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The ionospheric absorption at Gauhati

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Abstract. Some problems encountered in the process of estimation of calibration constant I_0h_0 have been discussed. The discrepancies observed in the I_0h_0 value determined by different methods were found to be mostly due to focussing. The difference observed between noontime values of absorption measured from different order echoes could be removed by a correction factor found after Piggot. But in certain cases the discrepancy in the reflection characteristics of single and multiple echoes were such that this correction factor did not give a consistent value. Such changes might be linked with sporadic E.

Keywords. Calibration constant; reflection coefficient; single and multiple echoes; fading characteristics; sporadic E.

1. Introduction

The propagation of radio waves in the ionosphere is subject to a great deal of control by a number of non-dissipative phenomena. Therefore, in order to select a method suitable for measuring absorption at a particular station, the effects of non-dissipative phenomena on absorption should be studied.

It is well known that two standard methods are generally used for measuring absorption by A_1 technique, *i.e.*, (1) from the study of time variation of amplitude of a single echo, (2) from the study of amplitude of multiple echoes. The standard equation for absorption measurement gives,

$$I_1h' = \rho I_0h_0 \tag{1}$$

and

$$L = 20 \log \rho \text{ (db)} \tag{2}$$

where the symbols have the usual meaning. The reflection coefficient measured from the study of the variation of amplitude of a single echo is given by,

$$\rho_{10} = (I_1h')/(I_0h_0) \tag{3}$$

and for multiple reflections of r-th order,

$$rh'\, I_r = \rho^r\, \rho_g^{r-1}\, h_0 I_0 \tag{4}$$

giving,

$$\rho_{21} = 2I_2/I_1\rho_g, \; r = 2 \tag{5}$$

and

$$\rho_{20} = (2h' \, I_2/\rho_g \, h_0 I_0)^{1/2} \tag{6}$$

2. Observations

Routine ionospheric observations were taken from 1971 to 1975 with a transmitter of peak power of at least 10 kW. For the measurement of ionospheric absorption the calibration constant $I_0 h_0$ must be determined, and it should be made during the period of minimum occurrence of non-dissipative phenomena and when absorption is minimum.

The effects of phenomena such as scattering from large-scale irregularities reflection from partially reflected E_s layer, focussing effects due to the tilts in the ionosphere, had been studied by large number of workers, namely, Piggot (1953, 1960), Baired (1954), Sastry *et al* (1970), Pillet (1961), Benkova (1965), Ganguly and Rao (1970) and others.

For the determination of calibration constant at this station the data were first screened for sporadic events and for proximity of critical frequency of layers, etc. To assess the period of minimum occurrence of the remaining phenomena, a plot of percentage fluctuations of a signal strength from grand mean with time was drawn (figure 1) expressing the strength as $(1/n) \sum_1^n (d\bar{x}/\bar{x})$, where $\bar{x}$ is the average of signal strength, $d\bar{x}$ is the magnitude of deviation from grand mean and n is the number of observations. This plot at once reveals a large percentage of fluctuations during the afternoon and a minimum after three to four hours of ground sunset.

After getting an idea of the period of minimum occurrence of the phenomena, the calibration constant was evaluated from the study of amplitudes of single echo and multiple echoes at 4 MHz. A discrepancy was noticed in the result

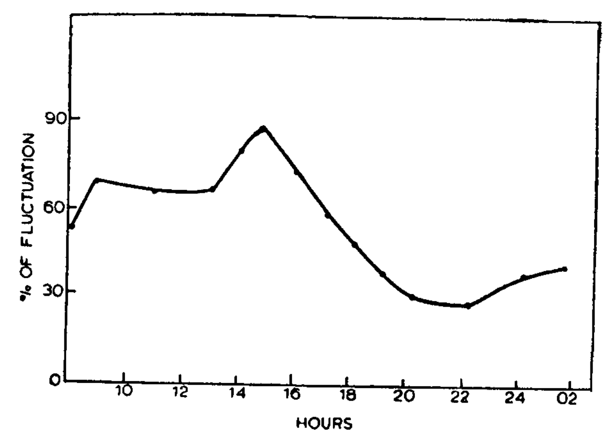

Figure 1. Plot of percentage of fluctuation of signal strength from grand mean with time.

which might be due to the focussing effect still present in the observed amplitude. Assuming that the cases of $\rho > 1$ were due to focussing as shown by Benkova (1965), Mitra and Rakshit (1933) and others, the data were screened by eliminating all the cases where ρ was found greater than unity. The percentage of occurrence of these cases in a typical set of data given in table 1 was carried out and is shown in the extreme right hand column of the table. Table 2 gives the values of I_0h_0 obtained after eliminating the cases of $\rho > 1$ and it will be seen that both the methods yield consistent result.

