Chapter III

Data acquisition and processing

I

Automatic acquisition of meteorological and oceanographic data : further developments and first results

by

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(Based on work by A. DE HAEN, H. PICARD, G. PICHOT, A. POLLENTIER, F. RIGOLE and M. VANDENBOSSCHE)

Introduction

Mathematical models describing and predicting the state of eco-systems such as the North Sea require many long time series of data which allow to effect good numerical values to the interactions parameters and to check their accuracy in the preparatory phase and which

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give the precise boundary conditions in the operational one. These can only be furnished by automatic data stations. It is the reason why a network of meteorological and oceanographic buoys has been planned in the frame of our research programme. These were widely described by Pichot *et al.* (1974).

Nevertheless, it seems worth while to present more clearly the data acquisition system, to give more details about the sensors which are used now and to comment the first results obtained during spring 1974.

1.- The data acquisition system

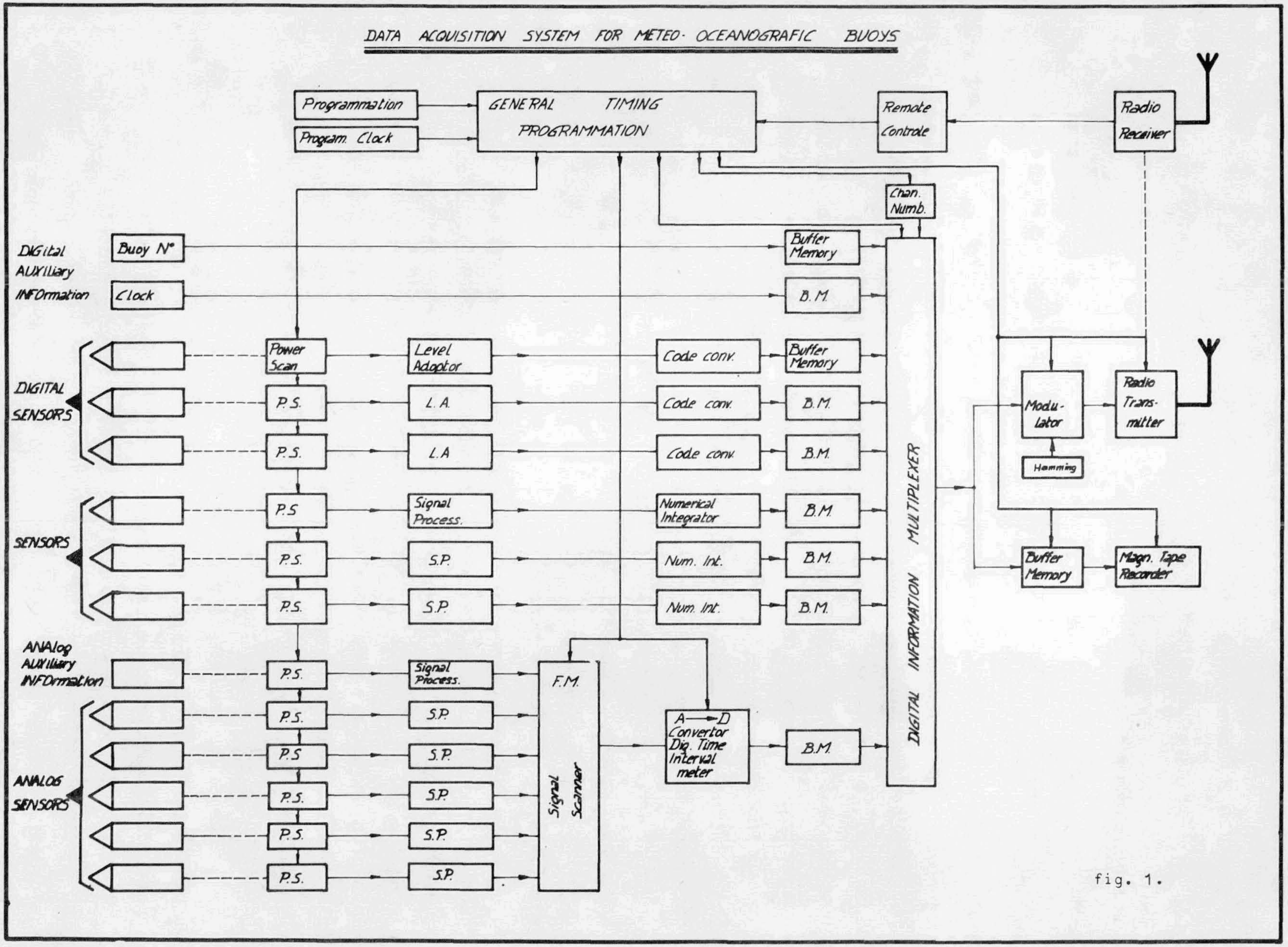
The major functions of the data acquisition system are shown in the block diagram (fig. 1).

