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PRECIPITATION SINGULARITIES IN THE VARIATION OF DIURNAL SUMS OF PRECIPITATION IN THE SUMMER SEASON ON THE TERRITORY OF THE CZECHOSLOVAK SOCIALIST REPUBLIC (CSSR)

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SUMMARY

The paper deals with the analysis of the precipitation phenomenon of the so-called summer European monsoon on the territory of the CSSR. Using the typization of meteorological situations the variations of diurnal precipitation and of precipitation probability are analyzed at selected stations in the years 1901—1975. Increases in the precipitation activity conditioned by the influence of the Atlantic Ocean were determined. Further, temporal variability of variations of diurnal precipitation and of precipitation probability in the period of 1901—1975 were analyzed.

1. INTRODUCTION

For the origin and distribution of atmospheric precipitation three factors are of decisive importance according to J. Brádka (1972): the type of the meteorological situation and its circulation mechanism, the effects of orography and of convection. While the first of them is more or less of global character, the latter two have rather local or regional character. The influence of orography is usually suppressed in summer, convection, however, is the most intense in the summer season. With sufficient amount of water vapours in the atmosphere it aids the origin of intense precipitation. Its accidental occurrence then considerably complicates the variation of diurnal precipitation during the summer season for the analysis of which it was necessary to level series of diurnal variations by means of gliding averages. In these series it is then possible to limit periods with higher and lower precipitation having the character of singulatities. The most conspicuous feature of the variation of diurnal precipitation sums of the summer in Central Europe is the occurrence of the so-called monsoon precipitation waves (Monsunwelle), which are due to the so-called summer European monsoon (europäischer Sommermonsun).

2. PROBLEMS OF THE EUROPEAN MONSOON

The term European monsoon (also summer European monsoon) is used by some authors for specifying the summer invasions of sea polar air to the European continent from the western sector. It was already known to H. Hellmann (1887) and to

E. Almstedt (1914). It is often quoted by German authors, such as G. Roediger (1929), H. Flohn, P. Heß (1949), H. Voigts (1951), H. Flohn (1954), but also in Czechoslovak climatological literature. Its genesis is explained in the following way. After cold invasions about the middle of May, in the latter half of this month quiet weather with a small amount of clouds of anticyclonic character becomes settled in Central Europe which is favourable for the heating of the European continent (the so-called late spring — Spätfrühling). At the same time the temperature contrast between land and sea grows. In that period a projection of the Azore pressure height penetrates to the north-east and near the British Isles an anticyclone is formed along whose periphery cold sea polar air accompanied by great cloudiness, frequent storms and precipitation penetrates to Central Europe at the beginning of June. The centre of this anticyclone shifts gradually southwards, so that even the original north-western streaming gradually passes into western streaming in Central Europe.

The above cold invasion is reflected most conspicuously in the variation of air temperature. According to M. Končok (1927, 1968, 1979) the June cooling at the turn of the first and the second decade is the most conspicuous and regular singularity of the anual variation of temperature. The above cooling is often denoted as sheep cold (Schaftkälte) by German climatologists. It is accompanied by increased precipitation activity as well. Thus, according to H. Flohn (1954) the period from 9 to 18 June includes in Central Europe almost 90 % of years with rains lasting several days. These changes in weather in June are so conspicuous that they were noticed in popular weather lore. Perhaps the best-known piece of weather lore relates to Medard (8 June): Medard's drop lasts 40 days. An analogical piece of weather lore exists also in France, but with 30 days of rain. The onset and duration of further monsoon waves are connected with a number of other items of weather lore (Hanzlík 1950, 1953). It is interesting to note that the weather lore does not include the June cooling. According to J. Jílek (1953) it is evidently due to the fact that temperatures do not drop below the freezing point. The probability of the June occurrence of monsoon reaches 80 % according to M. Končok (1968).

Thermal conditions in June are in close connection with atmospheric precipitation. According to F. Rein (1979) the mean precipitation in cold Junes in Prague was 63 mm, while in warm Junes (with temperature above 19.5 °C) only 35 mm. Thus, with intense north-western monsoon streaming the cold Atlantic air brings about double the amount of precipitation than that occurring in those cases when the monsoon does not appear and warm weather prevails in June with occasional storms.

Besides the June temperature singularity a second impact of the monsoon can be found in July according to M. Končok (1968). This singularity is, however, manifested relatively weekly and the probability of its occurrence is substantially lower.

As for storms, most of them occur on the territory of the CSSR in July, then in June and only then in August. The fact that August, which is on the average warmer, has a lower frequency of storms with respect to June, is explained by the monsoon character of the Central European summer (Stuchlík, Popolanský, Trefná 1961, Pejml 1969).

The duration and intensity of monsoon weather in Central Europe is essentially dependent on temperature and pressure differences between land and ocean which vary during the summer. That is why even the variation of diurnal precipitation can be divided into several periods of higher precipitation activity during the summer. These periods are denoted as monsoon precipitation waves. The periods of higher precipitation activity are separated from one another by periods of lower precipitation activity (Monsunpausen), when, with increased frequency of occurence of anticyclonic situations, fine weather prevails.

H. Flohn (1954) limited altogether seven monsoon precipitation waves for Central Europe: the beginning of June (marked as M 1), 12—14 June (M 2), 26—29 June (M 3), 5—11 July (M 4), 19—29 July (M 5), 5—7 August (M 6), and about 15 August (M 7). In an earlier paper by H. Flohn and P. Heß (1949) somewhat different data are given: for M 2 it is 9—18 June, for M 5 21—30 July, and for M 6 1—10 August, with the probability of occurrence being 89, 89, and 84 %, respectively and mean duration of 7.3, 7.2 and 7.2 days, respectively. The intensity of the July and August waves is diminished as compared with the June invasions due to the balance of temperature between the continent and the ocean.

For comparison with the above papers it is possible to quote the paper by F. Stuchlík (1960, 1962) who limited altogether 8 periods of higer precipitation activity for Prague (1838—1960): 4—5 June, 10—15 June, 22—26 June, 30 June—6 July, 10—13 July, 23—29 July, 1—4 August, and 13—23 August. The proper onset of monsoon precipitation waves, evident from the increase in precipitation frequency and intensity, begins as late as from 10 June onwards.

According to H. Flohn (1954) it is possible to include among the weather situations of the summer European monsoon not only western cyclonic situations, but also all northern and north-western ones, as well as the central cyclone in Central Europe. Their frequency reaches 59.4 % in the three summer months. Higher frequencies of the occurrence of western situations according to the typization of P. Heß and H. Brezowsky correspond to monsoon waves and can well be seen in Fig. 1.

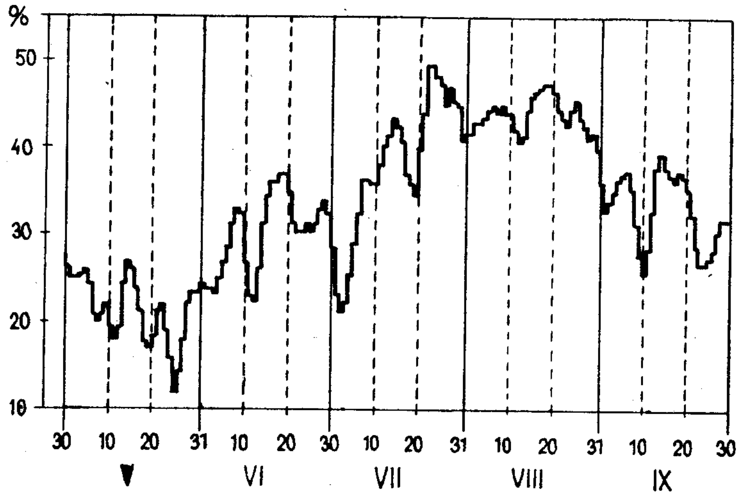


Fig. 1. Variation of the frequency of occurrence of western situations (according to the typization of P. Heß and H. Brezowsky) in May—September in the period of 1881—1947. According to H. Flohn (1954)

The streaming of maritime air masses into Central Europe under the monsoon circulation is well evident even from the annual variation of the value of dynamic oceanity (i.e. the probability of the day with the occurrence of maritime air mass). Thus, according to B. Hrudička (1935) its value reaches its chief peak in the annual variation particularly in June (58.4 %) for west Bohemia (station Cheb, period 1928—1933), followed by August (56.5 %) and July (52.2 %). Also the values of dynamic oceanity for the whole of Czechoslovakia were highest in June and in August. Also according to K. Krška and F. Molnár (1980) dynamical oceanity reaches it chief peak in June in Bratislava (period 1948—1977).

The term summer European monsoon has been justly objected to. Starting from the definition, under monsoon we understand constant air streamings of seasonal nature, characterized by sudden anatagonistic or almost antagonistic change in the prevailing wind direction between the winter and the summer seasons. Thus, besides the summer monsoon, blowing from the sea to the land, there also exists the reverse, the winter monsoon. This monsoon is, however, lacking in the case of Europe, as shown by V. Conrad, since the mean wind direction between the above seasons is only slightly changed. This view is also confirmed by the values of the average monthly direction of the resulting vector of wind on standard izobaric levels, as stated in the paper by A. Benešová, J. Iľko, and J. Pribiš (1980) for Prague and for Poprad (Tab. 1). Analogical opinions with that of Conrad are those of P. Pédelaborde (1963), S. P. Chromov and L. I. Mamontova (1974) and others, who are of the opinion that it is only a shift of air intensified in moderate latitudes in the summer season. According to H. Flohn (1954) it is, however, necessary — when judging the above problem — to refrain from formal monthly means and to take into consideration time periods of several days in which winds of eastern direction often prevail. H. Flohn and P. Heß (1949) even use the term winter monsoon for the period of 14—25 December (early winter — Frühwinter, relative frequency of occurence 67 %, mean duration 7.4 days), 15—26 January (culminating winter — Hochwinter, relative frequency of occurrence 78 %, mean duration 7.4 days), and 3—12 February (late winter — Spätwinter, relative frequency 67 %, mean duration 6.1 days). Besides, Flohn quotes the paper by H. Berg and S. W. Wisser, according to which on the coast of Holland and Germany there is a rotation of the annual wind direction by 120—180°. With respect to the definition of the monsoon the comments of critics on the use of the term summer European monsoon seem to be justified.

Tab. 1. Average monthly direction of the resulting wind vector (°) on isobaric levels of 85 and 70 kPa according to aerologic ascents in Prague (11 520) and at Poprad (11 592) in the period of 1961—1970. According to A. Benešová, J. Iľko, and J. Pribiš (1980)

Level [kPa]	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Prague (H = 303 m)											
85	290	294	291	270	279	295	276	274	274	256	260	280
70	299	300	301	265	272	278	277	273	275	267	269	288
	Poprad (*H* = 706 m)											
85	267	269	266	247	245	259	270	253	250	250	249	269
70	296	293	291	250	249	280	277	268	273	272	255	281

The fact, however, remains that the above precipitation waves appear in the study of series of diurnal precipitation in different time periods.

For the territory of the CSSR a relatively good agreement of the periods of higher precipitation activity with the so-called monsoon waves was demonstrated in the papers by F. Stuchlík (1962), F. Stuchlík and H. Křivánková (1966), K. Pejml (1970), K. Chomicz and F. Šamaj (1974) and others. Those papers, however, did not analyze synoptico-climatological causes of precipitation activity increases. Owing to the fact that Central Europe reflects not only the influence of the Atlantic Ocean, but also that of the Mediterranean Sea, the present paper performed an analysis of the variations of diurnal precipitation sums during the summer season with respect to these facts.

