# ANALYSIS OF REMOTELY SENSED DATA BY MEANS OF LOGIC FILTERS

Sinasi Kaya[a] , Cengizhan Ipbuker[b*], Fikret Pekin[3]

[a]Assoc.Prof.Dr.,ITU, Department of Geomatics, 34469, Maslak-Istanbul-TURKEY Tel:+902122856100,e-mail:kayasina@itu.edu.tr
[b*]Prof.Dr.,ITU, Department of Geomatics, 34469, Maslak-Istanbul-TURKEY
Tel:+902122856565,e-mail:buker@itu.edu.tr
[c]ITU, Informatics Institute, 34469-Maslak-Istanbul-Turkey
fikret.pekin@vodafone.com

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**Abstract:** Multi-disciplinarily, various scientific research fields need multi-temporal information about land use/cover rates. Especially in metropolitan areas quick data acquisition and processing is important due to the dynamic improvement. Nowadays, remotely sensed image data have considerable use in classifying the earth surface for land use/cover. Recent studies involve temporal detections, analysis and determinations of urban morphology using satellite sensor images. The aims of this paper i) to develop an algorithm using Matlab&Simulink program in order to filter Vegetation, Impervious and Soil (V-I-S) components ii) to analyze land use/cover by means of Landsat 5 TM image of region in Istanbul by using developed algorithms. Selected area from Landsat 5 TM image filters vegetation, impervious, soil and water components according to upper and lower Threshold values obtained under user supervision based on each bands histogram. If that component exists on the image then "1" and else if not "0" is recorded for the pixel on the new image. This procedure is repeated for each band. The results obtained using the suggested algorithm compared with the supervised classification results using Erdas Imagine Program. Algorithm is tested and proved in application for medium resolution satellite sensor images.

## 1. INTRODUCTION

Remote sensing data are a very important data type on classification of earth land use and cover. Many applications and studies require information about the surface structure or stratification of the surface. Many researchers carried out studies on the analysis of the results of obtaining information on earth surface use and cover in urban areas(Welch and Ehlers, 1987; Pathan et al., 1993; Muh Dimyati et al., 1996; Kaya and Curran, 2006; Kaya, 2007). Remote sensing data have wide application range on the analysis of urban areas. Various urban morphology studies use in their respective analysis the information of the earth surface obtained by the remote sensing data (Jensen and Toll, 1982; Forster and Jones, 1988; Kaya et al., 2004). It's very important for the researcher to compile the data and present it numerically for the end user. It's easier to track changes on a surface if the observed surface is given a numerical value. **V**egetative soil, **I**mpervious surface and **S**oil model (**V-I-S** model) is one of the models used in this purpose.

V-I-S model is developed in order to build the morphological structures of urban areas. The model states that the urban land is a linear combination of three components. Ridd (1995) proves that the V-I-S model can be used in the analysis of urban morphology, biophysical and human systems. The remote sensing data is similar to VIV-I-SS model but more practical when analyzing the time-based changes of the land use and cover in certain areas. It's easy to illustrate the changes of an area by analyzing the data taken at certain time intervals. Similarly, the effects of earthquakes, flood or any other natural disasters on an area can be observed by remote sensing data. In addition to this, most of the time a researcher doesn't require to do a lot of wide field work because the analysis is done on a digital data of a certain area obtained by remote sensing methods and results can be laid out easily. For all these reasons, the V-I-S model benefits from the remote sensing data.

The very first application of the V-I-S model was done by Ridd (1995) in Salt Lake City, and later on Ward et al.,2000 ; Madhavan et al., 2001; Setiawan and Mathieu, 2006; performed their own analysis in different cities. This approach provided tangible results by simultaneous use of different methods to observe the urban transformations. Pixel based classification, fuzzy classification and linear spectral mixture analysis (LSMA) are some of the methods that are used. The LSMA method is used deterministically to decompose a pixel to its very last components (Boardman et al. 1995). The last components are the land materials that show homogenous spectral character along the image. Due to these characteristics, LSMA method is mainly used for vegetation prediction (Lee and Lathrop 2005), impervious area prediction and urban morphology analysis (Lu and Weng, 2006; Wu et al., 2005), vegetation and earth classification (Lu and Weng, 2004), and transformation observations (Rashed et al., 2005; Powell et al., 2007). An important point in applications of land use and land cover classification is the choice of certain areas that the end user is interested. Many applications give limited working area to the end user when analyzing certain areas of a data set. However, the end user should in theory be able to choose these certain areas and analyze it in different ways.

