Correlations in daily deviations from the median of f_0F2, $M(3000)F2$ and $h'F$

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Abstract
The statistical analysis of the hourly daily deviations from the corresponding monthly-median values of the factor $M(3000)F2$ and of the critical frequency of the $F2$-layer, f_0F2, reveals that the correlation between these parameters is poor. A similar analysis between the hourly daily deviations from the corresponding monthly-median of the height $h'F$ and the f_0F2 leads to similar results. These results indicate that the factor $M(3000)F2$, the height $h'F$ and the critical frequency f_0F2 may have a different daily variability.

Key words *radio-wave propagation – ionosphere – aeronomy*

1. Introduction

In order to improve individual days forecasting the study of the daily variability of the $F2$-layer ionospheric characteristics is of great importance. An approach is to study the correlation between the hourly daily values of the factor $M(3000)F2$ and those of the f_0F2 on the one hand, and between the hourly daily values of the height $h'F$ and those of the f_0F2 on the other hand. Another way is to investigate the correlation of the hourly daily deviations from the corresponding monthly-median values of these characteristics. Their variability around the median values can be an index of the disturbed ionosphere (Gulyaeva 1992, 1993; Radicella *et al.*, 1993). Therefore, a comparison of the deviations of the hourly daily values from the corresponding monthly-median of $M(3000)F2$ and f_0F2, and $h'F$ and f_0F2 may be useful. For this purpose a statistical analysis of these deviations was carried out. This paper describes the results obtained from the linear regression analysis of the deviations $\Delta M(3000)F2$ and Δf_0F2, and $\Delta h'F$ and Δf_0F2.

2. Data and analysis

In this work the deviations ΔM of the hourly daily values of the factor $M(3000)F2$ from the monthly-median and the corresponding deviations ΔF of the hourly daily values of f_0F2 from their median values, are correlated using the linear regression equation

$$\Delta M = b_0 + b_1 \Delta F \qquad (2.1)$$

Similarly, the hourly daily deviations ΔH of the hourly daily values of $h'F$ from the monthly-median and the corresponding ΔF of f_0F2 are fitted by the method of least squares to the linear regression

$$\Delta H = c_0 + c_1 \Delta F \qquad (2.2)$$

Hourly daily data measured at the stations of Slough, Lannion and Rome during the years of maximum solar activity 1979

