UGGI - Grenoble - 25 August - 6 september 1975

LOW FREQUENCY OSCILLATIONS OF TEMPERATURE AND SEA LEVEL ALONG THE COAST OF THE GUINEA GULF.

J. PICAUT* - J.M. VERSTRAETE**

In this note, we present the first results of a detailed analysis of long time series collected all along the coast of the Guinea Gulf.

I. - THE TIME SERIES.

The data which are analysed cover the period from 1958 to 1974. They have been collected by different Research Centers and Offices : ORSTOM in Ivory Coast and Togo, the Hydrographical Offices in Ivory Coast and Ghana, the Fishery Research Unit in Ghana, the Fishery Office of Dahomey, and the Meteorological Offices in Ivory Coast and Ghana.

The time series used for these analysis are : the daily mean sea-level, the daily mean sea level pressure and the daily mean wind. The temperature measurements are based on daily observations at the costal sea surface, except at Abidjan where they consisted in a hydrographical station visited twice a week on the shelf (25 meters depth) (fig.1).

II. - SPECTRAL ANALYSIS.

We have used the common methods for estimating power spectra of geophysical time series : computation of the auto and cross-correlation coefficients and their Fourier transforms. The spectral Tuckey windows are used and the annual and lower frequencies are suppressed by Hanning filtering. The usual spectral bandwidth is around 0.0025 c.p.d.

* Laboratoire d'Océanographie Physique - Faculté des Sciences - 29283 BREST Cedex (France)
** Centre de Recherches Océanographiques - B.P. V 18 - ABIDJAN (République de Côte d'Ivoire)

The lower spectra are presented for the different coastal stations and the different parameters.

On the three following figures, we give the cut off frequency fc of the high pass filter and the 90 % confidence interval.

We observe numeral peaks in the period range 6 - 50 days.

In this report, we shall focus on the peak common to all the time series : One is in the period range 40 - 50 days, the others are the well known Mf period (13.7 days) and the beat M2-S2 (14.7 days).

The adjusted sea level is defined as the observed sea level with the atmospheric pressure eliminated according to the hydrostatic relation 1 cm decrease in sea level for 1 mb increase in pressure. Figure 2 gives the corresponding spectra : the 40 - 50 days peak is very conspicuous at Abidjan. We obtain a very good resolution and much energy concentrated in the two fortnight peaks.

In the temperature spectra (fig.3-4), there is less energy in Cotonou than in the other stations, particularly in the lower frequencies.

The oscillations do not concern the surface layer only : with Abidjan data, we find about five times more energy at 20 meters than at 0 meter.

We can note that the 40 - 50 days oscillations has been observed since 1958. It thus appears as a stationary feature.

With the temperature data, we did not succeed to separate the 13.7 and 14.7 days oscillations, the arrows indicate the common peak.

The meteorological data shows a similar peak in the period range 40 - 50 days (fig.5). Madden and Julian (1972) have found such an oscillation in the tropical atmosphere of the Pacific and Indian Oceans.

III. - FILTERED TIME-SERIES.

In order to estimate the amplitude of these oscillations, we have submitted these time-series to a band-pass filter centered on 45 days. The response of the filter used is given in figure 6.

Fairly strong oscillations are evident in the filtered data.

With sea surface temperature, the peak to trough amplitudes are about 1.5 degree Celsius. The amplitude is less important in Cotonou than in the other stations, which corroborates the spectral results. The similitude of the variations between the two nearest stations Tema and Takoradi is very conspicuous (fig.7).

With the adjusted sea level, the sea level pressure and the sea level zonal wind, the amplitudes are respectively 8 cm, 1.6 mb and 0.7 m/s (fig.8).

IV. - ANALYSIS OF THE 40 - 50 DAYS OSCILLATIONS.

- At different stations :

The sea surface temperature measurement have started in 1958 in Cotonou, this is why we have used this time serie as a reference.

The following table gives the phase angle with the 90 % confidence limit. We did the same computations with the adjusted sea level time-series of Tema, Takoradi and Abidjan (table 1). The phase angles are always near zero so that the 40 - 50 days oscillation seems to be stationary.

In order to control this result, we have computed the correlation coefficient of each pair of data after they have been filtered, for successive day lags (fig.9). Table 2 gives the day lags for the maximum correlation. It corroborates the preceeding conclusion.

- At the same station :

The table 3 gives the cross spectral and correlation results between different pairs of parameters : the mean sea level and the temperature are in phase. The barometric pressure is in opposition with the temperature and the mean sea level, and in phase with the zonal wind. This last result agrees with that of Madden and Julian at Canton Island (1972).

V. - ANALYSIS OF THE FORTNIGHT OSCILLATION.

The cross spectra with the temperature data between Cotonou and all the other stations give a good probability of a wave propagation at the 14.7 days period. We have plotted the phase angle as a function of the distance alongshore (fig.10). The coherence between Cotonou and Takoradi gives a value under the 90 % limit. So we use the sum of the phase angle and the corresponding error between Cotonou-Tema and Tema-Takoradi.

We find a westward phase speed of about 75 cm/s and a wave length of 950 Km.

With the sea level between Abidjan and Tema, we find a phase angle of $-152° \pm 30°$, which gives a phase speed of about 90 cm/s.

