee} = Q_{nn} = Q_{hh} = 0$$

6.4 Calculating Co-Quad Spectra

For each valid, cleaned ensemble raw data set (comprising three ensembles of equal size being heave, north and east displacement data), a cross-power spectrum is computed for each pair of axes in turn, being {east vs. north}, {east vs. heave} and {north vs. heave}.

The general cross power spectrum $P_{xy}(f)$ of the signals $x(t)$ and $y(t)$ is defined as:

$$P_{xy}(f) = X * X(f) \cdot Y(f)$$

where $X^*(f)$ is the complex conjugate of $X(f)$, $X(f) = F\{x(t)\}$, and $Y(f) = F\{y(t)\}$.

This gives three cross-power spectra, each spectrum consisting of a number of Fourier coefficients, which in turn each consist of a real and imaginary part, giving a total of six Fourier components for each frequency in the spectrum.

From this, the co-quad spectra can be calculated as detailed below.

There are three coincident spectra (the real part, or magnitude) as follows:

$$C_{en}(k) = \frac{1}{n^2} \cdot E * E(k) \cdot N(k) \quad \{\text{east, north}\}$$

$$C_{eh}(k) = \frac{1}{n^2} \cdot E * E(k) \cdot H(k) \quad \{\text{east, heave}\}$$

$$C_{nh}(k) = \frac{1}{n^2} \cdot N * N(k) \cdot H(k) \quad \{\text{north, heave}\}$$

where *E(k)* is the east, *N(k)* is the north, and *H(k)* are the heave displacements respectively, and *n* is the number of samples in the ensemble.

Note: For coincident spectra $C_{xy}(k) = C_{yx}(k)$, i.e. the coincident cross-spectrum of {east, north}gives the same result as the coincident cross-spectrum of {north, east}.

There are three quadrature spectra (the imaginary part, or phase) as follows:

$$Q_{ne}(k) = -\frac{1}{n^2} \cdot N * N(k) \cdot E(k) \qquad \{\text{north, east}\}$$

$$Q_{he}(k) = -\frac{1}{n^2} \cdot H * H(k) \cdot E(k) \qquad \{\text{heave, east}\}$$

$$Q_{hn}(k) = -\frac{1}{n^2} \cdot H * H(k) \cdot N(k) \qquad \{\text{heave, north}\}$$

where *E(k)* is the east, *N(k)* is the north, and *H(k)* are the heave displacements respectively, and *n* is the number of samples in the ensemble.

Note 1: For quadrature spectra, $Q_{xy}(k) = -Q_{yx}(k)$, i.e. the quadrature cross-spectrum of {north, east} gives the negated result of the quadrature cross-spectrum of {east, north}. Therefore only one set of quadrature spectra need be calculated; however it is important to ensure that the correct sign from this actual calculation (which will be either Q_{xy} or -Q_{yx}) is used in subsequent calculations.

Note 2: As the quadrature spectra represent rotation, only the rotations generated by rolling wave actions are relevant. Eddy currents (rotation in the horizontal plane) are not part of wave physics and would normally be zero. Therefore $Q_{ne}(k)$ is not used and need not be calculated.

6.5 Intermediate Storage as a Cross-Spectrum Matrix

A total of nine coincident, quadrature and auto spectra can be calculated and temporarily stored as a cross-spectrum matrix of results as follows:

Auto Spectra

Coincident Spectra

$$
\begin{array}{c|ccc}
 & \text{East} & \text{North} & \text{Heave} \\
\hline
\text{East} & \mathbf{C_{ee}(k)} & \mathbf{C_{en}(k)} & C_{eh}(k) \\
\text{North} & Q_{ne}(k) & \mathbf{C_{nn}(k)} & C_{nh}(k) \\
\text{Heave} & \mathbf{Q_{he}(k)} & \mathbf{Q_{hn}(k)} & \mathbf{C_{hh}(k)}
\end{array}
$$

Quadrature Spectra

CROSS-SPECTRUM MATRIX

The data stored in the cross-spectrum matrix will be used in subsequent calculation steps.

Note: Not all of the co-quad spectra are needed for further calculations. $Q_{ne}(k)$, $C_{eh}(k)$ and $C_{nh}(k)$ are not used in the next step and need not be calculated.

6.6 Calculating Normalised Direction Fourier Coefficients A_1, B_1, A_2 and B_2

The normalised directional distribution of the energy in the measured wave is expressed as:

$$G(\theta, f) = \frac{1}{\pi}\left\{\frac{1}{2} + a_1 \cos\theta + b_1 \sin\theta + a_2 \cos 2\theta + b_2 \sin 2\theta + \ldots\right\}$$

The first four Fourier coefficients a_1, b_1, a_2 and b_2 of this normalised directional distribution $G(\theta,f)$ for each frequency band in the spectrum are calculated as follows, using the co-quad spectra that were previously calculated and stored in the cross-spectrum matrix:

$$a_1 = \frac{Q_{he}}{\sqrt{(C_{ee} + C_{nn})C_{hh}}}$$

$$b_1 = \frac{Q_{hn}}{\sqrt{(C_{ee} + C_{nn})C_{hh}}}$$

$$a_2 = \frac{C_{ee} - C_{nn}}{C_{ee} + C_{nn}}$$

$$b_2 = \frac{2C_{en}}{C_{ee} + C_{nn}}$$

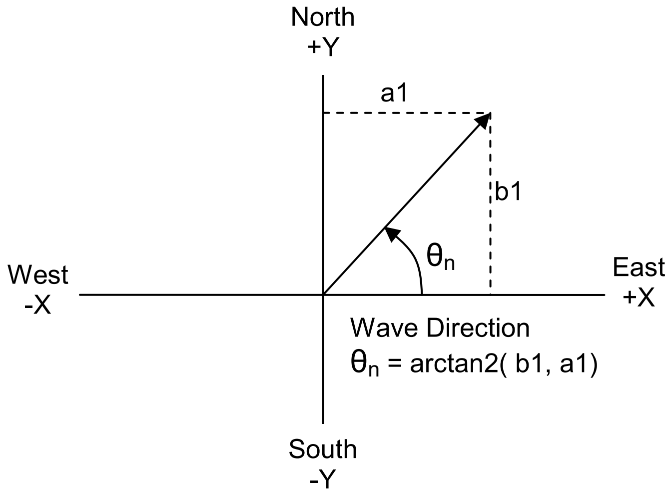
These normalised direction Fourier coefficients can be used to determine the mean direction, spread, asymmetry and flatness of the directional energy distribution, and also as inputs to various estimators of the directional energy distribution.

6.7 Calculating Wave Direction Theta at each Ordinate Frequency

The a_1 and b_1 normalised direction Fourier coefficients as calculated above contain directional information for the East or X axis, and for the North or Y axis, respectively.

The dominant wave direction θ_n at each of n frequency bands in the spectrum is then calculated from the a_1 and b_1 normalised direction Fourier coefficients using basic trigonometry, to produce a spectrum of n wave directions in Cartesian coordinates:

$$\theta_n = \arctan\left(\frac{b_1}{a_1}\right)$$



CALCULATING WAVE DIRECTION THETA

As both a_1 and b_1 are derived using the same denominator, the wave direction θ_n can also be calculated directly from the quadrature spectra $Q_{hn}(k)$ and $Q_{he}(k)$ as follows, if preferred:

$$\theta_n = \arctan\left(\frac{Q_{hn}}{Q_{he}}\right)$$

This wave direction θ_n is *not* the same as the energy weighted mean direction at frequency band n. It is merely the direction of the first or dominant harmonic in the complex waveform representing the sea state in that frequency band n.

Note: The arctan2(y, x) function should always be used to accommodate all four direction quadrants correctly. The output of the arctan2() function is radians in Cartesian coordinates and must be converted to degrees in geographic coordinates before display.

6.8 Calculating Wave Directional Spread at each Ordinate Frequency

A cos2s estimate r_n of the sharpness of the wave at each of n frequency bands in the spectrum can be derived as follows:

$$r_n = \sqrt{a_1^{\,2} + b_1^{\,2}}$$

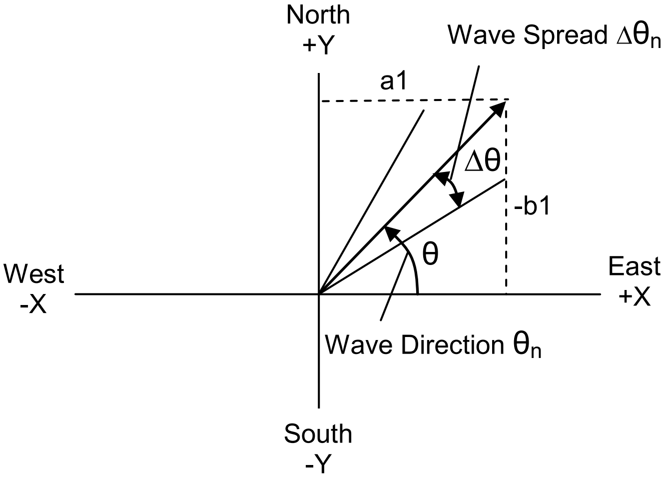
From this sharpness estimate, the RMS angular spread $\Delta\theta_n$ of the wave at each of n frequency bands in the spectrum can be calculated in radians:

$$\Delta\theta_n = \sqrt{\frac{2}{1+\frac{r}{1-r}}}$$

or in degrees:

$$\Delta\theta_n = \frac{360}{2\pi}\cdot\sqrt{\frac{2}{1+\frac{r}{1-r}}}$$

As $\Delta\theta$ is a measure of spreading angle about the dominant wave direction, it is only necessary to convert it into degrees, not into geographic coordinates as that would have no meaning. Wave directional spread and its relationship to the wave direction are shown diagrammatically:



CALCULATING WAVE SPREAD

6.9 Calculating Wave Ellipticity at each Ordinate Frequency

Wave ellipticity ε indicates the shape of the wave. For waves whose length is much shorter than the water depth, the waves describe a circular orbit and the ellipticity is near 1. If the length of the wave is comparable to or larger than the depth (i.e. waves in shallow water), the vertical displacements are smaller than the horizontal ones and ellipticity is less than 1. The variation of ellipticity with wave frequency can therefore be indicative of local depth.

The ellipticity of the wave at each of n frequency bands is calculated as follows:

$$\varepsilon_n = \sqrt{\frac{C_{hh}}{C_{nn}+C_{ee}}}$$

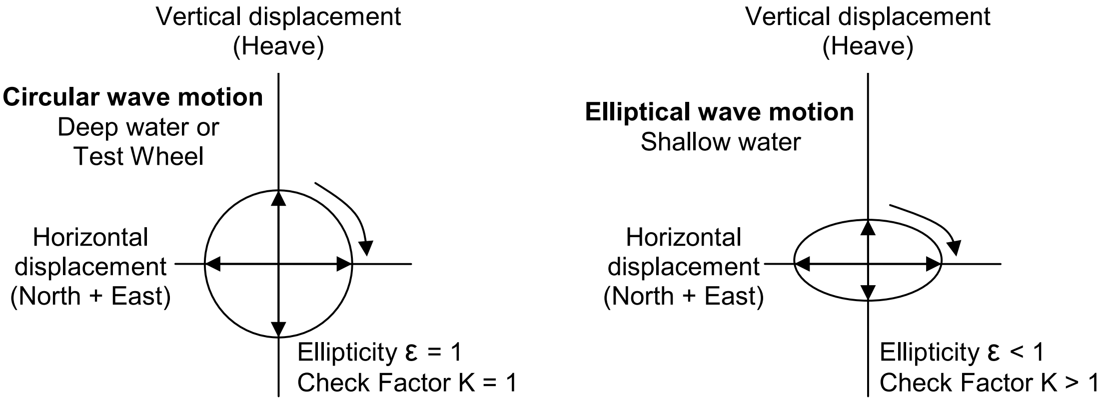
6.10 Calculating Check Factor at each Ordinate Frequency

The reciprocal of the ellipticity is the so-called check factor K (Datawell convention):

$$K_n = \frac{1}{\varepsilon_n}$$

The check factor can be used when testing a buoy in a rotating wheel. As this is a truly circular motion, both the ellipticity ε and check factor K should be 1. Any deviation from 1 may indicate internal problems with the accelerometer platform stability within the buoy.

Wave ellipticity and its reciprocal, Check Factor, are shown diagrammatically as follows:



7 CALCULATING SUMMARY DIRECTIONAL SPECTRAL PARAMETERS

The summary parameters Hs, Tm Tz and Tp are calculated from the heave energy density spectrum.

Once the directional spectra calculations are completed, some additional summary directional parameters can be obtained, as described in the following sections.

In each case, these summary parameters are calculated once each for the Total, Sea and Swell parts of the spectrum.

7.1 Peak Direction θ_{peak}

The peak spectral ordinate, i.e. the frequency band with the highest energy, can be found by locating the spectral ordinate of the heave energy density spectrum that contains the largest amount of energy.

The direction θ_{peak} of the peak spectral energy is simply the corresponding θ_i from the direction spectrum, where *i* is the index of the spectral ordinate containing the largest amount of energy.

7.2 Energy Weighted Mean Direction θ_{mean}

The energy weighted mean direction is obtained by first calculating the energy weighted mean sine and cosine components as follows:

$$S_{mean} = \frac{\sum_i E_i \sin\theta}{\sum_i E_i}$$

$$C_{mean} = \frac{\sum_i E_i \cos\theta}{\sum_i E_i}$$

Then the resulting energy weighted mean direction θ_{mean} is:

$$\theta_{mean} = \arctan\left(\frac{S_{mean}}{C_{mean}}\right)$$

Note: The arctan2(y, x) function should always be used to accommodate all four direction quadrants correctly.

7.3 Spread at Peak Direction $\Delta\theta_{peak}$

The peak spectral ordinate was previously found by locating the spectral ordinate of the heave energy density spectrum that contained the largest amount of energy.

The RMS angular spread at the peak direction $\Delta\theta_{peak}$ is simply the corresponding $\Delta\theta_i$ from the directional spread spectrum which was obtained previously as described in section 6.6.8 Calculating Wave Directional Spread, where *i* is the index of the peak spectral ordinate that contains the largest amount of energy.

7.4 Energy Weighted Spread of Mean Direction $\Delta\theta_{mean}$

The energy weighted RMS angular spread about the mean direction $\Delta\theta_{mean}$ is calculated as follows:

$$\Delta\theta_{mean} = \frac{\sum_i E_i \cdot \Delta\theta_i}{\sum_i E_i}$$

using the directional spread spectrum $\Delta\theta$.

8 CALCULATING DIRECTIONAL DISTRIBUTION USING MAXIMUM ENTROPY METHOD

Using the first four Fourier coefficients a_1, b_1, a_2 and b_2 of the normalised directional distribution $G(\theta,f)$ for each frequency band in the spectrum, there are various ways to estimate, the directional distribution function. The Maximum Entropy Method (MEM) is RPS recommended approach.

8.1 Summary of Theoretical Background

In summary, for a positive function on (0, 2π) expressed as its Fourier series:

$$F(\theta) = \frac{1}{2\pi}\sum_{n=-\infty}^{\infty} c_n e^{in\theta}, \; c_0 = 1, \;\; c_{-n} = c_n^*$$

using the Burg entropy function defined as

$$H(F) = -\int_0^{2\pi} \log(F(\theta))d\theta$$

it can be demonstrated that the solution to the optimisation problem of maximising entropy H:

$$\begin{aligned} &\max \;\; H(F) \\ &\text{subject to}: \int_0^{2\pi} F(\theta)e^{-ik\theta}d\theta = c_k, \;\; k \le N \end{aligned}$$

is

$$F(\theta) = \frac{1}{2\pi}\frac{1-\phi_1 c_1^* - \cdots - \phi_N c_N^*}{\left[1-\phi_1 e^{-i\theta} - \cdots - \phi_N e^{-iN\theta}\right]^2}$$

where the parameters can be obtained from:

$$\begin{bmatrix} 1 & c_1^* & \cdots & c_{N-1}^* \\ c_1 & 1 & \ddots & \\ \vdots & \ddots & \ddots & c_1^* \\ c_{N-1} & \cdots & c_1 & 1 \end{bmatrix}\begin{bmatrix} \phi_1 \\ \phi_2 \\ \vdots \\ \phi_N \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ \vdots \\ c_N \end{bmatrix}$$

Applying the above approach to the wave data triplets with *N*=2, we will have the MEM solution of the directional distribution function as:

$$D(\theta, f) = \frac{1}{2\pi} \frac{1 - \phi_1(f)c_1^*(f) - \phi_2(f)c_2^*(f)}{\left[1 - \phi_1(f)e^{-i\theta} - \phi_2(f)e^{-i2\theta}\right]^2}$$

where

$$\phi_1(f) = \frac{c_1(f) - c_2(f)c_1^*(f)}{1 - \left|c_1(f)\right|^2}$$

$$\phi_2(f) = c_2(f) - c_1(f)\phi_1(f)$$

and

$$c_1(f) = a_1(f) + ib_1(f)$$

$$c_2(f) = a_2(f) + b_2(f)$$

Note: The mean direction and spreading calculation will still use the cos2s approach as previously described using the first four Fourier coefficients $a_1(f)$, $a_2(f)$, $b_1(f)$ and $b_2(f)$.

8.2 Calculation of Directional Distribution using MEM

The MEM algorithm will produce a two-dimensional matrix of results at each direction at the chosen interval θ_Δ for each frequency band f_n. For example, for a spectrum of 128 frequency bands and a chosen θ_Δ of 5 degree, the resulting matrix would represent the energy contained in each of 72 directions for each of 128 frequencies (a matrix of 72 x 128 or 9,216 results).

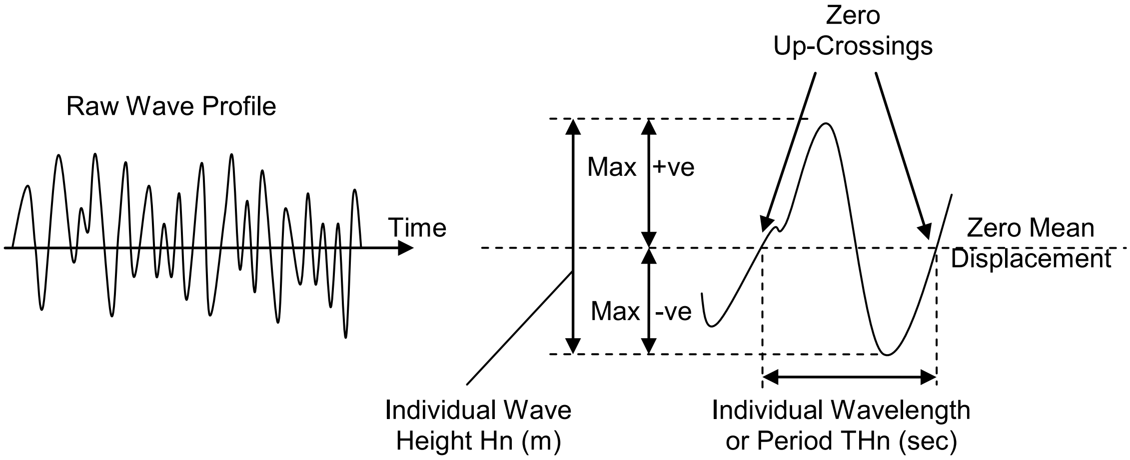
Time Domain Analysis

1 INTRODUCTION

1.1 Conventions

Time domain analysis involves identifying and categorising individual waves within the raw wave profile data, by analysing the measured displacements over a period of time.
For both non-directional and directional wave data, time domain analysis is done *only* on the heave displacement raw data set.

The following diagram illustrates the basic definition of an individual wave, which is the part between two successive zero up-crossings, or transitions from negative to positive through the mean of the data set:



BASIC WAVE ANALYSIS

Note: Some use the convention of zero down-crossings, i.e. transitions from positive to negative through the mean of the data set. RPS MetOcean uses and recommends the zero up-crossing convention as defined in [Tucker, 1963]. As waves are frequently asymmetric, the two conventions will give different results for any given wave profile. Whether or not there is any significant statistical difference over many wave profiles is not known.

2 OBTAINING ZERO MEAN

Before analysing the raw wave profile, it is essential that the raw data set is corrected so that it has a mean value of zero. This allows the transitions through zero, i.e. changes in displacement polarity from –ve to +ve and vice-versa, to be detected and used to accurately determine the start and end of individual waves in the raw wave profile.

In the case of raw wave profiles obtained from a fixed sensor such as an air space sensor, it is also necessary to invert the data and remove any rising or falling trend due to tide.

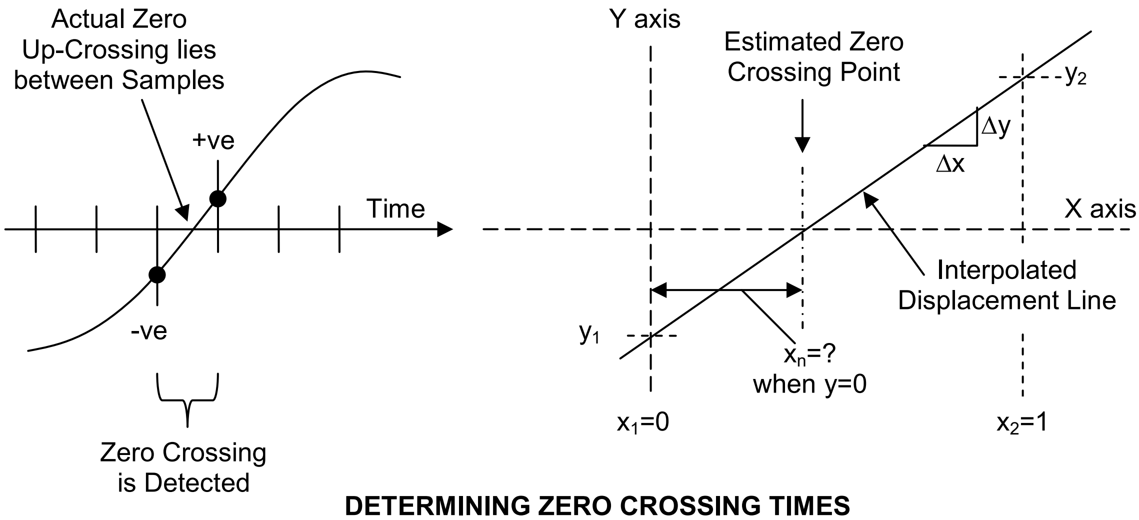
2.1 Establishing Individual Waves

Each individual wave is defined by successive up-crossings at the zero mean of the discrete wave profile.

Periods

Some inaccuracy in wave period will result due to the fact that the actual zero crossing will usually occur somewhere in between two discrete sampling intervals. This error could be in the worst case up to ±2 Raw Data Intervals, e.g. 1.56 seconds for DWR data or 1 second for air space data. Therefore linear interpolation between the two raw data samples adjacent to the zero crossing point should be used to obtain a better estimate of the actual crossing point in time.

The following diagram illustrates the problem and the basic straight line interpolation method used to estimate the actual zero crossing point:



DETERMINING ZERO CROSSING TIMES

The interpolated straight line between the previous data sample x_1, y_1 and the next data sample x_2, y_2 can be calculated from the straight line formula $y=mx+c$ as follows:

$$\text{Gradient } m = \frac{\Delta y}{\Delta x} \equiv y_2 - y_1 \quad \text{because } \Delta x \text{ is always } 1.$$

By definition, the Y axis intercept $c = y_1$

From the diagram above it can be seen that y = 0 at the point where the wave crosses through zero and x_n is the time interval of the estimated zero crossing point.
Therefore, to solve for x_n when y = 0 :

$$x_n = \frac{y - c}{m} \quad = \frac{0 - y_1}{m} \quad = \frac{-y_1}{y_2 - y_1}$$

The whole number of sample intervals between the two detected zero crossings is counted, and then the fractional parts from the calculation above for the start and end of the wave are added. The fractional part for the start of the wave is (1 - x_n), as it is the interval between the estimated crossing point and the next whole sample interval x_2 that is required here.

Heights

Further inaccuracy is associated with the individual wave height determination. Within each defined wave, the individual wave height is defined as the highest discrete profile value, minus the lowest discreet profile value. Slight inaccuracy will accrue because the discrete maxima and minima are unlikely to coincide precisely with the wave crest and trough. The wave height estimate will therefore **always** be low, but only by a very small amount provided the sampling interval is not too long.

3 WAVE PROFILE ANALYSIS

Prior to ranking individual waves by height, two fundamental time domain parameters are calculated. One is the variance of the discrete wave profile values about the zero mean line, and the other is the average of all individual wave periods in each profile. From these, are calculated:

$$\mathrm{H_{sigma}} = 4 \times (\mathrm{variance})^{1/2}$$

$$\mathrm{T_z} = \text{average mean zero up-crossing period}$$

Following this, all individual waves are ranked by height (with associated zero up-crossing periods). From the ranked data, the following parameters are determined:

$\mathrm{H_{max}} =$ the highest individual wave in the profile

$\mathrm{TH_{max}} =$ the zero up-crossing period associated with H_{max}

$\mathrm{H_{1/10}} =$ the average height of the highest one tenth of waves

$\mathrm{TH_{1/10}} =$ the average of zero up-crossing periods associated with the highest one tenth of waves

$\mathrm{H_{1/3}} =$ the average height of the highest one third of waves. This is also known as the significant wave height, H_s

$\mathrm{TH_{1/3}} =$ the average of zero up-crossing periods associated with the highest one third of waves. This is also known as the significant wave period T_s.

When wave profiles are not contiguous (i.e. there is a pronounced gap between each profile), the assumption is often made that the seastate is 'statistically stationary' (i.e. the statistics of the wave profile will remain representative of the seastate between successive profiles). This assumption is only good for an hour (or less) in severe tropical storms, but may be good for 3 hours in extratropical storms, or longer in more benign conditions,

For non-contiguous wave profiles, assumptions about the individual wave height distribution allow estimates of the expected maximum single wave height for the duration for which the seastate is assumed to be stationary. The Rayleigh distribution is considered to be representation of 'typical' seastates, but it is known to overestimate higher waves during storms. For tropical storms, the Forristall distribution provides a better description of higher waves. Both Rayleigh and Forristall EH_{max} estimates are available from the time domain analysis.

Appendix F
Data Processing Chain and QC

1 QUALITY CONTROL

Most data logging systems undertake Quality Assurance (QA), such as range checking and de-spiking, where as for design and engineering purposes metocean data requires Quality Control (QC) which involve checking that data are valid and fit for use. An example of this is QA will remove high values in a time series, but QC will retain these extrema unless proven to be incorrect. The extrema are the values that are required for return period calculations, for example calculating the 100 year wave height.

RPS has invested highly in ensuring that data are highly accurate and fully quality controlled. This includes pre-deployment rigorous checks and calibrations to ensure that measurements meet the client's requirements.   During processing, the results of the calibrations are applied, with full audit trail so that results can be verified.

The performance of the instruments is monitored closely, including detailed checks of real-time data (where available) during deployment to determine possible sensor drift and outages. Instrument details are logged, and post deployment documentation double checked. This includes logging of first and last samples for comparison against time from a reliable source which is also logged. This allows calculation of instrument time drift. Significant timing errors are corrected in post processing.

This document presents descriptions of the typical details considered when quality controlling each instrument type. Plus the data processing, QC, analysis and reporting flowchart with screen captures of the processing software “inst2moe” and the four quality control programs “moeqc”, “moewaveqc”, “moesedqc” and “moeprofileqc”.

Note that it is our practice to ensure that the quality control, using visual inspection by our scientist, is review by senior personnel.

2 POST PROCESSING AND QUALITY CONTROL

2.1 Lidar Buoy

The Lidar Buoy is typically fitted with a ZX LIdar and two anemometers, one anemometer is connected to the Lidar and used by the ZX firmware to resolve directional ambiguity, the other is stand-alone ultrasonic anemometer.

2.1.1 Lidar & Anemometer QC

The Lidar data are visually inspected to differentiate between outliers, spurious data and actual data. Quality flags are then set for each timestamp of each parameter between ‘good’, ‘suspect’ or ‘bad’. Detailed attention is given to flag 180° directional ambiguity errors that may not have been resolved by the ZX firmware. To check for consistency the stand-alone anemometer speed and direction are overlayed with each level of the Lidar speed and direction. Checks are made where large differences occur between the winds at different heights. The vertical profile should be feasible.

2.1.2 Meteorological Sensors (including Temperature (Air & Water) and Barometric Pressure)

These parameters require our meteorological team to perform a day-by-day (and often finer scale) visual inspection to differentiate between outliers, spurious data and actual data. Quality flags are then set for each timestamp of each parameter between ‘good’, ‘suspect’ or ‘bad’. Such detailed analysis of the data record allows us to identify various phenomena within the dataset, providing useful insight into local meteorology.

2.2 Waves (MRU)

The MRU samples wave profiles in 2048 second ensembles (at 1 Hz or 2 Hz), which are individually inspected for their heave, pitch and roll components. These data are then flagged ‘good’, ‘suspect’ or ‘bad’. Such visual quality checking methodology allows us to identify finer scale wave phenomenon such as shelf-waves, seiching, ultra-long period waves and freak waves, in addition to observing spectral wave energy and associated direction, check factor and spread. Such information allows us to provide crucial insight into localised wave climate that often has specific implications for various applications.

These data then undergo Wave Spectra Analysis to produce the 1D (cos2s) spectra and Time Domain Analysis (for Hmax and THmax). The output spectra and derived parameters are then visually inspected to ensure all data are valid. Note: 2D (Maximum Entropy Method) spectra can be calculated If required.

2.3 Currents

Time history plots of current speed and direction (derived from North and East speeds) are visually inspected on a day-by-day scale to identify poor quality data which can include marine fouling, fish interference, timing errors and sensor drift, which are flagged as ‘good’, ‘suspect’ or ‘bad’ for each record. In addition, such a fine-scale analysis can aid in the identification of more localised phenomena like solitons, infra-gravity waves and internal tides.

2.4 Tide Gauge

Tide and seawater temperature data are visually inspected via in-house quality checking programs that allow us to closely inspect changes in sensor depth that are caused by non-environmental factors. These include sensor drift, mooring setting and shifting, instrument logging issues and pressure sensor anomalies. Quality flags are then set for each timestamp between ‘good’, ‘suspect’ or ‘bad’.

Depending on location and use, the tide data are then analysed to derive constituents for comparison to nearby phases and amplitudes to ensure the timing and amplitude of tidal constituents are correct. Additional work is required over multiple deployments to match heights to aid in providing a more accurate suite of constituents.

3 FLOW CHARTS

The following flow charts show the steps taken to process, quality control and report data.

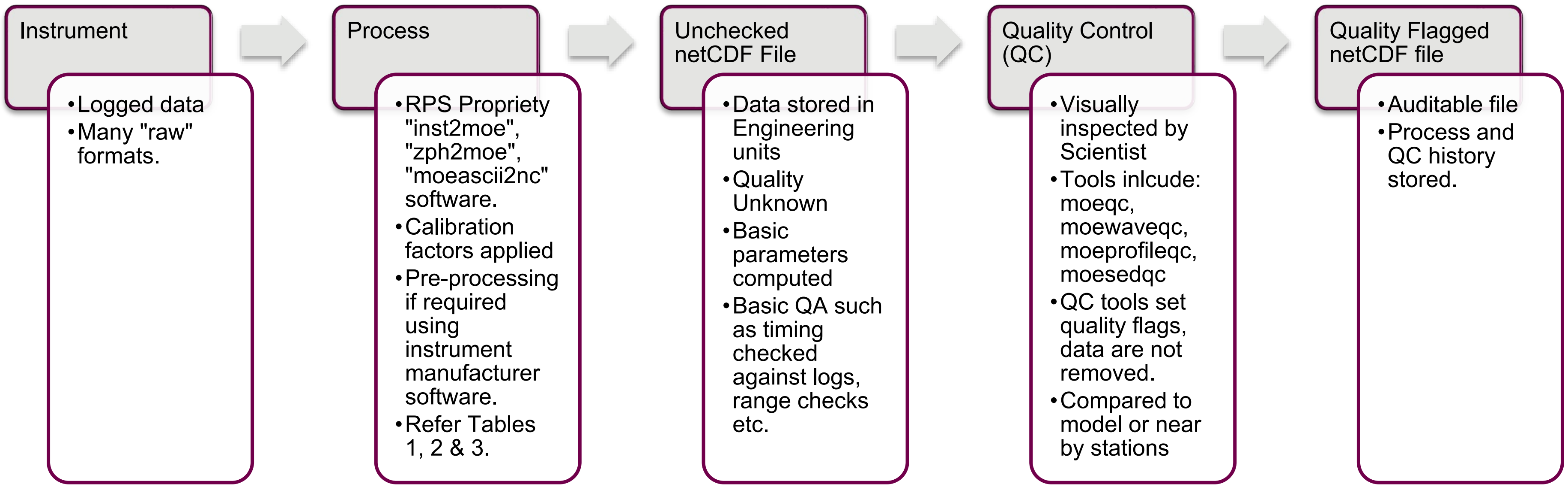


Figure 1 Data Processing and Quality Control flow chart

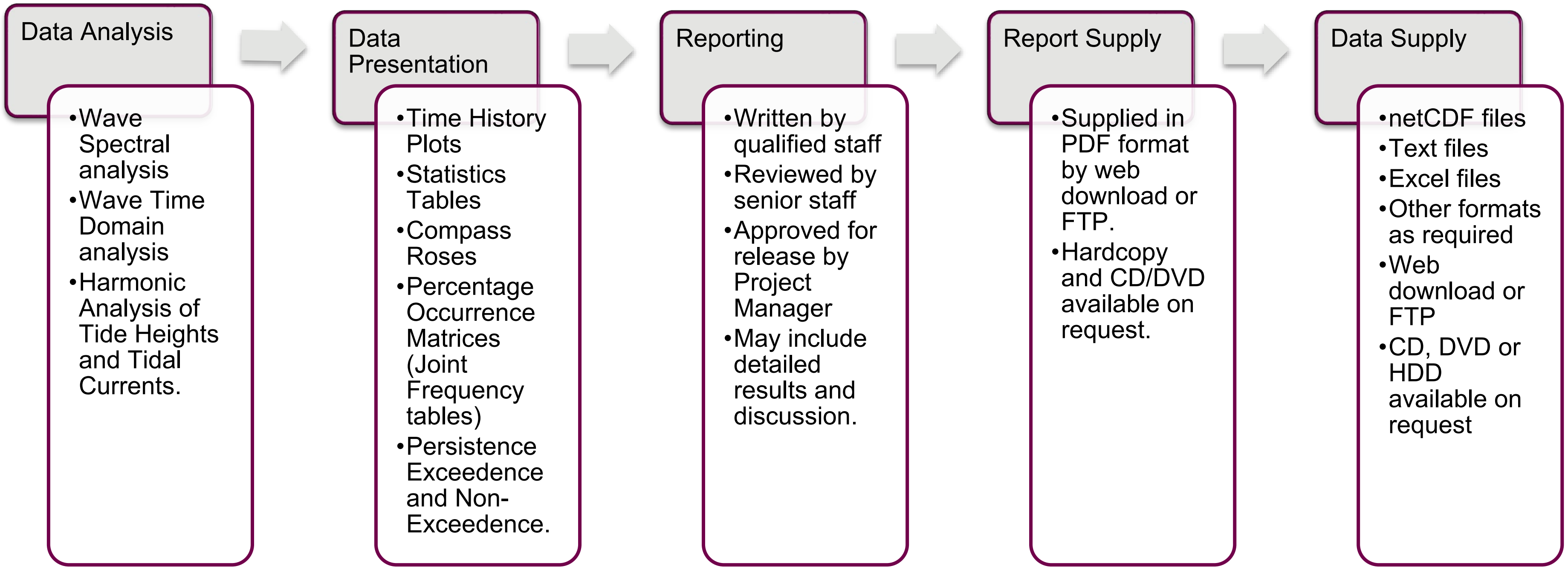


Figure 2 Data Analysis and Reporting flow chart

4 PROCESSING TABLES

The following lists the steps for processing data received from a RPS Floating Lidar Buoy 4.5

Table 1: Lidar Processing

Lidar Processing and Presentations		
Steps	**Where**	**Function**
1. unzip	Linux command line	Unzip the ZPH files logged by the ZX Lidar
2. zph2csv	Windows Command	ZX proprietary software to convert ZPH to CSV
3. zph2moe	Linux command line	RPS software to convert ZPH.csv files to netCDF
4. moetrim	Linux GUI	RPS software to remove pre-deployment and post-recovery records
5. moeqc	Linux GUI	RPS software to set quality flags. Initial values are flagged as unknown. A qualified staff member visually inspects the data and sets the flag to either good, suspect or bad.
6. moetimehist	Linux GUI	Time history plots of Quality Controlled data. Plots can be arranged in many ways, including plots of individual parameters or overlay plots. Both time and parameter axis are fully adjustable.
7. moematrix	Linux GUI	Percentage Occurrence Matices (Joint Frequency Tables) and Statistics table
8. moerose	Linux GUI	Direction “roses” and if required scatter plots
9. moecorel	Linux GUI	Correlation plots and tables

Table 2: MRU Processing

MRU Processing and Presentations of Wave data		
Steps	**Where**	**Function**
1. moemru2nc or inst2moe	Linux Command-line Linux GUI	Converts logged binary file to netCDF burst set by frequency of samples, interval between bursts and number of sample point. For example: 2 Hz, 30 minute interval records, 4096 samples per record. This gives a 34' 8" burst every 30 minutes, with a 34' 8" overlap. Each burst record consists of VertDisp, Pitch & Roll (moemru2nc is being incorporated into inst2moe)
2. moetrim	Linux GUI	RPS software to remove pre-deployment and post-recovery records
3. moewaveqc	Linux GUI	Quality control of wave burst data
4. moeburstproc	Linux GUI	Spectral and Time Domain Analysis of burst data file. Outputs cos2s and MEM spectra files with derived parameters and time domain file (for Hmax and THmax)
5. moetimehist	Linux GUI	Time history plots of Quality Controlled data. Plots can be formatted in many ways, including plots of individual parameters or overlay plots. Both time and parameter axis are fully adjustable.
6. moematrix	Linux GUI	Percentage Occurrence Matices (Joint Frequency Tables) and Statistics table
7. moerose	Linux GUI	Direction "roses" and if required scatter plots
8. moespectra (optional, if required)	Linux GUI	Plots of spectra, cos2s & MEM

Table 3: Other Meteorological Parameters Processing

Other Meteorological Parameters Processing and Presentation		
Steps	**Where**	**Function**
1. moeascii2nc	Linux GUI	RPS software to convert logged CSV files to netCDF.
2. moetrim	Linux GUI	RPS software to remove pre-deployment and post-recovery records
3. moeqc	Linux GUI	RPS software to set quality flags. Initial values are flagged as unknown. A qualified staff member visually inspects the data and sets the flag to either good, suspect, or bad.
4. moetimehist	Linux GUI	Time history plots of Quality Controlled data. Plots can be arranged in many ways, including plots of individual parameters or overlay plots. Both time and parameter axis are fully adjustable.
5. moematrix	Linux GUI	Percentage Occurrence Matices (Joint Frequency Tables) and Statistics table
6. moerose	Linux GUI	Direction “roses” and if required scatter plots
7. moecorel	Linux GUI	Correlation plots and tables

5 SOFTWARE EXAMPLES

The following examples show a selection of the GUI interfaces used to processing and QC data.

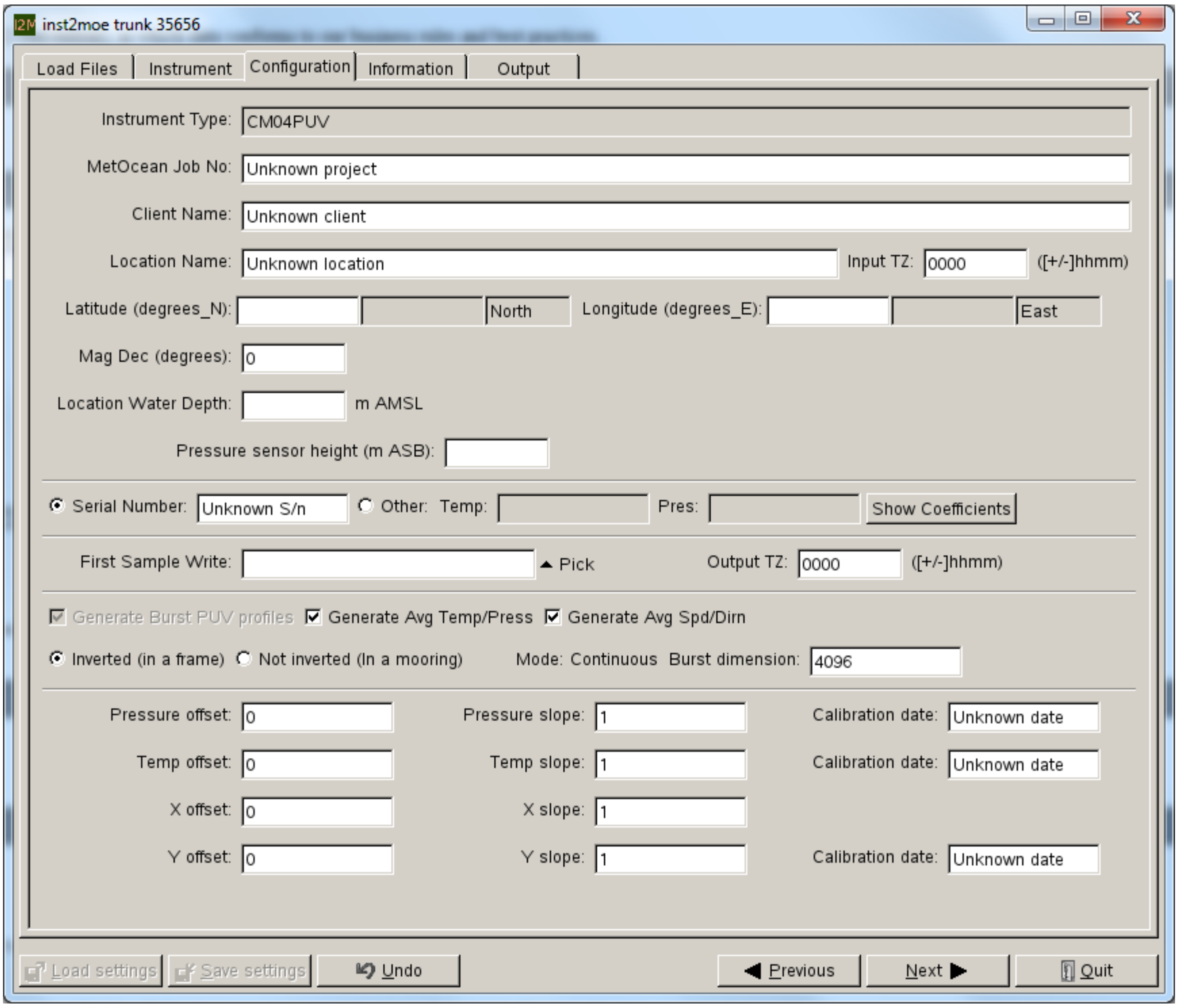


Figure 3 Inst2moe software configuration screen showing calibration information fields for pressure, temperature, X & Y velocity access. Offset, slope and date are entered

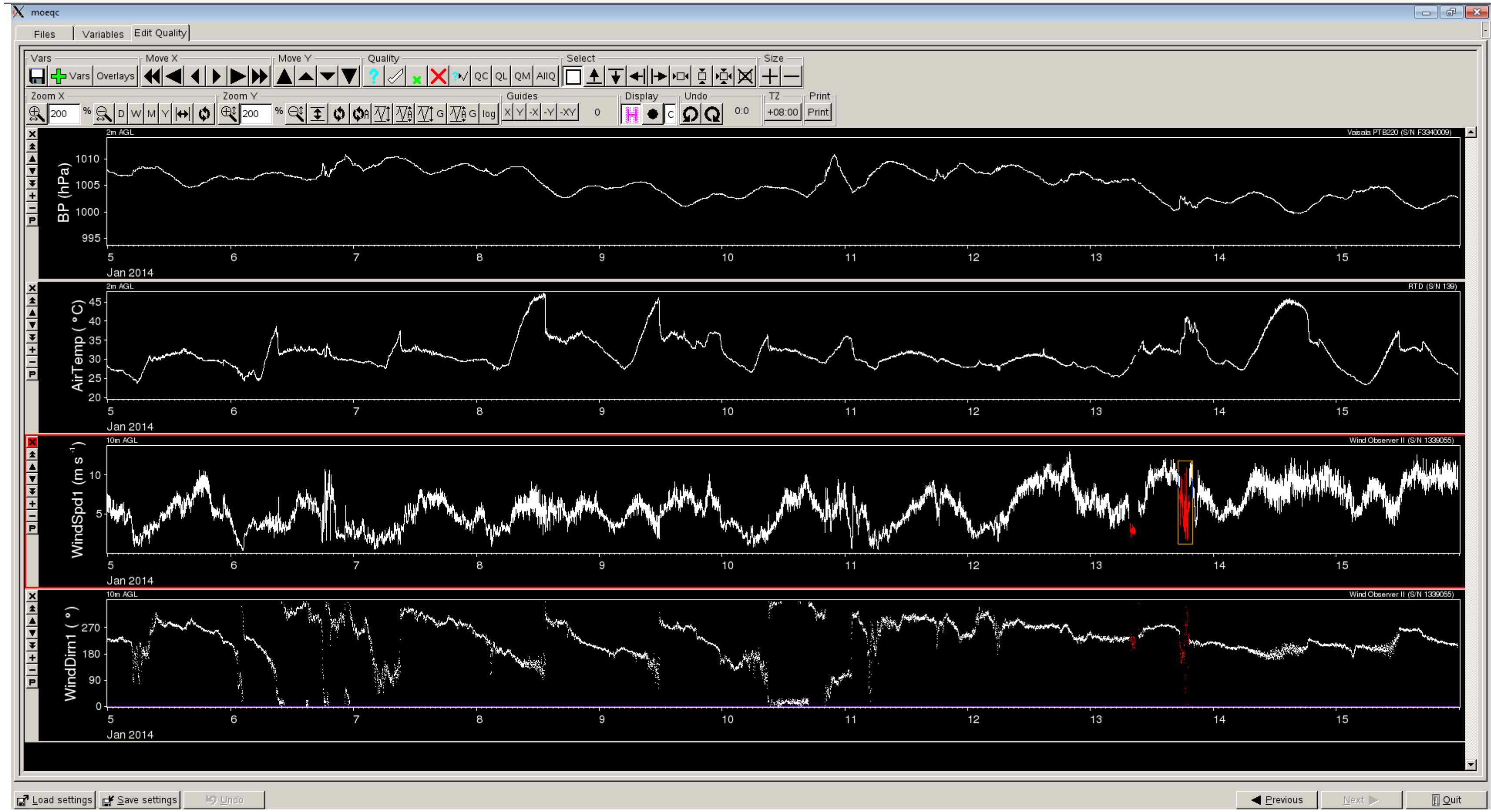


Figure 4 Quality Control software “moeqc” displaying meteorological parameters.

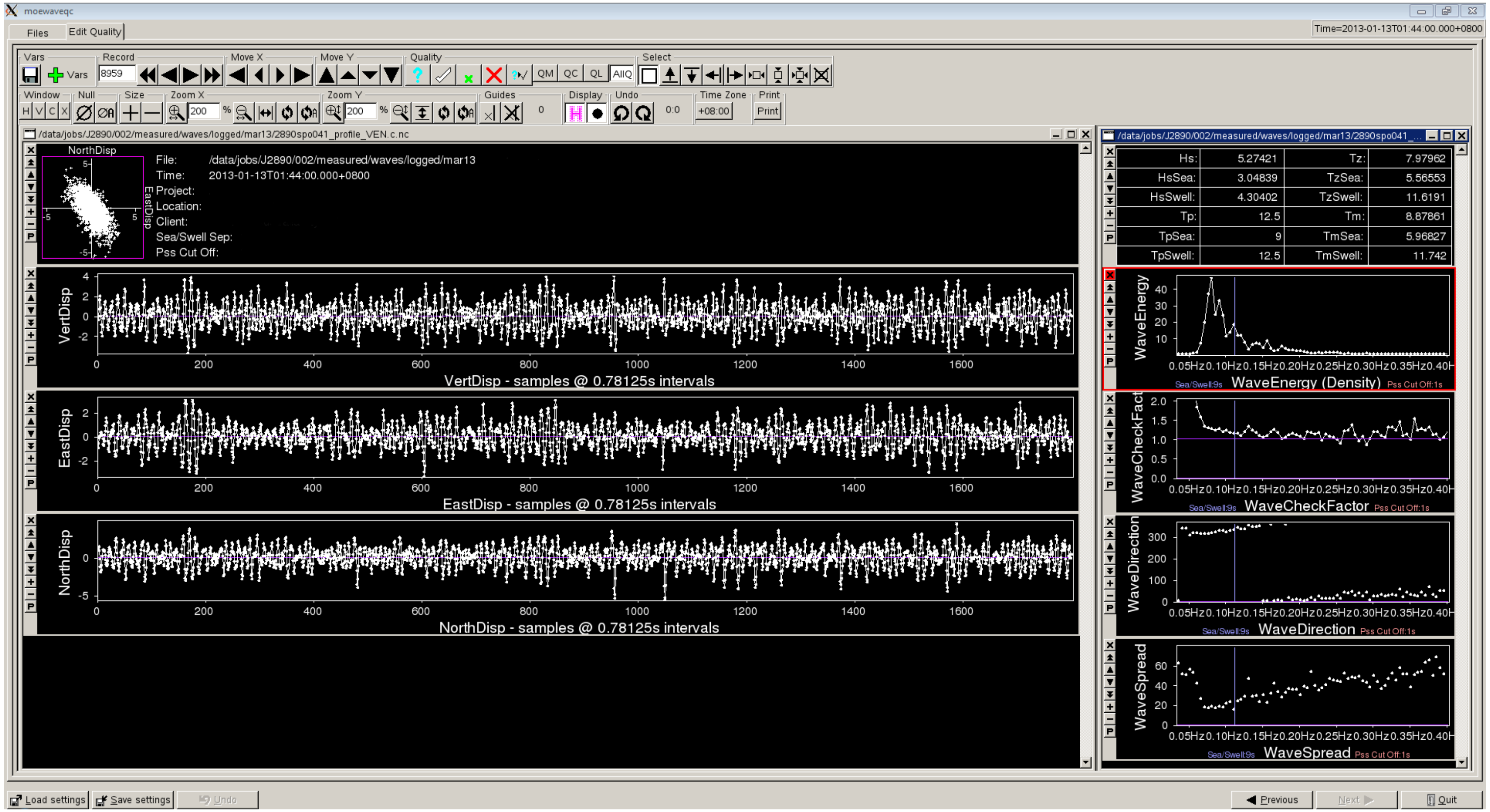


Figure 5 Quality Control software “moewaveqc” displaying wave profile and spectrum.

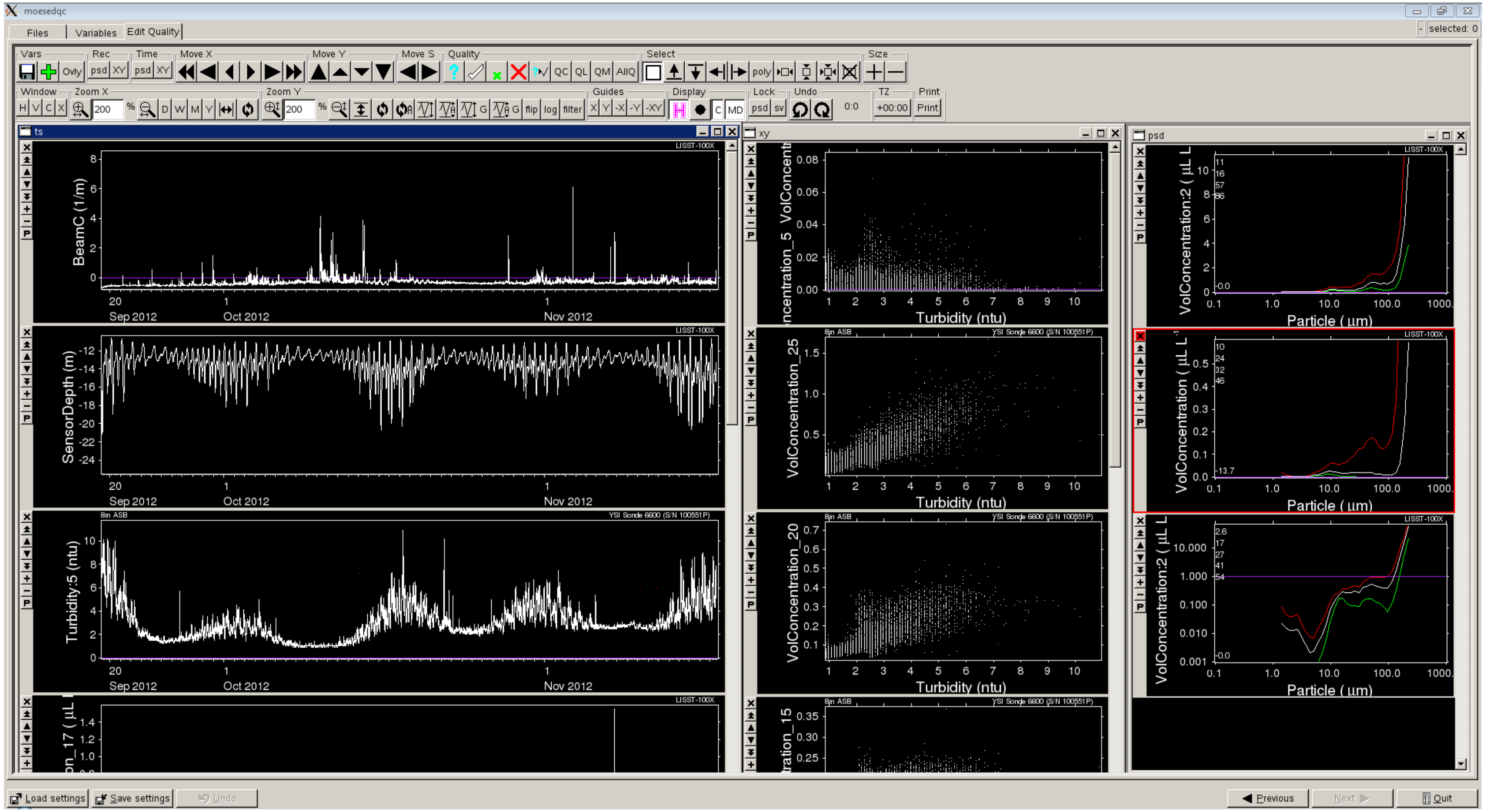


Figure 6 Quality Control software "moesedqc"displaying Water Quality data from LISST instrument. This software used for cross comparisons and deep investigation.

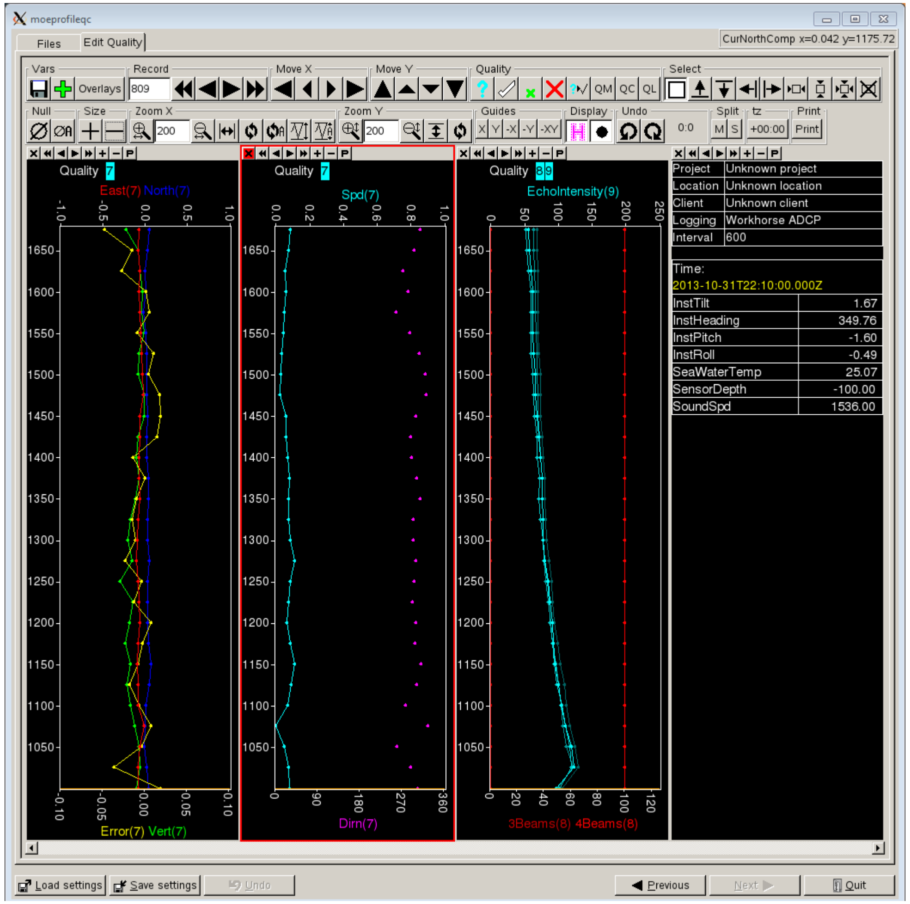


Figure 7 Quality Control software “moeprofileqc” displaying Acoustic Doppler Current Profile (ADCP) data.

6 REAL-TIME DATA PROCESSING AND QUALITY CONTROL

6.1 Onboard Logger

Pre-processing is completed onboard the Lidar Buoy by the M200 data logger. The data are then transmitted to RPS

6.2 DataFeeds and Quality Control

RPS DataFeeds software harvesst data acquired as part of a real-time MetOcean Measurement Program; by Clients using MetOcean Real-time Monitoring Systems; or published as Data Products (e.g., numerical models, climatology) by third party providers.

For Lidar Buoys, the transmitted messages are acquired, contextualised and persisted via the Data Hub. An example of contextualisation would be that the transmitted Wind Directions are not corrected for buoy heading, this is completed within DataFeeds.

The RPS DataFeeds Restful Web Service published the data which can be consumed via the API.

The RPS web site “Data-Access” also consumes the data for client access to view plots, tables, and spectra (for wave data).

With DataFeeds there are three basic quality controls applied to the data in real-time.

1. qc-range-filter

   Mark as bad (quality) any values falling outside specified range for a variable or variables.

2. qc-repeat-filter

   Mark as bad (quality) any value that has been repeated x number of times for a variable or variables.

3. qc-sdev-filter

   Mark as bad (quality) any value that falls outside a specified number of standard deviations for a variable or variables.

Offsets or corrections can be applied to the real-time data where necessary.

6.3 Data-Access

The Data-Access web site (https://rpsmetocean.com/data-access) is a client login site displaying real-time data and other information about the measurements program being undertaken. Data-Access is routinely checked by qualified staff to ensure that the data presented are valid.

6.4 Additional QC of Real-time Data

Real-time data can also be extracted from Data-Feeds into netCDF files. This allows staff to check in detail using the QC tools described in previous sections and to compare to other sites and modelled data.

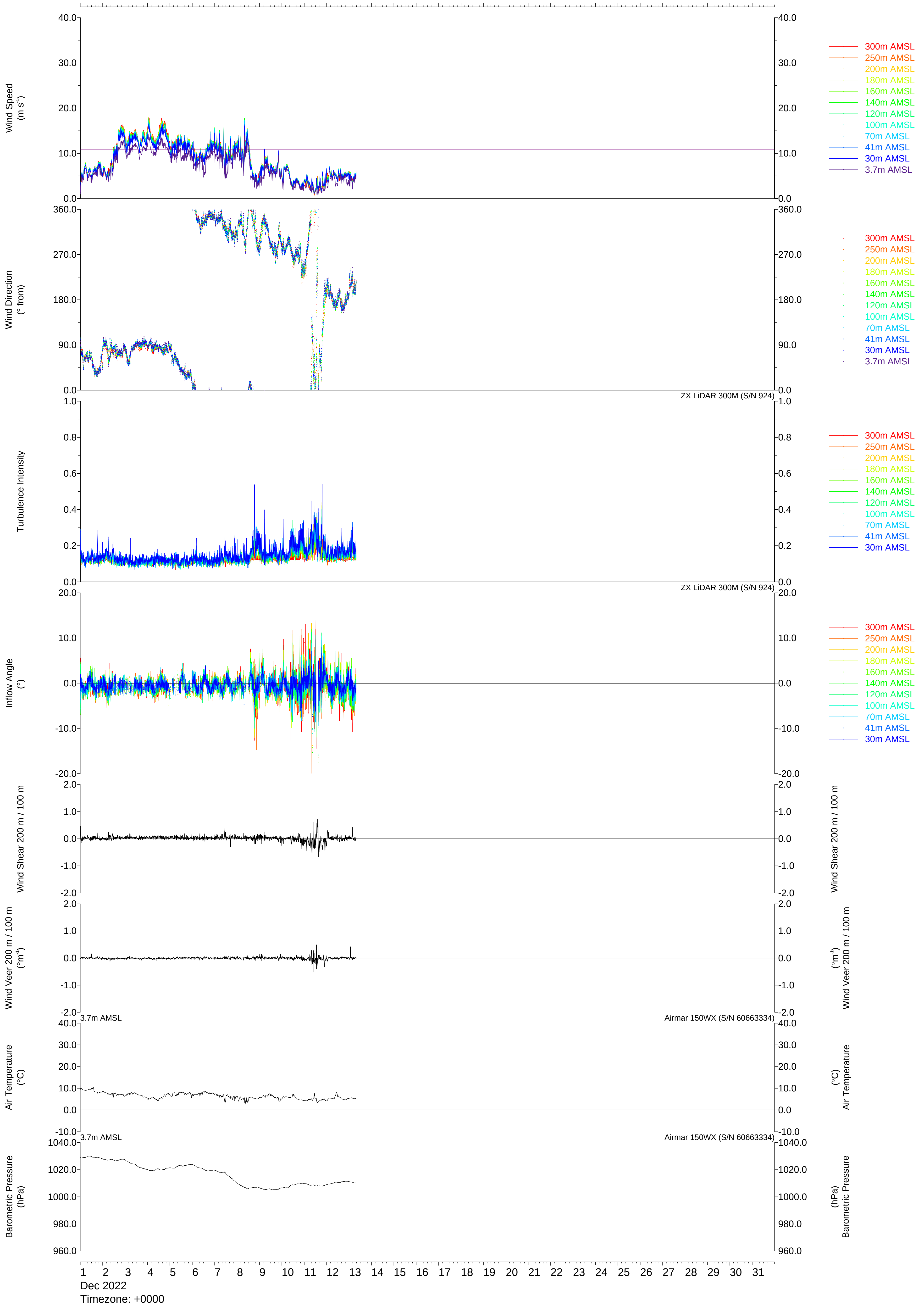
Appendix G
Meteorological Measurements

Standard analysis of the processed data was undertaken to produce the following presentations:

- Monthly time history overlay plots of wind speed, wind direction, turbulence intensity, inflow angle, wind shear, wind veer, air temperature and barometric pressure for each site.
- NW A versus NW B monthly time history overlay plots of air temperature, barometric pressure and wind speed and direction at representative heights of 3.7, 30, 100, and 200 m AMSL.
- Monthly data availability bar charts for each parameter at each site.
- Statistics tables of wind speed, wind direction, turbulence intensity, inflow angle, wind shear, wind veer, air temperature and barometric pressure for each site.
- Monthly rose plots and histograms of wind speed and direction accompanied by relevant statistical parameters (maximum, minimum, mean, and standard deviation values) at each height, for each site.
- NW A versus NW B monthly correlation plots of wind speed and direction (at representative heights of 3.7, 30, 100, and 200 m AMSL), and near-surface air temperature and barometric pressure.

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

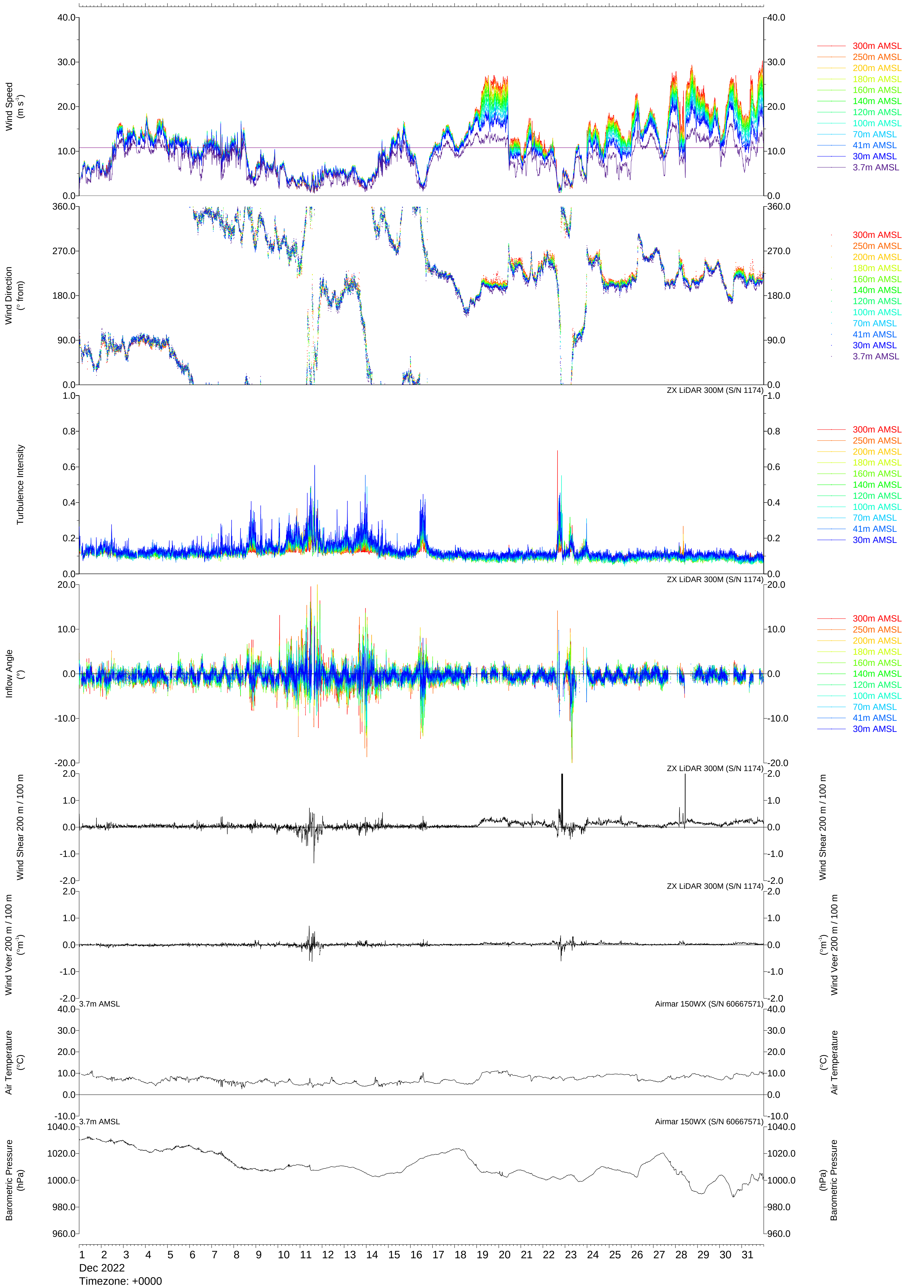
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		



Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
© RPS Australia West Pty Ltd	moetimehist: 16:18 24/Feb/2023 by MWB (AppendixG1.NW.A.2022.12.timehist.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

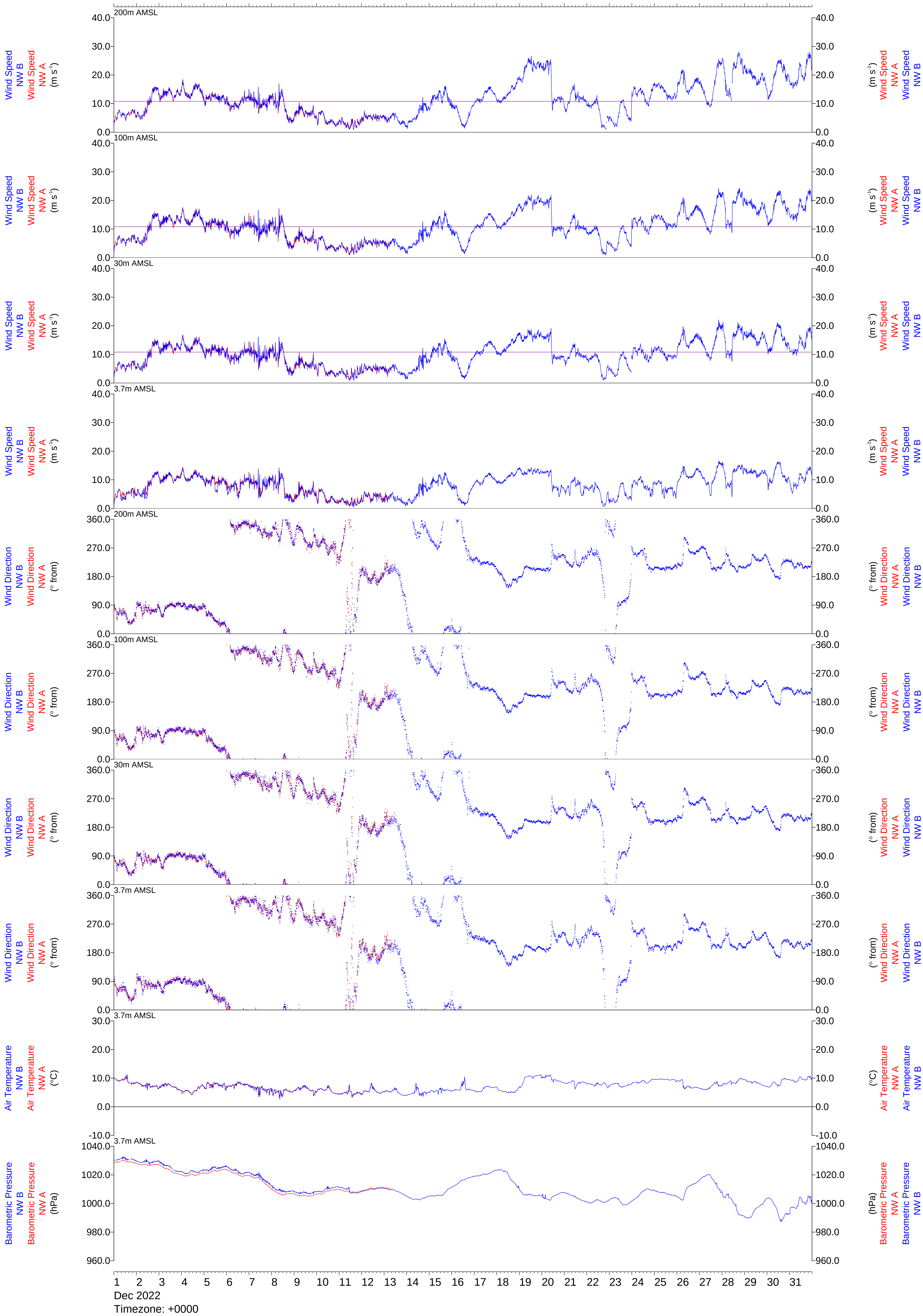
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		



Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
© RPS Australia West Pty Ltd	moetimehist: 16:18 24/Feb/2023 by MWB (AppendixG1.NW.B.2022.12.timehist.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location: NW
Client: RVO
Project: J3707



Time Zone: UTC +00:00 hours
© RPS Australia West Pty Ltd
NWWind{A,B}.2022.12.QC_dataReturn.nc, NWWind{A,B}.2022.12.OtherWinds.nc
moetimehist: 16:19 24/Feb/2023 by MWB (AppendixG2.NW.2022.12.overlay.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Available 10-minute records

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
© RPS Australia West Pty Ltd	moetimehist: 16:18 24/Feb/2023 by MWB (AppendixG2.NW.A.2022.12.barcharts.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Available 10-minute records

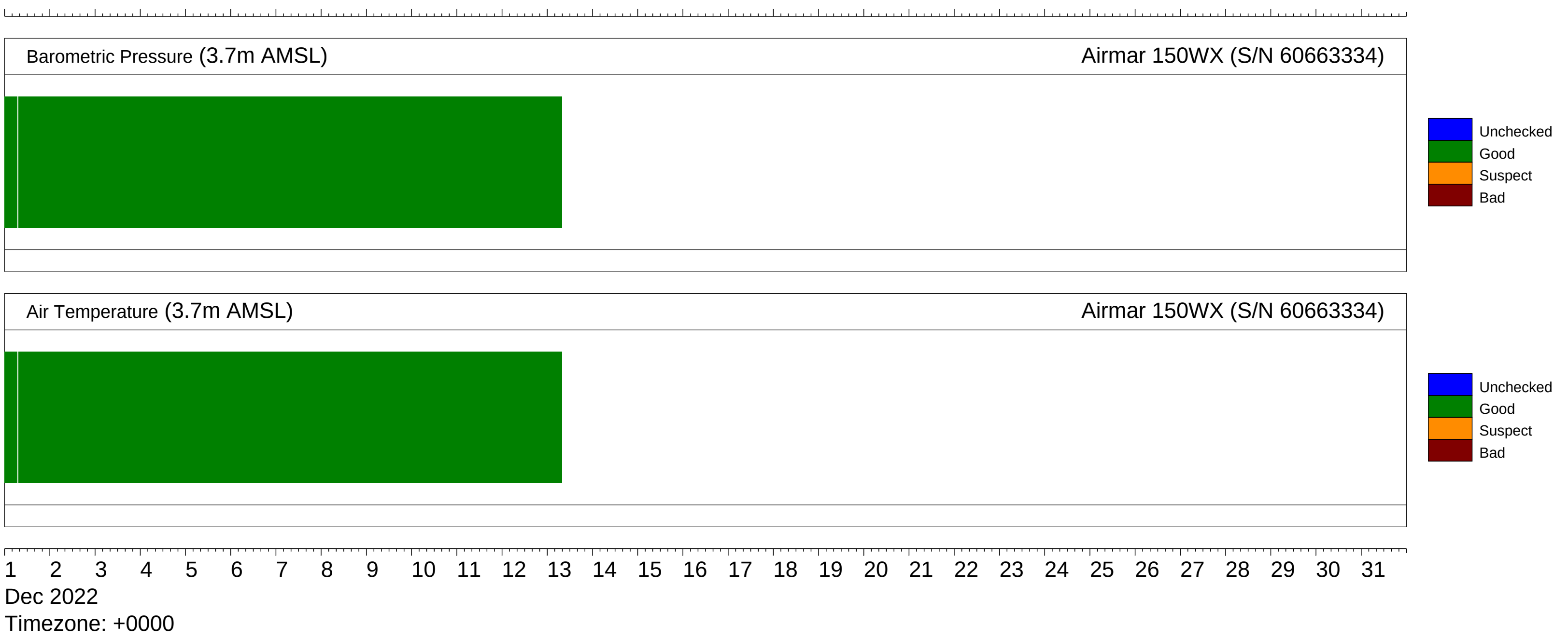
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
© RPS Australia West Pty Ltd	moetimehist: 16:18 24/Feb/2023 by MWB (AppendixG2.NW.A.2022.12.barcharts.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Available 10-minute records

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

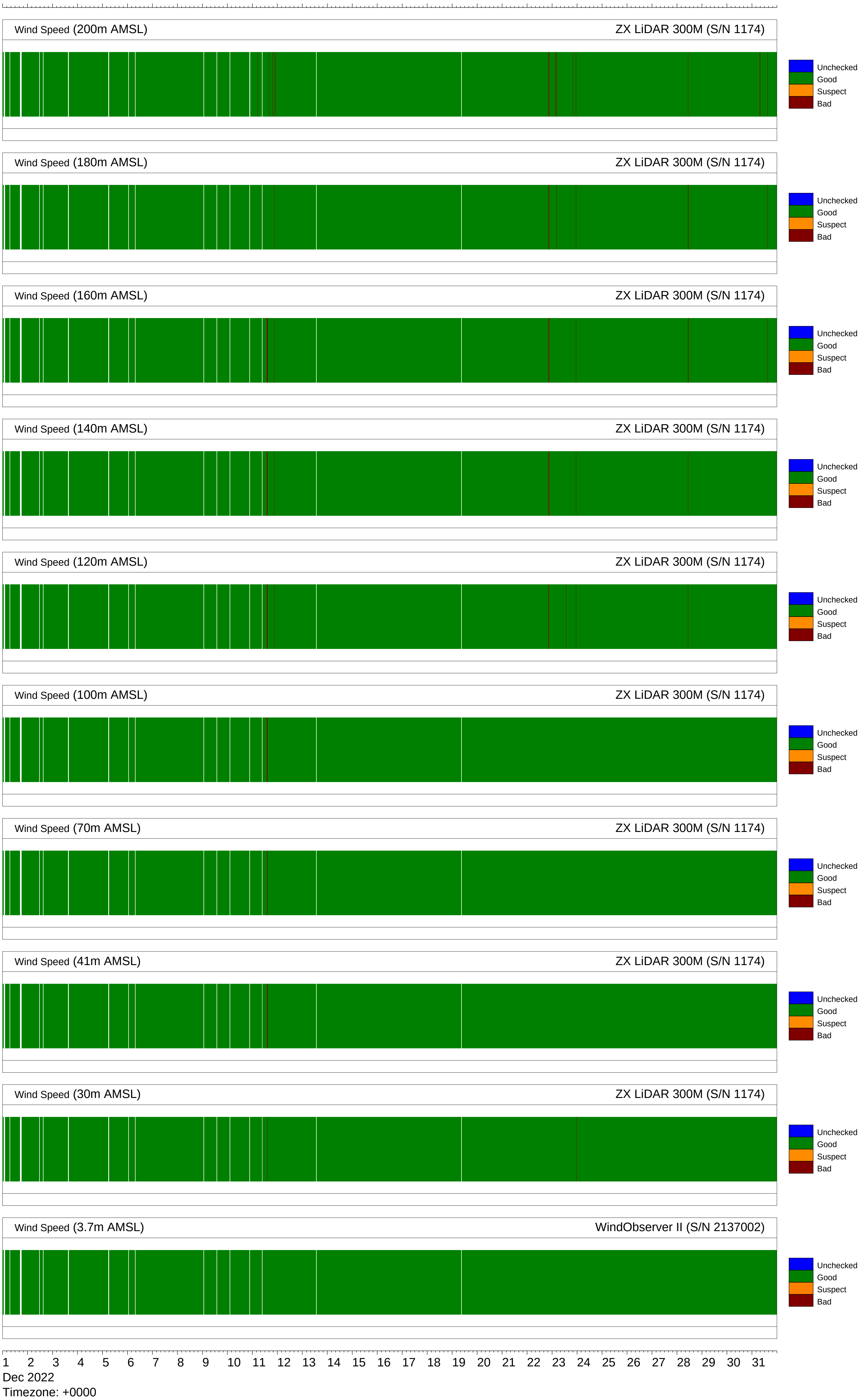


Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
© RPS Australia West Pty Ltd	moetimehist: 16:18 24/Feb/2023 by MWB (AppendixG2.NW.A.2022.12.barcharts.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Available 10-minute records

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

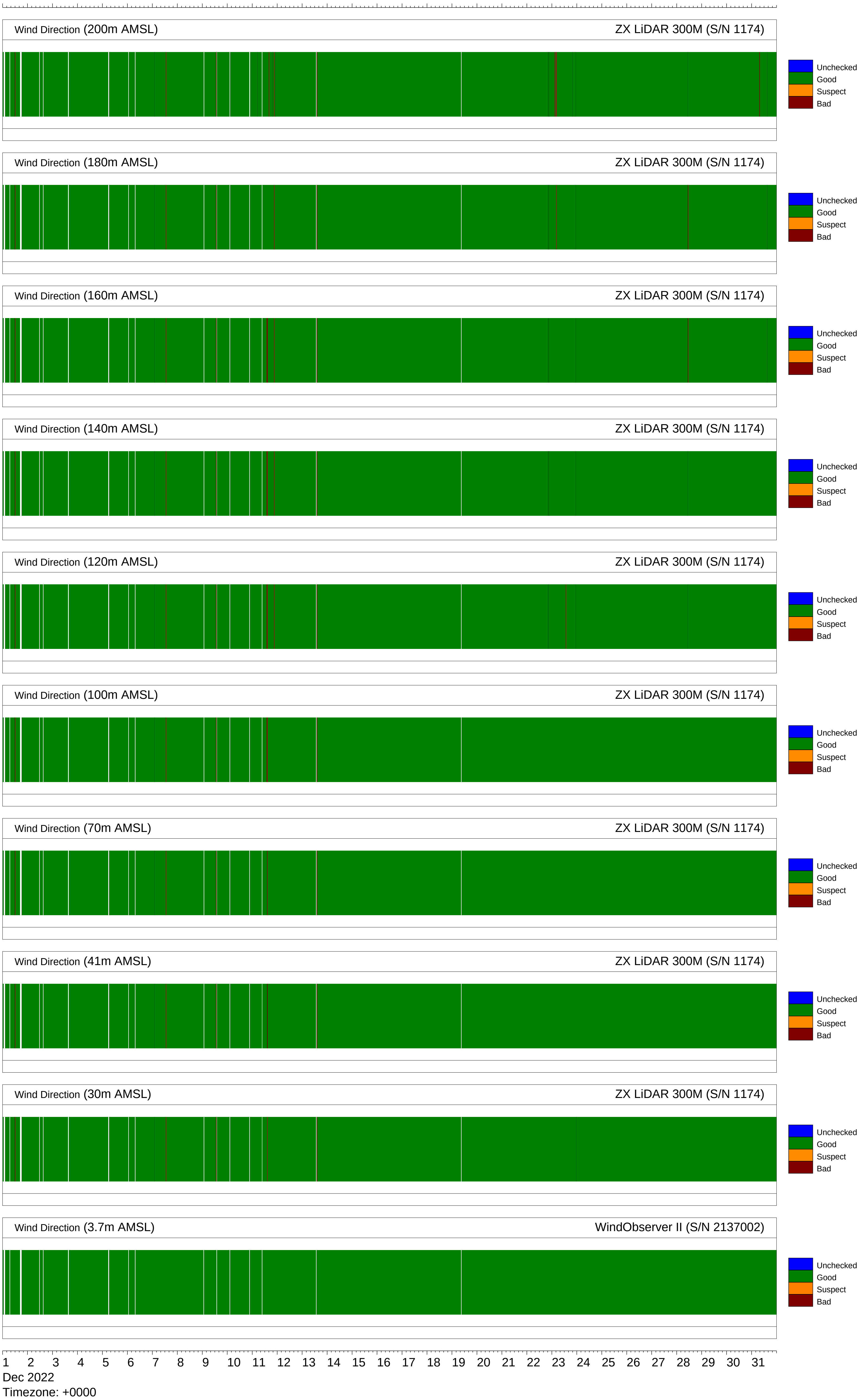


Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
© RPS Australia West Pty Ltd	moetimehist: 16:19 24/Feb/2023 by MWB (AppendixG2.NW.B.2022.12.barcharts.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Available 10-minute records

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

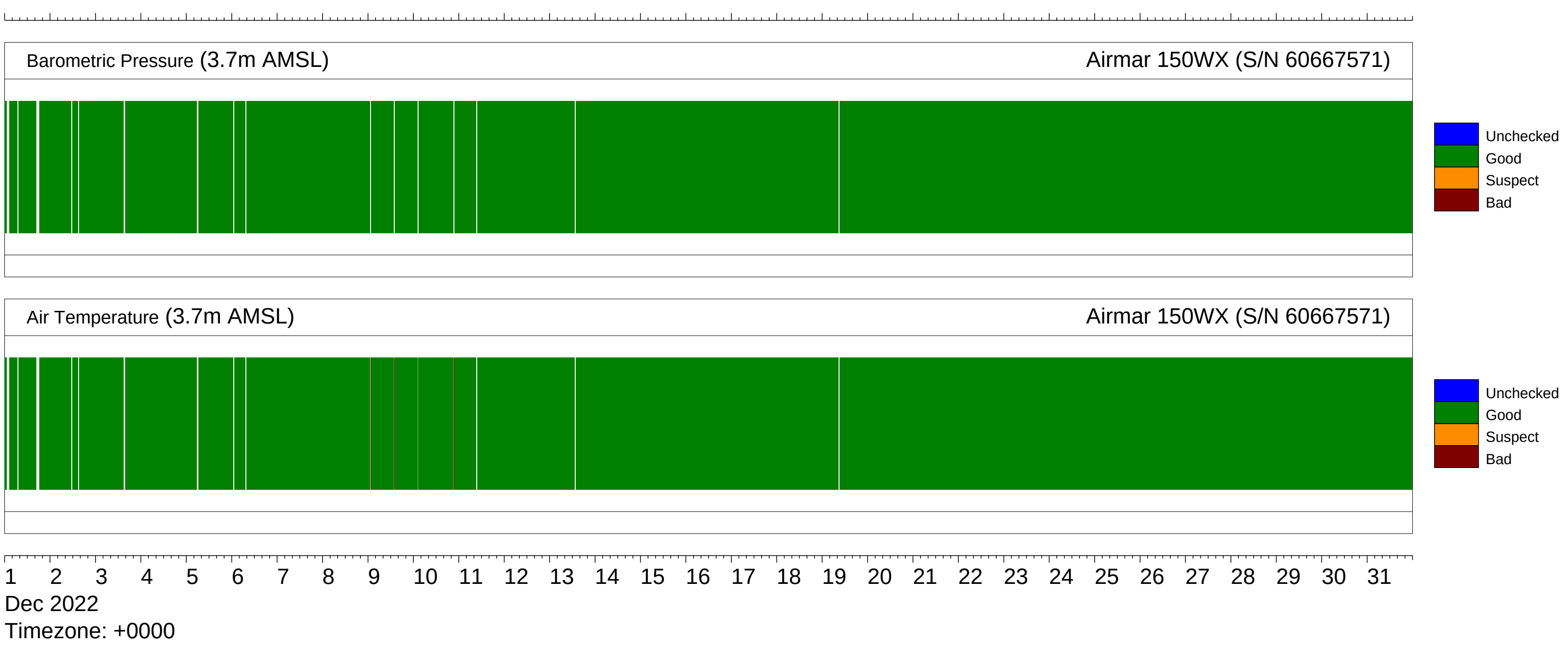


Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
© RPS Australia West Pty Ltd	moetimehist: 16:19 24/Feb/2023 by MWB (AppendixG2.NW.B.2022.12.barcharts.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Available 10-minute records

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		



Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
© RPS Australia West Pty Ltd	moetimehist: 16:19 24/Feb/2023 by MWB (AppendixG2.NW.B.2022.12.barcharts.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:40 13 December 2022
Air Temperature (°C), Airmar 150WX (S/N 60663334), 3.7m AMSL.

	Air Temperature (°C)															
	Statistics				Total	Exceedence Percentile Air Temperature (°C)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
Total Period [1]	2.65	10.50	6.41	1.3835	1772	3.75	4.40	4.66	5.30	6.35	7.20	7.65	8.20	8.62	9.50	9.86

Notes: 1) Total Period: 00:00 01 December 2022 to 07:40 13 December 2022

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moematrix: 16:18 24/Feb/2023 by MWB (./stats_AppendixG3.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:40 13 December 2022
Barometric Pressure (hPa), Airmar 150WX (S/N 60663334), 3.7m AMSL.

	Barometric Pressure (hPa)															
	Statistics				Total	Exceedence Percentile Barometric Pressure (hPa)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
Total Period [1]	1005.10	1030.20	1016.43	7.9695	1771	1005.30	1005.70	1006.50	1008.70	1018.50	1021.50	1023.90	1027.50	1028.95	1029.26	1029.90

Notes: 1) Total Period: 00:00 01 December 2022 to 07:40 13 December 2022

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moematrix: 16:18 24/Feb/2023 by MWB (./stats_AppendixG3.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:40 13 December 2022
Wind Speed (m s^{-1}), WindObserver II (S/N 1922006), 3.7m AMSL.
Wind Direction (°), WindObserver II (S/N 1922006), 3.7m AMSL.

