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Correlation of Soil and Air Temperature In Syria and Lebanon

A C S A D

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Soil temperature criteria are used in the definition of the Soil temperature regime (STR) and of the Soil moisture regime (SMR) according to the U.S. Soil Taxonomy. These criteria are:

- The mean annual soil temperature (for STR and SMR).
- The ifference between the mean summer and winter soil temperature at 50 cm depth (STR and SMR).
- The periods when the soil temperature at 50 cm depth is more than 8°C or more than 5°C (SMR).

In arid and semi-arid regions the data about soil temperature are scarce and it is a common practice to estimate soil temperature from air temperature, the latter being far better known.

For that purpose we try to determine, in this paper, the correlations existing between air and soil temperatures in Syria and Lebanon, by means of the available data.

In Syria, data about soil temperature (measured between 1960 and 1969) have been published for 13 climatologic[1] stations, while air temperature is measured in 97 stations. In Lebanon, the corresponding numbers are 9 stations out of 65, and the periods of measurement are not homogeneous: from 5 to 20 years.

All available data are given in tables 4 and 5.

This small number of stations is perhaps compensated by their distribution in the two countries. Fortunately indeed the stations are distributed in various regions which are representative of the main climatic conditions (inside the general climate of mediterranean type): 5 stations in the coastal area, the climate of which is warm and moist with high rainfall; 10 stations in the arid and semi-arid inland Syria; 6 stations in the south part of the high inland plain of Beqaa (Lebanon) with a more temperate and fairly rainy climate. The cold mountainous regions, however, are poorly represented by only one station: Nabek, in arid zone.

Table 6 gives the location of the stations and their average annual precipitation and air temperature.

The results of correlations between air and soil temperature are stated below and briefly commented.

I. Mean annual soil temperature "ta":

For all the stations the mean annual air temperature "Ta" has been compared to the mean annual soil temperature measured at 50 cm depth and (if data were available) at 100 cm (table 1).

The general average relationship is:

$$ta = Ta + 2^{o}C \text{ (standard deviation: } s = 2) \qquad (1)$$

Comments:

- This relationship is different from that proposed by Soil Taxonomy, which is: $ta = Ta + 1^{o}C$.
- The same relationship than (1) has been found by Y. EL KAWASMA* who made calculation for Jordan and Syria taken as a whole.
- A slightly different relationship has been used by R. TAVERNIER** when estimating soil moisture regimes in Syria: $ta = Ta + 2.5^{o}C$.
- The data of table 1 as well as tables 4 and 5 show that the difference between "ta" measured at 50 cm and 100 cm depth is small: $0.2^{o}C$ on an average.
- If calculations are made separately for the coastal and inland regions the relationships are slightly different: (ta - Ta) is lower than the average for the coast and higher for the inland (table 1).

II. Mean summer and winter soil temperature at 50 cm depth and their difference "dt".

For all the stations a comparison has been made: - between the mean summer air temperature "Ts" and soil temperature at 50 cm depth "ts" - and between the mean winter air temperature "Tw" and soil temperature at 50 cm depth "tw".

The results of (ts - Ts) and (tw - Tw) are given in table 1.

a) Mean summer soil temperature at 50 cm depth "ts".

In most stations "ts" is higher than the mean summer air temperature "Ts". The general average relationship is:

$$ts = Ts + 1.9^{o}C \text{ (standard deviation: } s = 2) \qquad (2)$$

Comments:

- This relationship is very different from that proposed by Soil Taxonomy: $ts = Ts - 0.6^{o}C$.

* Soil temperature regime in arid and semi-arid regions. First arab workshop in agrometeorology. ACSAD. Nov. 1979.

** Tableaux d'estimation des regimes hydriques pour les stations de Syrie. Franklin Newhall method. Rijksuniversiteit. Gand. 1976 - 1977.

- The standard deviation for the relationship (2) is high; moreover, the extreme values of (ts - Ts) range from -2.5°C to +6.7°C. Therefore the precision is very poor and the relationship is hardly of any use.
- Besides, if calculations are made separately for the coastal and inland regions, the relationships are different: (ts - Ts) varies from +3°C to + 1.6°C, with high standard deviations.
- For these reasons it seems hardly possible to get an accurate estimation of the mean summer soil temperature at 50 cm depth by means of the mean summer air temperature.
- The large variations of the summer monthly relationships between "t" and "T" are visualised by figure 6 .

b) Mean winter soil temperature at 50 cm depth "tw" .

The general average relationship between "tw" and the mean winter air temperature "Tw" is:

$$tw = Tw + 1.7^{\circ}C \quad \text{(standard deviation: } s = 1.21) \qquad (3)$$

The extreme values of (tw - Tw) range from -0.4 to +4.7°C.

This relationship is slightly more accurate than that of "ts". However, separate calculations for the coastal and inland regions lead to two very different and more precise relationships:

- Inland: $tw = Tw + 2.15^{\circ}C \quad (s = 1.06)$ (4)
- Coast : $tw = Tw + 0.18^{\circ}C \quad (s = 0.47^{\circ}C)$ (5)

c) Difference "dt" between "ts" and "tw" .

The mean summer and winter soil temperatures at 50 cm depth are nearly symmetrical compared to the mean annual soil temperature (table 2), which is in conformity with the statement of Soil Taxonomy.

On account of the results above, it is better to use the estimation of "tw" rather than of "ts" in order to calculate "dt":

$$dt = 2(ta - tw)$$

Moreover, it is advisable to use regional relationships, which are best suited to the local climatic conditions than a general relationship.

III. Periods during which the soil temperature at 50 cm depth is $> 8^{\circ}C$ or $> 5^{\circ}C$.

By comparing the monthly means of soil temperature at 50 cm depth "t" and of air temperature "T" , we have searched for relationships that would allow to estimate the dates at which "t" reaches the temperature levels of 8°C or 5°C .

Figures 1 to 5 give the curves of measured monthly "t" and "T" for each station.

a) Interval of time between the dates at which the curves of "t" and "T" reach the temperature levels of 8°C and 5°C .

Firstly let us note that in the coastal stations neither the air nor the soil mean monthly temperatures fall as low as 8°C .

In inland Syria and Beqaa the mean monthly air temperature "T" falls between 8 and 5°C in most stations (15 out of 17), and falls below 5°C in only one station (Nabek). But in only four of these stations the mean monthly soil temperature at 50 cm depth "t" falls between 8° and 5°C, and in none of them it falls below 5°C .

Therefore this set of stations does not allow to study the 5°C level in the soil, and it provides too little data to allow accurate relationship calculation for the 8°C level.

