

The Relationship between Air Stability and Visibility over Baghdad City

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ABSTRACT

In this study Pasquill atmospheric stability determined at daytime for January and July 2010 fixed for Baghdad city. The classification of stability was made using data of wind speed and solar radiation. These classes were compared with atmospheric stability that recorded hourly in Baghdad airport station. The results show that stability class, B and C make up the highest percentages, while the class A is non-existent during winter "this" can be attributed to prevailing parameter weather and their frequencies such as temperature, wind speed and solar radiation. The stability classes were estimated to be medium to moderate. In summer, B and A-B stability classes were more predominant than others. Visibility at January month is very high and concentrated at 8500-11500 meters and have rate 75%, while bad visibility range at this month is about 7.6%. In July month the rate of clear weather conditions of visibility is about 65.8%. Atmospheric elements (temperature, relative humidity wind speed, solar radiation) are compared with visibility at specified stability class to show its effects on visibility. If more stable conditions existed this refer to the better extent of visibility, this means unstable conditions reduce atmospheric visibility with help of atmospheric elements. Overall, the most effected class on the visibility is neutral condition and near neutral condition, but you may determine the location if there is near to location of emission pollutant or aerosols, consequently the case is different.

KEYWORDS: Baghdad; Stability Classes; Pasquill Stability; Visibility.

الخلاصة

في هذه الدراسة: الاستقرار الجوية باستخدام Pasquill لساعات النهار لشهري كانون الثاني وتموز 2010 لمدينة بغداد تم تحديدها. حيث تم تصنيف الاستقرار باستخدام بيانات سرعة الرياح والإشعاع الشمسي، وقرنت هذه الفئات مع الاستقرار الجوي المسجل كل ساعة في محطة مطار بغداد. أظهرت النتائج أن صنف الاستقرارية B و C يشكلان أعلى النسب، بينما الصنف A غير موجود خلال فصل الشتاء "وهذا" يمكن أن يعزى إلى معاملات الطقس السائدة وتردداته مثل درجة الحرارة وسرعة الرياح والإشعاع الشمسي تم تقدير فئات الاستقرار لتكون متوسطة إلى معتدلة. في الصيف كانت اصناف الاستقرارية B و A-B أكثر انتشاراً من غيرها. ان مدى الرؤيا خلال شهر كانون الثاني عالية نسبيا وتتركز حول 8500-11500 متر ولها نسبة 75% بينما مدى الرؤيا السيئة عند هذا الشهر كانت حوالي 7.6%. في شهر تموز الحالة سوف تختلف نسبيا حيث ان ظروف الجو الصافي تصل الى حوالي 65.8%. العناصر الجوية مثل درجات الحرارة و الرطوبة النسبية وسرعة الرياح والإشعاع الشمسي عند صنف معين تم تناولها لدراسة تأثيرها على مدى الرؤيا. اذا كانت الظروف مستقرة فهذا يشير الى امتداد افضل لمدى الرؤيا ولذلك لظروف عدم الاستقرارية وسوف تؤدي الى تقليل مدى الرؤيا برفقة العوامل الجوية الاخرى والظروف المرافقة. عموما صنف الاستقرارية الاكثر تأثيرا هو الظروف المتعادلة او القريبة الى التعادل ولكن يجب تحديد تأثير الموقع اذا كان هنالك انبعاثات للملوثات والعوالق قريبة الى موقع الرصد.

addition to the forecasting of vertical turbulent intensities, which mostly utilized to assess the dispersion of contaminant "clouds". The proper evaluation of the effects of atmospheric diffusion to mitigate the contamination hazards requires appropriate mathematical modeling and data [3]. For most projects, the deep knowledge of the turbulent boundary layer are not available, therefore the classification of stability becomes essential to determine the dispersive features of the atmospheric boundary layer required in the

INTRODUCTION

In 1976, Pasquill suggested an approach to compute the degree of dispersion of small particles that carried by air in the lower layer of atmosphere. (This month's represents winter and summer periods respectively) The technique became widely known and used in handbooks for atmospheric dispersal calculations such as meteorology and atomic energy [1] [2]. Hence, the determination of stability conditions is vital in

Gaussian models [4]. Six classifications “are normally” used to refer to the atmospheric stability conditions, namely, A for slightly unstable, D for neutral, E for moderately stable, and F for extremely stable. In addition, the stability G is used to address the nocturnal stable condition at light wind [5].

