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Specification Document for Riometer Installations

D.W. Danskin

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1. Riometer Description

A **R**elative **I**onospheric **O**pacity **Meter** (Riometer) is used to measure the absorption of radio waves as they pass through the ionosphere. The ionosphere is a region of ionized particles extending from ~90 to 500 km above the surface of the earth and is created by the interaction of particles from the sun with the atmosphere of the earth. The Riometer is essentially a radio receiver operating at a select frequency (usually 30 MHz) which monitors cosmic radio noise that passes through the ionosphere.

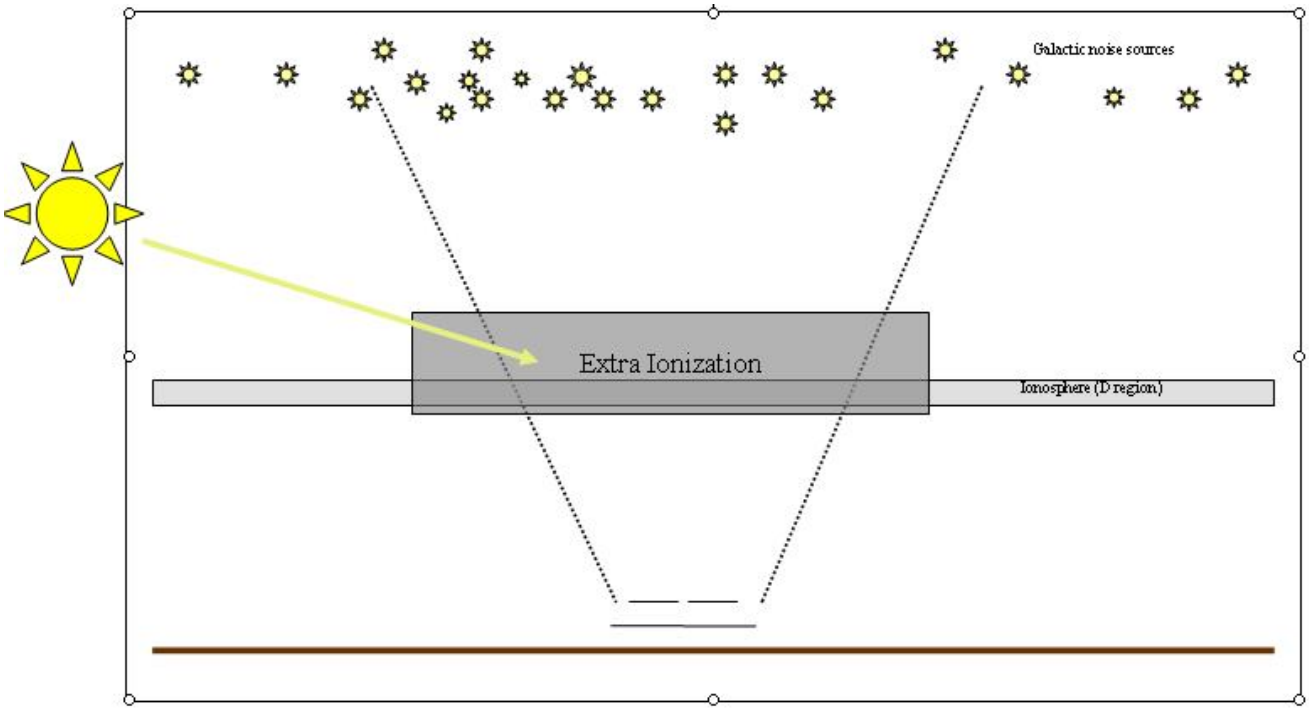

Figure 1. Schematic of the viewing condition for a riometer. The riometer antenna is three lines above the brown line which represents the ground at the bottom of the figure. The dotted lines represent the field-of-view of the antenna. Only the D-region (~90km) above the Earth is shown. The non-uniform distribution of stars is used to represent the variation in Galactic noise sources.

