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Research Article

The Relationship between the SST of the Surface Mediterranean and the Temperature/Precipitation of Middle East Using Empirical Orthogonal Function for the Period (1980-2009)

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Abstract
The aim of this study is to identify the variations of Sea Surface Temperature (SST) of the Mediterranean Sea and the variations of air surface temperature and to total precipitation over the Middle East. In order to find the possible correlation between SST and air surface temperature at 2 m (T2m)/total precipitation (TP) by using weather prediction tool, such as the spatial analysis by employing Empirical Orthogonal Function (EOF). The results show that the percentage of spatial variation of EOF1 for SST and T2m was 97% and 95% of total variance respectively, that indicate to have possible relationship between them while the spatial variance of TP record the lowest value in the period of study (1980-2009).

Keywords: Middle East, Empirical Orthogonal Function, variance.

الخلاصة
الهدف من هذه الدراسة هو لتحديد تغيرات درجة حرارة سطح البحر الابيض المتوسط وتغيرات درجة حرارة الهواء السطحية والتهاطل الكلي فوق منطقة الشرق الاوسط. من اجل ايجاد الترابط المحتمل بين SST ودرجة حرارة الهواء عند ارتفاع 2 m (T_{2m}) وTP باستخدام اداة التنبؤ الطقسي كأستخدام دالة التعامد التجريبية (EOF) للتحليل المكاني. النتائج اظهرت ان النسبة المئوية للتغاير المكاني الكلي للـ EOF1 لكل من SST وT_{2m} بلغت 97% و95% على الترتيب مما يشير الى وجود علاقة محتملة بين المتغيرين بينما التغاير المكاني للـ TP سجلت أقل قيمة خلال فترة الدرسة (1980-2009).

Introduction

EOF analysis and the related principal components analysis (PCA) are a set of powerful methods to extract information from large datasets, as will be mentioned in next section. The terminology of these methods is rather confusing as similar methods are used under number of different names [1].

A useful technique for compressing the variability in this type of time series data is PCA. In oceanography, the method is commonly known as EOF analysis. This procedure is one of a large class of inverse techniques and is equivalent to a data reduction method widely used in the social science known as factor analysis. EOFs are simply a method of partitioning the variance of a spatially distributed group of concurrent time series. They are called empirical to reflect the fact that they defined by the covariance structure of the specific data set being analyzed. The advantage of EOF analysis is that it provides a compact description of the spatial and temporal variability of data series in terms of orthogonal functions, or statistical modes. There are other advantages of statistical EOF descriptions of data: 1) the EOFs provide the most efficient method of compressing data, and 2) the EOFs may be regarded as uncorrelated (i.e. orthogonal) modes of variability of the field [2]. Most of the variance of the spatially distributed series is usually in the first few orthogonal functions whose patterns may then be linked to possible dynamical mechanisms. It should be emphasized that no direct or mathematical relationship necessarily exists between the statistical EOFs and any related dynamical modes. Dynamical modes conform to physical constraints through the governing Equations and associated boundary conditions [3]. Before

interoperating the meaning of EOFs, it should be keeping in mind that, the empirical modes do not necessary corresponds to true dynamical model or modes of physical behavior [4] [5] [6].
The EOF is for analyzing the variability of single field, i.e. a field of only one scalar variable (SLP and SST). The method finds the spatial patterns of variability, their time variation, and gives a measure of the importance of each pattern [7].

Data and Methods

The data used in this part of study were obtained from the ECMWF center re-analysis of monthly means during the period of 1980-2009 and use two grids of data represented two areas under the study. Firstly, the gird of monthly mean of SST (in Kelvin) for Mediterranean Sea of 0.5°x 0.5° is located at (-10° W-35° E, 30° N-45° N). The second grid represents the data of monthly mean of air surface temperature at 2 m (T_{2m}) in Kelvin and rainfall (TP) in millimeter for 0.5° x 0.5° of (30° E-65° E, 10° N-45° N) for Middle East. In order to extract the general behavior of variance of all variable, EOFGRADS package was applied (a tool to compute EOF and PCA).

