

THE HOMOGENIOUS TEMPERATURE SERIES AT SZEGED FOR 110 YEARS (1871—1980)

by

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Szeged 110 éves homogén hőmérsékleti sora (1871—1980). A tanulmány Szeged havi hőmérsékleti középértékeinek homogenizálásával foglalkozik. A meteorológiai állomás helye ugyanis az észlelések megindulása (1871) óta többször változott a városban.

A homogenizált sorok a város területén kívül telepített, jelenleg működő meteorológiai állomásra vonatkoznak.

The study deals with the homogenising of the data of mean monthly temperatures at Szeged. Namely the exposure of the meteorological station has changed several times inside the town since the beginning of the meteorological observations (1871).

The homogenised series refer to the present meteorological station located outside the town.

In 1871 systematic meteorological observations started in Szeged and since then — with the exception of an interruption in 1944 — they are still recorded. The site of the instruments, however, the instruments themselves and the staff working with them have continuously been changing, in this way the original observation material covering now more than 110 years is not homogenous, the data agglomeration consists of 7—8 different materials.

Especially temperature data were so much influenced by exposure and other changes that data originating from different exposures can only be compared with each other and with data originating from other stations, if the different series — with the help of an appropriate method — were united with reference to a single exposure, i. e. they were homogenised before processing. The significance of meteorological observation data of satisfying length great is from both scientific and practical point of view. The longer the homogenous observation data series at our disposal, the more exact and clearer picture can be obtained about meteorological conditions in our territory, about the average and extreme values of various elements (temperature, precipitation), about the frequency of certain value groups [8].

There are only five longer homogenous series of temperature observation in Hungary. In the work published in 1948 by *Bacsó* [2] contains 165 years of the Budapest series (1780—1945), while the series of Mosonmagyaróvár, Nyíregyháza and Szeged contain 75 years (1871—1945) each. Supplementing above data Pécs joined in a work of *Ferenc Simor* published in 1952 [8] representing southern Transdanubia with 80 years of homogenous temperature series. Present day homogenous temperature series naturally supplement above data. The series in Szeged from 1871 to 1924 was homogenised by *Lajos Steiner* and from 1925 to 1945 by *Bacsó*. The data of the homogenous series refer to the installation at the university sports ground from 1927 to 1944. *Ferenc Simor* — with the help of Kalocsa and Békéscsaba — established the difference between the sports ground exposure and the roof terrace exposure which

is in existence since April 1946, applying the obtained difference series to the original roof terrace data he supplemented the homogenised series of *Steiner—Bacsó* up to 1955 [10].

Only the series of Mosonmagyaróvár and Nyíregyháza originate from a sufficiently free exposure, in this way the data of series in Szeged, Budapest, Pécs possess an influenced characteristic because of the installation of the various stations. In case of the last stations the town-clima effects which characterise towns have a stronger predominance [7, 11].

On the basis of above mentioned it was found necessary to complete previous homogenising calculations referring to Szeged and on a wider basis, a larger scale. The most obvious solution was found in transforming every data to the airport exposure. This station has the advantage of being a more free exposure compared to the station at the university, moreover future observations can be directly attached to the homogenised series.

A historical survey of meteorological observations in Szeged

The first meteorological observation station was established in the military hospital of that time in 1853. The climatologic research station was reorganised in the Piarist Gymnasium in 1870. Observations were made by the teachers of the gymnasium at the station which was established at the same time as the National Institute of

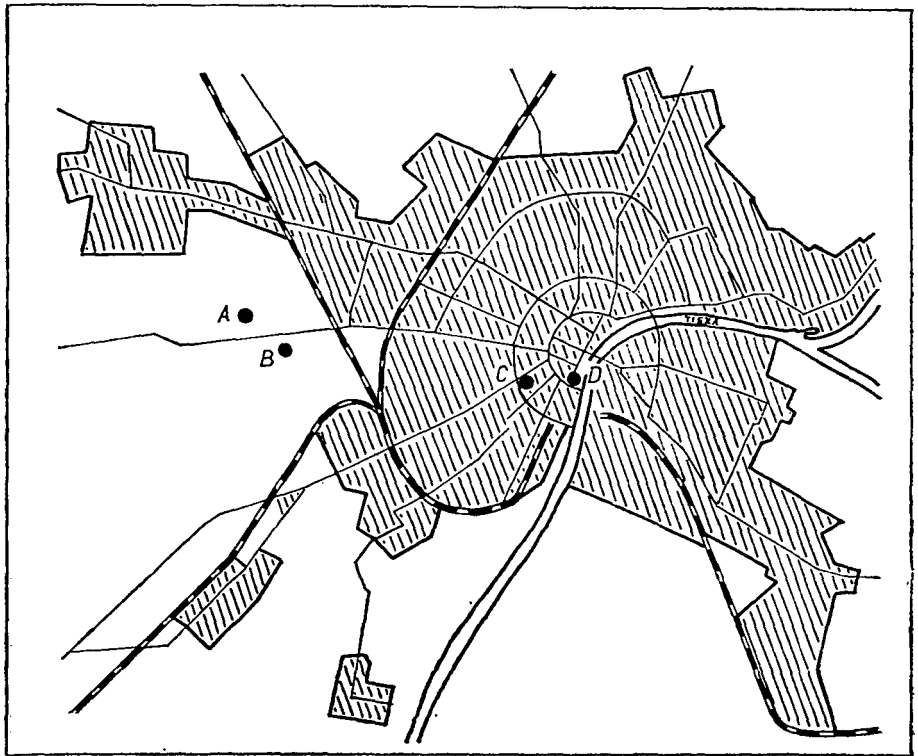


Fig. 1. Territorial situation of meteorological stations in Szeged

Meteorology. Meteorological telegrams were sent by the school as well until 4 April 1929 [1, 6]. The station's psychrometer was installed in the northern side of the gymnasium's building (northern part of Beloiannisz square) in front of a ground-floor window, in a distance of 75 cm from the window. The times of observation were 7 hours, 14 hours and 21 hours [3]. The station as such ceased to exist on 31 December 1929. The continuation of observations recorded for nearly 60 years uninterruptedly by the Piarist Gymnasium was taken over by a station installed at the university in January 1927, run by the Institut of Geography at the university. During the period between 1927 and August 1944 the temperature measuring huts stood on the Ady square of today, on the border of the university sport ground in 97 m altitude.

