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A STUDY OF VARIATIONS OF DIURNAL SUMS OF PRECIPITATION BY MEANS OF REGRESSION ANALYSIS

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SUMMARY

The contribution is an attempt at a theoretical and practical elaboration of the application of the method of regression analysis for studying the variations of diurnal precipitation sums. The method is verified in variations of diurnal sums of precipitation of the summer season at 50 stations on the territory of the CSSR in the years 1901—1975.

The acceleration or retardation in the onset of certain meteorological situations is reflected in shifts of local extremes of precipitation variations in different periods. The application of the above method allows to determine the mean length of time intervals (in days) by which the precipitation maxima and minima are shifted in the individual periods. In the values of shifts, at which maximum agreement is reached, considerable differences both in sign and in size appear, according to months as well as regions.

The method also enables to express the common features in the distribution of diurnal precipitation at different stations in the same period. Groups of stations have been delimited with maximum similarity which remain more or less the same in the individual months as wel as during the summer as a whole. A great relativity in the variations of diurnal precipitation at Slovak and partly at Moravian stations is a testimony to the fact that the region of Moravia and Slovakia is under the effect of analogical synoptical influences during the summer.

The process used shows that even between considerably distant stations on the territory of the CSSR there are many common features in the distribution of diurnal precipitation.

INTRODUCTION

Atmospheric precipitation belongs to the most variable meteorological elements This fact is reflected in analyzing its variation both according to monthly and, above all, according to diurnal sums. The amount of precipitation is influenced by a number of factors of different character which can be included into two basic groups, viz. the geographical factors and the circulatory ones. Due to the instability of the two groups of factors the variation of precipitation at different stations for the same period or at the same station in different periods (particularly in analyzing the variation according to diurnal sums of precipitation) can be greatly different. This is turn causes much trouble in comparing different variations, particularly if similar features are determined visually from graphs representing the variation (e.g. Nosek 1957, Brázdil 1977).

The present paper is an attempt at the application of the methods of regression analysis for comparing different variations of diurnal sums of precipitation.

WORKING OUT A STATISTICAL MODEL FOR THE EVALUATION OF THE VARIATION OF DIURNAL SUMS OF PRECIPITATION

At the same time two sets of problems of evaluating related features in the variations of diurnal sums of precipitation are solved:

a) at the same station in different periods (temporal changes of variations),

b) at two stations in the same period (spatial changes of precipitation).

It can be assumed that a certain relation will exist between the mean diurnal sums of precipitation at the same station in two different periods of the same lenght (e.g. between 1901—1925 and 1926—1950). Even more justified is the assumption of the dependence of variations of diurnal sums at two different stations over the same period.

Let us mark the mean diurnal sum of variations of the i-th station ($i = 1, 2$) over some period on the t-th day as $f(t)$, $t = 1, 2, \ldots, n$, where in variant a) one and the same station in the first period will be denoted by number 1, in the second by number 2. Due to our assumptions there exists a function G such that:

$$f_2(t) = G[f_1(t), p_1(t), \ldots, p_m(t)], \tag{1}$$

in which $p_1(t), \ldots, p_m(t)$ are the possible parameters. Function G represents a mathematically formulated climatological experience of relation of variations of the daily sums of precipitation or the assumed relation of variations to be tested by statistical methods based on data measured.

The obtained amount of precipitation $y_i(t)$ at the i-th station on day t is:

$$y_i(t) = f_i(t) + u_i(t), \qquad i = 1, 2, \tag{2}$$

where $u_i(t)$ are deviations from values of $f_i(t)$.

We have obtained a system of three equations [(1) and (2)]. As far as it is possible to eliminate from it $f_1(t)$ and $f_2(t)$, we get generally an equation of the form

$$F(y_1, y_2, p_1, \ldots, p_m, u_1, u_2) = 0. \tag{3}$$

The elimination of $f_1(t)$ and $f_2(t)$ can be performed for a relatively broad class of functions G. Equation (3) represents generally a regression dependence about which statistical conclusions can be made.

As an example let us choose $m = 3$, $p_1(t) = v$, $p_2(t) = k$, $p_3(t) = h$,

$$G(f_1(t), v, k, h) = k \cdot f_1(t + v) + h. \tag{4}$$

Evidently the simplest form of dependence between functions $f_2(t)$ and $f_1(t)$ is a linear function $G(f_1(t), k, h) = k \cdot f_1(t) + h$. Parametr v in relation (4) has been introduced to enable judging, say, time shifts corresponding to local extremes (i.e. maxima and minima in the variation of diurnal sums of precipitation). It is possible to introduce parameter v under the assumption that the distances of local extremes in the two temporal series are the same or almost the same. If not so, it is necessary to take parameter v into consideration as a function variable in time (see below the numerical proceesion of the measured values of the station Jizerka, assuming (4)).

From equations (1), (2) and (4), after eliminating $f_1(t)$ and $f_2(t)$, we get

$$y_2(t) = k \,.\, y_1(t + v) + h + u_2(t) - k \,.\, u_1(t + v). \tag{5}$$

Assuming $u_i(t)$ being randomly variables with the zero mean value and limited scattering, for different v it suffices to test the hypothesis of the valuability of relation:

$$y_2(t) = k \,.\, y_1(t + v) + h. \tag{6}$$

For a fixedly chosen v it is a linear relation and for the linearity test we use correlation coefficient r, obtained from the relation:

$$r = [n \sum_{t=1}^{n} y_1^2(t)\, y_2(t + v) - \sum_{t=1}^{n} y_1(t) \sum_{t=1}^{n} y_2(t + v)] \,.\, [n \sum_{t=1}^{n} y_1^2(t) - (\sum_{t=1}^{n} y_1(t))^2]^{-\frac{1}{2}} \,.$$

$$.\, [n \sum_{t=1}^{n} y_2^2(t + v) - (\sum_{t=1}^{n} y_2(t + v))^2]^{-\frac{1}{2}} \tag{7}$$

If correlation coefficient r for $v = a, a + 1, a + 2, \ldots, b$, where a, b are integers ($a \leqq b$), it is not enough to know the values $y_2(t)$ for $t = 1, 2, \ldots, n$, but we need to know $y_2(t)$ for $t = a + 1, a + 2, \ldots, n + b - 1, n + b$. Generally, for $a < 0$ values in the days that preceded, and for $b > 0$ in the days that followed the time interval under investigation. If those values are not known in "extra" days, relation (7) must be suitably modified.

