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Study of Diurnal, Seasonal and Annual Variations in the Cosmic Radio Noise Absorption at 30 MHz in the Australian Antarctic Research Stations

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Abstract

Riometer is equipment used to study the cosmic noise absorption (CNA) by the ionosphere. All the observations were made using riometer with dual dipole antenna system installed at Australian Antarctic divisions. These kinds of measurements are useful to determine the absorption in the D region of ionosphere. This paper is concerned with the study of diurnal, seasonal and annual variations in the absorption of cosmic radio noise at 30 MHz. In this study we have observed the effect of solar activity on the average absorption value. Additionally, an increment in the start level of absorption of different seasons with different years has been found.

1. Introduction

A riometer is equipment used to study the absorption in the cosmic noise power by ionosphere [1]. Measurements of absorption by ionosphere at middle and high latitude stations, using riometers, have been carried out in the past. It is has been shown that the total absorption occurs mainly in D-region of ionosphere [2-5]. For the measurements of absorption by riometer, quiet-day curve (QDC) for the system is required. A Quiet Day Curve (QDC) is defined as the variation of background cosmic radio noise signal power that is observed with a quiet and undisturbed ionosphere. The QDC is a continuous record of this background diurnal variation of the received cosmic noise power as a function of sidereal time [6].This curve serves as a reference, which can be used to derive ionospheric absorption. Determination of ionospheric D-region absorption of cosmic

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radio noise by riometer is a signal loss relative to the QDC. This curve gives the variation in pattern of the signal received through quiet ionosphere as the antenna scans the sky due to the rotation of Earth. Heisler R. and Howler G. L. [7], Lusignan [8], and Mitra A. P. Shain C. A. [9] suggested that the variation in QDC pattern changes with season.

In this study, we have mentioned the diurnal, seasonal and annual variation in the absorption (at 30 MHz) recorded by riometer operated at Antarctic stations (Australian). The diurnal changes in the intensity of cosmic radio noise, with zenith angle, vary relative to the galactic centre. The strong diurnal, seasonal and solar cycle variation in the absorption has been studied by Sarma S. B. S. S. and Sharma M. C. [10].

Here, we present the diurnal, seasonal and annual variations in the cosmic radio noise absorption recorded for the years 2009 to 2012 at Casey, Mawson and Davis (in geographic latitude range 66°S-68°S) Stations. The geographic coordinates of each station are given in Table 1. The signal strength of cosmic radio noise varies due to different galactic radio sources passing through the field of view of the antenna. It may be noted that the riometer technique has been used widely in high latitudes for absorption studies due to more ionization caused by the entry of energetic solar particles emitted during solar flares [11], substorm [12] solar proton events [13].

2. Data Collection:

All riometers are identical, operating at 30 MHz with two parallel dipole antennas. Data of absorption with sampling rate ten seconds have been used for the analysis. All the three riometers working simultaneously give the information of absorption which in turn given formation about ionization in the D-region over particular station.

The data was collected from IPS world data centre (with due permissions of PI). It gives- raw data, Quiet day curve and absorption. The geographic latitude and longitutes of the three Australian Antarctic divisions are shown in Table1.

Table 1. The list of stations with their geographic coordinates where riometers are operating and their data used in this study

Sr. No.	Station Name	Geographic Latitude	Geographic Longitude
1	Casey	66.2° S	110.50° E
2	Mawson	67.6° S	62.7° E
3	Davis	68.6° S	78.00° E

2.1. Method of analysis and the Results

The absorption is a process by which energy in a radio wave passing through the ionosphere is converted to heat through electron collisions with other particles. The amount of absorbed energy is normally expressed as a ratio of the expected level to the measured level, and is given in decibels (dB).

$$\text{CNA (dB)} = 10 \log[P/P'] \quad (1)$$

(Where: P is the noise power during quiet conditions and P' is the noise power during the day of interest).

Data of more than 25 days were selected of each month. Initially, data was collected with sampling rate of 10 seconds. Each data was obtained by averaging raw data for 30 minutes. Finally a graph of absorption vs.

universal time was plotted for each station. Monthly curves show tendency of repeating itself during each month. There is a small gap in the absorption data from16:30 to 16:34UT on each day due to self-calibration. During this period, normal receiving stops and in the output a fixed signal levels is obtained. This is done to check the stability of data acquisition system (DAS).

