# A FAST CORRELATION METHOD FOR STUDYING DRIFTING PATTERNS ASSOCIATED WITH IONOSPHERIC IRREGULARITIES*

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The method commonly used in the analysis of drifting patterns associated with ionospheric irregularities is the full-correlation method of Briggs, Phillips, and Shinn (1950, hereafter referred to as BPS). A full-correlation analysis requires lengthy calculations, even on a digital computer, as it involves repetitive calculations and complicated curve-fitting techniques. It is the purpose of this note to show that by extending the BPS analysis, (without making any additional assumptions), the computing time for the correlation method may be reduced considerably.

For simplicity we consider the case of two receivers spaced a distance $Z_0$ parallel to the direction of pattern drift. The first step in the full-correlation method is to compute the autocorrelation function of each spaced receiver record and then the crosscorrelation function. The velocities defined by BPS to describe the pattern drift are then obtained using the time delay $\tau_0$ to the maximum value $\rho_0$ of the crosscorrelation function and the time delay $t_0$ for the mean autocorrelation to fall to the value $\rho_0$. The expressions for the velocities are then (see equations (27) and (28) of BPS)

fading velocity

$$V_c^1 = Z_0/(t_0^2+\tau_0^2)^{\frac{1}{2}}, \tag{1}$$

drift velocity

$$V = Z_0\tau_0/(t_0^2+\tau_0^2), \tag{2}$$

characteristic velocity

$$V_c = Z_0 t_0/(t_0^2+\tau_0^2), \tag{3}$$

apparent velocity

$$V^1 = Z_0/\tau_0, \tag{4}$$

and

$$VV^1 = (V_c^1)^2 = V_c^2+V^2. \tag{5}$$

Expressions (1)–(5) are obtained by considering the geometry of the contour of constant correlation $\rho_0$ in the $Z,\tau$ plane. An extension of the analysis, which uses another contour of constant correlation $\rho_x$ ($< \rho_0$), leads to an equivalent set of expressions:

$$V_c^1 = Z_0/(t_x^2+\tau_x\tau_x^1)^{\frac{1}{2}}, \tag{6}$$

$$V = Z_0(\tau_x+\tau_x^1)/2(t_x^2+\tau_x\tau_x^1), \tag{7}$$

and

$$V^1 = 2Z_0/(\tau_x+\tau_x^1). \tag{8}$$

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The three delays $t_x$, $\tau_x$, and $\tau_x^1$ are defined by a line of constant correlation $\rho_x$ ($< \rho_0$), as shown on the correlograms of Figure 1. This line cuts the mean autocorrelation function at the delay $t_x$, and the crosscorrelation function at the delays $\tau_x$ and $\tau_x^1$.

A fourth-order polynomial fit to the *peak* of the crosscorrelation function is desirable in the full-correlation method if an accurate estimate of $\tau_0$ is to be obtained (Briggs 1968). If, however, a line of constant correlation is chosen which cuts the correlograms where they are approximately linear, then linear interpolation is satisfactory for estimating the delays $t_x$, $\tau_x$, and $\tau_x^1$. Expressions (5)–(8) may then be used to calculate the velocities. This method, which we have called the *three-delays method*, is the basis of a computer program applied to five digitized records of satellite scintillation taken at spaced receivers. (The receivers were aligned parallel to the subsatellite track, thus reducing the problem to one dimension.) Velocity calculations from the three-delays program and the full-correlation program yielded values differing typically by no more than a few per cent for $V_c^1$, $V$, and $V^1$ and up to about 20% for $V_c$. In all cases the three-delays method required less than 40% of the computing time of the full-correlation method as we applied it.

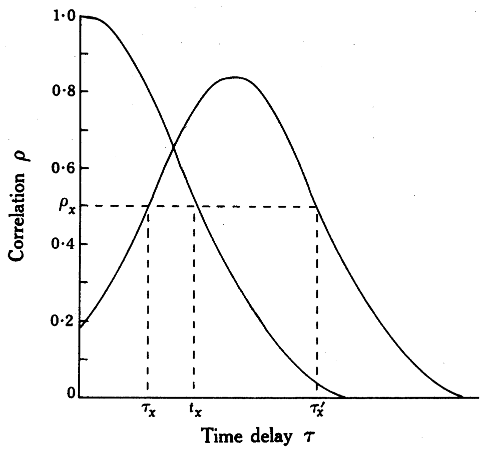


Fig. 1.—Correlograms showing the delays required for a three-delays analysis.

The full-correlation method program calculated the values of the autocorrelation and crosscorrelation functions for all delays out to a maximum chosen to display the peak of the crosscorrelogram. The time saving in the three-delays method program was achieved by:

(1) using logical procedures to limit calculations of the autocorrelation and crosscorrelation functions to the region about a predetermined value of $\rho_x$ and

(2) selecting $\rho_x$ so that linear interpolation could be used to obtain accurate estimates of the delays $t_x$, $\tau_x$, and $\tau_x^1$.

Limitations on the method are:

(1) Some idea of the expected maximum value of the crosscorrelation function is required so that a suitable level of constant correlation may be chosen. (In the above analysis $\rho_x = 0\cdot 5$ was found to be suitable.)

(2) $V_c$ is calculated using equation (5). Small errors in $V$ and $V^1$ produce large errors in $V_c$.

Flow charts, and an ALGOL listing of the three-delays method program are available from the authors on request.

*References*

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