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MEASUREMENTS OF SO_2 CONCENTRATIONS AT THESSALONIKI GREECE

by

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Abstract: *In this paper we undertake the study of SO_2 concentrations at the city of Thessaloniki and especially on top of the building of the Meteorological Institute of the University.*

These measurements were carried out with an Analyser-Ultragas-U3S (manufactured by H. Wösthoff-W. Germany).

Follows discussion of results, as a function of season and other meteorological parameters. Also the considerable increase of SO_2 concentrations during the cold season is explained.

INTRODUCTION

The importance of measurements for the determination of sulfur dioxide (SO_2) concentration, becomes higher every day in problems of air pollution.

Especially so at the area of Greater Thessaloniki, an area characterized by a gathering of many unfavorable factors against the effort of keeping «the air clean».

The principal of such factors are:

a. The rapid increase of the inhabitants not only of the city of Thessaloniki but also in the area of Greater Thessaloniki. This increase, during the last decade, has become a torrential reflux of new inhabitants into the area examined.

TABLE 1

Population movement at the area of Greater Thessaloniki and the municipality of Thessaloniki. (Papayiannopoulos, 1975[14]).

Census	Greater Thess.	Increase	Municip. Thess.	Increase
1951	302.635	—	217.049	
1961	380.648	25.8 %	250.920	15.6 %
1971	557.360	46.4 %	345.799	37.8 %

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This means that the area of Greater Thessaloniki has all the characteristics of urbanization at an accelerated rate; the phenomenon is common in most European countries, after the Second World War.

b. The increase of the national revenue by 60% during the 1960-69 decade, together with the spectacular increase of the inhabitants, produced the need for new building forms, especially in the city center. There the multistoried buldings resulted in quite high population densities, that is 1400-1600 inhabitants per acre.

With the erection of multistoried buldings, the traditional heating (mainly by firewood, coke or anthracite), has been almost totally replaced by oil heaters, mostly burning mazut (in 90%) of the 1500 and 3500 type.

The mazut used for heating in Greece, according to the Greek technical specifications has a quite high sulfur content, that is (Kourkoulas[8])

for mazut type 1500 maximum 3,5 %
» » » 3500 » 4,0 %

The actual percentage of sulfur content is for the 1500 type 2.8-3.4% and for the 3500-type it is 3-3.7%.

We give an emphasis to the sulfur content of fuel-oil used for heating, because this, in the authors' opinion, is one of the main sources of air pollution in the area of Greater Thessaloniki.

c. The increase in the mass of blocks of buildings in every direction, due to the already mentioned increase of the population, has produced a change in the wind-factor at least in the city of Thessaloniki, where meteorological stations have been operating ever since 1892, and the station of the Institute of Meteorology and Climatology of the Aristotelian University since 1931.

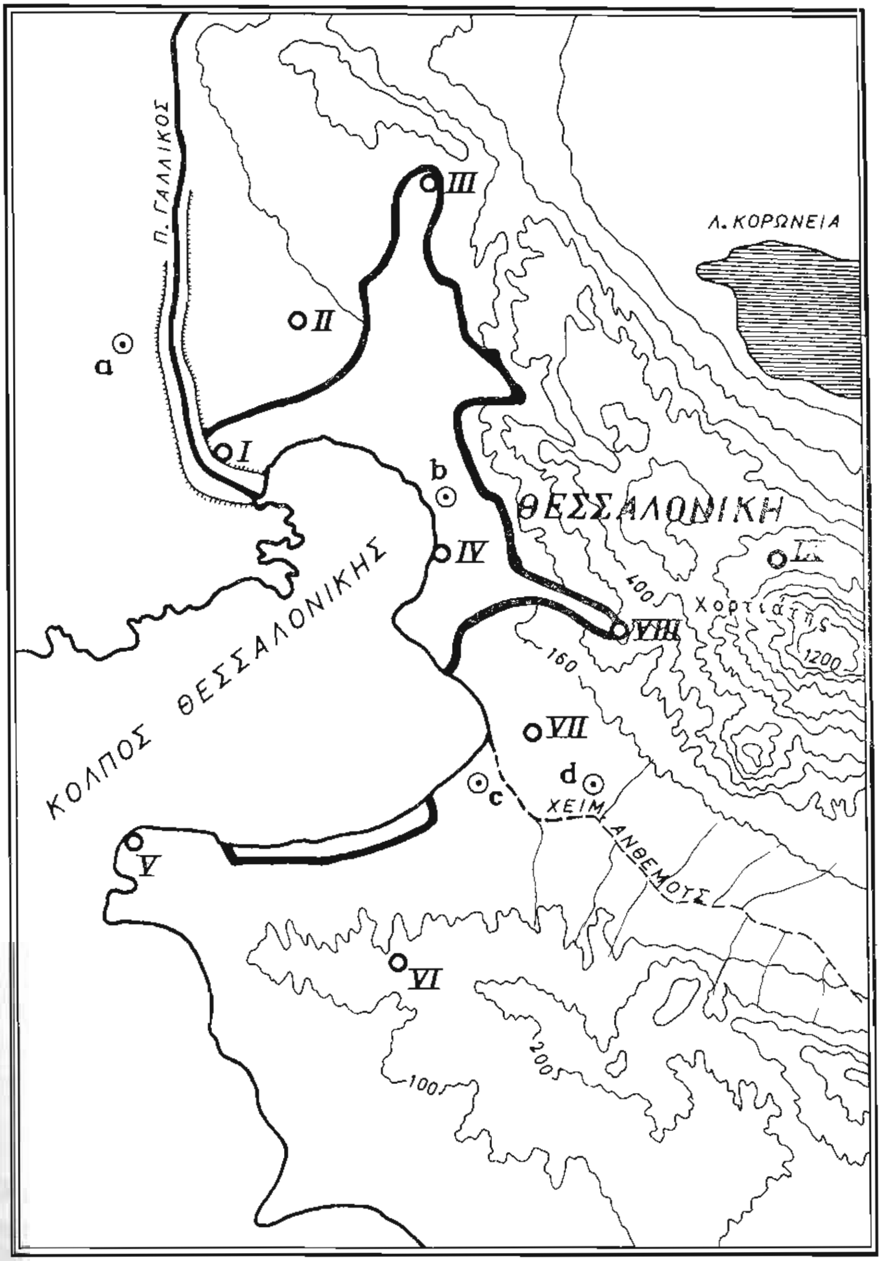
TABLE II

Comparison of wind data from various authors and different periods.

