Land Cover Change Detection by Remote Sensing

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***Abstract*— Land cover mapping is one of the most important and typical applications of remote sensing data. Land cover corresponds to the physical condition of the ground surface, for example, forest, grassland, concrete pavement etc., while land use reflects human activities such as the use of the land, for example, industrial zones, residential zones, agricultural fields etc. Land cover change detection is necessary for updating land cover maps and the management of natural resources. The change is usually detected by comparison between two multi-date images, or sometimes between an old map and an updated remote sensing image. Information on land cover and changing land cover patterns is directly useful for determining and implementing environment policy and can be used with other data to make complex assessments (e.g. mapping erosion risks). In this paper we focus on change detection techniques provided by IDRISI and eCognition software. Optical and multispectral methods include pixel-based and object-oriented approaches, and approaches that deal with changes between optical images and existing vector data. What method to use is dependent on the sensor, the size of the changes in comparison with the resolution, their shape, textural properties, spectral properties, and behavior in time, and the type of application.**

I. INTRODUCTION

Land cover changes continuously. The rate of change can either be dramatic and unexpectedly sudden, such as the changes caused by hurricanes, fire, or subtle and gradual, such as regeneration of forest, soils. Numbers of studies have described that land cover has changed dramatically during the past several centuries and that these changes have affected our ecosystems [1]. The causes of land cover changes are divided into five groups [2]:

- long-term natural changes in climate conditions
- geomorphological and ecological processes
- human-induced alterations of vegetation cover and landscapes
- interannual climate variability
- human-induced greenhouse effect

The analysis of land use and land cover change plays a key role in modern landscape research and landscape ecology. Different fields such as geographical information science and remote sensing have contributed considerably to this area [3], [4]. The change is usually detected by comparison between two multi-date images, so the length of a considered analysis period is limited to the time span for which remotely sensed data (aerial photography, satellite images) is available. To consider longer time periods, historical maps can be used [5]. Comparing these maps with contemporary maps requires an extensive evaluation since they usually contain considerable inherent uncertainty.

Land cover change detection is necessary for updating land cover maps, accurate and up-to-date information is needed for many applications. One of the objectives of land cover change detection is to understand relationships and interactions between humans and the environment in order to manage and use resources in a better way for sustainable development [4]. Information on land cover and changing land cover patterns is directly useful for determining and implementing environment policy and can be used with other data to make complex assessments (e.g. mapping erosion risks).

The number of remotely sensed dataset available for analysis has increased markedly since 1972, when LANDSAT data became available. The archive of LANDSAT datasets are especially useful for monitoring long-term ecosystem effects. Tools and techniques are needed to detect, describe, and predict these changes. During the last decades many change detection techniques have been developed and applied to assess land cover changes. The goal of this papers is to summarize some important aspects of change detection, including data selection, and detection tools and methods within IDRISI and eCognition software.

II. DATA SELECTION

The success of applying remotely sensed data for change detection depends on careful selection of the data source. The important attributes of images can be taken into consideration are spatial, temporal, spectral and radiometric resolution.

III. LAND COVER CHANGE DETECTION

There are two basic types of remote sensing change detection. The first one is map-to-map and the other is image-to-image comparison. In map-to-map comparison, individual land cover maps are created independently using different data of images, and the results are compared. In this paper are showed change detection techniques provided by IDRISI and eCognition software.

A. *Land Change Modeler*

The chapter is dealing with the results of the author long term researches on land use changes of Lake Velence watershed.

The Land Change Modeler is a vertical application within IDRISI oriented to the pressing problem of accelerated land conversion and the very specific needs of biodiversity conservation. The LCM application provides a robust set of tools for the analysis of change and the creation of viable plans and scenarios for the future. The major tasks of the Land Change Modeler interface are: Change Analysis (analyzing past land cover change), Transition Potentials (modeling the potential for land transitions) and Change Prediction (predicting the course of change into the future) [6].

Objectives of the study were the following: land use change in the last two decades (using remote sensing to classify land use), land change analysis (which land use changes have recently occurred and where), determine the landscape characteristics influencing the spatial pattern of the land use transitions, and to predict future land use change using information from past changes patterns.

LANDSAT TM (1990, 2006), SPOT (2000) and ASTER (2004) were interpreted and classified dynamic change analysis (spatial pattern of the changes; resolution 30m,15m, 10m).

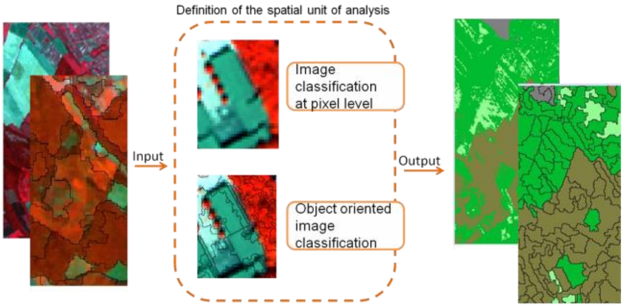

Figure 1. Land cover information extraction from satellite images

The land cover maps were created using supervised classification techniques (pixel- and segment-based) in IDRISI TAIGA. The classification was performed on multi-channel data and this process assigns to each pixel or segment of an image to a particular class based on statistical characteristics of the pixel (or segment) values (Fig.1) [7].

