The Possibilities of New Satellite Image Types in the Control of Area-based Subsidies and in Ragweed Monitoring System

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Abstract. To increase the efficiency of remote sensing applications, they are supported by classical on-the-spot check. In our article the connection between classical field survey and remote sensing with additional GIS processing will be presented in the frame of three operational projects of the Institute of Geodesy, Cartography and Remote Sensing (FÖMI).
The first one is Control with Remote Sensing of Area-based Agricultural Subsidies. Traditionally, the crop cultivated and its area are principal questions. In the last decade a new set of standards, called Good Agricultural and Environmental Conditions (GAEC), has gained more importance. For example, fighting against unwanted vegetation belongs to these standards. There is a possibility to carry out so-called Rapid Field Visits to complement remote sensing and to confirm its results. Currently it is compulsory to use very high resolution (VHR) images for area measurement. Their usage also provides a more precise control of GAEC.
The usage of VHR images has also become essential within the updating of Land Parcel Identification System. Some results of automatizing the delineation of ineligible landscape features are presented.
Due to the increasing pollen contamination in Hungary, Ragweed Control Program has grown to a priority project. Ragweed detection with remote sensing has been introduced formerly as one of the high-tech components of this program. Due to the spatial and temporal behavior of ragweed and the difficulties in its recognition it is very important to use a good quality remote sensing data set. In the past years FÖMI used medium and high resolution satellite images, which provided sufficient accuracy. Nevertheless, it is seen now that introducing very high resolution images would further increase spatial accuracy and thus the effectiveness of monitoring, and would give stronger support to on-the-spot checks.
It is demonstrated that increasing demands requires the integration of newly introduced remote sensing data sets into survey tasks.

Keywords. Control of area-based subsidies, ragweed monitoring, on-the-spot control, very high resolution images

Introduction

In the assessment of the effectiveness of remote sensing based land cover or land use mapping applications, it is desirable to survey as large area as possible at a given spatial resolution and with high thematic accuracy. To achieve these goals, remote sensing is usually supported by classical on-the-spot check, either in advance, with ground truth data collection, or after, with the validation of remote sensing mapping results.

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In the various applications there is a huge difference in the ratio between classical field survey and remote sensing approach. In our article the connection between field and GIS processing will be presented in the frame of three operational projects, together with the changes in the ratio of these approaches and the future possibilities.

1. VHR images in the control with remote sensing of agricultural subsidies

The first project is Control with Remote Sensing of Area-based Agricultural Subsidies. This kind of subsidies started in EU about two decades ago; while in Hungary it exists since the end of the 90's, within national framework. The Institute of Geodesy, Cartography and Remote Sensing (FÖMI) has been operationally carrying out the Control with Remote Sensing of Area-based Subsidies (CwRS) program since 2000. Since EU accession of Hungary in 2004, a substantial part of the area-based subsidies is financed by the European Agricultural Guarantee Fund and the European Agricultural Fund for Rural Development (earlier: European Agricultural Guidance and Guarantee Fund). The national regulations have to follow the EU legislation. The payments are managed within the Integrated Administration and Control System (IACS). In Hungary, the Agricultural and Rural Development Agency (ARDA) acts as the paying agency of agricultural subsidies. Administrative checks and classical field inspections are the responsibility of ARDA, while FÖMI carries out the remote sensing control as a delegated task.

Subsidy claim dossiers consist of alphanumerical and geographical data. In the latter years claims are submitted electronically, which makes their handling and control much easier, but the content essentially remained the same. Farmers declare the area and the crop for each parcel, together with some additional information. The aim of control is to answer three main questions for every declared parcel: whether the declared crop is produced in the parcel, whether the declared area is correct, and whether the parcel is kept in Good Agricultural and Environmental Conditions (GAEC).

In Hungary, currently 8% of claims are subject of on-the-spot controls. These controls can be performed either with classical field inspection or with remote sensing. Classical field inspections are carried out by ARDA; these consist about 20-25% of the total number of claims to be checked. Remote sensing checks are performed by FÖMI. However, this does not mean the sole usage of satellite images or ortho-photos, but it also includes a special kind of field control, called Rapid Field Visit (RFV).

