Title: Space Weather Study through Analysis of Solar Radio Bursts detected by a Single Station CALLISTO Spectrometer.

Answers to the referee # 2

Firstly, we thank the referee for providing useful comments on our manuscript. Following the referee's comments, we have carefully gone through the manuscript and revised it. **For the sake of convenience, the newly added text in the manuscript is highlighted in boldface.** Herewith, we provide the answers and/or explanations to the referee's comments:

Comment # 1

The paper summarizes the results of the first year of observations with an e-CALLISTO radio spectrograph at Kigali, Rwanda. It gives lists of the observed radio bursts, briefly discusses some statistics, and attempts to draw a few conclusions. The main problem with the paper is that the analysis and interpretation of the events is quite superficial. No qualitatively new results are obtained. I see two options: some more in-depth analysis, in particular putting elaborating on the statistical results and putting them into context of existing work, and/or focusing more on the technical and operational aspect, e.g. by demonstrating why this e-CALLISTO station is a valuable addition to the network. I have addressed particular issues below.

Comparison to existing event catalogs:
In assessing the performance of the instrument, it would be very instructive to compare the number of detected bursts with existing event catalogs. Radio bursts are available from the NOAA Space Weather Prediction Center at least for the second half of 2015 (ftp://ftp.swpc.noaa.gov/pub/indices/events/), so a partial comparison could be done. Such a discussion would significantly strengthen the case of the paper.

Response

Recent studies by Ndacyayisenga et al., 2021 found that out of 12971 type III bursts events reported from the NOAA Space Weather Prediction Centre (SWPC), CALLISTO spectrometers detected 698 type III bursts within the period from 2010 until 2017. Similar analysis by Umuhire et al.,2021 found that among 365 type II bursts, only 107 type II bursts could be detected by e-CALLISTO spectrometers.

The aim of the current paper is not to compare the efficiency of the CALLISTO spectrometer installed at University of Rwanda, College of Education with any other radio spectrometers. The overall objective is to demonstrate the possibility of such a single station of e-CALLISTO network to contribute to the space weather study through observation of solar radio bursts. We appreciate the referee for the suggestion to make comparison of CALLISTO with any other spectrometer. We would think that more emphasis on it might shift the focus of the current paper. However, we now provide sufficient discussion on the space weather part which was initially not done.

CALLISTO instrument was designed in the framework of IHY2007 and the idea of providing a cheap instrument to support developing countries in solar radio astronomy. Total cost for such a telescope was decided to be in the order of US2000$ which every interested institute can afford. This financial constraint was only possible by selecting a cheap antenna (LPDA) with main beam gain of ~6 dB and a low cost frequency agile spectrometer as a back-end. Any high sensitive digital back-end with similar frequency range would cost in the order of 100 times more than a CALLISTO spectrometer.

Comment #2

Type IV bursts, shocks, and CMEs (line 79 & 114): While the association of type IV bursts with CMEs is high, the claim that they are caused by CME-driven shocks is erroneous. It is well established that type IV bursts are generated by energetic electrons trapped in a magnetic structure, e.g. an erupting flux rope in the framework of a CME. This error has to be corrected.

Response

We thank the referee for pointing out this issue. We agree with him/her that type IV bursts are generated by energetic electrons trapped in a magnetic structure, e.g. an erupting flux rope in the framework of a CME. High association of Type IV bursts with CMEs can only be used to study the kinematics of CMEs and trace out the physical characteristics of the electrons generating type IV bursts. The mistake is corrected.

Referee #2 Minor issues:

Comment # 3

Sect. 2: Technical details of the Callisto system as implemented in Rwanda should be given, including temporal and frequency resolution and antenna characteristics.

Response

Given this low antenna gain of ~6 dB, selected frequency range 45 MHz - 80 MHz, low noise amplifier with ~2 dB noise figure, 300 KHz radiometric spectrometer bandwidth and 1 ms integration leads to a system sensitivity during transit of the Sun in the order of 22 sfu ... 66 sfu. Thus, such a low cost system can never see weak bursts, it can only detect strong bursts during Sun transit ± 3 hours.

A CALLISTO based radio telescope can never detect quiet Sun unless the antenna (LPDA) is replaced by a parabolic dish in the order of at least 5m diameter and an appropriate tracking system. Nevertheless a CALLISTO system allows one to step into solar radio astronomy and study dynamic radio spectra.

Temporal resolution is given by a fixed sampling rate of 800 S/s which is divided into a number of frequency channels, e.g. 200. In this case we get a time resolution of 800 S/s / 200 = 4 spectra per second which corresponds to 250 ms time resolution. For 100 frequency channels we would then get 125 ms time resolution and so forth. Frequency step size is given by the instrument firmware to 62.5 kHz, leading to theoretically 13'200 possible observing frequencies. In practice we select 200 best frequencies out of the maximum observable spectrum 45 MHz- 870 MHz for observation. Best in this context means lowest level of rfi. Different from step-size is the radiometric bandwidth which is given by a ceramic filter of 300 kHz. Detailed specification of the spectrometer can be found here:

http://www.e-callisto.org/Hardware/eCallistoSpecification.pdf

Detailed specification of the antenna CLP-5130-1 can be found here:

http://www.cd-corp.com/eng/cma/clp5130.pdf

Comment#4

Tables: How is the CME onset time defined?

Response

A coronal mass ejection (CME) is a significant release of plasma and accompanying magnetic field from the solar corona. The released plasma can be observed in coronagraph imagery. Its first appearance time in the coronagraphic field of view is known as the CME onset time.

Comment #5

line 82: It is said that a specific type II burst is chosen for its geo-effectiveness. It is more appropriate to say that it was chosen because it was associated with a geo-effective event, since a coronal shock by itself is not geo-effective.

Response

The line is rephrased as follows: Among type II bursts detected by the instrument, we have chosen the type II burst of August 22, 2015 because it is associated with a geo-effective event.

Comment # 6

line 97: It is claimed that outward-propagating waves are associated with the bursts. The statement is at odds with the next sentence that associates type III bursts with jets. A jet is not a wave, so please clarify this issue.

Response

The statement is rephrased as follows: With the help of images provided by AIA/SDO, the remaining 11 bursts are associated with leading jets on the west edge.

Comment#7

line 102: Not clear to me what the authors want to say here - please rephrase.

Response

From Figure 3, it is seen that the jets look the same from 06:55:15 UT to 10:04:05 UT, and it is believed that there is a repetitive type III radio emission associated with them (Chifor et al., 2008, https://doi.org/10.1051/0004-6361:200810265).

Comment # 8

lines 109-112: It should be noted that the latitudinal distribution of type III-associated

flares is not surprising, as it just reflects the distribution of flares (and active regions) in general.

Response

The paragraph is modified as follows: Although the small fraction of type III radio bursts, we have plotted the heliographic longitudes and latitudes of the associated solar flares as indicated in Figure 5. **It is seen that the distribution of flares associated with type III radio bursts originate near the equator (±30◦).** This result is consistent with the findings by Mahender et al. (2020) who found that 125 type III radio bursts among 426 are associated with the solar flares that originated close to the equator (i.e. heliographic latitudes ±23◦).

Comment #9

lines 126 & 127 (and potentially other places: When referring to the instrument please use "spectrometer" instead of spectrogram.

Response

We thank the referee for the suggestion. The mistake is corrected.