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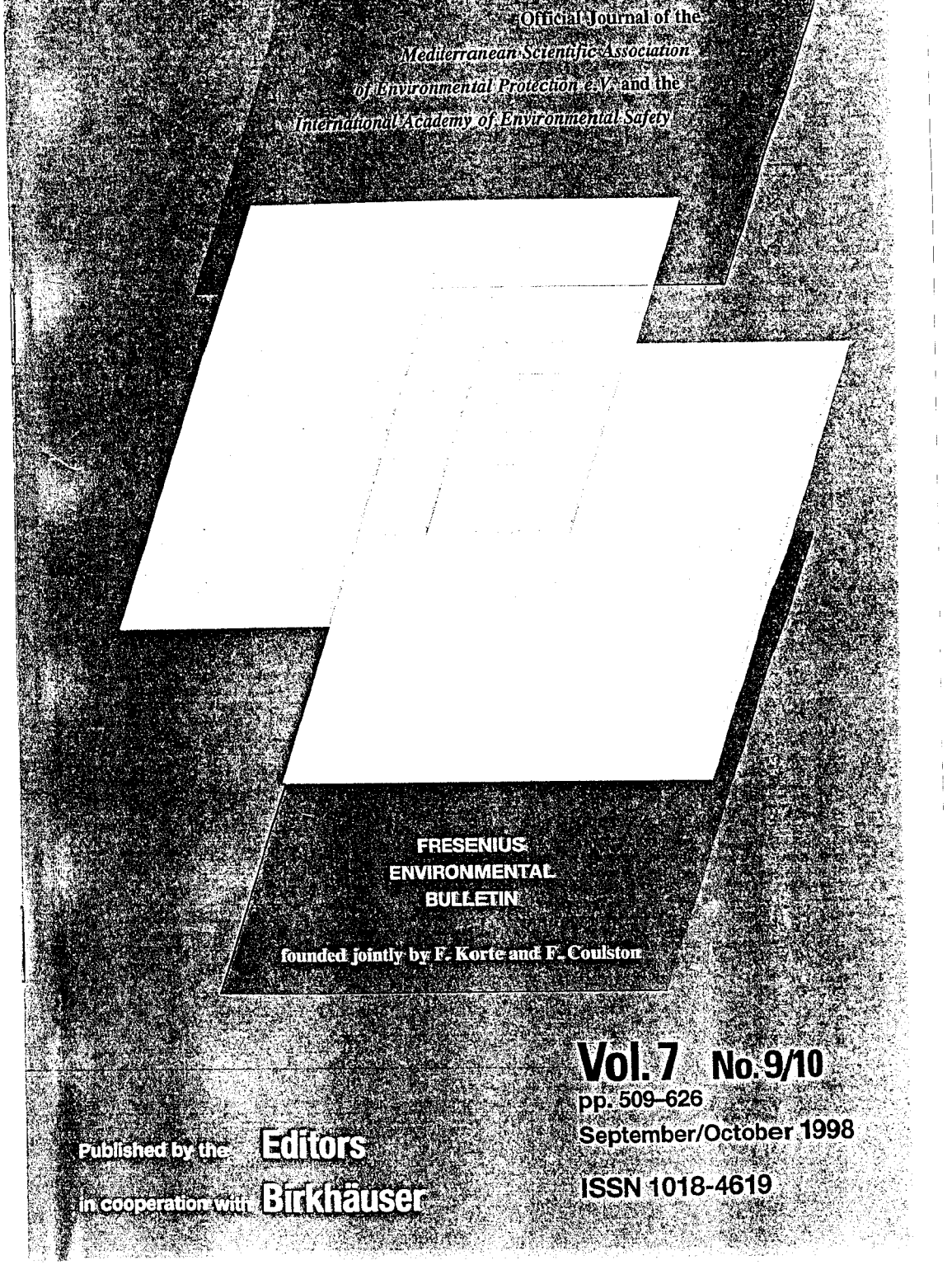

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MODELLING AND PREDICTION OF GRIDDED MEAN ANNUAL TEMPERATURE OVER THE GRID BOX : 20° - 30° W, 35° - 45° N.

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Summary.

