THE ALTITUDE SYSTEM OF RAINFALL IN THE MÁTRA HILLS

by

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A csapadék magassági rendszere a Mátra hegységben. A tanulmány a tengerszint feletti magasság és a csapadékmennyiség összefüggését vizsgálja a Mátra-hegység területén. Megállapítja, hogy ez az összefüggés tavasszal és ősszel szorosabb, mint nyáron és télen. A számított és a mért csapadék mennyiségének összevetésével meghatározza a Mátra orografikusan csapadékhiányos és orografikusan csapadéktöbblettel rendelkező területeit.

The study investigates the correlation between the height above sea level and the quantity of precipitation in the area of Mátra Hills. It points out that this correlation is closer in spring and autumn than in summer and winter. It determines the areas of Mátra Hills having orographically lack and orographically surplus of precipitation by the comparison of the quantities of the calculated and the measured precipitation.

The Mátra Hills is a part of the Hungarian Mountains of Medium Height. Its area is about 1000 km^2. Its extension can be decided by the following geographical coordinates: North Latitude 47° 40'— 48°10' (north-south extension). East Latitude 19°28'—20°25' (east-west extension). Its highest summit is Kékestető (1015 m).

It is a well-known fact that with the increase of the height above the sea level (to a certain height) the quantity of rainfall is increasing. The influence of the mountains made on the rainfall is caused by well-known physical reasons and regularities. In our paper we are going to reveal the relations between the height above the sea level and the quantity of rainfall referring to the Mátra.

The data of 64 rainfall-measuring stations found on the territory served as materials to our research with the rainfall-averages of 1949—78 among them. For 34 stations the whole 30 years series were at our disposal, while at the other 30 stations we found 10—19 years old (not full) series. So in the latter cases we considered reduced, 30 year-old averages.

The average height of the rainfall measuring stations is 300,1 m, its streoscopic position is shown on *Figure 1.*

Let us see on the hypsographical curve how the height of the examined area joins with the area itself *(Fig. 2)*. The average height of the examined area is 279,5 m, so the average height of the rainfall measuring stations is approaching this value, and the network of our stations gives representative data for the examined territory. We have examined the changes of rainfall according to height, its monthly averages in the function of height. On the basis of the data being available according to height levels we regard height an independent variable, while the quantity of rainfall a dependent variable. Representing the pairs of value in a system of co-ordinates, we receive the multitude of different points *(Fig. 3.)*

