Radio Frequency Interference Site Survey for Thai Radio Telescopes

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Abstract. Radio astronomical observations have increasingly been threaten by the march of today telecommunication and wireless technology. Performance of radio telescopes lies within the fact that astronomical sources are extremely weak. National Astronomy Research Institute of Thailand (NARIT) has initiated a 5-year project, known as the Radio Astronomy Network and Geodesy for Development (RANGD), which includes the establishment of 40-meter and 13-meter radio telescopes. Possible locations have been narrowed down to three candidates, situated in the Northern part of Thailand, where the atmosphere is sufficiently dry and suitable for 22 and 43 GHz observations. The Radio Frequency Interference (RFI) measurements were carried out with a DC spectrum analyzer and directional antennas at 1.5 meter above ground, from 20 MHz to 6 GHz with full azimuth coverage. The data from a 3-minute pointing were recorded for both horizontal and vertical polarizations, in maxhold and average modes. The results, for which we used to make preliminary site selection, show signals from typical broadcast and telecommunication services and aeronautics applications. The signal intensity varies accordingly to the presence of nearby population and topography of the region.

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1. Introduction

In addition to their specifications, environmental conditions are the key factors in determining the telescope's performance and therefore limit research topics of interest. The first key consideration is Radio Frequency Interference (RFI) from telecommunication and wireless technology, where the incident power can be more than 15 orders of magnitude stronger than brightest radio sources [1]. Strong interference may saturate the receiver system, where the system response is no longer in the linear regime, and therefore completely prohibit scientific observations. Weaker level of interference may instead degrade the quality and cause data loss. The Office of National Broadcasting and Telecommunications Commission of Thailand (NBTC) has entirely complied to Zone 3 International Telecommunication Union (ITU)'s spectrum allocation [2][3], where a number of spectrum windows have been assigned for radio astronomy observations. However, several preferred frequency bands indicated by ITU-R documentation [4] are not protected by ITU and NBTC.

In addition to RFI environment, at radio frequency more than ~10 GHz, atmospheric conditions become also important due to the resonance absorption of the rotational molecular bands of water (H_2O) at 22 GHz and Oxygen (O_2) at 60 and 119 GHz. More absorption lines can be found at higher frequency [1]. The water absorption line is the main reason for candidate locations to be located in the Northern Part of Thailand, where atmosphere is dry during winter time. The Oxygen absorption can only be mitigated by having a high altitude site.

National Astronomical Research Institute of Thailand (NARIT) has started the project called "Radio Astronomy Network and Geodesy for Development" (RANGD) in 2016 to expand the potential of science and technology development in the country. The main infrastructure consists of 40-meter and 13-meter radio telescopes, and advanced laboratories for engineering. Here, we focus on the frequency range from 20 MHz to ~115 GHz, which will be covered by both radio telescopes. Radio Frequency Interference (RFI) measurements have been conducted at the three candidate sites in 2016, described in Section 2, and the results and discussion are in Section 3.

2. Measurement

The equipment setup consists of R&S ZVL6 spectrum analyzer, R&S HE300 directional antenna (20 MHz to 7.5 GHz) and a low loss 2-feet RF cable. The settings are summarized in Table 1. The antenna was mounted on a rotator for azimuth scan automation. For each pointing, i.e. of polarization and of azimuth direction, the data were recorded in maxhold mode, where only the peak intensity were recorded, and average mode, where the values are averaged together. The two modes complement each other, that the maxhold mode has the advantage of detecting strong intermittent signal, while the average mode can detect weak persistent RFI.

ITU's documentation [5] defines the spectral flux density (SFD), $S(f)$, as in Equation (1) below, which is the relationship between the receiver gain and the antenna gain [5][6]:

$$S(f)[dBW/m^2/Hz] = P(f)[dBm] - G_{ant}(f)[dBi] - G_{LNA}(f)[dB] - 10\log(\Delta f_0)[kHz] + 10\log(f)[MHz] - 95.54 \quad (1)$$

, where f is the wave frequency, $P(f)$ is the power measured by the spectrum analyzer, G_{ant} is the antenna gain and the loss in the coaxial cables from the antenna to the analyzer, $G_{LNA}(f)$ is the gain of the pre-amplifier, which is zero for our case, and Δf_0 is the resolution bandwidth,.