Concerning the 4 stations where "t" and "T" pass the 8°C level, the curves in figures 2 and 4 show that:

- during the decrease of temperature, the 8°C level has been reached by the soil temperature at 50 cm depth "t" after the air temperature "T", the delay being of 2 to 3 weeks (13 to 24 days);

- during the increase of temperature, in 3 stations the 8°C level has been reached by "t" before "T", with an advance of 3 to 12 days (but at the station of Taanayel, "t" and "T" pass the 8°C level at the same time) .

However we cannot take such intervals of time as a general rule, because, as stated above for the set of stations in inland Syria and Beqaa, from the fact that the air temperature falls below 8°C or 5°C we cannot surely gather that the soil temperature at 50 cm depth will fall down to these same temperature levels.

b) Relationships between the mean monthly air temperature "T" and soil temperature at 50 cm depth "t" .

Is it possible to accurately estimate "t" from "T" for a given month ?

Table 3 gives the average monthly relationships (t - T) , with the standard deviation and extreme values, for all the stations as a whole and separately for the stations of the inland and coastal regions.

The two following statements may be made:

- the monthly relationships (t - T) are accurate enough only during the cold season;

- besides, the monthly relationships are very different in the coastal and in the inland regions (figure 6), and they should be employed in preference to the general relationships.

In the case of the inland regions of Syria and Lebanon, owing to their climatic conditions the 8°C and 5°C levels can only be reached from December to March. Therefore, the relationships given for the cold months in figure 6a (inland regions) could be an acceptable method to estimate monthly soil temperature at 50 cm depth and to draw the curve of "t" during the period when it may possibly reach the 8°C or 5°C levels.

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	ta - Ta annual		ts - Ts summer	tw - Tw winter
	t measured at 100cm	t measured at 50cm	t measured at 50 cm	
Inland Syria				
Abu Kamal	+1.6	+1.5	-0.7	+2.6
Aleppo	+2.7	+2.8	+2.0	+3.4
Damascus Mezze	+2.8	+3.1	+3.8	+2.5
Deir ez Zor	+3.0	+3.1	+0.3	+4.7
Fiq	+2.6	+3.0	+4.0	+2.0
Hama	+2.0	+1.6	+1.5	+2.4
Hassakeh	+2.4	+1.9	+0.9	+2.3
Nabek	+2.0	+1.7	+1.4	+1.9
Palmyra	+2.3	+1.9	+1.0	+2.1
Qamishli	+0.2	0	-2.5	+1.7
Raqqa	+4.0	+3.8	+4.3	+2.7
Coastal Syria				
Mina el Beida	+1.2	+1.1	+2.2	+0.1
Safita	+1.0	+1.4	+3.3	+0.8
Beqaa (Lebanon)				
Taanayel	-	+0.7	+1.0	+0.3
Ksara	+2.6	+2.7	+5.1	+0.6
Terbol	-	+2.2	+1.3	+2.3
Tell Amara	+1.7	+1.7	+2.1	+0.6
Kfardane	-	+1.6	+0.7	+1.6
Hauch Snaid	-	+2.1	+0.6	+2.8
Coastal Lebanon				
Tyr	+2.4	+0.9	+1.7	-0.4
Beyrouth airport	+3.7	+3.8	+6.7	+0.5
El Abde	+1.1	+0.8	+1.3	-0.1
Averages				
a) General	+2.18	+1.97	+1.91	+1.70
Standard deviation	0.95	1.01	2.00	1.21
b) Inland Syria and Beqaa	+2.30	+2.08	+1.57	+2.15
St. deviation	0.88	0.95	1.89	1.06
c) Coastal areas	+1.90	+1.60	+3.0	+0.18
St. deviation	1.16	1.25	2.18	0.47

Table 1 - Difference t - T between the mean annual, summer and winter soil temperature "t" and air temperature "T" (oC).

	ts - ta	ta - tw
Inland Syria		
Abu Kamal	8.2°C	8.5°C
Aleppo	9.0	9.6
Damascus Mezze	9.1	9.0
Deir ez Zor	8.1	8.2
Fiq	7.5	8.2
Hama	9.1	9.0
Hassakeh	10.2	9.6
Nabek	7.9	7.7
Palmyra	8.6	8.8
Qamishli	9.0	8.7
Raqqa	10.3	10.4
Coastal Syria		
Mina el Beida	7.9	7.3
Safita	8.4	7.6
Beqaa (Lebanon)		
Taanayel	6.6	6.8
Ksara	10.1	9.7
Terbol	5.8	6.2
Tell Amara	7.4	7.9
Kfardane	7.2	7.2
Hauch Snaid	6.0	6.5
Coastal Lebanon		
Tyr	6.3	6.2
Beyrouth airport	8.9	8.7
El Abde	6.2	6.6

Table 2 - Differences between the mean summer (ts) or winter (tw) soil temperature at 50 cm depth and the mean annual soil temperature (ta).

	J	F	M	A	M	J	J	A	S	O	N	D
a)All stations in Syria (13) and Lebanon (9)												
Average	+2.68	+1.43	+0.87	+0.67	+0.71	+0.91	+1.24	+1.69	+2.76	+3.28	+3.96	+3.59
Standard deviation	1.67	1.28	0.99	0.98	1.47	2.09	2.43	2.10	1.68	1.33	1.66	1.79
Maximum	+6.4	+4.7	+3.2	+2.9	+4.9	+6.6	+7.1	+6.9	+6.0	+5.5	+7.0	+7.3
Minimum	-0.4	-0.4	-0.7	-0.9	-2.4	-3.8	-4.1	-3.0	-0.4	+1.3	+1.1	+0.9
b)Inland Syria (11) and Beqaa (6)												
Average	+3.27	+1.87	+1.18	+0.69	+0.51	+0.45	+0.71	+1.29	+2.71	+3.57	+4.58	+4.27
Standard deviation	1.37	1.11	0.88	0.78	1.25	1.83	2.26	2.01	1.61	1.17	1.34	1.50
Maximum	+6.4	+4.7	+3.2	+2.2	+2.6	+3.9	+4.9	+5.1	+5.4	+5.5	+7.0	+7.3
Minimum	+1.0	0	-0.1	-0.9	-2.4	-3.8	-4.1	-3.0	-0.4	+1.4	+1.4	+1.1
c)Coastal area in Syria (2) and Lebanon (3)												
Average	+0.7	-0.2	-0.2	+0.6	+1.4	+2.5	+3.0	+3.0	+2.9	+2.3	+1.9	+1.2
Standard deviation	0.83	0.48	0.48	1.46	2.07	2.35	2.33	2.32	1.91	1.48	0.80	0.33
Maximum	+1.9	+0.5	+0.6	+2.9	+4.9	+6.6	+7.1	+6.9	+6.0	+4.9	+3.2	+1.6
Minimum	-0.4	-0.4	-0.7	-0.9	-0.6	+0.9	+1.5	+1.0	+1.3	+1.3	+1.2	+0.9

Table 3 - Difference (t - T) between the monthly means of soil temperature at 50 cm depth "t" and air temperature "T" (oC).

