Relation between Nebulosity and Diurnal Temperature Amplitude

by

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Az égbolt borultságának és a hőmérséklet napi ingásának kapcsolatáról. A tanulmány Magyarország északi, déli, nyugati és keleti szegélyéről egy-egy meteorológiai állomás 5 évi adatsorát használja fel. Minden hónapra meghatározza a lineáris regresszió egyenletét, a korrelációs együtthatót és egyéb paramétereket. Megállapítja, hogy a korrelációs együttható havonként és állomásonként – 0, 0 és —0,85 között ingadozik. A legerősebb korreláció szeptemberben és a nyári hónapokban mutatkozik. A regressziós együttható értéke 1° körül mozog, a reziduális szórás viszont 2°-nál is nagyobb.

Az azonos borultsággal számított napi ingás legnagyobb értékét a ténylegesen tapasztalt ingás havi átlagainak nyári és szeptemberi maximumával szemben májusban éri el.

A vizsgálatok eredményei arra vallanak, hogy a napi ingásnak a borultsággal való kapcsolata Magyarország különböző területein hasonló.

Über den Zusammanhang zwischen Bewölkung und täglicher Temperaturamplitude. In der Arbeit werden 5-jährige Beobachtungsreihen von vier meteorologischen Stationen verwendet, die je in den nördlichen, südlichen, westlichen und östlichen Grenzgebieten von Ungarn liegen. Für einen jeden Monat werden die linearen Regressionsgleichungen, die Korrelationskoeffizienten und manche andere statistische Parameter errechnet. Es wird festgestellt, dass der Korrelationskoeffizient nach Monaten und nach Beobachtungsstationen zwischen den Werten —0,50 und 0—85, schwankt. Die stärkste Korrelation zeigt sich im September und in den Sommermonaten. Der Wert der Regressionskoeffizienten schwankt um 1° herum, hingegen übertrifft die residuale Streuung selbst den Wert von 2°.

Der auf Grund der Annahme einer gleichbleibenden Bewölkung errechnete Wert der Tagesschwankung der Temperatur erreicht sein Maximum im Mai, im Gegensatz zu den beobachteten Werten, welche ihr Maximum in den Sommermonaten und im September erreichen.

Die Ergebnisse dieser Untersuchungen weisen darauf hin, dass der Zusammenhang zwischen der Tagesschwankung und der Bewölkung in den verschiedenen Gebieten Ungarns eine gleiche Struktur besitzen.

The paper is using 5-year data series from four meteorological stations situated respectively on the northern, southern, western and eastern boundaries of this country. For every month, the equation of linear regression, the correlation coefficient and some other parameters are determined. It is found that the correlation coefficient is fluctuating, according to the various months and various observing stations, in the range of —0,50 to —0,85. The strongest correlation is found in September and during the summer months. The value of the regressional coefficient is fluctuating around the value of 1°, while the residual scatter is higher than 2°.

The highest values of the diurnal amplitude computed under the assumption of identical nebulosities are occurring in May, in contrast to the observed amplitudes, which are reaching their highest values in the summer and in September.

The results of this investigation are indicating that the relation existing between diurnal temperature amplitude and nebulosity is a similar one in the different areas of this country.

The diurnal variation of temperature may be either a periodic or an aperiodic one. The periodical diurnal amplitude is identical to the measure of the diurnal rise of temperature and thus it is primarily depending on the diurnal amplitude of solar radiation, i.e. it is finally depending on solar elevation at noon. However, solar elevation is determining only an upper limit to the radiation intake: the radiation amount actually received by the terrestrial surface, as well as the emitted radiation of the soil surface and of the lower strata of the atmosphere, that is, the whole atmospheric radiation balance, is the result of the mutual effects of several atmospheric factors. Among these factors, primarily nebulosity is to be taken into account. In the present paper, we are analysing the relation existing among solar elevation at noon (i.e. solar declination), the amount of nebulosity, and the diurnal variation of temperature.

In this investigation, we selected meteorological stations located respectively in the northern, southern, western, and eastern parts of this country, namely the stations Budapest-Lőrinc, Szeged, Szombathely and Debrecen, and we used the data series collected during the five years 1970 to 1974 (Fig. 1). The data were processed without any alteration, disregarding the periodical or aperiodical nature of the amplitudes.

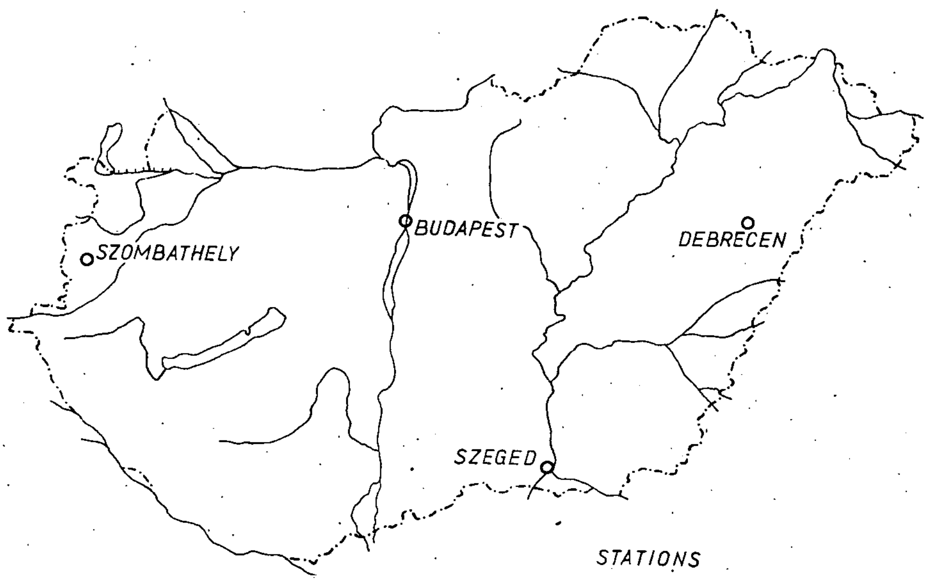

Fig. 1. The situation of the investigated stations
1. ábra. A vizsgálatba bevont állomások

