Marion Island RIOmeter and MOSAIC Installations

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1. Background

The South African National Space Agency's Space Science Directorate (SANSA), previously known as the Hermanus Magnetic Observatory (HMO) has had an overwintering position on Marion Island since 2010. This position is filled by a suitably qualified engineer, who is responsible for physical sciences including geodesy (GPS, DORIS, Tidal Gauge), VLF (Wideband and narrowband) and ionospheric scintillation (GISTM).

The Polar Space Weather Studies (PSWS) project has been running on successive SANAP grants since 2005. Throughout this period an extensive observational network has been established that has served various sectors of space physics research nationally and internationally.

Figure 1. Locations of the current physical science experiments and other key locations on Marion Island (Zone 1).

2. The Scientific Case

Radiation from the sun, in the form of energetic particles, is transported towards the earth by the solar wind. Most of this energy is reflected by the magnetosphere, but a fraction is trapped inside a region in near-Earth space known as the radiation belts. Eventually these particles escape into the ionosphere, causing harm to satellites and humans on aircraft, and destroying atmospheric ozone, which blocks UV radiation.

The RIOmeter that is to be installed at Marion Island will form part of a global ground station network, which aims to:

- use RIOmeters and ozone radiometers to determine the amount of ozone loss during high-energy particle precipitation events, and
- use RIOmeter data to confirm and augment in situ observations of the radiation belts from the Japanese ERG (Energisation and Radiation of Geospace) satellite.

Ozone is a trace gas, which is important to the radiative balance of the middle atmosphere. SANSA will deploy a mesospheric ozone radiometer, forming part of the International Mesospheric Ozone System for Atmospheric Investigations in the Classroom (MOSAIC) array of instruments, in order to:

- study global-scale impact of high-energy particle precipitation events. These produce short-lived HOx and long-lived NOx, both of which are effective catalysts for mesospheric ozone destruction.
- understand the link between space weather and climate change.

3. Previous RIOmeter and MOSAIC Installations

SANSA has significant experience installing, maintaining and running RIOmeters. There are two RIOmeters at the SANAE IV station and there is one at SANSA in Hermanus.

SANSA was also responsible for the installation and maintenance of the first generation Ozone Radiometer (MOSAIC) at SANAE IV in 2012.

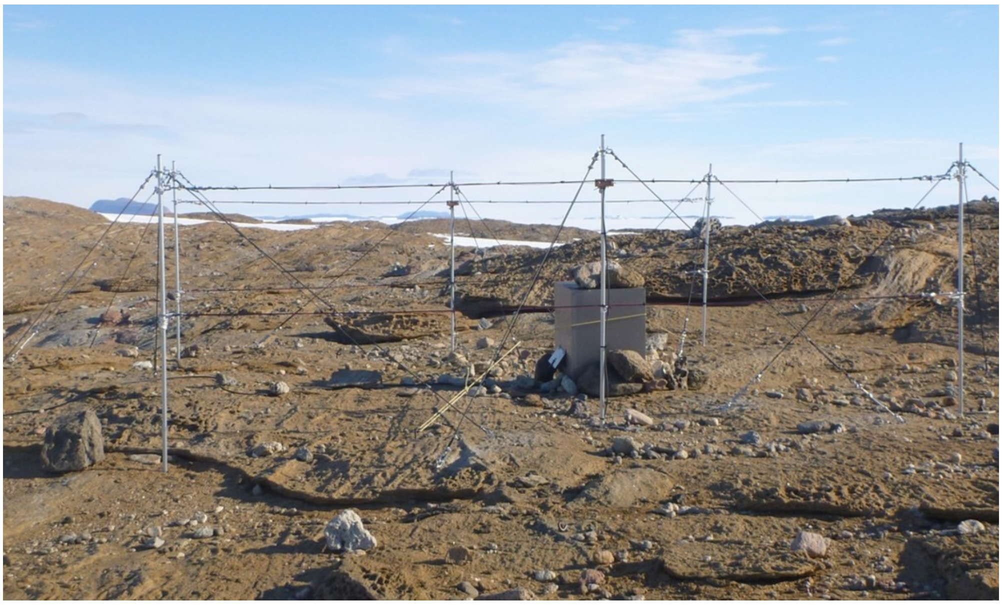

Figure 2. An example of a modern RIOmeter antenna array (1.5m height and 6m width).

