British Astronomical Association
Radio Astronomy Group

JULY 2010 UPDATE

Hello all,

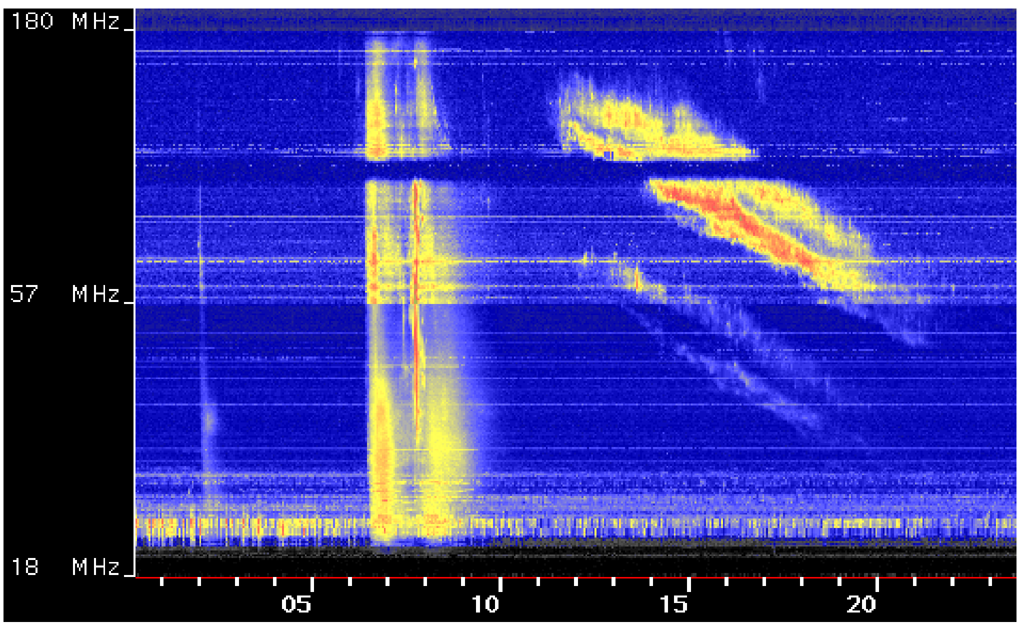
This is an informal note of some of the activities happening in the RAG world at the moment, well, at least the ones that I'm aware of. I'd like to produce something like this on a regular basis but its frequency will depend upon the material available. If you have anything that you can contribute, please do so. Comments are always welcome!

Observing the Sun at VHF

Several RAG members are experimenting with receivers for observing the Sun at lower frequencies, between 60 and 200MHz. Terry Ashton has provided the following note on what to look out for here and the issues that need to be addressed in the design of the receiver.

> *The most common event occurring at metre wavelengths is called a Noise Storm which is associated with sunspots but is sometimes triggered by flares. Its duration ranges from a few hours to a few days and is characterised by a general increase in radiated power over a bandwidth of about 100MHz. Accompanying this increase are sharp spikes known as Type I bursts which can occur singularly, although most often in groups, and last from a fraction of to a few seconds. They are more common at the lowest frequencies of the storm and drift downward in frequency at very fast rates of typically between 100 and 500 MHz per second, although 950 MHz per second has been observed. Noise storm radiation and Type I bursts are strongly circularly polarised, up to 100%, which illustrates their association with strong magnetic fields. The radiation is channelled into a diverging beam which peaks as its associated source crosses the Sun's central meridian. The bandwidth of a noise storm can drift upwards or downwards so single frequency observations don't give the complete picture: the event is best mapped with a scanning receiver (radio spectrograph) and suitable aerial, either helical or log-periodic. Noise storms can start at any frequency between 50 and 450 MHz with 250 to 300MHz being most common. As maximum is approached in a solar cycle, so the start frequency tends to reduce and a study of start frequency statistics would be a project for the RAG that could produce an interesting paper for The Journal.*
>
> *Another event occurring solely at metre wavelengths is the Type II or Slow-drift Burst. Type II bursts last from about five to 30 minutes and are usually flare associated. They drift downward in frequency at about 1 MHz per second, or slower, and are randomly polarised.*