The various meteorological and oceanographic sensors, together with a number of housekeeping data, are interrogated under control of the general timing unit. This general timing unit, which is programmed to give the required frequency of sampling and data collection, controls in fact the extendable 32 channel data multiplexer and the power scanner.

The power scanner, consisting of a number of relays, provides the appropriate power supply to the different sensors in a programmable sequence. This sequence depends upon the actual needed warming up time and the period a particular parameter needs to be interrogated.

The data multiplexer itself is divided into two distinct parts which consist in their standard version of a 16 channel analog (f.m.) signal scanner and of a 16 channel digital information multiplexer. Depending upon the nature of a certain sensor the output signal is an analog signal or is already present under digital form.

If a parameter is available in digital form the information is stored in a small buffer memory in BCD form, eventually after level adaptation and code conversion. This storage can happen during the actual measurement cycle or before, in this manner providing instantaneous or integrated measurements.



DATA ACQUISITION SYSTEM FOR METEO-OCEANOGRAFIC BUOYS
Programmation
Program. Clock
GENERAL TIMING PROGRAMMATION
Remote Controle
Radio Receiver
Chan. Numb.
DIGital AUXIliary INFOrmation
Buoy N°
Clock
Buffer Memory
B.M.
DIGITAL SENSORS
Power Scan
P.S.
Level Adaptor
L.A.
Code conv.
SENSORS
Signal Process.
S.P.
Numerical Integrator
Num. Int.
ANAlog AUXIliary INFOrmation
ANALOG SENSORS
F.M.
Signal Scanner
A—D Convertor Dig. Time Interval meter
DIGITAL INFORMATION MULTIPLEXER
Modulator
Hamming
Radio Transmitter
Magn. Tape Recorder

fig. 1.

If the data is not present in digital form the signal is processed into a frequency modulated signal by means of well known electronic circuitry, whilst reliability, power consumption and required accuracy are major design functions. Once the data is present as an f.m. signal it can be converted into a digital form in two ways taking into consideration whether the data should be integrated or not.

If the data is to be integrated, the analog-digital conversion is carried out by a frequency measurement with a time resolution according to authoritative data requirements. Each result is then stored in an identical buffer memory as normal digital data. Nevertheless, the flexibility of the system allows that this data is still available for instantaneous interrogation, *e.g.* for time series or in the event of a considerable difference between research and observational requirements.

If the data is not to be integrated the signal passes through the 16 channel analog multiplexer which is immediately followed by a time interval meter and the result is momentarily stored in a buffer memory. The sampling rate of the time interval meter is synchronous with the scanning frequency and the information of each analog channel is in turn available in the buffer memory.

Once the general timing clock starts a measurement cycle the contents of the buffer memories are, under control of the digital multiplexer, serially shifted towards the Hamming encoder and to the modulator. If analog channels are to be interrogated the digital multiplexer stays locked on the buffer memory related to the time interval meter and passes the scanning control to the analog multiplexer. As an additional feature the analog multiplexer itself can stay locked on certain channels for a programmable period of time.

The serial data present after the digital multiplexer receives also a continuous updated channel number and is then fed to the Hamming encoder. This encoder is in fact a parity bit generator that provides automatic error detection and correction at the receiving end. The output of the Hamming encoder activates the modulator which transforms the serial information into a pulse length modulated subcarrier applied directly to the transmitter input.

At the receiving station situated on shore or on an oceanographic vessel the data is available in real time. For certain applications, as in the case of too great distance, it can be more convenient to store the data *in situ* on a magnetic tape recorder. For this reason a serial data output is available before the Hamming encoder.

At last, the receiving station can also transmit a remote control signal which activates a sensing circuit. If at that moment the general timing unit has not prepared a measurement cycle it can be triggered off to start by the remote sensing circuit.

2.- The sensors

A "clever" sensor is a device sensitive to a given stimulus and able to transmit it under the form of an electrical signal such as a frequency, an AC or DC voltage, a binary coded decimal imput, etc.

For now the buoy is only equipped with such clever sensors measuring air and water temperatures, incident radiation, barometric pressure, salinity, heave, wind speed and direction for which a rather good mean term fiability can be hoped.

Table 1 gives details on these sensors concerning the working principle, the output signal, the measurement range and the accuracy.

