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ScienceDirect
Geomorphology 98 (2008) 187 – 198
GEOMORPHOLOGY
www.elsevier.com/locate/geomorph

The consequences of land-cover changes on soil erosion distribution in Slovakia

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Received 31 October 2005; received in revised form 13 September 2006; accepted 20 December 2006
Available online 2 June 2007

Abstract

Soil erosion is a complex process determined by mutual interaction of numerous factors. The aim of erosion research at regional scales is a general evaluation of the landscape susceptibility to soil erosion by water, taking into account the main factors influencing this process. One of the key factors influencing the susceptibility of a region to soil erosion is land cover. Natural as well as human-induced changes of landscape may result in both the diminishment and acceleration of soil erosion. Recent studies of land-cover changes indicate that during the last decade more than 4.11% of Slovak territory has changed. The objective of this study is to assess the influence of land-cover and crop rotation changes over the 1990–2000 period on the intensity and spatial pattern of soil erosion in Slovakia. The assessment is based on principles defined in the Universal Soil Loss Equation (USLE) modified for application at regional scale and the use of the CORINE land cover (CLC) databases for 1990 and 2000. The *C* factor for arable land has been refined using statistical data on the mean crop rotation and the acreage of particular agricultural crops in the districts of Slovakia. The *L* factor has been calculated using sample areas with parcels identified by LANDSAT TM data. The results indicate that the land-cover and crop rotation changes had a significant influence on soil erosion pattern predominately in the hilly and mountainous parts of Slovakia. The pattern of soil erosion changes exhibits high spatial variation with overall slightly decreased soil erosion risks. These changes are associated with ongoing land ownership changes, changing structure of crops, deforestation and afforestation.

Keywords: Land-cover change; Soil erosion; Geographic information system; Slovakia

1. Introduction

Since the Second World War the Central European countries (CEC) have undergone two main periods associated with communist and post-communist historic eras. These periods resulted in vast landscape changes where the original landscape structure has been almost completely modified. During the first four decades that began in 1948, the landscape development in Slovakia was driven by a planned communist economy. It significantly influenced the agricultural land utilisation and arrangement of individual agricultural plots. The processes of collectivisation and agricultural mass production transformed the original mosaic of small

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doi:10.1016/j.geomorph.2006.12.035

parcels of arable land and pastures to the landscape structure composed of large parcels with a size ranging from tens to several hundreds of hectares (Solin and Cebecauer, 1998; Van Rompaey et al., 2003; Cebecauerova and Cebecauer, in press). Moreover, the amelioration of areas with unsuitable conditions for intensive agricultural production resulted in the increase of arable land (Feranec et al., 2000) often with inappropriate crops thus accelerating land degradation processes (Van Rompaey et al., 2003). Several local studies, for example, (Hofierka and Šúri, 1996) or (Solin and Cebecauer, 1998), showed that these structural changes significantly accelerated soil erosion processes.

The second period of landscape development has started in 1989 by a change of political system. The society has undergone a deep economic transformation including the agricultural sector. Restitutions and new agricultural support measures and programmes are influencing current landscape developments. The CORINE land cover project revealed that during the 10-year period between 1990 and 2000 more than 4.11% of Slovak territory has changed (Feranec et al., 2005a). The largest changes occurred in agricultural areas and forestland as a result of several processes: extensification of agriculture, deforestation, afforestation and urbanisation. Restitution of arable land and forestland by original owners or their descendants caused changes in farming and forestry practices. Large parcels of arable land especially those in the vicinity of rural settlements were again split up, areas with unfavourable agricultural conditions were abandoned (Feranec et al., 2005b). Since the accession of Slovakia and other central European countries to the European Union in 2004 the landscape development has been influenced by the Common Agricultural Policy (CAP). Therefore further significant changes in the agricultural land can be expected. Moreover, recently started comprehensive land consolidation projects financially supported by the European Union include many activities and measures that strongly affect the landscape and landscape processes including soil erosion.

Soil erosion and sediment transport problems resulting from land-use/management changes attracted attention of many researchers. The CAP set-aside regulation, the main driving force of agricultural land change in Europe, has a strong influence on actual land management. This can be also expected for the CEC transforming agriculture. The land-use changes resulting from this regulation may have both positive (Kirkby et al., 2000; Van Rompaey et al., 2001; Fullen et al., 2005) and negative (Souchere et al., 2003; Boellstroff and Benito, 2005) influence on soil erosion and sediment transport because of changing climatic, environmental and economic conditions over Europe. Souchere et al. (2003) and Schoorl and Veldkamp (2001) point out the importance of spatial configuration of set-aside strategies on the off-site effects and overall sediment runoff. The effect of the agro-environmental policy measures in the context of soil erosion and sediment transport is related not only to the percentage of set-aside arable land, but also to the local conditions and spatial configuration of set-aside plots. The inverse relation between soil erosion and land-use changes was identified by Bakker et al. (2005) in the region of Lesvos, Greece where soil erosion is considered one of the main drivers of arable land abandonment.

The studies focusing on the specific land-use changes and arable land transformations in the CEC and their impact on soil erosion were presented by Van Rompaey et al. (2003) and Jordan et al. (2005) both utilising the WATEM/SEDEM model. While Jordan et al. (2005) studied the effect of the land-use changes on sediment transportation rates in the Balaton region in Hungary during the past two centuries (1784–2002), the study of Van Rompaey et al. (2003) analysed the effect of potential land development under the CAP regulation and land arrangement administration in the selected basins in the Czech Republic. Both studies identified a strong influence of land utilisation changes on sediment transport rates. Soil erosion modelling using historic land-use data offers a unique opportunity to study impacts of actual land-use changes on erosion and sediment discharges (Jordan et al., 2005). In this context, recent landscape changes induced by political and economic transformation are part of complex information needed for future landscape development plans in Slovakia and other CEC countries. Special attention should be given to the spatial distribution of these processes and their association with local environmental conditions, land utilisation and agricultural production. This knowledge is crucial for effective land management decisions, mitigation of land degradation processes and optimisation of landscape structure for a sustainable landscape development.

