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AN INTRODUCTION TO SPACE WEATHER

By Mark Little

Image from NASA website

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WHAT IS "SPACE WEATHER"?

The environmental conditions caused primarily by plasma and radiation from the Sun and their interaction with the Earth.

Image from NASA website

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WHY IS IT IMPORTANT?

- Power blackouts
- Weather effects
- Satellite communications and orbital decay
- HF Radio communications
- GPS Accuracy

Image from NASA website

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WHAT CAUSES "SPACE WEATHER"?

Image from NASA website

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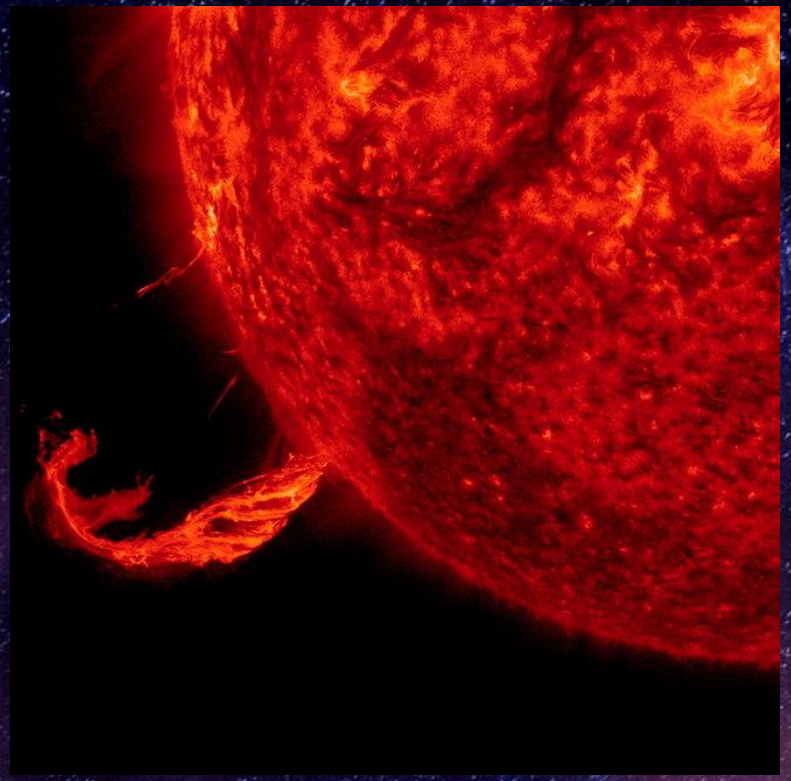

The Sun is a seething, boiling ball of hot gas. It continually ejects plasma streams and radiation.

These emissions flow out from the Sun and interact with the planets.

Image from Pintrest website

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Radiation from the Sun consists mainly of electromagnetic waves ranging from infrared (IR) to ultraviolet rays (UV).

Sunlight is the most obvious, but other radiation is absorbed and/or reflected by the atmosphere.

Image from Pintrest website

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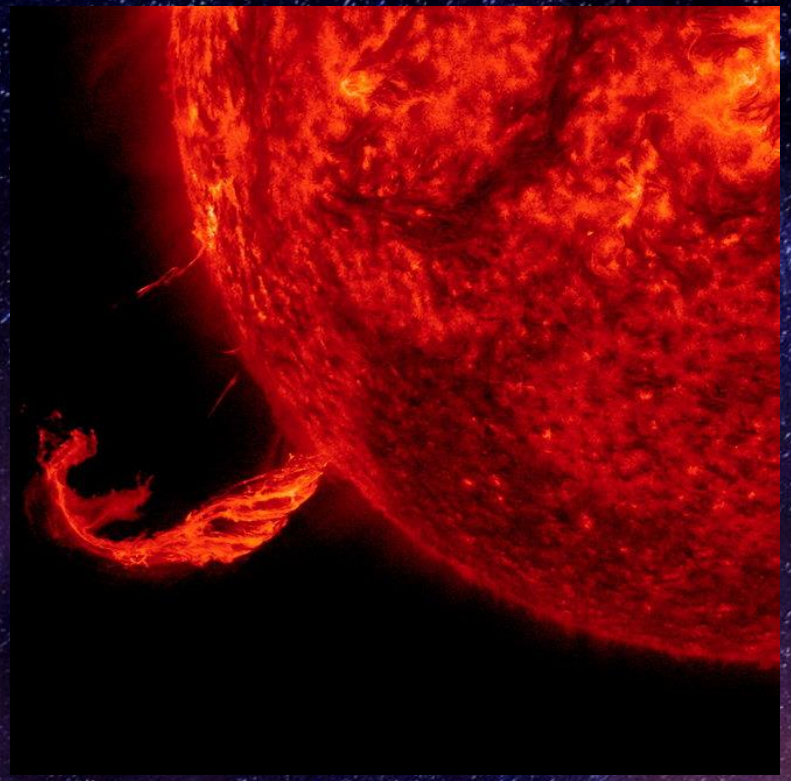

The solar plasma consists of mostly protons (90%), electrons (9%) and alpha particles (1%).

This stream of charged particles from the upper atmosphere of the Sun is called the *Solar Wind*.

Image from Pintrest website

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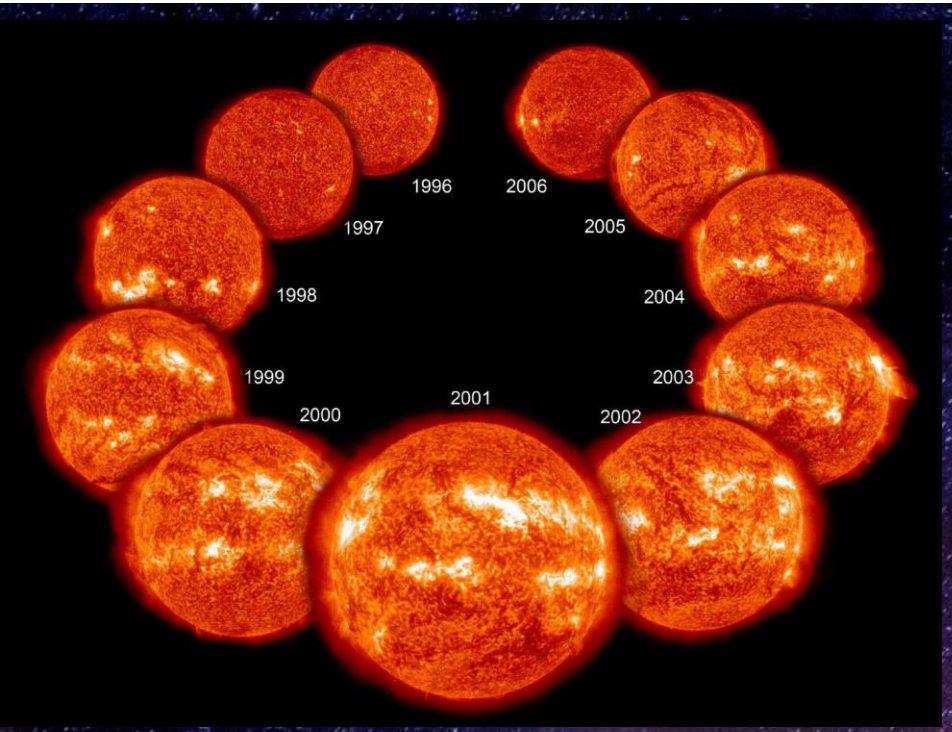

Spots on the Sun's surface indicates increased activity.

More sunspots mean more emissions.

Sunspot activity follows an approx. 11 year cycle. The period of most sunspots is called the maxima and the least, the minima.

Image from NASA website

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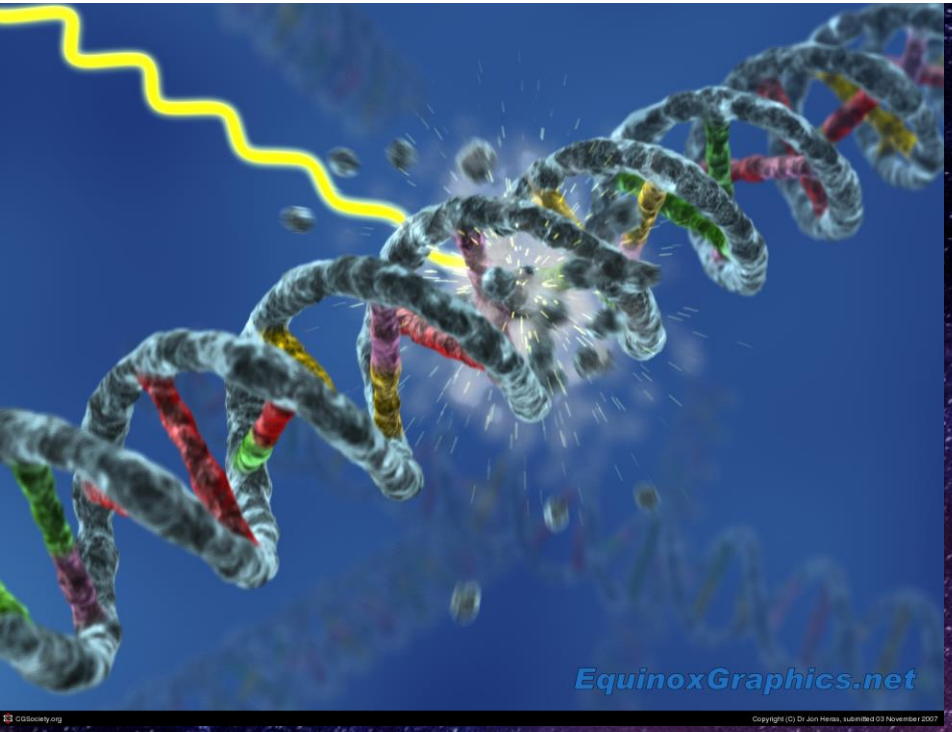

Solar wind's high energy ionised particles and radiation can severely damage living tissue.

