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Difficulties in the study of cosmic radio noise absorption at 30 MHz using riometer at low latitude station, Kolhapur (Lat-16.8°N, Long-74.25°E)

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Abstract

A dual dipole antenna has been installed at low latitude station Kolhapur (Geographic 16.8°N, 74.25°E), Maharashtra, India for the study of cosmic radio noise absorption using Solid State Riometer (which operates at 30 MHz) during pre phase of 24th solar maxima. The aim for this type of study over Kolhapur was to know the response of lower (D region) ionosphere over low latitude by cosmic radio noise absorption using riometer technique during quite period as well as sudden ionospheric disturbances (SID). The observations are being taken for 3 years. Two different sites (~40 km away from each other) were used for the installation of riometer equipment assuming minimum local noise. It is found that solar noise to cosmic radio noise hence resulting in signal saturation. The night time signal is relatively free of interference but sometimes local noise is responsible for spike-like signatures. Hence it is concluded that Kolhapur (a low latitude station) is not suitable for the study of cosmic radio noise absorption on 30 MHz with riometer and dual dipole antenna. Proper choice for operating frequency of riometer and antenna gain is suggested for low latitude use of this technique for ionospheric deviative and nondeviative absorption studies.

Keywords: Cosmic radio noise absorption; Riometer; Ionospheric absorption

1. Introduction

Riometer is sensitive, self-balancing and noise-measuring equipment (Little and Leinbach, 1959). It can operate in the frequency range 20–50 MHz (Jussila et al., 2004; Masanori et al., 1998). The principle of riometer technique is based on the detection of the relative changes in the ionospheric electron density by measuring the galactic noise intensity variations. Jansky (1937) was the first to recognize that variation in the ionosphere affects the reception of cosmic radio noise at 20.5 MHz. Cosmic radio noise intensities below 10 MHz were studied by Ellis (1957). Lunetta and Abdu (1971) suggested that the absorption of cosmic radio noise vary with the latitude of the observations.

Riometers are also operating at mid-latitude stations such as – Brandon, Fort McMurray, Gillam, Meanook, Ottawa, Penticton, Rabbit Lake, Pinawa, stations of Canada and Macquarie land of Antartica. Hargreaves and Friedrich (2003) and Danielides et al. (2001) reported at high latitudes

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the hard electron precipitation associated with auroral activity is a major source of ionization and hence the absorption in the D-region. Radio wave absorption, at South Pole, was measured by Stepanova et al. (2005). The riometer observations of a sub-storm electron injection were made by Spanswick et al. (2009). The effect of X-ray flares on mesosphere and lower thermosphere by coupled ion–neutral modeling was studied by Enell et al. (2008). They also made it is comparison with EISCAT and riometer. Hargreaves and Friedrich (2003) have given the relationship between the electron density at altitudes between 100 and 70 km and the total ionospheric radio absorption observed with a riometer at high latitude. Historically, using a total power radiometer the observations of intensity of cosmic radio noise at 18.3 MHz were taken by Shain (1951)and he found that the F region of the ionosphere was more effective than E region in partially absorbing cosmic radio noise. Bhonsle and Ramanathan (1958) determined the diurnal, seasonal, and annual variation in the ionospheric absorption of cosmic radio noise using total power radiometer (Operating on 25 MHz) during International Geophysical Year (IGY) at Ahmedabad. Cosmic-radio-noise measurements at 18 MHz from Hawaii, during November 1958 to December 1959 were reported by Walter and James (1961). Both Ahmedabad and Hawaii stations ware located close to Appleton anomaly region and hence, they could measure D-region absorption (nondeviative) as well as F-region absorption (deviative) very well during IGY period.

In this paper, we discussed the difficulties for study of cosmic radio noise absorption at low latitude station Kolhapur. In the end, criteria for successful use of riometer techniques for ionospheric absorption measurements at low latitudes are proposed.

2. Location and instrumentation

Kolhapur is lying between geomagnetic equator and Appleton anomaly region. Fig. 1 shows map of India and the asterisk ‘$*$’ indicates the location of site of our riometer. Initially, the riometer was installed at the campus of Shivaji University, Kolhapur but we observed much local noise in the signal pattern and hence to avoid those local noises we shifted this to a place called Borgoan, ~40 km away from University campus. The experience of last more than 2 years we observed the interference in the record which is mostly due to the solar noise during the day time and local noise during night time. Baseline of cosmic radio noise was comparatively smooth at night.

