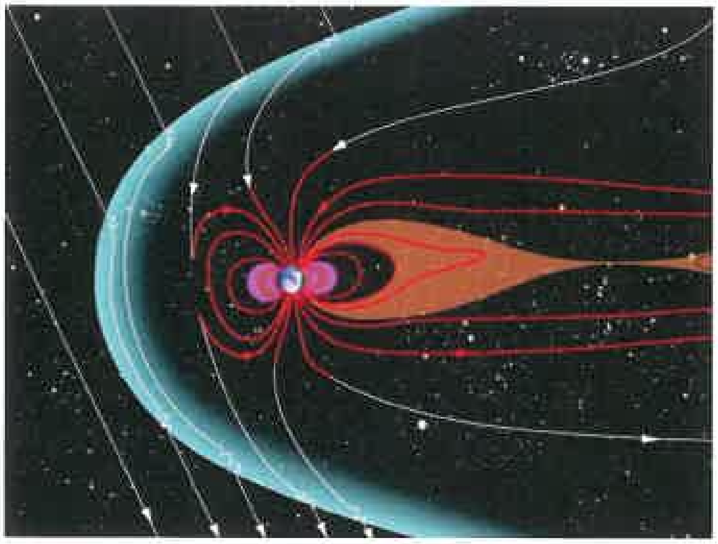
British Astronomical Association
Radio Astronomy Group



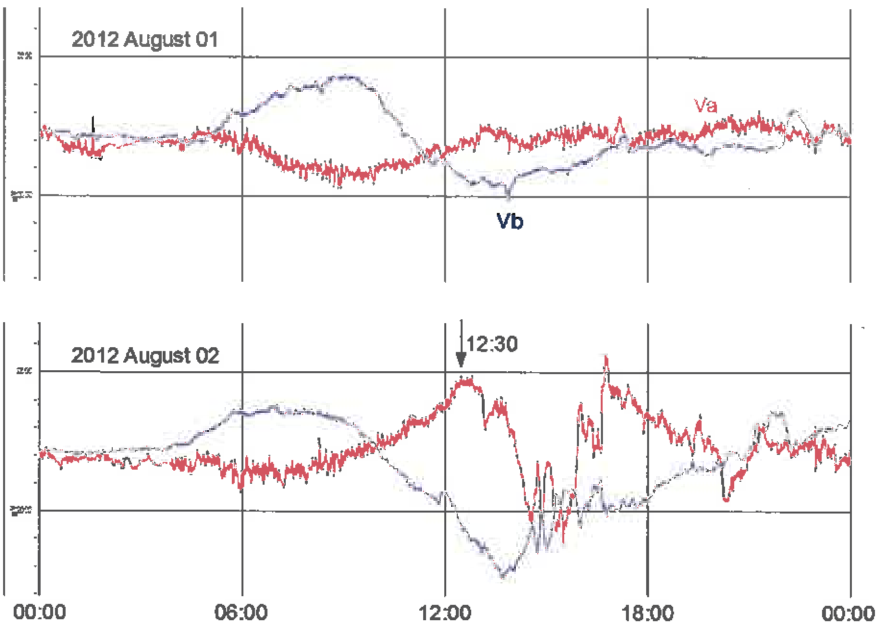
Magnetometry

Operating your own magnetometer can add an extra level of interest for the solar observer, and can provide an early warning of developing auroral conditions. There are some commercially available designs as well as the option of building a simple suspended magnet type (Jam-Jar magnetometer). A home built sensor can be quite inexpensive, while a full three axis design will be more expensive and will require careful consideration in mounting and operation.