During the Ghana upwelling season in 1974 Houghton (personnal communication) had found a wave of the same type.

Unfortunately, there is no phase difference between Tema and Takoradi sea level, so that one must be cautious with the preceeding results.

VI. - EXTENTION TO OTHER AREAS.

The ORSTOM Centers of Dakar and Pointe Noire also make daily measurement of temperature. On the figure 11, we give some power spectra of these two coastal stations.

The peak at 40 - 50 days appears clearly at Dakar, but not at 15 meters depth at Pointe Noire. Note the very high peak at 13.4 days at Pointe Noire.

VII. - CONCLUSION

The investigation has enabled the detection of a 40 - 50 day oscillation in the Gulf of Guinea. We can suppose that the atmosphere induces these low frequency variations of the mean sea level and sea temperature, which appear stationary.

We have also shown fortnightly oscillations with some probability of a westward wave propagation.

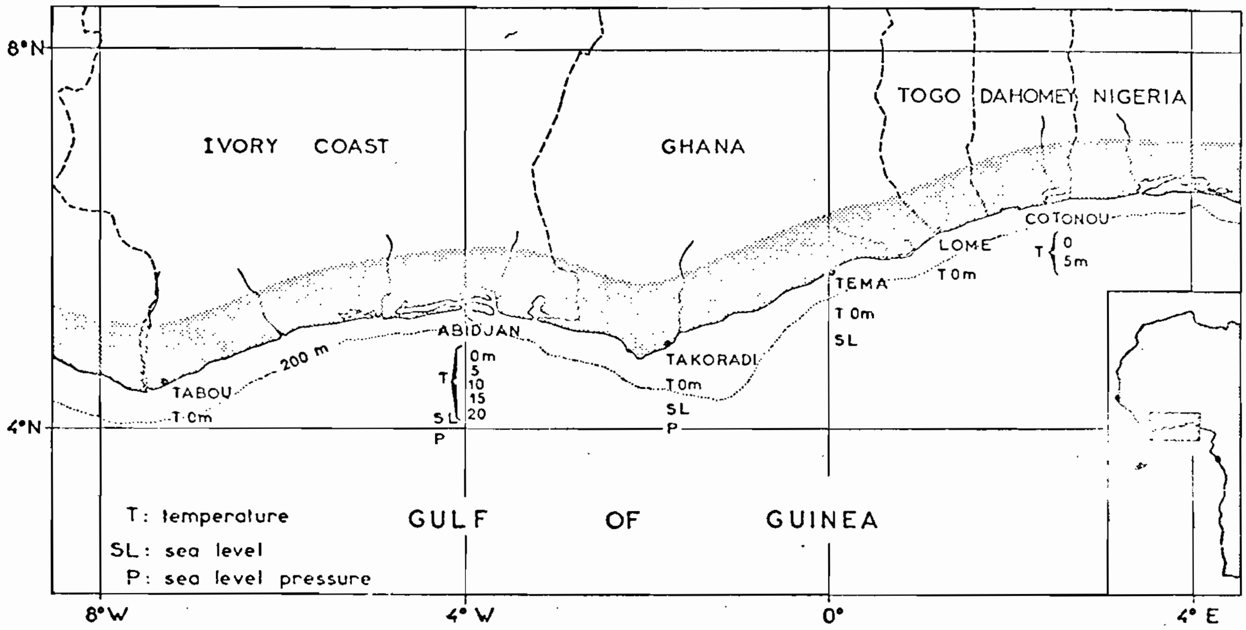


Fig. 1

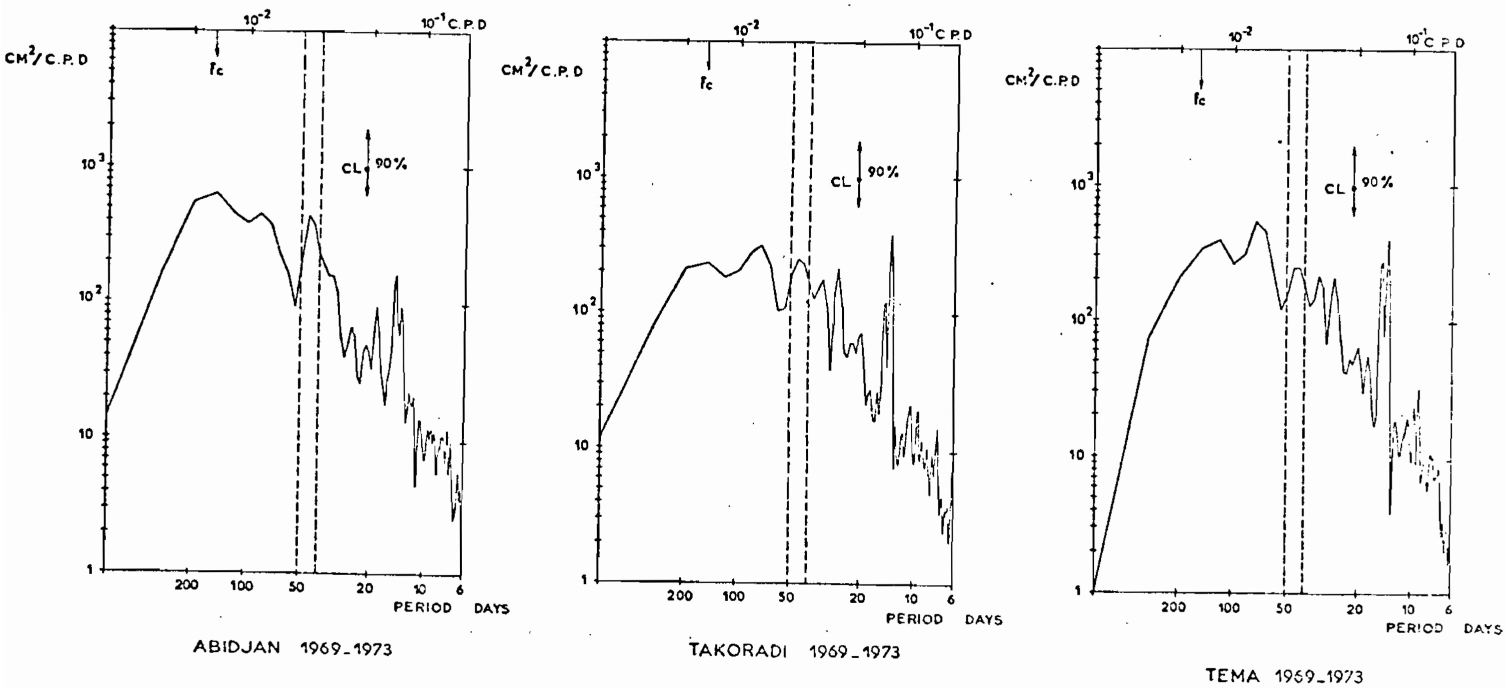
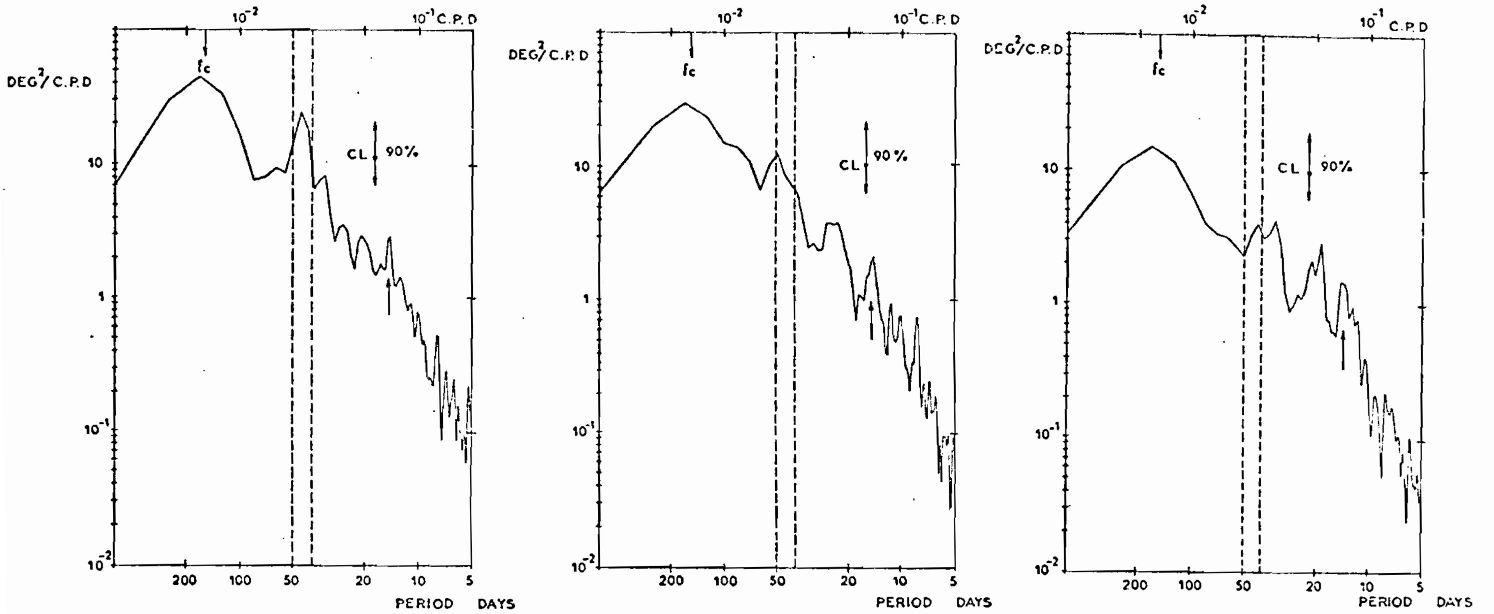