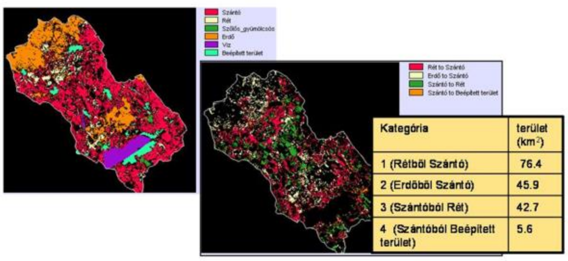

Figure 2. Land change analysis using LCM

The LCM provides a set of tools for analyzing land use (cover) change, including graphs of gains and losses, net changes and contributions experienced by any category. A simple one-click interface provides the ability to generate rapid maps of change, persistence, specific transitions and exchanges between categories. The analysis of two land use maps of different dates showed that between 1990 and 2004 the amount of urban land, rural cover types of agriculture and water class increased (Fig.2). The urban area increased by 13% of the total area, the agriculture by 15% and the water by 8%. The water area increase is dependent on drought. The meadow field, the forest category and vine-orchard decreased. Decreasing of the forest is connected with foresty and means land cover change, but not land use.

B. *Spectral Indices*

Spectral indices derived from satellite data are widely used for land cover change research. They can reduce the data volume for analysis and provide combined information that is more strongly related to changes than any single band [4].

Vegetation indices use various combinations of multi-spectral satellite data to produce single images representing the amount of vegetation present, or vegetation vigor. Low index values usually indicate little healthy vegetation while high values indicate much healthy vegetation. Different indices have been developed to better model the actual amount of vegetation on the ground.

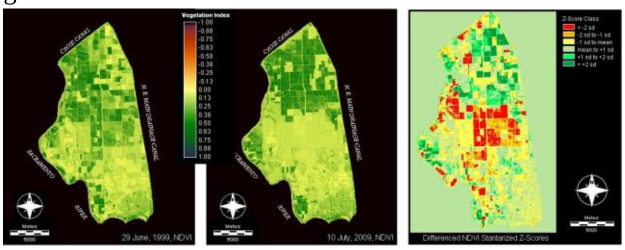

Figure 3. Land change analysis using vegetation indices [8]

There are many quantitative methods we can use to analyze change between images. One of them is simple differencing, when we merely subtract one images from the other, then analyze the result. Figure 3 illustrates the appearance of NDVI images and differencing image. The values are based on the multi-temporal NDVI values. The result values (Z-Scores = ((observed value - mean value)/standard deviation)) are calculated from pixel values, mean, and standard deviation values. The values represented with negative standard deviations (std) represent negative vegetation changes between 1999 and 2009. Positive values represent positive changes [8].

C. *Change Detection, working with "maps" in eCognition*

A successful change detection system has to analyze the change of each phenomenon in its characteristic scale and then fuses the resulting change maps into a single change map. Many studies made use of multi-scale analysis in literature. Multi-scale object specific analysis is a multi-scale approach that automatically defines unique spatial measures specific to individual image-objects composing a scene. These specific measures are used in a weighting function to automatically upscale an image to coarser resolution [9, 10].

Recently, a new system for multi-scale data set generation is implemented in eCognition software. This approach extracts objects of interest at the scale of interest, segmenting images by operating on the relationships between linked objects. The multi-scale change detection system consists of the following phases; superimposing the two-date images; multi-scale data-set generation, individual scale change detection, optimal scale detection, and scale-based change fusion.

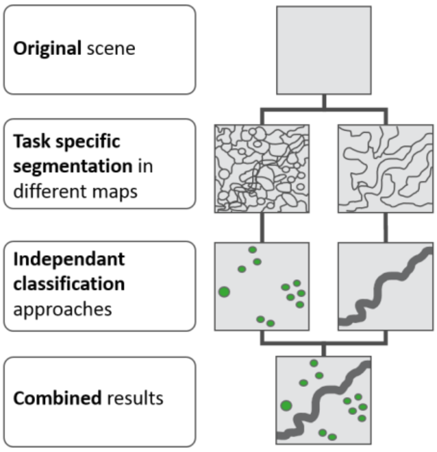

Figure 4. Change detection, working with „maps” in eCognition [11].

IV. Conclusion

In this paper we focus on change detection techniques provided by IDRISI and eCognition software. Optical and multispectral methods include pixel-based and object-oriented approaches. What method to use is dependent on the sensor, the size of the changes in comparison with the resolution, their shape, textural properties, spectral properties, and behavior in time, and the type of application.

The application of the multi-scale detection system ensures less false change alarms. The study of individual objects is performed in the object's preferred scale so that noise is rejected. The detected change objects keep their true shapes without any distortion on their boundaries or inside the objects that may result from noise or image sampling. Applying multi-scale change detection provides an advantage in the overall accuracy over the single scale change detection.

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