In this study we will investigate the effect of these six atmospheric stability classes on different of meteorological parameters, and concentrated on the visibility that is defined as the maximum distance at which the outline of a target can be recognized against the horizon as background [6]. In an unpolluted atmosphere, visibility will be within 250 km [7]. Dust carries many portable air pollutants such as toxins, heavy metals, salts, sulfur, pesticides and others; it reduces the horizontal vision especially that can affect human life in many ways. In recent years there has been a growing interest in the use of atmospheric

visibility measurements as a replacement for air pollution concentrations. Most studies carried out in the United States relate finer particulate concentrations (PM_{2.5}) with visibility degradation [8].

MATERIALS AND METHODS

There are many methods for determining the atmospheric stability classes [9], but the most commonly used ones are the Pasquill simplified method and modified method and temperature lapse rate. This study used the first two methods, the simple method uses wind speed, and insolation and cloud cover to determine the atmospheric stability classes. The certainty in determination of this approach is not sufficient; this may due to the errors in estimating the cloud cover caused by individuals [10]. The method may be summarized in Table 1.

Table 1. Atmospheric stability classes in simplified method criteria [10].

Wind speed U (m/s)	Stability classes for various solar insolation at daytime			Stability classes for various amounts of clouds at night	
	Strong	Moderate	Slight	NH or N ≥ 4/8	N < 3/8
U < 2	A	A-B	B	*	*
2 ≤ U < 3	A-B	B	C	E	F
3 ≤ U < 5	B	B-C	C	D	E
5 ≤ U < 6	C	C-D	D	D	D
6 ≤ U	C	D	D	D	D

In Table 1, the terms “Strong, Moderate, and Slight” belong to the incoming solar radiation at daytime as listed in Table 2. [11]: Where N: Clouds NH: high clouds.

Table 2. The relationship between solar altitude angles SA and Solar insolation [11].

Solar height angle	Solar insolation
0 < SA ≤ 35°	Slight
35° < SA ≤ 60°	Moderate
SA > 60°	Strong

SA is the solar altitude angle given by [11].
 $SA = \sin[\sin \delta \sin \Phi + \cos \delta \cos \Phi \cos \omega]$

$$\delta = 23.45 \sin \left[\frac{360}{365} (284 + dn) \right]$$

$$dn = 30(\text{month} - 1) + \text{day}$$

$$\omega = 15(12 - T_t)$$

Φ The latitude of the study location, δ the declination angle: number of days since January 1, ω is the solar hour angle which is equal to zero at noon and T_t is the local time [12].

In some parameters such as wind speed its direction, ambient air temperature, solar radiation and net radiation were used to estimate the atmospheric stability categories. The method is shown in the table 3 [13].

Table 3. Modified method classes (during daytime and nighttime) [13].

U (m/s)	Daytime incoming Solar Radiation (Langley/hour) 1(Lang/hour) = 11.63 (Watt/meter)				Stability classes (at night time)		
	R _D ≥ 50	50 > R _D ≥ 25	25 > R _D ≥ 12.5	RD < 12	R _N > -1.8	-1.8 ≥ R _N > -3.6	RN ≤ -3.6
U ≤ 2	A	A-B	B	D	D	--	--
2.0-3.0	A-B	B	C	D	D	E	F
3.0-5.0	B	B-C	C	D	D	D	E
5.0-6.0	C	C-D	D	D	D	D	D
>6.0	C	D	D	D	D	D	D

Where RD: the solar radiation (Langley/hr) RN: is the net radiation during the night.

Site and Data

In this research work, data were obtained from two sources. The first is the Automatic Weather Station which was installed on the roof of the building of the Department of Atmospheric Sciences in Mustansiriyah University (33.3°N, 44.44° E). The height of the building is 22 m. The location is to the north east of the center of Baghdad city, show Fig. 1. Baghdad city is capital of Iraq its urban city with 8116498 (million at 2012) [14]. This automatic station was programmed to record instantaneous data at 15 min increments (then these data would convert to an hourly basis data). The second source was the Iraqi Meteorological Organization and Seismology dataset, This organization is located at about 25km to the southwest of the location of the automatic weather station, second source is provide hourly visibility data in addition to other atmospheric parameters. The data were chosen for year 2010 and worked stated by study the relationship between atmospheric stability and visibility.