In this paper, we assess the changes in soil erosion in Slovakia caused by three main factors: land-cover changes in the 1990–2000 period identified by the CORINE Land Cover mapping project, changes in arable land utilisation and management practices using crop rotation statistics and changes in parcel morphology identified using LANDSAT TM data. We identify areas with increased/decreased soil erosion risks and discuss main reasons influencing these changes in the context of changing socio-economic conditions of Slovak regions.

2. Methods and data

2.1. Study area

The territory of Slovakia (49,030 km^2) is situated in the Western Carpathians and, due to complicated geological structure and tectonic development, it is strongly dissected. About 25% of the territory, located predominately in the south-west and south-east, represents flat alluvial plains or smoothly undulated hillylands. In the hillylands, the loamy and silty soils were developed on the loess and loess-like deposits, forming areas with high susceptibility to soil erosion, despite relatively gentle slopes. The rest of territory is formed by highlands and mountains with intra-mountainous valleys, developed on the crystalline and limestone rocks in the central part of the Carpathians and on shales and claystones in the northern part of the Carpathians. These areas are also highly susceptible to soil erosion mainly because of steep slopes. Soil erosion by water is a main process of soil degradation in 75% of Slovak territory with favourable natural conditions. Almost 50% of Slovakia is utilised for agricultural production mainly in alluvial plains, hillylands, intra-mountainous valleys and partially in highlands with moderate slopes. Forestlands cover almost 44% of the Slovak territory, mostly in mountainous areas. Since forests have a high protection function against soil erosion, these areas may be severely threatened by soil erosion in case of improper timber production or natural disasters (Šúri et al., 2002).

2.2. Soil erosion assessment

A regional assessment of soil erosion is influenced by the complexity of the soil erosion process and available level of detail in data describing the soil erosion factors. Regional assessments require simplified models because there is a relation between data accuracy, model complexity and a resulting model error (Van Rompaey and Govers, 2002), which can lead to a decrease of model reliability when simplified data are used in complex models. In the last decade, different approaches were adopted for national and continental assessment ranging from indicator or factor-based approaches to process-based models (Gobin et al., 2004). The assessment of soil erosion risk in this study is based upon principles and parameters defined by the Universal Soil Loss Equation (USLE, Wischmeier and Smith, 1978). This model and its modifications (e. g. RUSLE, Renard et al., 1997) are still widely used in many countries, including Slovakia. A set of experiments has been done to adapt and validate this model to the geographical conditions of the Czech and Slovak Republics (see e.g. Pasák et al., 1983; Alena, 1991; Malíšek, 1990, 1992). The advantage of this model over other process-based models used in regional assessments (e.g. PESERA (Kirkby et al., 2004)) is in its simplicity and a greater availability of input parameters, especially in Slovakia. As the USLE model was developed for a local-scale assessment of soil loss by sheet and rill erosion, its application to regional assessments needs some modifications (Šúri et al., 2002). Thus the model of soil erosion risk at the regional scale is defined by this formula:

$$E_A = R \cdot K \cdot L \cdot S \cdot C, \tag{1}$$

where E_A is the soil erosion risk, R is the rainfall erosivity factor, K is the soil erodibility factor that is a function of soil properties, $L \cdot S$ is the topographic factor (potential of relief), where L is the slope length factor and S is the slope steepness factor, C is the land cover/management factor that takes into account differences in density and structure of the vegetation cover reflecting its protective function and also the methods of land management. The USLE conservation practice factor, P, is not considered in this model.

The model has been implemented in the GRASS GIS environment (Neteler and Mitasova, 2004) and ArcView GIS. The GRASS GIS modules have been used for preparing the model factors (for example, map algebra, spatial interpolation and reclassification), while ArcView GIS has been used for data management, model results evaluation and visualisation. The datasets and performed spatial analyses were based on the raster data model with a spatial resolution of 50 m.

The effects of land-cover changes in this study are twofold. The first effect results from the land-cover change per se and it influences the C factor. The second effect arises from the parcel morphology in agricultural areas and this affects the L factor. Both these changes create large part of variability of input parameters in the one-decade time scale. The temporal variability of the other factors (R, K and S) is not considered in this study. They can be treated as quasi-constant factors in this relatively short period of time.

The proposed methodology has been applied to the territory of Slovakia in order to identify areas with increased or decreased soil erosion risk as a result of land utilisation and parcel morphology changes represented by the C and L factors during the 1990 to 2000 period. Two soil erosion risk maps derived using the model (1) separately for the years 1990 and 2000 reflect a mutual