In this paper, we deal with the ARIMA (Box-Jenkins) model of the gridded mean annual air temperature for the area included by the co-ordinates : 20° - 30° W, 35° - 45° N, (thus the South Balkan area, the most of its percentage covered by Greek peninsula). We analyse the gridded temperature time series which existed from 1851 to 1996. With the theoretical model's construction, we try to forecast the annual temperature till the year 2006, and the results were satisfactory enough. Also, from the analysis we found that the autocorrelation function (ASF) and the partial autocorrelation function (PASF) of the residuals were not significant, and the ARIMA model is quite reliable.

Key words : ARIMA modelling, grid box, stationary time series.

1. Introduction.

The forecast of the future climate has challenged a lot of researchers, [4, 5, 6] who try to give answers about the climatological behaviour using several statistical methods. Box and Jenkins [2] are the researchers who used an empirical technique which has been applied with success in real data sets, aiming to forecast the climatological parameters' change. The shorthand notation of the model is ARIMA (p,d,q), where ARIMA stands for AutoRegressive Integrated Moving Average, and p, d, q represent the order of the autoregressive polynomial, the order of differencing and the order of the moving average polynomial, respectively. Any stationary time series X_t can be written in the following way :

$$X_t = \sum_{i=1}^{p} \varphi_i X_{t-1} - \sum_{j=1}^{q} \theta_j a_{t-j} + a_t$$

or in the more analytical form :

$$X_t = \varphi_1 X_{t-1} + \varphi_2 X_{t-2} + \ldots + \varphi_p X_{t-p} - \theta_1 a_{t-1} - \theta_2 a_{t-2} - \ldots - \theta_q a_{t-q} + a_t$$

where a_t is a sequence of uncorrelated random shocks, well known as white noise. The parameters φ_i ($i = 1, \ldots, p$) and θ_j ($j = 1, \ldots, q$) are polynomials of p and q order respectively.

2. Application of the ARIMA modelling in the gridded mean annual temperature time series.

The time series of the grid box mean annual temperatures, concerning the period 1851 - 1996, were analysed using the ARIMA empirical technique. The grid boxes included by the co-ordinates : 20° - 30° W, 35° - 45° N [3], which cover the South Balkan area, appear in the Fig. 1.

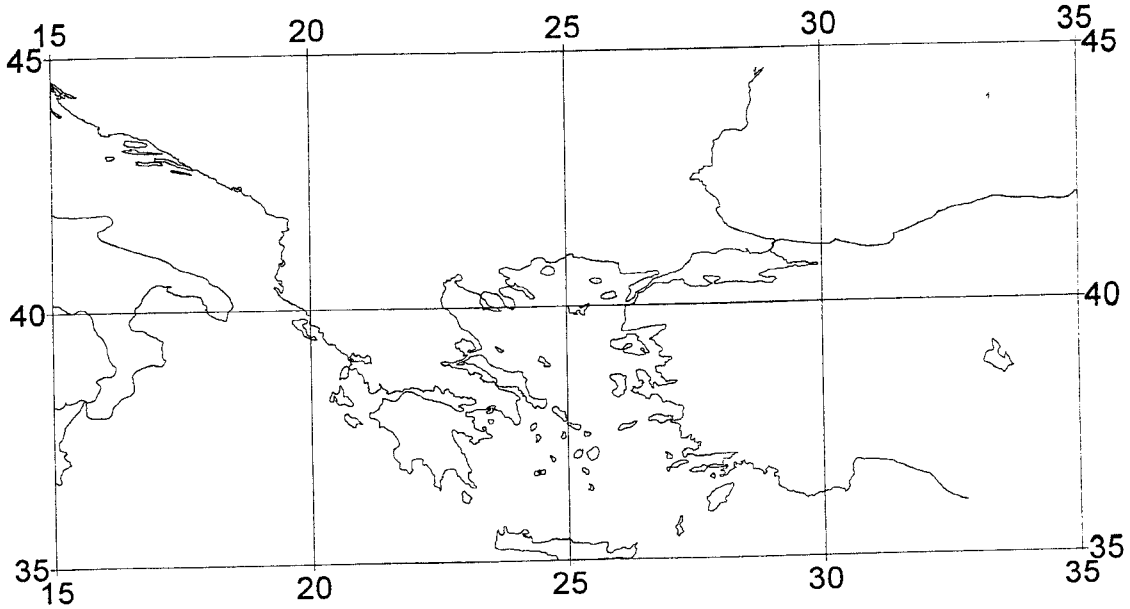

Fig. 1. Grid boxes of the wide Balkan area

In order to determine what type of ARIMA model is fitted to grid box mean annual temperature, we evaluate the autocorrelation (ASF) and partial autocorrelation (PASF) functions of the original time series and after several trials, it was found that the most reliable type of model for the grid box is : ARIMA (6,2,2).

