

The background of the cover is a composite of images. The top right shows a satellite in orbit with solar panels. The top left shows a satellite view of a green landmass. The bottom left shows a view of Earth from space with a bright orange and red horizon. The bottom right shows a close-up of a dark, textured surface, possibly a satellite component or a biological structure.

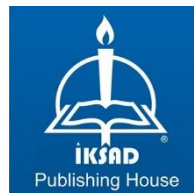
MASTERING OBJECT-BASED IMAGE ANALYSIS

Prof. Dr. A. Rasouli, Dr. M. Milani and Dr. B. Milani



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Mastering Object-Based Image Analysis

Imaging the Azerbaijan Geo-Environment

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Book Contents:	Pages
About The Authors:	1
Introduction: Object-Oriented Image Analysis Concepts	5
Section One: OBIA Basic Requirements	25
<i>Tutorial 1: Running the eCognition Trail Version 9.01</i>	27
<i>Tutorial 2: Picking Up the Landsat Imagery with eCognition</i>	45
<i>Tutorial 3: Practicing the eCognition Basic Structure</i>	67
<i>Tutorial 4: Illustrating Land Surfaces By Landsat Imagery</i>	89
<i>Tutorial 5: Landcover Spectral Indexing inside eCognition</i>	108
<i>Tutorial 6: Quick Look to the eCognition's OBIA Capabilities</i>	128
Section Two: Diving into the OBIA Advanced Skills	159
<i>Tutorial 1: Headlong Into The eCognition 9.5 with Sentinel-2</i>	159
<i>Tutorial 2: Taking a Plunge Inside eCognition 9.5</i>	183
<i>Tutorial 3: Examining The Image Segmentation Algorithms</i>	219
<i>Tutorial 4: Objective Image Classification Processes</i>	248
<i>Tutorial 5: Threshold Rule-Setting With eCognition</i>	275
<i>Tutorial 6: Introducing Change Detection with OBIA</i>	303

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About The Authors



Professor Dr. Aliakbar Rasouli is a geoscientist who accomplished his Ph.D. at Wollongong University in Australia. He had launched the most modern remote sensing real-time monitoring systems and digital weather observation devices at the University of Tabriz by teaching the principles of applied remote sensing and Geographic Information Systems. Later, he obtained an honorary fellow invitation from the Macquarie University, Environmental Sciences Department. Then, he completed a research fellow opportunely on severe thunderstorms monitoring and landcover changes in the New South Wales State and the Greater Sydney Metropolitan area. He has served as the author of numerous books, papers, and research focused on the practical training of advanced remote sensing, image processing, and geospatial information technology.

Over the past few years, Professor Rasouli has started a joint research and educational cooperation with the Azerbaijan National Academy of Sciences, the Institute of Geography. Such a thoughtful invitation led to a fruitful collaboration that resulted in the publication of several books, issuing various articles, presenting a few workshops, and lecturing in international conferences are among the latest scientific activities of Prof. Rasouli's up-to-date novelty Azerbaijan. Among his most important academic goals are the following:

- introducing the basic principles of a modern real-time satellite monitoring system and consequence digital image processing more ineffective manners,

- encouraging advanced image processing and Spatial Information Sciences (SIS) behaviors among young scholars through fast training programs in Azerbaijan.
- visualizing Azerbaijan's most recent hydro-climatic, agricultural, and landcover/landuse geo-environmental changes by applying a modern remote sensing technology.
- participation in the accurate identification of landcover/landuse changes in the liberated areas of Qarabag applying advanced remote sensing technologies and processing of satellite imagery utilizing Object-Based Image Analysis (OBIA) and Machin-Learning/Deep-Learning techniques.

**Assistant Professor Dr. Muhammed**

Milani was born in Iran, studied for a bachelor's and master's degree in computer engineering in Tehran, and completed his doctoral studies in Turkey. His interest in satellite imagery dates back to his undergraduate years. Then, during his postgraduate studies, he worked on several images, satellite image processing, and GIS projects. Muhammad is the author of VB programming and Automatic Generation and Solving of mathematical expressions books and currently lives in Turkey with his wife and daughter as an assistant professor.



Assistant Professor Dr. Bahar Milani

completed his bachelor's degree in mathematics in Iran. After several years of researches, she went to Turkey and completed her Ph.D. in Computer Engineering. After graduating, Bahar worked as an assistant professor at a Turkish university. Teaching and writing are among Bahar's hobbies. She has great enthusiasm for environmental research with computer sciences and artificial intelligence approaches, with some published papers in this regard.

An Introduction to OBIA Approach



OBIA overcomes the limitations of traditional image processing approaches

Basic Background

This book will familiarize you with the basics of Object-Base Image Analysis (OBIA), general aspects of uses, and an overview of their applications through the Republic of Azerbaijan countryside. In a simple view, OBIA is becoming the advanced primary image analysis and processing procedure. Furthermore, to understand the main concepts, you will experience your first glimpse of earlier version 9.01 of eCognition Software, rather than going into the new version's details too soon. Authors also recommend that new learners to OBIA start with theoretical and practical basics of pixel and objects fundamentals.

Essential of OBIA

Around 2000, GIS and image processing started to grow together rapidly through OBIA for geospatial object-based image analysis. Accordingly, significant advances have been

made in remote sensing in recent decades. Several factors seem to have simultaneously contributed to these remarkable successes, particularly in the field of satellite image processing. We paid the most attention to the category of knowledge creation procedures such as the OBIA field. The most feature of OBIA is directed to the object-oriented classification, which uses both spectral and spatial information for classification. The process involves the categorization of pixels based on their spectral characteristics, shape, texture, and spatial relationship with the surrounding pixels. To learn and apply OBIA approaches, new learners must pay attention to the other contributing variables associated with it, as a few important factors are presented in Figure 1.

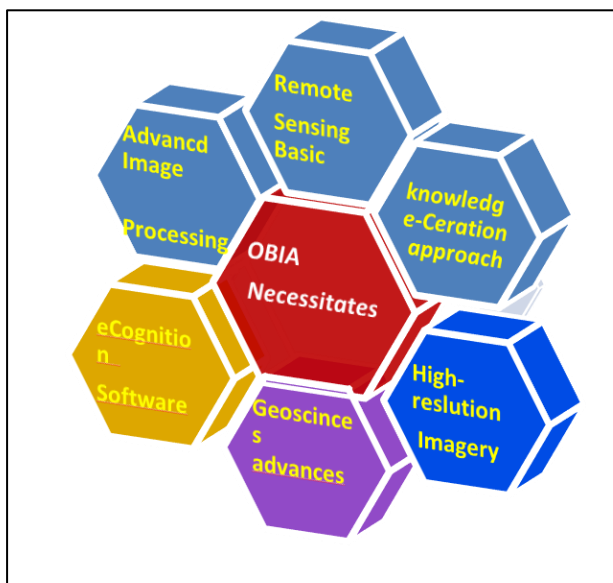


Figure 1. Controlling variables associated with OBIA

In practice, OBIA is one of several approaches developed to overcome the limitations of pixel-based approaches. It incorporates spectral, textural, and contextual information to identify thematic classes in an image. The first step in OBIA is to segment the image into homogeneous objects. The term object here stands for a contiguous cluster of pixels. Segmentation stands on pre-defined parameters like compactness, shape, and scale, derived from real-world knowledge of the features one wants to identify. For instance, crop mapping will require an understanding of the size and shape of farm fields in the area of interest. Over- and under-segmentation are obvious threats to these approaches, and they may not identify all semantically meaningful entities. Object-Based will generate segments by integrating similar pixels, and then segments will be assigned to landcover. In turn, Object-Based Classification is suitable for classification based on high-resolution satellite imagery.

Each object (segment) signifies the contained pixels' statistical properties in a second step. It means that all pixels within a segment are assigned to one class, eliminating the within-field spectral variability and mixed pixels problems associated with pixel-based approaches. Supervised and unsupervised classification is pixel-based. In other words, it creates square pixels, and each pixel has a class. But OBIA groups pixels into representative vector shapes with size and geometry.

In a simple view, OBIA segments an image by grouping pixels. It doesn't create single pixels. Instead, it generates objects with different geometries. If you have the right image, objects can be so meaningful that they digitize for you. For example, the segmentation process highlights buildings, roads, and water bodies. In OBIA based classification, you can employ different methods to classify objects, for example:

- ✓ **SHAPE:** If you want to classify buildings, you can use a shape statistic such as "rectangular fit that tests an object's geometry to the shape of a rectangle.
- ✓ **TEXTURE:** Texture is the homogeneity of an object. For case, water is mostly homogeneous because it's mostly dark blue. But forests have shadows and are a mix of green and black.
- ✓ **SPECTRAL:** You can utilize the mean value of spectral properties such as near-infrared, short-wave infrared, red, green, or blue band.
- ✓ **GEOGRAPHIC CONTEXT:** Objects have proximity and distance relationships between neighbors.

Think both Objects and Pixels

How amazing would it be if you could digitize all your features in an image with just a click of a button? On top of that, do you classify each feature with another click of a button? Sounds like magic? But these two processes are segmentation and classification performed in OBIA. Let's examine what it is and how you can use it to get your work done more efficiently and accurately. Human visual perception almost always outperforms computer vision algorithms. For example, your eyes know a river when it sees one. But a computer can't recognize rivers from lakes.

Traditional pixel-based image classification assigns a landcover class per pixel. All pixels are the same size, same shape, and don't have any concept of their neighbors. However, OBIA segments an image, grouping small pixels into vector objects. Instead of a per-pixel basis, segmentation automatically digitizes the image for you. OBIA segmentation is a process that groups similar pixels into objects. What segmentation does is replicate what your eyes are doing. But with these segmented objects, you use their spectral, geometrical, and spatial properties to classify them into land cover.

In turn, OBIA classification uses objects' shape, size, and spectral properties to classify each object. Otherwise, when using traditional image classification techniques, you often get a salt and pepper look in the classification result. To recap, the two basic principles of OBIA are:

- The layer arithmetic algorithms: use a pixel-based operation to merge up to four layers by mathematical operations. For example, you can apply the surface calculation algorithm to derive the slope for each pixel of a digital elevation model (DEM). It uses to determine whether an area within a landscape is flat or steep and is independent of the absolute height values.
- Index Layer Calculation algorithm that inserts a new image layer by calculating a spectral index. You may choose NDVI, NDWI, NDSI (soil), NDSnI (snow), NBR, SAVI, EVI, and GRV indexes.
- Segmentation that breaks the image up into objects representing land-based features. Segmentation algorithms subdivide entire images at a pixel level or specific image objects from other domains into smaller images. Trimble provides several different approaches to segmentation, ranging from very simple algorithms, such as chessboard and quadtree-based segmentation, to highly sophisticated methods

such as multiresolution segmentation and contrast filter segmentation. Segmentation algorithms are required to create new image object levels based on image layer information. But they are also a very valuable tool to refine existing image objects by subdividing them into smaller pieces for more detailed analysis.

- Classification algorithms analyze image objects according to defined criteria and assign them to a class that best meets them. You may evaluate the membership value of an image object against a list of selected classes. The classification result of the image object is updated according to the class evaluation result. The three best classes remain in the image object classification result.
- The RuleSet algorithms let you control certain settings for the rule set or parts of rule sets. For example, you may want to apply particular settings to analyze large objects and change them to analyze small objects. Because the settings are part of the ruleset and not on the client, they are when the rules are introduced.
- Deep learning, a subset of machine learning - utilizes artificial neural networks to analyze data. The approach and architectures were inspired by insights into the functioning of the nervous system and mimic human perception.
- Export algorithms let you can export the results in several vectors or raster formats. In addition, statistical information can be created or exported.

Many supplementary algorithms and operators could reach advanced applications inside the eCognition Developer 9.01 suits. During included tutorials, you will be familiar with many of them. But, here, two segmentation and classification algorithms are highlighted. When you segment an image, the process groups pixels to form objects; suddenly, landcover features start popping out, similar to how your eyes process your surroundings. Based on your compactness and shape settings, this is the preliminary step in OBIA. How big do you want the objects to be? There's a scale parameter that you can estimate to

generate more meaningful objects. Also, you can configure weights for all the layers you want to segment. It means that you only have to segment by red, green, or blue. Still, you can also segment a Digital Elevation Model (DEM), Digital Surface Model (DSM), Near Infra-Red (NIR), or even LiDAR imagery. After you segment the image, it's time to classify each object. You can now classify because each object has statistics associated with the others. For example, you can classify objects based on geometry, area, color, shape, texture, adjacency, and more. While options are not limiting, this is where the true power lies in eCognition Software. There are seemingly more practical examples in the following sections to recognize the eCognition powers.

Coping with eCognition Suits:

Trimble eCognition software, in different versions of 9.01, 9.5, 10.1.1, and recently 10.1.2), is based on a new, object-oriented approach to image analysis, used by remote sensing experts, data scientists, and GIS professionals. In contrast to traditional image processing methods, the basic processing units of object-oriented image analysis are image objects or segments and not single pixels. Even the classification acts on image objects. One motivation for the object-oriented approach is that the expected result of many image analysis tasks is the extraction of real-world objects, proper in shape and proper in classification. Common, pixel-based approaches cannot fulfill this expectation .

Although the eCognition 9.01 version is an earlier combination of different contributing procedures, some basic characteristic aspects of the underlying object-oriented approach are independent of the particular methods. The networking of these image objects is directly connected to the representation of image information utilizing objects. Whereas the raster models give the topological relation of single, adjacent pixels. Learners must explicitly work out the association of adjacent image objects to address neighbor objects. Consequently, the resulting topological network has a big advantage as it allows the efficient propagation of many different kinds of relational information. Inside eCognition, users can design feature extraction solutions to transform geo-data into geo-information with many possibilities as:

- eCognition makes a fundamentally different approach from usual approaches to data analysis due to its ability to emulate the human mind's cognitive powers and fuse geospatial input data .
- In terms of segmentation and classification processes, it can develop a robust method of rendering knowledge in a semantic network. The technology examines pixels/ points, not in isolation but context. It builds up a picture iteratively, recognizing groups of pixels as objects.
- Like the human mind, it uses objects' color, shape, texture, size, and context, and relationships to draw the same conclusions and inferences as an experienced analyst. Still, it adds the advantages of automation and standardization .
- eCognition classifies and analyzes imagery, vectors, and point clouds using all the semantic information required to interpret it correctly. Rather than examining stand-alone pixels or points, it distills meaning from the objects' connotations and mutual relationships, not only with neighboring objects but throughout various input data.

- The eCognition software fuse various geospatial data, such as spectral raster data, 3D point cloud data, and thematic data .
- You could convert satellite images to point clouds, vectors to images, and all three to one another. Users can leverage the full power of their input data independent of data type and source.
- Trimble eCognition is an advanced analysis software for geospatial applications. It is designed to improve, accelerate, and automate the interpretation of various geospatial data. It enables users to design feature extraction of change detection solutions to transform geo-data into geo-information.
- The eCognition suite offers three components: eCognition Developer, eCognition Server, and eCognition Architect, which can be used stand-alone or in combination to solve even the most challenging image analysis tasks. In the following sections, you will work with trial versions of eCognition functions that have a much more powerful development environment for object-based image analysis .

OBIA inside eCognition Developer:

The human mind has a remarkable ability to make sense of images, identify objects, and extract insights. It handles ambiguous or partial information by making inferences based on the image as a whole, the relationship between objects, and external and contextual information. Attempts to computerize this capacity for image analysis have been going on for decades. But despite increases in computational power and imaging capabilities, advances in automated image analysis have been limited.

The root of the problem is that computers examine images on a pixel-by-pixel basis. Along those lines, "objects of interest" can be identified by using a series of pixel-based filters. These filters, such as intensity thresholds and gradients, distinguish

patterns by comparing pixels to their neighbors. For an effective analysis, the original image transforms so that simple threshold measures can extract the areas of interest.

Identifying and analyzing objects using Cognition technology is an iterative one. While identifying and measuring "objects of interest," users can test, refine and fine-tune their analyses at any point in the workflow. This approach dramatically reduces the time needed to arrive at results and makes it easier and more intuitive to create and validate new applications that explore fresh avenues of investigation. We may Identify the basic OBIA functionality (Figure 2).

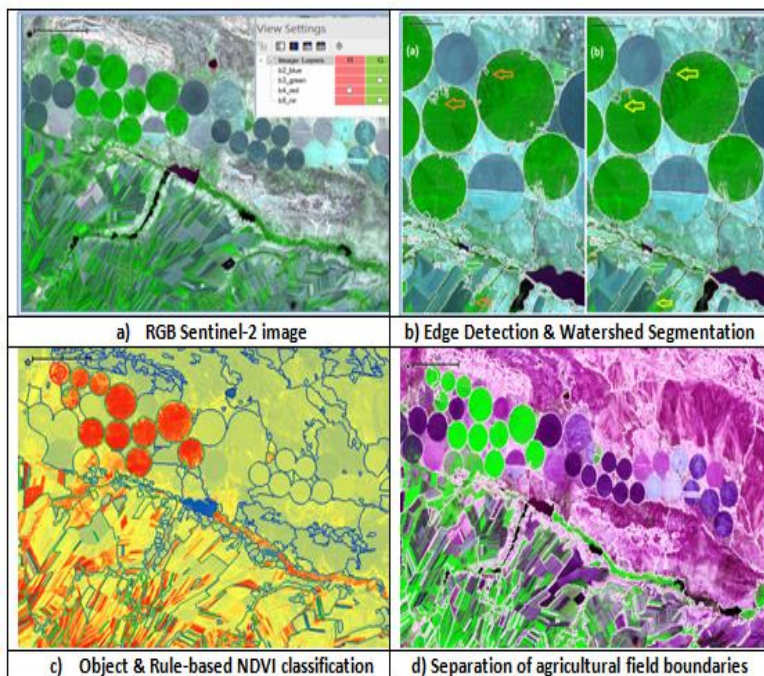


Figure 2. An example of a Sentinel-2 satellite image processing according to the OBIA concept.

- ✚ Figure 2-a): shows part of a Sentinel-2 satellite image of an agricultural part. It is a trivial exercise for a person to identify the green fields, but it is surprisingly difficult for a computer.
- ✚ Figure 2-b): by applying the eCognition technology, it is possible to identify greenish parts by searching for green pixels. However, not all blue pixels indicate farms - there may be individual green pixels in the middle of a field. Therefore, eCognition aggregates green pixels into clusters and identifies only those clusters as bodies of farms that are sufficiently detected and then delineated.
- ✚ Figure 2-c): separating green farms from non-green farms demands a different segmentation process for instant watershed segmentation. It requires the understanding that traditional agriculture farms are long and thin while modern farms are generally round.
- ✚ Figure 2-c): by translating these insights into a set of rules and parameters, a rule-based OBIA approach can distinguish the different forms of farms.

The most advanced process is that the technology can measure the size of agricultural farms and compare the results to images of the same region at a previous time, accurately quantifying any changes. The Cognition software allows users to easily identify objects of interest and automate image analysis tasks with high accuracy. Since the technology works for all modalities, images from different sources can be compared, facilitating maximum insight and applications extracted from image data.

Starting an eCognition Project:

Experience has proven that careful attention to several important factors in understanding and using eCognition Software has been very helpful. Based on the author's practical experience, the items listed in Table 1 are very effective factors in fast training programs limited to the eCognition Developer suit.

Table 1. Basic processing steps and experiences of OBIA inside the eCognition Software

Step	Basic Processing Activity	Experiences
1	Outline the research aim (s)	Define an understandable research problem.
2	Limit the study area to a small part	Subset a relatively small geographic area.
3	Download the satellite imagery	Provide high-resolution satellite imagery (Landsat & Sentinel series).
4	Open the eCognition Software	Start with eCognition Developer different versions (9.01) to get basic skills.
5	Create a project inside eCognition	Save and evaluate the project as it changes.
6	Combine image layers	Create an RGB combination image with a few bands.
7	Try to segment the image based on the correct scale, shape, and other relevant factors.	The segmentation process should to based on other researchers and your experiences.
8	Define the landcover & landuse classes	Do not label a lot of classes.
9	Extract statistics of bands and classes	Feature statistics layers result in the better recognition of the training areas.
10	Classify the segmented image based on a (un) supervised or ruleset classifies	Any ruleset is a key to achieving an accurate automated image classification process.
11	Assess the classification accuracy	Calculate the User's, Producers, and Overall accuracy.
12	Export the results to a GIS setting	You could export all classified classes and feature statistics to ArcMap for further analysis.
13	Create personal geo-Informative datasets	It will help you keep geo-datasets for the change detection procedure.
14	Reanalysis datasets and create final models to address the research aims	Verify the final modes by comparing them with real land facts.

The basic steps of running eCognition Software are schematically shown in Figure 3 to achieve the goals of the OBIA application in the information process.

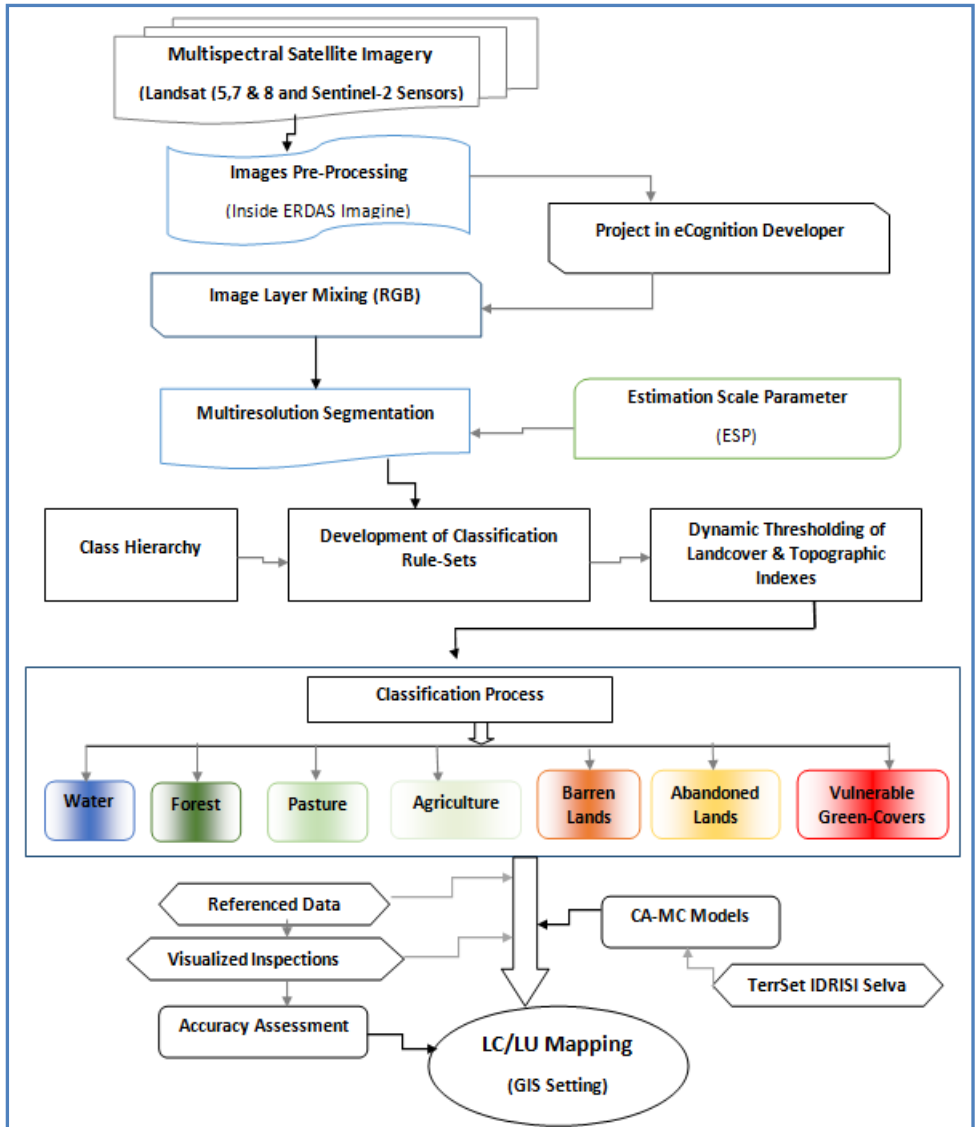


Figure 3. An example of basic OBIA process inside the eCognition Software

OBIA Applications:

Changes in landcover and landuse are pervasive, rapid and can significantly impact humans, the economy, and the environment. Accurate landcover mapping is of paramount importance in many applications, e.g., biodiversity conservation, urban planning, forestry, natural hazards, etc. Unfortunately, traditional landcover mapping processes are often inaccurate, costly, and time-consuming. A classification for an image - in one geographic location- cannot be directly applied to a different image on a different site.

In practice, land cover maps are built-up by analyzing remotely sensed imagery captured by satellites, airplanes, or drones, using different classification methods. The accuracy of the results depends on the quality of the input data (mainly based on the spatial, spectral, and radiometric resolution of the images) and on the used classification method. The most commonly used methods could be divided into pixel-based classifiers and OBIA. Pixel-based methods use only the spectral information available for each pixel. They are faster but ineffective in some cases, particularly for high-resolution images and heterogeneous objects detection. Object-based methods consider image segments' spectral and spatial properties (i.e., set of similar neighbor pixels). They are faster but ineffective, particularly for high-resolution images and heterogeneous object detection. Object-based methods consider image segments' spectral and spatial properties (i.e., set of similar neighbor pixels). The most

commonly used Software implementing OBIA-methods is the privative eCognition Developer, which provides a friendly graphical user interface for non-programmers. There exist several free and open-source OBIA-software, but they are less popular. There is a growing demand for accurate high-resolution land cover maps in many fields, e.g., land use planning and biodiversity conservation, particularly in geography and environmental research. Developing such maps has been traditionally performed using OBIA and GEOBIA methods, which usually reach good accuracies but require high human supervision.

Targeting Geo-Environmental Problems:

The Republic of Azerbaijan is situated in the Caucasus region of Eurasia, as three major physical features dominate it: the Caspian Sea, whose shoreline forms a natural boundary to the east; the Greater Caucasus mountain range to the north; and the extensive flatlands at the country's center. The elevation changes over a relatively short distance from lowlands to highlands; nearly half the country is mountainous. The climate of Azerbaijan varies from subtropical humid in the southeast to subtropical and dry in the central and eastern parts of the country. At a simple glance, the country can be divided into the recognized ecosystem complexes, all of which contribute to the large diversity of this wonderful country's forests, high mountains, scrublands, steppes, semi-deserts, wetlands, and coastal ecosystems (Figure 4).

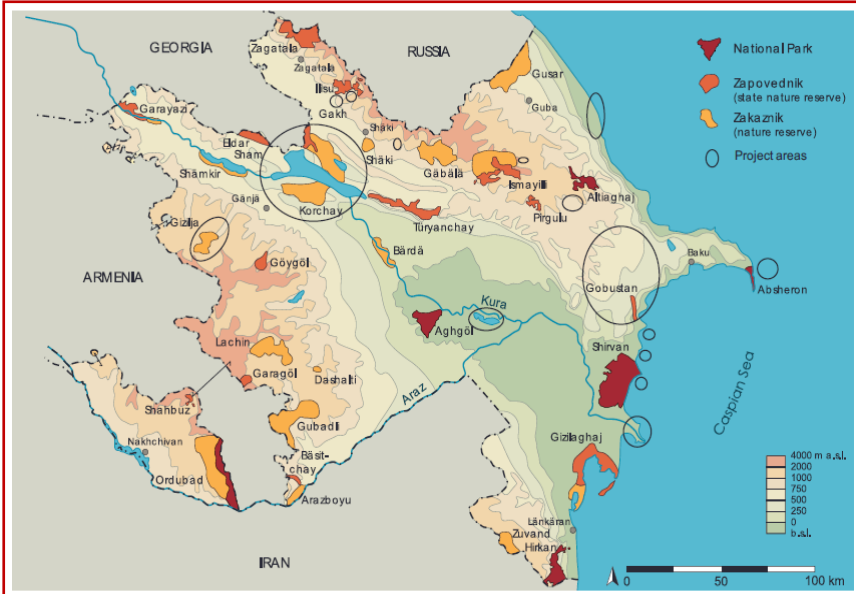


Figure 4. A general map for the protected areas in Azerbaijan

We purposely applied the OBIA's different image processing functions to recognize the geospatial features of Azerbaijan. Over time, Azerbaijan has had incredible natural resources unique to this part of the world, including its National Parks and State Reserves. Meanwhile, some parts of the country face serious environmental failures, such as air and water pollution and subtle changes due to the notable fluctuations in the Caspian Sea. Furthermore, other natural hazards such as droughts, floods, and bushfires may occasionally endanger the country's natural resources. For instance, local scientists consider the Apsheron Peninsula, including Baku and Sumqayit cities, and the Caspian Sea costliness to be the ecologically most

devastated area in the region because of severe air and water and soil pollutions. The occupied Qarabagh rich florae, fauna, and enormous natural resources have been in great confrontation due to occupation force action.

Sum Up:

Many OBIA users have been working intensively on geographic and environmental topics; most users run eCognition applications for "green, environmental and climate changes purposes." No doubt, there are thousands of different applications for those image analysis software. Authors convince that this is directly related to images' massive power. The conventional wisdom that "one image is worth a thousand words" fully applies to human understanding of environmental issues. Every eCognition user in the geosciences and environmental community has a story to tell. Some of these stories will help us better understand how far the situation has progressed.

We are sure that you don't want to stop here in the current introduction. You will try to find out what eCognition Software does (even having different progressive versions) is provide you with a detailed representation of all objects and their inter-relationships within the diverse satellite images. With this cognition developer, we can recognize and measure practically everything contained in an image – and do so across very large areas and over long periods. In short, the thousands of minuscule facts documented in an image are now becoming

available in a standardized way, including the following advantages:

- ❖ An object-oriented approach is better to reach practical knowledge on geographic and environmental behaviors.
- ❖ OBIA - and in specific geographic cases, GEOBIA - has to be integrated as a "particular vision" in the higher-education teaching programs.
- ❖ It is now possible to import external, pre-trained advanced models into eCognition. Deep Learning users can save time in the workflows' sample generation, model creation, and training phases.
- ❖ eCognition has added new tools to improve surface calculations and analysis. It is now possible to generate hill-shade layers based on DSM and DTM inputs. In addition, a Ridge Filter algorithm improves the extraction of ridge-like features in images and elevation data.
- ❖ The majority vote functionality is supported by the last eCognition versions, which increases the contextual relationship between image objects to make classification easier.
- ❖ The important point is that eCognition continues to improve its free trial versions. It makes access easier for new learners to utilize the last OBIA advantages.
- ❖ As a final point, eCognition Software should view as an advanced knowledge creation high-technology, an inevitable requirement for future Azerbaijan geo-environment research investigations.

Informative Practices

Tips:

- 1) Trimble eCognition enables you to accelerate and automate the interpretation of your geospatial data products by allowing you to design your feature extraction and change detection solutions.
- 2) You can learn about the technology that drives eCognition as a market leader in feature extraction.
- 3) The eCognition Software is used by professionals, remote sensing experts, and data scientists to automate geospatial data analytics.

Workouts:

- 1) Summarize the basic processing steps of the eCognition Software.
- 2) List the possible applications of OBIA in your research area.
- 3) List the eCognition suite of the different main components.

Quizzes:

- 1) What does an OBJECT mean?
- 2) What are the similarities and differences between OBIA and GEOBIA approaches?
- 3) What are the basic goals of the OBIA?

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The OBIA Approach Basic Requirements



a progressive OBIA needs a well-designed platform

Basic Concepts:

The current book prepares so that interested beginner, intermediate, and even advanced trainees, with introductory knowledge of image processing concepts and fewer software skills, could be familiar with the basic concepts of OBIA working in eCognition software 9.01 setting. Accordingly, we will train students to access and install the eCognition Developer 9.01 on their computers during the first section. They will learn to access, download, manage, and display the Landsat 4, 5, 7, and 8 imagery through simple steps from recognized international websites.

We expect students to, with access to acceptable standard satellite imagery and basic familiarity with eCognition software, it will be possible to practice with OBIA primary concepts. At the same time, one of the main goals of this section of the book is to teach how to extract applied information from raw satellite

images in the Republic of Azerbaijan geo-environment context. Due to the educational nature of the content provided, you may encounter duplicate content and work with similar data sets. Trainees have to try to understand the basic concepts of OBIA and the structural capabilities of the eCognition Developer settings during the first section. Nevertheless, we expect interested apprentices to achieve their desired educational and research goals with great perseverance before starting the lectures of "Section Two" with more evolved goals.

Tutorial 1

Running the eCognition Trail Version 9.01



any eCognition includes a range of new features and rule sets.

Opening Statement:

In the current tutorial, you will learn how to access and install the eCognition Developer 9.01 trial version, a powerful development environment for Object-Based Image Analysis (OBIA). eCognition 9.01 extends the existing knowledge-based and supervised classification methods available for geospatial applications. It is extensively used in earth sciences to develop rule sets for advanced remote sensing data analysis. In addition, you will have the first experience of importing Landsat-4 satellite MSS bands, subsetted for the small part of the Azerbaijan, Qarabag region, into the eCognition software environment.

Instructive Memo:

- ✓ *Level:* Beginner,
- ✓ *Time:* This tutorial should not take you more than 1 hour.
- ✓ *Data:* Landsat-4_19780713_T2.tar.gz,
- ✓ *Software:* eCognition Developer, Version 9.01,

✓ *Satellite Sence*: Part of the Qarabag region,
By the end of this unit, you should be familiar with:

- ✚ Free sources of the eCognition software.
- ✚ Install and set up the software.
- ✚ Start and run the eCognition Trail version.
- ✚ Import Landsat-4 bands to eCognition setting.

Background Concepts:

The eCognition software operates for all common image processing tasks such as vegetation mapping, feature extraction, change detection, and object recognition. The object-based approach facilitates analysis of all common data sources, such as medium to high-resolution satellite data, high to very high-resolution aerial photography, lidar, radar, and even hyperspectral data. In this tutorial, we experience the Landsat 1-4 satellites with the optimal ground resolution (60 meters) and fewer spectral bands (4 bands). However, they could be processed to track landcover efficiently and document land changes due to climate change, urbanization, drought, wildfire, vegetation changes, and a host of other natural and human-caused changes. You may use this version of eCognition to highlight the benefits of the most antiquated Landsat imagery of the Qarabag region; many years ago, military actions did not damage the region's lush forests during the long-drawn fights. You can download eCognition Developer 9.01 from different software libraries for free, as the Trimble GeoSpatial created the most popular program.

Mastering The Skills:

To learn the OBIA approaches, you need to install the Cognition Developer 9.01x64 on your personal computer. First launched in May 2000, eCognition introduced the more advanced method for extracting information from images using a hierarchy of image objects (groups of pixels) instead of traditional pixel processing methods. To practice the eCognition software, you need to undertake the following:

Step 1) Accessing the Free eCognition 9.01

1.1) Download the eCognition Developer version 9.01, one of the sites as listed follows:

- a) <https://en.freedownloadmanager.org/Windows-PC/eCognition-Developer.html>
- b) <http://edutechsoft.blogspot.com/2018/12/ecognition-developer-901-full-crack.html>
- c) https://mega.nz/file/54EgCKSB#Td_M2cQLwfTxjHEQbgkpxVfpitOneW1wqchGLJYAMsg

1.2) Make a backup from the zipped file inside a particular folder.

1.3) Unzip and extract and install the software with 'set license later.

Step 2) Installation of eCognition 9.01

2.1) First, run Setup.exe unzipped file inside the back-upped folder (Figure 1).

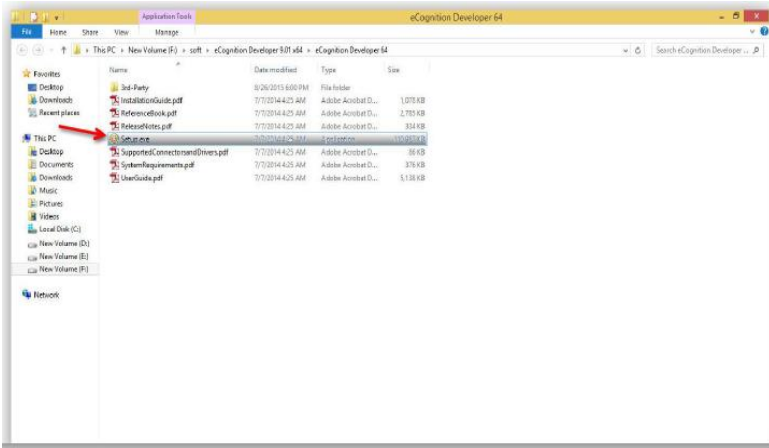


Figure 1: Running Setup.exe file

2.2) When the Welcome to the eCognition Developer 64 9.0 Setup Wizard comes up, click on the Next button (Figure 2).



Figure 2: eCognition Developer 64 9.0 Setup Wizard

2.3) Inside the License Agreement Window, click on the "I accept the terms of License Agreement and then get on the Next option (Figure 3).

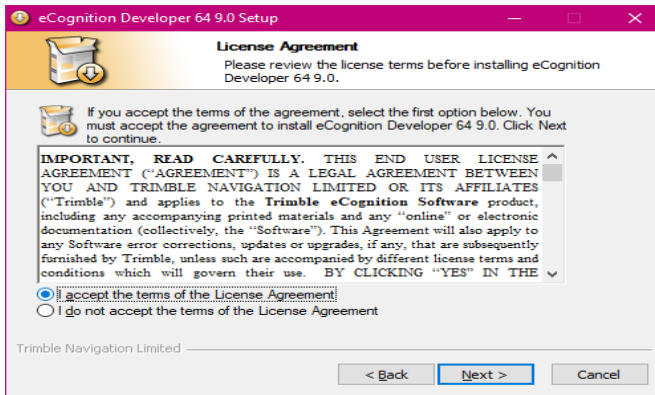


Figure 3: the License Agreement Window

2.4) Select the eCognition Licensing Option that comes up, select the Set Licensing Later option, and click on the Next button (Figure 4).

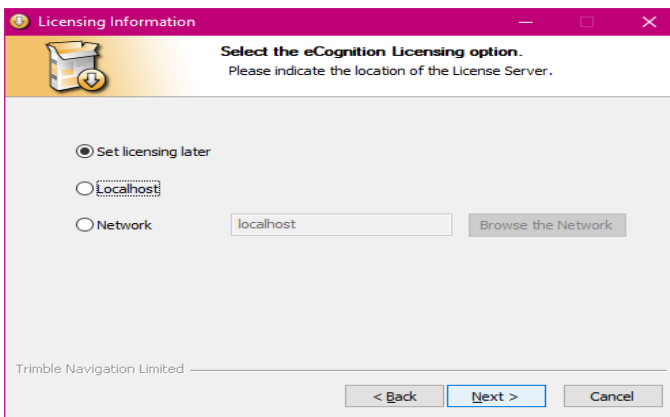


Figure 4: Choosing the Set Licensing Later

2.5) Inside the Choose Components, accept all options and click on the Next button (Figure 5).

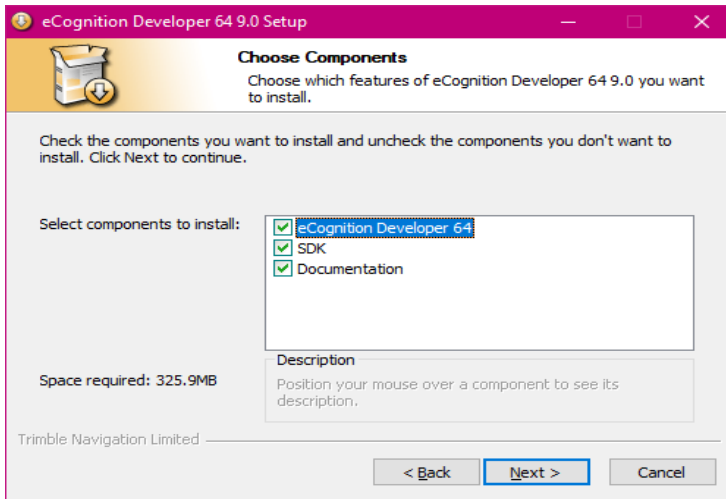


Figure 5: the Choose Components dialog box

2.6) When you notice the Choose Start Menu Folder, click on the Next option (Figure 6).

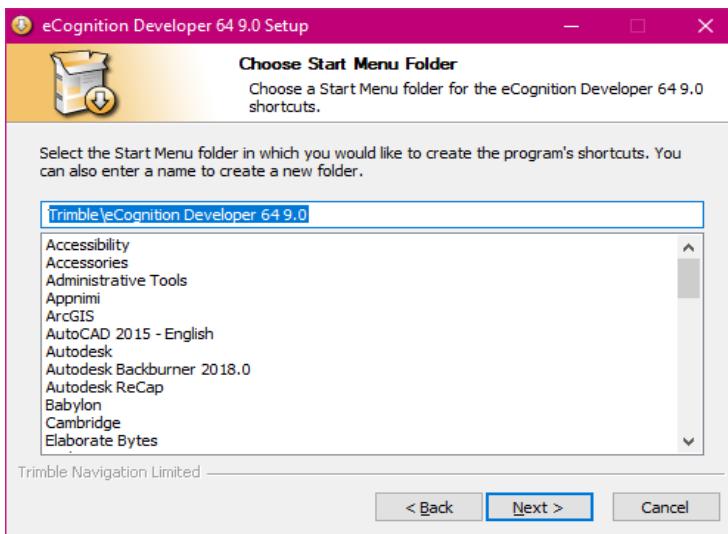


Figure 6: the Choose Start Menu Folder

2.7) In the Choose Install Location dialog box, accept the default path for the installation process (Figure 7).

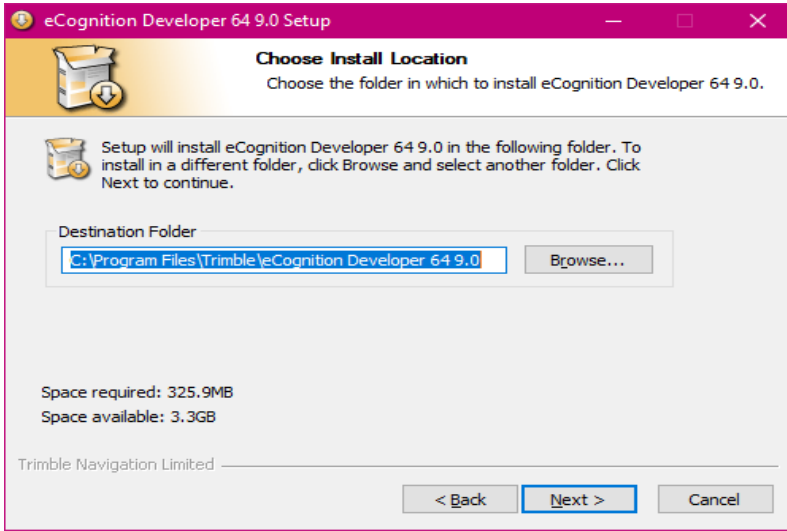


Figure 7: the Choose Install Location dialog box

2.8) When the "Installation is Configured Successfully" dialog box comes up, click on the Install option (Figure 8).

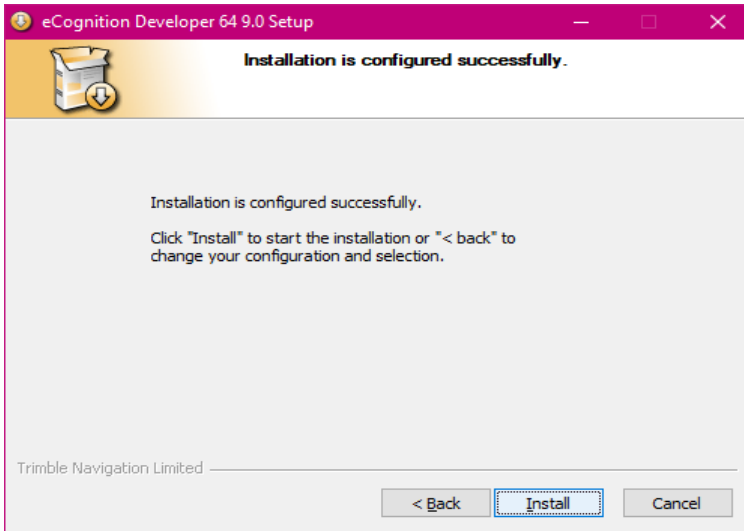


Figure 8: the Installation is Configured Successfully dialog box

2.9) eCognition software Installation state (Figure 9).

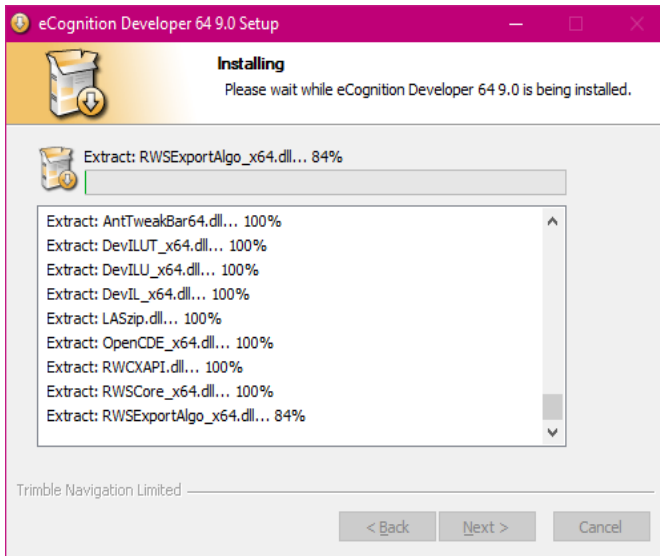


Figure 9: eCognition Installation state

2.10) When you notice the Installation complete dialog box, click on the Next button (Figure 10).

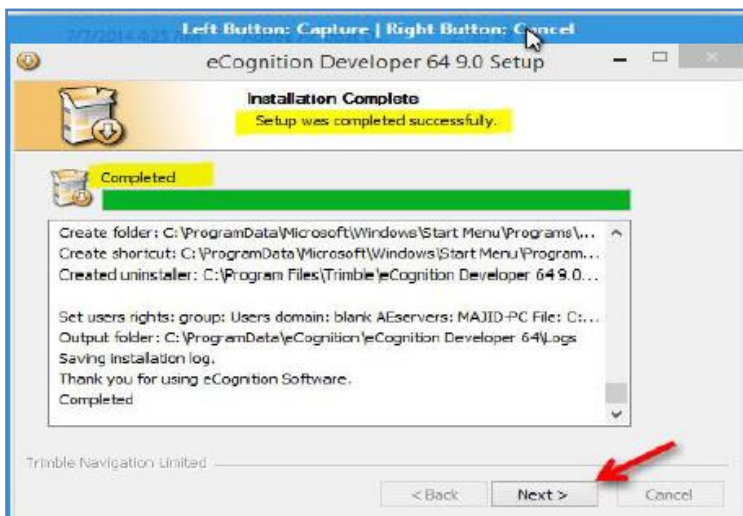


Figure 10: the Installation complete dialog box

2.11) When the Completing the eCognition Developer 64 9.0 Setup Wizard appears, click on the Finish button (Figure 11).



Figure 11: Completing the eCognition Developer 64 9.0 Setup Wizard

2.12) Open the patch\Program Files\Trimble\eCognition Developer 64 9.0\bin path.

2.13) Copy the listed files in Figure 12.

Name	Date modified	Type
lic	6/23/2016 2:38 AM	File folder
plugins	6/23/2016 2:38 AM	File folder
DIAClient	7/6/2014 5:19 PM	Application
DIAEngineService	7/6/2014 5:19 PM	Application
DIAImageProxy	7/6/2014 5:19 PM	Application
DIAJobScheduler	7/6/2014 5:19 PM	Application
Engine.dll	7/6/2014 5:19 PM	Application
ProdCnfg.dll	7/6/2014 5:19 PM	Application

Figure 12: The files to be copied to your system

2.14) Then all files have to be copy-pasted in the below path
 C:\Program Files\Trimble\eCognition Developer 64 9.0\bin.

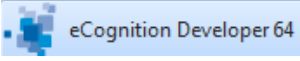
2.15) In the end, double-click on the  shortcut that runs the software based on your chooses (Figure 13).



Figure 13: The eCognition Developer start dialog box

2.16) Now, you can select one of the options to start the eCognition software. In this step, use the Quick Map Mode to notice the eCognition main window (Figure 14).

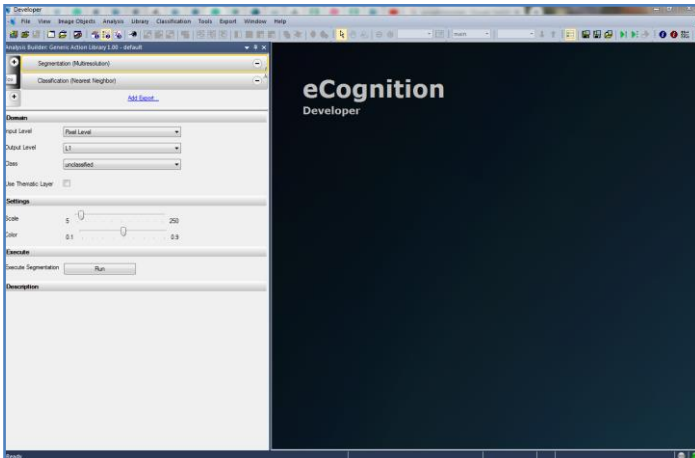


Figure 14: the eCognition software the main window, in the Quick Map Mode


2.17) Then, try to create the image of the Qarabagh area in the eCognition software by combining the Landsat 4 MSS bands, which you have already prepared from GLOVIS <https://glovis.usgs.gov/app> site. How to access the satellite imagery will be covered in later tutorials.

2.18) Landsat 4 is the fourth satellite of the Landsat program. It launched on July 16, 1982, with the primary goal of providing a global archive of satellite imagery.

Landsat 4 carried the Multispectral Scanner (MSS) with four spectral bands:

- Band 4 Visible (0.5 to 0.6 μm)
- Band 5 Visible (0.6 to 0.7 μm)
- Band 6 Near-Infrared (0.7 to 0.8 μm)
- Band 7 Near-Infrared (0.8 to 1.1 μm)

Step 3: Create a Project

3.1) You can create a project to display the Landsat 4 raster bands inside the eCognition software. Select File>NewProject on the main menu bar or click the button  in the toolbar.

3.2) Navigate and open the folder of the Landsat bands directory. When you notice the Import Image Layers dialog box, select the bands of 4 to 7 and click on the OK option (Figure 15).

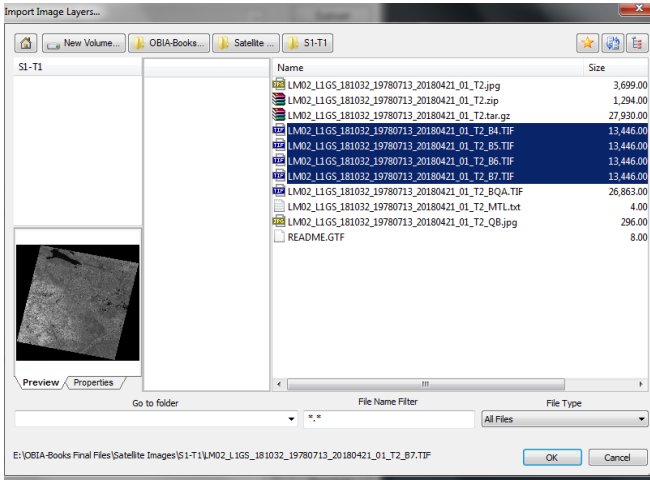


Figure 15: The Import Image Layers dialog box

3.3) Your project opens, and the image should be viewable in the Create Project window (Figure 16).

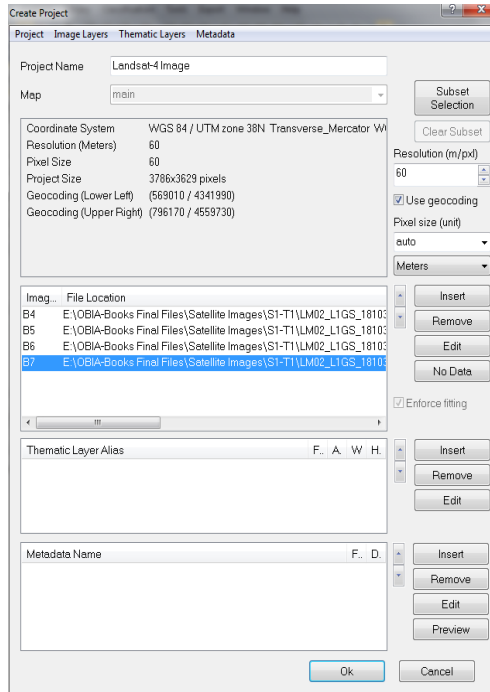


Figure 16: The Create Project window

3.4) Rename the image layers (channels) to make later references to them easier. Double-click on the band names, and when you notice the Layer Properties dialog box, rename the bands and click on the OK option (Figure 17).

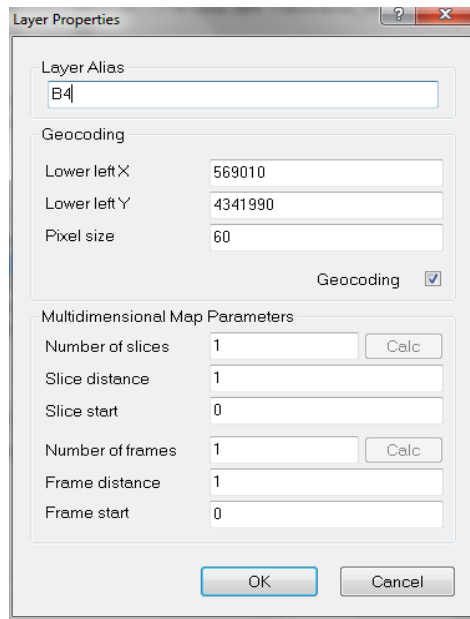


Figure 17: The Layer Properties dialog box

3.5) You should not forget to click on the Subset Selection option and select a small part of the whole image, where you prefer.

3.6) Then, inside the Create Project window, click on the OK option; this will produce your Landsat 4 image of the Qaradagh region (Figure 18).

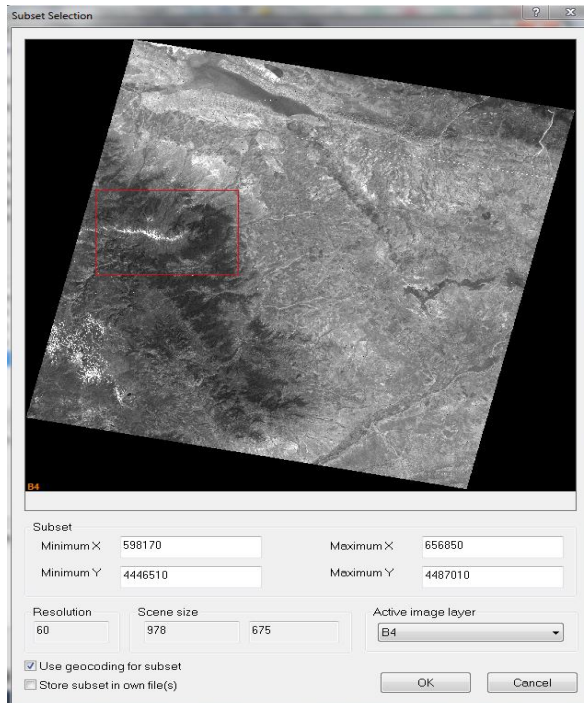



Figure 18: The Subset Selection option and selecting a small part of the image

3.7) Do not forget to select the Use Geocoding for Subset option and click on the OK option. Soon, you will illustrate the Landsat 4 image in natural false-color mode.

3.8) Change the Color Composition of the displayed image. Changing the color composition of the displayed image is rather easy and is done by using the following steps.

3.8.1) Select Image Layer Mixing from the View menu or click the "Edit Image Layer Mixing" button  on the View Settings toolbar (Figure 19).

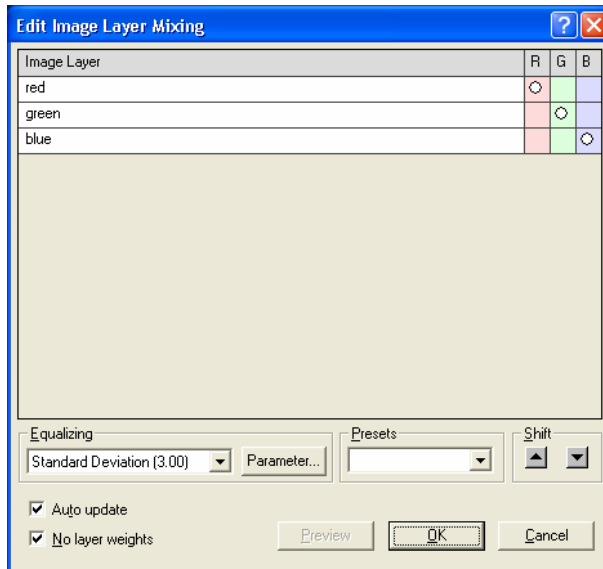


Figure 19: The "Edit Image Layer Mixing" dialog box

3.8.2) Select Standard Deviation (3.00) under Equalizing to apply a histogram stretch. By default, the first three channels are loaded with the first channel assigned to the red color gun of the monitor, followed by green and then blue, respective of the next two channels.

3.8.3) Selecting one layer grey under Presets allows a user to view one channel at a time. It can provide an excellent chance to review the channel data. Before proceeding to the next step, ensure that the three-channel options listed in #3 above are set.

3.8.4) Click OK. Soon, you will illustrate the Landsat 4 image in natural false-color mode (Figure 20).



Figure 20: The Landsat 4 MSS image subsetting image, a small part of Qarabag is illustrated in natural false-color mode

Sum Up:

eCognition 9.01 is a comprehensive image analysis platform for multi-dimensional OBIA procedures. It contains all the client and server software needed to extract information from any satellite image, for example, the Landsat 4, in a fully-automated or semi-automated way with the following advantages:

- eCognition software enables users to design feature extraction or change detection solutions to transform geospatial data into geo-information.
- You can import various geospatial data in eCognition, fusing them into a rich stack of geo-data for the analysis.
- The eCognition technology examines image pixels, not in isolation but context.

- The sensors on each of the Landsat satellite acquire data in different ranges of frequencies along the electromagnetic spectrum.

Informative Practices

Tips:

- 1) eCognition 9.01 was designed to improve, accelerate and automate the interpretation of various geospatial data.
- 2) Inside this version of eCognition, you can build analysis logic structures into a series of steps to create a computer-based representation of an expert's geospatial interpretation process, a so-called "ruleset."
- 3) Landsat's space-based land imaging is essential because it provides repetitive and synoptic observations of the Earth otherwise unavailable to researchers and managers who work across wide geographical areas and applications.

Workouts:

- 1) Try to access the free trial of eCognition available via the (<http://www.ecognition.com> website).
- 2) When installing the eCognition software, open the eCognition Developer version 9.01 in a ruleset mode. Go to file> Load Image File in the main menu.
- 3) Download the Landsat images for 1996 and 2016 and compare them with the Landsat data (1976) you worked on in this tutorial. Try to interpret the existing changes, particularly on vegetation cover.

Quizzes:

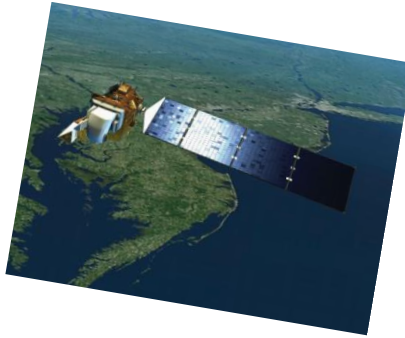
- 1) What are the differences between eCognition Trial and full-version modes?
- 2) How does the "software" work?
- 3) Are you familiar with earlier Landsat 4 applications?

Allied References:

- 1) Anuta, P. E., Bartolucci, L. A., Dean, M. E., Valdes, J. A., and Valenzuela, C. R. (1984). Landsat-4 MSS and Thematic Mapper design quality and information content analysis: ZEEE Transactions on Geoscience and Remote Sensing, v. GE-22, no. 3, pp. 222-236.
- 2) Benz, U. C.; Hofmann, P.; Willhauck, G.; Lingenfelder, I.; Heynen, M. (2004). "Multi-resolution, object-oriented fuzzy analysis of remote sensing data for GIS-ready information". ISPRS Journal of Photogrammetry and Remote Sensing. 58 (3): 239–258.
- 3) Castilla, G., & Hay, G. J. (2008). Image objects and geographic objects. In: Object-based image analysis. Springer Berlin Heidelberg. pp. 91-110.
- 4) DeGloria, S. D. (1984). Spectral variability of Landsat-4 Thematic Mapper and Multispectral Scanner data for selected crop and forest cover types: IEEE Transactions on Geoscience and Remote Sensing, v. GE-22, no. 3, pp. 308-311.
- 5) eCognition Developer (2014). Trimble Germany GmbH, Arnulfstrasse 126, 80636 Munich, Germany. All rights reserved.
- 6) Rasouli, A.A. and H. Mahmoudzadeh (2010). Fundamental of Knowledge-Based Remote Sensing. ElmIran Press, Tabriz, Iran.