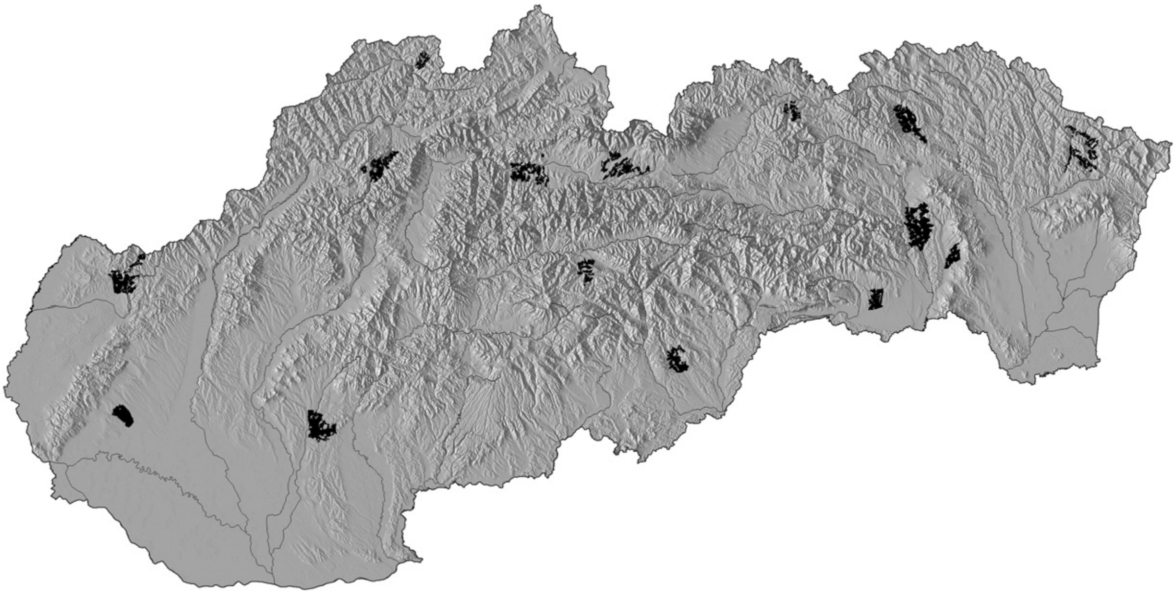

Fig. 1. Locations of 16 sample areas used in the analysis of average slope length.

interaction of changing and stable input parameters. The output of the model in tonnes/ha/year can be reclassified into soil erosion risk categories. In Slovakia, commonly used soil erosion risk categories have been defined by Zachar (1982). These categories help to analyse the overall trend in soil erosion risk in Slovakia.

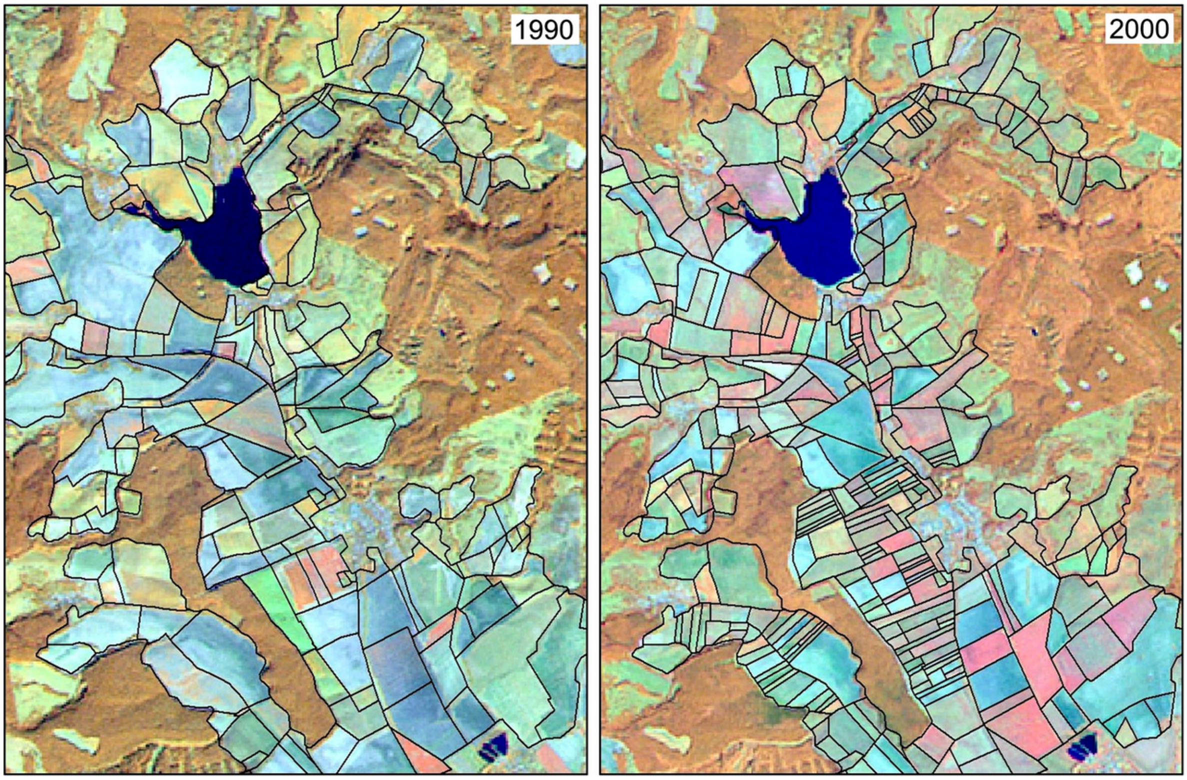

Fig. 2. Identification of parcels using LANDSAT TM data.

2.3. Input parameters

The input parameters of the model (1) are represented by factors R, K, L, S and C. A detailed description of the factors and derivation from the existing databases available in Slovakia was presented by Šúri et al. (2002). In this section, we briefly recall main principles and describe some differences in this presented approach.

Rainfall erosivity (R factor) is determined as a function of total storm kinetic energy (E) and its maximum 30-min intensity ($I_{\max30}$) (Wischmeier, 1959; Wischmeier and Smith, 1958). These two factors were estimated using the regression analyses of a long-term 15-minute rainfall intensity map published by Šamaj and Valovič (1980), and a long-term mean annual precipitation map spatially interpolated by Regularised Spline with Tension in GRASS GIS (Hofierka et al., 2002) and the R factor values for selected locations and areas published for Slovakia by Alena (1991) and Mališek (1990). The minimal values of the R factor (in metric units) are associated mainly with lowlands and basins ($R \sim 20$–25), while mountainous areas and eastern parts of the country with more intense rainfall events have higher values ($R \sim 30$–35).

