VARIABILITY OF THE DIURNAL COURSE OF RELATIVE AIR HUMIDITY IN THE DISTRICT OF UHERSKÉ HRADIŠTĚ - A CONSEQUENCE OF RELIEF MORPHOLOGY

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SUMMARY

In order to ascertain the influences of the relief on the diurnal course of relative humidity of the boundary atmosphere, two non-traditional criteria of the daily course of this character of humidity were introduced, based on hygrograph registrations at 15 topoclimatic stations in the territory of the district of Uherské Hradiště: the criterion of extremity and the criterion of the humidity character of the diurnal course. Their variations, caused by the height above sea level, were analytically expressed by means of polynomials of degree 2. Thanks to these methods it was possible to state a markedly different influence of the varied morphology of elevations in the western and eastern parts of the territory under study upon vertical variations of the two characteristics, and the extraordinary influences of concave forms of the relief due not only to their form but also to their size. The polynomial presentation was useful in a second step of work, in the compiling of maps featuring the fields of the given criteria of diurnal course of relative humidity, which is applicable to a complex climatological survey of a territory of interest.

INTRODUCTION

Air humidity is a meteorological element whose climatological treatment is not very frequent and more often does not methodologically go beyond the basic statistical processing of terminal measurement samples. In this regard, exceptional in Czech and Slovak meteorological bibliography are in fact only the works by Murínová (1967), Murínová and Ostrožlík (1977 a, b, 1983) or the studies by Kveták (1985 a,b,c,d,e,f,g).

The problems involved here are evidently associated with the accuracy of measuring the characteristics of humidity the necessity of evaluating humidity characteristics jointly with air temperature, and/or a small representativeness of terminal measurements for the assessment of the given course.

In view of what has been said before and of the fact that most climatic characteristics of atmospheric humidity are not very suitable for studies of humidity relations in the boundary atmosphere on the scale of local climate or topoclimate, the

Department of Geography at Masaryk University attempted in the early 1980s a non-traditional working out of the diurnal course of relative humidity (Prošek, 1981) to be later applied also for an evaluation of the climate of Brno (Brázdil et al., 1984; Gulčíková et al., 1983) and, during 1990-1993, for the same purpose, in the district of Uherské Hradiště (the basic procession of relative air humidity records over the period from July 1987 to November 1988 was carried out in Hoďáková (1993).

The methodology of elaborating relative humidity on the days with radiation character of the weather is described in more detail in Prošek (1981) and consists in the determination of exceeding mean times of relative humidity extremities from the duly corrected hygrograph registrations, from the first whole 10 % above the daily minimum by 10 % up to 90 % or 95 % in the period of day. The dependence of the exceeding mean times on the level of relative humidity is expressed in the second step of evaluation procedures by regression dependence in according with the nature and evaluation of suitability (by means of the standard error of the arithmetic mean of deviations of empiric values from the regression function) predominantly using equations of the straight line or polynomials of degree 3.

