# REMOTE SENSING SPACE WEATHER EVENTS THROUGH IONOSPHERIC RADIO: THE AARDDVARK NETWORK

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## Abstract

The Antarctic-Arctic Radiation-belt (Dynamic) Deposition - VLF Atmospheric Research Konsortium (AARDDVARK) provides a network of continuous long-range observations of the lower-ionosphere in the polar regions. The network of sensors detect changes in ionisation levels from ~30-90 km altitude, globally, continuously, and with high time resolution, with the goal of increasing the understanding of energy coupling between the Earth's atmosphere, Sun, and Space. We use the upper atmosphere as a gigantic energetic particle detector to observe and understand changing energy deposition from space weather events.

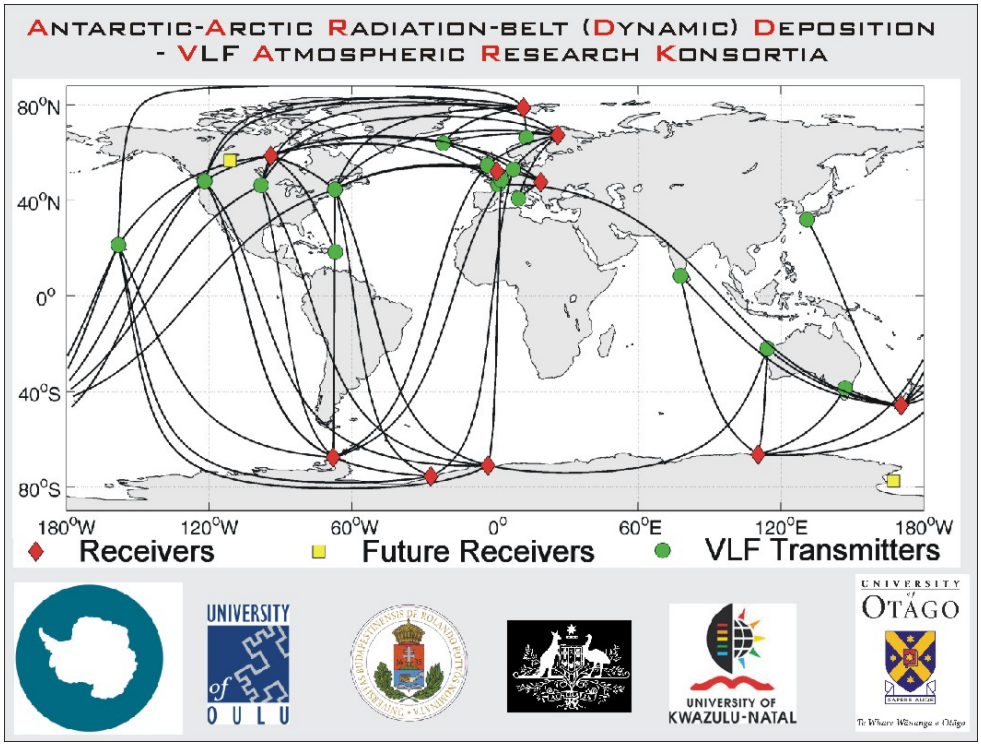
## Background Information

The joint NZ-UK Antarctic-Arctic Radiation-belt (Dynamic) Deposition - VLF Atmospheric Research Konsortia (AARDDVARK) is a new extension of a well-establish experimental technique, allowing long-range probing of ionisation changes at comparatively low altitudes. One of the few experimental techniques that can probe these altitudes uses very low-frequency (VLF) electromagnetic radiation, trapped between the lower ionosphere (~85 km) and the Earth; these signals can be received thousands of kilometres from the source. The nature of the received radio waves is determined by propagation inside the Earth-ionosphere waveguide, with variability largely coming from changes in the electron density profiles at and below the lower ionosphere. Most other instruments which can probe the same altitudes are limited to essentially overhead measurements. We have recently developed the AARDDVARK global-scale network of sensors that monitor fixed-frequency communications transmitters, and hence provide continuous long-range observations between the transmitter and receiver locations. Our receivers log small changes in the phase and amplitude of powerful VLF communications transmitters (~13-30 kHz). By monitoring distant VLF stations we undertake long-range remote sensing of changes to the waveguide, and particularly the ionosphere. At this stage AARDDVARK is essentially unique, as similar systems are only deployed at a regional level. This Science area impacts our knowledge of space weather processes, global atmospheric change, communications, and navigation.

Most of our AARDDVARK sensors are deployed to monitor the Antarctic and Arctic regions. The plot below shows our existing AARDDVARK receiver (Rx) locations (red diamonds). The great circle paths between the monitored VLF communications transmitters (Tx, circles) and the receiver sites are also shown, which indicates the atmospheric areas monitored. Our planned AARDDVARK sensors for the future are shown as yellow squares. The AARDDVARK network has contributed to the scientific understanding of a growing list of space weather science topics including SPEs, the descent of NOx into the middle atmosphere, EMIC, substorms, plasmaspheric hiss, CME's, microbursts. Future additions to the network will increase the science potential and provide global coverage of space weather event signatures. Extensions to the AARDDVARK network sensors, along with upgrades in the

sensors themselves, is currently being undertaken as part of the International Polar Year and International Heliospherical Year.

More information can be found at the homepage of the AARDDVARK network:
http://www.physics.otago.ac.nz/space/AARDDVARK_homepage.htm



Graphical summary of the AARDDVARK sensor array