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PRELIMINARY STUDY OF RADIO ASTRONOMICAL LINES EFFECT OF RAIN BELOW 2.9 GHZ

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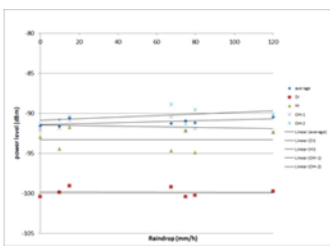
Graphical abstract



Abstract

An appropriate site selection for radio astronomy observation is very important in order to find a low level site in RFI value. The aim of this study is to select the best possible factors for astronomical observation sites. There are many factors such as slope, raindrop, river, population density, road network, land used, wireless telephone technology interrupts radio astronomy observation. In this study, we have reported one of the factors that affect radio observation which is rain effect. The site selection study is the most crucial part of decision makers proposes where to build an astronomical observatory, especially in radio astronomy with a maximum efficiency. The observation apparatus was set up to study the effect of rainfall and raindrop to the radio signal. We found that, in the inside observation, we found that spectral lines (Deuterium, Hydrogen, and two Hydroxyl lines) show that the rain gives no effect to radio signal in those windows. We also found that there is very small fluctuate value are very small (about -2 dB) for outside observation. It can be considered has no significant effect on rain below 2.9 GHz.

Keywords: Radio astronomy, site selection, rain effect, Radio frequency interference

Abstrak

Pemilihan tapak yang sesuai bagi kajian astronomi radio adalah sangat penting untuk memastikan tapak pilihan adalah mempunyai nilai RFI yang rendah. Tujuan kajian ini adalah untuk memilih faktor terbaik mungkin untuk dijadikan lokasi pemerhatian astronomi radio. Terdapat banyak faktor seperti kecerunan, kadar hujan, sungai, kepadatan penduduk, rangkaian jalan raya, guna tanah dan pencawang telefon tanpa wayar. Dalam kajian ini, kami telah melaporkan salah satu faktor yang mempengaruhi pemerhatian radio iaitu kesan hujan terhadap permerhatian radio. Kajian pemilihan lokasi yang sesuai adalah bahagian yang paling penting dalam membuat keputusan dan mencadangkan di mana lokasi sesuai membina sebuah balai cerap astronomi, terutama dalam bidang astronomi radio dengan kecekapan maksimum. Instrument untuk kajian ini telah dibina untuk mengkaji kesan hujan dan titisan hujan kepada isyarat radio yang diterima. Hasil kajian kami mendapati bahawa, garis spektrum (Deuterium, Hidrogen, dan dua spektrum Hidroksil) menunjukkan bahawa hujan tidak memberi kesan kepada isyarat radio dalam tetingkap tersebut. Kami juga mendapati bahawa terdapat nilai perbezaan sangat kecil yang sangat kecil (kira-kira -2 dB) untuk pemerhatian di luar. Kami membuat kesimpulan bahawa ia tidak mempunyai kesan yang signifikan ke atas factor kesan hujan di bawah 2.9 GHz.

Kata kunci: Astronomi radio, pemilihan tapak, kesan hujan, interferen frekuensi radio

1.0 INTRODUCTION

The condensed forms of water in the atmosphere can come in several sizes, which they are mostly scattered by visible light, but absorb over a broad range of infrared wavelengths. Water appears in the atmosphere in a variety of forms. Usually, it can be referred by the term of hydrometer, which includes particles as diverse as cloud, raindrops, snowflakes, ice crystals and hail [1]. Rainfall and raindrop are one of the important factors that affecting the propagation of the waves in the millimeter wave band [2].

Rain affects the transmission of an electromagnetic signal in three ways, such as attenuate the signal, increased the system noise temperature; and change the polarization. All these three mechanisms will degrade the signal quality [3]. At C- band the effect of rain is minor, while in the Ku-band the rain effect is significant. The effect of hydrometer on the radio astronomical observation system depends on the type of particle present [4].

