Northeast Monsoon Effect on Ultra High Frequency (UHF) Signal Attenuation at Kusza Observatory

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Abstract. Northeast (NE) monsoon season in Malaysia was developed due to conjunction with cold air outbreaks from Siberia produce heavy rains, strong wind, and high humidity. This weather condition can affect the radio signal transmission which is crucial to spectrum user. This work investigates the effect of the wet season due to Northeast season on radio signal power within Ultra High Frequency (UHF) band at KUSZA Observatory (KO). Three of weather parameters (wind speed, humidity and rain rate) was considered with the radio signal variation. Measurement of these weather parameters and radio signal power level (dBm) were collected using weather station and spectrum analyzer respectively. From the result obtained, we found that wind speed played a role in radio signal attenuation indirectly. The combination of wind speed (km/h) along with high humidity (%) and rain rate(mm/s) during NE monsoon season have given a significant impact to a radio signal. These findings is useful to radio astronomer to determine the best period for radio astronomical observation with minimum interference considering weather condition. This study will also beneficial to spectrum user such as mobile telecommunication, wireless internet and radio broadcasting in managing and improving their services.

1. Introduction
Electromagnetic (EM) waves comprised of radio waves, infrared, visible light, ultraviolet, x-ray and gamma-ray [1]. As noted by John Seybold, 2005, radio waves have wavelengths ranging from 1 millimeter (0.039 in) to 100 kilometers (62 mi) and frequencies from 300GHz to as low as 3kHz[2]. Generally, the radio signal was referred as radio waves that propagate from transmitting antenna to receiving antenna in three identical methods namely as following: line of sight, reflection and refraction [3]. In radio band, International Telecommunication Union, (ITU) have divided the radio spectrum into 12 bands as stated in Table 1 based on their frequencies and wavelength [4]. This frequency band has a different way of radio propagation [5]. UHF is mainly propagated in direct waves or called as Line of Sight (LOS) and ground reflection. Figure 1 illustrates the propagation mechanism of UHF band. Television broadcasting, cell phones, personal radio service (Wi-Fi) and walkie-talkies is the example of UHF band users. The main issue is the radio signal interference that interrupt the transmission of the radio signal. It is crucial to identify factors affecting the radio signal propagation, so the radio signal transmission
can be managed to reduce attenuations and path loss of radio signal. The interference usually comes from man-made interference such as radar, electronic equipment, AM/FM radio and service provider[6]. Apart from man-made interferences, atmospheric condition as temperature, humidity, and wind also can lead to the changes of radio signal propagation [7]. The propagation of radio waves through atmospheres is affected by the atmospheric condition which is come from different weather component. Several studies have been conducted on the effect of weather condition on radio signal by Umar et al. 2015[8]. They studied the effect of rain on radio signal attenuation and found the radio frequency interference (RFI) difference was increased with decreases of rain rate. They have stated that rain gave the significant effect to the attenuation of the radio signal. Apart from rain, the humidity also contributes to the attenuation of the signal. Hamza et al. 2017 has investigated the troposphere parameter (temperature, relative humidity and atmospheric pressure) effect on microwaves link[9]. They found the humidity is the major factor affects the refractivity index of the atmosphere. These high in refractivity causes to the greater attenuation of microwaves. Likewise, Amajama et al. 2016 found that humidity indicates the high correlation with radio signal with a value of r = -0.93ref[10]. Besides, wind speed also plays an important role in losing signal strength. Wind speed is found indirectly affect the radio signal by Meng et al. 2009, wind speed caused the movement of leaves and branches within foliage channel and obstructed the propagation [11]. Thus, attenuated the signal strength. Also, Chua et al. 2010 studies found that wind speed and direction was positively correlated with received signal strength for wireless link research . In this paper, we investigated the effect of NE monsoon on UHF signal attenuation at KO which is located on the east coast of Peninsular Malaysia. Three weather component has been considered namely wind speed, humidity, and rain rate, measured in km/h, % and mm/s respectively. They are believed to contribute to the radio signal power level attenuation. NE monsoon in Malaysia received high precipitation with high rain rate, high humidity and strong wind. The combination of these three weather parameter causes the attenuation of the strength of radio signal. This research will benefit radio astronomer for selecting a site with very minimum RFI by considering weather condition. Besides, this will benefit active spectrum user such as satellite broadcasting, AM, FM & TV transmission, internet service provider to manage and to improve their system performances.

