EVALUATION OF THE DATA QUALITY OF DIGITAL ELEVATION MODELS IN THE CONTEXT OF INSPIRE

HODNOTENIE KVALITY DIGITÁLNYCH VÝŠKOVÝCH MODELOV V KONTEXTE INSPIRE

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Abstract

The contribution deals with the evaluation of the quality of geographic information in accordance with the ISO standards from the family of ISO 19100. The quality assessment was carried out on a sample of the data of the digital elevation model of the Slovak republic – DMR3. The selected data quality elements and sub-elements were evaluated using measures defined in the INSPIRE data specification for Elevation.

Abstrakt

Príspevok sa zaoberá hodnotením kvality geografických informácií v súlade s dostupným ISO štandardami z rodiny ISO 19100. Hodnotenie kvality bolo vykonané na príklade vzorky údajov digitálneho modelu reliéfu SR -DMR3. Boli hodnotené vybrané elementy, subelementy kvality pomocou mier definovaných v údajovej špecifikácii INSPIRE pre výškové modely.

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Key words: INSPIRE, Geographic information – Data quality, digital elevation model, metadata

1 INTRODUCTION

The influence of georelief (relief of the Earth) and its geometrical properties on the spatial differentiation of processes in the geographical sphere is very significant. Digital elevation models and derived objects are ones of the basic sets of spatial data in the vast majority of spatial analyses. Therefore there are important not only the information on a spatial distribution of heights, but also the information about the quality of the information. A crucial role in determining the applicability of the model has the accuracy of the information that can be derived on the basis of the model.

Currently there is already a wide range of models available, which entirely cover the territory of the Slovak Republic. A permanent problem for these models is missing or only partial information about their quality. Since the quality of geographic data is one of the key parameters of data sets, which determines its usability and hence their price, it is necessary to solve the problem of missing quality metadata.

Every interested person solving the problem of missing metadata in our geographic area meets with the need of an INSPIRE directive application. The issue of the terrain models in detail covers the INSPIRE data specification Elevation, which is currently (5/2013) at a high level of elaboration. However, this specification is already implementable in its present state. It focuses on the data representation (a grid, a vector, a triangulated irregular network – TIN) for modelling different types of surfaces (a digital terrain model – DTM vs. a digital surface model – DSM). The specification also defines the quality requirements.

The main objective of this work was to verify the applicability of the data specification Elevation to a real digital elevation model – DMR3. We are primarily focused on addressing the quality of the data and metadata from the data specification. We published the results of the quality assessment by the metadata. As the author of this work known, this is the first work in our territory, in which the authors attempted to verify the possibility of applicability of the mentioned data specification and we will be happy if the results of our work will help to others.

2 INSPIRE DATA SPECIFICATION ELEVATION

The INSPIRE directive defines the topic of elevation as:

„Digital elevation models for land, ice and ocean surface. Includes terrestrial elevation, bathymetry and shoreline.“

This theme includes:

- Digital Terrain Models (DTM) describing the three-dimensional shape of the Earth’s surface (ground surface topography).
- Digital Surface Models (DSM) specifying the three-dimensional geometry of every feature on the ground, for example vegetation, buildings and bridges.
- Bathymetry data, e.g. a gridded sea floor model.

In terms of the spatial representation the data specification defines three models:

- Gridded data modelled as continuous coverages compliant with the standard ISO 19123 – Coverage geometry and functions which use a systematic tessellation based on a regular rectified quadrilateral grid to cover its domain.
- Vector objects comprise spot elevations (spot heights and depth spots), contour lines (land elevation contour lines and depth contours), break lines describing the morphology of the terrain as well as other objects which may help in calculating a Digital Elevation Model from vector data (void areas, isolated areas).
- TIN structures according to the GM_Tin class in ISO 19107 – Spatial schema. This is a collection of vector geometries (control points with known Elevation property values, break lines and stop lines).

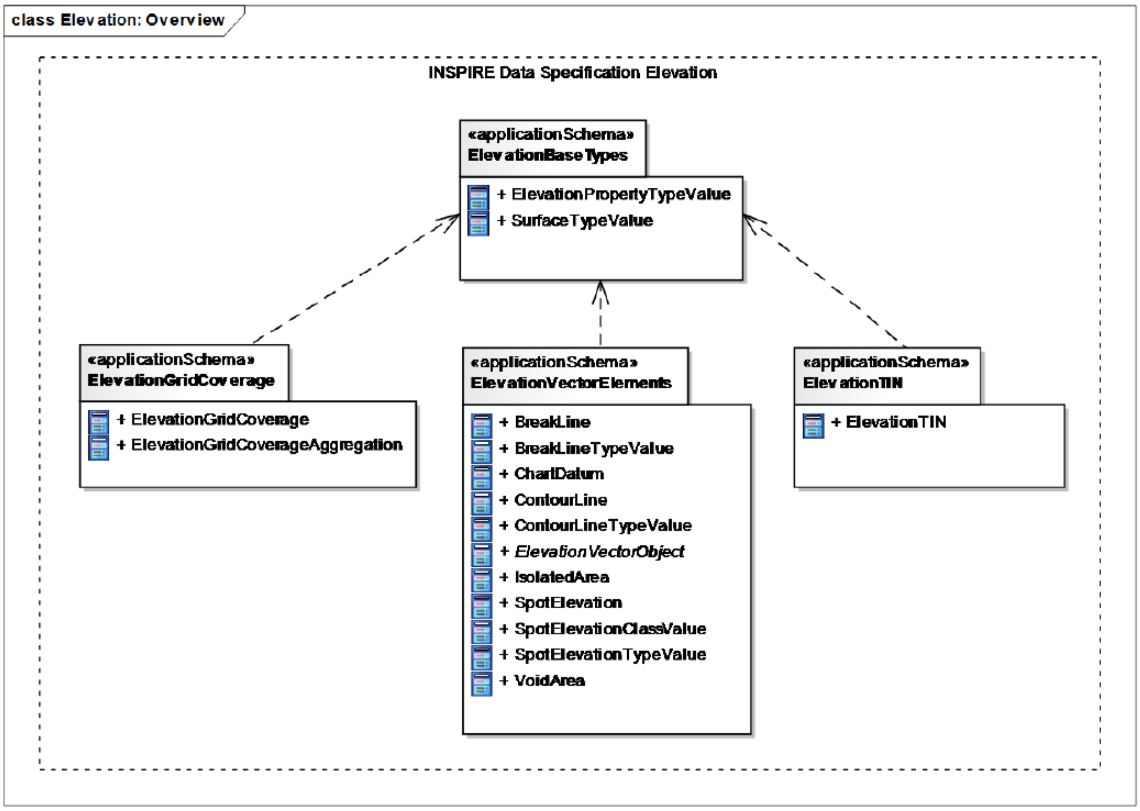

Fig. 1 Overview of Elevation application schemas [2]