To study diurnal, seasonal and annual variability of cosmic noise absorption during the pre- phase of solar maxima, we have selected the data of 2009 and 2010 (as low solar activity) and 2011 and 2012 (comparatively moderate solar activity). Absorption of signal/noise at high altitudes can be caused by several ways. During the day the Sun causes ionization (which is a function of the solar zenith angle) in the "D layer" at altitudes near 80 km. The absorption during 2009 and 2010 was very low because of the ionization due to “quiet” Sun.

The absorption during 2011 and 2012 was more because of the ionization due to “disturbed” Sun when Solar flares, solar proton events, CME’s, are recorded during these years. Hence absorption increases suddenly. Due to the tilt of the Earth and its revolution around the Sun; the poles receive different amount of energy and heat from the Sun. Therefore, it is important to study the seasonal and annual variations in the CNA. The months belonging to particular season in southern hemisphere are given in Table 2.

Table 2. Different Seasons and their months (Kenneth Davies)

Southern hemisphere	Months
Summer	December, January, February
Autumn	March, April, May
Winter	June, July, August
Spring	September, October, November

2.2. Variations in the absorption:

2.2.1. Diurnal variation:

The diurnal variations in the absorption were studied by Ranta et al. [14] using riometer data from Finnish stations (for the years 1972-73). Ranta et al. [15] also reported diurnal variations in CNA for five different stations in Finland at geomagnetic latitudes 57°-67°N (for the years 1971-74). Figure 1 (a-c) shows mean diurnal variation of total absorption of cosmic radio noise recorded at Casey, Davis and Mawson stations during different months of each year from 2009 to 2012, respectively. According to Hook et al. [16], Driatskiy [17] and Holt et al. [18] the diurnal pattern changes with both latitude and longitude. The results are in good agreement with the previous studies.

The monthly mean (30 min) variation of total ionospheric CNA at 30 MHz at Davis, Mawson and Casey stations during 2009 to 2012 are shown in Figure 2 (top to bottom). The absorption values observed during 2009 and 2010 are small but clear increments in the absorption level is seen during the year 2011 and 2012, this is because the pre phase of 24th solar cycle. Solar activity was observed more intense during 2011 and 2012 as shown in Figure 2.