Fig. 2

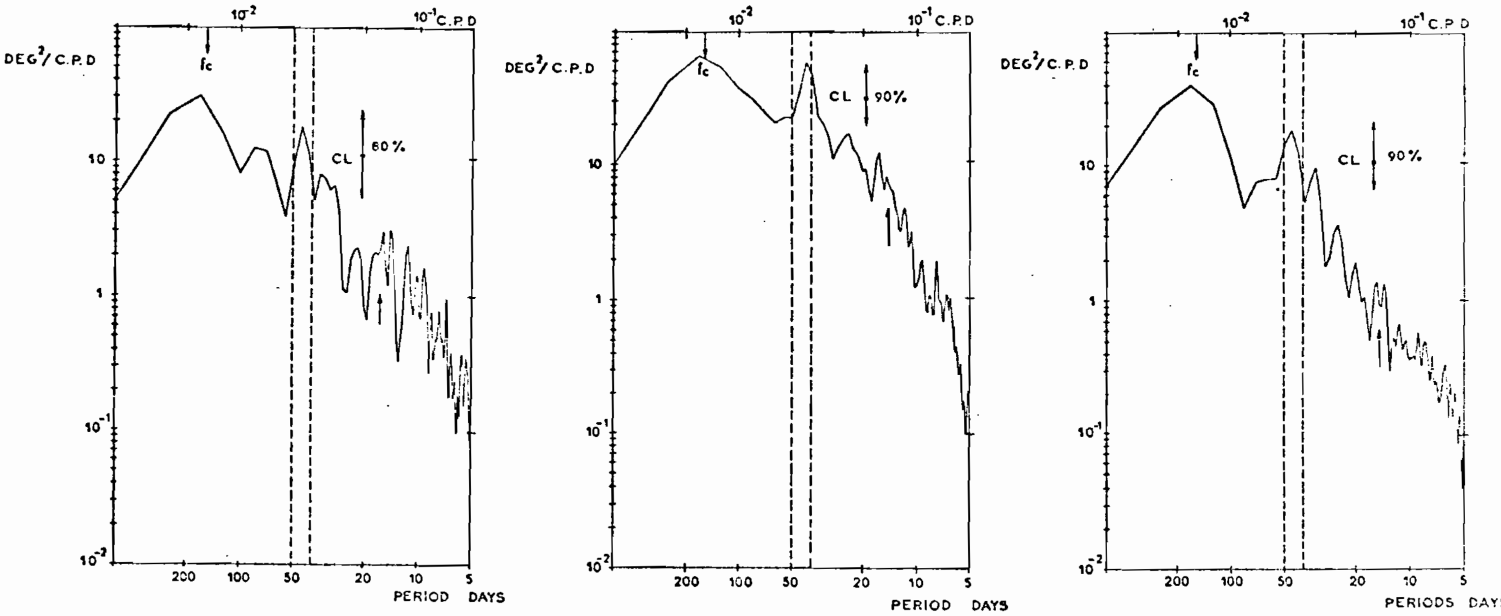
ADJUSTED SEA LEVEL



TEMA 1969_1973 LOME 1958_1962 COTONOU 1969_1973

Fig. 3

TEMPERATURE



TABOU 1958_1960 ABIDJAN _ 20m_ 