Tutorial 2

Picking Up The Landsat Imagery With eCognition



Landsat a right gate to pick up the satellite imagery

Opening Statement:

This tutorial will explore picking up the most valuable remote sensing sources available in the eCognition setting. To access stored Landsat resources from previous years and learn how to use one of the most popular data sources, the Global Visualization Viewer (Glovis). Doing an applicable practice, you will try to access the Landsat-5 imagery of the Shirvan National Park in the Republic of Azerbaijan and prepare them for use in an eCognition setting. The Landsat Collection 1 Level-1 has the highest available data quality and, it is important for change detection applications during the wet and dry months of the year.

Instructive Memo:

- ✓ *Level:* Beginner,
- ✓ *Time:* This tutorial should not take you more than 1 hour.
- ✓ *Software:* eCognition Developer, Version 9.01,

- ✓ *Data:* Landsat-5 Imagery: *LT05_166033_19860413*, and *LT05_167032_19860826*,
- ✓ *Subject Scene:* The Shirvan National Park, Azerbaijan.

Tutor Objectives:

By the end of this unit, you should be:

- ✚ Navigate the Glovis interface and successfully download Landsat-5 imagery.
- ✚ Explore some of the additional information on the Landsat-5 data products.
- ✚ Learn how to prepare Landsat-5 Imagery in the eCognition setting.
- ✚ Explore the landcover changes in the wet and dry months based on the Landsat images.

Background Concepts:

Landsat satellites provide the longest-running temporal observation of the Earth's surface. Since active satellite datasets are constantly expanding, most data sources let you filter the available imagery by your desired attributes to help you find the appropriate imagery for your application. For example, you may only be interested in a cloud-free Landsat 5 image from the wet and dry months of 1986—most data sources allow you to detect changes inside and around a protected area with unique vegetation for rare animals.

Several websites and repositories on the internet allow you to download remote sensing data products free of charge. Many sites include datasets from multiple satellites and sensors in one location. Glovis stands for the Global Visualization Viewer. Since 2001, it has been a tool for accessing remote sensing data. During this tutorial, you can take your data from Glovis, which includes data from Landsat, Sentinel, and many other missions.

Mastering the Skills:

As you continue to work with satellite data and become more accustomed to the sources available to you, you will notice subtle differences between them. These small differences often make one data source more advantageous for your particular application over the other.

Step 1: Downloading Landsat-5 Imagery

The United States Geological Service (USGS) Glovis site is perhaps the most comprehensive data portal. The Glovis is used to query, search, and order remotely sensed datasets, many offered globally. Alongside Landsat images, data is available, ASTER, and Sentinel-2, among others. The Glovis ordering page allows you to enter Landsat scene lists to see which are currently available for download, which ones need to be processed, and the unavailable ones.

1.1) Register for USGS (<https://glovis.usgs.gov>) to download data files from certain USGS sites; you need to register for a free account.

1.2) After registering, login with your username and password. Then "LANCH GLOVIS IN FULL-SCREEN MODE".

1.3) To view data from Landsat 5, choose "Choose Your Data Set(s)> Landsat 5 Level-1 from Menu.

1.4) Enter Path/Row numbers. For example, path 166 and row 33 are for the western coast of the Caspian Sea (Figure 1).

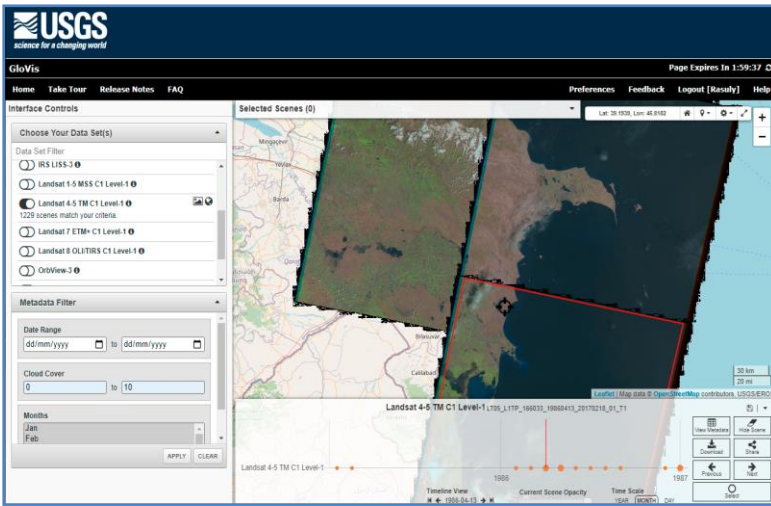


Figure 1: USGS the main entrance box

1.5) To manage the Landsat 5 data, you may wish to filter Date Range, Cloud Cover, and Months (Figure 2).

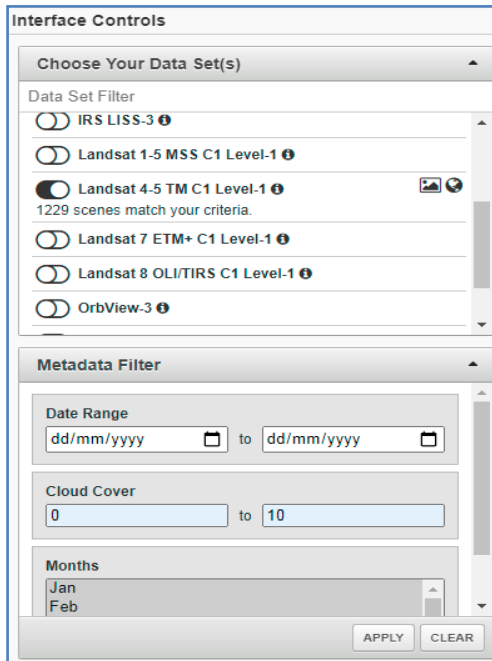


Figure 2: Data Set and Metadata Filtering

1.6) You can scroll through scenes chronologically using the Previous Scene and Next Scene buttons. Click the *download* icon for the file you selected (Figure 3).

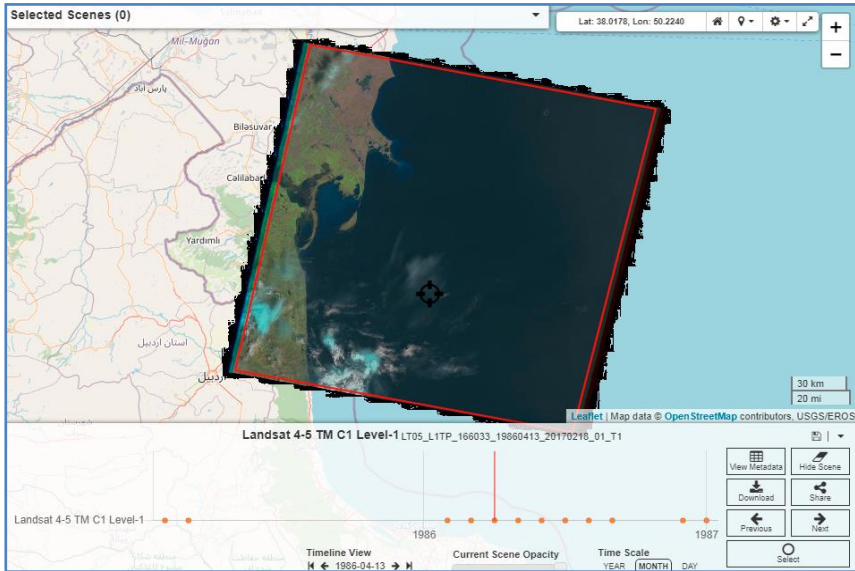


Figure 3: USGS Glovis Selecting scenes dialog box

Step 2: An alternative way to access data

When through the first way, you may not be able to access the images; therefore, you have to follow the following method:

2.1) Right-click on the mage that you have selected. Then, first, select the "Select Scene" option. It is another alternative way by clicking on the interactive map (Figure 4).



Figure 4: The interactive map for Landsat image options

2.2) Click on the View Metadata option to have information about the image you will download (Figure 5).

Field	Value
Landsat Product Identifier	LT05_L1TP_166033_19860413_20170218_01_T1
Landsat Scene Identifier	LT51660331986103XXX03
Acquisition Date	1986/04/13
Satellite	5
Collection Category	T1
Collection Number	1
Sensor Mode	
WRS Path	166
WRS Row	033
Date L-1 Generated	2017/02/18
Start Time	1986:103:06:44:55.6295600
Stop Time	1986:103:06:45:22.2688100
Station Identifier	XXX
Day/Night Indicator	DAY
Land Cloud Cover	21.00
Scene Cloud Cover	9.00
Ground Control Points Model	36

Figure 5: Metadata for a selected Landsat 5

2.3) Then, click on the "Share Scene" option until the Share Scene appears (Figure 6).

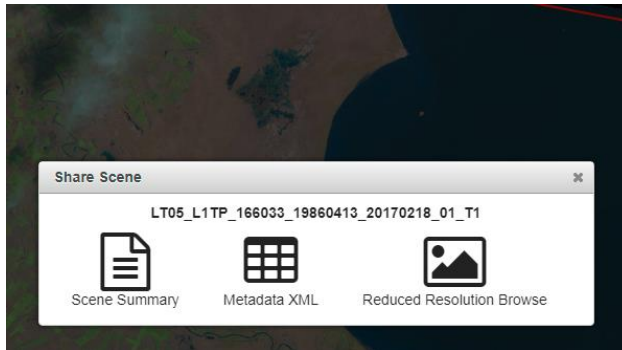


Figure 6: Share Scene dialog box

2.4) Click on the Scene Summary option until the ORDER SCENE message appears (Figure 7).

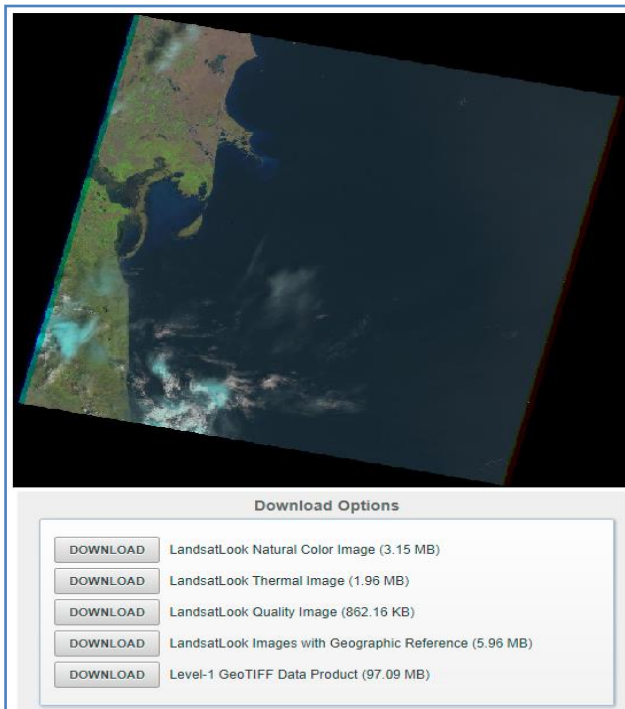


Figure 7: Scene Summary for Landsat-5 data

2.5) Another option is to click on the ORDER SCENE option.

2.6) You should convert your input to a scene list (List ID 'order-process-ee-1638493800'). This list will be available for seven days. Please note that some scenes may not have download or order options available (Figure 8).

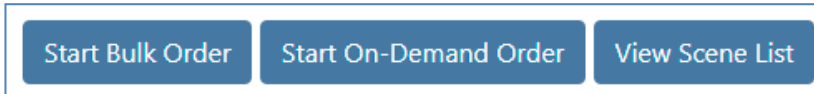


Figure 8: More ordering options

2.7) You need to select the View Scene List for our interesting data set. You will access the following window, and then you may request the Landsat image (Figure 9).

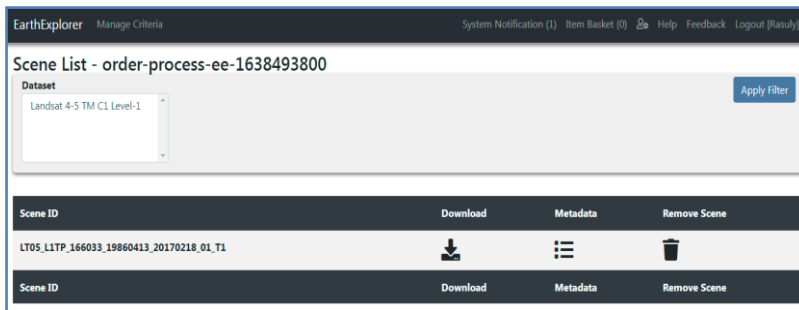


Figure 9: Landsat image and download order options

2.8) Select the Download option to have your image selected. Click on the Level-1 GeoTiff Data Product item. You may prefer to download a LandsatLook Natural Color Image for visualizing purposes. If you like to view the Landsat Image in your ArcGIS setting, you must select the LandsatLook Images with Geographic Reference option (Figure 10).

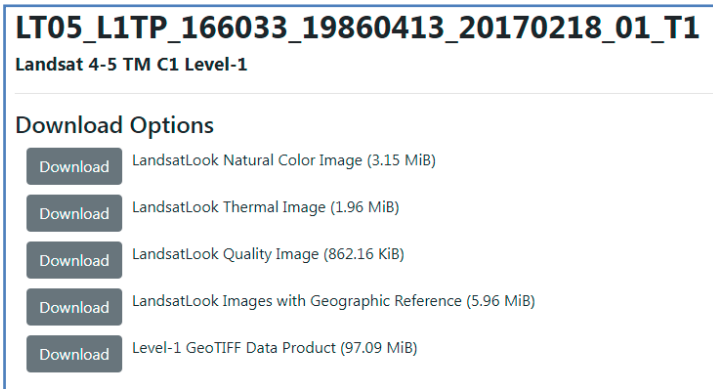


Figure 10: LandsatLook Natural Color Image

2.9) It takes time (normally 30-40 minutes) to download the image zip file.



2.10) Uncompress the zipped files inside a preformed folder, for our purposes, LC05_L1TP_166033_19860413 file (Figure 11).

Name	Date	Type	Size
LT05_L1TP_166033_19860413_20170218_01_T1_VER.jpg	18/02/2017 9:17 AM	ACDSee Pro 5 JPE...	87 KB
LT05_L1TP_166033_19860413_20170218_01_T1.tif	2/12/2021 6:29 AM	ACDSee Pro 5 TIFF...	3,231 KB
LT05_L1TP_166033_19860413_20170218_01_T1_B1.TIF	18/02/2017 9:17 AM	ACDSee Pro 5 TIFF...	55,752 KB
LT05_L1TP_166033_19860413_20170218_01_T1_B2.TIF	18/02/2017 9:17 AM	ACDSee Pro 5 TIFF...	55,752 KB
LT05_L1TP_166033_19860413_20170218_01_T1_B3.TIF	18/02/2017 9:17 AM	ACDSee Pro 5 TIFF...	55,752 KB
LT05_L1TP_166033_19860413_20170218_01_T1_B4.TIF	18/02/2017 9:17 AM	ACDSee Pro 5 TIFF...	55,752 KB
LT05_L1TP_166033_19860413_20170218_01_T1_B5.TIF	18/02/2017 9:17 AM	ACDSee Pro 5 TIFF...	55,752 KB
LT05_L1TP_166033_19860413_20170218_01_T1_B6.TIF	18/02/2017 9:17 AM	ACDSee Pro 5 TIFF...	55,752 KB
LT05_L1TP_166033_19860413_20170218_01_T1_B7.TIF	18/02/2017 9:17 AM	ACDSee Pro 5 TIFF...	55,752 KB
LT05_L1TP_166033_19860413_20170218_01_T1_BQA.TIF	18/02/2017 9:17 AM	ACDSee Pro 5 TIFF...	111,447 KB
LT05_L1TP_166033_19860413_20170218_01_T1_QB.tif	2/12/2021 6:29 AM	ACDSee Pro 5 TIFF...	863 KB
LT05_L1TP_166033_19860413_20170218_01_T1_TIR.tif	2/12/2021 6:29 AM	ACDSee Pro 5 TIFF...	2,012 KB
LT05_L1TP_166033_19860413_20170218_01_T1.zip	2/12/2021 3:59 PM	WinRAR ZIP archive	3,649 KB

Figure 11: Uncompressed Landsat-5 bands and associated attribute files

2.11) Now, you have all bands of the Landsat LT05_L1TP_166033 for the Shirvan National Park captured on 13th April 1986. Remember to take satellite imagery the next months, 1986-05-06 and 1986-08-26, to compare changes in landcover at your favorite location.

Step 3) Landsat 5 Bands Characters

3.1) When you unzip the Landsat 5 bands, you must understand their most characters. Landsat 5 carried the Thematic Mapper (TM) sensor and created images consisting of six spectral bands with a spatial resolution of 30 meters for Bands 1-5 and 7 one thermal band (Band 6).

3.2) The approximate scene size is 170 km north-south and 183 km east-west (106 mi by 114 mi). TM could not resolve individual houses or trees, but it could record houses constructed or cleared forests. Here are the Landsat satellite band designations (Table 1).

Table 1: Landsat-5 TM bands



Band number	Band name	Wavelength (μm)	Resolution (m)	Band Applications
1	Visible Blue	0.45 - 0.52	30	Bathymetric mapping, distinguishing soil from vegetation, and deciduous from coniferous vegetation
2	Visible Green	0.52 - 0.60	30	Emphasizes peak vegetation, which is useful for assessing plant vigor
3	Visible Red	0.63 - 0.69	30	Discriminates vegetation slopes
4	NIR	0.76 - 0.90	30	Emphasizes biomass content and shorelines
5	SWIR 1	1.55 - 1.75	30	Discriminates moisture content of soil and vegetation; penetrates thin clouds
6	Thermal	10.40 - 12.50	120	Thermal mappings and estimated soil moisture
7	SWIR 2	2.08 - 2.35	30	Hydrothermally altered rocks associated with mineral deposits

3.3) Landsat-5 bands can discriminate vegetation types, cultural features, biomass, vigor, etc. In turn, Band 6 measures Earth's thermal energy, particularly useful for tracking how land and water surfaces are changed. Later, we will have more information on Landsat data and their uses.

Step 4: Landsat Imagery inside eCognition

eCognition provides a selection of tools and user interface elements typically used for image processing and analysis within the applied science domain. Here, we will offer a brief on how to get the Landsat bands inside eCognition.

4.1) To set up Landsat-5 Imagery inside the eCognition setting – you need to execute the software first.

4.2) Click the  icon, Go to All Programs and click the icon  to boot the eCognition Developer.

4.3) You will see the Trimble eCognition startup; select the Quick Map Mode or Rule Set Mode by clicking its icon (presented in the previous tutoring). Selecting Rule Set Mode will take you to the standard Developer environment. For simple analysis tasks, you may wish to try Quick Map Mode.

4.4) Click any portal item to stop automatic opening. The most recently used portal will start if you do not click a portal within three seconds. To start a different portal, close the client and start again.

4.5) Click on the OK option to display the default eCognition 9.01. To collect the Landsat-5 bands inside eCognition, click File on the menu bar and select the Load Image File option (Figure 12).

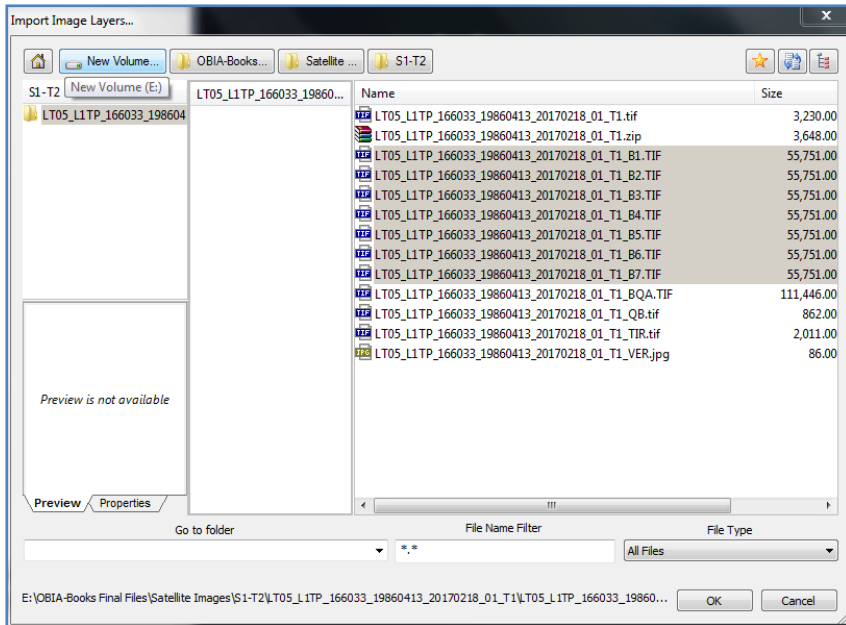


Figure 12: The "Load Image File" dialog box, with recursive file display selected

4.6) Click on the OK option to create an image. From the File menu, select the Save Project option to save your project. To Create New Project, Choose File > New Project on the main menu bar.

4.7) Using the "Modify a Project" function, you can add/remove more images or thematic layers or rename the project. Modify a selected project by exchanging or renaming image layers or other operations. Choose File > Modify Open Project on the main menu bar to modify a project. The Modify Project dialog box opens (Figure 13).

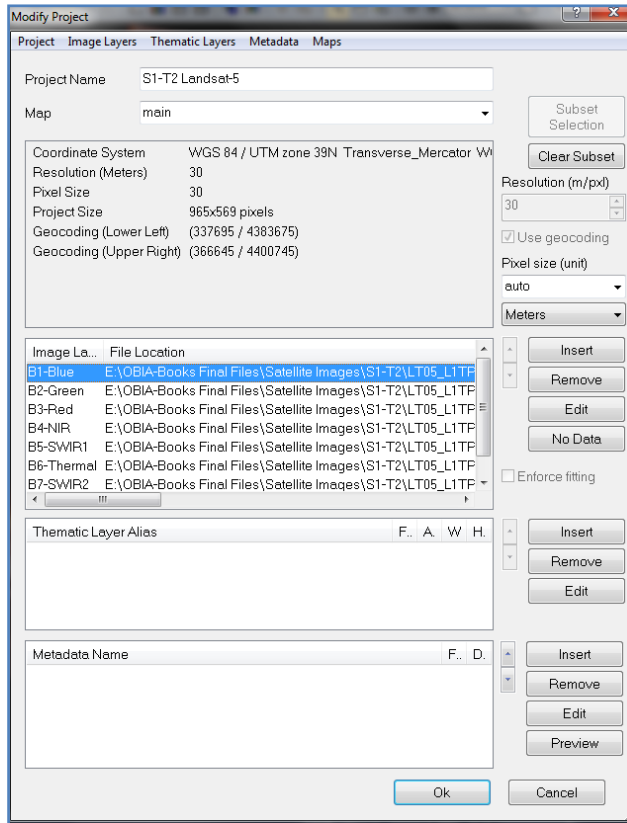


Figure 13: The Modify Project dialog box

4.8) Double-click on the "Image Layer Alias" item and rename all the layer's names as Layer 1 (B1-Blue), Layer 2 (B2-Green), Layer 3 (B3-Red), Layer 4 (B4-Near IR), Layer 5 (SWIR1), Layer 6 (B6-Thermal). And Layer 7 (B7-SWIR2).

4.9) Normally, image files are large and difficult to process. So, we should be working with a smaller area to manage easily, which will take less memory and time.

4.10) To open the Subset Selection dialog box (after importing image layers), press the Subset Selection button. Click on the

image and drag to select a subset area. For our interest, outline the Shirvan National Park in the image viewer. Alternatively, you may enter the subset coordinates. You can modify the coordinates by typing. Then you need to confirm with OK to return to the main dialog box. You can clear the subset selection by Clicking Clear Subset in the main dialog box. (Figure 14).

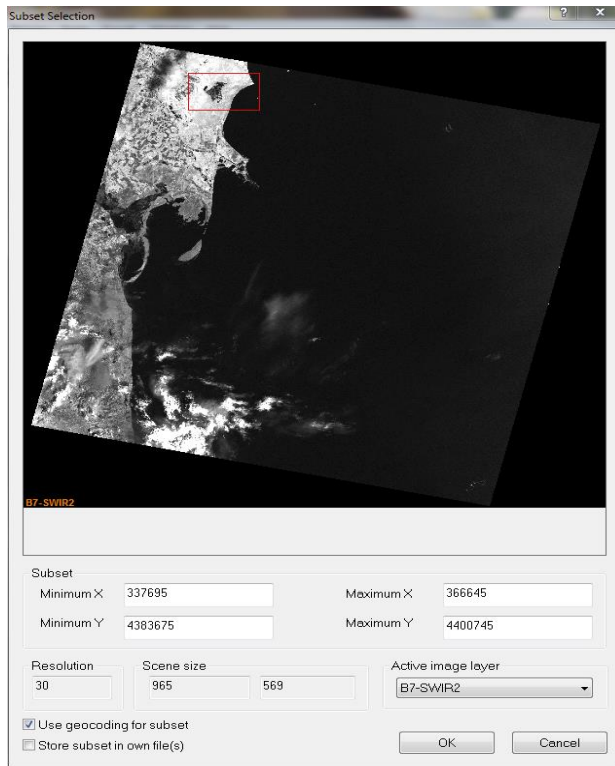


Figure 14: the Subset Selection dialog box

4.11) When you are happy with the new image set, click on the OK option. Then, click on the OK option in the Modify Project window again. Then, modify the band combinations using the "Edit Image Layer Mixing" dialog box (Figure 15).

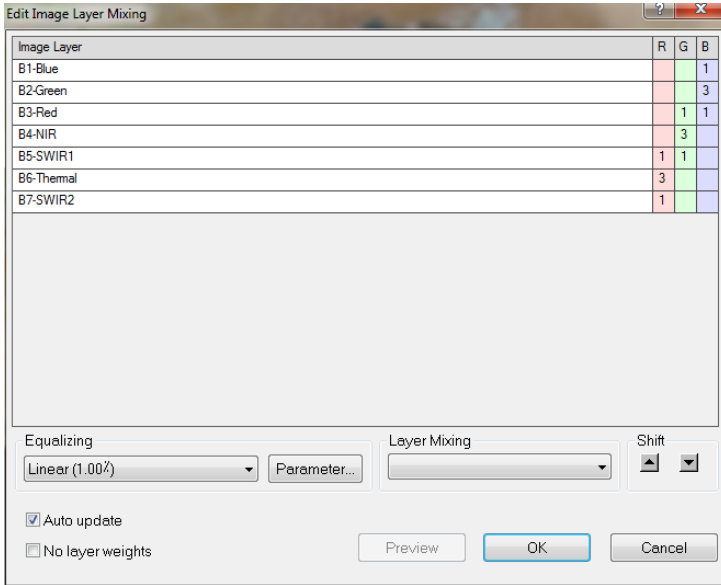


Figure 15: The "Edit Image Layer Mixing" dialog box.

4.12) Now, you could expect to work on the subsetting image with your desired adjustments (Figure 16).

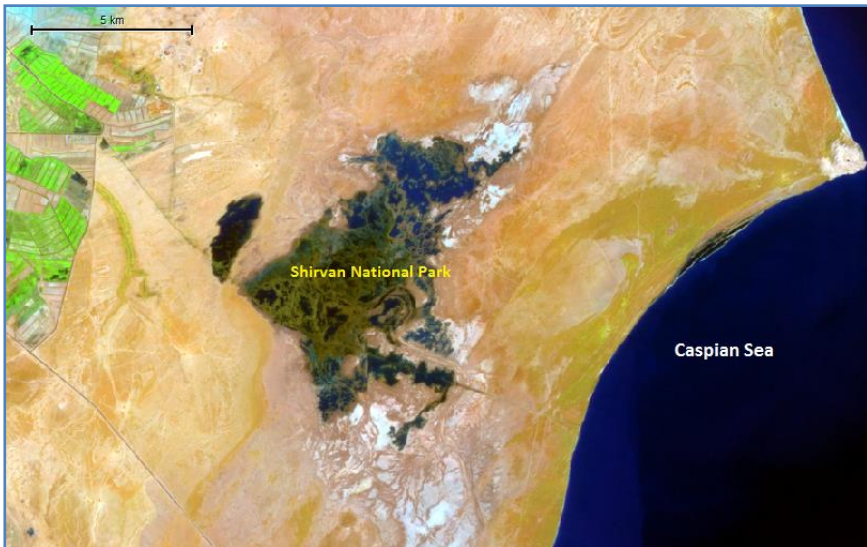


Figure 16: Landsat-5 subsetting image for the Shirvan National Park near the Caspian Sea coastlines




Step 5: Landsat-5 Bands Combinations

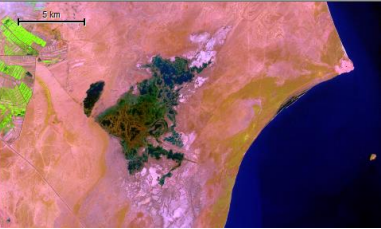
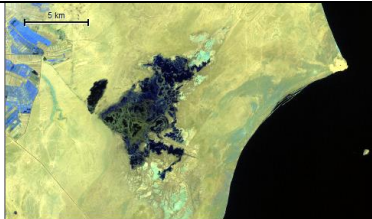
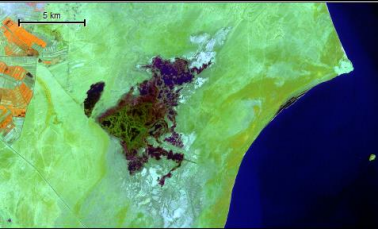
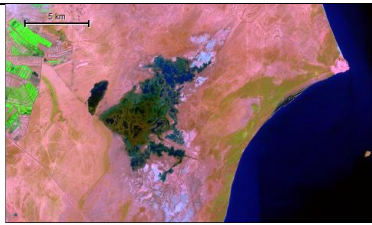
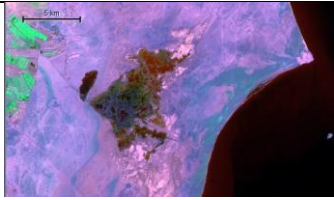
During image processing, you need better to understand the image layers composite inside the eCognition.

5.1) Inherently, Landsat 5 images have advantages and limitations. To get better mental perception and visual interpretation, you need to combine the relevant image bands.

5.2) It is necessary to practice the features and combine Landsat 5 bands in the eCognition software environment Table 2).

Table 2: Different Landsat-5 band combination inside the eCognition 9.01

Band Combinations	Example of Landsat-5	Applications
3, 2, 1		Natural Color
7, 5, 3		False Color (urban)
4, 3, 2		Color Infrared (vegetation)

<p>5, 4, 1</p>		<p>Agriculture</p>
<p>7, 5, 4</p>		<p>Atmospheric Penetration</p>
<p>4, 5, 1</p>		<p>Healthy Vegetation & Land/Water</p>
<p>7, 4, 2 & 7, 4, 3</p>		<p>Natural with Atmospheric Removal & Shortwave Infrared</p>
<p>5, 4, 3</p>		<p>Vegetation Analysis</p>

Step 6: Comparing Seasonal Landcover Changes

6.1) Once again, to compare potential landcover changes in the Shirvan Protected Area, perform an extra Landsat 5 composite for the dry season of 1986.

6.2) By paying attention to the details of Figure 17 visually, you can understand the changes made. Certainly, elements of interpretation such as color, shape, and patterns can help the interpreter to understand the scale of changes.

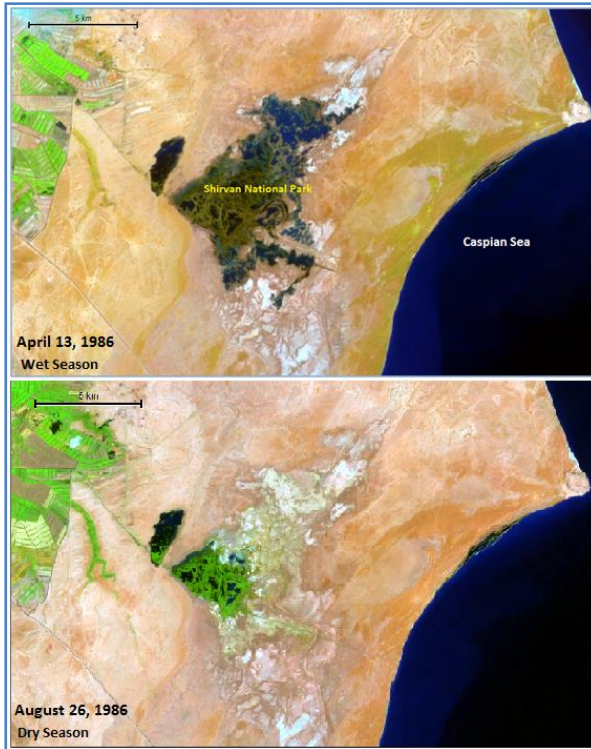


Figure 17: Landcover changes during wet and dry seasons in Shirvan National Park

6.3) At the end, you have to save the currently open project to a project file (extension. dpr). To save a project, do the following:

- Choose File> Save Project on the main menu bar.
- Choose File> Save Project As, on the main menu bar. The Save Project dialog box opens.
- Select a folder and enter a name for the project file (.dpr). Click the Save button to store the File.

Sum Up:

The Landsat program is the longest-running enterprise for acquiring satellite imagery of Earth, usually divided into scenes for easy downloading. Landsat-5 data can assist a broad range of specialists in managing the world's food, water, forests, and other natural resources for a growing world population. The Landsat images contain many layers of data collected at different points along the visible and invisible light spectrum as follows:

- ❖ As you may encounter, many distinct sorts of Landsat satellite images are available to you at no cost from different websites.
- ❖ Please note that Landsat scenes are large files, as unzipped Landsat 5 scenes are about 404, Landsat 7 scenes are about 654, and Landsat 8 nearly 972 megabytes. It is an important consideration when downloading and manipulating them.
- ❖ Landsat scenes are made of several files or layers (bands) of data. Each band represents a section of the electromagnetic spectrum that has been selected because it is useful for distinguishing kinds of landcover and landuse from one another and measuring the ways they change over time.
- ❖ Regularly, challenging satellite images and extracting useful information inside eCognition software would be an impressive enjoyment tutorial for educational purposes.

Informative Practices

Tips:

- 1) You have explored the most extensive and widely used remote sensing data portal (USGS EarthExplorer) in the current lesson. Still, many remote sensing data portals are available on the relevant websites, all with various applications and focus areas.
- 2) Take some time to explore some of the following data sources:
 - NASA EarthDataSearch: <https://search.earthdata.nasa.gov>.
- 3) Landsat satellites have the optimal ground resolution and spectral bands to efficiently track landuse and document land change due to climate change, urbanization, drought, wildfire, biomass changes (carbon assessments), and a host of other natural and human-caused changes.

Workouts:

- 1) Download the Landsat-5 imagery for your living area and carefully manage them.
- 2) Import Landsat bands to the eCognition software and list geographic and environmental characteristics.
- 3) Try combining different Landsat-5 bands and interpreting the landcover characters based on visualized interpretations elements (shape, color, and patterns).

Quizzes:

- 1) How many continents have Landsat-5 imagery available for them?
- 2) Will the cloud cover mask the satellite imagery considerably?
- 3) What are the following image's basic geographic and thematic characters?



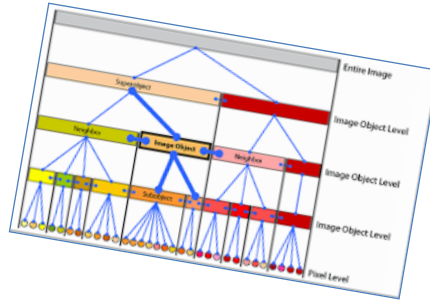
Allied References:

- 1) Irons, J.R., Dwyer, J.L., and Barsi, J.A. (2012). The next Landsat satellite: the Landsat data continuity mission. *Remote Sensing of Environment*, Vol. 122: pp.11–21.

- 2) National Aeronautics and Space Administration, (2018). BOREAS TE-18 Landsat TM Maximum Likelihood Classification Image of the NSA Paperback, 1st ed., NASA.
- 3) U.S. Geological Survey (2015). Landsat—Earth Observation Satellites. In Fact Sheet; U.S. Geological Survey: Reston, VA, USA.
- 4) U.S. Geological Survey, (2018). Landsat Analysis Ready Data: U.S. Geological Survey Fact Sheet.
- 5) Woodcock, C.E.; Allen, R.; Anderson, M.; Belward, A.; Bindschadler, R.; Cohen, W.; Gao, F.; Goward, S.N.; Helder, D.; Helmer, E. (2008). Free Access to Landsat Imagery. *Science*, 320, 1011a.
- 6) Wulder, M.A.; Masek, J.G.; Cohen, W.B.; Loveland, T.R.; Woodcock, C.E. (2012). Opening the Archive: How Free Data has Enabled the Science and Monitoring Promise of Landsat. *Remote Sens. Environ.* 122, 2–10.

Tutorial 3

Practicing the eCognition 9.01 Basic Structure



knowledge-based thinking with the eCognition

Opening Statement:

The main aim of the current tutorial is to familiarize students with the primary structure of the eCognition Developer software version 9.01. Accordingly, this tutor provides initial hands-on exercises, introducing the eCognition simple workflow. Data material focuses on Landsat-5 TM bands taken from the Republic of Azerbaijan, Absheron Peninsula, Baku City. In a general view, the eCognition Developer allows users to import many types of image raster layers and create targeted projects. The tutorial also extends the band combination of Landsat TM bands, providing qualitative landcover information.

Instructive Memo:

- ✓ *Level:* Beginner.
- ✓ *Time:* This tutorial should not take you more than 1.5 hours.
- ✓ *Software:* The eCognition Developer software, Version 9.01.
- ✓ *Data Sources:* The Landsat-5 Tiff format files (Row: 166 Path: 32 Date: 19/07/1998) are available from the NASA GloVIS service.

- ✓ *Subject Scene:* Baku region, Azerbyazan.

Tutor Objectives:

By the end of this unit, you should:

- ✚ Be aware of the structure and user interface of the eCognition Developer software and the types of projects the software you can be used for.
- ✚ Know how to create a new project within eCognition and the options available for creating a project.
- ✚ Be familiar with the main menu items of the eCognition Developer user interface.
- ✚ Recognize how to change the viewing properties and associated dialog boxes.
- ✚ Distinguish the geo-locational features of the Baku region.

Background Concepts:

The main purpose of the eCognition Developer is to facilitate the development of object-oriented rule-based image processing procedures. Therefore, rather than simply independently recognition the individual pixels within the scene, the image is split (segmented) into regions representing objects within the scene. Working with objects rather than pixels has numerous benefits over traditional pixel-based analysis; for instance, you can represent the spatial and context relationship between objects or the shape of an object analyzed. eCognition provides an easy-to-use interface to represent the classification rules and a visual scripting interface to control the segmentation and classification.

Mastering The Skills:

Inside the eCognition software, the object orient approach is applied to highlight the principle independent of the specific segmentation and classification techniques. However, the right choice of processing methods can add much power to the procedure. The right training and classification methods can give the user the full advantage of the approach's potential.

Step 1: Understanding the User Interface

eCognition Developer is normally available from the Windows start menu.

1.1) Start > All Programs > eCognition Developer 9.01. Once started, it will present you with an interface similar to the one shown in Figure 1.

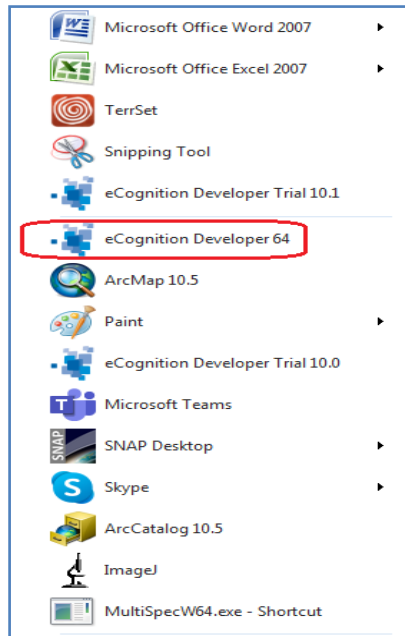


Figure 1: eCognition 9.01 Start Menu

1.2) You can choose one of Quick Map Mode or Rule Set Mode, for instance.

1.3) By choosing the Rule Set Mode and clicking on the OK button, you will face the flowing eCognition main interface with different interface modes.

1.4) To access other interface modes, you must toggle the View> Appearance buttons. You may choose one of the different interfaces series (Figure 2).

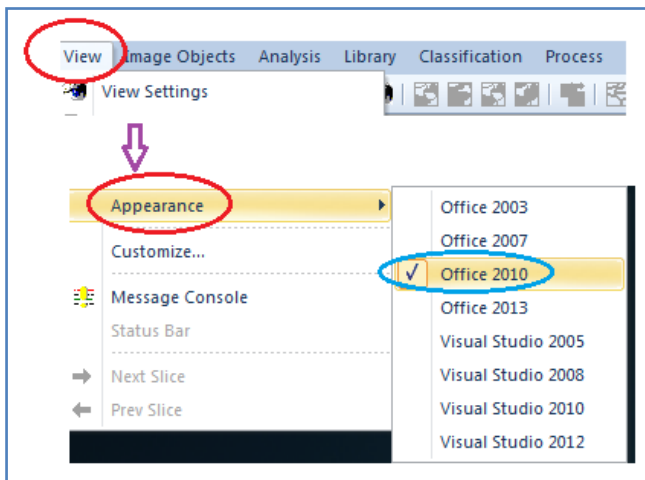


Figure 2: eCognition optional interface modes

1.5) The eCognition clients share portals with predefined user interfaces. Practically, a portal provides a selection of tools and user interface elements typically used for image analysis within an industry or science domain. However, most tools and user interface elements that are hidden by default are still available. Later, we will inform you of their functionalities in the following tutorials.

1.6)

Step 2: Components of the User Interface

When you start the eCognition software, you will see with at least five windows and associated menu-bars and many toolbars as follow:

2.1) Data/Image Viewer: The image and classification data viewer. The viewer lets you view the imagery you are classifying, including manipulating the band order and image stretching.

2.2) Process Tree: The Window within which you could develop your ruleset script.

2.3) Class Hierarchy: The Window displays the classes you develop.

2.4) Image Object Information: This Window displays selected feature values for a selected object.

2.5) Feature View: This Window displays a list of all the available features within eCognition Developer and allows the current image objects to be colored (high green values and low blue values) given their value for a special feature (Figure 3).

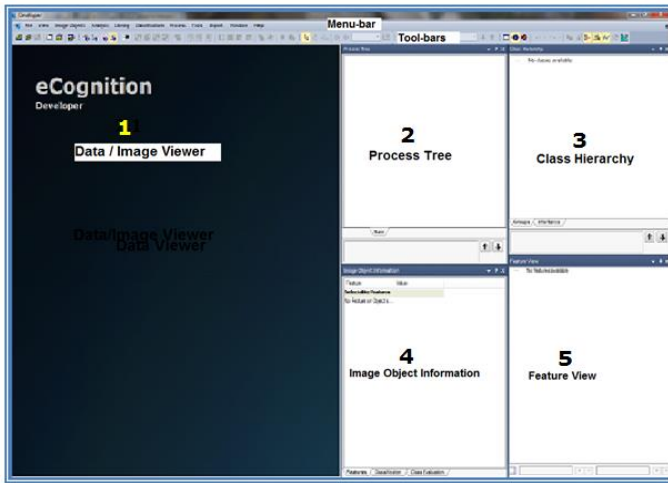


Figure 3: The user interface with the components labeled








Step 3: Toolbar Icons Functions

When you work inside the eCognition software, you need to run many functions, each with its order.

3.1) Table 1 provides a glossary of the icon available on the various toolbars within eCognition Developer.




Table 1: Default Toolbar Buttons

Group	Buttons	Functions
File Toolbar		This group of buttons allows you to load image files, open and save projects.
File Toolbar		This group of buttons allows you to open and create new workspaces and opens the Import Scenes dialog to select predefined import templates.
View Settings		These buttons, numbered from one to four, allow you to switch between the four window layouts. 1) Load and Manage data, 2) Configure Analysis, 3) Review Results, and 4) Develop Rule Sets. The Develop Rule Sets View is most commonly used to organize and modify image analysis algorithms.

Toolbar		This group of buttons allows you to select image view options. You can select between View of image layers, classification, samples, and any features you wish to visualize.
		This group is concerned with displaying outlines and borders of image objects and views of pixels. 1) Toggle between pixel view or object mean View; 2) Show or hide outlines of image objects; 3) Switch between transparent and non-transparent outlined objects, and 4) Toggle between show or hide polygons.
		With show polygons active, you can visualize the skeletons for selected objects (if this button is not visible, go to View>Customize > Toolbars and select Reset All).
		This button allows the comparison of a down-sampled scene and toggles between Image View or Project Pixel View.
		These toolbar buttons allow you to visualize different layers; in grayscale or RGB. If available, they also allow you to switch between layers.
		These toolbar buttons allow you to open the main View Settings, the Edit Image Layer mixing dialog, and the Edit Vector Mixing dialog.
		These toolbar buttons toggle between the 3D point cloud view and back to the 2D image view. The last button is only active in point cloud mode and opens the Point Cloud View Settings dialog.

3.2) Table 2 describes the Zoom functions toolbars within eCognition Developer.

Table 2: Zoom Tools and Functions

Zoom	Toolbar	Functions
Zoom Functions Toolbar		<p>This toolbar region offers natural selection and the ability to drag an image, along with several zoom options.</p>
View Navigate Toolbar		<p>The View Navigate folder allows you to delete levels, select maps and navigate the object hierarchy.</p>
Tools Toolbar		<p>The Tools toolbar allow access to advanced dialog boxes :</p> <p>The buttons on the Tools toolbar launch the following dialog boxes and toolbars:</p> <ul style="list-style-type: none"> •The Manual Editing Toolbar •Manage Customized Features •Manage Variables •Manage Parameter Sets •Undo •Redo •Save Current Project State •Restore Saved Project State

Step 4: Splitting Windows Functions

There are several ways to customize the layout in eCognition Developer, allowing you to display different views of the same image. For example, you may wish to compare the results of a segmentation alongside the original image.

4.1) Selecting Window> Split allows you to split the Window into four – horizontally and vertically – to a size of your choosing.

4.2) Alternatively, you can select Window> Split Horizontally or Window > Split Vertically to split the Window into two.

4.3) Two more options give you the choice of synchronizing the displays. Independent View allows you to change the size and position of individual windows – such as zooming or dragging images – without affecting other windows. Alternatively, selecting Side-by-Side View will apply any changes made in one Window to any other windows.

4.4) A final option, Swipe View, displays the entire image across multiple sections while still allowing you to change the view of an individual section.

Step 5: Magnifier Options

The Magnifier feature lets you view a magnified area of a region of interest in a separate window. It offers a zoom factor five times greater than the one available in the normal map view.

5.1) To open the Magnifier window, select View> Windows > Magnifier from the main men.

5.2) Holding the cursor over any point of the map centers the magnified View in the Magnifier window. You can release the Magnifier window by dragging it while holding down the Ctrl key.

Step 6: Docking Options
















By default, the four commonly used windows, Process Tree, Class Hierarchy, Image Object Information, and Feature View, are displayed on the right-hand side of the workspace in the default Develop Rule Set View. The menu item Window > Enable Docking facilitates this feature.































6.1) When you deselect this item, the windows will display independently of each other, allowing you to position and resize them as you wish. This feature may be useful if you are working across multiple monitors. Another option to undock windows is to drag a window while pressing the Ctrl key.

6.2) You can restore the window layouts to their default positions by selecting View> Restore default.

6.3) Selecting View > Save Current View also allows you to save any changes to the workspace view you make (Table 3).

Table 3: The most imported Toolbars and related functions

File Toolbar			
Icon	Description	Icon	Description
	Create New Project		Open Workspace
	Open Project		Save Workspace
	Save Project		Predefined Import
	Create New Workspace	-----	-----
View Settings Toolbar			
Icon	Description	Icon	Description
	Load & Manage Data		Transparent/Non Transparent
	Configure Analysis		Show / Hide Polygons
	Review Results		Single Layer Grayscale
	Develop Rule-Sets		Mix Three Layers RGB

	View Settings		Show Previous Image Layer
	View Layer		Show Next Image Layer
	View Classification		Edit Image Layer Mixing
	View Samples		Show / Hide Vector Layer
	Feature View		Point Cloud View or Image View
	Pixel View or Object Mean View		Point Cloud View Settings
	Show or Hide Outline	-----	-----
Zoom Toolbar			
	Normal Cursor		Zoom in Center
	Panning Tool	100% 	Select Zoom/Magnification Factor
	Area Zoom		Zoon Scene to Window
	Zoom Out Center	-----	-----
View Navigation Toolbar			
	Delete Level		Next Level Down in Object Hierarchy
main 	Select Active Map		Next Level Up in Object Hierarchy
Level-1 	Select Level in Object Hierarchy	-----	-----
Tools Toolbar			
	Workspace		Undo Process Editing
	Image Object Information		Redo Process Editing
	Object Table	-----	-----

Step 7: Creating the First eCognition Project

The first step when using eCognition Developer is to load your data into the software. The following Azer-OBIA exercises will always do this by creating an individual project. Just remember some vital points such as; taking into account images with less possible volumes, fewer bands, and small geographic areas for

fast-learning purposes during the learning course. Suppose you are later required to process very large datasets or many individual images. In that case, a workspace provides a convenient and efficient way to store and manage these data. Please refer to earlier lessons for information about workspaces. For now, to create your new project:

7.1) Either select File > New Project or select the new project icon that will present you with the box to enter your Landsat 5 datasets (for this practice *.Tiff files) and parameters to create your project. In this example, you are going to load the *LT05_L1TP_166032_19980719_20161223_01_T1_B1:B7* files (bands). The main spectral and spatial characters of the Landsat 5 bands are given in Tutorial 2.

7.2) It is worth the point that Landsat 5 recorded many significant events. It was the first satellite to capture the nuclear accident at Chernobyl in 1986. Landsat 5 documented deforestation occurring in tropical regions and captured the devastating 2004 tsunami in Southeast Asia.

7.3) Inside an appropriate folder (Baku L5-19980719), select all tiff files (bands) and inter OK (Figure 4).

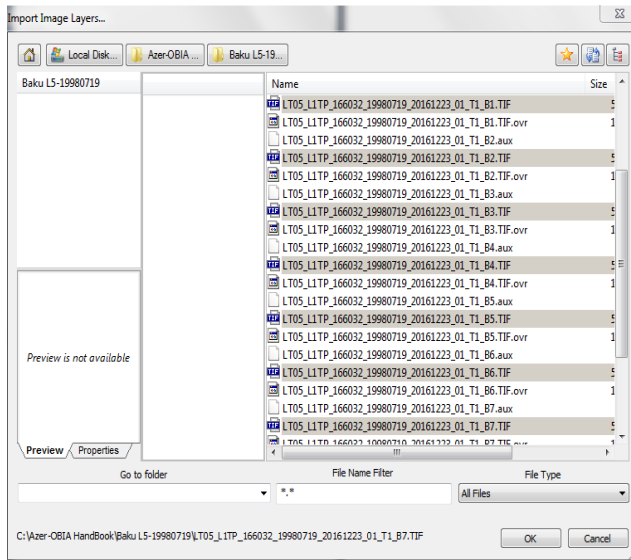


Figure 4: The Import Image Layers dialog

7.4) When you click OK, the Create Project window appears. By selecting 'Insert' next to the Image Layer List. Once you have loaded your data, you need to define the layer aliases, where bands 1-7 correspond with aliases BLUE, GREEN, RED, NIR SWIR1, Thermal, and SWIR2, respectively. To bring up the layer properties dialog, double click on each image band; in turn, select the band and select the file edit button.

7.5) You can also add many raster files (such as DEM files) in the list below the image layers list, which you could use during your classification and segmentation, for example, a polygon shapefile of building. The next step is to give your project a name; in this case, call it 'Baku-166032_19980719' and check the projection information for your image has been correctly read. If this information is incorrect, you need to check the 'Pixel

size (unit)' on the right-hand side. You also can re-sampling your imagery to a resolution of your choice using the 'Resolution (m/pxl)' dialog box and selecting a subset using the 'Subset Selection' button, which presents a dialog similar to the one shown in previous tutorials.

7.6) To select a subset, you can either draw a red box on the image in the dialog or provide the pixel limits of your subset. Before finalizing the project and selecting OK, we will subset the image, where minimum X is set to 2022, the maximum X is set to 4521, the minimum Y is set to 3410, and maximum Y is set to 4851.

7.7) Now click OK to create the project, and you will move back to the eCognition Developer interface, Figure 5.

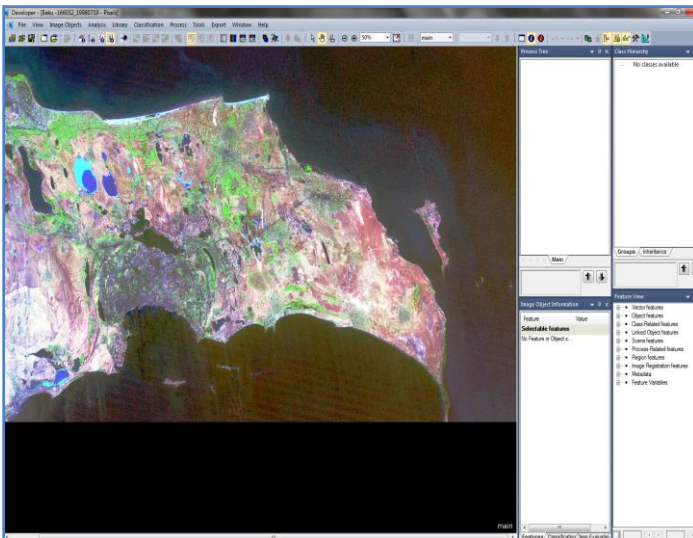


Figure 5: The eCognition Developer interface with a new project loaded

7.8) Once the project has been loaded, you can pan and zoom around the data in the display region using the zoom toolbar, shown below in Figure 6.

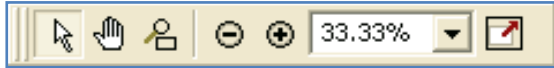



Figure 6: Zoom Functions toolbar

7.9) If the zoom functions toolbar is not displayed, you can turn it on using the View>Toolbars menu.

Step 8: Selecting bands for Display

8.1) To select the layer(s) to be displayed, you need to click on the 'Edit Image Layer Mixing'  dialog (Figure 7).

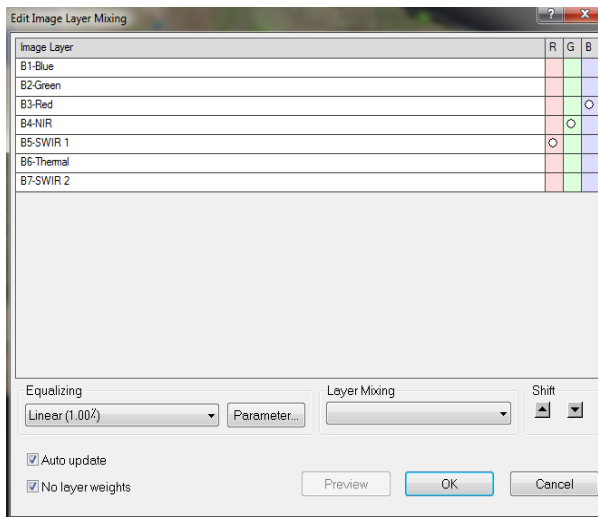


Figure 7: The "Edit Image Layer Mixing" dialog

8.2) Using the 'Layer Mixing' drop-down menu, you can select the number of layers to be mixed in the display, and then by selecting the individual layers, you may turn them on and off or increase the weight (Figure 8).

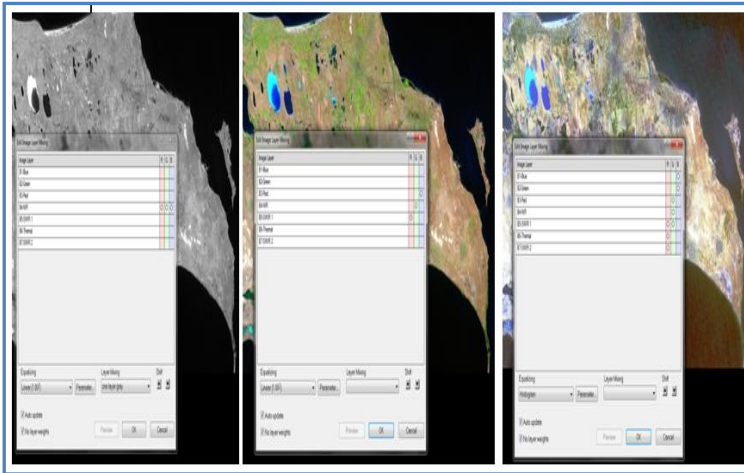


Figure 8: Selecting the layers for display in different modes

8.3) Also, you can adjust the equalization (or stretch) of the data layers is displayed using the 'Equalizing' drop-down menu. The available options are 'Linear (1.00%)', 'Standard Deviation (3.00)' 'Gamma Correction (0.50)', 'Histogram' and 'Manual.'

Step 9: Managing Multiple Views

9.1) eCognition Developer also allows you to split your display, allowing multiple views of the same data. This functionality is available from the Window menu (Figure 9).

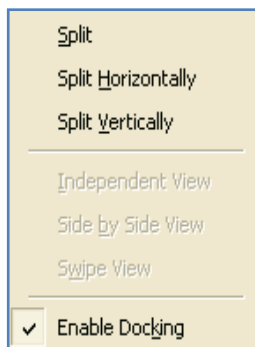


Figure 9: the Window Menu

9.2) Here, the current display can be split horizontally or vertically, and once split, it can be 'linked' to provide views that automatically move together.

9.3) Once you have split your screen by selecting the Window you wish to change, you can use the same tools outlined above to manipulate the display properties in each of the different views (Figure 10).

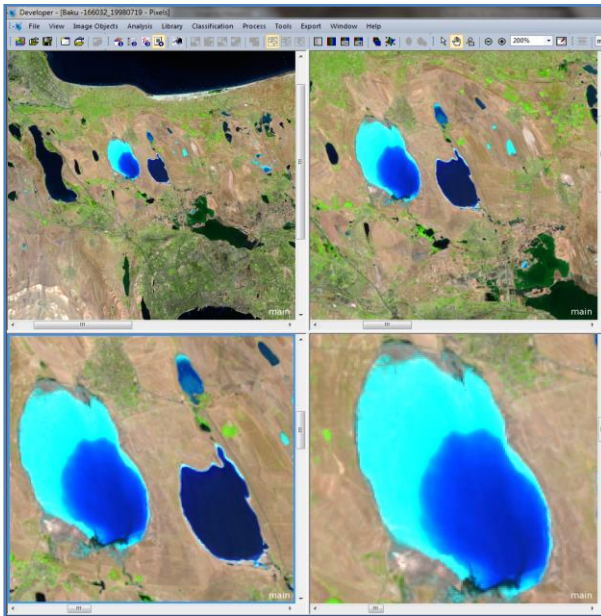


Figure 10: The result of window split functions


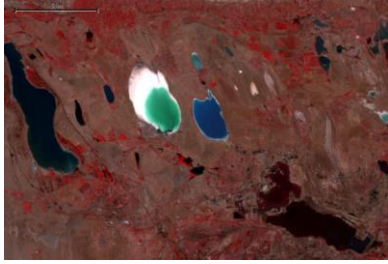
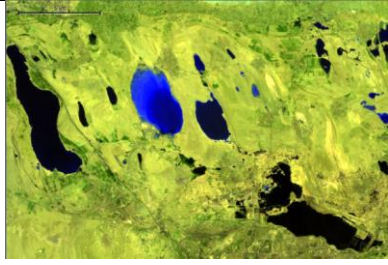
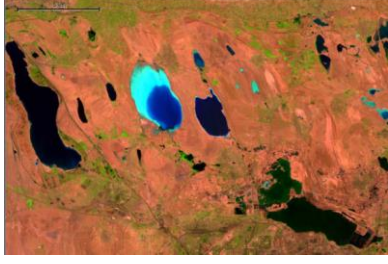
Step 10: Common Landsat 5 TM Band Combinations

The image bands of Landsat satellites cover a specific range of the electromagnetic spectrum; each has its characteristics and provides part of the landcover information. By combining different bands of Landsat images, you can access more

information. A few examples are provided in Table 5 to explain combining image bands and related applications.