Period	Mean velocity (m/sec)	Calms % (per year)	Gales (≥8B)
1892-1929[13]	—	23.0 %	—
1931-1937[11]	2.30 m/sec	26.4 %	20.1 days
1931-1971[12]	1.77 m/sec	48.9 %	13.5 days

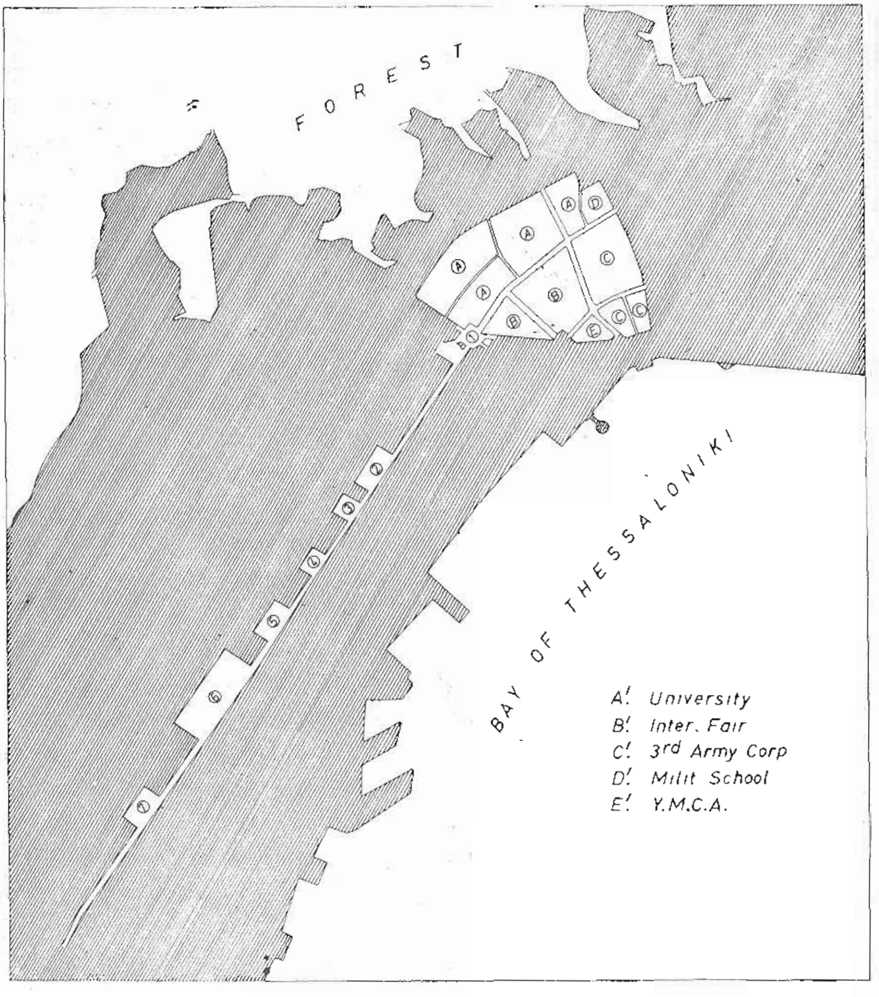
The apparent continuous decrease in the annual mean of wind velocity, and the doubling of calms, especially after the year 1950 onwards, are depressing factors for the city area.

The city of Thessaloniki together with the area of Greater Thessa-



MAP I. Area of Greater Thessaloniki. Letter b and latin numbers, denote positions of stations in the meteorological network of the Met. Institute of the University of Thessaloniki. Letters a, c. and d show positions of met. stations of other Services.

loniki take up almost the whole hemicycle of the Bay of Thessaloniki and its harbor as well, consisting the northern recess of Thessaloniki Gulf.



MAP II. The City of Thessaloniki

The contour-lines give a picture of the relief of the area of Greater Thessaloniki: To the east rises the mountain mass of Chortiates and to the west lies a low alluvial plain, formed by the Axios river until its bed and estuary were artificially altered before the Second World War.

Mt Chortiates, with its gullyiugs, produces in the east side of the city microzones where during the evening hours slight - down - slope winds blow. These light winds, bring down, during the cold season, cold air masses that mix with the humid air masses of the bay, finally producing ground fogs in the east side of Thessaloniki.

However, the main mass of the city of Thessaloniki is not affected by these light winds. The boundaries of the city of Thessaloniki are defined within its old walls. And since this area has been a city for 2500 years in a run, it has the same urbauization problems, common in most traditional European cities: A great number of monuments and churches, dating back to the Roman Empire, that is from the 1st century A.D. till the end of the 19th century A.D. Small narrow streets, rendering impossible the development of vast areas of green, that should ease the circulation of air masses. As a consequence, air pollution becomes considerable inside such areas.

Exactly at the edge of the above defined old city of Thessaloniki, extends a zone of greeu, where only public buildings stand, such as the International Fair of Thessaloniki, the 3rd Army Corps, and the University campus.

It must be mentioned that the harbor of Thessaloniki and its bay as well are both shallow, and this results in intense evaporation from a surface of about 25 km², or almost equal to the area of Greater Thessaloniki.

This strong evaporation throughout the year, fills the lower layers of the atmosphere with water vapors, whose presence during the cold season consists one of the main sources of frequent fogs, occuring not only in the area of Greater Thessaloniki but also over its bay.

TABLE III

Mean number of fogs (VV $\leqslant$1000 m) per year at Great Britain and in Greece.

Croydon	54.8[4]	Athens	0.4[2]
Farnborough	58.4	Thessaloniki	32.1 ($\leqslant$1 km)
Renfew	69.4	»	55.9 ($\leqslant$2 km)

From studies of fogs in the area of Thessaloniki (A n g o u r i d a k i s[(2)]), it results that fogs are quite frequent in this area, especially during the cold season, approaching in number per year those of the British Isles, an area well known for fogs; on the other hand they have nothing to do with the slight number of fogs occuring some 300 km to the south, that is at the Athens area.

