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Tropospheric Scatter Propagation Measurements Beyond the Horizon in Arid Zone—A Note

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Abstract. Tropospheric scatter study beyond the horizon radio link presently necessitates tests to establish the median path loss and to determine the magnitude and duration of the path loss variations. The average basic transmission loss of the scattered component, L_{bs}, can be found if K (ratio of r.m.s. value of scattered and constant component) and the resultant basic transmission loss L_{bm}, are known. This paper also deals with the diurnal and seasonal behaviour of signal strength, based on the analysis of about ten months recording on a C band Troposcatter Link between Pilani and Delhi.

1. Introduction

The primary purpose of this paper is to predict some significant parameters of tropospheric scatter propagation based on the experimental results of observation of nine months duration recorded at Pilani. This troposcatter link has been established between Indian Institute of Technology (IIT), Delhi and Central Electronics Engineering Research Institute (CEERI), Pilani. The great circle path length between Delhi and Pilani is about 158 km. The terrain is typical in the sense that most of the path towards Pilani is almost desert while it is rocky and inhabited towards the Delhi end. The path profile is having two obstacles, one is 400 metre high and 47 km from Pilani and the other is 277.6 metre high and at about 2.8 km from Delhi end. The hypothesis on which the analysis of these measurements was based is that the received field consists of a constant component and a scattered component. The purpose of the analysis was to determine the relative magnitude of these two components in terms of K, where K is the ratio in decibels of the root mean square amplitude of the constant component. The existence of diurnal variations is believed to be due to changes occurring in the characteristics of the lower atmosphere, the most important meteorological factors being temperature and humidity which along with pressure, determine the refractive index of the atmosphere.

The diurnal nature of these variation is due to the nightly formation and subsequent dispersal of ground based or elevated inversion layers promoted by the cooling of heated ground by radiation. The seasonal change at any particular location is almost entirely due to the seasonal change in temperature and relative humidity. Since very little experimental work has been done in arid zone, the experimental studies on short range Delhi-Pilani tropo link in arid zone is of great interest. The data were recorded at chart speed of 30 cm per minute on Rekadenki chart recorder.

Tropospheric wave propagation is strongly influenced by factors such as turbulent velocities. Temperature fluctuations and refractive index variations. The presented results of the correlation between the received signal variations and meteorological parameters is helpful in characterising the channel and conversely, a knowledge of the propagation conditions can be useful in defence applications.

2. Median Path Attenuation

The advantages of the concept of Transmission Loss in describing the characteristics of radio wave propagation have been discussed.[1,2] Median path attenuation is defined as

$$L_{bm} = L_b - R(0.5)$$

where L_b is basic transmission loss and $R(0.5)$ is the signal level in *dB* exceeding 50% of time. The median path attenuation L_{bm} varies with the time of day, day of month and the period of the year. Fig. 1 presents the mean of hourly median path attenuation for each hour of the day. The shape of such curves should be accepted with some reserve however, although they present a true summary of measurements made. Fig. 2 shows the mean of the hourly median path attenuation of the day for two months of extreme climates. Analysis of these measurements are based on the concept that the received signal consists of a constant component and a scattered component. Here the constant component is the resultant of direct and ground reflected waves, while the scattered component is the resultant of the scattered vectors associated with these two waves. The present analysis is to determine the

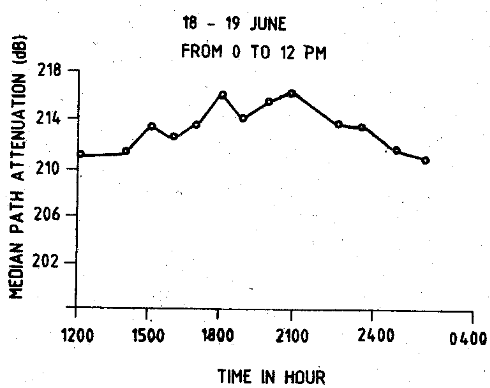

Figure 1. Diurnal variation of median path attenuation.