In this study, Matlab & Simulink software of the V-I-S model is used because of all the reasons stated above to automate the remote sensing data in user selected areas and to construct map of the each component in respective images. Therefore each image is decomposed into bands and each band is analyzed according to their components and the band images are classified according to vegetation, impervious areas and land areas components. The obtained results show that the developed software is suitable for medium resolution images and it gives faster and approximate results with methods such as uncontrolled classification.

## 2. V-I-S MODEL AND METHOD

V-I-S model expresses the changes on the earth's surface with percentages of the three components by using the data from satellite images. Lithological transformations can be laid out by V-I-S model. The purpose of the model is to simplify the urban morphology and demote it to three main components by using satellite image data (Ridd, 1995). According to the model in Figure 1 each axis represents one of the three components. The values on the axis represent the existing percentage of the component in the data. The boundary conditions of the model are described as when vegetation is 100% impervious areas are 0%, when impervious areas are 100% soil is 0% and when soil is 100% vegetation is 0%. The V-I-S model also provides important data on time based

observations of environmental and natural transformations. Thus, it's possible to analyze the development, its direction and future of existing urban development (Pekin and Kaya, 2010).

The models developed for logical filters is developed only the analysis of 3-band data. The normalization of the used bands is done by dividing the data on a band to the sum of the data on all bands. These bands are registered as RGB (Figure 2). The minimum and maximum threshold values of each value is found from the histogram of each band. The speficied components are registered as "1" or "0"on the new image if the component is present in the image or not, respectively (Figure 3). This process is repeated for each chosen band. The results for each component are also compared among themselves. At the end of this process the new pixel values consist of "0", "1", "2", "3". The results of this study show that the pixels with values "2" and "3" are the ones that are composed of components that are of interest. At this stage, it's imperative to choose the correct bands to analyze because the desired data can not appear on the same band with same amount. Therefore, it's vital to conduct the analysis on different bands simultaneously. The validity of the results is stated by comparing the results of developed algorithm with the results of uncontrolled classification method.

