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Some Remarks to Precipitation Measurements in Mountains

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ABSTRACT

The results of distribution of precipitation in a mountainous catchment are presented. Seasonal variations of precipitation gradients with altitude are pronounced, although winter regression is not very close. In spite of highly variable topography, the distribution of relative monthly precipitation within the catchment does not seem to vary remarkably from place to place. Systematic, mainly wind - induced errors resulted in differences between two types of rain gauges used in the study.

INTRODUCTION

Precipitation provides the basic input data for water-related studies. The distribution of precipitation in mountains is usually described by means of precipitation gradient that expresses changes of precipitation with altitude. This vertical gradient is used by hydrologists for estimation of areal precipitation. The increase of precipitation with altitude is limited by the mean height of clouds and decreasing of vapour pressure with the altitude. Thus, the decreasing of precipitation with altitude can take place in mountains above certain level. Due to the deformations of the wind field caused by topography, local gradients usually differ from the general gradient in particular catchment. As it was shown by Sevruk /5/, calculated precipitation gradients depend on the selections. Stations located in valleys give higher gradients than those on windward slopes.

During experimental hydrological research carried out in the Jalovecký creek catchment in the Western Tatra mountains it has been felt that standard precipitation network can not provide reliable precipitation data. About 37% of the territory of Slovakia is situated higher than 500 m a.s.l.. Only 2.1% of precipitation stations of the national meteorological service are located above 1000 m a.s.l. /2/, while the mean altitude of the experimental catchment is 1160 m a.s.l.. Therefore, new precipitation network has been built up. The preliminary results were published elsewhere /3/. This paper summarizes results for the period 1987-1991.

DESCRIPTION OF THE CATCHMENT

Experimental catchment of the Jalovecký creek is typical for the highest part of the Carpathians mountain range. The area of the basin is 42 km² and it consist of two distinctly different parts - mountain an foothill. The former is typical for its complex topography (elevations range 800-2178 m a.s.l.), while the latter is characterized by gently hilly surface (elevations range 570-800 m a.s.l.). Basic precipitation network consists of 7 storage gauges with the orifice 200 cm² shielded by Nipher shield located in the elevations 570-1775 m a.s.l. and 4 unshielded Czechoslovak standard rain gauges METRA with the orifice 500 cm² situated in the elevation range 570-1500 m a.s.l..

METHODS AND RESULTS

Measured period covers generally period of hydrological years 1987-1991. Standard gauges are measured daily or weekly, storage gauges monthly. During the data processing the ratio of the precipitation amount measured by particular gauge to the arithmetic mean of all gauges in the catchment was tested. This ratio is relatively stable for particular gauges and allows for indicating of inappropriate measurements.

Gradients of precipitation with the altitude were calculated by means of regression analysis using data from storage gauges for the period 1989-1991. Results are shown in Fig.1 and Table 1. Mean annual gradient is 86mm/100 m. This value corresponds to the long-term precipitation gradient determined by Pacl /4/ on the basis of data from the standard meteorological network stations in the vicinity of the catchment for the periods 1941-1960 and 1972-1980. Correlation coefficient for the period 1989-1991 is relatively high. However, high variability of annual gradients for particular years 1989--1991 does not allow for significant conclusions about the incidency of long and short-term annual gradients. Regression equations for monthly precipitation amounts clearly proved seasonal changes of annual gradient. Three seasons arepronounced-winter (7 mm/100 m), spring - summer (48 mm/100 m) and autumn (32 mm/100 m). High variability of the data during the winter season is believed to be caused mainly by wind-induced errors that are more effective during snowfall than during rainfall. This assumption is confirmed indirectly by closer relationships during summer-spring and autumn seasons. The month of December was expected to fall into the winter period. Nevertheless, on the basis of differences between regression equations it was introduced into the autumn period.