The task of control has undergone a development in the previous years: since a reform in the subsidy system after 2000, the preservation of environment gained much more importance. This makes the implementation and control of Good Agricultural and Environmental Conditions very important. These conditions are grouped into four issues by EU legislation: soil erosion, soil organic matter, soil structure and minimum level of maintenance. Within these issues there are several standards, for example, preventing soil erosion with the retention of terraces and avoiding the encroachment of unwanted vegetation. The actual set of issues and their implementation is subject of local, country-level legislation. The change in regulations and the development of technology results in a continuous evolution of control methods. Nowadays the effect of these changes can be experienced primarily in the control of GAECs.

Remote sensing control mainly uses satellite images. High resolution (HR) image time series are used to determine crops: in the majority of cases it is necessary to evaluate images from several dates over the vegetation period to properly observe the kind of crop. Area delineation is done using very high resolution (VHR) images, which are inevitable to reach the required positional accuracy and measurement precision. The so-called Rapid Field Visits (RFV) are also considered to be the part of remote sensing controls. They are a kind of a field survey, but instead of precisely measuring the parcel, its main purpose is to determine the land cover and land use with visual observation.

The above mentioned satellite image types and RFV are also used in the control of GAECs. Illustrations in the following part of this Section are taken from the year 2009 campaign of Control with Remote Sensing of Agricultural Subsidies in Hungary. The detection of appearance and encroachment of unwanted vegetation and its exact delimitation can be carried out much more efficiently with VHR images. Two GAEC standards are related to unwanted vegetation. The first one prescribes that agricultural areas must be kept in appropriate weed control. The second one tells that on agricultural areas undesirable shrubs and invasive trees must be eradicated.

To detect weeds, high resolution satellite image time series help in several ways. Uneven development of parcels of cultivated crop can be directly detected in images, which is often the sign of presence of weeds. The exact situation can be explored with elaborate examination of several high resolution images. VHR images help in both the identification and the delineation of weeds. In some cases, classical field control is necessary to confirm the presence of unwanted vegetation. But image time series are not only appropriate to indirectly detect the presence of weeds. Figure 1 shows an example of a compound examination. In the images taken in the spring, some waterlog spots can be observed (first two images, in the lower third) – open water surface is easily detected in images. One can conclude to the later appearance of weeds in these areas. Images taken in the summer confirm this suspicion: first the inappropriate crop development (the third VHR image, the fourth and fifth HR ones), later the appearance of weeds (the sixth image) is clearly observed in the same spots that were waterlogged in the spring.

