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Winter Anomaly in VHF Absorption Studies over Delhi

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Abstract. In an effort to understand the seasonal anomaly in absorption over this latitude the riometer and pulse absorption data over a period of 2 solar cycles is examined. The analysis indicates that during the high solar activity periods the riometer absorption and foF2 values are always larger in winter than in summer months, whereas during the low solar activity period an exactly opposite feature is observed both for foF2 and absorption. It is concluded that during the high sunspot period the seasonal anomaly is mainly due to F region parameters alone.

Key words: Ionosphere – Absorption – Solar activity – F-region – D-region.

Riometer is a device for measuring the ionospheric absorption using cosmic radio noise. In the present case 22.4 MHz equipment has a directional antenna system of a half power bandwith (HPBW) of $17° \times 24°$ followed by an ultrastable low noise receiving system. The 20 and 30 MHz equipments are, Mark II-A Model ARI-100B, loaned from AFCRL, U.S.A. In these the receiver assumes the role of a sensitive null indicator. The antennas are three element Yagi with HPBW of 60° in E-plane and 110° in H-plane. Every care is taken to maintain the equipments in a stable condition over long periods of operation. The equipments are located at a relatively interference free site and the bandwith of the receiving systems are kept at 3 KHz so as to keep interference to a minimum. The errors in unattenuated cosmic noise intensity over a sidereal day are eliminated using the sky brightness distribution to get reliable absorption data. The blocking effect of the ionosphere, for zenith angles greater than a critical value, (window effect) is thoroughly examined, in the present case for all the three systems during the period of data collection by evaluating the window angles. The window angle is given by

$$\mathrm{Cos}\,\phi = \frac{\mathrm{foF2}}{f}$$

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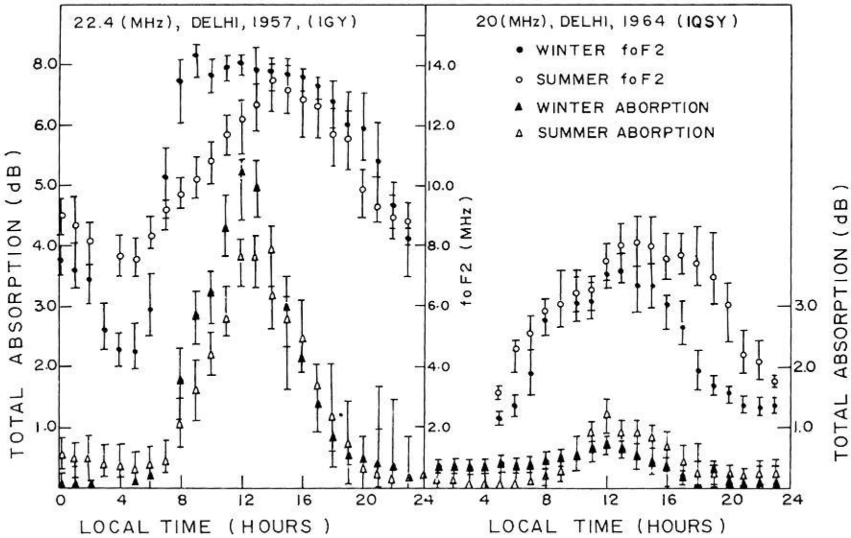


Fig. 1. Seasonal variation of absorption and foF2. (a) Sunspot maximum day foF2 (Summer) < foF2 (winter) also day absorption (summer) < absorption (winter). (b) Sunspot minimum day foF2 (summer) > foF2 (winter) also day absorption (summer)|>absorption (winter)