		J	F	M	A	M	J	J	A	S	O	N	D	Année a	Eté e	Hiver h
Abu Kamal	t.50	12.3	12.4	15.0	19.4	23.9	28.1	29.6	31.1	29.2	25.1	19.7	14.8	21.7	29.9	13.2
	t.100	15.2	14.4	15.9	18.5	21.8	25.4	27.9	29.1	28.3	25.8	22.0	18.0	21.8		
	T	7.9	10.0	14.0	19.3	24.8	30.0	32.4	32.0	27.4	21.5	14.3	9.3	20.2	30.6	10.6
Alep	t.50	11.2	10.5	12.7	15.1	21.3	26.1	29.0	29.9	28.4	24.7	18.9	13.7	20.1	29.1	11.5
	t.100	13.6	12.2	13.2	15.7	19.6	23.5	26.0	27.3	27.2	24.7	20.7	16.6	20.0		
	T	6.0	7.4	10.8	15.5	21.0	25.9	28.2	28.4	24.7	19.5	12.9	7.9	17.3	27.1	8.1
Damas	t.50	10.8	10.7	13.6	17.2	22.4	27.4	29.9	30.7	28.8	24.8	19.0	13.4	20.7	29.8	11.7
	t.100	13.5	12.4	14.0	16.4	19.9	24.0	26.6	28.1	27.5	25.2	21.2	16.5	20.4		
	T	7.2	8.7	11.7	16.2	21.1	25.5	26.9	27.2	23.9	20.0	14.1	9.4	17.6	26.0	9.2
Deir ez Zor	t.50	13.7	14.0	16.5	20.8	25.2	29.4	31.3	31.9	29.9	25.8	20.8	16.0	22.9	31.0	14.7
	t.100	16.1	16.2	16.7	19.3	22.7	26.4	28.8	30.0	29.2	26.6	22.9	18.7	22.8		
	T	7.3	9.3	13.3	18.6	24.3	29.8	32.5	32.1	27.5	21.1	13.8	8.7	19.8	30.7	10.0
Fiq	t.50	13.7	12.5	14.7	18.1	23.2	27.2	29.0	29.9	29.0	26.0	22.2	16.4	21.8	29.3	13.6
	t.100	15.0	13.9	14.9	17.1	20.3	24.6	26.8	28.0	28.1	26.5	23.5	18.4	21.4		
	T	10.3	11.1	13.3	17.0	21.2	24.7	25.4	26.0	24.4	22.1	17.4	12.6	18.8	25.3	11.6
Hama	t.50	10.4	9.8	12.0	16.1	21.0	26.0	28.9	29.6	28.0	23.9	18.3	13.1	19.7	28.8	10.7
	t.100	13.0	11.6	12.6	15.2	19.3	24.0	27.0	28.5	27.9	25.1	20.8	16.1	20.1		
	T	7.3	8.7	11.8	16.3	21.6	26.3	28.3	28.5	25.2	20.3	13.7	8.8	18.1	27.3	9.3
Hassakeh	t.50	9.6	9.7	12.5	16.6	21.7	27.3	30.9	31.4	28.8	23.6	17.8	12.2	20.2	30.4	10.6
	t.100	13.2	12.1	13.6	16.2	19.9	24.8	28.2	29.4	28.3	25.1	20.7	16.5	20.7		
	T	6.0	7.7	11.3	16.5	22.6	28.5	31.6	31.0	25.8	19.3	12.2	7.5	18.3	29.5	8.3
Nabek	t.50	5.8	5.7	8.5	12.5	15.9	20.4	22.6	23.1	21.1	17.1	12.4	8.1	14.4	22.3	6.7
	t.100	8.8	7.9	9.2	11.4	14.3	17.9	20.2	21.4	20.7	18.2	14.8	11.4	14.7		
	T	3.0	4.2	7.1	11.3	15.5	20.2	22.2	22.2	18.4	14.3	9.1	5.3	12.7	20.9	4.8
Palmyra	t.50	10.7	10.9	14.2	18.7	23.3	27.5	29.8	29.9	28.3	23.9	18.4	13.2	20.7	29.3	11.9
	t.100	14.5	13.8	15.1	17.5	20.8	24.6	26.8	28.1	27.7	25.3	21.5	17.4	21.1		
	T	7.2	9.1	13.0	17.8	22.9	27.6	29.5	29.6	25.9	20.7	13.7	8.8	18.8	28.3	9.8
Qamishli	t.50	9.8	9.3	11.4	15.0	19.6	24.7	28.1	28.9	26.8	22.7	17.6	12.9	18.9	27.9	10.2
	t.100	13.2	11.6	12.3	14.5	17.7	21.6	25.1	26.6	26.4	23.5	20.1	16.4	19.1		
	T	6.5	7.9	11.2	15.9	20.0	28.5	32.2	31.9	27.2	21.0	13.8	8.6	18.9	30.4	8.5
Raqqa	t.50	10.7	11.1	14.3	19.6	25.6	31.1	33.5	33.8	30.9	25.5	19.5	13.7	22.4	32.7	12.0
	t.100	14.4	13.4	15.0	18.4	23.0	27.9	30.6	31.6	30.4	27.1	22.3	17.5	22.6		
	T	6.9	8.6	12.4	17.5	23.0	28.2	30.1	29.6	25.5	20.0	13.2	8.5	18.6	28.4	9.3
Mina el Beida	t.50	12.6	12.3	14.4	17.0	21.3	25.8	28.3	29.1	27.4	23.5	18.9	14.8	20.4	28.3	13.1
	t.100	14.7	13.6	14.7	16.5	19.8	23.7	26.2	27.5	26.9	24.5	20.8	17.2	20.5		
	T	11.8	12.6	14.7	17.1	20.3	23.9	26.2	27.0	25.0	21.8	17.8	13.9	19.3	26.1	13.0
Safita	t.50	11.6	11.2	12.8	15.5	19.4	24.2	27.5	28.8	27.4	23.3	19.1	13.8	19.5	27.9	11.9
	t.100	12.9	11.9	13.1	14.9	17.5	21.0	24.4	26.3	26.4	24.0	20.8	15.6	19.1		
	T	9.7	10.7	13.0	16.4	20.0	23.3	24.6	25.3	24.0	21.4	17.3	12.2	18.1	24.6	11.1

Tableau 4 – Températures moyennes du sol "t" mesurées à 50 et 100 cm et température moyenne de l'air "T" pour certaines stations de Syrie (°C).

