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Geoinformation technologies in the identification of meandering section of the river

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Abstract: The aim of this study was to present the capabilities of using geoinformation technologies in the process of outlining meandering section of the river.
Development of valley plain rivers landscape is connected with occurrence of old river beds, which came into existence because of natural changing of river-bed (meandering) or man interference in water system (Glińska-Lewczuk et al. 2010). Survey results from terrestrial laser scanning (TLS) combined with hydrologic data can be successfully used to determine area, borders and duration of overflow of the old river beds. It is a complex problem which requires operations with large data sets. These actions include determination of the appropriate means of execution, data integration and conducting calculations and analyses (Gotlib et al. 2007).
In this study terrestrial laser scanning was used for monitoring of meandering section of the Drweca River. Measurements took place in two specific times of the year: in May 2011 (spring thaw) and in October 2011 (after draught in summer time). Obtained point clouds became a basis for differential models, which were used for monitoring. They also enable to determine the rate of the changes in river beds and to observe changes in meanders. Authors claim that terrestrial laser scanning is a good alternative for a river monitoring, although it has limitations.

***Keywords**:* Geoinformation technologies, scanning, TLS, 3D model

1. INTRODUCTION

There is not even one natural river bed with straight course along the whole distance of the river. Each watercourse has wimples and meanders (Czaya 1987). In the middle section of the river side erosion usually predominates bottom erosion, what in result leads to natural changes in the course of river bed and cut-offs appear (Klimaszewski 1978, Starkel 1995). The rate of change of river channel is mainly determined by regime of river estuary, which is affected by set of natural features of river valley such as climatic, geomorphologic, soil conditions and landuse (Babiński 1990, 1992, Józefaciuk 1995, Leopold et al. 1957, Makaske 2001, Malanson 1995, Meakin et al. 1996, Schumm 1985, Ward 1998).
Engineering and geomorphologic studies prove that there is great diversity of river beds. Brice et al. (1978) distinguish three types: winding, braid and branched river beds (Kobus et al., 2010). Cut-offs, especially those permanently connected with

river channel, are transitory stages between river channel and lake. Those, with no strict connection with the river, create different types of water environment in comparison to river bed conditions.

Cut-offs, as well as small water basins in agricultural landscape, play many valuable and complex functions (Koc et al. 2001, Glińska-Lewczuk 2004). Among many of them, functions that should be mentioned, are: biotic, hydrologic, environmental, scenic, educational, cognitive, economic, recreational. From ecological point of view, in modern and complex understanding of landscape, waters ecosystems are living space for people, animals, vegetation and microorganisms which take part in natural environment processes. Rivers and wetlands are the most varied, sensitive and endangered ecosystems in Europe. Therefore complex protection and preservation of waters and theirs re-naturalization, revitalization and reasonable sharing becoming a necessity (Kulesza et al. 2007).

2. STUDY AREA

The area of study is valley of the Drweca River located in its middle reaches. The Drweca River is a right-hand tributary of the Vistula River, with the catchment area of 5343,5 km2 (Fig. 1). Total river length is 207 km. In the lower and middle reaches the river intensively meanders in a 1-3 km wide flat bottom valley. The hydrological regime of Drweca River is characterized by long-lasting flood period resulted from snow and ice melting (about 44% days of a year) and decline of water level in early autumn (Burandt 2011). The period of inundation lasts from March till April and usually finishes at the beginning of June. However, sometimes additional input of precipitation prolongs the flood until June. Changes in water levels in the valley reach to 2 m.