Figure 2 shows one of the temperature sensors we have developed. It has been noticed that these can give, in the air, a little variable results probably when differently shielded from the solar radiation. To check this hypothesis, a simple sensor for the incident light we built has been added on the buoy. As it very quickly reaches its saturation level, it only shows if there is a high amount of incident radiation but it cannot be useful for scientific needs such as the measure of the light available for the photosynthesis. It is why it must be replaced by a KIPP albedometer for which the sensitive device is a photoelectric cellule measuring incident and reflected light within a wave length range from 3×10^{-7} to 2.5×10^{-6} m .

Table 1

Sensors now working on our buoy .

Parameter	Principle	Manufactured by	Output	Range	Accuracy	Remarks
Air and water temperature	R.C. oscillating circuit of which the frequency is controlled by a thermistor	us	F.M. pulses 16 – 100 Hz	3-30 °C	± 0.05 °C	Time constant : 1 s
Incident radiation	R.C. oscillating circuit of which the frequency is controlled by a photoresisting cellule	us	F.M. pulses 400-750 Hz	50-1300 mW / cm^2		intercalibrated with a KIPP albedometer
Barometric pressure	Straingage connected to a Wheatstone bridge	M.B.	A.C. Voltage 0 – 10 mV	900-1100 mbars	± 0.5 mbars	calibrated at the pressure room of the Royal Meteorological Institute, Brussels
Salinity	Measure of sea water conductivity by induction	PLESSEY	F.M. pulses 4995-7901 Hz	10-40 %	± 0.03 %	intercalibrated with a Beckman lab salinometer
Heave	Twice integrated accelerometer	DATAWELL	D.C. Voltage ± 10 V	± 10 m	± 3 %	
Wind speed	Three-cups assembly directly coupled to an optical interrupter device	NBA	F.M. pulses 10-50 Hz	3-150 knots	± 0.3 knots	
	Three-cups assembly directly coupled to a disc moving in a magnetic field	FRIEDRICHS	F.M. pulses 0.2 – 40 Hz	0.6-120 knots	± 0.3 knots	
Wind direction	Vane coupled to a disc optically coded in a 7 bits Gray code	NBA	B.C.D. parallel	0 – 360°	± 2.8°	