Another factor affecting the pollution or not of the lower layers of the atmosphere is relative humidity of the air. This meteorological parameter has comparatively high values at the area of Greater Thessaloniki the whole year through. Maxima of relative humidity, recorded at the city's meteorological station (Institute of Meteorology & Climatology of the Aristotelian University) included in Table IV, give a not so pleasant picture, since in all ten months it is posible to have saturation values (100%) and only in the main two warm summer months the maxima are$<$100%. Besides, monthly mean values of relative humidity are$\geqslant$70% from November till April and only the warm and dry August, that is the month of the etesian winds, has a mean value$<$60%.

TABLE IV

Maximum and Mean Values of Relative Humidity (%) at Thessaloniki.

	Max	Mean (1931-1971)	Mean (1965-1974)		Max	Mean (1931-1971)	Mean (1965-1974)
J	100	75	77	J	96	56	60
F	100	73	75	A	94	57	59
M	100	70	72	S	100	63	66
A	100	68	70	O	100	73	68
M	100	67	67	N	100	77	75
J	100	64	62	D	100	78	77
				Year		68.4 %	69.0 %

Measurements of SO_2 at the Area of Thessaloniki

The first measurements of SO_2 at the area of Greater Thessaloniki, were effected toward the end of 1970; results of these first measurements have been published by the second of the authors[9]. Measurements were repeated in 1972[10].

The above measurements were effected at various places of the main traffic artery of the city, the Egnatia street, starting at NW end of the University campus (Syndrivani-Papanastassiou place) till the site of Ghefyra, that is the NW limit of the city of Thessaloniki, on a straight line 5.4 km long (the sampling locations are marked on MAP II).

From the above measurements resulted the first indications of SO_2 pollution of the lower layer of the atmosphere of Thessaloniki, which can be summarized as follows:

a. Of the 17 measurements in Table V, 15 were effected during the cold season, that is a period when the «walled-in» part of the city consumes large quantities of mazut for heating.

TABLE V

Results of SO_2 measurements (in γ/m^3) at various places along the Egnatia Street in Thessaloniki[9,10]. (Kovatsis - Koufidis 1971-1972 [9,10])

	No. of observations	Max.	Mean	Min.
1. Egnatia - Syndrivani Place	17	262	67.9	14
2. » - Ag. Sophias »	17	302	101.2	18
3. » - Aristotelous Square	17	266	103.2	20
4. » - Kolombou Place	17	362	135.2	30
5. » - Vardariou »	17	221	97.5	6
6. » - New Railroad Station	17	180	72.8	8
7. » - Gefyra	16	174	64.7	26

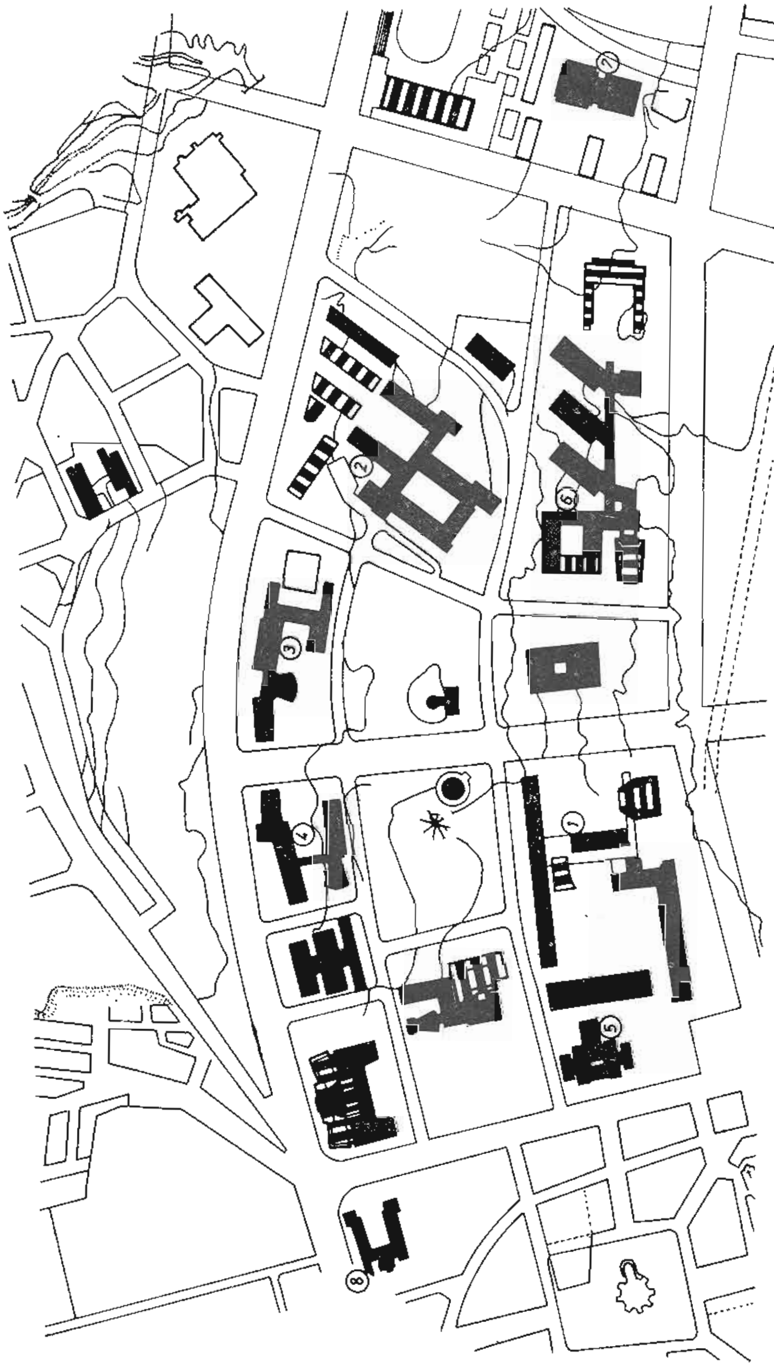
b. The locations of Papanastassiou Place (Syndrivani) and Ghefyra have the smallest concentration values of SO_2, while the area with the highest population and building density has also the highest SO_2 concentrations.