Table 1 : Precipitation gradients in the Jalovecký creek catchment (1989-1991)

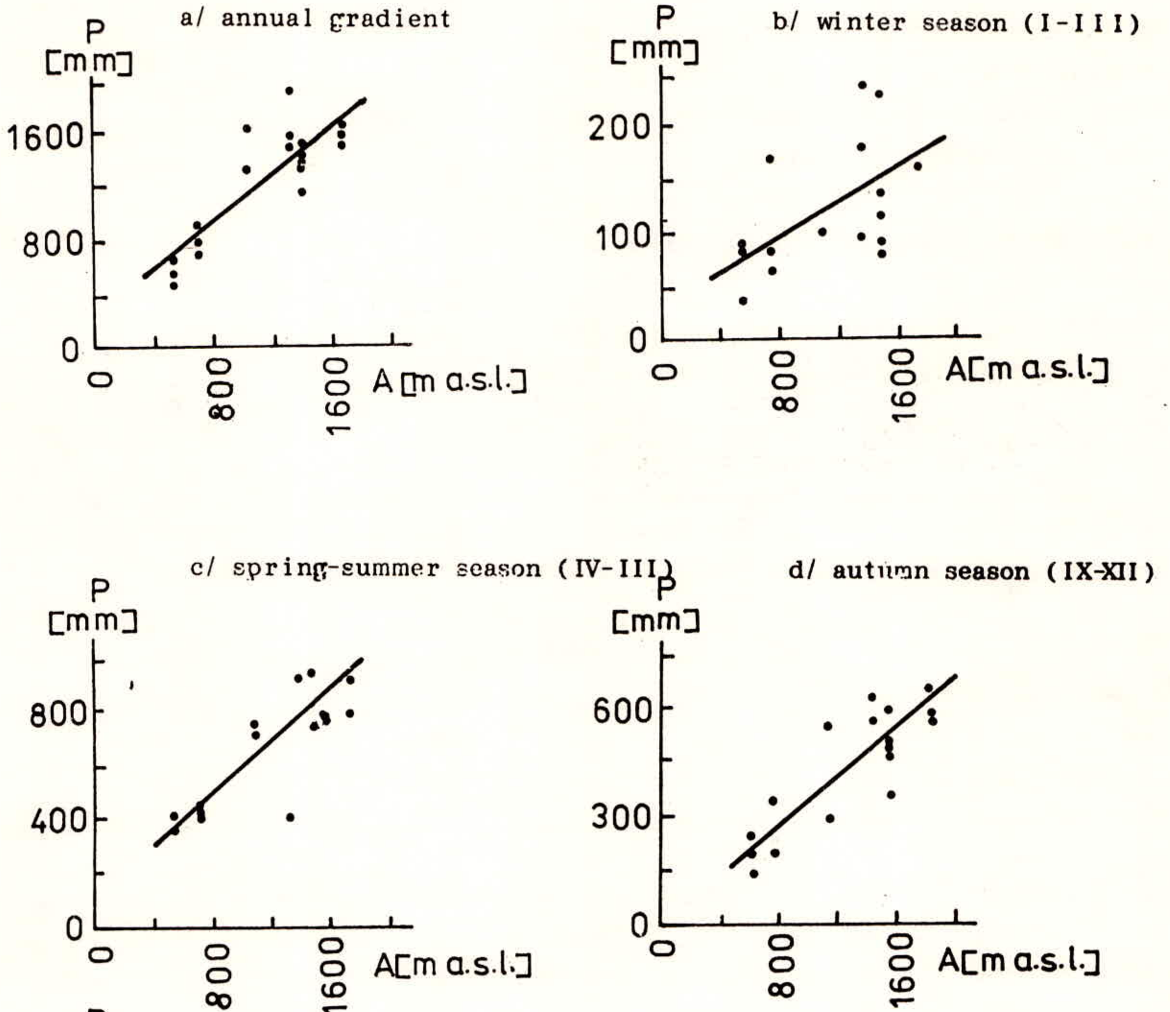
A - altítude

	Gradient (mm/100m)	Regression equation	Correlation coefficient
Year	86	y = 0.86A + 212.1	0.85
winter (I-III)	8	y = 0.08A + 30.7	0.53
spring-summer (IV-VIII)	48	y = 0.48A + 114.3	0.91
autumn (IX-XII)	32	y = 0.32A + 6.1	0.87

Great topographical variability results naturally in different precipitation amounts throughout the catchment. In spite of this it seems that relative monthly distributions do not differ so much. Fig.2 shows the share of precipitation amounts in total annual precipitation for 3 standard gauges located at different elevations (570-1500 m a.s.l.) in the hydrological year of 1988. Similar results were achieved for other years too.