	Wind Speed (m s^{-1})															
	Statistics				Total	Exceedence Percentile Wind Speed (m s^{-1})										Main Direction(s)[2]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
Total Period [1]	0.72	14.23	7.00	3.1916	1772	1.31	2.24	2.83	4.35	6.63	9.40	10.20	11.22	11.88	12.55	12.88	ENE E NNW

Notes: 1) Total Period: 00:00 01 December 2022 to 07:40 13 December 2022
2) Main directions are where occurrence is greater than 10.0%.

Expected Record Interval: 10.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moematrix: 16:18 24/Feb/2023 by MWB (./stats_AppendixG3.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:40 13 December 2022
InflowAngle1 (°), ZX LiDAR 300M (S/N 924).

	InflowAngle1 (°)															
	Statistics				Total	Exceedence Percentile InflowAngle1 (°)										
December 2022	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
300m AMSL	-14.43	13.61	-0.69	2.6573	1522	-7.95	-4.39	-3.35	-2.03	-0.76	0.14	0.88	2.22	3.56	5.71	7.26
250m AMSL	-19.94	13.99	-0.67	2.5464	1532	-7.78	-4.30	-3.22	-1.95	-0.69	0.16	0.92	1.93	3.13	5.35	6.59
200m AMSL	-15.64	13.26	-0.58	2.3701	1540	-6.38	-4.09	-3.11	-1.79	-0.69	0.23	0.94	2.00	3.22	5.08	6.27
180m AMSL	-16.08	12.02	-0.58	2.3354	1542	-6.86	-3.93	-2.98	-1.77	-0.67	0.22	0.93	2.06	3.18	4.75	6.32
160m AMSL	-17.51	12.00	-0.56	2.2997	1543	-6.59	-3.77	-2.87	-1.80	-0.71	0.26	0.87	1.93	3.34	4.82	5.95
140m AMSL	-16.81	11.64	-0.53	2.2470	1545	-6.01	-3.75	-2.82	-1.73	-0.56	0.30	0.86	1.94	2.93	4.70	5.61
120m AMSL	-15.98	11.30	-0.51	2.1728	1545	-5.84	-3.55	-2.73	-1.64	-0.64	0.22	0.88	1.89	3.10	4.63	5.82
100m AMSL	-15.81	10.64	-0.53	2.0259	1545	-5.65	-3.36	-2.59	-1.64	-0.59	0.22	0.77	1.69	2.73	4.12	5.44
70m AMSL	-13.69	10.63	-0.49	1.9026	1545	-6.14	-3.05	-2.45	-1.51	-0.56	0.19	0.78	1.67	2.57	3.78	4.80
41m AMSL	-8.56	9.66	-0.44	1.6173	1545	-4.19	-2.75	-2.25	-1.38	-0.54	0.21	0.73	1.47	2.23	3.22	4.30
30m AMSL	-7.46	6.62	-0.38	1.4858	1545	-4.55	-2.44	-1.98	-1.28	-0.43	0.25	0.66	1.40	2.02	3.03	3.84

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moeprofilestats: 16:18 24/Feb/2023 by MWB (./stats_profile_AppendixG3.NW.A.2022.12.stats.profile.IA.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:40 13 December 2022
Turbulence Intensity (dimensionless), ZX LiDAR 300M (S/N 924).

	Turbulence Intensity (dimensionless)															
	Statistics				Total	Exceedence Percentile Turbulence Intensity (dimensionless)										
December 2022	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
300m AMSL	0.067624	0.309215	0.119538	0.02178454	1749	0.091226	0.097897	0.101843	0.109096	0.116819	0.121996	0.123012	0.130197	0.166177	0.195152	0.213019
250m AMSL	0.073726	0.315994	0.124610	0.02779483	1759	0.088566	0.096708	0.101602	0.109224	0.119205	0.128212	0.132632	0.151242	0.180405	0.220666	0.241299
200m AMSL	0.081356	0.437214	0.129597	0.03284706	1767	0.089560	0.096097	0.100315	0.110018	0.122261	0.135083	0.142953	0.165081	0.194162	0.231332	0.261205
180m AMSL	0.083177	0.422906	0.131239	0.03459692	1768	0.088448	0.095793	0.101064	0.110190	0.122726	0.137181	0.145912	0.170632	0.199284	0.241692	0.266308
160m AMSL	0.069571	0.369538	0.133511	0.03625633	1768	0.087023	0.095716	0.101050	0.110703	0.125262	0.140375	0.150688	0.173074	0.206455	0.245775	0.279302
140m AMSL	0.078509	0.416548	0.135859	0.03778662	1771	0.085637	0.096222	0.101994	0.112265	0.126320	0.142829	0.154293	0.183187	0.211295	0.247323	0.279587
120m AMSL	0.078165	0.435518	0.138309	0.03893193	1771	0.086669	0.097281	0.102534	0.112952	0.129087	0.145534	0.160250	0.185376	0.214978	0.258047	0.282567
100m AMSL	0.067706	0.406406	0.140368	0.04093920	1772	0.086063	0.095630	0.101821	0.114029	0.130324	0.148631	0.162186	0.192682	0.220689	0.263068	0.293452
70m AMSL	0.071056	0.452615	0.144313	0.04481753	1771	0.084627	0.095685	0.103455	0.114671	0.132089	0.153596	0.172101	0.197760	0.235448	0.275444	0.308966
41m AMSL	0.076012	0.476181	0.150267	0.04933747	1771	0.085749	0.098058	0.105178	0.117590	0.136967	0.160528	0.179013	0.209884	0.250779	0.296835	0.329133
30m AMSL	0.067033	0.541040	0.153614	0.05083385	1770	0.088174	0.098852	0.107522	0.120660	0.141279	0.163069	0.181909	0.217479	0.254731	0.292892	0.342969

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours — Data Source: NWWindA.2022.12.QC_dataReturn.nc

moeprofilestats: 16:18 24/Feb/2023 by MWB (./stats_profile_AppendixG3.NW.A.2022.12.stats.profile.TI.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:40 13 December 2022
Wind Speed (m s^{-1}), ZX LiDAR 300M (S/N 924).
Wind Direction (°), ZX LiDAR 300M (S/N 924).

	Wind Speed (m s^{-1})																
	Statistics				Total	Exceedence Percentile Wind Speed (m s^{-1})											Main Direction(s)[1]
December 2022	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
300m AMSL	0.73	17.99	8.79	4.0979	1749	1.67	2.72	3.58	5.24	8.74	11.89	12.71	14.24	15.32	16.37	16.82	ENE E NNW
250m AMSL	0.87	17.86	8.72	4.0176	1759	1.66	2.83	3.71	5.22	8.52	11.77	12.65	14.10	15.08	16.13	16.65	ENE E NNW
200m AMSL	1.06	18.08	8.64	3.9576	1767	1.72	2.89	3.68	5.22	8.30	11.67	12.52	13.97	14.95	15.83	16.42	ENE E NNW
180m AMSL	1.01	17.97	8.61	3.9275	1768	1.77	2.89	3.69	5.23	8.24	11.59	12.47	13.91	14.89	15.83	16.49	ENE E NNW
160m AMSL	1.07	17.74	8.58	3.9039	1768	1.81	2.91	3.71	5.23	8.16	11.57	12.45	13.86	14.83	15.69	16.33	ENE E NNW
140m AMSL	1.15	17.75	8.55	3.8823	1771	1.84	2.95	3.67	5.23	8.12	11.50	12.38	13.82	14.76	15.61	16.30	ENE E NNW
120m AMSL	1.00	17.57	8.51	3.8493	1771	1.90	2.96	3.66	5.22	8.01	11.45	12.35	13.71	14.57	15.52	16.19	ENE E NNW
100m AMSL	1.06	17.31	8.46	3.8275	1772	1.87	2.92	3.70	5.21	8.04	11.37	12.29	13.58	14.63	15.45	16.12	ENE E NNW
70m AMSL	0.78	17.18	8.40	3.7762	1771	1.90	2.96	3.68	5.18	7.89	11.29	12.22	13.48	14.40	15.31	16.03	ENE E NNW
41m AMSL	0.87	16.77	8.25	3.6921	1771	1.86	2.96	3.65	5.10	7.77	11.08	11.96	13.20	14.15	14.98	15.45	ENE E NNW
30m AMSL	1.01	16.64	8.16	3.6421	1770	1.82	2.96	3.60	5.08	7.70	10.93	11.84	13.06	13.94	14.73	15.23	ENE E NNW

Notes: 1) Main directions are where occurrence is greater than 10.0%.

Expected Record Interval: 10.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moeprofilestats: 16:18 24/Feb/2023 by MWB (./stats_profile_AppendixG3.NW.A.2022.12.stats.profile.WS.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:40 13 December 2022
Wind Shear 200 m / 100 m (dimensionless)

	Wind Shear 200 m / 100 m (dimensionless)															
	Statistics				Total	Exceedence Percentile Wind Shear 200 m / 100 m (dimensionless)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
Total Period [1]	-0.67	0.71	0.02	0.0970	1767	-0.34	-0.13	-0.06	-0.01	0.02	0.05	0.07	0.09	0.12	0.19	0.26

Notes: 1) Total Period: 00:00 01 December 2022 to 07:40 13 December 2022

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moematrix: 16:18 24/Feb/2023 by MWB (./stats_AppendixG3.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:40 13 December 2022
Wind Veer 200 m / 100 m (° m^{-1})

	Wind Veer 200 m / 100 m (° m^{-1})															
	Statistics				Total	Exceedence Percentile Wind Veer 200 m / 100 m (° m^{-1})										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
Total Period [1]	-0.52	0.49	-0.00	0.0496	1767	-0.17	-0.06	-0.04	-0.02	0.00	0.01	0.02	0.04	0.05	0.07	0.13

Notes: 1) Total Period: 00:00 01 December 2022 to 07:40 13 December 2022

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moematrix: 16:18 24/Feb/2023 by MWB (./stats_AppendixG3.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 23:50 31 December 2022
Air Temperature (°C), Airmar 150WX (S/N 60667571), 3.7m AMSL.

	Air Temperature (°C)															
	Statistics				Total	Exceedence Percentile Air Temperature (°C)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
Total Period [1]	2.65	11.25	7.20	1.7109	4405	4.00	4.56	5.00	5.75	7.20	8.25	8.75	9.50	10.05	10.70	10.90

Notes: 1) Total Period: 00:00 01 December 2022 to 23:50 31 December 2022

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moematrix: 16:19 24/Feb/2023 by MWB (./stats_AppendixG3.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 23:50 31 December 2022
Barometric Pressure (hPa), Airmar 150WX (S/N 60667571), 3.7m AMSL.

	Barometric Pressure (hPa)															
	Statistics				Total	Exceedence Percentile Barometric Pressure (hPa)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
Total Period [1]	987.40	1032.70	1010.94	9.7201	4404	990.10	996.60	1000.53	1004.30	1008.80	1016.40	1021.30	1024.70	1029.00	1030.60	1031.00

Notes: 1) Total Period: 00:00 01 December 2022 to 23:50 31 December 2022

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moematrix: 16:19 24/Feb/2023 by MWB (./stats_AppendixG3.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 23:50 31 December 2022
Wind Speed (m s^{-1}), WindObserver II (S/N 2137002), 3.7m AMSL.
Wind Direction (°), WindObserver II (S/N 2137002), 3.7m AMSL.

	Wind Speed (m s^{-1})															
	Statistics				Total	Exceedence Percentile Wind Speed (m s^{-1})										Main Direction(s)[2]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
Total Period [1]	0.54	16.59	8.06	3.6342	4404	1.35	2.19	2.81	4.96	8.48	10.37	11.51	12.76	13.53	14.59	15.41	SSW SW

Notes: 1) Total Period: 00:00 01 December 2022 to 23:50 31 December 2022
2) Main directions are where occurrence is greater than 10.0%.

Expected Record Interval: 10.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moematrix: 16:19 24/Feb/2023 by MWB (./stats_AppendixG3.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 23:50 31 December 2022
InflowAngle1 (°), ZX LiDAR 300M (S/N 1174).

	InflowAngle1 (°)															
	Statistics				Total	Exceedence Percentile InflowAngle1 (°)										
December 2022	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
300m AMSL	-20.82	23.50	-0.57	2.3898	3697	-7.37	-3.74	-2.57	-1.51	-0.62	0.12	0.59	1.43	2.55	4.97	7.52
250m AMSL	-21.62	18.11	-0.56	2.2729	3706	-6.93	-3.64	-2.50	-1.47	-0.60	0.11	0.56	1.39	2.44	4.68	6.50
200m AMSL	-17.20	21.38	-0.54	2.0945	3721	-6.67	-3.24	-2.35	-1.41	-0.57	0.13	0.56	1.33	2.33	4.36	5.76
180m AMSL	-20.91	18.56	-0.51	2.0021	3730	-6.10	-3.14	-2.31	-1.39	-0.57	0.11	0.58	1.28	2.23	4.06	5.48
160m AMSL	-19.19	16.15	-0.51	1.9580	3731	-6.00	-3.11	-2.27	-1.39	-0.56	0.13	0.55	1.30	2.21	3.97	5.42
140m AMSL	-16.58	15.63	-0.53	1.8748	3731	-5.66	-3.10	-2.29	-1.42	-0.54	0.11	0.54	1.29	2.07	3.90	5.09
120m AMSL	-12.37	14.59	-0.50	1.7851	3731	-5.67	-2.96	-2.20	-1.32	-0.54	0.08	0.52	1.30	2.04	3.35	5.10
100m AMSL	-12.99	14.66	-0.49	1.7164	3732	-5.33	-2.84	-2.10	-1.32	-0.53	0.10	0.52	1.19	1.96	3.42	4.55
70m AMSL	-10.82	14.71	-0.50	1.5276	3732	-4.83	-2.61	-2.05	-1.30	-0.52	0.09	0.48	1.12	1.72	2.83	3.86
41m AMSL	-10.70	9.85	-0.45	1.3381	3732	-3.92	-2.39	-1.89	-1.22	-0.49	0.09	0.49	1.06	1.67	2.49	3.17
30m AMSL	-9.16	11.80	-0.43	1.3004	3731	-3.80	-2.27	-1.83	-1.20	-0.45	0.12	0.48	1.01	1.55	2.27	2.84

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moeprofilestats: 16:19 24/Feb/2023 by MWB (./stats_profile_AppendixG3.NW.B.2022.12.stats.profile.IA.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 23:50 31 December 2022
Turbulence Intensity (dimensionless), ZX LiDAR 300M (S/N 1174).

	Turbulence Intensity (dimensionless)															
	Statistics				Total	Exceedence Percentile Turbulence Intensity (dimensionless)										
December 2022	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
300m AMSL	0.061516	0.691928	0.109811	0.02395167	4340	0.076762	0.084306	0.088469	0.096377	0.107464	0.116552	0.121389	0.123280	0.141941	0.172882	0.201801
250m AMSL	0.056270	0.367840	0.111418	0.02776895	4359	0.072141	0.080962	0.085751	0.094613	0.106951	0.118743	0.126261	0.133483	0.155880	0.195392	0.219528
200m AMSL	0.058830	0.474914	0.113328	0.03303378	4379	0.069602	0.077940	0.082448	0.092853	0.106226	0.120458	0.131409	0.145390	0.173126	0.214718	0.242633
180m AMSL	0.052035	0.582895	0.114383	0.03537606	4391	0.067837	0.076309	0.081982	0.092133	0.106926	0.121803	0.133813	0.150618	0.179000	0.218118	0.244793
160m AMSL	0.050647	0.513858	0.114977	0.03694267	4387	0.066707	0.075863	0.081544	0.091612	0.106487	0.122626	0.135678	0.154840	0.184417	0.220931	0.255468
140m AMSL	0.052494	0.493243	0.116813	0.03998563	4391	0.065873	0.075326	0.081151	0.091278	0.107602	0.124840	0.137833	0.159238	0.190076	0.239226	0.267384
120m AMSL	0.048030	0.505057	0.118302	0.04144290	4391	0.066023	0.075500	0.080941	0.092016	0.107958	0.125777	0.140461	0.163562	0.197198	0.244798	0.275182
100m AMSL	0.042652	0.558806	0.120584	0.04488999	4400	0.065030	0.075164	0.081513	0.092925	0.108771	0.128175	0.143996	0.168153	0.208492	0.255162	0.294949
70m AMSL	0.054657	0.606087	0.124425	0.04653146	4401	0.068113	0.078520	0.084363	0.095577	0.111217	0.130781	0.149330	0.177984	0.214604	0.265337	0.310522
41m AMSL	0.056664	0.605666	0.130666	0.04933858	4399	0.072945	0.083501	0.090117	0.101126	0.116507	0.135691	0.153508	0.187587	0.226909	0.279909	0.327501
30m AMSL	0.061690	0.610349	0.133659	0.04940190	4400	0.076497	0.086478	0.092959	0.104143	0.119366	0.138001	0.156584	0.190309	0.233179	0.286177	0.332185

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moeprofilestats: 16:19 24/Feb/2023 by MWB (./stats_profile_AppendixG3.NW.B.2022.12.stats.profile.TI.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 23:50 31 December 2022
Wind Speed (m s^{-1}), ZX LiDAR 300M (S/N 1174).
Wind Direction (°), ZX LiDAR 300M (S/N 1174).

	Wind Speed (m s^{-1})															
	Statistics				Total	Exceedence Percentile Wind Speed (m s^{-1})										Main Direction(s)[1]
December 2022	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
300m AMSL	0.80	30.31	12.31	6.4491	4338	1.73	3.06	4.13	6.97	11.96	14.81	17.27	22.40	25.20	26.38	27.32	SSW SW WSW
250m AMSL	0.81	29.04	12.12	6.2637	4359	1.84	3.09	4.13	6.94	11.83	14.62	16.97	21.88	24.57	25.74	26.66	SSW SW
200m AMSL	0.90	28.07	11.85	6.0252	4379	1.87	3.13	4.09	6.86	11.62	14.35	16.54	21.19	23.58	24.86	25.62	SSW SW
180m AMSL	0.95	27.52	11.72	5.8952	4391	1.92	3.16	4.05	6.83	11.55	14.22	16.31	20.86	23.08	24.33	25.00	SSW SW
160m AMSL	0.69	27.40	11.59	5.7447	4387	1.84	3.19	4.09	6.79	11.44	14.07	16.08	20.42	22.47	23.71	24.54	SSW SW
140m AMSL	0.84	26.33	11.43	5.5711	4391	1.94	3.22	4.09	6.76	11.33	13.96	15.79	19.95	21.76	23.07	23.88	SSW SW
120m AMSL	0.81	25.17	11.25	5.3872	4391	1.90	3.21	4.10	6.71	11.18	13.81	15.54	19.43	21.02	22.58	23.17	SSW SW
100m AMSL	0.87	24.18	11.05	5.2015	4400	1.84	3.18	4.04	6.66	11.03	13.60	15.29	18.80	20.19	21.87	22.53	SSW SW
70m AMSL	0.77	23.46	10.75	4.9238	4401	1.86	3.19	4.05	6.63	10.77	13.25	14.93	17.86	19.12	20.90	21.44	SSW SW
41m AMSL	0.86	22.17	10.34	4.5875	4399	1.82	3.18	4.00	6.52	10.45	12.72	14.36	16.78	17.94	19.70	20.18	SSW SW
30m AMSL	0.80	22.10	10.12	4.4332	4400	1.76	3.09	3.95	6.48	10.27	12.46	14.05	16.25	17.35	19.11	19.72	SSW SW

Notes: 1) Main directions are where occurrence is greater than 10.0%.

Expected Record Interval: 10.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moeprofilestats: 16:19 24/Feb/2023 by MWB (./stats_profile_AppendixG3.NW.B.2022.12.stats.profile.WS.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 23:50 31 December 2022
Wind Shear 200 m / 100 m (dimensionless), ZX LiDAR 300M (S/N 1174).

	Wind Shear 200 m / 100 m (dimensionless)															
	Statistics				Total	Exceedence Percentile Wind Shear 200 m / 100 m (dimensionless)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
Total Period [1]	-1.35	6.20	0.08	0.2377	4385	-0.27	-0.08	-0.03	0.01	0.05	0.12	0.16	0.21	0.26	0.31	0.36

Notes: 1) Total Period: 00:00 01 December 2022 to 23:50 31 December 2022

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moematrix: 16:19 24/Feb/2023 by MWB (./stats_AppendixG3.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 23:50 31 December 2022
Wind Veer 200 m / 100 m (° m^{-1}), ZX LiDAR 300M (S/N 1174).

	Wind Veer 200 m / 100 m (° m^{-1})															
	Statistics				Total	Exceedence Percentile Wind Veer 200 m / 100 m (° m^{-1})										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
Total Period [1]	-0.63	0.71	0.01	0.0512	4386	-0.12	-0.05	-0.03	-0.01	0.01	0.03	0.04	0.06	0.08	0.11	0.14

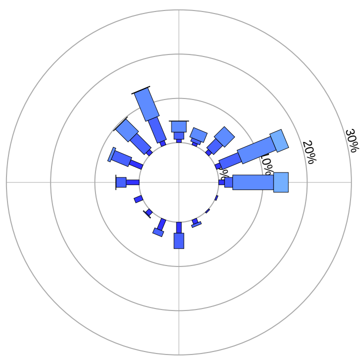
Notes: 1) Total Period: 00:00 01 December 2022 to 23:50 31 December 2022

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moematrix: 16:19 24/Feb/2023 by MWB (./stats_AppendixG3.NW.B.2022.12.statistics.ps)

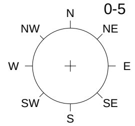
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

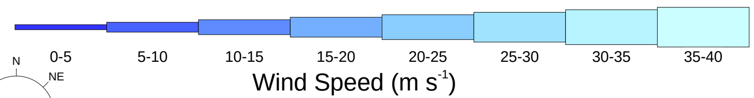
Deployment
(00:00 01 December 2022 to 07:40 13 December 2022)



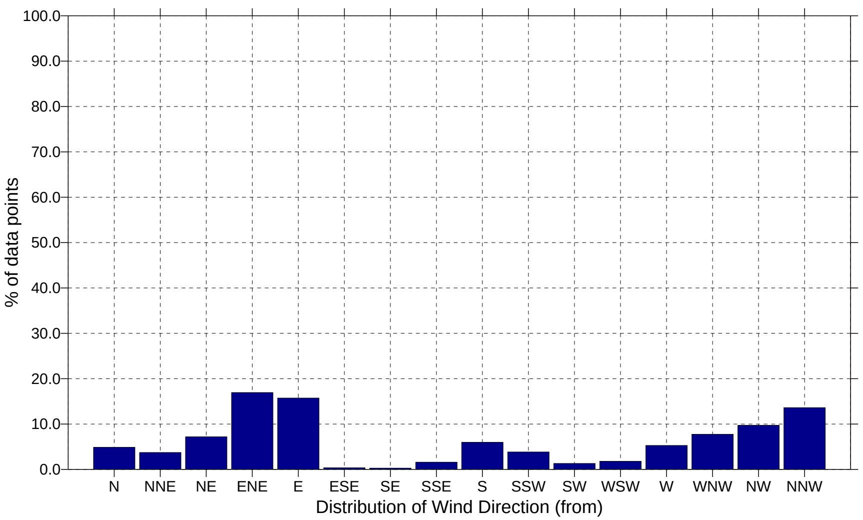
Deployment

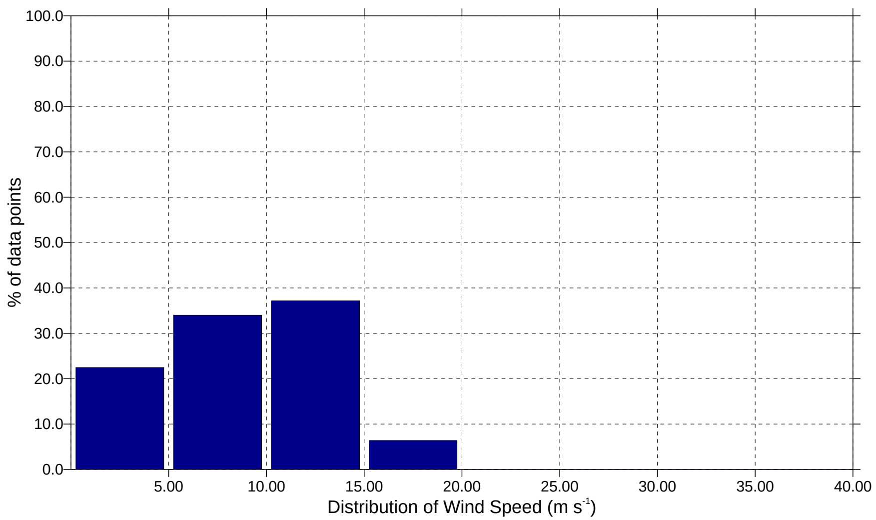
Maximum Wind Speed (m s^{-1}): 17.99 from 84.00° North
Minimum Wind Speed (m s^{-1}): 0.73 from 22.00° North
Standard deviation: 4.10 m s^{-1}
Mean: 8.81m s^{-1}





Instruments: ZX LiDAR 300M (S/N 924) 300m AMSL
Data Quality: good **Total Records:** 1741



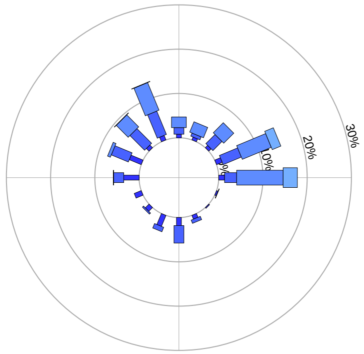


Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moerose: 16:18 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

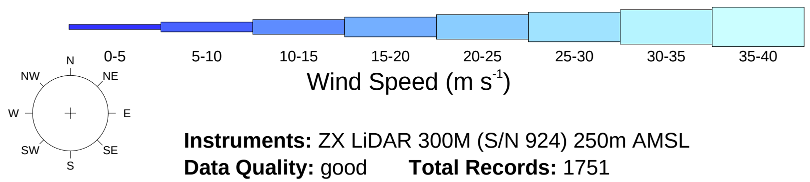
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Deployment
(00:00 01 December 2022 to 07:40 13 December 2022)

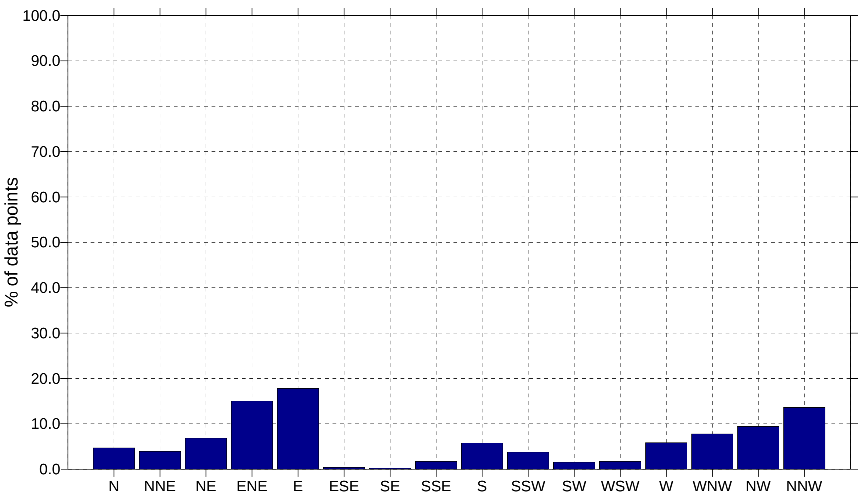


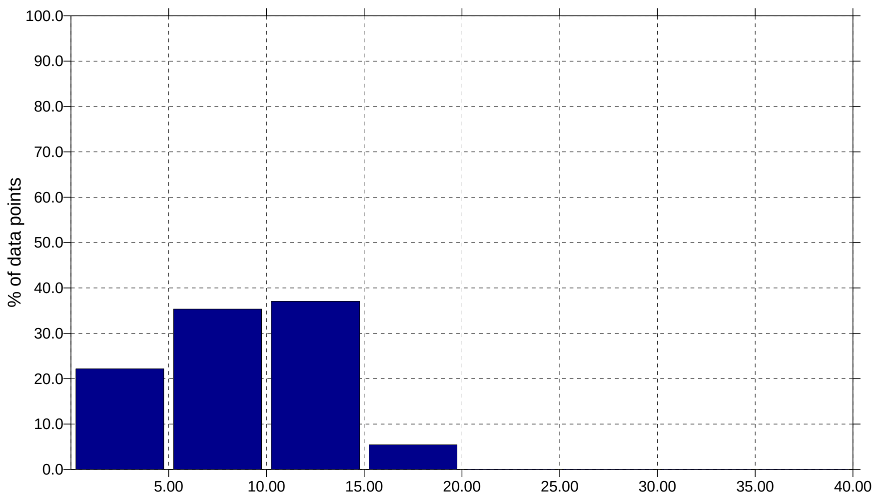
Deployment

Maximum Wind Speed (m s^{-1}): 17.86 from 93.00° North
Minimum Wind Speed (m s^{-1}): 0.87 from 24.00° North
Standard deviation: 4.02 m s^{-1}
Mean: 8.73m s^{-1}



Instruments: ZX LiDAR 300M (S/N 924) 250m AMSL
Data Quality: good **Total Records:** 1751



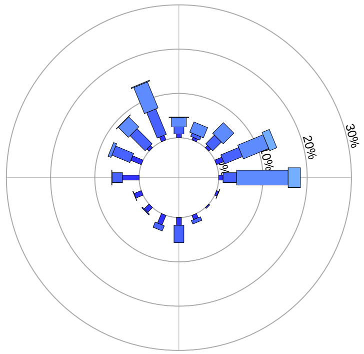


Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moerose: 16:18 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

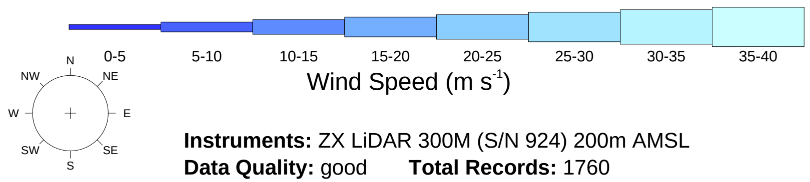
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Deployment
(00:00 01 December 2022 to 07:40 13 December 2022)

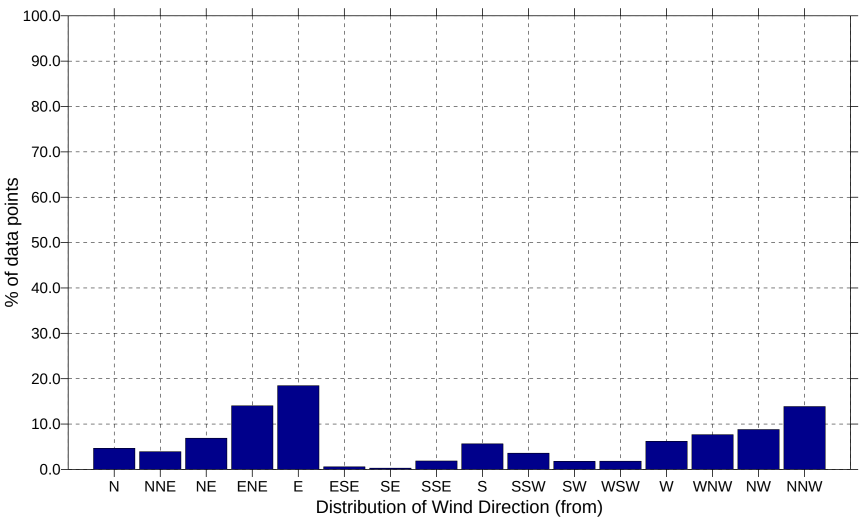


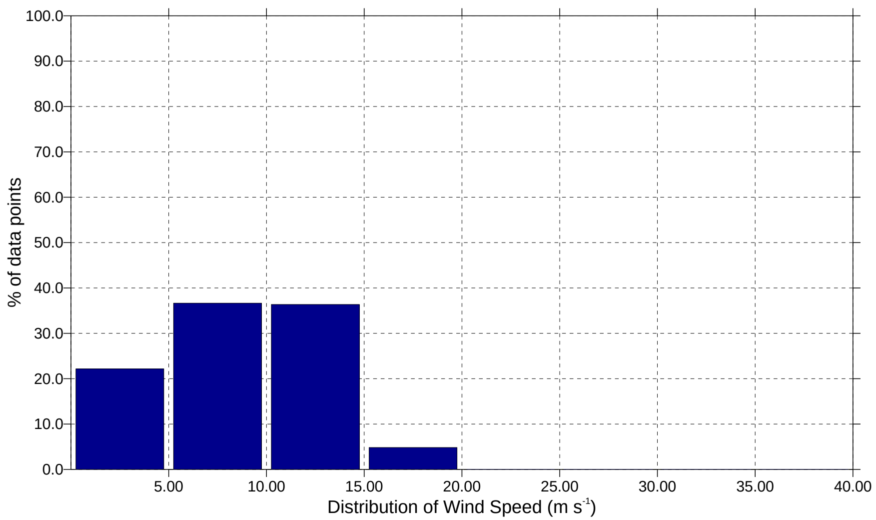
Deployment

Maximum Wind Speed (m s^{-1}): 18.08 from 94.00° North
Minimum Wind Speed (m s^{-1}): 1.06 from 350.00° North
Standard deviation: 3.96 m s^{-1}
Mean: 8.65m s^{-1}



Instruments: ZX LiDAR 300M (S/N 924) 200m AMSL
Data Quality: good **Total Records:** 1760



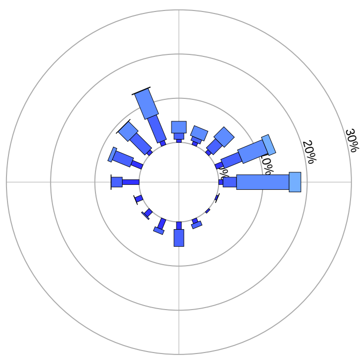


Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moerose: 16:18 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

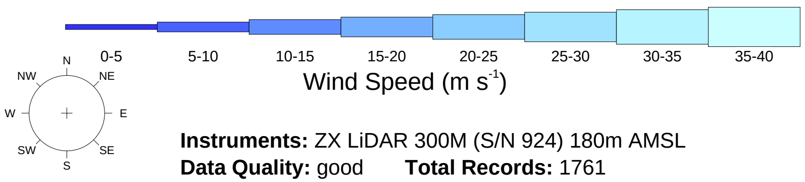
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Deployment
(00:00 01 December 2022 to 07:40 13 December 2022)

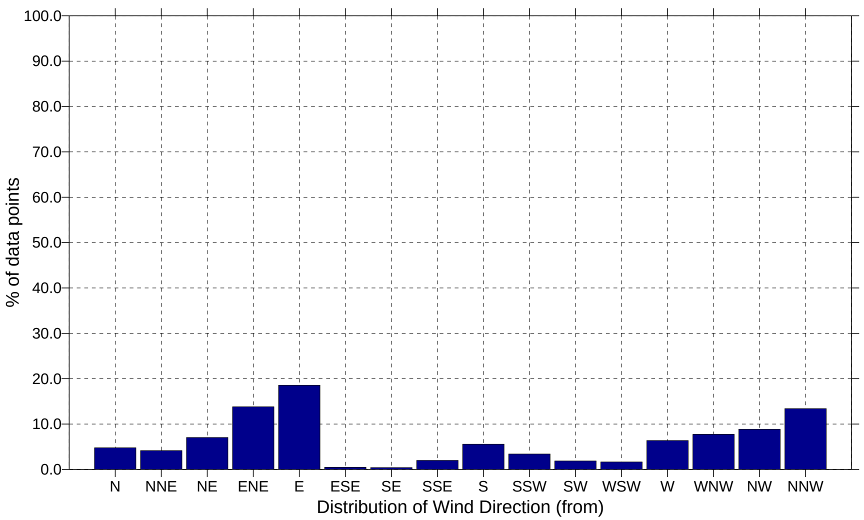


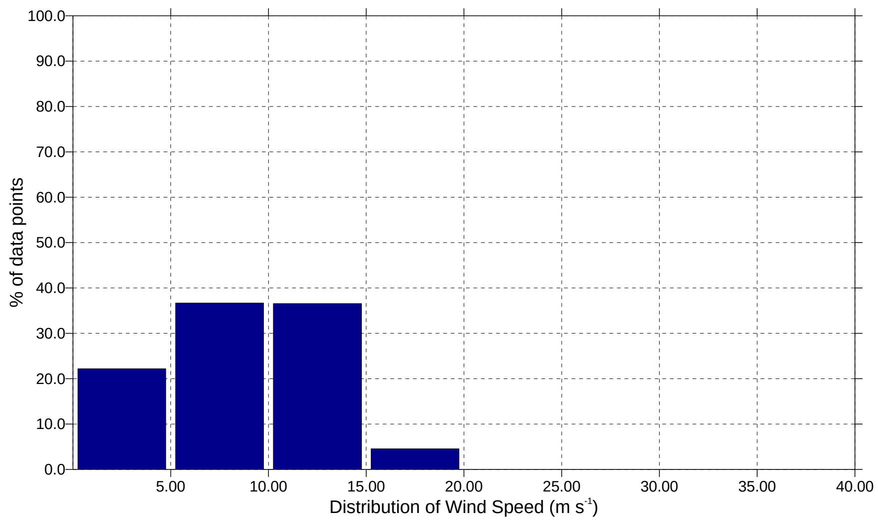
Deployment

Maximum Wind Speed (m s^{-1}): 17.97 from 94.00° North
Minimum Wind Speed (m s^{-1}): 1.01 from 34.00° North
Standard deviation: 3.93 m s^{-1}
Mean: 8.62m s^{-1}



Instruments: ZX LiDAR 300M (S/N 924) 180m AMSL
Data Quality: good **Total Records:** 1761



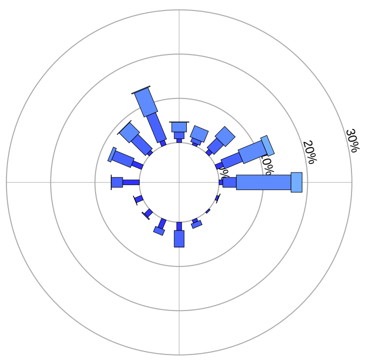


Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moerose: 16:18 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

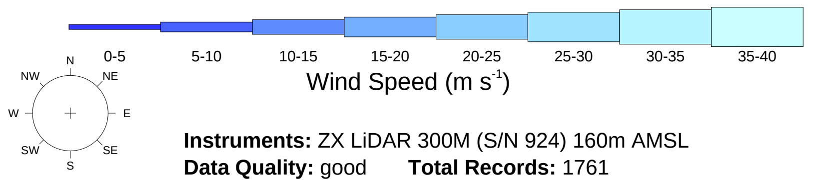
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Deployment
(00:00 01 December 2022 to 07:40 13 December 2022)

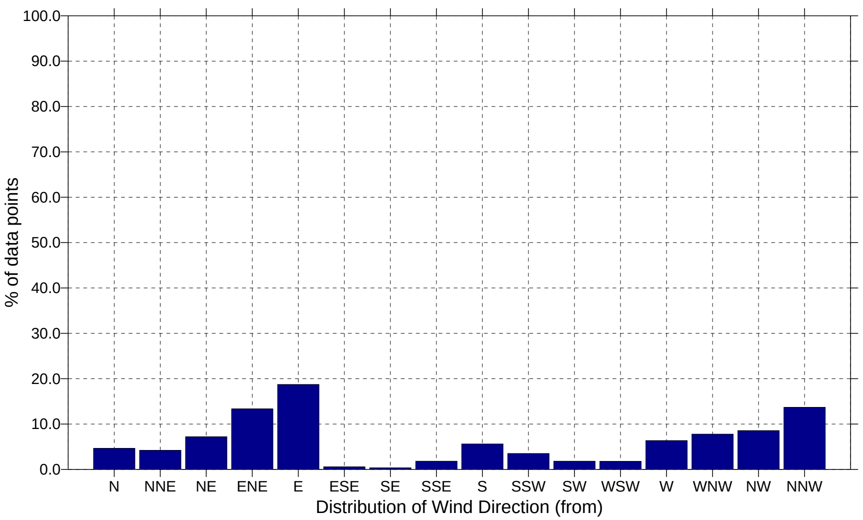


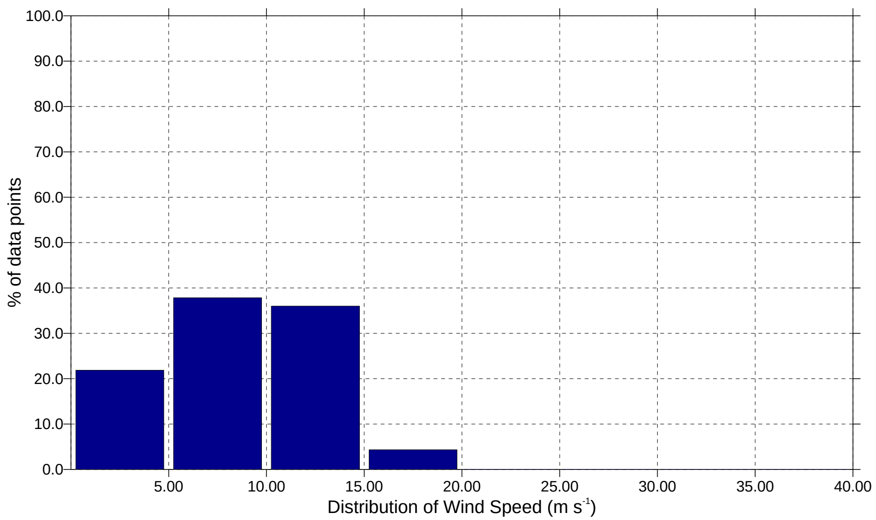
Deployment

Maximum Wind Speed (m s^{-1}): 17.74 from 95.00° North
Minimum Wind Speed (m s^{-1}): 1.07 from 39.00° North
Standard deviation: 3.91 m s^{-1}
Mean: 8.60m s^{-1}



Instruments: ZX LiDAR 300M (S/N 924) 160m AMSL
Data Quality: good **Total Records:** 1761



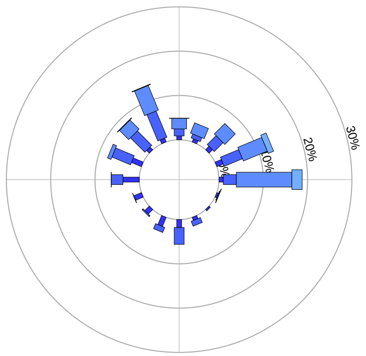


Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moerose: 16:18 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

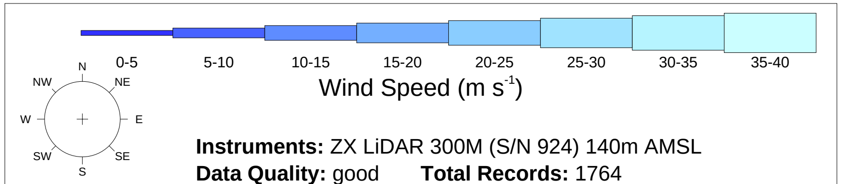
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Deployment
(00:00 01 December 2022 to 07:40 13 December 2022)

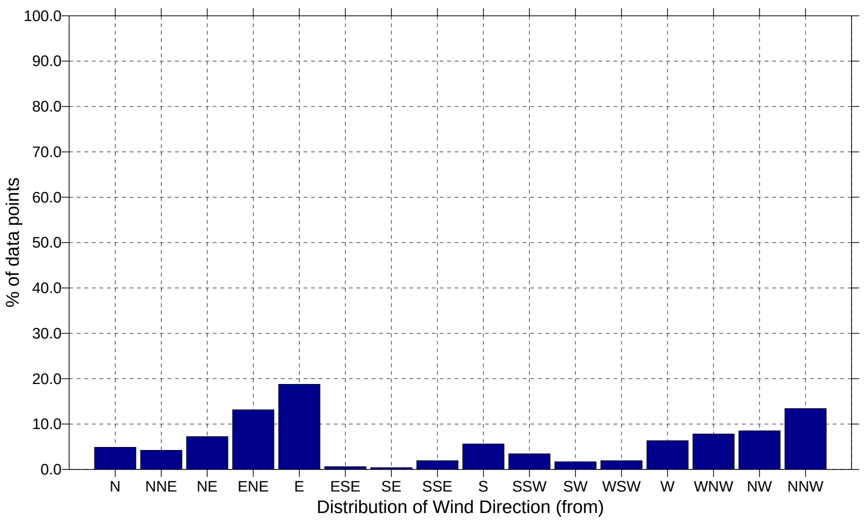


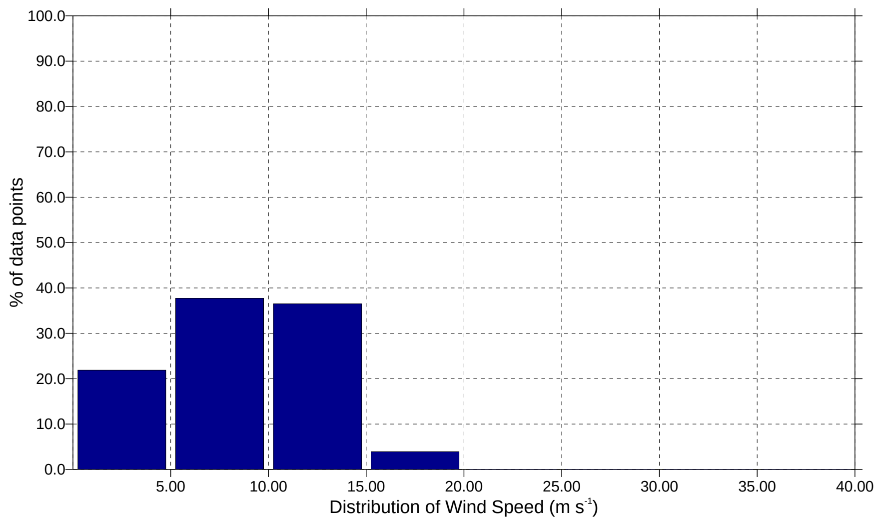
Deployment

Maximum Wind Speed (m s^{-1}): 17.75 from 87.00° North
Minimum Wind Speed (m s^{-1}): 1.15 from 4.00° North
Standard deviation: 3.88 m s^{-1}
Mean: 8.56m s^{-1}



Instruments: ZX LiDAR 300M (S/N 924) 140m AMSL
Data Quality: good **Total Records:** 1764



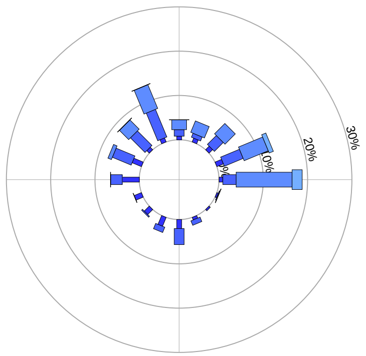


Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moerose: 16:18 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

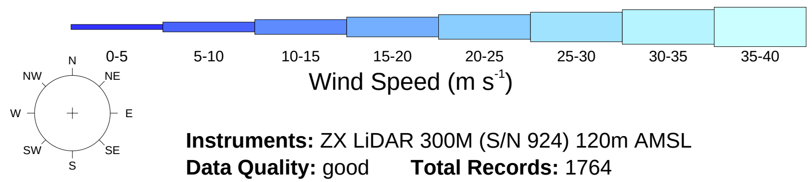
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Deployment
(00:00 01 December 2022 to 07:40 13 December 2022)

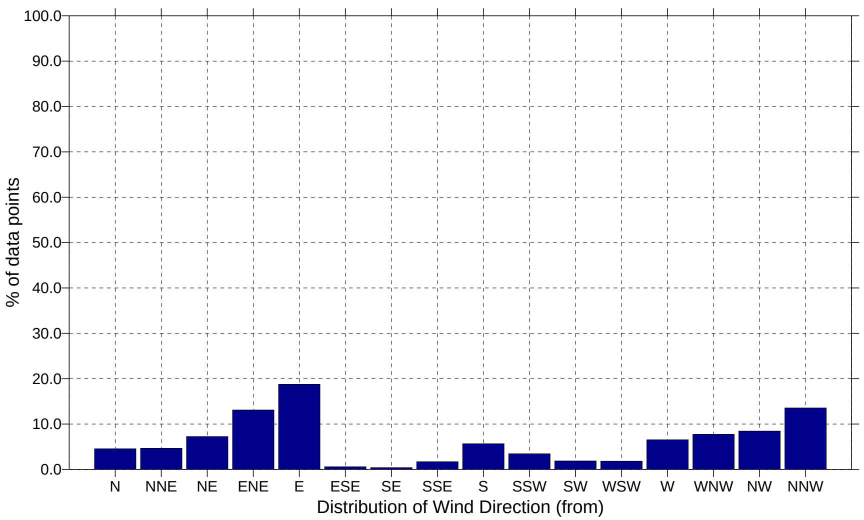


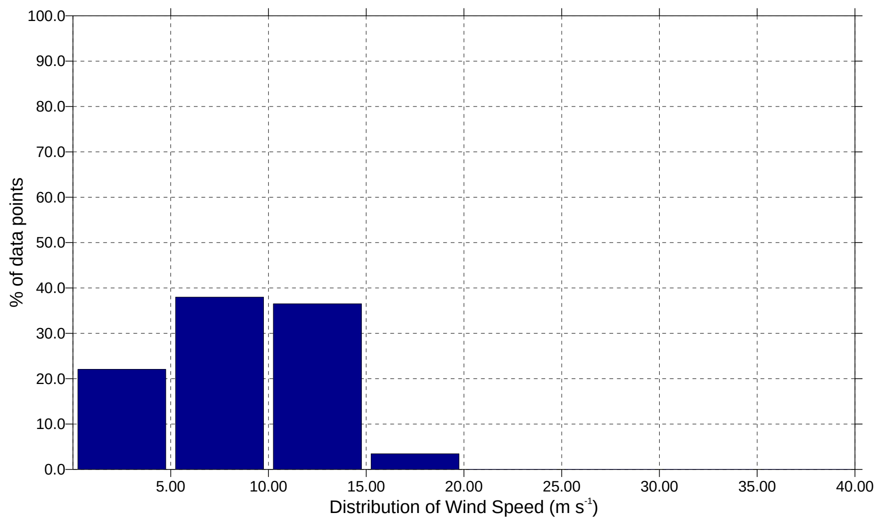
Deployment

Maximum Wind Speed (m s^{-1}): 17.57 from 87.00° North
Minimum Wind Speed (m s^{-1}): 1.00 from 23.00° North
Standard deviation: 3.85 m s^{-1}
Mean: 8.52m s^{-1}



Instruments: ZX LiDAR 300M (S/N 924) 120m AMSL
Data Quality: good **Total Records:** 1764



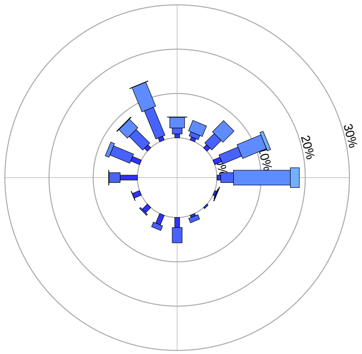


Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moerose: 16:18 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

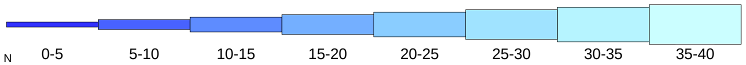
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

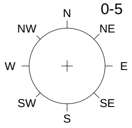
Deployment
(00:00 01 December 2022 to 07:40 13 December 2022)



Deployment

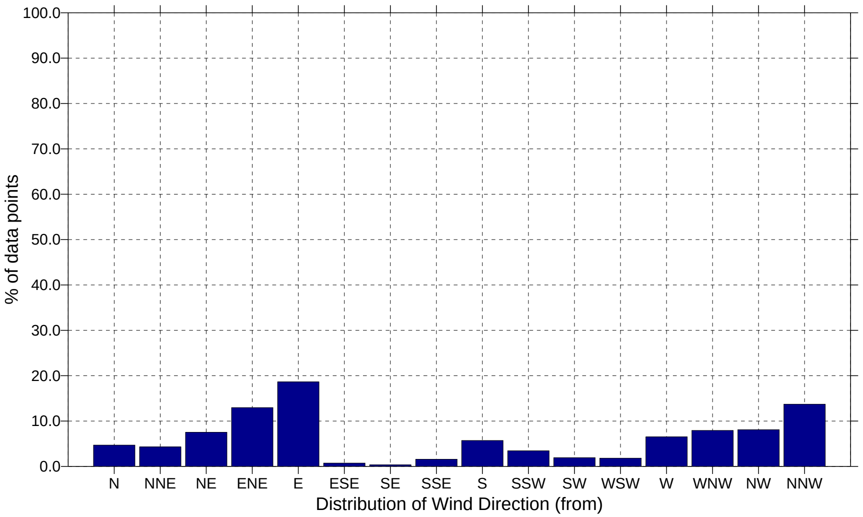
Maximum Wind Speed (m s^{-1}): 17.31 from 86.00° North
Minimum Wind Speed (m s^{-1}): 1.06 from 23.00° North
Standard deviation: 3.83 m s^{-1}
Mean: 8.47m s^{-1}

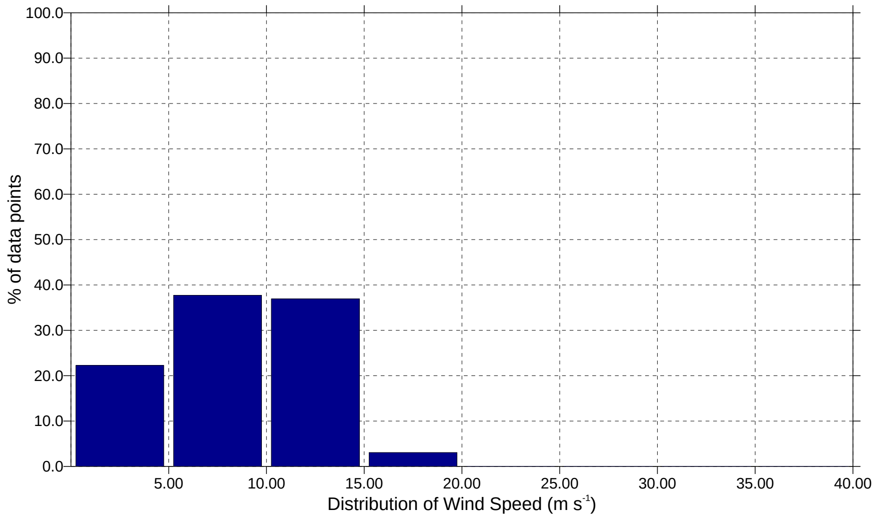




Wind Speed (m s^{-1})

Instruments: ZX LiDAR 300M (S/N 924) 100m AMSL
Data Quality: good **Total Records:** 1765



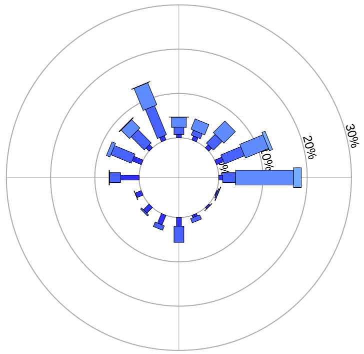


Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moerose: 16:18 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

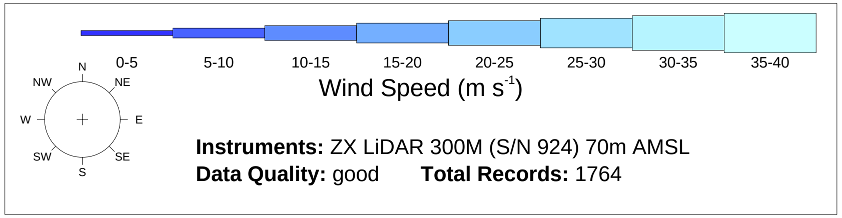
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Deployment
(00:00 01 December 2022 to 07:40 13 December 2022)

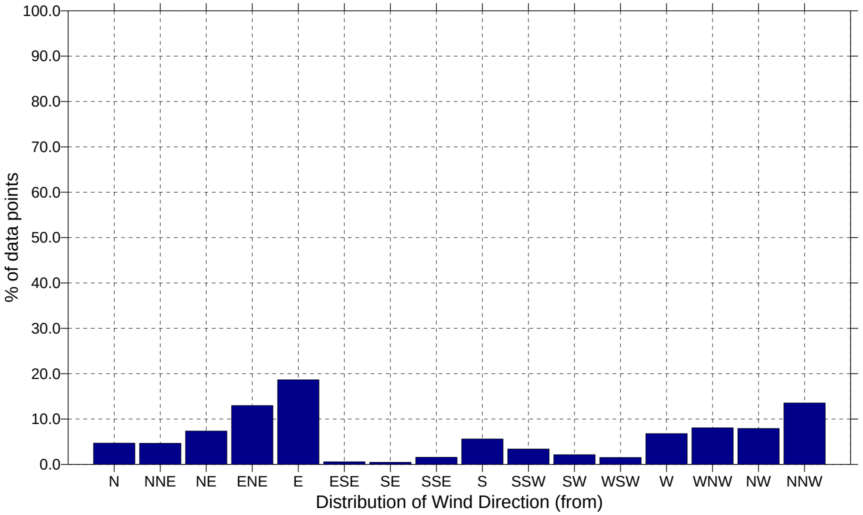


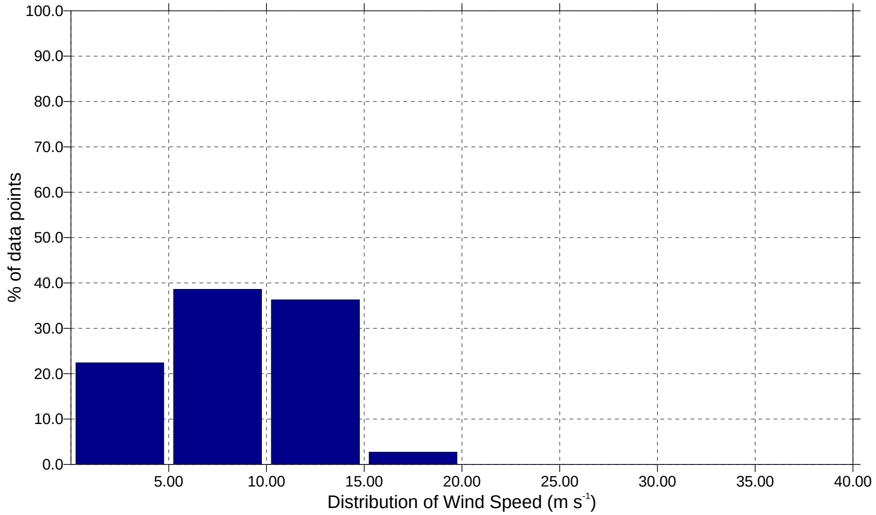
Deployment

Maximum Wind Speed (m s^{-1}): 17.18 from 307.00° North
Minimum Wind Speed (m s^{-1}): 0.78 from 14.00° North
Standard deviation: 3.78 m s^{-1}
Mean: 8.41m s^{-1}



Instruments: ZX LiDAR 300M (S/N 924) 70m AMSL
Data Quality: good **Total Records:** 1764





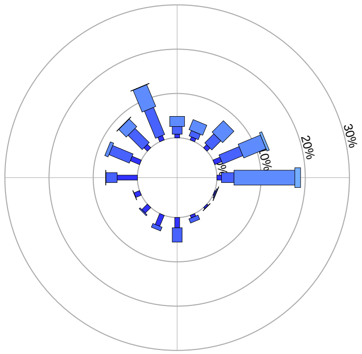
Time Zone: UTC +00:00 hours

Data Source: NWWindA.2022.12.QC_dataReturn.nc
moerose: 16:18 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

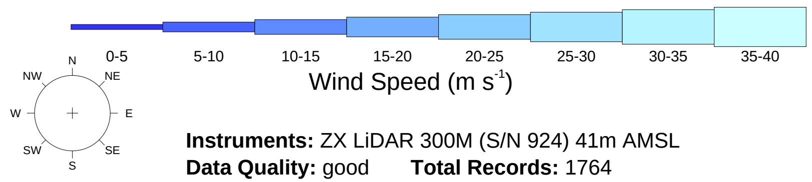
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Deployment
(00:00 01 December 2022 to 07:40 13 December 2022)

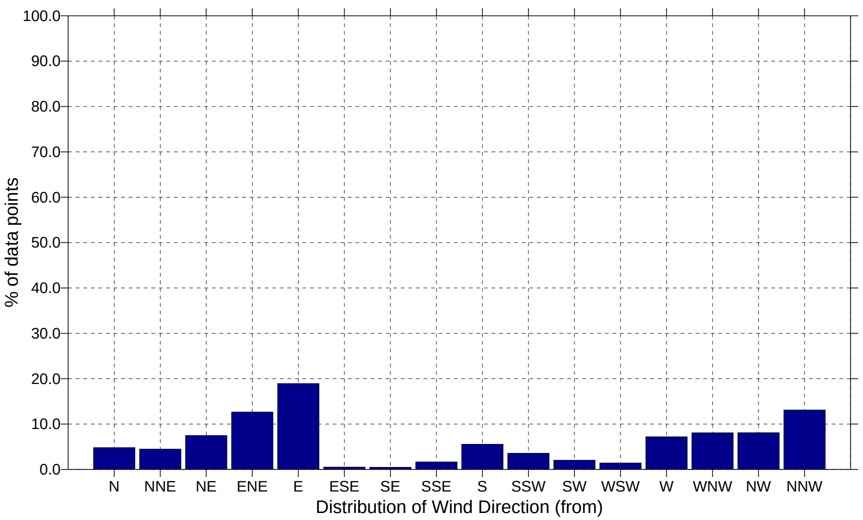


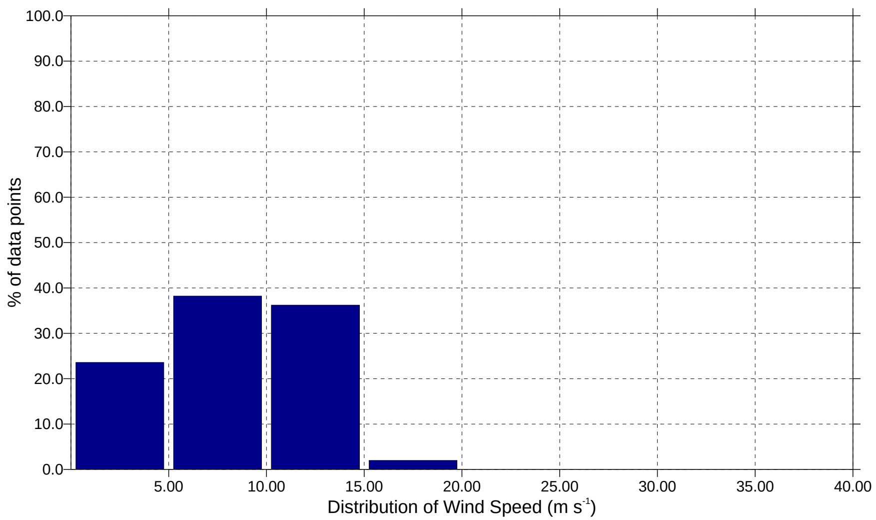
Deployment

Maximum Wind Speed (m s^{-1}): 16.77 from 87.00° North
Minimum Wind Speed (m s^{-1}): 0.87 from 339.00° North
Standard deviation: 3.69 m s^{-1}
Mean: 8.26m s^{-1}



Instruments: ZX LiDAR 300M (S/N 924) 41m AMSL
Data Quality: good **Total Records:** 1764



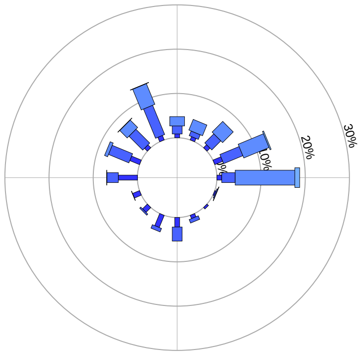


Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moerose: 16:18 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

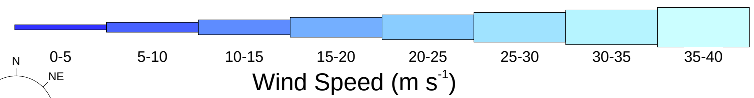
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

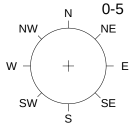
Deployment
(00:00 01 December 2022 to 07:40 13 December 2022)



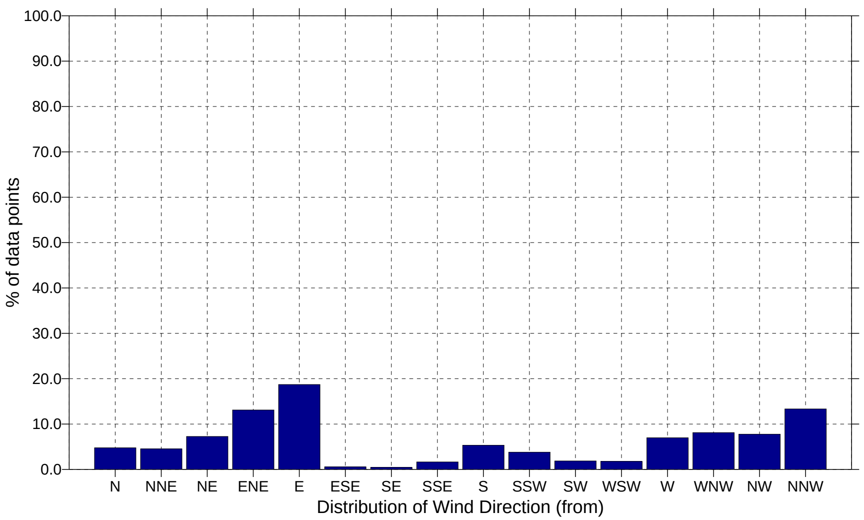
Deployment

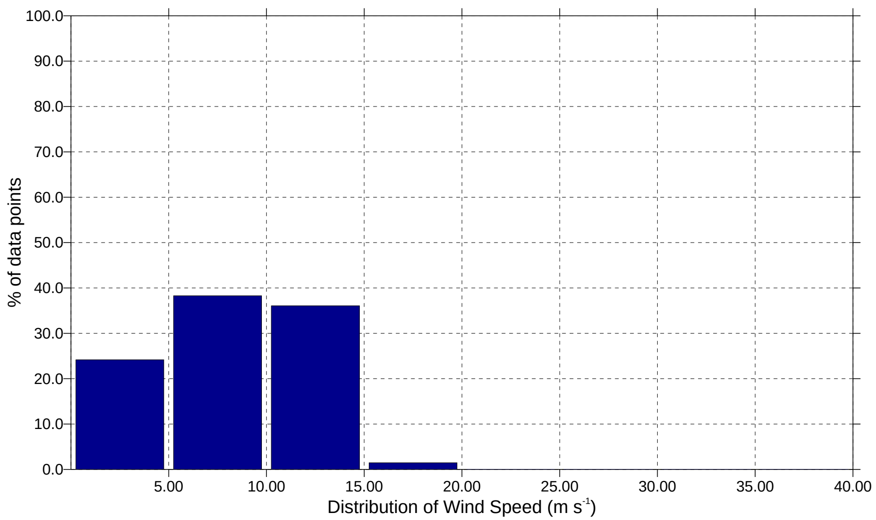
Maximum Wind Speed (m s^{-1}): 16.64 from 92.00° North
Minimum Wind Speed (m s^{-1}): 1.01 from 344.00° North
Standard deviation: 3.64 m s^{-1}
Mean: 8.17m s^{-1}





Instruments: ZX LiDAR 300M (S/N 924) 30m AMSL
Data Quality: good **Total Records:** 1763



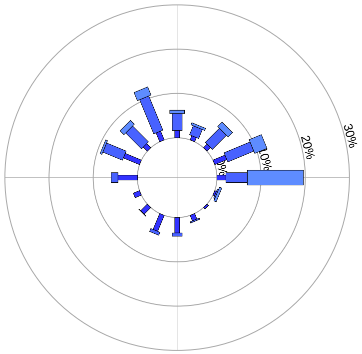


Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moerose: 16:18 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

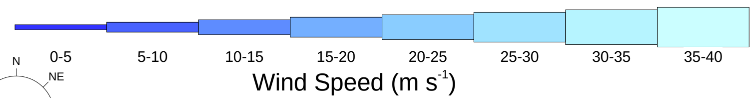
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

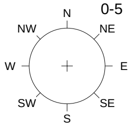
Deployment
(00:00 01 December 2022 to 07:40 13 December 2022)



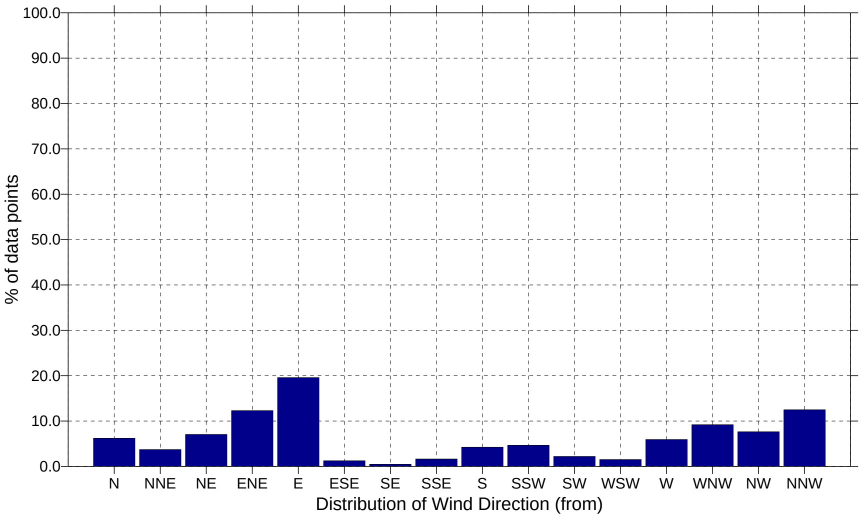
Deployment

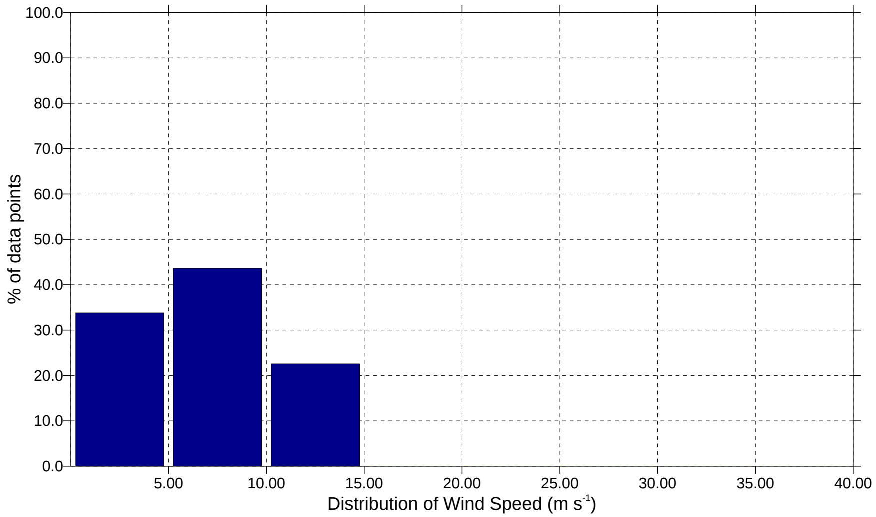
Maximum Wind Speed (m s^{-1}): 14.23 from 87.00° North
Minimum Wind Speed (m s^{-1}): 0.72 from 339.00° North
Standard deviation: 3.19 m s^{-1}
Mean: 7.00m s^{-1}





Instruments: WindObserver II (S/N 1922006) 3.7m AMSL
Data Quality: good **Total Records:** 1772



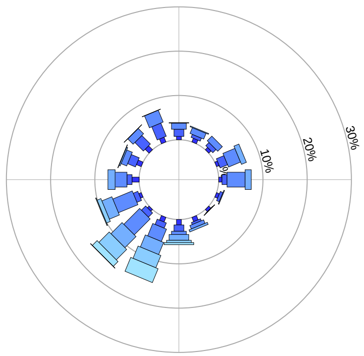


Time Zone: UTC +00:00 hours	Data Source: NWWindA.2022.12.QC_dataReturn.nc
	moerose: 16:18 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

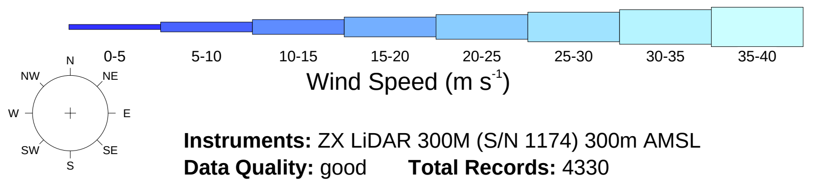
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Deployment
(00:00 01 December 2022 to 23:50 31 December 2022)

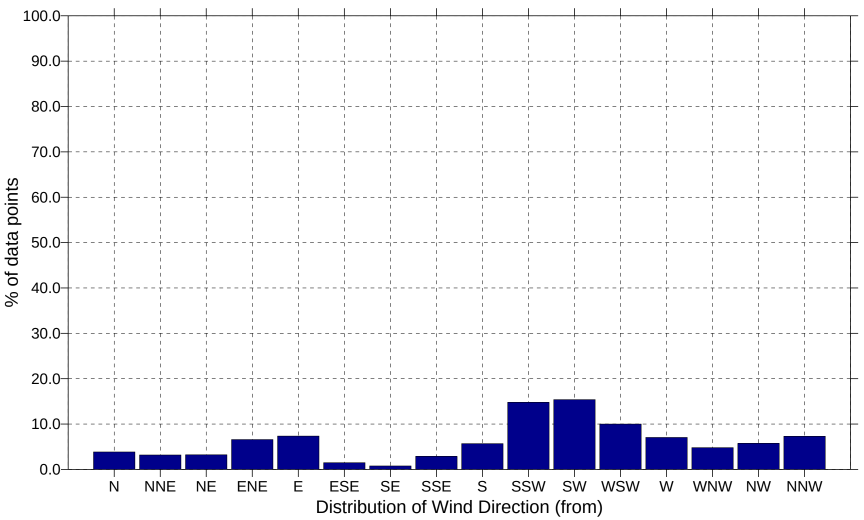


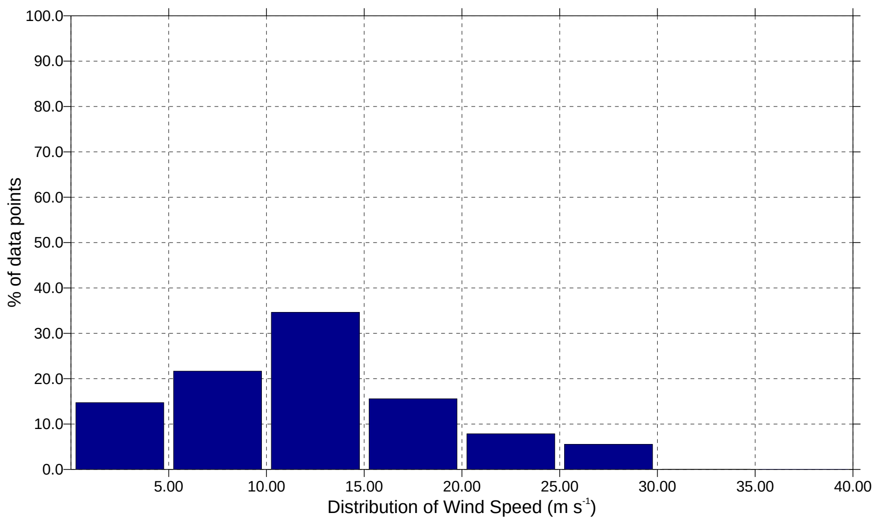
Deployment

Maximum Wind Speed (m s^{-1}): 30.31 from 224.00° North
Minimum Wind Speed (m s^{-1}): 0.80 from 29.00° North
Standard deviation: 6.45 m s^{-1}
Mean: 12.32m s^{-1}



Instruments: ZX LiDAR 300M (S/N 1174) 300m AMSL
Data Quality: good **Total Records:** 4330



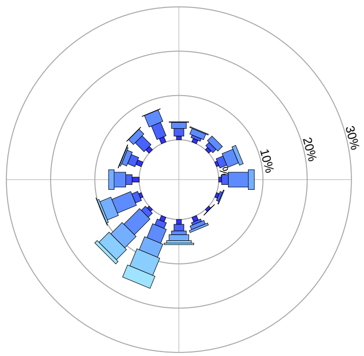


Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moerose: 16:19 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

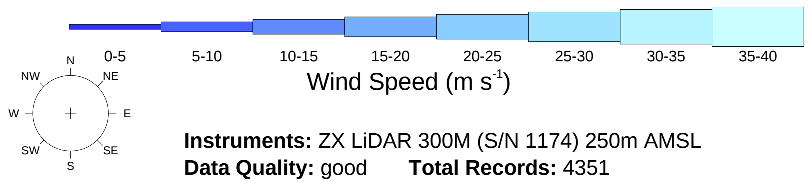
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Deployment
(00:00 01 December 2022 to 23:50 31 December 2022)

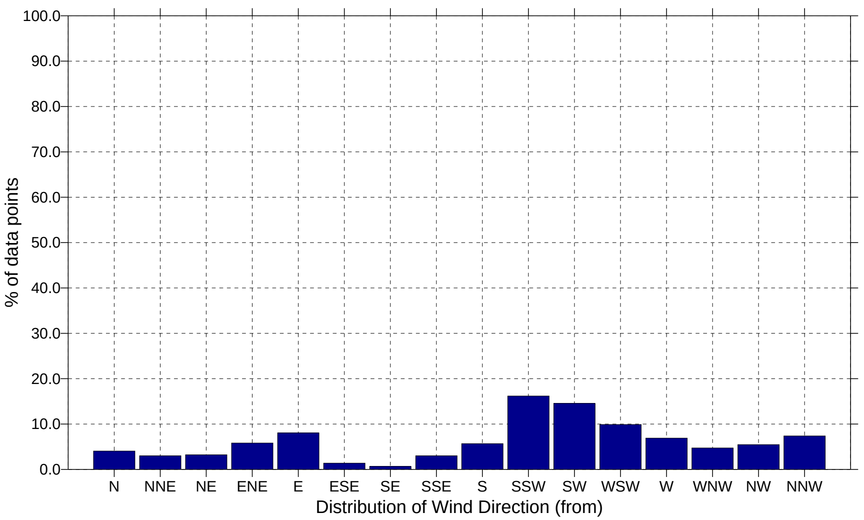


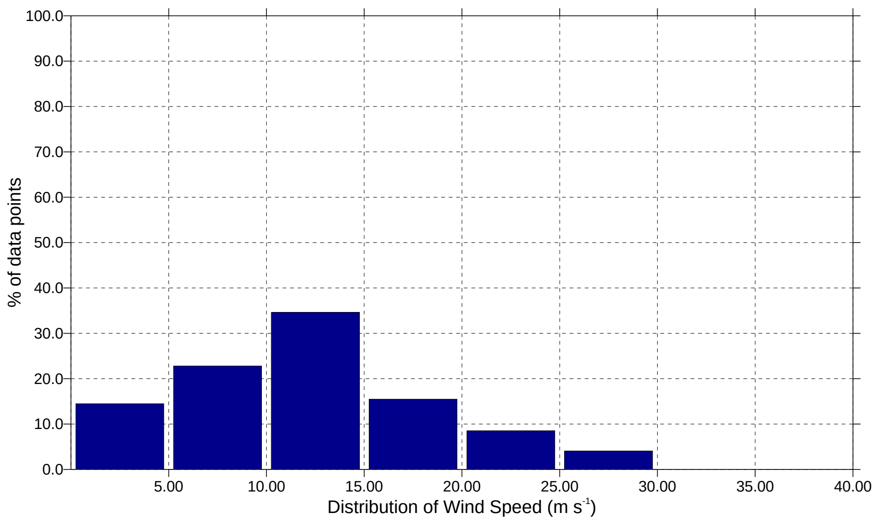
Deployment

Maximum Wind Speed (m s^{-1}): 29.04 from 214.00° North
Minimum Wind Speed (m s^{-1}): 0.81 from 44.00° North
Standard deviation: 6.26 m s^{-1}
Mean: 12.13m s^{-1}



Instruments: ZX LiDAR 300M (S/N 1174) 250m AMSL
Data Quality: good **Total Records:** 4351



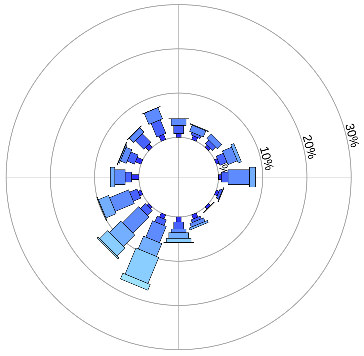


Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moerose: 16:19 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

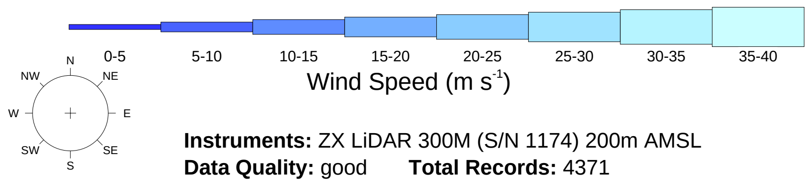
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Deployment
(00:00 01 December 2022 to 23:50 31 December 2022)

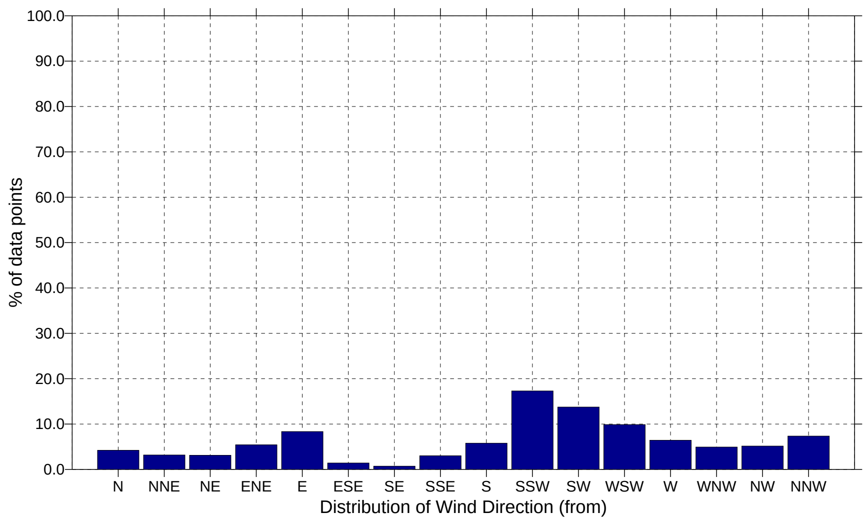


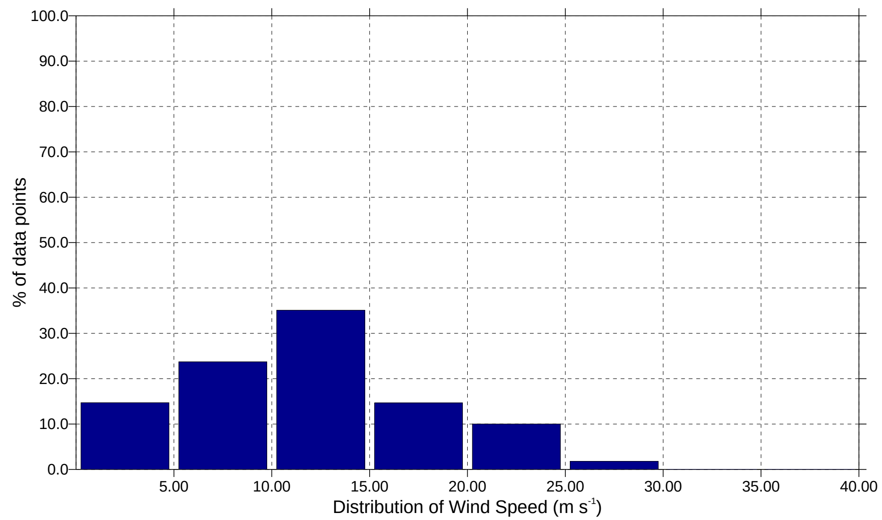
Deployment

Maximum Wind Speed (m s^{-1}): 28.07 from 212.00° North
Minimum Wind Speed (m s^{-1}): 0.90 from 8.00° North
Standard deviation: 6.03 m s^{-1}
Mean: 11.86m s^{-1}



Instruments: ZX LiDAR 300M (S/N 1174) 200m AMSL
Data Quality: good **Total Records:** 4371



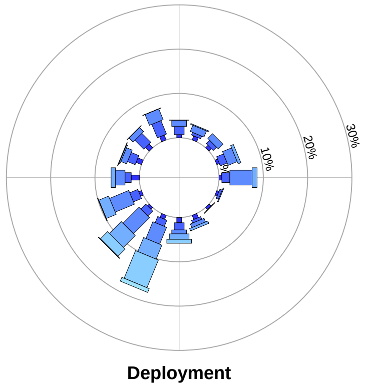


Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moerose: 16:19 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.B.2022.12.rose.ps)

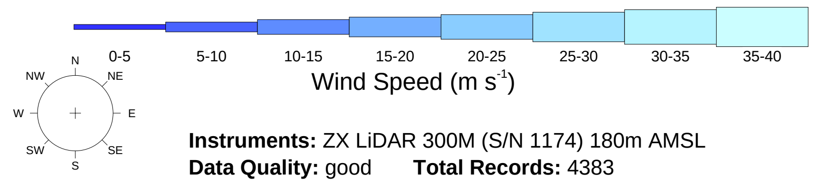
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

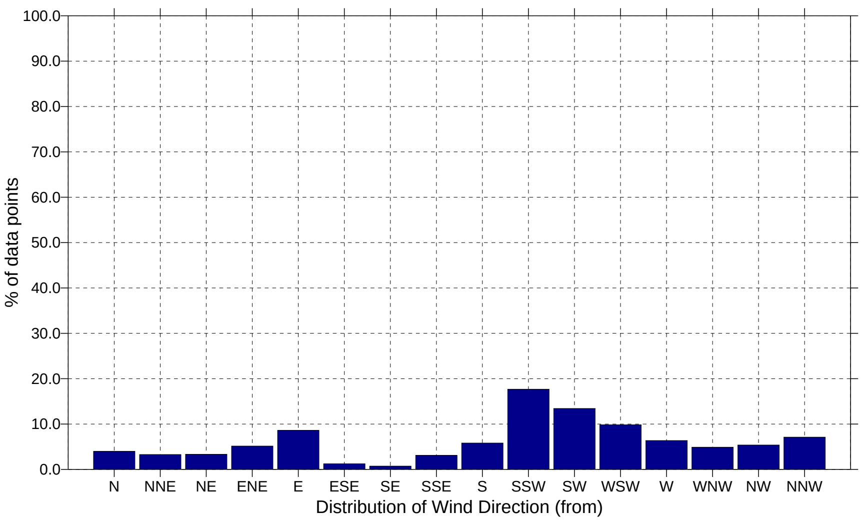
Deployment
(00:00 01 December 2022 to 23:50 31 December 2022)