Diagram credit: NASA/Goddard/Kasse

Theory

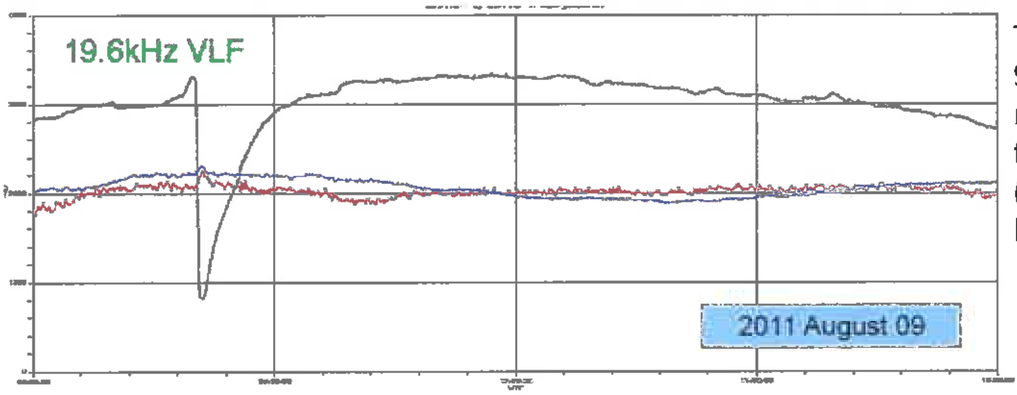
As the solar wind rushes past the Earth, the day side magnetic field is squashed down to about 6-10 times the Earth's radius. A supersonic bow shock (blue in the picture) is formed as the high speed wind is diverted around the Earth's magnetosphere and drawn out into a long (over 1000 time the Earth's radius) magnetotail on the night side. A magnetometer at the Earth's surface will therefore see the local magnetic field (red in the picture) gently vary through the night and day as the Earth rotates. The Earth's magnetosphere is a very dynamic structure, and changes shape in response to changes in the solar wind. Solar flares can eject large volumes of coronal plasma at high speed in the form of Coronal Mass Ejections (CMEs). If a CME is directed towards the Earth, then the magnetic field locked within that plasma can interact with the Earth's magnetosphere to produce a magnetic disturbance. Depending on the strength and orientation of the interacting fields, charged particles from the solar wind can enter the Earth's field through the polar cusps to produce aurora.



Observations

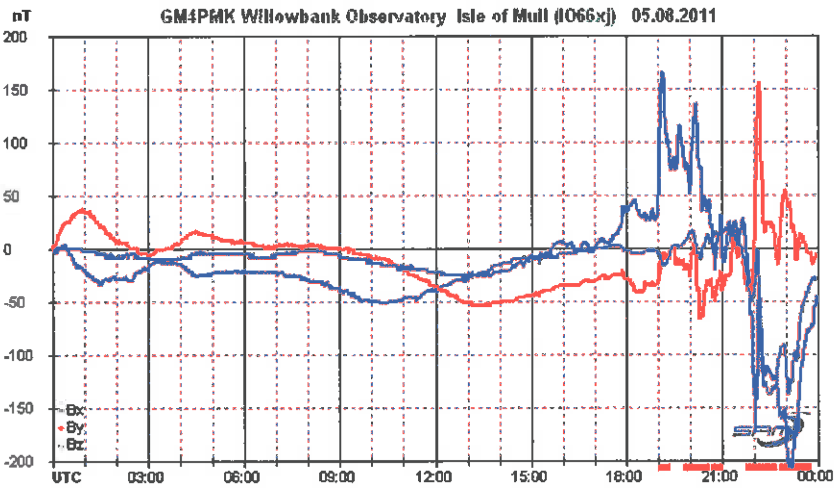
The top chart shows the diurnal curves recorded by a two axis magnetometer on 2012 August 1st, a quiet day. The blue trace shows variations in magnetic declination, while the red trace shows variations in the east/west field. There is some minor local interference present, but the typical curves can be seen.

The lower chart is from the following day, and shows a very noticeable disturbance to the diurnal curves from about 12:30. The disturbance that follows was due to the arrival of a CME associated with an M6.1 flare at 20:56 on July 28th. From these timings we can measure a CME transit time of 111 hours.



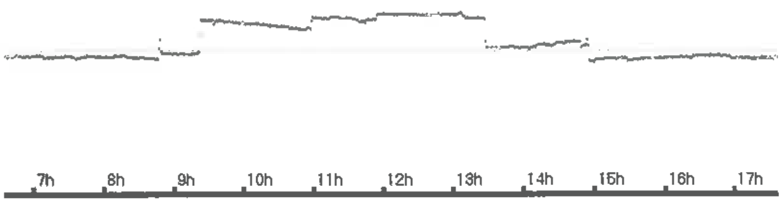
This chart from 2011 August 9th shows a more subtle magnetic disturbance in the form of a Solar Flare Effect (SFE). They are also sometimes known as magnetic crochets.