3. ANALYSIS OF THE VARIATIONS OF DIURNAL SUMS OF PRECIPITATION AND OF PRECIPITATION PROBABILITIES ON THE TERRITORY OF THE CSSR IN THE YEARS 1951—1975

50 stations on the territory of the CSSR were selected for the analysis of the precipitation activity (their list is included in the paper by R. Brázdil and I. Moll, 1981) with data for the period of 1951—1975. For a more detailed analysis only the following 14 stations were chosen which, more or less, cover regularly the territory of the CSSR and which represent major regional units: Cheb (abbreviation Ch), Teplice (Te), Jizerka (Ji), Prague-Klementinum (Pr), Srní (Sr), Nové Město na Moravě (NM), Rokytnice v Orlických horách (Ro — Rokytnice in the Orlické hory Mountains), Ostrava (Os), Smolenice (Sm), Hurbanovo (Hu), Nitrianské Pravno (NP), Štrbské Pleso (ŠP), Medzilaborce (Me), and Trebišov (Tr). For the synoptico-climatological analysis the catalogue of weather situations by the team of authors of the Hydrometeorological Institute (1967, 1972) was chosen. The weather situations included in it were — in accordance with the paper by J. Brádka (1973) — divided into Atlantic, Mediterranean, and others.

The variation of the diurnal precipitation sums of the summer at each station was levelled by means of five-day gliding sums which were calculated as a sum of mean diurnal sums of precipitation in five successive days, the calculated value being attached to the middle day. Besides, at selected stations the sum of precipitation during Atlantic and during Mediterranean situations was calculated for each day of the summer and for the two groups the variation was expressed again by means of five-day gliding averages (hatched parts in Fig. 3 mark the prevalence of precipitation of Atlantic situations over the Mediterranean ones). Besides the amount of precipitation also precipitation probability was found for each station for the days with the diurnal sum $\geqq 0.1$ mm. Analogically to the case of precipitation sum also precipitation probability was calculated during Atlantic and Mediterranean situations. The values of precipitation probability were levelled by means of five-day gliding averages.

The division of weather situations of the HMI typization (1967, 1972) into Atlantic, when frontal systems proceed into Central Europe from the western sector (from the region of the Atlantic Ocean) and Mediterranean, when frontal systems progress from the region of the southern sector (the region of the Mediterranean and/or the Black Seas, makes it possible to judge the rate of influence of the Atlantic Ocean and of the Mediterranean Sea on the distribution of the diurnal sums of precipitation during the summer on the territory of the CSSR. If the influence of Atlantic situations is identified with the monsoon influence, it is possible to judge the rate of influence of the so-called summer European monsoon as well. However, due to the above remarks we shall preferably speak about the influence of the Atlantic Ocean.

A detailed characteristics of the studied period of 1951—1975 from the synoptico-climatological point of view was given by R. Brázdil (1980). As follows from Tab. 2,

Tab. 2. Relative frequencies of occurrence (%) of Altantic (Z), Mediterranean (M), and other (Cv + A) situations in the summer and in summer months on the territory of the CSSR in the period of 1951—1975

	June	July	August	June—August
Z	45.0	52.2	50.8	49.4
M	51.1	38.1	39.0	42.6
Cv + A	3.9	9.7	10.2	8.0

in the course of the summer the most frequent situations were the Atlantic ones with 49.4 % cases of occurrence against 42.6 % case of occurrence of Mediterranean ones. Mediterranean situations prevailed in the frequencies of occurrence and in the shares in the number of precipitation days in essence only in June. Thanks to higher precipitation activity they played the decisive role in the total amount of precipitation of the summer period. In Bohemia their share in the summer total of precipitation was by 5—10 % higher, and in Moravia and Slovakia by 10—30 % higher than the share of precipitation during Atlantic situations.

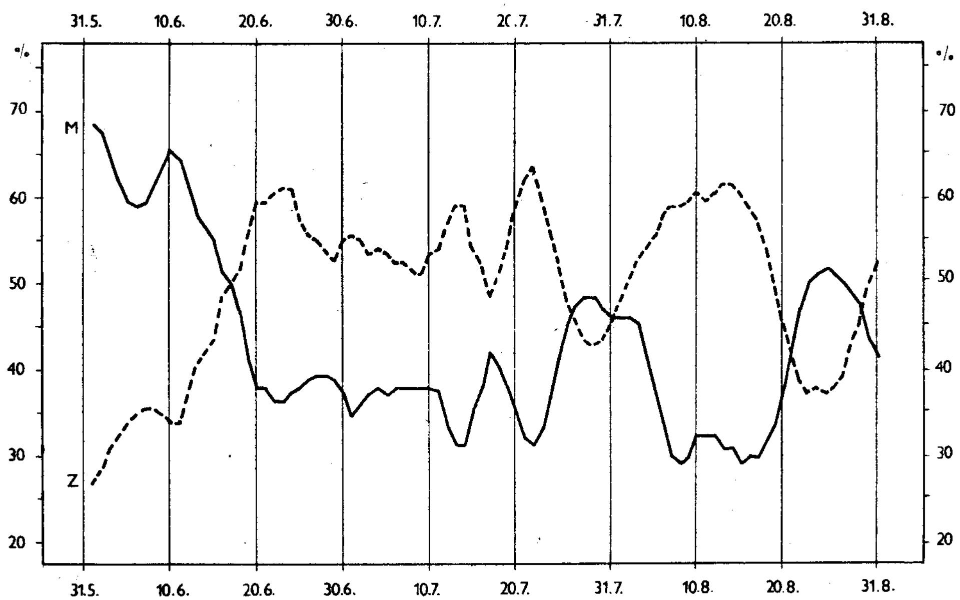


Fig. 2. Variation of relative frequencies of occurrence of Atlantic (Z) and Mediterranean (M) weather situations of the typization of the HMI during the summer in the period of 1951—1975. Levelled by five-day gliding averages

Following the variation of frequencies of occurrence of situation groups (Fig. 2), one can see that Mediterranean situations prevailed over Atlantic situations by the frequencies of occurrence only up to the middle of June, at the end of July, and then only in the last decade of August.

Tab. 3. Climatological similarity of variations of diurnal precipitation sums of the summer at selected stations on the territory of the CSSR expressed by the correlation coefficient. Period 1951—1975

June-August

Stat.	Ch	Te	Ji	Pr	Sr	NM	Ro	Os	Sm	Hu	NP	ŠP	Me	Tr
Ch	1	0.48	0.26	0.43	0.37	0.57	0.11	0.35	0.25	0.45	0.44	0.14	0.07	0.13
Te	0.55	1	0.59	0.53	0.40	0.52	0.29	0.42	0.47	0.47	0.48	0.41	0.45	0.30
Ji	0.40	0.34	1	0.37	0.48	0.37	0.54	0.49	0.38	0.30	0.37	0.53	0.51	0.19
Pr	0.57	0.34	0.25	1	0.42	0.34	0.19	0.14	0.33	0.47	0.17	0.25	0.31	0.23
Sr	0.54	0.22	0.40	0.15	1	0.47	0.23	0.47	0.52	0.53	0.55	0.37	0.34	0.41
NM	0.58	0.56	0.51	0.04	0.27	1	0.43	0.46	0.43	0.33	0.57	0.38	0.22	0.41
Ro	–0.15	–0.21	0.64	–0.21	0.27	0.19	1	0.24	0.30	0.05	0.14	0.46	0.27	0.13
Os	0.57	0.24	0.30	–0.09	0.51	0.50	0.02	1	0.73	0.62	0.65	0.71	0.48	0.51
Sm	0.72	0.48	0.26	0.24	0.67	0.37	–0.11	0.75	1	0.70	0.66	0.69	0.52	0.51
Hu	0.51	0.33	–0.04	0.41	0.41	0.00	–0.34	0.55	0.77	1	0.62	0.51	0.55	0.64
NP	0.55	0.39	0.16	–0.03	0.58	0.34	–0.14	0.78	0.90	0.62	1	0.55	0.54	0.64
ŠP	0.43	–0.15	0.52	0.14	0.57	0.11	0.37	0.62	0.57	0.34	0.52	1	0.75	0.60
Me	0.41	0.31	0.32	0.50	0.45	–0.19	–0.07	0.36	0.56	0.69	0.45	0.50	1	0.68
Tr	0.16	0.05	–0.61	0.10	0.20	–0.23	–0.53	0.26	0.45	0.68	0.41	–0.01	0.27	1

June

Following *Tab. 3:*

August

Stat.	Ch	Te	Ji	Pr	Sr	NM	Ro	Os	Sm	Hu	NP	ŠP	Me	Tr
Ch	1	0.68	0.61	0.28	0.29	0.73	0.24	0.52	–0.09	0.73	0.65	0.31	0.53	0.60
Te	0.23	1	0.27	0.52	0.17	0.71	0.48	0.33	0.15	0.38	0.35	0.58	0.49	0.27
Ji	–0.17	0.68	1	0.25	0.57	0.74	0.31	0.68	0.24	0.63	0.47	0.40	0.64	0.72
Pr	0.40	0.76	0.66	1	0.11	0.52	0.58	0.11	0.39	0.26	0.05	0.37	0.42	0.18
Sr	0.25	0.69	0.74	0.82	1	0.54	0.13	0.50	0.28	0.08	0.46	0.07	0.25	0.28
NM	0.39	0.27	0.07	0.20	0.35	1	0.49	0.48	0.22	0.52	0.60	0.46	0.68	0.59
Ro	0.14	0.18	0.35	0.18	0.40	0.71	1	0.23	0.47	0.09	–0.18	0.42	0.31	0.10
Os	–0.31	0.05	0.29	–0.14	0.21	0.04	0.30	1	0.37	0.57	0.25	0.49	0.27	0.38
Sm	–0.23	0.35	0.35	0.06	0.33	0.39	0.56	0.63	1	0.22	–0.25	0.32	–0.10	–0.08
Hu	0.18	0.55	0.51	0.50	0.76	0.30	0.38	0.46	0.59	1	0.53	0.33	0.42	0.64
NP	–0.01	0.48	0.42	0.23	0.47	0.68	0.57	0.58	0.75	0.54	1	–0.05	0.41	0.64
ŠP	–0.36	0.23	0.27	–0.10	0.23	0.35	0.42	0.76	0.83	0.54	0.79	1	0.66	0.46
Me	–0.57	0.30	0.42	0.00	0.30	0.10	0.23	0.72	0.73	0.55	0.67	0.88	1	0.83
Tr	–0.40	0.17	0.31	–0.04	0.31	0.48	0.44	0.65	0.58	0.44	0.78	0.81	0.82	1

July

The variation of summer precipitation expressed by diurnal precipitation sums differs considerably in the individual stations (Fig. 3). Based on the methods employed in the paper by R. Brázdil and I. Moll (1981) the degree of similarity of their variations was quantified by the use of a correlation coefficient whose values are given in Tab. 3. From this table it follows that the selected stations express quite well the peculiarities of the variations and their differences in the individual parts of the CSSR. As followed from the above paper, using a correlation coefficient with a shift would make the rate of similarity even higher.

