Case report

Statistical study of the solar eclipses over Egypt during 20 centuries (1–2000)

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ABSTRACT

During solar eclipses the scientists can be observe and studying the solar atmosphere. The stratified structures of the solar atmosphere are mainly the photosphere, the chromosphere and the corona.

In this work we used the Least Square (LS) method to investigate the statistical study of the solar eclipses during 20 centuries (1–2000). We found the formula for total number of every types of solar eclipse. We get the frequency distribution of all eclipses for 20 centuries over Egypt; the percentage ratio for partial solar eclipse is 43.2%, while the percentage ratio for the annular solar eclipse is 30.1%, and the percentage ratio for total and hybrid solar eclipses are 22.3% and 4.4% respectively.

The General Linear Trend formula for predicting the future values for every types of solar eclipse was obtained and determined during next 500 years (2001–2500). We compare our results with calculated once by NASA for each types of solar eclipse. Our results are in a good agreement with that published by NASA.

1. Introduction

At any given location, total eclipses will only recur on average every 375 years and are thus extremely rare events.

Eclipse events are highly predictable, given our knowledge of the mathematics of celestial mechanics, but this advantage may not have been enjoyed by the ancient Egyptians. Solar and lunar eclipses occur in regular cycles, known as the "Saros", a fact that was well known in antiquity (Neugebauer, 1957).

Apparently, when an eclipse terrified the soldiers of Alexander who were fighting the Persians under Darius, appeal was made to the explanations of an Egyptian priest to calm the panic that overcame the troops (Sauneron, 2000).

Foley (1989) used a statistical study to investigation the solar eclipse records from 26 Dynastic Histories of China, from 204 B.C. - 1621 A.D., and the Korean records from 1009–1621 A.D., and found the solar eclipse records are interesting and tell a great deal about the Chinese and Korean approach to astronomy in the pre-telescopic era. The eclipse efficiency can act as a guide to the quality of their astronomical records as a whole. The sunspot records are mainly affected by the solar activity variations but the observing efficiency plays a significant role when the solar activity variations are stable {neither at a maximum nor a minimum nor fluctuating wildly}.

The history books of East Asia about Astronomical phenomena have the more records of the solar eclipse frequently than any other ones. It is because traditionally, the solar eclipse meaned the fate of dynasty and the king's rule (Youn Sook and Yong Sam, 2004).

Han and Qiao (2009) studied the perception, observations and recording of solar and lunar eclipses in the ancient Chinese astronomers. They found that the ancient Chinese astronomers used the solar and lunar eclipses to assess and improve calendars, so they carefully observed and studied the movement of the celestial body in the solar system as well as the theory of solar and lunar eclipses.

Marzouk et al. (2016) investigated the Solar Eclipses During Four Centuries (1601–2000) and found that the percentage ratio

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for partial solar eclipse is 35.707%, while the percentage ratio for the annular solar eclipse is 31.166%, and the percentage ratio for total and hybrid solar eclipses are 26.522% and 6.605% respectively. And found a new formula for predicting the future values of all types of the solar eclipse types (partial, annular, total and hybrid).

In the present paper, we used the solar eclipses data occurrence over Egypt from NASA solar eclipse atlas. We applied the Least Squares (LS) method to find the general trend for each types solar eclipse occurrence over Egypt during 20 centuries (1–2000), the frequency distributions of each type of solar eclipses over Egypt are obtained. Then we calculate the forecasting of the future eclipses over Egypt for all types of solar eclipse during 5 centuries (2001–2500), and compared with published by NASA website.

2. Data used and method of analysis

We selected the path of every solar eclipse types (Annular, Partial, Total and Hybrid) data occurrence over Egypt from the NASA solar eclipse atlas at website: "http://eclipse.gsfc.nasa.gov/SEatlas/SEatlas.html#2CE" to find the formula for total number of every types of solar eclipse, this site contain the solar and lunar eclipses path for the past and the future.

We used the Least Squares (LS) method to find the general trend, which we used the time as "Independent Variable" and find series for all eclipse number, and each types of solar eclipse.

The general linear trend equation is:

$$\hat{y} = \hat{a} + \hat{b}x \tag{1}$$

where $\hat{a}$ is the cute distance from horizontal axis, $\hat{b}$ is the slope, and $\hat{y}$ is the "the estimated value for phenomena trend", x is the time (which $x = 1$ for first series, $x = 2$ for second series…etc., every series = 100 years). The first from 1–100, the 2nd from 101 to 200, …, and so on.

If we apply the Least Squares (LS) method in equation (1) we can get to:

$$\hat{b} = \frac{\sum xy - n\bar{x}\bar{\bar{y}}}{\sum x^2 - n\bar{\bar{x}}^2} \tag{2}$$

$$\hat{a} = \bar{\bar{y}} - \hat{b}x \tag{3}$$

From Eqs. (2) and (3) we can find the estimation values for $\hat{a}$, $\hat{b}$, then substitute in equation (1) to get the future values for every type of solar eclipses.

3. Results and discussions

As we showed, we used the Least Squares (LS) method to find the general trend; before we apply this method we calculated the frequency distribution of all types of solar eclipse over Egypt during 20 centuries (1–2000).

Table 1 shows the frequency distribution of Annular eclipse for twenty centuries, while Table 2 shows the frequency distribution of total eclipse for twenty centuries, the frequency distribution of hybrid eclipse for twenty centuries shown in Table 3, the frequency distribution of partial eclipse for twenty centuries shown in Table 4,

Table 2
The frequency distribution and percentage ratio of total eclipse for 20 centuries (1–2000).

Centuries	Total frequency	Percentage ratio (%)
1–100	2	4.35
101–200	2	4.35
201–300	1	2.17
301–400	3	6.52
401–500	3	6.52
501–600	2	4.35
601–700	5	10.87
701–800	1	2.17
801–900	1	2.17
901–1000	2	4.35
1001–1100	1	2.17
1101–1200	5	10.87
1201–1300	3	6.52
1301–1400	2	4.35
1401–1500	2	4.35
1501–1600	3	6.52
1601–1700	0	0
1701–1800	2	4.35
1801–1900	5	10,87
1901–2000	1	2.17
Sum	46	100

Table 1
The frequency distribution and percentage ratio of Annular eclipse for 20 centuries (1–2000).

Centuries	Annular frequency	Percentage ratio (%)
1–100	5	8.06
101–200	2	3.23
201–300	2	3.23
301–400	3	4.84
401–500	2	3.23
501–600	5	8.06
601–700	4	6.45
701–800	0	0
801–900	4	6.45
901–1000	2	3.23
1001–1100	5	8.06
1101–1200	5	8.06
1201–1300	4	6.45
1301–1400	4	6.45
1401–1500	4	6.45
1501–1600	0	0
1601–1700	2	3.23
1701–1800	2	3.23
1801–1900	4	6.45
1901–2000	3	4.84
Sum	62	100

Table 3
The frequency distribution and percentage ratio of hybrids eclipse for 20 centuries (1–2000).

Centuries	Hybrids frequency	Percentage ratio (%)
1–100	2	22.22
101–200	0	0
201–300	0	0
301–400	0	0
401–500	0	0
501–600	0	0
601–700	0	0
701–800	0	0
801–900	0	0
901–1000	0	0
1001–1100	1	11.11
1101–1200	0	0
1201–1300	0	0
1301–1400	2	22.22
1401–1500	0	0
1501–1600	1	11.11
1601–1700	1	11.11
1701–1800	2	22.22
1801–1900	0	0
1901–2000	0	0
Sum	9	100