Buffeting by solar winds can strip the atmosphere from a planet by a process called "sputtering".

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WHAT HELPS PROTECT THE EARTH FROM "SPACE WEATHER"?

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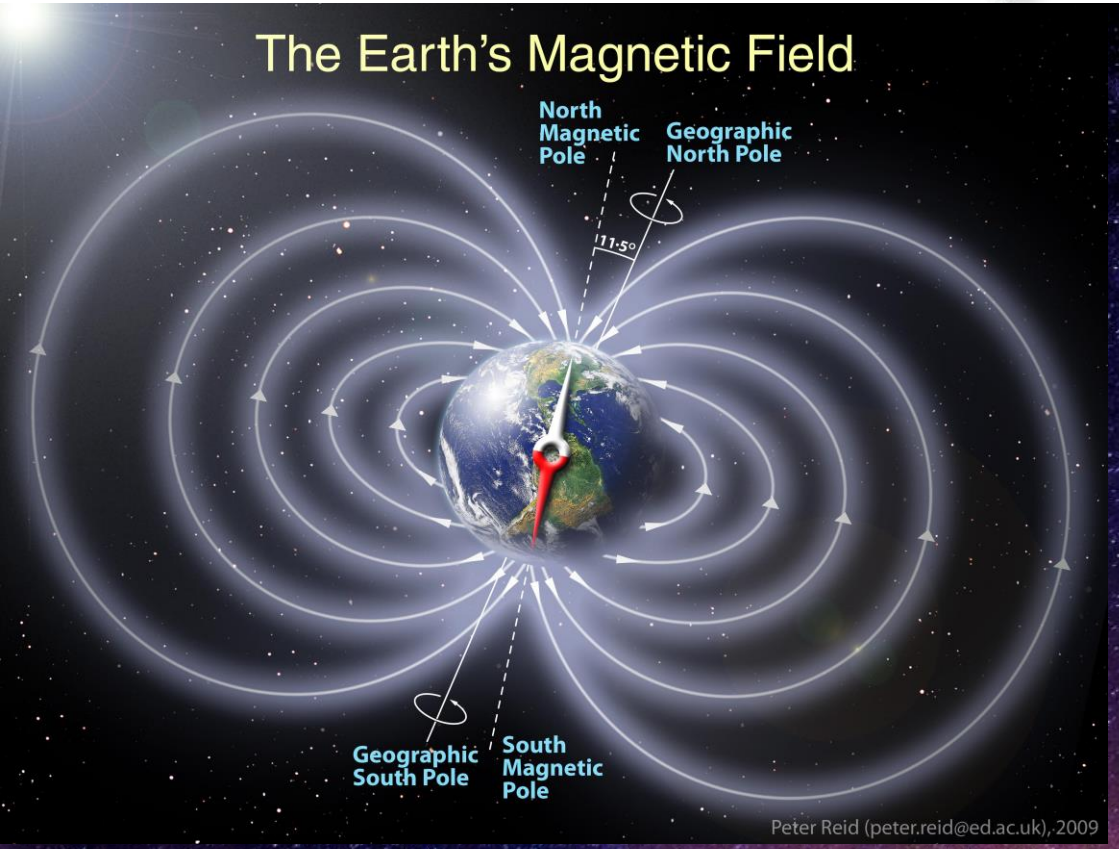

The Earth has a magnetic field, resulting from the movement of its liquid iron core.

The magnetic field comes through the atmosphere to the ground at the magnetic poles.

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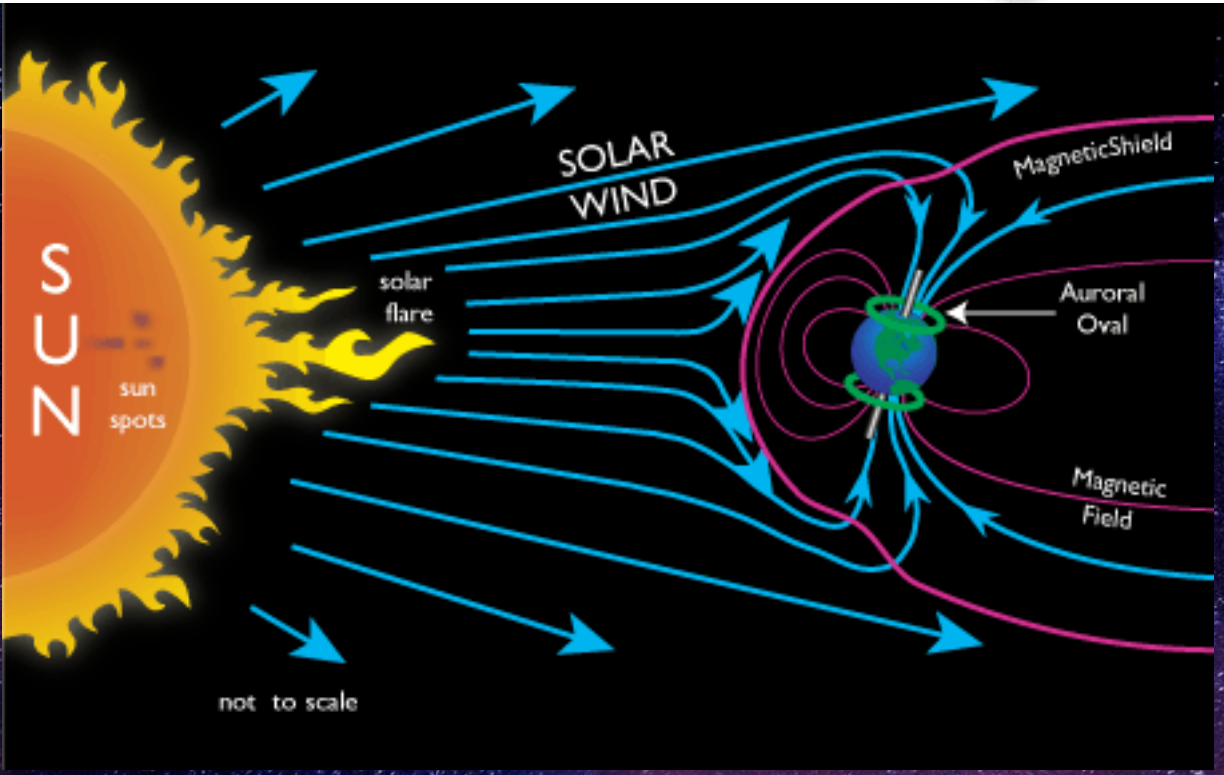

The charged particles of the solar wind interact with the Earth's magnetic field, and are deflected around the Earth, although particles reach the atmosphere at the poles.

Image from Aurora Service (Europe) website

Energetic particles spiral down the magnetic lines near the magnetic poles.

Atmospheric gases are ionised and glow causing the Aurora.

Other planets, like Jupiter, also have auroras.

Image from NASA website

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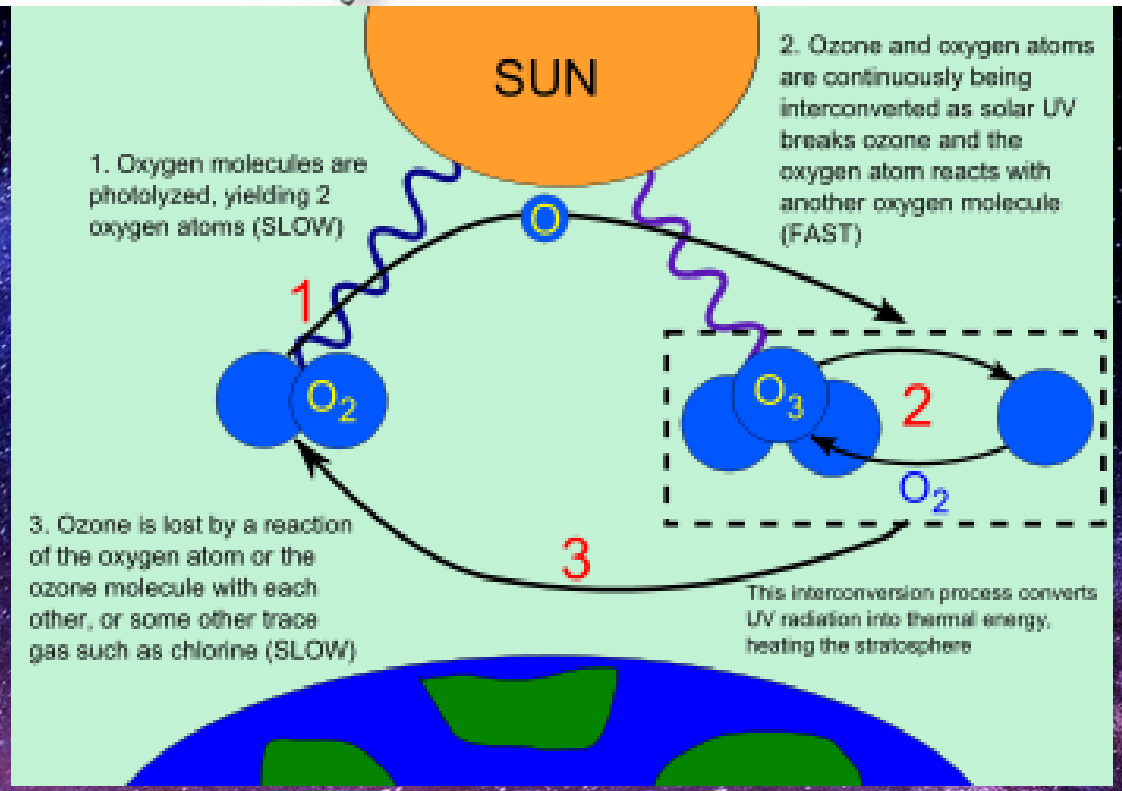

The Ozone Layer in the atmosphere protects life on the surface by partially absorbing Ultra-Violet (high energy) radiation from the Sun.

