

USAGE OF DIFFERENT SPECTRAL BANDS IN AGRICULTURAL ENVIRONMENTAL PROTECTION

P. Burai ^a, J. Tamas ^b, Cs. Lenart ^c, I. Pechmann ^d

^a Department of Water and Environmental Management, University of Debrecen, Hungary, 4032 Debrecen, Böszörményi út 138. - pburai@gissserver1.date.hu

^b Department of Water and Environmental Management, University of Debrecen, Hungary, 4032 Debrecen, Böszörményi út 138. - tamas@gissserver1.date.hu

^c Department of Water and Environmental Management, University of Debrecen, Hungary, 4032 Debrecen, Böszörményi út 138. - lenart@gissserver1.date.hu

^d Department of Water and Environmental Management, University of Debrecen, Hungary, 4032 Debrecen, Böszörményi út 138. - ipechmann@gissserver1.date.hu

KEY WORDS: Agriculture, Hyperspectral, Multispectral, Classification, GIS

ABSTRACT:

Hyper and multispectral imaging systems widely used in agricultural and environmental protection. Remote sensing techniques are suitable for evaluating environmental protection hazards, as well as for agriculture resource exploration. In our research we compared aerial hyper and multispectral images, as well as multispectral digital camera images with the background data in the test site. Hyperspectral records were obtained by a new 79-channeled aerial /DAIS 7915/. We made additional images with a TETRACAM ADC wide band multispectral camera. We have chosen an farm as test sites, where intensive crop cultivation takes place, so soil degradation and spreading of weeds can be intensive as a result of land use and irrigation. The first objective of this study was to evaluate the applicability and usability of the multi- and hyperspectral images in large spatial resolution according to the prescription of NAKP (National Program of Agri- Environmental Protection). Multispectral analyses were compiled for to evaluate the solidity of supervised classification. During the analyses of the images, the spectral characters of various vegetation types and possibilities of their classification as well as the spectral identification of the ecological buffer zones and filtering areas and their GIS interpretation were investigated.

INTRODUCTION

Among the aims of the National Program for Agri-Environmental Protection (NAKP) the principles of a sustainable landuse matched to the facilities of Hungary's different regions are declared according to the Union's 2078/92 directive (Angyan et al., 1999). The farmers who have joined the above mentioned program for to gain the support cannot lead their farms without considering its principles in connection with environmental protection and nature reservation. Assignment the suitable landuse system means a serious problem, but to control whether the regulations are kept or not is much more difficult. To the right application of this supporting system the investigation of the biotical and abiotical environment surrounding the cultivated lands is needed. Environmental information can be obtained by classifying air- and spaceborn remote sensing images. Knowledge of changes in land cover is becoming increasingly important from both the ecological and economical point of view (Janssen et al, 1990).

There is an increase in the use of remote sensing technologies. Image interpretation is faster and less expensive than conducting ground survey (Floyd, 1996). Remote sensing data have been used to detect and classify vegetation using supervised classification, cluster analysis, decision trees, neural networks, etc. (Carpenter et al., 1999; DeFries & Townshend, 1994; Friedl & Brodley, 1997; Martonchik, 1994; Running et al., 1995).

For environmental state assessment and score of the areas involved in the Program, data sources with large spatial resolution are worth to apply. To distinguish the commonly small fields from the island-like vegetation spots inserted in the culture land the traditional methods (CORINE) are not suitable any more. Our study's aims are to evaluate the applicability and usability of the multi- and hyperspectral images in large spatial resolution according to the prescription of NAKP. During the analyses of the photos, the spectral characters of various vegetation types and possibilities of their classification as well as the spectral identification of the ecological buffer zones and filtering areas and their GIS interpretation were investigated.

MATERIALS AND METHODS

Test region

The investigated area is situated in the eastern part of the Hungarian Great Plain, next to a small rural town called Hajdúánás. It has a special location being on the border of two geographical regions. On one hand, it is continuous with the area of the Hortobágy, a typical solonetz-type salt-affected area of the country. On the other hand, the area of the Hajdúság loess field characterized by chernozem-type soils also reaches the region. Its climate is mainly continental, strictly saying wet-contitnetal with 9,9°C mean temperature. The annual average rainfall takes 580 mm, which's inhomogeneous distribution often causes inauspicious conditions in agricultural point of view. Besides intensive cultivation forms, extensive grassland and water reservoir are

also common landuse types. Related to the special climatical and soil facilities there are several native vegetation spots inserted into the cultivated fields as well.

