

# TECHNICAL NOTE

## AQ500 SODAR

**CLIENT: AQSystems**



**JULY 2011**



## TECHNICAL NOTE: AQ500 SODAR

### LIST OF DOCUMENTATION AND TIMETABLE OF REVISIONS AND CHECKS

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42711	00	TECHNICAL NOTE: AQ500 SODAR		14/07/2011

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Barlovento Recursos Naturales, S.L. will provide this Technical Note to its clients who ask questions about the AQ500 SODAR device.

This technical note has been prepared from data collected in the period detailed in the report. Therefore, the results presented here are subject to change in subsequent revisions with additional information.

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## **1.- INTRODUCTION**

The AQ500 is a remote sensing device based on SODAR technology developed by AQSystem.

Barlovento has had the opportunity to test for two and a half months the AQ500 SODAR device.

Throughout the test period Barlovento has carried out several tests with the AQ500, located in a non-simple terrain area. The AQ500 measurements have been compared against standard met-mast measurements (installed according to IEC-61400-12-1 [1]) and measurements from other remote sensor devices located.

There are some references [2], [3] and [4] that have shown a good agreement between the AQ500 measurements and the standard met-mast measurements (cup anemometers), therefore this technical note only assess the behavior of the AQ500 measurements itself.

The purpose of this Technical Note is therefore to evaluate the quality of the AQ500 measurements and assessing their suitability for wind resource assessment.

In the present Technical Note Barlovento shows the AQ500 behaviour itself without comparing the AQ500 measurements with others measurements systems (cup anemometers, wind vanes and other remote sensor devices).

The following parameters have been assessed and showed in the Technical Note:

- Raw data availability
- Filtered data availability
- Rejected data.
- Data availability vs. Wind speed.
- Data availability vs. Temperature.
- Data availability vs. Rainy events.

However in order to use the SODAR measurements for wind resource assessment purposes Barlovento considers that the SODAR systems measurements has to be evaluated by a comparison to cup anemometer and vane measurements from a met-mast installed as close as possible to the SODAR device (avoiding fixed echoes) according to MEASNET Guideline [5].

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## 2.- DESCRIPTION OF THE AREA

The AQ500 SODAR device is located at the South East part of La Rioja region, in Spain. Next figure shows the AQ500 location.



Figure 1. Location of AQ500 area.

### 2.1.- Orography

The area where the AQ500 is installed is a slightly complex terrain. There are some small hills around the SODAR area.

### 2.2.- Roughness

There are small vegetation present in the surrounding area (bushes, ..) and no high vegetation like trees is present. The roughness of the AQ500 area is quite homogeneous.

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### 2.3.- Photographs

Following pictures show the AQ500 surrounding area.



**Photograph 1. AQ500 SODAR device.**




**Photograph 2. AQ500 SODAR surroundings.**

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**Photograph 3. AQ500 SODAR surroundings.**

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### 3.- MEASUREMENT CAMPAIGN

The main features of the measurement campaign carried out with the AQ500 SODAR device are shown below.

SODAR	Measurement Levels (m)	Measurement Period
AQ500	20 m – 150 m Every 5 meters	24-01-2011 – 17-04-2011

**Table 1. Measurement campaign.**

#### 3.1.- *Measurement Period*

The AQ500 SODAR was installed on January 24, 2011. The AQ500 has been in operation until April 17, 2011. Therefore there is two and a half months of measurements available.


#### 3.2.- *AQ500 measurement parameters*

The following parameters have been measured by the AQ500 throughout the measurement period:

Parameter	Measurement Levels (m)
Date	-
Time	-
Wind Speed	20 m – 150 m Every 5 meters
Std. Wind Speed	20 m – 150 m Every 5 meters
Vertical Wind Speed	20 m – 150 m Every 5 meters
Std. Vertical Wind Speed	20 m – 150 m Every 5 meters
Wind Direction	20 m – 150 m Every 5 meters
Battery Level	-
Temperature	2 m
Turbulence	20 m – 150 m Every 5 meters
Signal/Noise	20 m – 150 m Every 5 meters
Humidity	2 m

**Table 2. AQ500 measurement parameters.**

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### ***3.3.- Data checking and filtering***

Data measured by AQ500 throughout the measurement campaign has been checked and filtered by Barlovento according to MEASNET guideline [5] and AQ500C Wind Finder Manual [6].