As a first step, we determined the equation of the regressional straight line of the stochastic relation existing between the monthly average values of solar elevation at noon on the one hand, and the monthly average values of the amplitude of temperature (as, according to the results of a preliminary graphical investigation, this relation is a linear one); further, we determined the correlation coefficient, the standard deviation of average monthly amplitudes, the residual scatter and the quotient of the residual scatter by the regressional coefficient. The results are shown in *Table I.*

It is a well-known fact, that the value of diurnal amplitude is grosso-modo following the variations of solar declination. However, the high value of the correlation coefficient obtained here is still somewhat surprising. The average value of the four correlation coefficients corresponding to the four observing stations is

0,8663

Table I

Annual scatter of the monthly average values of the diurnal amplitude of temperature [S_y], correlation coefficient between the monthly average values of solar elevation at noon and the monthly average values of diurnal amplitude of temperature [r_{xy}], equation of the straight line of regression [y=value computed for the diurnal amplitude of temperatur, x=value of the solar elevation at noon in degrees], residual scatter [S_{yx}] and the quotient of residual scatter by the regression coefficient [S_{yx}/a], for the stations Budapest-Lőrinc, Szeged, Szombathely and Debrecen, 1970—74

	S_y	r_{xy}		S_{yx}	S_{yx}/a
Budapest-Lőrinc	2,27°	0,9003	y=3,21+0,126x	0,99°	7,86
Szeged	2,31°	0,8403	y=5,04+0,119x	1,25°	10,50
Szombathely	2,33°	0,8777	y=4,34+0,126x	1,12°	8,89
Debrecen	2,32°	0,8469	y=4,61+0,121x	1,23°	10,17

The differences among the various correlation coefficients corresponding to the various stations are not exceeding the value of 0,0600. Similarly to the correlation coefficients, the regressional coefficients are varying also very slightly, and the regressional coefficients obtained from the data series Budapest-Lőrinc and Szombathely are identical to the fourth decimal digit. The quotients of the residual scatter by the regressional coefficient are indicating that an amplitude variation corresponding to a variation of 7,9 to 10,5 degrees in solar declination or, respectively, of solar elevation angle, is corresponding to the magnitude of the residual scatter.

From the very close correlation found between the monthly average values of temperature amplitude on the one hand and solar elevation on the other hand, it appears probable that in a good correlation to the solar elevation at noon, there should be a variation in another meteorological element which is of influence on the magnitude of the diurnal amplitude of temperature. Such a meteorological factor is the nebulosity. Although the diurnal temperature variation is not independent from the types, altitudes and thicknesses of the clouds which are present, we are omitting, in this analysis, these factors and we are taking into account exclusively the degree of nebulosity. We are using the monthly average values of nebulosity expressed in the unit "octa". We are presenting the equation of the regression line of the relation existing between this quantity and the monthly average values of the temperature amplitude, as well as the correlation coefficient, the standard deviation of the average values of the diurnal amplitude, the residual scatter and the quotient of this latter quantity by the regressional coefficient in *Table II*, while the same characteristics for the relation existing between solar elevation at noon and the degree of nebulosity are shown in *Table III.*

Table 2

Correlation coefficient between the monthly average values of nebulosity and the monthly average values of diurnal amplitude of temperature [r_{xy}], equation of the straight line of regression [y=value computed for the diurnal amplitude of temperature, x=value of nebulosity in octas], residual scatter [S_{yx}] and the quotient of the residual scatter by the regression coefficient [S_{yx}/a] for the stations Budapest-Lőrinc, Szeged, Szombathely and Debrecen 1970—74

	r_{xy}		S_{yx}	S_{yx}/a
Budapest-Lőrinc	—0,8739	y=20,86—2,55x	1,11°	0,435
Szeged	—0,8997	y=21,77—2,43x	1,01°	0,416
Szombathely	—0,9114	y=23,36—2,67x	0,96°	0,360
Debrecen	—0,8270	y=23,20—2,53x	1,30°	0,513

Table 3

Correlation coefficient between the monthly average values of solar elevation at noon and the monthly average values of nebulosity [r_{xy}], equation of the straight line of regression [y=value computed for nebulosity, in octas, x=value of the solar elevation at noon in dgrees], the residual scatter of the monthly average values of nebulosity [S_{yx}] and the quotient of the residual scatter by the regression coefficient [S_{yx}/a] for the stations Budapest-Lőrinc, Szeged, Szombathely and Debrecen, 1970—74

	r_{xy}		S_{yx}	S_{yx}/a
Budapest-Lőrinc	—0,6717	y=6,18—0,032x	0,58	18,13
Szeged	—0,6946	y=6,34—0,037x	0,62	16,76
Szombathely	—0,6668	y=6,47—0,032x	0,58	18,13
Debrecen	—0,6164	y=6,54—0,029x	0,60	20,69

Between nebulosity and the monthly average values of diurnal amplitude there is similarly a very close correlation. The average of the four correlation coefficients corresponding to the four observing stations is

$$-0{,}8780$$

and the highest difference among them is lower than 0,0850. There are two stations for which the correlation between the diurnal amplitude and the solar elevation at noon is slightly closer, while for the two other stations, this is the case for the correlation between the diurnal amplitude and the nebulosity. Both types of correlations are significant ones at a probability level which is lower than 0,1 per cent. Among the regressional coefficients, the highest difference is 0,25°, which is a value that is even lower than 10 per cent of the smallest coefficient. On the basis of the quotient of residual scatter by the regressional coefficient, the residual scatter is not exceeding 36 to 51 per cents of the variation of the amplitude for 1 octa of nebulosity variation.