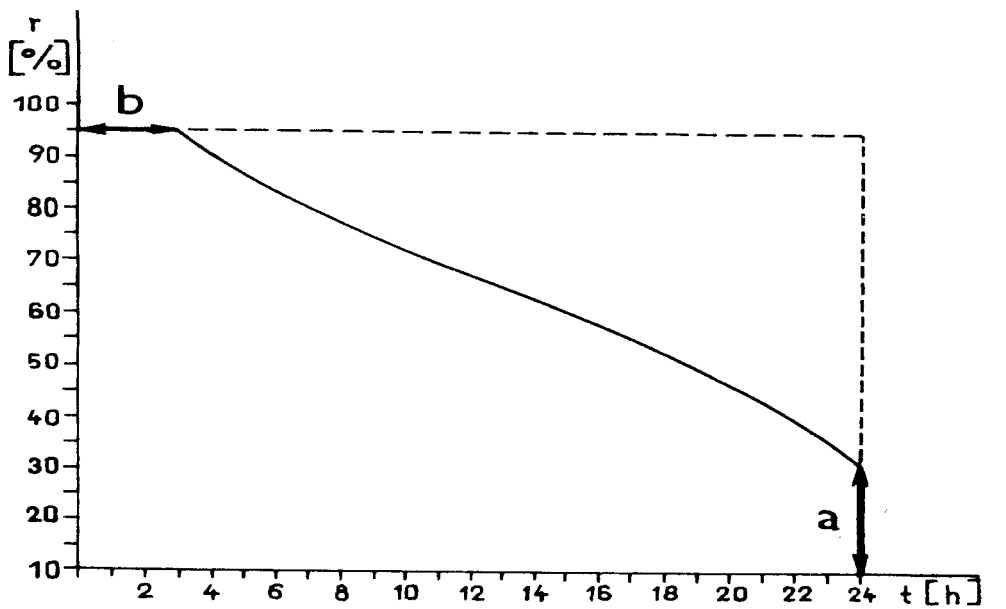

Fig. 1. An example of regression dependence of mean exceeding time on the level of relative humidity in the period of a day, expressed by a polynomial of degree 3. a - criterion of extremity, b - criterion of humidity character of the diurnal course of relative humidity (station Bunč, spring months)

From the course of the regression line, two characteristics of the daily course of relative humidity are subsequently determined:

(1) the criterion of diurnal course extremity (hereafter $\bar{R}_{min}$ only), i.e., the mean value of minimal relative humidity, exceeded 24 hrs a day, defined by point of intersection of the regression line with the axis exceeding time (Fig. 1, Table 1),

(2) the criterion of humidity character of the diurnal course of relative humidity (hereafter Δt_{95} only) defined as the exceeding time of relative humidity 95 % (Fig. 1, Table 1).

Station	height above sea level [m]	spring		summer		autumn	
		$\bar{R}_{min}$	Δt_{95}	$\bar{R}_{min}$	Δt_{95}	$\bar{R}_{min}$	Δt_{95}
Uh. Hradiště-Kunovice	177	13,8	1,5	23,5	3,7	19,6	2,3
Staré Město	212	31,4	0,6	32,5	2,7	33,7	1,4
Velehrad	220	40,6	2,3	41,7	5,6	48,7	9,7
Salaš	262	41,8	4,7	50,8	8,6	51,1	14.7
Chabaně	322	39,6	0,3	48,6	0,9	48,9	1,2
Dubiny	333	41,3	0,9	49,8	2,6	50,0	3,7
Bunč	462	31,5	2,8	41,6	3,0	48,6	7,5
Buchlov	464	29,6	1,1	31,7	2,5	40,9	3,4
Hluk	225	16,5	3,3	20,1	6,7	22,5	8,3
Mistřice	285	31,0	0,9	34,5	3,7	40,0	5,0
Horní Němčí	348	31,4	0,8	36,1	2,4	43,9	2,0
Strání	390	29,0	3,8	27,7	2,3	31,7	3,7
Suchov	444	31,3	0,6	33,6	0,4	42,1	0,0
Nová Lhota	510	31,0	0,4	40,0	2,0	43,5	1,4
Velká Javořina	970	41,0	2,6	46,0	2,7	51,0	2,9

Table 1. Values of the criterion of extremity ($\bar{R}_{min}$[%]) and of the criterion of humidity character of relative humidity diurnal course (Δt_{95} [h]) in spring, summer and autumn months of the period July 1987 - November 1988

The above treatment of hygrograph registrations was carried out separately the spring (March-May), summer (June-August) and autumn (September-November) months.

With a view of accentuating the influences of different parts of the relief only the days with radiation weather conditions were chosen for evaluation (the criteria of this

selection are given, e.g., in the work by Prošek, 1978). The totals of these days are 37 in the spring months of the period under analysis, 65 in the summer months and 34 in the autumn months.

A total of 15 stations were installed in the territory of the district of Uherské Hradiště for use over the given period, equipped with thermographs, hydrographs and August psychrometers (control instruments for determination of registration corrections). They were located globally in the transect from the top parts of the Chřiby hills across the flood plain of the river Morava and the Hluk hilly land (Hlucká pahorkatina) to the main range of the White Carpathians. From a more detailed view, part of the stations represented, in each of the orographic wholes and, in addition to the top parts, also the middle-slope and valley positions (Figs. 6, 7).