Filtering applied consist in the elimination by the user of wrong data, identified according the criteria defined in [5], as for example valid data at all levels below a selected level.

## **4.- ANALISYS OF AQ500 MEASUREMENTS**

In the present Technical Note Barlovento shows the AQ500 behaviour itself without comparing the AQ500 measurements with others measurements systems (cup anemometers, wind vanes and other remote sensor devices).

However in order to use the SODAR measurements for wind resource assessment purposes Barlovento considers that the SODAR systems measurements has to be evaluated by a comparison to cup anemometer and vane measurements from a met-mast installed as close as possible to the SODAR device (avoiding fixed echoes) according to MEASNET Guideline [5].

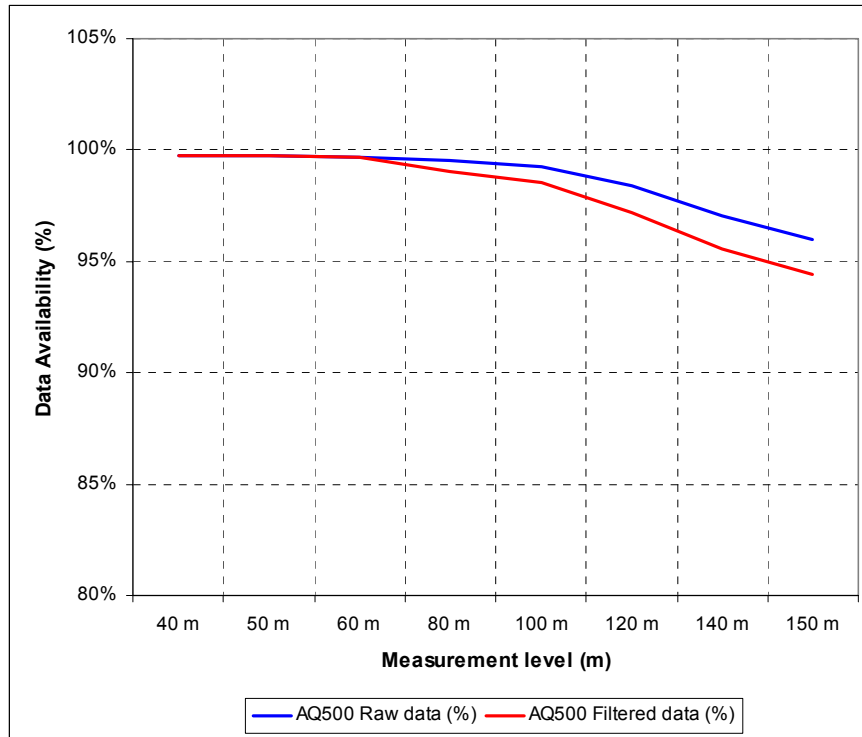
### **4.1.- Data Availability**

Following table and figures show the availability of raw data, filtered data and the total rejected data throughout AQ500 measurement period.