Soil erodibility (K factor) is a function of soil texture, organic matter content, structure and permeability. In Slovakia, there is no national database of the K factor or individual soil properties covering the whole territory of Slovakia. Therefore the estimation of the K factor was based only on the map of soil texture at scale 1:500 000 published by Fulajtár and Čurlík (1980) who used the national textural classification based on the content of clay and very fine silt fraction (0–0.01 mm). Individual soil texture classes of soil texture map were reclassified to the K factor values (Šúri et al., 2002). Low values of the K factor are associated with high clay-content soils ($K \sim 0.1$–0.25), whereas high values are associated with sandy-loam soils ($K \sim 0.66$–0.75). Most areas are covered by loamy soils with $K \sim 0.51$–0.65.

Potential of relief (S and L factor) is a function of slope inclination and slope length. The S factor was derived from a digital model of relief (DMR) with a grid resolution of 50 m. This DMR is based on the digitised contours of topographic maps in scale 1:50 000. The Regularised Spline with Tension method has been used to interpolate the grid-based DMR. The root mean square error of interpolation at given points is less than 2.3 m (Šúri et al., 1997; Hofierka et al., 1998). The selected spatial resolution reflects the scale of primary data and provide a sufficient level of detail for this type of regional assessments. The S factor values for individual grid cells were derived from the slope angle A (%) map using the standard USLE formula:

$$S = 0.065 + 0.045\mathrm{A} + 0.0065\mathrm{A}^2 \qquad (2)$$

The slope length factor is defined as the slope distance from the point of origin of overland flow to the point of concentrated flow or until deposition occurs (Haan et al., 1994). At a regional scale, the computation of the L factor cannot solely rely on the DMR because it does not contain all information necessary to derive a spatially-distributed L factor. Moreover, the CORINE land cover database used in this study does not provide information about individual parcels of arable land and landscape features influencing the runoff concentration and deposition. A similar problem was solved by Van Dijk (2001) and Molnár and Julien (1998) by choosing a fixed value of slope length for the entire study area reflecting a typical or average value. The same approach was used in this study, however, the average slope length factor was determined separately for each time horizon. To account for temporal changes in parcel sizes and morphology, 16 sample areas in different regions of Slovakia were selected (Fig. 1). Parcel borders usually present lines were overland flow is concentrated or deposition occurs, so they can be considered as bounding lines when calculating the slope length L factor. The parcels were visually identified and vectorised

Table 1
Land cover/management (C factor) derived from the CORINE land cover classes

CORINE land cover classes*	Land cover/management (C factor)
141, 31×, 321,322, 41×	0.001–0.005
142, 231, 324	0.006–0.010
243	0.100
22×	0.350–0.450
333, 334	0.500–0.550
211	0.166–0.335**
242	0.108–0.218**
11×, 12×, 13×, 331, 332, 51×	Not considered

*The codes represent the following classes:
141 — green urban areas, 31× — forests, 321–322 — scrub and/or herbaceous vegetation associations, 41× — inland wetlands.
142 — sport and leisure facilities, 231 — pastures, 324 — transitional woodland-scrub.
243 — land principally occupied by agriculture, with significant areas of natural vegetation.
22× — vineyards, fruit trees and berry plantations.
333 — sparsely vegetated areas, 334 — burnt areas.
211 — non-irrigated arable land, 242 — complex cultivation patterns.
11× — urban fabric, 12× — industrial, commercial and transport units, 13× — mine, dump and constructions sites, 331 — sands, 332 — bare rocks, 51× — inland waters.
**Based on crop rotation statistics.

using LANDSAT TM data for both the time horizons (Fig. 2). Then the slope lengths in the individual parcels were calculated using the DMR data by r.flow command in GRASS GIS (Mitasova et al., 1996). The analysis of sample areas led to the average slope length of 191 m for 1990 and 171 m for 2000 that have been applied as constants in agricultural areas. The semi-natural and forest areas showed no change in average slope lengths and a constant value of 185 m has been used for both the times. Despite the fact that the average value does not contain spatial variability in parcel sizes and morphology, the sampling helped us to assess the temporal changes in the *L* factor for the given period. Manual delineation of all parcels in the territory of Slovakia would not be feasible within a reasonable time frame.

Land cover/management (*C* factor) takes into account differences in properties of the vegetation cover and methods of land management, reflecting their protective function. The *C* factor was determined from the CORINE land cover (CLC) database and crop rotation statistical data for 72 Slovak districts.