Three locations have been chosen on the requirement to have good surrounding mountains for RFI shielding. Site A is located inside Mae Fha Luang University, Chiang Rai (latitude, longitude = 20.054522, 99.906697). Site B and C situate in Maejo, San Sai District (latitude, longitude = 18.946022, 99.063719), and Mae Dok Dang, Doi Saket (latitude, longitude = 18.919964, 99.191074), respectively, in Chiang Mai. The measurements were conducted in 2016 on February 8 (4h) for site B, and on February 18 (8h), March 10 (8h) and 24 (4h), and May 4 (4h) for site A, and on June 7 (4h), 13 (4h) and 29 (4h) for Site C, where x in (xh) indicates the number of observing time in hours.

Table 1. Measurement parameters.

Frequency Range	Resolution Bandwidth (kHz)	Sweep time (s)	Sweep counts (time)	Pointing time (s)	Antenna beam (Deg.)	Numbers of pointing	Session time (min)
20 – 200 MHz	3	20	5	100	45	8x2pol	26.7
200 – 500 MHz	3	33	5	165	45	8x2pol	44.0
0.5 – 6.0 GHz	10	54	3	162	30	12x2pol	64.8

3. Results and Discussion

The spectral flux density (SFD) is calculated with equation (1). The SFD plots, which include the data from all azimuth directions, from the three sites are shown in Figure 1 for maxhold mode, and in Figure 2 for average mode. Firstly, it appears that the noise floor in average mode is lower, hence has a better detection limit for persistence signal, than that in maxhold mode by approximately 10 dBW/m^2/Hz.

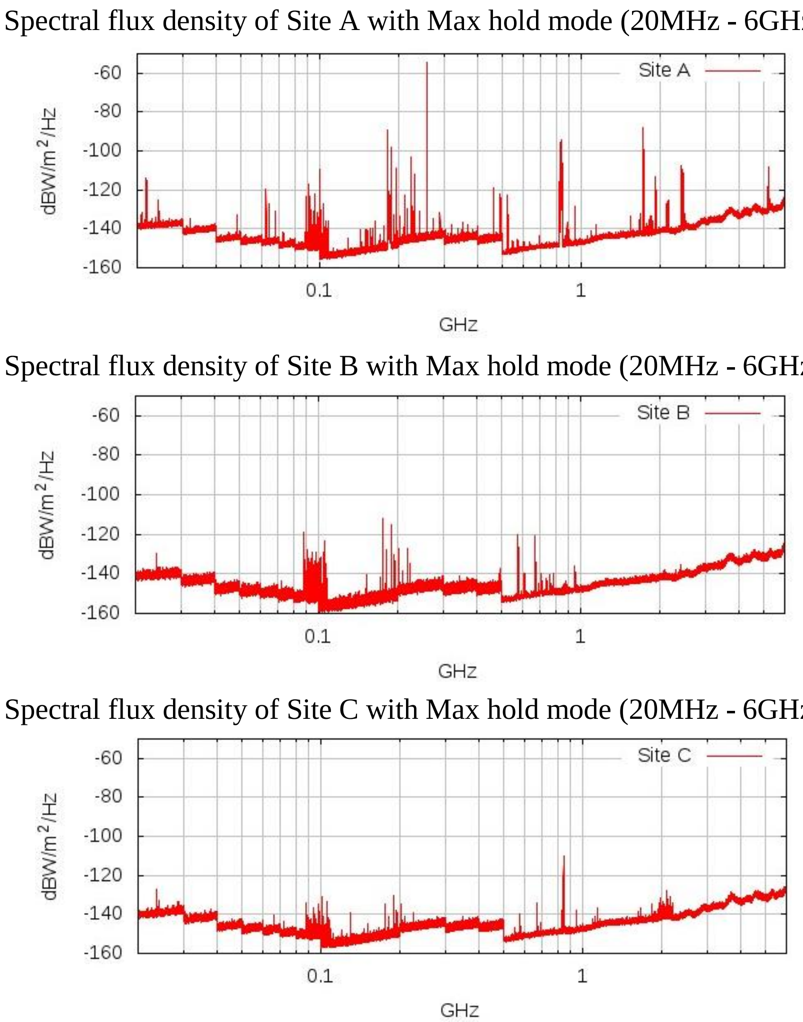

Figure 1. The SFD plots in the maxhold mode for Site A (top), Site B (middle) and Site C (bottom).

