Flooding Classification

Flood map creation

SARscape Version 6.1.0

January 2025

Table of Contents

1. Introduction

The main goal of this tutorial is to give a basic description of the SARscape Flooding Classification tool to obtain a classification raster that highlights flooded and permanent water areas.

The tool requires a set of input images to classify permanent water and a post-event image to identify flooded areas. The input images should span a meaningful time interval. The algorithm classifies pixels based on their backscatter behavior over time.

Note: The higher the number of pre-event images the higher is the classification quality of permanent water bodies.

The Flooding Classification Refinement tool allows user to obtain a flood probability raster map, indicating the probability for each class for every pixel within the Area of Interest (AOI).

Technical Note

Here below the requirements regarding the input images:

- The images **must** be coregistered since the analysis is performed pixel by pixel
- The images **must** be geocoded.

SARscape version	6.1.0
ENVI version	6.1.0
SO	64-bit Windows 10 Pro
RAM	32 GB
Processor	Intel (R) Core (TM) i9-9980HK CPU @ 2.40GHz
OpenCL	NVIDIA Quadro RTX 3000
HD	SSD EVO 2TB (as working directory)

How to read the tutorial

The text written in black contains information regarding input files and general notes.
The text written in gray corresponds to the information reported in the help page.
The text written in orange indicates parameter values that need to be modified from their default settings.

2. Training Data sets description

Jiangxi experienced major floods in July 2020, primarily along the Poyang Lake and its tributaries in Jiujiang, Shangrao, and Pingxiang.

At 0:00 a.m. on 12 July, the water level at Xingzi station of Poyang Lake reached 22.53 metres (73.9 ft), exceeding the record of 22.52 metres (73.9 ft) in 1998 China floods.[92]

Residents were forced to evacuate Jiangzhou Town and Sanjiao Township of Jiujiang on 12 July as the flooded river began to overtake homes.

On 11 July, the Government of Jiangxi raised its flood-control response from level II to level I, the top level of China's four-tier emergency response for floods. Rao River rose to an all-time high of 22.65-metre (74.3 ft), crossing the danger mark and surpassing the previous record of 22.43-metre (73.6 ft) set in 1998. Parks, homes, and businesses in Poyang County were overtaken by the Rao River, leaving parts of the county accessible only by boat. The 73123 Army of the Eastern Theater Command Ground Force rushed to Poyang County to fight flood. In Dongzhi County, floods had affected more than 260,000 people, or about half of the county's population.

On the afternoon of 8 July, Qinghua Rainbow Bridge was devastated by flood. In the early morning of 9 July, the highest water level of Sandu Hydrological Station in Wuyuan County reached 62.74-metre (205.8 ft), exceeding the warning water level by 4.74-metre (15.6 ft).

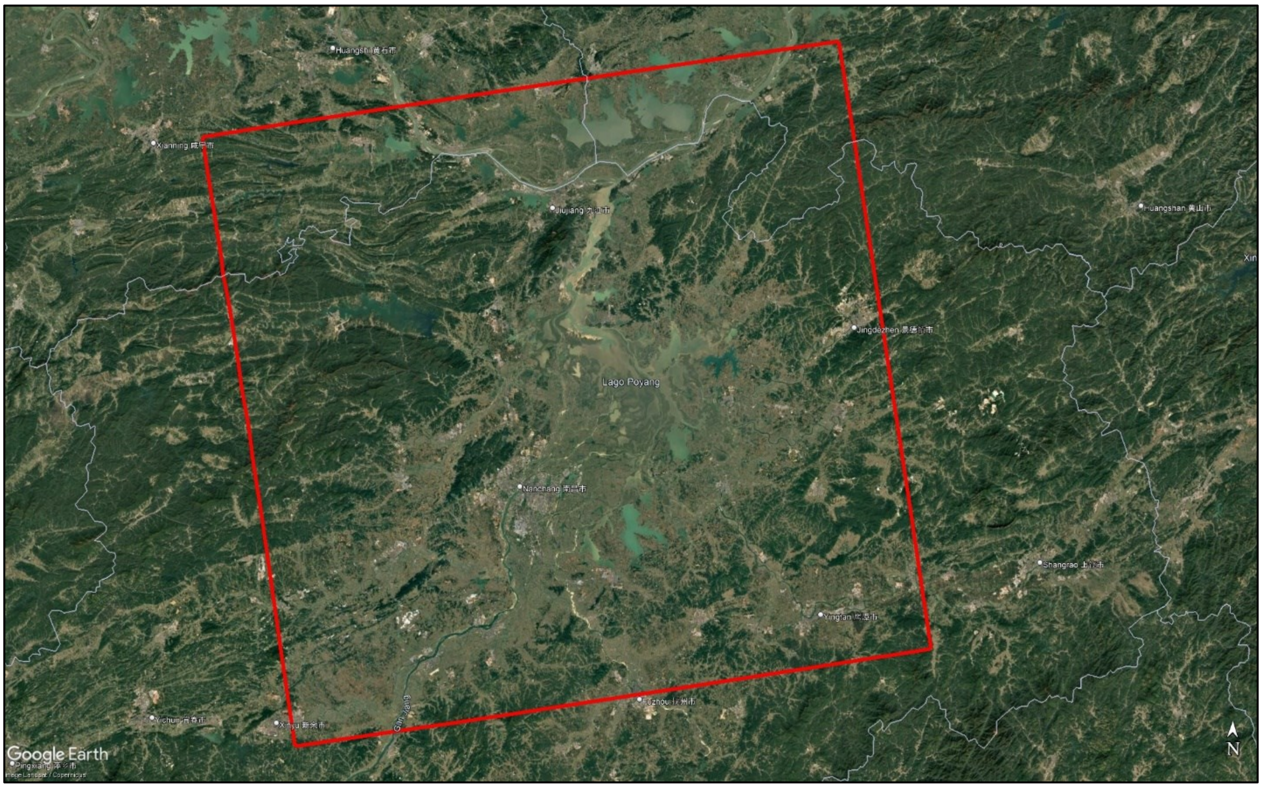

Figure 1 Area of Interest.

4. Before starting

Before starting to run the InSAR DEM processing chain, it is strongly recommended to:

- set the ENVI Preferences setting the proper root folders.
- set the SARscape Preferences (Specific) based on the specific to *Sentinel TOPSAR (IW-EW).*
- read the Getting Started, Data Preparation and Basic Tutorial to become familiar with the basic.processing chain that allows managing the dataset provided to run the InSAR processing.
- Send an email to the sarmap support team to get the access to the data stack.

The dataset contains:

- Three Sentinel-1 images, two pre-event and one post-event image
- Digital Elevation Model

5. Import Sentinel-1

Run the Sentinel-1 tool, located under the path */SARscape/Import Data/SAR Spaceborne/Single Sensor/.*

The images acquired by the SENTINEL-1 missions are imported into the SARscape Data Format for further processing.

Input Files

Input Parameters File list

Insert the three original files:

S1B_IW_SLC__1SDV_20200503T101813_20200503T101848_021416_028A7F_1B64.zip
S1B_IW_SLC__1SDV_20200515T101814_20200515T101849_021591_028FD0_A30D.zip
S1B_IW_SLC__1SDV_20200714T101817_20200714T101852_022466_02AA36_8455.zip

Tip: In order to import a large amount of acquisition, we suggest to use the "*Open Folder*" or "*Browse Files*" function. Please refer to the overview chapter for more information.

Tip: In order to import a large amount of acquisition in , we suggest to use the "*Open Folder*" function.

Optional Files

Area of interest in Geographic Coordinates

In case of SLC IW import, a vector file (.shp) can be upload to specify a region of interest. Only the bursts intersecting this region will be imported. This will reduce the import processing time and disk space needs. This file is optional.

Note: Only shapefiles in geographic coordinates (Lat/Long) are supported. If the needed shapefile is available only in another cartographic system, please use the Cartographic Transformation Shape tool to convert it in Lat/Long.

Note: In case the AOI is included, the _slc_list sampling does follow the given shapefile coordinates. The intersected part of the bursts are kept. It is possible to give a threshold of valid pixels inside the selected area to determine if the burst has to be kept in the sampled image.

Progress File Name

A .txt file named "**_progress.txt*" is generated whenever the software crashes during the import phase. The software will import only for those files that has not been imported yet if the "**_progress.txt*" file is uploaded.

Parameters - Principal Parameters

Make power QL

A multilooked power image is created in case of SLC import. Please use this file as *reference* in case of further use of Sample Selection tool.

Polarization

This option let to choose which polarization should be imported in case the original data contains more than 1 polarization.

Options are All, Copolarization, Copolarization as:

All,
VV HH only
VH HV only
VV VH only
HH HV only
HH only
VV only
VH only
HV only

This is helpful in case of only one polarization is needed (e.g. only copolarization for interferometry purposes) reducing the time of the import and the space on disk needed.

Make mosaic same track

If this option is set and all the files in the input file list are acquired in succession on the same track, the output will be one single _slc_list with only one .split_bursts folder (for each polarization).

Thermal Noise Removal

By setting this flag the software will remove the thermal noise from the Sentinel-1 SAR image.

Removing thermal noise is required to normalize the backscatter signal within the entire SAR image, which is essential to both qualitative and quantitative use of SAR data.

Thermal noise is most obvious in cross-polarization SAR images, such as VH or HV, and SAR images with low backscatter.

Skip Sample Selection

If this option is set to True, the burst that intersect the AOI are imported and the sample selection is not performed. If this option is set to False (default) the burst imported are also sampled based on the AOI.

Fill dummy during import

Possibility to replace invalid backscatter pixel values with random low values.

Rename the file Using Parameters

If this option is not set, the output files will be placed in the output directory with the root name which appears in the Output File List.

If this option is set (recommended), the output files will be placed in the output directory with an automatically generated root name, assigned based on the input file parameters.

Note: the Data Type is automatically detected and selected.

Output Files

Output file list

Output file name(s) of the imported data.

Each entry specifies the output path (output directory and root name) of the imported file and associated header files (.sml, .hdr). The output directory can be changed by right-clicking on the displayed root name, and selecting Change Output Directories from the dropdown menu. Click on the folder icon to browse to the output directory and then click on the green tick mark to apply the change.

These files are mandatory.

Root name of the imported file and associated header files (.sml, .hdr). Specific file suffixes are added according to the data type.

.shp

Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml

ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the measurement units and naming of the output products can be found in the Data Format section.

6. Multilooking

The SAR signal processor can use the full synthetic aperture and the complete signal data history in order to produce the highest possible resolution: this is the Single Look Complex (SLC) SAR product. Multiple looks may be applied by averaging over range and/or azimuth resolution cells. Typically, the improvement in radiometric resolution involves a degradation in spatial resolution.

The goal is to obtain approximately square pixels considering the ground range resolution and the pixel spacing in azimuth. In particular, in order to avoid over-sampling effects once the data will be geocoded, it is recommended to set the multilooking factors taking into account the spatial resolution foreseen as geocoded product grid size.