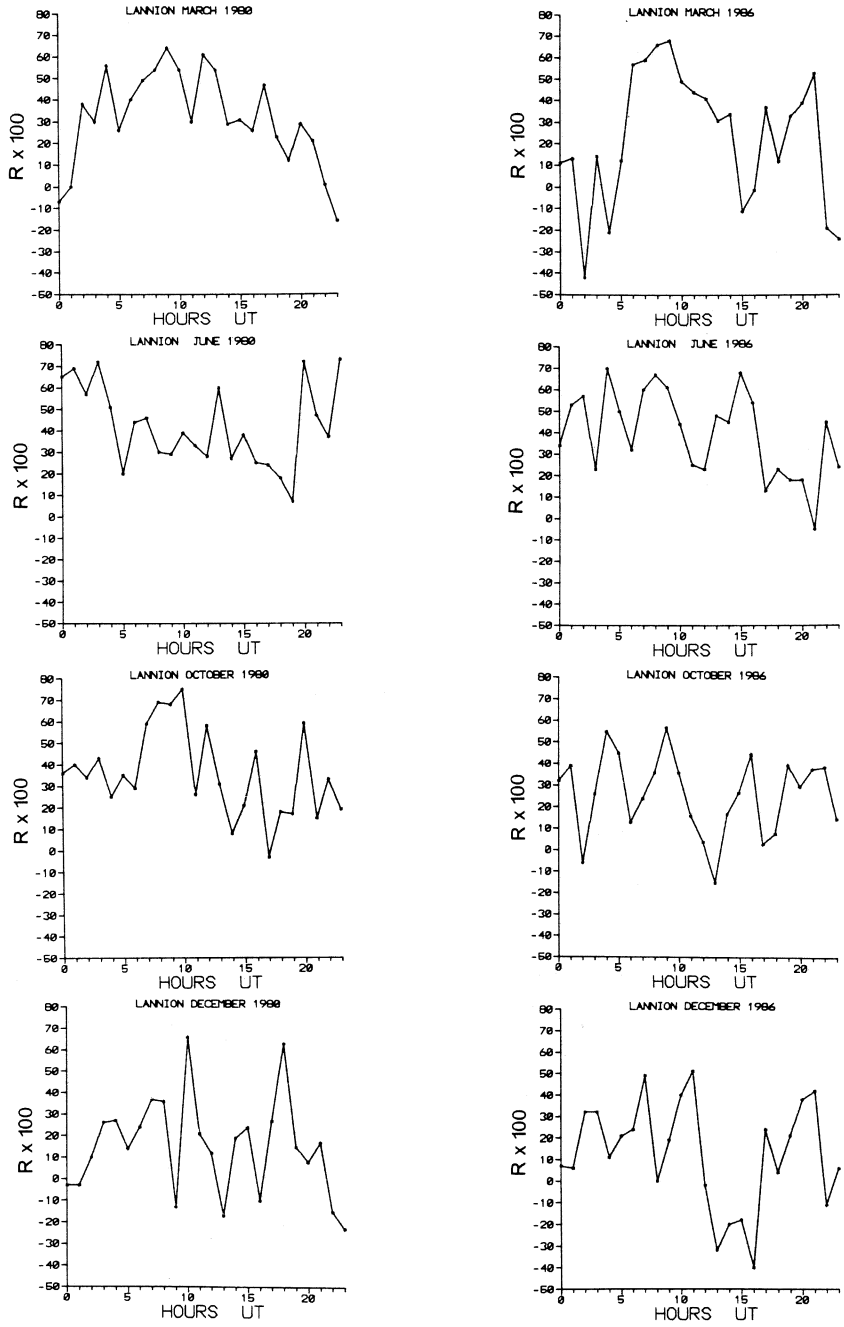

Fig. 1. Correlation coefficients resulting from the regression analysis of hourly daily deviations ΔM and ΔF (monthly variation).

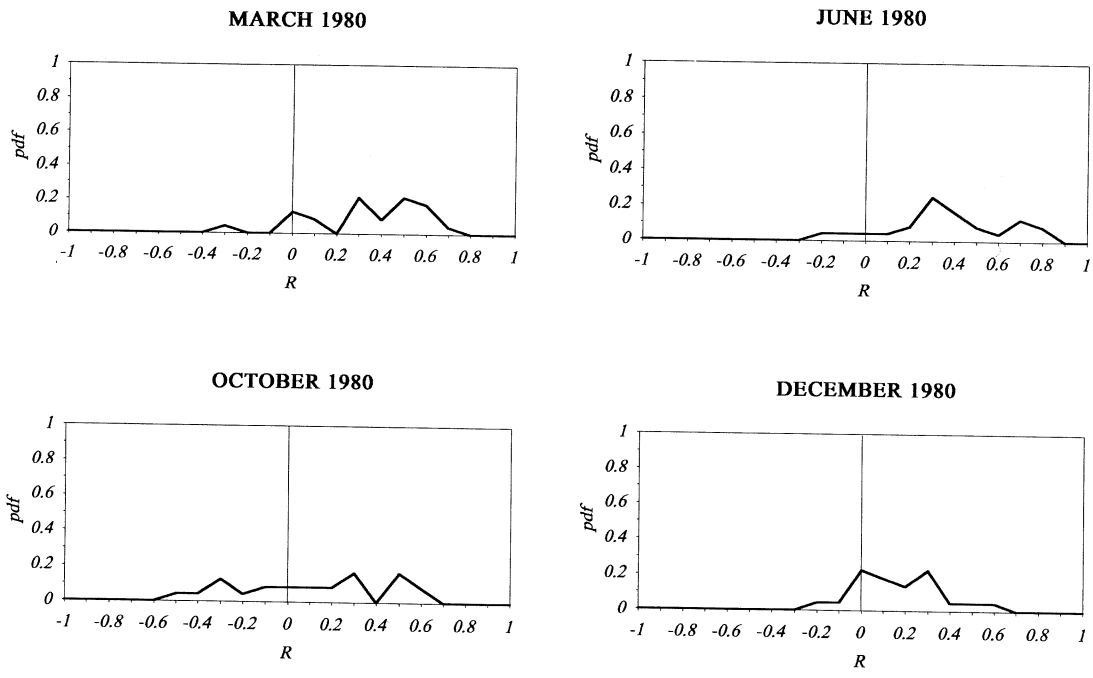

Fig. 2. Distribution of the correlation coefficients of the daily deviations ΔM and ΔF for Slough (1980).

and 1980, and of minimum solar activity 1976 and 1986, and for the four characteristic months March, June, October and December are used in this analysis.

Furthermore, two procedures of analysis are followed: 1) the linear regression eqs. (2.1) and (2.2) are fitted by the method of least squares respectively to the daily deviations ΔM, ΔF and ΔH, ΔF of a given hour of the day throughout a given month and year at a given station (hour-to-hour or monthly variation); and 2) eqs. (2.1) and (2.2) are fitted to the corresponding hourly deviations of each day of a given month and year at a given station (day-to-day variation).

3. Results and discussion

3.1. *Correlation between ΔM and ΔF*

Figure 1 shows the correlation coefficients (R) resulting from the statistical analysis of the deviations ΔM and ΔF of the daily values from the median of a given hour of the day throughout the month (March, June, October and December, respectively) and for the years 1980 and 1986, using data from the station of Lannion (monthly variation). Similarly, fig. 2 illustrates the distribution of the correlation coefficients resulting from the analysis of the hourly daily deviations ΔM and ΔF measured at Slough during the year 1980.