Data

Aerial photos, hyper- and multispectral images were taken from the test site. Hyperspectral records were obtained using a new 80-channeled aerial spectrometer (Digital Airborne Imaging Spectrometer /DAIS 7915/. We took additional images of air and ground with a TETRACAM ADC wide band multispectral camera, which can sense green, red(635-667nm) and near infrared(835-870nm) bands. The size of pixels is approximately 5 by 5 meters. In 2002 the soil genetic and surplus water maps were constructed with GPS support. We also own the 3D digital relief model based on a contour-map with scale of 1:10000. The evaluation of the soil conditions was completed using an air-photo taken in 2000 with scale of 1:10000 and with a weed and vegetation map of the area in the spring and the summer aspects taken in 2002 as well as in 2003.

Data processing

Vector data were stored and processed by ArcGIS while the hiperspectral data were processed by ENVI. Object boundaries and actual land-cover classes were digitized as

ROI (Region of Interest) by ENVI. The ROI files with the ground truth were used to validate the result of both classifications by calculating confusion matrices and the overall accuracy. Furthermore after multispectral classification image processing was calculated by ArcGIS. Integrated GIS database and remote sensing data were georeferenced by Hungarian Georeferenced System (EOV).

RESULTS

For evaluating the landuse types we reflection values of the visible, near and middle infrared ranges of the DAIS image (400-1800 nm) were considered. For studying the state of the vegetation the wavelength range between 400-2500 nm is the most suitable one (Zilinyi, 1990; Turner et al., 1999), which is can be explained most likely by the spectral character of the green leaves. In this range differences spectral profiles can be observed, with which help not only the soil from the vegetation, but the various native plant associations can be well separated (figure 1).

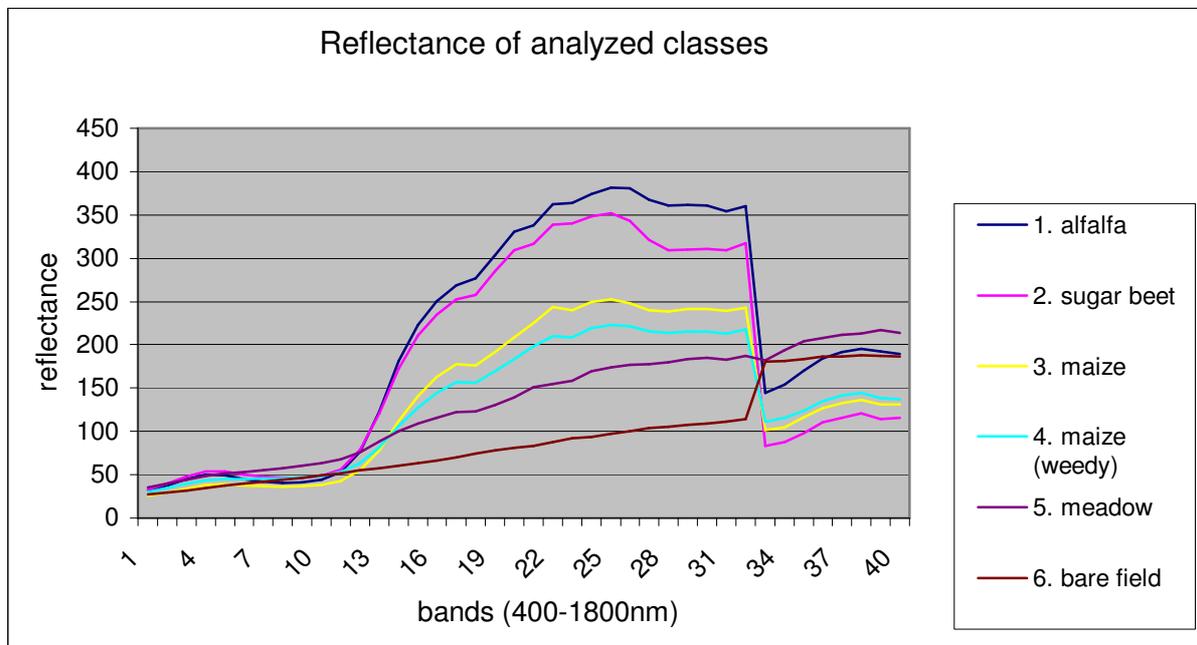


Figure 1. Reflectance of analyzed classes

Our previous knowledge about occurred soil types, cultivated plant types with known number of crops provided us opportunity to study the reflectance values of different plant associations according to the above defined variables.

