RELATIVE HUMIDITY AT THESSALONIKI-GREECE (I)

by

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Abstract. *Relative humidity at the city of Thessaloniki is studied from data of the meteorological station of the Aristotelian University ($\varphi=40^o$ 37' N, $\lambda=22^o$ 57.E, $h\rho=31,9$ m) of the period 1930-1974.*

Conclusions are drawn as to monthly and annual values as well as on the local and general conditions that produce the mean and extreme values of relative humidity.

Also the resultant monthly mean values of relative humidity are compared with those mentioned by previous authors working on the same subject, and explanations are given for the apparent increase of these values during the last years.

INTRODUCTION.

We study here relative humidity at the city of Thessaloniki; the subject has been examined in the past by every author studying the weather or the climate of Northerm Greece (Macedonia), i.e. *Kuhlbrodt*[8,9] *Philippson*[16], *Mariolopoulos*[15], *Livathinos*[14], *Kyriazopoulos*[10] e.t.c.

This meteorological parameter has also heen examined in special studies on the climate of the city of Thessaloniki by *Eredia*[7] and *Alexandrou*[1], (see Table V).

However all previous authors hased their studies on data of various meteorological stations that have operated in the city of Thessaloniki for rather short intervals.

Alexandrou[1] and *Kyriazopoulos*[10] based theirs on the first data of the meteorological station of the Aristotelian University of Thessaloniki; the former for one year only (1930) and the second for the also short period of the years 1930-1937.

Data of the period before the Second World War have been also used by Biel[6].

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University of Thessaloniki, being the most appropriate agent for the study of the climate of the Northern Greek area, is actually carrying out a Project on the «Climate of Thessaloniki»; part of this project is the study of relative humidity of the air, of which the paper in hand consists the first part.

MATERIAL

The meteorological data used in the present work result from observations, measurements and recordings of hair-hygrographs (various models («M» etc.) manufactured by J. Richard), effected at the meteorological station of the Aristotelian University of Thessaloniki ($\varphi =$ 40° 37° N, $\lambda = 22°$ 57° E, Hp $= 31$, 9) present position.

Monthly mean and annual mean values have been taken from the series «Annuaire de l'Institut Météorologique et Climatologique-Observations Météorologiques de Thessaloniki» (*Mariolopoulos*[17], *Kyriazopoulos*[18], *Livadas*[19]. Hourly values as well as absolute maxima and minima have been taken from the processing sheets of recorders.

The period covered by the present study is that between 1930-1974, with the exception of the 1940-45 interval; and this because Thessaloniki with the whole area of Northern Greece took a great share in the fates of the Second World War. Consequenty the period examined herein represents 39 full years.

We should also mention that in 1958 the meteorological station was moved some 220 m from its old position to where it actually stands, within the University Campus, because the Institute itself was also moved to its own new building; however the difference of elevation between the two sites being very small (old Hp 23.7 m, new Hp 31, 9 m) no difference occured in the observational series, as it resulted from observations effected simultaneously in both sites (*Livadas*[13]).

ANNUAL VALUES

We observe that the annual mean values of relative humidity appear to be higher at the city of Thessaloniki than almost every other station on the west coast of the Agean Sea.

TABLE I

Mean and extreme annual values of relative humidity (%)
at the city of Thessaloniki (1930-1974)

Maximum	74.5	(1946)
Mean	70.0 ± 3.4	
Minimum	62.8	(1933)

Comparing the extreme values of Table I with mean values of relative humidity mentioned by *Mariolopoulos*[15] for various greek stations, we observe that it is possible to have at Thessaloniki higher values than those of the island of Corfu (Kerkyra) belonging in a «pocket» of high relative humidity values in the Ionian Sea, as well as those of the island of Lesvos also belonging in a second «pocket» of high relative humidity in the eastern Aegean Sea. At other times however, its values approach the small relative humidity recorded at the area of Athens, Saronikos Gulf and the Cyclades, that is the area with the smallest amount of annual precipitation.

As to the distribution of annual mean values, we observe that in 18 years, values were at least by 1% higher than average, in 14 years they were by 1% smaller, and only in 5 years out of 39 (13% of the cases) they approached the mean value.

TABLE II

Frequency of annual mean relative humidity values in Thessaloniki (1930-1974)

75.0 - 73.1	11
73.0 - 71.1	7
71.0 - 69.1	7
69.0 - 67.1	5
67.0 - 65.1	5
65.0 - 63.1	3
63.0 - 61.1	1

The frequency distribution of annual mean values of relative humidity, indicates that the rate of dry and humid years at the city of Thessaloniki is one to one.

