Date 06 September 2016
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Our reference ECN-WIND-2016-128

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THE NETHERLANDS

Subject Supply of Meteorological and Oceanographic data for Borssele Wind Farm Zone : Period 14 September – 6 October 2015 & 15 December 2015 – 19 January 2016 (Lot1)

Dear Sir/Madam,

The following two Meteorological and Oceanographic data reports produced by Fugro OCEANOR AS for Lot1 measurement campaign have been reviewed by ECN Wind Energy:

1. Supply of Meteorological and Oceanographic data at Borssele Wind Farm Zone (BWFZ)
   Monthly Progress Report : 14 September – 6 October 2015 &
   15 December 2015 – 19 January 2016.
   Reference No: C75339_MPR03A-4A_R1
2. Supply of Meteorological and Oceanographic data at Borssele Wind Farm Zone (BWFZ)
   Validation report : 14 September – 6 October 2015 &
   15 December 2015 – 19 January 2016.
   Reference No: C75339_VAL03A-4A_R1

ECN has found that the above referenced reports provide a sufficient detail for potential users of the provided data to perform analysis.

Please note that the provided dataset (Period 3A-4A , Version 1 dd. 20160627) can be retrieved via the website : www.WindOpZee.net. It should also be noted that this additional data set presents short data sets which were not present in the regular monthly progress reports because they do not contain a full month of continuous wind profile data. In the documents it is mentioned that additional Water Level Sensor data will become available after retrieving the sensor. This data is at the present moment not available via the website and is also not part of this review. Additional actions need to be taken after the data becomes available.

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Yours sincerely,

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THE NETHERLANDS ENTERPRISE AGENCY (RVO)

Supply of Meteorological and Oceanographic data at Borssele Wind Farm Zone (BWFZ)

Monthly Progress Report.

14 September - 6 October 2015

15 December 2015 - 19 January 2016

Reference No: C75339_MPR3A-4A_R1

6 September 2016

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Supply of Meteorological and Oceanographic data at Borssele Wind Farm Zone (BWFZ): C75339_MPR3A-4A_R1				
Rev	**Date**	**Originator**	**Checked & Approved**	**Issue Purpose**
0	22.07.2016	Lasse Lønseth	Vegar Neshaug	Draft report.
1	06.09.2016	Lasse Lonseth	Arve Berg	Final report.

Rev 1 – 06 September 2016	**Originator**	**Checked & Approved**
Signed:	for Lasse Lønseth	

This report is not to be used for contractual or engineering purposes unless the above is signed where indicated by both the originator of the report and the checker/approver and the report is designated 'FINAL'.

TABLE OF CONTENT

SUMMARY

The Seawatch Wind Lidar buoy is deployed at the Borssele Wind Farm Zone (BWFZ). The buoy was first deployed on 11 June 2015 at 15:55 UTC. The transmissions from the buoy stopped on 11 September 2015. However, the Lidar and the current meter continued recording data until the buoy was recovered to shore on 6 October 2015.

After repair on shore the buoy was redeployed on 12 November 2015. The buoy collected good data from all the sensors until 26 December 2015. Then the Lidar stopped working due to a problem with its power switch, while collection of data from the other sensors continued until 29 December. Collection of data, except wind profile data, was resumed on 8 January and continued until the buoy was recovered for repair on 19 January 2016.

This report presents time series plots and summary statistics of data collected during the periods 14 September – 6 October 2015, 15 – 29 December 2015, and 8 – 19 January 2016. Data collected prior to 14 September 2015 and in the period 12 November – 14 December 2015 have been presented in previous reports.

1. INTRODUCTION

The Seawatch Wind Lidar buoy with serial no. WS149 is deployed at the Borssele Wind Farm Zone (BWFZ) in the Dutch sector of the North Sea. The buoy was first deployed on 11 June 2015 at 15:55 with the bottom mooring weight at position 51° 42.41388’ N, 3° 2.07708’ E. A bottom mounted water level recorder (WLR) at position 51° 42.4362’ N, 3° 02.1030’ E transmits data to the buoy in real time data via an acoustic link. The water depth at this location is approximately 30 m.

This report presents short data sets which were not presented in the regular monthly progress reports because they do not contain a full month of continuous wind profile data. Data for the following periods are presented:

- 14 September – 6 October 2015: The transmissions and recording of data in the central Geni processor stopped on 11 September 2015 at 16:00. The storage of data in the Lidar and the current profiler as well as storage of motion data continued, and it was possible to reconstruct wind profile and current profile measurements until the buoy was recovered to shore on 6 October 2015.
- 15 – 29 December 2015: The buoy collected data from all sensors from buoy deployment on 12 November until 26 December 2015 at. 13:10. Then the Lidar stopped due to failure of its power switch, while recording of data from all other sensors continued. The buoy recorded data from all sensors except the Lidar until 29 December 16:50 at 16:50. Then the transmissions and storage of data stopped.
- 8 – 19 January 2016: The buoy was restarted on 8 January and recorded data from all sensors except the Lidar until 19 January 2016 at 12:00. At that time the buoy was recovered for maintenance and repair.

The time reference used in this report is UTC.

2. Instrumentation and measurement configuration

The buoy is a Seawatch Wind Lidar Buoy based on the original Seawatch Wavescan buoy design with the following sensors:

- Wavesense: 3-directional wave sensor
- Xsens 3-axes motion sensor
- Gill Windsonic M acoustic wind sensor
- Vaisala PTB330A air pressure sensor
- Vaisala HMP155 air temperature and humidity sensor
- Nortek Aquadopp 600kHz current profiler.
- ZephIR 300S Lidar.

An independent self-recording Aanderaa SeaGuard WLR tide gauge is located on the bottom. The WLR transmits data to the buoy via an acoustic link.

The buoy with mooring as deployed is presented in Figure 2.1, including the mooring for the WLR.

The measurement setup is detailed in Table 2-1. Details of sensor types and serial number can be found in Appendix A.

Table 2-1 Configuration of measurements by the Seawatch Wind Lidar buoy at Borssele Wind Farm Zone (BWFZ).

Instrument type	Sensor height (m)	Parameter measured	Sample height[2)] (m)	Sampling interval (s)	Averaging period (s)	Burst interval (s)	Trans-mitted?
Wavesense 3	0	Heave, pitch, roll, heading	0	0.5	Time series duration: 1024 s	600	No
		Sea state parameters (1)	0	600	1024	600	Yes
Xsens		Heave,east,north acceleration, q0,q1,q2,q3 (attitude quaternion)	0	0.5	N/A	3600	No
Gill Windsonic M	4.1	Wind speed, wind direction	4.1	1	600	600	Yes
Vaisala PTB330A	0.5	Air pressure	0.5	30	60	600	Yes
Vaisala HMP155	4.1	Air temperature Air humidity	4.1	5	60	600	Yes
Nortek Aquadopp	-1	Current speed and direction profile, water temperature (at 1 m depth)	-4 -6 … -30 (14 levels)	N/A	600	600	Yes
ZephIR 300S Lidar	2	Wind speed and direction at 10 heights (The 11th level, the so called reference level which is not configurable, is also located at 40 m and referred to as 40.0 Ref.)	30.0 40.0 40.0 ref 60.0 80.0 100.0 120.0 140.0 160.0 180.0 200.0	≈ 17.4 s[1)]	600	600	Yes
Aanderaa WLR (SeaGuard) via acoustic link	-30	Water pressure Temperature	-30	600	60	600	Yes

1) This is the approximate time between the beginning of one sweep of the profile and the next one, the interval may vary slightly. The ZephIR sweeps one level at a time beginning at the lowest one, and after the top level has been swept it uses some time for calculations and re-focusing back to the lowest level for a new sweep.

2) Height relative to actual sea surface. The depth of the WLR is an approximate number.

Table 2.2 Definitions of wave parameters presented in this report

H	Individual wave height
Hmax	= Max(H): Height of the highest individual wave in the sample, measured from crest to trough
m0, m1, m2, m4, m-1, m-2	Moments of the spectrum about the origin: $\int f^k S(f)df$ where $S(f)$ is the spectral density and the wave frequency, f, is in the range 0.04 - 0.50 Hz
Hm0	Estimate of significant wave height, Hs, $Hm0 = 4\sqrt{m0}$
Tp	Period of spectral peak = 1/f_p, The frequency/period with the highest energy
Tm01	Estimate of the average wave period; $Tm01 = m0/m1$
Tm02	Another estimate of the average wave period; $Tm02 = \sqrt{\frac{m0}{m2}}$
ThTp	Mean wave direction at the spectral peak ("The direction of most energetic waves")
Mdir	Wave direction averaged over the whole spectrum
	Directions are given in degrees clockwise from north, giving the direction the waves come from. (0° from north, 90° from east, etc.)

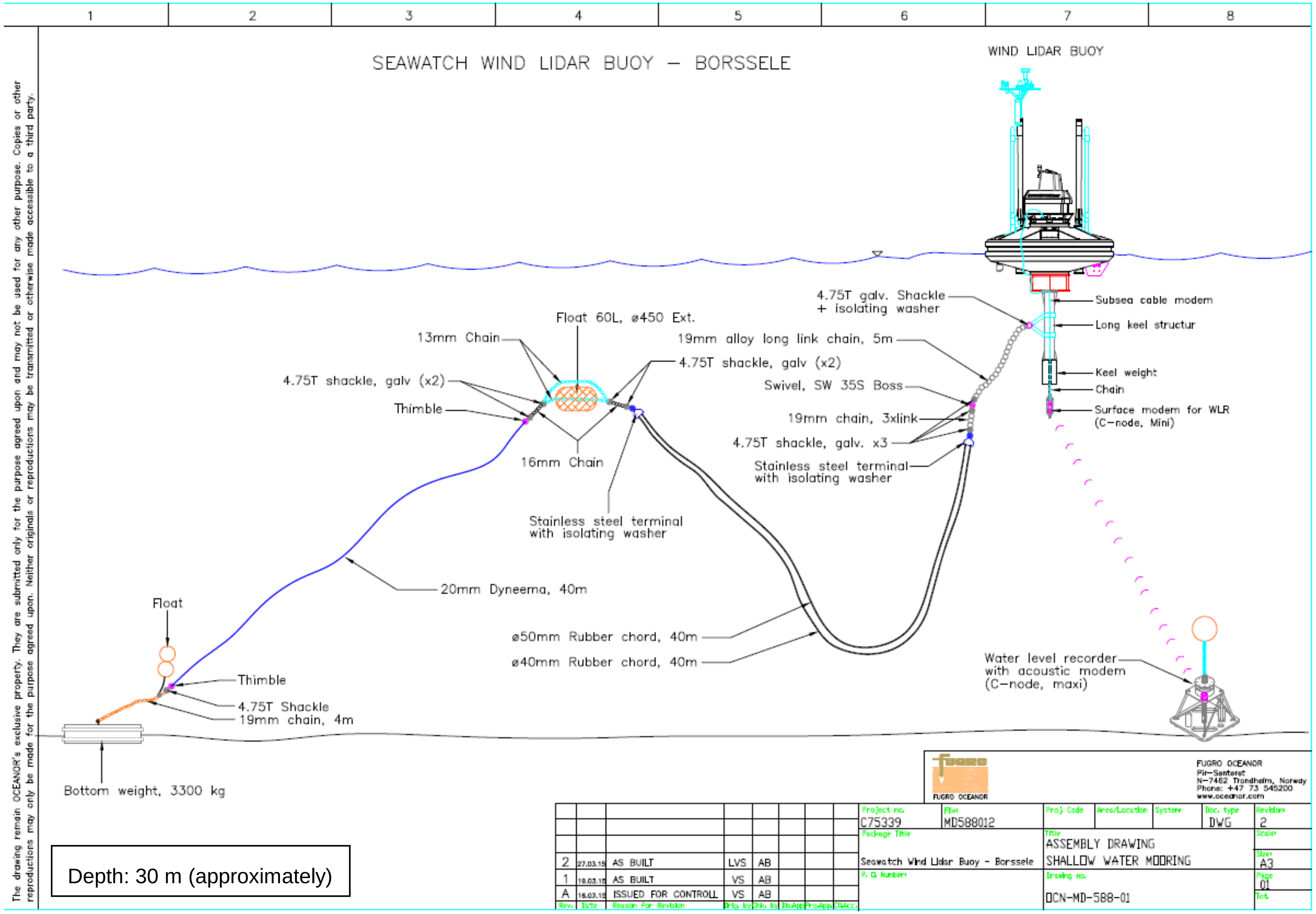

Figure 2.1 Mooring design for the Wind Lidar Buoy as deployed at Borssele Wind Farm Zone (BWFZ).

3. Summary of activities

3.1 Buoy operation

The Seawatch Wind Lidar buoy with serial no. WS149 and a bottom mounted Water Level Recorder (SeaGuard WLR) were deployed at the Borssele Wind Farm Zone in the Dutch sector of the North Sea on 11 June 2015. The buoy was deployed at 15:55 with the bottom mooring weight at position 51° 42.41388' N, 3° 2.07708' E. A bottom mounted WLR was deployed at position 51° 42.4362' N, 3° 02.1030' E. The WLR transmits data to the buoy in real time data via an acoustic link. The sounder depth was recorded as approximately 30 m.

During after the deployment the buoy was in continuous good operation until 11 September 2015 at 15:50. After that time the buoy did not transmit any data, and did not store data on its internal hard disk. Wind profiles and current profiles were later recovered from the data storage in the instruments and are presented in this report. Due to the failure of transmissions the buoy had to be recovered to shore for diagnosis and repair. The recovery was achieved on 6 October 2015 at 11:30 by the multicat type workboat Multrasalvor 3.

The buoy was re-deployed by the Multrasalvor 3 on 12 November 2015 at 14:00. The Lidar stopped working on 26 December 2015. The buoy system stopped recording data from all sensors on 29 December 2015, but restarted automatically on 8 January 2016. After a long period of mainly unworkable weather conditions, and some delay due to vessel unavailability, the buoy was recovered for repair on 19 January 2016 at 11:15.

3.2 Health, Safety and Environment

There were no incidents, near misses or accidents in connection with the deployment and recovery operations.

4. Results

4.1 Summary of results and data return

4.1.1 Period: 14 September – 6 October 2015

During this period the buoy transmitted no data, and measurements were not stored by the Geni processor, except for the raw data from the motion sensor Xsens. However, the Lidar and the current profiler continued to work and stored data in their respective data loggers. The wind profile and current data collected until the buoy recovery on 6 October 2015 are presented in this report. The number of hours of good data compared to the total obtainable hours of data is presented in Table 4-1.

Table 4-1 Data return during the period 14 September 2015 at 15:40 – 6 October 2015 at 00:00.

Measurement device	Length of data period (days)	Length of data set (days)	Average availability (%)
Lidar wind profile sensor	21.354	21.313	99.80
Wave sensor	21.354	0.000	0.00
Current velocity and direction sensor	21.354	21.354	100.00
Atmospheric pressure sensor	21.354	0.000	0.00
Air temperature sensor	21.354	0.000	0.00

4.1.2 Period: 15 December 2015 – 19 January 2016

The buoy transmitted and stored good data from all sensors from the beginning of this period. The Lidar stopped working on 26 December 2015 at 12:10. The buoy continued transmitting and recording data from all other sensors until 29 December at 16:00. After that time the buoy recorded no data before it restarted and resumed data collection from all sensors except the Lidar on 8 January 2016 at 20:00. There is a gap in the collected data from 23:50 on 8 January to 05:00 on 9 January 2015, and after that the buoy collected data continuously until it was recovered on 19 January at 11:15, with the exception of the Lidar which remained non-responsive. The number of hours of good data compared to the total obtainable hours of data is presented in Table 4-2.

Table 4-2 Data return during the period 15 December 2015 at 15:40 – 19 January 2016 at 11:10.

Measurement device	Length of data period (days)	Length of data set (days)	Average availability (%)
Lidar wind profile sensor	35.472	11.278	31.79
Wave sensor	35.472	24.944	70.32
Current velocity and direction sensor	35.472	20.854	58.79
Atmospheric pressure sensor	35.472	24.951	70.34
Air temperature sensor	35.472	24.951	70.34

4.2 Presentation of data for 14 September – 6 October 2015

The following presentations show good post-processed wind profile and current data stored internally by the Lidar and Aquadopp current profiler, while the central Geni processor in the buoy did not store the measurement data. The wind profiles have been compensated for buoy motion using the data from the Xsens motion sensor.

4.2.1 Wind profile data

In the wind and wave direction plots 0° and 360° indicate direction from the north.

The wind profiling data from the Lidar are presented in the following plots showing the time series of 10 min. mean wind for each individual level. Plots of the derived parameters Inflow Angle and Turbulence Intensity are also presented.

The Inflow Angle (IA) is the angle of the 3-dimensional wind vector based on the ten minute averaged values of the horizontal and vertical wind velocity components. IA can be positive or negative; a positive IA means that the wind vector has an upward directed vertical component. The Turbulence Intensity (TI) is defined as $TI = \sigma/\bar{u}$ where σ is the standard deviation and $\bar{u}$ is the mean of the wind speed for a 10-min period. Note that this definition frequently gives relatively high values in situations with low mean wind speed, which is noticeable in the plots.

The 180° directional ambiguity in the Lidar wind directions has largely been resolved using a correction with directions from the Gill wind sensor as ground truth. From 11th September at 16:00 UTC data from the Gill sensor were no longer available, as explained above. Instead a correction based on wind direction data from the Vlakte van Raan wind station has been applied. Due to the distance to the reference station, 27.6 km, this correction is obviously not as accurate as the correction based on the buoy mounted sensor.

The highest observed horizontal mean wind speed during this period varies from 22.1 m/s at 30 m to 24.9 m/s at 120 m above the surface. These maxima were measured on 15 September 2015 at 10:40.

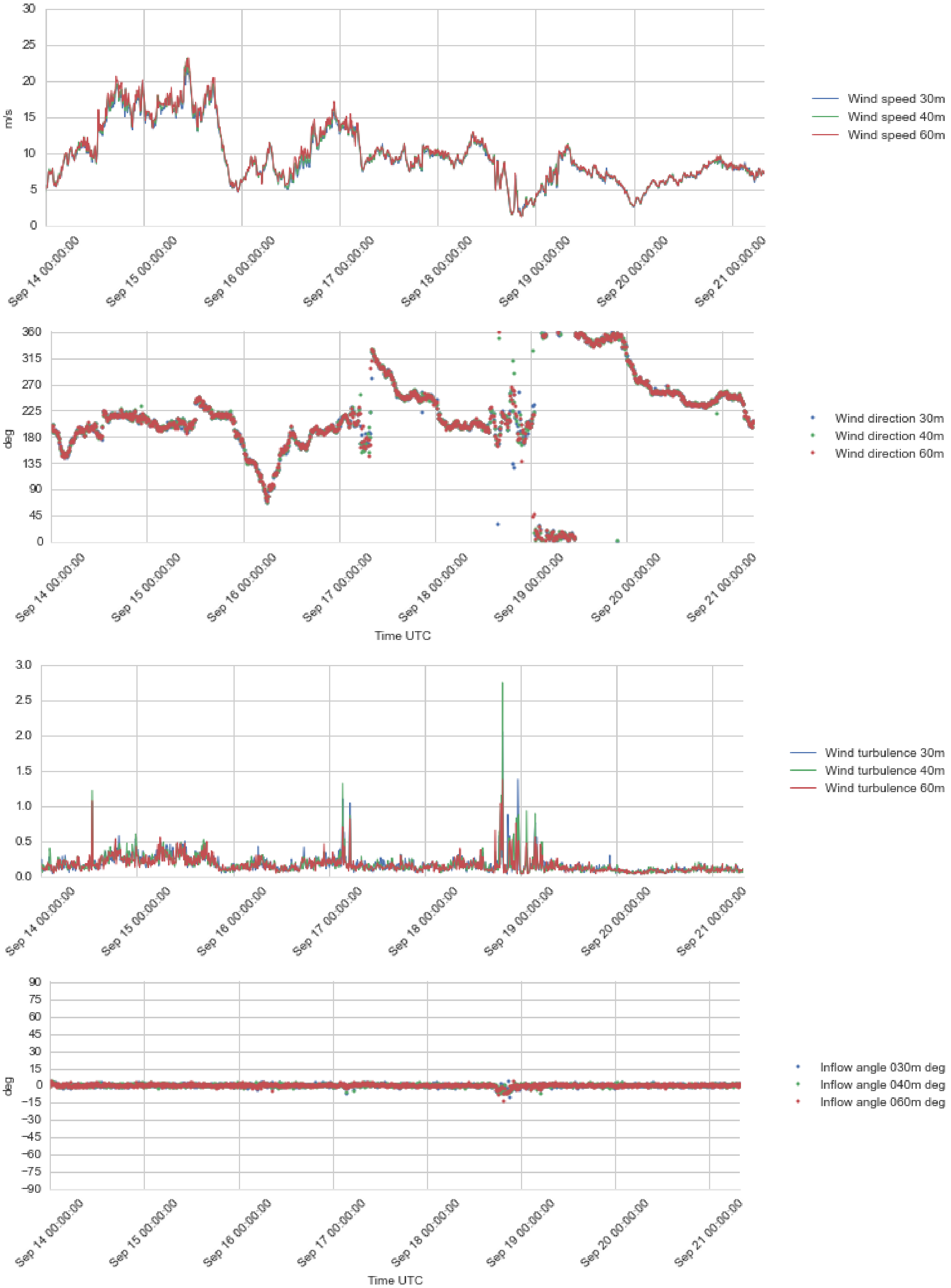

Figure 4.1 Plots of wind profile data, 30 – 60 m a.s.l., 14 - 21 Sep 2015.

From top to bottom: Wind speed, Wind direction, Turbulence Intensity, and Inflow Angle.

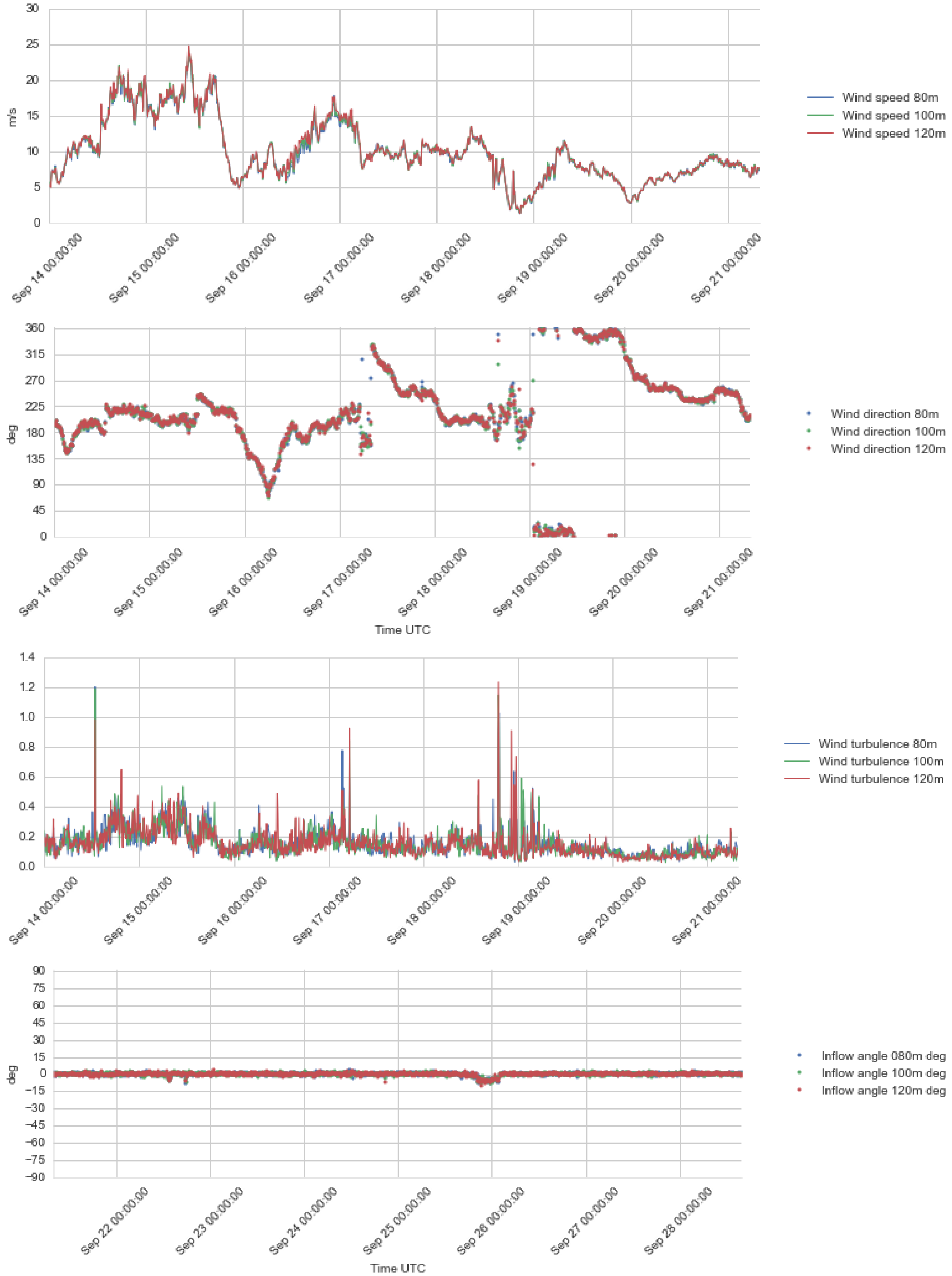

Figure 4.2 Plots of wind profile data, 80 – 120 m a.s.l., 14 - 21 Sep 2015.

From top to bottom: Wind speed, Wind direction, Turbulence Intensity, and Inflow Angle.

