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Sea Surface Temperature Anomalies in the South Eastern Mediterranean Sea

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Abstract. The hydrographic data of 61 years were used to study the regular formation of the sea surface temperature anomalies (SSTA) and their evaluation in the South Eastern Mediterranean Sea in front of the northern Egyptian waters. The area of study lies between 31-33^{o}N and 25-34^{o}E. 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. Normal SSTA band occupies only 21.41%, while the positive and negative bands occupy 32.90% and 45.69%. Active zones and periods were determined from the zonal and time distribution of the mean positive, negative and amplitude of SSTA in the study period (1948-2008) for each 1^{o} x1^{o} grid. The active period of the year is from June to August. The coastal areas are more active especially in the positive and amplitude bands due to the Interannual variations in coastal heating and cooling. The anti-cyclonic gyre areas are more active especially in the negative band due to Interannual variations in gyre strength.

Keywords: Mediterranean, Physical Oceanography, SSTA.

Introduction

The relationship between sea surface temperature (SST) and atmospheric variables is very important for the formation of the intermediate and deep waters (Maiyza, 1986 and Maiyza *et al.,* 1995). The south eastern Mediterranean needs more detail studies to increase the knowledge about the possible second source of intermediate Mediterranean water and its periods of formation (Morcos & Hassan 1976, Gerges 1978, Maiyza 1984 & 1986, Abdel-Moati & Said 1987 and Said & Karam 1990).

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 oscillation of the mean 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 of the physical properties (Millot 2007).

As the wind stress and the thermodynamic effects are important agents for the change in thermal structure of the upper layer (Heburn, 1985), the variability and formation of sea surface temperature anomaly (SSTA) is fairly essential for solving many meteorological and oceanographic problems.

The duration and wide occupation of SSTA give the reason to study it as one of the main factors affecting climatic system of the earth (Fedrouich, 1985). By studying this system we can discover the energetic active areas in which the air-sea and sea-continent interactions are considerably more active.

In this paper, the formation and evaluation of the SSTA will be studied.

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). The area of study lies between 31 - 33^{o}N and 25 - 34^{o}E basin (Fig. 1).

The vertical mean temperature of the upper 10 m layer is considered as sea surface temperature to reduce the diurnal variations. The monthly mean sea surface temperature (T) is calculated for each 1^{o}x1^{o} grid (18 grids, Fig. 1) for every month in the period from April 1948 to August 2008 using the available historical WDC's A (Washington D C), 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 deviation from the mean (ΔT) is computed and considered as monthly SSTA for every grid.

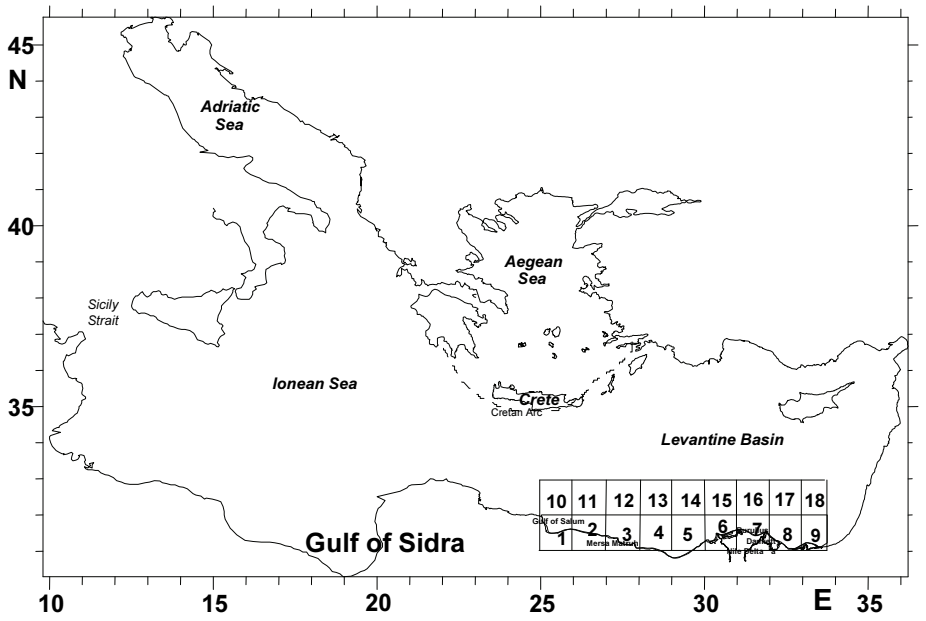

Fig. 1. Area of investigation, the south Eastern Mediterranean Sea.