The station, which had been destroyed during the war, was rebuilt in April 1946, where the measuring huts were placed on the roof terrace of the university on Ady square in 24 m altitude above ground level. The new station with the management of professional observers became a synoptic main station. The observations were continued even when the station lost its main station characteristic in February 1951. From February 1951 for exactly ten years the main synoptic station functioned near the station building of the airport. In January 1961 the station moved to its own building in the immediate vicinity of the airport, 800 m far from its previous location. Since then measurements are taken here (Weather forecast station of the National Meteorological Service).

The territorial location of meteorological stations in Szeged is illustrated in Fig. 1.

Definition of homogenous temperature series of Szeged

The climatological regularity (Lamont, Hahn) that the course of weather within a greater area is nearly identical has long ago been recognised. This way the differences between homogenous temperature mean values (monthly, yearly) originating from two attaching territories with nearly identical climatological endowments and experienced during the same period are constant and exposed to a low-scale fluctuation only [9]. Homogenous series of sufficient length offer a thorough information about the alteration of climatologic elements, the size of extremities, fluctuation and changeability, about the frequency of the different value groups.

The exposure of climatologic research station built in Szeged at the function of the rivers Tisza and Maros has been more times changed. Its thermometer exposures were mostly of municipal characteristics and especially older data originate from closed installations. Not homogenous observation material is at our disposal in Szeged for the period between 1871 and 1981. Data from different observation points in town and the airport data representing the outskirts of the town show a significant difference [7, 11].

In the course of our work the homogenising of temperature series of Szeged was done for the *real (24 hours) temperature averages* instead of calculating termin-averages with various hour combinations. This way every observation has been laid on a uniform base.

The processed real (24 hours) temperature data originate from stations listed in Tab. 1. The table gives the names of the various stations, their period of functioning (with an interruption of a few months) as well as the duration of homogenous temperature series of this study.

The differences of averages between the homogenous series of two places for the period of 8—10 years are nearly of the same value as the divergences of homogenous

Table 1
Data of station-net considered while homogenising

Station	Years of functioning	Duration of considered homogenous temperature data
Arad	1871—	1880—1909
Ásotthalom (Királyhalom)	1892—1918	1911—1918
	1922—1972	1927—1971
Kalocsa (astronomical observatory)	1872—	1873—1909
Szeged-gymnasium	1871—1929	1871—1880
		1881—1899
		1900—1926
Szeged-university (sport grounds)	1927—1944	1927—1944
Szeged-university (roof terrace)	1946—1971	1946—1971
Szeged-Agricultural Institute (Scientific Institute of the Great Hungarian Plain)	1929—1954	1929—1944
		1948—1954
Szeged airport (previous exposure)	1951—1960	1951—1960
Szeged airport (new exposure)	1961—	1961—

series originating from the same observation period of 30—40 years length [8]. The *Hahn* difference method is based upon the practical application of above climatic regularity which is essentially as follows: if there is a reliable station with sufficient series in the vicinity, with the help of series the differences of inherently homogenous temperature series caused by the change in exposure can be justified and investigated (in present case the successive exposures in Szeged). In order to unit these different series first of all we had to determine the rate of difference between individual exposures and between the obtained series.

Our homogeneity calculations were correlated with the new airport exposure. The station's immediate vicinity has been completely free of buildings (and it still is) during observations. Taking this into account the data originating from the period which started in January 1961 and still lasts can be regarded homogenous, this way the real (24 hours) temperature means were left untouched. Observation data of the future can be directly joined to the homogenous series.

To determine the differences (Δ) between the individual exposures the following signs were applied:

- (A1): Szeged airport (present exposure) — Szeged airport (previous exposure) °C (Tab. 2)
- (A2): Szeged airport (present exposure) — Szeged university (roof terrace) °C (Tab. 3)
- (A3): Szeged airport (present exposure) — Szeged university (sport grounds) °C (Tab. 4)
- (A4): Szeged airport (present exposure) — Szeged Gymnasium (exposure III) °C (Tab. 5)
- (A5): Szeged airport (present exposure) — Szeged Gymnasium (exposure II) °C (Tab. 6)
- (A6): Szeged airport (present exposure) — Szeged Gymnasium (exposure I) °C (Tab. 7)

a) Determination of the difference between the present and previous airport exposure ($\Delta 1$)

From February 1951 meteorological measurements were taken in the vicinity of the airport's traffic building. In January 1961 the meteorological station was transferred to the immediate vicinity of the airport, ca. 800 m far from the original exposure. Today measurements are taken here. The difference ($\Delta 1$) between the previous and the present exposure was determined with the help of homogenous data of Szeged university (roof terrace) and Ásotthalom. The differences of monthly and yearly mean values of real (24 hours) temperatures were calculated for the previous exposure at Szeged airport and at the university's roof terrace (March 1951—December 1960) as well as for the present exposure at Szeged airport and the roof terrace of Szeged university (January 1961—December 1971). The two different airport exposures were compared with data from Ásotthalom regarding previous periods. The difference between the two exposures was obtained from the averages of difference series, i. e. if the present airport exposure was colder or warmer than the previous one. The obtained results are listed in *Table 2*.

Table 2

Demonstration of the difference between the previous and present exposure at Szeged airport, °C ($\Delta 1$)

1. Szeged airport (previous exposure) — Szeged university (roof terrace) March 1951—December 1960
2. Szeged airport (present exposure) — Szeged university (roof terrace) January 1961—December 1971

3. Szeged airport (present exposure) — Szeged airport (previous exposure)														
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year	
1.	-0,4	-0,6	-0,5	-0,4	-0,5	-0,5	-0,7	-0,8	-0,8	-0,7	-0,4	-0,3	-0,6	°C
2.	-0,6	-0,4	-0,4	-0,6	-0,6	-0,5	-0,6	-0,9	-0,7	-0,9	-0,4	-0,3	-0,6	°C
3.	-0,2	0,2	0,1	-0,2	-0,1	0,0	0,1	-0,1	0,1	-0,2	0,0	0,0	0,0	°C

1. Szeged airport (previous exposure) — Ásotthalom March 1951—December 1960
2. Szeged airport (present exposure) — Ásotthalom January 1961—December 1971

3. Szeged airport (present exposure) — Szeged airport (previous exposure)														
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year	
1.	-0,2	-0,2	0,1	-0,1	-0,1	0,1	0,2	0,2	0,3	0,3	0,1	0,1	0,1	°C
2.	-0,1	-0,2	0,2	0,1	0,1	0,1	0,2	0,1	0,0	0,1	0,1	0,2	0,1	°C
3.	0,1	0,0	0,1	0,2	0,2	0,0	0,0	-0,1	-0,3	-0,2	0,0	0,1	0,0	°C

Szeged airport (present exposure) — Szeged airport (previous exposure) (Szeged university, Ásotthalom)

$\Delta 1$	-0,1	0,1	0,0	0,0	0,0	0,0	0,1	-0,1	-0,1	-0,2	-0,0	0,0	0,0	°C
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b) Determination of difference between exposure at Szeged airport (present) and at Szeged university (terrace) ($\Delta 2$)

As previously outlined the individually homogenous temperature data of university terrace exposure and the present airport exposure data was compared ($\Delta 2$). Calculations were based upon data of parallel observations made during the period between January 1961 and December 1971. The yearly course of the difference between the two exposures is illustrated in *Tab. 3*. The dates make evident the climainfluencing effect of the town. It can be stated that the real (24 hours) temperature means of the airport representing the outskirts of the town are unanimously lower than the temperatures measured in town. This difference amounts to an average of 0,6 °C per year.

