Title: *Change at the mean annual surface temperature in the Mediterranean Sea over the last 160 years*

INTRODUCTION

There has been a lot of study regarding the world surface temperature during the last century. The results show that Earth is becoming warmer with a fast pace. According to IPCC there has been an augmentation of 0.6 °C to 0.7 °C at the global surface temperature from 1951 to 2010 [1].

The present study tries to investigate the change at the surface temperature in the Mediterranean over the last 160 years. For this purpose it was used a simple linear model to define the rate of warming. Furthermore, we use the same model to make predictions about the future of the Mediterranean area.

METHODS

Data Collection

The data were downloaded from the Climate Time Series Browser (CTSB) [2]. We selected 48 stations that are around the Mediterranean Sea (see Appendix). The processing of the data as well as the analysis were made with the R Project [3].

Exploratory Analysis

Initially we made some exploratory plots in order to see which stations had enough data for our analysis. More precisely, we decided to keep the stations that provided data at least for the years 1950-2000. Once we cleaned up the data from stations that didn't meet our standards, we redownloaded the data from the CTSB, in order to be reproducible for peers. Furthermore, we checked for unusual temperatures, calculating the minimum and maximum value for every station.

Statistical Modelling

The method used in the present study was a simple linear model [4]. We used the same model to define the temperature change for two different time periods and also to make predictions.

RESULTS

The data from the stations included measures from 1849 to 2011. The linear model we fitted is the below:

$$T_i = T_0 + b_1 t_i + e_i \qquad (1)$$

where T_i is the temperature at time i, T_0 is the temperature at time t=0 years, b_1 is the slope that indicates the rate of warming, t_i is the time in years and e_i is the error.

At the beginning of the analysis we calculated the mean annual temperature taking into consideration all the available values for each year. That gave us a first glance of the mean temperature over the Mediterranean. Afterwards, we made a plot for the total time period we had available data [Figure (a)]. The green dots represent the mean annual temperature while the red line shows us the trend. At this first step the slope was found to equal to 0.0175± 0.0014 (99% Confidence Interval: 0.0139-0.0210), meaning that we have an increase of 0.0175 °C every year. The previous result was found to be very significant (P<0.001). According to this model, the surface temperature in the Mediterranean has changed 2.85 °C over the last 160 years. Additionally, we made a prediction for the mean annual surface temperature in the Mediterranean for the year 2100. The temperature then will have reached 19.10 °C from 17.58°C that is today.

Due to the fact that not all the stations have data from 1850, the above results may be biased. Thus, we decided to make a second linear model, including only the measurements from 1950 to 2011. This could also be useful to compare our results with the IPCC's findings. At Figure (b) is illustrated the mean annual temperature with blue dots. The red line represents the trend. The slope term is 0.0135±0.0038 (99% Confidence Interval: 0.0035-0.0235), which is very similar to our first attempt. The result is again very significant (P<0.001). The change of the surface temperature during the last 60 years was found to be 0.84 °C, which is a little higher than the IPCC's result of 0.6-0.7 °C. This variation may be attributed to the fact that we study only a small geographical region on earth or because we didn't use all the available stations near the Mediterranean Sea. The same prediction for the year 2100 results in an annual mean surface temperature of 18.34 °C. Today's mean temperature with the use of this model is 17.16 °C. It is obvious that the second model make milder predictions, which appear to be more accurate, according to the IPCC.

DISSCUSION

In the present paper we communicate the results of a study that tried to light the mean temperature change in the Mediterranean. In particular, using the same linear model for two different time periods, we attained to estimate the change of surface temperature, which is 2.85 °C over the last 160 years and 0.84 °C over the last 60 years. Furthermore, we predicted the temperature in year 2100, which will be equal to 19.10/ 18.34 °C respectively for the two models.

Our findings may not be very accurate because we didn't use a large size of data. In addition, we considered that surface temperature depends linearly with

time, which may be a false assumption. In any case, the present analysis suggests that the Mediterranean is getting warmer. There is plenty of space for future studies, considering different models or different variables to predict the temperature.

REFERENCES

[1] Highlights of the New IPCC Report - Gian-Kasper Plattner, Director of Science, AR5 IPCC WGI TSU.

URL: http://www.ipcc.ch/pdf/unfccc/cop19/cop19_pres_plattner.pdf. Accessed 12/10/2013.

[2] Climate Time Series Browser of the University of Chicago. URL: http://climatemodels.uchicago.edu/timeseries/.

[3] The R Project for Statistical Computing. URL: http://www.r-project.org/. Accessed 12/11/2013.

[4] John F. Monahan. A primer on linear models: Texts in statistical science. Chapman & Hall/CRC, 2008.

APPENDIX

URL of the stations selected for the study:

http://climatemodels.uchicago.edu/timeseries/#BiFrBCBCDhGDbLiIdyBBBCf GtDFCdFLPDCHHSICBdHEeBGCEEqDFEDCCDCBEGr

In the table below are listed the names of the stations as well as the country they are located in:

Station	Country	Station	Country
Ain/ Sefra	Algeria	Moron/ De.La.F	Spain
Akhisar	Turkey	Napoli/ Capodi	Italy
Alexandria	Egypt	Nicosia	Cyprus
Alexandria. No	Egypt	Palermo/ Bocca	Italy
Alicante/ Ciudad/ Jardin	Spain	Palma. De. Mall	Spain
Almeria. Aerop	Spain	Pantelleria	Italy
Amendola	Italy	Pescara	Italy
Athinai/ Obser	Greece	Port Said/ El	Egypt
Barcelona	Spain	Portalegre	Portugal
Beja	Portugal	Roma/ Urbe	Italy
Burgos/ Villaf	Spain	Rome	Italy
Cabo/ Carvoeir	Portugal	San. Sebastian	Spain
Cairo. Airport	Egypt	Sasso/ Feltrio	Italy
Casablanca	Morocco	Sevilla/ Tablada	Spain
Catania/ Sigon	Italy	Shkodra	Albania
Faro/ Aeroport	Portugal	Tenerife. Los	Spain
Korca	Albania	Thessaloniki	Greece
Larissa	Greece	Tirana	Albania
Lisboa/ Geof	Portugal	Tripoli	Lebanon
Luqa	Malta	Tripoli.1	Libya
Madrid/ Retiro	Spain	Valencia	Spain
Mahon/ San. Luis	Spain	Venezia/ Tesse	Italy
Mersa/ Matruh	Egypt	Vlore	Albania
Milano/ Linate	Italy	Zuara	Libya