MONTHLY VALUES

The study of monthly mean values of relative humidity leads to the following conclusions:

We observe that the annual variation of relative humidity has a single fluctuation, with its maximum in December, which is actually the first month of the truly cold quarter of the year, and its minimum in August.

Also the value for July, the warmest month of the year, is $<60\%$, while we have values $>70\%$ during the October - March semester,

In the column listing the most humid months in this time-series, we observe that this same semester has monthly mean values >85%, while in the first winter months values exceed the 90% grade.
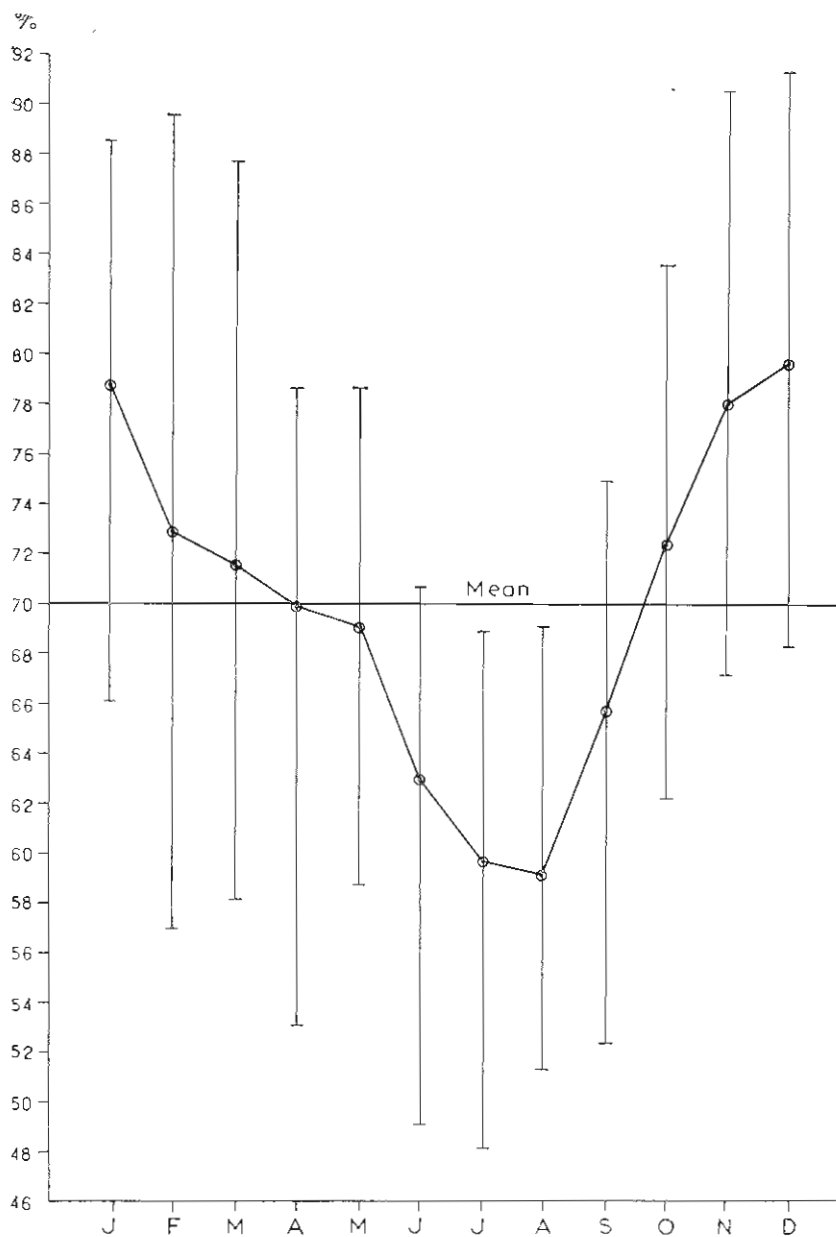
TABLE III

Relative humidity (%) in Thessaloniki (1930-74).