The study of millimeter-wave propagation effect was done in 1956, in 35GHz band [4]. Radio waves attenuate due to rain was anticipated to be increased in severe frequency which is higher than 10 GHz [6]. Above of certain threshold of frequency, the excess of attenuate because of rainfall become one of the most important limitation of line-of-sight (LOS) microwave link [7]. This frequency threshold is approximately 10 GHz for temperate climate and in tropical climates or educational climate the effect of rainfall on radio link becomes more important as low as about 7 GHz. This happened because of a raindrop large in temperate [8].

A comparison one minute rain attenuate statistic at 32:6 GHz have made using several rain attenuation models such as ITU-R P.530-12, Synthetic storm Technique (SST) [8]. At 20 GHz for example the attenuation down to uniform rain rate at 100 mm/hour is about 10 dB/km. The radio is path defines as the volume of the Fresnel zone and the rain attenuation is assuring proportional to the number of raindrops in this path volume [9].

At frequency below 60 GHz, the attenuation caused by frozen particles such as snow or ice or ice crystal is very small and may neglected.

Thus, the knowledge of a raindrop effect on the frequency of operation is necessary, especially to choose or design a reliable telescope system at a particular location. The effect of raindrop below 3 GHz, especially on L-Band not thoroughly investigated since it well known that the rainfall effect of radio wave only at high frequency as above 5 GHz [10].

Recently, according by Meng in 2009 a study of VHF and UHF radio-wave propagation near the forests has been conducted. From the literature review, it shows that, the effects of rainfall on the forested still haven't thoroughly investigated [11].

In Malaysia the study radio frequencies for radio astronomical purposed was begins and conducts early 2005 in University of Malaya [12]. Radio astronomy window below 2.9 GHz very important to study, in order to understand how the signals attenuate by rain effect. Malaysia is a tropical country, which usually very hot and humid, especially in the major cities. Malaysia always has high humidity to its proximity to the equator and tropical status. It is a suitable area to study the radio penetration effect by rain. There are two types of observation that we have done, there are inside observation and outside observation.

2.0 EXPERIMENTAL

Another supported apparatus for this experiment are raindrop simulator and rain gauge. We had managed two types of observation: inside observation and outside observation. While raining, we placed the discone inside the building for inside observation. For outside observation, we put the discone in contact with different size of a raindrop.

To observe the RFI, Ambrosini reported that the discone antenna can be used for the SKA project to identify the low or high RFI [10]. The discone has a pattern which is uniform in azimuth, with a maximum gain slightly below the horizon and nulls toward the zenith and nadir [12]. These antennas are vertically polarized with uniform azimuthal directivity. The Discone antenna was used as a one solution in order to identify Figure 1 surrounding RFI near the observation site. Material for discone may be made from solid metal (normally we used copper) [12]

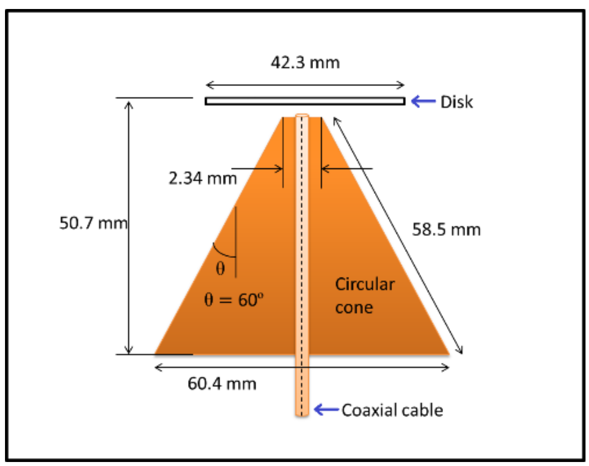


Figure 1 Dimension discone antenna used

Discone antenna is suitable for the VHF frequencies, such as applications that are used in the use internet and WIFI10. It optimizes also appropriate to assess RFI around 0-2800 MHz (the frequency of 1420 MHz). Values such as the diameter and radius in their discone form as shown in Figure 2. In this section, we attempted to characterize the profile with the effect of rain in frequency 0-2:8 GH. We suggested that rainfall is a very important factor and need to consider even for L-Band study. The objective of this study is to investigate the rainfall and the raindrop effect on radio astronomy observation in frequency 2.8 GHz, especially in four radio astronomy windows there are deuterium (D), hydrogen (HI) and two hydroxyl lines (OH-1 & OH-2) [10].