SFEs occur synchronously with the arrival of ultraviolet and X-rays from a solar flare. They cause a sudden and rapid change in the electrical currents flowing through the ionosphere, and therefore alter the Earth's magnetic field. An X6.9 flare at 08:05UT is shown in green by the Sudden Ionospheric Disturbance (SID) at 19.6kHz. A small rise in both magnetometer channels can be seen as the SID reaches its minimum level. These may be followed by a CME disturbance later, but may also occur without an Earth-directed CME. This recording and those on the previous page were made by Paul Hyde.



This recording was made using a three axis fluxgate magnetometer, aligned in 3D with the Earth's magnetic field.The third axis (Bz, in green) measures the vertical component of the field. It shows another CME disturbance starting around 18:00UT on 2011 August 5th. The sensor has been calibrated to show the strength of the field in nT (nano Tesla), having been reset to zero at midnight. The recording was made by Roger Blackwell.

The recording on the right is not of solar origin. It shows the effect of large vehicles being parked in the road about 10m west of the sensor. The vertical edges make this sort of interference easy to see, but can still hide genuine solar disturbances.



It was made using a single axis sensor mounted horizontally indoors by John Cook.

In periods with lower flare activity, coronal holes can provide long periods of magnetic disturbance. Coronal Hole High Speed Streams (CHHHS) can be quite turbulent and produce magnetic disturbances lasting for many days as solar rotation aims them towards the Earth.

Contact details: Co-ordinator: radio@britastro.org Membership: radiolist@britastro.org
VLF and magnetic observations: John Cook, jacook@jacook.plus.com
Website: www.britastro.org/radio

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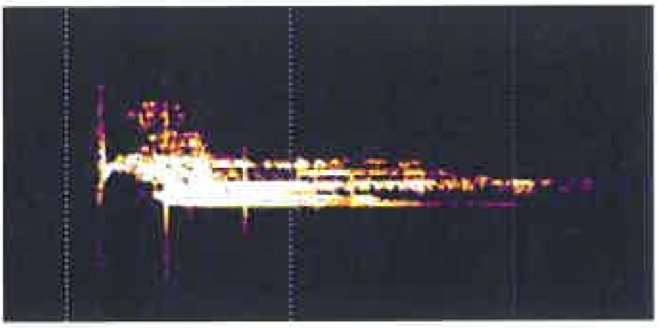


Meteor Scatter

Meteor Scatter enables you to monitor meteor activity using the radio signals reflected from the associated plasma trails. This is one of the easiest applications for the amateur radio astronomer as the reflected signals can be quite strong and the receiving equipment is relatively simple and compact. You can also monitor meteor activity throughout the day, even under cloudy skies, moonlit nights and light pollution.

Suitable observing frequencies are 143.05 MHz, using the powerful GRAVES radar system in France, or at 49.97 MHz using the low-power BRAMS meteor beacon in Belgium.

Theory

As a meteroid burns up (ablates) in the upper atmosphere it creates a region of ionised gas, or plasma. Depending upon its density, plasma can reflect radio waves from far-off transmitters so that you can detect the signal until the plasma dissipates away. The duration of these reflected signals can last from a fraction of a second to over a minute.

