

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

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Abstract: Radio astronomy uses the radio spectrum to identify weak emissions from outer space sources and the others signal so-called Radio Frequency Interference (RFI). It is a very important issue to address in order to setup a radio astronomical facility. Different altitude of observation for example will effect on RFI level or noise environment to radio astronomy. In this paper, we report the initial testing of the usage of this system in order to classify the areas with the lowest RFI. The important parameter used to develop the database for our modeling is information on elevation or altitude. Three selected sites were Doi Inthanon National Park (Chiang Mai site), Pha Taem National Park, Ubon Ratchatani (Ubon site) and University of Malaya (UM site). University of Malaya site was use as a reference site. The RFI surveys are done to study Hydrogen lines (1400-1427MHz). The spectra RFI in these windows was carefully measured and monitored. In this paper, we report the initial testing of the usage of this system in order to classify the areas with the lowest RFI. The measured averaged RFI floor noise levels for Ubon, Chiang Mai and UM sites are -97.4291 (± 2.17) dBm, -96.6217 (± 4.05) dBm, -97.0157 (± 2.66) dBm for the narrow band (1300-1500MHz) and -97.5295 (± 4.54) dBm, -93.5205 (± 6.87) dBm, -97.9551 (± 5.03) for wide band (1MHz-2800MHz). Our target is to locate the best location for the purpose of building a radio astronomical dish system in Thailand. In this paper, we will also discuss the possibilities of the planned science goals that can be done with the future radio telescope facility in Thailand.

Key words: Astronomy and Astrophysics • Radio Astronomy and Radio Frequency Interferences (RFI)

INTRODUCTION

In this paper, three 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 value are 150m, 1100m and 106m representatively. Both of sites 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 on the frequency windows of 1300 MHz 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 (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. Three sites were used for this investigation.

Radio Frequency Interference (RFI): 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]. 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. A wide range of RFI was infected radio astronomical observation. 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. Human-made RFI for example is Global System for Mobile Communications (GSM) networks, meaning frequency dispute to radio astronomy observation [6]. 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 [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 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 sites are chosen (Table 1) with different topology (altitude).In this paper 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-hour [3][4][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.

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.

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)

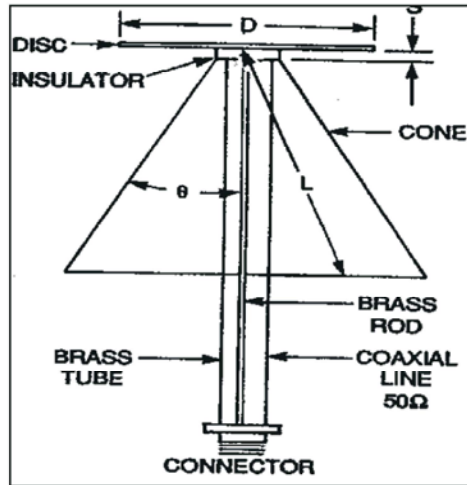


Fig. 1: The diagram and specification used in making the antenna.