2. Methodology
The 24-hour measurement was done at 21th January 2016 and 3th February 2016 which both were in NE monsoon season. NE Monsoon received high precipitation with heavy rain and strong
Table 1. Designation of radio band by ITU

| Radio Band         | Frequency range | Wavelength range |
|--------------------|-----------------|------------------|
| Very Low Frequency (VLF) | 3-30kHz         | 10 to 100km      |
| Low Frequency (LF)  | 30-300kHz       | 1 to 10km        |
| Medium Frequency (MF)| 300-3000kHz     | 100 to 1000m     |
| High Frequency (HF) | 3-30MHz         | 10 to 100m       |
| Very High Frequency (VHF)| 30-300MHz   | 1 to 10cm        |
| Ultra High Frequency (UHF)| 300-3000MHz | 100 to 1000cm    |
| Super High Frequency (SHF)| 3-30GHz    | 10 to 100cm      |
| Extremely High Frequency (EHF)| 30-300GHz | 1 to 10cm        |
| Tremendously High Frequency (THF)| 300-3000GHz | 0.1 to 1mm       |

Figure 2. Receiver system of measurement [13]

wind which happened from November to March. These measurements were carried out at KO which located on top of the hill, surrounded with forest, rural area and the nearby South China Sea. This feature of KO allows receiving strong wind, high humidity and far from human-made interferences. Weather parameter was collected using Davis Vantage Pro 2 weather station. At the same time, radio signal power level (dBm) data had also been collected by a spectrum analyzer. The data was collected for each minute, so the total weather data (wind, humidity and rain rate) were 2880 each. Similarly, the radio signal strength data were 2880 so the plot of wind speed and radio signal power level against time could be determined. The measurement receiver system was comprised of an antenna, low noise amplifier (LNA) and 9 GHz spectrum analyzer (Keysight N99150) connected to the computer. The antenna was kept in vertical polarization with height taller than trees. Figure 2 illustrate the receiver system of this study.
Figure 3. Graph of RFI at frequency up to 3000MHz at KO with 4 interferences peaks and sources were labelled

3. Results and Finding
The radio signal power level detected at KO for all frequencies up to 3GHz is shown in Figure 3. Based on the graph, four (4) prominent peaks were detected. They were peaks at frequencies of 382MHz, 945MHz, 1867.5MHz and 2160MHz. These frequencies are in UHF band and mostly come from mobile phone and digital trunked radio sources. In this study, the effect of wind speed on a radio signal is discussed and also relate to other meteorological factors which are humidity and rain rate. Figure 4 and Figure 5 show the change in signal power level as the wind speed varies with time.

From Figure 4, we can see that the change of power level is not obviously seen by the change of wind speed, while in Figure 5, the drop of signal power level is noticeable around 1.24pm until 5.03pm at 3rd February 2016. However, the average of the radio signal power level at each frequency had been plotted to see the overall performance of the signal power level (Figure 6). We can see the average signal power level is lower at 3rd February 2016 compared to 21st January 2016. It was corresponds to the value of wind speed, humidity and rain rate for each day. All of the meteorological factors considered were higher at 3rd February 2016 as illustrated in Figure 7.