Through the field study bounded with GIS we sorted out homogeneous vegetation spots as teaching regions for supervised classification, by which the similar plant categories were identified (figure 2).

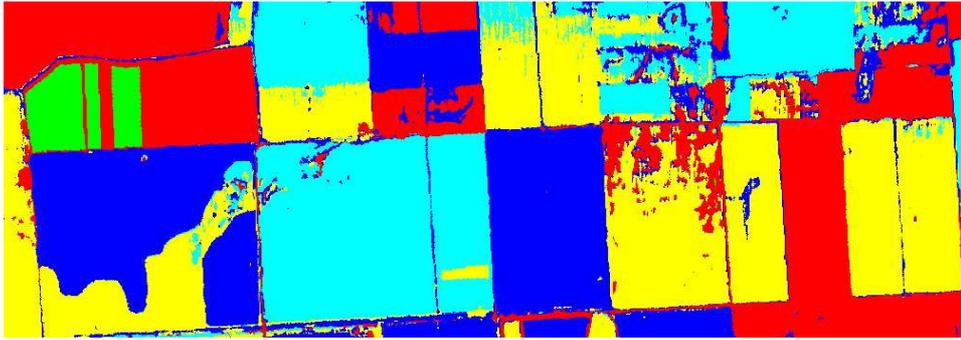


Figure 2. Test area was classified by supervised classification (ENVI)

Comparing the results of the various classification methods the maximum likelihood one provided the least difference

between the calculated and the real landuse categories (table 1).

Table 1. Confusion matrix for maximum likelihood classification

| Class name | Reference total pixel | Classified total pixel | Correctly classified | Accuracy % |
|---------------|-----------------------|------------------------|----------------------|------------|
| alfalfa | 52800 | 58429 | 52100 | 98,67 |
| maize (1,2,) | 69200 | 53900 | | 77,22 |
| maize (1) | 44380 | - | 38024 | 85,67 |
| maize (2) | 24740 | - | 15338 | 61,99 |
| sugar beet | 43980 | 43620 | 42894 | 97,53 |
| wheat stubble | 8395 | 18650 | 8237 | 98,11 |
| bare field | 15605 | 15301 | 15143 | 97,03 |
| Total | 189900 | 189900 | 171736 | 90,43 |

(maize 1.: low number of crops, weedy maize, maize 2.: normal number of crops)

Considering the spectral profiles of the certain plants we were looking for the wavelength range, where there were the largest distances gained between the studied values. Comparing the variance coefficients the most differences in spectrums from 623 to 657nm (DAIS bands 8-10) and from 814 to 904nm (DAIS bands 19-24) were observed, but if only the vegetation covered regions were taken into consideration the range from 762 to 886nm (DAIS bands 16-23) showed the biggest variance coefficient (CV=0,30-0,33).

Whilst we the teaching areas pointed out for study of various vegetations and landuse types were being analysed we found, that in the crop with canopy over 75% the obtained reflectance values remained homogeneous (CV= 0,008-0,027) showing no significant correlation to the local soil facilities. Lowest diversity were gained at the longer wavelengths. In the case of disturbed crop with lower number of plant stocks the bigger values of variance coefficient were caused by the differences in reflection of the soil and the green leaves.

We made additional images from air and ground with a TETRACAM ADC wide band multispectral camera. Several

images were taken to detected the changing of the land use. With help of the image complied by supervised classification and the layer containing buffer zones related to the prescriptions fields can be defined, which are not cultivated as it had been negotiated.