The autocorrelation (ASF) and the partial autocorrelation (PASF) functions of the residuals were not significant, (Fig 2a), while the normal probability plot of the residuals was successful (Fig 2b), and the mentioned ARIMA model gave the smallest statistical values for the criteria : AIC (Akaike's information criterion, [1]) and SBC (Schwartz information criterion, [7]).

The result of the ARIMA application on the mentioned grid box gave the following model : ARIMA (6,2,2). The analytical formula of the ARIMA (6,2,2) model is :

$$X_t = -1.424X_{t-1} - 0.975X_{t-2} - 0.809X_{t-3} - 0.553X_{t-4} - 0.369X_{t-5} - 0.248X_{t-6} - 0.084a_{t-1} - 0.911\,a_{t-2} + a_t$$

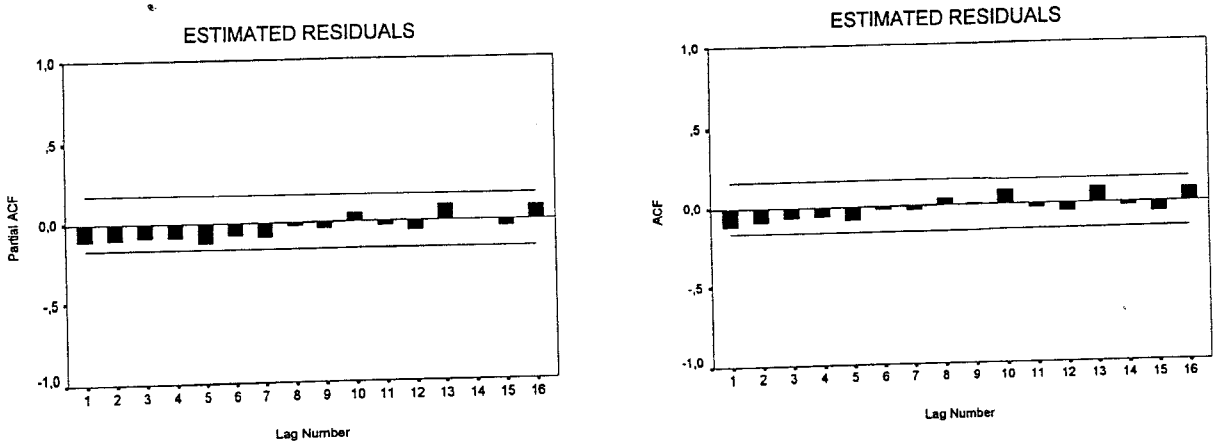

Fig. 2a. Autocorrelation Function (ASF) and Partial Autocorrelation Function (PASF) of the residuals for the Grid Box : 20° - 30° W, 35° - 45° N.

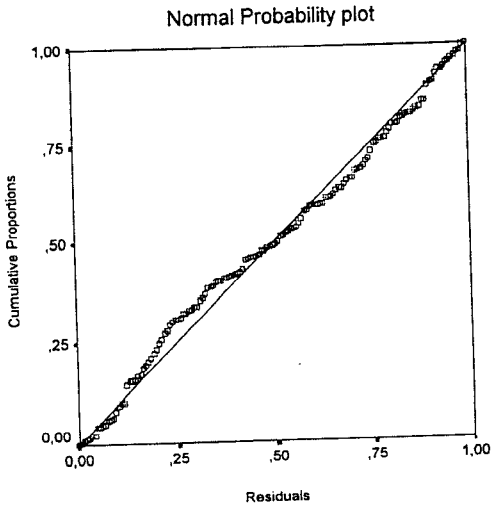

Fig. 2b. Normal Probability plot of the residuals

3. Results and Discussion.

The plot of the estimated, by the above model, gridded mean annual temperature anomalies -reference period 1960-1990- fits quite successfully the observed temperature values. Taking into account the time length of the examined time series (146 years), on which the suggested ARIMA model was applied, it is quite reliable to try a successful forecast for the following ten years beyond the year 1996. Of course, as the time distance from the 1996 increases, the estimated values are of lower probability to be verified. The course of the observed and estimated values by the model time series is represented in fig. 3, while the predicted mean annual temperature values are presented in Table 1. It should be mentioned that the values of Table 1 are within the interval $T \pm SD$.