The positions of the stations were conditional not only on mere heights above sea level but also on the morphological representativeness. Besides the stations located

Fig. 2	1: $\bar{R}_{min} = -61{,}3 + 6{,}0.10^{-1}z - 8{,}6.10^{-4}z^2$
	2: $\bar{R}_{min} = -61{,}1 + 6{,}5.10^{-1}z - 9{,}5.10^{-4}z^2$
	3: $\bar{R}_{min} = -58{,}1 + 5{,}9.10^{-1}z - 8{,}0.10^{-4}z^2$
Fig. 3	4: $\bar{R}_{min} = 6{,}7 + 7{,}2.10^{-2}z - 3{,}9.10^{-5}z^2$
	5: $\bar{R}_{min} = 15{,}2 + 6{,}5.10^{-2}z - 3{,}5.10^{-5}z^2$
	6: $\bar{R}_{min} = 9{,}3 + 1{,}1.10^{-1}z - 6{,}8.10^{-5}z^2$
Fig. 4	1: $\Delta\bar{t}_{95} = 4{,}0 - 2{,}1.10^{-2}z + 3{,}3.10^{-5}z^2$
	2: $\Delta\bar{t}_{95} = 6{,}8 - 4{,}5.10^{-2}z + 7{,}8.10^{-5}z^2$
	3: $\Delta\bar{t}_{95} = 13{,}6 - 7{,}5.10^{-2}z + 1{,}1.10^{-4}z^2$
	4: $\Delta\bar{t}_{95} = 6{,}4 - 2{,}2.10^{-2}z + 3{,}1.10^{-5}z^2$
	5: $\Delta\bar{t}_{95} = 8{,}3 - 4{,}9.10^{-2}z + 8{,}3.10^{-5}z^2$
	6: $\Delta\bar{t}_{95} = 5{,}0 - 2{,}8.10^{-2}z + 7{,}2.10^{-5}z^2$
Fig. 5	7: $\Delta\bar{t}_{95} = 2{,}8 - 9{,}0.10^{-3}z + 9{,}3.10^{-6}z^2$
	8: $\Delta\bar{t}_{95} = 5{,}1 - 1{,}0.10^{-2}z + 8{,}2.10^{-6}z^2$
	9: $\Delta\bar{t}_{95} = 3{,}4 - 7{,}0.10^{-3}z + 6{,}6.10^{-6}z^2$

Table 2. Equations of polynomials of degree 3, presented graphically in Figs. 2-5 (in figures numerated in the circles)

in the flood plain of the Morava river, or on the border of it (Uh. Hradiště - Kunovice and Staré Město), the following positions were chosen as representative in the area of the Chřiby hills: positions of the valley bottoms separating the individual ridges which run from the top levels toward the east (Velehrad and Salaš), medium height levels of these ridges (Chabaně and Dubiny), and the highest top parts (Buchlov,

Bunč). In the part lying east of the Morava river were then chosen: valley positions (Hluk) and the levels of elevations in the Hluk hilly land (Mistřice), foothill ridges of the White Carpathians (Horní Němčí), parts of their ridges running out from the main ridge (Suchov, Nová Lhota), valley positions which separate these ridges (Strání), and the top parts (Velká Javořina).

For the purpose of an analytical expression of the dependence of the two criteria of the relative humidity diurnal course upon the height above seal level, polynomials of degree 2 were used (Figs. 2-5, Table 2); these, however, were not employed at some of the stations (see further) which were departing from the predominant trend of vertical change in the characteristic concerned.

RESULTS AND DISCUSSION

As can be seen from the graphic presentation of the vertical variations in both criteria (Figs. 2-5), they vary partly with the season of the year, partly (and that quite more markedly) in both main parts of the territory under investigation, that is, between the Morava flood plain and Chřiby hills on the one hand and betwen the Morava flood plain and the range of the White Carpathians on the other hand. This regional difference is due, above all, to the different morphology of the both areas, which can be briefly characterized as follows: typical of the eastern part of the Chřiby hills are narrow and rather conspicuous ridges running from the highest elevation levels and separated by deep-cut valleys of the dextral tributaries to the Morava, whereas the relief of the Hluk hilly land is soft, with typical rounded elevations, separated by wide-open valleys and gradually continuing eastward into the massif of the White Carpathians.

