Variations of Temperature Over Jeddah During Recent Solar Cycle

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ABSTRACT. This paper studies the temperature variations during the last three decades in Jeddah, Saudi Arabia. Part of this variation is thought to be due to solar activity parameters; in here we will discuss sunspot numbers. For this purpose, we started with a theoretical representation for the variations in the mean temperature and sunspot number during the years from 1990 to 2000 over Jeddah. In this respect, and by utiliziug Fourier series, the results are very accurate in sueh a way that the calculated and the observed variations for hoth temperature and sunspots are typically identical. A result which is optimistic for obtaining accurate prediction formulae for climatical parameters.

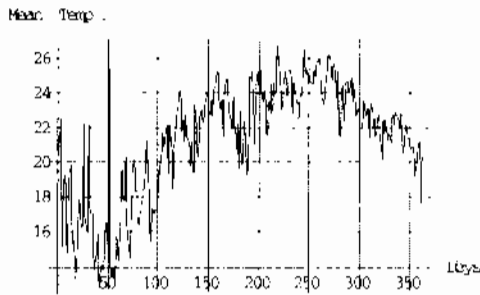In addition, we investigated the changes in the air temperature of Jeddah which is clearly evident for the available data, that ranges from 1977-2003. A preliminary conclusion indicates that there is a general increasing trend in the average temperatures during the recent three decades, reaching up to 1 degree Celsius. A very good correlation has been found between the annual temperatures and the length of the sunspot cycle.

1. Introduction

One of the most important and active issues in solar physics is understanding solar activity and predicting climate changes as well as their interactions, which in fact are found to be strongly related. Different attempts have been made over the years to link various aspects of solar variability to changes in the Earth's climate. There has been growing interest in this possible connection in recent years, spurred largely by the need to understand the natural causes of climate change, against which the expected global warming due to man's activity will have to be detected, (Lean and Rind 1996, Soon *et al* 1996, Ogurtsov *et al* 2002, Friis-Christensen 2001).

Many scientists have observed correlations between the solar magnetic activity, which is reflected in the sunspot frequency, and climate parameters at the Earth. Sunspots have been recorded through several hundreds of years which makes it possible to compare their variable frequency to climate variations to the extent that reliable climatological records exist, (Mosalam 1993, Hansen 2000).

It has been noticed that there is a general increasing trend in the solar activity from the start of the 20th century till now, i.e. there is an increase in the total solar irradiance, and the solar proton events, which lead to decrease in the cloudiness and increase in the

atmospheric transparency. Thus, leading consequently to an increase in the air temperature, as well as in the sea level, where the south of the Mediterranean sea (North Africa and Arabian Peninsula) will become dry and high, (Mosalam 1990 and 1993). For that reason, studying the variability of the solar activity from space and ground base is very important to know the role of the sun on climatic change. Therefore, we will discuss in this paper the relation between the sunspots and the temperature variations over one of the cities located at the west coast of Saudi Arabia, namely Jeddah.

In the present paper, we started the 1st phase of our study by devoloping the variation of the the mean temperature during the years from 1990 to 2000 over Jeddah of Saudi Arabia. This will be achieved vie Fourier Series of the form ;

$$a_0 + \sum a_j \cos \frac{2\pi j(x - x_0)}{L} + \sum b_l \sin \frac{2\pi j(x - x_0)}{L}$$

where $L = x_1 - x_0$ is the fundamental period. Moreover, we devoloped the variation of the sunspots number during the above years utilizing the same techniqe. The results are very accurate, where we obtained the calculated variations for both tempereture and sunspots which were typically identical. This result is optimistic for obtaining accurate prediction formulea for the climatical parameters.

2. Numirical Results

In Figs. 1 and 2 the observed variations of the mean tempcreture and the sunspots number for different years for Jeddah are plotted with the calculated variations from Fourier serics. In both figures the above comparison has been shown for the whole period, i.c. from 1990 to 2000.

By looking into Fig.s 1 we could see that the observed variations and the calculated are very much identical. Meanwhile in Fig. 2, we could see the resembelance between the observed varaitions and the caleulated one for the complete period. In addition, there is an inerease in the mean temperature values near the years 1998 and 1999, i.c. near the maximum of the 23 solar cycles, which range from 1996-2006.
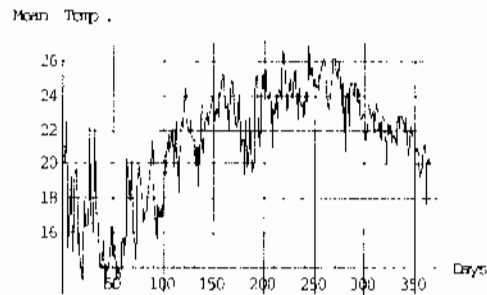
By analysing the temperature variations for Jeddah station , it is evedent that there is an increasing trend of a bout 1 degree in the air temperature (see Figure 3, and Table 1), which is considered to be a very significant increase. In Figure 4a, we have plotted both sunspot numbers for the period from 1970-2005, and in Figure 4b the annual and the smoothed temperature avarages of Jeddah during the period from 1977-2003. By ivestigating the correlation between the annual temperature avarages and the filtered length of the sunspot cyele (from Friis-Christensen and Lassen, 1991), Figure 5 shows a very good correlation reaching up to 0.71.

