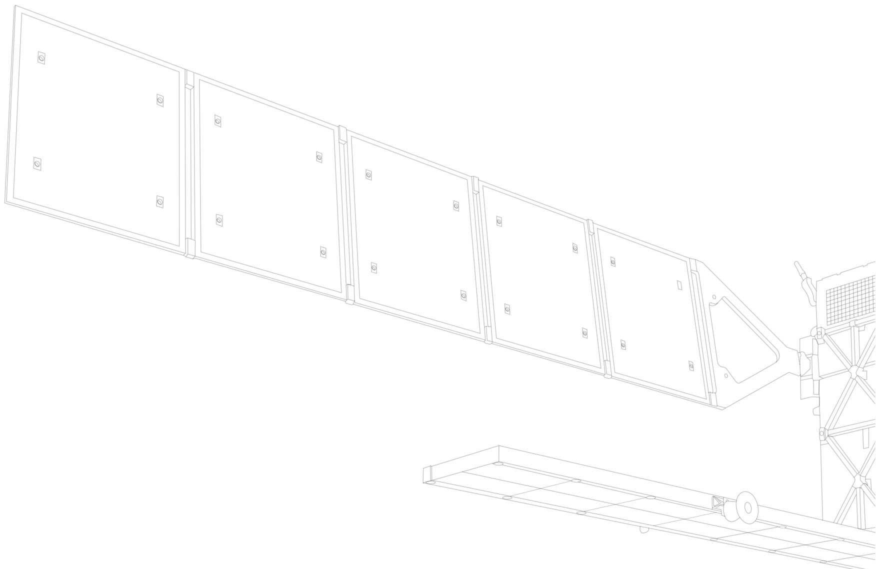
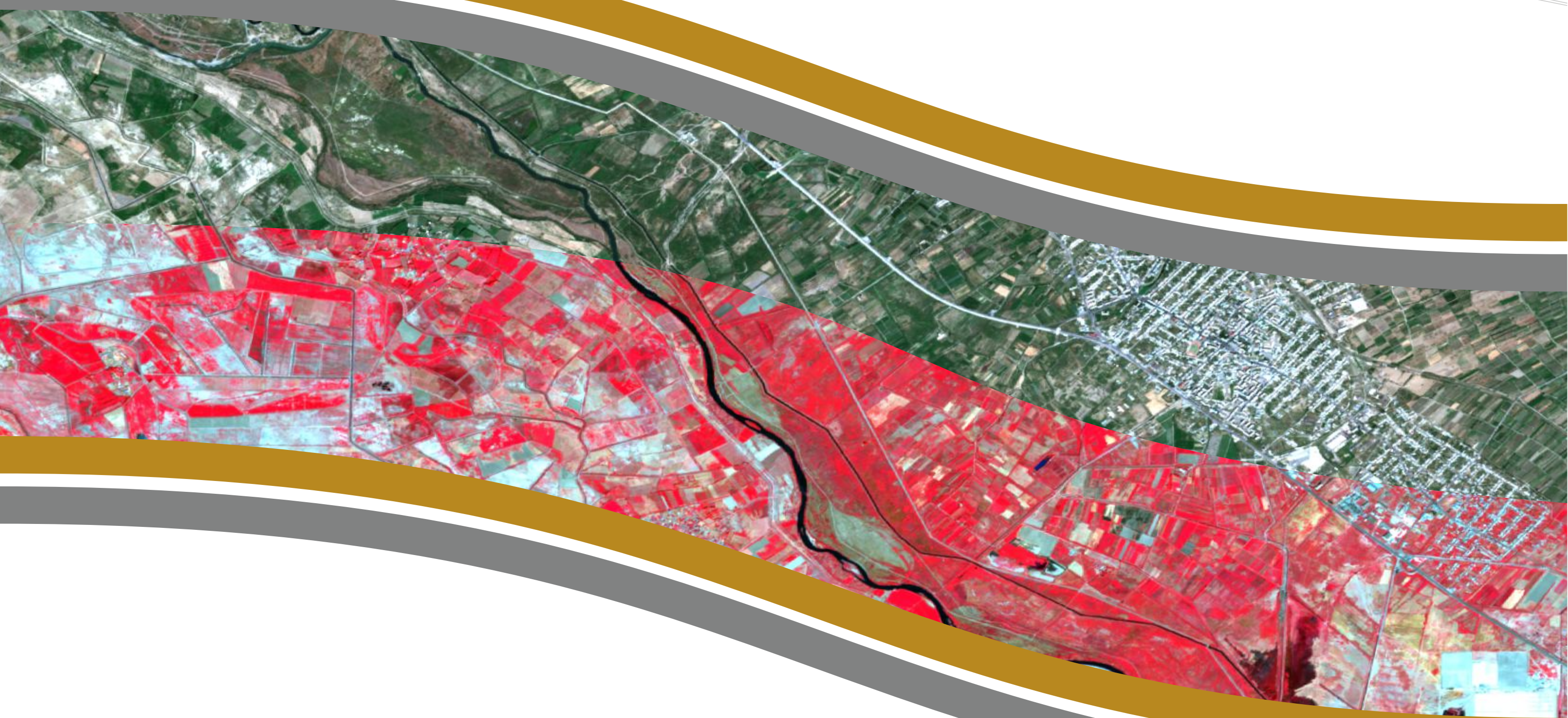
Earth Observation for Sustainable Development

eastern european region
eo4sd

Earth Observation for Eastern Partnership





ESA SNAP WORKBOOK

BY

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1 Introduction to ESA SNAP software and work with Sentinel-1 & Sentinel-2 satellite imagery

1.1 ESA SNAP software

ESA SNAP is as free software distributed under GNU license. Developed and supported by ESA, first of all aims to offer efficient, public tool for raster satellite data processing (optical and radar).

1.1.1 Installation

Installation files of ESA SNAP software are available to download on the http://step.esa.int/main/download/ website. User has a possibility to download one of three installation versions according to his needs (Fig. 1):

- Sentinel-1, Sentinel-2 and Sentinel-3 toolboxes,
- SMOS (Soil Moisture and Ocean Salinity) data toolbox,
- Sentinel-1, Sentinel-2 and Sentinel-3, SMOS data and PROBA-V toolboxes – all accessible tools.

	Windows 64-Bit	Windows 32-Bit	Mac OS X	Unix 64-bit
Sentinel Toolboxes	These installers contain the **Sentinel-1**, **Sentinel-2**, **Sentinel-3** Toolboxes			
	Download	Download	Download	Download
SMOS Toolbox	These installer contains only the **SMOS Toolbox**. Download also the Format Conversion Tool (Earth Explorer to NetCDF) and the user manual.			
	Download	Download	Download	Download
All Toolboxes	These installers contain the **Sentinel-1**, **Sentinel-2**, **Sentinel-3** Toolboxes, **SMOS** and **PROBA-V** Toolbox			
	Download	Download	Download	Download

Fig. 1. Available installation versions of ESA SNAP Software (source: step.esa.int)

Work with satellite imagery of Sentinels family requires downloading first or third version. To download the installation file, please point *Download* choosing software version which also fits to users operating system (Windows 32- or 64-bit, Mac OS X, Unix 64-bit) and save it in a known directory.

To install ESA SNAP software please double point the file. Then proceed through the entire installation process.

1.1.2 Application launch and interface overview

ESA SNAP software can be launched by shortcut on the desktop (created during the installation) or by *Start Menu → Search → ESA SNAP Desktop*.

ESA SNAP software main window can be divided into several parts (Fig. 2):

a) main toolbar – grouped in several categories tools for application configuration and read, write and process data,

b) shortcuts toolbar – direct links to some functions of the software,

c) navigation and data display panel – allows for easy navigation through read data, changing its visualization, saving after edition and calling some functions,

d) product library and layer manager panel – expandable windows allowing for managing large data sets and changing the way of current map window presentation (vector data style and transparency, layers order etc.)

e) map window – allows for a visualisation of possessed data.

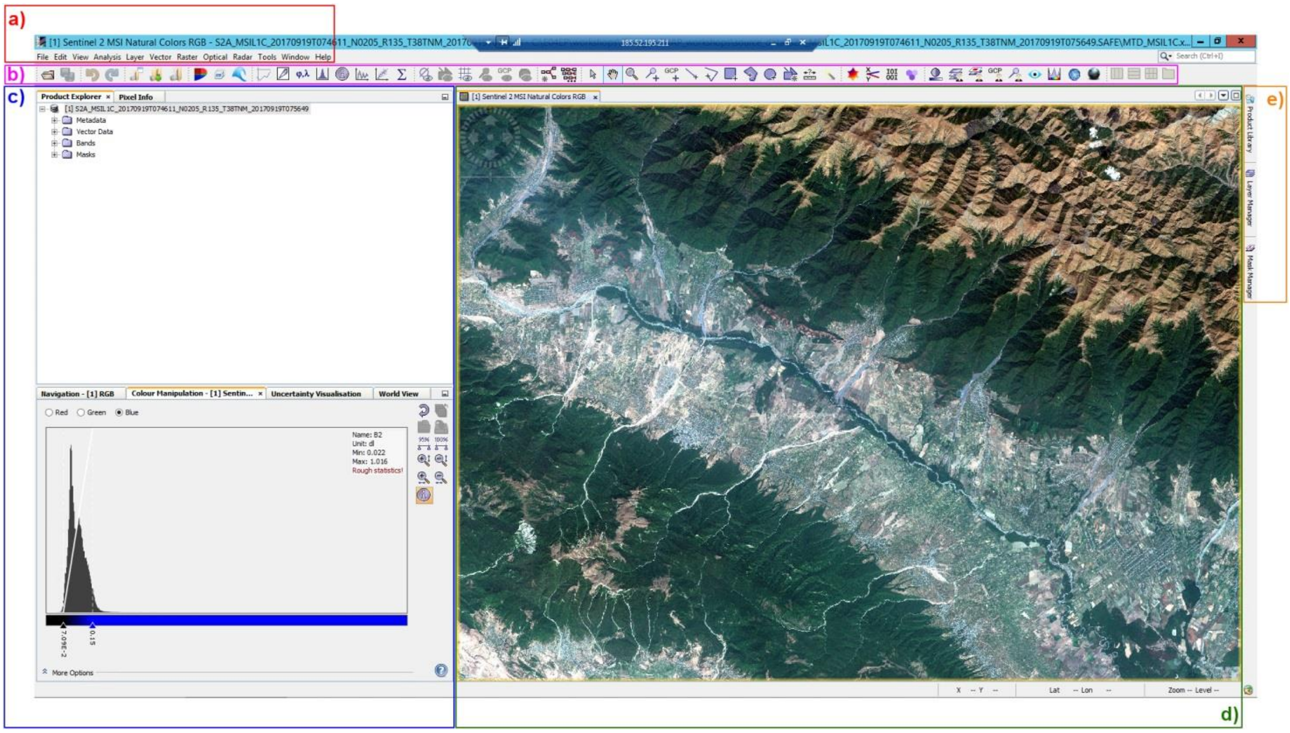


Fig. 2. Main window of the ESA SNAP software

It is only a default interface of application window, which can be configured during user needs and preferences to create user-friendly workspace for efficient work.

1.1.3 Overview of software configuration capabilities

Configuration options of ESA SNAP allows to fit the software interface to user needs, optimal allocation of hardware resources, defining the default way to display data and several other capabilities. Making changes in the interface is available in *View* panel from main toolbar (Fig. 3), and the other configuration tools are collected in *Tools → Options* window (Fig. 4).

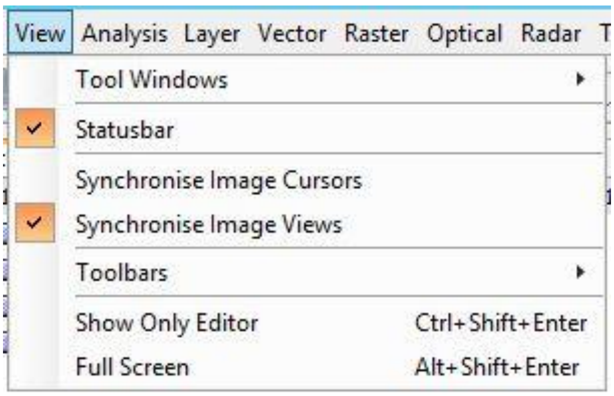


Fig. 3. ESA SNAP interface configuration menu

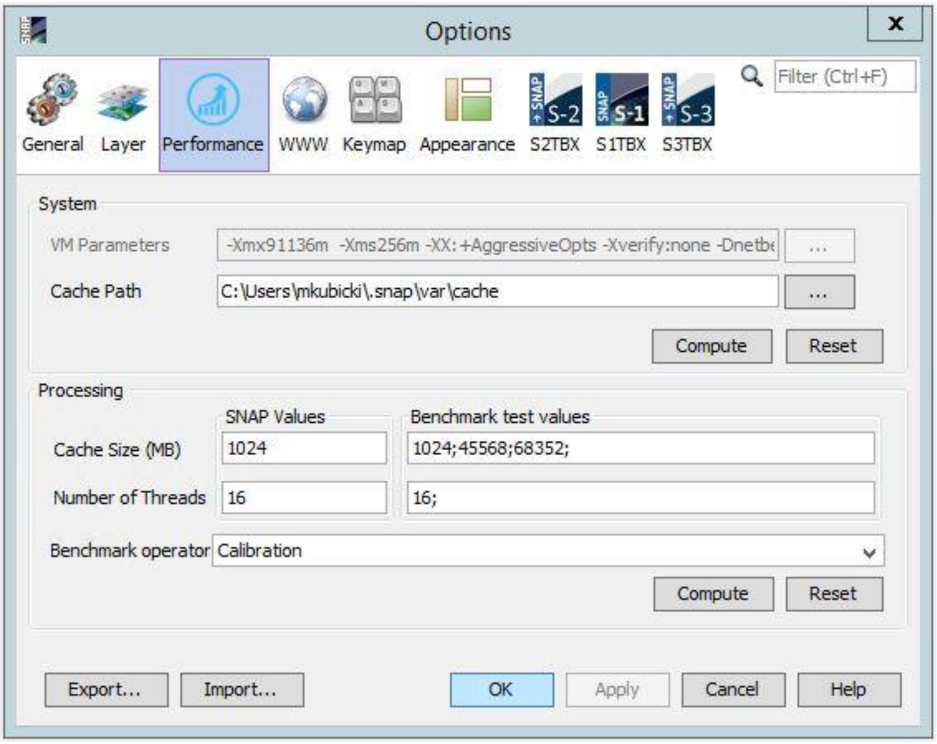


Fig. 4. ESA SNAP settings window

1.2 Search, browse and download the Sentinel-1 & Sentinel-2 data

SciHub is a website providing access to Sentinel-1, Sentinel-2 and Sentinel-3 data. The website is available at https://scihub.copernicus.eu/. *Open Access Hub* is a map browser for download data of all the Sentinel missions working in operational mode through graphical user interface. For using the *SciHub* website it is necessary to own the user account. *SciHub* allows to search data by area, sensing time, ingestion time, sensor type, product type, three features typical for Sentinel-1 mission: polarisation, sensor mode, orbit number and one feature typical for Sentinel-2 data - the cloud cover.

The content of map browser contains the following elements (Fig. 5):

a) sign up and login buttons,

b) tool for change the map backgrouod,

c) tools for navigation and defining the area of interest,

d) expandable search toolbar.

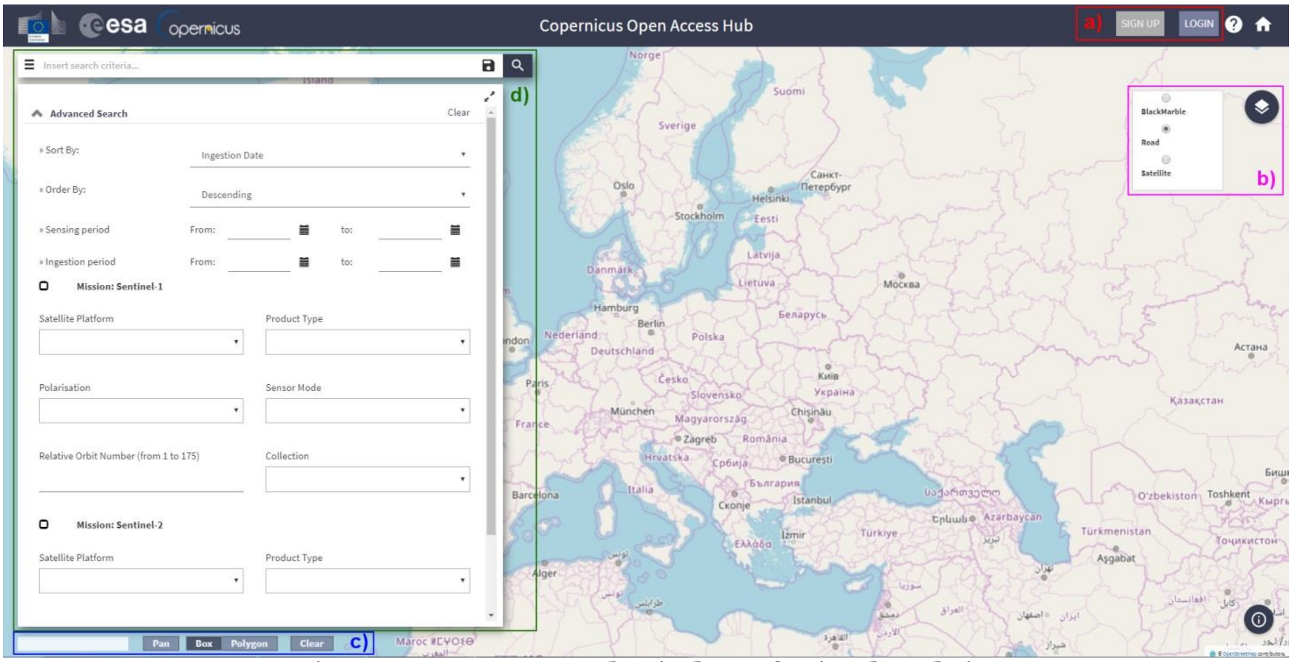


Fig. 5. Open Access Hub window of SciHub website

Exercise 1 *Search and download Sentinel-1 data through SciHub website*

- Step 1. Open the web browser, type in address bar: https://scihub.copernicus.eu/, confirm [Enter], and go to *Open Hub* access point.
- Step 2. Log in LOGIN typing login and password provided by trainer.
- Step 3. Set navigation tool Pan, slide view to your area of interest and choose rectangle Box or polygon Polygon area of interest drawing tool.
- Step 4. Expand the list of advanced search options ≡ .
- Step 5. Set the *Sensing period* as 1.09.2017-31.09.2017 r., mark *Mission:Sentinel-1* checkbox, choose *Product Type: SLC* and apply a search .

All images of the given parameters, whose range crosses the given area of interest, have been shown in the map window and listed on the results list on the left (Fig. 6).

After point some image it is possible to move and zoom map range to this image, view its metadata and download the image to hard drive.

