Available online at www.worldscientificnews.com

World Scientific News

WSN 46 (2016) 165-175 EISSN 2392-2192

The Solar Radio Burst Type II Correlated With Minor CME Contributes to The Production of Geomagnetic Disturbance

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ABSTRACT

The solar radio burst type II on 4th November 2015 was associated with minor CME that not lead towards the Earth. This clear type II burst recorded on spectrographs detected by the antenna in several locations (Gauri, Almaty, Kasi and Ooty) were obtained from CALLISTO website. The average time of the burst occurred are around 03:24 UT until 03:28 UT with the clear minor CME emerged recorded by SOHO at 03:12 UT. Although it just a minor CME but it is still giving the effect on Earth as it contributes to geomagnetic disturbance on the Earth during that day. The affected region reported by The Local news is Sweden, where the radar system for aviation was not clear, but it is back to normal after a few hours later. This geomagnetic disturbance is powerful enough that may cause the satellite damage, endanger astronauts and produce destructive surges on power grids.

Keywords: Solar radio burst; solar radio burst type II; Coronal Mass Ejections; geomagnetic disturbance

1. INTRODUCTION

During the recent years there has been a considerable renewal of interest in the solar radio burst. The solar radio burst type II is classified as slow drift burst [1] with the frequency range between 20 – 150 MHz. The associated phenomena of this type II burst including flares, proton emission and magnetohydrodynamic shock waves. It is generally believed that the solar radio burst type II usually correlated with the production of the Coronal Mass Ejections (CMEs) [2,3]. The type II burst is always seen in conjunction with flares, even though some of those flares are very small events, and there is a very healthy controversy as to whether the shocks are driven by CMEs or by some other flare phenomenon; with the improved coverage and sensitivity of coronagraphs in recent years, the correlation between type II bursts and the presence of coronal mass ejection (CME) has become increasingly tight, lending support to the idea that the shocks that produce type II bursts are being driven by CMEs, without resolving the issue [4-11]. The particle acceleration exhibited by type II driving shocks, and their associations with flares and/or CMEs, make them important for Space Weather studies [12]. Coronal mass ejection is a massive burst of solar wind and magnetic fields rising above the solar corona that can trigger major disturbances in Earth’s magnetosphere [13]. The CME is categorized by two types; i) flare related CME and ii) CME associated with filament eruption [13]. The CME potentially be observed during the solar flare. This is due to magnetic flux in the active region. Normally, the solar radio burst type II [14] and complex Type III bursts would be observed in conjunction with CME [1]. For the CME associated with filament eruption, it is quite complex, so that the process is not barely understood [13,15].

In the space weather prediction center websites, it is reported that the CME may lead to the geomagnetic disturbance where a billion tons or so of plasma from the Sun with its embedded magnetic field arrives at Earth [16]. It is very dangerous to the living on Earth. It may disrupt the wireless communications, produce destructive surges on power grids, satellites damages and endanger astronauts. It was reported in March 1989 the geomagnetic disturbance collapse the Hydro-Québec system in North America and leaving more than six million people without power for nine hours. CMEs typically takes several days to reach Earth’s surface, but in several cases the most intense storm may take as short as18 hours to reach [17].

2. METHODOLOGY

The low frequency range considered here extends from 400 MHz (λ = 0.7 meter) to 30 MHz (λ = 10 meters). In this case, we are focusing on the meter region [18]. The data used in this paper obtained from CALLISTO websites. CALLISTO (Compound Astronomical Low-Cost, Low-Frequency Instrument for Spectroscopy and Transportable Observatory) is a project of the solar radio spectrometer used to monitor solar radio emission [19-21]. A number of CALLISTO spectrometers have been commissioned worldwide to work as network which is known as e-CALLISTO [22] and the collaboration between the countries around the world provide the advantages in monitoring the solar activity within 24 hours per day. The CALLISTO system covers the frequency range between 45 MHz – 870 MHz [23]. Radio observation is highly complicates the radio diagnostic and thus the comparison of the data with the models is still in its infancy [24].

Figure 1. The antenna in Almaty, Kazakhstan.