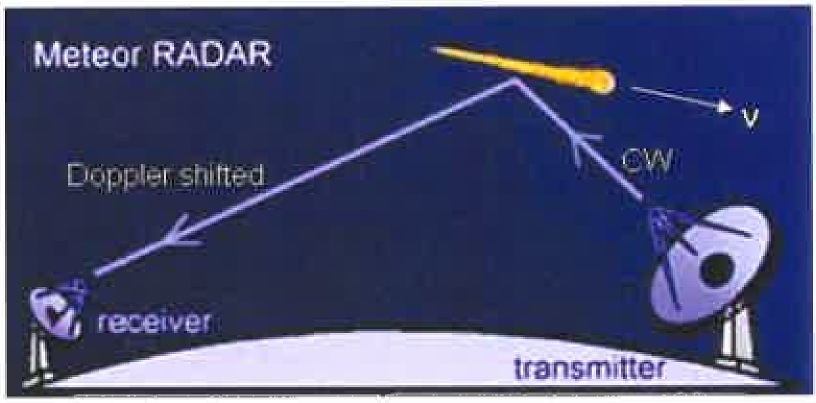
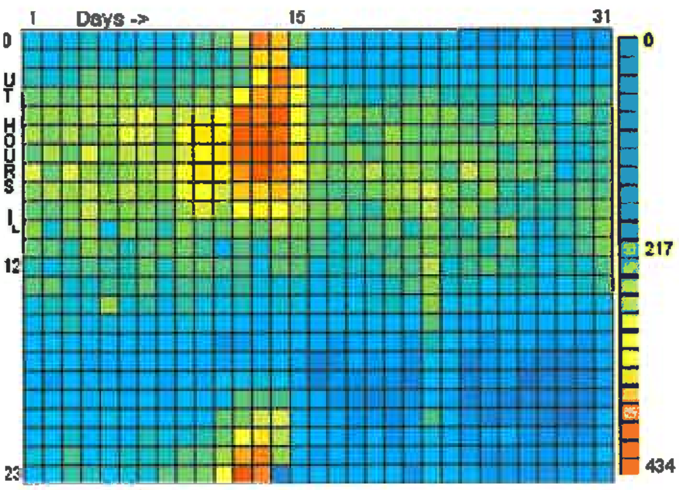


Image credit: NASA

The frequency of the reflected radio signal is also Doppler-shifted by the moving plasma, allowing you to measure the line of sight velocity of the plasma. In the images above the plasma trail has split into a number of tubes moving at slightly differing velocities, providing information on how the trail dissipates.



Observations

Meteor activity is very dynamic with both daily and seasonal variations. This chart shows activity during a typical December with each hour colour-coded to represent the number of meteors detected. 'Sporadic' meteors occur throughout the year and are strongest during the early hours of the morning. There is also increased activity at certain times of the year as the Earth passes through streams of meteors left by comets, in this case the Geminids.

Diagram credit: Radio Meteor Observing Bulletin

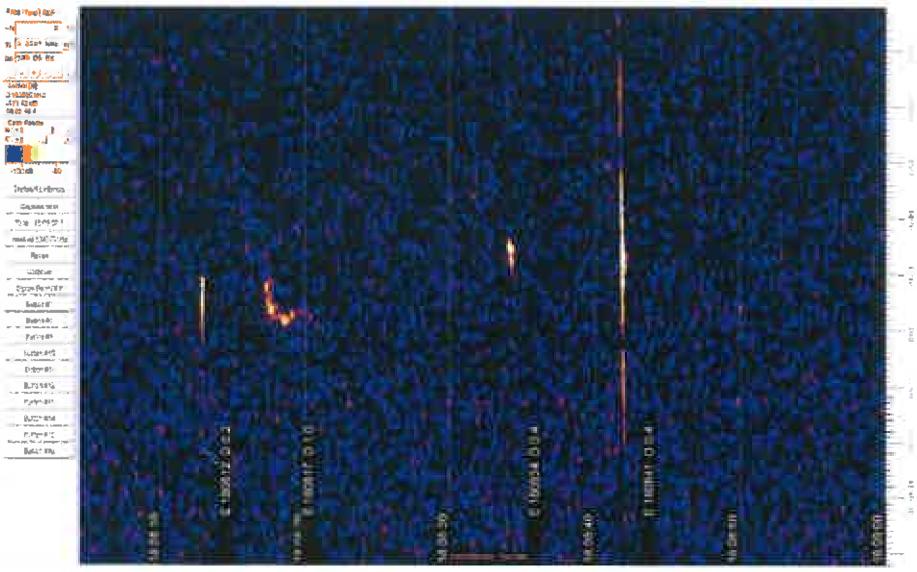
The equipment

Meteor Scatter signals can be received using any communications receiver covering the required frequency and which can demodulate Upper Sideband (USB) signals. It is an advantage if you can switch off any Automatic Gain Control (AGC) function. You can also use one of the new SDR-based receivers such as the FUNcube Dongle, shown here.