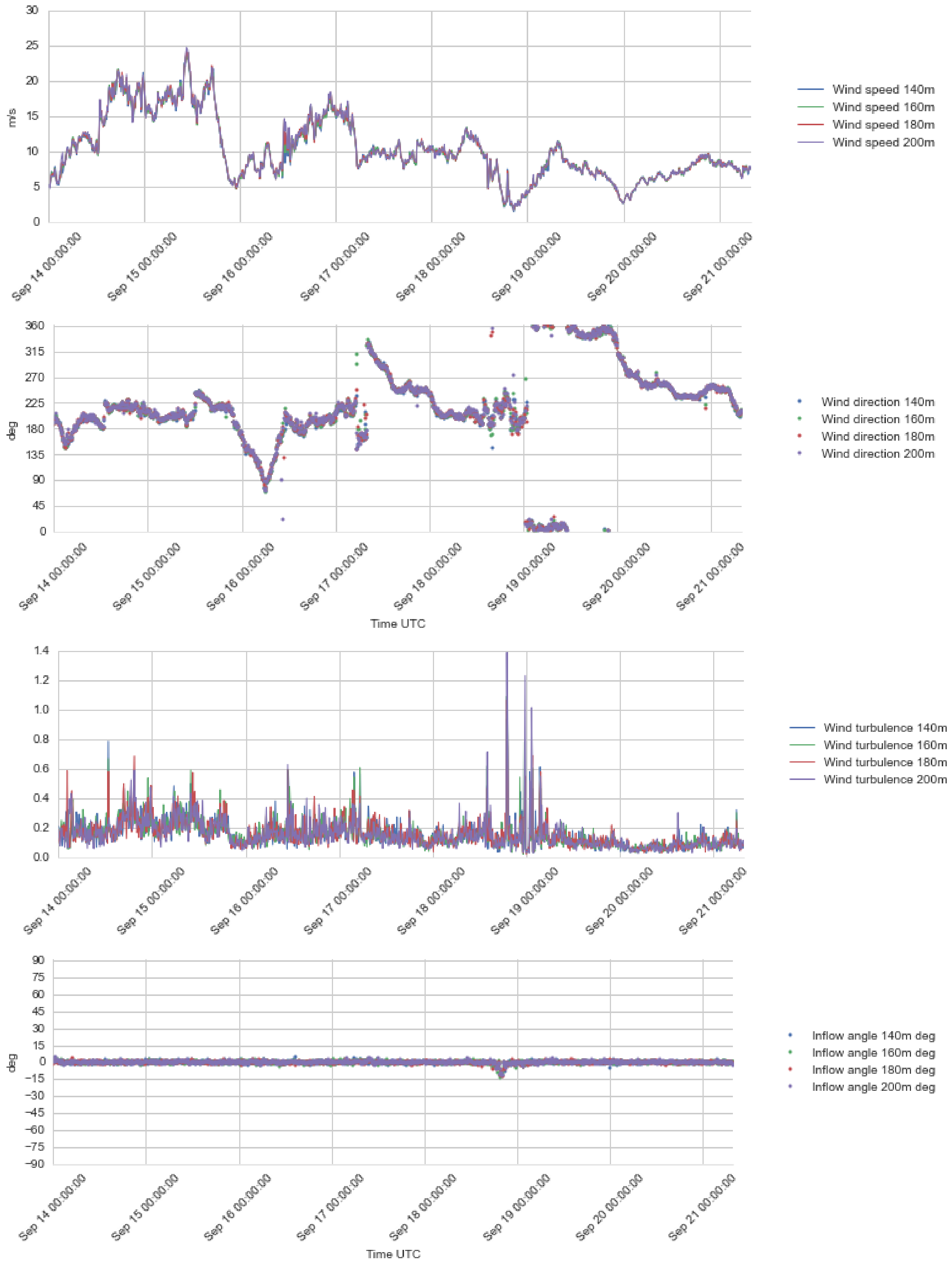

Figure 4.3 Plots of wind profile data, 140 – 200 m a.s.l., 14 - 21 Sep 2015.

From top to bottom: Wind speed, Wind direction, Turbulence Intensity, and Inflow Angle.

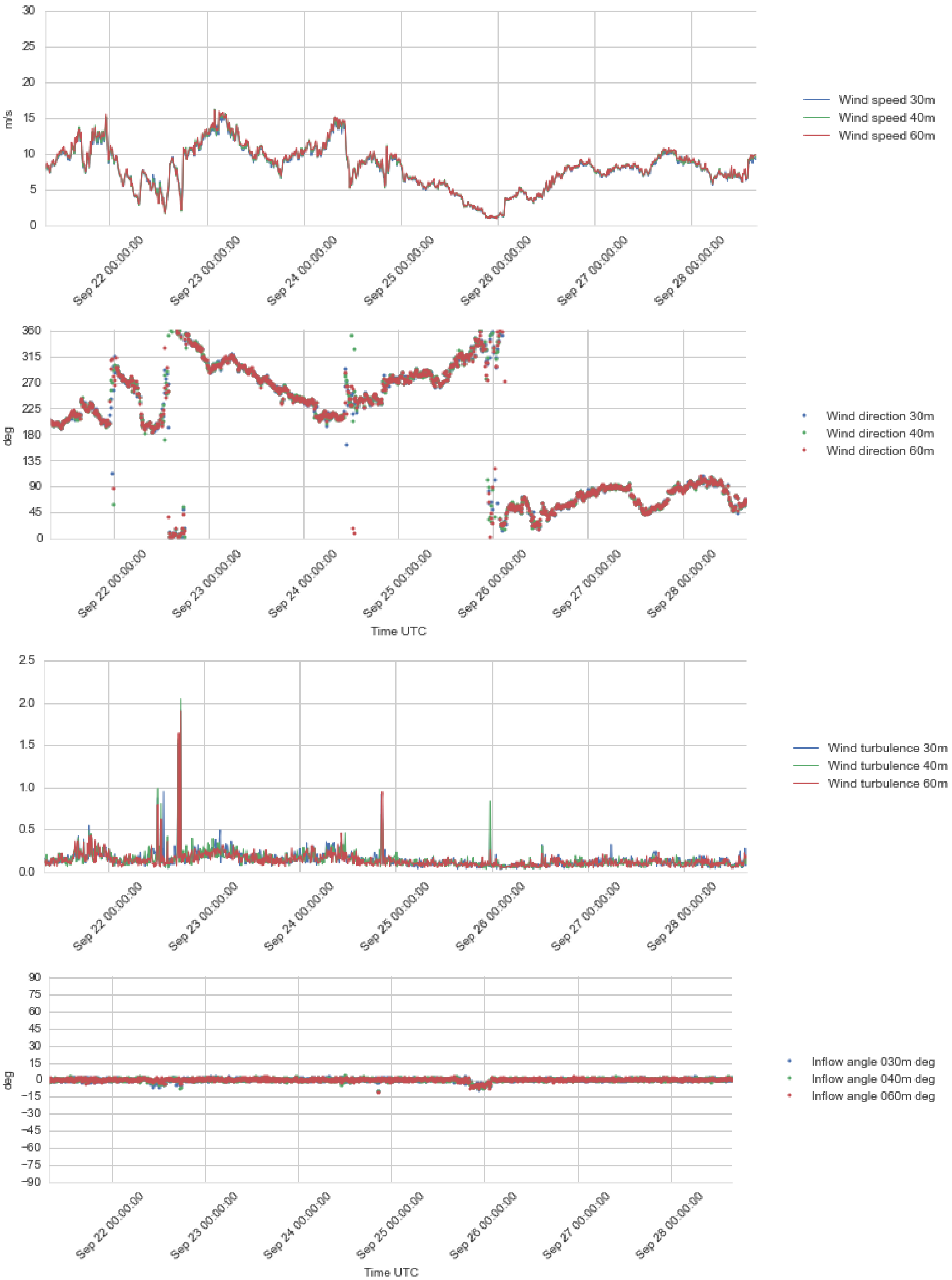

Figure 4.4 Plots of wind profile data, 30 – 60 m a.s.l., 21 - 28 Sep 2015.

From top to bottom: Wind speed, Wind direction, Turbulence Intensity, and Inflow Angle.

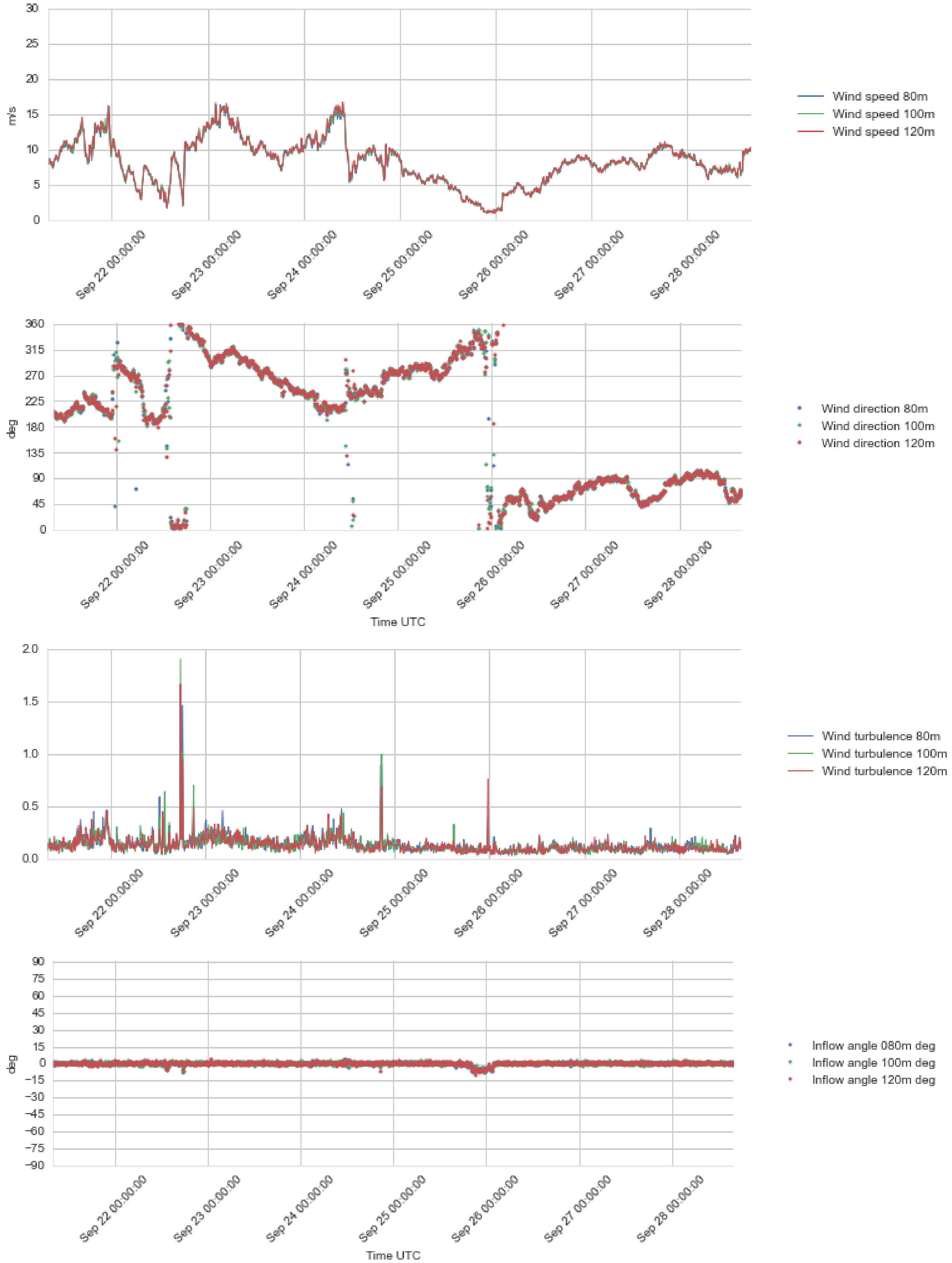

Figure 4.5 Plots of wind profile data, 80 – 120 m a.s.l., 21 - 28 Sep 2015.

From top to bottom: Wind speed, Wind direction, Turbulence Intensity, and Inflow Angle.

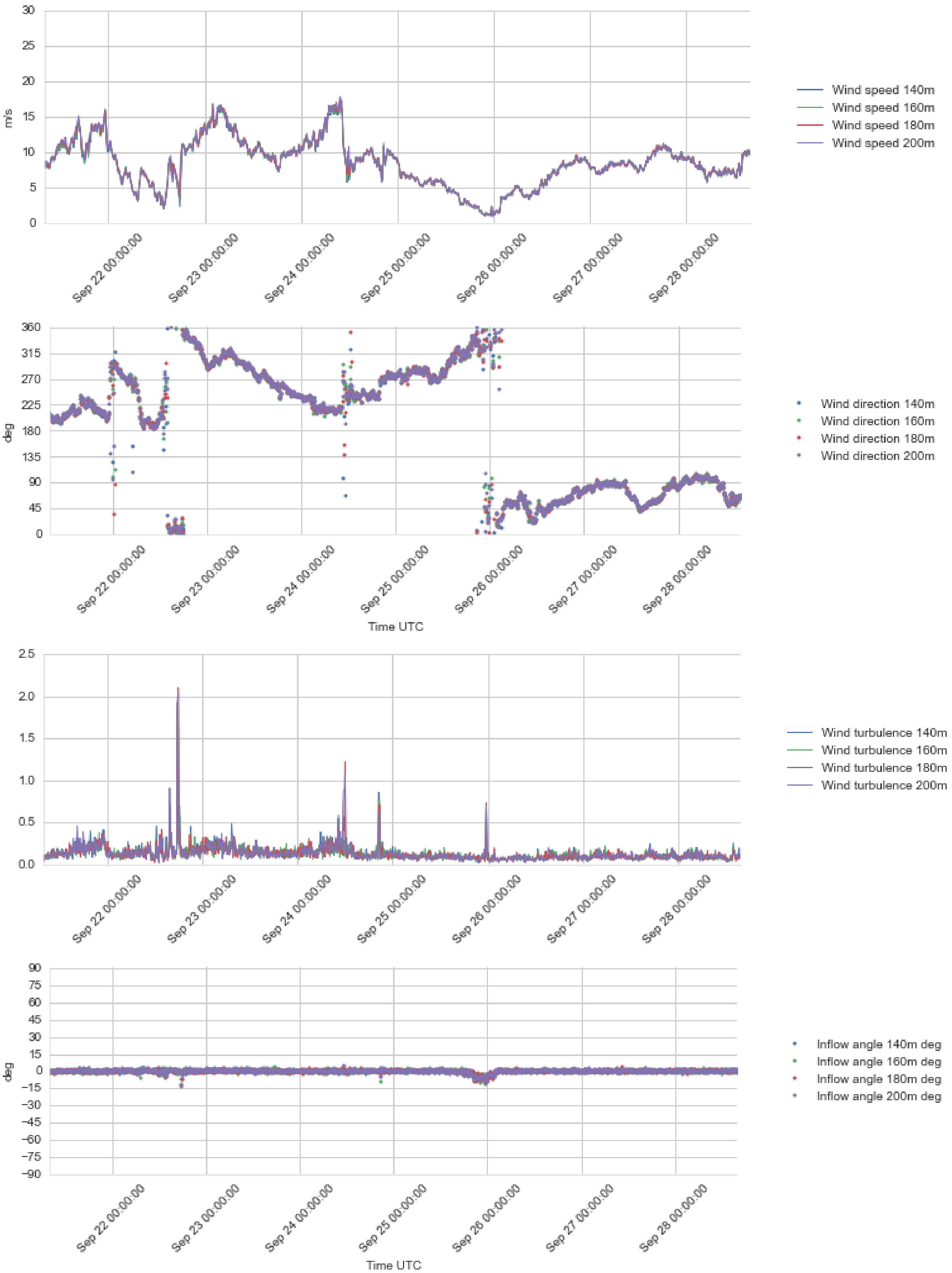

Figure 4.6 Plots of wind profile data, 140 – 200 m a.s.l., 21 - 28 Sep 2015.

From top to bottom: Wind speed, Wind direction, Turbulence Intensity, and Inflow Angle.

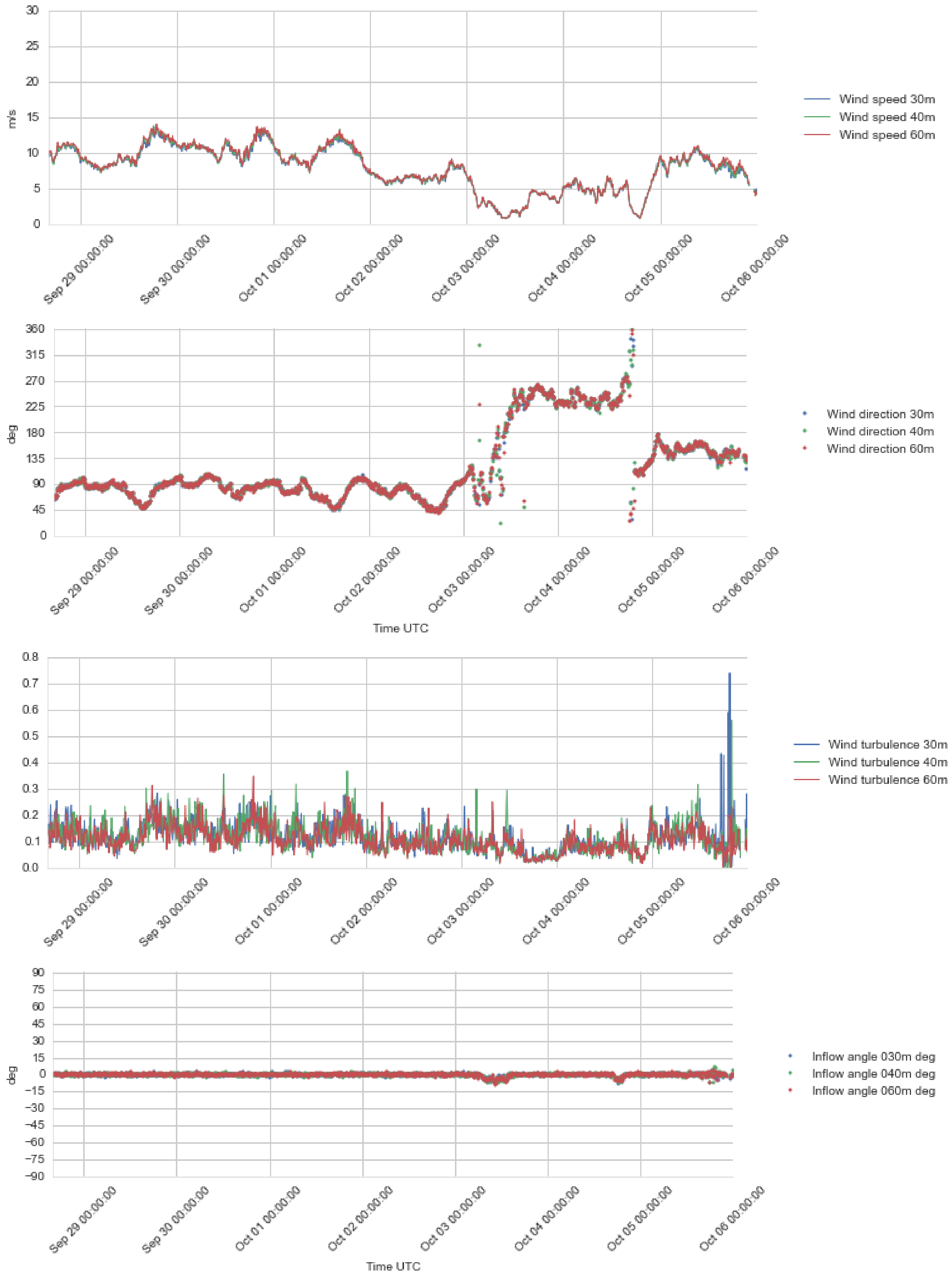

Figure 4.7 Plots of wind profile data, 30 – 60 m a.s.l., 28 Sep – 6 Oct 2015.

From top to bottom: Wind speed, Wind direction, Turbulence Intensity, and Inflow Angle.

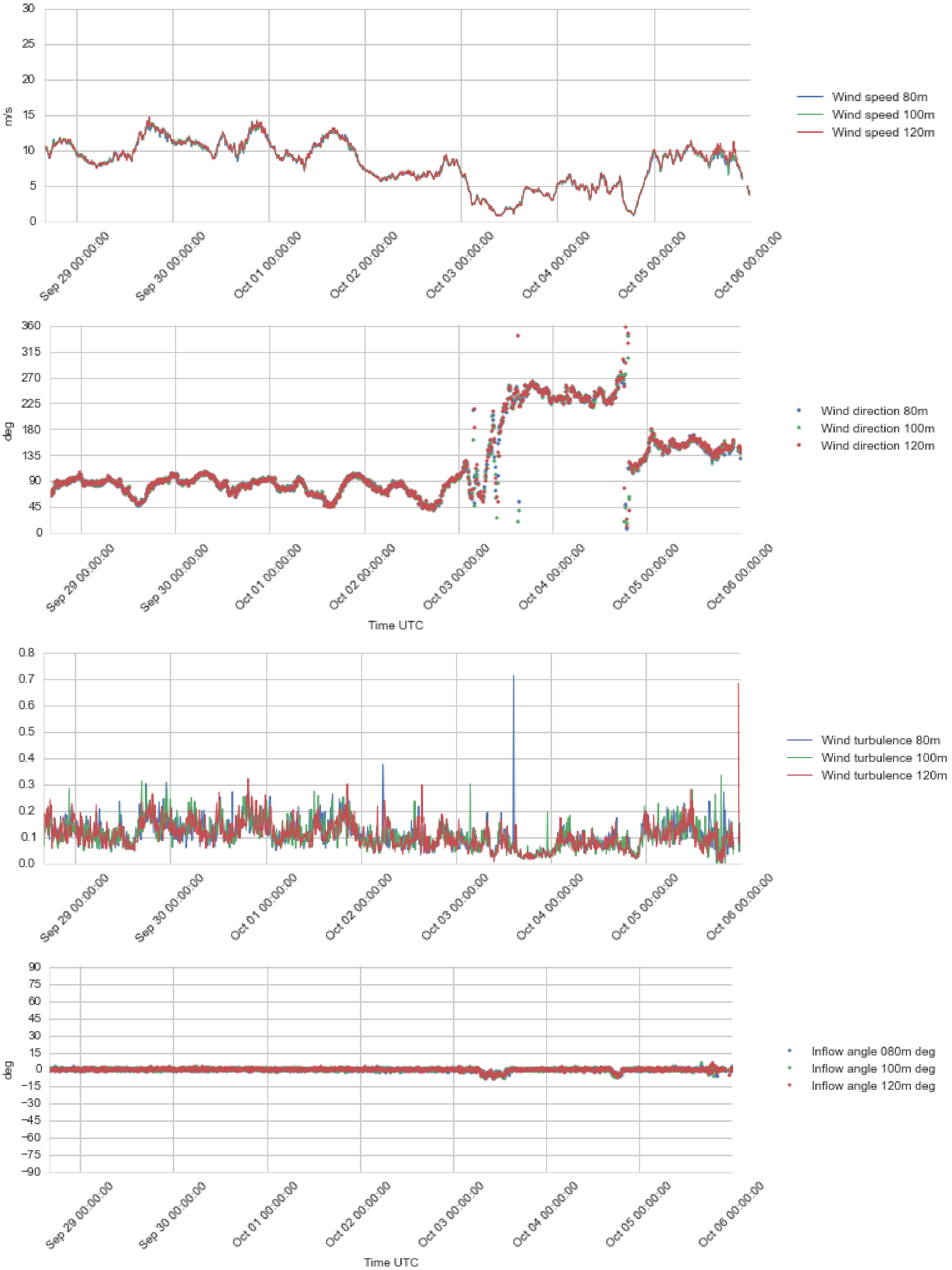

Figure 4.8 Plots of wind profile data, 80 – 120 m a.s.l., 28 Sep – 6 Oct 2015.

From top to bottom: Wind speed, Wind direction, Turbulence Intensity, and Inflow Angle.

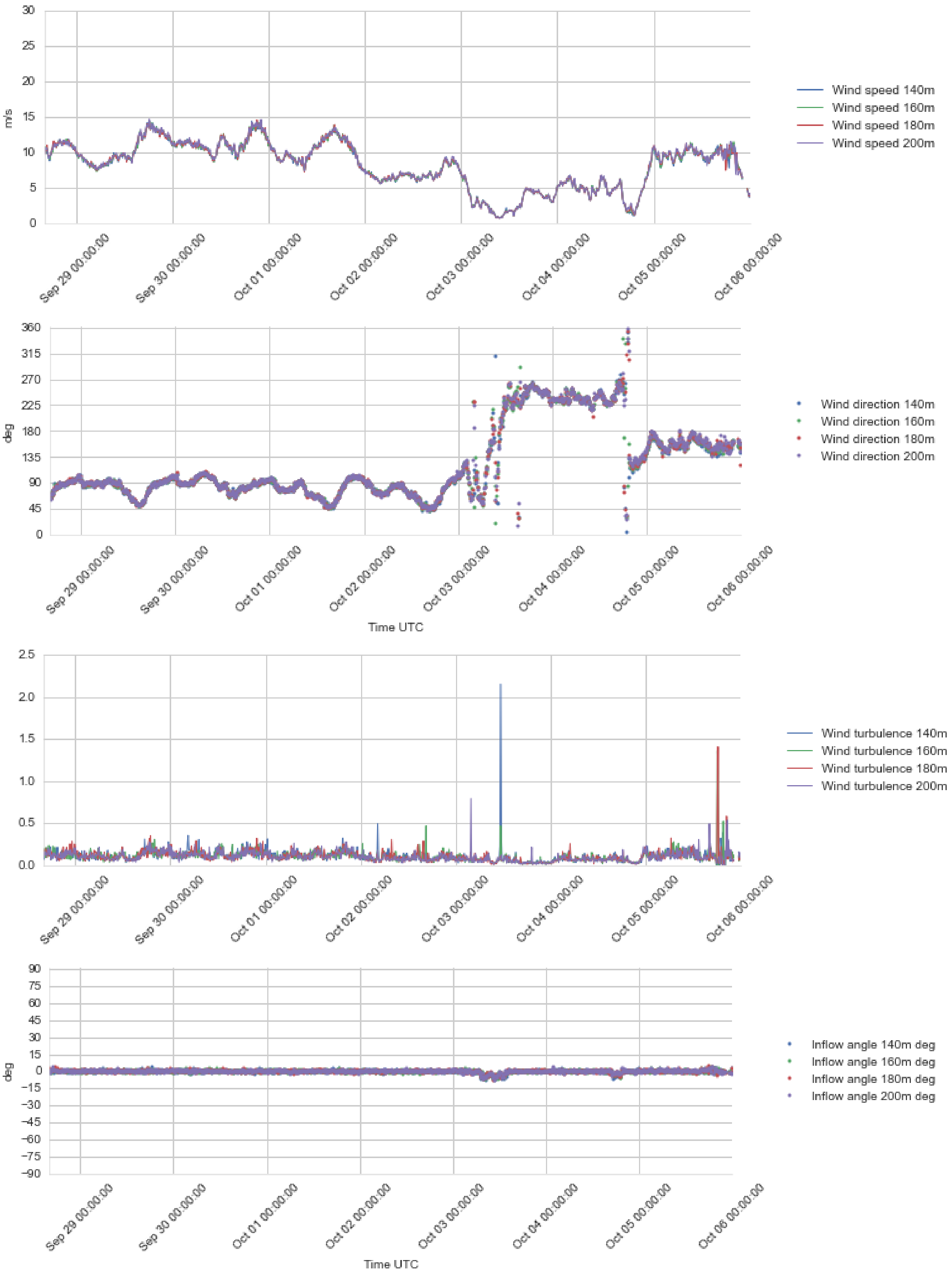

Figure 4.9 Plots of wind profile data, 80 – 120 m a.s.l., 28 Sep – 6 Oct 2015.

