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Space Weather: The Role of Solar Radio Monitoring in Malaysia and Implications of Sun Activities to the Earth

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ABSTRACT

Space weather is very synonymous with the activities of our nearest star, the Sun. Recently; the space weather program has stimulated interest in this issue. The main reason is due to the extreme climate change and towards to the solar maximum at the beginning of 2013. It is believed that the Earth environment has a close connection with Sun activities, such as solar flares and Coronal Mass Ejections (CMEs). However, to prove it is not an easy way. The dynamism of the Sun also still is not easy to be understood. To improve our understanding of the solar activities, a new experimental approach by 24 hours monitoring has been done since 2007 by e-CALLISTO network. This work is a part of International of Space Weather Initiative Program (ISWI). As one of equatorial country, Malaysia also could contribute in terms of a consistent 12 hours monitoring and one of the earliest sites that observe the Sun every day. Here, we will highlight the role of our site, mechanism and implications of Sun activities to the Earth. It is hoped to meet the current knowledge about the Sun with this new method of experimental approach.

Keywords: Space weather, Climate changes, Solar radio burst, E-CALLISTO network, Sun activities, Solar flare, Coronal Mass Ejections (CMEs)

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INTRODUCTION

Space weather has close connection with the environments and processes occurring on the Sun, ionosphere, magnetosphere, and thermosphere that can affect the performance and reliability of space-borne and ground-based technological system as well as endangered human lives. For instance, it had the potential to disrupt global positioning systems, satellites and power grids and can caused some air carriers to change their planes polar flight paths. It is believed that the sun environment initiate the variations in the interplanetary magnetic field, solar flares, Coronal Mass Ejections (CMEs), and thus, the disturbances in the Earth's magnetic field contribute to the development of this weather. There are several factors and Sun activities that need to be understood such as geomagnetic storms, solar radiation storms, and ionospheric disturbances, energization of the Van Allen radiation belts, aurora and geomagnetically induced currents at the Earth's surface. Therefore, space weather relies on ground based radio observations. Indirect, radio monitoring of solar activity has an important economic potential.

Solar events might trigger shock waves at propagate in the solar corona or in the interplanetary medium. These shocks are detected primarily through their specific signatures (type II solar bursts) in the metric range (corona) until kilometer range (interplanetary medium). With a minimal assumption of the electron density profile along the trajectory of the propagating disturbance, it is possible to estimate its velocity in the corona or in the interplanetary medium. Arrival time at the Earth can then be deduced with reasonable accuracy, leading to an early warning of potential risks to satellite operators, telecommunications and other relevant human activities. Normally, in a view of the space weather implication, excess radio noise produced by a strong solar radio burst has impacts on geosynchronous satellite transmission, wireless cell sites, Global Positioning Satellite (GPS) signals and radars (Cerruti et al., 2008; Lanzerotti, 2005).

Solar flare monitoring in radio region is very important in order to identify the active flares sources based on their nature and emission mechanisms and to relate their properties with plasma parameters in flaring regions (Grechnev & Nakajima, 2002). During solar flares there may be large increases (bursts) in radio emission lasting anywhere from a few seconds to several hours. These bursts originate by bremsstrahlung, gyrosynchrotron and plasma radiations. Characteristics of the bursts vary with wavelength. Bursts in the meter-wave range (12 m to about 50 cm) are classified by spectral type. They almost invariably occur at sharp inversions of the sign of the longitudinal field, in places where the magnetic field gradient is so steep that only a force-free field, with strong currents flowing along the field lines could obtain.

The surface migration of magnetic elements (in particular sunspots) builds up these currents and through the flare events, the field can jump to a much lower energy potential field, usually by means of magnetic reconnection. The emission of the spikes usually occurring on very short time small spatial scale is very significant to correlate the elementary processes of the magnetic field annihilation in the energy release region of the solar flare (Arzner & Vlahos, 2004; Bastian, Benz, & Gary, 1998) while second fragmentation of the magnetic fields directly in radio source (Aschwanden & Benz, 1997; Fleishman, Gary, & Nita, 2003; Güdel, 1992). The solar flare and Corona Mass Ejections are usually accompanied by solar radio bursts and the signals are usually can be characterized by background levels of radiation upon which are superimposed bursts.

It is believed that the dominant radio emission mechanism during impulsive flares depends on the wavelength observed and local conditions in the flaring source. The solar flares and Corona Mass Ejections (CMEs) are usually accompanied by solar radio bursts and the signals are usually can be characterized by background levels of radiation upon which are superimposed bursts. As the largest scale eruptive phenomenon in the solar atmosphere, it can be observed as observed as enhanced brightness propagating out from coronal-loop-sized scale (104 km), expand to cover a significant part of the solar surface which is responsible for the most extreme space weather effects at Earth (Baker et al., 2008). Moreover, CMEs may frequently interact with the Earth (and other planets), producing a series of impacts on the terrestrial environment and the human high-tech activities (Pulkkinen, 2007; Schwenn, 2006).

Further observations indicate that CMEs can also be observed in other wavelengths, such as soft X-rays (Nat Gopalswamy, 2006; Rust & Webb, 1977), extreme ultra-violet (EUV, (Chen, 2011), radio (Kundu, 2002) and so on (Hudson & Cliver, 2001). Variation of radio signal fading events caused by ionospheric absorption should be studied for clearer picture because maximum flares can produce streams of highly energetic particles a solar proton event which can impact the Earth's magnetosphere and performance of radio-communication systems and strongly influences the local space weather in the vicinity of the Earth. Unfortunately, until now, how this energy is liberated into the solar atmosphere is not well understood, but its effect includes the rapid acceleration of charged particles. Melrose (1997) has proposed a model for solar flare for estimating the magnetic energy release that results from reconnection between current-carrying magnetic flux loops.

These dynamical activities can be proven through long term observations. However, like the other astronomical studies, it faces more and more difficulties because of man-made emissions, especially because solar spectral events occur over several decades of frequency A detailed analysis of variation of radio signal fading events caused by ionospheric absorption should be studied for clearer picture because maximum flares can produce streams of highly energetic particles a solar proton event which can impact the Earth's magnetosphere and performance of radio-communication systems and strongly influences the local space weather in the vicinity of the Earth.

The major concern of the possible effect of space weather will be primarily on its impact on telecommunications, navigation of satellites, electricity supply networks, aviation industries and spacecraft operations. As the cycle of the Sun is towards to the new cycle of solar maximum, the eruption mechanism of coronal mass ejections (CMEs) is currently an extremely active area of research.

Due to the large scale eruptive phenomenon in the solar atmosphere, they were verified to be the major driver of the disastrous space weather environment. While there is a consensus that coronal mass ejections (CMEs) are the drivers of interplanetary shocks (N Gopalswamy et al., 2008), the origin of coronal shock waves is not completely understood. Not only that, investigations on them and their relations with all other accompanied phenomena, such as solar flares, filament eruptions, radio bursts, and particle accelerations are also involved. Previous study also focused on the properties of CMEs such as occurrence rates, kinetic energy, the locations relative to the solar disk, angular widths, speeds and accelerations, masses, and energies.

There have been many studies on the statistical properties of CMEs since their discovery based on SOHO/LASCO observations. In general, this work is purposely for monitoring a space weather event or solar activity observations specifically the radio flux observation of solar flares and solar bursts are caused coherently by electron beam, shocks, possibly trapped electrons, and high-frequency waves in the plasma

This paper contains two (2) analyses that address (i) the role of solar monitoring in Malaysia and comparison with other sites and (ii) significant data solar radio burst type II and III due to Coronal Mass Ejections (CMEs) and solar flare events within (5) years. CALLISTO network will be discussed in section 2, while the role of Malaysia as an important site of this network will be explained in the following section. Discussion and conclusions are presented in section 4.

CALLISTO NETWORK

With higher temporal resolution, radio instrument with a complex interrelated analysis could provide a better data concerning small and short scale physical processes as well as the main properties of the area involved (Aschwanden & Benz, 1997; Fleishman et al., 2003; Messmer, Benz, & Monstein, 1999; Willes & Robinson, 1996). Compact Astronomical Low-cost Low-frequency Instrument for Spectroscopy in Transportable Observatories (CALLISTO) spectrometer is designing and leading by Christian Monstein and Radio and Plasma Physics Group from ETH Zurich, Switzerland is used to understand the pattern of solar activities such as solar flare and Coronal Mass Ejections. It is hoped that with the collaboration of research we could possible to make a model of each type of solar burst. Figure 1 to Figure 5 show 25 sites of this network research.

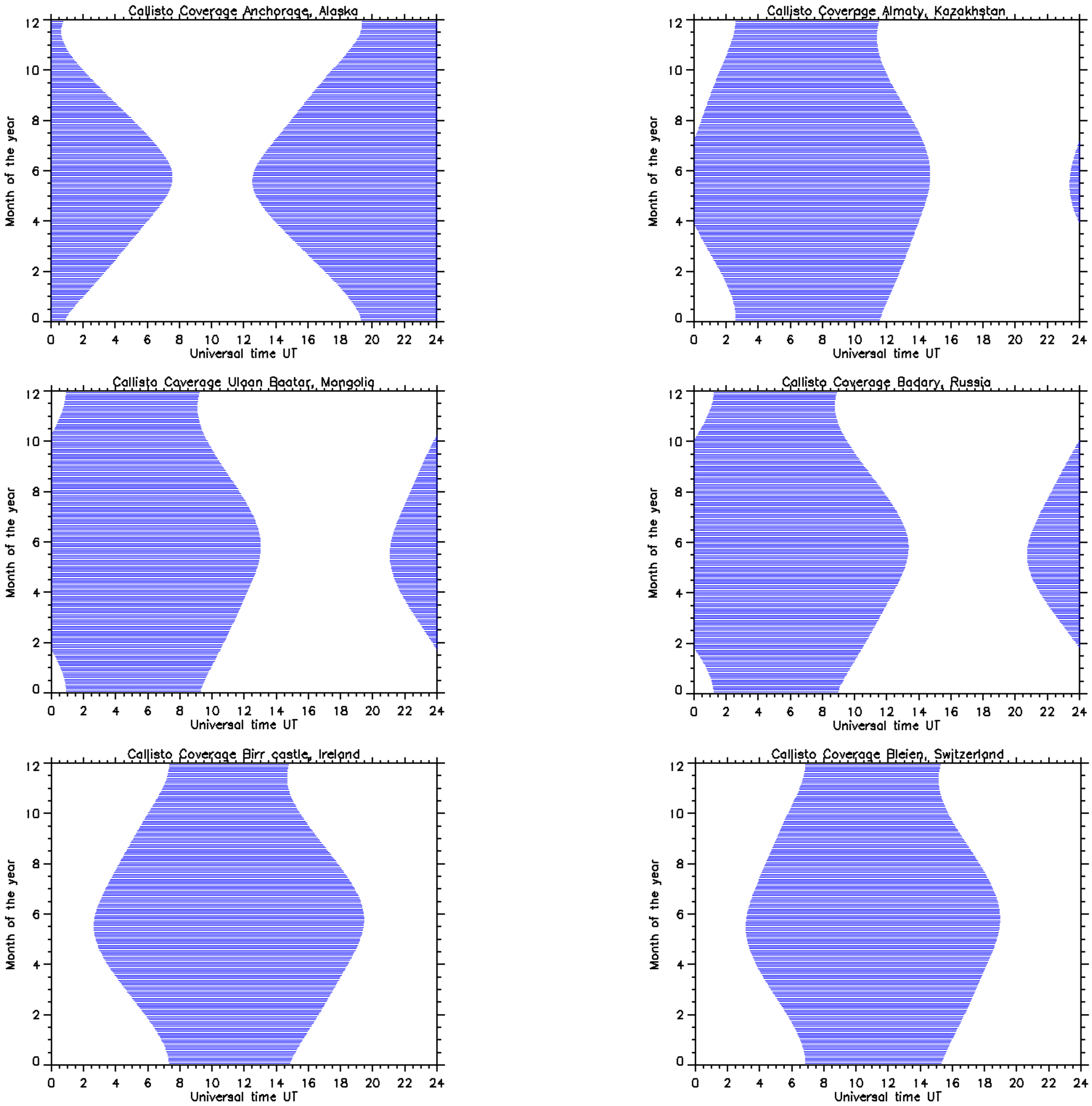


Figure.1 Coverage of solar monitoring of e-CALLISTO network (i) Anchorage, Alaska (ii) Almaty, Kazakhstan (iii) Baatar, Mongolia (iv) Badary, Russia (v) Birr Castle, Ireland (vi) Bleien, Switzerland

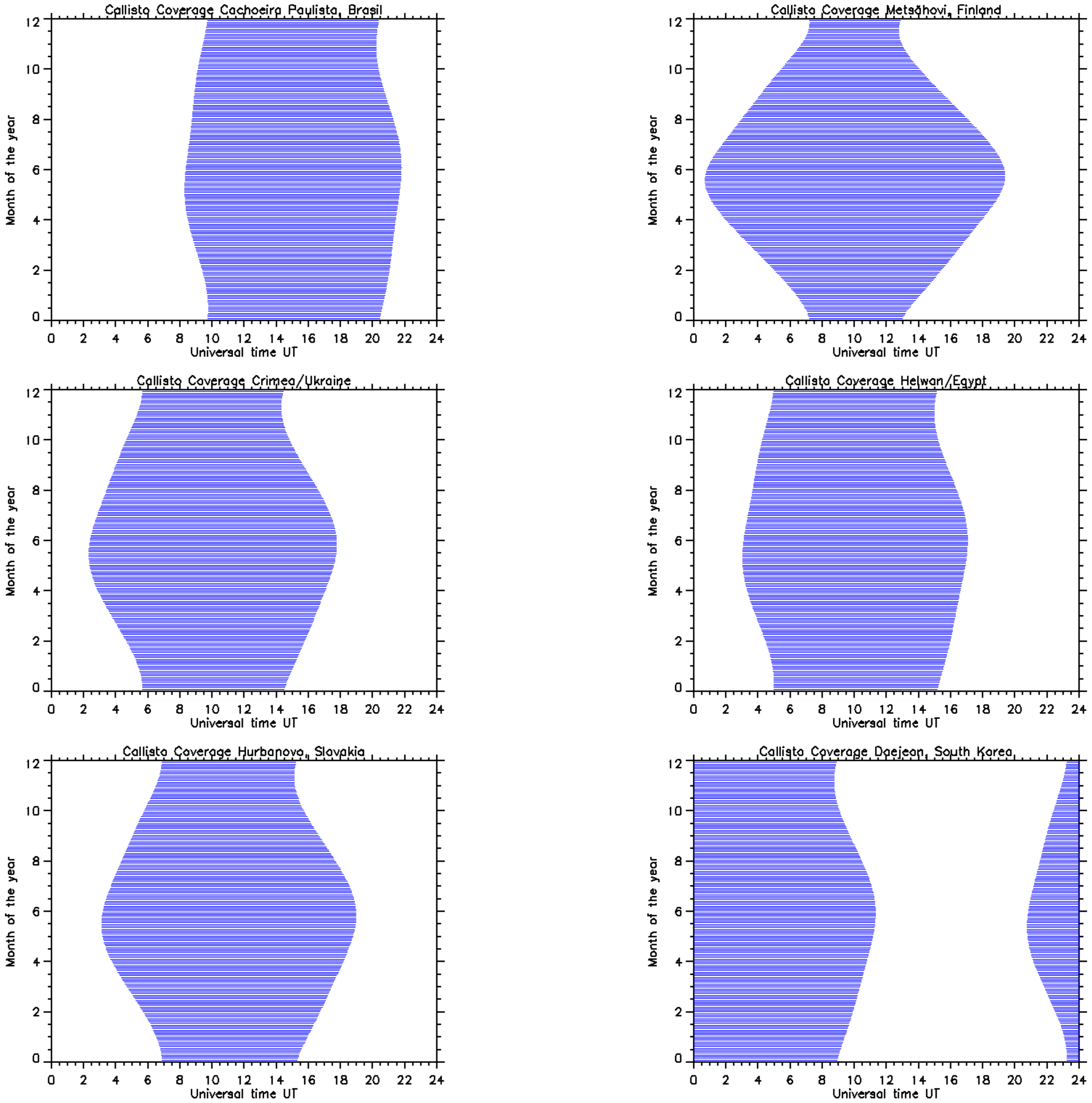
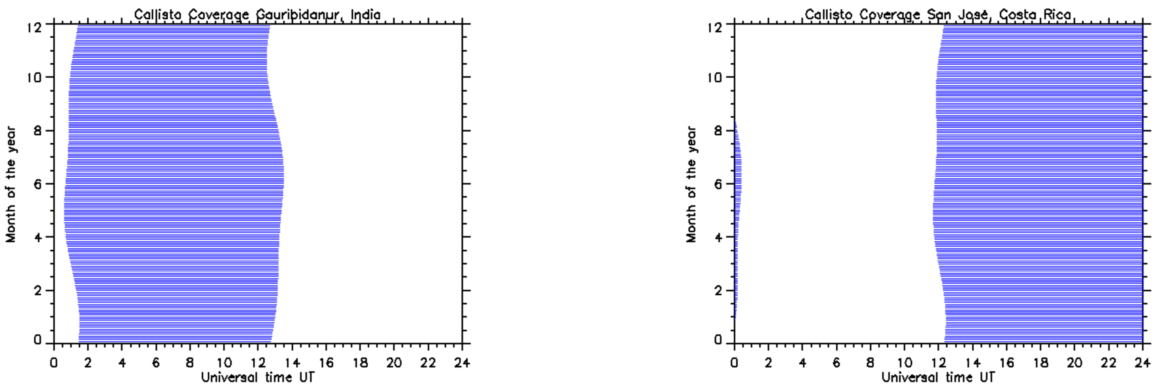


Figure.2 Coverage of solar monitoring of e-CALLISTO network (i) Cachoeira Paulista Brazil (ii) Methodhovi, Finland (iii) Crimea, Ukraine (iv) Helwan, Egypt (v) Hurbanovo, Slovakia (vi) Daejeon, South Korea



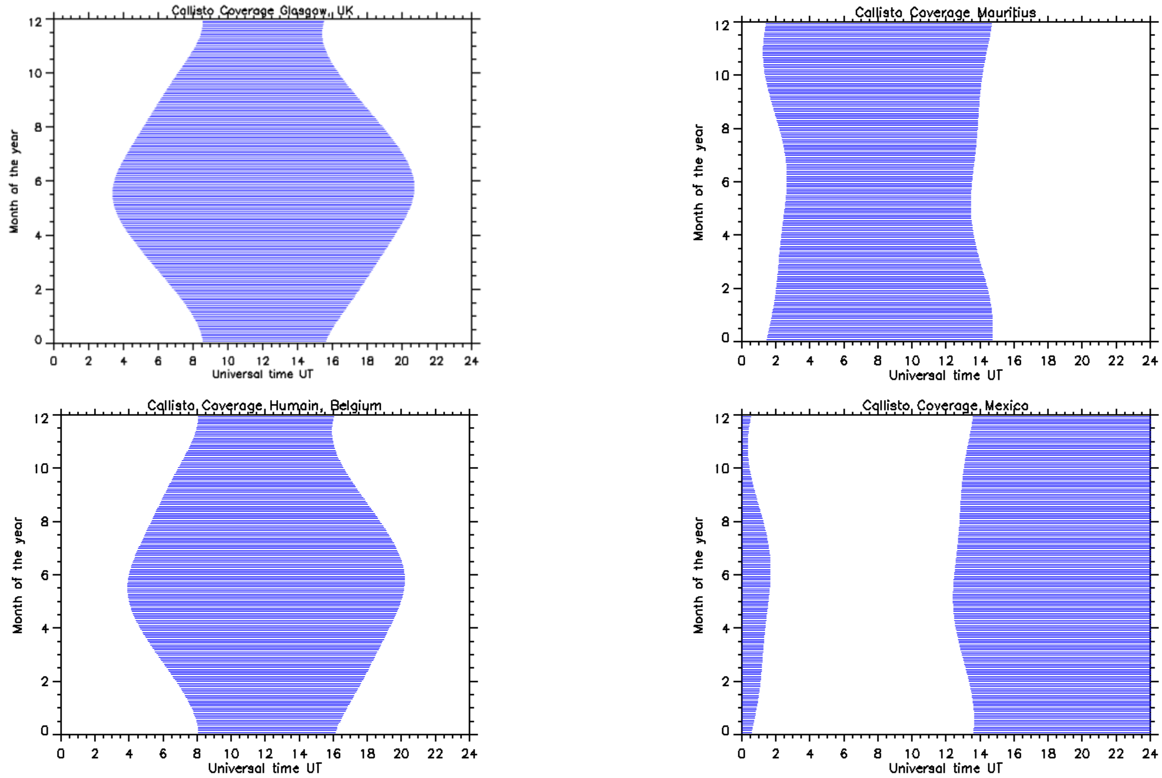
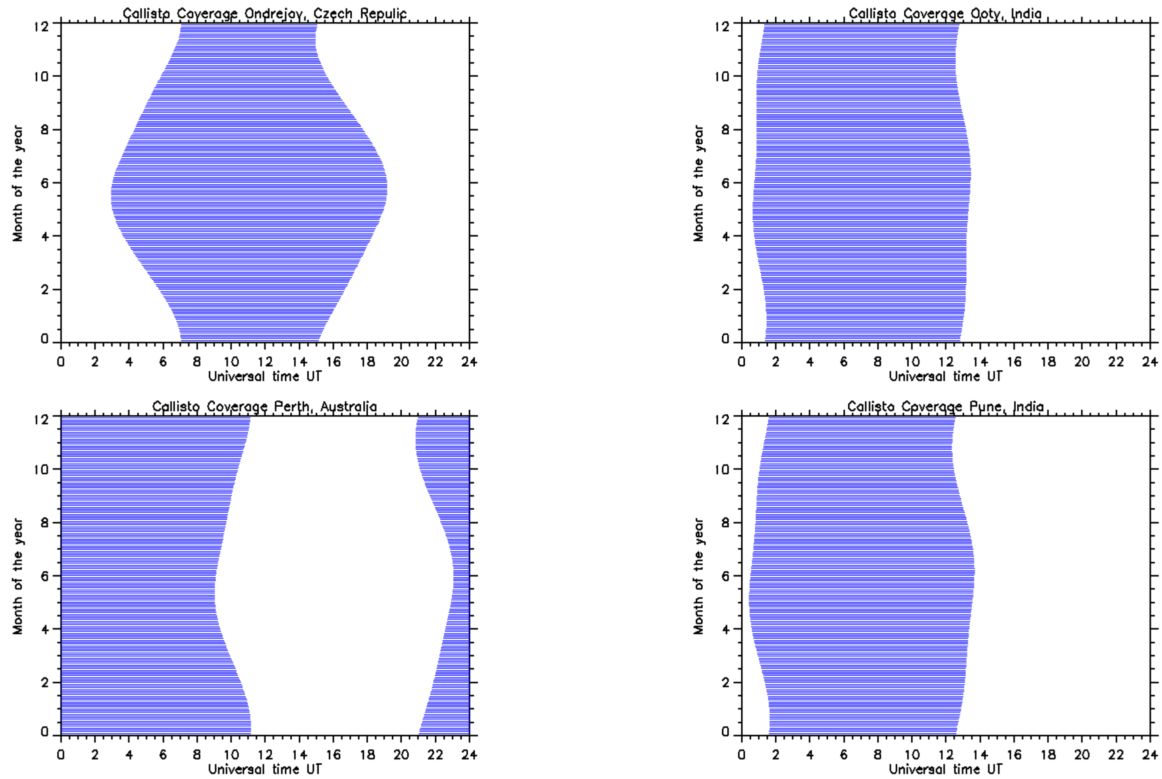


Figure.3 Coverage of solar monitoring of e-CALLISTO network (i) Gauribidanur, India (ii) San Jose, Costa Rica (iii) Glasgow, UK (iv) Mauritius (v) Humain, Belgium (vi) Mexico



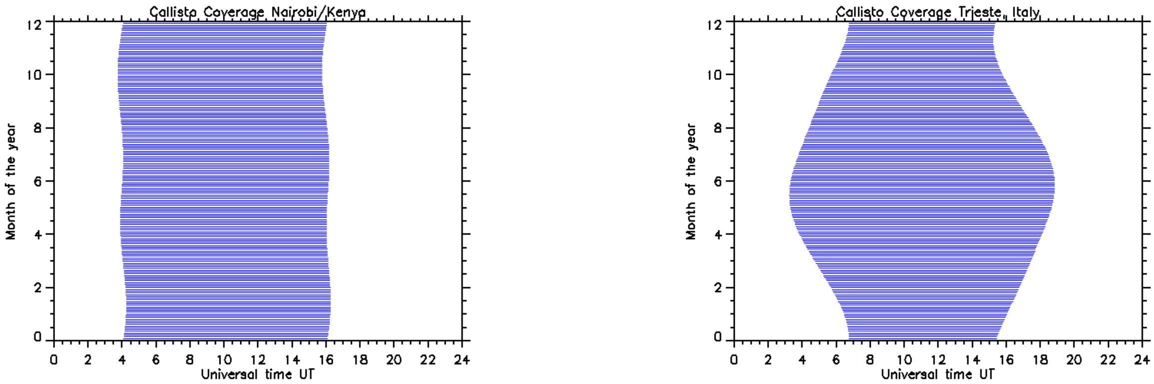


Figure.4 Coverage of solar monitoring of e-CALLISTO network (i) Ondrejov, Czech Republic (ii) Ooty, India (iii) Perth, Australia (iv) Pune, India (v) Nairobi, Kenya (vi) Trieste, Italy

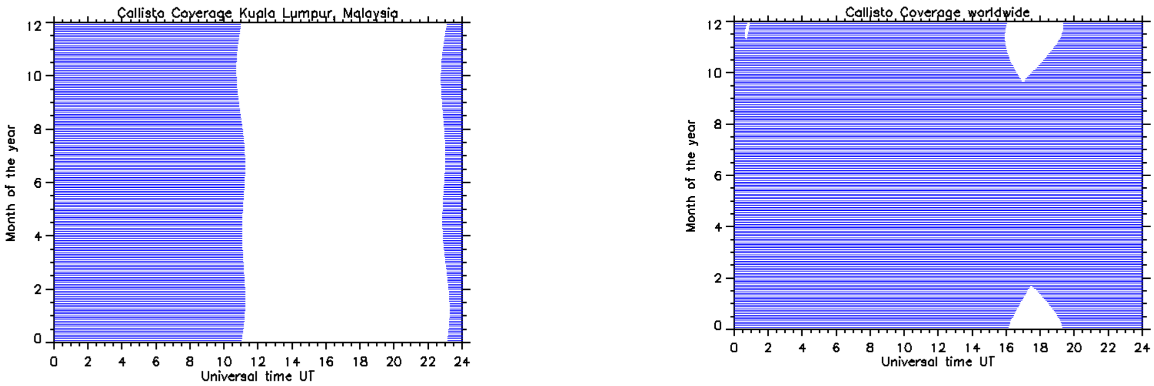


Figure.5 Coverage of solar monitoring of e-CALLISTO network (i) Kuala Lumpur, Malaysia (ii) Overall sites of e-CALLISTO

The role of Malaysia as an important site of solar monitoring: Located at 2º30´ North of the equator and longitude 112º30´East, our system has start operated since 22nd February 2012 (Hamidi, Abidin, Ibrahim, Monstein, & Shariff, 2012). Currently, there are 25 sites that are confirmed to obtain a daily data from CALLISTO network. In this section, we will report the current status of the space weather program in Malaysia. Although this project has started since 2007, we believed that it is still not too late to participate the e-CALLISTO network. This system has been set up of the at National Space Centre, Banting Selangor. We also possible to get a very nice data to be analyze in detail (Hamidi et al.). One of the significant advantages is that our site, Malaysia almost covered fifty percent of the CALLISTO data. A routine daily observations beginning from 1130 UT till 730 UT make our data should be reliable and consistent (Hamidi, Shariff, Abidin, Ibrahim, & Monstein, 2012). This is very important especially we are the second earliest site that can observe the Sun after ALASKA. Moreover, our site as one of an equatorial site will possible to obtain a different perspective in terms of the variability of the Sun's signal. Due to that factor, therefore the potential to observe solar activities especially solar flare and Coronal Mass Ejection (CMEs) also becomes very possible. Figure 6 shows the overall distribution of the CALLISTO system over the world.

DISCUSSIONS AND CONCLUSION

Radio observation of the Sun is still relevant and possible to understand the dynamics of solar activities until now. The e-CALLISTO network is one of the most outstanding project under the International Space Weather Initiative (ISWI) that possible to encourage an international research collaboration regarding space weather issue. This is very important seems we need to monitor a continuously Sun's activity for a long term purpose. It should be noted that Sun has a very close connection and impact of our space weather and climate changes. With this collaboration, one could possible to correlate the solar burst signal with the condition of the weather each site. Nevertheless, it was not the aim of this research to study on the impact of this phenomenon to the Earth critically, although we will make a general conclusion regarding the effect to the space weather.

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