Tracking Ultra-low Frequency Waves with Radar

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What are ULF Waves?

Ultra-low frequency (ULF) waves are naturally occurring vibrations in the Earth’s magnetic field, which protects us from harmful material from the Sun, called space weather. ULF waves are important because this is how the Earth’s magnetic field stores and transports energy from the Sun around near-Earth space.

They can be caused by external sources such as the solar wind, or internal sources such as energetic particles. These waves transfer energy around the Earth’s magnetosphere and eventually to the upper atmosphere. When these waves reach the atmosphere, they heat it and cause plasma in the ionosphere (a layer of the upper atmosphere) to move, which we can detect with radar.

SuperDARN Radars

Super Dual Auroral Radar Network (SuperDARN) is a network of HF radars designed to look at the polar ionosphere.

The radar scatters off weak plasma in the ionosphere and we can use the returned signal to determine the speed and direction the plasma moves at. The radar can scan along many beams for many distances.

The plot below shows an example of a ULF wave detected in SuperDARN radar data. The wave causes the plasma to move away (blue) and towards (red) the radar. The measured frequency of this wave is approximately 10 mHz.

Purpose of the Project

Using automated detection algorithms, a large dataset of ULF waves will be created. Their properties can then be analysed to determine how they change in response to the solar wind conditions, seasons, and location in the Earth’s magnetic field.

It is hoped that by doing this, we can track how this energy moves towards the Earth. This will help us gain a greater understanding of how space weather impacts the Earth and will help us protect satellites and astronauts.