From top to bottom: Wind speed, Wind direction, Turbulence Intensity, and Inflow Angle.

4.3 Presentation of data for 15 December 2015 – 19 January 2016

The following presentations show good data transmitted from the buoy via Iridium satellite during the period 15 December 2015 at 00:00 – 19 January 2016 at 11:10. Wind profile data collection ended on 26 December 2015 at 12:00, giving only 11.278 days of good wind profile data. No data were recorded from any sensor in the period 29 December 2015 at 16:00 – 8 January 2016 at 20:00.

4.3.1 Meteorological data

The following plots present the air pressure, air temperature, and sea surface temperature. The sensors have generally performed well. The water temperature sensor is part of the current profile sensor, Aquadopp, and data recovery for water temperature is the same as for current profile data.

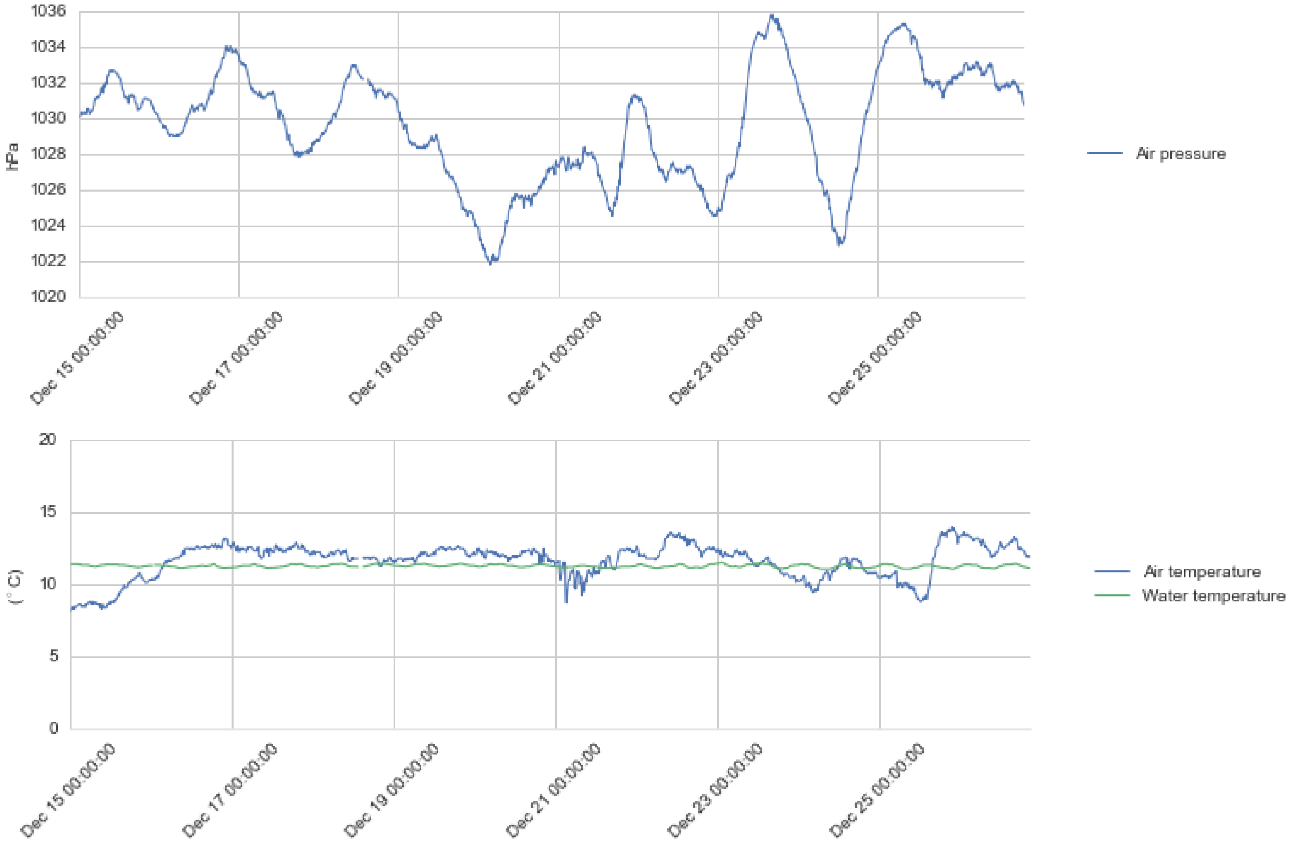

Figure 4.10 Time series plots of air pressure (upper panel), air and water temperature (lower panel), 15 - 26 Dec 2015.

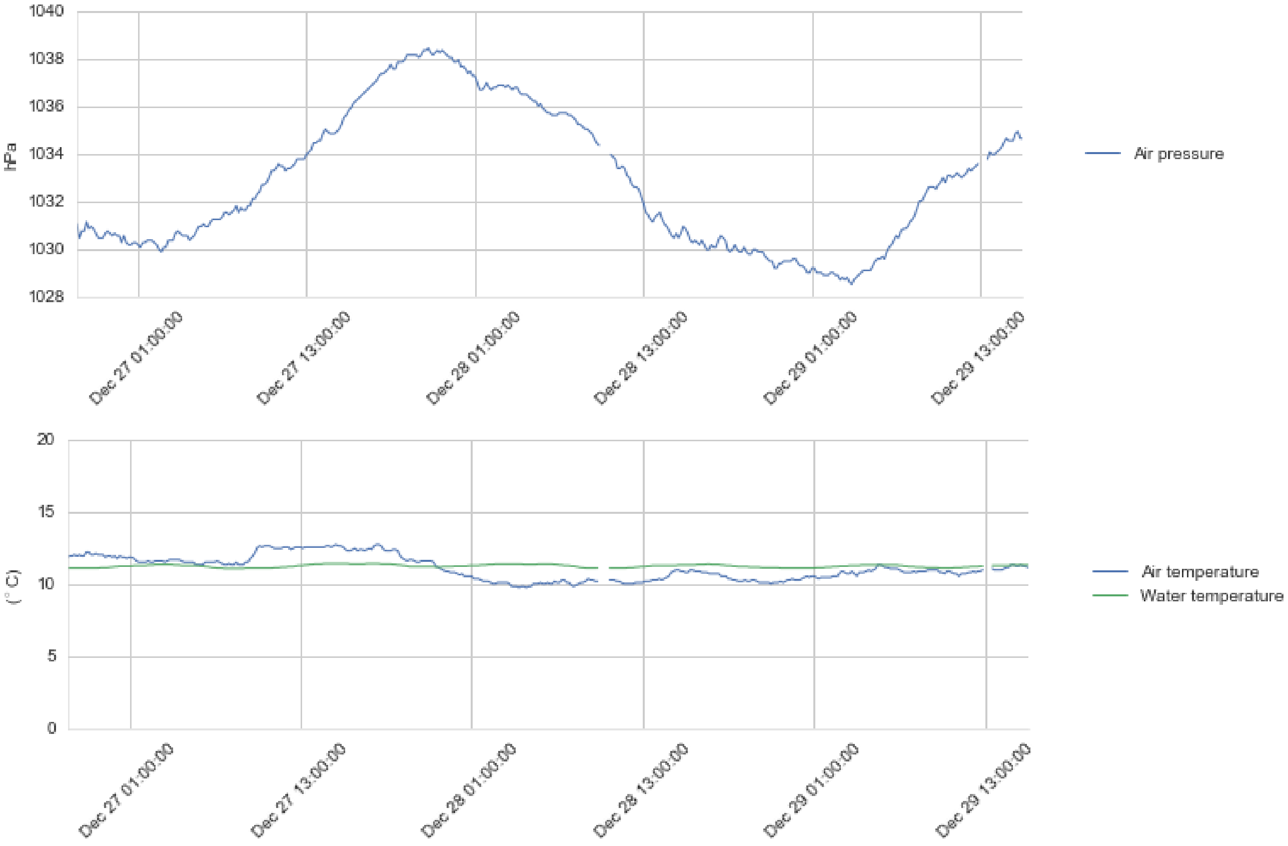

Figure 4.11 Time series plots of air pressure (upper panel), air and water temperature (lower panel), 26 – 29 Dec 2015.

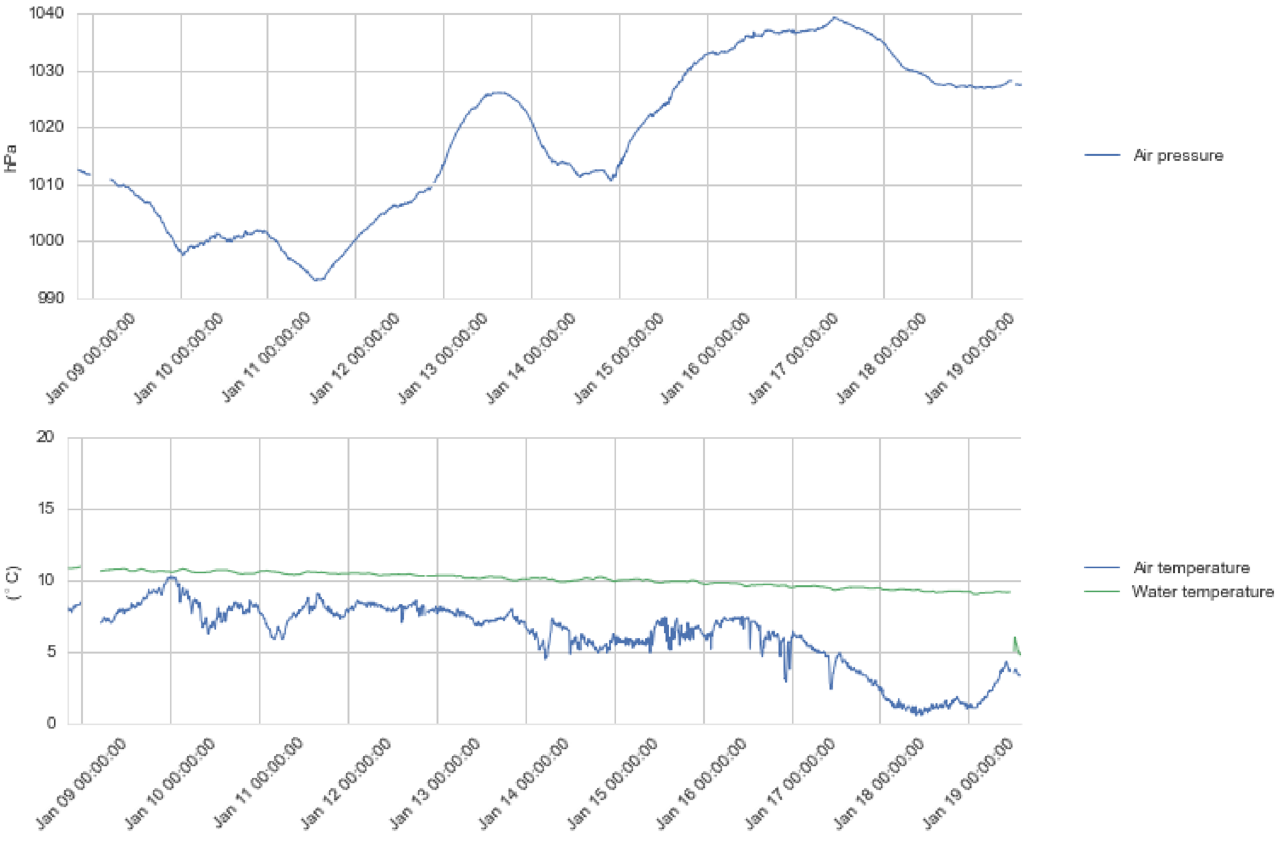

Figure 4.12 Time series plots of air pressure (upper panel), air and water temperature (lower panel), 8 - 19 Jan 2016.

4.3.2 Wave data

The next plots present wave height, period and direction. The wave sensor has generally functioned well. Some dropouts shown in the plots are due to loss of data within the first half hour after rebooting of the buoy.

The highest significant wave height (Hm0) measured in this period is 3.28 m from a north-northwesterly direction on 6 September at 03:20-03:30. The highest single wave was 5.13 m observed at the same time.

Variations in wave height agree well with the wind speeds in general. The average wave period parameters Tm01 and Tm02 show semidiurnal variations which can be explained by the shift in frequency when the waves are travelling along with or opposing the current direction, since the tidal current direction varies in a semi-diurnal pattern.

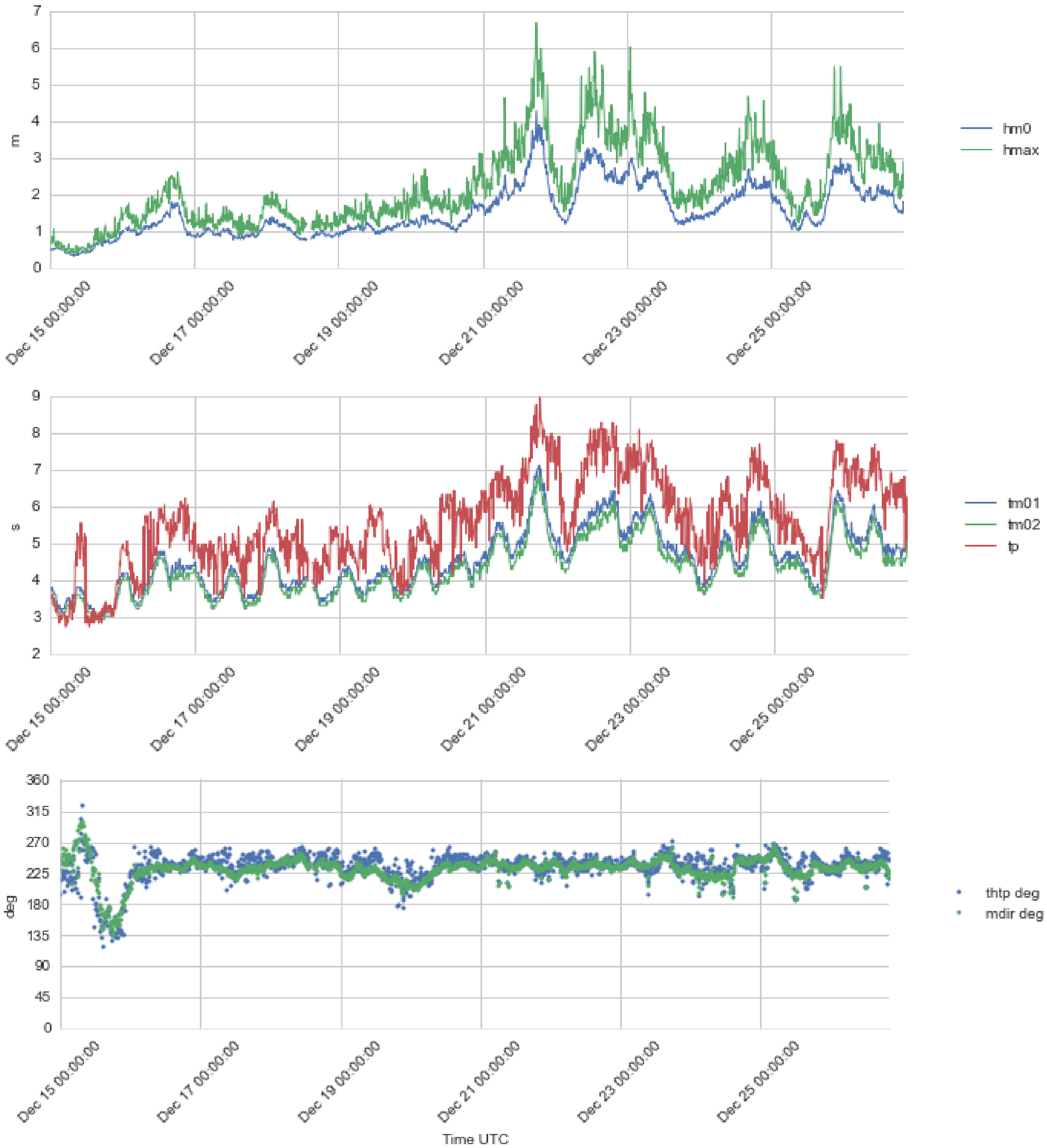

Figure 4.13 Time series plots of wave height (Hm0 and Hmax) (upper panel), wave period (Tm01, Tm02 and Tp) (second panel), and wave direction (ThTp and Mdir) (lower panel), 15 – 26 Dec 2015.

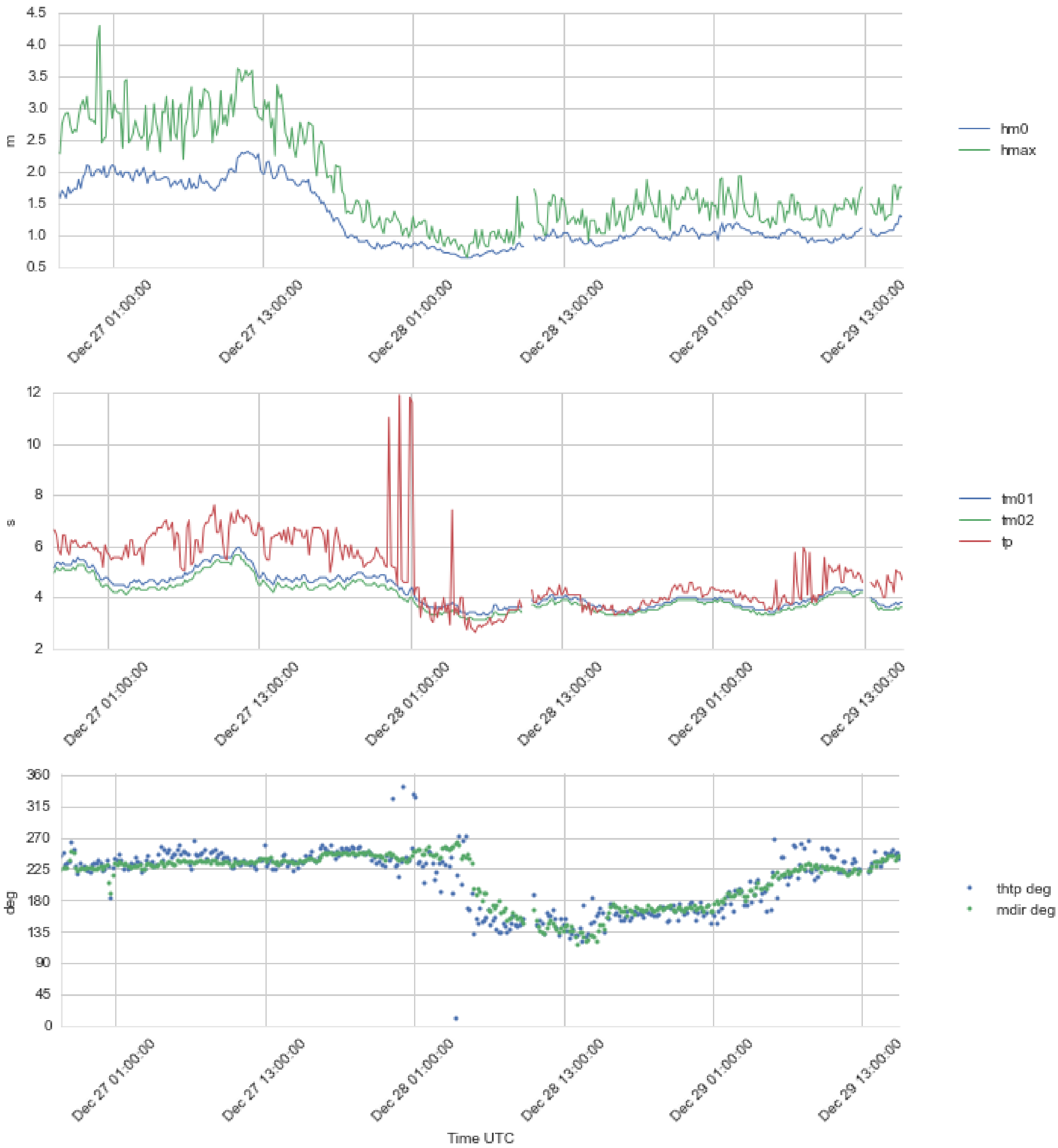

Figure 4.14 Time series plots of wave height (Hm0 and Hmax) (upper panel), wave period (Tm01, Tm02 and Tp) (second panel), and wave direction (ThTp and Mdir) (lower panel), 26 – 29 Dec 2015.

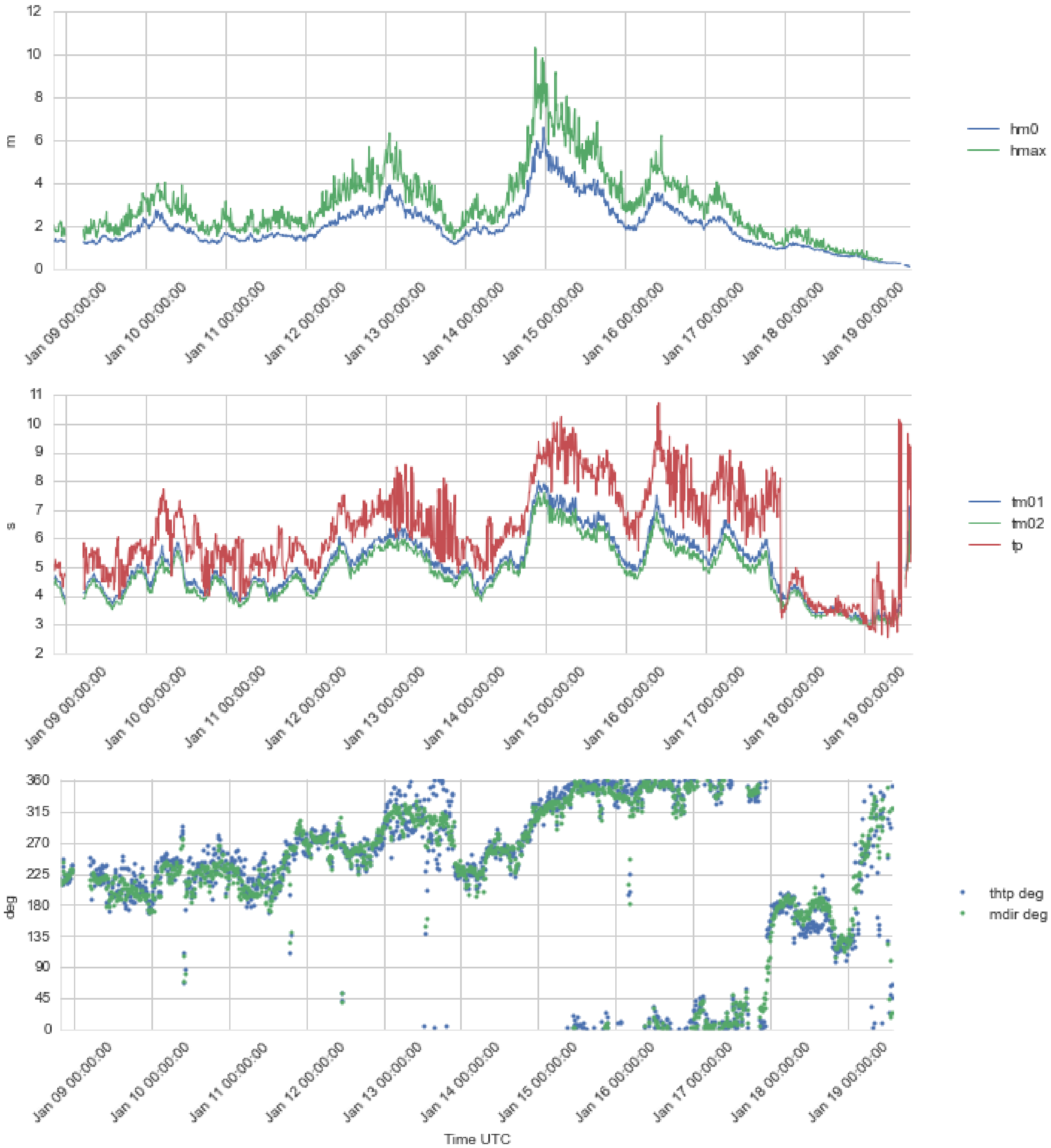

Figure 4.15 Time series plots of wave height (Hm0 and Hmax) (upper panel), wave period (Tm01, Tm02 and Tp) (second panel), and wave direction (ThTp and Mdir) (lower panel), 8 - 19 Jan 2016.

