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MULTIFREQUENCY RIOMETER MEASUREMENTS AT HIGH LATITUDES

by

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Abstract

The diurnal variation of radio wave absorption measured by a riometer is similar at the frequencies 20 MHz, 27.6 MHz, 40 MHz and 50 MHz at the high latitude station Sodankylä (L = 5.1), having two maxima, one at midnight and another in the morning. The variation of n in the equation $A_1/A_2 = (f_2/f_1)^n$, where A = radio wave absorption (dB) and f = frequency, is studied. The daily and seasonal variation of n shows than n is smaller under sunlit conditions than during darkness, meaning that the ionization is extended to smaller altitudes under sunlit conditions. No difference could be observed in comparing the values of n connected to electrons precipitated to nightside to those causing ionization on the dayside, supporting the view that the energies of the particles ionizing the D region on the nightside and on the dayside do not differ enough to be detected by this experiment.

1. *Introduction*

Multifrequency riometer measurements have been made at Sodankylä (geogr. coord. 67°25′ N, 26°24′ E, L=5.1) since 1969 at the frequencies 20 MHz (o- and x-polarization), 27.6 MHz, 40 MHz and 50 MHz. In this paper the data at the frequencies 27.6 MHz, 40 MHz and 50 MHz are analyzed for the time interval July 1970 – December 1975 and at the frequency 20 MHz for the time interval January 1973 – December 1975. The riometers at the frequency of 20 MHz have 6-element turnstile antennas covering an area of about 63 km in both east-west and north-south directions at 100 km altitude and the other riometers have 3-element yagi antennas covering a region of about 200 km in east-west and about 90 km in north-south direction at the same altitude.

Theoretically the absorption at the frequencies of 20–50 MHz occurs in the height range 40–85 km (LERFALD *at al.*, [5]). The ratio of the absorptions at different frequencies obeys the equation

$$A_1/A_2 = (f_2/f_1)^n \tag{1}$$

where A = radio wave absorption (dB)
$f_{1,2}$ = frequencies used

The exponent n can theoretically have values between 1–2. The values of n depends on the heights where the maximum absorption at different frequencies occurs. For example, for n equal to about 1.1 the maximum absorption at the frequency 20 MHz occurs at the height of 55 km, whereas for n about 1.9 the height is 78 km (HARGREAVES, [4]).

2. *Diurnal and seasonal variation of absorption at different frequencies*

Typical mean diurnal variations of the absorption measured by riometers at different frequencies are seen in Figure 1. The absorption has been computed for

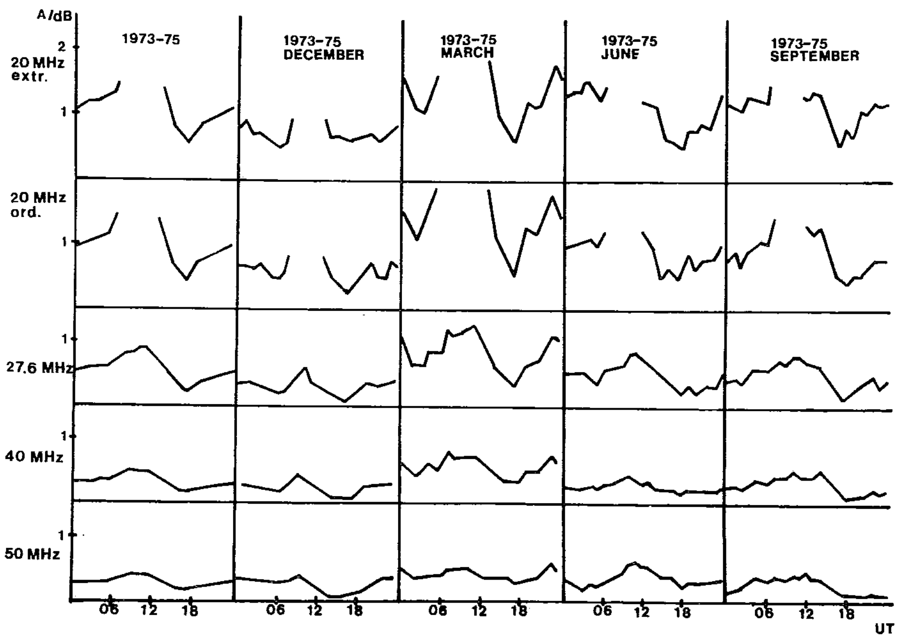

Figure 1. The mean diurnal variation of the absorption measured by a riometer at 20–50 MHz in the years 1973–75 at Sodankylä.

