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Research Article

# The Study of Refractive-Index Structure Coefficient Behavior Derived from Two Weather Stations at Baghdad City

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**Abstract**

Refractive –Index Structure Coefficient $c_{\mu}^{2}$ behavior derived between horizontal points over at Baghded city was studied during the days containing different weather conditions where we used a horizontal relation to calculate $c_{\mu}^{2}$ between two points where we considered the first point Al-Mustansiyah university and the second point Iraqi Meteorological Organization and Seismic Monitoring (IMOSM).

This provided us with data from the automatic weather station installed mounted near (ASB) the height of 4m and the second station was set at a height of 2m. The data recorded were pressure and temperature where we calculated the relationship between the different rates of temperature and distance between the two stations where the distance is 20 km. For the heat of $C_{T}^{2}$ which when finding its value, the value of $C_{\mu.}^{2}$ and the period was several days represented by a group of atmospheric phenomena and these days are rainy and foggy and clear sky data taken by what was available from measurement at the station. A relationship was found between $C_{\mu.}^{2}$. With time and also with temperature and atmospheric pressure and difference in temperature for each hour.

**Keywords**: Refractive –Index Structure, Behavior derived , Two weather stations, horizontal points.

**الخلاصة**

في هذه الدراسة تم الاشارة الى دراسة تأثير سلوك معامل تركيب مؤشر الانكسار الاضطراب الجوي بين نقطتين افقيه فوق مدينة بغداد خلال ايام تحتوي على ظروف جويه مختلفة حيث استخدمنا علاقة افقيه لحسابه بين نقطتين حيث اعتبرنا النقطة الاولى الجامعة المستنصرية والنقطة الثانية الهيئة العامة للأنواء الجوية والرصد الزلزالي. وذلك بتزويدنا بالبيانات من محطة الطقس الاوتوماتيكية البطيئة الاستجابة والمنصوبة بالقرب من بناية قسم علوم الجو –الجامعة المستنصرية وعلى ارتفاع ٤ م والمحطة الثانية كانت منصوبة على ارتفاع ٢م وكانت البيانات المسجلة هي ضغط جوي ودرجات حرارة حيث قمنا بحساب العلاقة بين معدلات الفرق في درجات الحرارة والمسافة بين المحطتين حيث كانت المسافة هي ٢٠ كم لأيجاد قيمة معامل مركبة درجة الحرارة الذي عن طريقة يتم ايجاد قيمة معامل تركيب مؤشر الانكسار ولفترة كانت عدة ايام متمثلة بمجموعة من الظواهر الجوية وهذه الايام هي امطار والضباب وسماء صافية والبيانات التي استخدمناها هي ما كان متوفر من القياسات في المحطة. حيث تم ايجاد العلاقة ما بين معامل مؤشر الانكسار والزمن ومعدل الفرق في درجات الحرارة ومعامل تريب مؤشر الانكسار ومع الزمن لكل ساعة.

## 1. Introduction

In recent times, there is considerable interest in the development of optical communication systems in a variety of visual applications, particularly within the last mile access networks. Free space optical (FSO) communication is commonly. Seen as promising alternative technology for band with hungry applications in last mile access networks. For better performance rate in operating FSO systems, it is required a direct line of sight fairing of weather stations, such as rain, snow, fog, dust and turbulence.

Turbulence effect will be involved, because it is available in the atmosphere causing by variation in air temperature, which leads to spatial and temporal random fluctuations in the refractive index along the beam propagation through the channel. This effect causes deterioration in the quality of the received signal.

The most significant parameter that is used in expressing of optical turbulence is refractive-index structure coefficient, $C_{\mu}^{2}$ which is a function of location, altitude, and time of the day. Random variations in the refractive index of the earth's atmosphere are responsible for random fluctuation in beam spreading beyond the spreading predicted by diffraction and random motion of the beam centroid about the receiver that result in random signal losses at the receiver and thus increases the system bit error rates due to signal fading. It is a measure of the strength of the fluctuations in the refractive index [1].

Al-Towig, *et al.* (2010) [2] With his group of researcher noted that the turbulence and its effects, example, for. They pointed to the effect of clear atmospheric turbulence on quality of free space optical communication in Yemen. They focused on scintillation and its impact on the performance of FSO links .Where these variances were BER in the environment of Yemen. Scintillation for the Yemen environment is wavelength and distance dependent. The wavelength of 1550 nm turned out to be interesting since it is less sensitive to atmospheric turbulence and harmless to the human eye.

