ANALYSIS OF LAND COVER CHANGES USING SENTINEL-1 DATA. CASE STUDY- GALATI COUNTY, ROMANIA

Nicoleta-Violeta IURIST (DUMITRAȘCU) – Ph.D Student, Eng., „Gheorghe Asachi" Technical University of Iasi, Faculty of Hydrotechnical Engineering, Geodesy and Environmental Engineering, nicoleta.dumitrascu@tuiasi.ro
*Florian STATESCU – Professor Ph.D. Eng.,"Gheorghe Asachi" Technical University of Iasi, Romania, Faculty of Hydrotechnical Engineering, Geodesy and Environmental Engineering, e-mail:*fstatescu@hidro.tuiasi.ro
Cezarina Georgiana BARTIC (LAZĂR) – Ph.D Student, Eng., „Gheorghe Asachi" Technical University of Iasi, Faculty of Hydrotechnical Engineering, Geodesy and Environmental Engineering, bartic.georgiana91@gmail.com

Abstract: *The study of land cover changes is very important to have proper planning and utilization of natural resources and their management. The aim of this paper is to classify the study area, for two different time periods and to analyses the change detection using free-of-charge Sentinel-1 data. For this case study, dual-polarization (VV+VH) Interferometric Wide swath mode (IW) data collected on August 16th 2017 and October 11st 2017, over South-Est of Romania, were used. Pre-processing and processing were conducted using ESA Sentinel-1 toolbox (S1TBX) in the Sentinel Application Platform provided by ESA. Data have been calibrated, terrain corrected, and classified using supervised classification. The training and test data have been collected from Sentinel- 2 images.*

Keywords: *Land Cover Classification, Random Forest, Change Detection, Sentinel-1, SAR.*

1. Introduction

Land use and/or land cover is the result of human uses of land and the interactions of global climate changes on the Earth's surface [1]. Understanding landscape patterns, changes and interactions between human activities and natural phenomenon are essential for proper land management and decision improvement. Today, earth resource satellites data are very applicable and useful for land use/cover change detection studies [2].

With the invent of remote sensing and Geographical Information System (GIS) techniques, land use/cover mapping has given a useful and detailed way to improve the selection of areas designed to agricultural, urban and/or industrial areas of a region [2].

Copernicus is a European space flagship program led by the European Union in partnership with the European Space Agency (ESA). In order to meet the operational needs of Copernicus program, ESA developed the Sentinel family of missions [3].

Sentinel-1 is a radar mission composed by two satellites, Sentinel-1A and Sentinel-1B, which provides images of the Earth's surface regardless the weather conditions, day or night. Satellites have a capacity of 6-day revisit, providing information in various fields, from monitoring the effects of floods, up to analysis land cover changes [3].

The aims of this study are to classify the same study area, for two different time periods, using Sentinel-1 images and to analyses the results.

2. Presentation of the Study Area, Materials and Equipment

2.1. Presentation of the Study Area

The study area is represented by South- Est area of Galati county, situated in the South-Est of Romania, in Moldavia region, centered at N45°50′, E27°56′ (Fig. 1). The study area is 16,5 km X 16,5 km and 269000ha, nearby Scanteiesti commune.

The county lies on a low plain, with elevation from 5-10 meters in South, up to 310 meters in North.

(a) (b)

Fig. 1. (a) Area covered by satellite images used in study (b) Galati county

2.2. Materials and Equipment

To analyze land cover, Level-1 Single Look Complex (SLC) Setinel-1C-Band SAR data was used, collected in the Interferometric Wide swath (IW) mode. This mode allows the combination of a large swath width (250 km) and it has dual polarization capability (VV+VH), which can provide more ground surface information [1].

Fig. 2. Area covered by satellite images used in this study

The satellite images were captured by satellite Sentine-1B (Fig. 2) in the summer and autumn of 2017. The acquisition dates are 16 August 2017, at 4:20 a.m. and 11 October 2017 at 4:00 p.m. Sentinel-1 is a two-SAR satellite constellation designed to guarantee global coverage with a revisit time of 6 days.