$$\Delta T = T - T^{**}$$

The mean monthly positive and negative SSTA through the investigated period are determined, from which the SSTA amplitudes are calculated using the following equation:

$$\text{Amplitude} = \{SSTA^{+}\} + \{SSTA^{-}\}$$

Results and Discussion

Spatial and Temporal Distribution of SSTA

The time distribution of the mean SSTA for the south eastern Mediterranean reveals a positive and negative anomalies cycles (Fig. 2). The period of these cycles varied from 9 to 15 years (Fig. 3). Generally, this cycle period coincides with the eleven years cycle of sun-spot activities (Maiyza, 1984) and/or Interannual to decadal scale variability (Levetus, 1995). From the mean positive and negative anomalies one can determine some considerable warm years; 1955, 1960, 1966, 1975, 1992 and 1999 and some considerable cold years; 1950, 1953, 1973, 1980, 1993 and 2002.

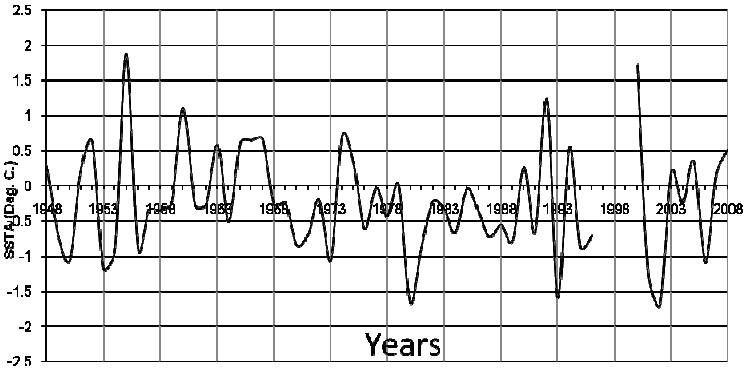

Fig. 2. Mean annual variation of SSTA of the South Eastern Mediterranean Sea.

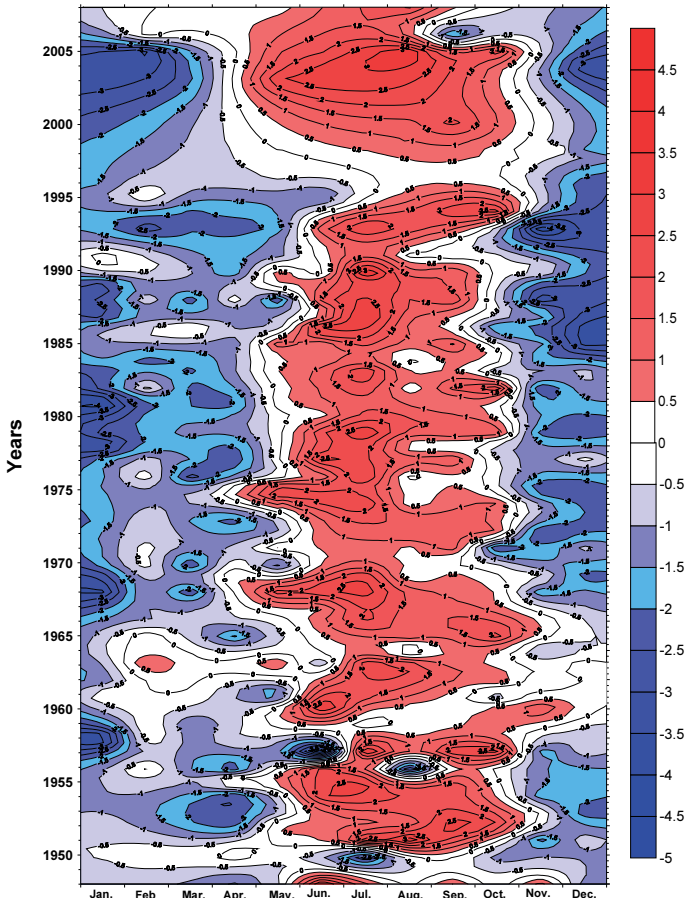

Fig. 3. The time distribution of the mean monthly SSTA of the South Eastern Mediterranean Sea.