	most humid	month	Mean	± σ	driest month		A-B
J	88.5	1955	78.8	4.9	66.1	1932	22.4
F	89.6	1954	72.9	6.5	56.9	1934	32.7
M	87.7	1954	71.6	5.8	58.3	1933	29.4
A	78.7	1953	69.9	5.0	53.0	1933	25.7
M	78.7	1948	69.1	4,7	58.7	1932	20.0
J	70.7	1953	62.9ˋ	5.2	49.1	1932	21.6
J	68.9	1951	59.7	4.8	48.1	1934	20.8
A	69.1	1947	59.1	4.2	51.3	1931	17.8
S	75.0	1958	65.6	5.3	52.4	1935	22.6
O.	83.7	1955	72.4 .	5.5	62.2	1961	21.5
N	90.7	1946	78.2	5.6	67.2	1931	23.5
D	91.4	1947	79.8	4,7	68.3	1936	23.1
Year			70.0 ± 3.4				

On the other hand, in the column listing the driest months of the period examined, we observe that monthly mean values below the annual normal (<70%) have been recorded in every month of the year, while, as should be expected, the smallest monthly mean values have been recorded during the warm season, when we can have monthly values as small as <50%.

If we count now the differences between the highest and the smallest monthly mean values for each month separately, we find that August has the smallest difference, meaning that this month has the smallest variations of relative humidity, at least for tbe period examined. Consequently this should be considered as the most stable month from the viewpoint of relative humidity; the same applies for almost every meteorological parameter during this month (*Livadas-Flocas*[11], *Balafoutis-Livadas*[5] etc.).

If we examine now the frequency distribution of monthly mean values of relative humidity at Thessaloniki, we observe that extreme values, above 90% and below 50%, represent only a small percentage. On the contrary the longest percentage (73.3% or 343 months out of a total of 468 of the period examined) has monthly mean values staning

GRAPH I

*Annual Variation of Relative Humidity and Most Humid ant Driest Months
of the Period.*

TABLE IV

Frequency distribution of monthly mean relative humidity values in Thessaloniki

Scale	J	F	M	A	M	J	J	A	S	O	N	D	Total	%
45.0 - 49.9						1	1						2	0.43
50.0 - 54.9				1		1	6	7	1				16	3.42
55.0 - 59.9		1	2		2	8	8	18	3				42	8.97
60.0 - 64.9		3	1	4	6	13	19	12	12	4			74	15.81
65.0 - 69.9	2	9	13	14	15	13	5	2	16	8	3	2	102	21.79
70.0 - 74.9	3	11	13	15	13	3			6	15	9	5	93	19.87
75.0 - 79.9	19	9	8	5	3				1	8	11	10	74	15.81
80.0 - 84.9	11	4	1							4	14	19	53	11.32
85.0 - 89.9	4	2	1								1	2	10	2.14
90.0 - 94.9											1	1	2	0.43
Total	39	39	39	39	39	39	39	39	39	39	39	39	468	99.99

between the grades of 60.0 - 79.9% of relative humidity.

Besides we also note, the outstanding high monthly mean values of relative humidity of the November-January quarter.

It is worth noting that for the two months of February and March monthly mean values extend to seven grades of 5% each; meaning that it is possible during this interval to have quite high (85.0 - 89.9%) as well as quite small (55.0-59.9%) relative humidity values. As a matter of fact, these two months may be extremely humid or rather dry, depending on the persistence of high pressure systems over the Balkans, when we have comparatively dry air masses, or to the intense activity of the Mediterranean-Polar front, when we have continuously low-pressure centers crossing the area of Greece and bringing along warm and humid air masses from the ever-warm Mediterranean.

The months of April and May resemble each other (see Table III) not only as to their normal mean value but also in their absolute maximum value during the period examined. These two months are usually the forerunners of the warm summer season.

DISCUSSION

A study of relative humidity at the city of Thessaloniki, based on data of the meteorological station of the Aristotelian University, leads to the following conclusions on this meteorological parameter:

a. Its annual mean value of 70.0±3.4% is quite high for the area of Greece. This rather high value is partly due to the existence of the Bay of Thessaloniki which is the northern recess of Thermaikos Gulf.

The Bay of Thessaloniki is shallow, whith a maximum depth of 30 m, and consists a continous source of water-vapors for the surrounding area which is no other than the area of Greater Thessaloniki.

Besides the diffusion of water-vapors and the resulting sea fogs, we also have another factor: this is the sea-breeze that blows the whole year through (*Livadas-Sahsamanoglou*[12]). This sea-breeze of SSW-SW component, continuously brings along water-vapors to the city's area.

b. The annual variation of relative humidity has a single fluctuation with its maximum in December, the first month of the cold quarter, and its minimum in August the second warmest month of the year.