As it follows from Fig. 2, variation of $\bar{R}_{min}$, depending upon the height above sea level, in the western part of the territory under study, shows essentially the same course during all the seasons of the year. The most extreme diurnal course of relative

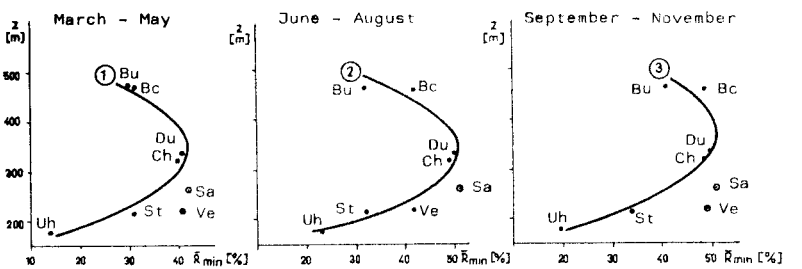

Fig. 2. Dependence of the criterion of extremity of the diurnal course of relative humidity (R_{min}[%]) on the height above sea level (z [m]) in the western part of the district of Uherské Hradiště in spring, summer and autumn months of the July 1987 - November 1988, expressed by polynomials of degree 3

humidity, (i.e., minimum R_{min} values) occurs at the lowest heights above sea level (Uh. Hradiště-Kunovice, Staré Město), the extremity rapidly falling (R_{min} is increasing) with the growing heights above sea level to reach minima at the middle heights of the Chřiby hills (Dubiny, Chabaně), from where it again increases up to the top levels (Buchlov, Bunč). A comparison of the R_{min} values with the daily mean temperature amplitudes (T_A) and the daily mean temperature maxima (T_{max}) (Table 3) documents that the extremity of the diurnal course of relative humidity is influenced at the lowest to middle heights most of all by the extremity and the level of the daily course of temperature. Surprising, however, is the increase in extremity from the middle to the highest elevations of the Chřiby hills (explicitly evident mainly in spring), whose T_A and T_{max} are comparable or smaller than those at the stations located at middle heights. The only possible explanation of this fact is the decreased evaporation at generally lower temperatures and a good ventilation of the highest parts of the Chřiby hills by day.

Polynomial relationships are beyond compare in all the seasons under study at the Velehrad and Salaš stations. While there are no substantial differences between these two stations in the spring and autumn periods, the summertime extremities recorded at the Salaš station are substantially lower than those of the Velehrad station. Both these stations are closest to the polynomial dependence in this period. That means that, thanks to the smaller shading of the valley parts in summer, their temperature and humidity relations approximate the trend of variation with the height above sea level. The diurnal course of relative humidity in the area of the Salaš station in summer is due to sufficient evapotranspiration at higher summer temperatures and to the full development of vegetation in the wooded and deep-cut, relatively narrow valley of the

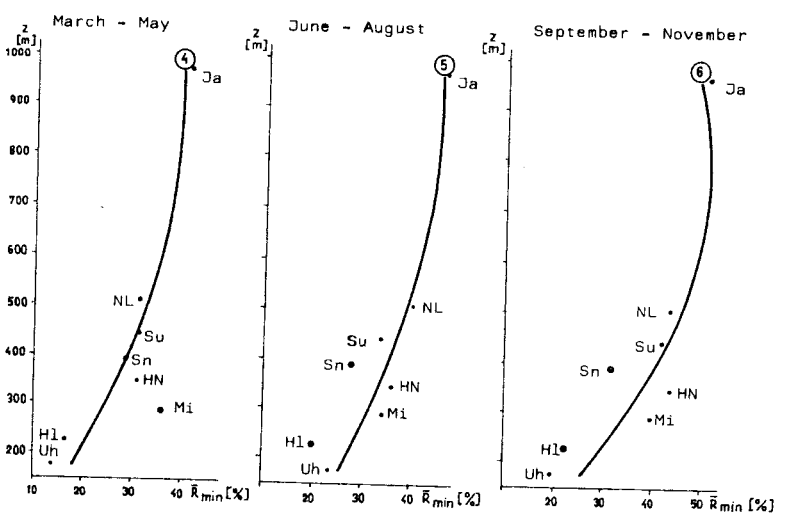

Fig. 3. For text see Fig. 2 - in the eastern part of the district of Uherské Hradiště