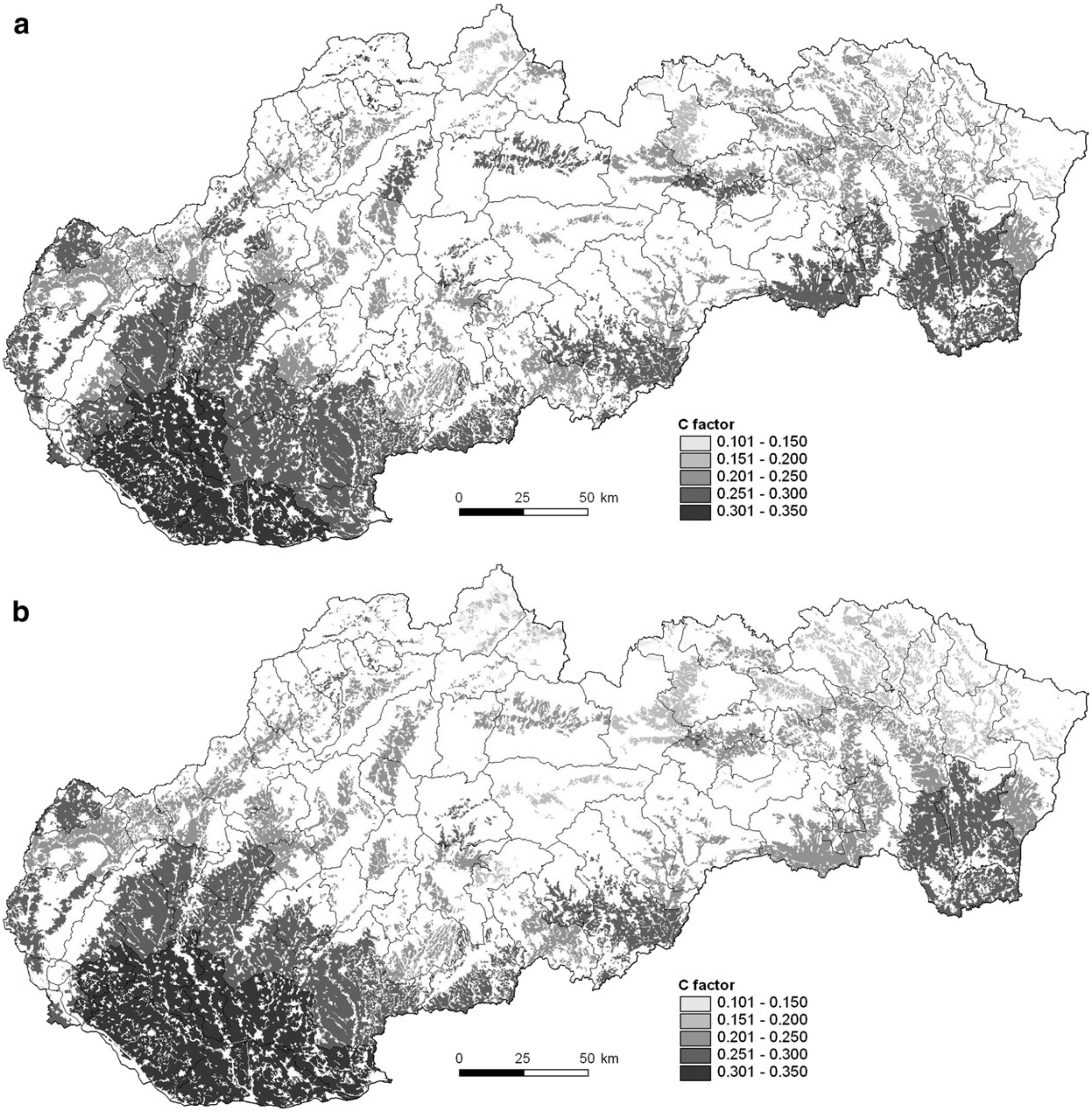

Fig. 3. The mean annual *C* factor in arable land areas based on crop rotation data for districts. a) 1990, b) 2000.

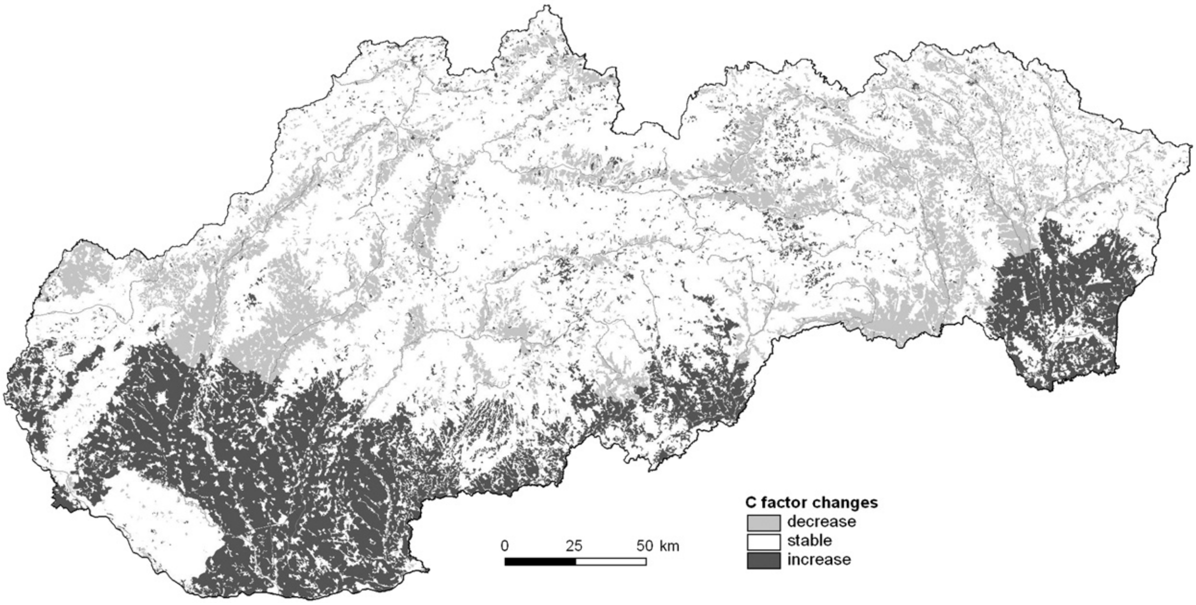

Fig. 4. The *C* factor change in the 1990–2000 period.

The CLC database (SAZP, 2004) contains land cover classes mapped using the LANDSAT TM images by methodology and nomenclature unitedly defined for the whole Europe at scale of 1:100,000 (Heymann et al., 1994). Currently, two time horizons for Slovakia are available describing the land cover in the 1989–1992 (CLC90) and 1999–2001 (CLC2000) periods. The vector version of the CLC databases was used, later converted to a raster format at 50-m resolution in accordance with the other data layers used in this study. The resolution and level of detail of the CLC databases with a minimum mapping unit size of 25 ha and minimum linear features width of 100 m are acceptable for this type of regional analysis. Moreover, currently no other land cover database with a complete coverage of the territory of Slovakia is available.

