



UPOTREBA OTVORENIH PODATAKA I APLIKACIJA U PROCESU EDUKACIJE

Dušan Jovanović, *dusanbuk@uns.ac.rs*,
University of Novi Sad, Faculty of technical sciences
Bojan Popović, *bojanpop94@uns.ac.rs*,
University of Novi Sad, Faculty of technical sciences
Miro Govedarica, *miro@uns.ac.rs*,
University of Novi Sad, Faculty of technical sciences

Abstract:

Ovaj rad ima za cilj da prikaže iskustva u obrazovanju u upotrebi pre svega satelitskih snimaka ali i drugih podataka sa otvorenim pristupom. Prikazane su različite satelitske platforme sa različitim prostornim i spektralnim rezolucijama. Takođe razmatramo primenljivost ovih podataka u obrazovnom procesu, posebno sa studentima sa studijskog programa Geodezija i geomatika na Fakultetu tehničkih nauka Univerziteta u Novom Sadu. Prikazani su i neki praktični primeri. Na kraju, ovaj rad takođe opisuje probleme iz praktičnog pogleda na nastavu i daje preporuku o tome kako rešiti te probleme koristeći pristup učenja zasnovanog na problemu.

Keywords: satelitski snimci, obrazovanje, geoinformatika, daljinska detekcija

USE OF OPEN DATA AND APPLICATIONS IN THE EDUCATION PROCESS

Abstract:

This paper aims to show experience in education using open access data, especially satellite images. We describe different satellite platforms with different spatial and spectral resolution. We also discuss applicability of these data in education process especially with students on study program Geodesy and Geomatics on Faculty of technical sciences, University of Novi Sad. Some practical examples are also shown. At the end, the paper also describes problems from practical view of teaching and recommendation how to solve those problems using Problem based learning approach.

Keywords: open data, education, geoinformatics, remote sensing, satellite images

1. INTRODUCTION

The Sustainable Development Goals (SDGs) were born at the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012 [1]. The objective was to produce a set of universal goals that meet the urgent environmental, political and economic challenges facing our world. There are 17 goals which are interconnected, so often the key to success in one will involve tackling issues more commonly associated with another. The most powerful and proven tool for sustainable development, education, is also one of the 17 goals. According to this goal, the desire is to provide the same opportunities in terms of accessible vocational education, as well as to eliminate disparity in terms of gender and wealth, with the aim of achieving universal access to quality higher education. The data are probably the most valuable and least-used resource for the entire region of southeastern Europe, especially in the countries of the former Yugoslavia. Local and national authorities in those countries don't understand that intelligent data management helps them to create new opportunities for the development of the economy and employment. If they increase the availability of data of each type, they will increase efficiency in service delivery, and improve the outcome of the education.

The EU Commission has been investing significant resources over the years to overcome the challenges it entails by supplying large amounts of data for public use. The opening of data is recognized globally as a process that will significantly contribute to the achievement of the Sustainable Development Goals after 2015 [2].

The Global Open Data Index, The Global Open Data Initiative (GODI), The Open Data Foundation (ODaF), The Open Data Handbook, Open Gov Partnership (OGP), are just some of the organizations which define what open data are and how should they be treated by governmental and non-governmental institutions. "Open data and content can be freely used, modified, and shared by anyone for any purpose" [3] is the most common and the most frequently used definition of open data.

The importance of spatial data in the 21 century is increasing exponentially, mainly because of growing availability and usability in everyday life, and because of the vast data quantity which are being collected, processed and analyzed in different ways and by different profit or non-profit institutions. The objective of this paper is to introduce open access spatial data and open source GIS applications in education process, especially with students from study programs, where "geo" and "spatial" is normal way of thinking and viewing the world. These data and application and their open availability can have a significant influence on the mindset of future generations that are now being educated.

This paper is organized as follows: the next section presents what is most use open access spatial data and application. Section three gives an explanation about data applicability, and how open access data can be used in higher education. Also, this section describes the importance and opportunities of remotely sensed data for different kind of applications. Paper concludes with an outlook on problem-based learning (PBL) approach using open access data and open source GIS.