From the plot, the wind speed, humidity and rain rate were 10.7484665 km/h, 2.238948171 % and 75.52820122 mm/s at 3rd February 2016 respectively. These values are higher than in 21st January 2016 which are 9.335827897 km/h, 0.390631506 % and 74.44136017 mm/s respectively. These shows that, collectively, the wind speed, humidity and rain rate level give a significant effect on the radio signal strength. However, as discussed by Meng et al. 2009, the radio signal strength was affected by the wind speed indirectly. The analysis suggests that stronger wind speed attenuate the radio signal strength in the presence of high precipitation and high humidity level. It may because of the strong wind has brought voluminous rainwater due to high rain rate and humidity. The water content causes the absorption and scattering on a radio signal. Hence, the radio signal strength interferes. It were concluded that the combination of wind speed, humidity and rain rate affected radio signal in UHF radio propagation.
Figure 4. Graph of Wind speed, Power level against time for frequency 382.5MHz, 945MHz, 1867.5MHz and 2160MHz at 21st January 2016.
**Figure 5.** Graph of Wind speed, Power level against time for frequency 382.5MHz, 945MHz, 1867.5MHz and 2160MHz at 3rd February 2016
Figure 6. The average of radio signal power level in 21th January 2016 and 3th February 2016 for frequency of 382.5MHz, 945MHz, 1867.5MHz and 2160MHz.

Figure 7. The average values of wind speed, humidity and rain rate in 21th January 2016 and 3th February 2016.

4. Conclusion
In this study, we have presented the effect wet season due to Northeast monsoon in Malaysia on the radio signal power level in UHF band. It was determined that the combination of weather parameters which are wind speed, humidity and rain rate affected radio signal in UHF band. These will benefit radio communication services and another related spectrum user. The data collected for 24 hours each day. Clouds data could be included to investigate the effect on radio signal strength in future work.

References
[1] Sasao, Tetsuo and Fletcher, André B. Basic knowledge of radio astronomy. Suwon: Ajou University, 2005
[2] Seybold, John S. Introduction to RF propagation. John Wiley & Sons, 2005
[3] Meeks, R and Beafore, FJ. The science and study of radio wave reflection refraction diffraction absorption polarization and scattering. WS8B, 2011.
[4] Bakshi, Uday A and Bakshi, Ajay V. Antenna and wave propagation. Technical Publications, 2009.
[5] Haslett, Christopher. Essentials of radio wave propagation. Cambridge University Press, 2008.
[6] Umar et al. 2013. The Study of Radio Frequency Interference (RFI) in Altitude Effect on Radio Astronomy In Malaysia And Thailand. Middle East Journal of Scientific Research, 14(6), 861–866.
[7] Olutola, Famoriji J and Olajolu, Oyeleye M. 2013. A test of the relationship between refractivity and radio signal propagation for particulates. Research desk, 2(4), 334-338.
[8] Umar et al. 2015. Radio frequency interference: The study of rain effect on radio signal attenuation. Malaysian Journal of Analytical Sciences, 19(5), 1093-1098.
[9] Hamza, Mohd Ghazali and Latiff, Liza A and Mustafa, Eltayeb M and Gasim, Waleed M. 2017. Radio propagation and troposphere parameters effect for Microwave links in Sudan. Communication, Control, Computing and Electronics Engineering (ICCCCEE), 2017 International Conference on, (pp. 1-5). IEEE.
[10] Joseph, Amajama. 2016. Force of Atmospheric Humidity on (UHF) Radio Signal. International Journal of Scientific Research Engineering & Technology, 2(4), 56-59.
[11] Meng, Yu Song and Lee, Yee Hui and Ng, Boon Chong. 2009. The effects of tropical weather on radio-wave propagation over foliage channel. IEEE Transactions on Vehicular Technology, 58(8), 4023-4030.
[12] Chua, TH and Wassell, IJ and Rahman, T Abd. 2010. Combined effects of wind speed and wind direction on received signal strength in foliated broadband fixed wireless links. Antennas and Propagation (EuCAP), 2010 Proceedings of the Fourth European Conference on, (pp. 1-5). IEEE.
[13] Sabri NH, Syed Zafar SNA, Umar R, Mokhtar WZAW. 2015. Radio Frequency Interference: The Effect of Ambient Carbon Dioxide (CO2) Concentration on Radio Signal for Radio Astronomy Purposes. Malaysian Journal of Analytical Sciences, 19(5), 1065-1071.
[14] Sabri NH, Atiq WA, Umar R, Shahirah SS, Ibrahim ZA, Mokhtar WZAW. 2015. The Effect of Solar Radiation on Radio Signal for Radio Astronomy Purposes. Malaysian Journal of Analytical Sciences, 19(6), 1374-1381.