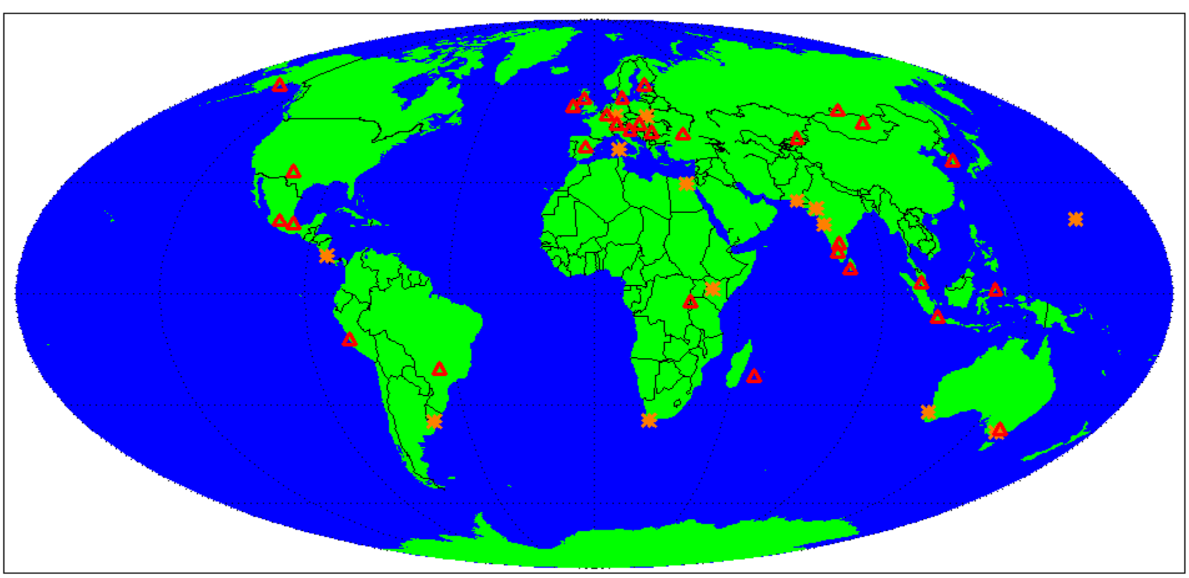


Figure 2. The location of CALLISTO around the world in November 2015

Until now more than 116 instruments in more than 66 locations with users from more than 120 countries. The Figure 2 below shows the current distribution of CALLISTO instruments in November 2015. It is noted that some locations mark as red triangle are can not provide data anymore and some of them still cannot provide data yet (refer to Figure 2). The CALLISTO spectrometer is a programmable heterodyne receiver built in the framework of IHY2007 and ISWI by former Radio and Plasma Physics Group (PI Christian Monstien) at ETH Zurich Switzerland. This CALLISTO system has low-cost instruments, allowing worldwide installation and networking, which enhances the observed data [19,25]. The instruments include antenna, a preamplifier, a superheterodyne receiver with spectroscopic capability (CALLISTO spectrometer itself), and a data-recording device [26].

The Figure 3 above shows the CALLISTO framework with main focus to observe the solar radio spectrum. The CALLISTO software produces several output files. The most important are the data files, which use the Flexible Image Transport System (FITS) file format. The FITS are typically produced at 15 minute intervals throughout the specified observation period. The instruments automatically collect and send the observed data to a central data archive via the internet and all the data are gathered in a database [22]. These data can achieve by browsing the link http://www.e-callisto.org/.