Figure 3 illustrates the correlation coefficients using data from Lannion measured in 1980 and 1986 when the regression analysis is carried out to assess the correlation between the diurnal variation of the hourly ΔM and ΔF for each day of a given month and year (day-to-day variation). The same results are obtained when hourly deviations ΔM and ΔF for each day of a given month and years (1976 and 1979) are compared using data from Slough and from Lannion.

Figures 1 to 3 show that the correlation

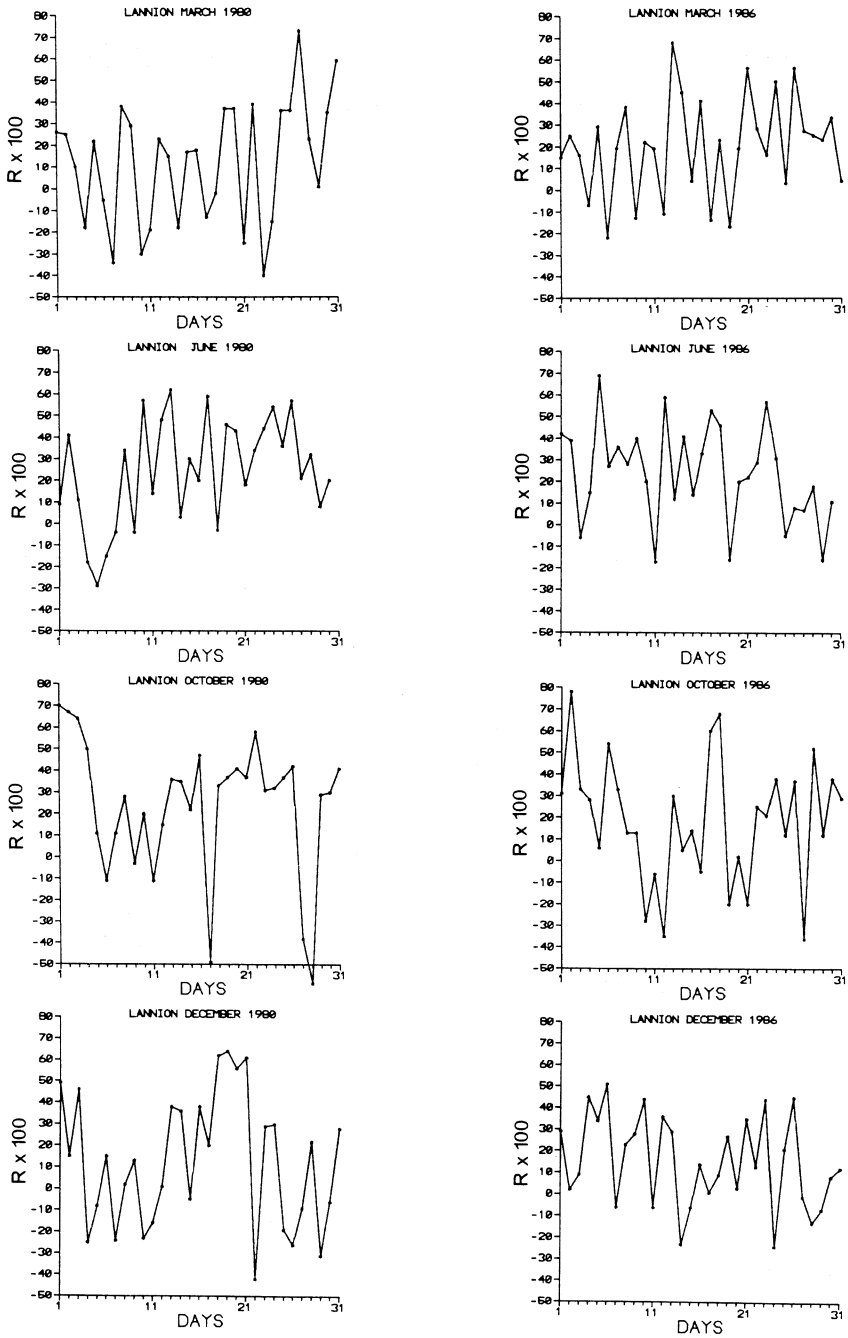

Fig. 3. Correlation coefficients of ΔM and ΔF for each day of a given month and year (day-to-day variation). Data from Lannion.