The unified CLC methodology of mapping for both databases allows to study temporal changes in land cover and their impact on soil erosion processes. However, these databases are not meant primarily for soil erosion assessments, therefore the *C* factor values for some CLC classes are based rather on rough estimates using available literature (Cebecauer et al., 2004). The *C* factor values were attributed individually to each of the mapped land cover classes (Table 1), taking into consideration their internal heterogeneity and its specific manifestation

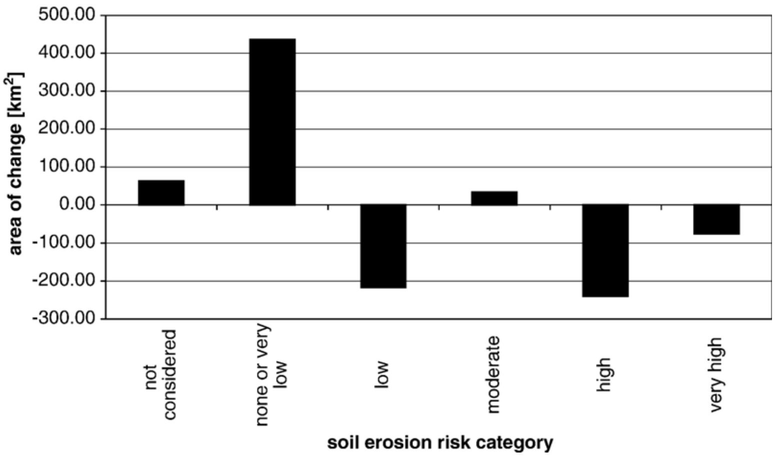

Fig. 5. Total area of soil erosion risk categories in 1990 and 2000.

Table 2
The extent of spatial changes in soil erosion risk categories in the 1990–2000 period

Erosion risk change interval	Area		Total increase/decrease
	[km^2]	[%]	[%]
<−75	8.7	0.00	
−75–−22.6	85.4	0.17	
−22.5–−7.6	424.9	0.87	12.6
−7.5–−0.8	5,688.5	11.61	
−0.7–0.7	42,174.3	86.05	86.1
0.8–7.5	459.5	0.94	
7.6–22.5	109.6	0.22	1.3
22.6–75	63.1	0.13	
75>	5.4	0.01	
Total area	49,010.6		

in landscape within the natural conditions of Slovakia (Feranec and Oťaheľ, 2001). Values of the *C* factor were derived using the vegetation classes published by Wischmeier and Smith (1978), Pasák et al. (1983) and for the territory of Slovakia by Alena (1991) and Malíšek (1992). Built-up areas, bare rocks and water surfaces were excluded from the evaluation.

The *C* factor is dependent not only on the actual land cover class, but it also reflects applied utilisation and management practices (Cebecauer et al., 2004). The crop rotation on arable land strongly influences the long-term value of the *C* factor. Therefore the *C* factor for the CLC arable land classes (211 — non-irrigated arable land and 242 — complex cultivation patterns) was derived using the published statistical data on the mean crop rotation and the acreage of used agricultural crops for 72 Slovak districts (Pflüger, 1998; Škultéty, 1999, 2000). The *C* factor for the individual areas of classes 211 and 242 of the CLC databases was determined as a weighted average of the mean annual values of the *C* factor for the main crops in the districts. To compute the mean annual *C* factor for 1990 and 2000, statistical data for the periods 1989–1991 and 1998–2000 were used, respectively. The average of 3 years was used to minimise the short-term (yearly) variation in the crop rotation. The districts with the most intensively utilised agricultural areas (mostly in lowlands) and crops with a low protective function (such as maize, sunflower, sugar beet and vegetables) have higher values of the *C* factor than districts in submountainous and mountainous areas (Fig. 3a, b). This holds for both the times horizons, however, the *C* factor for the CLC arable land classes increased in southern regions in 2000, whereas northern regions, mostly mountainous, have experienced a decrease in the *C* factor. Overall, the average *C* factor in arable land areas was slightly lower in 2000 ($C=0.26036$) than in 1990 ($C=0.26135$) due to changes in individual crop shares.

The analysis of the *C* factor for all CLC classes in 1990 and 2000 showed that the CLC changes occurring in 4.11% of the territory and the crop rotation changes in

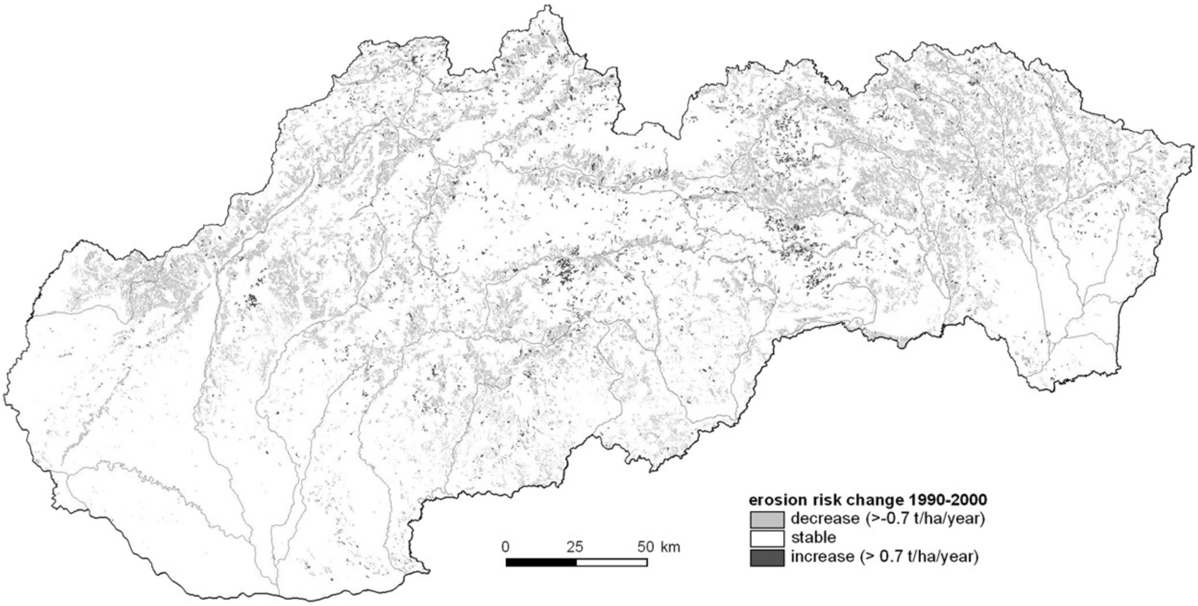

Fig. 6. Map of soil erosion changes in the 1990–2000 period.