3 DATA QUALITY OF GEOGRAPHIC INFORMATION

Quality is a summary of the characteristics of geographic data, which have an impact on their ability to meet established or implied requirements (STN EN ISO 19101). Quality management of geographic data should be carried out in conformity with the standards of the quality of geographic information. Standardization in the field of the quality of the geographic data has already taken place and in this day it is represented by international standards: STN EN ISO 19113, STN EN ISO ISO 19114, 19138 and particularly by ISO 19115. In the future, the standards STN EN ISO 19113, STN EN ISO 19114, ISO 19138 should be replaced by the ISO standard ISO19157 (4/13, it is still in the process of finalization and official publication), which will deal with the spatial data quality comprehensively.

The principle of the data quality evaluation is determined by a set of standard data quality components used to express the quality of geographic data. The components are divided into two basic groups. The first group contains a set of quality elements of geographic data and deals with the quantitative aspect of quality. The second group is made up of a set of elements of review of geographical data quality and deals with the qualitative aspect of quality.

The standard ISO 19157 defines the following data quality elements:

- Completeness
- Logical consistency
- Spatial accuracy
- Temporal quality
- Thematic accuracy
- Usability

If the standard set of elements does not cover all aspects of quantitative quality, it is possible to define own data quality elements. For the expression of quantitative data quality in more details its own standard sub-elements are defined for each element. If these do not reflect all aspects of the quality, it is possible to proceed to the definition of other custom sub-elements.

Completeness

- Commission
- Omission

Logical consistency

- Conceptual consistency
- Domain consistency
- Format consistency
- Topological consistency

Spatial accuracy

- Absolute accuracy
- Relative accuracy
- Gridded data position accuracy

Temporal quality

- Accuracy of time measurement
- Temporal consistency
- Temporal validity

Thematic accuracy

- Classification correctness
- Non-quantitative attribute correctness
- Quantitative attribute accuracy

Each sub-element of the data quality must be applied by using of assessments of seven quality descriptors:

- Data quality scope
- Data quality measure
- Data quality evaluation
- Data quality result
- Data quality type
- Data quality measure type
- Data quality date

The standard STN EN ISO 19113 defines three review elements of the non-quantitative data quality of geographic data

- Purpose
- Usage
- Lineage

If standard elements do not cover all non-quantitative requirements, it is possible to define other new data quality elements. The scope of data quality must be defined for each element.

3.1 INSPIRE data quality requirements for elevation models

The INSPIRE directive and its implementing rules require the evaluation of the quality of harmonized spatial data. The data specification involves the requirements defined in chapter 7. The chapter contains a definition of the elements of quality, the minimum quality requirements and recommendations for the quality of the data.

The following elements are defined for each application scheme of quality.

Tab. 1 Elements and sub-elements of Elevation data quality

Data quality element/sub-element	Evaluation scope	Application schema		
		Vector	Grid	TIN
Completeness /Commission	dataset /dataset series	*		*
Completeness /Omission	dataset /dataset series/ spatial object type	*	*	*
Logical consistency /Conceptual consistency	spatial object /spatial object type	*	*	*
Logical consistency /Domain consistency	spatial object /spatial object type	*		*
Logical consistency /Format consistency	dataset /dataset series	*	*	*
Logical consistency /Topological consistency	spatial object type / dataset / dataset series	*		*
Positional accuracy /Absolute or external accuracy	spatial object / spatial object type / dataset series / dataset	Horizontal component		
		*		*
		Vertical component		
		*	*	*
Positional accuracy /Gridded data position accuracy	spatial object / spatial object type / dataset series / dataset	Horizontal component		
			*	

Each data quality element has its own data quality measure. All measures are based on the standard ISO 19157. For Completeness/Commission the measure *Rate of excess items (measure num. 3 ISO/DIS 19157:2012)* is proposed. It is a number of the excess items in the dataset in relation to the number of the items that should have been present. Element Completeness/Omission is evaluated by the measure *Rate of missing items (measure num.7 ISO/DIS 19157:2012)* – a number of the missing items in the dataset in relation to the number of the items that should have been present. Logical consistency/Conceptual consistency is evaluated by the measure *Non-compliance rate with respect to the rules of the conceptual schema (measure num. 12 ISO/DIS 19157:2012)* – a number of the items in the dataset that are not compliant with the rules of the conceptual schema in relation to the total number of these items supposed to be in the dataset. Logical consistency /Domain consistency must be evaluated by the measure *Value domain non-conformance rate (measure num. 18 ISO/DIS 19157:2012)* – a number of the items in the dataset that are not in conformance with their value domain in relation to the total number of the items. Logical consistency/Format consistency is evaluated by the measure *Physical structure conflict rate (measure num. 20 ISO/DIS 19157:2012)* - a number of the items in the dataset that are stored in conflict with the physical structure of the dataset divided by the total number of the items. For all this four measures, the evaluation scope is defined at the level of a data set or data set series.

For the element, Logical consistency/Topological consistency four data quality measures are defined. The first is *Rate of missing connections due to undershoots (measure num. 23 ISO/DIS 19157:2012).* The measure defines the count of the items in the dataset, within a parameter tolerance, which are mismatched due to undershoots divided by the total number of elements in the data set. Missing connections exceeding the parameter tolerance are considered as errors (undershoots) if the real linear elevation features have to be connected. The tolerance parameter is the distance from the end of a dangling line in which it is possible to consider the line as to be continuous (Fig.2).

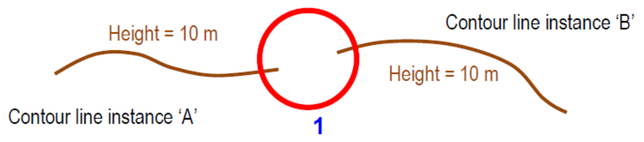

Fig. 1 Example of Rate of missing connections due to undershoots [2]

This parameter is specific for each data provider's dataset and must be reported as metadata using DQ_TopologicalConsistency – 102nd measure Description. The measure is applicable to the objects/feature classes from the application schema Vector – contour lines and break lines with the same height value.

