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Effect of Some Meteorological Variables and Conditions on Mobile Phone and TV Satellite Signal

Hussain A. Nemah*, Mohammed M. Ahmed, Omar L. Khaleed, Ghasaq S. Nemat

Department of Atmospheric Sciences, College of Science, Mustansiriyah University, Baghdad, IRAQ

*Correspondent contact: Husain_abodi.atmsc@uomustansiriyah.edu.iq

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ABSTRACT

The study aimed to seek for the effect of meteorological parameters and conditions on wave transport for both radio wave band that used by mobile phone communication and microwave band that used in 'TV' satellites by showing which atmospheric variable and conditions have a positive or negative effect on signal strength. Data of study was recorded perfectly from one selected point by hand using the same devices for all recording to exclude the error caused by changing device types. The results showed that atmospheric conditions had a noticeable effect on microwave signal band that used by 'TV' satellite especially when there was a rainy case, and for atmospheric 'UV' index it had a direct positive effect on radio waveband used by mobile phone because there was an increase in signal strength corresponding with increasing of 'UV' index (from 1 to 5 of UV index range). For temperature, the result showed inverse proportion with radio waveband signal, but relative humidity didn't show up any relations with both study bands' signals. Day time variation of signals was recorded for both wavebands, the result of radio waveband signal fluctuated in semi sine wave shape but with decreasing trend along day time, and for 'TV' satellite microwave band signal the result recorded increasing trend along day time, and this may because of solar radiation activity but in general, the satellite band signal was higher affected by weather condition as compared with mobile phone radio wave signal band.

KEYWORDS: Electromagnetic spectrum; Micro wave; Radio wave; Signal strength; Weather conditions.

الخلاصة

هدفت الدراسة إلى البحث عن تأثير المتغيرات والظروف الانوائية على انتقال الموجة لكل من نطاق الموجات الراديوية المستخدمة في اتصالات الهاتف المحمول ونطاق الموجات المايكروية المستخدمة في الأقمار الصناعية من خلال إظهار المتغيرات الجوية والظروف التي لها تأثير إيجابي أو سلبي على قوة الإشارة. تم تسجيل بيانات الدراسة بشكل مثالي من نقطة واحدة محددة باليد باستخدام نفس الأجهزة لجميع التسجيلات لاستبعاد الخطأ الناجم عن تغيير أنواع الأجهزة. أظهرت النتائج أن الظروف الجوية كان لها تأثير ملحوظ على نطاق إشارة الميكروويف الذي يستخدمه القمر الصناعي الخاص بالتلفاز خاصة عندما يكون هناك حالة ممطرة ، وبالنسبة لمؤشر 'UV' الجوي فقد كان له تأثير إيجابي مباشر على نطاق الموجات الراديوية المستخدم بواسطة الهاتف المحمول بسبب ان هناك زيادة في قوة الإشارة تقابل زيادة مؤشر "UV" (من ١ إلى ٥ من نطاق مؤشر الأشعة فوق البنفسجية). بالنسبة لدرجة الحرارة ، أظهرت النتيجة نسبة عكسية مع إشارة النطاق الموجي الراديوي ، لكن الرطوبة النسبية لم تظهر أي علاقات مع إشارات نطاقي الدراسة. تم تسجيل اختلاف التوقيت النهاري لكل من نطاقي الموجات ، وكانت نتيجة إشارة النطاق الموجي الراديوية تتأرجح في شكل موجة شبه جيبية ولكن مع اتجاه تنازلي على مدار اليوم ، وبالنسبة لإشارة نطاق الموجات المايكروية الخاصة بالتلفازفقد سجلت النتيجة اتجاهًا متزايدًا على مدار اليوم و قد يكون هذا بسبب نشاط الإشعاع الشمسي ، ولكن بشكل عام فقد كانت إشارة نطاق القمر الصناعي المايكروية تتأثر بشكل أكبر بحالة الطقس مقارنةً بنطاق إشارة موجات الراديو للهاتف المحمول.