Note that ground resolution in range is defined as:

$$Ground\ range\ resolution = \frac{pixel\ spacing\ range}{sin(incidence\ angle)}$$

The multilooking process generates a power image (_pwr)

Input Files

Insert the three _*slc_list* files generated by the import Sentinel-1:

sentinel1_40_20200503_101813561_IW_A_VV_slc_list
sentinel1_40_20200515_101814059_IW_A_VV_slc_list
sentinel1_40_20200714_101817603_IW_A_VV_slc_list

SARscape automatically provide the suggested looks value according to the grid size value set by default according to the chosen Preferences Specific.

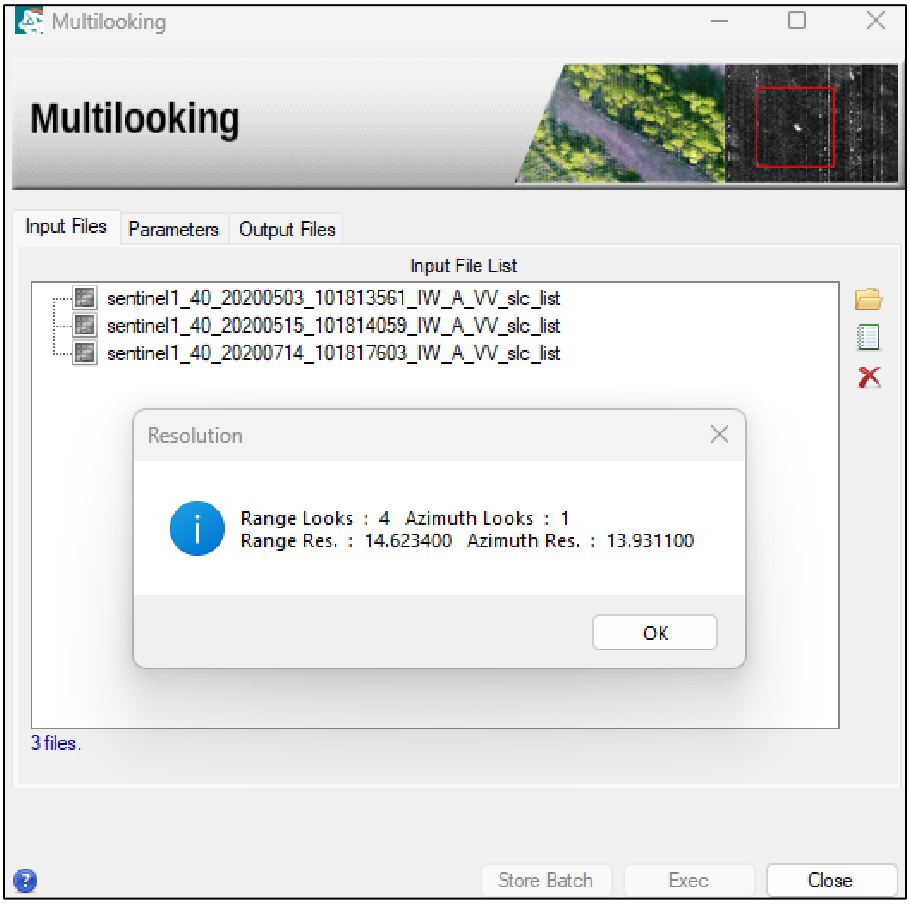

Figure 2 Suggested looks for the input Sentinel-1 images.

Input file name:

- Single Look Complex (_slc). Note: it is converted in intensity (_pwr) image.
- Slant range (_pwr) intensity
- Ground range (_gr) data

Parameters - Principal Parameters

Multilooking Method

Time or frequency domain where the multilook should be performed.

Range looks

Number of looks in range.

Azimuth looks

Number of looks in azimuth.

Grid Size for Suggested Looks

The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Output Files

Output file list

Output file name(s) of the multi-looked Intensity data. This file list is mandatory.

_pwr

Multi-looked slant range Intensity image and associated header files (.sml, .hdr).

_pwr.xml

Xml file containing the geographic co-ordinates of the scene corners.

_pwr.shp

Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

_pwr.kml

ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

_par.sml

Xml file containing temporary processing parameters.

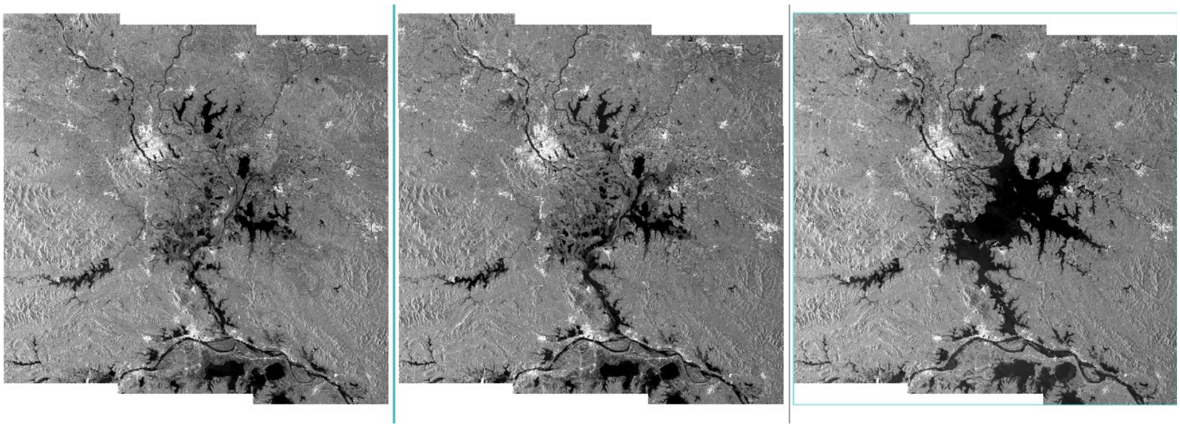

Figure 3 Multilooked images. The first two images are pre-event while the third one is post-event.

Figure 3 shows the evolution in time of the backscatter in the analyzed area

7. Coregistration

The coregistration process ensures a pixel-to-pixel match between all pixels within the SAR data stack. Co-registration is simply the process of superimposing, in the slant range geometry, two or more SAR images that have the same orbit and acquisition mode.

Input Files

Insert the three *_slc_list_pwr* files generated by the import Sentinel-1:

sentinel1_40_20200503_101813561_IW_A_VV_slc_list_pwr

sentinel1_40_20200515_101814059_IW_A_VV_slc_list_pwr
sentinel1_40_20200714_101817603_IW_A_VV_slc_list_pwr

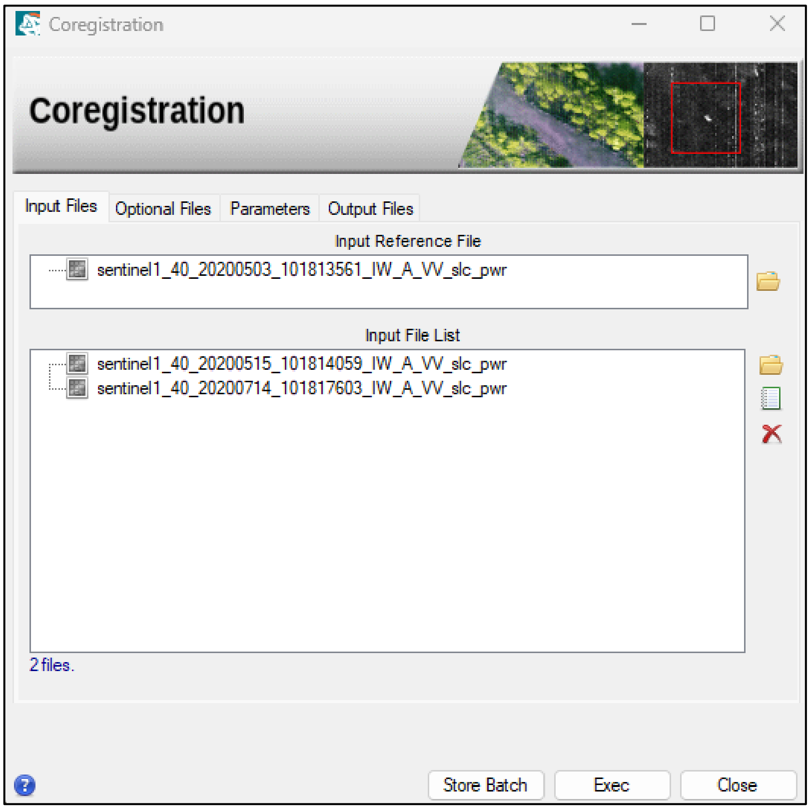

Figure 4 Suggested looks for the input Sentinel-1 images.

Input reference file

File name of the reference image to which the other input files will be coregistered. The input reference file can be a slant or ground range Intensity or Complex image (e.g. _pwr, _pri, _sgf, _slc). This file list is mandatory.

Input file list

Input file name(s) of all file(s) to be coregistered to the reference image. The Input file list must be one (or more) slant or ground range Intensity image (e.g. _pwr, _pri, _sgf, _slc). This file list is mandatory.

Optional Files

Digital Elevation Model file

Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the coregistration is carried out without considering the topography.

Coregistration file

A previously created Ground Control Point file (.xml), with the points used for the manual coregistration (.xml), is automatically loaded. These points represent the center of the coregistration windows. This file is optional.

Shift Parameter file

Name of the file with the shift parameters used for the coregistration (_par). If the Compute shift parameter flag is set, it is generated as output.

Geometry GCP file

*Either a previously created Ground Control Point file (.xml) can be loaded or the interface to create a new Ground Control Point file is automatically loaded (refer to the "*Tools>Generate Ground Control Point*" for details). This file is optional; it can be entered only whether the "Digital Elevation Model file" is used in input.*

Parameters - Principal Parameters

Always compute shift

By setting this flag it is assumed that all the images in the input file list are not already coregistered each other. Unset this flag if the images in the input file list are already coregistered each other, but they are not coregistered to the reference file; in such case the first image in the input file list will be considered for the calculation of the coregistration parameters.

Compute Shift Parameters

By setting this flag, the coregistration shifts between Reference and Secondary image are calculated and saved into the _par file.

Output Files

Output reference file

Output reference image to which the other input files will be coregistered (_rsp). This file list is mandatory.

Output file list

Output file name(s) of all coregistered file(s). The number of output files must be equal to the number of input files. This file list is mandatory.

_rsp

coregistered slant or ground range detected images and associated header files (.sml, .hdr). In case of _slc files in input, the output will consist in 1x1 multilooked _pwr.

_rsp_par.sml

Xml file containing temporary processing parameters.

_meta

This file allows to load the specific processing results together with the input reference file.

_orb.sml

Xml file containing the scene orbital parameters. This file is generated only if an input Digital Elevation Model is entered.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format section.

In Figure 5 are shown the output files of the Coregistration process, that includes the _rsp_meta and series file. The meta consists of an RGB made of the output files ordered by date in the relevant bands, red, green and blue.