As mentioned above, basic precipitation network consists of two different types of gauges. For further utilization of data it is necessary to compare the measurements. Fig.3 shows the catch of precipitation by both instruments for different elevations. Storage gauge is measured monthly with the accuracy of reading 8 mm. In comparison with unshielded Czechoslovak standard rain gauge wind-induced and evaporation errors are lower, while the wetting error should be excluded /1/. Therefore, considerable differences between the measurements were ex-

Figure 1. Precipitation gradients in the Jalovecky creek catchment for 1989-1991



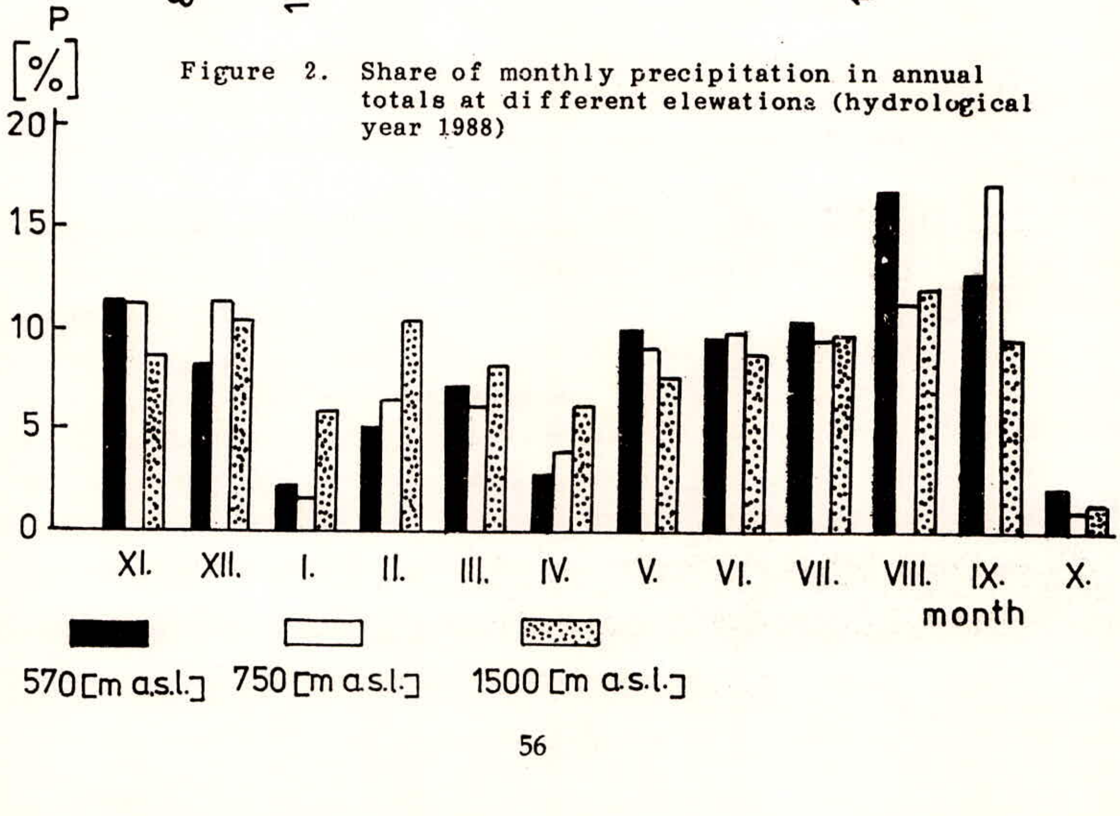


Figure 2. Share of monthly precipitation in annual totals at different elevations (hydrological year 1988)

