Relief Index (RI) as a simple tool for geomorphometry

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I. INTRODUCTION

Common availability of LiDAR data - high-quality digital elevation data, with a vertical accuracy of approx. 0.15 m and horizontal resolution of approx. 0.5 m makes, that very precise geomorphometric calculations of the relief (or microrelief) of different areas becomes possible. This work is part of the current research tendency related to find some kind of indicator which can quantitatively describe the diversity of the surface relief. Sometimes in geomorphology were used terms as relief intensity or energy of relief (Szczepankiewicz 1948, Szumowski 1967, Grygorenko 1973, Richling 1973, Kaulfuss 1974, and others) or elevation-relief ratio (Pike, Wilson 1971) based mainly on the relative heights, slopes, or the number of depressions. Relief Index (RI) is a simple mathematical tool which characterizes the quantity of relief. This index is based on the ratio of the summary length of the contour lines and the surface area at which they occur.

II. DATA MATERIAL AND METHODS

The primary research material were ASCII GRIDs data with 1m horizontal resolution, which are derived from LiDAR data types. From these ASCII GRIDs 1m-contour lines were generated, and then results were filtered by removing the contour lines of less than 3m length (3m is the length threshold of the biggest circle in 1m x 1m square - accurately 3.12 m). The basic calculation field was a square of 10m x 10m. The results represented the average total length of contour lines per each $1m^2$ of the basic field area ($100m^2$). The total length of the contour lines pays attention to two aspects of the relief: 1. relative heights (the number of contour lines and the distance between them), 2. horizontal curvatures (length of the contour lines and sinuousity connected with it). The results show the degree of diversification (or complication) surface relief, ie. character of the surface.

III. STUDY AREAS

Application of Relief Index was describing using three areas of variable relief. Each study place had area of approx. 47 km^2 (6.7 km x 7.0 km).

Interest has covered three different areas, which were analysed: the Silesian Upland, Czestochowska Upland and the Tatra Mountains. Silesian Upland is a typical upland landscape, with gentle ridges and hills of 30-70 m (building of middle-triassic dolomites) and broad river valleys (filled with pleistocene sands and gravels). Czestochowska Upland is a karst area (formed by the upper-jurassic limestones and holocene sands and clays) with numerous karst outliers on the surface. Tatra Mountains are alpine high-mountains landscape, with large relative altitudes (> 1000 m) and very steep walls (> 80°), built of paleozoic granitoids and quaternary sands, gravels and rock rubbles.

IV. RESULS

Results show that in areas of low relief (Silesian Upland - height st.dev <20m) Relief Index takes values from 0.0 to 1.5 and mean value about 0.1. Relief Index results are very homogeneous (st. dev. 0.10). It nearly corresponds with slopes and local relief - so it seems be good quantity measure which describes diversification of surface relief. As one can see in TAB. 1 - Relief Index values rise with local relief and slope values. For high-mountains relief (Tatra Mountains) values of Relief Index are very high - almost 30 (sic!). This large effect is for places with slope values more than 80 degrees. Moreover these results of Relief Index also refer to slopes: correlation coefficient for the Silesian Upland was amounted to 0.64, for Czestochowska Upland to 0.54 and for Tatra Mountains to 0.82.

Basic morphometric statistics (for hyspometry, slopes, and the Relief Index results) shows the TAB. 1.

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TABLE 1. Statistics of heights, slopes and Relief Index values of study areas

Study Area	Heights [m a.s.l.]				Slopes [°]				Relief Index [m/m^2]			
	min	*max*	*mean*	*SD**	*min*	*max*	*mean*	*SD*	*min*	*max*	*mean*	*SD*
Silesia Upland	238.4	381.5	272.9	14.6	0.0	37.2	2.7	2.8	0.0	1.35	0.09	0.10
Częstochowska Upland	329.2	457.9	389.8	24.4	0.0	54.2	4.4	3.1	0.0	3.91	0.10	0.09
Tatra Mountains	1021.0	2388.4	1694.6	246.2	0.0	83.6	30.0	15.0	0.0	29.48	0.71	0.58

SD - standard deviation

V. CONCLUSIONS

Relief Index is a simple and good quantitative measure shows the degree of differentiation surface relief of the area. The total length of the contour lines occured on the surface unit (here: 1m^2) clearly reflects the nature of the surface. In addition, Relief Index has a high correlation with slopes (from 0.54 to 0.82), especially in the areas with the high altitude, where the slopes are the dominant morphometric feature of the landscape. Relief Index can be used to compare the amount of the relief of different areas with each other or in the same area for different time moments (if we only provided with suitable reference material). Elementary data for Relief Index indicator must be given the highest quality elevation data (from the laser scanning LiDAR), because only such data provide adequate quality (mainly vertical accuracy). Relief Index indicator can also be used in presently glaciated areas because the glacier is a system with dynamically changing of the surface geometry.

REFERENCES

[1] Grygorenko W., 1973. Numerical criteria of assessment of cartographical image value. Polski Przegląd Kartograficzny 5, 3: 117–125. [in polish]

[2] Kaulfuss W., 1974. Darstelungsmetode und Anwendungsmoglichkeiten eines Kartogramms Reliefenergie fur den Bezirk Dresden. Petermanns Geogr. Mitteilungen. Dresden. Heft 4, 13.

[3] Pike R.J., Wilson S.E., 1971. Elevation − relief ratio, hypsometric integral and geomorphic area − altitude analysis. Geol.Soc.Am.Bull. vol.82. p.1079-1084.

[4] Richling A., 1973. About of ways of relief showing in young-glacial areas. Przegląd Geograficzny XLV, 1: 109–117. [in polish]

[5] Szczepankiewicz S., 1948. Relief intensity of Wałbrzych landscape. Prace Wrocławskiego Towarzystwa Naukowego, ser. B, 8: 23 pp. [in polish]

[6] Szumowski A., 1967. Development of main trends in morphometry. Czasopismo Geograficzne XXXVIII,1: 37–54. [in polish]