The constant value of I_0h_0 thus obtained was then used to evaluate reflection coefficients ρ_{10}, ρ_{20} for different periods and ρ_{21} was calculated from eq. (5) for the same periods. A systematic difference in the noontime values of ρ_{10}, ρ_{20} and ρ_{21} was still observed. The nature of discrepancy was studied using the method of Piggot (1960). Considering reflection from the second order echo, *i.e.*, for $r = 2$, Piggot deduced that,

$$\log(2h' I_2) = 2\log(h' I_1) + \log(\rho_g/h_0 I_0). \tag{7}$$

This relation gives a straight line of slope 2, if the amplitudes of first and second order echoes are consistent. The plot 2 *a* drawn after Piggot with the routine data taken during winter months of 1971, 1973 and 1974 shows that the straight line drawn through the nighttime data keeps the theoretical slope 2. The midday values are found to lie away from the theoretical line. This might be due to the first order echo being too weak or the second order echo being too strong at noon. To find out the actual discrepancy, sample of data had been selected so as to have the same mean absorption loss. ρ_{10}, ρ_{20}, ρ_{21} were then evaluated from the selected data taken at 4·0 MHz for F_1 layer. The noontime values

Table 1. Typical values of I_0h_0 measured from different order echoes

Time IST (hrs)	I_0h_0 single echo	I_0h_0 multiple echo	Percentage of cases of $\rho > 1$
2000	42×10^4	55×10^4	20
2200	40×10^4	45×10^4	nil
2400	38×10^4	54×10^4	25
0200	46×10^4	70×10^4	35

Table 2. Values of I_0h_0 determined after eliminating the cases of $\rho > 1$

Time IST (hrs)	I_0h_0 single echo	I_0h_0 multiple echo
2000	40×10^4	42×10^4
2200	40×10^4	45×10^4
2400	50×10^4	52×10^4
0200	52×10^4	54×10^4

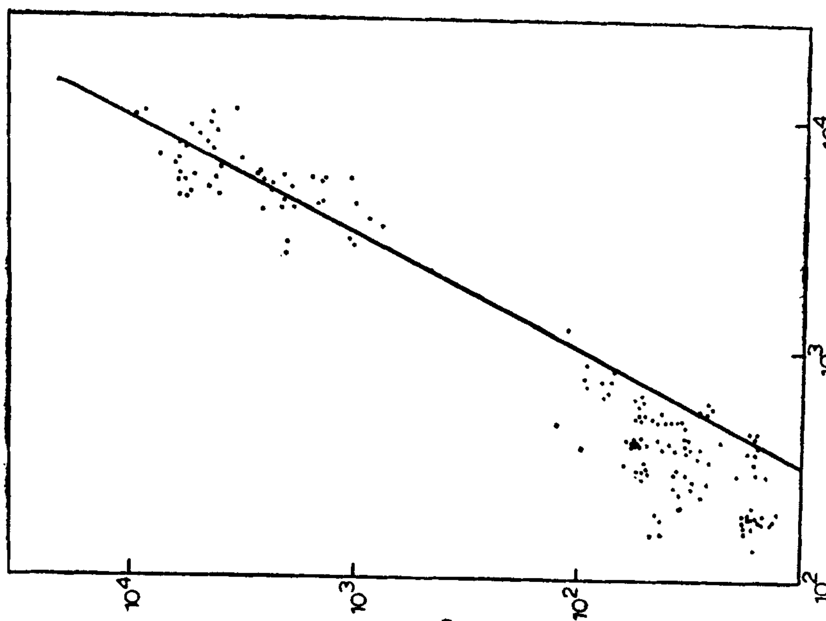

Figure 2a. Day and nighttime plot of I_1h' against $2h'\ I_2$ observed generally.

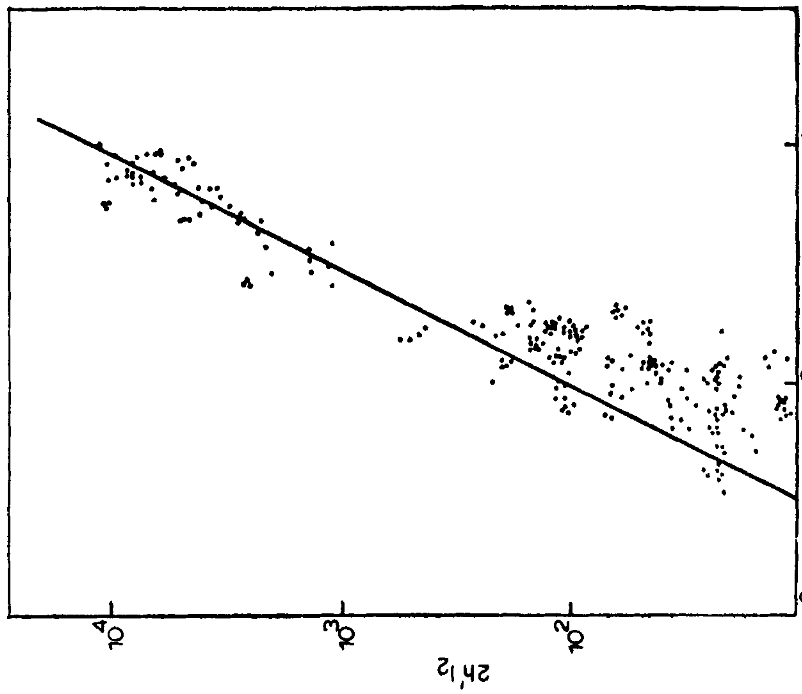

Figure 2b. Plot of I_1h' against $2h'\ I_2$ as observed in 1972 winter.