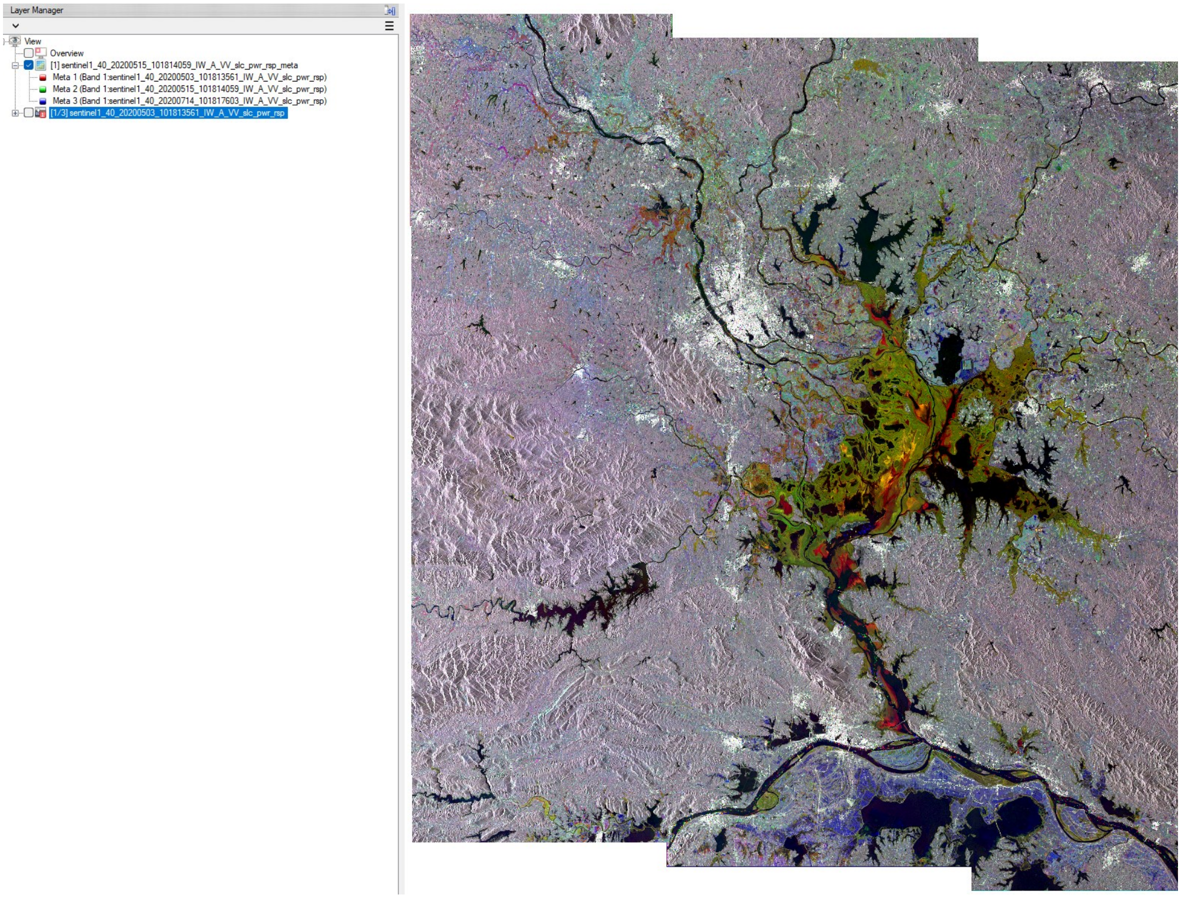

Figure 5 _*meta* output file. In this case the RGB is composed as follows: Red and Green bands → Two pre-event images. Blue band → Post event image.

8. Single image Filtering

The presence of several scatterers within each SAR resolution cell generates the so-called speckle effect that is common to all coherent imaging systems. Homogeneous areas of surface that extend across many SAR resolution cells (for example, a large agricultural field covered by one type of cultivation) are imaged with different amplitudes in different resolution cells. The visual effect is a sort of 'salt and pepper' screen superimposed on a uniform amplitude image. Speckle can be reduced by applying a Multilooking or a specific filtering technique. In this tutorial a SAR-specific filter named "Frost" will be applied.

The Frost filter is an adaptive Wiener filter, and convolves the pixel values within a fixed size window with an adaptive exponential impulse response. The Lee filters perform a linear combination of the observed intensity and of the local average intensity value within the fixed window. They are all adaptive as a function of the local coefficient of variation and can be enhanced by fixing a minimum value for better speckle smoothing and an upper limit texture or point target preservation. The coefficient of variation is a good indicator of the presence of some heterogeneity within the window; it is well adapted when only isotropic texture is present and it can be assisted by ratio operators for anisotropic oriented textural features.

Input Files

Insert the three _*slc_list* files generated by the import Sentinel-1:

sentinel1_40_20200503_101813561_IW_A_VV_slc_list_pwr_rsp
sentinel1_40_20200515_101814059_IW_A_VV_slc_list_pwr_rsp
sentinel1_40_20200714_101817603_IW_A_VV_slc_list_pwr_rsp

In this tutorial the **Frost** filter will be applied.

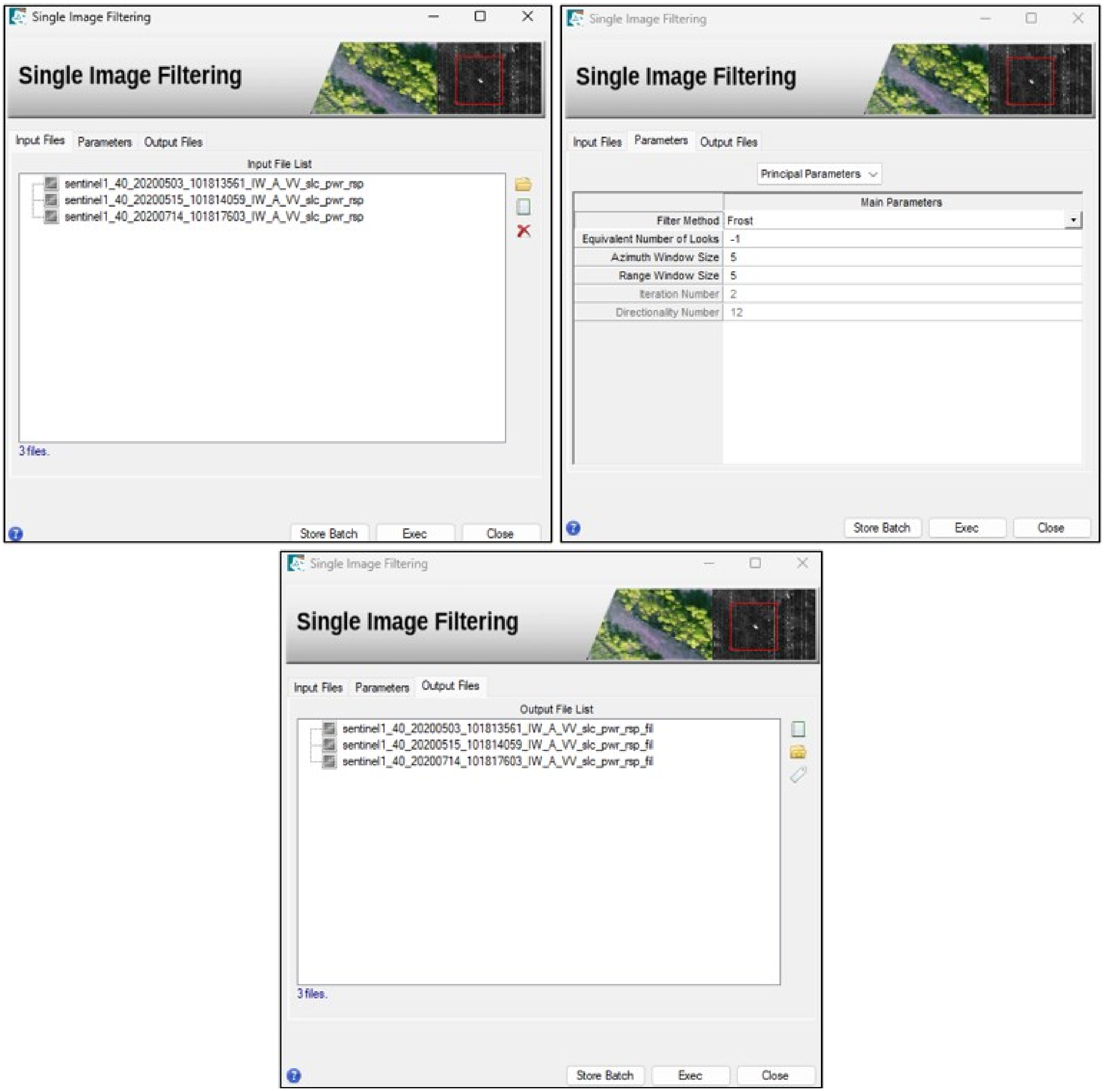

Figure 6 Single Image Filter windows.

Input file list

Input file names (e.g. _pwr, _rsp, _geo). This file(s) is mandatory.

Parameters - Principal Parameters

Depending on the chosen filtering method, one or more of the following fields will be activated.

Select Frost as Filter Method.

Filter method:

Mean, Median, Mode. Active parameters:

- Azimuth window size
- Range window size

Edge Preserving Smoothing. Active parameters:

- Azimuth window size
- Range window size
- Iterations Number
- Directionality Number

Frost, Lee, Refined Lee. Active parameters:

- Azimuth window size
- Range window size
- Equivalent Number of Looks (ENL)

Equivalent number of looks (ENL)

The Equivalent Number of Looks is equivalent to the number of independent Intensity values averaged per pixel during the multi-looking process. This parameter can be easily estimated over a homogeneous (stationary) sample in the input Intensity data according to:

ENL = $mean^2$ / standard $deviation^2$

In case that ENL is not set, the software tries to retrieve it automatically; if it fails it takes the Number of Looks (NL) used during the multi-looking process is considered.

Note that, to tune the strength of speckle filtering and the level of preservation of scene details, it is preferable to adjust the value of the ENL, rather than to change the size of the processing window:

- To reduce the strength of speckle filtering, with the aim to preserve the thinnest details of the scene, enter a ENL value slightly higher than the calculated one;
- Inversely, to improve the filtering of the speckle (possibly at the cost of the thinnest details of the scene), enter a ENL value slightly lower than the calculated one.

Azimuth window size

Size – in pixel units – of the moving window in azimuth.

Range window size

Size – in pixel units – of the moving window in range.

Iteration number

Iteration times.

Directionality number

Depending upon the window size, different directions – in degree unit – can be considered during the filtering. An increase in the number of directions corresponds to a better preservation of the structures.

Output Files

Output file list

Filtered power and coregiestered images (_fil). This file list is mandatory.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format section.

The image below show the difference between the original pwr and the filtered pwr image.