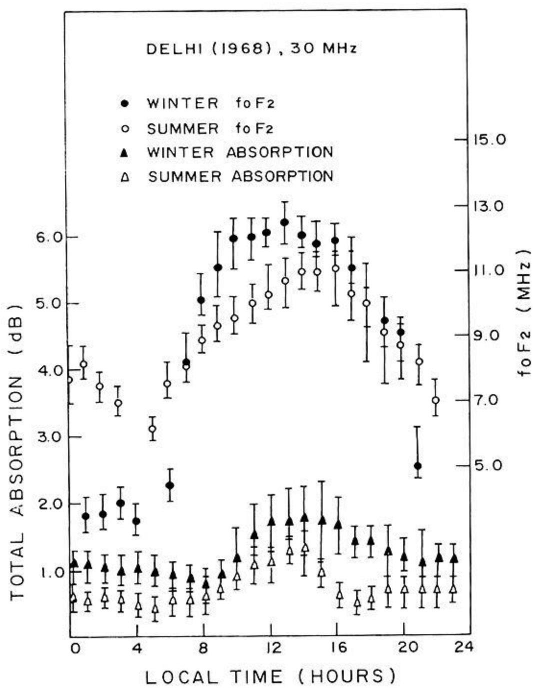


Fig. 2. Seasonal variation of absorption and foF2. Sunspot maximum day foF2 (summer) < foF2 (winter) also day absorption (summer) < absorption (winter)

where ϕ is the window angle, foF2 is the critical frequency of the F2 layer and f is the operating frequency. It is observed that the window effect is outside the edge of the effective antenna beams during the periods of measurements for all the three equipments (Sharma, 1976). Hence, the contribution to absorption through the window effect is non-existing. It is also seen that factors like refraction, ionospheric noise etc. have negligible affect on absorption evaluation. The reliability of the data at Delhi has been discussed (Sharma, 1976) by comparing the calculated absorption (using model electron density and collision frequency profiles appropriate for this station) with the observed values. As there is a remarkable agreement between the two (Sharma, 1976) it is concluded that observed values can safely be used for the study of winter anomaly over this latitude.

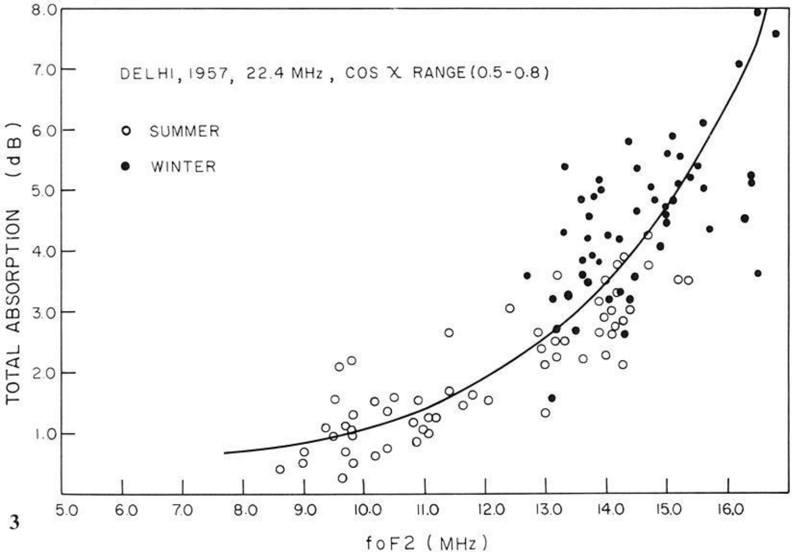
Riometers are under operation at Delhi since 1957. Intensive studies on cosmic radio noise absorption at this latitude covering the periods IGY, IQSY and IASY have revealed certain anomalous behaviour when plotted against seasons (Sharma, 1976). For high solar activity period (IGY) Sarada and Mitra (1961) reported, for this latitude, an absorption maximum during winter and minimum during summer. Sarma et al. (1970) reported, for this latitude, for low solar activity conditions (IQSY) exactly the reverse of the above results i.e., the absorption was maximum during summer and minimum in winter. The same type of behaviour as reported by Sarada and Mitra (1961) was repeated, for the years 1968–69 (IASY), again a high solar activity period. This type of behaviour has raised the curiosity to investigate further into this aspect in greater detail. The present investigation is mainly dealt with to have a thorough understanding regarding the above seasonal anomaly in absorption over this latitude. For this purpose we also made use of the data on pulse absorption and foF2 for the corresponding periods at this latitude.