Experimental set up consists of a riometer, two copper wire dipole antennae, reflectors, data acquisition system and 12 V power supply. Fig. 2 indicates the standard antenna system consists of two half-wave dipoles separated horizontally by $\lambda/2$ to give effective half power bandwidth of 60° in both the E and H planes. The two dipoles consist of copper clad wire connected to central insulating blocks and the nylon rope at each end. The two reflectors consist of individual copper clad wires tensioned by nylon rope. The distances between ground and reflector as well as between reflector and antenna are 30 inch. The dipoles

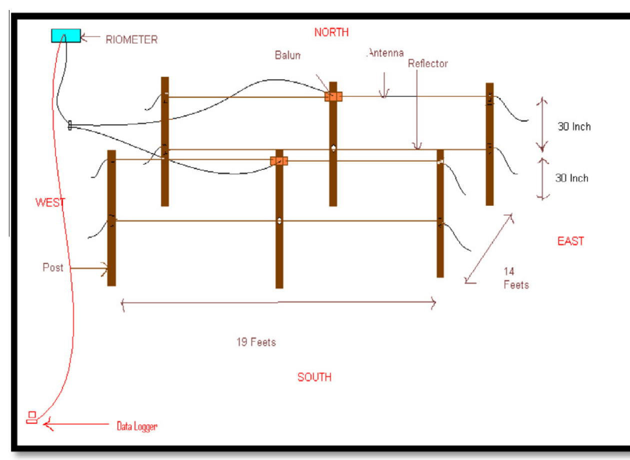

Fig. 2. Schematic diagram of the 30 MHz riometer antenna system.

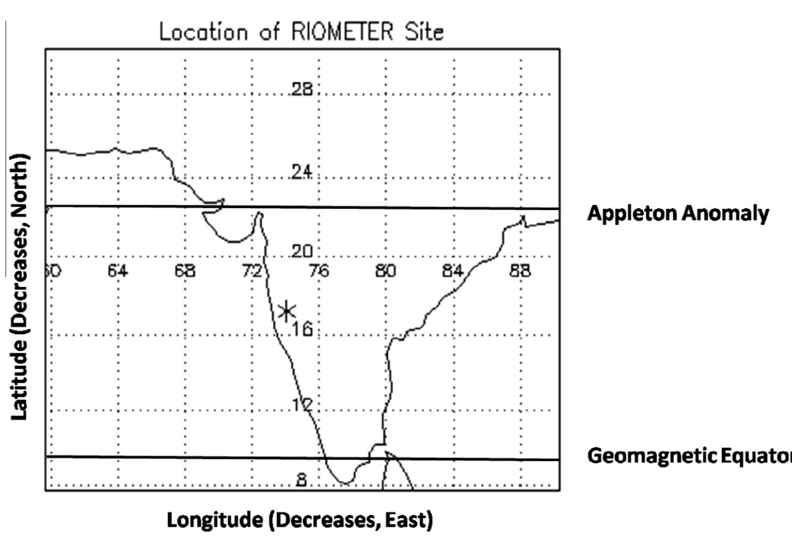

Fig. 1. Location of installed riometer is shown on the map of India by asterisk ‘$*$’.