Table 3

*Real temperature differences between Szeged airport (present exposure) and Szeged university (roof terrace), °C, $\Delta 2$
January 1961—December 1971*

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
-0,6	-0,4	-0,4	-0,6	-0,6	-0,5	-0,6	-0,9	-0,7	-0,9	-0,4	-0,3	-0,6

c) Determination of difference between exposures at Szeged airport (present) and Szeged university (sport grounds) ($\Delta 3$)

The temperature measuring huts stood in downtown on the border of the university's sport grounds during the period from 1927 to 1944. Since the station had been destroyed during the war a new one was placed on the roof terrace of the Geographical Institute of the University in April 1946. The terrace lies in 24 m altitude above ground level. Consequently, the placing of the university station was altered and because of the war no observations were made during 1945. The missing data (monthly and yearly real temperature data) was supplied by stations at Kalocsa, Ásotthalom and at the Agricultural Institute in Szeged. Homogenous mean values transferred to the airport station are given in *Tab. 4*.

The definition of real temperature differences caused by exposure change at Szeged university (terrace and sport grounds) was based upon measurements made by a station at Ásotthalom and at the Agricultural Institute of Szeged (which is called Scientific Institution of the Great Hungarian Plain from 1950). Subsequently the difference data series of the university sport grounds was first transferred to the university roof terrace exposure and afterwards to the present airport exposure. A demonstration of the difference between the exposures at the university sport grounds and at the airport is given in *Tab. 4*.

d) Determination of difference between exposures at Szeged Gymnasium and airport ($\Delta 4, \Delta 5, \Delta 6$)

In Szeged meteorological measurements were taken at the Piarist Gymnasium of that time from 1871 to 31 December 1929, when the station ceased to exist. Measurements were subsequently transferred to the university exposure. The installation at the gymnasium was altered in 1881, 1889 and in 1900 [4, 5]. The influence caused by

Table 4

Demonstration of the difference between the university (sport grounds) and the airport exposure, °C, ($\Delta 3$)

1. Szeged university (sport grounds) — Ásotthalom January 1927—December 1971														
2. Szeged university (terrace) — Ásotthalom April 1946—December 1971														
3. Szeged university (terrace) — Szeged university (sport grounds)														
	I	II	III	IV	V	VI	VII	VIII	IX	X	X	XI	XII	Year
1.	0,3	0,4	0,6	0,4	0,5	0,6	0,6	0,7	0,8	0,7	0,5	0,5	0,5	°C
2.	0,4	0,3	0,5	0,5	0,5	0,7	0,9	1,0	1,0	0,9	0,5	0,5	0,6	°C
3.	0,1	-0,1	-0,1	-0,1	-0,2	0,1	0,3	0,3	0,2	0,2	0,0	0,0	0,1	°C
1. Szeged university (sport grounds) — Szeged Agricultural Institut January 1929—May 1944														
2. Szeged university (terrace) — Szeged agricultural Institut June 1948—December 1954														
3. Szeged university (terrace) — Szeged university (sport grounds)														
1.	0,1	0,2	0,1	0,1	-0,1	0,0	0,1	0,0	0,1	0,1	0,1	0,1	0,1	°C
2.	0,0	0,1	0,0	0,1	0,2	0,2	0,2	0,0	0,1	0,3	0,0	0,1	0,1	°C
3.	-0,1	-0,1	-0,1	0,0	0,3	0,2	0,1	0,0	0,0	0,2	-0,1	0,0	0,0	°C
1. Szeged university (terrace) — Szeged university (sport grounds) (Ásotthalom, Szeged Agricultural Institut)														
2. Szeged airport (present exposure) — Szeged university (terrace)														
3. Szeged airport (present exposure) — Szeged university (sport grounds)														
1.	0,0	-0,1	-0,1	0,0	0,1	0,2	0,2	0,1	0,1	0,2	-0,1	0,0	0,05	°C
2.	-0,6	-0,4	-0,4	-0,6	-0,6	-0,5	-0,6	-0,9	-0,7	-0,9	-0,4	-0,3	-0,6	°C
$\Delta 3$	-0,6	-0,5	-0,5	-0,6	-0,5	-0,3	-0,4	-0,8	-0,6	-0,7	-0,5	-0,3	-0,55	°C

several exposural modifications cannot be demonstrated by comparing the real temperature averages of Kalocsa and Arad in 1889. Between the individual members of the individual columns of monthly and yearly real temperature difference series no sudden change can be experienced, so homogenisation was not disturbed by this. Three different, individually homogenous (but compared with each other not homogenous) series are differentiated, as follows: gymnasium exposure I, (1871—1880), gymnasium, exposure II (1881—1899), gymnasium, exposure III (1900—1929).

Following the previously outlined method on the basis of data from more stations (Kalocsa, Ásotthalom, Arad) the differences between the real temperature averages between the three stations and the exposures at the gymnasium were one by one determined. Temperature differences between gymnasium exposure III (1900—1927) and the university sport grounds exposure were determined by the individually homogenous temperatures of Ásotthalom (Királyhalom) and Kalocsa. On the basis of this data and the differences of the airport and university exposures the difference between Szeged airport (present) exposure and Szeged gymnasium (exposure III) ($\Delta 4$) was demonstrated, as illustrated in *Tab. 5*.

The temperature data of gymnasium exposure II (1881—1899) was homogenised with the help of temperature data of Kalocsa and Arad [4] and it was transformed to gymnasium exposure III as well as to the exposure at the airport ($\Delta 5$). Calculated data is shown in *Tab. 6*.