arable land areas induced the *C* factor changes in 17,518 km^2 (35.73%) of the territory. The *C* factor decreased in 15.54% and increased in 20.20% of the territory. Lowlands and hillylands in the south are affected predominately by the increase in the *C* factor, whereas submountainous and mountainous areas in the north benefited mostly from the decrease in the *C* factor with small area exceptions (Fig. 4). The overall protective function of land cover slightly decreased during the 1990 to 2000 period. Almost 65% of the territory has not changed or experienced the land-cover change with no impact on its protective function.

3. Results and discussion

The comparison of the total soil erosion risk categories extent in 1990 and 2000 (Fig. 5) shows a slight decrease in the high and very high risk categories (239.90 and 74.21 km^2, respectively), decrease in the low risk category (216.05 km^2) and increase in the none or very low risk category (435.22 km^2) and moderate risk category (32.75 km^2). Total areas for soil erosion risk categories in Slovakia in 1990 and 2000 are almost stable with only minor changes that mostly reduce soil erosion risk in higher categories. However, this figure shows only a cumulative effect of changes that does not exhibit the full extent of spatial changes in soil erosion risk during the considered period in Slovakia. The comparison of soil erosion risk maps on a per-cell basis gives us better information on the spatial extent and intensity of undergone changes (Table 2). The identified changes reveal that the affected area covers around 13.9% of the territory. A decrease in the erosion risk category occurred in 12.6% of the territory and an increase in the erosion risk category affected only 1.3% of the territory.

The spatial extent of changes in soil erosion risk due to considered factors has a character of small patches distributed over the whole territory and exhibits strong spatial differences (Fig. 6). The soil erosion risk changes are the strongest in mountainous and submountainous regions with high topographic potential for soil erosion. In lowlands in the south-west and the south-east, the studied changes had only a subtle impact on soil erosion, even though the C factor increased in these areas (Fig. 4). The unfavourable changes in *C* factor (especially in arable land areas) were mitigated by the small susceptibility of area to soil erosion given by the other factors. The increase in erosion rates in mountainous and submountainous areas is attributed mainly to the ongoing local deforestation caused by timber production and to the intensification of agricultural production in vulnerable areas (e.g. conversion of pastures to arable land). This type of land-use change stands for the most dangerous changes as the significant decrease of the protective function may initiate strong erosion processes. For example, the area of 102 km^2 of the moderate and high erosion risk increase (>7.5 tonnes/ha/year) in the northern part of Slovakia is related to the intensification of agricultural production. The decreases in erosion risk, mainly in the east, are attributed to the conversions of arable land to semi-natural and forest land areas and changes in the crop rotation system towards a higher share of crops with a higher protective function against soil erosion.

These changes with substantial regional differences are also related to a diverse regional development under varying socio-economic and environmental conditions.

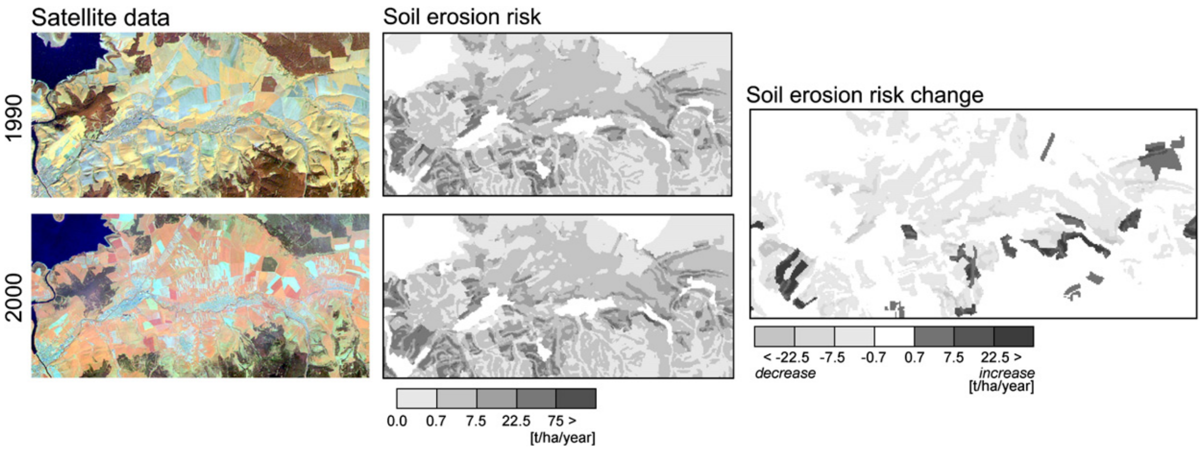

Fig. 7. Example of soil erosion risk changes in agricultural area.

The transformation of economy strongly hit the agriculture sector. The animal production fell by more than 30% during the studied period and consequently the acreage of fodder crops decreased, resulting in the shifts in the proportion of planted crops within the crop rotation system. Thus the acreage of potatoes decreased by 50%, fodder maize by 42% and annual and perennial fodder by 20% (source: Eurostat). The agricultural production in areas with low soil production potential has shifted towards extensive utilisation (e.g. pastures) or even land abandonment followed by the succession of shrub — tree formations. The original large-parcel pattern of arable land was locally changed to small parcels together forming complex cultivation patterns. These changes have increased the protective function of land cover and reduced the soil erosion risk predominantly in submountainous regions. On the other hand, the land ownership changes (mainly via land restitution) induced many local changes in the land utilisation often with a significant decrease in the protective function of land cover (e.g. areas of pastures were changed to arable land (Fig. 7)).