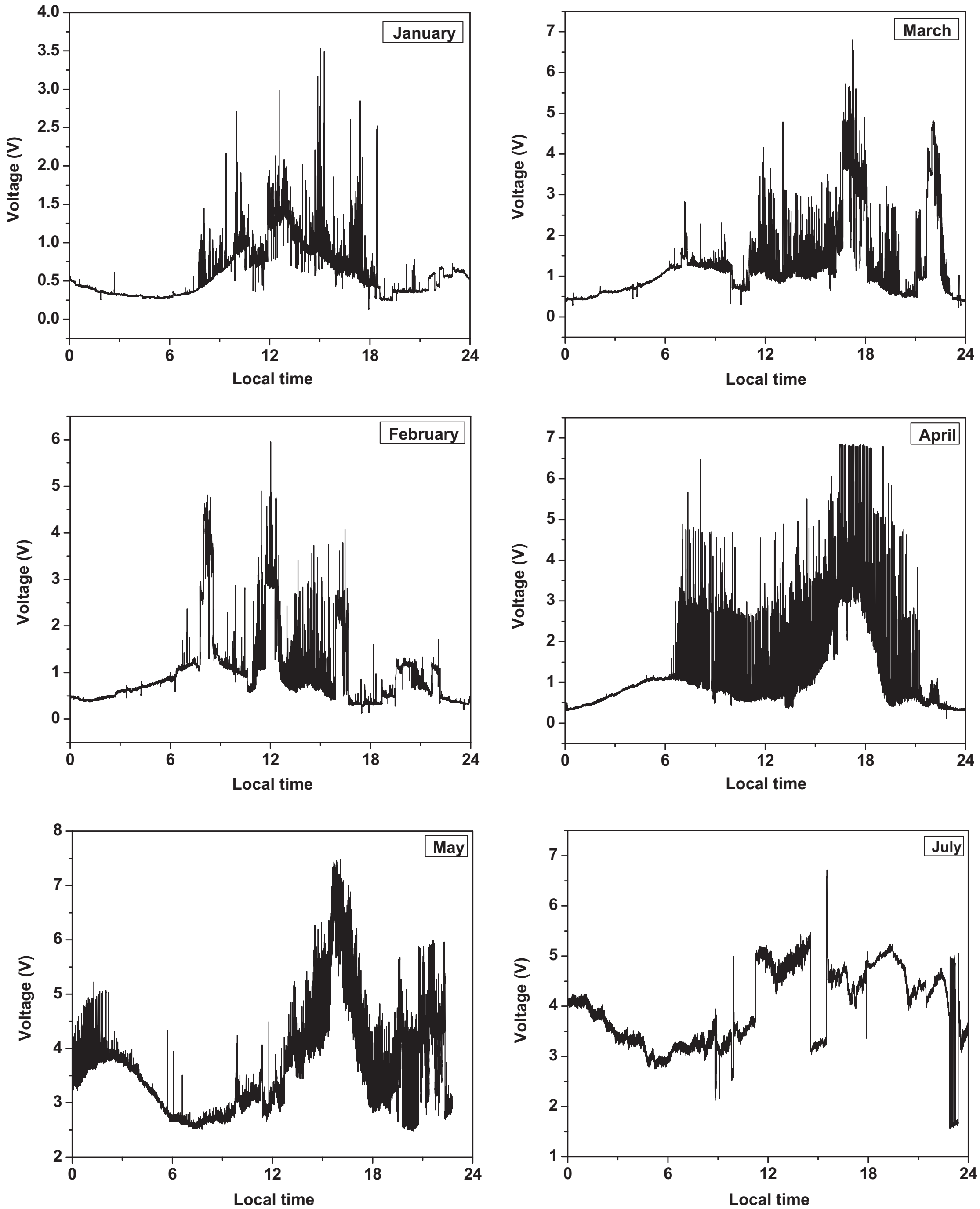

Fig. 3. Pattern of monthly variation in the signal strength of cosmic radio noise at low altitude station Kolhapur.

are connected to baluns, which consist of a $3/4\lambda$ length of 75 Ω triaxial cable to act as impedance transformer. The common terminals from two baluns are connected to riometer by good quality 50 Ω coaxial cable (Solid state riometer manual, 1974).

2.1. Riometer

The riometer is simply a receiver that measures intensity of the random noise that impinges on the earth from space. It consists of radio frequency (RF) switch, receiver, synchronous filter, phase detector, integrator, servo noise source, calibration noise source, timing unit etc. The size of riometer is $10.1 \times 12.7 \times 17.8$ cm and weight is 1.8 kg. Range of operating temperature is from −25 °C to +30 °C and it operates on 12 V power supply (Solid state riometer manual, 1974).

2.2. Data acquisition system

For the purpose of data acquisition, we have used the Shibacom data logger and a computer. The signal is