4.3.3 Wind data

In the wind and wave direction plots 0° and 360° indicate direction from the north.

The following plots show the wind speed and direction data from the Gill wind sensor mounted at 4 m height on the buoy mast. The data from the Gill sensor are generally good without dropouts, except for those associated with restarting of the whole buoy system. In this periods wind speeds up to 19.5 m/s and gusts up to 26.1 m/s were measured at 4 m above the sea surface.

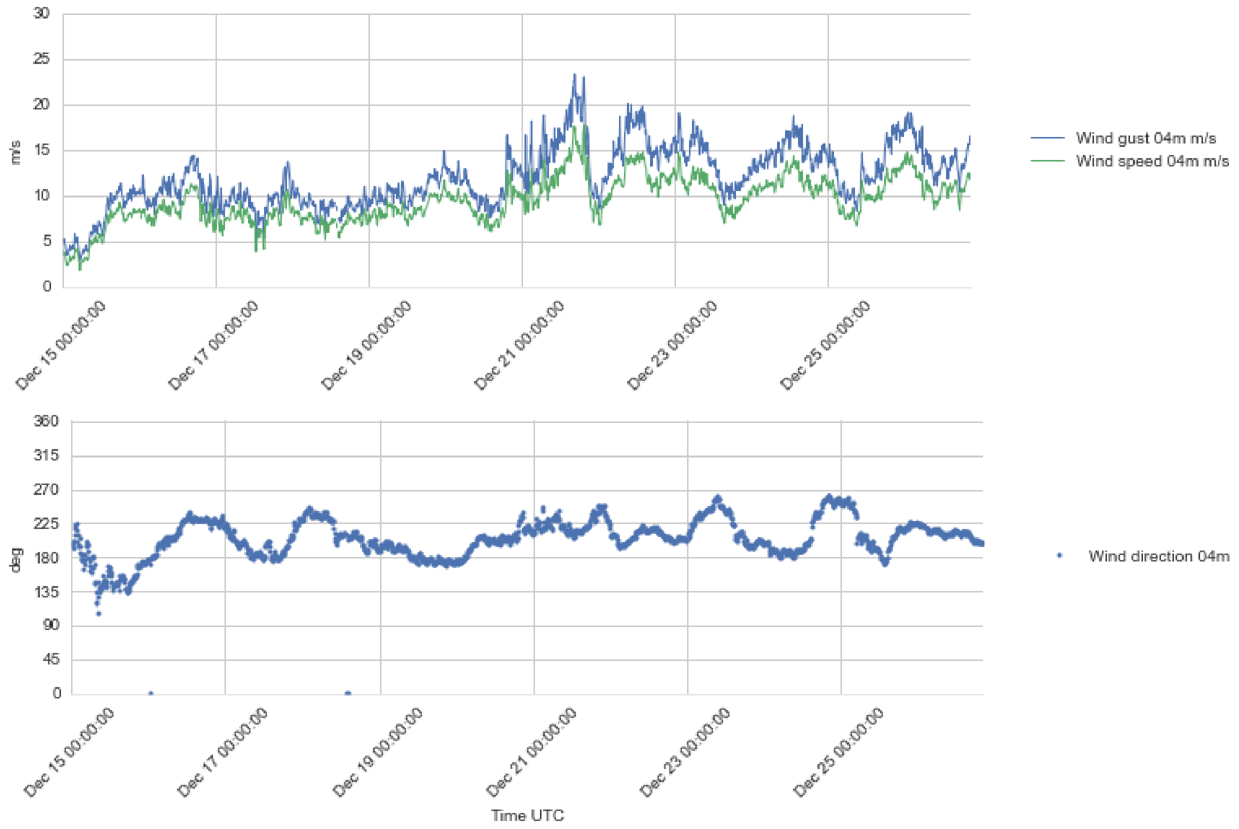

Figure 4.16 Plots of wind speed and gust (upper), and wind direction (lower) at 4 m a.s.l., 15 - 26 Dec 2015.

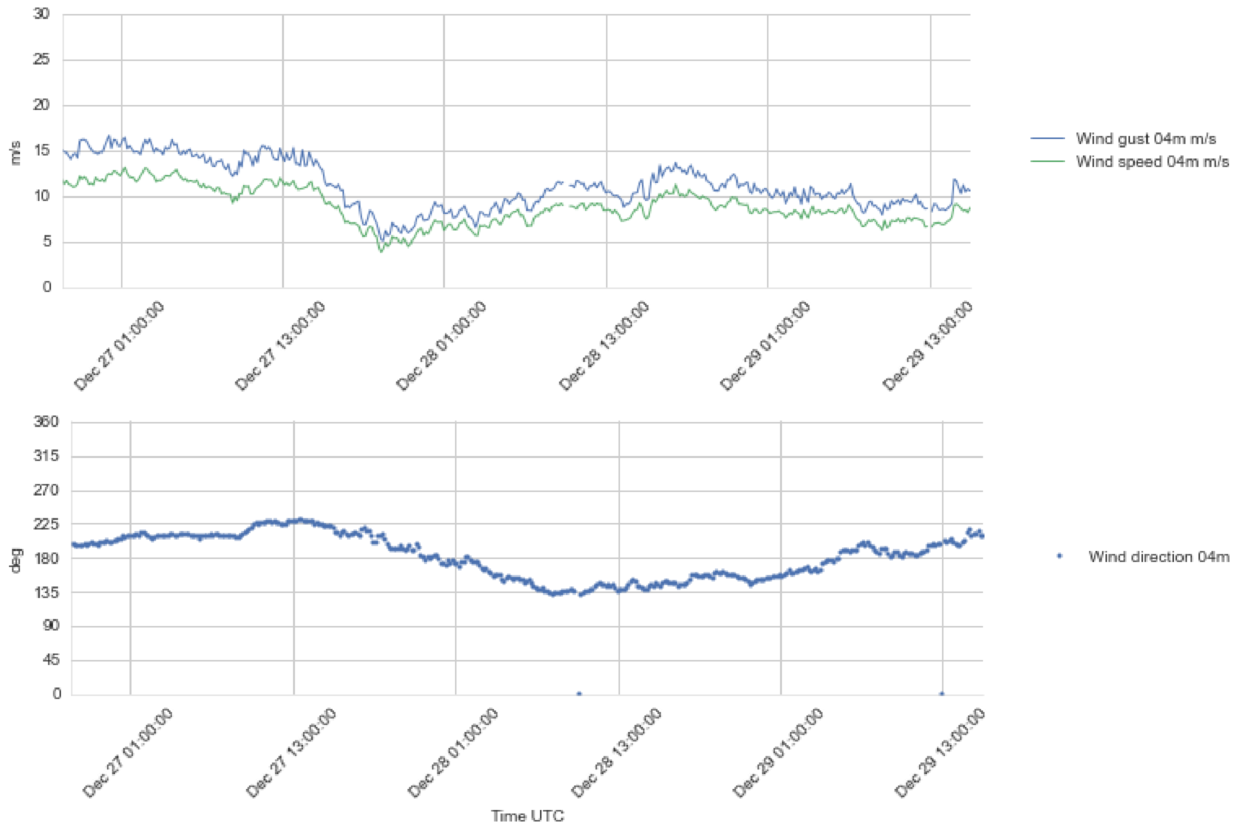

Figure 4.17 Plots of wind speed and gust (upper), and wind direction (lower) at 4 m a.s.l., 26 – 29 Dec 2015.

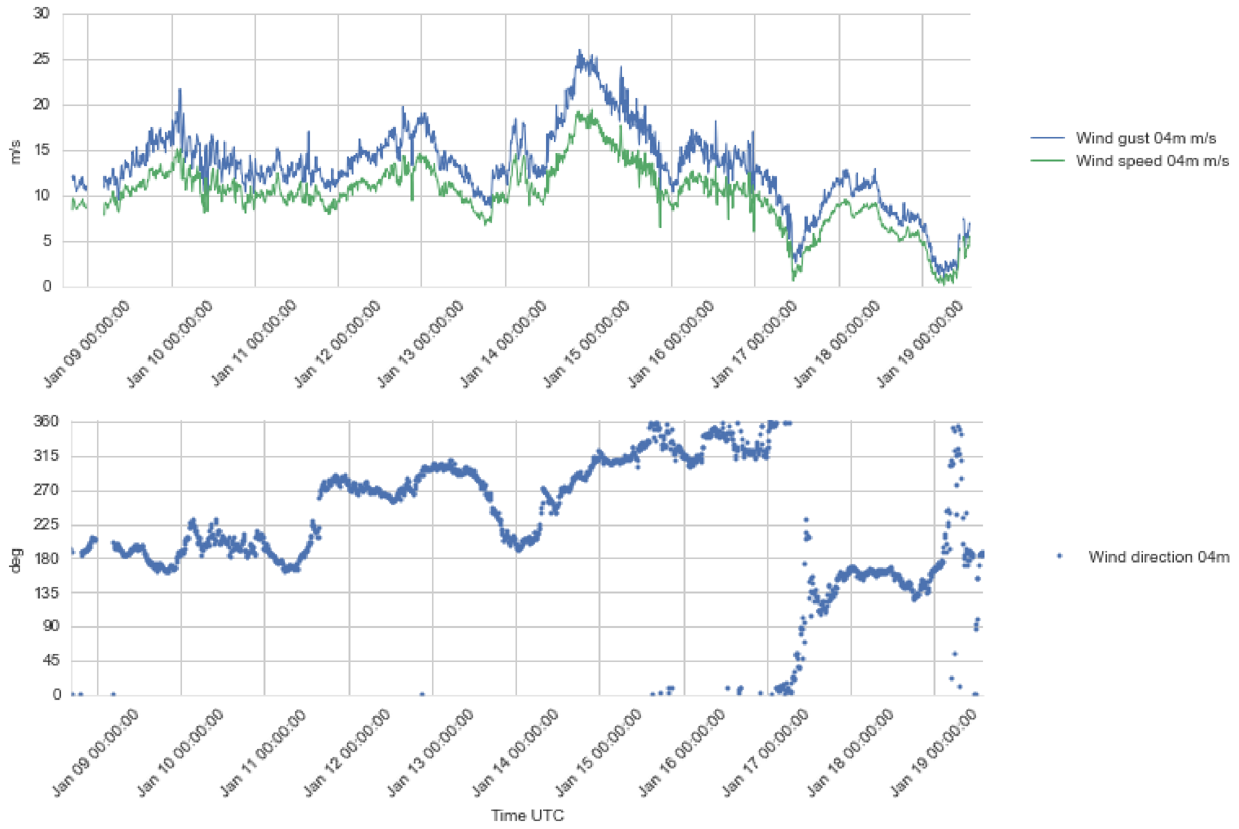

Figure 4.18 Plots of wind speed and gust (upper), and wind direction (lower) at 4 m a.s.l., 8 – 19 Jan 2016.

The wind profiling data from the Lidar are presented in the following plots showing the time series of 10 min. mean wind for each individual level. Plots of the derived parameters Inflow Angle and Turbulence Intensity are also presented[1].

The Inflow Angle (IA) is the angle of the 3-dimensional wind vector based on the ten minute averaged values of the horizontal and vertical wind velocity components. IA can be positive or negative; a positive IA means that the wind vector has an upward directed vertical component. The Turbulence Intensity (TI) is defined as $TI = \sigma/\bar{u}$ where σ is the standard deviation and $\bar{u}$ is the mean of the wind speed for a 10-min period. Note that this definition frequently gives relatively high values in situations with low mean wind speed, which is noticeable in the plots.

The highest observed horizontal mean wind speed during the period 15 – 26 December 2015 varies from 22.9 m/s at 30 m (measured 21 December at 16:40) to 31.3 m/s at 200 m (observed 22 December at 08:50).

[1] TI is not included in the regular Iridium transmissions, and only received through the dialup connection. Consequently, TI is missing for some periods when the dialup connection failed.

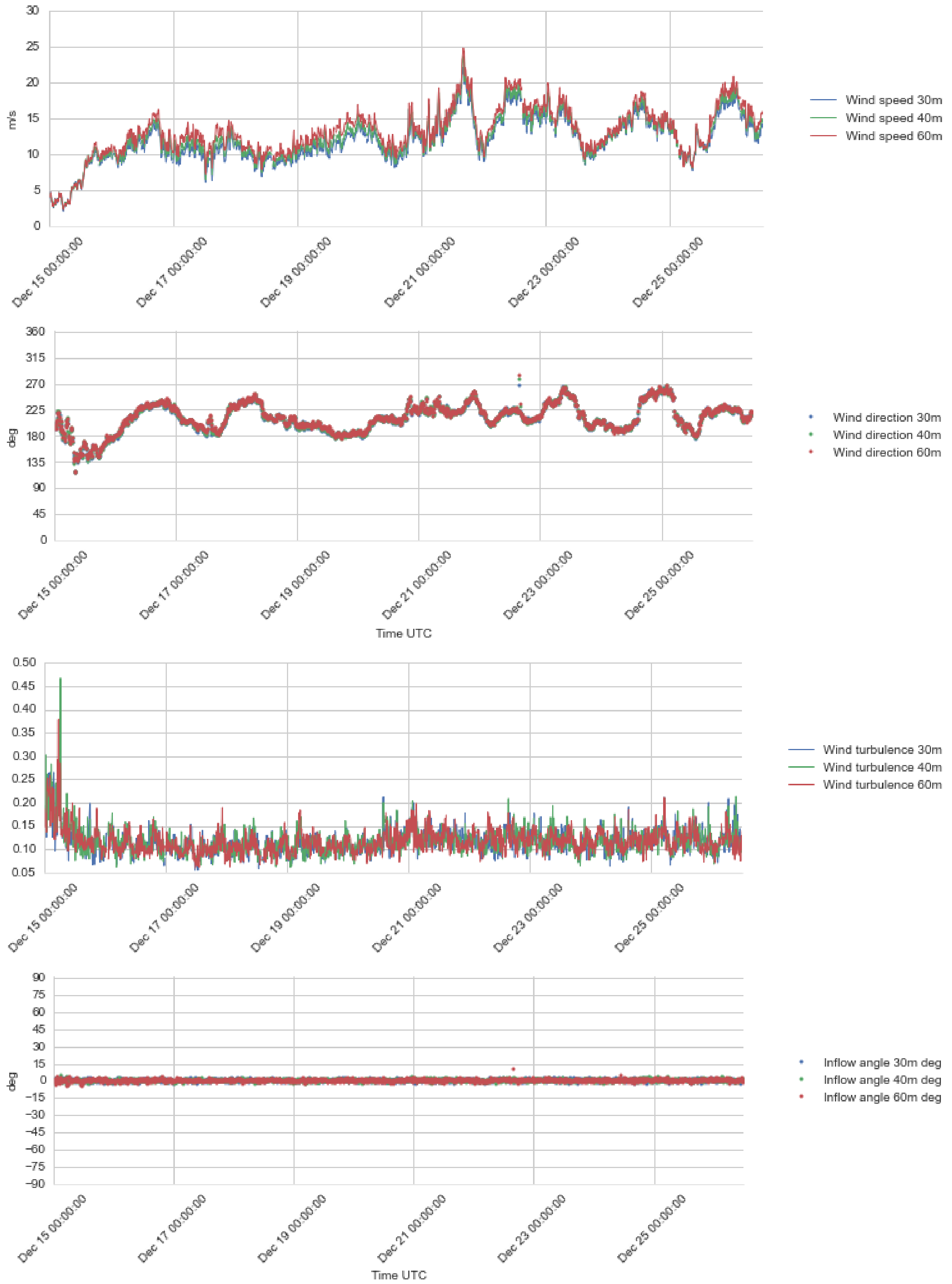

Figure 4.19 Plots of wind profile data, 30 – 60 m a.s.l., 15 - 26 Dec 2015.

From top to bottom: Wind speed, Wind direction, Turbulence Intensity, and Inflow Angle.

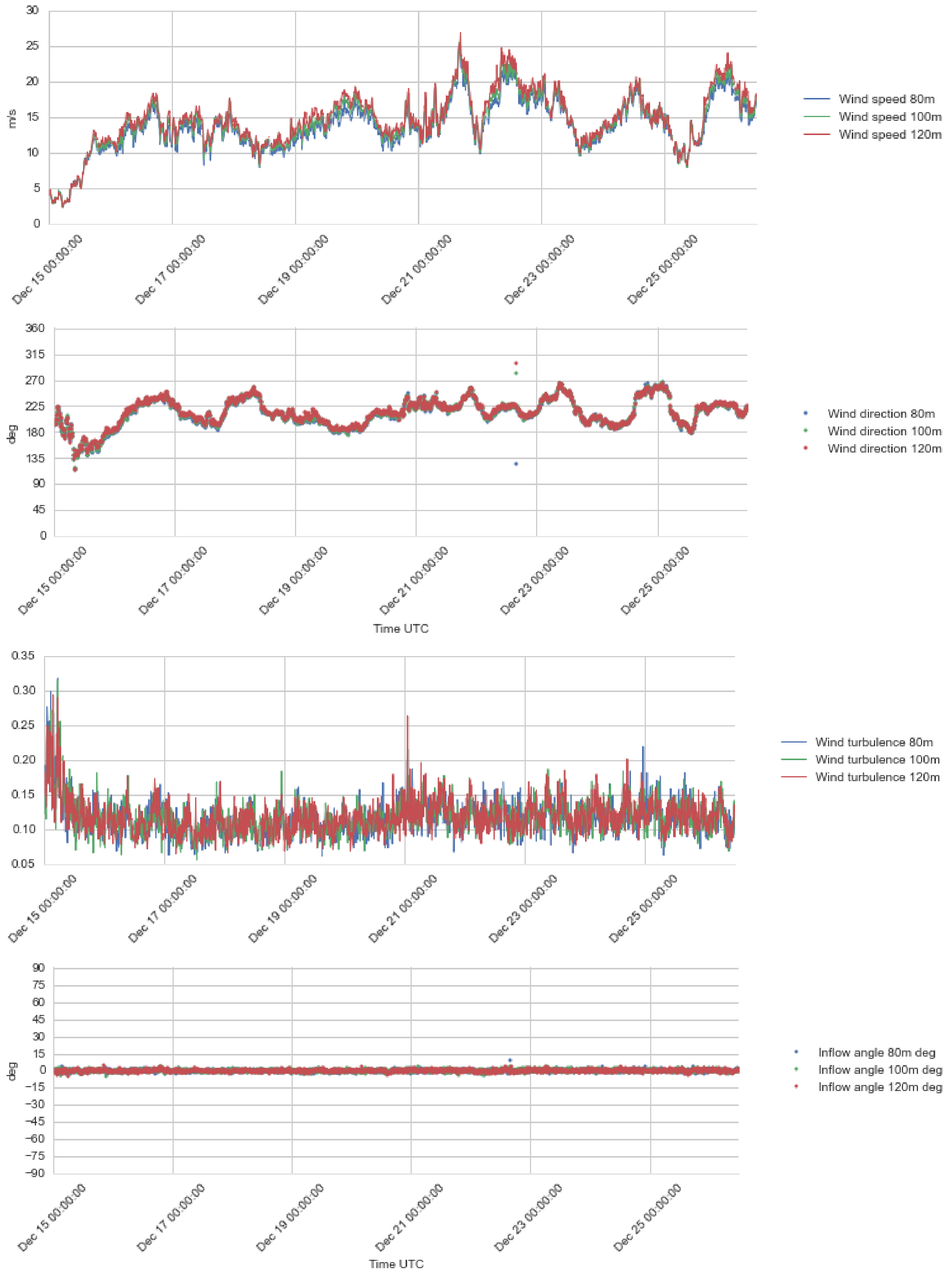

Figure 4.20 Plots of wind profile data, 80 – 120 m a.s.l., 15 - 26 Dec 2015.

From top to bottom: Wind speed, Wind direction, Turbulence Intensity, and Inflow Angle.

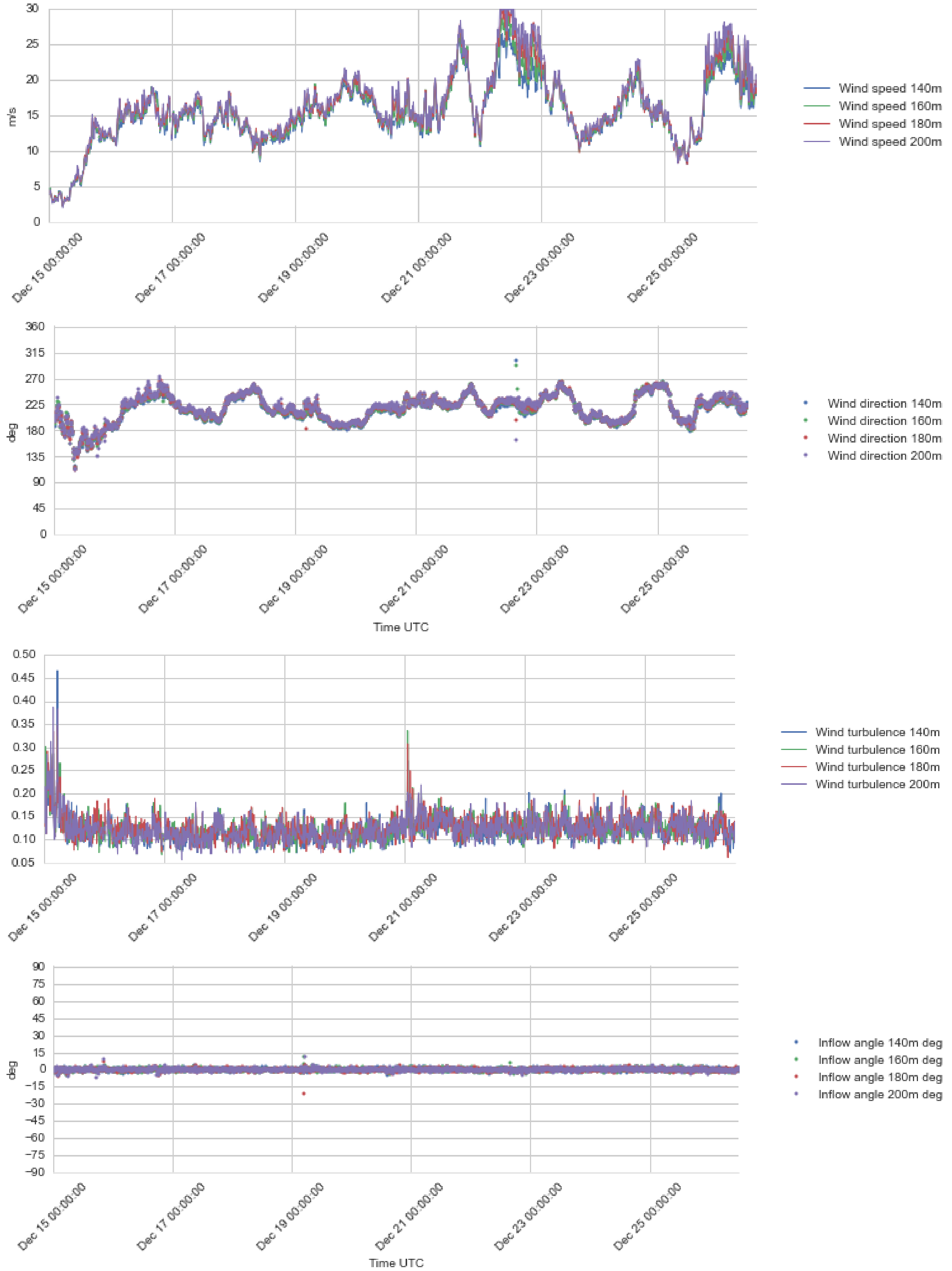

Figure 4.21 Plots of wind profile data, 140 – 200 m a.s.l., 15 - 26 Dec 2015.

From top to bottom: Wind speed, Wind direction, Turbulence Intensity, and Inflow Angle.

4.3.4 Current velocity profile data

The following plots show the current velocity profile time series. In these plots current direction 0° or 360° means that the current flows toward north, 90° indicates flow toward east etc. In general the current profiler has worked well, just a few data points were lost due to buoy restarting, but otherwise the series is continuous

As expected for this location the current velocity data show a very strong and consistent semi-diurnal tidal current pattern, completing two full rotations of the current vector per day, and four tidal current maxima; two toward south-southwest and two toward north-east. The quarter-diurnal peaks in the current speed vary between 60 – 90 cm/s over the month, depending on the phases of the moon.

The measurements close to the surface, 4 – 6 m depth, show lower speed than the measurements in the deeper layers. It may be that the speeds measured near the surface are reduced due to wake effects from the buoy hull and keel structure. The maximum measured speed was 82 cm/s at 10 m depth, and the average was 44 cm/s. At the lowest level, 30 m depth, the current speeds are reduced when the profiling beam hits the bottom. This usually occurs at every other peak in the current speed; that is when the strong current coincides with relatively low water level.