Typically, the signal strength varies due to different galactic radio sources passing through the field-of-view of the antenna as a result of the rotation of the earth. By plotting the data, a quiet-day signal level for undisturbed conditions can be determined. During ionospheric disturbances caused by precipitation of particles or solar X-ray events, the signal strength drops below the quiet-day curve and provides a measure of the absorption of radio waves by the ionosphere.

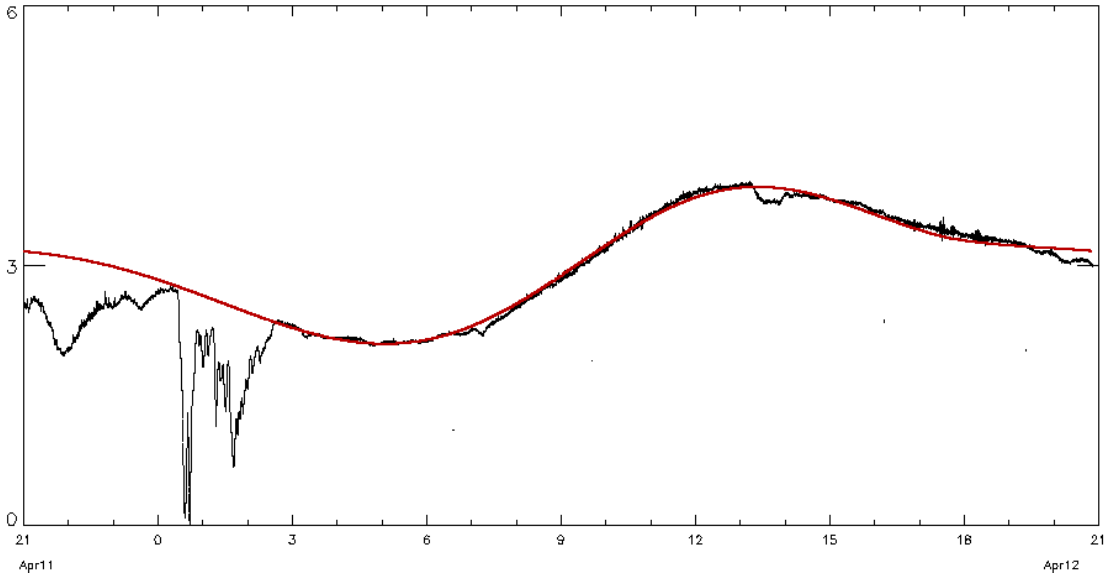

Figure 2. Plot of the variation of the Riometer voltage as function of time for a complete day. The red line is the quiet-day curve determined from a period of time when the ionosphere was quiet. The Black line is data from a disturb day. Absorption can be observed from 21 UT Apr 11 until ~3 UT Apr 12. The vertical scale is in volts.

The Riometer installation consists of an antenna, riometer and computer. A vertical antenna beam is created by a twin-dipole mounted on a wooden frame. The antenna is connected by low-loss coaxial cable to the riometer in a nearby building.

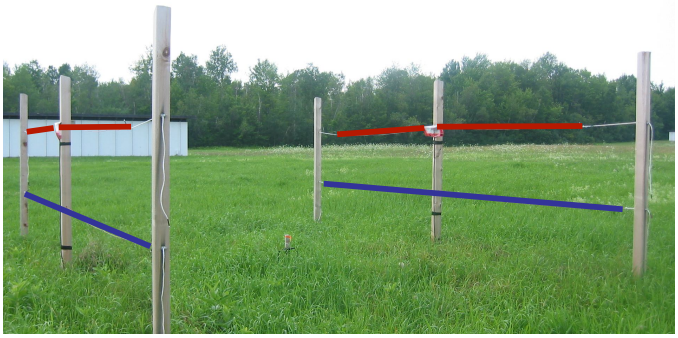

Figure 3. Antenna of the riometer. The red lines represent the driven elements of the twin-dipole antenna. The blue lines are the reflectors and are not connected electrically to the driven elements, but they reflect radio waves to the driven elements. The driven elements are connected to a balun mounted to the central post on each side and connect to a T-junction at the centre of the antenna. The third part of the T-junction is connected to the antenna feed which carries the signal to the riometer in the building.