The second measure for the evaluation of topological consistency is *Rate of missing connections due to overshoots.* It is the count of the items in the dataset, within the parameter tolerance, which are mismatched due to overshoots divided by the total number of elements in the dataset. The missing connections exceeding the parameter tolerance are considered as errors (overshoots) if the real linear elevation features have to be connected. The value of the tolerance parameter is a distance from the dangling end of the line in which the overshoots needs to be found. This parameter is specific for each data provider's dataset and must be reported as metadata using DQ_TopologicalConsistency - 102. measureDescription. The measure is applicable to the objects/feature classes from the application schema Vector – contour lines and break lines with the same height value.

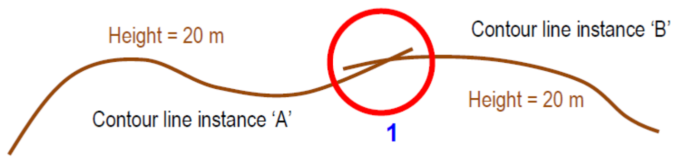

Fig. 2 Example of Rate of missing connections due to overshoots [2]

The third measure is *Rate of invalid self-intersect errors (measure num. 26 ISO/DIS 19157:2012)*. It is the count of all items in the data that illegally intersect with themselves divided by the total number of the elements in the dataset. The measure is applicable to the objects/feature classes from the application schema Vector – contour lines, break lines, void areas, and isolated areas.

Fig. 3 Example of Rate of invalid self-intersect errors [2]

The last measure of the topological consistency is *Rate of invalid self-overlap errors* (*measure num. 27 ISO/DIS 19157:2012)*. It is the count of all items in the data that illegally show a self-overlap divided by the total number of the elements in the data set.

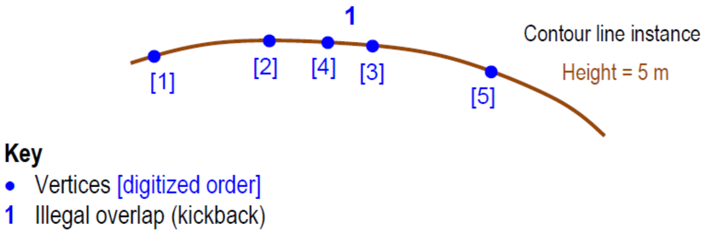

Fig. 4 Example of Rate of invalid self-overlap errors (taken from [2])

The measure is applicable to the objects/feature classes from the application schema Vector – contour lines, break lines, void areas, and isolated areas.

For the element Positional accuracy /Absolute or external accuracy two measures are defined to evaluate the data quality. The first measure is *Root mean square error of planimetry (RMSEP measure num. 47 ISO/DIS 19157:2012).* It is the radius of a circle around a given point, in which the true value lies with probability P.

Equation 1

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left[(x_{mi} - x_t)^2 + (y_{mi} - y_t)^2\right]} \qquad (1)$$

where:
σ – Root mean square error of planimetry
x_t – true value of X coordinate
y_t – true value of Y coordinate
x_{mi} – measured value of X coordinate
y_{mi} – measured value of Y coordinate

The measure is applicable to the objects/feature classes from the application schema Vector as well as the whole dataset or dataset series.

The second measure is *Root mean square error RMSE* in a coordinate Z value. It is a standard deviation, where the true value is not estimated from the observations but known a priori. The measure is applicable to the objects from the application schema Grid – ElevationGridCoverage, feature classes from the Vector application schema– Spotelevetion, contour lines, break lines and the application schema Grid – ElevationGridCoverage at a level of a data set/data set series.

Equation 2

$$\sigma_z = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(z_{mi} - z_t)^2} \qquad (2)$$

where:
σ_z – Root mean square error
z_t – true value of X coordinate
z_{mi} – measured value of X coordinate

The Positional accuracy/Gridded data position accuracy is also evaluated by the Root mean square error of planimetry at a level of an object, feature classes, a dataset, data set series from the Grid application schema.

The data specification doesn't define any minimum data quality requirements, only recommends the values for each of the proposed measures.

Tab.2 Recommended minimum data quality results for spatial data theme Elevation

Data quality element and sub-element	Measure name(s)	Target result (s)
Completeness/Commission	Rate of excess items	0%
Completeness/Omission	Rate of missing items	0%
Logical consistency/Conceptual consistency	Non-compliance rate with respect to rules of conceptual schema	0%
Logical consistency/Domain consistency	Value domain non-conformance rate	0%
Logical consistency/Format consistency	Physical structure conflict rate	0%
Logical consistency/Topological consistency	Rate of missing connections due to undershoots	0%
	Rate of missing connections due to overshoots	0%
	Rate of invalid self-intersect errors	0%
	Rate of invalid self-overlap errors	0%
Positional accuracy/Absolute or external accuracy	Root mean square error of planimetry (RMSEP)	Vector / TIN objects *Horizontal (m):* Max RMSEH = E / 10000 *Example.: For map scale 1: 10 000 is max RMSEH = 1*
	Root mean square error (RMSE)	Vector / TIN objects *Vertical (m):* Max RMSEv = Vint / 6 NOTE: Vint can be approximated by E / 1000. *Example.:For scale 1: 10 000 is max RMSEv = 1.67*
		Grid *Vertical (m):* Max RMSEv = GSD / 3 *Example.: Data with resolution 10 m is max RMSE = 3,34*
Positional accuracy/Gridded data position accuracy	Root mean square error of planimetry	Grid *Horizontal (m):* Max RMSEH = GSD / 6 *Example.: Data with resolution 10 m is max RMSE = 1,67*

3.2 Data quality metadata

The results of the data quality evaluation must be reported by metadata. The standard ISO 19115, which defines metadata elements, deals with the issues of metadata. For the evaluation of the data quality, ISO 19115 defines the package of metadata DQ_DataQuality. Each data quality element/sub-element has its own sub-package e.g. DQ_LogicalConsistency.

