Wind Data Analysis for NIMRD's Oceanographic Measurement Point "Estacada Mamaia" *(Teodor-Mihai Cristescu, Gabriel Ganea, Adrian Niculescu, Luminița Buga, Marius Nedelcu, Dan Diaconeasa, Răzvan Mateescu, Dragoș Niculescu)*	**"Cercetări Marine" Issue no. 46** **Pages 19-30**	**2016**

WIND DATA ANALYSIS FOR NIMRD'S OCEANOGRAPHIC MEASUREMENT POINT "ESTACADA MAMAIA"

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ABSTRACT

The authors try to establish the utility and possible use of the wind data from a Gill sensor at the recent installed oceanographic measurement point as well as necessary data processing. The wind speed is analyzed from large datasets (over 26.2 millions of wind vector values for the first year of functioning) trying to estimate the real phenomenon in nature using appropriate mathematical analysis. Synthetic statistical parameters as well as comparisons were done.

A deep analysis was applied to important partial sets: distribution type study and harmonic analyze.

There is also discussed the type of the data (to be considered onshore or offshore). It makes possible to enhance knowledge on Black Sea shelf specific meteorological conditions.

The results are intended as an initial background support for scientists or technicians dealing with Mamaia bay wind data.

Key-words: *Black Sea, wind, Gill anemometer, data processing, errors*

INTRODUCTION

The Gill sensor [1] (type Wind Sonic 1405-PK-021, Fig.1) installed one year ago at sea, included in the oceanographic measurement point named "Estacada Mamaia" (Fig. 2), was a new and amazing device. At a height of 7.8 m from the sea surface, offshore 400 m (where water depth is 4 m) the system was obtained through senior scientist Viorel Malciu's diligences, who supported also the installation.

Fig. 1 GILL anemometer

Fig. 2. The placement of the device

MATERIAL AND METHODS

The provided data are wireless transmitted and registered (at NIMRD building) into a database (no human intervention if everything works; otherwise maintenance should be considered or back-up)

The complete set of data comprises 26,767,080 vector values (speed and direction), meaning 84.8 % from all the time of a year (July 17th, 2014 - July 17th, 2015). The gaps were produced by different technical problems (mainly power downs). All data, stored in a database at IT&GIS department were extracted as .csv files (including direction, speed, date and time).

Data processing was based on: ad hoc or older created FORTRAN programs under Force 2.0 support, Microsoft Excel and AddIn and so on.

It must be specified that this paper is a preliminary synthesis.

RESULTS AND DISCUSSIONS

Most presentations of data about wind are based on hourly or daily values, so there were generated result files containing daily or hourly averages, standard deviations, skewness and kurtosis (normal statistics), as well as maximum and minimum values for speed, -u and -v components (- to maintain the meteorological direction) and computed direction (from -u,-v averages to use real vector averaging). It must be noted that wind speed values were considered the vector module at every moment while mean directions were computed from mean u and v values.

Mostly, authors agree that wind distribution is not normal but also there is no agreement on the best fitted distribution[2], [3], [4], so statistical values are just informative. The data synthesis for the whole set is displayed the standard style (Fig. 3 and Fig. 4).