the first minute of each hour from the formula

$$A = 10 \log_{10} (P_0/P) \quad (2)$$

where P is the received cosmic noise power and P_0 the cosmic noise under quiet conditions at the same sidereal time. The quiet day level has been determined separately for every month from a cosmic noise-sidereal time. The maximum at about 10–11 UT is seen at all frequencies, but the maximum is greatest at 20 MHz. Also the minimum at about 17 UT and the night maximum are seen at all frequencies. Because of interference no absorption values could be given at 20 MHz in the time interval 07–13 UT. The only difference between the diurnal variations of the absorption at the different frequencies is that the daytime and nighttime maxima are more clearly seen at the lower frequencies.

The monthly meadians of the absorption over the years 1970–1975 at the dif-

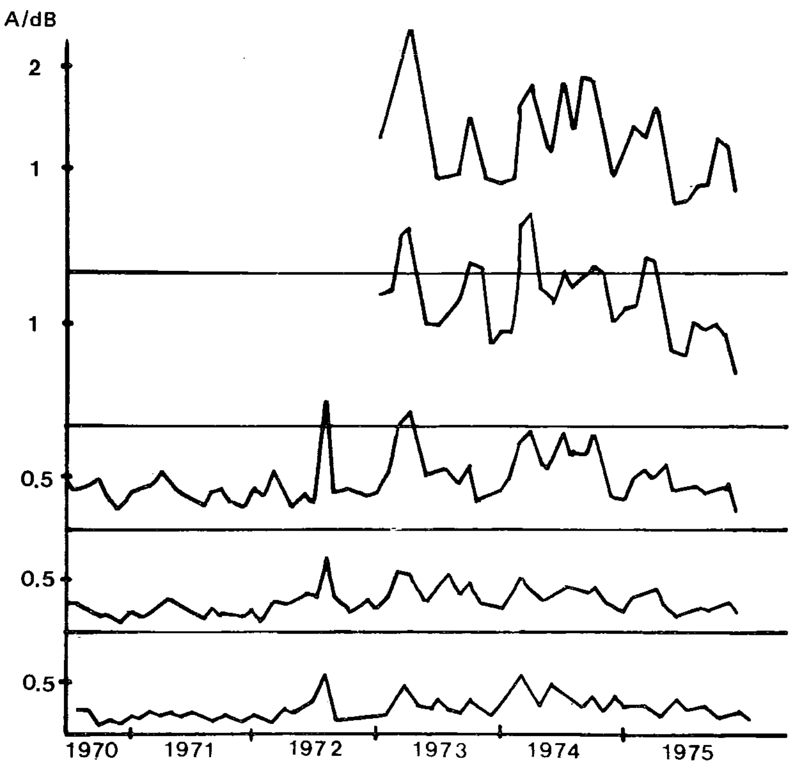

Figure 2. The monthly medians of the absorption (from top to bottom) at 20 MHz (extr.), 20 MHz (ord.), 27.6 MHz, 40 MHz and 50 MHz at Sodankylä. Data for 20 MHz exist from January 1973 onwards only.

ferent frequencies are seen in Figure 2. For example, the strong PCA event in August 1972 is very clearly seen in this figure.

3. *Multifrequency analysis*

The variation of n in equation 1 was studied using the three frequencies 27.6 MHz, 40 MHz and 50 MHz only, because at these frequencies the antennas were of the same kind, and no correcting calculations were thus needed. The studied events were selected from the time interval November 1975 – October 1976, and about 700 analyses were made.

