SENSUM Earth Observation Tools
Medium Resolution algorithms

USER MANUAL

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Contents

List of acronyms

ACRONYM	DESCRIPTION
MR	Medium Resolution
HR	High Resolution

Document Purpose

Purpose of this document is to provide a concise user manual related to the version of the SENSUM Earth Observation tools implemented into the G-POD infrastructure.

This manual is addressed to people familiar with interpretation of medium resolution optical satellite imagery.

SENSUM Earth Observation tools

EO-based exposure and vulnerability proxies can be defined at different spatial levels. Extension and outline of a built-up area, for example, is a valuable piece of information when assessing exposure to various natural risks on a vast area. Zooming into the urban areas, other proxies can be defined like buildings regularity and density, height, shape etc. Different open-source C and Python libraries are already available for image processing and geospatial information handling (e.g. OrfeoToolbox, OpenCV and GDAL) providing basic processing tools, producing results that reach a point located one step behind the exposure target. Therefore, it is of significant importance to provide end-users with a set of tools based on simple work flows capable of returning information at a higher level, in other words to "include the last mile".

The research group at the University of Pavia developed a set of python algorithms, integrating low-level image processing techniques with exposure-oriented workflows. This set of tools is available as QGIS plugin[1] and source code[2]. Details related to each function can be found on the online SENSUM EO tools user guide[3].

Following, the complete list of algorithms including a brief explanation of each algorithm and the resolution the algorithms can focus on (medium or high resolution).

Table 1. List of algorithms available through the QGIS plugin

ICON	NAME	DESCRIPTION	MR/HR
	Pan-sharpening	Pan-sharpening algorithm from OrfeoToolbox.	MR and HR
	Classification	Unsupervised/Supervised classification from OrfeoToolbox.	MR and HR
	Segmentation (including optimizer option)	Segmentation algorithms from OrfeoToolbox, TerraAIDA (InterImage) and Skimage (python library).	MR and HR
	Features	Computation of spectral and textural features from segments.	MR and HR
	Co-Registration	Co-registration algorithm designed for medium resolution. SURF and FFT alternatives are included. While services of Open CV library are used in our approach, the FFT algorithm comes from Numpy (python library).	MR
	Stack satellite	Stack satellite workflow including co-registration and built-up extraction with 4 different methodologies.	MR
	Unsupervised change detection	Automatic analysis of the outcome of the object-based built-up area extraction algorithms.	MR

[1] https://plugins.qgis.org/plugins/sensum_eo_tools/
[2] https://github.com/SENSUM-project/sensum_rs_qgis
[3] http://ldt.unipv.it/sensum-docs/

Extr	Footprints extraction	Supervised extraction of building footprints.	HR
Hgt	Building height	Combination of shadows and footprints with acquisition date for height extraction.	HR
Den	Building density	Calculation of the density of building in an area of interest.	HR
Reg	Building regularity and alignment	Computation of alignment and regularity of buildings.	HR

G-POD integration

From the set of algorithms proposed before, the MR-oriented workflows have been chosen to be integrated as G-POD service. The idea is to take advantage of the direct link with the Landsat and Sentinel catalogues.

NOTE: Landsat and Sentinel-2 data cannot be processed together.

Stack Satellite

The processing workflow "backbone" is unchanged in respect of the QGIS plugin. Major adjustments have been carried out in order to parallelize tasks and take advantage of the available worker nodes. Details related to the implementation can be found in *De Vecchi et al., 2016*[4].

5 different methods are integrated to extract built-up areas from MR imagery:

- Built-up Index method is based on an index computed using green, NIR and IR bands; the result is a raster layer called "built_up_index.tif" with 5 bands (SAVI, NDVI, NDBI, MNDWI and BUILT_UP). The built-up area can be extracted by applying a threshold over the last band. The same raster layer is also used as input for the segmentation (see Dissimilarity method and PCA OB method).
- PCA index method is a combination of PCA bands; the result is a raster layer called "pca_index.tif" with 1 band related to the computed index. The built-up area can be extracted by applying a threshold.
- PCA classification method is the result of an unsupervised classification with PCA bands as input. The built-up area usually corresponds to one or two classes.
- PCA OB method[5] is the combination of PCA bands averaged within segments computed over "built_up_index.tif" from the most recent input year. Segments are then classified using an unsupervised approach.
- Dissimilarity method[6] is based on the computation of the dissimilarity texture over the area of interest and the consequent combination with segments. The outcome is classified using an unsupervised classification.