The months of December and January have the highest monthly mean values. These same months have also the highest frequency of fogs (*Angouridakis*[2,3]).

c. If we compare monthly mean values of the present work with those given by previous authors (Table V) we observe the folowing:

TABLE V

Comparison of monthly relative humidity values in Thessaloniki according to various authors

	Kuhlbroodt 1892–1900	Kuhlbroodt 1894–1911	Eredia 1893–1911	Greek Gymnasium 1909–1923	American Farm School 1924–1929	Alexandrou composite serie	Mario-lopoulos composite serie	Livathinos composite serie	Kyriazopoulos 1904–1911	Kyriazopoulos 1930–1937	American Farm School 1930–1936	Present work 1930–1974
J	78	71	71	73	73	75	74	74	73	75	. 81	79
F	71	69	69	77	72	73	73	74	74	66	74	73
M	67	67	67	71	70	70	69	70	70	67	73	72
A	67	65	65	68	66	68	67	67	68	63	67	70
M	66	63	64	67	65	67	65	66	67	63	71	69
J	62	59	59	61	56	64	60	60	63	55	62	63
J	57	55	54	56	50	56	54	54	57	51	55	60
A	58	57	56	56	52	57	56	55	59	52	55	59
S	62	61	62	63	60	63	61	62	64	59	61	66
O	74	71	71	75	69	73	72	72	74	69	73	72
N	74	72	72	76	77	77	74	75	74	72	77	78
D	76	74	74	80	79	78	77	78	77	75	78	80
Year	68	65	65	69	65	68	67	67	68	64	69	70

All previous works on the same subject are, as already mentioned, based on data of rather short periods, taken from various meteorological stations that have been operating inside or near the ciy of Thessaloniki.

As it results from rhe works of *Alexandrou*[1] but especially that of *Kyriazopoulos*[10] all the stations included in Table V, operated inside the city of Thessaloniki except for the station of the American Farm School which stands within the area Greater Thessaloniki but still out of the city limits.

Values given by Alexandrou (6th column), Mariolopoulos (7th column), Livathinos (8th column), resulted from inter-filling data of the years 1900-1929 from the following meteorological stations: Austrian, Bulgarian Gymnasium, Greek Gymnasium and American Farm School.

However, the missing data of the stations that have been taken into account in producing the above mixed series, give rise to certain doubts as to whether the resultant numbers really represent the relative humidiry of the area during the observational years.

The series of the meteorological station of the Bulgarian Gymnasium is the more complete and may be considered as representing the actual values of relative humidity at the old city of Thessaloniki during the first decade of the 20th century.

Columns 2 (Kuhlbrodt) and 3 (Eredia) are based on data of this same station; these same data of relative humidity are also mentioned by *Biel*[6].

Comparing these values with those mentioned by *Kyriazopoulos*[10] (10th column) for the meteorological station of the Aristotelian University and for the 8-year period 1930-1937, we observe that during the third decade of the century there is no essential difference as to the annual mean value of relative humidity.

While if we take into account the annual mean value of relative humidity at the same station for the 1930-1974 period, as per the present work, we observe an increase of the annual mean. This increase results from the systematic increase of monthly mean values by 3%-9%. We should also mention that increase of 8% or 9% has been recorded during the two warm months, June (8%) and July (9%).

We attribute this iucrease of monthly mean values of relative humidity to the following factors:

I. The increased height of new buildings after the Second World War. Two - storied buldings have been replaced in Thessaloniki after 1950, by multi-storied appartment houses. This resulted in the lessen-

ing of wind speed recorded in the meteorological station of the Aristotelian University (*Livadas-Sahsamanoglou*[12]).

In other words the city of Thessaloniki, at the begining of the century, when we have the first meteorological observations, was a Middle-Eastern type of town with some 50.000-60.000 inhabitants; before the Second World War it had already the aspect of a Balkan city of 100.000-120.000 inhabitants; it has actually reached the level of European cities, with 600.000 inhabitants. This increase in area and height of buildings has produced the decrease of ventilation of the city, resulting in the increase of relative humidity.

II. During this last decade we have recorded an increase of precipitation during the warm season; the same trend is apparent in the annual amount of precipitation as well as in the number of rain days per annum (*Angouridakis*[4]), which is also attributed to the city's growth.