Station	spring			summer			autumn		
	T_{max}	T_{min}	T_A	T_{max}	T_{min}	T_A	T_{max}	T_{min}	T_A
Uh. Hradiště -Kunovice	19,1	3,8	15,3	26,2	10,9	15,3	21,0	7,1	13,9
Staré Město	15,2	3,1	12,1	25,8	13,1	12,7	19,8	10,3	9,5
Velehrad	17,9	3,3	14,6	25,7	10,8	14,9	19,7	7,2	12,5
Salaš	18,5	3,6	14,9	25,8	10,8	15,0	19,8	7,1	12,7
Chabaně	16,3	5,8	10,5	25,4	13,4	12,0	19,1	9,3	9,8
Dubiny	17,1	5,9	11,2	24,6	13,1	11,5	18,4	9,1	9,3
Buně	15,6	4,3	11,3	22,5	11,8	10,7	17,7	8,2	9,5
Buchlov	15,3	4,7	10,6	23,2	12,2	11,0	17,9	8,7	9,2
Hluk	19,1	4,0	15,1	27,2	11,1	16,1	21,1	7,5	13,6
Mistřice	18,5	5,7	12,8	25,4	12,7	12,7	21,3	11,1	10,2
Horní Němčí	17,9	4,5	13,4	25,6	12,7	12,9	18,9	9,8	9,1
Strání	19,9	4,7	15,2	27,3	12,4	14,9	21,0	7,4	13,6
Suchov	17,3	5,6	11,7	25,2	13,1	12,1	18,5	9,9	8,6
Nová Lhota	16,0	5,8	10,2	24,4	13,2	11,2	18,4	10,1	8,3
Velká Javořina	11,7	4,7	7,0	19,5	11,9	7,6	13,6	8,0	5,6

Table 3. Mean daily maximum and minimum temperatures of air (T_{max} , resp. T_{min} [°C]) and mean daily temperature amplitudes (T_A[°C]) on days with radiation character of weather at stations of the district of Uherské Hradiště in spring, summer and autumn months in the period of July 1987 - November 1988 (according Kumhalová, 1990)

Salaš brook. The space in the valley is slightly ventilated in the day-time and therefore the air enclosed there becomes saturated with water vapour to a higher degree than is the case in the more open section of the valley in the area of Velehrad, or in the top positions.

Apparently, in spring and autumn, the main cause of decreasing extremity of the daily course of relative humidity is to be sought in the lower values of daily temperature maxima (Table 3) taking part in the decrease of the daily amplitude of relative air humidity.

Unlike the eastern parts of the district, the western part does not practically show any increase in extremity with the height above sea level in the upper part of the profile (Fig. 3). Moreover, typical of the area between the Morava flood plain and the White Carpathians is only its insignificant decrease with the height. Both diffrences are evidently conditional on the different relief morphology as described above. In this part of the station profile, too, there appear deviations from the prevailing character of the vertical variation of R_{min}, and that at the stations of Hluk, Strání and Mistřice (at the first two mainly in summer and autumn months). However, typical of both these

lowland stations, in contrast to the lowland stations of the Chřiby (Velehrad, Salaš), is the increase in extremity with regard to the analytical course of the vertical R_{min} variation. In evaluating this difference, the decisive factor responsible for it can be seen in the area of the cross profile of the valley, making up for the particular valley stations as follows: Salaš - 133,300 m^2, Velehrad - 50,300 m^2, Hluk - 302,500 m^2 and Strání - 905,900 m^2. The markedly smaller volume of the valley area around the stations of Salaš and Velehrad, to wit, brings about its saturation with water vapour in a greater degree than is the case at the stations of Hluk and Strání, which is reflected in decreased extremity of the diurnal course of relative humidity. Search for the cause of the low extremity at the Mistřice station in spring months is a difficult task. Considering the fact that, together with the Horní Němčí station, this station somewhat deviates in all the seasons investigated, in terms of extremity, from the analytical dependence towards higher R_{min} values, we can express an assumption based on the analogous position of the two stations on, or near to, the little rounded peaks of the elevations of the Hluk hilly land. In those places, the extremity of the diurnal course