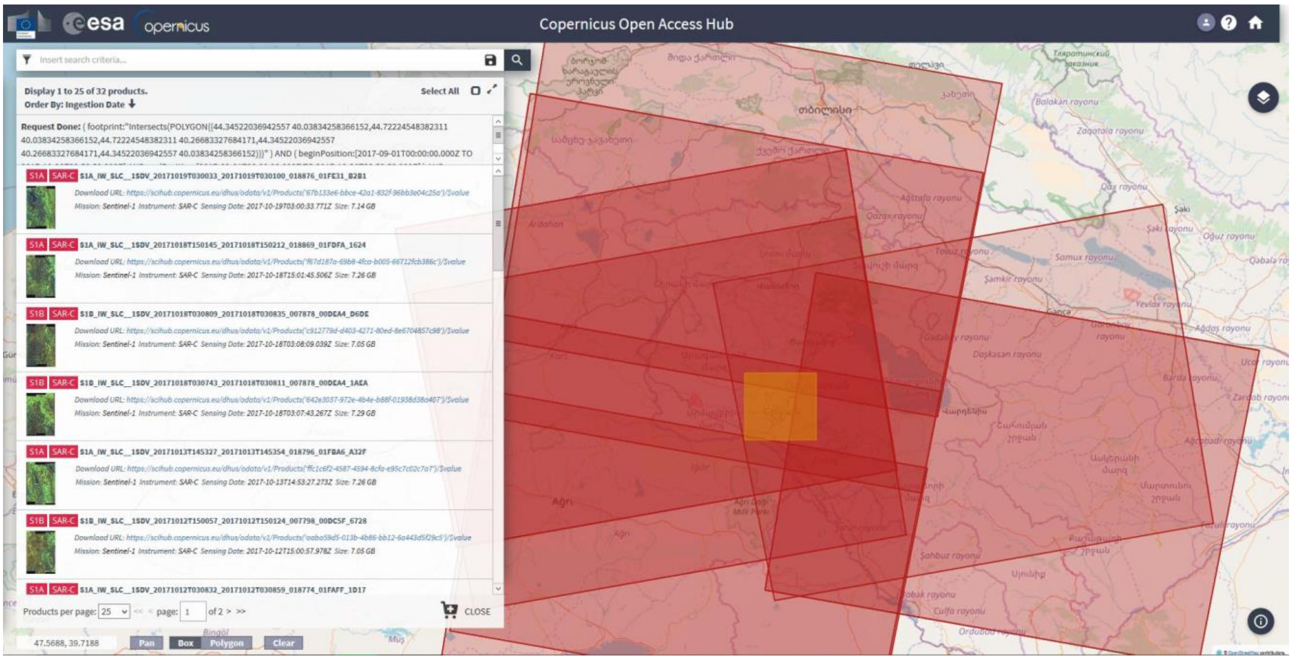


Fig. 6. The effect of searching in Open Hub access point

2 General raster tools

2.1 Read, view and save the data

It is advised to extract the downloaded file – it is necessary for working with Sentinel-2 data. According to system limitation of file path length, files should be placed so high in the hierarchy of directories as possible before extraction. To load data to workspace data can be opened (exercises 2 and 3) or imported (exercise 4). Data import tool allows to work with many supported sensors and data formats (Fig. 7).

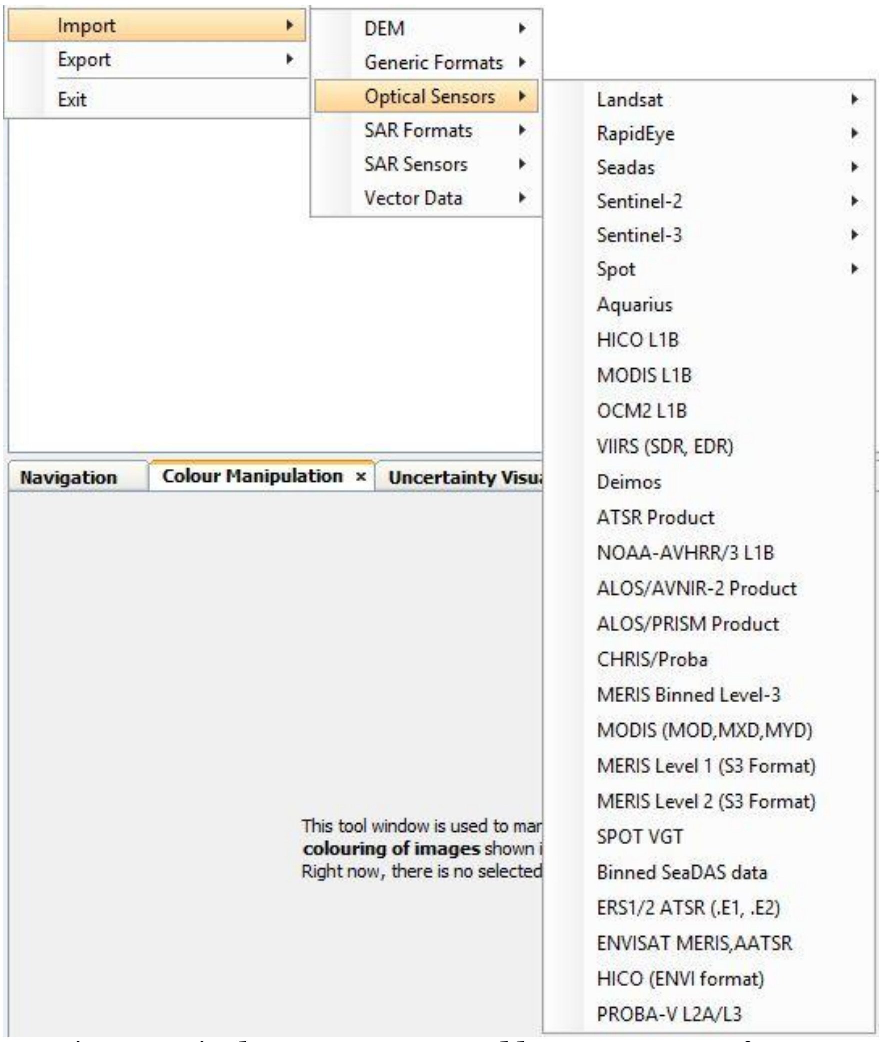


Fig. 7. Optical sensors supported by ESA SNAP software

Exercise 2 *Sentinel-1 data reading in ESA SNAP software*

- Step 1. Launch the file adding window by select from the main toolbar *File → Open Product* or icon from the shortcuts toolbar.
- Step 2. In the opened add file window select *Sentinel-1 Products* from the *Files of type* drop-down list.
- Step 3. Find Sentinel-1 image in the *\\ESA_SNAP_workshops\source_data* directory, open the main catalogue of the image, point *manifest.safe* file which allows for correct opening Sentinel-1 data and click *Open* (Fig. 8). Image will be added to application workspace and placed in *Product Explorer* tab.

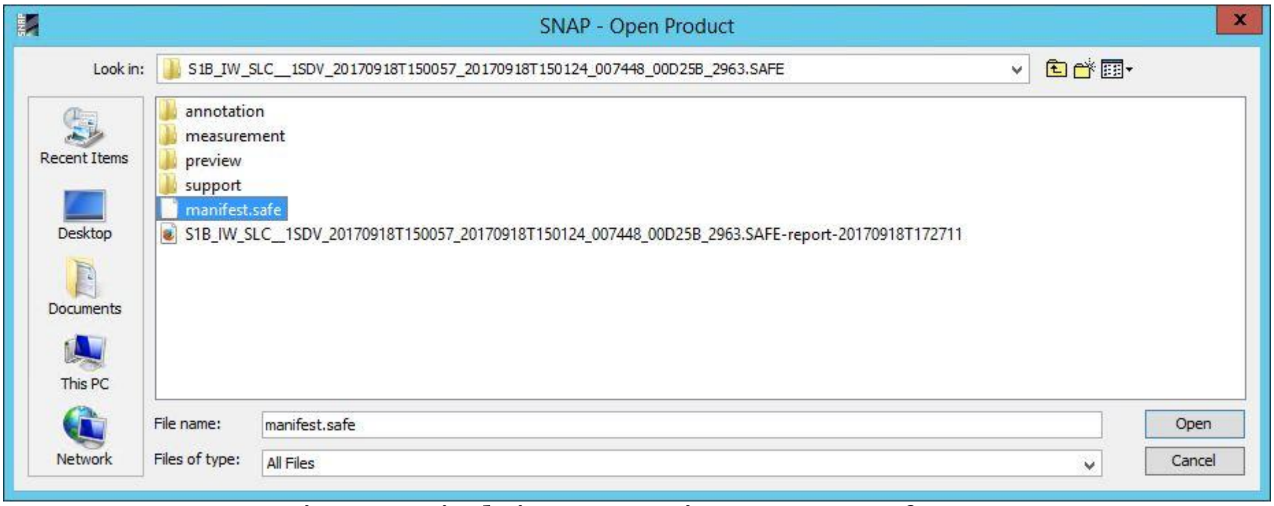


Fig. 8. Sentinel-1image open in ESA SNAP Software

Exercise 3 <u>*Sentinel-2 data reading in ESA SNAP software*</u>

- Step 1. Launch the file adding window by select from the main toolbar *File → Open Product* or icon from the shortcuts toolbar.
- Step 2. In the opened add file window select *Sentinel-2 Products* from the *Files of type* drop-down list.
- Step 3. Find Sentinel-2 image in the *\\ESA_SNAP_workshops\source_data* directory, open the main catalogue of the image, point *MTD_MSIL1C.xml* which allows for correct opening Sentinel-2 data and click *Open* (Fig. 9). Image will be added to application workspace and placed in *Product Explorer* tab.

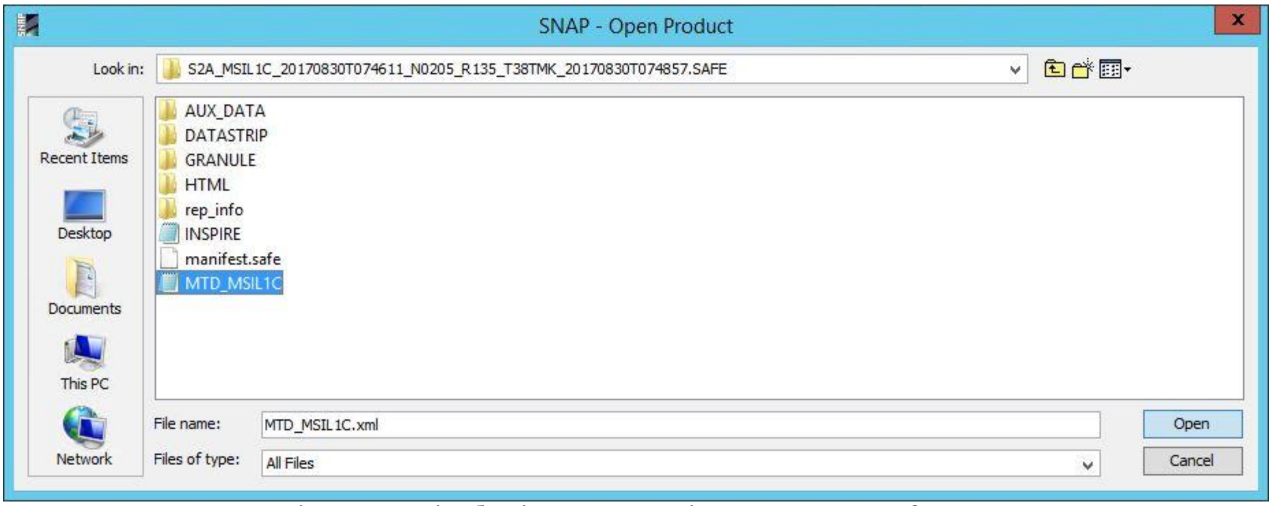


Fig. 9. Sentinel-2 image open in ESA SNAP Software

Exercise 4 <u>*Data import in ESA SNAP software*</u>

- Step 1. Launch the data import window by select from the main toolbar *File → Import → Optical Sensors → Sentinel-2 → S2-MSI*.
- Step 2. Find Sentinel-2 image in the *\\ESA_SNAP_workshops\source_data* directory, open the main catalogue of the image, point *MTD_MSIL1C.xml* file, used for Sentinel-2 data import and point *Import Product* (Fig. 10). Image will be added to workspace and placed in *Product Explorer* tab.

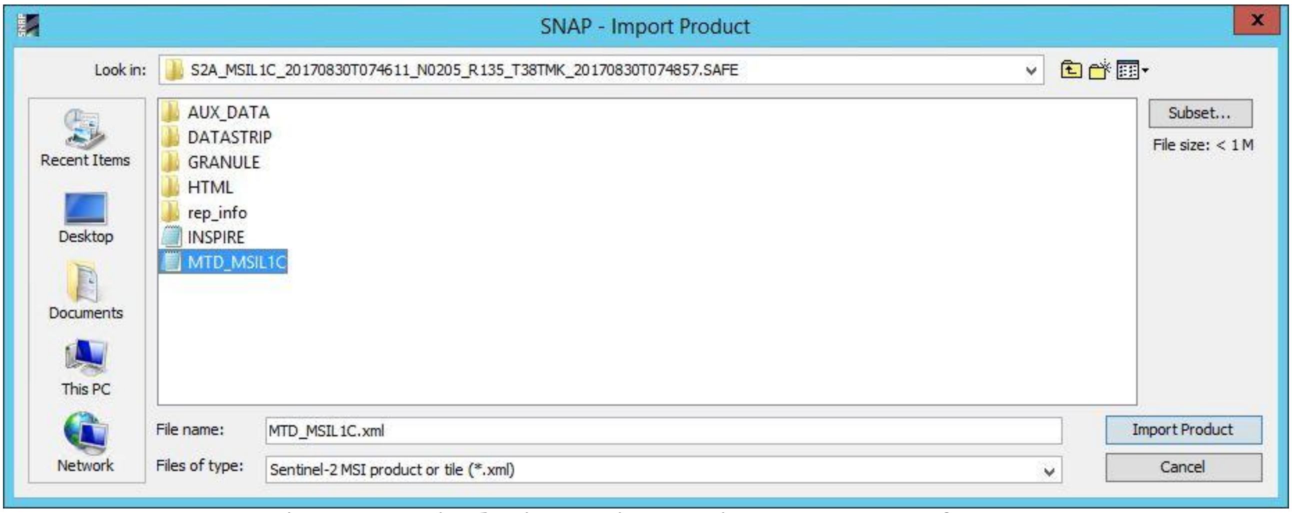


Fig. 10. Sentinel-2 image import in ESA SNAP Software

Add or import data does not display the raster data in map window – it should be done by using a separate tool. ESA SNAP software allows to overview data from one or more sources in various configurations.

Exercise 5 <u>*Raster spatial data display in ESA SNAP software*</u>

- Step 1. Add the Sentinel-2 image from *\\ESA_SNAP_workshops\source_data* directory to the application workspace (you can also use the image added in previous exercise).
- Step 2. Run the open map window tool from the main toolbar by *Window → Open RGB Image Window* or by point with right mouse button the added file in *Product Explorer* tab and selection *Open RGB Image Window* from the list.
- Step 3. In the open map window tool set *Profile* as *Sentinel 2 MSI Natural Colors* (Fig. 11), which is responsible for standard RGB composition of the image bands by assign corresponding spectral bands to red, blue and green colour of the composition. Confirm with OK.

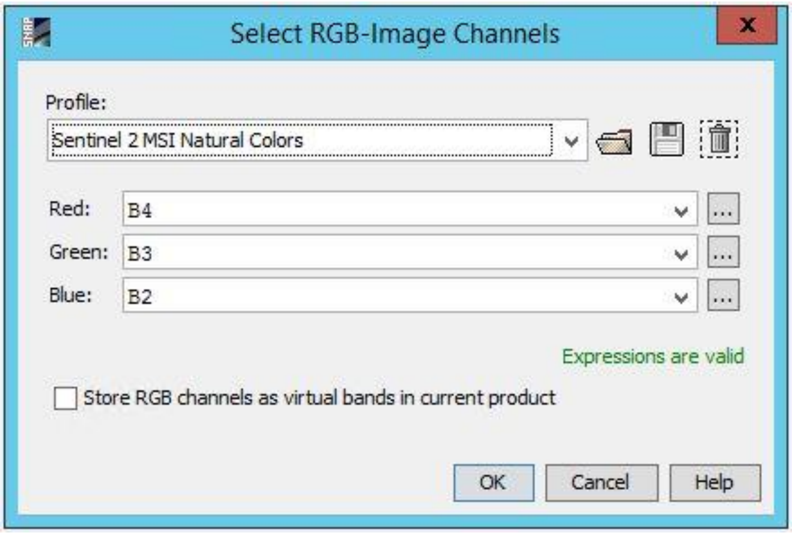


Fig. 11. Open map window tool

- Step 4. Repeat the operation of map window add, this time setting P*rofile* as *Sentinel 2 MSI False-color Infrared*.

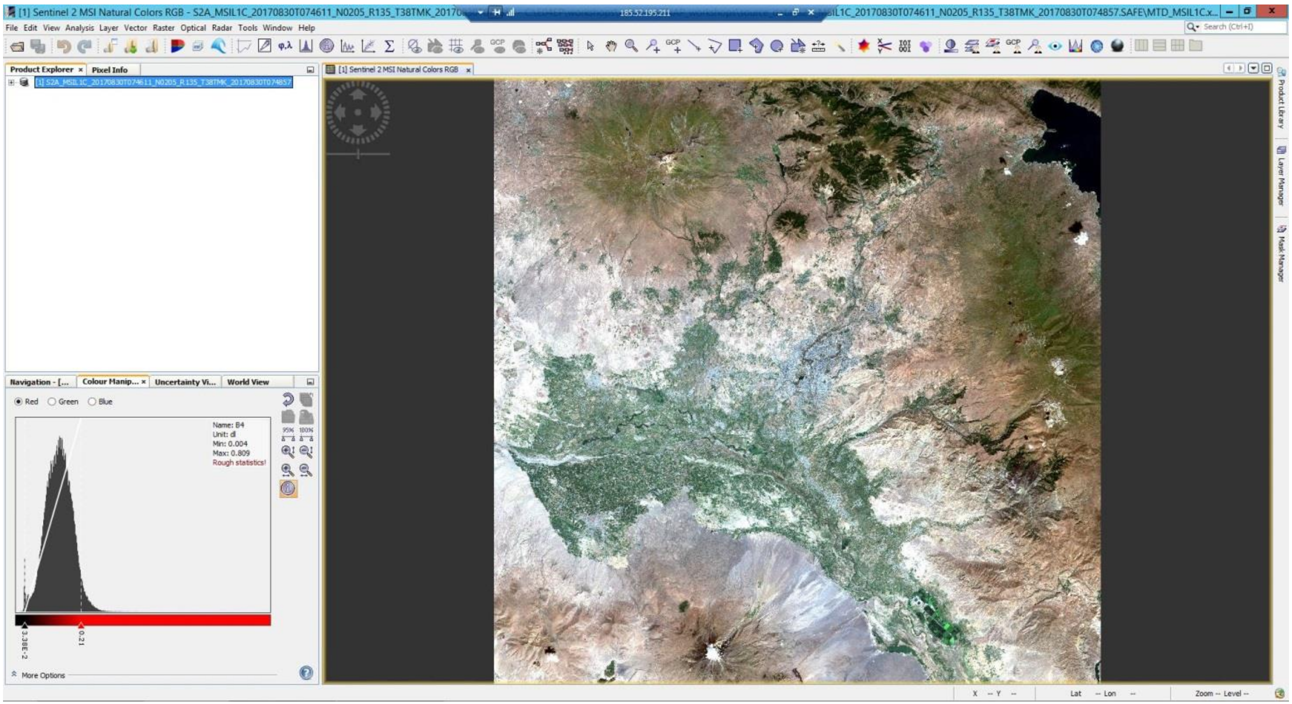


Fig. 12. ESA SNAP workspace with the RGB composition of Sentinel-2 image

- Step 5. Repeat the operation of map window adding, this time setting *Profile* as *Sentinel 2 MSI Atmospheric penetration*.
- Step 6. Open the map window adding tool once again. Besides predefined profiles there is also possibility of user composition creation. Create some composition by setting as *Red*, *Green* and *Blue* any band of *<B2, B3, B4, B8 – 10 m spatial resolutnion>*, *<B5, B6, B7, B8a, B11, B12 – 20 m spatial resolutnion>* lub *<B1, B9, B10 – 60 m spatial resolutnion>* group (ESA SNAP demands RGB compositions be created from the bands with the same spatial resolution).