Year 1990

Year 1991

Year 1992

Year 1993

Fig. (1).   Mean Temperature during the years 1990 to 1992 for Jeddah city – Saudi Arabia

Year 1994

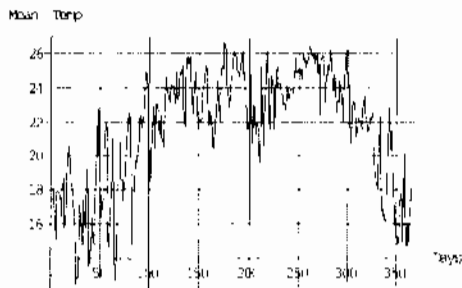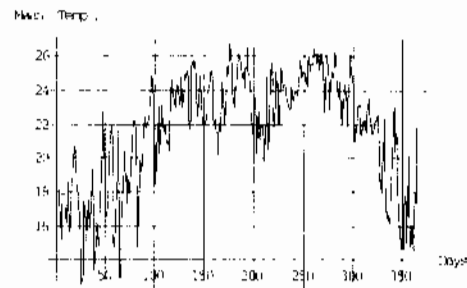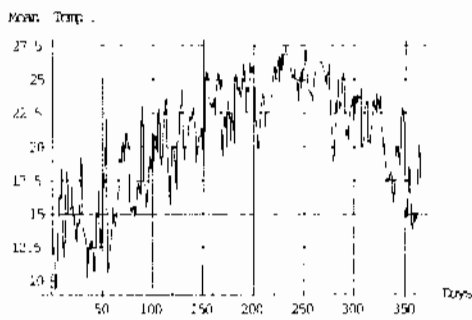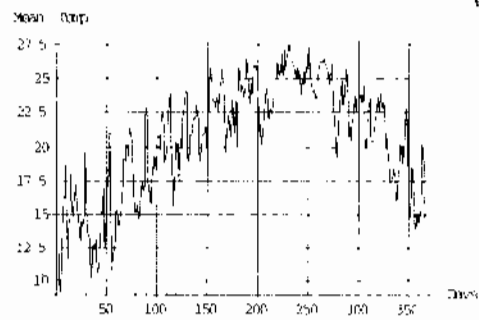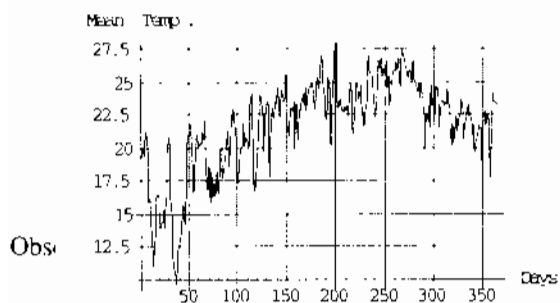Observed Variations   Calculated Variations from Fourier Series