All the methods present above are available as input parameters along with:

- Cloud cover threshold: percentage of cloud cover allowable. Data with cloud cover exceeding this value will not be processed.
- Segmentation parameters [spatial radius, range radius, threshold, max iterations, min size]: input parameters of the 'Meanshift' segmentation. Check the Orfeo Toolbox cookbook for more details related to the algorithm[7]. Default values are provided.
- Number of classes: number of classes for the unsupervised classification. Default value is 5.
- DEM: use SRTM 30 meters DEM to mask mountains out.

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[4] D. De Vecchi, F. Dell'Acqua, R. Cuccu, C. Orrù and G. Rivolta, "Integration of tools for Large-Scale Exposure and Vulnerability assessment into the Remote Geospatial Processing Environment of the European Space Agency: an experience on "SENSUM Tools", ESA Big Data from Space Conference (BiDS'16), Tenerife, Spain, 15-17 March 2016.

[5] D. De Vecchi, M. Harb and F. Dell'Acqua, "A PCA-based hybrid approach for built-up area extraction from Landsat 5, 7 and 8 datasets", Geoscience and Remote Sensing Symposium (IGARSS), 2015 IEEE International, Milan, 2015, pp. 1152-1154. doi: 10.1109/IGARSS.2015.7325975

[6] M. Harb, D. De Vecchi and F. Dell'Acqua, "Automatic hybrid-based built-up area extraction from Landsat 5, 7, and 8 data sets", *Urban Remote Sensing Event (JURSE), 2015 Joint*, Lausanne, 2015, pp. 1-4.
doi: 10.1109/JURSE.2015.7120475

[7] https://www.orfeo-toolbox.org/CookBook/CookBooksu127.html#x159-9680004.9.8

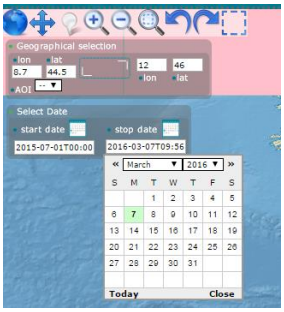
Unsupervised Change Detection

TO BE IMPLEMENTED SOON

Create a SENSUM Stack Satellite task

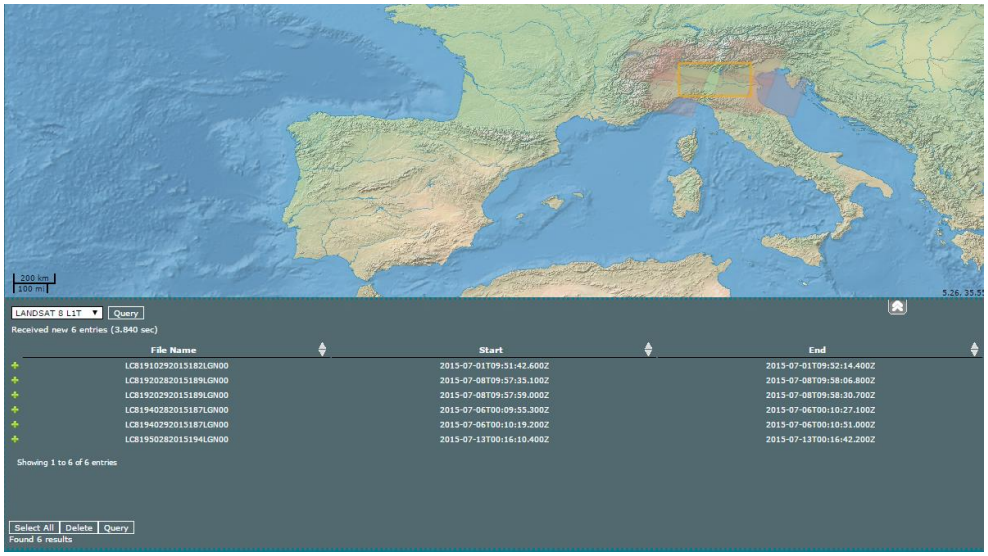
1. Connect to the following website: http://gpod.eo.esa.int/
2. Log into the G-POD portal using your EO-SSO Login information
3. Click on ‘Land’ and then jump to the second page or simply type ‘sensum’ in the search bar
4. Click on the ‘SENSUM’ service