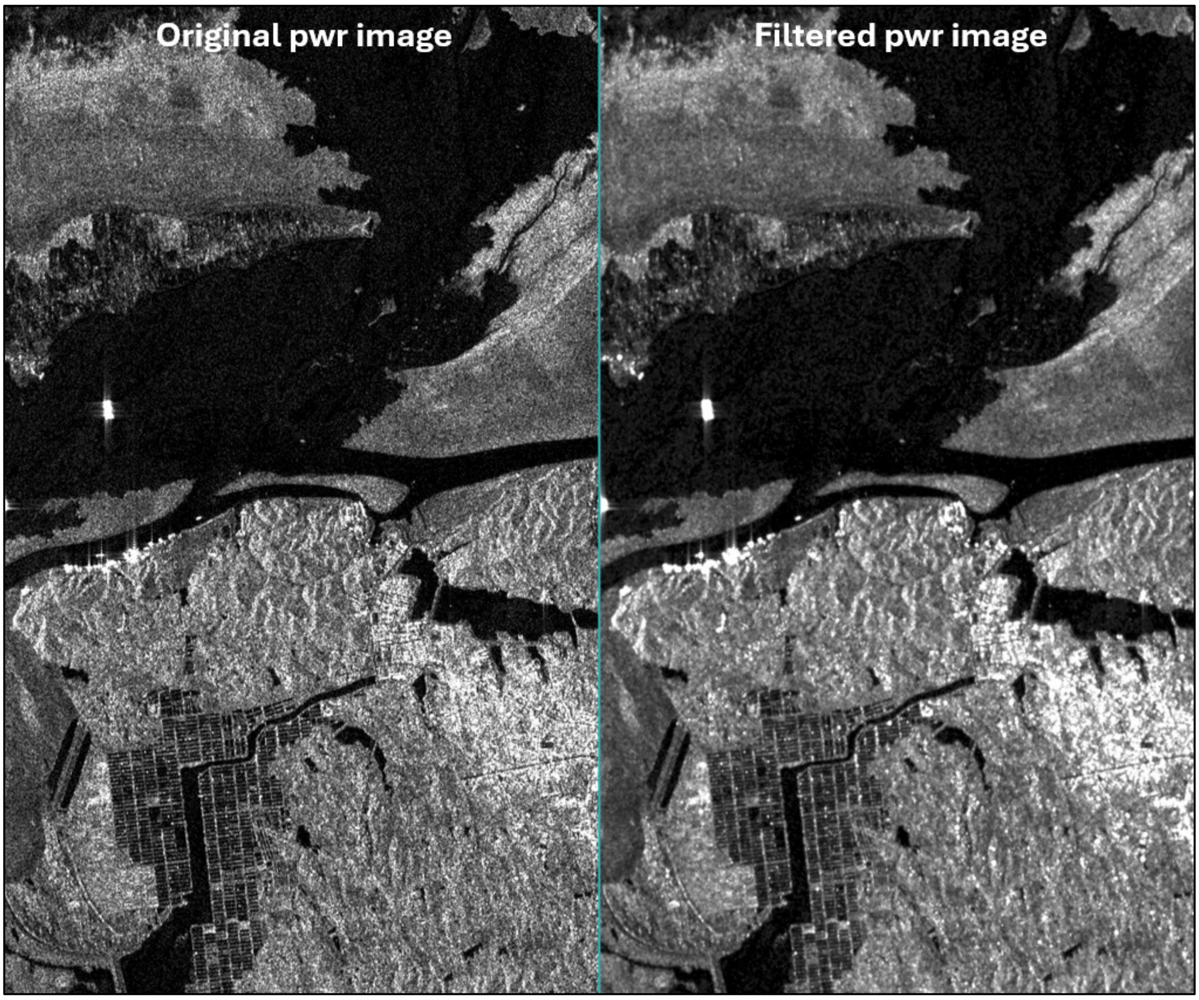

Figure 7 Original pwr vs Filtered pwr image.

9. Geocoding and Radiometric Calibration

SAR systems measure the ratio between the power of the pulse transmitted and that of the echo received. This ratio (so-called backscatter) is projected into the slant range geometry. Geometric and radiometric calibration of the backscatter values are necessary for inter-comparison of radar images acquired with different sensors, or even of images obtained by the same sensor if acquired in different modes or processed with different processors.

Due to the completely different geometric properties of SAR imagery in range and azimuth direction, across- and along-track directions have to be considered separately to fully understand the acquisition geometry of SAR systems. According to its definition, SAR images are characterized by large distortions in range direction. They are mainly caused by topographic variations and they can be relatively easily corrected. The distortions in azimuth are much smaller but more complex.

Note: The Flooding Classification tool perform a compatibility check on the input images based the following requirements:

- Images must have same acquisition geometry (orbital path, direction, etc.).

- Images must have same polarization.

- Images must be calibrated.

- Images must overlap by at least 60%.

Radiometric Calibration

Radars measure the ratio between the power of the transmitted pulse and the power of the received echoes. This ratio is called backscatter. The calibration of the backscatter values is necessary to compare radar data acquired with different sensors, in different acquisition modes, at different times, or generated by different processors.

Radiometric Normalization

Even after a rigorous radiometric calibration, backscattering coefficient variations are clearly identifiable in range direction and in presence of topography. Note that these variations are an intrinsic property of each imaged object, and thus might be compensated, but it may not be corrected in absolute terms. The used method is named Cosine Correction:

Input Files

Input File List
Input file name(s) of all data to be geocoded. Intensity, amplitude as well as any other data type (coherence, interferogram, etc.) in slant or ground range geometry can be used. This file list is mandatory.

Optional Files

Geometry GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP file) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP file, refer to the "Tools>Generate Ground Control Point" for details). This file is optional.

DEM/Cartographic System

Click on the binocular icon to download the DEM; select the box of the ALOS World 3D 30m DEM.

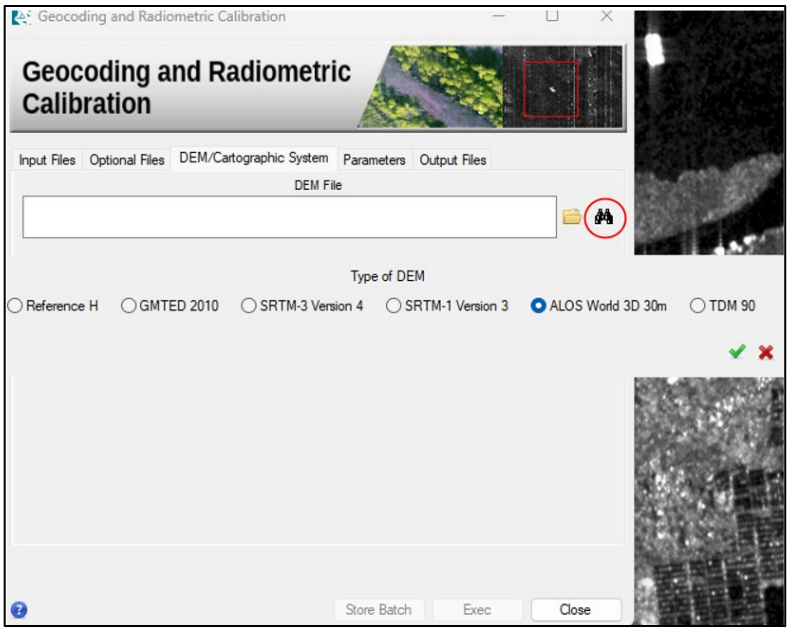

Figure 8 ALOS World 3D 30 m DEM Download.

Note: Downloading the ALOS World 3D DEM requires a user account. The relevant credentials must be entered in the **"Parameters"** tab of the DEM Download panel. A new account can be created on the JAXA website: https://www.eorc.jaxa.jp/ALOS/en/aw3d30/registration.htm.

Digital Elevation Model file

Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered.

Output Projection

In case that the Digital Elevation Model is not used, it is mandatory to define the Cartographic System.
To use the same coordinate system as another dataset, click the Import from Existing Dataset button and select the source dataset. To apply the same Coordinate System of the current selected layer. The reset icon allows to reset the coordinate system field.

Parameters - Principal Parameters

X Grid Size

The Easting (X) grid size of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Grid Size

The Northing (Y) grid size of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Radiometric Calibration

By setting true this parameter radiometric calibration is performed.

Scattering Area

It can be determined using two different methods:

➢Local incidence angle - this is the fastest approach in terms of processing time, but it is not the most accurate way to calibrate the data in presence of topography.
➢True area - it requires more computing resources, but it is the most accurate approach to calibrate the data in presence of topography. It makes sense to apply this method when a good (in terms of quality and spatial resolution) Digital Elevation Model is available.

Radiometric Normalization
By setting this flag radiometric normalization is performed.

Normalization Method
It can be determined using two different methods:

➢Cosine correction - backscatter coefficient variations are compensated only in range direction.
➢Semi-empirical correction - the backscatter coefficient variations are compensated by considering both the range position and the dependency on the topographic conditions.

Local Incidence Angle
By setting this flag the map of the local incidence angle – in degree – is generated.

Output type

Select Linear and dB.
By setting this flag the output type can be selected: calibrated products, dB units or both (default setting is linear units only).

Output Files

The output folder contains the following products:

Output file list
Output file name(s) of all geocoded file(s). The number of output files must be equal to the number of input files. This file list is mandatory.

_geo
Geocoded Intensity/Power image and associated header files (.sml, .hdr). In case that radiometric calibration is selected, the output will contain geocoded backscattering coefficient values.

_geo_dB
Calibrated product in dB units and corresponding header file (.sml, .hdr). This file is generated only if the "Additional output dB" flag is selected.

_geo_lia
Geocoded Local Incidence Angle Map and corresponding header file (.sml, .hdr). This file is generated only if the "Local Incidence Angle" flag is selected.

_meta
It allows to load the geocoded outputs as a single file.

Please Note: the annotations of the geocoded files are displayed in ENVI View according to Preferences Common.

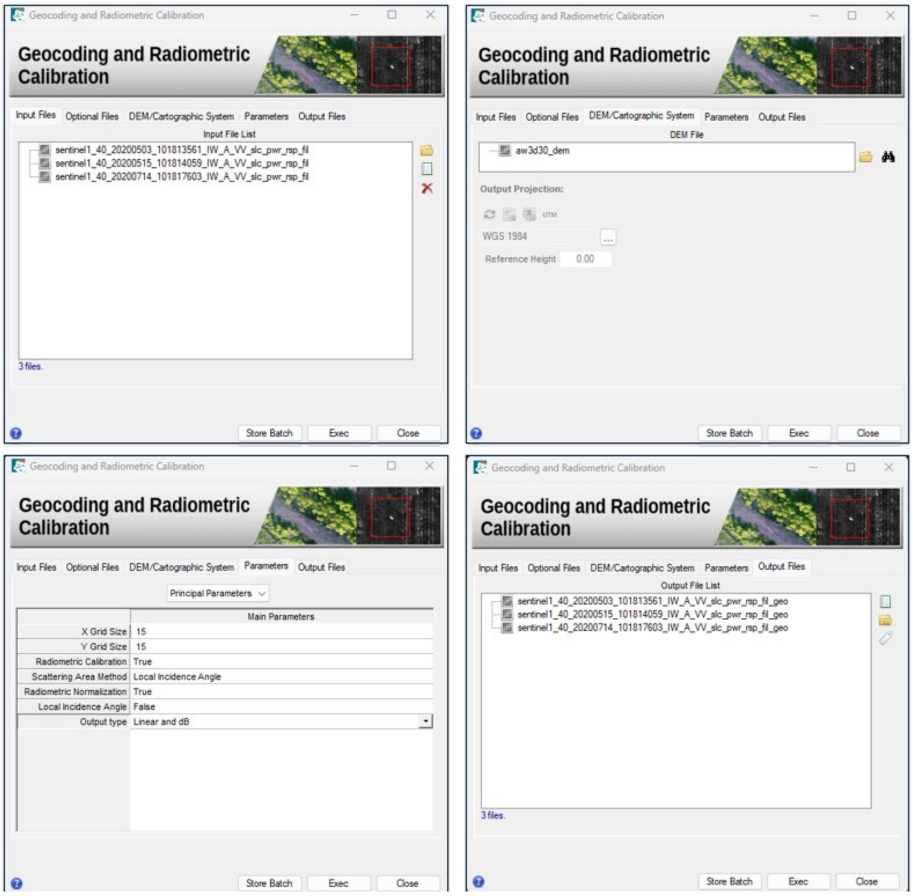

Figure 9 Geocoding panels and input files.