The material on which the above methodological approach was verified, were 5 day gliding sums of precipitation (calculated as a sum of mean diurnal sums of pre-

Tab. 1. Correlation coefficients (with shift v) between the variations of diurnal sums of precipitation in the periods 1901—1925 and 1951—1975 at the station Jizerka in the summer months

v	June	July	August	summer
—10	—0.51	0.19	0.27	—0.04
—9	—0.40	—0.09	0.28	—0.07
—8	—0.28	—0.37	0.40	—0.06
—7	—0.16	—0.42	0.34	—0.07
—6	0.04	—0.34	0.27	—0.03
—5	0.24	—0.29	0.19	0.01
—4	0.47	—0.13	0.07	0.06
—3	0.70	0.03	—0.04	0.14
—2	0.84	—0.06	—0.19	0.15
—1	0.81	—0.17	—0.24	0.13
0	0.75	—0.23	—0.30	0.08
1	0.66	—0.22	—0.21	0.06
2	0.48	—0.18	—0.07	0.02
3	0.23	0.02	0.13	0.02
4	0.07	0.24	0.24	0.04
5	0.00	0.39	0.28	0.06
6	—0.04	0.54	0.21	0.06
7	0.00	0.65	0.08	0.06
8	0.09	0.62	—0.11	0.02
9	0.21	0.63	—0.29	0.01
10	0.33	0.57	—0.40	0.00

cipitation in five successive days, when the calculated value was always attached to the middle day) of summer months of selected stations on the territory of the CSSR. Using the Wang computer the correlation coefficients was calculated according to relation (7) with shifts $v = -10, -9, \ldots, 9, 10$ (i.e. $a = -10$, $b = 10$) for variations of diurnal precipitation in the period of 1901—1925, 1926—1950 and 1951—1975 (variant a) and with shifts $v = -3, -2, \ldots, 2, 3$ (i.e. $a = -3$, $b = 3$) for variations in diurnal precipitation for a pair of stations in the period of 1951—1975 (variant *b*), always for the individual summer months and the summer as a whole.

Thus in station Jizerka, when comparing the variations of diurnal sums of precipitation in 1901—1925 (series $\{f_1(t)\}_{t=1}^n$) and in 1951—1975 (series $\{f_1(t)\}_{t=1}^n$) the highes coefficients were those for June, 0.84 (with $v = -2$), for July, 0.65 ($v = 7$), and for August, 0.40 ($v = -8$), and for the whole summer only 0.15 ($v = -2$) — Tab. 1. The positive value corresponds to the shift of series $\{f_2(t)\}_{t=1}^n$ by v days to the left i.e. the onset of local extremes of this series sets in with a v day delay behind the onset of extremes of series $\{f_1(t)\}_{t=1}^n$.

From the results of the example it can further be judged that assumption (4) with a constant parameter v may have been justified for the individual months (i.e. shorter periods of time), but definitely was not justified for the whole summer season, either because another dependence between $f_1(t)$ and $f_2(t)$ must be assumed (such as (4) with a variable v) or because a dependence of type (1) does not exist.

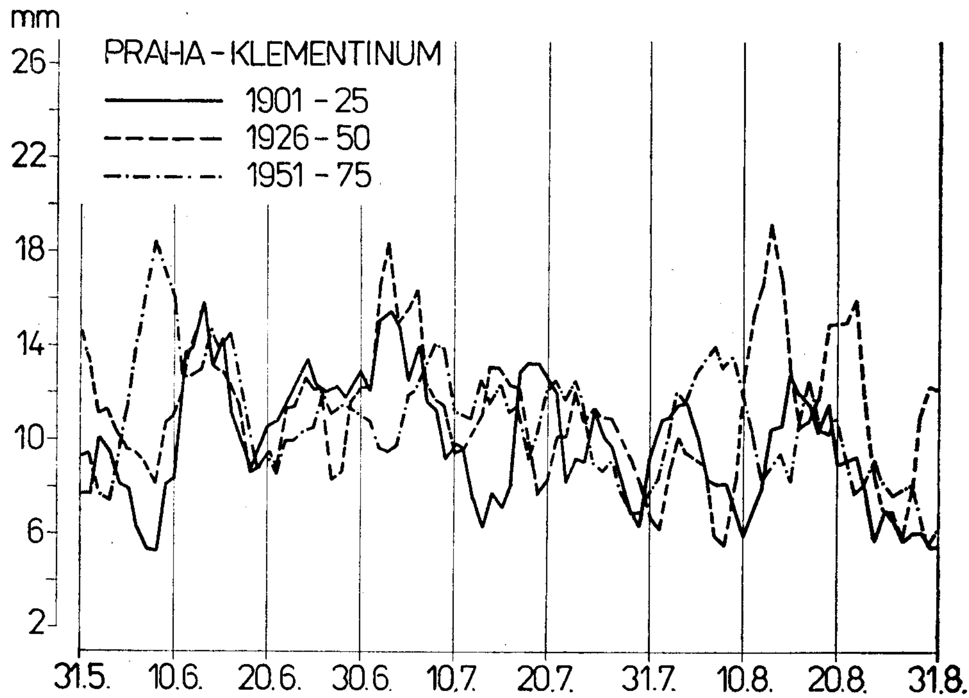


Fig. 1. **The variation of diurnal sums of precipitation in summer months at the station Prague-Klementinum in the periods 1901—1925, 1926—1950, and 1951—1975. Levelled by five-day gliding sums**

TEMPORAL CHANGES IN THE VARIATION OF DIURNAL SUMS OF PRECIPITATION OF THE SUMMER ON THE TERRITORY OF THE CSSR IN THE PERIOD OF 1901—1975