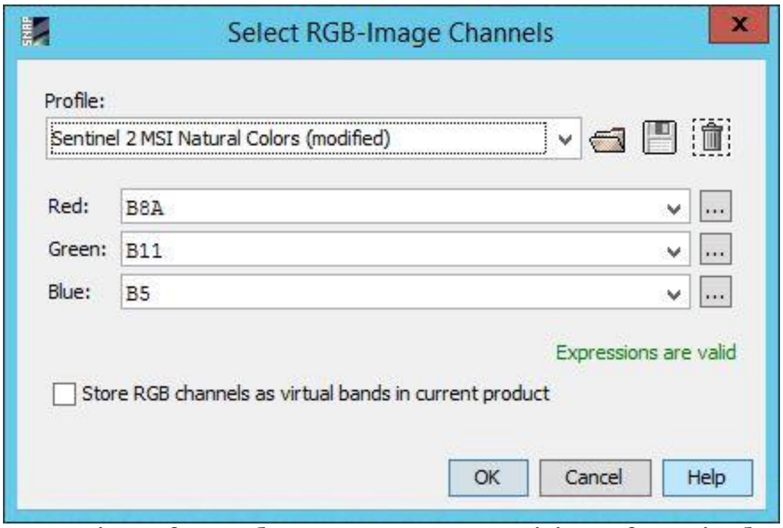


Fig. 13. Creation of sample user RGB composition of Sentinel-2 image

- Step 7. Active function allows for slide view (with the left mouse button pressed) and change the scale of the displayed image (scroll wheel). Test the various capabilities of map windows arrangement selecting one by one icons from shortcuts toolbar (Fig. 15). Activation the *Synchronises views across multiple image windows* function in the *Navigation* tab (Fig. 14) allows to perform these operations simultaneously for all images.

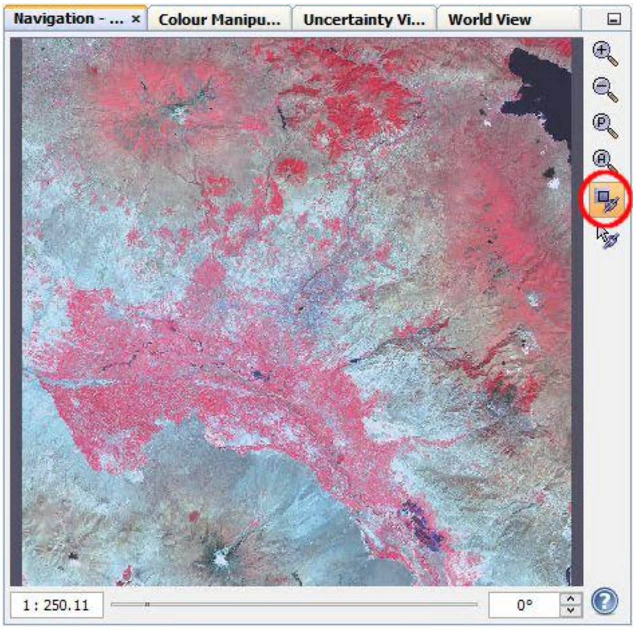


Fig. 14. Placement of the synchronization views function

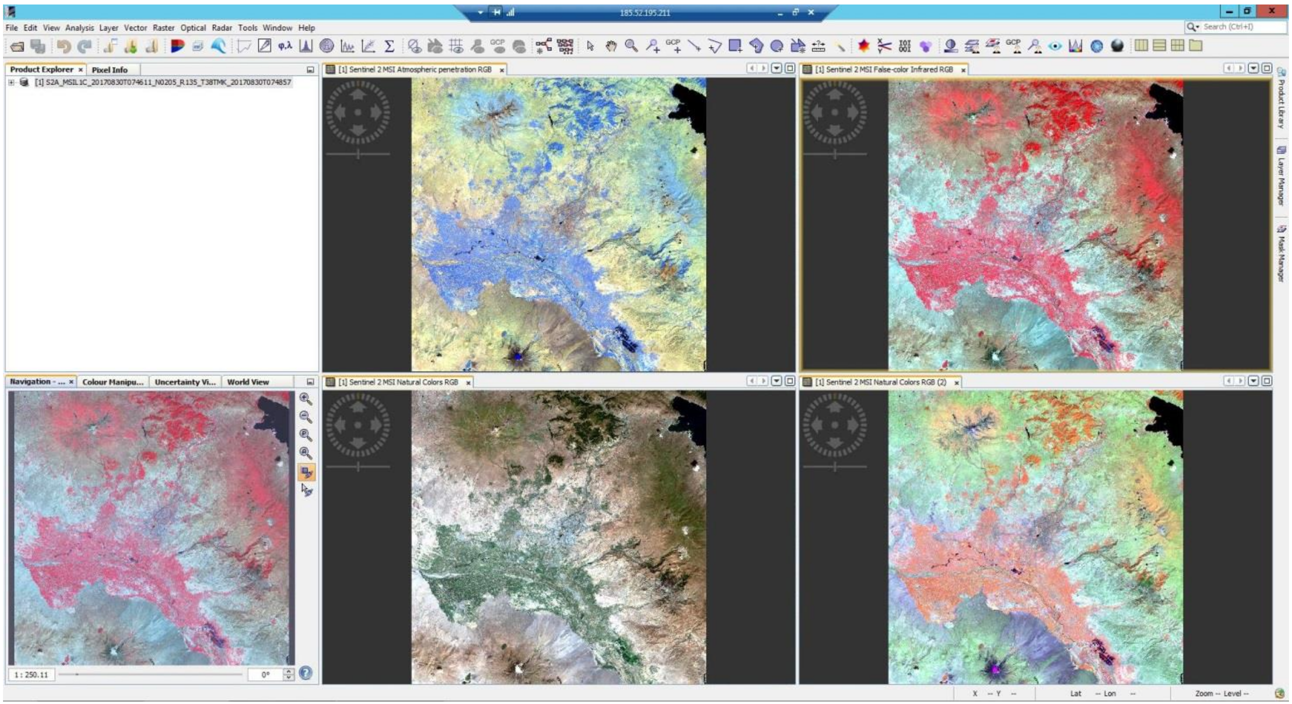


Fig. 15. ESA SNAP workspace with various RGB compositions of one image

- Step 8. Go from the Navigation to Colour Manipulation tab. Inside this tab is placed the histogram of the image, under witch are placed sliders for change the image presentation in map window – separately for bands Red, Green and Blue (Fig. 16). Try to change any of the image colorization watching at the same time how it is changing RGB visualizations.

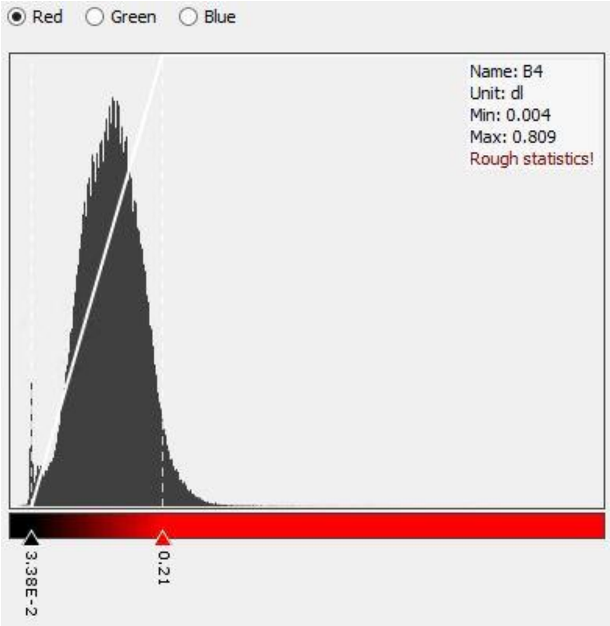


Fig. 16. Red band of the image histogram in Colour Manipulation tab

Exercise 6 *Metadata*

Metadata is the necessary information about the data included in spatial data set. Its structure and content is usually defined in regulations e.g. INSPIRE Directive of the European Union. Metadata for satellite data includes, among other things, information about coordinate reference system, sensing time, spatial resolution and processing level. Without this information work with satellite data could be hard or even unavailable.

- Step 1. Add the Sentinel-2 image from *\\ESA_SNAP_workshops\source_data* directory to the workspace (or use the image added in previous exercise).
- Step 2. Explore the image in *Product Explorer* tab. Find the *Metadata* → *Granules* files and open metadata tab *Level-1C_Tile_38TNM* by double click. (Fig. 17).

Fig. 17. Sentinel-2 image metadata exploration in ESA SNAP software

- Step 3. View the content of the sample metadata tab. Try to find at least information about coordinate reference system of the image. (Fig. 18).

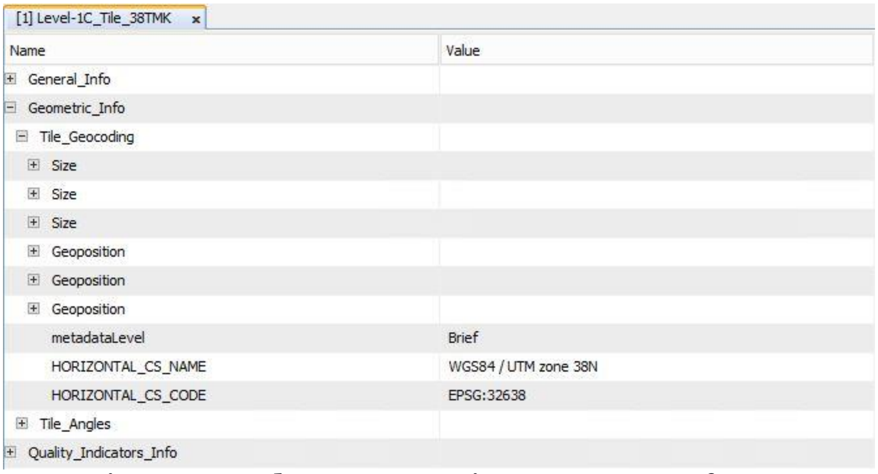


Fig. 18. Metadata presentation ESA SNAP software

Exercise 7 *Data save*

For data save it is necessary to make some change in dataset. Because of that all the ways to save the data will be presented in following exercises. Data save in ESA SNAP software is available by:

- *File → Save* (Fig. 19) option,
- definition of directory, name and format of the target data during set the process parameters → Exercise 8,
- saving the copy of the data with made changes *(File → Save As)* → Exercise 10,
- change data format *(File → Export → ...)*→ Exercise 12.

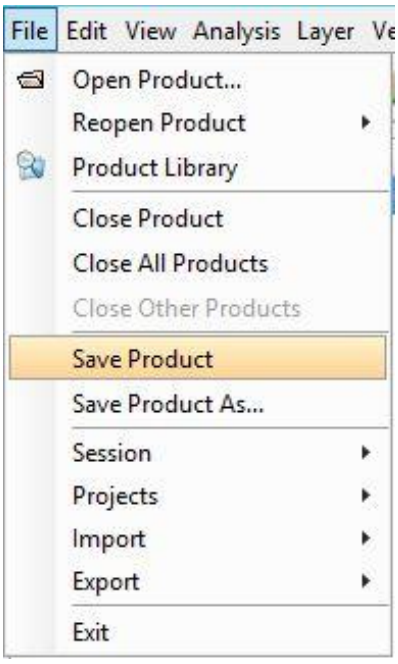


Fig. 19. Placement of File → Save option of ESA SNAP software

2.2 Change the spatial resolution of image (Resampling)

Resampling is the function which changes the size of image pixel to demand size. It allows to present and process data with different spatial resolution (e.g. from different sources) in a uniform way. In case of work with Sentinel family satellite data it matters mainly for optical data, which are provided with three different pixel sizes – 10, 20 and 60 meters. Additionally, ESA SNAP software requires the same spatial resolution of every band in source image in most of the functions.

Exercise 8 *The spatial resolution change of Sentinel-2 image*

- Step 1. Add the Sentinel-2 image from *\\ESA_SNAP_workshops\source_data* directory to the workspace.
- Step 2. Run the resampling window by *Raster → Geometric Operations → Resampling*.
- Step 3. In *I/O Parameters* tab in *Source Product* section choose the name of the added image from the drop-down list (Fig. 20).

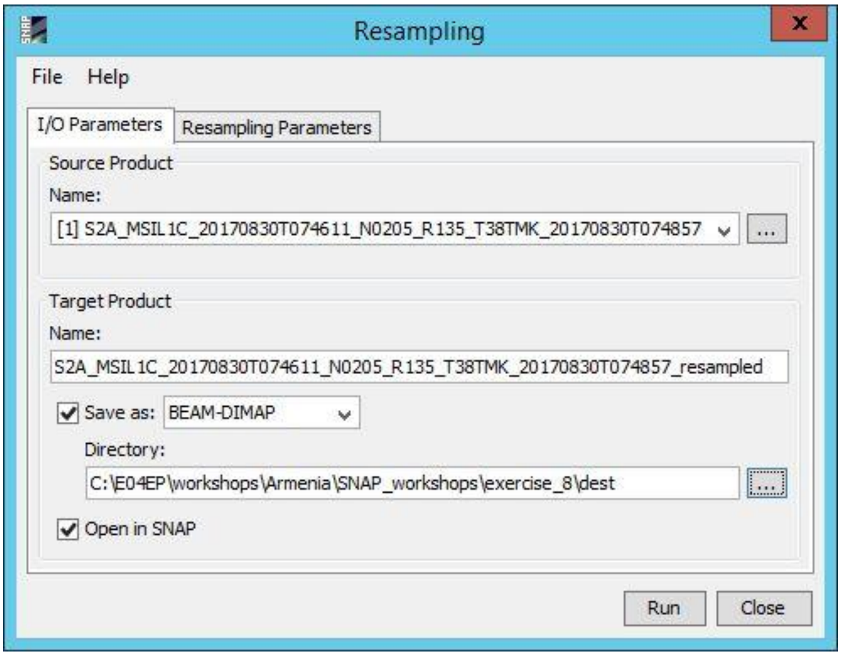


Fig. 20. The source and target data definition of the resampling operation

- Step 4. In *Target Product* section set the target directory as *\\ESA_SNAP_workshops\exercise_8\dest* and the name of the resampled file. By default it is name of the source file with *resampled* suffix. Mark *Open in SNAP* checkbox to load new created data in *Product Explorer* tab
- Step 5. In *Resampling Parameters* tab sign *By reference band from source product* option and set band B2, B3, B4 or B8 (Fig. 21) – each of them has spatial resolution of 10 meters – the rest of bands will be resampled to this size in resampling process (Fig. 22). Leave the other settings as default and run the resampling with  button.

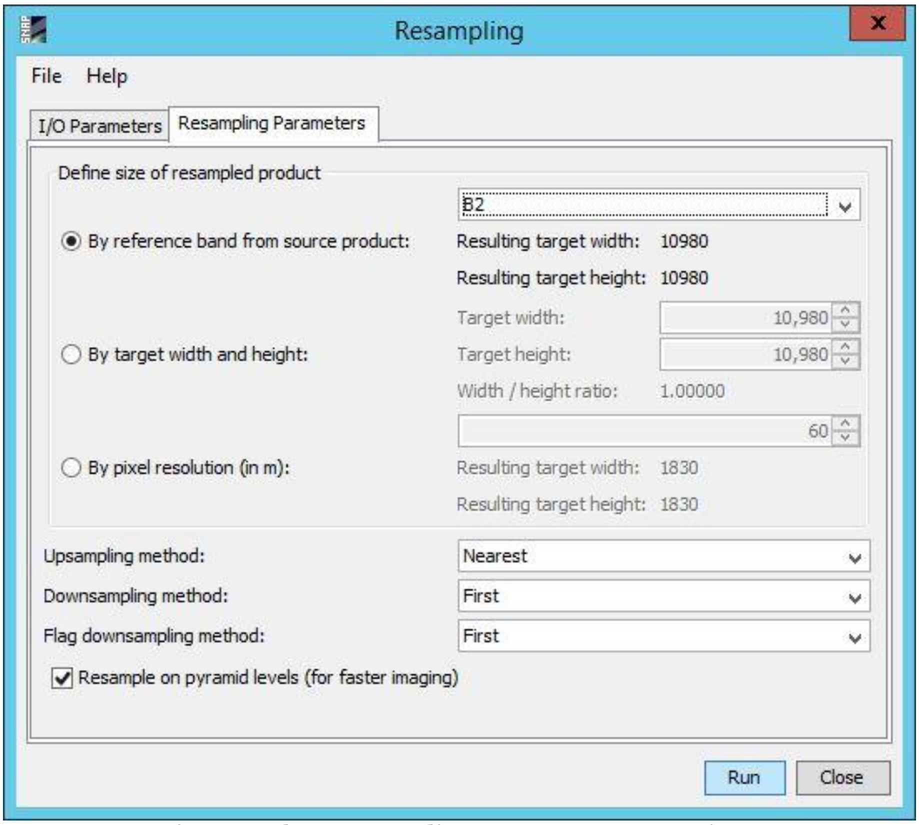


Fig. 21. The resampling parameters settings

- Step 6. Create map windows of B1 band before and after resampling operation and set the simultaneous view of both windows. Zoom to the area of large changes in brightness as far to see single pixels (Fig. 22).

