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Climatological Trend of Sea Surface Temperature Anomalies in the South Eastern Mediterranean Sea

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Abstract. The Linear and quadratic regressions have been used to investigate the relationship between SSTA and time (month or year) to get the general SSTA possible trends. Regardless the propaganda concerning increasing or oscillating of climate parameters. The present work depends on analyzing series of observed data (61 years, January 1948 to December 2008) for a limited geographic area (south eastern Mediterranean Sea in front of the Egyptian Mediterranean coast). The linear regression and model results reveal a trend of general decrease of SST with time in the order of about −0.3°C/61 years. The quadratic regression trend of the mean monthly and annual SST has a parabola form. The parabolas show a decrease in SST in the period from 1948 to 1985 then increasing forward. The present work may strengthen the suggestion of oscillating sea surface temperature (SST) with time rather than continuous increasing due to the so called global warming. The cycle of that oscillation must have a period much more than 61 years and may reach to centuries.

Keyword: Mediterranean, SSTA, Trend.

Introduction

The study of sea surface temperature anomaly (SSTA) is fairly essential for solving many meteorological and oceanographic problems (Heburn, 1985). The duration and wide occupation of SSTA gives the reason to study it as one of the main factors affecting climatic system of the earth (Fedrouich, 1985 and Levitus, 1995). Marullo *et al*. (2007) and Salat & Pascual (2007) studied the sea surface temperature trend in the

Mediterranean Sea, from daily to decadal variations. They suggested both increasing and oscillating of the mean sea surface temperature (SST) with time. For the sea, not only studies about hydrological trends but also studies about dense water formation and circulation must take into account the Interannual variability (Millot, 2007).

Maiyza (1984) and Maiyza *et al*. (1995) studied the long term variation of water temperature in the eastern and western Mediterranean Sea. Time distribution of SSTA values display both positive and negative cycles. The periods of these cycles fluctuated between 8 and 15 years. These cycles are nearly associated with the 11 year cycle of sun-spots activities (Maiyza *et al*., 2008).

In this paper, the linear and quadratic regressions have been used to investigate the relationship between SSTA and time (month or year) to get the general SSTA possible trends (increasing or decreasing temperature). In the present work the long period trends in series of SSTA (monthly and annual) are used as an indicator of temperature change regardless the present propaganda concerning increasing or oscillating of climate parameters. The work depends on analyzing series of observed data (61 years) for a limited geographic area (South Eastern Mediterranean Sea).

Data and Method of Analysis

The area under study is the south eastern Mediterranean Sea in front of the Egyptian Mediterranean coast (the southern part of the Levantine Basin). It lies between 30 50' - 33^{o}N and 25 - 34^{o}E basin (Fig. 1).

The vertical mean temperature of the upper 10 m layer is considered as SST to reduce the diurnal variations. The monthly mean sea surface temperature (T) is calculated for each $1^{o} \times 1^{o}$ grid (18 grids, Fig. 1) for every individual month in the period from January 1948 to December 2008 using the available historical WDC-A (Washington D C), WDC-B (Moscow) and Egyptian National Oceanographic Data Centre (ENODC) Data files. The mean monthly Sea surface temperature (T**) is obtained from the Climatological Atlas of the Mediterranean Sea (Maiyza *et al*., 1993). The monthly deviation from the mean **(ΔT_m)** is computed and considered as monthly SSTA for every grid.