Jassim *et al.* (2015) [3] They determined the optical turbulence parameter ($C_n^2$)in Babylon city –Iraq .and that with through optical turbulence structure and refractive index information a long near horizontal (0,035km) free space path length . measurement the optical turbulence structure ($C_n^2$), refractive index ,pressure and temperature for several cases in winter, spring, summer and autumn. Optical measurement can be obtained using three different wavelengths of laser sources (808, 632 and 1064 nm). They found that the refractive index is affected by the temperature and pressure difference but still it is very small in Babylon city and it is affected by different wavelengths of laser sources but the optical turbulence in high (0.035km) is limited variation and strong.

The purpose of this paper is to (evaluate the effect of atmospheric turbulence causing by horizontal gradient of temperature and then studying the effect of both rain and fog on $C_{\mu}^{2}$.

## 2. Theoretical frame

Refractive index structure $C_{\mu}^{2}$ is the most important parameter that determines the optical turbulence strength, which is one of variables used in structure functions for plane and spherical waves over a horizontal path. Based on experimental and theoretical evidence, $C_{\mu}^{2}$ is given by:

$$C_{\mu}^{2} = D_{\mu}(P)\, P_S^{-2/3} \qquad (1)$$

where $D_{\mu}(p)$ is the refractive –index structure function is defined as:

$$D_{\mu}(p) == \overline{[\Delta\mu(x+p_s) - \Delta\mu(x)]^2} \qquad (2)$$

where x is the point in the path of the propagated wave, $p_s$is the sample point separation in the aperture plane ($\lambda X_L f_s$), $f_s$ is the spatial frequency in the image plane and $X_L$ is the local length of the lens, λ is wave length [4]. Close to ground, there exists the largest horizontal gradient of air temperature associated with the largest values of atmospheric pressure. There fore$C_{\mu}$ is defined according to fried law as follows:

$$\overline{(T_1 - T_2)^2} = C_T^2\, x^{2/3} \qquad (3)$$

where:

$$C_T^2 = \frac{\overline{(T_1 - T_2)^2}}{x^{2/3}} \qquad (4)$$

where $T_1$and $T_2$ are the temperature at two point a horizontal distance x apart (the bar denotes a time average). Thus, $C_T$ is the rms temperature difference divided by the cube root of the distance between the sensors.

$C_{\mu}$ is then related to $C_T$ by [5].

$$C_{\mu} = \frac{69 \times 10^{-6}}{T^2}\, PC_T \qquad (5)$$

T is the average temperature in kelvin, P is the pressure in mb $C_T$ can be measured directly from Equation (4).

## 3. Site and Data

The first site is Atmospheric Science Building (ASB), College of Science, Al-Mustansiriyah

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University located at northeast of Baghdad. The other site is located at west south of the city. This site belongs to IMOSM. These sites are shown in Figure 1 denoted by the small opened cycles. The horizontal distance between the positions is about 20 km[6].The instrument used to achieve this work is automatic weather stations.


**Figure 1**: Map of Baghdad city on which the study sites (1) Mustansiriyah University and (2) International Baghdad Airport (IBA)

The devices used to provide us with temperature and pressure data to calculate $C_\mu^2$ between two points by the horizontal relationship is the Automatic weather station located also at (ASB). The data used are the values of air pressure and temperature. The devices were programmed that each monitor is taken every quarter of an hour so the station that provides us with the data to calculate the time variation with the rate $C_\mu^2$ and with temperature and pressure through the horizontal relationship is automatic weather station.

These data are presented from two locations which are Al-Mustansiryah University as it is considered in the center of Baghdad city and IMOAS which is considered as the outside of Baghdad city. They are measured by automatic weather station for each location and recorded each hour for both at first location mounted at 4 m and second station (IMOAS) mounted at 2 m. The data used are air temperature and pressure. The total number of runs are (368) distributed among clear, light fog and rain situation, as shown in Table 1.

For applying method, the average were taken for observations at one hour to be monitored one per hour and the amount of observations are 24 monitored per day, depending on the number of observations available per day, we also calculate the change in the disturbance within these periods of the horizontal relationship.