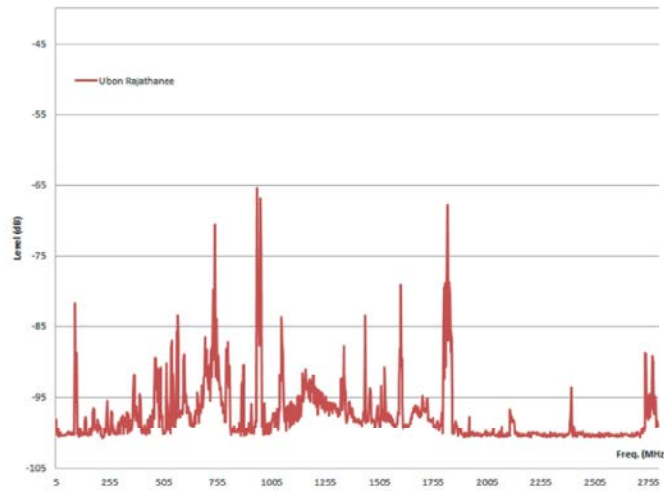


Fig. 2: Average RFI for 1-2800MHz in UR

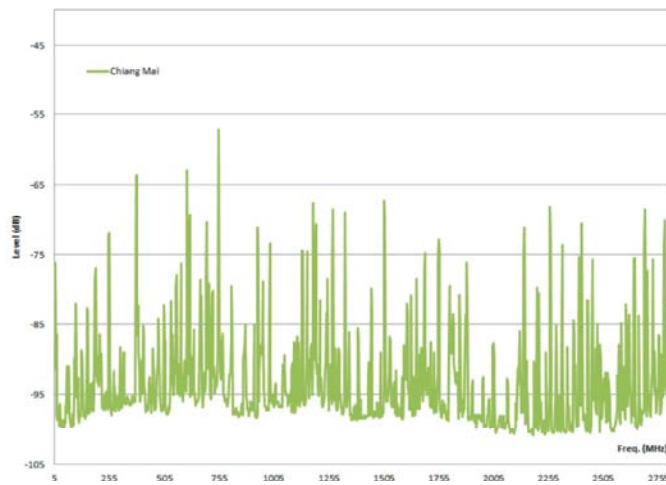


Fig. 3: Average RFI for 1-2800MHz in CM

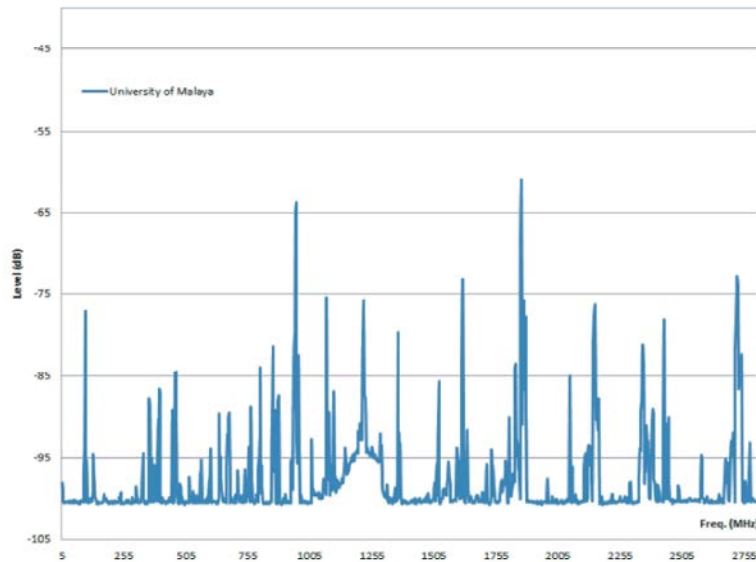


Fig. 4: Average RFI for 1-2800MHz in UM

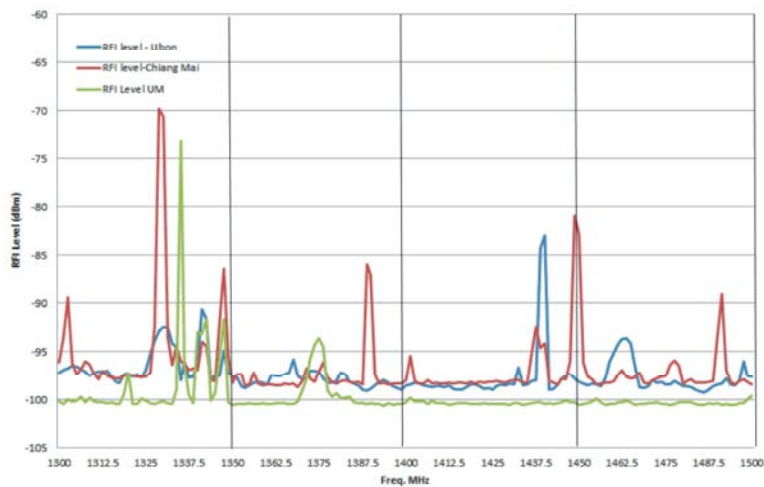


Fig. 5: RFI spectra at three sites for narrow band (1.3-1.5GHz)