$$\Delta T_m = T - T^{**} \quad (1)$$

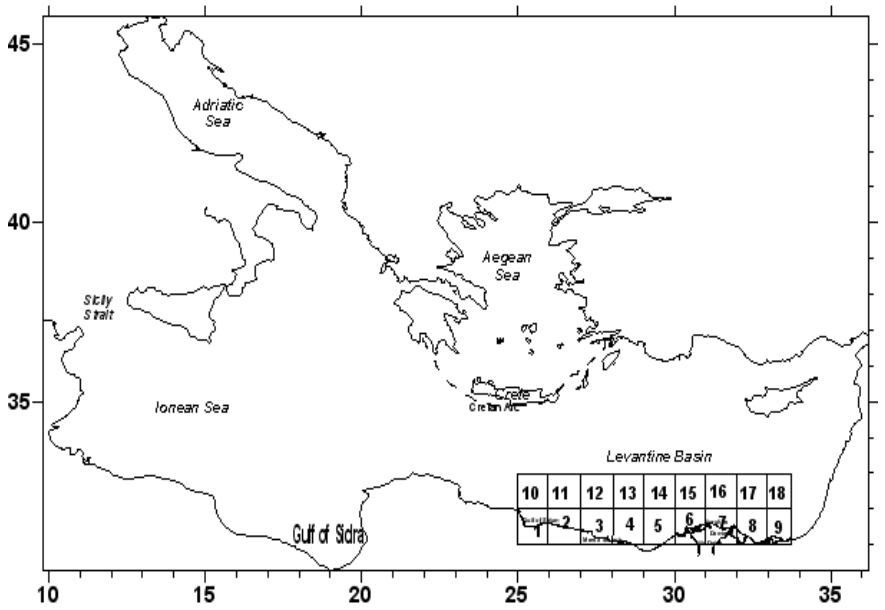

Fig. 1. Area of investigation, the south eastern Mediterranean sea.

The mean monthly SSTA of all grids is considered as the monthly SSTA of the area under study. Then the mean annual SSTA, for every calendar year, **(ΔT_a)** in the investigated period (1948-2008) are determined.

Linear and quadratic regressions have been used, on the calculated mean monthly SSTA and mean annual SSTA, to investigate and model the relationship between SSTA (Y^oC) and time (X; month or year) to get the SSTA possible trends through the period of investigation. The four regression equations for the long-term tendency of a SSTA series to rise or fall (upward trend or downward trend) were calculated and presented.

Results and Discussion

Figure 2(a,b) shows the linear regression and model the relationship between mean monthly and mean annual SSTA respectively with time (month or year) for the period of investigation. The result reveals a trend of general very slight decrease of SSTA, and consequently SST, with time in the order of about -0.3^oC/61 years (1948-2008).

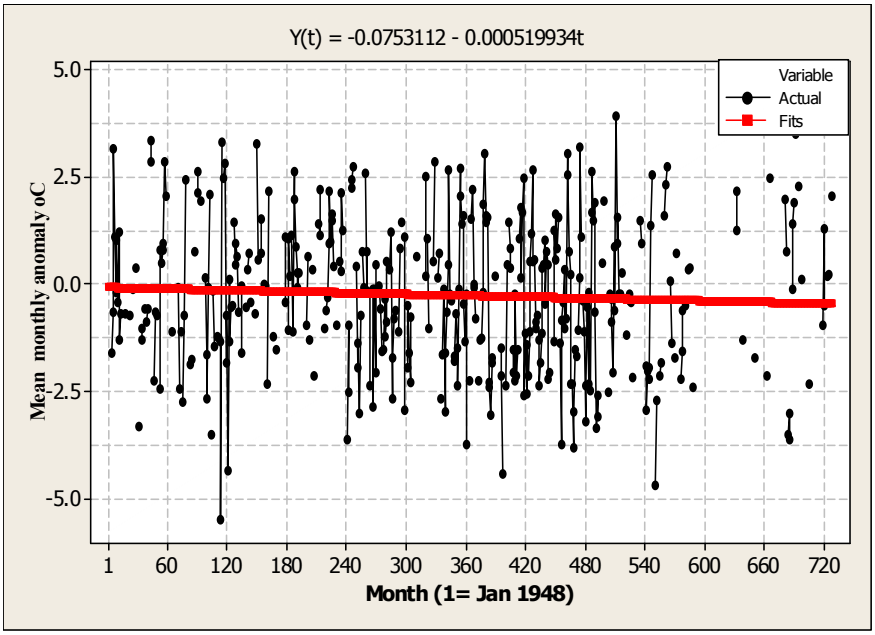

Fig. 2a. Linear trend analysis plot for mean monthly SSTA.