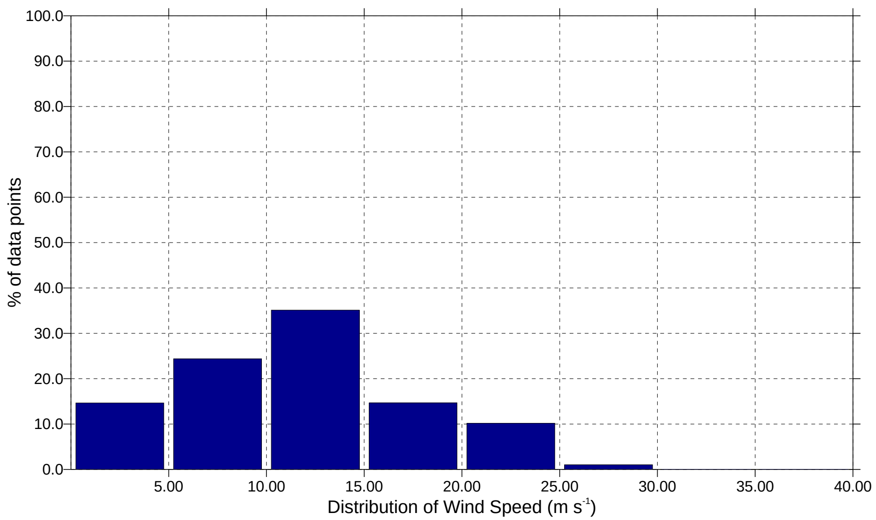


Maximum Wind Speed ($m\ s^{-1}$): 27.52 from 212.00° North
Minimum Wind Speed ($m\ s^{-1}$): 0.95 from 20.00° North
Standard deviation: 5.90 $m\ s^{-1}$
Mean: 11.73$m\ s^{-1}$



Instruments: ZX LiDAR 300M (S/N 1174) 180m AMSL
Data Quality: good **Total Records:** 4383



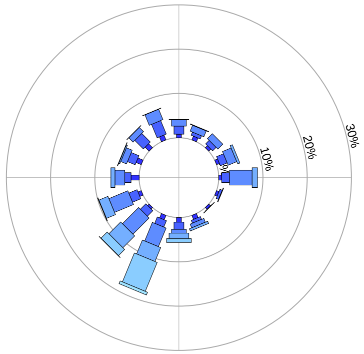


Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moerose: 16:19 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

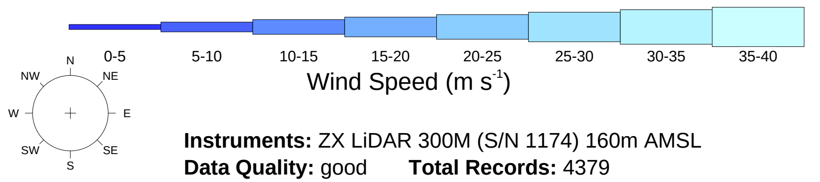
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Deployment
(00:00 01 December 2022 to 23:50 31 December 2022)

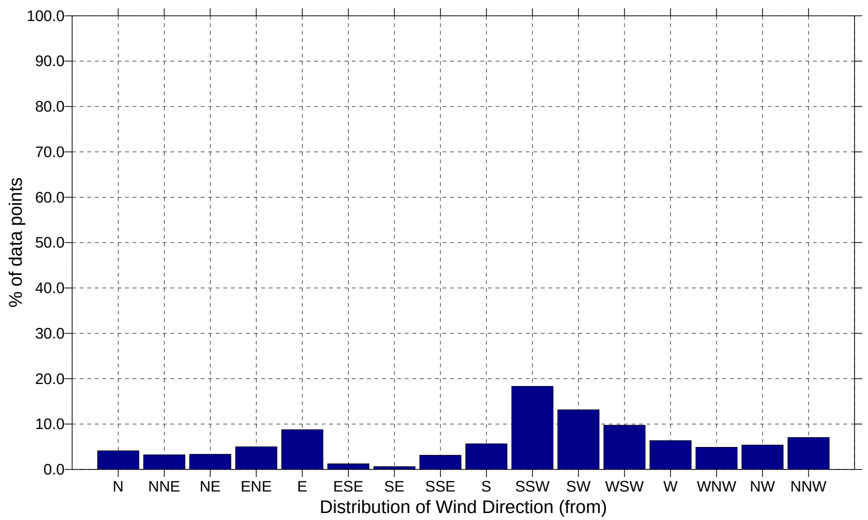


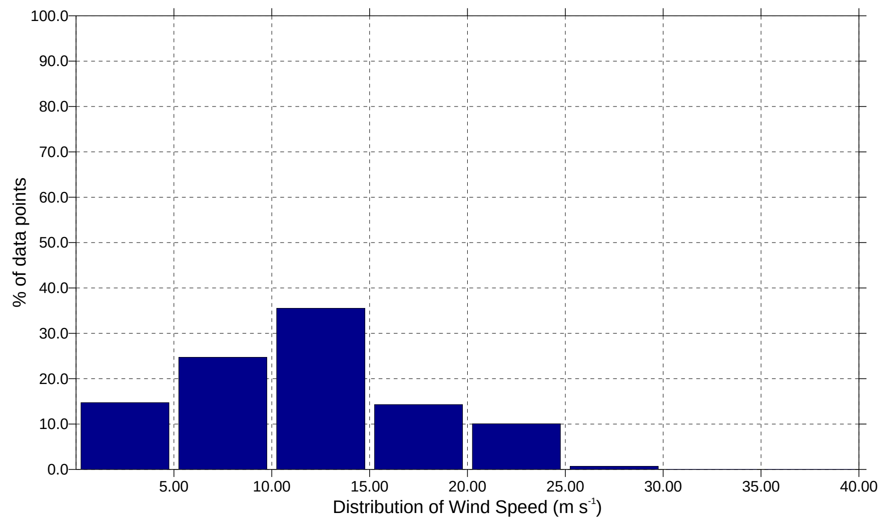
Deployment

Maximum Wind Speed (m s^{-1}): 27.40 from 213.00° North
Minimum Wind Speed (m s^{-1}): 0.69 from 335.00° North
Standard deviation: 5.75 m s^{-1}
Mean: 11.60m s^{-1}



Instruments: ZX LiDAR 300M (S/N 1174) 160m AMSL
Data Quality: good **Total Records:** 4379



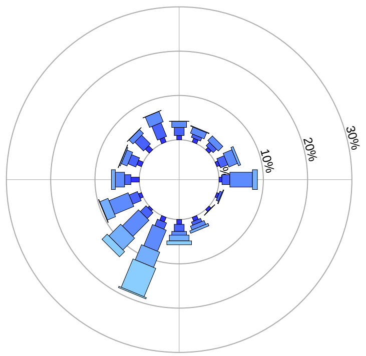


Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moerose: 16:19 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

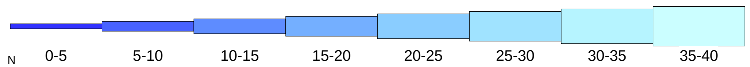
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

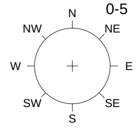
Deployment
(00:00 01 December 2022 to 23:50 31 December 2022)



Deployment

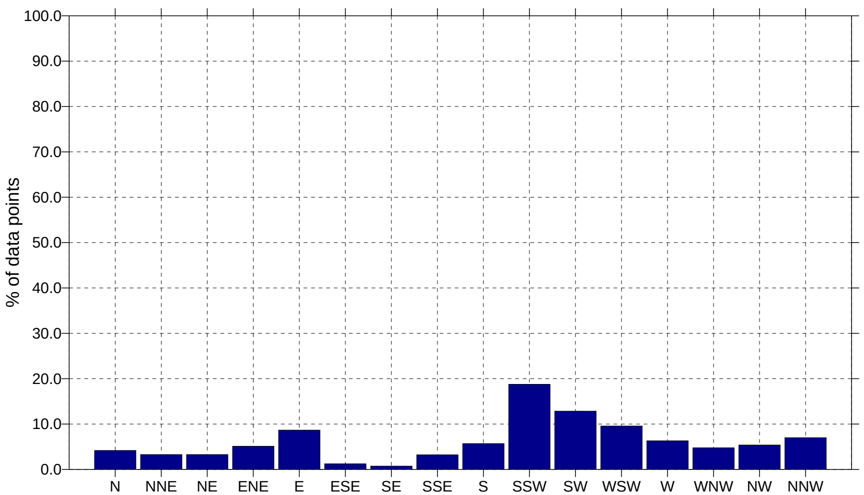
Maximum Wind Speed (m s^{-1}): 26.33 from 213.00° North
Minimum Wind Speed (m s^{-1}): 0.84 from 357.00° North
Standard deviation: 5.57 m s^{-1}
Mean: 11.44m s^{-1}



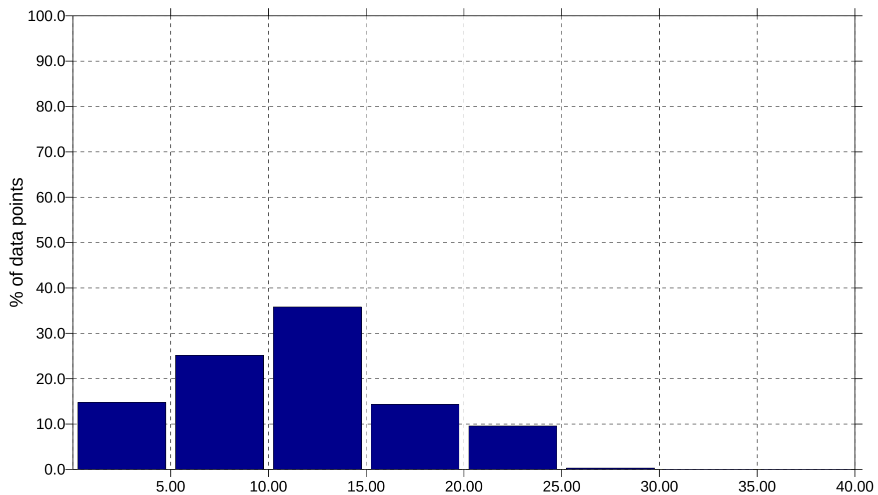


Wind Speed (m s^{-1})

Instruments: ZX LiDAR 300M (S/N 1174) 140m AMSL
Data Quality: good **Total Records:** 4383



Distribution of Wind Direction (from)



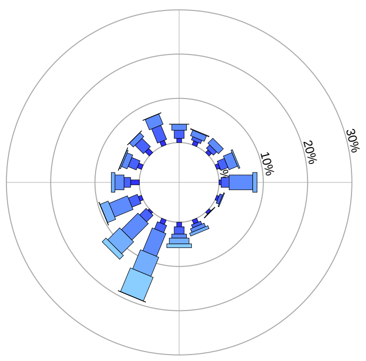
Distribution of Wind Speed (m s^{-1})

Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moerose: 16:19 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Deployment
(00:00 01 December 2022 to 23:50 31 December 2022)



Deployment

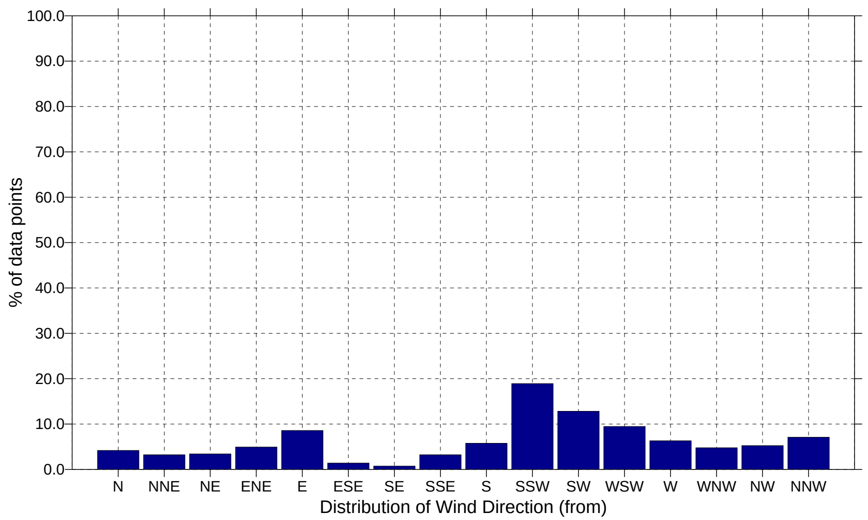
Maximum Wind Speed (m s^{-1}): 25.17 from 209.00° North
Minimum Wind Speed (m s^{-1}): 0.81 from 7.00° North
Standard deviation: 5.39 m s^{-1}
Mean: 11.26m s^{-1}

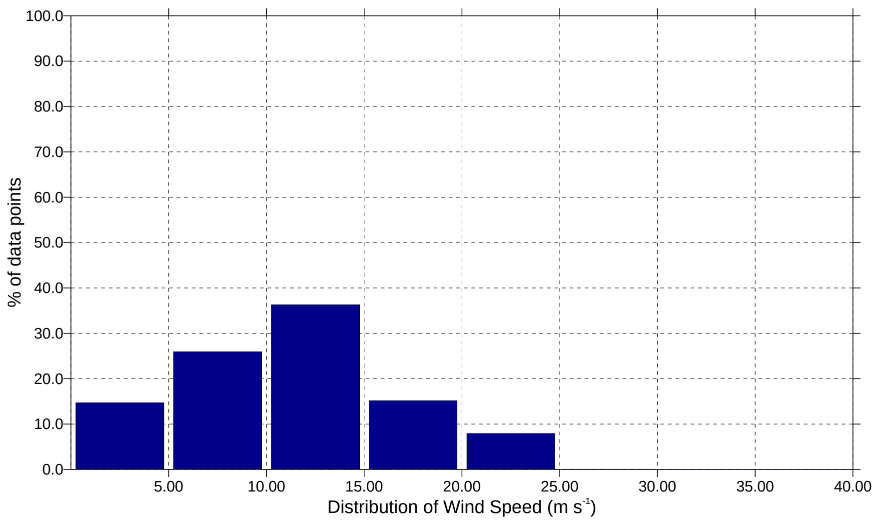
0-5 5-10 10-15 15-20 20-25 25-30 30-35 35-40

Wind Speed (m s^{-1})

N NE E SE S SW W NW

Instruments: ZX LiDAR 300M (S/N 1174) 120m AMSL
Data Quality: good **Total Records:** 4383





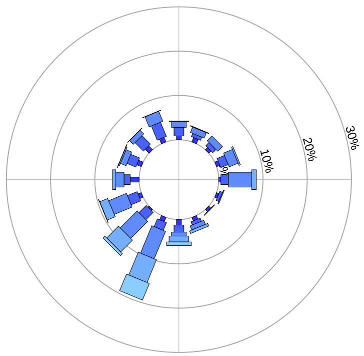
Time Zone: UTC +00:00 hours Data Source: NWWindB.2022.12.QC_dataReturn.nc

 moerose: 16:19 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

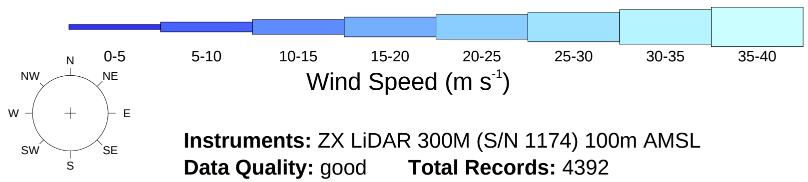
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Deployment
(00:00 01 December 2022 to 23:50 31 December 2022)

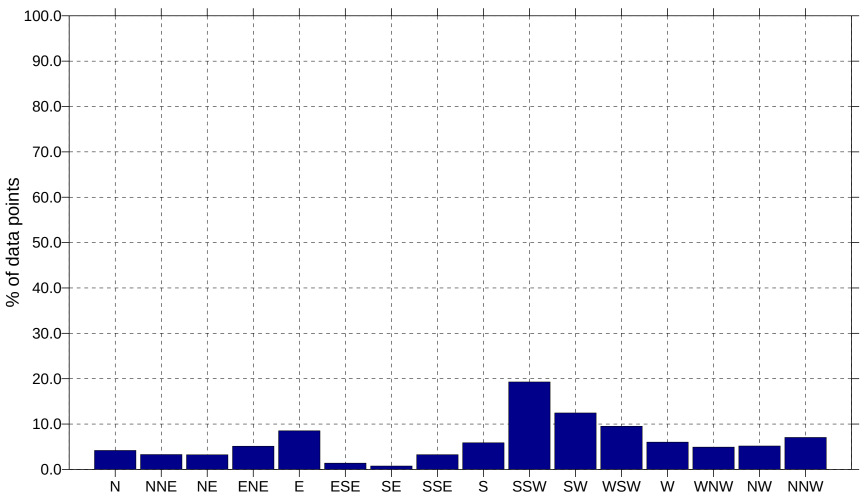


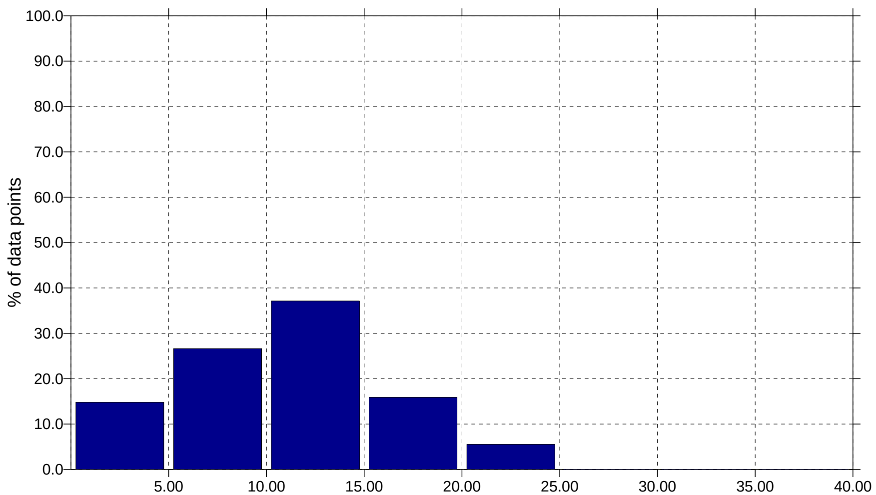
Deployment

Maximum Wind Speed (m s^{-1}): 24.18 from 208.00° North
Minimum Wind Speed (m s^{-1}): 0.87 from 356.00° North
Standard deviation: 5.20 m s^{-1}
Mean: 11.06m s^{-1}



Instruments: ZX LiDAR 300M (S/N 1174) 100m AMSL
Data Quality: good **Total Records:** 4392



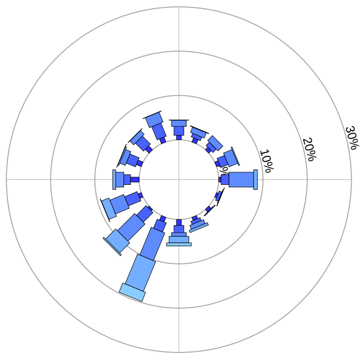


Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moerose: 16:19 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

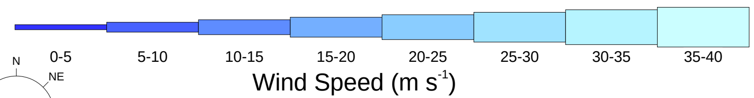
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

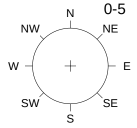
Deployment
(00:00 01 December 2022 to 23:50 31 December 2022)



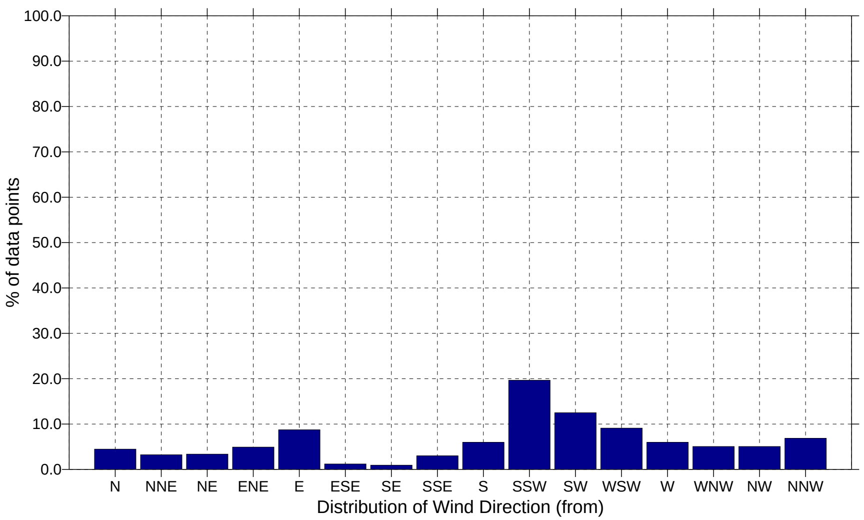
Deployment

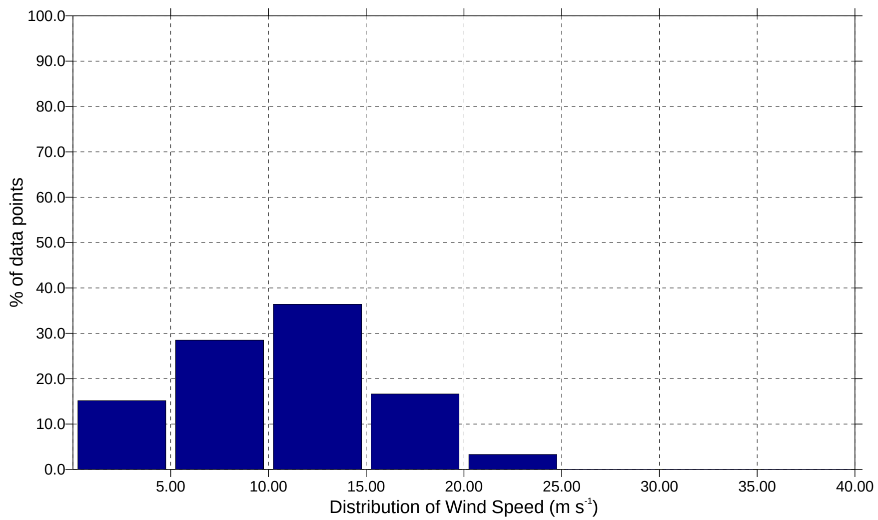
Maximum Wind Speed (m s^{-1}): 23.46 from 209.00° North
Minimum Wind Speed (m s^{-1}): 0.77 from 22.00° North
Standard deviation: 4.92 m s^{-1}
Mean: 10.75m s^{-1}





Instruments: ZX LiDAR 300M (S/N 1174) 70m AMSL
Data Quality: good **Total Records:** 4393



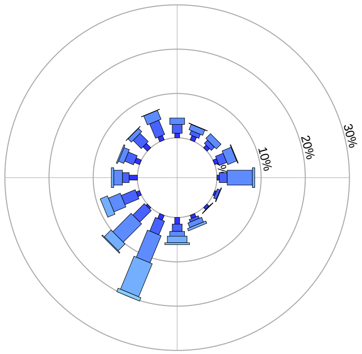


Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moerose: 16:19 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

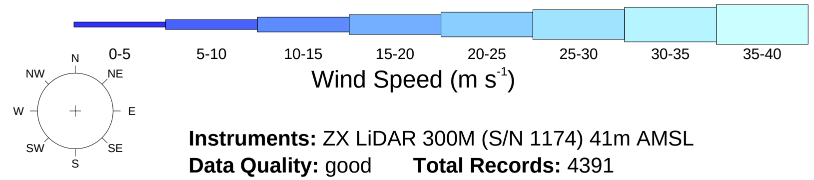
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Deployment
(00:00 01 December 2022 to 23:50 31 December 2022)

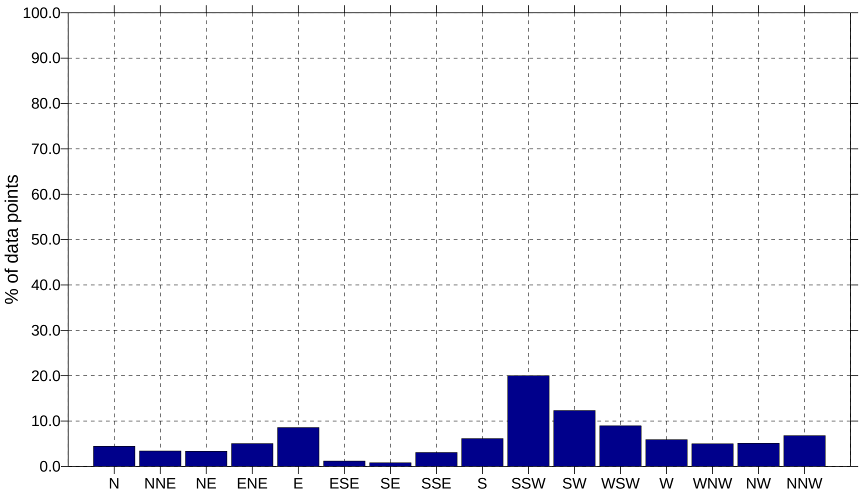


Deployment

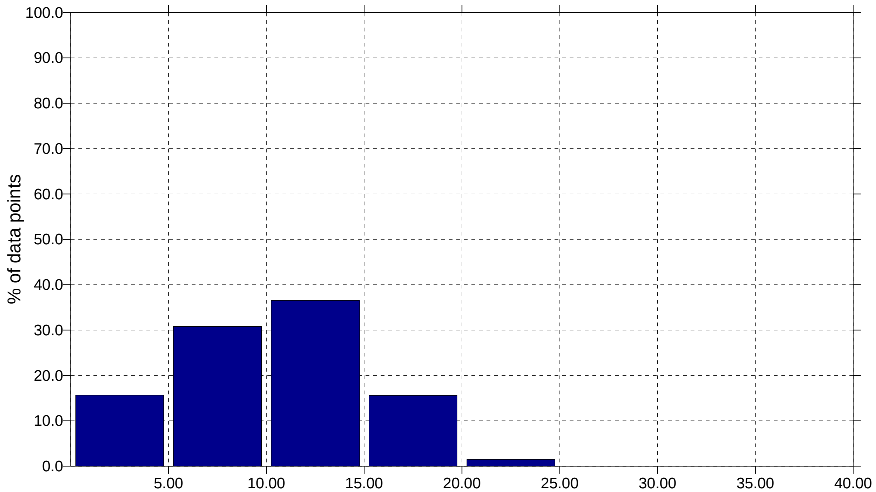
Maximum Wind Speed (m s^{-1}): 22.17 from 208.00° North
Minimum Wind Speed (m s^{-1}): 0.86 from 26.00° North
Standard deviation: 4.59 m s^{-1}
Mean: 10.35m s^{-1}



Instruments: ZX LiDAR 300M (S/N 1174) 41m AMSL
Data Quality: good **Total Records:** 4391



Distribution of Wind Direction (from)



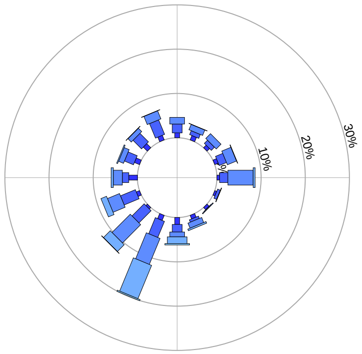
Distribution of Wind Speed (m s^{-1})

Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moerose: 16:19 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Deployment
(00:00 01 December 2022 to 23:50 31 December 2022)



Deployment

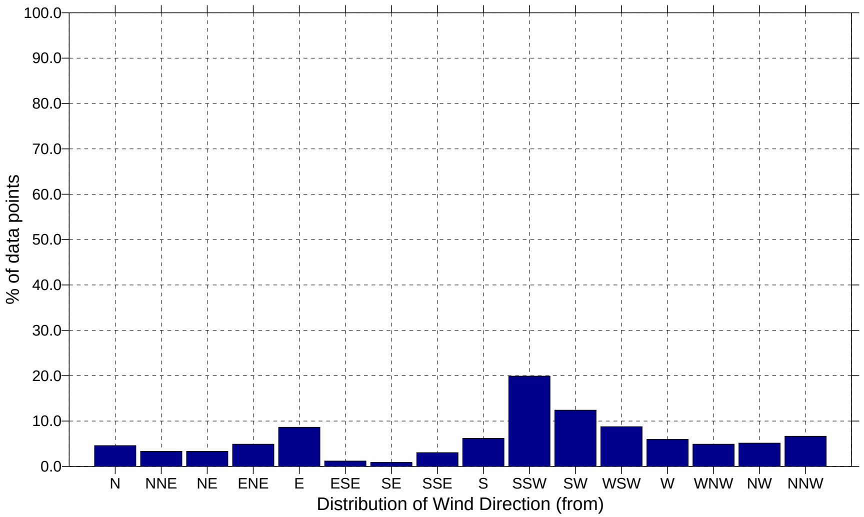
Maximum Wind Speed ($m\ s^{-1}$): 22.10 from 208.00° North
Minimum Wind Speed ($m\ s^{-1}$): 0.80 from 23.00° North
Standard deviation: 4.43 $m\ s^{-1}$
Mean: 10.13$m\ s^{-1}$

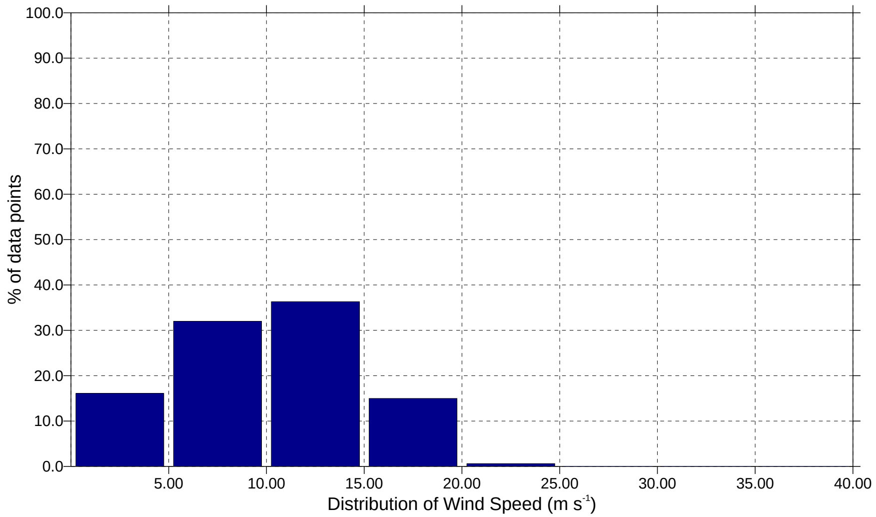
0-5 | 5-10 | 10-15 | 15-20 | 20-25 | 25-30 | 30-35 | 35-40

Wind Speed ($m\ s^{-1}$)

N NE E SE S SW W NW

Instruments: ZX LiDAR 300M (S/N 1174) 30m AMSL
Data Quality: good **Total Records:** 4392



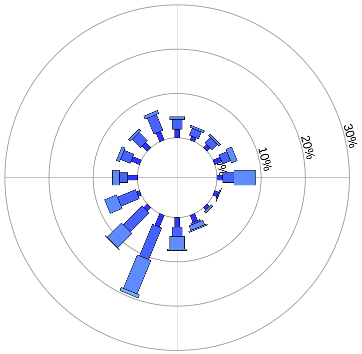


Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
© RPS Australia West Pty Ltd	moerose: 16:19 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

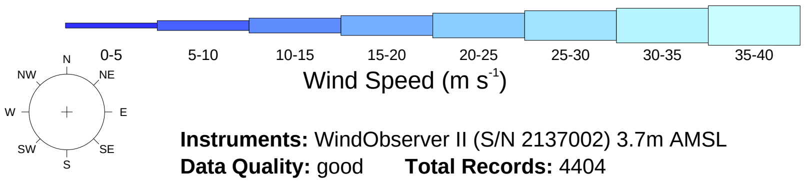
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Deployment
(00:00 01 December 2022 to 23:50 31 December 2022)

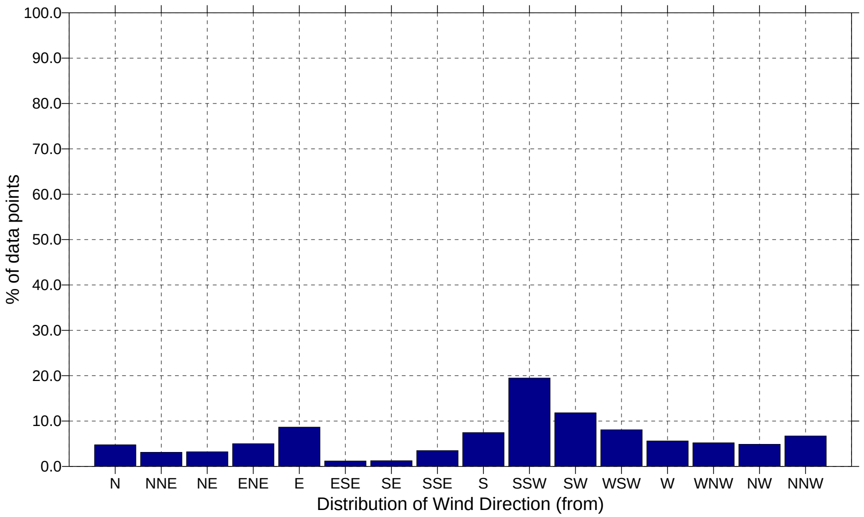


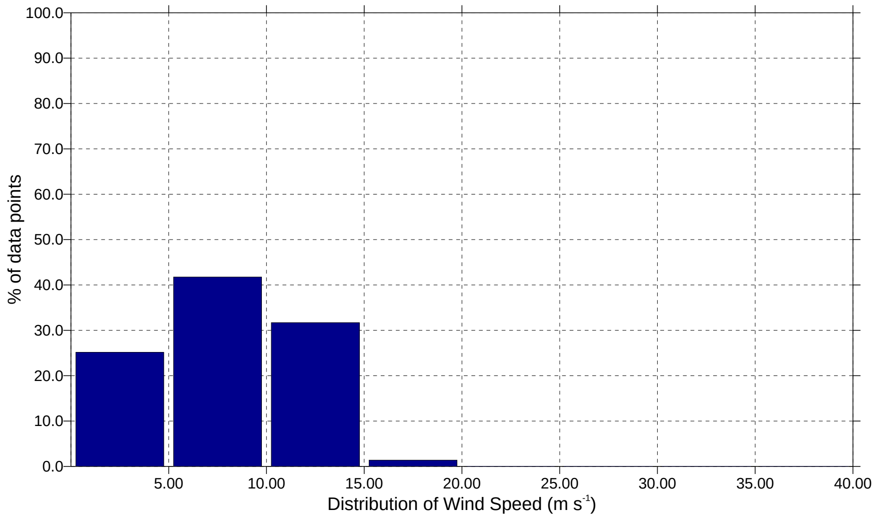
Deployment

Maximum Wind Speed (m s^{-1}): 16.59 from 204.00° North
Minimum Wind Speed (m s^{-1}): 0.54 from 354.00° North
Standard deviation: 3.63 m s^{-1}
Mean: 8.06m s^{-1}



Instruments: WindObserver II (S/N 2137002) 3.7m AMSL
Data Quality: good **Total Records:** 4404





Time Zone: UTC +00:00 hours	Data Source: NWWindB.2022.12.QC_dataReturn.nc
	moerose: 16:19 24/Feb/2023 by MWB (rose.histogram.AppendixG4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

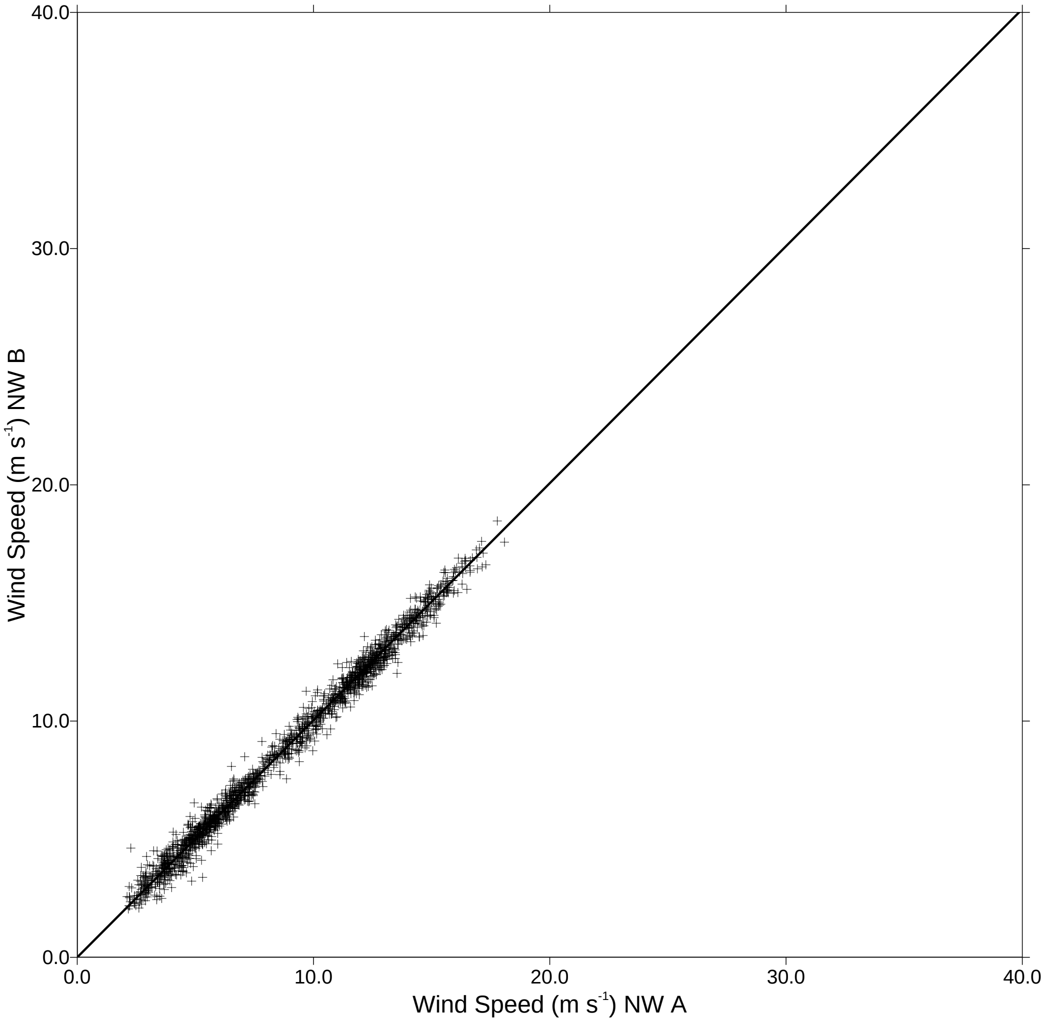
NW A vs NW B

Location:	**NW**		
		Client:	RVO
		Project:	J3707

Period: 00:00 01 December 2022 to 07:40 13 December 2022

Wind Speed (m s^{-1}) NW A 200m AMSL ZX LiDAR 300M (S/N 924)

Wind Speed (m s^{-1}) NW B 200m AMSL ZX LiDAR 300M (S/N 1174)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 1674
Slope	= 1.003	Bias	= 0.0387485
Standard Error	= 0.291	RMS error	= 0.412615
Correlation Coefficient	= 0.994	Scatter Index	= 0.04671

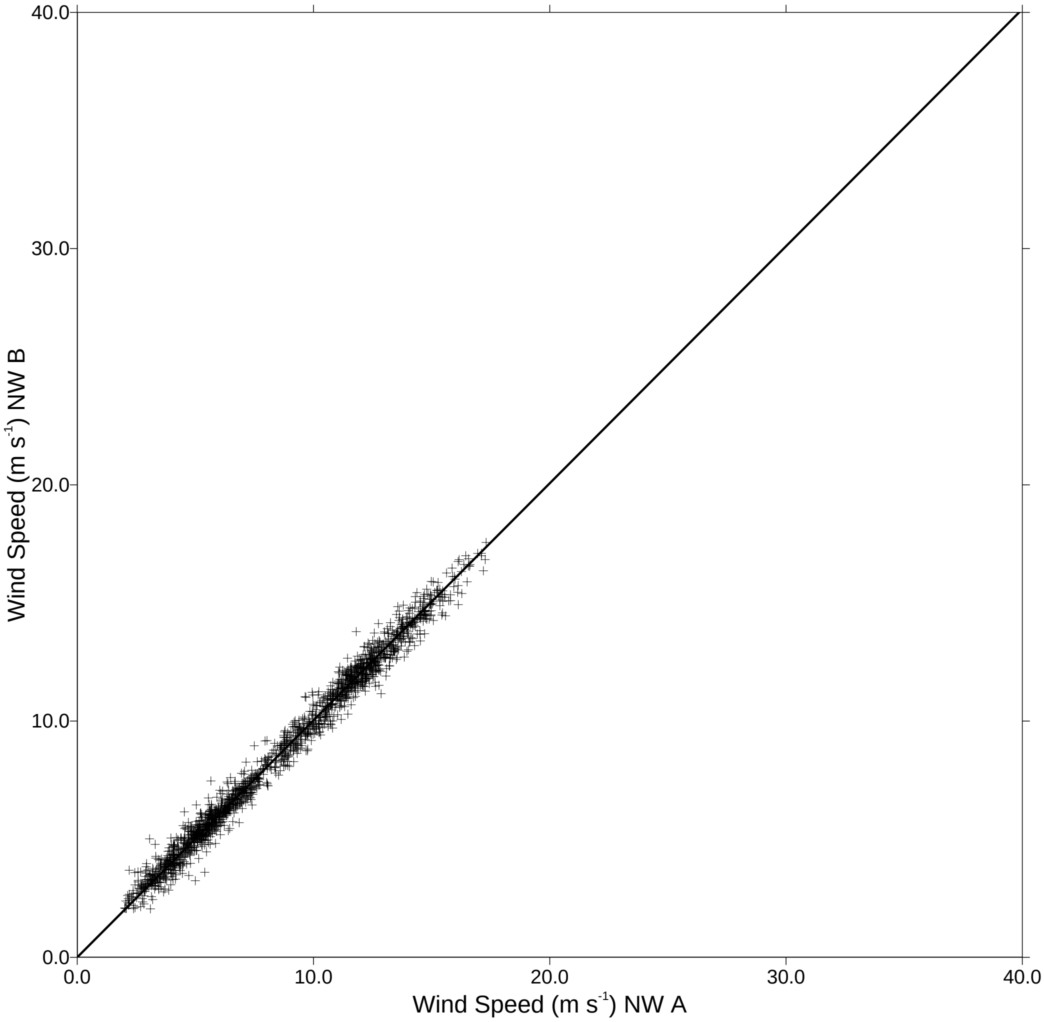
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

NW A vs NW B

Location:	**NW**		
		Client:	RVO
		Project:	J3707

Period: 00:00 01 December 2022 to 07:40 13 December 2022

Wind Speed (m s^{-1}) NW A 100m AMSL ZX LiDAR 300M (S/N 924)
Wind Speed (m s^{-1}) NW B 100m AMSL ZX LiDAR 300M (S/N 1174)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 1691
Slope	= 1.003	Bias	= 0.0404772
Standard Error	= 0.315	RMS error	= 0.446152
Correlation Coefficient	= 0.993	Scatter Index	= 0.05185

Time Zone: UTC +00:00 hours ...,B}.2022.12.QC_dataReturn.2mps.omni.nc, NWWind{A,B}.2022.12.OtherWinds.2mps.omni.nc
 moecorel: 16:19 24/Feb/2023 by MWB (AppendixG5.NW.2022.12.corel.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

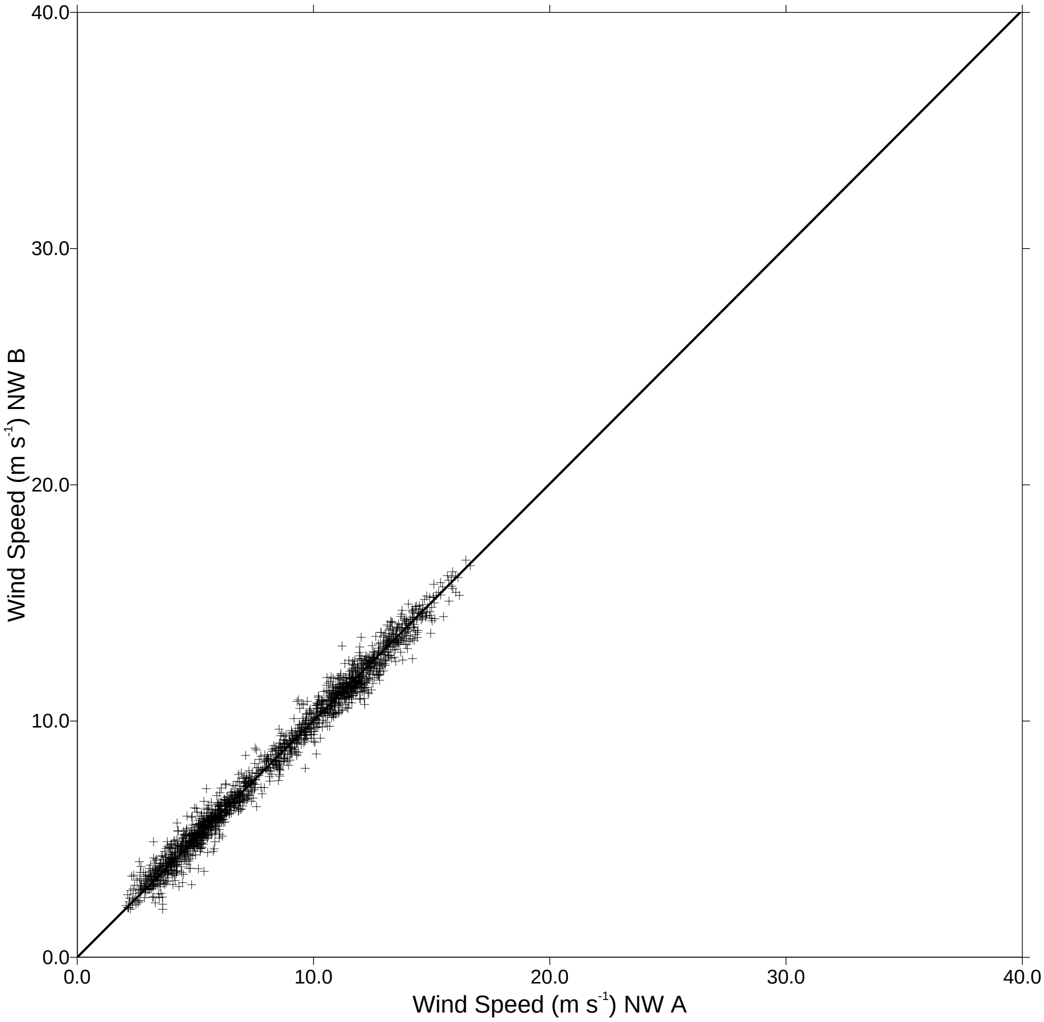
NW A vs NW B

Location:	**NW**		
		Client:	RVO
		Project:	J3707

Period: 00:10 01 December 2022 to 07:40 13 December 2022

Wind Speed (m s^{-1}) NW A 30m AMSL ZX LiDAR 300M (S/N 924)

Wind Speed (m s^{-1}) NW B 30m AMSL ZX LiDAR 300M (S/N 1174)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 1682
Slope	= 1.002	Bias	= 0.0308157
Standard Error	= 0.322	RMS error	= 0.455736
Correlation Coefficient	= 0.992	Scatter Index	= 0.05475

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

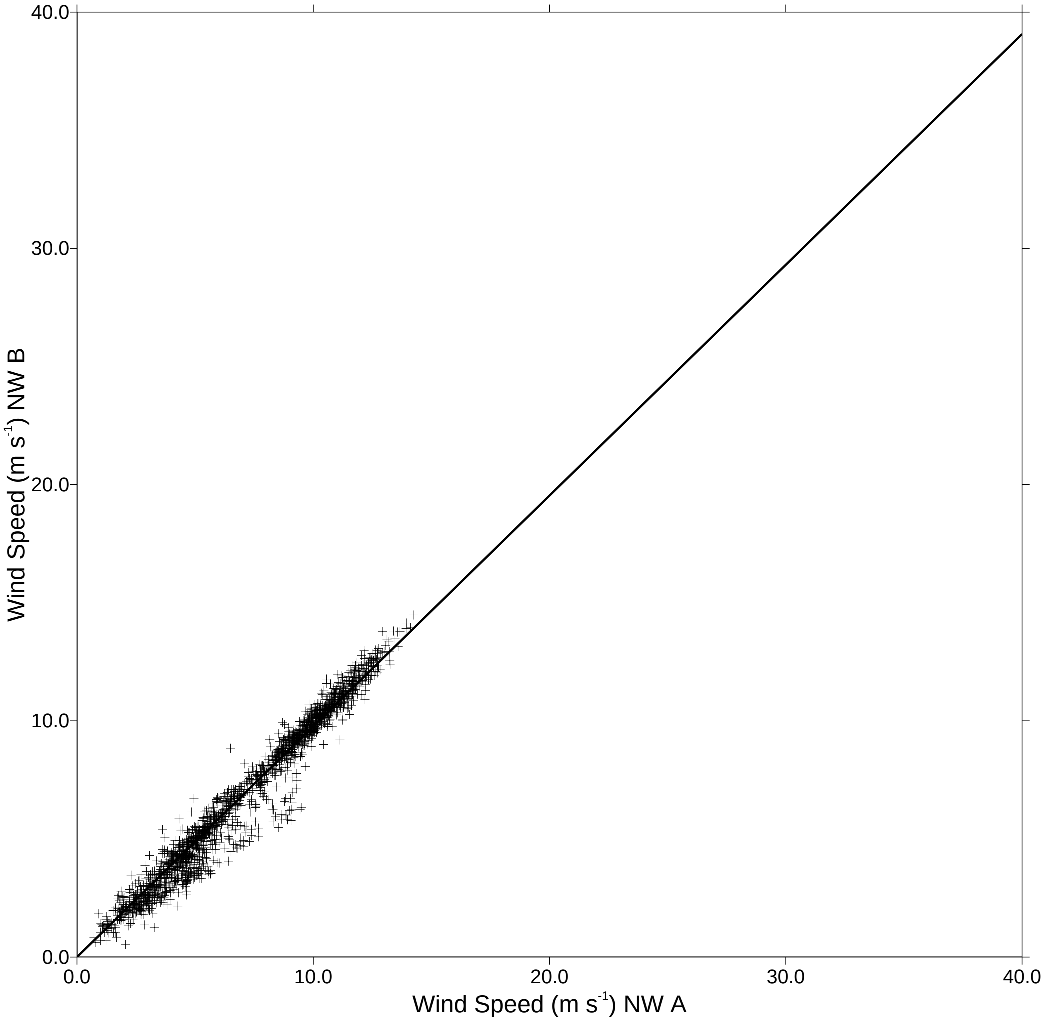
NW A vs NW B

Location:	**NW**		
		Client:	RVO
		Project:	J3707

Period: 00:00 01 December 2022 to 07:40 13 December 2022

Wind Speed (m s^{-1}) NW A 3.7m AMSL WindObserver II (S/N 1922006)

Wind Speed (m s^{-1}) NW B 3.7m AMSL WindObserver II (S/N 2137002)



Line of Best Fit (Perpendicular)			
Ordinate Intercept	= 0.000	Number of Data Points	= 1721
Slope	= 0.977	Bias	= -0.24717
Standard Error	= 0.460	RMS error	= 0.674368
Correlation Coefficient	= 0.982	Scatter Index	= 0.09606

Time Zone: UTC +00:00 hours	...,B}.2022.12.QC_dataReturn.2mps.omni.nc, NWWind{A,B}.2022.12.OtherWinds.2mps.omni.nc
	moecorel: 16:19 24/Feb/2023 by MWB (AppendixG5.NW.2022.12.corel.ps)

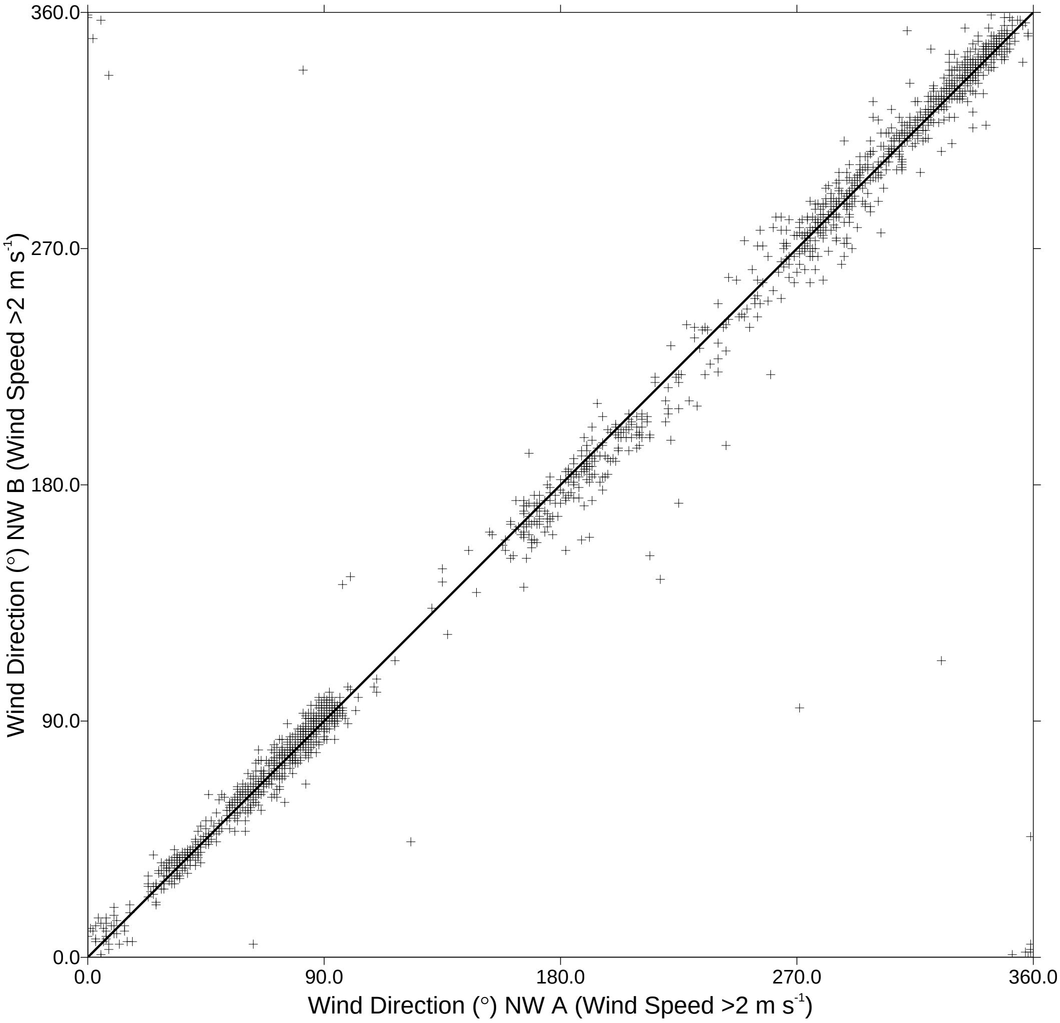
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

NW A vs NW B

Location:	**NW**		
		Client:	RVO
		Project:	J3707

Period: 00:00 01 December 2022 to 07:40 13 December 2022

Wind Direction (°) NW A (Wind Speed >2 m s-1) from 200m AMSL ZX LiDAR 300M (S/N 924)
Wind Direction (°) NW B (Wind Speed >2 m s-1) from 200m AMSL ZX LiDAR 300M (S/N 1174)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -0.007	Number of Data Points	= 1665
Slope	= 1.000	Bias	= -0.00720721
Standard Error	= 9.819	RMS error	= 9.81572
Correlation Coefficient	= 0.996	Scatter Index	= 0.05252

* both axes are polar variables

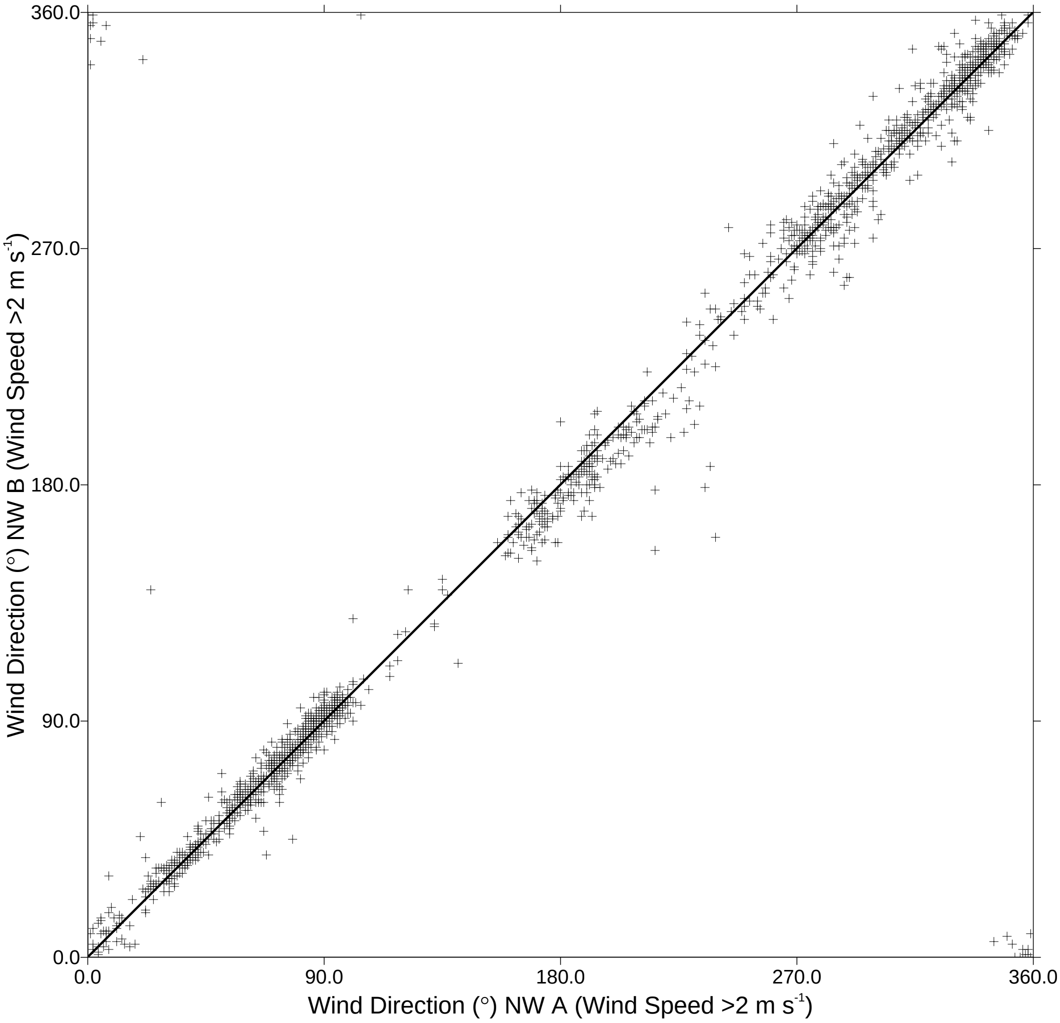
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

NW A vs NW B

Location:	**NW**		
		Client:	RVO
		Project:	J3707

Period: 00:00 01 December 2022 to 07:40 13 December 2022

Wind Direction (°) NW A (Wind Speed >2 m s-1) from 100m AMSL ZX LiDAR 300M (S/N 924)
Wind Direction (°) NW B (Wind Speed >2 m s-1) from 100m AMSL ZX LiDAR 300M (S/N 1174)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.118	Number of Data Points	= 1682
Slope	= 1.000	Bias	= 0.117717
Standard Error	= 8.602	RMS error	= 8.60053
Correlation Coefficient	= 0.997	Scatter Index	= 0.04617

* both axes are polar variables

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

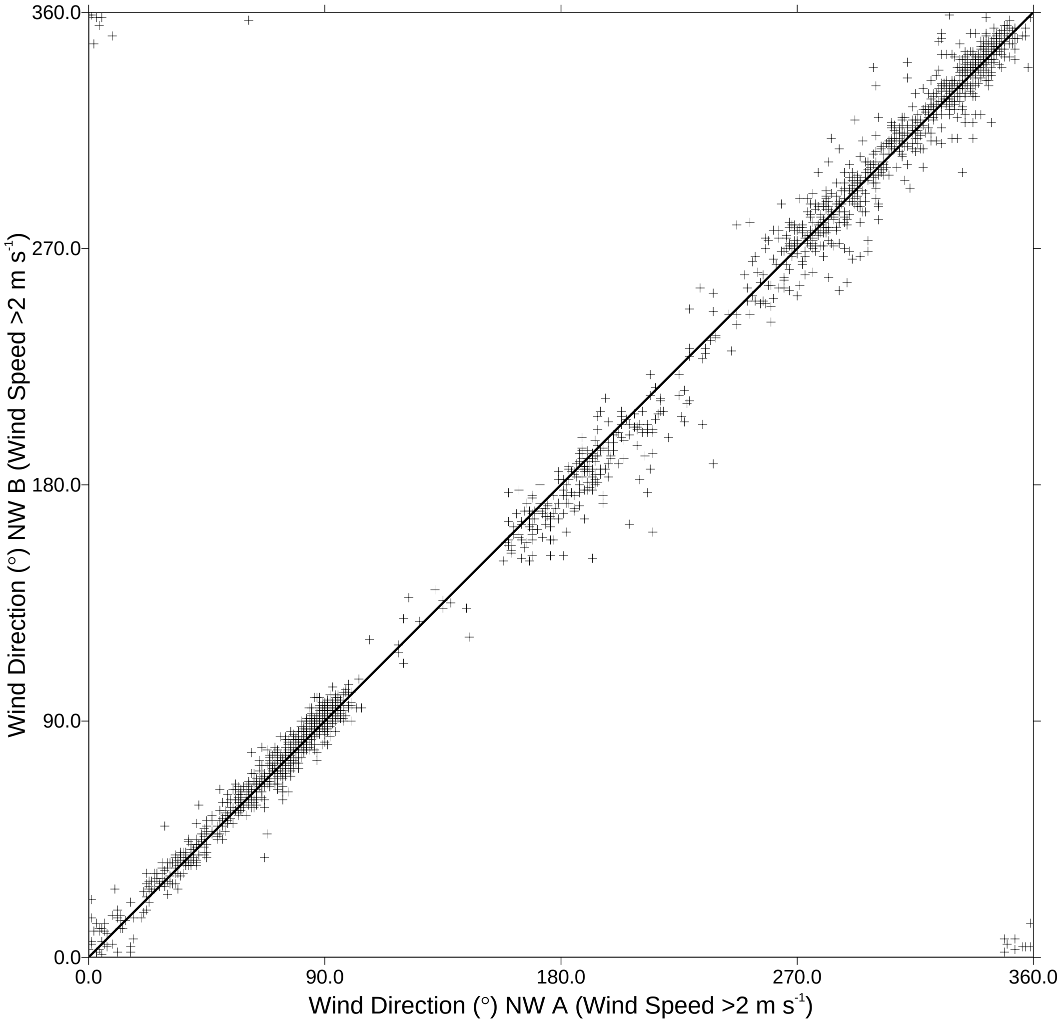
NW A vs NW B

Location:	**NW**		
		Client:	RVO
		Project:	J3707

Period: 00:10 01 December 2022 to 07:40 13 December 2022

Wind Direction (°) NW A (Wind Speed >2 m s^{-1}) from 30m AMSL ZX LiDAR 300M (S/N 924)

Wind Direction (°) NW B (Wind Speed >2 m s^{-1}) from 30m AMSL ZX LiDAR 300M (S/N 1174)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.035	Number of Data Points	= 1673
Slope	= 1.000	Bias	= 0.0346683
Standard Error	= 7.972	RMS error	= 7.96953
Correlation Coefficient	= 0.998	Scatter Index	= 0.04280

* both axes are polar variables

Time Zone: UTC +00:00 hours	...,B}.2022.12.QC_dataReturn.2mps.omni.nc, NWWind{A,B}.2022.12.OtherWinds.2mps.omni.nc
© RPS Australia West Pty Ltd	moecorel: 16:19 24/Feb/2023 by MWB (AppendixG5.NW.2022.12.corel.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

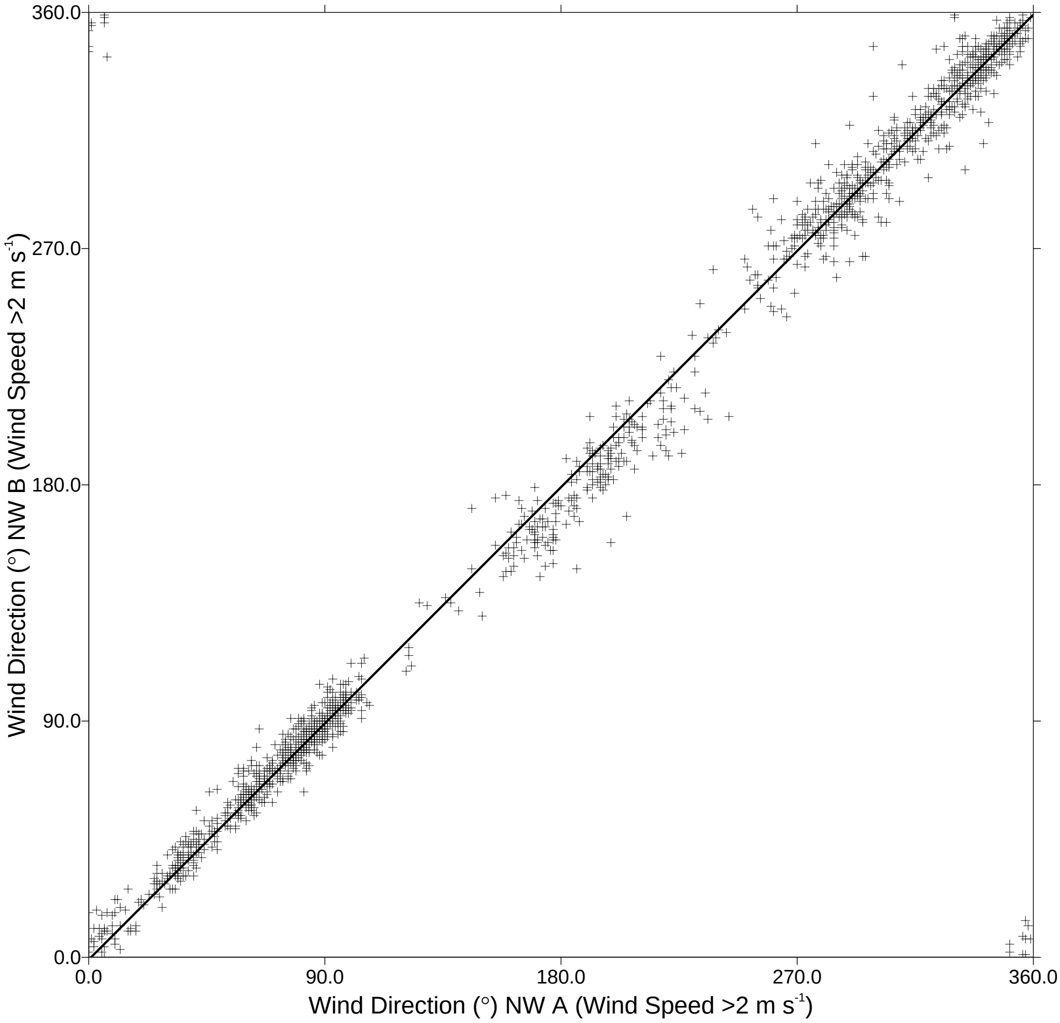
NW A vs NW B

Location:	**NW**		
		Client:	RVO
		Project:	J3707

Period: 00:30 01 December 2022 to 07:40 13 December 2022

Wind Direction (°) NW A (Wind Speed >2 m s^{-1}) from 3.7m AMSL WindObserver II (S/N 1922006)

Wind Direction (°) NW B (Wind Speed >2 m s^{-1}) from 3.7m AMSL WindObserver II (S/N 2137002)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -0.889	Number of Data Points	= 1625
Slope	= 1.000	Bias	= -0.888615
Standard Error	= 8.084	RMS error	= 8.1301
Correlation Coefficient	= 0.998	Scatter Index	= 0.04357

* both axes are polar variables

Time Zone: UTC +00:00 hours	...,B}.2022.12.QC_dataReturn.2mps.omni.nc, NWWind{A,B}.2022.12.OtherWinds.2mps.omni.nc
	moecorel: 16:19 24/Feb/2023 by MWB (AppendixG5.NW.2022.12.corel.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

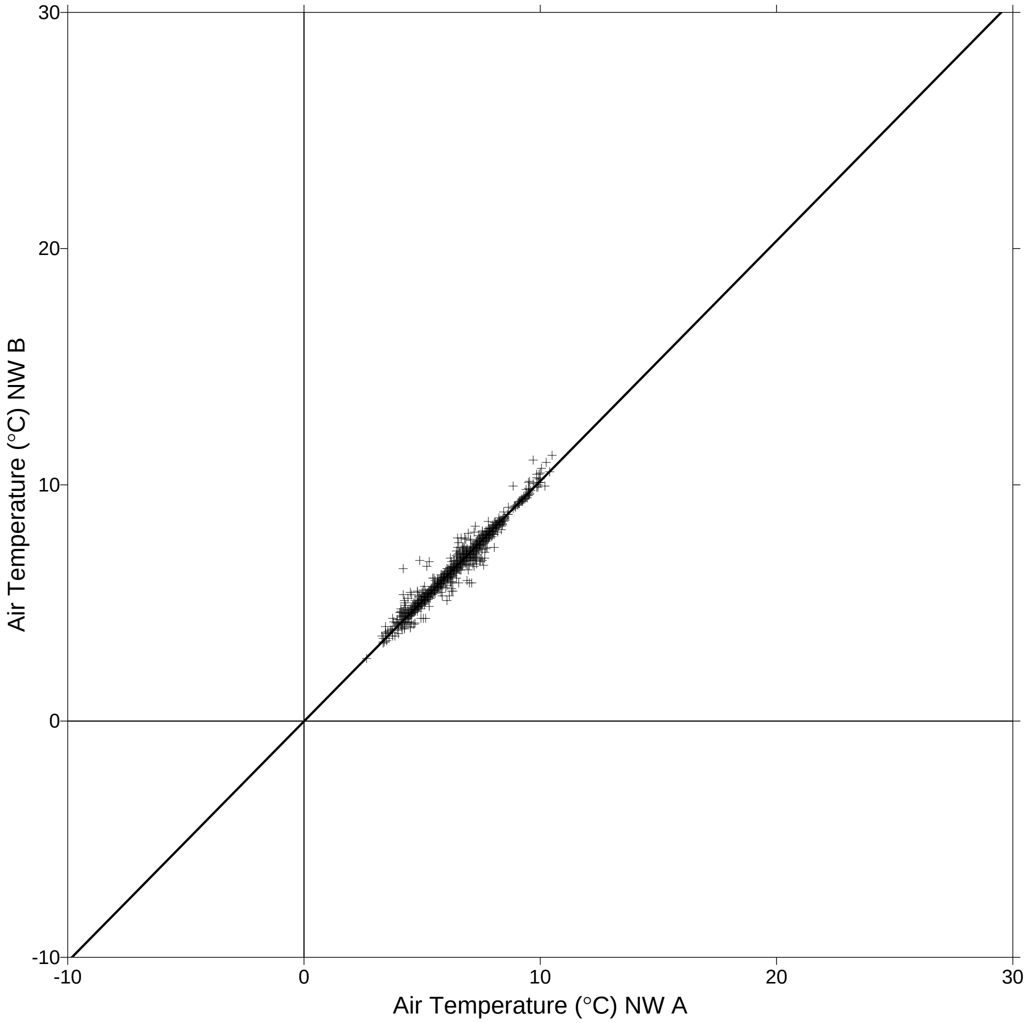
NW A vs NW B

Location:	**NW**		
		Client:	RVO
		Project:	J3707

Period: 00:00 01 December 2022 to 07:40 13 December 2022

Air Temperature (°C) NW A 3.7m AMSL Airmar 150WX (S/N 60663334)

Air Temperature (°C) NW B 3.7m AMSL Airmar 150WX (S/N 60667571)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -0.011	Number of Data Points	= 1722
Slope	= 1.017	Bias	= 0.0973287
Standard Error	= 0.152	RMS error	= 0.23688
Correlation Coefficient	= 0.988	Scatter Index	= 0.03707

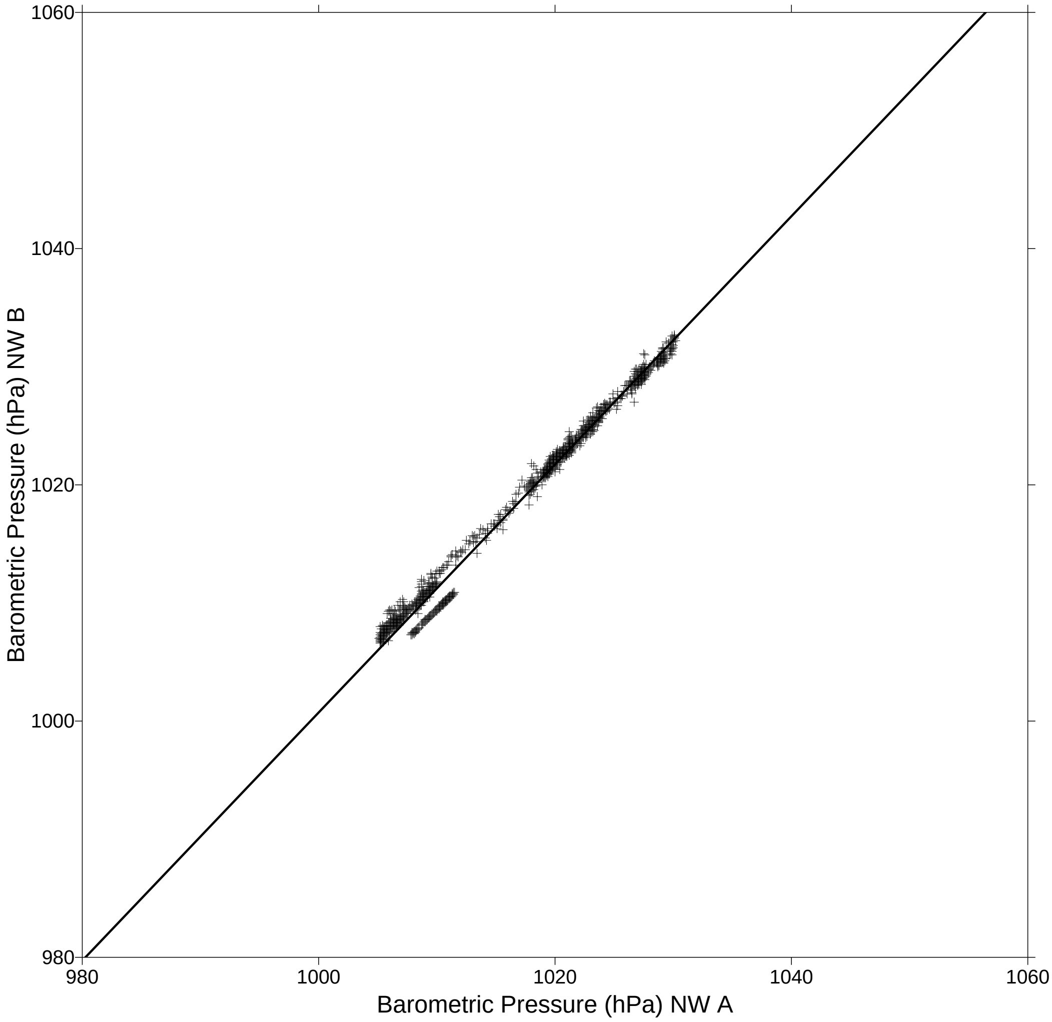
NW A vs NW B

Location:	**NW**		
		Client:	RVO
		Project:	J3707

Period: 00:00 01 December 2022 to 07:40 13 December 2022

Barometric Pressure (hPa) NW A 3.7m AMSL Airmar 150WX (S/N 60663334)

Barometric Pressure (hPa) NW B 3.7m AMSL Airmar 150WX (S/N 60667571)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -49.587	Number of Data Points	= 1720
Slope	= 1.050	Bias	= 1.54581
Standard Error	= 0.633	RMS error	= 1.82986
Correlation Coefficient	= 0.994	Scatter Index	= 0.00180

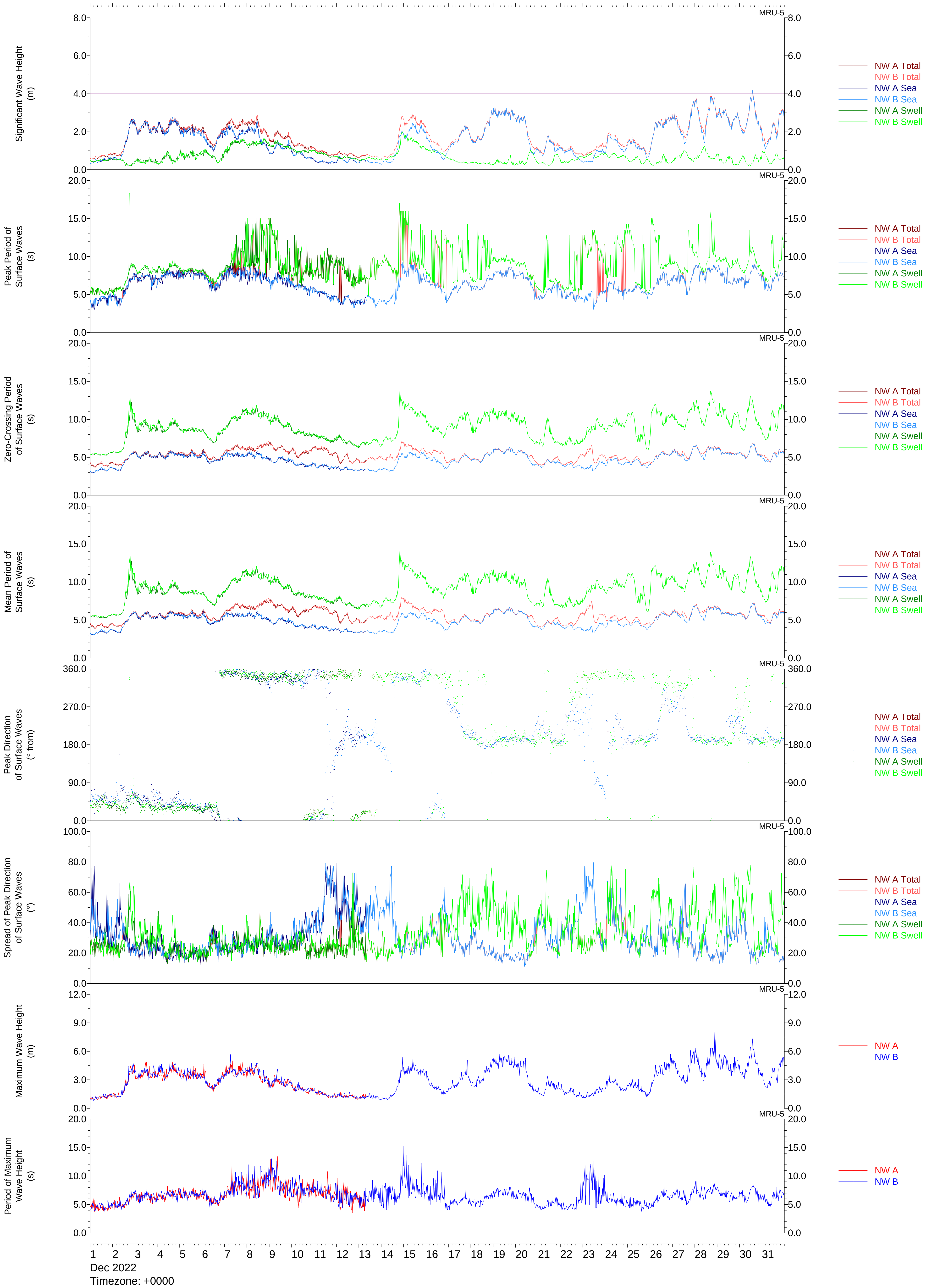
Appendix H
Wave Measurements

Standard analysis of the processed data was undertaken to produce the following presentations:

- NW A versus NW B monthly time history overlay plots of H_s, T_p, T_z, T_m, θ_p, $\Delta\theta_p$, H_{max}, and T_{Hmax}.
- Monthly data availability bar charts for each parameter at each site.
- Statistics tables of H_s with θ_p, T_p with θ_p, H_{max} with θ_p, T_{Hmax} with θ_p, and T_z for each site.
- Monthly rose plots and histograms of H_s with θ_p, and T_p with θ_p accompanied by relevant statistical parameters (maximum, minimum, mean, and standard deviation values) for each site.
- NW A versus NW B monthly correlation plots of H_s, T_m, θ_p, θ_m. and T_z.

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	NW	
		Client: RVO
		Project: J3707
		Sea/Swell: (5.5√Hs) s

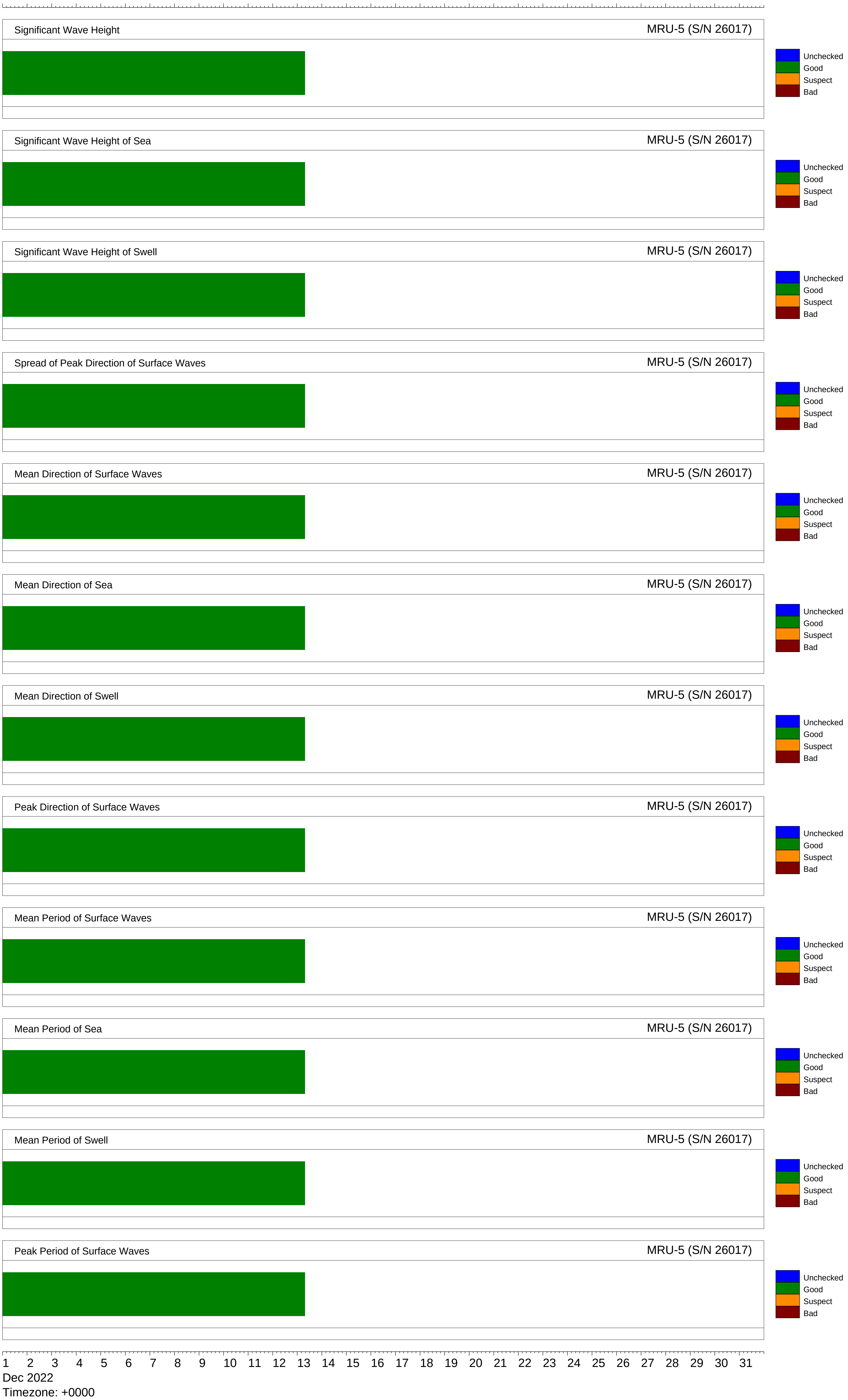


Time Zone: UTC +00:00 hours	NWWave{A,B}.2022.12.QC_dataReturn.cos2s.nc
© RPS Australia West Pty Ltd	moetimehist: 14:19 24/Jan/2023 by JTL (AppendixH1.NW.2022.12.overlay.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Available 30-minute records

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s



Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moetimehist: 14:19 24/Jan/2023 by JTL (AppendixH1.NW.A.2022.12.barcharts.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Available 30-minute records

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Timezone: +0000

Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moetimehist: 14:19 24/Jan/2023 by JTL (AppendixH1.NW.B.2022.12.barcharts.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022
Significant Wave Height (m), MRU-5 (S/N 26017).
Peak Direction of Surface Waves (°), MRU-5 (S/N 26017).

	Significant Wave Height (m)															
	Statistics				Total	Exceedence Percentile Significant Wave Height (m)										Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	0.55	2.78	1.63	0.6702	592	0.59	0.68	0.73	0.89	1.74	2.16	2.29	2.45	2.55	2.61	2.65	NNE NE NNW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022
Significant Wave Height of Sea (m), MRU-5 (S/N 26017).
Peak Direction of Sea (°), MRU-5 (S/N 26017).

	Significant Wave Height of Sea (m)															
	Statistics				Total	Exceedence Percentile Significant Wave Height of Sea (m)										Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	0.32	2.67	1.33	0.7349	592	0.34	0.37	0.42	0.56	1.30	1.96	2.07	2.27	2.43	2.53	2.57	NE NNW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022
Significant Wave Height of Swell (m), MRU-5 (S/N 26017).
Peak Direction of Swell (°), MRU-5 (S/N 26017).

	Significant Wave Height of Swell (m)															
	Statistics				Total	Exceedence Percentile Significant Wave Height of Swell (m)										Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	0.21	1.64	0.81	0.3550	592	0.23	0.35	0.44	0.52	0.71	0.96	1.20	1.38	1.45	1.52	1.55	NNE NE NNW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022
Peak Period of Surface Waves (s), MRU-5 (S/N 26017).
Peak Direction of Surface Waves (°), MRU-5 (S/N 26017).

	Peak Period of Surface Waves (s)															
	Statistics				Total	Exceedence Percentile Peak Period of Surface Waves (s)										Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	3.94	15.06	7.72	1.8183	592	4.56	5.33	5.57	6.74	7.53	8.00	8.53	9.85	11.64	13.47	14.22	NNE NE NNW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**			
Latitude:	53° 22′ 44″		Client:	RVO
Longitude:	3° 07′ 51″		Project:	J3707
Location Water Depth:	29.10 m MSL		Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022
Peak Period of Sea (s), MRU-5 (S/N 26017).
Peak Direction of Sea (°), MRU-5 (S/N 26017).

	Peak Period of Sea (s)															
	Statistics				Total	Exceedence Percentile Peak Period of Sea (s)										Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	2.98	8.85	6.25	1.4245	592	3.46	3.91	4.20	4.84	6.60	7.31	7.53	7.89	8.07	8.26	8.53	NE NNW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022
Peak Period of Swell (s), MRU-5 (S/N 26017).
Peak Direction of Swell (°), MRU-5 (S/N 26017).

	Peak Period of Swell (s)																
	Statistics				Total	Exceedence Percentile Peak Period of Swell (s)											Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	4.92	15.06	8.28	1.9070	592	5.02	5.45	5.82	7.31	8.14	8.70	9.14	10.62	12.80	14.22	14.22	NNE NE NNW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022
Maximum Wave Height (m), MRU-5 (S/N 26017).
Peak Direction of Surface Waves (°), MRU-5 (S/N 26017).