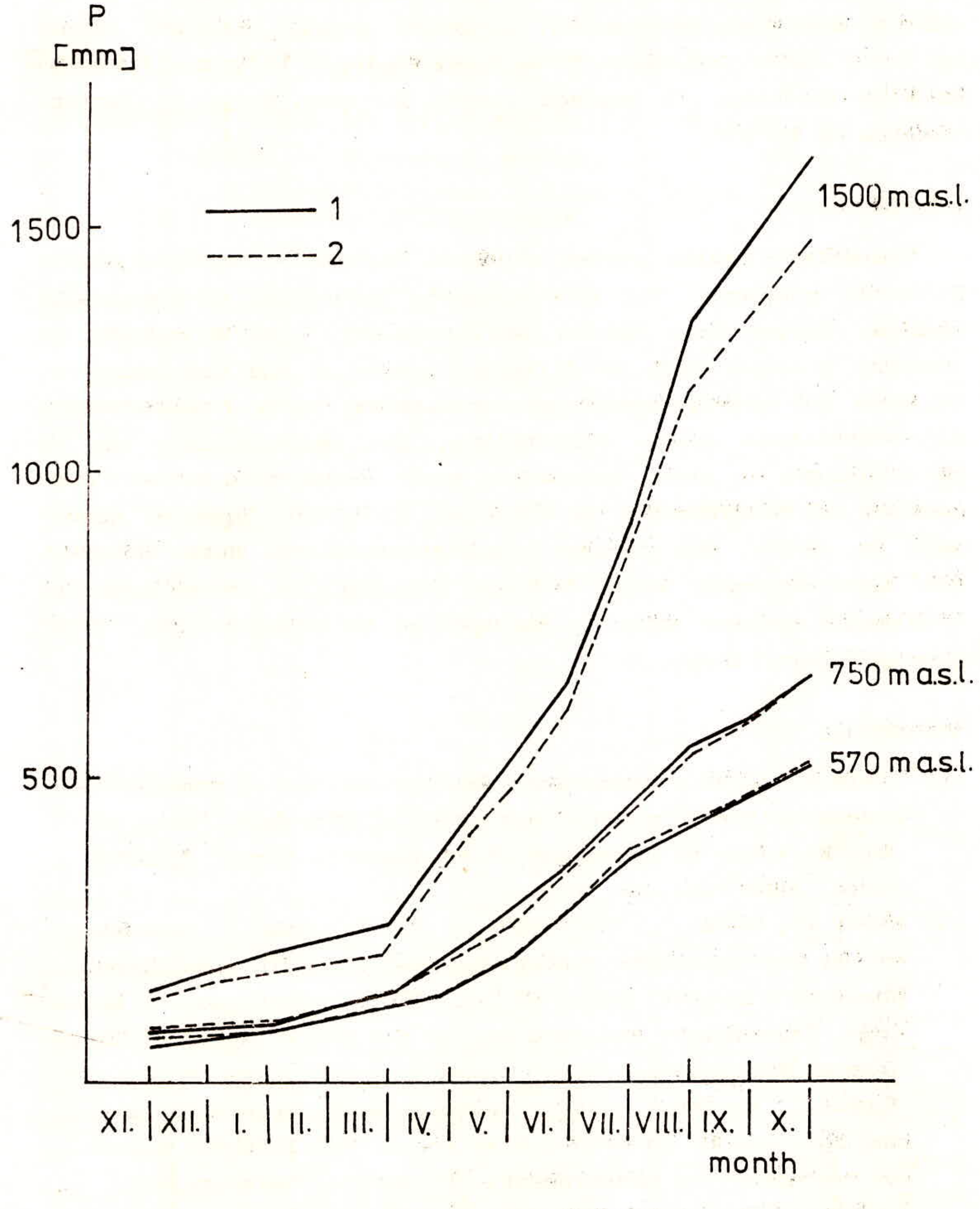


Figure 3. Comparison of different precipitation gauges (hydrological year 1991)
1 - storage gauge
2 - standard rain gauge METRA

pected. However, for the foothill part of the catchment the results are almost identical. In mountainous part the differences are more pronounced, although nearly parallel course of both lines indicates (Fig.3 elevation 1500 m a.s.l.) comparable readings. On exposed places the mean annual difference reaches up to 30%.

CONCLUSIONS

Presented results proved seasonal changes of vertical precipitation gradient. For more accurate definition of particular seasons longer data series are necessary. Similar pattern of monthly precipitation in different parts of the catchment can be used for transformation of cummulative rainfall measurements in mountainous areas. Nonetheless, its applicability has to be confirmed in other catchments with longer data series. Comparison of measurements by means of different types of gauges will be useful for further utilization of the data. However, for more accurate water balance computations corrections for systematic errors have to be applied in order to get "true" precipitation values.

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