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Study the effect of position on the time of astronomical twilight

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Abstract:
Twilight is that light appear on the horizon before sunrise and after sunset, Astronomically it is known that sunrise and sunset are effected by high above sea level, but the effect of high above sea level on the time of astronomical twilight still not decided and controversy among astronomers, in This research we studies the effect of high above sea level on the time of astronomical twilight, through adding the equation correct high above sea level to equation computation of twilight and then calculate of changing in the time of twilight for different highest (0-10000) meters above sea level , and the ratio of increase for time with high between (15.45-20.5) minutes. It was found that there was an increase in the time of the twilight along the year when increasing high above sea level and that surely effected time of astronomical twilight with high above sea level, but this effect is strong for high to 2000 meters and then high effect will be less to increasing the time of twilight.

Key words: astronomical twilight, effect position on twilight, time twilight.

Introduction:

The effect time of twilight by high above sea level still not decided. and controversy among astronomers, recalled Mohamad "Twilight influence important on the Islamic schedules change with the rise but not well known [1].

And Ilays mention that the increase elevation above sea level atmospheric will decrease then of thickness and scatter and thus influence on the time of twilight [2].

While Scheffer stressed has not been affected by the time of twilight rise above sea level [3].

In this research was to examine the impact of rising sea level on the time of astronomical twilight, by adding the equation correct elevation above sea level to the expense of twilight and thus the expense of changing the time of twilight of different altitudes above sea level the observer.

Theory:

The calculation of the time of twilight are done through the following steps [5.4]:

1 – Calculation of Julian date (JD) for A.D (Y, M, D) purposed calculating the time of twilight on it, and then calculates the centuries Juliana (T) of history Julian (JD) as follow:

$$T= (J.D-2415020)/ 36525 \qquad (1)$$

2 -The rate of solar longitude (L) is defined by:

In addition to L1 corrections due to the effect of the planets I1, I2, I3, I4, I5 is a calculated by follows:

$$L1=279.69688 + 36000.76892\ T + 0.0003025\ T^2 \ \ldots (2)$$

The Solar Longitude (L) will be after the additions of the above corrections are:

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L=L1+ 0.00134 cos (I1) + 0.0015 cos (I2) + 0.002 cos (I3) + 0.00179 sin(I4) + 0.00178 sin(I5) … (3)

3 - The Solar Mean Anomaly (M) is given by [5.4]:

$M=358.47583 +35999.04975 T - 0.00015 T^2 - 0.000033 T^3$ …(4)

4- The value of center of the Sun (C) is given by [5.4]:

$C = \{0.91946 - 0.004789 T -0.000014 T^2\}\sin(M) +\{0.020094-0.0001 T\} \sin(2M) + 0.000293 \sin(3M)$ …(5)

5 - The value of the in Longitude ecliptic of the Sun (λ) can be calculated [5.4]:

$\lambda= L+C-0.00569-0.00479 \sin(w)$ …(6)

Since (w) given by the relation

$W=259.18 +1934.142 T + 0.00207 T^2+2.2 \times 10^{-6} T^3$ …(7)

6 - The sun ecliptic coordinates (λ) must be convert to Equatorial coordinates by [5.4]:

$E = \varepsilon + 0.00256 \cos (w)$ … (8)

ε is the inclination eclipse circle (Obliquity) and given by the following:

$\varepsilon=23.452294-0.0130125T-0.00000164 T^2 +5.63 \times 10^{-7} T^3$ … (9)

7 - calculation of the value of two factors (X) and (Y)to calculate equatorial coordinates by the relations [5.4]:

$Y= \cos (E) .\sin(\lambda)$ …(10)

$X =\cos (\lambda)$ … (11)

8 - The sun declination (δ) can be calculated as follow [5.4] :

$\delta = \sin^{-1} \{\sin(E).\sin(\lambda)\}$ … (12)

9 - Calculation of the value of hour angle to the sun at sunset and sunrise by the following relationship [5.4]:

$H_1 = \cos^{-1}\{\tan (\Phi) .\tan (\delta)\}$ ...(13)

Since Φ Latitude of the observer.