Image credit: Howard Long/AMSAT UK

The antenna can be a simple Yagi, using standard copper pipe fixed to a wooden boom. A suitable design for 143.05 MHz was featured in the June 2014 edition of Sky at Night magazine, a reprint of which can be found on the RAG website at the address below.

Whilst the antenna can be located in the loft, much better results will be obtained if it is mounted outside at about 3 metres above ground. You do need a location that does not have any major obstructions in the direction of the radio source being used, for instance to the south-east for the GRAVES source.

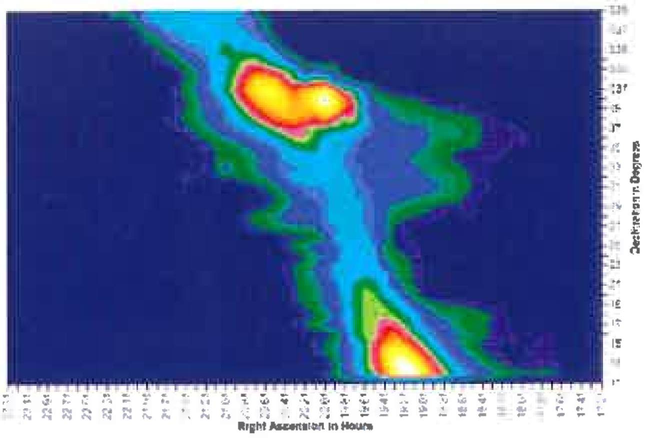


There are several freely downloadable software packages for displaying meteor events. The Spectrum Lab application automatically captures screen shots, audio recordings and timestamps to help you analyse meteor activity.

Further information on setting up a simple meteor scatter observatory can be found on the BAA RAG website. There are several web resources providing more information about meteor scatter and a good place to start is with the International Meteor Organisation at www.imo.net/radio

Contact details

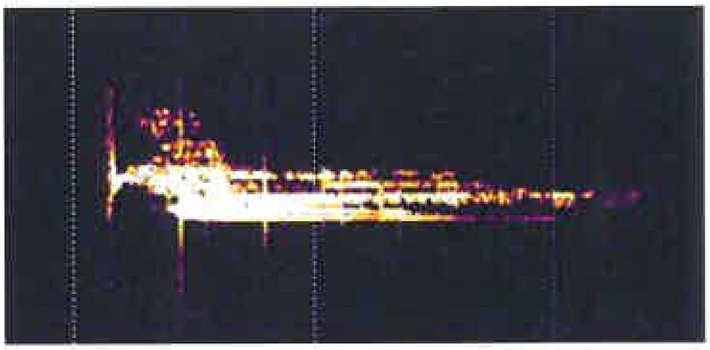
RAG Co-ordinator:	radio@britastro.org	**Membership:**	radiolist@britastro.org
Website:	www.britastro.org/radio	**Discussion Group:**	baa-rag-subscribe@yahoogroups.com



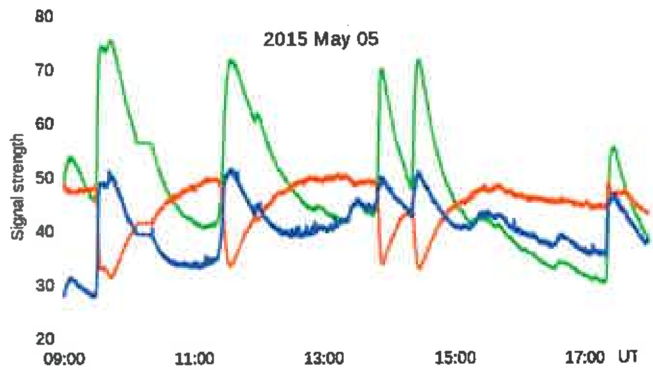
The Milky Way at 408 MHz (by John Smith) with the radio sources Cygnus A (right) and Cygnus X (left) at the top of the image

Amateur Radio Astronomy

Radio astronomy provides a very different view of the Universe compared to that obtained at optical frequencies. As with optical astronomy, professional astronomers use very large instruments located in locations chosen for low background noise, but amateurs can still undertake observing work at home. Objects such as supernova remnants and radio galaxies need dishes of 2 metres dia. or more and are susceptible to local electrical noise, but other targets are attainable through much simpler equipment and are within the reach of non-radio experts.