1969_1973 TAKORADI 1970_1973

Fig. 4

TEMPERATURE

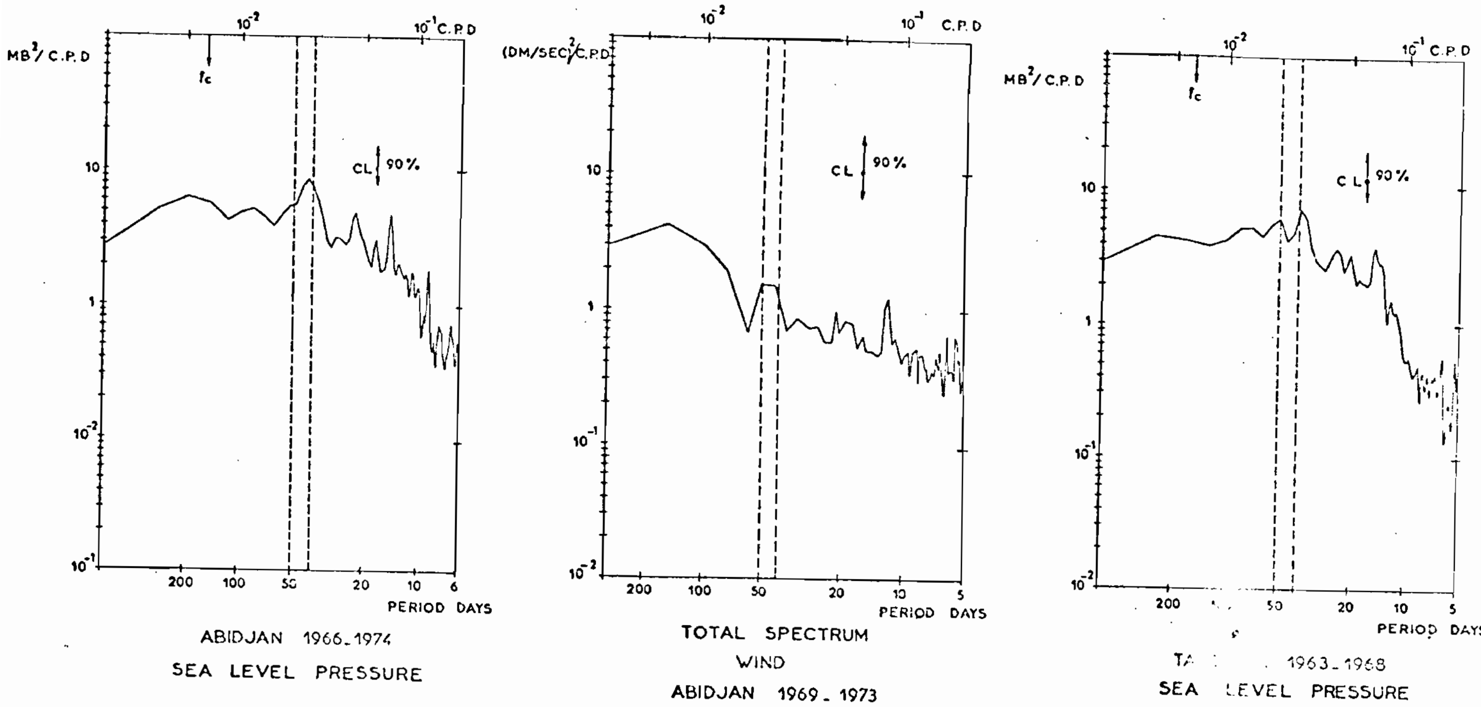
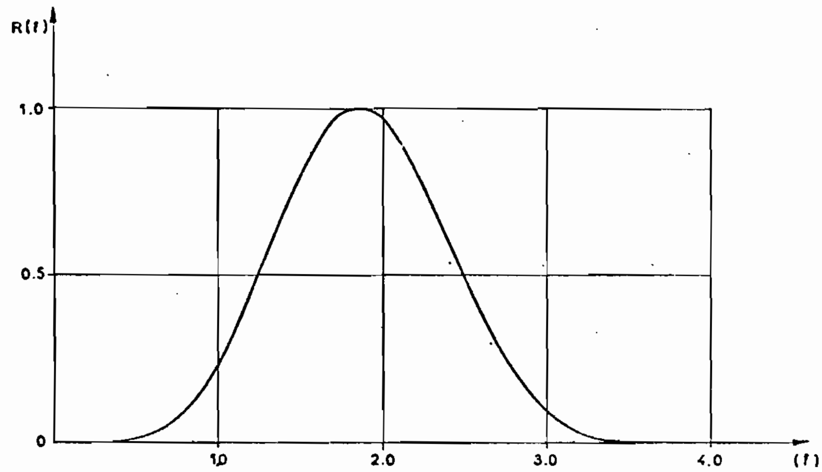
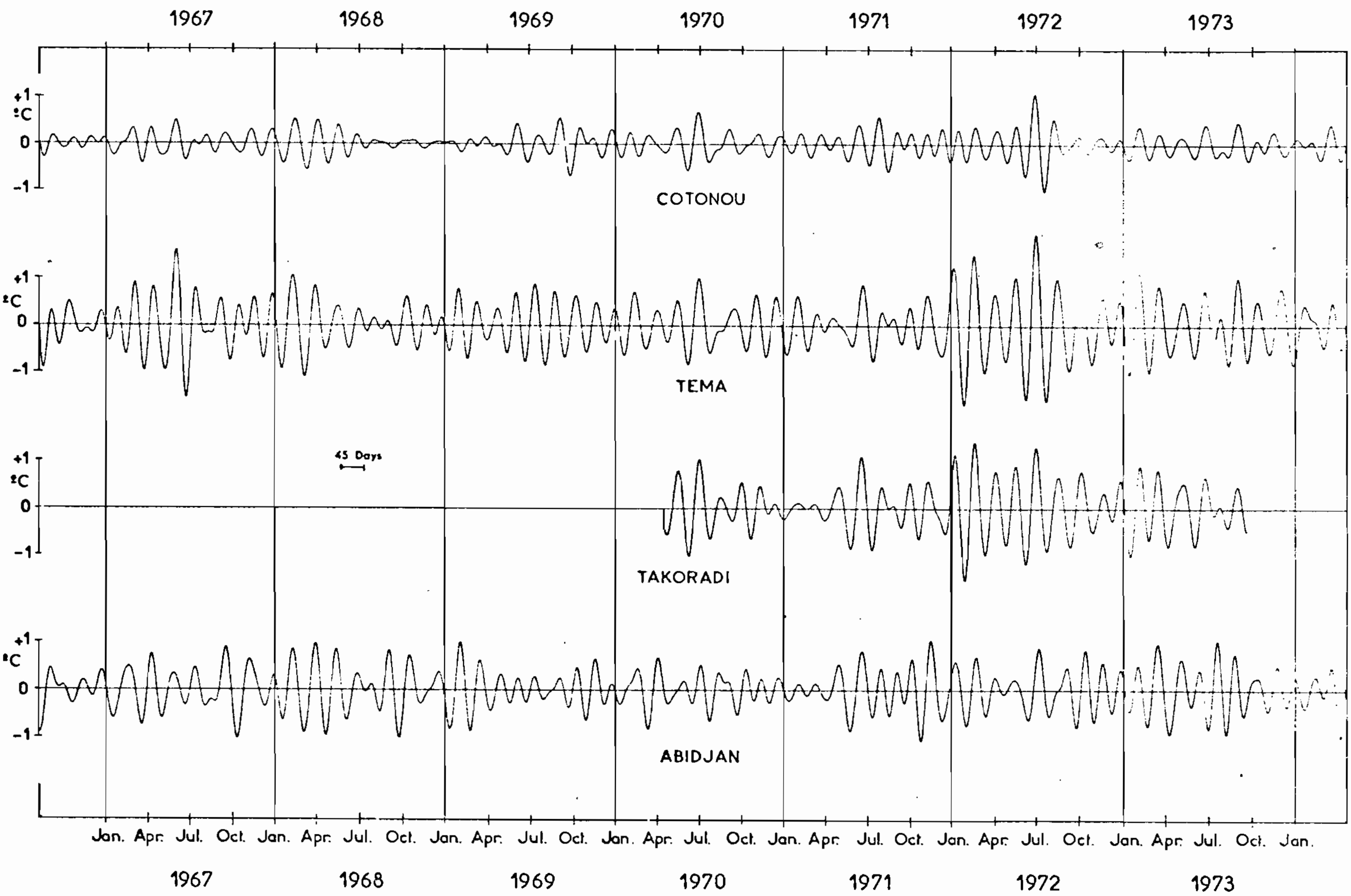