Image from Wikipedia website


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HOW DO WE MEASURE "SPACE WEATHER"?
If you can't measure something, you can't understand it.
- H. James Harrington

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LOOKING AT THE SUN

Visual observation of the Sun provides an indication of the Sun's activity

Light arrives at the same time as radiation from an outburst, but before the particles.

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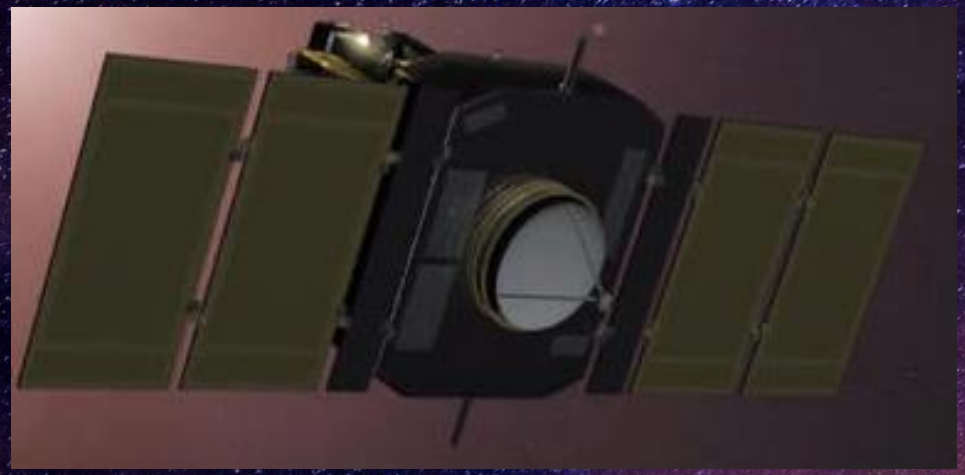
Satellite Observations



The Solar & Heliospheric Observatory (SOHO) satellite studies the Sun's internal structure, its outer atmosphere and solar wind, a stream of highly ionized gas.

Image from NASA website

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Terrestrial Observations

BOM Learmonth W.A.

- Helioseismology
- Optical telescope
- Radio telescope
- Radio spectrograph

Image from BOM website

LOOKING AT THE EARTH

Earth's Magnetic Field – Impacted by solar wind and its associated magnetic fields.

Earth's Atmosphere – Impacted by radiation and solar wind, causing ionisation and other changes.

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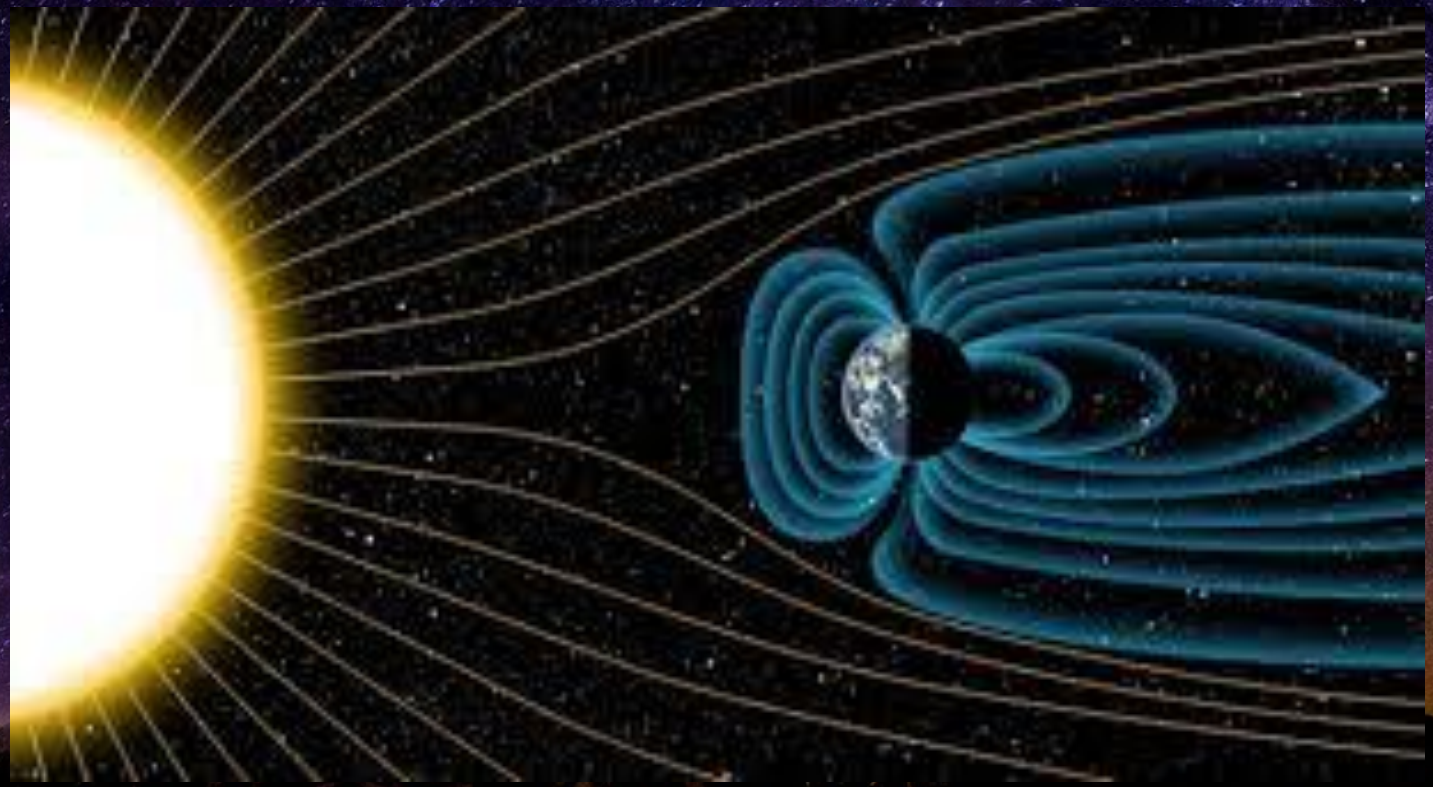
EARTH'S MAGNETIC FIELD



The Solar Wind creates a magnetic field this interacts with the Earth's magnetic field.

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MAGNETOMETER

A Magnetometer measures the strength of the Earth's magnetic field in 3 dimensions (X, Y, Z).