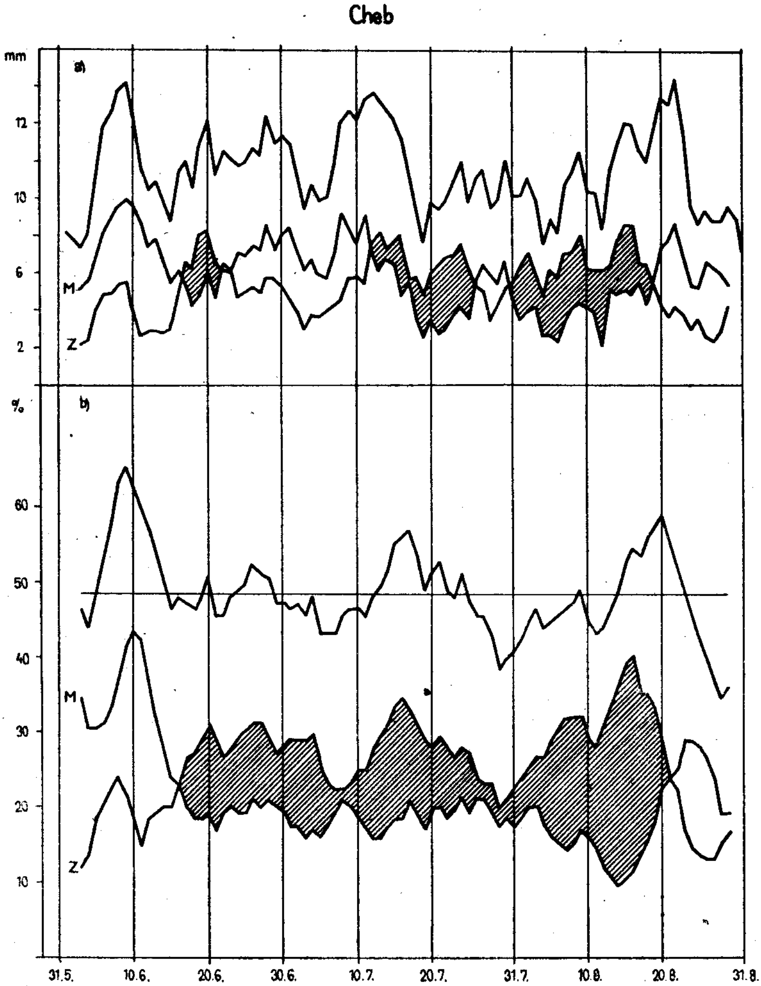
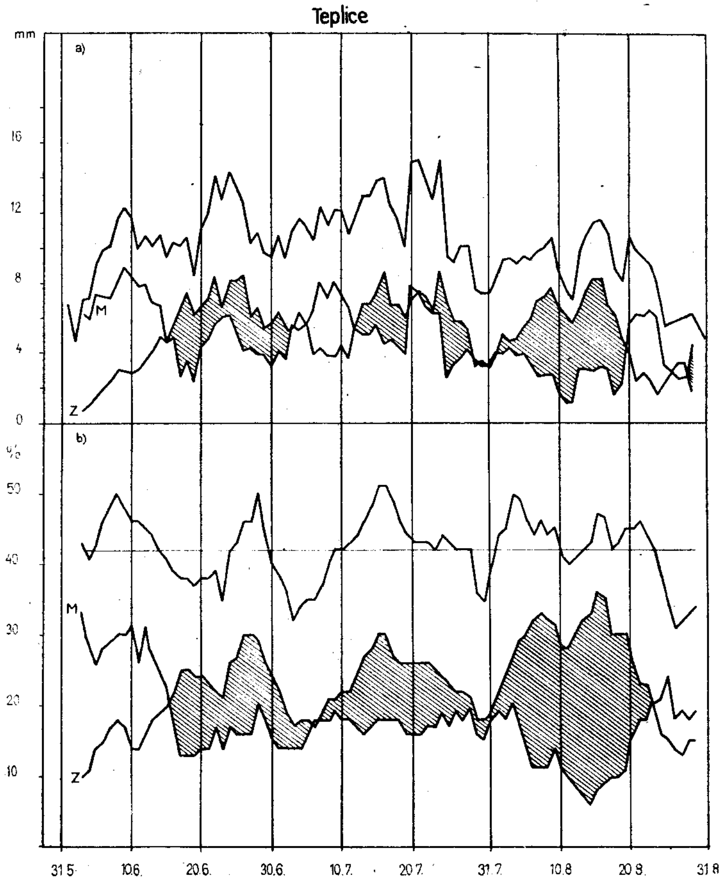


Fig. 3. Variations of diurnal precipitation sums (a) and of precipitation probability (b) of the summer at selected stations on the territory of the CSSR. Period 1951—1975. Levelled by five-day gliding sums and/or averages. Marking: Z — variation during Atlantic situations, M — variation during Mediterranean situations, horizontal lines — in part b) mean precipitation probability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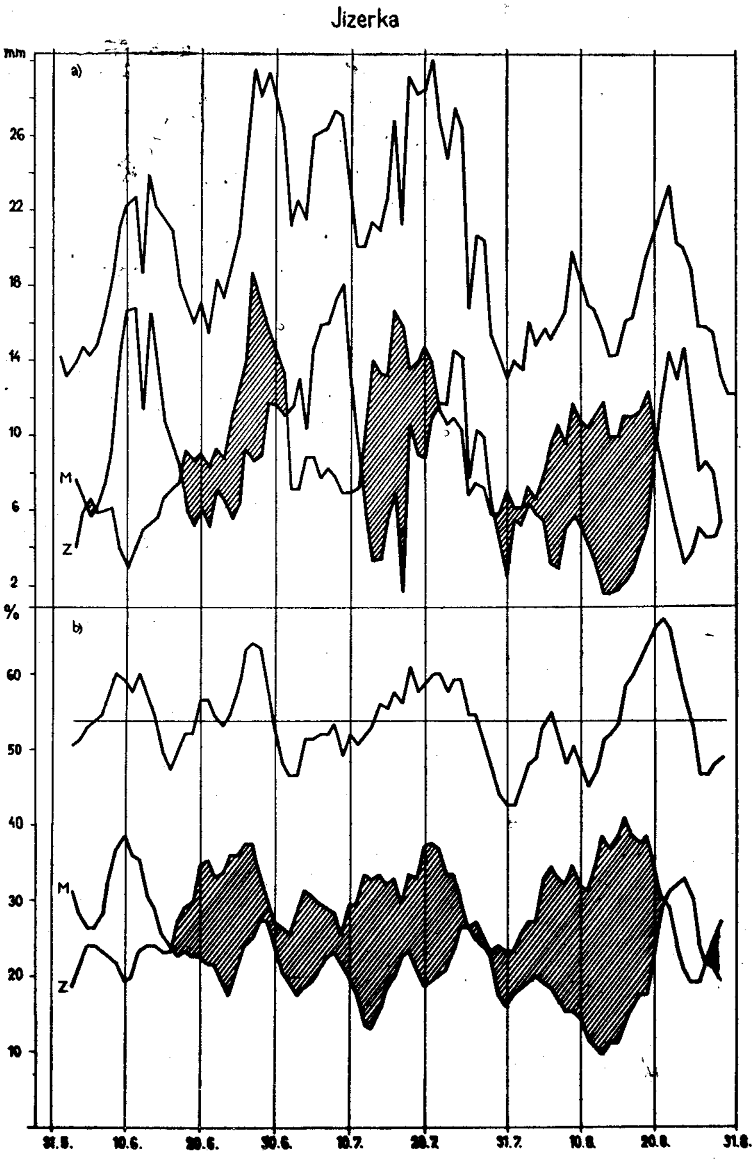
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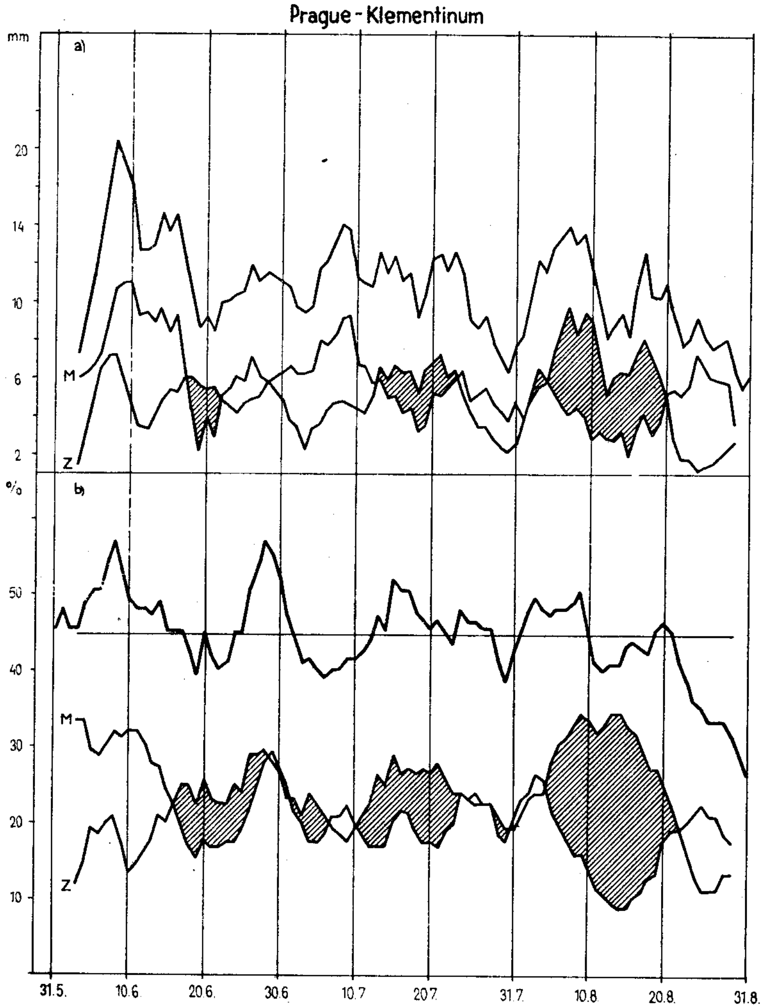
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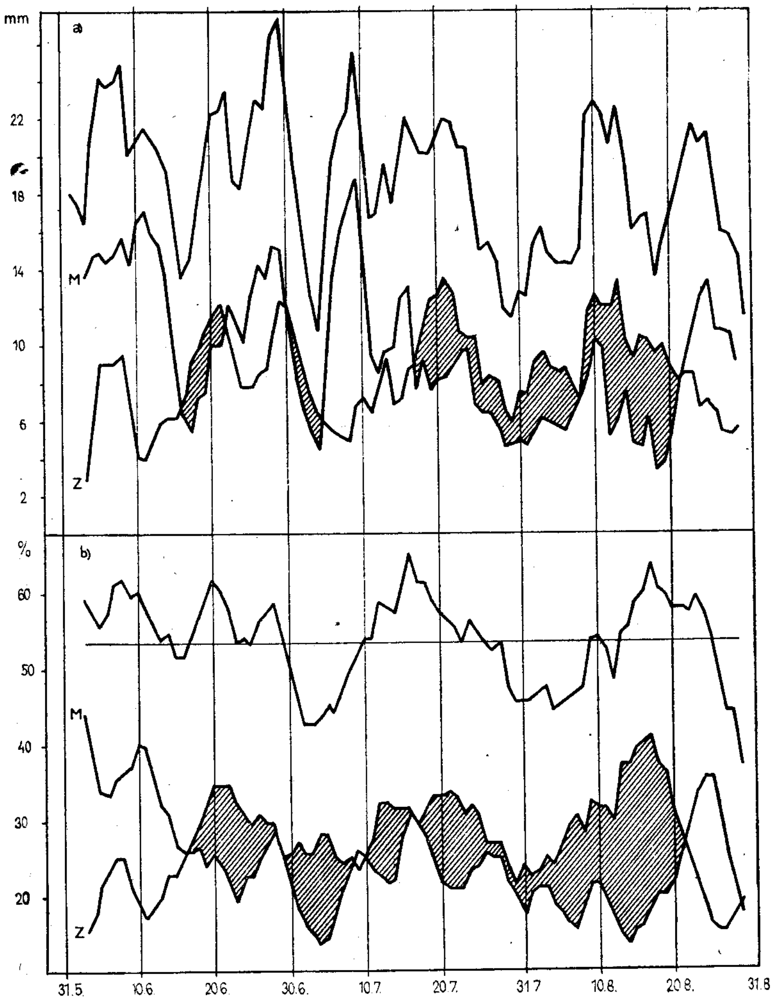
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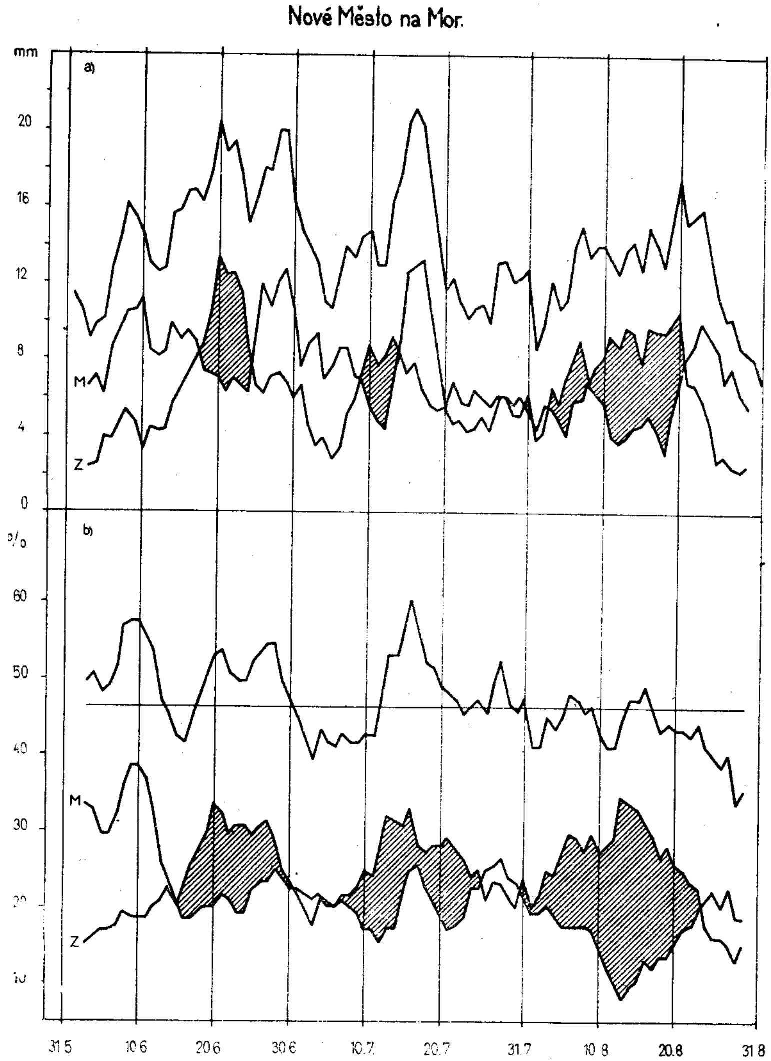
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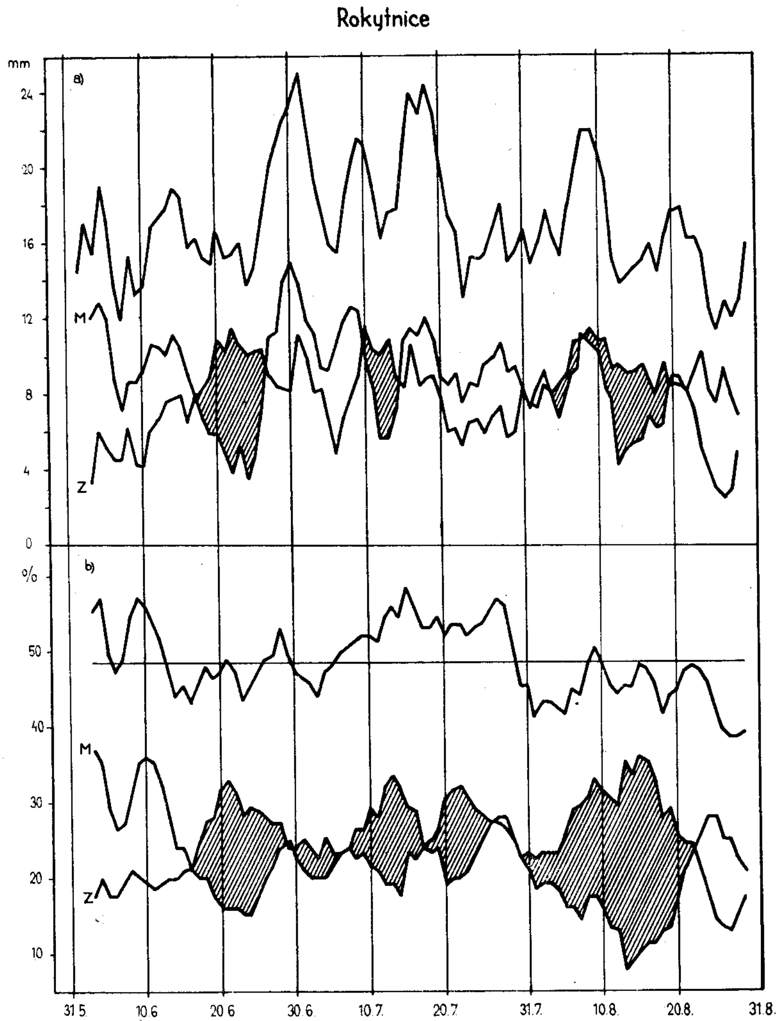
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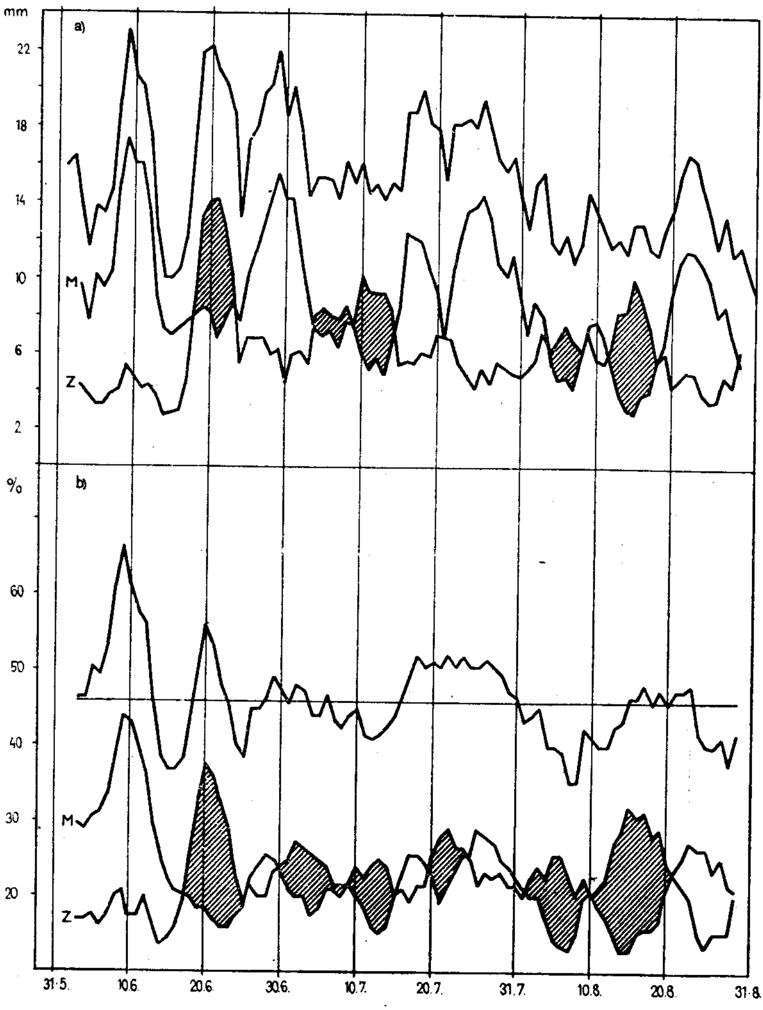