**Table 1:** The dates, periods and number of daily runs for AWS data.

| Date of observation | Season | Periods (day) | No. of runs | weather Status |
|---|---|---|---|---|
| 6, 13, 27, 28 Dec 2015 3 Jun 2016 | Winter | 5 | 80 | Rain |
| 1, 2, 12, 13, 16, 29 Apr 2016 | Spring | 6 | 144 | Light fog |
| 1, 2, 12, 13, 16, 29 Jul 2016 | Summer | 6 | 144 | Clear |
| Total summation | | 17 | 368 | |

The horizontal relationship between two points for describing spatial turbulence: where measurements of temperature (°C) and pressure (mb) and also we took data form General Authority about route slow responsiveness device to measured temperature and pressure where we found the average temperature difference between the two points and found out the distance between them to calculate the value of $C_T$, the temperature structure coefficient, is calculated by Eq.(4), where it compensates in Eq.(5) to calculate the $C_\mu$ value.

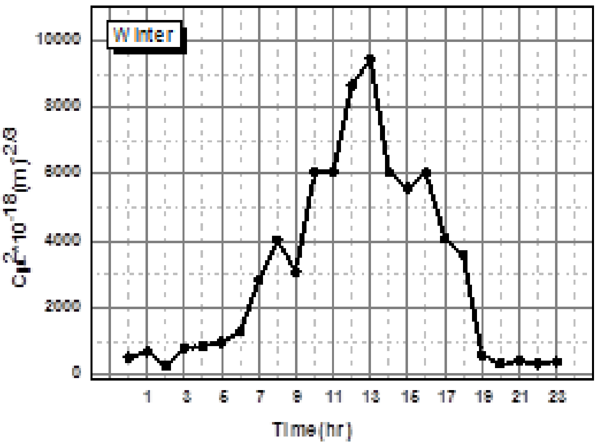


**Figure 2**: Relationship between diurnal variation in $C_\mu^2$for the days of Dec. and Jun.

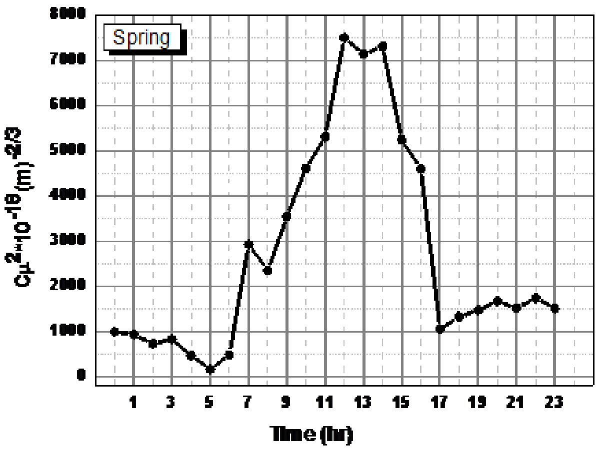


**Figure 3**: Same as Figure 2, but for the dates: (1, 2, 12, 13, 16, 29 April 2016).

Lastly, the results of hourly means of $C_{\mu}^{2}$ during the days in summer are plotted in Figure 6. They show the same behavior over the whole day, with smaller values. At sunny hours of the noontime, the peak is largest lasting four hours starting from (12:00 to 16:00) pm.

With average value (58000), the atmospheric turbulence is strongest. Then these results depression sharply to lowest one after midnight especially at (01:00) o'clock with value of (2000), which approaches to zero expressing there is noise caused by turbulence.

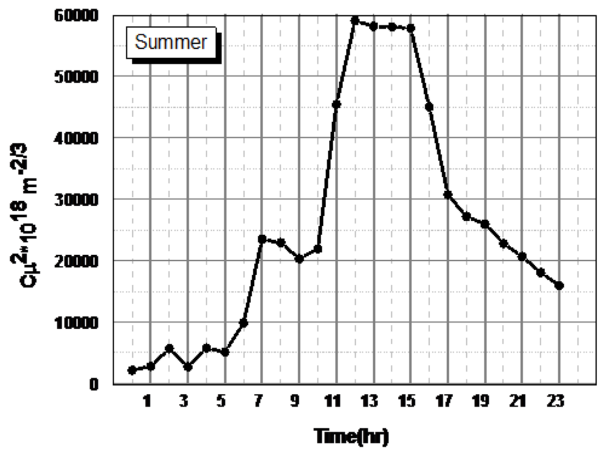


**Figure 4**: Same as Figure 2, but for the dates (1, 2, 12, 13, 16, 29 July2016).

## 4. Difference in temperature $|\Delta\overline{T}|$ with Time

These Figure 5 show the rate of difference in temperature $|\Delta\overline{T}|$ and Time between two regions, first represent the General Authority for Iraqi Aeronautics and second area of the University of. we notice that the highest difference recorded is the beginning of the period of sunrise and the beginning of the sunset , but the difference is less than zero at (6:00and 13:00) during the Winter while the spring is a small difference at 5:00and 2hours (14:00 and 15:00), while Summer is the difference between (5:00 am and 13:00 pm).