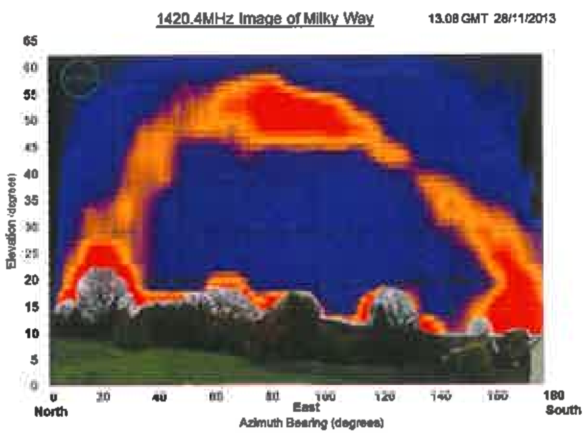


Meteor activity can be monitored throughout the day and under cloudy skies. There is still work to be done to increase our understanding of this phenomena

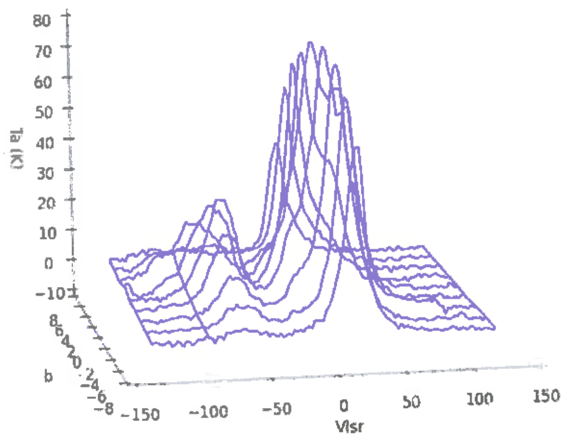


Sudden Ionospheric Disturbances are caused by solar x-ray flares and can be observed using a simple indoor loop antenna

Hydrogen Line radio emissions (at a wavelength of 21 cm) are more demanding and may be better suited as a club or society project. Measuring the Doppler shift of these signals reveals the structure of the Milky Way and can be used to map out the spiral arms.



H-Line emissions from the Milky Way, courtesy David Morgan.



Velocity map of H-Line emissions, courtesy HLOG (Brian Coleman/Gordon Dennis)

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The BAA Radio Astronomy Group

The aim of the Group is to encourage and support amateur radio astronomy through the exchange of information on radio telescope design, observing techniques and data analysis. Membership is free and open to non-BAA members, though we do encourage people to join the BAA as part of supporting amateur astronomy in general.

The Group maintains a website providing resources for amateur radio astronomy and where members can publish details of their work. We also publish a quarterly newsletter and run a web discussion group hosted by Yahoo. You can subscribe to this by sending an e-mail to the address listed in the Contact details below. You not need to be a Yahoo group member to participate in discussions.

The Group also organises one-day General Meetings with talks on a range of amateur and professional activities , plus Workshop events covering the more practical aspects of amateur radio astronomy and geophysics. These events are also open to non-BAA members.

Contact details

RAG Co-ordinator: radio@britastro.org
Website: www.britastro.org/radio
Membership: radiolist@britastro.org
Discussion Group: baa-rag-subscribe@yahoogroups.com

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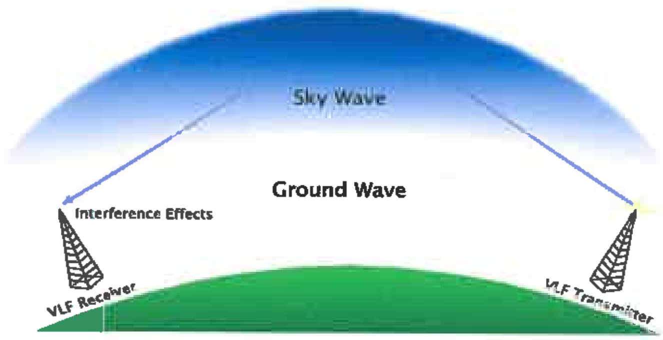
Image courtesy of SOHO (NASA/ESA)

Detecting Solar X-ray Flares by Radio

Very energetic solar flares produce huge amounts of X-ray and UV radiation. Detecting these events is an easy way into radio astronomy as the equipment is simple and compact and the costs are low to negligible.