Table 5

Demonstration of the difference between Szeged airport (present exposure) and Szeged gymnasium (exposure III), °C, (Δ4)

1. Szeged gymnasium (exposure III)—Ásotthalom 1911—1917, 1924—1928													
2. Szeged university (sport grounds)—Ásotthalom January 1927—August 1944													
3. Szeged university (sport grounds) — Szeged gymnasium (exposure III)													
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
1.	0,3	0,3	0,3	0,4	0,4	0,4	0,5	0,6	0,4	0,4	0,4	0,4	0,4 °C
2.	0,3	0,4	0,6	0,4	0,5	0,6	0,6	0,7	0,8	0,7	0,5	0,5	0,5 °C
3.	0,0	0,1	0,3	0,0	0,1	0,2	0,1	0,1	0,4	0,3	0,1	0,1	0,1 °C
1. Szeged gymnasium (exposure III) — Kalocsa (astronomical observatory) 1911—1926													
2. Szeged university (sport grounds) — Kalocsa (astronomical observatory) January 1927—August 1944													
3. Szeged university (sport grounds) — Szeged gymnasium (exposure III)													
1.	0,2	0,2	0,2	0,5	0,3	0,6	0,4	0,3	0,2	0,4	0,6	0,4	0,4 °C
2.	0,2	0,1	0,3	0,4	0,5	0,5	0,5	0,4	0,4	0,5	0,4	0,4	0,4 °C
3.	0,0	0,1	0,1	-0,1	0,2	-0,1	0,1	0,1	0,2	0,1	-0,2	0,0	0,0 °C
1. Szeged university (sport grounds) — Szeged gymnasium (exposure III) 1900—1926													
2. Szeged airport (present exposure) — Szeged university (sport grounds)													
3. Szeged airport (present exposure) — Szeged gymnasium (exposure III) 1900—1926													
1.	0,0	0,1	0,2	0,0	0,1	0,1	0,1	0,1	0,3	0,2	0,0	0,1	0,1 °C
2.	-0,6	-0,5	-0,5	-0,6	-0,5	-0,3	-0,4	-0,8	-0,6	-0,7	-0,5	-0,3	-0,5 °C
Δ4	-0,6	-0,4	-0,3	-0,6	-0,4	-0,2	-0,3	-0,7	-0,3	-0,5	-0,5	-0,2	-0,4 °C

Table 6

Demonstration of the difference between Szeged airport (present exposure) and Szeged gymnasium (exposure II), °C, (Δ5)

1. Szeged gymnasium (exposure II) — Arad 1881—1899													
2. Szeged gymnasium (exposure III) — Arad 1900—1909													
3. Szeged gymnasium (1900—1909) — Szeged gymnasium (1881—1899)													
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
1.	-0,1	0,0	0,0	0,0	0,1	0,2	0,2	-0,1	-0,1	-0,2	-0,2	-0,2	0,0 °C
2.	-0,7	-0,6	-0,3	0,1	0,0	0,1	0,1	-0,1	-0,2	-0,4	-0,7	-0,6	-0,3 °C
3.	-0,6	-0,6	-0,3	0,1	-0,1	-0,1	-0,1	0,0	-0,1	-0,2	-0,5	-0,4	-0,3 °C
1. Szeged gymnasium (exposure II) — Kalocsa 1881—1899													
2. Szeged gymnasium (exposure III) — Kalocsa 1900—1909													
3. Szeged gymnasium (1900—1909) — Szeged gymnasium (1881—1899)													
1.	-0,6	-0,7	-0,4	-0,1	-0,2	-0,1	-0,1	-0,5	-0,6	-0,3	-0,5	-0,5	-0,4 °C
2.	-0,4	-0,4	-0,3	-0,4	-0,1	-0,5	-0,2	-0,5	-0,3	-0,2	-0,1	-0,1	-0,3 °C
3.	0,2	0,3	0,1	-0,3	0,1	-0,4	-0,1	0,0	0,3	0,1	0,4	0,4	0,1 °C
1. Szeged gymnasium (exposure III) — Szeged gymnasium (exposure II), (Arad, Kalocsa)													
2. Szeged airport (present exposure) — Szeged gymnasium (exposure III), 1900—1926													
3. Szeged airport (present exposure) — Szeged gymnasium (exposure II) 1881—1899													
1.	-0,1	-0,1	-0,1	-0,1	0,0	-0,2	-0,1	0,0	0,1	0,1	0,0	0,0	-0,1 °C
2.	-0,6	-0,4	-0,3	-0,6	-0,4	-0,2	-0,3	-0,7	-0,3	-0,5	-0,5	-0,2	-0,4 °C
Δ5	-0,7	-0,5	-0,4	-0,7	-0,4	-0,4	-0,2	-0,7	-0,2	-0,4	-0,5	-0,2	-0,5 °C

The temperature data from 1871 to 1879 (gymnasium exposure I) was correlated with homogenous data from Kalocsa (1873—1899), the obtained data was transferred to data representing the outskirts of town ($\Delta 6$). The results of our calculations are listed in *Tab. 7*.

Table 7

Demonstration of the difference between Szeged airport (present exposure) and Szeged gymnasium (exposure I), °C, ($\Delta 6$)

1. Szeged-gymnasium (exposure I) — Kalocsa 1873—1880														
2. Szeged-gymnasium (exposure II) — Kalocsa 1881—1899														
3. Szeged-gymnasium (1881—1899) — Szeged-gymnasium (1871—1880)														
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year	
1.	-0,4	-0,8	-0,4	0,0	0,0	-0,3	-0,1	-0,6	-0,3	-0,2	-0,2	-0,1	-0,3	°C
2.	-0,6	-0,7	-0,4	-0,1	-0,2	-0,1	-0,1	-0,5	-0,6	-0,3	-0,5	-0,5	-0,4	°C
3. Szeged-airport (present exposure) — Szeged gymnasium (1871—1899)														
1.	-0,2	0,1	0,0	-0,1	-0,2	0,2	0,0	0,1	-0,3	-0,1	-0,3	-0,4	-0,1	°C
1. Szeged-gymnasium (1881—1899) Szeged-gymnasium (1871—1880)														
2. Szeged-airport (present exposure) — Szeged gymnasium (1881—1899)														
3. Szeged-airport (present exposure) — Szeged gymnasium (1871—1899)														
1.	-0,2	0,1	0,0	-0,1	-0,2	0,2	0,0	0,1	-0,3	-0,1	-0,3	-0,4	-0,1	°C
2.	-0,7	-0,5	-0,4	-0,7	-0,4	-0,4	-0,4	-0,7	-0,2	-0,4	-0,5	-0,2	-0,5	°C
$\Delta 6$	-0,9	-0,4	-0,4	-0,1	-0,6	-0,2	-0,4	-0,6	-0,5	-0,5	-0,8	-0,6	-0,6	°C

