JOURNAL OF KUFA–PHYSICS
www.uokufa.edu.iq/journals/index.php/jkp | ISSN: 2077–5830

Using Sun Fits images for calculation of terrestrial aerosol optical depth (AOD) and Ångström turbidity parameters in countryside of Kufa district

* **Hayder Hasan Jawad** **Aref Saleh Baron**

Physics Department, Faculty of Science-Kufa University, Iraq.

*Corresponding Author E-mail: hayderh.albaghdadi@uokufa.edu.iq

ARTICLE INF

Article history:
Received: 05 FAB, 2020
Revised: 15 MAR, 2020
Accepted: 06 JUN, 2020
Available Online: 30 SEP, 2020

Keywords:

Arosol optical depth
Angstrom turbidity
Angstrom exponent

ABSTRACT

Since there are no previous studies conducted for calculating Kufa turbidity parameters considering that the urban pollutions is less than that of the Kufa city. For this The prior location of the Faculty of science telescope was chosen to make such observation using a 60 mm solar telescope Coronado of $H\alpha$ filter equipped with CCD DSI III pro connected to laptop computer .

Sun Fits images were captured under a clear sky as well as dusty conditions. Two types of images were classified, one in the clear sky and the other in dusty weather. Matlab code was used to estimate sun intensities in order to calculate aerosol optical depth and Ångström turbidity parameters from sun images. These values are expressing the normality behavior with nearer places in territorial region.

DOI: http://dx.doi.org/10.31257/2018/JKP/2020/120203

استخدام صور Sun Fits لحساب العمق البصري للهباء الأرضي (AOD) ومعلمات التعكر Ångström في ريف منطقة الكوفة

*حيدر حسن جواد عارف صالح بارون

قسم الفيزياء، كلية العلوم ، جامعة الكوفة ، العراق

الكلمات المفتاحية:

العمق البصري للهباء الجوي
عكارة انجستروم
الأس أنجستروم

الـــخُـــلاصـــة

يعتبر قضاء الكوفة من المناطق التي لم تتم فيها دراسات سابقة لمعاملات العكورة وحيث ان التلوث الحضري يقل كلما ابتعدنا عن المدينة فقد تم اختيار المكان السابق لمرصد كلية العلوم لإجراء الارصاد باستخدام تلسكوب كاسر شمسي نوع كورونادوا قطر عدسته 60 mm مزود بفلتر شمسي نوع $H\alpha$ مع كاميرا فلكيه نوع DSI III pro مربوطة مع حاسوب محمول .

صنفت الصور الشمسية الملتقطة والتي حفظت بامتداد Fits لمجموعتين حسب الظروف

الجوية لالتقاطها حيث تضمنت المجموعة الاولى الصور الملتقطة خلال ظروف جوية صافية فيما كانت المجموعة الثانية قد التقطت في جو مغبر واستخدم برنامج بلغة الماتلاب لغرض استخلاص الشدة الشمسية من الصور ومن ثم تم حساب كل من العمق البصري لدقائق الغبار ومعاملات انكستروم للعكورة ، حيث كانت القيم المحسوبة متوافقة مع القراءات لاقرب منطقه جغرافية .

1. INTRODUCTION

Sun represents the main source of the light to the earth so its intensity could be used as turbidity reference for the atmosphere as it dim under the weather extinction effects upon the light. This therefore included the influence of absorption and scattering due to the solid or liquid particles suspended in the atmosphere which called aerosol and gas[1]. Whereas the terrestrial atmospheric layers within the interest of research, so the gas effect will be excluded and the aerosol influence will be left [2], where that aerosol dealing is called the primary aerosol which is emanated into the atmosphere by the wind effect when it lift the dust particle in the barren regions[3]. Aerosols at ten sites in northwestern desert of China are studied using aerosol optical depth (AOD) $\tau(\lambda)$ and Ångström turbidity parameters [4]. Also the variations of aerosol optical depth and Angstrom parameters at a suburban location in Iran has been investigated[5]**.** In Iraq the atmospheric turbidity has been inquired [6] as well as the effect of aerosol optical depth upon Ångströms parameters have been achieved [7], the Kufa district are absents in previous studies of turbidity , and where it lies in the important region of the middle east Euphrates at Najaf which means close to the western desert , so its aerosol investigation are important. In this work a new method was used for calculating the aerosol optical depth (AOD)(the aerosol extinction arise from both scattering and absorption) $\tau_{a\lambda}$ and Ångström turbidity parameters, β and α by using the monochromatic flexible image transport system (FITS)[8] of sun as indicator for scattering and absorption which happened by aerosol at the former location of Faculty of Science in Al Qazwiniya campus 25 m over sea level at a distance of 20 km north to the Kufa.