Forests have the highest protective function against soil erosion. The comparison of CLC databases for the considered time horizons showed deforestation in large areas of Slovakia. During the 1992–2000 period, the roundwood production had increased 22% (from 4.755 to 5.788 million m^3/year; source: Eurostat). This trend is the consequence of large timber production exports as new owners seek quick profits. The emergence of clearcuts in the areas susceptible to soil erosion resulted in the soil erosion risk increase (Fig. 8), predominately in the central and northern parts of Slovakia (Fig. 6). On the other hand, the afforestation of transitional woodland-scrub areas altered the protective function of the land cover positively towards the reduction of soil erosion risk (Fig. 8). The overall result of these contradictory processes leads to a slight increase in soil erosion risk in forestland areas.

From the results is clear, that the transformation of political system followed by the transformation of society, and economic environment may induce significant transformation of the land utilisation with consequences on the soil erosion risk pattern. The regional disparities in socio-economic status can be increased by the inappropriate land management practices in vulnerable areas with generally low soil production potential. In these areas, the increase of soil erosion may lead to even a further loss of soil production potential with a negative impact on the local economy and overall regional development. In the next decades this may induce further land-use changes towards land abandonments and afforestations.

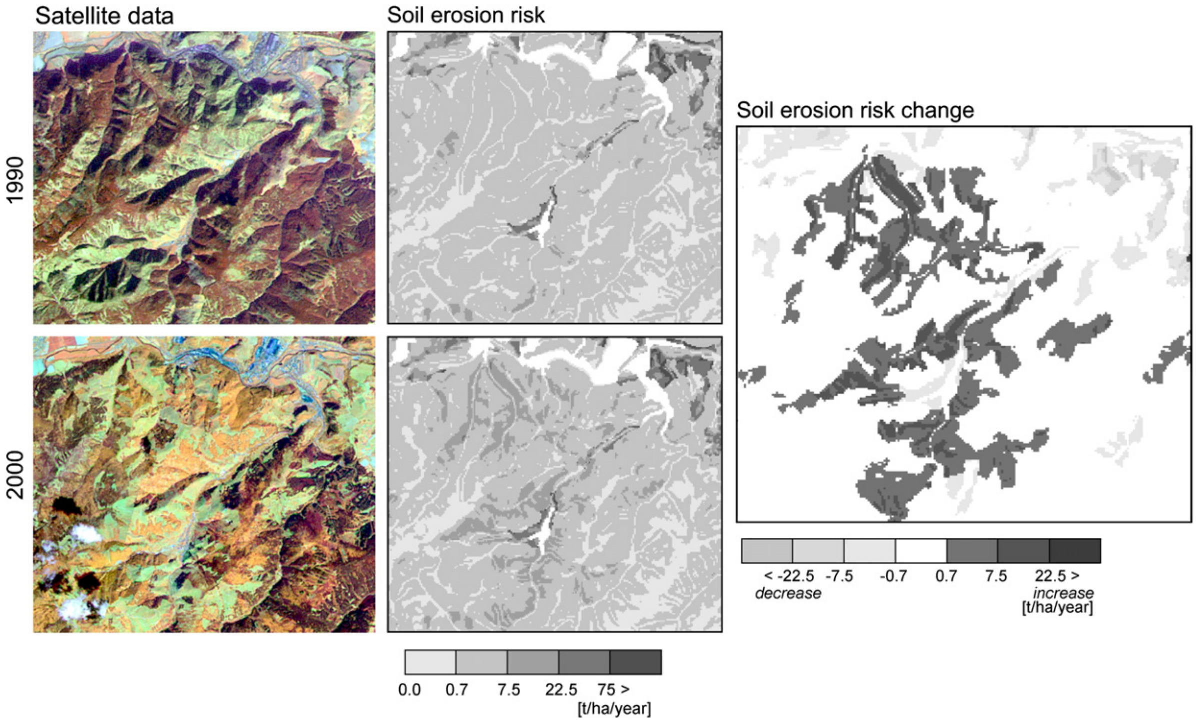

Fig. 8. Example of soil erosion risk changes in semi-natural and forest areas.

4. Conclusions

Our study showed that land-cover changes in Slovakia over the period 1990–2000 lead to changes in soil erosion risk with a mixed character. While some parts of Slovakia have experienced an increased protective function of land cover, other, dominantly mountainous, parts were affected by deforestation, natural disasters and conversion to arable land at locations that are inherently erosion prone and showed increased erosion risks. However, the overall effect of land-cover change over the 1990–2000 period has been slightly positive, lowering soil erosion risks in most areas across the country. The analysis of regional differences in land cover and crop rotation system showed main causes of changes and helped the explanation of ongoing changes in soil erosion pattern in Slovakia.

The changes in land cover and consequently in soil erosion are primarily associated with human activities and changes in landscape utilisation. We expect that a recent accession of Slovakia to the EU and implementation of common agricultural policy will lead to further land-cover changes that will have positive effects with increased protective function of land cover and thus reduced erosion rates. However, the global climate changes may offset these effects at least partially. The complex interaction of evolving factors will be a subject of our further study.

Acknowledgement

The authors wish to thank the reviewers for their comments and suggestions that significantly improved the original manuscript. This research was supported by VEGA Grant Agency of the Slovak Republic within the scientific project No. 1/3049/06 and Slovak Research and Development Agency under the contract No. COST-0016-06. Authors also thank the GeoModel s.r.o. company for providing the digital model of relief of Slovakia.

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