Fig. 5



FREQUENCY RESPONSE OF THE BAND-PASS FILTER

Fig. 6



SEA SURFACE TEMPERATURE

Fig. 7

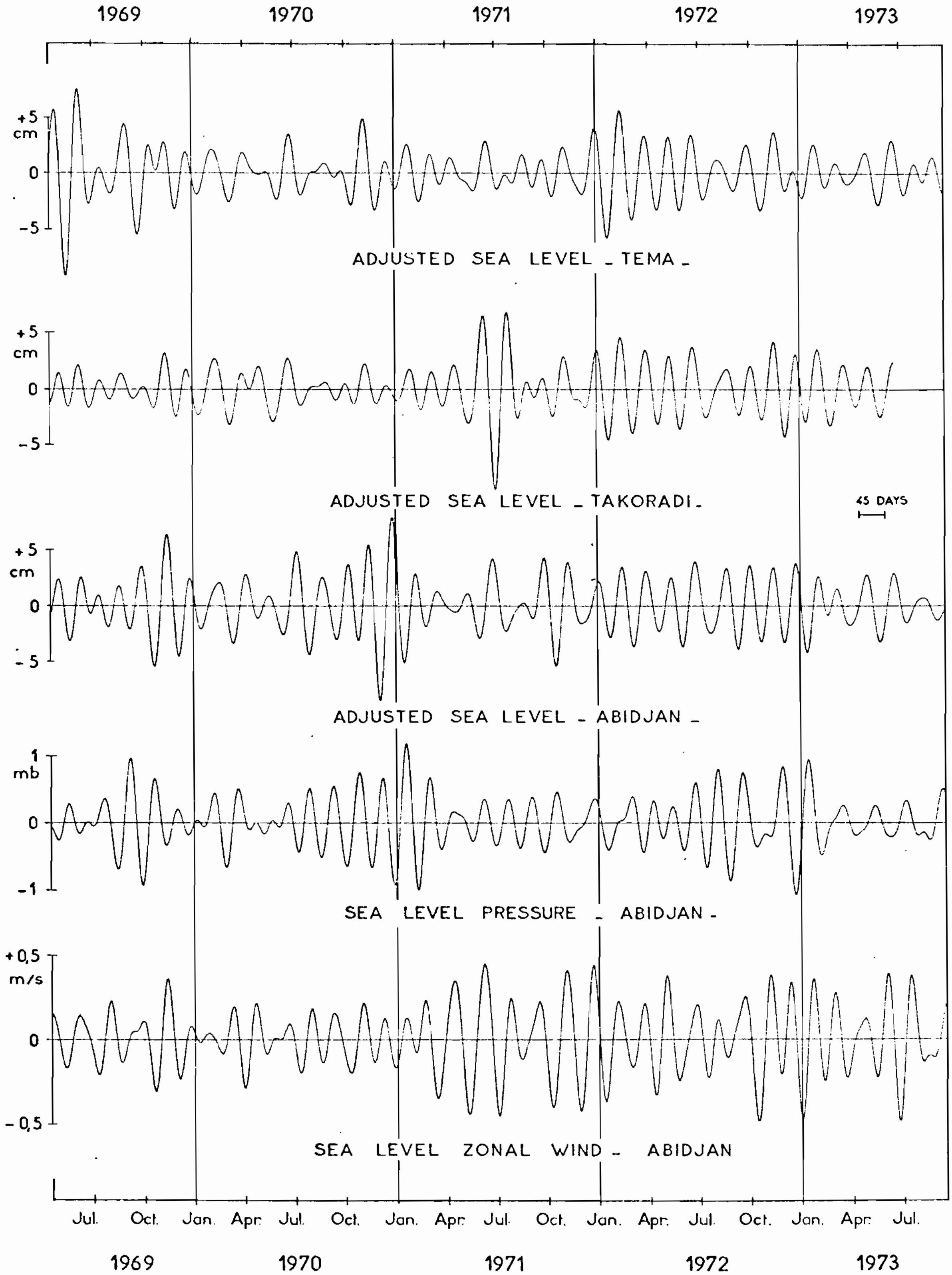

1969
1970
1971
1972
1973
+5
cm
0
-5
ADJUSTED SEA LEVEL _ TEMA _
+5
cm
0
-5
ADJUSTED SEA LEVEL _ TAKORADI _
45 DAYS
+5
cm
0
-5
ADJUSTED SEA LEVEL - ABIDJAN -
1
mb
0
-1
SEA LEVEL PRESSURE - ABIDJAN -
+0,5
m/s
0
-0,5
SEA LEVEL ZONAL WIND - ABIDJAN
Jul.
Oct.
Jan.
Apr.
Jul.
Oct.
Jan.
Apr.
Jul.
Oct.
Jan.
Apr.
Jul.
Oct.
Jan.
Apr.
Jul.
1969
1970
1971
1972
1973