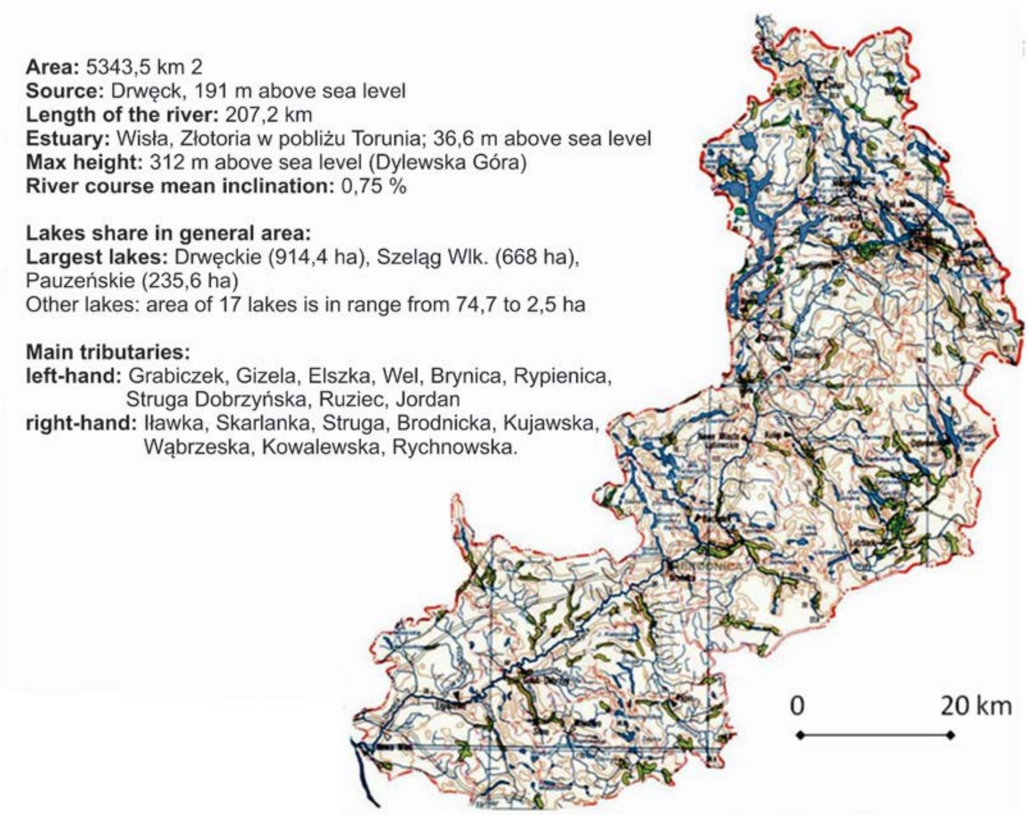

Figure 1. Characteristics of the Drwęca River catchment.

For detailed study section with morphological and hydrological diversity was chosen. The most important criterion was the occurrence of very varied reaches of the river with many meanders and cut-off channels. The study area is located in vicinity of Jajkowo, near Brodnica. It is naturally meandering part of valley and distinguished by mild man interference. (Fig. 2).