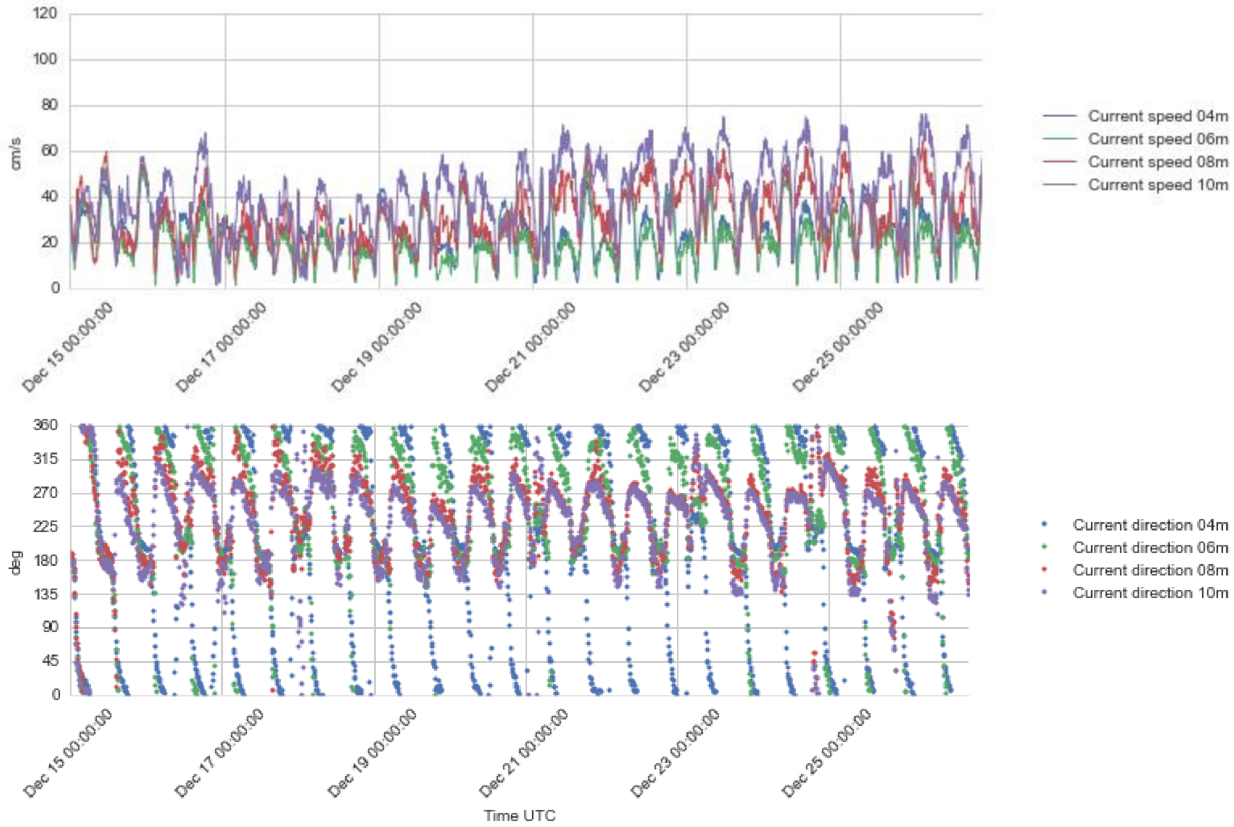

Figure 4.22 Time series plots of current speed (upper) and direction (lower panel), 4 - 10 m depth, 15 - 26 Dec 2015

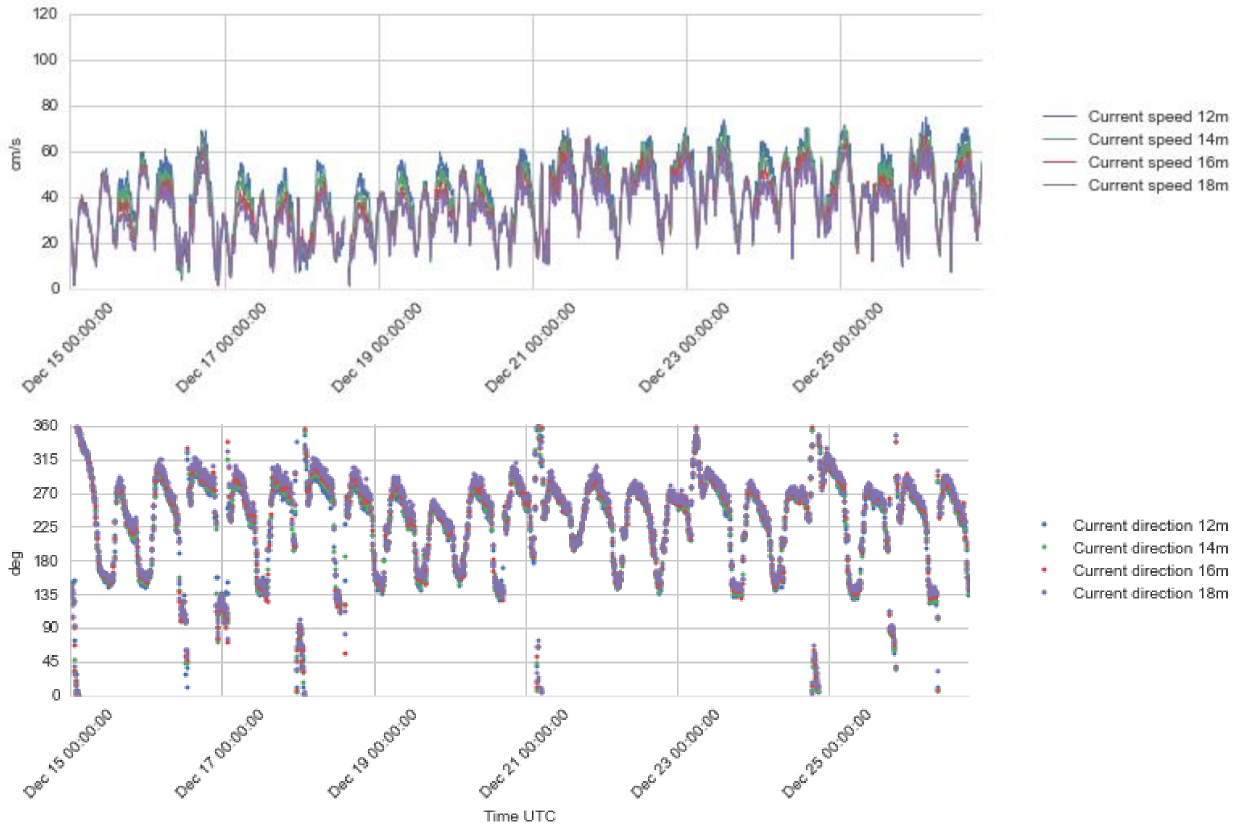

Figure 4.23 Time series plots of current speed (upper) and direction (lower panel), 12 - 18 m depth, 15 - 26 Dec 2015

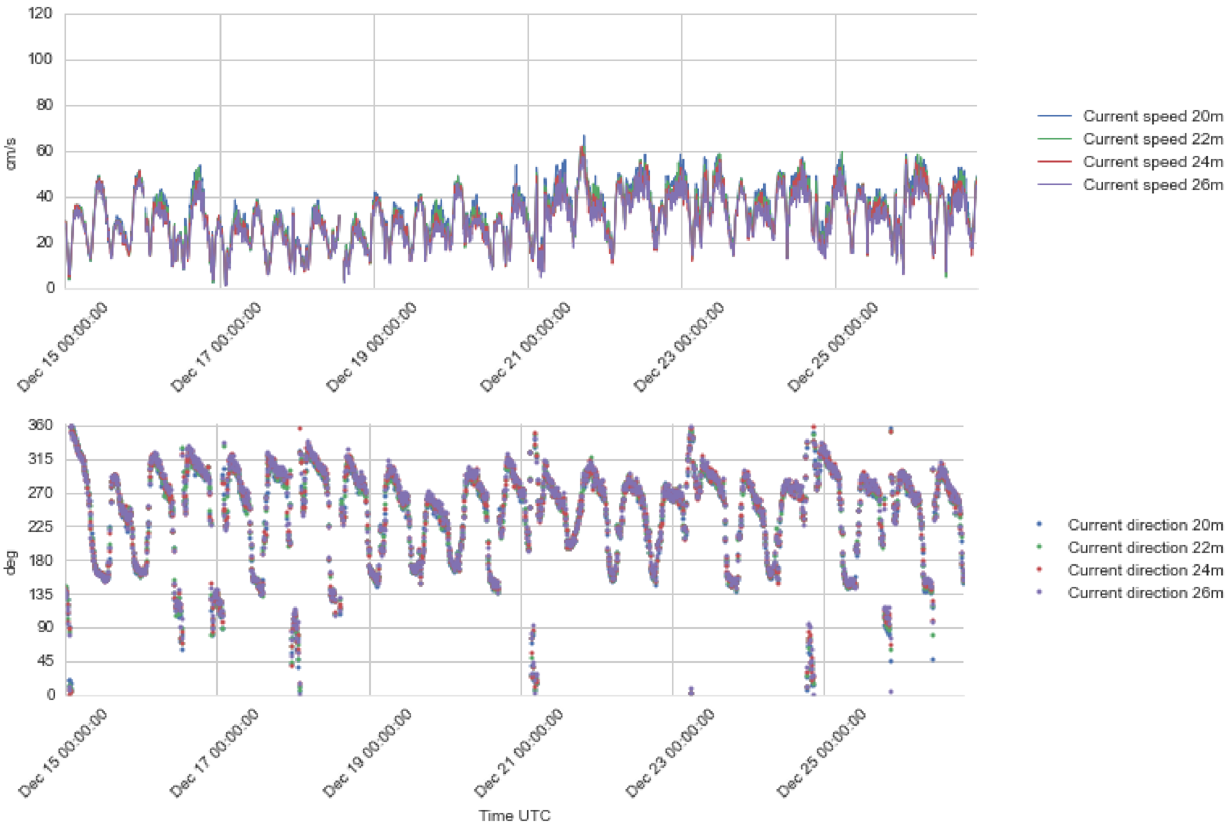

Figure 4.24 Time series plots of current speed (upper) and direction (lower panel), 20 - 26 m depth, 15 - 26 Dec 2015

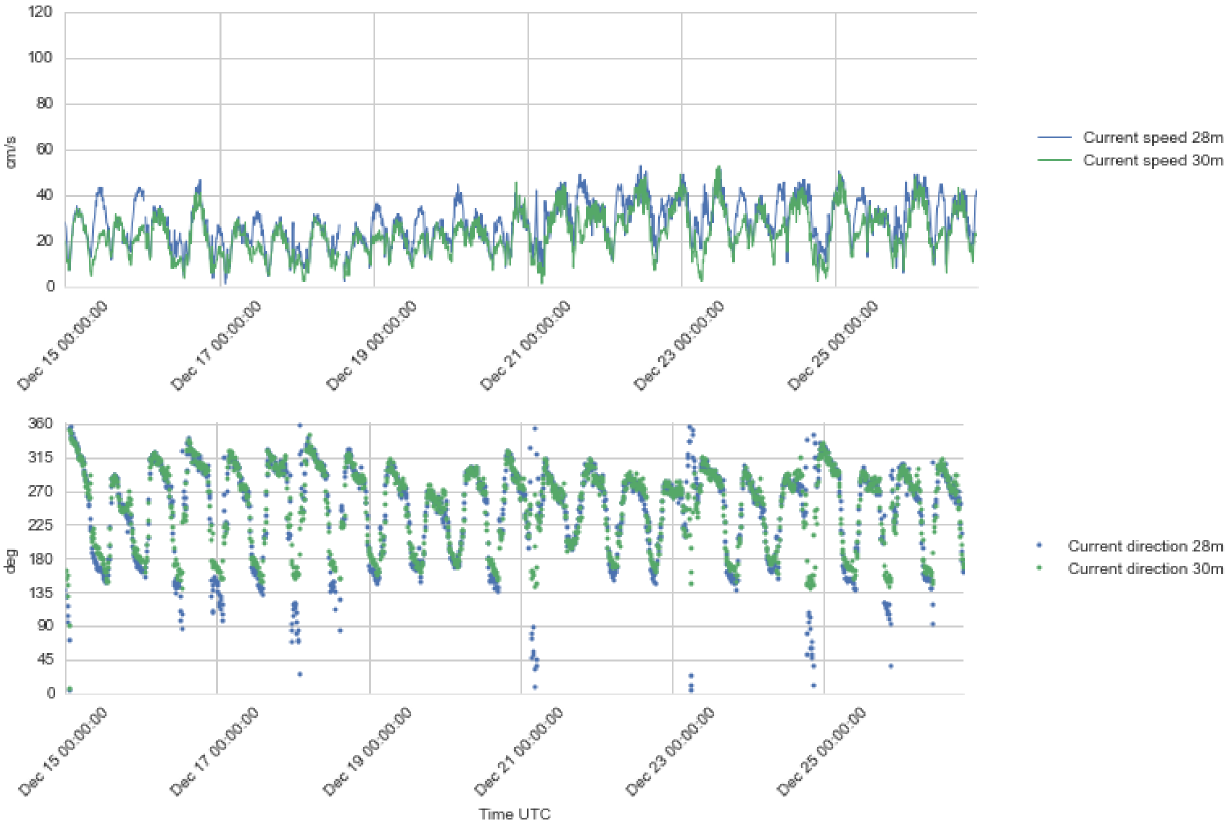

Figure 4.25 Time series plots of current speed (upper) and direction (lower panel), 28 - 30 m depth, 15 - 26 Dec 2015

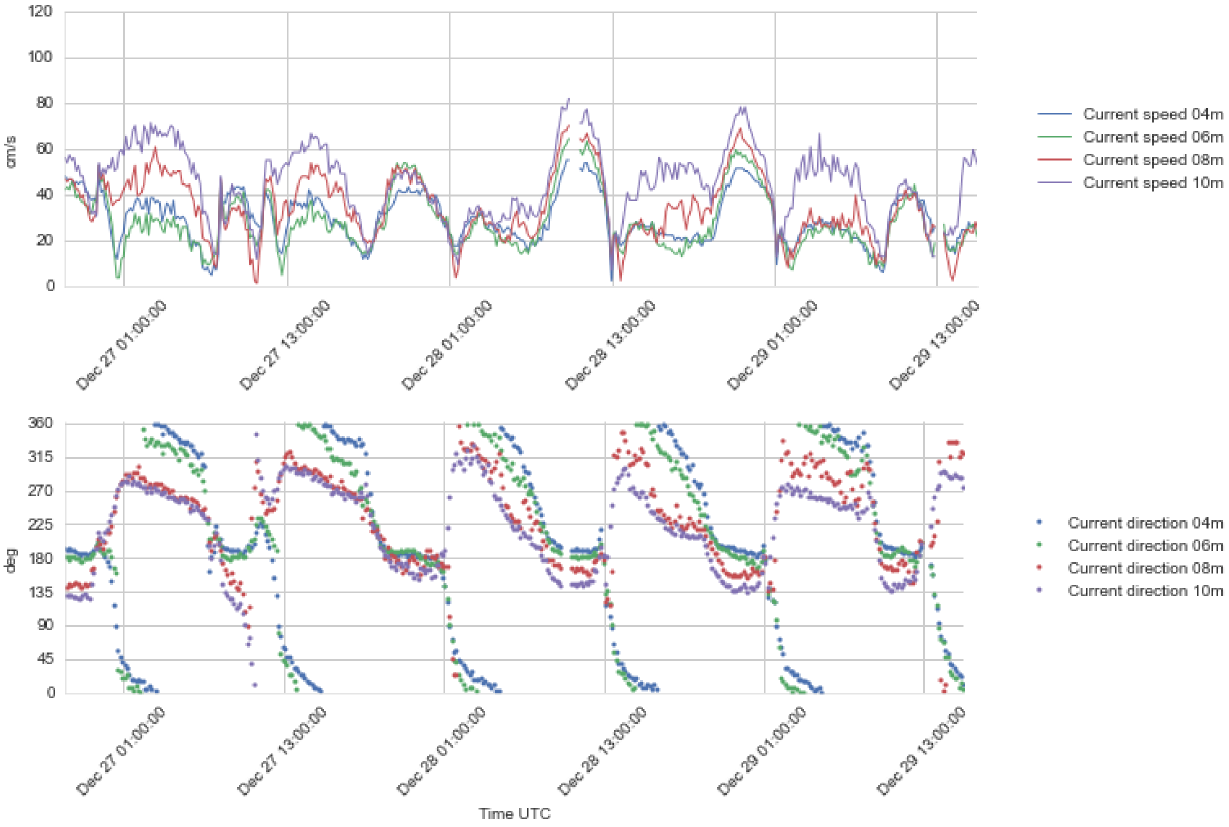

Figure 4.26 Time series plots of current speed (upper) and direction (lower panel), 4 - 10 m depth, 26 – 29 Dec 2015

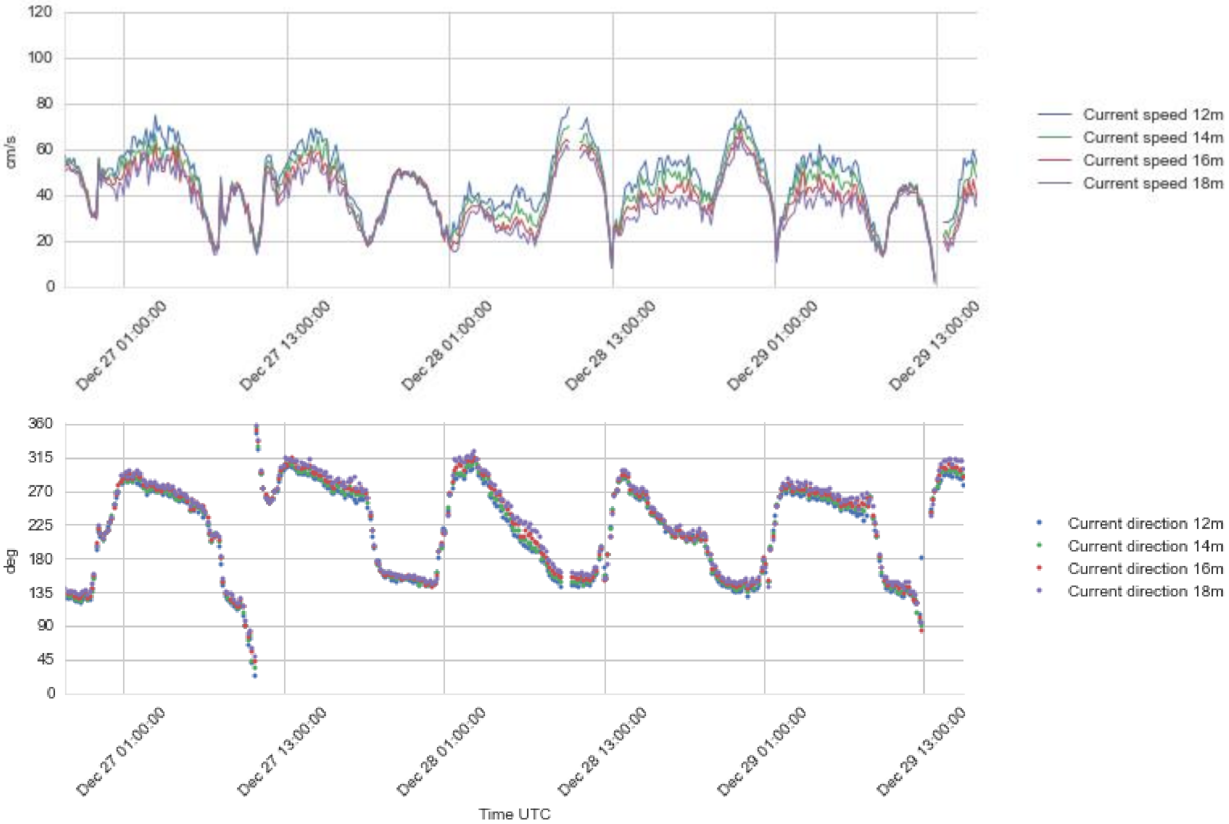

Figure 4.27 Time series plots of current speed (upper) and direction (lower panel), 12 -18 m depth, 26 – 29 Dec 2015

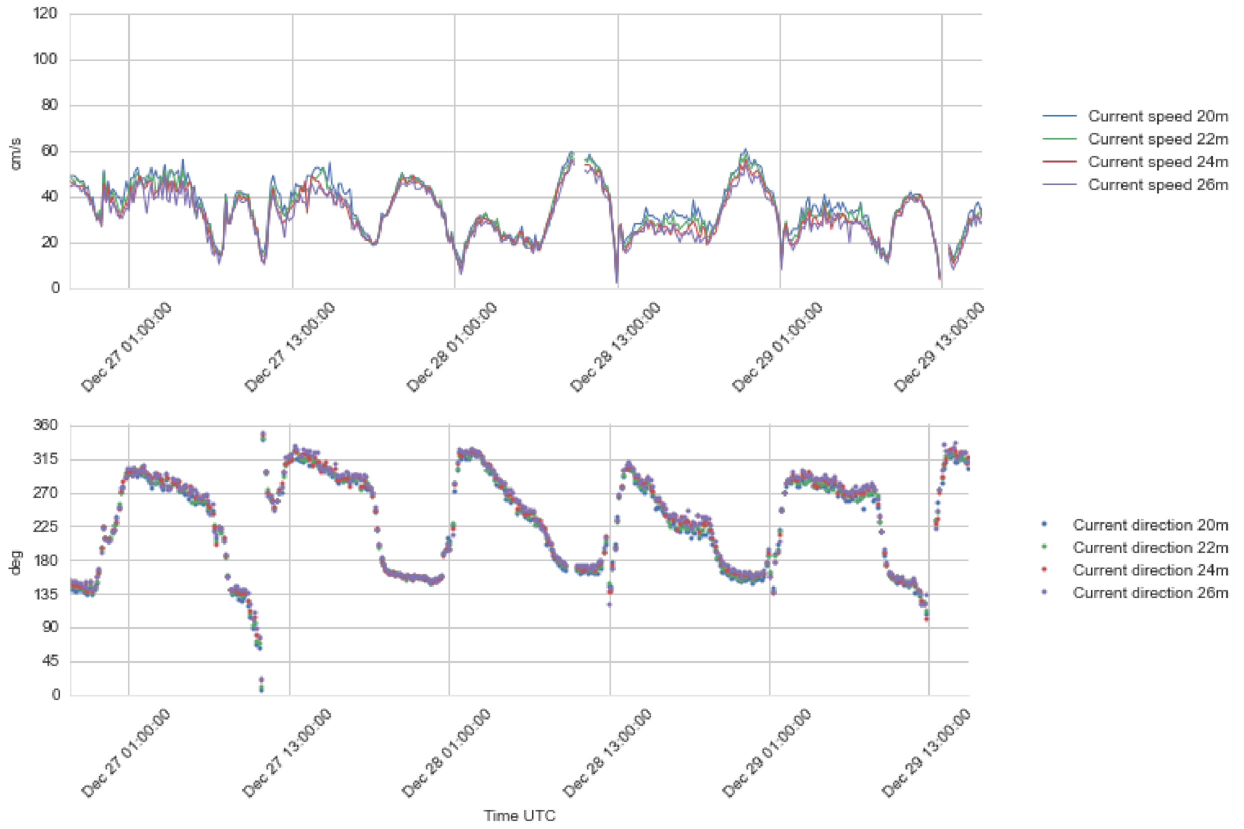

Figure 4.28 Time series plots of current speed (upper) and direction (lower panel), 20 – 26 m depth, 26 – 29 Dec 2015

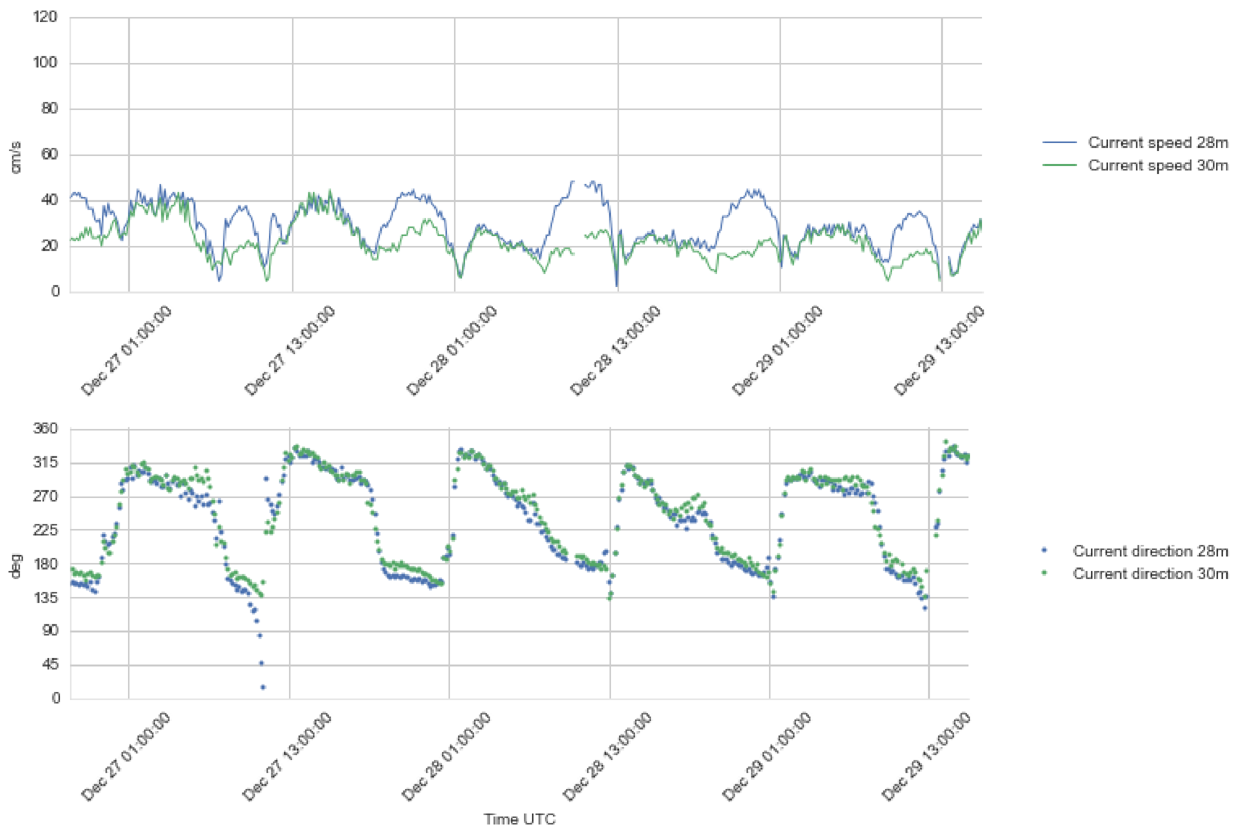

Figure 4.29 Time series plots of current speed (upper) and direction (lower panel), 28 – 30 m depth, 26 – 29 Dec 2015