Table 4 – Average measured soil temperatures "t" at 50 and 100 cm depth and average air temperature "T" for some stations of Syria (°C)

(Agroclimatological reference book for the Syrian Arab Republic 1969)

		J	F	M	A	M	J	J	A	S	O	N	D	Year	Summ.	Winter	Period
Taanayel	t.50	6.9	6.9	9.3	12.7	16.3	20.0	21.5	21.5	20.3	17.1	12.9	9.3	14.5	21.1	7.7	65-70
	T	5.9	6.9	9.4	12.4	15.9	19.3	20.6	20.8	19.1	15.7	11.5	8.2	13.8	20.1	7.4	
Ksara	t.50	7.2	7.3	10.0	13.7	19.8	25.5	28.4	28.9	26.5	21.9	15.6	9.7	17.8	27.9	8.1	57-77
	t.100	9.1	8.4	10.2	13.3	17.8	22.8	25.9	26.9	25.8	22.6	17.6	12.1	17.7			
	T	5.8	6.8	9.9	13.6	17.4	21.6	23.5	23.8	21.3	17.3	12.2	7.6	15.1	22.8	7.5	
Terbol	t.50	8.8	8.9	10.6	13.6	16.8	19.3	21.1	22.1	21.1	19.1	15.0	10.7	15.6	21.4	9.4	70-73
	T	5.7	6.4	9.3	12.6	15.9	18.9	20.6	20.4	19.5	16.0	9.8	5.6	13.4	20.1	7.1	
Tell Amara	t.50	6.8	7.0	9.6	13.0	16.8	21.3	23.3	23.8	22.4	29.6	14.7	10.1	15.7	23.1	7.8	64-73
	t.100	8.3	7.3	9.1	12.2	15.6	20.2	22.4	23.5	22.9	20.3	15.5	11.1	15.7			
	T	5.8	6.6	9.2	12.6	16.3	19.7	21.4	21.7	20.1	16.5	11.4	7.1	14.0	21.0	7.2	
Kfardan	t.50	8.2	8.2	10.2	13.4	17.3	21.0	22.8	23.9	22.9	19.9	14.4	10.0	16.0	23.2	8.8	69-73
	T	5.8	6.5	9.5	12.5	17.0	21.0	22.7	23.4	21.6	17.3	10.2	5.7	14.4	22.5	7.2	
Hauch Snaid	t.50	8.6	8.5	10.6	13.6	16.8	20.3	22.0	22.0	21.2	18.7	14.9	11.1	15.7	21.7	9.2	64-73
	T	5.0	5.9	8.4	11.7	15.7	19.5	21.5	21.8	20.0	16.0	10.9	6.6	13.6	21.1	6.4	

Table 5 - Average measured soil temperature "t" at 50 and 100 cm depth and average air temperature "T" for some stations of Lebanon (oC).
a) Inland plain of Beqaa.

		J	F	M	A	M	J	J	A	S	O	N	D	Year	Summ.	Wint.	Period
Tyr	t.50	13.4	13.5	15.6	18.4	21.2	24.6	26.3	27.2	26.3	23.7	18.9	15.2	20.3	26.6	14.1	69-73
	t.100	16.8	16.2	17.1	19.3	21.2	24.1	26.3	27.3	27.1	25.7	22.2	18.8	21.8			
	T	13.8	13.9	15.8	17.4	20.0	22.6	24.7	25.4	24.8	22.4	17.7	14.3	19.4	24.9	14.5	
Beyrouth airport	t.50	13.6	14.0	16.2	20.2	25.2	29.8	32.3	32.9	31.5	27.7	20.9	15.8	23.3	32.2	14.6	69-73
	t.100	15.1	14.8	16.2	19.2	23.4	27.6	30.4	31.4	30.9	28.5	23.1	17.7	23.2			
	T	13.2	13.6	15.6	17.3	20.3	23.2	25.2	26.0	25.5	22.8	17.7	14.3	19.5	25.5	14.1	
El Abde	t.50	13.3	12.6	14.4	17.4	20.8	24.1	26.2	26.5	26.0	23.7	20.0	15.5	20.0	26.2	13.4	64-73
	t.100	15.1	13.7	14.9	16.9	20.2	22.7	24.7	25.9	26.1	24.3	21.5	17.9	20.3			
	T	12.5	13.0	15.1	17.4	20.3	23.1	24.7	25.5	24.7	22.1	18.0	14.1	19.2	24.9	13.5	

Table 5 - (continued) - Average soil temperature "t" at 50 and 100 cm depth and average air temperature "T" for some stations of Lebanon (oC).
b) Coastal area.

References - Climat du Liban; bulletins statistiques mensuels. Direction generale de l'aviation civile. Service meteorologique. Beyrouth.

- Annales climatologiques de l'Observatoire de Ksara (Liban). Annees 1957 - 77.

	Lat.N	Long.E	Alt. m	Mean annual rain-fall mm	Mean annual air temp. oC
Inland Syria					
Abu Kamal	34°25	40°55	174	108	20.2
Aleppo	36.11	37.13	392	323	17.3
Damascus Mezze	33.29	36.14	729	213	17.6
Deir ez Zor	35.20	40.09	204	143	19.8
Fiq	32.46	35.42	349	476	18.8
Hama	35.08	36.45	316	325	18.1
Hassakeh	36.30	40.45	300	279	18.3
Nabek	34.02	36.43	1325	128	12.7
Palmyra	34.33	38.18	404	127	18.8
Qamishli	37.03	41.13	467	480	18.9
Raqqa	35.57	39.00	251	207	18.6
Coastal Syria					
Mina el Beida	35°33	35°45	8	859	19.5
Safita	34.49	36.08	350	1112	18.1
Beqaa (Lebanon)					
Taanayel	33°48	35°52	880	695	13.8
Ksara	33.50	35.54	920	634	15.1
Terbol	33.49	35.59	890	570	13.4
Tell Amara	33.51	35.59	905	622	14.0
Kfardane	34.01	36.03	1080	430	14.4
Hauch Snaid	33.56	36.04	995	470	13.6
Coastal Lebanon					
Tyr	33°16	35°12	5	636	19.4
Beyrouth airport	33.48	35.29	15	850	19.5
El Abde	34.31	36.00	40	796	19.2

Table 6 - Location, mean annual rainfall and air temperature for the meteorological stations of syria and Lebanon where soil temperature has been measured (published data).

