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CONTRIBUTION TO THE STUDY OF FREQUENCY DISTRIBUTION OF WARM AND COLD MONTHS AT THESSALONIKI (1892 - 1973) AND LARISSA (1899 - 1973).

by

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Abstract : *The frequency distribution of warm and cold months at Thessaloniki* (1892-1973) *and Larissa* (1899-1973) *is studied, based upon the terms of their respective time - series of monthly mean air temperature.*

Results indicate that in both places, warm and cold months as well have equal occurence probalibities (Thessaloniki: 48.5 *warm,* 48.3 *cold; Larissa:* 48.6 *warm,* 48.4 *cold). The frequency distribution of warm and cold months, is more or less uneven, for months occuring in isolation as well as in sequences of* 2, 3, 4...*etc.*

At the end, we give the actual and the «chance» distribution by Gold's formula of warm and cold months.

INTRODUCTION

As it is known the forecast of air temperature in a certain place for a period of one or more months, is of great and multiple practical importance. Also the study of the frequency and especially of the occurence in sequences of days, months or even years of various meteorological phenomena in a long time - series, is extremely interesting for climatological purposes. And this because from the whole behaviour of such sequences it is always possible to decide if they are due to chance or to some special cause.

In this paper we examine the frequency distribution of warm and cold months in Thessaloniki (1892-1973)[2], and Larissa (1899-1973)[3] according to the terms of the two time series of monthly mean values of air temperature.

We consider «warm» months, those months on which mean temperature was above that considered as normal, and «cold» months

Frequency of sequences of warm and cold months at Thessaloniki and Larissa

No. of months in sequence	Warm months						Cold months					
	No. of cases		Total No. of months		Percentage (%)		No. of cases		Total No. of months		Percentage (%)	
	Thessaloniki	Larissa	Thessaloniki	Larissa	Thessaloniki	Larissa	Thessaloniki	Larissa	Thessaloniki	Larissa	Thessaloniki	Larissa
1	84	76	84	76	17.6	17.4	85	67	85	67	17.9	15.4
2	43	34	86	68	18.0	15.6	50	43	100	86	21.0	19.7
3	29	15	87	45	18.2	10.3	21	17	63	51	13.3	11.7
4	17	19	68	76	14.3	17.4	9	11	36	44	7.6	10.1
5	13	4	65	20	13.6	4.6	11	9	55	45	11.6	10.3
6	3	5	18	30	3.8	6.9	5	8	30	48	6.3	11.0
7	3	6	21	42	4.4	9.6	5	4	35	28	7.4	6.4
8	1	2	8	16	1.7	3.7	4	5	32	40	6.7	9.2
9	2	1	18	9	3.8	2.0	3	3	27	27	5.7	6.2
10	1	1	10	10	2.1	2.3	—	—	—	—	—	—
11	—	3	—	33	—	7.5	—	—	—	—	—	—
12	1	1	12	12	2.5	2.7	1	—	12	—	2.5	—
Total			W=477	W′=437	100.0	100.0			C=475	C′=436	100.0	100.0

those with values below normal, while months with equal to normal values have also been characterized as «normal».

In Athens the persistence of warm and cold months has been studied by *Karapiperis*[6], and the monthly and seasonal persistence of air temperature was studied by *Metaxas*[7].

FREQUENCY OF WARM AND COLD MONTHS

Out of a total of 984 months examined for Thessaloniki, 32 (3.2%) have been «normal», while 477 (48.5%) of the rest have been warm (W) and 475 (48.3%) have been cold (C).

To the same, out of 900 months examined for Larissa 27 (3%) have been normal, 437 (48.6%) warm (W′) and 436 (48.4%) Cold (C′).

This means that in both cities, warm and cold months as well occur with almost equal probability.

The distribution of the 477 (W) warm and 475 (C) cold months at Thessaloniki and the 437 (W′) warm and 436 (C′) months at Larissa, those occuring in isolation (one warm month surrounded by cold ones, or a cold one surrounded by warm months) as well as those occuring in sequences of 2, 3, 4...e.t.c., months, is given in Table I.

The resulting percentage of months occuring in isolation or in runs of consecutive months (Table I) indicates a more or less uneven distribution of warm and cold months at the areas examined.

During the whole period examined, the longest (twelve months) run of consecutive warm months at Thessaloniki has been recorded from June 1896 till May 1897 included; while at Larissa the longest three (eleven months) cases were recorded in the period between October 1907 to April 1936.

On the other hand, the longest (twelve months) run of consecutive cold months has been recorded in Thessaloniki between May 1941 and April 1942, and in Larissa three (nine months) cases after the year 1960.

This fact may be considered as a mere indication of a relative increase of air temperature from 1896 till 1937 in the two areas examined; since another (ten months) long run of consecutive warm months was recorded in Thessaloniki from March 1934 till October 1934, and a comparative decrease in air temperature during the last 40 years.