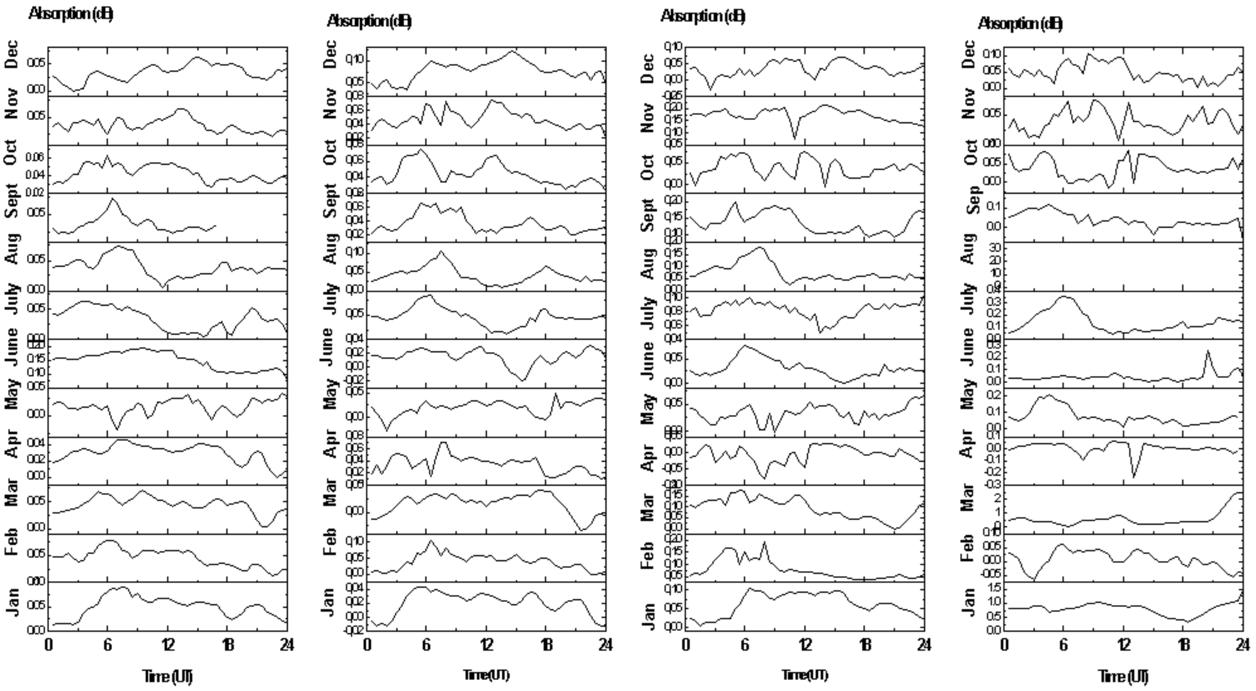


Figure 1. (a) Mean diurnal variations of total absorption of cosmic radio noise by ionosphere at 30 MHz at Casey station during different months of each year from 2009 to 2012 (From left to right).

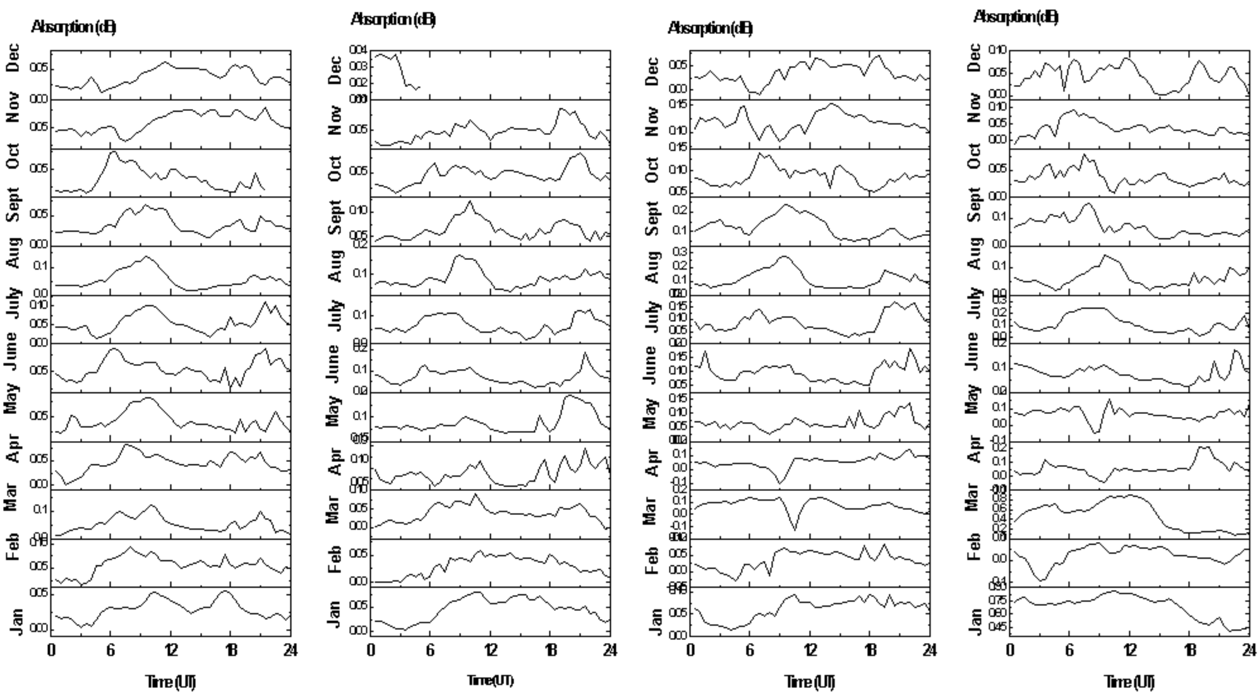


Figure 1. (b) Mean diurnal variations of total absorption of cosmic radio noise by ionosphere at 30 MHz at Davis station during different months of each year from 2009 to 2012 (From left to right).