Between the monthly average values of solar elevation at noon on the one hand, and of nebulosity on the other hand, there is also a rather good correlation, however it is significantly looser than the correlation between the same variable and the diurnal amplitude. The average of the four correlation coefficients corresponding to the four observing stations is

$$-0{,}6624$$

with a significance level lower than 5 per cents. The difference among the correlation coefficients are lower than 0,0800. From the quotient of residual scatter by the regressional coefficient it can be stated, that the magnitude of residual scatter is only reached by a change in nebulosity which corresponds to a change of 16,8° to 20,8° in solar declination.

As the correlations of the diurnal amplitude with both solar elevation at noon and nebulosity are much more close ones than the correlation between the latter two variables under themselves, it appears to be advisable to carry out also correlation and regressional calculations for three variables. The three dimensional regressional equations, which are expressing the mutual relation existing among the quantities (average values of diurnal amplitude, average solar elevation at noon, and average nebulosity) as well as the mutual correlation coefficients are shown in *Table IV*.

Table 4

Mutual correlation coefficient among the following quantities: monthly average values of the solar elevation at noon, monthly average values of the nebulosity and monthly average values of diurnal amplitude of the temperature [$r_{x_1 x_2 y}$] and the regression eqution with three variables [y = value computed for the diurnal amplitude of temperature, x_1 = value of the solar elevation at noon in degrees, x_2 = value of the nebulosity in octas] for the stations Budapest-Lőrinc, Szeged, Szombathely and Debrecen, 1970—74

Budapest-Lőrinc	0,9708	$y = 12{,}07 + 0{,}080x_1 - 1{,}43x_3$
Szeged	0,9482	$y = 15{,}48 + 0{,}059x_1 - 1{,}65x_2$
Szombathely	0,9808	$y = 15{,}73 + 0{,}070x_1 - 1{,}76x_2$
Debrecen	0,9348	$y = 14{,}46 + 0{,}078x_1 - 1{,}51x_2$

The average of the common correlation coefficients corresponding to the four observing stations is

0,9586

a value which is by 0,0923 higher than the average of the four correlation coefficients for the solar elevation at noon and by 0,0806 higher than the average of the four correlation coefficients for nebulosity. It is seen that taking simultaneously into account the solar elevation at noon and the nebulosity, only a slight increase in the correlation coefficient is experienced. This slight increase, however, is decreasing by some tenths of degrees the value of residual scatter, and, in the case of the residual scatter obtained from the observations taken at Szombathely, even a decrease of more than 0,5 degrees is occurring, which is more than the half of the residual scatter calculated for the two variables.

On the basis of the regressional coefficients, it can be stated that from the point of view of the effect on the magnitude of diurnal amplitude, at Budapest-Lőrinc, a variation of about 18°, at Debrecen of 19°, at Szombathely of 25° and at Szeged of 28° in solar elevation at noon (or, respectively, in solar declination) is equivalent to a variation of nebulosity by 1 octa. These figures are, at the same time, also expressing, that the variation of about 47° in solar declination, which is experienced between two solstices, is equivalent only to a variation in nebulosity by 1,7 to 2,6 octas. At a first glance, this may appear to be an irrealistic statement. However, it should be taken into account, that we are dealing with monthly average values and the annual variation of the monthly averages of nebulosity is comporting only some 2 to 3 octas, to which is corresponding the annual variation of the diurnal amplitude as well as it is corresponding to a variation in solar declination of 47 degrees. (However, it should be noted, that the annual variation of the monthly average values of solar declination is equal not to 47, but only to 46 degrees.) A different result should be obtained when using not monthly average values, but daily values in the calculation. In addition, the reliabilities of the values of the solar elevation at noon and of the nebulosity, used in the calculation, are not of the same order. The values of solar declination are known, with suitable exactitude, without making measurements; while the determination of nebulosity is the kind of meteorological observations which is exhibiting the highest numbers of errors, without mentioning the circumstance that a nebulosity consisting of clouds of various altitudes and thicknesses is characterized by one and the same value.

In the further discussions, the relation between daily values of diurnal amplitude and nebulosity is analysed, by grouping the data according to months. The relation existing between the solar elevation at noon and the diurnal amplitude will not be investigated on the basis of daily values.

A similar analysis has been carried out earlier by *E. Antal* [*1*] on the basis of diurnal amplitudes observed at Budapest. *Antal* proceeded by sifting very carefully his data and taking into account only the days which were synoptically free from advection. This author is calling the temperature amplitude "the measure of temperature rise". Hi is approximating the relation existing between nebulosity and this quantity by a curve of the third order, stating, that the variation of diurnal amplitude with nebulosity is a different one for low, medium and high values of nebulosity. Thus, the values calculated by *Antal* are not differing by more than 0,5 degree from the observed values of the temperature amplitude. In the course of our own investigations, a preliminary graphical test showed that the unsifted diurnal variation data are not exhibiting such a degree of discrepancy from the linear relation with nebulosity, that a search for linear equations should not be justified.