2. OPEN DATA AND APPLICATIONS

Open spatial data from different sources provides geospatial engineering solutions for managing spatial data from survey through design, construction and data distribution, utilising open standards and engineering best practices. If we need information about land cover monitoring, land cover change detection, weather disasters, floods, fires, and other

occurrences, there are a lot of agencies that are monitoring and collecting data from the whole planet or just some part of it on a daily basis. These information's are collected with satellite platforms with different spatial, spectral, temporal and radiometric resolutions. Property and access to this information's present an important step towards understanding the environment in which we live in and how do we influence on our environment.

On the other side, beside data that are coming from different ways of monitoring, there are lot of type of spatial data which arise from different kind of community. One of the best examples is Open Street Map (OSM) [4]. OSM has created a cartograph community that adds and maintains information about roads, paths, bars, railroad stations and many other facilities around the world. The OSM community is diverse, and include enthusiasts, GIS professionals, engineers running OSM servers, humanitarians mapping areas affected by disasters, and many others. OSM gives open data, which means that you can freely use it for any purpose as long as you give credit to OpenStreetMap and contributors.

An open source application by definition is software that you can freely download, use and also modify for your own needs. Open source projects are typically created from a community of volunteer programmers. There is very large number of open source GIS programs, and globally they can be divided into several groups. Usually, they can be divided on desktop and web open source GIS, or they can be divided in terms of programming languages that they are based on (for example Java, and .NET). In addition to the benefit of cost reduction, there are many advantage of using GIS open source applications. Open source GIS software will give you the opportunity to learn all aspects of GIS through the free use of available courses and resources. Having access to the source code, allows users to customize application in any way that they can think of.

In addition to all the benefits of open source tools there are some disadvantages. Some open source software doesn't have user-friendly interface and for new users it's hard to conduct even simple tasks. Commercial solutions often have better and more complete documentation and better user support. Also, commercial software typically offers a robust suite of features right out of the box

2.1. SATELLITE DATA

2.1.1. European Space Agency - ESA

European Space Agency (ESA) is an international agency, founded in 1975., which deals with space exploration and coordinates European civil space activities. ESA is an international organization with 22 Member States. By coordinating the financial and intellectual resources of its members, it can undertake programs and activities far beyond the scope of any single European country. [10]

Copernicus is the most ambitious Earth observation program to date. It will provide accurate, timely and easily accessible information to improve the management of the environment, understand and mitigate the effects of climate change and ensure civil security. This initiative is headed by the European Commission (EC) in partnership with the European Space Agency (ESA).

European Space Agency (ESA) within the Copernicus program is constantly developing and planning new Sentinel satellite platforms. The Sentinels will provide a unique set of observations, starting with the all-weather, day and night radar images from Sentinel-1A and -1B, launched respectively in April 2014 and April 2016.

The Sentinel-1 mission comprises a constellation of two polar-orbiting satellites, operating day and night performing C-band synthetic aperture radar imaging, enabling them to

acquire imagery regardless of the weather. Sentinel-1 satellites produce radar images with the repeat cycle of 6 days. [11]

Sentinel-2 mission provides multispectral high-resolution images of the Earth's surface. The mission consists of two satellites that are in the same orbit at a height of 786 km and are positioned 180° from each other. Sentinel-2A was launched on June 23, 2015, and Sentinel-2B on March 7, 2017.

Each of the Sentinel-2 mission satellites has a Multispectral Instrument (MSI) capable of recording in 13 spectral bands: 4 bands at 10 m, 6 bands at 20 m and 3 bands at 60 m spatial resolution. The Multispectral Instrument (MSI) works passively by collecting the Sun's rays that are reflected from the Earth's surface. It uses push-broom concept by collecting rows of image data across the orbital swath and uses the forward motion of the spacecraft along the path of the orbit to provide new rows for acquisition. Temporal resolution of one Sentinel-2 satellite is 10 days, which means that the combined temporal resolution of the whole system is 5 days. [11]

Sentinel-3 is an European Earth Observation satellite mission developed to support GMES ocean, land, atmospheric, emergency, security and atmospheric applications. The main objective of the Sentinel-3 mission is to measure sea surface topography, sea and land surface temperature, and ocean and land surface color with high accuracy and reliability to support ocean forecasting systems, environmental monitoring and climate monitoring. The mission definition is driven by the need for continuity in provision of ERS, ENVISAT and SPOT vegetation data, with improvements in instrument performance and coverage. [11]

Images from these 3 missions are open access data and users only need to register at the Copernicus Data Hub in order to download it. Hub offers different filters for the image data acquisition, amount of cloud coverage, area of interest. Beside raw images users can download preprocessed data with different level of corrections. For Sentinel-2 there are processing levels 1C (radiometric and geometric corrected data) and 2A (scene classification and an atmospheric correction applied to Top-Of-Atmosphere (TOA) Level-1C orthoimage product).