INTRODUCTION

The atmosphere has a wide effect on all atmospheric parameters; in addition to that it affects electromagnetic wave transfer because of its meteorological elements variation especially in the troposphere layer [1]. The way that control wave transferring from transmitter device to receiver device is considered very important when starting to make a new communication system, therefore it is very useful to take into account the nature of the new place [2]. The electromagnetic wave is involved inside the electromagnetic spectrum which extended from shorter to longer wavelength [3]. Humans were able to exploit all parts of the electromagnetic spectrum at various levels and in many medical, engineering and space communications fields [4]. Many wireless receivers that work in space encounter interruption caused by variable weather condition,

this in rule leads to weak connection system [5]. So, this study aims to investigate the effect of some meteorological variables and conditions on radio waves and microwaves communication systems depending on real recorded data measured by hand. Without the air in the atmosphere, electromagnetic wave can't transport over all earth and make this wide communication, thus the atmospheric meteorological weather condition is considered as the most important factor that cause weaken in electromagnetic waves propagation [6]. Experiments referred to that the weather condition and the air directions caused by high or low pressure systems and geographic nature is widely effects on radio wave quality [7]. Many scientists aimed to study the electromagnetic radiation transportation over the atmosphere, for example (philps) in 1960 tried to study the effects of ionized air on electromagnetic wave propagation and also the effect of oxygen and nitrogen on it, he reached to that the higher effect was when higher pressure and lower temperature values are exists [8]. (Griffiths, S.) in 1987 recorded large data about water content in some selected points and he correlated it with recorded radio wave signals at the same time, he reached to that most of wave attenuation is caused by this water content, he also encourages to make strict rules for installing wireless towers depending on modern recorder meteorological parameters [9]. (Siingh) in 2005 tried to understand the effect of upper and lower level of the atmosphere on electromagnetic wave as well as the effect of space outer the atmosphere and he found that there is a clear effect of ionosphere layer on these wave propagation[10]. (Gunashekar, S.) in 2006 studied the effect of wave refraction in the troposphere layer over the sea depending on radio wave propagation, he reached to that the climatologically nature of exact place in addition to sea wave disorder are widely effects on (Vhf) and (Uhf) Radio Paths [11]. (Golubkov, G.) In 2018 studied the effect of atmospheric aerosols on microwave transfer over troposphere layer that comes from satellites to the earth, he found that the aerosols make high attenuation especially at daylight because it charged by solar radiation [12].

The current study aimed to investigate how the atmospheric variable effects on electromagnetic wave transport, as well as the signal strength fluctuation along the day time in order to understand the relation and find the best condition that leads to the higher signal strength of both mobile and TV satellite signals.

MATERIALS AND METHODS

It was shown in the introduction, this study deals with the effect of atmospheric variables and conditions on mobile phone signal and 'TV' satellite signal. The study selected one fixed location to take the data measurements by hand and very carefully in order to neglect external effects such as changing communication towers or using another receiver device, so it was done by the same devices and from the same point, also the recording time extended from the starting of winter to the end of summer season. These data records needed many days to be complete, so to make the best comparison it's very important to record more records to increase the accuracy, then the study focused on more accurate records to avoid non-trusted records and reach to highly accurate results.

The study selected some variables and they were (temperature, humidity, UV index) as well as recorded weather conditions at that time such as (fair, cloudy, rainy, ... etc) to show the effect of these variables and conditions on wave transfer over the air. In addition to that, the changes of the signal were recorded over day time for (24) hours to show signal fluctuation over the day time. After that figures were drowning to show the result clearly for all of the temperature, UV index, and weather condition as well as day time.

RESULTS AND DISCUSSION

After collecting the daily information for many times of the day and for winter and summer seasons which included (fair, cloudy, and rainy days) with different variable values, so the data were arranged in tables showing the values for each of mobile signal and 'TV' satellite signal including corresponding values of other variables at the same time of temperature, humidity and UV index, as well as corresponding weather condition, see Table.1 which show the variation of meteorological variables comparing with mobile signal strength in (dp) unit. The result shows that the weather condition has a clear effect on radio wave signal value, and this is clearly shown on Figure 1 where it shows that rainy days are corresponding with the lowest signal range as compared with other cases because of increasing water intensity in the air that effects on wave transport from the tower to the mobile phone,

therefore it leads to lower signal values reaching (15 dp).the result also showed that the cloud can affect on mobile phone signal strength because when compare between two days with different conditions "first one spatially clouded and the second one is fully clouded", then it found that the signal strength is affected by fully clouded day more than its effect with spatially clouded day, so can say that the signal strength always effected by cloud and records approximately (30 dp) but it considered acceptable ratio to make good communication, It is worth noting that previous studies have indicated similar results related to rain intensity and its effect on signal strength [3]. On the other side the days with fair weather correlated with the highest signal strength because of the absence of meteorological obstacles that effect wave transfer, see Figure 1.