We have plotted the values of total riometer absorption against local time for summer and winter months separately for the high and low solar activity periods along with the corresponding foF2 values and are shown in Figures 1a, b and 2. An examination of these figures indicate:

1. The daytime absorption in winter is larger than in summer during the high sunspot period. The winter anomaly is nonexistent in low sunspot years.

2. foF2 values show a corresponding trend. However, it is also to be noted that during IGY and IQSY foF2 values behave exactly in opposite manner.

After establishing that there exists seasonal anomaly in absorption and that it is at least partly due to the F region, we tried to see if there is any contribution from the D region. To examine the F region contribution quantitatively we have plotted absorption against foF2 for a fixed range of values of Cos χ where χ is the zenith distance (so that the D region absorption is maintained constant) as shown in Figures 3 and 4. It is seen from the figures that for a given foF2 the absorption is larger in winter than in summer (in both high solar activity periods) even when Cos χ values are essentially kept invariant. This feature is brought out more clearly in Figure 5, where Cos χ is kept at 0.5 a fixed value (instead of a range), a more restrictive plot. Further, the pulse absorption values do not show this type of behaviour instead they are always



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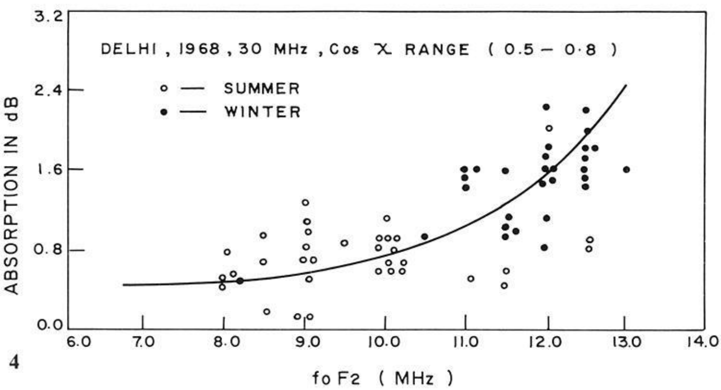

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Figs. 3–4. Absorption versus foF2 for a fixed range of solar zenith angles. (χ is the zenith distance)

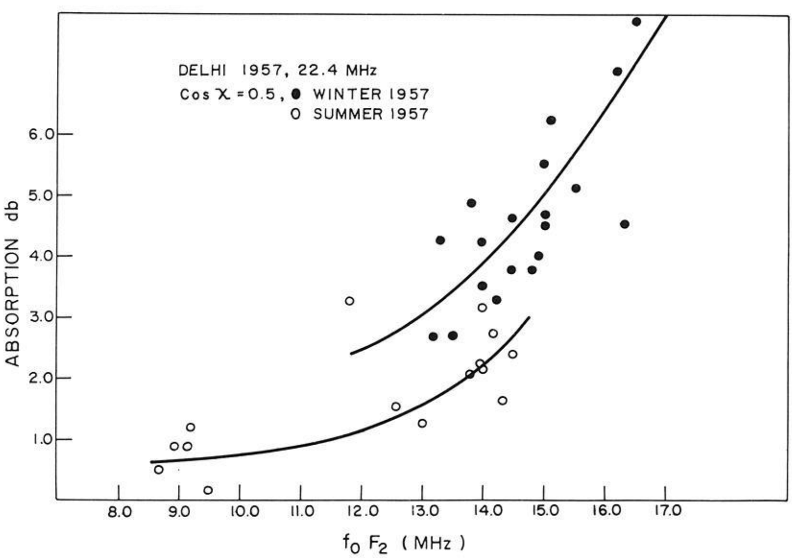
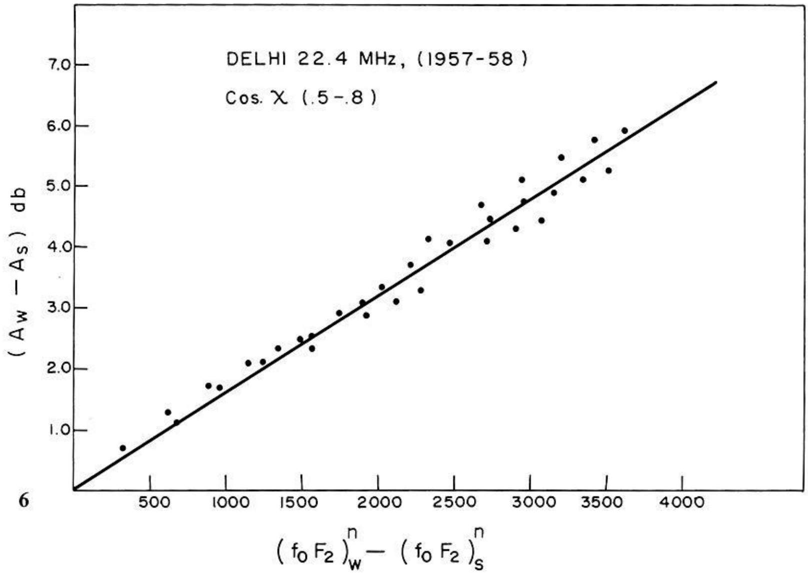