In figure 3 the distribution of all calculated day- and nighttime n values is shown. The most common value of n is 1.6–1.8. According to the theory this means that the main absorption occurs on the average in the height region of 50–70 km.

The absorption at Sodankylä is mainly caused by precipitated auroral electrons. It was attempted to study with the aid of the n values possible differences in the energy of electrons directly precipitated on the nightside and those being drifted towards the dayside of the magnetosphere and precipitated there. Therefore the values of n have been separated in figure 4 into two groups, in the first group values of n between 17–05 UT and in the second one those between 05–17 UT. The time 05 UT was chosen as the dividing line between the two groups because

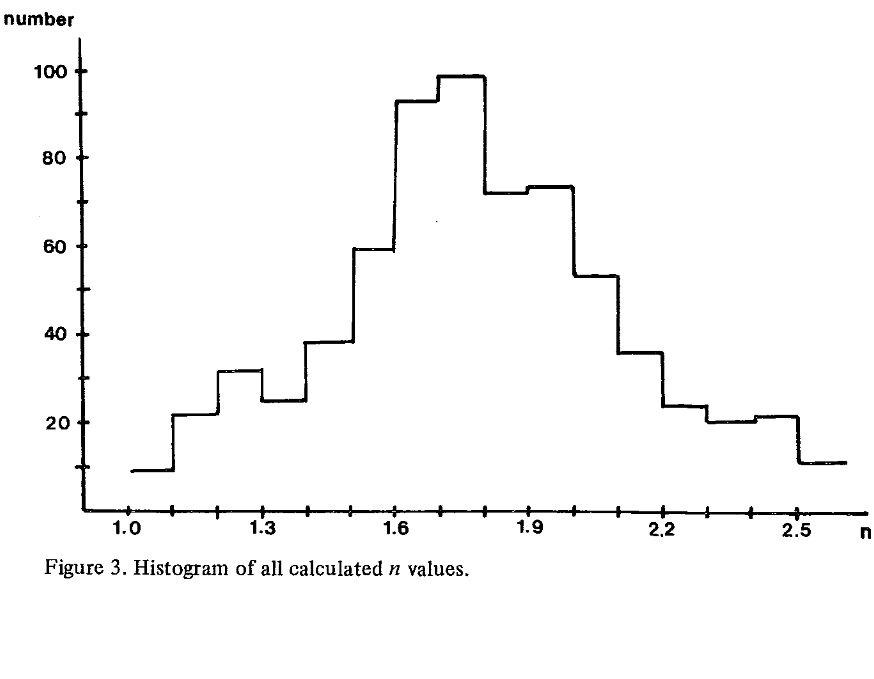

Figure 3. Histogram of all calculated n values.

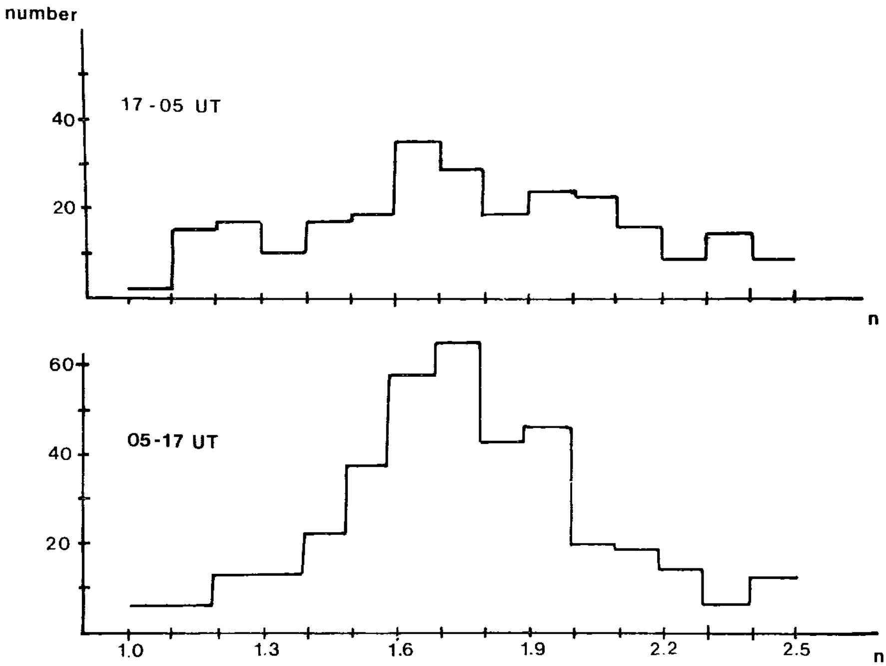

Figure 4. Histograms of n values during the hours 17–05 UT and 05–17 UT.