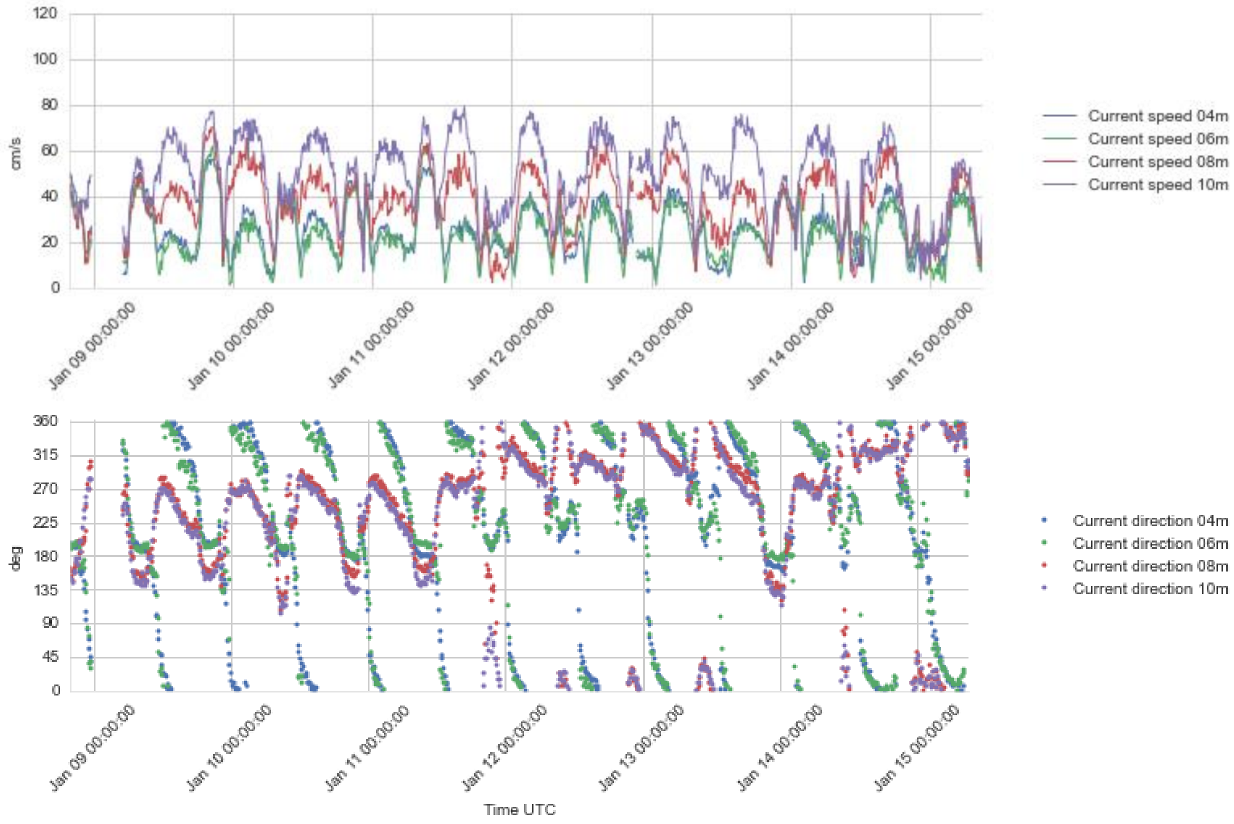

Figure 4.30 Time series plots of current speed (upper) and direction (lower panel), 4 - 10 m depth, 8 – 15 Jan 2016

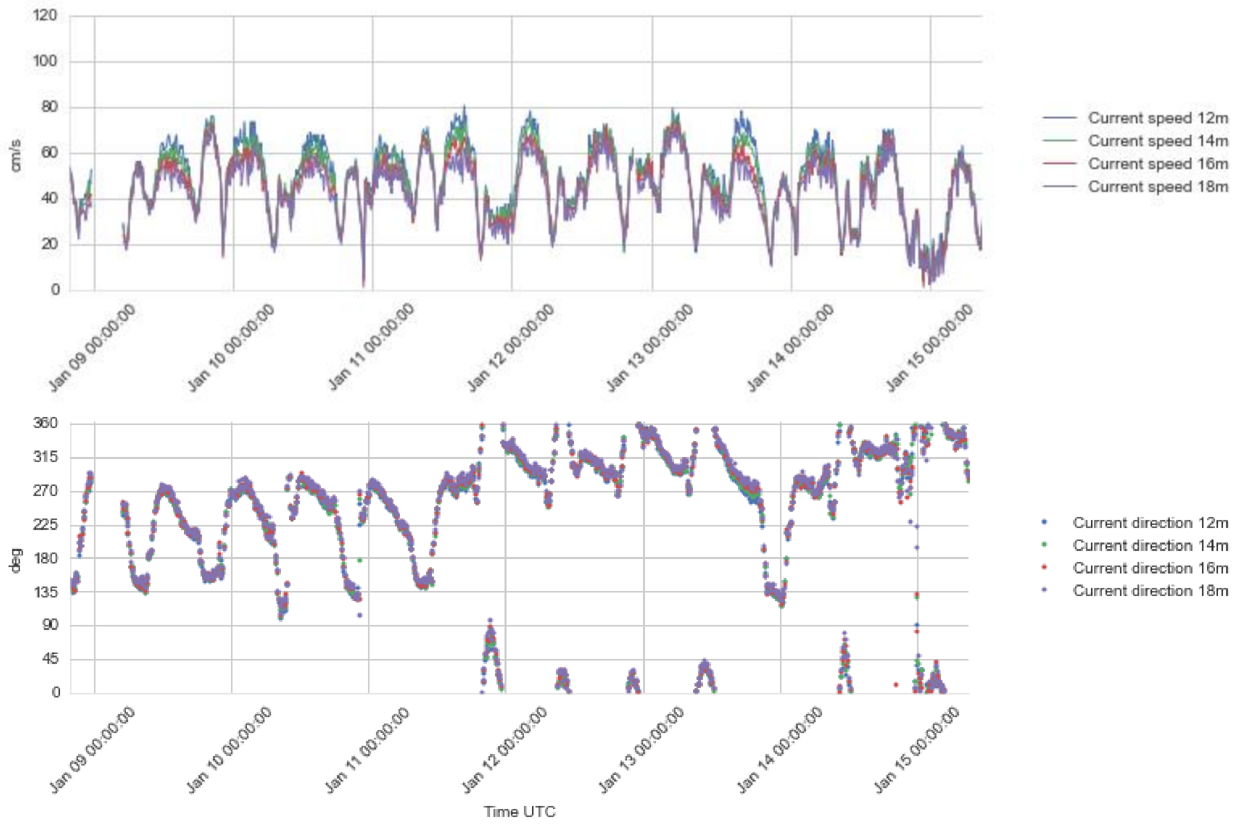

Figure 4.31 Time series plots of current speed (upper) and direction (lower panel), 12 - 18 m depth, 8 – 15 Jan 2016

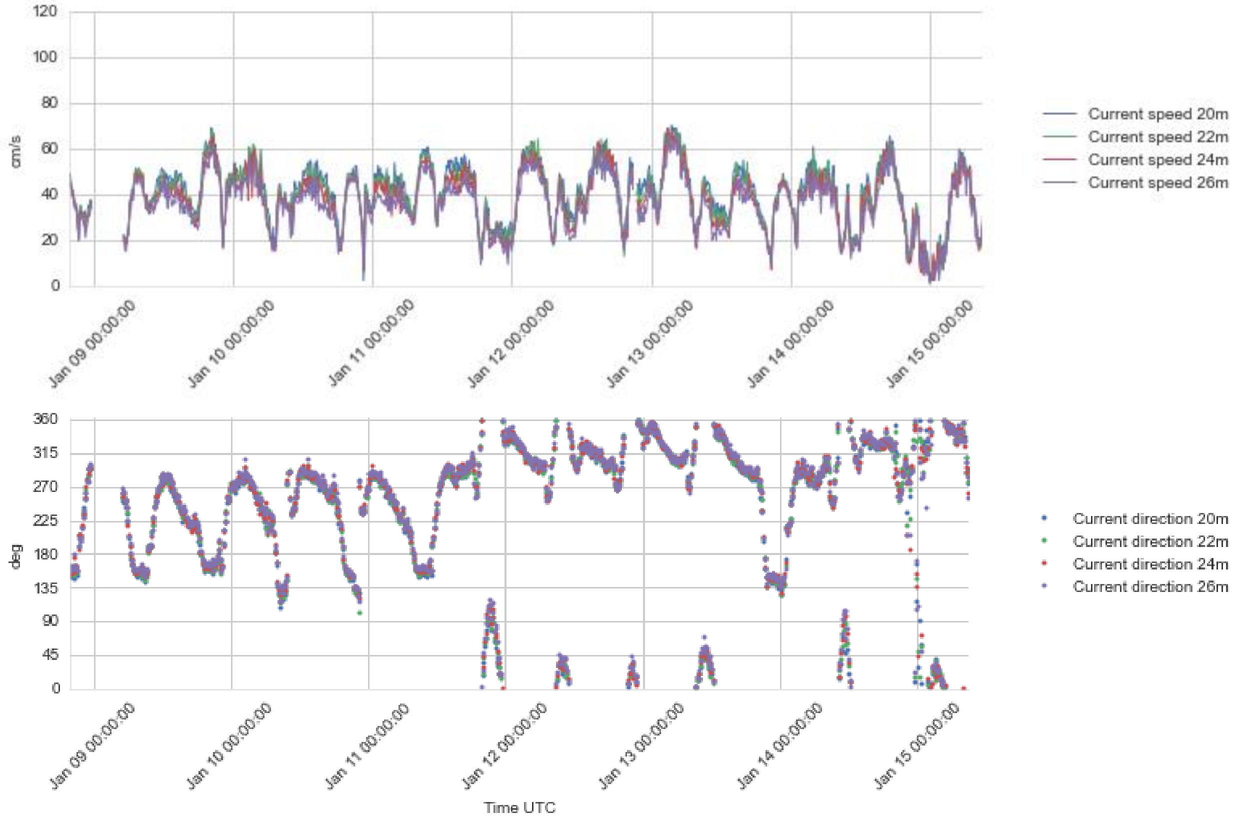

Figure 4.32 Time series plots of current speed (upper) and direction (lower panel), 20 - 28 m depth, 8 – 15 Jan 2016

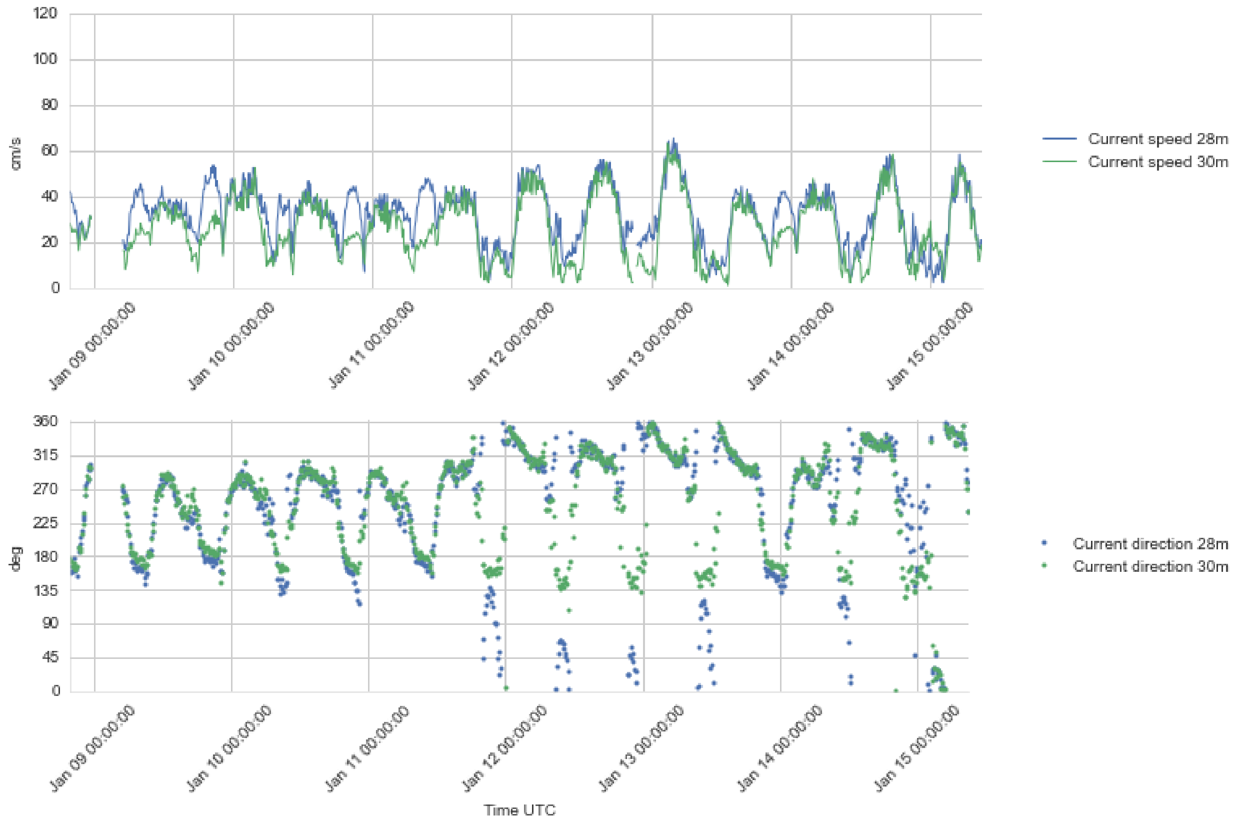

Figure 4.33 Time series plots of current speed (upper) and direction (lower panel), 28 - 30 m depth, 8 – 15 Jan 2016

4.3.5 Water level and bottom temperature data

The buoy received no data from the bottom mounted Seaguard WLR via the acoustic data link during this month. The received data indicate that the communication link between the sensor and the buoy was broken on 8 July 2015. It is expected that the data can be recovered from the internal storage in the WLR when it is recovered from the seabed.

Appendix A

Buoy deployment record

BUOY DEPLOYMENT SHEET

Project Name:	**WS Lidar buoy to Borssele, Nederland**		
Project no:	C75339	Latitude:	51°42.41388'N (x=502392)
Station name:	Borssele	Longitude:	3°2.07708'E (y=5728440)
WS buoy no:	WS149	Approx. depth:	30m
PFF numbers:	33900 – 33904, 33909	Buoy marking:	

Buoy module/sensor	**Serial number/ID**
Wavesense 3 data logger	276
XSense	077003A0
PMU	333
Vaisala PTB330	J4010005
Compass	1035375
Iridium modem	IMEI: 300125010219460 SIM: 8988169514001092357
UHF service radio Adeunis ARF7940BA	B134300547
L3 AIS	S.n: 000990022 MMSI. 992572057
Gill wind sensor	13220063
Vaisala air HMP155 temperature/humidity	J1130019
Buoytracker	736565
ZephIR 300S Lidar	428
Flashlight	
Nortek Current meter	AQP7355
Seaguard w/sensor 5217A	1620 222

CONFIGURATION

Data transmission interval:	Continuous mode. '
Listening window	NA

POWER OPTIONS

Lead batteries type	**4 x 62Ah**
Lithium batteries:	**6 x 272Ah**
Fuel cells	**4 fuel cells with 10 methanol cartridges 28 litres each.**

DEPLOYMENT HISTORY

	YEAR	**MONTH**	**DATE**	**Local time**
First measurement	2015	06	11	16:55
First measurement in position	2015	06	11	18:14
Out of measuring position	2015	10	06	11:30
Last measurement				

Comments:
WLR deployment position:
51° 42.4362N, 3° 02.1030E, Depth: 30m
Time reference: CET (DST) (UTC + 2 hours)

Deployment vessel: MPR3	Recovery vessel: Multrasalvor 3
Deployed by: EME & OKH	Recovered by:

BUOY DEPLOYMENT SHEET

Project Name:	**WS Lidar buoy to Borssele, Nederland**		
Project no:	C75339	Latitude:	51°42.41388'N (x=502392)
Station name:	Borssele	Longitude:	3°2.07708'E (y=5728440)
WS buoy no:	WS149	Approx. depth:	30m
PFF numbers:	33910 – 33914, 33919	Buoy marking:	

Buoy module/sensor	**Serial number/ID**
Wavesense 3 data logger	276
XSense	077003A0
PMU	333
Vaisala PTB330	J4010005
Compass	1035375
Iridium modem	IMEI: 300125010219460 SIM: 8988169514001092357
UHF service radio Adeunis ARF7940BA	B134300547
L3 AIS	S.n: 000990022 MMSI. 992572057
Gill wind sensor	13220063
Vaisala air HMP155 temperature/humidity	J1130019
Buoytracker	736565
ZephIR 300S Lidar	428
Flashlight	
Nortek Current meter	AQP7355
Seaguard w/sensor 5217A	1620 222

CONFIGURATION

Data transmission interval:	Continuous mode. ‘
Listening window	NA

POWER OPTIONS

Lead batteries type	**4 x 62Ah**
Lithium batteries:	**6 x 272Ah**
Fuel cells	**4 fuel cells with 10 methanol cartridges 28 litres each.**

DEPLOYMENT HISTORY

	YEAR	MONTH	DATE	Time (UTC)
First measurement	2015	11	12	14:00
First measurement in position	2015	11	12	14:20
Out of measuring position	2016	01	19	11:15
Last measurement				

Comments:
WLR deployment position:
51° 42.4362N, 3° 02.1030E, Depth: 30m
Time reference: UTC

Deployment vessel: Multrasalvor 3	Recovery vessel: Multrasalvor 3
Deployed by: EME & OKH	Recovered by:

THE NETHERLANDS ENTERPRISE AGENCY (RVO)

Supply of Meteorological and Oceanographic data at Borssele Wind Farm Zone (BWFZ)
Validation report
14 September - 6 October 2015
15 December 2015 - 19 January 2016

Reference No: C75339_VAL03A-4A_R1
6 September 2016

Fugro OCEANOR AS
Pirsenteret, P.O. Box 1224, Sluppen, N-7462 Trondheim, Norway
Tel: +47 73545200 Fax: +47 73525033, e-mail: oceanor@oceanor.com

Supply of Meteorological and Oceanographic data at Borssele Wind Farm Zone (BWFZ): C75339_VAL03A-4A_R1				
Rev	**Date**	**Originator**	**Checked & Approved**	**Issue Purpose**
0	31.08.2016	Lasse Lønseth	Arve Berg	Draft report.
1	06.09.2016	Lasse Lønseth	Arve Berg	Final report.

Rev 1 – 06 September 2016	Originator	Checked & Approved
Signed:	for Lasse Lønseth	

This report is not to be used for contractual or engineering purposes unless the above is signed where indicated by both the originator of the report and the checker/approver and the report is designated 'FINAL'.

TABLE OF CONTENT

SUMMARY

The Seawatch Wind Lidar buoy is in operation at the Borssele Wind Farm Zone (BWFZ). The buoy was first deployed on 11 June 2015 at 15:55 UTC, and the bottom mounted tide gauge (WLR) was deployed at 16:15 UTC on the same day. The transmissions from the buoy stopped on 11 September 2015. However, the Lidar and the current meter continued recording data until the buoy was recovered to shore on 6 October 2015.

After repair on shore the buoy was redeployed on 12 November 2015. The buoy collected good data from all the sensors until 26 December 2015. Then the Lidar stopped working due to a problem with its power switch, while collection of data from the other sensors continued until 29 December. Collection of data, except wind profile data, was resumed on 8 January and continued until the buoy was recovered for repair on 19 January 2016.

This report presents an evaluation of the wind and wave data collected during the periods 14 September – 6 October 2015, 15 – 29 December 2015, and 8 – 19 January 2016. Data collected prior to 14 September 2015 and in the period 12 November – 14 December 2015 have been validated in previous reports. The validation procedure compares the buoy data to data from two fixed measurement stations in the region. The reference stations are a Waverider buoy at Schouwenbank (station SCHB) and a platform with a wind sensor at Vlakte van de Raan (VR).

Although the reference stations are some 20 – 30 km away from the buoy location we see good agreement between the buoy and references.

1. INTRODUCTION

The Seawatch Wind Lidar buoy with serial no. WS149 is deployed at the Borssele Wind Farm Zone (BWFZ) in the Dutch sector of the North Sea. The buoy was first deployed on 11 June 2015 at 15:55 UTC with the bottom mooring weight at position 51° 42.41388' N, 3° 2.07708' E. A bottom mounted water level recorder (WLR) at position 51° 42.4362' N, 3° 02.1030' E transmits data to the buoy in real time data via an acoustic link. The water depth at this location is approximately 30 m.

This report validates short data sets which were not presented in the regular monthly progress reports because they do not contain a full month of continuous wind profile data. Data for the following periods are validated:

- 14 September – 6 October 2015: The transmissions and recording of data in the central Geni processor stopped on 11 September 2015 at 16:00. The storage of data in the Lidar and the current profiler as well as storage of motion data continued, and it was possible to reconstruct wind profile and current profile measurements until the buoy was recovered to shore on 6 October 2015.
- 15 – 29 December 2015: The buoy collected data from all sensors from buoy deployment on 12 November until 26 December 2015 at. 13:10. Then the Lidar stopped due to failure of its power switch, while recording of data from all other sensors continued. The buoy recorded data from all sensors except the Lidar until 29 December 16:50 at 16:50. Then the transmissions and storage of data stopped.
- 8 – 19 January 2016: The buoy was restarted on 8 January and recorded data from all sensors except the Lidar until 19 January 2016 at 12:00. At that time the buoy was recovered for maintenance and repair.

The data are presented in the data presentation report ref. C75339_MPR03A-4A_R1.

This report presents an evaluation of the wind and wave data, comparing the buoy data to data from fixed measurement stations in the area. The reference stations are the Waverider buoy at Schouwenbank (station SCHB) and a platform with a wind sensor at Vlakte van de Raan (VR). The wave data are compared to measurements from SCHB, and the wind data are compared to data from VR. The comparisons are shown in time series and scatter plots.

The time reference used in this report is UTC.

2. Instrumentation and measurement configuration

The buoy is a Seawatch Wind Lidar Buoy based on the original Seawatch Wavescan buoy design with the following sensors:

- Wavesense: 3-directional wave sensor
- Xsens 3-axes motion sensor
- Gill Windsonic M acoustic wind sensor
- Vaisala PTB330A air pressure sensor
- Vaisala HMP155 air temperature and humidity sensor
- Nortek Aquadopp 600kHz current profiler.
- ZephIR 300S Lidar.

An independent self-recording Aanderaa SeaGuard WLR tide gauge is located on the bottom. The WLR transmits data to the buoy via an acoustic link.

The buoy with mooring as deployed is presented in Figure 2.1, including the mooring for the WLR.

The measurement setup is detailed in Table 2.1. Detail information such as sensor types and serial numbers can be found in the deployment record in Appendix A.

Table 2.1 Configuration of measurements by the Seawatch Wind Lidar buoy at Borssele Borssele Wind Farm Zone (BWFZ).

Instrument type	Sensor height (m)	Parameter measured	Sample height[2)] (m)	Sampling interval (s)	Averaging period (s)	Burst interval (s)	Trans-mitted?
Wavesense 3	0	Heave, pitch, roll, heading	0	0.5	Time series duration: 1024 s	600	No
		Sea state parameters (1)	0	600	1024	600	Yes
Xsens		Heave,east,north acceleration, q0,q1,q2,q3 (attitude quaternion)	0	0.5	N/A	3600	No
Gill Windsonic M	4.1	Wind speed, wind direction	4.1	1	600	600	Yes
Vaisala PTB330A	0.5	Air pressure	0.5	30	60	600	Yes
Vaisala HMP155	4.1	Air temperature Air humidity	4.1	5	60	600	Yes
Nortek Aquadopp	-1	Current speed and direction profile, water temperature (at 1 m depth)	-4 -6 … -30 (14 levels)	N/A	600	600	Yes
ZephIR 300S Lidar	2	Wind speed and direction at 10 heights (The 11th level, the so called reference level which is not configurable, is also located at 40 m and referred to as 40.0 Ref.)	30.0 40.0 40.0 ref 60.0 80.0 100.0 120.0 140.0 160.0 180.0 200.0	≈ 17.4 s[1)]	600	600	Yes
Aanderaa WLR (SeaGuard) via acoustic link	-30	Water pressure Temperature	-30	600	60	600	Yes

1) This is the approximate time between the beginning of one sweep of the profile and the next one, the interval may vary slightly. The ZephIR sweeps one level at a time beginning at the lowest one, and after the top level has been swept it uses some time for calculations and re-focusing back to the lowest level for a new sweep.

2) Height relative to actual sea surface. The depth of the WLR is an approximate number.

Table 2.2 Definitions of wave parameters presented in this report

H	Individual wave height
Hmax	= Max(H): Height of the highest individual wave in the sample, measured from crest to trough
m0, m1, m2, m4, m-1, m-2	Moments of the spectrum about the origin: $\int f^k S(f)df$ where $S(f)$ is the spectral density and the wave frequency, f, is in the range 0.04 - 0.50 Hz
Hm0	Estimate of significant wave height, Hs, $Hm0 = 4\sqrt{m0}$
Tp	Period of spectral peak = $1/f_p$, The frequency/period with the highest energy
Tm01	Estimate of the average wave period; $Tm01 = m0/m1$
Tm02	Another estimate of the average wave period; $Tm02 = \sqrt{\frac{m0}{m2}}$
ThTp	Mean wave direction at the spectral peak ("The direction of most energetic waves")
Mdir	Wave direction averaged over the whole spectrum
	Directions are given in degrees clockwise from north, giving the direction the waves come from. (0° from north, 90° from east, etc.)