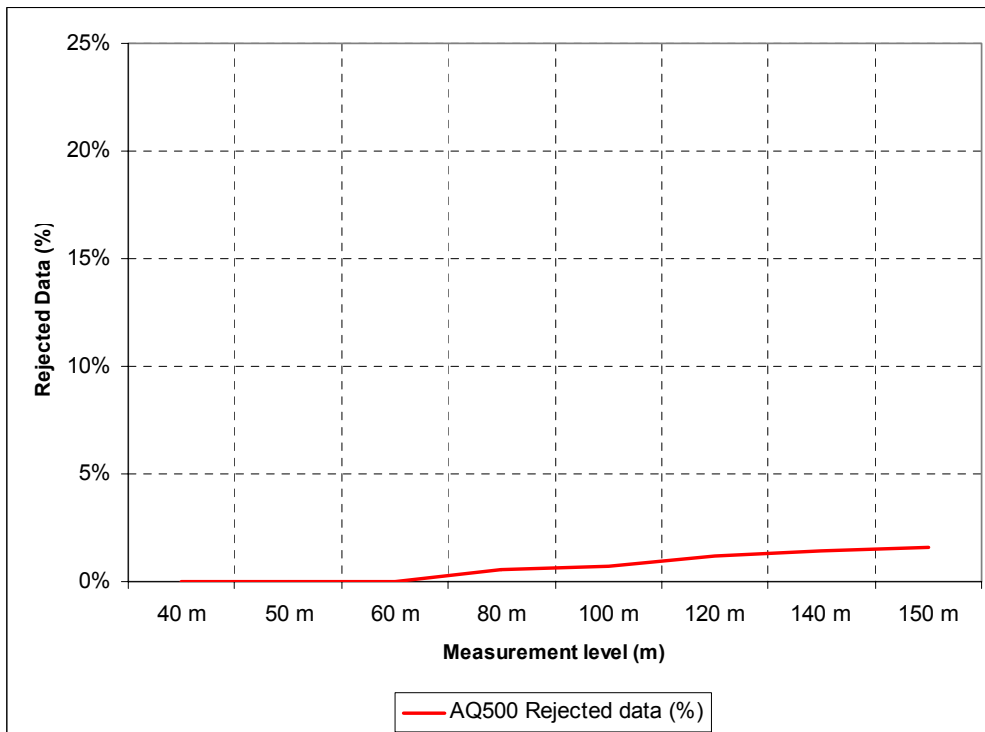
As it can be seen the total rejected data of AQ500 SODAR is below the 2% for all measurements levels.

Level (m)	Total data	Raw data	% Raw data	Filtered data	% Filtered data	Rejected data	% Rejected data
40 m	11997	11965	99.7%	11965	99.7%	0	0.0%
50 m	11997	11965	99.7%	11965	99.7%	0	0.0%
60 m	11997	11956	99.7%	11954	99.6%	2	0.0%
80 m	11997	11943	99.5%	11878	99.0%	65	0.5%
100 m	11997	11904	99.2%	11823	98.5%	81	0.7%
120 m	11997	11804	98.4%	11661	97.2%	143	1.2%
140 m	11997	11639	97.0%	11463	95.5%	176	1.5%
150 m	11997	11518	96.0%	11327	94.4%	191	1.6%