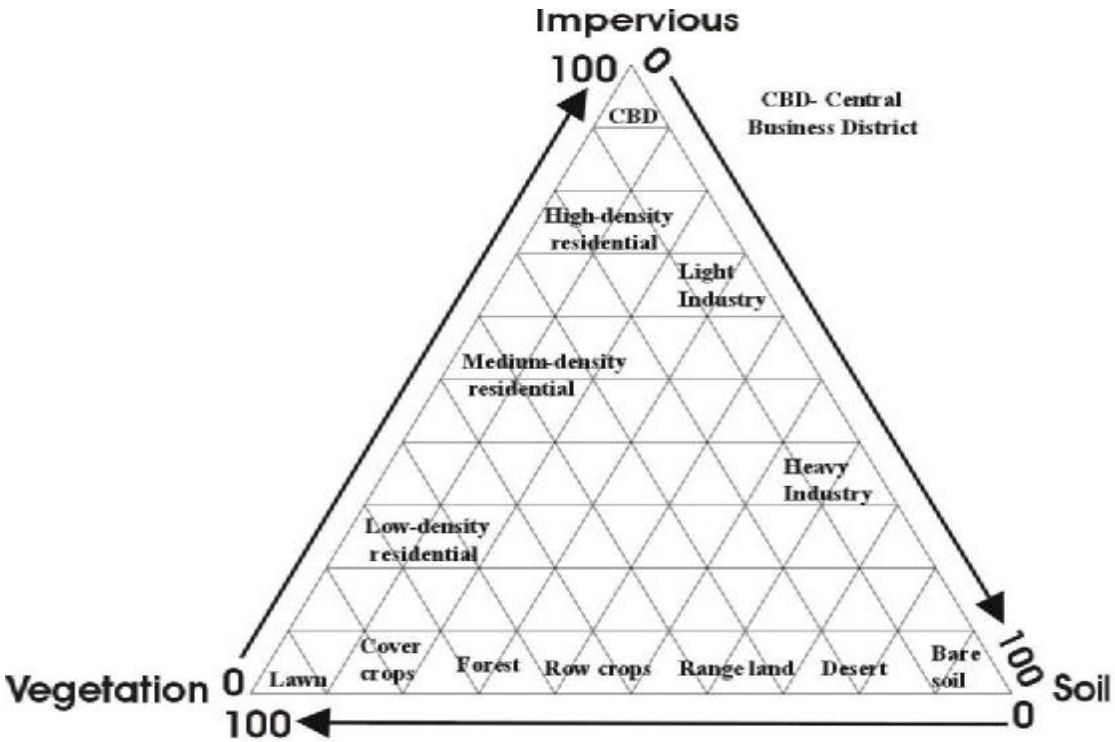



**Figure 1.** The Vegetation-Impervious-Soil (V-I-S) model (Ridd, 1995).

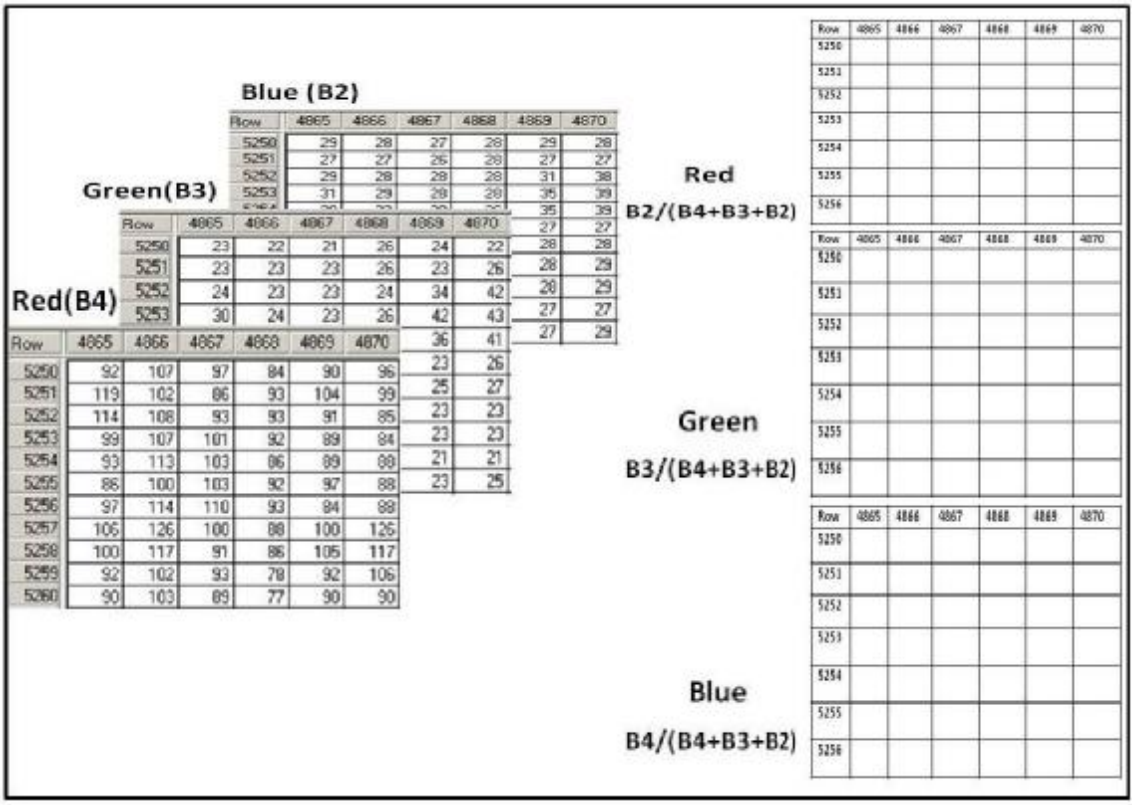
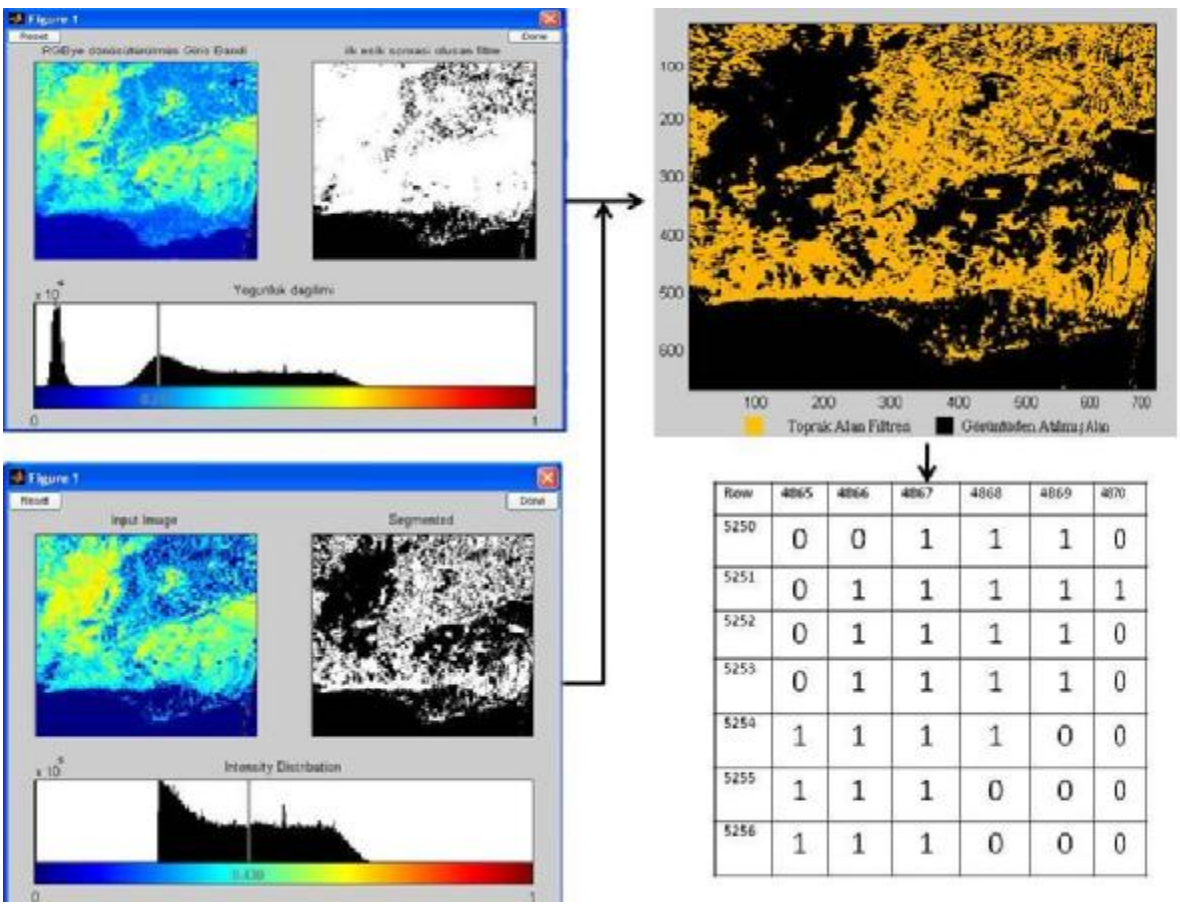