Figure 1. Automatic weather station that used in this study

RESULTS AND DISCUSSION

Stability and atmospheric elements at January and July

At January Hourly wind speed and solar radiation data (Table 3), were used to classify the

atmospheric stability at daytime for January. Typical daytime stability classes in this month are A-B, B, C start to increase significantly at hour 800 LST in the morning and deviate around 1700 LST. Total daytime hours at this month reach to 289 and this belongs to the short daytime period, see Table 1 and Fig. 2. Class B has the largest frequency (35.7 %) The dominant of class B may due to the cold weather condition and low active wind speed. There is difference between classes In January and July, see Fig 4, because number daytime difference in January and July.

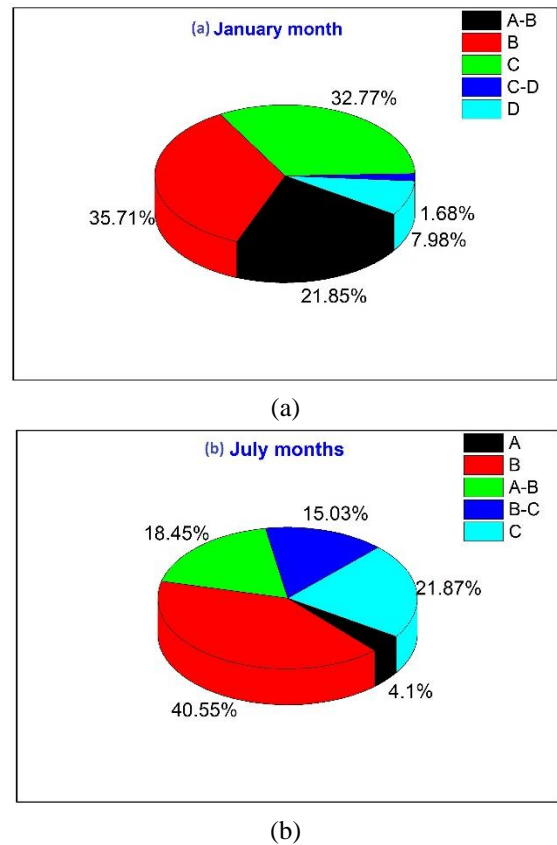


Figure 2. Percent ratio of stability classes at (a) January and (b) July months.

Table 4. Frequency and percent ratio from total of stability classes at January and July Months

Class	January		July	
	<i>Freq.</i>	<i>Freq. %</i>	<i>Freq.</i>	<i>Freq. %</i>
A	----	----	18	4.1
A-B	52	21.85	81	18.45
B	85	35.7	178	40.55
B-C			66	15.03
C	78	32.77	96	21.87
C-D	4	1.6	----	----
D	19	8		
Total	238		439	

Fig. 3a visualizes the frequency of atmospheric elements at this month such as temperature, solar radiation, wind speed and visibility. Temperature domain at daytime through this month have range (17-20)C° with frequency 40-45%, this consider a moderate temperature, wind speed that responsible for dynamic unstable from the change of wind with height taken 0-5 m/s and ratio 30% from total observed. Solar radiation at this period is 0-100 W/m² and its frequency of this value reach to about 50%.

The aforementioned case for stability classes and atmospheric elements in January changes in July, where the temperature rises to 40-43 degrees Celsius at a rate of 50%, and this raises the temperature and reduces the wind speed to 3m/s at a rate of 70% Fig. 3b. On the other hand, the solar radiation in this month also has a significant increase in altitude up to 850 W/m². From the review of the weather conditions of the field in this month, the atmospheric stability will change as we observe Class A, this class is a not established in January, and the frequency

distribution of Class B will be very large Fig. 2 and table 4.

Visibility and atmospheric Stability Classes

Fig. 4(a, b) shows the frequency of visibility observed in Baghdad city in July and January. It note that the visibility values in January is high (weather is clear all most) and concentrated at visibility range between 8500-11500 meters, its composition about 74.76%. At this month rate of moderate weather is 17.62%, concentrated at range 4500-7500 meters. The visibility range 500-3500 meters, consider as bad weather conditions have about 7.61%, all this percentage is taken from the observed data for about 749 hour, which represents hours of night and daytime of this month, Fig. 4 (b).

On the other hand, the sum of all hourly recorded data through the July month is 735 hour, 4.21% from its consider a worst condition weather where visibility is from 500 to 3500 meter. Visibility range from 4500-7500 meter considers moderate condition it have rate 25.71%. The rate of clear weather condition of visibility is about 65.85% have values in range 8500-11500 meter, Fig. 4a.