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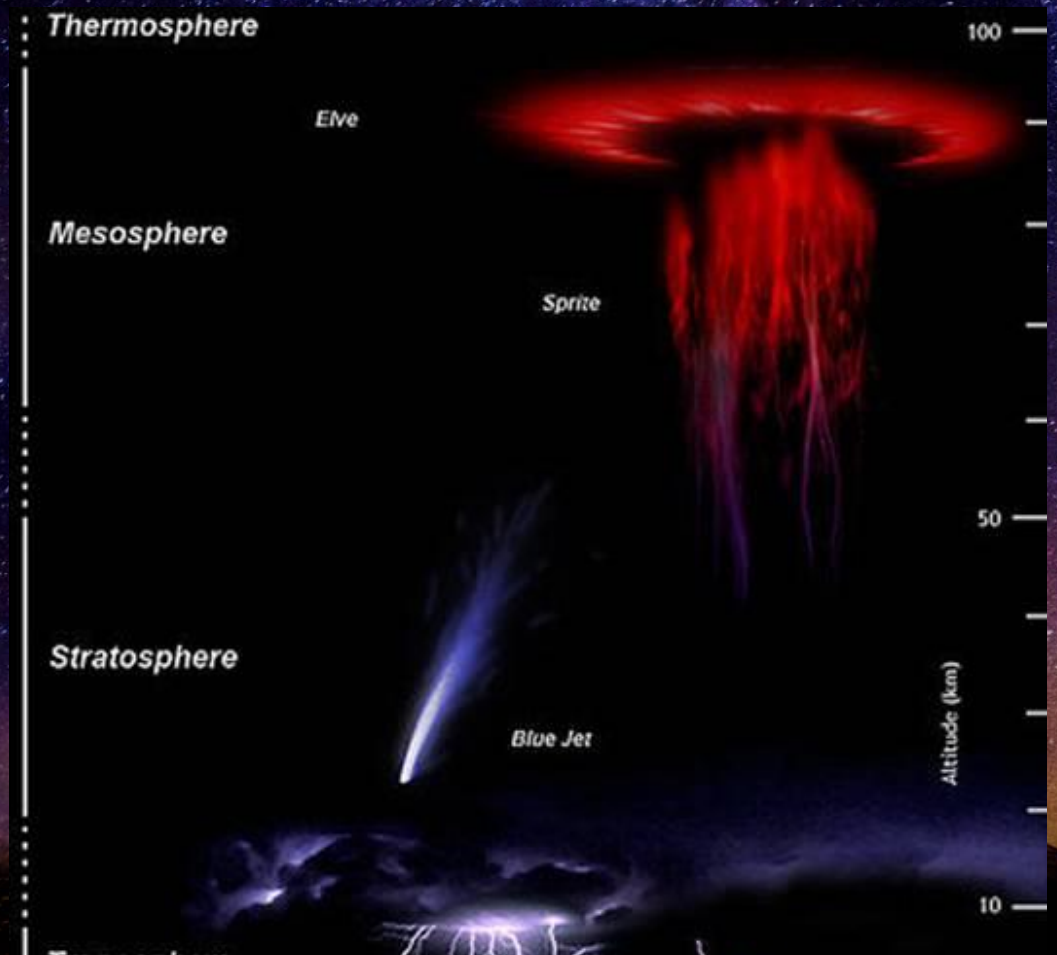
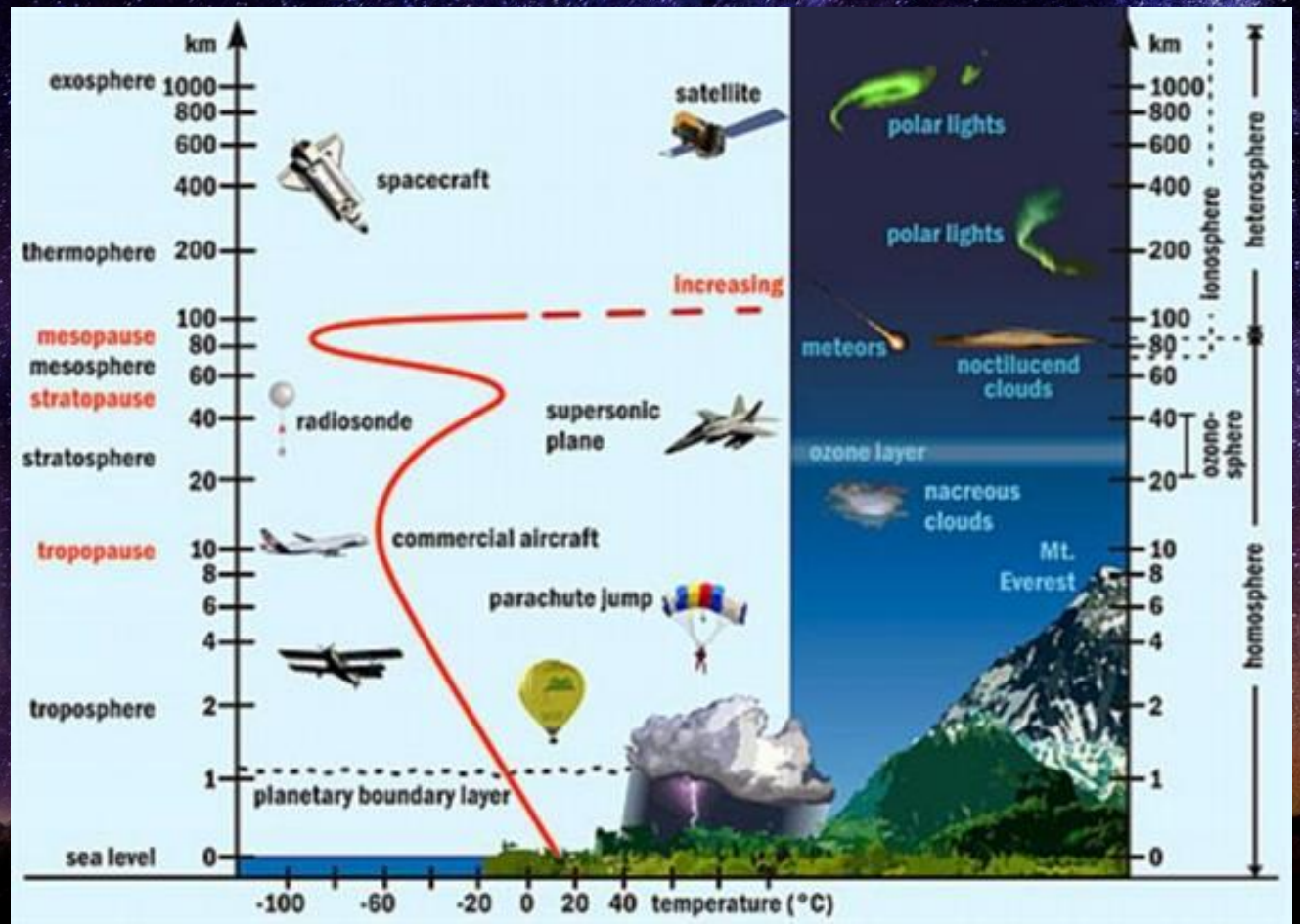
UPPER LEVEL DISCHARGES



Atmospheric electrical discharges can occur at altitudes well above the cloud levels & are influenced by space weather.

IONOSPHERE



The Ionosphere is the layer that interacts most with the sun's high energy radiation and particles.

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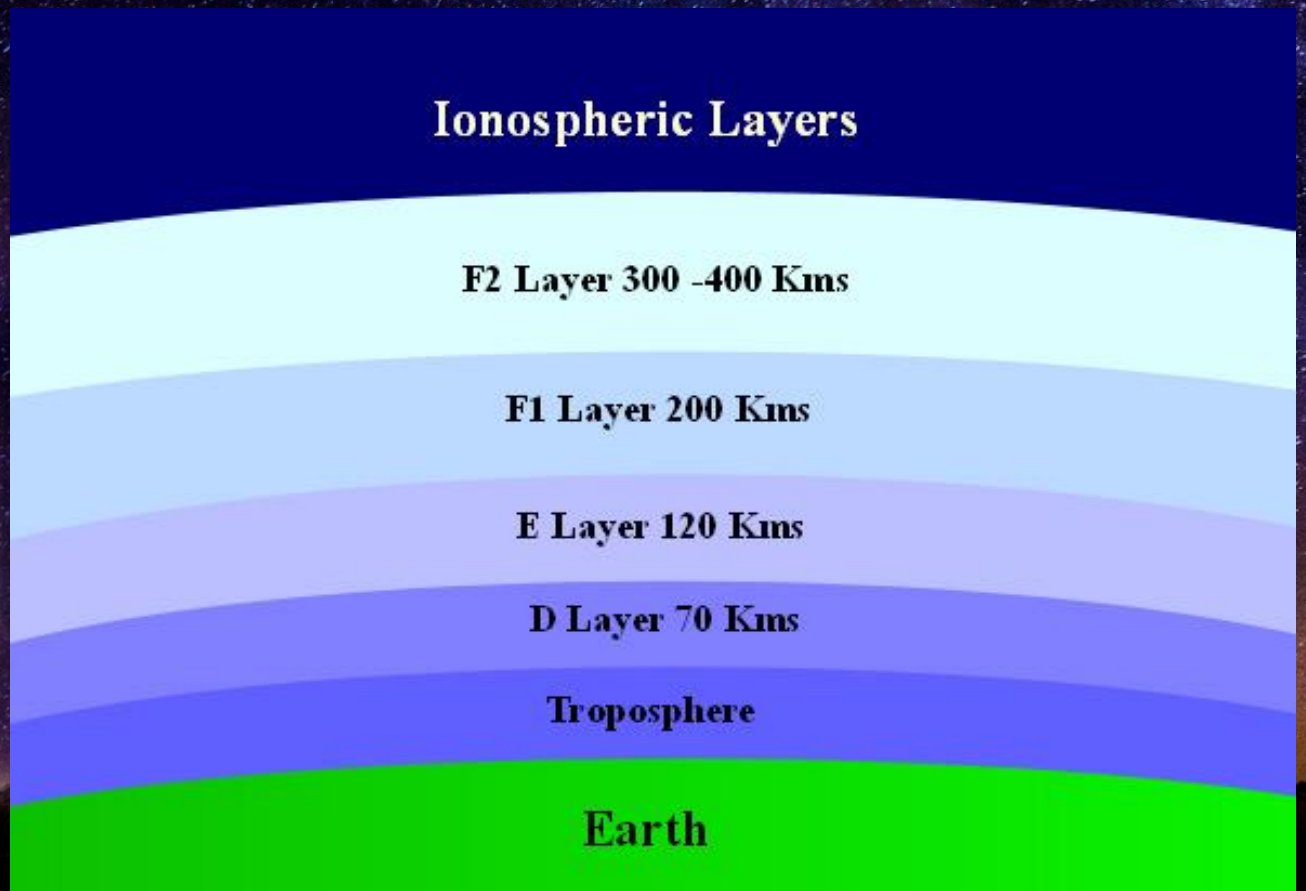
IONOSPHERE



The Ionosphere is composed of a number of layers that can have different effects of radio waves.

