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Solar Activity Observatory early stages: Analysis of the diurnal variations in the amplitude strength at 20.1MHz

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Abstract

We present the results of the early stages of a Solar Activity Observatory: the continuous monitoring of 20.1MHz signal strength in order to study the solar activity. Since the project is quite young, as to say, we have 3 months of observations, in this sense, we were able to observe diurnal changes. The difference between the day and night amplitude strength, the time it takes the amplitude to increase and decrease from day to night, and some special features such as a B class solar flare during May 6.

1 Introduction

The ionosphere is the part of the atmosphere closest to the surface of the Earth. During the day, it is ionized by solar radiation, increasing the total electron content, and giving place to the D layer, characterized by the strong absorption of radio frequencies. At night, the D layer disappears as a consequence of electron recombination, decreasing the electron content. This change might appear as a drastic feature [1].

The changes in the amplitude signal in radio frequencies, is strongly related to solar activity, originating the so called Sudden Ionospheric Disturbance (SID). In this sense, it is quite common to monitor SID's with very low frequencies [2], to correlated them to solar activity, meteor showers, Jovian storms and in some cases, to earthquakes.

The Solar Activity Observatory is an educational and scientific project meant to bring radio astronomy to students, and from the continuous monitoring of solar activity try to correlate it to changes in weather parameters.

2 Instrumentation and location

The Solar Activity Observatory is located at the CECyT18 in Zacatecas, Mexico, with the support of UAZ. It consist, so far, of a grid of small weather stations based on arduino, and a RadioJOVE receptor with a dipole antenna. It is worth notice, that the project is still in its early stages, in the sense that, its main purpose is to correlate solar activity and its implications in weather parameters

The RadioJOVE project consists in a dipole antenna design to operate at 20.1MHz, and a receptor which receives, amplifies and helps record the signal to a computer [3,4]. As an early stage, it is worth noting that the signal is not calibrated, in this sense our observations are recorded in arbitrary units.

Since the Solar Activity Observatory is located in a public institution, the receptor is working non stop, in the sense that we are continuously receiving signal during day and night. This has allowed us to identify some important features of such daily signals, the most significant is the difference in amplitude strength between day and night, this can be observed in figure 1, an example of a single day signal record.

As mentioned above, thanks to the fact that the receptor is continuously working, the data sample consists of 3 months observed in a systematic and consistent way, ruling out some days due to malfunction of the computer and technical issues.

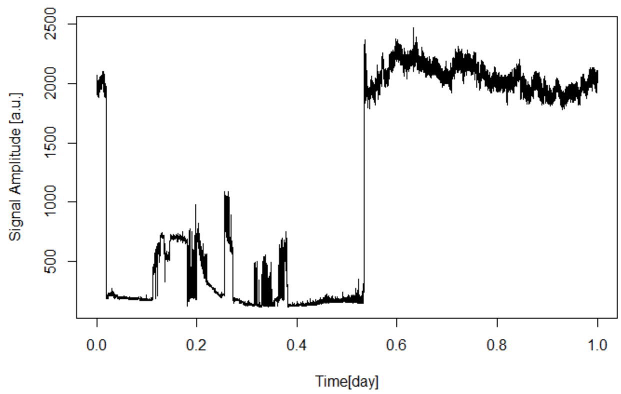

Figure 1. An example of a single day signal strength. In which, can be observed the difference in amplitude strength between day and night.

3 Diurnal variations

An example of the actual observed light curve, i.e. the amplitude strength along time, is represented in figure 1. In which the expected square emission is observed, where the minimum emission is during the day time, and the maximum during nighttime. This feature is consistent with the fact that the D region formed during day strongly absorbs HF radiation, and is indeed, during night that, such astronomical radio sources, as well as proper atmospheric variations are observed.

3.1 Amplitude strength

In order to visualize the difference between the day and night emission, the average amplitude was obtained, before, during and after nighttime. All the averages for each day of the three months, are represented in figure 2, in which the green character represent May of 2019, the red ones represent June and the blue ones July. The squares denote the night average, the triangles and the dots are for the after and before the night, respectively.

As can be seen, the night amplitude strength during May is the strongest respect to June and July. The strength measured during July has the lowest values recorded during the night, specially by the end of the month. One of the reasons for this particular aspect, might be the fact that the Sun was going trough the 24 solar minimum cycle, reaching its lowest point by the end of the last year. In this sense, it will be interesting noting if the difference between day and night amplitude strength will become less prominent as the solar minimum is achieved.

The error bars indicate the standard deviation, in this sense, the larger they are, the more variability was observed. It is still unclear the nature of such variability, there are many possible candidates, being one of them the transit of center of the galaxy during the night, radio interference during day, and perhaps weather conditions such as electrical storms.