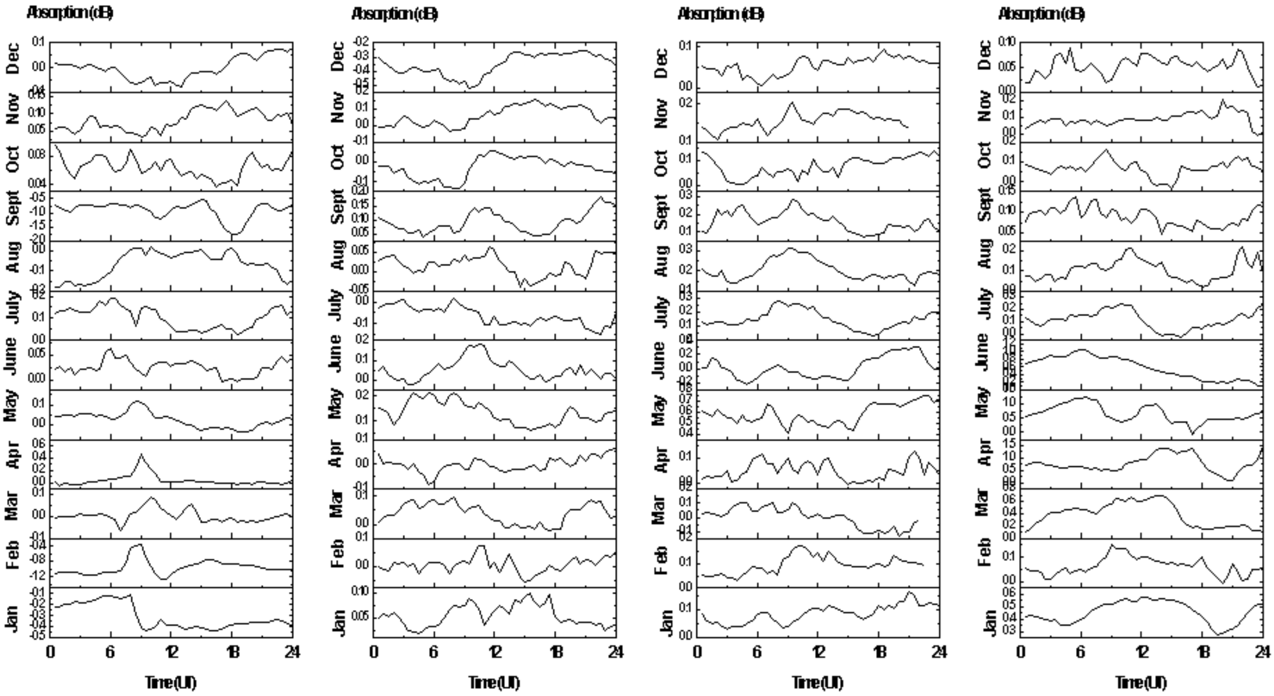


Figure 1. (c) Mean diurnal variations of total absorption of cosmic radio noise by ionosphere at 30 MHz at Mawson station during different months of each year from 2009 to 2012 (From left to right).