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CITIZEN SCIENCE MONITORS

Stanford University runs a Sudden Ionospheric Disturbance (SID) program to detect solar flares and other ionospheric disturbances

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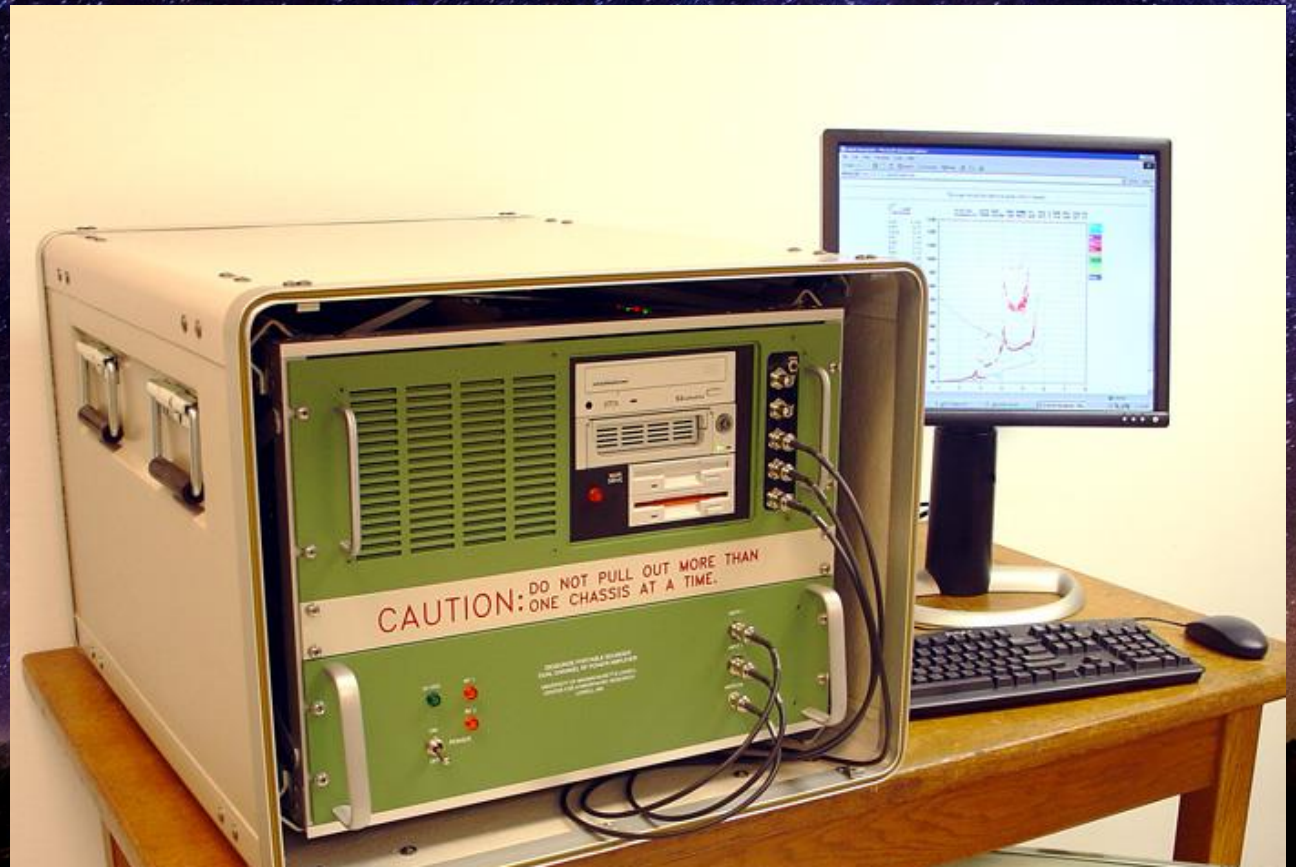
IONOSPHERIC SOUNDERS



The ionosphere can be profiled by measuring the effect it has on radio waves.

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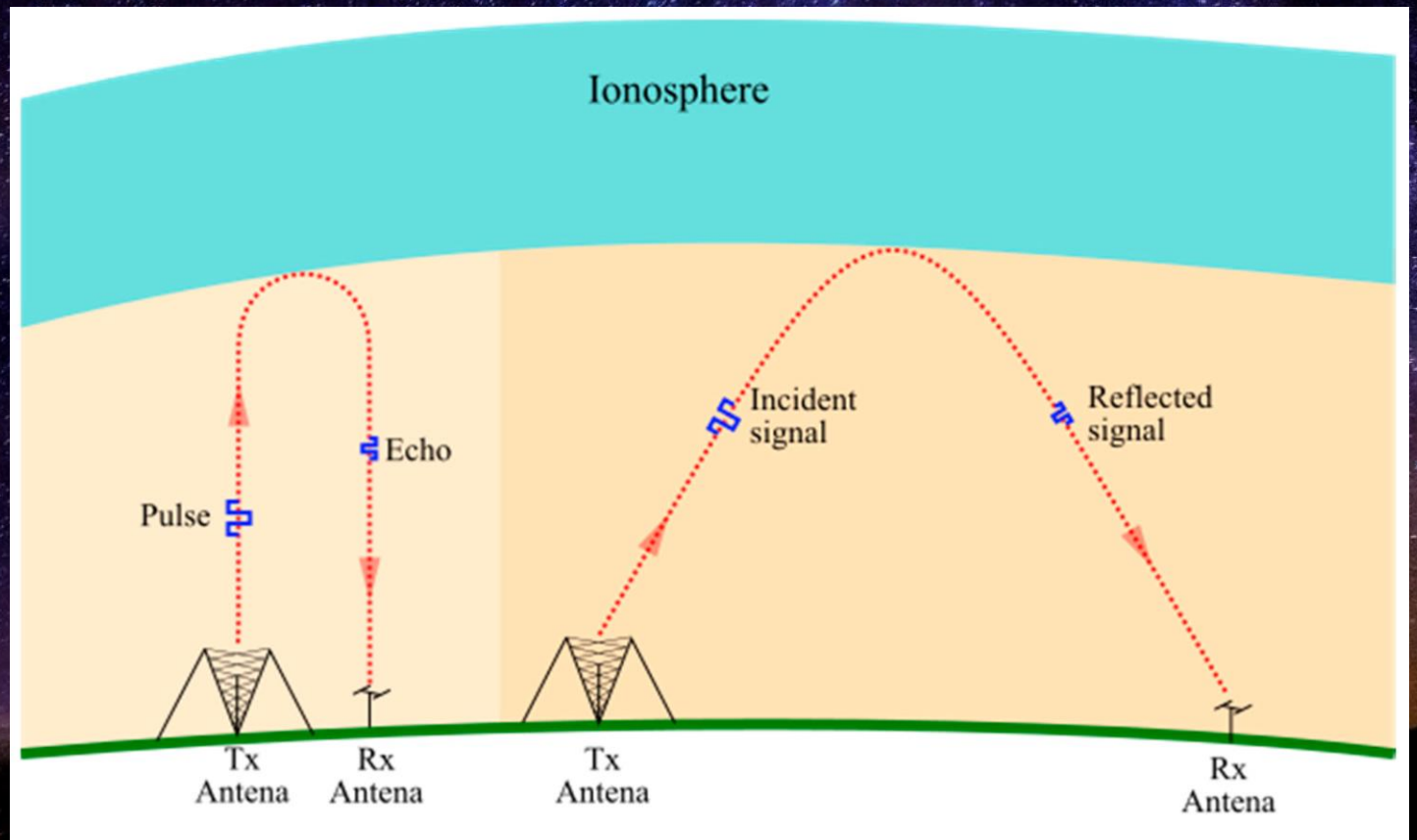
Australian Equipment For Export

Vertical & Oblique Sounders



Measures of time required for signal to return to estimate high of ionised layers