5. Define an AOI on the map (yellow rectangle), specifying also the time period

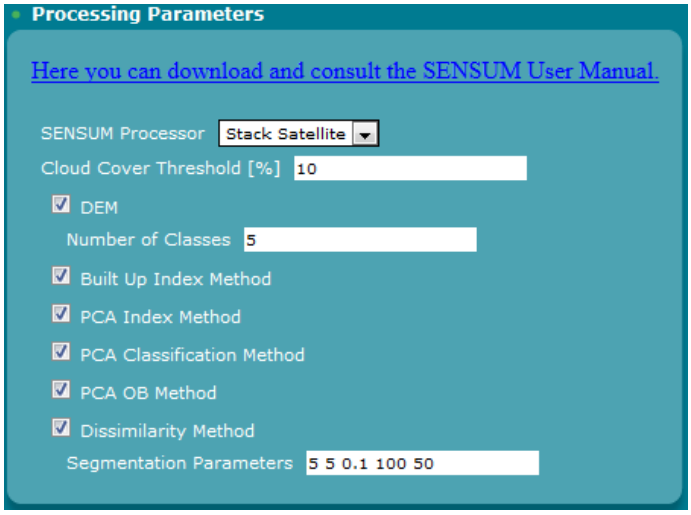


6. Select the catalogue to query (‘LANDSAT 8 L1GT’, ‘LANDSAT 8 L1T’, ‘LANDSAT-7 ETM+ GTC’, ‘SENTINEL-2 MSI L1C’)

7. Click on the ‘Query’ button
8. From the provided list, select the data to be processed (CTRL+click)
    a. [Suggestion] try to select data with homogeneous acquisition time covering the AOI
    b. The algorithm automatically merges all the tiles necessary to fill the AOI
    c. Multiple years can be selected and processed separately



9. Fill the parameters box
    a. Cloud cover threshold: images with Cloud Cover exceeding these values will not be processed
    b. Segmentation parameters: default values are provided
    c. Number of classes: used as input of the unsupervised classification, default is 5
    d. Select/deselect the methods to be applied
    e. Select/deselect the DEM option (default is true)

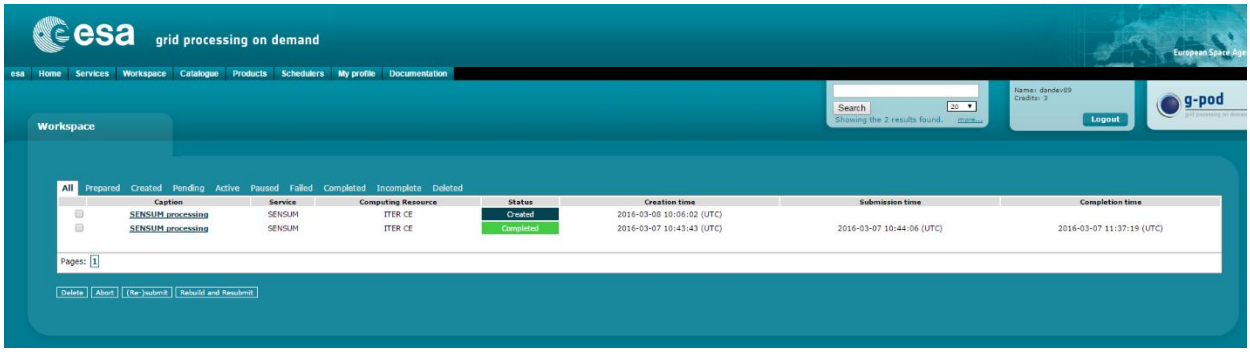


10. Click ‘Save in Workspace’ if you want to add more datasets or check the parameters. Click ‘Process it’ to start immediately the procedure.