In addition to the above measurements, the Laboratory of Hygiene of the Medical School of our University began in 1971 its own series of SO_2 concentration measurements at various places of the Greater Thessaloniki area, by its special mobile unit and using a Leeds & Northrup sampler[18].

Data of these measurements are given in Table VI; they indicate that in the area of the Medical School building complex, within the University Campus of Thessaloniki, we have some of the smallest SO_2 concentrations ever measured by this Laboratory at the Greater Thessaloniki area.

The above mentioned measurements[9,10,18], at first approximation, indicate that the area of the University Campus may be considered as a green zone with small SO_2 concentrations.

As a matter of fact this green zone and the public buildings extends to some 110 acres (See Map III).



MAP III. University Campus. Nº 1-8 Emission sources. Asterisk shows positions of measuring instruments.

TABLE VI

Mean and extreme monthly values of SO_2 concentration pphm, during the years 1971 & 1972, within the University Campus of Thessaloniki (Vlachos, Tables VIII & X[18].)

	Max.		Mean		Min.	
	1971	1972	1971	1972	1971	1972
J	1.80	0.95	1.15	0.75	0.32	0.25
F	3.20	6.00	2.26	3.20	0.56	0.40
M	2.80	1.50	1.80	1.15	0.15	0.90
A	0.97	2.20	0.60	1.00	0.12	0.35
M	1.80	0.95	1.10	0.65	0.38	0.32
J	2.60	3.70	1 50	1.70	0.42	0.28
J	0.88	0.68	0.60	0.45	0.11	0.15
A	0.85	1.20	0.40	0.65	0.12	0.28
S	1.40	0.95	1.00	0.80	0.37	0.15
O	1.20	0.95	0.80	0.65	0.35	0.25
N	1 90	3.50	1.55	2.00	0.82	0.50
D	0.55	2.50	0.60	1.20	0.13	0.35

Sampling devices employed and sampling locations.

Our own measurements have been carried out by an Analyser-Ultragas-U3S (manufactured by H. Wösthoff O. H. G., Bochum-W. Germany). Measurements by the above analyser are based on the principle of conductivity change measuring, as this has been developed by Thomas[16,17]. The same analyses and process has been used by the second of the authors in previous SO_2 concentration measurements at the city of Thessaloniki.

Essentially the above Ultragaz instrument consists of the two function groups:

a) the analyser unit, and b) the measuring part.

The analyser unit comprises a group of pumps for suction of the air that is to be analyzed. If the air containing SO_2 is conducted into diluted acid-hydrogen peroxide solution (H_2O_2), then oxydation of SO_2 to SO_3 takes place, finally resulting in sulphuric acid (H_2SO_4). This produces an increase in the conductivity values of the solution.

The analyser unit comprises also the measuring cell with reaction tubes and electrodes measuring conductivity changes.

The measuring part comprises the connections for temperature compensating resistances, so that any conductivity differences are transmitted under stable temperature and are recorded in two dinstinct reading-forms: a continuous curve and by printing the average readings at fixed time intervals (15′, 30′ or 60′ minutes).

The instrument has been placed on the roof of the Institute of Meteorology and Climatology building (asterisk on Map III) at a height of 12.5 m from the ground and elevation of 45.5 m.

The air to be analyzed is sucked through an inlet by a suction pipe, 0.80 m long, placed at a height of 1.20 from the roof-surface. Provision has been made so that the inlet of the pipe should be sheltered from being drenched or blocked, in cases of strong precipitation.

Service, maintenance and control of the apparatus was continuous throughout the year, so that results obtained should be as reliable as possible.

The diluted acid hydrogen peroxide solution, used as a reagent, was prepared every week, so as to be always recent.

Our Measurements.

Our own measurements, programmed on a dayly basis, were started towards the end of January 1974; this research includes data till the end of January 1975, covering a whole year.

TABLE VII

Number of Observational Days

	09:00-10:00		12:30-13:30	
	Possible	Actual	Possible	Actual
J	31	4	31	4
F	28	20	28	21
M	31	25	31	25
A	30	22	30	22
M	31	26	31	25
J	30	23	30	23
J	31	26	31	24
A	31	26	31	26
S	30	25	30	26
O	31	25	31	23
N	30	26	30	26
D	31	28	31	27
J	31	26	31	26
Total	396	302	396	298
Percentage		76.26 %		75.25 %

Measurements with simultaneous recording were effected at fixed intervals that is at 09: 00-10: 00 (local time GMT+2h) and at 12: 30 -13: 30. The amount of observations effected is included in Table VII.

With the exception of January 1974, the percentage of effected measurements may be considered quite satisfactory (80%), if one takes into account that we had only one measuring instrument and had to suspend measurements for service and accuracy control of this.

The observational hours were not picked at random they have been chosen after a study of SO_2 concentration variations conducted by the second of the author's[10], agreeing with results of other researchers, which indicate an increase of SO_2 concentration in every city around 9 a.m.[15].

Thus the first observation corresponds to the morning traffic-peak, and at the same time according to living conditions at the city of Thessaloniki, this is an hour when central-heating installations operate during the winter season while sea-breezes that blow even in winter, although not so frequently as in other seasons, have not yet begun at this time[12]. Also, radiation fogs, that are quite frequent in winter, still persist at this hour.

TABLE VIII

Mean and Extreme Monthly Values of SO_2 Concentration at Thessaloniki. Jan. 1974-Jan. 1975 ($mgr.m^{-3}$)

