Digital upgrade of SuperDARN radar at SANAE

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1. SuperDARN Radar

SuperDARN (Super Dual Auroral Radar Network) is an international Radar network for studying the Earth's upper atmosphere, ionosphere and connection into space, with radars observing the northern and southern auroral regions. There are currently 22 radars in the Northern Hemisphere and 11 in the Southern Hemisphere. The network provides data to scientists in 16 countries. The SuperDARN radars provides insight into the dynamics of Space Weather.

The South African Southern Hemisphere Auroral Radar Experiment (SHARE) radar at SANAE IV (71°40'37.67"S, 2°49'41.09"W), has been part of SuperDARN since 1997.

During the Austral Summer of 2013/14, the South African National Space Agency (SANSA) became the second organization to install the T3 implementation of the all-digital HF Radar in the SuperDARN network. The new radar, which replaced the previous radar at SANAE IV was based on the Australian design from La Trobe University.

The new radar was fully built and tested at SANSA Space Science in Hermanus, South Africa and it was funded through grants from the South African National Research Foundation and SANAP. SANAE IV's strategic location close to the South Atlantic Anomaly makes the data invaluable for geospace observations.

2. Research Goals

The scientific goal of the SANAE HF radar programme is to increase understanding of aspects of the dynamics of the high latitude ionosphere and magnetosphere, magnetosphere-ionosphere coupling, the interaction of the magnetosphere with the solar wind and the energy transfer mechanisms between the solar wind, the magnetosphere, the ionosphere and the upper atmosphere, by addressing the following key questions in Space Science:

1. What is the nature of ultra-low frequency pulsations observed in the radar data, and how are they related to events in the solar wind?
2. What further information on such pulsations can be obtained using wavelet analysis?
3. What is the nature of the excitation mechanism of pulsations with large azimuthal wavelength?
4. What are the source and propagation mechanism of Pc5 band pulsations?
5. What are the mechanisms by which the interplanetary magnetic field controls convection in the high latitude ionosphere under different conditions?

3. Installation

The All-digital HF Radar in the container in which it is installed at SANAE-IV. The SANSA Engineers on the team that installed it during the 2013/2014 Summer Expedition are from left to right: Roger van Schie (SANAE 2010 overwintering team), Jonathan Ward (SANAE 2012 overwintering team), Philip Mey (SANAE 2013 overwintering team), Francois Olivier (SANAE 2014 overwintering team).

4. Applications

The key questions in the research goals will be addressed through the use of data from the SANAE HF radar in collaborative programmes with other investigators.

The research aims to answer the key questions by, inter alia
1. analysing, using a variety of complex time series analysis tools, sample pulsation events observed in the radar data, together with solar wind data;
2. analysing convection patterns associated with different interplanetary magnetic field configurations; and
3. using the interferometer antenna system, undertaking atmospheric wave studies at SANAE, and combining these data with other SuperDARN data.

Coverage and national associations of the 11 SuperDARN radars in the Southern Hemisphere. The beam of each radar scans an area of about 4 million square kilometres. The overlapping of the beams permit the estimation of both the speed and the direction of travel of ionospheric structures over the South Pole. A similar network is monitors ion flow over the North Pole.

6. FPGA Technology

Due to the new radar being based on Field Programmable Gate Arrays (FPGAs), it provides a flexible platform that will allow researchers to run a diversity of experiments that fall outside the mandate of SuperDARN without having to invest in expensive and difficult to install infrastructure, whilst still satisfying its commitments to the SuperDARN network.

One of the T3 Transceiver units of the new HF Radar at SANAE-IV. All 16 the units for the HF Radar were built and tested at SANSA Space Science in Hermanus.

6. SuperDARN Antenna

The new Antenna array of the HF Radar at SANAE-IV. The Twin folded dipole array replaced the previous 16 elementLog-periodic array which was demolished by strong winds in 2008.

7. Calibration

One of the proposed new experiments is to receive the signals from a 14 MHz HF beacon on the first South African CubeSat (Tshepiso - Sat) launched on 21 November 2013. The CubeSat was built by students in the Satellite Engineering Programme of the Cape Peninsula University of Technology (CPUT). The beacon signals will be used to calibrate the beam pattern and elevation estimation algorithm of the SANAE HF Radar. The experiments at SANAE will be supported by a HF DF array at SANSA Space Science in Hermanus which is designed to determine the direction of arrival of the signals. A similar array is to be built at SANAE-IV in future.