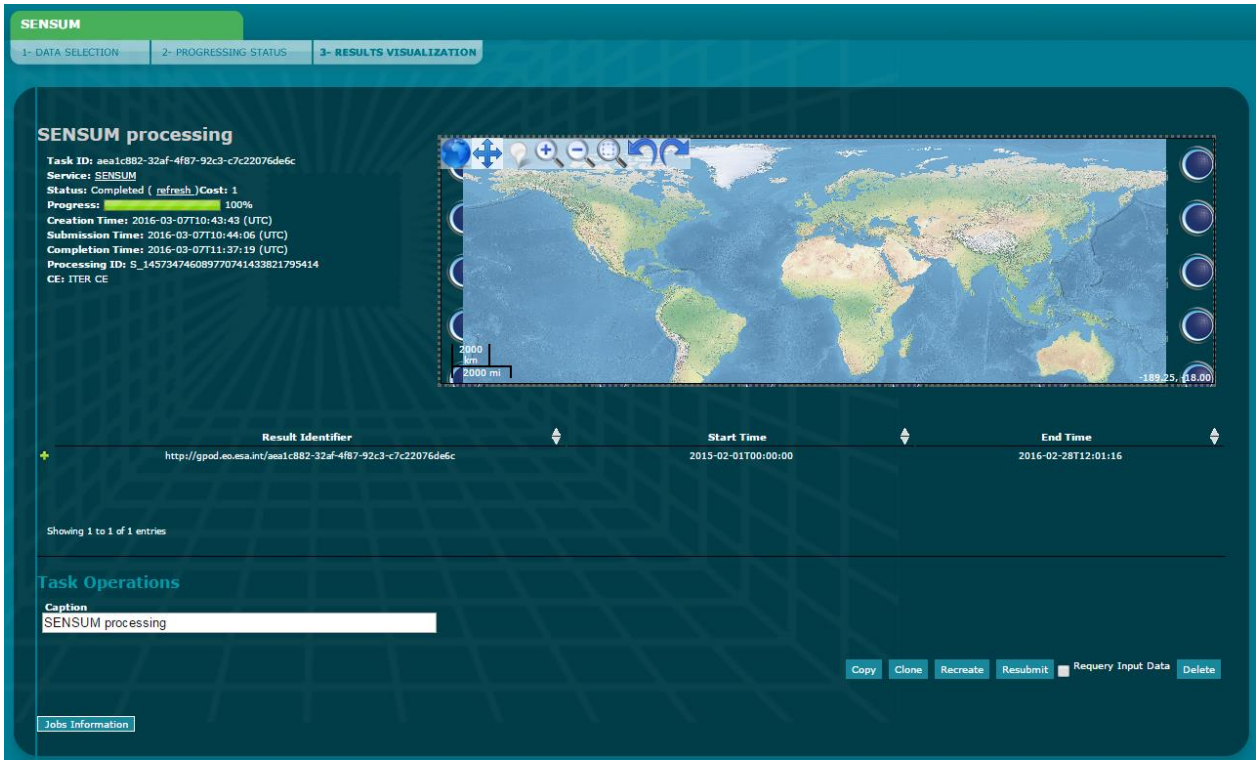
11. Status of the process and other details can be checked by clicking on the ‘Workspace’ tab. The next paragraph is dedicated to the ‘Workspace’ section.

Check and download the results

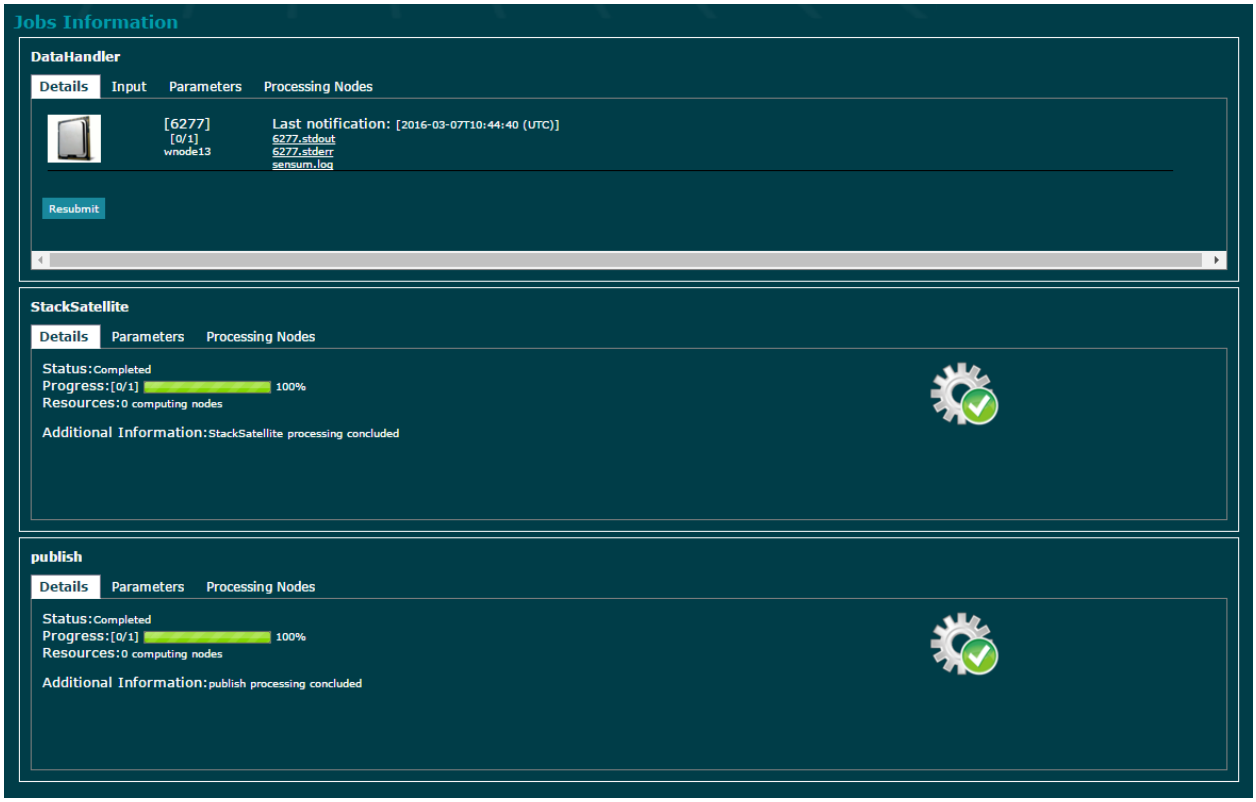
Information related to the status of the procedure can be found in the ‘Workspace’ section.