III. The authors believe that: this increase of relative humidity values should be partly attributed to a more general deterioration of weather conditions appearing lately in the area of Greece, that affects also Greece's «fair weather».

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ΠΕΡΙΛΗΨΙΣ

Η ΣΧΕΤΙΚΗ ΥΓΡΑΣΙΑ ΣΤΗ ΘΕΣΣΑΛΟΝΙΚΗ (I).

Ὑπὸ

ΓΕΩΡΓΙΟΥ Κ. ΛΙΒΑΔΑ ΚΑΙ ΒΛΑΔΙΜΗΡΟΥ Α. ΣΕΜΕΡΤΖΙΔΗ

Στὴν ἐργασία αὐτὴ μελετοῦμε τὴ Σχετικὴ Ὑγρασία στὴν πόλη τῆς Θεσσαλονίκης, ἔχοντας σὰ βάση τὸ ἐπιστημονικὸ ὑλικὸ τοῦ Μετεωρολογικοῦ Σταθμοῦ τοῦ Ἀριστοτελείου Πανεπιστημίου Θεσσαλονίκης (φ = 40° 37′ N, λ = 22° 57′ E, ὑψόμ. 31.9 μ) γιὰ τὴ χρονικὴ περίοδο 1930-1974.

Ἀπὸ τὴ μελέτη, τόσο τῆς μέσης ἐτήσιας τιμῆς τῆς σχετικῆς ὑγρασίας, ὅσο καὶ ἀπὸ τὶς μέσες μηνιαῖες τιμές, βγαίνουν συμπεράσματα, τὰ ὁποῖα καὶ αἰτιολογοῦμε σύμφωνα μὲ τὰ γενικὰ καιρικὰ στοιχεῖα ποὺ ἐπικρατοῦν στὴν περιοχή, ὅσο καὶ μὲ τὴν ἐπίδραση τοπικῶν παραγόντων, ὅπως π.χ. εἶναι ἡ ἐπίδραση τοῦ ἴδιου τοῦ ὅρμου τῆς Θεσσαλονίκης.

Ἐπίσης, συγκρίνονται οἱ μηνιαῖες τιμές τῆς ὑγρασίας τοῦ ἀέρος μὲ τὶς τιμές ποὺ μᾶς ἔδωσαν ἄλλοι ἐρευνητὲς ποὺ ἐργάσθηκαν πάνω στὸ ἴδιο θέμα μὲ παλαιότερα στοιχεῖα. Στὴν πραγματικότητα, πρόκειται γιὰ μετεωρολογικὰ στοιχεῖα ποὺ καλύπτουν τὴν μπροστὰ ἀπὸ τὸν Δεύτερο Παγκόσμιο Πόλεμο χρονικὴ περίοδο. Ἀπὸ τὴ σύγκριση αὐτή, βγαίνει ὅτι οἱ μηνιαῖες τιμές τῆς σχετικῆς ὑγρασίας αὐξήθηκαν ἀπὸ 4-9% στὰ τελευταῖα 30 χρόνια.

Σὰν αἰτιολογία δίνουμε:

α) Τὴν σημαντικὴ αὔξηση σὲ ἔκταση καὶ ὄγκο τῆς ἴδιας τῆς πόλης, γεγονός ποὺ προκάλεσε τὴν ἐλάττωση τῆς ταχύτητας τοῦ ἀνέμου, ἄρα σὲ τελικὴ ἀνάλυση ἐλάττωσε τὸν ἀερισμὸ τῆς πόλης, αὐτὸ δὲ εἶχε σὰν ἀποτέλεσμα τὴν αὔξηση τῶν τιμῶν τῆς σχετικῆς ὑγρασίας.

β) Ἡ μεγαλούπολη Θεσσαλονίκη, δημιουργεῖ ἡ ἴδια σὰν πολεοδομικό-οἰκιστικὸ συγκρότημα, μιὰ τάση γιὰ αὔξηση τῶν ἡμερῶν βροχῆς, καὶ τέλος

γ) Πιστεύουμε ὅτι ἡ αὔξηση αὐτή, τουλάχιστον κατὰ ἕνα μέρος, πρέπει νὰ ἀποδοθῆ σὲ μιὰ «ἐπιβάρυνση» τῶν καιρικῶν συνθηκῶν, ποὺ παρουσιάζεται στὸν Ἑλλαδικὸ χῶρο τὴν τελευταία δεκαετία.