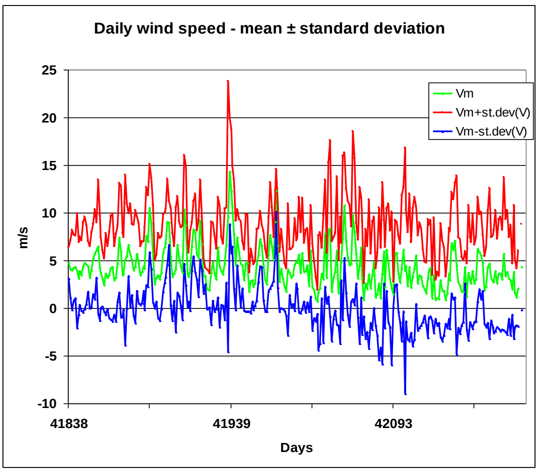


Fig. 3 Daily wind speed means and standard deviation

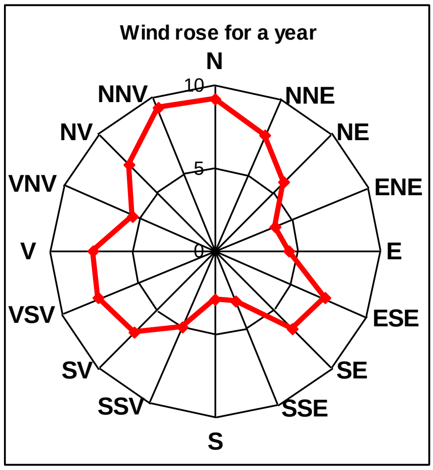
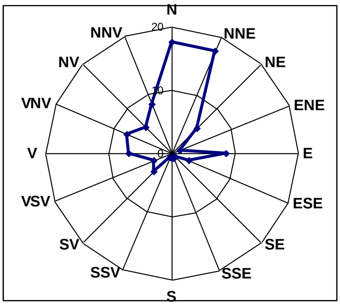
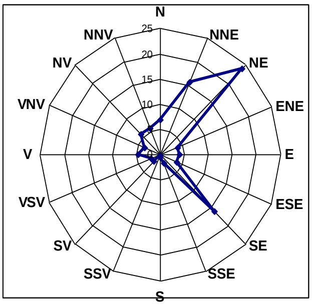


Fig. 4 Annual wind rose

It must be noted that, due to the 1 second sampling time (and also to the free space around) the wind rose shows a smooth distribution. The wind roses for Constanta (Fig. 5), Mangalia (Fig. 6) and Sulina (Fig. 7) meteorological stations data [5] (for the same period) are quite strange to compare to. The explanation resides on one hand in the number of data (7970, 2654 and 8260, respectively) corresponding to 1 h, 3 h and 1 h for the their sampling intervals and on the other hand on the landscape of the respective stations (modified by the 30-40 last years buildings), affecting the air flow.





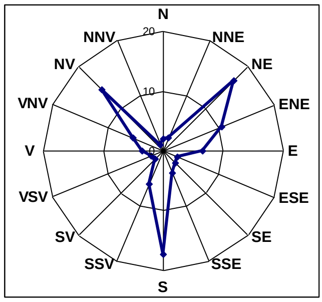


Fig. 5. Constanta wind rose (07.2014-07.2015) **Fig. 6 Mangalia wind rose (07.2014-07.2015)** **Fig. 7 Sulina wind rose (07.2014-07.2015)**

The registered extremes for every day (Fig. 8) reveal an interesting phenomenon: many days includes a minimum of 0 m/s (or very near zero: 0.01m/s to 0.1 m/s) value. A different display of that data will be discussed later (Fig. 14).

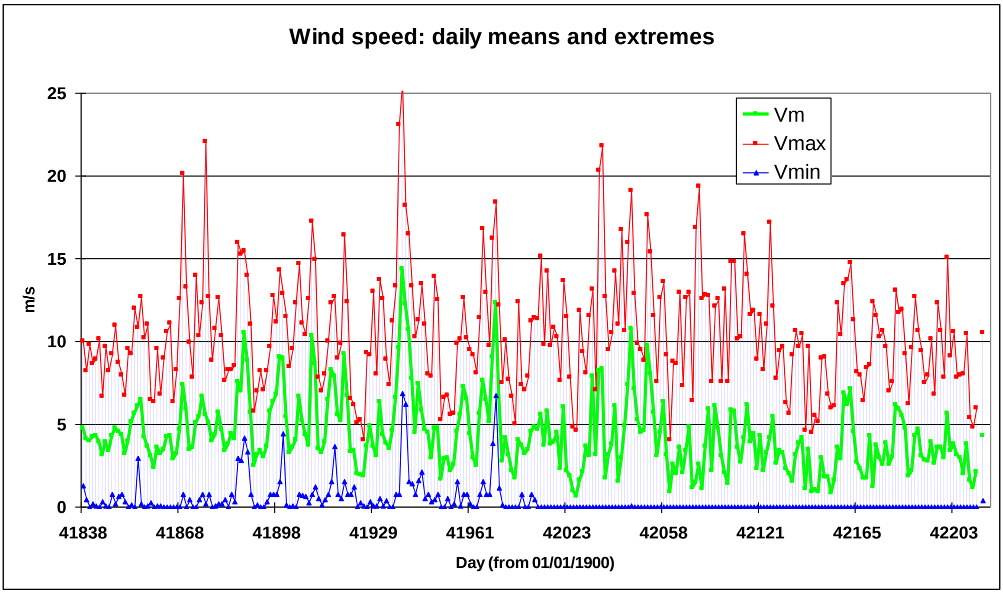


Fig. 8. Daily means and daily extremes of the wind speed

The wind speed distribution is different of on shore or main offshore distribution data so the system may be until now considered as significant mainly for limit processes.