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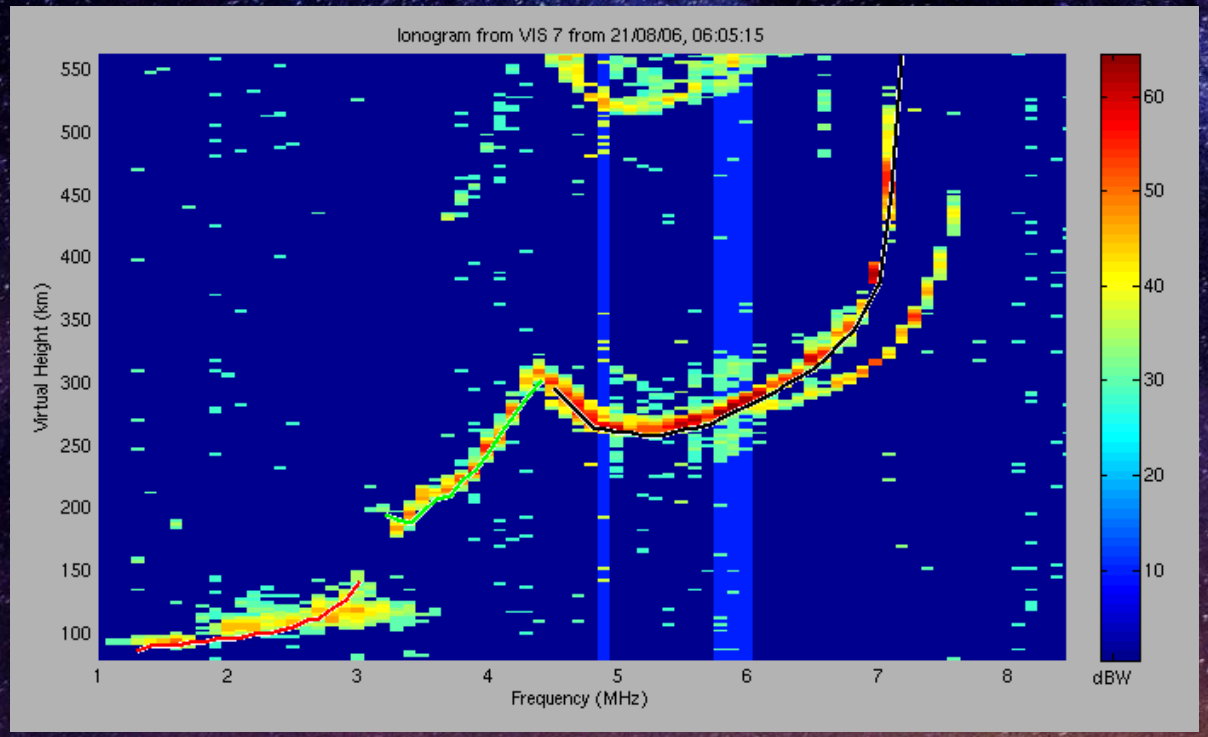
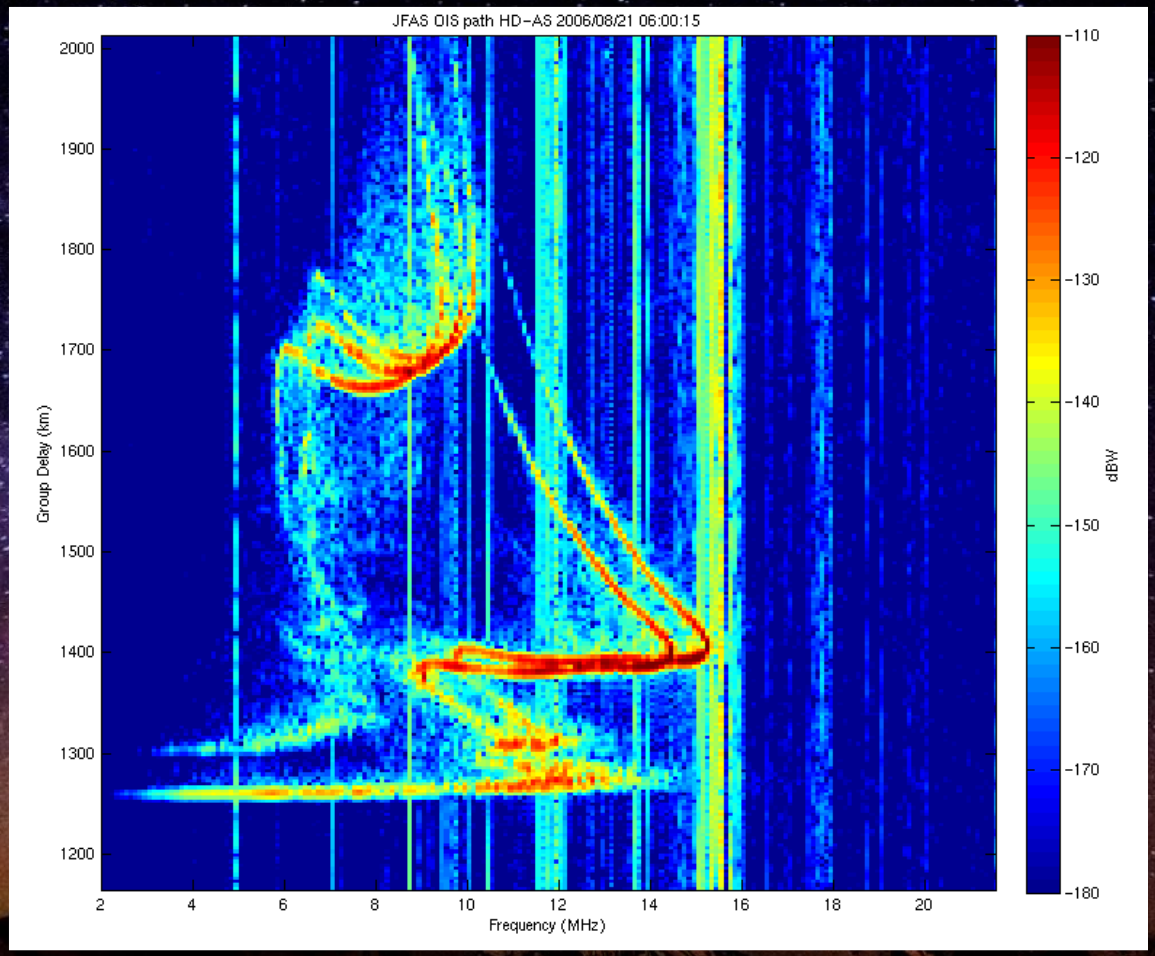
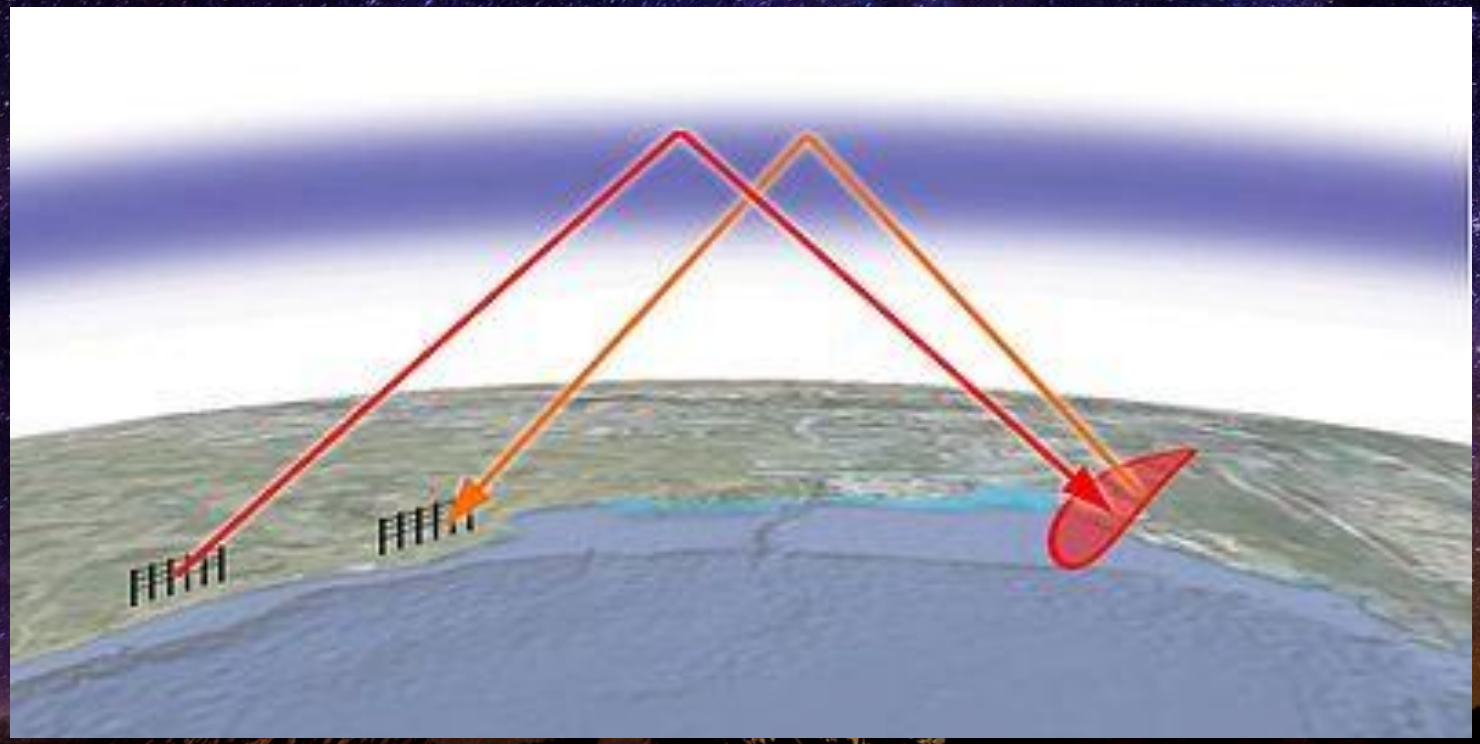
Vertical & Oblique Sounders





Backscatter Sounder



Works like an Oblique Sounder, but the signal goes through the ionosphere twice.

