Diurnal & Seasonal Variations in the Duty Cycle of Meteor Forward Scatter Communication

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Diurnal and seasonal variations in the duty cycle of vhf (48-2 MHz) radio wave propagation, due to meteor forward scatter, between Dehra Dun and Waltair (distance 1760 km) have been studied. The diurnal variation is found to be sinusoidal with maximum at 0600 and minimum at 1800 hrs LT, as is expected from the apex and antapex effects on meteor activity. The seasonal variation shows a minimum around February and a general increase thereafter. The contribution to the duty cycle is found to be mostly from the under-dense meteor echoes. The most favourable time for communication in this link is found to be 0400-0800 hrs LT every day.

1. Introduction

It is well known that, when a meteoroid enters the earth's atmosphere at high velocity a portion of the kinetic energy is expended in creating large number of ions along the path of the meteor. This long thin column of ions rapidly expands and diffuses and is distorted by winds of the ionosphere until it eventually disappears. This meteoric ionization may serve as a radio target and it makes possible a new method of studying both the astronomical properties of meteors and the physical conditions of the upper atmosphere. Some aspects of the scattering of radio waves by meteor trails have been studied in the past, by Lovell [back-scatter (radar) case], McKinley and Millman and Manning. The study of radio meteors using forward scatter system has been carried out by a number of workers.

In this paper, the results of the duty cycle analysis obtained from the meteor echo rates, observed on a forward scatter link between Dehra Dun and Waltair for a 12-month period (Dec. 1974-Nov. 1975), are reported.

2. Experimental Set-up

The CW transmissions on 48-2 MHz and 200 W power from Dehra Dun are received at Waltair at a distance of 1760 km by way of meteor forward scatter. Six-element Yagi antennas with 10 dB gain are used at both transmitting and receiving ends and pointing towards the meteoric region at a height of 100 km above the ground midway between Dehra Dun and Waltair. The design details of 48-2 MHz forward scatter meteor radar equipment used in this circuit are already published (Rao et al.). Forward scatter meteor echoes are recorded using a Brush recorder on a continuous basis round the clock, during the second half-hour of every hour using an automatic timer arrangement. Results of the study of meteors obtained over this path during the Geminid shower period (Rao et al.) and during the Quadrantid shower period (Rao et al.) have already been published.

3. Observations and Analysis

The method of analysis of the forward scatter meteor records has already been published in our earlier paper by Rao et al. From the data the total number of meteor echoes recorded in each of the echo duration ranges of 0-1, 1-2, 2-3, 3-4, 4-5, 5-10, 10-15, 15-20, 20-25, 25-30 sec and those greater than 30 sec during the half-hour periods of recording, are obtained. Now the integrated duration of these echoes is \( \sum N_i T_i \) where \( N_i \) is the number of echoes with average duration \( T_i \) in any range of duration.
We now define the duty cycle \(d\) as the fraction of the total observing time during which meteor signals are received above the arbitrary power level. So \(d = \Sigma N_i T_i / T\), where \(T\) is the total duration for which the transmitter is on (McKinley\(^{11}\)).

### 3.1. Diurnal Variation

The duty cycle values thus obtained at different times of day are noted every day. The corresponding values for each time of observation every day have been averaged to get the average diurnal variation of the monthly values. The average diurnal variation curves of duty cycle for all the 12 months are shown in Fig.1. The average diurnal variation of duty cycle for the whole year is shown in Fig.2. The most common feature observed in all these curves is that they exhibit a general sinusoidal trend with a maximum value around 0600 hrs LT as is expected from the apex concentration of meteors and minimum around 1800 hrs LT as is expected from the antapex effect. It is further known that the meteors recorded correspond mostly to underdense echoes, the long duration echoes being very small in number. Hence it may be concluded that the duty cycle for communication of vhf radio waves by meteor forward scatter is mostly contributed by underdense meteor echoes. It is found from a comparison of this curve with that of radio meteor activity that the duty cycle variation does not show the post-sunrise steep fall as in the case of meteor activity (Rao et al.\(^{12}\)). The fall in the meteor activity around 0800 hrs LT has been explained as due to rise in the D-region absorption due to rapid production of \(O^+\) ionization after sunrise. The absence of this fall in the duty cycle curve has been found to be caused by rapid rise in the frequency occurrence of long duration echoes after sunrise (unpublished data). Although the underdense trails are few in number compared with the underdense trails, their contribution to the integrated echo duration may be so much as to compensate for the reduction in number of the underdense trails due to increased absorption around 0800 hrs LT. It is found that the most favourable time of the day for communication of signals by way of meteors is the period between 0400 and 0800 hrs LT every day. The average duty cycle obtained for this meteor forward scatter communication is of the order of 8%.

### 3.2 Seasonal Variation

Fig.3 shows the seasonal variation in the monthly average duty cycle together with those of maximum and minimum observed values of duty cycle in the monthly average diurnal variation curves. The seasonal variation in duty cycle shows that it is maximum in December and minimum in February with a secondary maximum in September. The general trend of increase in duty cycle from the earlier part of the year to the later part of the year is, in general, similar to that of radio meteor activity as shown in Fig.3. This indicates that the variation of duty cycle depends mostly upon the rate of influx of meteor activity. The maximum observed values of duty cycle during each month show similar variations as the monthly
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4. Conclusion

It is found that the average duty cycle for meteor forward scatter communication between Dehra Dun and Waltair is of the order of 8%. The most favourable period for such communication is found to be between 0400 and 0800 hrs LT. The average duty cycle during this time of the day is 11%. On the whole, this type of communication system may be said to be unreliable from the communication angle where reliable message transmission is important, because of the low percentage of duty cycle involved.

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