**Table 3. AQ500 Data Availability.**



**Figure 2. AQ500 Raw data and Filtered data availability.**



**Figure 3. AQ500 rejected data.**

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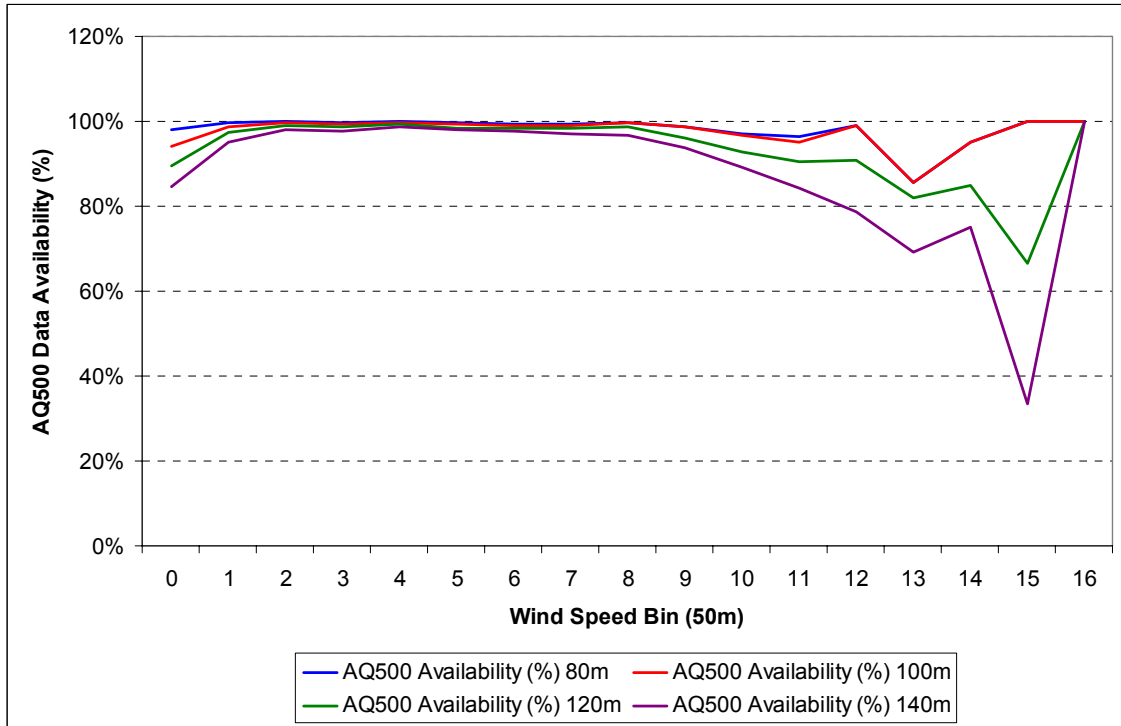
#### 4.2.- Data availability per Wind Speed Bin

Following table and figure show the AQ500 data availability (filtered data) per wind speed bin (50 m level) throughout the measurement period.

As it can be seen the AQ500 availability in the wind speed range (1 – 10 m/s) is quite good for every measurerent level.

BIN WS (m/s) 50m	Total data Level 50m	Total Filtered data Level 80m	% Total Filtered data Level 80m	Total Filtered data Level 100m	% Total Filtered data Level 100m	Total Filtered data Level 120m	% Total Filtered data Level 120m	Total Filtered data Level 140m	% Total Filtered data Level 140m
0 – 1	521	511	98%	491	94%	467	90%	441	85%
1 – 2	1130	1125	100%	1114	99%	1099	97%	1076	95%
2 – 3	1698	1697	100%	1692	100%	1684	99%	1663	98%
3 – 4	1717	1713	100%	1708	99%	1695	99%	1680	98%
4 – 5	1156	1155	100%	1153	100%	1147	99%	1141	99%
5 – 6	1156	1151	100%	1147	99%	1138	98%	1134	98%
6 – 7	1144	1136	99%	1134	99%	1125	98%	1118	98%
7 – 8	984	976	99%	975	99%	967	98%	956	97%
8 – 9	862	859	100%	858	100%	851	99%	835	97%
9 – 10	693	684	99%	684	99%	665	96%	650	94%
10 – 11	497	482	97%	481	97%	461	93%	443	89%
11 – 12	230	222	97%	219	95%	208	90%	194	84%
12 – 13	98	97	99%	97	99%	89	91%	77	79%
13 – 14	55	47	85%	47	85%	45	82%	38	69%
14 – 15	20	19	95%	19	95%	17	85%	15	75%
15 – 16	3	3	100%	3	100%	2	67%	1	33%
16 – 17	1	1	100%	1	100%	1	100%	1	100%
17 – 18	-	-	-	-	-	-	-	-	-