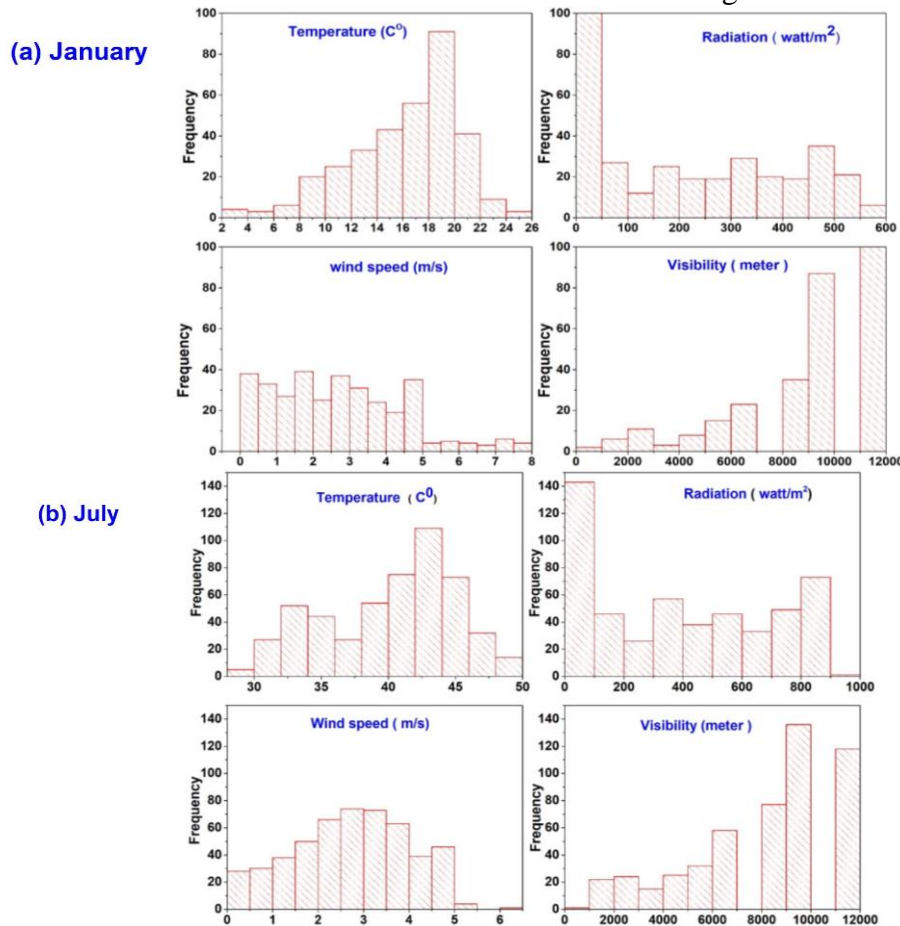


Figure 3. Frequency distribution of observed atmospheric element (temperature, solar radiation, wind speed, atmospheric visibility at (a) January. (b) July months.