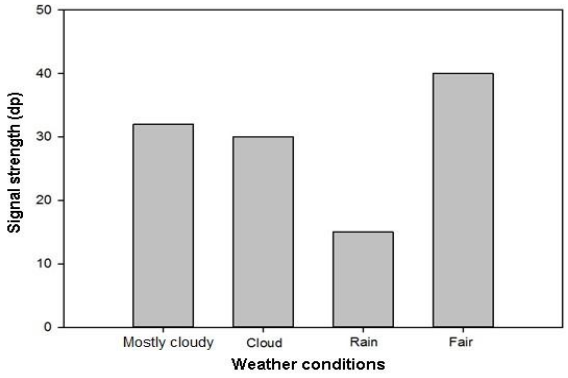

Figure 1. Effects of weather conditions on mobile phone signal strength.

When seeking about the effect of other meteorological parameters on mobile phone signal strength, the result shows that the increase in atmospheric temperature degree has an inverse correlation with signal strength, where the strength becomes lower when measured temperature increases in the atmosphere and the highest signal recorded when the temperature was below (5 ^{o}C) but it becomes less until reach lowest recorded value when the temperature at (30^{o}C) as it shown on Figure 2. When showing the effect of (UV index) value on the mobile phone signal, the result shows that the (UV index) value is proportional with signal strength because it recorded lowest signal value when the index was equal to zero but it increased when (UV index) value increased to (5), this clearly shown on Figure 3 and Table.1

Table 1. sample of recorded meteorological variables and conditions with signal strength for mobile phone recorded at fixed location.

Weather status	UV Index	RH (%)	T (^{o}C)	Signal (dp)
R	0	45	28	15
R	0	59	24	17
C	0	79	19	29.5
C	1	80	16.3	29.2
C	1	60	14.4	32
MC	1	73	12.7	33.8
F	4	70	7.8	39.1
F	4	58	7.7	36.8
F	5	47	7.4	38

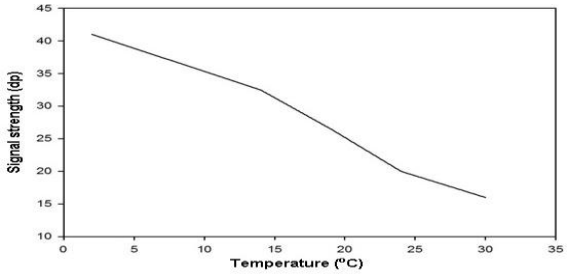

Figure 2. Effect of temperature on mobile phone signal strength.

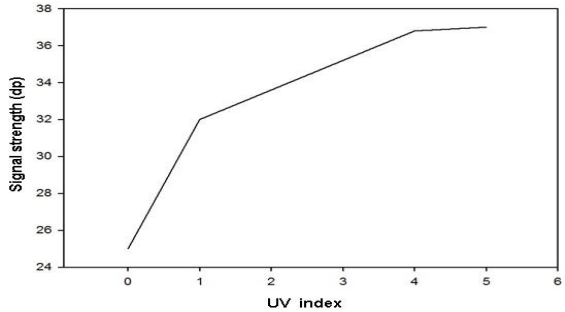

Figure 3. Effect of (UV) index on mobile phone signal strength.

For relative humidity the result showed that it was not affected on mobile phone signal strength, this may due to the very weak correlation between them and it may be increased when the range of relative humidity becomes less than zero or more than (100%), because another studies on other regions referred to that the ratio of relative humidity correlated with the signal strength when the value of relative humidity reach about to about more than (100%) [13]. Day time also effects on wave signal for a mobile phone because the result showed that there is a clear fluctuation in signal strength over day time including overall decreasing trend, and that means the recoded signal reached to the highest value at (00:00) time and then it fluctuated with decreasing trend over

day time in semi sine wave shape, see Figure 4 and Table 2.

Table 2. Sample of day time recording of both mobile phone and 'TV' satellite signal strength.