Results and Discussion

Spatial Pattern of EOF Analysis

In this paper, the whole of data set divided into three groups in order to explore the decadal variation of variable (SST, T_{2m} and TP). Also the first two EOFs analysis (EOF1 and EOF2) of data set for each variable will be performed to better visualize the different spatial and temporal patterns in these areas of study. Comparison among the decades will be shown to see how this variability changes climate too locally.

Sea Surface Temperature

Table 1 shows the percentage of variance explained by each EOF. It should note the first mode has the most amount of variance (97%), while the second mode has (1.1%) of the variance. So we will display below the plots only for them.
To illustrate the analysis results, the spatial patterns of EOF1 and EOF2 for SST at Mediterranean Sea region are displayed in Figure 1, which shows that EOF1 pattern has two areas of maximum and minimum values of variance located in the south and the north, respectively. Meanwhile EOF2 pattern in the north part of the region has the positive values with its maximum, while in the southeast part there is the minimum negative value of variance.

Table 1: The percentage of variance for all EOF modes for the period (1980-2009).

EOF modes	SST (%)	T_{2m} (%)	TP (%)
1	97	95	45
2	1.1	2.2	12
3	0.6	0.7	8.6
4	0.2	0.3	4.5
5	8.1E-02	0.28	3.7
6	6.7E-02	0.21	2.7
7	5.4E-02	0.15	2.4
8	4.7E-02	0.10	2.0
9	4.0E-02	8.3E-02	1.5
10	3.0E-02	5.7E-02	1.14
11	2.8E-02	5.2E-02	1.04

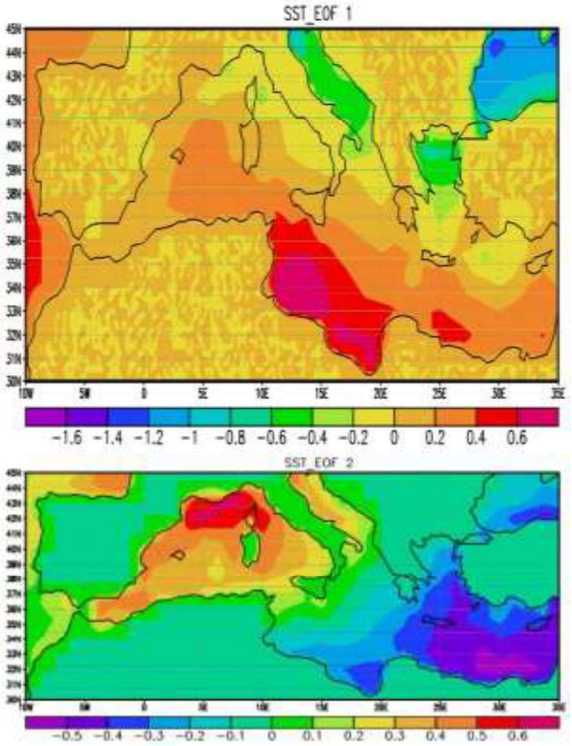

Figure 1: Spatial pattern of EOF1 (above) and EOF2 (bottom) modes of SST for the period (1980-2009).

Air Surface Temperature

This subsection deals with identifying the variability of air surface temperature (T_{2m}) in the Middle East. The variance is very strong (95%) for the first mode and (2.2%) for the second EOF as shown in Table 1. Figure 2 shows a region of the negative values of variance in the all part and

just a small area with positive variance position between the latitude 24° N and 12° N, that is for the first spatial pattern while the second mode, it obviously finds out a region with positive value of variance, which have the range (0-0.9) of variability.