It should be noted that Sentinel data can be downloaded from other sources such as USGS or PEPS hubs or through some software such as QGIS with its Semi-Automatic Classification Plugin.

Beside the listed missions above ESA is planning to launch 3 more satellite systems: Sentinel-4, Sentinel-5 and Sentinel-6 which will be equipped with different types of sensors and whose data will be used for various research.

2.1.2. United States Geological Survey - USGS

The United States Geological Survey is a scientific agency of the United States government whose subjects of research are natural hazards, water, energy, minerals and the impacts of climate and land-use change. To achieve that they collect a large amount of data about Earth, atmosphere and even space. They provide real-time or near real-time data and information on current conditions and Earth observations to users under open data license. In the real-time data section users can find information about earthquakes (auto update KML file), water (graphs and reports), floods (real-time map), geomagnetism, remote land sensing (Landsat) and so on. They also offer large number of thematic maps, GIS data and geological maps. It should be noted that the most of these data are only for the area of U.S. Their Landsat satellite program offers satellite images of the whole world and it was the first program of its kind.

Landsat program for Earth observation lasts from 1972 when the first Landsat was launched. Since 1982 Landsat 4 satellite platform began to deliver satellite images with 30 meters spatial resolution in visible, near-infrared and short-wave-infrared wavelengths, which enabled the first severe Earth land cover monitoring [5]. A big step forward in information access occurred in 2008 when the US Geological Survey issued a decision that enabled all of the Landsat images to become free and open access to anyone [6].

Today Landsat 7 and Landsat 8 satellites are still active from which Landsat 8 images are more used today. Landsat 8 carries two push-broom instruments: Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS). The Operational Land Imager (OLI) measures in the visible, near-infrared, and short-wave infrared portions of the spectrum. Its images have 15 m panchromatic and 30 multi-spectral spatial resolutions. Thermal Infrared Sensor (TIRS) measures temperature of Earth surface in two spectral bands with spatial resolution of 100 m. Temporal resolution of Landsat 8 satellite is 16 days.

Figure 1 shows some of the results that can be obtained from the open access satellite data for the area of Republic of Serbia. Landsat satellite images can be used for generation of land cover maps, or maps of different vegetation indices that can be used in the area of agriculture (quality of agricultural cultivated plants or condition of other types of crops and fruit fields) or in environmental applications. Also, Landsat satellite images can be used for mapping flooded areas and flood simulations. Figure 1 also illustrates forest map for the area of Fruška gora National Park, obtained from radar PALSAR images, while Aster images, among other applications, can be also useful for Digital Elevation Model (DEM) generation [7].

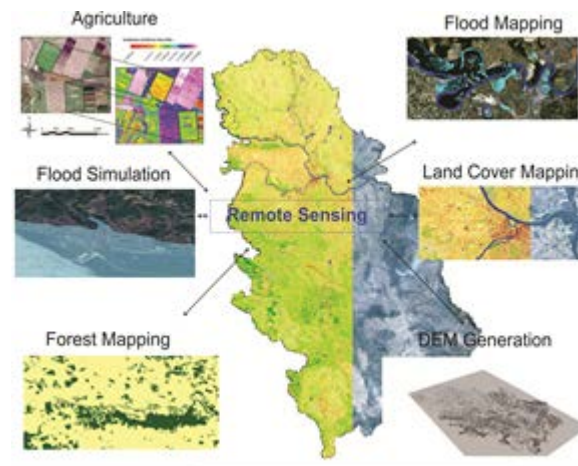


Figure 1. Examples of products obtained from the processing of open access satellite data for the area of Republic of Serbia

2.2. VOLUNTEERED GEOGRAPHIC INFORMATION - VGI

2.2.1. Open Street Map - OSM

Sites such as Wikimapia and OpenStreetMap are empowering citizens to create a global patchwork of geographic information, while Google Earth and other virtual globes are encouraging volunteers to develop interesting applications using their own data [7].