This small decreasing trend of air temperature in the above areas is also mentioned in our previous works[2,3].

PERSISTENCE OF WARM AND COLD PERIODS:

As it is known, the persistence in the occurence of a certain phenomenon is of paramount importance for climatological statistics (Synoptic Climatology). *Cochran*[1] notes that, if there is a real persistence of, say, warm weather, then the probability of a warm month will be greater if the preceding month was warm than if the preceding month was cold.

According to the kind of occurence of each month (cold or warm) after the occurence of another warm or cold month, we have drawn Table II. In this Table, by W, W_1' we indicate the amount of warm months that occured after another warm month at the cities of Thessaloniki and Larissa respectively. By W_2 and W_2 we indicate the amount of warm months that occured after a cold month again for Thessaloniki and Larissa. Accordingly, by C_1, C_1' and C_2, C_2' we indicate the amount of cold months preceded by a warm or cold month respectively.

From Table II it results that there is a certain persistence tendency in the occurence of warm as of cold months at Thessaloniki

$$\left(\frac{W_1}{W_2} = 1.42, \frac{C_2}{C_1} = 1.45\right) \text{ and Larissa } \left(\frac{W_1'}{W_2'} = 1.61, \frac{C_2'}{C_1'} = 1.61\right).$$

Also, the probability of weather change from the occurence of warm and cold month is $\frac{C_1 + W_2}{W + C} = 0.41$ for Thessaloniki and $\frac{C'_1 + C_2'}{W' + C'} = 0.38$ for Larissa.

While the probability of having the same weather for at least a two month run, is 0.59 and 0.62 for Thessaloniki and Larissa respectively.

ACTUAL AND »CHANCE» DISTRIBUTION OF THE FREQUENCY OF WARM AND COLD MONTHS.

According to *Gold*[4] for a long set of observations including two categories of phenomena P and Q (i. e. warm and cold months), occuring with almost equal probability, it is possible to find the occurence probability of one category P surrounded by Q or consecutive cases of P and Q, by the following formula

$$f_{m,r} = \frac{2^{m-(r+1)}\,(m + 3 - r)}{2^m} \text{ or } f_{m,r} = \frac{m + 3 - r}{2^{r+1}}$$

TABLE II

P r e c e d i n g m o n t h

Months	Warm	Cold	Similar	Different	Total
Warm	$W_1 = 280$ (58.7%) $W_1' = 270$ (61.8%)	$W_2 = 197$ (41.3%) $W_2' = 167$ (38.2%)	$W_1 + C_2 = 561$	$C_1 + W_2 = 391$	$W = 477$ $W' = 437$
Cold	$C_1 = 124$ (40.8%) $C_1' = 167$ (38.3%)	$C_2 = 281$ (59.2%) $C_2' = 269$ (61.7%)	$W_1' + C_2' = 539$	$C_1' + W'_2 = 334$	$C = 475$ $C' = 436$
Total	$W_1 + C_1 = 474$ $W_1' + C_1' = 437$	$W_2 + C_2 = 478$ $W_2' + C_2' = 436$			$W + C = 952$ $W' + C' = 873$
Ratio	$W_1 / W_2 = 1.42$	$C_2/C_1 = 1.45$	$\frac{W_1 + C_2}{W + C} = 0.59$	$\frac{C_1 + W_2}{W + C} = 0.41$	
	$W_1'/W_2' = 1.62$	$C_2'/C_1' = 1.61$	$\frac{W_1' + C_2'}{W' + C'} = 0.62$	$\frac{C_1' + W_2'}{W' + C'} = 0.38$	

where m = the total number of the terms in a long observational series

r = the number of months is consecutive runs $1 \leqslant r \leqslant m - 1$

Also, according to *Cochran*[1], *Gold's* method can be applied, since warm and cold months occur with equal chance at Thessaloniki (48.5%, 48.3%) and Larissa (48.6%, 48.4%).

Based on the data of Table I for the cities of Thessaloniki and Larissa, we have drawn Table III, giving on one hand the actual frequency distribution of warm or cold months occuring in isolation or in runs of consecutive months, and on the other hand the «chance» distribution arrived at through Gold's method, as well as the size of the departure of the actual from the «chance» distribution, for each city separately.

TABLE III

Actual and chance distribution of the whole amount of warm and cold months at Thessaloniki and Larissa.

Number of warm or cold months in sequence	Actual Distribution (A)		Chance Distribution (B)		Departure (absolute) (B) - (A)	
	Thessaloniki	Larissa	Thessaloniki	Larissa	Thessaloniki	Larissa
1	169	143	247	226	78	83
2	93	77	123	113	30	36
3	50	32	62	56	12	24
4	26	30	31	28	5	2
5	24	13	15	14	9	1
6	8	13	8	7	0	6
7	8	10	4	4	4	6
8	5	7	2	2	3	5
9	5	4	1	1	4	3
10	1	1	0	0	1	1
11	—	3	0	0	0	3
12	2	1	0	0	2	1
Total					148	171

From Table III it results that there is a more or less essential difference between «chance» and «actual» distribution of air temperature at Thessaloniki and Larissa. To the same, while actual distribution of warm or cold months is as a rule in defect of chance distribution up to sequences of five months, it becomes in excess of expectation for sequences of six months upwards. This should be considered an indication of the persistence at Thessaloniki and Larissa of sequences

of six or more consecutive months with high as well as small temperatures, due to more general dynamic conditions.