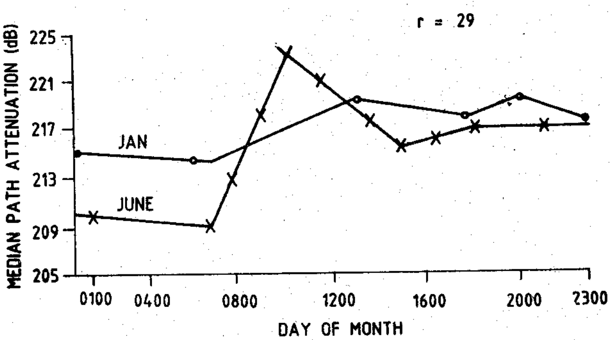

Figure 2. Diurnal variation of median path attenuation for extreme climates.

relative magnitude of the two components in terms of K. The procedure was to determine, from the distribution of instantaneous field intensity levels (or from fading range), the corresponding value of K. Fading range is defined as the ratio in dB of the amplitudes exceeded 10% and 90% of the time interval being analysed.

According to Norton[1], the relationship between fading range and K is given approximately by

$$R(0.1) - R(0.9) = 22.2628\,K + 12.188\,k\ 3$$

Where $K = 20 \log k$, and $R(0.1) - R(0.9)$ is the fading range.

This relation was used to obtain K from the fading range, measured at Pilani as shown in Fig. 3. Number of fades N is defined as the number of times per minute that the field strength trace level crosses the median level with the positive slope. The median of all the one minute values of the three quantities L_{bm}, K and N were determined for each hour of the day and the variation with time is shown in Fig. 4. These curves are presented to illustrate some rather persistent diurnal trends of data in the arid zone. During the noon, L_{bm} follows the familiar pattern of low median path attenuation.

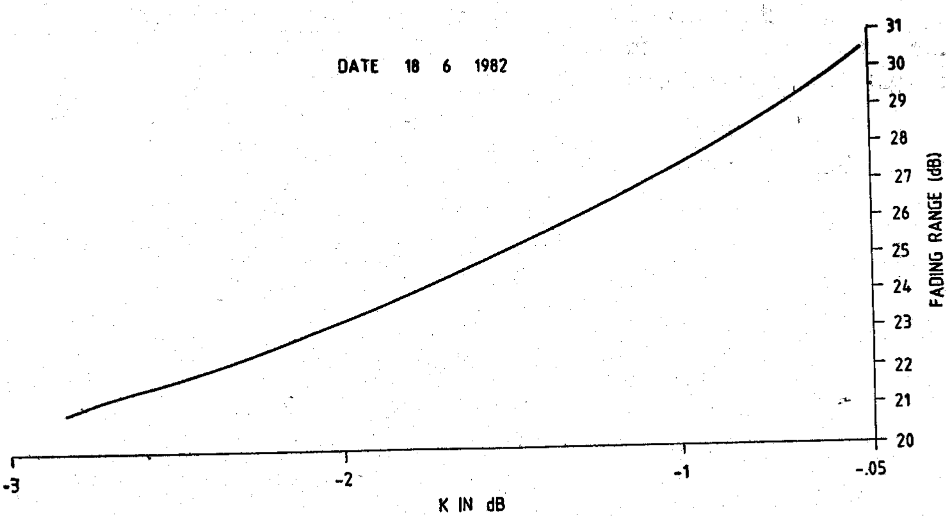

Figure 3. Variation of K with fading range.