Figure 3. An example of a MOSAIC receiver antenna dish at the SANAE IV small-sat-dome

4. Location & Placement Requirements

The RIOmeter needs an area that is relatively flat and that is far away from sources of Radio Frequency Interference (RFI) such as HF, VHF and UHF transmissions as well as high voltage electric power lines. The latter is of no concern on Marion Island, however, the former poses a problem as the base broadcasts radio transmissions on all of the above mentioned frequency bands.

The instrument also needs accessibility to power and network connections and the signal cables can be a maximum of 100m from where the electronics and logger are situated.

A site survey was conducted during the previous funding cycle, which confirmed the area to the South of the Doris Hut was the ideal for this instrument as it is the furthest position from the base.

Figure 3 shows the Doris Hut, which houses a large number of instrument loggers for SANSA and has the necessary power and network requirement already in place to accommodate the RIOmeter.

Figure 3. DORIS Hut and some associated instrument antennas.

The MOSAIC receiver consists of a small antenna dish, which needs to be mounted to a wall or to a pole. The LNB electronics, which sit on the arm of the dish, need to be somewhat protected from severe weather.

The dish needs a clear, unobstructed view of the southern horizon. The exact azimuth angle is not important, but it must be towards south to avoid interference from satellite TV, which will be towards the north. Additional shielding needs to be placed behind the dish to prevent unwanted signals from behind the dish, or from the side-lobes of the dish, interfering with the measurement.

SANSA considered putting the dish on the South facing wall of the Doris Hut, however, during a site survey in the previous funding cycle, it was discovered that the old SAWS dome was unused and could house this instrument. We proceeded to get permission from SAWS to use this dome and they agreed.

The dome has the advantage of being able to isolate and insulate the dish from the elements as well as providing a structure inside which we can place shielding to block the back-lobe and side-lobe interference.

Figure 4 shows the SAWS dome in which we wish to place the MOSAIC receiver. The dome is approximately 50m from the Sat-Dome, from which we are able to run power and network connection cables.

Figure 4. The SAWS dome which can house the MOSAIC receiver

5. Proposed New RIOmeter and MOSAIC Instrument

The RIOmeter will require a flat area of ground up to 75m away from the Doris Hut. The electronics box will be placed at this point, which has been designed to be as waterproof as possible. To ensure that water does not get inside, this waterproof box will be placed on a small aluminium frame and wrapped with a tarp. The frame together with the wrapped box will be anchored to the ground using metal stakes and strapping. This will prevent the structure from blowing away in the wind.

Figure 5. Waterproof case for the electronics

The two antennas should be placed as far apart as possible and up to 15m away from the electronics box (along the red circle in Figure 5)
The electronics will consume some 50 Watt of power will come from the inside the Doris Hut. The cables will be buried approximately 10cm below the surface and the soil that is removed will be replaced after the cable is placed.

The antenna array will be made up of only metal poles and stakes with UV resistant, PVC insulated cables. These materials have been used at the SANAE IV station for many years and are proven to not decompose and contaminate the environment.

The antenna will not exceed 1.5m in height and is approximately 6 metres in length.