**Table 4. AQ500 Filtered Data Availability per Wind speed Bin.**



**Figure 4. AQ500 Filtered Data Availability per Wind Speed Bin.**

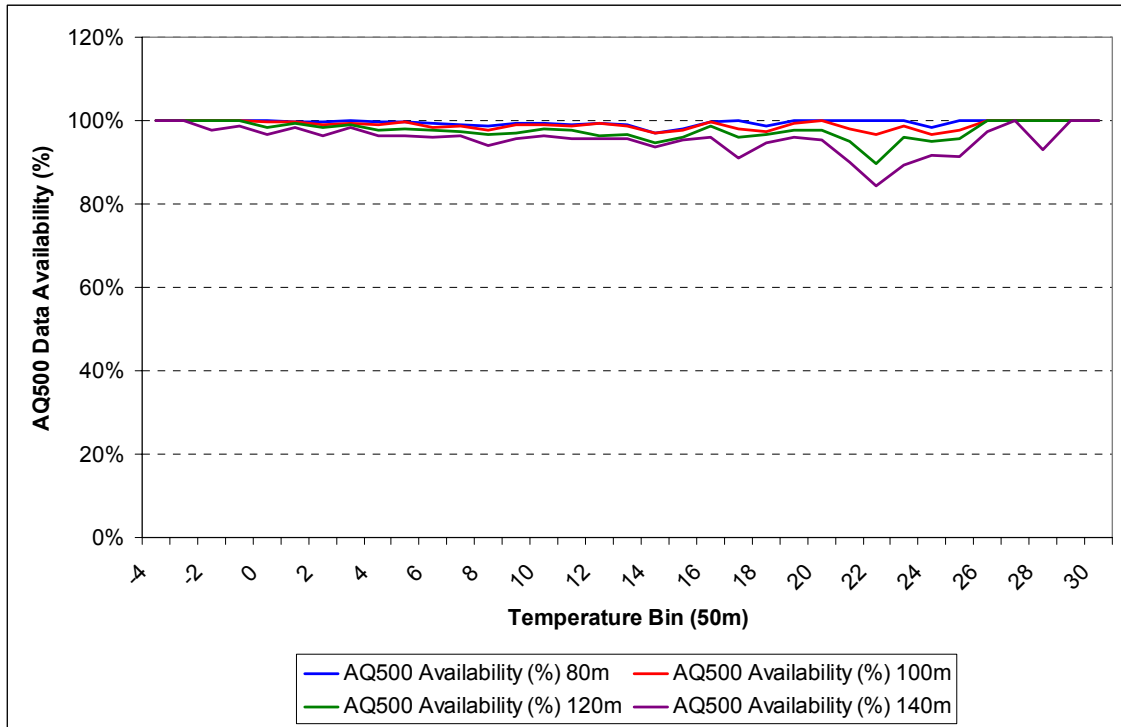
### 4.3.- Data availability per Temperature Bin

Following table and figure show the AQ500 data availability (filtered data) per Temperature Bin throughout the measurement period.


As it can be seen the AQ500 availability in the Temperature range (-4°C – 30°C) is quite good for every measurerent level.

BIN T <sup>a</sup> (°C)	Total data T <sup>a</sup> (°C)	Total Filtered data Level 80m	% Total Filtered data Level 80m	% Total Filtered data Level 100m	Total Filtered data Level 100m	% Total Filtered data Level 120m	Total Filtered data Level 120m	% Total Filtered data Level 140m	% Total Filtered data Level 140m
-4 – -3	2	2	100%	2	100%	2	100%	2	100%
-3 – -2	50	50	100%	50	100%	50	100%	50	100%
-2 – -1	86	86	100%	86	100%	86	100%	84	98%
-1 – 0	78	78	100%	78	100%	78	100%	77	99%
0 – 1	245	245	100%	244	100%	241	98%	237	97%
1 – 2	382	381	100%	381	100%	380	99%	375	98%
2 – 3	575	574	100%	569	99%	565	98%	553	96%
3 – 4	795	794	100%	791	99%	788	99%	782	98%
4 – 5	770	768	100%	763	99%	752	98%	741	96%
5 – 6	776	773	100%	773	100%	760	98%	747	96%
6 – 7	813	808	99%	800	98%	793	98%	780	96%
7 – 8	1119	1107	99%	1105	99%	1091	97%	1078	96%
8 – 9	821	810	99%	801	98%	793	97%	773	94%
9 – 10	1075	1067	99%	1065	99%	1044	97%	1028	96%
10 – 11	733	728	99%	726	99%	719	98%	707	96%
11 – 12	677	671	99%	669	99%	661	98%	647	96%
12 – 13	537	534	99%	533	99%	518	96%	513	96%
13 – 14	448	443	99%	442	99%	433	97%	428	96%
14 – 15	447	433	97%	433	97%	423	95%	419	94%
15 – 16	309	303	98%	302	98%	297	96%	295	95%
16 – 17	205	204	100%	204	100%	202	99%	197	96%
17 – 18	147	147	100%	144	98%	141	96%	134	91%
18 – 19	154	152	99%	150	97%	149	97%	146	95%
19 – 20	174	174	100%	173	99%	170	98%	167	96%
20 – 21	130	130	100%	130	100%	127	98%	124	95%
21 – 22	100	100	100%	98	98%	95	95%	90	90%
22 - 23	58	58	100%	56	97%	52	90%	49	84%
23 – 24	75	75	100%	74	99%	72	96%	67	89%
24 – 25	59	58	98%	57	97%	56	95%	54	92%
25 – 26	46	46	100%	45	98%	44	96%	42	91%
26 – 27	39	39	100%	39	100%	39	100%	38	97%
27 – 28	16	16	100%	16	100%	16	100%	16	100%
28 – 29	14	14	100%	14	100%	14	100%	13	93%
29 - 30	9	9	100%	9	100%	9	100%	9	100%
30 - 31	1	1	100%	1	100%	1	100%	1	100%