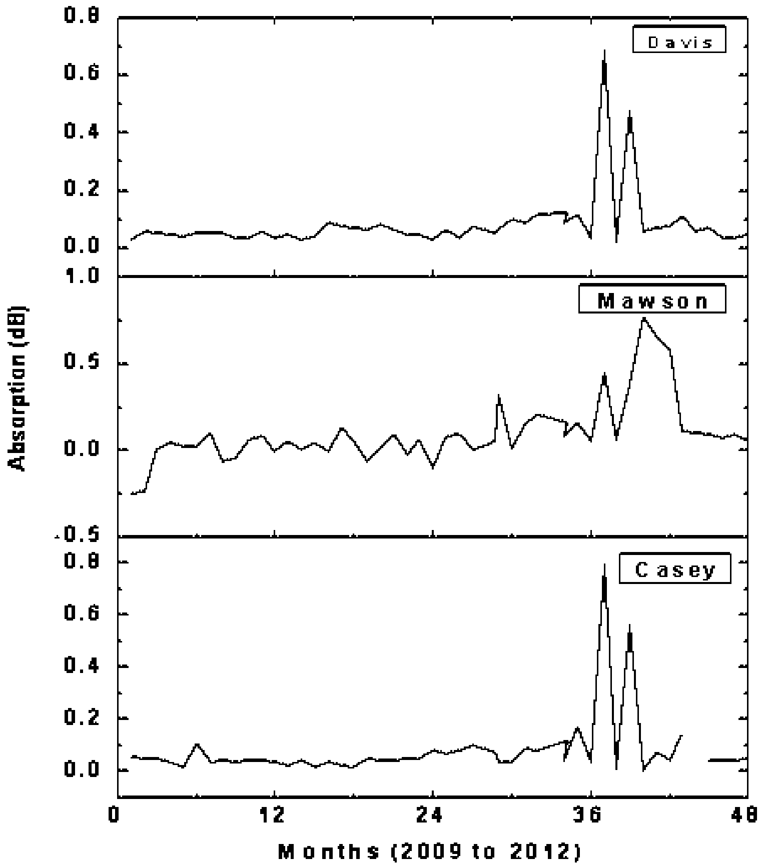
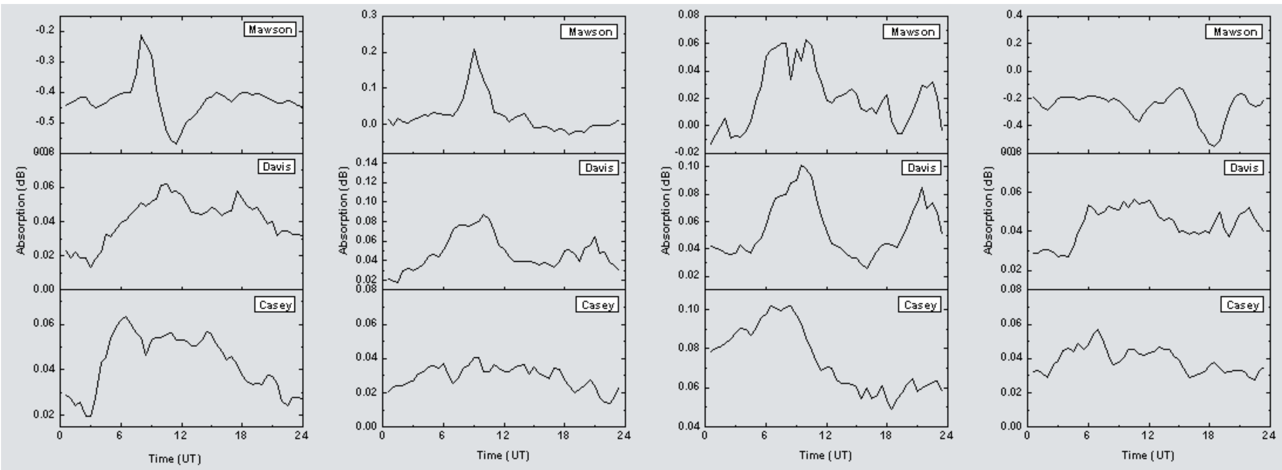


Figure 2. The monthly medians of absorption from the years 2009 to 2012 for Davis, Mawson and Casey (top to bottom) stations. The sharp increase in the absorption in the beginning of 2012 is due to the SPEs.

2.2.2. Seasonal variation

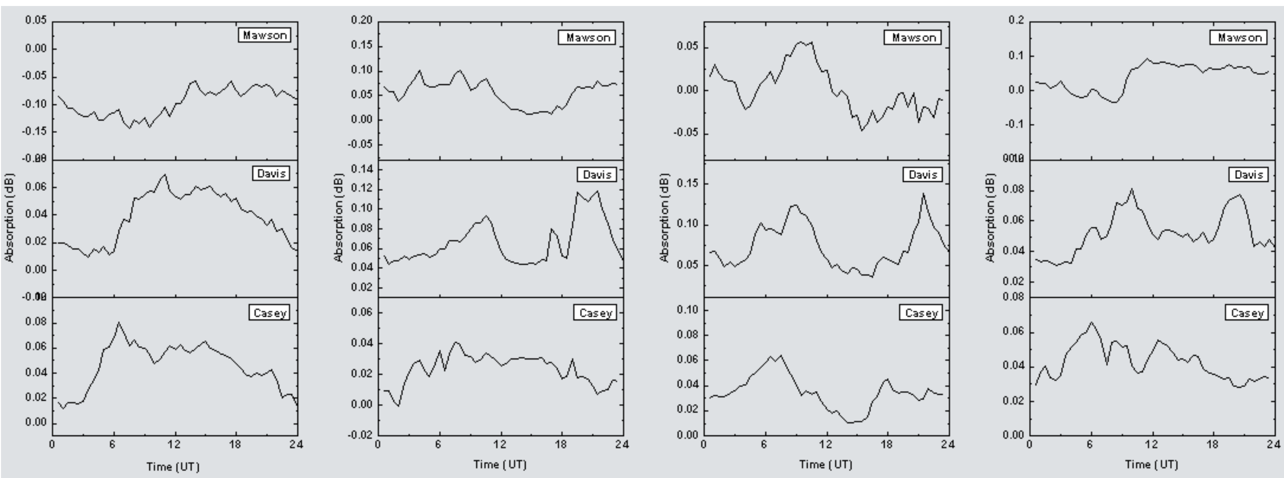
We have studied the seasonal variation of CNA. We have analyzed the data of riometer operating at Casey, Mawson and Davis. The absorption occurs mainly in the D-region. Figure 3 (a-d) shows seasonal variation of absorption received at all three stations.