Table 8

Corrections applied in the course of combining real (24 hours) temperature data (°C)

	$\Delta 1$	$\Delta 2$	$\Delta 3$	$\Delta 4$	$\Delta 5$	$\Delta 6$
January	-0,1	-0,6	-0,6	-0,6	-0,7	-0,9
February	0,1	-0,4	-0,5	-0,4	-0,5	-0,4
March	0,0	-0,4	-0,5	-0,3	-0,4	-0,4
April	0,0	-0,6	-0,6	-0,6	-0,7	-0,8
May	0,0	-0,6	-0,5	-0,4	-0,4	-0,6
June	0,0	-0,5	-0,3	-0,2	-0,4	-0,2
July	0,1	-0,6	-0,4	-0,3	-0,4	-0,4
August	-0,1	-0,9	-0,8	-0,7	-0,7	-0,6
September	-0,1	-0,7	-0,6	-0,3	-0,2	-0,5
October	-0,2	-0,9	-0,7	-0,5	-0,4	-0,5
November	0,0	-0,4	-0,5	-0,5	-0,5	-0,8
December	0,0	-0,3	-0,3	-0,2	-0,2	-0,6
Year	0,0	-0,6	-0,5	-0,4	-0,5	-0,6

Designation:

$\Delta 1$: Szeged airport (present exposure) — Szeged airport (previous exposure)

$\Delta 2$: Szeged airport (present exposure) — Szeged university (terrace)

$\Delta 3$: Szeged airport (present exposure) — Szeged university (sport grounds)

$\Delta 4$: Szeged airport (present exposure) — Szeged gymnasium (exposure III)

$\Delta 5$: Szeged airport (present exposure) — Szeged gymnasium (exposure II)

$\Delta 6$: Szeged airport (present exposure) — Szeged gymnasium (exposure I)

Table 9
The homogenous temperature series at Szeged
1871—1980

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
1871	-1,9	0,1	5,6	9,8	15,6	20,0	22,9	21,4	17,2	8,6	4,6	-8,2	9,6
1872	-2,4	0,0	6,8	13,0	18,8	18,3	21,1	19,5	16,5	13,7	7,4	3,6	11,3
1873	0,4	2,0	8,7	10,5	13,8	19,0	23,3	22,2	15,8	13,9	5,7	-1,3	11,0
1874	-2,7	-1,7	2,3	12,7	11,9	21,0	24,3	20,1	18,0	10,2	0,3	1,2	9,8
1875	-2,3	-7,5	-2,1	8,7	16,0	22,5	21,6	20,5	14,6	9,7	3,4	-2,9	8,5
1876	-7,5	-0,6	7,6	13,8	12,7	20,2	21,0	21,6	14,9	13,2	-0,2	3,5	10,0
1877	0,8	1,8	5,3	9,4	13,2	19,9	20,1	21,9	13,2	7,7	4,9	-0,2	10,1
1878	-4,2	1,1	3,8	10,3	15,9	19,2	19,6	20,5	18,3	12,6	6,2	-0,6	10,1
1879	-2,8	3,8	4,4	10,8	14,8	21,4	19,7	20,7	17,7	9,3	0,9	-10,4	8,8
1880	-6,4	-2,6	2,8	13,4	14,5	19,1	23,1	17,7	15,8	10,4	5,1	3,1	9,6
1881	-4,9	-2,3	4,9	8,7	15,3	18,5	21,3	20,6	15,6	8,6	2,5	-0,3	9,0
1882	-0,4	0,7	9,7	10,7	15,7	16,9	21,8	17,8	17,1	12,0	5,8	2,5	10,8
1883	-2,8	0,3	1,0	8,4	15,7	19,3	21,7	19,7	15,9	10,8	4,8	-0,5	10,5
1884	-0,4	2,4	6,1	9,2	16,4	16,5	20,2	18,3	16,3	9,0	0,3	1,0	10,5
1885	-2,4	2,1	6,2	13,0	15,0	20,6	21,6	18,9	17,0	11,7	5,8	-3,7	10,4
1886	-0,1	-1,5	2,1	11,2	16,5	18,8	21,7	21,0	18,3	12,2	5,7	2,5	10,7
1887	-2,0	-2,9	3,4	10,2	16,1	18,2	24,0	21,2	18,1	8,9	5,8	-1,5	9,9
1888	-7,9	-5,2	4,6	10,2	16,6	21,2	21,4	20,3	17,9	9,8	0,6	0,2	9,1
1889	-3,8	-1,9	2,4	10,2	18,9	22,2	22,8	20,9	13,8	13,1	4,3	-5,4	9,7
1890	-1,2	-1,8	5,5	11,5	17,8	18,3	22,9	24,3	15,2	9,5	6,0	-3,4	10,3
1891	-8,2	-6,0	3,2	8,2	18,5	20,0	22,3	20,8	17,1	12,8	5,1	1,2	9,6
1892	-1,7	1,0	3,0	11,2	16,6	20,6	21,6	22,9	19,9	11,9	2,4	-3,2	10,5
1893	-11,2	-1,4	4,9	9,3	15,8	19,1	21,6	19,0	16,1	12,5	4,9	1,5	9,3
1894	-4,0	0,7	6,1	13,6	16,8	18,8	24,6	21,2	15,7	12,3	4,5	-0,8	10,7
1895	-2,2	-6,3	2,8	10,4	16,4	19,6	22,9	20,1	17,3	11,2	5,5	0,1	9,8
1896	-8,2	-1,0	6,4	8,0	15,4	19,9	21,4	19,3	16,9	14,5	3,7	1,6	9,8
1897	-0,7	0,9	7,5	11,2	14,4	19,4	21,1	20,8	17,4	8,9	1,5	-2,4	10,0
1898	-1,0	0,7	6,1	11,9	16,3	19,0	19,5	20,5	16,2	12,1	7,1	1,6	10,8
1899	1,7	1,8	4,0	11,7	15,3	17,1	20,6	19,7	16,6	9,1	5,4	-2,5	10,0
1900	0,8	5,1	3,2	10,4	15,8	20,1	23,2	19,9	16,9	12,0	7,2	1,2	11,3
1901	-7,5	-3,8	6,2	10,4	16,2	20,6	22,2	19,5	15,8	11,9	2,9	4,0	9,9
1902	1,3	2,9	4,3	9,4	12,2	18,5	20,3	21,0	16,3	10,6	1,4	-4,9	9,4
1903	-2,5	3,1	8,1	7,9	15,4	17,9	20,5	19,4	17,3	11,2	6,2	2,4	10,6
1904	-2,6	2,9	5,3	11,0	15,8	19,5	23,5	21,2	15,3	10,9	2,6	1,2	10,5
1905	-6,5	0,1	5,6	9,1	16,3	20,5	23,8	22,4	18,5	6,2	6,8	1,3	10,3
1906	-2,4	0,4	5,6	11,3	16,2	18,8	21,8	19,9	15,0	10,6	7,0	-1,3	10,3
1907	-3,3	-3,1	1,9	7,7	18,9	20,1	20,2	20,6	16,6	15,8	3,9	2,4	10,2
1908	-3,2	0,3	4,8	9,4	19,0	21,4	21,5	18,9	15,2	9,5	-0,9	-0,9	9,6
1909	-3,7	-3,7	5,7	10,9	15,4	19,3	20,4	21,8	17,5	12,9	3,8	4,4	10,4
1910	0,7	4,5	6,2	10,2	15,9	20,1	21,0	20,2	15,3	10,7	4,1	4,0	11,1
1911	0,0	-2,1	5,7	9,8	15,9	19,0	23,0	21,4	17,3	11,3	8,0	3,0	11,1
1912	-3,7	3,2	8,2	8,1	14,9	20,3	21,6	18,3	11,5	8,3	2,7	1,9	9,6
1913	-2,5	-1,0	7,9	10,4	14,6	18,7	18,4	18,0	16,5	11,3	6,0	1,5	10,0
1914	-6,6	-3,7	6,8	11,8	15,3	18,2	19,9	20,2	15,0	9,7	2,9	3,2	9,4
1915	1,5	1,3	3,7	9,6	16,0	20,4	20,3	17,8	13,4	9,4	3,0	4,7	10,1
1916	2,1	0,9	9,3	10,5	15,7	19,2	21,4	19,5	14,8	10,3	7,1	4,8	11,3
1917	0,1	-6,3	4,3	9,6	16,7	21,1	21,4	22,3	18,6	12,3	6,2	-1,1	10,5
1918	0,4	0,7	5,8	14,0	16,1	17,9	20,9	19,9	18,5	11,6	3,4	1,0	10,9