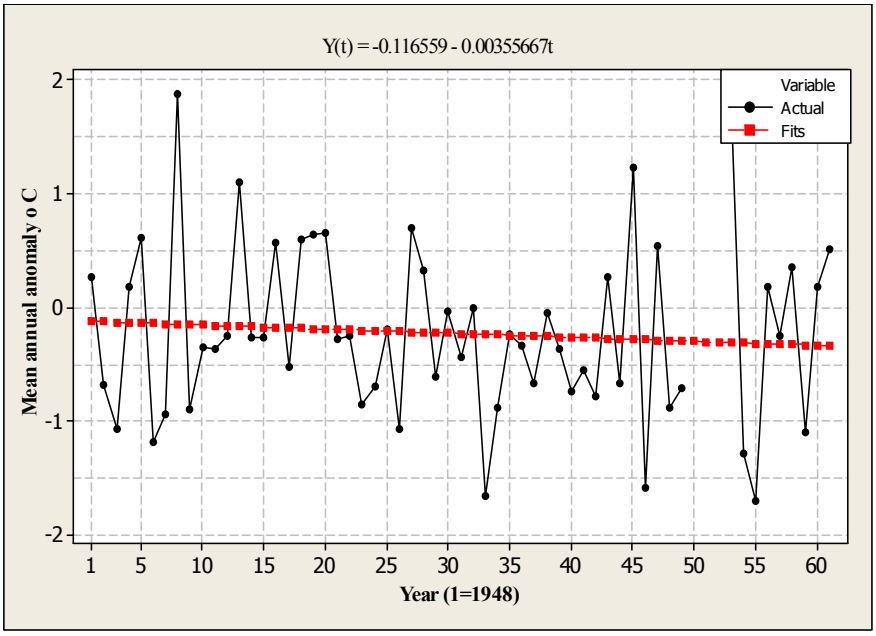

Fig. 2b. Linear trend analysis plot for mean annual SSTA.

The linear model for the mean monthly SSTA trend has the form:

$$\mathbf{y(t) = -0.0753112 - 0.000519934\ t} \quad (2)$$

Where: t(1 to 732) = t(Jan, 1948 to Dec, 2008).

While the linear model for the mean annual SSTA trend has the form:

$$\mathbf{y(t) = -0.116559 - 0.00355667\ t} \quad (3)$$

Where: t(1 to 61) = t(1948 to 2008).

These two linear modes show a trend of continuous decrease of SSTA with time and consequently SST when applying the reverse of Equation (1) in the form:

$$\mathbf{T = \Delta T_m + T^{**}} \quad (4)$$

Figure 3(a,b) shows the quadratic regression and model the relationship between ΔTm and ΔTa respectively with time (month or year) for the period of investigation.

The quadratic model for the mean monthly SSTA trend has the form:

$$\mathbf{y = 0\ 143100 - 0.00234735\ t + 2.711817\ E\text{-}06\ t^2} \quad (5)$$

While the quadratic model for the mean annual SSTA trend has the form:

$$\mathbf{y = 0.00962704 - 0.0156062\ t + 0.000195383\ t^2} \quad (6)$$

The quadratic regression trend of the mean monthly and annual SSTA has a parabola form. The parabolas show a decrease in SSTA, and consequently SST, in the period 1948 to 1985 then increasing forward.

Summary and Conclusions

The linear and quadratic regressions have been used to investigate the relationship between SSTA and time (month or year) to get the general SSTA possible trends.

Regardless the propaganda concerning increasing or oscillating of climate parameters. The present work depends on analyzing series of observed data (61 years, January 1948 to December 2008) for a limited geographic area (south eastern Mediterranean Sea in front of the Egyptian Mediterranean coast).

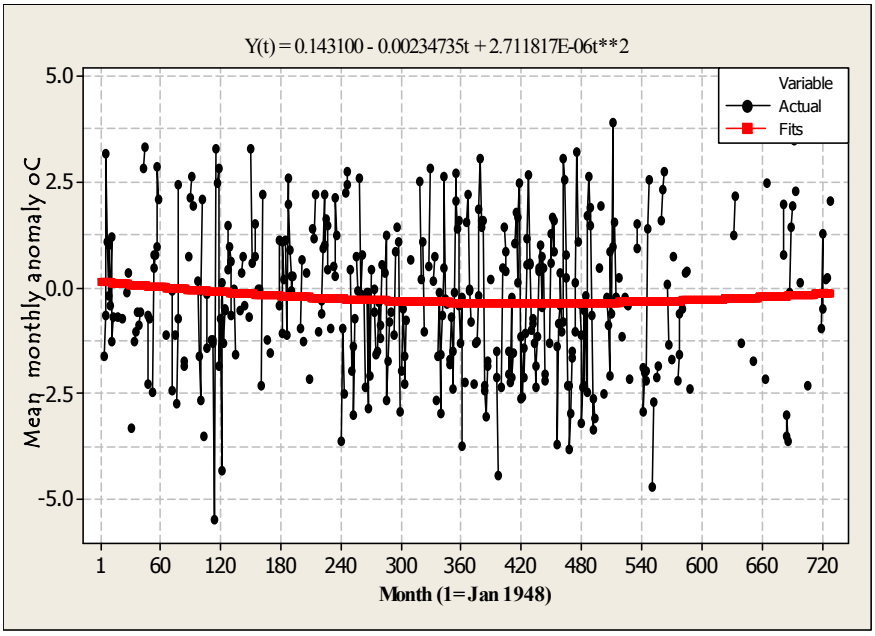

Fig. 3a. Quadratic trend analysis plot for mean monthly SSTA.