The occurrence of SSTA is divided into bands. These bands and the percentage of occurrence of SSTA values are shown in Table 1. The normal positive and negative SSTA bands occupy 21.41%, 32.90% and 45.69% of the investigated period respectively. The present percentage of normal band is considerably small compared to the previous one for the Eastern Mediterranean Basin (Maiyza,1984) and Western Mediterranean Basin (Saad, 1993) which were about 52%. This, may be due to the fact that, the present area is considerably shallower and more exposed to continental effect.

Table. 1. The percentage of occurrence of SSTA bands.

SSTA band (^{o}C)	Percentage of occurrence (%)
<-2.0^{o}C	17.75%
-2.0 ≤ band ≥ -1.0 ^{o}C	18.02%
-1.0 ≤ band ≥ -.05 ^{o}C	9.92%
-0.5 ≤ band ≥ 0.5 ^{o}C (Normal)	21.41%
0.5 ≤ band ≥ 1.0 ^{o}C	8.62%
1.0 ≤ band ≥ 2.0 ^{o}C	12.79%
band >2.0 ^{o}C	11.49%

SSTA Structure

a- With Time

The monthly distribution of positive, negative and amplitude of SSTA are shown in Fig. 4. The negative SSTA is developed in January, June and November with maximum value during June (–5.4 ^{o}C). As for positive SSTA, there are another active periods from May to August and November. The maximum SSTA amplitude occurs in June, which coincided with negative and earlier than positive anomalies. The active period of the SSTA amplitude is extended between May and November.

b- With Space

For every 1^{o}x1^{o} grid, the maximum, minimum and amplitude values of SSTA were determined over the study area under consideration. The horizontal distribution of the mean positive, negative, and amplitude of SSTA are shown in Fig. 5.

Gulf of Sallum in the west (25.5^{o}E) has the highest SSTA amplitude. Generally, the high amplitude lies close to land with inverse relation to the shelf width. The low amplitude is centered off the Nile Delta (30.5^{o}E) characterized by very wide continental shelf.

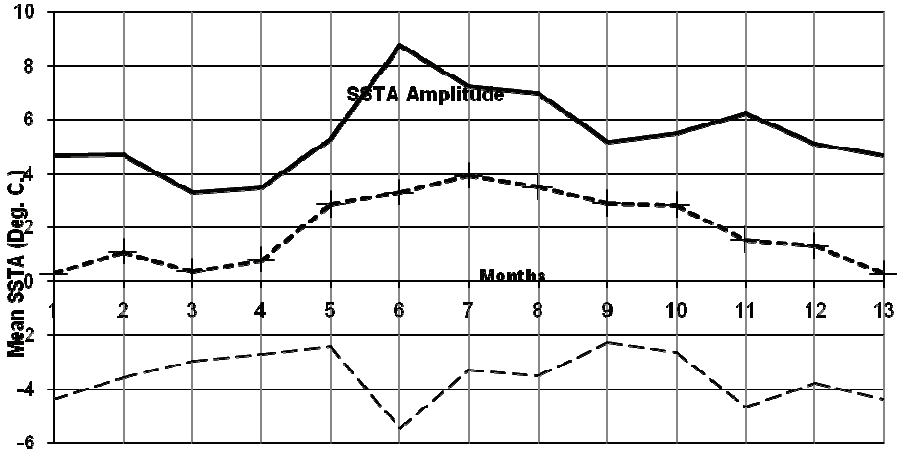

Fig. 4. The monthly positive, negative and amplitude of SSTA.