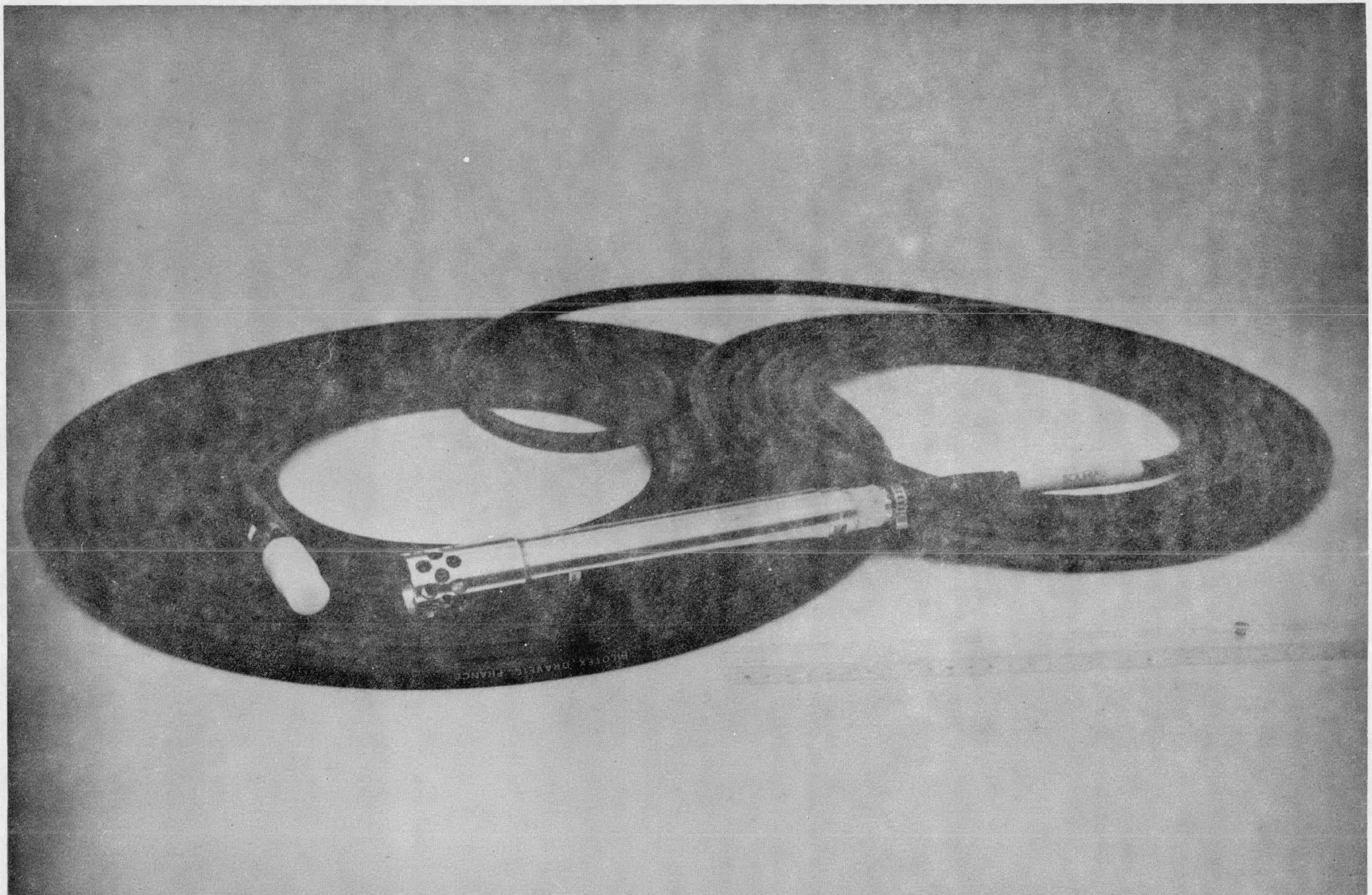


fig. 2.

As far as the wind speed and direction are concerned, the instantaneous values which are measured do not have many meanings because of the movement of the buoy itself. So, it seemed necessary for our purposes to take not only the average speed and direction values over a given time but also their vector averaging ones. All the details on these technics are given by Pollentier *et al.* (1974). To summarize them, let us remember that during the integration time, the wind direction is sampled every time that the anemometer has counted 20 pulses which correspond to an air displacement of 3.08 m . At each sampling, this unit vector is projected on the north and east axis. At the end of the integration, it is easy to express the air displacement and direction in function of sums of north and east components of all these unit vectors.

3.- First results

A first experimental mooring occured from March 19th to April 15th 1974 at the station 51° 20' 45" N 2° 53' 40" E , 13 km from the Ostend receiving station (fig. 3).

There were two sensors for the air temperature, two for the subsurface water temperature, two for the wind speed and one for the heave. House keeping sensors continuously watched over the current supplied by the wind generators, the voltage of the batteries and the humidity inside the electronics compartment.

All the sensors except the heave one were sampled every hour. Each hourly interrogation cycle has immediately been repeated three times in order to check the errors which could occur during the transmission. The heave has been sampled once per second during ten minutes every two hours. Each interrogation gave thus a record of 600 measurements which becomes sufficient for spectral analysis purposes. Figure 4 is an example of a one day heave record.