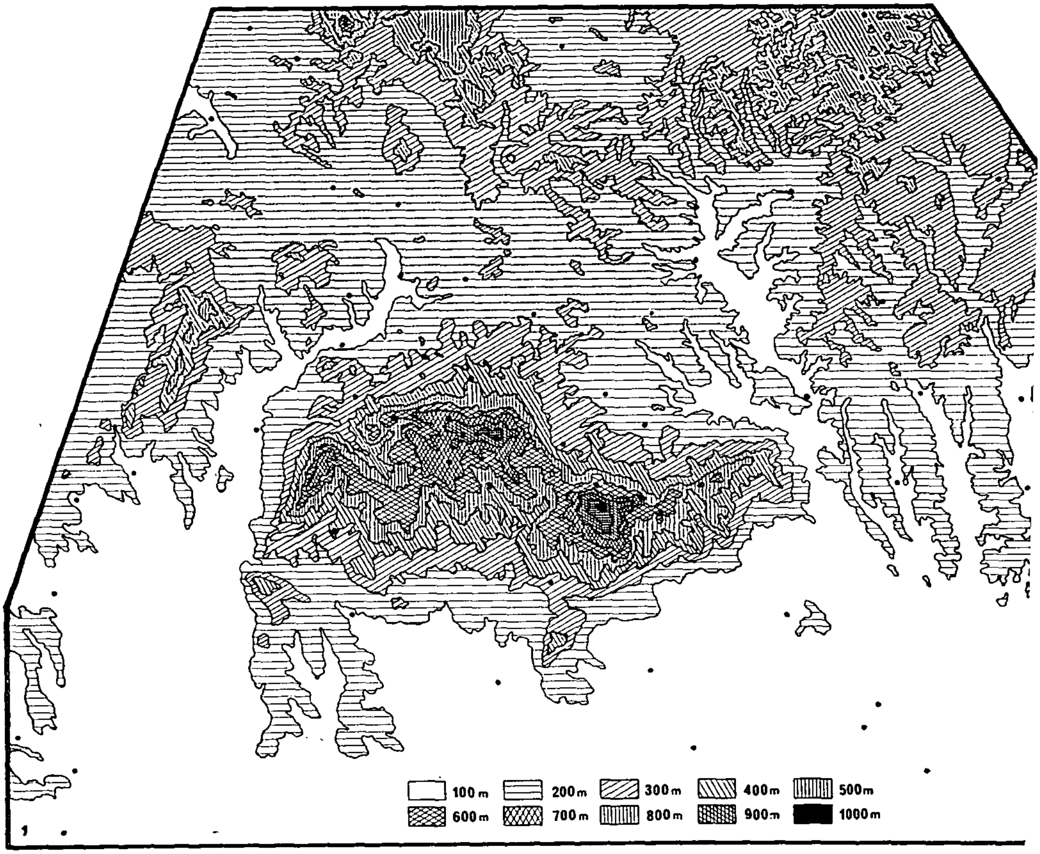

Fig. 1. Contour line map of the Mátra Hills with network of stations

The relation shows an unambigously linear connection of stochastic character, which can be described with the following formula:

$$y = a_0 + a_1 x \tag{1}$$

y = quantity of rainfall x = height.

Determining the equation of the straight which approaches best the observed data the *Table 1* contains the constants in monthly, annual groups and according to the seasons of the year. We marked in it as well the co-efficient of correlation between the amount of rainfall and the height above the see level (r), and the territorial average of the rainfall (y) and its standard deviation (s).

Constant a_1 gives the increase of rainfall falling on the height, its annual way is shown in *Figure 4*. In the annual course of constant a_1 typical double wave can be observed. We distinguish a summer maximum (June, July) and an autumn secondary maximum, as well as a January minimum and a September secondary minimum. According to our assumption the annual course is influenced by two factors: the frequency of the average rainfall outputs and the average rainfall. The reason for the summer maximum is the fact that the one-day rainfall outputs are the greatest; the

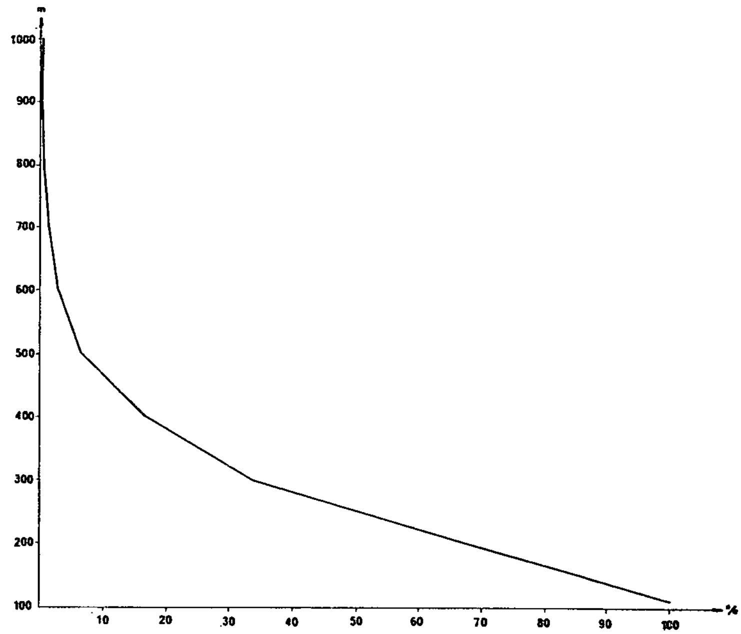

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Fig. 2. Hypsographical curve concerning the Mátra Hills