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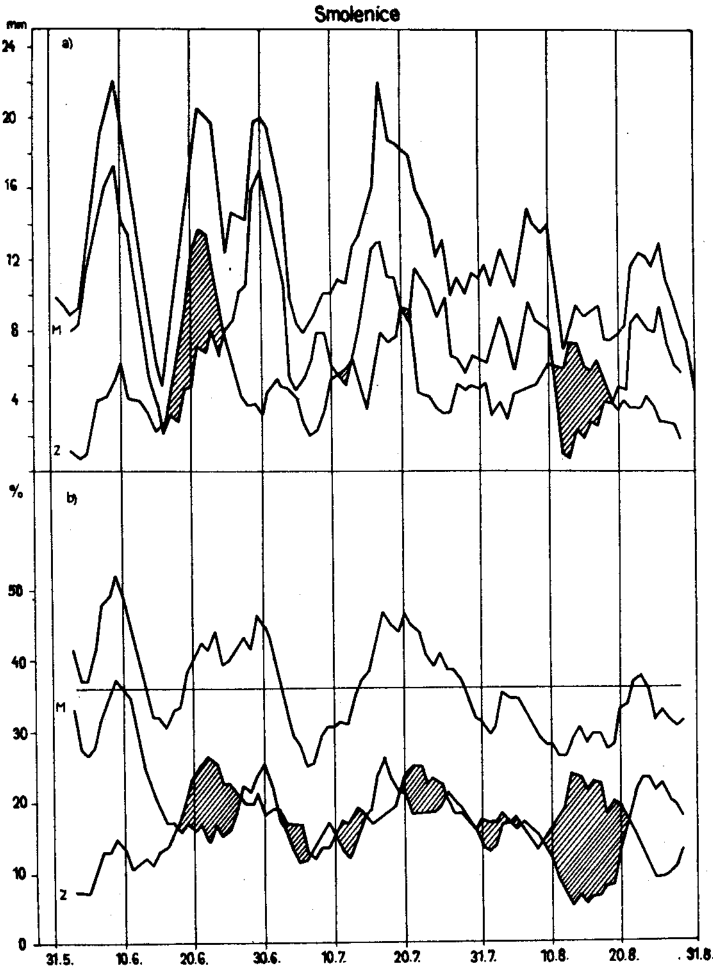
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31.8.

Fig. 3

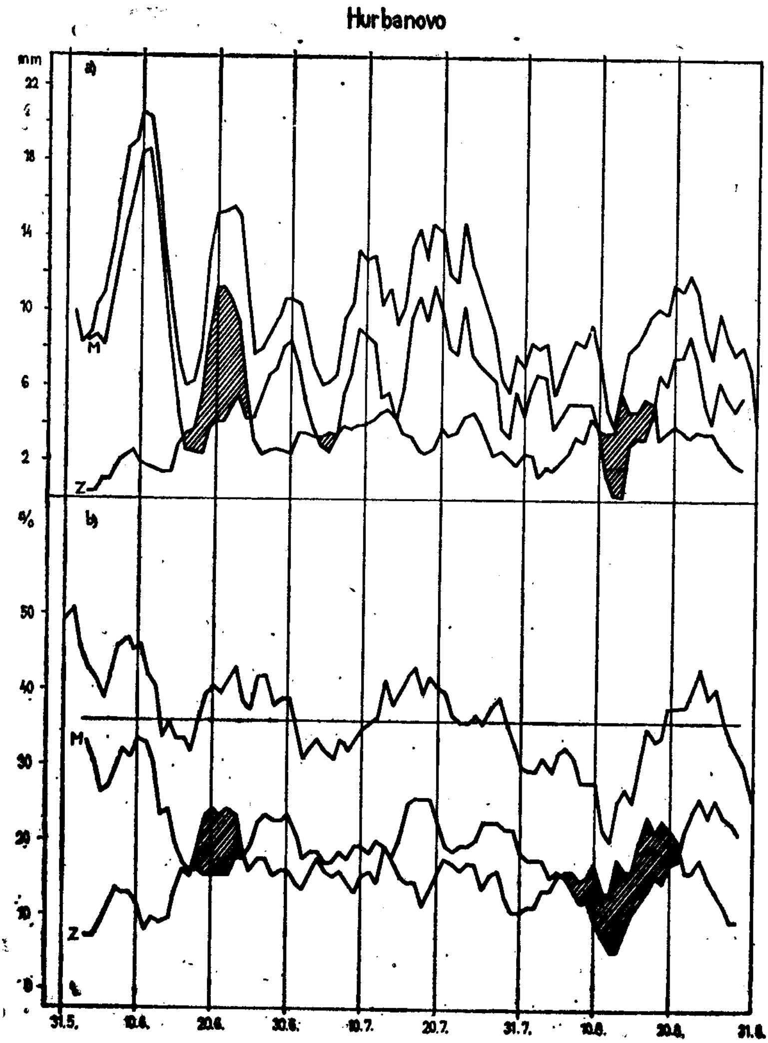

Hurbanovo
mm
a)
22
18
14
10
6
2
M
Z
%
b)
50
40
30
20
10
0
M
Z
31.5.
10.6.
20.6.
30.6.
10.7.
20.7.
31.7.
10.8.
20.8.
31.8.