Figure 10 shows the output files of the Geocoding and Radiometric calibration tool. The layer visible is the geo_meta file that contains the three geocoded files ordered by that and assigned to the three RGB bands:

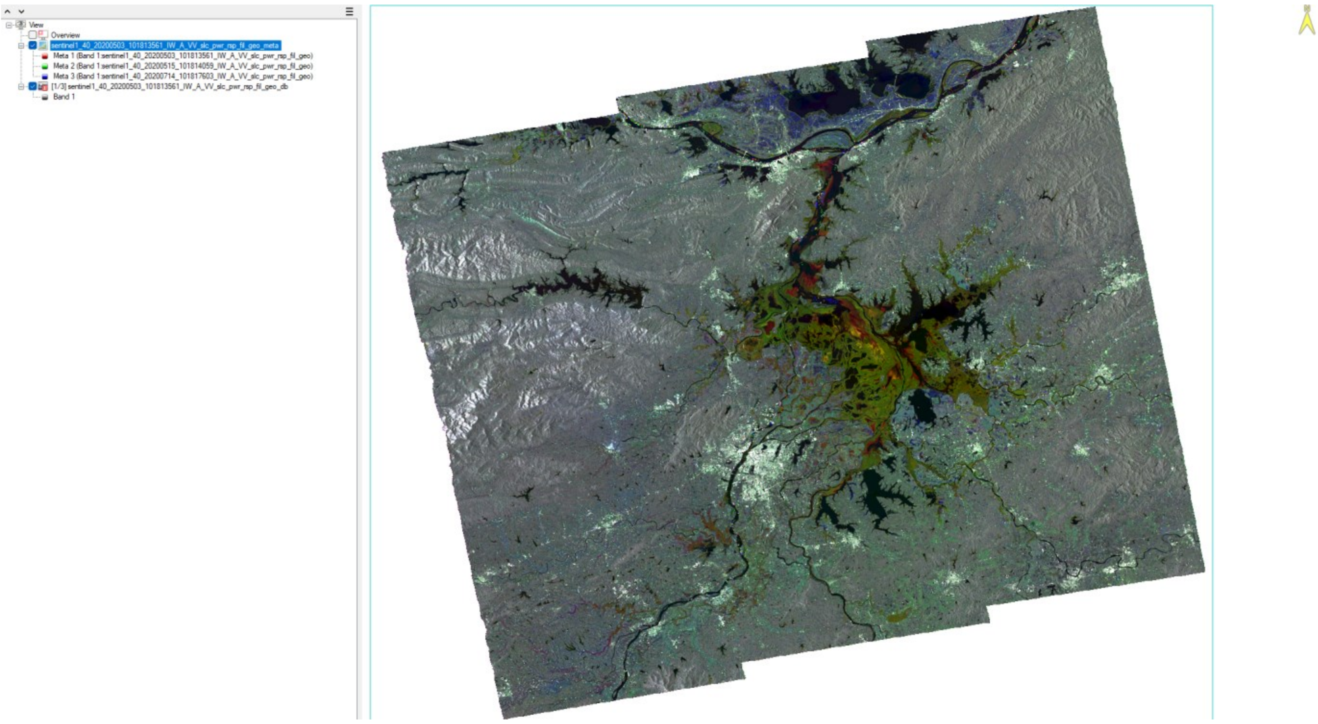

Figure 10 Geocoding and Radiometric calibration output files

10. Conversion DEM to Slope and Aspect

A slope layer is required to out possible false positives from areas characterized by high slope values that are unlikely to be affected by flooding.

Starting from an input Digital Elevation Model (in SARscape format), two different outputs are generated:

- The slope (in degrees) along the Easting and Northing direction
- The Aspect, a layer that identifies the downslope direction of the maximum rate of change in value from each cell to its neighbors.

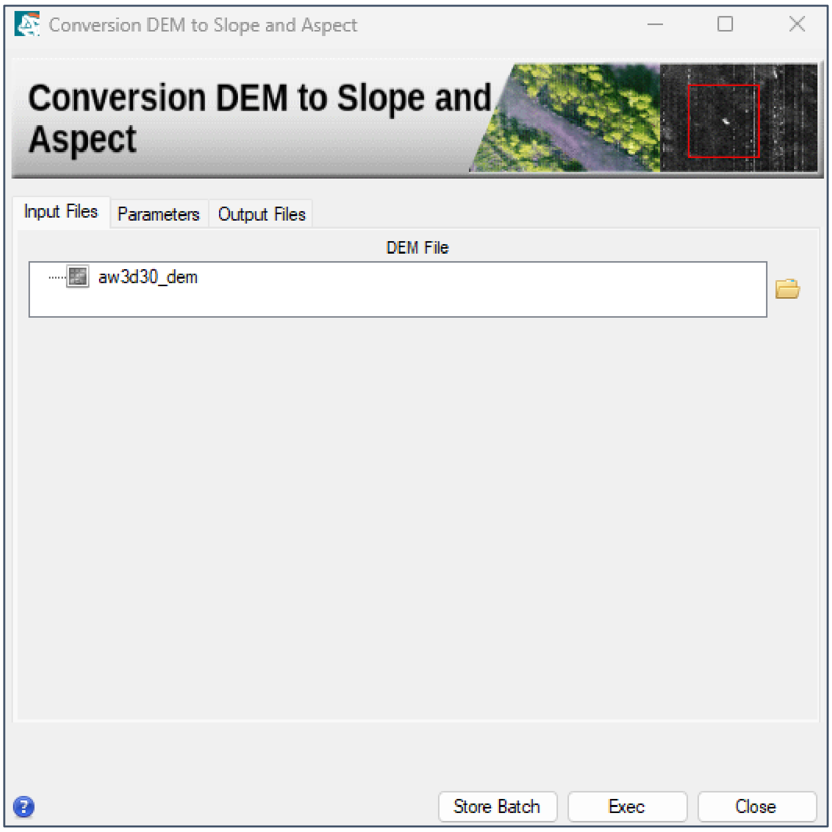

Figure 11 Conversion DEM to Slope panel.

Input Files

DEM File
Insert the ALOS World 3D 30m DEM previously downloaded.

Input Digital elevation Model (_dem). This file is mandatory.

Parameters - Principal Parameters

Window Size
Size of the window used to compute the Slope and aspect layer. Larger window are used with high resolution DEM to get a SLope/Aspect layer.

Output Files

Output file
Output file name of the slope image. This file is mandatory.

The following file are generated:

_aspect
Aspect layer which identifies the downslope direction of the maximum rate of change in value from each cell to its neighbors. The values of each cell in the output raster indicate the compass direction of the surface faces at that location. It is measured clockwise in degrees from 0 (due north) to 360 (again due north), coming full circle. Flat areas having no downslope direction are given a value of -1.

_meta
A meta (_meta) file is generated to load at once all relevant output products.

_W2E_slope
Easting direction slope image and associated header files (.sml, .hdr).

_S2N_slope
Northing direction slope image and associated header files (.sml, .hdr).

_slope
Combined slope image and associated header files (.sml, .hdr).

Figure 12 shows the slope layer generated by the Conversion DEM to Slope and Aspect tool, darker color correspond to high slope value, while yellowish pixels indicates low slope value areas:

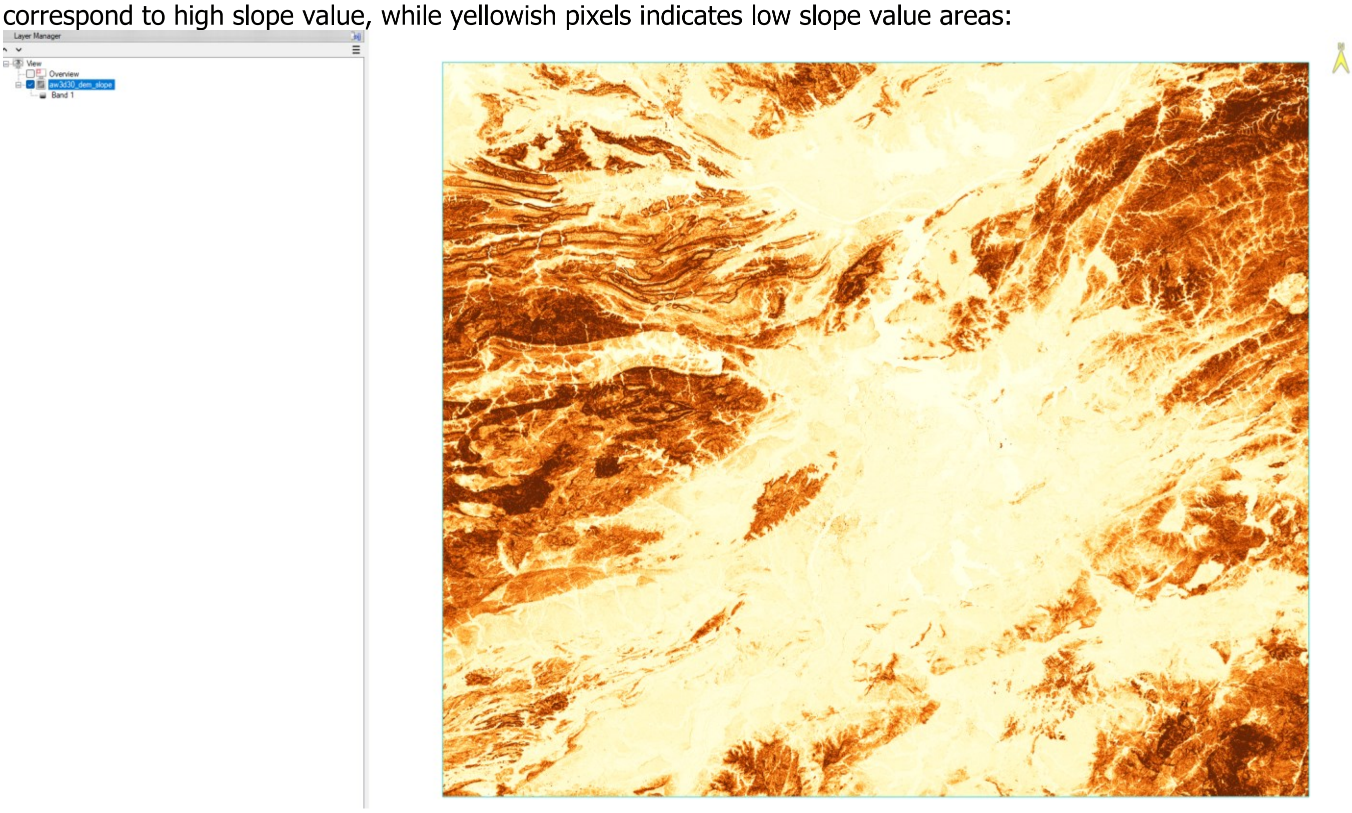

Figure 12 Slope layer generated by the Conversion DEM to Slope and Aspect tool.