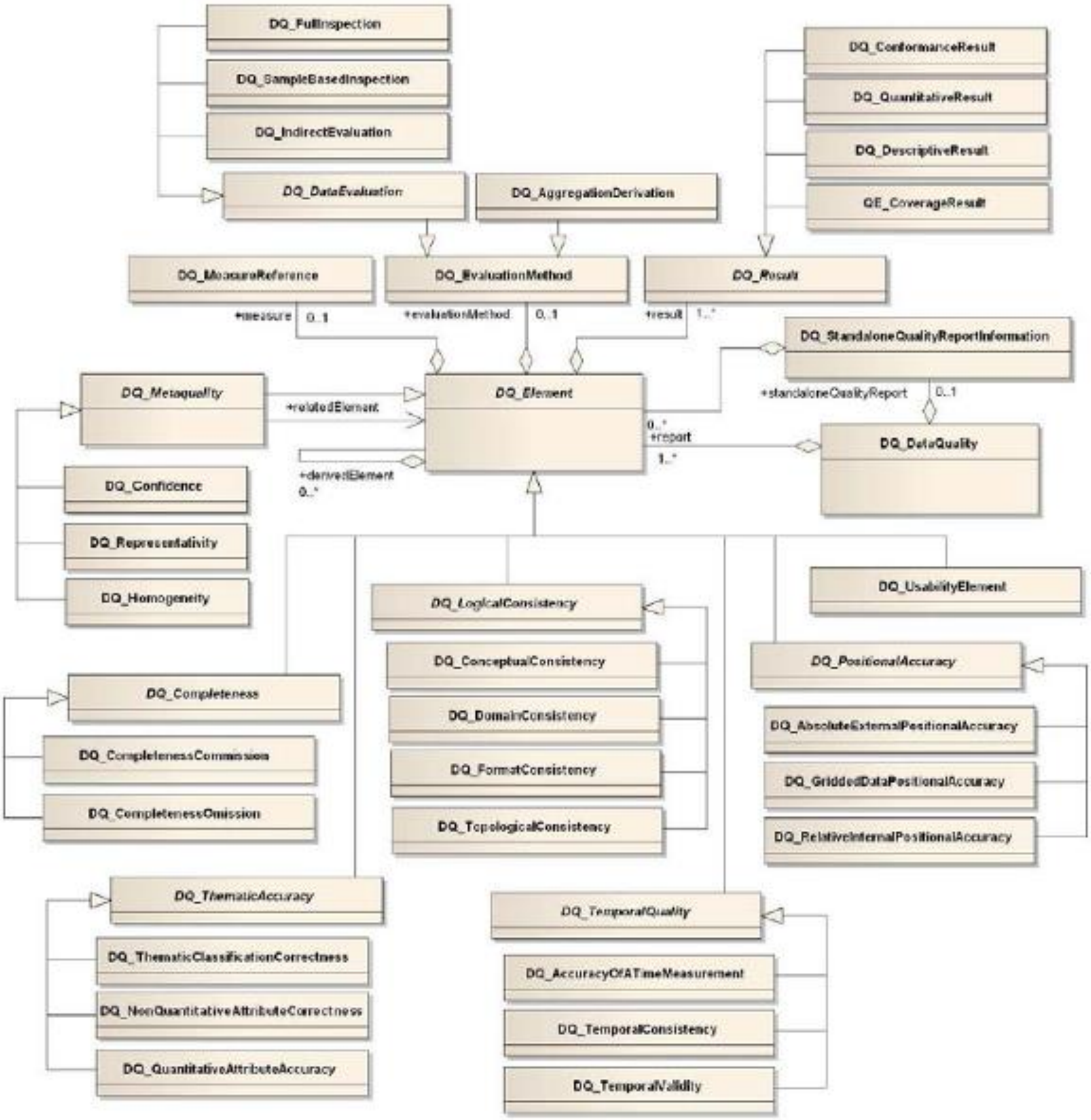

Fig. 6 UML model of data quality metadata [4]

The Foundation is an element DQ_Element, which carries all the elements for reporting the data quality. This element aggregates metadata packages for the data quality evaluation. DQ_MeasureReference is a collection of metadata elements which describes references on the used measure, DQ_EvaluationMethod is a collection of metadata used to describe the methods of the data quality evaluation, and DQ_Result is a collection of elements for reporting the results of the data quality evaluation. The Group DQ_Result includes several types of results. Compliance-DQ_ConformanceResult, the quantitative evaluation using DQ_QuantitativeResult, a text description of the result using DQ_DescriptiveResult and QE_CoverageResult to report the quality using a surface. For the quality evaluation it is necessary to specify the level at which the quality was evaluated in the metadata. This level is defined by the element DQ_DataQuality – DQ_Scope. It is recommended to use the data of values for the DQ_Scope-data set/data set series/feature class.

Under the rules of the INSPIRE data quality evaluation, it is necessary to use the quantitative evaluation using DQ_QuantitativeResult or the descriptive evaluation using DQ_DescriptiveResult. In the data specifications Elevation, the results of the evaluation of the quality are of the quantitative nature and must be reported by the metadata elements DQ_QuantitativeResult.

4 CHARACTERISTICS OF INPUT DATA

In the practical part of our work, we worked with the elevation data derived from the digital elevation model of the third generation – DMR3. For the testing area, we choose the territory on the border of Malé Karpaty (Little Carpathians Mountains) and Podunajská pahorkatina (Danube Wold) defined by the following geographical coordinates:

48°:34':06.978512'' N.

48°:05':54.007436'' N.

17°:42':48.66972'' E.

17°:00':29.420426'' E.

Those geographic coordinates correspond approximately to the extent of map sheet M-33-131-Db topographic maps in a scale of 1:25 000 (TM25).

Fig. 7 Map sheet M-33-131-D-b TM25

DMR3 was created by the Topographic Institute Banská Bystrica in 2004 from altimetry map print base topographic maps at a scale of 1:10 000 (TM10) and 1:25 000 and some small parts from the basic maps at a scale of 1:10 000 (ZM10) [1]. Fig. 8 contains a sample altimetry map print base in the map sheet M-33-131-Db topographic maps at a scale of 1:25 000. Timeliness of DMR3 matches the state of TM10 and TM25, possibly ZM10. DMR3 has a form of a regular grid with a horizontal resolution of 10, 25, 50, or 100 m in the coordinate system S-JTSK. Models with a lower horizontal resolution were generated from the model with 10m resolution. Primarily, DMR3 is provided in the coordinate system S-JTSK and the height system Balt after adjustment, but there are versions in other coordinate systems (e.g. UTM34 and WGS84) as well. Since it is not publicly known which of these systems had been used in the process of building and which is the original version, while the remains are derived by transformation and resampling, we decided to use it as input DMR3 in S-JTSK. Inputs, the production process and also the data quality information about DMR3 were not published by their creator. The results of the independent evaluation for the whole territory of the Slovak Republic can be found in [7].