10 - To correct elevation above sea level (h) meters by adding the following:

A- The value of lower horizon (D) in degrees for observer at high (h) above sea level calculated by [3]:

$$D = 0 .02917^{o} \sqrt{h} \quad …(14)$$

B- Correcting refractive ray (R) Special Areas of high degrees of the observer at a high (h) above sea level by [3]:

$$R= 0 .00061^{\circ} \sqrt{h} \quad …(15)$$

Thus the total correction (DR) resulting from the high of sea level (h) m (total two corrections and b) is given by [3]:

$$DR= 0.035333^{\circ} \sqrt{h} \quad …(16)$$

11- The Value of Azimuth angle corrected (Z) can be calculated from add the correct elevation above sea level (DR) to Azimuth angle ° 108 (end of Twilight Time)

$Z = 180^{o} + DR$ …(17)

12- The value of Hour angle to the sun for Azimuth angle corrected (Z) can by calculated by [5,4]:

$$H_2=\cos^{-1}\left\{\frac{\cos(Z).\ \sin(\Phi).\sin(\delta)}{\cos(\Phi).\cos(\delta)}\right\} …(18)$$

13 - The time of astronomical twilight (t) is calculated by [5.4]:

$t=\{ H_2 - H_1 \}/ 15$ (in hours) …(19)

14- Greenwich (GMT) multiply value (0.99727), is given by [5]:

$T= (0.99727) . t$ … (20)

15 - The value of time of astronomical twilight (T) Limited between (0 – 24) hours, then multiplication in 60 to convert units to the minutes[6].

Results:

In this work a computer program has been builted to calculate the time of astronomical twilight, using the relationships described in the theoretical part, and after insure the validity and accuracy of results, comparing results with the global astronomical tables [7], calculated in a period of astronomical twilight of different altitudes above sea level rise (0-10000)m Using corrections elevation above sea level and latitude are different (0, 30 and 45), and the results were as illustrated in Table-1-. After that we draw changes of time astronomical twilight with the high a above of sea level as in Figure-1-.

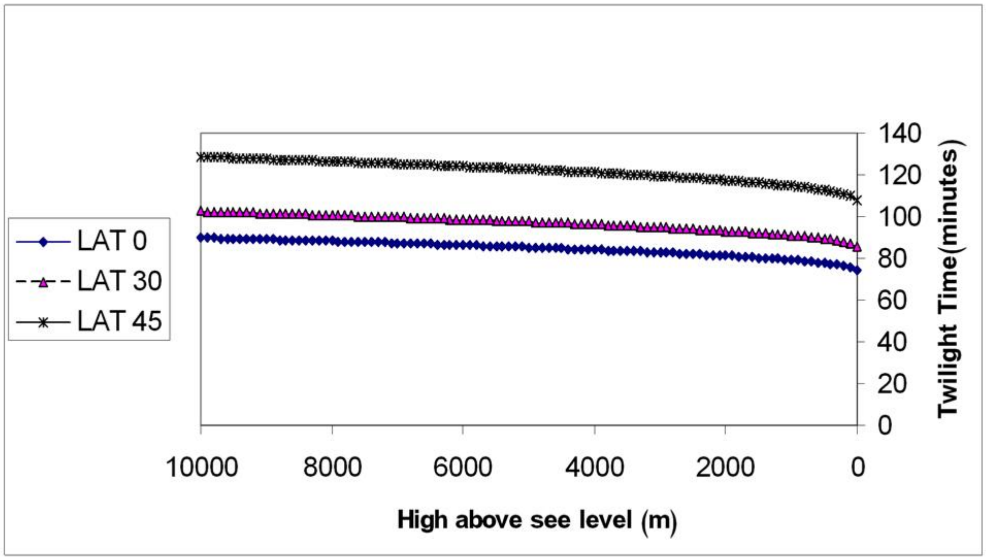

Figure (1) represented change Twilight time With high above see level.