In the course of our investigations, we determined, for the four observing stations, the monthly values of the nebulosity and of the diurnal amplitude; the standard deviations of the monthly distributions of the nebulosity and the diurnal amplitudes; the variation coefficients after *Pearson* of the monthly distributions of the diurnal amplitude; the regressional equations which are describing the relation existing between the nebulosity and the diurnal amplitude; the correlation coefficients, the quotients of residual scatter by the regressional coefficient; the amplitude values corresponding to the nebulosities of 0, 4 and 8 octas; and finally the values of the residual scatter expressed in per cents of the value of the diurnal amplitude computed for 4 octas of nebulosity. These data are contained in the *Tables 5—8*.

Table 5

Correlation coefficient between the nebulosity and the diurnal amplitude of temperature [r_{xy}], equation of the straight line of regression [y=value computed for the diurnal amplitude of temperature, x=value of the nebulosity in octas], residual scatter of the diurnal amplitude [S_{yx}], quotient of the residual scatter by the regression coefficient [S_{yx}/a] and the values of the residual scatter expressed in percents of the computed values of the amplitude of temperature under the assumption of 4 octas of nebulosity [$100 \cdot S_{yx}/y_{4octas}$] for various months of the year at the station Budapest-Lőrinc, 1970—74

	r_{xy}		S_{yx}	S_{yx}/a	$\frac{100 \cdot S_{yx}}{y_{4octas}}$
Januar	—0,6675	y= 9,07—0,74x	1,76°	2,38	28,8
February	—0,6198	y= 9,75—0,71x	1,94°	2,73	28,1
March	—0,6760	y=13,89—1,01x	2,67°	2,64	27,1
April	—0,6603	y=14,91—0,99x	2,28°	2,30	20,8
May	—0,6735	y=15,52—1,07x	2,21°	2,07	19,5
June	—0,6791	y=14,81—0,98x	1,99°	2,03	18,3
July	—0,6438	y=14,73—0,97x	2,15°	2,22	19,8
August	—0,8025	y=14,69—1,08x	1,76°	1,63	17,0
September	—0,7144	y=14,19—1,02x	2,25°	2,21	22,3
October	—0,7602	y=14,18—1,15x	2,38°	2,07	24,8
November	—0,5804	y=11,05—0,83x	2,56°	3,08	33,1
December	—0,4756	y= 8,26—0,55x	2,22°	4,04	36,6

It is conspicuous, that, while between the nebulosity and the monthly averages of the diurnal amplitude, a very close correlation exists: the correlation becomes very much looser when using daily values of the same quantity, even within a period of a month.

The values of the correlation coefficient are fluctuating within the following limits:

at Budapest-Lőrinc	−0,8025	and	−0,4756
at Szeged	−0,8028	and	−0,5685
at Szombathely	−0,8392	and	−0,6016
at Debrecen	−0,8522	and	−0,5040

The highest values are occurring at Szeged, at Szombathely and at Debrecen in September and at Budapest-Lőrinc in August; however, the September value is also on the latter station a very high one. The lowest value of the correlation coefficient occurs at Szeged and at Szombathely in February, at Budapest-Lőrinc in December,

Table 6

Correlation coefficient between the nebulosity and the diurnal amplitude of temperature [r_{xy}], equation of the straight line of regression [y=value computed for the diurnal amplitude of temperature, x=value of the nebulosity in octas], residual scatter of the diurnal amplitude [S_{yx}], quotient of the residual scatter by the regression coefficient [S_{yx}/a] and the values of the residual scatter expressed in percents of the computed values of the amplitude of temperature under the assumption of 4 octas of nebulosity [$100 \cdot S_{yx}/y_{4octas}$] for various month of the year at the station Szeged, 1970—74

	r_{xy}		S_{yx}	S_{yx}/a	$\frac{100 \cdot S_{yx}}{y_{4octas}}$
January	—0,6061	y=12,36—1,05x	2,68°	2,58	32,7
February	—0,5685	y=12,46—0,85x	2,70°	3,18	29,8
March	—0,6638	y=16,96—1,26x	3,59°	2,85	30,1
April	—0,6342	y=17,69—1,24x	3,27°	2,64	25,7
May	—0,6953	y=18,14—1,30x	2,67°	2,05	20,6
June	—0,6707	y=16,39—1,11x	2,44°	2,20	20,4
July	—0,7686	y=16,54—1,16x	2,13°	1,84	17,9
August	—0,7790	y=15,54—1,21x	2,18°	1,80	18,6
September	—0,8028	y=17,20—1,24x	2,25°	1,81	18,4
October	—0,7795	y=16,78—1,35x	2,97°	2,20	26,1
November	—0,6128	y=14,71—1,08x	2,37°	3,12	32,4
December	—0,5905	y=11,06—0,84x	2,57°	3,06	33,4