More complex studies of the wind include harmonic analysis. There were selected four subsets to test the aspect of spectra: two for calm wind and two for stormy weather. The normal statistics are presented in Table 1.

Table 1. (Normal) Statistics of calm and stormy subsets

Wind set	N	Mean (m/s)	St.Dev. (m/s)	Skewness	Kurtosis	Coef. Var.
C1=CA1	35982	1.64	0.60	0.47	0.19	0.37
C2=CA2	4499	0.65	0.42	0.57	0.01	0.65
FU2	24588	15.29	2.15	0.39	0.45	0.14
FU9	138323	11.40	1.40	-0.07	-0.13	0.12

As it was already asserted it is not to expect a normal statistics. The fourth value for kurtosis proves the un-normal distribution. The four wind speed distributions (Fig. 9) were tested for most known distribution but Kolmogorov-Smirnov and χ^2 tests rejected any fit (even at 80 % confidence level).

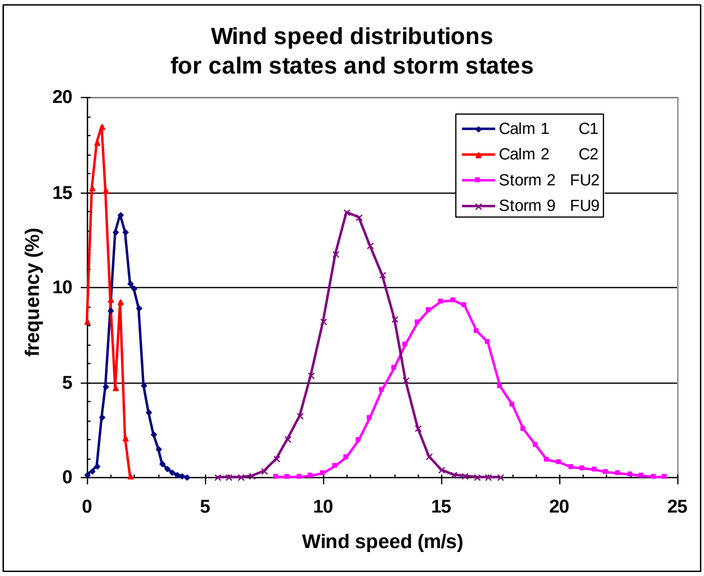


Fig. 9. The distributions of subsets used in harmonic analysis

As harmonic analysis does not depend on distribution, the resulted spectra should be considered correct and are displayed in Fig. 10.

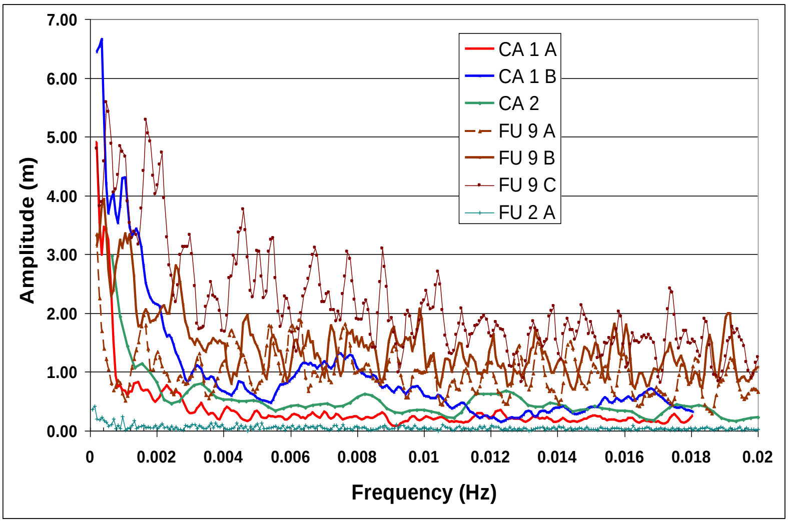


Fig. 10. Spectra for subset C1 (sub subsets CA1A and CA1B), C2 (CA2), FU2 (FU2A) and FU9 (three sub-subsets: FU9A, FU9B and FU9C)