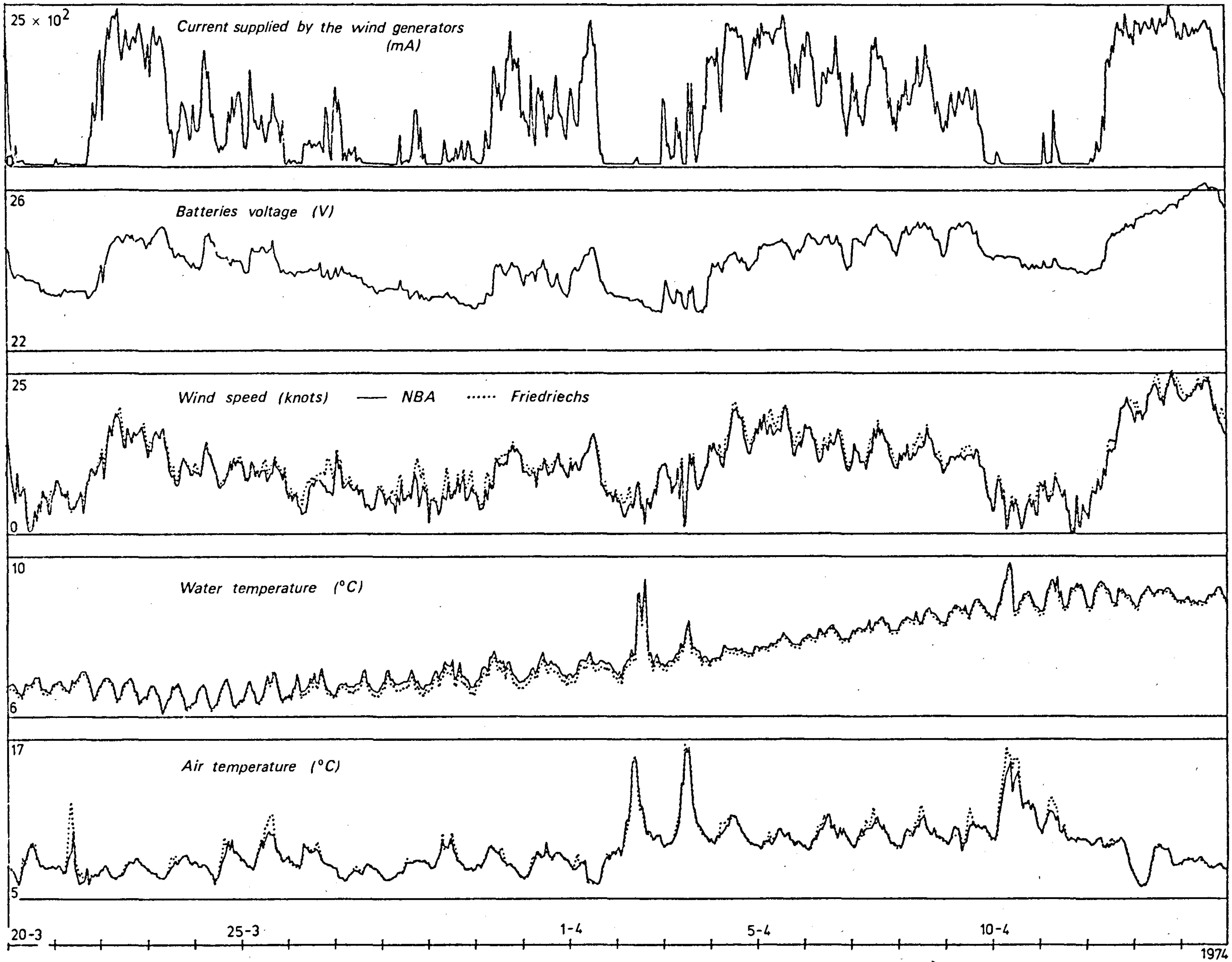

25 × 10²
Current supplied by the wind generators (mA)
0
26
Batteries voltage (V)
22
25
Wind speed (knots) —— NBA ······ Friedriechs
0
10
Water temperature (°C)
6
17
Air temperature (°C)
5
20-3
25-3
1-4
5-4
10-4
1974

fig. 3.