Table 7

Correlation coefficient between the nebulosity and the diurnal amplitude of temperature [r_{xy}], equation of the straight line of regression [y=value computed for the diurnal amplitude of temperature, x=value of the nebulosity in octas], residual scatter of the diurnal amplitude [S_{yx}], quotient of the residual scatter by the regression coefficient [S_{yx}/a] and the values of the residual scatter expressed in percents of the computed values of the amplitude of temperature under the assumption of 4 octas of nebulosity [$100 \cdot S_{yx}/y_{4octas}$] for various months of the year at the station Szombathely, 1970—74

	r_{xy}		S_{yx}	S_{yx}/a	$\frac{100 \cdot S_{yx}}{y_{4octas}}$
January	—0,7506	y=14,44—1,40x	2,39°	1,71	27,0
February	—0,6016	y=12,34—0,87x	2,33°	2,68	26,3
March	—0,6849	y=17,37—1,37x	3,39°	2,46	28,5
April	—0,6705	y=17,91—1,38x	3,31°	2,39	26,7
May	—0,6722	y=18,20—1,29x	2,92°	2,26	22,4
June	—0,6511	y=17,08—1,21x	2,66°	2,19	21,7
July	—0,7631	y=17,88—1,31x	2,55°	1,95	20,2
August	—0,6909	y=17,18—1,29x	2,90°	2,25	24,1
September	—0,8392	y=17,89—1,54x	2,31°	1,50	19,7
October	—0,6712	y=15,25—1,13x	3,09°	2,73	28,8
November	—0,6721	y=14,79—1,16x	3,21°	2,77	31,6
December	—0,5598	y=12,01—1,01x	2,43°	2,41	30,5

Table 8

Correlation coefficient between the nebulosity and the diurnal amplitude of temperature [r_{xy}], equation of the straight line of regression [y=value computed for the diurnal amplitude of temperature, x=value of the nebulosity in octas], residual scatter of the diurnal amplitude [S_{yx}], quotient of the residual scatter by the regression coefficient [S_{yx}/a] and the value of the residual scatter expressed in percents of the computed values of the amplitude of temperature under assumption of 4 octas of nebulosity [$100 \cdot S_{yx}/y_{4octas}$] for various months of the year at the station Debrecen, 1970—74

	r_{xy}		S_{yx}	S_{yx}/a	$\frac{100 \cdot S_{yx}}{y_{4octas}}$
January	—0,5851	y=12,05—0,94x	2,72°	2,89	32,8
February	—0,5559	y=13,09—0,93x	2,54°	2,73	27,1
March	—0,6075	y=17,33—1,12x	3,54°	3,16	27,6
April	—0,5040	y=16,37—0,91x	3,14°	3,45	24,7
May	—0,6298	y=17,02—1,04x	2,78°	2,67	21,6
June	—0,6960	y=16,43—1,04x	2,25°	2,16	18,3
July	—0,6201	y=16,00—0,95x	2,35°	2,47	19,3
August	—0,6546	y=16,04—0,98x	2,62°	2,67	21,6
September	—0,8522	y=16,66—1,10x	1,93°	1,75	15,7
October	—0,7471	y=16,14—1,29x	3,03°	2,35	27,6
November	—0,4446	y=13,40—0,99x	2,76°	2,79	29,2
December	—0,5888	y=12,10—1,06x	2,30°	2,17	29,3

end at Debrecen in April. There appears to be a relation between the monthly average value of nebulosity and the monthly correlation coefficient. In the rather cloudless months, the correlation is a closer one, while in cloudier months, it is looser. All of the correlation coefficients are significant at a probability level lower than 0,1 per cent.

The value of the regressional coefficient is fluctuating, for all of the four observation stations, around 1°. The variation in the amplitude corresponding to 1 octa of variation in nebulosity is possessing its highest value at Szombathely (annual average: 1,25°). For Szeged, this average value is 1,14°, for Budapest-Lőrinc, 0,93° and for Debrecen, 0,92°. The regressional coefficient is reaching its highest value at Budapest-Lőrinc, at Szeged and at Debrecen in October, and at Szombathely in September. Lowest values of the regressional coefficient are characterizing the relation between nebulosity and diurnal amplitude in the winter months, mainly in February.

The values of the residual scatter are relatively high ones, their annual average is on all of the four stations exceeding the value of 2°. They are possessing a definite annual variation with maxima in the spring and in the autumn, and minima in the winter and the summer; however, the values obtained for various months are only slightly differing from each other. This annual variation is similar to that of the (whole) standard deviation, which is again characterized by maxima in spring and in autumn, a fact stated already by *Antal* [*1*] and also by our earlier work [*2*]. The residual scatter, however, possesses a main maximum in the spring, in March. Actually, the correlation is the closest one in the autumn, and thus in the autumn, namely in September and in October, the residual scatter is a lower one than in the spring. On two stations, the September value is even lower than the similar values of the summer months.

The quotient of the residual scatter by the regressional coefficient is for all of the four stations exceeding the value of 2. In annual average, a variation of the diurnal amplitude corresponding to a variation in nebulosity of 2,28 to 2,61 octas is reaching the magnitude of the residual scatter. The value of the quotient is lowest in September and in the summer months, while it is highest in November, in February and in March.