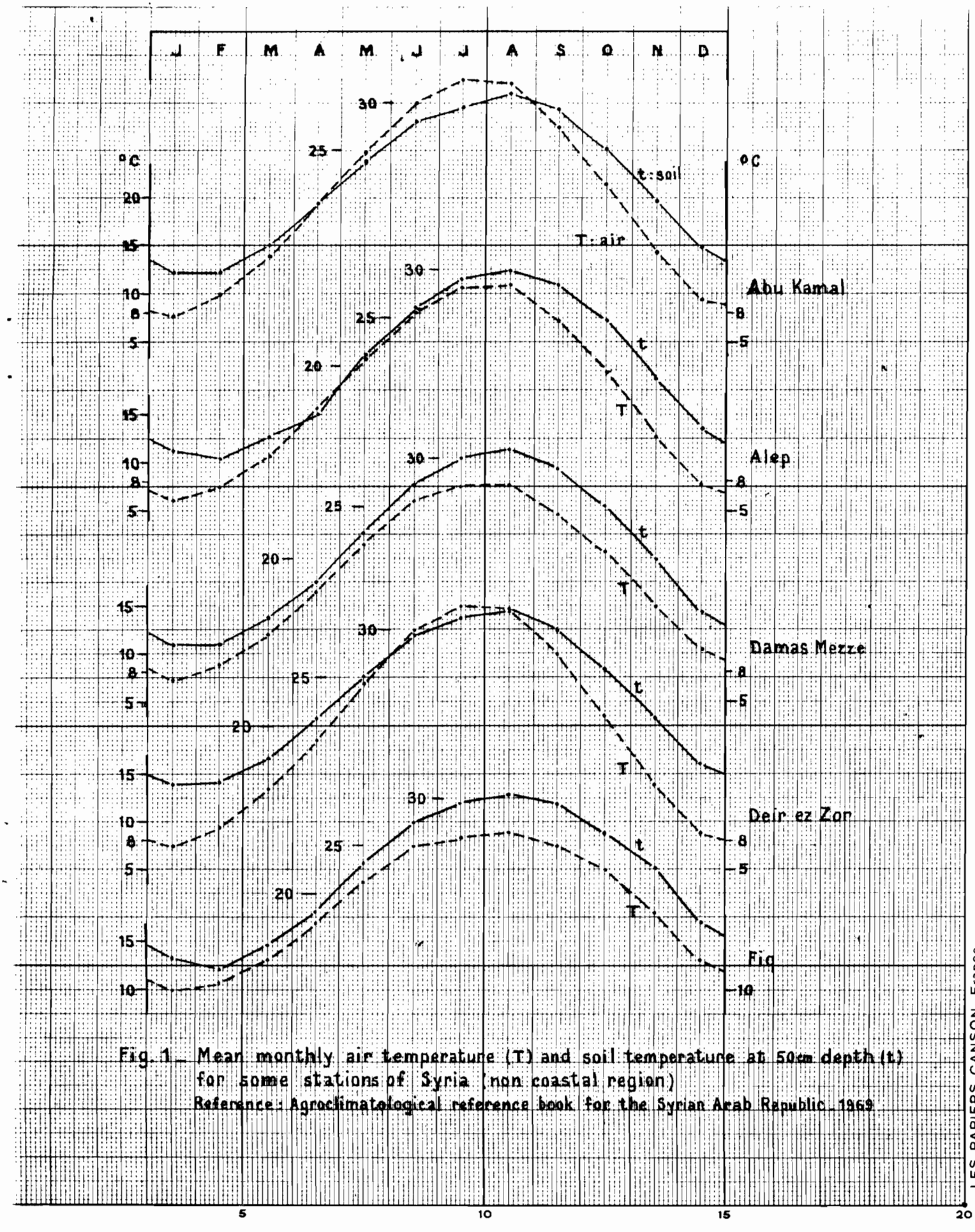

Fig. 1 _ Mean monthly air temperature (T) and soil temperature at 50cm depth (t) for some stations of Syria (non coastal region)
Reference : Agroclimatological reference book for the Syrian Arab Republic. 1969

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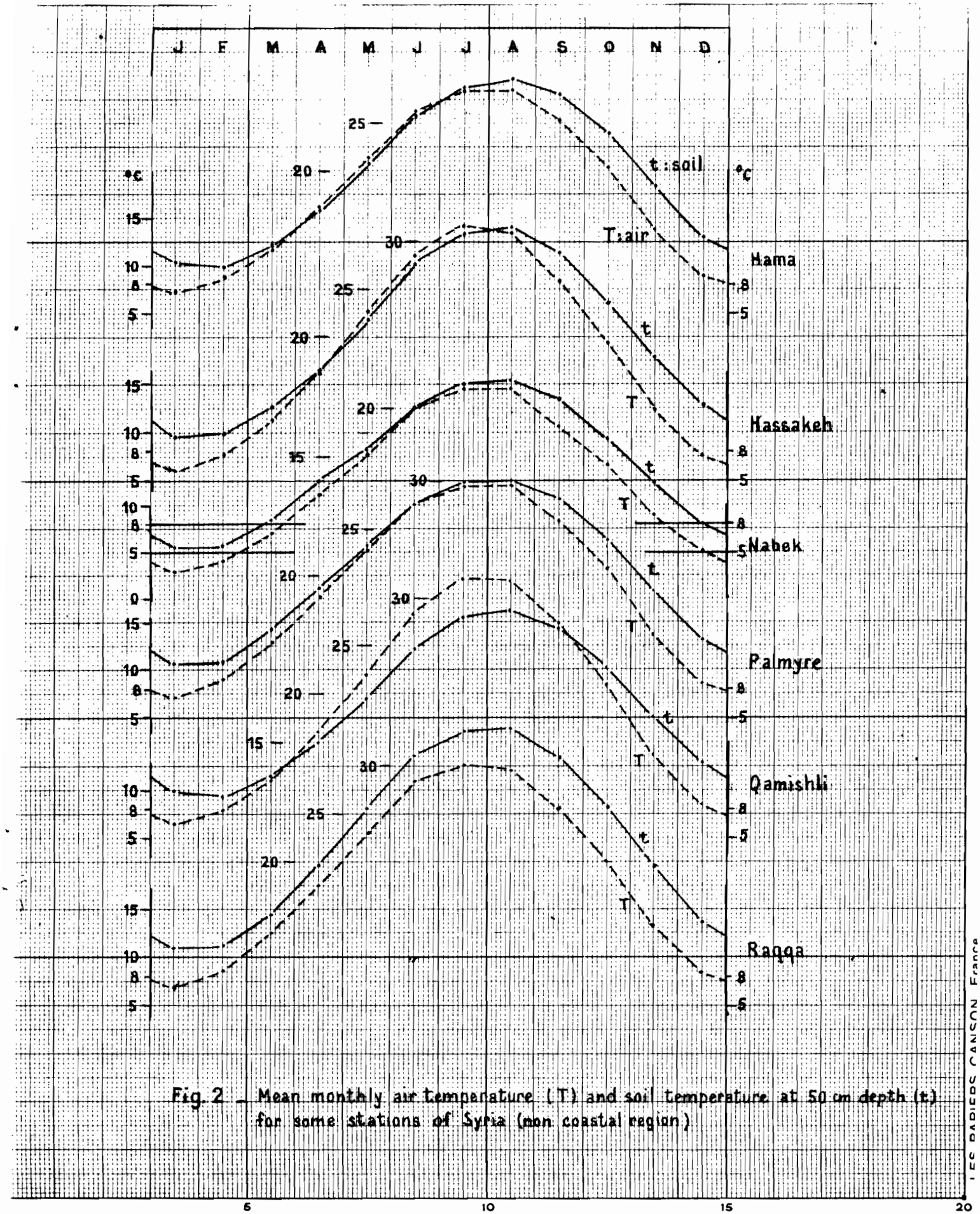