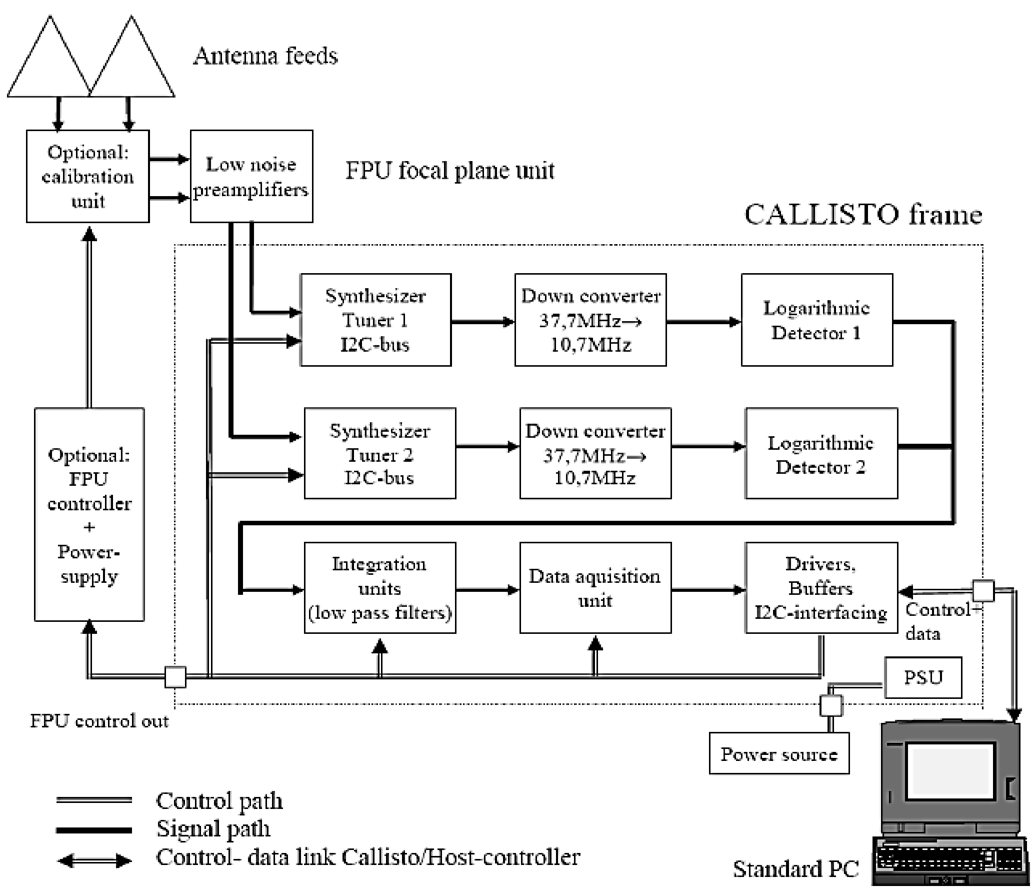


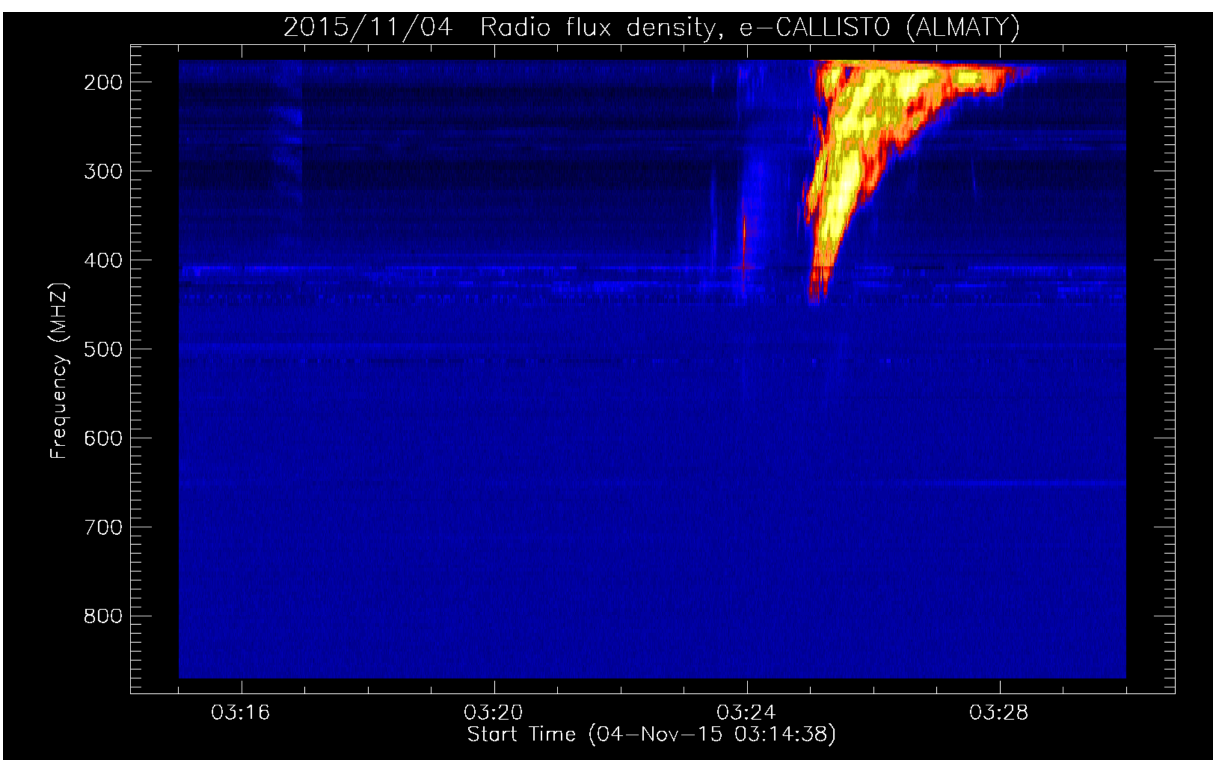
Figure 3. The basic design of the CALLISTO spectrometer with two receivers (top and middle row) operates in phase.