	Maximum Wave Height (m)															
	Statistics				Total	Exceedence Percentile Maximum Wave Height (m)										Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	0.91	5.00	2.62	1.1106	592	0.95	1.09	1.16	1.44	2.76	3.46	3.68	4.00	4.28	4.54	4.71	NNE NE NNW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022
Period of Maximum Wave Height (s), MRU-5 (S/N 26017).
Peak Direction of Surface Waves (°), MRU-5 (S/N 26017).

	Period of Maximum Wave Height (s)															
	Statistics				Total	Exceedence Percentile Period of Maximum Wave Height (s)										Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	3.51	13.41	6.77	1.5645	592	3.93	4.41	4.73	5.77	6.63	7.34	7.94	8.77	9.53	10.37	11.02	NNE NE NNW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022
Zero-Crossing Period of Surface Waves (s), MRU-5 (S/N 26017).

	Zero-Crossing Period of Surface Waves (s)															
	Statistics				Total	Exceedence Percentile Zero-Crossing Period of Surface Waves (s)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
December 2022	3.69	7.05	5.35	0.7543	592	3.80	3.99	4.20	4.81	5.47	5.82	6.05	6.22	6.48	6.62	6.75

Expected Record Interval: 30.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.A.2022.12.statistics.ps)

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022
Zero-Crossing Period of Sea (s), MRU-5 (S/N 26017).

	Zero-Crossing Period of Sea (s)															
	Statistics				Total	Exceedence Percentile Zero-Crossing Period of Sea (s)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
December 2022	2.95	5.87	4.50	0.8153	592	3.04	3.26	3.33	3.70	4.68	5.12	5.31	5.50	5.57	5.63	5.72

Expected Record Interval: 30.00 minutes.

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022
Zero-Crossing Period of Swell (s), MRU-5 (S/N 26017).

	Zero-Crossing Period of Swell (s)															
	Statistics				Total	Exceedence Percentile Zero-Crossing Period of Swell (s)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
December 2022	5.23	12.25	8.31	1.5797	592	5.28	5.41	5.67	7.26	8.46	9.17	9.74	10.33	10.84	11.21	11.43

Expected Record Interval: 30.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 23:30 31 December 2022
Significant Wave Height (m), MRU-5 (S/N 25081).
Peak Direction of Surface Waves (°), MRU-5 (S/N 25081).

	Significant Wave Height (m)															
	Statistics				Total	Exceedence Percentile Significant Wave Height (m)										Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0 (from)
December 2022	0.55	4.19	1.82	0.7803	1488	0.61	0.72	0.79	1.15	1.80	2.34	2.54	2.83	3.06	3.41	3.71	SSW NNW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 23:30 31 December 2022
Significant Wave Height of Sea (m), MRU-5 (S/N 25081).
Peak Direction of Sea (°), MRU-5 (S/N 25081).

	Significant Wave Height of Sea (m)															
	Statistics				Total	Exceedence Percentile Significant Wave Height of Sea (m)										Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	0.29	4.18	1.60	0.8615	1488	0.35	0.40	0.45	0.87	1.58	2.12	2.40	2.76	3.02	3.38	3.68	S SSW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 23:30 31 December 2022
Significant Wave Height of Swell (m), MRU-5 (S/N 25081).
Peak Direction of Swell (°), MRU-5 (S/N 25081).

	Significant Wave Height of Swell (m)															
	Statistics				Total	Exceedence Percentile Significant Wave Height of Swell (m)										Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	0.21	1.96	0.70	0.3483	1488	0.24	0.29	0.34	0.44	0.62	0.80	0.94	1.25	1.44	1.59	1.67	NNW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 23:30 31 December 2022
Peak Period of Surface Waves (s), MRU-5 (S/N 25081).
Peak Direction of Surface Waves (°), MRU-5 (S/N 25081).

	Peak Period of Surface Waves (s)															
	Statistics				Total	Exceedence Percentile Peak Period of Surface Waves (s)										Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	3.88	17.07	7.52	2.0255	1488	4.34	5.02	5.33	6.24	7.31	8.00	8.53	9.85	11.64	13.47	15.06	SSW NNW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 23:30 31 December 2022
Peak Period of Sea (s), MRU-5 (S/N 25081).
Peak Direction of Sea (°), MRU-5 (S/N 25081).

	Peak Period of Sea (s)															
	Statistics				Total	Exceedence Percentile Peak Period of Sea (s)										Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	3.05	9.21	6.30	1.3727	1488	3.60	4.00	4.34	5.22	6.40	7.31	7.53	8.00	8.26	8.53	8.83	S SSW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 23:30 31 December 2022
Peak Period of Swell (s), MRU-5 (S/N 25081).
Peak Direction of Swell (°), MRU-5 (S/N 25081).

	Peak Period of Swell (s)															
	Statistics				Total	Exceedence Percentile Peak Period of Swell (s)										Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	4.82	18.29	8.92	2.2698	1488	5.12	5.57	6.10	7.36	8.58	9.48	10.67	12.19	13.47	14.22	15.06	NNW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 23:30 31 December 2022
Maximum Wave Height (m), MRU-5 (S/N 25081).
Peak Direction of Surface Waves (°), MRU-5 (S/N 25081).

	Maximum Wave Height (m)															
	Statistics				Total	Exceedence Percentile Maximum Wave Height (m)											Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	0.79	8.05	2.96	1.3121	1488	0.96	1.13	1.25	1.84	2.89	3.80	4.13	4.69	5.16	5.60	6.09	SSW NNW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 23:30 31 December 2022
Period of Maximum Wave Height (s), MRU-5 (S/N 25081).
Peak Direction of Surface Waves (°), MRU-5 (S/N 25081).

	Period of Maximum Wave Height (s)															
	Statistics				Total	Exceedence Percentile Period of Maximum Wave Height (s)										Main Direction(s)[1]
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(from)
December 2022	3.62	15.25	6.59	1.5224	1488	4.09	4.46	4.74	5.52	6.48	7.12	7.57	8.31	9.36	10.79	11.74	SSW NNW

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 30.00 minutes. Direction label is sector centre (22.5 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 23:30 31 December 2022
Zero-Crossing Period of Surface Waves (s), MRU-5 (S/N 25081).

	Zero-Crossing Period of Surface Waves (s)															
	Statistics				Total	Exceedence Percentile Zero-Crossing Period of Surface Waves (s)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
December 2022	3.65	7.08	5.31	0.7089	1488	3.91	4.12	4.30	4.76	5.37	5.70	5.93	6.25	6.46	6.68	6.80

Expected Record Interval: 30.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 23:30 31 December 2022
Zero-Crossing Period of Sea (s), MRU-5 (S/N 25081).

	Zero-Crossing Period of Sea (s)															
	Statistics				Total	Exceedence Percentile Zero-Crossing Period of Sea (s)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
December 2022	2.98	6.87	4.69	0.8413	1488	3.14	3.32	3.45	3.98	4.74	5.28	5.46	5.68	5.96	6.22	6.40

Expected Record Interval: 30.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 23:30 31 December 2022
Zero-Crossing Period of Swell (s), MRU-5 (S/N 25081).

	Zero-Crossing Period of Swell (s)															
	Statistics				Total	Exceedence Percentile Zero-Crossing Period of Swell (s)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
December 2022	5.27	13.98	8.99	1.6877	1488	5.37	6.06	6.83	7.63	9.06	10.03	10.56	11.08	11.59	12.13	12.51

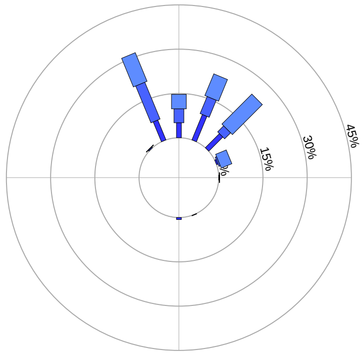
Expected Record Interval: 30.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moematrix: 14:19 24/Jan/2023 by JTL (./stats_AppendixH2.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

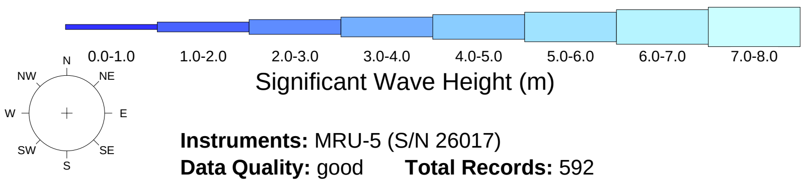
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

Deployment
(00:00 01 December 2022 to 07:30 13 December 2022)



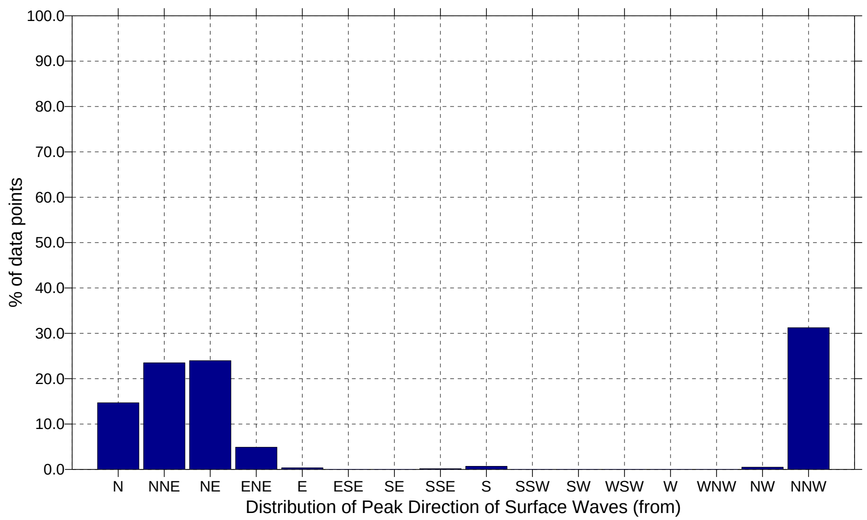
Deployment

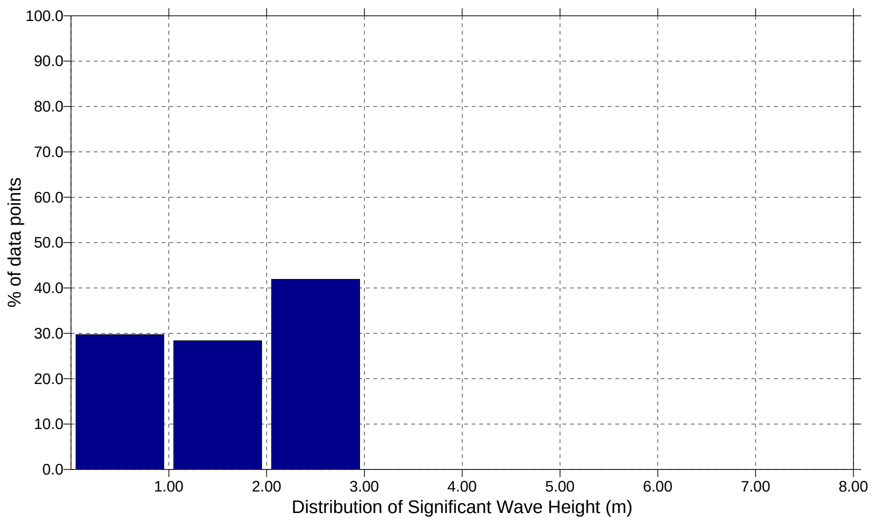
Maximum Significant Wave Height (m): 2.78 from 336.41° North
Minimum Significant Wave Height (m): 0.55 from 44.84° North
Standard deviation: 0.67 m
Mean: 1.63m



Significant Wave Height (m)

Instruments: MRU-5 (S/N 26017)
Data Quality: good **Total Records:** 592



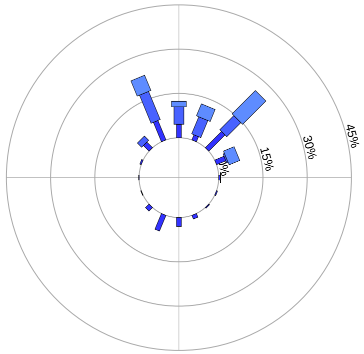


Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moerose: 14:19 24/Jan/2023 by JTL (rose.histogram.AppendixH3.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

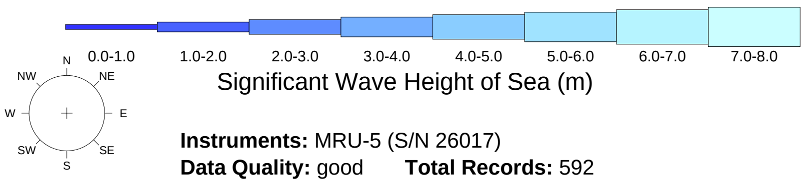
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

Deployment
(00:00 01 December 2022 to 07:30 13 December 2022)



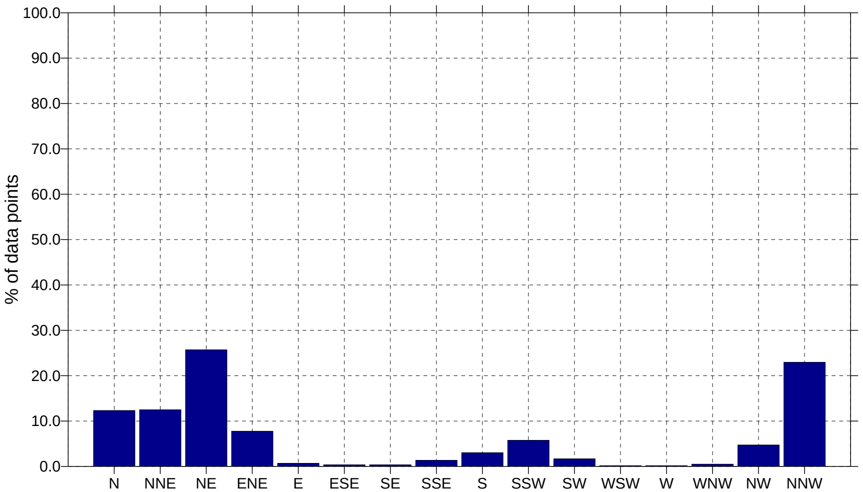
Deployment

Maximum Significant Wave Height of Sea (m): 2.67 from 58.02° North
Minimum Significant Wave Height of Sea (m): 0.32 from 305.27° North
Standard deviation: 0.73 m
Mean: 1.33m

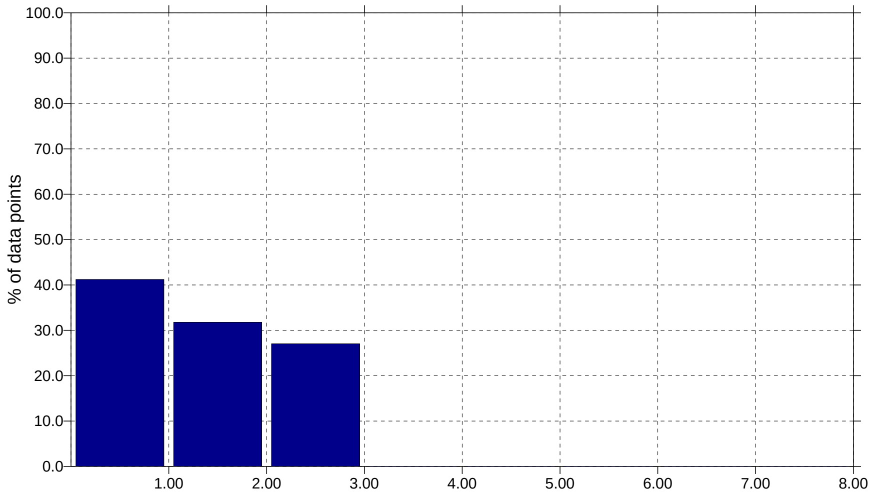


Significant Wave Height of Sea (m)

Instruments: MRU-5 (S/N 26017)
Data Quality: good **Total Records:** 592



Distribution of Peak Direction of Sea (from)



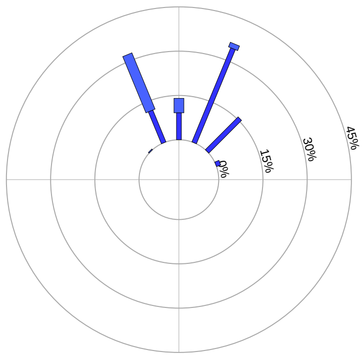
Distribution of Significant Wave Height of Sea (m)

Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moerose: 14:19 24/Jan/2023 by JTL (rose.histogram.AppendixH3.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

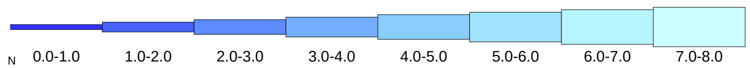
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

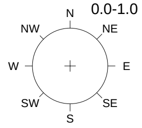
Deployment
(00:00 01 December 2022 to 07:30 13 December 2022)



Deployment

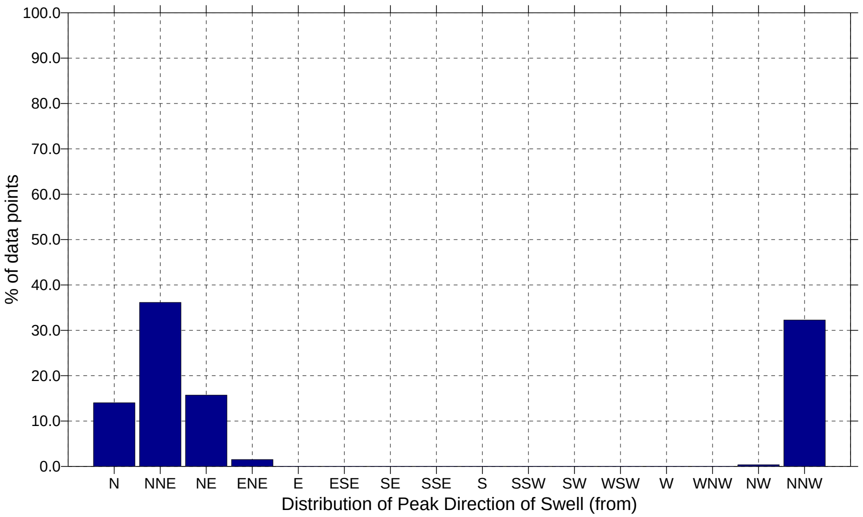
Maximum Significant Wave Height of Swell (m): 1.64 from 337.82° North
Minimum Significant Wave Height of Swell (m): 0.21 from 59.79° North
Standard deviation: 0.36 m
Mean: 0.81m

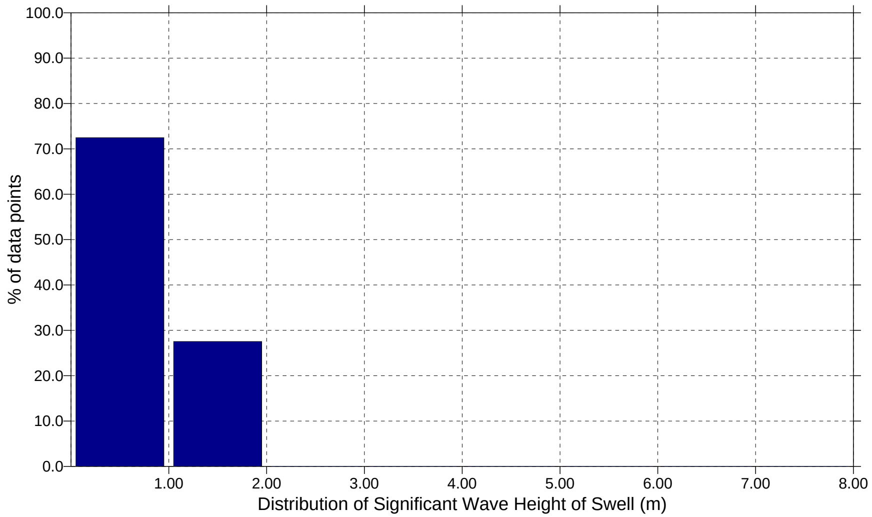




Significant Wave Height of Swell (m)

Instruments: MRU-5 (S/N 26017)
Data Quality: good **Total Records:** 592



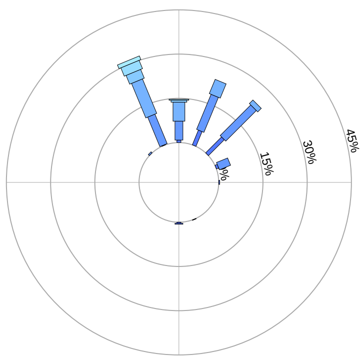


Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moerose: 14:19 24/Jan/2023 by JTL (rose.histogram.AppendixH3.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

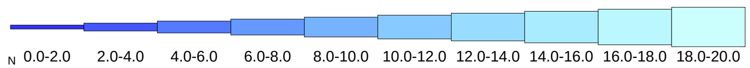
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

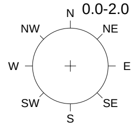
Deployment
(00:00 01 December 2022 to 07:30 13 December 2022)



Deployment

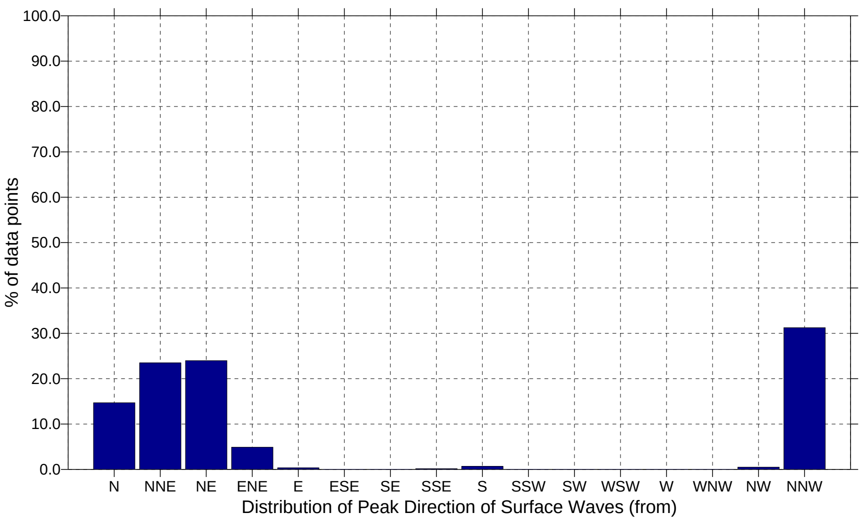
Maximum Peak Period of Surface Waves (s): 15.06 from 339.94° North
Minimum Peak Period of Surface Waves (s): 3.94 from 187.42° North
Standard deviation: 1.82 s
Mean: 7.72s

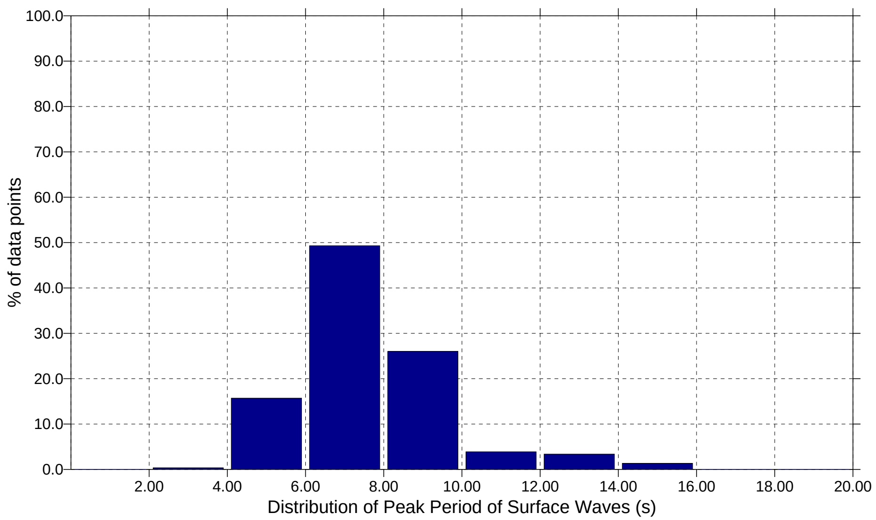




Peak Period of Surface Waves (s)

Instruments: MRU-5 (S/N 26017)
Data Quality: good **Total Records:** 592



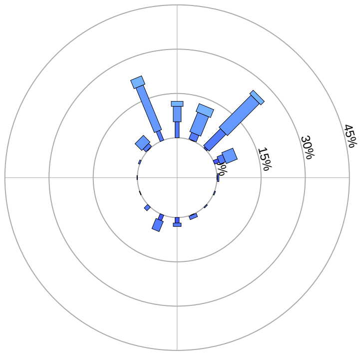


Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moerose: 14:19 24/Jan/2023 by JTL (rose.histogram.AppendixH3.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

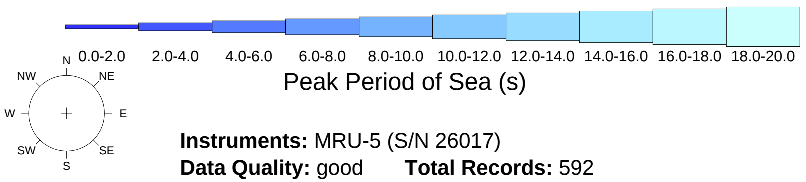
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

Deployment
(00:00 01 December 2022 to 07:30 13 December 2022)

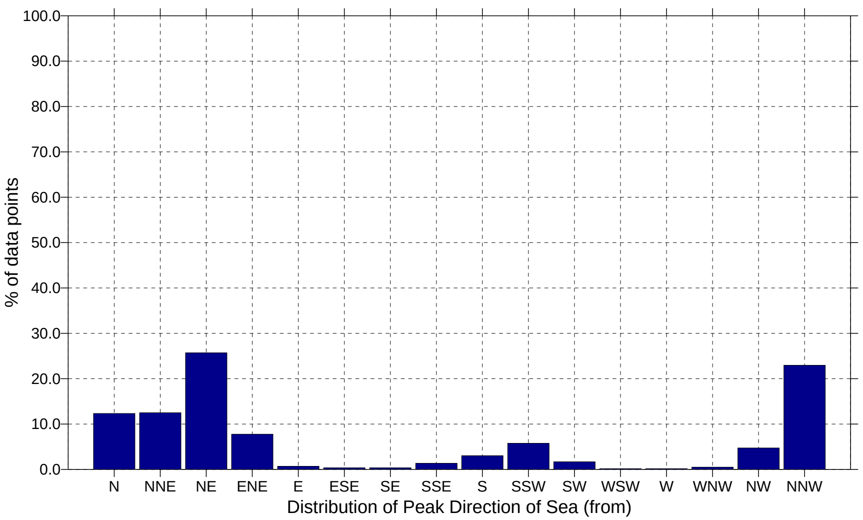


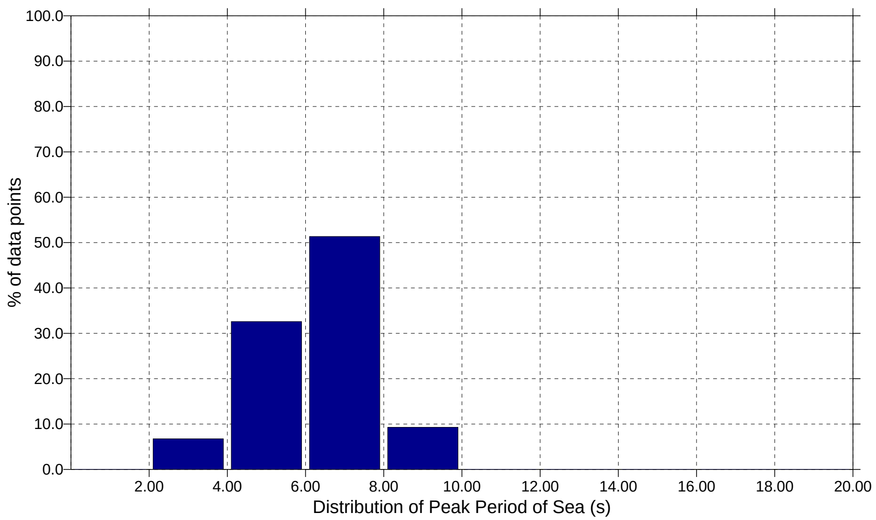
Deployment

Maximum Peak Period of Sea (s): 8.85 from 341.57° North
Minimum Peak Period of Sea (s): 2.98 from 321.95° North
Standard deviation: 1.42 s
Mean: 6.25s



Instruments: MRU-5 (S/N 26017)
Data Quality: good **Total Records:** 592



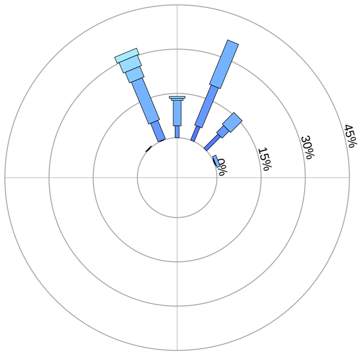


Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moerose: 14:19 24/Jan/2023 by JTL (rose.histogram.AppendixH3.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

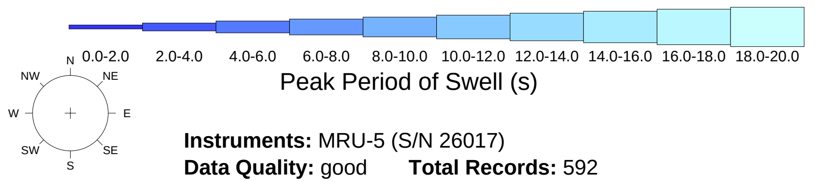
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	(5.5√Hs) s

Deployment
(00:00 01 December 2022 to 07:30 13 December 2022)

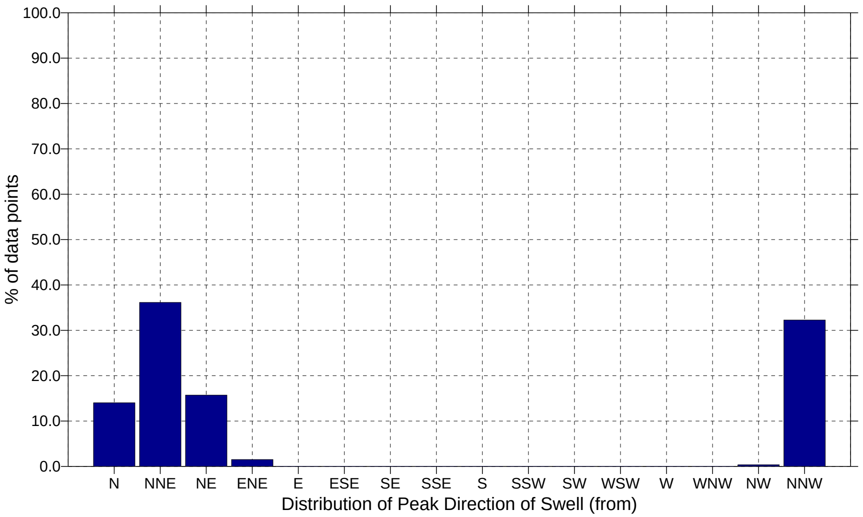


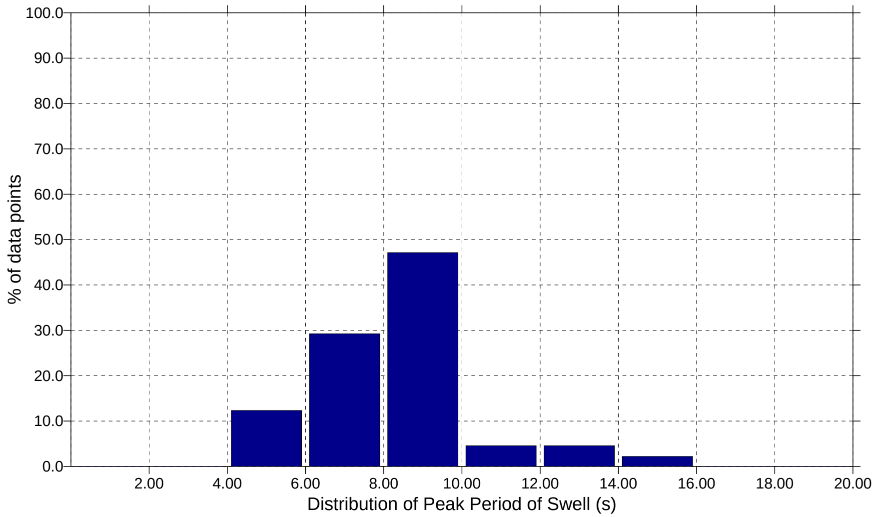
Deployment

Maximum Peak Period of Swell (s): 15.06 from 344.06° North
Minimum Peak Period of Swell (s): 4.92 from 41.57° North
Standard deviation: 1.91 s
Mean: 8.28s



Instruments: MRU-5 (S/N 26017)
Data Quality: good **Total Records:** 592



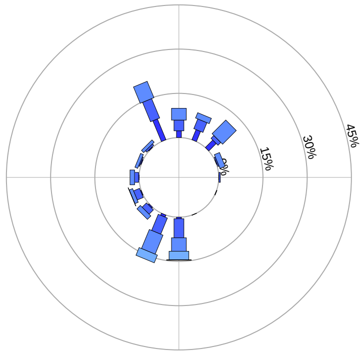


Time Zone: UTC +00:00 hours	Data Source: NWWaveA.2022.12.QC_dataReturn.cos2s.nc
	moerose: 14:19 24/Jan/2023 by JTL (rose.histogram.AppendixH3.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

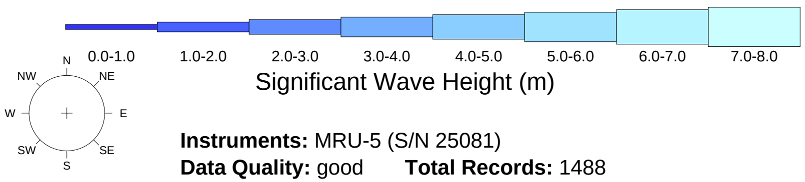
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Deployment
(00:00 01 December 2022 to 23:30 31 December 2022)

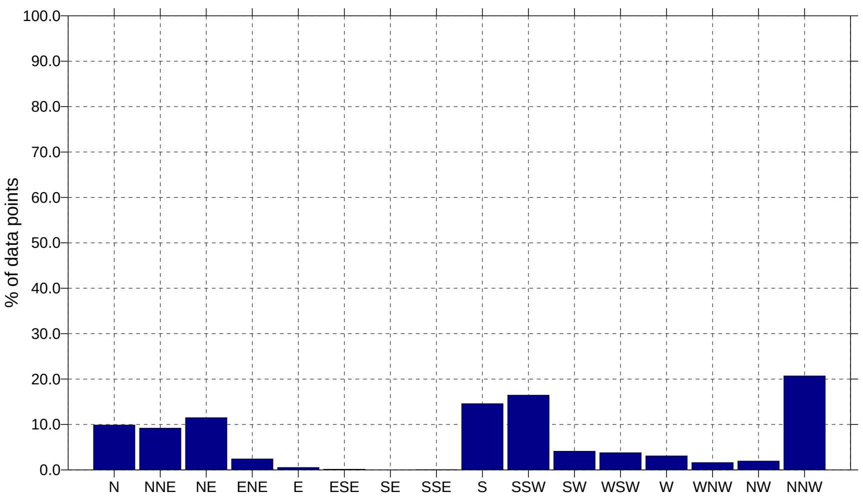


Deployment

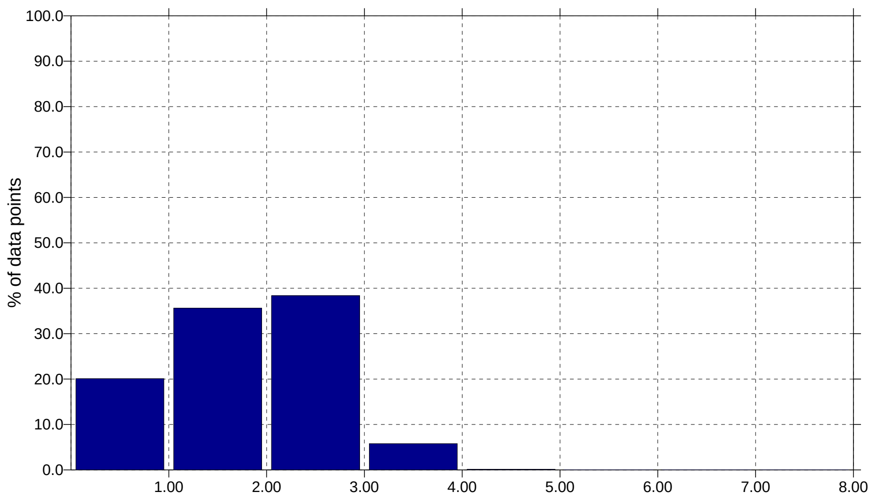
Maximum Significant Wave Height (m): 4.19 from 185.86° North
Minimum Significant Wave Height (m): 0.55 from 42.32° North
Standard deviation: 0.78 m
Mean: 1.82m



Instruments: MRU-5 (S/N 25081)
Data Quality: good **Total Records:** 1488



Distribution of Peak Direction of Surface Waves (from)



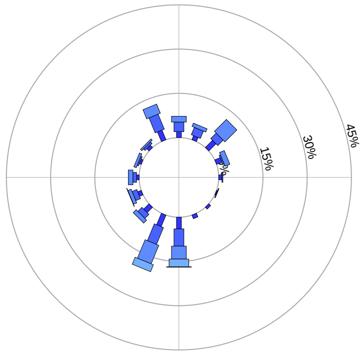
Distribution of Significant Wave Height (m)

Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moerose: 14:19 24/Jan/2023 by JTL (rose.histogram.AppendixH3.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

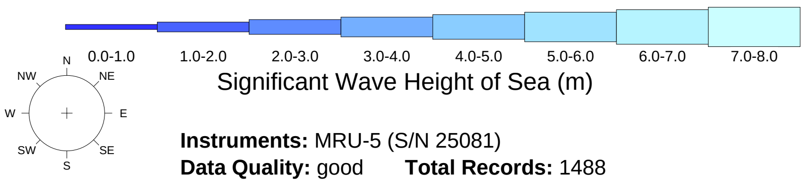
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Deployment
(00:00 01 December 2022 to 23:30 31 December 2022)



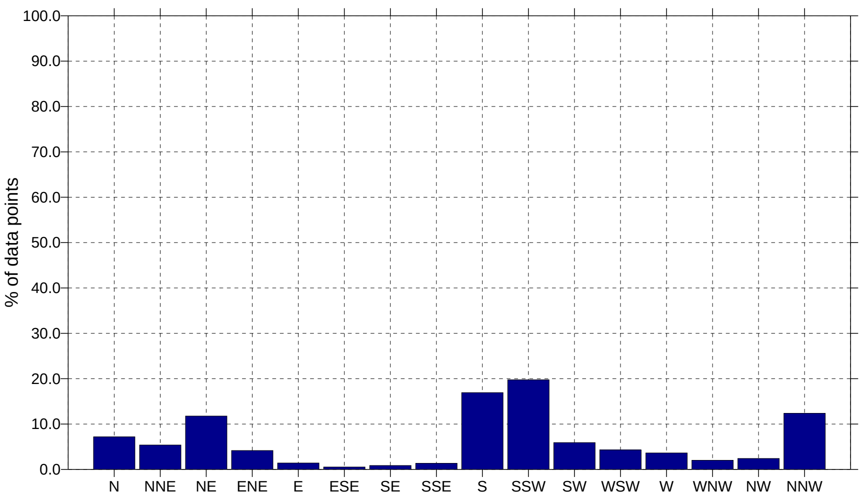
Deployment

Maximum Significant Wave Height of Sea (m): 4.18 from 185.86° North
Minimum Significant Wave Height of Sea (m): 0.29 from 174.92° North
Standard deviation: 0.86 m
Mean: 1.60m

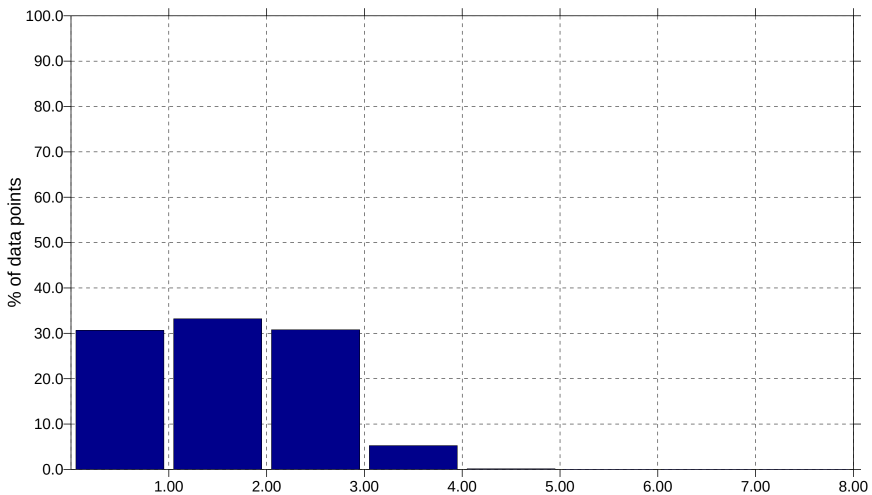


Significant Wave Height of Sea (m)

Instruments: MRU-5 (S/N 25081)
Data Quality: good **Total Records:** 1488



Distribution of Peak Direction of Sea (from)



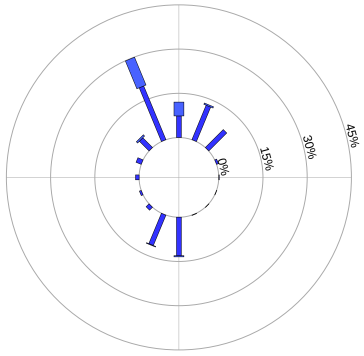
Distribution of Significant Wave Height of Sea (m)

Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moerose: 14:19 24/Jan/2023 by JTL (rose.histogram.AppendixH3.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

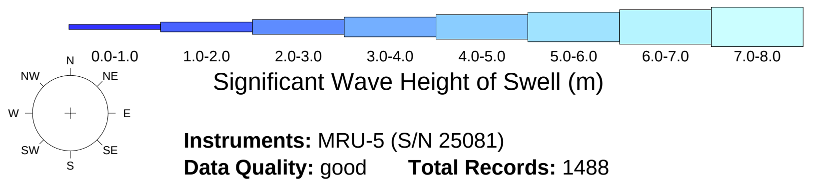
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Deployment
(00:00 01 December 2022 to 23:30 31 December 2022)

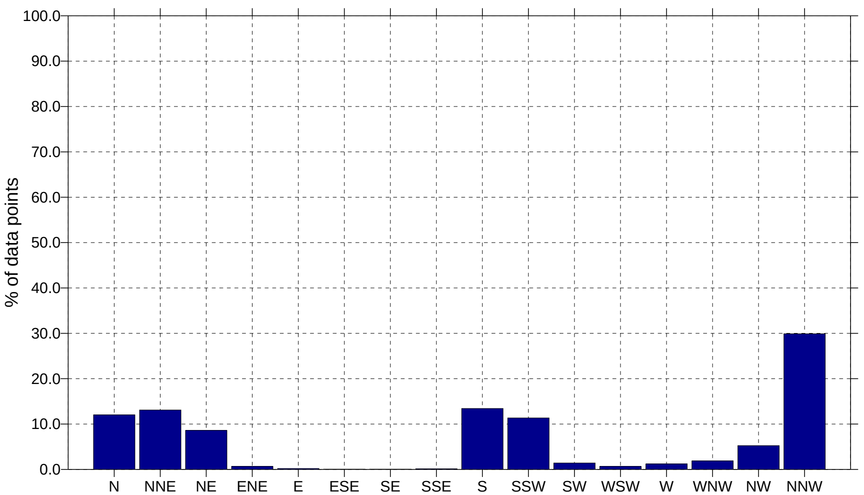


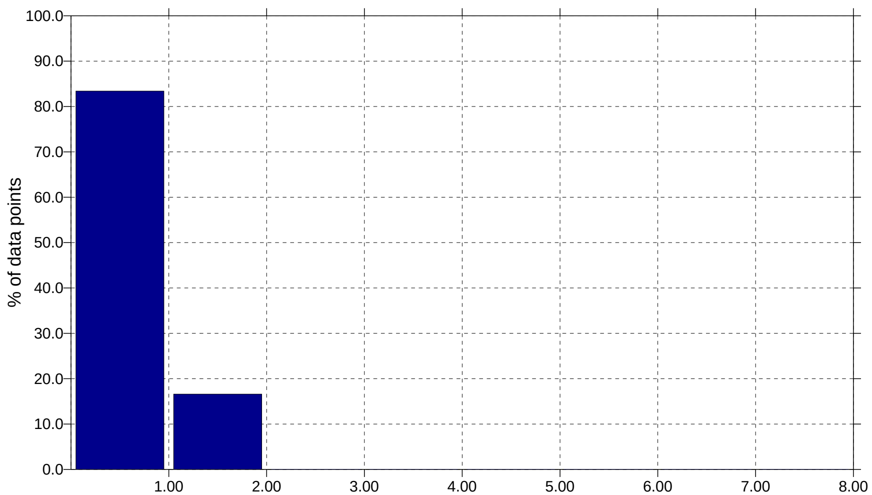
Deployment

Maximum Significant Wave Height of Swell (m): 1.96 from 342.26° North
Minimum Significant Wave Height of Swell (m): 0.21 from 137.54° North
Standard deviation: 0.35 m
Mean: 0.70m



Instruments: MRU-5 (S/N 25081)
Data Quality: good **Total Records:** 1488



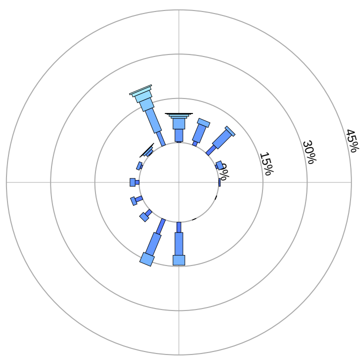


Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moerose: 14:19 24/Jan/2023 by JTL (rose.histogram.AppendixH3.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

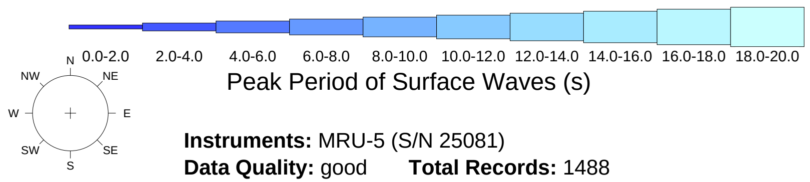
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Deployment
(00:00 01 December 2022 to 23:30 31 December 2022)



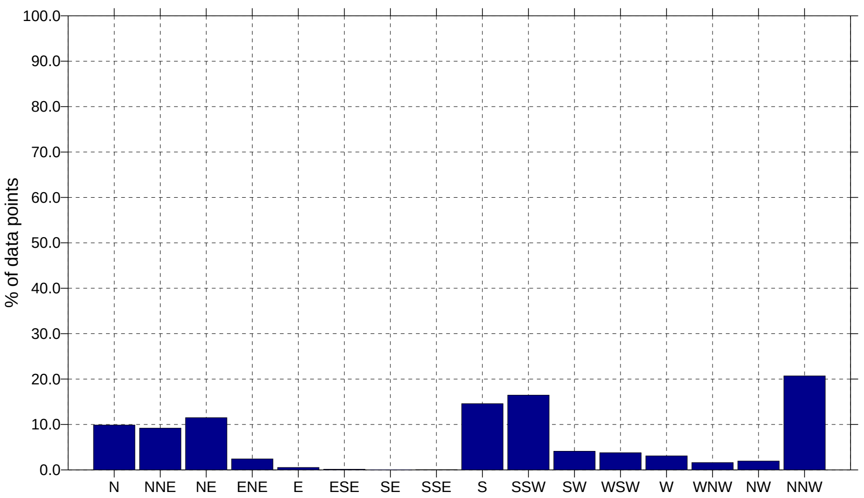
Deployment

Maximum Peak Period of Surface Waves (s): 17.07 from 0.70° North
Minimum Peak Period of Surface Waves (s): 3.88 from 92.70° North
Standard deviation: 2.03 s
Mean: 7.52s

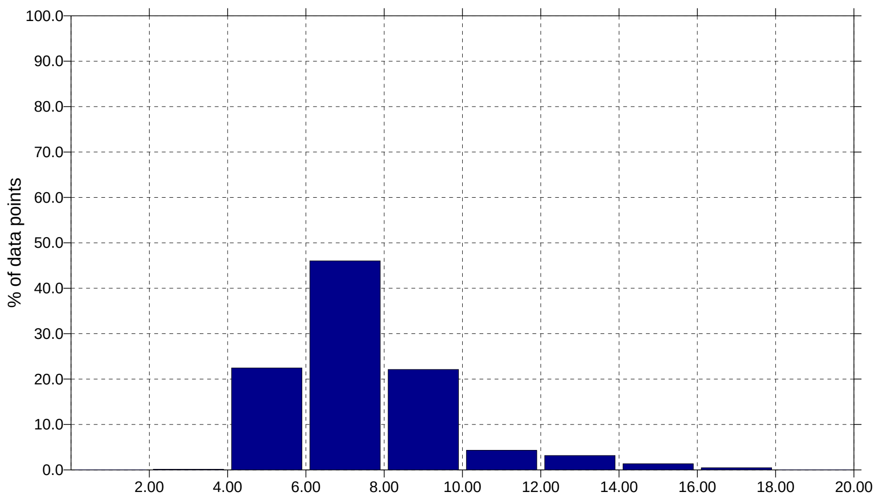


Peak Period of Surface Waves (s)

Instruments: MRU-5 (S/N 25081)
Data Quality: good **Total Records:** 1488



Distribution of Peak Direction of Surface Waves (from)



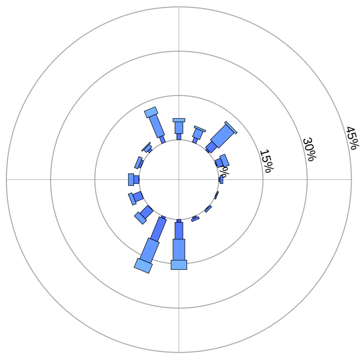
Distribution of Peak Period of Surface Waves (s)

Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moerose: 14:19 24/Jan/2023 by JTL (rose.histogram.AppendixH3.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

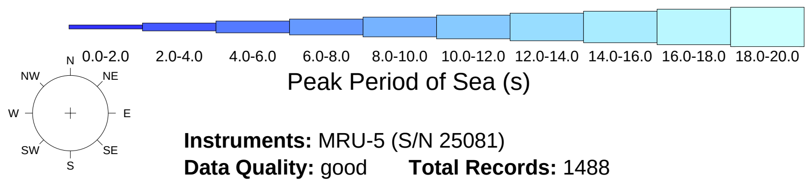
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Deployment
(00:00 01 December 2022 to 23:30 31 December 2022)

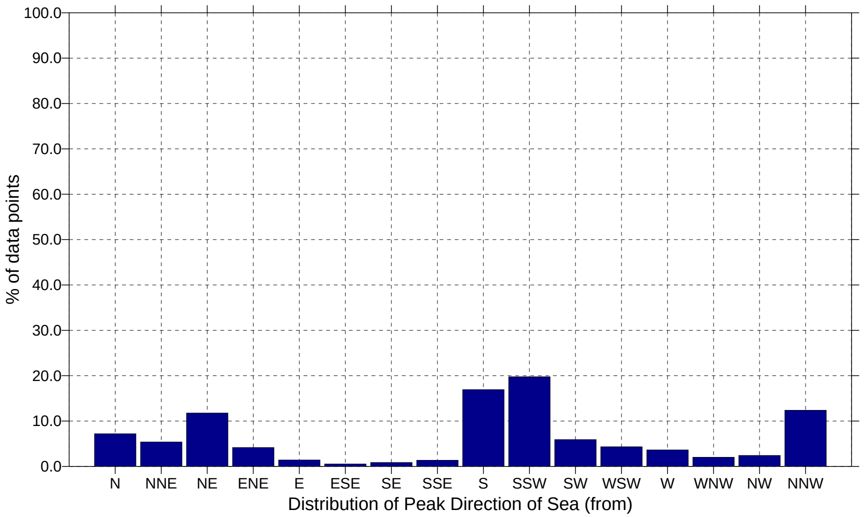


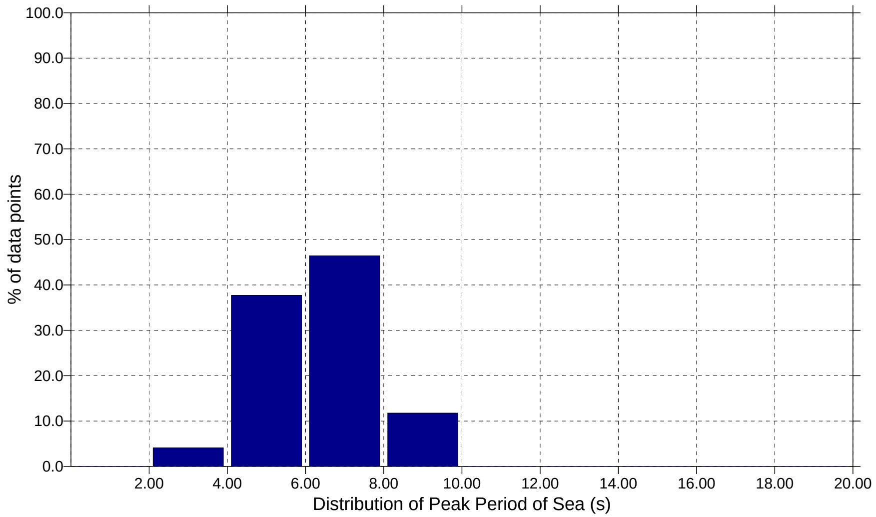
Deployment

Maximum Peak Period of Sea (s): 9.21 from 336.46° North
Minimum Peak Period of Sea (s): 3.05 from 139.52° North
Standard deviation: 1.37 s
Mean: 6.30s



Instruments: MRU-5 (S/N 25081)
Data Quality: good **Total Records:** 1488



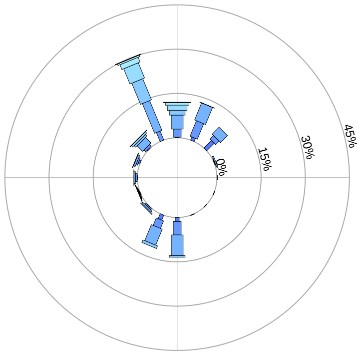


Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moerose: 14:19 24/Jan/2023 by JTL (rose.histogram.AppendixH3.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

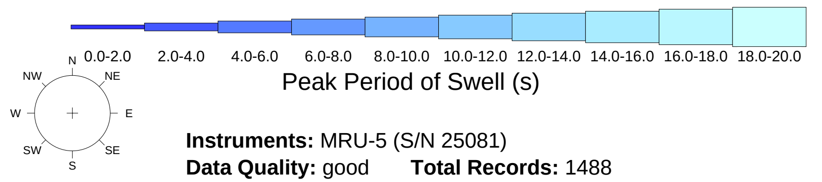
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	(5.5√Hs) s

Deployment
(00:00 01 December 2022 to 23:30 31 December 2022)

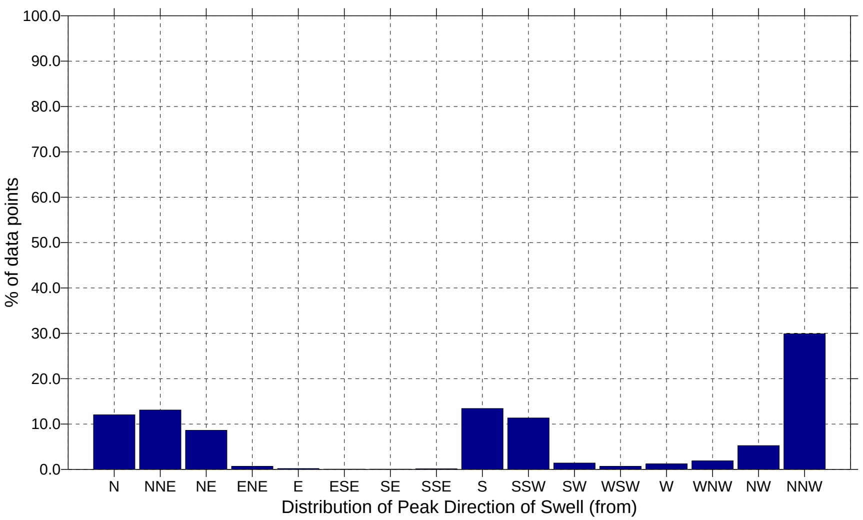


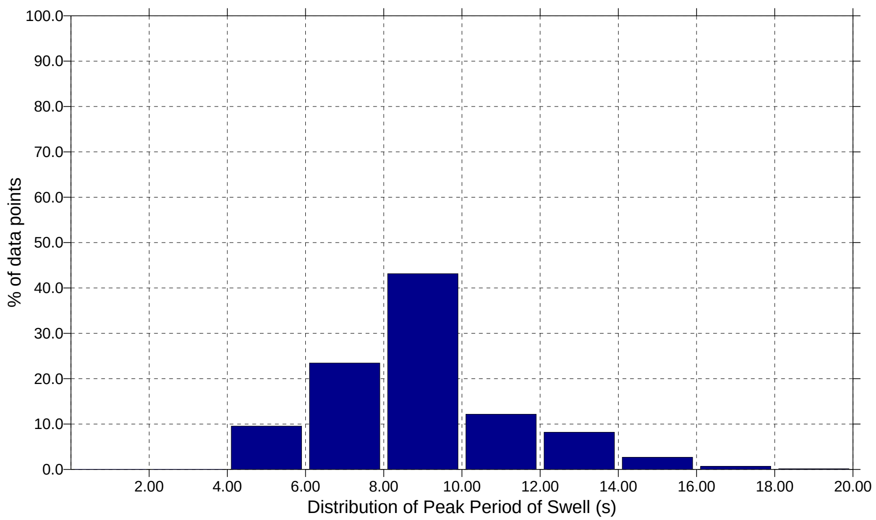
Deployment

Maximum Peak Period of Swell (s): 18.29 from 335.01° North
Minimum Peak Period of Swell (s): 4.82 from 204.52° North
Standard deviation: 2.27 s
Mean: 8.92s



Instruments: MRU-5 (S/N 25081)
Data Quality: good **Total Records:** 1488





Time Zone: UTC +00:00 hours	Data Source: NWWaveB.2022.12.QC_dataReturn.cos2s.nc
	moerose: 14:19 24/Jan/2023 by JTL (rose.histogram.AppendixH3.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

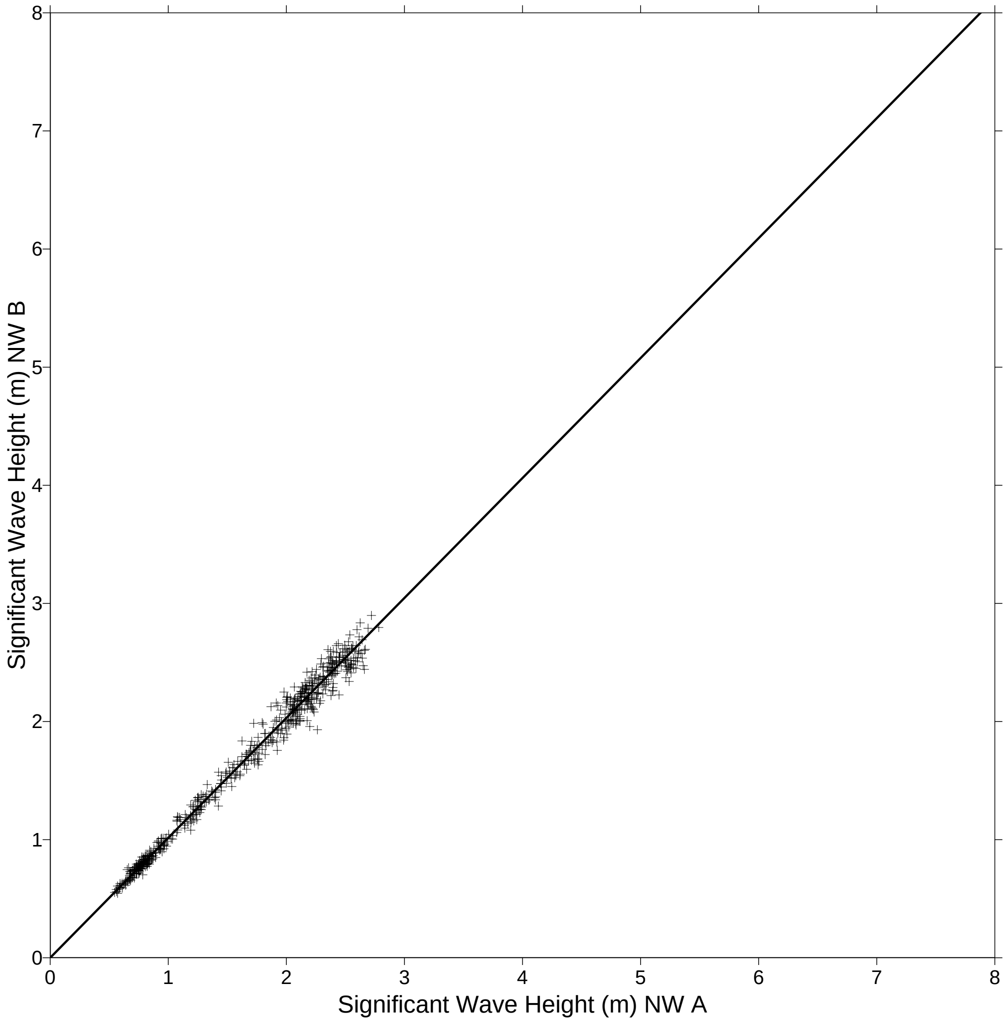
NW A vs NW B

Location:	**NW**		
		Client:	RVO
		Project:	J3707
		Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022

Significant Wave Height (m) NW A MRU-5 (S/N 26017)

Significant Wave Height (m) NW B MRU-5 (S/N 25081)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 592
Slope	= 1.015	Bias	= 0.0239083
Standard Error	= 0.056	RMS error	= 0.0833876
Correlation Coefficient	= 0.993	Scatter Index	= 0.05130

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

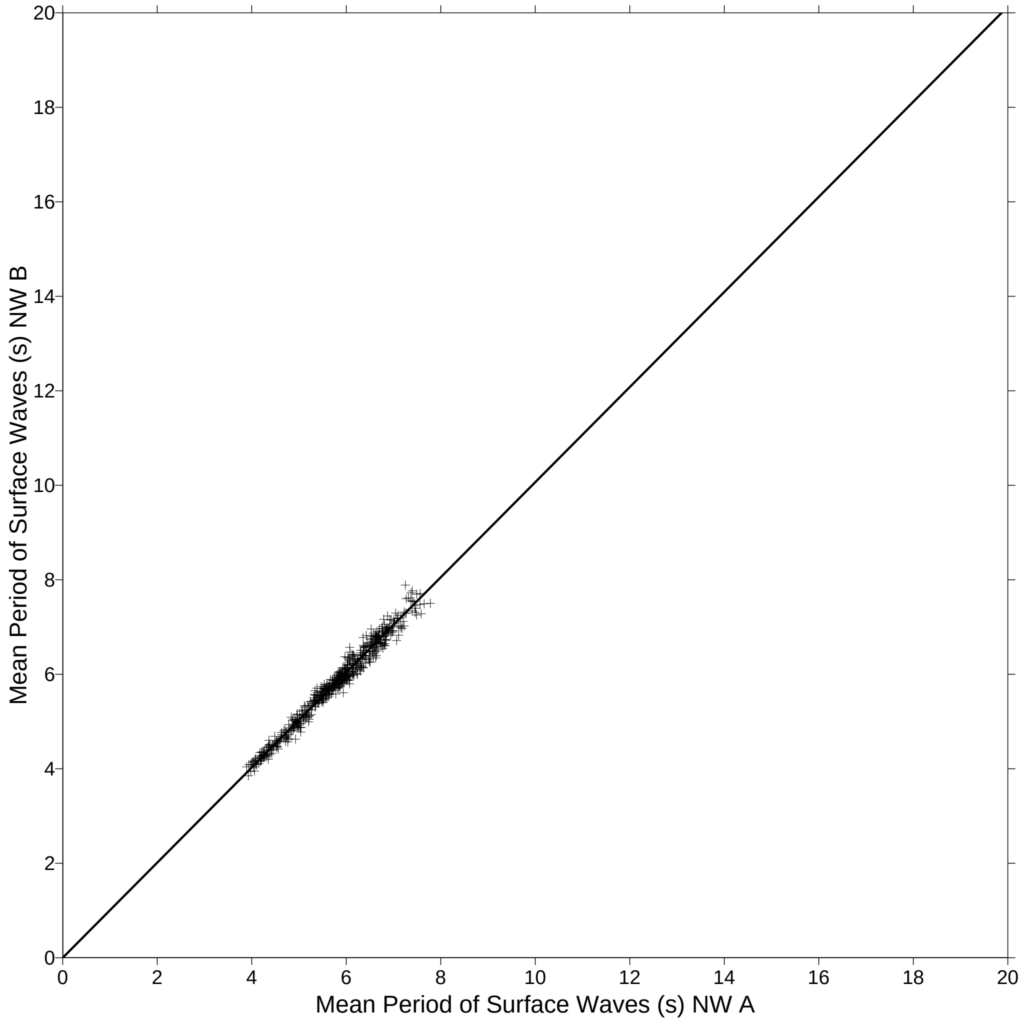
NW A vs NW B

Location:	**NW**		
		Client:	RVO
		Project:	J3707
		Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022

Mean Period of Surface Waves (s) NW A MRU-5 (S/N 26017)

Mean Period of Surface Waves (s) NW B MRU-5 (S/N 25081)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 592
Slope	= 1.007	Bias	= 0.0375029
Standard Error	= 0.094	RMS error	= 0.138476
Correlation Coefficient	= 0.989	Scatter Index	= 0.02403

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

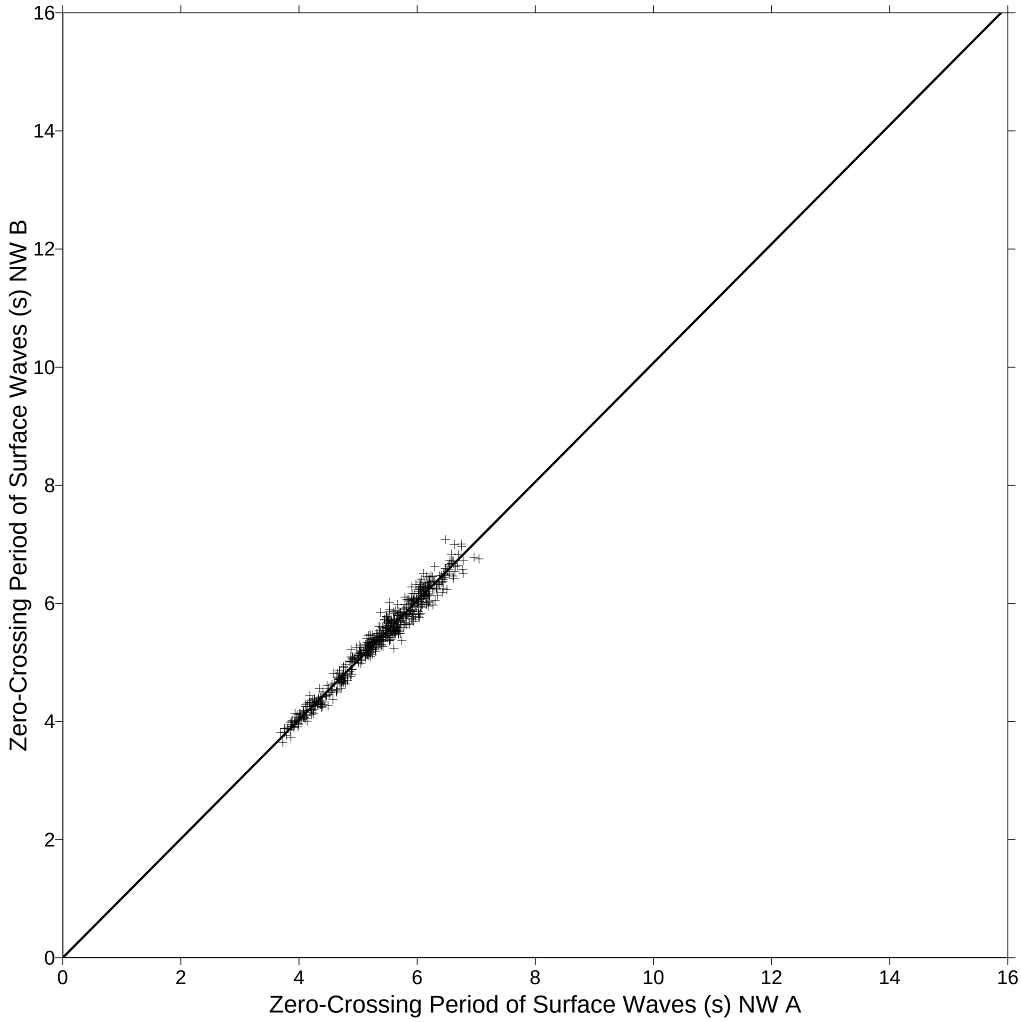
NW A vs NW B

Location:	**NW**		
		Client:	RVO
		Project:	J3707
		Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022

Zero-Crossing Period of Surface Waves (s) NW A MRU-5 (S/N 26017)

Zero-Crossing Period of Surface Waves (s) NW B MRU-5 (S/N 25081)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 592
Slope	= 1.007	Bias	= 0.0377145
Standard Error	= 0.093	RMS error	= 0.136832
Correlation Coefficient	= 0.985	Scatter Index	= 0.02556

Time Zone: UTC +00:00 hours	NWWave{A,B}.2022.12.QC_dataReturn.cos2s.nc
	moecorel: 14:19 24/Jan/2023 by JTL (AppendixH4.NW.2022.12.corel.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

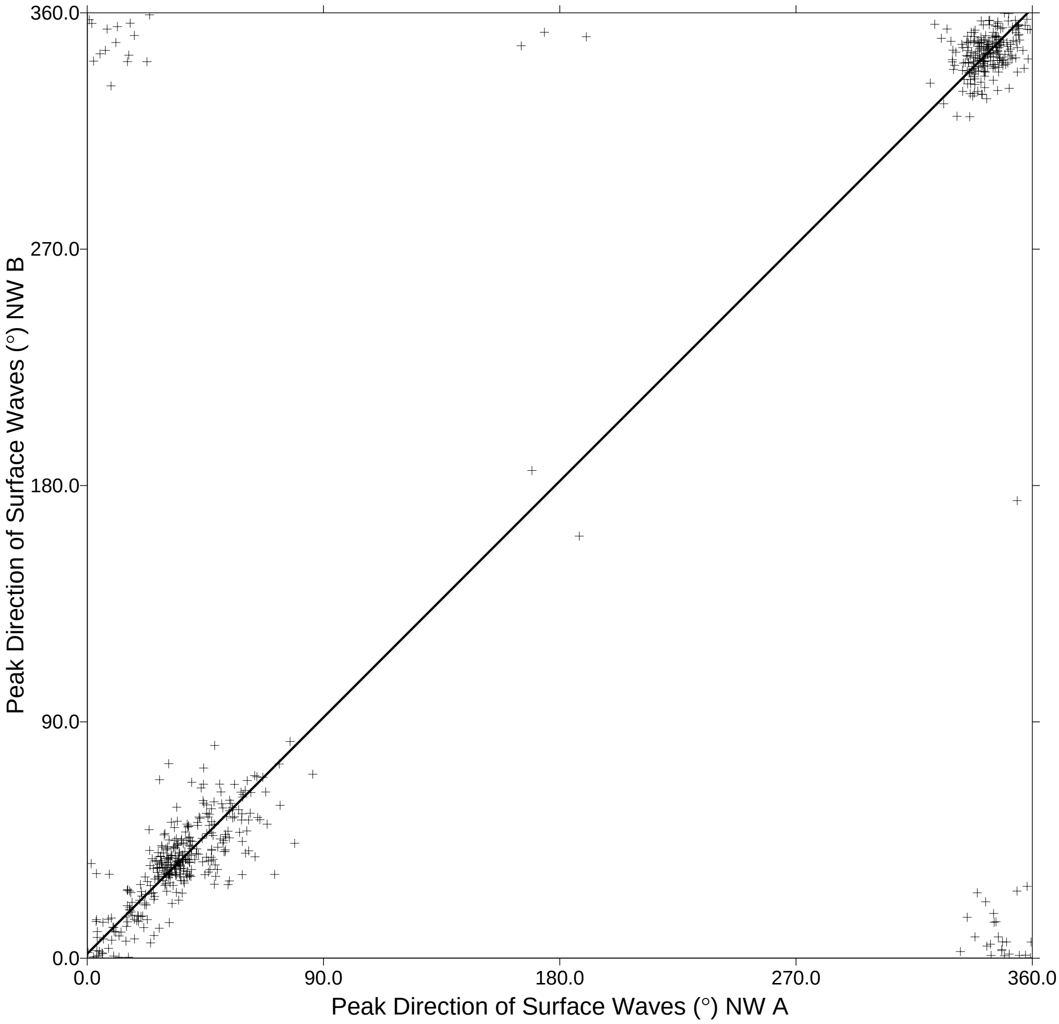
NW A vs NW B

Location:	**NW**		
		Client:	RVO
		Project:	J3707
		Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022

Peak Direction of Surface Waves (°) NW A from MRU-5 (S/N 26017)

Peak Direction of Surface Waves (°) NW B from MRU-5 (S/N 25081)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 1.697	Number of Data Points	= 592
Slope	= 1.000	Bias	= 1.69729
Standard Error	= 18.211	RMS error	= 18.2744
Correlation Coefficient	= 0.993	Scatter Index	= 0.10689

* both axes are polar variables

Time Zone: UTC +00:00 hours	NWWave{A,B}.2022.12.QC_dataReturn.cos2s.nc
	moecorel: 14:19 24/Jan/2023 by JTL (AppendixH4.NW.2022.12.corel.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

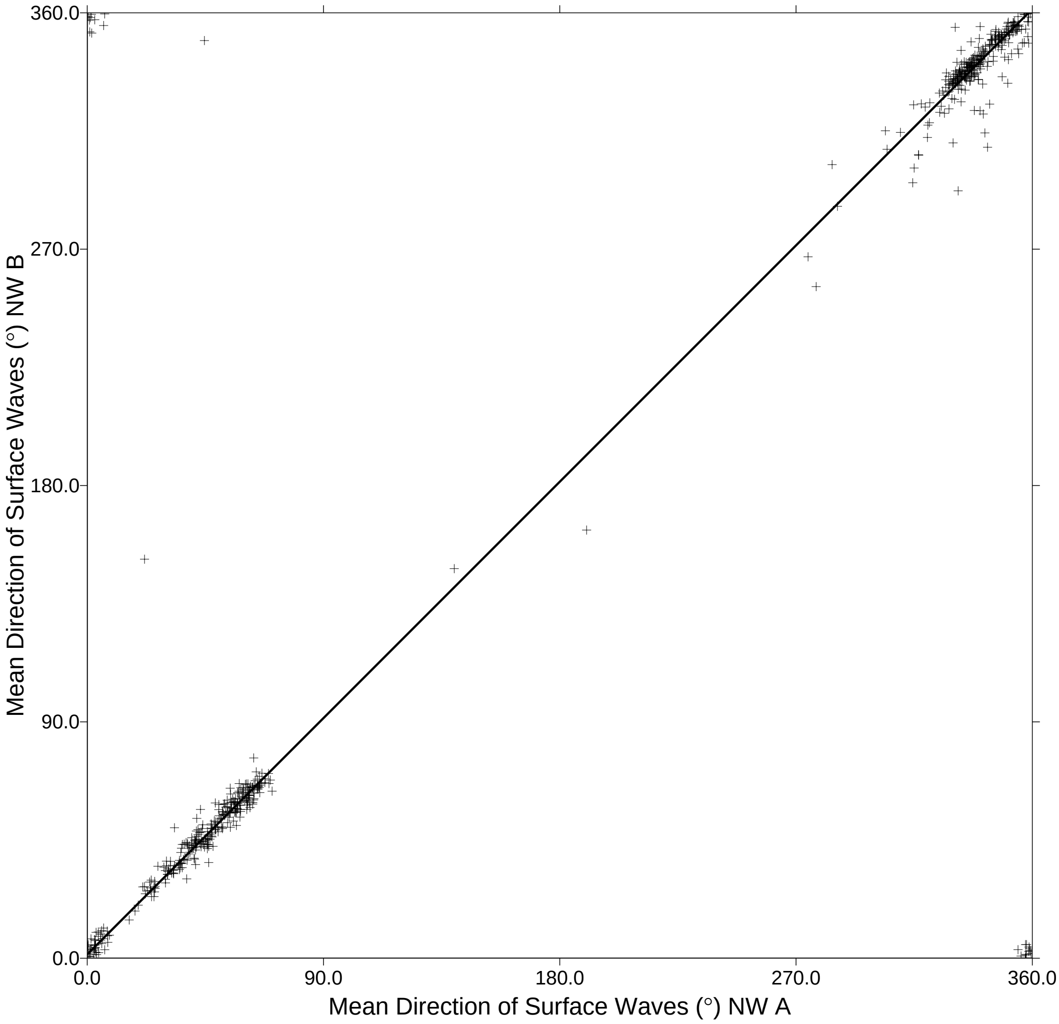
NW A vs NW B

Location:	NW		
		Client:	RVO
		Project:	J3707
		Sea/Swell:	(5.5√Hs) s

Period: 00:00 01 December 2022 to 07:30 13 December 2022

Mean Direction of Surface Waves (°) NW A from MRU-5 (S/N 26017)

Mean Direction of Surface Waves (°) NW B from MRU-5 (S/N 25081)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 1.445	Number of Data Points	= 592
Slope	= 1.000	Bias	= 1.44527
Standard Error	= 7.941	RMS error	= 8.06529
Correlation Coefficient	= 0.999	Scatter Index	= 0.04236

* both axes are polar variables

Time Zone: UTC +00:00 hours	NWWave{A,B}.2022.12.QC_dataReturn.cos2s.nc
	moecorel: 14:19 24/Jan/2023 by JTL (AppendixH4.NW.2022.12.corel.ps)

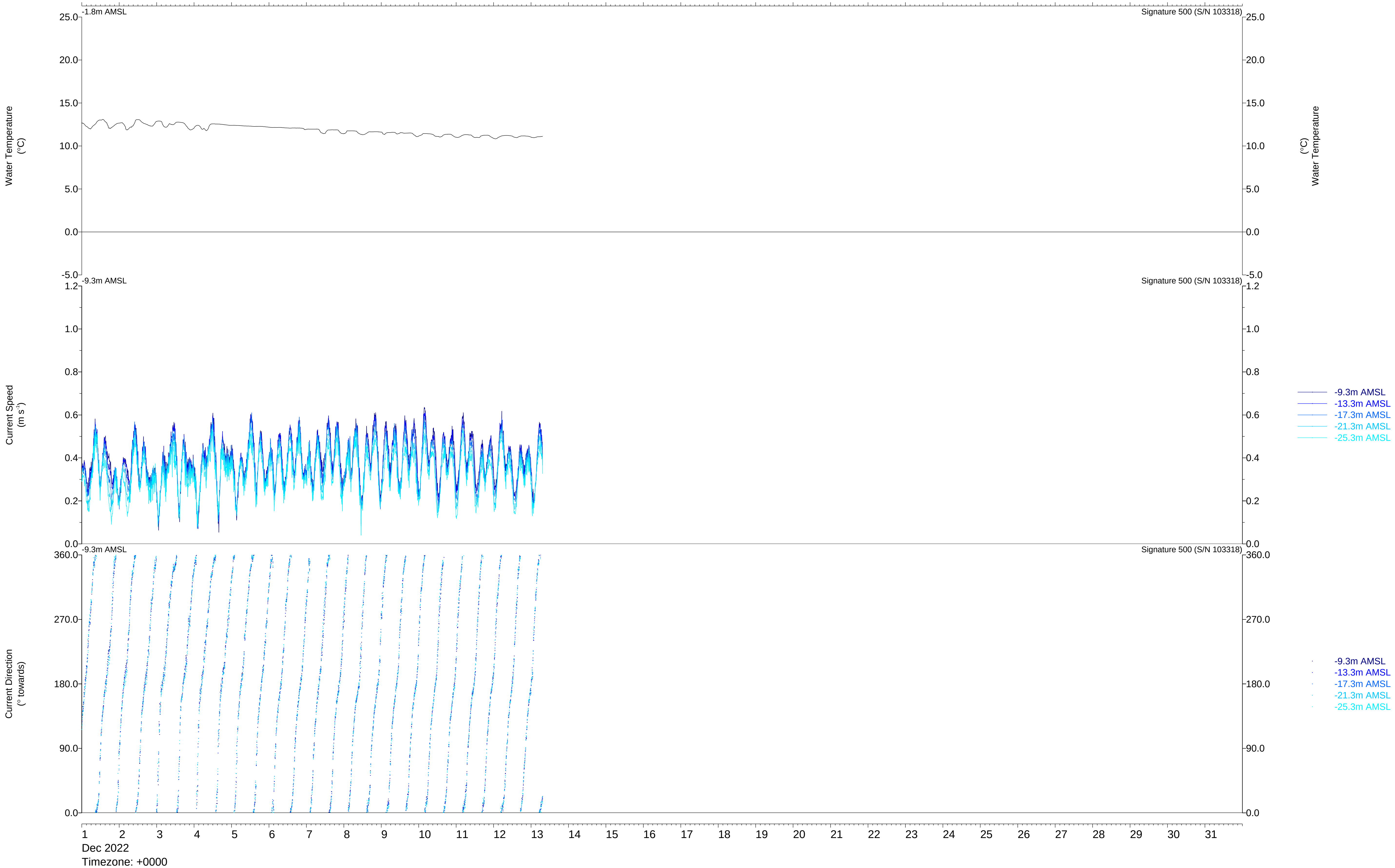
Appendix I
Current Measurements

To keep the volume of presentations succinct and relevant, only measurements from 5 levels are presented (Bins 7, 11, 15, 19, and 23 for the Signature), rather than 17+ levels (which are all contained within the monthly data files). Standard analysis of the processed data was undertaken to produce the following presentations:

- Monthly time history overlay plots of current speed, current direction, and water temperature for each site.
- NW A versus NW B monthly time history overlay stack plots of current speed, current direction, and water temperature.
- Monthly data availability bar charts for each parameter at each site.
- Statistics tables of water temperature, current speed and current direction for each site.
- Monthly rose plots and histograms of current speed and direction accompanied by relevant statistical parameters (maximum, minimum, mean, and standard deviation values) for each site.
- NW A versus NW B monthly correlation plots of water temperature, current speed and current direction.