Fig. 3

Nitrianské Pravno

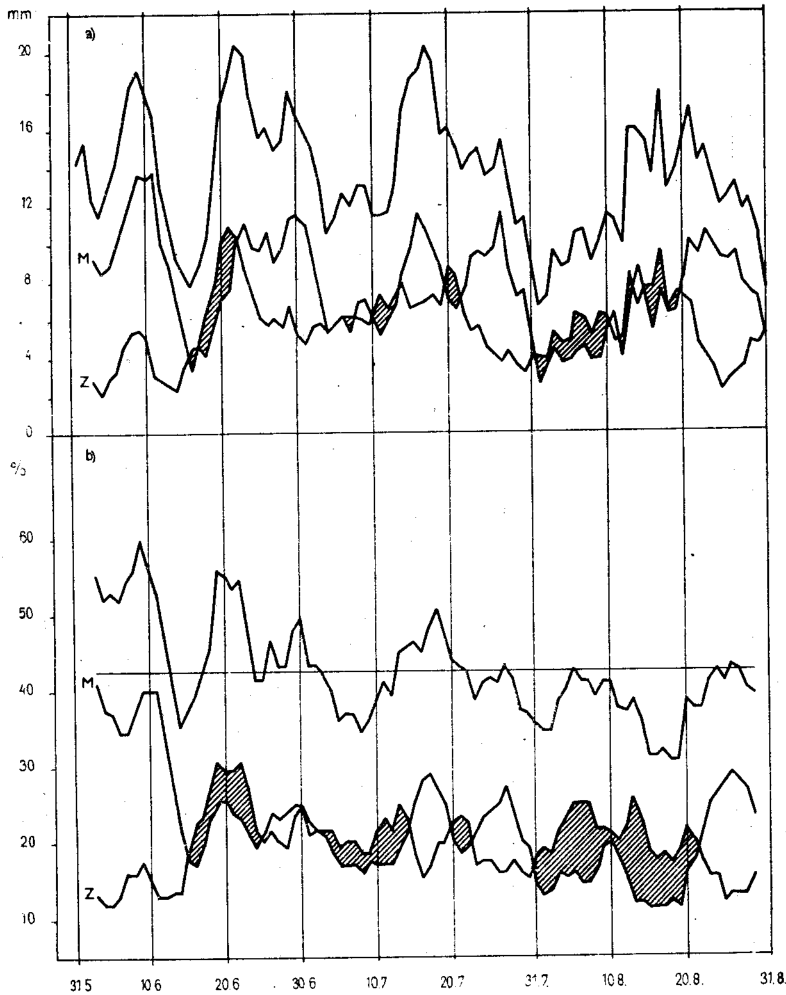
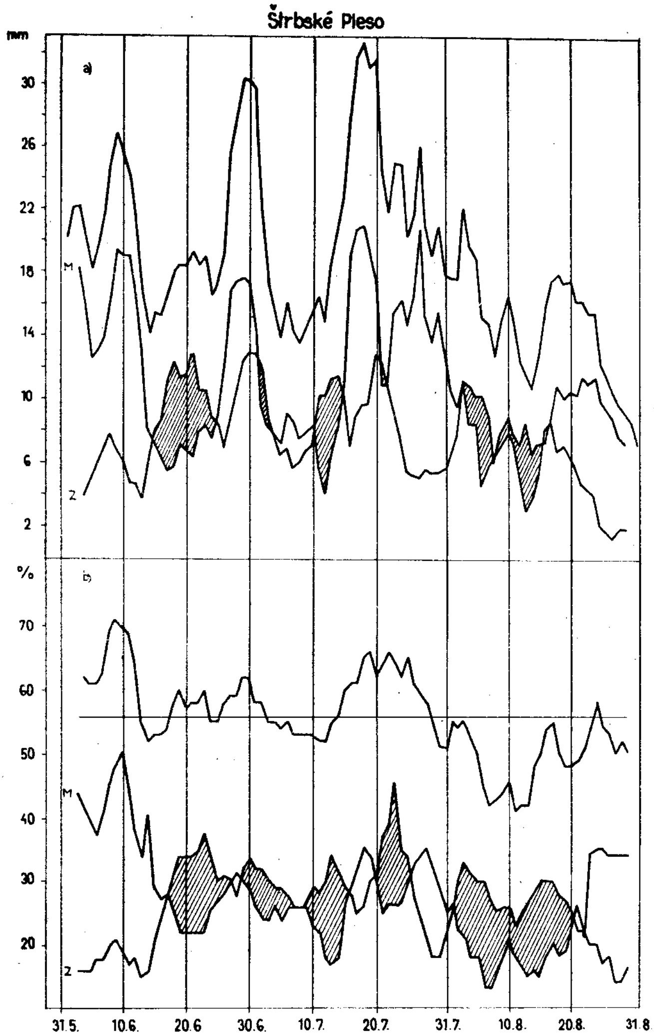


Fig. 3



Štrbské Pleso
mm
a)
30
26
22
18
14
10
6
2
M
Z
%
b)
70
60
50
40
30
20
M
Z
31.5.
10.6.
20.6
30.6.
10.7.
20.7.
31.7.
10.8.
20.8.
31.8.

Fig. 3

Medzilaborce

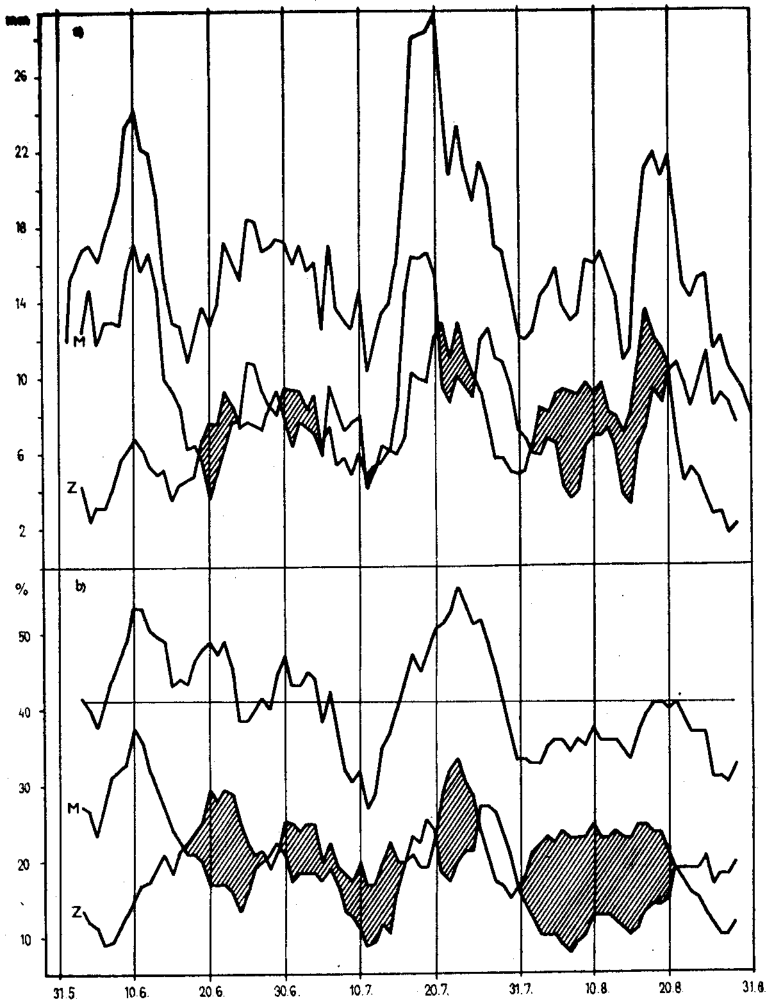


Fig. 3

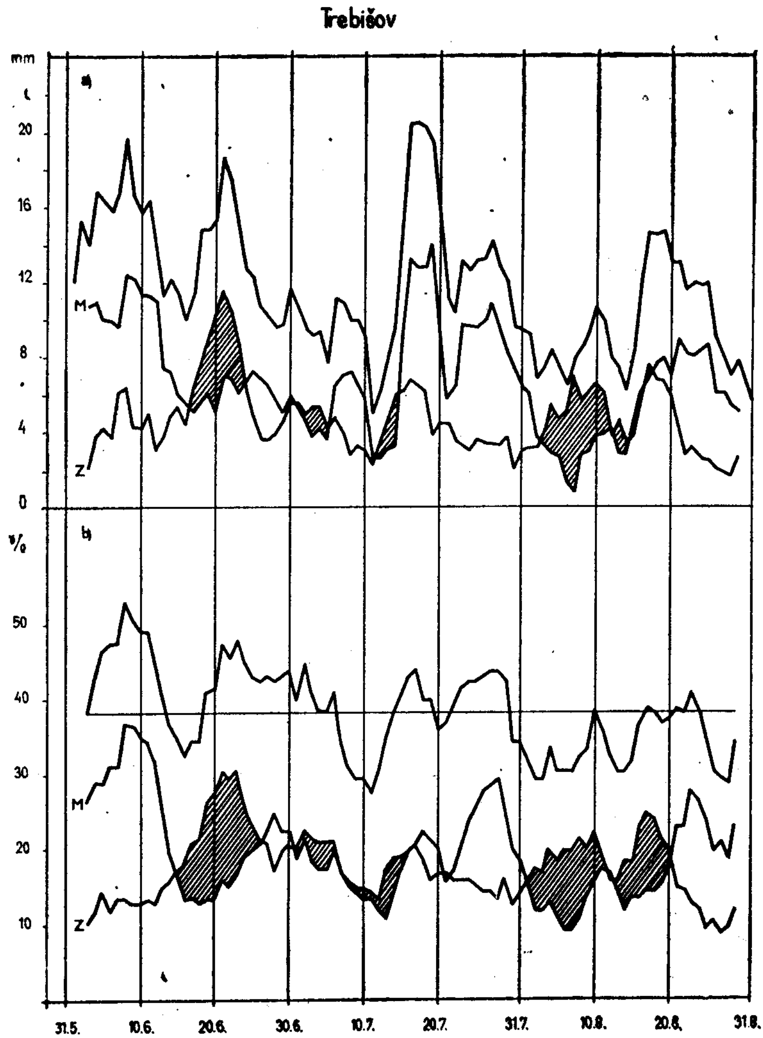

Trebišov
mm
t
20
16
12
8
4
0
a)
M
Z
b)
%
50
40
30
20
10
31.5.
10.6.
20.6.
30.6.
10.7.
20.7.
31.7.
10.8.
20.8.
31.8.

Fig. 3

3.1 Variations of diurnal precipitation and of precipitation probabilities in June

In June, to which H. Flohn (1954) adjudges three monsoon precipitation waves, three well-distinguished peaks are apparent particularly in Moravian and Slovak, but also in south Bohemian stations which, with respect to the expected retardation against Flohn's dates, could corresponds to waves M 1—M 3 (Fig. 3). The individual peaks differ in their intensity according to regions. The first increase in diurnal precipitation falls to the 2nd pentade of June, the second to the beginning of the 3rd decade, and the third to the turn of June and July (Brázdil 1979). A number of stations reach through one of the peaks maximum values of diurnal precipitation for the whole summer season (e.g. Ostrava, Banská Bystrica, Hurbanovo, and Smolenice in the 2nd pentade, Rokytnice v Orlických horách and Srní at the end of June). The increase in precipitation probabilities also correspond to the above peaks (in the 2nd pentade most of the Slovak stations, but also Ostrava and Cheb reached the highest precipitation probabilities in the whole summer season).