The complexity of information contained postpones for other studies an in-depth harmonic analysis. It is to observe and mention:

- The higher energy at very low frequencies of the calm wind;
- The multitude of spikes (split or not) and harmonics in the spectra of the stormy sub-sets FU9 (A, B and C) - revealing the energy distributed through all frequencies;
- the very low amplitudes for FU2A spectra - suggesting that most energy is into the basic kinetic not oscillating form or that it is, maybe, at even higher frequencies.

From a limited dataset (17 hours) obtained at 4 Hz sampling frequency the 64 spectra obtained showed a lot of information. We present only six coupled spectra at different wind speeds (Fig. 11, Fig. 12 and Fig. 13).

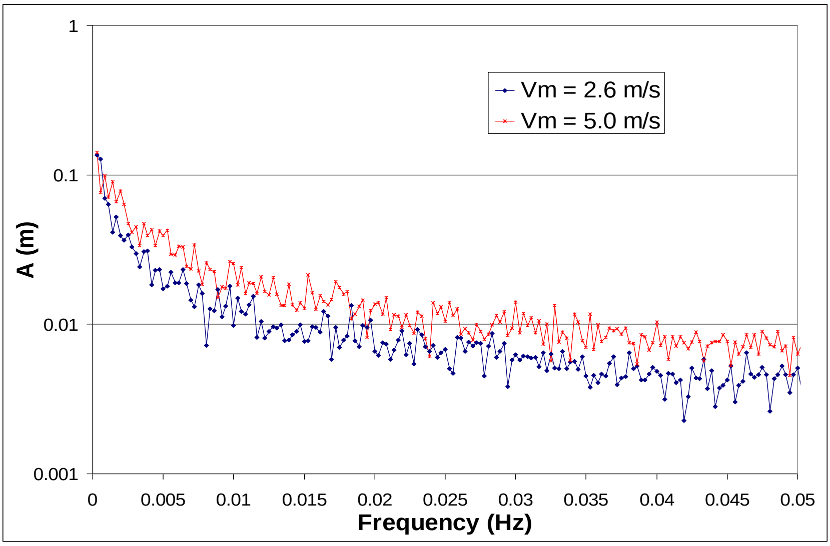


Fig. 11. Spectra (A) of subsets (4 Hz sampling)

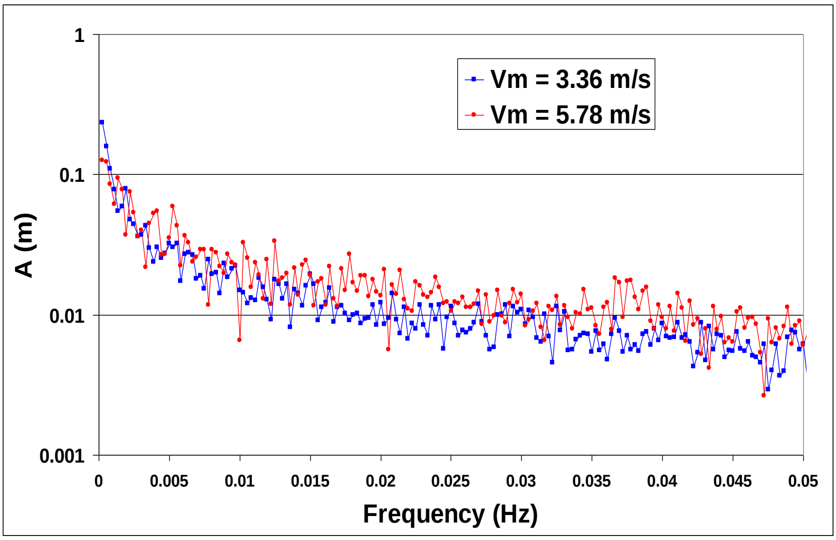


Fig.12 Spectra (B) of subsets (4 Hz sampling)