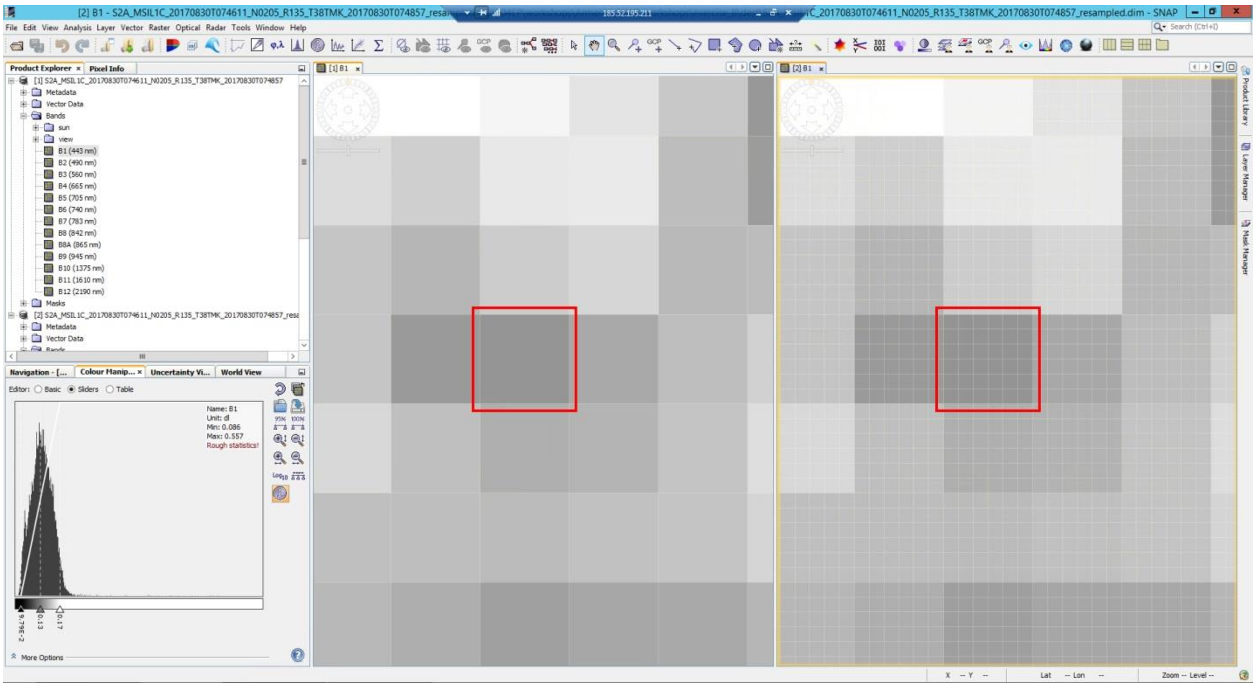


Fig. 22. The result of resamplig operation in Sentinel-2 image

Note that despite changing the size of single element of the image, general information provided by B1 spectral band did not change.

2.3 Change the coordinate reference system of the image (Reprojection)

Every dataset exists in some coordinates reference system. Change the reference system is sometimes unnecessary, especially in work with data from various sources. Sentinel-2 data are delivered in UTM coordinate system.

Exercise 9 *Change the coordinate reference system of Sentinel-2 image*

- Step 1. Add the Sentinel 2 data from *\\ESA_SNAP_workshops\exercise_9\src* directory (or use the target file from **exercise 8**).
- Step 2. Run the reprojection window by *Raster → Geometric Operations → Reprojection* (Fig. 23).
- Step 3. In *I/O Parameters* tab in *Source Product* section choose the name of the added image from the drop-down list.
- Step 4. In T*arget Product* section set the target directory as *\\ESA_SNAP_workshops\exercise_9\dest* and the name of the reprojected file. By default it is name of the source file with *reprojected* suffix. Mark *Open in SNAP* checkbox to load new created data in *Product Explorer* tab.

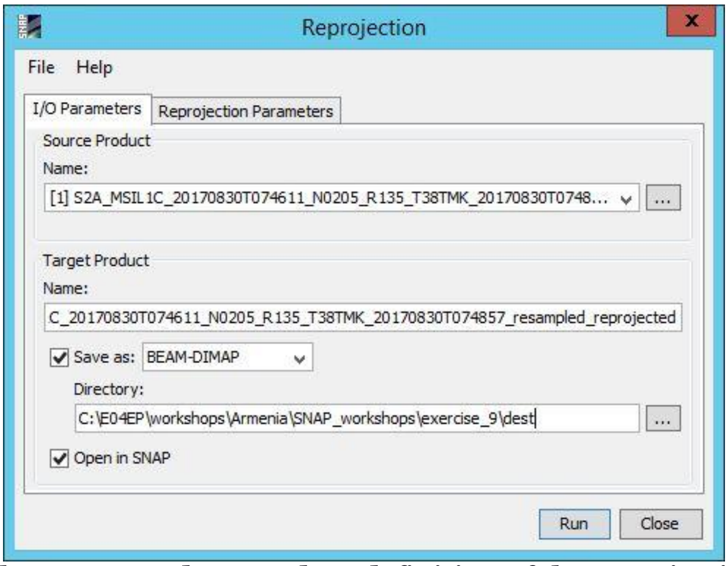


Fig. 23. The source and target data definition of the reprojection operation

- Step 5. In Reprojection Parameters tab choose the Predefined CRS option, and run the coordinate reference system selection window by Select... . In new opened window type 4326 – EPSG code of WGS84 reference system, point it on the list and confirm OK. (Fig. 24).

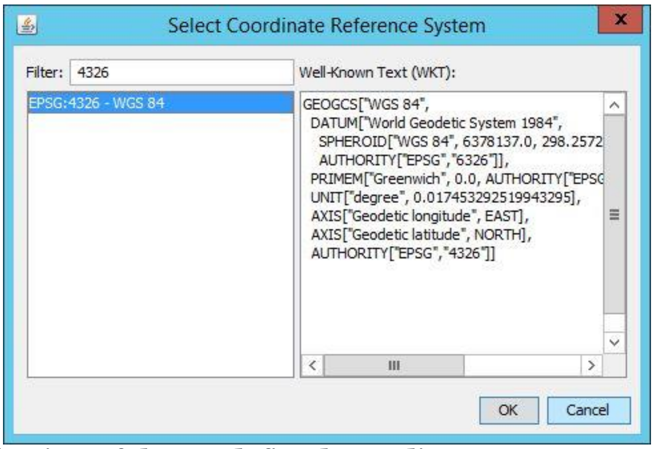


Fig. 24. Selection of the predefined coordinate system to reprojection

- Step 6. Leave the rest of the settings as default and run the reprojection with Run button.

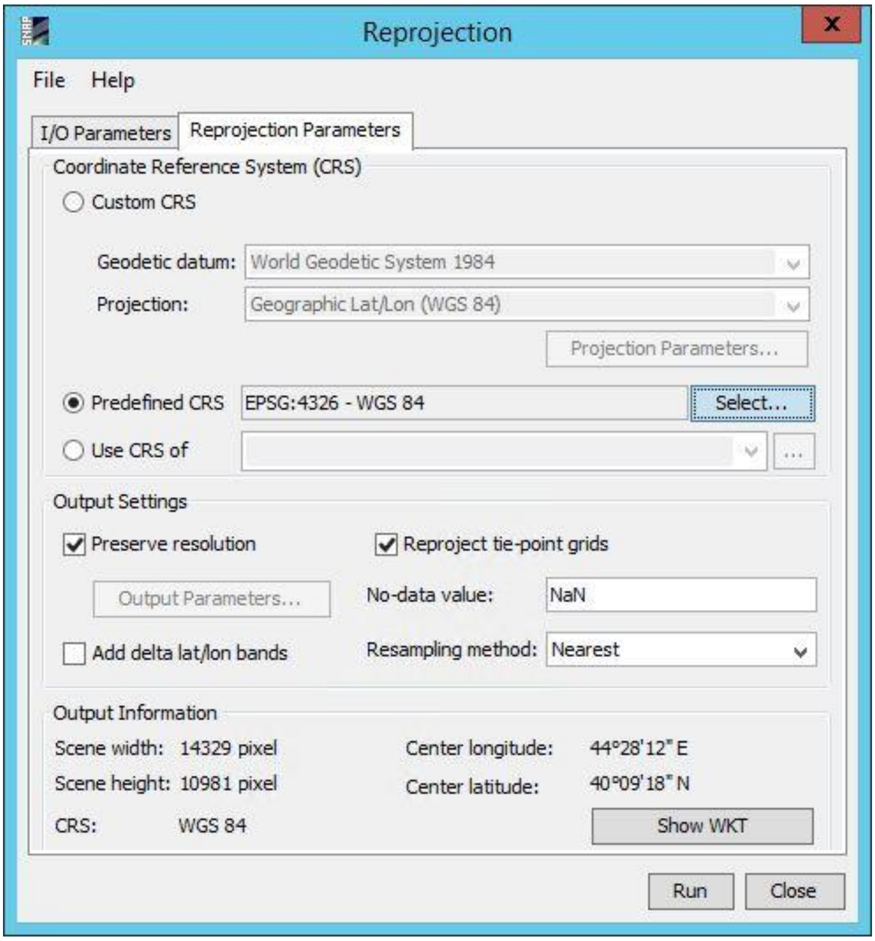


Fig. 25. The reprojection parameters settings

EPSG is common, universal way for coordinate reference systems encoding. Every offical and national coordinate system should have its own EPSG code predefied in any GIS .

2.4 Dataset clipping

Data from the Sentinel mission covers large area (10 000 km² in case of optical imagery, about 38 000 km² in case of radar data) what makes it large in size and has negative impact on the processing time. For this reason ESA SNAP software offers an opportunity of limiting the spatial range of the data or choosing only that bands which are necessary for processing.

Exercise 10 *Spatial limitation of the Sentinel-1 dataset*

- Step 1. Add the Sentinel 2 data from *\\ESA_SNAP_workshops\exercise_10\src* directory.
- Step 2. Select the added file from the list in the *Product Explorer* tab and run the subset window by *Raster → Subset*.
- Step 3. In *Spatial Subset* tab go to the *Geo Coordinates* section and type the range of subset data (Fig. 26), and confirm OK.

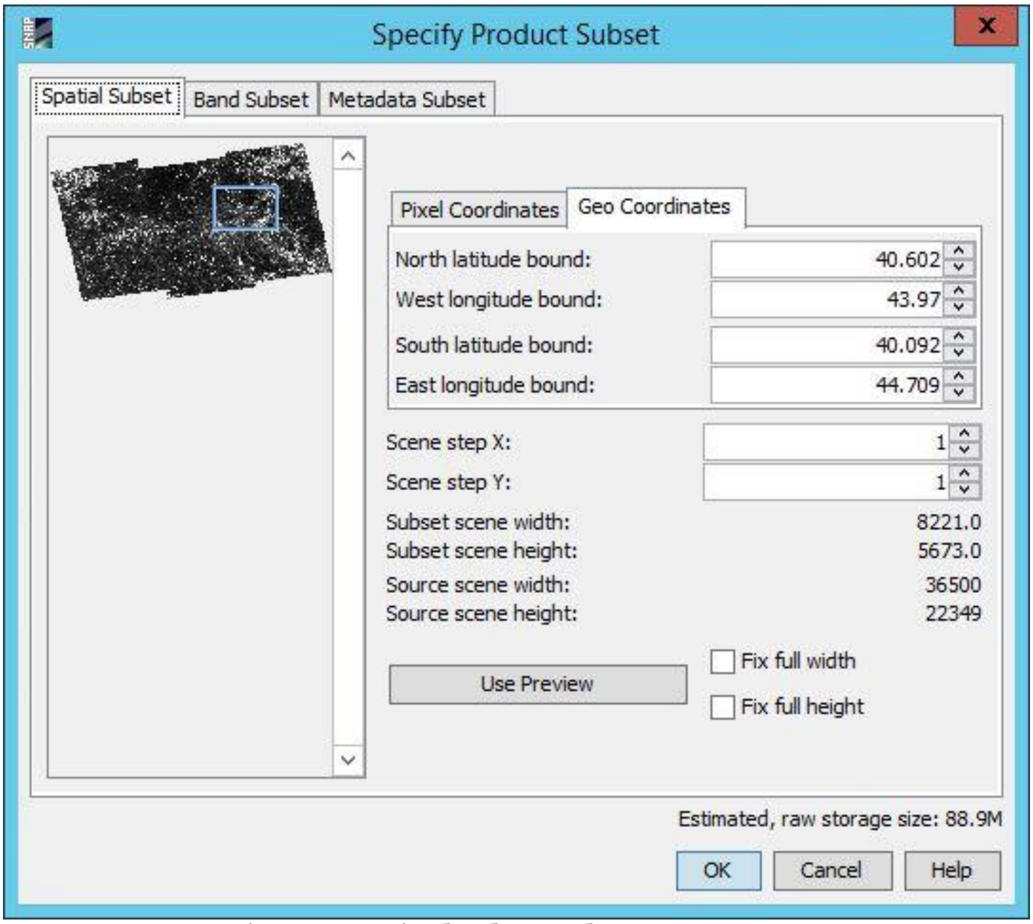


Fig. 26. Sentinel-1 data subset parameters

- Step 4. Create map windows with RGB composition of source and target image and set the simultaneous view of both windows. Slide and zoom the view to the range of the target image (Fig. 27).

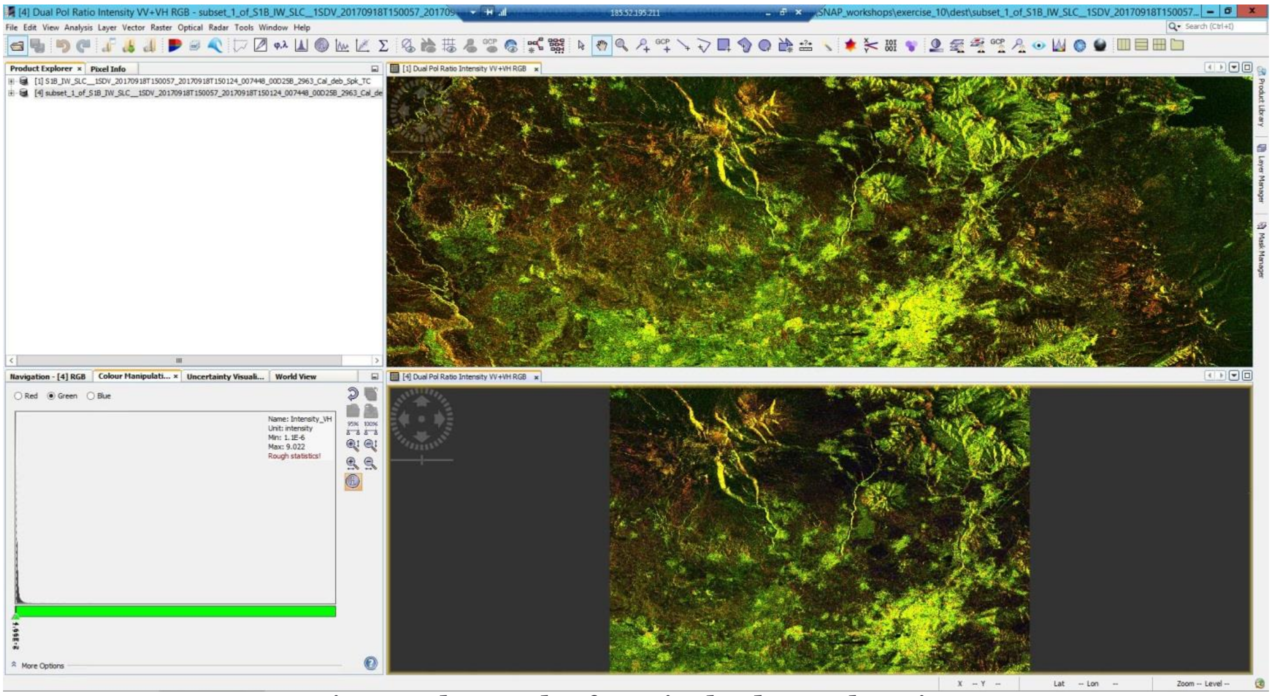


Fig. 27. The result of Sentinel-1 data subsetting

Note that despite difference in colorization of the images (which is tailored only to the change of the histogram statistics) in the common part the images provide the same information.

- Step 5. The new data was created and added in *Product Explorer* tab, but the files was not stored on the hard drive. To save created dataset, select it on the list in *Product Explorer* and set *File → Save Product As…* or point dataset with right mouse button and choose *Save Product As…* from the list to open the data saving window (Fig. 28).

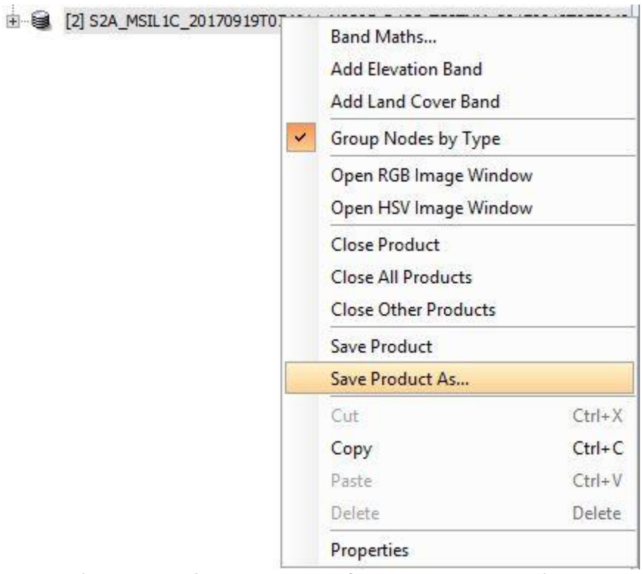


Fig. 28. Placement of Save as… option

- Step 6. In new opened window open navigation panel *Save in:*, select hard drive *Local Disk (C:)* and go to the *\\ESA_SNAP_workshops\exercise_10\dest* (Fig. 29).

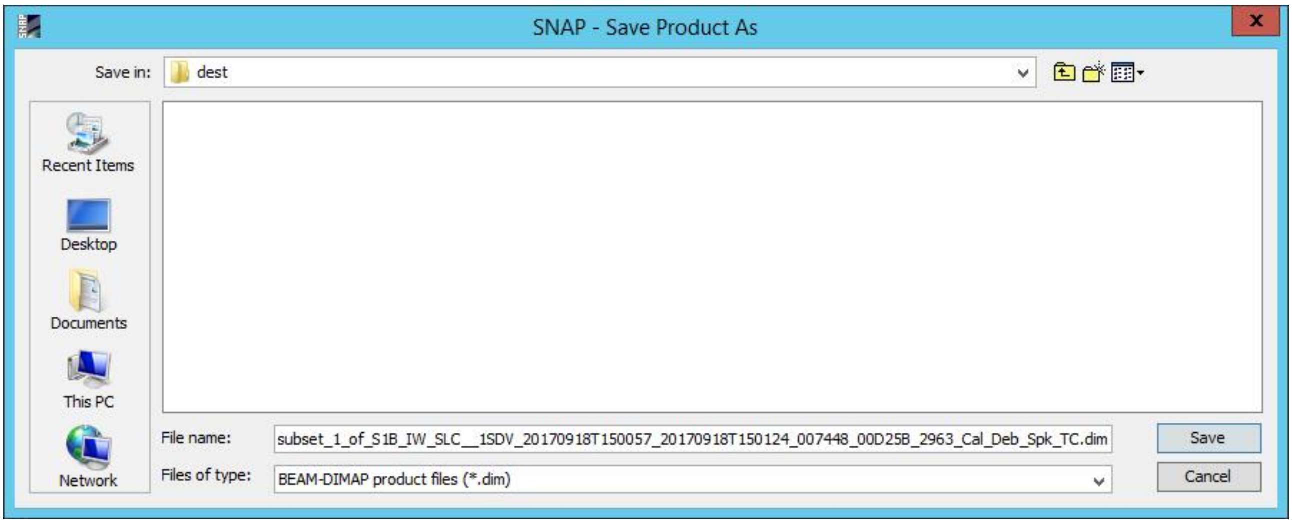


Fig. 29. Data saving window of ESA SNAP software.