Mobile Signal (dp)	Satellite signal (dp)	Time (hours)
43	43	0
61	44	3
53	50	6
38	56.5	9
46.5	57	12
52.5	58.5	15
43	60	18
33.5	61	21
46.5	63	24

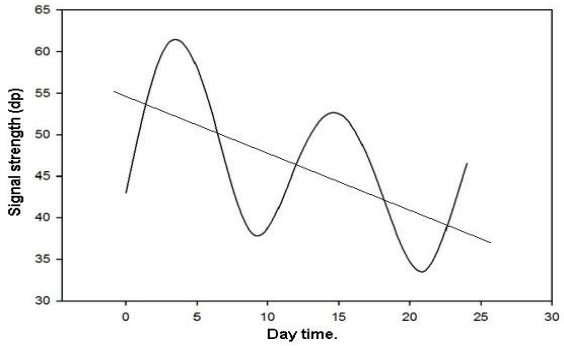

Figure 4. Mobile phone signal strength fluctuation over day time.

For microwave signal that used on (TV) satellites, Table. 2 with Figure 5 shows that the behavior of signal with day time has opposite relation as compared with phone wave signal because it increases with day time hours gradually to reach its maximum value and then it decreases after 18:00 hour "after sunset", and this may due to the effect of solar radiation on wave propagations from satellite to receiver devices.

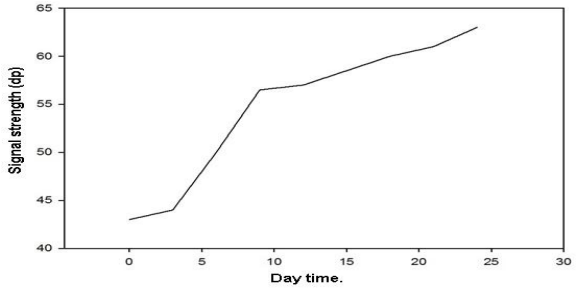

Figure 5. 'TV' satellite signal strength over day time.

Weather conditions also affect satellite microwave signal because the result showed that the lowest value of signal strength was about (43 dp) when there was a rainy case, in this case, the signal was totally missing and the 'TV' picture was disappeared. The result also shows that the highest strength of the signal was recorded when it was fair weather, and in case of foggy and cloudy days, the result showed a weak correlation. it is worth saying that the 'TV' satellite microwave signal is larger affected by rain as compared with the mobile phone radio wave signal, this clearly seen in Figure 6 , other studies preferred the cable networking for this communication instead of satellite signal to reduce the effect of these weather conditions [14]. For 'UV' index and relative humidity, the result showed very weak correlation with 'TV' satellite signal and this may need wider recording data ranges to show that effect, see Table.3.

Table 3. Sample of recorded meteorological variables and conditions with signal strength of 'TV' satellite at fixed location.

Weather status	UV Index	RH (%)	T (^{o}C)	Signal (dp)
R	0	50	16	45
C	1	50	11	74
C	1	44	2	76
C	0	48	1	77
F	0	64	8	91
F	1	63	7	90
F	1	62	11	93
F	1	44	19	91
R	4	91	17	43
FOG	1	91	17	90
C	1	94	17	72
C	1	93	17	72

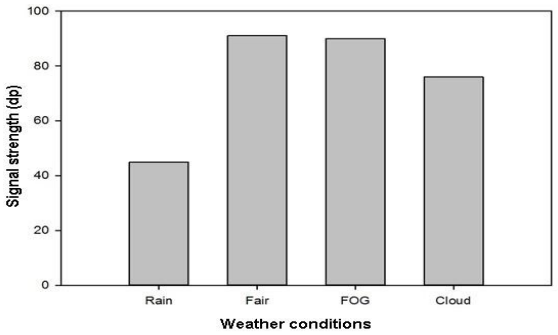

Figure 6. Effects of weather conditions on 'TV' satellite signal strength.

CONCLUSION

Atmospheric elements have clear effects on the transmission of electromagnetic waves, and the result showed that weather conditions (such as rain) have wider effects on 'TV' microwave signals than mobile phone radio signals. It also shows that the 'UV' index is directly proportional to the mobile phone's radio wave signal, but the temperature is inversely proportional to this signal strength. It is worth noting that there is an inverse behavior between the intensity of the radio wave

and the strength of the microwave signals throughout the day because the radio wave has fluctuated descending trend throughout the day while the strength of the microwave signal has an increasing trend along day time.

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