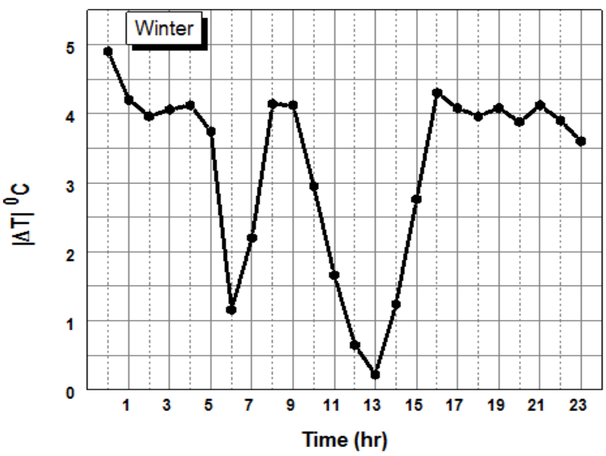


**Figure 5**: Show the rate of difference in temperature $|\Delta\overline{T}$ | with time during three seasons.

## 5. Relationship of $C_{\mu}^{2}$ with $|\Delta\overline{T}|$

Figure 6 shows the rate of difference in temperature $|\Delta\overline{T}$ |and $C_{\mu}^{2}$ between two regions, represent the General Authority for Iraqi Aeronautics and second area of Mustansiriyah University. In this form we note that the relationship between $|\Delta\overline{T}|$ and $C_{\mu}^{2}$ the greater the difference in temperature the Greater the value of $C_{\mu}^{2}$ we notice in the Winter the difference value is 3 degrees, where the Spring is about 4.5 while in summer we noticed the difference has increased to about 6 degrees and almost as a result of high temperature during the season the summer.ie, we observe the highest difference in temperature is in the summer and we have found 6 degrees as we mentioned earlier where we found here that the value of $C_{\mu}^{2}$ which is the highest value regardless of the rest of the seasons . in this form proved that the highest value of $C_{\mu}^{2}$ is composed at high temperatures and conditions the cause of the disturbance is the presence of a high thermal load and this is found in the summer.