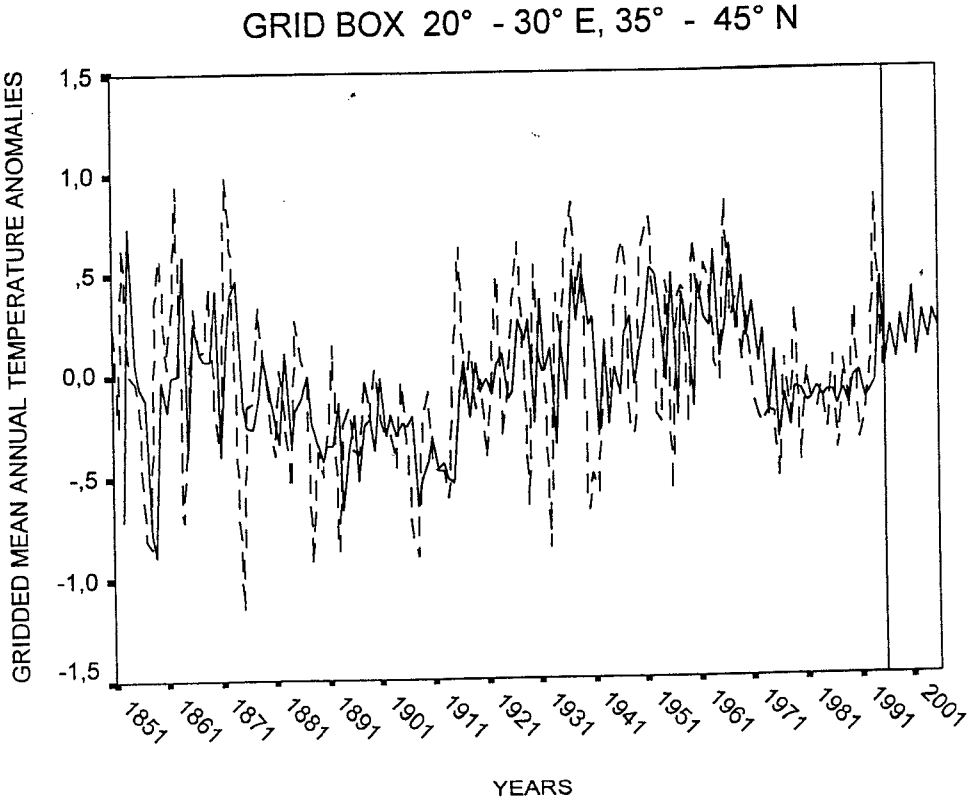

Fig. 3. Time series of Mean Annual Temperature. Original (slash lines) and estimated values (Solid lines).

It is obvious from the fig.3 that air temperature appears an ascending trend from the beginning of the 1990's which continues to exist till the year 2006, the terminal of the forecasting year of the ARIMA model.

Table 1. Predicted mean annual temperature values for the years 1996 ... 2006.

YEAR	PREDICTED GRIDDED MEAN ANNUAL TEMPERATURE
1997	0.21
1998	0.05
1999	0.27
2000	0.10
2001	0.40
2002	0.06
2003	0.28
2004	0.15
2005	0.28
2006	0.21

4. Conclusions.

According to the above analysis, it is obvious that the empirical method of Box-Jenkins (ARIMA models), can be used successfully for reliable forecast in air temperature. The solution of the empirical function shows, that the mean annual air temperature of the investigated region will rise for the following ten years, beyond the starting year 1996. Of course, as the time distance from the 1996 increases, the estimated values are of lower probability to be verified. However, they will be within the interval T±SD.

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