- Step 7. Leave the new file name *(File Name)* as default and save the image with 

button.

2.5 Area of interest clipping

Limiting the source dataset with rectangular bounding box is not always satisfied to reach appropriate target data. Sometimes clipping source data to irregular shape of area of interest (AOI) is also needed. In this case *Land/Sea Mask* tool of ESA snap is very useful. To perform the operation, the vector layer which defines border of clipping is necessary.

Exercise 11 <u>*Clipping the Sentinel-1 image to the area of interest*</u>

- Step 1. Add the Sentinel 2 data from *ESA_SNAP_workshops**exercise_11**src* directory, (or use the target file from **exercise 10**).
- Step 2. Select the added file from the list in the *Product Explorer* tab and run vector file import window by *Vector* → *Import* → *ESRI Shapefile* (Fig. 30).

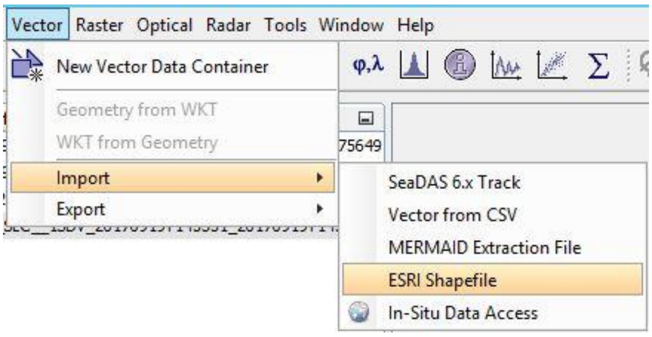


Fig. 30. Placement of ESRI shapefile import tool

- Step 3. Find vector layer *AOI.shp* in *ESA_SNAP_workshops**exercise_11**src* directory and add to previously selected raster file using *Open* button.
- Step 4. Create map window with data visualization and look how vector data was shown on the satellite image.
- Step 5. Run the window of area of interest clipping tool by *Raster* → *Masks* → *Land/Sea Mask* (Fig. 31).
- Step 6. In *I/O Parameters* tab in *Source Product* section choose the name of the added image from the drop-down list.
- Step 7. In T*arget Product* section set the target directory as *ESA_SNAP_workshops**exercise_11**dest* and the name of the masked file. By default it is the name of the source file with *msk* suffix. Mark Open in SNAP checkbox to load new created data in *Product Explorer* tab.

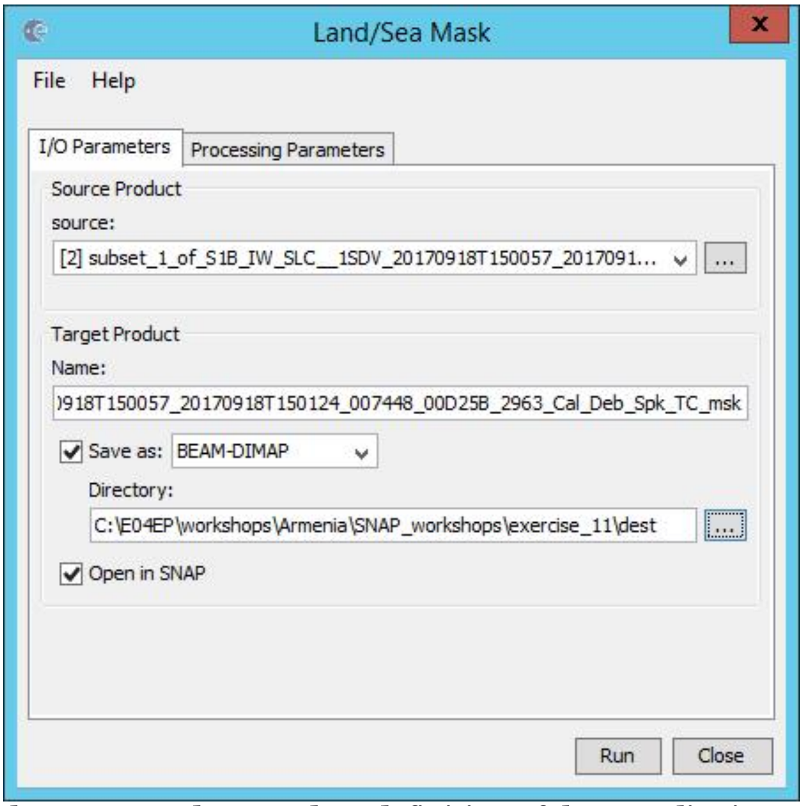


Fig. 31. The source and target data definition of the AOI clipping operation

- Step 8. In the *Processing Parameters* tab mark the option *Use Vector as Mask* and from the drop-down list choose the layer added in Step 3. vector layer. Leave the other settings as default and run the resampling with Run button.

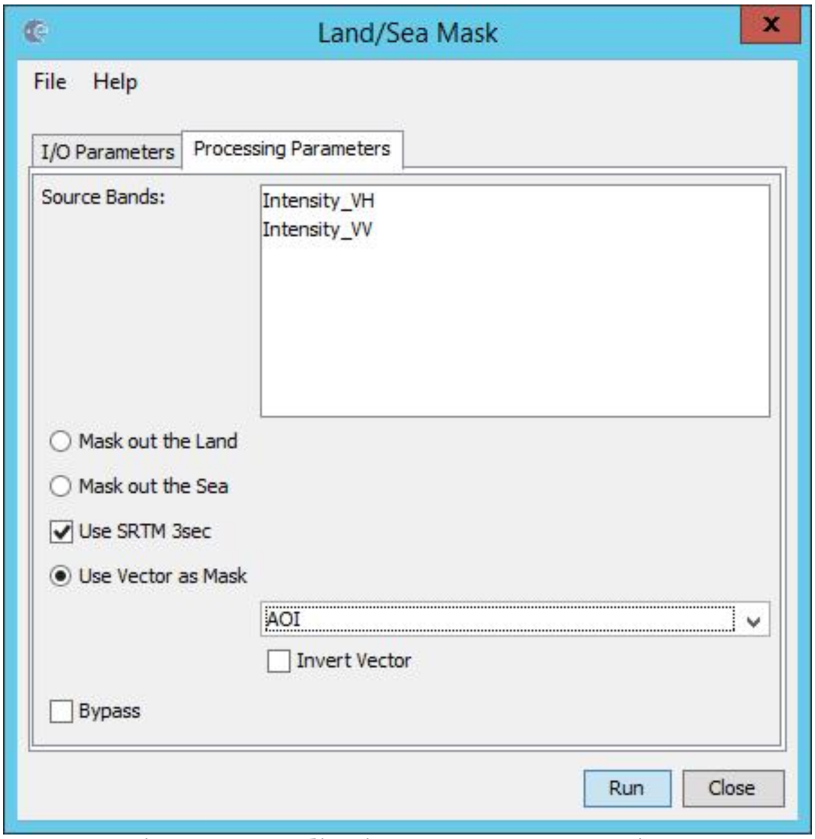


Fig. 32. AOI clipping parameters settings

- Step 9. Create the map windows with RGB composition of source image and image after AOI clipping, and set the simultaneous view of both windows (Fig. 33). In the panel *Layer Manager* (on the right side of application window) unmark visibility of vector layer *AOI*.

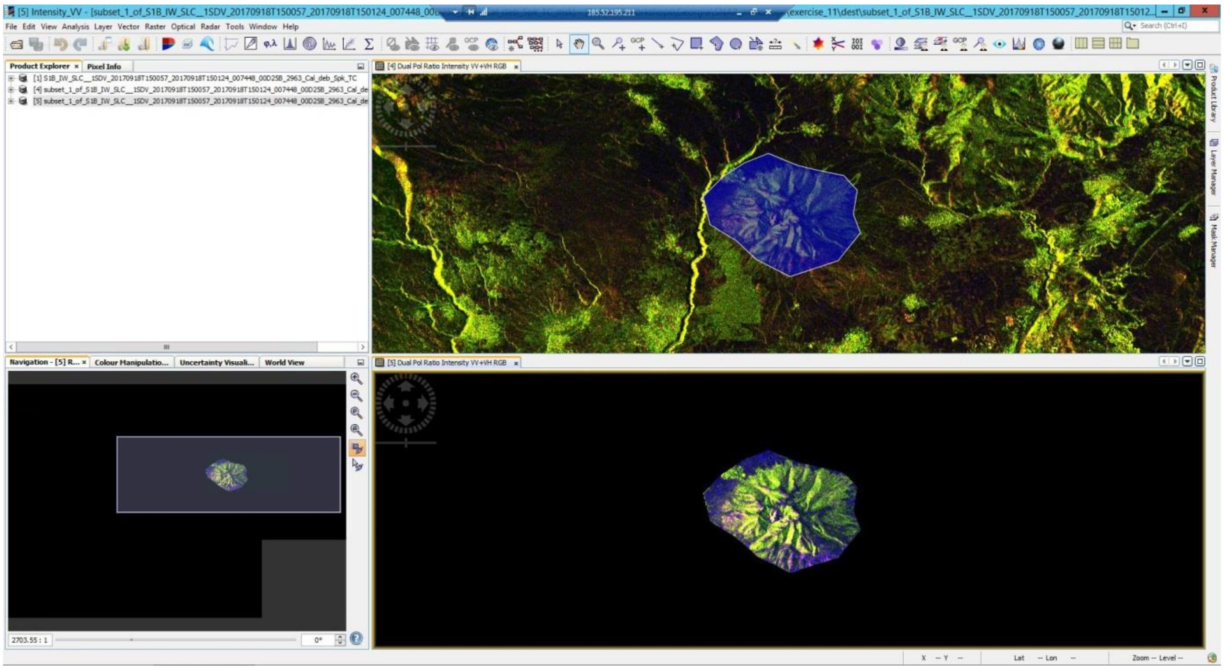


Fig. 33. The result of the area of interest clipping

Note that the borders of clipped area are exactly the same as the range of the vector layer.

2.6 Band calculator

Every raster image is in fact the table of the values (matrix) which makes performing arithmetic and logical operations on images possible, which allows to extract needed information from the satellite data.

Exercise 12 *Arithmetic operations on the Sentinel-1image bands*

- Step 1. Add the Sentinel 2 data from *\\ESA_SNAP_workshops\exercise_12\src*, directory (or use the target file from **exercise 11**).
- Step 2. Run the band calculator window by *Raster* → *Band Maths*.
- Step 3. Set image on which the calculations will be performed as the layer added in Step 1., name the new layer as *intensity_div,* unmark the *Virtual* option and run the expression creator with *Edit Expression* button (Fig. 35).

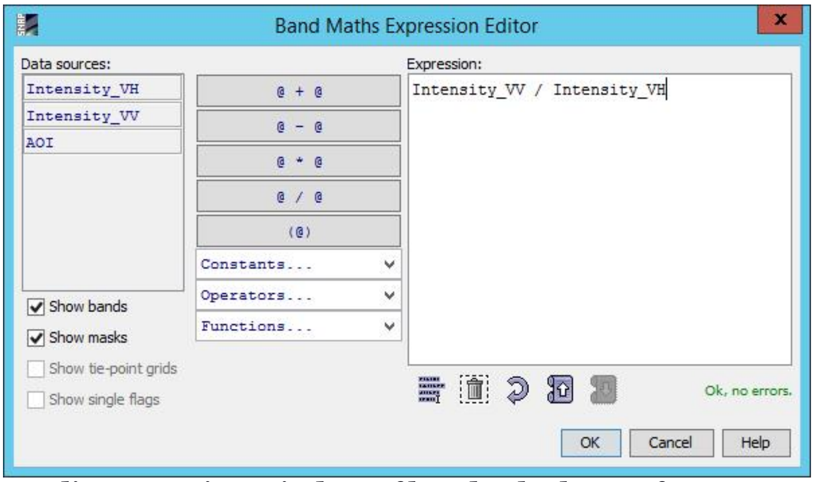


Fig. 34. Edit expression window of band calculator of ESA SNAP software

- Step 4. In new opened window type *Intensity_VV/Intensity_VH* – the operation of dividing pixel values of backscatter intensity in VV polarisation by corresponding values of backscatter intensity in VH polarisation. If the control of typed expression does not return any errors („Ok, no errors" statement), confirm the expression with OK button and run the calculation with OK button in the *Band Maths* window.

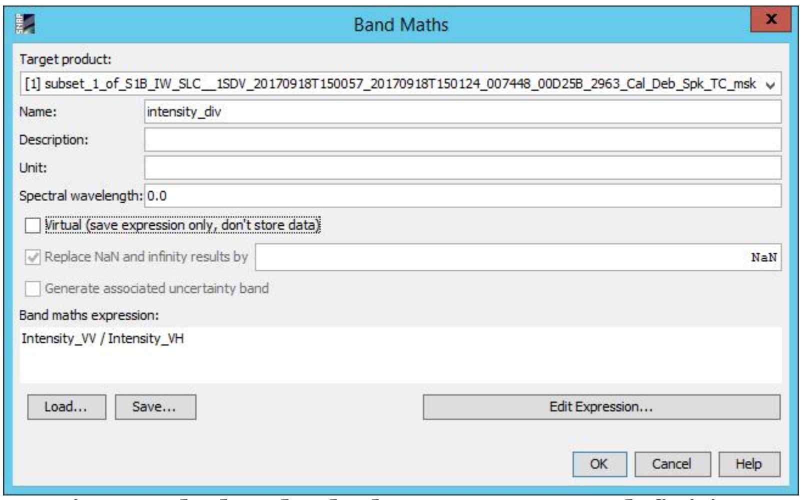


Fig. 35. The band calculator parameters definition

- Step 5. The new layer was calculated and automatically opened in map window. Close this window and open map window with RGB composition of the source raster layer.

Note that Blue band of the default composition is a realization of the expression from the previous step.

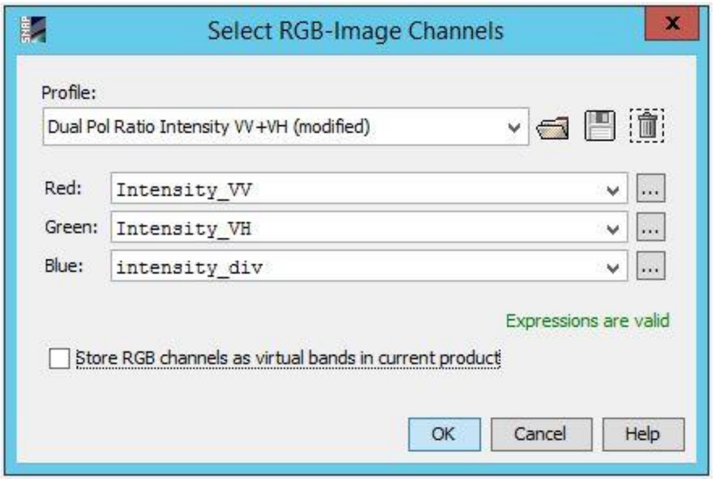


Fig. 36. Change of the default RGB composition band to the band from the exercise

- Step 6. Open new map window, in which default Blue band will be changed to intensity_div layer created during the exercise. Open this two map windows simultaneously (Fig. 37).

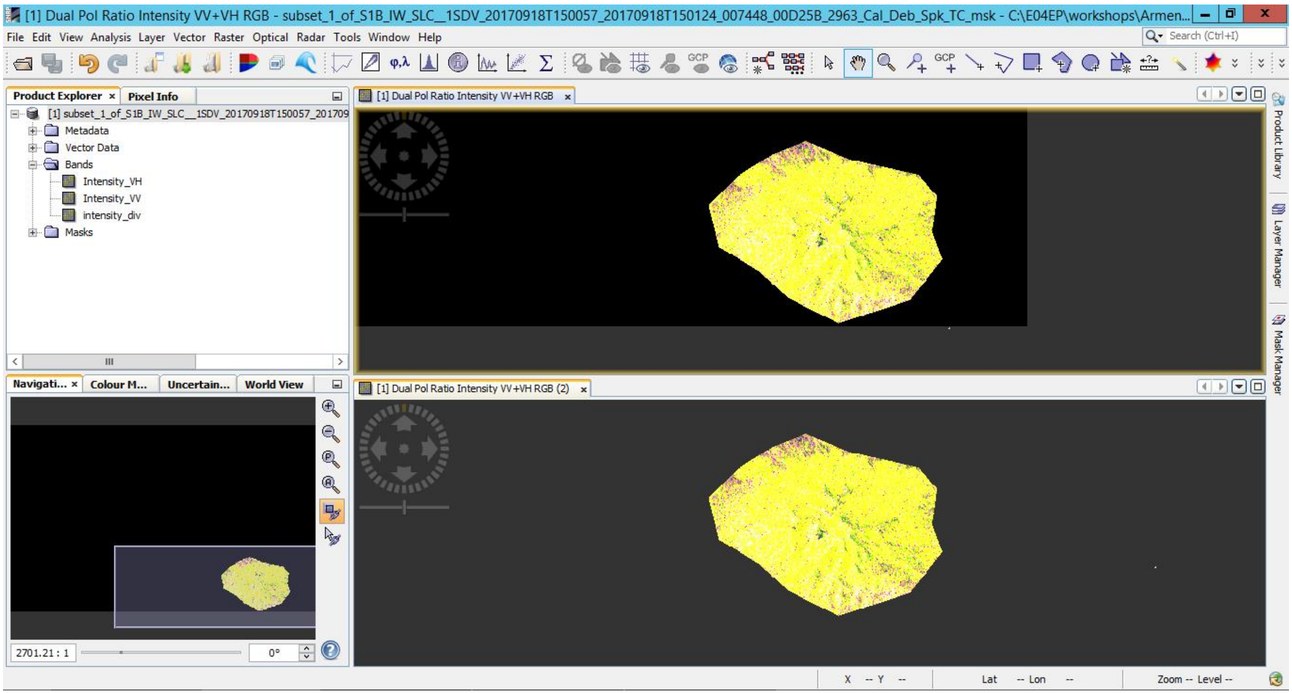


Fig. 37. Comparison of default (bottom) RGB composition of the image with composition with the layer created during exercise (upper)

Note that both visualisations present exactly the same information.

- Step 7. Image with new calculated band could be export in that form for allowing to RGB visualisation of that composition in any GIS software without doing on-the-fly calculation. Select image with three bands in *Panel Explorer* tab and choose *File → Export → GeoTIFF/BigTIFF*.

GeoTIFF is a universal graphic format supported by the most of the software dedicated to spatial information processing which allows also to save the georeference of the data.

- Step 8. In new opened window open navigation panel *Save in:*, select hard drive *Local Disk (C:)* and go to the *\\ESA_SNAP_workshops\exercise_12\dest*.
- Krok 9. Leave the new file name as default and export the image with Run button.

3 Optical images processing tools

3.1Spectral indices

The spectral indices calculations allows to extract or underline on the optical image information about condition of vegetation, presence of the water and other features demand by user. The Sentinel-2 images, because of the wide range of spectral bands are very good source for that type of processing.