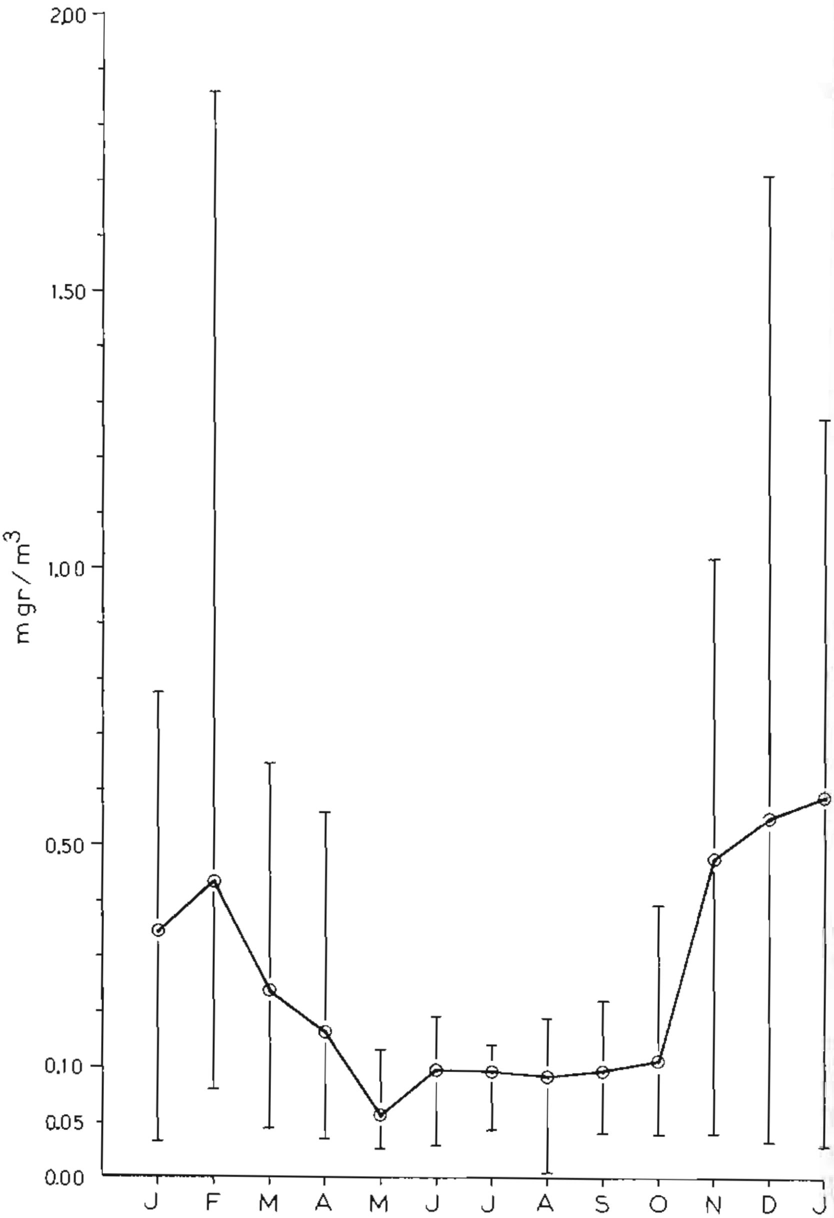
	09.00-10.00			12.30-13.30		
		Absolute			Absolute	
	Mean	Max	Min	Mean	Max	Min
J	0.3451	0.7855	0.0265	0.1331	0.2468	0.0305
F	0.4345	1.8530	0.0530	0.2268	1.1855	0.0250
M	0.2377	0.6430	0.0445	0.1091	0.3300	0.0015
A	0.1562	0.5535	0.0345	0.0520	0.2040	0.0226
M	0.0626	0.1285	0.0265	0.0386	0.0925	0.0140
J	0.0990	0.1585	0.0300	0.0685	0.1165	0.0435
J	0.0976	0.1385	0.0430	0.0891	0.1850	0.0605
A	0.0845	0.1860	0.0045	0.0722	0.1005	0.0010
S	0.0981	0.2175	0.0415	0.0727	0.1795	0.0473
O	0.1117	0.3910	0.0415	0.0741	0.3040	0.0290
N	0.4732	1.0160	0.0410	0.2166	0.5760	0.0360
D	0.5491	1.7020	0.0330	0.2958	0.7970	0.0575
J	0.5843	1.3630	0.0260	0.2864	0.8485	0.0335
Total*	76.2049			40.3733		
Mean**	0.2523			0.1355		

On the contrary, the second time interval (12:30-13:30) is characterized by pleasant noon hours. The morning fogs have usually dispersed, and on days that are not affected by strong weather types, we have a sea-breaze, which means a renewal of air masses in the city. It should be mentioned that measurements mentioned in a previous study[10], were effected by the second of the authors, at this same hour.

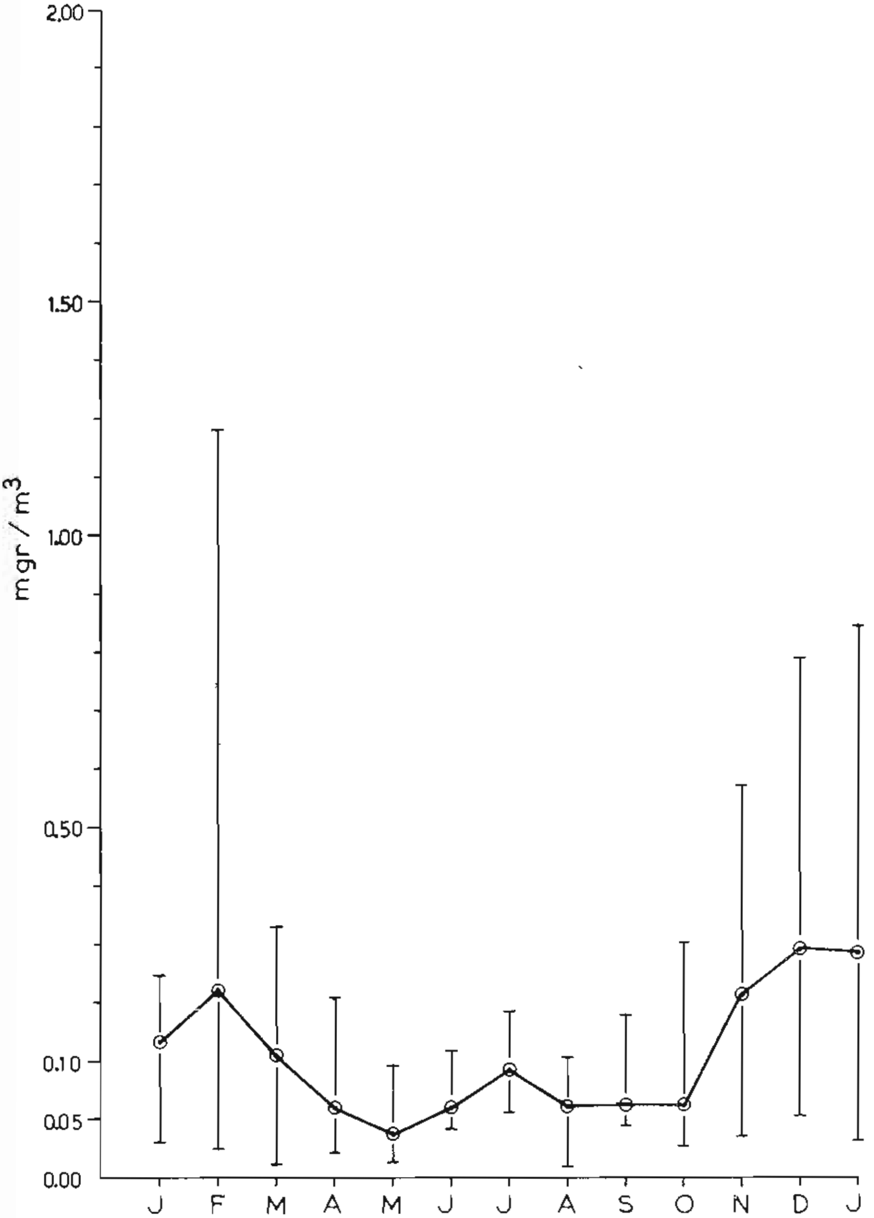
In Table VIII we have included mean and extreme SO_2 concentration values, recorded during the above mentioned measurements.