DISCUSSION AND CONCLUSION

- Using the supervised classification we could gain accurate landuse results only in case of the homogeneous plant cover. Through the decreasing of vegetation cover the reflection of the soil increases strongly modifying the reflectance values.
- The island-like protected associations with a small expanse and the breeding habitats can be classified well and separated from cropped area using these large spatial resolute images.
- Images taken in various period during the year are practical for to complete the sate assessment and the control functions (table 2). Through the combination of images taken in different seasons exact landuse map can be complied.

Table 2. Suggested periods for taking the images

| Season | State assessment | Control |
|-------------------|--|---|
| 1. March - April | <ul style="list-style-type: none"> - assuming the hazard of flood and surplus water - study of soil facilities - identification of fields of winter and perennial crop (wheat, alfalfa, etc.) - surveying of the expansion of wetlands | <ul style="list-style-type: none"> - distinguishing the cultivated and not disturbed areas |
| 2. April-Mai | <ul style="list-style-type: none"> - assuming the hazard of flood and surplus water - identification of fields of winter and perennial crop (wheat, alfalfa, etc.) - identification of buffer zones | <ul style="list-style-type: none"> - protection of breeding habitats - limitation of grazing and assignation of expansion of filtering zones |
| 3. July-September | <ul style="list-style-type: none"> - evaluation of salinity processes - risk and damage estimation of drought - identification of fields of the vernal crop (maize, sugar beet, etc.) | <ul style="list-style-type: none"> - limitation of grazing and assignation of expansion of buffer zones - the expansion of stubble burning - soil status |

- There are many rule points in NAKP, where these remotely sensed images can be applicable for identification and control of the time and spatial frame of natural phenomena.
For example: Checking of growing areas of the plants appropriate to the cropping plans (5-10 years), distinguishing the small spots of plant associations from the cultivated lands, etc.
- High resolved and multispectral data can give spatial information for detecting the land cover and controlling the cropping. RS data taken by airborne digital multispectral camera can be used for updating the contents of GIS

REFERENCES

Angyan, J., Fésűs, L., Podmaniczky L., Tar F., Vajnáné, M., A., 1999. Nemzeti Agrár-környeztvédelmi Program. FVM agrár-környeztgazdálkodási tanulmánykötetek. Budapest

Carpenter, G. A., Gopal, S., Macomber, S., Woodcock, C. E., Franklin, J., 1999. A neutral network method for efficient vegetation mapping. *Remote Sensing of Environment*, 70. pp. 326-338.

DeFries, R. S., Townshend, J. R. G., 1994. NDVI-derived land cover classification at global scales. *International Journal of Remote Sensing*, 15, pp. 3567-3586.

Friedl, M., Brodley, C., 1997. Decision tree classification of land cover from remotely sensed data. *Remote Sensing of Environment*, 61, pp. 399-409

Floyd F. Sabins, 1996. *Remote Sensing. Principles and Interpretation*. W. H. Freeman and Co. Los Angeles

L. L. F. Janseen, M. N: Jaarsma, E.T.M. van der Linden, 1990. Integrating Topographic data with Remote Sensing for Land-Cover Classification. *Photogrammetric Engineering & Remote Sensing*, Vol. 56, No. 11, pp. 1503-1506.

Martonchik, J. V., 1994. Retrieval of surface directional reflectance properties using ground level multiangle measurements. *Remote Sensing of Environment*, 50, pp. 303-316.

Running, S.W., Nemani, R. R., Peterson, D.L., 1989. Mapping regional forest evapotranspiration and photosynthesis by coupling satellite data with ecosystem simulation. *Ecology* 70, pp. 1090-1101.

Running, S. W., Loveland, T. R., Pierce, L. L., Nemani, R. R., Hunt Jr., E. R., 1995. A remote sensing classification logic for global land cover analysis. *Remote Sensing of Environment*, 51, pp. 39-48.

Turner, D.P., Cohen, W.B., Kennedy, R.E., Fassnacht, K.S., Briggs, J.M., 1999. Relationships between Leaf Area Index and Landsat TM Spectral Vegetation Indices across three temperate zone sites: *Remote Sensing of Environment*, 70, pp. 52-68.

Zilinyi V., 1995. Természetes felszínek spektrális reflexiós tulajdonságai, es hasznosításuk az optikai távérzékelés interpretációjában. Egyetemi Doktori Értekezés, DATE, MTK, Debrecen, pp. 24-43.