Figure 4. Computer and riometer. A mini-pc (silver box) controls the riometer (blue box) via a RS232 analog to digital converter. The keyboard and mouse are standard size. The monitor is used to view the data collected.

The computer digitizes and timestamps the riometer output, archives the data into files and stores the data until retrieval by the Ottawa RWC. The riometer is the small blue box depicted in Figure 4.

Current riometer locations in Canada are shown Figure 5. Red dots indicate the Riometer locations operated by Natural Resources Canada. The grey dots are the location for those operated by the University of Calgary under the NORStar array. The white circle represents the approximate field-of-view at 90 km altitude of the antenna for operating Riometers.

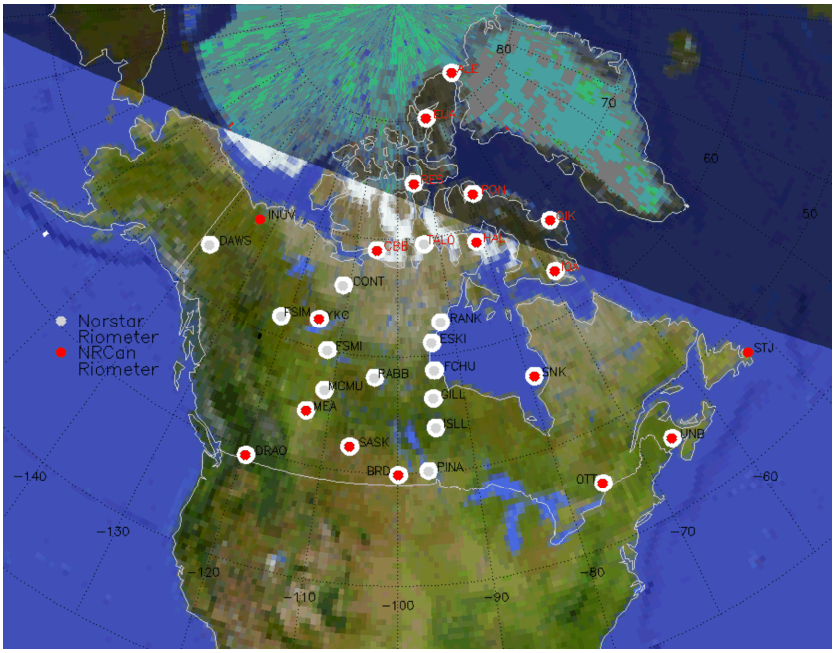

Figure 5. Riometer locations in Canada

Two types of antenna support are available, one for solid rock (Figure 6) and the other for soils where posts can be installed (Figure 7). The solid rock antenna can be placed anywhere at any time of the year. It consists of a 2x4 base connected together with plywood triangles. The triangles are also attached to 4x4 posts. The post antenna is the most structurally stable, but requires the post to be buried at least 2 ft into the ground.