10.1) Accordingly, as with any Landsat bands, you can arrange them in such a way as to extract unique and new information inside the eCognition 9.01. Matching the most suitable informative band combinations with their respective images can be done with the Edit Vector Layer Mixing dialog box.

Table 5: Dissimilar Landsat 5 TM band combinations indicating the Baku, Azerbaijan

Band Combination	Sample Image	Application
(B3, B2, B1)		<p>The Natural color: The natural color composite uses a band combination of red (3), green (2), and blue (1). It replicates close to what our human eyes can see.</p>
(B4, B3, B2)		<p>Color Infrared: This band combination is also called the near-infrared (NIR) composite. It uses near-infrared (4), red (3), and green (2). Because chlorophyll reflects near-infrared light, this band composition is useful for analyzing vegetation. In particular, areas in red have better vegetation health.</p>
(B7, B5, B3)		<p>Short-Wave Infrared: The short-wave infrared band combination uses SWIR-2 (7), SWIR-1 (5), and red (3). This composite displays vegetation in shades of green.</p>
(B6, B5, B2)		<p>Agriculture: This band combination uses SWIR-1 (6), near-infrared (5), and blue (2). It's commonly used for crop monitoring because of the use of short-wave and near-infrared. Healthy vegetation appears dark green.</p>

10.2) It would be best if you opened by double-clicking in the lower right pane of the view settings dialog, selecting View > Vector Layer Mixing, or selecting the Show/hide vector layers button. This dialog lets you change the order of different layers by dragging and dropping a thematic vector layer.

10.3) In the case of Landsat-5, some of the popular band combinations include natural color, color infrared, and various vegetation indexes. To create Landsat 5 TM band combinations, you need to check out the "Edit Image Layer Mixing" dialog box to help you visualize different band combinations in different ways. You can read the next tutorials for more details.

Sum Up:

eCognition is an intuitive end-user software used to configure and execute image analysis applications. It supports fully automated or semi-automated workflows and guides users through the application they are running. eCognition 9.01 incorporates all the necessary tools for users to import, view, and visualize more Landsat bands and create associated imagery. You should now open the eCognition Developer, create a project and manipulate the display to view the band-combinations as you wish. The next tutorials will take you through the much imagery you ought to load into your project and some more advanced features of the eCognition software.

Informative Practices

Tips:

- 1) The eCognition software is powerful out-of-the-box Landcover and changes detection mapping solution.
- 2) eCognition enables users at any skill level to quickly produce high-quality, GIS-ready deliverables from imagery.
- 3) By eCognition, you can rapidly and easily combine Landsat's different bands to perceive much landcover information.

Workouts:

- 1) List the satellite imagery which could be inter to the eCognition setting.
- 2) Name the main parts and functions of the View Settings Toolbar.
- 3) List the "Edit Image Layer Mixing dialog box" main applicability.

Quizzes:

- 1) What is unique in eCognition?
- 2) What is typical Trimble eCognition use Cases?
- 3) What is the main aim of band combination ideas?

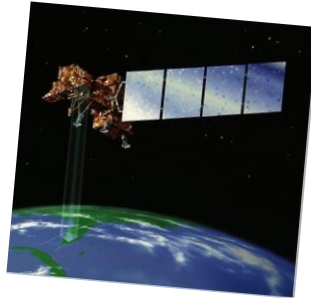
Allied References:

- 1) eCognition Reference Book (2014). Trimble eCognition Reference Book, Munich, Germany: Trimble Germany GmbH.
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- 5) Trimble eCognition Suite (2015). SYSTEM REQUIREMENTS, eCognition 9.1. Trimble Documentation.
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Tutorial 4

Illustrating Land Surfaces by Landsat Imagery



Landsats are the most accurately informative Earth-observing satellite.

Opening Statement:

This tutorial teaches you through simple steps to find, download and view free Landsat-7 imagery to extract useful landcover information inside the eCognition software. Geospatial students and even professionals looking for satellite imagery prefer to use medium-resolution satellite imagery applied for a specific application, but they are unsure where to start. The primary method is to combine different bands to combine a few color images, enabling you to interpret qualitative information visually. Meanwhile, the main aim of the tutorial is to develop a few band ratios of water surfaces for separating the water surfaces from other types of landcover along the Kura River, Aran Rayon, Azerbaijan.

Instructive Memo:

- ✓ *Level:* Intermediate
- ✓ *Time:* This tutorial should not take you more than 1.5 hours.
- ✓ *Software:* The eCognition Developer software (Version 9.01),

- ✓ *Data Sources:* Landsat-7, Glovis site, <https://glovis.usgs.gov/app>,
- ✓ *Subject Scene:* Kura River, LE07_L1TP_168032_2000-05-11.

Tutor Objectives:

By the end of this unit, you should:

- ✚ Access to Landsat-7 bands.
- ✚ Register and log in to the site.
- ✚ Create image combinations.
- ✚ Rationig Water Surfaces.

Background Concepts:

Surface water change is an important indicator of environmental, climatic, and anthropogenic activities. Remote sensors, such as Landsat-7, have been providing data for the last four decades, useful for extracting landcover types such as green-covers (forest, pasture, agriculture) and water sources. Researchers have proposed many surface water extraction techniques, among which different band-combination methods are popular owing to their simplicity and cost-effectiveness. Also, by applying the standard methods, you can visualize water features; thus, everyone can detect changes. We will apply a few well-known water band combinations and band ratios for surface water extraction using Landsat-7 images based on the current tutorial aims. A unique geographic site represents overall water features, such as rivers, lakes, ponds, creeks, and other morphologic shapes such as meanders the region.

Table 1: Landsat 7 Enhanced Thematic Mapper Plus (ETM+)

Band	Wavelength	Resolution (meters)	Useful for mapping
Band 1 - Blue	0.45-0.52	30	Bathymetric mapping, distinguishing soil from vegetation and deciduous from coniferous vegetation
Band 2 - Green	0.52-0.60	30	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 3 - Red	0.63-0.69	30	Discriminates vegetation slopes
Band 4 - Near Infrared	0.77-0.90	30	Emphasizes biomass content and shorelines
Band 5 - Short-Wave Infrared	1.55-1.75	30	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 6 - Thermal Infrared	10.40-12.50	60 (30)	Thermal mapping and estimated soil moisture
Band 7 - Short-Wave Infrared	2.09-2.35	30	Hydrothermally altered rocks associated with mineral deposits
Band 8 - Panchromatic	0.52-0.90	15	15 meter resolution, sharper image definition

Landsat 7 Enhanced Thematic Mapper Plus (ETM+) images consist of eight spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 (Table 1). The resolution for Band 8 (panchromatic) is 15 meters. All bands can collect one of two gain settings (high or low) for increased radiometric sensitivity and dynamic range, while Band 6 collects both high and low

gain for all scenes. The approximate scene size is 170 km north-south by 183 km east-west.

Landsat-7 data products are provided free of charge to all data users, including the students and researchers, under the terms and conditions prescribed by the Glovis NASA Programme.

Mastering The Skills:

Step 1: Setting up Landsat-7 Bands

1.1) Go to <https://glovis.usgs.gov/app> and create a User Account for yourself. For more details, notice previous tutorials.

1.2) Click the icon  to boot the eCognition Developer in the Rule Set Mode.

1.3) Set up Landsat-7 Imagery all bands inside the eCognition setting and subset image layers. For more details, notice the earlier tutorials.

1.4) Create a project, for example, Kura River, adjusted for part of the Aran Rayon, the longest River in Azerbaijan (Figure 1).

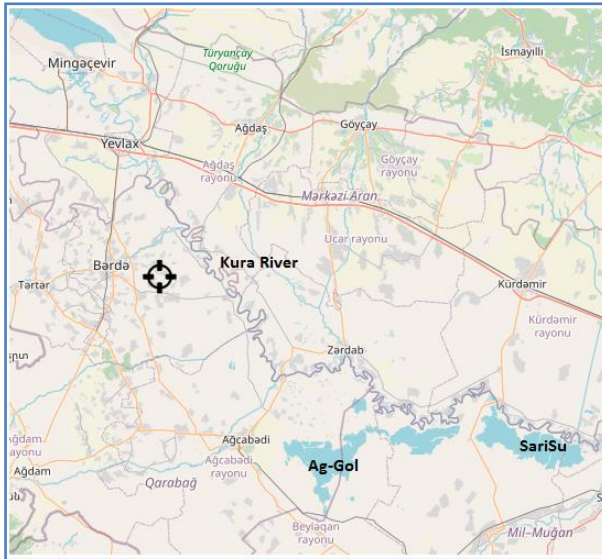



Figure 1: The Kura River location, in the Aran Rayon

Step 2: Mixing Image Layers

- 2.1) Set the layer mixing and equalizing options based on the "Edit Image Layer Mixing dialog box capabilities. It affects the display of Landsat-7 images, with nine bands (see Table 2), as subsetted for small parts of the Aran Rayon.
- 2.2) Define the color composition to visualize image layers in the map view. In addition, you can choose from different equalizing options. It enables you to visualize the image better and recognize the visual structures without changing them.
- 2.3) Choose to hide layers, which can be very helpful when investigating image data and results. Note that changing the image layer mixing changes the visual display of the image but not the underlying image data – it has no impact on the process of image analysis.

2.4) To do so, you need to open the Edit Image Layer Mixing dialog box  icon (Figure 2).

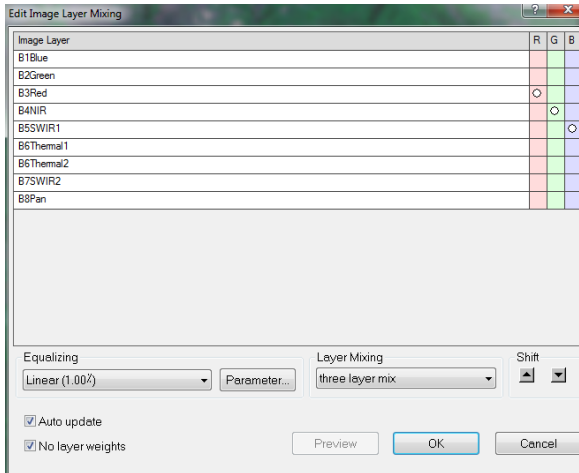


Figure 2: The "Edit Image Layer Mixing" dialog box, the layer mixing and equalizing options

2.5) You may define the color composition to visualize image layers in the map view, based on different RGB Layer Mixing presets (Figure 3).

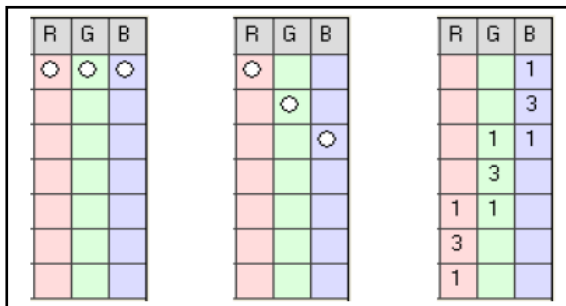


Figure 3: Layer Mixing presets (from left to right): One-Layer Gray, Three-Layer Mix, Six-Layer Mix

2.6) You can also choose from different equalizing options. It enables you to visualize the image better and recognize the visual structures without changing them. You can also choose to

hide layers, which can be very helpful when investigating image data and results.

2.7) Note that changing the image layer mixing' only changes the visual display of the image but not the underlying image data – it has no impact on the process of image analysis.

2.8) When creating a new project, the first three image layers are displayed in red, green, and blue. Open the "Edit Image Layer Mixing" dialog box to change the layer mixing. Choose View > Image Layer Mixing from the main menu.

2.9) Define the display color of each image layer. You can also set the weighting of the red, green, and blue channels. Your choices can be displayed together as additive colors in the map view. Any layer without a dot or a value in at least one column will not display.

2.10) Choose a layer mixing preset (see Figure 4).

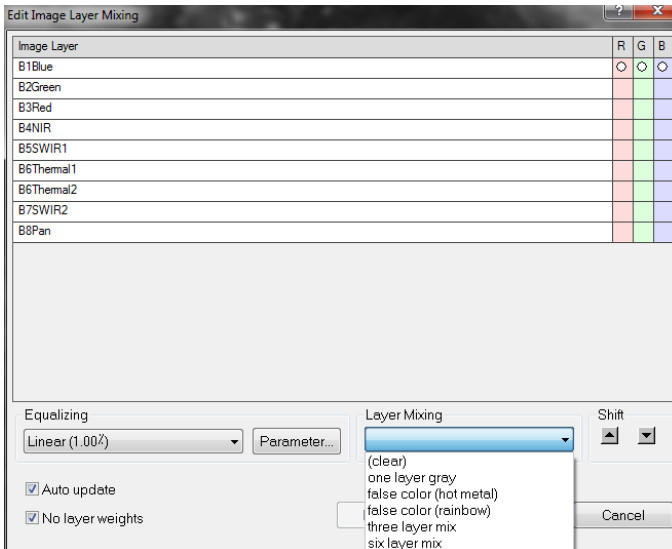


Figure 4: Edit Image Layer Mixing dialog box, Layer Mixing options

2.10.1) Clear option: all assignments and weighting are removed from the Image Layer table. One Layer Gray displays one image layer in grayscale mode with red, green, and blue.

2.10.2) False Color (Hot Metal) is recommended for single image layers with large intensity ranges to display in a color range from black over red to white. Use this preset for image data created with positron emission tomography.

2.10.3) False Color (Rainbow) is recommended for single image layers to visualize rainbow colors. Here, the regular color range is converted to a color range between blue for darker pixel intensity values and red for brighter pixel intensity values

2.10.4) Three Layer Mix displays layer one in the red channel, layer two in green, and layer three in blue

2.10.5) Six Layer Mix displays additional layers. You may change these settings to your preferred options with the Shift button or by clicking the respective R, G, or B cell. It can display one layer in more than one color, and you can display more than one layer in the same color.

2.10.6) You can assign individual weights to each layer. Clear "the No Layer Weights checkbox" and click a color for each layer. Left-clicking increases the layer's color weight while right-clicking decreases it. The Auto Update checkbox refreshes the view with each change of the layer mixing settings. Clear this check box to show the new settings after clicking OK. With the Auto Update check box cleared, the Preview button becomes active.

2.10.7) Compare the available image equalization methods and choose one that gives you the best visualization of the objects of interest. Equalization settings are stored in the workspace and applied to all projects or stored in a separate project. In the Options dialog box, you can define a default equalization setting (Figure 5).

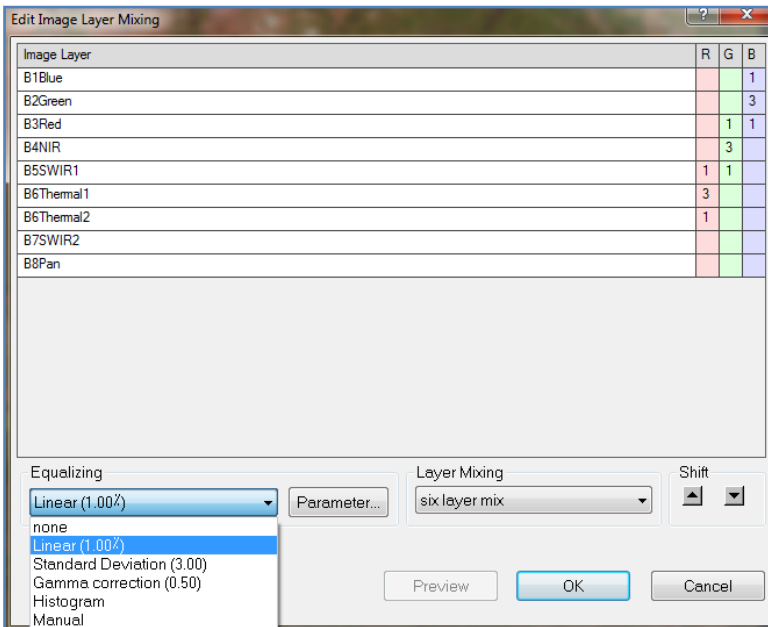


Figure 5: Edit Image Layer Mixing dialog box, Equalizing options

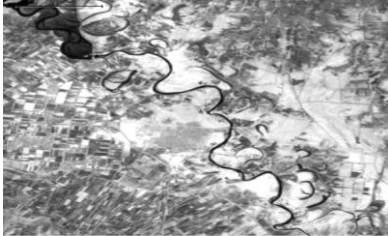

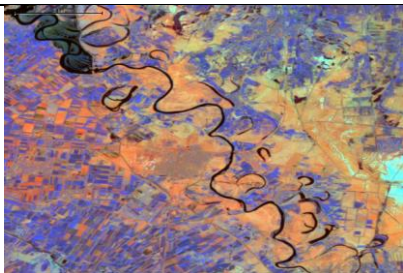
2.10.8) You may prefer to click the Parameter button to change the equalizing parameters, if available.


Step 3: Landsat-7 Band Combinations

As you noticed, based on the Edit Image Layer Mixing dialog box capacities, you can extract specific qualitatively information from any Landsat-7 mage inside the eCognition setting.

3.1) In Table 2, different band combinations highlight water surfaces in a subsetting image, indicating the Kura Rivers and around in Aran Rayon.

Table 2: Dissimilar band combinations indicating the Kura River and surrounding water surfaces

Band (s)	Equalizing Parameters	Layer Appearance
B6	Linear (1.00%) No layer weights	
B5, B4, B3	Linear (1.00%) No layer weights	
B6 ₁ , B5, B4	Standard Deviation (3) No layer weights	

B5, B4, B3	Standard Deviation (3) No layer weights	
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3.2) As can be seen from the appearance of the above images, each of the Landsat band compositions reveals water levels. However, the combination of different bands of Landsat-7 by the Gamma Correction method illustrates the water levels more clearly.

3.3) To create more Landsat-7 band combinations for more information, you can check out the Edit Image Layer Mixing dialog box that could help you visualize the more (six) band combinations in different ways.

3.3.1) Set the Edit Image Layer Mixing dialog box for six bands, as you see in Figure 6 (a & b).

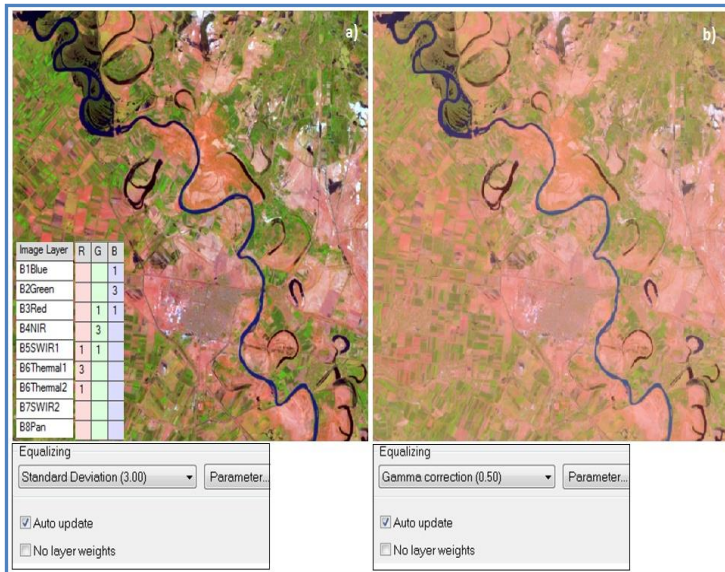


Figure 6 (a & b): Setting the Landsat-7 bands for the Standard Deviation and Gamma Correction parameters

3.3.2) Set the Equalizing mode to the Standard Deviation and Gamma correction options separately and check out the No layer weights options. Then, click on OK to result, as appears in Figure 6.

3.3.3) As you notice from Figure 6 a, the water surfaces are highlighted in dark and blue colors and the vegetation in green colors. Non-vegetated and buildup areas are quite apparent and marked in white to yellowish colors. If you change the Equalizing mode to the Gamma Correction, you will find much-visualized information on the water surfaces (Figure 6 b).

3.3.4) In the Landsat-7 visible spectrum, clearer water reflects less than turbid water. In the Near IR (B4) and visible bands, water increasingly absorbs the light making it darker. It depends

on water depth and wavelength, as increasing amounts of dissolved inorganic materials in water bodies tend to shift the peak of visible reflectance toward the red region from the green region (clearer water) of the spectrum.

3.3.5) Applying the "Edit Image Layer Mixing" dialog box of eCognition, based on B1, B3, B24, B5, B27, and B8 bands combined with the Gamma Correction parameters is very helpful when you intend to pick out the land from water.

Step 4: Landsat-7 Water Ratioing

A very useful image processing technique is band rationing. For each pixel, there is the possibility to divide the digital number (DN) value of any one band by the value of another band. You can rescale these resulting ratio values to provide gray-tone (even colorful) images, in which you can reach higher levels of information, depending on the eCognition algebra computation power.

4.1) To start, right-click inside the Process Tree, and select Append New. When the Edit Process dialog box opens, give a name as Water Rationing and click on the OK option as Figure 7.

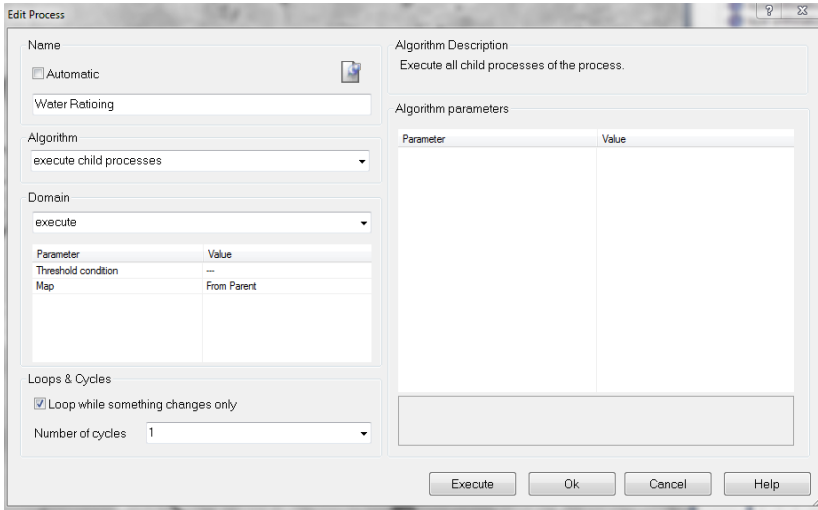
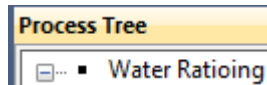


Figure 7: The Edit Process dialog box saved as Water Rationing



4.2) Then, right-click on **Water Rationing** and, from the list appears, the insert child option. When the Edit Process dialog box opens, from the algorithms list, choose the "layer arithmetics" (1) and set up other options as Figure 8.

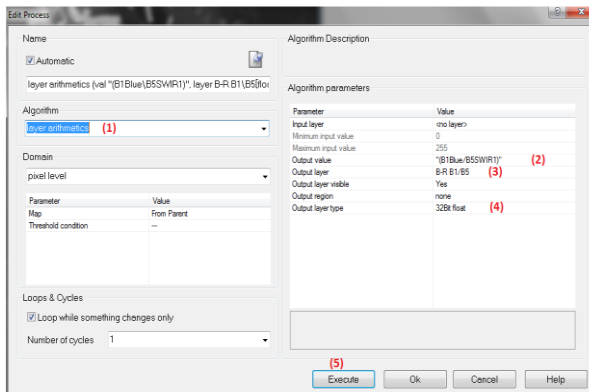



Figure 8: The Edit Process window; inserting a water rationing based on the "layer arithmetics functionality in the eCognition software

4.3) First, set a ratio equation, for example, "(B1Blue/B5SWIR1)" in the Output Value option (2). For the Output Layer, type a name, for example, "B-R B1/B5" (3). Then, the Output Layer Typeset "32Bit float" option (4). Finally, click on the Execute key (5) to run the rationing algorithm.

4.4) When the ratio equation finishes, from the menu bar, click on the Edit Image Layer Mixing icon  to open its dialog box. Now you can set to the output layer mode. Once again, repeat the above-mention procedure for another band rationing, for example, "(B3Red/B4NIR)" to extract another water component.

4.5) When you insert different water rationing algorithms inside the Process Tree, it looks like Figure 9.

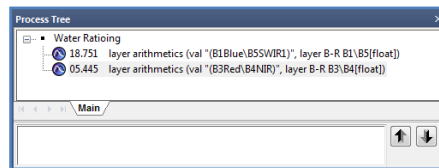


Figure 9: The Process Tree, two water ratios algorithms

4.6) The results of two different water ratios are illustrated in Figure 10 (a & b).

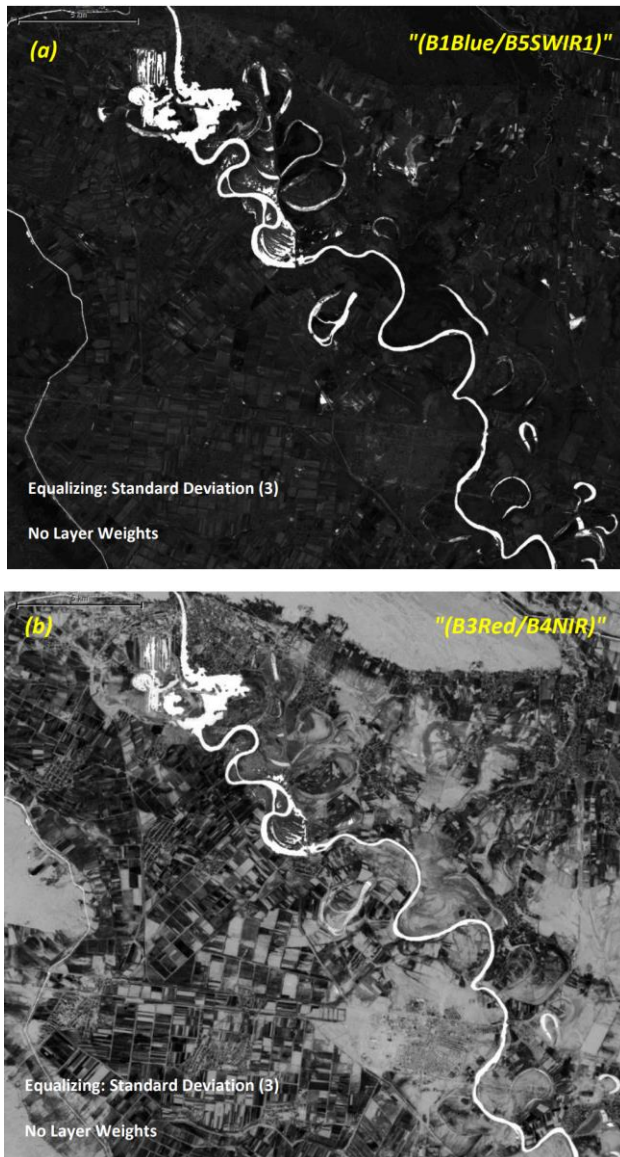


Figure 10: Examples of band rationing to extract other water components around the Kura River

4.7) Hence, the NIR band is better than SWIR1 and SWIR2 for water extraction. Another band's spectral image of Landsat-7 reveals large contrast between water and non-water bodies.

4.8) inside the eCognition, there are more algebra algorithms to combine and permute the Landsat 7 bands (for example, 1-5,7) in more than 20 RGB combinations. You may observe that contrast increased with bands in different spectral regions and using the bands 5,7,3 as the numerator for Landsat 7 and bands (6,7,4). In addition, you could apply thresholding methods to the resulting ratio files to get much more accurate information on the water surfaces.

Sum Up:

Earth's surface has undergone various landcover/landuse changes in recent years. Detecting these changes or specific classes such as farmland, forest, urban, and water has been important in various studies. However, these changes are slow and take a long time, and thus, they are unnoticed unless they occur to large extents. Long historical data, such as Landsat-7, provides concrete evidence to the scientific community to detect, understand, and prevent these changes. In the first step, Surface water is a very vital resource in everyday life; some of its uses are for drinking, irrigation, aquaculture, and thermoelectric cooling. Surface water is also a good indicator of landcover changes in environments affected by climatic and anthropogenic activities.

Informative Practises

Tips:

- 1) At an altitude of 705 km, a full surface scan by Landsat 7 takes 232 turns or 16 days. According to local solar time, the terrain survey takes place at approximately 10 am (\pm 15 minutes).
- 2) You can fuse (combine) Landsat-7 bands, particularly Panchromatic B8, with other sensor data to enhance your reachers approaches.
- 3) You could process the Landsat-7 images to preserve land monitoring studies, monitoring of vegetation, soil, and water cover, as well as observation of inland waterways and coastal areas.

Workouts:

- 1) Clarify the difference between TM and ETM+ sensors.
- 2) Download a set of Landsat-7 imagery for a region where you live.
- 3) Moisture Stress Index (MSI (Landsat 4 – 7) = $B5 / B4$) is applied for canopy stress analysis, productivity prediction, and biophysical modeling. Apply this index for your selected Landsat imagery.

Quizzes:

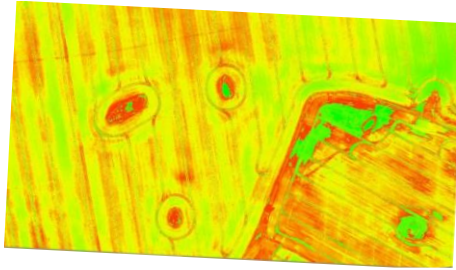
- 1) What sorts of band combinations are suitable for demonstrating fired lands?
- 2) Which bands of Landsat-7 have the highest spatial resolutions?
- 3) How many Landsat satellites are there in space?

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- 4) Etter, M. P. (1990). Viewing the Earth: The Social Construction of the Landsat Satellite System (Inside Technology), The MIT Press.
- 5) Holm, T. (2013). "Landsat: Building a Future on 40 Years of Success - Status: Landsat 7," 12th Annual JACIE (Joint Agency Commercial Imagery Evaluation) Workshop, St. Louis, MO, USA.
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Tutorial 5

Landcover Spectral Indexing inside eCognition



indices key-signs in the landcover identification

Opening Statement:

In the current tutorial, you will learn to generate spectral indicators captured by Landsat-8 imagery applying the eCognition software computational methods that offer qualitative information about the ground surfaces. You will cover creating spectral indices by highlighting vegetation and water features in the SariSu Lake region, Aran Rayon, in Azerbaijan to emphasize the "Image Object Information" and "Feature View windows " roles as key entries to the OBIA procedures.

Instructive Memo:

- ✓ Level: Beginner and Intermediate
- ✓ Time: This tutorial should not take you more than 1.5 hours.
- ✓ Software: The eCognition Developer software (Version 9.01),
- ✓ Data Sources: Landsat-8 Imagery, <https://glovis.usgs.gov/app>,
- ✓ Subject Scene: Sari-Su Lake, Kura River, Azerbaijan.

Tutor Objectives:

By the end of this unit, you should be able to:

- ✚ Understand Spectral Indices creation.
- ✚ Prepare the Landsat-8 imagery.
- ✚ Create spectral indices.
- ✚ Manage Customized Features inside the eCognition.

Background Concepts:

Inside the eCognition software, it is possible to form many spectral indices by transforming spectral data using ratios between bands to reduce the data into meaningful information. Landcover features could be extracted using spectral indices ranging from vegetation, water, burned areas, snow, and among many others. These indices enhance data interpretation and are used in many scientific applications such as monitoring plant/crop health, delineating water bodies, calculating burn extents, spatial modeling, and even climate change detection procedures.

While numerous spectral indices are available that emphasize some different landscape features, perhaps the most common spectral index is the normalized vegetation difference index (NDVI). You can use this index to detect vegetation density and health. NDVI could be derived from Equation $NDVI = (NIR - Red) / (NIR + Red)$. Where NIR is the near-infrared band and Red is the red band. Resultant values scale from -1 to 1, where positive values typically represent vegetation and (with denser vegetation closer to 1), and negative values represent no vegetation (bare soil, snow, water, etc.), as shown in Figure 1.

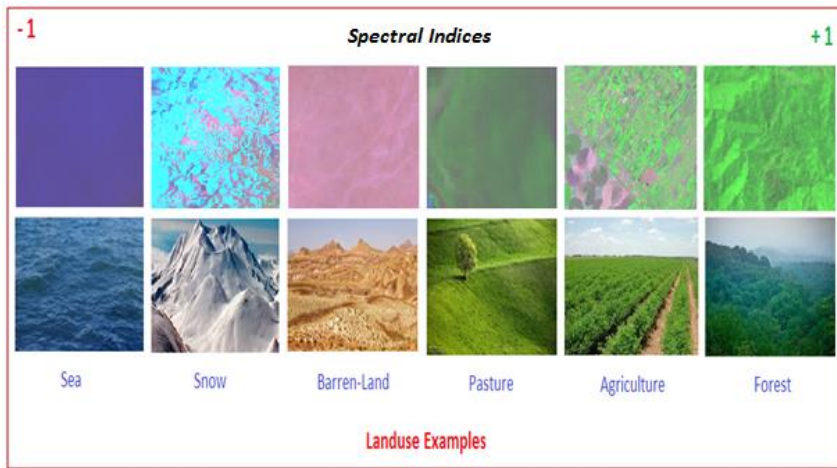


Figure 1: Representation of NDVI values scaled from -1 to +1 for different landcover types

The Subject Scene is part of the Aran Rayon, where the Sari-Su, the largest lake of Azerbaijan located in the Kur-Araz Lowland. This lake stretches along the Kura River from Imishli Rayon southeast to Sabirabad Rayon. It is one of the four lakes in the area mainly made up of wetlands and swamps, surrounded by rural residents and agricultural lands (Figure 2).

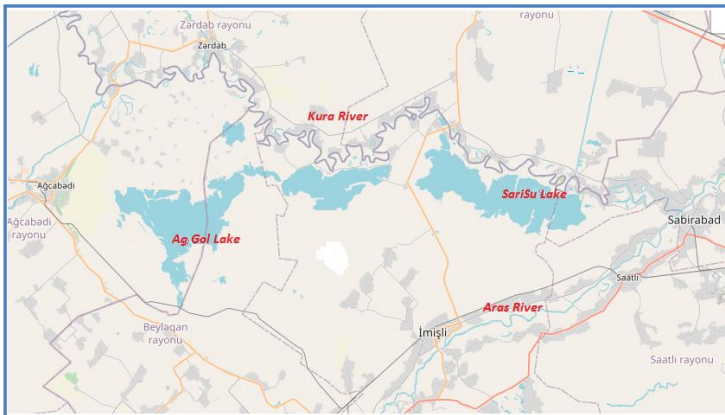


Figure 2: The Subject Scene, where the SariSu and Kura River are located

Mastering the Skills:

There are several methods in creating spectral indexes, some of which are presented in this tutorial. Before producing these indicators, you should note that you need to provide the required conditions for the indexing procedure inside eCognition.

Step 1: Landsat-8 Data Preparation

Landsat-8, a collaboration between NASA and the U.S. Geological Survey, provides moderate-resolution measurements of the Earth's terrestrial and polar regions in the visible, near-infrared, short wave infrared, and two thermal bands (Table 1). Every day, staff receive and process approximately 450 new Landsat 8 scenes. These scenes are available for download at no cost within 24 hours of acquisition.

Table 1: Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)

Band Numbers	Band Characters	Wavelength (micrometers)	Resolution (meters)
1	Coastal aerosol	0.43-0.45	30
2	Blue	0.45-0.51	30
3	Green	0.53-0.59	30
4	Red	0.64-0.67	30
5	Near Infrared (NIR)	0.85-0.88	30
6	SWIR 1	1.57-1.65	30

Band Numbers	Band Characters	Wavelength (micrometers)	Resolution (meters)
7	SWIR 2	2.11-2.29	30
8	Panchromatic	0.50-0.68	15
9	Cirrus	1.36-1.38	30
10	Thermal Infrared (TIRS) 1	10.6-11.19	100
11	Thermal Infrared (TIRS) 2	11.50-12.51	100

1.1) As you learned in the previous steps, download Landsat-8 images from the relevant site (Glovis) and manage them to TIF format.

1.2) Import Landsat-8 bands into the eCognition 9.01 setting. Enter only the required bands (2-8) into the software environment to create water and vegetation indexes.

1.3) Inside the eCognition software, create a required project and save data in a specific path and folder. You may need to review the previous tutorials for more details.

Step 2: Basic Spectral Indexes

2.1) There are many spectral indices that you may like to analyze various aspects of vegetation, water resources, snow, soil, fire, among others, inside the eCognition setting.

Table 2: The main spectral indices adjusted for Landsat-8 bands

Index	Formula	Correspond Used
Normalized Difference Vegetation Index	$NDVI = (B5 - B4) / (B5 + B4)$	NDVI is highly associated with vegetation content. High NDVI values correspond to areas that reflect more in the near-infrared spectrum.
Normalized Difference Water Index	$NDWI = (B3 - B5) / (B3 + B5)$	This index is used for water bodies analysis and can enhance water information efficiently in most cases. It is sensitive to the buildup of land and results in over-estimated water bodies.
Green Normalized Difference Vegetation Index	$GNDVI = (B5 - B3) / (B5 + B3)$	It is a modified version of NDVI to be more sensitive to the variation of chlorophyll content in the crop.
Enhanced Vegetation Index	$EVI = 2.5 * ((B5 - B4) / (B5 + 6 * B4 - 7.5 * B2 + 1))$	EVI corrects for some atmospheric conditions and canopy background noise and is more sensitive in areas with dense vegetation.
Advanced Vegetation Index	$AVI = [B5 * (1 - B4) * (B5 - B4)]^{1/3}$	It is used in vegetation studies to monitor crop and forest variations over time.
Soil Adjusted Vegetation Index	$SAVI = ((B5 - B4) / (B5 + B4 + 0.5)) * (1.5)$	SAVI is used to correct NDVI for the influence of soil brightness in areas where vegetative cover is low.
Normalized Difference Moisture Index	$NDMI = (B5 - B6) / (B5 + B6)$	NDMI is used to determine vegetation water content.
Green Coverage Index	$GCI = (B5 / B3) - 1$	The Green Chlorophyll Index is used to estimate leaf chlorophyll content in various species of plants.
Normalized Burned Ratio Index	$NBRI = (B5 - B7) / (B5 + B7)$	This index highlights forest fires that are severe artificial or natural phenomena that destroy natural resources, livestock and unbalance local environments.
Bare Soil Index	$BSI = (B6 + B4) - (B5 + B2) / (B6 + B4) + (B5 + B2)$	BSI combines blue, red, near-infrared, and short wave infrared spectral bands, to capture soil variations.
Normalized Difference Snow Index	$NDSI = (B3 - B6) / (B3 + B6)$	NDSI shows snow cover over land areas. Since snow absorbs most of the incident radiation in the SWIR while clouds do not, NDSI can distinguish snow from clouds.
Normalized Difference Glacier Index	$NDGI = (B3 - B4) / (B3 + B4)$	This index helps detect and monitor glaciers using the green and red spectral bands.

2.2) In Table 2 summarised a compilation the formulas and conceptualizes of the main spectral indices adjusted for Landsat-8.

Step 3: Setting the eCognition Outline

3.1) Start the eCognition software and create the required initial image based on the different band combinations.

3.2) Now, you need to set the main functional windows as View Settings, Process Tree, Image Object Information, and Feature View, as illustrated in Figure 3.

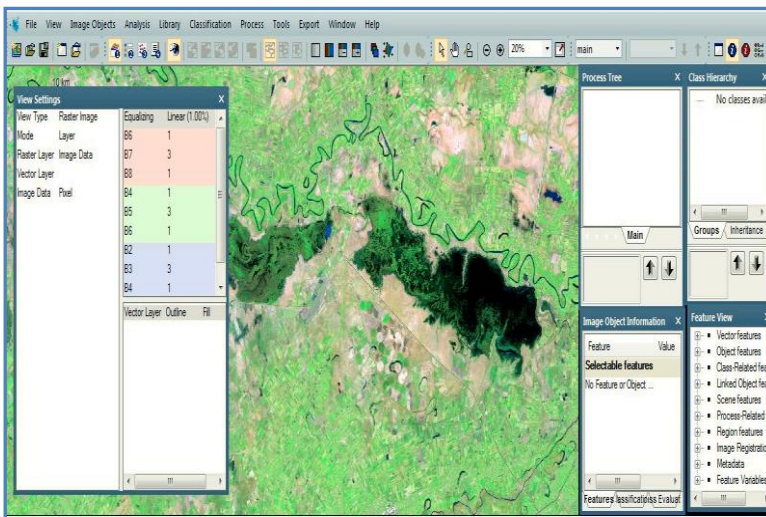


Figure 3: the eCognition main dialog boxes setting Landsat-8 band combinations

Step 4: Indices by Arithmetic Algorithm

4.1) When you set the Landsat-8 imagery, the first opportunity is to apply the Layer Arithmetic Algorithm to execute equations that could help you create popular well-known spectral indices of $NDVI = (NIR_{B5} - Red_{B4}) / (NIR_{B5} + Red_{B4})$ and $NDWI =$

$(Green_{B3} - NIR_{B5}) / (Green_{B3} + NIR_{B5})$. The procedure below also guides you through creating any spectral index applying the arithmetic customized feature.

4.2) Inside the eCognition, right-click in the Process Tree and select the Layer Arithmetic algorithm. Set up all parameters and options as you notice in Figure 4.

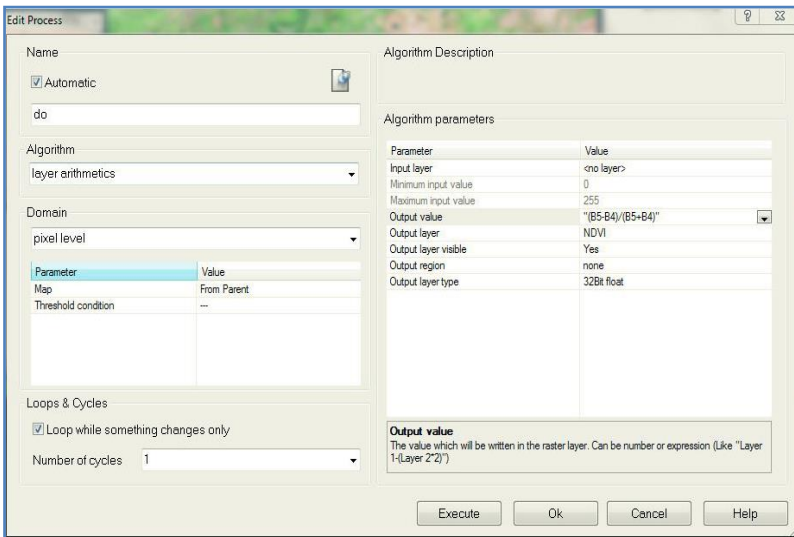


Figure 4: The Edit Process dialog box, setting up the Layer Arithmetic algorithm parameters

4.3) Click on the Execute option and wait for a second to finish the process. Soon you will notice the NDVI layer created.

4.4) Click on the Edit Image Layer Mixing and set it up, as you can see in Figure 5. Then, click on the OK option to notice your desired NDVI layer.

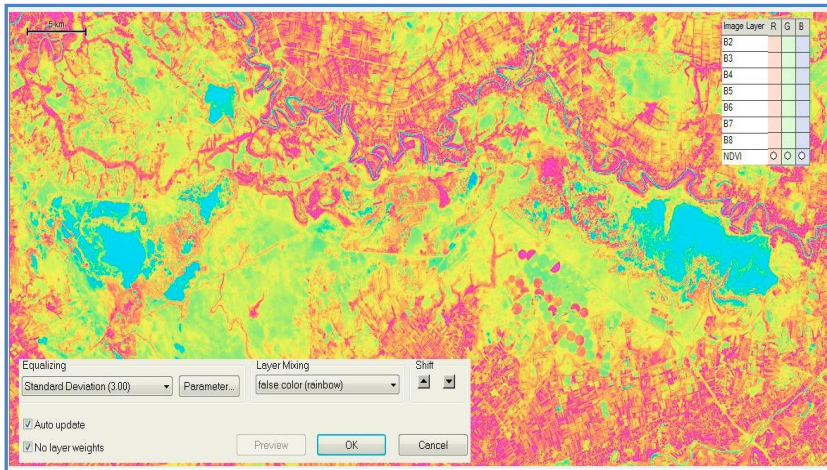


Figure 5: The resulting NDVI layer, based on linear equalizing and false-color layer mixing options

4.5) Throughout the subsetted area, because near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs), the vegetation index is clearly illustrated for quantifying the amount of vegetation. Water surfaces are shown in blue color, and areas without or little vegetation in the range of yellow colors are quite clear.

4.6) Repeat the above-mentioned steps (4-2 to 4-5) this time to create the NDWI index. Keep in mind the needed changes required to apply the corresponding formula.

4.7) As you notice, the NDWI index is ideal for water bodies analysis and can enhance water information efficiently in most cases. It is sensitive to the buildup of land and results in over-estimated water bodies. In Figure 6, the blue false-red surfaces are completely recognizable.

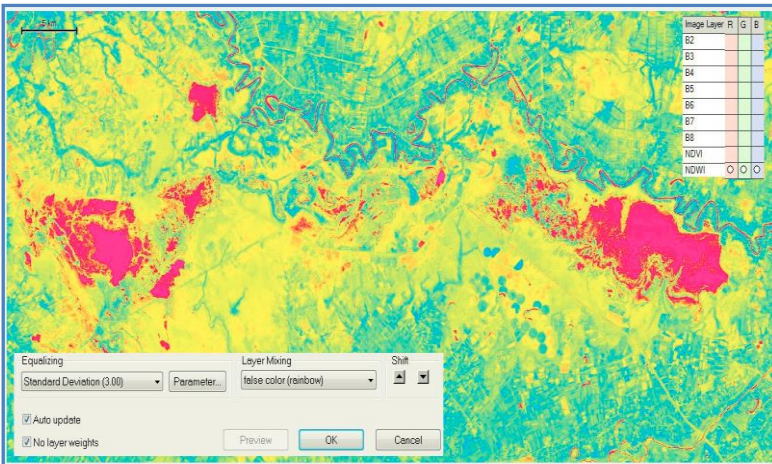


Figure 6: The resulting NDWI layer, based on linear equalizing and false-color layer mixing options

4.8) You can even clearly see the vegetation expansion inside the Sarisu Lake and river forms (meanders and oxbows) alongside the Kura River.

4.9) When you conclude spectral indexing inside the eCognition 9.01, your Process Tree looks like Figure 7.

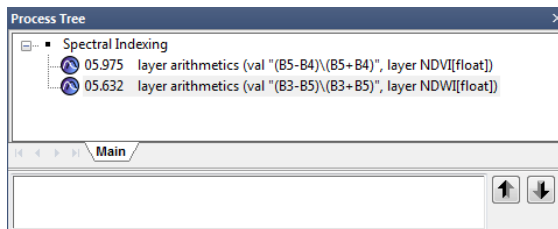


Figure 7: Process Tree, Spectral Indices defined

Step 5: Manage Customized Features

Customized tools are eCognition features to create and adapt to your needs. They can be arithmetic or relational features that depend on other existing features. All customized features are based on the features shipped with eCognition Developer 9.0

and newly created customized features. The Manage Customized Features dialog box allows you to add, edit, copy, and delete customized features. It enables you to create new arithmetic and relational features based on the existing ones.

5-1) Arithmetic Features

5.1.1) Arithmetic features are existing features, variables, and constants combined via arithmetic operations. Arithmetic features can be multiple but apply only to a single object.

5.1.2) To open the Manage Customized Features dialog box, do one of the following:

5.1.2a) On the menu bar, click on Tools and select Manage Customized Features.

5.1.2b) Or right-click on the "Image Object Information" dialog box and click on the Manage Customized Features option (Figure 8).

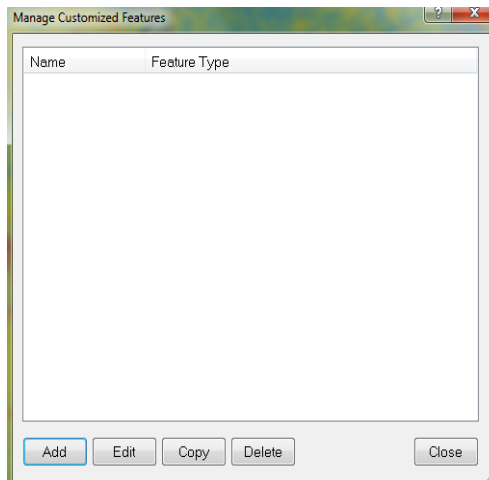


Figure 8: Manage Customized Features dialog box

5.1.3) Click Add to create a new customized feature. The Customized Features dialog box will open, providing you with tools to create arithmetic and relational features (Figure 9).

5.1.4) To edit a feature, select it and click edit to open the Customized Features dialog box. Click Copy or Delete options to copy or delete a feature.

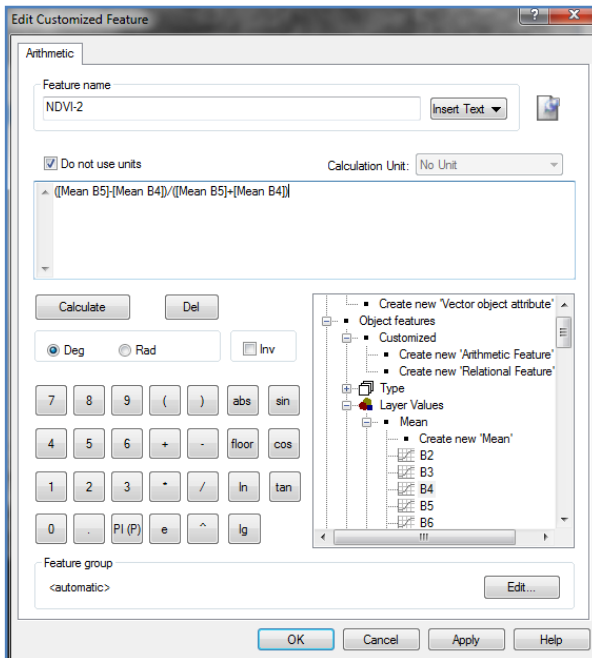


Figure 9: Creating an arithmetic feature in the Customized Features dialog box

5.1.5) To create an arithmetic customized feature, select Object Features > Customized > Create New Arithmetic Feature. Then, In the Feature View window, double-click on Create New Arithmetic Feature and Insert a name (for example, NDVI-2) for the customized feature to be created.

5.1.6) Use the calculator to create the arithmetic expression. You can type in new constants to select features or variables in the feature tree on the right.

5.1.7) Choose arithmetic operations or mathematical functions. The expression you create is displayed in the text area above the calculator. To calculate or delete an arithmetic expression, highlight the expression with the cursor and click either Calculate or Del as appropriate.

5.1.8) You can switch between degrees (Deg) or radians (Rad) measurements and invert the expression. If you want to create the new feature, click Apply, create the feature without leaving the dialog box, or OK to create the feature and close the dialog box (Figure 10).

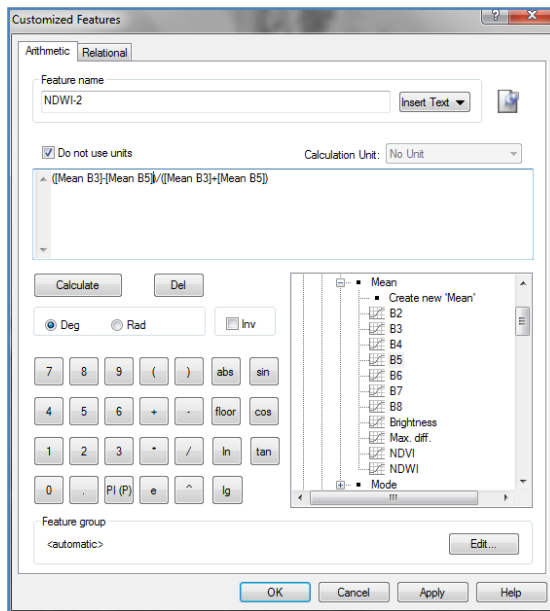


Figure 10: An modified arithmetic feature in the Customized Features dialog box

5.1.9) The initial black and white maps of vegetation and water indices are illustrated in Figure 11.

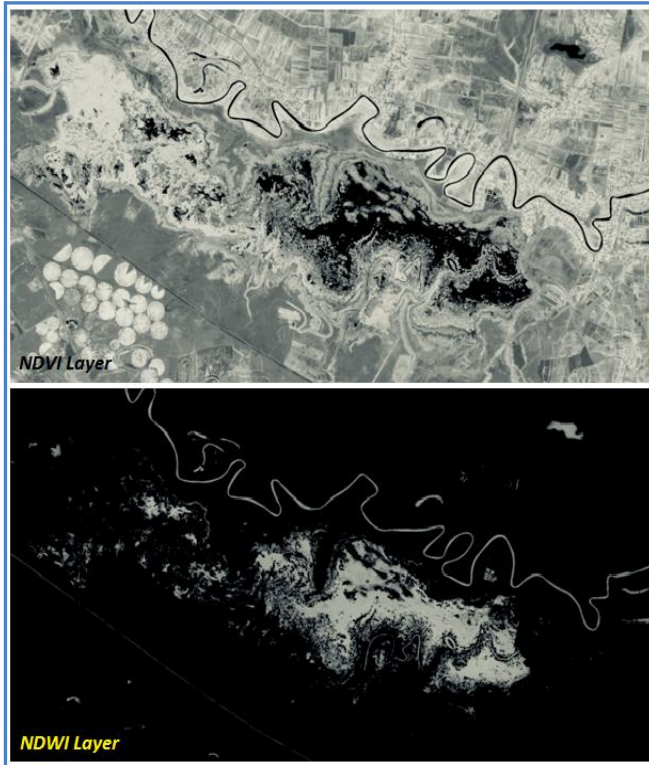


Figure 11: Black and white maps of NDVI-2 and NDWI-2 spectral indices created through an Arithmetic Customized Feature method

5.1.10) After creating NDVI and NDWI indices, you can find the new arithmetic feature in the Image Object Information window or the Feature View window under Object features > Customized options.

5-2) Relational Features

Relational features are used to compare a particular feature of one object to those of related objects of a specific class within a specified distance. Related objects are surrounding neighbors,

sub-objects, super-objects, or whole image object levels. Relational features are composed of only a single feature but refer to related objects. We will outline this subject during the coming tutorials when the learners become more familiar with the nature and structure of segmented objects. In the following tutorials, we will again discuss these topics in more detail.

Step 6: Image Object Information Window

When analyzing individual images or developing rule sets, you will need to investigate single image objects. The Features tab of the Image Object Information window is used to gain information on a selected image object.

6.1) Image objects consist of spectral, shape, and hierarchical elements. These elements are called features in eCognition Developer 9.0. The Feature tab in the Image Object Information window displays the values of selected attributes when an image object is selected from within the map view. The Image Object Information window is open by default but can also be selected from the View menu if required.

6.2) To get information on a specific image object, click on an image in the map view (some features are listed by default).

6.3) To add or remove features, right-click the Image Object Information window and choose Select Features to Display. The Select Displayed Features dialog box opens, allowing you to select a feature of interest (Figure 12).

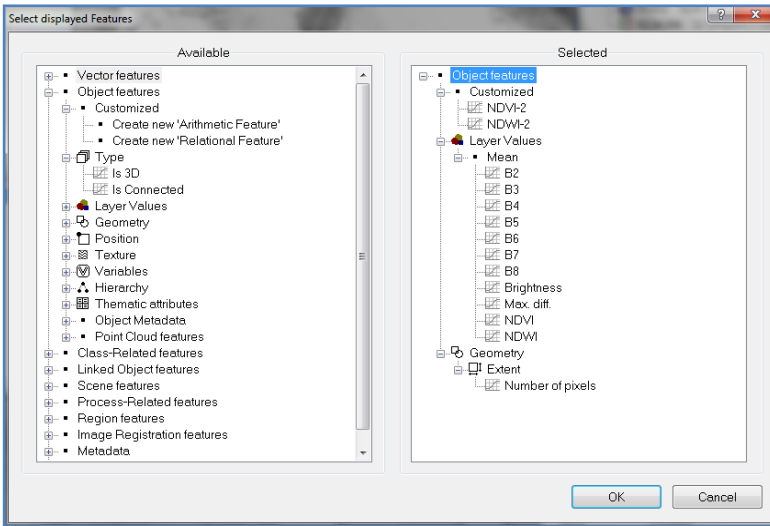


Figure 12: The Select Features to the Display dialog box

6.4) The selected feature values are displayed in the map view. To compare single image objects, click another image object in the map view, and the displayed feature values are updated (Figure 13).

Feature	Value
Image Object Rel...	
Object features	Customized
NDVI-2	0.4100
NDWI-2	-0.3735
Layer Values	
Mean	
Brightness	11504.08
B2	10196.25
B3	9765.10
B4	8959.65
B5	21410.85
B6	12038.05
B7	8780.65
B8	9378.04
Max. diff.	1.098
NDVI	0.4099
NDWI	-0.3735
Geometry	
Extent	
Number of pixels	80

Figure 13: The Image Object Information window

6.5) Double-click a feature to display it in the map view; click it in the map view a second time to deselect a selected image object. If the processing for image object information takes too long, or if you want to cancel the processing for any reason, you can use the Cancel button in the status bar.

Step 7: Feature View Window

Image objects have spectral, shape, and hierarchical characteristics and these features are used as sources of information to define the inclusion-or-exclusion parameters used to classify image objects.

7.1) There are two major types of features. First, the Object features are attributes of image objects (for example, the area of an image object). And Global features that are not connected to an individual image object (for example, the number of image objects of a certain class).

7.2) Available features are sorted in the feature tree, displayed in the Feature View window (Figure 14). It is open by default but can also be selected via Tools > Feature View or View > Feature View.

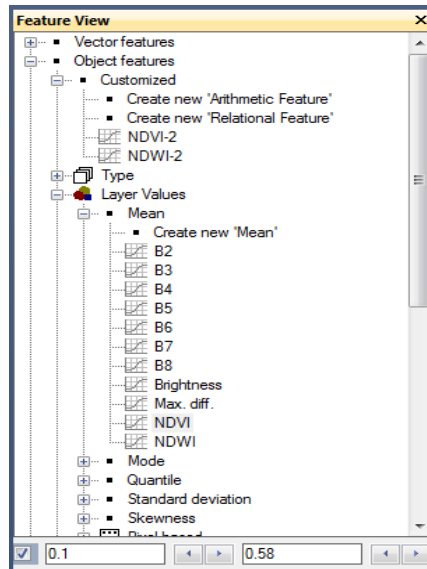


Figure 14: The Feature View window

Sum Up:

In the current tutorial, you have attended to process the Landsat-8 images inside the eCognition to determine various spectral indices, particularly vegetation and water indices. The tutorial added a brief overview of functions to your current experiences in OBIA learning procedures. For more details, notice the contents of the next tutorial. Spectral indexing is also very important for effectiveness related to the landcover/landuse applications as:

- ❖ monitoring plant growth,
- ❖ landcover and forests monitoring,
- ❖ providing information on pollutions,
- ❖ detecting lakes and coastal changes,
- ❖ mud-volcanic eruptions,
- ❖ landslides modeling, and disaster mapping
- ❖ flash-floods monitoring, and watershed modeling.

Informative Practises

Tips:

- 1) The Normalized Difference Vegetation Index (NDVI) is a simple numerical indicator that you can use to analyze remote sensing measurements. NDVI is related to vegetation, where healthy vegetation reflects very well in the near-infrared part of the spectrum.
- 2) Index values can range from -1.0 to 1.0, but vegetation values typically range between 0.1 and 0.7. Freestanding water (ocean, sea, lake, river, etc.) gives a rather low reflectance in both spectral bands and thus result in very low positive or even slightly negative NDVI values.
- 3) Soils that generally exhibit a near-infrared spectral reflectance are somewhat larger than the red, thus generating rather small positive NDVI values (say 0.1 to 0.2).

Workouts:

- 1) Clarify the difference between GNDVI and EVI Indices.
- 2) Download a set of Landsat-8 imagery for a region where you live.
- 3) Try to create the basic domain spectral indices in the region.