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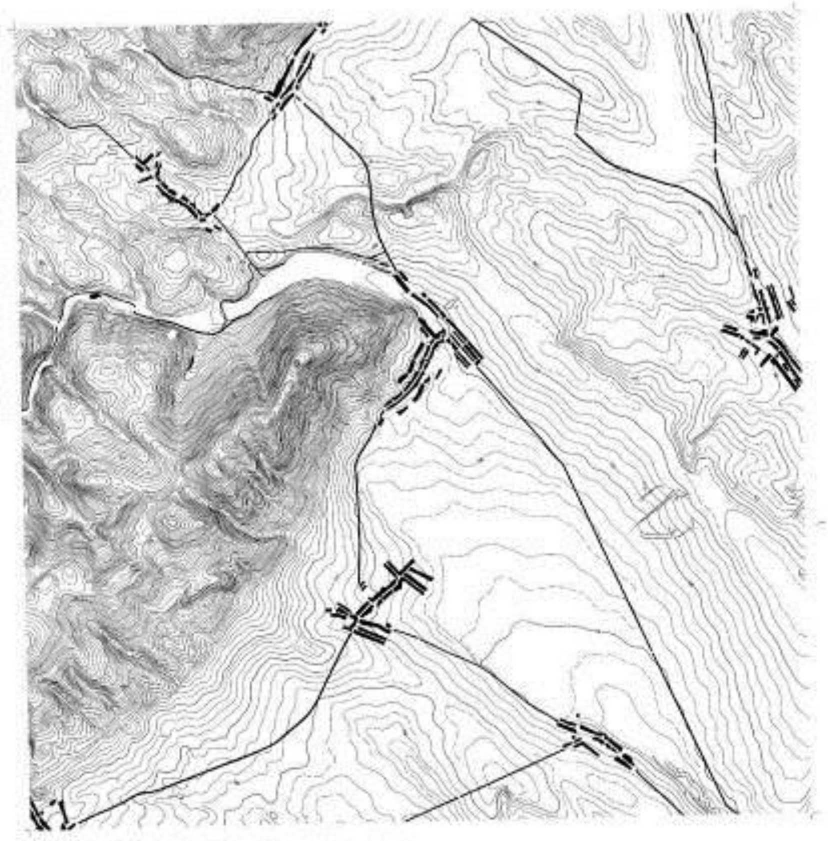

Fig. 5 Print pattern of hypsography of M-33-131-D-b TM25

DMR3 were used to prepare four layers according to the specification of the application scheme for the theme Elevation:

- Regular grid
- Triangulated irregular network - TIN
- Contour lines
- SpotElevation (Singular points of elevation)

4.1 Preparing data generation

The input DMR3 data have already been in the form of a regular grid, it was enough to transform them to a coordinate system ETRS89 and crop them by the vector representation of the map sheet M-33-131-Db. For the coordinate transformation from S-JTSK -> ETRS89 binding parameters from [11] were used. The error of the missing conversion of S-JTSK-> S-JTSK (JTSK03) could be neglected due to the nature and scale of the input DMR3 data. In order to minimize the distortion values of elevation, on the one hand, and efforts to preserve the smoothness of relief on the other hand, a resampling method of bilinear interpolation was used in the transformation process. The resulting regular grid resolution was 0°:00':00.41463". The model is shown in Fig. 9.

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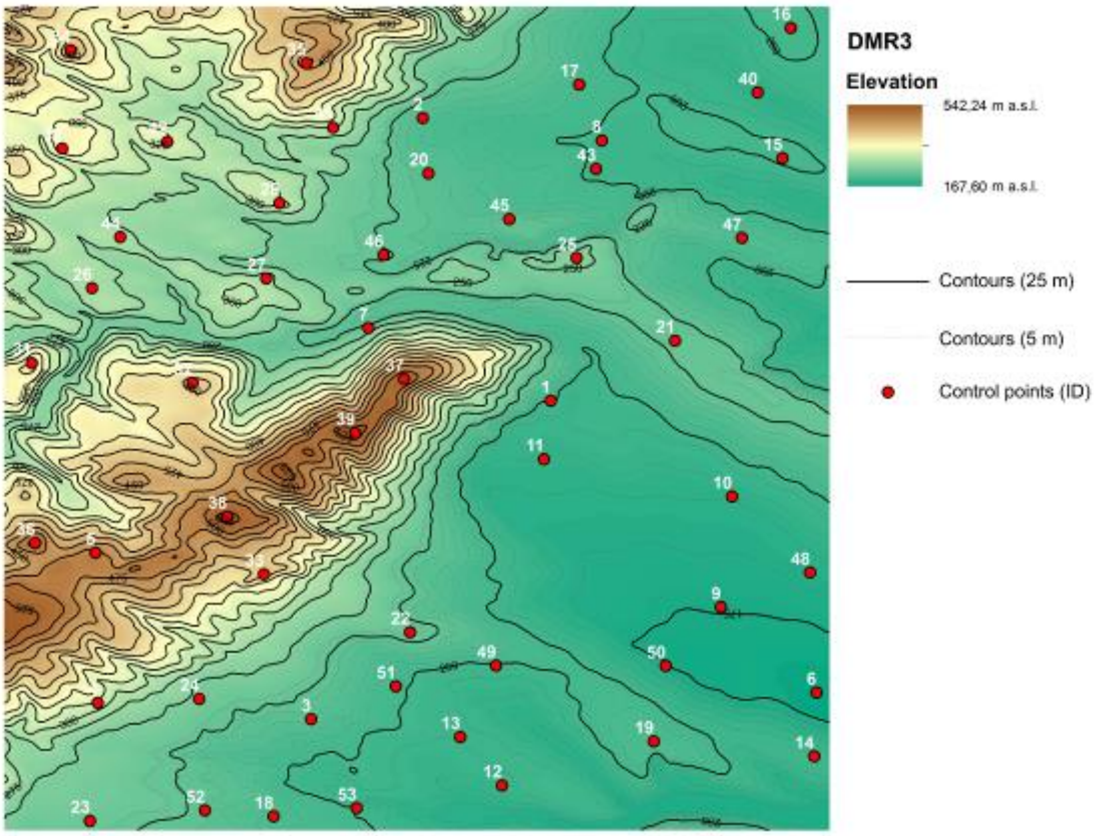

Fig. 9 Testing area with control points

In the following steps, the created regular grid was a basis for the derivation of three remaining layers.

The creation of an elevation model with the data representation in the form of a triangulated irregular network (TIN) was solved in two steps. At first it was necessary to create an input point field whose points will form the vertices of triangles. To utilize the ability of adapting the model (in this case, the distribution and local density of points) to the shape of the modelled surface, we chose a memoryless simplification method for reducing the model elements. This method works with a polyhedral model, reducing the elements by edge contraction. When contracting the edges, their two endpoints V0 and V1 are merged into a new vertex V. The algorithm minimizes partial changes in the model volume by the contraction as well as the total volume of the model. It proceeds from the edges, where the contraction creates the slightest change, which even in a small number of model elements maintains high geometric fidelity [6]. The number of nodes in the input grid was 754,292; we generated a set of 83,408 points which formed the vertices of triangles. We reduced the number of points to about 11 % of the original number.