Moreover, the sum total of absolute values of the departure between actual and chance distribution is 148 for Thessaloniki and 171 for Larissa.

The difference resulting from the comparison of these sums, is characteristic of the difference existing between the two stations in the distribution of warm and cold months.

The sum total of such of differences amounts to 209 for the period 1861-1950 at Athens[6] while at Greenwhich[5] for the 1841-1930 period they are 148.

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ΠΕΡΙΛΗΨΙΣ

ΣΥΜΒΟΛΗ ΕΙΣ ΤΗΝ ΜΕΛΕΤΗΝ ΤΗΣ ΣΥΧΝΟΤΗΤΟΣ ΘΕΡΜΩΝ ΚΑΙ ΨΥΧΡΩΝ ΜΗΝΩΝ ΕΙΣ ΘΕΣΣΑΛΟΝΙΚΗΝ (1892-1973) ΚΑΙ ΛΑΡΙΣΑΝ (1899-1973)

Ὑπὸ
ΑΠΟΣΤΟΛΟΥ Α. ΦΛΟΚΑ

Μελετᾶται ἡ κατανομὴ τῆς συχνότητος τῶν θερμῶν καὶ ψυχρῶν μηνῶν εἰς Θεσσαλονίκην (1892 - 1973) καὶ Λάρισαν (1899 - 1973), μὲ βάσιν τοὺς ὅρους τῶν μέσων μηνιαίων τιμῶν θερμοκρασίας ἀέρος τῶν ἀντιστοίχων χρονοσειρῶν.

Ἐκ τῆς μελέτης ταύτης εἰς τὰς δύο περιοχὰς προέκυψεν ὅτι:

α. Τόσον οἱ θερμοὶ μῆνες ὅσον καὶ οἱ ψυχροὶ παρουσιάσθησαν μὲ τὴν αὐτὴν περίπου πιθανότητα (Θεσ/νίκη: 48.5% θερμοί, 48.3% ψυχροί, καὶ Λάρισα: 48.9% θερμοὶ καὶ 48.4% ψυχροὶ μῆνες).

β. Μία ἀνομοιόμορφος κατὰ τὸ μᾶλλον ἢ ἧττον κατανομὴ τῆς συχνότητος ἐμφανίσεως τῶν θερμῶν καὶ ψυχρῶν μηνῶν τόσον διὰ τοὺς μεμονωμένους μῆνας ὅσον καὶ διὰ τοὺς ἐν διαδοχικῇ ἀκολουθίᾳ 2,3,4.... μῆνας (Πίναξ Ι).

γ. Ὑπάρχει κάποια τάσις ἐμμονῆς εἰς τὴν ἐμφάνισιν τόσον θερμοῦ ὅσον καὶ ψυχροῦ μηνὸς ἐκ τῆς ἐπικρατήσεως προηγουμένως ἑνὸς παρομοίου μηνὸς (θερμός, ψυχρὸς) (Θεσσαλονίκη: $\frac{W_1}{W_2} = 1.42$, $\frac{C_2}{C_1} = 1.45$, Λάρισσα: $\frac{W_1'}{W_2'} = 1.61$, $\frac{C_2'}{C_1'}$ 1.61).

δ. Μέχρι τῆς διαδοχικῆς ἀκολουθίας τῶν πέντε μηνῶν, ἡ πραγματικὴ κατανομὴ τοῦ συνόλου τῶν θερμῶν ἢ ψυχρῶν μηνῶν ὑπολείπεται, κατὰ κανόνα, τῆς τυχαίας τοιαύτης, ἐνῶ ἀπὸ τῆς ἀκολουθίας τῶν ἓξ διαδοχικῶν μηνῶν καὶ πέραν, ἡ πραγματικὴ ὑπερτερεῖ τῆς τυχαίας (Πίναξ ΙΙΙ). Τοῦτο δύναται νὰ θεωρηθῇ ὡς μία ἔνδειξις ἐπικρατήσεως, εἰς ἀμφοτέρας τὰς μελετωμένας περιοχάς, ἓξ ἢ καὶ περισσοτέρων συνεχῶν μηνῶν τόσον μὲ ὑψηλὰς ὅσον καὶ μὲ χαμηλὰς θερμοκρασίας, αἱ ὁποῖαι ὀφείλονται εἰς γενικώτερα δυναμικὰ αἴτια.