Year 1995

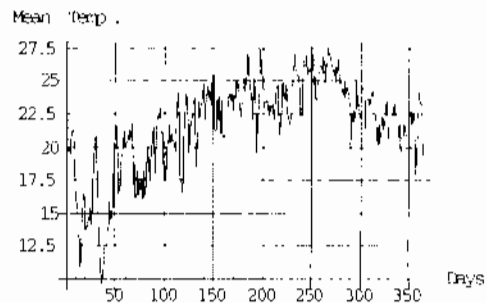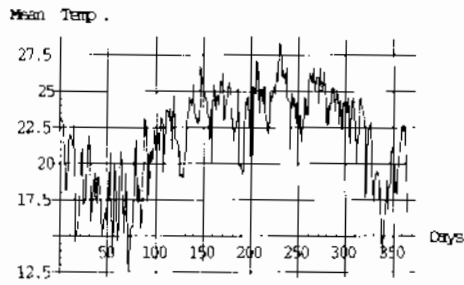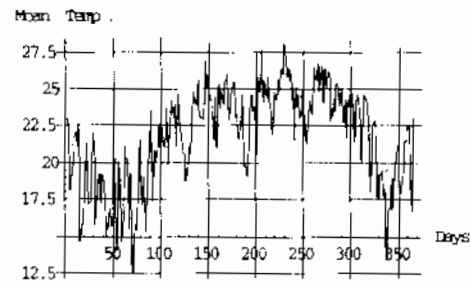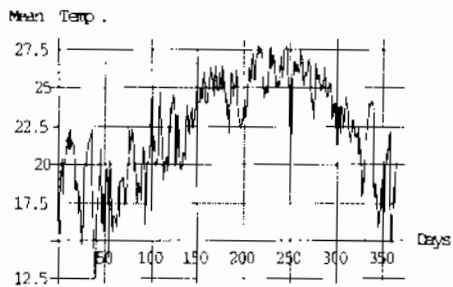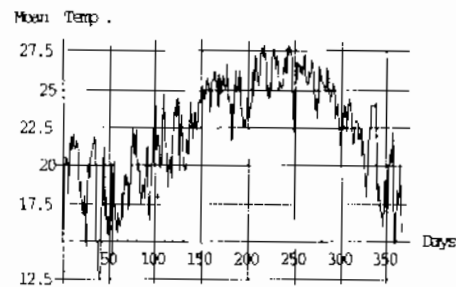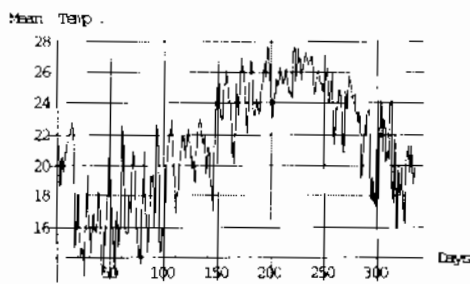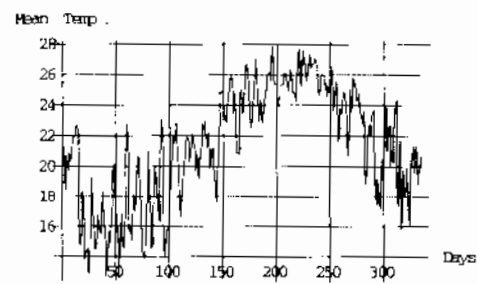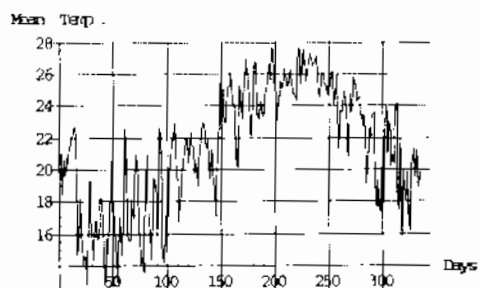Observed Variations   Calculated Variations from Fourier Series
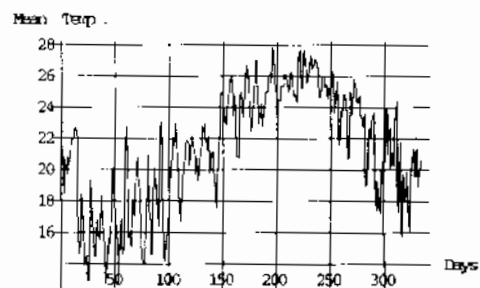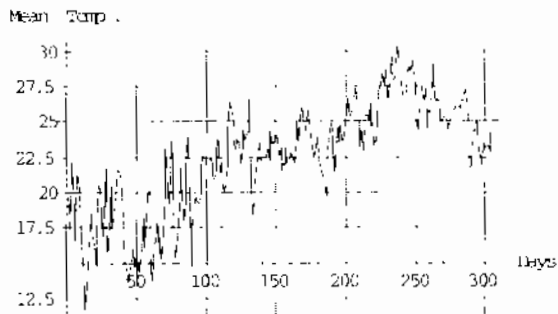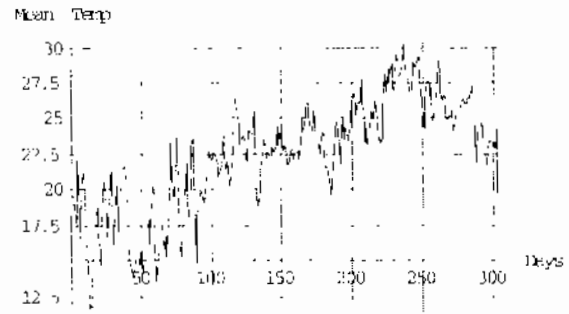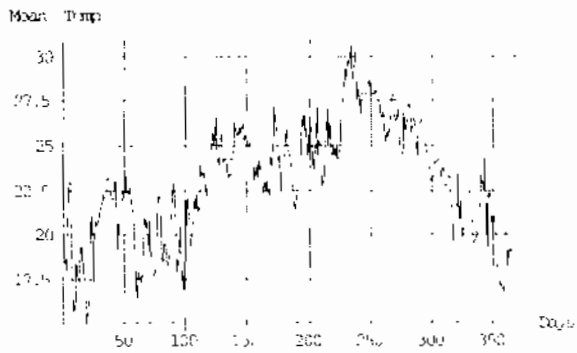
Year 1996

Observed Variations   Calculated Variations from Fourier Series

Year 1997

Observed Variations   Calculated Variations from Fourier Series

Fig. (1). (continue): Mean Temperature during the years 1996 to 1998 for Jeddah city – Saudi Arabia.

Year 1998

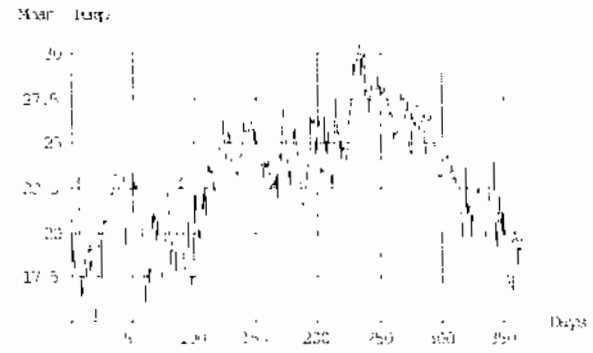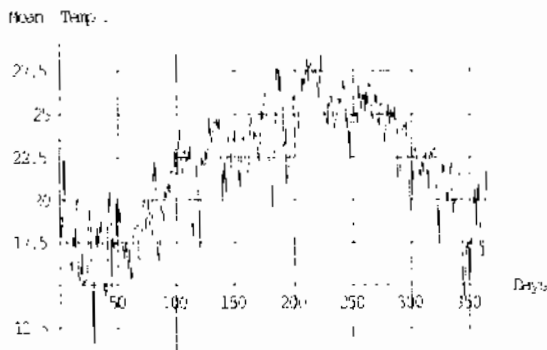Observed Variations