when direct precipitation can be assumed to end. No clear difference in the distribution of n can be seen between those groups. Separating the values of n in the way that one group contains the values under sunlit conditions and another group those under darkness, a clear difference can be seen (figure 5): Under sunlit conditions the values of n are, on the average, smaller than under darkness.

The seasonal variation of n is shown in figure 6. The greatest values of n are seen in the winter and the smallest ones in the summer.

The mean value of n has no clear dependence on the intensity of the absorption (figure 7) but the distribution of n is broader at low absorption values.

4. *Discussion*

The fact that no clear difference can be seen in the diurnal variations of the absorption at frequencies varying in the range 20 to 50 MHz confirms the theoretical result that the absorption measured at these frequencies by a riometer occurs in so narrow a height interval that no difference in the shape of the diurnal varia-

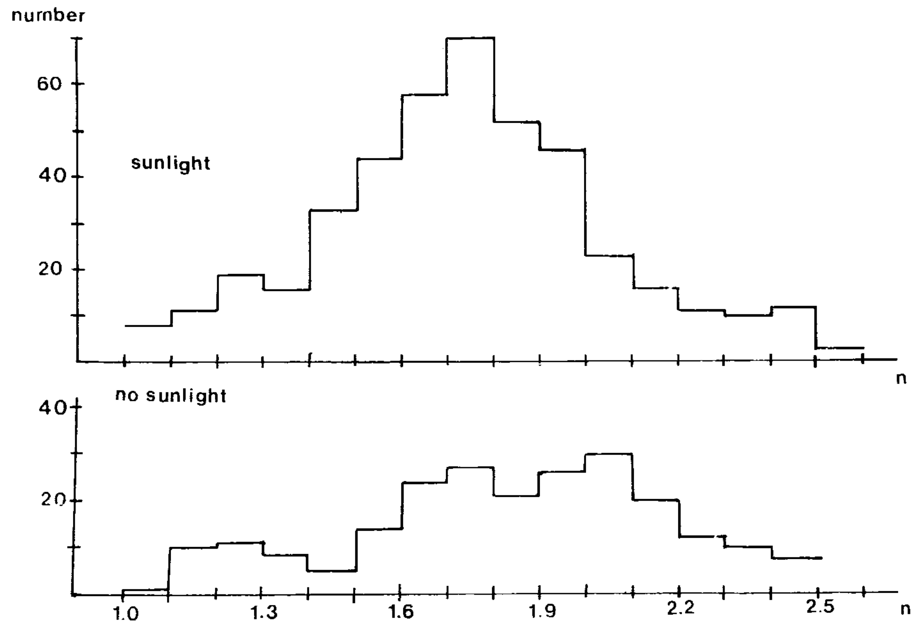

Figure 5. Histograms of *n* during sunlit conditions and during darkness.