obtained from such a sample data taken at 1973 are shown in table 3. The table indicates that a discrepancy lies in the first order echo which perhaps being too weak gives ρ_{10} a value less than that of ρ_{21} while ρ_{20} maintains an intermediate value. A correction of 3 db removes the observed difference. The corrected values are also shown on the right hand side of table 3. The correction factor of 3 db had been added to L_{21} while 3 db had been subtracted from L_{10}, to get a consistent value.

It was seen that the same difference in the measured absorption by the two methods was observed during the winter months of the years under observation from 1971 to 1974 except for 1972 as can be seen from plot 2 *b*, which was drawn from the observations taken only for that year. Contrary to the usual pattern ρ_{10} was found to be higher than ρ_{21} in this case, while ρ_{20} maintains an intermediate value as observed in the other years. However, even for that year the same correction factor of 3 db when added to L_{10} and subtracted from L_{21} brings in the uniformity in the result as shown in table 3.

3. Discussions and conclusions

To explain the above discrepancies Piggot (1960) suggested a difference in the mechanism of fading between the first and higher order echoes, and that between day and nighttime echoes. He pointed out that the roughness of the ionosphere might be a cause of such anomalies. Since multiple orders suffer reflections at the earth's rough surface, the echoes suffer deep fading. But the first order echoes, which show shallow fading during the day, and deep fading at night, indicate reflections from specular and rough surface respectively.

The analysis of the amplitude data for the years 1971 to 1974 except for 1972 shows that the first order echoes suffer rapid shallow fading with a superimposition of long periodic fading of low intensity at noon, and less shallow rapid fading at night. The second order echoes suffer very shallow rapid fading during noon which might be linked with the weakening of the first order echo giving $\rho_{10} < \rho_{21}$. On the other hand, as the fading pattern for both the first and the second order echoes become similar at night, a theoretical slope is expected.

Table 3. Noontime reflection coefficient and absorption in db before and after correction in 1972 and 1973

	Observed				Corrected			
	1972		1973		1972		1973	
	Nov.	Dec.	Nov.	Dec.	Nov.	Dec.	Nov.	Dec.
ρ_{10}	0·16	0·17	0·06	0·06	0·11	0·12	0·09	0·09
L_{10}	15·91	15·39	24·15	24·15	19·02	18·59	21·15	21·15
ρ_{20}	0·10	0·13	0·08	0·08	0·10	0·13	0·08	0·08
L_{20}	20·00	18·06	21·93	22·15	20·00	18·06	21·93	22·15
ρ_{21}	0·07	0·08	0·12	0·12	0·10	0·11	0·08	0·08
L_{21}	23·09	22·50	18·41	18·56	21·18	19·50	21·41	21·56

Analysis of amplitude data for 1972 shows that the first order fading are reverse to the above pattern. In the case of second hop echoes the long and rapid fadings are relatively deep during day and night. This characteristic has to be linked with $\rho_{10} > \rho_{21}$. It is interesting to note that such scattering patterns were observed whenever strong sporadic E events were seen in any year. Since such events were found to be relatively higher in this year, the observed change in the reflection pattern might be related with this event. The changes in the fading pattern might be caused due to scattering of radio waves in the diffused E_s layer. In this connection Pillet's (1961) observation of $\rho_{10} > \rho_{21}$, except for reflection from E_s layer, might be noted. He suggested that such values might result from long periodic fading suffered by the second order echoes. Skinner and Wright's (1956) observation suggesting a large specular reflection during the nighttime at equatorial stations does not generally hold good here except when strong E_s layer is present.

References

Baired K 1954 *Aust. J. Phys.* **7** 165
Benkova N P 1965 *J. Atmos. Terr. Phys.* **27** 47
Ganguli S and Rao M 1970 *J. Atmos. Terr. Phys.* **32** 1995
Mitra S K and Rakshit H 1933 *Phil. Mag.* **15** 20
Piggot W R 1953 *J. Inst. Elec. Engrs.* III **100** 61
Piggot W R 1960 *Some Ionospheric Results obtained during the International Geophysical Year* (Elsevier Publishing Co. Amsterdam, London, New York, Princeton) p. 263
Pillet G 1961 *J. Atmos. Terr. Phys.* **23** 57
Sastry G S, Rao T S and Krishnamurthy M 1970 *Proc. IGY Symp.* (CSIR, New Delhi) p. 233
Skinner N J and Wright R W 1956 *J. Atmos. Terr. Phys.* **29** 103