Calculated Variations from Fourier Series

Year 1999

Observed Variations

Calculated Variations from Fourier Series

Year 2000

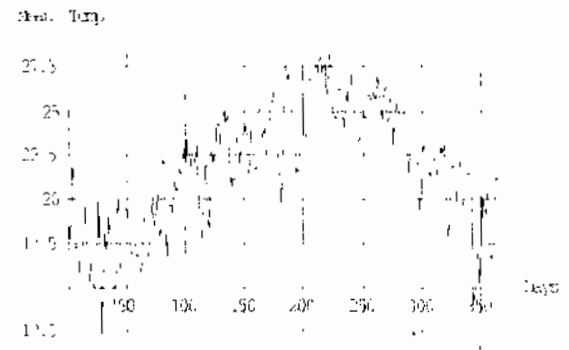Observed Variations
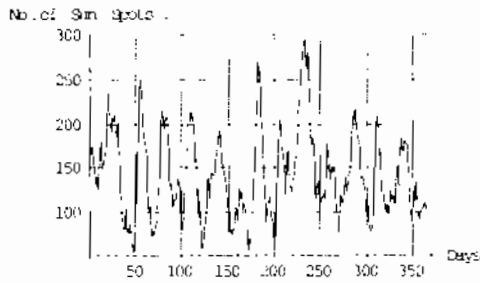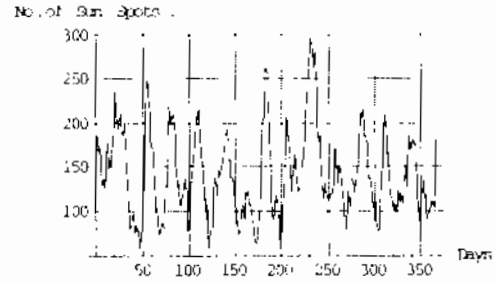
Calculated Variations from Fourier Series

Fig. (1). (continue): Mean Temperature during the years 1996 to 1998 for Jeddah city - Saudi Arabia.
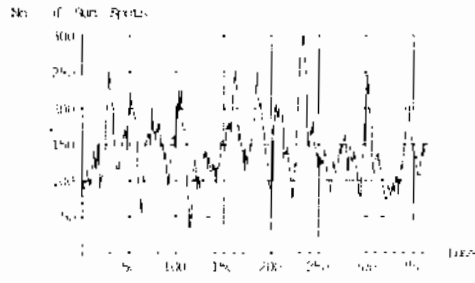
Year 1990

Observed Variations   Calculated Variations from Fourier Series
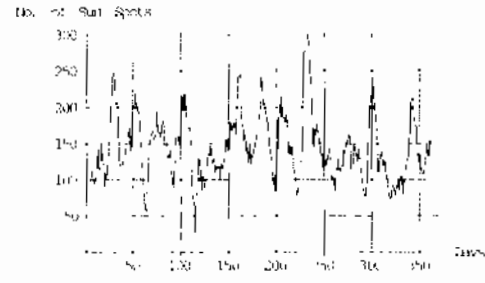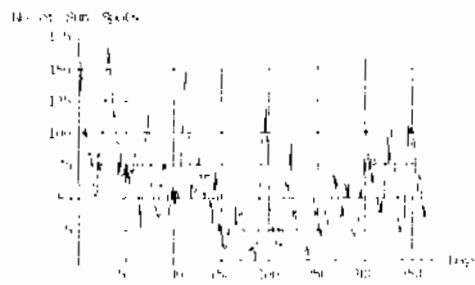
Year 1991

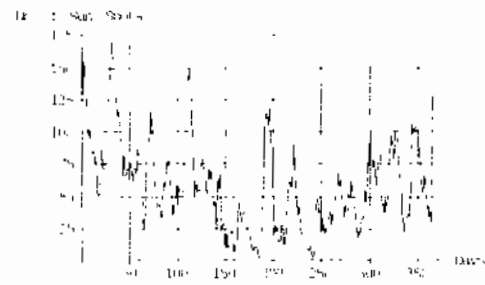Observed Variations   Calculated Variations from Fourier Series

Year 1992

Observed Variations   Calculated Variations from Fourier Series

Year 1993

Observed Variations   Calculated Variations from Fourier Series

Fig. (2)   Sunspots number for the years 1990-1992.