OpenStreetMap was created in 2004 by Steve Coast in UK inspired by the success of the Wikipedia. It was created as an answer to the European restrictions on use or availability of map information. A key motivation for this project is to enable free access to current geographical information where, in European countries, accurate digital geographical information is considered to be expensive and out of the reach for individuals, small businesses, and community organizations [9]. The idea soon spread to the rest of the world. Number of OSM users grown exponentially and OSM database was filled with more and more data. All registered users can enter new data that they've collected using manual survey, GPS devices, aerial photography, and other free sources. Entered data is then validated by other users, so everyone is contributing as much as they can. Crowdsourced data collected by the users are then distributed under the open data license. Today OSM is one of the biggest map providers and source of different spatial information. Rather than the map itself, the data generated by the OpenStreetMap project is considered its primary output.

OSM uses topological data structures for storing data. Elements that have been used are: nodes (stored as coordinate), ways (ordered lists of nodes), relations (ordered lists of nodes, ways and relations) and tags (metadata). All OSM data are stored in a PostgreSQL database with PostGIS extension. Database has 4 different tables for each of the primitives in which objects are stored. Data download can be done through the OSM export page. Data for the given area are created as a database dump that exist in two formats: XML and PBF. Downloaded data can be then opened in some GIS tool such as QGIS.

QGIS treats OSM files as a regular vector files, grouping together points, lines and polygons into separate layers. Once loaded into QGIS data can be used for different spatial analysis and can be exported as a different data format.

2.3. QGIS

QGIS is a user friendly open source Geographic Information System (GIS) application licensed under the GNU General Public License. QGIS was released in July 2002 as official project of the Open Source Geospatial Foundation (OSGeo). Its core functions provide powerful desktop tool for spatial data manipulation, spatial file browser, a server application that provides OGC compatible WMS and WFS services and a QGIS web client. QGIS supports both raster and vector layers; vector data is stored as either point, line, or polygon features. Multiple formats of raster images are supported, and the software can georeference images. QGIS provides a continuously growing number of capabilities provided by core functions and plugins. QGIS supports shapefiles, coverages, personal geodatabases, dxf, MapInfo, PostGIS, and other formats. Web services, including Web Map Service and Web Feature Service, are also supported to allow use of data from external sources.

The main advantage of QGIS over other tools is its big community. QGIS is a volunteer driven open source project, which means that anyone can see the source code of the program and modify the existing functions or create new ones. There are more than 500 plugins developed by users which extend the basic functionality of the program. Plugins are written in C++ or Python.

Developed by Luca Congedo, the Semi-Automatic Classification Plugin (SCP) is a free open source plugin for QGIS that allows for the semi-automatic classification (also known as supervised classification) of remote sensing images. It provides several tools for the download of free images, the preprocessing, the postprocessing, and the raster calculation.

The overall objective of SCP is to provide a set of intertwined tools for raster processing in order to make an automatic workflow and ease the land cover classification, which could be performed also by people whose main field is not remote sensing.

SCP includes the tool for searching and downloading Landsat images (from Landsat 1 MSS to Landsat 8 OLI), Sentinel-2, Sentinel-3, ASTER and MODIS satellite images. In the process of image download automatic conversion to reflectance of downloaded bands is available. Atmospheric correction can also be conducted later with the use of the image metadata file. SCP uses dark object subtraction algorithm for image preprocessing.