Exercise 13 _Spectral indices calculations on the Sentinel-2 image_

- Step 1. Add the Sentinel 2 data from *\\ESA_SNAP_workshops\exercise_13\src* directory,(or use the target file from **exercise 9**).
- Step 2. Run the window of NDVI calculation by *Optical → Thematic Land Processing → NDVI Processor* (Fig. 38).
- Step 3. In *I/O Parameters* tab in *Source Product* section choose the name of the added image from the drop-down list, on which NDVI will be calculated.

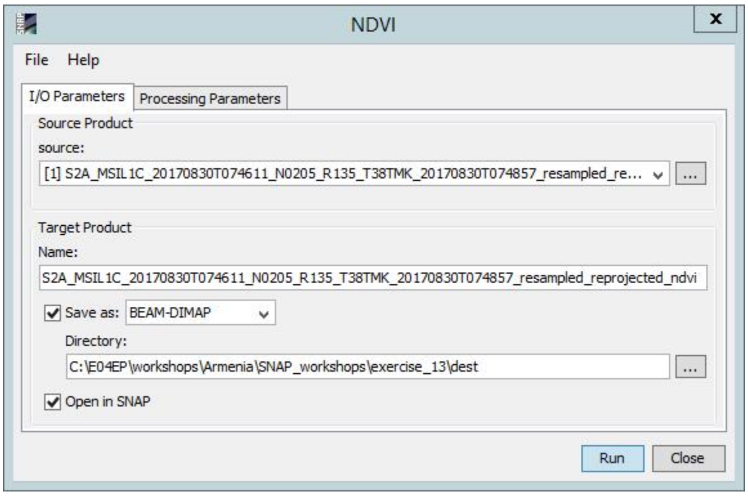


Fig. 38. The source and target data definition for the NDVI calculation

- Step 4. In *Target Product* section set the target directory as *\\ESA_SNAP_workshops\exercise_13\dest* and the name of created file. By default it is the name of the source file with *ndvi* suffix. Mark *Open in SNAP* checkbox to load new created data in *Product Explorer* tab.
- Step 5. In *Processing Parameters* tab set *Red source band* as *B4* and *NIR source band* as *B8*, and run the process with  button (Fig. 39).

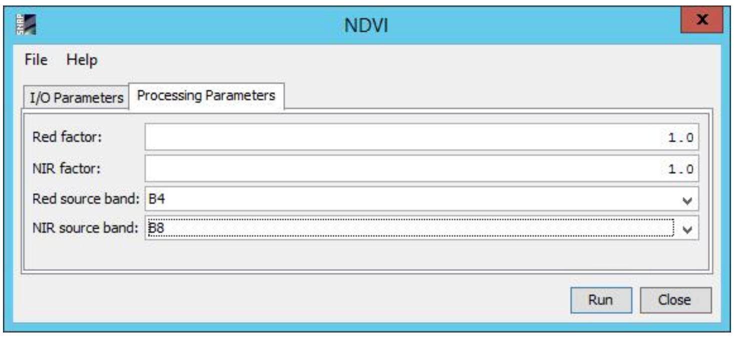


Fig. 39. The NDVI calculation parameters settings

- Step 6. Create map windows of RGB composition of the source image and NDVI image and set the simultaneous view of both windows. Compare the land cover in bright and dark areas. (Fig. 40).

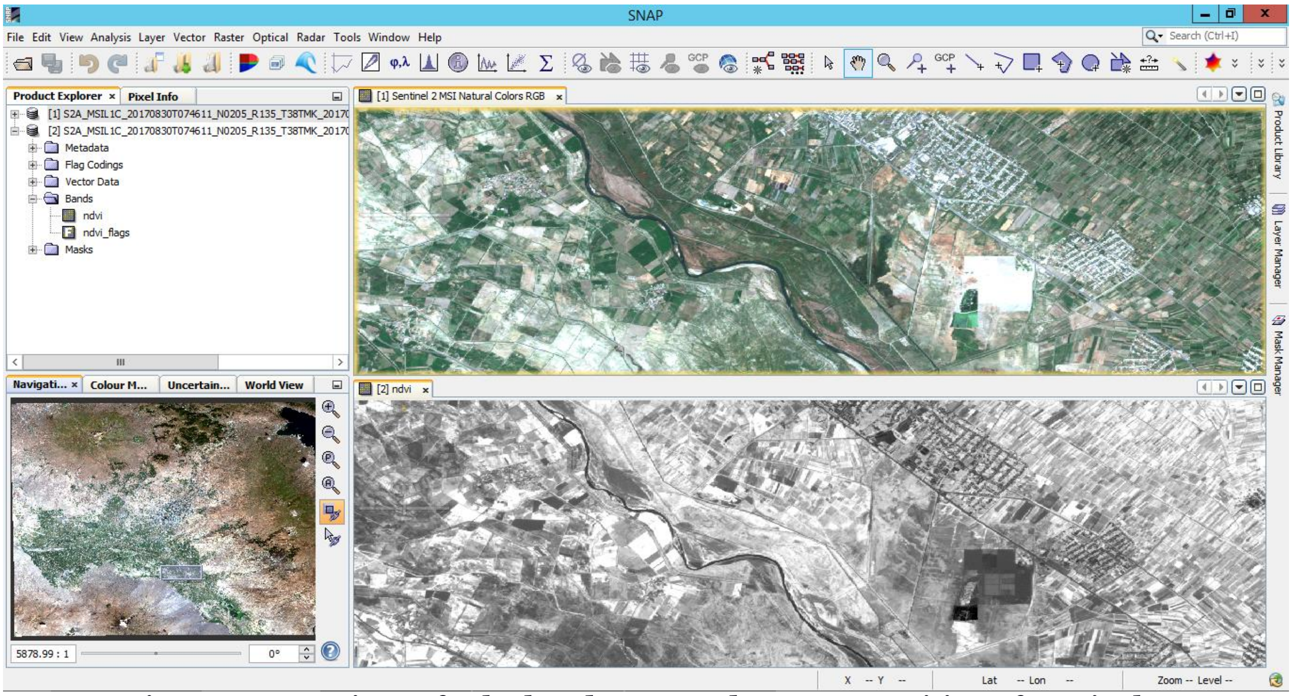


Fig. 40. Comparison of calculated NDVI and RGB composition of Sentinel-2

Note that areas covered by green vegetation (forest, grasslands, crops) reach high (bright) values of NDVI. General range of the NDVI values is <-1 ; 1>.

3.2 The comparison of Sentinel-2 images with the high resolution images

The Sentinel-2 imagery offers the best spatial resolution from all the free of charge optical data, but they do not exhaust the current possibilities of satellite imaging technology. 10 meters of size pixel is enough to create exact processing and value added data for the agricultural and less urbanized areas. More exact, commercial satellite data shows their advantages mainly in the cities, where spatial resolution in meters is not enough for precise analysis.

Exercise 14 *Comparison of Sentinel-2 and VHR Pleiades data.*

- Step 1. Add the Sentinel 2 data from *\\ESA_SNAP_workshops\exercise_14\src* directory.
- Step 2. Add to the workspace also the VHR Pleiades image *yerevan_pleiades.tif* from the same directory.
- Step 3.Create map windows with RGB composition of both images
    - Sentinel 2: *Red* – B4, *Green* – B3, *Blue* – B2,
    - Pleiades: *Red* – 1, *Green* – 2, *Blue* - 3,
- and set simultaneous view of both windows. Zoom to the area of the city of Yerevan to be able to distinguish individual building. Compare the quality of the images.

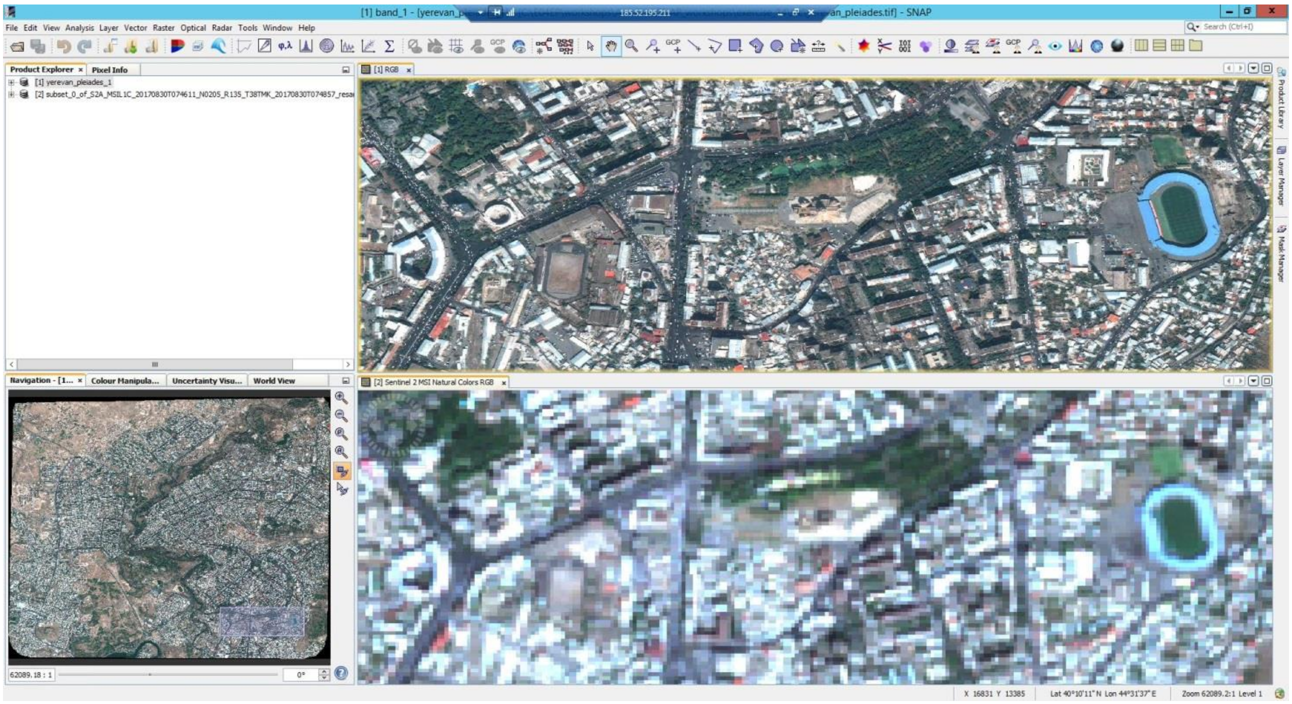


Fig. 41. Comparison of the Sentinel-2 image (10 m spatial resolution, upper) with Pleiades VHR image (0,5m spatial resolution, bottom), Yerevan, Armenia

4 Radar data processing tools

4.1Calibration

Radar image calibration aims to associate the pixel value of the scene directly with the microwaves reflection from the surface of the image. In fact, non-calibrated image allows to performing the qualitative analysis, but the analysis with quantitative methods are possible only after calibration.

Exercise 15 <u>*Calibration of Sentinel-1 image*</u>

- Step 1. Add to the ESA SNAP workspace Sentinel-1 source file from the *\\ESA_SNAP_workshops\source_data* directory.
- Step 2. Run the calibration tool window by *Radar → Radiometric → Calibrate* (Fig. 42).
- Krok 3. In *I/O Parameters* tab in *Source Product* section set the added file from the drop-down list.

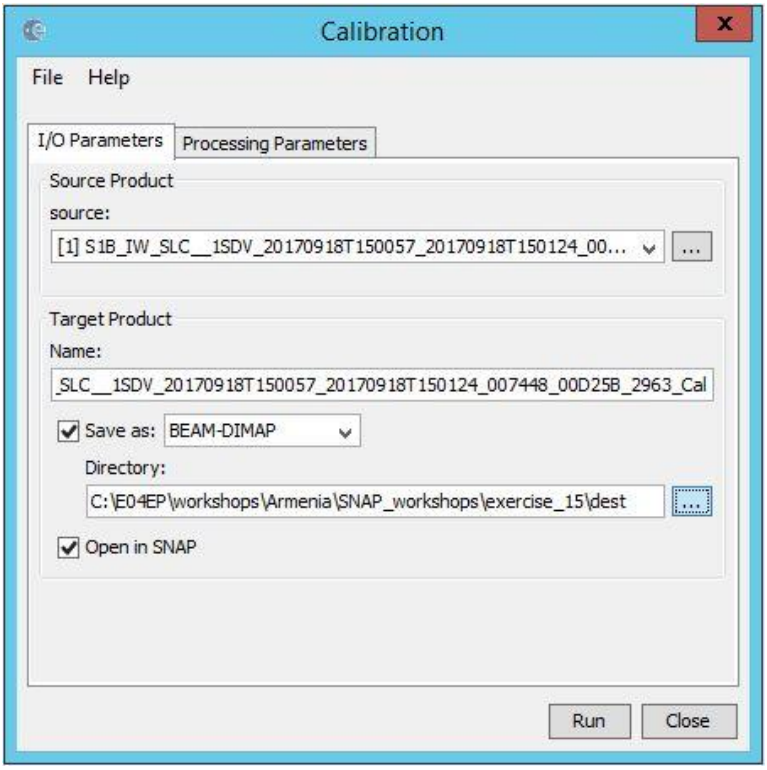


Fig. 42. The source and target data definition for the calibration process of Sentinel-1 image

- In T*arget Product* section set the target directory as *\\ESA_SNAP_workshops\exercise_15\dest* and the name of the calibrated file. By default it is the name of the source file with *Cal* suffix. Mark *Open in SNAP* checkbox to load new created data in *Product Explorer* tab.
- Step 5. In *Processing Parameters* tab mark *Save as complex output* checkbox and both polarisations (left mouse button with pressed [Ctrl] button) and run the calibration process with Run button (Fig. 43).

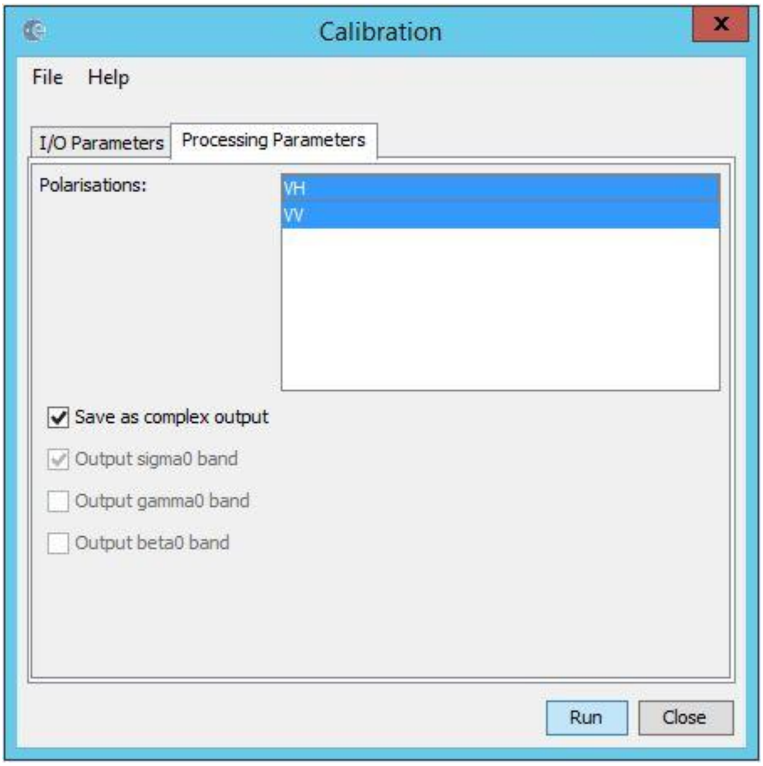


Fig. 43. The calibration process parameters settings

4.2 Debursting

Sentinel-1 data for single image are collecting with three swaths, which needs to be joined for the whole scene processing. This operation is called debursting.

Exercise 16 *__The Sentinel-1 image debursting operation__*

- Step 1. Add to the ESA SNAP workspace source file from the *\\ESA_SNAP_workshops\exercise_15\src* directory (or use the target file from **exercise 15**).
- Step 2. Run the debursting tool window by *Radar → Sentinel-1 TOPS →Sentinel-1 TOPS Deburst* (Fig. 44).
- Step 3. In *I/O Parameters* tab in *Source Product* section set the added file from the drop-down list.

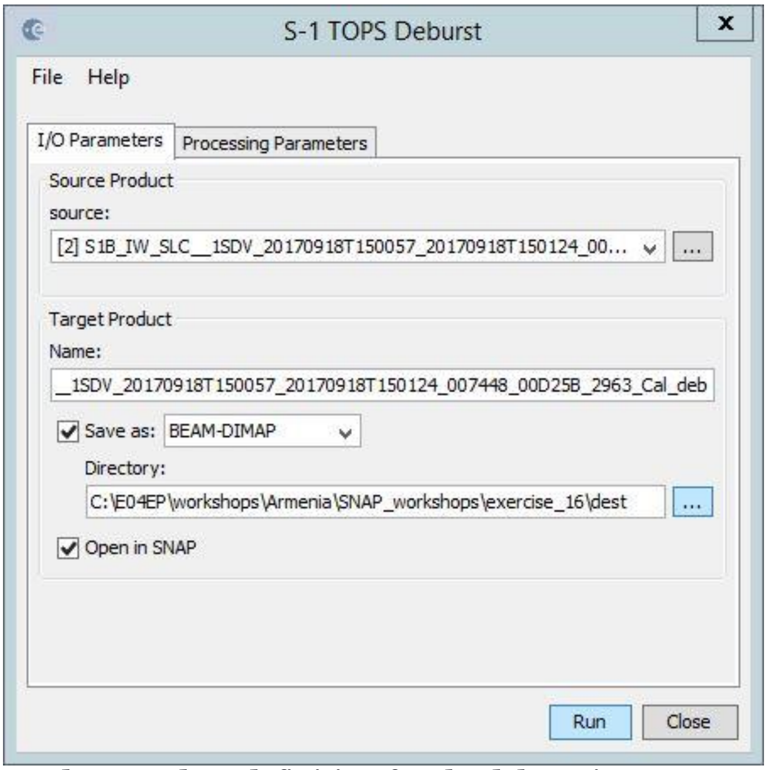


Fig. 44. The source and target data definition for the debursting process of Sentinel-1 image

- Step 4. In *Target Product* section set the target directory as *\\ESA_SNAP_workshops\exercise_16\dest* and the name of the debursted file. By default it is the name of the source file with *deb* suffix. Mark *Open in SNAP* checkbox to load new created data in *Product Explorer* tab.
- Step 5. In *Processing Parameters* mark both polarisations, which will qualify them to the process and run the debursting process with Run button (Fig. 45).