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

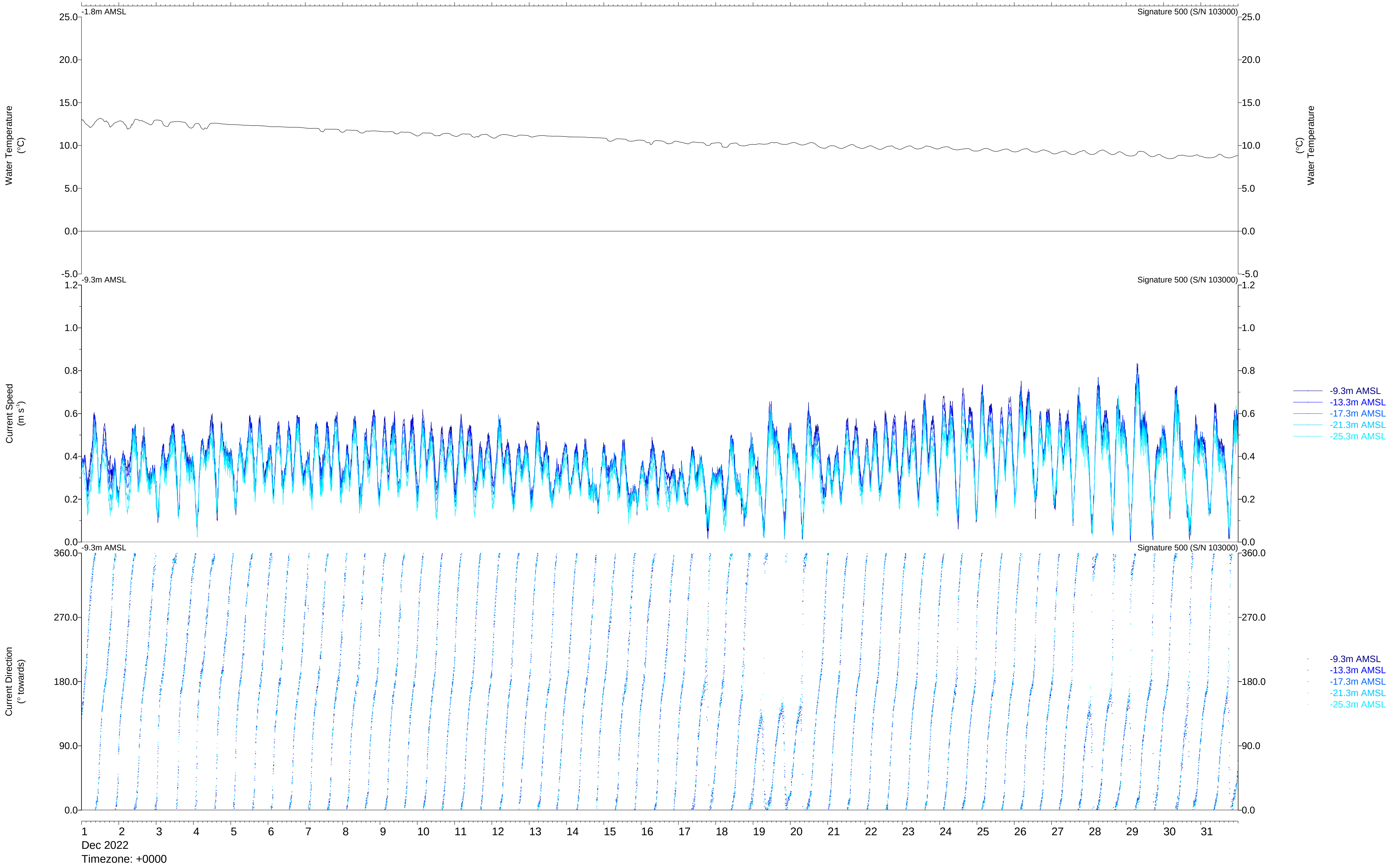
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		



Time Zone: UTC +00:00 hours	Data Source: NWADCPA.2022.12.QC_dataReturn.nc
	moetimehist: 16:49 24/Feb/2023 by JTL (AppendixI1.NW.A.2022.12.timehist.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

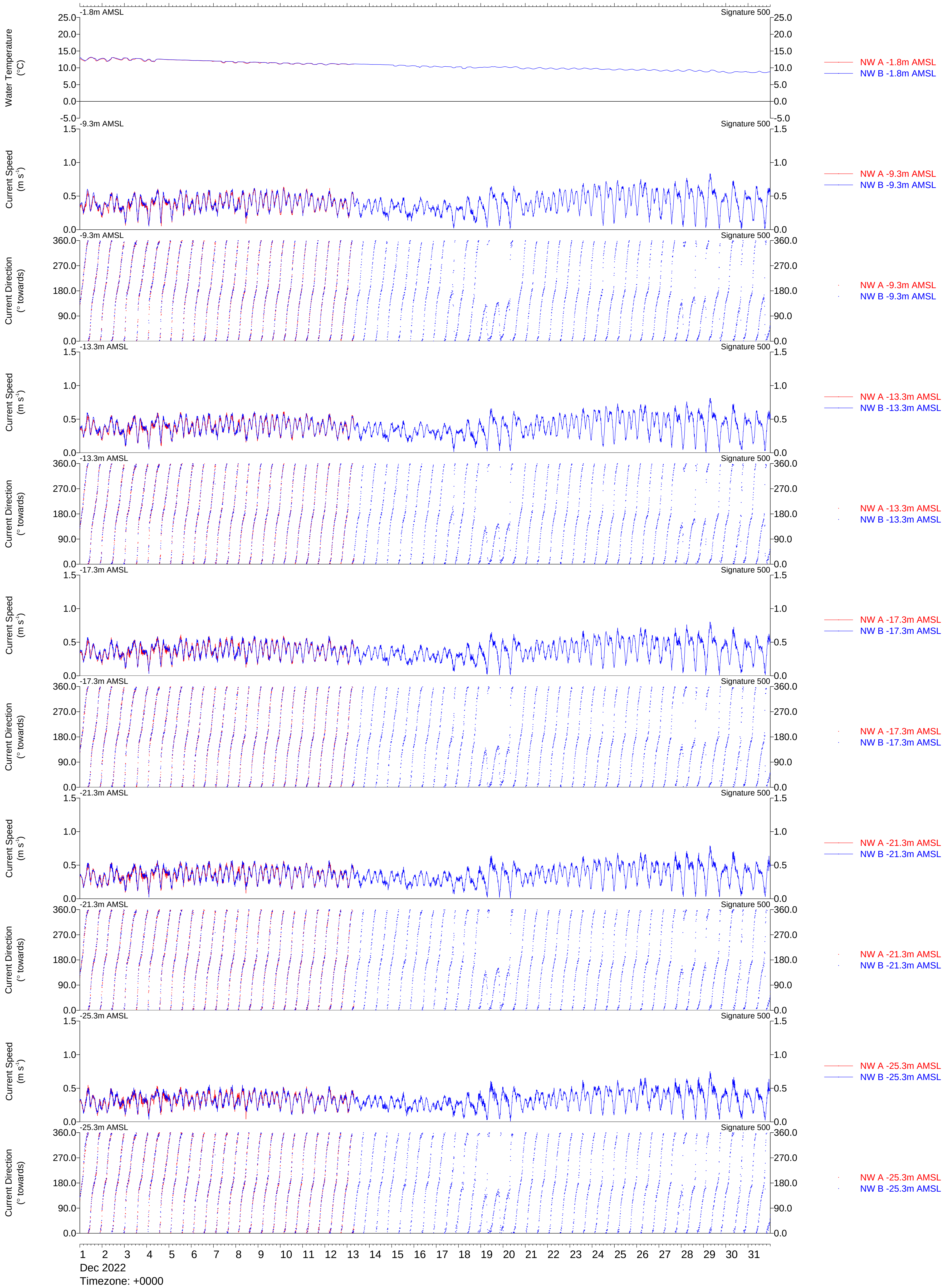
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		



Time Zone: UTC +00:00 hours	Data Source: NWADCPB.2022.12.QC_dataReturn.nc
© RPS Australia West Pty Ltd	moetimehist: 16:49 24/Feb/2023 by JTL (AppendixI1.NW.B.2022.12.timehist.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

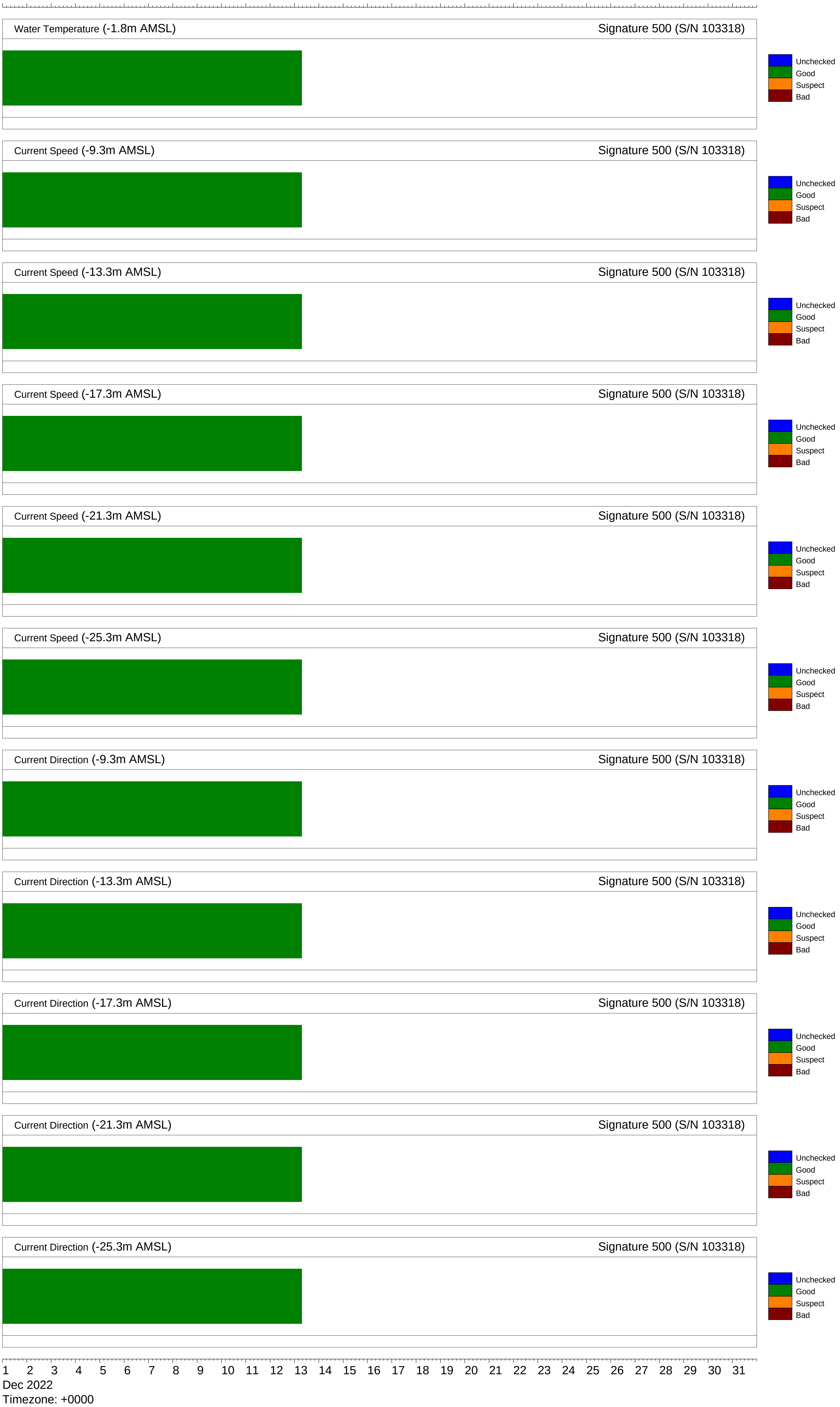
Location:	**NW**	
		Client: RVO
		Project: 3707



Time Zone: UTC +00:00 hours	NWADCP{A,B}.2022.12.QC_dataReturn.nc
	moetimehist: 16:50 24/Feb/2023 by JTL (AppendixI2.NW.2022.12.overlay.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

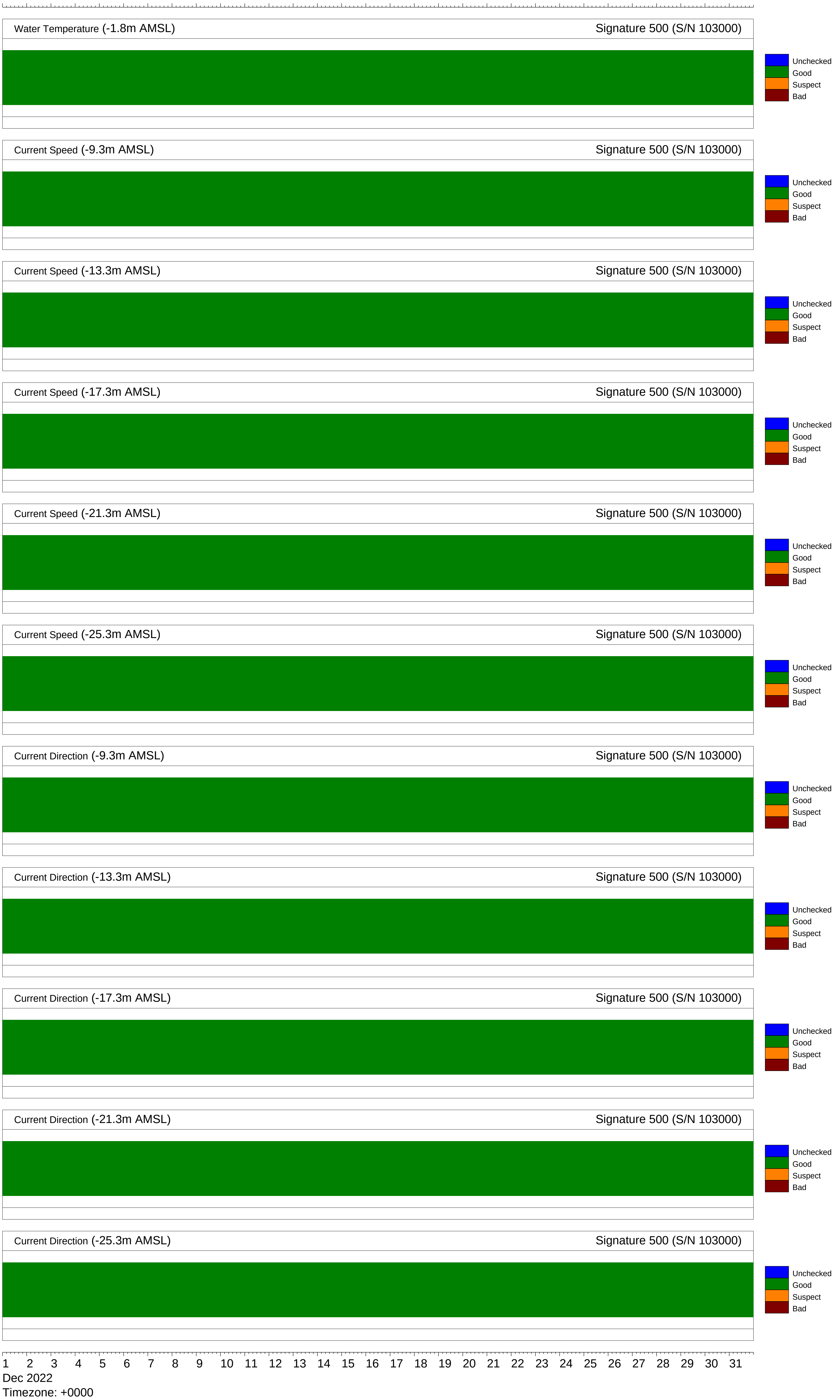
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		



Time Zone: UTC +00:00 hours	Data Source: NWADCPA.2022.12.QC_dataReturn.nc
	moetimehist: 16:49 24/Feb/2023 by JTL (AppendixI1.NW.A.2022.12.barchart.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		



Time Zone: UTC +00:00 hours	Data Source: NWADCPB.2022.12.QC_dataReturn.nc
	moetimehist: 16:49 24/Feb/2023 by JTL (AppendixI1.NW.B.2022.12.barchart.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:03 01 December 2022 to 07:23 13 December 2022
Water Temperature (°C), Signature 500 (S/N 103318), -1.8m AMSL.

	Water Temperature (°C)															
	Statistics				Total	Exceedence Percentile Water Temperature (°C)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
December 2022	10.83	13.09	11.87	0.5787	1773	10.93	11.02	11.10	11.34	11.91	12.27	12.40	12.61	12.77	13.00	13.05

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWADCPA.2022.12.QC_dataReturn.nc
	moematrix: 16:49 24/Feb/2023 by JTL (./stats_AppendixI3.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:03 01 December 2022 to 07:23 13 December 2022
Current Speed (m s^{-1}), Signature 500 (S/N 103318).
Current Direction (°), Signature 500 (S/N 103318).

	Current Speed (m s^{-1})															
	Statistics				Total	Exceedence Percentile Current Speed (m s^{-1})										Main Direction(s)[1]
December 2022	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(towards)
-9.3m AMSL	0.05	0.64	0.39	0.1036	1772	0.12	0.22	0.26	0.33	0.39	0.46	0.49	0.53	0.56	0.58	0.59	N S
-13.3m AMSL	0.07	0.61	0.39	0.1001	1772	0.15	0.22	0.26	0.32	0.39	0.45	0.48	0.52	0.54	0.57	0.58	N S
-17.3m AMSL	0.07	0.61	0.38	0.0981	1772	0.15	0.21	0.24	0.31	0.38	0.43	0.47	0.50	0.53	0.55	0.56	N S
-21.3m AMSL	0.07	0.57	0.36	0.0956	1772	0.14	0.19	0.22	0.29	0.36	0.41	0.45	0.48	0.50	0.53	0.54	N S
-25.3m AMSL	0.04	0.55	0.33	0.0904	1772	0.13	0.16	0.20	0.27	0.33	0.38	0.41	0.44	0.47	0.49	0.50	N S

Notes: 1) Main directions are where occurrence is greater than 15.0%.

Expected Record Interval: 10.00 minutes. Direction label is sector centre (45 degrees).

Time Zone: UTC +00:00 hours — Data Source: NWADCPA.2022.12.QC_dataReturn.nc

 — moeprofilestats: 16:49 24/Feb/2023 by JTL (./stats_profile_AppendixI3.NW.A.2022.12.stats.profile.Currents.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:08 01 December 2022 to 23:58 31 December 2022
Water Temperature (°C), Signature 500 (S/N 103000), -1.8m AMSL.

	Water Temperature (°C)															
	Statistics				Total	Exceedence Percentile Water Temperature (°C)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
December 2022	8.46	13.17	10.64	1.2410	4464	8.56	8.77	8.99	9.61	10.45	11.36	11.98	12.42	12.70	12.90	12.97

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWADCPB.2022.12.QC_dataReturn.nc
	moematrix: 16:50 24/Feb/2023 by JTL (./stats_AppendixI3.NW.B.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:08 01 December 2022 to 23:58 31 December 2022
Current Speed (m s^{-1}), Signature 500 (S/N 103000).
Current Direction (°), Signature 500 (S/N 103000).

	Current Speed (m s^{-1})																
	Statistics				Total	Exceedence Percentile Current Speed (m s^{-1})											Main Direction(s)[1]
December 2022	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0	(towards)
-9.3m AMSL	0.01	0.83	0.40	0.1355	4464	0.07	0.17	0.23	0.31	0.40	0.47	0.52	0.57	0.61	0.66	0.70	N SE S
-13.3m AMSL	0.00	0.81	0.39	0.1303	4464	0.08	0.18	0.23	0.30	0.39	0.47	0.51	0.56	0.60	0.64	0.68	N SE S
-17.3m AMSL	0.01	0.80	0.38	0.1253	4464	0.08	0.17	0.22	0.29	0.38	0.45	0.49	0.54	0.57	0.62	0.66	N SE S
-21.3m AMSL	0.01	0.79	0.36	0.1201	4463	0.09	0.17	0.20	0.27	0.36	0.43	0.47	0.51	0.55	0.60	0.63	N SE S
-25.3m AMSL	0.01	0.75	0.33	0.1120	4464	0.08	0.15	0.18	0.25	0.33	0.39	0.43	0.47	0.50	0.55	0.59	N SE S

Notes: 1) Main directions are where occurrence is greater than 15.0%.

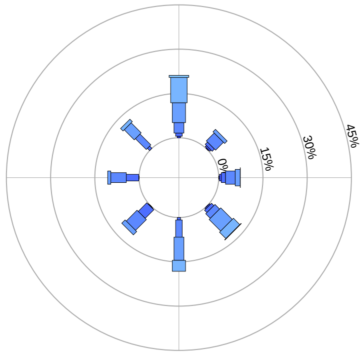
Expected Record Interval: 10.00 minutes. Direction label is sector centre (45 degrees).

Time Zone: UTC +00:00 hours	Data Source: NWADCPB.2022.12.QC_dataReturn.nc
	moeprofilestats: 16:50 24/Feb/2023 by JTL (./stats_profile_AppendixI3.NW.B.2022.12.stats.profile.Currents.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

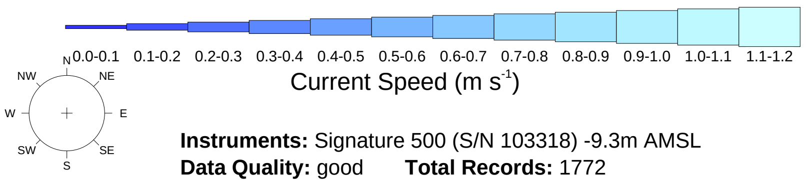
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Deployment
(00:03 01 December 2022 to 07:23 13 December 2022)

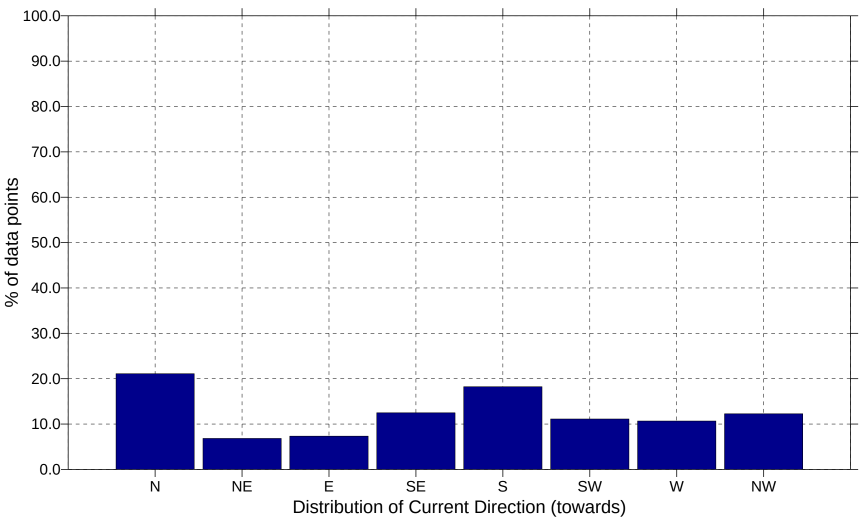


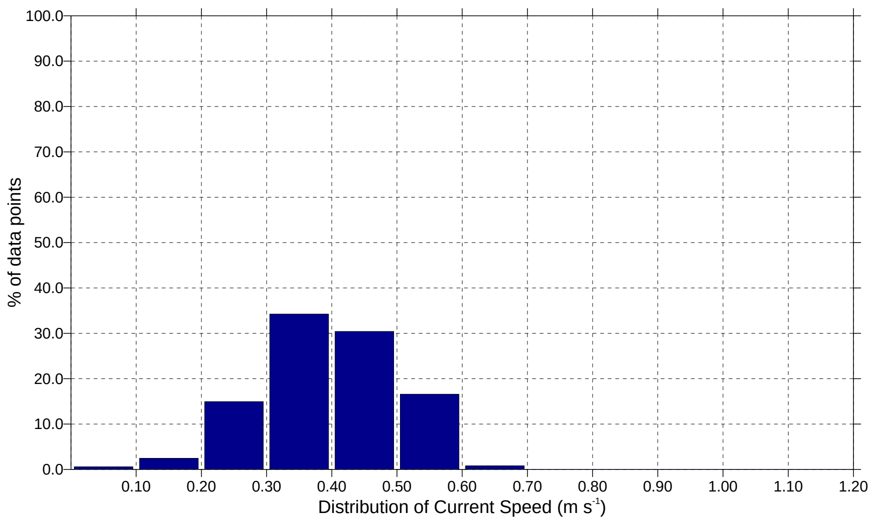
Deployment

Maximum Current Speed (m s^{-1}): 0.64 towards 359.00° North
Minimum Current Speed (m s^{-1}): 0.05 towards 96.29° North
Standard deviation: 0.10 m s^{-1}
Mean: 0.39m s^{-1}



Instruments: Signature 500 (S/N 103318) -9.3m AMSL
Data Quality: good **Total Records:** 1772



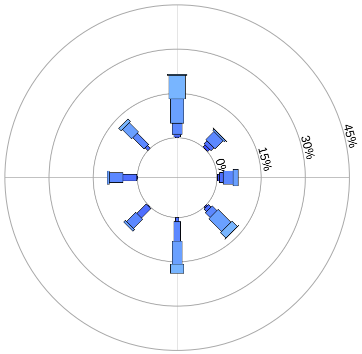


Time Zone: UTC +00:00 hours	Data Source: NWADCPA.2022.12.QC_dataReturn.nc
	moerose: 16:49 24/Feb/2023 by JTL (rose.histogram.AppendixI4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

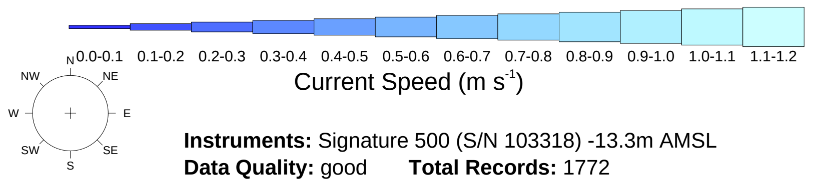
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Deployment
(00:03 01 December 2022 to 07:23 13 December 2022)

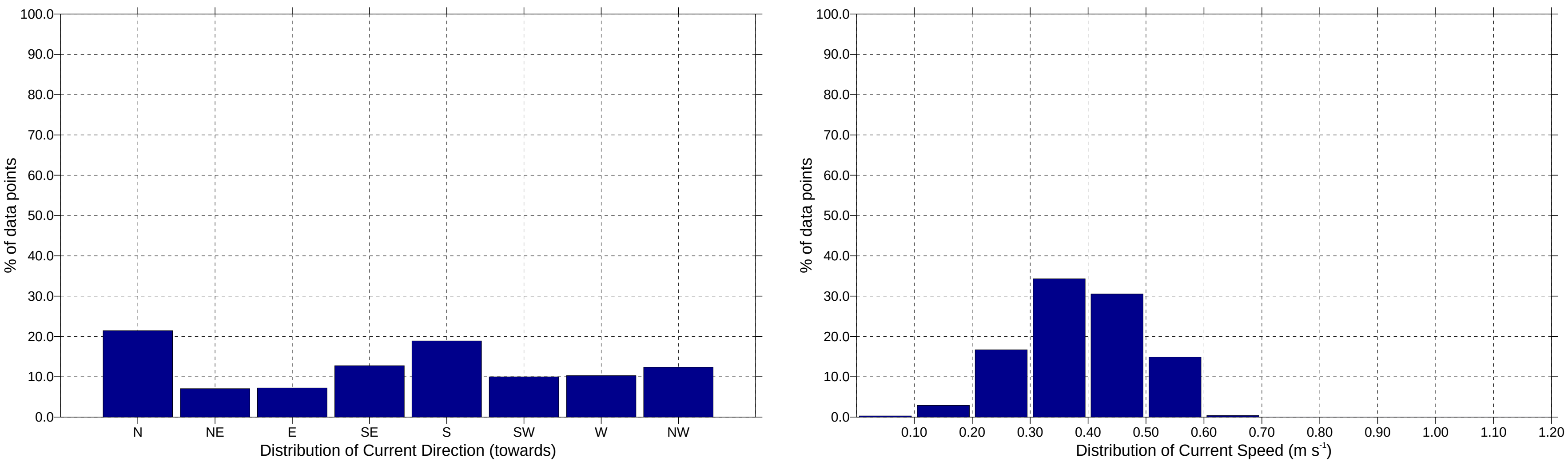


Deployment

Maximum Current Speed (m s^{-1}): 0.61 towards 7.06° North
Minimum Current Speed (m s^{-1}): 0.07 towards 91.98° North
Standard deviation: 0.10 m s^{-1}
Mean: 0.39m s^{-1}



Instruments: Signature 500 (S/N 103318) -13.3m AMSL
Data Quality: good **Total Records:** 1772

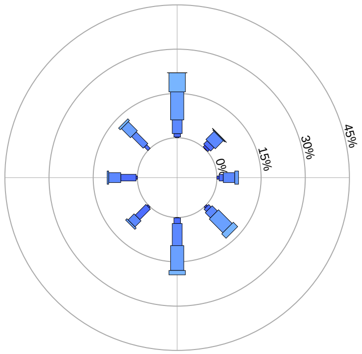


Time Zone: UTC +00:00 hours	Data Source: NWADCPA.2022.12.QC_dataReturn.nc
	moerose: 16:49 24/Feb/2023 by JTL (rose.histogram.AppendixI4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

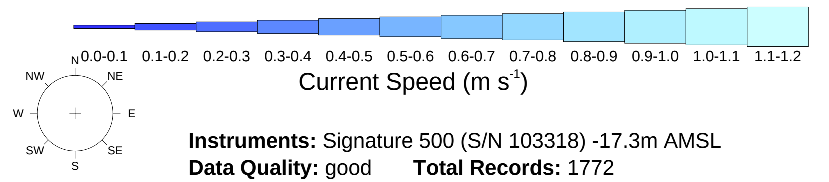
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Deployment
(00:03 01 December 2022 to 07:23 13 December 2022)

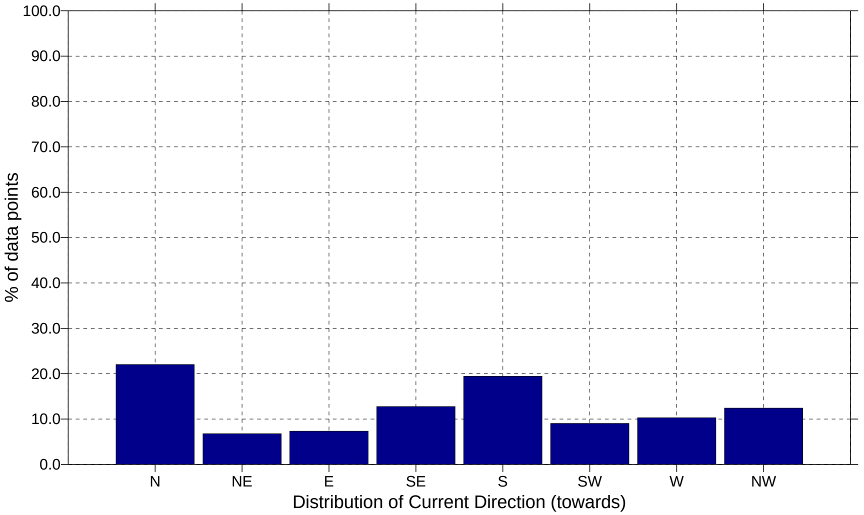


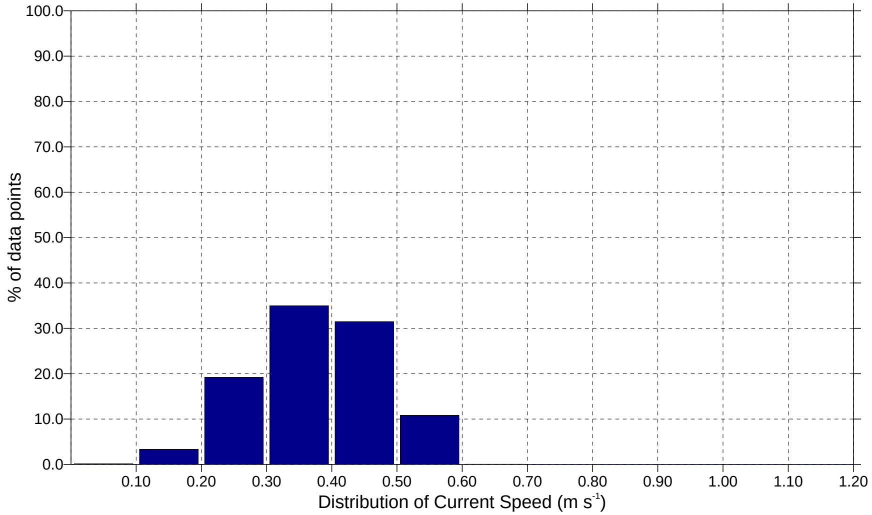
Deployment

Maximum Current Speed (m s^{-1}): 0.61 towards 358.71° North
Minimum Current Speed (m s^{-1}): 0.07 towards 55.36° North
Standard deviation: 0.10 m s^{-1}
Mean: 0.38m s^{-1}



Instruments: Signature 500 (S/N 103318) -17.3m AMSL
Data Quality: good **Total Records:** 1772



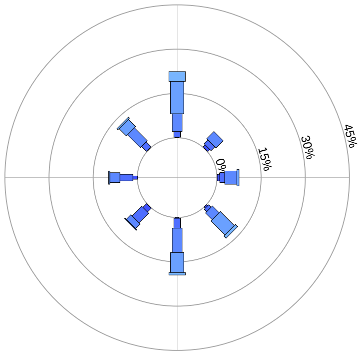


Time Zone: UTC +00:00 hours	Data Source: NWADCPA.2022.12.QC_dataReturn.nc
	moerose: 16:49 24/Feb/2023 by JTL (rose.histogram.AppendixI4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

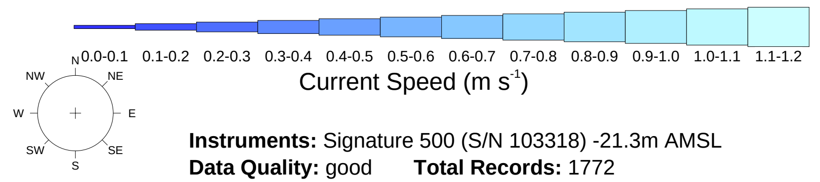
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Deployment
(00:03 01 December 2022 to 07:23 13 December 2022)

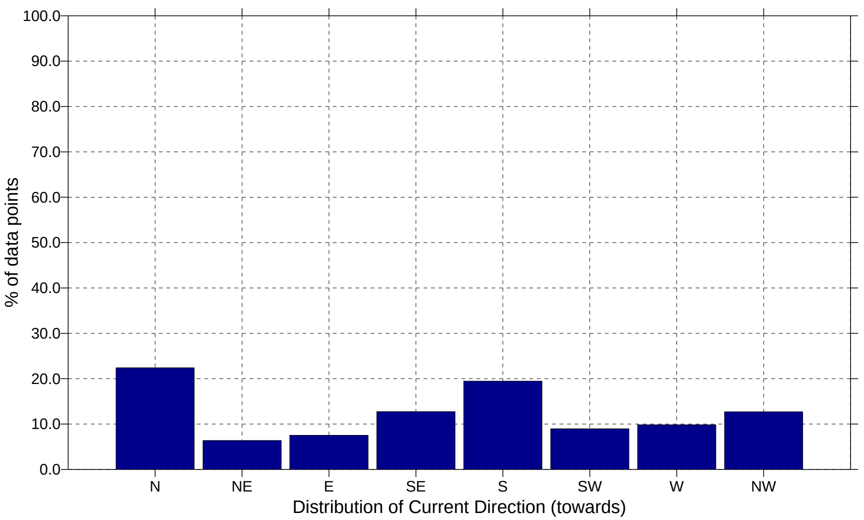


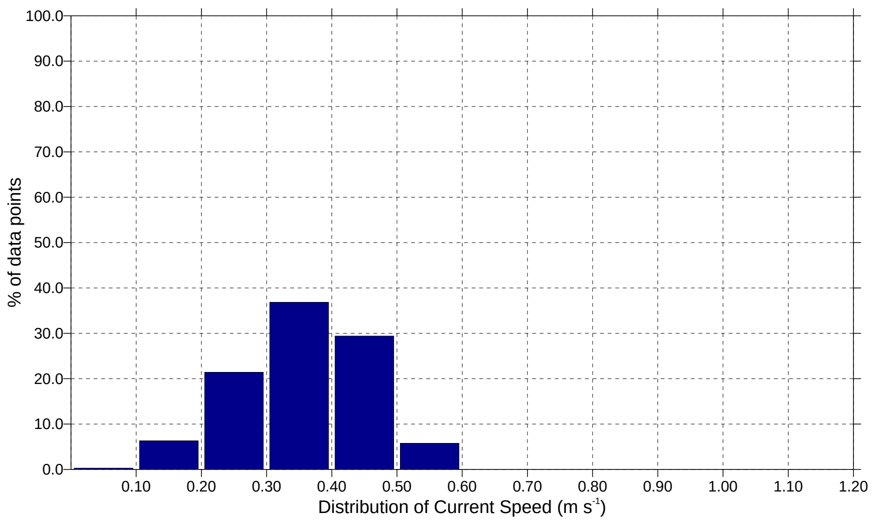
Deployment

Maximum Current Speed (m s^{-1}): 0.57 towards 354.41° North
Minimum Current Speed (m s^{-1}): 0.07 towards 63.18° North
Standard deviation: 0.10 m s^{-1}
Mean: 0.36m s^{-1}



Instruments: Signature 500 (S/N 103318) -21.3m AMSL
Data Quality: good **Total Records:** 1772



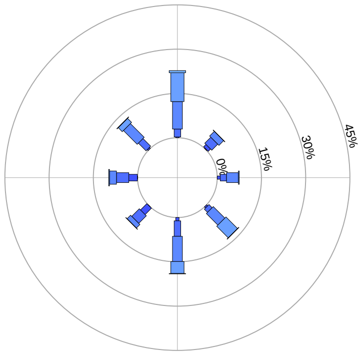


Time Zone: UTC +00:00 hours	Data Source: NWADCPA.2022.12.QC_dataReturn.nc
	moerose: 16:49 24/Feb/2023 by JTL (rose.histogram.AppendixI4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

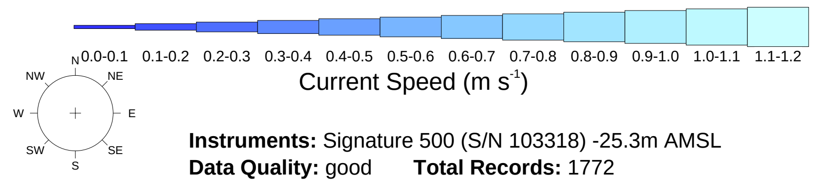
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Deployment
(00:03 01 December 2022 to 07:23 13 December 2022)

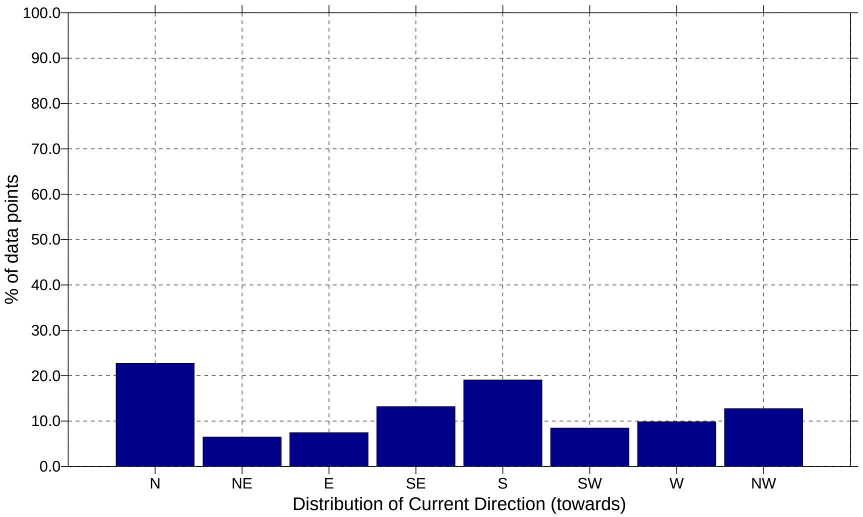


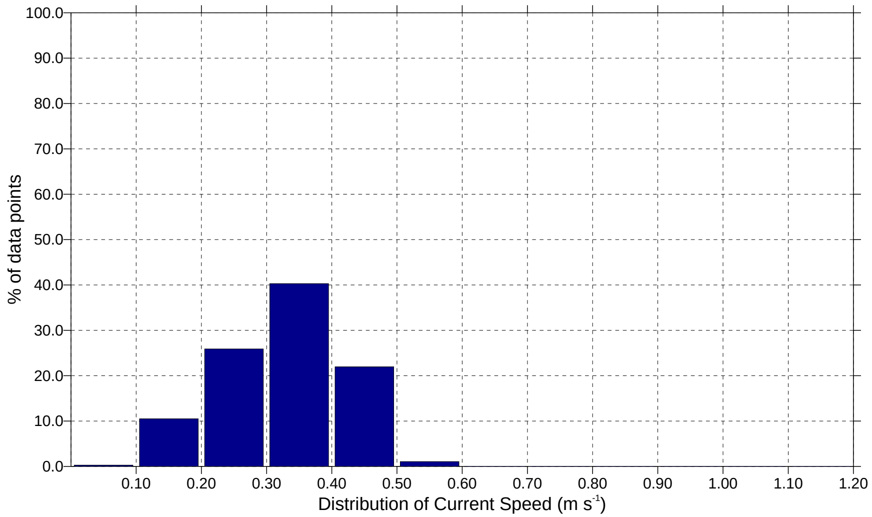
Deployment

Maximum Current Speed (m s^{-1}): 0.55 towards 1.35° North
Minimum Current Speed (m s^{-1}): 0.04 towards 202.93° North
Standard deviation: 0.09 m s^{-1}
Mean: 0.33m s^{-1}



Instruments: Signature 500 (S/N 103318) -25.3m AMSL
Data Quality: good **Total Records:** 1772



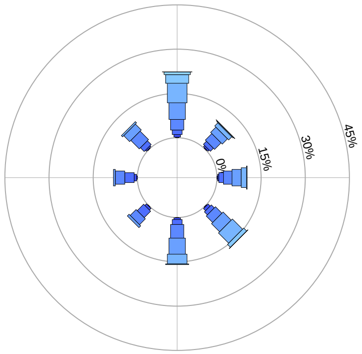


Time Zone: UTC +00:00 hours	Data Source: NWADCPA.2022.12.QC_dataReturn.nc
	moerose: 16:49 24/Feb/2023 by JTL (rose.histogram.AppendixI4.NW.A.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

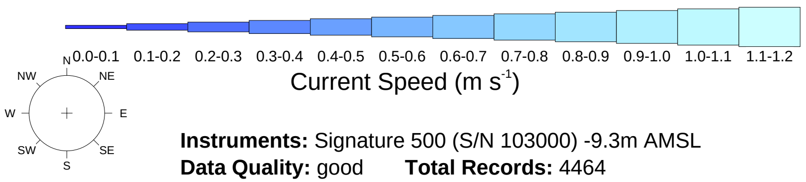
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Deployment
(00:08 01 December 2022 to 23:58 31 December 2022)

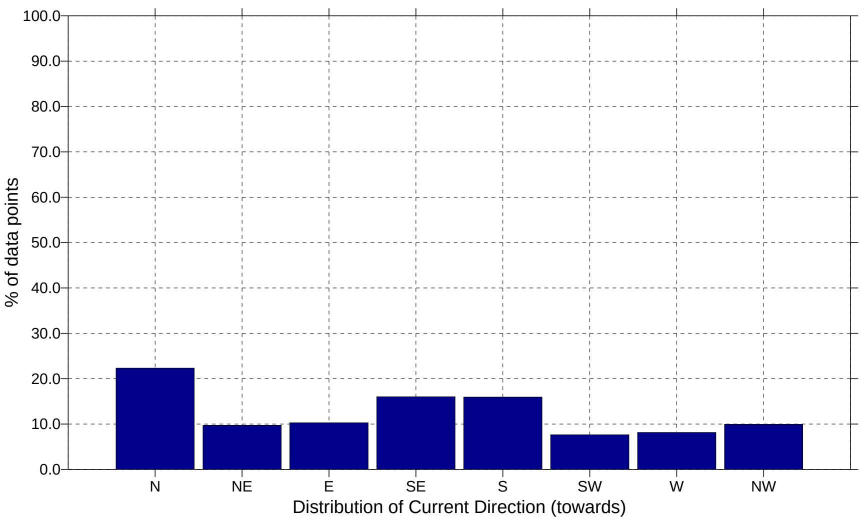


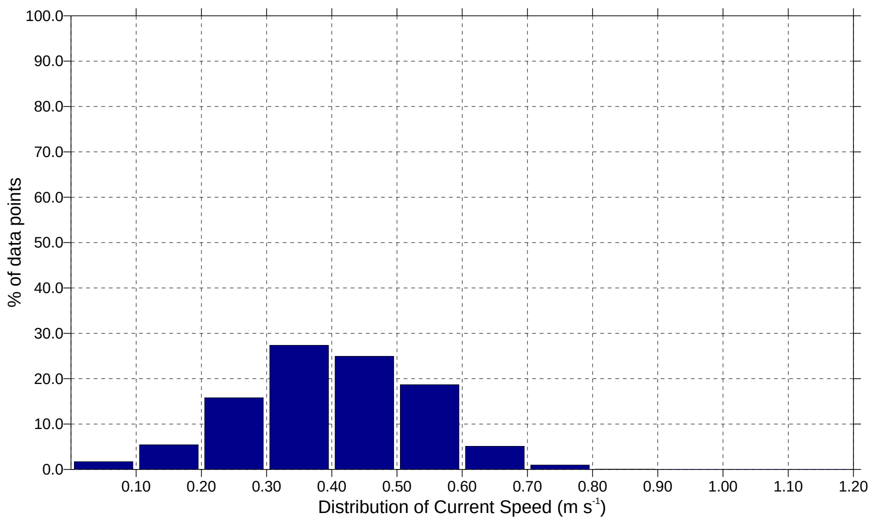
Deployment

Maximum Current Speed (m s^{-1}): 0.83 towards 14.06° North
Minimum Current Speed (m s^{-1}): 0.01 towards 193.61° North
Standard deviation: 0.14 m s^{-1}
Mean: 0.40m s^{-1}



Instruments: Signature 500 (S/N 103000) -9.3m AMSL
Data Quality: good **Total Records:** 4464



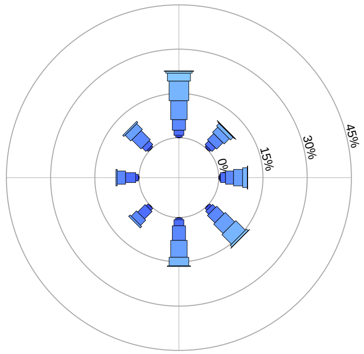


Time Zone: UTC +00:00 hours	Data Source: NWADCPB.2022.12.QC_dataReturn.nc
	moerose: 16:50 24/Feb/2023 by JTL (rose.histogram.AppendixI4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

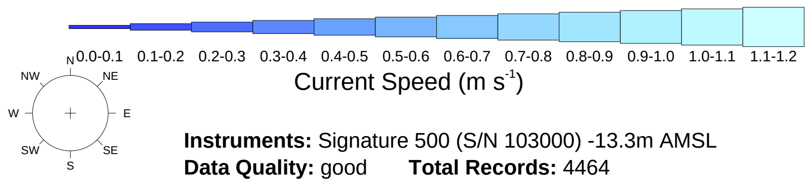
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Deployment
(00:08 01 December 2022 to 23:58 31 December 2022)

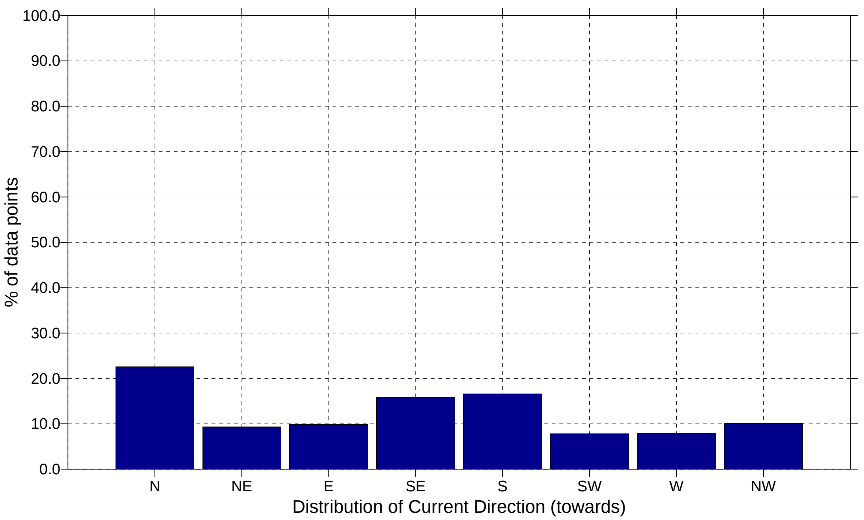


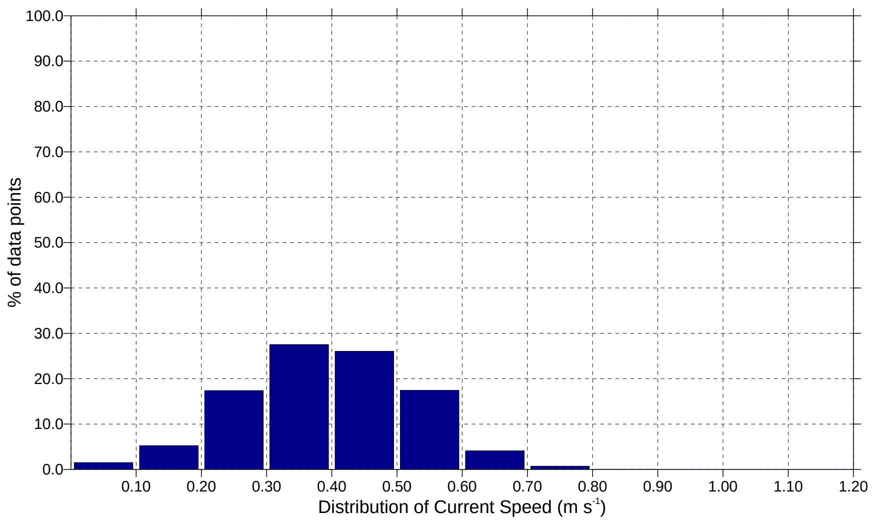
Deployment

Maximum Current Speed (m s^{-1}): 0.81 towards 11.40° North
Minimum Current Speed (m s^{-1}): 0.00 towards 90.00° North
Standard deviation: 0.13 m s^{-1}
Mean: 0.39m s^{-1}



Instruments: Signature 500 (S/N 103000) -13.3m AMSL
Data Quality: good **Total Records:** 4464



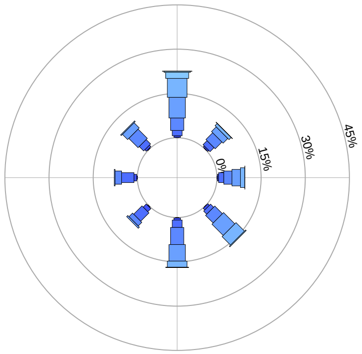


Time Zone: UTC +00:00 hours	Data Source: NWADCPB.2022.12.QC_dataReturn.nc
	moerose: 16:50 24/Feb/2023 by JTL (rose.histogram.AppendixI4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

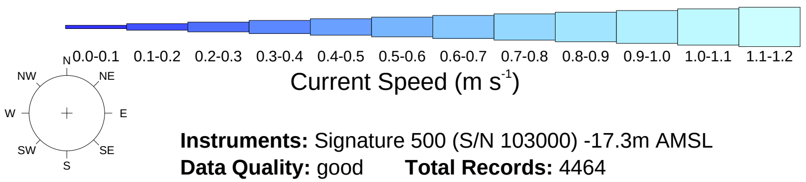
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Deployment
(00:08 01 December 2022 to 23:58 31 December 2022)

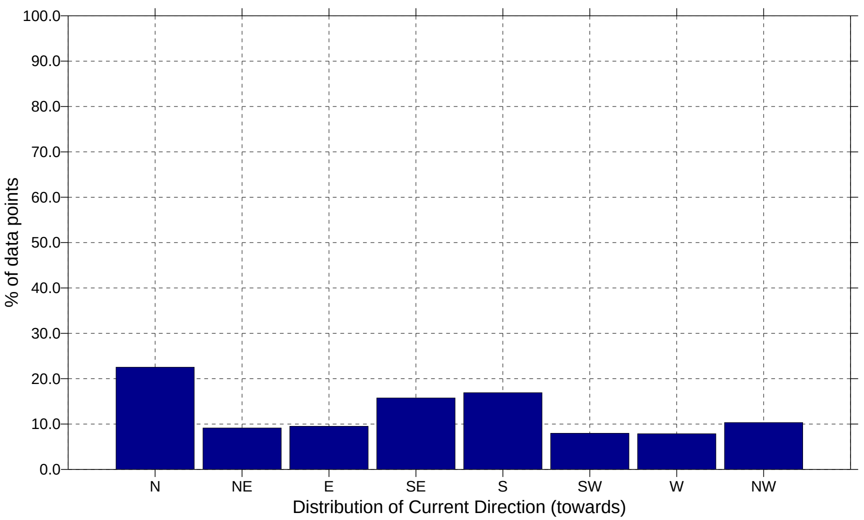


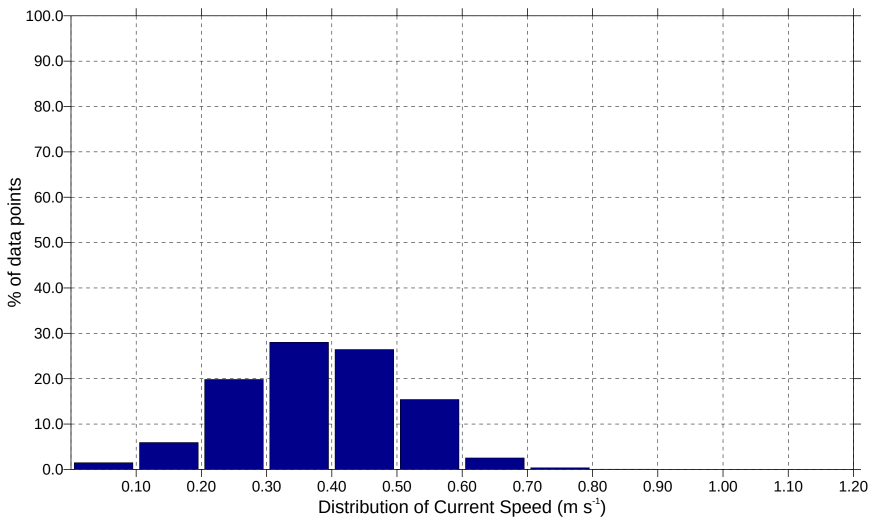
Deployment

Maximum Current Speed (m s^{-1}): 0.80 towards 13.92° North
Minimum Current Speed (m s^{-1}): 0.01 towards 277.21° North
Standard deviation: 0.13 m s^{-1}
Mean: 0.38m s^{-1}



Instruments: Signature 500 (S/N 103000) -17.3m AMSL
Data Quality: good **Total Records:** 4464



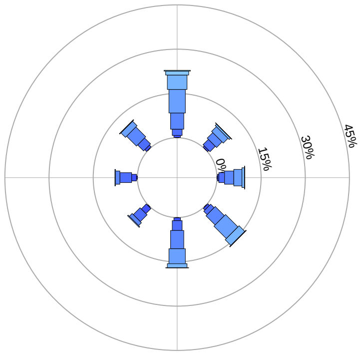


Time Zone: UTC +00:00 hours	Data Source: NWADCPB.2022.12.QC_dataReturn.nc
	moerose: 16:50 24/Feb/2023 by JTL (rose.histogram.AppendixI4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

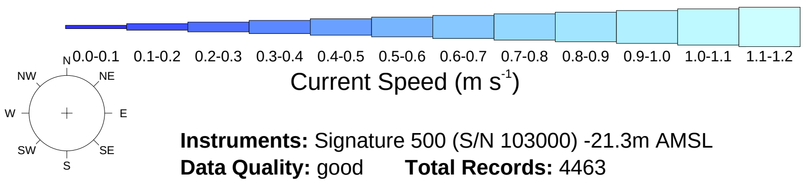
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Deployment
(00:08 01 December 2022 to 23:58 31 December 2022)

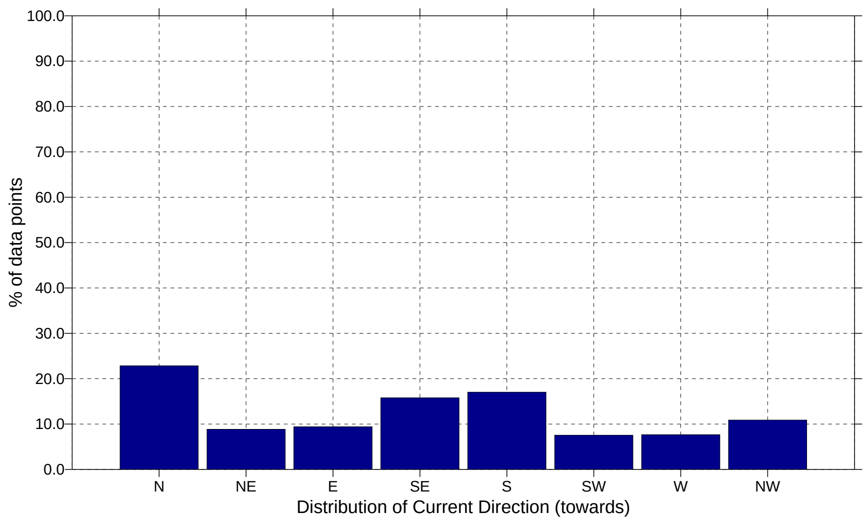


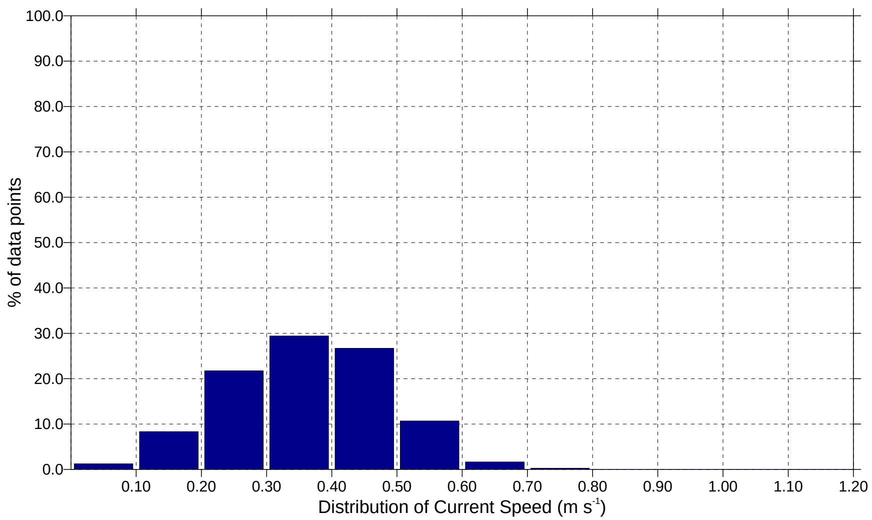
Deployment

Maximum Current Speed (m s^{-1}): 0.79 towards 10.77° North
Minimum Current Speed (m s^{-1}): 0.01 towards 95.09° North
Standard deviation: 0.12 m s^{-1}
Mean: 0.36m s^{-1}



Instruments: Signature 500 (S/N 103000) -21.3m AMSL
Data Quality: good **Total Records:** 4463



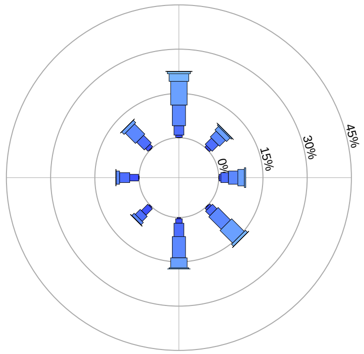


Time Zone: UTC +00:00 hours	Data Source: NWADCPB.2022.12.QC_dataReturn.nc
	moerose: 16:50 24/Feb/2023 by JTL (rose.histogram.AppendixI4.NW.B.2022.12.rose.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

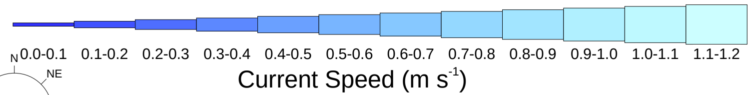
Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

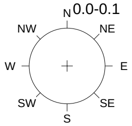
Deployment
(00:08 01 December 2022 to 23:58 31 December 2022)



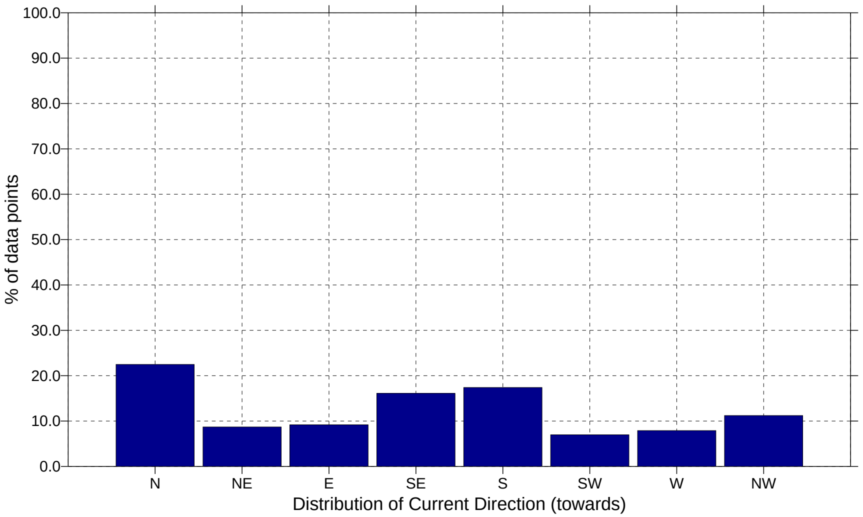
Deployment

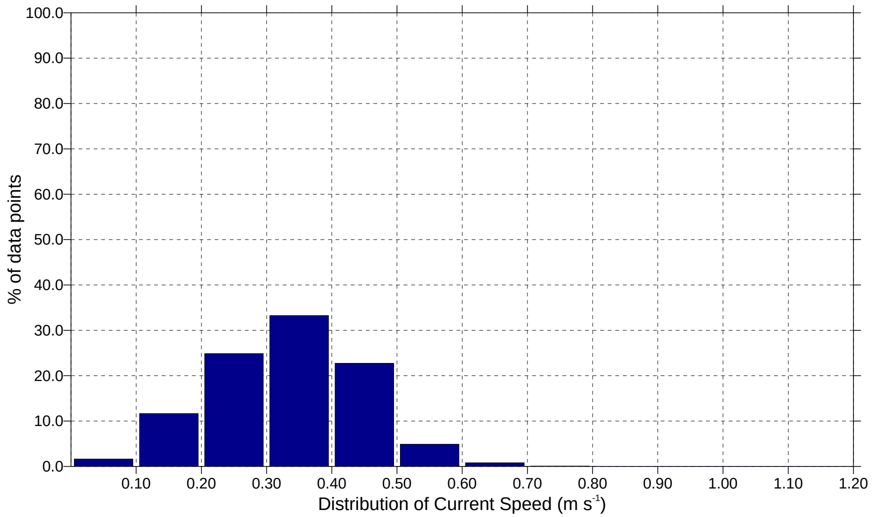
Maximum Current Speed (m s^{-1}): 0.75 towards 12.69° North
Minimum Current Speed (m s^{-1}): 0.01 towards 275.09° North
Standard deviation: 0.11 m s^{-1}
Mean: 0.33m s^{-1}





Instruments: Signature 500 (S/N 103000) -25.3m AMSL
Data Quality: good **Total Records:** 4464





Time Zone: UTC +00:00 hours	Data Source: NWADCPB.2022.12.QC_dataReturn.nc
	moerose: 16:50 24/Feb/2023 by JTL (rose.histogram.AppendixI4.NW.B.2022.12.rose.ps)

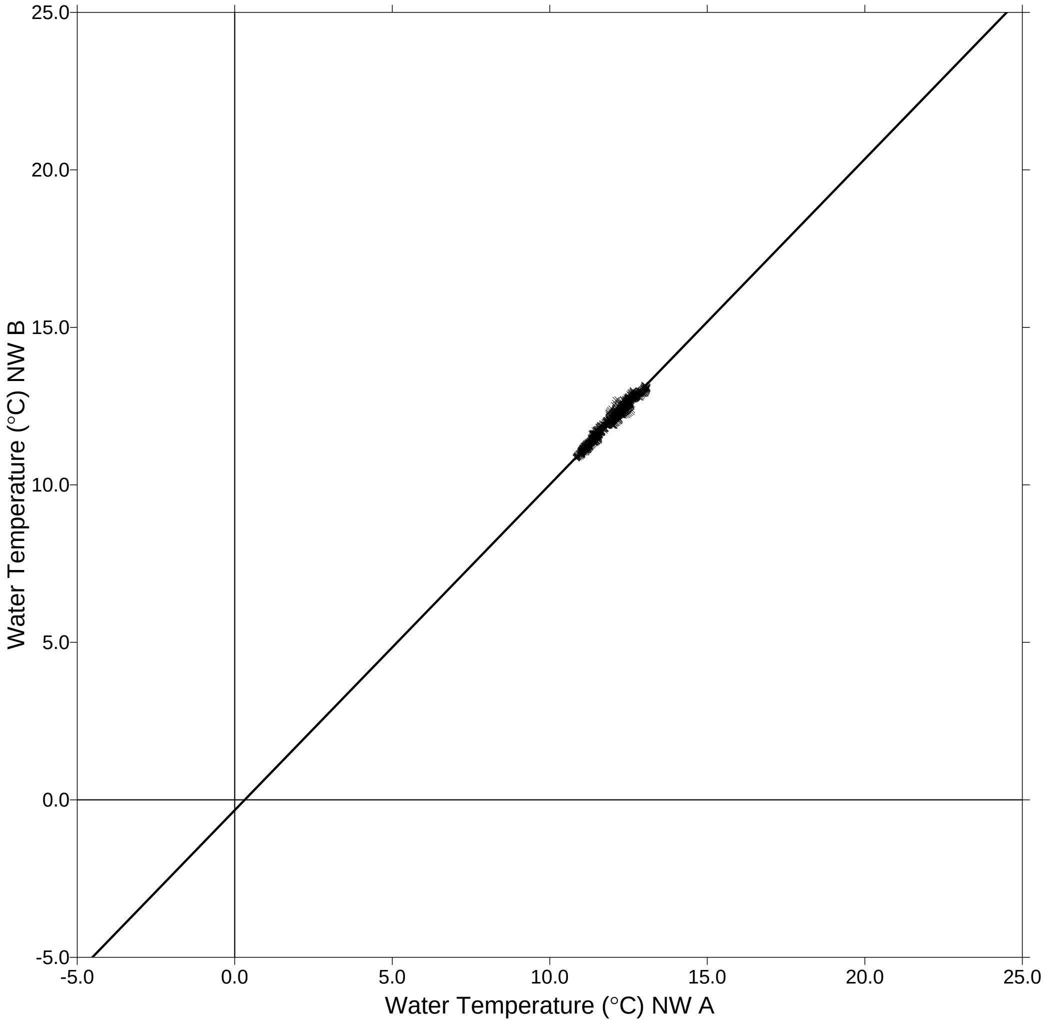
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**		
		Client:	RVO
		Project:	3707

Period: 00:08 01 December 2022 to 07:23 13 December 2022

Water Temperature (°C) NW A -1.8m AMSL Signature 500 (S/N 103318)

Water Temperature (°C) NW B -1.8m AMSL Signature 500 (S/N 103000)



Line of Best Fit (Perpendicular)			
Ordinate Intercept	= -0.329	Number of Data Points	= 1772
Slope	= 1.034	Bias	= 0.0697404
Standard Error	= 0.059	RMS error	= 0.110207
Correlation Coefficient	= 0.990	Scatter Index	= 0.00929

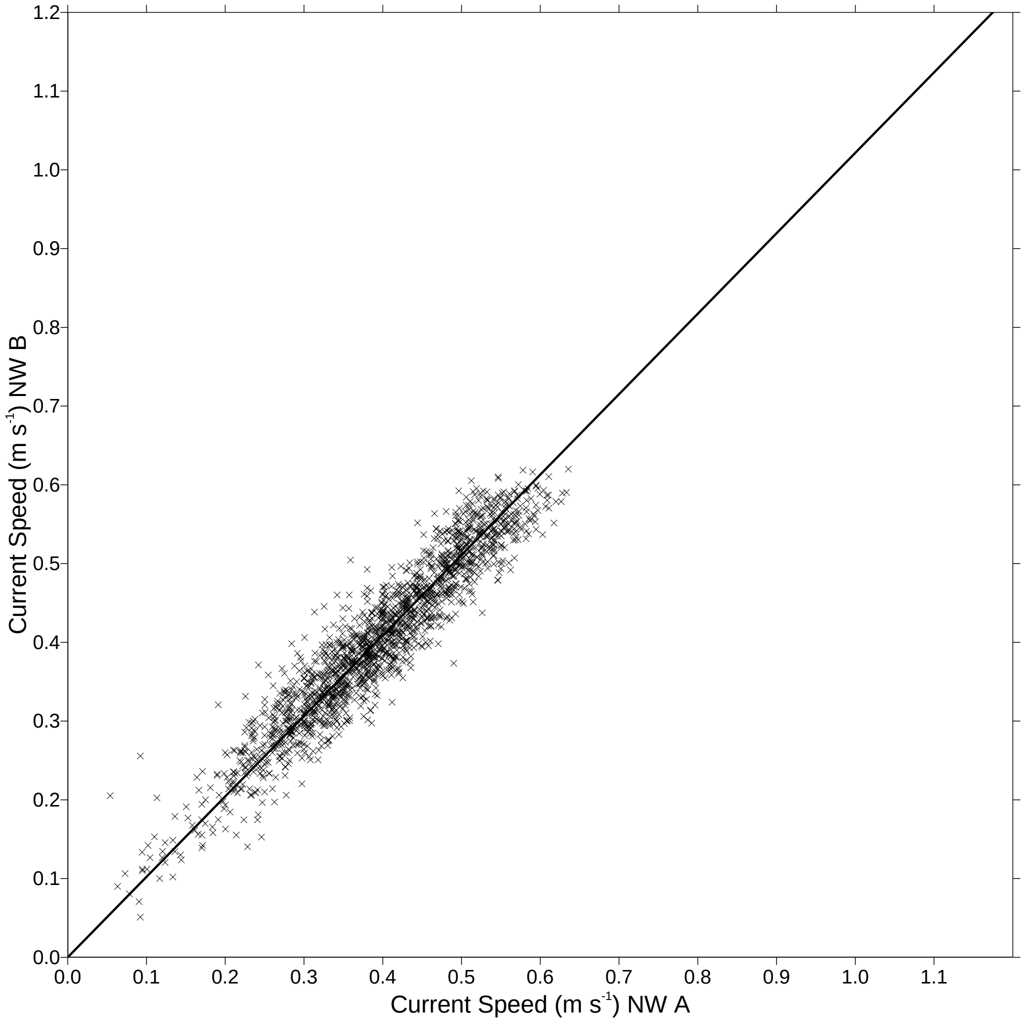
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**		
		Client:	RVO
		Project:	3707

Period: 00:08 01 December 2022 to 07:23 13 December 2022

Current Speed (m s^{-1}) NW A -9.3m AMSL Signature 500 (S/N 103318)

Current Speed (m s^{-1}) NW B -9.3m AMSL Signature 500 (S/N 103000)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 1771
Slope	= 1.022	Bias	= 0.00903279
Standard Error	= 0.024	RMS error	= 0.0353991
Correlation Coefficient	= 0.945	Scatter Index	= 0.08982

Time Zone: UTC +00:00 hours	NWADCP{A,B}.2022.12.QC_dataReturn.nc
© RPS Australia West Pty Ltd	moecorel: 16:50 24/Feb/2023 by JTL (AppendixI6.NW.2022.12.corel.ps)

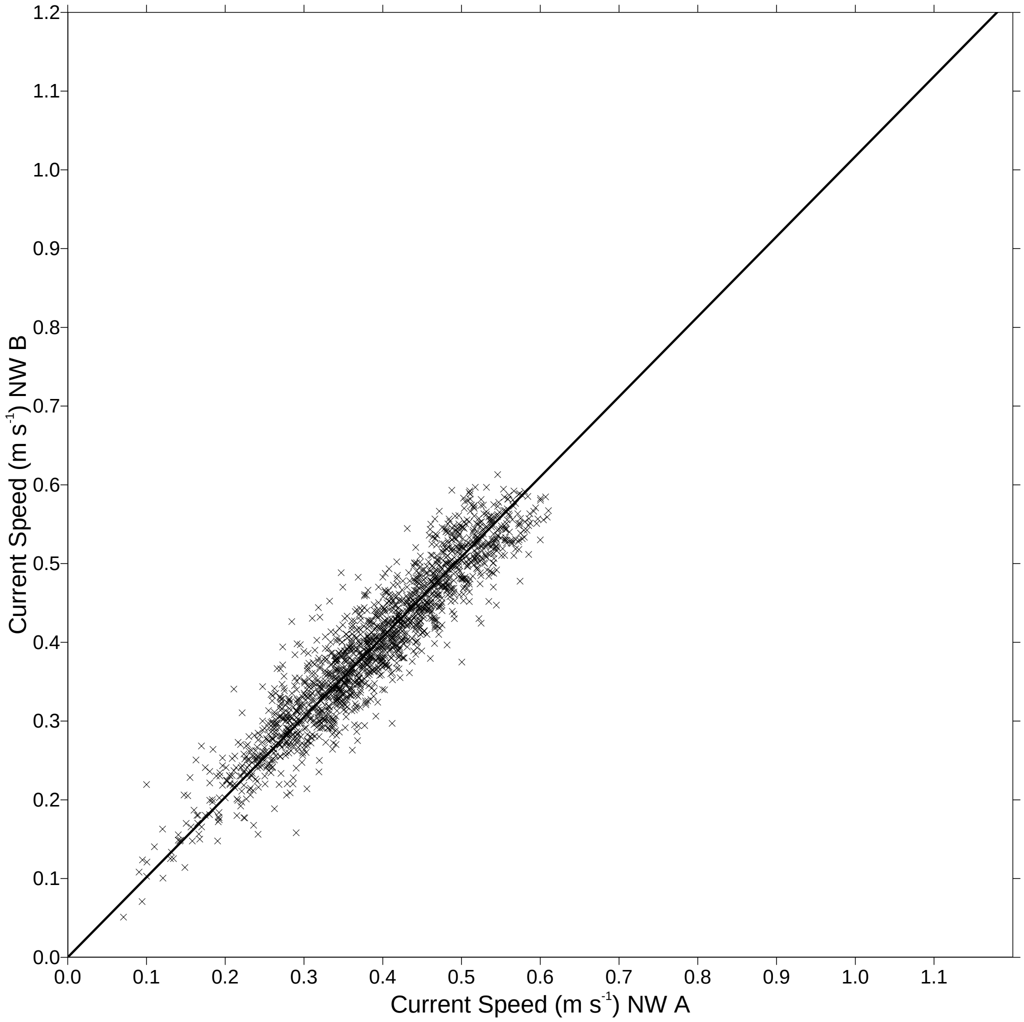
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**		
		Client:	RVO
		Project:	3707

Period: 00:08 01 December 2022 to 07:23 13 December 2022

Current Speed (m s^{-1}) NW A -13.3m AMSL Signature 500 (S/N 103318)

Current Speed (m s^{-1}) NW B -13.3m AMSL Signature 500 (S/N 103000)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 1771
Slope	= 1.017	Bias	= 0.00689854
Standard Error	= 0.025	RMS error	= 0.0358429
Correlation Coefficient	= 0.938	Scatter Index	= 0.09237

Time Zone: UTC +00:00 hours	NWADCP{A,B}.2022.12.QC_dataReturn.nc
	moecorel: 16:50 24/Feb/2023 by JTL (AppendixI6.NW.2022.12.corel.ps)

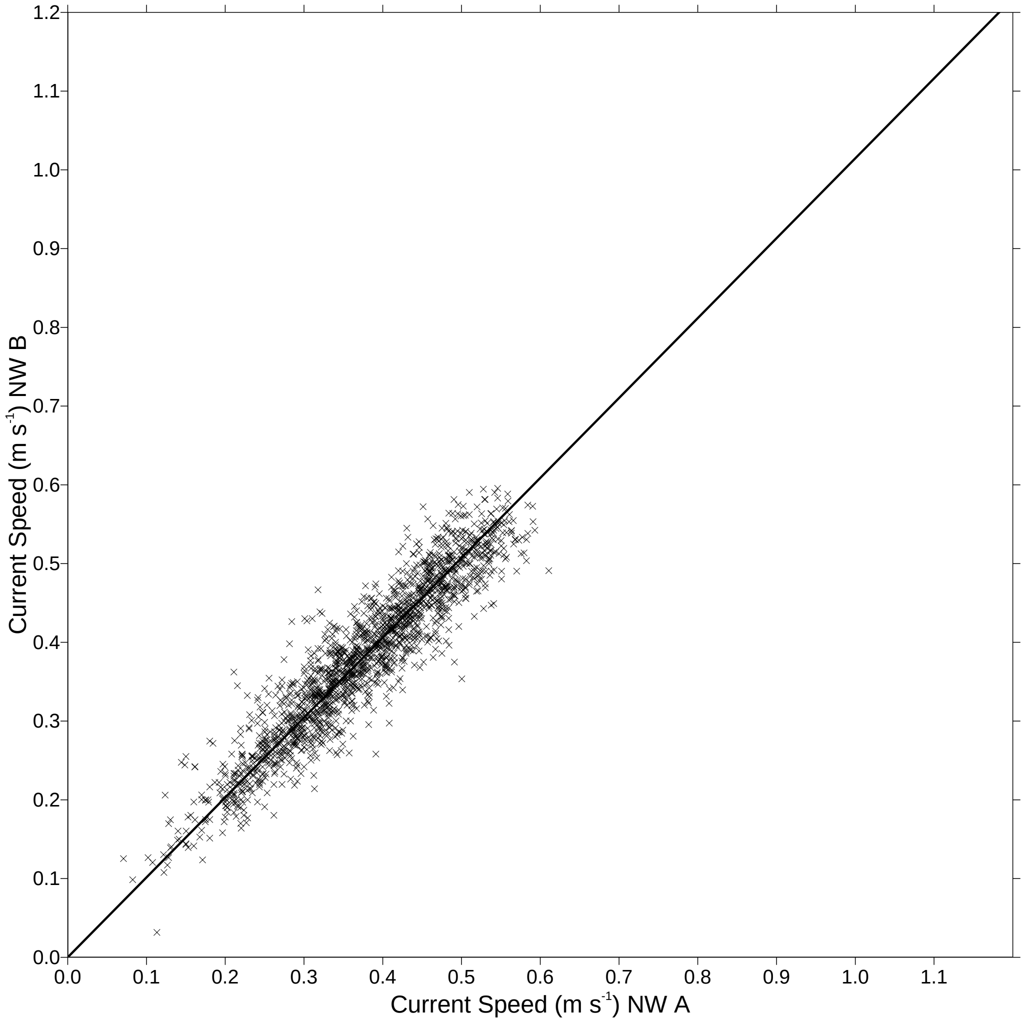
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**		
		Client:	RVO
		Project:	3707

Period: 00:08 01 December 2022 to 07:23 13 December 2022

Current Speed (m s^{-1}) NW A -17.3m AMSL Signature 500 (S/N 103318)

Current Speed (m s^{-1}) NW B -17.3m AMSL Signature 500 (S/N 103000)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 1771
Slope	= 1.015	Bias	= 0.00560269
Standard Error	= 0.026	RMS error	= 0.036743
Correlation Coefficient	= 0.932	Scatter Index	= 0.09796

Time Zone: UTC +00:00 hours	NWADCP{A,B}.2022.12.QC_dataReturn.nc
	moecorel: 16:50 24/Feb/2023 by JTL (AppendixI6.NW.2022.12.corel.ps)

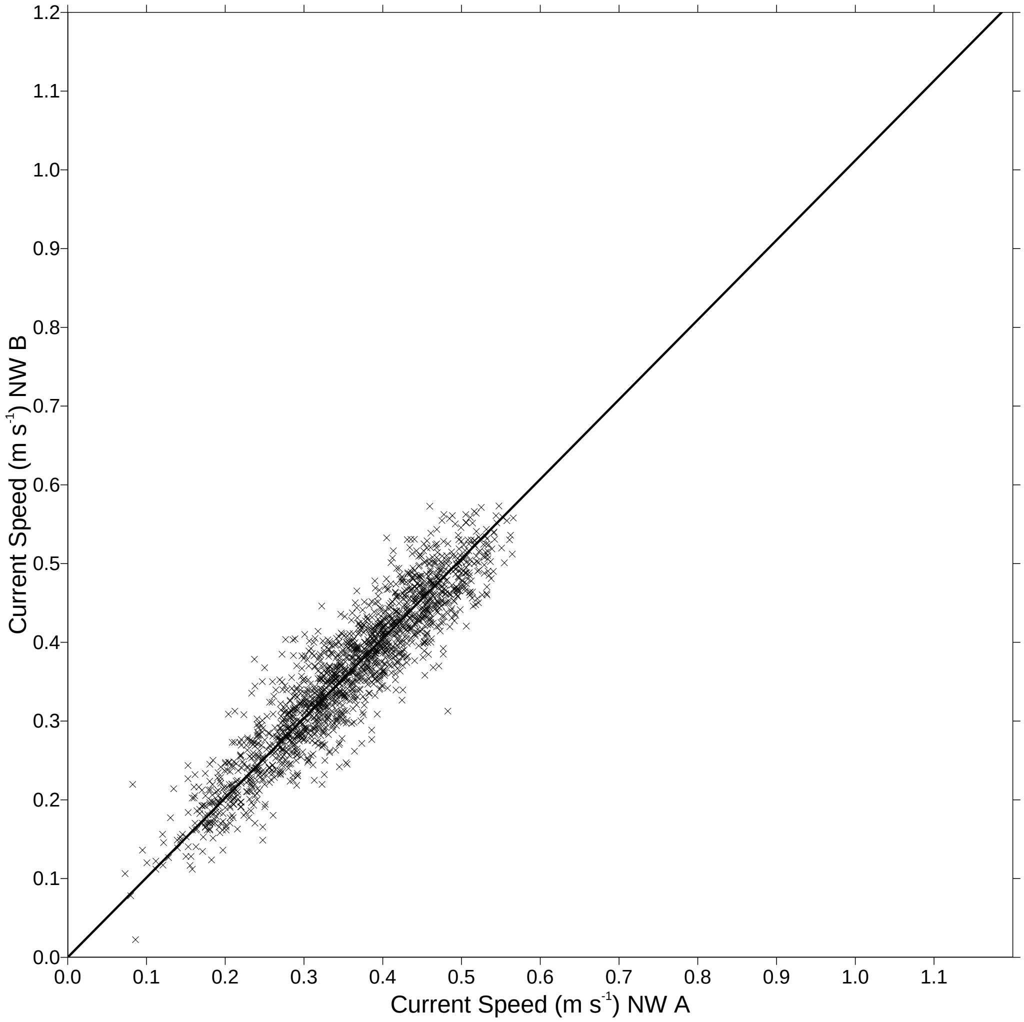
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**		
		Client:	RVO
		Project:	3707

Period: 00:08 01 December 2022 to 07:23 13 December 2022

Current Speed (m s^{-1}) NW A -21.3m AMSL Signature 500 (S/N 103318)

Current Speed (m s^{-1}) NW B -21.3m AMSL Signature 500 (S/N 103000)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 1770
Slope	= 1.012	Bias	= 0.00407069
Standard Error	= 0.026	RMS error	= 0.0369318
Correlation Coefficient	= 0.928	Scatter Index	= 0.10370

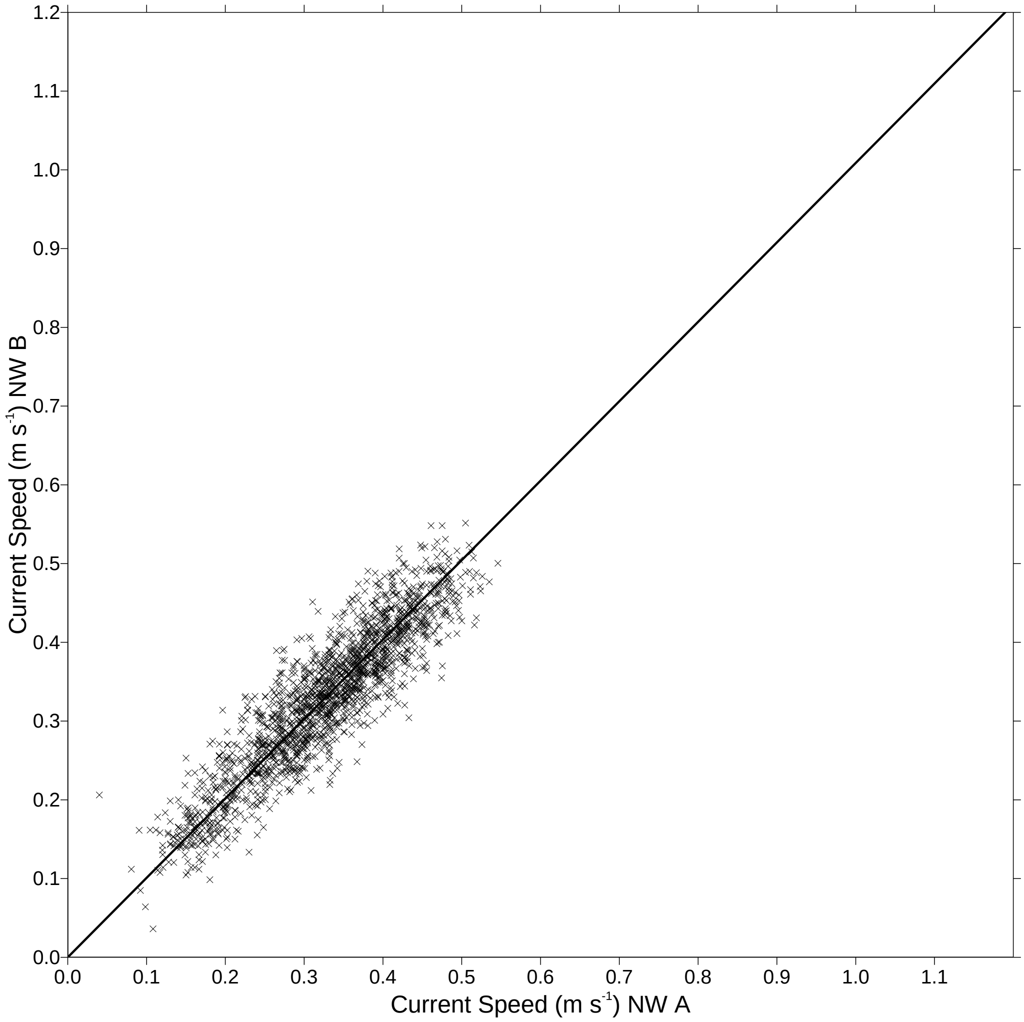
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**		
		Client:	RVO
		Project:	3707

Period: 00:08 01 December 2022 to 07:23 13 December 2022

Current Speed (m s^{-1}) NW A -25.3m AMSL Signature 500 (S/N 103318)

Current Speed (m s^{-1}) NW B -25.3m AMSL Signature 500 (S/N 103000)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 1771
Slope	= 1.009	Bias	= 0.00275643
Standard Error	= 0.028	RMS error	= 0.0396604
Correlation Coefficient	= 0.905	Scatter Index	= 0.12153

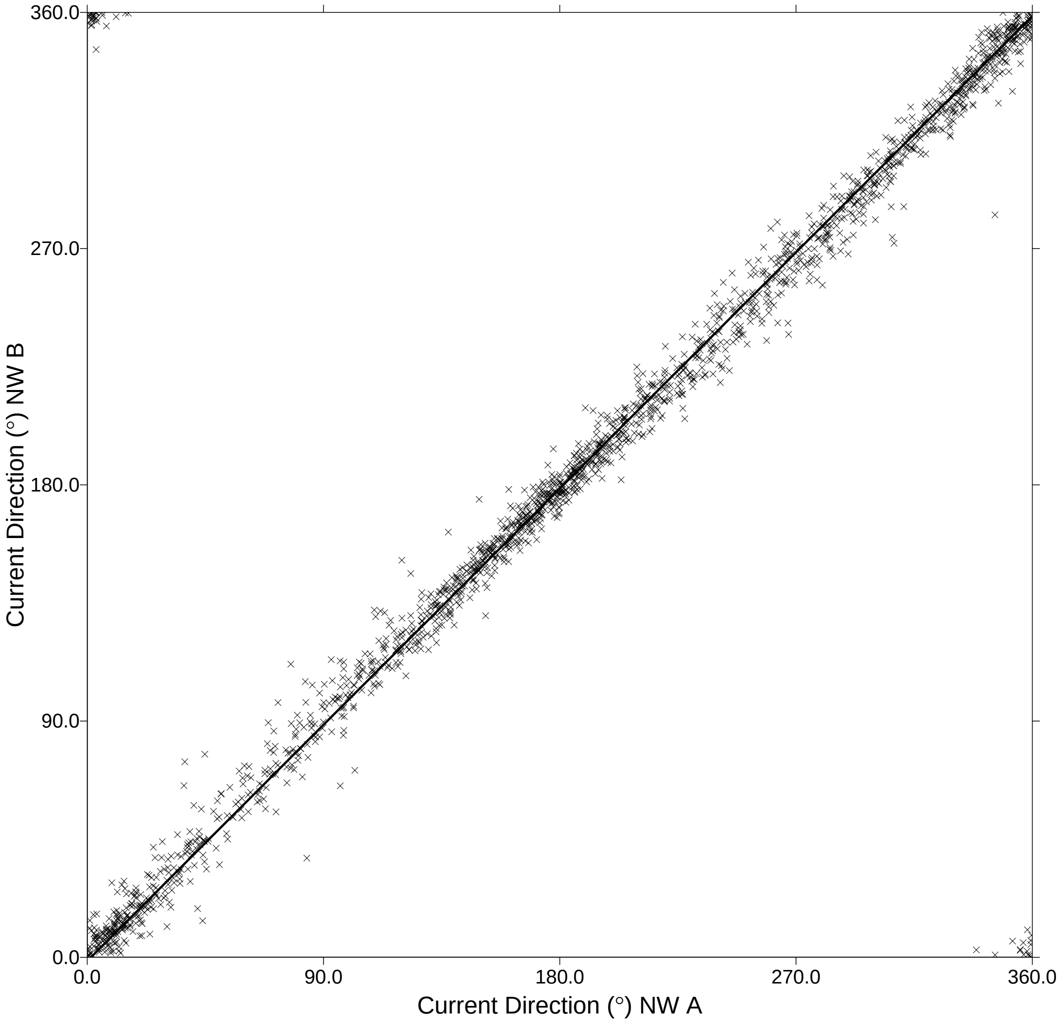
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**		
		Client:	RVO
		Project:	3707

Period: 00:08 01 December 2022 to 07:23 13 December 2022

Current Direction (°) NW A towards -9.3m AMSL Signature 500 (S/N 103318)

Current Direction (°) NW B towards -9.3m AMSL Signature 500 (S/N 103000)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -1.401	Number of Data Points	= 1772
Slope	= 1.000	Bias	= -1.40094
Standard Error	= 7.333	RMS error	= 7.46349
Correlation Coefficient	= 0.998	Scatter Index	= 0.03823

* both axes are polar variables

Time Zone: UTC +00:00 hours	NWADCP{A,B}.2022.12.QC_dataReturn.nc
	moecorel: 16:50 24/Feb/2023 by JTL (AppendixI6.NW.2022.12.corel.ps)