The data used in this study have been downloaded for free from the European Space Agency (ESA) through Sentinels Scientific Data Hub (https://scihub.esa.int/).

2.3 Data processing

The images were processed, analyzed and classified using SNAP software, Sentinel-1 Toolbox (S1TBX) module developed by ESA. The module contains a set of tools for readers, writers, analysis and processing for SAR data. The program can process, besides images from the satellite Sentinel-1, the images taken from satellites such as ALOS PALSAR, TerraSAR-X, COSMO-SkyMed and RADARSAT-2 [3].

The Toolbox includes tools for calibration, speckle filtering, coregistration, orthorectification, mosaicking, data conversion, polarimetry and interferometry. Also, the program can automatically detect ship, windfields, oilspill detection and export them as shape vectors.

3. RESULTS AND DISCUSSION

3.1 Pre-processing corrections

The Toolbox Sentinel-1 of the SNAP software was utilized to pre-process the SAR images. In order to correct the images, the following steps were applied: Apply-Orbit-File, Calibration, TOPSAR-Deburst, Multilook and Terrain- Correction (fig. 3).

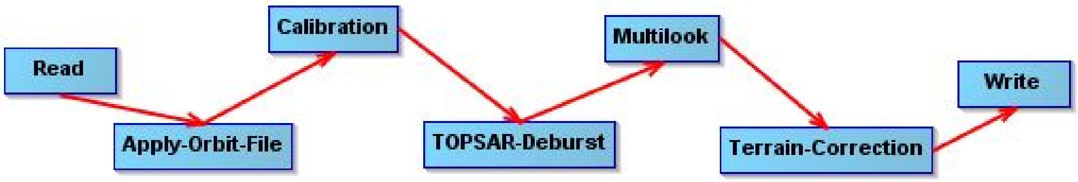

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Fig. 3. Sentinel-1 pre-processing steps

The Apply -Orbit- File operator update the orbit state vectors provided initially in the metadata of a SAR product with precise orbit files. which are available days-to-weeks after the generation of the product. The orbit file provides accurate satellite position and velocity information [4].

The Calibration operator calibrate the imagery such that so that the pixel values of the SAR images truly represent the radar backscatter of the reflecting surface, Also, the radiometric correction is necessary for the comparison of SAR images acquired with different sensors, or acquired from the same sensor but at different times, in different modes, or processed by different processors [4].

TOPSAR IW products have 3 swaths. Each sub-swath image consists of a series of bursts (9 in our case), where each burst was processed as a separate SLC image. Using TOPSAR- Deburst operator images for all bursts in all sub-swaths of an IW SLC product are re-sampled to a common pixel spacing grid in range and azimuth [4].

The multilook process assumes that several images are incoherently combined as if they corresponded to different looks of the same scene, in order to reduce the inherent speckled appearance of a SAR image. As a result, the multilooked image improves the image interpretability [4].