There is often a brighter second harmonic and both the fundamental and harmonic exhibit the phenomenon of band splitting. The changing slope of the burst can reveal details relating to movement of the source within the solar atmosphere. Type II bursts are fairly rare and at times of solar maximum their occurrence averages around one per 50 hours. Often after a Type II burst there is a broadband continuum emission increase extending over the whole range of observable radio frequencies. This is known as a Type IV burst (or just Type IV radiation) and lasts from about 10 minutes up to several hours. With such a wide bandwidth there are sub-classifications of Type IV radiation to cater for the different properties that are seen at different frequencies.



Dynamic spectrum of Type III and II events obtained with a radio spectrograph

Although Type II bursts can occur on their own, they are most usually preceded by a series of Type III or Fast-drift Bursts. Type III bursts are most usually found in groups and are almost always associated with the onset or duration of a flare. They drift downward in frequency (but can reverse) at about 20 MHz per second, are (usually) randomly polarised and, like Type II bursts, often produce a second harmonic. However, such is the repetition frequency of this mode of emission that a lot of the detailed structure is masked by successive bursts. Individual Type III bursts have a life-time of about one fifth to one half of a second but groups of them *may last several seconds. At times near solar maximum you can expect to observe around three Type III bursts per hour. After a series of these bursts there is usually an increase in the continuum emission at metre wavelengths lasting for about one to three minutes. This is known as a Type V Burst and radiates most strongly at frequencies below 150 MHz.*

An important point to note is that the absence of a dynamic spectrum (i.e. one produced by scanning multiple frequencies) makes classification of an observation uncertain. If you were observing at just one frequency, say 120MHz, then a rise in detector output followed by a fall a few seconds later could be a group of type III events or a type II (assuming you're not being interfered with) – you just don't know. After "seeing" this and it's followed by a steady increase in output, how do you know if a type IV or type V event is occurring? If you're observing at another frequency as well, say 500MHz, and there's a similar increase there then you could convince yourself that a type IV event was in progress. A dynamic spectrum from a scanning receiver kills this sort of guesswork in an instant, as well as identifying interference from fixed frequency terrestrial sources, such as radio and television transmitters. These appear as fixed horizontal lines and hence are easily distinguishable from the variable frequency solar noise.

Although not necessary to identify the type of stronger outbursts, precision work requires constant sensitivity over the frequency range being observed, with background subtraction to reduce the impact of non-solar emissions.

The more obvious problems concern changes in gain such as attenuation of signal with frequency by interconnecting cables, aerial gain vs. frequency, position of the sun within the beam if using a transit aerial and so forth. These corrections are applied to the gain of the IF amplifier in step with the local oscillator. There is, too, a question of calibration to address if you require absolute values of the observed flux. If the sensitivity is not constant, a signal that is barely detectable at one frequency can be invisible at another even though the source output may be constant at these frequencies. This can trick you into thinking that you've seen part of a solar burst whereas, in reality, it is a product of poor receiver design.

The subtraction of background noise is probably the most important thing to do as the galactic background flux can exceed radiation from weak bursts or the quiet Sun, especially in December/January when the Sun appears to be in line with the galactic centre. One method of doing this is to take measurements with the receiver system of the background when the Sun is asleep and enough of them over a year to cover the Sun's annual path along the ecliptic. Then it's a "simple" matter to subtract the background from the measured Sun-plus-

background at the detector. Of course there's the problem when the signal from the Sun is much less than the background when small errors in measurement lead to large errors in calculating the solar flux.