One of the main functionalities of SCP is supervised image classification which is done through SCP dock. The SCP dock allows creation of ROIs (Regions Of Interest) and spectral signatures, and the classification of a band set image. The training input, created with SCP, stores the ROI polygons and spectral signatures used for the land cover classification. [12]

In SCP, land cover classes (and ROIs) are defined with a system of classes (Class ID) and macroclasses (Macroclass ID) that are used for the classification process. Each macroclass ID is related to a macroclass name and each class ID is related to a class name, but only macroclass ID and class ID are used for the classification process and SCP recognises classes based on ID. Once training sets are collected, SCP dock allows signature analysis by reviewing signature plot and scattering. Three classification algorithms can be used: Minimum Distance; Maximum Likelihood and Spectral Angle Mapping. Accuracy assessment can also be done through SCP. Plugin allows a random ROI generation and class photointerpretation that are later used for classification assessment. [12]

Beside listed, SCP offers a lot of image manipulation tools. Images can be subset to a shape of a ROI or shapefile, band sets can be created by merging different bands into different levels of the image, image RGB preview can be set to a specific set of bands. SCP is a powerful plugin for remote sensing based analysis and it's been constantly upgraded through many of its iterations. Current version is 6.0.1.1

3. EXPERIENCE IN DATA APPLICABILITY IN EDUCATION PROCESS

In the framework of this paper, an overview of the use of open data and open source application on the study program Geodesy and Geomatics, Faculty of Technical Sciences in Novi Sad is given. Within this study program, students are familiarized with various subjects that are basically based on spatial data. The trend of collecting spatial data is increasingly relied on knowledge in the area of remote sensing. Courses Photogrammetry and remote sensing in the fourth and Remote sensing and computer image processing in the seventh semester are substantially interconnected, and fully enable students to learn about the method of collecting spatial data from different types of platforms. Students are primarily learned on how to collect and process data from satellite platforms, as well as how to do the post-processing of such data and raises the value of the input spatial information to an entirely new level.

Teaching and exercises from these subjects are designed so that students fully master the basic techniques of collecting and processing spatial data, as well as mastering the use of different software in the field of remote sensing.

In the seventh semester of 2017/18, one part of the course Remote sensing and computer image processing has been changed, in the way to introduce problem-based learning

approach. This practical mean that 15% of exercises from those subject is changed. All students who attended the course were divided into 12 groups of 5 students. Each group was formed so it contained students with different level of knowledge. Members of every group had to choose one student for the group leader. The leader of the group shared tasks among other members, organized a work plan, and if necessary arranged consultations with the professor. The students assignments were: Red edge band impact analysis; Flood monitoring; Urban area growth detection; Temperature trends in urban areas; Forest fire detection; Tree species classification, Forest area identification; Water bodies mapping; Correlation between vegetation indexes; Vegetation stress analysis; Analysis of vineyard health and Chlorophyll content detection. Assignments were given in a form of template, which is shown in the Figure 2