2-THEORETICAL PART

The attenuation that took place in the earth atmosphere which affects sunlight could be attributed to the scattering and absorption that caused by aerosols and gas molecules according to its wavelength these effects could be gathered mono chromatically by the relation[9].

$$\tau_\lambda = \tau_{R\lambda} + \tau_{a\lambda} + \tau_{g\lambda} + \tau_{w\lambda} \quad \text{----------(1)}$$

The total monochromatic atmospheric extinction can be represented by τ_λ where $\tau_{R\lambda}$, $\tau_{a\lambda}$, $\tau_{g\lambda}$, $\tau_{w\lambda}$ are molecular scattering (Rayleigh) optical thickness , the extinction result from scattering and absorption by aerosol(aerosol optical depth) , the absorption optical depth due to atmospheric gases (gas) and water vapour optical thickness ,in which the selected wavelength is $(0.6563\mu m)$ therefore the absorption of the most atmosphere components such as molecules, gas and water vapour can be ignored [9] , so the relation (1) will be reduced to the following:

$$\tau_\lambda = \tau_{a\lambda} \text{ ----------(2)}$$

On the other hand relation (2) can be written with embedded scattering and absorption phenomena as follows[10].

$$\tau_\lambda = \tau_{a\lambda} = \beta \frac{\lambda}{a_0}^{-\alpha} \text{ ----------(3)}$$

Where,$(a_0 = 1\mu m)$ is easy a multiplier for dimensional uniformity were introduced, (α) is the Angstrom exponent that is related to the size distribution of the aerosols, (λ) the wavelength

in μm and (β) is the Angstrom turbidity and equal to aerosol optical depth, at $1\,\mu m$ wavelength also it varies with latitude and altitude according to an empirical relationship[11].

$$\beta = [0.025 + 0.1\cos^2\phi]e^{-0.7h} \text{ ----------(4)}$$

Where ϕ , h are the latitude and the height in km above sea level.

However the Beer Lambert - Bouguer law involve these parameters as well as the spectral irradiance before and after the extinction we can put it in the form [9].

$$I_\lambda = I_{o\lambda}e^{-\tau_\lambda m_r} \text{----------(5)}$$

Where $I_{o\lambda}$, I_λ , m_r represent the spectral irradiance before and after the extinction and the relative air mass which is expressed as[12],[13].

$$m_r = [cos\, z + 0.15(93.885 - z)^{-1.253}]^{-1}(\frac{P}{1013.25}) \text{ ----------(6)}$$

Where z the solar zenith angle in degrees and P is the local pressure in mbar.

3-EXPERIMENTAL PART

3-1 Instruments

The system which was used comprise of (Solar Max II 60 Dedicated H-α Telescope) Coronado solar telescope of 60mm diameter, Focal Length - 400mm and f-Ratio - f/6.6 with alt -azimuth mounting equipped with Etalon $H\alpha$ filter of a wavelength (656.3nm) and a DSI Pro III MEADE CCD camera with specification listed in Table(1)[14],[15].

Table (1) specification of (DSI Pro III MEADE) CCD camera

Model	DSI Pro III
Resolution	1360×1029
Colour	Black and white
Gain	$0.25\, e^-/ADU$

3-2 DATA COLLECTION

At 20 km north to the Kufa and 25 m over sea level height in the former location of Faculty of Science in Al Qazwiniya campus (32.1125N,44.3778E) as shown in Figure (1) ,the image of the sun was captured using the DSI - Coronado solar telescope system during two days. These images were classified into two groups first one in the clear sky at(2/2/2011) and the second one during stormy weather at (9/2/2011) with registered weather conditions as in Table (2) using the system that mentioned previously and saved in FITS type as shown in Figure (2).