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 $-97.5295 (\pm 6.87)$ dBm (Figure 2), this site located at middle of the forest reserve land (PhaTaem National Park). While the others site is CM with RFI value is $-93.5205 (\pm 6.87)$ dBm (Figure 3), it located on the mountain (Doilthanon 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 $-97.9551 (\pm 5.03)$ dBm (Figure 3). It located in the centre 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 $-97.4291 (\pm 2.17)$. While CM and UM sites have RFI value are $-96.6217 (\pm 4.05)$ dBm and $-97.0157 (\pm 2.66)$ dBm representatively.

CONCLUSION

Figure 6 shows the detail comparison made between all the selected sites. From the all spectra we can conclude that the CM site is relatively having a strong RFI compared to both sites CM and UM.

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, <i>radio astronomy</i>	Fixed, <i>radio astronomy</i>	Solar observation
2	25.55–25.67	Exclusively for <i>radio astronomy</i>	Exclusively for <i>radio astronomy</i>	Jupiter observation
3	37.50–38.25	Fixed, mobile, <i>radio astronomy</i>	Fixed, mobile, <i>radio astronomy</i>	Continuum observation
4	73.00–74.60	Exclusive use for Government of Malaysia	<i>radio astronomy</i>	Solar wind observation
5	150.05–53.00	Fixed, mobile	Fixed, mobile, <i>radio astronomy</i>	Pulsar observation Deuterium observation
6	322.00–28.65	Fixed, mobile, Government Malaysia, <i>radio astronomy</i>	Fixed, mobile, <i>radio astronomy</i>	Deuterium observations, continuum observation and VLBI
7	406.00–10.00	Fixed, mobile, <i>radio astronomy</i>	Fixed, mobile, <i>radio astronomy</i>	Pulsar observation
8	1400.00–27.00	Earth exploration – satellite (passive), <i>radio astronomy</i>	Earth exploration – satellite (passive), space research (passive), space research (passive), <i>radio astronomy</i>	Hydrogen- line observation

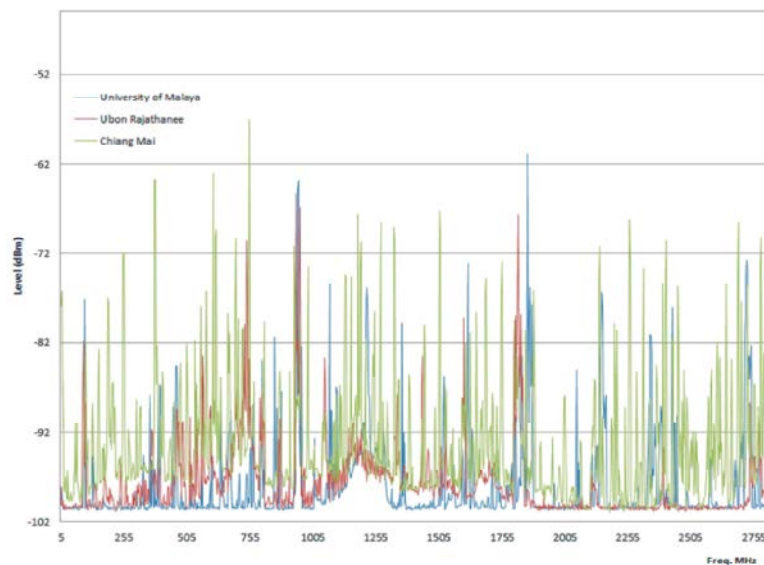


Fig. 6: RFI spectra at all selected sites for 1-2800MHz

Referring to the frequency table from MCMC, here we state Malaysian allocation compared to the National Broadcasting and Telecommunication Commission (NBTC) and International Telecommunication Union (ITU) allocation for eight radio astronomy windows (Table 3) [6][7]. It is different with NBTC and ITU, it only two 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 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 can be one 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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