**Figure 2.** Selected bands and normalization




| Row | 4865 | 4866 | 4867 | 4868 | 4869 | 4870 |
|---|---|---|---|---|---|---|
| 5250 | 0 | 0 | 1 | 1 | 1 | 0 |
| 5251 | 0 | 1 | 1 | 1 | 1 | 1 |
| 5252 | 0 | 1 | 1 | 1 | 1 | 0 |
| 5253 | 0 | 1 | 1 | 1 | 1 | 0 |
| 5254 | 1 | 1 | 1 | 1 | 0 | 0 |
| 5255 | 1 | 1 | 1 | 0 | 0 | 0 |
| 5256 | 1 | 1 | 1 | 0 | 0 | 0 |

**Figure 3.** Analyze of threshold value and logic filters.

## 3. RESULTS

In this study, the exemplary satellite image data taken from Landsat 5 TM with 7 bands and covering the Anatolian Side of Istanbul and the City of Izmit is used. The analysis of the satellite imagery is carried out with the algorithms developed for Green, Red and Infrared bands. At the end of the analysis, "0" and "1" values are registered instead of values below and above the two threshold values that are dynamically chosen from the histogram for each band. The pixels inside the filters are coded with "1" and "0" for the ones that are outside of the filters. The value of "1" stands for the availability of the component that wants to be filtered and the value of "0" stands for the lack of such component. The desired data to be analyzed can't appear on the same band with same amount. Therefore, the analysis must be carried out on different bands for the sake of assessing data with large spectrum. The association is done by matching the filters obtained from the three bands. This association states that the components are available if the pixels overlap at least for two bands. As a result of this overlapping process, the new filters contain "0","1","2" and "3" values as pixel values (Pekin and Kaya, 2010, Pekin, 2010). The results of this study show that the pixels with values "2" and "3" are the ones that are composed of components that are of interest (Figure 4, 5). A result can be obtained by taking the average of the components from the same band or the land use & cover obtained by merging the three components can be compared and declared valid with the ones that are obtained by classification method. In table 1, the result obtained by developed model in the Matlab & Simulink software and the classification method are compared. The vegetation, impervious areas and soil components and the percentage of water component that is considered as a workable area are given comparatively.