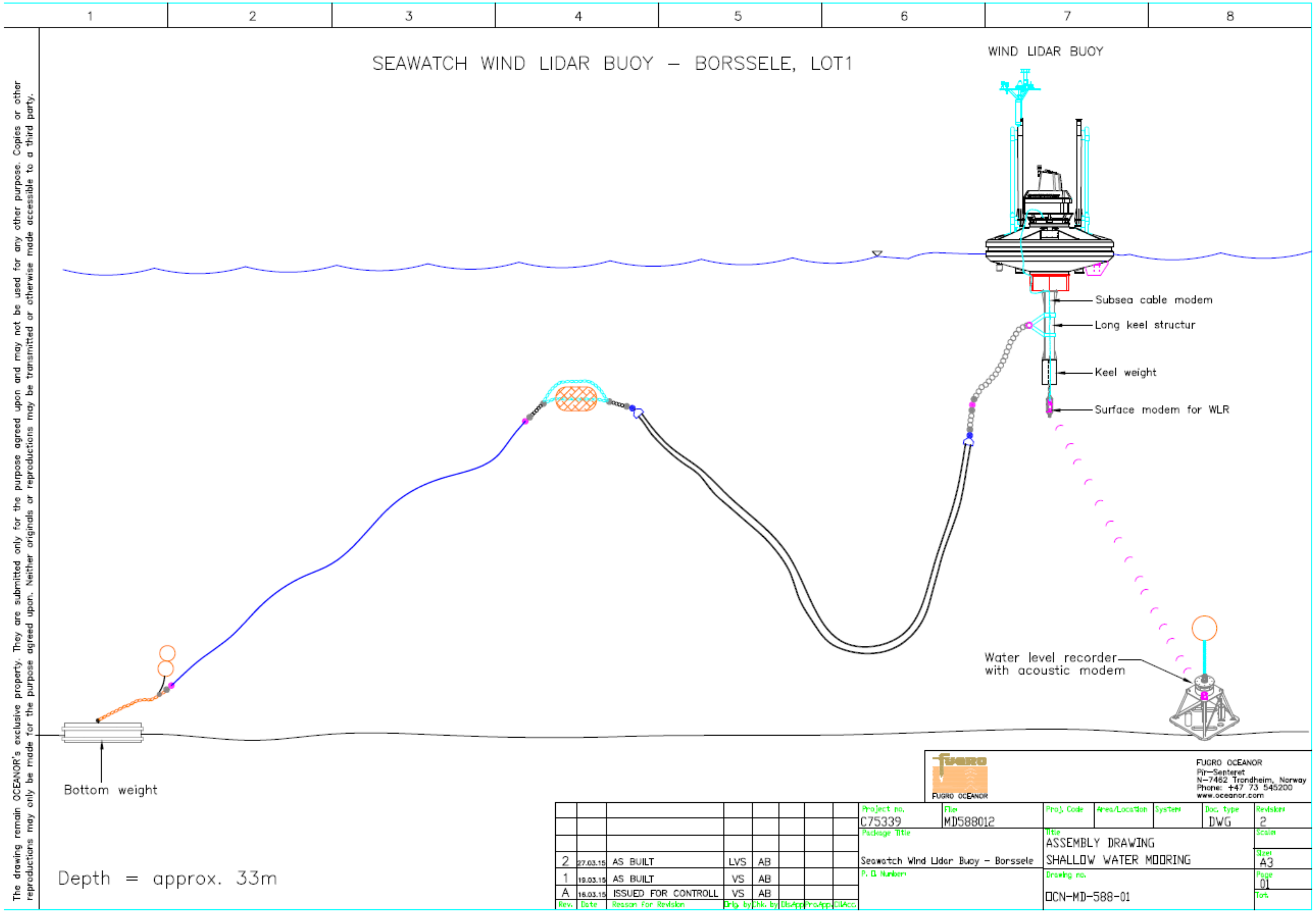

Figure 2.1 Mooring design for the Wind Lidar Buoy as deployed at Borssele Wind Farm Zone (BWFZ).

3. Results

3.1 Data recovery

3.1.1 Period: 14 September – 6 October 2015

During this period the buoy transmitted no data, and measurements were not stored by the Geni processor, except for the raw data from the motion sensor Xsens. However, the Lidar and the current profiler continued to work and stored data in their respective data loggers. The wind profile and current data collected until the buoy recovery on 6 October 2015 are validated in this report. The number of hours of good data compared to the total obtainable hours of data is presented in Table 3-1.

Table 3-1 Data return during the period 14 September 2015 at 15:40 – 6 October 2015 at 00:00.

Measurement device	Length of data period (days)	Length of data set (days)	Average availability (%)
Lidar wind profile sensor	21.354	21.313	99.80
Wave sensor	21.354	0.000	0.00
Current velocity and direction sensor	21.354	21.354	100.00
Atmospheric pressure sensor	21.354	0.000	0.00
Air temperature sensor	21.354	0.000	0.00

3.1.2 Period: 15 December 2015 – 19 January 2016

The buoy transmitted and stored good data from all sensors from the beginning of this period. The Lidar stopped working on 26 December 2015 at 12:10. The buoy continued transmitting and recording data from all other sensors until 29 December at 16:00. After that time the buoy recorded no data until it restarted and resumed data collection from all sensors except the Lidar on 8 January 2016 at 20:00. There is a gap in the collected data from 23:50 on 8 January to 05:00 on 9 January 2015. After that the buoy collected data continuously until it was recovered on 19 January at 11:15, with the exception of the Lidar which remained non-responsive. The number of hours of good data compared to the total obtainable hours of data is presented in Table 3-2.

Table 3-2 Data return during the period 15 December 2015 at 15:40 – 19 January 2016 at 11:10.

Measurement device	Length of data period (days)	Length of data set (days)	Average availability (%)
Lidar wind profile sensor	35.472	11.278	31.79
Wave sensor	35.472	24.944	70.32
Current velocity and direction sensor	35.472	20.854	58.79
Atmospheric pressure sensor	35.472	24.951	70.34
Air temperature sensor	35.472	24.951	70.34

3.2 Reference stations

3.2.1 Positions and distances

Two public reference stations are used in the validation of the data; a Waverider buoy at Schouwenbank and a weather station at a small platform on the Vlakte van de Raan. The positions of the stations are given in Table 3.3, which gives an overview of the location and distances.

Table 3.3 Postitions of the Lidar buoy and the reference stations used in the evaluation of the buoy data.

Station	Latitude	Longitude	Distance from the Lidar buoy	Shortest distance from land
Borssele Lidar buoy	51° 42.41' N	3° 2.08' E		32.5 km
Schouwenbank Waverider buoy (SCHB)	51° 44.8' N	3° 18.3' E	19.3 km	22.0 km
Vlakte van de Raan (VR)	51° 30' N	3° 15' E	27.6 km	12.2 km

3.2.2 Schouwenbank

The wave measuring buoy at Schouwenbank (SCHB station) is a directional ("2D") Datawell Waverider buoy. This buoy measures the wave height and directional spectrum using 3-axis accelerometers.

The SCHB station should be expected to have lower heights of wind sea than the Borssele Lidar buoy location in southerly to north-easterly winds due to the more limited fetch distance in those directions. In situations with wind sea from north-east to north-west, and situations dominated by northerly swells the two buoy should be exposed to approximately the same wave heights.

3.2.3 Vlakte van de Raan

The Vlakte van de Raan (VR) station is measuring wind speed and wind direction. Figure 3.2 shows a photo of the wind mast. Wind speed is measured with the KNMI cup-anemometer. Cup diameter is 105 mm and the distance between the centre of the cups to the rotation axis is 100 mm. Wind direction is measured with the KNMI wind vane. Distance between axis and the outer side of the vane is 535 mm. The anemometer and wind vane are located 13.9 m above the mean sea level. The azimuth of the wind vane plugs at the tip of the booms are determined with a camera relative to distant objects at close to the horizon. The instruments are logged with the KNMI wind SIAM. Wind gusts are determined from a running 3 sec mean value.

Calibration of the cup anemometers is done in the wind tunnel of KNMI. Wind vanes are balanced and the direction of the vane is tested. Sensors are replaced after 26 month. The cup anemometer contains a photo-chopper with 32 slits. The accuracy is 0.5 m/s. The treshold velocity is 0.5 m/s. The resolution is 0.1 m/s. The response length is 2.5 m. The wind vane contains a code disk. Accuracy is 3°. Resolution is 1°. [ref. Chapter 5 "Handbook for the Meteorological Observation. Koninklijk Nederlands Meteorologisch Instituut KNMI, De Bilt September 2000.]

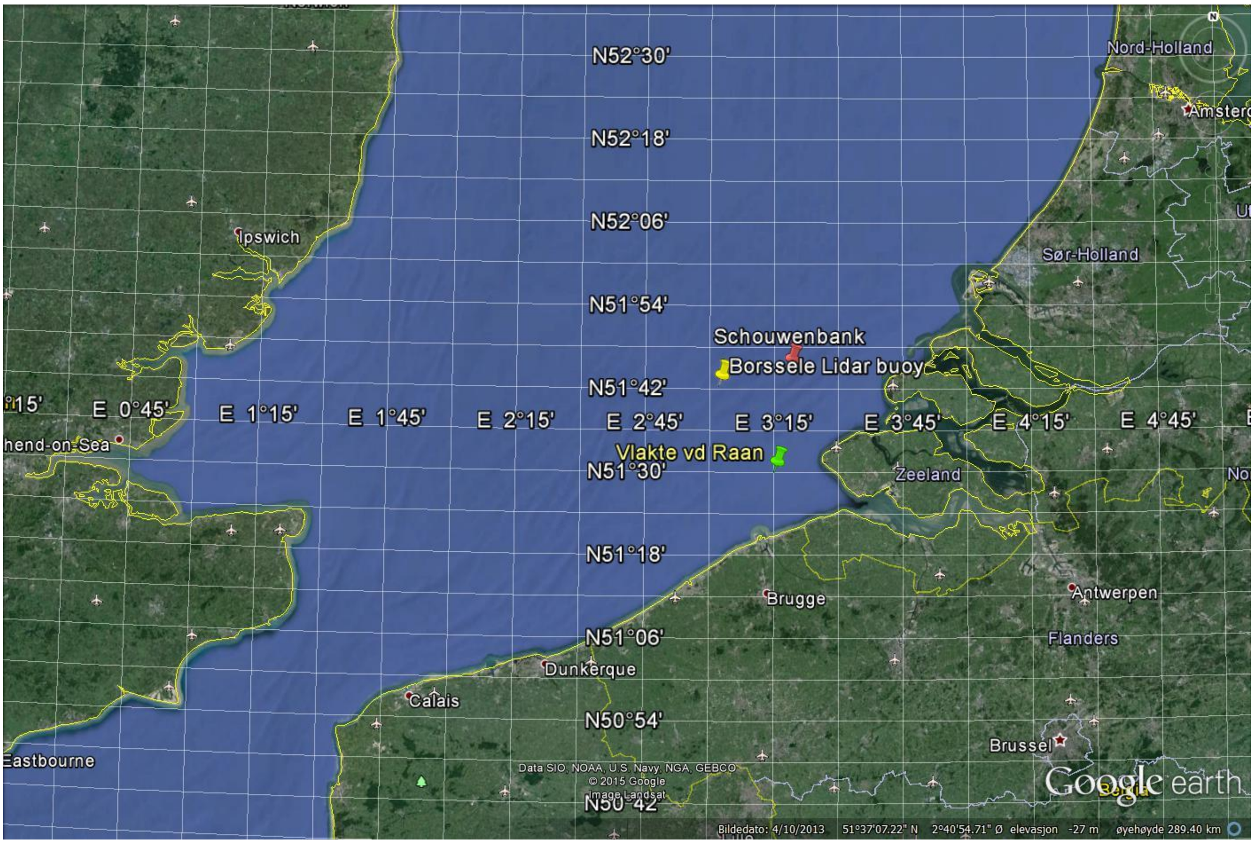

Figure 3.1 Google Earth image with indication of the Lidar buoy position and reference stations.

The VR station is located only 12 km from the coast and much closer to land than the Lidar buoy, and that is expected to have some effect on the winds, both speed and direction, especially for wind with direction from shore; directions from south-southwest to east-northeast in particular. This means that there can be considerable differences in wind speed and direction at any given time, while the long term overall averages are expected to be approximately the same.

Figure 3.2 The wind measuring station at Vlakte van de Raan.

3.3 Evaluation of the collected data

3.3.1 Wave data

The wave data from the Lidar buoy are compared to data from the Waverider at Schouwenbank in time series and scatter plots. The distance of about 20 km between the two locations and the different distance from shore is expected to cause some differences in these shallow waters.

The time series plot in Figure 3.3 and scatter plot in Figure 3.4 compares the significant wave height (Hm0). All peaks in the time series occur at almost exactly the same time, showing good coherence. The average Hm0 values for the periods with simultaneous data at buoy and reference stations are 1.75 m at the Lidar buoy compared to 1.65 m at Schouwenbank. The difference as well as the scatter with R^2 = 0.920 may be attributed to differences in location, depth and distance from the shore line at the two locations.

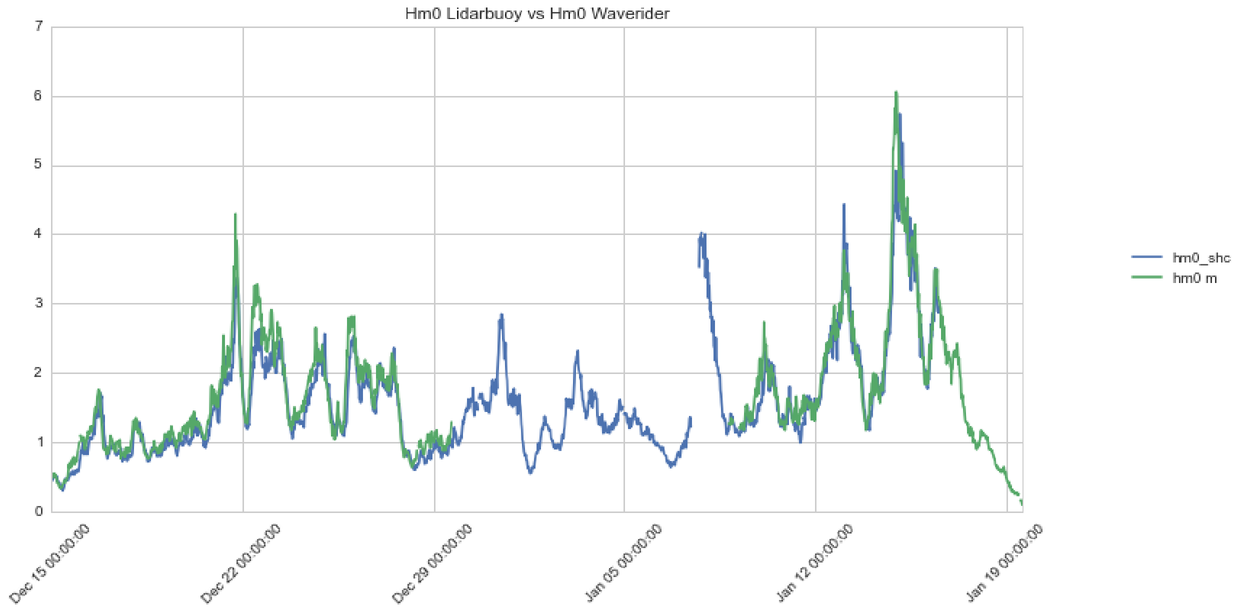

Figure 3.3 Time series plot of significant wave height (Hm0) from the Lidar buoy (green curve) and the Schouwenbank Waverider buoy (blue).

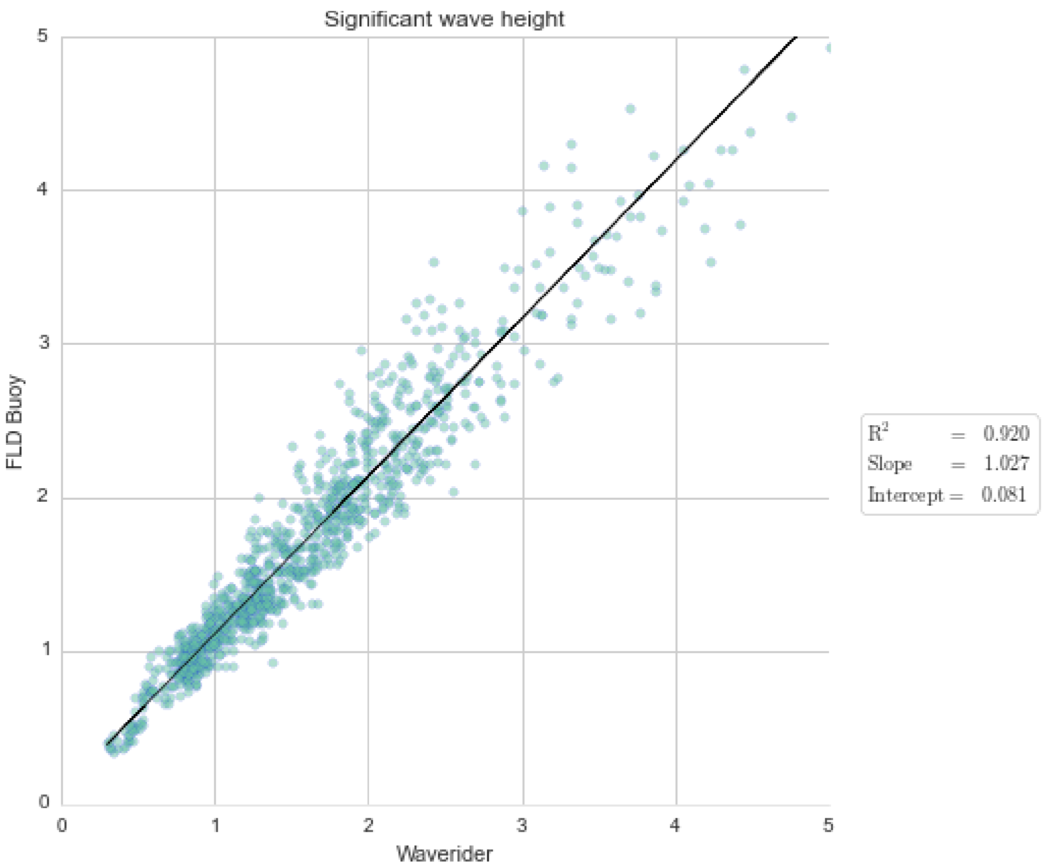

Figure 3.4 Scatter plot comparing Hm0 measured by the Lidar buoy toHm0 from the Schouwenbank Waverider buoy.

The mean wave period (Tm02) from the Lidar buoy is compared to the Waverider Tm02 in the time series plot in Figure 3.5 and the scatter plot in Figure 3.6. The time series plot shows good coherence and the values appear very similar. The scatter plot shows R^2 = 0.895. Some scatter must be expected due to the distance between the stations. The average values of Tm02 are 4.51 s at the Lidar buoy compared to 4.43 s at the Waverider.

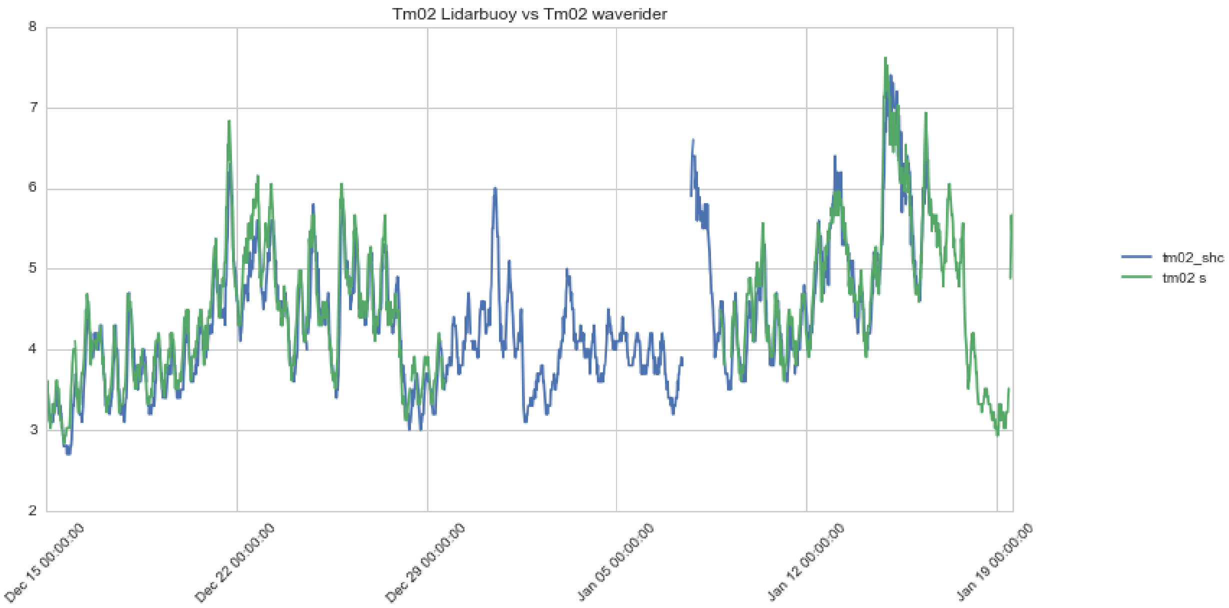

Figure 3.5 Time series plot of mean wave period (Tm02) from the Lidar buoy (green curve) and the Schouwenbank Waverider buoy (blue).

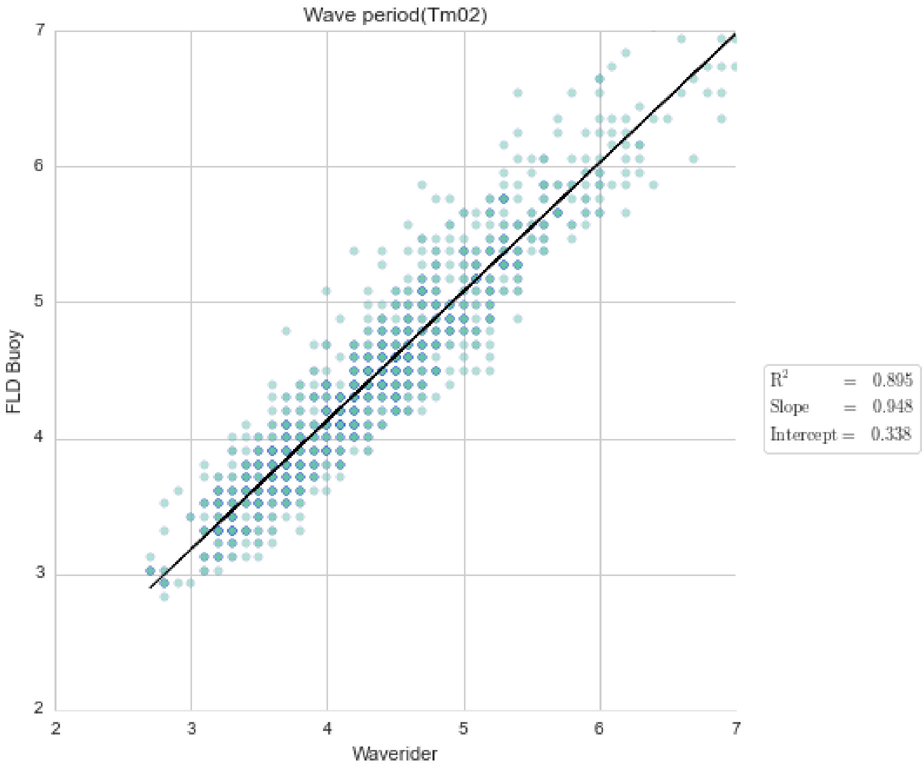

Figure 3.6 Scatter plot comparing Tm02 measured by the Lidar buoy toTm02 from the Schouwenbank Waverider buoy.

3.3.2 Wind data

The Vlakte van de Raan (VR) wind station is located about 28 km away from the Lidar buoy and closer to shore. The VR station is about 12 km from the nearest shore, while the buoy is 33 km from land. The wind speeds measured at anemometer height, 13.9 m above the mean sea level, have been reduced to 10 m above mean sea level by a factor of 0.95. The horizontal Lidar wind speed data from the lowest cell, at 30 m above the sea surface, have been compared to the wind data from VR adjusted from 10 m to 30 m height by a factor of 1.15. The time series plots presented in Figure 3.8 for the period 14 September – 6 October 2015, and in Figure 3.8 for the period 15 December 2015 – 19 January 2016 both show good agreement. The maxima in wind speed at both locations appear at the same time, showing good coherence. In average the data compare well with 30 m average speed of 8.34 m/s at the buoy versus 8.39 m/s at the VR station during the first period, and 12.4 m/s versus 11.4 m/s during the 15-26 December period.

The scatter plots in Figure 3.9 and Figure 3.10 compare the wind speeds when the VR station speed exceed 2 m/s. The correlation is seen clearly, although there is a reasonable degree of scatter due to the distance between the stations and the differences in the way land effects influence the local wind. This gives no reason to suspect that the Lidar did not measure the wind speed correctly.