Fig. 8

Temperature: reference COTONOU

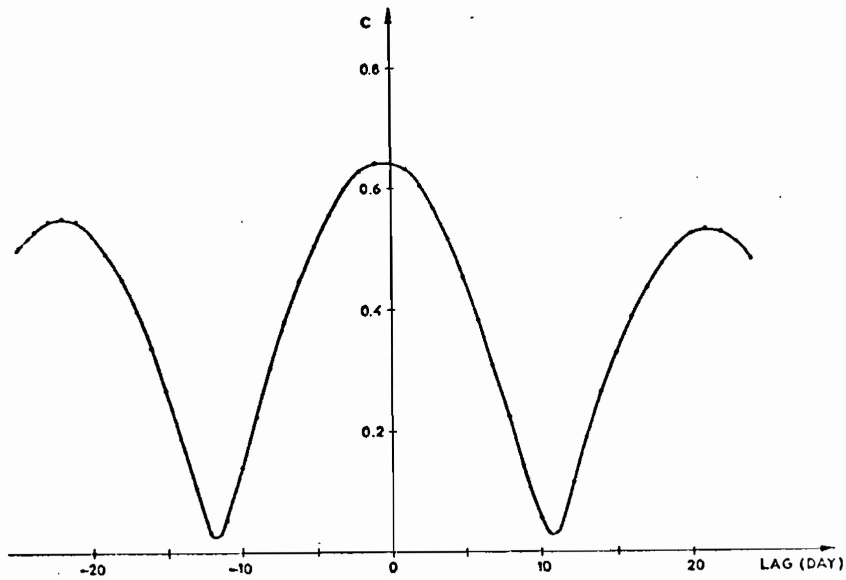
LOME	TEMA	TAKORADI	ABIDJAN	TABOU
5° ∓ 12°	0° ∓ 33°	-11° ∓ 35°	-12° ∓ 46°	-27° ∓ 70°

Adjusted sea level: reference TEMA

TAKORADI	ABIDJAN
-9° ∓ 38°	-40° ∓ 43°

Cross spectral analysis

(Table 1)



Filtered sea level

TAKORADI - TEMA 1970 - 1973

Fig. 9

Temperature : reference COTONOU

LOME	TEMA	TAKORADI	ABIDJAN	TABOU
- 1	0	+ 2	+ 1	- 2

Adjusted sea level: reference TEMA

TAKORADI	ABIDJAN
0	+5

Correlation analysis

(Table 2)

Adjusted sea level - Temperature

Station / Type of analysis	TEMA	TAKORADI	ABIDJAN
Cross spectral	$-12^\circ \mp 25^\circ$	$-28^\circ \mp 37^\circ$	$8^\circ \mp 45^\circ$
Correlation	+ 2	- 4	- 1

Sea level pressure ABIDJAN

Type of data / Type of analysis	Temp. 20m	Sea level	Zonal wind
Cross spectral	$-154^\circ \mp$ xxx	$-170^\circ \mp 31^\circ$	$-16^\circ \mp$ xxx
Correlation	+ 18	- 20	+ 4

xxx Indefinite phase confidence limit

(Table 3)