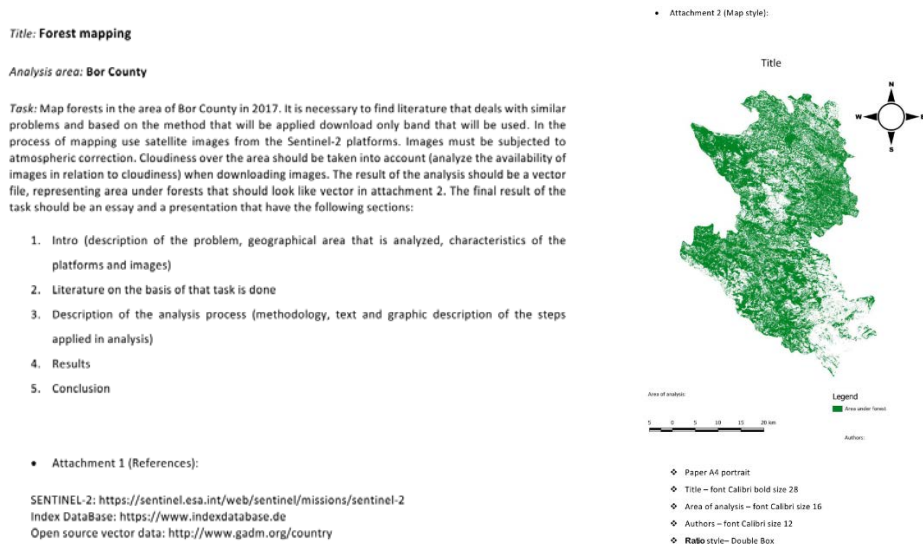


Figure 2. Example of PBL task

Each group had the title of their assignments, followed by a geographical area that they were analyzing. The most given areas were from wider area of Serbia. Next part contained a detailed description of the problem and the time period for which the analysis was to be performed. All satellite images had to be open access and cut to the shape of the area of interest (AOI). Those AOI's were most often administrative units of Serbia, Montenegro or Republic of Srpska in a form of shapefile that are open access from websites such as Global Administrative Areas (<http://www.gadm.org/country>). Then the groups task was to analyze existing literature dealing with that problem and to find the best solution for their assignments. In the last part we gave them useful references as a starting point for their analysis. As a result, group had to produce some raster or vector file that contained the resulting data, write down all what they have done in a form of essay, prepare adequate map or maps of the results and to prepare power point presentation to present their results to the entire class. Next two chapters present two student assignments, methods that they used and obtained results.

3.1. FOREST FIRE DETECTION

Title of this assignment was Forest fire detection, and area of interest for this assignment was area of Montenegro. In this assignment students must detect area of forest fire using Landsat8 satellite images. Students must find literature that deals with similar problems and based on the method that they find in literature, download only bands that they will be used. The analysis should be based on the temporal comparison of images before and after the fire. Images must be subjected to atmospheric correction. Cloudiness over the area should be taken into account (analyze the availability of images in relation to cloudiness) when downloading images. For the realization of this assignment we propose QGIS software. The result of the analysis must be raster that should look like raster given in description of assignment and the final result of the task should be an essay and a presentation.

Based on their analysis students concluded that they will use Normalized Burn Ratio (NBR) and difference Normalized Burn Ratio (dNBR) indices, to highlight areas that have been burned and to index the severity of a burn area using Landsat imagery. Students first downloaded images from USGS website for the area of Montenegro, one image with the date of acquisition 10.07.2017. and other 30.10.2017. For the entire assignment they used an open-source software QGIS. In QGIS they used Semi-Automatic Classification Plugin for atmospheric correction (Dark object subtraction method), NBR and dNBR calculation and Print composer for generating final result in a form of map. Because dNDR results vary from case to case and can be interpreted in different ways, they used USGS dNBR classification suggestion shown in the Table 1.

Table 1. Levels of vegetation burn, proposed by the USGS

SEVERITY LEVEL	NBR RANGE
Enhanced Regrowth, High	-0.500 to -0.251
Enhanced Regrowth, Low	-0.250 to -0.101
Unburned	-0.100 to 0.099
Low Severity	0.100 to 0.269
Moderate-low Severity	0.270 to 0.439
Moderate-high Severity	0.440 to 0.659
High Severity	0.660 to 1.300

The results of the dNBR and scaled dNBR are shown in the Figure 3 and Figure 4 below.