3. RESULT

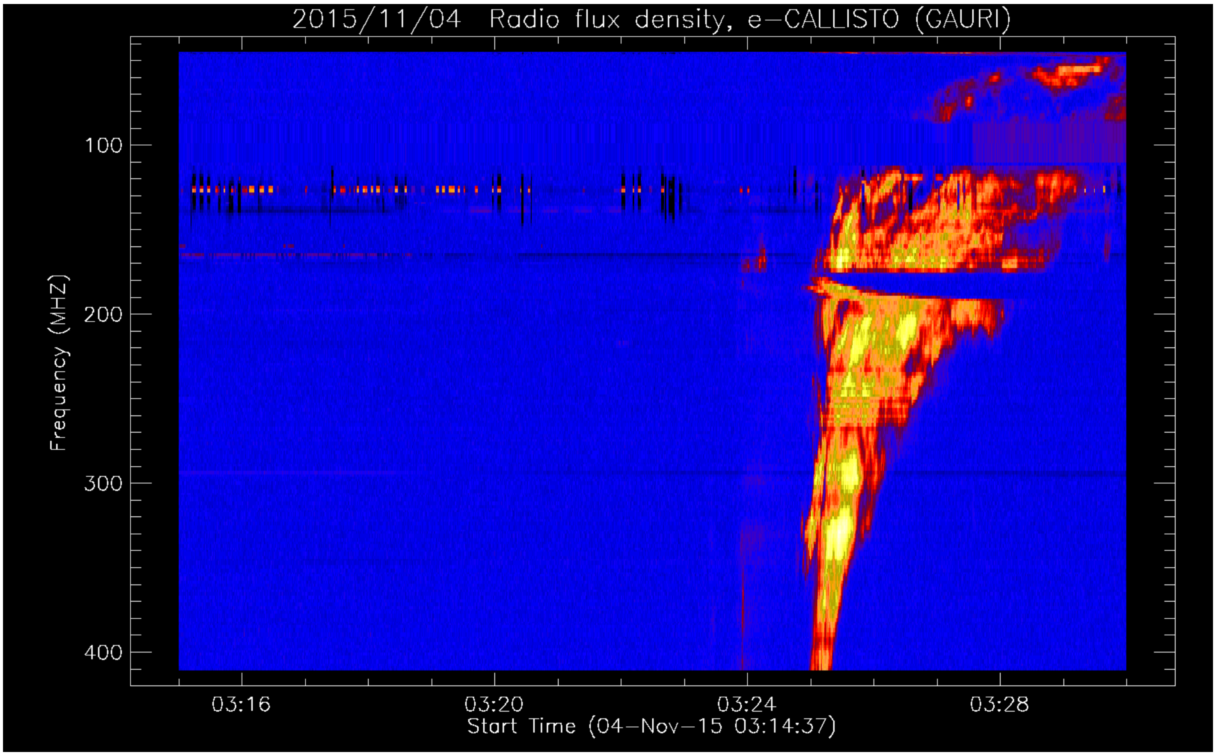
There are four sites of CALLISTO network can detect this burst as illustrated in Figure 4 at (i) Gauri, (ii) Al-Maty, (iii) Kasi, and (iv) Ooty. It can be found in the range of 50 MHz to 420 MHz. This type II burst is longer and has a slow drift rate. The structure of the herringbones is very clear during this event.

Plasma rushed away from the blast, sit, but only a fraction of it escaped. The SOHO also recorded a minor CME emerging from the area and luckily it is not heading towards the Earth. From this event, it was reported that the minor CME start to onset at 02:12 UT and the clear CME emerged at 03:12 UT. Then the solar radio burst type II observed at spectrograph several minutes after the CME formation recorded by SOHO.

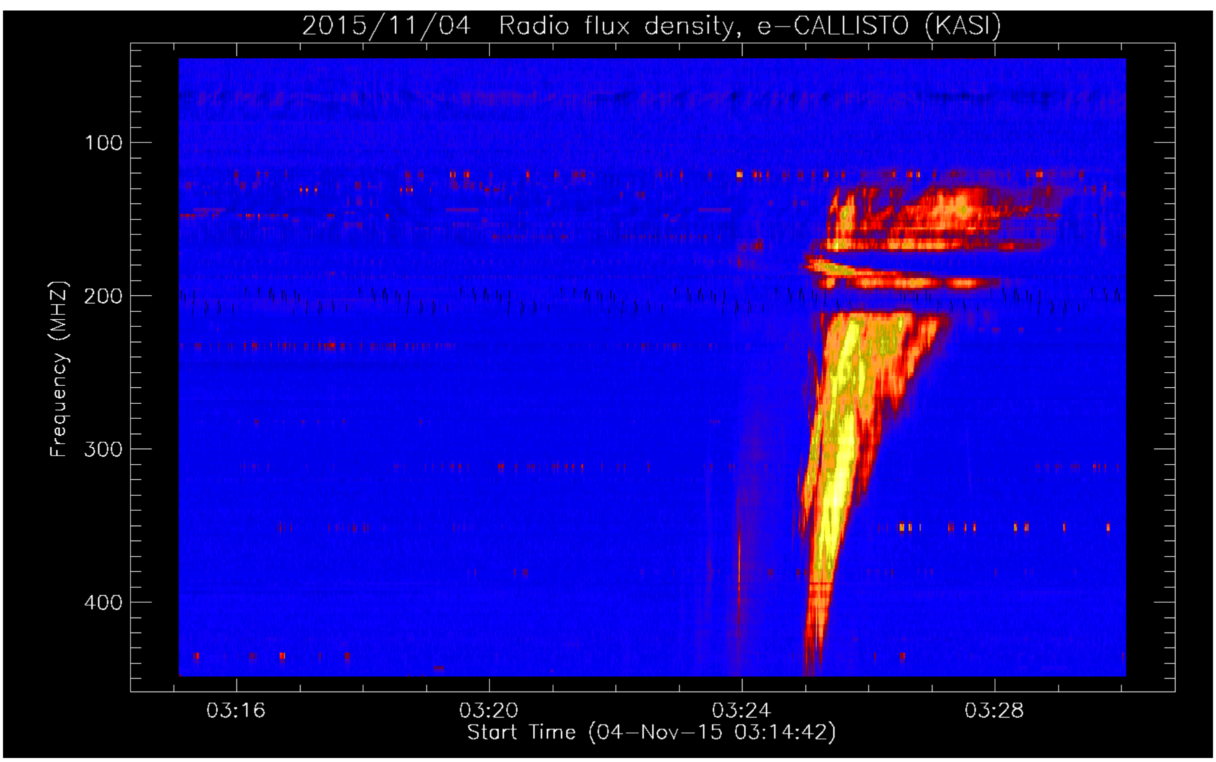
Although it is only a minor CME emerged on 4th November 2015, the geomagnetic disturbance is still occurring during that day. It was reported in the Local news (http://www.thelocal.se/20151104/solar-storm-grounds-swedish-air-traffic) that the radar in Sweden was blind during the solar activity and no aircraft were allowed to take off from airports in southern and central Sweden due to a massive geomagnetic solar flare storm causing problems for radar systems. The press spokesperson at Swedavia, the organization managing Sweden's airport, Ulf Wallin told TT that the airports at Landvetter in Gothnburg and Arlanda and Bromma in Stockholm were affected. The problems have been around 3.30 pm (Swedish time) on Wednesday and begun to return to normal an hour later. During the solar storm the airplanes could not be seen clearly on the radar screen. It is powerful enough which can disrupt the satellite-based communications, including radar and GPS systems. In 2003, a similar storm caused power blackouts for thousand of homes in southern Sweden.