Quizzes:

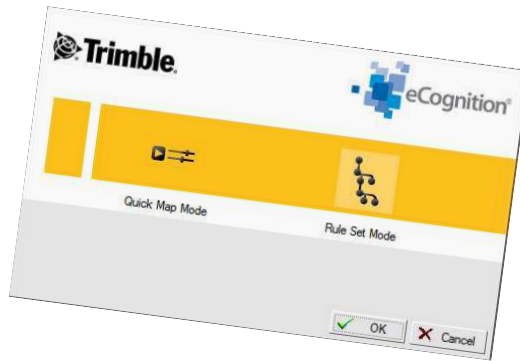
- 1) What sorts of indices are suitable for demonstrating fired lands?
- 2) What is the basic functionality of the Image Object Information window?
- 3) How could you use the Feature View window for the thresholding aims?

Allied References:

- 1) Flanders, D., M. Hall-Beyer, and J. Pereverzoff. (2003). Preliminary evaluation of eCognition object-based software for cut block delineation and feature extraction. *Can J Remote Sens* 29(4):441–52.
- 2) Fuentes, S. R. de Bei, J. Pech, and S. Tyerman (2012). Computational water stress indices obtained from thermal image analysis of grapevine canopies," *Irrigation Science*, vol. 30, no. 6, pp. 523–536.
- 3) Liu, B.; Chen, J.; Chen, J.; Zhang, W. (2018). Landcover Change Detection Using Multiple Shape Parameters of Spectral and NDVI Curves. *Remote Sens.*, 10, 1251.
- 4) McFeeters, S. K. (1996). The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features," *International Journal of Remote Sensing*, vol. 17, no. 7, pp. 1425–1432.
- 5) Rasouli, A.A., and Mammadov, R. (2020). *Preliminary Satellite Image Analysis Inside the ArcGIS Setting*, Lambert Academy Publishing, Germany.
- 6) Vermote, E., Justice, C., Claverie, M., & Franch, B. (2016). Preliminary analysis of the performance of the Landsat 8/OLI land surface reflectance product. *Remote Sensing of Environment*, 185, 46-56.

Tutorial 6

Quick Look to the eCognition's OBIA Capabilities



Any eCognition remains a powerful environment for OBIA.

Opening Statement:

The current tutorial introduces the basic functionality of the eCognition 9.01 that you will encounter and process the Landsat-8 imagery. To reach the main skills inside the Software, step-wisely, at the first step, you will load the raster data and create a new project. By subsetting, a small part of the Landsat-8 imagery focused in the Greater Caucasus Mountains, on the North of Azerbaijan. The second step is to segment your image to create objects for the Nearest Neighbor classification, one of the basic OBIA operations inside the eCognition Software. At least you will learn how to calculate the classification accuracy and export the final classified layers to the GIS setting.

Instructive Memo:

- ✓ *Level:* Intermediate
- ✓ *Time:* This tutorial should not take you more than 1.5 hours.
- ✓ *Software:* The eCognition Developer, Version 9.01.

- ✓ *Data Sources:* Landsat-8, LC08_167032_2020-02-29 subsetting image.
- ✓ *Subject Scene:* North Azerbaijan, part of the Caucasus Mountains.

Tutor Objectives:

By the end of this unit, you should:

- ✚ Be familiar with the main functionalities of eCognition 9.01 software.
- ✚ Change the color composition of the displayed image.
- ✚ Create image objects in a common-used multiresolution segmentation algorithm.
- ✚ Classify the Landsat 8 imagery raster layers.
- ✚ Calculate the accuracy of classified maps.
- ✚ Export the results to the ArcGIS setting.

Background Concepts:

Trimble eCognition software exists to improve, accelerate and automate the interpretation of geospatial data. In eCognition, some real solutions are available for geospatial data analysts, giving full flexibility and power to solve even the most challenging remote sensing projects. Rather than going into too much detail too soon, you start with this tutorial rather than the theoretical chapters to get a feel for eCognition's user interface and its most basic features. eCognition Developer is a powerful development environment for object-based image analysis. It is used in earth sciences to develop rule sets for automatic remote sensing data analysis.

For this exercise, a small part of the Landsat-8 satellite image from the north of Azerbaijan has been selected, with the highest peak of "Bazarduzu" in the Greater Caucasus range at 4,466 meters above sea level. Landcover in this area mostly includes

snow zones, forest cover, pastures, agriculture, and lands affected by winter ice and snow patches (Figure 1).



Figure 1: The location of the current tutorial Subject Scene

Mastering The Skills:

Since eCognition stands on a new approach to image analysis, taking this short tutorial may sometimes make you feel as if you have been "thrown into the deep end." It is just what is intended. The purpose of the tutorial is to get a first impression of how to work with the eCognition traditional version, with a complex set of algorithms to reach the OBIA aims.

Step 1: Setting Up the eCognition Software

1.1) Start the eCognition 9.01 Software by clicking on

 eCognition Developer 64 to notice the Trimble eCognition start modes.

1.2) Select the Rule Set Mode option and click on the OK option.

1.3) The eCognition Software's main empty set appears.

Step 2: Creating a new project

2.1) From the "File" menu, choose "New Project" or click



in the toolbar.

2.2) Navigate to your working directory, for example, "E:\Satellite Images\S1-T6-North Azer\LC08_L1TP_167032_20210522". You may have your personnel directory setting.

2.3) Select all *.Tif image files you need and click on the OK button.

2.4) Inside the Create Project dialog box, you can edit or remove any band or bands that you do not need or may insert another raster layer.

2.5) For the current tutorial, you may keep the Landsat bands of 2, 3,4,5,6,7, 8 and a subset of a raster ALOS-Palsar DEM file as AP_05189_FBS_F0810_RT1, with 12.5-meter spatial resolution. Notice Table 1 to realize the Landsat 8 bands designations in the current tutorial.

Table 1: Landsat-8 bands designations

Band (s) Combination	Operation
2, 3, and 4	These bands are used to create a true-color band combination or normal RGB picture of the visible light. The basic aim of these filters is to create a visual map of the area.
4, 3, and 2	These bands show agricultural farms around the image. Dark Green in the picture indicates woods; greens are healthy plantations.
Bands 5,4,3	You could use a combination of these bands to create a false-colored image. To the bright red, band 4 is green, and band 3 is blue.
Bands 6 and 7	use different parts of shortwave infrared and are helpful in terms of monitoring rocks and soils. When analyzing the image, the spectrum is almost fully absorbed by

	water; it easily reflects the water sources. These bands are also employed for ecological and geological researches due to their properties. The geological band combinations allow specifying the areas of interest for future geological study.
Bands 7, 6, 4	indicate the vegetation: the dark-blue or black highlights water sources. Towns and urban areas are spread within white to cyan to purple ranges. If the image indicates red, this would mean the sensor has taken a picture of the volcano, forest fire, or solar panel field mentioned above are reflecting or radiating the whole spectrum of IR.
Band 8	A panchromatic band (black and white band) is one band that usually contains a couple of hundred nanometers bandwidth. The bandwidth enables it to hold a high signal noise, making the panchromatic data available at a high spatial resolution. This band also could be used in the image sharpening and fine segmentation processes.

2.6) When you have the Landsat-8 bands, you can select one or several bands to create a clearer picture of the landcover due to the specific needs of different research kinds. For example, it is possible to use false-color Images to enhance the visual appearance of the data. The opportunity given is to substitute the true color of the image with the color required as the following combinations:

2.7) To speed the processing procedure, you must first select the bands you need, as indicated in Table 1. Also, you can subset a small interest part of the image.

2.8) When you are happy with the image selection mode, click on the OK option. The new image project is created with Blue, Green, and Red bands.

Step 3: Creating Color Composition

3.1) Select "Image Layer Mixing" from the "View" menu or click



in the toolbar to open the layer mixing dialog.

3.2) Select the "Linear" option or "Standard Deviation" under "Equalizing" to apply a histogram stretch. And choose "six-layer mix" as "presets" and click "OK" to notice the image band color changes (Figure 2).

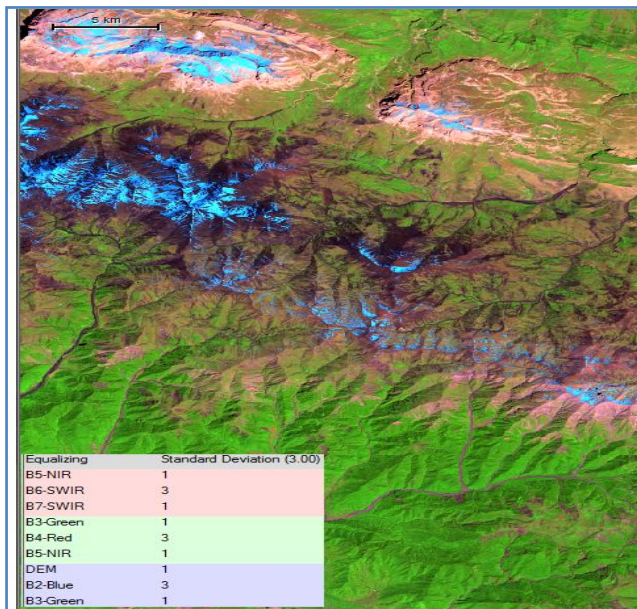


Figure 2: Image layer mixing as representing false-color

3.3) Choose "Edit Highlight Colors" from the "View" menu > Display Mode to change the highlight color setting. You may like to select red as the selected color. Click "Active View" to activate these highlight color settings.

3.4) From the File menu, select Save project in a working drive-by given a name, for example, North-Azer.dpr.

Step 4: Creating Image Objects

Now that you have created a project, you can make your first object-oriented image analysis as the main feature of eCognition. For this reason, the first step in eCognition is always to extract image object primitives (segments), which will become the building blocks for subsequent classifications. You will now produce such image objects with multiresolution segmentation that generates image objects at any chosen resolution.

4.1) Right-click inside the Process Tree and click on Append New; in the drop-down for Algorithm, select the multiresolution segmentation and set other segmentation parameters as the Figure 3. You may try different segmentations settings to find the best-fit image objects.

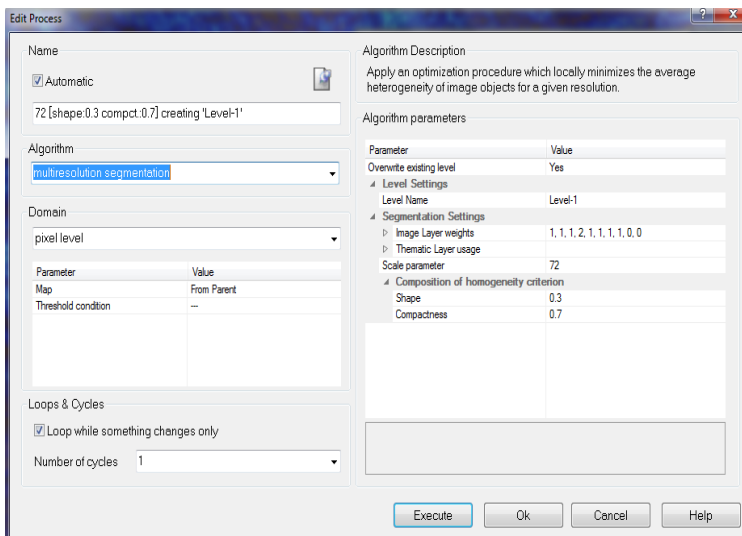


Figure 3: Edit Process dialog box, with an arbitrary segmentation parameters

4.2) From the "Segmentation" menu, choose "Multiresolution Segmentation and Domain with the pixel level.

4.3) Weight "B5-Near Infrared.tif" 2 in the field "and keep other bands with weights equal to 1.

4.4) Insert 72 in the field "Scale Parameter. Weight "Shape" with 0.3 and Compactness 0.7 in the "Composition of homogeneity criterion section.

4.5) Later, you might perform at least two more segmentation modes with varying scale, shape, and compactness parameters. State what parameters you used for the final segmentation and attach them to your report. You can ask yourself which layers to be used for creating Objects?

4.6) Remember that the basis of creating image objects is the input data. According to the data and the Algorithm you use, objects result in different shapes—the first thing you have to evaluate, which layers contain the important information. For example, In our case, we made double the weight of the NIR band for image object creation. Also, you need to know which scale parameter to be set. The 'Scale parameter' is an abstract term. It is the restricting parameter to stop the objects from getting to heterogeneity. For the 'Scale parameter,' there is no definite rule. You have to use trial and error to determine which 'Scale parameter' results in the objects are useful for your further classifications steps.

4.7) To start the segmentation process, click on the Execute button.

4.8) When the segmentation process is finished, there are different ways to display the image objects (Figure 4).

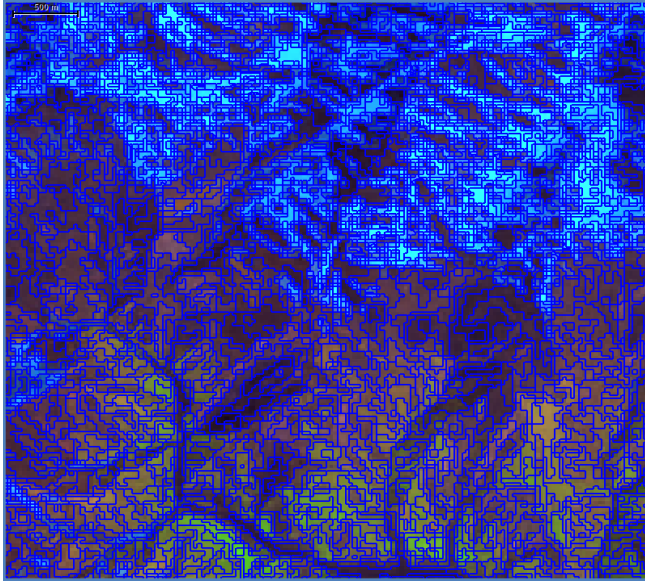




Figure 4: A part of a segmented image, displaying the image objects



4.9) By default, the image objects are transparent and highlighted only on mouse-click. To view the image objects colored in their mean value, click the  icon or change the view settings for image data from "Pixel" to "Object mean."


4.10) To view the borders of the objects, there are two possibilities in eCognition:

4.10.1) To show or hide the polygons, use the  button. Since polygons use memory, they should only be created if you use features based on polygons or skeletons in the later classification or exported vector files. You could use these icons




as you may need.

4.10.2) Use the  button to show or hide outlines without creating polygons first. However, it is possible to view the outlines in the color of the classification of the corresponding object. You can use the  button to show the outlines colored in the classification colors after classification is performed.

4.11) In this stage, you can right-click on the created segmented Level-1 inside the Process Tree and modify the segmentation process  02:33.926 72 [shape:0.3 compct.:0.7] creating 'Level-1' .

Step 5: Obtaining information about image objects

The "Image Object Information" dialog provides detailed information about the selected image objects and their features and classification. Since you have not classified the image, there is no classification information available yet.

5.1) Open the image object information dialog by clicking the  icon if it is not yet open.

5.2) Click an arbitrary image object (Figure 5).

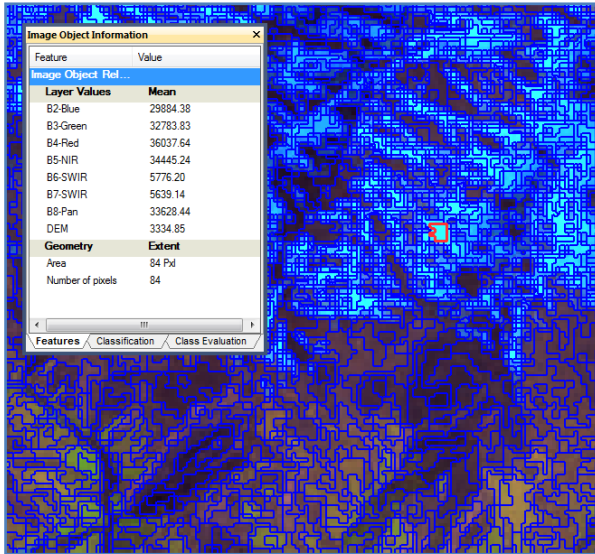


Figure 5: A segmented image and an Image Object Information box

5.3) Image Object Information window gives you all the necessary information about one object. When creating a class hierarchy, this dialog helps you find features that separate one class from another (Figure 6).

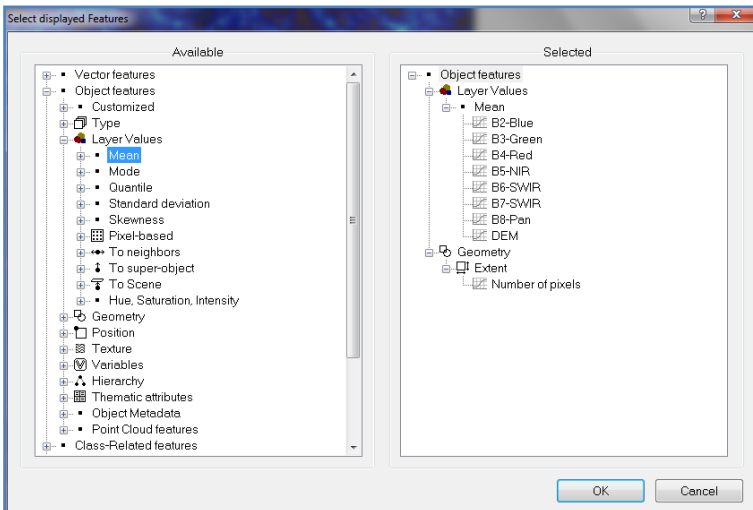


Figure 6: The Select displayed Features dialog box

5.4) Another tool that helps you with this task is the feature view. The featured view allows you to display one feature for all image objects. The image objects are rendered in gray values, corresponding to the feature value. The brighter an object is, the higher is its feature value for the selected feature.

5.5) From the "Tools" menu, choose "Feature View. Select the feature "Object features > Layer values > Mean > B2-Blue.tif" by double-clicking it. The objects will then be colored according to their feature value for the selected feature. A low weight value represents a high feature value; a high weight value a low feature value. You can also visualize features out of every other dialog where features are selected, such as the "Insert Expression" dialog or the "Select displayed Feature" dialog (Figure 7). In these cases, you open a pop-up menu with a right-click and select "Update range."

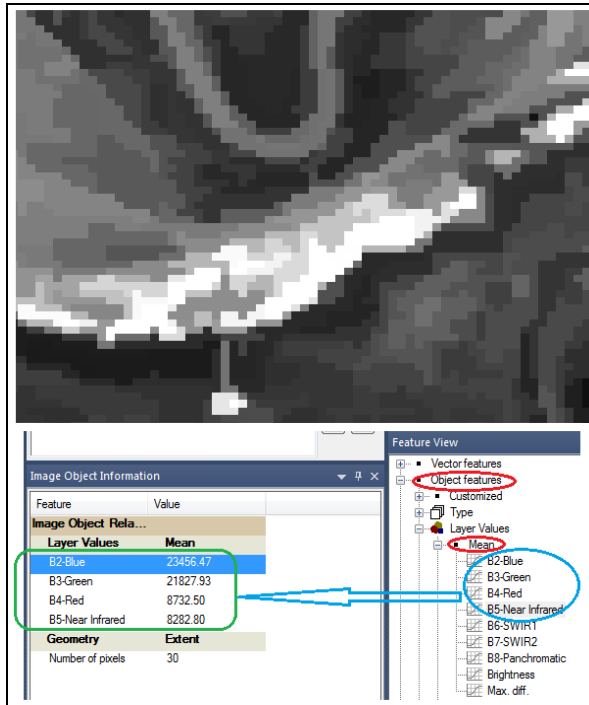


Figure 7: Image Object Information, based on Feature View

Step 6: Class Sampling Procedures

Up to now, you have extracted image objects and learned how to call up the information contained in them. You will use this information for classifying the previously segmented image objects. Before introducing the current uncomplicated classification process, you need to define the classes.

6.1) Right-click inside the Class Hierarchy box and select Insert Class (Figure 8).

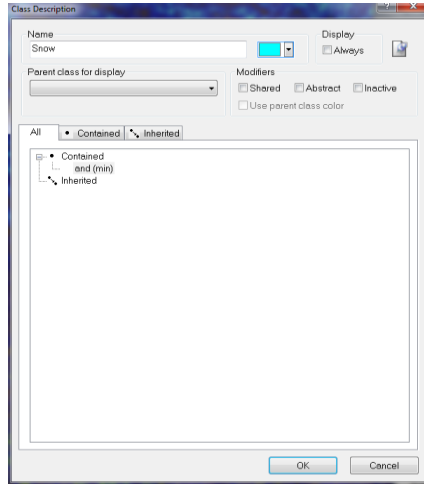


Figure 8: Class Description dialog box

6.2) Type Snow into the box for name and change the box for selecting colors to Blue, then click OK.

6.3) Repeat these steps for Agriculture, Barren, Forest, Pasture, Snow, Water, and Snow-Tracks (patches), a geomorphological pattern of snow and firn accumulation that lies on the surface longer than others seasonal snow covers. Make sure that you label and give the appropriate colors to all classes (Figure 9).

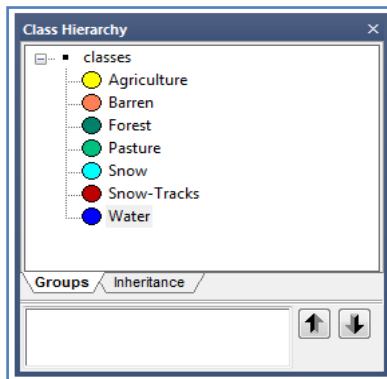


Figure 9: Class Hierarchy dialog box

6.4) On the toolbar, go to Classification → Samples → Select Samples (Figure 10).

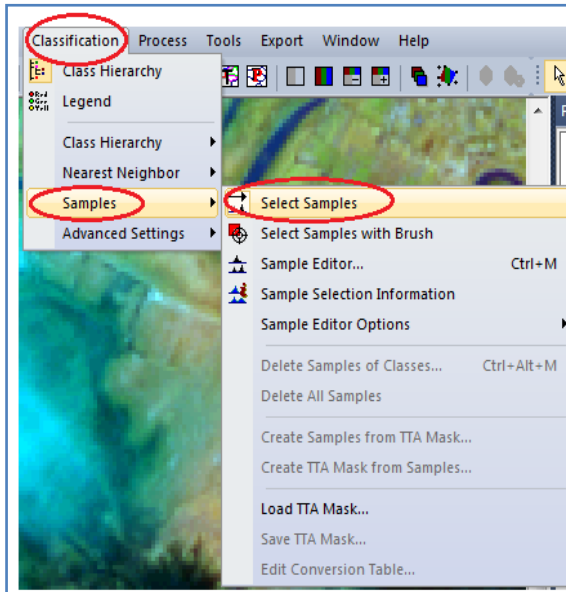


Figure 10: Selecting classification samples

6.5) Go to the Class Hierarchy box, click on the Snow class, and make sure it is highlighted. It makes you confident that your selections go to that class.

6.6) Zoom down to an area called Snow and double click inside the segments that overlay Snow areas or hold the shift key and click once in the segment. It will turn the segment to the color of the selected class. It is easier to figure out what plays with the segmentation tools shown in the image below (Figure 11).

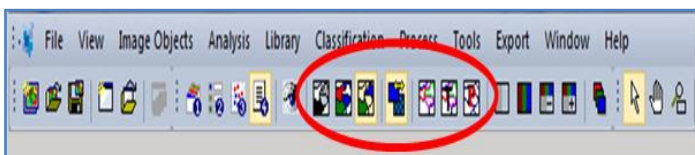


Figure 11: The Segmentation tools

6.7) Select at least 30 samples for each class and remember to select the class in the class hierarchy before selecting the samples for it.

Step 7: Checking Sampling Procedures

You can check your samples during and after the sampling process using two important tools.

7.1) First, you can apply the Sample Editor window, the principal tool for inputting samples. From the Classification, select menu Samples and then Sample Editor option. A selected class (for example, Snow class) shows histograms of selected features of samples in the currently active map. You can display the same values for other image objects (for instance, Snow-Tracks) at a certain level or all levels in the image object hierarchy (Figure 12).

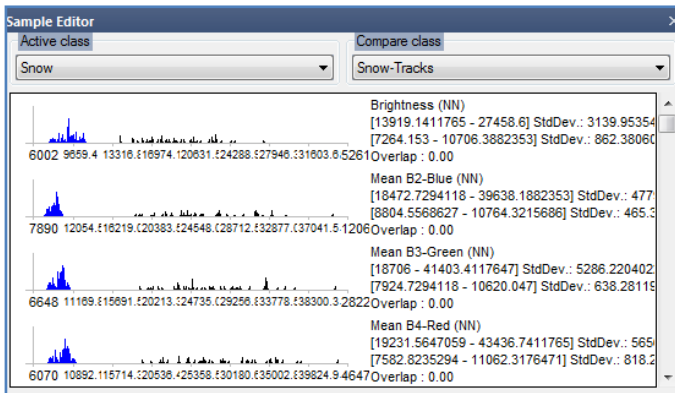


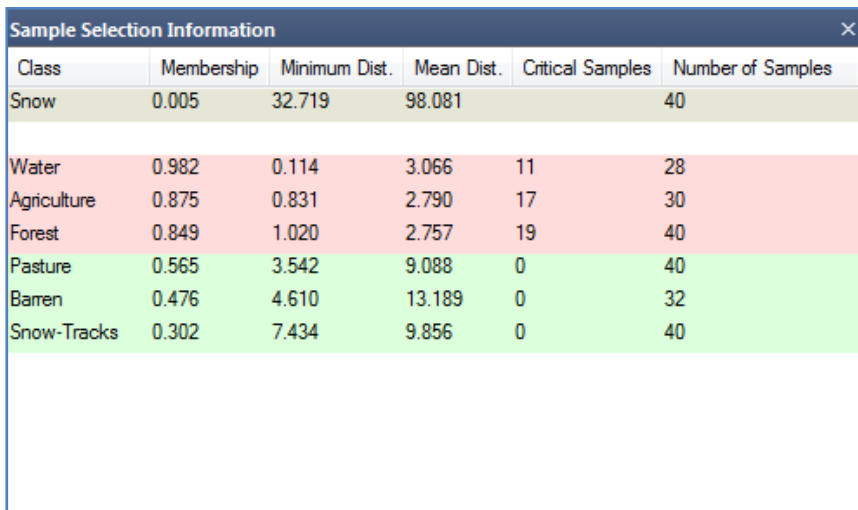
Figure 12: The Sample Editor window

7.2) You can use the Sample Editor window to compare the attributes or histograms of image objects and samples of different classes. It is helpful to get an overview of the feature

distribution of image objects or samples of specific classes. You can compare the features of an image object to the total distribution of this feature over one or all image object levels.

7.3) Also, once a class has at least one sample, You can assess the quality of a new sample in the Sample Selection Information window. It can help you decide if an image object contains new information for a class or belongs to another class.

7.4) To open the Sample Selection Information window choose Classification > Samples > Sample Selection Information or View > Sample Selection Information from the main menu (Figure 13).



Class	Membership	Minimum Dist.	Mean Dist.	Critical Samples	Number of Samples
Snow	0.005	32.719	98.081		40
Water	0.982	0.114	3.066	11	28
Agriculture	0.875	0.831	2.790	17	30
Forest	0.849	1.020	2.757	19	40
Pasture	0.565	3.542	9.088	0	40
Barren	0.476	4.610	13.189	0	32
Snow-Tracks	0.302	7.434	9.856	0	40

Figure 13: The Sample Selection Information window

7.5) Names of classes are displayed in the Class column. The Membership column shows the membership value of the Nearest Neighbor classifier for the selected image object.

7.6) The Minimum Distance column displays the distance in feature space to the closest sample of the respective class. The Mean Distance column indicates the average distance to all samples of the corresponding class.

7.7) The Critical Samples column displays the number of samples within a critical distance to the selected class in the feature space. The critical sample membership value can be changed by right-clicking inside the window. Select Modify Critical Sample Membership Overlap from the context menu. The default value is 0.7, which means all membership values higher than 0.7 are critical.

7.8) The Number of Samples column indicates the number of samples selected for the corresponding class. The following highlight colors are used for a better visual overview:

7.8.1) Gray: Used for the selected class.

7.8.2) Red: Used if a selected sample is critically close to samples of other classes in the feature space.

7.8.3) Green: Used for all other classes are not in a critical relation to the selected class.

Step 8: Classification Procedures

8.1) Once finished selecting and matching samples, go back up to classification → Nearest Neighbor → Edit Standard NN Feature Space.

8.2) Open up 'Object features' and double click on 'Layer Values' and click on OK (Figure 14).

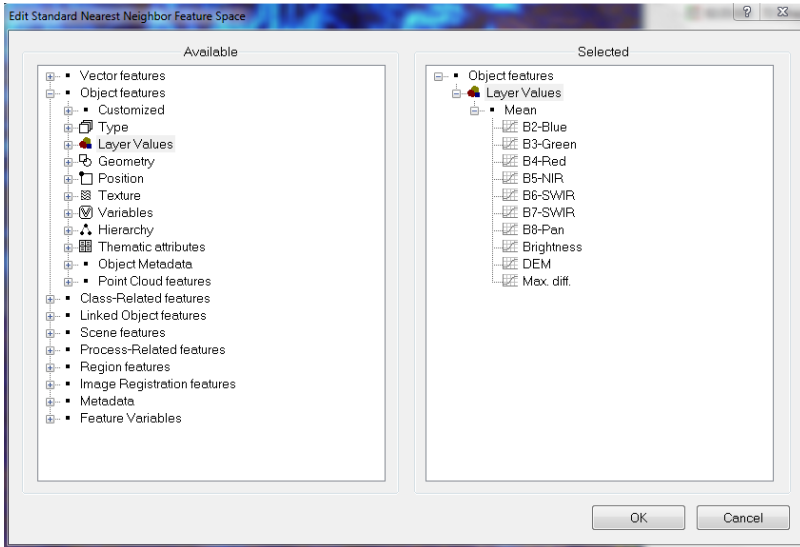


Figure 14: Edit Standard NN Feature Space dialog box

8.3) Go back to Nearest Neighbor and select Apply Standard NN to Classes. Click the All—>> button, then click OK (Figure 15).

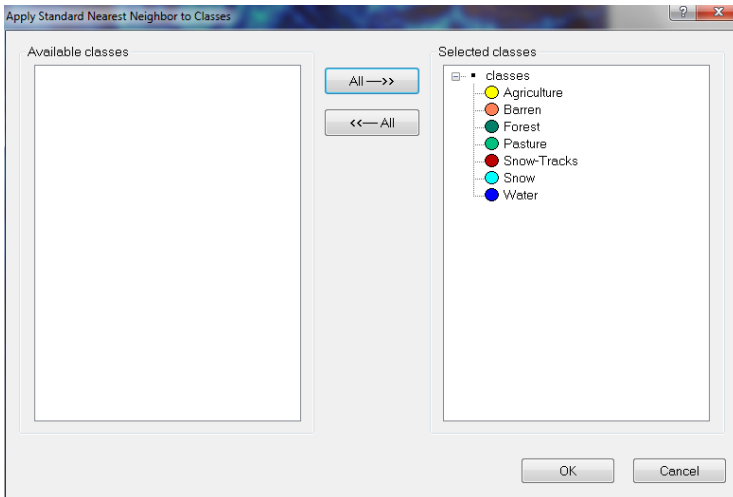


Figure 15: Apply Standard NN to the Classes dialog box

8.4) Right-click in the Process Tree box and click on Append New; select classification for the Algorithm drop-down menu (Figure 16).

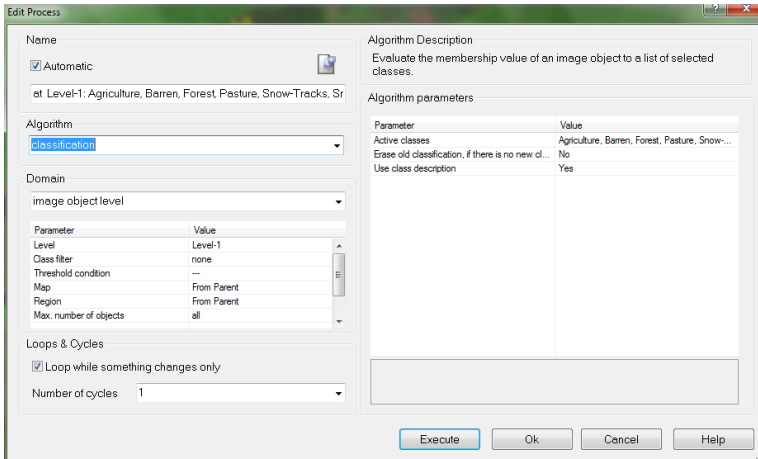


Figure 16: Edit Process, with its Classification algorithm

8.5) Then, inside the Edit Process dialog box for Active classes, change the none by clicking in the box to see the three dots, double-clicking on the field till the Edit Classification Filter appears.

8.6) Ensure that inside the Edit Classification Filter, every class besides Unclassified has a check (Figure 17).

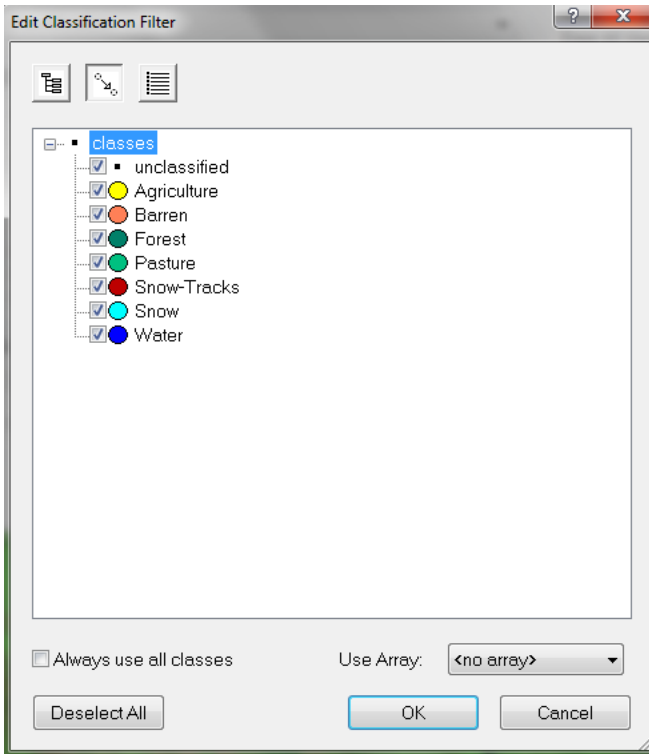


Figure 17: The "Edit Classification Filter" dialog box

8.7) In the Edit Classification Filter dialog box, click on the OK and then click Execute option in the Edit Process dialog box. After several minutes, the classified map appears, with all defined classes (Figure 18).

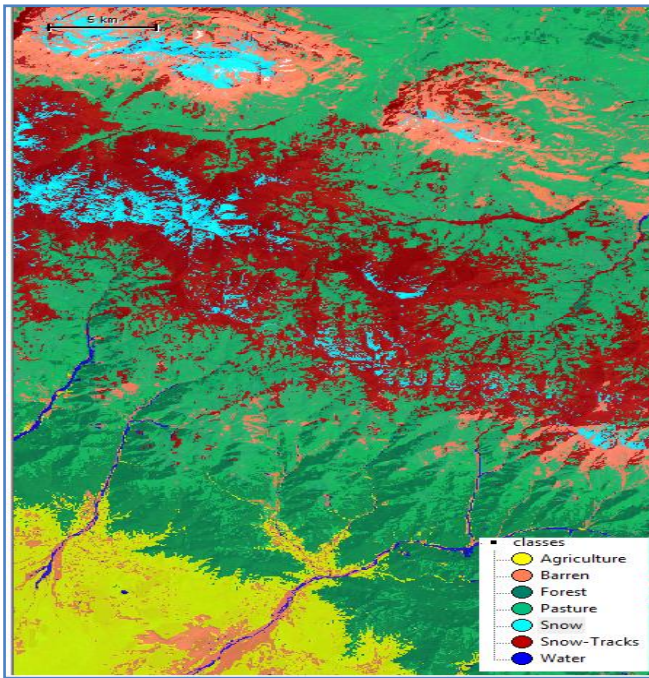


Figure 18: The final classified map

8.8) Before the classified results are exported, they need to be reviewed to ensure that everything worked correctly; to do this, we will experiment with the visualization options. View the following image for details on what each button does. Be sure to view your classification by clicking the Classification View button (Figure 19).

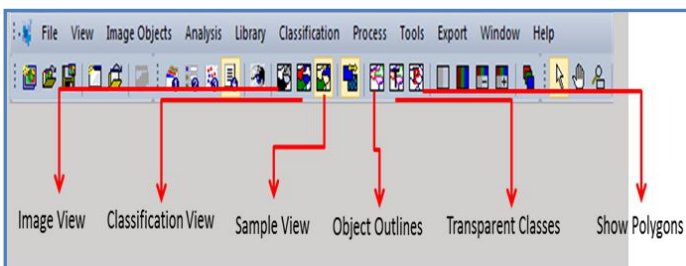


Figure 19: The visualization options

Step 9: Accuracy Assessment Tools

Accuracy assessment methods can produce statistical outputs to check the quality of the classification results. Tables from statistical assessments can be saved as .txt files, while you can export graphical results in raster format.

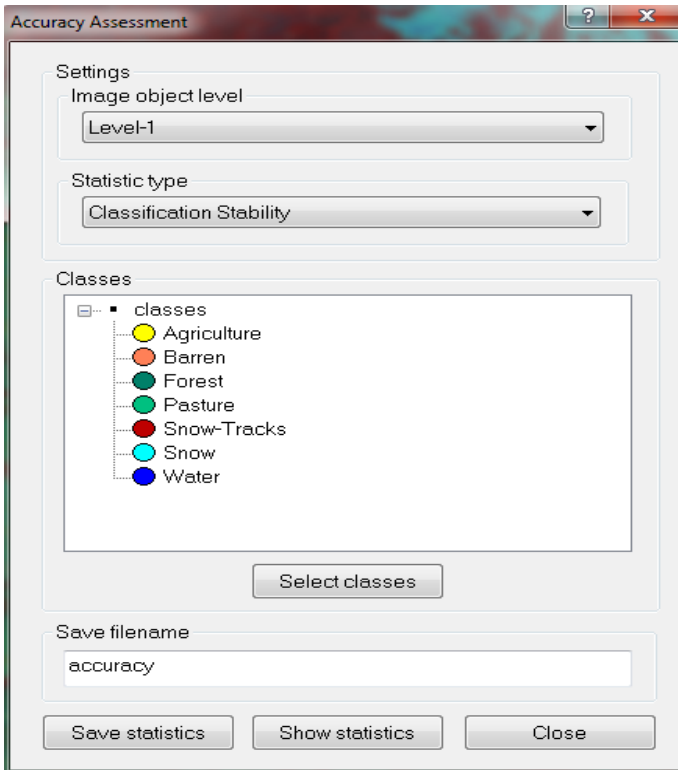


Figure 20: Accuracy Assessment dialog box

9-1) Choose Tools > Accuracy Assessment on the menu bar to open the Accuracy Assessment dialog box (Figure 20).

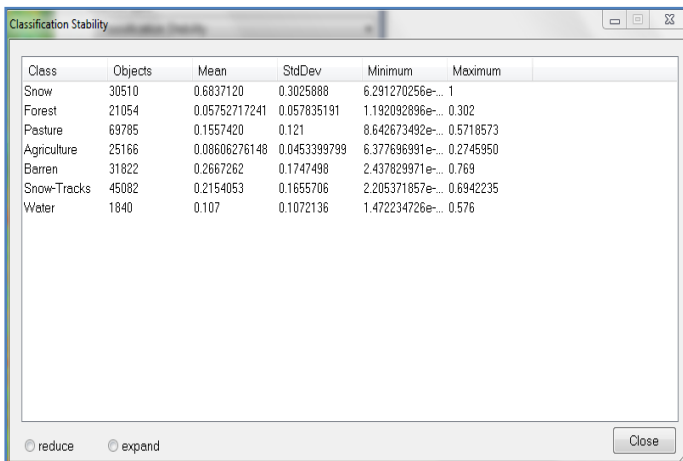
9-2) A project can contain different classifications on different image object levels. Specify the image object level of interest using the image object level drop-down menu. In the Classes

window, all classes and their inheritance structures are displayed.

9-3) To select classes for assessment, click the Select Classes button and make a new selection in the Select Classes for the Statistic dialog box. By default, all available classes are selected. You can deselect classes through a double-click in the right frame.

9.4) In the Statistic type drop-down list, select one of the following methods for accuracy assessment:

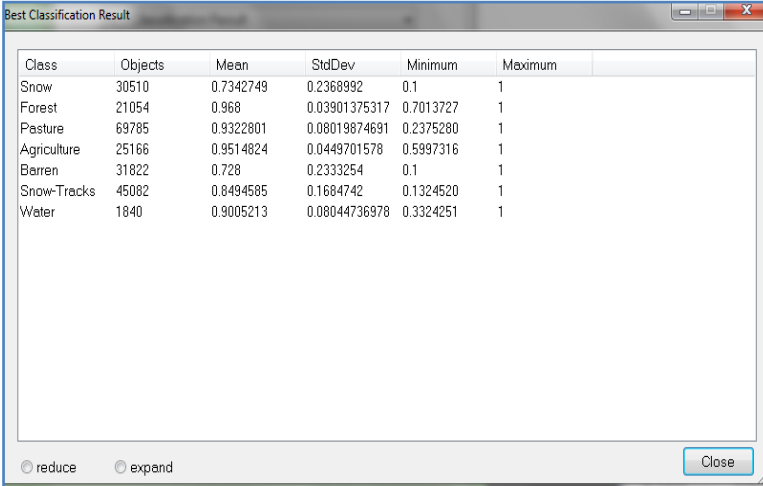
9.4.1) Classification Stability dialog box displays a statistic type used for accuracy assessment (Figure 21). The difference between the best and the second best class assignment is calculated as a percentage. The statistical output displays basic statistical operations (number of image objects, mean, standard deviation, minimum value and maximum value) performed on the best-to-second values per class.



Class	Objects	Mean	StdDev	Minimum	Maximum
Snow	30510	0.6837120	0.3025888	6.291270256e...	1
Forest	21054	0.05752717241	0.057835191	1.192092896e...	0.302
Pasture	69785	0.1557420	0.121	8.642673492e...	0.5710573
Agriculture	25166	0.08606276148	0.0453399799	6.377696991e...	0.2745950
Barren	31822	0.2667262	0.1747498	2.437829971e...	0.769
Snow-Tracks	45082	0.2154053	0.1655706	2.205371857e...	0.6942235
Water	1840	0.107	0.1072136	1.472234726e...	0.576

Figure 21: Output of the Classification Stability statistics

9.4.2) Best Classification Result dialog box displays a statistic type used for accuracy assessment (Figure 22). The statistical output for the best classification result is evaluated per class. Basic statistical operations are performed on the best classification result of the image objects assigned to a class (number of image objects, mean, standard deviation, minimum value, and maximum value).



Class	Objects	Mean	StdDev	Minimum	Maximum
Snow	30510	0.7342749	0.2368992	0.1	1
Forest	21054	0.968	0.03901375317	0.7013727	1
Pasture	69785	0.9322801	0.08019874691	0.2375280	1
Agriculture	25166	0.9514824	0.0449701578	0.5997316	1
Barren	31822	0.728	0.2333254	0.1	1
Snow-Tracks	45082	0.8494585	0.1684742	0.1324520	1
Water	1840	0.9005213	0.08044736978	0.3324251	1

Figure 22: Output of the best Classification results

9.4.3) Error Matrix based on TTA Mask dialog box displays a statistic type used for accuracy assessment. Test areas are used as a reference to check classification quality by comparing the classification with reference values (called ground truth in geographic and satellite imaging) based on pixels. For this option, we have not so-called the ground truth samples (Figure 23).

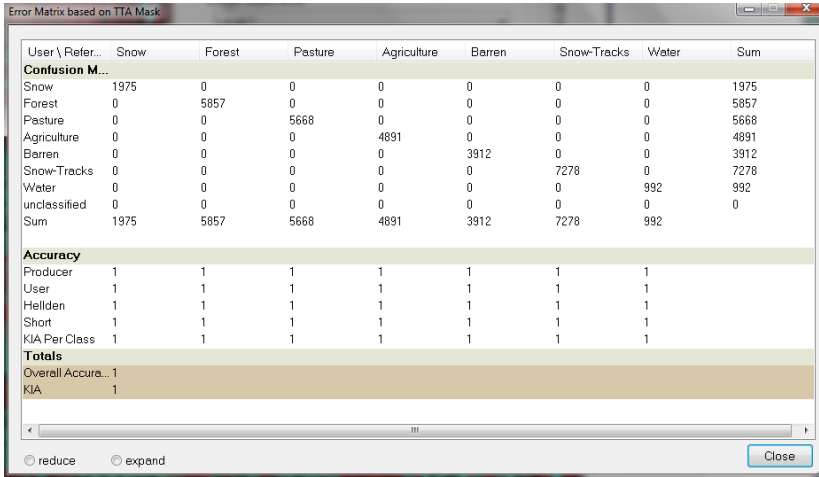


Figure 23: Output of the Error Matrix based on TTA Mask statistics

9.4.4) The Error Matrix Based on Samples dialog box displays a statistic type used for accuracy assessment. Error Matrix based on Samples is similar to Error Matrix Based on TTA Mask but considers samples (not pixels) derived from manual sample inputs. The match between the sample objects and the classification is expressed in terms of parts of class samples (Figure 24).

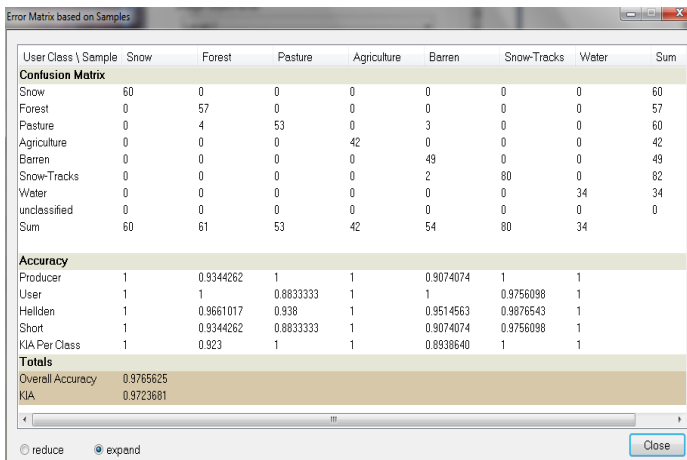


Figure 24: Output of the Error Matrix based on Samples statistics

9.5) To view the accuracy assessment results, click Show statistics. To export the statistical output, click Save statistics. You can enter a file name of your choice in the Save filename text field. You may save it in comma-separated ASCII .txt format; the extension .txt is attached automatically.

Step 10: Exporting the Results

10.1) When are happy with the results, you can export the results by clicking on Export → Export Results.

10.2) Leave the buttons to the left default; change the Export File Name to Bazarduzu, for example.

10.3) Click on Select Classes and select all except for unclassified, then click OK (Figure 25).

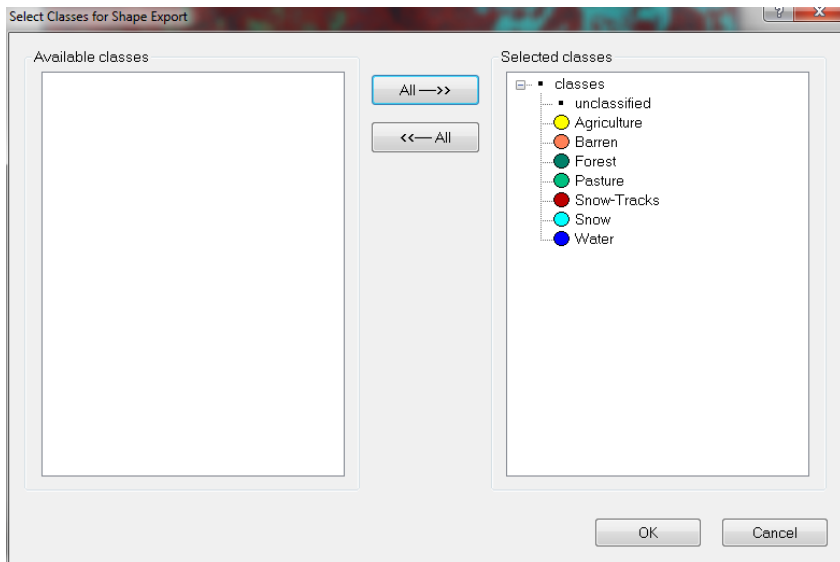


Figure 25: Export Results dialog box

10.4) Click on Select Features to add all the attributes. The first feature you want to add to the attribute table is the area of each class.

10.5) Follow this path to add the area: Object Features → Geometry → Extent → Area and then double click on the area to add it to the space to the right (Figure 26).

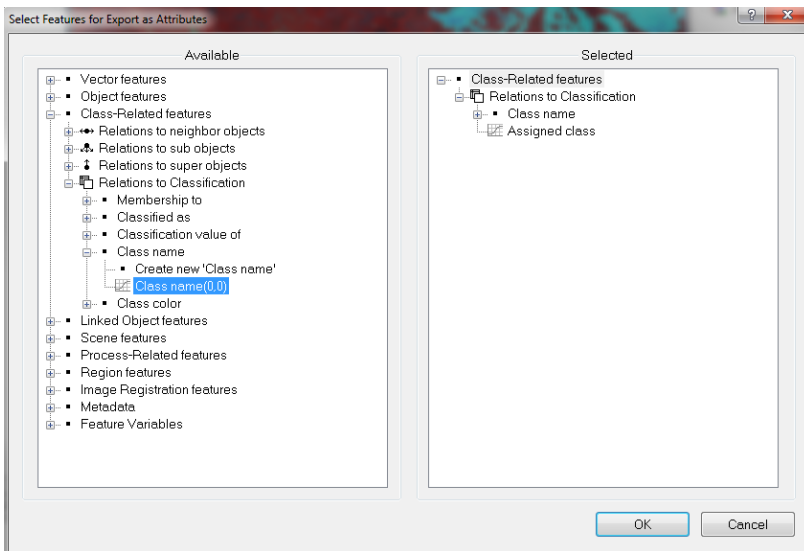


Figure 26: Select Features for Export as Attributes dialog box

10.6) The class name is the second feature you want to add to the attribute table. Follow this path to add the name: Class-Related features → Relations to Classification → Class name and double click on Create new Class Name, and in the new window, click OK. It will let you select the box (Figure 27).

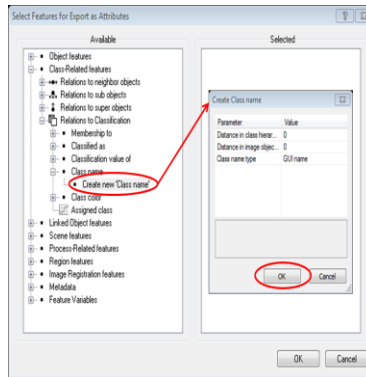


Figure 27: Adding New Class Name

10.7) Click OK to close the Feature Select window, make sure your window matches the image below, and click Export.

10.8) Open the newly created shapefile in ArcMap and evaluate the classified map.

Sum Up:

eCognition is such powerful software that it is challenging to summarize its advantages and benefits within one chapter. In the current tutorial, we tried to introduce some of its main concepts before you can start working through specific tasks learning how to apply the main approaches step-by-step in the following sections. In this exercise, you learned how to:

- ❖ load Landsat 8 imagery into a project,
- ❖ perform image segmentation,
- ❖ create a class hierarchy and insert the standard nearest neighbor as a classifier,
- ❖ declare sample objects as initial points for the nearest neighbor classification and feature space optimization,
- ❖ perform a nearest neighbor classification: click and classify,
- ❖ try to have some ideas on the accuracy assessment processes,
- ❖ export the results to the ArcGIS setting.

Informative Practices

Tips:

- 1) In eCognition Developer, segmentation is an operation that creates new image objects or alters the morphology of existing image objects according to specific criteria. It means a segmentation can be a subdividing operation, a merging operation, or a reshaping operation.
- 2) There are two basic segmentation principles: Cutting something big into smaller pieces, which is a top-down strategy, and merging small pieces to get something bigger, which is a bottom-up strategy.
- 3) Inside the eCognition 9.01, four classification algorithms are available: Optimal Box, Nearest Neighbor, Brightness Threshold, and Clutter Removal.

Workouts:

- 1) Define the different color compositions to visualize image layers for display in the map view.
- 2) Try two different segmentation actions (for instant, Quadtree and Multiresolution modes) to create image objects and compare the results.
- 3) Use the Classification, Brightness Threshold action to classify objects based on brightness.

Quizzes:

- 1) According to the experience from current and previous tutorials, what are the eCognition software advantages and disadvantages in processing Landsat-8 imagery?
- 2) How would you evaluate the final segmented map accuracy inside the eCognition?

- 3) What does the Classification (Nearest Neighbor) action mean?

Allied References:

- 1) eCognition Reference Book (2014). Trimble eCognition Reference Book (Munich, Germany: Trimble Germany GmbH).
- 2) Gonzalez R. and Woods R. (1992). Digital Image Processing, Addison Wesley, pp 414 - 428.
- 3) Jalan, S. (2011). Exploring the Potential of Object-Based Image Analysis for Mapping Urban Land Cover. Journal of the Indian Society of Remote Sensing, vol. 40, no., pp. 507–518.
- 4) Schiewe, J. (2002). Segmentation of high-resolution remotely sensed data – concepts, applications, and problems. In: Symposium on Geospatial Theory, Processing, and Applications, Ottawa.
- 5) The eCognition User Guide (2014). Trimble eCognition Developer User Guide (Munich, Germany: Trimble Germany GmbH).
- 6) United States Geological Survey - USGS (2015). Landsat Earth observation satellites, Earth Resources Observation and Science (EROS) Center, Earth Resources Observation, and Science.

Diving into the OBIA Advanced Skills



What would be the future of advanced image processing?

Basic Concepts:

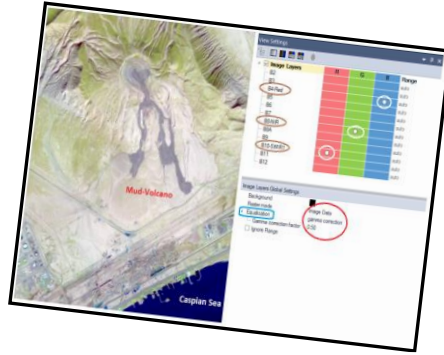
Continuing Season One, Section Two introduces the eCognition much-advanced capacity to import satellite image bands, manage a workspace, create projects, and target the Sentinel-2 imagery, with some recurrences. Any interested learner who experienced the Section One tutorials will dive into OBIA much-advanced skills by segmentation, classifying the satellite images, developing rulesets, and exporting the results to the ArcGIS setting.

At a glance, beginners learn how to manage workspaces and create a project in tutorial one. Then, in tutorial two, with access to Sentinel-2 images, trainees will practice creating complex landcover indices. Next, in the third workout, better-educated followers will work to produce the main components of the OBIA framework, image objects, by applying several segmentation methods. In the fourth tutorial, every learner will deal with the main subject of satellite image processing, namely

classification procedures. After that, during tutorial five, intermediated students will learn how to produce and implement rulesets with combined thresholding techniques to classify water bodies. In tutorial six's last step, you will try a change detection process based on an "Unsupervised Classification (USC)" algorithm. This section will inform learners of accuracy calculation methods and export more accurate results aiming at the OBIA targets.

Tutorial 1

Headlong Into The eCognition 9.5 with Sentinel-2



advanced analysis software available for geospatial applications

Opening Statement:

The main purpose of the current tutorial is to teach students how to work professionally inside the trial version of the eCognition 9.5. Accordingly, you will download and install the eCognition Developer version 9.5 on your computer at the first step. In the second step, the tutorial teaches you simple steps to find, download, and manage free Sentinel-2 data by accessing the Copernicus Open Access Hub. At the third step, you will learn to import downloaded imagery to the inside of the eCognition software. Creating a simple project helps the intermediate learners understand the main aims of OBIA concepts, helping to design, improve, and accelerate practicing the real-world high-resolution satellite imagery during the next tutorials.

Instructive Memo:

- ✓ Level: Intermediate
- ✓ Time: This lesson should not take you more than 1 hour.
- ✓ Resources: The eCognition Developer software, Version 9.5
- ✓ Data Sources: *Sentinel-2 Imagery, LIC_T39TVE_A030362_20210415.jp2*
- ✓ Scene Site: *The Baku Peninsula*

Tutor Objectives:

By the end of this unit, you should:

- ✚ Learn how to download the eCognition Developer 9.5.
- ✚ Start to install the eCognition Version 9.5.
- ✚ Be trained to access the Sentinel-2 imagery.
- ✚ Bring into the high-resolution imagery inside eCognition.

Background Concepts:

The eCognition trial version 9.5 enables researchers to examine almost all high-resolution satellite imagery in pixel and object levels, not in isolation, but contextual relations. Although students do not have access to the official version of the new eCognition software, they will acquire the necessary constructive skills over time by doing simple exercises. Inside the Trimble eCognition Developer Trial 9.5 version, you can experience many image processing, classification functions as experts and data scientists do in the geospatial data analyzing main steps. Intermediate learners can design feature extraction solutions to transform geo-data into geo-information. The possibilities are continuous, with more feature extraction experience. Besides, researchers could pioneer OBIA techniques and continue to push the envelope of Sentinel-2 newly provided imagery and integrated analyses.

As soon as you can bring multispectral high-resolution Sentinel-2 (A & B) into the eCognition setting, you will be able to get more information from the landcover/landuse of your projected area. Sentinel-2 carries an innovative wide swath high-resolution multispectral imager with 13 spectral bands for a new perspective of our land and vegetation. The combination of high resolution, novel spectral capabilities, a swath width of 290 km, and frequent revisit times provides unprecedented views of Earth. The Sentinel 2 (A & B) spectral bands are given in Table 1.

Table 1: Sentinel 2 spectral bands

Band	Description	Central Wavelength (μm)	Resolution (m)
B1	Ultra Blue (Coastal and Aerosol)	0.443	60
B2	Blue	0.490	10
B3	Green	0.560	10
B4	Red	0.665	10
B5	Visible and Near Infrared (VNIR)	0.705	20
B6	Visible and Near Infrared (VNIR)	0.740	20
B7	Visible and Near Infrared (VNIR)	0.783	20
B8	Visible and Near Infrared (VNIR)	0.842	10
B8a	Visible and Near Infrared (VNIR)	0.865	20
B9	Short Wave Infrared (SWIR)	0.940	60
B10	Short Wave Infrared (SWIR)	1.375	60
B11	Short Wave Infrared (SWIR)	1.610	20
B12	Short Wave Infrared (SWIR)	2.190	20

Also, Figure 1 indicates the Sentinel-2 bands spectral in graphical characteristics.

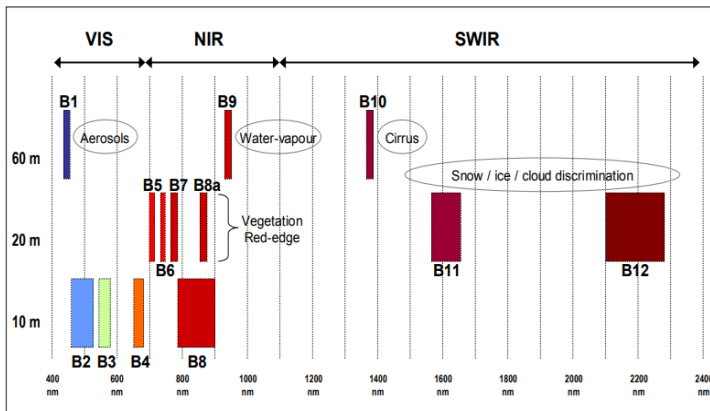


Figure 1: Sentinel-2 bands and spectral characteristics

Mastering The Skills:

The eCognition technology enables researchers to examine almost all high-resolution satellite imagery in pixel and object levels, not in isolation but in contextual relations. Although you do not have access to the official version of the new eCognition Software, you will acquire the necessary constructive skills over time by doing simple exercises based on the Sentinel-2 images.

Step 1: Accessing the eCognition Software

1.1) Note that customers with a valid maintenance contract are entitled to the latest version of eCognition. This version of the eCognition Suite 9.5 includes a variety of new and improved productivity tools. To download the current trial version eCognition, you need to try support@eCognition.com.

1.2) Fill out the form to request the eCognition Developer Trial software. In the comments section, you are requested to offer some information about the application you're interested in and any other questions you have.