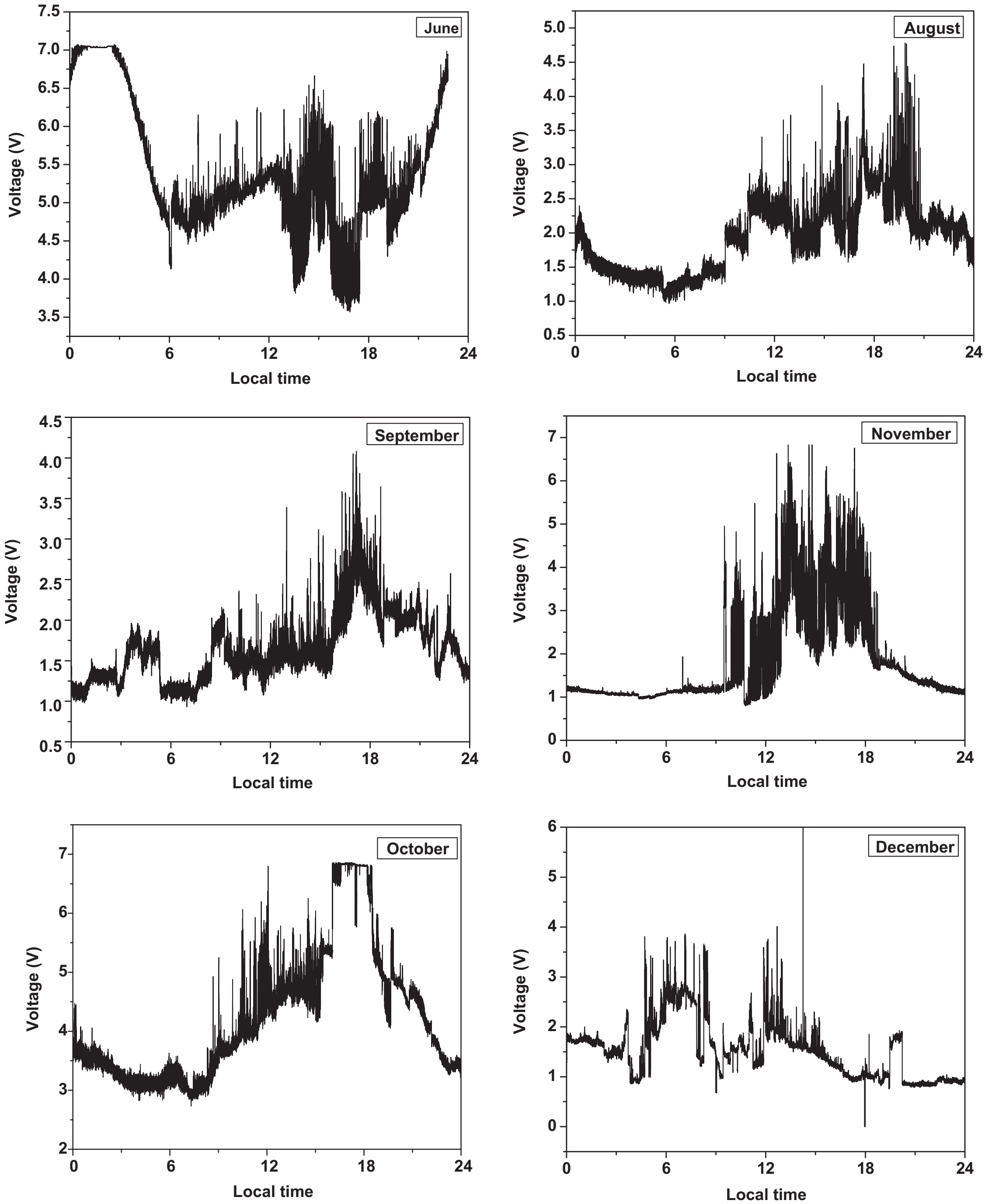

Fig 3. *(continued)*

digitized at a sampling rate of two seconds and recorded for 24 h. Data files are saved in the computer. The graphs are plotted with the help of Origin software.

3. Result and discussion

Use of riometer at low latitudes has been relatively less in comparison with that of high latitudes. In this study the riometer is used for the study of Sudden Ionospheric Disturbances (SID) by cosmic radio noise absorption in D region over low latitude (Geographic 16.8°N, 74.25°E) station such as Kolhapur. The ring current lies in the equatorial plane and circulates clockwise around the Earth. The ring current energy is mainly carried around by the ions, most of which are protons. In addition, a certain percentage are O+ oxygen ions, similar to those in the ionosphere of Earth, though much more energetic. The particles of this region produce a magnetic field in opposition to the Earth's magnetic field and so an Earthly observer would observe a decrease in the magnetic field in this area. Rajaram et al. (2002) studied magnetosphere–ionosphere coupling using riometer and magnetometer observations.