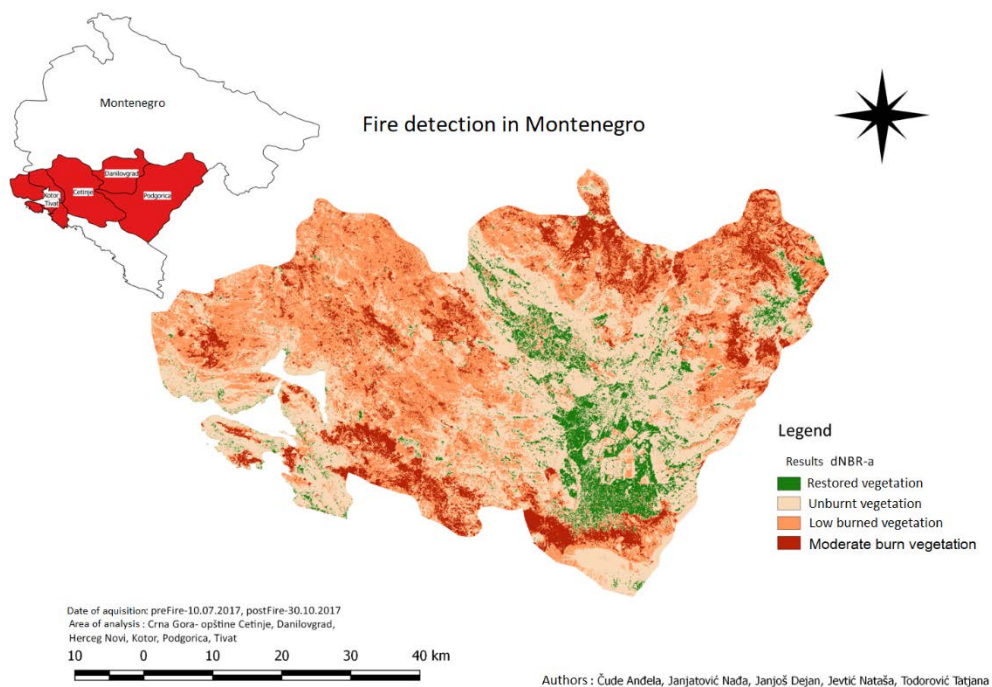


Figure 3. Results of dNBR classification

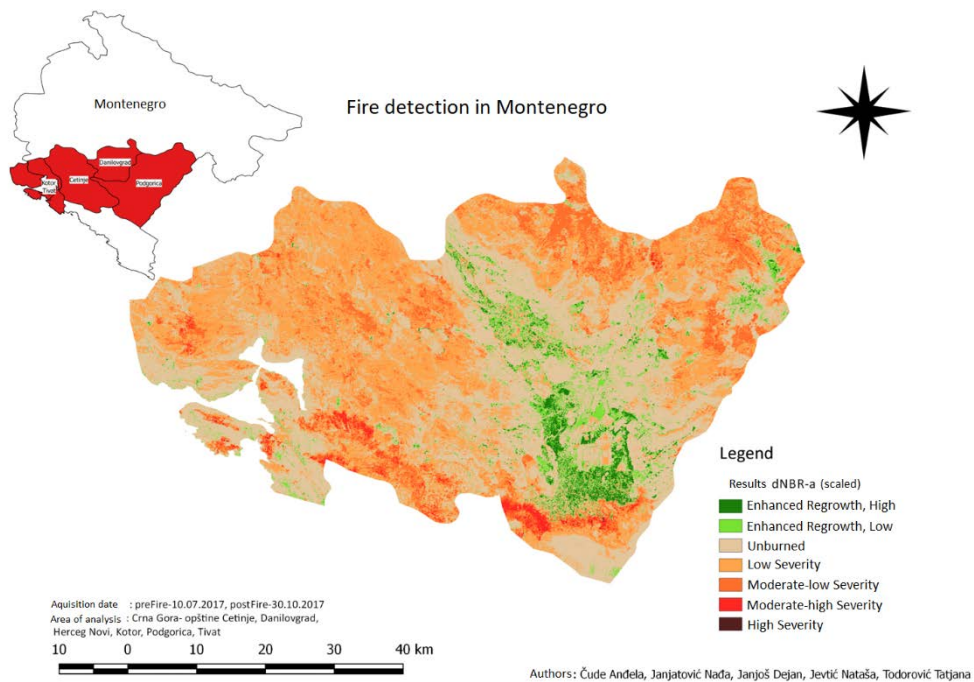


Figure 4. Results of scaled dNBR classification

3.2. FLOOD MONITORING

Title of this assignment was Flood monitoring, and area of analysis for this assignment was area of river Sava. In this assignment students must detect flooded area around river Sava in 2014. using Landsat8 satellite images. They have to find literature that deals with similar problems and based on found methods, to download only bands that will be used. The analysis should be based on the temporal comparison of images before and after the flood. Images must be subjected to atmospheric correction and cloudiness over the area should be taken into account when downloading images. For the realization of this assignment we propose QGIS software. The result of the analysis should be map of flooded area with OSM data as background, an essay and a presentation.

Based on their analysis students concluded that the best solution is to use supervised classification on two images, extract only pixels containing water and then use the change detection algorithm from QGIS. They conducted the same steps for image preprocessing as the group described above (atmospheric correction, band stack and image subset) in Semi-Automatic Classification plugin (QGIS). They collected training sites (areas in the map that are known to be representative of a particular land cover type) for water from downloaded images. Based on the training sites QGIS calculates spectral signature for water combining spectral information's from each band. Based on spectral signatures classification algorithm decides which pixel belongs in which class. Classification results are shown in Figure 5 and Figure 6.