Year 1994

Observed Variations

No. of Sun Spots

Calculated Variations from Fourier Series

No. of Sun Spots

Year 1995

Observed Variations

No. of Sun Spots

Calculated Variations from Fourier Series

No. of Sun Spots

Year 1996

Observed Variations

No. of Sun Spots

Calculated Variations from Fourier Series

No. of Sun Spots

Year 1997

Observed Variations

No. of Sun Spots

Calculated Variations from Fourier Series

No. of Sun Spots
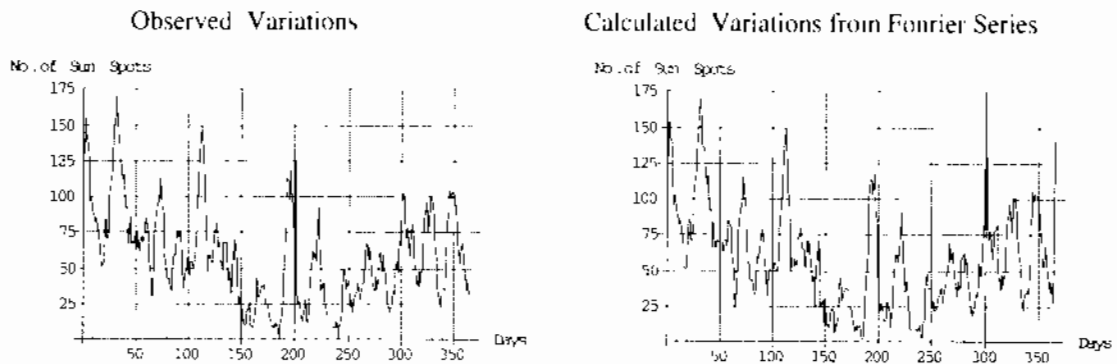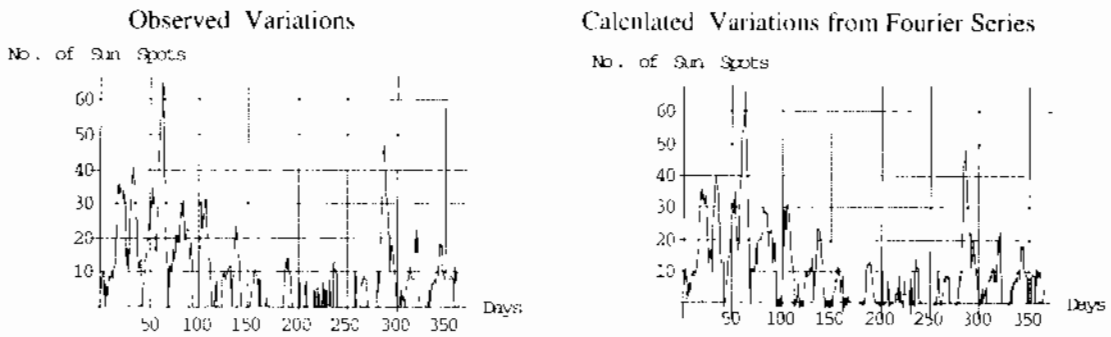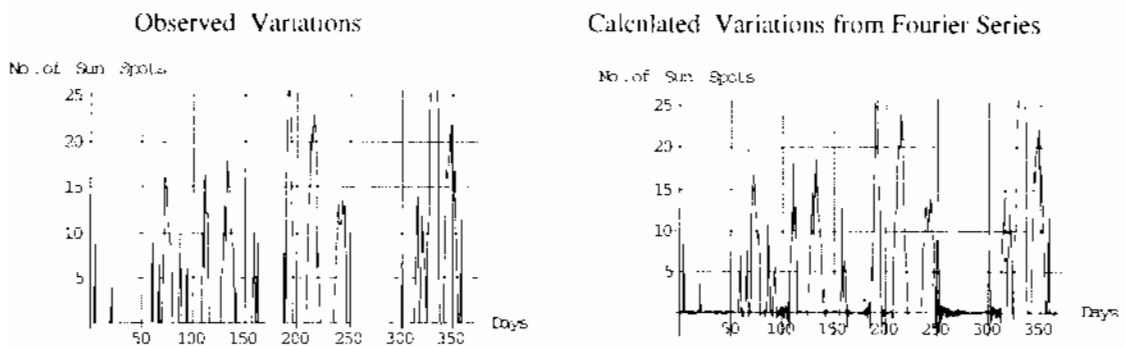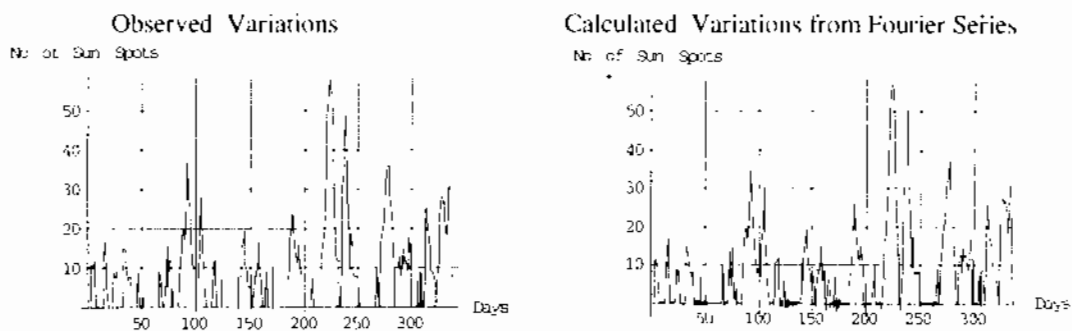
Fig. (2) (continue): Sunspots number for the years 1999-2000.

Year 1998

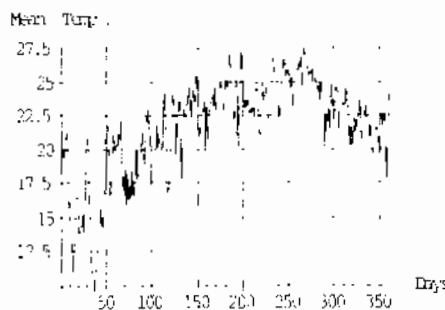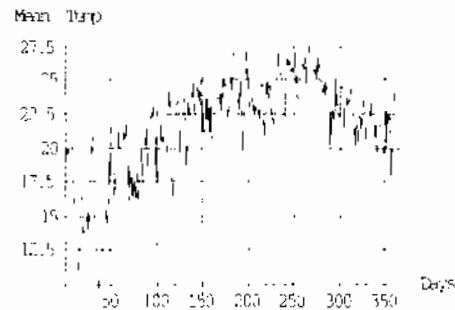Observed Variations   Calculated Variations from Fourier Series