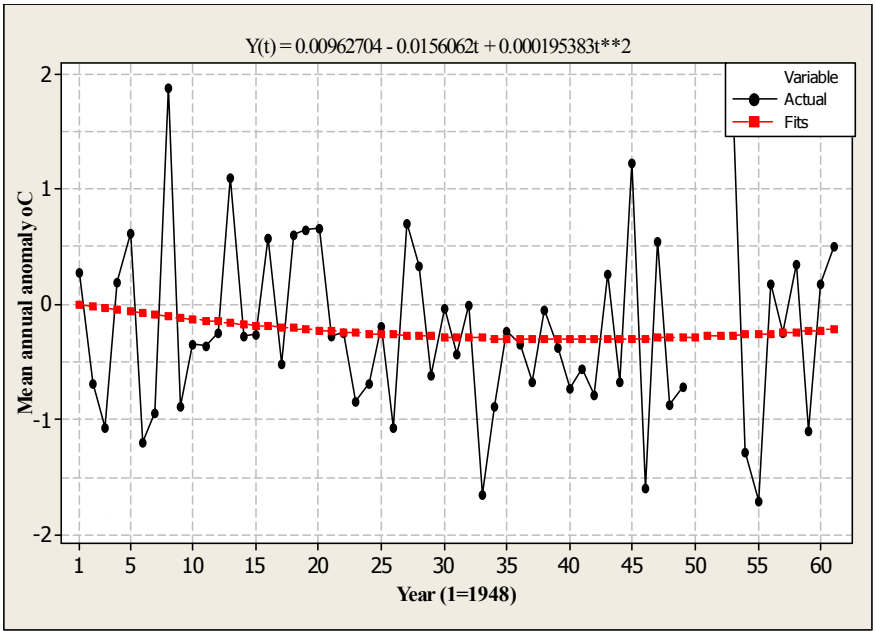

Fig. 3b. Quadratic trend analysis plot for mean annual SSTA.

The linear regression and model results reveal a trend of general decrease of SST, with time in the order of about −0.3°C/61 years. The quadratic regression trend of the mean monthly and annual SST has a parabola form. The parabolas show a decrease in SST in the period from 1948 to 1985 then increasing forward.

The present work may strengthen the suggestion of oscillating sea surface temperature (SST) with time rather than continuous increasing due to the so called global warming. The cycle of that oscillation must have a period much more than 61 years and may reach to centuries.

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اتجاه حيود درجة حرارة المياه السطحية في جنوب شرق البحر المتوسط

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المستخلص. استخدم التدرج الخطي والتربيعي الإحصائي لدراسة العلاقة بين المتوسطات الشهرية والسنوية لحيود درجات حرارة المياه السطحية مع الزمن للحصول على أتجاه الانحدار العام لهذه المتوسطات (زيادة أو نقصان أو ثبات). وأعتمد هذا العمل على تحليل بيانات ٦١ سنة ميلادية بدءًا من يناير ١٩٤٨م وحتى ديسمبر ٢٠٠٨م لمنطقة محددة وهي جنوب شرق البحر المتوسط أمام الساحل المصري بعيدًا عن الجدل المثار حاليًا عن ارتفاع أو تذبذب العناصر الجوية. وقد اتضح من التدرج الخطي أن هناك انخفاض في درجات حرارة المياه السطحية مع الزمن بمقدار – ٠.٣ درجة مئوية خلال الواحد وستين عامًا، وهذه الدراسة تقوى الفرض القائل بأن هناك تذبذب في درجات الحرارة للمياه مع الزمن وأنها ليست زيادة مستمرة بسبب مايسمى التسخين العالمي، وقد يتعدى زمن التذبذب الواحد وستين عامًا بكثير وربما يصل إلى قرون.