Fig. 2 – Mean monthly air temperature (T) and soil temperature at 50 cm depth (t) for some stations of Syria (non coastal region)

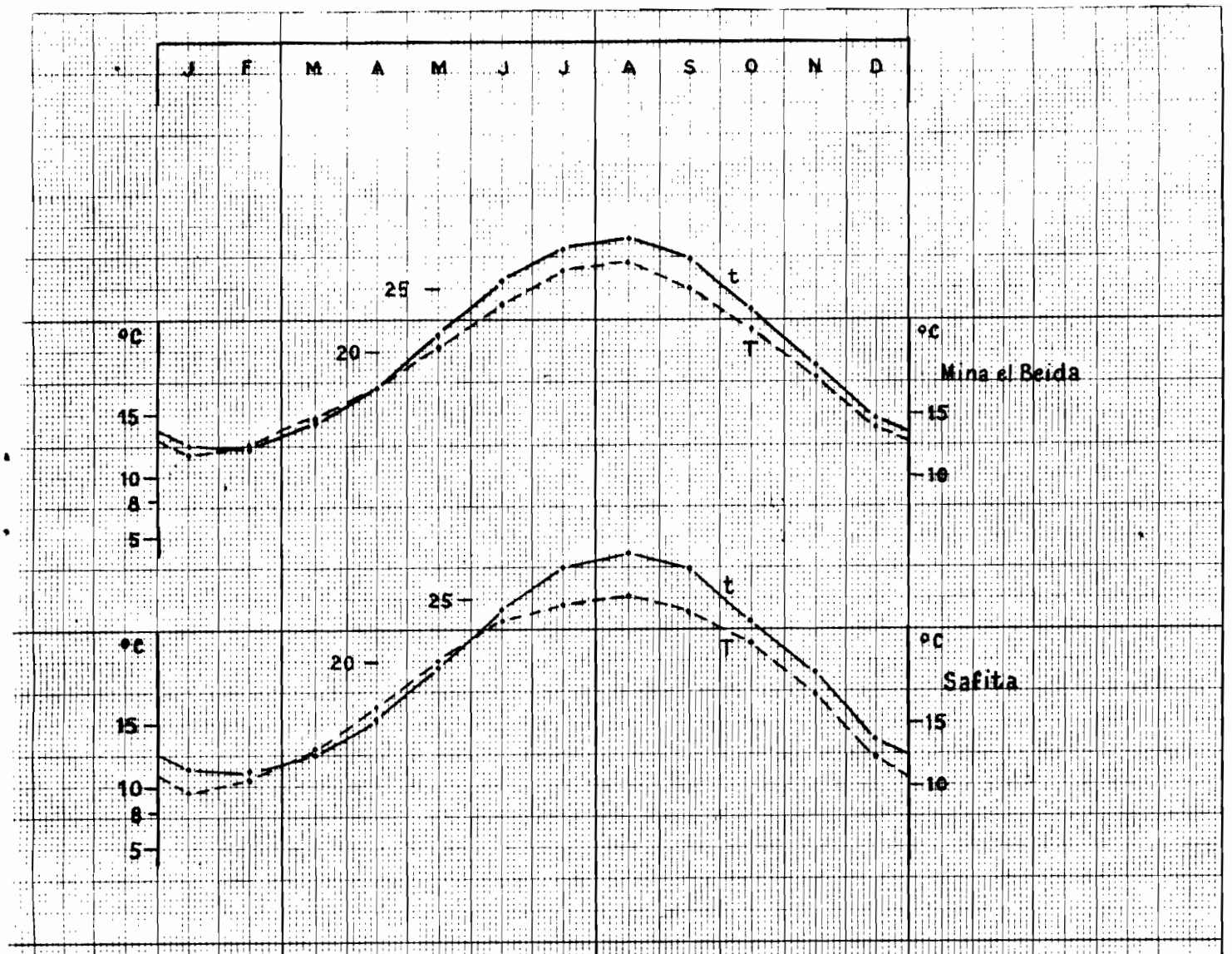

Fig.3 - Mean monthly air temperature (T) and soil temperature at 50cm depth (t) for 2 stations of the coastal region of Syria