By using the regressional equation, we computed the values of diurnal amplitudes to be expected in the various months and on the various stations under the assumption that the nebulosity will be everywhere the same, namely, 4 octas, which is representing the middle point of the nebulosity range extending from 0 octas to 8 octas. Comparing

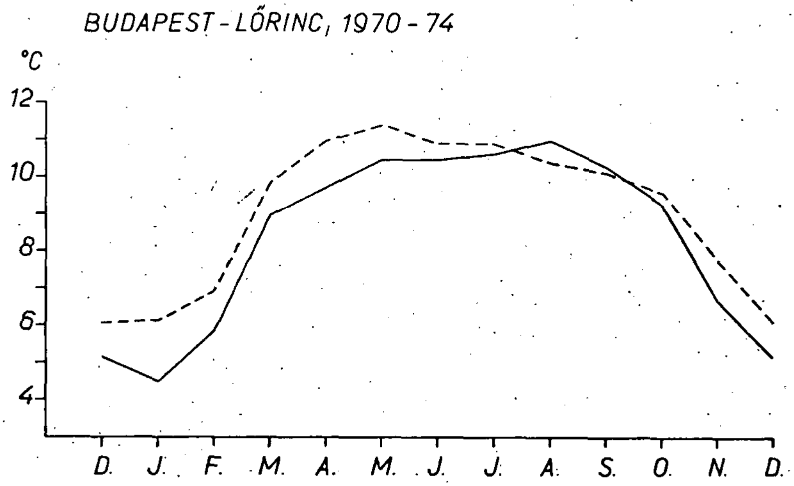

Fig. 2. Annual variations of the diurnal amplitudes as computed for a nebulosity of 4 octas (— — — —) and of the observed diurnal amplitudes (———) on the station Budapest-Lőrinc, 1970—74
2. ábra. A 4 okta felhőzetre számított napi ingás (— — — —) és a tapasztalt napi ingás (———) havi átlagainak évi menete Budapest-Lőrinc állomásról, 1970—74

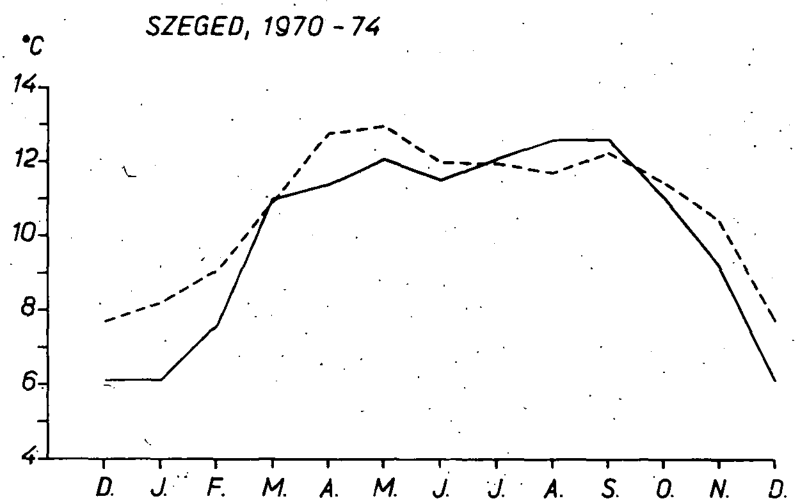

Fig. 3. Annual variations of the diurnal amplitudes as computed for a nebulosity of 4 octas (— — — —) and of the observed diurnal amplitudes (———) on the station Szeged, 1970—74
3. ábra. A 4 okta felhőzetre számított napi ingás (— — — — —) és a tapasztalt napi ingás (———) havi átlagainak évi menete Szeged állomásról, 1970—74

the values obtained in this way to the monthly average of observed amplitudes (*Fig. 2—5*) it is found that the annual variation of amplitudes computed on the assumption of a nebulosity of 4 octas is smaller than that of the monthly averages of the really

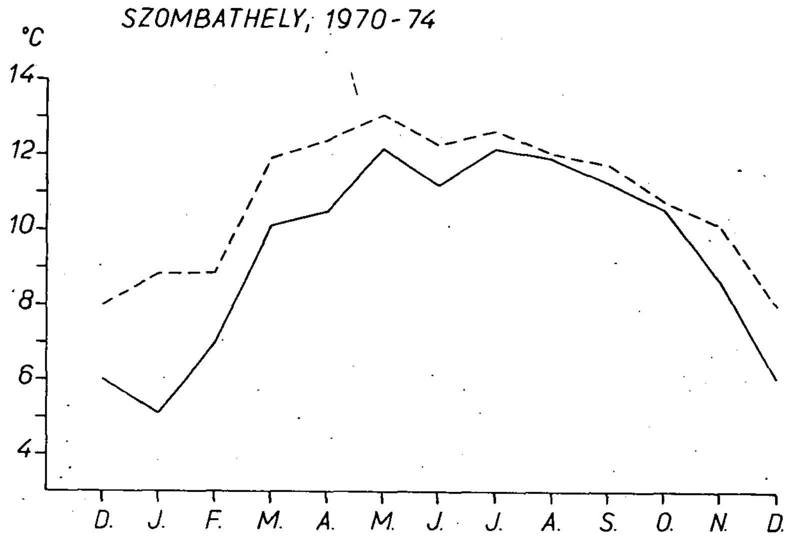

Fig. 4. Annual variations of the diurnal amplitudes as computed for a nebulosity of 4 octas (— — — — —) and of the observed diurnal amplitudes (———) on the station Szombathely, 1970—74

4. ábra. A 4 okta felhőzetre számított napi ingás (— — — — —) és a tapasztalt napi ingás (———) havi átlagainak évi menete Szombathely állomásról, 1970—74