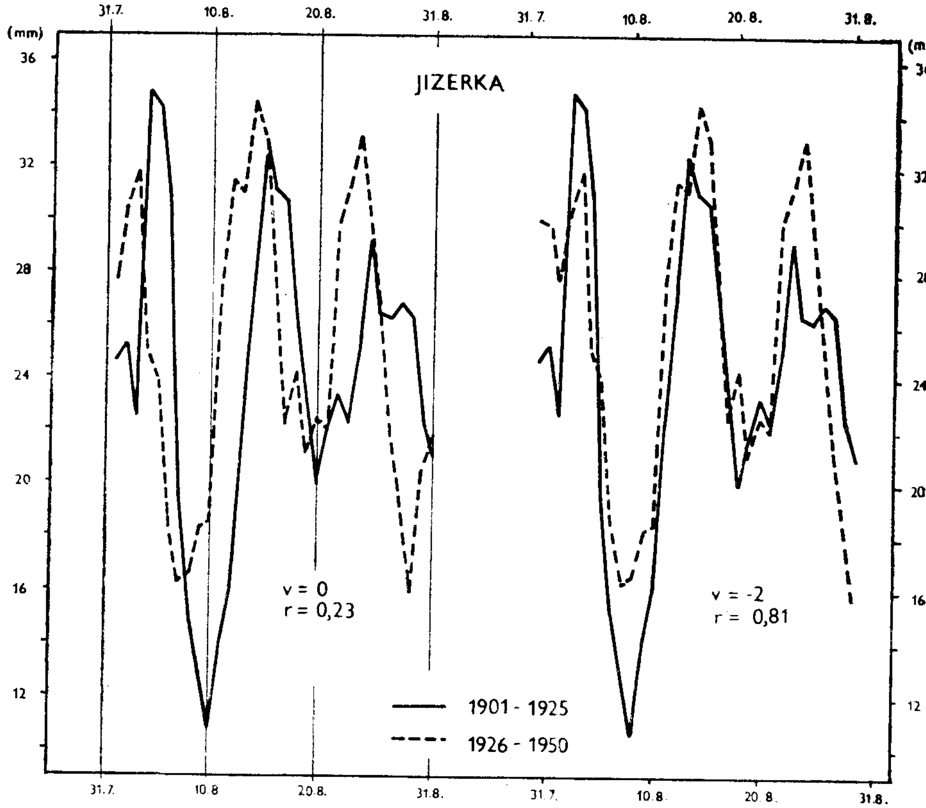
In the variation of the diurnal sums of precipitation in periods of the same length, but selected at different times, it is possible to find, besides common features, also a number of antagonistic ones. Evidence of it its Fig. 1, representing the variation of the diurnal sums of precipitation of the summer season at the station Prague—Klementinum in the periods of 1901—1925, 1926—1950, 1951—1975. In all three periods a conspicuous peak appears in the first half of June, but in the period of 1951—1975 as early as about 8 June, whereas in the two preceding periods as late as about 13 June, so that the above peak in the variation of diurnal sums corresponds to conspicuous minima of diurnal precipitation. The result of the visual comparison should, therefore, be a statement of the antagonistic character of the variation of diurnal precipitation of June in the period of 1951—1975 as against the periods of 1901—1925 and 1926—1950. An unanswered question remains whether in this case it is the actual difference in variation of precipitation due to a change in some basic factors or a results of the variation of occurrence of synoptical situations. Although circulation relations in the given region can differ conspicuously from year to year, it is possible to find time spaces in different periods in which the frequencies of certain weather situations increase more conspicuously, bringing higher precipitation or those which are poor in precipitation. Starting from the assumption of a relative stability of those situation for a certain period (e.g. that of twenty-five years) it may be assumed that they vary within a range about some date (Flohn, Hess 1949, admit a deviation of 5—6 days to both sides), which in turn can be in connection with shifts of conspicuous precipitation peaks or minima in corresponding time spaces from one period to the other. It is the calculation of the correlation coefficient according to relation (7) that renders the possibility of objectively expressing the rate of relativity of variations of diurnal precipitation in the individual periods and shifts in precipitation maxima and minima.

The results of the procession for 10 selected stations on the territory of the CSSR are documented in Tab. 2. Fig. 2 gives a realistic picture concerning the comparison of the variations of diurnal precipitation and changes in the correlation coefficient r when changing the shift from $v = 0$ to $v = \mathrm{k}$ (maximum positive correlation coefficient). Because of a small number of stations it is difficult to draw conclusions concerning the changes in the variation of precipitation from period to period within the limits of our Republic. At $v = 0$ the correlation coefficients in a number of cases are statistically insignificant (Tab. 3), particularly when the variation of diurnal precipitation during summer is compared as a whole, in some cases it approaches zero (there is no correlation dependence), and there are even negative cases (an antagonistic variation of diurnal precipitation). On the other hand, correlation coefficients calculated with a shift of $v = \mathrm{k}$ give substantially higher values which, in most cases, are statistically significant, but they often do not exceed the value of 0.50 which, according to Janko (1944), corresponds to a mild to low degree of relation closeness (Tab. 4).

On the whole, it is possible to state that in many ways the difference of Czech and Slovak stations is reflected as well as the fact that, according to the distribution of diurnal precipitation in the summer months, Moravian stations tend more towards the Slovak than to the Czech stations. There is also a remarkable agreement of va-

Tab. 2. Correlation coefficients at shift $v = 0$ (first line) and maximum correlation coefficients with a corresponding shift v (second line) for diurnal sums of precipitation of the summer and summer months at selected stations in the CSSR in the periods 1901—1925 and 1926—1950 (1 : 2), 1901—1925 and 1951—1975 (1 : 3), 1926—1950 and 1951—1975 (2 : 3)

	June		July		August		summer	
	v	*r*	v	*r*	*v*	*r*	*v*	*r*
	Prague — Klementinum							
1 : 2	0	0.62	0	0.51	0	0.23	0	0.39
	0	0.62	—2	0.52	—2	0.40	0	0.39
1 : 3	0	—0.26	0	0.03	0	0.34	0	0.10
	—5	0.60	3	0.49	2	0.62	—5	0.30
2 : 3	0	—0.01	0	0.20	0	—0.24	0	—0.05
	—4	0.42	6	0.29	—5	0.49	—6	0.32
	Jizerka							
1 : 2	0	0.63	0	0.50	0	0.23	0	0.41
	1	0.79	2	0.55	—2	0.81	—1	0.48
1 : 3	0	0.75	0	—0.23	0	—0.30	0	0.08
	—2	0.84	7	0.65	—8	0.39	—2	0.15
2 : 3	0	0.34	0	—0.48	0	0.08	0	0.05
	—4	0.81	6	0.34	7	0.39	—3	0.32
	České Budějovice							
1 : 2	0	0.47	0	0.51	0	0.01	0	0.49
	—2	0.56	9	0.83	—3	0.24	—1	0.52
1 : 3	0	—0.20	0	0.44	—0	—0.08	0	0.09
	—10	0.37	6	0.58	—3	0.50	—3	0.27
2 : 3	0	0.05	0	0.17	0	0.34	0	0.28
	—10	0.76	7	0.68	—1	0.42	—3	0.37
	Rokytnice							
1 : 2	0	0.51	0	—0.26	0	0.07	0	0.20
	1	0.63	4	0.66	—4	0.76	0	0.20
1 : 3	0	0.80	0	0.05	0	—0.37	0	0.21
	0	0.80	7	0.75	—9	0.53	—9	0.44
2 : 3	0	0.44	0	0.14	0	—0.44	0	0.03
	0	0.44	4	0.55	—5	0.53	—4	0.34
	Brno-Pisárky							
1 : 2	0	0.12	0	0.33	0	—0.29	0	0.15
	—10	0.45	9	0.57	—5	0.68	9	0.22
1 : 3	0	—0.01	0	—0.05	0	—0.05	0	0.28
	—8	0.69	6	0.55	—1	0.09	—8	0.47
2 : 3	0	—0.42	0	0.07	0	0.06	0	0.02
	9	0.61	8	0.59	8	0.31	8	0.44



