Dispersion in Ionospheric Drift—Comparison of Filter Method with Cross-spectral Method

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Spaced fading records obtained at Tiruchirapalli are analyzed by filtering the data employing low pass and high pass filters with varying cut-off frequencies and the variation of the apparent and true drift velocities with fading frequency obtained by full-correlation analysis studied. The variation of the apparent drift velocity obtained is similar to that obtained from cross-spectral method.

Amplitude fluctuations of the radio waves reflected/scattered from the ionosphere or propagating through the ionosphere are commonly used to study the movement of ionization irregularities in the ionosphere. Fluctuations recorded at spaced receivers at ground are usually analyzed either by the similar fade method which gives the apparent drift velocity or by the full-correlation analysis which determines both the apparent and the true drift velocities. A new approach to analyze such records was followed by Jones and Maude who applied cross-spectral analysis to fading records and obtained apparent drift velocities at different fading frequencies. The method was developed essentially to find the presence of wave motions. It has been argued, however, that there could be an apparent dispersion noted due to other reasons also like variation in velocity or the presence of vertical velocity gradients. A common feature of the results obtained using this method reported by different workers is an increase in velocity with fading frequency noted in about 25% of cases. The true drift velocity at different fading frequencies can also be found by filtering the fading records before subjecting to full-correlation analysis and thus select amplitude fluctuations at a particular fading frequency. Sprenger and Schminder first used this method and reported true drift velocity to increase with the cut-off frequency of the high pass filters used, the apparent drift velocity remaining independent of filtering. Chandra and Briggs found the true drift velocity to increase with high pass filtering and to decrease with low pass filtering. They also showed mathematically that filtering beyond a certain limit (typical cut-off of 1 Hz for ionospheric conditions) would change the true drift velocity which should not be taken as an evidence of dispersion. The apparent drift velocity was found independent of the filtering unless there is dispersion. Therefore, a change in apparent drift velocity only would imply dispersion. Comparative study of the two methods to study dispersion in ionospheric drift motions is the prime motivation of this study. Results of an investigation where a large number of fading records obtained at Tiruchirapalli were subjected to both cross-spectral analysis and the filter method to see the variation of the velocities with fading frequency, are presented in this communication.

Ionospheric drift measurements over Tiruchirapalli were started in October 1972 using spaced-receiver method. The experimental arrangement has been described in an earlier paper. Cross-spectral analysis was applied to about 600 observations and the variation of the apparent drift velocity with fading frequency studied. Both E and F region records showed a similar trend of results with about 25% of cases showing velocity independent of the fading frequency and in nearly same number of cases velocity increasing with fading frequency. Cases of velocity decreasing with fading frequency was noted in about 10% of cases only and the remaining of about 40% of cases showed no consistent variation of velocity with the fading frequency. Due to this reason no distinction has been made in the E or F region records. Further, in a comparison of the results of the cross-spectral method with filter method it is not going to influence the outcome of the comparison. Based on these results the fading records were grouped according to the presence or absence of dispersion. In all about a quarter of the records showed a positive dispersion while nearly same amount of records showed velocity independent of the fading frequency. The rest of records essentially showed no consistent variation. The cases which showed positive dispersion or no dispersion (velocity independent of fading frequency) have been subjected to low pass and high pass filters with varying cut-off frequency to study variation of the apparent and true drift velocities with fading.
Fig. 1—Variation of the apparent and true drift velocities with fading frequency determined by the correlation analysis using various low-pass and high-pass filters

Fig. 2—Variation of the apparent and true drift velocities with fading frequency determined by correlation analysis using low-pass and high-pass filters

Frequency. Rectangular (running mean type) filters have been used with cut-off frequency (inverse of the filter width) of the high pass filters 0.5, 1, 2, 4 and 8 Hz and 0.125, 0.25, 0.5, 1 and 2 Hz for the low pass filters.

The variations of the apparent and true drift velocities with fading frequency for the records which showed velocity independent of fading frequency by cross-spectral methods are shown in Fig. 1. Both low pass and high pass filter results are shown in Fig. 1 along with the velocities for unfiltered data. The apparent drift velocity remains independent of fading frequency by the filter method also. The true drift velocity shows changes with filtering as expected theoretically. Similar results for the cases when the velocity increased with fading frequency as determined by cross-spectral method are shown in Fig. 2. In this case, apparent drift velocity increased with high pass filtering and decreased with low pass filtering. The change in the true drift velocity remains as in the first case and again this variation arises due to filtering and does not represent dispersion. Thus the results obtained by the cross-spectrum method and by correlation analysis using filters on the variation of the apparent drift velocity with fading frequency are in agreement qualitatively. No quantitative comparison has been done at this stage; however, it is suggested that such comparison must be done using band pass filters rather than the low pass or high pass filters used here.

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References