Table-1-: Changes the time of astronomical twilight with the rise of sea level.

LAT 45	LAT 30	LAT 0	HIGHT
108.152721	85.57991938	74.35503	0
110.214199	87.27887192	75.90215	100
111.067176	87.98214327	76.54317	200
111.721331	88.52160212	77.03512	300
112.27257	88.97626598	77.44991	400
112.758041	89.37674157	77.81538	500
113.196796	89.73872583	78.14583	600
113.600153	90.07154342	78.44973	700
113.975486	90.38126988	78.73262	800
114.327916	90.67212528	78.99834	900
114.661174	90.94718221	79.24968	1000
114.978073	91.20876023	79.48875	1100
115.280802	91.45866141	79.7172	1200
115.571099	91.69831882	79.93632	1300
115.850375	91.9288944	80.14718	1400
116.119792	92.15134574	80.35065	1500
116.380321	92.36647314	80.54745	1600
116.632785	92.57495353	80.73821	1700
116.877884	92.7773656	80.92344	1800
117.116226	92.97420864	81.1036	1900
117.348337	93.16591702	81.27909	2000
117.574679	93.35287141	81.45025	2100
117.79566	93.53540766	81.6174	2200
118.011642	93.71382384	81.78079	2300
118.222948	93.88838595	81.94067	2400
118.429866	94.05933255	82.09727	2500
118.632658	94.22687854	82.25077	2600
118.83156	94.39121836	82.40135	2700
119.026787	94.55252859	82.54918	2800
119.218532	94.71097017	82.6944	2900
119.406976	94.8666903	82.83714	3000
119.592282	95.01982398	82.97752	3100
119.7746	95.17049542	83.11567	3200
119.95407	95.31881919	83.25167	3300
120.13082	95.46490126	83.38564	3400
120.30497	95.60883982	83.51766	3500
120.47663	95.75072615	83.64781	3600
120.645903	95.89064518	83.77617	3700
120.812886	96.02867617	83.90281	3800
120.977668	96.16489319	84.0278	3900
121.140333	96.29936559	84.1512	4000
121.300961	96.4321584	84.27307	4100
121.459626	96.56333274	84.39348	4200
121.616397	96.69294607	84.51246	4300
121.77134	96.82105255	84.63007	4400
121.924517	96.94770329	84.74635	4500
122.075987	97.07294655	84.86135	4600
122.225805	97.196828	84.97512	4700
122.374023	97.31939089	85.08768	4800
122.520692	97.44067622	85.19908	4900
122.665858	97.56072292	85.30936	5000
122.809567	97.67956796	85.41854	5100
122.95186	97.79724654	85.52666	5200

LAT 45	LAT 30	LAT 0	HIGHT
123.09278	97.91379215	85.63375	5300
123.232364	98.02923671	85.73983	5400
123.370649	98.14361069	85.84494	5500
123.507672	98.25694315	85.94911	5600
123.643464	98.36926189	86.05235	5700
123.77806	98.48059345	86.15469	5800
123.911489	98.59096329	86.25616	5900
124.043781	98.70039575	86.35678	6000
124.174964	98.80891418	86.45656	6100
124.305066	98.91654097	86.55553	6200
124.434113	99.02329761	86.65371	6300
124.56213	99.12920474	86.75112	6400
124.68914	99.23428221	86.84777	6500
124.815167	99.3385491	86.94368	6600
124.940234	99.44202376	87.03888	6700
125.064361	99.54472387	87.13336	6800
125.18757	99.64666646	87.22716	6900
125.30988	99.74786794	87.32029	7000
125.43131	99.84834414	87.41275	7100
125.551879	99.94811035	87.50457	7200
125.671605	100.0471813	87.59575	7300
125.790506	100.1455712	87.68632	7400
125.908597	100.2432939	87.77628	7500
126.025895	100.3403626	87.86564	7600
126.142416	100.4367903	87.95442	7700
126.258175	100.5325893	88.04263	7800
126.373186	100.6277718	88.13027	7900
126.487463	100.7223494	88.21737	8000
126.601021	100.8163334	88.30393	8100
126.713872	100.9097347	88.38995	8200
126.82603	101.0025641	88.47546	8300
126.937507	101.0948318	88.56045	8400
127.048315	101.1865478	88.64494	8500
127.158466	101.2777219	88.72894	8600
127.267971	101.3683634	88.81246	8700
127.376841	101.4584815	88.89549	8800
127.485088	101.5480851	88.97806	8900
127.592722	101.637183	89.06017	9000
127.699752	101.7257834	89.14183	9100
127.80619	101.8138945	89.22304	9200
127.912043	101.9015244	89.30381	9300
128.017323	101.9886808	89.38415	9400
128.122038	102.0753711	89.46407	9500
128.226197	102.1616028	89.54357	9600
128.329808	102.247383	89.62266	9700
128.432881	102.3327187	89.70135	9800
128.535423	102.4176166	89.77964	9900
128.637442	102.5020834	89.85753	10000