Tab. 3. Critical values of r_p for testing the significance of the correlation coefficient (ν — number of degrees of looseness the level of significance 5 %)

	June	July	August	summer
ν	28	29	· 29	90
r_p	0.362	0.356	0.356	0.206

Tab. 4. Classification of the closeness of the relation between the variables, based on the value of the correlation coefficient according to Janko (1944)

Value of r	Characteristics of relation
< 0.30	low degree of closeness
0.30—0.50	mild degree of closeness
0.50—0.70	conspicuous closeness
0.70—0.90	high degree of closeness
> 0.90	very high degree of closeness

Following part Tab. 2

	June		July		August		summer	
	v	r	v	r	v	r	v	r
	Ostrava							
1 : 2	0 —1	0.50 0.55	0 9	—0.39 0.49	0 —5	—0.13 0.59	0 —5	—0.03 0.39
1 : 3	0 4	—0.04 0.51	0 10	—0.29 0.54	0 5	0.15 0.56	0 4	0.09 0.42
2 : 3	0 —8	—0.08 0.71	0 —1	0.09 0.35	0 9	—0.55 0.74	0 9	—0.08 0.17
	Hurbanovo							
1 : 2	0 2	0.22 0.34	0 8	0.02 0.56	0 —5	—0.32 0.01	0 9	0.07 0.31
1 : 3	0 —5	—0.24 0.51	0 8	0.17 0.35	0 8	—0.37 0.53	0 8	0.10 0.44
2 : 3	0 8	—0.69 0.60	0 9	0.28 0.60	0 4	—0.12 0.27	0 8	—0.18 0.36
	Nitrianské Pravno							
1 : 2	0 8	0.09 0.37	0 0	0.64 0.64	0 9	—0.03 0.53	0 9	0.38 0.47
1 : 3	0 0	0.34 0.34	0 —8	—0.49 0.34	0 —8	—0.30 0.56	0 —8	0.06 0.24
2 : 3	0 8	—0.44 0.43	0 8	—0.13 0.38	0 4	0.28 0.49	0 7	0.10 0.46
	Štrbské Pleso							
1 : 2	0 —10	—0.25 0.68	0 2	0.28 0.53	0 10	0.03 0.52	0 10	0.14 0.24
1 : 3	0 —10	—0.38 0.54	0 —10	—0.57 0.76	0 —9	0.46 0.56	0 —10	0.04 0.58
2 : 3	0 —5	—0.42 0.42	0 6	—0.09 0.76	0 5	0.12 0.73	0 6	0.08 0.55
	Košice							
1 : 2	0 0	0.63 0.63	0 —2	0.42 0.60	0 8	—0.52 0.29	0 10	0.03 0.10
1 : 3	0 5	—0.60 0.67	0 9	—0.03 0.68	0 —10	—0.34 0.48	0 10	0.04 0.50
2 : 3	0 5	—0.49 0.56	0 10	—0.18 0.66	0 3	0.39 0.78	0 5	—0.12 0.37

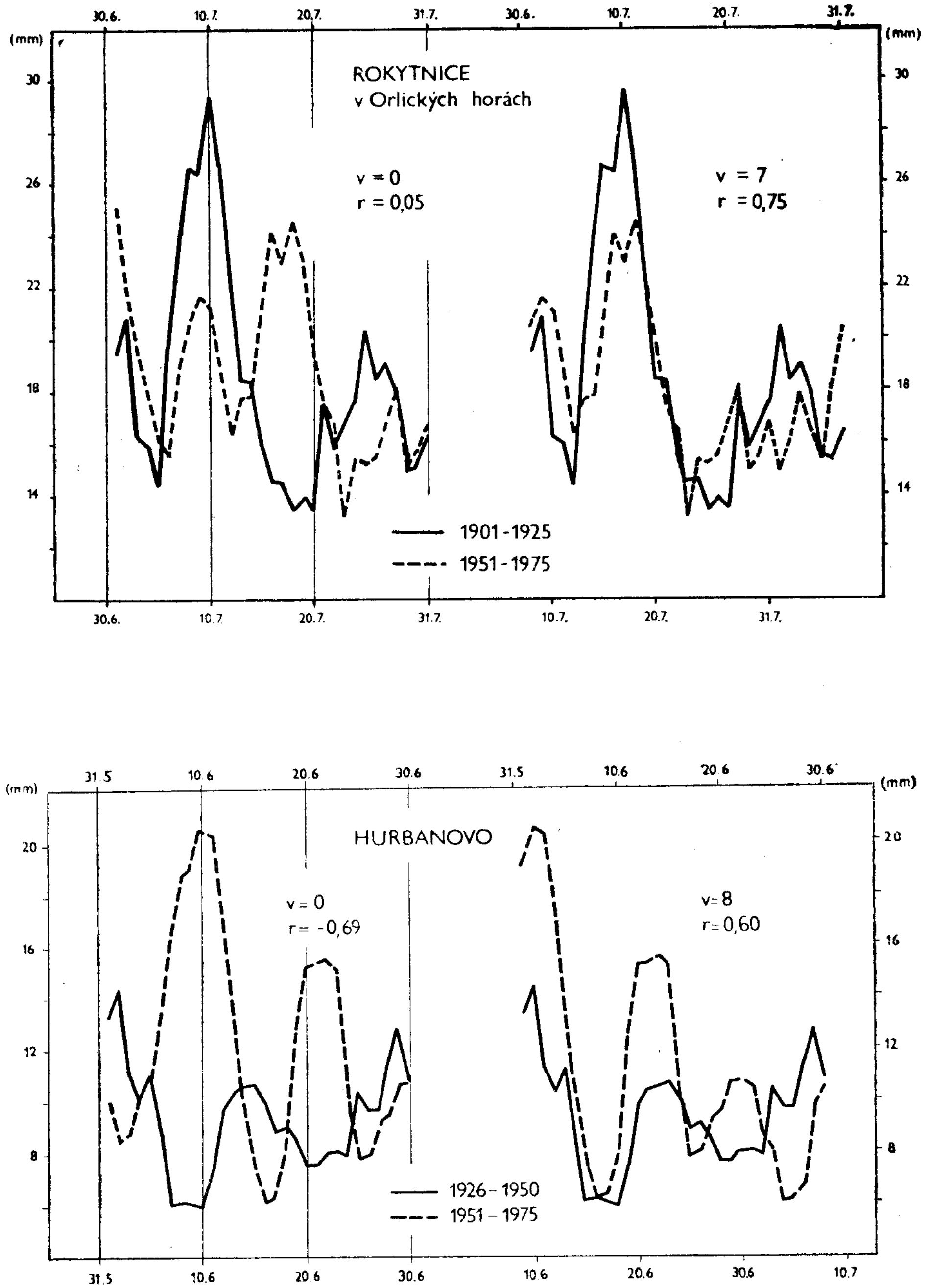


Fig. 2. Comparison of variation of diurnal sums of precipitation at zero shift ($v = 0$) and at a shift corresponding to maximum similarity at selected stations in different periods