Figure (1) the geographical location of Al Qazwiniya campus

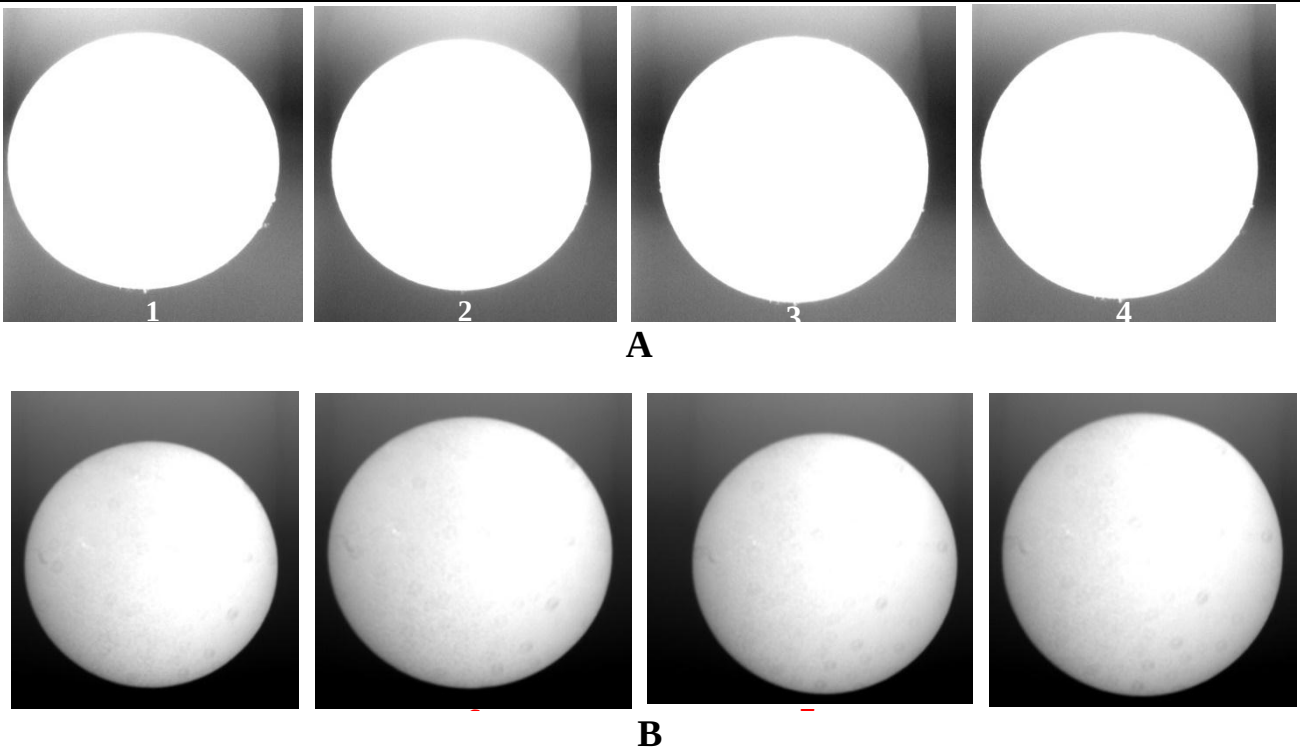

Figure (2) A &B- set of sun images in clear sky condition and during stormy weather

Table (2) weather conditions during images capture

Weather elements	**2/2/2011(11.0 am) clear sky**	**9/2/2011(10.0 am) stormy weather**
Temperature (C°)	10.8	9.2
Atmospheric pressure ($mbar$)	1010	1012
Humidity	0.84	0.86
solar zenith angle(degrees)	27.9557	36.6938

4-Data analysis

These groups of images were treated by Matlab code in order to extract the absolute intensity of the sun disc at the filter wavelength ($0.6563\mu m$) ,the relative air mass were computed according to the relation (6) , the total monochromatic atmospheric extinction(aerosol optical thickness) , the Angstrom turbidity and the Angstrom exponents was computed using of the following relations (5),(4) (3), all these are arranged in Tables (3),(4).

Table (3) extracting intensities from images

A- set		**B- set**		$I/I_{\circ}$	$ln(I/I_{\circ})$
Image number	Intensity($I_{\circ}$)	Image number	Intensity(I)		
1	65535	5	49880	0.7611220721	-0.27296152
2	65535	6	46306	0.7065842679	-0.34731280
3	65535	7	37523	0.5725642786	-0.55763027
4	65535	8	42080	0.6420996414	-0.44301178

Table (4) atmospheric calculations results

m_r	τ_λ	$\tau_{\lambda_{ave}}$	β	α	α_{ave}
1.1858	0.247272971	0.3460052	0.09506352	2.269919209	2.99699
	0.292893496			2.671964306	
	0.37359771			3.249853132	
	0.470257002			3.796230275	

Nevertheless, there are no previous studies for aerosol optical depth (AOD) and Ångström turbidity parameters calculation in the area under consideration, so that the nearest area studies were used for comparison purposes.