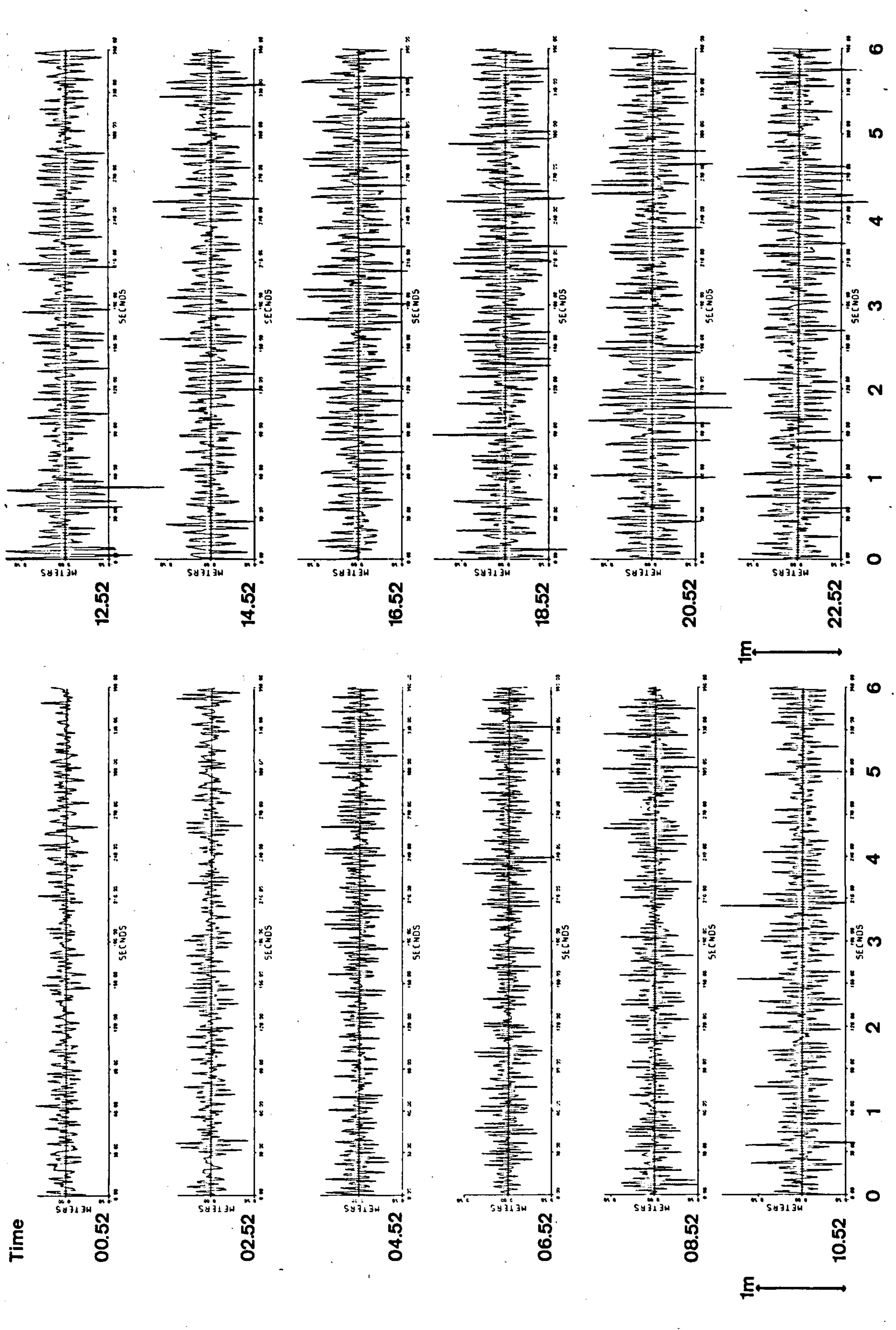

Time
00.52
02.52
04.52
06.52
08.52
10.52
12.52
14.52
16.52
18.52
20.52
22.52
1m
1m
0
1
2
3
4
5
6
METERS
SECONDS

fig. 4.

3.1.- House keeping sensors

The current supplied by the wind generators roughly follows the profile of the wind speed. But it vanishes for wind speeds equal to 7 knots which is the starting velocity of the generators. It occured during 25 % of the mooring period and corresponds to a decrease of the batteries voltage of about 0.5 volt per day. This confirms that the buoy can properly work during at least seven days without any external energy supply.

3.2.- Air temperature

The air temperature profiles have classical diurnal oscillations. The two sensors give slightly different results mainly when the air temperature increases or reaches its maximum at midday. This error which has a maximum of 1 °C probably occurs because of thermistors differently shielded from the solar radiation, as explained above.

3.3.- Water temperature

The two sensors give almost the same results. The curves of the subsurface water temperature shows up a little increasing trend without any clear cross correlation with the air temperature.

It has to be noticed that from March 20th to March 26th, the water temperature semi-diurnally oscillates with a mean amplitude of 0.56 °C . This could reveal an input of cold fresh water from the Schelde estuary reaching at least the area in front of Ostende. If it is true, this confirms the water gyres predicted by the hydrodynamical models of Nihoul and Ronday (1975).

3.4.- Wind speed

The two sensors are manufactured by two different firms and work differently. For the first one (NBA), the measure consists in reading an optical disc and for the second one (Friedrichs), in recording an induction variation.

Nevertheless the results which are the mean values over ten minutes are very similar and have a maximum error of 1.5 knots . They have been compared with the data taken every day at 6 , 9 , 12 , 15 and 18 hours by the light-vessel West Hinder which stays 32 km west from the mooring station. These are received at Liège University by telex via the *Régie des Voies Aériennes.*