**Table 5. AQ500 Filtered Data Availability per Temperature Bin.**



**Figure 5. AQ500 Filtered Data Availability per Temperature Bin.**

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#### **4.4.- Data availability during rainy events**

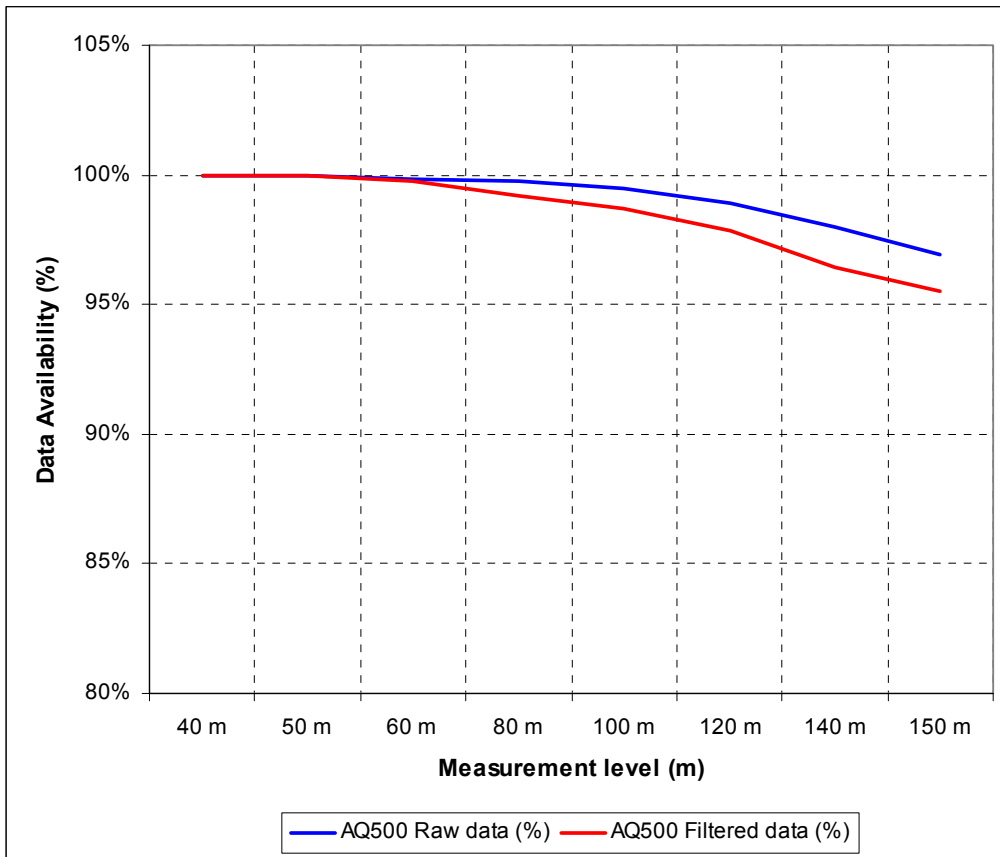
Throughout the AQ500 measurement period have been several rainy events. The rainy events have been identified from precipitation sensors located at nearby meteorological mast and high relative humidity (HR) values (over 65%) in the AQ500 HR sensor.