Figure 6. Riometer antenna support for solid rock or frozen ground conditions

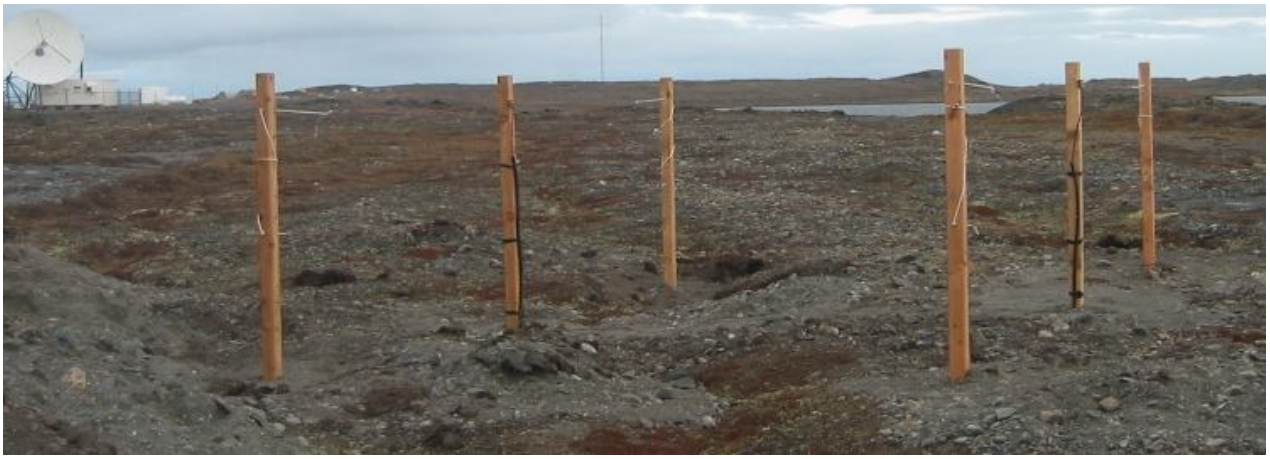

Figure 7. Riometer antenna support for dig-able ground conditions

Footprint of the antenna is 14ft x ~20 ft (4.25m x ~6.1 m) and should be located ~200 ft (61m) from any building. The lower and upper antenna wires are 2.5 ft (0.76m) and 5.0 ft (1.52m) above the ground respectively. The ground should be as level as possible and it can be gently sloping. Since the wavelength of 30 MHz is 10m a tolerance of +/- 2" (5cm) is acceptable for horizontal measurement. Vertical measurement need to be +/- 0.5" (1cm).

2. Site Requirements

The riometer needs to be installed in a location away from radio noise but with access to power and internet. These considerations mean that most locations are on the edge of a community. A suitable site needs space for the antenna plus room in a building for the riometer receiver and computer.

AC power (~110V, 60 Watts (max))
Internet
Space in building to house riometer and computer (2ft x 2ft, .6mx.6m)
Space outside for antenna (14ft x 20ft, 4.25m x ~6.1m)
Away from building (200ft, 61m)
Whole site away from sources of HF radiation especially at 30 MHz

3. Power Requirements

The riometer and computer run on 110 V. We provide a small 500VA UPS to provide backup power to cover short periods of power outage. The system consumes 60 W of power when the monitor is on and 30 W when the monitor is off. Typically the monitor is off, except for troubleshooting periods.

4. Internet Requirements

Data is retrieved from the riometer computers which use the linux OS using a rsync pull every 5 minutes. Each pull is about 5 kB of data, giving a very low data rate of ~ 1kB/minute. The computers are routinely monitored remotely via ssh. Rsync uses port 873 and SSH uses port 22. These ports may have to be opened on external firewalls.

5. Repair Requirements

Only minor repairs are expected to be done by an operator. These repairs would be such as rebooting the computer (either via software or hardware). Most of the riometer computers have run for several years without failure. Occasionally internet modems will need to be reset and these tend to be the most common internet/computer problems.

The antenna elements may need to be replaced. This is accomplished by untying the ropes from both ends, detaching the coax of antenna from the central T-junction, and installing the new antenna. The antenna is fastened to the central post by a screw. Typical replacement time is 20 minutes.

A riometer may have to be replaced due to failure in the field. There are no field serviceable parts in the box, so a new riometer will be shipped and the old one can be returned to Ottawa RWC. Replacement duties would be to unplug the Riometer power supply, detach the bnc connection between the Riometer and the antenna cable and the db25 connector between the Riometer and the computer. The cables are attached to the replacement riometer and it is powered up. On rare occasions the computer may have to changed and the UPS may need to be replaced.