1.3) Trial software access is not limited to a specific period, but export functions, saving projects, and the workspace environment are restricted. Rulesets saved in trial software cannot be opened in a fully-licensed version of eCognition Software. eCognition Trial versions are available exclusively for 64-bit versions of Windows.

1.4) When you download the eCognition Trial version, keep it in a folder inside one of your computer partitions.

1.5) Right-click on the eCognition Developer Trial Zip folder and select the Extract Here option (Figure 2).

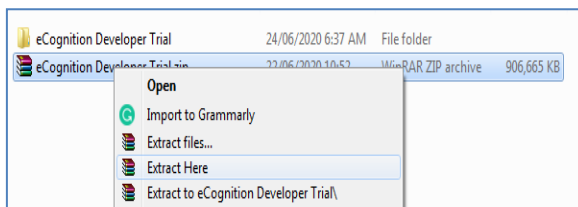


Figure 2: Extracting eCognition Developer Trial zip files

1.6) When the eCognition Developer Trial 9.5 Setup dialog box appears, click the Next option (Figure 3).



Figure 3: eCognition Developer Trial 9.5 Setup dialog box

1.7) In the License Agreement dialog box, select the I accept the terms of the License Agreement option and click the Next tab (Figure 4).

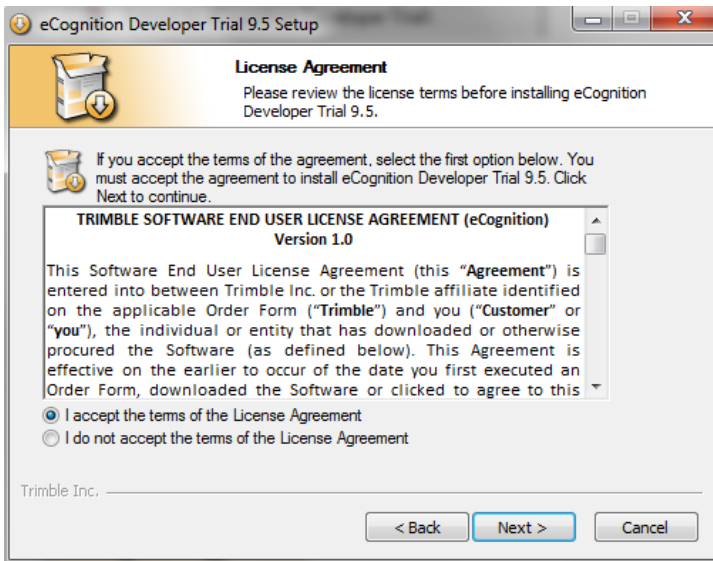


Figure 4: The License Agreement dialog box

1.8) When the Choose Components appears, select both the eCognition Developer Trial and NVIDIA GPU-accelerated TensorFlow Library options, click the Next tab. Note that you need to have nearly more than 1.7 GB of required space in your select partition (Figure 5).

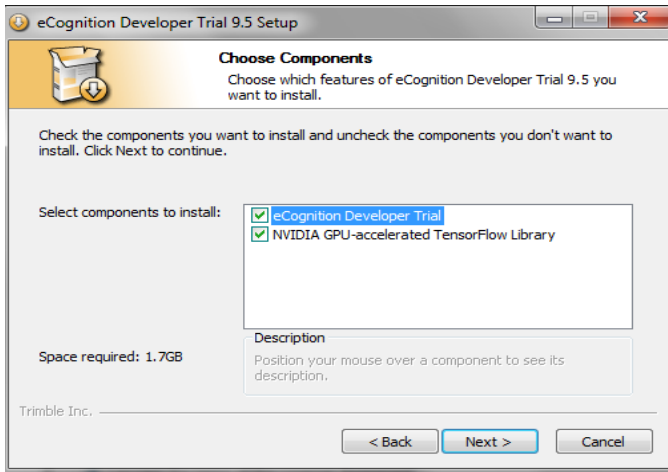


Figure 5: The Choose Cpmponents installation option dialog box

1.9) When choosing Start Menu Folder appears, select the Trimble eCognition Developer Trial 9.5 and the Start Menu folder where you want to set the software shortcuts (Figure 6).

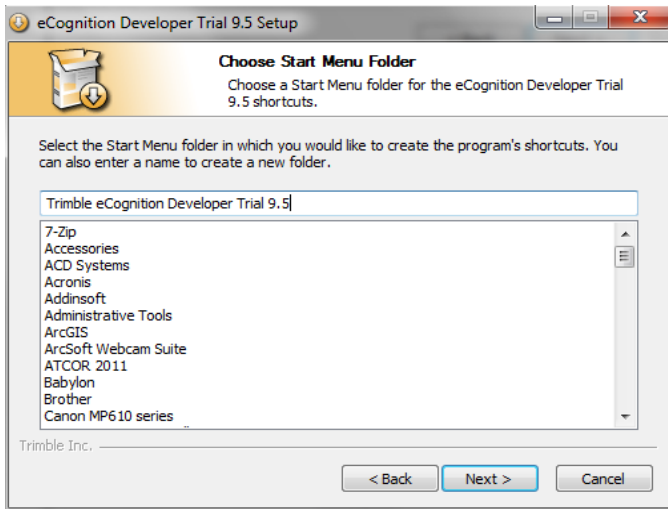


Figure 6: the Choose Start Menu Folder dialog box

1.10) Click on the Next tab to have the Choose Install Location dialog box. For example, you may prefer to select the

E:\ partition to install the eCognition Developer Trial 9.5 version (Figure 7).

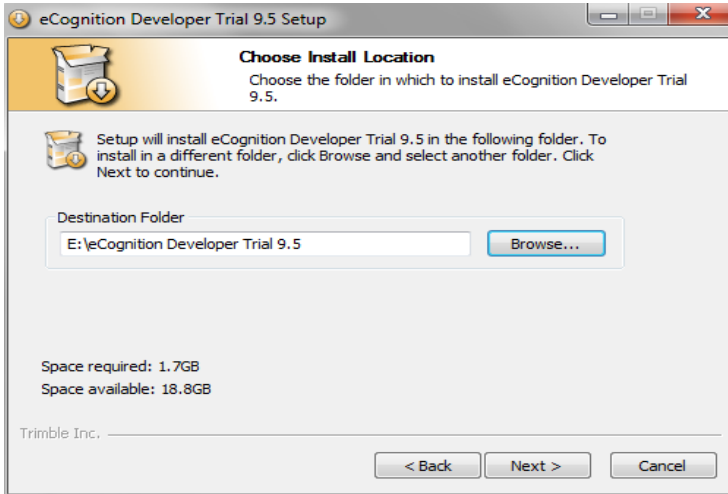


Figure 7: Selecting of the Destination Folder

1.11) The installation dialog box appears by selecting the Next Tab. Click on the 'Install Tab' to start the installation process (Figure 8).

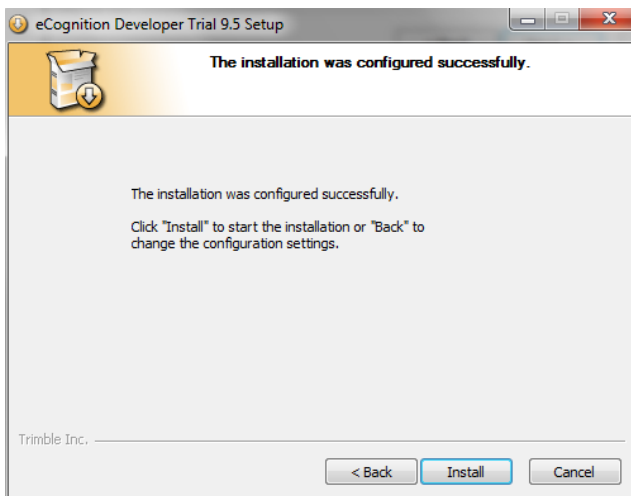


Figure 8: The installation process dialog box

1.12) The eCognition Developer Trial software installing process starts. It would be best if you wait while the software was installed (Figure 9).

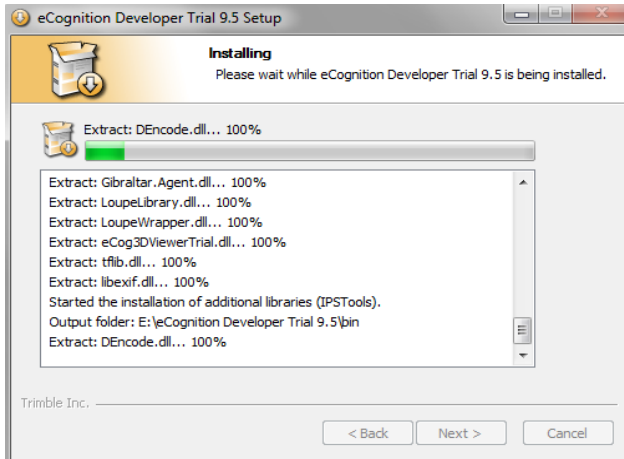


Figure 9: The Installing dialog box

1.13) When the installation process is completed successfully, click on the Next Tab (Figure 10).

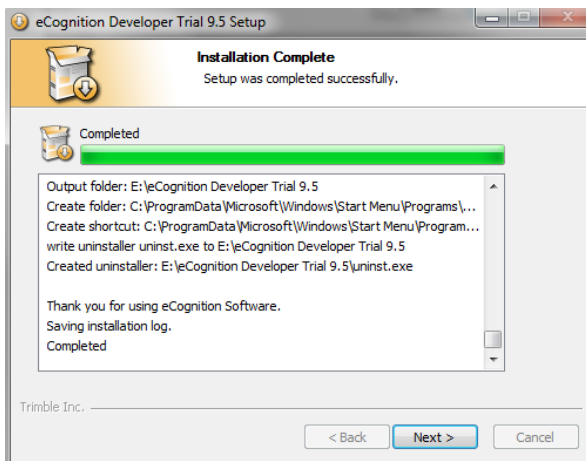


Figure 10: Announcing the Installation completion dialog box

1.14) In the last step, inside the Completing the eCognition Developer Trial 9.5 Setup Wizard window click on the Finish Tab to end the installation process (Figure 11).



Figure 11: the Completing the eCognition Developer Trial 9.5 Setup Wizard window

1.15) You can start the eCognition Developer Trial version and set up the software based on your choosier (Figure 12).

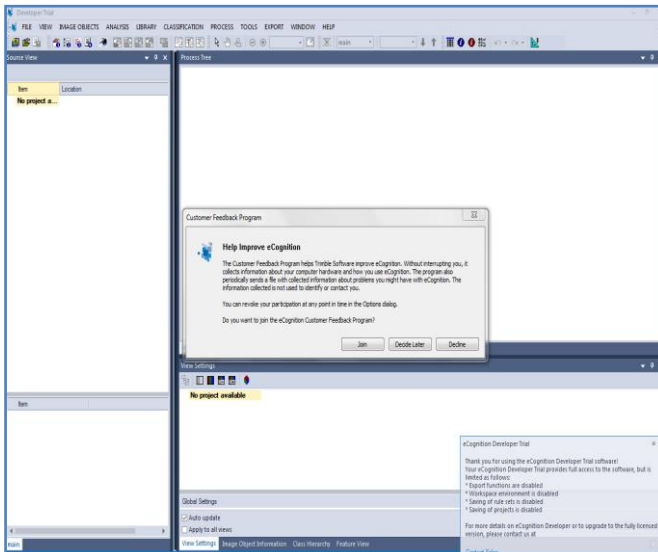


Figure 12: the eCognition developer Trial Version start state


Step 2: Accessing the Copernicus Hub



Sentinel-2 data products are provided free of charge to all data users, including the students, and researchers under the terms and conditions prescribed by the European Commission's Copernicus Programme.

2.1) Go to <https://scihub.copernicus.eu/dhus/#/home> and create a User Account for yourself.

2.2) In the top-right of the website map, click the Sign Up option. Insert valid entries for your name, email and location. Click register, and validate your email.

2.3) With a few clicks of the mouse, you've gained access to ESA's Sentinel site.

2.4) Click on the  icon (1) to log in to the site. Enter your username and password to access the main Copernicus Open Assess Hub.

2.5) Press on  the insert research criteria icon (2) to notice windows. You can now fill in all exciting options to define all images you need inside the Advanced Search box. The most important subject is selecting the Sentinel Mission type; in our case, we want to tick the  **Mission: Sentinel-2** option.

2.6) There are viable options that are optionally able to help the users in the selection procedure, such as satellite platforms, product type, cloud cover (%), sensing period, and so on (Figure 13).

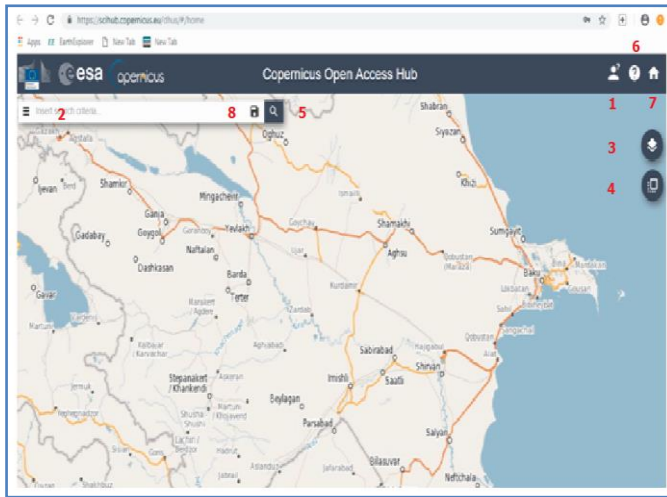


Figure 13: Copernicus Open Access Hub

2.7) Also, you could use two other options as map layer (3)



and switch to area mode



(4) in the better selection of the

Sentinel images (Figure 14).

Insert search criteria...

Advanced Search Clear

» Sort By: Ingestion Date

» Order By: Descending

» Sensing period From: to:

» Ingestion period From: to:

Mission: Sentinel-1

Satellite Platform Product Type

Polarisation Sensor Mode

Relative Orbit Number (from 1 to 175) Collection

Mission: Sentinel-2

Satellite Platform Product Type

Relative Orbit Number (from 1 to 1423) Cloud Cover % (e.g. [0 TO 9.4])

Figure 14: Insert search criteria dialog

- 2.8) To select the Area of Interest (AOI), Zoom in your study area. In our example, Azerbaijan, Baku region.
- 2.9) Click Polygon in the bottom-left and draw a polygon around your interested area (Figure 15).

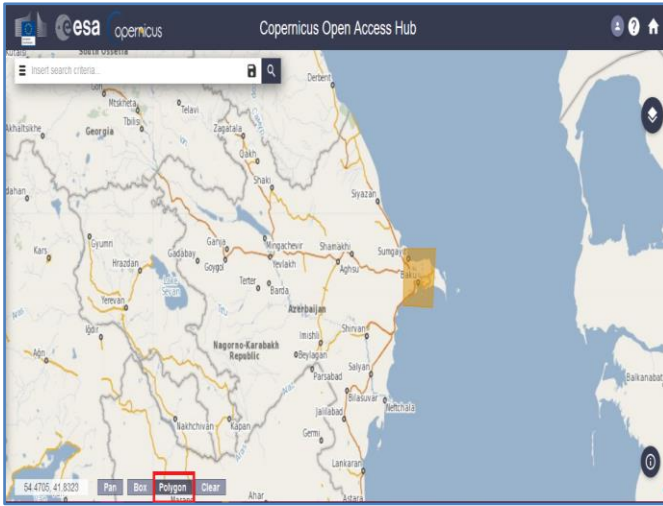


Figure 15: Copernicus Open Access Hub dialog

2.10) Using the Search Criteria text box in the top-left, click on the menu and choose your data to feature, for instance, which date and sentinel mission you need (Figure 16).

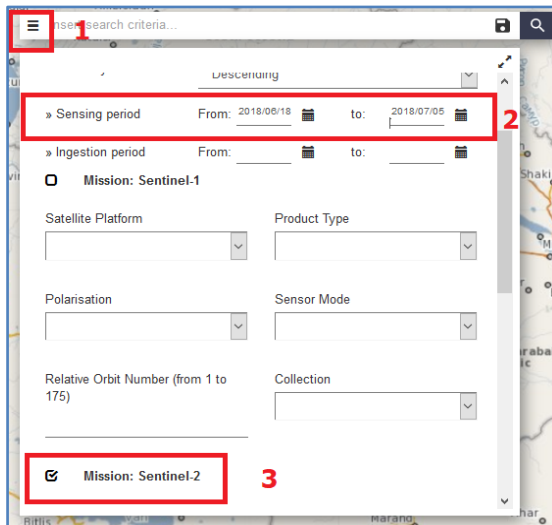


Figure 16: Search criteria dialog box

2.11) Click on the search button to show the results. All available images will be displayed (Figure 17).

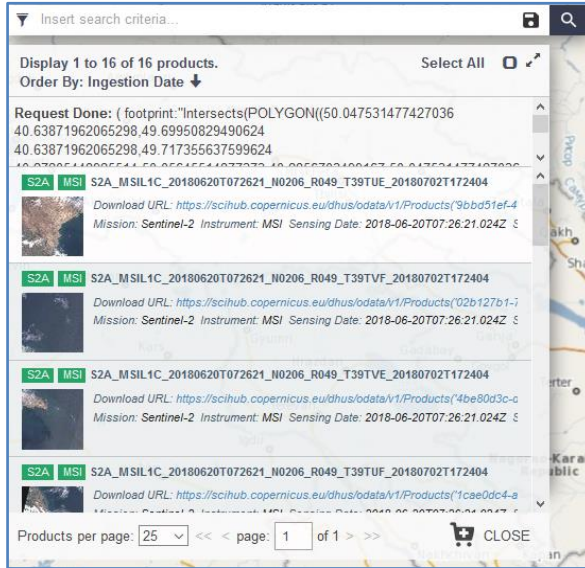


Figure 17: Result of selected Sentinel 2A images

2.12) Click on this sign to view the product details (Figure 18).

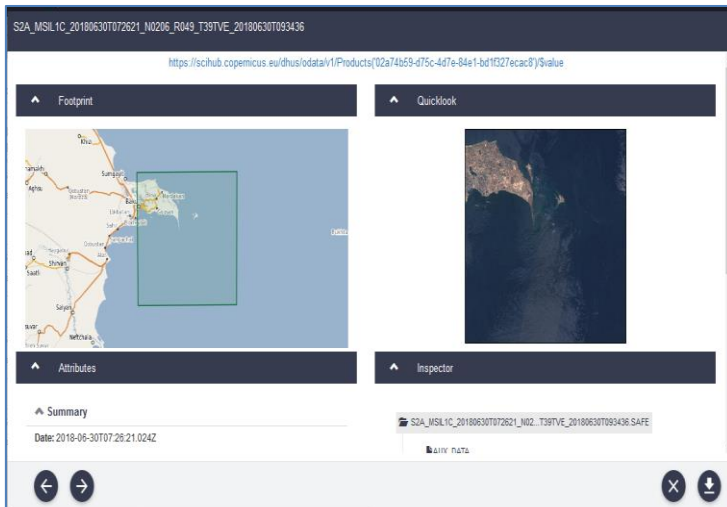



Figure 18: Footprint and Quicklook summary

- 2.13) Select the product you want to download. When the downloading process is finished, you will notice a zip folder similar to  LIC_T39TVE_A030362_20210415T073141.zip in the jp2 format. Now, you need to unzip the contents of the above folder in a particular folder.
- 2.14) The Sentinel-2 satellites will each carry a single multi-spectral instrument (MSI) with 13 spectral channels in the visible/near-infrared (VNIR) and short wave infrared spectral range (SWIR). Keep in mind that the Sentinel 2A level 1c already has values in TOA reflectance. Therefore, you need to convert its bands into GeoTIFF in SNAP software. Besides, you can convert Sentinel image format inside the ArcGIS setting into GeoTIFF format.
- 2.14.1) Download the SNAP software from Sentinel Data Hub: <http://step.esa.int/main/download/snap-download/>. It is free, open-source software. It is a common open-source architecture for ESA Toolboxes ideal for exploiting Earth Observation data.
- 2.14.2) Sentinel Data Hub offers three different installers for your convenience. Choose the one which suits your needs. During the installation process, each toolbox can be excluded from the installation. Note that SNAP and the individual Sentinel Toolboxes also support numerous sensors other than Sentinel. Inside the SNAP software, try File/ Open Product.

2.14.3) After importing each band click File/ Export/ GeoTIFF. Now the entire bands with GeoTIFF format are ready to take inside the eCognition software.

Step 3: Sentinel-2 imagery inside the eCognition

3.1) When you click on the eCognition Developer Trial version shortcut *.exe, you will soon notice the Developer Trial Window (Figure 19).

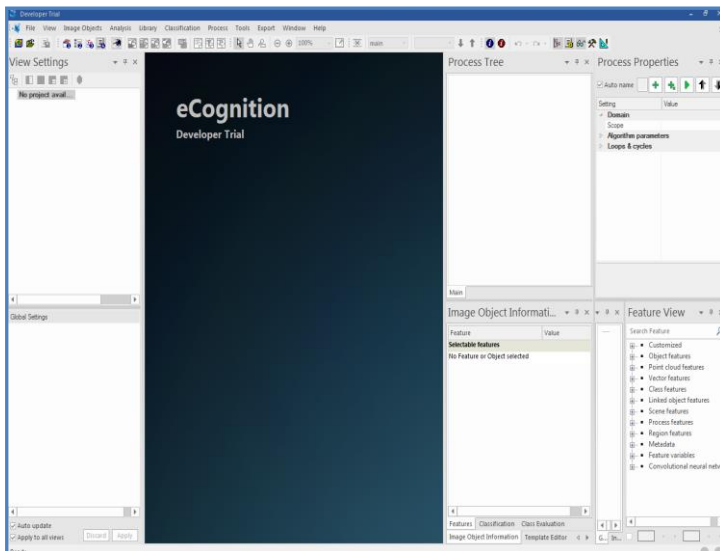


Figure 19: the eCognition Developer Trial version start-up

3.2) From the menu bar, click on the File and select the New Project option. Soon the Create Project Window opens by accompanying the Import Image Layers dialog box (Figure 20).

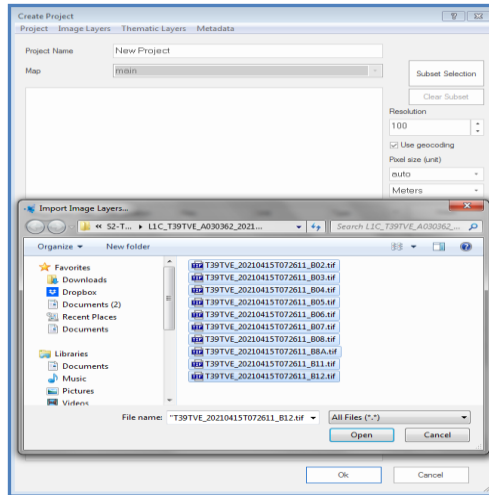


Figure 20: The Create Project Window accompanying the Import Image Layers dialog box

3.3) Select Sentinel-2 bands as you want and click OK. Inside the Create Project, the image layer name set up other options, and click OK (Figure 21).

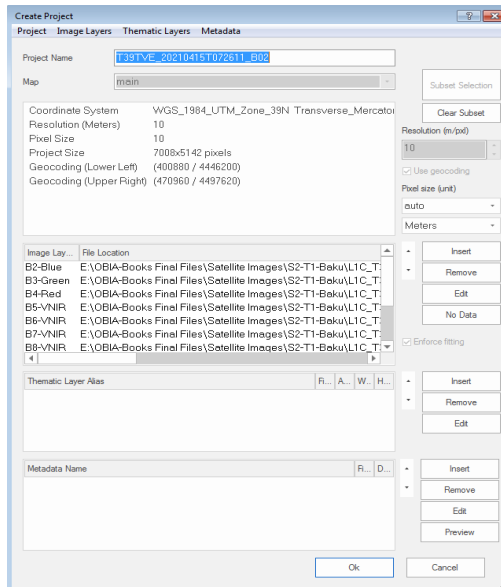


Figure 21: The Create Project Window, setting up layers name

3.4) From the Subset Option, select a portion of the image using your mouse device and click OK (Figure 22).

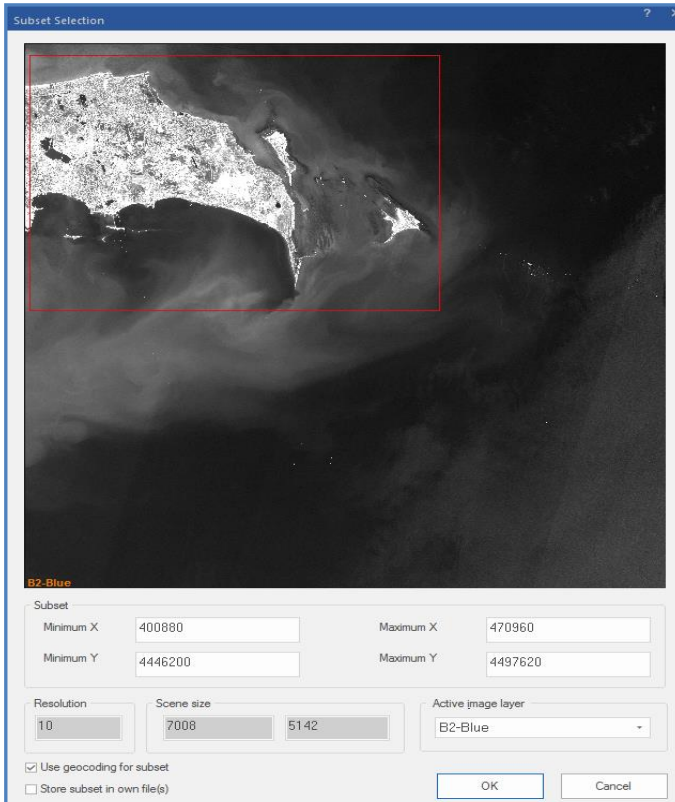


Figure 22" The Subset Option, selecting a portion of the image

3.5) By setting the View Setting options, as you notice from Figure 23 you can create your first project inside the eCognition 9.5.

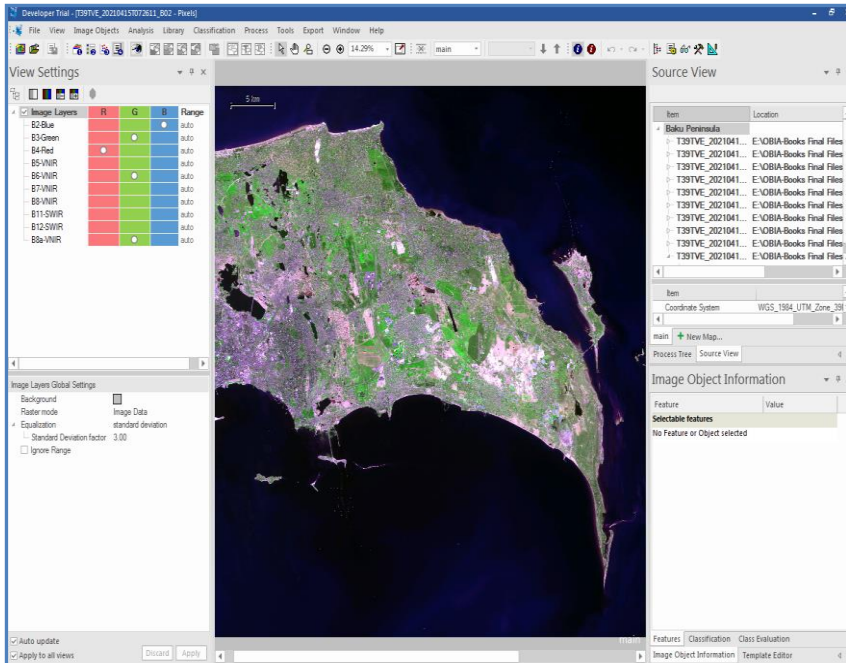


Figure 23: An eCognition 9.5 project, adjusted to the Baku Peninsula, Azerbaijan

3.6) At this point, your first project in the Alpha software environment is ready. In the next chapter, you will follow your project in more detail

Sum Up:

The eCognition Suite 9.5 is an advanced analysis software available for many OBIA applications. It is designed to improve, accelerate and automate the interpretation of various geospatial data and enables users to design feature extraction or change detection solutions to transform geospatial data into geo-information. These help us identify changes over time or features on the earth's surface across very large data sets.

As is highlighted above, Sentinel-2 products are provided free of charge to all data users, including the students, and researchers under the terms and conditions prescribed by the European Commission's Copernicus Programme. You can process satellite images to determine various plant indices such as vegetation and water content indexes. It is particularly important for applications related to the country landcover/landuse mapping such as vegetation stands, rivers and lakes bodies, mud-volcanic eruptions, particularly detecting the Caspian Sea coastal changes.

Informative Practices

Tips:

- 1) eCognition 9.5 empowers customers with highly sophisticated pattern recognition and correlation tools that automate the classification of objects of interest for faster and more accurate results.
- 2) eCognition 9.5 now provides new algorithms to directly leverage this state-of-the-art machine learning technology.
- 3) You could process the Sentinel-2 images to preserve land monitoring studies, vegetation monitoring, soil and water cover, and observation of inland waterways and coastal areas.

Workouts:

- 1) Install the eCognition 9.5 Trial version on your computer, according to the current tutorial. And keep in your mind and fully understand what the eCognition Developer Trial provides and is limited.
- 2) Open the eCognition software, and from the Help menu, select the System Info option. It gives you a lot of basic information about your installed platform.
- 3) Download a set of Sentinel imagery for a region where you live. Have you any idea about counterpart multi-spectral satellite images.

Quizzes:

- 1) What does the eCognition Developer Trial software offer freely?
- 2) What are its limitations, and what are the main windows of the eCognition Developer when it starts?
- 3) How many Sentinel satellites are there in space?

Allied References:

- 1) Trimble eCognition Suite (2019) eCognition Developer 9.5 Reference Book, Munich, Germany. All rights reserved. Trimble Documentation, Munich, Germany.
- 2) Trimble eCognition Suite (2019) eCognition Developer 9.5 System Requirements for Windows operating system. Munich, Germany. All rights reserved. Trimble Documentation, Munich, Germany.
- 3) eCognition Available online (2019): <http://www.ecognition.com/suite/ecognition-developer> (accessed on 3 April 2019).
- 4) Yan, L., D.P. Roy, H. Zhang, J. Li and H. Huang (2016) An Automated Approach for Sub-Pixel Registration of Landsat-8 Operational Land Imager (OLI) and Sentinel-2 Multi-Spectral Instrument (MSI) imagery. *Remote Sens.* 8, 520.
- 5) Radiometric Resolutions Sentinel-2 MSI (2020) User Guides, Sentinel Online. Sentinel.ESA.int. Retrieved 5 March 2020.
- 6) Sentinel-2 MSI: Overview (2015) European Space Agency, 17 June 2015.

Tutorial 2

Taking a Plunge Inside The eCognition 9.5



establishing your home workspace is the first milestone

Opening Statement:

In the first step, this tutorial teaches you to be familiar with the eCognition 9.5 structure and functionality. In the second step, the tutorial will teach you how to set up and configure your workspace and projects within eCognition, based on Sentinel-2 datasets. Setting up a workspace and project is the first step in eCognition, in which you configure your folder structure and import your data. A project is the most basic format in eCognition architect that contains one or more sets of satellite imagery.

Instructive Memo:

- ✓ *Level:* Intermediate,
- ✓ *Time:* This tutorial should not take you more than 1.5 hours,
- ✓ *Software:* A eCognition Developer, Version 9.5,
- ✓ *Data Sources:* Sentinel-2 imagery *T39TUE_20200311.Tif*,
- ✓ *Subject Scene:* Baku region, Azerbaijan.

Tutor Objectives:

- ✚ By the end of this unit, you should:
- ✚ Learn how to download Sentinel-2 Imagery.
- ✚ Be familiar with the workspace and projects.
- ✚ Create a unique workspace and a project.
- ✚ Create multiple projects inside a workspace.

Background Concepts:

Using the new eCognition software, you can import various geospatial data, fusing them into a rich stack of geo-data for the analysis. You may prefer to have a logic arrangement step-wisely to create a computer-based representation of an expert's geospatial interpretation process, a so-called OBIA. eCognition then combines the analysis logic with scalable computing power to identify changes over time or features on the earth's surface across very large sets of data.

The eCognition technology enables researchers to examine almost all high-resolution satellite imagery, such as Sentinel-2 (A & B), in pixel and object levels, not in isolation but in contextual relations. Inside the eCognition software, you can build up a picture iteratively, recognizing groups of pixels as objects. Just like the human mind, it uses color, shape, texture, shape, and size of objects, as well as their context and relationships, to draw the same conclusions that an experienced analyst would draw. Although you do not have access to the official version of the new eCognition software, you will acquire the necessary constructive skills over time by doing simple exercises.

Mastering The Skills:

The main aim of this tutorial is to introduce the trial version of eCognition 9.5 that was designed to improve, accelerate and automate the processing and interpretation of geospatial data. You can discover the full power of the eCognition's development environment for data analysis. Inside eCognition 9.5, it is possible to develop rule sets and workflows for advanced classification, feature extraction, and batch processing.

Step 1: Being Familiar with the eCognition Structure

1.1) When you click on the eCognition Developer Trial version shortcut *.exe, you will soon notice the Developer Trial Window (Figure 1).

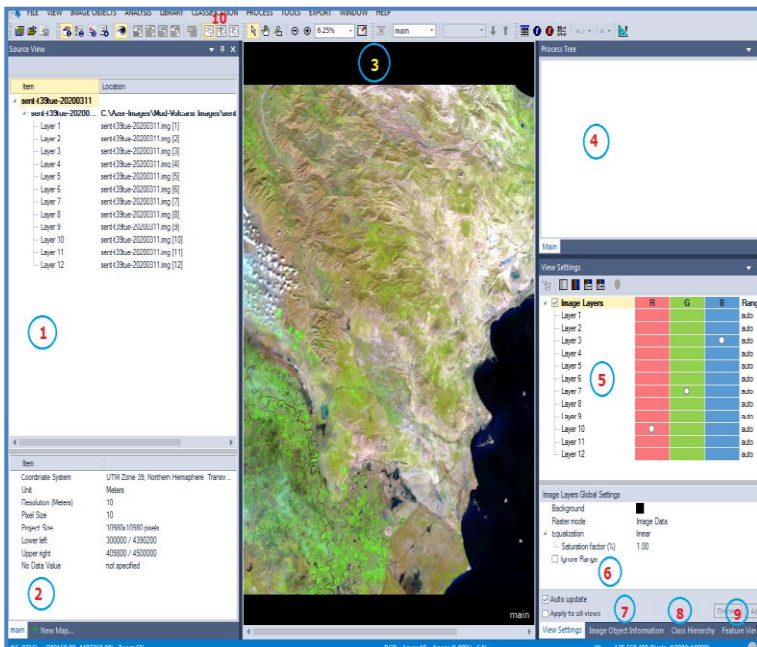


Figure 1: The eCognition Developer version Default View main parts

1.2) The Developer version has the parts, each with its function as follows:

- 1) *Source View*: This dialog provides users a simple data management area to modify input layer alias, display orders, and access information on file details. To open the dialog, choose View > Source View.
- 2) *Item*: All metadata items are listed in the feature tree if existing. You can define a new metadata item by clicking on Create a new Metadata item.
- 3) *Main View*: Inside the Main View, you could display raster data, vector layers, and other derivative map products.
- 4) *Process Tree*: eCognition Developer uses a cognition language to create ruleware. These functions are created by writing rule sets in the Process Tree window.
- 5) *View Settings*: In this dialog, you can add image, vector, and point cloud layers via drag and drop and edit them according to view settings. Toggle between detailed layer properties switches between grayscale and RGB mixing, or - for point cloud data - select a 3D subset to open the 3D viewer. The upper pane allows individual layer settings, the lower pane global view settings for the respective data type. If you click on the View Settings Tab, you will notice the Process Tree,

View Settings (image layers), and the Global Settings tab.

- 6) *Global Settings*: This option shows image layers background, raster dataset mode, equalization mode, and situation percentage.
- 7) *Image Object Information Tab*: This window provides information about the characteristics of image objects.
- 8) *Class Hierarchy Tab*: Image objects can be assigned to classes by the user, which is displayed in the Class Hierarchy window. The classes can be grouped in a hierarchical structure, allowing child classes to inherit attributes from parent classes.
- 9) *Feature View Tab*: In eCognition software, a feature represents information such as measurements, attached data, or values.
- 10) *Default Toolbar Buttons and Dialogs*: The eCognition Developer has eleven Toolbar Tabs, each having several illustrated buttons. These are shown in Figure 2 and associated descriptions in Table 1 in brief.

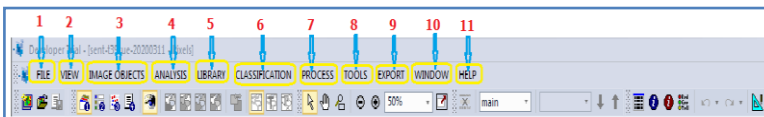












Figure 2: The eCognition 9.5 main Toolbar Tabs

Table 1: The eCognition 9.5 toolbars and buttons descriptions

<i>Toolbar</i>	<i>Buttons</i>	<i>Description</i>
File Toolbar		This group of buttons allows you to create a new project, open and save projects
View Settings Toolbar		These buttons are numbered from 1 (Load and Manage Data), 2 (Configure Analysis), 3 (Review Results) to 4 (Develop Rule Sets), allow you to switch between the four window layouts. To organize and modify image analysis algorithms, the Develop Rule Sets view (4) is most commonly used.
View Settings		This button allows you to open the View Settings dialog. Add layers via drag and drop and edit image, vector, and point cloud view settings
image view options		This group of buttons allows you to select image view options. You can select between view image layers, classification, samples, and any features you wish to visualize.
displaying outlines of pixels and image objects		This group is concerned with displaying outlines and borders of image objects, and views of pixels and polygons based on image objects as 1) Toggle between pixel view or object mean view; 2) Show or hide outlines of image objects; 3) Switch between transparent and non-transparent outlined objects, and 4) Toggle between show or hide polygons.
Zoom Functions Toolbar		This region of the toolbar offers natural selection and the ability to pan through an image, along with several zoom options. You can enter the zoom level manually to any user-defined value.
View Navigate Toolbar		The View Navigate folder allows you to delete levels, select maps and navigate the object hierarchy.

Tools Toolbar		The Tools toolbar allow access to the following dialog boxes and options: Workspace management, Image object information, Object and Object Table.
Tools Toolbar		These tools allow Undo, Redo, Save Current Project State, and Restore Saved Project State.
<i>Legend and Manual Editing Toolbar</i>		These tools allow access to Class hierarchy, Process tree, Feature view, Manage, Customized Features, Manual Editing Toolbar.


1.3) eCognition offers the possibility to add all kinds of data via drag and drop to the View Settings dialog. You can add image layers, vector, and point cloud layers to a new or existing project. You may wish to select the layers in the Windows File Explorer and drag and drop them to the View Settings dialog to import them. The upper pane allows individual layer settings, the lower pane global view settings for the respective data type.


1.4) Alternatively, you can select File > Add data layer or View > Source View > Add data layer button.


1.5) Furthermore, eCognition project (.dpr) and workspace (.dpj) files can be added to eCognition by drag and drop (Figure 3).




Figure 3: View Settings showing the Sentinel 2 A bands, excluding layer (band) 1

1.6) Inside the View Settings  button toggles between an expanded or collapsed view of layers, visualizing or leaving out details of loaded layers.

1.7) These buttons  visualize different image layers in grayscale or RGB. If more than one image layer is loaded, they also allowed shifting between layers and their layer mixing (details see below).

1.8) The 3D subset selection button  enables the selection of a subset in the view to open a 3D view window (active on availability of at least one point cloud layer).

Step 2: Recognition the Image Layer Tools

2.1) Single Layer Grayscale  Scenes are automatically assigned RGB (red, green, and blue) colors by default when image data with three or more image layers are loaded.


2.2) Use the **Single Layer Grayscale** button in the View Settings dialog to display image layers separately in grayscale.


2.3) To change from RGB to grayscale mode, press the button, and the first image layer is shown in grayscale mode.

2.4) Step through all loaded image layers by using the **Show Next/Previous Image Layer** button or open multiple views for comparison (Figure 4).




Figure 4: Single layer grayscale view with layer 2 (left) and layer 12 (right)

2.5) *Three Layers RGB*  button displays the first three layers of your scene in RGB. By default, layer one is assigned to the red channel, layer two to green, and layer three to blue, indicated by a small circle in the respective field. You can change view settings by clicking on a circle (removes circle) or an empty field (adds circle).

2.6) *Show Previous Image Layer*  In Grayscale mode, this button displays the previous image layer. The number and name of the image layer are indicated in the middle of the status bar.

In Three Layer Mix, the color composition for the image layers changes one image layer up for each image layer. For example, if layers two, three and, four are displayed, the Show Previous Image Layer Button changes the display to layers one, two, and three. If the first image layer is reached, the previous image layer starts again with the last image layer.

2.7) *Show Next Image Layer*  In Grayscale mode, displays the next image layer down. In Three Layer Mix, the color composition for the image layers changes one image layer down for each layer. For example, if layers two, three, and four are displayed, the Show Next Image Layer Button changes the display to layers three, four, and five. If the last image layer is reached, the next image layer begins again with image layer one (Figure 5).

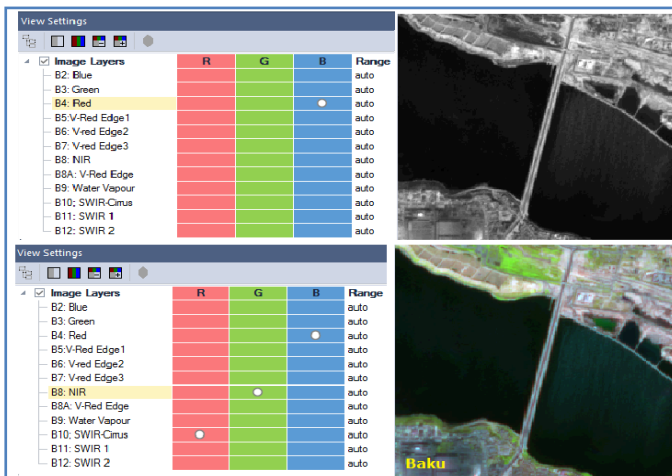


Figure 5: Single Layer Grayscale (left) and Three-Layer Mix (right) for Sentinel 2A imagery

2.8) Image Layer Properties and Settings

2.8.1) *R-G-B*: To define the display color of each image layer, you can add a circle for the red, green, and blue channels by a single click for each layer separately. They are then displayed as additive colors in the View. Any layer without a circle in at least one column is not shown. When creating a new project, the first three image layers are displayed in red, green, and blue. You can change the order of image layers by dragging and dropping within the Image Layer(s) section (Figure 6).

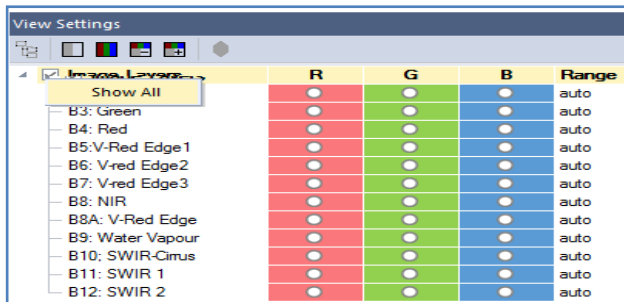


Figure 6: View Settings dialog - Image Layer Properties - Show All

2.8.2) A right-click on image layers opens the context menu where you can select to Show All or Hide All image layers at once or Delete and Rename single image layers. You can also rename an image layer by double click in the view settings dialog. One layer can be displayed in more than one color, and more than one layer can be displayed in the same color. Change these settings to your preferred by clicking in the respective R, G, or B cell.

2.8.3) *Range*: For the equalization settings (lower pane of dialog) manual, false color (hot metal), and false color (rainbow), you can define the displayed range individually based

on the Image Layer Equalization dialog for each image layer. To open the dialog, click on the small dots at the end of the line of the image layer you want to adjust (details see Equalization and Image Layer Equalization dialog).

2.8.4) Changing the view settings only changes the visual display of the image but not the underlying image data – it has no impact on the Process of image analysis. You can define the color composition to visualize image layers in the View. Additionally, you can choose from different equalizing options. It enables you to visualize the image better and recognize the visual structures without changing them. You can also choose to hide layers, which can be very helpful when investigating image data and results.

Step 3: Lower Pane - Image Layers Global Settings

3.1) By changing the Global Settings in the lower pane - all settings in the upper pane are overwritten:

a) *Background*: Click on the square to change the background color of the image view.

b) *Raster mode*: Select between *Image Data* and *samples (rasterized)*. The View visualizes a rasterized version of these layers if vector layers or samples in a TTA mask are loaded. (The rasterized layer is used in segmentation algorithms).

c) *Equalization*: There are several modes for image equalization stretches. Compare the available methods and

choose one that gives you the best visualization of the objects of interest. Equalization settings are stored in the workspace and applied to all projects within the workspace or stored in a separate project. In the Options dialog box, you can define a default equalization setting (Figure 7).

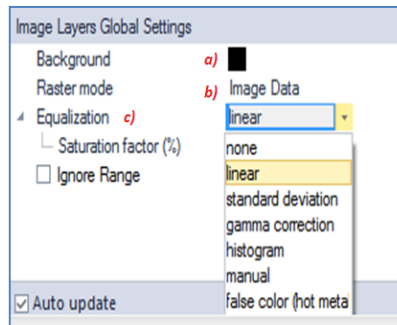


Figure 7: Image Layers Global Setting, Image Layer Equalization dialog

3.2) Notice Table 2 for more details on the functionalities of the Image Layers Global Settings options.

Table 2: The main functionalities of the Image Layers Global Settings options.

Option	Function
<i>None:</i>	No equalization allows you to see the scene as it is, which can be helpful at the beginning of ruleset development when looking for an approach. The image layer is displayed without further modification.
<i>Linear:</i>	Linear equalization with selectable saturation factor [Range 0-50]. Default value 1.00%. Displays images with higher contrast than without image equalization.
<i>Standard deviation:</i>	This equalization is a default mode. It renders a display similar to linear equalization. Use a parameter around 1.0 to exclude dark and bright outliers [Range 0-10].
<i>Gamma correction:</i>	Equalization improves the contrast of dark or bright areas by spreading the corresponding gray values [Range 0-5]. Default factor 0.5.
<i>Histogram:</i>	The histogram equalization increases the contrast of image layer but can lead to over-stretching. Because intensity values

	are better distributed on the histogram, it can be helpful in cases where you want to display areas with more contrast.
<i>Manual:</i>	Image Layer Equalization enables you to control equalization in detail for each layer individually.
<i>False-color (hot metal):</i>	False-color is recommended for single image layers with large intensity ranges to display in a color range from black over red to white. Select either the Range field in the upper pane of the dialog and insert border values to be displayed. Alternatively, you can open the Image Layer Equalization dialog with a single click on the small dots at the end of the column. For details see also Image Layer Equalization dialog.
<i>False-color (rainbow):</i>	is recommended for single image layers to display a visualization in rainbow colors. Here, the regular color range is converted to a color range between blue for darker pixel intensity values and red for brighter pixel intensity values. Select either the <i>Range</i> field in the <i>upper pane</i> of the dialog and insert border values to be displayed. Alternatively, you can open the <i>Image Layer Equalization</i> dialog with a single click on the small dots at the end of the column. For details, see also Image Layer Equalization dialog.
<i>Ignore Range:</i>	Activating the <i>Ignore range check-box</i> , you can enter a range of values that will be ignored when computing the image statistics for the image equalization. (Only active for Equalizing modes <i>linear</i> , <i>standard deviation</i> , <i>gamma correction</i> , and <i>histogram</i>). This option is useful when displaying e.g., elevation data excluding values and background areas in visualization. This option is only for image visualization. No data values can also be assigned when creating a project see chapter Assigning No-Data Values in Projects and Workspaces.
<i>Elevation (3D view):</i>	With point cloud data loaded and the 3D viewer active, image layers can be activated in the View Settings dialog (upper pane) and are then visualized as a 2D image in the 3D viewer. The default elevation for the image layer is the minimum elevation of all currently displayed point cloud points in the 3D viewer; this corresponds to the lower pane parameter value: -auto-. Enter a new height value (in the project unit) in this field to change the elevation.
<i>Auto update:</i>	This checkbox updates the view with each change of the view settings on the fly. Clear this checkbox to show the new settings after clicking Apply only. The Discard and Apply buttons become active with the Auto-update check box cleared.
<i>Apply to all views:</i>	With this checkbox activated, you can apply selected settings to all views at once.

3.3) You can easily change image layers' order and aliases in the Source View dialog (View > Source View). To rename a layer alias, you can right-click and select rename or press F2 to enter renaming mode or and double-click on a layer alias.

Step 4: Image Layer Equalization Dialog

4.1) To open the Image Layer Equalization dialog, single click on the small dots at the end of the line of the image layer you want to adjust. In this dialog, you can define the input range by either setting minimum and maximum values or dragging the borders with the mouse (yellow lines). You can set the equalization range for each layer individually (Figure 8).

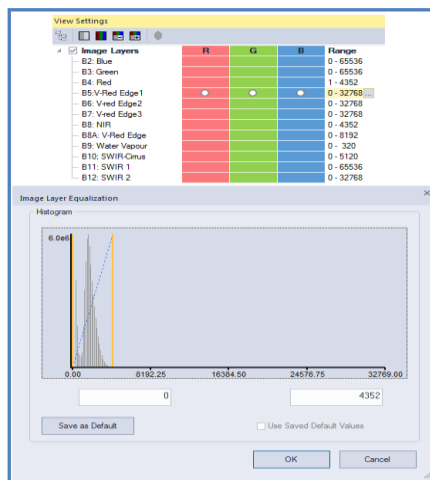


Figure 8: Image Layer Equalization Dialog box

4.2) It is also possible to adjust these parameters for all image layers using the mouse. With the right-hand mouse button held down in the image view: moving the mouse in a vertical direction adjusts the center value; moving it in vertical adjusts the width of the interval.

4.3) This function must be enabled in: Tools > Options > Display > Use right-mouse button for adjusting window leveling > Yes.

4.4) Image equalization is performed after mixing image layers into a raw RGB (red, green, blue) image. If, as is usual, one image layer is assigned to each color, the effect is the same as applying equalization to the individual raw layer gray value images. Image equalization leads to higher quality results if more than one image layer is assigned to one screen color (red, green, or blue). If it is performed after all image layers are mixed into a raw RGB image (Figure 9).

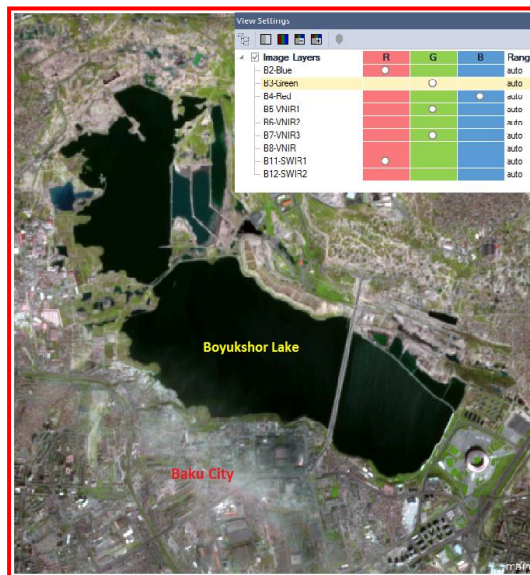




Figure 9: An RGB setting, subsetted from Sentinel 2 A imagery, Baku City

4.5) You can change the point cloud settings in the upper and lower pane of the View Settings dialog. You can also show point cloud layers individually using the respective checkbox of

a single point cloud layer. Deactivate the Point Clouds checkbox to hide all point cloud layers in the View or select specific point clouds to hide. You can change the order of point cloud layers by dragging and dropping within the Point Clouds section.

4.6) 3D subset selection button  is active on availability once a point cloud layer is loaded to the project. Select a subset using the 3D subset selection button. Subsequently, an additional window is opened where the subset is visualized in 3D (see Navigating in 3D). You can shift the subset when the left View is active, using the left, right, up, and down arrows of your keyboard.

4.7) With the 3D viewer active, image layers can be activated in the View Settings dialog (upper pane) and are then visualized as a 2D image in the 3D viewer. The default elevation for the image layer is the minimum elevation of all currently displayed point cloud points in the 3D viewer (-auto-). Change the elevation of the image layer by using the parameter in the lower pane Elevation (3D View) and enter a new height value (in the project unit). 3D vector layers can be displayed in the 3D viewer, supporting 2D and 3D points, lines, and polygon outlines (without fill).

4.8) The Zoom Scene to Window button  helps you reset the observer position and all zoom and rotation steps to default. With point cloud data loaded, you can open an additional toolbar View > Toolbars > 3D for more visualization options.

Step 5: Vector Layer Settings

5.1) You can change the vector layer settings in the upper pane (individual vector layer settings) and lower pane (global settings) of the View Settings dialog. You can change the order of thematic layers by drag and drop. All thematic layers can be activated and inactivated for display via the Vector Layers checkbox or individually using the respective checkbox of a single vector layer.

5.1.1) Upper pane - Individual Vector Layer Properties

- **Outline:** Select an outline color for vector layers.
- **Fill:** Choose a fill color for polygons.
- **Outline Width:** The value for the outline width changes the thickness of the vector outline for all vector layers. (This value is saved in the user settings and therefore applied to different projects.)
- **Transparency:** Select the transparency for a vector layer individually.

5.1.2) Lower pane - Vector Layers Global Settings

- ✓ **Background:** Click on the square to change the background color of the image view.
- ✓ **Outline Width:** The value for the outline width in this lower pane of the dialog changes the thickness of the vector outline for all vector layers. (This value is saved in the user settings and therefore applied to different projects.)
- ✓ **Auto Update:** This checkbox updates the view with each change of the view settings on the fly. Clear this check box to

show the new settings after clicking *Apply* only. The Discard and Apply buttons become active with the Auto-update check box cleared.

- ✓ Apply to all Views: With this checkbox activated, you can apply selected settings to all views at once.
- ✓ Note that by changing the Global Settings in this lower pane - all settings in the upper pane are overwritten (Figure 10).

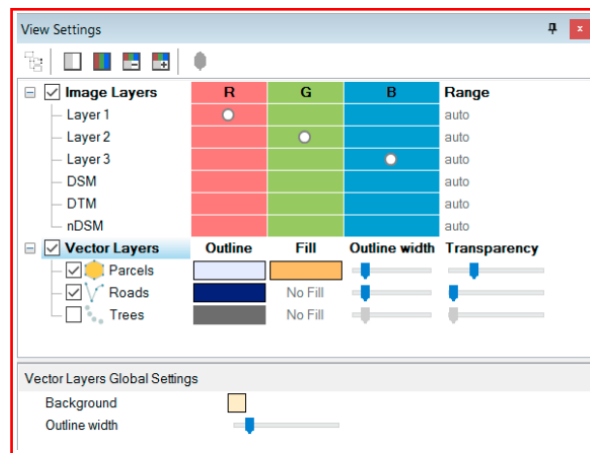


Figure 10: Vector Layer Settings for visualization of a vector layer

5.2) *The Layer Visibility Flag*: It is also possible to change the visibility of individual layers and maps in the Manage Aliases for Layers dialog box.

5.2.1) To display the dialog, go to Process > Edit Aliases > Image Layer Aliases (or Thematic Layer Aliases).

5.2.2) Hide a layer by selecting the alias in the left-hand column and un-checking the 'visible' checkbox (Figure 11).

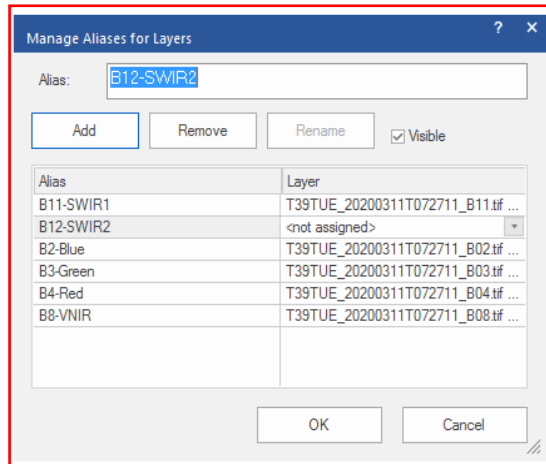



Figure 11: Manage Aliases for Layers dialog box

Step 6: Workspace inside eCognition 9.5

Workspaces are at the top of the hierarchical tree and are essentially containers for projects, allowing you to bundle several of them together. They are especially useful for handling complex image analysis tasks where information needs to be shared.

6-1) How to Create a Workspace:

6.1.1) You can start by creating a new workspace by selecting New Workspace from the File menu. Also, you may click on the Create New Workspace icon . This workspace will contain all of our projects.

6.1.2) We'll give our workspace a name, confirm it's in the appropriate folder, and click OK to create the workspace. Once we've created a workspace, you'll see that on the left side of the screen underneath the workspace section (Figure 12).

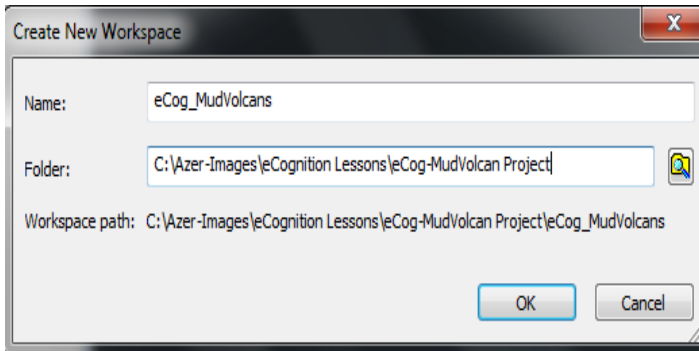





Figure 12: Create New Workspace dialog box

6.1.3) Moving over to Windows Explorer, we see a new folder created with the name of our workspace. In this case, eCog_MudVolcan project. The folder is a *. DPJ file within that workspace, which is the workspace file. So once again, when you create a workspace, it creates a folder and a *.DPJ file

 eCog_MudVolcans.dpj , which is the workspace file. So once again, when you create a workspace, it creates a folder  eCog_MudVolcans and a *.DPJ file.

6.1.4) Back in eCognition, you can now create your desired projects by clicking on the Create New Project icon . This project will be created within your workspace automatically. Or navigate to the directory containing our data, and we'll begin by loading our data.

6.1.5) Then, you may start by loading in the image data set called naip. Ing. Now I paid attention to the metadata, so I'm going to specify the layer alias names for each of my layers. Band two corresponds to the blue wavelengths, band three to

green wavelengths, band four to red, and finally, band four to near-infrared.

6.1.6) Later, you can repeat this process for the Sentinel 2A data sets. Don't be confused by the fact that it says import image layers. It is the term eCognition used for continuous raster data. Once again, I'm giving these layers meaningful aliases. Aliases make it easier for me to work with these raster data sets within eCognition. They also allow me to apply my ruleset to other data sets, providing the alias names are the same. So this gives me a tremendous amount of flexibility in developing and sharing rulesets.

6.1.7) You may load in my mud-volcanoes location data as shapefile data. So instead of loading it as an image layer, we load it as a thematic layer. Nevertheless, we're still going to give it a layer alias. So once again, if we have a separate project that uses a feature data set similar to this one, our rules set will work thanks to the alias name. Finally, we're going to give our project a meaningful name. I'm just going to call it eCog_Mud Volcans in this case, and then we'll click OK to create the project.

6.1.8) Now that I've created my project, I'll want to save it. I can go over to my taskbar and click on the Save Project icon.

6-2) Working with the Workspace

6.2.1) We see a new DPR folder in our workspace folder within Windows Explorer. This DPR folder contains all of the projects within our workspace. Every time we save a project, it stores its version number.

6.2.2) Now that we've created our project, let's explore how eCognition handles these data sets. First, we will go to Edit Aliases, Image Layer Aliases (Figure 13) under the Process menu.