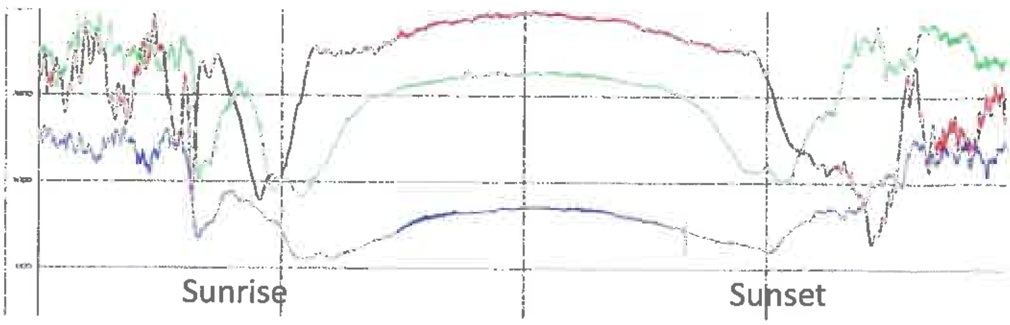
Theory

Radio waves emitted at very low frequencies (15 to 25 kHz) are reflected by the D-layer of the earth's ionosphere. This layer is only formed during the daytime. When solar flares occur, the D-layer becomes more reflective and the strength of the signal's Sky Wave increases, producing a noticeable change in the receiver output. These events are called Sudden Ionospheric Disturbances (SIDs) and provide a simple way of detecting when an X-ray flare occurs.

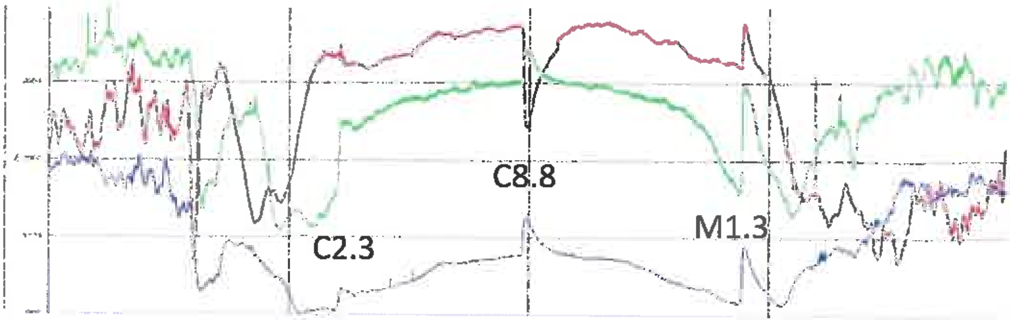
There are several VLF transmitters around the world that can be used to detect SIDs. The charts below show how the signal strengths of three of these transmitters are affected by these flares.

Observations

During the night time, signal levels vary rapidly and no useful information can be obtained. Sunrise results in the formation of the D-layer in the ionosphere and signal levels stabilise until sunset



Solar X-ray flares produce characteristic 'sharks-fin' variations in received signal levels



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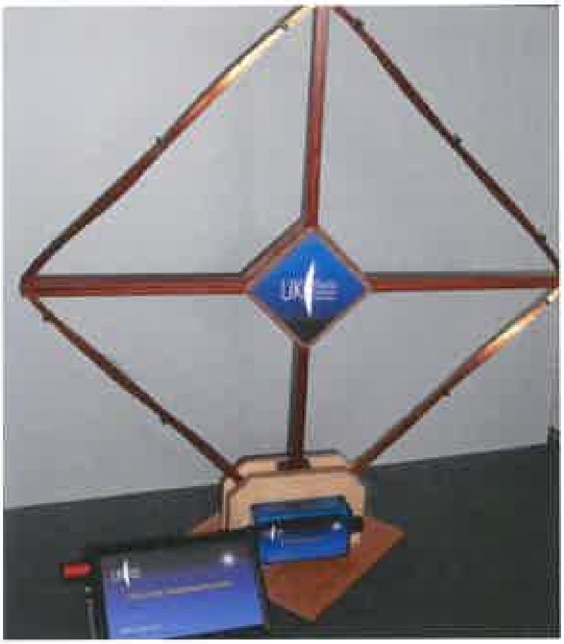