11. Flooding Classification

This tool creates a classification raster that highlights flooded and permanent water areas.

Here below the requirements regarding the input images:

- The images **must** be coregistered since the analysis is performed pixel by pixel
- The images **must** be geocoded.

Notes:

- The usage of a DEM and Slope files will increase the accuracy of the result.
- To increase the accuracy of the result it is suggested using multiple pre-event images.

Input Files

Post Event File
Input file name of the coregistered and geocoded post-event image. This file is mandatory.

Pre Event File List
Input file name of the coregistered and geocoded pre-event images. At least one image is required.

Optional Files

DEM Files
Digital Elevation Model file name. This should be referred to the ellipsoid. In case a list of input files is entered, the DEM must cover the whole imaged area.

Slope File
Slope file name.

Principal Parameters

Water Threshold (dB)
This is the minimum dB value that will be used to detect the presence of water, all the pixels under this value will be considered.
In case of stable water area between the pre-event image and the post event image, the area will be classified as Persistent Water Area.
This parameter is band dependent and it is automatically set from the Flooding Menu inside Preferences Common.

DEM Threshold (m)
This is the minimum m value that will be used to remove the presence of Stable Water or Flood, all the pixels over this value will be considered.

Slope Threshold (deg)
This is the minimum deg value that will be used to remove the presence of Stable Water or Flood, all the pixels over this value will be considered.

Ratio Threshold
This is the minimum ratio value between pre-event and post-event image, that will be used to detect the presence of a flooded area. All the pixels over this value will be considered.
In case of the presence of water in the area and a sufficient ratio value, the area will be classified as Flooded Area.

This parameter is band dependant and it is automatically set from the Flooding Menu inside Preferences Common.

High Scattering Point (dB)
This is the backscatter value expressed in decibels relevant to high reflectivity targets, such as ships. This parameter helps avoiding the identification of false positive.

Note: The side lobes effect may cause the identification of false positive areas surrounding high reflectivity targets.

Output Files

_class
Classified raster file of the flooded areas.

_postEvent
Mean amplitude image of the post-event image.

_preEvent
Mean amplitude image based on the list of pre-event images.

_ratio
Geocoded ratio (expressed in dB) between the post-event backscatter value and the pre-events backscatter value.

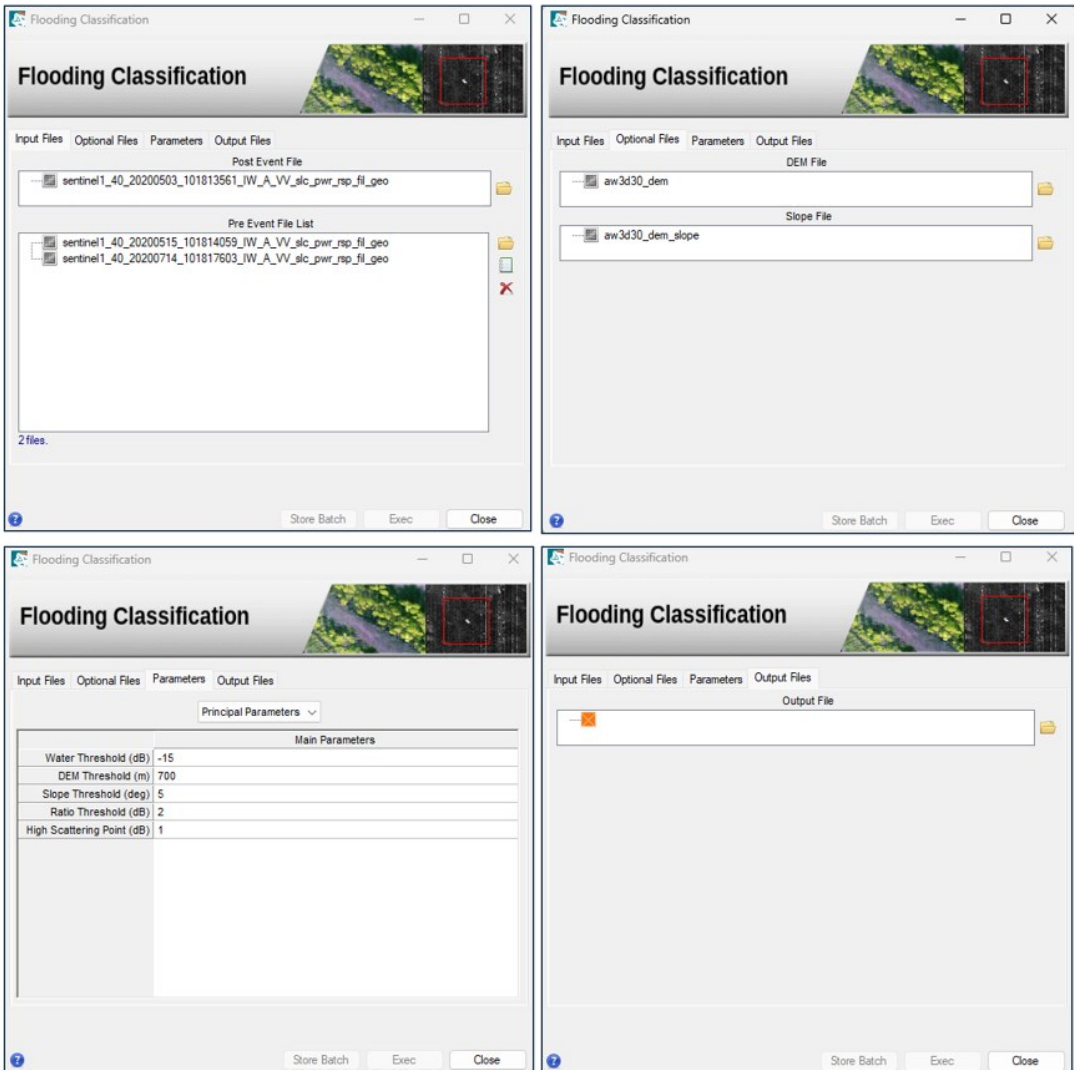

Figure 13 Flooding Classification panels and input files.

Figure 14 shows the classified raster file, red pixels represents flooded areas while blue pixels represents persistent water. Green pixels are classified as Non-Event Areas and yellow pixels are classified as High Scattering Points.

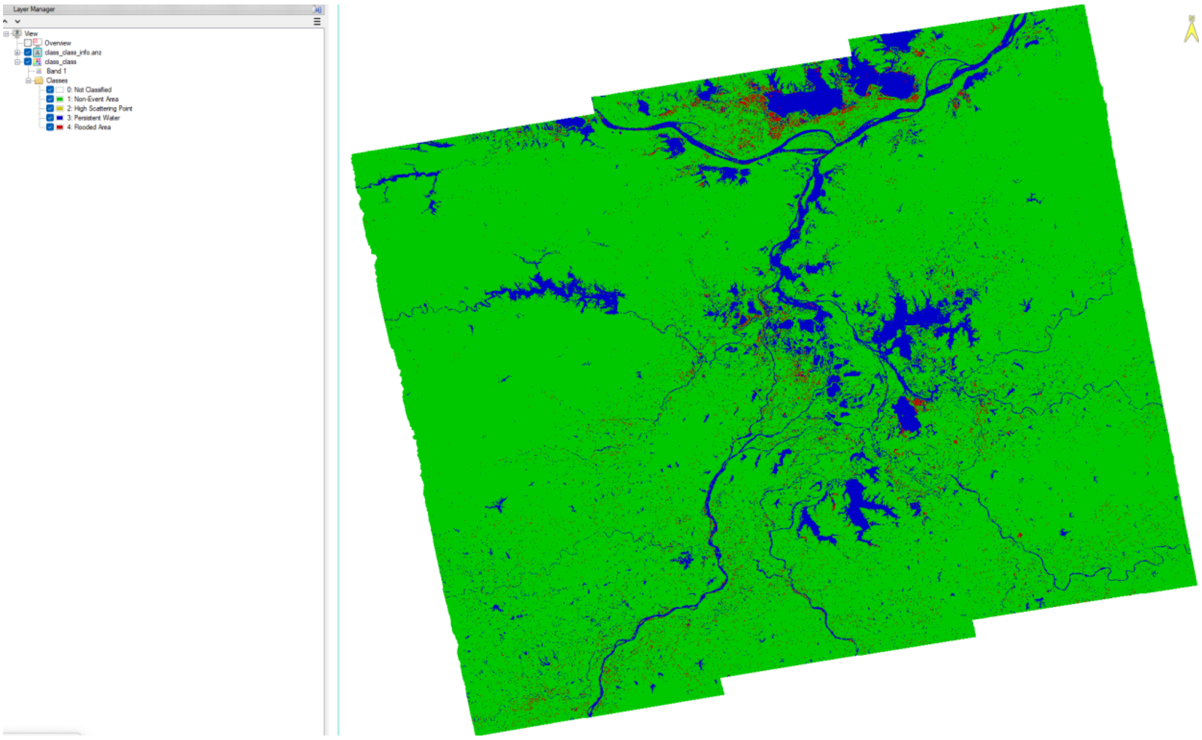

Figure 14 Classified raster file.

Note: Ecco una versione corretta e più fluida della frase:

False positive classified pixels can be observed near the ships floating on the river, caused by the side lobes generated by such high reflective object (see Figure 15). This occurs because the bright side lobe pixels are present in the pre-event image but not in the post-event image, as the ships moved from their original positions.