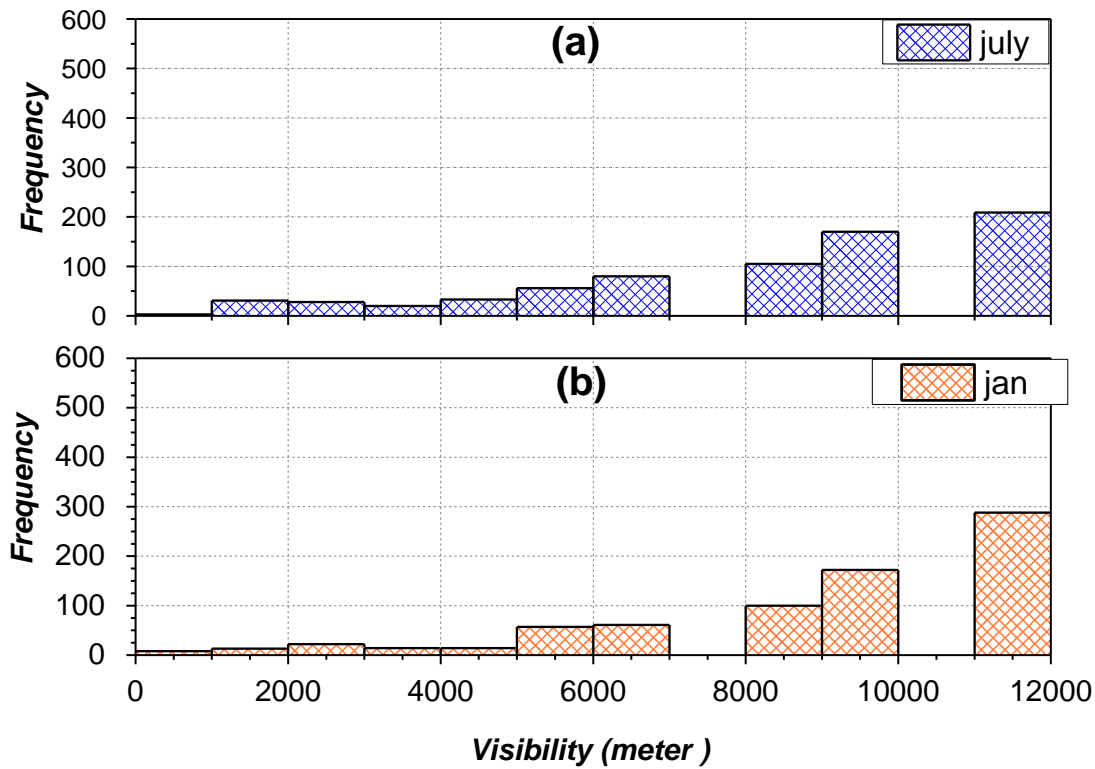


Figure 4. frequency of observed visibility at (a) July and (b) January months.

Atmospheric visibility according to stability classes is plotted in Fig. 5, this figure also taken conditions of atmospheric elements for all observed data (Jan. and July). Where the atmospheric elements on the y axis with the visibility on the x axis Represents the relationship between the atmospheric elements (temperature, relative humidity, wind speed, and solar radiation) according to atmospheric stability classes. Where the atmospheric stability is more stable, the better the extent of visibility and all known that most of the atmospheric elements work to destabilize the stability, causing a clear effect on the extent of the range of visibility. For example, in class (A-B) wind speed is low with high in solar radiation, resulted most condition of visibility to higher that 8000meter, this due to vertical movement of atmosphere and turbulent because the convection. Condition will change in stability class B because wind speed increases and atmospheric stability will transform to effect on

horizontal force, and visibility will become bad. In stability class D condition

Visibility greatly changed to below 2000meter, in this class wind speed is very large Table 1. Overall, in this case it can be say that the most effect of stability on visibility is from the mechanical turbulent according to classification of the stability and the most effect class of the visibility is neutral condition and near neutral condition, but you may determine the location if there is sources of emission pollutant or aerosol near to observed site. Wind speed also may be having the opposite effect on visibility from dissipation pollutant concentration is diluted in atmosphere. Many work for stability classes calculation over Baghdad done see references [10,11].

Most local and global previous study don't deal directly with stability classes, but divided stability to stable and unstable condition some time neutral conditions consider as unstable.