The generated entry points were a base for the Delaunay triangulation. This method of triangulation is recommended by Directive ISO 19107:2003 for the geometric object GM_Tin. Triangulation constraints (Breakline, Stopline or maxLength) were not used. The resulting TIN created by Delaunay triangulation consists of 166,787 triangles.

The layer containing contours was created from a regular grid by the module for creating isolines in the GRASS GIS environment. A ten-meter contour spacing was chosen in a minimum of 160 m above sea level. Fig. 9 and Fig. 10 show the demonstration of the contour level representation, however it was necessary to modify the contour spacing to 25 meters for the main contour lines, and auxiliary contour lines spaced at 5 m intervals were added into flat areas because of clarity.

The layer of singular points was generated from a regular grid. There were calculated isolines of zero value of the first partial derivatives of the elevation in the direction of the axes X and Y. The singular points are determined by their intersections. We wanted to determine the type of singular points on the basis of positive resp. negative values of the second partial derivatives at those points. Whereas DMR3 does not allow to calculate partial derivatives of the second order in sufficient precision, this procedure has a high error rate, and we determined the type of singular points applying a professional manual approach. The resulting layer of the singular points is shown in Fig. 10.

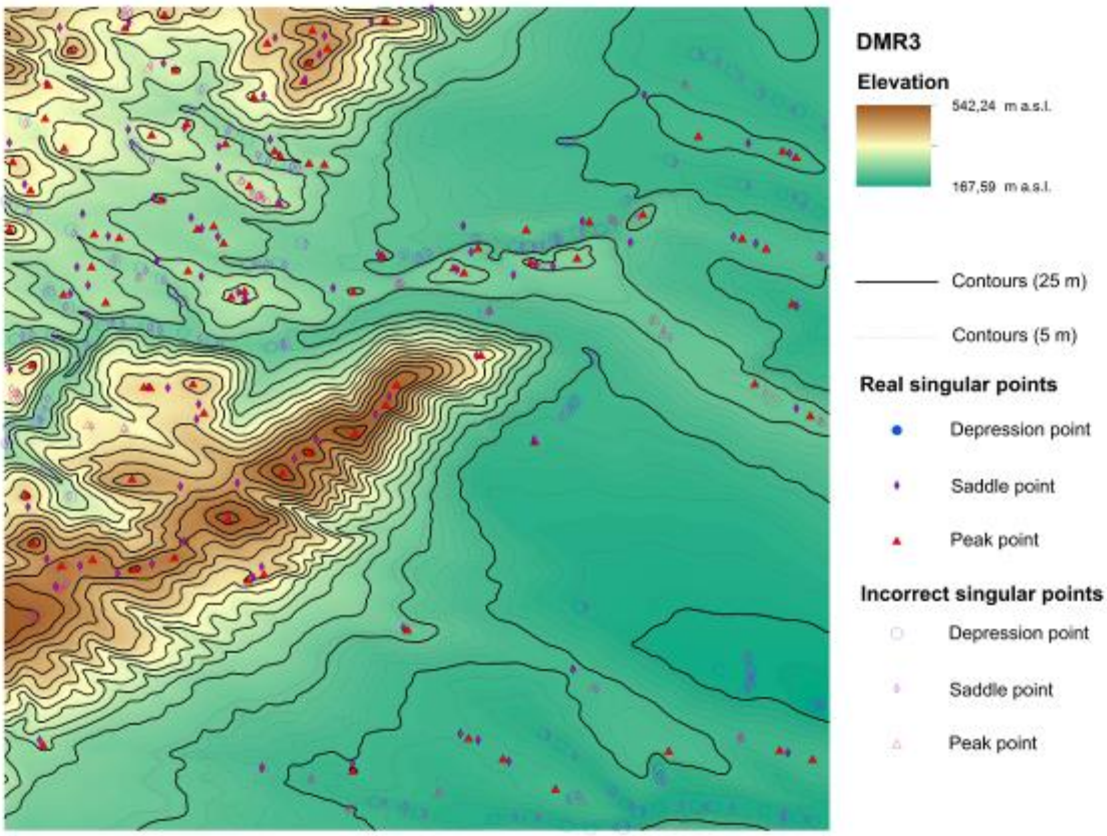

Fig. 10 Spatial distribution of elevation singular points

5 DATA QUALITY EVALUATION

The evaluation of data quality in the above layers was carried out in a defined set of quality components by applying all mandatory descriptors. In evaluating the quality parameters, we focused on the assessment of absolute positional accuracy, topological consistency and completeness of singular points. The quality in elements conceptual consistency, domain consistency and format consistency were not evaluated, because the raw data were not harmonized in accordance with the data model defined in the data specification. All layers were evaluated in all of the required components in the full territorial scope of the test area. In work [7] there was published the information on the procedure for the assessment and evaluation of results for the DMR3 in other thematic defined ranges (depending on the type of land cover and the degree of vertical relief segmentation).

Within the meaning of division of geographic data quality evaluation methods according to ISO 19114 a direct external-data-based method with a quasi-random variant or choosing control sites was used at all levels and in all evaluated elements. The method was applied mainly in an automated form.

The external data, for which the positional accuracy of the tested layers was evaluated, were a set of 52 geodetic survey points with the declared maximum mean error in position mxyz = 0:15 cm. The layout of control points in the test area is shown in Fig. 9.

5.1 Procedure of evaluation of absolute positional accuracy

For a regular grid in this element, we evaluated the quality of its vertical component. The actual evaluation was undertaken by obtaining values of altitude from DMR3 on the coordinates of control points and subtracting it from the control point attribute value of altitude.