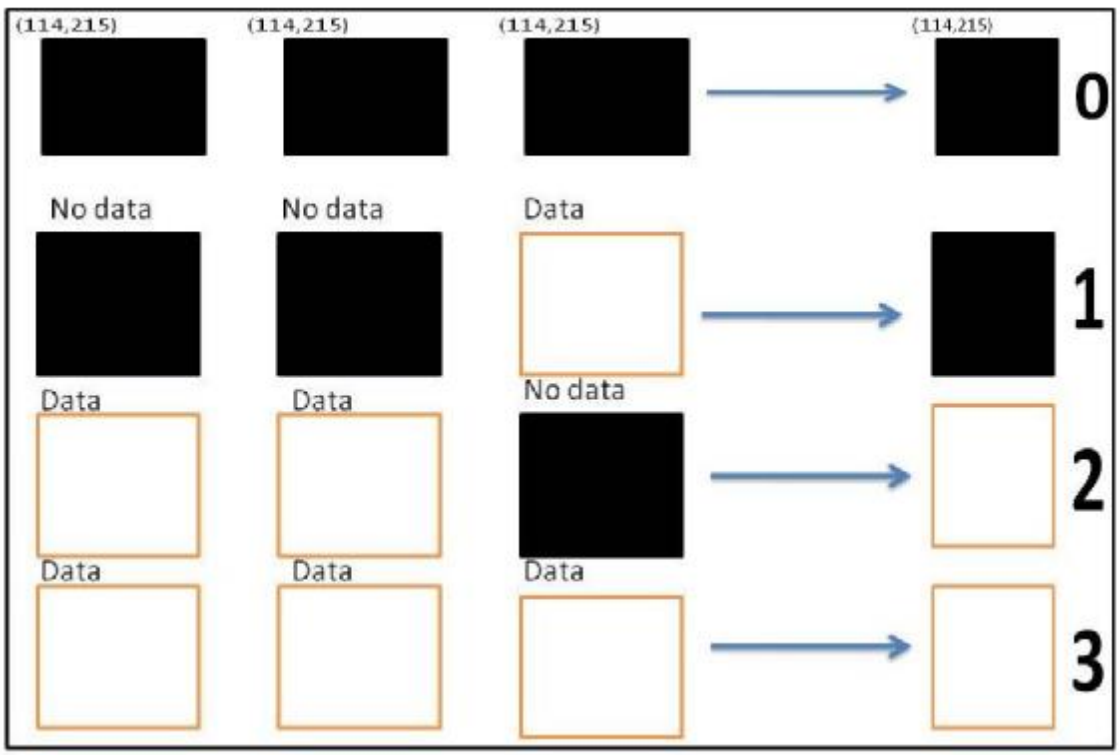


**Figure 4.** The correlation of the data obtained for each band

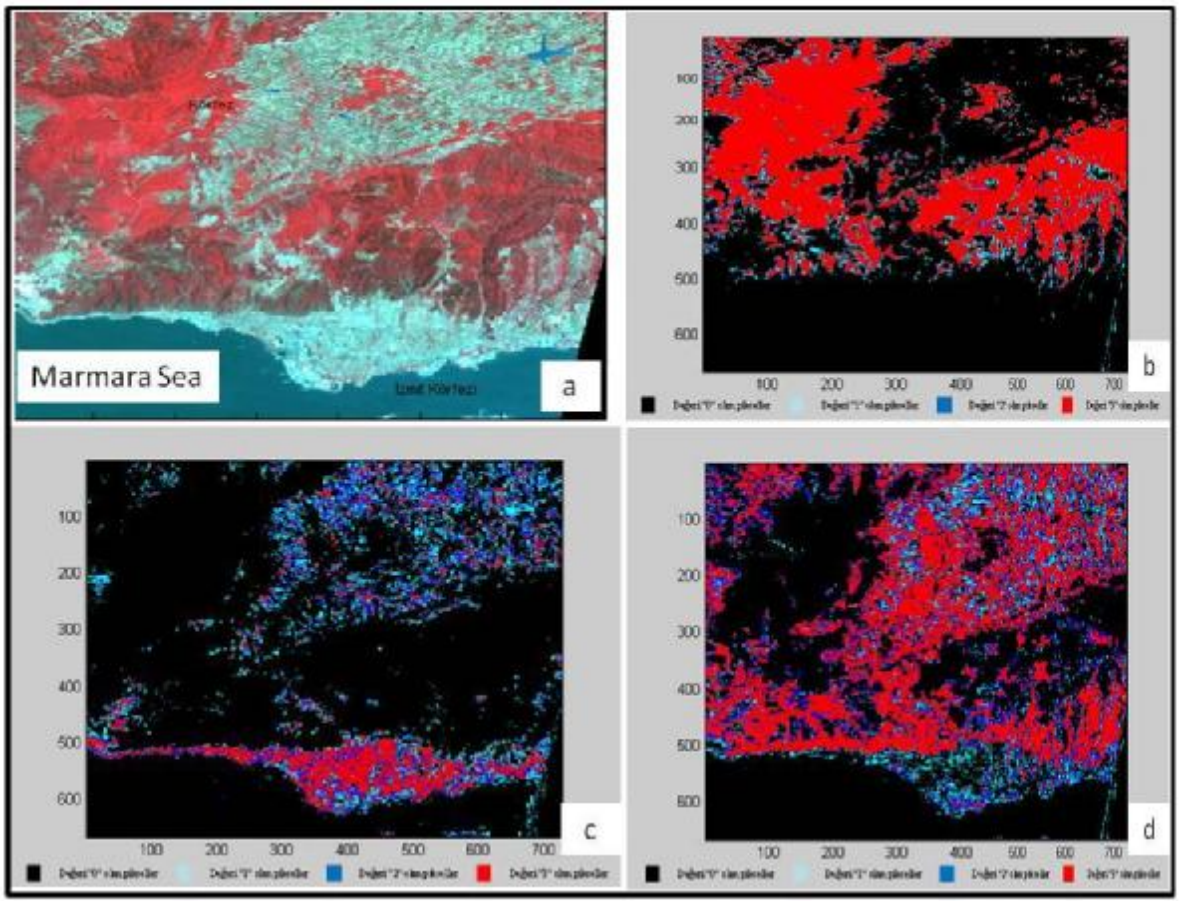



**Figure 5.** a) Study Area b) Filter of Vegetation c) Filter of Impervious d) Filter of Soil, Legend of Fig. 5, Others class (black), "1" value (cyan), "2" value (blue), "3" value (red).

**Table 1:** The comparison of the results from the controlled classification method and Matlab&Simulink

| **V-I-S Components** | **Uncontrolled Classification %** | **Controlled Classification %** | **Matlab&Simulink Results %** | **Difference between Model and Conttrolled Classification %** |
|---|---|---|---|---|
| Vegetation | 35,3 | 34,3 | 33,0 | 1,3 |
| Impervious | 14,9 | 11,9 | 12,1 | 0,2 |
| Soil | 34,6 | 38.4 | 39,2 | 0,8 |
| Water (outer V-I-S) | 15,2 | 15,4 | 15,7 | 0,3 |

## 4. CONCLUSION

Obtaining data on the land use and cover is very important for urban morphology and regional governments. This data can be obtained very fast and economically from the satellite image data with large spectrum. This data can be obtained with various ways. In this study, the logical filters applied with Matlab&Simulink is used for the analysis of various bands. The results vary according the the bands' spectral characteristics. These differences are removed when associating the results for each band thus validating the results. The precision of the applied method is linear with threshold values the end user determines on the image. The obtained results is 90% similar to the ones obtained by controlled classification with Erdas Imagine. This represents the reliability of the proposed method. The method developed with Matlab&Simulink is very convenient because it gives access to choosing various regions thus making it possible for the end user to analyze different points. It's observed that some pixels are not decomposed in complex pixeled areas. In order to solve this problem, the minimum and maximum threshold values must be found by iteration. Moreover, the desired component should be filtered not only between two chosen threshold but also among many user selected thresholds. This way, it's possible to express the sum obtained data more precisely. There are problems in analyzing the satellite image data with high resolution due to memory related problems. However, when finding the land components of the working area the results are obtained more quickly compared to the controlled classification method.

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