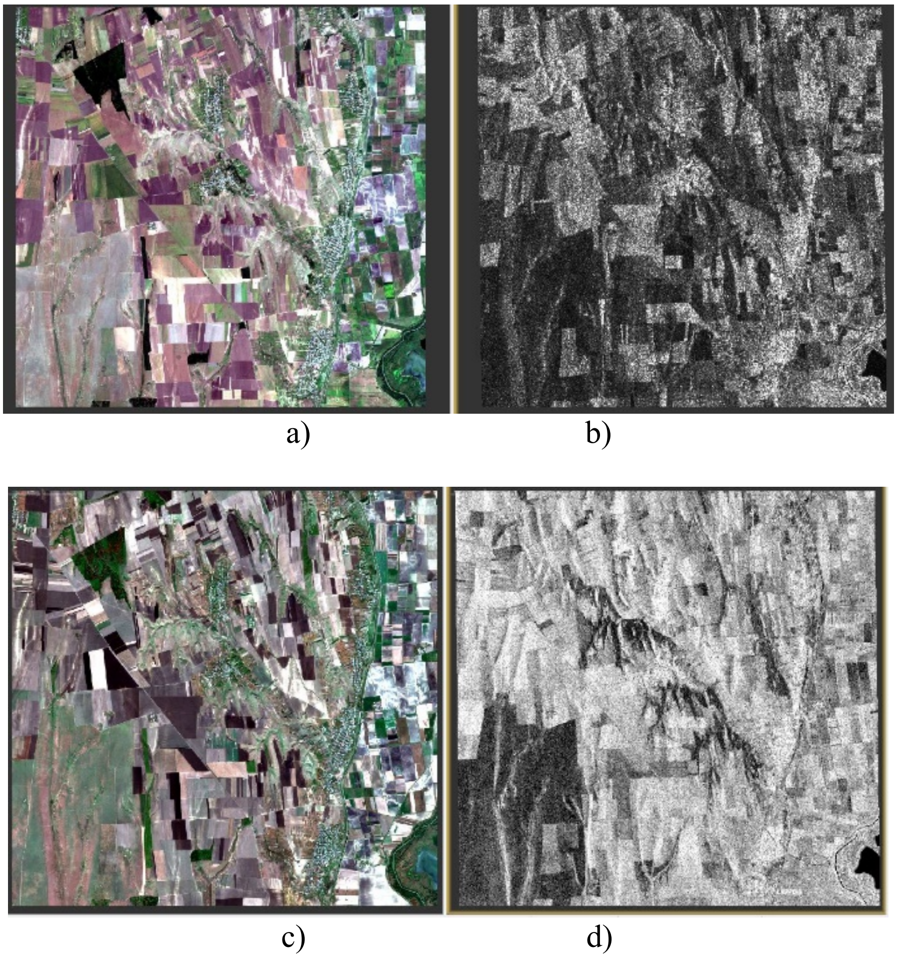


Fig. 4. Study area: a) Sentinel- 2A (26.08.2017); b) Sentinel- 1B (16.08.2017); c) Sentinel- 2A (11.10.2017); d) Sentinel- 1B (20.10.2017).

The original SAR image is inverted in the SNAP. It is displayed according to the order of data acquisition, which is not according to a cartographic representation. To reproject the images from geometry of the sensor to the geographic projection, terrain correction was applied. For this case study, the WGS 84 geographic projection was used [3].

Terrain Correction will geocode the image by correcting SAR geometric distortions using a digital elevation model (DEM) and producing a map projected product. The Digital Elevation Model used to correct the terrain was Shuttle Radar Topography Mission (SRTM) with spatial resolution 3 arc- second. For SRTM the height information is automatically corrected to obtain height relative to the WGS84 ellipsoid [3].

3.2 Supervised classification

Supervised classification is a technique for extracting information from image data. The goal is to classify pixels in an image into different classes based on features of the pixels. There are two stages: training stage and classification stage. During the training stage, a set of vectors (each vector is associated with a pixel) called training samples are used to train a classifier. Each training sample vector is made up of the class the pixel belongs to and feature values of the pixel. In the classification stage, the trained classifier is used to classify pixels with known feature values but unknown class [4].

Table 1. Training set

Value	Classes	Training (August 2017)	Training (October 2017)
0	Agriculture	81	92
1	Bareland	51	59
2	Forest	25	35
3	Urban	42	55
4	Water	18	16

Random Forest (RF) is a classification and regression tree technique invented by Breiman [5]**Error! Reference source not found.**. A RF randomly and iteratively samples the data and variables to generate a large group, or forest, of classification and regression trees. The classification output from RF represents the statistical mode of many decision trees achieving a more robust model than a single classification tree produced by a single model run [6][4].

We defined 5 classes in order to classified the SAR images (Table 1): Agriculture, Bareland, Forest, Urban and Water. The Agriculture class includes area covered by green vegetation, Bareland class includes bare land and soil without vegetation, Forest class represents areas covered by forest, Urban class defines settlements, artificial and industry areas, while Water class defines lakes and areas covered by water.