riations of diurnal precipitation in June in different periods at stations situated high in the north (Jizerka) and in the east (Rokytnice in the Orlické hory Mts). of Bohemia, reflecting high values of r both at a zero and at a certain shift. This is testimony to a great stability of synoptical influences conditioning the variation of the precipitation in the course of the month in this region. On the other hand, in Slovakia, in regions where the June peak in the annual variation of precipitation alternates with the May one, it is possible to find in this month an explicitly antagonistic variation (Hurbanovo).

THE CORRELATION COEFFICIENT AS THE MEASURE OF SIMILARITY OF VARIATIONS OF DIURNAL SUMS OF PRECIPITATION

In spite of a great fluctuation of variations of diurnal precipitation at different stations it is possible to find among them also a number of similar characters. The measure of this similarity can objectively be characterized by means of the correlation coefficient (when $v = 0$). That coefficient was in turn calculated for variations of diurnal precipitation sums at 50 selected stations on the territory of the CSSR (Tab. 5) for the summer as a whole as well as for the individual summer months in the period of 1951—1975. A summary outline of the results obtained is given in Tab. 6.

From the table it follows that in the summer months of the period of 1951—1975 the positive correlation dependence is typical of the great majority of correlated stations, only 8 pairs tend to the antagonistic variation of precipitation. Almost two-thirds of the correlated pairs are characterized by a mild to low degree of relation closeness, in 101 cases the correlation coefficient r is statistically insignificant. Only 6.8 % of all pairs get above the value of 0.70 (a high degree of closeness). The highest degree of similarity is that exhibited by the variation of diurnal precipitation at stations Štrbské Pleso and Spišská Nová Ves, where $r = 0.89$. Slovak stations achieving a substantially higher degree of similarity (more exactly linear dependence) in the variation of diurnal precipitation than stations in Bohemia. Thus the correlation coefficient between Slovak stations exceeds the value of 0.70 in 23.5 % cases, 83.8 % of all correlated pairs exhibit a correlation coefficient higher than 0.50. This means that Slovak stations, in spite of more complicated orographic conditions in which they are situated, are much more homogeneous than those in the CSR by the variation of the diurnal precipitation of the summer.

This was also reflected in delimiting the stations with the highest degree of climatological similarity as far as the variations of diurnal precipitation sums are concerned. As a limiting value the value of $r = 0.70$ was chosen. One group then included such stations where the similarity of the variation of precipitation at one of them with respect to the variation of diurnal precipitation at all others was given by the value of the correlation coefficient $r \geqq 0.70$. Only exceptionally also stations were included in the group which exhibited $r < 0.70$ with some station of the other group. It can be understood that r reaches the highest values as a rule in the "nucleus" of such a group of stations, the value of r usually diminishing with the distance of the stations.

The limited groups of stations for the summer as a whole with corresponding correlation coefficients are included in Tab. 7. They are a group of north-Bohemian stations with the "nucleus" in the Jizerské hory Mts., further also stations from the

Tab. 5. List of stations used

Name of station	Abbreviation	H(m)	φ	λ
Brno-Pisárky	Bo	204	49°12'	16°34'
Broumov	Br	410	50°35'	16°20'
Čáslav	Ča	249	49°54'	15°24'
České Budějovice	ČB	383	48°59'	14°28'
Dačice	Da	495	49°05'	15°26'
Doksy	Do	282	50°34'	14°39'
Havlíčkův Brod	HB	455	49°37'	15°35'
Hodonín	Ho	169	48°51'	17°08'
Horní Lipová, Ramzová	Ra	740	50°12'	17°04'
Hoštejn	Hš	311	49°53'	16°46'
Cheb	Ch	455	50°05'	12°22'
Jablonec	Ja	512	50°44'	15°09'
Jizerka	Ji	870	50°50'	15°20'
Lysá hora	Ly	1317	49°33'	18°27'
Miroslav	Mi	270	48°57'	16°19'
Napajedla	Na	203	49°10'	17°31'
Nové Město na Moravě	NM	614	49°34'	16°05'
Nové Město pod Smrkem	NS	510	50°56'	15°15'
Opava	Ov	261	49°56'	17°54'
Orlík	Or	396	49°31'	14°10'
Ostrava-Vítkovice	Os	212	49°51'	18°18'
Plzeň	Pl	354	49°46'	13°21'
Prague - Klementinum	Pr	197	50°05'	14°25'
Přerov	Př	213	49°28'	17°28'
Rokytnice v Orlických h.	Ro	580	50°10'	16°28'
Srní	Sr	930	49°04'	13°30'
Stránské	St	670	49°54'	17°19'
Tábor	Ta	441	49°25'	14°40'
Teplice	Te	228	50°39'	13°51'
Vejprty	Ve	780	50°29'	13°02'
Vysoká nad Labem	Vy	275	50°09'	15°51'
Žatec	Ža	207	50°20'	13°33'
Žlunice	Žl	270	50°18'	15°23'
Banská Bystrica	BB	343	48°44'	19°09'
Bratislava	Ba	206	48°10	17°07'
Horné Srnie	HS	250	49°00'	18°06'
Hurbanovo	Hu	115	47°52'	18°12'
Košice	Ko	216	48°44'	21°15'
Liptovský Hrádok	LH	648	49°02'	19°44'
Medzilaborce	Me	322	49°16'	21°54'
Nitrianské Pravno	NP	384	48°53'	18°39'
Nová Baňa	NB	221	48°26'	18°38'
Oravský Podzámok	OP	493	49°15'	19°20'
Rimavská Sobota	RS	208	48°24'	20°01'
Smolenice	Sm	241	48°30'	17°26'
Spišská Nová Ves	SV	466	48°57'	20°34'
Štrbské Pleso	ŠP	1330	49°07'	20°04'
Tisovec	Ti	411	48°42'	19°57'
Trebišov	Tr	107	48°39'	21°43'
Varín	Va	362	49°12'	18°52'

Tab. 6. **Numbers of correlation coefficients according to size groups and numbers of negative correlation coefficients (—) of relation of variations of diurnal precipitation sums among 50 stations on the territory of the CSSR in the period of 1951—1975**

r	June (%)	July (%)	August (%)	summer (%)
≧ 0.9	0.6	0.4	0.2	—
0.8—0.89	3.9	4.9	2.7	1.1
0.7—0.79	7.9	9.5	6.5	5.7
0.6—0.69	10.4	8.9	11.1	13.6
0.5—0.59	13.1	15.3	14.4	18.9
0.4—0.49	10.7	12.2	16.4	21.7
0.3—0.39	10.7	12.9	15.8	19.1
0.0—0.3	25.8	25.1	26.0	19.3
(—)	16.9	10.8	6.9	0.6
$\sum$	100.0	100.0	100.0	100.0

Bohemian part of the Bohemian-Moravian Highland, and from an adjacent part of the Elbe River basin, the south-Bohemian, the Moravian-Slovak, and the east-Slovak groups. The "nuclei" of these groups remain more or less preserved also in the individual summer months.