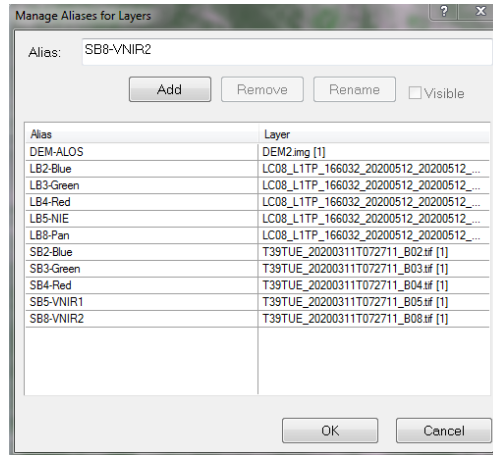


Figure 13: Manage Aliases Layers dialog box

6.2.3) Manage Aliases Layers dialog box lists all of the data sets we specified as image layers. So those continuous rasters, the Landsat 8, Sentinel 2A, and the DEM model, all bands corresponding to our image data sets. We may see that we have the alias names and the particular layers corresponding to them.

6.2.4) We can then do the same for our thematic aliases. It will show the alias we identified for our vector data set of mud-volcanoes location point data. The layers that we specified as image layers could be viewed using the Image Layer Mixing Dialogue.

6.2.5) Clicking on the Edit Image Layer Mixing Dialogue opens the Image Layer Mixing Dialogue window. We can change the

layer mixing down below. For this example, we'll move to a one-layer grey. And then, we'll cycle through all of our layers to ensure that they're being displayed correctly within eCognition.

6.2.6) To confirm that our thematic data loaded correctly, we can go to our view settings, and in the view settings dialogue, change the layer from image data to our thematic point layer.

6.2.7) By right-clicking on your project and choosing to modify it, you can go in and change the name of your project, add or remove layers, or view your project setup.

6.2.8) If your project is large, it may be advantageous to establish a subset of that project when developing your ruleset. Subsets are smaller versions of your project that contain subsets of the data. As a result, many of your algorithms, particularly time-consuming ones such as a segmentation algorithm, will run significantly faster.

6.2.9) To establish your subset, click on the subset tool, draw a rectangle around an interesting area you'd like to subset, then right-click and choose Save Subset to Workspace. This action will save the subset as a new project within your workspace. It will retain all the data and layers of the original project, only for the smaller subset section that you selected.

6.2.10) You can establish multiple subsets from a single project. For example, the first subset I establish would be good for testing a building algorithm, but the second would be great for testing out a water extraction algorithm. Once you've created your subsets, you can double-click on them to view them and

then click on the Save Project icon to ensure they save in the workspace.

6.2.11) Moving over to Windows Explorer, we see that our subsets save as new project files within the DPR folder, located within our workspace demo folder.

Step 7: Creating an Initial Project

7.1) To create a simple project – one without thematic layers, metadata, or scaling (geocoding is detected automatically) – go to File> Load Image File in the main menu (Figure 14).

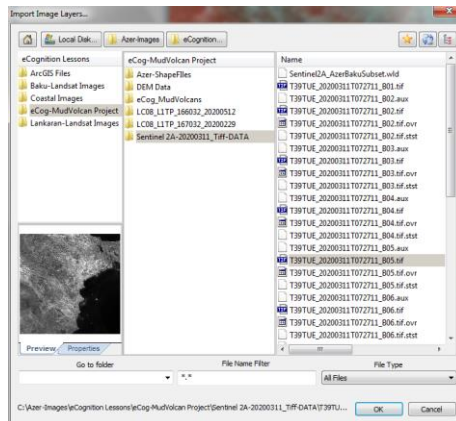


Figure 14: Load "Image File dialog box" for a simple project, with recursive file display, selected

7.2) Load Image File (along with Open Project, Open Workspace, and Load Ruleset) uses a customized dialog box. Selecting a drive displays sub-folders in the adjacent pane; the dialog will display the parent folder and the subfolder.

7.3) Clicking on a sub-folder then displays all the recognized file types within it (this is the default).

7.4) You can filter file names or file types using the File Name field. To combine different conditions, separate them with a semicolon (for example *.tif; *.las). The File Type drop-down list lets you select from a range of predefined file types. The buttons at the top of the dialog box let you easily navigate between folders. Pressing the Home button returns you to the

root file system  .

7.5) There are three additional buttons available. The Add to Favorites button on the left lets you add a shortcut to the left-hand pane, listed under the Favorites heading. The second button, Restore Layouts, tidy up the display in the dialog box. The third, Search Subfolders, additionally displays the contents of any subfolders within a folder. By holding down Ctrl or Shift, you can select more than one folder. Files can be sorted by name, size, and by date modified. In the "Load Image File" dialog box, you can:

7.5.1) Select multiple files by holding down the Shift or Ctrl keys, as long as they have the same number of dimensions.

7.5.2) Access a list of recently accessed folders displayed in the Go to Folder drop-down list. You can also paste a file path into this field (updating the folder buttons at the top of the dialog box).

Step 8: Creating a Project with Predefined Settings

8.1) When you create a new project, the software generates a main map representing the image data of a scene. You select

image layers and optional data sources like thematic layers or metadata for loading to a new project to prepare this. You can rearrange the image layers, select a subset of the image or modify the project default settings. In addition, you can add metadata.

8.2) An image file contains one or more image layers. For example, an RGB image file contains three image layers, which are displayed through the Red, Green, and Blue channels (layers).

8.3) Open the Create Project dialog box by going to File> New Project (for more detailed information on creating a project, refer to The Create Project Dialog Box). The Import Image Layers dialog box opens. Select the image data you wish to import, then press the Open button to display the Create Project dialog box.

8.3.1) Opening certain file formats or structures requires selecting the correct driver in the File Type drop-down list.

8.3.2) Then, select from the main File in the files area. If you select a repository file (archive file), another Import Image Layers dialog box opens, where you can select from the contained files. Press Open to display the Create Project dialog box.

8.3.3) The Create Project Dialog Box looks like Figure 15.

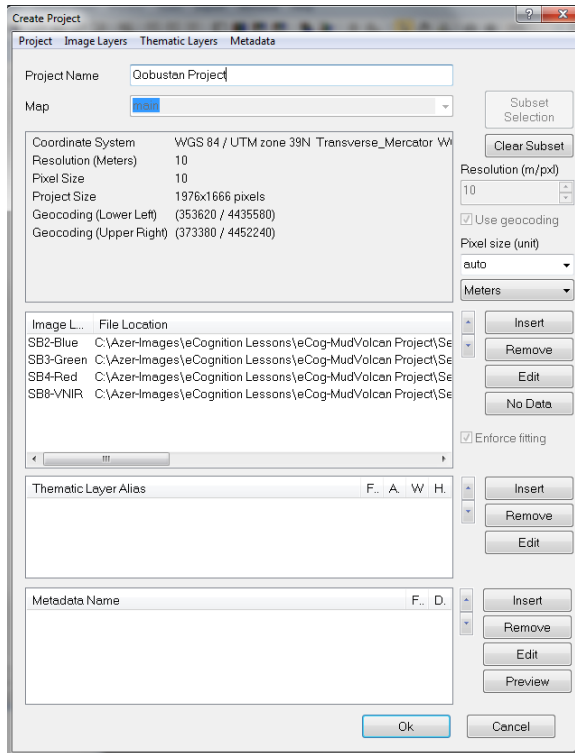


Figure 15: Create Project dialog box

8.4) The Create Project dialog box gives you several options. We can edit these options at any time by selecting File> Modify Open Project:

8.4.1) Change the name of your project in the Project Name field. The Map selection is not active here but can be changed in the Modify Project dialog box after project creation is finished.

8.4.2) If you load two-dimensional image data, you can define a subset using the Subset Selection button (Figure 16).

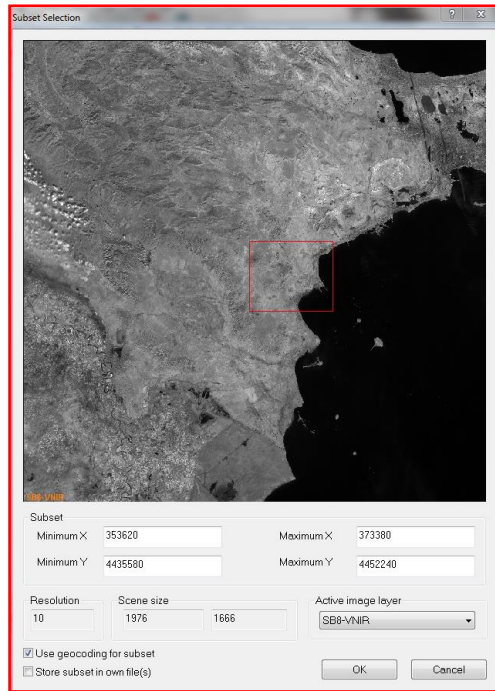


Figure 16: The Subset Selection dialog box

8.4.3) If the complete scene to be analyzed is relatively large, subset selection enables you to work on a smaller area to save processing time (Figure 17).

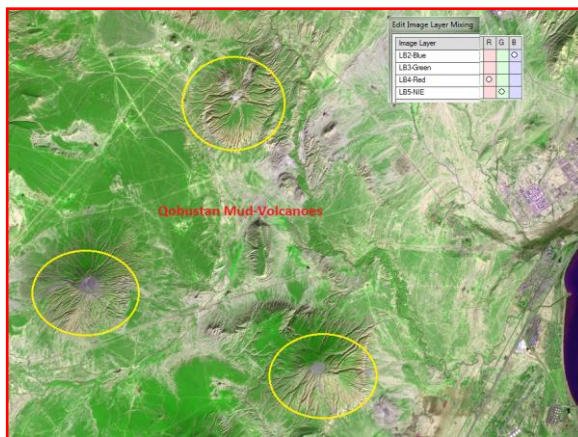


Figure 17: A subsetted project for a smaller Qobustan area

8.4.4) If you want to rescale the scene during import, edit the scale factor in the text box corresponding to the scaling method used: resolution (m/pxl), magnification (x), percent (%), or pixel.

8.4.5) To use the geocoding information from an image file to be imported, select the Use Geocoding checkbox.

8.4.6) For feature calculations, value display, and export, you can edit the Pixels Size (Unit). If you keep the default (auto), the unit conversion is applied according to the coordinate system of the image data.

8.4.7) If geocoding information is included, the pixel size equals the resolution. In other cases, pixel size is 1.

8.5) In special cases, you may want to ignore the unit information from the included geocoding information. To do so, deactivate Initialize Unit Conversion from the Input File item in Tools > Options in the main menu

8.6) The Image Layer pane allows you to insert, remove and edit image layers. The order of layers can be changed using the up and down arrows – If you use multi-dimensional image data sets, you can check and edit multi-dimensional map parameters. You can set the number, the distance, and the starting item for both slices and frames.

8.6.1) If you load two-dimensional image data, you can set the value of those pixels that are not to be analyzed. Select an image layer and click the No Data button to open the Assign No Data Values dialog box.

8.6.2) If you import image layers of different sizes, the largest image layer dimensions determine the scene's size. When importing without geocoding, the smaller image layers keep their size if the Enforce Fitting check box is cleared.

8.6.3) Select the Enforce Fitting checkbox to stretch the smaller image layers to the scene size.

8.6.4) Thematic layers can be inserted, removed, and edited similarly to image layers. If not done automatically, you can load Metadata source files to make them available within the map.

Step 9: Setting the Geocoding

9.1) Geocoding is the assignment of positioning marks in images by coordinates. In earth sciences, position marks serve as geographic identifiers. But geocoding is helpful for life sciences image analysis too. Typical examples include working with subsets, multiple magnifications, or thematic layers to transfer image analysis results.

9.2) Typically, available geocoding information is automatically detected: if not, you can enter coordinates manually. Images without geocodes automatically create a virtual coordinate system with a value of 0/0 at the upper left and a unit of 1 pixel. For such images, geocoding represents the pixel coordinates instead of geographic coordinates. The Layer Properties dialog box allows you to edit the geocoding information (Figure 18).

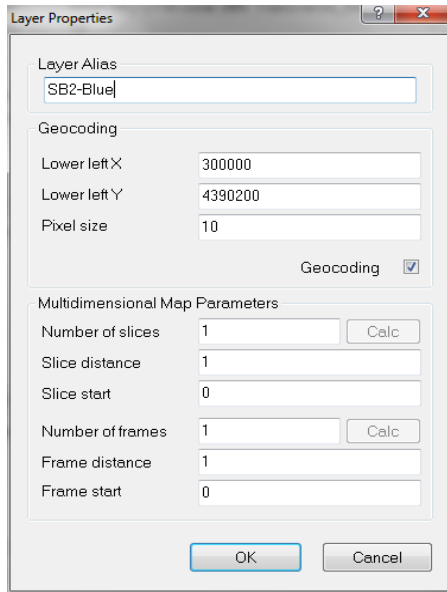


Figure 18: Layer Properties dialog box

9.3) The software cannot re-project image layers or thematic layers. Therefore all image layers must belong to the same coordinate system to be read properly. If the coordinate system is supported, geographic coordinates from inserted files are detected automatically. If the information is not included in the image file but is nevertheless available, you can edit it manually.

9.4) After importing a layer in the Create New Project or Modify Existing Project dialog boxes, double-click on a layer to open the Layer Properties dialog box. To edit geocoding information, select the Geocoding check box. You can edit the following:

- x coordinate of the lower-left corner of the image
- y coordinate of the lower-left corner of the image
- Pixel size defining the geometric resolution

9.5) More Options To Apply

9.5.1) *The Assign No Data Values Dialog Box:* No-data values can only be assigned to scenes with two dimensions. It allows you to set the value of pixels that are not analyzed. You can apply only no-data-value definitions to maps that have not yet been analyzed.

9.5.2) *Importing Image Layers of Different Scales:* You can insert images and thematic layers with different resolutions (scales) into a map. They need not have the same number of columns and rows. To combine image layers of different resolutions (scales), the images with the lower resolution – having a larger pixel size – are resampled to the smallest pixel size. If the layers have the same size and geographical position, then geocoding is not necessary for the resampling of images.

9.5.3) *Editing Multidimensional Map Parameters:* When creating a new map, you can check and edit parameters of multidimensional maps that represent time series. Typically, these parameters are taken automatically from the image data set, and this display is for checking only. However, you may want to change the number, distance, and frames' starting item in special cases.

9.5.4) *Multisource Data Fusion:* If the loaded image files are geo-referenced to one single coordinate system, you can insert image layers and thematic layers with different geographical coverage, size, or resolution. It means that you can simultaneously use image data and thematic data of various

origins. It can bring the different information channels into a genuine relationship.

Sum Up:

eCognition version 9.5 is such powerful software that it is challenging to summarize all of its advantages and benefits within one tutorial. But in the current tutorial, we tried to introduce some of its main structure and functionalities before you can start working through specific tasks learning how to apply the main approaches step-by-step in the following tutorials.

Likewise, we believe that workspaces are at the top of the hierarchical tree and are essentially containers for projects, allowing you to bundle several of them together. They are especially useful for handling complex image analysis tasks where you must process high-resolution satellite imagery.

Informative Practices

Tips:

- 1) Any Workspace is a safe house for eCognition projects.
- 2) The image file and the associated data within a scene can be independent of eCognition software (although this is not always true).
- 3) You can fuse (combine) Sentinel-2 data and other sensor data to enhance your research approaches.

Workouts:

- 1) Create a workspace and place two different subsetted projects inside it.
- 2) Load Image bands for the project as you created and then change image layers differently.
- 3) Clarify the difference between Sentinel 2a and 2b.

Quizzes:

- 1) What does this group of buttons allow you to do?



- 2) After the workspace is created, what to do next?
- 3) How many Sentinel-2 satellites are there in space?

Allied References:

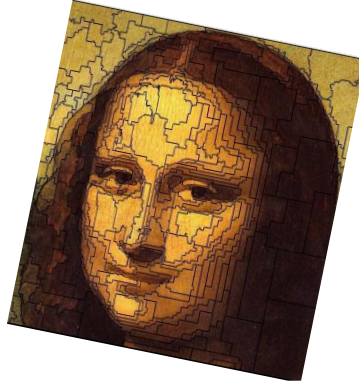
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Tutorial 3

Examining The Image Segmentation Algorithms



sets of related pixels, also prized as image objects

Opening Statement:

In the current tutorial, you first become acquainted with the other way of accessing the Sentinel-2 imagery adjusted to the northwest of Azerbaijan, around the Mingachevir Dam. Then, you will learn how to segment such imagery in different ways inside the eCognition software, which advances a new, object-oriented approach to image analysis. In contrast to traditional image processing methods, the basic processing units of OBIA are image objects or segments and not single pixels. Even the classification acts on image objects. For this reason, one motivation for the object-oriented approach is that the expected result of many image analysis tasks is the extraction of real-world objects, proper in shape and proper in classification.

Instructive Memo:

- ✓ *Level:* Intermediate
- ✓ *Time:* This unit should not take you more than 1.5 hours.
- ✓ *Software:* eCognition Developer version 9.5.

- ✓ *Data Sources:* Sentinel-2, L1C_L1C_T38TPL_A030262_20210408T074154.tif.
- ✓ *Subject Scene:* Mingachevir Dam, Azerbaijan.

Tutor Objectives:

By the end of this unit, you should:

- ✚ Be able to access the Sentinel-2 Images through the GLOVIS website.
- ✚ Be able to apply each of the segmentation techniques available with eCognition Developer to an image.
- ✚ Be aware of the difference between the various segmentation algorithms and the types of objects (size and shape) they produce.

Background Concepts:

Segmentation is defined as the partitioning of an image into image objects; in a way, an image object is a group of connected pixels in a scene. Segmentation means grouping neighboring pixels into regions (or segments) based on similarity criteria (digital number, texture). Image objects in remotely sensed imagery are often homogenous and can be delineated by segmentation. It is always the first step of any process within eCognition Developer as it generates the image objects on which the classification process will be performed. The important part is for the segmentation process to identify objects that represent the features you wish to classify and are distinct in terms of the features available within eCognition (e.g., spectral values, shape, and texture). You could capture the data sources from Sentinel-2 imagery, adjusted for the around Mingachevir Dam. Mingachevir is the fourth-largest city in

Azerbaijan, with about 110,000. It's often called the "city of lights" because of its hydroelectric power station on the Kur River, which divides the city down the middle (Figure 1).

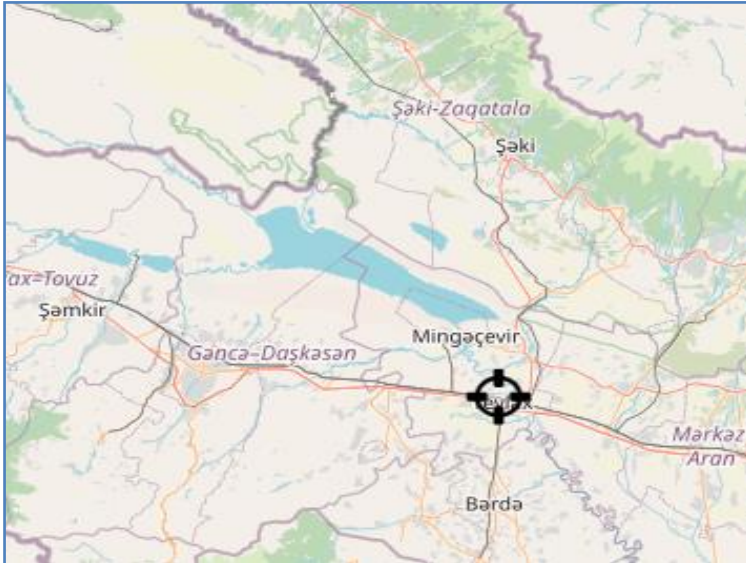


Figure 1: The selected subject *Scene*, the Mingachevir Lake

The Mingachevir Dam (Hydro Power Station) is an earth-fill embankment dam on the Kura River north of Mingachevir in Azerbaijan.

Mastering The Skills:

In image segmentation, the expectation is, in many cases, to automatically extract the desired objects of interest in an image for a certain task. However, this expectation ignores the considerable semantic multitude that in most cases needs to be handled to achieve this result successfully, or it leads to the development of highly specified algorithms applicable to only a reduced class of problems and image data.

Step 1: The Sentinel-2 Images From GLOVIS

1.1) Registration and Login

GloVis utilizes the USGS EROS Registration System (ERS) and can be accessed with existing GloVis or Earth Explorer credentials.

1.1.1) The ERS Help Document has step-by-step instructions on the registration process. To set up new credentials, click Create New Account to register.

1.1.2) Select Login on the top toolbar. Enter your username and password and then click Sign In to access all features of GloVis (Figure 2).

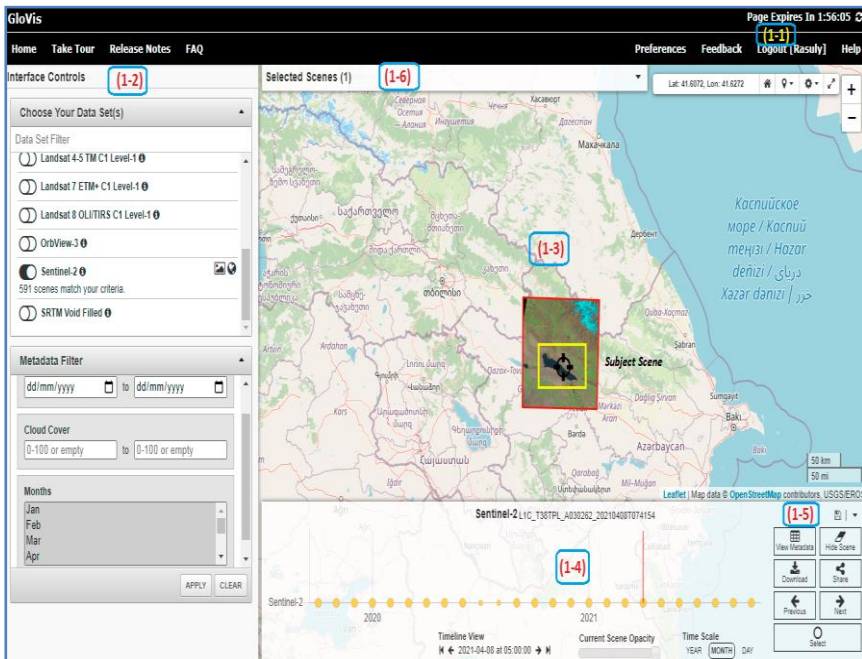




Figure 2: USGS Glovis site, the entrance Hub


1.2) Select Data Set(s) and Apply Filters

Navigate GloVis by using the Interface Controls panel on the left side of the screen. This panel provides options to set up a data search.

1.2.1) Choose Your Data Set(s). To begin, select a data set from the Choose Your Data Set menu. Toggle the data set on ( Sentinel-2) to activate and save the selection. The total number of available scenes is listed below the data set name, and the map view shows a coverage map to indicate data availability. The coverage map for each data set is a different color (). You can turn off the coverage map by clicking the icon.

1.2.2) Metadata Filter: The Metadata Filter provides options that narrow search results. Update one or more filters, then click Apply to save all selections and view the matching scenes.

- a) You can Filter data temporally by Date Range using mm/dd/yyyy to mm/dd/yyyy.
- b) Enter a Cloud Cover range to narrow the results based on the percentage (0-100%) of the scene covered by clouds. Leave this filter empty for data sets that do not report cloud cover, such as GLS.
- c) Select Months to further limit search results to scenes acquired during a portion of the year. Hold down the Shift or Ctrl keys to select more than one month while selecting additional rows.

1.2.3) Click the triangle () in the upper right of the header to collapse the menu.

1.3) *Define Area of Interest*

The next step is to define the geographic area of interest.


1.3.1) To select a location, click and drag the map to pan and scroll to zoom into your area of interest. Then, utilize the Jump To... menu (📍) in the upper right of the map. As the zoom function is activated, the display shows browse images that intersect the Map Center Point crosshair (📍) in the center of the viewport. To see data behind the Interface Controls, click the triangle in the upper right of that panel to collapse the panel. As the mouse moves across the map, the coordinates are displayed in decimal degrees in the upper right portion of the map view area. You can enable the Full Screen (⌕) mode to view the map in Full-Screen mode.

a) Pan and Zoom: Use the mouse scroll wheel or the +/- controls in the upper right corner of the map view to activate the browse imagery display or enlarge the browse images. The zoom level required to activate to browse images depends on scene size and varies by data set.

b) Pan to adjacent areas by clicking and dragging the map. The data sets automatically refresh if the zoom level allows imagery to display.

c) Jump To... Options (📍): The Jump To... menu, in the upper right of the map field, provides the opportunity to use Current Location, Latitude/Longitude, or WRS Path/Row to select a location. The Current Location shifts the center point of the map to the current physical browser location once the browser shares the current location with the GloVis site.

d) As the area of interest is modified, each data set updates the count of scenes that match.

To indicate data availability, you can toggle on the "browse level coverage map icon" ()

1.4) *Scene Navigation and Selection*

The Scene Navigator panel appears near the lower right portion of the screen when browse images are loaded.


1.4.1) The Scene Navigator shows the Data Set, Entity ID, and Acquisition date of the most recent scene. The current scene is depicted with a red outline and is displayed on top of all other browse images. For the visually impaired, You can change the outline's color in the Map Preferences section of the Preferences menu.

1.4.2) Scenes are arranged by acquisition date. The Previous button selects and highlights the next most recent scene. Use the Previous and Next buttons to scroll through the results. The display uses a rolling display of browse images closest to the acquisition date of the current scene.

1.4.3) The Select button adds a scene to the Selected Scenes list just below the black toolbar across the top of the map view. Once a scene has been selected, click Unselect to remove it from the Selected Scenes.

1.5) Scene Navigator Controls

The Scene Navigator panel also includes icons to Share Scene, View Metadata, Download Scene, and Hide Scene. Login is required for downloading.

1.5.1) Share Scene (): The Share Scene icon opens a menu with options for Scene Summary, Metadata XML, and Reduced Resolution Browse (Figure 3).

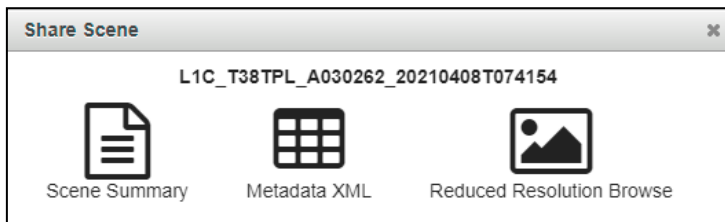




Figure 3: Share Scene Summary dialog box


1.5.2) Scene Summary opens a new browser tab that shows the browse image, links to download available products, full metadata for the current scene, and links to order products (WMS On-Demand and Bulk Download) options are available. Metadata XML opens a new tab with the scene XML metadata. And Reduced Resolution Browse opens a new tab with a larger browse image.

1.5.3) View Metadata (): Click the View Metadata icon to display the full metadata for the current scene. The data set attributes are displayed in table format (Figure 4).

Scene Metadata	
Field	Value
Entity ID	L1C_T38TPL_A030262_20210408T074154
Acquisition Start Date	2021-04-08T07:41:54.809Z
Acquisition End Date	2021-04-08T08:00:40.434Z
Tile Number	T38TPL
Cloud Cover	0.00000
Agency	ESA
Platform	SENTINEL-2A
Vendor	VGSA
Vendor Tile ID	L1C_T38TPL_A030262_20210408T074154
Orbit Number	92
Orbit Direction	Descending Orbit
Vendor Software Version	03.00
Production Date	2021-04-08T09:11:12.000000Z
Vendor Product ID	S2A_MSIL1C_20210408T073611_N0300_R092_T38TPL_20210408T091112
Archiving Center	VGSA
Datatake Type	INS-NOBS
Datatake Identifier	GS2A_20210408T073611_030262_N03.00
Data Type	UINT16
Product Type	S2MSI1C
Product Format	JPEG2000
Processing Level	LEVEL-1C
Datatrip ID	S2A_OPER_MSI_L1C_DS_VGSA_20210408T091112_S20210408T074154_N03.00
Datum	WGS84
Map Projection	UTM
UTM Zone	38N
EPSG Code	32638
Resolution	10, 20, 60
Units	METER

Figure 4: display the full metadata for the current scene

1.5.4) Download Scene (

1.5.5) Hide Scene (227

1.6) Scene List

Go to Selected Scenes at the top of the map view to view the scene list created by selecting scenes in the Scene Navigator panel (Figure 5).

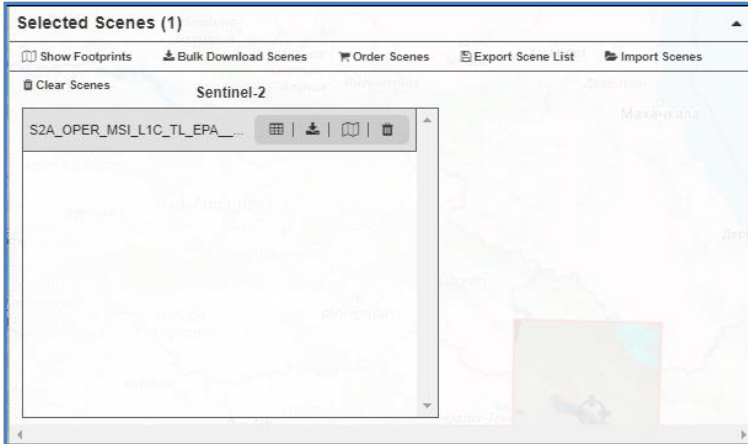






Figure 5: Selected Scenes dialog box

1.6.1) Individual Scene Controls: The scene list shows each scene's data set and entity ID. Individual Scene Controls include Show Metadata (), Download Scene (), Order Scene (), or Show Footprint (). Download and Order options vary by data set.

1.6.2) Scene List Controls: The selected scenes panel allows users to Show All Footprints, Export Scene ID List, Import Scene List, or Clear All Scenes.

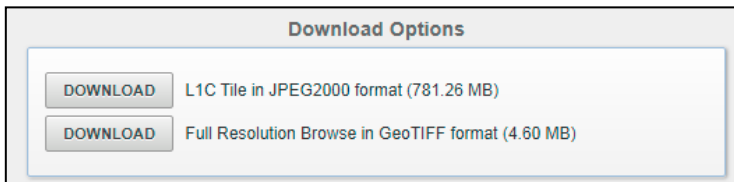


Figure 6: Sentinel 2A format, Download Options dialog

1.6.3) Download and Order options vary by data set (Figure 6). The Export Scene List and Import Scene List are functions of GloVis only.

Step 2: Set up a Project

As with all work within eCognition Developer, the first step is to create a project containing all the datasets required for the study.

2.1) Your targeted project should have the same parameters as that shown in these steps in the previous tutorials.

2.2) Figure 7 shows the current tutorial selected area, part of the Mingachevir area, Azerbaijan, inside the eCognition project.

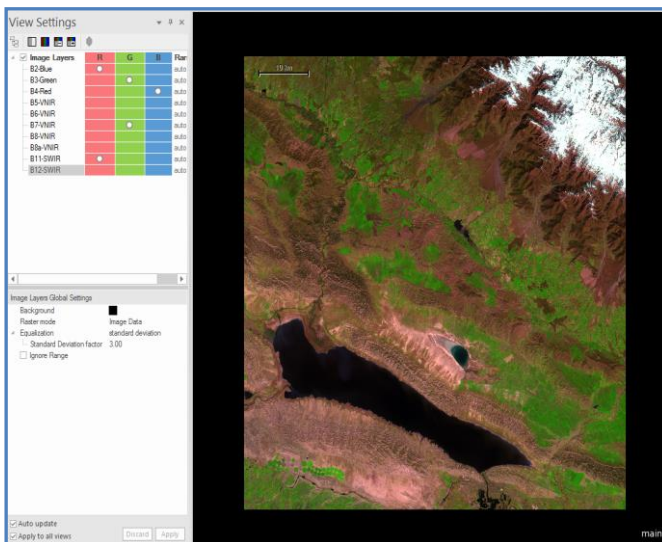


Figure 7: setting up the Mingachevir area inside the eCognition Project

2.3) Please note the order in which the image bands have been loaded, i.e., the high-resolution bands (blue, green, or red) first, as this will decide the project's image resolution. In case the 20 m multispectral of Sentinel-2 channels are resampled to the 10

m of the first data. Once you have matched your project window select OK and create your project.

2.4) Although it is important to keep an eye on the size of the images you are creating, a project with an eCognition Developer can become very slow with very large datasets due to the number of objects generated during the segmentation process.

Step 3: Display Imagery

3.1) Doing these exercises, we recommended you subset a small part of the Sentinel-2 imagery.

3.2) For the multispectral false-color image, use the band combination B2-Blue, B3-Green, B4-Red, B7-VNIR, and B11-SWIR components, as is illustrated in Figure 8.

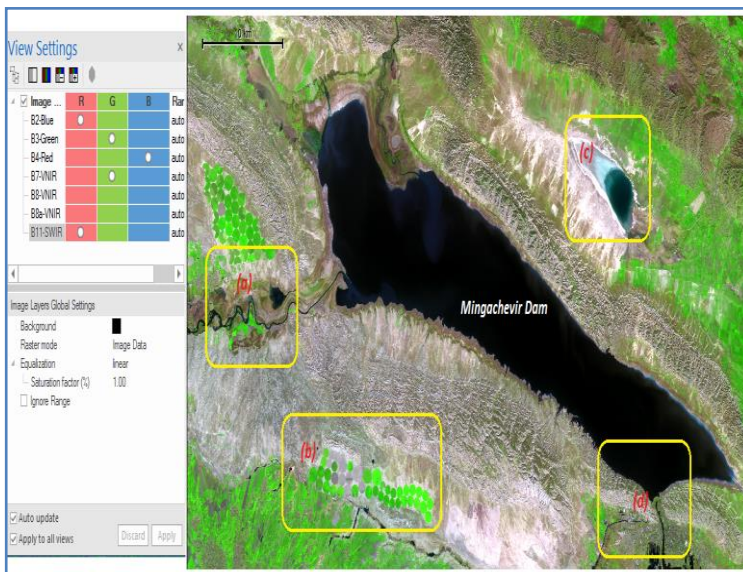



Figure 8: The layer mixing properties for the subsetting image

3.3) You need to set the eCognition interface with the project and display parameters defined. For more details, read previous tutorials.

Step 4: Setup your Process Tree

The Process Tree () will contain the script you produce to control the processes (algorithms) that run and the order in which they are executed. To insert a process:

4.1) Right-click within the process tree window, and the following menu will appear (Figure 9).

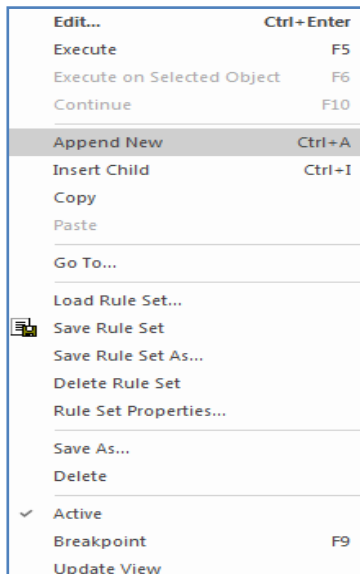


Figure 9: Process tree context menu

4.2) Select 'Append New,' and the Edit Process dialog will appear (Figure 10).

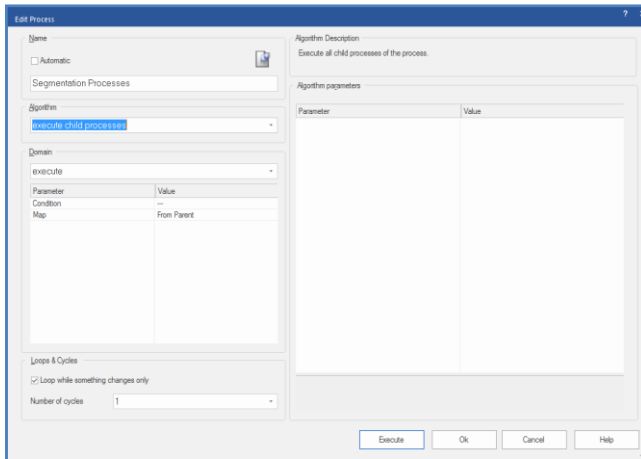


Figure 10: The Edit Process dialog box, a basic outline for the segmentation processes

4.3) The Edit Process dialog box would be the main segmentation process. You can put several underset segmentations processes by selecting the Insert Child option. In addition, you may like to arrange other algorithm arrangements in the Template Process Tree before or after segmentation processes, as you notice in Figure 11.

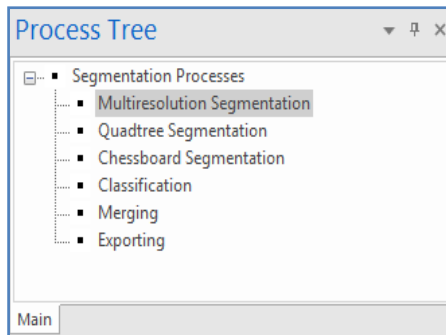


Figure 11: Template Process Tree, a suggested arrangement

4.4) It is important to keep the scripts that you produce during your segmentation procedures as organized as possible. It will allow you to understand what you have done when you come

back to it. With this in mind, Figure 11 contains a template you may aim to adhere to during your exercises.

Step 5: Examples of Segmentation Algorithms

5.1) Starting with Multiresolution Segmentation

5.1) The first and most general segmentation technique available within eCognition Developer is multiresolution segmentation. To insert this algorithm within your Process Tree, right-click on your 'Segmentation' process in the template you previously entered and select 'Insert Child.'

5.2) Select the algorithm as 'multiresolution Segmentation within the created dialog box. If this algorithm is not available, scroll to the bottom of the list, select more, and move the algorithms you wish to have in the list to the right-hand column. It should now present you with the dialog box shown in Figure 12.

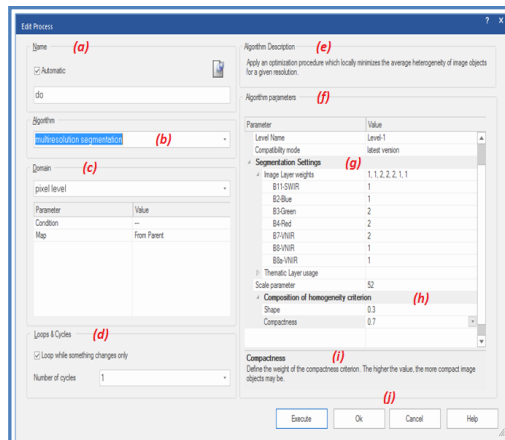


Figure 12: Edit Process dialog box, adjusted for the multiresolution segmentation algorithm

5-3) Table 1 briefly describes the parameters available for this segmentation algorithm. The 'Edit Process' dialog is made up of

elements. Each of which will become clear as you move through the notes:


Table 1: An overview of parameters for segmentation

Parameter	Function Description
<i>a) Name:</i>	The name of the process and can either be manually entered or automatically provided by the software. A good convention is to manually edit the name where nothing else is changed within the process. Otherwise, use the automatic function. The note icon allows a comment to be written about the process.
<i>b) Algorithm:</i>	The algorithm to execute. This drop-down menu allows you to select the algorithm you wish to execute; there is an extensive list of algorithms that it will use during these units.
<i>c) Image Object Domain:</i>	The image object domain defines the object(s) that will execute the algorithm. The drop-down box and 'Parameter' box allow the level to be selected. The following button ('all objects') allows a class(es) to be defined, while the final button ('no condition') allows a rule to be used, for example, $\text{area} > 20 \text{ m}^2$.
<i>d) Loops & Cycles:</i>	It is possible to allow a process to form a loop, often in the form of a while loop, and the tick box allows this to be selected .
<i>e) Algorithm Description:</i>	A simple description of the algorithm you are using.
<i>f) Algorithm Parameters:</i>	These are the parameters associated with an algorithm that you could select, such as the name of the level in the hierarchy created by the segmentation algorithm.
<i>g) Segmentation Settings:</i>	Increases the weighting of the layer when calculating the heterogeneity measure used to decide whether pixels/objects are merged. Zero ignores layer. Scale parameter controls the amount of spectral variation within objects and their resultant size with no unit. Suppose any thematic layers are available. Thematic Layer Usage allows thematic layers to be turned on and off individually for use within the segmentation process.
<i>h) Composition of homogeneity criterion: Shape</i>	Shape factor acts as a weighting between the object's shape and its spectral color whereby if 0. Only color is considered, whereas if > 0 , the object's shape and the color are considered, and, therefore, fewer fractal boundaries are produced.

	The higher the value, the more that shape is considered. Compactness is a weighting factor for representing the compactness of the objects formed during the segmentation process.
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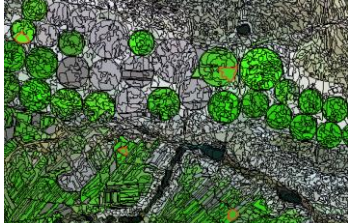
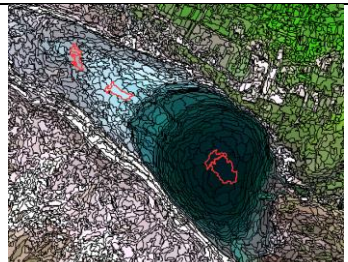
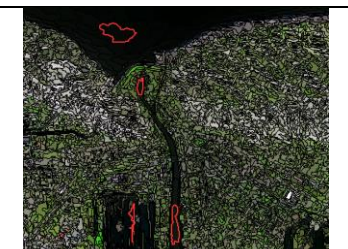
5.4) To run the segmentation process, leave the parameters at their default values (as it is shown in Figure ?) and click execute. It is recommended that you give your level a proper name. A common level name convention is to number them, starting with Level 1. Once you are happy with the parameters and have executed the process, you should have completed your first segmentation.

5.5) The multiresolution segmentation creates objects using an iterative algorithm, whereby objects (starting with individual pixels) are grouped until a threshold representing the upper object variance is reached. The variance threshold (scale parameter) is weighted with shape parameters (with separation of shape and compactness parameters) to minimize the fractal borders of the objects. By increasing the variance threshold, larger objects will be created, although their exact size and dimensions are dependent on the underlying data.

5.6) Once the segmentation is executed, select the 'Show or Hide Outlines' icon () , and the outlines of the objects (segments) created will be displayed over the image. Make sure you have the cursor in the 'cursor mode' rather than the 'zoom mode,' select the objects (with either the outlines turned on or off) in turn. Using the 'Image Object Information' window, you will see

the values for features associated with the selected object. Examples of a few segmented samples are shown in Table 2.

Table 2: Image objects created by Multiresolution Segmentation for different sampled sites (see Figure 8).

Sampled Sites	Segmented Samples	Image Objects Created
(a)		image objects well-adapted to the river path, a small lake and traditional agricultural fields.
(b)		image objects well-adapted to the traditional and modern agricultural fields.
(c)		image objects well-adapted to a small salty lake and non-vegetated areas around.
(d)		image objects well-adapted to the Mingachevir Dam water surface and downstream channels

5.7) In Table 2, image objects created by Multiresolution Segmentation algorithm for part of modern irrigated agricultural fields located in the southwest of the Mingachevir Dam.

Step 6: Streaming Other Segmentation Processes

By spending approximately 30 minutes experimenting with different segmentation and input parameters, you will observe the differences in the images objects created. A few examples are given as follow:

6.1) Quadtree-based Segmentation

A Quadtree segmentation creates regular square objects, where the variation of the object defines the size. Unlike multiresolution segmentation, the objects are created by dividing larger objects until the resultant objects are all within the upper boundary of allowed variation. As with the multiresolution segmentation, the variation at which a final object is defined using a scale parameter.

6.1.1) To create a quadtree segmentation, follow the same procedure used in Figure 13.

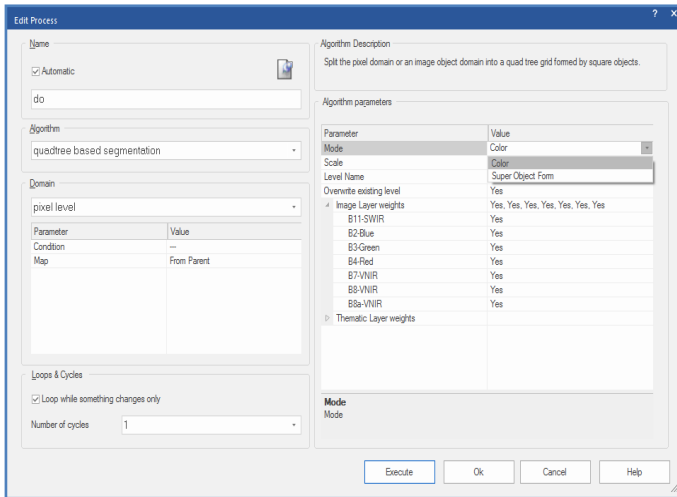


Figure 13: The Edit Process dialog box, Quadtree based segmentation

6.1.2) A scale factor of 20-60 is recommended for the segmentation, although others might be more appropriate. Try several scale factors for representing different landcover types (Figure 14).

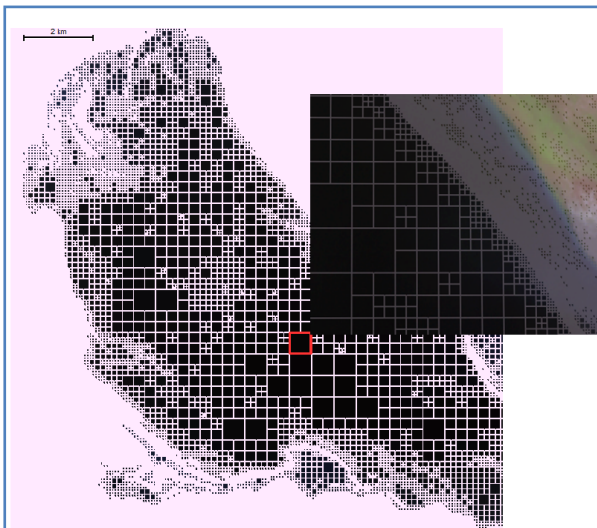


Figure 14: The Quadtree segmentation resulted for the part of the Mingachevir Lake

6.2) Chessboard Segmentation

A chessboard segmentation is the simplest segmentation available as it just splits the image into square objects with a size predefined by the user. The segmentation does not consider the underlying data, and therefore when large objects are created. It will not delineate the features within the data you are trying to classify.

6.2.1) To start a Chessboard segmentation, right-click on the associated item inside the Process Tree and select the Edit option.

6.2.2) When the Edit Process dialog box opens, set up all parameters as Figure 15.

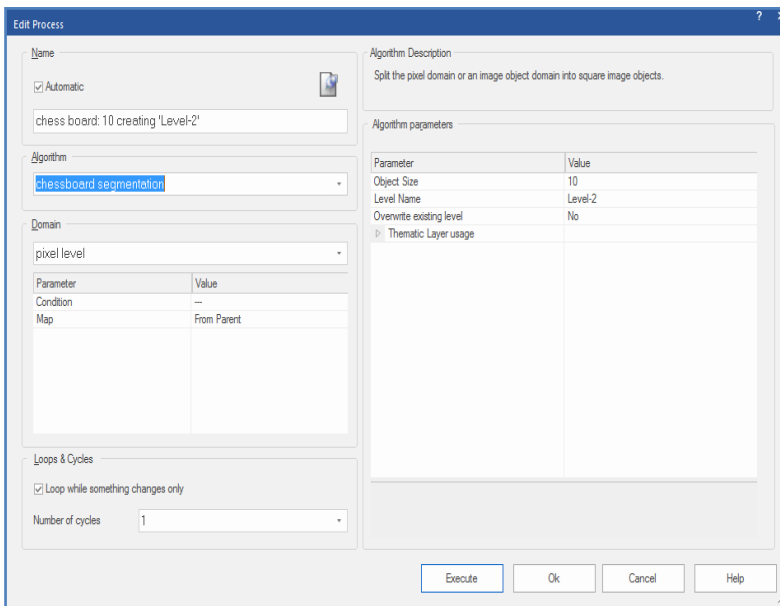


Figure 15: The Edit Process dialog box, Quadtree based segmentation

6.2.3) This type of segmentation tends to be used in more advanced processes where segmentation is undertaken in several steps combined with a classification (Figure 16).

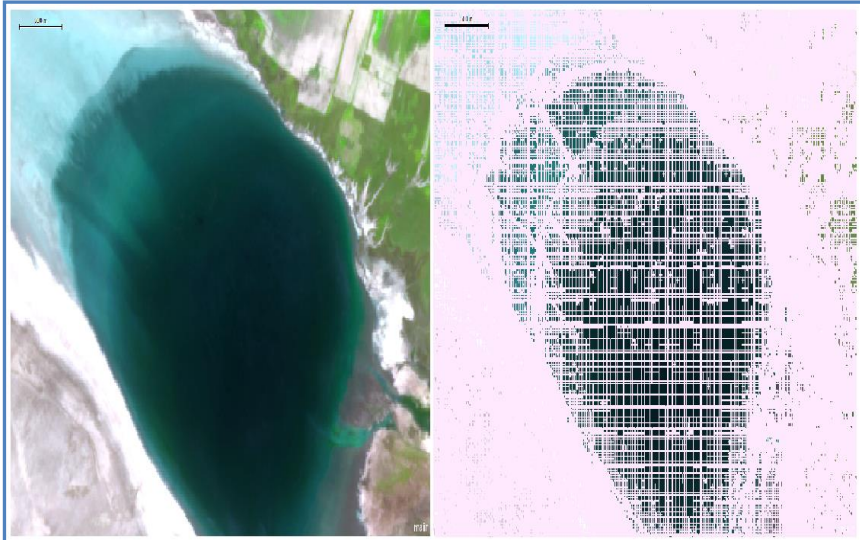


Figure 16: The chessboard segmentation result

6.2.4) To perform a default chessboard segmentation, set up the process the same way as the multiresolution and Quadtree Segmentation, but selecting the chessboard segmentation algorithm. To begin with, use a value of 10 for the Segmentation that generates objects of 10x 10 pixels and then progressively increase or decrease this value. Notice, in each case, how the boundaries and spectral information of the underlying data are ignored.

6.2.5) Inside the eCognition 9.5, you could experience more segmentation algorithms to create an adjusted segmentation for your data and aims. For some of the segmentation algorithms' descriptions and uses are given in Table 3.

Table 3: More dissimilar segmentation methods available inside the eCognition 9.5

Segmentation Type	Description	Uses
<i>Contrast Split Segmentation</i>	This algorithm aims to split bright and dark objects using a threshold that maximizes the contrast between the resulting bright objects (consisting of pixel values above the thresholds) and dark objects (consisting of pixel values below the threshold). To execute this algorithm, you will need to create two classes, one for the bright and one for the dark.	The algorithm aims to optimize this separation by considering different pixel values within the range provided by the user parameters, with values selected based on the inputted step size and stepping parameter.
<i>Spectral Difference Segmentation</i>	is a merging algorithm that will merge neighboring objects with a spectral mean below the threshold given to produce the final objects.	To use this segmentation algorithm, you must already have segmentation (level) in place. You cannot create a new level using this algorithm.
<i>Contrast Filter Segmentation</i>	The contrast filter segmentation uses a combination of two-pixel filters to create a thematic raster layer, with the values no object, objects in the first layer (filter response 1), an object in the second layer (filter response 2), object in both layers and ignored by threshold.	As with the previous simple exercises, experiment with this algorithm to segment the image provided. Although, as you will see, this algorithm does not produce results on par with the other algorithms outlined in this unit for the image subset provided.
<i>Multi-Threshold Segmentation</i>	Multi-Threshold segmentation splits the domain based on pixel values. This kind of segmentation creates image objects and classifies them based on user-created thresholds. It can also create unclassified image objects based on pixel values thresholds.	Combining the automatic threshold algorithm with multi-threshold segmentation allows you to create fully automated and adaptive image analysis algorithms based on threshold segmentation. A manual definition of fixed thresholds is not necessary.

Step 7: Information from Image Objects

7.1) Image Object Information Window

image objects consist of spectral, shape, and hierarchical elements. If required, these objects' information could be extracted using the Image Object Information window and Feature View Window inside the eCognition 9.5.

7.1.1) To get information on a specific image object, click on an image in the map view (some features are listed by default).

7.1.2) To add or remove features, right-click the Image Object Information window and choose the "Select Features to Display." The Select Displayed Features dialog box opens, allowing you to select a feature of interest.

7.1.3) If the Object Features are not listed in the "Available Search Feature list (on the left side of the "Select Displayed Features"), double-click on the "Create new Mean" to show the Create Mean dialog box (Figure 17).

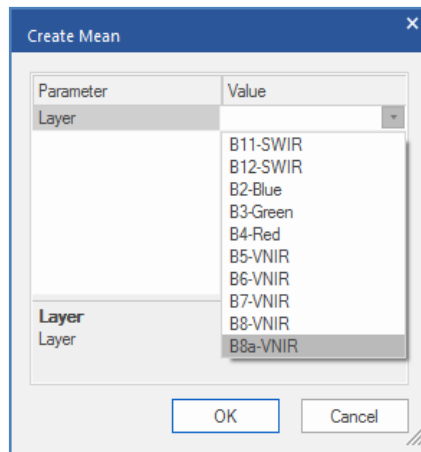


Figure 17: The Create Mean dialog box

7.1.4) Then, from the Value list, select bands or features to add them to the Selected Search Feature on the right side of the Select displaced Features list. Remember that you can even add some of Geometry, such as Area and Number of pixels, to the mean values list.

7.1.5) The selected feature values are displayed in the map view. To compare single image objects, click another image object in the map view, and the displayed feature values are updated (Figure 18).

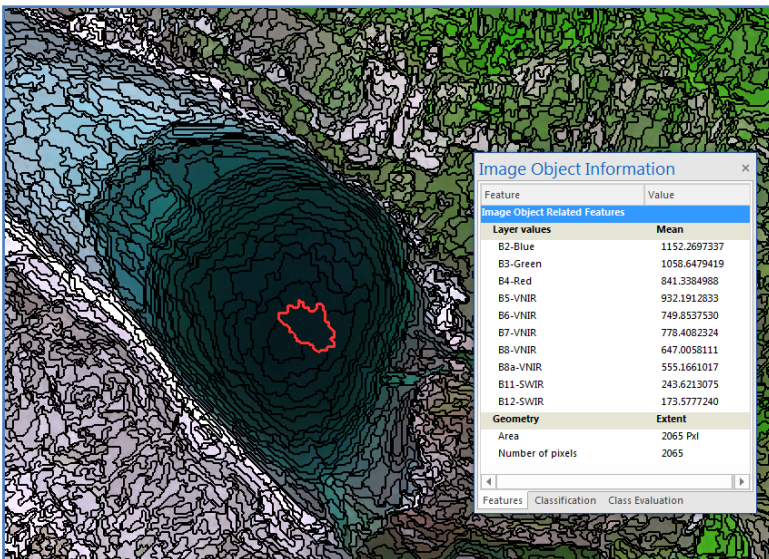


Figure 18: The Image Object Information window and associated information on segmented objects

7.1.6) Double-click a feature to display it in the map view; click it in the map view a second time to deselect a selected image object. If the processing for image object information takes too long, or if you want to cancel the processing for any reason, you can use the Cancel button in the status bar. For more details, refer to the previous tutorials.

7.2) Feature View Window

Image objects have spectral, shape, and hierarchical characteristics and these features are used as sources of information to define the inclusion-or-exclusion parameters used to classify image objects.

7.2.1) There are two major types of features. First, the Object features are attributes of image objects (for example, the area of an image object). And Global features that are not connected to an individual image object (for example, the number of image objects of a certain class).

7.2.2) Available features are sorted in the feature tree, displayed in the Feature View window (Figure ?). It is open by default but can also be selected via Tools > Feature View or View > Feature View.

7.2.3) To set mean ranges for each select band, right-click on and select the Update Range (Figure 19). By arranging the mean values, it is possible to find out thresholds values for each feature.

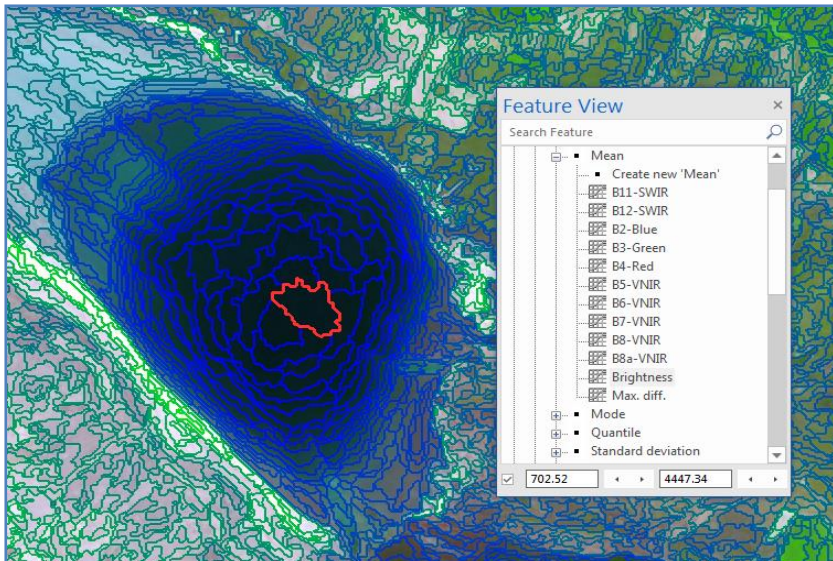


Figure 19: The Feature View window and information about objects

Sum Up:

You could use segmentation algorithms to subdivide entire images at a pixel level or specific image objects from other domains into smaller image objects. eCognition 9.5 software provides several diverse approaches to Segmentation. It may range from very simple algorithms, such as Chessboard and Quadtree-based Segmentation, to highly sophisticated methods such as Multiresolution Segmentation Multi-Threshold Segmentation algorithms. Those are required to create new image object levels based on image layer information. But they are also a valuable tool to refine existing image objects by subdividing them into smaller pieces for more accurate classification.

A few examples of image segmentation algorithms are given during the current tutorial. If you spend approximately 30

minutes with different segmentation algorithms and parameters, you will observe the differences in the images objects created. Generally speaking, there is no definitive answer as to whether one Segmentation is better than another. The final selection depends upon whether you are satisfied that the objects you are interested in classifying are adequately delineated.

Informative Practices

Tips:

- 1) The first step of an eCognition image segmentation is to cut the image into pieces.
- 2) Segmentation serves as a building block for further analysis.
- 3) There is a choice of several algorithms to do the segmentation process.

Workouts:

- 1) Using the layer combination of your choice (bands with the 10-meter resolution are recommended), experiment with the image equalizations available. Again, observe how the various land cover types change to these changes.
- 2) Decide on the most appropriate segmentation algorithm for segmenting this scene.
- 3) As you are doing this, consider what elements you think to provide a better segmentation and how it could use the different characteristics of the various algorithms to achieve the segmentation you require.

Quizzes:

- 1) What are the main differences between a Chessboard Segmentation and a Multi-Threshold segmentation?
- 2) What are the scale and shape parameters?
- 3) Why is the Multiresolution Segmentation algorithm the best choice in the segmentation process?

Allied References:

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Tutorial 4

Objective Image Classification Processes



from raw images to informative Knowledge

Opening Statement:

The current tutorial will create a nearest neighbor classification of a segmented Sentinel-2 image acquired from an area around the Baku region, Azerbaijan. The main objective of image classification is to identify and portray, as a unique gray level (or color), the features occurring in an image in terms of the object or type of landcover these features represent on the ground.

Instructive Memo:

- ✓ *Level:* Intermediate,
- ✓ *Time:* This unit should not take you more than 1.5 hours,
- ✓ *Software:* The eCognition version 9.5,
- ✓ *Data Sources:* Sentinel-2:
L1C_T39TVE_A030362_20210415,
- ✓ *Subject Scene.* Baku Region, The Republic of Azerbaijan.

Tutor Objectives:

By the end of this unit, you should:

- ✚ Be able to complete all the steps required in the process tree.
- ✚ Complete a classification based on the nearest neighbor classifier.
- ✚ Be aware of the parameters and features to aid classification process.
- ✚ Be attentive to the merge and export processes.

Background Concepts:

Image classification is the process of categorizing and labeling groups of pixels or vectors within an image based on specific rules. The categorization law can be devised using spectral or textural characteristics. Two general classification methods are 'supervised' and 'unsupervised.' In simple words, image classification is a technique used to classify or predict the class of a specific object in an image. This technique's main goal is to identify the features in an image accurately. The OBIA, nearest neighbor classification, approach is one of the most recent methods that delineate segments of homogeneous image areas as objects. In the next step, the delineated segments could be classified into real-world objects based on spectral, textural, neighborhood, and object-specific shape parameters and context information.