The training sample were defined on two Sentinel 2A images, purchased on August 2017 and October 2017 (Fig 5.).

a) b)

Fig. 5. a) Training set for August 2017; b) Training set for October 2017

In order to achieve high classification accuracy, different cases were defined, using dual polarimetric data of Sentine-l (Table 2). The image classification increased in accuracy using dual polarimetry [7].

Table 2. Dataset of experiments

Scenario	No of variables	Description of variables
1	3	VV, VH, VV-VH
2	3	VV, VH, (VV+VH)/2
3	3	VV, VH, VV/VH
4	5	VV, VH, VV/VH, (VV+VH)/2, VV-VH

The higher accuracy was obtained for August 2017 data set using scenario no. 3 (72.57%), while for October 2017 data set the higher accuracy was obtained using scenario no. 4 (68.15 %).

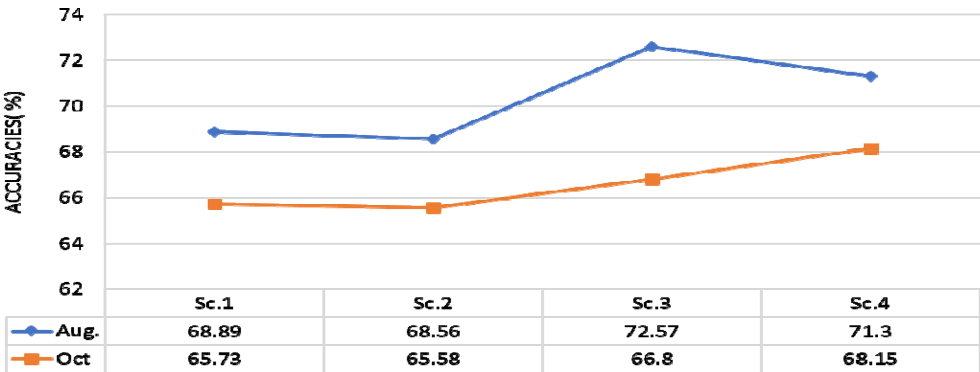
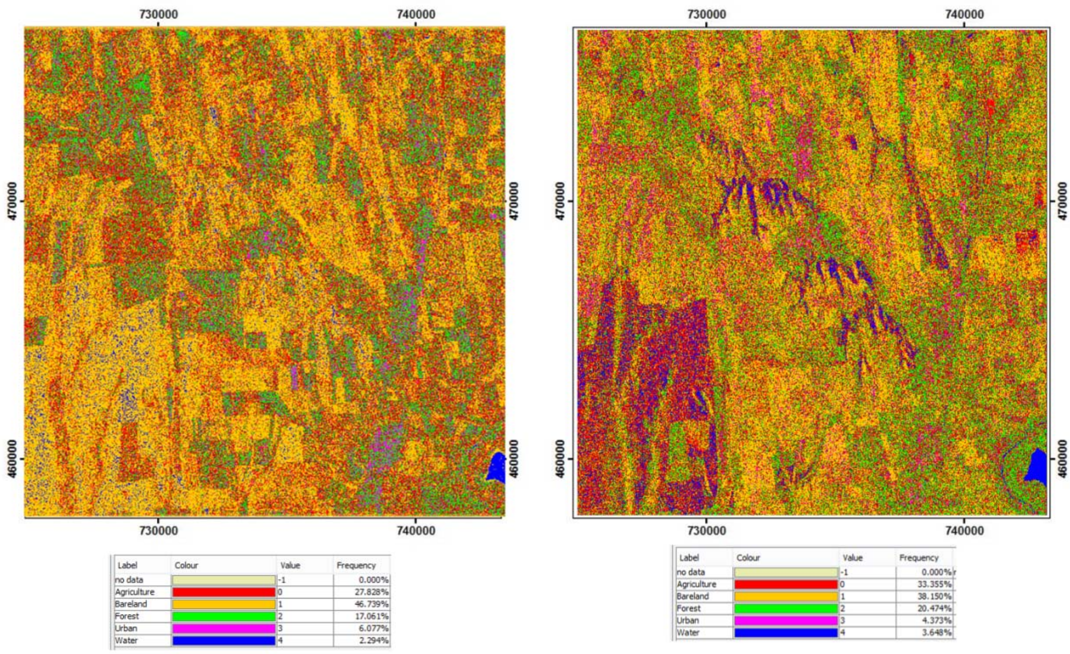