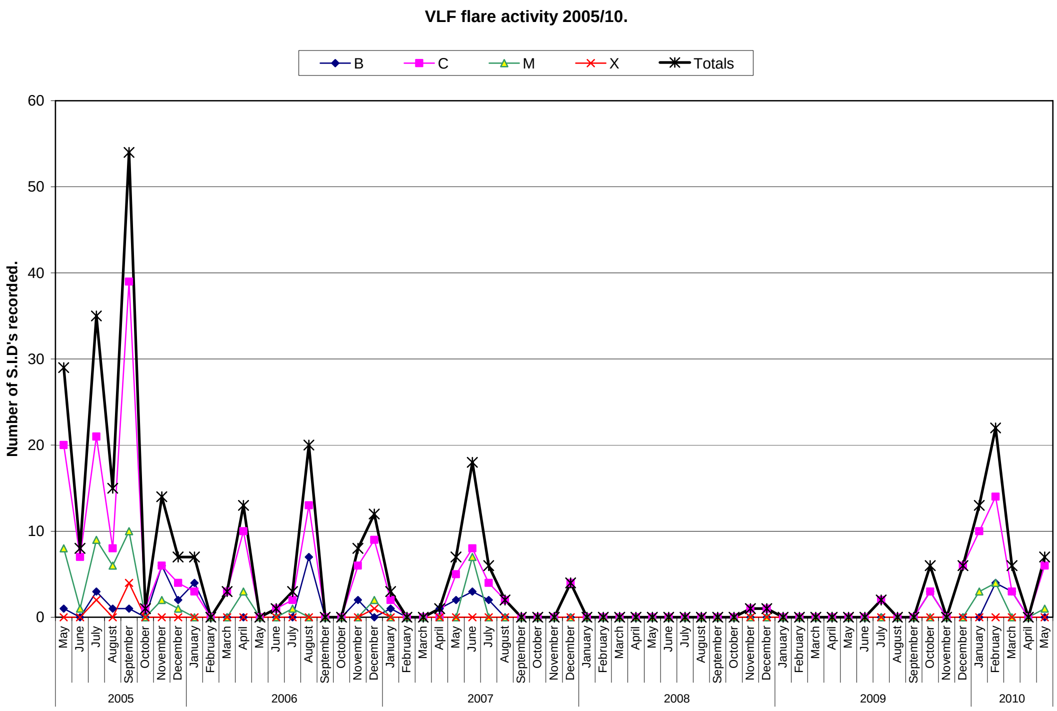
Alternatively, there is a strong case for the use of a two-element interferometer for "automatic" background subtraction. A two-aerial interferometer with spacing 'L' is sensitive to components of the brightness distribution (i.e. amongst the background, quiet Sun and any bursts) having spatial frequency L/wavelength. Hence if you get the separation right the receiver will discriminate against the background to give an output due solely to solar emissions. Unfortunately this method requires a lot of space to set up and is likely to be outside the scope of the average back garden.

A third method can be employed by recording the signals as the aerial is scanned across the Sun. Noting the aerial's beamwidth (and sidelobes) you could move it so that the signal at the ends of each scan was background only. You can then interpolate what the background might be at the Sun's location and do the necessary subtraction. This is, of course, subject to errors of interpretation which reduce as the beamwidth reduces. Overall I think the first method is the best from the amateur's point of view with accurate measurements being available after six months' of measuring backgrounds.