Click on caption name to explore the details



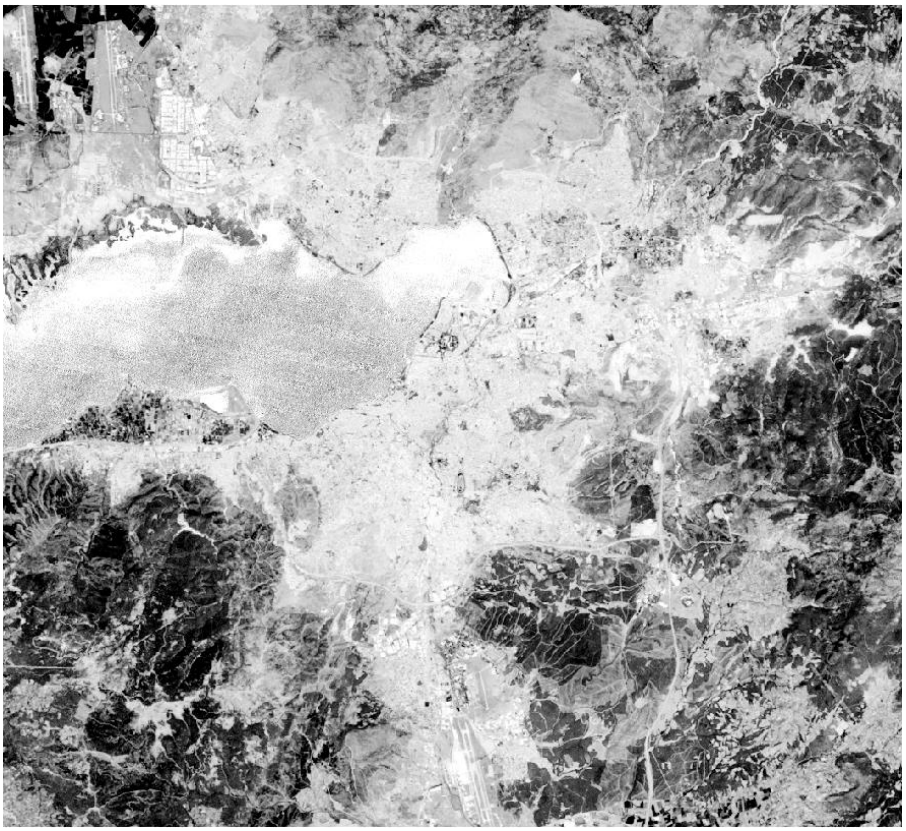
Press the ‘Jobs Information’ button



Results interpretation

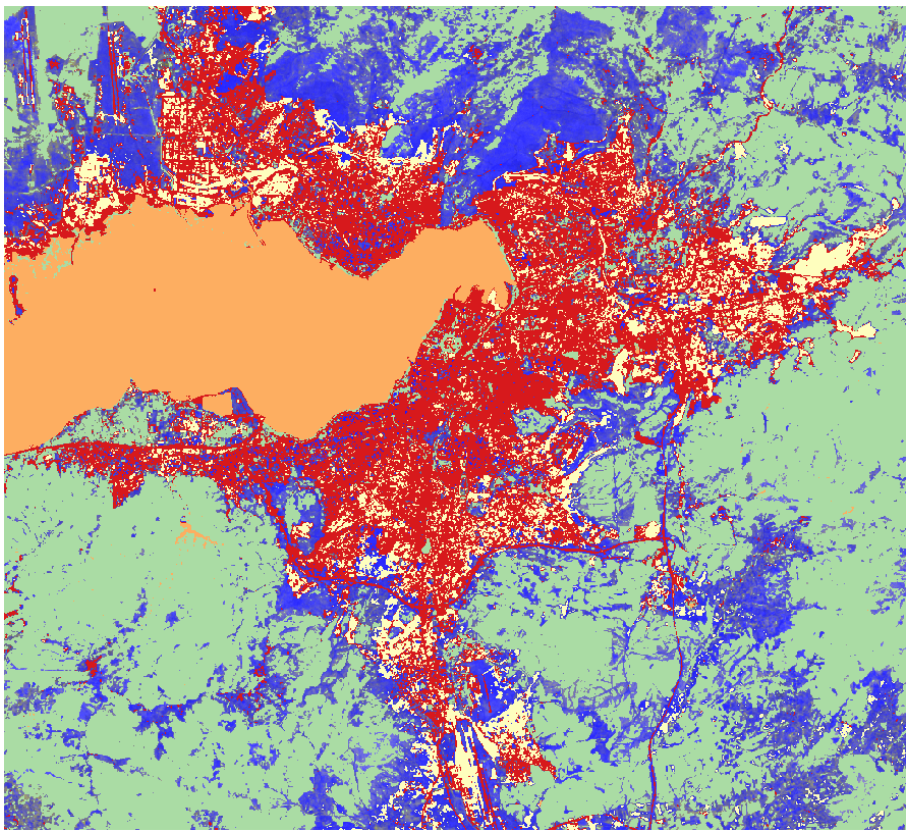