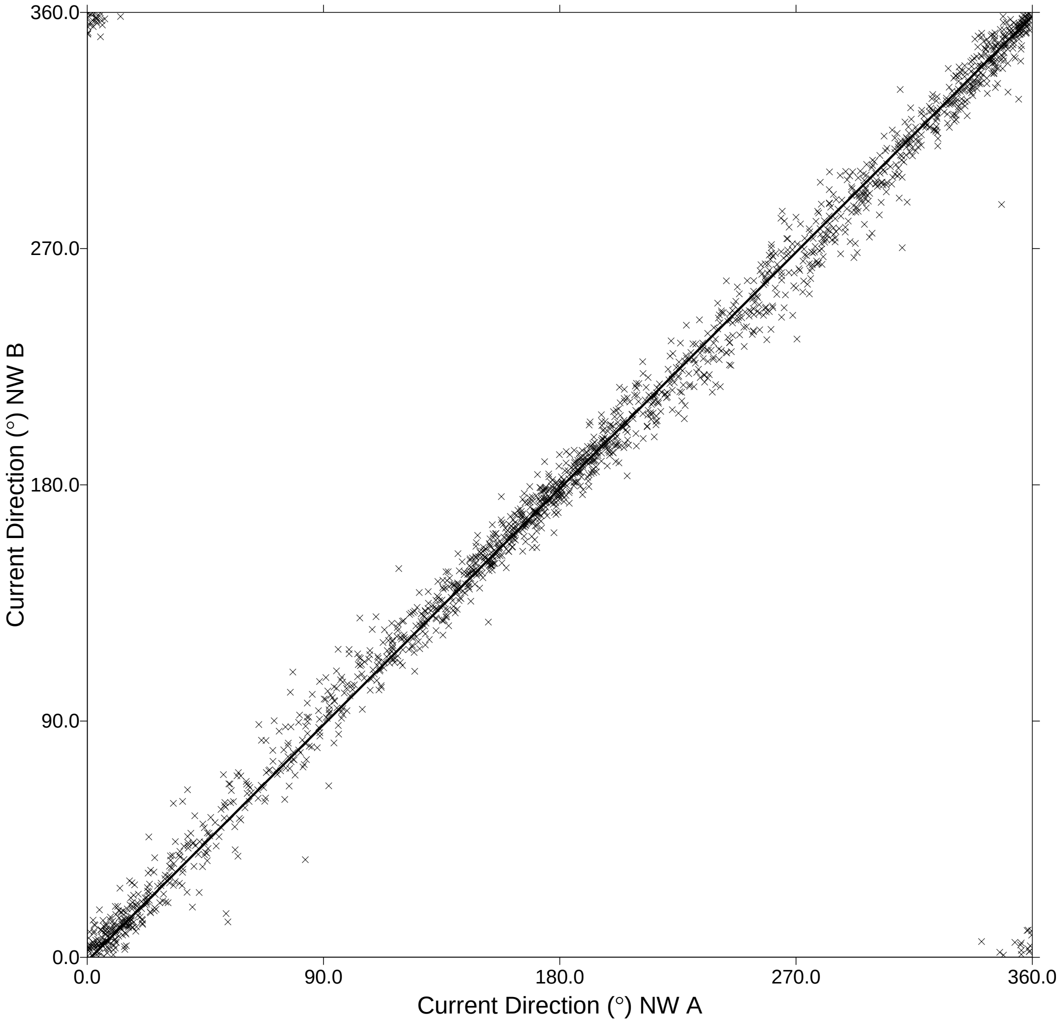
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**		
		Client:	RVO
		Project:	3707

Period: 00:08 01 December 2022 to 07:23 13 December 2022

Current Direction (°) NW A towards -13.3m AMSL Signature 500 (S/N 103318)

Current Direction (°) NW B towards -13.3m AMSL Signature 500 (S/N 103000)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -1.381	Number of Data Points	= 1772
Slope	= 1.000	Bias	= -1.38114
Standard Error	= 7.531	RMS error	= 7.65497
Correlation Coefficient	= 0.998	Scatter Index	= 0.03938

* both axes are polar variables

Time Zone: UTC +00:00 hours	NWADCP{A,B}.2022.12.QC_dataReturn.nc
	moecorel: 16:50 24/Feb/2023 by JTL (AppendixI6.NW.2022.12.corel.ps)

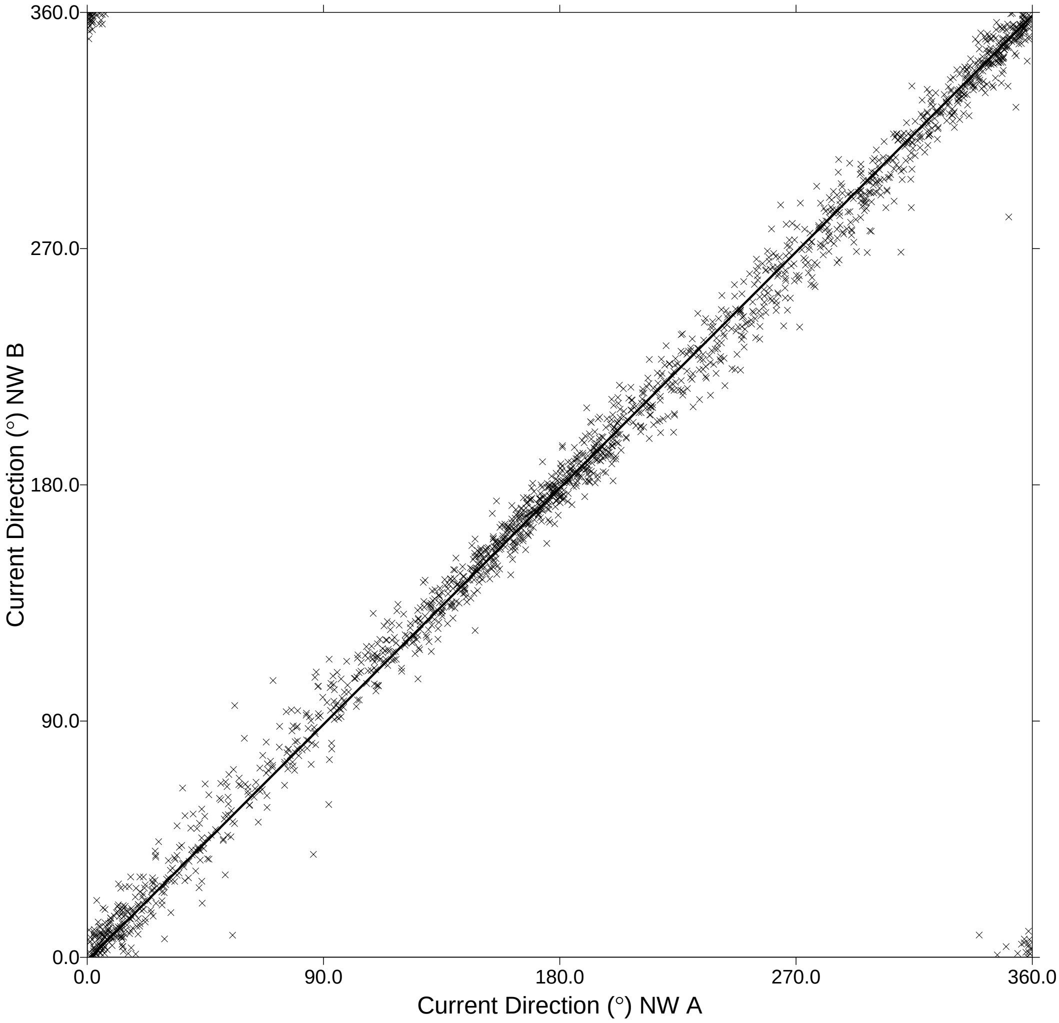
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**		
		Client:	RVO
		Project:	3707

Period: 00:08 01 December 2022 to 07:23 13 December 2022

Current Direction (°) NW A towards -17.3m AMSL Signature 500 (S/N 103318)

Current Direction (°) NW B towards -17.3m AMSL Signature 500 (S/N 103000)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -1.277	Number of Data Points	= 1772
Slope	= 1.000	Bias	= -1.27713
Standard Error	= 7.802	RMS error	= 7.90391
Correlation Coefficient	= 0.997	Scatter Index	= 0.04068

* both axes are polar variables

Time Zone: UTC +00:00 hours	NWADCP{A,B}.2022.12.QC_dataReturn.nc
	moecorel: 16:50 24/Feb/2023 by JTL (AppendixI6.NW.2022.12.corel.ps)

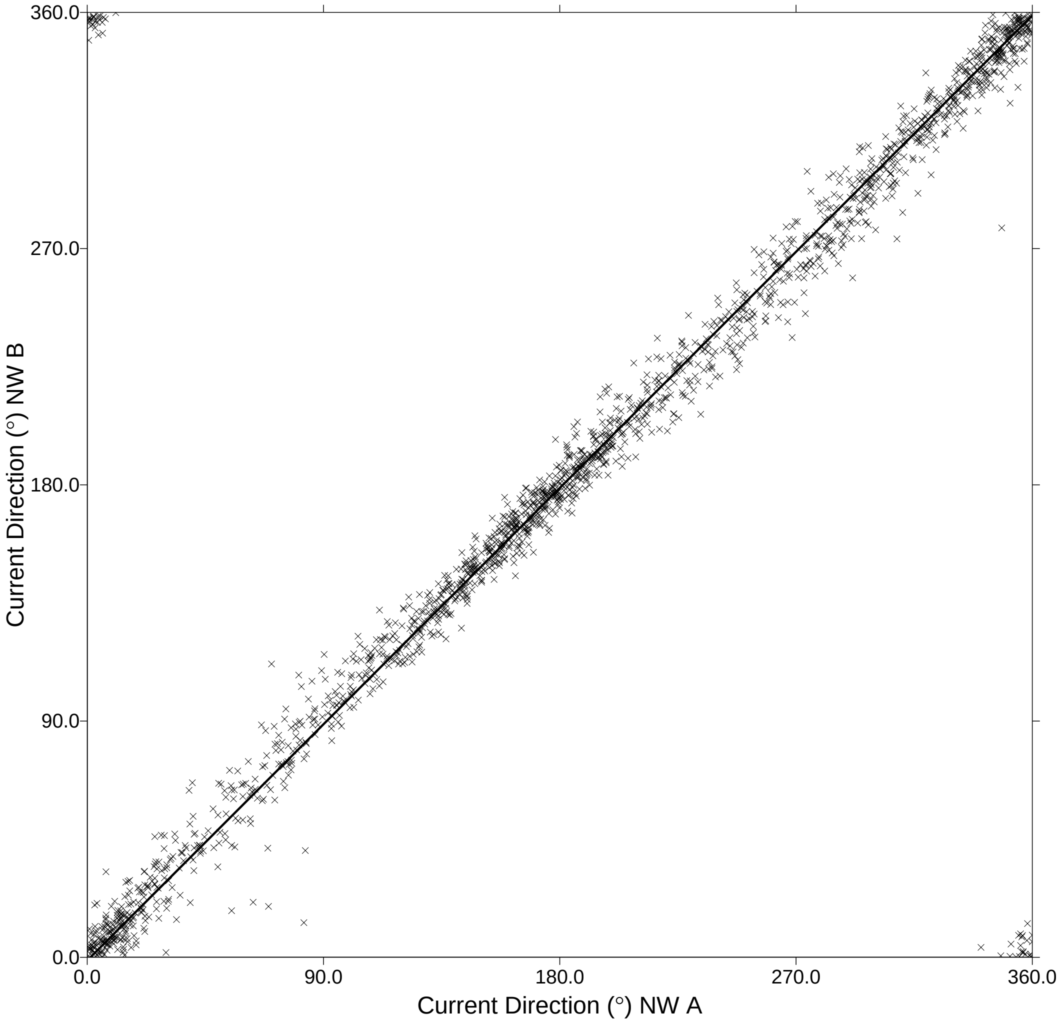
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**		
		Client:	RVO
		Project:	3707

Period: 00:08 01 December 2022 to 07:23 13 December 2022

Current Direction (°) NW A towards -21.3m AMSL Signature 500 (S/N 103318)

Current Direction (°) NW B towards -21.3m AMSL Signature 500 (S/N 103000)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -1.220	Number of Data Points	= 1772
Slope	= 1.000	Bias	= -1.22038
Standard Error	= 8.452	RMS error	= 8.53777
Correlation Coefficient	= 0.997	Scatter Index	= 0.04367

* both axes are polar variables

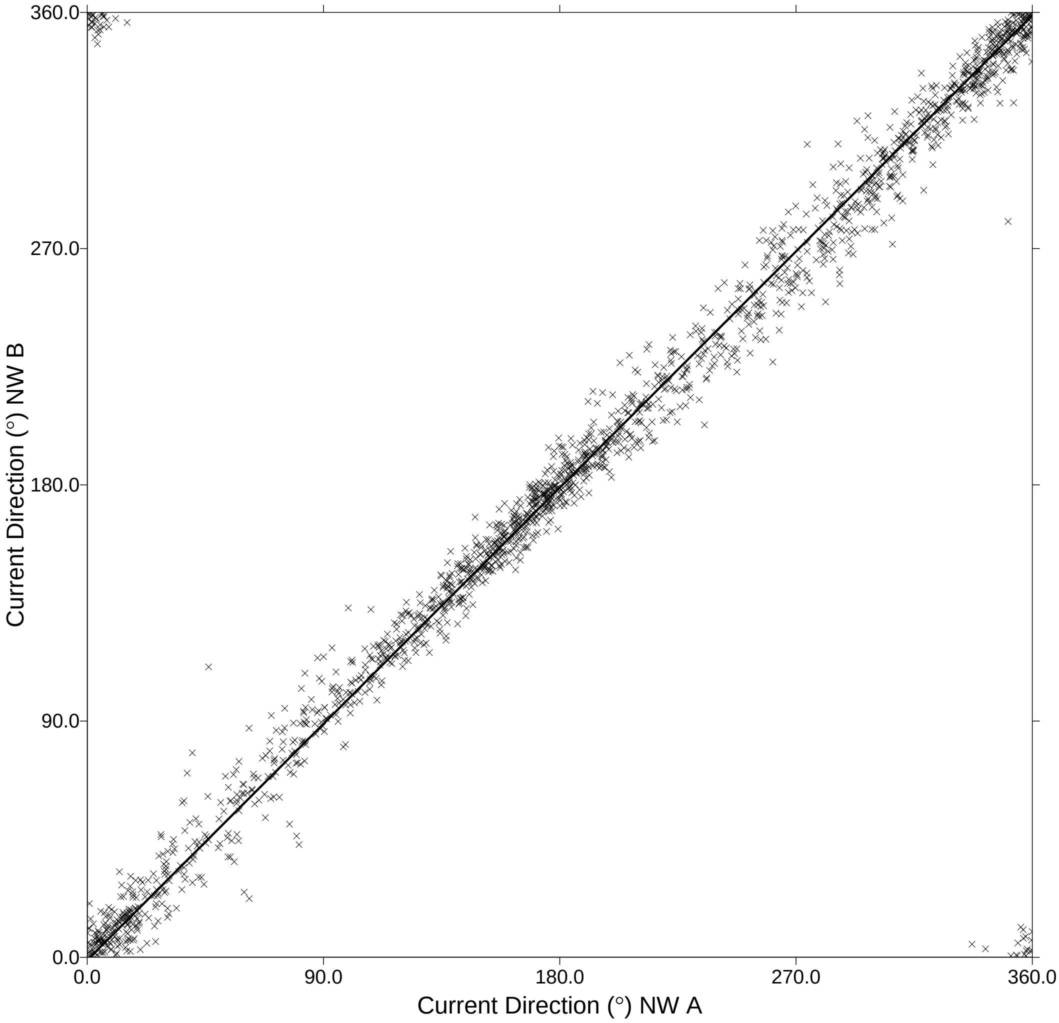
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**		
		Client:	RVO
		Project:	3707

Period: 00:08 01 December 2022 to 07:23 13 December 2022

Current Direction (°) NW A towards -25.3m AMSL Signature 500 (S/N 103318)

Current Direction (°) NW B towards -25.3m AMSL Signature 500 (S/N 103000)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -1.066	Number of Data Points	= 1772
Slope	= 1.000	Bias	= -1.06624
Standard Error	= 9.000	RMS error	= 9.06002
Correlation Coefficient	= 0.997	Scatter Index	= 0.04580

* both axes are polar variables

Appendix J
Tide Measurements

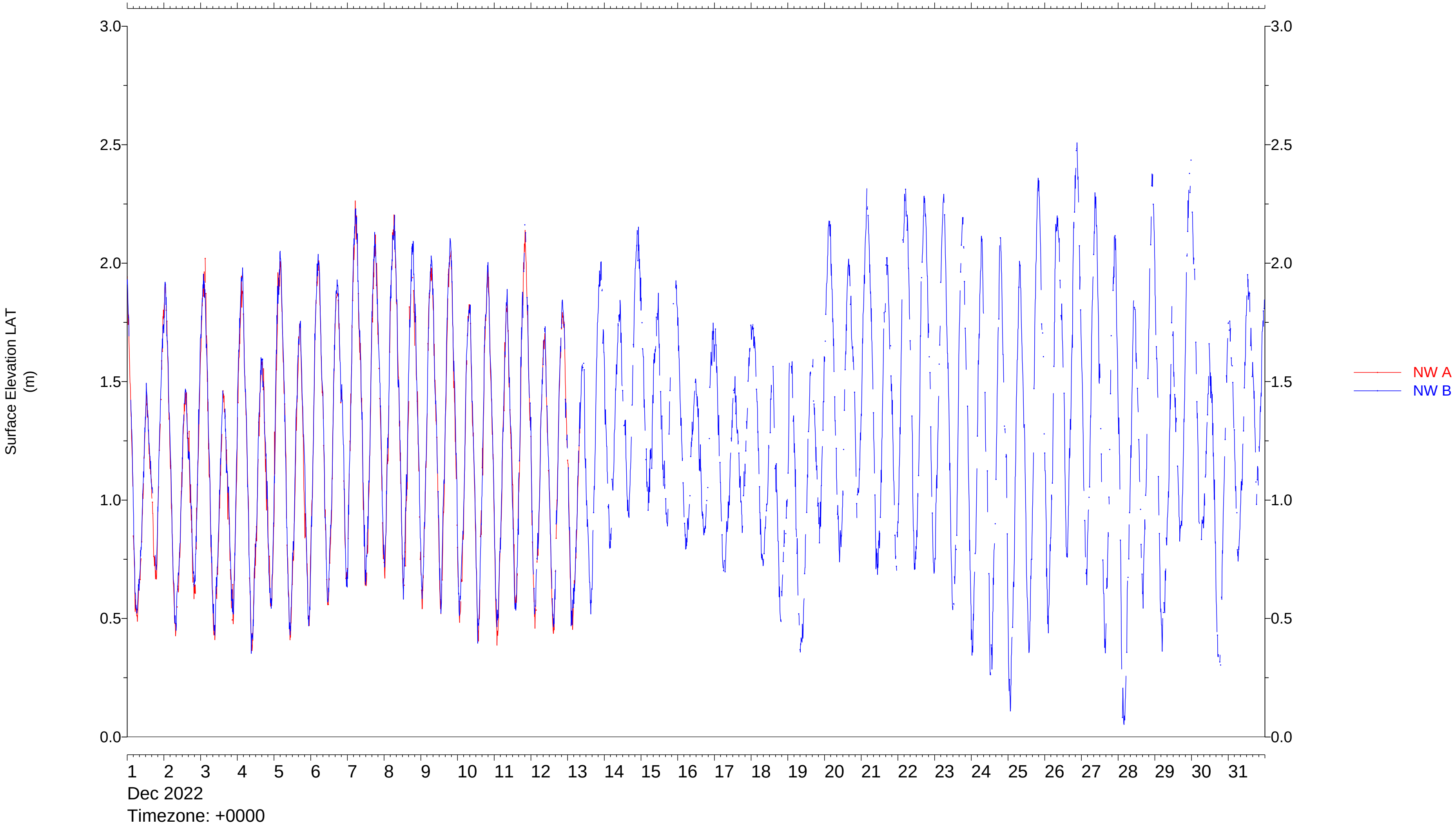
Standard analysis of the processed data was undertaken to produce the following presentations:

- NW A versus NW B monthly time history overlay plots of measured water levels.
- Monthly data availability bar charts for water level at each site.
- Statistics tables of tide height for each site.
- NW A versus NW B monthly correlation plots of water levels.

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location: **NW**

Client: RVO
Project: J3707

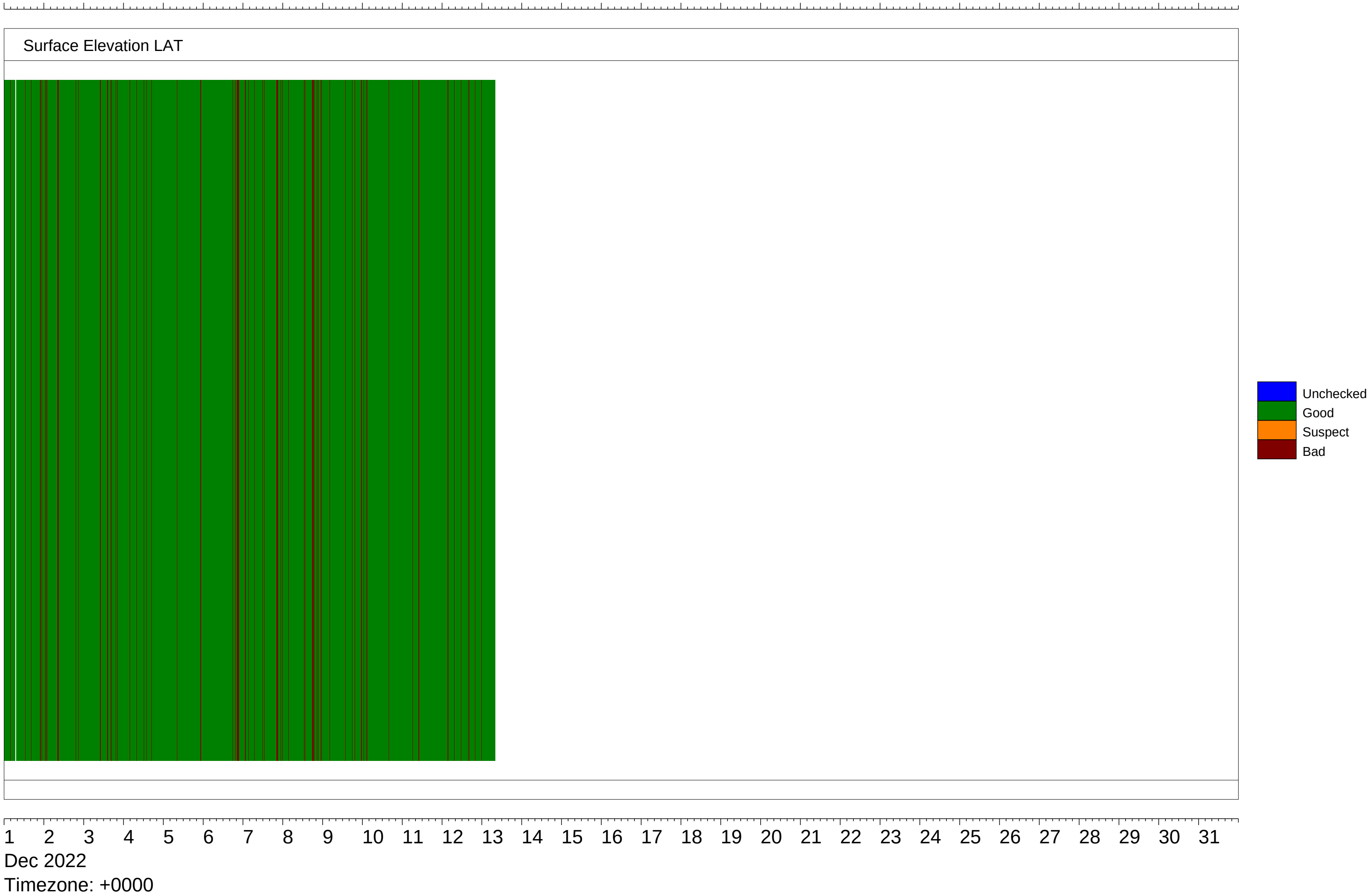


Time Zone: UTC +00:00 hours NWTide{A,B}.2022.12.QC_dataReturn.nc

 moetimehist: 10:56 27/Feb/2023 by JTL (AppendixJ1.NW.2022.12.overlay.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

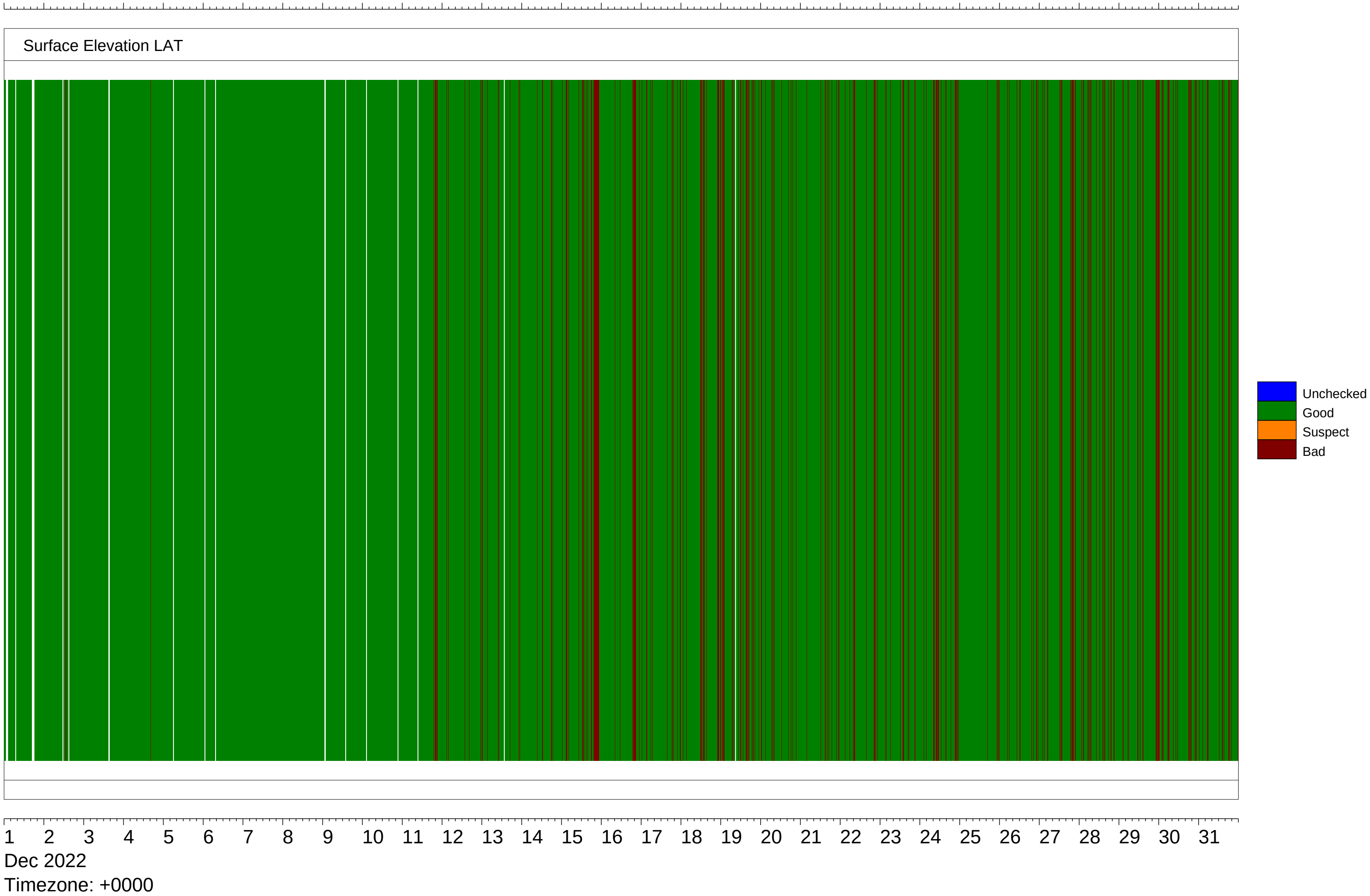
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		



Time Zone: UTC +00:00 hours	Data Source: NWTideA.2022.12.QC_dataReturn.nc
© RPS Australia West Pty Ltd	moetimehist: 10:56 27/Feb/2023 by JTL (AppendixJ1.NW.A.2022.12.barchart.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		



Time Zone: UTC +00:00 hours	Data Source: NWTideB.2022.12.QC_dataReturn.nc
	moetimehist: 10:56 27/Feb/2023 by JTL (AppendixJ1.NW.B.2022.12.barchart.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 08:00 13 December 2022
Surface Elevation LAT (m)

	Surface Elevation LAT (m)															
	Statistics				Total	Exceedence Percentile Surface Elevation LAT (m)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
December 2022	0.36	2.26	1.21	0.4693	1630	0.44	0.51	0.59	0.79	1.19	1.51	1.70	1.86	1.96	2.05	2.12

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWTideA.2022.12.QC_dataReturn.nc
	moematrix: 10:56 27/Feb/2023 by JTL (./stats_AppendixJ2.NW.A.2022.12.statistics.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 23:50 31 December 2022
Surface Elevation LAT (m)

	Surface Elevation LAT (m)															
	Statistics				Total	Exceedence Percentile Surface Elevation LAT (m)										
	Min	Max	Mean	Std. Dev	Records	99.0	95.0	90.0	75.0	50.0	30.0	20.0	10.0	5.0	2.0	1.0
December 2022	0.05	2.51	1.28	0.4898	3941	0.35	0.53	0.64	0.88	1.27	1.58	1.75	1.95	2.09	2.20	2.28

Expected Record Interval: 10.00 minutes.

Time Zone: UTC +00:00 hours	Data Source: NWTideB.2022.12.QC_dataReturn.nc
	moematrix: 10:56 27/Feb/2023 by JTL (./stats_AppendixJ2.NW.B.2022.12.statistics.ps)

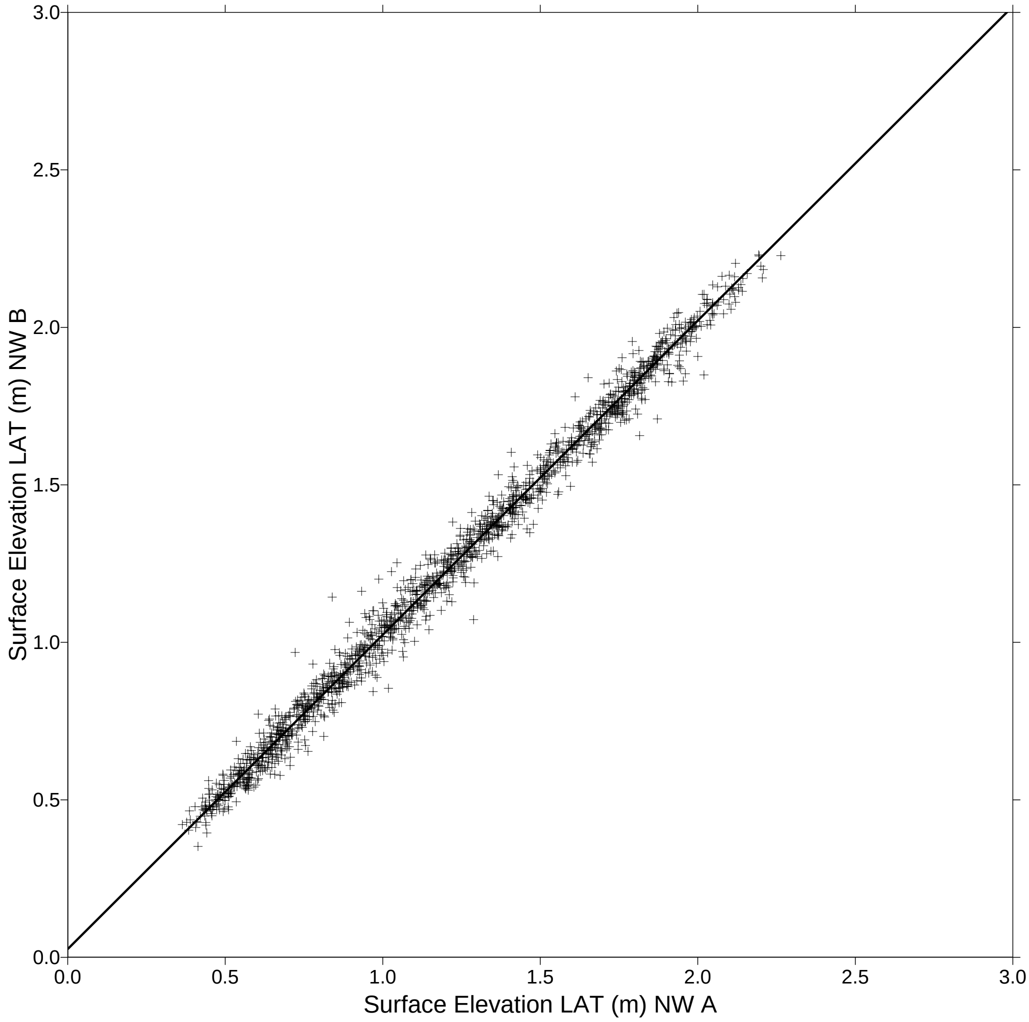
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**		
		Client:	RVO
		Project:	J3707

Period: 00:00 01 December 2022 to 08:00 13 December 2022

Surface Elevation LAT (m) NW A OEM7700 (S/N DMMU 21200157D)

Surface Elevation LAT (m) NW B OEM7700 (S/N BMHR 21420112P)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.026	Number of Data Points	= 1550
Slope	= 0.998	Bias	= 0.0233196
Standard Error	= 0.034	RMS error	= 0.0529605
Correlation Coefficient	= 0.995	Scatter Index	= 0.04387

Time Zone: UTC +00:00 hours	NWTide{A,B}.2022.12.QC_dataReturn.nc
	moecorel: 10:56 27/Feb/2023 by JTL (AppendixJ3.NW.2022.12.corel.ps)

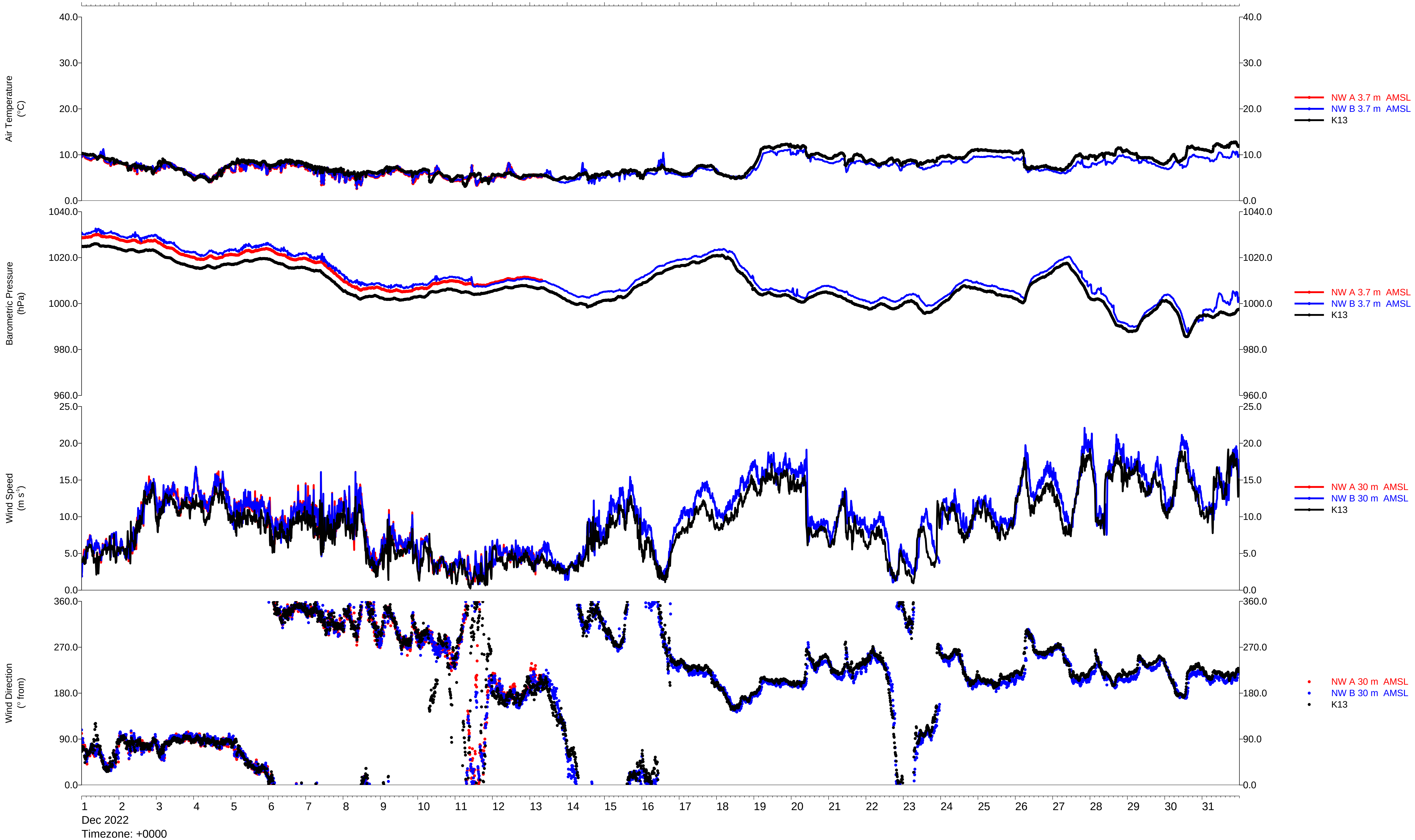
Appendix K
Independent Validation

Standard analysis of the processed data was undertaken to produce the following presentations of measured versus independent data:

- Monthly time history overlay plots of wind speed, wind direction, air temperature and barometric pressure.
- Monthly correlation plots of wind speed, wind direction, air temperature and barometric pressure.
- Monthly time history overlay plots of H_s, T_z, and θ_m.
- Monthly correlation plots of H_s, T_z, and θ_m.
- Monthly time history overlay plots of current speed, current direction, and water temperature.
- Monthly correlation plots of current speed and direction at ~10 and 20 m BSL, and water temperature.
- Monthly rose plots and histograms of current speed and direction.
- Monthly time history overlay plots of tide heights.
- Monthly correlation plots of tide heights.

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

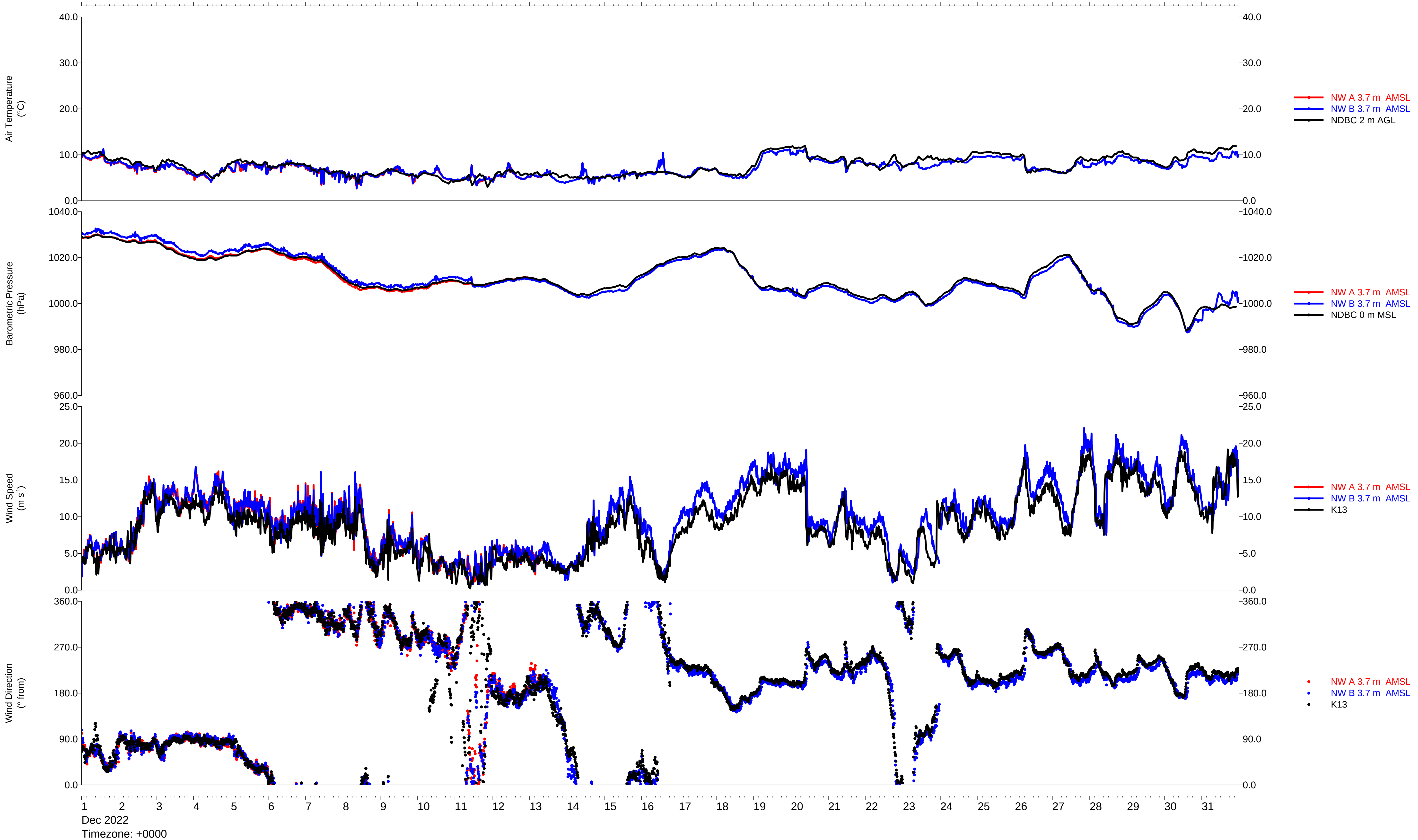
Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		



Time Zone: UTC +00:00 hours	NWWind{A,B}.2022.12.{QC_dataReturn,OtherWinds}.nc, validationSite.2022.12.nc
© RPS Australia West Pty Ltd	moetimehist: 16:29 24/Feb/2023 by MWB (AppendixK1a.NW.val.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

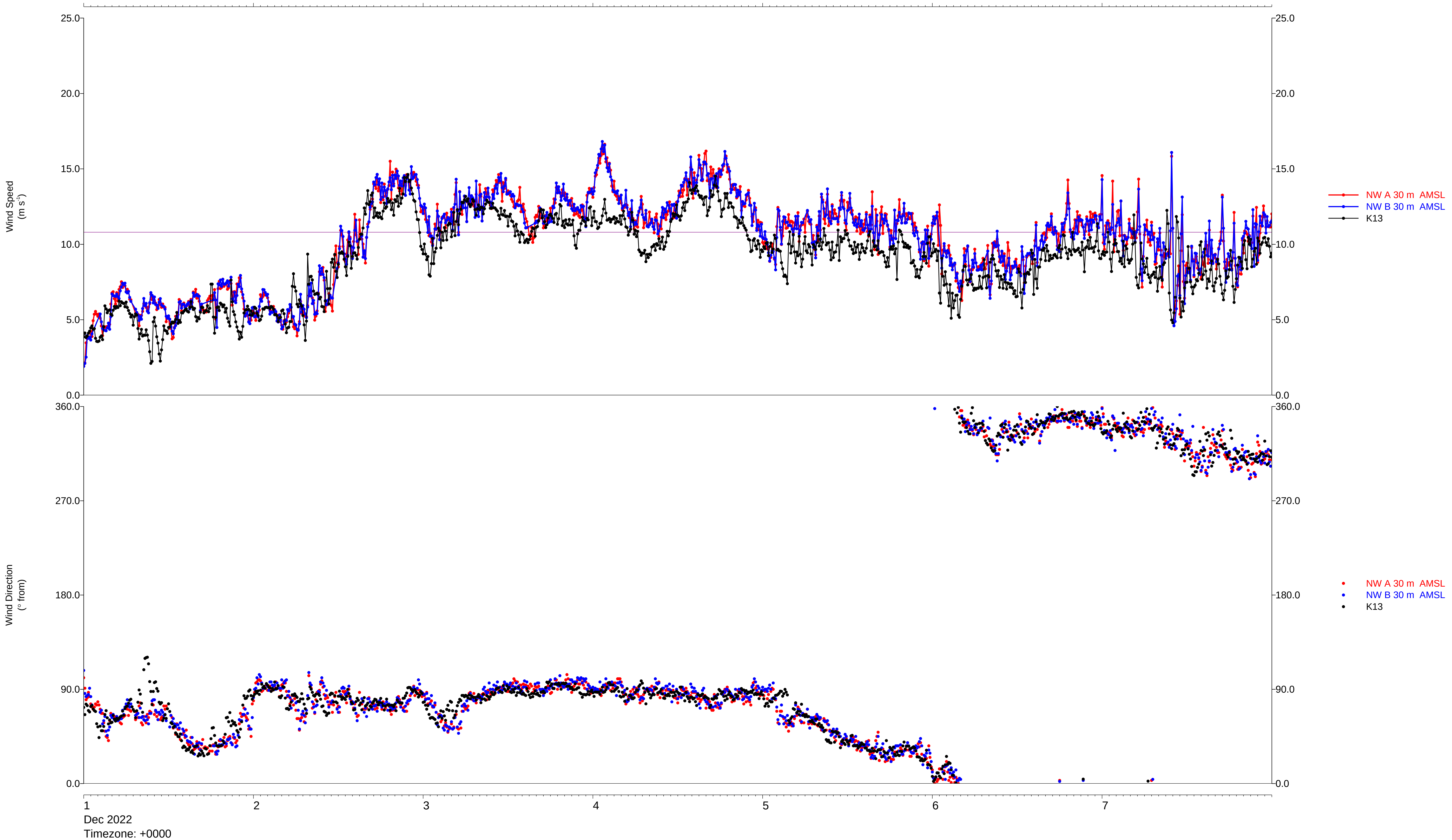


Time Zone: UTC +00:00 hours	NWWind{A,B}.2022.12.{QC_dataReturn,OtherWinds}.nc, validationSite.2022.12.nc
	moetimehist: 16:29 24/Feb/2023 by MWB (AppendixK1a.NW.val.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location: NW

Client: RVO
Project: J3707

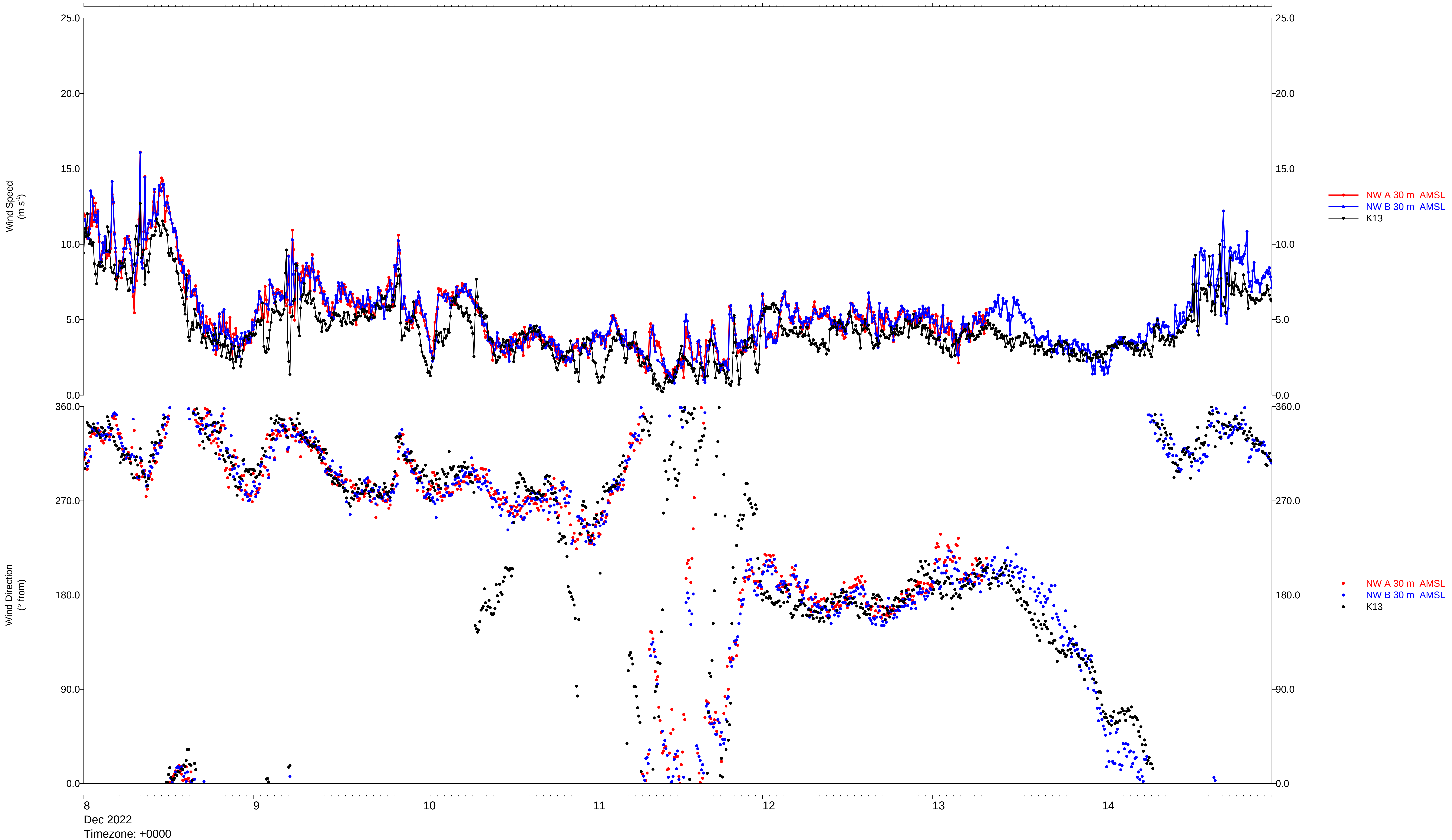


Time Zone: UTC +00:00 hours NWWind{A,B}.2022.12.QC_dataReturn.nc, NWWind{A,B}.2022.12.OtherWinds.nc, validationSite.2022.12.nc

 moetimehist: 16:29 24/Feb/2023 by MWB (AppendixK1b.NW.ABH.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**	
		Client: RVO
		Project: J3707

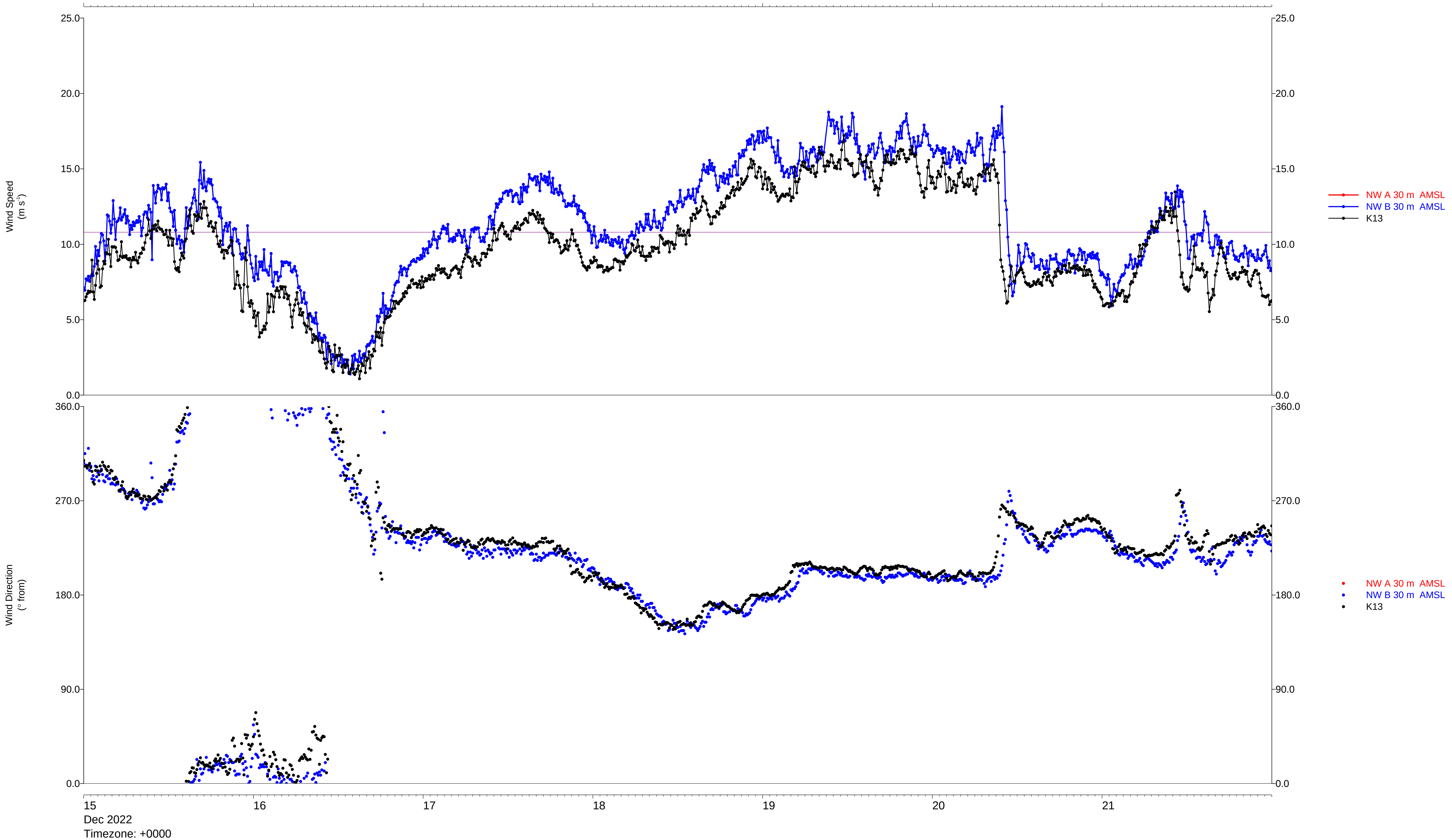


Time Zone: UTC +00:00 hours	NWWind{A,B}.2022.12.QC_dataReturn.nc, NWWind{A,B}.2022.12.OtherWinds.nc, validationSite.2022.12.nc
© RPS Australia West Pty Ltd	moetimehist: 16:29 24/Feb/2023 by MWB (AppendixK1b.NW.ABH.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location: NW

Client: RVO
Project: J3707

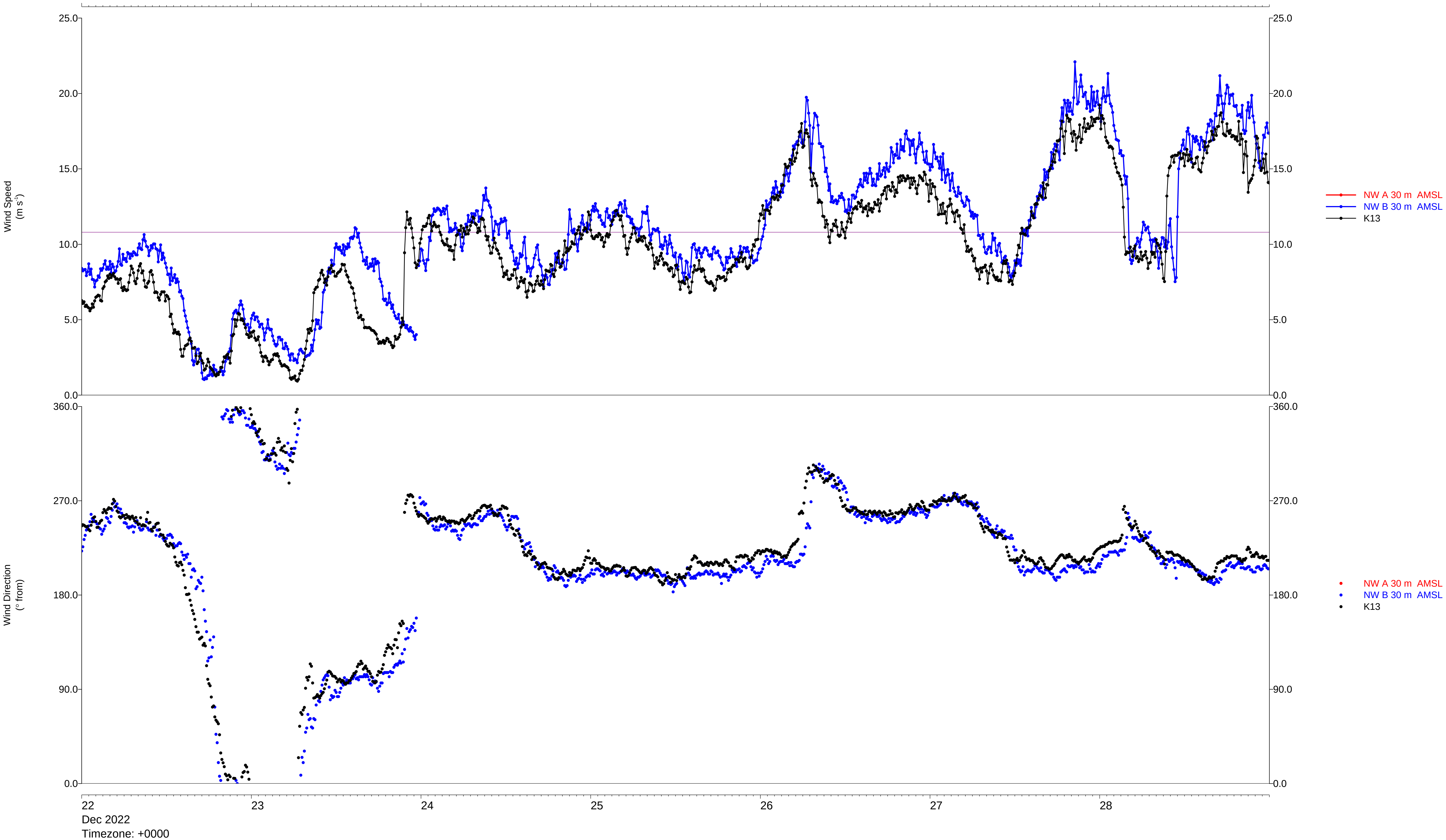


Time Zone: UTC +00:00 hours NWWind{A,B}.2022.12.QC_dataReturn.nc, NWWind{A,B}.2022.12.OtherWinds.nc, validationSite.2022.12.nc

 moetimehist: 16:29 24/Feb/2023 by MWB (AppendixK1b.NW.ABH.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

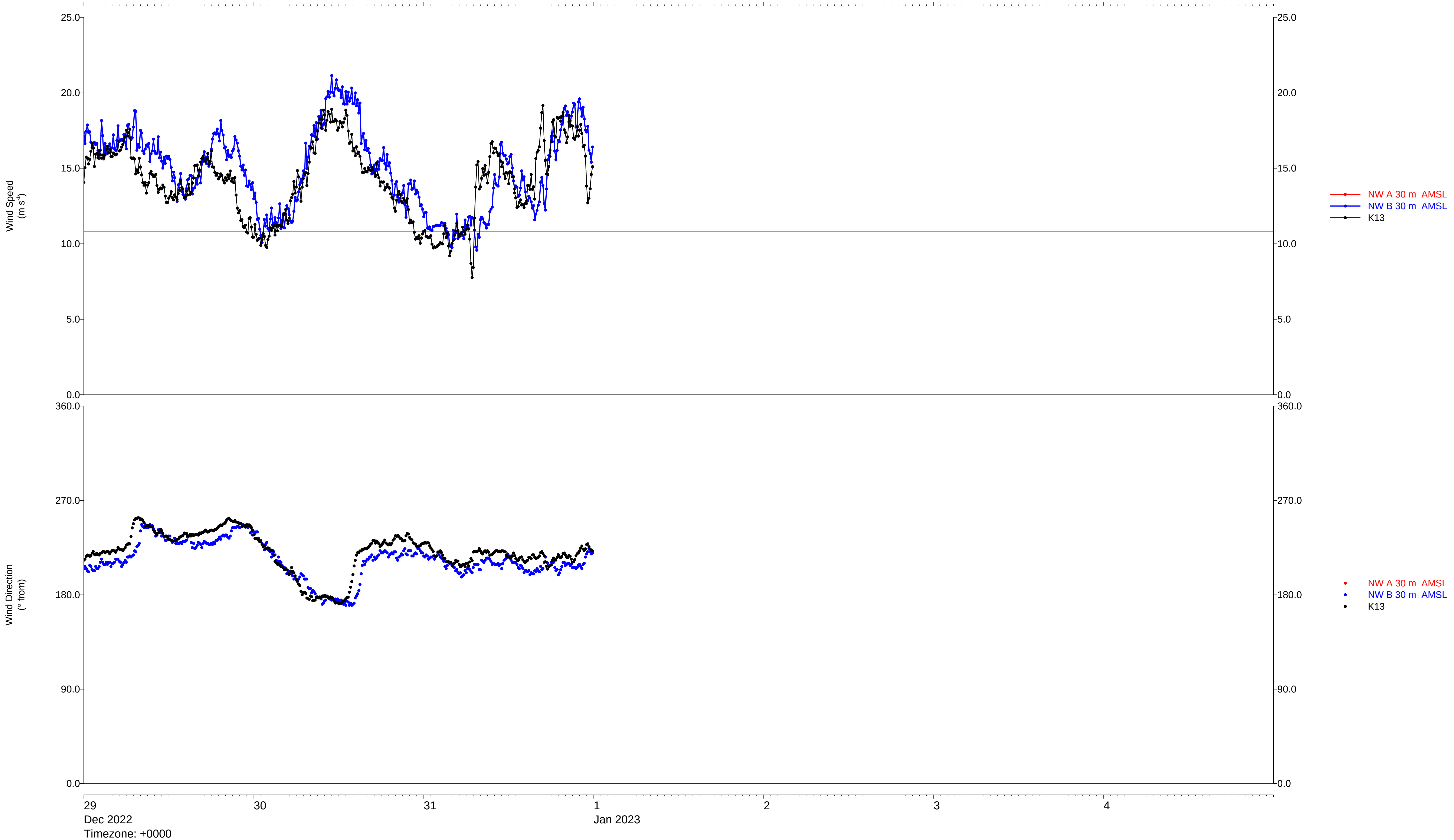
Location:	**NW**	
		Client: RVO
		Project: J3707



Time Zone: UTC +00:00 hours	NWWind{A,B}.2022.12.QC_dataReturn.nc, NWWind{A,B}.2022.12.OtherWinds.nc, validationSite.2022.12.nc
© RPS Australia West Pty Ltd	moetimehist: 16:29 24/Feb/2023 by MWB (AppendixK1b.NW.ABH.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**	Client: RVO Project: J3707



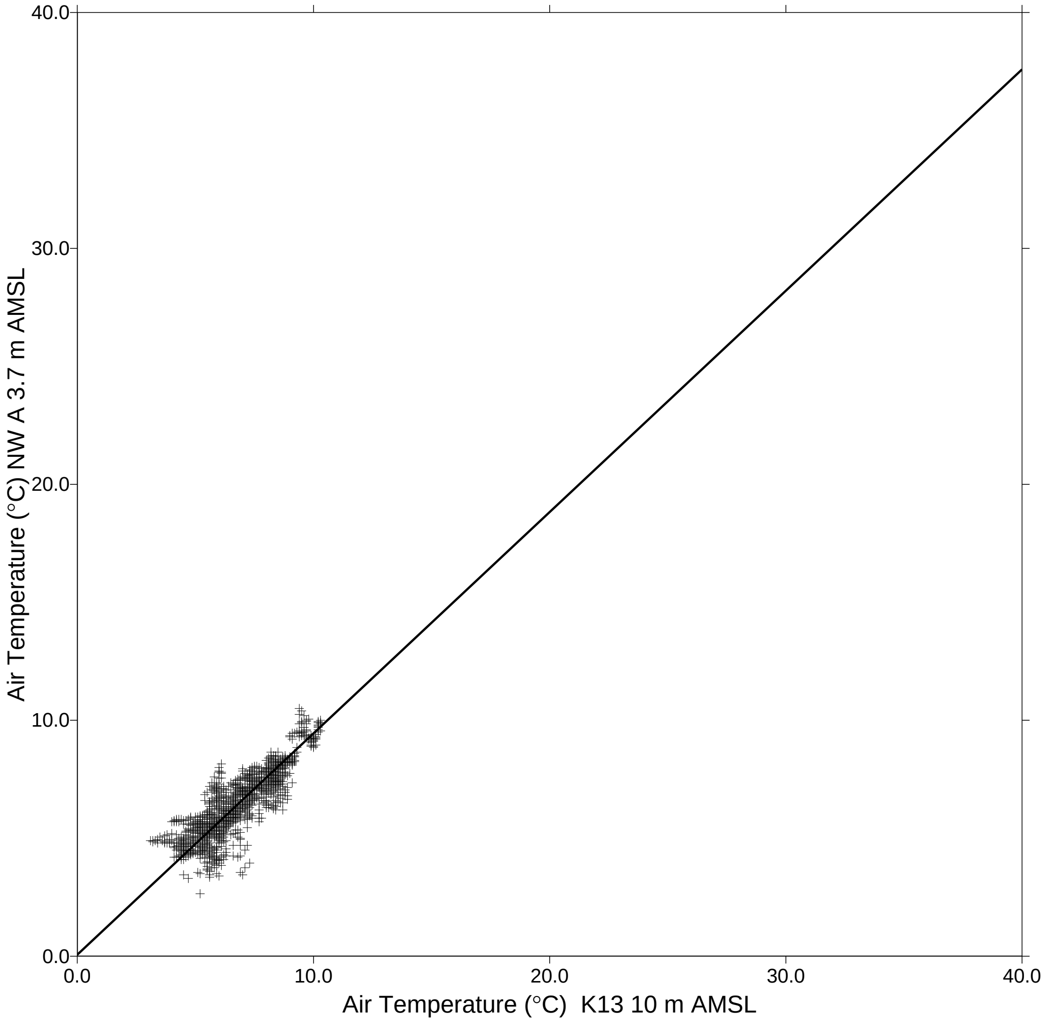
Time Zone: UTC +00:00 hours	NWWind{A,B}.2022.12.QC_dataReturn.nc, NWWind{A,B}.2022.12.OtherWinds.nc, validationSite.2022.12.nc
© RPS Australia West Pty Ltd	moetimehist: 16:29 24/Feb/2023 by MWB (AppendixK1b.NW.ABH.week.ps)

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:40 13 December 2022

Air Temperature (°C) K13 10 m AMSL

Air Temperature (°C) NW A 3.7 m AMSL Airmar 150WX (S/N 60663334)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.064	Number of Data Points	= 1771
Slope	= 0.938	Bias	= -0.354687
Standard Error	= 0.509	RMS error	= 0.806459
Correlation Coefficient	= 0.872	Scatter Index	= 0.11918

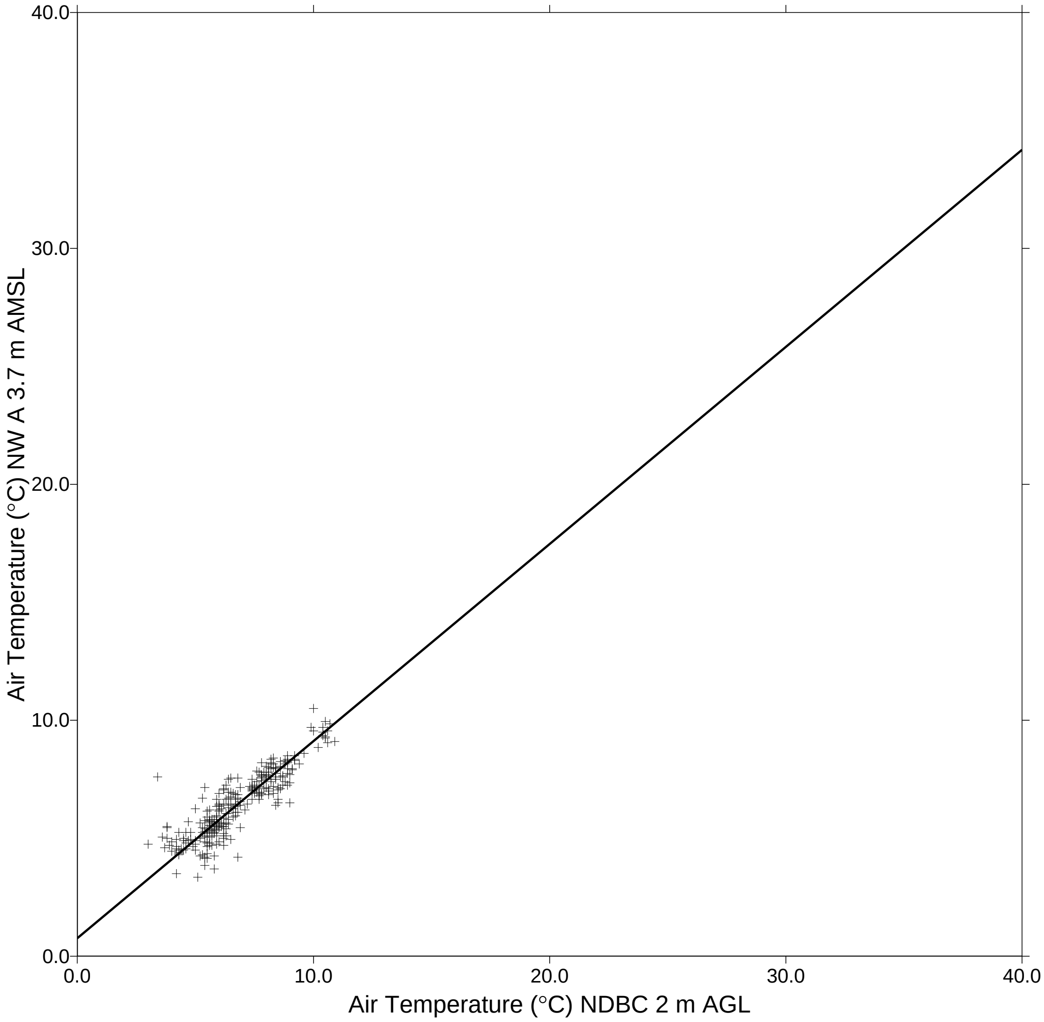
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:00 13 December 2022

Air Temperature (°C) NDBC 2 m AGL

Air Temperature (°C) NW A 3.7 m AMSL Airmar 150WX (S/N 60663334)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.762	Number of Data Points	= 295
Slope	= 0.835	Bias	= -0.352373
Standard Error	= 0.518	RMS error	= 0.849262
Correlation Coefficient	= 0.879	Scatter Index	= 0.12536

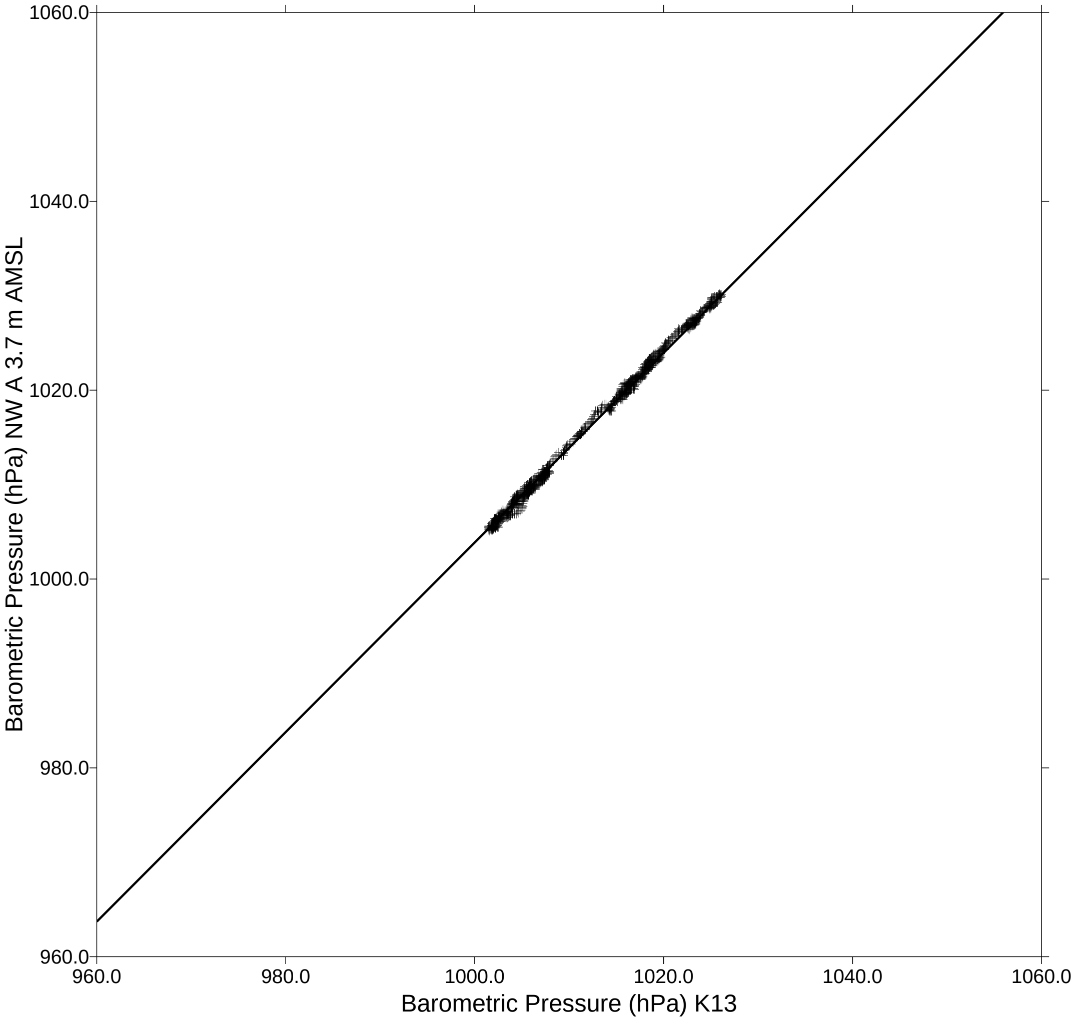
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:40 13 December 2022

Barometric Pressure (hPa) K13

Barometric Pressure (hPa) NW A 3.7 m AMSL Airmar 150WX (S/N 60663334)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 1770
Slope	= 1.004	Bias	= 3.91469
Standard Error	= 0.264	RMS error	= 3.93393
Correlation Coefficient	= 0.999	Scatter Index	= 0.00389

Time Zone: UTC +00:00 hours ...ndA.2022.12.QC_dataReturn.nc, NWWindA.2022.12.OtherWinds.nc, validationSite.2022.12.nc

 moecorel: 16:30 24/Feb/2023 by MWB (AppendixK1c.NWA.val.pdf)

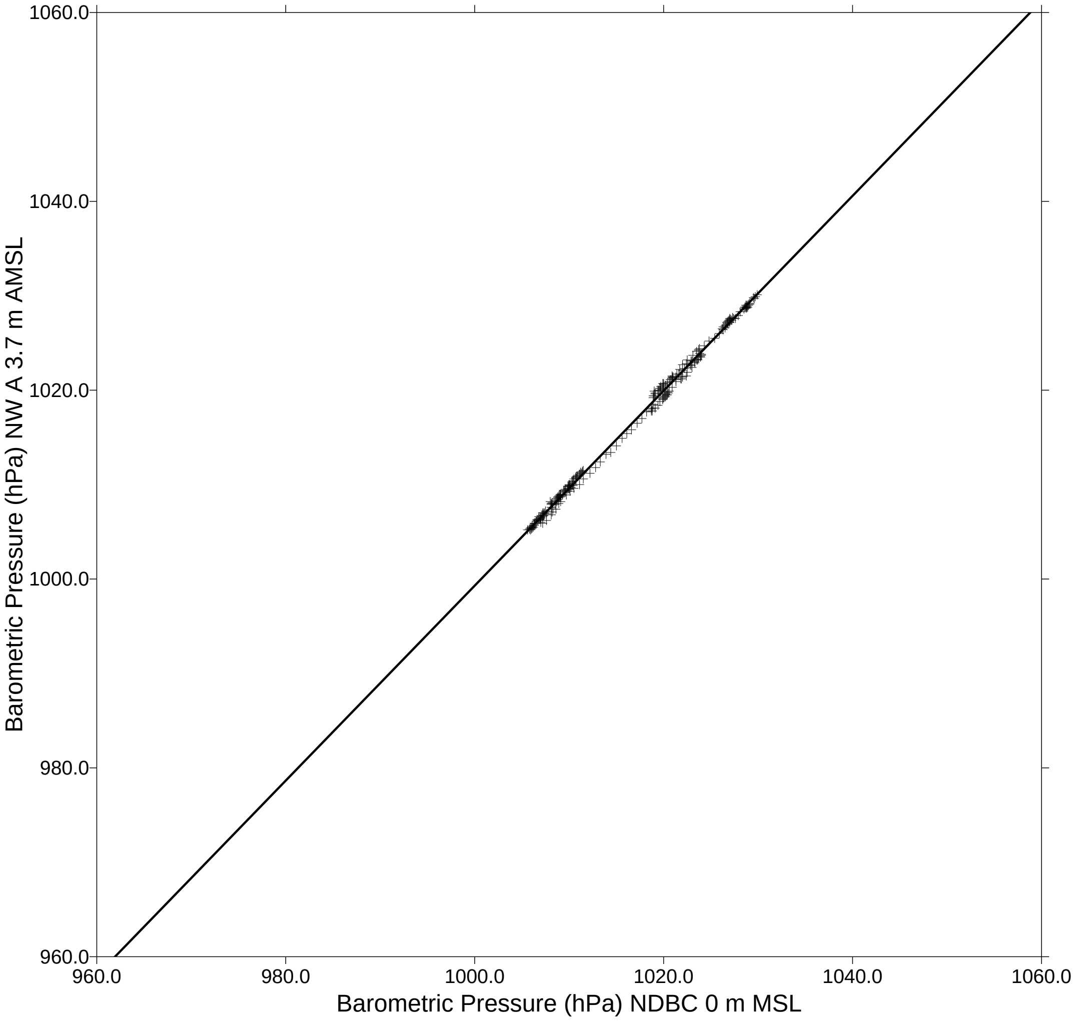
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:00 13 December 2022

Barometric Pressure (hPa) NDBC 0 m MSL

Barometric Pressure (hPa) NW A 3.7 m AMSL Airmar 150WX (S/N 60663334)



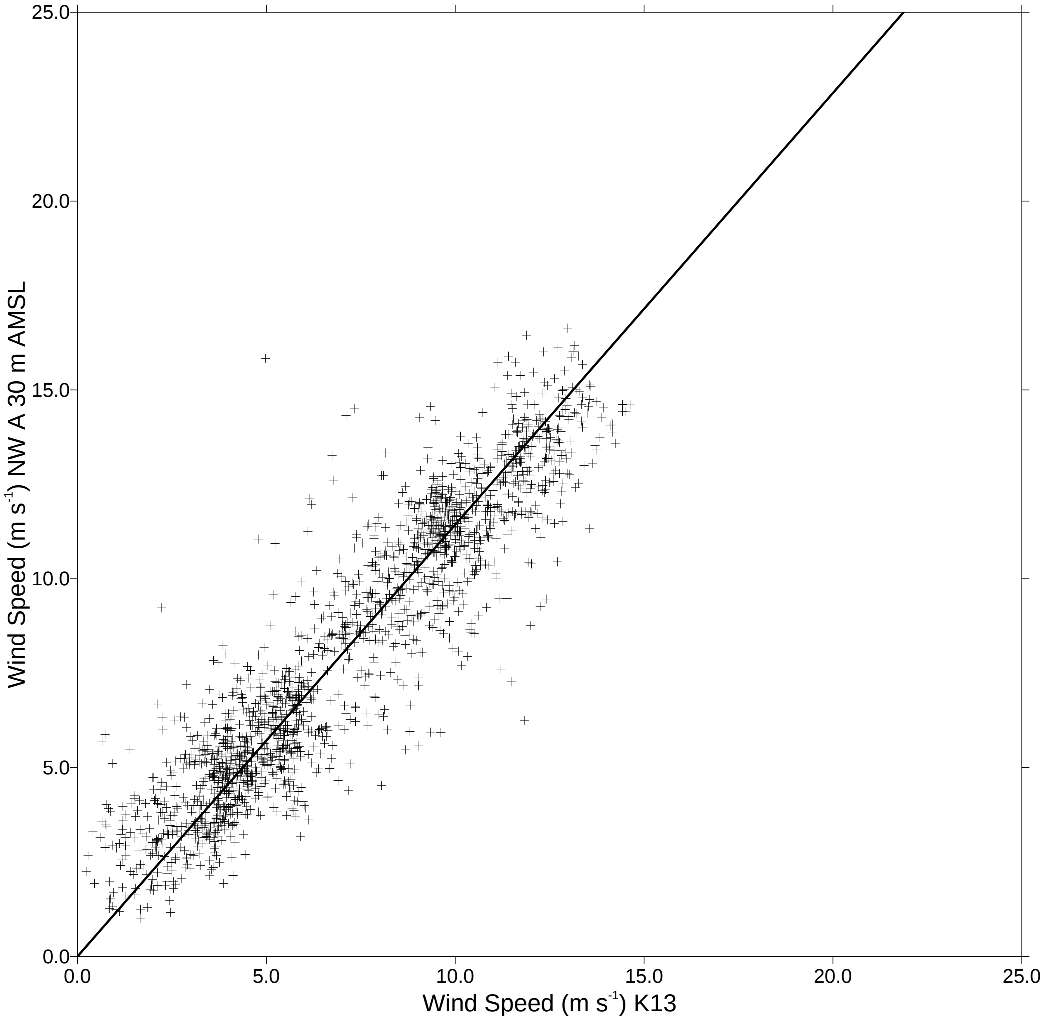
Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -32.846	Number of Data Points	= 295
Slope	= 1.032	Bias	= -0.171524
Standard Error	= 0.284	RMS error	= 0.501049
Correlation Coefficient	= 0.999	Scatter Index	= 0.00049

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:40 13 December 2022

Wind Speed ($m\ s^{-1}$) K13

Wind Speed ($m\ s^{-1}$) NW A 30 m AMSL ZX LiDAR 300M (S/N 924)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 1768
Slope	= 1.143	Bias	= 1.07945
Standard Error	= 0.962	RMS error	= 1.75703
Correlation Coefficient	= 0.925	Scatter Index	= 0.24797

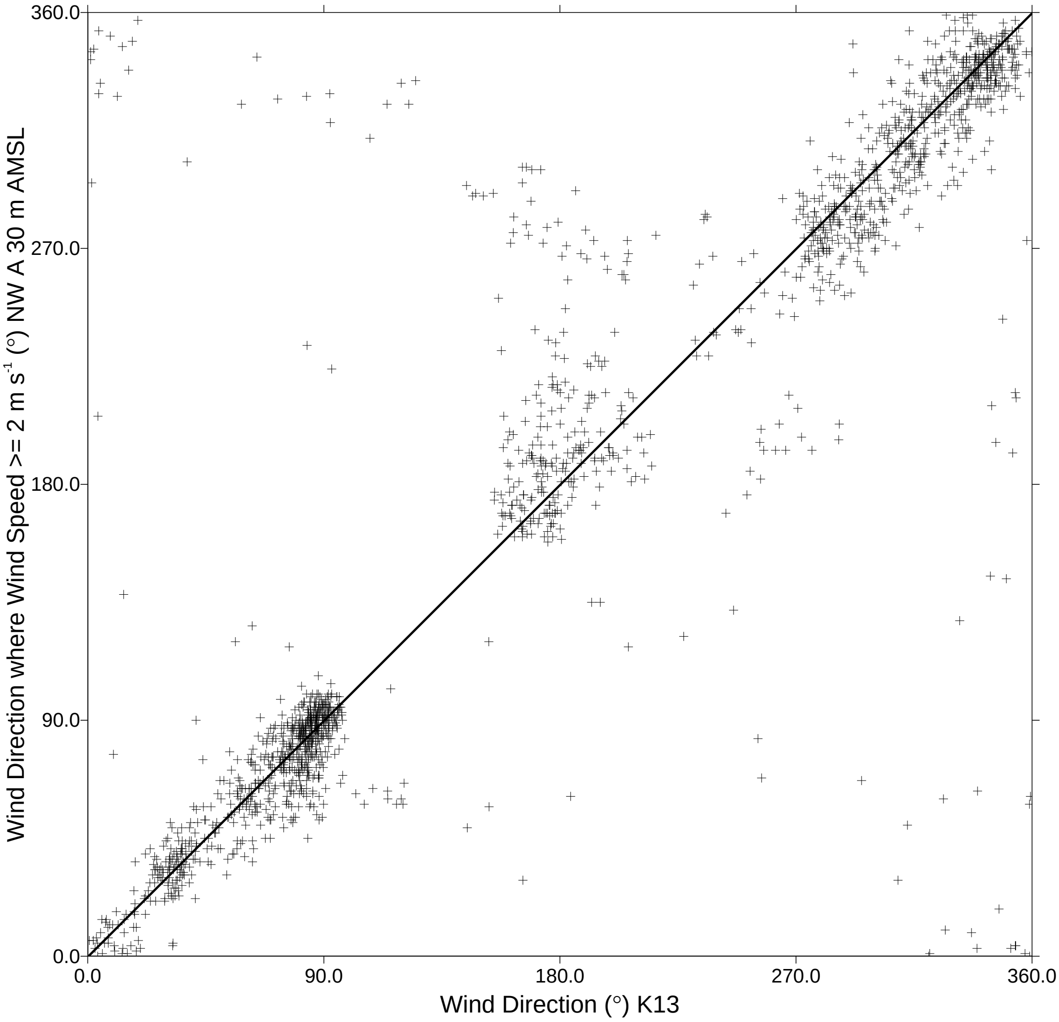
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:10 01 December 2022 to 07:40 13 December 2022

Wind Direction (°) K13 from

Wind Direction where Wind Speed >= 2 m s^{-1} (°) NW A 30 m AMSL from ZX LiDAR 300M (S/N 924)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -0.294	Number of Data Points	= 1733
Slope	= 1.000	Bias	= -0.294172
Standard Error	= 29.675	RMS error	= 29.6682
Correlation Coefficient	= 0.968	Scatter Index	= 0.15834

* both axes are polar variables

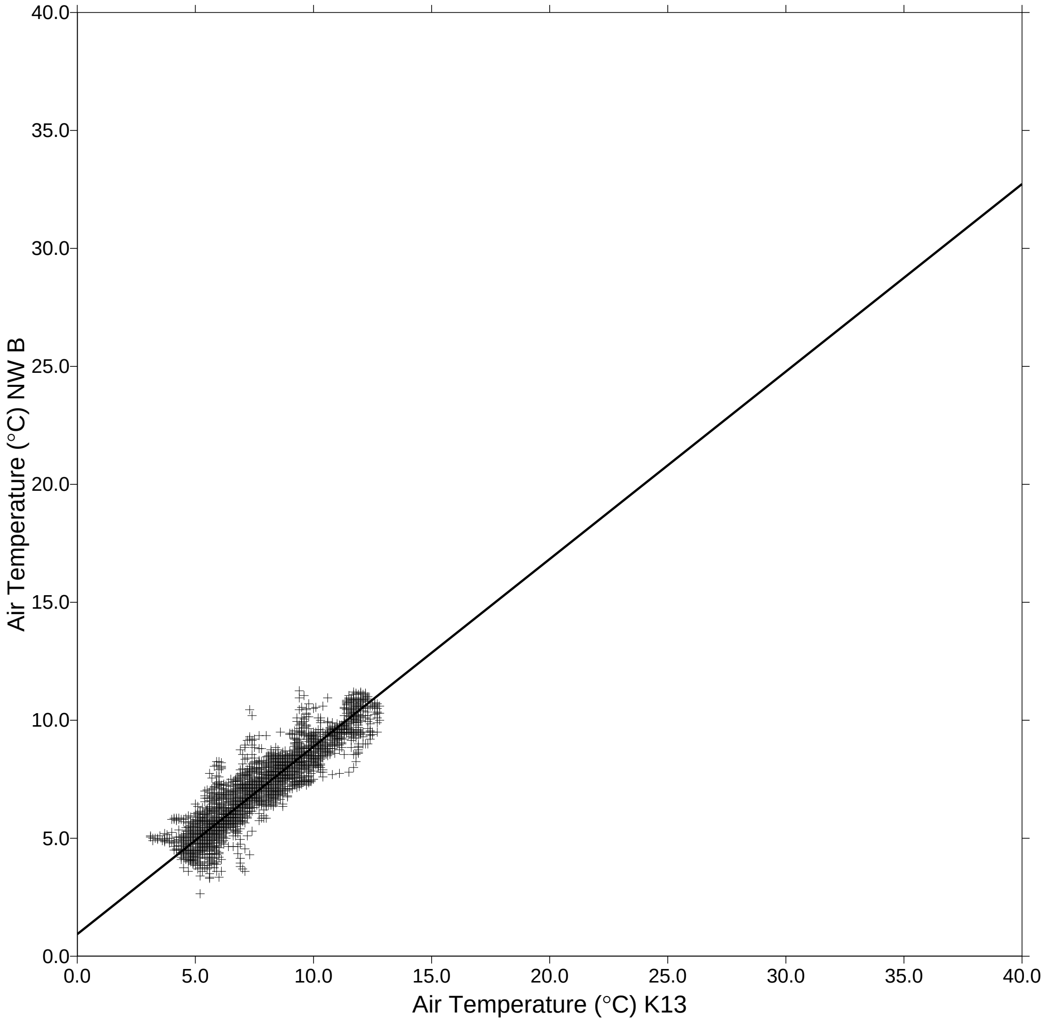
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 23:50 31 December 2022