Year 1999

Observed Variations   Calculated Variations from Fourier Series

Year 2000

Observed Variations   Calculated Variations from Fourier Series

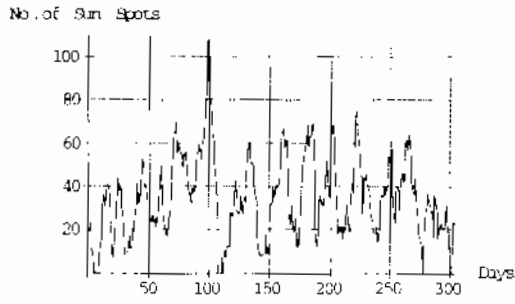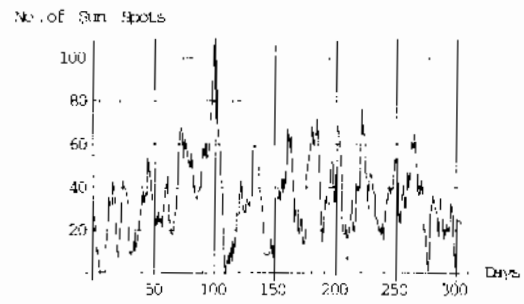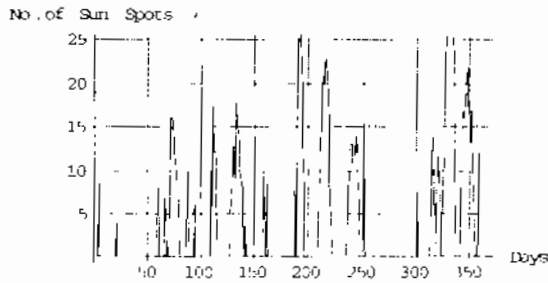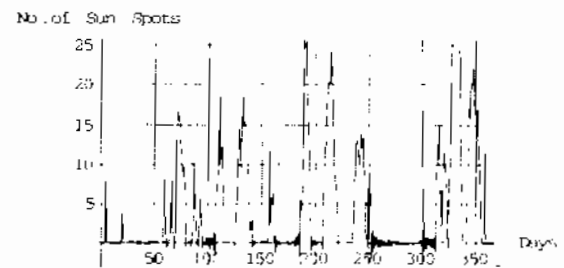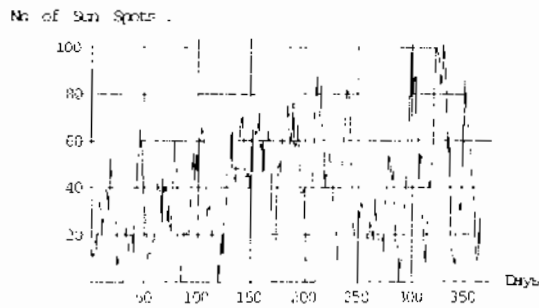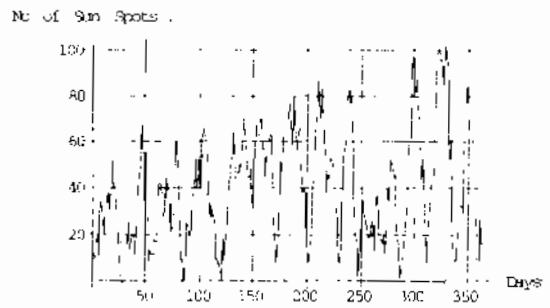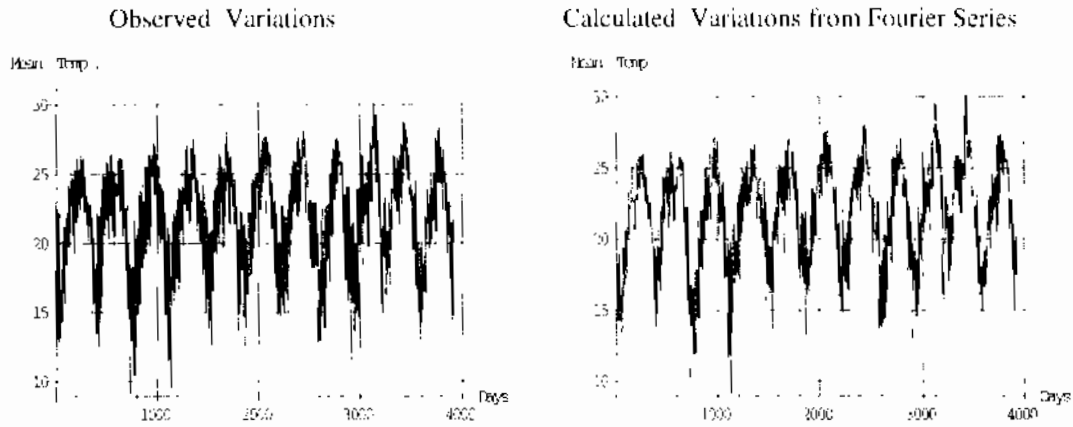Fig. (2).   (continue): Sunspots number for the years 1999-2000.

Mean Temperature During the Years 1990 to 2000 for Jeddah , Saudi Arabia

Observed Variations   Calculated Variations from Fourier Series

Sun Spots Number For the years 1990 to 2000

Observed Variations   Calculated Variations from Fourier Series
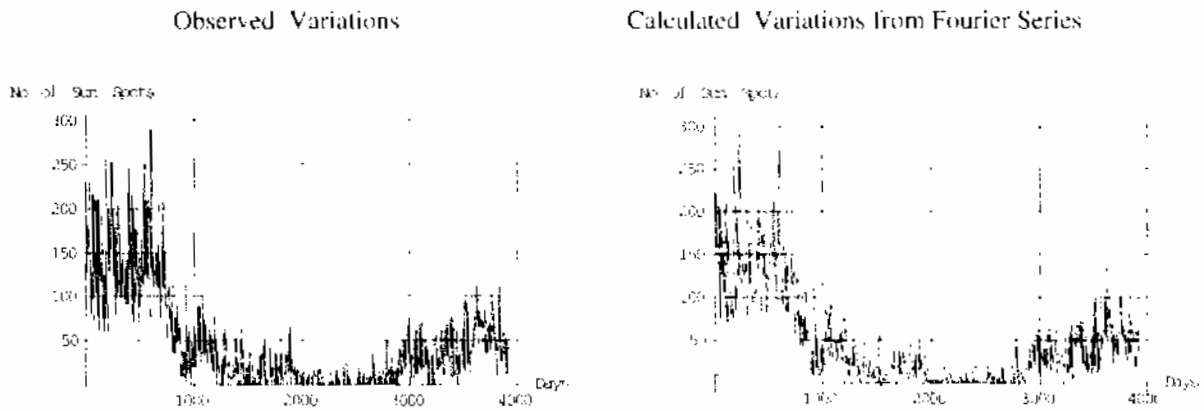
Fig. (2). (continue): Mean Temperature for Jeddah city, Saudi Arabia and Sunspots number during the years 1990-2000, for comparison .