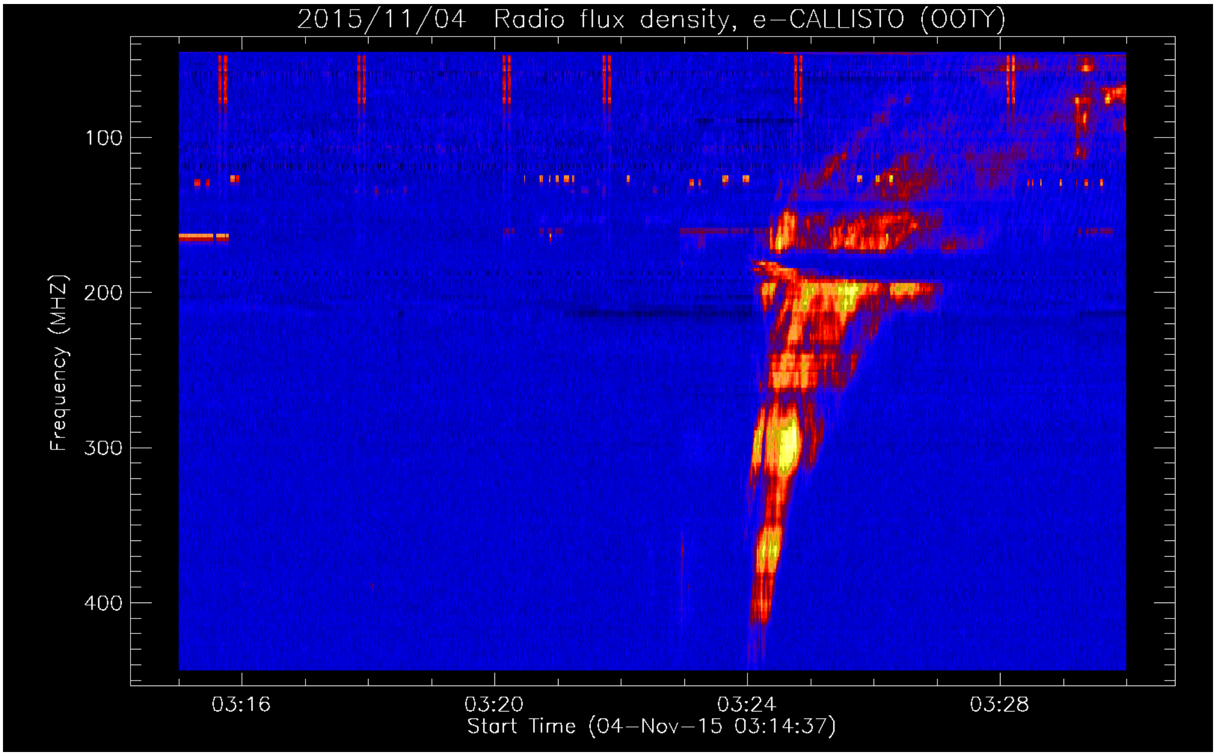
(A)


2015/11/04 Radio flux density, e-CALLISTO (GAURI)
Frequency (MHZ)
100
200
300
400
03:16
03:20
03:24
03:28
Start Time (04-Nov-15 03:14:37)

(B)


2015/11/04 Radio flux density, e-CALLISTO (KASI)
Frequency (MHZ)
100
200
300
400
03:16
03:20
03:24
03:28
Start Time (04-Nov-15 03:14:42)

(C)



(D)

Figure 4(A,B,C,D). The comparison data in four different locations on 4th November 2015.

This type II solar radio burst occurred on 4th November 2015. From the comparison of four different locations it showed that the solar radio burst type II occurred around 03:24 UT until 03:28 UT.

There are eight active regions (AR) during this date and the AR 2445 is the most active which producing 2 types of M class flare and 8 C class flare. The first M class flare occurred at 11:55 UT with reading M3.7 class scale and the second occurred at 03:20 UT with M1.9 class scale of solar flares.