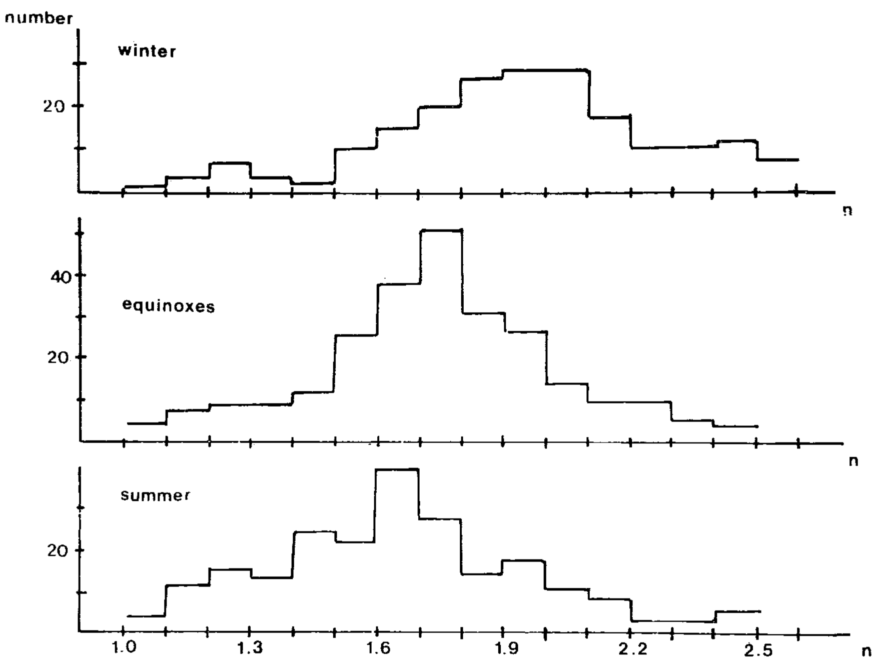

Figure 6. Histograms of *n* in winter, at the equinoxes and in summer.

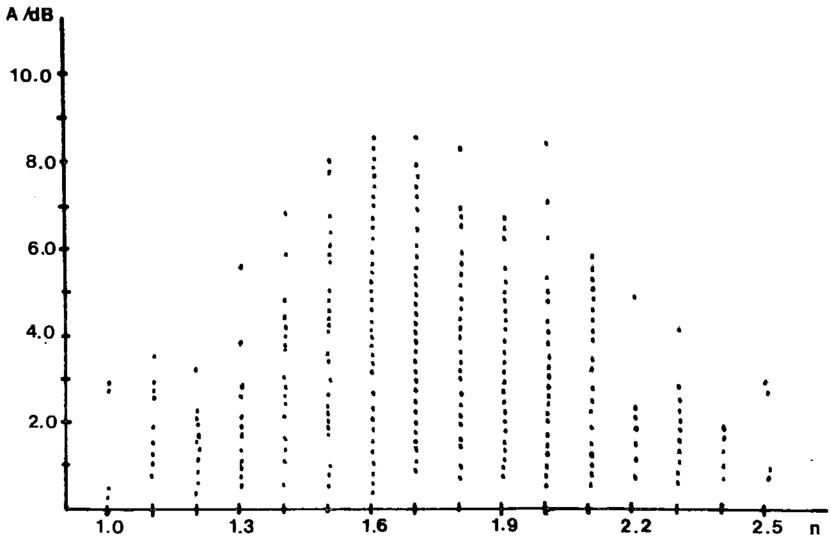

Figure 7. The values of *n* vs. the intensity of the absorption at a frequency of 27.6 MHz.

tion can be observed. The diurnal variation of the absorption at 20–50 MHz with one maximum at midnight and another one in the morning suggests that at high latitudes the main ionizing factor affecting the absorption are auroral electrons.

The distribution of *n* values has been studied by LERFALD *et al.*, [5] and BELINKOVICH *et al.*, [1, 2, 3]. The results obtained in our study agree rather well with the results of these authors, but in our study the variation of *n* values could be studied in more detail. The daily and seasonal variations of *n* show that *n* is smaller under sunlit conditions than during darkness, meaning that the ionization is located lower down in the ionosphere. This result agrees very well with our earlier result (RANTA and RANTA, [6]) obtained by comparing the annual changes of the diurnal variation of absorption. The effect is at least partly due to the different effect of sunlight. Under sunlit conditions the recombination rate is decreased when the cluster ions are split into simpler ions and the electrons are detached from negative ions, both factors increasing the electron density in the lower D-region.

No difference could be observed in comparing the values of *n* connected to electrons precipitated to the nightside and to the dayside, suggesting that the energies of the particles ionizing the D-region in these local time sectors do not differ enough to be detected by this experiment.

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