* Sum total of hourly values of this observational series.

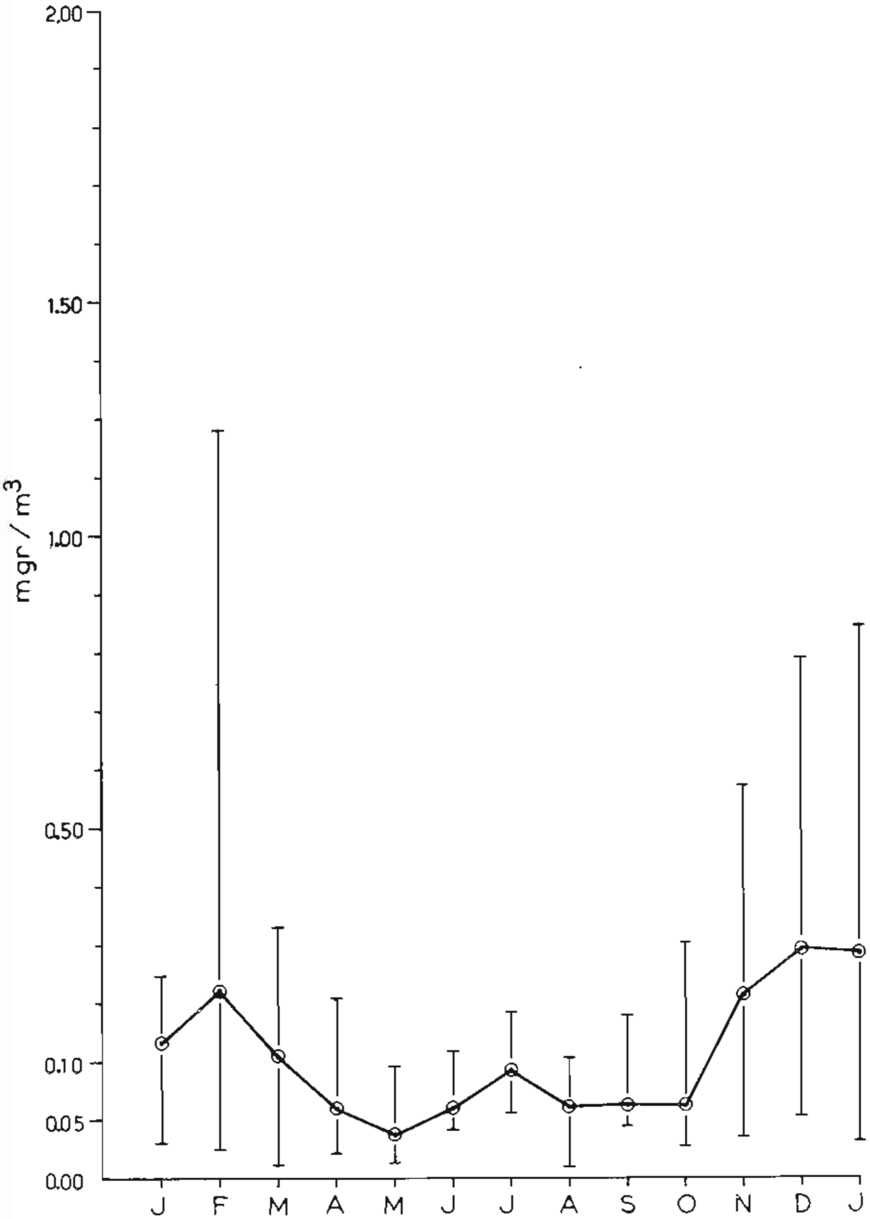
** Mean of above sum total divided by the number of observations effected.



GRAPH I. Mean and extreme monthly values of SO_2 concentration at Thessaloniki (Jan. 1974 - Jan. 1975) (hours of observation 09:00 - 10:00)



GRAPH II. Mean and extreme monthly values of SO_2 concentration at Thessaloniki (Jan. 1974 - Jan. 1975) (hours of observation 12:30 - 13:30)



GRAPH II. Mean and extreme monthly values of SO_2 concentration at Thessaloniki (Jan. 1974 - Jan. 1975) (hours of observation 12:30 - 13:30)

TABLE IX

Frequency Distribution of SO_2 Concentrations. Observation of: 09:00 - 10:00

	J_{74}	F	M	A	M	J	J	A	S	O	N	D	J_{75}	Total
1.800 - 2.000		1												1
1.600 - 1.799												1		1
1.400 - 1.599														0
1.200 - 1.399		1											1	2
1.000 - 1.199											3	2	3	8
0.900 - 0.999		1										1	3	5
0.800 - 0.899		1									2	2	1	6
0.700 - 0.799	1	1									1	5	2	10
0.600 - 0.699		1	1								4	1	3	10
0.500 - 0.599			2	1							1	3	3	10
0.400 - 0.499			1								3	2		6
0.300 - 0.399		1	2	1						2	2		1	9
0.200 - 0.299	2	4	6	3					1	1	5	2	5	29
0.100 - 0.199		5	7	11	4	12	14	5	9	3	3	5		78
0.050 - 0.099		4	5	1	9	9	11	18	13	17	1	1	3	92
0.000 - 0.049	1		1	5	13	2	1	3	2	2	1	3	1	35
Total	4	20	25	22	26	23	26	26	25	25	26	28	26	302