Air Temperature (°C) K13

Air Temperature (°C) NW B 3.7m AMSL Airmar 150WX (S/N 60667571)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.936	Number of Data Points	= 4402
Slope	= 0.795	Bias	= -0.679475
Standard Error	= 0.495	RMS error	= 1.06288
Correlation Coefficient	= 0.931	Scatter Index	= 0.13496

Time Zone: UTC +00:00 hours	...ndB.2022.12.QC_dataReturn.nc, NWWindB.2022.12.OtherWinds.nc, validationSite.2022.12.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK1c.NWB.val.pdf)

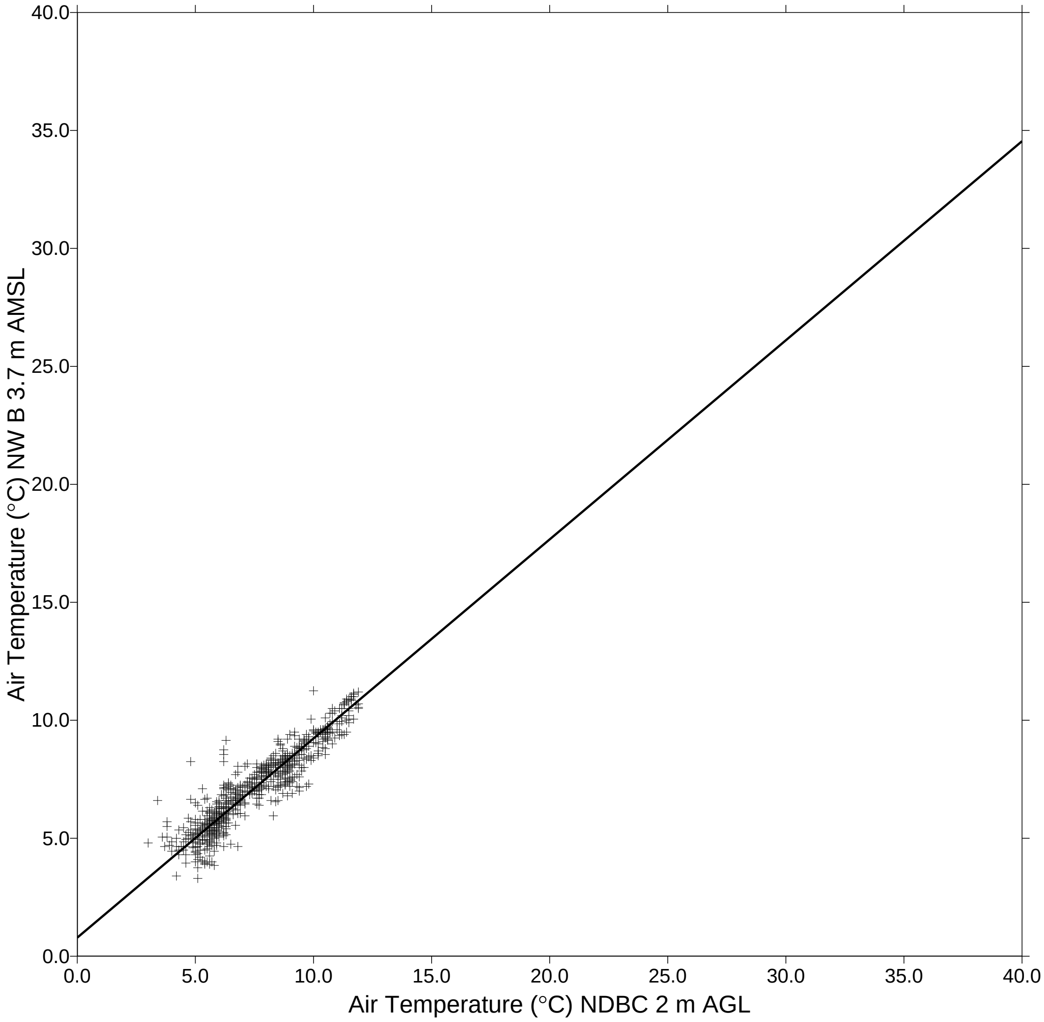
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 22:00 31 December 2022

Air Temperature (°C) NDBC 2 m AGL

Air Temperature (°C) NW B 3.7 m AMSL 3.7m AMSL Airmar 150WX (S/N 60667571)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.787	Number of Data Points	= 733
Slope	= 0.844	Bias	= -0.396658
Standard Error	= 0.486	RMS error	= 0.848518
Correlation Coefficient	= 0.930	Scatter Index	= 0.11185

Time Zone: UTC +00:00 hours	...ndB.2022.12.QC_dataReturn.nc, NWWindB.2022.12.OtherWinds.nc, validationSite.2022.12.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK1c.NWB.val.pdf)

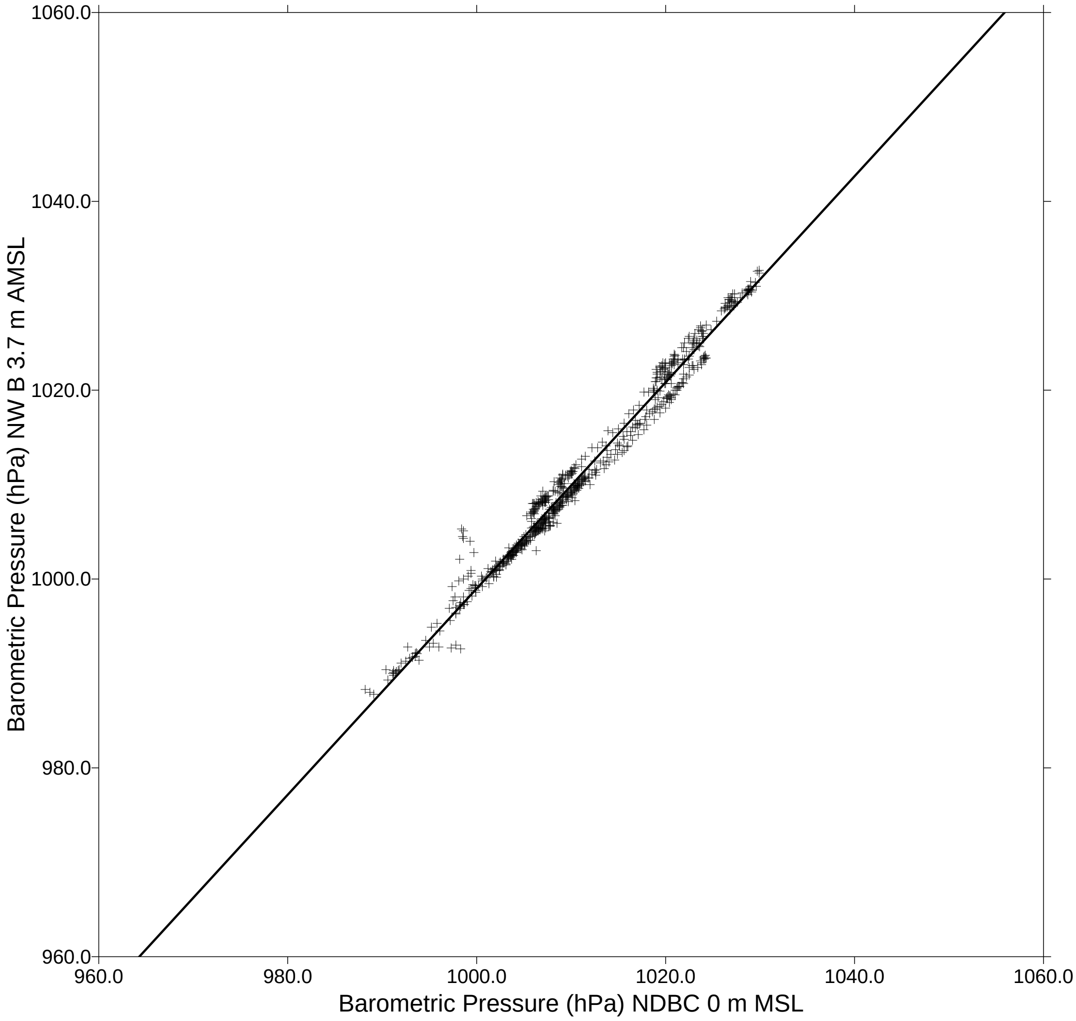
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 22:00 31 December 2022

Barometric Pressure (hPa) NDBC 0 m MSL

Barometric Pressure (hPa) NW B 3.7 m AMSL 3.7m AMSL Airmar 150WX (S/N 60667571)



Line of Best Fit (Perpendicular)			
Ordinate Intercept	= -92.820	Number of Data Points	= 733
Slope	= 1.092	Bias	= -0.00613842
Standard Error	= 0.929	RMS error	= 1.54302
Correlation Coefficient	= 0.990	Scatter Index	= 0.00153

Time Zone: UTC +00:00 hours	...ndB.2022.12.QC_dataReturn.nc, NWWindB.2022.12.OtherWinds.nc, validationSite.2022.12.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK1c.NWB.val.pdf)

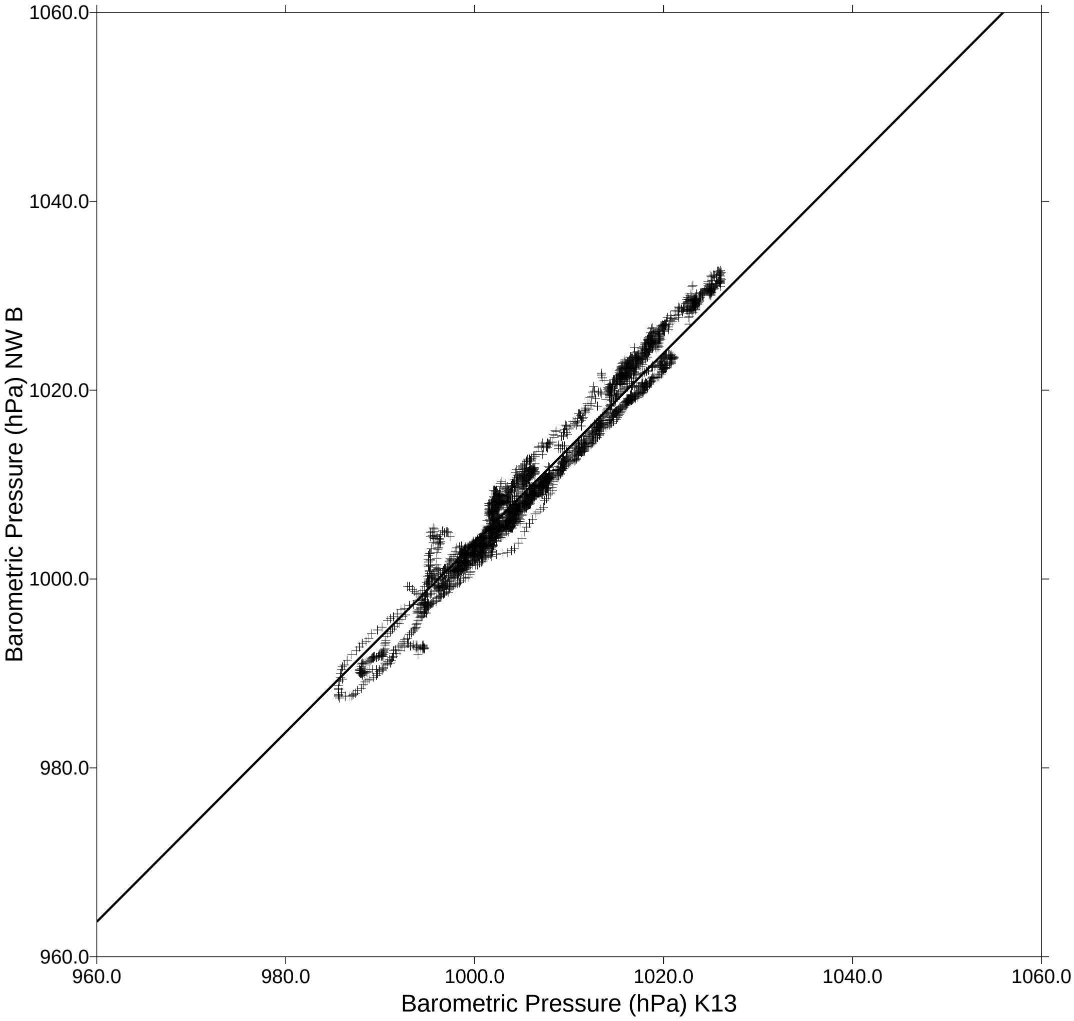
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 23:50 31 December 2022

Barometric Pressure (hPa) K13

Barometric Pressure (hPa) NW B 3.7m AMSL Airmar 150WX (S/N 60667571)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 4401
Slope	= 1.004	Bias	= 3.86824
Standard Error	= 1.221	RMS error	= 4.24322
Correlation Coefficient	= 0.987	Scatter Index	= 0.00421

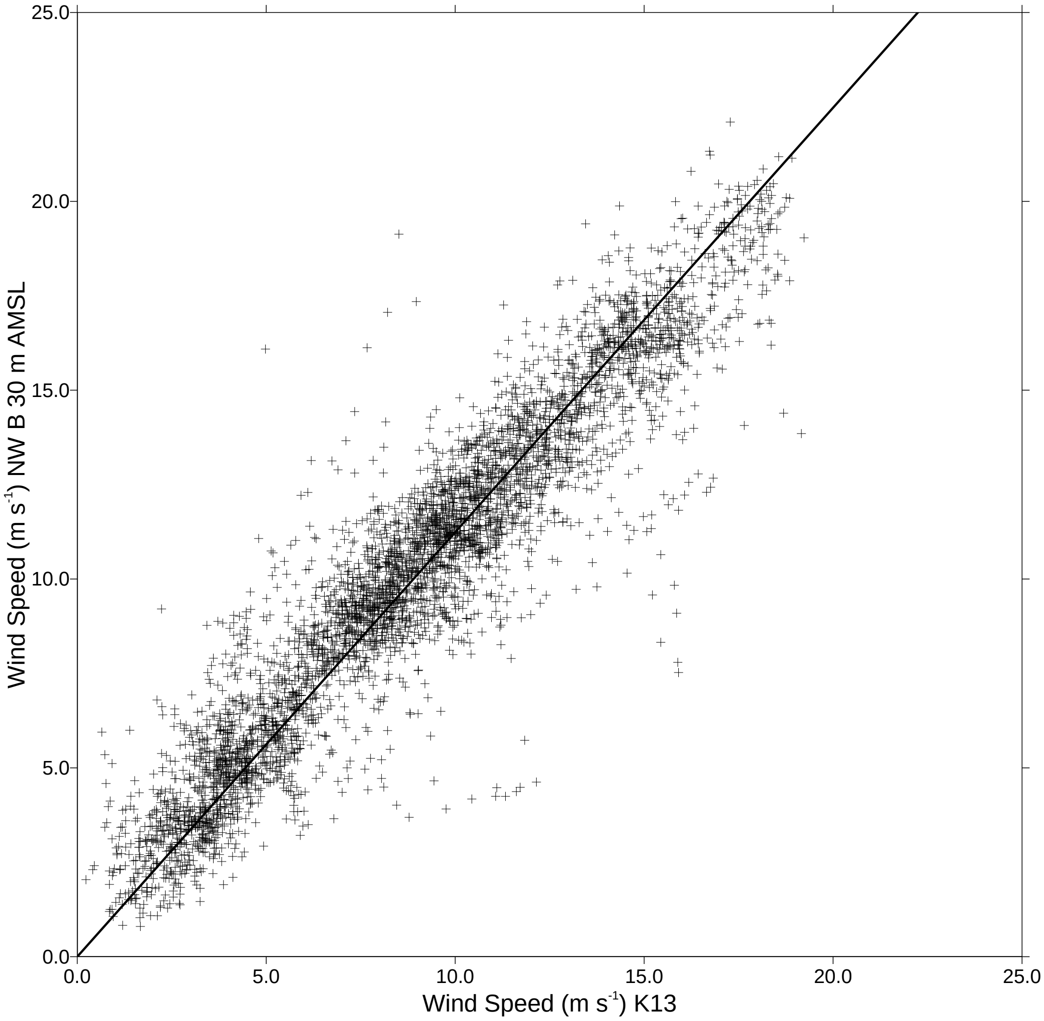
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 23:50 31 December 2022

Wind Speed (m s-1) K13

Wind Speed (m s-1) NW B 30 m AMSL 30m AMSL ZX LiDAR 300M (S/N 1174)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 4396
Slope	= 1.124	Bias	= 1.21659
Standard Error	= 1.054	RMS error	= 1.92191
Correlation Coefficient	= 0.942	Scatter Index	= 0.21566

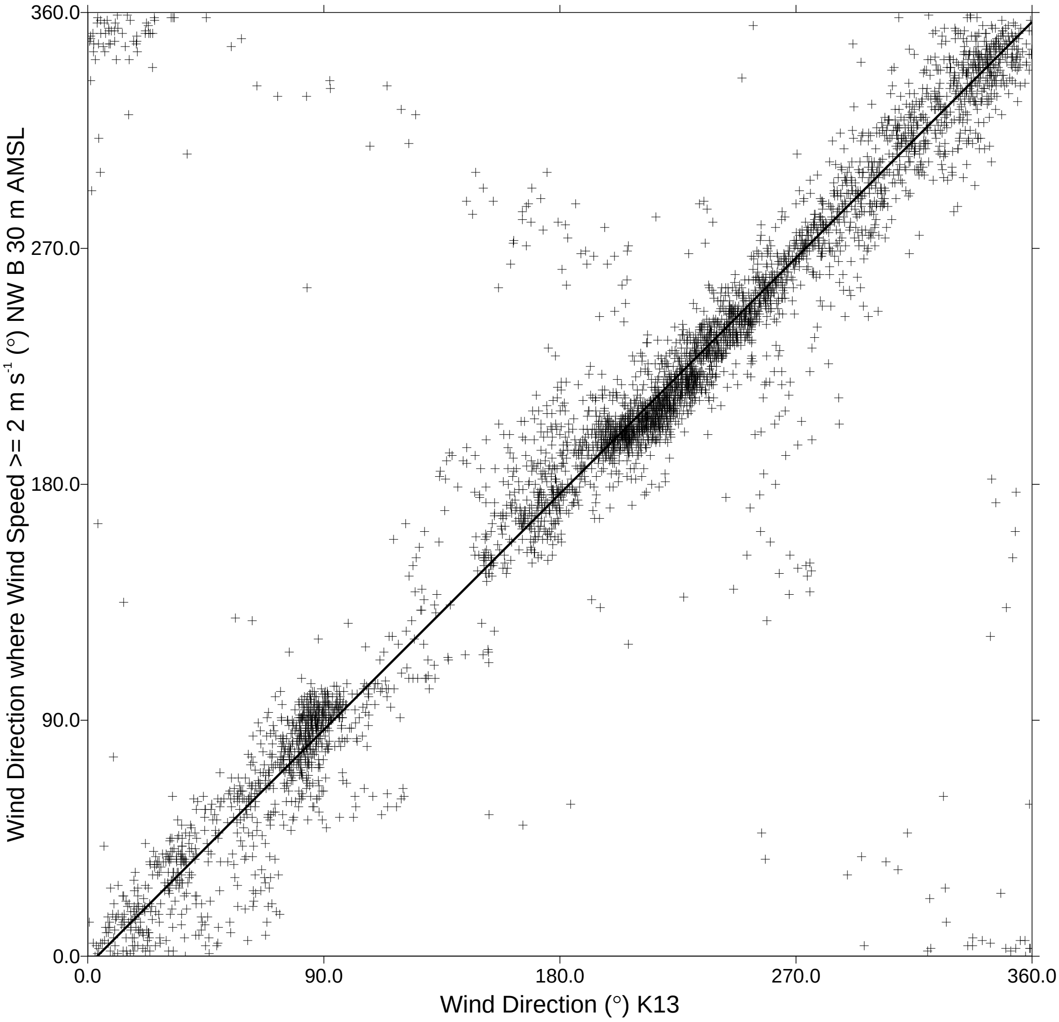
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:10 01 December 2022 to 23:50 31 December 2022

Wind Direction (°) K13 from

Wind Direction where Wind Speed >= 2 m s^{-1} (°) NW B 30 m AMSL from 30m AMSL ZX LiDAR 300M (S/N 1174)



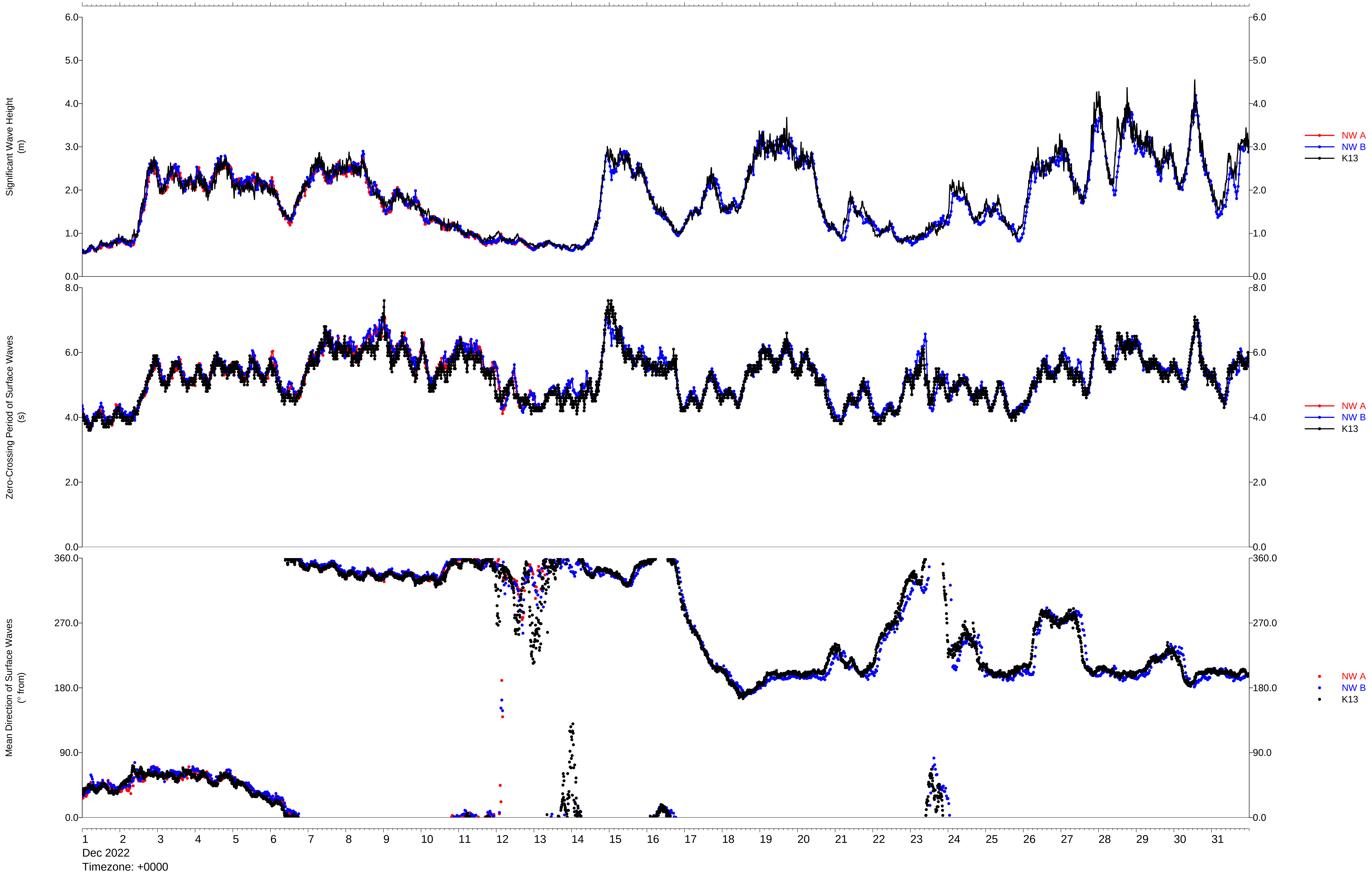
Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -3.605	Number of Data Points	= 4326
Slope	= 1.000	Bias	= -3.60495
Standard Error	= 21.974	RMS error	= 22.2655
Correlation Coefficient	= 0.971	Scatter Index	= 0.10739

* both axes are polar variables

Time Zone: UTC +00:00 hours	...ndB.2022.12.QC_dataReturn.nc, NWWindB.2022.12.OtherWinds.nc, validationSite.2022.12.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK1c.NWB.val.pdf)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

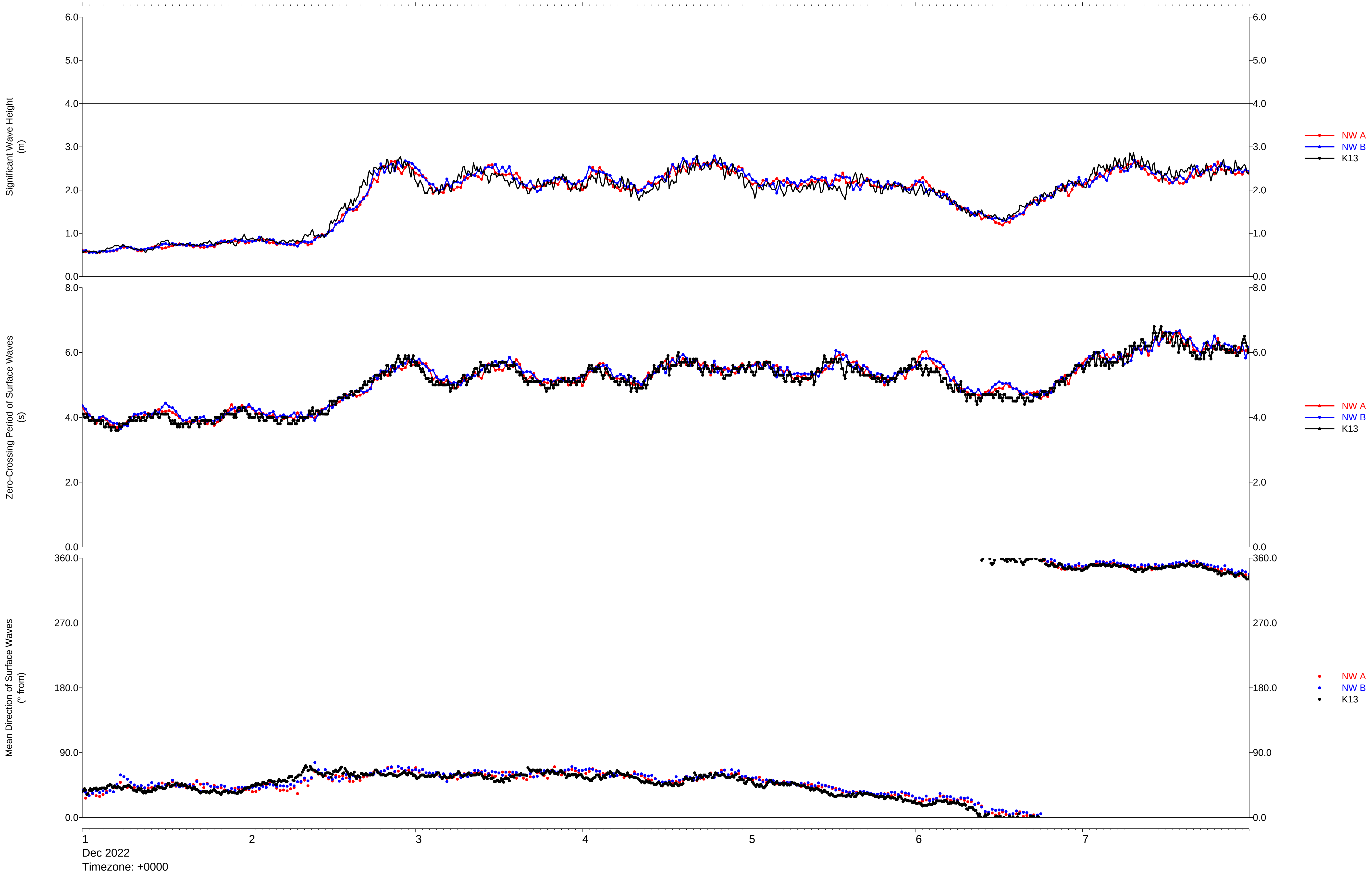
Location:	**NW**	Client: RVO Project: J3707



Time Zone: UTC +00:00 hours	NWWave{A,B}.2022.12.QC_dataReturn.cos2s.nc, NWWindA.2022.12.OtherWinds.nc, validationSite.2022.12.nc
© RPS Australia West Pty Ltd	moetimehist: 16:29 24/Feb/2023 by MWB (AppendixK2a.NW.ABN.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

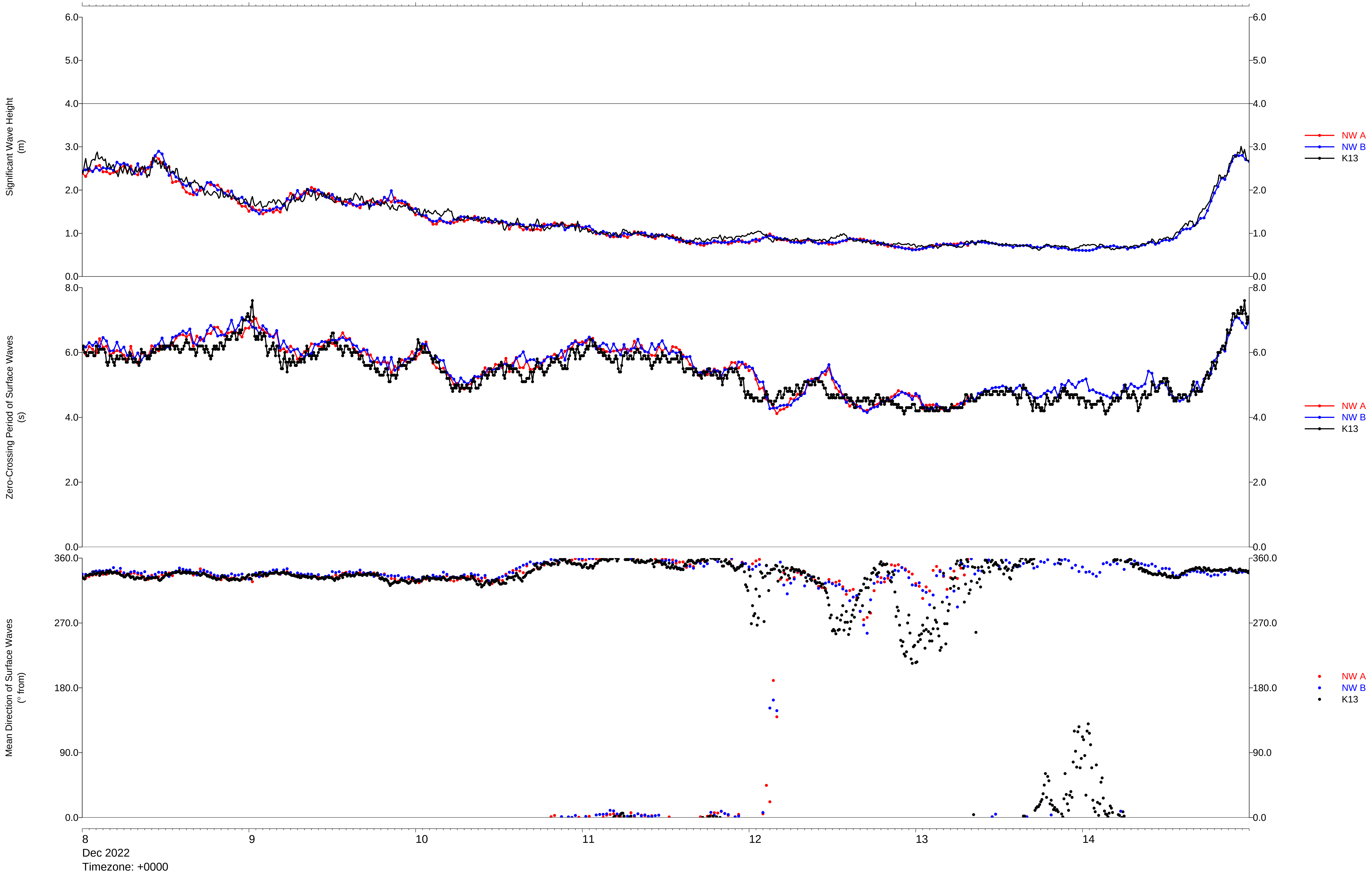
Location:	**NW**	Client: RVO Project: J3707



Time Zone: UTC +00:00 hours	NWWave{A,B}.2022.12.QC_dataReturn.cos2s.nc, NWWindA.2022.12.OtherWinds.nc, validationSite.2022.12.nc
	moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK2b.NW.ABN.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

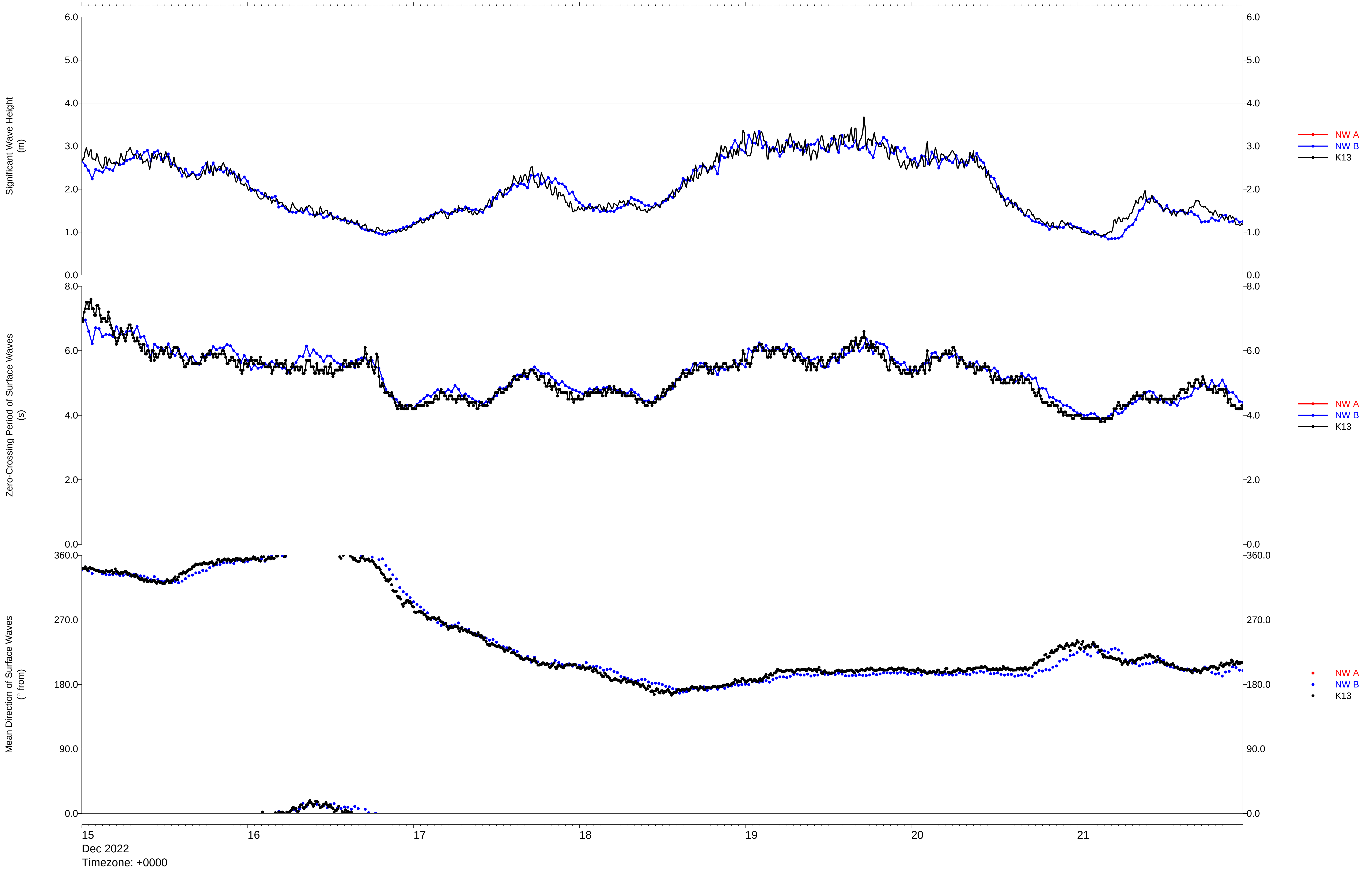
Location:	**NW**	Client: RVO Project: J3707



Time Zone: UTC +00:00 hours	NWWave{A,B}.2022.12.QC_dataReturn.cos2s.nc, NWWindA.2022.12.OtherWinds.nc, validationSite.2022.12.nc
© RPS Australia West Pty Ltd	moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK2b.NW.ABN.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

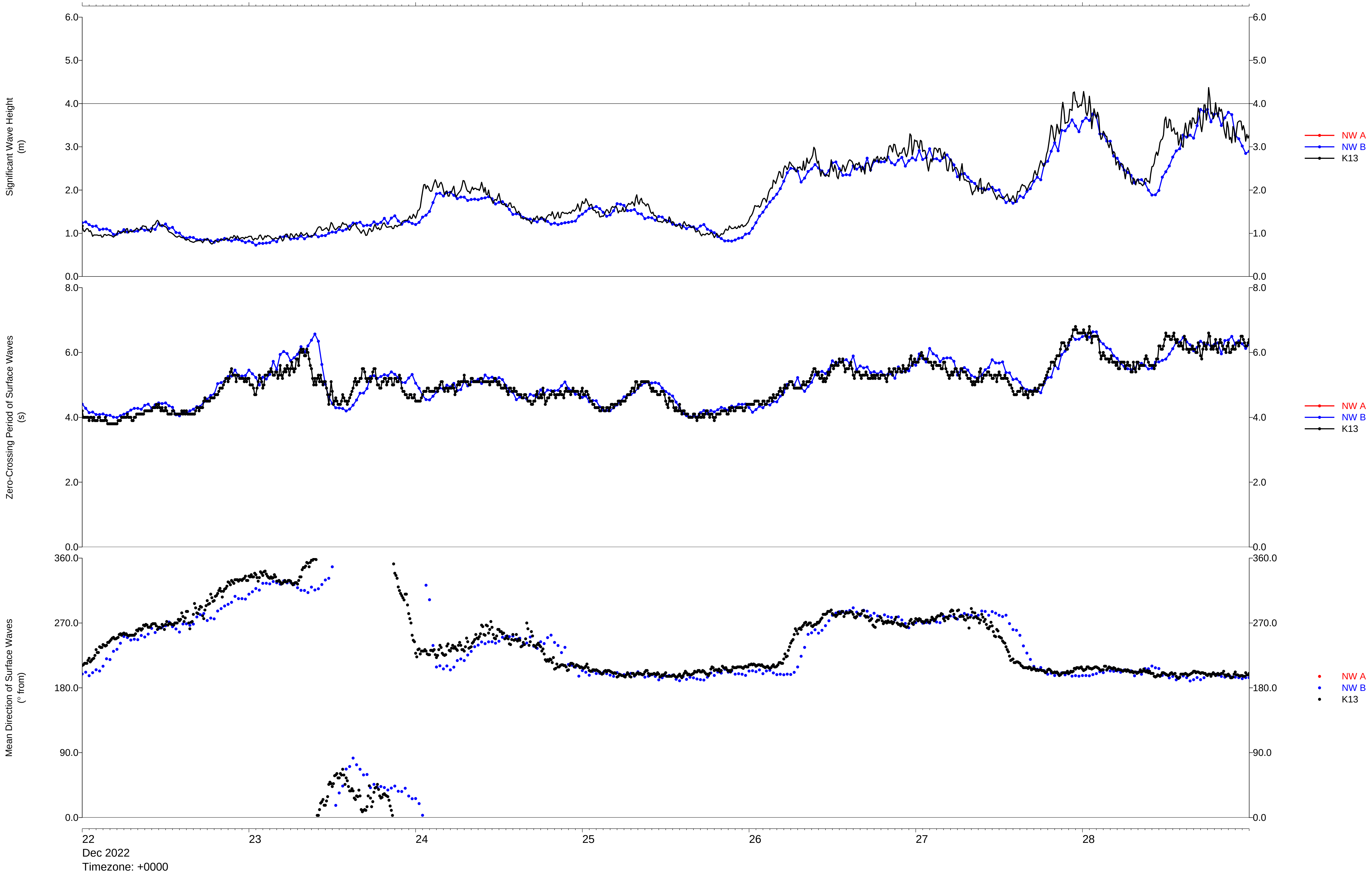
Location:	**NW**	
		Client: RVO Project: J3707



Time Zone: UTC +00:00 hours	NWWave{A,B}.2022.12.QC_dataReturn.cos2s.nc, NWWindA.2022.12.OtherWinds.nc, validationSite.2022.12.nc
© RPS Australia West Pty Ltd	moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK2b.NW.ABN.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

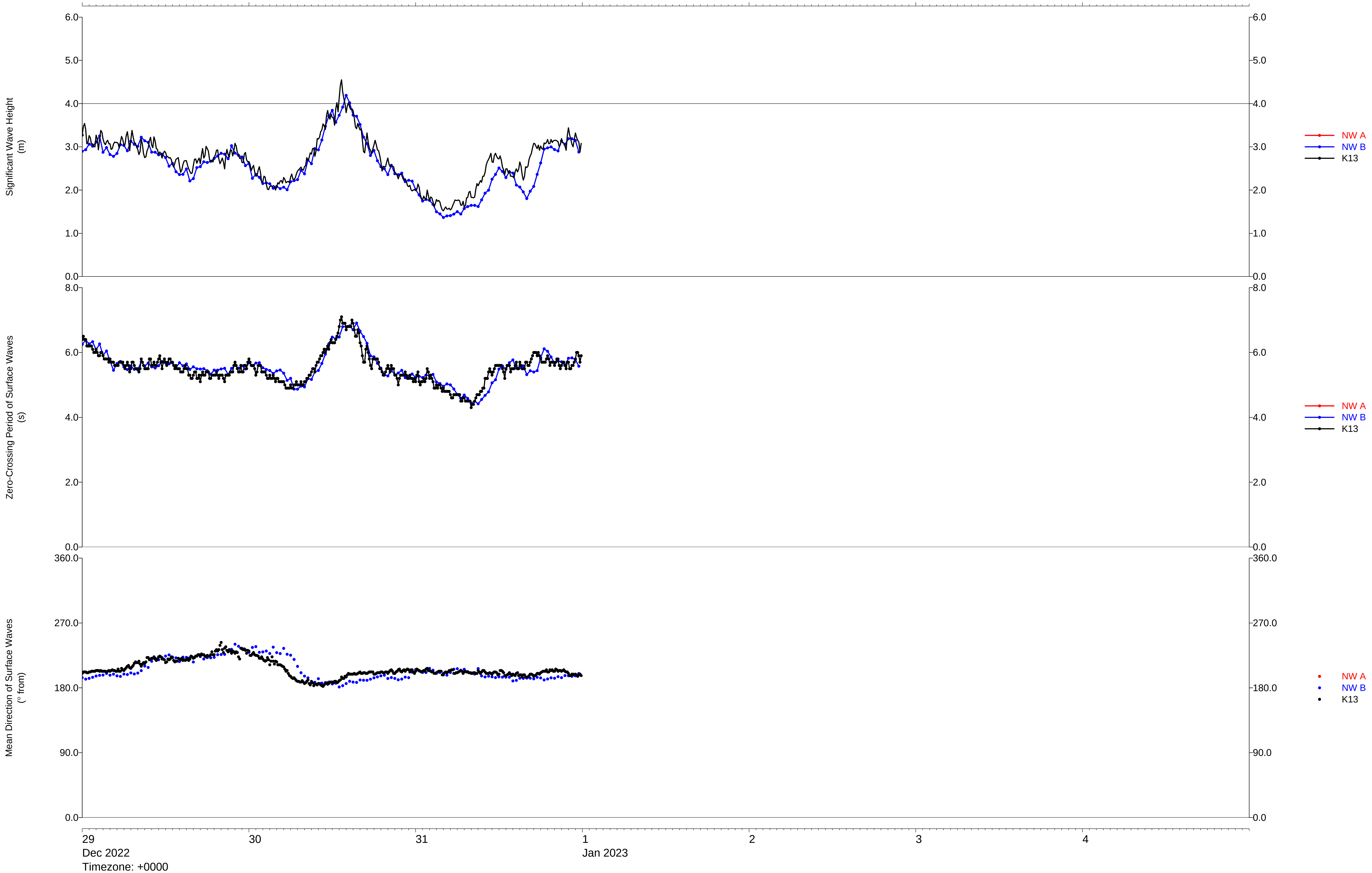
Location: NW	Client: RVO Project: J3707



Time Zone: UTC +00:00 hours	NWWave{A,B}.2022.12.QC_dataReturn.cos2s.nc, NWWindA.2022.12.OtherWinds.nc, validationSite.2022.12.nc
© RPS Australia West Pty Ltd	moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK2b.NW.ABN.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location: NW	Client: RVO
	Project: J3707



Time Zone: UTC +00:00 hours	NWWave{A,B}.2022.12.QC_dataReturn.cos2s.nc, NWWindA.2022.12.OtherWinds.nc, validationSite.2022.12.nc
© RPS Australia West Pty Ltd	moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK2b.NW.ABN.week.ps)

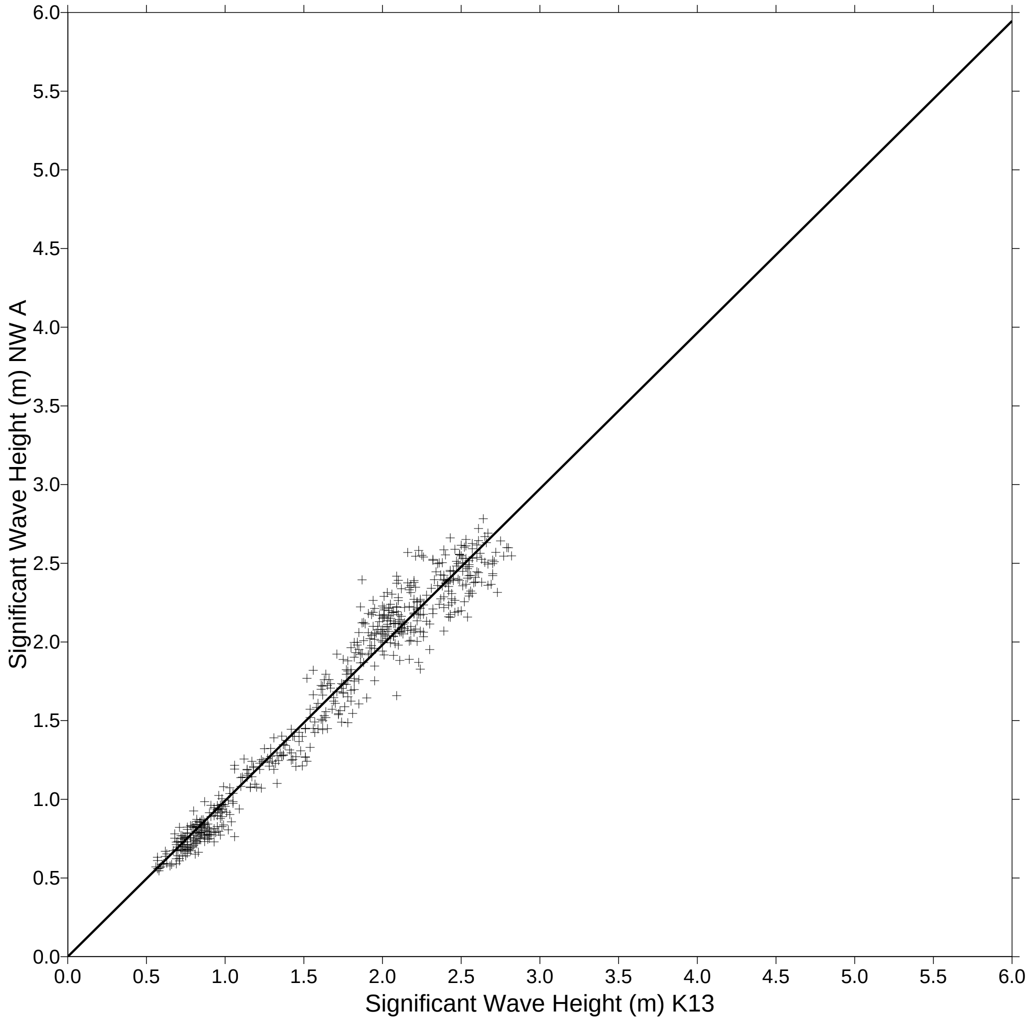
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	4.3 s

Period: 00:00 01 December 2022 to 07:30 13 December 2022

Significant Wave Height (m) K13

Significant Wave Height (m) NW A MRU-5 (S/N 26017)



Line of Best Fit (Perpendicular)			
Ordinate Intercept	= 0.000	Number of Data Points	= 592
Slope	= 0.991	Bias	= -0.02225
Standard Error	= 0.094	RMS error	= 0.134352
Correlation Coefficient	= 0.980	Scatter Index	= 0.08153

Time Zone: UTC +00:00 hours	NWWaveA.2022.12.QC_dataReturn.cos2s.nc, validationSite.2022.12.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK2c.NWA.val.pdf)

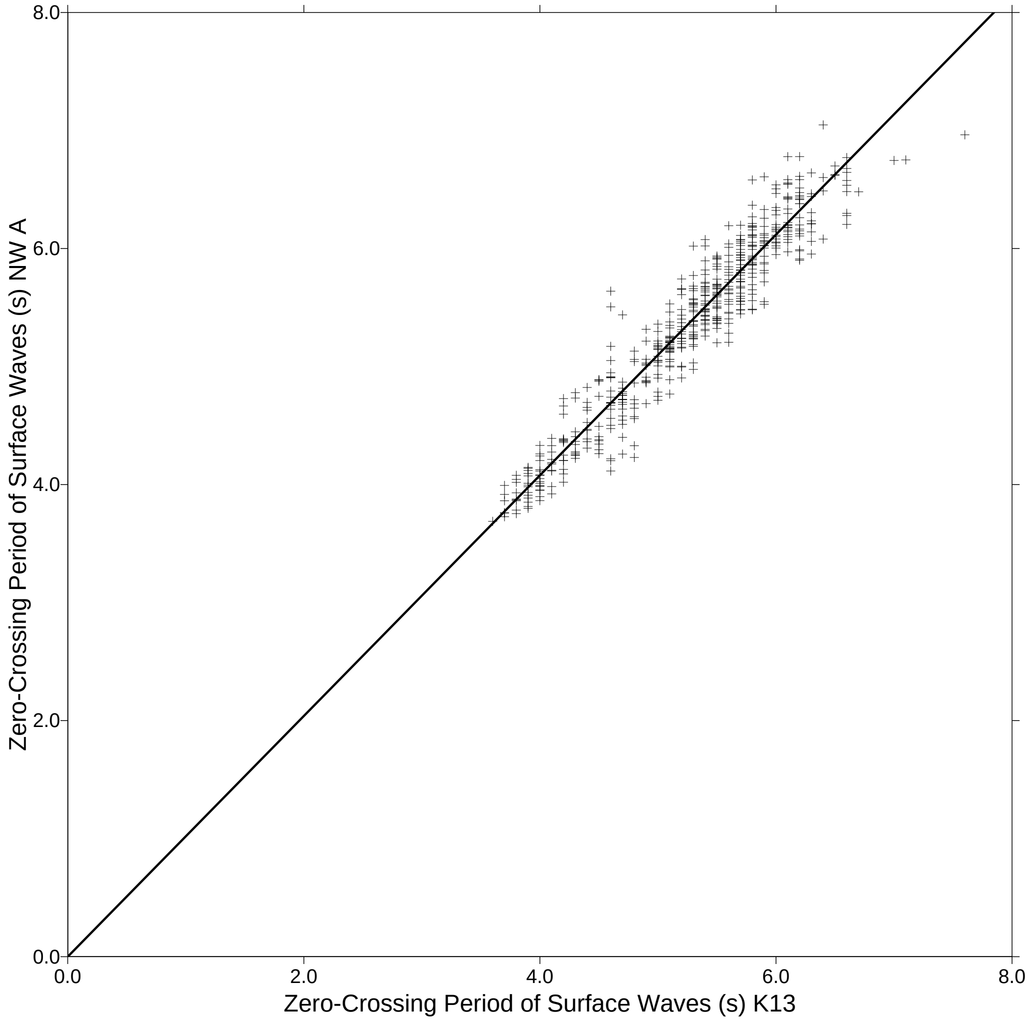
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	4.3 s

Period: 00:00 01 December 2022 to 07:30 13 December 2022

Zero-Crossing Period of Surface Waves (s) K13

Zero-Crossing Period of Surface Waves (s) NW A MRU-5 (S/N 26017)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 592
Slope	= 1.020	Bias	= 0.100765
Standard Error	= 0.156	RMS error	= 0.243333
Correlation Coefficient	= 0.956	Scatter Index	= 0.04633

Time Zone: UTC +00:00 hours	NWWaveA.2022.12.QC_dataReturn.cos2s.nc, validationSite.2022.12.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK2c.NWA.val.pdf)

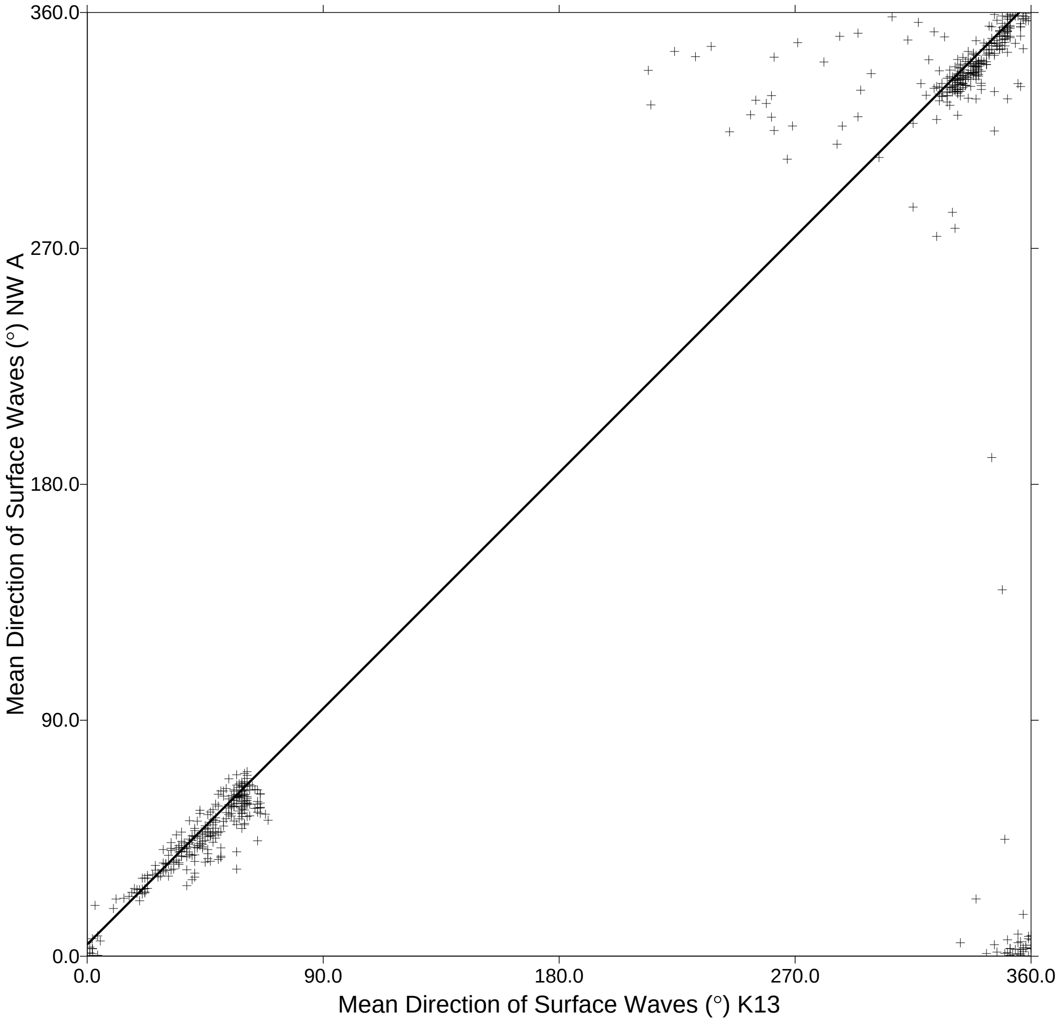
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m MSL	Sea/Swell:	4.3 s

Period: 00:00 01 December 2022 to 07:30 13 December 2022

Mean Direction of Surface Waves (°) K13 from

Mean Direction of Surface Waves (°) NW A from MRU-5 (S/N 26017)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 4.492	Number of Data Points	= 592
Slope	= 1.000	Bias	= 4.49244
Standard Error	= 18.669	RMS error	= 19.1868
Correlation Coefficient	= 0.992	Scatter Index	= 0.09512

* both axes are polar variables

Time Zone: UTC +00:00 hours	NWWaveA.2022.12.QC_dataReturn.cos2s.nc, validationSite.2022.12.nc
© RPS Australia West Pty Ltd	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK2c.NWA.val.pdf)

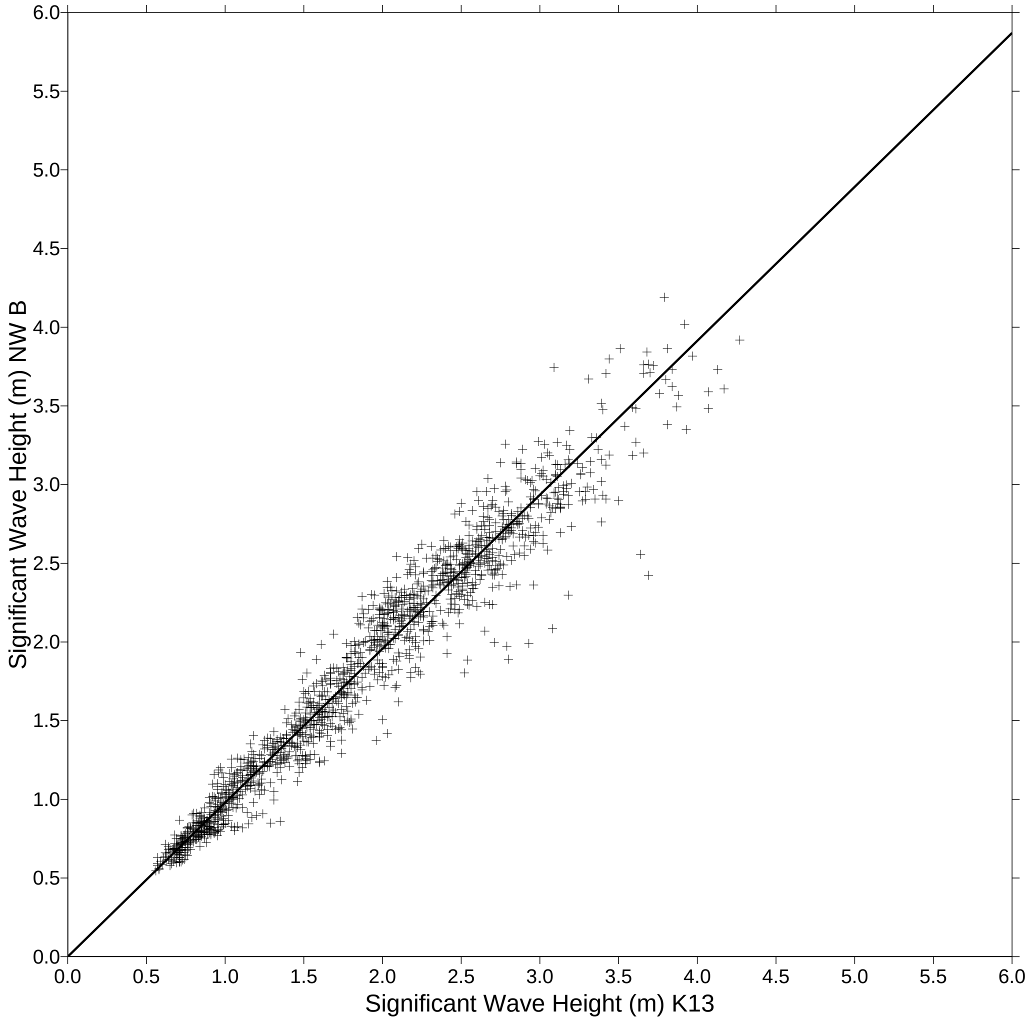
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	4.2 s

Period: 00:00 01 December 2022 to 23:30 31 December 2022

Significant Wave Height (m) K13

Significant Wave Height (m) NW B MRU-5 (S/N 25081)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 1488
Slope	= 0.978	Bias	= -0.0410149
Standard Error	= 0.124	RMS error	= 0.180621
Correlation Coefficient	= 0.975	Scatter Index	= 0.09712

Time Zone: UTC +00:00 hours	NWWaveB.2022.12.QC_dataReturn.cos2s.nc, validationSite.2022.12.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK2c.NWB.val.pdf)

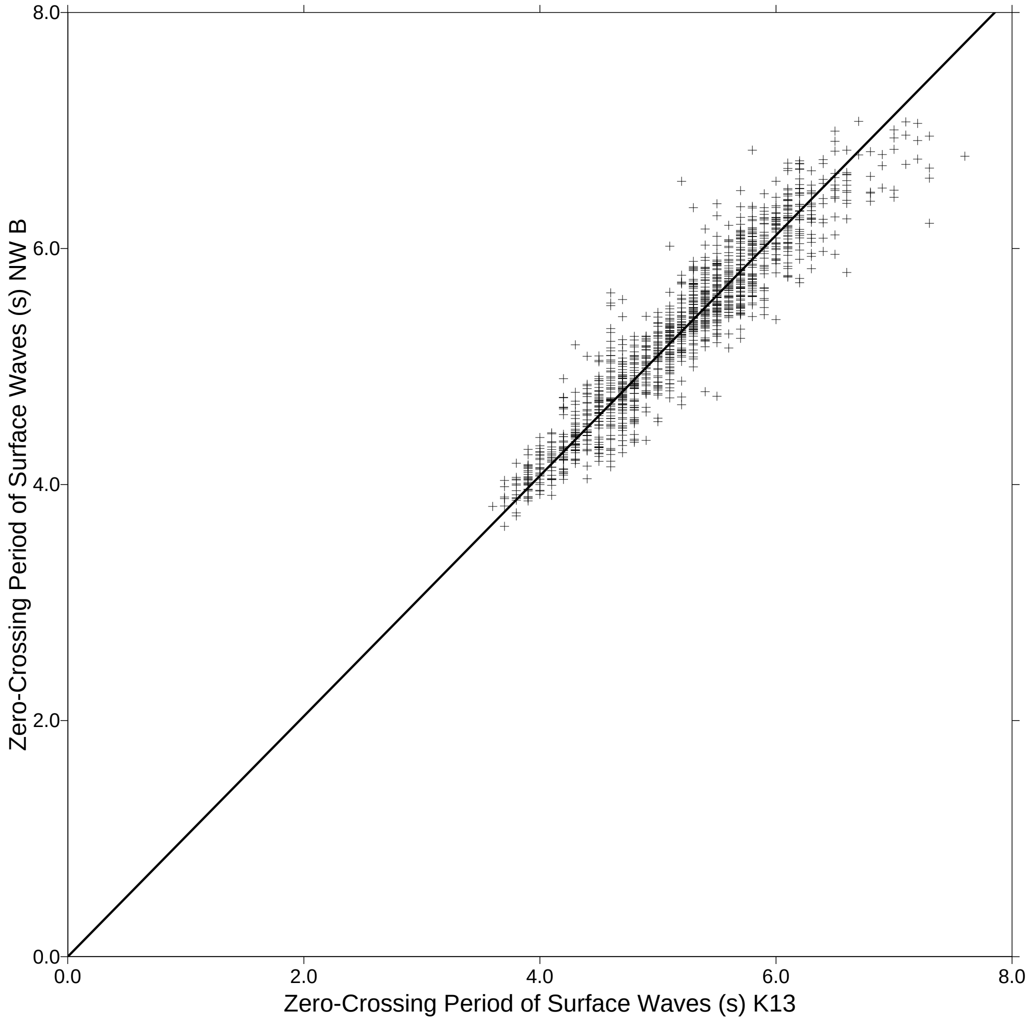
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	4.2 s

Period: 00:00 01 December 2022 to 23:30 31 December 2022

Zero-Crossing Period of Surface Waves (s) K13

Zero-Crossing Period of Surface Waves (s) NW B MRU-5 (S/N 25081)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 1488
Slope	= 1.019	Bias	= 0.098293
Standard Error	= 0.164	RMS error	= 0.251384
Correlation Coefficient	= 0.947	Scatter Index	= 0.04826

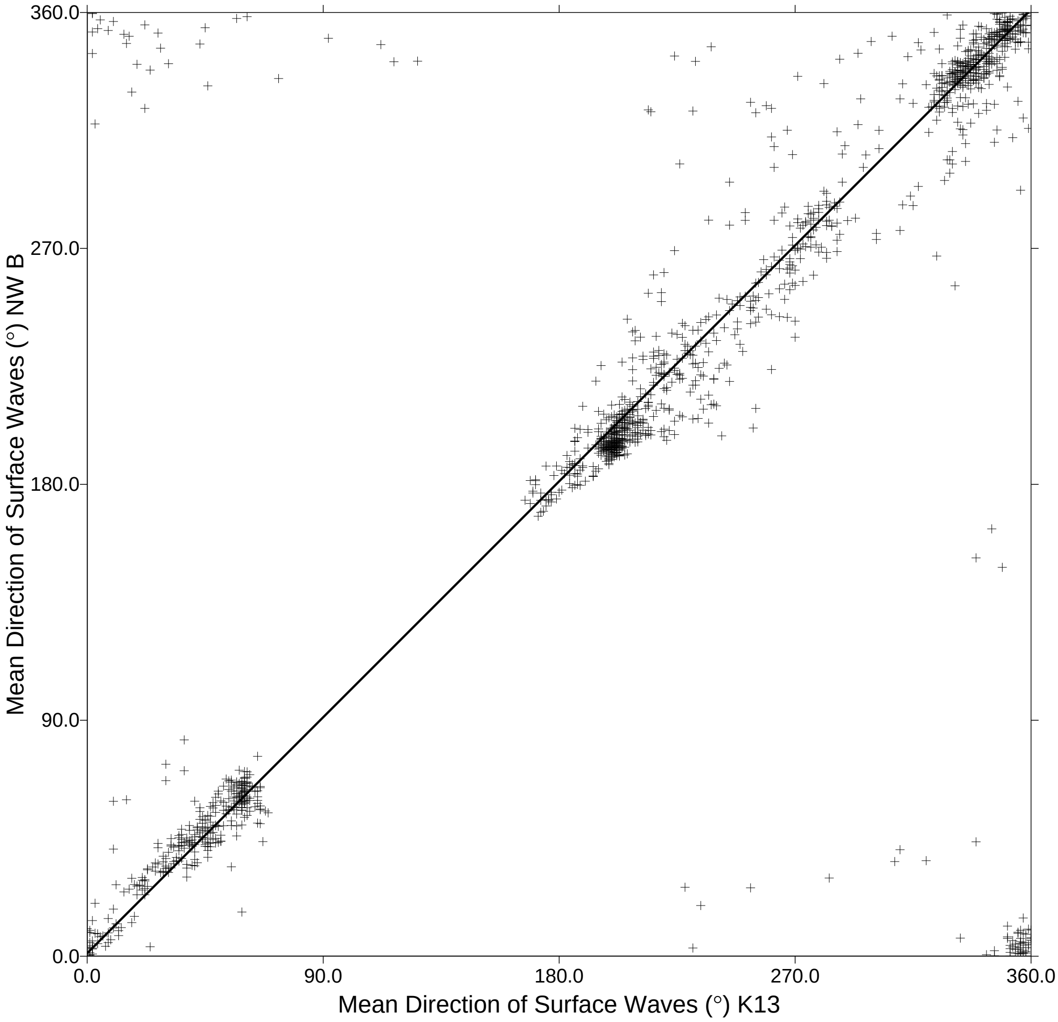
Time Zone: UTC +00:00 hours	NWWaveB.2022.12.QC_dataReturn.cos2s.nc, validationSite.2022.12.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK2c.NWB.val.pdf)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m MSL	Sea/Swell:	4.2 s

Period: 00:00 01 December 2022 to 23:30 31 December 2022

Mean Direction of Surface Waves (°) K13 from
Mean Direction of Surface Waves (°) NW B from MRU-5 (S/N 25081)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 1.156	Number of Data Points	= 1488
Slope	= 1.000	Bias	= 1.15631
Standard Error	= 20.262	RMS error	= 20.288
Correlation Coefficient	= 0.983	Scatter Index	= 0.09076

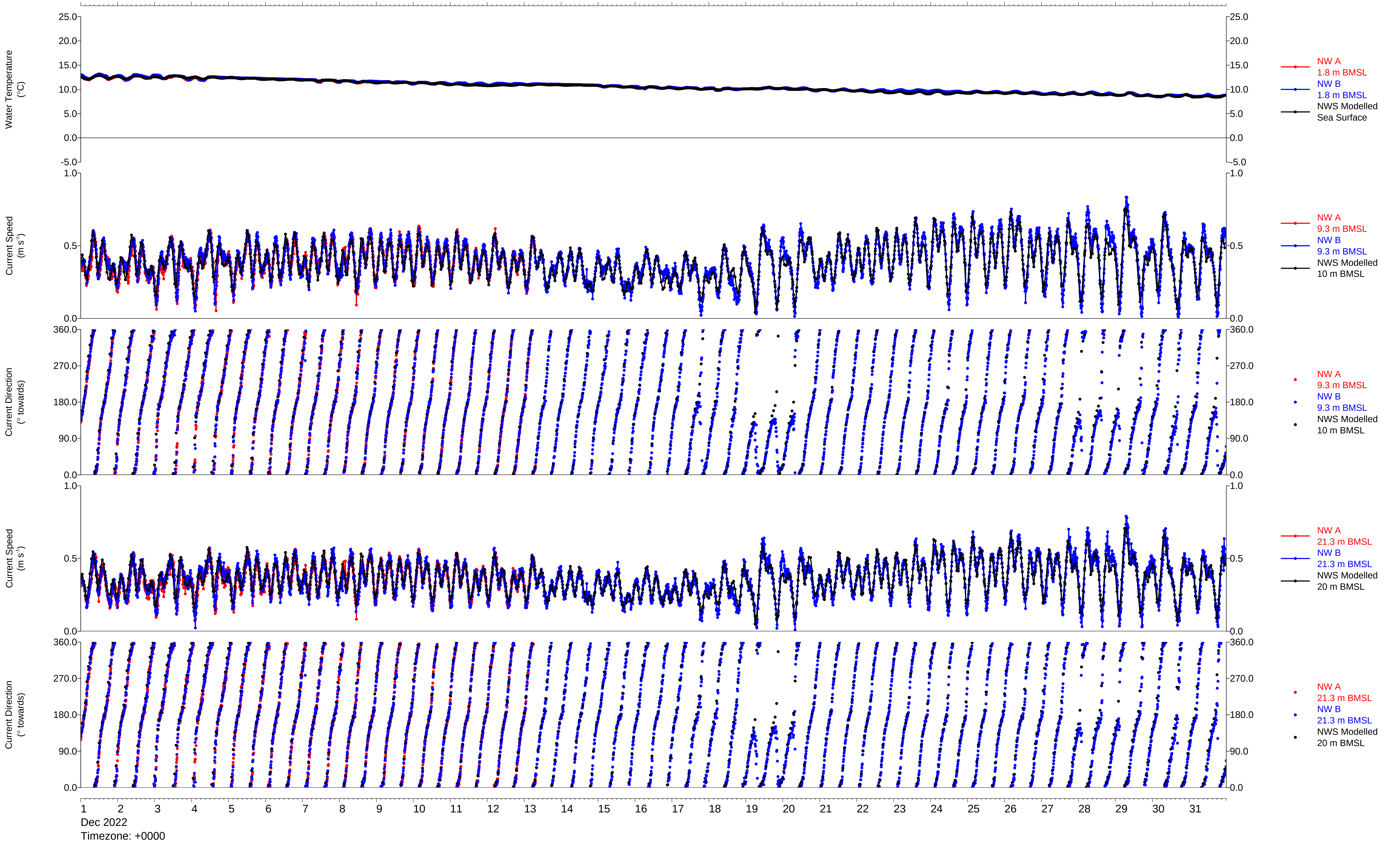
* both axes are polar variables

Time Zone: UTC +00:00 hours	NWWaveB.2022.12.QC_dataReturn.cos2s.nc, validationSite.2022.12.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK2c.NWB.val.pdf)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location: NW

Client: RVO
Project: J3707



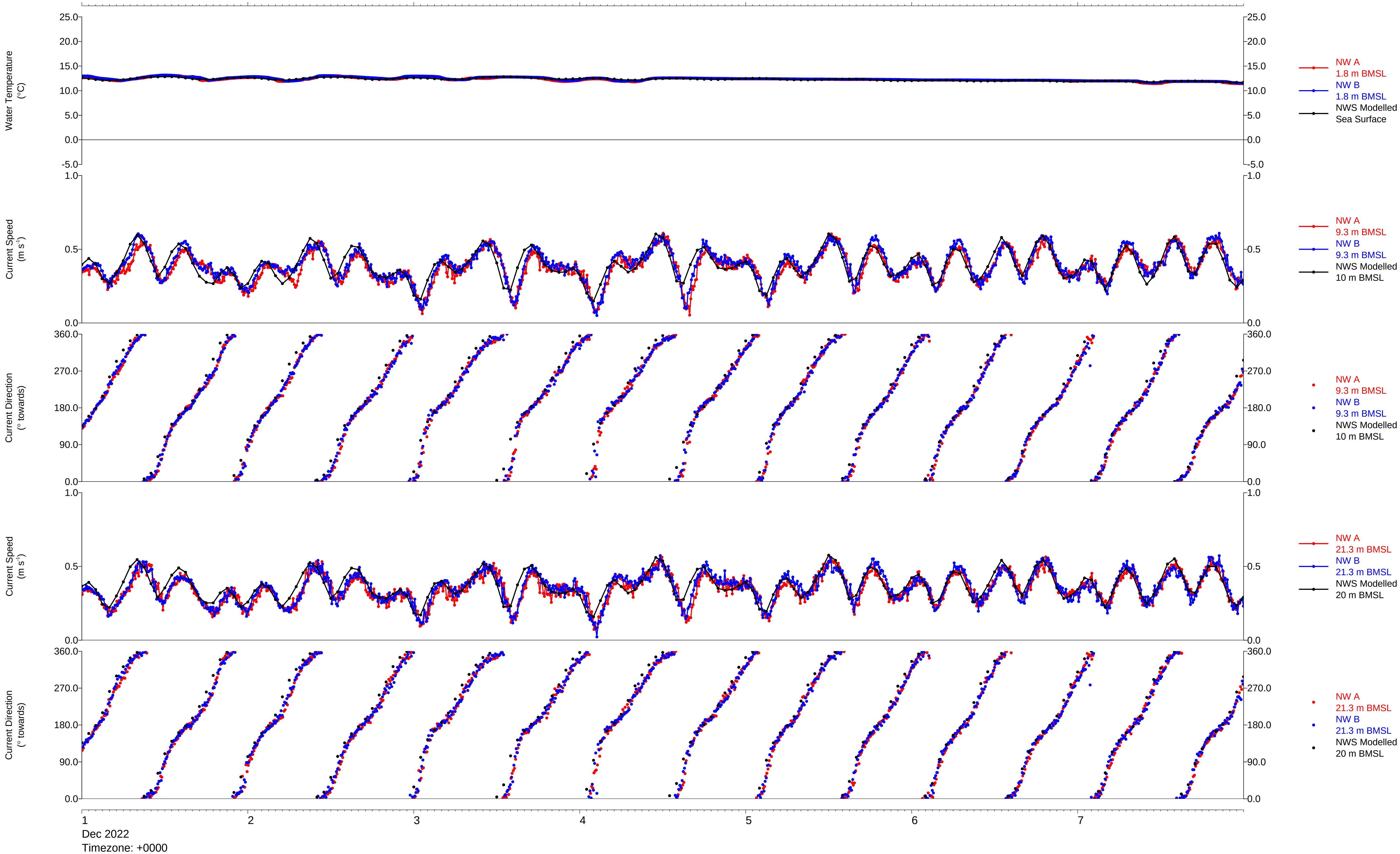
Time Zone: UTC +00:00 hours NWADCP{A,B}.2022.12.QC_dataReturn.nc, MetO.NW.CUR.mov3.ext.nc, MetO.NW.SST.mov3.nc

 moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK3a.NW.ABM.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location: **NW**

Client: RVO
Project: J3707



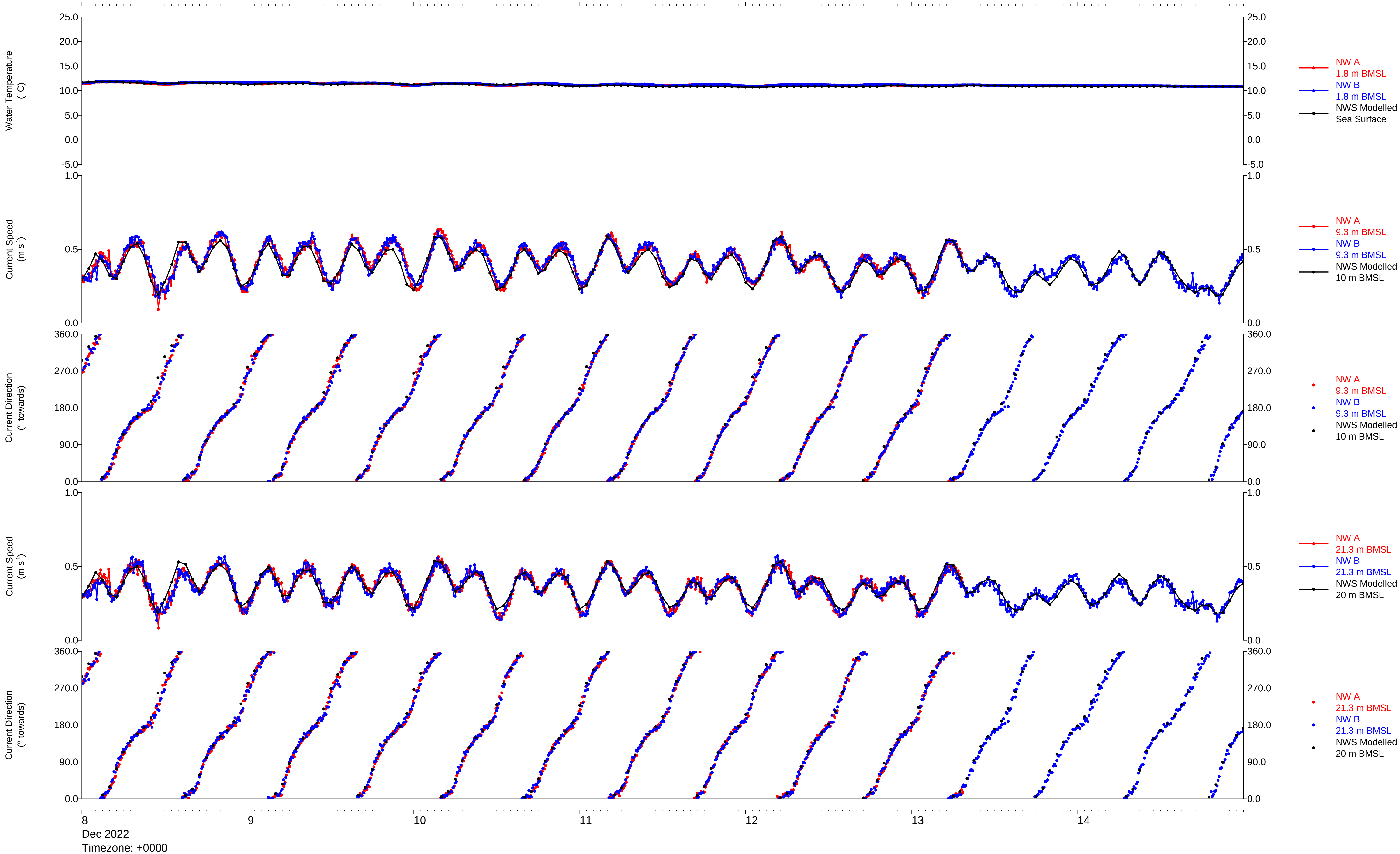
Time Zone: UTC +00:00 hours NWADCP{A,B}.2022.12.QC_dataReturn.nc, MetO.NW.CUR.mov3.ext.nc, MetO.NW.SST.mov3.nc

 moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK3b.NW.ABM.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location: NW

Client: RVO
Project: J3707

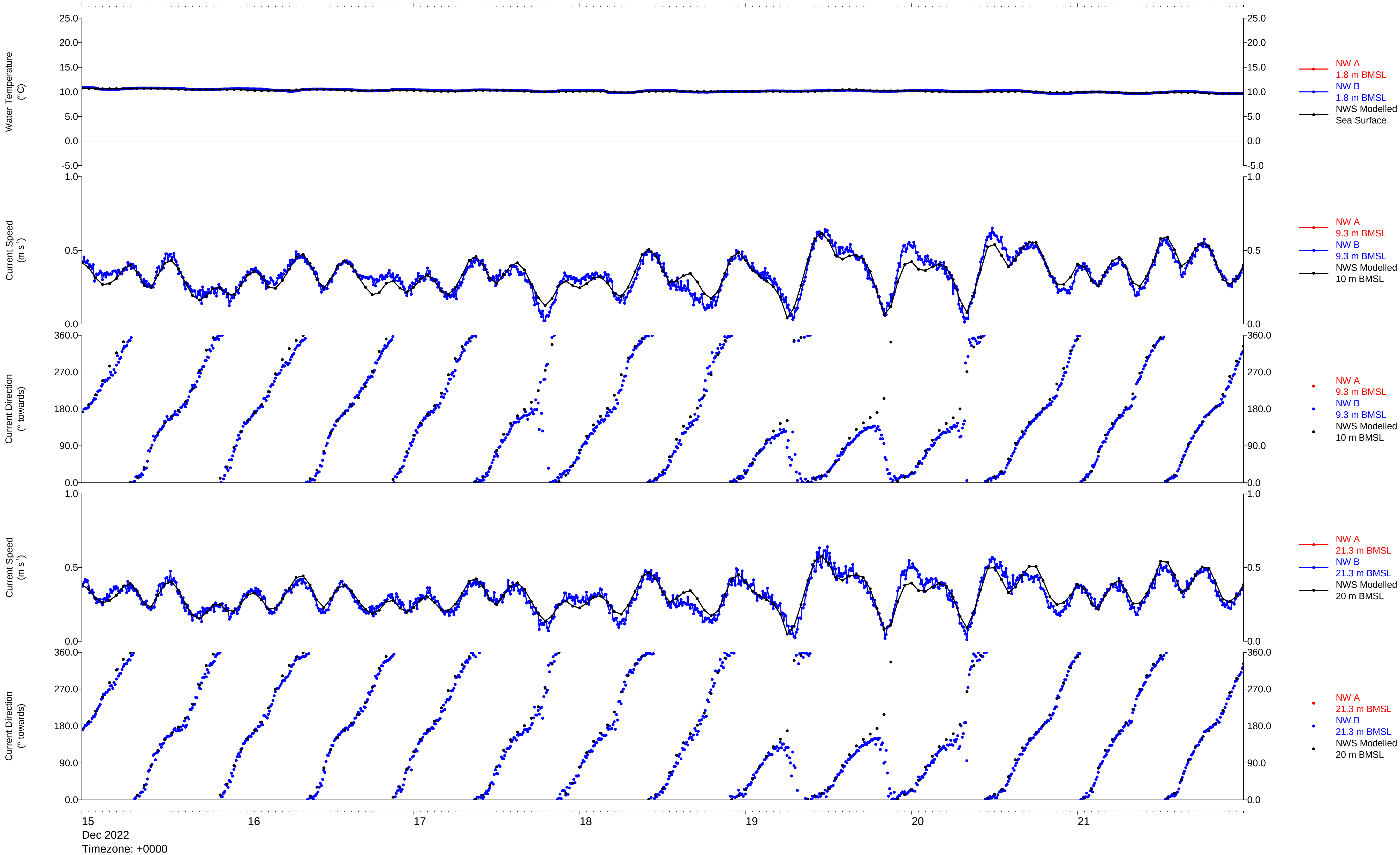


Time Zone: UTC +00:00 hours	NWADCP{A,B}.2022.12.QC_dataReturn.nc, MetO.NW.CUR.mov3.ext.nc, MetO.NW.SST.mov3.nc
	moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK3b.NW.ABM.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location: NW