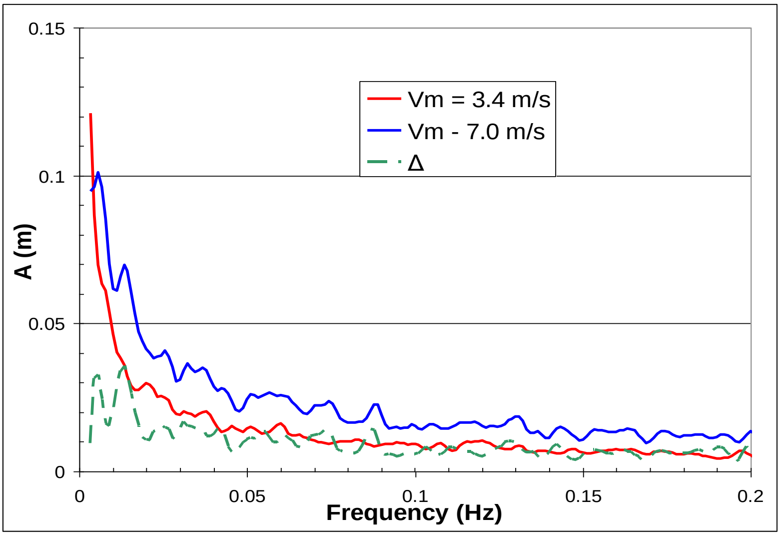


Fig. 13. Spectra(C) of subsets (4 Hz sampling) and differences between

The before mentioned results allow to conclude that such devices as Gill are a good source not only for significant wind datasets, better than classical meteorological data, but also a data source to use in complex studies (air sea interaction, wind energy transfer etc.).

DISCUSSION

The log graph for mean and extreme daily values in Fig. 14 shows a significant difference for minimum daily speed between the first 150 days and last 138 days: the 0.00 m/s values are in 6 % cases and 80 % cases respectively. The 'cutting' date (January, the 15th) being in the middle of the winter season the only explanation we found was a modification in the sensor system. As such event raises more and more questions the data were tested in different ways.

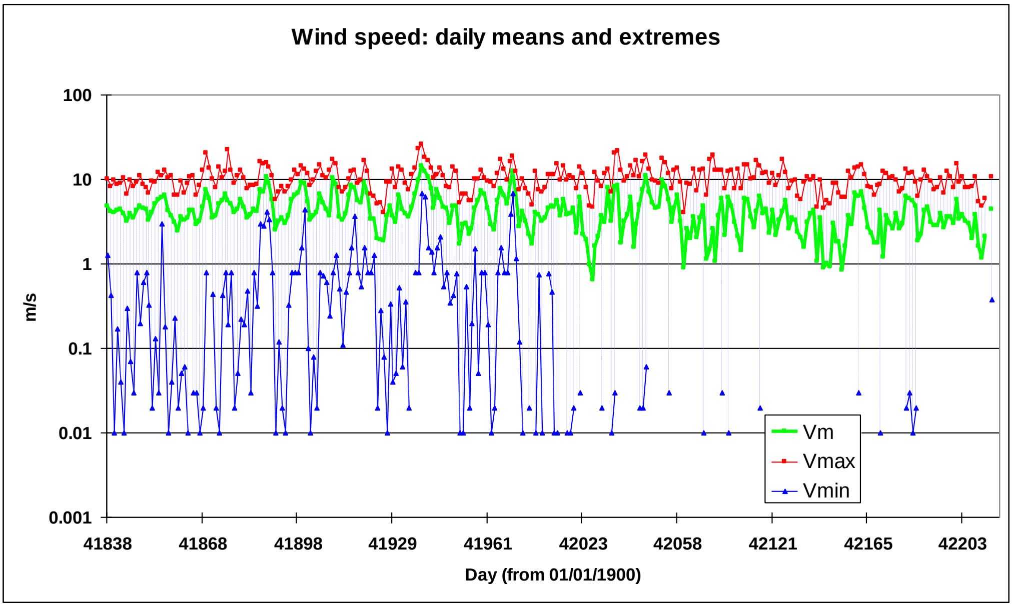


Fig. 14. Daily means and daily extremes of the wind speed

The first test was to verify the wind speed distribution at very low resolution, first at minimum and then increasing the class dimensions. Fig. 15 indicates an other functioning threshold between 0.05 m/s and 0.1 m/s width of classes. As differences between successive values are up to ±25 % (being successive they do not affect averages), it is a problem to be taken into account.