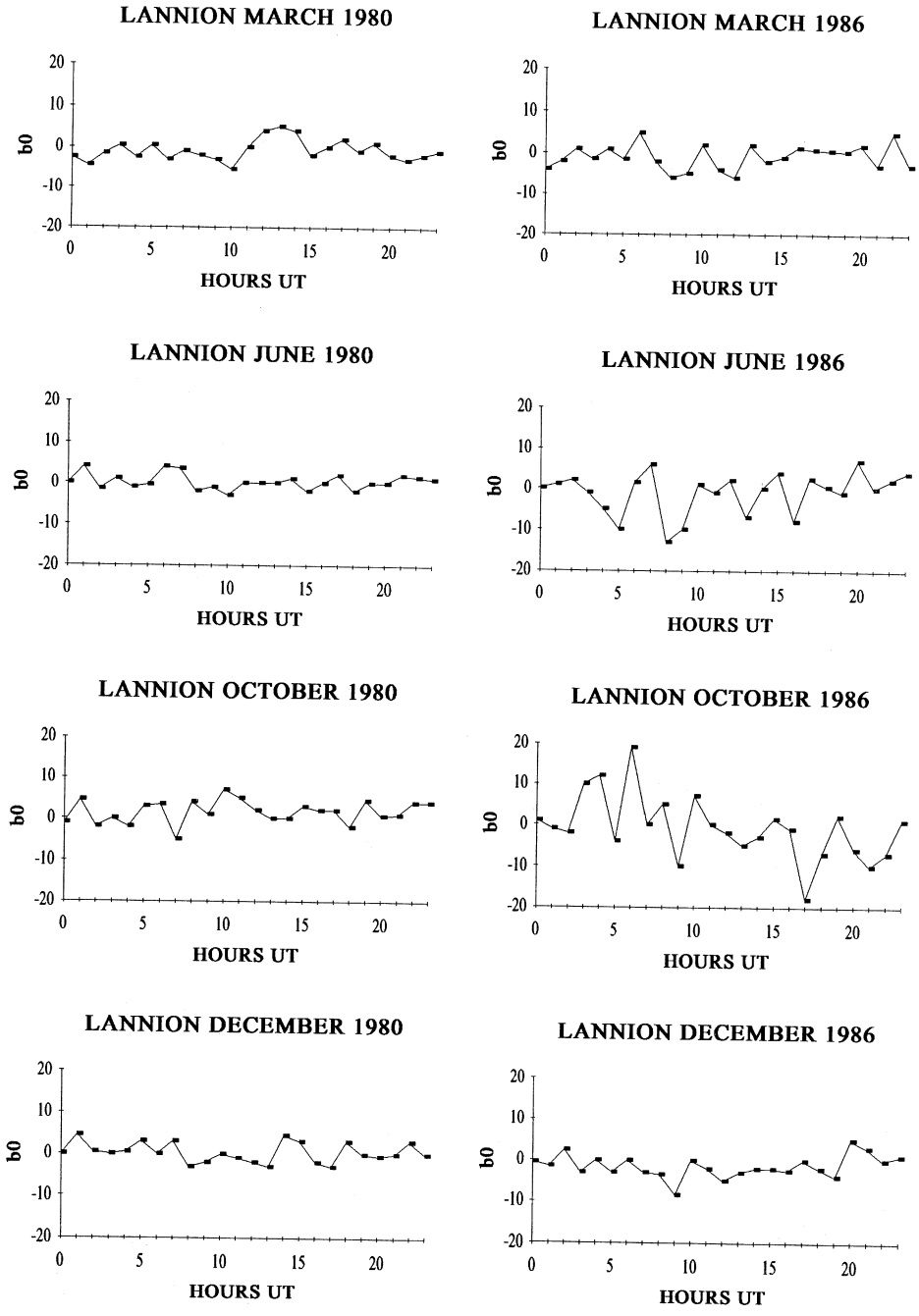

Fig. 4a. Showing the variability of the coefficient b_0 in eq. (2.1). The values b_0 must be multiplied by 10^{-1}.