The greatest variety in the variations of diurnal precipitation sums occurs in June, when 12.4 % of correlated pairs exhibit r higher than 0.70 (Liptovský Hrádok and Tisovec have $r = 0.93$), but 16.9 % of all pairs exhibit an antagonistic distribution of diurnal precipitation (Jizerka and Trebišov having $r = —0.61$). Most often negative correlation appears when comparing the variation of precipitation of the stations in the Elbe River basin and in the eastern part of Bohemia (Žlunice, Vysoká n. L., Rokytnice, Havlíčkův Brod) with stations in the north and east of Moravia and in Slovakia. Furthermore, in 46.7 % of all cases the correlation coefficients on the level of 5 % are statistically insignificant and often there is no correlation between pairs of stations.

In July, when compared with June, the number of pairs with $r \geqq 0.70$ increases to 14.8 % (Štrbské Pleso and Spišská Nová Ves having $r = 0.95$).There is a further levelling of Slovak stations (Tab. 8) which for July allows to limit there a more or less homogeneous region of maximum similarity, only 5 stations in the southern part of Slovakia remaining outside the group.

In August, when compared with the two preceding months, there is a lowering of the degree of the assumed climatological similarity, the groups of stations with maximum similarity shifting from the SSR into the CSR. These regional changes in the limitation of station groups with the highest climatological similarity of diurnal precipitation are in good accord with the conclusions about the influence of Atlantic and Mediterranean meteorological situations on precipitation conditions of the summer season on our territory (Brázdil 1980).

The present processing documents the suitability of using the correlation coefficient as a measure of similarity of variation of diurnal sums of precipitation and the characteristics mentioned appears to yield a good view for utilizing it for precipitation regionalization. The advantage of r as a measure of similarity consists among others in the fact that it suppresses differences due to orographic factors (chiefly due to elevation and expozition). In remains to be added, however, that in some cases high

Tab. 7. Groups of station with the highest climatological similarity of diurnal precipitation in summer in the period of 1951—1975 (similarity expressed by the correlation coefficient)

group 1

	NS	Ji	Ja	Br
NS	1.00	0.82	0.79	0.80
Ji		1.00	0.81	0.69
Ja			1.00	0.72
Br				1.00

group 2

	Žl	Ča	HB
Žl	1.00	0.72	0.73
Ča		1.00	0.80
HB			1.00

group 3

	Ta	ČB	Da	Sr
Ta	1.00	0.70	0.72	0.74
ČB		1.00	0.70	0.72
Da			1.00	0.61
Sr				1.00

group 4

	Os	Na	Sm	HS	Ti	OP	LH
Os	1.00	0.78	0.73	0.79	0.75	0.79	0.75
Na		1.00	0.76	0.75	0.79	0.71	0.72
Sm			1.00	0.72	0.76	0.75	0.74
HS				1.00	0.70	0.79	0.71
Ti					1,00	0.81	0.79
OP						1.00	0.84
LH							1.00

group 5

	OP	LH	ŠP	SV	Ko	Me
OP	1.00	0.84	0.78	0.79	0.73	0.66
LH		1.00	0.88	0.87	0.70	0.60
ŠP			1.00	0.89	0.81	0.75
SV				1.00	0.81	0.73
Ko					1.00	0.88
Me						1.00

Tab. 8. Groups of stations with the highest climatological similarity of diurnal precipitation in Slovakia in the period 1951—1975 (similarity expressed by the correlation coefficient)

June

	Os	Ly	Př	Na	HS	Sm	NP	Va	OP	LH	Ti
Os	1.00	0,85	0.88	0.83	0.87	0.75	0.78	0.84	0.79	0.77	0.74
Ly		1.00	0.82	0.83	0.91	0.77	0.77	0.80	0.91	0.86	0.83
Př			1.00	0.78	0.84	0.71	0.80	0.75	0.75	0.77	0.78
Na				1.00	0.86	0.78	0.70	0.68	0.81	0.79	0.78
HS					1.00	0.81	0.78	0.86	0.91	0.82	0.88
Sm						1.00	0.90	0.75	0.82	0.78	0.82
NP							1.00	0.77	0.83	0.82	0.85
Va								1.00	0.73	0.62	0.66
OP									1.00	0.91	0.92
LH										1.00	0.93
Ti											1.00

July

	Ba	Sm	NP	BB	Va	OP	LH	ŠP	SV	RS	Ko	Tr	Me
Ba	1.00	0.92	0.85	0.80	0.68	0.75	0.83	0.84	0.83	0.83	0.71	0.68	0.69
Sm		1.00	0.75	0.63	0.65	0.71	0.77	0.83	0.78	0.81	0.73	0.58	0.73
NP			1.00	0.85	0.75	0.77	0.88	0.79	0.80	0.81	0.71	0.78	0.67
BB				1.00	0.55	0.60	0.80	0.72	0.77	0.78	0.71	0.72	0.52
Va					1.00	0.79	0.64	0.74	0.72	0.71	0.89	0.75	0.86
OP						1.00	0.83	0.85	0.88	0.68	0.83	0.79	0.80
LH							1.00	0.87	0.93	0.83	0.76	0.87	0.70
ŠP								1.00	0.95	0.84	0.85	0.81	0.87
SV									1.00	0.82	0.84	0.89	0.82
RS										1.00	0.75	0.75	0.78
Ko											1.00	0.85	0.93
Tr												1.00	0.82
Me													1.00

correlation coefficients appreared even for stations considerably distant from each other, without any apparent connection in the analogical local or synoptical and climatological influencing of the falling precipitation.