The values of AOD that estimated are expressing the normality behavior in comparison with that which were computed by [7] in spite of these studies were carried out in locations that slightly far from Kufa this study is unique to AOD as being the first of its kind in Iraq this century as well as the method has been used is unprecedented in that field Table (5).

Table (5) comparison data of other local calculations

Parameters	Present work	Baghdad [7]	Basrah [7]
aerosol optical thickness	0.3460052	0.4672	0.4289
the Angstrom turbidity	0.09506352	-	-
the Angstrom exponent	2.99699	-	-

5- CONCLUSIONS

The narrow band width of the filter $H\alpha$ which about (0.07nm)[14]and its central wavelength lead to avoid much undesirable absorption which perform for make the result small accuracy.

Since the value of the Angstrom exponent were greater than 2. This refer to that the aerosol were at fine mode and the particles diameters were around $1\mu m$ so maybe classified as urban pollution [16] and this could be arise from the soil particles of windblown [17].

The Angstrom turbidity is less than 0.1 which mean that the atmosphere are relatively clear [18] this could be attributed to the area of research located in rural area.

2. REFERENCES

[1] L´opez, G. and Batlles, f.g. (2004) Estimate of the atmospheric turbidity from three broad-band solar radiation algorithms. A comparative study. Annales Geophysicae 22, 2657–2668.

[2] Killinger, D.K. et al. (1995) Hand of Optics, 2nd edn., McGRAW-HILL , INC .

[3] Chandrasekar, A. (2013) Basics of atmospheric science, PHI Learning Private Limited.

[4] Yu, J. et al. (2015) Investigation of Aerosol Optical Depth (AOD) and Ångström Exponent over the Desert Region of Northwestern China Based on Measurements from the China Aerosol Remote Sensing Network (CARSNET). Aerosol and Air Quality Research 15, 2024–2036.

[5] Khoshsima, M. et al. (2014) Variations of aerosol optical depth and Angstrom parameters at a

suburban location in Iran during 2009–2010. J. Earth Syst. Sci. 123 (1), 187–199.

[6] Abdul-Wahid, S.N. et al. (2008) An investigation of atmospheric turbidity of sixteen Iraq. Journal of Kerbala University 6 (6), 118-121.

[7] AL-Salihi, A.M. (2018) impact of aerosols optical depth on Ångström exponent and microphysical properties of clouds over iraq. ARPN Journal of Engineering and Applied Sciences 13 (5), 1887-1899.

[8] McLean, I.S. (2008) Electronic imaging in astronomy detectors and instrumention, 2nd edn., Springer.

[9] Cuomo, V. et al. (1993) Determining Ångström's Turbidity Coefficients: An Analysis with a Wide-Range Grating Spectrometer. Acrosol Scicncc and Technology 18, 59-69.

[10] Aljawi, O. et al. (2018) Estimation of the Angstrom Turbidity Parameters in the Ultraviolet Spectrum over Bangi, Malaysia. Asian Journal of Scientific Research 1 (11), 118-125.

[11] Mani, A. et al. (1969) A Study of Angstrom's turbidity parameters from solar radiation measurements in India. Tellus 6 (XXI), 829-843.

[12] Kasten, F. (1966) A new table and approximate formula for relative optical air mass. Arch. Metorol. Geophys. Bioklimatol 14, 206-223.

[13] Iqbal, M. (1983) An Introdiction to Solar Radiation, 1st edn., Academic Press.

[14] Solar Max® II Series manual in: Corp, M.I. (Ed.) 2010.

[15] MEADE Deep Sky Imager the basics black and white Pro II manual, in: Crop, M.i. (Ed.) USA, 2007.

[16] Ekere, V.O. et al. (2017) Assessment of Atmospheric Turbidity and Attenuation Coefficients for Efficient Visibility Estimation in Makurdi-North Central Nigeria. Mind Sourcing.

[17] Hinds, W.C. (1999) Aerosol Technology properties , behaivor ,and measurment of airborne particles, second edition edn., JOHN WILEY & SONS, INC.

[18] Akpootu , D.O. and Momoh, M. (2013) The Ångström Exponent and Turbidity of Soot Component in the Radiative Forcing of Urban Aerosols. Nigerian Journal of Basic and Applied Science 21 (1), 70-78.