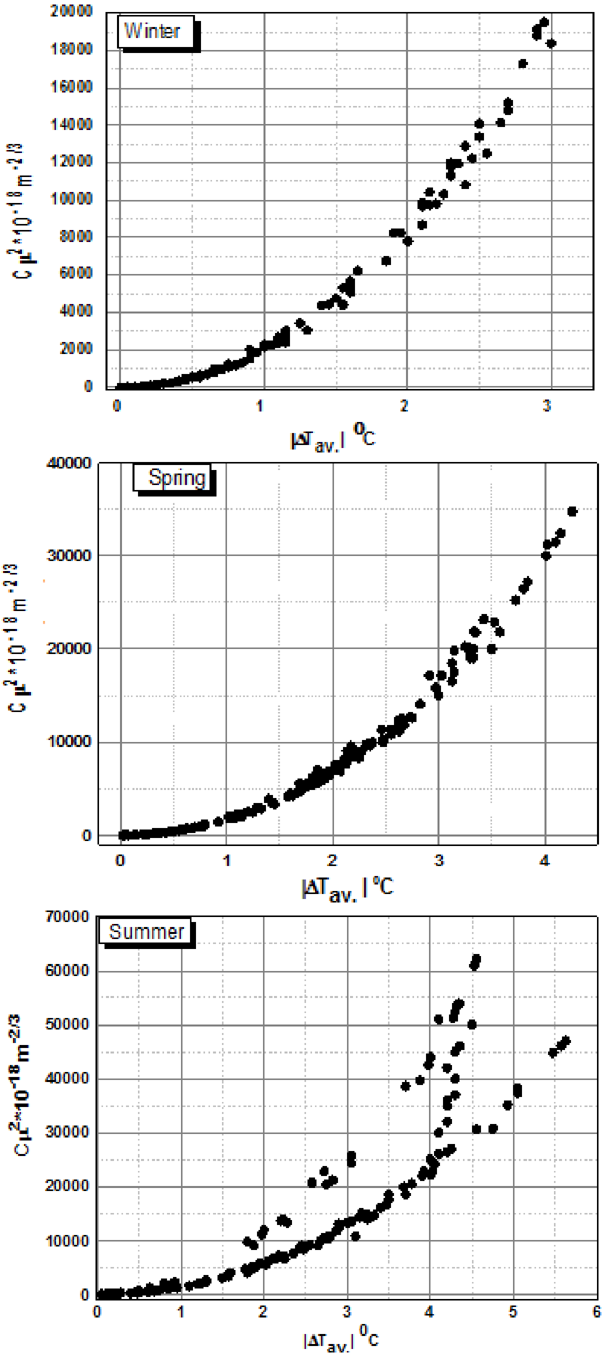


**Figure 6**: Relation of $C_\mu^2$ with $|\Delta\overline{T}|$ during the three seasons.

## 6. Study of $C_\mu^2$ under weather cases

Using the previous method, which is the relationship Diurnal variations of $C_\mu^2$, which are in to case (low response data) to find the value of $C_\mu^2$ and same Equation (5) used previously. However, here we focused only on the days that contain Rain and Fog to know the impact of these conditions on the atmosphere increase or decrease the value of $C_\mu^2$ during the existing Rain or Fog.

Figure 7 also shows Rain and Fog but slow response data state and not the highest value of $C_\mu^2$at (00:00) and then took its value as a result of the increase in the amount of rain , where the value of $C_\mu^2$ to zero at about (06:00)am. Then it took its value up and reached its highest value at (08:00) am. Then its value dropped to almost zero.

As Fog, the $C_\mu^2$ value will be low from (00:00 am. to 18:00 pm.) and then it will rise from (19:00 to 21:00) pm. Due to fog during those hours.

Finally, we concluded in both cases or shapes that rain and fog had a significant effect on reducing the rate of $C_\mu^2$ during their lifetime.

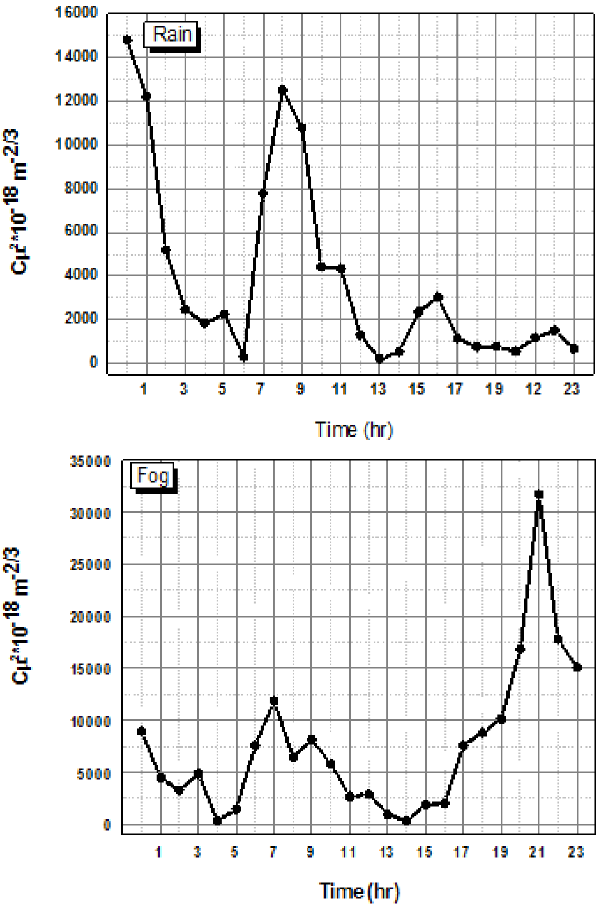


**Figure 7**: Shown effect Rain and Fog on $C_\mu^2$on horizontal distance.

# 7. Concluding remarks

By collecting data and analyzing them according to the atmospheric conditions that accompanied the time of data recording and using the horizontal relationship between two points to calculate $C_{\mu}^{2}$ our study reached the following:

General $C_{\mu}^{2}$ values in summer and larger than those in winter and spring .highest values of $C_{\mu}^{2}$ is fairly occurred at noon times for three seasons: winter, spring and summer, while lowest values occurred at night times.

The differences in air temperature between two weather stations are found to be large at night times and small at noon times. These differences have more values in summer with approaching to 8 ˚C at 02:00 o'clock. The $C_{\mu}^{2}$ results are found to increase with increasing are temperature differences. Lastly also these values are affected at rain and fog cases with decreasing to lowest values, especially for rainy days. Turbulence intensity was increased from (12:00 to 16:00) pm, where the turbulence was high during summer season, with high fluctuations in the values of turbulence between the two periods of the sunrise and sunset times.

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