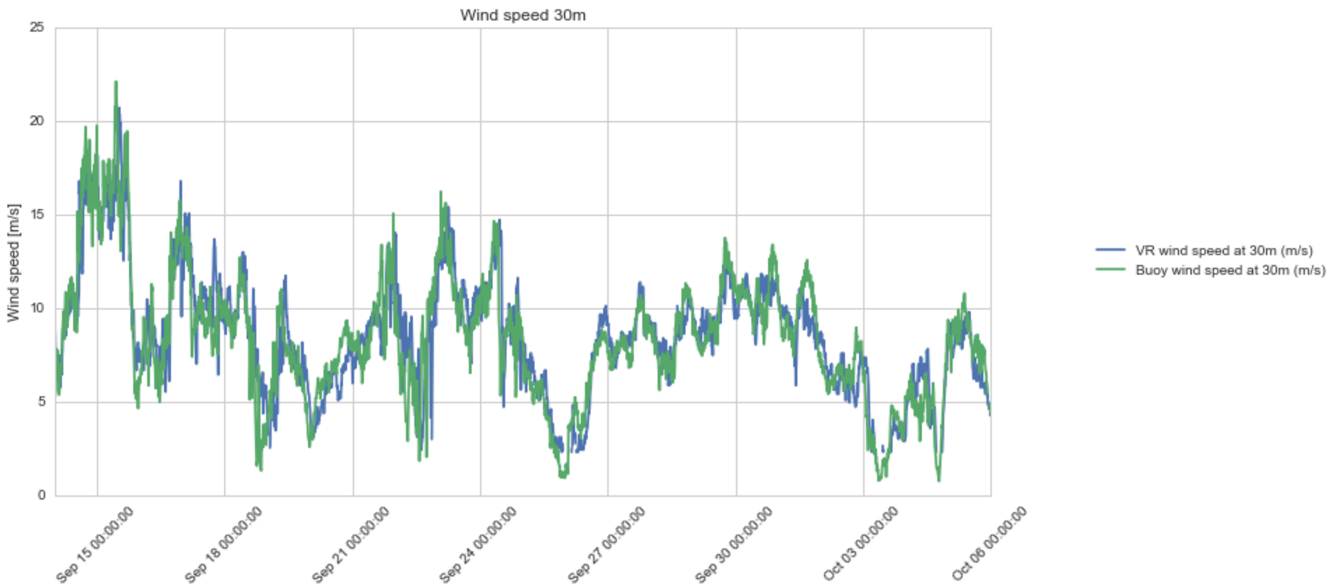

Figure 3.7 Wind speed at 30 m above sea level measured by the Lidar buoy (green curve) compared to wind speed at Vlakte van de Raan adjusted to 30 m (blue) in the period 14 September – 6 October 2015.

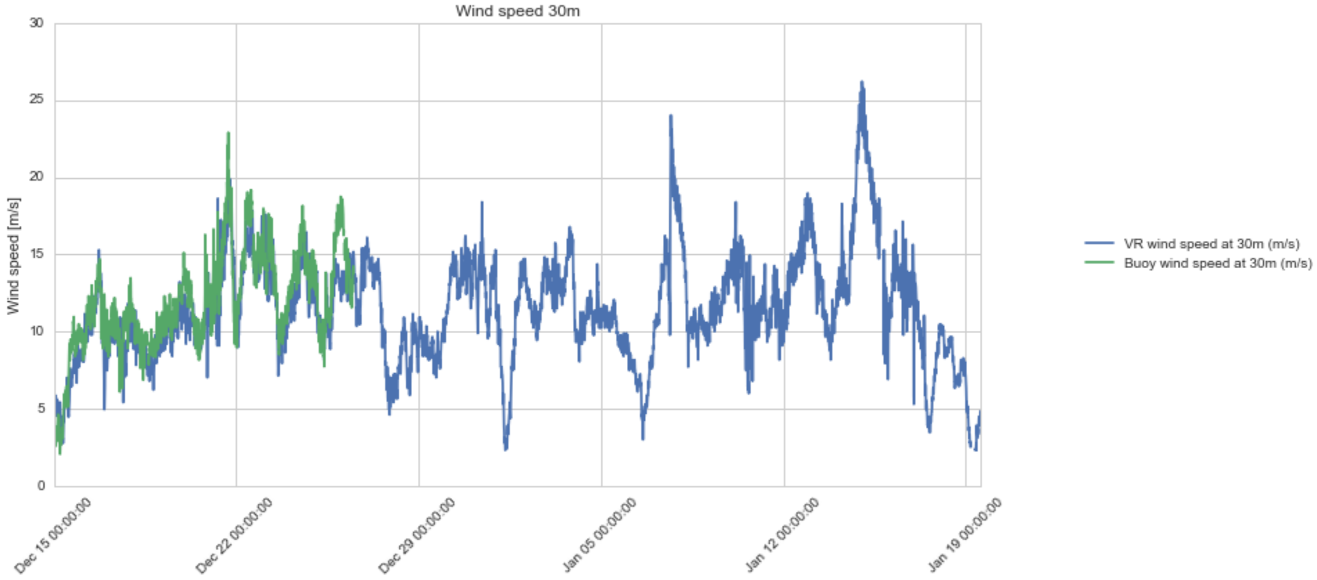

Figure 3.8 Wind speed at 30 m above sea level measured by the Lidar buoy (green curve) compared to wind speed at Vlakte van de Raan adjusted to 30 m (blue) in the period 15 December 2015 – 19 January 2016. (The Lidar data end on 26 December 2015.)

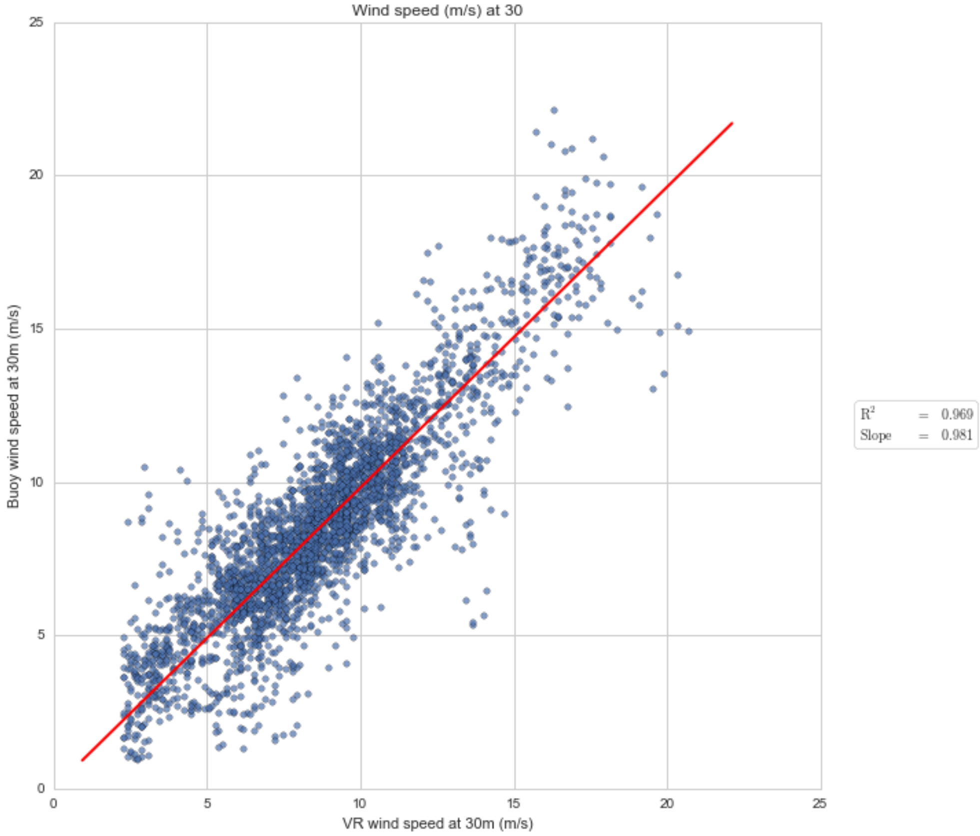

Figure 3.9 Scatter plots comparing the wind speed at 30 m above sea level measured by the Lidar buoy compared to the wind speed at Vlakte van de Raan adjusted to 30 m a.s.l. in the period 14 September – 6 October 2015. (Regression formula: y = Slope * x)

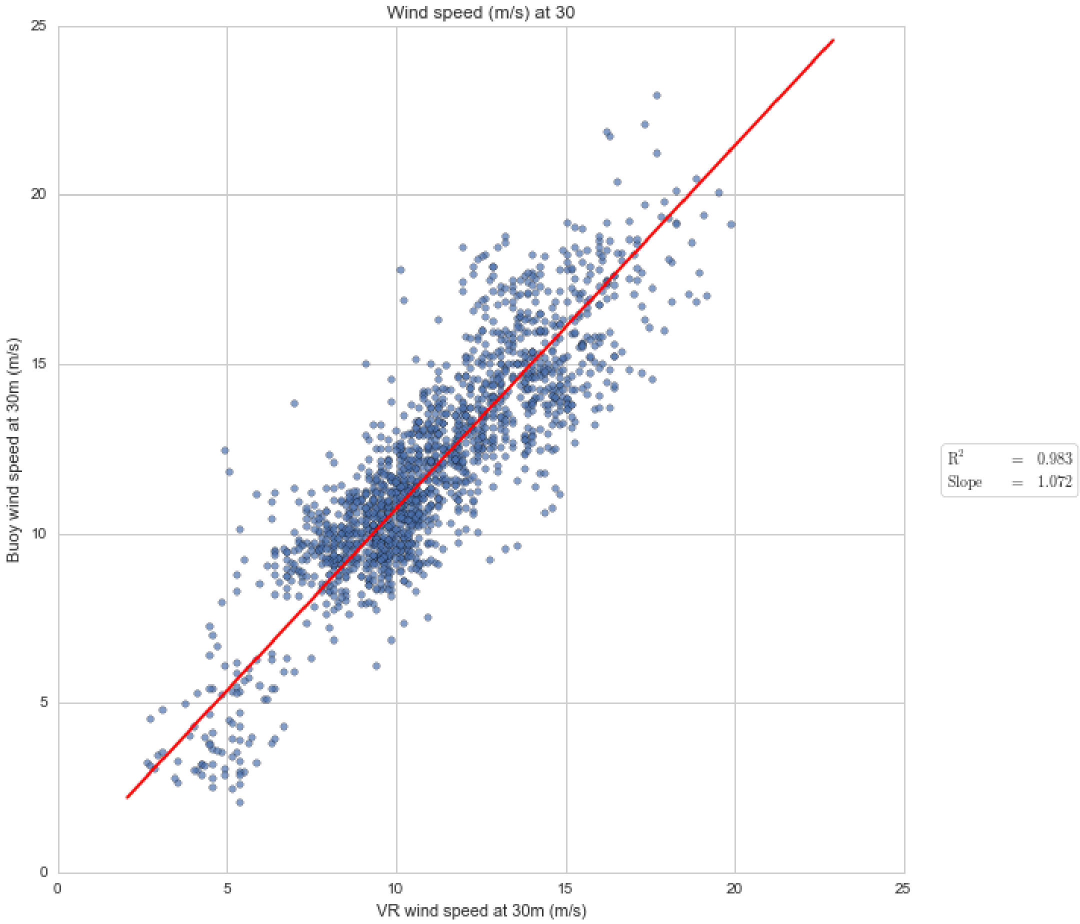

Figure 3.10 Scatter plots comparing the wind speed at 30 m above sea level measured by the Lidar buoy compared to the wind speed at Vlakte van de Raan adjusted to 30 m a.s.l. in the period 15 – 26 December 2015. (Regression formula: y = Slope * x)

The time series of wind direction are compared in Figure 3.11 and Figure 3.12, which also show the wind speed at Vlakte van de Raan. Samples with speed less than 2 m/s are excluded. Again we see that there is a general agreement between the measurements, and this is seen also in the scatter plot in Figure 3.13. The offset is calculated as the average of the difference between the wind directions. The offset is quite small, about 5° in the September/October period, and 8°in the mid December period. It was expected that the wind directions would differ at any given time due to the distance between the locations, and this may well explain the scatter seen in the plots.

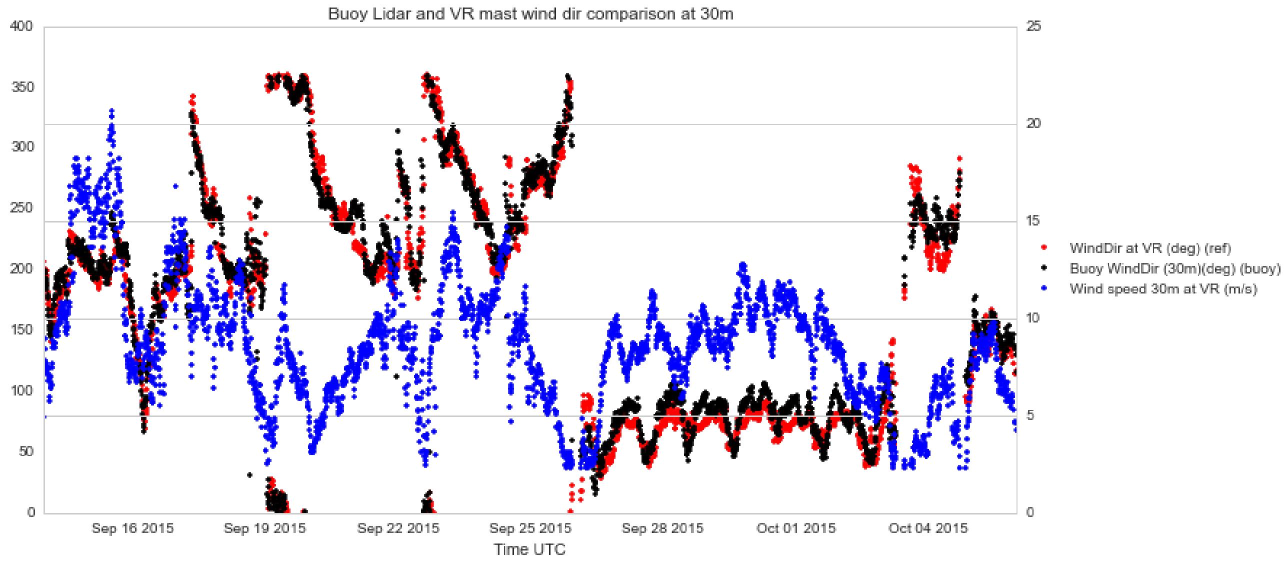

Figure 3.11 Wind direction at 30 m above sea level measured by the Lidar buoy (black dots) compared to wind direction at Vlakte van de Raan (red). The blue dots show the VR station 10m wind speeds in the period 14 September – 6 October 2015. (Samples with VR wind speed less than 2 m/s are excluded.)

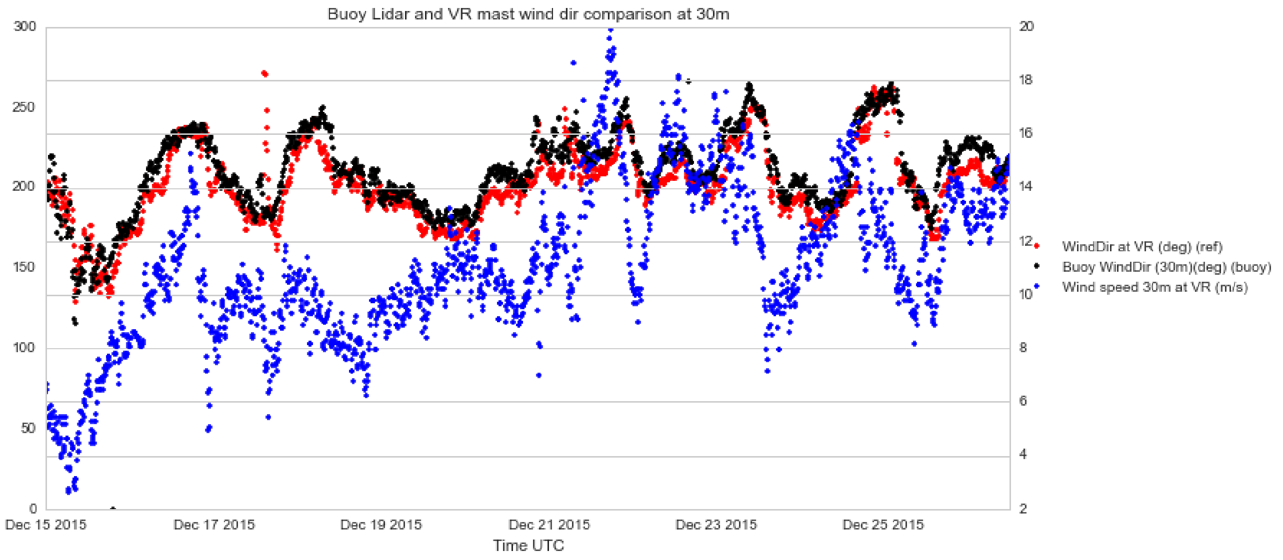

Figure 3.12 Wind direction at 30 m above sea level measured by the Lidar buoy (black dots) compared to wind direction at Vlakte van de Raan (red). The blue dots show the VR station 10m wind speeds in the period 15 – 26 December 2015. (Samples with VR wind speed less than 2 m/s are excluded.)

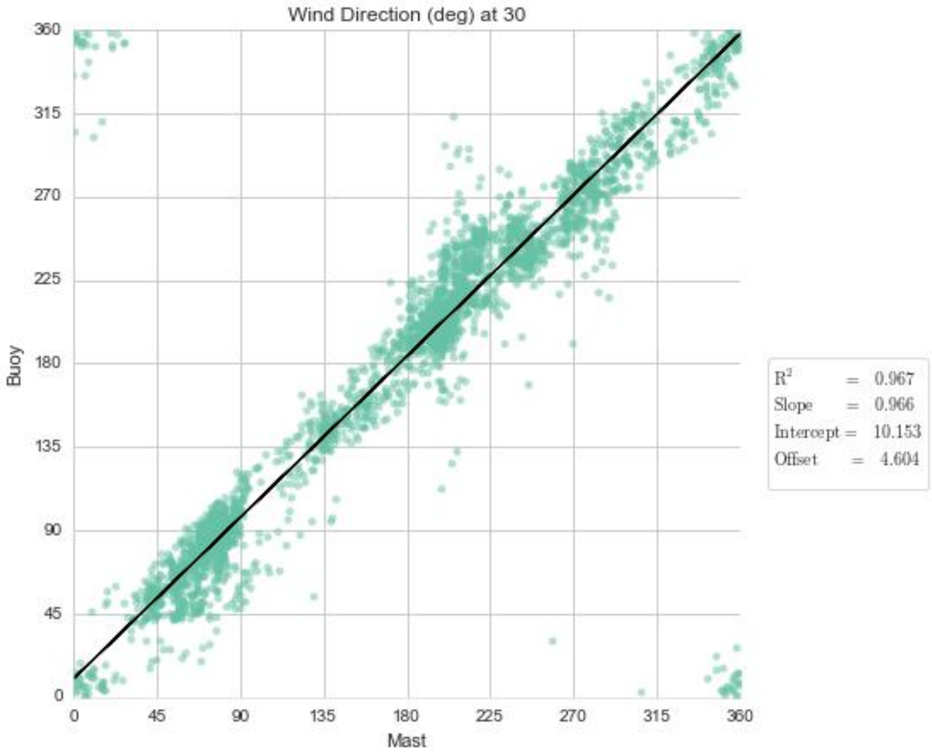

Figure 3.13 Wind direction at 30 m above sea level measured by the Lidar buoy compared to wind direction at Vlakte van de Raan in the period 14 September – 6 October 2015. (Samples with VR wind speed less than 2 m/s are excluded.) ("Offset" is the average difference of directions.)

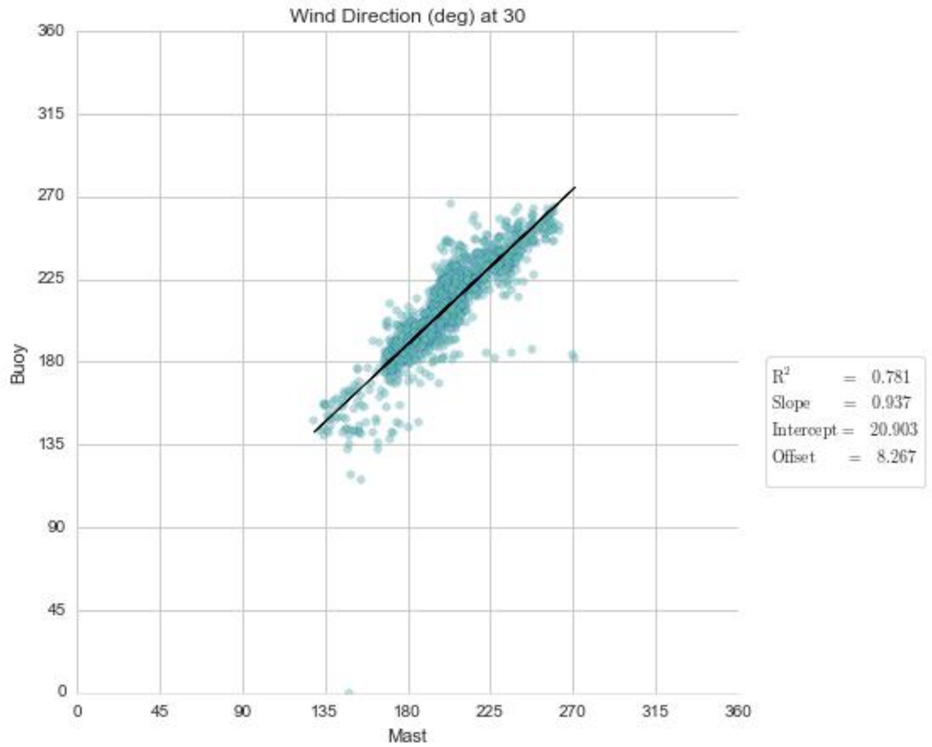

Figure 3.14 Wind direction at 30 m above sea level measured by the Lidar buoy compared to wind direction at Vlakte van de Raan in the period 15 – 26 December 2015. (Samples with VR wind speed less than 2 m/s are excluded.) ("Offset" is the average difference of directions.)

3.4 Conclusions

Shorter pieces of data records that each do not make up a whole month were collected during 14 September – 6 October 2015 and 15 December 2015 – 19 January 2015 have been validated. Wind profiles and wave data were missing during parts of this period, because various systems including the LiDAR failed during part of the time. Thus the basis for the validation is not as solid as it would be with full months of data.

The comparisons to the reference station data presented above still indicate that the wind and wave data collected by the buoy are of good quality.

Appendix A

Buoy deployment record

BUOY DEPLOYMENT SHEET

Project Name:	**WS Lidar buoy to Borssele, Nederland**		
Project no:	C75339	Latitude:	51°42.41388'N (x=502392)
Station name:	Borssele	Longitude:	3°2.07708'E (y=5728440)
WS buoy no:	WS149	Approx. depth:	30m
PFF numbers:	33900 – 33904, 33909	Buoy marking:	

Buoy module/sensor	**Serial number/ID**
Wavesense 3 data logger	276
XSense	077003A0
PMU	333
Vaisala PTB330	J4010005
Compass	1035375
Iridium modem	IMEI: 300125010219460 SIM: 8988169514001092357
UHF service radio Adeunis ARF7940BA	B134300547
L3 AIS	S.n: 000990022 MMSI. 992572057
Gill wind sensor	13220063
Vaisala air HMP155 temperature/humidity	J1130019
Buoytracker	736565
LIDAR ZephIR300	428
Flashlight	
Nortek Current meter	AQP7355
Fuel Cell 1	efoy : 302303-1407-32524 stack: 151010084—00501
Fuel Cell 2	efoy : 302302-1324-30871 stack: 151010084-
Fuel Cell 3	efoy : 302303-1407-32516 stack: 151010084—00491
Fuel Cell 4	efoy : 302303-1407-32515 stack: 151010084--00492
Seaguard w/sensor 5217A	1620 222

CONFIGURATION

Data transmission interval:	Continuous mode. '
Listening window	NA

POWER OPTIONS

Lead batteries type	**4 x 62Ah**
Lithium batteries:	**6 x 272Ah**
Fuel cells	**4 fuel cells with 10 methanol cartridges 28 litres**

	each.			
DEPLOYMENT HISTORY				
	YEAR	**MONTH**	**DATE**	**Local time**
First measurement	2015	06	11	16:55
First measurement in position	2015	06	11	18:14
Out of measuring position	2015	10	06	11:30
Last measurement				
Comments: **WLR deployment position:** **51° 42.4362N, 3° 02.1030E, Depth: 30m** **Time reference: CET (DST) (UTC + 2 hours)**				
Deployment vessel: MPR3	Recovery vessel: Multrasalvor 3			
Deployed by: EME & OKH	Recovered by:			

BUOY DEPLOYMENT SHEET

Project Name:	**WS Lidar buoy to Borssele, Nederland**		
Project no:	C75339	Latitude:	51°42.41388'N (x=502392)
Station name:	Borssele	Longitude:	3°2.07708'E (y=5728440)
WS buoy no:	WS149	Approx. depth:	30m
PFF numbers:	33910 – 33914, 33919	Buoy marking:	

Buoy module/sensor	**Serial number/ID**
Wavesense 3 data logger	276
XSense	077003A0
PMU	333
Vaisala PTB330	J4010005
Compass	1035375
Iridium modem	IMEI: 300125010219460 SIM: 8988169514001092357
UHF service radio Adeunis ARF7940BA	B134300547
L3 AIS	S.n: 000990022 MMSI. 992572057
Gill wind sensor	13220063
Vaisala air HMP155 temperature/humidity	J1130019
Buoytracker	736565
ZephIR 300S Lidar	428
Flashlight	
Nortek Current meter	AQP7355
Seaguard w/sensor 5217A	1620 222

CONFIGURATION

Data transmission interval:	Continuous mode. ‘
Listening window	NA

POWER OPTIONS

Lead batteries type	**4 x 62Ah**
Lithium batteries:	**6 x 272Ah**
Fuel cells	**4 fuel cells with 10 methanol cartridges 28 litres each.**

DEPLOYMENT HISTORY

	YEAR	**MONTH**	**DATE**	**Time (UTC)**
First measurement	2015	11	12	14:00
First measurement in position	2015	11	12	14:20
Out of measuring position	2016	01	19	11:15
Last measurement				

Comments:
WLR deployment position:
51° 42.4362N, 3° 02.1030E, Depth: 30m
Time reference: UTC

Deployment vessel: Multrasalvor 3	Recovery vessel: Multrasalvor 3
Deployed by: EME & OKH	Recovered by: