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The Study of Radio Frequency Interference (RFI) in Altitude Effect on Radio Astronomy in Malaysia and Thailand

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Abstract: In radio astronomy, the radio spectrum is used to identify the weak emissions from the outer space sources and the other signal so-called Radio Frequency Inteference (RFI). It is a very important issue to address upon before we/anyone want to setup a radio astronomical facility. The different level of observation altitude is one of the factors that will effect to the RFI level or noise environment to as well as to the radio observation. This factor will be an for our database development and our modeling. There are three sites were selected for this study, i.e. Doi Inthanon National Park (Chiang Mai site), Pha Taem National Park, Ubon Ratchatani (Ubon site) and University of Malaya (UM site). Throughout this paper, the UM site will be used as a reference site. Since the RFI surveys are done for the study of Hydrogen lines in the range of (1400-1427)MHz, the spectra RFI in these windows is need to be carefully measured and monitored. We found that, the measured averaged RFI floor noise levels for the narrow band (1300-1500)MHz at three different sites, Ubon, Chiang Mai and UM sites are -97.4291 (±2.17) dBm, -96.6217 (±4.05) dBm, -97.0157 (±2.66) dBm, respectively. While for the wide band (1-2800)MHz, the measured averaged RFI floor noise are respectively, -97.5295 (±4.54) dBm, -93.5205 (±6.87) dBm and -97.9551(±5.03) dBm. Thus, in this paper, we report the areas with the lowest RFI from the altitude effect and recommended to be be the best location for the radio astronomical dish system in Thailand. We also discuss the possibilities of the planned science goals with the future radio telescope facility in Thailand.

Key words: Astronomy and Astrophysics · Radio Astronomy and Radio Frequency Interferences (RFI) · Altitude effect · Weak emissions

INTRODUCTION

In this paper, three (3) sites are chosen. Selected sites are Doi Inthanon National Park in Chiang Mai (CM) and Pha Taem National Park in Ubon Ratchatani (UR) and University of Malaya (UM) as a reference site and with different altitude values (I) 150m, (ii) 1100m and (iii) 106m representatively. Both of sites are located in Thailand. The University of Malaya site was used as the reference site. These locations are chosen as it possible for the future to be site of first radio telescope in Thailand. In this study, our attention focused on the frequency windows of 1300MHz to 1500MHz which is corresponds to the L-Band, Continuum Observations and Line Observation. Base on the International Astronomical Union (IAU), this window is important because the spectral lines

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Table 1: Selected RFI survey sites

Sites	Alt. (m)	Latitude/ Longitude	Pop. Density (peoples /km^2)	Criteria
UR	150	105°27' 37.8" E/ 15°22' 34.5''N	110	Surrounded by trees, near to the river and low population density. 100 km from city
CM	1100	98°32. 92.5' E/ 18°29.288' N	91.5	Shielded by mountain range, very low population density 150 km from city.
UM	109	101°39.445" E/ 03°0.443''N	7000	Near Kuala Lumpur city, crowded with peoples and very high population.

(hydrogen line) are at rest frequencies 1420.405752 MHz. These frequencies are listed by the IAU as important astrophysical windows in the radio frequency [1, 2]. The spectra of radio frequency interference (RFI) in these bands were carefully measured and monitored. The main RFI sources were also identified.

Radio Frequency Interference (RFI): An RFI is an increasing problem nowadays, with the ever expanding use of the radio spectrum by both the radio astronomer (receiving) and the communications industry (transmitting) [1, 2]. In order to establish any radio astronomical observation, it is important to initially identify all the possible RFI in the targeted site. RFI of selected sites are very important to avoid the disturbance in radio astronomy observation. In our case, the purpose of doing so was to find out if there was only influenced from other means that have been included in the measurements of those orientation distributions of the samples [8]. This will helps us to appreciate what questions we might hope to answer by analyzing the frequencies [8]. A wide range of RFI was infected radio astronomical observation. Currently, the astronomers as well as engineers are facing unprecedented challenges as they try to answer several problem of RFI mitigation. Human-made RFI are still one of the main threats in the selection of suitable sites for radio astronomy observation and the installation of new radio telescopes sources. For instance, the Global System for Mobile Communications (GSM) networks, meaning frequency dispute to radio astronomy observation [6]. Meanwhile, other transmitters concerns are radio broadcast emissions, analog and digital television broadcast emissions, aeronautical communications – mainly along air corridors and airports, satellite communications (communications, meteorological and GPS) and amateur radio services also will affected the observations [1, 2]. The transmitters may either mobile or stationary and they maybe on the ground, airborne, in orbit or in deep of space. As a result for radio astronomy observation, one solution is by doing observation far away from human activities or residents. We as astronomers have an educational role in making others active radio spectrum users as well as the general public to aware of the high sensitivity of radio telescopes and the consequent need for protection of the Radio Astronomy Service [1, 2].

Altitude Effect: In this paper, three (3) sites are chosen (Table 1) with different topology (altitude). Here, we reported how the altitude will effect on RFI value. This RFI is an increasing problem for radio astronomers due to the spread of, electronic devices (mobile phone, smart phone etc), microwave oven, digital radio and television transmission and the like. It is corresponding to the same problem of light pollution faced in optical astronomy. Highest places (high altitude) possible a factor contribute to this RFI where as may receive a higher noise for examples, easy exposed to the transmitters such mobile phone, radio or television broadcast, aeronautical communications and airports, satellite communications transmitter (GPS). However, the others problem could contribute to the radio astronomical observation supposed to be built in the remote area (low density population) to make sure RFI-free site area or we call radio quite zone.

Experiment: In order to measure the RFI, we use several instrument such as discone antenna 1420MHz (Figure 1) that is connected to a low noise amplifier (LNA) a 3GHz spectrum analyzer using coaxial cables. Antenna is crucial part in this RFI study because it receives the signal from surrounding area. Observations of the RFI are taken in an interval of 15 minutes. Survey was done at every site covering the wide bands for a 24-hours [3-5]. This is done to see how the RFI vary over a long stretch of time. The results for both sites with different in altitude, as shown on Table 1. The measured RFI value at chosen sites is compare to each other to determine which site has lowest RFI.

The result showed that the signals from the chosen potential sites. According to the result in wide band range (1-2.8MHz), the lowest RFI for among the both sites in Thailand taken is located at UR site with average signals of -97.5295 (±6.87) dBm (Figure 2), this site located at middle of the forest reserve land (Pha Taem National Park). While the others site is Chiang Mai (CM) with

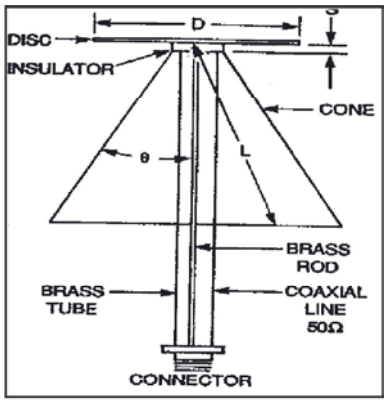

Fig. 1: The diagram and specification used in making the antenna

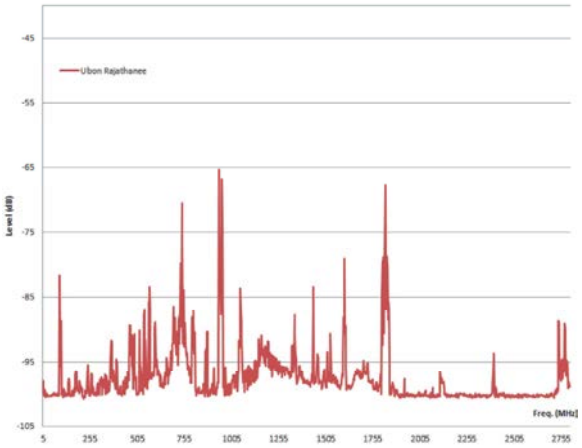

Fig. 2: Average RFI for 1-2800MHz in Ubon Ratchatani (UR)

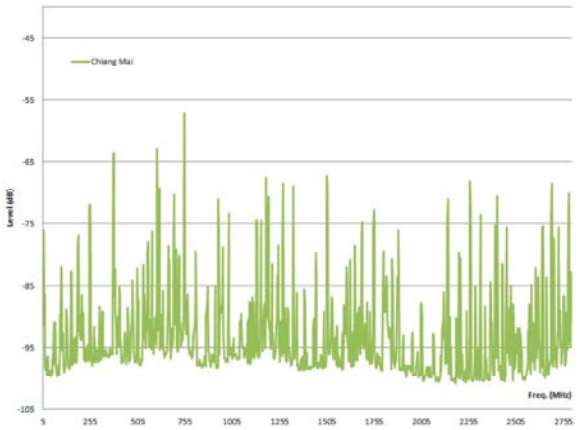

Fig. 3: Average RFI for 1-2800MHz in Chiang Mai (CM)

RFI value is -93.5205 (±6.87) dBm (Figure 3), it located on the mountain (Doi Ithanon National Park) which is 1100 m above sea level, hence the very high in RFI level. For comparison in Malaysia site's which is UM is -97.9551

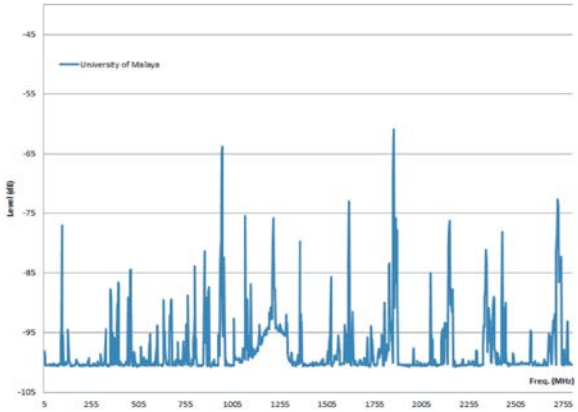

Fig. 4: Average RFI for 1-2800MHz in University of Malaya (UM)

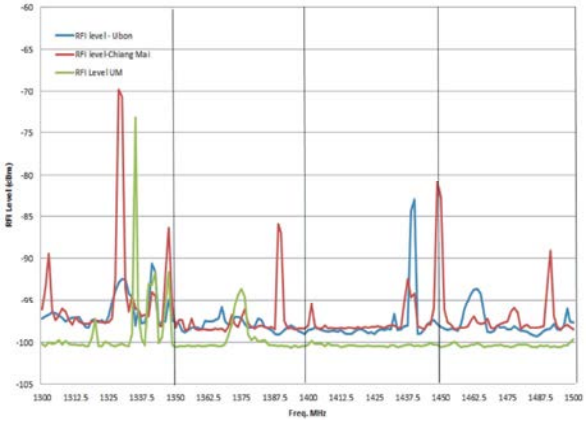

Fig. 5: RFI spectra at three sites for narrow band (1.3-1.5GHz)

Table 2: Average RFI survey for selected sites

Sites	Altd. (m)	Averaged RFI (dBm) for wide band	Averaged RFI (dBm) for narrow band
UR	150	-97.5295 (±4.54)	-97.4291 (±2.17)
CM	1100	-93.5205 (±6.87)	-96.6217 (±4.05)
UM	109	-97.9551 (±5.03)	-97.0157 (±2.66)

(±5.03) dBm (Figure 3). It located in the center of Kuala Lumpur. However in the narrow band range (1.3-1.5GHz), Figure 5 shows the best site for the hydrogen line (HI) study also at the same site with RFI value is -97.4291 (±2.17). While Chiang Mai (CM) and University of Malaya (UM) sites have RFI value are -96.6217 (±4.05) dBm and -97.0157 (±2.66) dBm representatively.

CONCLUSIONS

Figure 6 shows the detail comparison made between all the selected sites. From the all spectra we can conclude

Table 3: Malaysian, Thailand and ITU allocation radio astronomy windows for 1-2800MHz

No	Frequency (MHz)	MCMC allocation	NBTC/ITU allocation	Purpose
1	13.36–13.41	Fixed, *radio astronomy*	Fixed, *radio astronomy*	Solar observation
2	25.55–25.67	Exclusively for *radio astronomy*	Exclusively for *radio astronomy*	Jupiter observation
3	37.50–38.25	Fixed, mobile, *radio astronomy*	Fixed, mobile, *radio astronomy*	Continuum observation
4	73.00–74.60	Exclusive use for Government of Malaysia	*radio astronomy*	Solar wind observation
5	150.05–53.00	Fixed, mobile	Fixed, mobile, *radio astronomy*	Pulsar observation Deuterium observation
6	322.00–28.65	Fixed, mobile, Government Malaysia, *radio astronomy*	Fixed, mobile, *radio astronomy*	Deuterium observations, continuum observation and VLBI
7	406.00–10.00	Fixed, mobile, *radio astronomy*	Fixed, mobile, *radio astronomy*	Pulsar observation
8	1400.00–27.00	Earth exploration – satellite (passive), space research (passive), *radio astronomy*	Earth exploration – satellite (passive), space research (passive), *radio astronomy*	Hydrogen- line observation

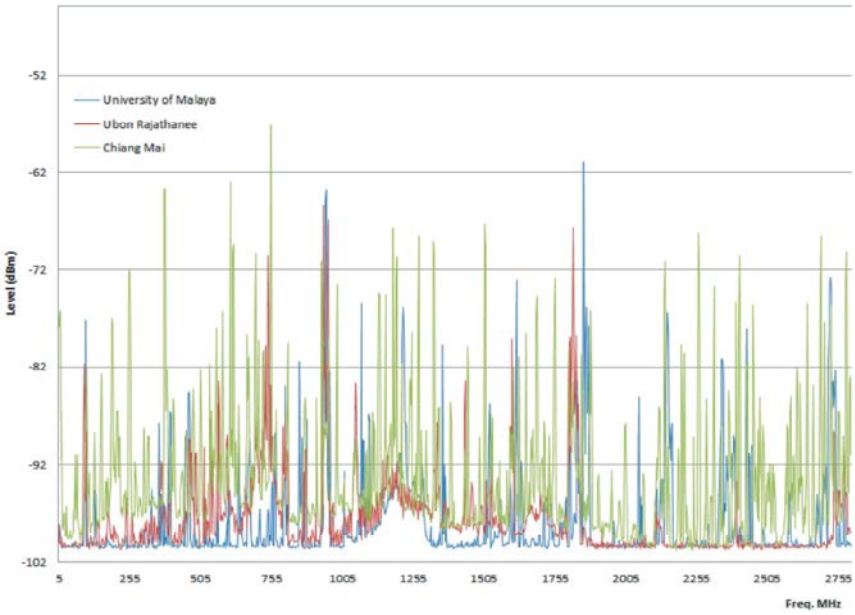

Fig. 6 : RFI spectra at all selected sites for (1-2800) MHz

that the CM site is relatively having a strong RFI compared to both sites Chiang Mai (CM) and University of Malaya (UM).

Referring to the frequency table from MCMC, here we state the Malaysian allocation compared to the National Broadcasting and Telecommunication Commission (NBTC) and International Telecommunication Union (ITU) allocation for eight (8) radio astronomy windows (Table 3) [6, 7]. It is different with NBTC and ITU, it only two (2) windows are exclusively reserved for radio astronomical purpose in Malaysia. Those two windows are in the range 25.5-25.67 MHz for Jupiter observation and the range (1400-1427) MHz for hydrogen line study.

In the future, we may consider the new parameters and different sites as well more sites in Thailand to find an appropriate location with RFI-free site in order to identify best place to locate first Radio Telescope in Thailand. New technique such *Kurtosis* method can be one of the solution in the future to detect free-RFI sites. We also conclude that in order to establish a radio telescope for the future, the site population density, transmitter location, road network, elevation and land uses need to carefully study.

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