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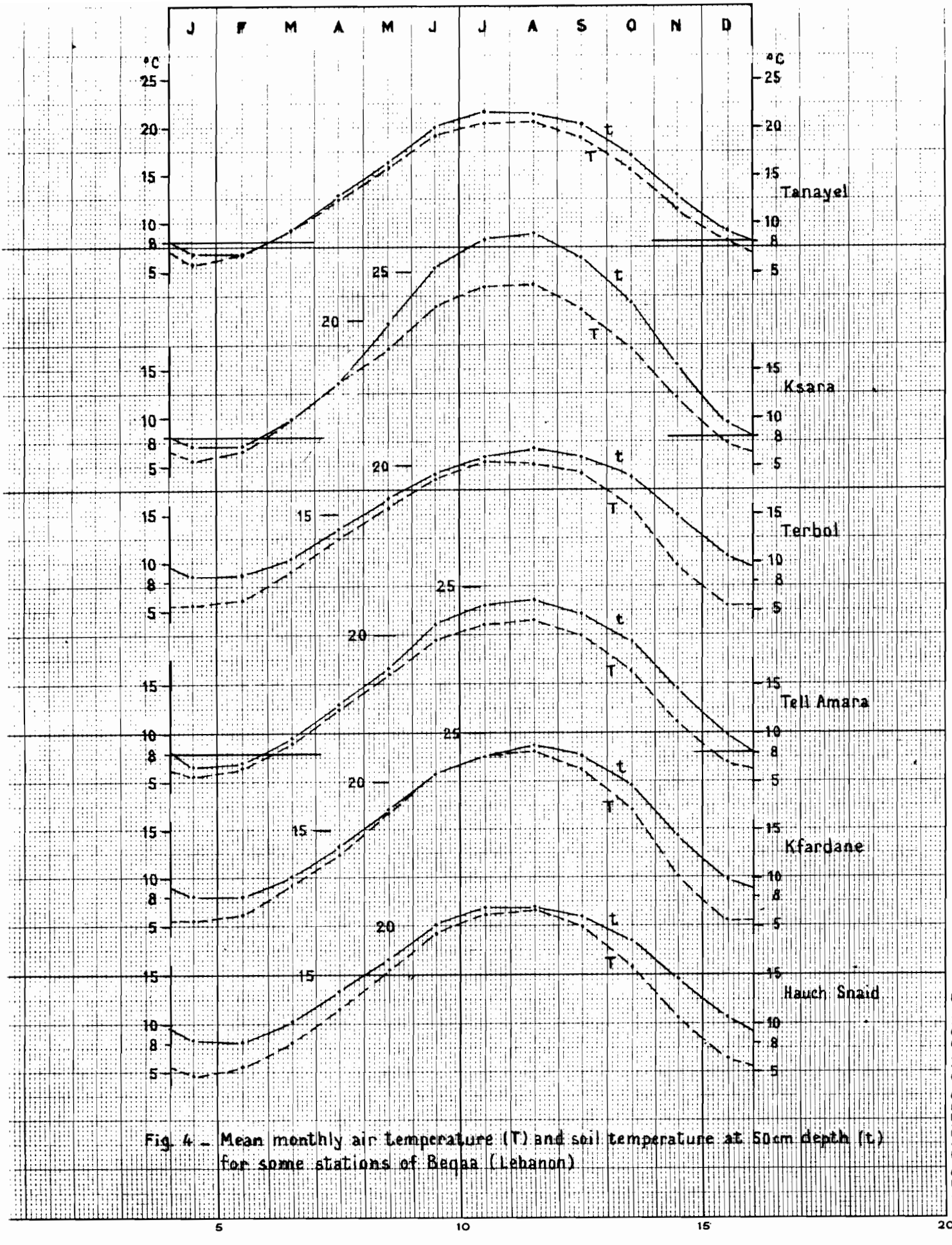

Fig. 4 – Mean monthly air temperature (T) and soil temperature at 50cm depth (t) for some stations of Beqaa (Lebanon)

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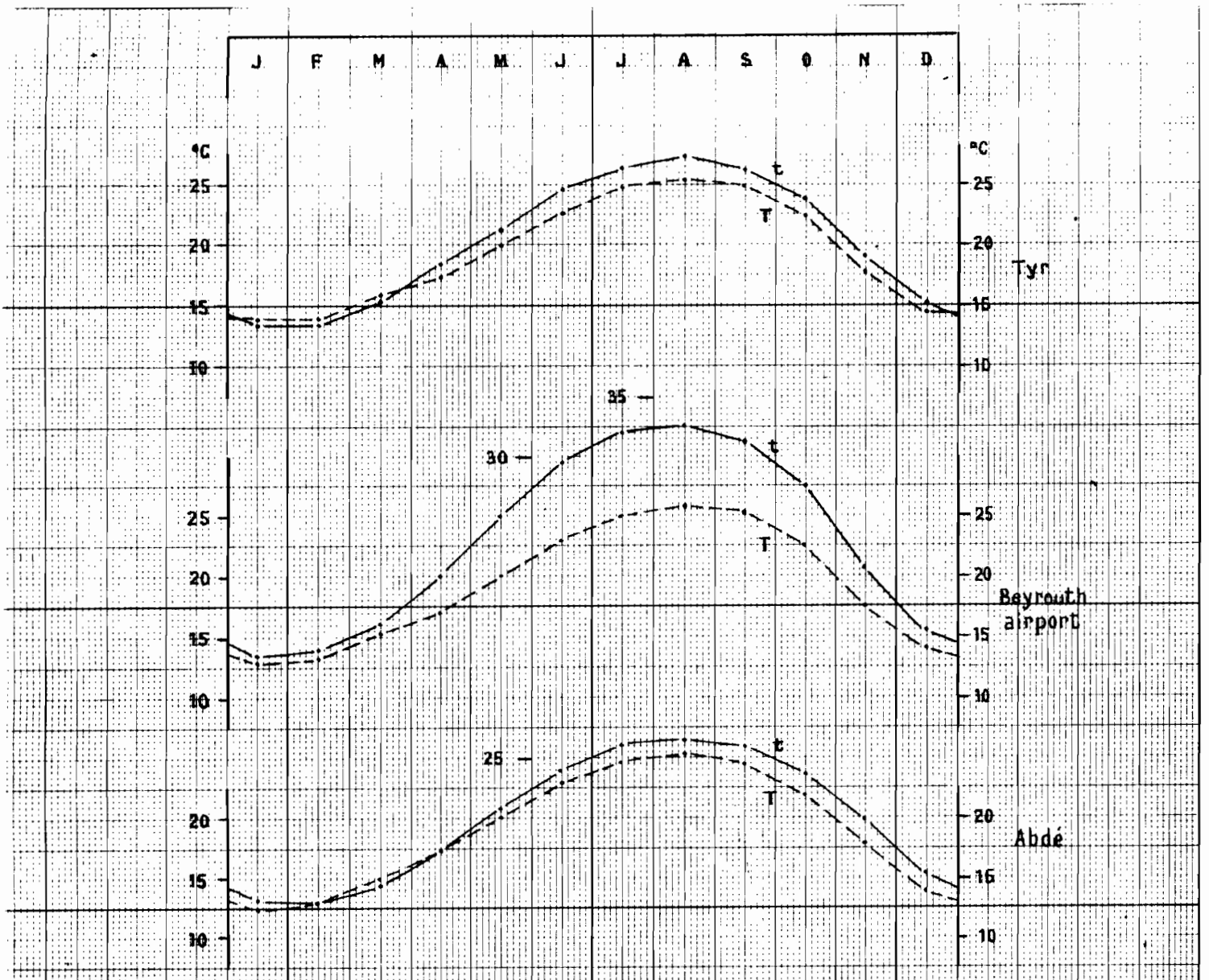

Fig. 5 – Mean monthly air temperature (T) and soil temperature at 50 cm depth (t) for some stations of coastal Lebanon