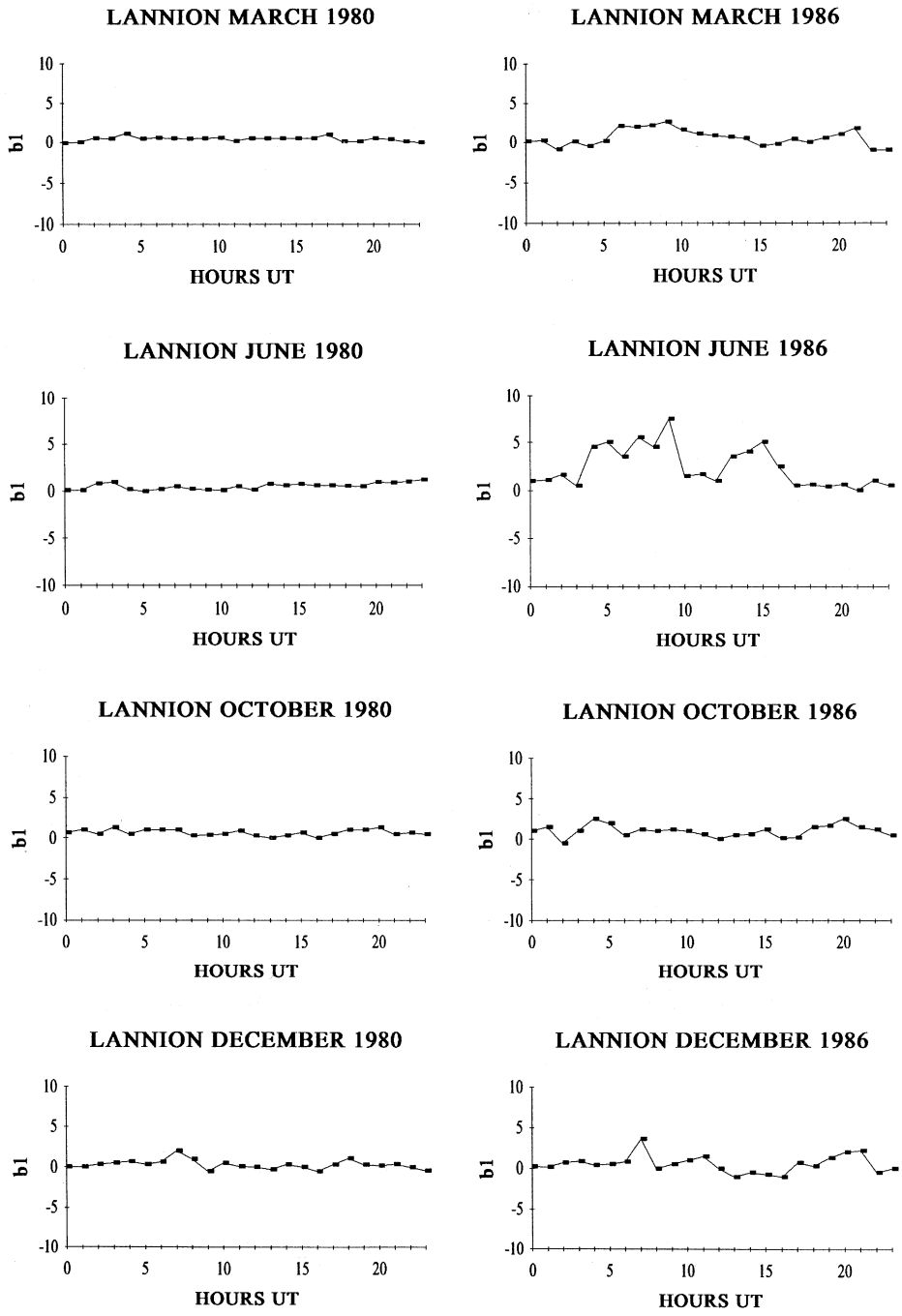

Fig. 4b. Showing the variability of the coefficient b_1 in eq. (2.1). The values b_1 must be multiplied by 10^{-1}.