3.0 RESULTS AND DISCUSSION

The rain simulator was used to simulate various raindrop sizes. Table 1 shows the calculated drop shapes of 6 water drops whose volume value range from 0.5 mm to 5 mm. There are 6 types of rain drop are used in this study. Finally, we plot a graph to see RFI profile for both observation see an effect of rain to the observation as shown in Figure 2 to Figure 5. RFI level for both observations also listed in Table 1 and Table 2.

The spectra observed for both observation see an effect of rain to the observation as shown in Figure 2 to Figure 6. The rain attenuation effect is studied. There is no trend in all graphs plotted for both observations. Raindrop factor gives no effect to the radio signal for both observations (inside and outside). The size of a raindrop is not significant to frequency below 2.8 GHz. In order to see the correlation RFI and rain effect for inside observation, power level for the overall spectrum line were combined (Figure 7).

To see relationship between raindrop effect and RFI, spectra at various sizes of raindrop were obtained (Figures 8-13). There is no signal attenuation when the size of raindrop increased.

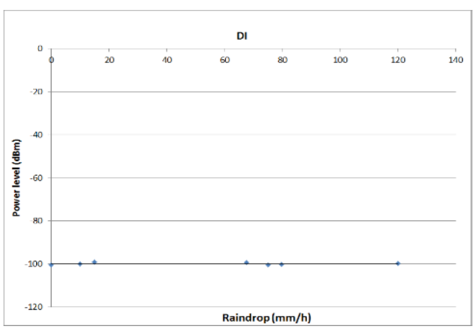


Figure 2 Rain effect for inside observation for deuterium line

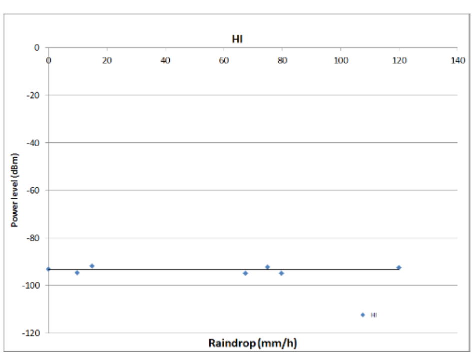


Figure 3 Rain effect for inside observation for hydrogen line

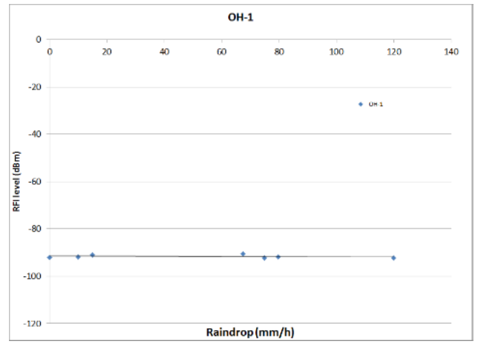


Figure 4 Rain effect for inside observation for hydroxyl-OH-1 line

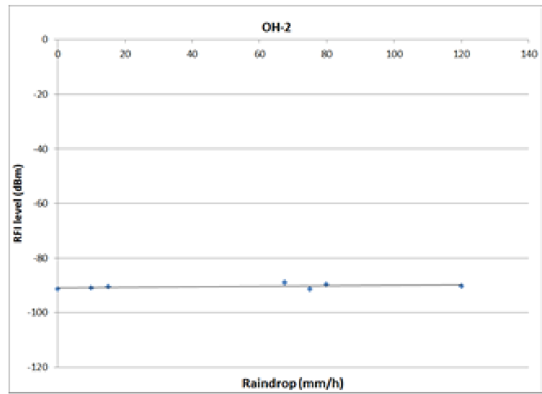


Figure 5 Rain effect for inside observation for hydroxyl-OH-2 line

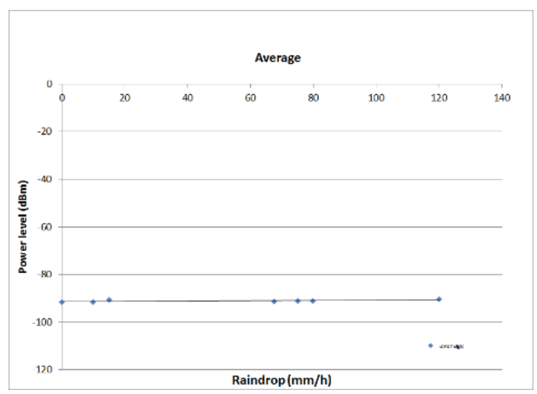


Figure 6 Average RFI for rain effect for inside observation

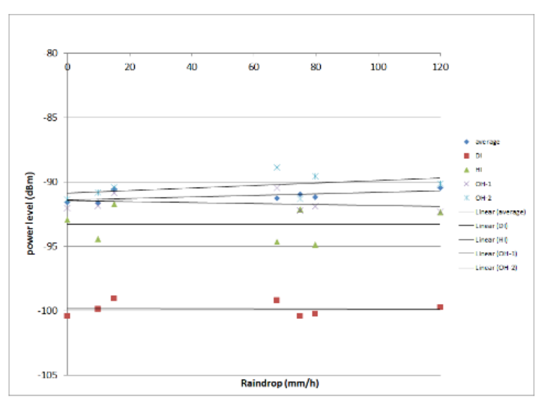


Figure 7 All spectrum lines for inside observation

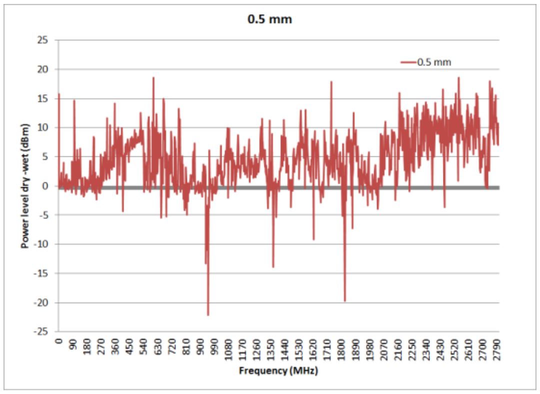


Figure 8 Rain effect for outside observation for various sizes of raindrop for 0.5 mm

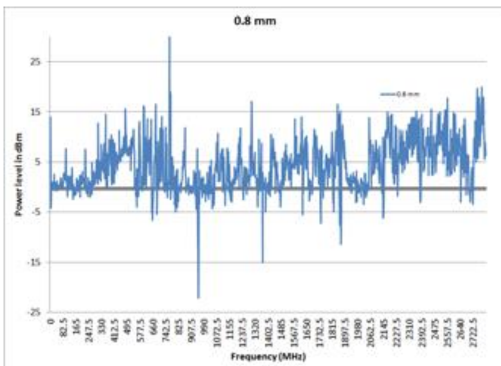


Figure 9 Rain effect for outside observation for various sizes of raindrop for 0.8 mm

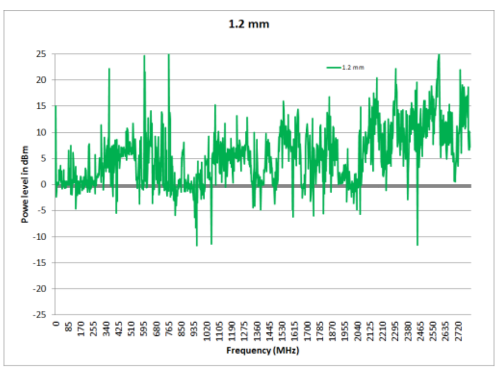


Figure 10 Rain effect for outside observation for various size of raindrop for 1.2 mm