Table 9

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
1919	2,7	0,6	6,5	10,1	11,4	19,1	19,8	19,4	18,1	9,7	4,6	0,5	10,2
1920	2,0	1,2	7,1	14,7	18,5	19,1	22,4	19,5	17,1	7,9	0,7	3,0	11,1
1921	3,4	1,2	7,8	10,6	18,1	18,5	23,6	22,3	16,1	11,6	2,8	0,0	11,4
1922	-3,0	-4,7	7,3	9,4	16,7	20,6	22,4	21,1	15,7	8,9	2,5	2,1	10,2
1923	0,9	1,5	6,8	9,9	18,6	17,8	22,5	21,0	18,1	14,2	8,4	1,7	11,8
1924	-4,6	-0,7	4,4	10,0	18,7	21,4	21,8	19,2	18,4	11,3	3,1	0,3	10,3
1925	0,1	5,9	5,3	11,7	17,5	18,5	22,5	21,3	16,0	12,0	6,3	-2,6	11,2
1926	-0,2	4,6	4,9	13,0	15,6	18,8	20,4	18,6	18,1	12,6	11,4	1,5	11,6
1927	1,8	-0,3	8,6	10,6	15,4	21,9	23,2	21,8	18,2	10,7	6,2	-2,7	11,3
1928	-2,3	0,5	3,8	11,9	13,6	18,8	25,0	21,7	17,6	10,5	7,3	-0,6	10,7
1929	-4,2	-8,9	2,3	7,3	17,6	19,2	21,6	22,7	16,7	13,1	7,2	2,3	9,8
1930	0,1	1,4	7,5	12,0	15,5	21,9	22,5	20,6	18,6	11,4	7,7	1,0	11,7
1931	-0,4	1,7	2,2	8,8	18,6	22,3	23,2	20,6	12,8	9,7	4,6	-1,1	10,2
1932	-3,2	-7,2	-0,8	10,3	17,0	18,7	23,5	21,4	20,5	12,7	4,6	0,7	9,9
1933	-3,3	1,2	5,8	7,7	14,3	17,3	21,7	20,4	15,8	11,5	6,1	-5,7	9,5
1934	-2,8	0,2	9,6	14,5	18,8	19,2	21,6	21,5	18,1	11,5	7,2	4,9	12,0
1935	-4,2	-1,5	4,1	10,7	15,1	22,0	21,8	20,6	16,8	14,5	4,9	2,4	10,6
1936	4,4	2,2	8,7	11,3	17,3	19,5	24,2	19,1	15,8	6,7	4,7	0,4	11,2
1937	-2,8	2,0	8,3	10,3	18,6	21,0	21,3	19,7	18,4	11,3	5,8	1,3	11,3
1938	-1,8	0,9	7,8	8,2	14,6	22,0	22,5	20,7	15,9	12,0	6,8	-0,7	10,8
1939	0,6	2,1	3,5	13,7	15,5	20,4	23,0	21,0	16,3	10,1	5,5	0,3	11,0
1940	-8,6	-5,8	2,0	10,7	14,0	18,6	20,9	17,0	16,6	11,1	7,7	-5,2	8,2
1941	-2,4	3,2	6,0	10,6	13,9	18,4	20,8	19,5	13,4	9,5	2,5	0,6	9,6
1942	-9,5	-3,7	1,9	9,1	16,6	20,1	21,6	21,2	20,3	12,0	3,7	2,1	9,6
1943	-4,7	2,6	6,1	11,9	14,5	18,6	22,3	23,9	19,4	13,5	5,1	1,8	11,2
1944	1,1	-1,1	2,2	10,9	15,1	20,2	20,8	22,7	16,9	11,9	5,9	0,4	10,4
1945	-4,3	1,6	7,1	11,2	19,0	20,6	22,6	20,9	16,8	10,8	5,5	1,8	11,1
1946	-5,1	1,9	7,2	14,2	19,5	22,7	24,6	24,2	19,6	6,9	6,2	-0,8	11,7
1947	-7,7	-1,8	8,0	13,6	18,2	21,1	23,0	21,3	20,6	9,7	6,9	2,2	11,2
1948	4,6	0,9	6,5	13,0	18,0	19,3	20,4	21,7	17,8	11,7	3,3	-4,0	11,0
1949	0,9	1,8	2,8	12,5	17,2	17,1	20,8	19,4	17,9	12,0	7,5	2,9	11,0
1950	-3,3	1,3	7,0	12,6	18,6	21,7	24,2	23,0	17,7	9,6	5,8	4,1	11,8
1951	2,1	4,0	6,8	11,4	16,1	20,2	22,2	22,6	18,7	9,7	8,1	1,6	11,8
1952	0,8	0,8	2,9	14,4	15,4	20,6	24,2	24,6	16,5	10,7	5,2	1,5	11,5
1953	0,5	0,4	5,0	11,5	14,7	20,0	23,1	19,5	17,8	12,7	3,4	-1,0	10,6
1954	-7,2	-7,4	6,0	8,7	15,6	21,1	19,9	20,8	18,4	10,4	5,0	3,5	9,6
1955	-0,4	2,5	3,1	7,7	15,3	19,1	20,5	19,4	16,7	11,2	5,2	3,1	10,3
1956	1,1	-9,3	1,5	11,0	15,5	18,5	21,5	21,4	17,3	10,6	2,1	0,5	9,3
1957	-3,0	4,4	6,8	11,7	13,4	21,5	22,2	20,5	16,3	10,4	6,5	-0,3	10,9
1958	-2,7	4,0	1,2	8,4	20,0	18,8	22,8	21,8	16,6	10,8	6,3	3,5	11,0
1959	-0,7	-0,7	7,8	11,1	15,6	19,0	22,2	20,1	14,8	9,5	5,3	4,0	10,7
1960	-3,1	0,0	6,1	11,0	15,2	20,0	20,4	21,0	15,6	12,5	7,9	4,9	11,0
1961	-0,5	3,3	8,0	14,0	14,5	20,0	19,9	20,4	17,9	13,4	7,0	0,0	11,5
1962	0,1	-0,8	0,8	12,4	15,5	18,2	19,4	22,2	14,8	11,5	6,6	-2,2	9,9
1963	-7,8	-4,0	3,5	12,2	16,7	20,6	22,8	22,0	18,0	10,6	10,3	-4,6	10,0
1964	-9,3	-2,0	2,9	11,6	14,9	22,4	21,1	19,3	16,2	11,6	7,0	0,6	9,7
1965	0,3	-3,7	6,2	9,4	14,7	19,2	20,8	18,1	17,1	9,7	3,4	3,0	9,9
1966	-4,3	6,0	5,4	12,7	15,8	18,7	20,3	20,1	16,3	15,6	5,3	1,6	11,2
1967	-5,2	1,1	7,0	10,6	16,3	18,7	22,7	20,9	18,4	13,2	5,6	-0,1	10,7
1968	-1,7	3,0	5,7	13,0	17,4	20,6	20,7	18,8	16,0	10,8	7,3	-1,0	10,9