Typical broadcast and telecommunication emission, i.e. FM (87 - 108 MHz), TV (510 - 790 MHz), Mobile (870 - 960, 1,805 - 2,170 MHz) and Wi-Fi (2,306 - 2,481 MHz), are present at all sites, where Site A has the strongest and most polluted RFI environment. The level at Site B is slightly better than Site C for the observing window between ~1,000 – 1,800 MHz, which is for spectral line observations of HI (~1,420 MHz) and OH (1,600 - 1,700 MHz) and for pulsar observation. This window is normally allocated for aeronautical radar and communication (960 -1,400 MHz), and satellite applications (1,525 - 1,660 MHz). This means the ideal location should not be too closed to airports and takeoff-landing path, while the telescope location makes no difference with interference from Geo Stationary Orbit satellites. Site C appears to have best overall RFI conditions throughout the frequency range for both maxhold and average modes. And the fact that it is only thirty kilometers from NARIT head office makes it our best candidate. Although, the RFI detrimental threshold recommended in [5] (table 2) is approximately at -230 dBW/m^2/Hz, which is 80 dBW/m^2/Hz lower than our noise floor, it has been suggested that such limit assumes the condition that the RFI source is located in the main beam of the radio telescope. The ITU recommendation ITU-R RA.1513-2 clarifies that such case will cause only 2% data loss at 5-degree elevation [7]. More intensive RFI measurements at Site C have been planned in the near future.

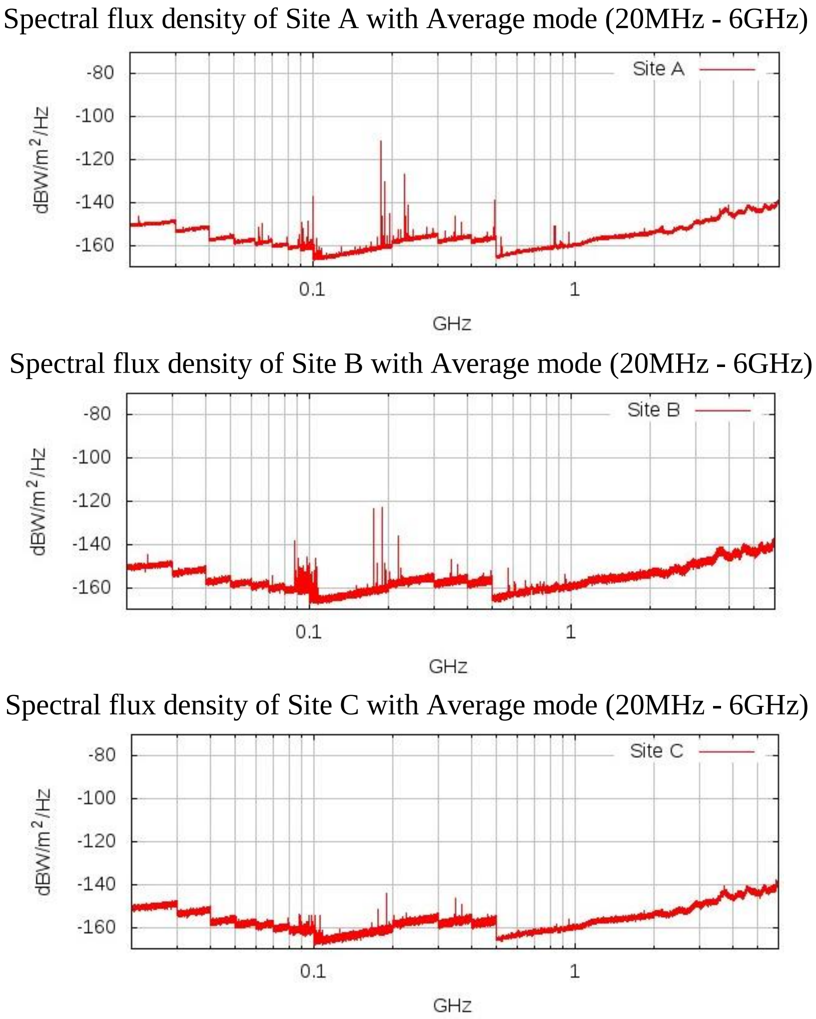

Figure 2. The SFD plots in the average mode for Site A (top), Site B (middle) and Site C (bottom).

References

1. Wilson, Thomas L (et al) *2003 Tools of Radio Astronomy (6th ed.)* (Springer: Berlin)
2. National Broadcasting and Telecommunication Commission of Thailand "http://www.nbtc.go.th"
3. International Telecommunication Union "http://www.itu.int"
4. ITU-R RA.314-10 2003 *Preferred frequency bands for radio astronomical measurements*
5. ITU-R RA.769-2 2003 *Protection criteria used for radio astronomical measurements*
6. S B Dunn 2008 *A study of the SA SKA RFI Measurement Systems* (University of Cape Town)
7. ITU-R RA.1513-2 2015 *Levels of data loss to radio astronomy observations and percentage-of-time criteria resulting from degradation by interference for frequency bands allocated to the radio astronomy service on a primary basis*