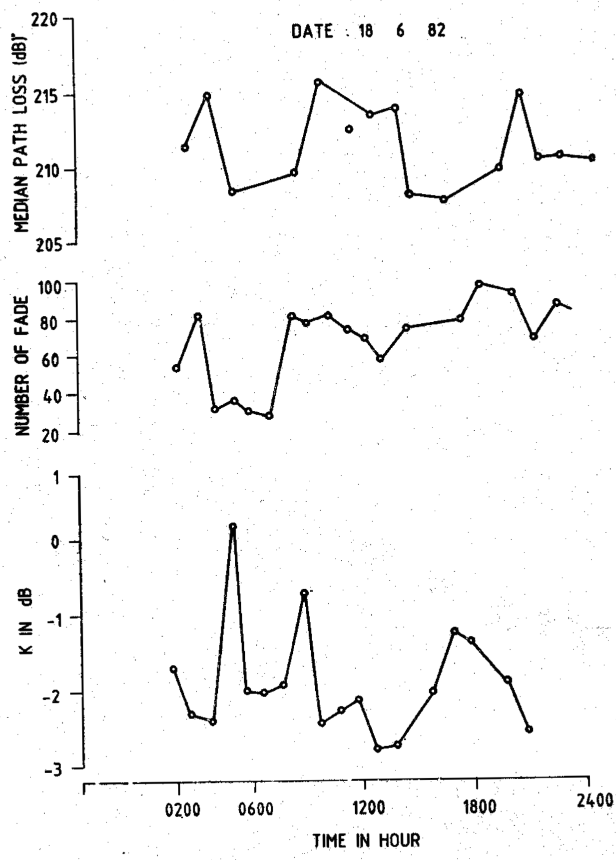

Figure 4. Diurnal variation of L_{bm}, K and number of fades.

Similarly in the early morning hours and in the afternoon, there is a definite build up in K i.e. in the scattered components of the received field. There is a substantial decrease in number of fades during early morning hour at about the same time that the path attenuation is less.

If K and L_{bm} are known, the average basic transmission loss for the scattered component L_{bas} can be determined by using the relation,

$$L_{bas} = L_{bm} + R\,(0.5) - K$$

Fig. 5 gives the comparative results of free space loss,

L_{bm} and L_{bas},

Fig. 6 shows the diurnal variation of path attenuation and refractive index. For the hourly mean values, a correlation coefficient 0.31 is found between NS and path attenuation.

Fig. 7 shows the seasonal behaviour of path attenuation. It is observed that in the summer season when the refractive index is more the path attenuation is less. For

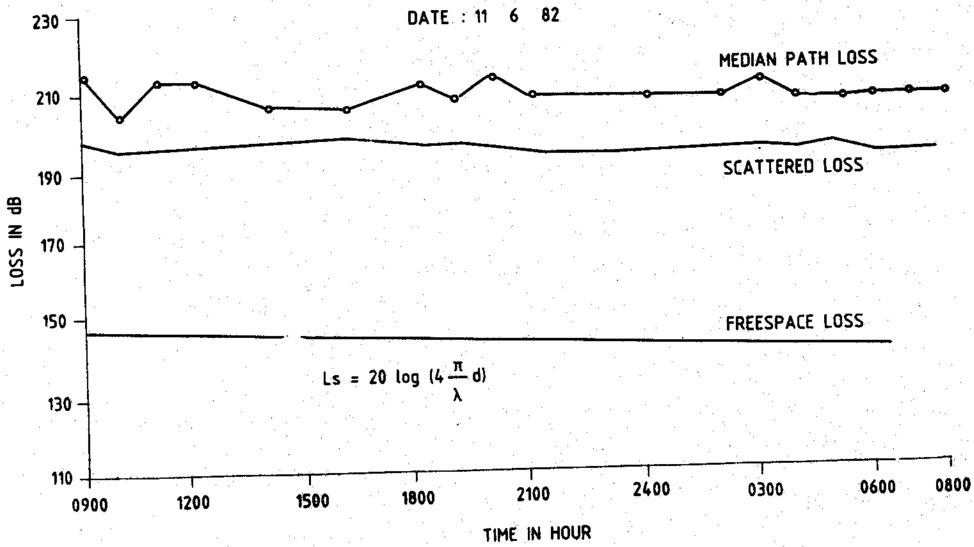

Figure 5. Comparative performance.