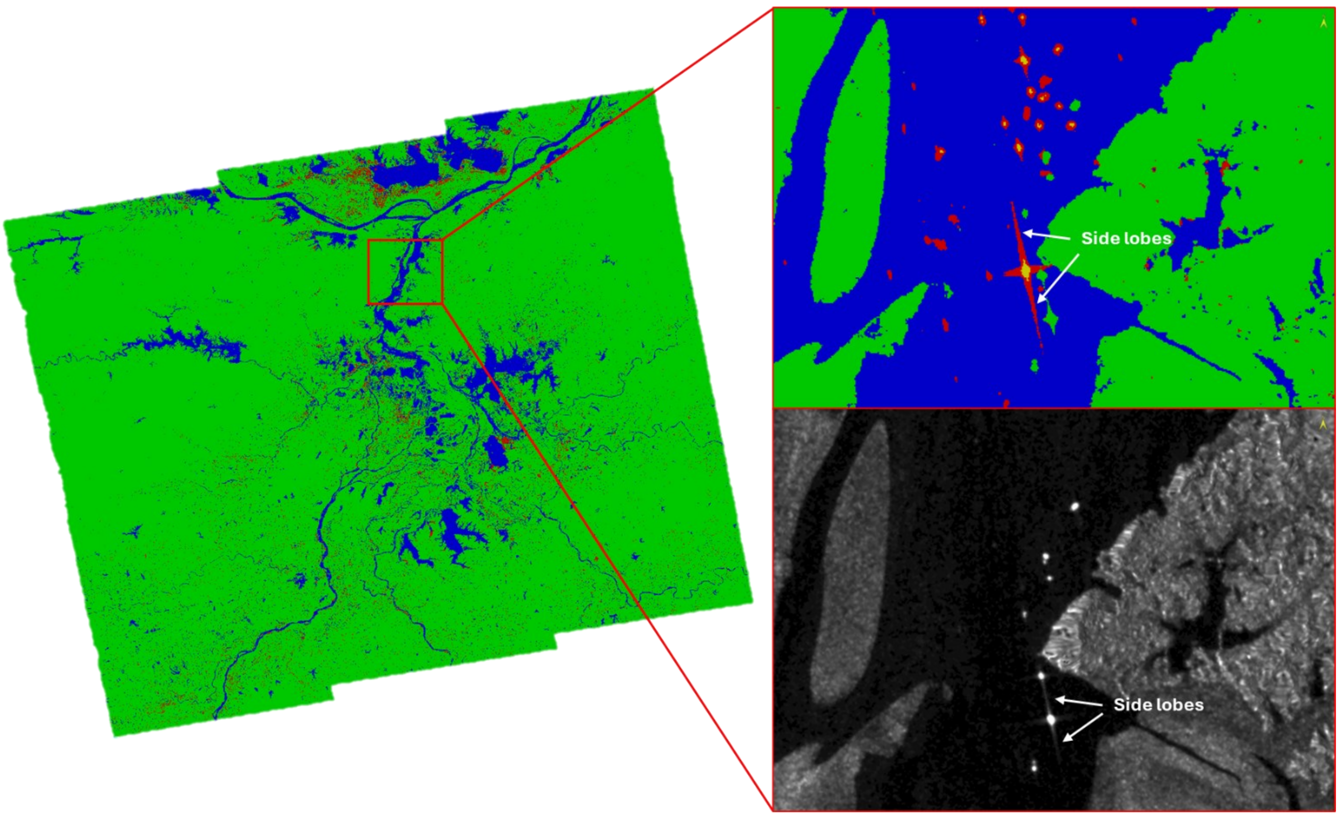

Figure 15 Ships with the relevant side lobes effect mapped as flooded area.

12. Flooding Classification Refinement

This tool generates a flood probability raster map, indicating the probability for each class for every pixel within the Area of Interest (AOI).

Notes:

•The usage of a DEM and Slope files will increase the accuracy of the result.

•To increase the accuracy of the result it is suggested using multiple pre-event images.

The tool required approximately 22 hours to generate the output. For future use cases, it is strongly recommended to run the tool on a smaller area to minimize computation time.

Input Files

Classified File
Load the classified file (_class) generated in the previous step. The remaining fields will be automatically populated by SARscape.

The Classified raster file generated by Flood Classification tool. This file is mandatory.

Post Event File
Input file name of the coregistered and geocoded post-event image generated by the *Flooding Classification* tool. This file is mandatory.

Pre Event File
Input file name of the coregistered and geocoded pre-event images generated by the *Flooding Classification* tool. At least one image is required.

Ratio File

The geocoded ratio raster file generated by Flood Classification tool. This file has the suffix "_ratio". This file is mandatory.

Optional Files

DEM Files

Digital Elevation Model file name. This should be referred to the ellipsoid. In case a list of input files is entered, the DEM must cover the whole imaged area.

Slope File

Slope file name.

Principal Parameters

Water Threshold (dB)
This is the minimum dB value that will be used to detect the presence of water, all the pixels under this value will be considered.

In case of stable water area between the pre-event image and the post event image, the area will be classified as Persistent Water Area.

This parameter is band dependent and it is automatically set from the Flooding Menu inside Preferences Common.

Slope Threshold (deg)
This is the minimum deg value that will be used to remove the presence of Stable Water or Flood, all the pixels over this value will be considered.

Water Probability Threshold
This is the percentage threshold related to the probability of water presence to consider when determining the presence of water in the AOI.

Flood Low Probability Threshold
This is the percentage threshold related to the low probability of flooded areas being present in the AOI.

Flood Mid Probability Threshold

This is the percentage threshold related to the Mid probability of flooded areas being present in the AOI.

Flood High Probability Threshold
This is the percentage threshold related to the High probability of flooded areas being present in the AOI.

Parameters - Other Parameters

Fuzzy Coefficient Persistent Water
This is the coefficient that controls the degree of fuzziness of the Persistent Water cluster. Higher values of this coefficient make the clusters fuzzier. When the value is equal to 1, the clustering is crisp, like in k-means, with each data point belonging to a single cluster. When the coefficient is > 1, the clusters become fuzzier, allowing data points to belong to multiple clusters with varying degrees of membership.

MRF Kernel Size Persistent Water
This is the dimension of the Markov Kernel window size used to account for the dependence of the persistent water pixel probability with respect to the nearest ones.

MRF Spatial Penalty Coefficient Persistent Water
This is the penalty coefficient of the Markov Kernel size used to weight the dependence of the persistent water pixel probability with respect to the nearest ones.

Iteration Threshold Persistent Water
This is the threshold of the intensity centroid variation that defines the convergence criterion.

Iteration Max Persistent Water
This is the maximum number of iteration of the convergence cycle.

Fuzzy Coefficient Flood
This is the coefficient that controls the degree of fuzziness of the Flood cluster. Higher values of this coefficient make the clusters fuzzier. When the value is equal to 1, the clustering is crisp, like in k-means, with each data point belonging to a single cluster. When the coefficient is > 1, the clusters become fuzzier, allowing data points to belong to multiple clusters with varying degrees of membership.

MRF Kernel Size Flood
This is the dimension of the Markov Kernel window size used to account for the dependence of the Flood pixel probability with respect to the nearest ones.

MRF Spatial Penalty Coefficient Flood

This is the penalty coefficient of the Markov Kernel size used to weight the dependence of the Flood pixel probability with respect to the nearest ones.

Iteration Threshold Flood

This is the penalty coefficient of the Markov Kernel size used to weight the dependence of the Flood pixel probability with respect to the nearest ones.

Iteration Max Flood

This is the maximum number of iteration of the convergence cycle.

Output Files

_refinement_class

Classified raster file that provides the probability of a certain pixel to be included in the ''Flooded Area'' class.

_refinement

Raster file providing the flooding probability value, higher is the value higher is the probability of the pixel to be flooded.

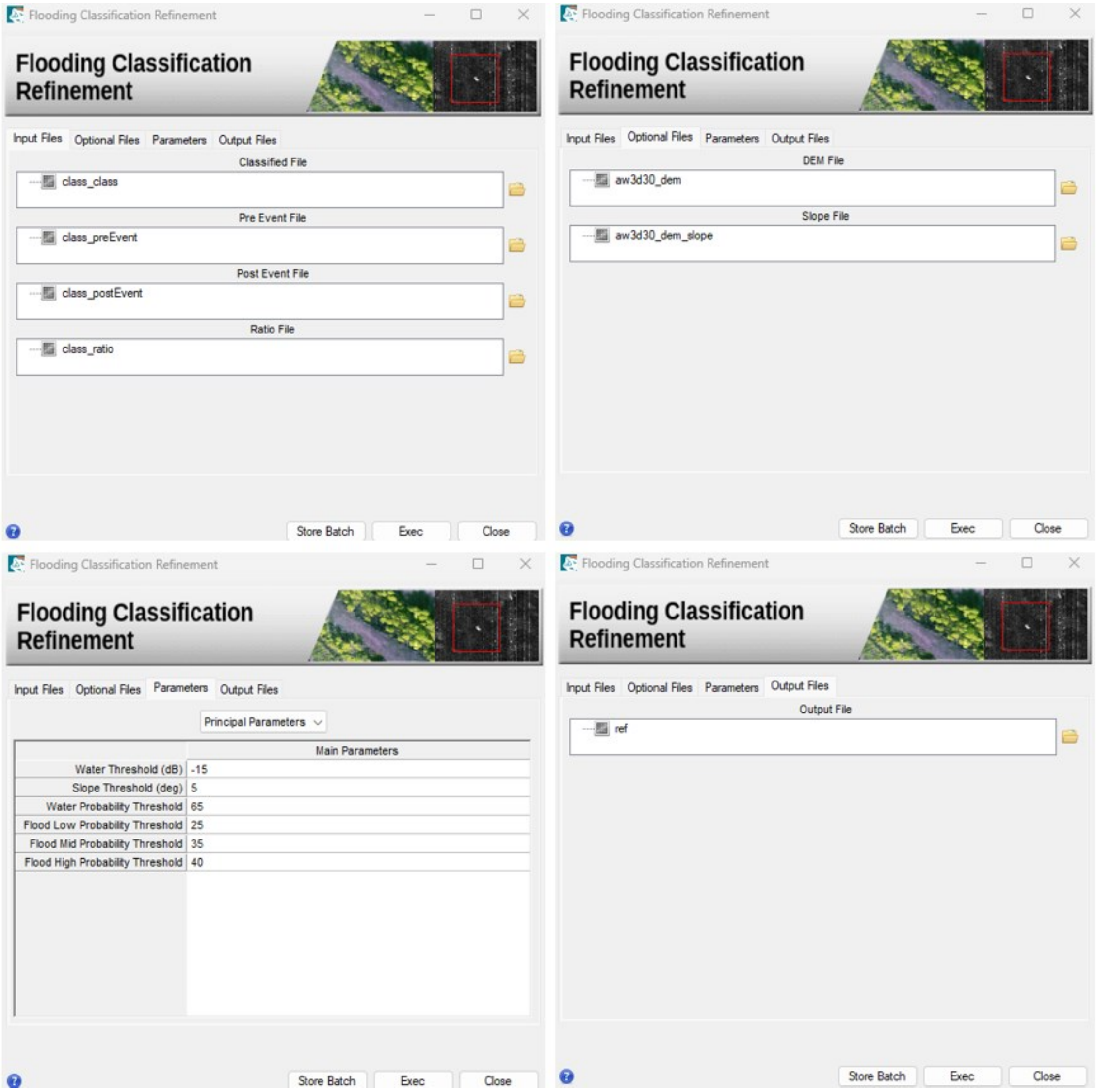

Figure 16 Panels and input file of the Flooding Classification Refinement tool.