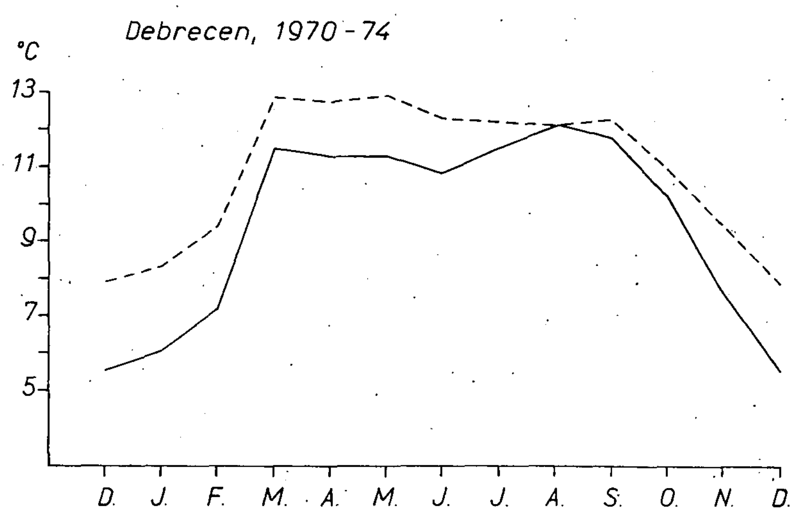

Fig. 5. Annual variations of the diurnal amplitudes as computed for a nebulosity of 4 octas (— — — — —) and of the observed diurnal amplitudes (———) on the station Debrecen, 1970—74

5. ábra. A 4 okta felhőzetre számított napi ingás (— — — — —) és a tapasztalt napi ingás (———) havi átlagainak évi menete Debrecen állomásról, 1970—74 observed amplitudes. This is indicating again that the discrepancies found between the summer and winter values of the diurnal amplitudes are partly to be attributed to a variation in nebulosity. Let us compare the observed annual average values of diurnal amplitudes to those computed on the basis of a nebulosity of 4 octas.

	Real average	Computed under the assumption of a nebulosity of 4 octas
Budapest-Lőrinc	8,57°	9,23°
Szeged	10,26°	11,01°
Debrecen	9,74°	11,10°
Szombathely	9,72°	11,04°

From the table above it appears that when assuming a uniform nebulosity of 4 octas, then the annual average, as compared to the real one, is at Szombathely and at Debrecen increased, at Szeged it is decreased, and among the average values for the three stations, there is not even a discrepancy of 0,1 degree. In the case of Budapest-Lőrinc, not only the real, but also the computed average values are different ones, a fact which should be attributed to local environmental inffuences.

Further it can be stated, that, while the monthly average values of the observed amplitudes are highest in the summer months and in September, the diurnal amplitudes computed on the assumption of a nebulosity of 4 octas is reaching on all of the four stations its highest value in May.

By using the regressional equation, we computed for every month those amplitude values, which are to be expected on entirely clear days (nebulosity 0 octas). From the monthly values obtained in this way, an annual average is derived with the following results: Budapest-Lőrinc, 12,94°; Szeged, 15,57°; Szombathely, 16,03° and Debrecen, 15,52°. The average values for Szeged and Debrecen are almost the same ones, however, that for Szombathely is by a half degree higher. (Among the four stations, Szombathely is characterized by the highest value of the regressional coefficient between nebulosity and diurnal amplitude.)

The annual maximum of the amplitude computed under the assumption of a nebulosity of 0 octas is in May, similarly as in the case of amplitudes computed under the assumption of a nebulosity of 4 octas. In an earlier paper [3] we investigated the highest amplitudes that occurred in the middle months of the four seasons, that is, in January, April, July and October, by using 60-year data series from the meteorological stations Szeged and Kecskemét. The average of these "monthly maximal amplitudes" is, among the four months, the highest at Szeged in April, while at Kecskemét in October, and on neither of these stations in July. The results mentioned above are rendering it desirable to carry out a study of the maximum amplitudes which should extend to every month. However, from the fact, that the diurnal variation computed under the assumption of a nebulosity of 0 octas has a higher value in May than in April, it is still not following that the maximum monthly amplitude should be also necessarily higher in May than in April. The residual scatter is higher in April than in May, and the April value of the diurnal amplitude computed under the assumption of a nebulosity of 0 octas, when increased by the residual scatter, is, according to the data of Szeged and Szombathely already higher than the corresponding value in May.

In addition to the values on entirely clear days and on days possessing a nebulosity of 4 octas, we determined, using again the regressional equation, also the daily values of the diurnal amplitude to be expected on overcast days (nebulosity 8 octas).

The annual average of these values is, for Budapest-Lőrinc, 5,42°; for Szeged, 6,45°; for Szombathely, 6,06° and for Debrecen, 6,06°. The ratio of the annual averages of this quantity on the two stations has indeed an inverse character to those computed under the assumption of a nebulosity of 0 octas, a circumstance which is connected to the fact that, among the three stations, Szombathely is possessing the highest value of the regressional coefficient, while Dbrecen is possessing the lowest one.

In contrary to the amplitudes computed for the two former values of nebulosity (0 and 4 octas), in the case of amplitudes computed under the assumption of overcast days, the maximum values are occurring on three stations not in May, but in April.