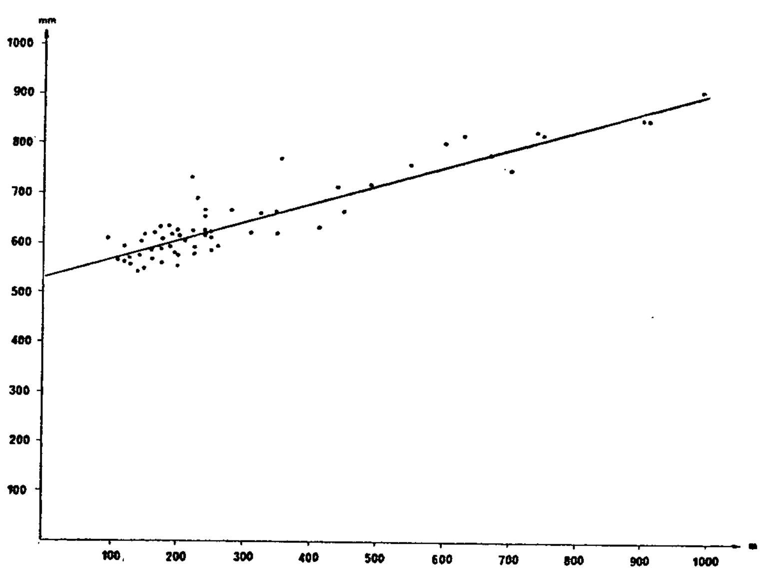

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Fig. 3. Relation between the quantity of the annual average rainfall and the height above see level

Table 1

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year	Spring	Summer	Autumn	Winter
r	0,787	0,783	0,901	0,922	0,893	0,837	0,669	0,625	0,795	0,888	0,839	0,777	0,919	0,933	0,799	0,892	0,801
a_0	29,94	30,18	25,02	37,18	52,33	74,00	59,98	59,93	37,88	35,43	47,36	44,26	534,57	114,53	193,58	120,55	104,23
a_1	0,019	0,023	0,026	0,035	0,039	0,043	0,042	0,025	0,019	0,029	0,038	0,028	0,367	0,101	0,109	0,087	0,070
$\bar{Y}$	35,6	37,1	32,8	47,8	64,2	87,0	72,7	67,2	43,7	442	58,8	52,5	644,6	144,8	226,5	146,7	125,3
S	5,2	6,3	6,2	8,3	9,6	11,2	13,7	8,4	5,3	7,1	9,8	7,7	86,3	23,4	29,7	21,1	18,9

maximum at the end of autumn is the result of the frequent rainy days, but the daily outputs are smaller. During the January minimum rainfalls are quite frequent, but the outputs are small. At the September minimum it is just on the contrary: the number of rainy days are less, and the daily outputs are bigger (at the same time they are smaller from the summer outputs).

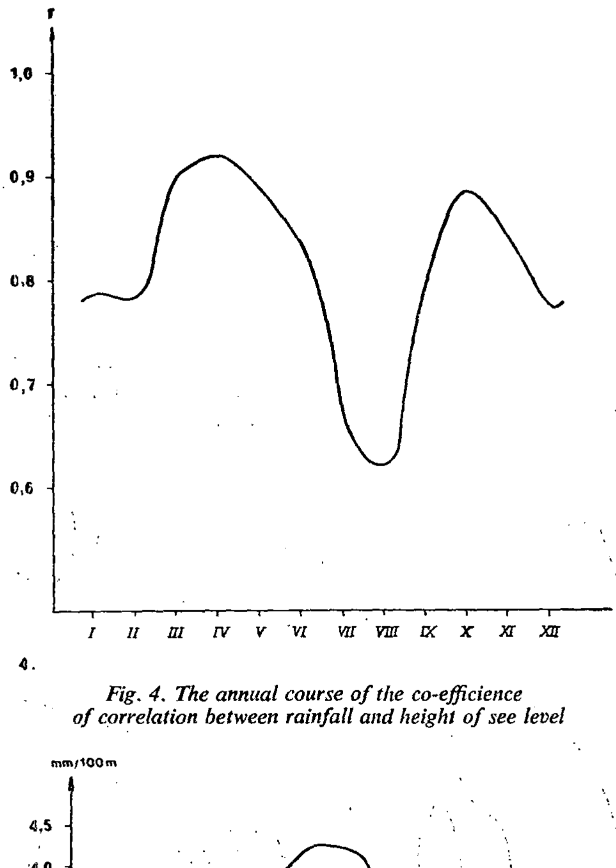

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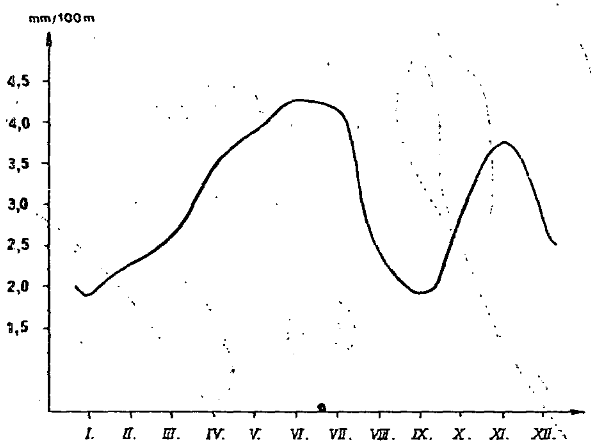
Fig. 4. The annual course of the co-efficience of correlation between rainfall and height of see level



5.