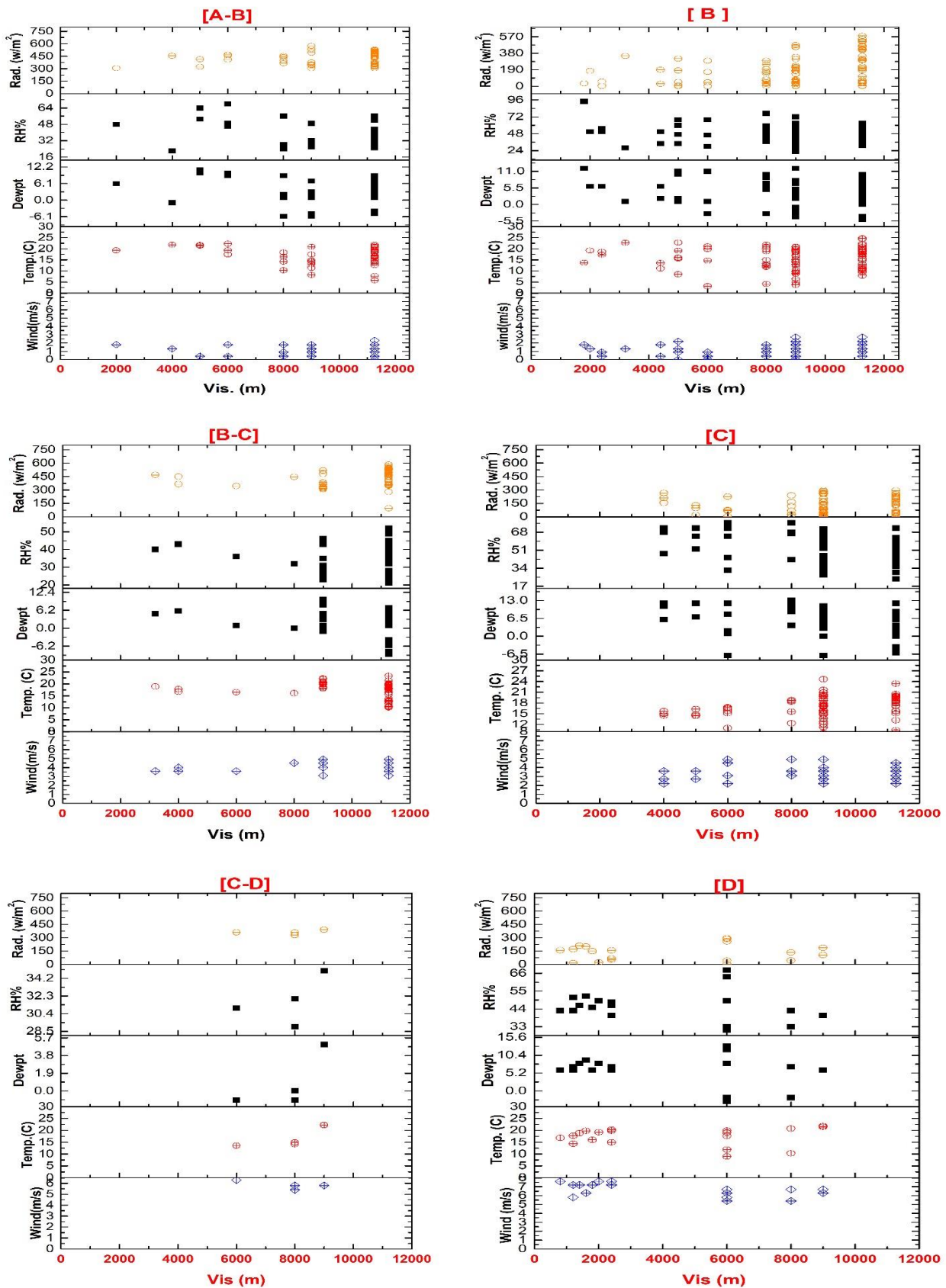


Figure 5. The influence of weather factors at specified stability conditions on the range of visibility.

Most local and global previous study don't deal directly with stability classes, but divided stability to stable and unstable condition some time neutral conditions consider as unstable. Particulate matter

and pollutant concentration ruled largely by stability conditions, for example Wang F. [15]. notes there is high responded of the pollutant concentration such as CO, SO₂ and NO_x and also

the secondary pollutant to the atmospheric stability, and the most extreme events occurred in winter, and at the morning periods, were most stability classes is in stable condition this case will be responsible to the low values recorded of visibility. Relationship between visibility and pollutant concentrations calculated statistically (multiple nonlinear regression) by Ahmed F. [16], over Baghdad city through the comparison with wind speed and temperature solar radiation and other atmospheric elements where empirical equation resulted. Xue D. [6], study the relationship between visibility and atmospheric element related to atmospheric stability in shanghai city (china), visibility have negative correlated with pollutant such as NO₂, CO, PM_{2.5}, PM₁₀ and so, while under the meteorological condition of high temperature and wind speed the visibility in shanghai reached to 25km, visibility decrease to 16km under low wind speed weather type and temperature and relative humidity. Overall results show that low visibility over Shanghai was mainly due to the high air pollution concentrations associated with low wind [17].

CONCLUSION

This study considers first one to relate between the aerodynamic movement of air parcel and important element that refer to air quality (visibility). Atmospheric visibility can change according to many elements but the active one is the air motion. This motion related to atmospheric stability that depends on the vertical and horizontal air flow. In this study data of wind speed consider as horizontal motion and solar radiation as thermal convection consider as vertical motion used in classification according to Pasquill - Turner, in addition to other atmospheric element also tested. This study explain that Stability class B, C has a large average in hourly frequency distribution while stability class A, A-B have no distributions in this period. Stability class B and A-B have a high rate of 60% during the summer month, as well as other unstable classes such as A that did not appear during this period in winter month (January) .In the summer month temperature is most valuable, and solar radiation is the domain of a frequency distribution. In winter (month) the frequency distribution of high

wind speed is have large range, while it is weak in summer. This study reached to conclusion that the most effect atmospheric stability classes on the visibility is class D because the mechanical turbulent where wind speed at this class is very large see table 1.

the results of this study is real in atmosphere if you assumed that there is not founded sources of pollutant and dust storm and there is also not effect of the synoptic element, and the results will different according to stability condition and stability classes F and G will direct proportional with visibility.

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