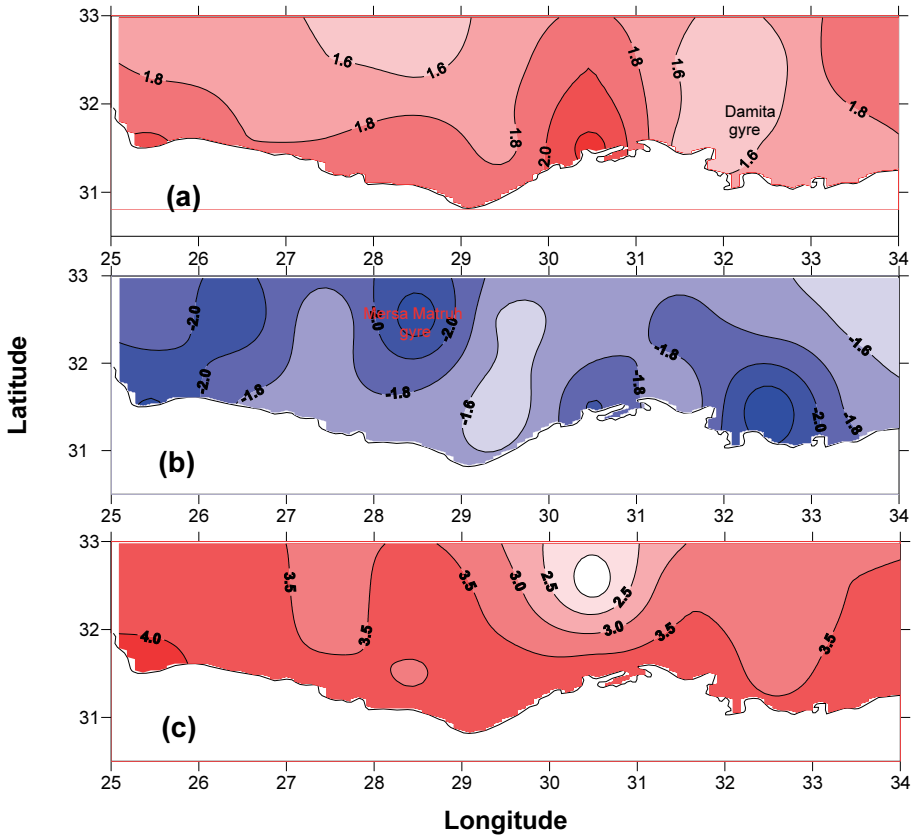

Fig. 5. Horizontal distribution of Positive (a), Negative (b) and Amplitude (c) of SSTA.

The positive SSTA is the highest in the Gulf of Sallum in the west and Burrullus in the centre decreasing seaward. In the north-east there is an area of high positive anomaly off Philistine. The two areas of low positive anomaly (<1.6^{o}C; at 28^{o} and 32^{o} E) coincide with Mersa Matruh and Dammetta anticyclonic gyres (Abdel-Moati & Said, 1987 and Said & Karam, 1990).

The negative SSTA is high in the above mentioned anticyclonic gyres besides the Gulf of Sallum, but the majority lies in the open sea.

The Interannual variability of the anticyclones is the reason of the presence of negative active areas. This conclusion agrees with the results of Maiyza (1984) and Fedrouich (1985).

Summery and Conclusions

The hydrographic data were used to study the regular formation of SSTA and their evaluation in the South Eastern Mediterranean Sea in front of the northern Egyptian waters.

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 sunspots activities. Normal SSTA band occupies only 21.41%, while the positive and negative bands occupy 32.90% and 45.69%. The active period of the year is from June to August. The coastal areas are more active especially in the positive and amplitude bands due to the Interannual variations in coastal heating and cooling. The anti-cyclonic gyre areas are more active especially in the negative band due to Interannual variations in gyre strength.

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حيود درجة حرارة المياه السطحية في جنوب شرق البحر المتوسط

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المستخلص. باستخدام البيانات الهيدروجرافية لمدة ٦١ سنة ميلادية (١٩٤٨–٢٠٠٨م) تمت دراسة حيود درجات حرارة المياه السطحية في جنوب شرق البحر المتوسط أمام الساحل المصري (بين خطي عرض ٣١° و ٣٣° شمالاً، وخطي طول ٢٥° و ٣٤° شرقاً). وقد تراوحت فترات الدورات الموجبة والسالبة ما بين ٨ و١٥ سنة، وهذه الدورات مرتبطة بدورة النشاط الشمسي (١١ سنة). وكانت نسبة حيود درجات الحرارة الموجبة والسالبة هي ٣٢,٩٠٪ و٤٥,٦٩٪ على الترتيب. وكانت فترة نشاط الحيود الكلي السنوي ما بين شهري يونية إلى أغسطس. وقد اتضح أن مناطق الدوران الأنتيسيكلوني هي الأنشط، وذلك بسبب التغير طويل المدى في قوة الدوران.