By this procedure, we obtained a vertical error, for which a statistical method was subsequently used. For selecting the values of altitude from DMR3, a bilinear interpolation method was used. The interpolated surface of the value of the vertical error of DMR3 and the control points are given in Fig. 11:

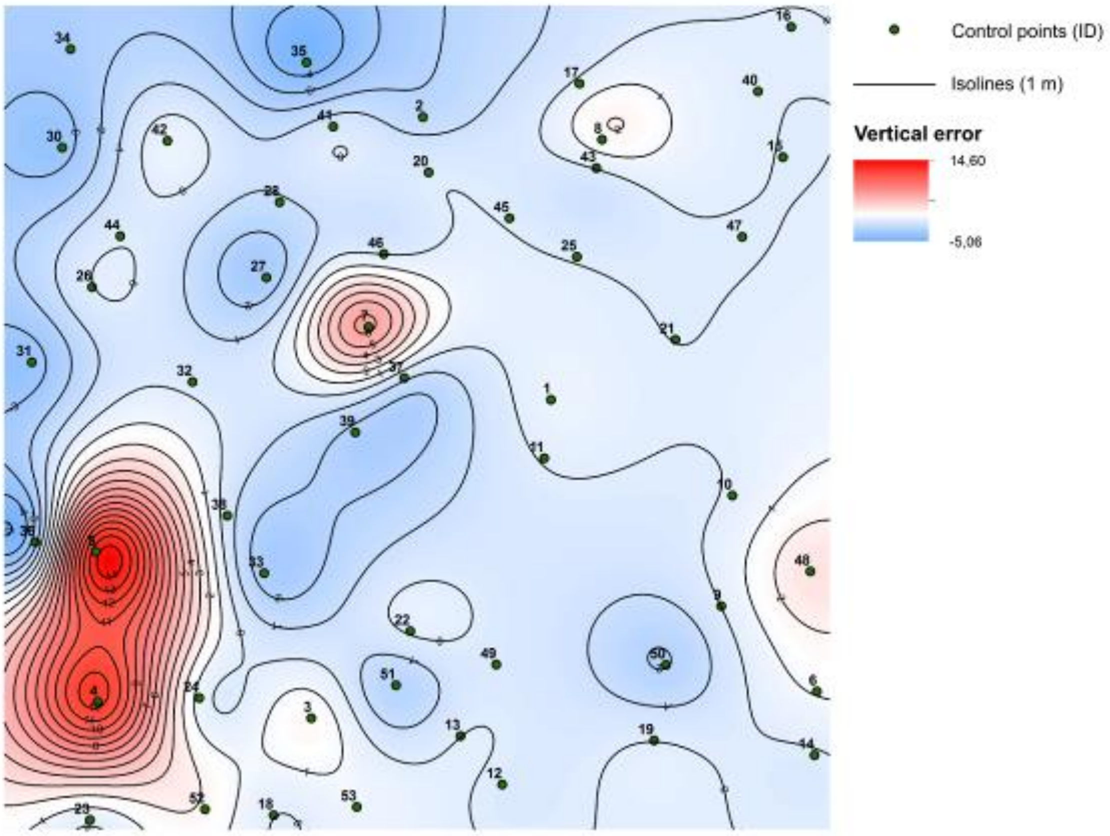

Fig. 11 Spatial distribution of values of the vertical errors for regular grid

For the TIN, we evaluated the quality in absolute positional accuracy of its vertical component. The actual evaluation was undertaken by obtaining the values of altitude from TIN on the coordinates of control points and subtracting it from the attribute value of altitude of control points.

By this procedure, we obtained the value of a vertical error, for which a statistical method was subsequently used. For selecting the values of altitude from TIN, a linear interpolation method was used at the vertices of the triangle which were spatially appertained to the checkpoint. The interpolated surface of the value of the vertical error of TIN and the control points are given in Fig. 12.

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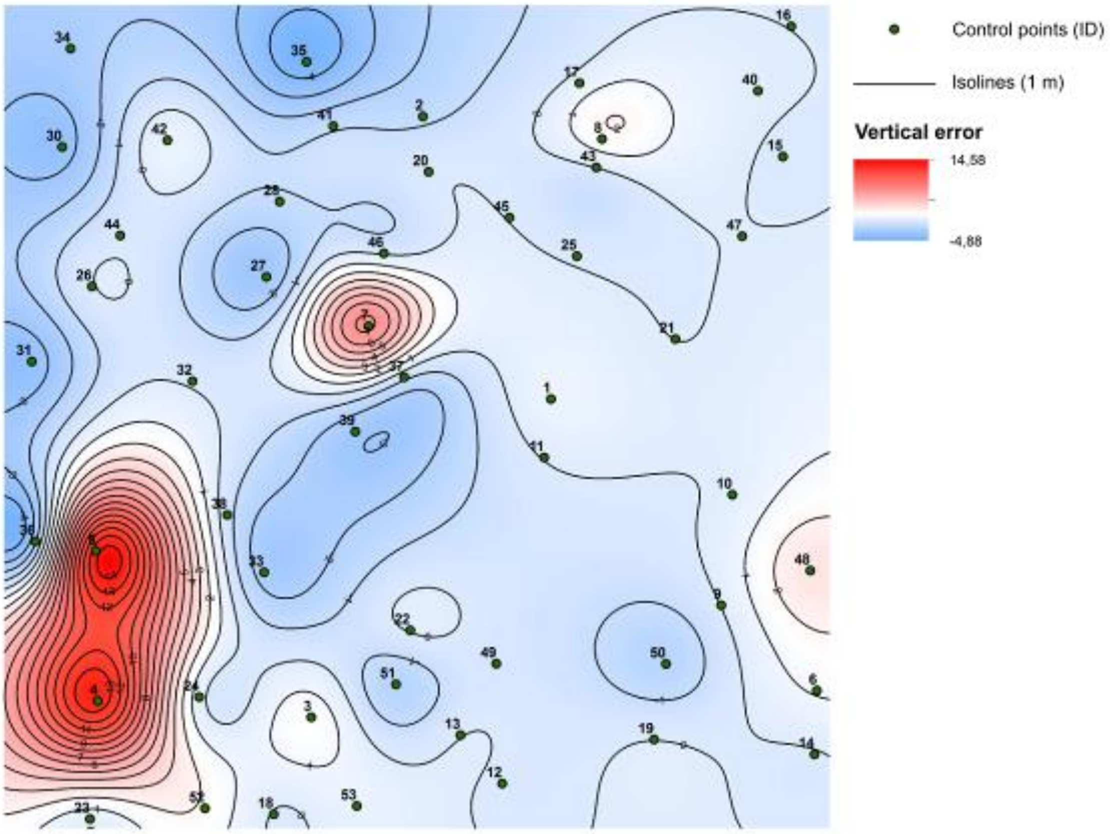

Fig. 12 Spatial distribution of values of vertical errors for TIN

For the isolines, we evaluated the quality in absolute positional accuracy of its horizontal component. The values of the horizontal errors for each control point were determined by a distance between the checkpoint and its appertained point on the isoline. We were not able to locate any appertained isoline for eleven control points and thus they were not used. They were the checkpoints in the top areas of the relief where DMR3 underestimated the height of relief.