Ranta *et al.* [15] reported that the diurnal variation of absorption changes with seasons (summer and winter). They also reported that during equinoxes value of absorption during day and night is almost same but in summer, day time value is twice than that of night. Figure 3 (a-d) represents the mean diurnal variation of absorption in summer, spring, winter and autumn for years 2009-2012, respectively. In this seasonal study we have observed that in spring and autumn the day maxima have almost same value but in the summer and winter the day value is greater than that of night. The greater day maxima at the summer and winter are supposed to be caused partly by changes due to recombination rate of ions.



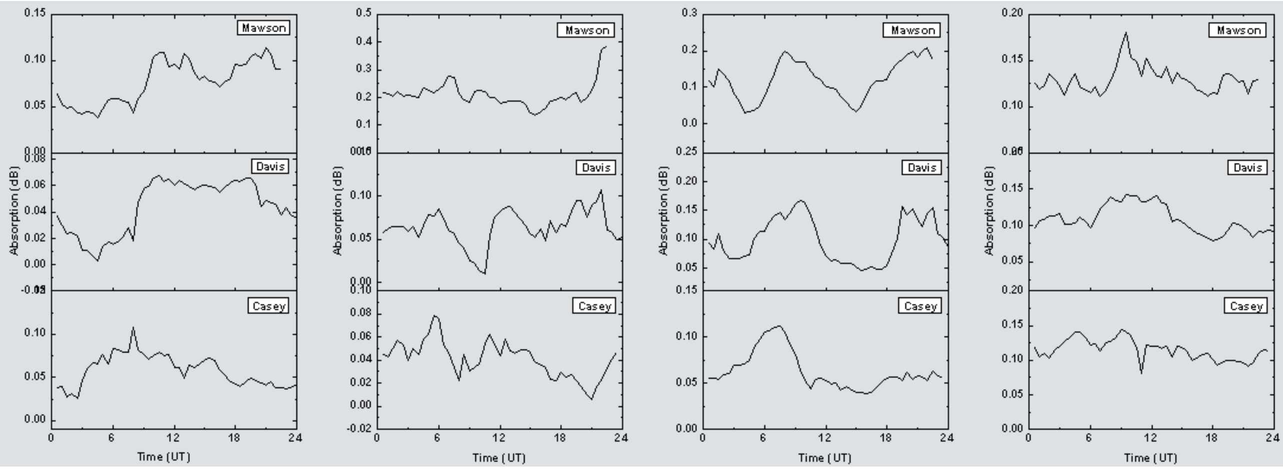
Summer Autumn Winter Spring

Figure 3. (a) Mean diurnal variation of total absorption during 2009 with different seasons atMawson, Davis and Casey stations. Here Spring (Sept -Nov), summer (Dec-Feb), autumn (Mar-May), winter (Jun-Aug).