Table (1). Average temperatures for the years 1977-2003 for Jeddah city.

Year	Average	Year	Average	Year	Average
1977	33.7555	1986	34.6063	1995	34.7732
1978	34.017	1987	34.9219	1996	34.7779
1979	34.457	1988	35.1235	1997	34.4984
1980	33.7781	1989	34.1104	1998	35.5559
1981	33.9989	1990	33.9027	1999	35.4304
1982	33.9304	1991	33.8518	2000	34.4675
1983	33.7666	1992	33.2915	2001	35.2923
1984	33.9683	1993	34.0033	2002	35.0507
1985	34.3885	1994	34.834	2003	35.8132

Temp . Variation of the Average Temp .
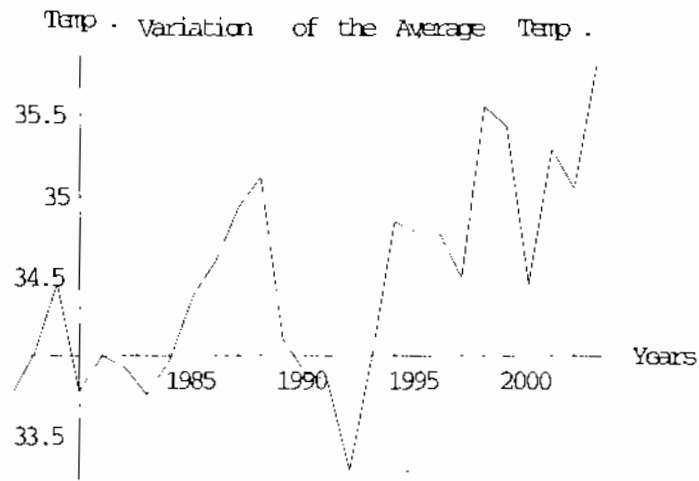
Graphics

Fig. (3).   Mean Temperature Trend in Jeddah Area During the Years: 1977 to 2003.

(1) The Given Base Functions are

$F_1=1$

$F_2=Tav$

(2) The Solutions and their Probable Errors

$c_1=-106.011\pm16.4324$

$c_2=0.053272\pm0.00825742$

(3) The Annual Rate of the Mean Temperature is

$=0.053272$ C° $\overline{y}$

(4) Graphical Representations

4-a Graph of the Raw Data
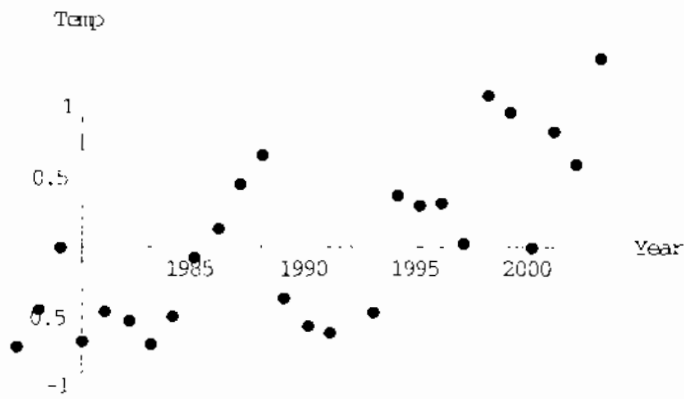
4-b Graph of the Raw and the Fitted Data
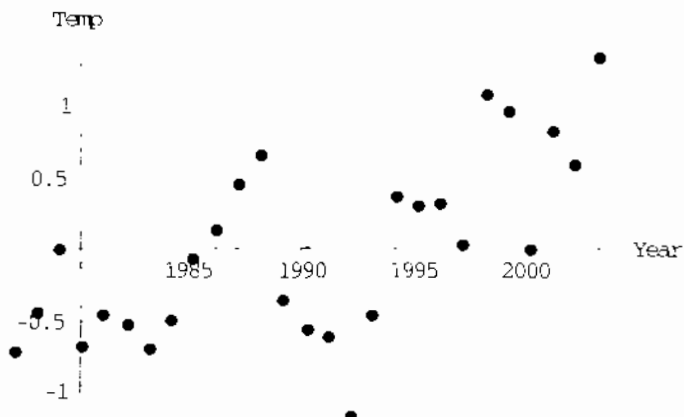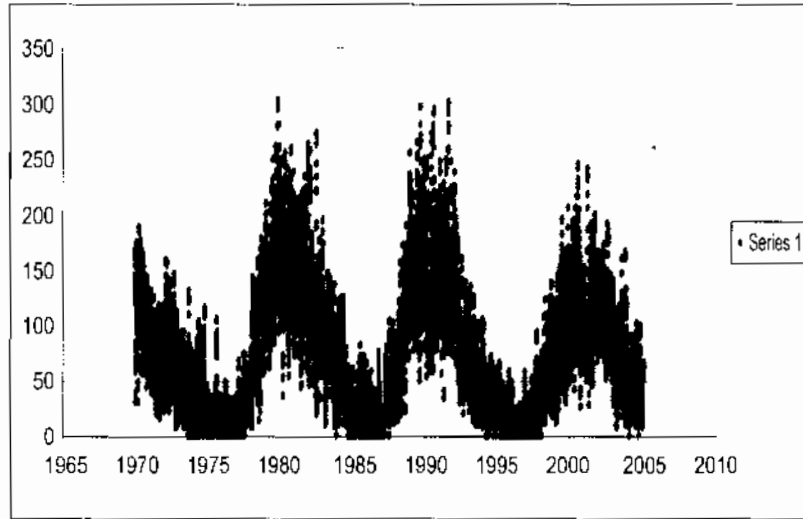
Fig. (4a). Sunspot number during the period from 1970-2005.