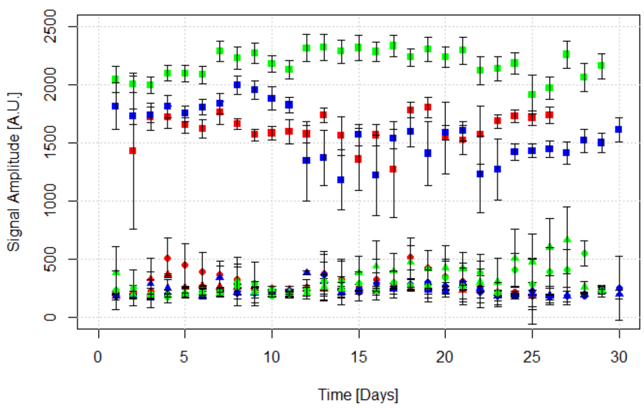

Figure 2. Average amplitude strength for May, green bullet points, June, red ones and July blue ones. The squares indicate the average during nighttime, triangles and circles the average after and before night, respectively, the error bars indicate the standard deviation.

3.2 Time delay

One of the things that caught our attention, is the time interval in which the signal emission goes from minimum to maximum, and vice versa. Since it is linked to the nature of the ionosphere, it might be related to the time it takes to the solar radiation to ionize the upper atmosphere, and on the other hand, the time it takes to recombine. The time interval was measured, from day to night and from night to day, it turns out that both values were quite similar, ranging from 1.087 seconds to 1,642 seconds, as can be observed in figure 3. It is worth noting such a small time lapse, in which the amplitude strength increases almost ten times from day to night, and decreases almost ten times form night to day. As can be seen from figure 3, the most common value is approximately around 1.2 seconds.

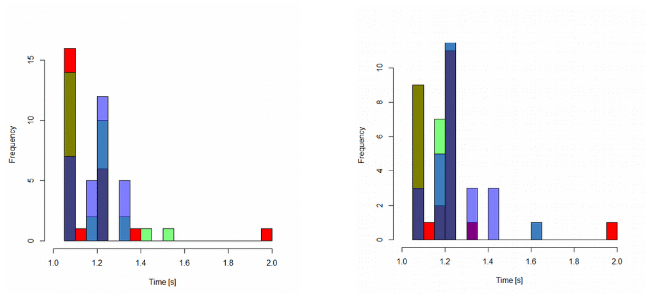

Figure 3. Histograms of the measured time lapse, left: from day to night; right: from night to day.

3.3 Special features.

In a close inspection, there is one feature that it is important to measure. As it is mentioned previously, the time transition between day and night is quite small, and the amplitude strenght raises and decreases, almost in a linear way during this time interval, but, before it raises, the amplitude behaves quite differently. As well as the night signal seems to have an almost constant value, just like two minutes before, the signal amplitude seems to have a constant value.

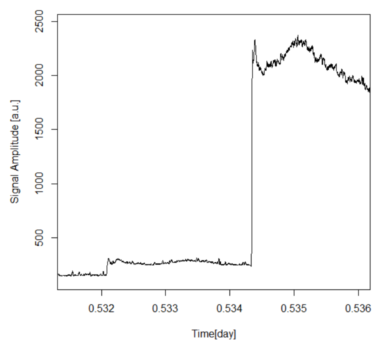

Figure 4. A detail from the 3 of May in which can be observed the behavior of the amplitude strength in the transition between day to night.

An example of this feature is observed in figure 4, in which, the amplitude signal raises a bit, and it remains with the same value for almost two minutes, then it raises to the night amplitude. It is worth noting that this feature only appears in the transition from day to night.

Between May 5 and 6, the sunspot 2740 emerged, along with a solar storm, which was observed in the daily records. This solar storm was used to support our observations, since thanks to the RadioJOVE data archive, we were able to confirm our observations with other radio telescopes.

The signal variation registered in 20.1MHz is observed in figure 5, which consist in two spikes during almost 3 minutes, this is 0.002 days, in agreement with other observatories from the RadioJOVE data archive.

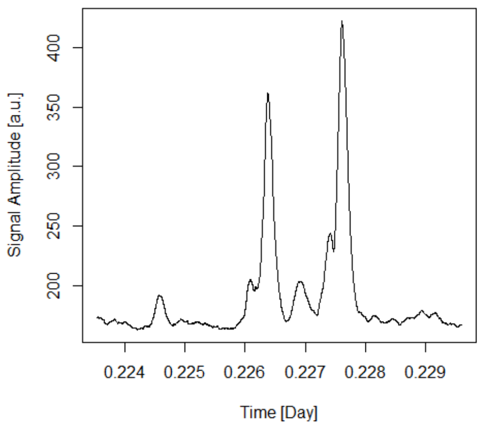

Figure 5. Solar flare observed on May 6 2019

4 Conclusions

We presented the first observations of the Solar Activity Observatory at Zacatecas, Mexico, an effort achieved thanks to the high school students and teachers at CECyT18. Thanks to the continuous monitoring, we were able to observe and analyze diurnal variations, such as the average strength amplitudes during day and night, and measure the time it takes the radiation to change from day to night and vice versa. Indeed, there is a lot of work left to do, as mentioned above, this are the first steps to calibrate, analyze and describe the signal variations we observe.

5 References

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