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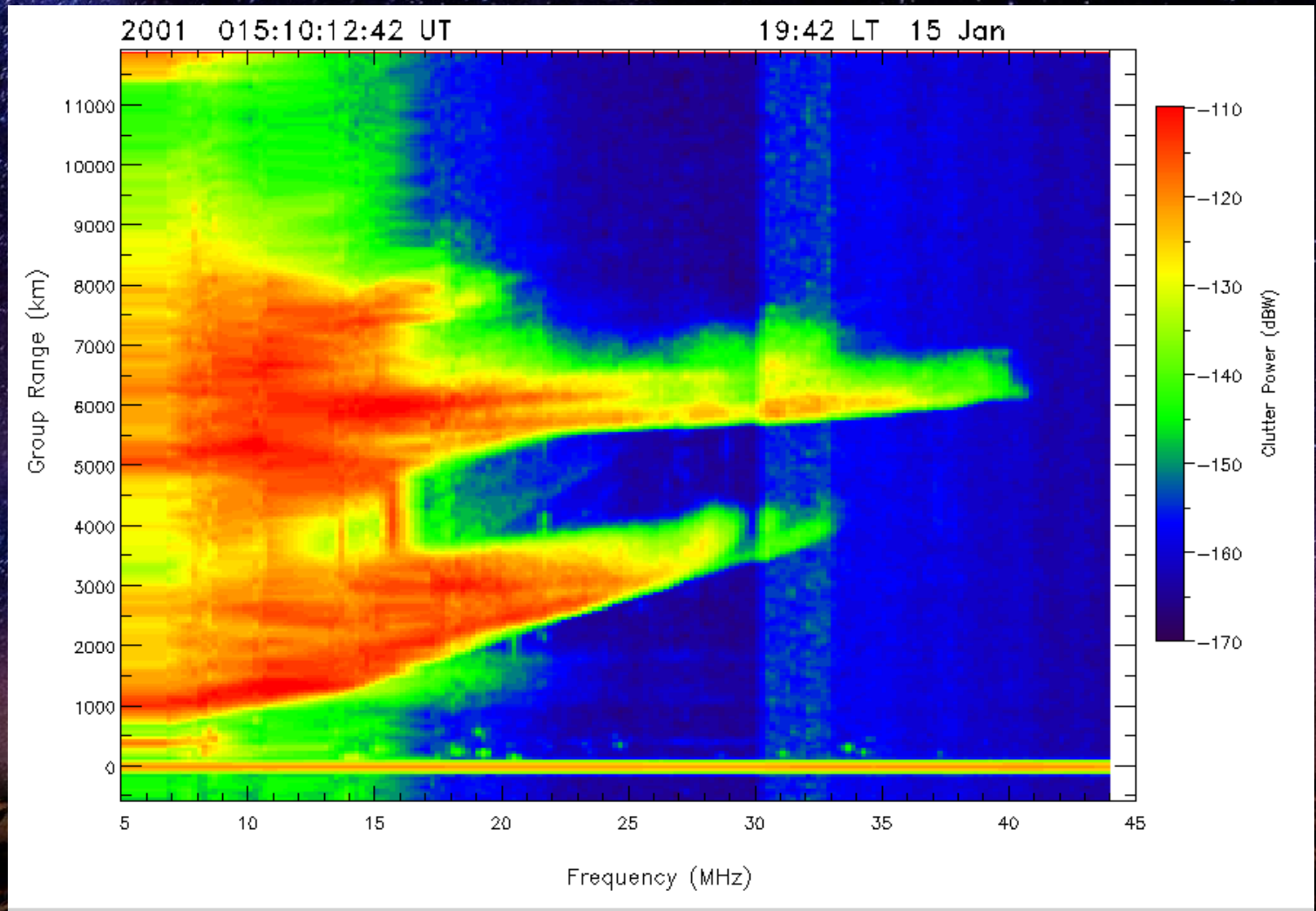
Backscatter Sounder



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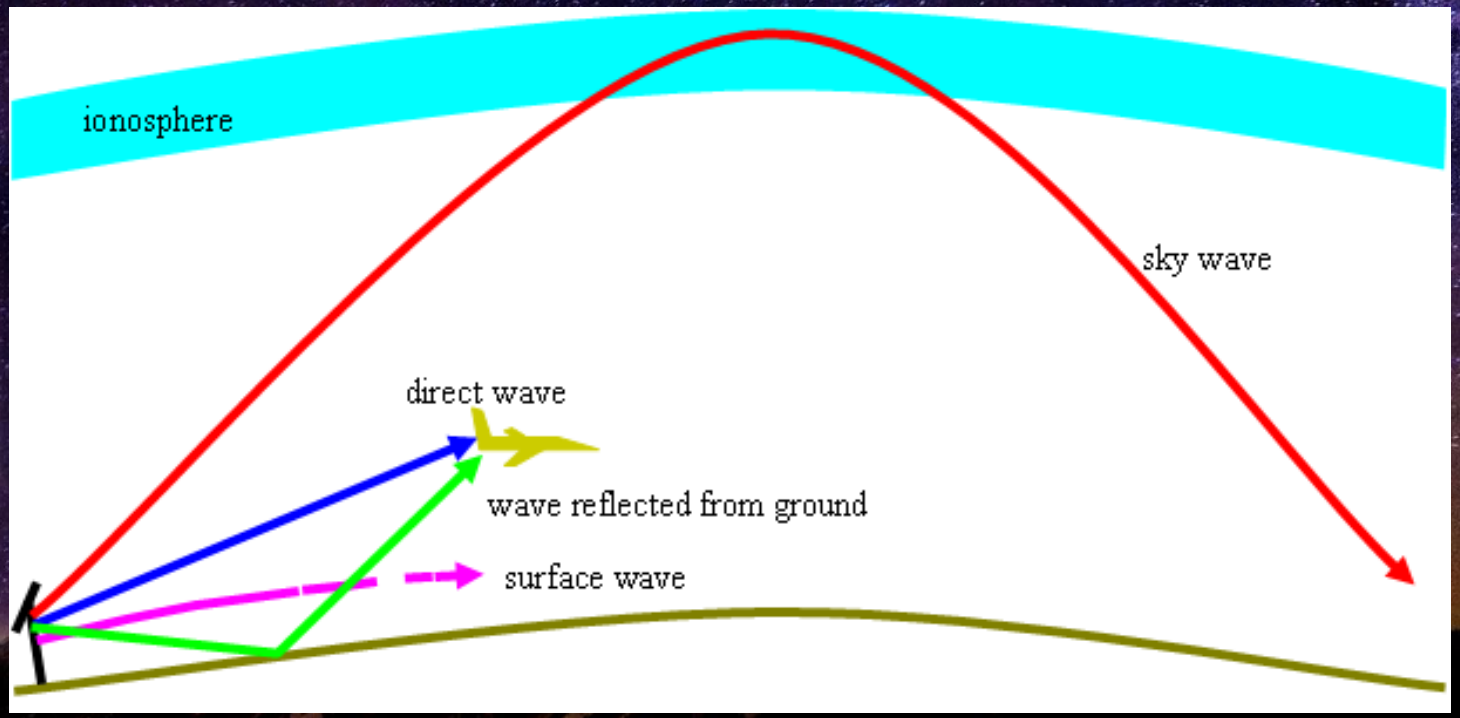
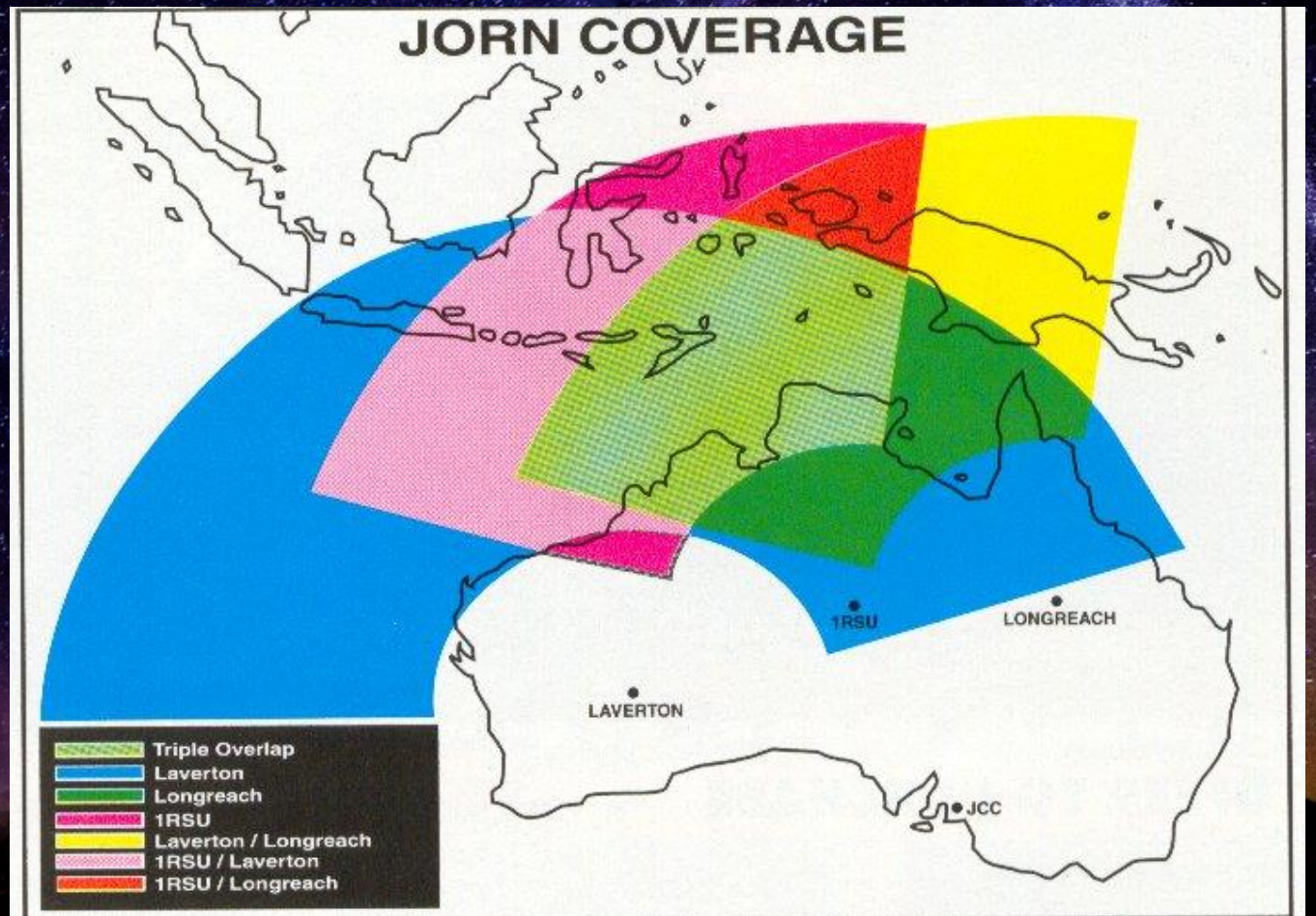
Long Distance Radio Comms



Understanding the Ionosphere allows global radio communication without relying on satellites.