Fig. 5. Absorption versus foF2 for a fixed value of solar zenith angle (χ is the zenith distance)



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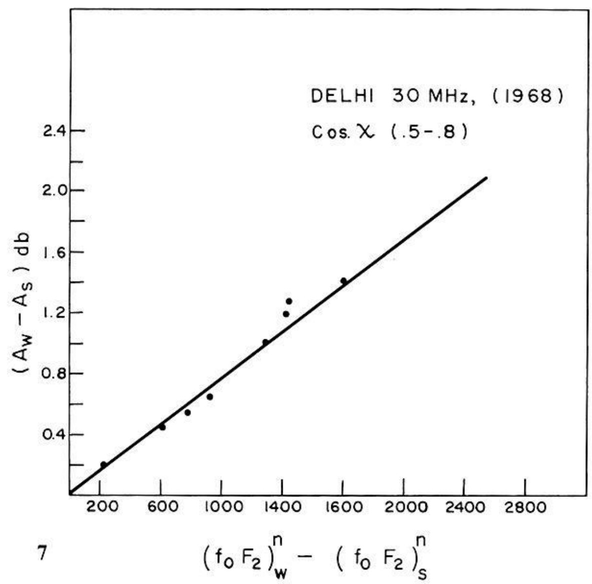

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Figs. 6–7. Excess absorption during winter versus $(\text{foF2})^n_w - (\text{foF2})^n_s$

more in summer than in winter months irrespective of the solar activity (Sharma, 1976). The result is somewhat intriguing. One may infer that not only is the winter absorption anomaly during high solar activity period a result of the F region, but that it is not foF2 alone that controls the anomaly. Otherwise, when plotted against foF2 (and with fixed Cos χ) the winter and summer values should be indistinguishable. This additional factor might be due to F region electron temperature.

This predominant control of the winter anomaly by the F region parameters give us an additional method of separating the D and F region absorption contributions. One can write:

$$A_t = A_D + b(\mathrm{foF2})^n$$

where

A_t = Total cosmic noise absorption.
A_D = D region contribution.
$b(\mathrm{foF2})^n$ = F region contribution with b and n are constants appropriate for this latitude.

Then $(A_t)_w = (A_D)_w + b(\mathrm{foF2})^n_w$

and

$$(A_t)_s = (A_D)_s + b(\mathrm{foF2})^n_w$$

where the suffixes w and s refer to winter and summer values respectively.

Further, if Cos χ values are kept reasonably constant, then

$$(A_D)_w \approx (A_D)_s$$

Hence

$$(A_t)_w - (A_t)_s = b[(\mathrm{foF2})^n_w - (\mathrm{foF2})^n_s].$$

When $(A_t)_w - (A_t)_s$ is plotted against $(\mathrm{foF2})^n_w - (\mathrm{foF2})^n_s$ for this latitude the result was a straight line as shown in Figures 6 and 7. This confirms our conclusion that the seasonal anomaly is entirely due to the F region alone.

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