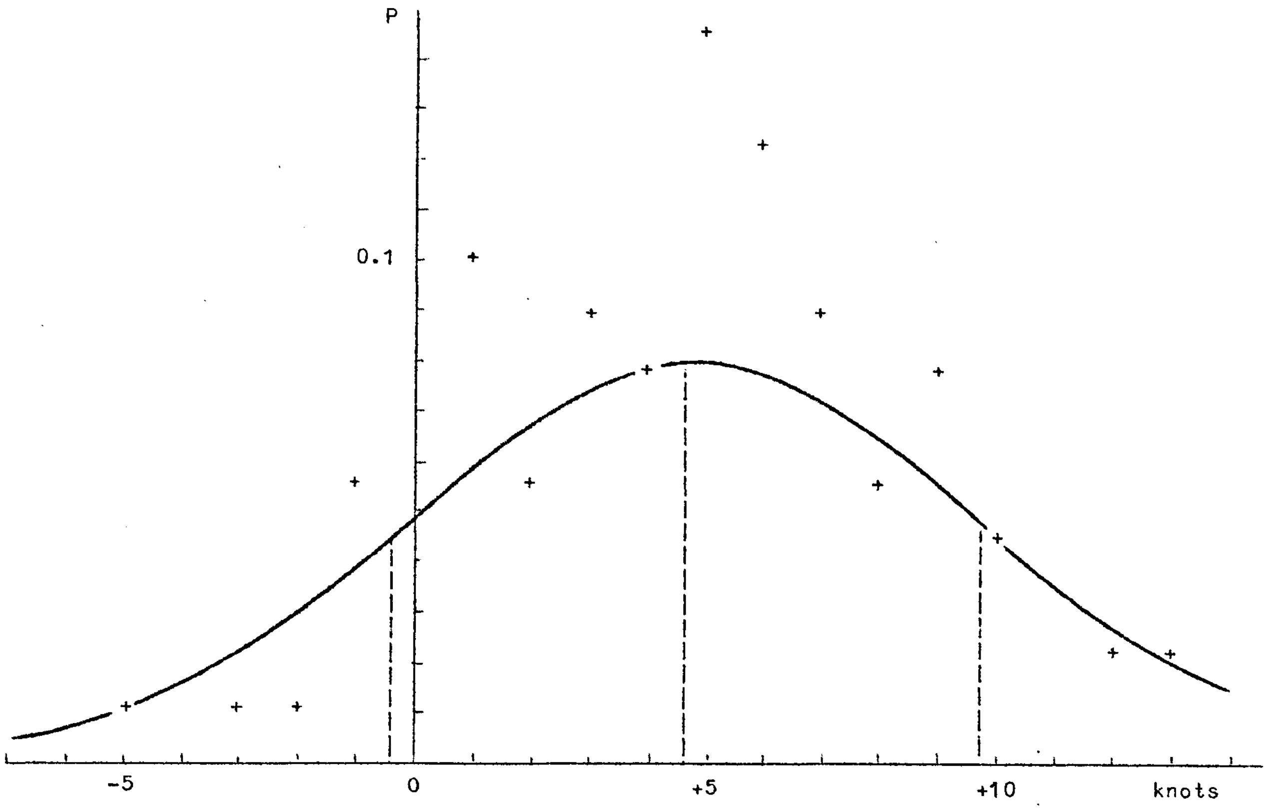
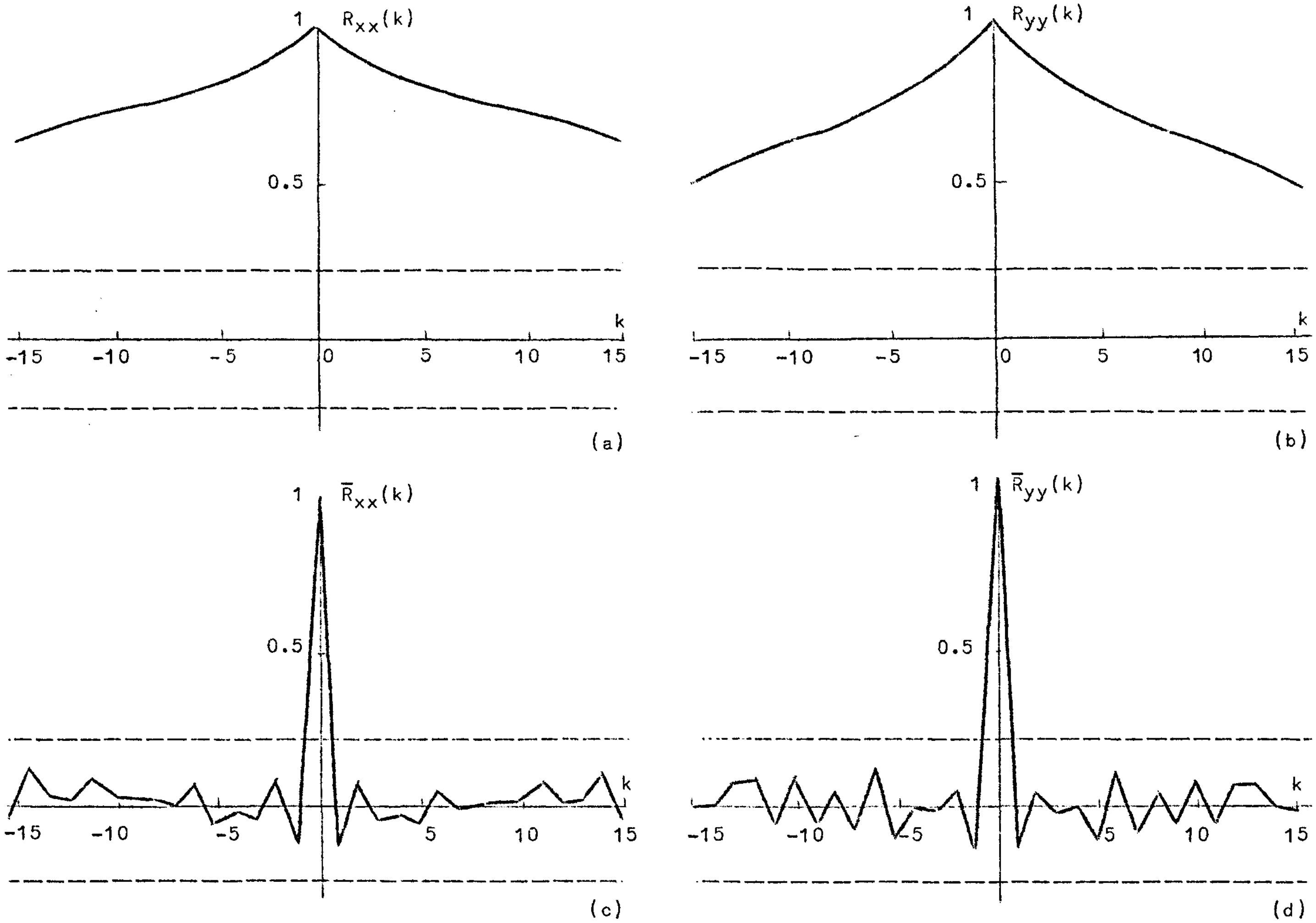