Correlation coefficients, as calculated according to relation (7) at $v = 0$ for the variation of diurnal precipitation at 50 stations studied, need not always express the highest degree of similarity. It is evident that if it starts raining at Cheb when a frontal system proceeds from the west to the east, the same rain bound to this frontal system will appear in the east of the Republic with some time delay depending on a number of different factors. That is why the calculated correlation coefficient between, say, Cheb and Medzilaborce can be lower than the calculation of the correlation coefficient shifted by the time interval mentioned. Thus it would be possible to take into account different directions of progress of the frontal systems on the territory of the CSSR, finding in these directions the mean values of the time shift in which the maximum coincidence occurs, i.e. to follow the similarity in a case when the places followed are under the same synoptical influences. Thus in Slovak stations at western meteorological situations as compared with those in western or northwestern Bohemia the maximum similarity should occur at some positive shift, etc.

To judge these facts, correlation coefficients were calculated at $v = -6, -5, \ldots, 5, 6$, the variation of diurnal sums of precipitation being correlated in the period of 1951—1975 at all stations processed with the distribution of diurnal precipitation at Teplice, Hurbanovo, and Medzilaborce. The choice of these three stations followed from the paper by Brázdil (1980), since Teplice and Hurbanovo are stations reflecting most conspicuously the influence of Atlantic and Mediterranean situations, respectively. Medzilaborce represents a station with the most intense Atlantic influences in Slovakia.

The region of the greatest precipitation similarity can be expected to be bound to a relatively near neighbourhood of the station. Since the measure of similarity is the highest value of r which can be reached when $v \neq 0$, it is not always the case. Thus in August, when $v = 0$, r is only 0.49 between the variations of diurnal precipitation at Teplice and at Medzilaborce, but when $v = 3$ it is as high as 0.82; in the same month between Teplice and Košice $r = 0.62$ when $v = 0$, but 0.83 when $v = 1$ and 0.81 when $v = 2$. In July the dependence of the variations of diurnal precipitation at Teplice and at Napajedla is given by the value of $r = 0.39$ when $v = 0$, but with a positive shift by 2 days it is 0.81. Between Hurbanovo and České Budějovice in July at zero shift $r = 0.58$, at $v = -2$ even 0.87 and at $v = -3$ is $r = 0.86$. The fact that between much distant stations on the territory of the ČSSR there are very similar features in the distribution of diurnal precipitation with some time interval can be of considerable practical and prognostic importance, particularly in the study of precipitation at individual meteorological situations.

The results of the processing were pictured in maps in which isolines express the maximum value of climatological similarity given by the value r, as well as the corresponding shift. Only two of the maps are included present paper — one concerning the similarity of precipitation with Teplice in August (Fig. 3), the other the similarity of precipitation with Medzilaborce in July (Fig. 4). In these months the importance of Atlantic situations for the distribution of diurnal precipitation increases which is reflected by the retardation of precipitation minima and maxima with respect to Teplice in the whole territory of the CSSR with the exception of western Bohemia (in a number of stations the best agreement is reached at the shift of 5—6 days) and, on the other hand, by the acceleration with respect to Medzilaborce with the exception if the region of north-eastern Moravia and northern Slovakia. Thus in June in the distribution of diurnal precipitation at Teplice a retardation is reflected with respect to most Moravian and Slovak stations which is in connection with the decisive influence of Mediterranean situations for the distribution of diurnal precipitation in this month.

CONCLUSION

This contribution is an attempt at a theoretical and practical elaboration of the application of the method of regression analysis to the study of variations of diurnal precipitation. The method is verified at the variations of diurnal sums of precipitation of the summer season on the territory of the CSSR in the years 1901—1975. The applied method allows the formulation of the following conclusions drawn from the analysis performed:

1. The variation of the onset of certain groups of precipitation significant or insignificant meteorological situations arround a certain mean date and an irregular occurence of local shower and storm downpours considerably complicates the distribution of diurnal precipitation sums in differently chosen periods of equal lengths

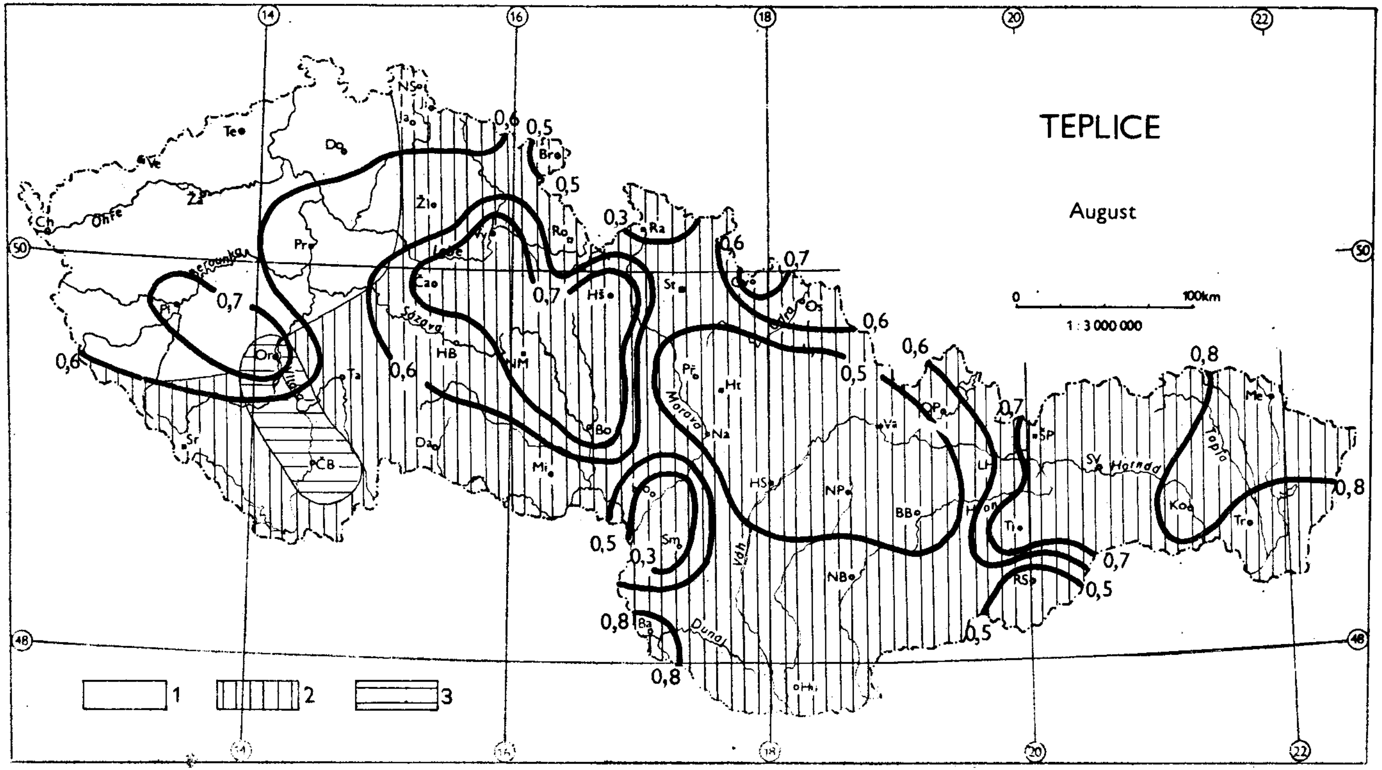


Fig. 3. Isolines of the maximum degree of climatological similarity of variations of diurnal sums of the precipitation of August with respect to station Teplice and the corresponding values of shift (1 — zero shift, 2 — positive shift, 3 — negative shift)