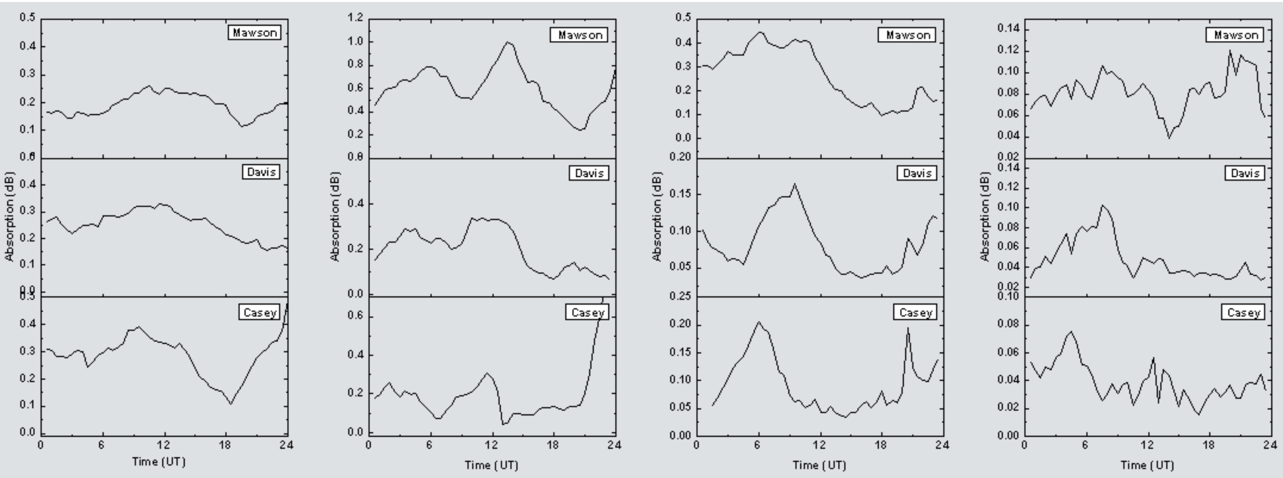
Summer Autumn Winter Spring

Figure 3. (b)Mean diurnal variation of total absorption during 2010 with different seasons at Mawson, Davis and Casey stations.



Summer Autumn Winter Spring

Figure 3. (c) Mean diurnal variation of total absorption during 2011 with different seasons atMawson, Davis and Casey stations.



Summer Autumn Winter Spring

Figure 3. (d)Mean diurnal variation of total absorption during 2012 with different seasons atMawson, Davis and Casey stations.

2.2.3. Annual variations

Yearly mean values of absorption have been plotted against years from 2009 to 2012 as shown in Figure 4. These values have been plotted, for comparison, with the sunspot number R (in Figure 5). Now 24th Solar cycle is going on, during pre phase (2009-2010) to solar maxima (2012) an increment in the value of absorption with solar activity or sunspot numbers was observed. The absorption is related very much with the sunspot number. In 2012, maximum absorption was observed at all the three stations.

In addition to this, we studied the shift in start level of CNA in different seasons. Table 3 shows the shift in start level of CNA from 2009 to 2012. From the values of absorption a systematic increase in its level was found in each season of each year.

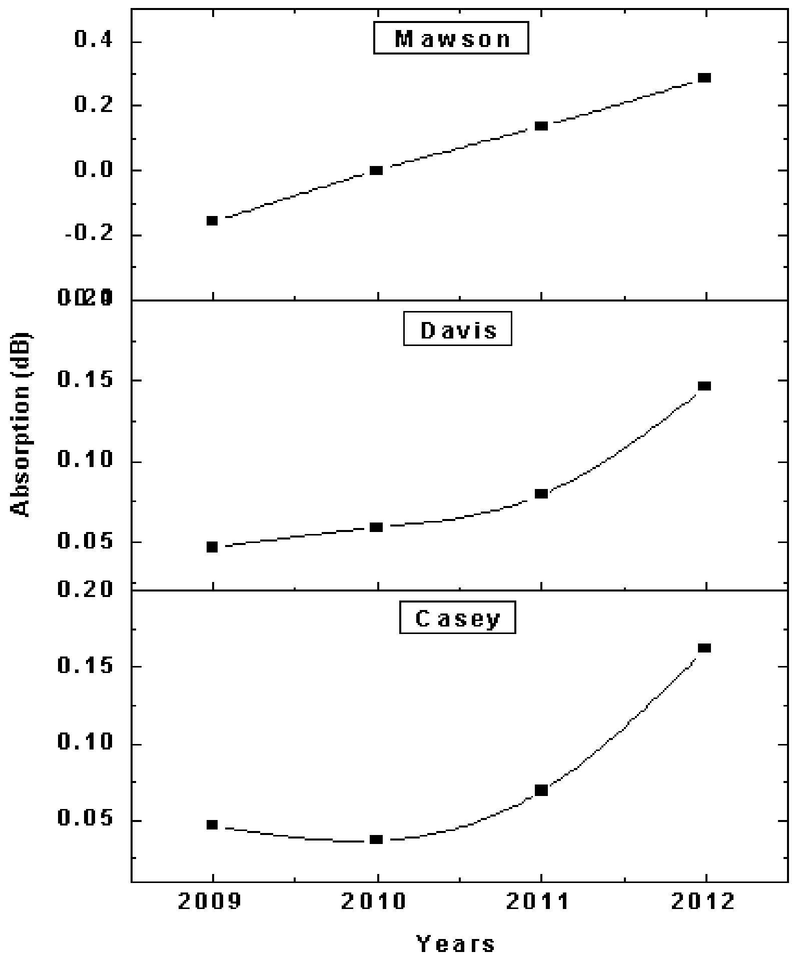


Figure 4. Annual variation of total absorption during 2009 to 2012 with different stations Mawson, Davis and Casey stations (from top to bottom)