Following table and figure shows the AQ500 data availability (filtered data) during rainy events.


As it can be seen the AQ500 availability during rainy events is very similar to the availability of the entire measurement period. The AQ500 measurement's availability is not much affected by rain.

Level (m)	Total data (Rainy Events)	Filtered data (Rainy Events)	% Filtered data (Rainy Events)
40 m	3677	3677	100.0%
50 m	3677	3677	100.0%
60 m	3671	3669	99.8%
80 m	3667	3648	99.2%
100 m	3658	3629	98.7%
120 m	3637	3597	97.8%
140 m	3602	3545	96.4%
150 m	3564	3511	95.5%

**Table 6. AQ500 Data Availability during rainy enents.**



**Figure 6. AQ500 Data Availability during rainy events.**

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## 5.- CONCLUSIONS

The purpose of this Technical Note is therefore to evaluate the quality of the AQ500 measurements and assessing their suitability for wind resource assessment.

There are some references [2], [3] and [4] that have shown a good agreement between the AQ500 measurements and the standard met-mast measurements (cup anemometers), therefore this technical note only assess the behavior of the AQ500 measurements itself.

In the present Technical Note Barlovento shows the AQ500 behaviour itself without comparing the AQ500 measurements with other measurements systems (cup anemometers, wind vanes and other remote sensing devices).


As it can be seen in tables and figures above the AQ500 SODAR device is considered as suitable tool for the wind resource assessment since:

- The total rejected data of AQ500 SODAR is below the 2% for all measurements levels under 120 meters throughout the measurement period.
- The filtered data availability is quite high for all meteorological conditions up to 120 meters level throughout the measurement period.
- The AQ500 availability in the wind speed range (1 – 10 m/s) is quite good for every measurement level throughout the measurement period.
- The AQ500 availability in the Temperature range (-4°C – 30°C) is quite good for every measurement level throughout the measurement period. The availability for lower temperatures is high. The availability has shown a decrease for temperatures above 20 °C at levels higher than 120 meters.
- The AQ500 measurements are not much affected by rain. The AQ500 availability during rainy events is very similar to the availability of the entire measurement period.

As a general conclusion, the filtered data availability during the measurement period has been high for all the meteorological conditions analysed, up to 120 meters. The availability decreases in some circumstances at levels higher than 120 meters.

In order to use the SODAR measurements for wind resource assessment purposes Barlovento recommends to follow the MEASNET Guideline [5].

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## **6.- REFERENCES**

- [1] IEC: IEC61400-12-1 Wind turbines - Part 12-1: Power performance measurements of electricity producing wind turbines, 1st ed., 2005.
- [2] "Comparative measurements between an AQ500 Wind Finder SODAR and Meteo Measurements at the EWTW, The Netherlands", Ref. ECN-X—10-094, by Hans Verhoef, ArnoVan der Werff, Henk Oostrum, ECN, July 2010.
- [3] "Myres Hill – Analysis of AQ500 SODAR System", Ref. AQSMH0001\_211209, By Andy Oldroyd, Oldbaum Servides Ltd. UK, December 2009.
- [4] "Technical Note: GL Garrard Hassan position statement on the AQSystem AQ500 device". Ref. WNDGP074a by Detlef Kindler, Dariush Faghani, Andrew Tindal, GL Garrad Hassan, January 2011.
- [5] "MEASNET Procedure: Evaluation of Site Specific Wind Conditions. Version 1, November 2009. MEASNET.
- [6] "AQ500C WIND FINDER MANUAL", AQSystems doc. no. MAN100602.
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