In contrast to traditional image processing methods, the basic processing units of OBIA classification are image objects or segments, not single pixels, and even the classification acts on image objects. One motivation for the object-oriented approach is that the expected result of many image analysis tasks is the extraction of real-world objects, proper in shape and proper in classification. Common, pixel-based approaches cannot fulfill

this expectation .Figure 1 illustrates an area that contains extensive build-up and water surfaces at various levels of improvement.



Figure 1: Map of the Baku Region, Abshour Peninsula

Mastering the Skills:

There are many image classification techniques inside the eCognition software. One of the most used is The Nearest Neighbour (NN) that classifier is a supervised classification approach whereby training samples are located and used to classify all remaining (unknown) objects in the image for each class required. The NN classifier has been used successfully for many classification problems.

Step 1: Creating a Project

1.1) As with previous works within eCognition Developer, the first step is to create a project containing all the datasets required for the study. You will create a subset of the inputted

images once again. Your project should have the same parameters as that shown in former tutorials

1.2) For the current tutorial, we clipped the subsetting area from the Sentinel-2 image with, as a part of the Baku City, with Minimum X: 400430, Maximum X: 414230 in the upper-left and Minimum 4482250 Y; Maximum Y: 4490670 at the lower-left coordinates (Figure 2).

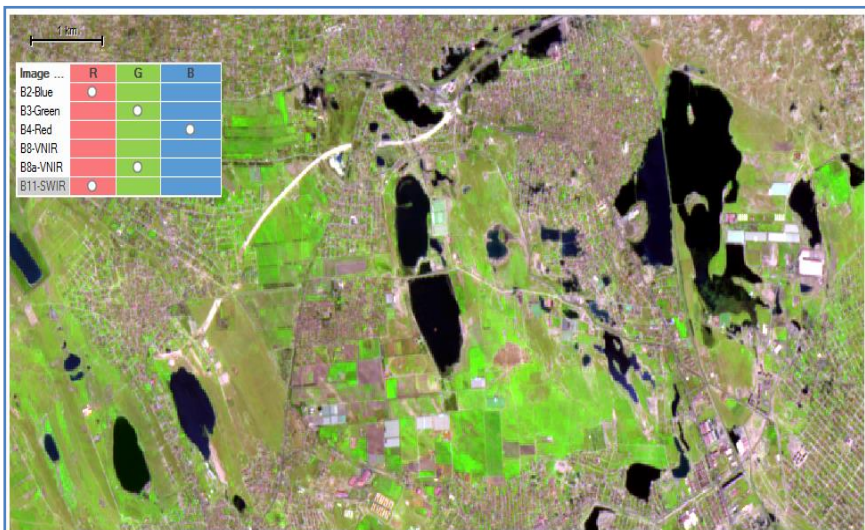


Figure 2: A project adjusted for the northern part of the Baku city, RGB image

1.3) As with previous works within eCognition Developer, you may prefer to create a project containing all the datasets required for your desired study area. We recommended creating a small subset of the inputted images with the same parameters as in former tutorials.

1.4) Note the order in which the image bands were loaded, i.e., the Blue (B2), Green (B3), Red (B4), and VNIR (B8) bands first sets, as these will decide the project's image (with 10 m)

resolution. In this tutorial, the 20 m VNIR (B8a) and SWIR (B11) bands are resampled to the 10 m of the first set bands.

1.5) Once you have matched your project window to those shown in Figure 2. Select OK and create your project.

Step 2: Setting-Up the Class Hierarchy

2.1) For classification, the first task is to create the classes you require and (in this case) to insert the Nearest Neighbour Feature into each class.

2.2) To create a class, you require the 'Class Hierarchy' window (shown in Figure 3) to be open. If the window is not already visible, then click on the icon.

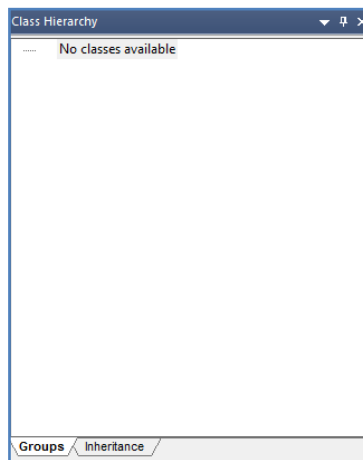


Figure 3: Class Hierarchy Window before inserting any classes

2.3) To insert a class, right-click in the Class Hierarchy window and select 'Insert Class' (Figure 4).

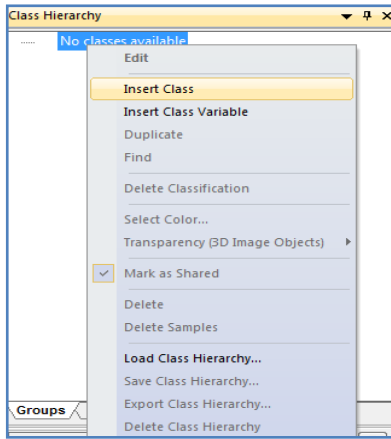


Figure 4: Inserting a class into the class hierarchy

2.4) This provides you with an empty 'Class Description' (Figure 5).

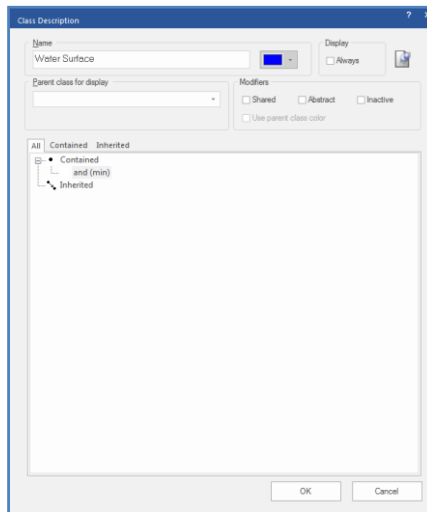


Figure 5: Class Description window for the Water Surface class

2.5) The next step is to edit your class description by giving your class a name. For example, give the class "Water Surface" and assign a blue color (Figure 5). When you have done this, insert and name other new classes. You should then have four

classes inserted and named: Water Surface, Green-Cover, Built-up Area, Mixed Landuse, and Non-Vegetated classes.

2.6) After giving each class a name, select an appropriate color for each. It can be anything you wish, although the final classification will be easier to understand and interpret if you choose a logical color (e.g., Green for vegetation).

2.7) Next, the features (e.g., mean object spectral response) to be used for classification (in this case, the standard nearest neighbor algorithm) need to be inserted into the class. To do this, right-click on the 'and (min)' and select 'Insert new Expression' (Figure 6).

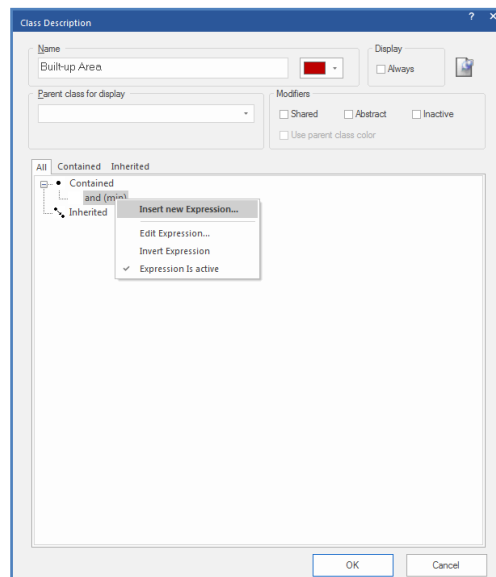


Figure 6. Inserting a new expression into the Built-up class

2.8) This will present the window, where you need to select 'Standard Nearest Neighbour' and click Insert (Figure 7).

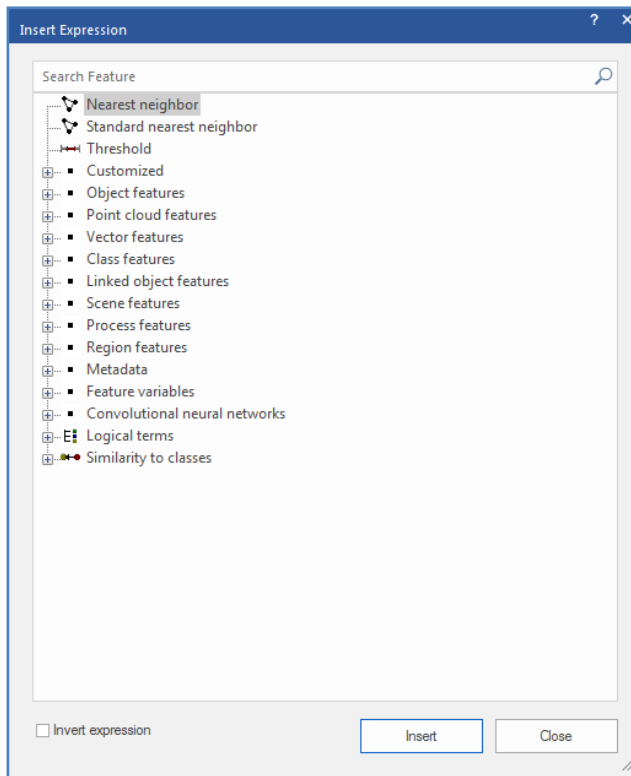


Figure 7: Selecting the expression to be used for the classification

2.9) Your resulting class description should be similar to that shown in Figure 8 for the Built-up class, for example.

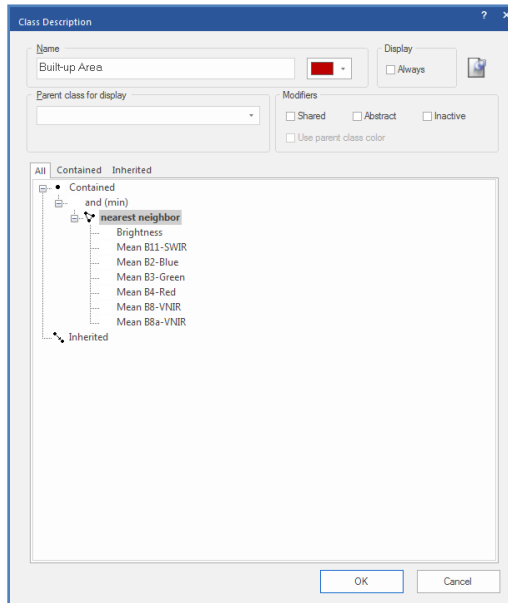


Figure 8: The resulting Built-up class description used for the classification

2.10) The same procedure needs to be repeated for the remaining classes so that you end up with a classification hierarchy similar to that shown in Figure 9.

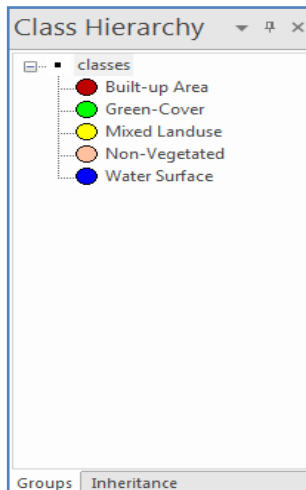


Figure 9: The class hierarchy outline

2.11) To select the features used for the nearest neighbor classification, use the 'Edit Standard NN feature Space' function (Figure 10). Initially, it would help if you used the mean spectral values of the objects.

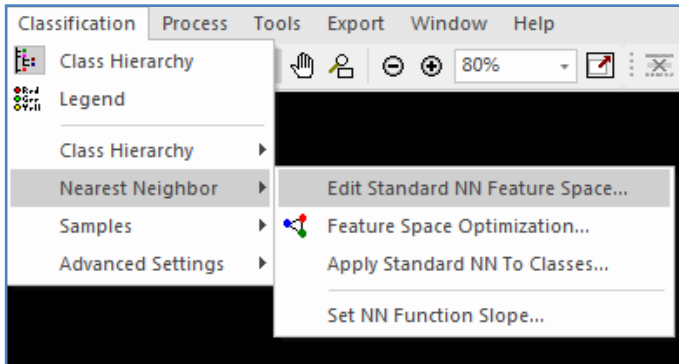


Figure 10: The menu for editing the NN feature space

2.12) When the Edit Standard NN feature Space dialog box opens, you can set the parameters as you want (Figure 11).

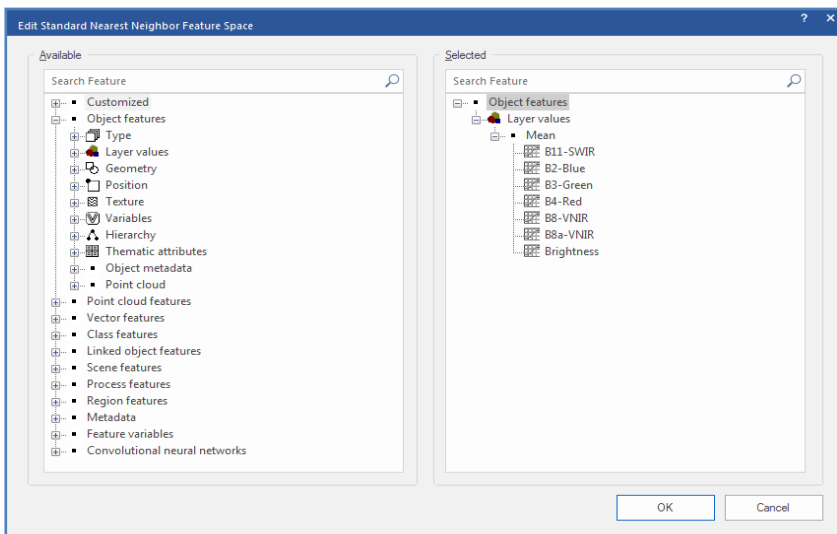


Figure 11: Editing dialog for selecting the features within the NN feature space

Step 3: Setting up the Process Tree

3.1) As with all classifications in eCognition Developer, the first task is to perform segmentation. In this case, using a multi-resolution segmentation is recommended, although you could investigate others.

3.2) As with previous units, it is recommended you create an outline within your process tree mirroring that outlined in Figure 12. Remember, a process is created by right-clicking in the process tree window and selecting 'Append Process' or 'Insert Child Process'.

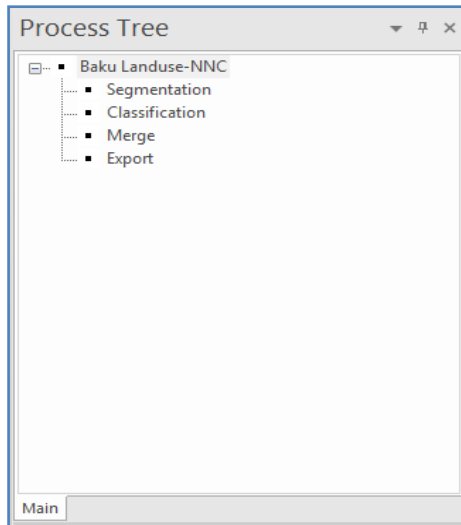


Figure 12: Process outline and Segmentation process

3.3) To create the process that performs the segmentation, right-click on the Segmentation process you have already created, select 'Insert Child Process,' and then the algorithm 'Multiresolution Segmentation'.

3.4) Choose the parameters shown in Figure 13 and once you have entered these parameters, click on 'Execute' to perform the segmentation.

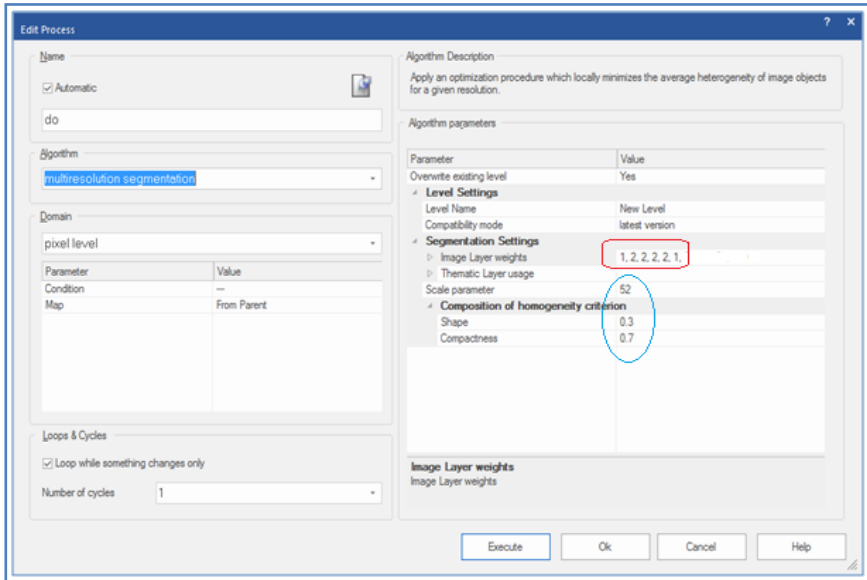


Figure 13: Parameters used for the segmentation of the Sentinel-2 image

3.5) Note that the layer weighting for the B2, B3, B4, and B8 bands could be increased to 2. It takes advantage of the extra spatial resolution of these bands, 10 m rather than 20 m of the multispectral. In addition, you may attention to the wights of Scale (52), Shape (0.3), and Compactness (0.7) paramaters (Figure 14).

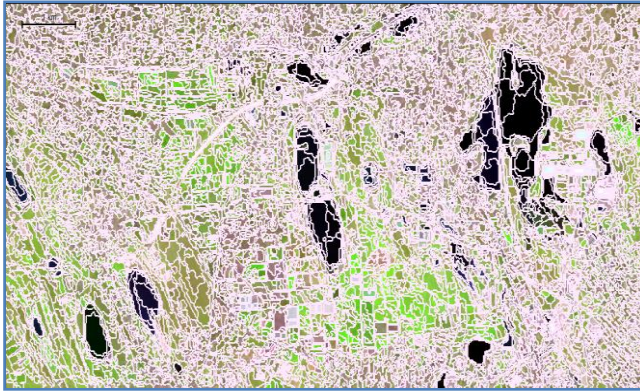


Figure 14: The Multispectral Segmentation algorithm result

Step 4: Classification Process

4.1) To run the classification, you need to add a classification process to your process tree. You could achieve it by right-clicking on the process you named 'Classification' and selecting 'Insert Child Process.' Edit the new process such that it is similar in appearance to that shown in Figure 15.

4.2) To select multiple classes, use the 'Shift' and 'Control' keys as you would in Windows Explorer.

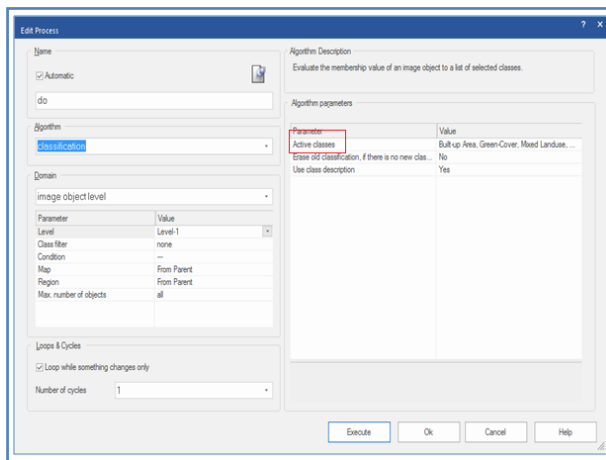


Figure 15: The process parameters used for the classification

4.3) After inputting the parameters into the process, click on the 'OK' button at the bottom. You need to select samples before performing your classification by clicking the Active classes option that illustrates the Edit Classification Filter (Figure 16).

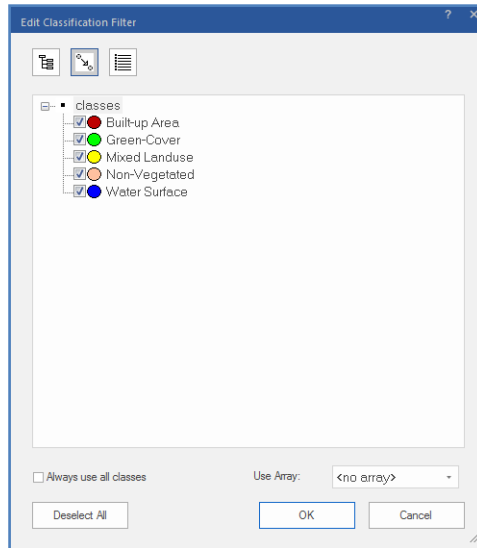


Figure 16: The Edit Classification Filter

4.4) Select all classes inside the Edit Classification Filter and click on OK.

Step 5: Selecting Samples to Train Classifier

5.1) The next stage is to select the samples for each of the five classes. You need to have executed the segmentation process before undertaking these steps.

5.2) To create a sample, you need to activate the tool for sample selection (Select Samples), as shown in Figure 17.

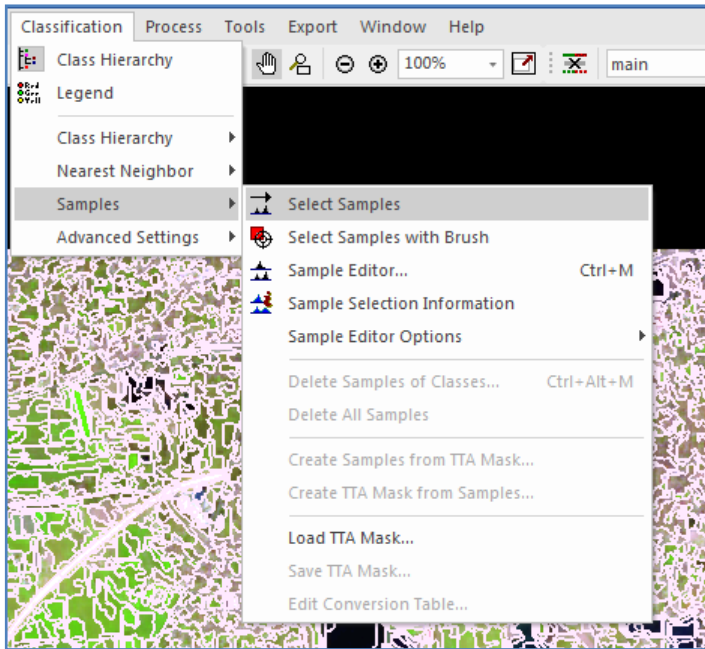


Figure 17: Activating sample selection function

5.3) Once you have activated sample selection, highlight the class you wish to create a sample for in the class hierarchy window. Double-click on the objects (you wish to select as samples) or hold down the Shift key and use a single click. To unselect a sample, repeat the selection process for each chosen object.

5.4) To aid the selection of your samples, eCognition Developer offers two windows (both available from the menu of information based on the selected samples. Firstly, the 'Sample Editor' window and secondly the 'Sample Selection Information' window (Figure 18).

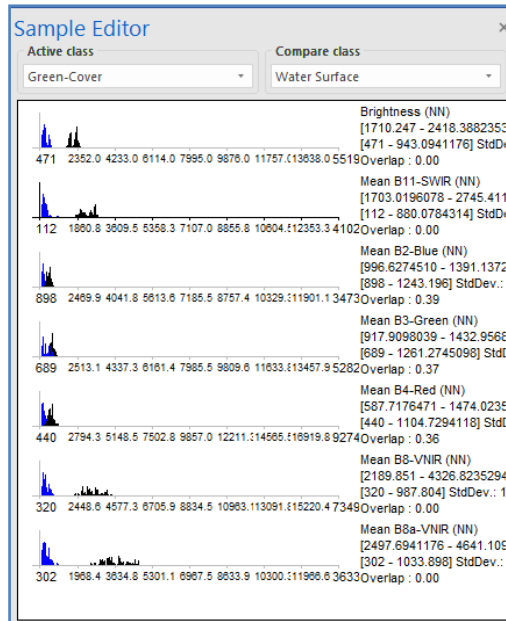


Figure 18: Sample Editor Window

5.5) The Sample Editor provides a visual comparison of two classes using a range of selected features. In Figure 18, the Green-Cover and Water Surface are compared using the object means from each spectral band of the Sentinel-2. When an object is selected, a red arrow is illustrated where the object means fits the other samples' mean (Figure 19).

Class	Membership	Minimum Dist.	Mean Dist.	Critical Samples	Number of Samples
Non-Vegetated	1.000	0.000	118.384		30
Built-up Area	0.850	0.704	7.843	1	30
Mixed Landuse	0.537	2.705	11.377	0	29
Green-Cover	0.202	6.950	14.090	0	30
Water Surface	0.000	49.261	67.672	0	30

Figure 19: Sample Selection Information Window

5.6) To change the displayed features, right-click within the main window and select 'Features to Display.' If you only want the features used within the NN calculation, select 'Display Standard Nearest Neighbour Features' (Figure 20).

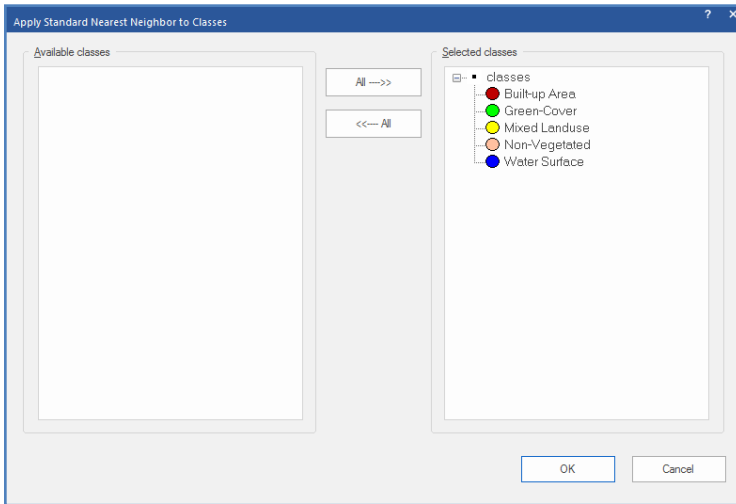


Figure 20: The Apply Standard NN to Classes dialog box

5.7) The Sample Selection Information window displays information on the NN membership boundaries and the distances to the other classes of the selected object from the selected samples.

5.8) To select the classes to be displayed, right-click within the window and select 'Select classes to Display.' Classes displayed in red have, for the selected object, an overlap in the distance measure, and therefore the samples may need to be re-analyzed and altered. To set the threshold at which a class is highlighted in red, right-click in the Sample Selection Information window and select 'Modify critical sample membership overlap.' The threshold ranges from 0 - 1, and 0 highlights any overlap.

5.9) Once you have selected your samples, you should have an image that is similar in appearance. Bear in mind that the selection of samples does not have a correct answer. Just select the samples you consider to be most representative of the classes you wish to separate and give the best separation in the Sample Editor and Sample Selection windows.

Step 6: Running the Classification Process

6.1) Now, you can execute the classification process you previously created (right-click and select execute on the classification process). You should now have a nicely classified image similar to Figure 21.

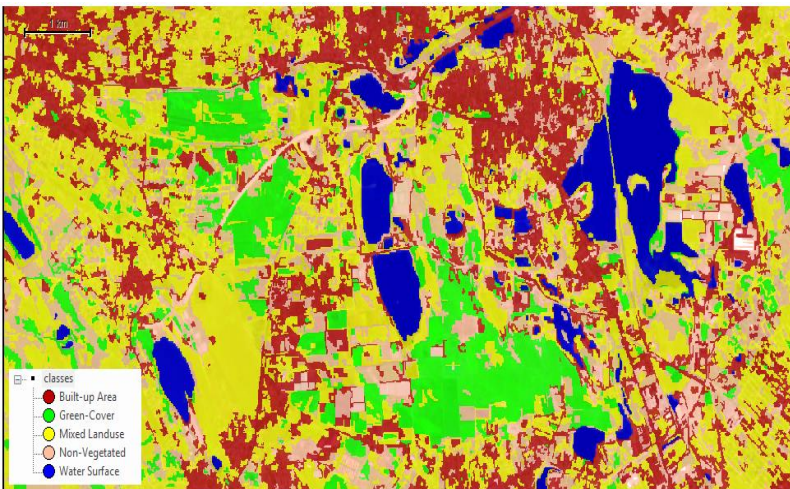


Figure 21: Final classification map of the Baku region

6.2) If you are unhappy with the classification, repeat the procedure but select more or alternative samples before reclassifying the image. The Process Tree after the classification process is shown in Figure 22.

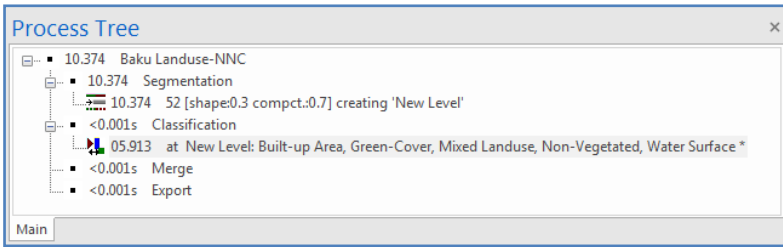


Figure 22: The Process Tree after the inclusion of the classification process

6.3) To re-run the classification, open the process and click on execute or select the process and press F5 or right-click on the process and select 'execute'.

Step 7: Merging the Result

7.1) The next step is to set up the processes which will merge your classification so that all neighboring objects of the same class will form single objects.

7.2) It is important to merge your classification to identify complete objects. For instance, you can query the Urban Area to find its complete area once merged. To merge the result, you will need to enter a merge process for each class; 'Insert Child'. The merge parameters for the vegetation class are shown in Figure 23.

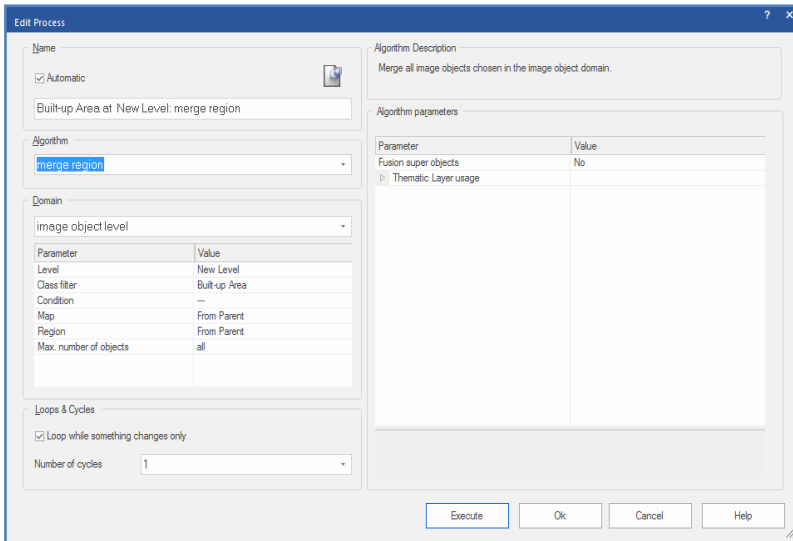


Figure 23: The Edit Process dialog box, the merge algorithm parameters for the Built-up class

7.3) The class for merging is defined using the Image Object Domain. The class of interest is defined; if you were to select multiple classes, all the privileged classes would be merged, removing the boundaries and classification of these objects.

7.4) To save time, once you have created your first merge process, you can copy-and-paste (ctrl-c, ctrl-v, or right-click on the process) to duplicate it and then edit the class you wish to merge.

7.5) Once you are happy with your classification, execute the merge image objects processes you have previously created. Your results should appear similar to those shown in Figure 24.

7.6) The purpose of merging is to create a final classification representing the scene's objects. For example, we will now calculate the area of the whole water surface features. But, be

aware that merging the image objects removes your samples, as the segmentation will have changed.

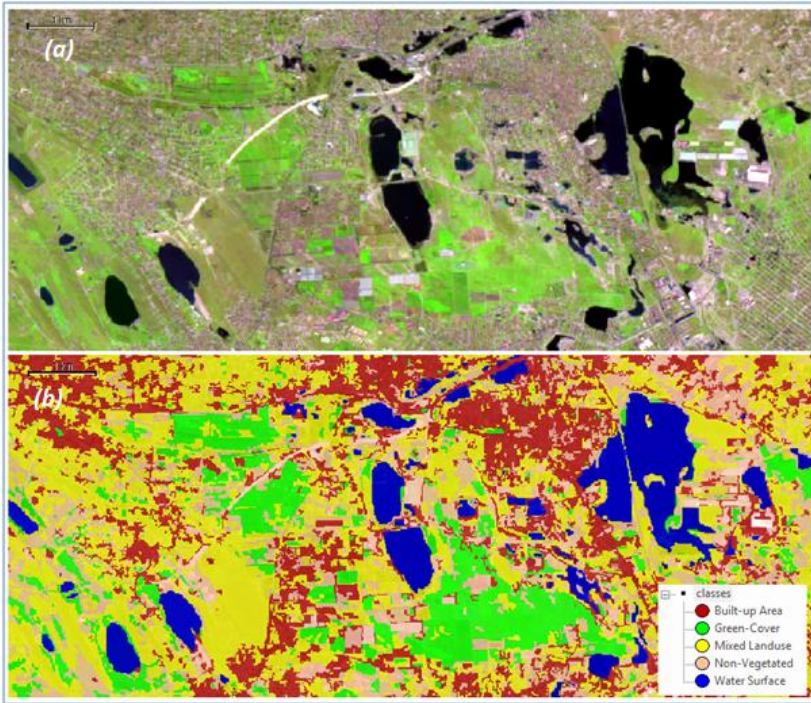


Figure 24: Sentinel-2 RGB image (a) and the classified map (b)

Step 8: Feature Space Optimization Tool

8.1) To refine the classification further, eCognition Developer offers an automated feature, the Feature Space Optimization function, to automatically identify the features which 'best' separate the classes for which samples have been selected (Figure 25).

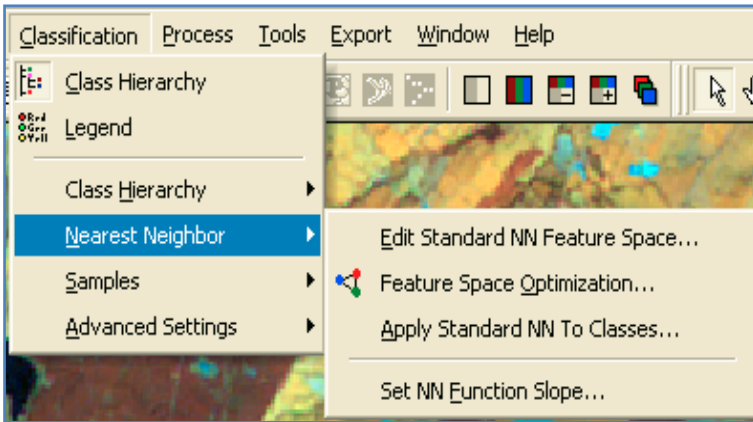


Figure 25: The NN classification menu, Feature Space Optimization function

8.2) To use this feature delete your classification (delete level) and re-run the segmentation process. You will also need to re-select that will delete your samples as these each time you change the segmentation (i.e., merge or delete level).

8.3) After selecting your samples, open the Feature Space Optimization dialog box (Figure 26).

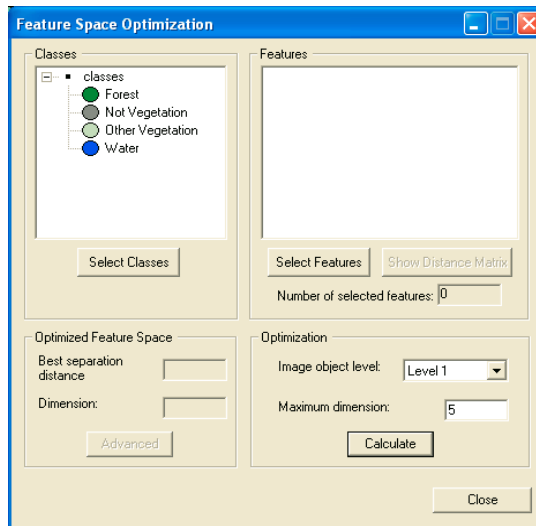


Figure 26: The Feature Space Optimization dialog box

8.4) To use this tool, select the features you wish to compare – Initially, try the mean, standard deviation, and pixel ratio but later try other combinations. Then select calculate; once the calculation has finished, select advanced to see which features offered the best separation, and 'Apply to the Std NN' to use within the classification. You can now run your classification step.

Step 9: Exporting Result

9.1) To end with, run the results to export. It will result in an ESRI shapefile and create a map shown in Figure 27. Researchers usually wish to export the classification result from eCognition into a GIS, mostly ArcGIS, for further processing or the production of a map.

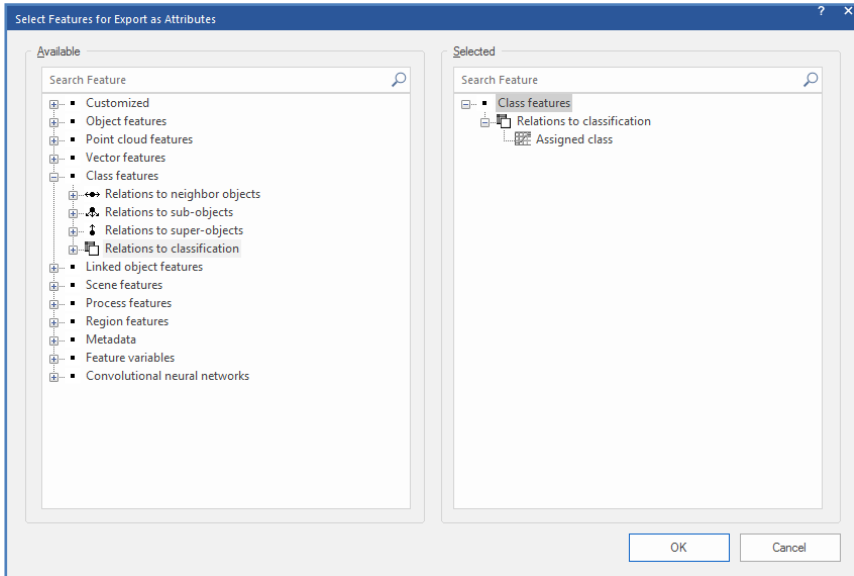


Figure 27: The Select Features for Export dialog box

9.2) The final process will be to export the classification to an ESRI shapefile (Figure 28).

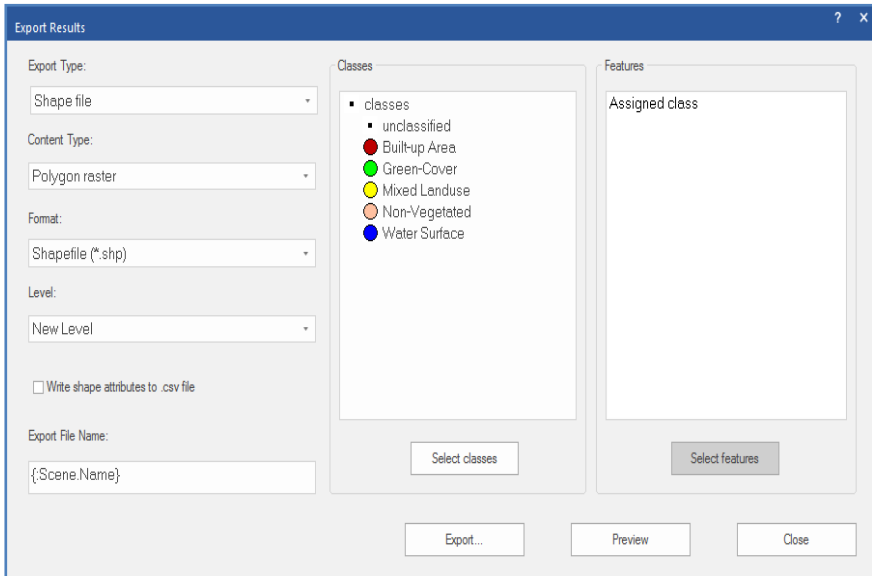


Figure 28: Process parameters to export the classification as a shapefile

9.3) Area is found under Object Features > Shape > Generic while class name is found under Class-Related features > Relations to Classification > Class name.

9.4) You will need to create the class name feature, right-click on the 'Create new Class name' and select Create, leave the parameters as their default values, and select OK. The shapefile will output to the directory within which your project is saved. If you have not saved your project, it will export the shapefile to the input imagery's directory.

9.5) To select the classes to export, you again edit the Image Object Domain, remember these parameters define the image objects to which it will apply the process. The outputted

shapefile is defined as 'Classification.' The features to be exported are the area (of the image object) and the class name. Remember that, when you are working inside a trial version of eCognition version 9.5, you may notice a message as "Sorry, this feature is not supported by this version. In this case, accept the message and enjoy your tutor finishing up.

9.6) When you finish your tutorial successfully, the Process Tree should then be the same as the one shown below in Figure 29.

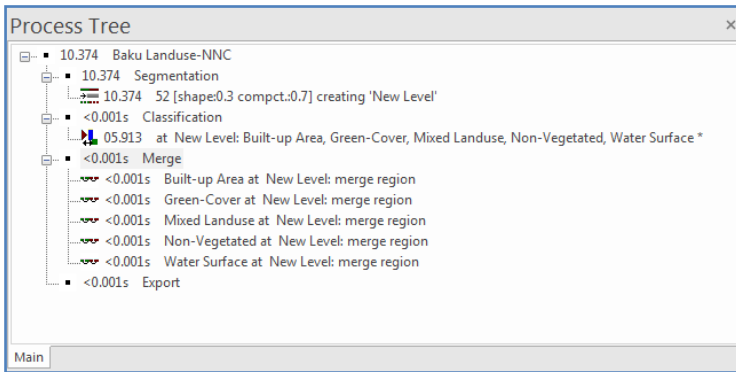


Figure 29: The final "Process Tree" dialog box algorithms

Sum Up:

You can process image objects locally in specific Sentinel satellite imagery based on the classification. Object-oriented image analysis is a specific strength, a circular interplay between processing and classifying image objects. Regularly, specific information is available for classification based on segmentation, scale, and shape of image objects, as you have experienced during the previous tutorials. In turn, based on classification, specific processing algorithms, such as NNC and Support Vector Machine (SVM), can be activated. In many

applications, the desired geo-information and objects of interest are extracted step by step by iterative loops of classifying and rule-based image processing.

Informative Practices

Tips:

- 1) Assign Class assigns a class to an image object with certain features, using a threshold value,
- 2) Classification uses the class description to assign a class, Hierarchical Classification uses the class description and the hierarchical structure of classes,
- 3) Advanced Classification Algorithms are designed to perform a specific classification task, such as finding minimum or maximum values of functions or identifying connections between objects.

Workouts:

- 1) Experiment with different classification methods, and be aware of what types of landcover/landuse you need to create.
- 2) Experiment with different features within the standard NN feature space. (Classification > Nearest Neighbor > Edit Standard NN feature space).
- 3) Experiment with different features and maximum dimension levels within the feature optimization tool by applying classification> Nearest Neighbor > Feature Space Optimization.

Quizzes:

- 1) Could you list the process parameters used for the classification?
- 2) What is the Sample Editor Window main functionality?
- 3) What does the Feature Space Optimization Tool do?

Allied References:

- 1) Foody, G. Approaches for the production and evaluation of fuzzy land cover classifications from remotely-sensed data. *Int. J. Remote Sens.* 1996, 17, 1317–1340.
- 2) Franklin, S. E., & Wulder, M. A. (2002) Remote sensing methods in medium spatial resolution satellite data landcover classification of large areas. *Progress in Physical Geography*, 26, 173–205.
- 3) Gregorio, A (2005) Land Cover Classification System (LCCS), version 2: Classification Concepts and User Manual. FAO Environment and Natural Resources Service Series, No. 8, Rome: FAO.
- 4) Haase, G. (1989) Medium-scale landscape classification in the German Democratic Republic. *Landscape Ecology* 3 (1): 29-41.
- 5) Kaplan, G., Avdan, U. (2017) Object-based water body extraction model using Sentinel-2 satellite imagery. *European Journal of Remote Sensing*, 50(1), p. 137-143.
- 6) Leckie, D.G., Gougeon, F.A., Tinis, S., Nelson, T., Burnett, C.N., & Paradine, D. (2005) Automated tree recognition in old-growth conifer stands with high-resolution digital imagery. *Remote Sensing of Environment*, 94, 311-326.

Tutorial 5

Threshold Rule-Setting With eCognition



inside the eCognition, a child process is a matter

Opening Statement:

The main purpose of the current tutorial is to teach the application of combined methods of thresholding rule-set techniques in the classification of water bodies. For this practice, there is a need for six high-resolution bands of Sentinel 2A imagery subsetted inside the eCognition 9.5 version for the Neftchala Peninsula, Azerbaijan. Accordingly, first, you will need to load satellite imagery, create a new project, segment the imagery. In the second step, you will create two customized Normalized Difference Water Index (NDWI) and Brightness indices, which help you start a threshold-based classification of water bodies in a wetland illustrating the sea, rivers, water canals, ponds, and lakes.

Initial Memo:

- ✓ Level: Intermediate,
- ✓ Time: This tutorial should not take you more than 2 hours,

- ✓ Resources: A eCognition software, Version 9.5,
- ✓ Data Sources: *Sentinel 2A imagery, LIC_T39SUD_A022097_20210530_Tif*
- ✓ *Subject Scene: Azerbaijan, Caspian Sea, Neftchala Peninsula.*

Tutor Objectives:

By the end of this unit, you should:

- ✚ learn how to create a multiresolution segmentation within eCognition Developer.
- ✚ distinguish how to create customized NDWI and Brightness indexes,
- ✚ recognize the difference between absolute and fuzzy thresholds.
- ✚ Introduce threshold-based classification of water bodies.

Background Concepts:

The first step of an eCognition image analysis is to cut the image into pieces, which is called segmentation, and there is a choice of several algorithms to do this. Another OBIA typically follows this, for example, a few spectral indices, to yield more practical information by processing high-resolution satellite imagery. Such information could be threshold rule-setted that determines whether an image object matches a condition or not. Typically, you can apply thresholds in class descriptions if a feature can separate classes. It is also possible to assign image objects to a class based on only one condition; however, the advantage of using class descriptions lies in combining several conditions. The concept of threshold conditions is also available for ruleset-based classification; in this case, the threshold condition is part of the domain and can be added to most algorithms. This tutorial will practice some of these concepts in the eCognition 9.5 software environment in a part of the

Neftchala Peninsula, mainly dominated by water surfaces (Figure 1).

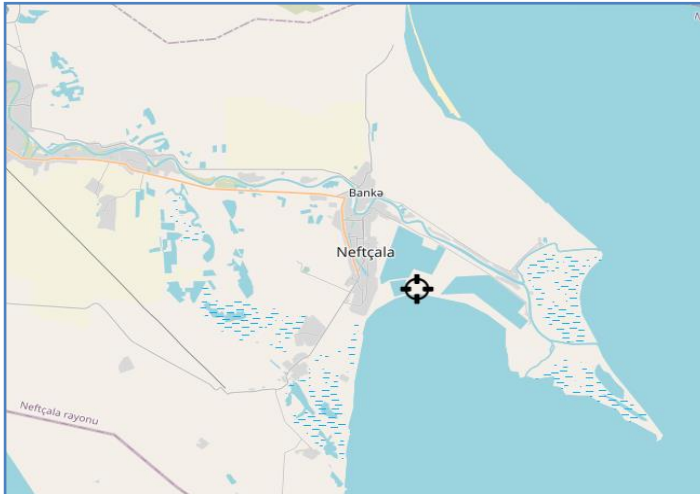


Figure 1: The location of Neftchala Peninsula, Azerbaijan

Mastering The Skills:

Following on from the previous tutorials, you are now implementing a more detailed classification, for example, the nearest neighbor. Continue teaching OBIA methods. The main aim of the tutorial is to provide you with experience in entering thresholds for a rule-based classification and creating the corresponding image objects to classify water surfaces. Multiple tools are at the users' fingertips for much subsequent analysis inside the eCognition software to obtain this aim.

Step 1: Create a New Project

A project is the most basic format in eCognition Architect. A project contains one or more maps and optionally a related rule set. Projects can be saved separately as a *.dpr project file, but

one or more projects can also be stored as part of a workspace.

To create a simple project:

- 1.1) Open the eCognition Developer Trial version 9.5.
- 1.2) Go to File > New Project in the main menu.
- 1.3) The Import Image Layers dialog box opens.
- 1.4) Inside the "Import Image Layers" dialog box, you have the right to access the Local Disk, main folders, Subfolders, and other options shown in Table 1. You took an example of the Sentinel 2A image from the western coastal part of the Caspian Sea, Azerbaijan (Figure 2).

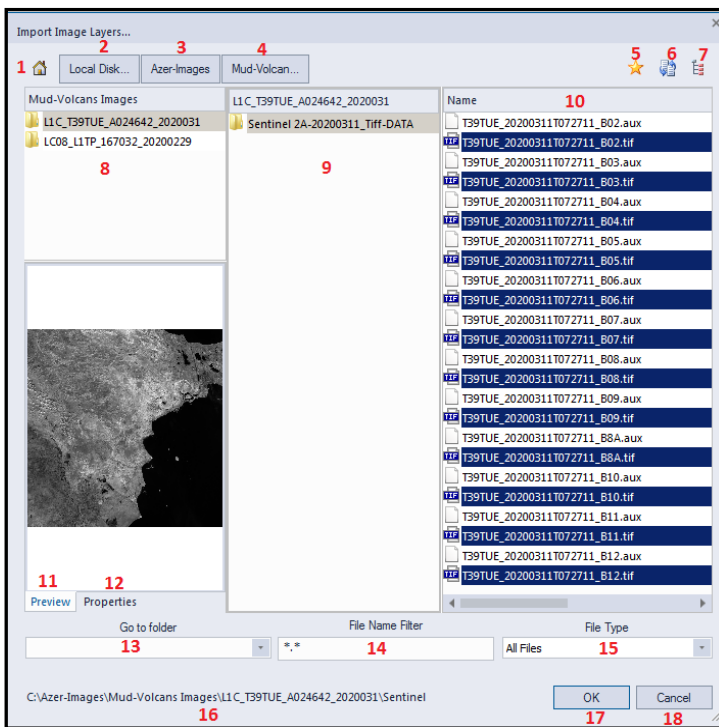






Figure 2: The Import Image Layers dialog box

- 1.5) In Table 1, all descriptions are indicated with their main functions.

Table 1: The Import Image Layers dialog box main functions

Item	Descriptions
1	This icon  shows the data source panel
2	Local Disk, for example, C:/
3	Main Folder, for example, Azer-images
4	Subfolder, for example, Mud-Volcano
5	Click on  to add to favorites
6	Click on  to restore Layouts
7	Click on  to search Subfolders
8	Main Folder Name
9	Subfolder Name
10	image layers
11	Image Band Preview
12	Image Properties
13	Accessing to the folder
14	File Name filtering
15	File Type (*.Tiff., img, and many other extensions)
16	File Path
17	Confirming the next step
18	Canceling the import layers process

1.6) Select the image bands you wish to import, then press the Ok button to display the Create Project dialog box.

Step 2: Managing the Project Dialog Box

2.1) The Create Project dialog box gives you several options. You can edit these options at any time by selecting File > Modify Open Project as follows:

- 1) The Menu Bar has the same functions inside the Create Project Dialog Box (Figure 3).

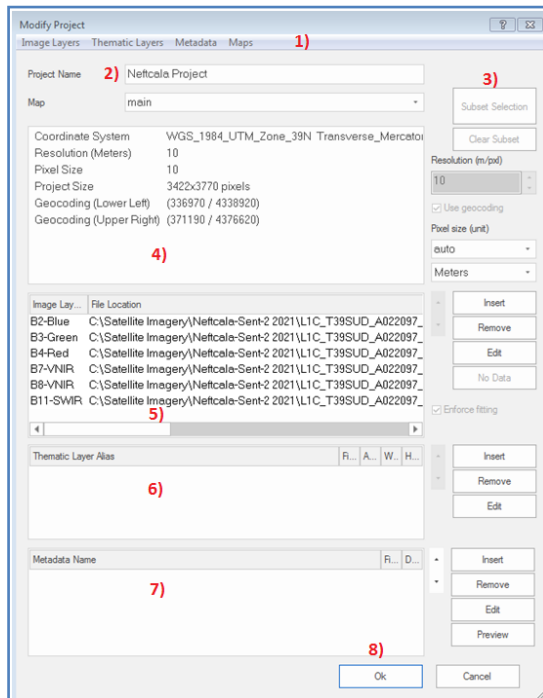


Figure 3: The Project Dialog Box

- 2) You may change the name of your project in the Project Name field. The Map selection is not active here but can be changed in the Modify Project dialog box after project creation is finished.
- 3) If you load two-dimensional image data, you can define a subset using the Subset Selection button. If the complete

scene to be analyzed is relatively large, subset selection enables you to work on a smaller area to save processing time (Figure 4).

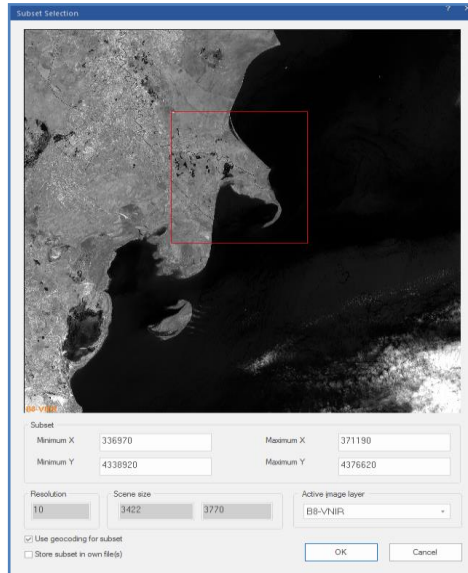


Figure 4: Subset Selection Dialog Box

- 4) You can view the image metadata and associated information. Here for image bands, the pixel resolution is presented. Select the Use Geocoding checkbox to use the geocoding information from an image file to be imported. You could set pixel size for each unit:
- If geocoding information is included, the pixel size equals the resolution. In other cases, pixel size is 1. The image bands are listed here.
 - If you want to rescale the scene during import, edit the scale factor in the text box corresponding to the scaling method used: resolution (m/pxl), magnification (x), percent (%), or

pixel (pxl/pxl). You can edit the Pixels Size (Unit) for feature calculations, value display, and export, and you can edit the Pixels Size (Unit).

- c) If you keep the default (auto), the unit conversion is applied according to the unit of the coordinate system of the image data. You may want to ignore the unit information from the included geocoding information in special cases. To do so, deactivate Initialize Unit Conversion from the Input File item in Tools > Options in the main menu. Geocoding is the assignment of positioning marks in images by coordinates. In earth sciences, position marks serve as geographic identifiers. But geocoding is helpful for life sciences image analysis too. Typical examples include working with subsets, multiple magnifications, or thematic layers to transfer image analysis results. Typically, available geocoding information is automatically detected.
 - d) if not, you can enter coordinates manually. Images without geocodes automatically create a virtual coordinate system with a value of 0/0 at the upper left and a unit of 1 pixel. For such images, geocoding represents the pixel coordinates instead of geographic coordinates.
- 5) The Image Layer pane allows you:
- a) to insert, remove and edit image layers (Figure 4). The order of layers can be changed using the up and down arrows.

- b) If you use multidimensional image data sets, check and edit multidimensional map parameters. If you load two-dimensional image data, you can set the value of those pixels that are not to be analyzed. Select an image layer and click the No Data button to open the Assign No Data Values dialog box.
- c) If you import image layers of different sizes, the largest image layer dimensions determine the scene's size. When importing without geocoding, the smaller image layers keep their size if the Enforce Fitting check box is cleared.
- d) If you want to stretch the smaller image layers to the scene size, select the Enforce Fitting checkbox. Also, you can change the band name by activating the Layer Properties dialog box (Figure 5).

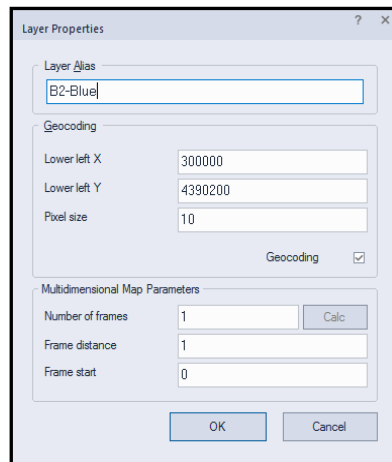


Figure 5: The Layer Properties dialog box and the geocoding information

- 6) Thematic layers can be inserted, removed, and edited similarly to image layers.

- 7) If not done automatically, you can load Metadata source files to make them available within the map.
- 8) If you click on the OK option, you can create a new project inside the eCognition Developer.

Step 3: Rearrange the eCognition Setting

When you start any eCognition projects, you can have your modification and schedule set.

3.1) You may prefer to change the color composition of the subsetted Image.

3.2) For Sentinel-2, the RGB composite is as natural colors (4, 3, 2); false color Infrared (8, 4, 3); false color urban (12, 11, 4); agriculture (11, 8, 2); healthy vegetation (8, 11, 2); land/water (8, 11, 4).

3.3) You could also rearrange the eCognition main windows for better use, as shown in Figure 6.

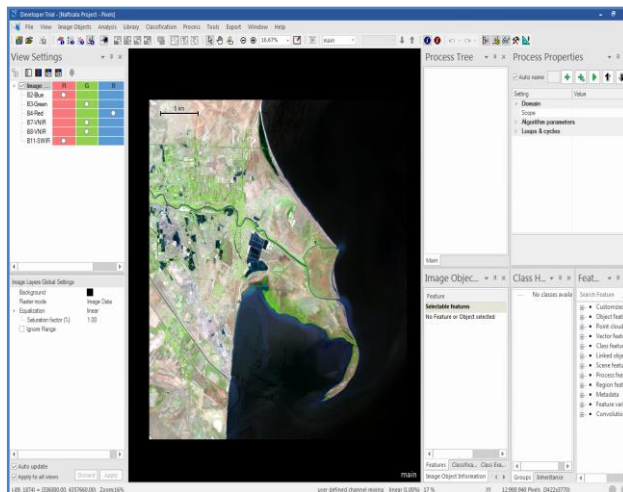


Figure 6: A new project for the Neftchala Peninsula subsetting the Sentinel-2, inside the eCognition Developer

Step 4: Setting up the Process Tree

eCognition provides an artificial language for developing advanced image analysis algorithms. These algorithms use object-oriented image analysis and local adaptive processing principles. You could achieve this by developing a series of processes, also known as a rule-set. A single process is the elementary unit of a rule-set providing a solution to a specific image analysis problem. A single process allows the application of a specific algorithm to a specific region of interest in the image, the image object domain. All conditions for classification and region of interest selection may incorporate semantic information. Processes may have an arbitrary number of child processes. The so formed hierarchy defines the image analysis's structure and flows control. Arranging processes containing different types of algorithms allows the user to build a sequential image analysis routine.

4.1) To begin, the process window will need to be opened. On the main toolbar, under Process Tab, you can click Process Tree to open it. Remember that you can dock this window at any location within or outside the software.

4.2) Right-click within the Process Tree window, and a context menu offers commands for process management (Figure 7).

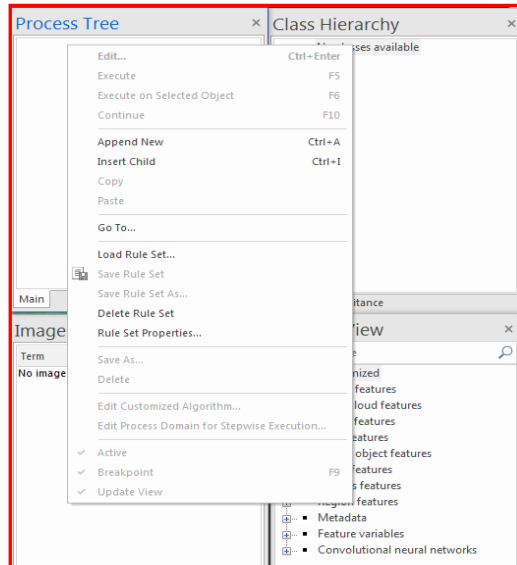


Figure 7: Context menu of the Process Tree window

4.3) Select Append New Process or click Ctrl + A. It will now open the Edit Process dialog box (Figure 8).

4.4) Give a name, as Threshold –Rule Sets, for instance, and click OK. This process will serve as a parent process for all your algorithms to fall underneath. It is handy because you can execute this single process, and all other algorithms will subsequently execute, as well.