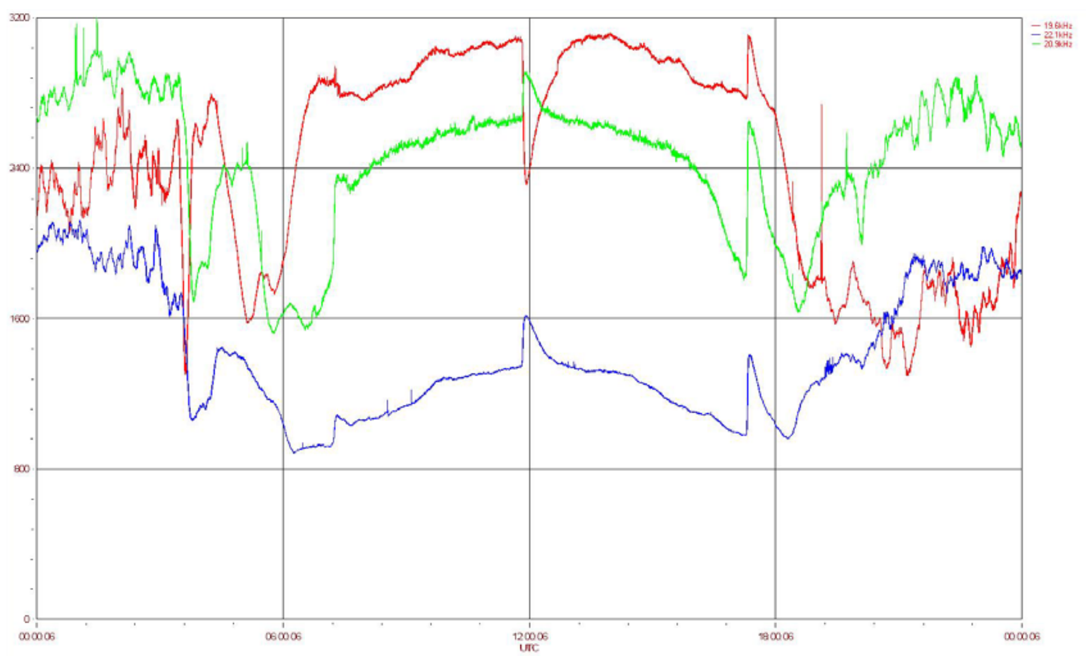
There are various possibilities for displaying the output from a scanning receiver depending on your software skills. The problem is clear: how best to present a cube of data (i.e. time vs. frequency vs. intensity) that is comfortable for you. I favour a vertical string of pixels displayed on a monitor relating to the frequency channels and colour-coded to match intensity. For real-time observing the scans stack side by side, filling up the screen with one column dropping off the left side as a new one is added at the right side. You can then watch for any events moving slowly from right to left and hit a button to capture anything of interest. The best way of doing this is a subject for further discussion.

VLF Report

A number of observers have been providing data on the Sudden Ionospheric Disturbances (SIDs) caused by solar flares. John Cook consolidates these reports and maintains a long-term record of solar activity in this regard, see Figure 1. There is more on the work of the group in John's report in the June edition of the BAA Journal.



May produced some nice examples of SIDs and two events are instantly recognisable in the following plot for 5th May.



A C8.8 flare at 1140 UTC resulted in strong increases in received signal levels from two Very Low Frequency (VLF) radio transmitters: Le Blanc in France (at a frequency of 20.9 kHz); and Skelton in Cumbria (22.1 kHz). There was an even more pronounced reduction in the signal received from Anthorn (19.6 kHz), also in Cumbria. An M1.3 event at 1715 produced even larger disturbances.

Not quite so obvious is the disturbance caused by a C2.3 event at 0710, though closer inspection shows the tell-tale signs of a fast initial change in signal level as ionisation levels in the 'D' Layer of the Earth's atmosphere quickly rise, followed by a much slower return to normal signal levels. After the excitement of May, June proved to be a quiet month with only six events noted by observers:

			John Cook (23.4kHz)				Roberto Battaiola (18.3kHz)				Mark Edwards (18.3kHz)			
	Xray class	Observers	Tuned radio frequency receiver, 0.58m frame aerial.				Modified AAVSO receiver.				Spectrum Lab / PC 2m loop aerial.			
DAY			START	PEAK	END (UT)		START	PEAK	END (UT)		START	PEAK	END (UT)	
12	C6.1	5	09:14	09:19	10:15	2+	09:09	09:20	09:55	2+	09:13	09:19	10:09	2+
13	**M1.0**	4	05:35	05:36	05:39	1-	05:33	05:41	06:04	1+	05:33	05:41	06:01	1+
13	C1.2	2									07:07	07:10	?	-
13	C1.2	1									07:33	07:40	07:59	1+
13	C1.2	4	08:11	08:11	08:18	1-	08:05	08:15	08:23	1-	08:09	08:15	08:45	2
13	C1.7	5	09:46	09:47	09:50	1-	09:43	09:49	10:01	1-	09:45	09:43	10:15	1+
13	C1.5	5	10:52	10:54	11:00	1-	10:51	10:55	11:11	1	10:52	10:55	11:27	2