Fig. 5. The value of rainfall increase falling on 100 m height

Now we are going to examine what close connection exists between the rainfall and height on the basis of co-efficient of correlation *(Fig. 5)*.

Our figure demonstrates very well when is the rainfall-increase less close together with the height. The double wave is to be found at the co-efficient of correlation (r) just like as we hawe seen it at the representation of a_1 *(Fig. 4)*. The closest connection is experienced in spring and autumn, the loosest in summer and winter. The spring and autumn maximums, the closer connections are caused by the more equal dispersion of rainfall in the gliding up fronts and by the larger outputs (which are smaller in summer). The summer minimum that is to say the less closer connection between rainfall and height can be attributed to the fact that the dispersion of rainfall is capricious on the examined area (local rain-storms, showers). The discovery of the reasons for the the secondary winter minimum and the less closer connections requires further datailed examinations. Yet we can already as certain that even the less closer connections are real statistically.

An the basis of the above mentioned calculations we can state that 37 mm/100 m is the average height increase in the Mátra Hills at the annual ammount of rainfall.

For the practical application of our above expounded method we can draft a more datailed and precise plan of rainfalls, because with the help of this mathematical model we can draw up the datailed rainfall map of such areas where we have no rainfall map of such areas where we have no rainfall measuring stations with appropriate density. By interpolation the most probable rainfall quantity belonging to given heights can be determined.

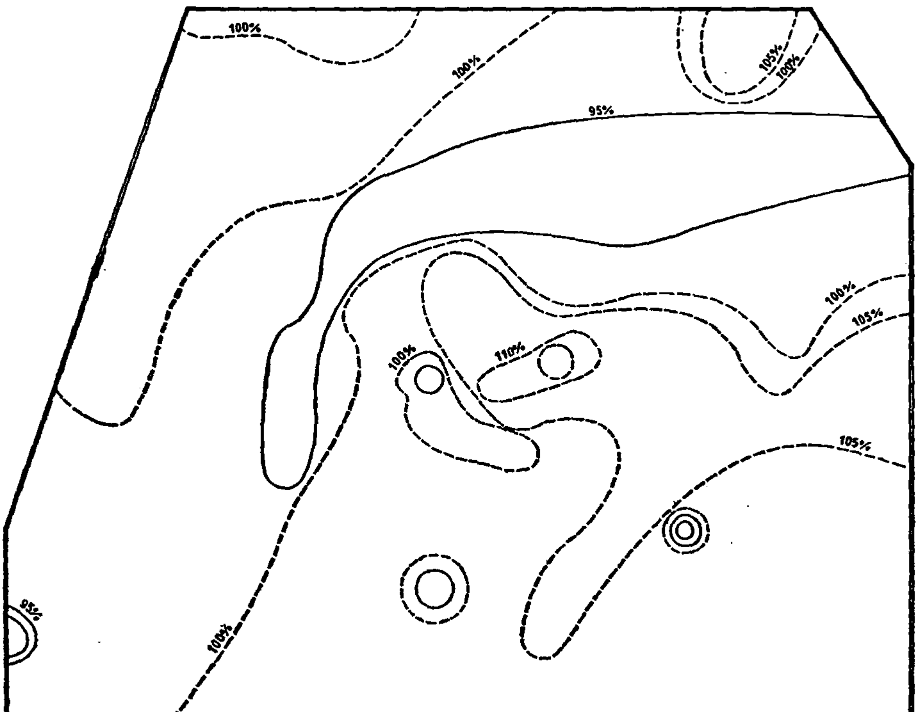


Fig. 6. Areas of orographical rainfall surplus and lack in Mátra — spring.

The Areas of the Orographical Rainfall Surplus and Lack in the Mátra Hills

We can determine the disperse of rainfall averages according to height on the basis of function No 1, that is to say the quantity of expected rainfall on a gived height above the sea level. Let this calculating value be C^x, and C is the really noticen rainfall (30 year old chief value).