A precipitation wave unambigously due to Atlantic situations can be considered the increase in diurnal precipitation at the beginning of the 3rd June decade, when Atlantic situations reached their maximum June value by their frequency of occurrence about 60 %. The reason of this wave was above all intense precipitation under western situations Wc, Wcs, and Vfz (see Fig. 2 in the paper by R. Brázdil, 1979), which can be well observed from the increase in the value of precipitation intensity (amount of precipitation under these situations divided by the frequency of their occurrence) on 17—24 June (Tab. 4). But at the station Jizerka this marked increase in diurnal precipitation during the given situations was not at all reflected in the total variation, evidently because of the fact that before and after this period higher precipitation occurred during situations NEc, B, C, SWc_{1-3}.

Tab. 4. Average diurnal precipitation sum (mm) during situations Wc, Wcs, nad Vfz in the days of 17—24 June in the period of 1951—1975 a their relative frequencies of occurrence in % (r.f.)

Stat.	17.	18.	19.	20.	21.	22.	23.	24.
Ji	3.8	6.1	3.6	5.6	2.3	4.7	2.9	0.9
Sr	1.2	5.9	8.8	6.4	5.6	1.4	4.6	0.1
Os	1.2	2.4	6.0	11.7	14.3	1.3	2.3	1.8
Hu	0.3	2.7	2.8	4.4	6.3	1.4	3.6	2.8
ŠP	2.2	3.5	5.2	4.0	5.4	4.3	6.1	2.2
r.f.	12.0	28.0	32.0	36.0	32.0	32.0	20.0	8.0

On the other hand, the first June precipitation wave was conditioned by the effect of Mediterranean situations which is about twise as great as during the Atlantic situations. Most important from the precipitation point of view were situations C, B, Bp, NEc, and Ec. During Atlantic situations only a slight increase appeared both in the amount of precipitation and in the precipitation probability thanks to the situations SWc_{2-3}.

As for the third precipitation wave towards the end of June, its monsoon-like character was reflected in a higher frequency of occurrence of rainy days during

Atlantic situations with respect to Mediterranean ones (at Bohemian stations practically throughout the 3rd June decade). At a number of stations the probabilities of precipitation days under Mediterranean situations were increasing from the middle of the last June decade up to the end of the month. They also decided about the intensity of this precipitation wave, as they conspicuously surpassed Atlantic situations by the amount of precipitation in a belt of the territory starting from the region of the Bohemian-Moravian Highlands up to central Slovakia, but also at Cheb. They were chiefly situations B, Bp, NEc, Ec, in places also C. By the amount of precipitation the increased influence of Atlantic situations affected only higher situated stations (Jizerka, Srní, Štrbské Pleso). In the case of Jizerka the dominating share in the precipitation increase was that of situations Wc, Wcs, and Vfz (thus on 29 June 1971 during situations Wc there was a 142.0 mm precipitation). With respect to the other stations, at the end of June the importance of further Atlantic situations increased in the Šumava Mountains (NWc, Nc, SWc_{2-3}). At stations of the northern part of the CSSR also situations Wal had a great share in the increase in precipitation (Jizerka, Ostrava, Štrbské Pleso). Thus, in the period of 27 June to 2 July during the twenty-five years under investigation the following precipitations were registered during situations Wal: Štrbské Pleso 211.4 dm, Medzilaborce 84.5mm, Trebišov 56.8 mm, and Hurbanovo only 24.3 mm.

Three June precipitation waves are well evident also in Bratislava, as stated in the paper by K. Krška and F. Molnár (1980). They correlate very well with the variation of values of dynamical oceanity, while in the curve of occurrence of cyclonic situations they are only weakly marked (this gives testimony of great precipitation intensity).

3.2 Variations of diurnal precipitation and of precipitation probability in July and August

The four remaining monsoon precipitation waves, as determined by Flohn, fall to July and August. In the variation of diurnal precipitation the fourth monsoon wave is intensely felt only at Czech stations, partly in Slovak lowland stations (Hurbanovo, Trebišov) at the end of the 2nd July pentade, a slight increase in the frequencies of precipitation days during Atlantic situations being observed at Jizerka only. In the total amount of precipitation this wave is only manifested thanks to a conspicuous increase in precipitation during Mediterranean situations. At some stations (such as Nové Město na Moravě, Štrbské Pleso) a slight increase in precipitation appeared at the end of the 2nd pentade during Atlantic situations which, however, was not projected into the total variation. The most intense share in precipitation in the above increase was that due to situations B, C, NEc, Bp, from the Atlantic ones chiefly Wal, partly also NWc and Wc, but they did not reach the importance of the former ones.

The fifth wave given by Flohn, M 5, evidently corresponds to a conspicuous increase in precipitation in the 4th and 5th July pentades with the main peak in the 4th pentade, when the stations in the east of the Republic, but also Jizerka and Nové Město na Moravě reached their highest summer values. At Bohemian stations there was a marked prevalence in the probability of precipitation days of Atlantic situations above Mediterranean ones, keeping to a certain extent also in the precipitation amount, mainly during situations Wc, Wcs, Wal, SWc_{2-3}, and Vfz. In Slovakia the conspicuous peak in precipitation in the 4th July pentade was above all due to exceedingly high precipitation at situation B and C, situations NEc, Bp, Ec also taking a significant part in the total increase. In this case the above precipitation wave was due to the effect of Mediterranean situations. At Štrbské pleso and at Medzilaborce there was an increase in precipitation during Atlantic situations about 20 July, but it was not reflected in the curve of diurnal precipitation (being caused mainly by situations Wal, Wcs, Wc, and SWc_2).

Two monsoon precipitation waves adjudged to August by Flohn are well perceptible in the prevalence of precipitation probability of Atlantic situations over Mediterranean ones in the first two August decades. Practically, with the exception of stations in the Danube valley where the prevalence of Atlantic situations in the 1st August decade is not so evident, it is possible to find two peaks in the middle of the 1st of the 2nd decade. On the whole precipitation probability reached above average values only at Bohemian stations (at the station Jizerka about 20 August maximum for the whole summer), otherwise it varid about the average or below it, as with relatively high values of precipitation probability during Atlantic situations the probability of precipitation during Mediterranean situations dropped deep. Mediterranean situations reached their minimum mostly in the 2nd decade. K. Pejml (1970), in processing precipitation probability at Jičín (period 1951—1960), also found a conspicuous rise in precipitation probability in the period of 14—23 August which in his opinion due to storm activity (in August storms reached their maximum there). From approximately the middle of August the variation of precipitation probability of both situation groups was antagonistic — during Mediterranean situations the frequencies increased (up to the middle of the 3rd decade), during Atlantic ones they dropped. At most of the stations two precipitation waves were registered, the first at the end the 1st decade, the second at the beginning of the 3rd decade of August. The first was conditioned by Atlantic situations, the second by Mediterranean ones. About the middle of August an increase was observed at stations in the western part of Bohemia (Cheb, Prague, Teplice), which was also conditioned by Atlantic situations (mainly situations SWc_3, Wcs, Wc and Wal). The greatest share in the precipitation peak at the beginning of the 3rd decade was that of situations B, C, NEc, SWc_1, and Ec. An increase in precipitation due to Atlantic situation with maximum about 10—11 August an at the end of the 2nd August pentade also appeared in the east of the CSSR (Medzilaborce, Trebišov), even though precipitation under Mediterranean situations had a share in the second peak.

The period of lower diurnal precipitation separating the individual precipitation waves was most conspicuous about the middle of June and towards the end of August, further during the first July decade (thus at Cheb as early as about 3 July, in the east of the Republic as late as about 11 July), at the turn of July and August and during the 3rd August pentade. In those periods precipitation probability also acquired values below the average.

4. TEMPORAL CHANGES IN VARIATIONS OF DIURNAL SUMS OF PRECIPITATION AND OF PRECIPITATION PROBABILITY ON THE TERRITORY OF THE CSSR IN THE PERIOD OF 1901—1975

As stated in the paper by R. Brázdil and I. Moll (1981), the occurrence of the corresponding increases and decreases in precipitation in periods of the same length but differently chosen as for time can differ. A method of regression analysis with a correlation coefficient as the rate of similarity which was stated for 10 selected stations (see Tab. 2 of the above paper) was elaborated for evaluating the similarity of variations of diurnal precipitation. From them the stations Prague-Klementinum, Jizerka, and Hurbanvo were chosen for documenting the variability of the phenomenon studied. For each of them the variations of diurnal sums of precipitation and of precipitation probability of the summer in the periods of 1901—1925, 1926—1950, 1951—1975, 1901—1950, and 1901—1975 were pictured in Fig. 4 with marked data of occurrence of monsoon precipitation waves according to data by H. Flohn (1954).

The corresponding increases in precipitation activity in the values of diurnal sums of precipitation and of precipitation probability differ in various periods both in intensity and in the date of occurrence and duration. Besides, some of the above monsoon precipitation waves did not manifest themselves at all in some periods. Also differences are evident due to different positions of stations. Despite this, as follows from Fig. 4, the occurrence of the periods of increased precipitation activity corresponding to monsoon waves is a conspicuous feature of the precipitation régime of the summer on the territory of the CSSR (and also of Central Europe). Thus, in the period of 1926—1950 all precipitation waves were evident in the variations of diurnal precipitation and of precipitation probability at Hurbanovo, in the period of 1901—1925 at the station Jizerka (excepting M 5), as well as in Prague-Klementinum. Of course, as documented by the preceding analysis for the period of 1951—1975, not all increases in precipitation must be due to the precipitation influence of the Atlantic Ocean.

5. CONCLUSION

The variation of diurnal precipitation sums of the summer on the territory of the CSSR in the period of 1951—1975 was characterized by several well-expressed precipitation peaks which are often identified with monsoon precipitation waves M 1—M 7 according to H. Flohn (1954). In this paper only those precipitation waves were considered to be due to the Atlantic Ocean (i.e. monsoon waves) when the probabilities of precipitation and its amount during Atlantic situations were higher than during Mediterranean ones. From that point of view precipitation waves arriving at the end of the 2nd and at the beginning of the 3rd June decades (corresponding to M 2) and at the end of the 1st decade in August (M 6), about the middle of August (M 7), at Bohemian stations in the 4th and 5th July pentade (M 5), in the north of Bohemia at the turn of June and July (M 3) were conditioned by the precipitation influence of the Atlantic Ocean. The other periods of higher precipitation in the second pentade of June, at the turn of June and July, at the end of the 2nd July pentade and, besides Bohemian stations, also in the 4th and 5th July pentades were conditioned by the precipitation influence of Mediterranean situations. The onset of some waves is somewhat retarded when compared with the data by Flohn. At some stations precipitation increases that should correspond to monsoon waves are not at all expressed in the total precipitation sum. Monsoon precipitation waves are mostly well perceptible in the variations of diurnal precipitation and of precipitation probability during Atlantic situations.

