The application of the Geographic Information System and remote sensing in identification of the flooded and waterlogged areas

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Abstract: This paper concerns the application of remote sensing and the Geographic Information System (GIS) to the identification of standing water bodies during floods and the differentiation of landforms in flooded areas. The methodology was applied to the flood plain of the Morava, south of the village Vysoká pri Morave, Slovakia, with respect to the August 1985 flood.

Key words: aerial photographs, flood plain, river Morava, flooded and waterlogged areas, abandoned arms and meanders, oxbow lakes

Introduction
The study deals with the application of remote sensing and GIS methods to the identification of flooded and waterlogged areas in flood periods. Research into these phenomena was directed to the identification of landforms in flood plains. The different degrees of flooding or waterlogging can disclose or indicate fluvial landforms, which were partially covered or simply not mapped before.

The study emphasizes the following possible applications of aerial image interpretation and GIS technology:

i) the identification of spatial extent of flooded and waterlogged areas corresponding to a particular N-year discharge during floods,

ii) the specification of fluvial relief forms and the recognition of small terrain irregularities, which are not always precisely represented on existing 1:10 000 scale topographic maps.

The method was applied to the Slovak–Austrian boundary reach of the Morava river fluvial plain from Vysoká pri Morave, where it is about 5 km long, and in places 3 km wide. The flood plain is bounded by the river Morava, the dike and the channel of the Malina. Also, because the Morava channel represents a state border, and was therefore a strictly guarded area until 1989, the flood plain area preserves a largely undisturbed natural complex. It displays the forms typical of fluvial morphology and only minimal traces of anthropogenic activity.

The Morava floods this area annually, at which times it is almost inaccessible. Thus, identification of the extent of the flooding is impossible using conventional methods of field research. The dominant function of a flood area is retention or drainage of the flood water, though the grassland on the Morava flood plain is regularly mown for agricultural purposes.

Methodology
When applying remote sensing data at a research level such tasks as the identification and surveying of flooded and waterlogged area require the use of GIS technologies. These enable the integration of extensive data sets from several thematic layers and they permit a comprehensive solution to the problem. The density of information, the situational accuracy and the accessibility of the required information at times when field research is not possible represent the chief usefulness of these techniques. Their principal drawback may be the difficulty of harmonizing the imaging interval with the flood event. Clearly, the
The present contribution is an extension to existing research into floodplain of the Morava south from Vysoké p. Morave. This area has been selected as the archetype for the application of remote sensing data and GIS in the analysis and registration of physiographic vegetation forms and land cover (Fernance et al. 1993; Oltýř et al., 1994).

**Characteristics of the study area**

The procedure outlined here was applied to the southern part of the Morava delineated by the road, which connects the river with the dike in the vicinity of Marchegg, which forms part of the eastern bank of the river between 10.6 and 15 river km of the confluence with the Danube (Fig. 1). The study area is part of the Zahrortska nižina lowland. The accumulation of the Quaternary sediments is the result of past climatic changes and tectonic movements, which are ongoing. As in the case of standing water bodies, there is a very low risk of misinterpretation, but it may occur. This may be due, for instance, to waves on the water surface, in which case the water does not appear to be homogeneous on the images. As in the case of terrestrial imagery, it is usually easy to differentiate standing water bodies from waterlogged ground. But it is not easy to differentiate different degrees of waterlogging, and, in such cases, the interpreter has to apply his or her best judgment. The following classes of flooded and waterlogged areas were distinguished in the air photograph analysis:

1. **Territory with higher level of flood**
   - The ground surface lies deep below the water table and is covered by a relatively thick layer of water (darker).
2. **Territory with lower level of flood**
   - The terrain lies close below the level of the water table, it is covered by a thinner and therefore lighter layer of water. This particular class occurs, for instance, inside meander loops and it was identified on relatively higher situated spots with thicker fluvial deposits.
3. **Telephone with very waterlogged surface**
   - An intensely waterlogged area is defined as ground where standing water is discontinuous. Inside these areas water may be concentrated in small shallow depressions along the network of abandoned arms. Bovides and standing water smaller than 1x1 m (10x10 m in the field) are categorized as Class 3 areas. If larger, they are Class 1 or 2. Field roads are usually covered by water during floods.
4. Territory with waterlogged surface
   Class 4 areas often grade imperceptibly into those of Class 5, but, owing to pronounced difference of tone of gray on aerial images, it is easy to differentiate them from Class 3 areas.

5. Relatively dry territory
   These areas are never flooded. They are often similar to those of Class 4 but may have a distinctive feature, which may be attributed to the farming activity, e.g. stripped ground following mowing and the farming activity. It is the case of mown meadows with distinct strips after mowing and with presence of field footpaths.

In the identification process also abandoned arms and meanders and oxbow lakes (7) were distinguished. The abandoned arms and meanders are in an advanced stage of development, being silted-up and overgrown, often fringed by vegetation. In flood times they are normally filled with water. The boundary between Classes 6 and 7 is often gradational. Hydrophilous plants inhabit the more recently abandoned arms or meanders of the old river system of the Morava and there are often semi-permanent ponds.

Except at time of flood, they are part of a well-preserved system of oxbow lakes, which documents the past development of the Morava fluvial plain. Woodlands, solitary trees and shrubs, water streams and channels, standing water (the Hajbrooske Jazierko Lake) and the dike which border the area, were also identified. It was not possible to differentiate between the flooded and unflooded forest but it seems that at least some of the woodland bordering the Morava and the Malina were also flooded.

Results of interpretation were processed into a scheme at scale 1:10 000, scanned, georeferenced, and adapted by means of identical ground control points into the national cartographic coordinate system (S-JTSK), which also contains topographic elements. Vectorisation of the interpretation scheme was achieved by means of the r2v semi-automated programme (Able Software Company). Then polygonsisation and identification of closed polygons were carried out by designating to each of them a digital code, which corresponds to the identified class. The interpretation is given as the digital map of flooded and waterlogged areas in ArcView GIS (Fig. 2).

Conclusion
Aerial images are now a common source of reliable and precise information at times of flood and they offer a variety of applications for flood-protection measures. It is important to realize that the image records an immediate situation. However, changes caused by floods can be detected by comparing images taken at different times. Serial imaging makes it possible to determine the areas flooded only at certain times. Changes can be identified by means of GIS. The information obtained finds a wide use in the prediction of the extent of flooding area, which corresponds to a particular N-year discharge (Q) or the water level (H) during the flood.

It is concluded that interpretation of aerial images in a GIS environment is an efficient means of precisely establishing the extent of flooding and waterlogging at times of flood, as well as enabling the recognition and specification of the fluvial plain morphology. The interpretation of aerial images makes it possible to recognize the courses of old river arms in various stages of their development, and also shallow terrain irregularities, which are filled with water only at times of flood and in the immediate aftermath. The present results emphasize the inadequacies of the existing 1:10 000 maps, which in this case did not exactly represent the locations of the old arms and shallow (up to 0.5 m) terrain depressions.

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References