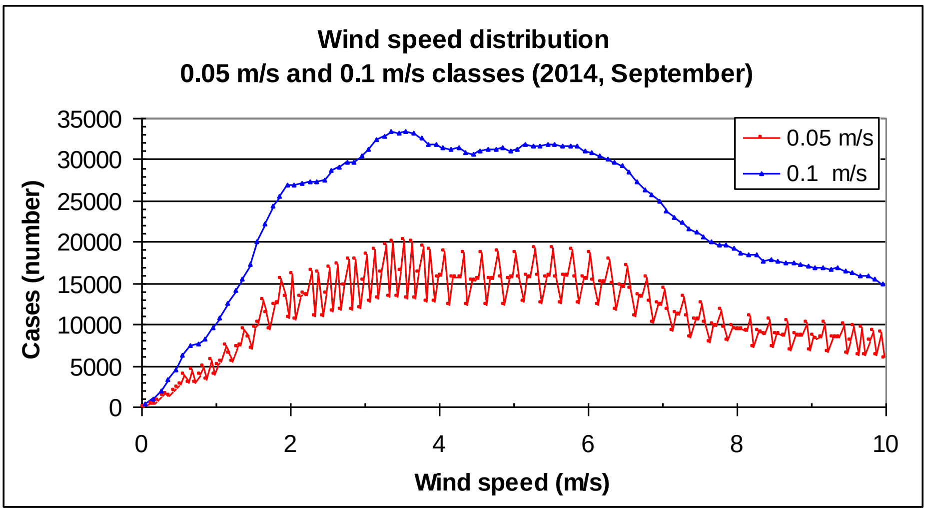


Fig. 15. Wind speed distribution of the same subset at different width classes

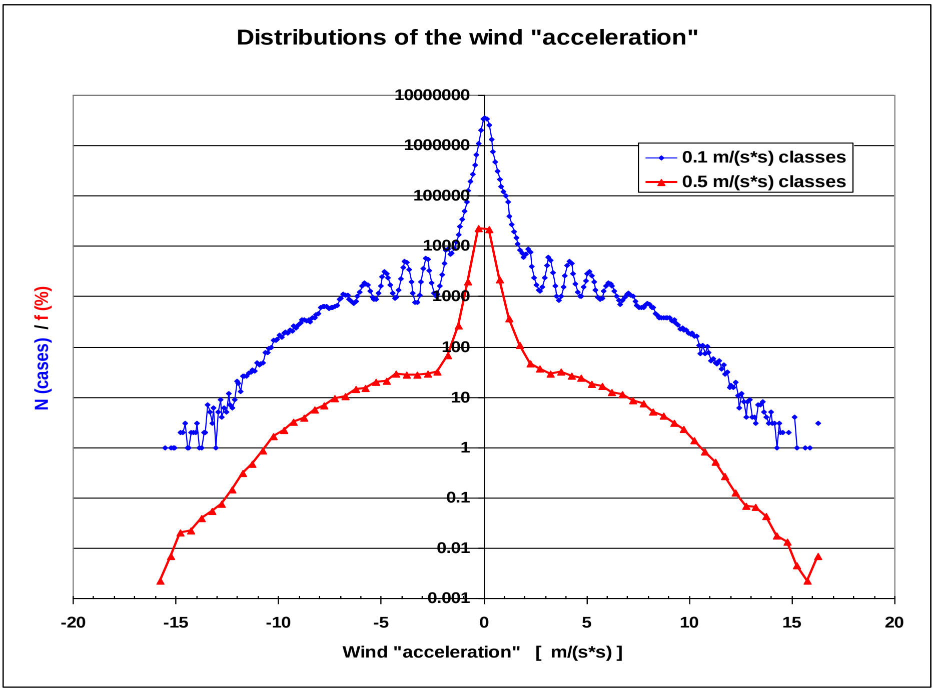


Fig. 16. Distribution of wind speed variation for different width classes

An in-depth analysis of values in Fig. 16 indicated that for speed variation greater than (1.7÷2.3) m/s^2 the curves second derivative changes so it is expected to get erroneous data as the distribution shape changes in an unexpected way. Even more, the visual inspect of data files containing the every second differences revealed that there are many successive "errors" (in opposite directions); it is normal as single errors generated double differences. (Table 2)