For a further characterization of the relation existing between nebulosity and diurnal amplitude, we are introducting another parameter which is derived in an analogous way to Pearson's variation coefficient. This parameter is expressing the

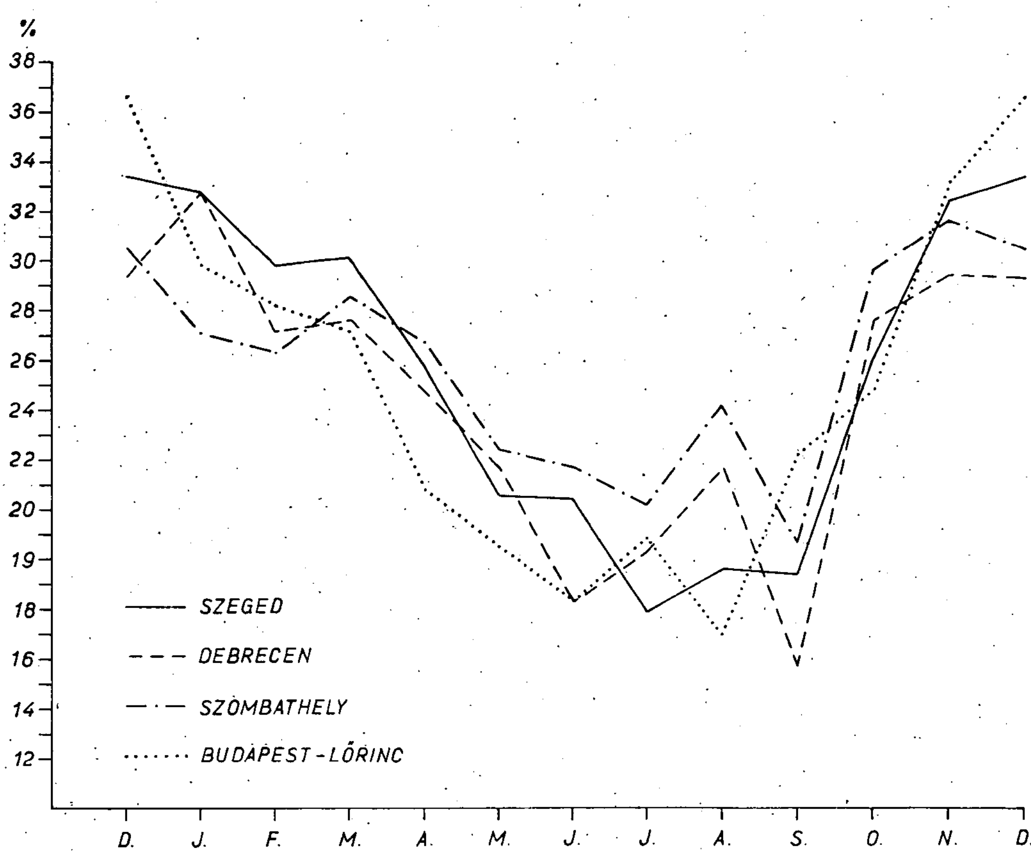

Fig. 6. Values of the residual scatter around the regression line between nebulosity and diurnal amplitude expressed in percents of the amplitude computed for days with 4 octas of nebulosity on the stations Budapest-Lőrinc, Szeged, Szombathely and Debrecen, 1970—74

6. ábra. A borultság és a napi ingás kapcsolatának regressziós egyenesétől számított reziduális szórás a 4 okta borultságú napokra számított napi ingás értékeinek százalékaiban, Budapest-Lőrinc, Szeged, Szombathely és Debrecen állomásokról, 1970—74 residual scatter in per cents of the amplitude computed under the assumption of a nebulosity of 4 octas. The monthly values of this parameter for the four stations are shown on *Fig. 6*. It is seen in this figure that the values of this parameter, called the "variation coefficient of residual scatter", are slowly decreasing from the winter months toward July, August and September, while they are, from September on, rapidly increasing. The curve is not a symmetrical one. Its amplitude is reaching on no station 20 per cents, and a Szombathely, it is not even reaching the value of 12 per cents. It is rather surprising, that the annual averages of these "coefficients" are only very slightly differing one from the other. The annual average is for Budapest—Lőrinc 24,7 per cent; for Szeged 25,5 per cent; for Szombathely, 25,6 per cent and for Debrecen 24,6 per cent. In spite of nearly identical annual averages, there are, among the various monthly values, some more important differences.

Summary

In this investigation, we used 5-year data series from four representative meteorological stations situated respectively in the northern, southern, western and eastern parts of this country.

We found that there exists a close correlation between the monthly average values of the diurnal temperature amplitude on the one hand and nebulosity on the other hand. The values of the correlation coefficient, the regressional coefficient, and the residual scatter are on all of the four observing stations nearly identical ones. The values of the correlation coefficient are fluctuating in the range of

$$0,8 \text{ to } 0,9$$

or, respectively, in the range of

$$-0,8 \text{ to } -0,9$$

and the magnitude of the residual scatters is fluctuating around 1°. The relation of three variables is yielding a common correlation coefficient of about 0,95 and it is characterized by a residual scatter of 0,5° to 0,8°.

On the basis of daily values, we investigated only the relation existing between the diurnal amplitude and the nebulosity. This correlation is not so close as the relation found among the monthly average values, and, among the correlation coefficients computed for various months, thre are experienced differences of about 0,3. The values of residual scatter are higher than 2°.

While the monthly averages of the really observed diurnal amplitude have their maximum in the summer months and in September, the values computed under the assumption of a uniform nebulosity of 4 octas or 0 octas have their highest values, on all four of the observing stations, in May.

Expressing in per cents the values of the scatter in the case of a nebulosity of 4 octas, a definite annual variation is found, with a minimum at the end of the summer, in September. Among the annual average values of the "variation coefficient" of the residual scatter as computed for the four observing stations, no difference exceeding 1 per cent could be found. This circumstance is again indicating that the relation existing between diurnal temperature amplitude and nebulosity has a similar structure in the different areas of this country.

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