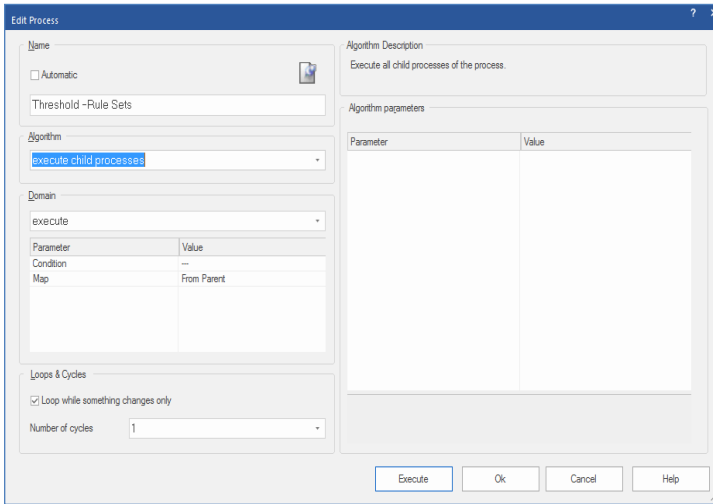


Figure 8: Edit Process dialog box with a known name: "Threshold Rule-Sets" process

4.5) For detailed information regarding the Edit Process dialog box, see the contents of the previous tutorial.

Step 5: Operating a Multiresolution Segmentation Algorithm

An Object-based classification requires image objects, so you need to insert a child process employing a segmentation algorithm.

5.1) Right-click on the "Threshold Rule-Sets" process and select the Child Process option.

5.2) The "Edit Process" dialog box is displayed. Select the multiresolution segmentation algorithm to segment pixels into objects (Figure 9).

5.3) Define a new level, the level that the image objects are stored on, as Level-1.

5.4) Adjust the image layer weight settings to emphasize the near-infrared band (B8-VNIR), given that you've got only three

visible bands (B2, B3, and B4) and a SWIR band. Keep in mind that a band combination of Sentinel-2 satellite would be a useful RGB composite in recognizing water surfaces.

5.5) Finally, you need to update the scale parameter (52) to make your image objects a bit larger and then adjust the shaping compactness settings to emphasize the shape (0.3) a little bit more, and also to try and get more compact objects (0.7).

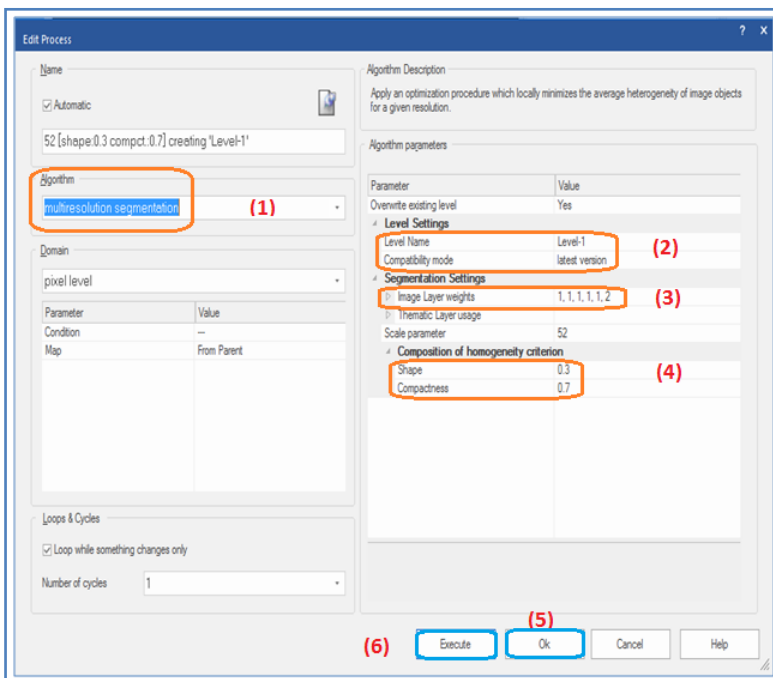


Figure 9: Edit Process dialog box, defining a multiresolution segmentation algorithm

5.6) When you get happy with the settings, click on the OK button.

5.7) To execute the multiresolution segmentation algorithm, click on it and choose the Execute button. It runs the algorithm,

grouping the pixels into objects. In Figure 9, more details are given by a sequence of numbers.

5.8) Figure 10 shows a segmented image and View Settings arrangement.

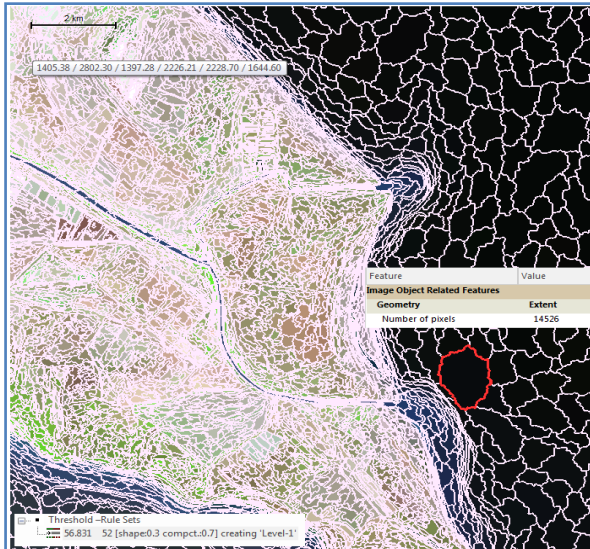



Figure 10: The segmented process result for the part of the Neftchala Peninsula

5.10) You can then toggle on and off the image objects using the Show/Hide outlines button . To try more options, see the previous tutorials.

Step 6: Getting the Image Objects Information

The attributes about image objects known as features within eCognition are displayed within the Image Object Information window. Not all features are displayed by default.

6.1) So, by right-clicking and choosing Select Features to Display, you can choose from the available list of features (Figure 11).

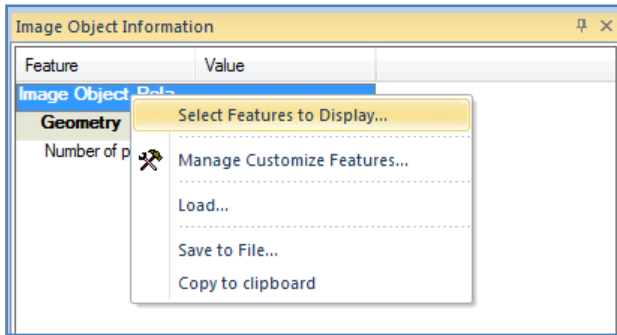


Figure 11: Image Object Information window

6.2) Some of the most popular ones are under object features, layer values, and mean values (Figure 12).

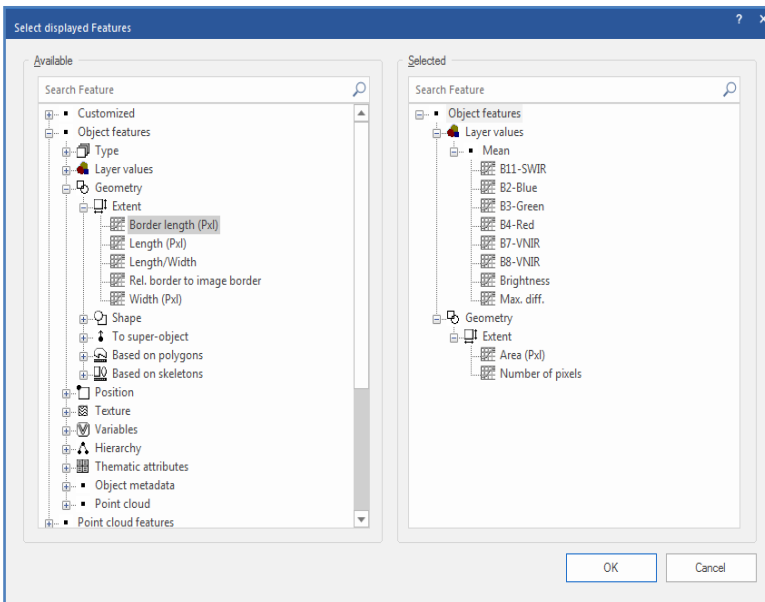


Figure 12: Select displayed Features box

6.3) You have to add the mean values for all image layer bands for this aim.

6.4) Then, go down to geometry, extent, and double-click on Area to add the Area feature. It is the area of each image object and pixels.

6.5) When you select an object, you'll notice that the corresponding feature information is displayed in the Image Object Information window (Figure 13).

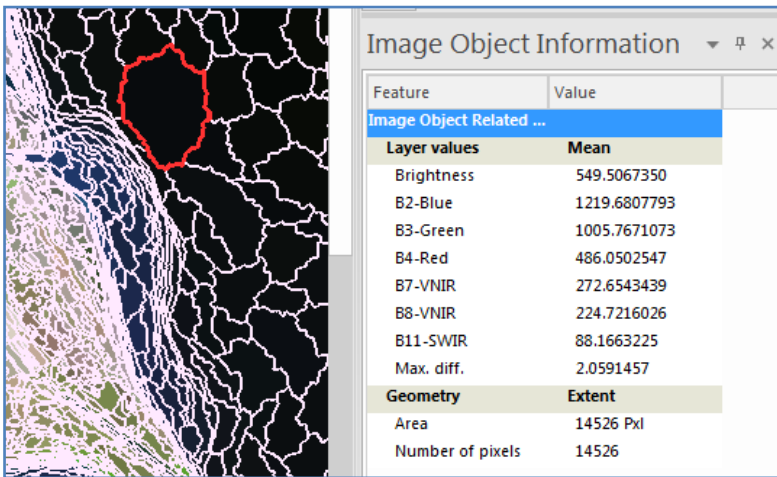


Figure 13: A selected image object-related features

6.6) Clicking around on the image objects, you will see that the mean band values are useful but not yet perfect for separating water bodies from the other features.

Step 7: Getting Customized Features

7.1) To create a customized feature, click on Tools from the main Menu and select the Manage Customized Feature option (Figure 14).

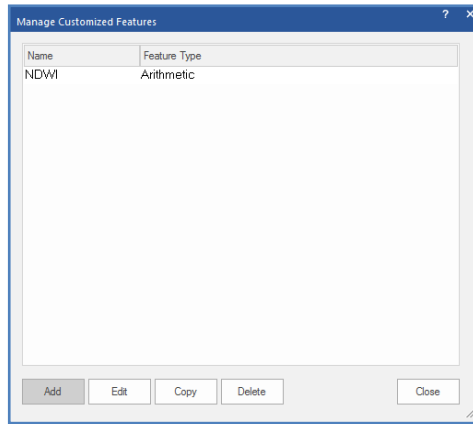


Figure 14: Manage Customized Features dialog box

7.2) Click on the Add option to notice the Customized Features dialog box. A customized feature allows us to create indices such as NDWI. You can give the feature a name and plug in the formula for NDWI (Figure 15).

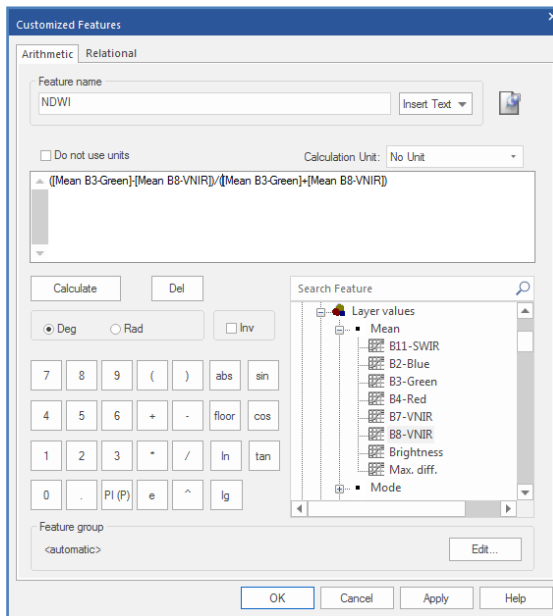


Figure 15: the Customized Features dialog box, A formula for NDWI

7.3) The following question calculates the NDWI formula:

NDWI Sentinel-2= $([\text{Mean B3-Green}] - [\text{Mean B8-VNIR}] / ([\text{Mean B3-Green}] + [\text{Mean B8-VNIR}]])$. The NDWI monitors changes related to water content in water bodies. As water bodies strongly absorb light in the visible to the infrared electromagnetic spectrum, NDWI uses green and near-infrared bands to highlight water bodies. It is sensitive to built-up land and can result in the over-estimation of water bodies.

7.4) When you select an object, the NDWI index appears in the Image Object Information window (Figure 16).

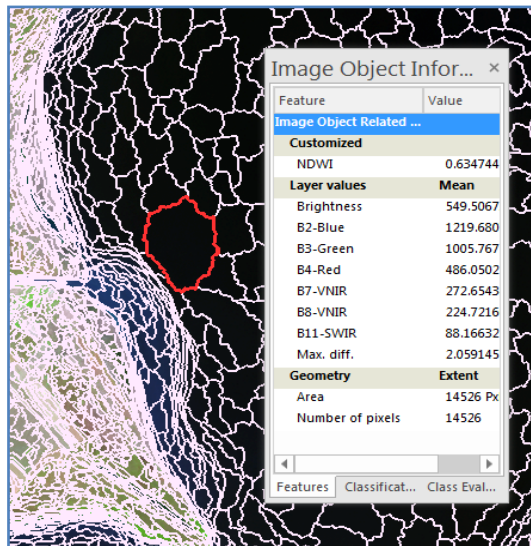


Figure 16: NDWI values showing inside the "Image Object Information" dialog box

7.5) The NDWI index provides a robust means to separate water bodies from vegetated and impervious surfaces. The values within the Image Object Information window help you to assist with bands and spectral indices information.

7.6) You can also display the actual values by going to the Feature View window. Double-clicking on NDWI, for example, assigns a gray-scale color ramp based on the NDWI values to each of the objects.

7.7) By going into the lower left-hand corner of the Feature View window and selecting the checkbox, you can play around with the actual NDWI value ranges. You'll probably want to right-click on the feature and choose update range to get the full range of values before doing this. You can then use the arrows to select the lower and upper range of values.

7.8) This isn't doing classification; it's just previewing what would happen if you use these threshold values for classification (Figure 17).

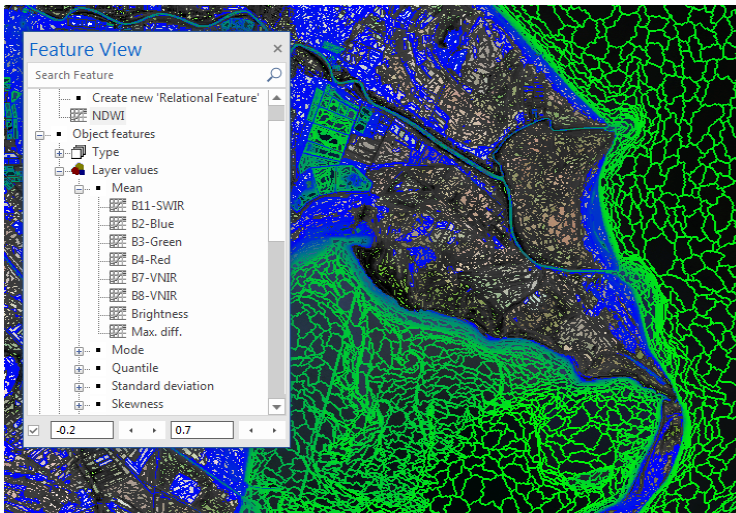


Figure 17: Adjusted NDWI values for the water bodies, including the segmented objects

7.9) When you get satisfied with adjusted water bodies (Figure 18) by ranging the Feature View window tools, you may move to the next step.

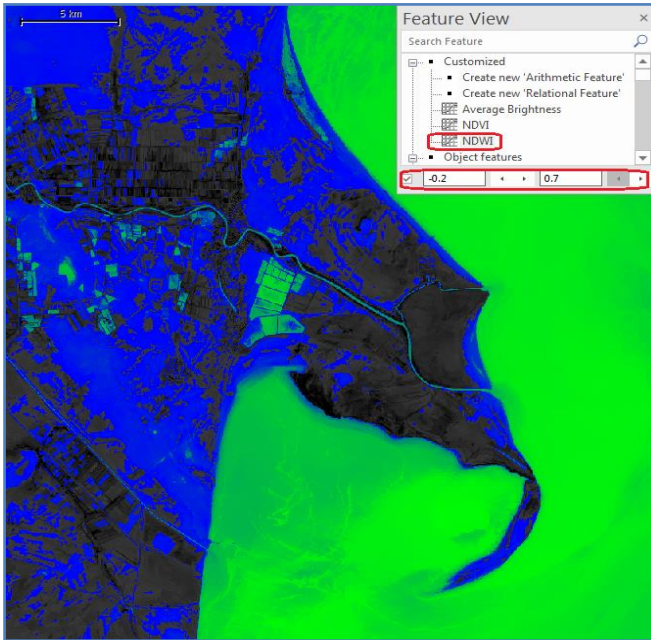


Figure 18: Illustration of the water bodies (greenness color)

Step 8: Threshold-Based Classification

Now that you have a good idea (created thresholds) about the features, you can classify the threshold objects into the water bodies class.

8.1) Let's right-click on the multiresolution segmentation algorithm, choose to append new, and insert the 'assign' class algorithm (Figure 19).

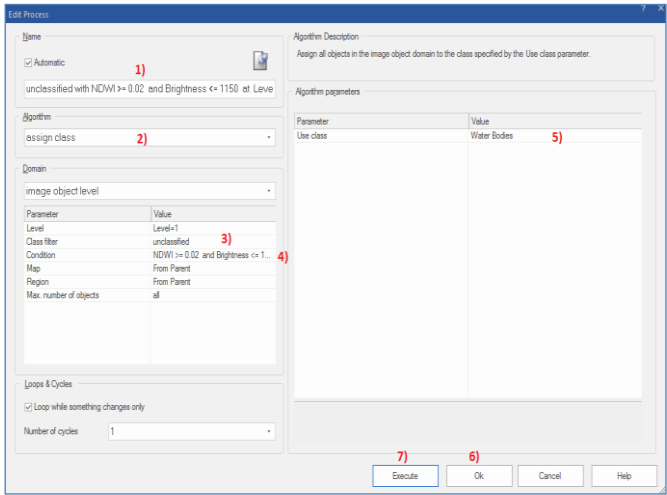


Figure 19: The Edit Process dialog box, an assigned class algorithm with class filter and conditions

8.2) For classification, you can use the assigned class algorithm, a very simple classification algorithm for threshold-based classification.

8.3) Under the cross-filter, you could check the box for unclassified so that we're only focusing on objects that are unclassified (Figure 20).

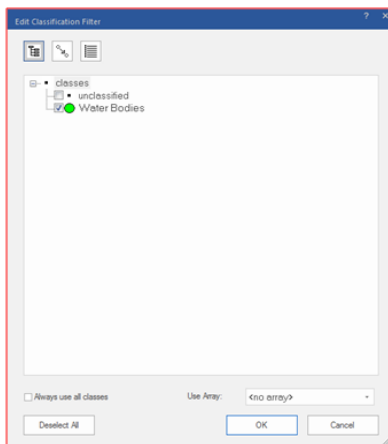


Figure 20: The "Edit Classification Filter" dialog box

8.4) Then, you'll go to condition, and you'll click the ellipse button. The first condition you'll use is on the NDWI values. So undervalue one, you need to choose from a feature, then go to the customized features and select NDWI. Now you need to choose anything that has a value greater than 0.02. This threshold condition says any unclassified objects, all image objects, and have an NDWI value greater than 0.02 and the Brightness ≤ 1150 (Figure 21).

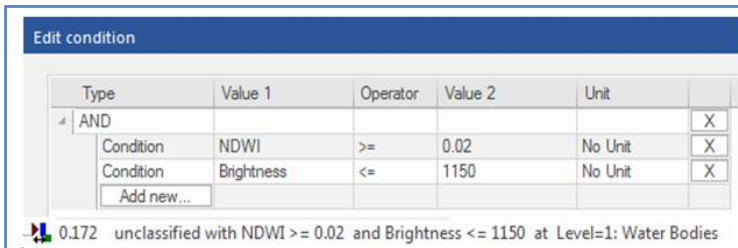


Figure 21: Defining two thresholds of NDWI and Brightness values for the water bodies

8.5) By accepting these conditions, the result of the thresholding process is shown in Figure 22.



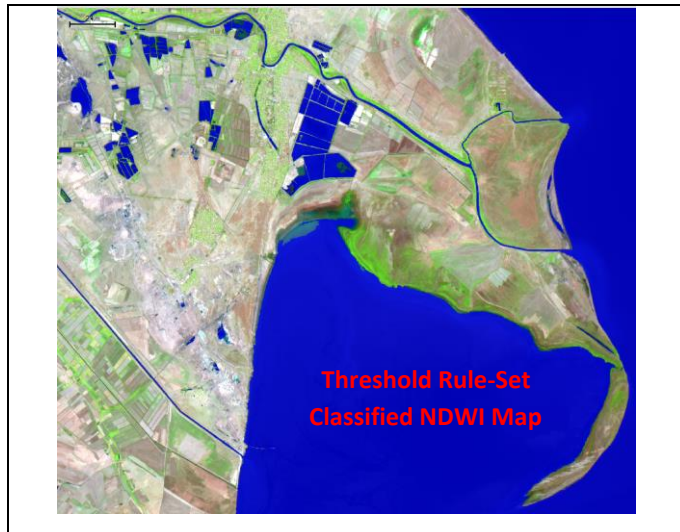


Figure 22: The result of the thresholding process, Neftchalar Peninsula water bodies

Step 9: Looking for an Alternative Approach

Now let's look at an alternative approach, in which you may separate the classification into separate steps, rather than using both conditional statements within a single assigned class algorithm.

9.1) In the next step, you can also assign the thresholding, as mentioned earlier, to a new Green-Cover class. Because Vegetation is highly cross-related to the water bodies in the wetland area that you just created, the clause description dialogue pops up. You can choose a color to represent that class.

9.2) Once we right-click and execute this algorithm, any objects that meet the criteria, that is, they have an NDVI greater than 0.25, and the Average Brightness ≥ 2000 , will be assigned to the Green-Cover class. With trial and error efforts, you may

apply more accurate thresholds to determine the exact NDVI and Average Brightness values (Figure 23).

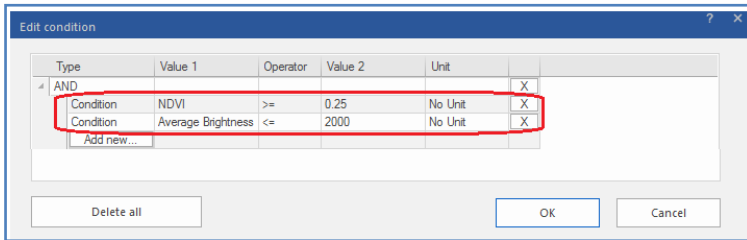


Figure 23: Edit Condition dialog box NDVI and Average Brightness values

9.3) The view classification button will display the classification, and then you can choose to display the classification as either outlines or a solid fill. Overall, NDVI was very effective in helping us classify vegetated objects (Figure 24).



Figure 24: The result of the thresholding process for the green-cover classification

9.4) You can go back into the assigned clause algorithm and remove that visible brightness condition. You may insert this later and in a different assigned class algorithm. Rerunning the segmentation algorithm every time I change my threshold parameters for classification isn't very efficient.

9.5) If you need to insert a new algorithm, you can use the "remove classification" algorithm. It will go right after the segmentation algorithm, and it simply clears the classification from the image objects. This is a very quick algorithm, and it's an efficient algorithm to run if I want to play around with my classification parameters.

9.6) Finally, you can go back to the original rule sets, with all objects with an NDWI, NDVI, or Brightness threshold indices, and modify less or greater than specific values assigned to the water or the vegetation classes.

Sum Up:

This tutorial introduced you to threshold-and rule-based classifications inside eCognition 9.5 by processing the Sentinel-2 imagery just adjusted to the parts of Neftcala Peninsula in nearby the Caspian Sea. You looked at different approaches in your next exercise as you handled the following procedures:

- ✓ a project by loading Sentinel 2A images,
- ✓ a multiresolution segmentation to create image objects,
- ✓ an impression of how to obtain information associated with NDWI indexing,
- ✓ a threshold-rule-based classified water bodies.

Informative Practices

Tips:

- 1) Note that the eCognition 9.5 trial software access is not limited to a specific period.
- 2) Keep in mind that export functions, saving projects, and the workspace environment are restricted.
- 3) The most important point is that you cannot open the rule sets saved in trial software in a fully-licensed version of eCognition software. If you are interested in exporting and analyzing the processed data, use the eCognition authorized versions.

Workouts:

- 1) Experiment with different segmentation algorithms and parameters. It would help if you did not have to edit the thresholds you have entered to reclassify the resulting segments. Still, you may notice varying levels of accuracy between different segmentations.
- 2) The classification produced during this unit is superficially OK but contains numerous errors when viewed in more detail. Try to improve the quality of the classification through the refinement of the existing rules.
- 3) In addition to the rule used within the classification, there may be other features available within eCognition Developer which could aid the classification.

Quizzes:

- 1) Which subsetting options are selectable inside the Subset Selection Dialog Box?
- 2) What exactly does the Threshold Classification Process do?
- 3) Why do you use the "assign class algorithm" through a threshold-based classification procedure?

Allied References:

- 1) Agency, E. S. (2015). Sentinel-2 MSI: Overview. https://sentinel.esa.int/documents/247904/685211/Sentinel-2_User_Handbook.
- 2) Athelougou, Maria; Schmidt, Günter; Schäpe, Arno; Baatz, Martin; Binnig, Gerd (2007). Cognition Network Technology – A Novel Multimodal Image Analysis Technique for Automatic Identification and Quantification of Biological Image Contents. *Imaging Cellular and Molecular Biological Functions*. Principles and Practice. pp. 407–422.

- 3) Blaschke T. and J. Stroble (2001). What's wrong with pixels? Some recent developments interfacing remote sensing and GIS, *GIS-Zeitschrift für Geoinformationssysteme* 6:12-17.
- 4) Blaschke, T. (2010). Object based image analysis for remote sensing. *ISPRS Journal of Photogrammetry and Remote Sensing*, 1-6.
- 5) Lucas R.M. Rowlands A., Brown, A., Keyworth, S and Bunting, P. (2007). Rule-based classification of multi-temporal satellite imagery for habitat and agricultural land cover mapping. *International Society for Photogrammetry and Remote Sensing*, 62(3), 165-185.
- 6) Torres-Sánchez, J., F.López-Granados and J. M. Peña (2015). An automatic object-based method for optimal thresholding in UAV images: Application for vegetation detection in herbaceous crops, *Computers and Electronics in Agriculture*, Volume 114, June 2015, Pages 43-52.

Tutorial 6

Practicing Change Detection with OBIA



OBIA provides an accurate change detection

Opening Statement:

In the current tutorial, you will learn how to detect changes on the small part of the Caspian Sea by processing the Sentinel-2 imagery sampled for 2015 and 2021. The functionality is explained based on an example of change detection use of the "Unsupervised Classification (USC)" algorithm within the Trimble eCognition software 9.5 step-wisely. It is based on the Iterative Self-Organizing Data Analysis Techniques (ISODATA) approach and creates a single raster landcover output with pixel values corresponding to the water, non-water classes. Furthermore, you will learn how to apply the crucial "copy map" algorithm and how implementing it together could strengthen a rule set USC procedure.

Instructive Memo:

- ✓ Level: intermediate and advanced levels,
- ✓ Time: This tutorial should not take you more than 2 hours.
- ✓ Software: an eCognition Developer version 9.5,
- ✓ Data Sources: *Sentinel-2 images for 2015 and 2021*

✓ *Subject Scene: Caspian Sea, Gil Island.*

By the end of this unit, you will:

- ✚ create two independent maps.
- ✚ understand the nature of unsupervised ISODATA,
- ✚ customize algorithm for 'USC and segmentation.'
- ✚ assign classes to each cluster.
- ✚ Classifying water and non-water classes in both maps individually
- ✚ Illustrating the actual changes on the Caspian Sea,

Background Concepts:

Coastal zone detection is an important task in national development and environmental protection, in which extraction of shorelines should be regarded as fundamental research of necessity. Very dynamic coastlines such as the Caspian Sea coasts and its islands could pose considerable risk to the surrounding countries' economic-social developments. Due to the rapid advances in image processing methods, modern and reliable OBIA techniques are required to detect and update the coastline geodatabase of these areas to explore rates of physical and ecological retreats. Natural and artificial land features are very dynamic, changing somewhat rapidly in our lifetime. Thus, accurately, you can more fully understand the physical and human processes at work. An advanced OBIA plays a unique role for easier interpretation in the Caspian Sea changes.

In eCognition Developer, you can work with so-called 'maps.' A map is a "sub-project" where you can process independently. Within one project, you can have several maps. Maps are independent "sub-projects," The original scene is always the

'main' map; all other, created maps can have individual names. One of the needs for the changes detection process is to map multispectral images in a fast manner correctly. USC is where the outcomes (groupings of pixels with common characteristics) are based on the software analysis of an image without the user providing sample classes. The eCognition uses techniques to determine which pixels are related and groups them into classes. USC using cluster algorithms is often used when there are no field observations and other reliable geographic information. For USC, eCognition users can execute an ISODATA cluster analysis and categorize continuous pixel data into classes/clusters having similar spectral-radiometric values.

Mastering The Skills:

Inside the eCognition, one application field of maps is for change detection by setting up two maps. There is a main map containing all image layers from both points of times (T1=2015 and T2=2021), then two independent maps are created, with only the image layers of one point of time. These follow the ISODATA approach, spectral indexing, and multi-threshold segmentation algorithms that are the most straightforward techniques for the final accurate classification and logical way to detect actual change detection from both maps.

Step 1: Preparation of Sentinel-2 Imagery

1.1) To access the main aims of the current tutorial, you need to download images from the Sentinel-2 satellite acquired by ESA's Open Access (<https://scihub.copernicus.eu>), selected for specific dates 2015 and 2021. Basic information on the Sentinel-2 satellites is given in the previous tutorials.

1.2) For the current tutorial, we selected the environmentally sensitive coastal part of the Caspian Sea in Azerbaijan, an internationally recognized greatest lake of global importance.

1.3) To achieve the main objectives of the current practice, several methods of image pre-processing have to step-wisely apply the sentinel-2 zipped datasets, including opening the downloaded zipped files and managing the corresponding Geo-Tiff bands. The details of conversion methods are given in the previous tutorials.

Step 2: Starting the eCognition Software

2.1) eCognition version 9.5 is yet powerful software that it is a challenge to summarize all of its advantages and benefits within one tutorial. But let's give it a try to introduce some of its main concepts by working through specific change detection tasks and learning how to apply the main approaches step-by-step.

2.2) If you have not accessed the official version of the eCognition software, the eCognition Trial 9.5 software is now available due to the free installation steps. For more details on this process read the previous tutorials. It must be mentioned

that the free version is limited as saving of rule sets, saving of projects, and export functions which are disabled. But, there is much to experience and learn on advanced image processing from such a superior developer program.

2.3) As soon as you access the trial version of eCognition 9.5, you can follow the main functionality of the software. You may start by setting the Sentinel-2 imagery inside the eCognition Developer to begin this tutorial.

Step 3: Setting image layers of the ‘main map’

3.1) From the main menu, select File> New Project to access the downloaded two sets of multispectral image layers from a subset of a Sentinel-2 scene. T1 is the layers from 2015,09,14 and T2 is from 2021,09,27. Evaluate the loaded Image Layers in the new project named as Gi-Island Changes.

3.2) When you set the desired bands inside the eCognition, you will notice the following screen in which the layers of T1 and T2 are displayed (Figure 1).

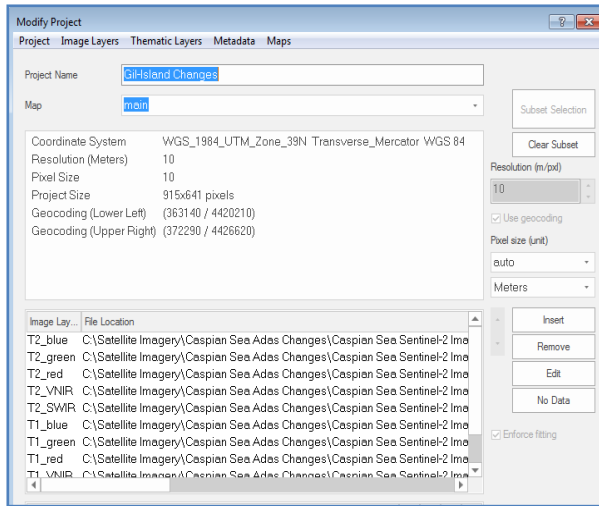


Figure 1: Create Project window, notice Sentinel-2 selected T1 and T2 bands

3.2) It is preferable to start with a small area subsetted from the main Sentinel-2 image, as you can see in Figure 2.

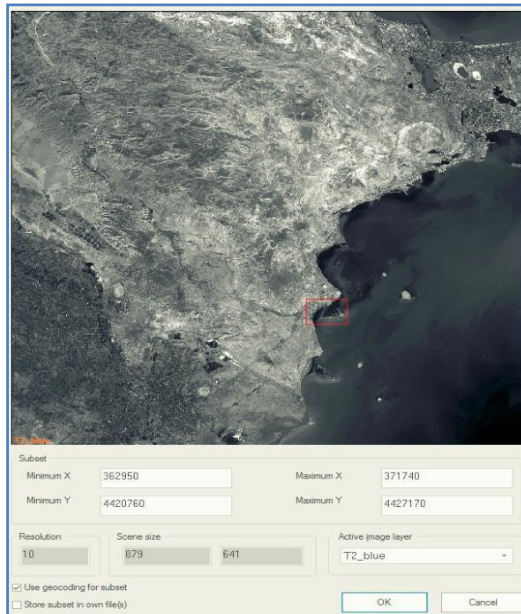


Figure 2: Create Project, Subset Selection option

3.3) Click the ‘Edit Image Layer Mixing’ button in the ‘View’ toolbar or go to the main menu View > Image Layer Mixing. Note that In the lower right corner of the viewer, you see which map is currently displayed (Figure 3). In our example right now, it is the ‘main’ map.

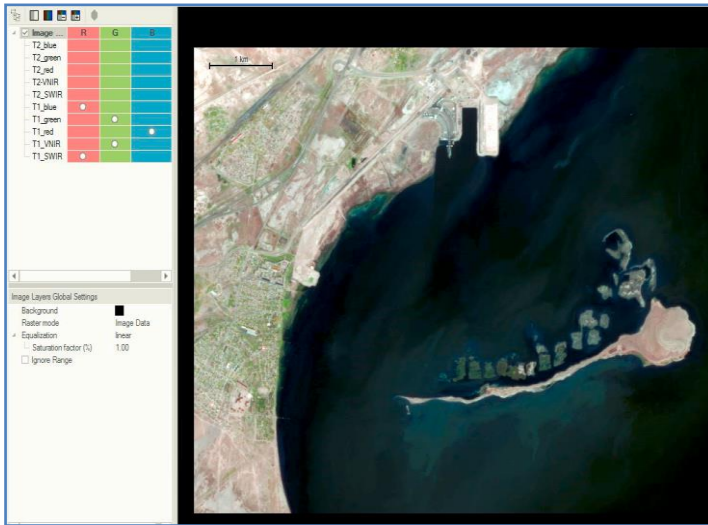


Figure 3: The Image Layers of T1 (2015) are displayed

3.4) Click on the up arrow in the lower right of the ‘Edit Image Layer’ dialog box until the bullets are moved completely to the T2 multispectral layers (Figure 4).

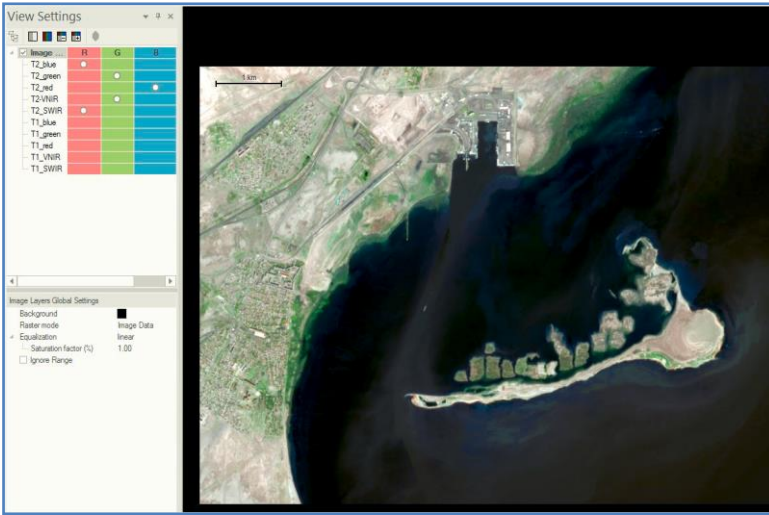


Figure 4: The Image Layers of T2 (2021) are displayed

Step 4) Creating two independent maps

4.1) Right-click in the Process Tree and select Append New. Set the Edit Process dialog box as Figure 5.

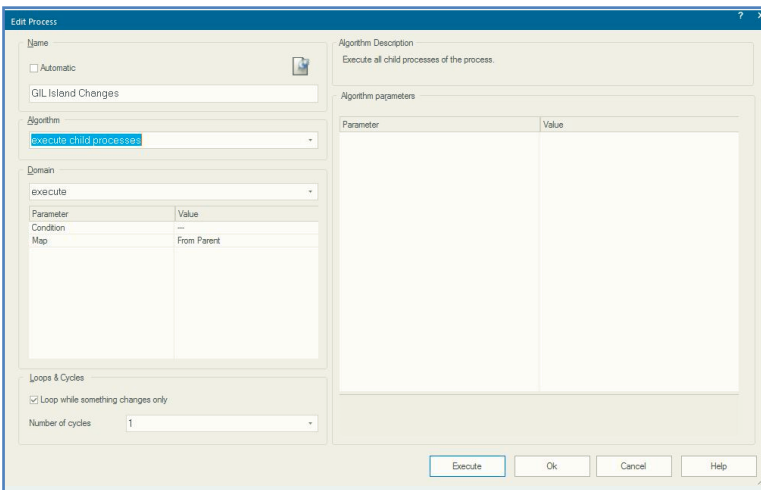


Figure 5: The Edit Process dialog box, named the Gil-Island Changes

4-2) Right-click on the Gil-Island Changes and select the Insert Child option. Set up all 'Copy Map' algorithm parameters as Figure 6.

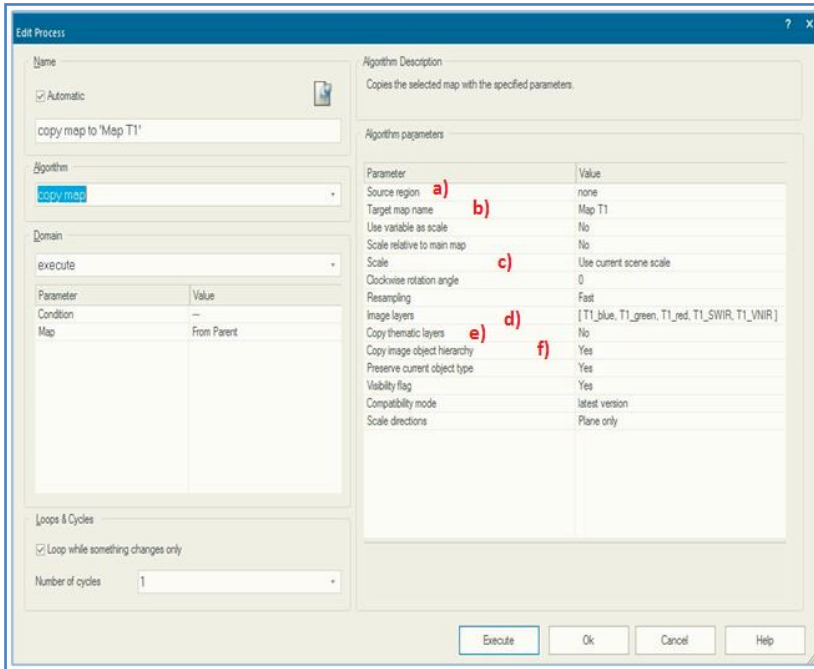


Figure 6: Process settings of algorithm 'copy map'

4.3) The most important parameters of this algorithms are:

a) The 'Source Region' defines whether you want to create a map from the full extent of the original scene or if a region is a basis for the new map.

b) The 'Target Map Name' is where the name of the new map is defined.

c) If the map to be created should have a different resolution, this is defined in the 'field Scale.'

d) In the field 'Image Layers,' the Image layers needed for the new map are defined. If nothing is set, all Image layers of the source map are copied to the new map.

e) In the field 'Thematic Layers,' the thematic layers for the new map are defined.

f) If 'Yes' is set in the field 'Copy Image Object Hierarchy,' the existing Image Object Levels are copied to the new map. If you want a backup map, you will use this option.

4.4) The process settings to create the map for T1 are shown in Figure 7.

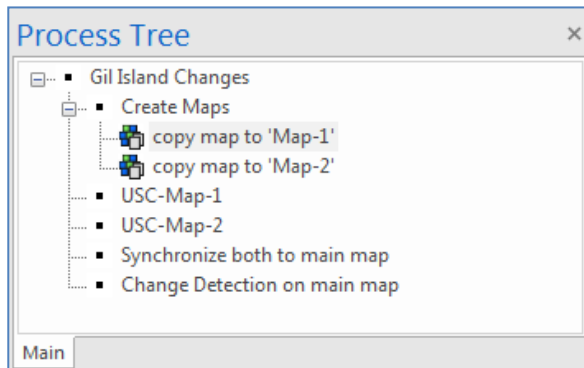


Figure 7: Process Tree with a process to create the MapT1 highlighted

4.4.1) Double-click on the first child process 'copy map to 'MapT1' to open it. In the Domain, the default settings are kept. No threshold must be set, no specific map, as there is only one existing.

4.4.2) The Source Region is kept as 'none' because no region exists, which could be the basis for the map. You shall copy the full extent of the loaded subset to the new map.

4.4.3) In the 'Target Map Name field,' the name 'MapT1' is entered. To insert a name for the new map, type it in.

4.4.4) In the field 'Scale,' the default setting 'Use current scene scale' is kept, as no change in resolution for the change detection analysis is needed.

4.4.5) In the field 'Image Layers,' only the layers from T1 are chosen. The new map will then contain only these layers. Click on the '...' next to the 'Image Layers' field. The 'Select Image Layers' dialog box opens (Figure 8).

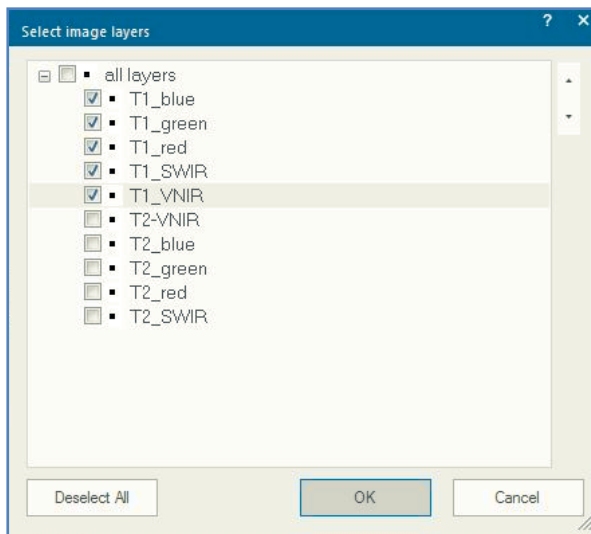


Figure 8: The 'Select Image Layers' dialog box, only the T1 Layers are selected

4.4.6) To explore the new map, click on the 'Execute' process to create 'MapT1'.

4.4.7) To display a map, use the dropdown list in the 'View Navigate' toolbar, right beside the 'Delete Level' button. Select 'MapT1' (Figure 9).

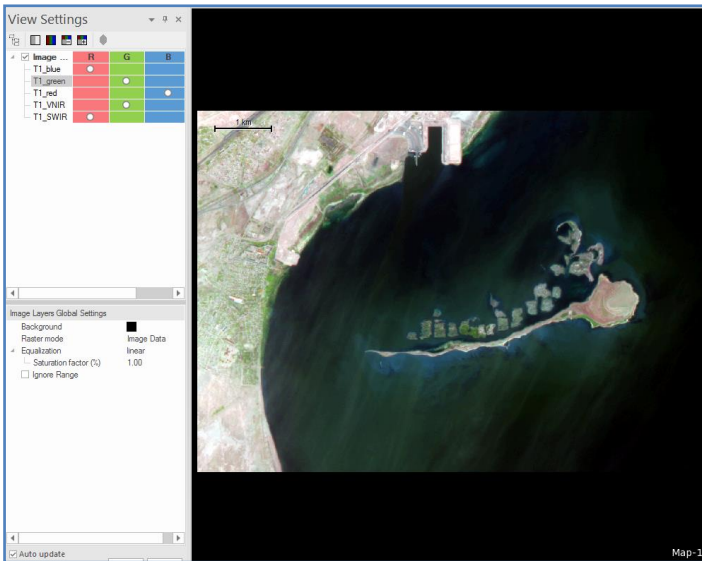


Figure 9: The name of the displayed map appears in the lower right corner of the viewer window, now ‘MapT1’ is displayed.

4.4.8) Now repeat the settings mentioned above to create a map for T2 (Figure 10).

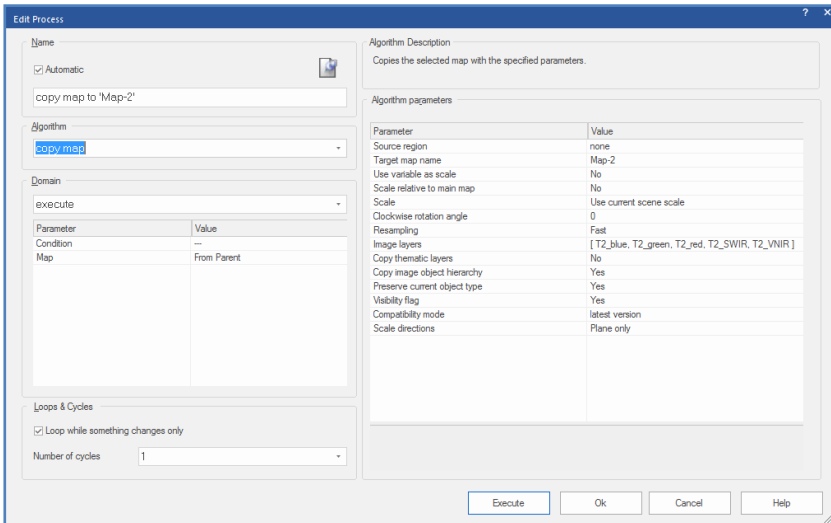


Figure 10: The Edit Process dialog box, process settings to create the Map-T2.

4.4.9) Examine the algorithm parameters as the process before; the default settings are kept for the Domain. Here, of course, the 'Target Map Name' is 'MapT2'. In the field 'Image Layers,' only the layers of T2 are chosen. Then, Execute the algorithm.

4.4.10) To evaluate both new maps, first open a second viewer, then display T1 in the one, T2 in the other viewer. Link both viewers with 'Side by Side' mode. To open a second viewer, go to the main menu Window and select either 'Split Horizontally' or 'Split Vertically.' Then, click in the left viewer window to make it active and select MapT1 from the dropdown list in the 'View Navigate' Toolbar.

4.4.11) By finishing up the first stage, click in the right viewer window to make it and select MapT2 from the drop-down list in the 'View Navigate' Toolbar. Then, go to the main menu 'Windows' and select 'Side by side View.' After that, you need to zoom in on maps T1 and T2 and compare the differences in both maps. Especially the water is quite different in the two maps (Figure 11). Two maps are created, and then the views synchronized: MapT1 (left) and MapT2 (right).

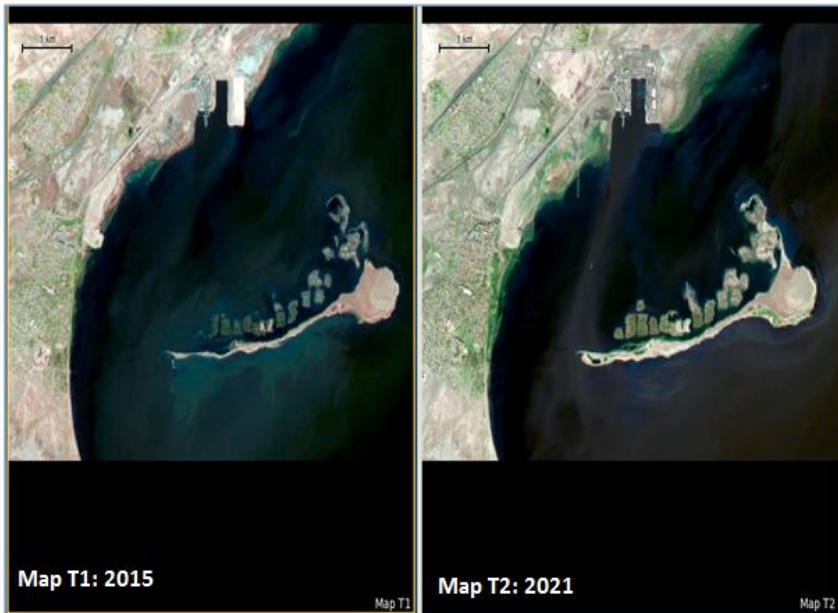


Figure 11: Synchronized MapT1 and MapT2

Step 5: Classifying water in both maps independently

Now that you have two separate maps, you can segment and classify both individually. It means you can create two independent Image Object Hierarchies within one project, separated into two maps. Which process is applied to which map is controlled by the algorithm Domain? If you need to apply several processes to a map, you can define the map in the parent process as a domain and use the settings 'From Parent' in the subsequent child processes.

5.1) When setting up maps T1 T2, right-click on the Process Tree and select Add New Process. Then, select the Cluster analysis (Unsupervised Classification) algorithm from the Algorithm list to see the Edit Process dialog box (Figure 12).

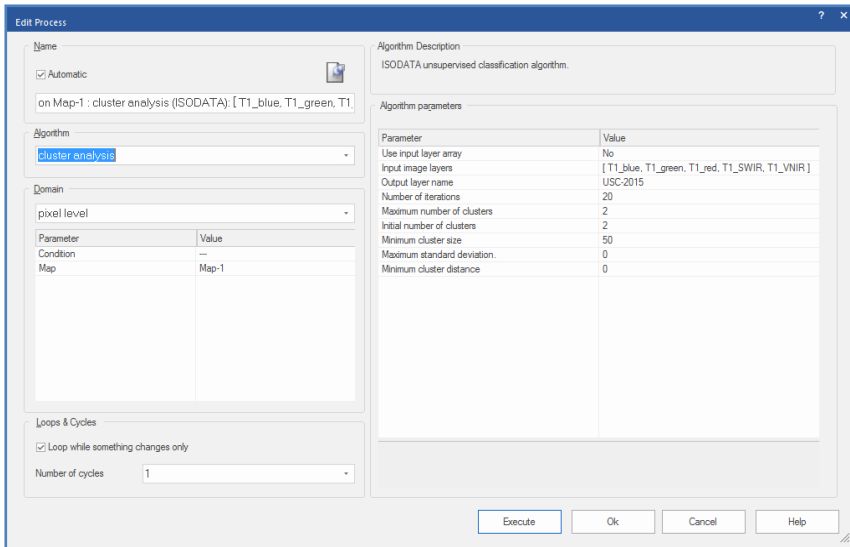


Figure 12: Edit Process dialog box set to Map1 with the USC algorithm

5.2) To run the USC algorithm, you may prefer to set all parameters as default settings that it shown in Figure 12. More details on the functionality of all required parameters are stated in Table 1.

Table 1: Required parameters for USC Functionality

Function	Algorithm Description
Supported Domains	Pixel Level; Image Object Level; Current Image Object; Neighbor Image Object; Super Object; Sub Object; Linked Objects
Algorithm Parameters	Parameters that have to be set to run USC algorithm
Use Input Layer Array	Choose whether to provide your input layers in a layered array or select the layers explicitly.
Input Image Layers	Select the layers to be considered for cluster analysis.

Output Layer Name	Define the name for the temporary layer that contains the result of the cluster analysis (cluster IDs).
Number of Iterations	Define how many times the clustering algorithm will iterate.
Maximum number of clusters	Define the maximum number of clusters to be created.
The Initial number of clusters	Define an initial number of clusters to be created.
Minimum cluster size	Define the minimum number of pixels per cluster.
Maximum standard deviation	Define the standard deviation that has to be exceeded for cluster splitting to occur. A value of 0 means that splitting is always allowed
Minimum cluster distance	You can define a distance threshold for cluster centers. If cluster centers are closer than this, clusters are merged. A value of 0 means that this threshold is ignored.

5.3) When you set all parameters, click on the Execute button to produce the USC ISODATA output map with a defined number of classes (Figure 13).

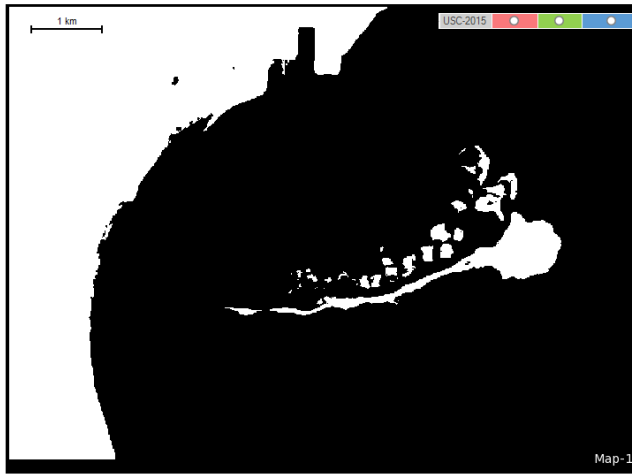


Figure 13: Selecting image layers for the Map-1 classified by USC algorithm
 5.4) Do not forget to select the image layers (for the Map-T2 bands) with adequate information in the USC procedure as Figure 14.

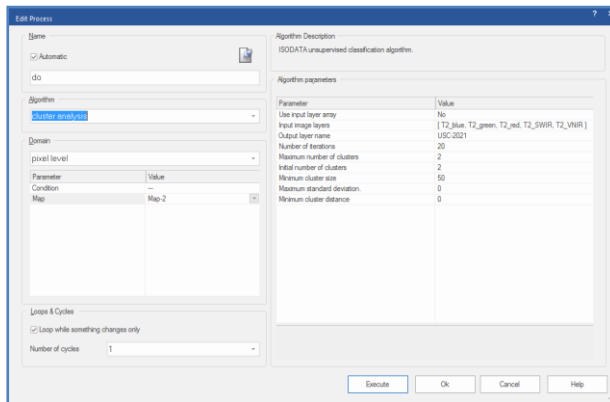


Figure 14: Edit Process dialog box set to Map 2 with the USC algorithm
 5.5) The result of the USC algorithm for Map 2 is shown in Figure 15.

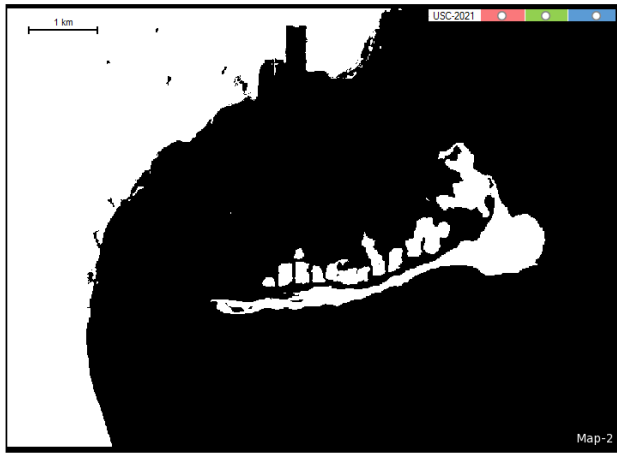


Figure 15: Selecting image layers for the Map-2 classified by USC algorithm

5.6) Figure 16 shows many details on the Visual comparison of the Gil Island Caspian Sea changes.

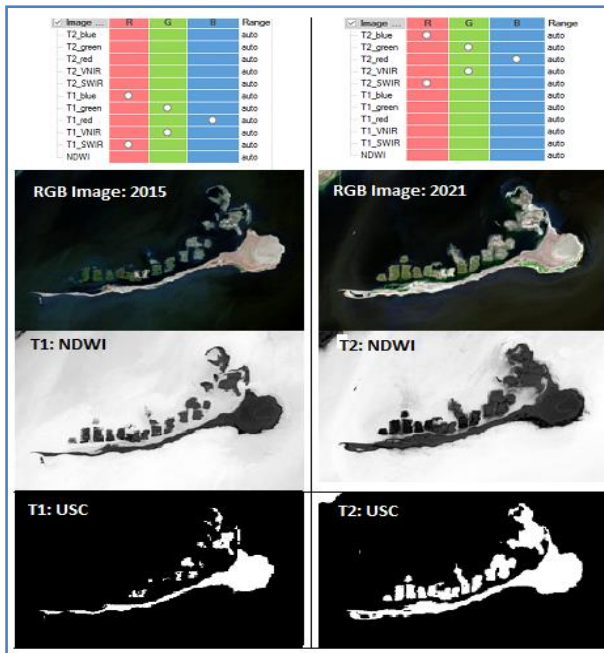


Figure 16: Visualizing change detection on RGB images, NFDWI values, and USC results adjusted for the Gil Island, Caspian Sea

5.7) Changes in the Caspian Sea water depletion trend for seven years is quite visually detectable. Most likely, due to climate change in the region, the trend of lowering the water level in the coming years will be quite tangible. Such changes will lead to negative changes in the region's coastal environment, animal species, and downbeat economic and social problems.

Step 6: Other complementary applicable methods

Based on the OBIA capabilities, there is more eCognition software to develop the current change detection procedure as:

6.1) For a different stage, you may prefer to create a few index layers such as NDVI by applying Index Layer Calculation algorithms (please notice previous tutorial contents). Such spectral indices could be used along with different segmentation and classification process.

6.2 The next step would be to introduce a multi-threshold segmentation based on the USC outputs. They effectively help you to move to the most advanced OBIA techniques.

6.3 After both maps have been classified, they could be synchronized back to the main map. With their different classification of water, the two levels will form the basis for a change detection procedure.

6.4) To reduce the rate of inaccuracy that may introduce in the USC steps, you may prefer to apply a few more object-based analyses. For example, Remove Object algorithm considering neighborhood properties or context information) inside the

eCognition software, such as removing small doubtful objects from the USC result that will considerably improve the final USC map.

6.5) At least one application field of maps is for real change detection; there are more algorithms for both time points (T1, T2, T3, and so on) inside the eCognition 9.5.

Sum Up:

eCognition offers many Geoscience analysis methods: supervised and unsupervised machine learning, deep learning, knowledge-based analysis with Fuzzy Logic and threshold conditions, all together to run OBIA procedures. For unsupervised classification, we tutored the possibility of executing an ISODATA cluster analysis addressing part of the Caspian Sea, subsetting coastal, by processing two sets of Sentinel-2 imagery. You learned how to place maps in one project. After that, you understood that ISODATA could categorize continuous pixel data into classes/clusters with similar spectral-radiometric values. Indeed, you learned how to apply a 'copy map' algorithm that can be used for multi-scale image analysis.

Informative Practices

Tips:

- 1) USC is where the outcomes (groupings of pixels with common characteristics) are based on the software analysis of an image without the user providing sample classes.
- 2) USC algorithms discover hidden patterns or data groupings without the need for human intervention.
- 3) The 'copy map' algorithm's most frequently used options are: defining a subset of the selected map using a region variable, selecting a scale, setting a resampling method, copying all layers, selected image layers, and thematic layers, and copying the image object hierarchy of the source map.

Workouts:

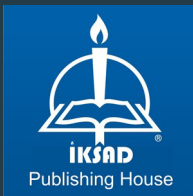
- 1) List the different methods of image classifications.
- 2) Apply the current tutorial methodology to the Sentinel-2 data for the Caspian Sea major islands for the years 1995 and 2000 and compare the results.
- 3) Use an NDWI spectral indexing and multi-threshold segmentation algorithm to detect changes on the other coastal sides of the Caspian Sea.

Quizzes:

- 1) What is the difference between object-based and pixel-based classification?
- 2) Is object-based classification supervised?
- 3) Which classification method is better for the high-resolution satellite imagery?

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- 6) Zerrouki, N. and Bouhaffra, D. (2014). Pixel-based Or Object-based: Which Approach Is More Appropriate for Remote Sensing Image Classification? IEEE International Conference on Systems, Man & Cybernetics, San Diego(CA), pp. 864-869.



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