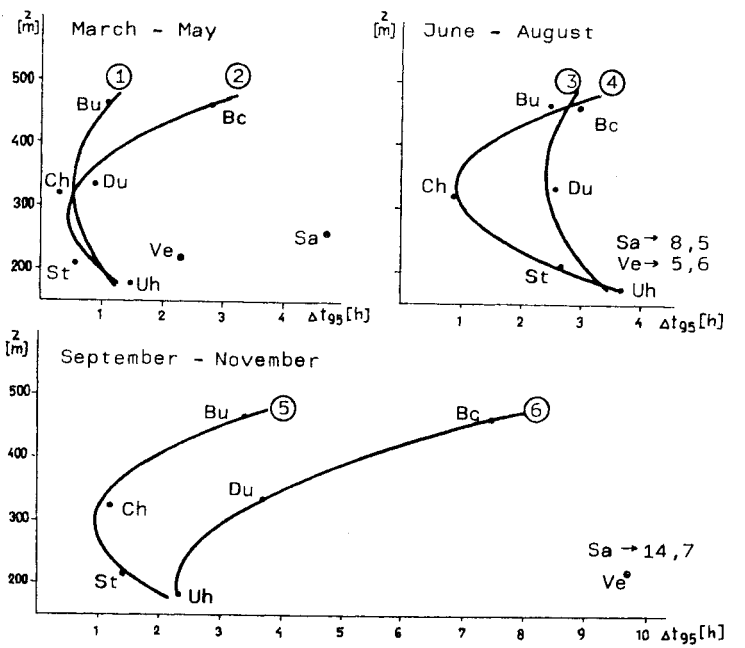

Fig. 4. Dependence of the criterion of humidity character of the diurnal course of relative humidity (Δt_{95}[h]) on the height above sea level (z[m]) in the western part of the district of Uherské Hradiště in spring, summer and autumn months of the period July 1987 - November 1988, expressed by polynomials of degree 2.

is evidetly lower in comparison with the flood plain of the Morava river in terms of both a lower level of T_{max} and a better ventilation.

Variations of Δt_{95} with the height had to be formulated for two partial vertical profiles of the stations: Uh. Hradiště-Kunovice - Staré Město - Chabaně - Buchlov and Uh. Hradiště-Kunovice - Dubiny - Bunč, whose relations vary significantly with the season of the year (Fig. 4). At the same time, typical of all the stations is a shortening of Δt_{95} from the bottom of the Morava valley to the middle height levels, which is apparently caused by temperature conditions. In the wide flood plain of the Morava river, an accumulation occurs at night because of the radiation of the cooled air (Table 3).

A lower level of temperature in the lowest parts (Uh. Hradiště-Kunovice) signifies better conditions for atmosphere saturation and hereby also for a longer duration of relative humidity greater than 95 %.

The differing intensity of Δt_{95} variations in the middle to the highest parts of the Chřiby hills is probably related to the prevailing character of the active surface. In the first of the profiles mentioned above there predominates farmland and/or grassland, which is reflected in a lowered level of Δt_{95}. In the second profile, on the contrary, there are more or less continuous woods, whose evapotranspiration brings about a longer duration of high relative humidity. Also, a prolongation of Δt_{95} from the middle to the top parts of the relief corresponds with the downward trend of minimum temperature with the height (Table 3), whose effects, together with the influences of the predominant character of the active surface, also cause differences between the top stations of Buchlov and Bunč (chiefly in spring and autumn).