Every result can be downloaded and further refined using software like QGIS.

- Built-up index method

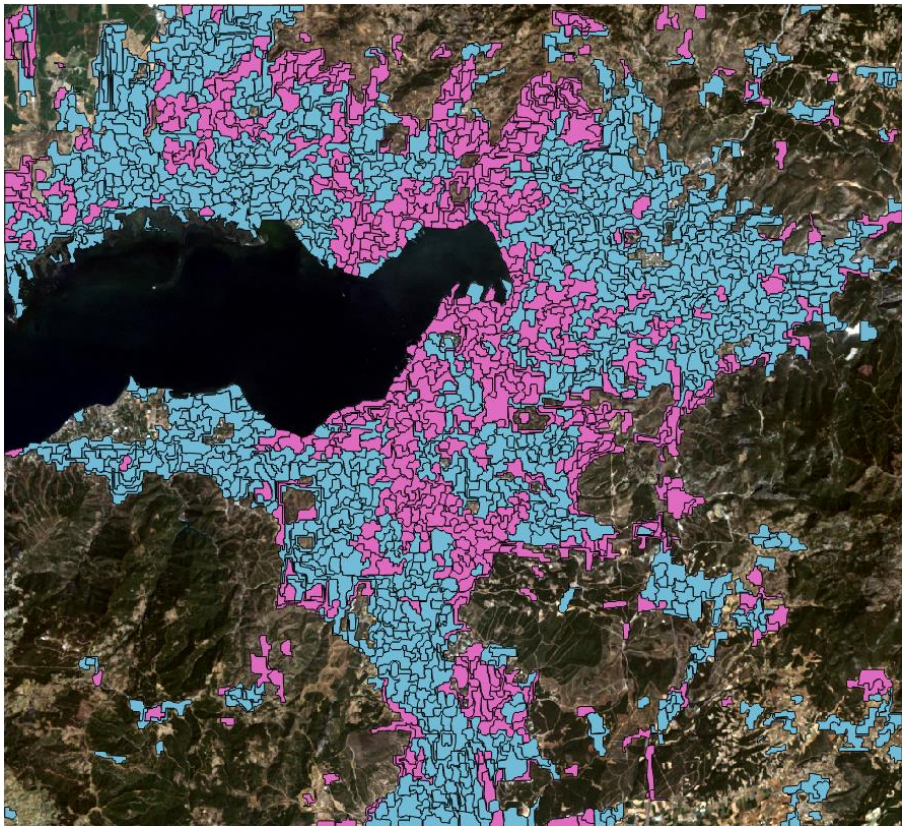


- PCA index method

- PCA classification method



- PCA OB method



- Dissimilarity method