Table 2. Samples of erroneous data

D(°)	V(m/s)	Year	Month	Day	Hour	Minutes	Seconds	Difference
351	7.29	2014	10	30	16	0	54	
345	8.39	2014	10	30	16	0	55	1.10
345	**1.58**	**2014**	**10**	**30**	**16**	**0**	**56**	**-6.81**
344	9.46	2014	10	30	16	0	57	**7.88**
342	9.39	2014	10	30	16	0	58	-0.07
294	10.02	2015	4	29	20	24	29	
289	10.27	2015	4	29	20	24	30	0.25
287	**0.10**	**2015**	**4**	**29**	**20**	**24**	**31**	**-10.17**
287	10.52	2015	4	29	20	24	32	**10.42**
289	10.05	2015	4	29	20	24	33	-0.47

The same way, the verification of direction data showed a quite similar problem presented in Fig. 17; as

- 98 % of the direction differences were less than 11°

- The distribution of greater differences is relative uniform;
- There are not coincidences to moments of wind speed erroneous casesthere is not reason to correlate the two speeds of variation. On the other hand, great variations in direction may appear at very low speeds as a natural phenomenon so, due to lack of reasons the direction "jumps" can not (yet) be eliminated or considered suspect.

The authors granted even more attention to wind speed errors. The time evolution of the frequency of errors resides in Fig. 18. The number of errors increased in time in an interesting way, (we consider) revealing two changes in the system: the first on August, the 13th, 2014 and the second on January 9th, 2015. In spite of all presumed causes (oscillations of the support due to ships or birds, birds hitting, uncivilized tourists etc) none proved preeminent at a thoroughly analyze. The users of the system must continue to try to explain the things and find a way to eliminate the errors.

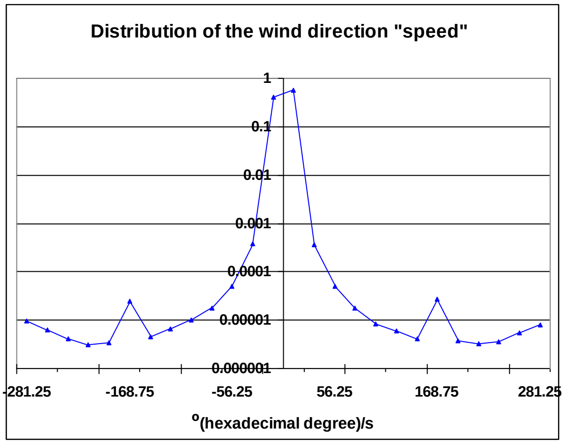


Fig. 17 Distribution of direction variations

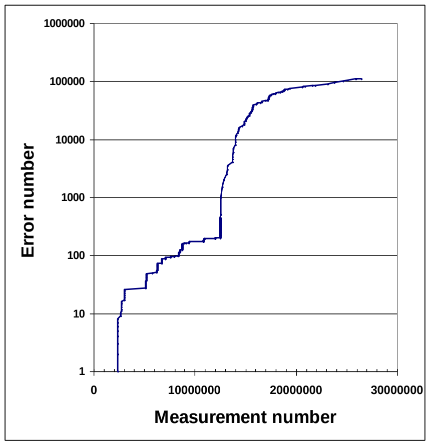


Fig. 18 The evolution of the number of errors

LESSONS TO BE LEARNED

The first author considers there are some ideas to be kept alive:
- For a system, increasing complexity implies more uncertainties (no matter what the producer says);
- Any measurement device has to be tested/verified *in vivo* and its calibration (even if it is perpetual guaranteed) checked at the very first moment and later (if you afford to buy two identical devices, you may verify anytime if one is not quite right);
- Digging data (it is a must, however) too much may reveal (yours or others') hidden mistakes (you or others don't want to see).

CONCLUSIONS

The use of this brand new anemometer is a step forward for the scientists, offering a bulk of data to be used in many ways, from general monitoring to special studies.

The maintenance, mechanical or electric, especially cleaning, has to be very thoroughly executed at intervals short enough (completed with comparisons between before and after datasets).

The placement is very good (statistics of the data shows it may be considered closer to offshore types of data (even for W wind) than to on shore datasets.

A better placement (far from complex structures) would be, of course, a resource of more valuable information as well as the use of a 3D device.

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