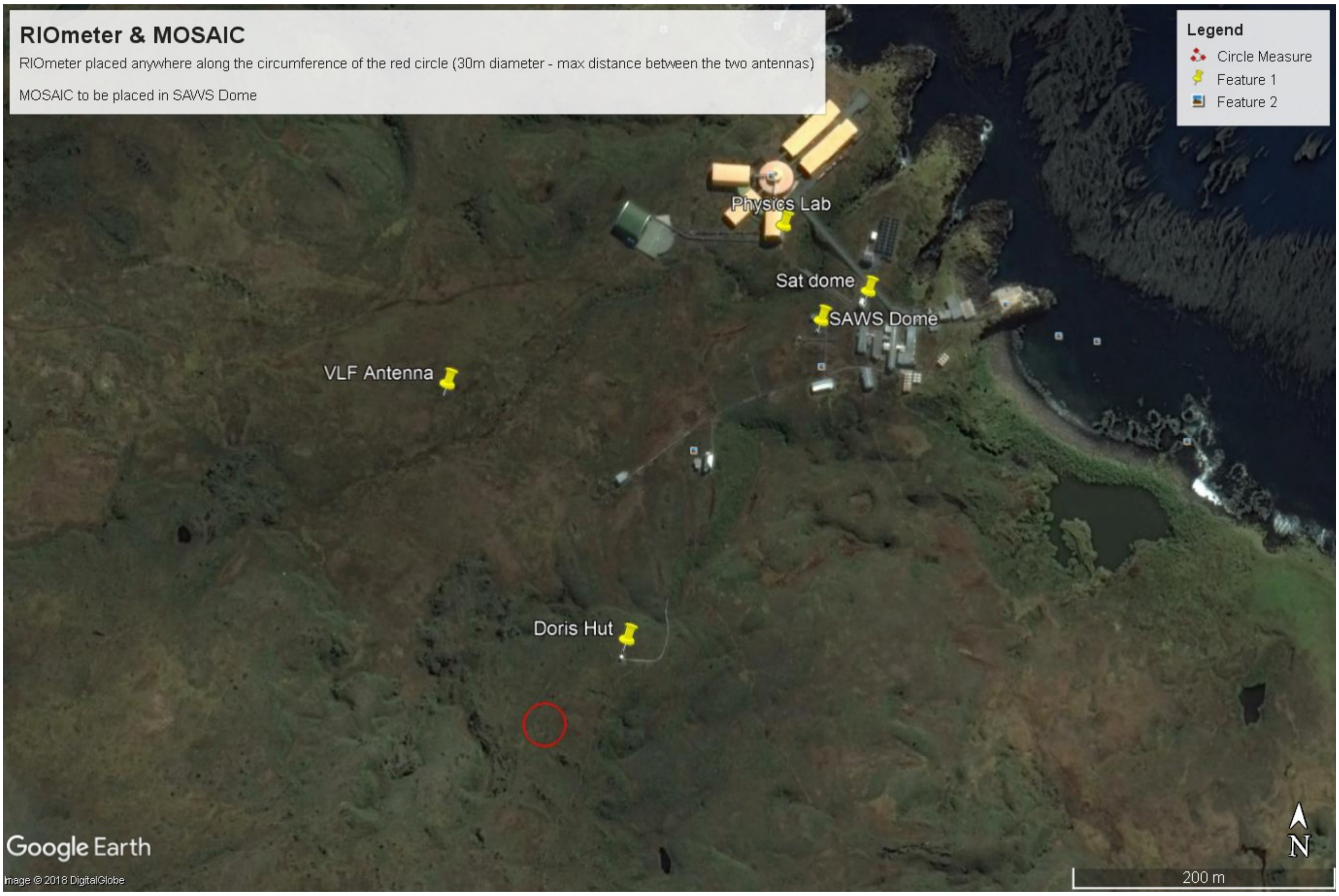

Figure 5. The most suitable area for the RIOmeter (Red Circle) and MOSAIC instruments (SAWS Dome) – in Zone 1

The MOSAIC instrument requires space inside the SAWS dome. The antenna and the logging electronics are co-located and need only power and network connections to be placed.

6. Installation of the Instrument

Figure 6 shows how the antennas and electronics are connected. Figure 7 shows the approximate dimensions of the antenna. The antenna will be pre-assembled at SANSA and then rolled up and transported to Marion Island. The installation only requires a measuring tape and a mallet to secure the ground stakes.