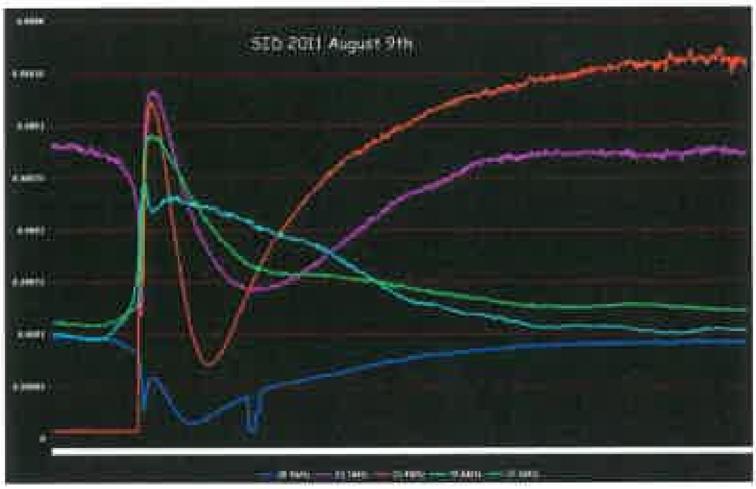
The equipment

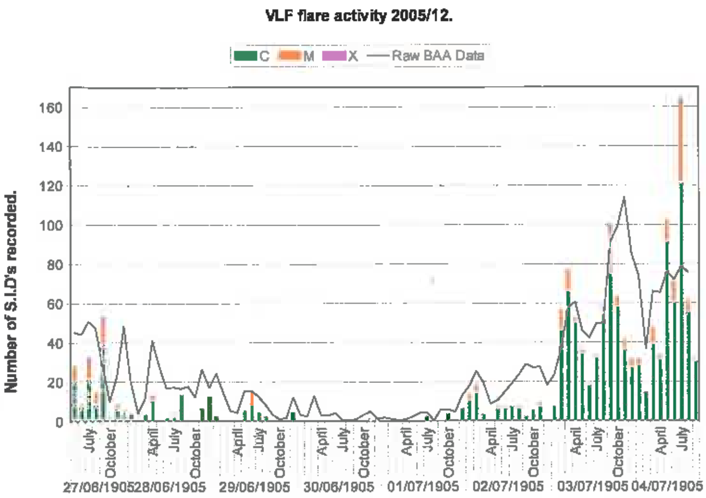
Detecting a SID requires a VLF radio receiver. This example has been tuned to the 23.4 kHz transmissions from a station in Germany. These receivers can be purchased or made from a kit; BAA RAG can advise on how to get started for either method.

The aerial is a coil of wire wound onto a 42 cm square frame. This is tuned for resonance at a particular frequency using a variable capacitor. Once set up correctly the receiver will provide a slowly varying DC voltage output where the voltage level is directly proportional to the strength of the received signal. A datalogger then records the results for later analysis.

Because VLF frequencies are so low, they can also be received using the sound card in most home computers In this case the aerial is not tuned to any one frequency so is less sensitive and needs to be a couple of metres square. This can be easily draped from hooks on the wall of an observatory.

The chart to the right shows the effect of an X-class flare on five different VLF signals over a 2-hour period (Chart courtesy Mark Edwards)





The BAA RAG VLF Observing Group

The VLF Observing Group is coordinated by John Cook and has been recording SID activity for over 10 years. New contributors are always welcome and receive a monthly summary of reported observations. If you are interested in joining the Group please contact John Cook at the address below.

Contact details: Co-ordinator: radio@britastro.org Membership: radiolist@britastro.org
VLF and magnetic observations: John Cook, jacook@jacook.plus.com
Website: www.britastro.org/radio