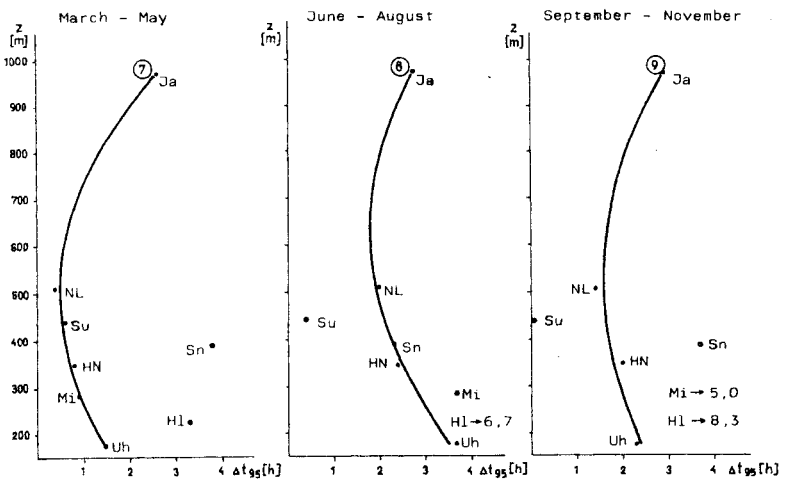

Fig. 5. For text see Fig. 4 - in the eastern part of the district of Uherské Hradiště

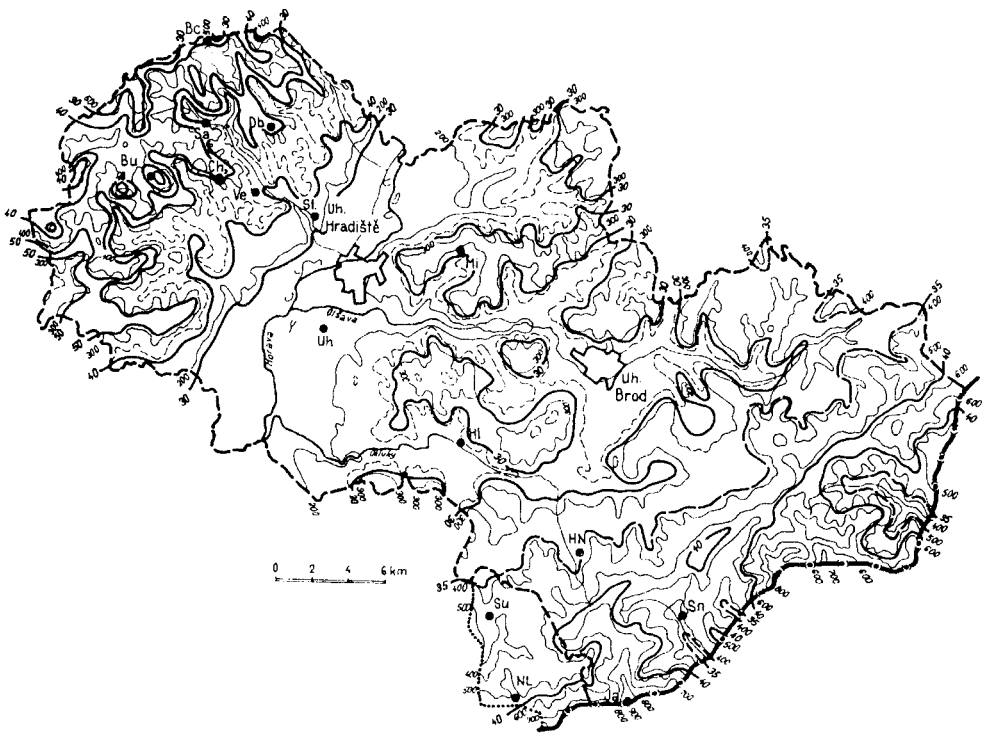

Fig. 6. Generalized map of the field of the criterion of extremity of the diurnal course of relative humidity in the district of Uherské Hradiště in summer months. Abbreviations: UH - Uherské Hradiště-Kunovice, St - Staré Město, Ve - Velehrad, Sa - Salaš, Ch - Chabaně, Du - Dubiny, Bc - Bunč, Bu - Buchlov, Hl - Hluk, Mi - Mistřice, HN - Horní Němčí, Sn - Strání, Su - Suchov, NL - Nová Lhota, Ja - Velká Javořina

In the case of Δt_{95} evaluation we also meet with values of this characteristic markedly deviating from the analytically formulated dependence at the stations Velehrad and Salaš, where the Δt_{95} values are extremely high especially in summer and autumn. They evidence the strong cooling effect of the relatively large hillside area on the atmosphere of the valley which turns quickly cool in the evenings and warms up very slowly in the mornings. These processes are, of course, most pronounced in the deep-cut part of the valley featuring steep slopes (Salaš).