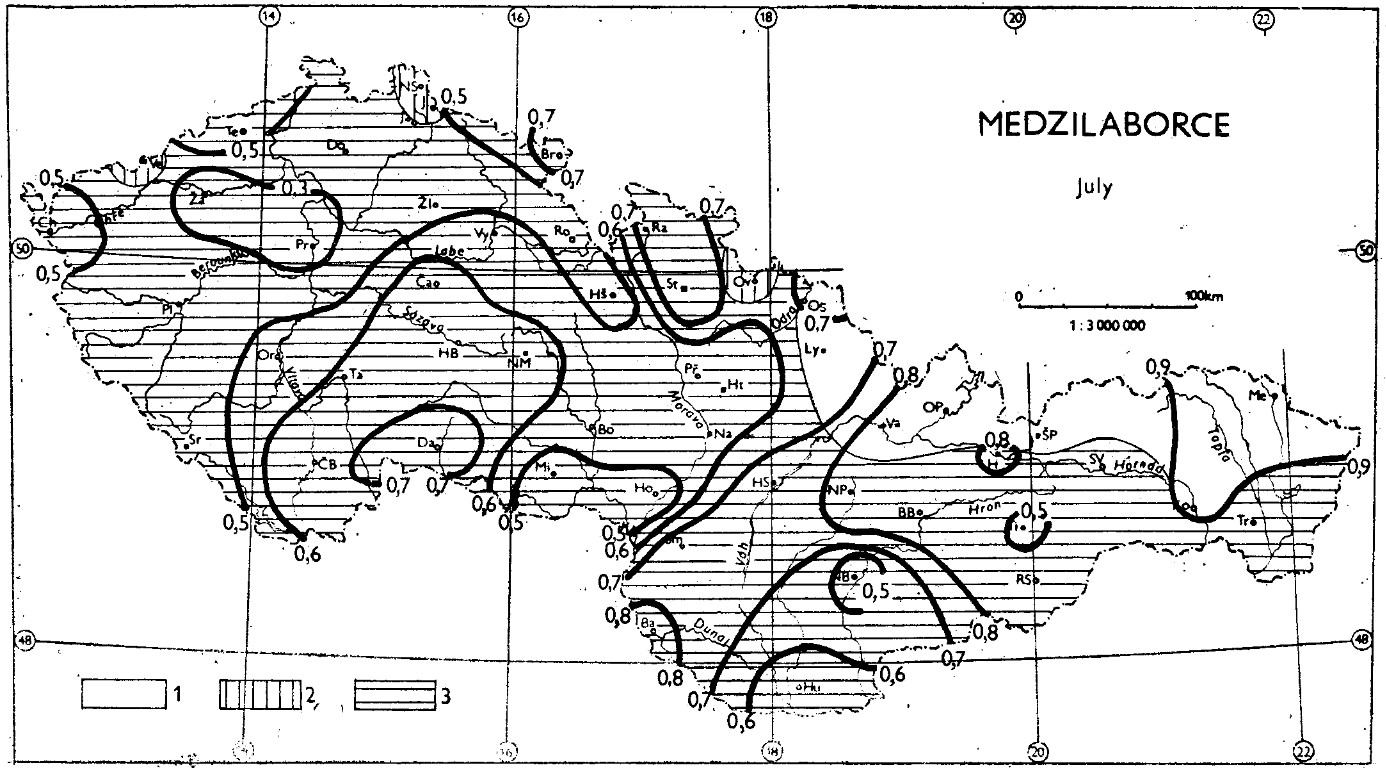


Fig. 4. Isolines of the maximum degree of climatological similarity of variations of diurnal sums of the precipitation of July with respect to station Medzilaborce and the corresponding values of shift (1 — zero shift, 2 — positive shift, 3 — negative shift)

(1901—1925, 1926—1950, 1951—1975). The acceleration and retardation of the onset of certain meteorological situations is reflected in shifts of local extremes of curves of variations, which gives the impression of antagonism of variations in different periods. The employment of the correlation coefficient r with the shift v allows to determine the mean length of time intervals (in days) by whih the precipitation maxima and minima are shifted in the individual periods. It appears that in Bohemia the most common features are those of the periods 1901—1925 and 1926 to 1950, in Moravia and Slovakia rather the years 1901—1925 and 1951—1975. In the values of shifts at which the maximum agreement is reached there are on the whole considerable differences in sign and in the size, both according to months and according to regions.

2. The correlation coefficient enables to render the common features in the distribution of diurnal precipitation at different stations for the same period, thus pionting to the socalled climatological similarity of variations of diurnal precipitation. According to $r \geqq 0.70$ groups of stations with the greatest similarity were delimited which remain more or less the same in the individual summer months as well as during the whole of summer. Attention should be paid above all to a great similarity in the variations of diurnal precipitation at Slovak stations in June and July, the regions of maximum similarity of variations shifting to Bohemia in July and, above all, in August. There is a conspicuous inclination of Moravian stations to Slovak ones by the variation of diurnal precipitation. This is testimony to the fact that the region of Moravia and Slovakia in the course of summer months is under the effect of analogical synoptival influences.

3. Since summer precipitation is bound on the one hand to Atlantic situations when frontal systems proceed from the western sector, and on the other hand to Mediterranean situations with the progress of frontal disturbances from the southern sector, it is possible to assume a certain time shift at stations in different parts of the CSSR and their analogical precipitation manifestations. If diurnal precipitation is correlated, the result of these shifts, particularly between distant stations, are small or negative correlation coefficients. When using correlation coefficients with a shift it appears that there are many commom features even between stations on the territory of our Republic that are considerably distant, the mean lengths of shifts found being in accordance with theoretical assumptions, limiting regions of analogical precipitation relations.

The elaboration of the above method of regression analysis appears to be an advantageous method for the evaluation of temporal and spatial changes of value of meteorological elements.

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