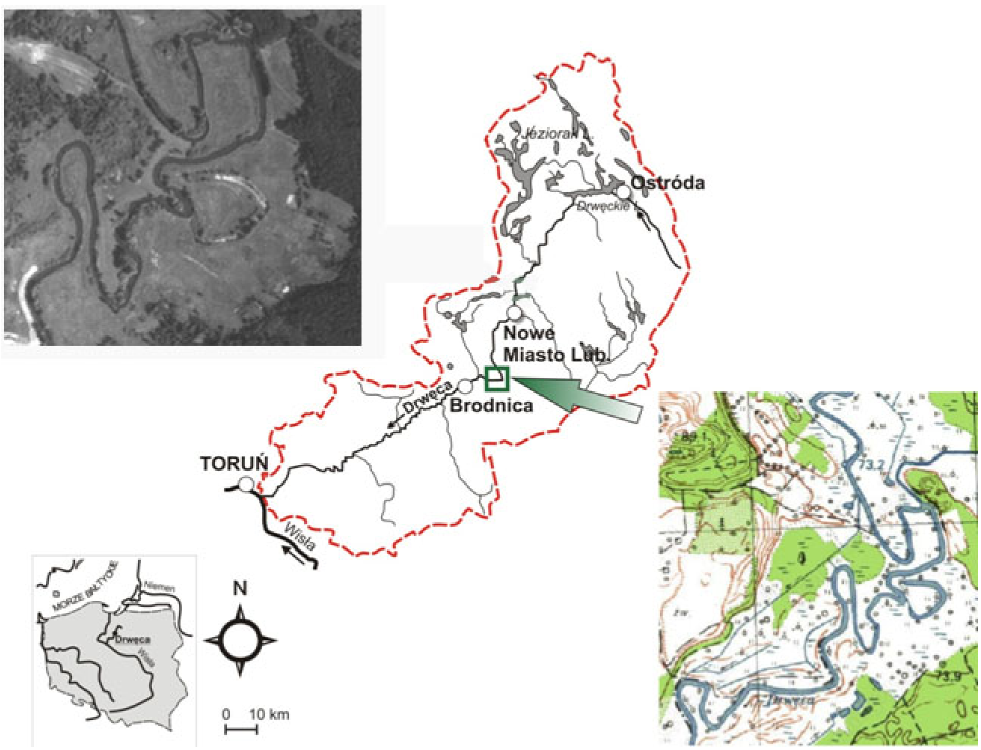

Figure 2. Localization of studied oxbow lake on the background of the Drwęca river basin.
(Source: Kalinowski et al., 2011).

Characteristics of study area are as follows: great diversity of temperature (cv = 72,8%) and oxygenation (cv = 66,3%) related to the season of the year and water level of the river. During period of accelerated water circulation (spring) oxbow is fed mostly by very well oxygated water from river (raised water stage, flash flood). Periodic inundation of the valley leads to significant changes of these ecosystems, because raised water not only changes chemical content and accessibility of allochthonous matter (vivid organisms included) but also regulates oxygen budget in whole water body. Another feature is land use. In study area there are pastures, meadows, wasteland. There is a lack of forest. The course of the river is straighten. Annual precipitation is 600 – 700 mm (40% in winter), average temperature is +6˚C (Kalinowski et al., 2011).

3. GEOINFORMATION TECHNOLOGIES

As yet, monitoring of river bed changing (windings) phenomenon has meant conducting specialized field surveys, which were applied by hydrologists and soil scientists. Due to obtained data, 2D hydrodynamic models were created. Development in data acquiring, processing, especially data like aerial photos, satellite images and data from terrestrial laser scanning is a good base for 3D models creation. 3D models enable to simulate many various processes and occurrences of the real world and often replace 2-dimentional maps and databases (Tymków et al. 2010).

Effective generation of spatial models requires fast method of relief and objects surveying and fast and reliable algorithms for modeling. For data collection, laser scanning technology (aerial and terrestrial) is mostly used. Thanks to precision and resolution of terrestrial laser scanning it is possible to reconstruct the geometry of objects in macrostructural approach (outline of an object is modeled) as well as in microstructural (shape and topology is modeled) (Tymków et al. 2010).

3.1 The aim, conditions and technical aspects of conducted study

Potentialities of using geoinformation technologies and terrestrial laser scanning for monitoring of meandering section of the river were evaluated in this study.
In May 2011, planned field work was supposed to focus on measurements of the section called "Jajkowo". The range of work was extended because of observed changes in river location in October 2011. Double measurement with five month hiatus fulfilled monitoring requirements. Results of measurement are presented in 3.2 section.
In this project terrestrial laser scanning was used. Result of scanning was a basis for digital terrain model generation. Measurement were made by means of Leica terrestrial scanner ScanStation C10. Terrestrial laser scanning should be qualified as modern technology in geodetic measurements. Principle of its operation is based on determination of coordinates X,Y,Z of a large amount of points (1000-500000) within a second (Kamiński et al. 2008). Point sets are called "point cloud" because of its range. During scanning the density of scanning was determined. It resulted from relief and terrain cover (Toś et al. 2011).
Results of measurement were processed by means of softwares provided by Leica with scanner: Cyclone and CloudWorx for Microstation. Others softwares, such as Pointtools, PollyWorsk were also used. In ArcGis 10 Esri topographical map was imported and then vector map was created. Digital Terrain Model was generated by Golden Software Surfer 10.