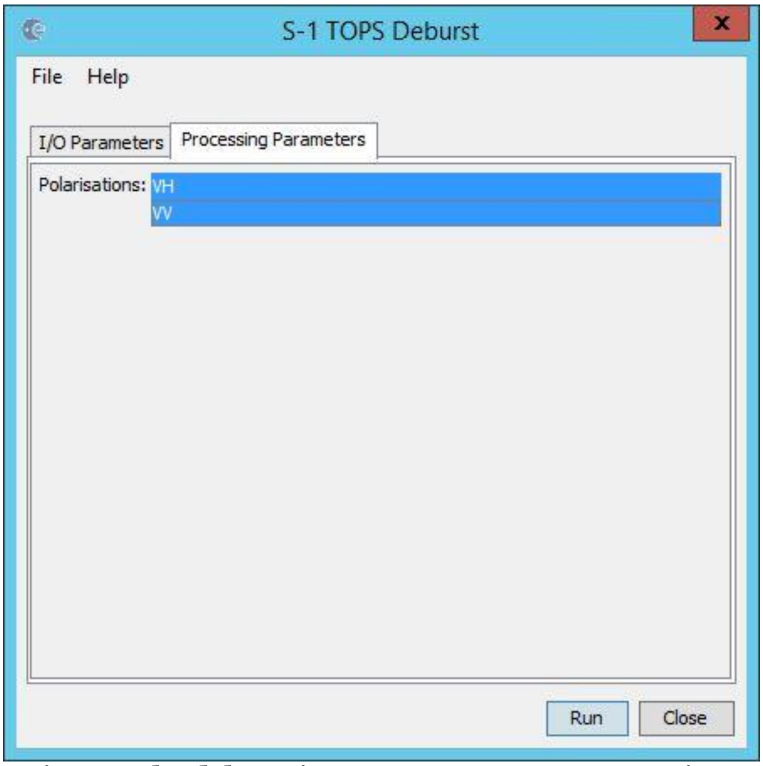


Fig. 45. The debursting process parameters settings

4.3 Speckle filtering

Looking at the raw radar image it is simply to assume that all of it is cover by a „fog", which disturbs the perception of the information from the image. This noise is called „speckle", which is available to delete in speckle filtration process.

Exercise 17 _Speckle filtering of Sentinel-1 image_

- Step 1. Add to the ESA SNAP workspace source file from the *\\ESA_SNAP_workshops\exercise_17\src* directory (or use the target file from **exercise 16**).
- Step 2. Run the speckle filtering tool window by *Radar → Speckle Filtering →Single Product Speckle Filter* (Fig. 46).
- Step 3. In *I/O Parameters* tab in *Source Product* section set the added file from the drop-down list.

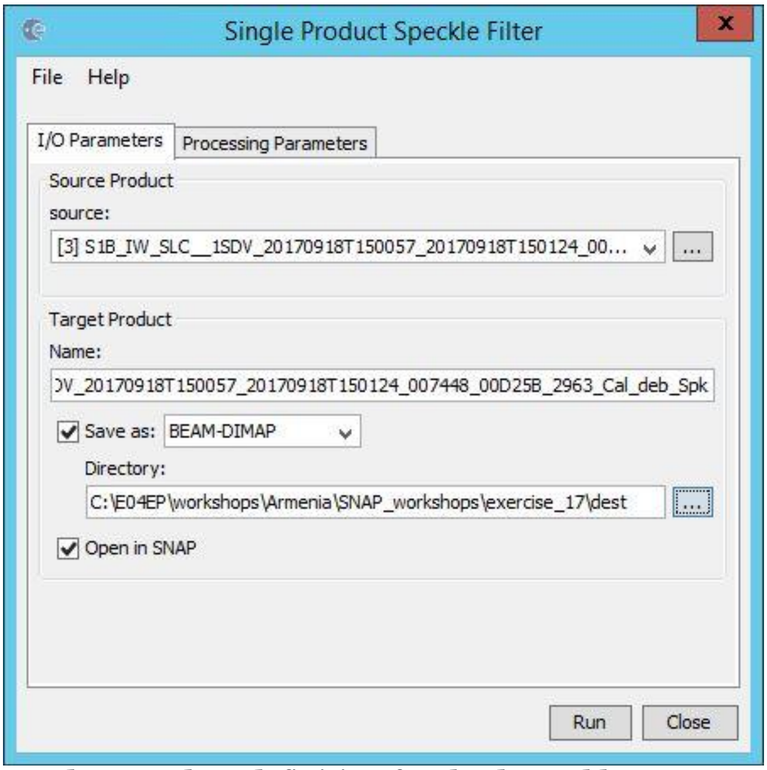


Fig. 46 The source and target data definition for the despeckle process of Sentinel-1 image

- Step 4. In *Target Product* section set the target directory as *\\ESA_SNAP_workshops\exercise_17\dest* o and the name of the filtered file. By default it is the name of the source file with *Spk* suffix. Sign *Open in SNAP* checkbox. Mark *Open in SNAP* checkbox to load new created data in *Product Explorer* tab.
- Step 5. In *Processing Parameters* tab set *Filter* as *Refined Lee and* run the despeckle process with Run button (Fig. 47).

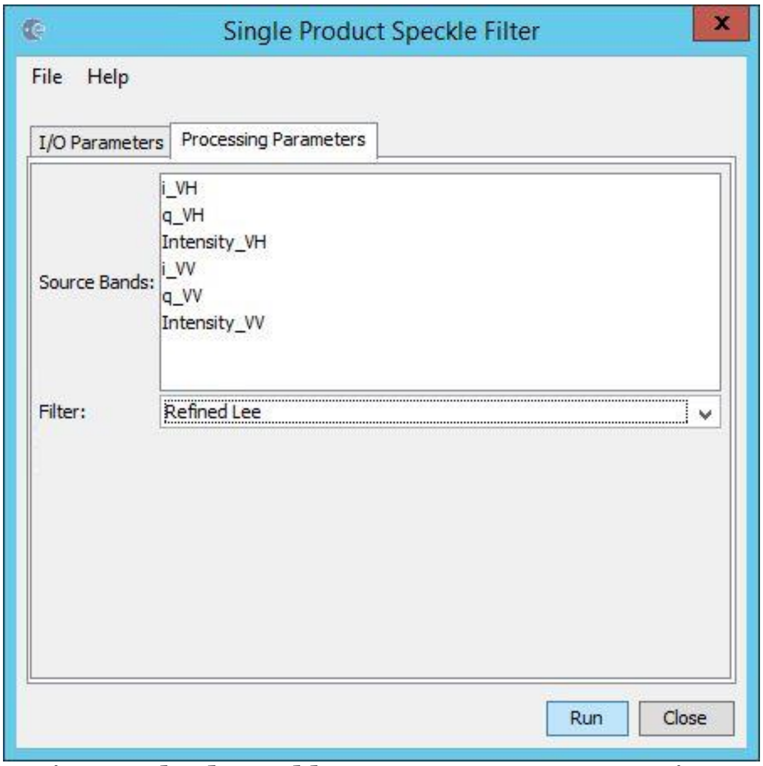


Fig. 47. The despeckle process parameters settings

- Step 6. Create map windows with RGB composition of the image before and after speckle filtering and set simultaneous view of both windows. Compare how the perception of the image increased thanks to despeckle process (Fig. 48).

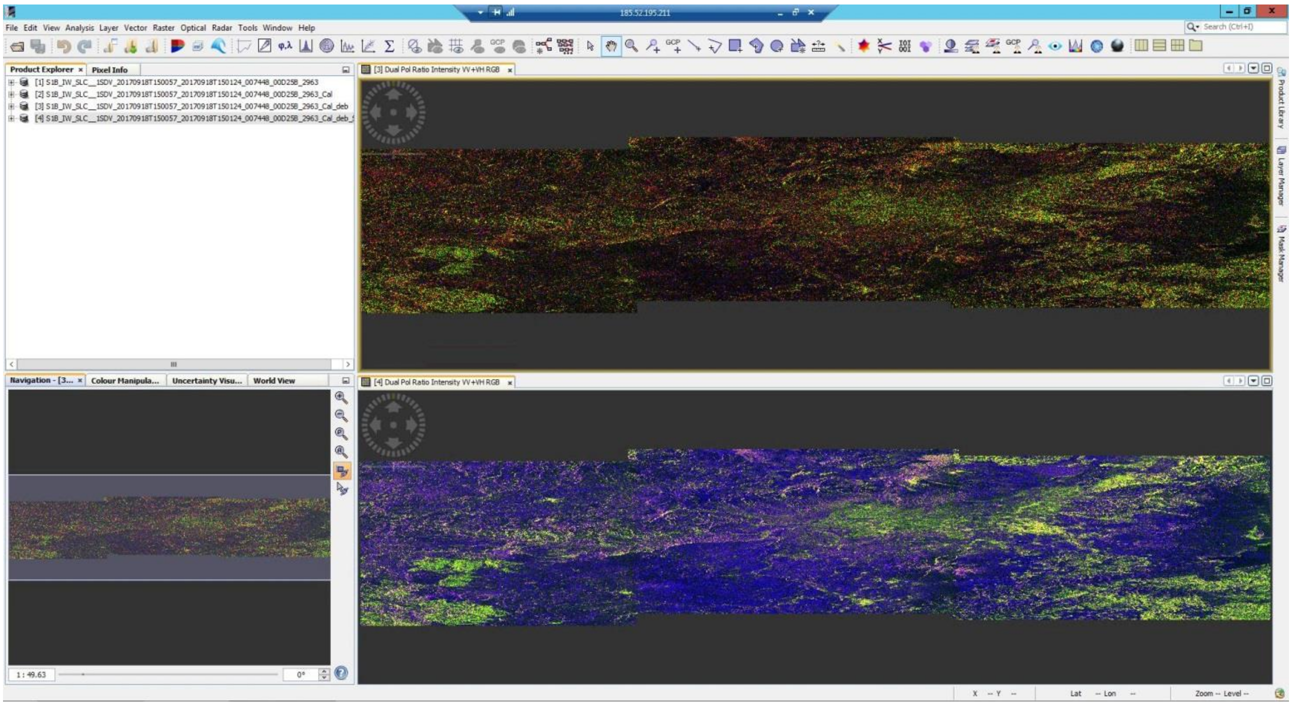


Fig. 48. Comparison of image before (upper) and after (bottom) despeckle operation

4.4 Terrain Correction

The arrangement of Sentinel-1 image directly read from the source files reflects the direction of satellite flight over the collecting terrain and has only approximate georefence. For this reason to effective work with radar data performing the terrain correction is necessary

Exercise 18 *Terrain Correction of Sentinel-1 image*

- Step 1. Add to the ESA SNAP workspace source file from the *\\ESA_SNAP_workshops\exercise_18\src* directory (or use the target file from **exercise 17).**
- Step 2. Run the terrain correction tool window by *Radar → Geometric →Terrain Correction → Range-Doppler Terrain Correction* (Fig. 49).
- Step 3. In *I/O Parameters* tab in *Source Product* section set the added file from the drop-down list.

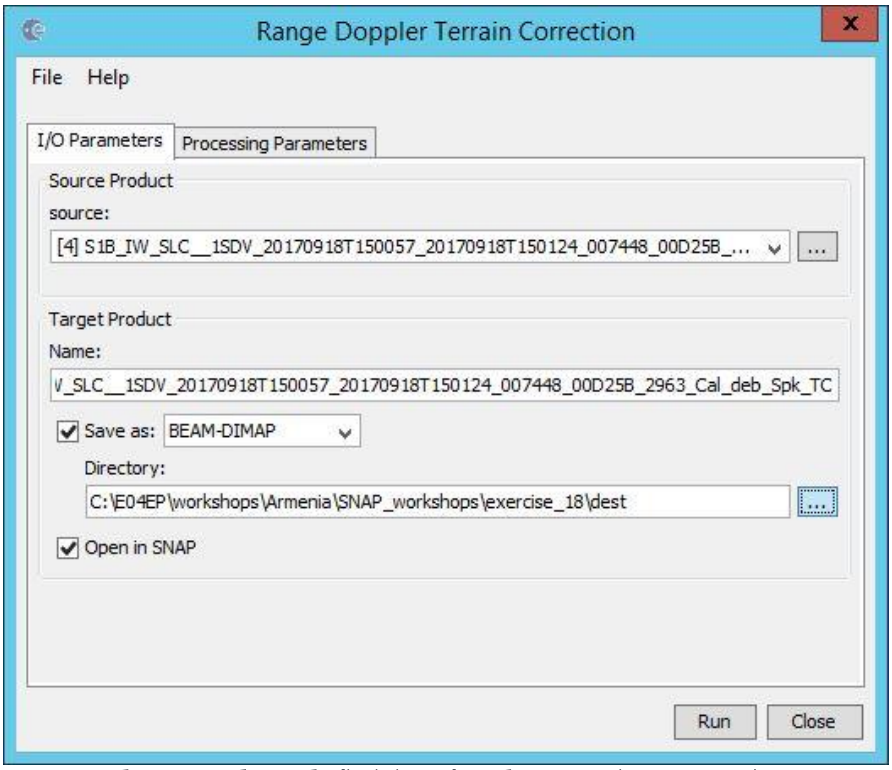
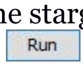


Fig. 49. The source and target data definition for the terrain correction process of Sentinel-1 data

- Step 4. In *Target Product* section set the target directory as *\\ESA_SNAP_workshops\exercise_18\dest* and the name of the file after terrain correction. By default it is the name of the source file with *TC* suffix Mark *Open in SNAP* checkbox to load new created data in *Product Explorer* tab.
- Step 5. In *Processing Parameters* tab set the starget piksel size *(Pixel Spacing)* as 10 meters and run the terrain correction process with 

 button (Fig. 50).

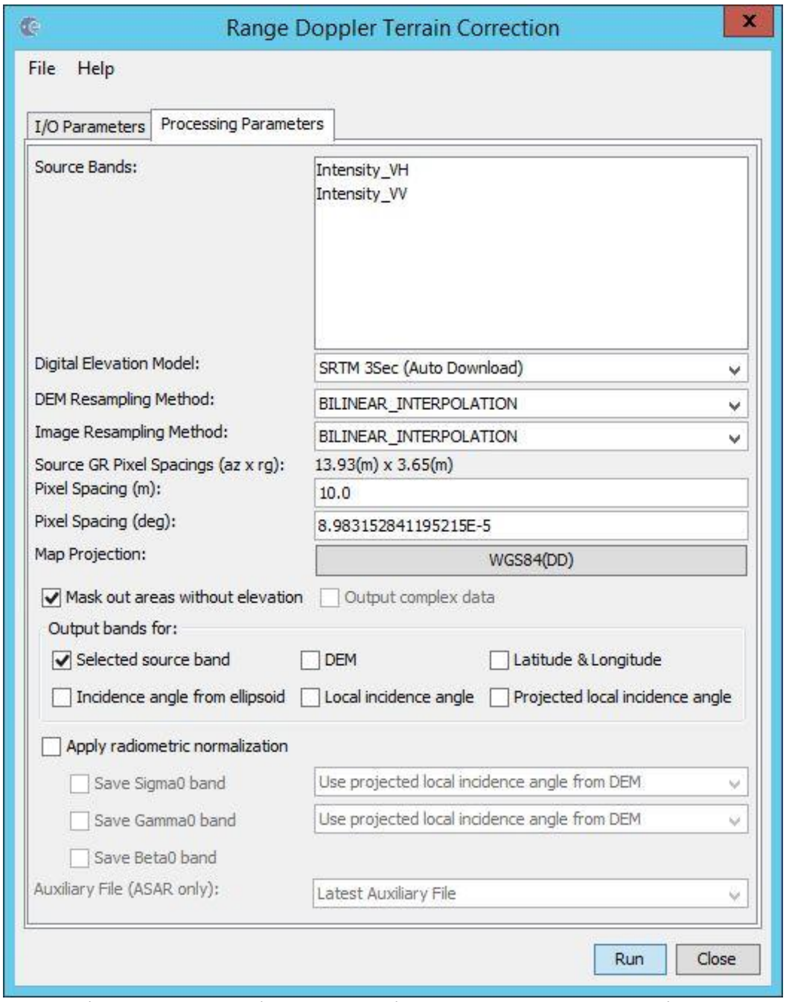


Fig. 50. Terrain correction parameters settings

- Step 6. Create map windows with RGB composition of the image before and after terrain correction. Unmark the simultaneous view (in *Navigation* tab) because the images operate now in different coordinates systems *(Fig. 51)*.

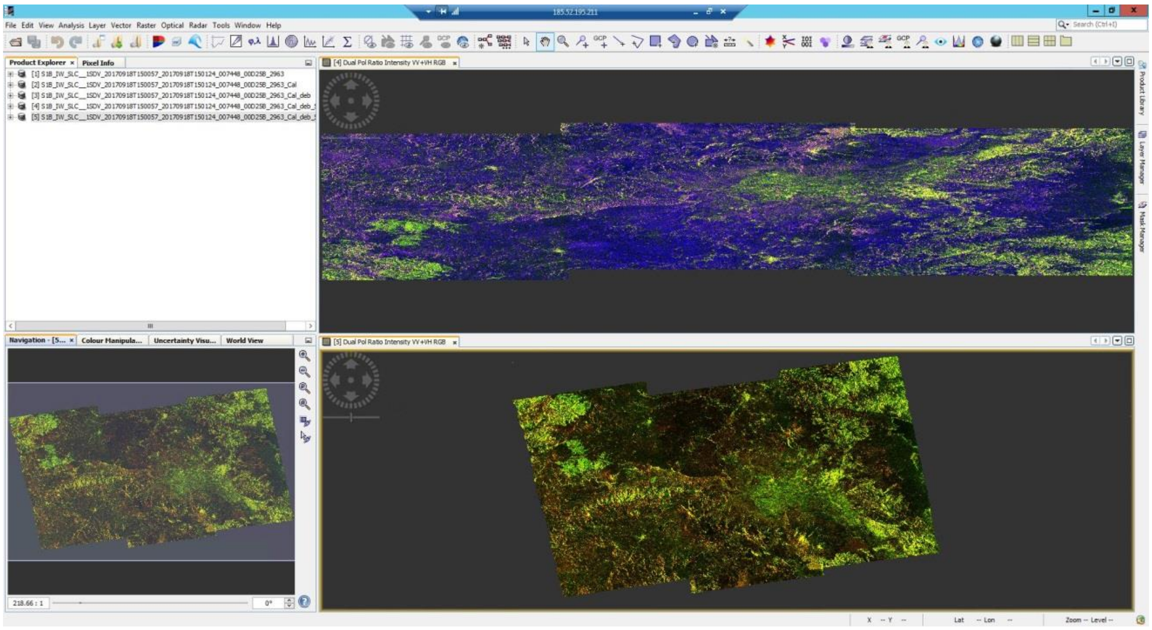


Fig. 51. Comparison of Sentinel-1 image before (upper) and after (bottom) terrain correction

5 Processing paths creation and processing automation

During the performing exercise 1-17 it can be noted that some processes are connecting into series, when the target image of one process become the source of the next one. Thanks to the *GraphBuilder* tool there is a possibility of automatic transistion through several processes and saved only the target data from the last of them.

Exercise 19 *Automation of optical images processing*

- Step 1. Run the *GraphBuilder* tool by *Tools* → *GraphBuilder* or by the icon (Fig. 52).
- Step 2. Load with Load button prepared file *Sentinel-2_graph.xml* with processing graph from *\\ESA_SNAP_workshops\exercise_19\src* directory.