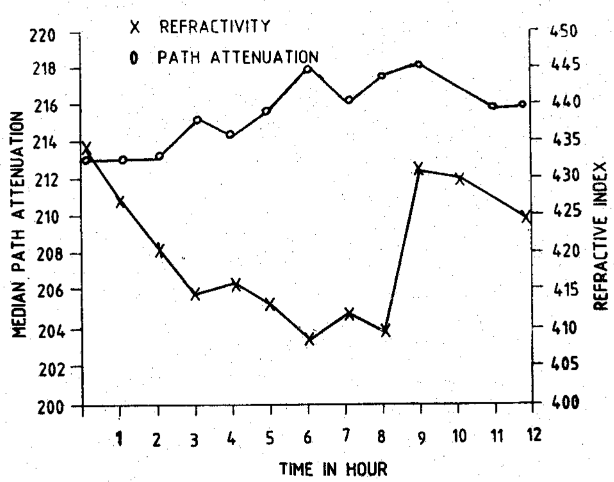

Figure 6. Diurnal variation of path attenuation.

the monthly mean values, a correlation coefficient 0.89 is obtained between *NS* and path attenuation. It shows a close correlation.

3. Conclusion

The measured fields are assumed to be the resultant of two field components. The cumulative distribution of median path attenuation with different time samples follows Rayleigh distribution and the variation of path attenuation is about 2 *dB* during the day. Variations of median path loss *K* and number of fades illustrated some diurnal trends of data in arid zone. It is interesting to note that there is a substantial decrease in fade numbers during early morning hours, when the path loss is less.

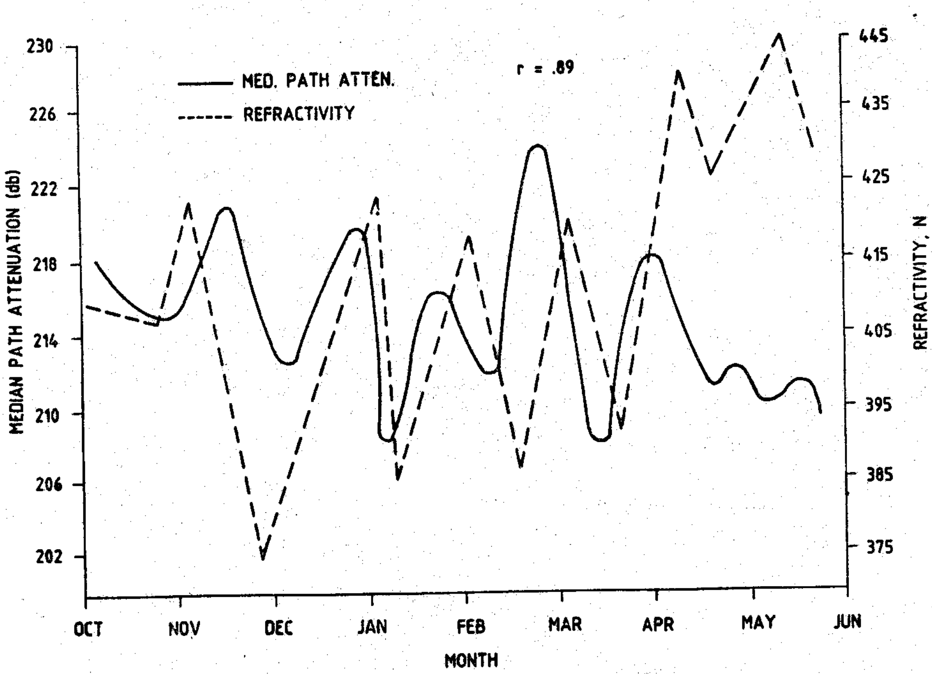

Figure 7. Seasonal variation of path attenuation.

It may be concluded from Fig. 6, that in the noon time, when the refractive index is highest, more bending occurs and therefore the received power is more and path attenuation is less. For the monthly mean values, a close correlation is observed between surface refractivity and path attenuation.

References

1. Norton, K. A., *Proc. IRE*, **41** (1953), 146–152.
2. Norton, K. A., *Proc. IRE*, **43** (1955), 1341–1368.