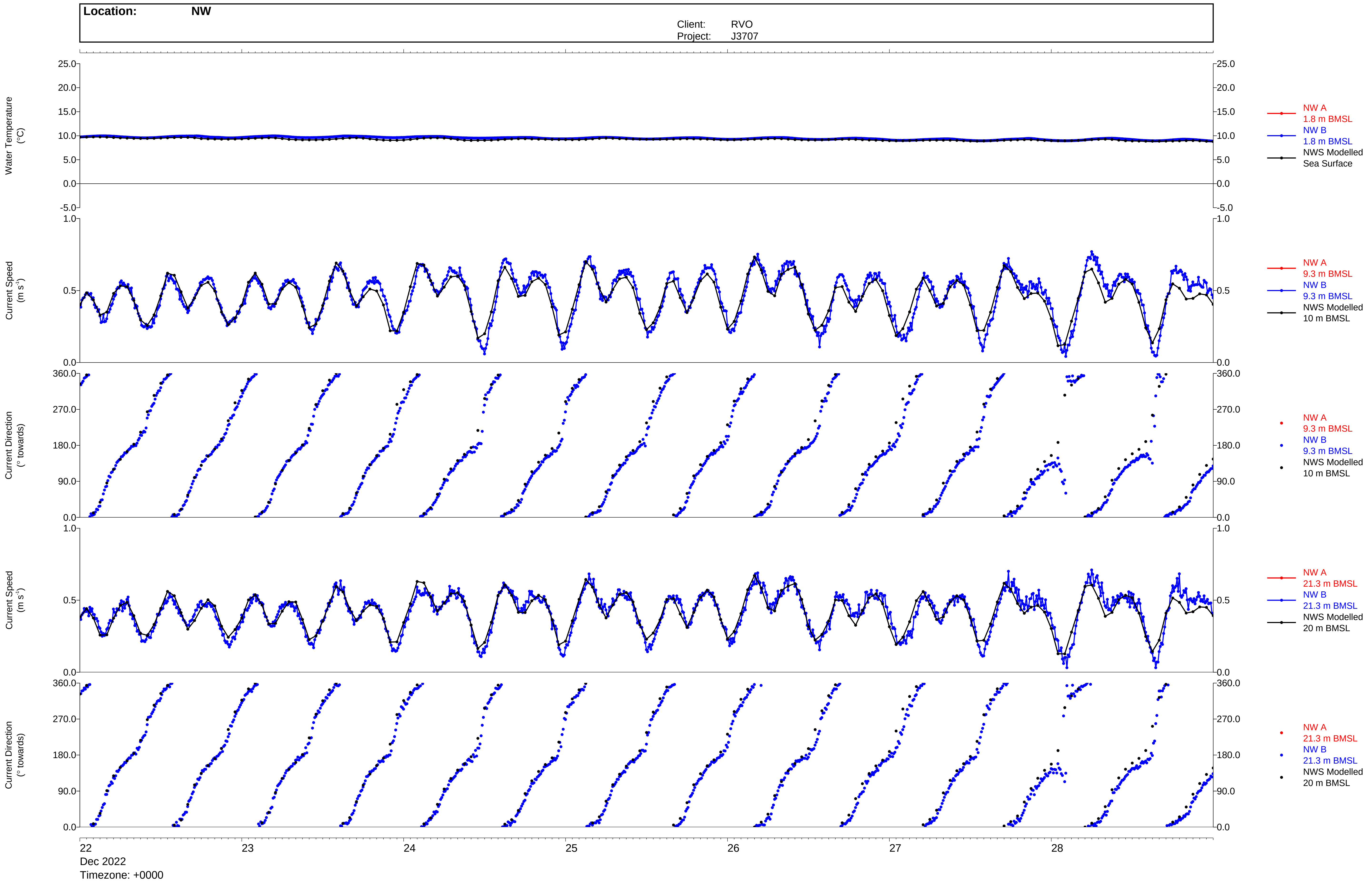
Client: RVO
Project: J3707



Time Zone: UTC +00:00 hours
© RPS Australia West Pty Ltd

NWADCP{A,B}.2022.12.QC_dataReturn.nc, MetO.NW.CUR.mov3.ext.nc, MetO.NW.SST.mov3.nc
moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK3b.NW.ABM.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

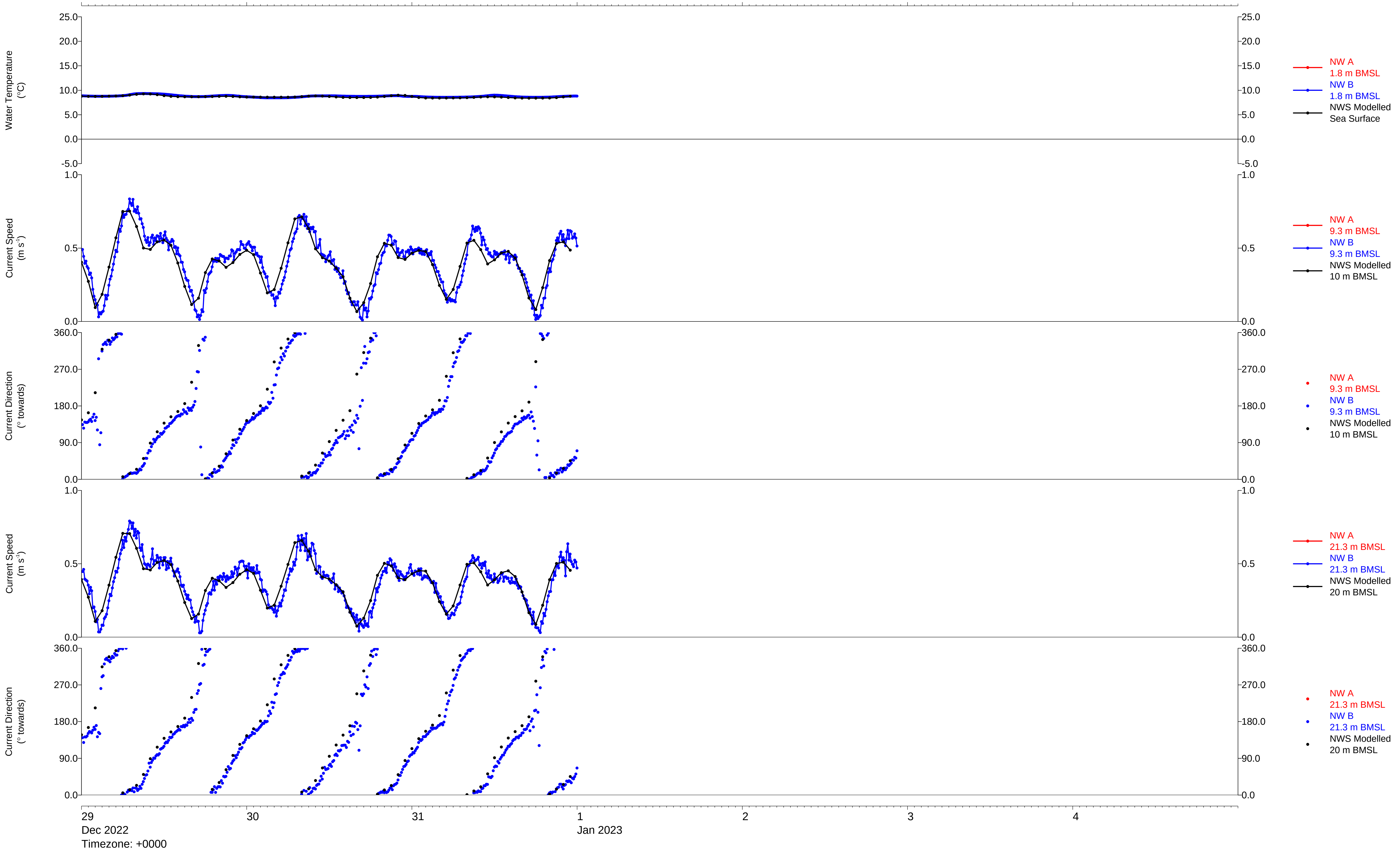


Time Zone: UTC +00:00 hours	NWADCP{A,B}.2022.12.QC_dataReturn.nc, MetO.NW.CUR.mov3.ext.nc, MetO.NW.SST.mov3.nc
	moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK3b.NW.ABM.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location: **NW**

Client: RVO
Project: J3707



Time Zone: UTC +00:00 hours NWADCP{A,B}.2022.12.QC_dataReturn.nc, MetO.NW.CUR.mov3.ext.nc, MetO.NW.SST.mov3.nc

 moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK3b.NW.ABM.week.ps)

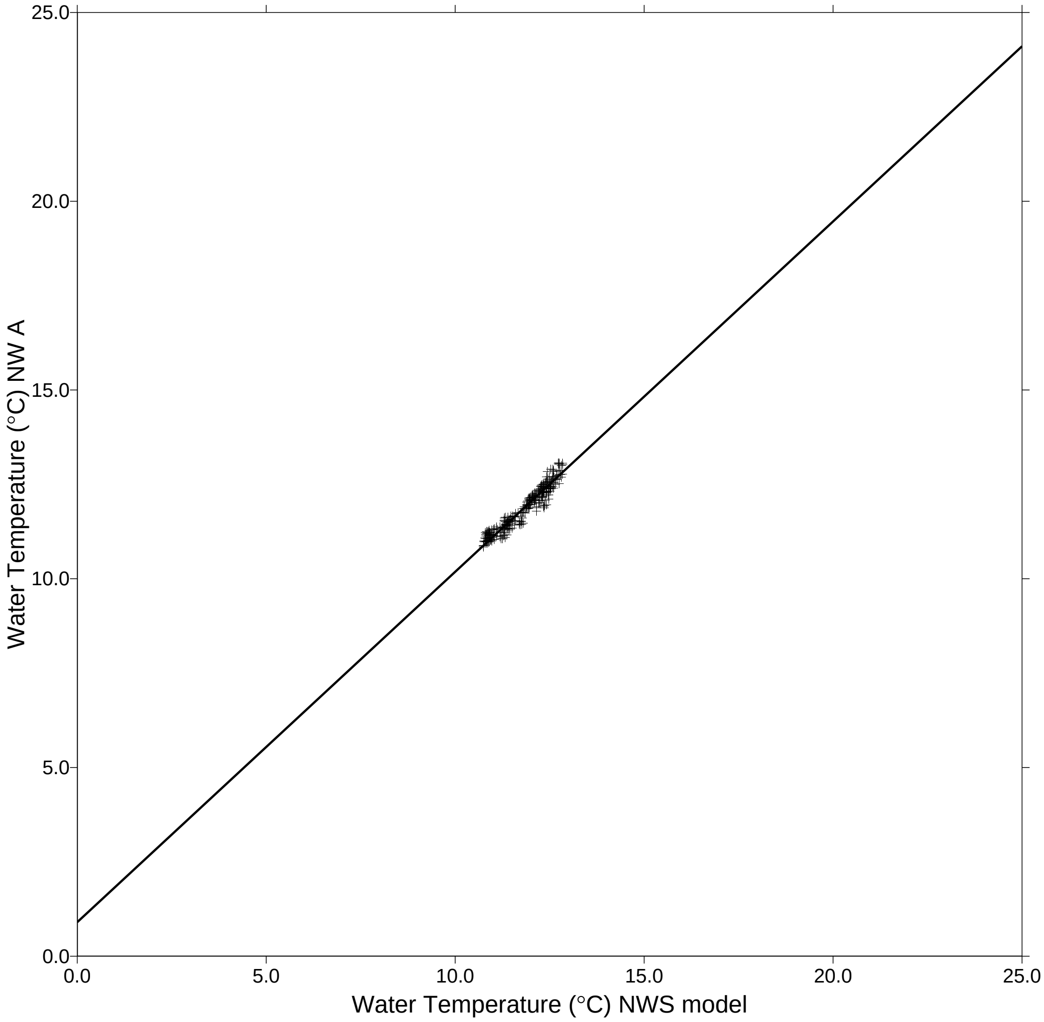
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:03 13 December 2022

Water Temperature (°C) NWS model

Water Temperature (°C) NW A Signature 500 (S/N 103318)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.903	Number of Data Points	= 296
Slope	= 0.928	Bias	= 0.053446
Standard Error	= 0.117	RMS error	= 0.178651
Correlation Coefficient	= 0.962	Scatter Index	= 0.01512

Time Zone: UTC +00:00 hours	NWADCPA.2022.12.QC_dataReturn.nc, MetO.NW.CUR.mov3.ext.nc, MetO.NW.SST.mov3.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK3c.NWA.val.pdf)

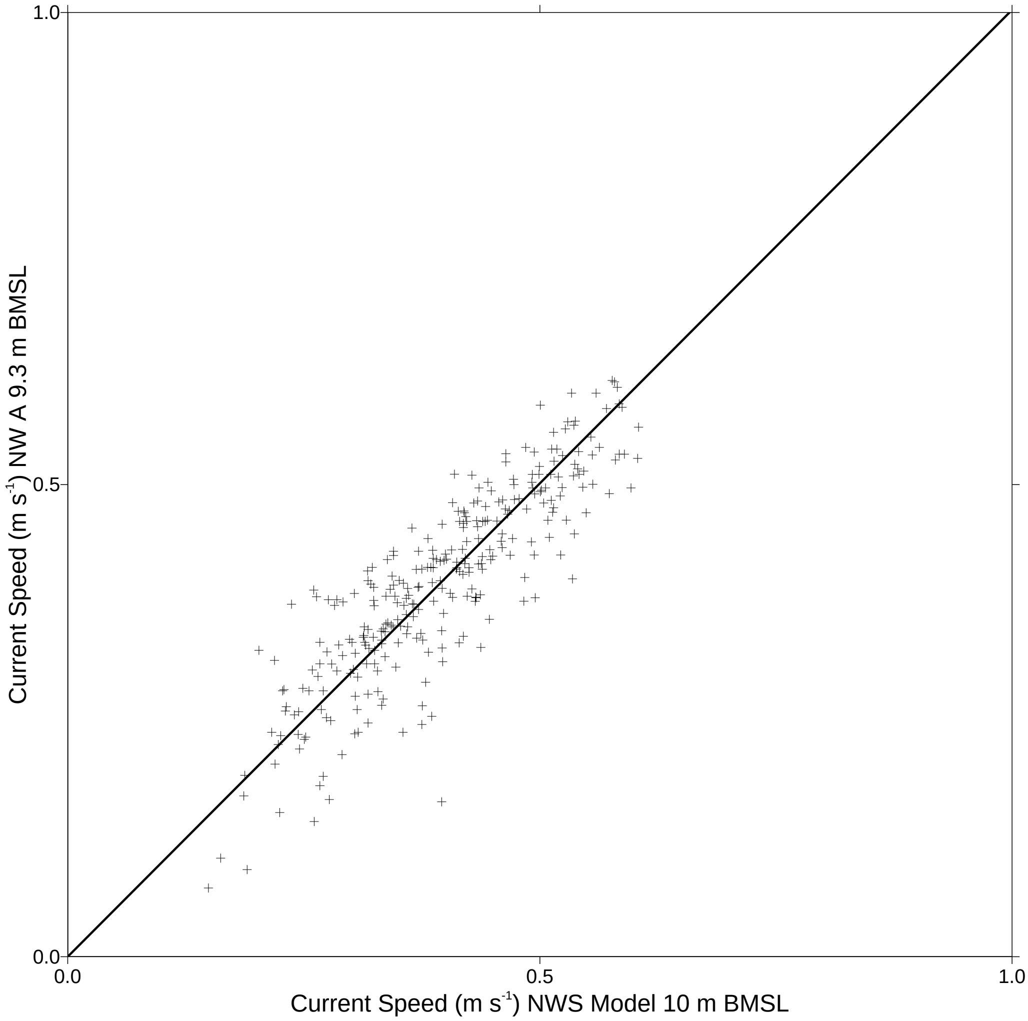
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:03 13 December 2022

Current Speed ($m\ s^{-1}$) NWS Model 10 m BMSL

Current Speed ($m\ s^{-1}$) NW A 9.3 m BMSL Signature 500 (S/N 103318)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 296
Slope	= 1.003	Bias	= 0.000443733
Standard Error	= 0.037	RMS error	= 0.0520385
Correlation Coefficient	= 0.867	Scatter Index	= 0.13167

Time Zone: UTC +00:00 hours	NWADCPA.2022.12.QC_dataReturn.nc, MetO.NW.CUR.mov3.ext.nc, MetO.NW.SST.mov3.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK3c.NWA.val.pdf)

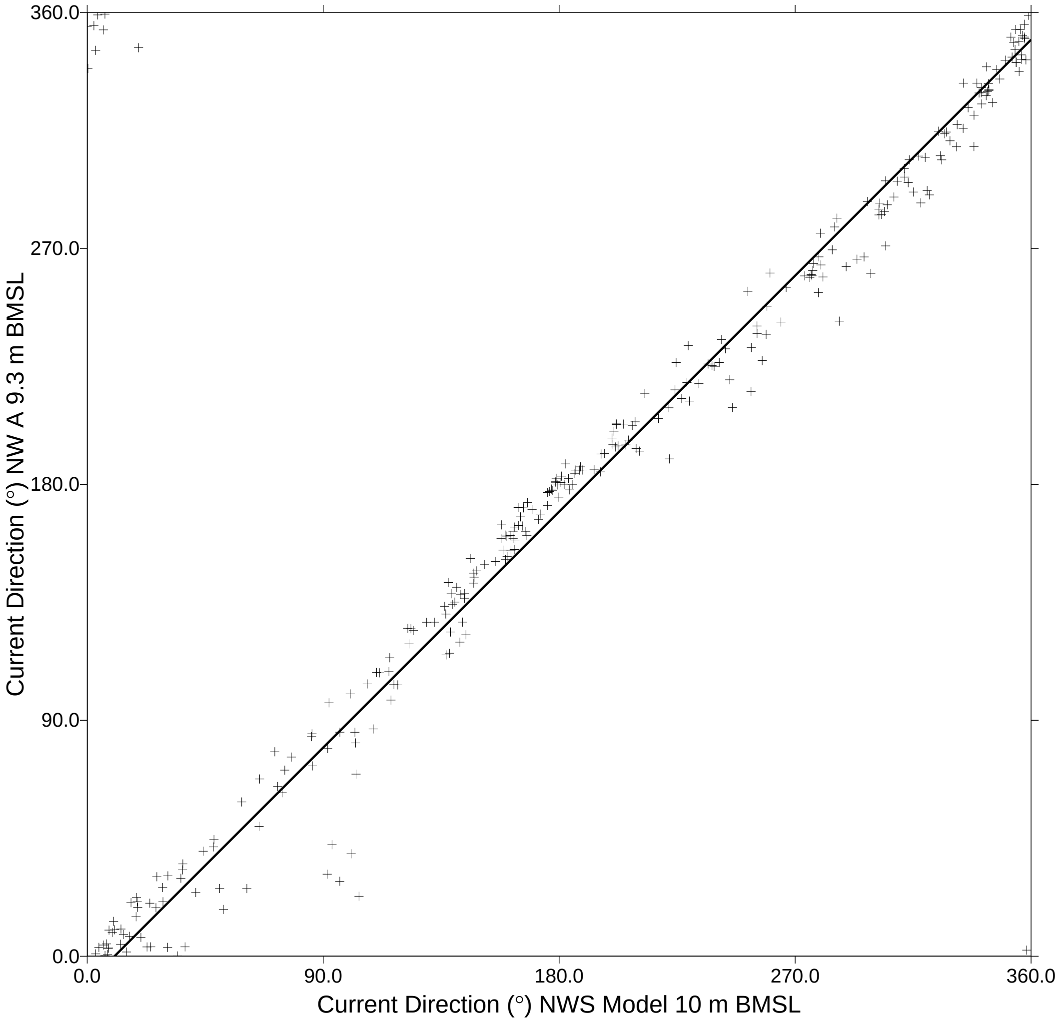
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:03 13 December 2022

Current Direction (°) NWS Model 10 m BMSL towards

Current Direction (°) NW A 9.3 m BMSL towards Signature 500 (S/N 103318)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -10.392	Number of Data Points	= 296
Slope	= 1.000	Bias	= -10.3925
Standard Error	= 12.134	RMS error	= 15.9604
Correlation Coefficient	= 0.994	Scatter Index	= 0.08114

* both axes are polar variables

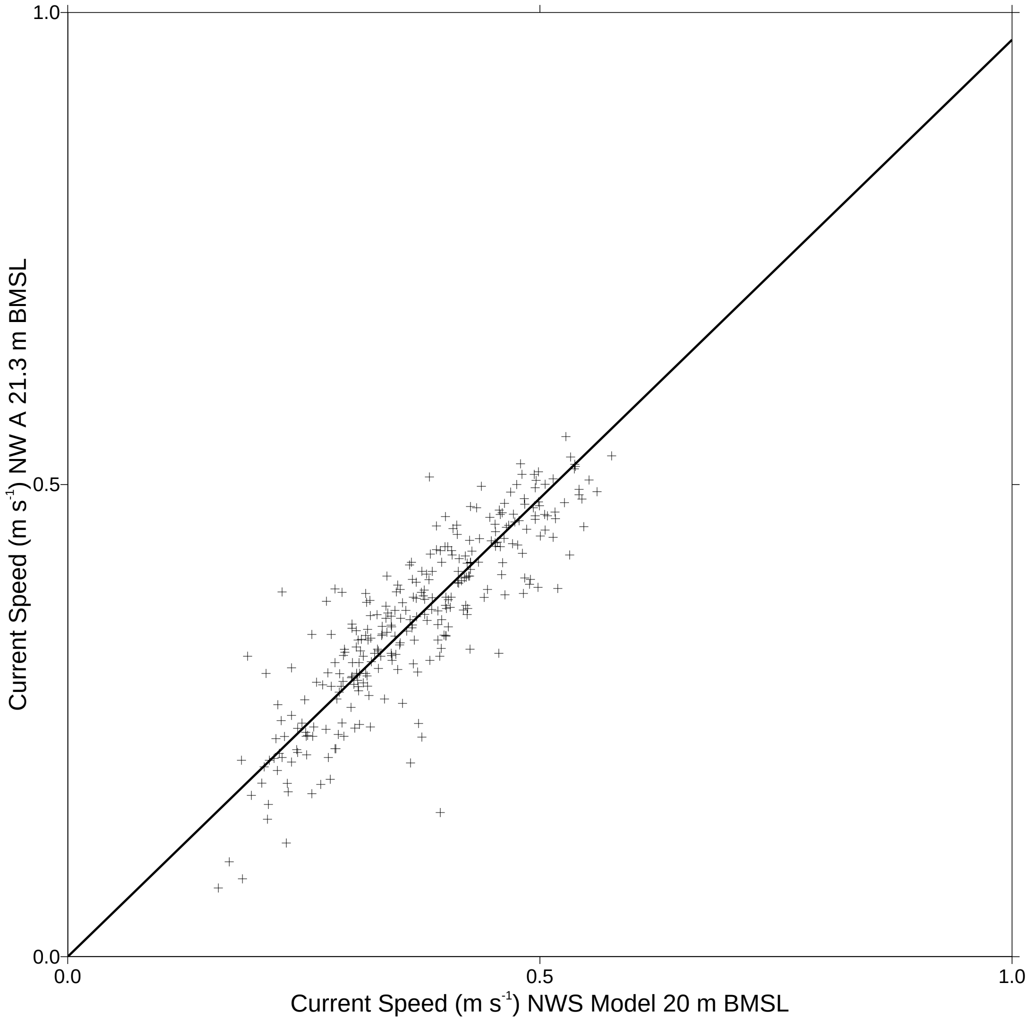
Time Zone: UTC +00:00 hours	NWADCPA.2022.12.QC_dataReturn.nc, MetO.NW.CUR.mov3.ext.nc, MetO.NW.SST.mov3.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK3c.NWA.val.pdf)

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:03 13 December 2022

Current Speed (m s^{-1}) NWS Model 20 m BMSL

Current Speed (m s^{-1}) NW A 21.3 m BMSL Signature 500 (S/N 103318)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 296
Slope	= 0.971	Bias	= -0.0119055
Standard Error	= 0.034	RMS error	= 0.0489864
Correlation Coefficient	= 0.868	Scatter Index	= 0.13248

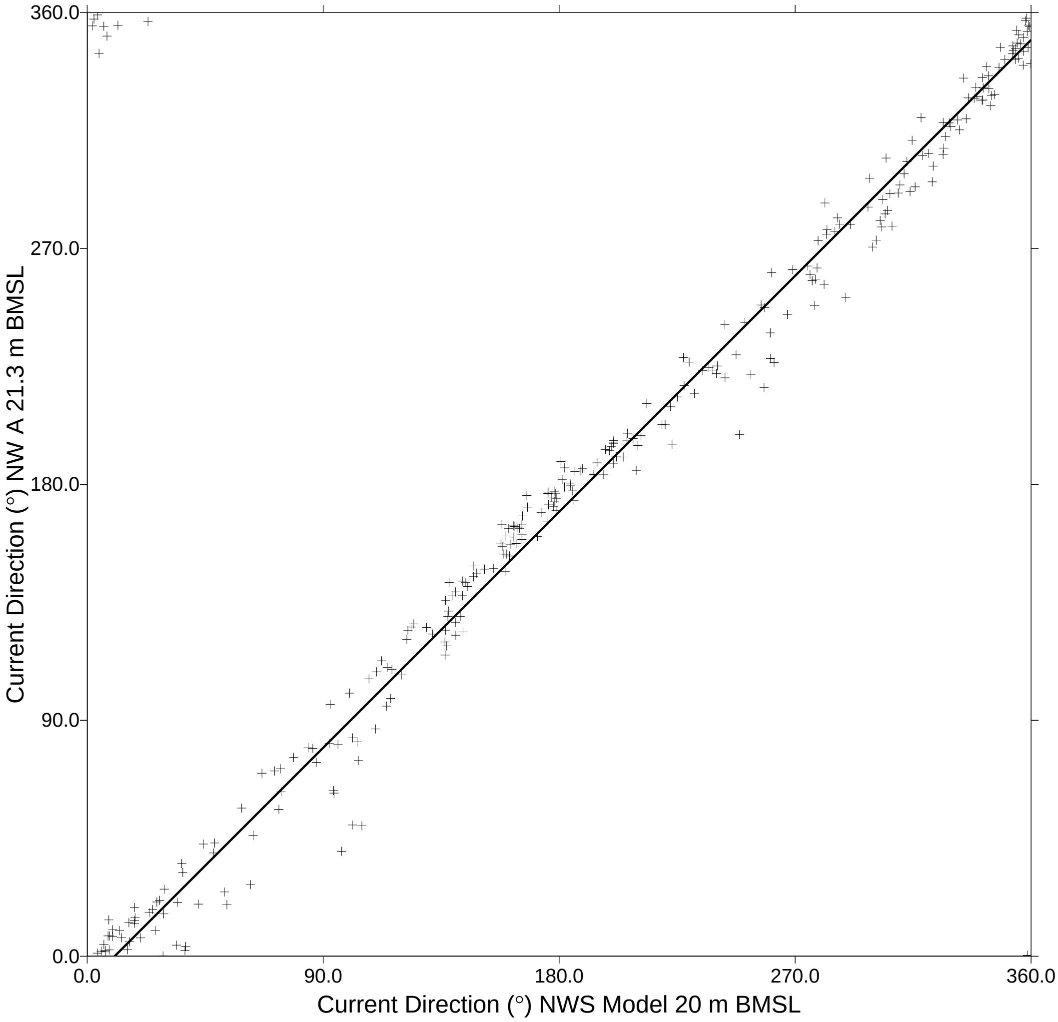
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 07:03 13 December 2022

Current Direction (°) NWS Model 20 m BMSL towards

Current Direction (°) NW A 21.3 m BMSL towards Signature 500 (S/N 103318)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -10.469	Number of Data Points	= 296
Slope	= 1.000	Bias	= -10.4688
Standard Error	= 10.513	RMS error	= 14.8238
Correlation Coefficient	= 0.995	Scatter Index	= 0.07435

* both axes are polar variables

Time Zone: UTC +00:00 hours	NWADCPA.2022.12.QC_dataReturn.nc, MetO.NW.CUR.mov3.ext.nc, MetO.NW.SST.mov3.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK3c.NWA.val.pdf)

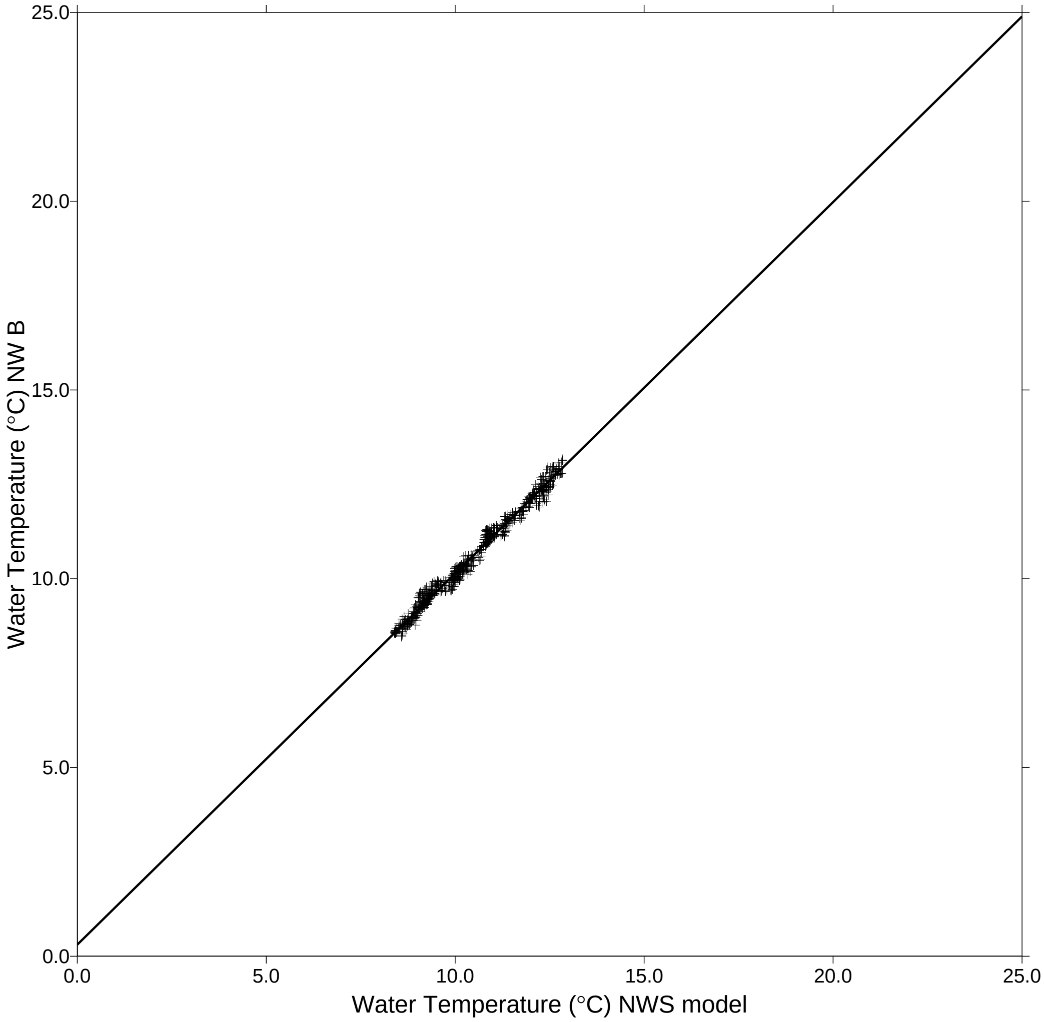
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:58 01 December 2022 to 23:00 31 December 2022

Water Temperature (°C) NWS model

Water Temperature (°C) NW B Signature 500 (S/N 103000)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.306	Number of Data Points	= 743
Slope	= 0.984	Bias	= 0.13374
Standard Error	= 0.107	RMS error	= 0.203275
Correlation Coefficient	= 0.993	Scatter Index	= 0.01936

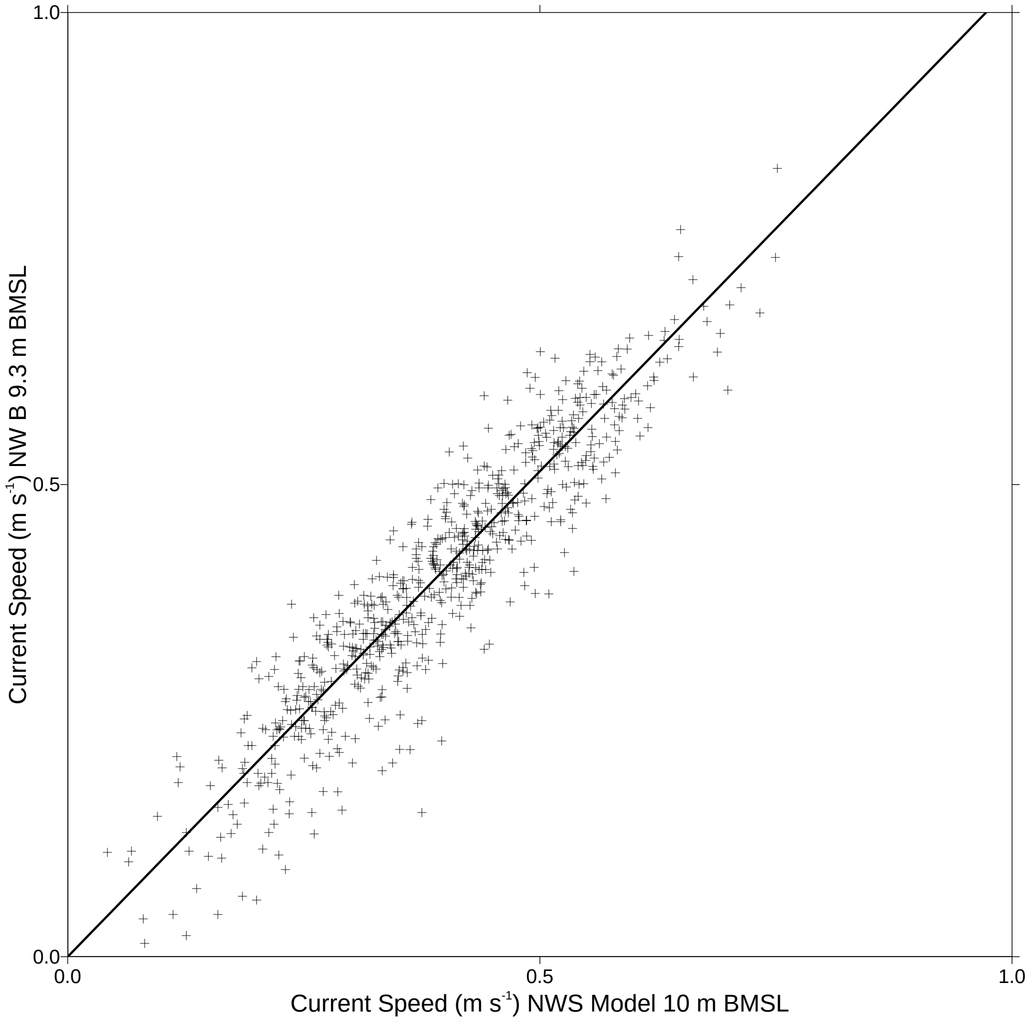
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:58 01 December 2022 to 23:00 31 December 2022

Current Speed (m s^{-1}) NWS Model 10 m BMSL

Current Speed (m s^{-1}) NW B 9.3 m BMSL Signature 500 (S/N 103000)



Line of Best Fit (Perpendicular)			
Ordinate Intercept	= 0.000	Number of Data Points	= 743
Slope	= 1.028	Bias	= 0.00864575
Standard Error	= 0.036	RMS error	= 0.051758
Correlation Coefficient	= 0.927	Scatter Index	= 0.13197

Time Zone: UTC +00:00 hours	NWADCPB.2022.12.QC_dataReturn.nc, MetO.NW.CUR.mov3.ext.nc, MetO.NW.SST.mov3.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK3c.NWB.val.pdf)

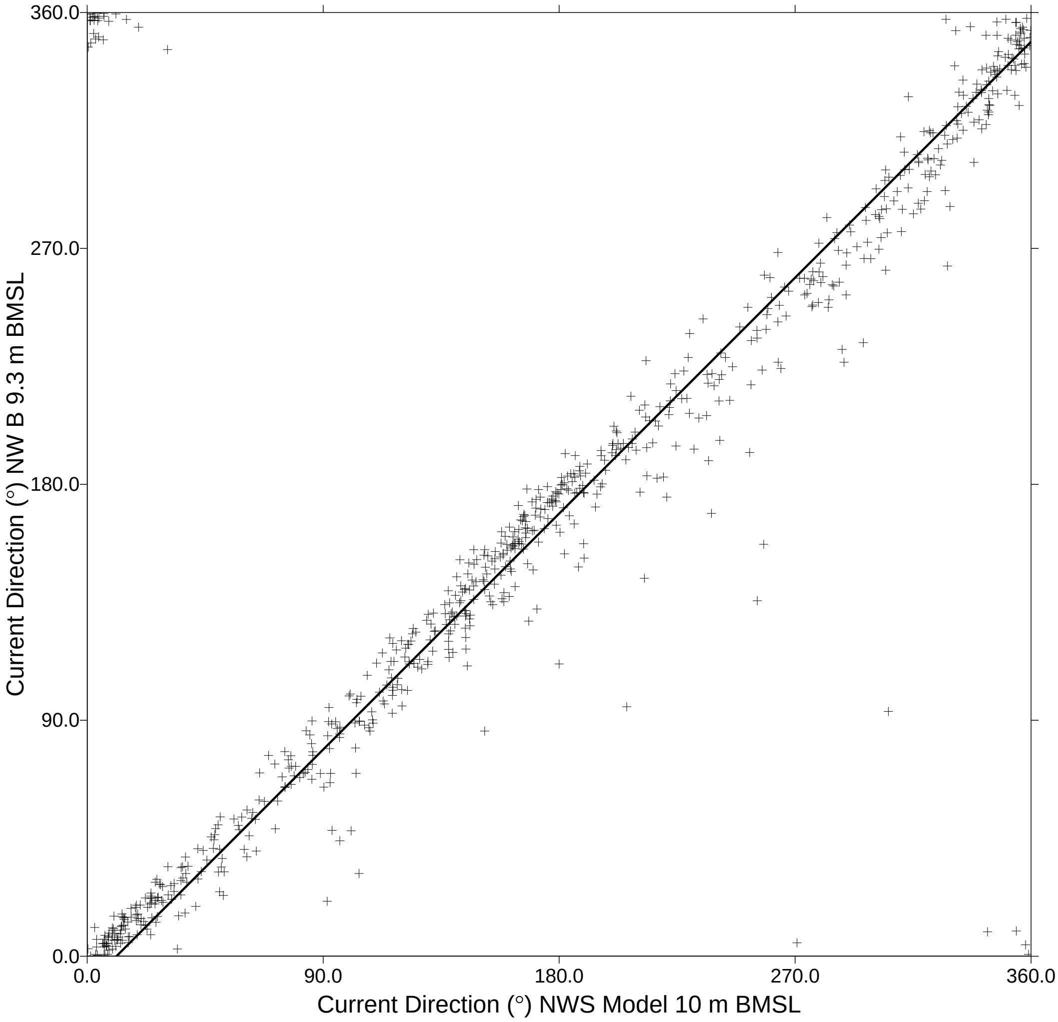
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:58 01 December 2022 to 23:00 31 December 2022

Current Direction (°) NWS Model 10 m BMSL towards

Current Direction (°) NW B 9.3 m BMSL towards Signature 500 (S/N 103000)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -11.150	Number of Data Points	= 743
Slope	= 1.000	Bias	= -11.1501
Standard Error	= 15.792	RMS error	= 19.3227
Correlation Coefficient	= 0.990	Scatter Index	= 0.10535

* both axes are polar variables

Time Zone: UTC +00:00 hours	NWADCPB.2022.12.QC_dataReturn.nc, MetO.NW.CUR.mov3.ext.nc, MetO.NW.SST.mov3.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK3c.NWB.val.pdf)

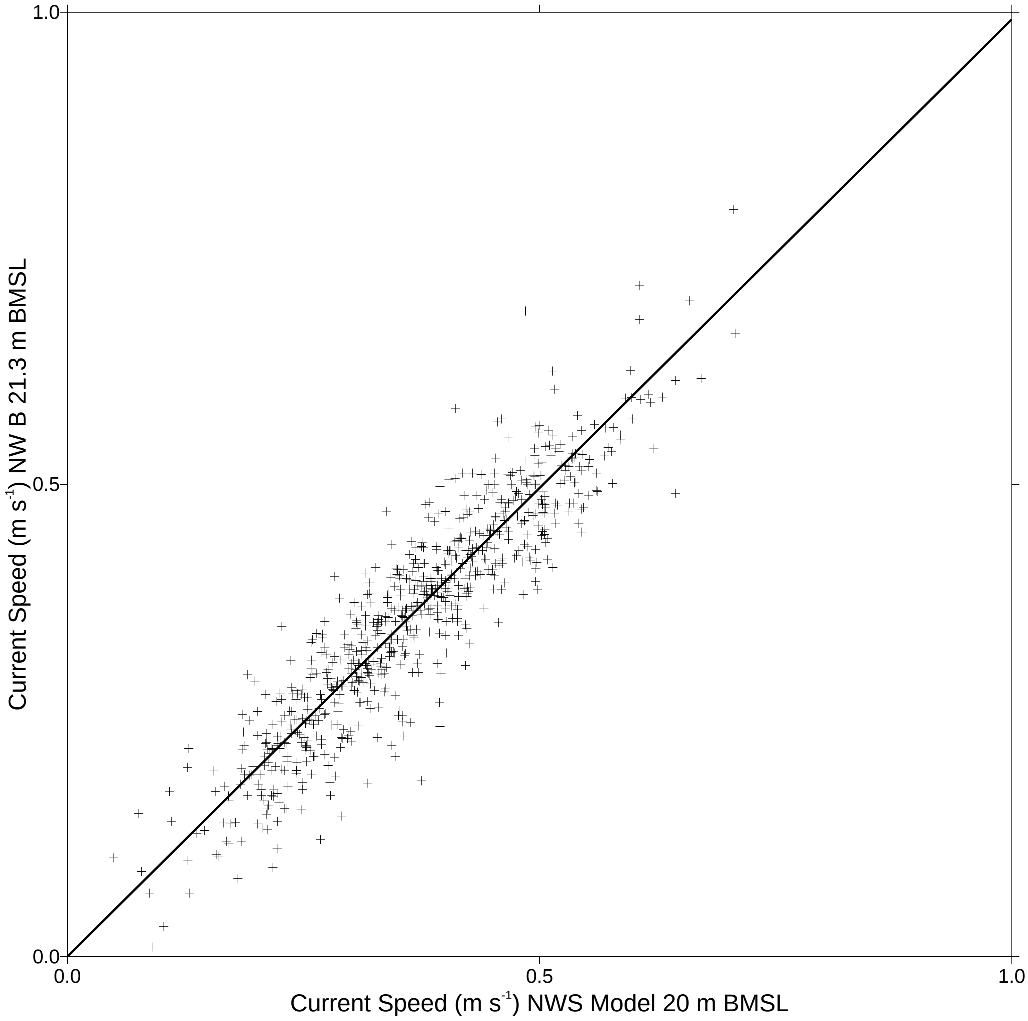
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:58 01 December 2022 to 23:00 31 December 2022

Current Speed (m s-1) NWS Model 20 m BMSL

Current Speed (m s-1) NW B 21.3 m BMSL Signature 500 (S/N 103000)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.000	Number of Data Points	= 743
Slope	= 0.992	Bias	= -0.0049518
Standard Error	= 0.034	RMS error	= 0.0478088
Correlation Coefficient	= 0.916	Scatter Index	= 0.13052

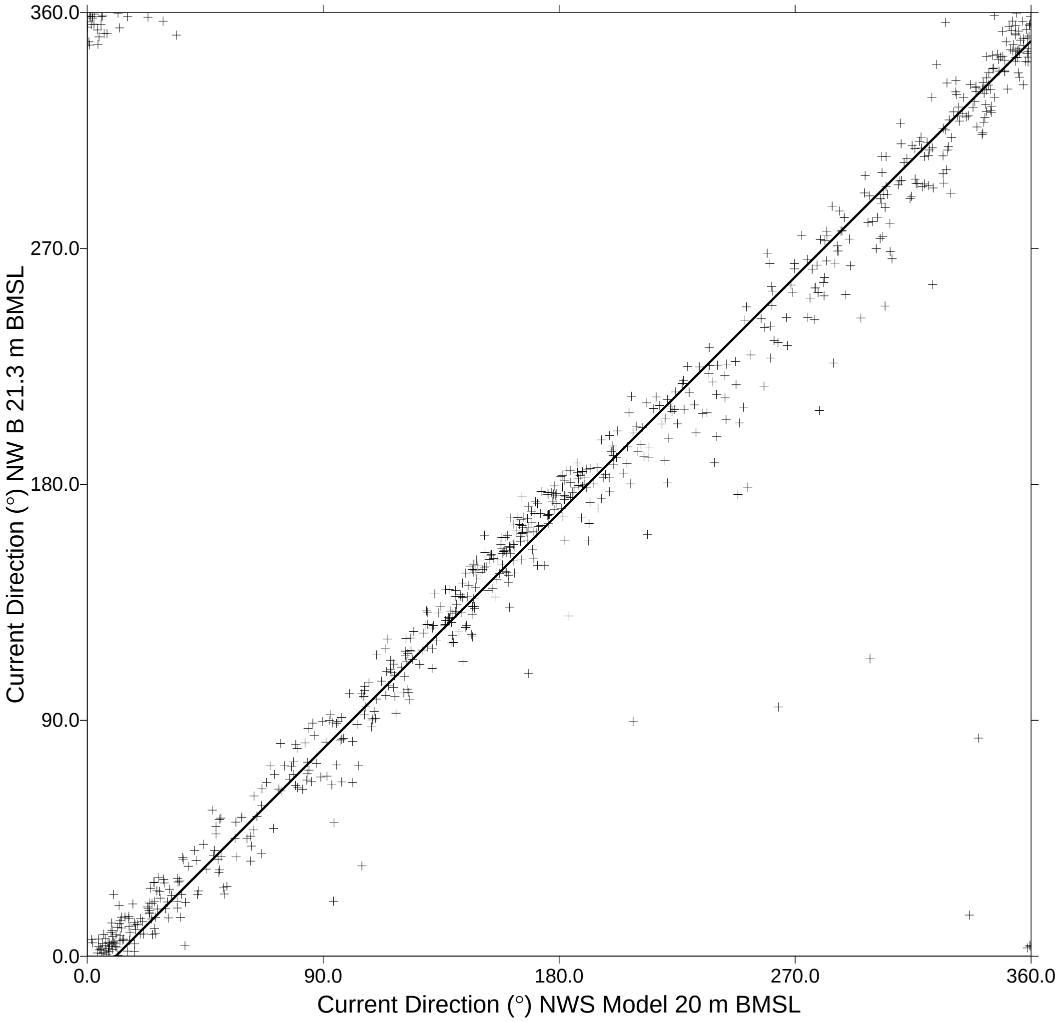
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:58 01 December 2022 to 23:00 31 December 2022

Current Direction (°) NWS Model 20 m BMSL towards

Current Direction (°) NW B 21.3 m BMSL towards Signature 500 (S/N 103000)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= -10.877	Number of Data Points	= 743
Slope	= 1.000	Bias	= -10.8774
Standard Error	= 16.111	RMS error	= 19.4301
Correlation Coefficient	= 0.990	Scatter Index	= 0.10391

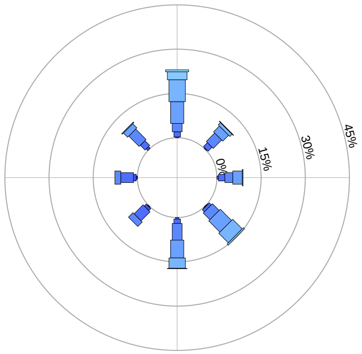
* both axes are polar variables

Time Zone: UTC +00:00 hours	NWADCPB.2022.12.QC_dataReturn.nc, MetO.NW.CUR.mov3.ext.nc, MetO.NW.SST.mov3.nc
	moecorel: 16:30 24/Feb/2023 by MWB (AppendixK3c.NWB.val.pdf)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

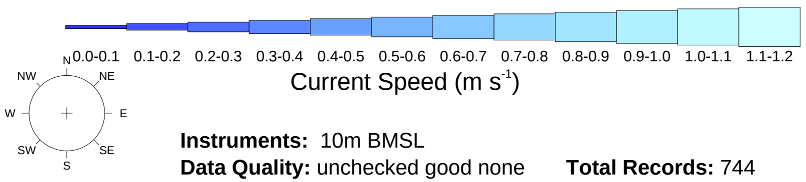
Location:	**North Sea Grid**		
Latitude:	53° 22' 42" N	Client:	RVO
Longitude:	3° 7' 16" E	Project:	J3707

Deployment
(00:00 01 December 2022 to 23:00 31 December 2022)

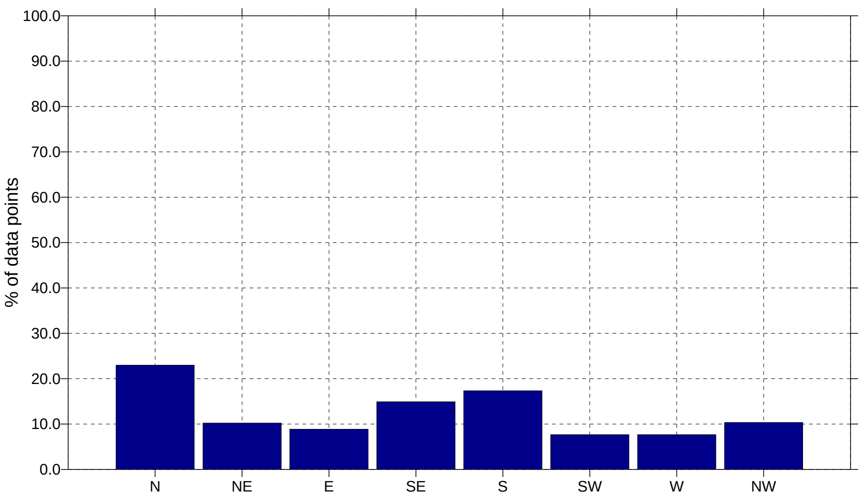


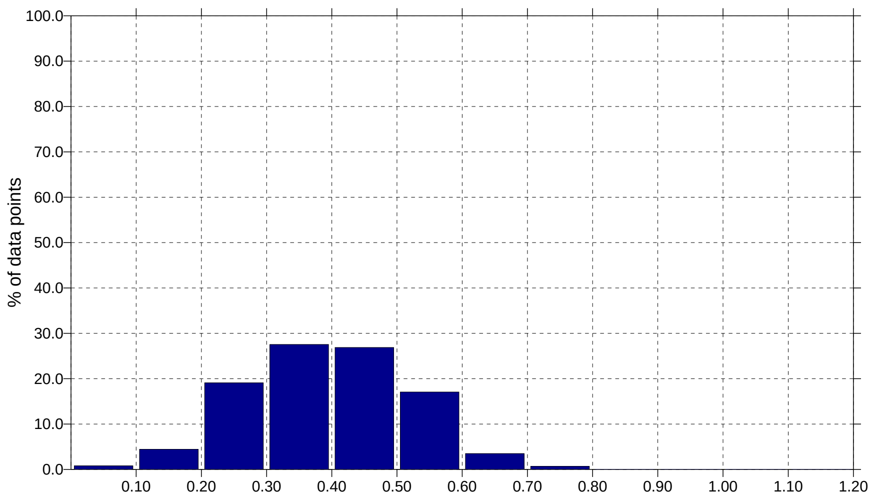
Deployment

Maximum Current Speed (m s^{-1}): 0.75 towards 14.09° North
Minimum Current Speed (m s^{-1}): 0.04 towards 151.60° North
Standard deviation: 0.12 m s^{-1}
Mean: 0.39m s^{-1}



Instruments: 10m BMSL
Data Quality: unchecked good none **Total Records:** 744



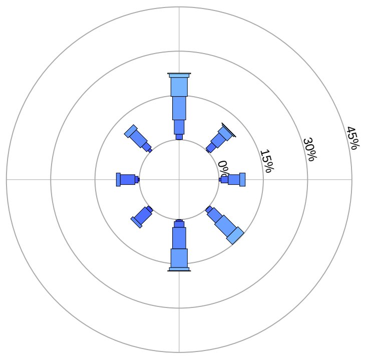


Time Zone: UTC +00:00 hours	MetO.NW.CUR.mov3.ext.nc
	moerose: 16:30 24/Feb/2023 by MWB (rose.histogram.AppendixK3d.NW.M.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

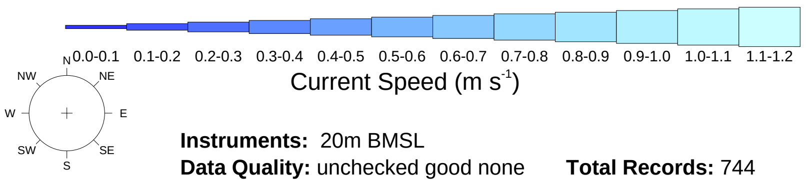
Location:	**North Sea Grid**		
Latitude:	53° 22' 42" N	Client:	RVO
Longitude:	3° 7' 16" E	Project:	J3707

Deployment
(00:00 01 December 2022 to 23:00 31 December 2022)

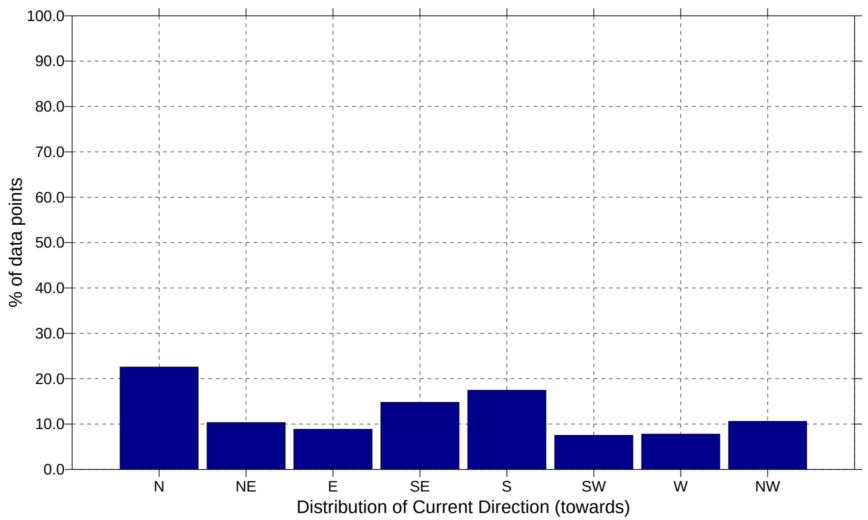


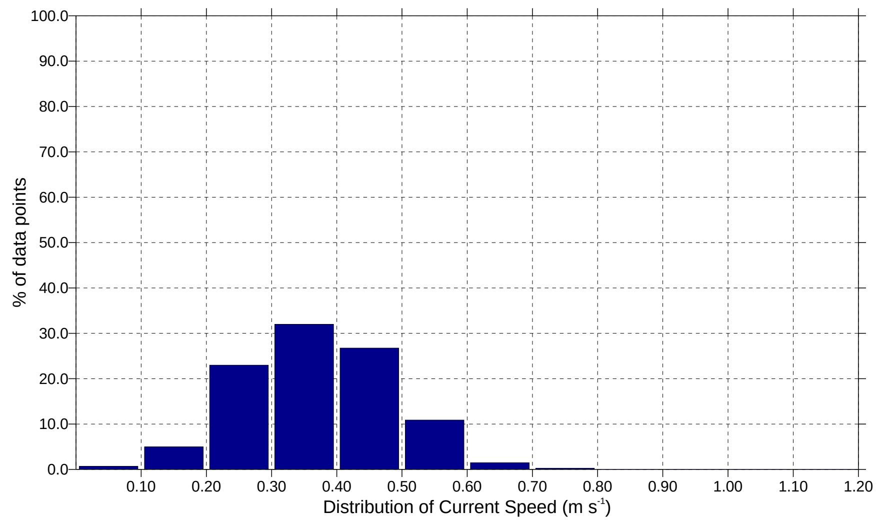
Deployment

Maximum Current Speed (m s^{-1}): 0.71 towards 5.44° North
Minimum Current Speed (m s^{-1}): 0.05 towards 168.23° North
Standard deviation: 0.11 m s^{-1}
Mean: 0.37m s^{-1}



Instruments: 20m BMSL
Data Quality: unchecked good none **Total Records:** 744

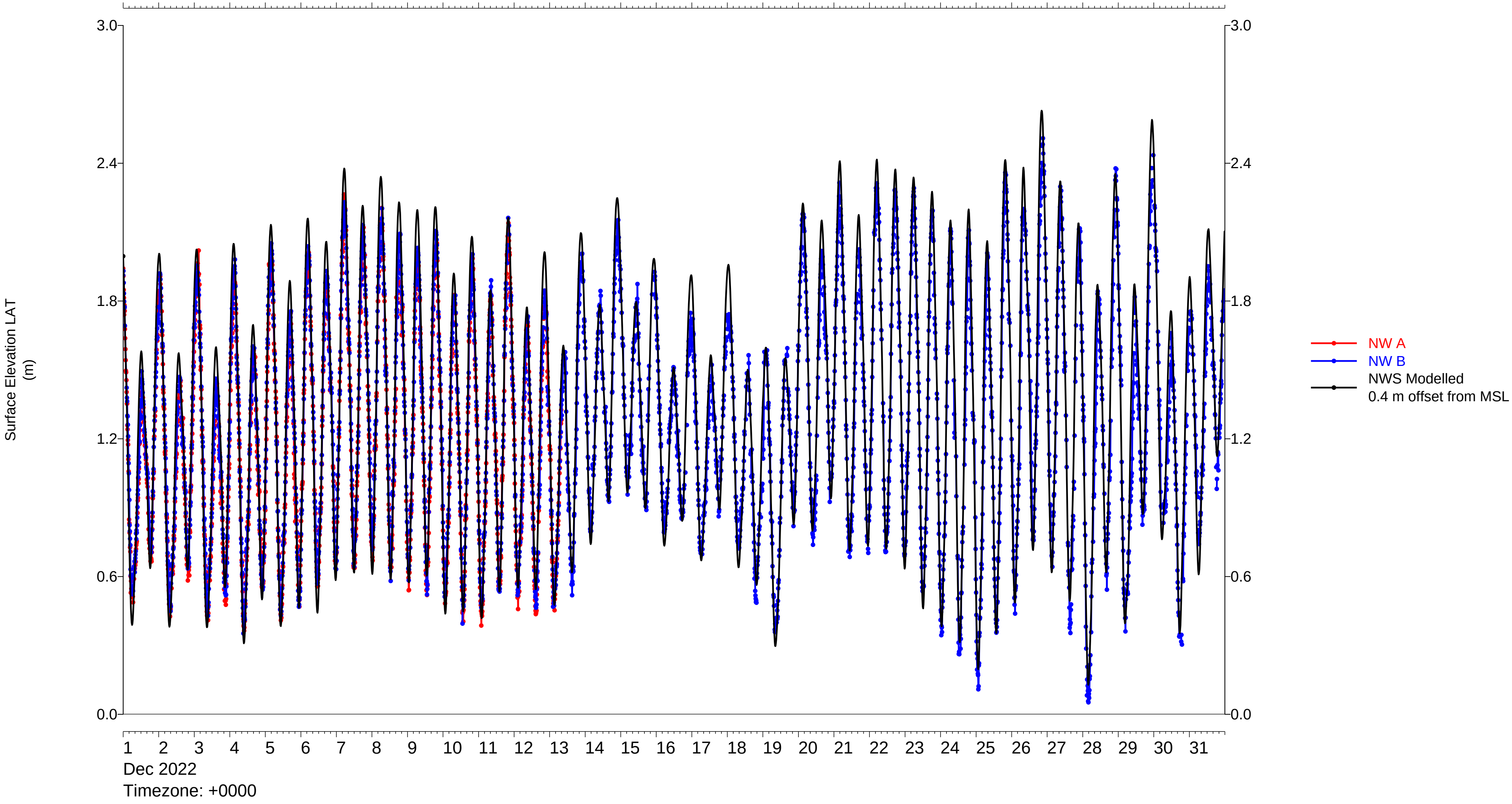




Time Zone: UTC +00:00 hours	MetO.NW.CUR.mov3.ext.nc
	moerose: 16:30 24/Feb/2023 by MWB (rose.histogram.AppendixK3d.NW.M.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

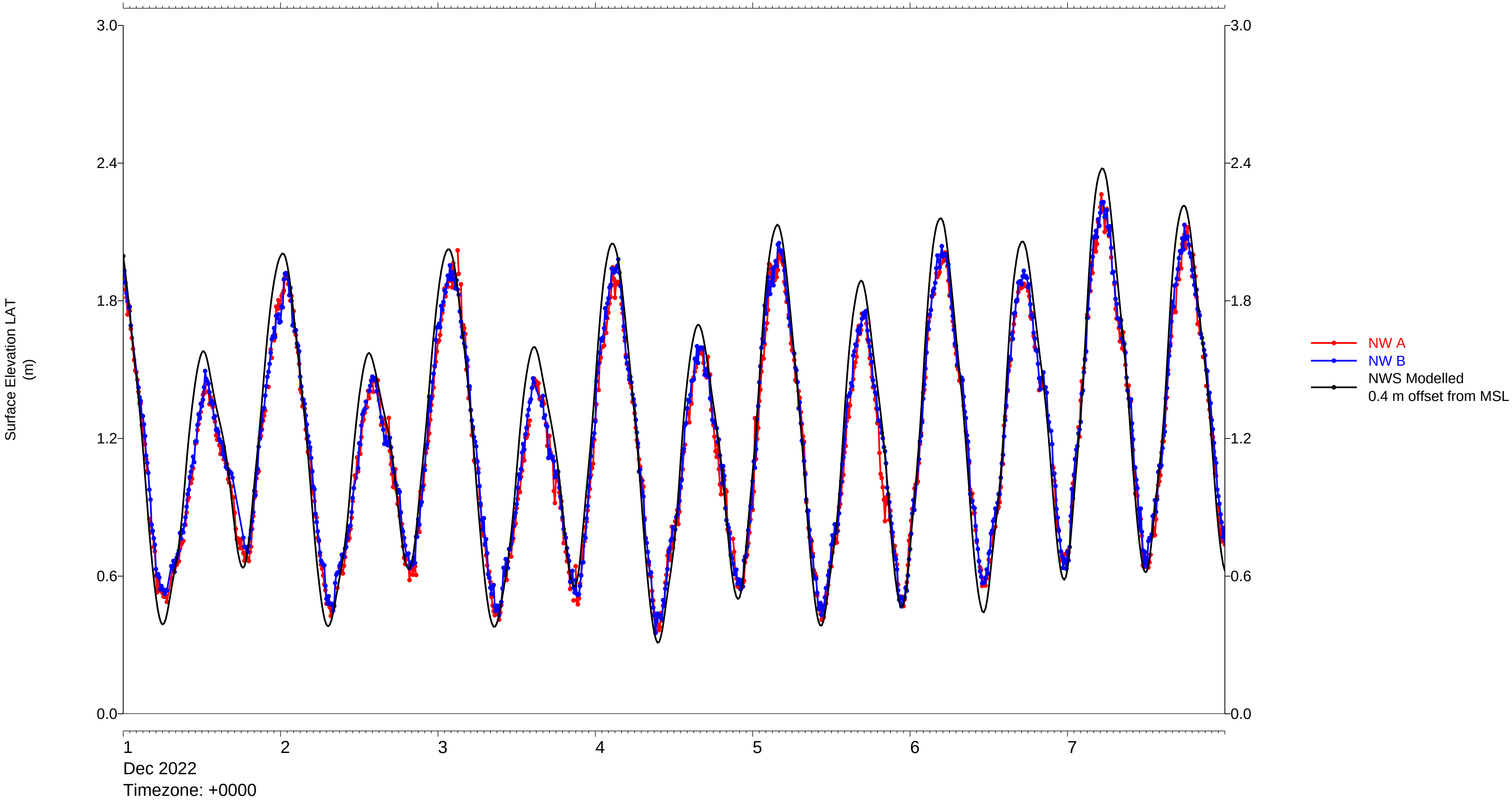
Location:	**NW**
Client:	RVO
Project:	J3707



Time Zone: UTC +00:00 hours	NWTide{A,B}.2022.12.QC_dataReturn.nc, MetO.NW.SSH.mov3.nc
© RPS Australia West Pty Ltd	moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK4a.NW.ABModel.ps)

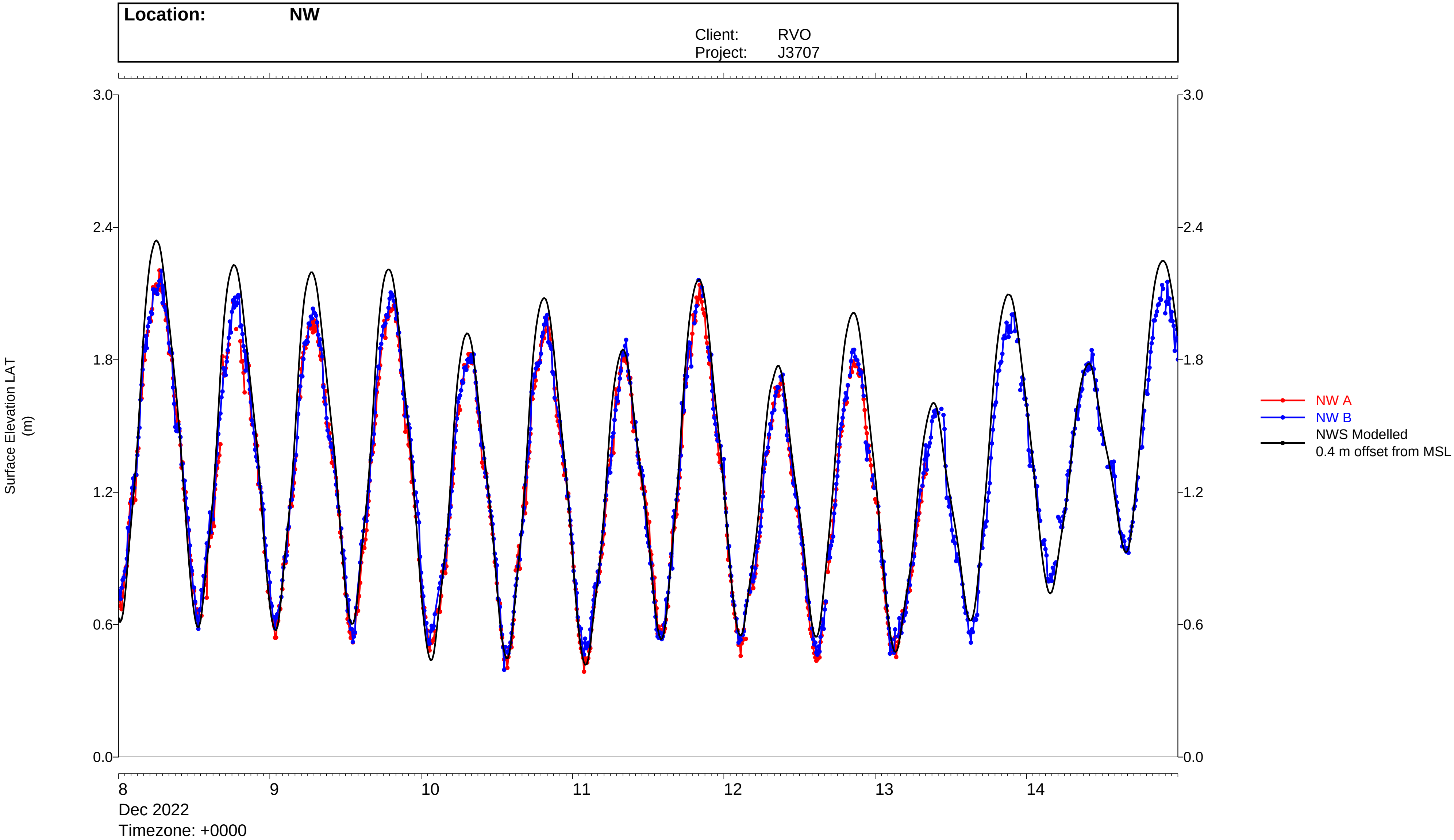
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**	Client: RVO Project: J3707



Time Zone: UTC +00:00 hours	NWTide{A,B}.2022.12.QC_dataReturn.nc, MetO.NW.SSH.mov3.nc
© RPS Australia West Pty Ltd	moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK4b.NW.ABModel.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

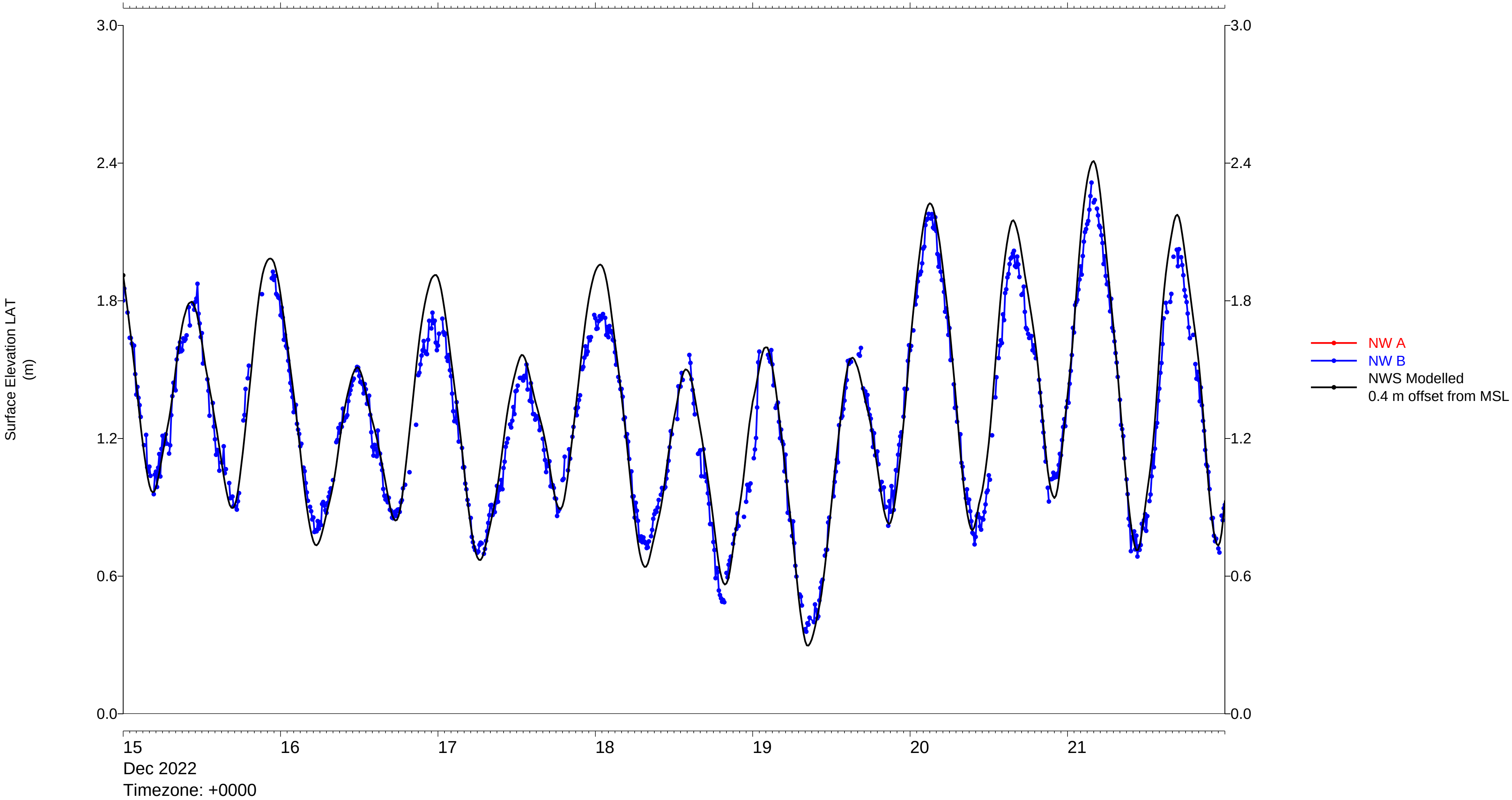


Time Zone: UTC +00:00 hours	NWTide{A,B}.2022.12.QC_dataReturn.nc, MetO.NW.SSH.mov3.nc
© RPS Australia West Pty Ltd	moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK4b.NW.ABModel.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location: **NW**

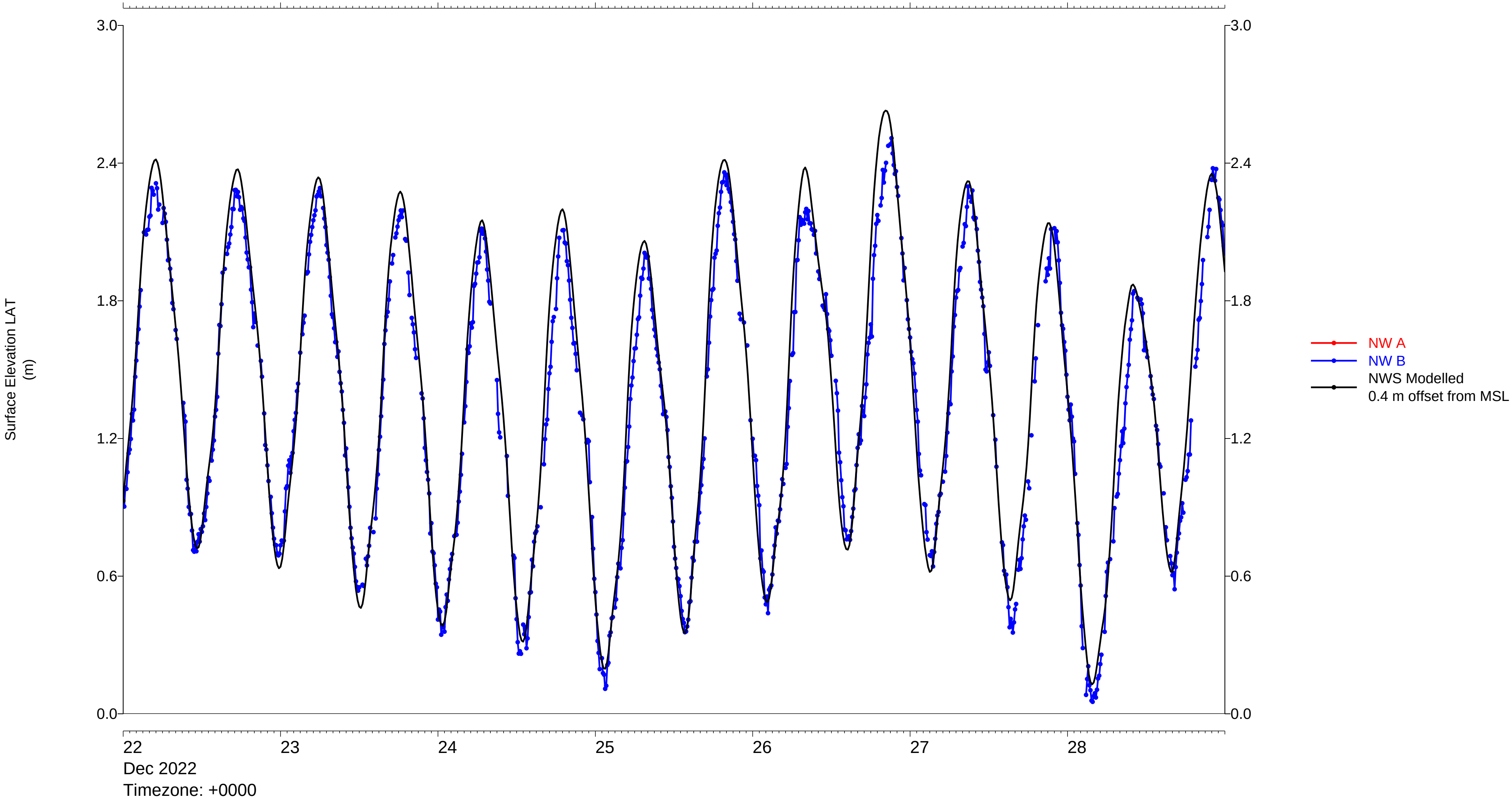
Client: RVO
Project: J3707



Time Zone: UTC +00:00 hours	NWTide{A,B}.2022.12.QC_dataReturn.nc, MetO.NW.SSH.mov3.nc
© RPS Australia West Pty Ltd	moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK4b.NW.ABModel.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

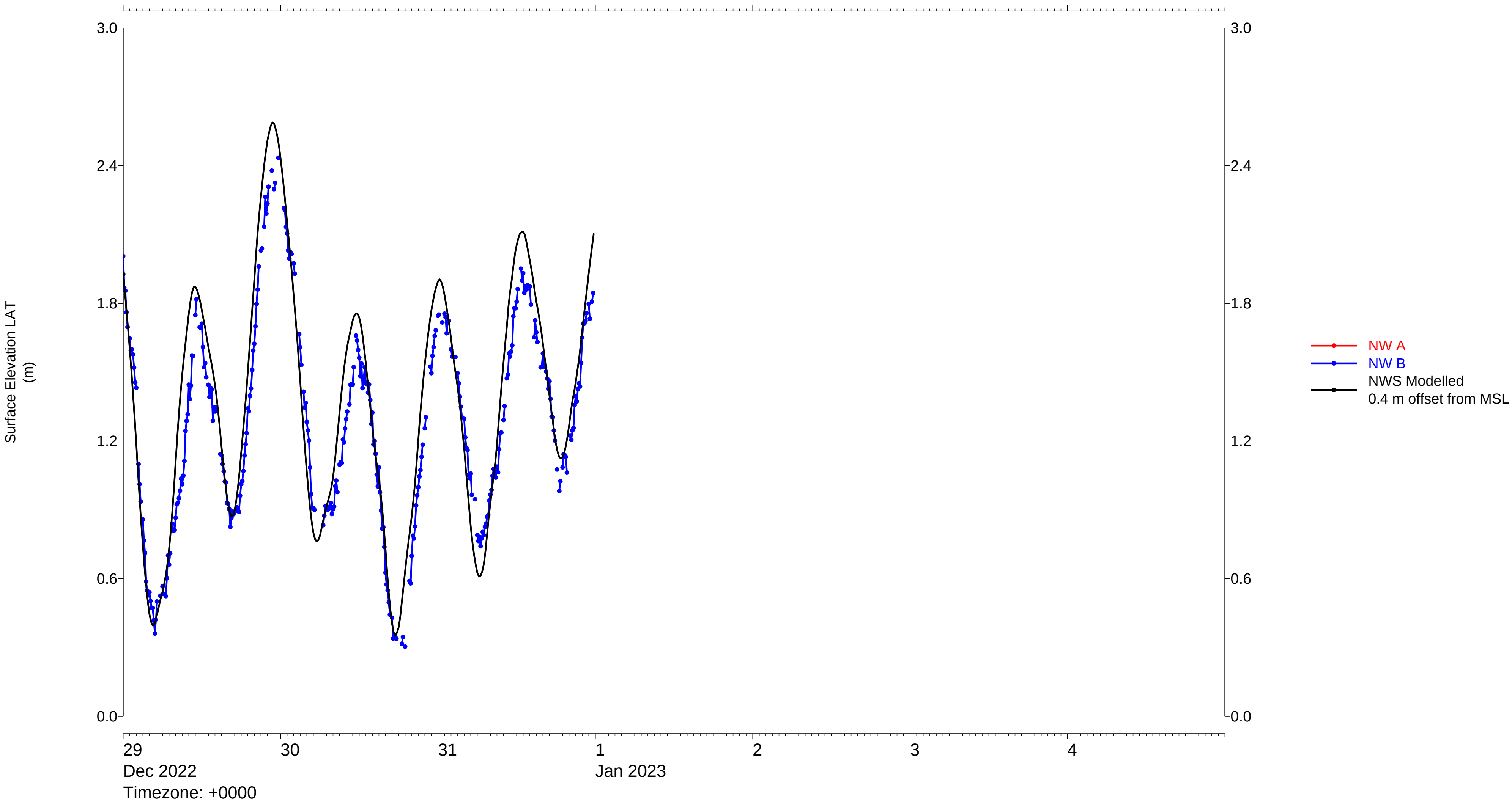
Location:	**NW**		
		Client:	RVO
		Project:	J3707



Time Zone: UTC +00:00 hours	NWTide{A,B}.2022.12.QC_dataReturn.nc, MetO.NW.SSH.mov3.nc
© RPS Australia West Pty Ltd	moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK4b.NW.ABModel.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW**	Client: RVO Project: J3707



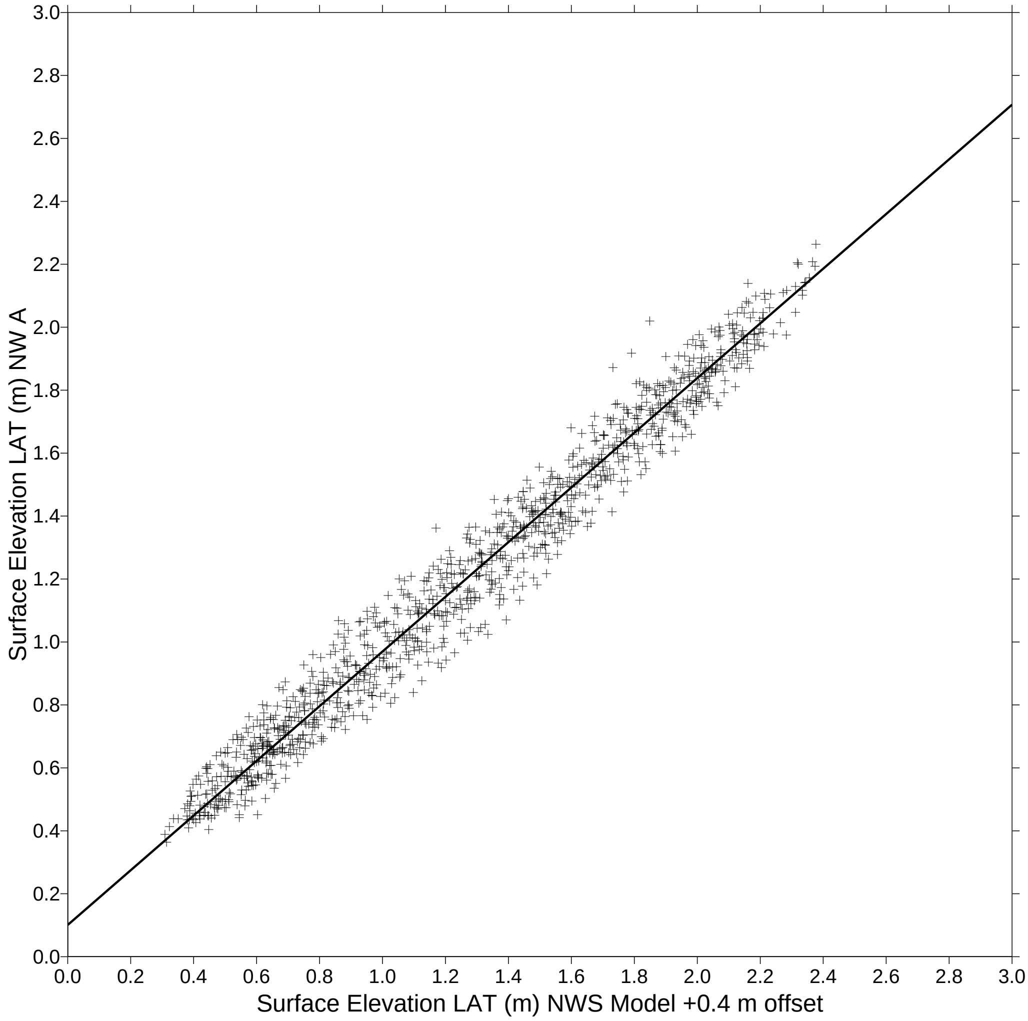
Time Zone: UTC +00:00 hours	NWTide{A,B}.2022.12.QC_dataReturn.nc, MetO.NW.SSH.mov3.nc
© RPS Australia West Pty Ltd	moetimehist: 16:30 24/Feb/2023 by MWB (AppendixK4b.NW.ABModel.week.ps)

NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW A**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 07′ 51″	Project:	J3707
Location Water Depth:	29.10 m LAT		

Period: 00:00 01 December 2022 to 08:00 13 December 2022

Surface Elevation LAT (m) NWS Model +0.4 m offset
Surface Elevation LAT (m) NW A OEM7700 (S/N DMMU 21200157D)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.101	Number of Data Points	= 1115
Slope	= 0.869	Bias	= -0.066675
Standard Error	= 0.062	RMS error	= 0.130874
Correlation Coefficient	= 0.985	Scatter Index	= 0.10250

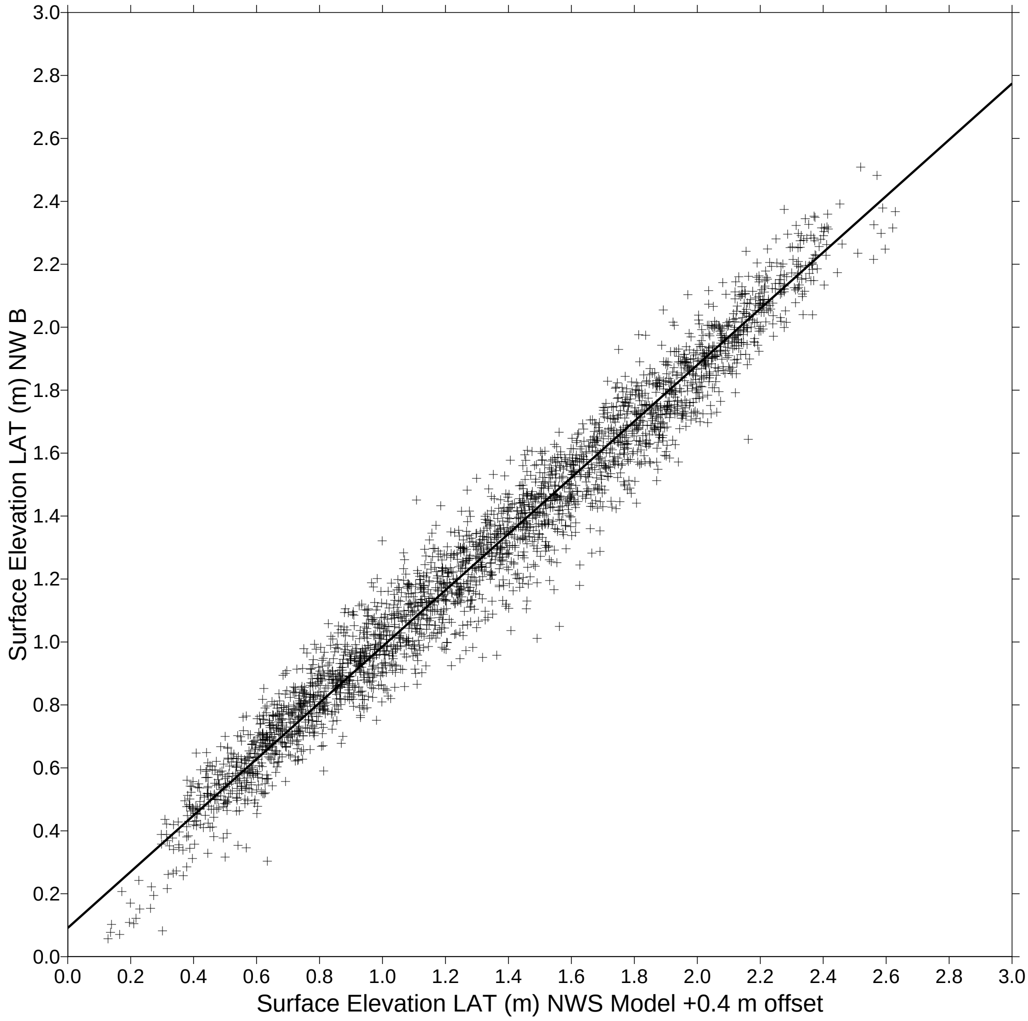
NW B data are from buoy 101 prior to 11/12/2022 11:00 UTC, and buoy 106 thereafter.

Location:	**NW B**		
Latitude:	53° 22′ 44″	Client:	RVO
Longitude:	3° 06′ 57″	Project:	J3707
Location Water Depth:	29.60 m LAT		

Period: 00:00 01 December 2022 to 23:30 31 December 2022

Surface Elevation LAT (m) NWS Model +0.4 m offset

Surface Elevation LAT (m) NW B OEM7700 (S/N BMHR 21420112P)



Line of Best Fit	(Perpendicular)		
Ordinate Intercept	= 0.091	Number of Data Points	= 2691
Slope	= 0.894	Bias	= -0.0493171
Standard Error	= 0.068	RMS error	= 0.122532
Correlation Coefficient	= 0.983	Scatter Index	= 0.09212

Time Zone: UTC +00:00 hours | NWTideB.2022.12.QC_dataReturn.nc, MetO.NW.SSH.mov3.nc

 | moecorel: 16:30 24/Feb/2023 by MWB (AppendixK4c.NWB.val.pdf)