3.2 Method for determination of meandering section of the river

Concept of using terrestrial laser scanning is based on scanning flood-endangered area in a chosen moments. Therefore, measurements were planned in May – T_1, during spring thaw, and in October – T_2, after draught in summer time. Then authors focused on generating 3D models for those moments.
Digital Terrain Model generation included two stages. First stage included general filtration of point cloud from terrestrial laser scanning. The results were points representing terrain. The final filtration was executed by means of TIN (*Triangulated Irregular Network*), based on points which left. Coastal vegetation was eliminated, embankment of meandering river was vectorized (Fig.3 – MEASUREMENT 1 and Fig. 4 – MEASUREMENT 2).

(**Figure 3**. and **Figure 4.** – stages of point cloud filtration for outlining meandering section of the river – MEASUREMENT 1 and MEASUREMENT 2).

Second stage is a model generation from selected points (figure 5 and figure 6).

(**Figure 5.** and **Figure 6.** Digital Terrain Model – selection 1, Digital Terrain Model – selection 2).

Differential model is a basis for monitoring (Niemiec et al. 2009), determination of the rate of changes in river bed and enables to observe changes in location of meanders. In figure 7 differential model created from measurement 1st and 2nd is presented:

$$DTM\_T_1 – DTM\_T_2$$

Figure 7. Differential model created from measurement 1st and 2nd.

3.3 Field work

In May 2011 (1st measurement T_1) and in October 2011 (2nd measurement T_2) control net was established. In those measurements GNSS receiver was used (Fig.8). Points were measured and marked by fixed targets for identification. In account of possibilities of using them for point cloud filtration, scanning correction and natural texture generation photos of them were taken by camera of ScanStation C10 in October 2011, (Toś et al. 2011). Scanning in both cases was conducted from two stations. Stations were located about few meters from the river. It was not the best location, because of flat terrain in vicinity of the river bank. Scanning density was varied as result of change in land cover (grass, bushes, trees) in May and October. Area was scanned with average density 0,2 points/m2. Total number of points form stations is: 1 913 450 ”1st measurement”, 1 554 819 ”2nd measurement”.

Figure 8. Minor control within point cloud.

Selected parameters of scanner and brief of measurement:

- Scanner Leica ScanStation C10, field of view: 360° (horizontal), 270° (vertical), with maximum range of 300 m,
- accuracy of distance measurement: 4 mm,
- accuracy of angle determination (horizontal/vertical): 12''/12'',
- speed of scanning: 50,000 point/sec,
- in the study area minor control were establish,
- measurement method of points of control was GPS-RTK (ASF-EUPOS), coordinates were determinated in National Coordinate System 2000 (zone 7) and height system Kronsztad 86.

4. ABRIDGMENT OF RESULTS

Sequence of works during study:

- for each scanning station there was orientation target above nearest control point,
- each point has coordinates in the same (local) coordinate system, therefore it was possible to merge few point cloud into one,
- after merging, filtration were conducted in order to eliminate points, for which laser did not reflect from terrain surface,
- generation of two DTMs: one DTM with connected meander and second DTM with separated meander.

Based on conducted works and obtained results authors claim it is possible to use terrestrial laser scanning for determining meandering section of the river. Terrestrial scanning is a good alternative for a river monitoring. It is a cheaper option than an airborne laser scanning. However, the method has a few requirements, which can be seen as its limitations:

– appropriate station location, which depends on the type of ground, the floodplain range, the river width and the scanner range;

– a lot of stations along the river (Leica ScanStation C10 scanner has a range up to about 300 meters, 500 meters can be assumed for open areas).

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