fig. 5.
Frequency distribution of the difference between the wind speed data of the West-Hinder and of our buoy. Mean : + 4.86 knots ; standard deviation : 4.96 knots ; number of observations : 90 .

Figure 5 shows the frequency distribution of the difference between the wind speed measurements of the West Hinder and of our buoy. This difference is equal to + 4.86 ± 4.96 knots . So, the West Hinder systematically gives higher values than our station and this is observed for any wind direction.



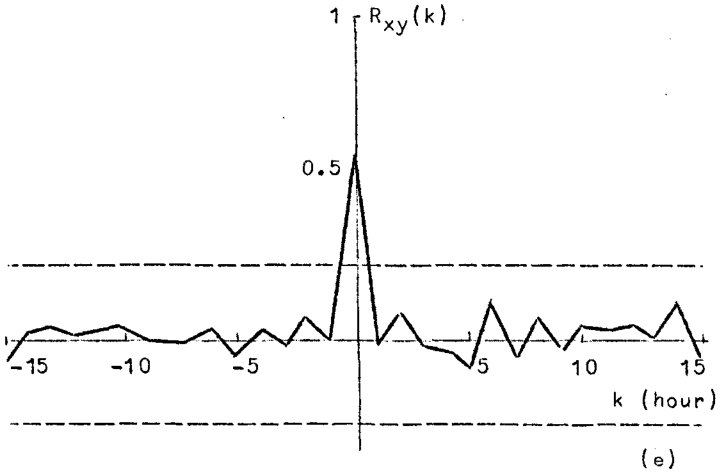


fig. 6.

(a) : autocorrelogram of the wind speed data.

(b) : autocorrelogram of the current supplied by the wind generators data.

(c) : autocorrelogram of the wind speed data, after filter of first order desautocorrelation.

(d) : autocorrelogram of the current supplied by the wind generators data after filter of first order desautocorrelation.

(e) : crosscorrelogram between the wind speed and the current from the wind generators.

The spatial variability of the wind and different levels of sensors above the sea surface are not sufficient enough reason to explain such a difference. It seems necessary to plan a next mooring in the vicinity of the West Hinder in order to make an *in situ* intercalibration between the data of this light vessel and ours.

Figure 6 gives an example of the kind of processing which can directly be made on these time series. Figures 6a and b are the autocorrelograms of the data of the NBA wind speed and of the current supplied by the wind generators. These two series are very highly autocorrelated. Figures 6c and d are the autocorrelograms of the same series after a filter of first order desautocorrelation. They are now stochastic. Figure 6e is the crosscorrelogram between the two series. It can be seen that the current from the wind generators is simultaneously highly correlated with the wind speed and it is obvious that the behaviour of a wind generator is rather similar to the one of an anemometer.

References

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