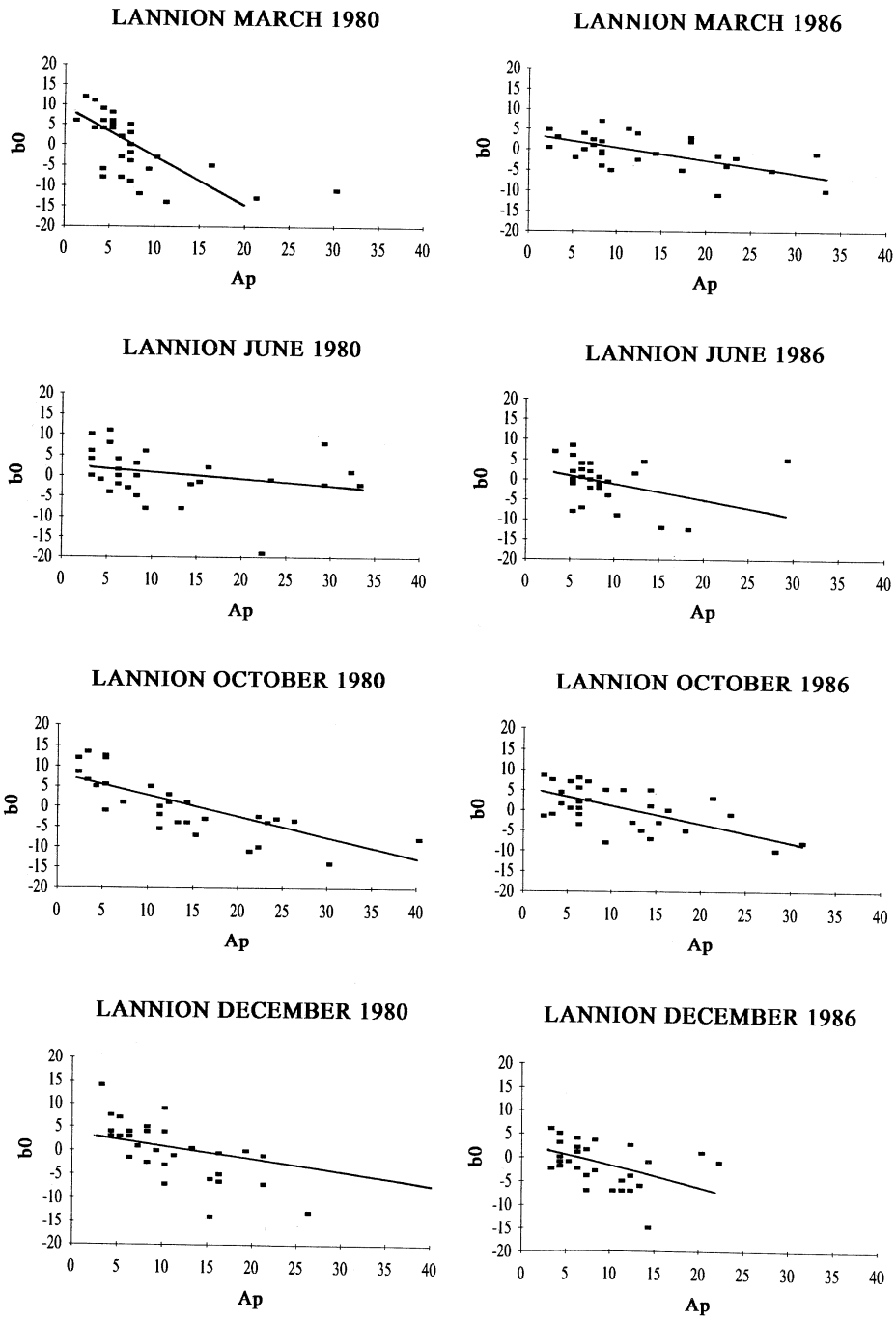

Fig. 5. Regressions of the coefficient b_0 in eq. (2.1) versus the geomagnetic index A_p.

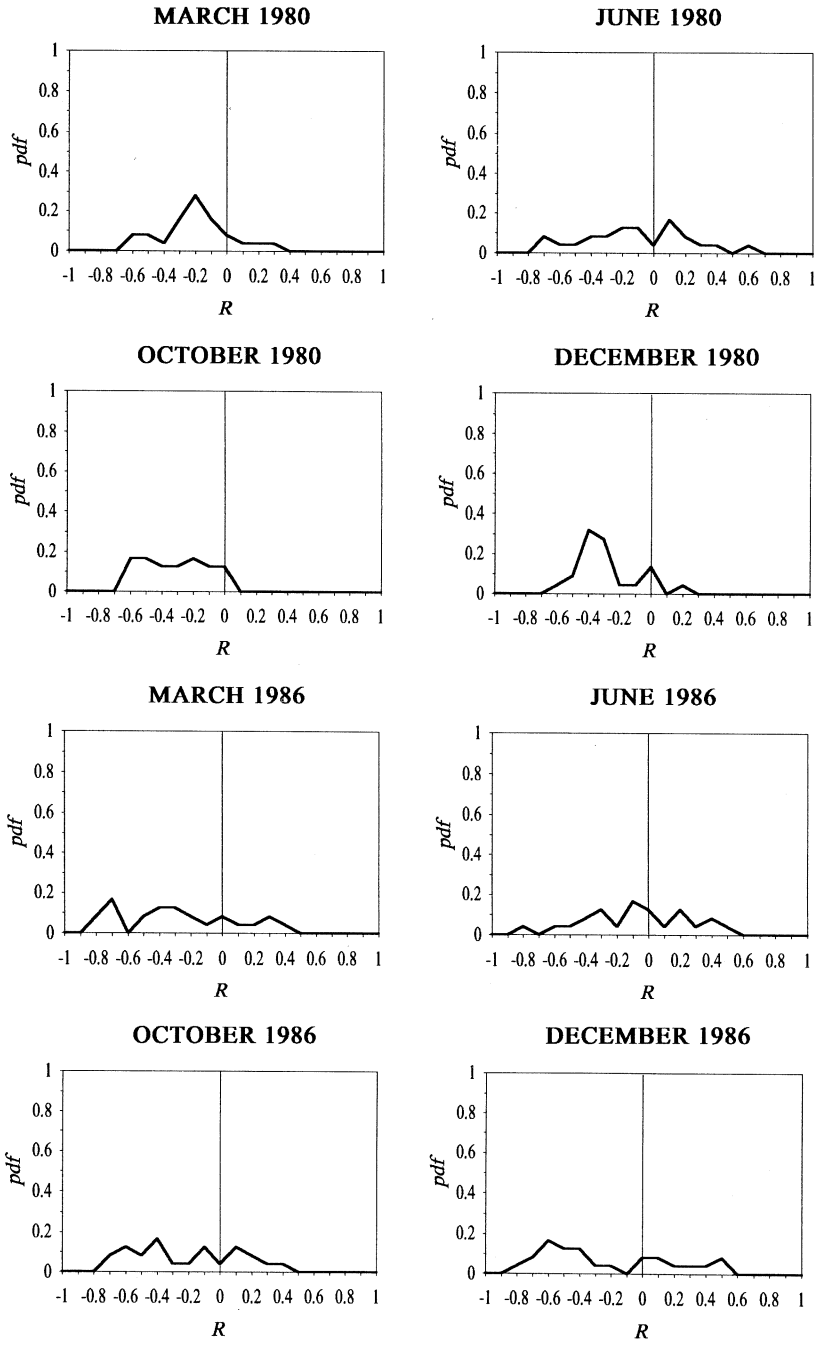

Fig. 6. Distribution of the correlation coefficients resulting from the analysis of daily deviations ΔH and ΔF at a given hour (monthly variation) at Slough (1980, 1986).