Despite the regional shift and a different period of procession (Flohn started mostly from data up to 1930) the analysis of temporal changes in the variations of diurnal precipitation and of precipitation probability during the years 1901—1975

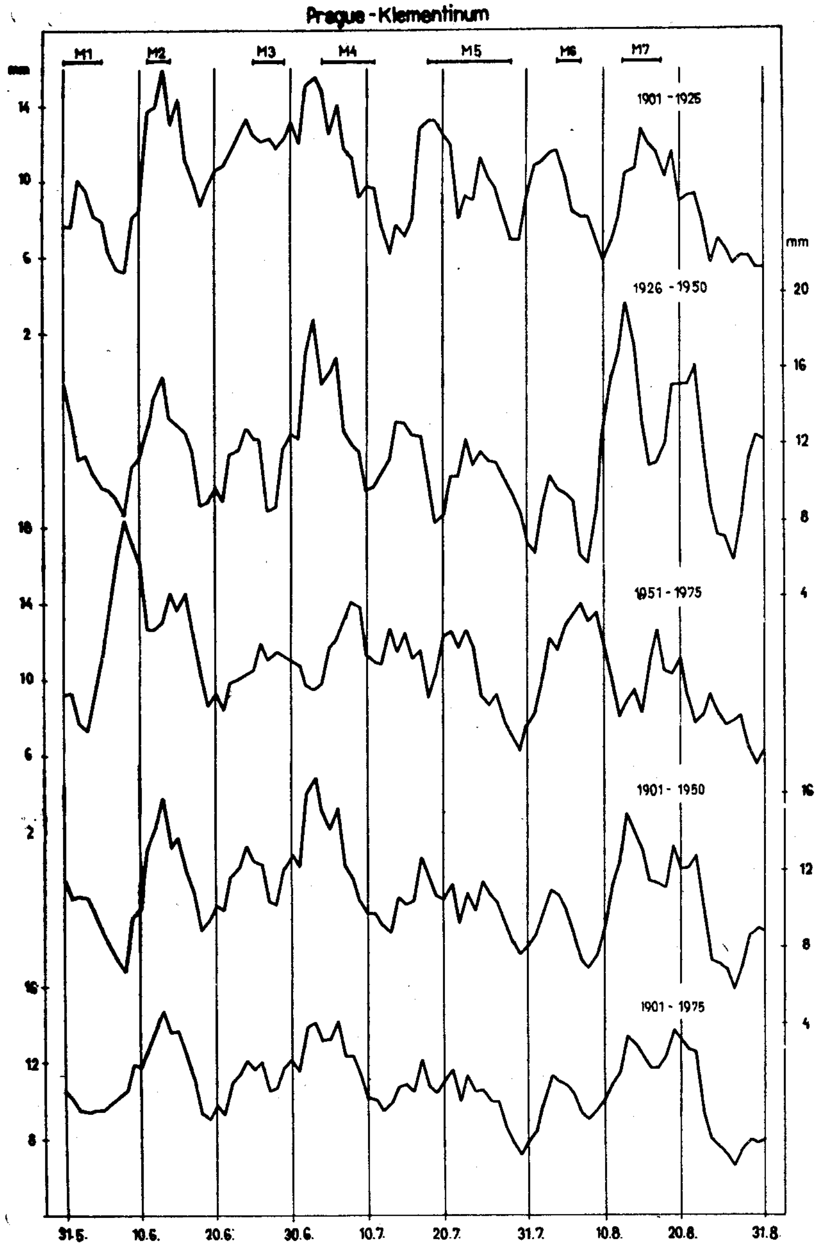


Fig. 4. Variations of diurnal precipitation sums (a) and of precipitation probability (b) of the summer at stations Prague-Klementinum, Jizerka, and Hurbanovo in different periods. Levelled by five day gliding sums and/or averages

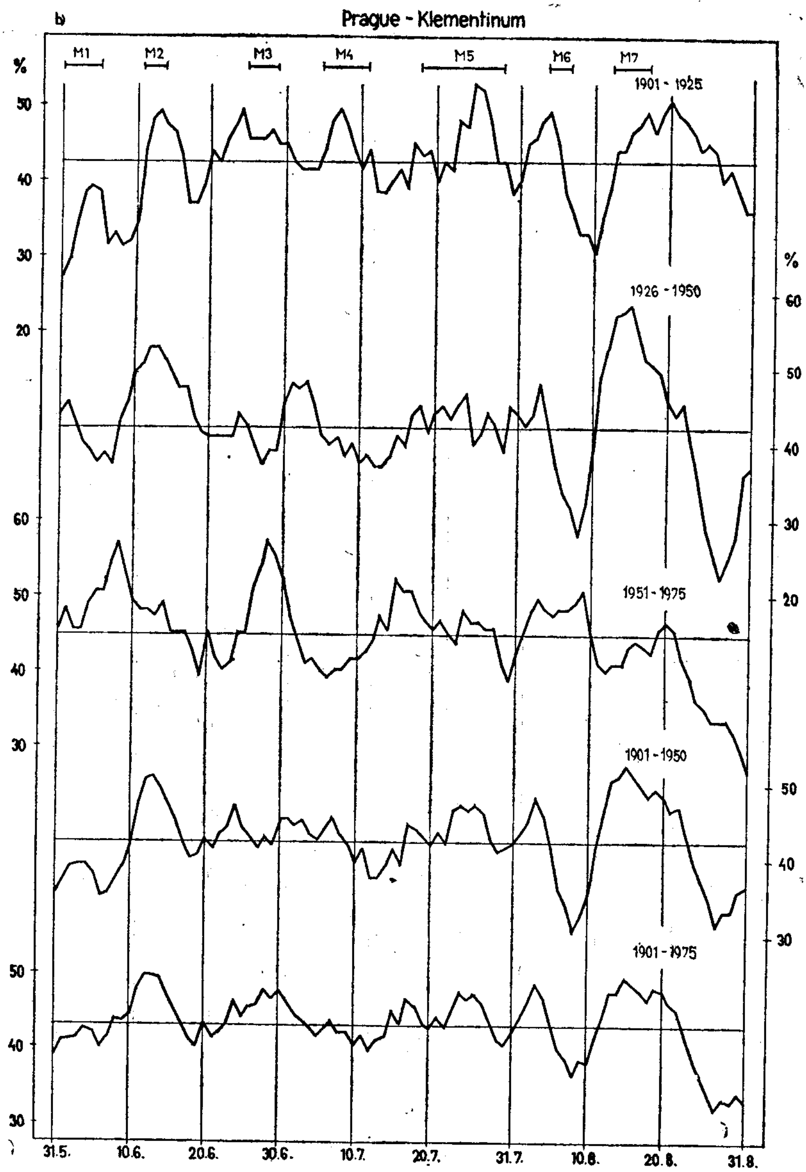

b)
Prague - Klementinum
M1
M2
M3
M4
M5
M6
M7
%
50
40
30
20
60
50
40
30
50
40
30
1901 - 1925
%
1926 - 1950
60
50
40
30
20
1951 - 1975
1901 - 1950
50
40
30
1901 - 1975
31.5.
10.6.
20.6.
30.6.
10.7.
20.7.
31.7.
10.8.
20.8.
31.8.

Fig. 4

Jizerka

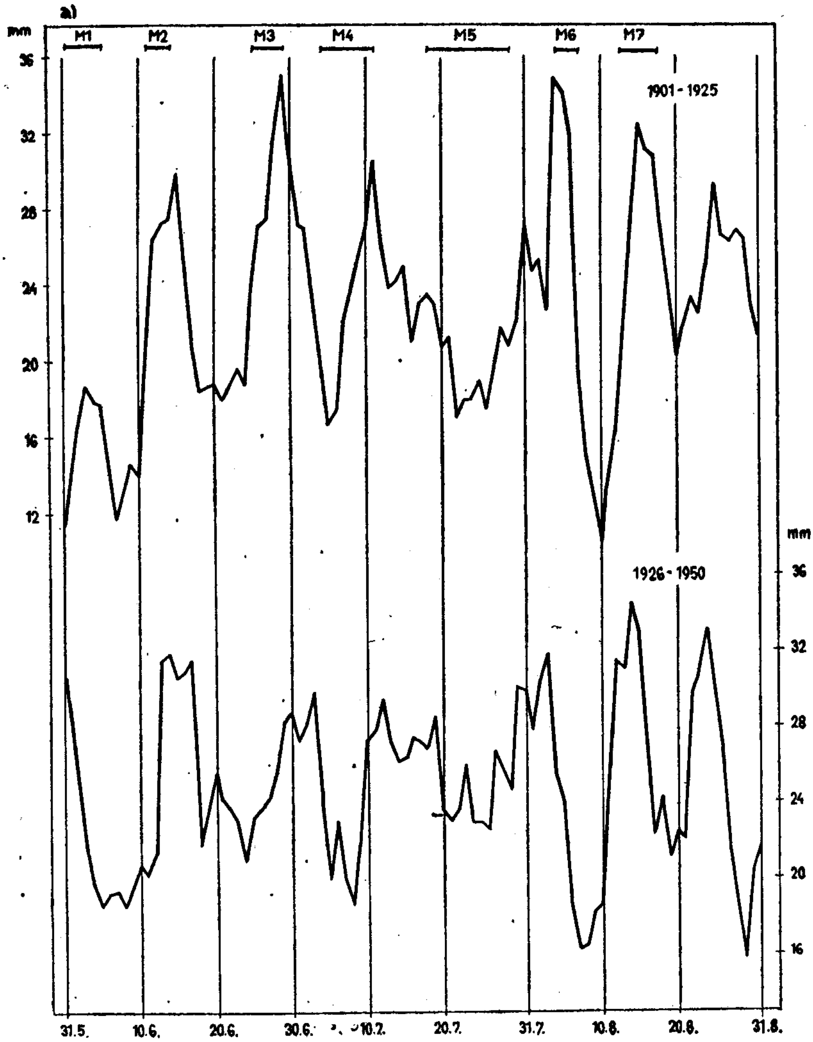


Fig. 4

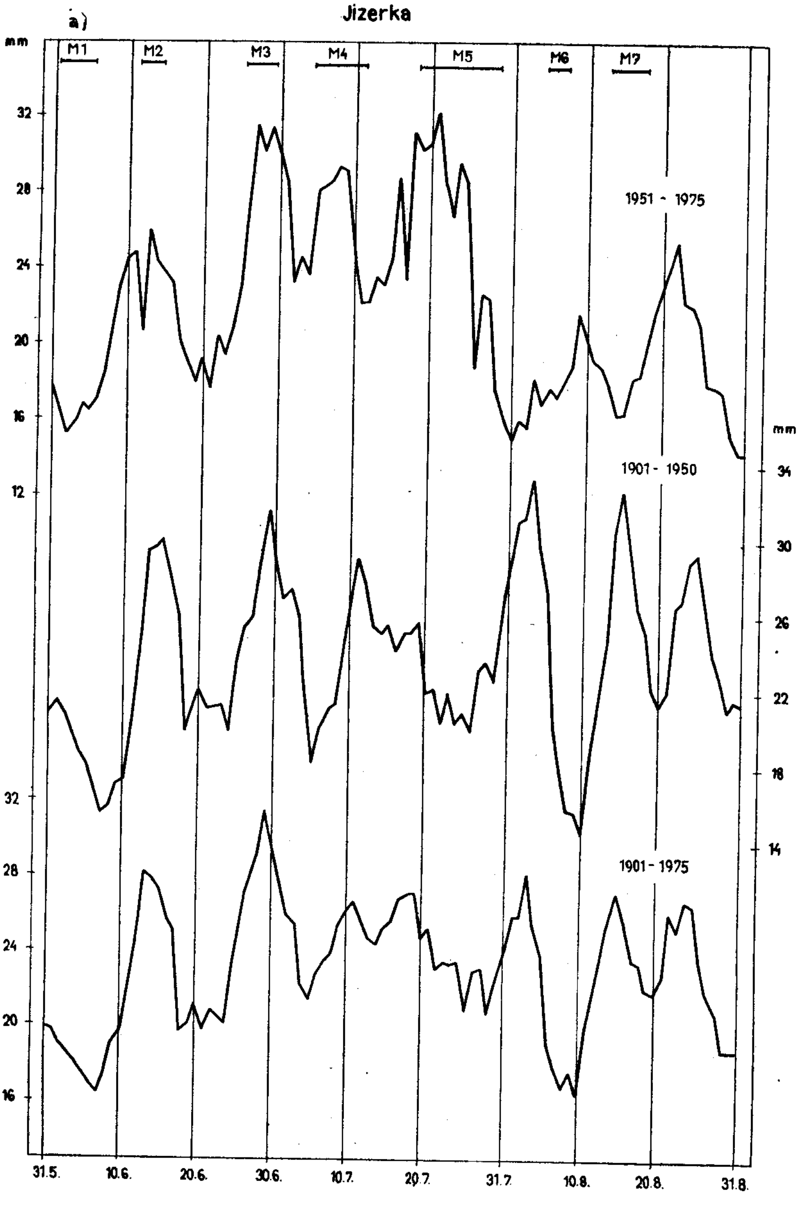

a)
Jizerka
mm
M1
M2
M3
M4
M5
M6
M7
32
28
24
20
16
12
1951 - 1975
mm
34
30
26
22
18
14
1901 - 1950
32
28
24
20
16
1901 - 1975
31.5.
10.6.
20.6.
30.6.
10.7.
20.7.
31.7.
10.8.
20.8.
31.8.