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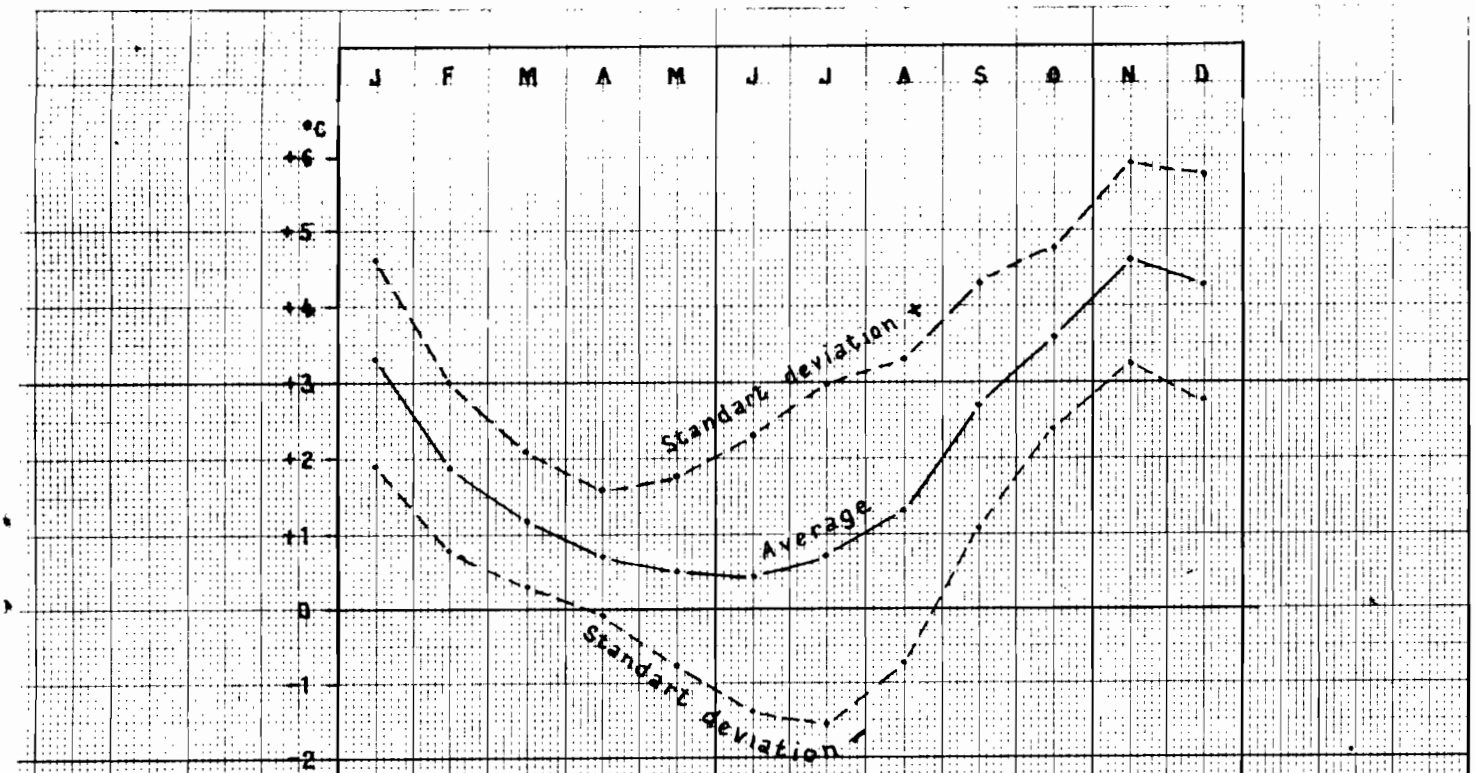
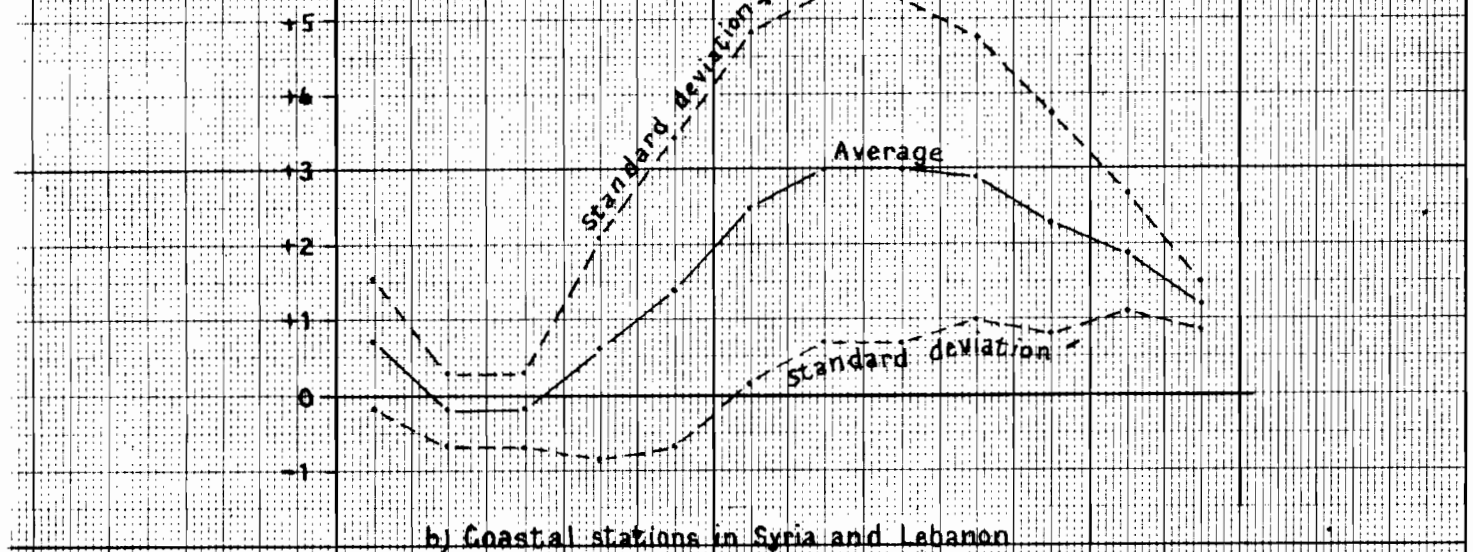


a) Inland Syria and Beqaa stations



b) Coastal stations in Syria and Lebanon

Fig. 6 – Difference (t – T) between the monthly means of soil temperature at 50 cm depth (t) and air temperature (T)

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