The decrease in Δt_{95} values with the height above sea level approximately up to half the height difference between the Morava valley and the main range of the White Carpathians, and the re-prolongation up to the ridge levels have, in a less marked form, similar character and causes like in the western part of the territory (Fig.5). In all seasons of the year under analysis, the effects of the formation and accumulation of

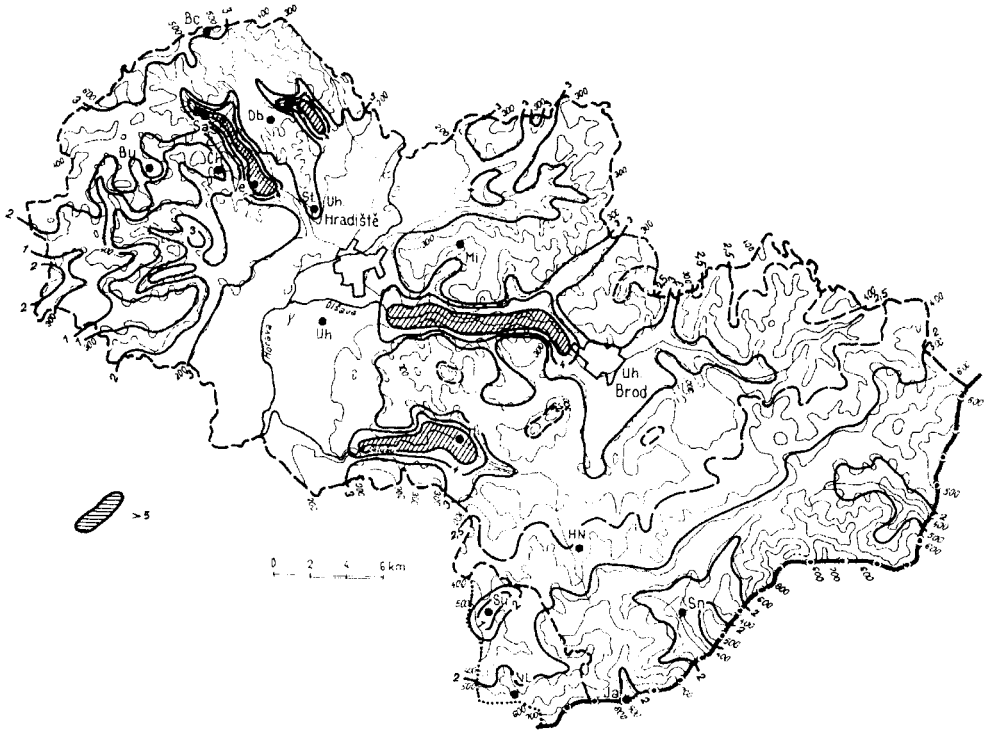

Fig. 7. Generalized map of the field of the criterion of humidity character of the diurnal course of relative humidity in the district of Uherské Hradiště in summer months. For explanations see Fig. 6

cool air upon the increase of Δt_{95} in the valley parts (Hluk, Strání) are seen, here as well, to depend on the morphology of the valley. For example, the station at Strání shows, in summer, the smallest effect of the above air conditions thanks to the wide area of the valley and thus to a less intense cooling of its atmosphere.

In the summer and autumn periods, differences between the Mistřice and Suchov stations (in similar positions, both being located at the higher levels of the convex forms of the relief) are worthy of being noted. The relatively short duration of Δt_{95} at Suchov is apparently due to its location in a saddleback, separating the highest valley parts of streams. The high values of Δt_{95} at the Mistřice station are probably influenced by the stagnation of the air cooling down on the flat, elongated top of one of the Hluk hilly land elevations.

CONCLUSIONS

Analytical formulations of the dependence of the two criteria of the diurnal course of relative humidity on the height above sea level were used at the final stage of this study for the construction of isolines maps presenting the spatial distribution of $\bar{R}_{min}$ and Δt_{95}.In compiling these charts account was also taken to local specific features, resulting from the position of some stations and described in the foregoing text. Figures 6 and 7 may serve as examples of such analytical climatic maps compiled for each season of the year. The cartographic presentation of the results was motivated, similar to the presentation of temperature characteristics from the given territory (Kumhalová, 1990) by a prospective application in creating a climatological information system for the territory of the district of Uherské Hradiště.

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