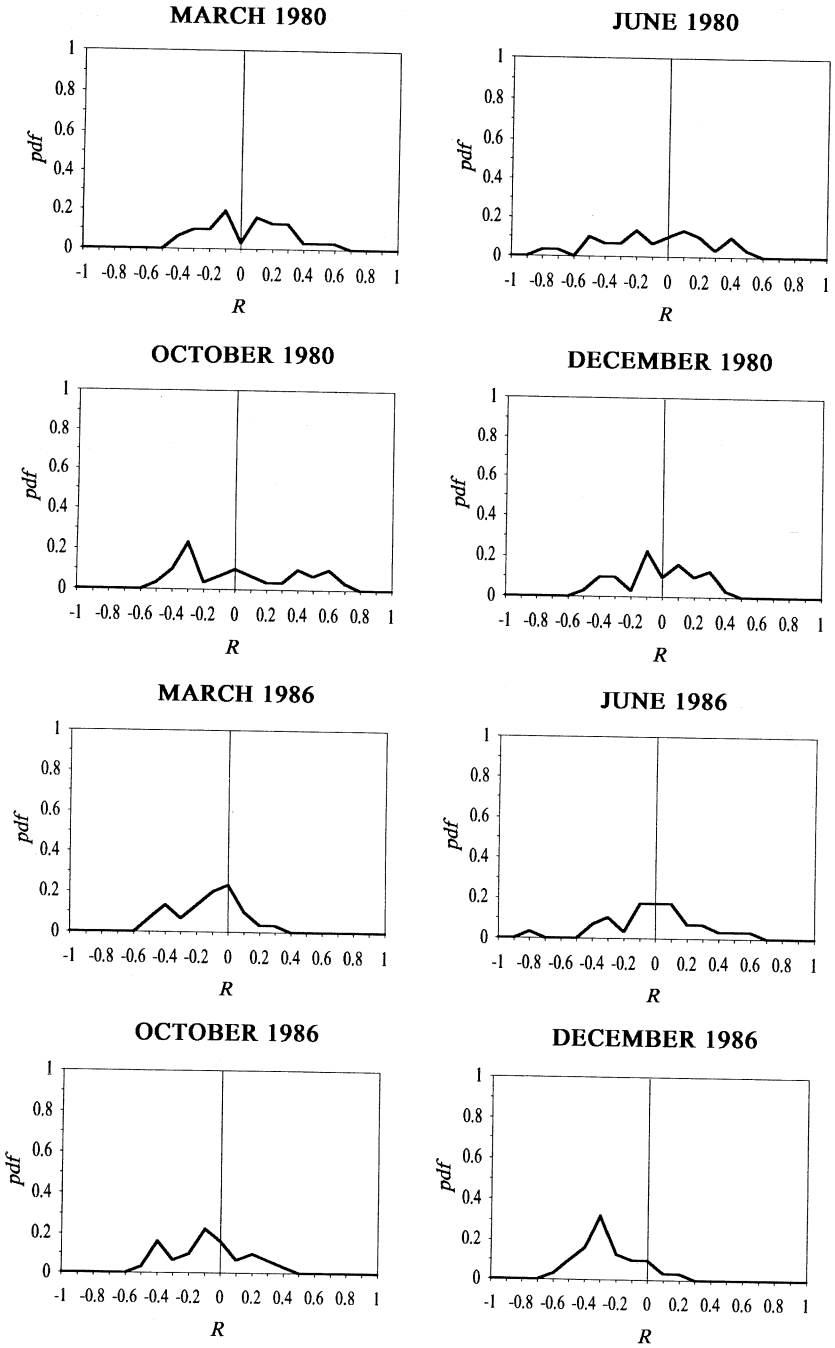

Fig. 7. Distribution of the correlation coefficients of hourly daily deviations ΔH and ΔF in a given day (hour-to-hour variation) of a given month. Slough (1980, 1986).

coefficients are generally lower than 0.60 and could be positive or negative. On the other hand, the coefficients b_0 and b_1 in eq. (2.1) show a high variability within the same month and from month to month and year to year (figs. 4a, b). Their average monthly value, especially that of b_0, is around zero. The obtained results indicate that there is not a close correlation between the hourly daily deviations from the median of $M(3000)F2$ and f_0F2.

Finally, an attempt to correlate the coefficients b_0 and b_1 resulting from the second procedure with the geomagnetic A_p index has revealed that these correlations are rather low (*e.g.* fig. 5). In fact, the correlation coefficient was found to vary between -0.30 and -0.80 for b_0 when correlated with A_p, whereas for b_1 the correlation coefficient was less than 0.4. We may therefore conclude that the relation between ΔM and ΔF is very poor, and consequently further studies are needed to establish a relationship between the daily deviations from the median of $M(3000)F2$ and f_0F2.