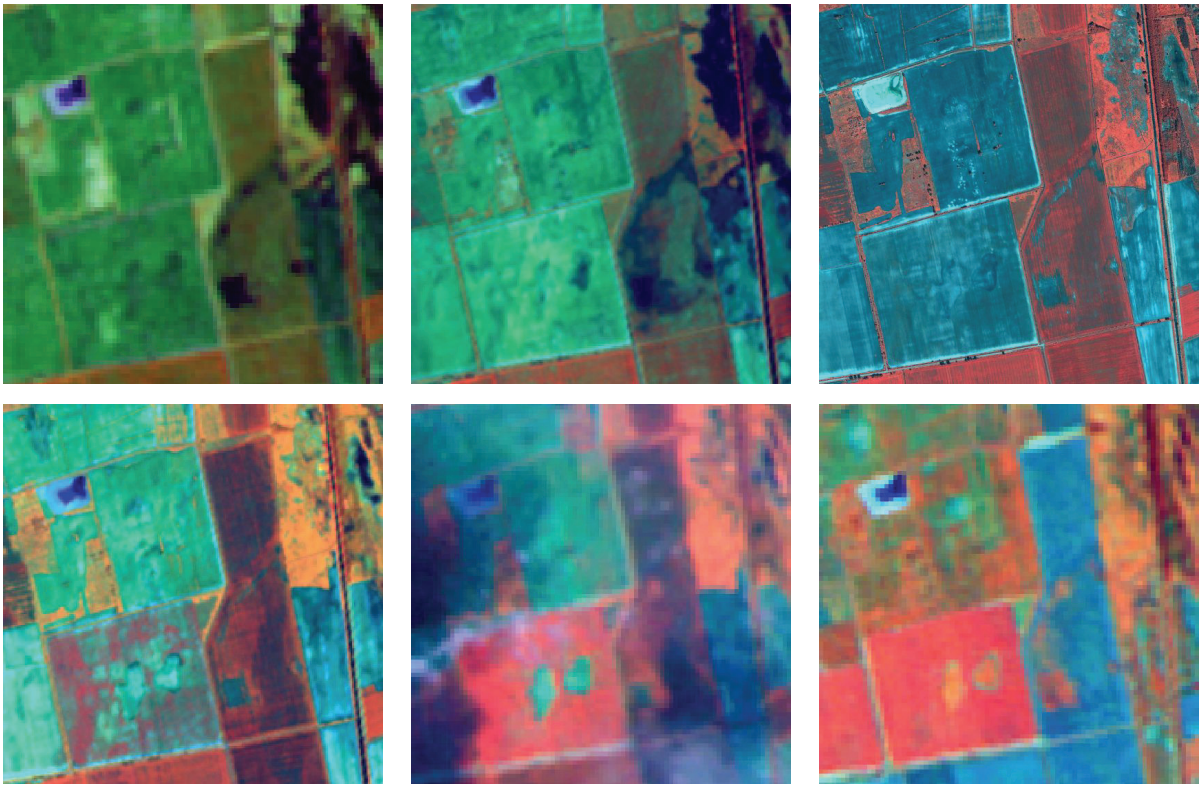


Figure 1. Time series demonstrating waterlog spots and the appearance of weeds

VHR images are also of great help in determining the situation regarding the encroachment of shrubs. In the example of Figure 2 it is seen that using HR images (first and third ones, taken in April and August, respectively) we can get an idea that the orchard is not well maintained, but only VHR image shows properly that the orchard is indeed abandoned, and some invasive trees appeared among the rows. In our case, this finding was confirmed by a classical field visit.

There is a third GAEC standard that can be efficiently detected with remote sensing and GIS tools. It requires that on arable land steeper than 12%, the cultivation of some crops is prohibited;

some other crops are allowed to be cultivated only in some circumstances. The basic methodology of controlling this standard was demonstrated in [2]. In Hungary, the regulation mainly builds on the prevention of soil erosion, and this is also followed by the control methodology. But remote sensing technology can also be used to detect the traces of erosion, if a farmer has not applied appropriate preventive measures.

These three standards are the most important ones where the on-the-spot control is highly supported by remote sensing and GIS, but these tools can also be used in the management of some other standards. Moreover, based on the several years experience, the methodology applied in subsidy control can be extended to other projects as well, which will be demonstrated in Section 3.

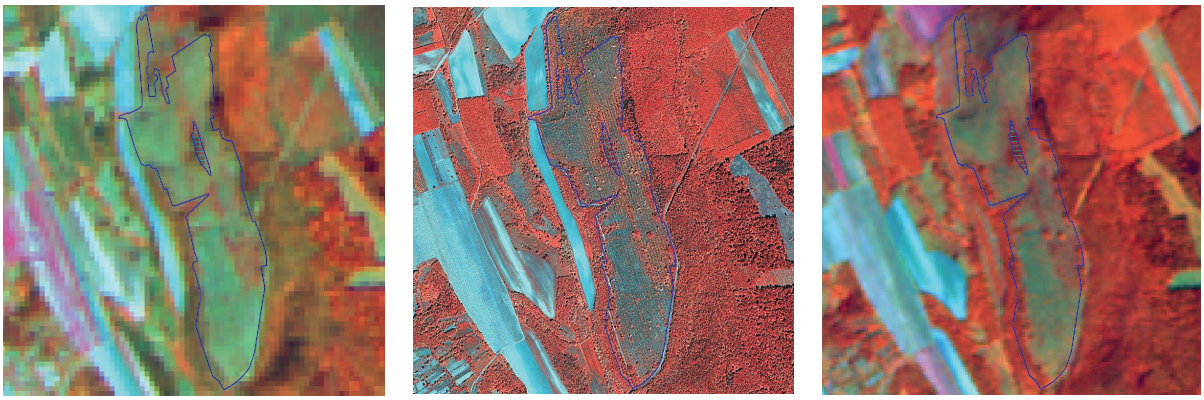


Figure 2. Images of an abandoned orchard with invasive trees

2. Possibilities of very high resolution imagery in updating of Land Parcel Identification System

Within the system for managing and controlling agricultural subsidies, Land Parcel Identification System is the exclusive system for identifying agricultural parcels. In Hungary, it is the task of FÖMI to regularly update LPIS, which is mainly carried out on the basis of ortho-photos, but satellite images are used as well as auxiliary data sources.