			Peter King (16kHz)				Paul Hyde (22.1kHz)				Mark Horn (23.4kHz)			
			Own designed receiver, 1.4m loop aerial.				Tuned radio frequency receiver, 0.96m frame aerial.				Tuned radio frequency receiver, 0.58m frame aerial.			
DAY			START	PEAK	END (UT)		START	PEAK	END (UT)		START	PEAK	END (UT)	
12	C6.1		09:00	09:15	09:25	1	09:13	09:18	09:45	1+	09:12	09:22	09:55	
13	**M1.0**						05:34	05:43	06:28	2+				
13	C1.2		07:05	07:10	07:15	1-								
13	C1.2													
13	C1.2		08:05	08:10	08:15	1-								
13	C1.7		09:40	09:45	09:50	1-	09:45	09:48	09:54	1-				
13	C1.5		10:45	10:50	10:55	1-	10:51	10:55	11:13	1				

Unfortunately it looks as if July will be even quieter, showing that we are still in the early stages of Cycle 24.

Proposal for a New Study

Alan Melia has provided the following proposal for an additional observing programme which would combine the results from both VLF receiver and magnetometer instruments:

> *Variations in geomagnetic activity are caused by variations in the pressure of the Solar Wind or the impact of Coronal Mass Ejections (CMEs). There is also some disturbance due to the so-called high-speed flow from coronal holes. The latter is a relatively broad event like the water shaken off a wet dog. The disturbances due to the CME in contrast is like the impact of a ball of fast moving plasma. Many CMEs are associated with the eruption of solar flares which we attempt to detect with our VLF receivers. These take approximately 9 minutes to reach the earth so are virtually instantaneous. Assuming a CME is ejected at the same instant, this ball of plasma travels much more slowly, and the time to reach the earth and provoke a magnetic storm is usually around 56 hours. This time delay depends upon the ejection speed, and tends to be related to the intensity of the flare event producing it.*
>
> *It seems that it might be an interesting experiment to try to relate the arrival time of a CME and the onset of a Magnetic Storm, with the time of the associated flare emission. The delay can allow the speed of the plasma ball to be calculated, and an attempt to correlate this with the flare intensity. CMEs emitted with very energetic flares (X-Class) can take as little as 32 hours to reach Earth.*
>
> *This does have some impact on public awareness as recent "scare" stories in the press, and on TV, about the consequences of gigantic solar eruptions have all stated that there is no warning. Even the august Scientific American make the mistake of repeating this as fact.*
>
> *Alan Melia*

Of course not all flares are associated with CMEs and not all CMEs result in significant magnetic storms, but the increasing activity of the next few years will provide an opportunity to put the theory to the test. You do not need to own a VLF receiver to participate, just a magnetometer that is sensitive enough to detect major magnetic events (the National Grid for instance ☺). Please let me know directly if you would be interested in participating in this programme.

New Starbase Release

You will have seen Laurence Newell's mail regarding the availability of a new release of his Starbase observatory application. This is available (a 52MB download) from the UK Radio Astronomy Association website, at:

http://www.ukraa.com/ukraa/starbase/downloads/dist-2010-07-18-build986.zip

If you would like more information on the Starbase application you can find the User Guide at http://www.ukraa.com/downloads/downloads.html

For more information contact Laurence directly at radio.telescope@btinternet.com or starbase@ukraa.com

That's all folks! As I say, any comments are very welcome, and content for the next version doubly so. A few photographs of reader's installations wouldn't go amiss. Please mail me directly, rather than broadcast to the whole group.

Thanks,

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BAA RAG Coordinator