In this case the second type M class flare considered as the flare which associated with this type II burst as the time of burst occurred 4 minutes after the M1.9 class flare recorded by the GOES satellite. The M class flare is a medium sized of class flare which can cause brief radio blackouts that affect the Earth's polar regions.

From Figure 7 above, it shows that the geomagnetic disturbance occurred during 4th November 2015. This disturbance continued until 6th November 2015 and it becomes calm on 7th November 2015. However, during 4th November 2015 it still disrupts the flight radar system in Sweden.

This geomagnetic storm also can disrupt the normal operations of the power grid. Even though the CME does not blast toward the Earth it still have geomagnetic storm on the Earth. This is because of the strong energy of plasma ejected from the Sun during this event which contributed to the high intensity of type II burst.

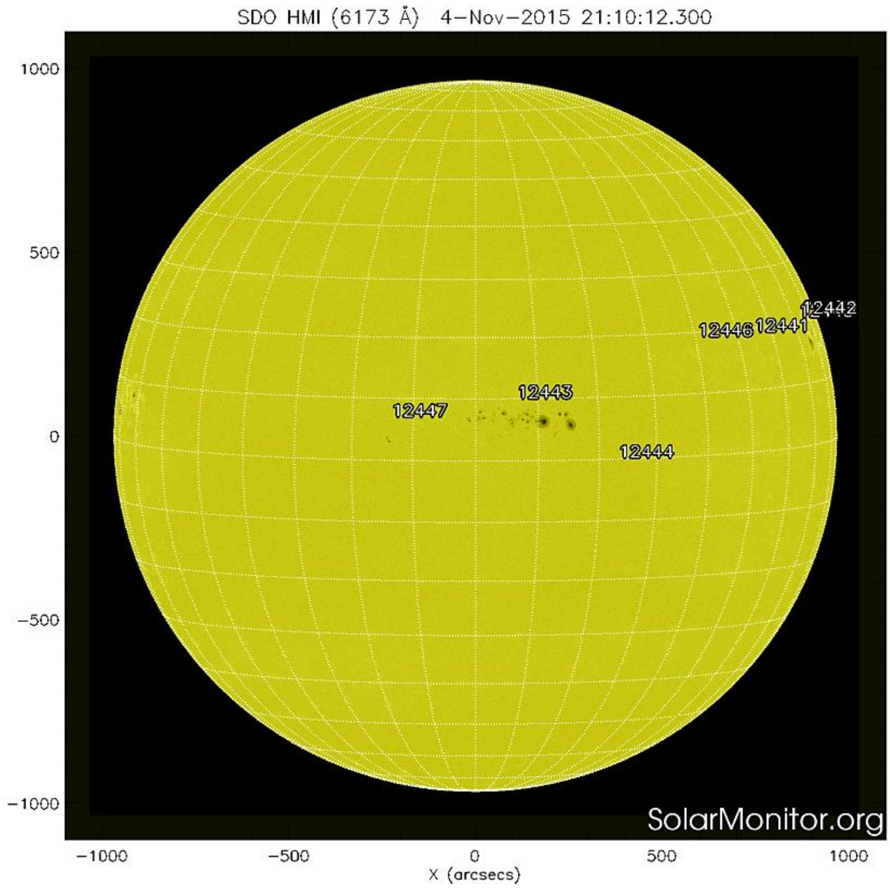


Figure 5. The active region on 4th November 2015.