Managing and controlling the area-based subsidies it is necessary to delineate the objects that hamper cultivation as non-eligible area. Besides buildings these objects consist mainly of undesirable shrubs and areas with invasive or scattered trees. The delineation of the latter is extremely time-consuming owing to their small size and scattered location. Therefore it is reasonable to make an effort to automate this process.

The authors of this article developed a method to delineate non-eligible features, which is used in the updating of Land Parcel Identification System (LPIS). Color infrared (CIR) ortho-photos with resolution of 0.4 m are taken as input, and they are processed with the Definiens eCognition software package. The first crucial step is an appropriate segmentation. The borders of the resulting segments coincide with object borders as much as possible. Classification of segments is performed mainly on the basis of a vegetation index (NDVI). Besides, other spectral and textural features that are characteristic of trees are used as well.

Problem needs to be divided into subtasks both according to the cultivation method of regions and to the types of non-eligible area. For instance, continuous clumps of young trees close to forest, scattered trees with large crown and homogeneous scrub with look very dissimilar regarding their texture. These three kinds of non-eligible land cover require different recognition methods.

However, vegetation index and spectral features of exuberant arable lands and scrub segments can be so similar that they can only be separated with exploiting their relations to neighboring segments. As Definiens can properly handle such relations, the authors refined class definitions in this way.

To properly use the algorithm, some parameters need to be determined. Among these, the most important ones are the size of the smallest non-eligible area to be delineated and the measure of smallest area-growth regarded as a substantive change. An example of automatic delineation of ineligible groups of trees is seen in Figure 3. It shows the dependence of results on the above-mentioned parameters. This example is taken from the year 2009/2010 updating campaign, which used aerial photos taken in the summer of 2009. To achieve a more accurate and less region-specific solution further input data need to be involved like Digital Terrain Model (DTM), Digital Surface Model (DSM) data and a time series of high resolution images.