The C/C^x quotient marks whether any examined station receives more rainfall or less than it would be suitable on the given height above its see level.

In case when $C/C^x > 1$, we can speak of *orographical lack of rainfall,* and when $C/C^x < 1$, of *orographical surplus of rainfall.*

Counting with the equation (1) we have determined the probable C^x according to height concerning the Mátra Hills by seasons, and then we have compared it with the real data (C). On the basis of C/C^x quotient we have marked the areas of the Mátra having orographical lacks of rainfall as well as surplus of rainfall according to the seasons of the year. The geographical dispersion of these values can be seen on *Figures 6—9.*

Their common feature is the change from season to season of the areas with orographical surplus of rainfall and lack of rainfall as well with their values. The difference is most striking between the winter and summer periods. But quite typical is the deviation between autumn and summer too. We can distinguish even such areas where the areas of surplus and lack of rainfall change places (for example in the

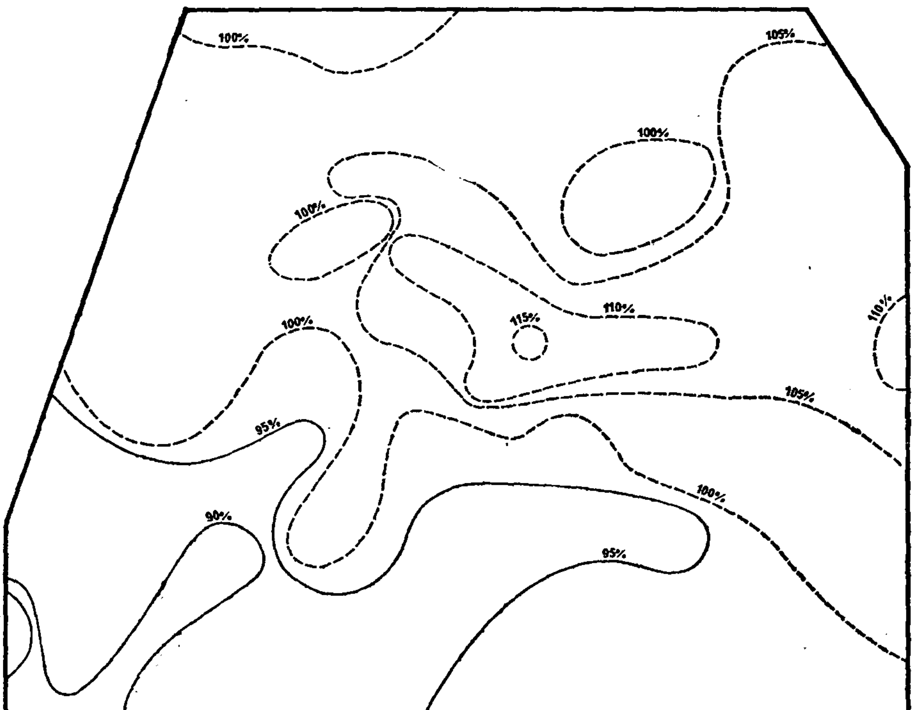


Fig. 7. Areas of orographical rainfall surplus and lack in Mátra — summer

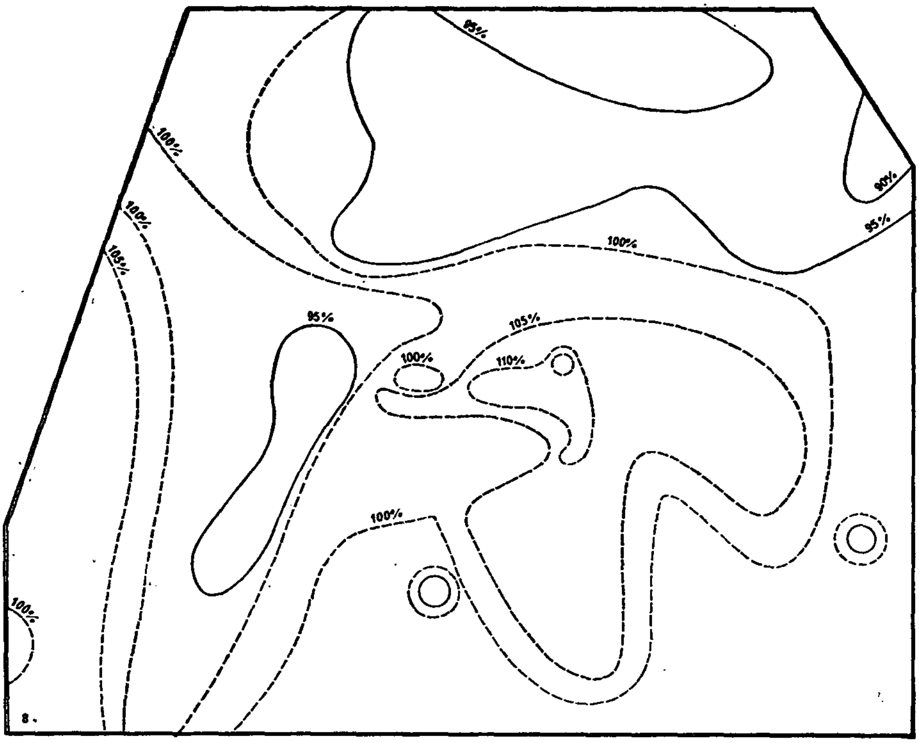


Fig. 8. Areas of orographical rainfall surplus and lack in Mátra — autumn

South-East of the Mátra surplus of rainfall can be observed in winter and lack of rainfall in summer).

The reasons for the basic deviations are to be found in the fact that the reigning air currents are changing by the seasons, and the character and structure of rainfall is different. During the winter halfyear the rainfall joins with the warm fronts (gliding up front) caused dominantly by the south air currents, while during the summer period it joins with the cold front caused by the North-West air currents. It is justified by the frequency of direction of winds as well *(Fig. 10)*.

The figures illustrate well that in winter the reigning direction of winds is that of South-South-West, while in summer that of North-West-North.

On this basis examining the lack or surplus of the orographical rainfall we can come to the following conclusion:

In that case when in winter a surplus of rainfall, and in summer a lack of rainfall appears on the given area, the rainfall relations of the area formally stand closer to the mediterranian type (*M*). On the other hand when there is a lack of rainfall in winter and a surplus of rainfall in summer, the rainfall relations of the area are much more similar to Continental climate (*K*). These relatively not great differences can be demonstrated in botanical associations from time to time *(Fig. 11—12)*.