e) Combination of various temperature series (1871—1980)

After having defined the differences caused by exposural modifications of the individually homogenous temperature series obtained from successive exposures in Szeged the next step is a combination of the different series. Homogenising calculations were transformed to the present airport exposure representing the outskirts of town. The real temperature averages of the airport station measured during the period between 1961 and 1980 were left unchanged. In order to convert the original data of the individual stations in Szeged the corrections summarised in *Tab. 8.* were effectuated.

Values transformed to present airport installation are given in *Tab. 9* in this way we

Table 9

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
1969	-3,9	-0,6	4,0	9,9	17,9	17,9	20,6	19,6	16,9	11,0	7,9	-2,2	9,9
1970	-1,4	0,5	4,9	10,6	14,3	19,5	20,3	20,1	15,2	9,3	7,6	0,8	10,1
1971	-1,9	2,4	2,8	11,3	18,1	18,9	20,7	21,8	14,1	9,0	4,7	2,3	10,4
1972	-0,8	3,6	7,6	12,7	16,4	20,5	21,6	19,2	13,4	8,5	5,4	0,8	10,7
1973	-0,8	2,4	5,0	9,6	17,1	19,2	21,0	20,6	17,7	9,6	2,3	-0,3	10,3
1974	1,4	5,2	7,9	9,9	14,5	17,3	19,6	22,0	16,8	7,8	5,0	2,8	10,9
1975	1,3	0,1	8,3	10,4	17,5	19,1	20,9	19,8	18,5	10,4	3,9	0,5	10,9
1976	-0,2	-1,3	2,4	11,4	15,3	17,9	21,4	17,9	15,3	11,9	6,9	0,6	10,0
1977	1,0	5,0	8,5	8,9	15,9	19,5	20,3	20,1	14,1	11,2	5,8	-2,0	10,7
1978	-0,2	0,3	6,8	9,9	13,7	18,2	19,2	18,5	14,5	10,3	1,8	1,6	9,6
1979	-2,1	2,3	7,9	9,6	17,4	21,7	18,8	19,2	16,8	9,4	5,7	4,1	10,9
1980	-4,2	1,0	5,3	8,1	13,4	18,5	19,7	20,1	15,6	11,4	4,0	-0,2	9,4

have a homogenously combined series of real temperature averages of 110 years (1871—1980) originating from different exposures in Szeged.

Characteristic features of homogenous temperature series of Szeged

The unhomogenous original temperature observation material was homogenised as previously described. Following this, the direction of temperature changes in Szeged during the past 110 years was investigated on the basis of observational data. While processing the index numbers of averages (*A*), standard deviation (σ) and skewness were applied as summarised in *Tab. 10.*

Table 10

Averages of the monthly mean temperature at Szeged during 110 years (1871—1980), °C

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Average (<i>A</i>)	-2,1	0,1	5,3	10,8	16,0	19,6	21,6	20,5	16,7	10,9	5,0	0,5	10,4
Standard deviation (σ)		3,15	3,18	2,33	1,72	1,70	1,35	1,38	1,46	1,65	1,78	1,24	2,73
Skewness (α)		-0,52	-0,79	-0,46	0,24	-0,01	0,23	0,22	0,26	-0,27	0,04	-0,31	-1,07
													-0,26

First 110 year averages (A =arithmetic mean value) of homogenous series consisting of monthly and yearly real (24 hours) mean temperatures were calculated on the basis of the following formula:

$$A = \frac{\sum X}{N}.$$

The monthly mean averages demonstrate that the coldest month ($-2,1^{\circ}\text{C}$) was January, while the warmest one appeared to be July ($21,6^{\circ}\text{C}$). The difference between the mean temperatures of the coldest and the warmest month, that is the value of *yearly mean oscillation* is $23,7^{\circ}\text{C}$. The *yearly real temperature average* is $10,4^{\circ}\text{C}$ in Szeged.