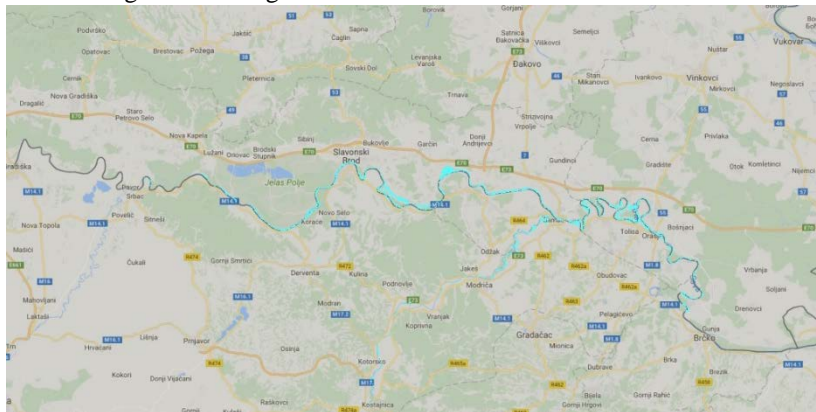


Figure 5. Classification before flood

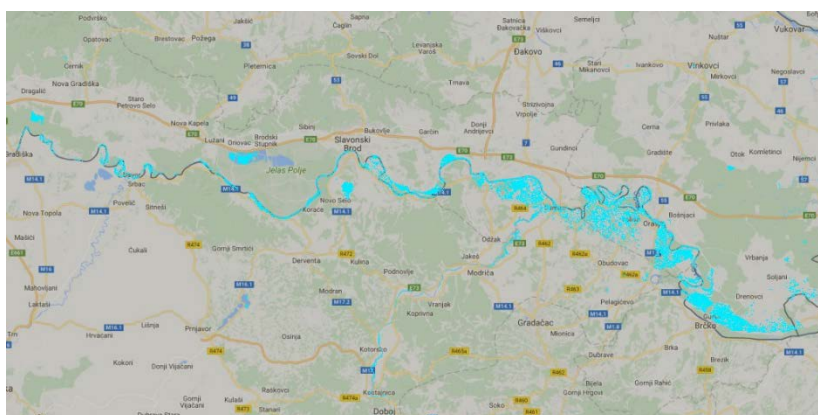


Figure 6. Classification after flood

In order to isolate areas that have been flooded, they used Land cover change option from SCP, which compares two images and produces third raster on which are shown areas where land cover changed. Figure 7 show the results, where red color represents flooded areas.

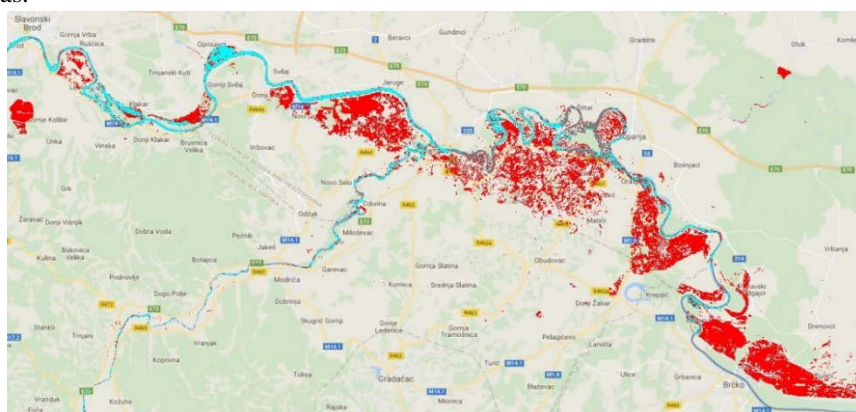


Figure 7. Flooded areas around river Sava in 2014.

4. CONCLUSION

There are 1 738 active satellites in the Earth's orbit from which 596 are used for Earth observation. Europe decided to send significant number of remote sensing satellites in space, and the data will be delivered free of charge. In combination with other platforms such as USGS platforms and volunteered geographic information such as OSM this will create new opportunities for the development in all fields.

In this paper we have introduced possibility of using open access data in Higher Education, in a way of promoting not just how to download and present such data, but also to promote simple way of how to process data, and how to do that with open source application. Also, we want to promote PBL as a way of standard way of learning in Higher education, especially with "geomatics" or let's say students that have touching points with geoinformatics area.

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