Fig. 6. RF accuracies with different variable



a) **b)**

Fig.7. Classification results: a) August- Scenario no. 3; b) October- Scenario no. 4

Analyzing the classification results we can observe that in August, the South-West area is classified as Bareland, while in October this area is classified as Water. This area is covered with pasture and was flooded in October (Fig. 7). Due to rainfall in the autumn the bare land area is larger in August. The classification of areas covered by Forest and Agriculture is not precise, these being combined.

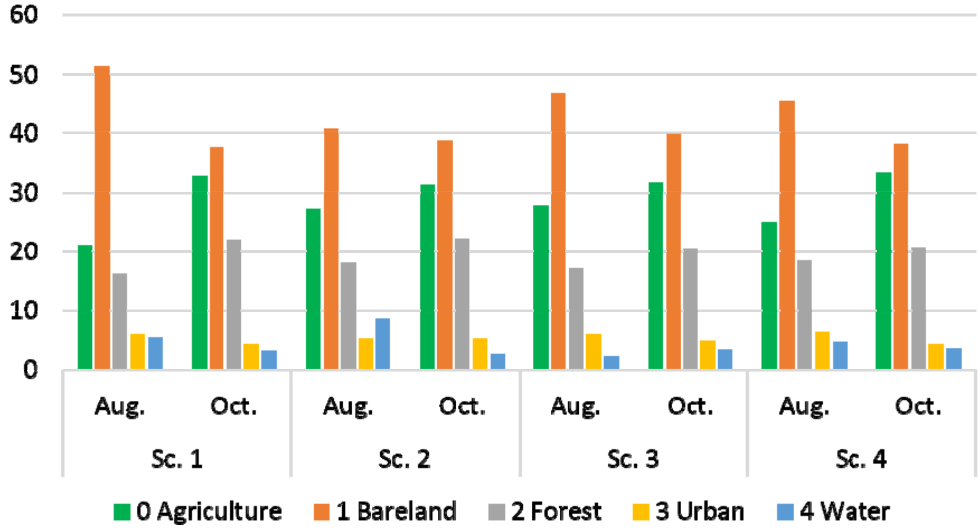


Fig. 8. Land cover changes

4. Conclusions

Sentinel-1 provides images of the Earth's surface regardless of weather conditions, day or night and have a capacity of 6-day revisit, providing information for land cover of vegetation and agricultural areas.

In this study, we analyzed the change detection using Sentinel-1 imagery. Using dual-polarization (VV+VH) Interferometric Wide swath mode (IW) data collected on August 16th 2017 and October 11st 2017, over South-Est of Romania, we classified the study area using different scenarios.

The SAR images were classified using supervised classification, Random Forest method. 5 classes (Agriculture, Bareland, Forest, Urban, Water) were defined in order to classified the images. The training sample were defined on two Sentinel 2A images, purchased on August 2017 and October 2017.

In order to achieve better results, we defined 4 scenarios, with different variables: VV, VH, VV/VH, (VV+VH)/2, VV-VH.

The higher accuracy was obtained for August 2017 data set using scenario no. 3 (72.57%), while for October 2017 data set the higher accuracy was obtained using scenario no. 4 (68.15 %).

The results of this study indicate that dual polarized IW Sentine-1A is suitable for land cover analyses. As further research, the land cover obtained based on SAR images will be compare with the land cover obtained based on optical images.

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