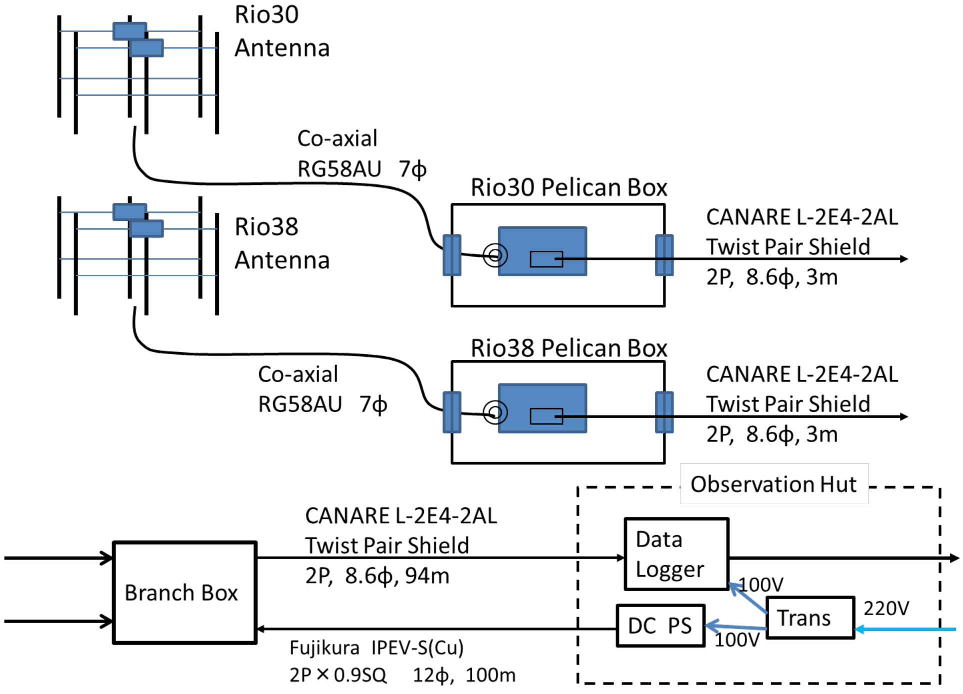

Figure 6. Typcial installation of a RIOmeter

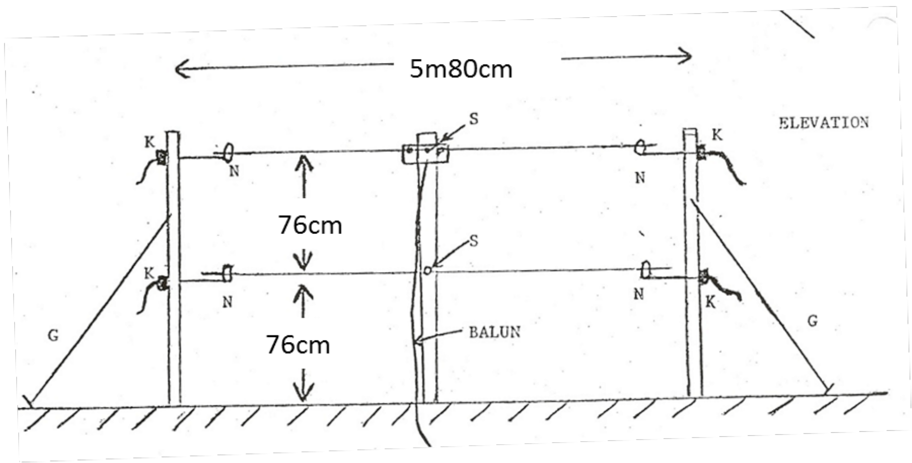

Figure 7. Approximate dimensions of the Antennas

The MOSAIC instrument will be mounted on to an aluminium mast that will be secured to the floor using machine screws. The aluminium mast will be manufactured at SANSA and assembled on site. The shielding, which is thin aluminium sheeting will be placed along the northern side on the inside wall of the SAWS dome. A power and network cable, approximately 50m in length will be run from the Sat-dome, beneath the walkway along the same path as existing cables.

7. Maintenance

The RIOmeter antennas and electronics will be maintained by the SANSA overwintering engineer. The MOSAIC receiver, along with the SAWS dome will also be maintained by the SANSA overwintering engineer. Complete training will be provided prior to deployment and during the handover period.

8. Decommissioning

Both the RIOmeter and MOSAIC instruments are of a non-permanent nature and can easily be packed up and removed and the end of the project with little to no impact on the environment.

9. Conclusion

A complete project background and installation plan has been presented that shows minimal impact to the environment and makes use of existing infrastructure.