In order to determine the places of the individual values around the mean values a dispersion index number, the average quadratic divergence or shortly the *standard deviation* (σ) was calculated. These values were determined with the following formula for the period between 1871 and 1980:

$$\sigma = \sqrt{\frac{\sum (X - A)^2}{N}}.$$

The yearly course of standard deviation values shows a characteristic picture (*Tab. 10*) it has a contrasting course with the yearly temperature course. The standard deviation of monthly mean temperatures is wider in the winter months (3,0) and more moderate during the summer months (1,4). During the winter months the great oscillation values are not so much determined by greater values of maximums but by those of minimums — December 1879, January 1893 (*Fig. 2, Tab. 11*). The greatest negative anomalies of December mean temperatures were unanimously observed in the whole country in December 1879. In forming the yearly course of standard deviation the main role is played by advective factors. In this way during the months when the occurrence of oceanic air mass appears to be the most frequent — that is, in summer, the standard deviation is lower while during the months when oceanic air masses occur less frequently consequently continental advections have a stronger influence the standard deviation is wider as well.

In a numerical expression the characteristic of divergency from normal distribution is given by the rate of skewness (α).

$$\alpha = \frac{\frac{\sum (X - A)^3}{N}}{\sqrt{\left(\frac{\sum (X - A)^2}{N}\right)^3}} = \frac{\frac{1}{N} [\sum X^3 - 3A \sum X^2 + 2NA^3]}{\sqrt{\left[\frac{1}{N} (\sum X^2 - NA^2)\right]^3}}.$$

Referring to the period between 1871 and 1980 temperature distributions approach normal distribution mostly during spring and autumn (May, October) during this interwall the value of skewness stays near zero. It appears from data in *Tab. 10* that the distribution of mean temperatures has a right skewness while during the winter months the rate of skewness is negative which means that the distribution has a left side skewness.

The extrem values of monthly and yearly mean temperatures measured in Szeged during 110 years are given in *Tab. 11* determining the rate of oscillation as well. The warmest month in Szeged appeared to be July in 1928 (25°C) and the coldest one was January in 1893 ($-11,2^{\circ}\text{C}$). The temperature values of August in 1952 ($24,6^{\circ}\text{C}$)

Table 11

The extremes of the monthly and annual temperatures at Szeged during 110 years (1871—1980), °C

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Maximum Year	4,6 1948	6,0 1966	9,7 1882	14,7 1920	20,0 1958	22,7 1946	25,0 1928	24,6 1952	20,6 1947	15,8 1907	11,4 1926	4,9 1960 1934	12,0 1934
Minimum Year	-11,2 1893	-9,3 1956	-2,1 1875	7,3 1929	11,4 1919	17,1 1899 1949	18,4 1913	17,0 1940	11,5 1912	6,2 1905	-0,9 1908	-10,4 1879	8,2 1940
Variation	15,8	15,3	11,8	7,4	8,6	5,6	6,6	7,6	9,1	9,6	12,3	15,3	3,8

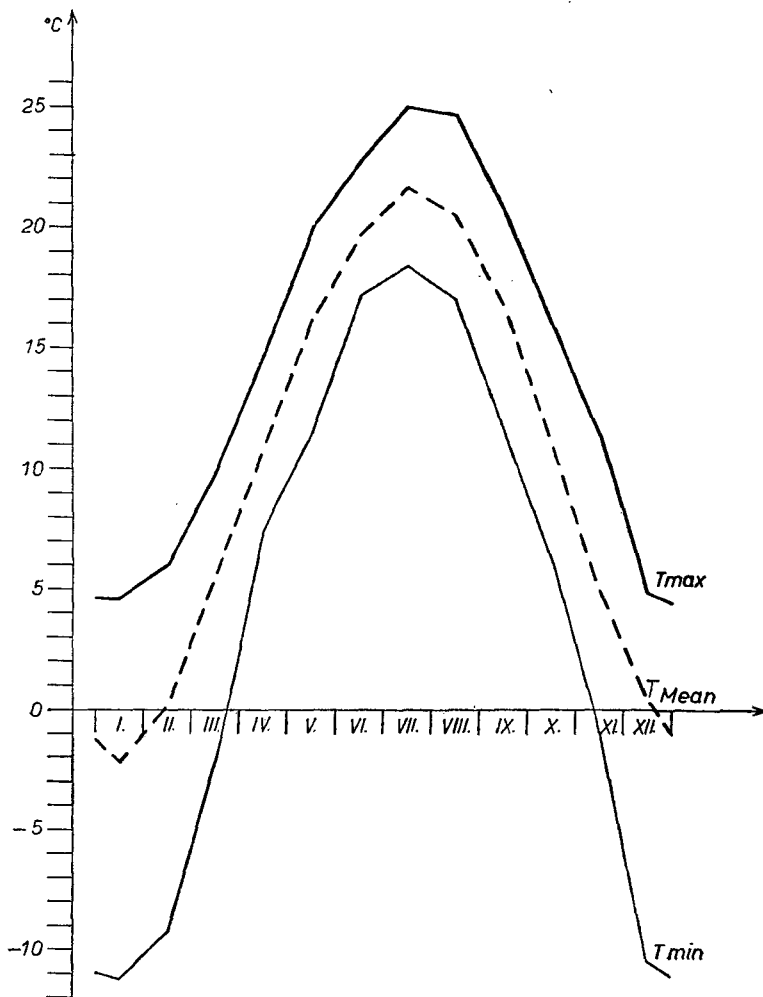


Fig. 2. Extrem values of monthly mean temperatures at Szeged (1871—1980)

and December in 1879 ($-10,4^{\circ}\text{C}$) are worth mentioning being of more striking character. In yearly aspect extrem values — according to other temperature data of the country — at the same time, i. e. in 1934 (max. : $12,0^{\circ}\text{C}$) and in 1940 (min. : $8,2^{\circ}\text{C}$). The yearly courses of extrem values and mean values are illustrated in Fig. 2.

By determining homogenous temperature series of Szeged a town representing the south-eastern part of the country, and by discussing the characteristic features of temperature data a contribution was made to the advancement of town-climatological researches in Szeged.

Summary

The main object of present study was to homogenise temperature data obtained in Szeged, since the exposure of climatologic research stations of the town has been more times modified. Homogenising calculations were based upon measurements made at observation stations situated at various points of the town as well as on the basis of measurements taken at the airport representing the outskirts of the town. Measurements taken during the period between 1871 and 1980 were considered. In the course of our work the homogenisation of temperature series of Szeged was done for the real (24 hours) temperature averages this way every observation was placed on a uniform basis. On the basis of the obtained homogenous series of sufficient length (1871—1980) the rate of changeability, oscillations and extremes were emphasised. The town-climatic effects characterising towns are less predominating at the airport exposure. The advantage of homogenous series converted to this exposure is that observations made in the future can be directly joined to this homogenous series.

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