Fig. 4

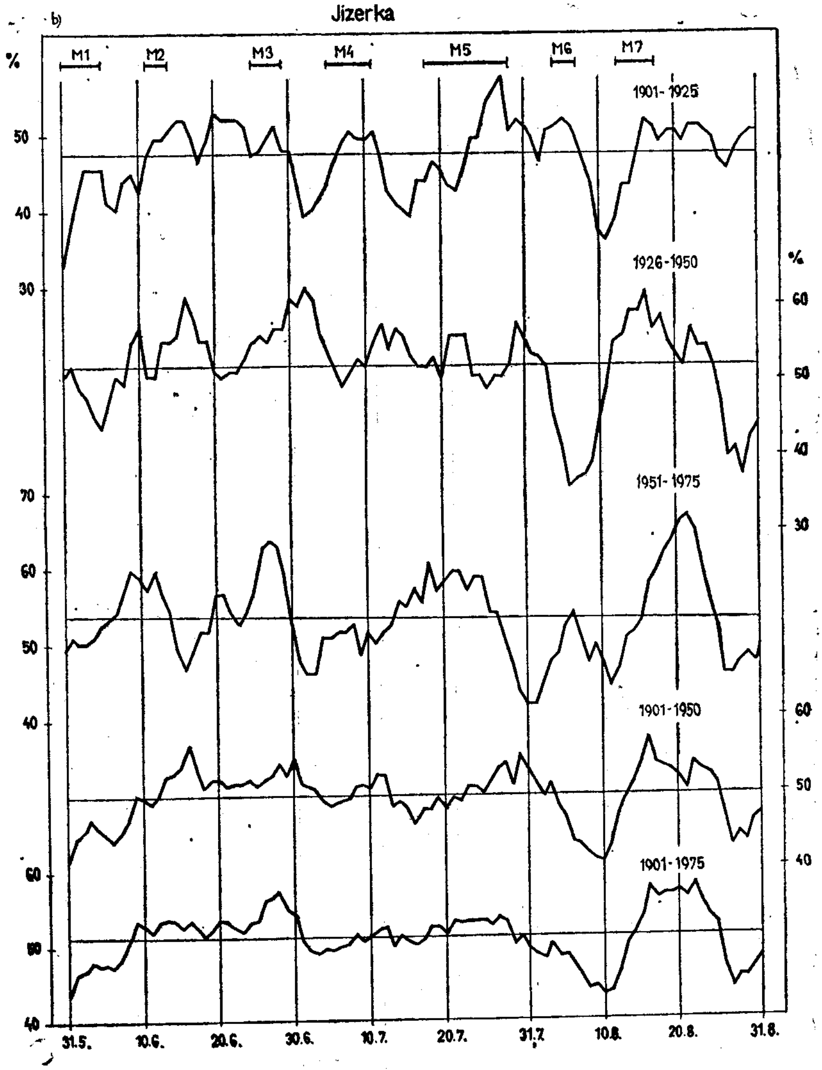

b)
Jizerka
%
M1
M2
M3
M4
M5
M6
M7
1901-1925
1926-1950
1951-1975
1901-1950
1901-1975
50
40
30
70
60
50
40
60
50
40
%
60
50
40
30
60
50
40
31.5.
10.6.
20.6.
30.6.
10.7.
20.7.
31.7.
10.8.
20.8.
31.8.

Fig. 4

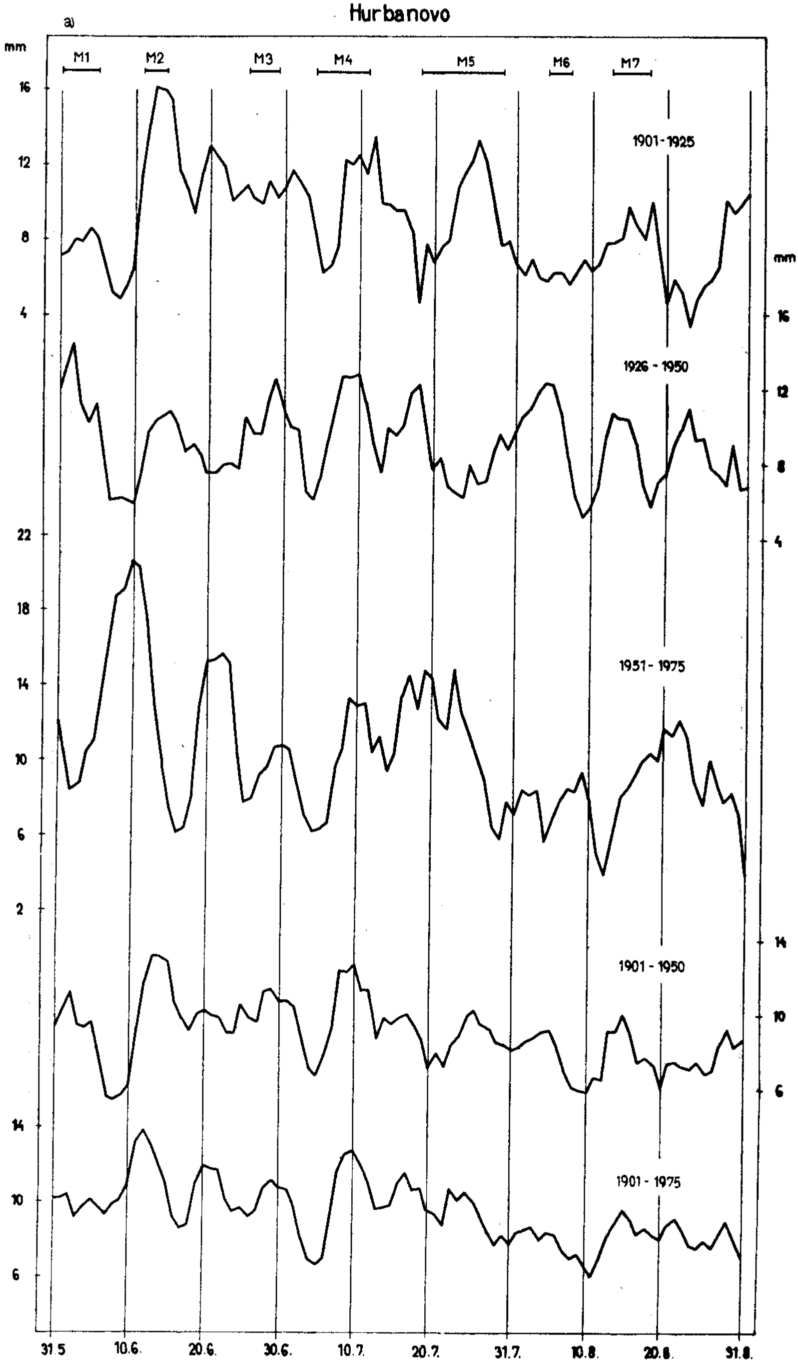
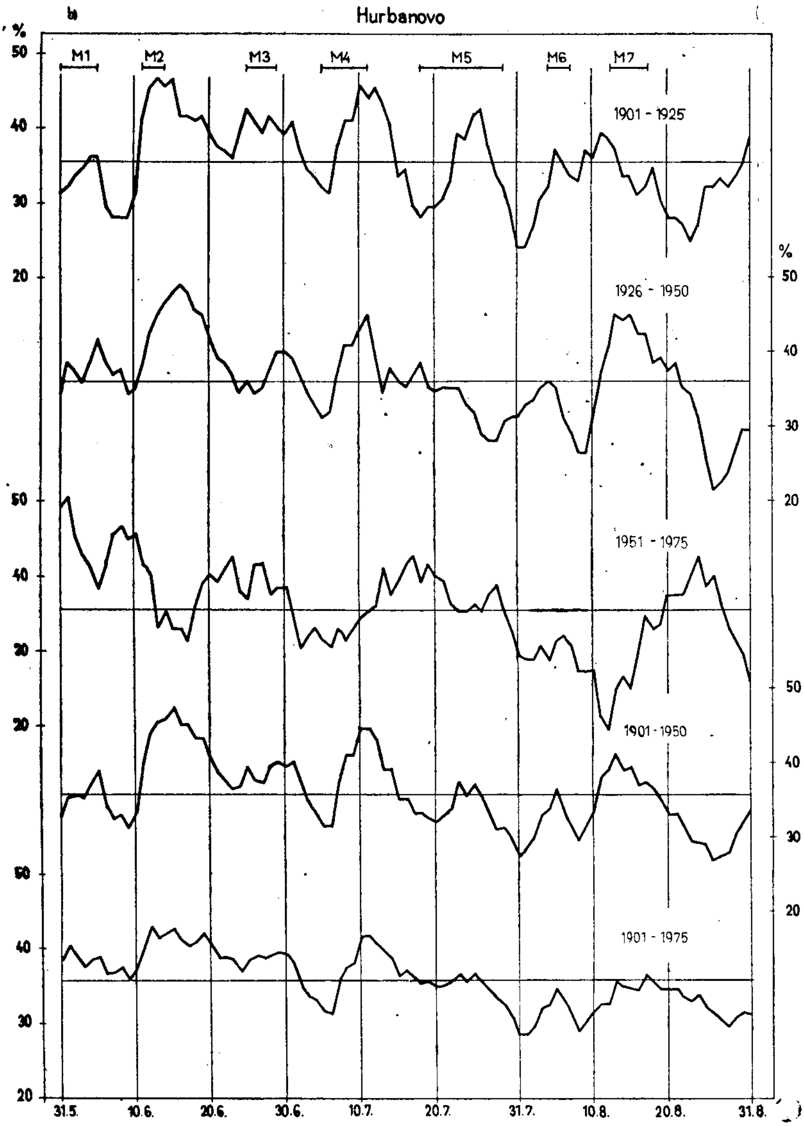

a)
Hurbanovo
mm
M1
M2
M3
M4
M5
M6
M7
1901-1925
1926-1950
1951-1975
1901-1950
1901-1975
16
12
8
4
22
18
14
10
6
2
14
10
6
mm
16
12
8
4
14
10
6
31.5
10.6.
20.6.
30.6.
10.7.
20.7.
31.7.
10.8.
20.8.
31.8.

Fig. 4



Hurbanovo
%
M1
M2
M3
M4
M5
M6
M7
1901 - 1925
1926 - 1950
1951 - 1975
1901 - 1950
1901 - 1975
50
40
30
20
31.5.
10.6.
20.6.
30.6.
10.7.
20.7.
31.7.
10.8.
20.8.
31.8.

Fig. 4

showed that the periods of the precipitation activity of the monsoon precipitation wave in Central Europe keep a relatively high temporal stability and hence they have the character of precipitation singularities and are a conspicuous feature of the régime of precipitation in the summer season. This is in accordance with the conclusion by F. Stuchlík (1962) about a considerable persistence of precipitation singularities.

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