Discussion and Consolation:

From Figure 1, which represents the time of behavior change Astronomical twilight with high above sea level and latitude (0 °), and (30 °), and (.45 °), we find that:

1- General behavior for curve changed of the time of astronomical twilight with the high above of sea level at three latitudes its one, that time of twilight begins increase when the rise high above of sea level are clear, then at the height (2000) meters start giving the curve increase in the time of astronomical twilight will change little with the high above sea level.

2- There was an increase in the time of twilight of three latitude when increasing high above sea level from (0 to 10000) meters, and this increase for latitude (0) is (15.45) minutes, and for latitude (30) is (17) minutes, and for a latitude (45) is (20.5) minutes.

The reason for this increase in the time of twilight is the high above sea level, which affects the refraction of sunlight and the value angle to the sun at the horizon due to down horizon as shown in equations (14) to (18) of the theory

3- we found difference in the time of twilight between the latitudes of the three ranges difference between the latitude of 0 and 30 (11.2 - 12.7) minutes, and the difference between the latitude of 0 and 45 (30 - 38.8) minutes. The reason for this difference is the difference in three latitudes, which affects the value of hours of sun angle as shown in equations (13) and (18) of the theory.

4- Less time for time of twilight Astronomical be in the equator (latitude 0) and at different heights have increased the time of twilight greater latitude north and south of the equator.

5- The increase in the time of the time twilight along the year when increasing high above sea level confirms the effect of time of astronomical twilight of high above sea level, but this effect is will be more at highest to 2000 meters and then high effect will less at increase the time of twilight.

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دراسة تأثير ارتفاع الموقع على مدة الشفق الفلكي

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الخلاصة:

الشفق (Twilight) هو الإضاءة التي تظهر في الأفق قبل شروق الشمس وبعد غروبها، من المعروف فلكياً أن شروق الشمس وغروبها يتأثران بالارتفاع عن مستوى سطح البحر، لكن تأثر مدة الشفق بالارتفاع عن مستوى سطح البحر مازال غير محسوم ومثار جدل ما بين الفلكيين، تم في هذا البحث دراسة تأثير الارتفاع عن مستوى سطح البحر على مدة الشفق الفلكي، وذلك بإضافة معادلة تصحيح الارتفاع عن سطح البحر إلى معادلة حساب الشفق ومن ثم حساب تغير مدة الشفق لارتفاعات مختلفة(0-10000) متر عن سطح البحر، وان نسبة الزيادة في الزمن مع الارتفاع تتراوح ما بين(15.45-20.5) دقيقة. كما وجد أن هناك زيادة في مدة للشفق على طول السنة عند زيادة الارتفاع عن مستوى سطح البحر والذي يؤكد على تأثر مدة الشفق الفلكي بالارتفاع عن مستوى سطح البحر، لكن هذا التأثر يكون قويا في الارتفاعات إلى 2000 متر ثم بعد ذلك يقل تأثير الارتفاع ذلك على زيادة مدة الشفق.