TEMP ANNAUL MEAN JEDDAH

Fig. (4b). Annual Temperatures (blue=smoothed) during the period from 1977-2003.

Fig. (5). Correlation between annual temperatures and the filtered length of the snnspot cycle (from Friis-Christensen and Lassen, 1991).

Conclusion

In concluding the paper, three main results are evident:

1- Full statistical analyses of the temperature variation during 26 years are established and available for Jeddah, Kingdom of Saudi Arabia.
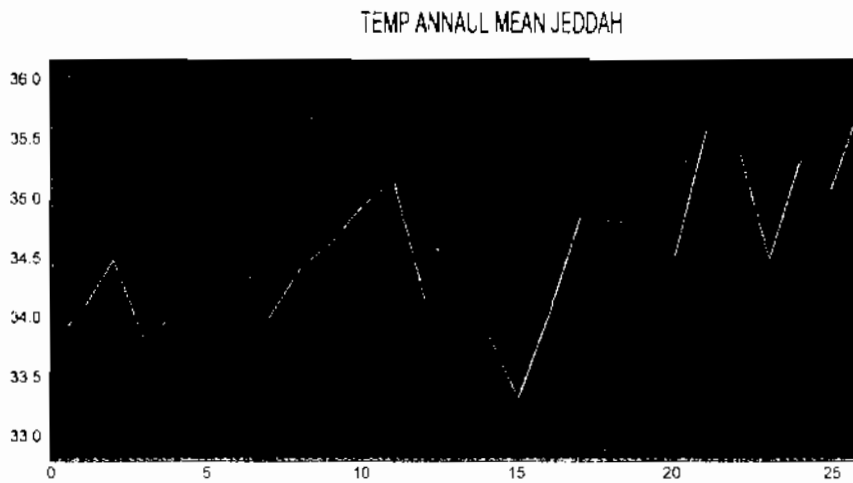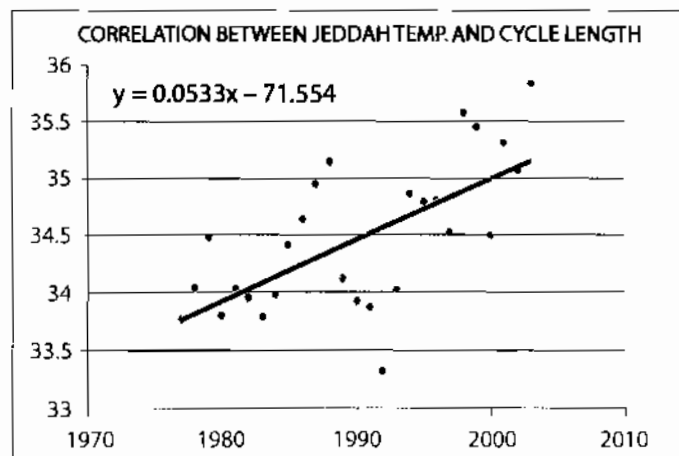
2- There exists amonotonic increasing trend in the temperature during that period of study reaching to one degree celsius.

3- There is a very good correlation between the temperature and the filtered length of the sunspot cycle.

Aknowledgments

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Mosalam Shaltout, M.A., *Proceedings of the International Conference on Applications of Time Series Analysis in Astronomy and Meteorology,* University of Padoua, Italy 6-10 September 1993, PP. 383-386, (1993).

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Soon, W., Posmentier, E., and Baliunas S., *Astrophysical Journal,* **472:** 891, (1996).

التغيرات في درجة الحرارة على جدة خلال دورة النشاط الشمسي الحالي

ياسين المليكي[1] ، عادل شرف[1]، حسن باصرة [1]، عبد الرحمن ملاوي[1]، زكي المصطفى[2].

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المستخلص. يناقش هذا البحث تغيرات درجة الحرارة لمدينة جدة بالمملكة العربية السعودية خلال العقود الثلاث الأخيرة والمتوفرة لدينا أرصادها لدينا. ويعتقد أن جزءاً من هذا التغير بسبب تغير معاملات النشاط الشمسي المختلفة، والتي سنناقش منها هنا البقع الشمسية فقط. لذا فقد بدأنا بدراسة العلاقة النظرية لتغير متوسطات درجة الحرارة وأعداد البقع الشمسية منذ عام ١٩٩٠–٢٠٠٠ . وباستخدام متوالية فورير وجد أن النتائج دقيقة جدا مما يجعل التغيرات النظرية والمرصودة لكل من الحرارة والبقع الشمسية متطابقة بشكل كبير.وهي نتيجة مشجعة للحصول على نماذج رياضية للمتغيرات المناخية.

وقد تم كذلك دراسة مدى التغير في درجة الحرارة خلال الفترة من عام ١٩٧٧–٢٠٠٣، والتي قد تم ملاحظتها بشكل كبير. وقد وجد أن هنالك ميل كبير للتغير في متوسطات درجة الحرارة خلال العقود الثلاثة والتي تصل لدرجة واحدة. كما وجد ارتباط كبير بين هذا التغير في الحرارة وبين طول دورة أعداد البقع الشمسية.