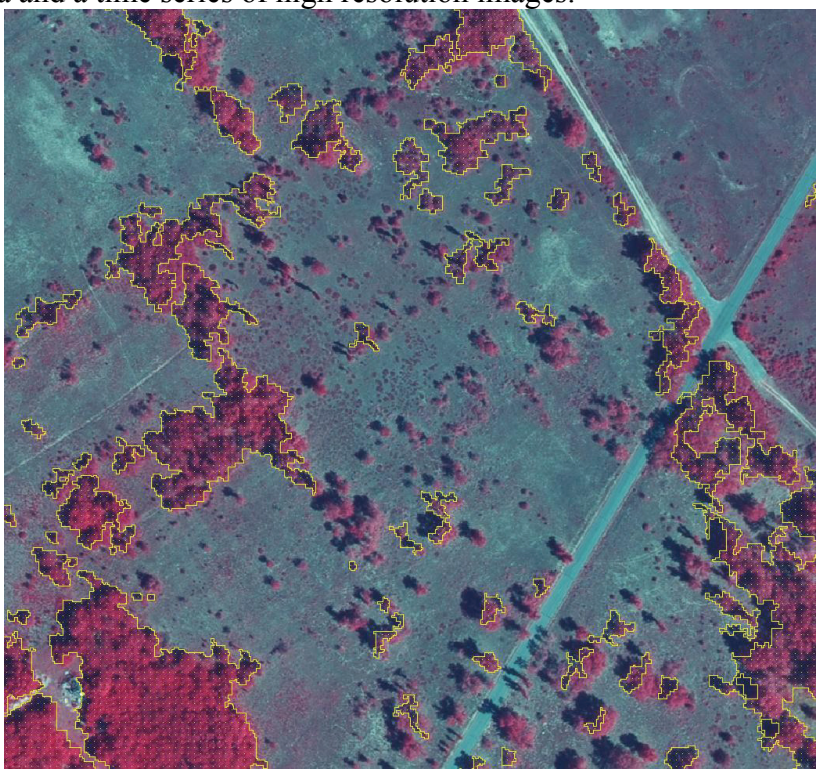


Figure 3. An example of automatic delineation of ineligible groups of trees

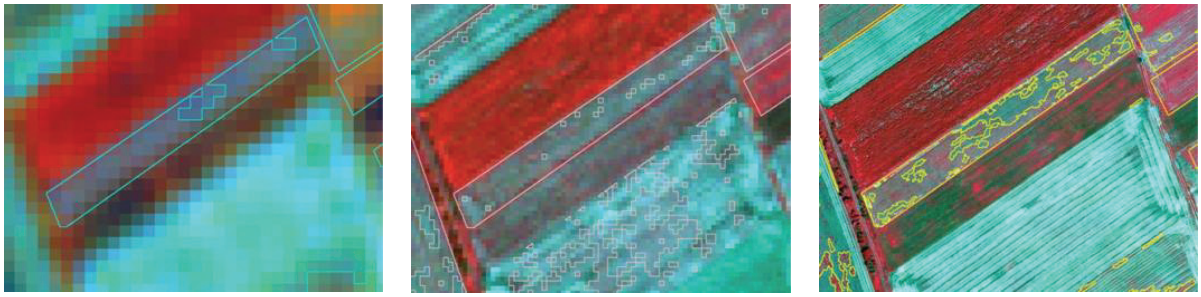
3. Improving the accuracy of delimitation within ragweed monitoring

The third project is ragweed monitoring. Due to the increasing pollen contamination in Hungary, Ragweed Control Program has grown to a priority project of past years. It can be concluded from the results achieved so far that the tremendous problem of pollen and allergy cannot be solved without the most advanced space technology. It integrates the usage of remote sensing, Global Positioning Systems (GPS), Geographical Information Systems (GIS) and the publication of results via Internet. Based on experience, the introduction and integrated usage of these four components in ragweed exemption is inevitable.

Ragweed detection with remote sensing has been introduced formerly as one of the high-tech components of this program. Due to the spatial and temporal behavior of ragweed and the difficulties in its recognition it is very important to use a good quality remote sensing data set. A necessarily dense time series plays a crucial role, as ragweed must be recognized and exempted before pollen scattering in order to successfully block pollen spread.

However, measures against ragweed are restricted by the available resources of classical field inspection. It is crucial to shift the burden from ground control to remote sensing. The aim is to increase the role of remote sensing in documentation – in our case, the delimitation of ragweed spots. It has been proven during the control program carried out in past years that the effectiveness of the

follow-up field inspection highly depends on the accuracy of spots delineated with remote sensing. In the past years the Institute of Geodesy, Cartography and Remote Sensing used medium and high resolution satellite images in this task, which provided sufficient accuracy. Nevertheless, it is seen now that introducing very high resolution (VHR) images would further increase spatial accuracy and thus the effectiveness of monitoring, and would give stronger support to on-the-spot checks. In Figure 4 the difference in exactness of ragweed delineation on several types of remote sensing images is illustrated.



SPOT5, 2009. 07. 17. Spatial resolution: 100 m^2

Ikonos, 2009. 07. 23. Spatial resolution: 16 m^2

Ortho-photo, 2009. 07. 17. Spatial resolution: 0.16 m^2

Figure 4. Ragweed delineation on several types of images

The procedure built on HR and VHR images has been used with proven efficiency for several years in the national and EU subsidy controls, audited yearly by the Services of Commission. Within subsidy control, this procedure is successfully applied in the control of GAEC standards (see Section 1), especially, in the detection of weeds and other unwanted vegetation. This is a very promising method in ragweed reconnaissance, which can be adapted with low risk. Beside the operational ragweed control program, in the frame of a research project the opportunities of using VHR images in ragweed recognition are being assessed.

4. Conclusions

It is demonstrated by these three projects that increasing demands and the change of regulatory background requires the continuous development of technology. An important element of this is getting acquainted with newly introduced remote sensing data sets and integrating them into survey tasks. It is an important aim in research to find the adequate types of images to the variety of remote sensing applications. Usually several data sets are appropriate for a given application; thus, mutually advantageous properties of different image types can further improve the quality of solutions.

Acknowledgement

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