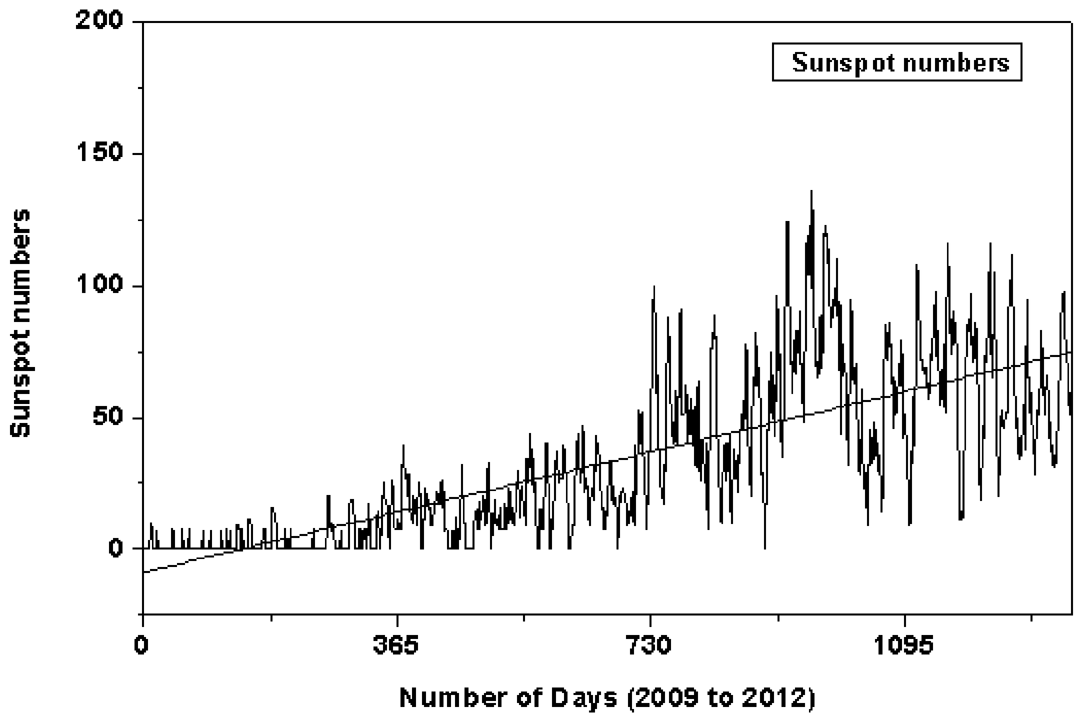


Figure 5. Variation of sunspot in the year 2009 -2012

Table 3. The study of seasonal shift in start level of CNAs during 2009 to 2012.

	Year	Casey	Mawson	Davis
Summer				
	2009	0.02	-0.43	0.02
	2010	0.02	-0.09	0.02
	2011	0.03	0.06	0.046
	2012	0.32	0.16	0.26
Autumn				
	2009	0.02	0.01	0.02
	2010	0.01	0.09	0.05
	2011	0.04	0.24	0.05
	2012	0.18	0.31	0.15
Winter				
	2009	0.08	0.007	0.04
	2010	0.03	0.01	0.07
	2011	0.06	0.13	0.10
	2012	0.04	0.30	0.10
Spring				
	2009	0.038	-0.20	0.03
	2010	0.008	0.03	0.01
	2011	0.13	0.12	0.10
	2012	0.03	0.06	0.03

3. Conclusions

1) Diurnal, seasonal and annual variability of cosmic radio noise absorption at 30 MHz, for years 2009 to 2012, has been found.
2) We have seen the effect of the solar activity on the average absorption value.
3) For southern hemisphere we have observed that in spring and autumn seasons the day and night maxima have about the same value but in the summer and winter the value of day maximum is greater than that of the night.
4) A shift in the start level of absorption of different seasons with different years has been found.

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