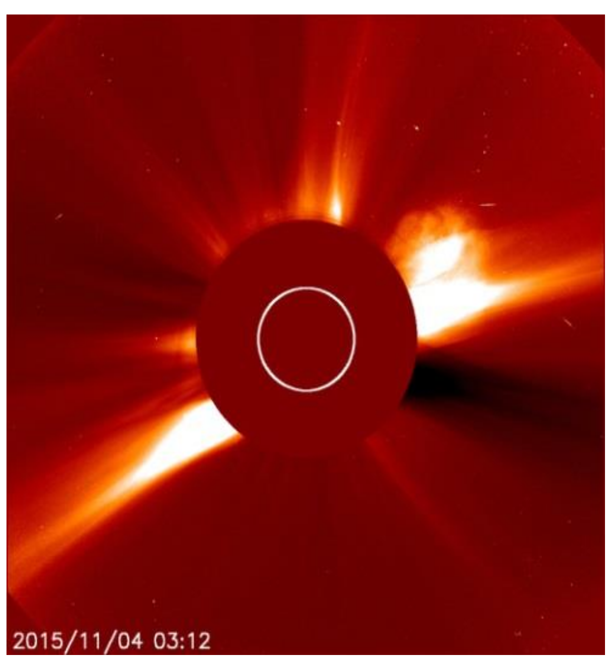


Figure 6. CME recorded by SOHO

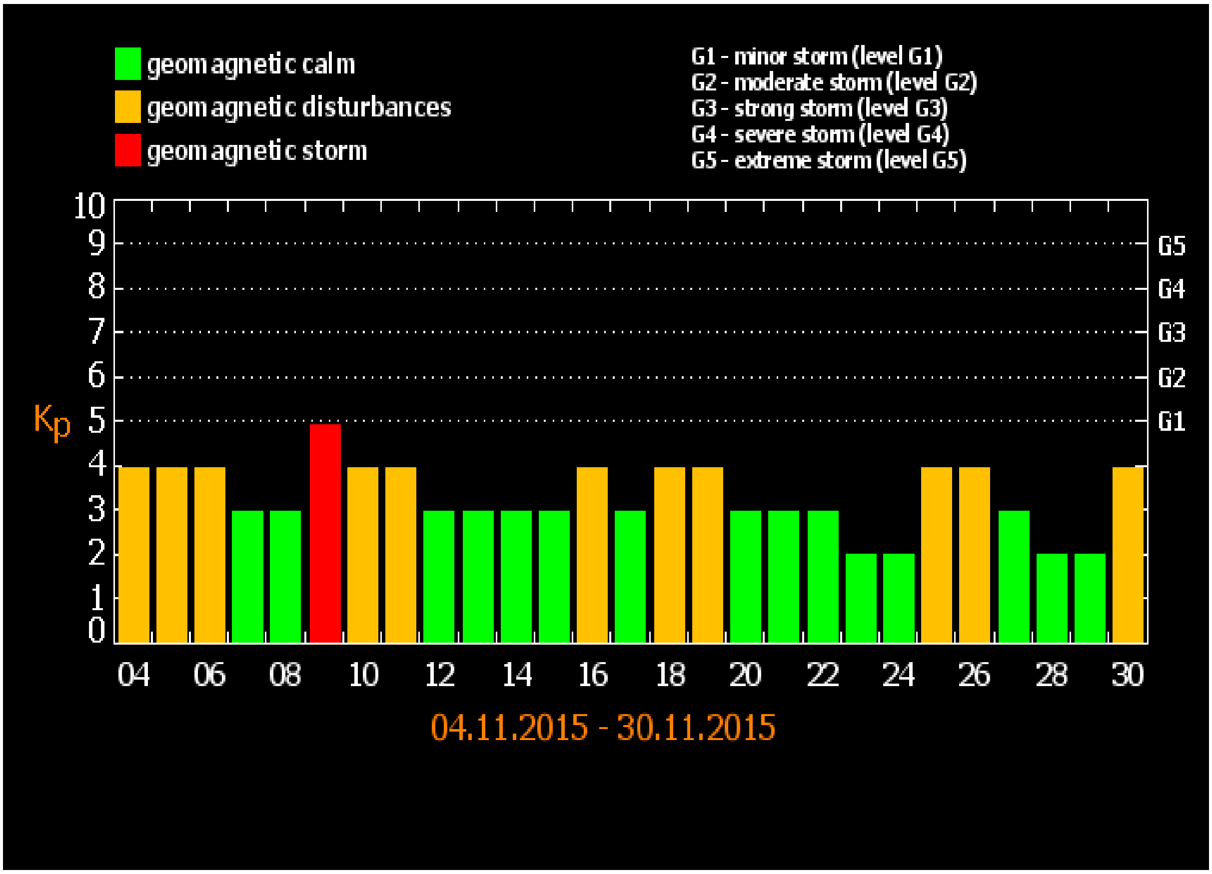


Figure 7. The27 days forecast of solar activity

4. CONCLUSION

The solar radio burst type II on 4th November 2015 was associated with minor CME. This burst observed on spectrograph several minutes after the production of CME recorded by SOHO. Although this CME does not direct towards the Earth it is still giving some effect on the Earth as it is contributing to the geomagnetic disturbance which disrupt the radar system in Sweden. This happened due to the high energy of particle ejected during the CME events which lead to high intensity of type II burst observed in all four spectrograph from different locations and geomagnetic disturbance on the Earth.

ACKNOWLEDGMENT

We are grateful to CALLISTO network, STEREO, LASCO, SDO/AIA, NOAA, SOHO, SolarMonitor and SWPC make their data available online. This work was partially supported by the 600-RMI/FRGS 5/3 (135/2014) and 600-RMI/RAGS 5/3 (121/2014) UiTM grants and Kementerian Pengajian Tinggi Malaysia. Special thanks to the National Space Agency and the National Space Centre for giving us a site to set up this project and support this project. Solar burst monitoring is a project of cooperation between the Institute of Astronomy, ETH Zurich, and FHNW Windisch, Switzerland, Universiti Teknologi MARA and University of Malaya. This paper also used NOAA Space Weather Prediction Centre (SWPC) for the sunspot, radio flux and solar flare data for comparison purpose. The research has made use of the National Space Centre Facility and a part of an initiative of the International Space Weather Initiative (ISWI) program. We are also thanks to Perpustakaan Tun Abdul Razak 1, UiTM Shah Alam, for giving us the facility to book and use the discussion room to complete this paper.

References

[1] Gopalswamy, N., *Interplanetary radio bursts*, in *Solar and Space Weather Radiophysics*. 2004, Springer. p. 305-333.

[2] Hamidi, Z., et al., *Theoretical Review of Solar Radio Burst III (SRBT III) Associated With of Solar Flare Phenomena.* International Journal of Fundamental Physical Sciences, 2013. 3(2).