3.2. *Correlation between ΔH and ΔF*

Similar results are obtained when the same procedures of regression analysis are

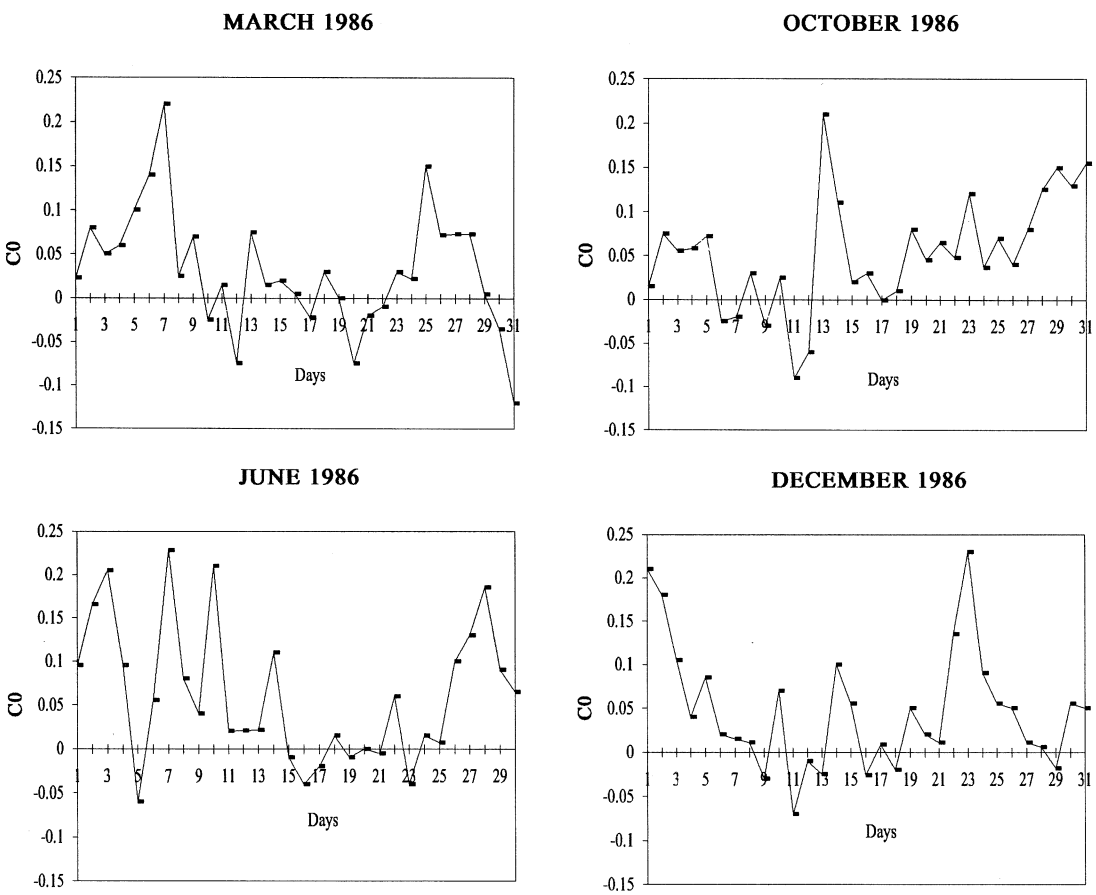

Fig. 8. Plots of the values of the coefficient c_0 in eq. (2.2). Slough (1986).

applied to the daily deviations from the median values of $h'F$ and f_0F2. Examples are given in figs. 6 to 8. Indeed, fig. 6 shows the distribution of the correlation coefficients obtained when the first procedure (monthly variation) is used. Figure 7 shows the distribution of the correlation coefficients obtained following the second procedure (day-to-day variation). It can be seen that the correlation is very poor being negative and positive at random. The coefficients c_0 and c_1 in eq. (2.2) present a high variability. As an example fig. 8 illustrates the distribution of the coefficient c_0 in eq. (2.2) versus the day of the month, for March, June, October and December 1986. It is to be noted that the error on c_0 and c_1 is of the same order of the value of these coefficients. The same is also valid for b_0 and b_1 in eq. (2.1). These results lead to the conclusion that the relation between ΔH and ΔF is very loose and therefore further studies of the variabilities of ΔH and ΔF are needed to investigate this low correlation.

4. Conclusions

The regression analysis between the hourly daily deviations from the corresponding monthly-median values ΔM and ΔF, and ΔH and ΔF, respectively shows that they are poorly correlated. Their correlation can hardly give a satisfactory result, which might indicate a different daily behaviour of these ionospheric characteristics. The question that arises is why this poor correlation between ΔM and ΔF, and between ΔH and ΔF?

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