Over The Horizon Radar



OTHR provides surveillance of Australia's northern coast using the ionosphere

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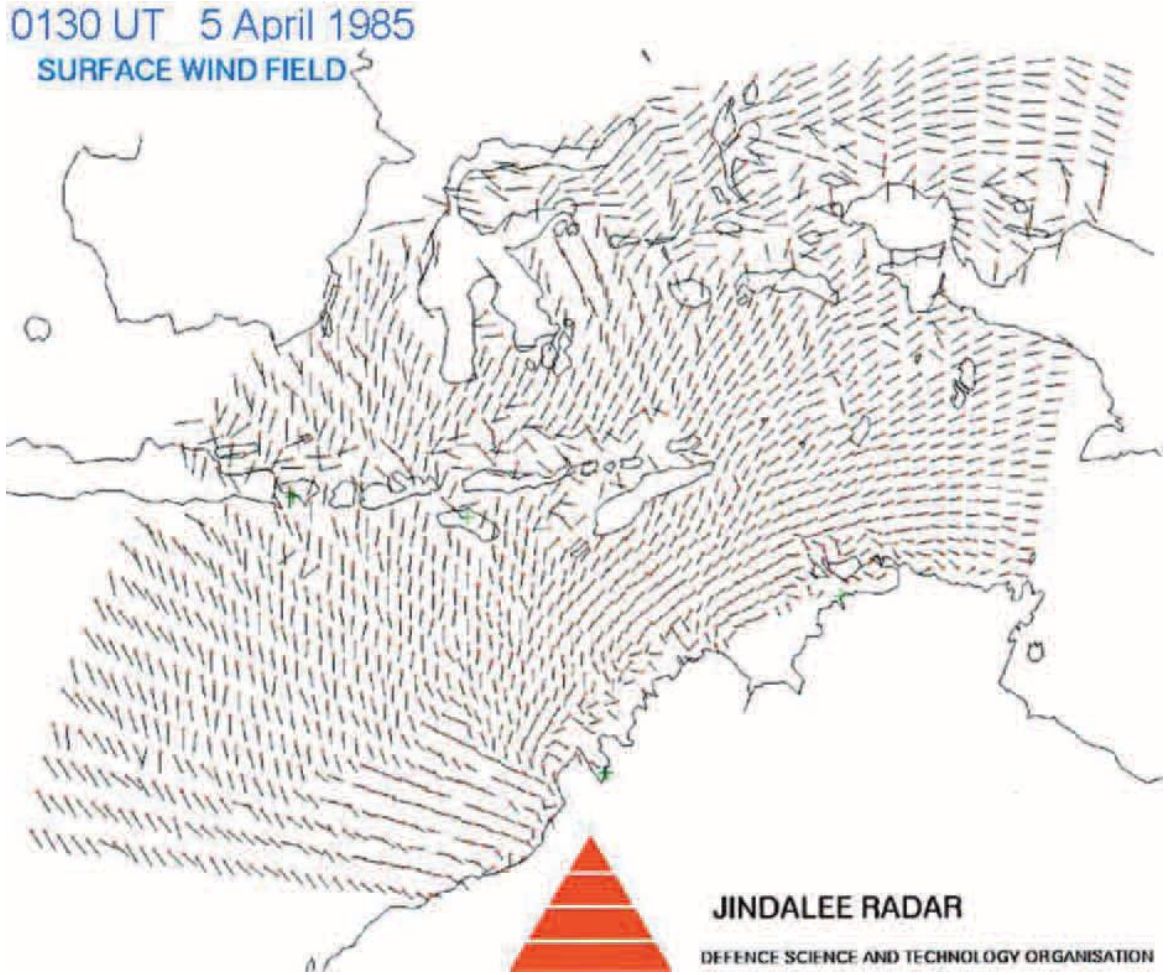
WIND MAPPING



The waves on the surface of the ocean are caused by the wind.

By measuring movement of the surface of the ocean, it is possible to use that information to estimate the direction and speed of the wind.

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OVER THE HORIZON RADAR

- HF RADAR first used by British from 1935
- Line of Sight only
- Long distance signals were interference

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OVER THE HORIZON RADAR

1974 – 1978 Jindalee Stage A
1979 – 1985 Jindalee Stage B
1986 JORN Announced
1986 – 1989 Jindalee Stage C
1990 Jindalee transferred to RAAF
2002 JORN commissioned
2008 Australian OTHR exports start
2017 JORN Phase 6 upgrade
2017 Australian OTHR exports continue
Australia remains a OTHR leader

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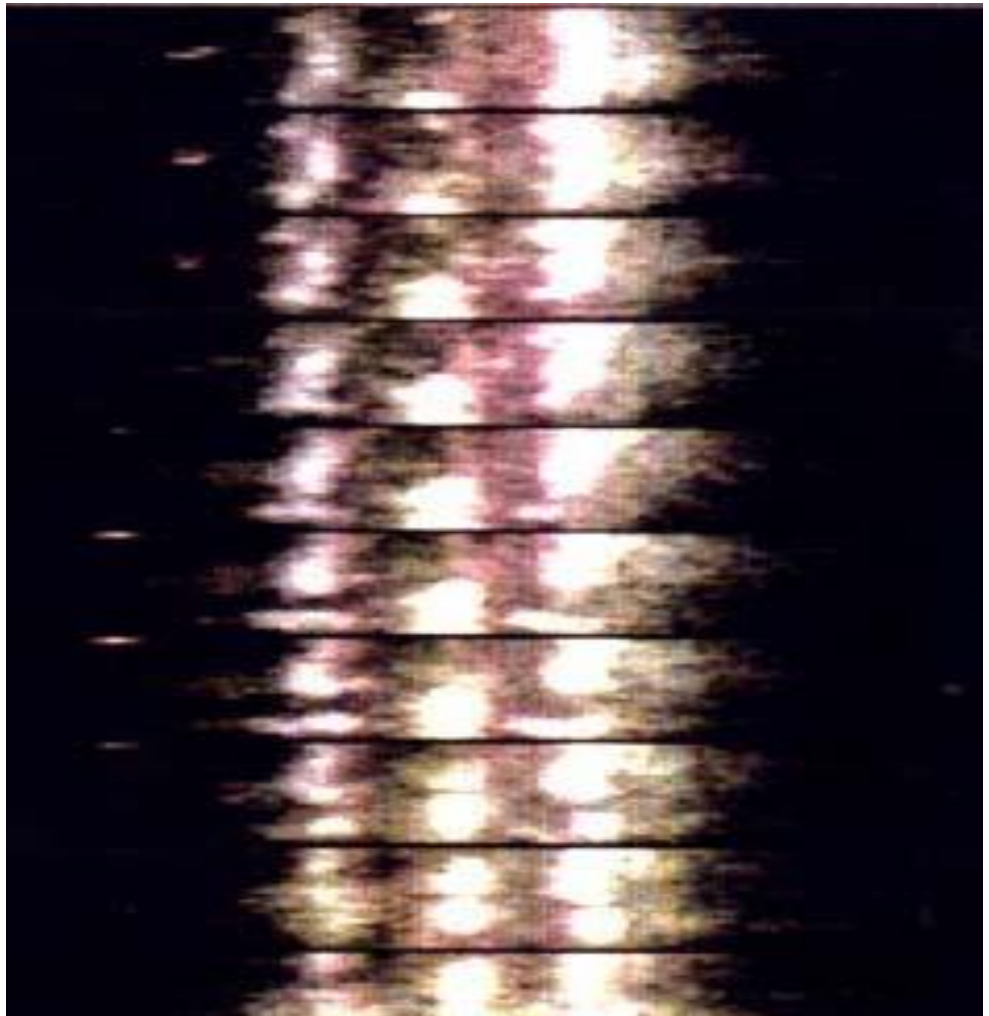
OVER THE HORIZON RADAR



Jindalee is a Doppler Radar and is able to detect the movement of aircraft and ships by their Doppler shift.

The land is detectable since it is not moving, while the waves on the surface of the oceans move water to and fro, allowing waves to be detected as being different to the land.

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Thank You
For
Your Interest