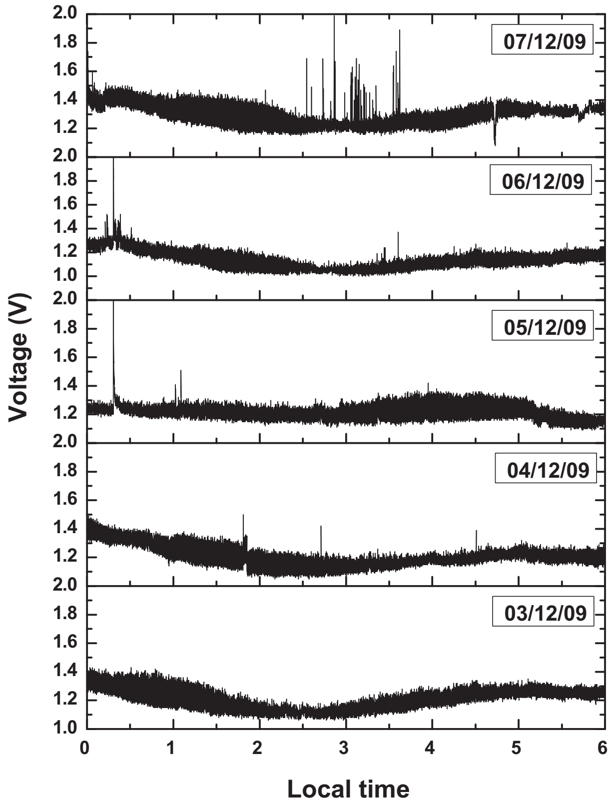

Fig. 4. Signal strength of cosmic radio noise at recorded on 30 MHz at Kolhapur during Night time (0000 h to 0600 h LT).

It is assumed that the radio noise from the quiet Sun is much less than the quiet-day cosmic noise background which was measured in the absence of the Sun. At high latitude Little (1957) recognized the significance of solar radio noise when active sunspot groups were present. During a relatively active period from October 13 through October 28, 1963, Dyce et al. (1963) reported some interesting results on solar radio emission on 30 MHz radio noise which is due to solar bursts. Heisler and Howeb (1970) suggested that the solar zenith angle as well as solar activity affect the measurements of seasonal variations in absorption. The observations of Washington State University riometer record for March 8, 1959 represents further evidence of a recognizable component of solar radio emission at 27.6 MHz. These records recorded at high latitude during solar maxima are well matches with (day time) monthly plots of cosmic radio noise signals recorded during pre phase of solar maxima at Kolhapur.

Antenna scans the sky day and night, it receives the intensity of the cosmic radio noise at 30 MHz, and its output is given to riometer. The output is in the form of voltage ranging from zero to five volts. This is recorded with respect to local time. A riometer is ground-based method used to measures the opacity of the ionosphere to radio noise emanating from distant stars and galaxies. Average of three days is done to execute a signal pattern for a particular month. Fig. 3 shows pattern of monthly variation in the signal strength of cosmic radio noise at Kolhapur. It is also seen that the solar noise makes interference in the signal of cosmic radio noise at low latitude and results in signal saturation. In the month of summer (March, April and May) signal mostly saturated. Hargreaves and Friedrich suggested that at high latitude the hard electron precipitation associated with auroral activity is a major source of ionization for the D-region [7]. The ionospheric absorption of cosmic radio noise at low latitude is mostly due to the ionization by solar, UV and X ray radiations.

4. Conclusions

The riometer measurement technique is most useful at high latitudes. Use of riometer at low latitudes has been relatively less in comparison with that of the high latitudes. Our observations from Kolhapur, a low latitude station, are not free from interference. This is due to local as well as solar noise during daytime. Due to solar noise, the base line the cosmic radio noise shifted upward and output of riometer goes in the saturation state, which is clearly shown in Fig. 3. Cosmic radio noise with comparatively low interference was recorded during nighttime (0000 h to 0600 h LT) shown in Fig. 4. From all observations, we conclude that the cosmic noise absorption measurement (on 30 MHz) is very difficult at low latitude station Kolhapur due to the addition of solar noise and local noise in it. The local noise can be avoided if one goes to remote place away from industrial area and big cities. For non-sunlit ionosphere at night only F-region study can be done with riometer operating at 10 MHz or less with high gain antenna will have to be used. F-region absorption (deviative) data and nightglow intensity at 630 nm can be compared and study transport of ionization between Appleton anomaly region and geomagnetic equator.

To get better response, high gain (and narrow beam) antenna will be useful at such low latitude. For earlier work at Ahmedabad on 25 MHz total power radiometer F-region deviative absorption becomes measurable only if critical frequency of the ionosphere is more then 1/3 of the operating frequency of radiometer. This will be a major R&D program in instrumentation. Therefore for F region studies over Kolapur, frequency in the range 18–20 MHz will be ideal. SID monitor equipment at VLF for solar flare detection is in operation at Shivaji University, Kolhapur and is giving useful data on solar flare activity. Data analysis is in progress. Here we suggest that, if one wants to use riometer for low latitude total ionospheric absorption (deviative or nondeviative) measurements, the following precautions will have to be taken.

(1) Use high gain antenna (an array of at least 16 dipoles).
(2) Operating frequency of riometer should be at least 3 times greater than the maximum daytime critical frequency of the F region of the ionosphere.
(3) With these improvements in instrumentation. It should be possible to study effect of solar flare,

magnetic storms on ionospheric absorption using riometer technique at low latitudes.

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