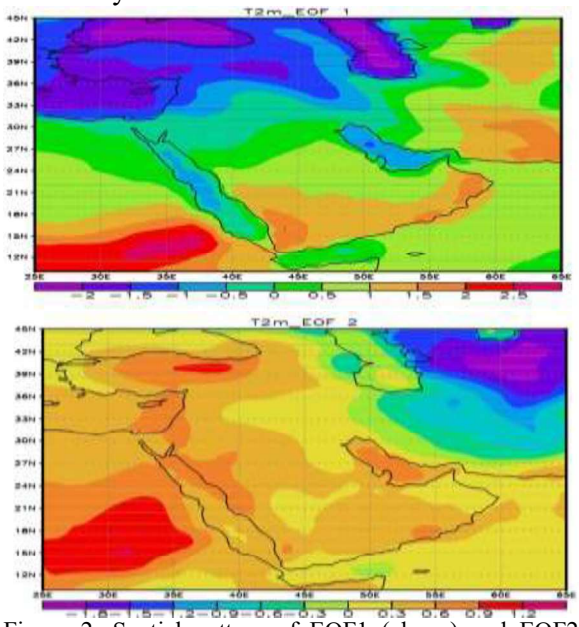

Figure 2: Spatial pattern of EOF1 (above) and EOF2 (bottom) modes of T2m for the period (1980-2009).

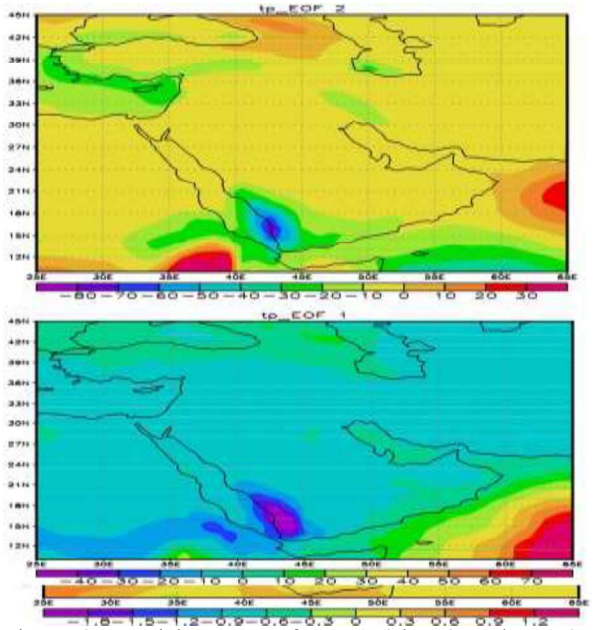

Figure 3: Spatial pattern of EOF1 (above) and EOF2 (bottom) modes of TP for the period (1980-2009).

Total Precipitation

The variability in the annual rainfall for the period (1980-2009) in the Middle East can be specified with presence of a moderate variance about 45% for EOF1 and weak variance of 12% as reported in Table 1. From Figure 3, the annual spatial pattern of both first and second EOF has clearly low variation with regular color, which has a negative value of variance.

The analysis described above has a vital possible link between the SST and air surface temperature made by the available strong variability associated in the same period. It recognized that, the precipitation affected by more than the SST and there are essential factors provide the response of the oceans to the atmosphere. Precipitation cannot be ruled by oceans and SST only and must be significant factors in the atmosphere to determine the rainfall on seasonal time scale.

Conclusion

Based on the data used in this work that were obtained from ECMWF center reanalysis of represented means during the period of 1980-2009, the spatial analysis of variances computed by EOF technique carried out. The main concluding remarks can be summarized as: The percentage of variance of spatial pattern of EOF1 modes of SST and T_{2m} has the high value of 97% and 95% respectively, which indicate there is a possible relationship between the variability of SST and T_{2m} in whole period of this paper. The percentage of variance of spatial pattern of EOF1 modes of SST and TP has moderate value of 45% that indicate there is a weak relationship between the variability of SST and TP.

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