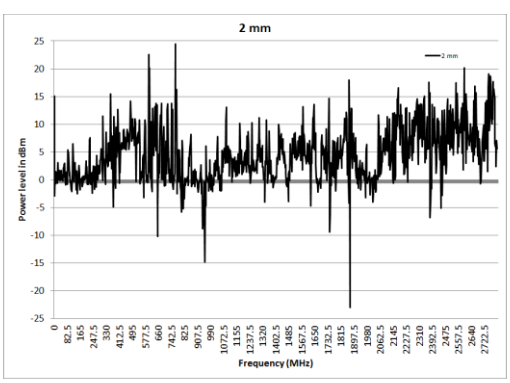


Figure 11 Rain effect for outside observation for various size of raindrop for 2 mm

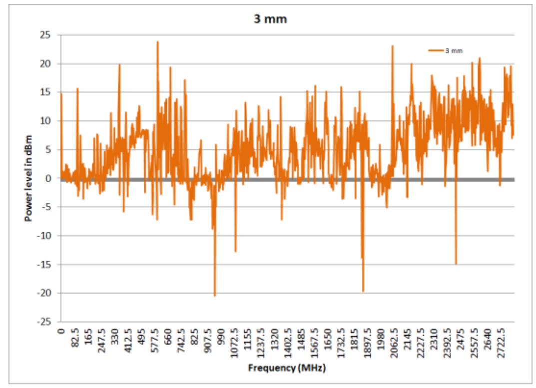


Figure 12 Rain effect for outside observation for various sizes of raindrop for 3 mm

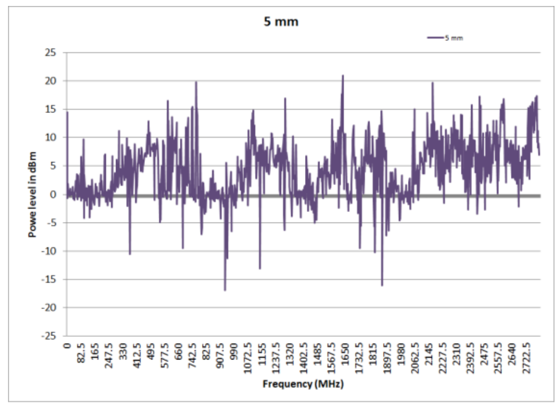


Figure 13 Rain effect for outside observation for various sizes of raindrop for 5 mm

Table 1 Power level of RFI for inside observation

Rainfall (mm/hr)	RFI Level (dBm)	Standard deviation (+/-)
0	-91.5	-3.8
9.9	-91.6	-3.6
15	-90.5	-3.7
67.5	-91.2	-4.1
79.8	-91.2	-4.2
120	-90.5	-3.9

Table 2 Power level of RFI for outside observation

Size of raindrop (mm)	RFI Level (dBm)	Standard deviation (+/-)
0.5	-91.8	-2.5
0.8	-91.9	-2.6
1.2	-91.2	-1.8
2	-92.9	-3.5
3	-89.2	-0.2
5	-92.4	-3.1

4.0 CONCLUSION

In the future, new equipment such as spectrum analyzer with higher frequency (more than 3 GHZ) is suggested to study the effect of rain to radio astronomy observation, especially for the high frequency. This study should be repeated in highest frequency to obtain the threshold level and compared to the ITU.

From this observation, to operate a radio observation, we should consider that amount of rain drop at selected site or may be should avoid sites which are having a maximum value of rainfall in order to reduce the effect on radio signal attenuation. In the future we should consider others parameters such as wind and thunder effect of radio wave propagation.

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