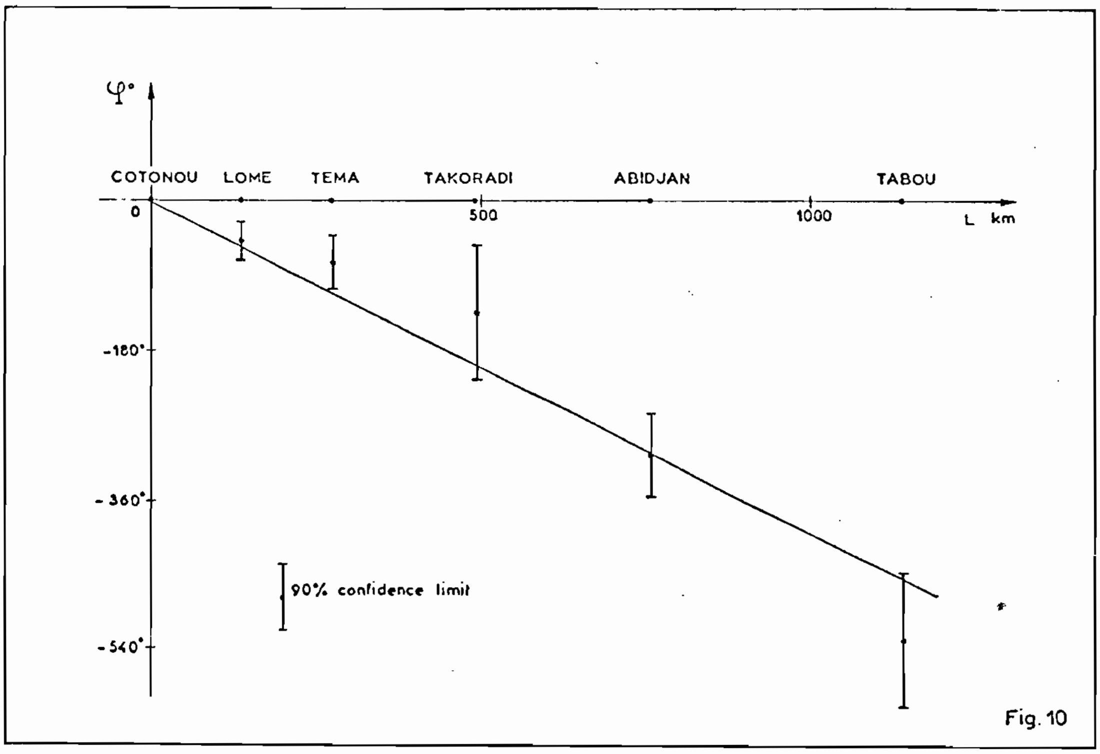
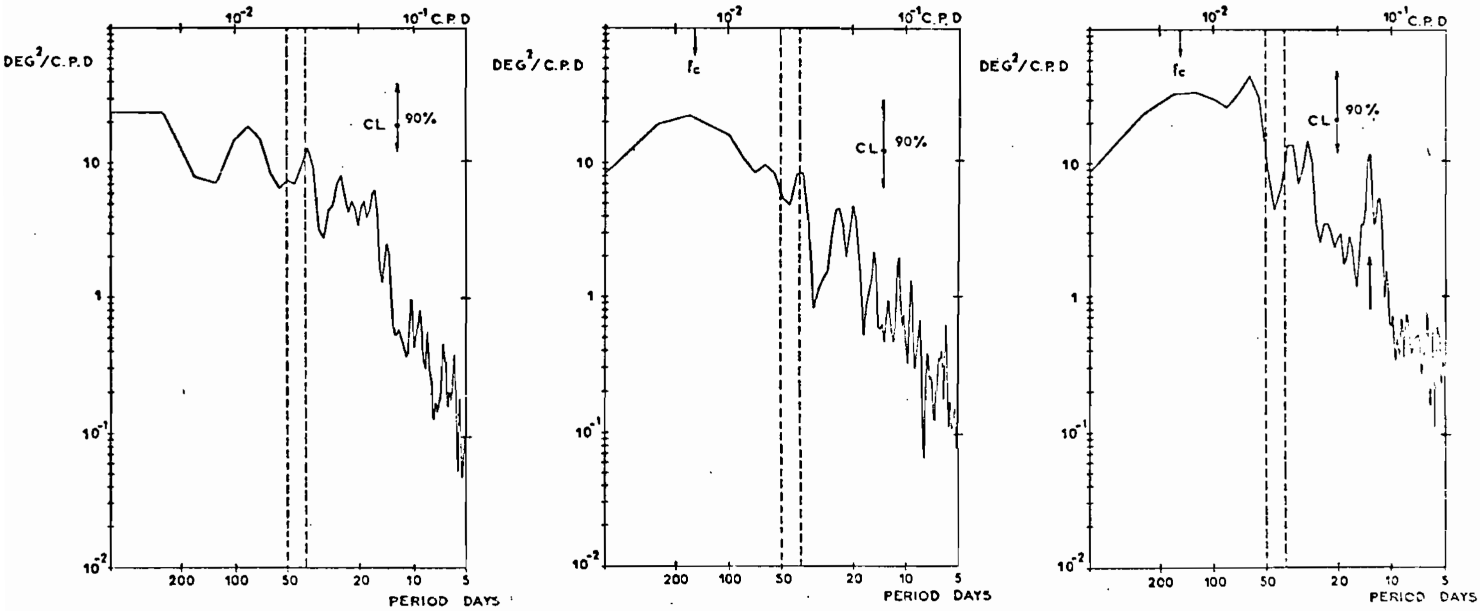


Fig. 10



DAKAR 1966-1969

POINTE NOIRE 0m - 1972-1974

POINTE NOIRE 15m - 1972-1974

Fig. 11

TEMPERATURE

REFERENCES

- BLACKMAN, R.B. and J.W. TUCKEY, 1958.
  The measurement of power spectra.
  Dover Publ., New-York.

- MADDEN, R.A. and P.R. JULIAN, 1971.
  Detection of a 40 - 50 day oscillation in the zonal wind in the tropical Pacific.
  J. Atmos.Sci., 28, 702-708.

- MADEN, R.A. and P.R. JULIAN, 1972.
  Description of global - scale circulation in the tropics with a 40 - 50 day period.
  J. Atmos.Sci., 29, 1109-1123.

- MAZÉ, R., 1973.
  Recherche et étude de mouvements à période propre du domaine des ondes internes dans l'Iroise.
  Thèse 3ème cycle. Fac.Sc., Brest.

- MUNK, W.H., F.E. SNODGRASS and M.J. TUCKER, 1959.
  Spectra of low frequency ocean waves.
  Bull. Scripps Inst.Oceanogr., 7 (4), 283-362.

Picaut Joël, Verstraete Jean-Marc. (1975).

Low frequency oscillations of temperature and sea level along the coast of the Guinea Gulf.

In : Symposium UGGI. Grenoble : UGGI, 13 p. multigr.

Symposium UGGI, Grenoble (FRA), 1975/08/25.