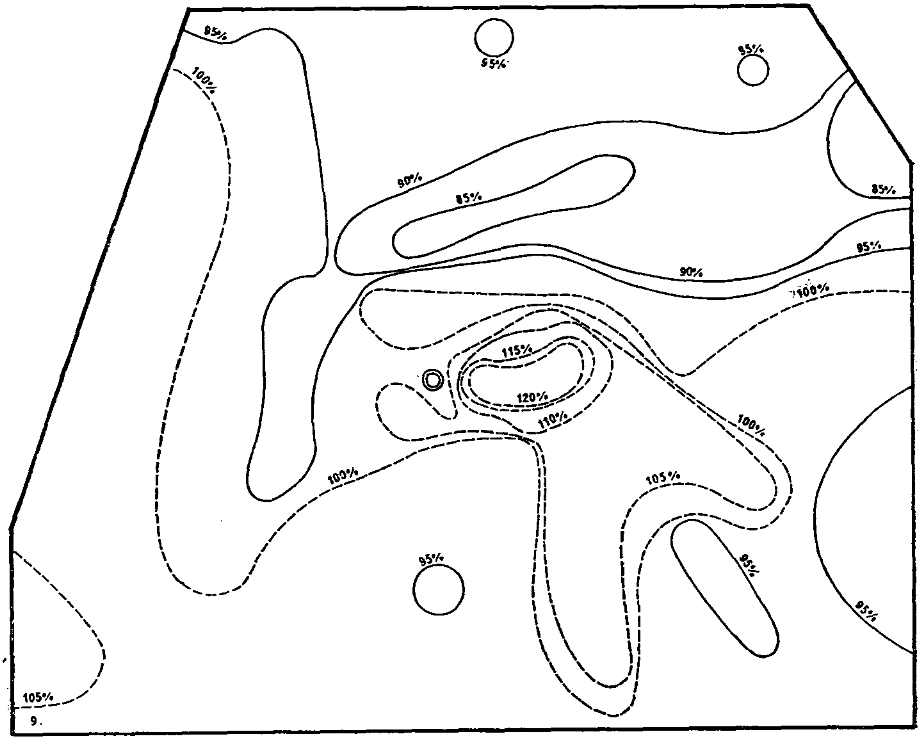


Fig. 9. Areas of orographical rainfall surplus and lack in Mátra — winter

Summary

In the first part of our paper we have examined the changes of rainfall according to height, and their monthly averages in the subordination of height. Having represented the data by levels being at our disposal in a co-ordinate system it can be stated that there is a linear relationship between rainfall and height. We have expressed it with the relation $Y=a_0+a_1x$. Substituted the measured data we have received the values of a_1 and a_0, as well as the value of the co-efficient of correlation (r) concerning the Mátra Mountains. Having represented them we have demonstrated that the relation between height and rainfall in the course of a_1 and the co-efficient of correlation is closest in spring and autumn, while it is the least closest in summer and winter.

In the second part of the paper we have determined on the basis of the calculations represented in part I how much rainfall can be expected at the given height above see level. On the basis of the quotient C/C^x we have determined the areas with the lack and surplus of orographical rainfalls of Mátra (where C^x is a calculated value, C — effectively observed rainfall), and tried to find explanations to the reasons of their formation.

A practical application of the method described in the paper can be used at making detailed plans of rainfalls in cases when we have no rainfall measuring stations at our disdosal with adequate density on a given area.

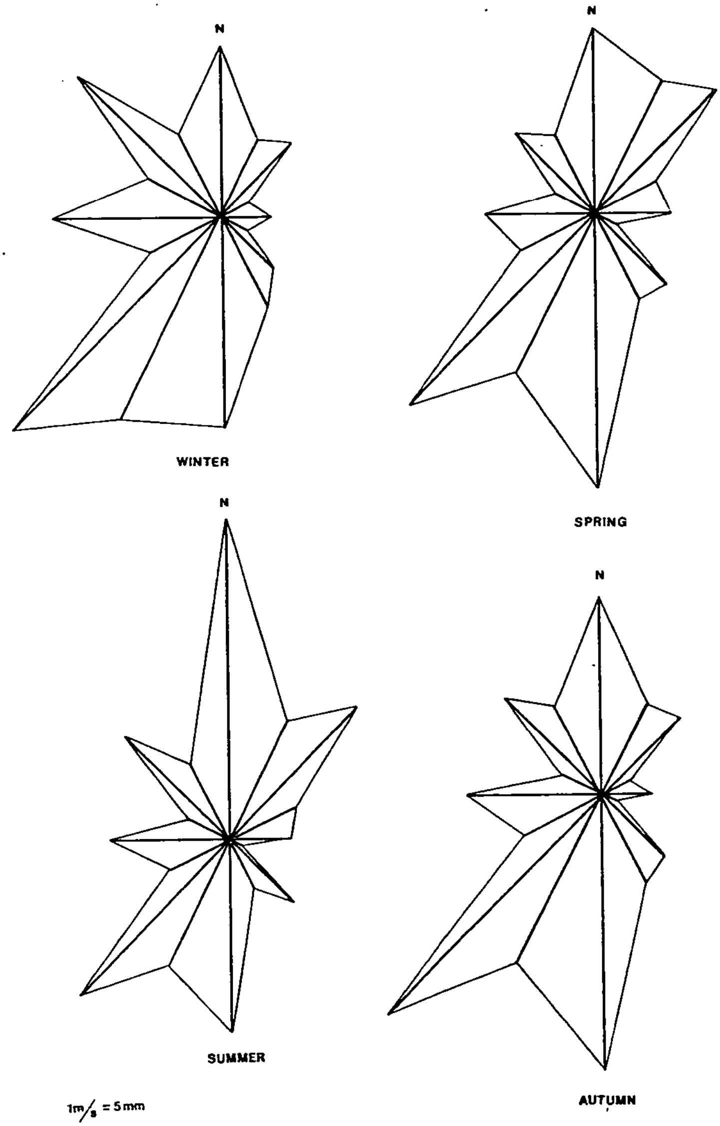


Fig. 10. Relative frequency of directions of winds at different seasons on Kékes-tető (calculating from 8 daily observations in 1975—79)