[3] Hamidi, Z., et al. *Dynamical structure of solar radio burst type III as evidence of energy of solar flares*. in *Persidangan Fizik Kebangsaan (PERFIK) 2012*. 2012: Universiti Kebangsaan Malaysia.

[4] Cliver, E., *Comment on "Origin of coronal and interplanetary shocks: A new look with Wind spacecraft data" by N. Gopalswamy et al.* Journal of Geophysical Research: Space Physics, 1999. 104(A3): p. 4743-4747.

[5] Hamidi, Z., et al., *Signal Detection Performed by Log Periodic Dipole Antenna (LPDA) in Solar Monitoring.* International Journal of Fundamental Physical Sciences, 2012.

[6] Gopalswamy, N., et al., *On the relationship between coronal mass ejections and magnetic clouds.* Geophysical research letters, 1998. 25(14): p. 2485-2488.

[7] Cliver, E.W., D.F. Webb, and R.A. Howard, *On the origin of solar metric type II bursts.* Solar Physics, 1999. 187(1): p. 89-114.

[8] Stone, R.G., et al., *Radio astronomy at long wavelengths.* Washington DC American Geophysical Union Geophysical Monograph Series, 2000. 119.

[9] Shanmugaraju, A., et al., *An investigation of solar maximum metric type II radio bursts: Do two kinds of coronal shock sources exist?* Solar Physics, 2003. 215(1): p. 161-184.

[10] Cliver, E., et al., *Coronal Shocks of November 1997 Revisited: The Cme–Type II Timing Problem.* Solar Physics, 2004. 225(1): p. 105-139.

[11] Cane, H. and W. Erickson, *Solar type II radio bursts and IP type II events.* The Astrophysical Journal, 2005. 623(2): p. 1180.

[12] White, S.M., *Solar radio bursts and space weather.* Asian Journal of Physics, 2007. 16: p. 189-207.

[13] Hamidi, Z., et al., *An X-ray Observations of A Gradual Coronal Mass Ejections (CMEs) on 15th April 2012.* International Letters of Chemistry, Physics and Astronomy, 2014. 8: p. 13.

[14] Gopalswamy, N., R. Mewaldt, and J. Torsti, *Solar eruptions and energetic particles.* Washington DC American Geophysical Union Geophysical Monograph Series, 2006. 165.

[15] Hamidi, Z., C. Monstein, and N. Shariff, *Radio Observation of Coronal Mass Ejections (CMEs) Due to Flare Related Phenomenon on 7 th March 2012.* 2012.

[16] Hamidi, Z.S., et al., *Solar Studies in Radio Emission and Optical Photometry*, in *Dimensi Penyelidikan Astronomi Islam*. 2013, University of Malaya Publisher: University of Malaya. p. 33-40.

[17] Hamidi, Z.S., et al., *An X-ray Observations of A Gradual Coronal Mass Ejections (CMEs) on 15th April 2012 International Letters of Chemistry, Physics and Astronomy* 2014. 8(3): p. 13 -19.

[18] Hamidia, Z., et al., *Observations of Coronal Mass Ejections (CMEs) at Low Frequency Radio Region on 15th April 2012.* AIP Conf. Proc, 2013. 1528: p. 55-60.

[19] Benz, A.O., C. Monstein, and H. Meyer, *CALLISTO–a new concept for solar radio spectrometers.* Solar Physics, 2005. 226(1): p. 143-151.

[20] Z.S. Hamidi, et al., *Effective temperature of the sun based on log periodic dipole antenna performance in the range from 45 Mhz to 870 Mhz.* American Journal of Modern Physics, 2013. 2(2): p. 4.

[21] Z.S. Hamidi, N.N.M. Shariff, and R. Umar, *Influence Factors of Radio Frequency Interference (RFI) for Solar Radio Astronomy Purpose at National Space Centre, Malaysia* Thailand Journal of Physics, 2012. 3(2): p. 6.

[22] Zavvari, A., et al., *Analysis of radio astronomy bands using CALLISTO spectrometer at Malaysia-UKM station.* Experimental Astronomy, 2015: p. 1-11.

[23] Z.S. Hamidi and N.N.M. Shariff. *Evaluation of Signal to Noise Ratio (SNR) of Log Periodic Dipole Antenna (LPDA)* in *Business Engineering and Industrial Applications Colloquium 2013*. 2013. Langkawi, Malaysia: IEEE.

[24] Z.S. Hamidi, et al., *E-Callisto Collaboration: Some Progress Solar Burst Studies Associated with Solar Flare Research Status in Malaysia.* Malaysian Journal of Science and Technology Studies, 2013. 9(2): p. 15-22.

[25] Benz, A., et al., *A world-wide net of solar radio spectrometers: e-CALLISTO.* Earth, Moon, and Planets, 2009. 104(1-4): p. 277-285.

[26] Zavvari, A., et al., *CALLISTO Radio Spectrometer Construction at Universiti Kebangsaan Malaysia.* IEEE Antennas and Propagation Magazine, 2014. 56(2): p. 278-288.

(Received 28 March 2016; accepted 14 April 2016)