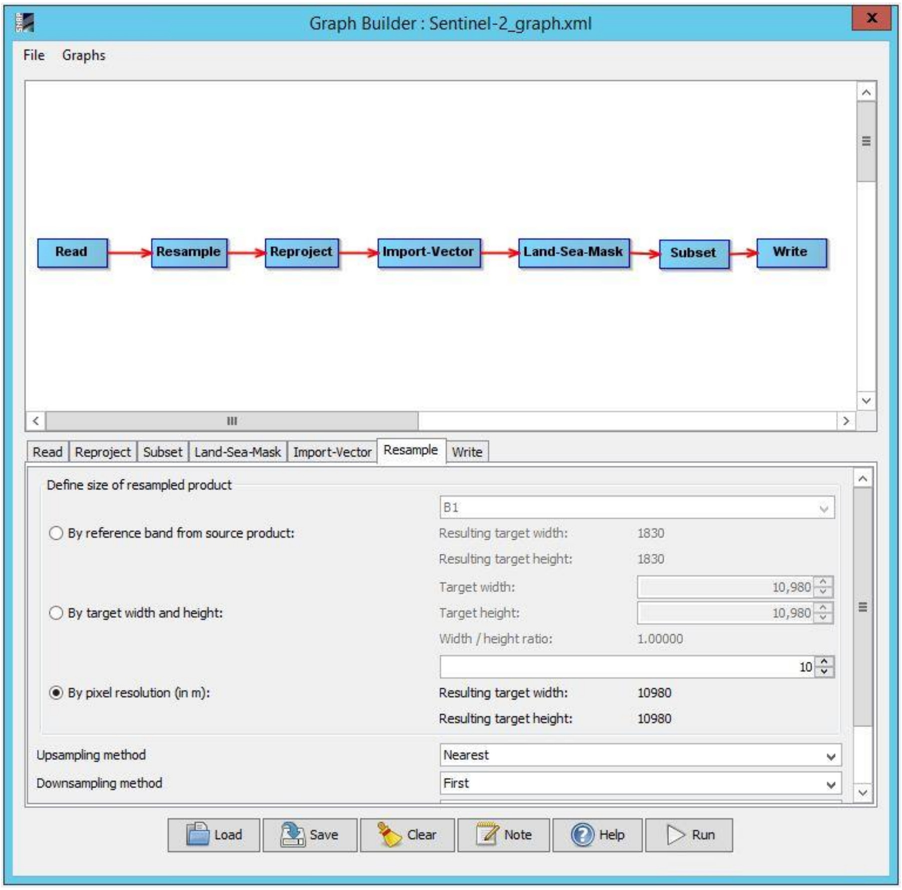


Fig. 52. GraphBuilder tool window

- Step 3. Validate the parameters entered into graph (and it is needed – correct them) starting with source data through values in particular processes, to directory and name of target files. Especially:
    - *Read* block: Sentinel-2 image from *\\ESA_SNAP_workshops\source_data* directory;
    - *Resample* block: *By pixel resolution (in m)* option with value *10*;
    - *Reproject* block: *Predefidned CRS* option with coordinate system *WGS84* set*;*
    - *Import-Vector* block: *AOI.shp* file from *\\ESA_SNAP_workshops\exercise_18\src* directory, unmarked *Separate shapes* checkbox;
    - *Land-Sea-Mask* block: *Use Vector as Mask* option with selected *AOI* layer;

  - *Subset* block: *Geographic Coordinates* option, after zoom to image range (red frame) on the map, yellow area of clipping terrain should be placed inside image range. Navigation: right mouse button – sliding, scroll wheel – zoom;
  - *Write* block: the name of read file from *Read* block, *marked save into \\ESA_SNAP_workshops\exercise_18\dest directiory and Open in Snap* option.

- Step 4. When all the parameters were entered correctly and *GraphBuilder* does not return any errors, run the process path with Run button.
- Step 5. When the processing is done, open the map window with RGB composition of target image. It was in sequence: resampled, reprojected, subset to close range and to the specific irregular area of interest (Fig. 53).

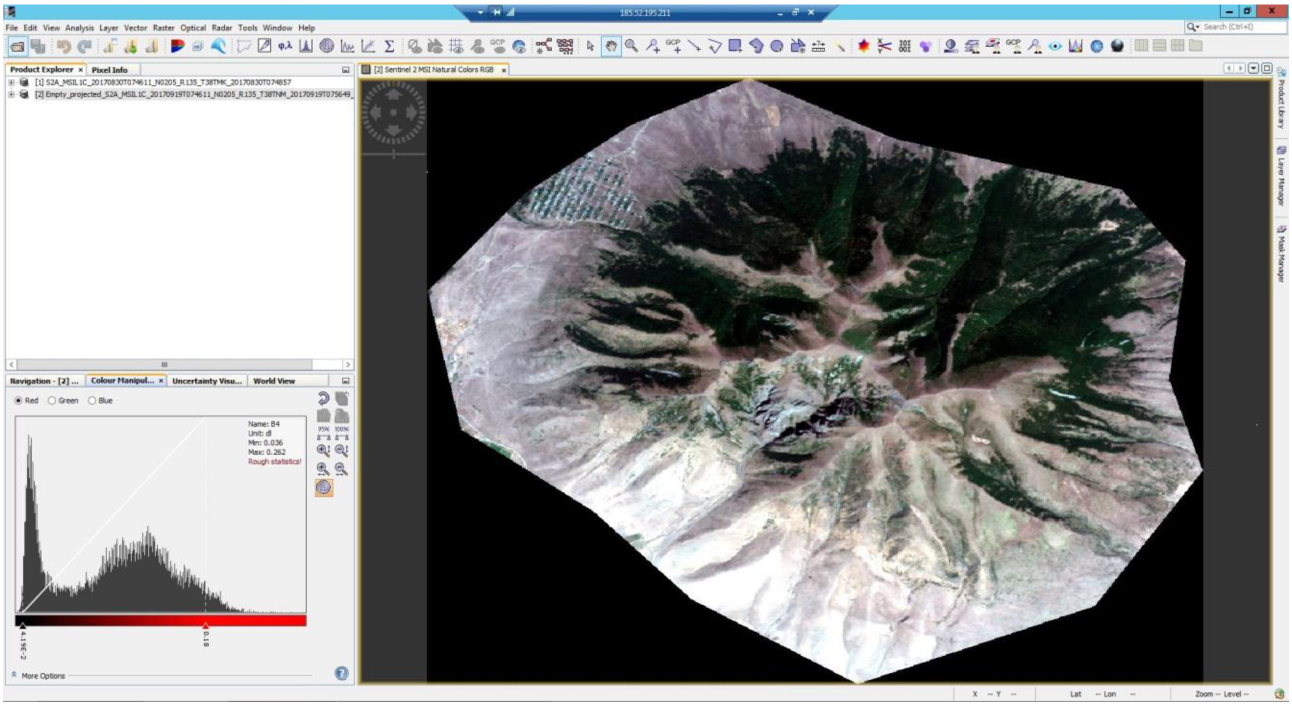


Fig. 53. The effect of performing the series of operations on Sentinel-2 image by processing path collected in graph

Exercise 20 *Automation of optical images processing, graph building*

- Step 1. Run the *GraphBuilder* tool by *Tools → GraphBuilder* or icon.
- Step 2. Clicking right mouse button in graphic window of *GraphBuilder* add calibration block by *Add → Radar → Radiometric → Calibration* (Fig. 54).

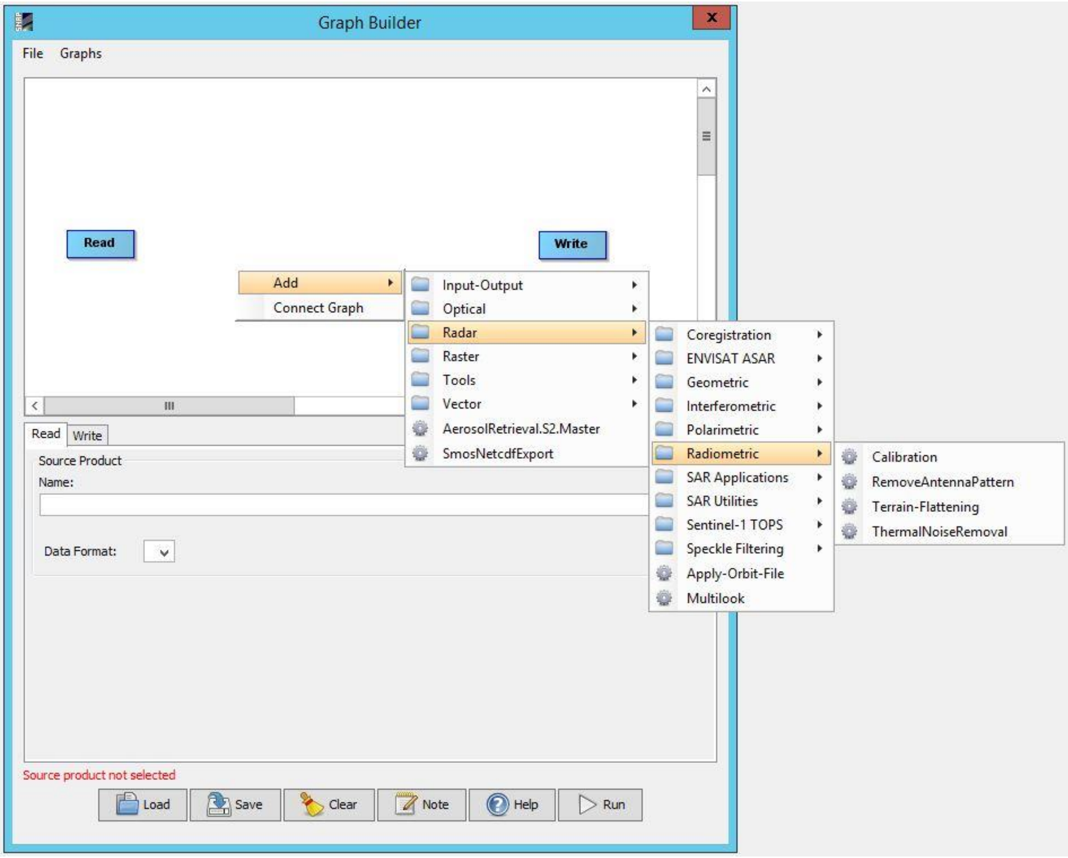


Fig. 54. Adding new block to ESA SNAP Graph Builder

- Step 3. Clicking right mouse button in graphic window of *GraphBuilder* add debursting block by *Add → Radar → Sentinel-1 TOPS → TOPSAR Deburst*;
- Step 4. Clicking right mouse button in graphic window of *GraphBuilder* add despeckle block by *Add → Radar → Speckle Filtering → Speckle-Filter*;
- Step 5. Clicking right mouse button in graphic window of *GraphBuilder* add terrain correction block by *Add → Radar → Geometric-Terrain-Correction → Terrain-Correction*;

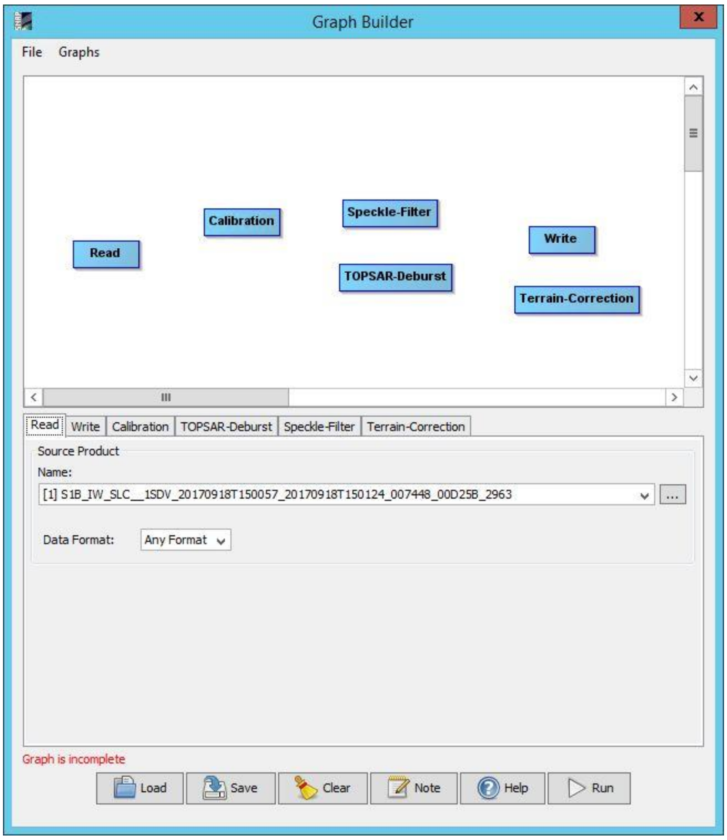


Fig. 55. Graph Builder tool window with added blocks creation for process path creation

- Step 6. Place (by drag&drop) added block into a path Read → Calibration → TOPSAR Deburst → Terrain-Correction → Speckle-Filter → Write i połącz je ze sobą (Fig. 56).

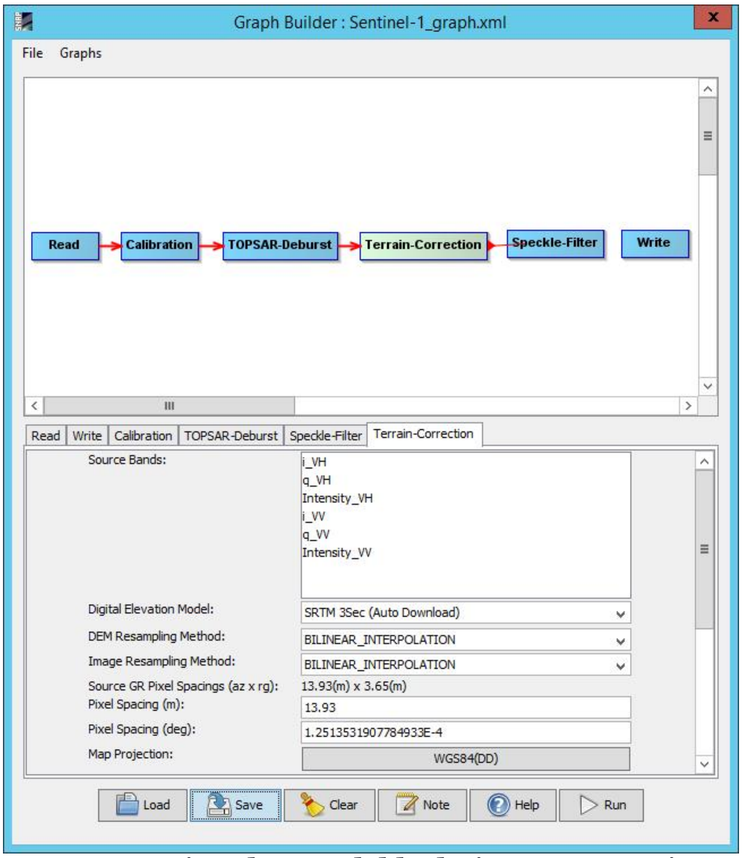


Fig. 56. Connection the graph blocks into a processing path

- Step 7. Passing one by one through every block add Sentinel-1 source file from *ESA_SNAP_workshops\source_data* directory, set parameters of subsequent operations analogous to exercises 15-18 and define target directory as *ESA_SNAP_workshops\exercise_20\dest*.

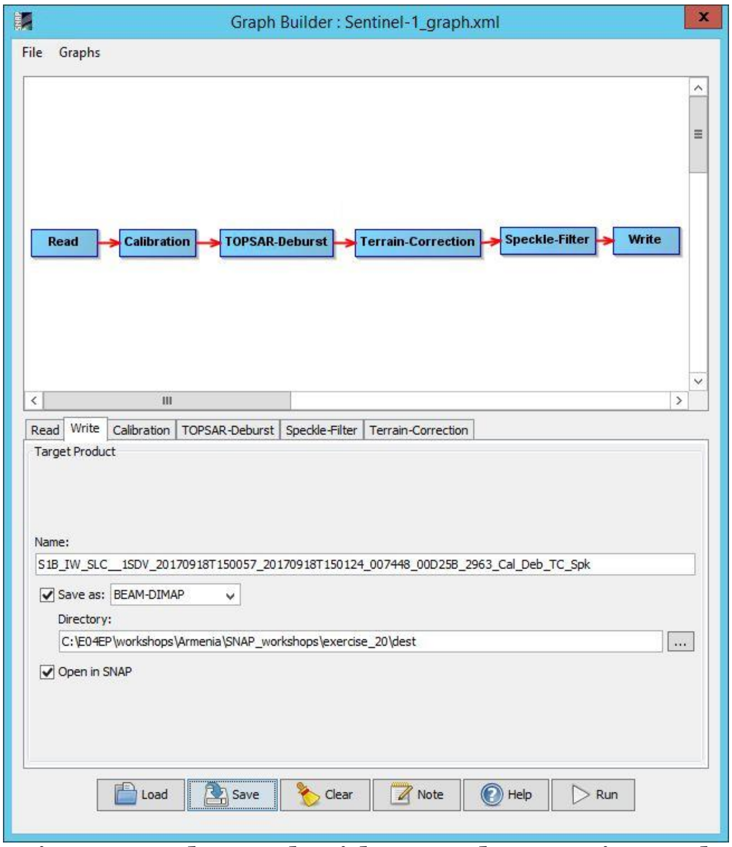


Fig. 57. Ready graph with created processing path

- Step 8. Save graph as *Sentinel-1_graph.xml* file in *ESA_SNAP_workshops\exercise_20\dest* directory and run the processing path with button .

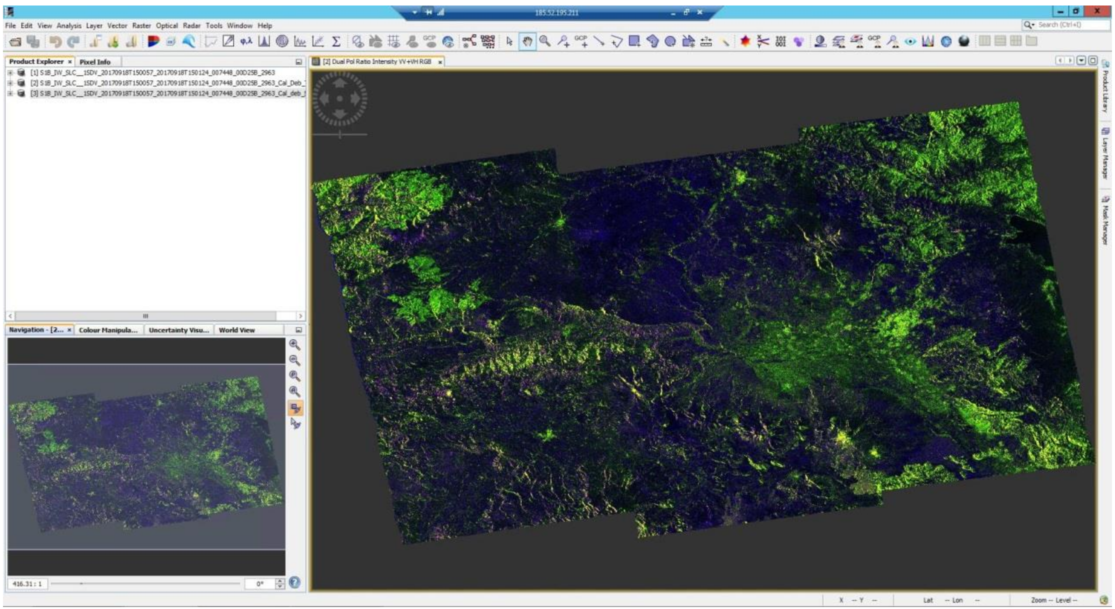


Figure 58. The effect of performing the series of operations on Sentinel-1 image by processing path collected in graph