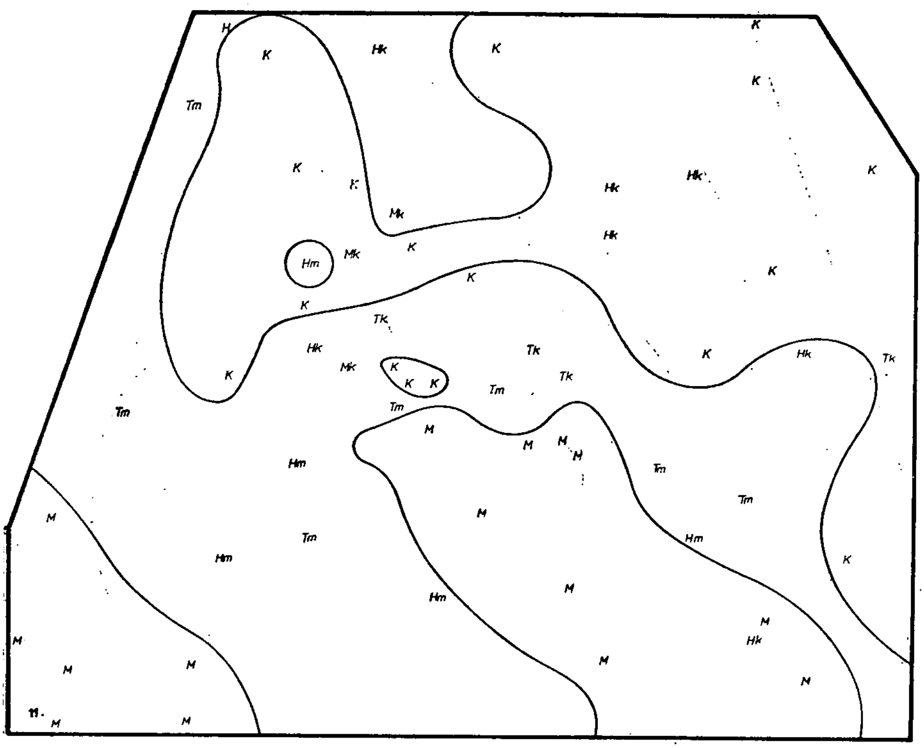


Fig. 11. Areas of Mediterranian (M) and Continental (K)-like rainfalls (in winter-summer relation)

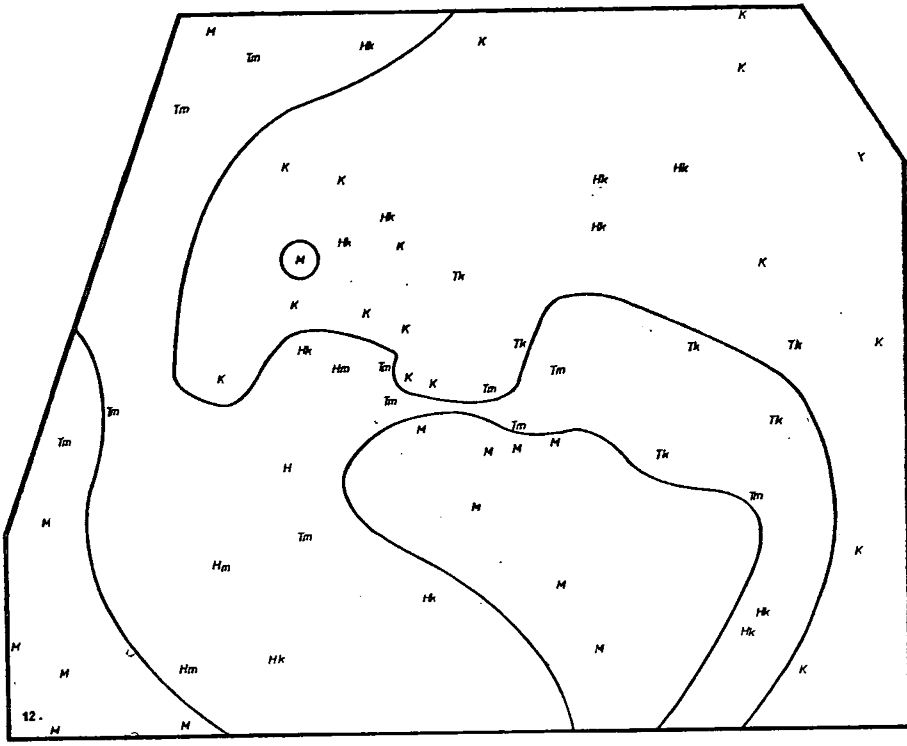


Fig. 12. Areas of Mediterranian (M) and Continental (K)-like rainfalls in summer-autumn relation)