Sum total includes the 4 values of January 1974

TABLE X

Frequency Distribution of SO_2 Concentrations. Observation of: 12:30 - 13:30

	J_{74}	F	M	A	M	J	J	A	S	O	N	D	J_{75}	Total
1.800 - 2.000														
1.600 - 1.799														
1.400 - 1.599														
1.200 - 1.399														
1.000 - 1.199		1												1
0.900 - 0.999														0
0.800 - 0.899													1	1
0.700 - 0.799												3		3
0.600 - 0.699												3	1	4
0.500 - 0.599		2									1	1	2	6
0.400 - 0.499		1									2	2	3	8
0.300 - 0.399		2	1							1	6	1	3	14
0.200 - 0.299	1	1	1	1						1	4	2	6	17
0.100 - 0.199	1	6	9			2	4	1	1	1	4	4	3	36
0.050 - 0.099	1	5	12	6	5	19	20	23	18	9	5	11	6	140
0.000 - 0.049	1	3	2	15	20	2		2	7	11	4		1	68
	4	21	25	22	25	23	24	26	26	23	26	27	26	298

Sum total includes the 4 values of january 1974

From these mean and extreme values, it appears that the highest SO_2 concentrations have been recorded during the cold season.

Especially, monthly mean values of the 09-10h time interval have their maximum in January 1975, with December 1974 coming next, whereas those of the 12: 30-13: 30 time interval, have their maximum in December 1974 with January 1975 coming next.

The smallest monthly mean values of SO_2 concentrations, appear in August, for both observational hours.

A study of extreme values, indicates the existence of a large amplitude between absolute maxima and absolute minima, especially during the cold months, while this range decreases during the warm season. It is also larger during the morning (09: 00-10: 00) observations, than in the noon (12: 30-13: 30) measnrements.

Believing that the occurence frequency of a certain value is more important than the value itself, we have drawn Tables IX & X, in which we give the frequency distribution of various values, and also their percentage.

A study of these frequencies, shows that values of $\geqslant 1.0$ mgr/m^3, hold only a small percentage of the morning observations, while practically they do not exist at noon measurements.

Whereas values$\leqslant 0.2$ mgr/m^3 consist 67.9 % of morning measurements and 81.9% of mid-day ones.

The Weather Data.

An important role for SO_2 concentration in the atmosphere, is played by the prevailing weather conditions and especially by such meteorological parameters as relative humidity of the air and wind velocity.

In Table XI we have included values of the above parameters plus those of air temperature, as they have been recorded at the meteorological station of the Institute of Meteorology and Climatology, within the University Campus and at a distance of about 100 m from the site where SO_2 measurements were conducted.

TABLE XI

Mean Monthly Values of Air Temperature, Relative Humidity, and Wind Velocity at Thessaloniki (Jan. 1974 - Jan. 1975).

	09:00 - 10:00			12:30 - 13:30		
	Tair	RH	W.V.	Tair	RH	W.V.
J	5.55	77.2	3.77	8.04	68.4	5.61
F	8.33	75.5	4.50	10.91	67.5	4.40
M	9.92	74.0	2.66	12.40	64.4	4.78
A	13.18	67.0	3.55	15.22	61.2	5.91
M	19.10	61.3	5.10	22.09	50.2	8.06
J	23.04	59.9	5.22	26.26	50.7	7.79
J	25.83	50.6	6.98	28.92	41.0	8.61
A	26.18	55.3	6.02	29.72	45.5	7.52
S	22.93	58.4	3.97	25.89	50.5	6.62
O	18.69	61.7	3.81	21.66	51.1	7.38
N	10.99	81.4	2.92	14.19	67.3	5.87
D	6.60	72.7	5.52	10.46	58.2	8.86
J	4.44	76.9	6.13	8.28	62.5	8.79

These values are monthly mean values, including every day of the period examined, that is regardless if on a certain date measurements were effected or not. Whereas in Table XII we have included values of the same as above parameters but only for those days which SO_2 measurements have been effected.

From Tables XI and XII it arises that at the city of Thessaloniki there is a clear difference between weather conditions of 09:00-10:00 and 12:30-13:30, that is at the hours when our observations were being made.

Weather conditions as a whole favor less SO_2 concentrations in the lower atmosphere during the mid-day observation.

Temperature, as an average, increases by 3.2° C; which in the case of stagnant air mass produces a decrease of relative humidity. As a matter of fact it decreases as an average between the two observations by 11%; this difference is larger during the main winter months.

Wind velocity also increases by 2.1 km/h (or 47.7%). This increase of wind velocity produces a renewal of air masses in the city, which should have an adverse influence on SO_2 concentrations.

It should be stressed that this combination of temperature increase with simultaneous increase of wind velocity, produce up-drafts over the area of Greater Thessaloniki, which at noon-time (hour of

TABLE XII

Mean Monthly Values of Air Temperature, Relative Humidity and Wind Velocity during the days of SO_2 Measurements at Thessaloniki:

	Air Temperature (°C)			Relative Humidity (%)			Wind Velocity (km/h)		
	09:00 -10:00	12:30 -13:30	Δ_1	09:00 -10:00	12:30 -13:30	Δ_2	09:00 -10:00	12:30 -13:30	Δ_3
J	5.0	9.5	4.5	82	65	17	1.3	2.6	1.3
F	8.4	11.0	2.6	74	67	7	4.4	4.7	0.3
M	9.7	12.2	2.5	76	66	10	2.1	3.0	0.9
A	13.3	15.6	2.3	63	56	7	4.6	6.3	1.7
M	19.2	22.4	3.2	62	49	13	4.7	7.5	2.8
J	23.9	26.7	2.8	58	49	9	5.0	7.5	2.5
J	25.9	29.1	3.2	50	40	10	7.1	9.3	2.2
A	26.1	29.6	3.5	55	45	10	6.4	7.6	1.2
S	22.9	25.8	2.9	57	51	6	4.4	6.8	2.4
O	18.7	21.8	3.1	62	51	11	4.4	6.5	2.1
N	11.1	14.1	3.0	83	70	13	3.0	6.2	3.2
D	6.6	10.6	4.0	73	58	15	5.9	9.2	3.3
J_{75}	4.6	8.5	3.9	78	63	15	4.4	7.9	3.5
Mean	15.0	18.2	3.2	67.2	56.2	11.0	4.4	6.5	2.1

the mid-day observation) carry the polluted surface layers to greater heights thus lessening SO_2 concentrations in the surface layer.