5.2 Procedure of evaluation of singular points completeness

The layer of singular points was evaluated in two sub-components of completeness. Completeness - Omission and Completeness - Commission were evaluated on the basis of professional manual typing singular points. It was assessed whether the presence of singular points in DMR3 corresponds to reality. The basis for this was typing a contour with a small pitch. Most of the results of this evaluation showed DMR3 interpolation errors, which caused a large number of defective items in the valleys of depression and their related saddle points.

5.3 Procedure of evaluation of topological consistency

The evaluation of the quality in element topological consistency was performed for the isolines of layers and TIN, for which the topological consistency could be evaluated. The isolines were generated from the grid using GRASS GIS tools that help prevent creating the topologically incorrect data. Therefore, we further evaluated the topological consistency by other means, and consider it as correct. On the other hand, TIN was created out of the GRASS GIS environment, and after its import, a module was therefore launched for checking and correcting the topology, which revealed no topological error.

6 RESULTS OF DATA QUALITY EVALUATION

On the basis of the above procedures, we obtained the following results.

Absolute positional accuracy (vertical)

The most likely size of a vertical error of DMR3 in the test area for a regular grid has a value of 0.22 m and 0.25 m for TIN. The standard deviation of the vertical error of DMR3 in the test area is 3.04 m for a regular grid and 3.19 m for TIN. Ninety per cent of the surface of the tested area of DMR3 has the value of the vertical error in the range of -5.74 m to + 6.19 m for the regular gird and -6 m to +6.51 for TIN. The graphical representation of spatial distribution of the vertical error is shown in Fig.11 and Fig.12.

Absolute positional accuracy (horizontal)

The most likely size of a horizontal error of DMR3 contours in the test area has a value of 32.85 m. The standard deviation of the horizontal error of DMR3 in the test area has a value of 71.68 m. Ninety per cent of the surface of the test area has the value of the horizontal error in the range of 107.98 to 173.69 meters.

Tab. 2 Results of absolute positional accuracy evaluation

Data quality elements	Mean error [m]	RMSE [m]	90 % confident interval [m]
absolute positional accuracy – regular grid	0.22	3.04	<-5.74;6.19>
absolute positional accuracy - TIN	0.25	3.19	<-6.00;6.51>
absolute positional accuracy - Isolines	32.85	71.86	<107.98;173.69>

Completeness – singular points

The layer contains all existing singular points. It contains 472 points, from which 303 (64.2 %) doesn't exist in terrain. The graphical representation of the distribution of the existing and abundant singular points is shown in Fig. 10. The classification of types of singular points is shown in Tab. 4.

Tab. 3 Results of singular points completeness evaluation

Type of singular point	Valid		Invalid		Sum
	[abs.]	[%]	[abs.]	[%]	
Depression points	0	0.00	116	100.00	116
Saddle points	81	34.76	152	65.24	233
Peak points	88	71.54	35	28.46	123
All points	169	35.81	303	64.19	472

7 CONCLUSIONS

The evaluation of the quality of geographic information is an important element in building the infrastructure for spatial data. It contributes to the more efficient access of users to spatial data with the required quality. The INSPIRE directive and its implementing rules require the data providers to evaluate the data quality of individual data sets referred in Annexes I to III of the directive. Currently, this issue is not paid so much attention, as providers of spatial data are more focused on the process of harmonization of the data with the data models defined in implementing rules of the INSPIRE directive. Our aim was to point out the way how to approach the evaluation of quality in the context of INSPIRE. As an example, we chose a sample of data from the digital height model of the Slovak Republic – DMR 3. In view of the fact that we didn‘t harmonize the input data with the INSPIRE Elevation data model; we selected those data quality elements and measures, which didn't require any harmonized data model as well as we consider them as a crucial and very important in the process of the data quality evaluation of a digital height model. This was the absolute positional accuracy where we used mean error rates, a standard deviation and an error limit of 90% confidence interval. For a regular grid and TIN model, we evaluated the vertical accuracy and horizontal accuracy for contours. The resulting values reflect the way, in which DMR 3 was originated. We evaluated the quality of singular points of the relief by element completeness, where we identified the missing objects and objects in addition. In our case, we didn't want to highlight the resulting values, but rather the procedures of the spatial data quality evaluation. We summarized the results of the data quality evaluation by filling required data quality metadata elements; and the created metadata was published by the CSW service, which is available at http://gis.fns.uniba.sk/geonetwork.

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RESUMÉ

Hodnotenie kvality geografických informácií patrí medzi dôležité elementy pri budovaní infraštruktúry priestorových údajov. Prispieva k zefektívneniu prístupu užívateľov k priestorovým údajov v požadovanej kvalite. Smernica INSPIRE a jej implementačné pravidlá kladú na poskytovateľov údajov požiadavky na hodnotenie kvality pre jednotlivé dátové sady podľa príloh smernice I až III. Tejto problematike sa v súčasnosti nevenuje až taká pozornosť, nakoľko poskytovatelia priestorových údajov sú viac zameraný na proces harmonizácie údajov do údajových modelov definovaných v implementačných pravidlách smernice INSPIRE. Našim cieľom bolo poukázať na spôsob akým pristupovať k hodnoteniu kvality v rámci INSPIRE. Ako príklad sme zvolili vzorku z údajov z digitálneho výškového modelu Slovenskej republiky - DMR 3 . Vzhľadom na fakt, že sme vstupné údaje nepodrobili harmonizácii do údajového modelu z údajovej špecifikácie Výška, vybrali sme tie elementy a miery kvality, na ktoré nemal nevykonaný proces harmonizácie vplyv a z hľadiska použiteľnosti DMR 3 v praxi sme ich pokladali aj za najdôležitejšie. Ide o absolútne polohové presnosti, kde sme využili miery stredná chyba, smerodajná odchýlka chyby a hranica 90 % intervalu spoľahlivosti. Pre pravidelnú mriežku a TIN model sme hodnotili vertikálnu presnosť a pre vrstevnice horizontálnu presnosť. Výsledné hodnoty reflektujú spôsobom akým DMR 3 vznikal. Kvalitu singulárnych bodov reliéfu sme zhodnotlili pomocou element úplnosť, kde sme identifikovali chýbajúce objekty ako aj objekty navyše. V našom prípade sme však nechceli poukázať na výsledné hodnoty, ale skôr na postup, ako pristupovať k hodnoteniu kvality a akým spôsobom ju vykázať. V našom prípade sme vykázali kvalitu údajov pomocou vyplnenia položiek v metaúdajoch zaoberajúcich sa kvalitou a výsledky sme sprístupnili pomocou katalógovej služby na http://gis.fns.uniba.sk/geonetwork.