Discussion.

From the above statements we draw the following conclusions:

a. There is a seasonal fluctuation of SO_2 concentrations at the city of Thessaloniki. This fluctuation has its maximum in the cold season and its minimum in the warm one. Similar variations in average SO_2 concentration values are mentioned by Coin[6] for such megapolis as London, Paris and Rotterdam. This coincidence is in favor of the view that the city of Thessaloniki is beginning to behave like a megalopolis at least as to air pollution from SO_2.

b. All research scientists accept today the important role of climatological factors (Berljand[3]). This applies in the city of Thessaloniki too, where meteorological parameters contribute considerably to the annual variation of SO_2 concentration. The most important of these factors are the sea-breezes, which blow most often in summer (Livadas - Sahsamanoglou[12]).

However, the authors believe that this seasonal variation is also attributable to the fact that in winter the consumption of liquid fuel is highly augmented. And since the main emission sources of SO_2 (73.5%) for the U.S.A. in the year 1968 (Finkelstein et al.[7]) were stationary combustion sources**, we could, with due allowance being made, accept that something of the kind happens also in Thessaloniki.

c. Concerning annual mean values, we observe that at Thessaloniki the average annual mean is 0.194 mg m^{-3}. or 194γ/m^3

Comparing these values with those of i.e. american megapolis, as they are given by Altshuller[1], we can still hold some hope.

TABLES XIII

Comparison of Annual Mean Values of SO_2 Concentrations at Cities of the U.S.A. and Thessaloniki (γ/m^3).

New York City	410.0	Cincinati	80.0
Chicago	370.0	Los Angeles	50.0
Philadelphia	200.0	San Francisco	25.0
St. Louis	170.0	Thessalonki (University Campus)	194.0
Washington D. C.	130.0		

It is noteworthy that the American cities with the smallest concentration values (at least as they appear in Table XIII), belong to the same climatic type (Cs) in Köppen's classification; the only difference being in Thessaloniki's warmer summers (Csa) as compared with Los Angeles and San Francisco, whose climate is Csb.

d. The frequencies of SO_2 concentration maxima recorded during our observations, indicate that, at least for the time being, the greater percentage of these valnes remains at a small level (see Tahles IX, X).

Beyond the limit of 0.500 mg m^{-3}, 53 cases bave been recorded out of 302 during the morning observation, and 15 cases out of 298 during the mid-day one. All these cases, for both observations, have been recorded during the main four cold months (November-February), that is in the season with tbe maximum fuel consumption at the city of Thessaloniki.

e. Comparisons between the morning (09:00-10:00) and noon observations (12:30-13:30), indicate a considerable variation of SO_2 concentrations in the surface layer of the atmosphere during the 24-hours; however this part of the research sbould form a separare publication.

** National Inventory of Air Pollution Emission-1968. U. S. Department of Health etc., Raleigh, N. C. 1970.

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ΠΕΡΙΛΗΨΙΣ

ΜΕΤΡΗΣΕΙΣ ΤΩΝ ΣΥΓΚΕΝΤΡΩΣΕΩΝ ΤΟΥ SO_2 ΕΙΣ ΘΕΣΣΑΛΟΝΙΚΗ

ὑπὸ
Γ. Κ. ΛΙΒΑΔΑ, ΑΝ. ΚΟΒΑΤΣΗ, Χ. ΜΠΑΛΑΦΟΥΤΗ (J)

Μελετῶνται συγκεντρώσεις SO_2 εἰς τὴν πόλιν τῆς Θεσσαλονίκης, μὲ βάσι τὶς μετρήσεις ποὺ ἔγιναν μὲ συσκευὴ Analyser - Ubtragas - V3S (κατασκευῆς οἴκου H. Wosthoff Δ. Γερμανίας). Ὁ μετρητὴς εἶχε ἐγκατασταθῆ στὸ δῶμα τοῦ κτιρίου τοῦ Ἐργαστηρίου Μετεωρολογίας - Κλιματολογίας τοῦ Α.Π.Θ. καὶ τὰ δημοσιευόμενα ἀποτελέσματα καλύπτουν τὴν χρονικὴ περίοδο Ἰανουαρίου 1974 μέχρις τέλους Ἰανουαρίου 1975.

Δίδονται τὰ ἀπαραίτητα στοιχεῖα τοῦ περιβάλλοντος ὅπως:

α. Ρυθμὸς αὐξήσεως τοῦ οἰκιστικοῦ συγκροτήματος τῆς μείζονος Θεσσαλονίκης, κ.ἄ.

β. Ὑλικὰ θερμάνσεως γιὰ οἰκιακὴ χρήση κατὰ τὴν ψυχρὴ περίοδο, ὡς ἐπίσης

γ. Οἱ μετεωρολογικοὶ παράγοντες ποὺ ἐπηρεάζουν τὶς συγκεντρώσεις τοῦ SO_2 στὸ κατώτερο στρῶμα τῆς ἀτμοσφαίρας στὴν Θεσσαλονίκη.

Τέλος, στὴν συζήτησι δίδονται ἐξηγήσεις γιὰ τὶς παρατηρούμενες μεγάλες συγκεντρώσεις τοῦ SO_2 κατὰ τὴν ψυχρὴ περίοδο, δηλαδὴ κατὰ τὴν περίοδο ποὺ χρησιμοποιεῖται μεγάλη ποσότης πετρελαίου γιὰ θέρμανσι.

Ἐπίσης συγκρίνονται οἱ μέσες μηνιαῖες τιμὲς τῆς Θεσσαλονίκης (στὴν περίοδο τῶν μετρήσεών μας) μὲ τὶς τιμὲς τῶν ἀμερικανικῶν μεγαλουπόλεων.