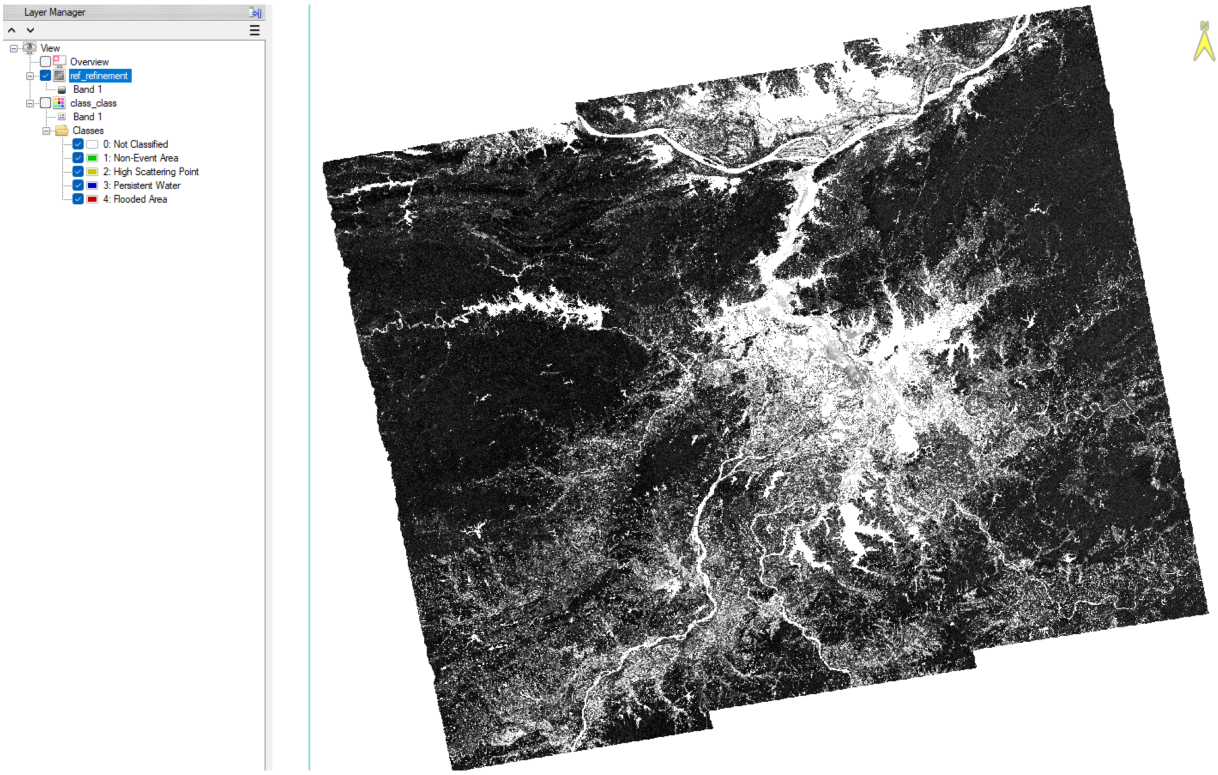

Figure 17 Refinement output raster file.

Right-click on the Refinement output file to apply a different color table, allowing for better interpretation of the output, as shown in Figure 18:

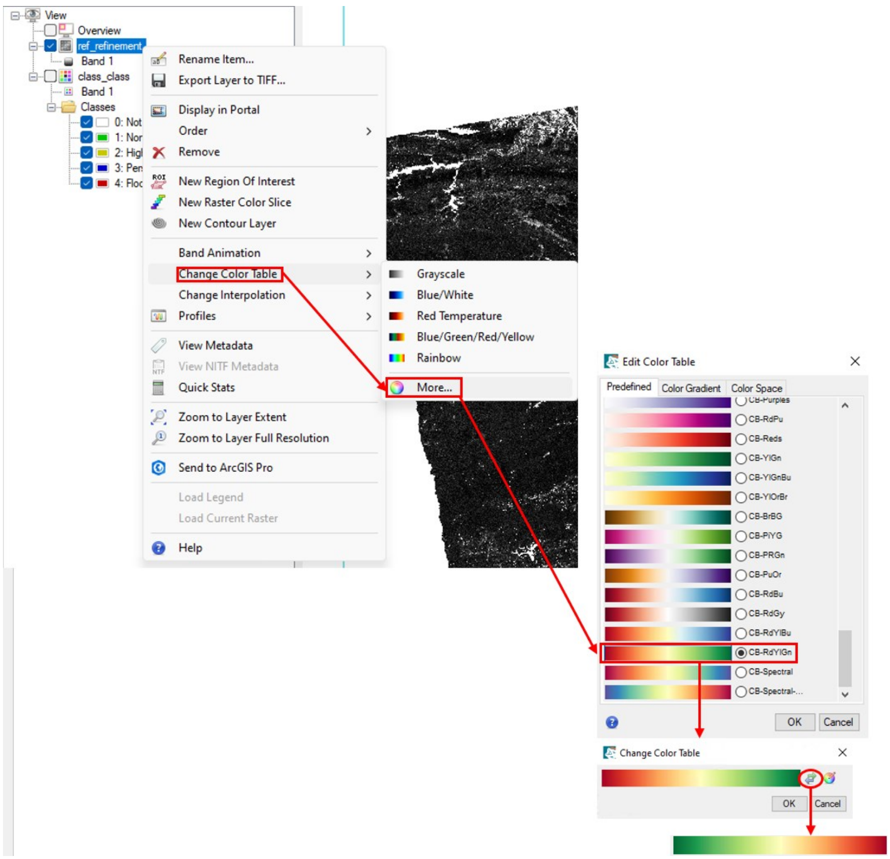

Figure 18 Change Color Table procedure.

Pixels in red (high values) represent areas where the probability of flooding is higher, while green pixels (low values) indicate areas with a lower probability of flooding (Figure 19). The permanent water pixels are discarded from the refinement result.

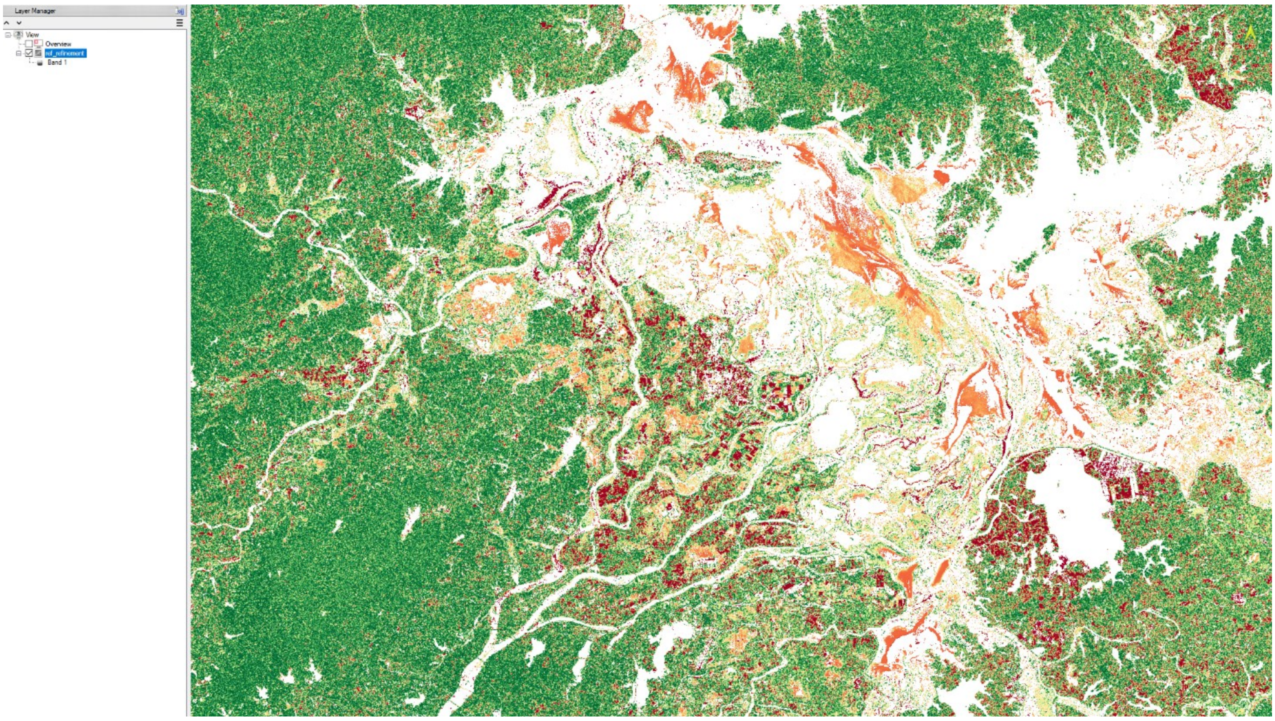

Figure 20 Refinement output file after the application of the Color Table.

The image represented in Figure 21 corresponds to the <u>classified</u> refinement output file where the cells in red correspond to the class ''high probability'' of flooded areas.

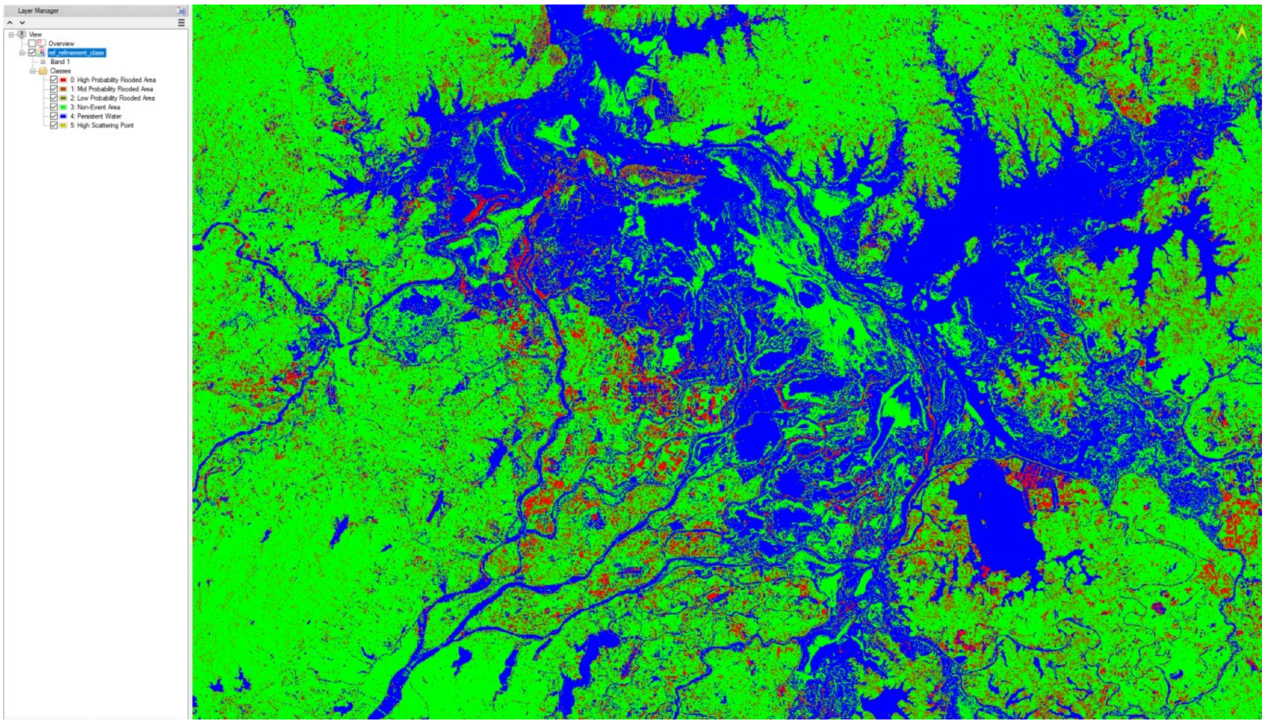

Figure 21 Classified refinement output.

13. Flooding Classification Workflow

The operations described in the previous paragraphs can be executed in a single iteration through the Flooding Classification Workflow tool (Basic/Flooding Classification Workflow).

This functionality enables to execute, in a single iteration, the following processing sequence:

- Import Generic SAR Data
- Multilooking
- Coregistration
- Single Image Filtering
- Geocoding and Radiometric Calibration
- Conversion DEM to Slope and Aspect
- Flooding Classification
- Flooding Classification Refinement

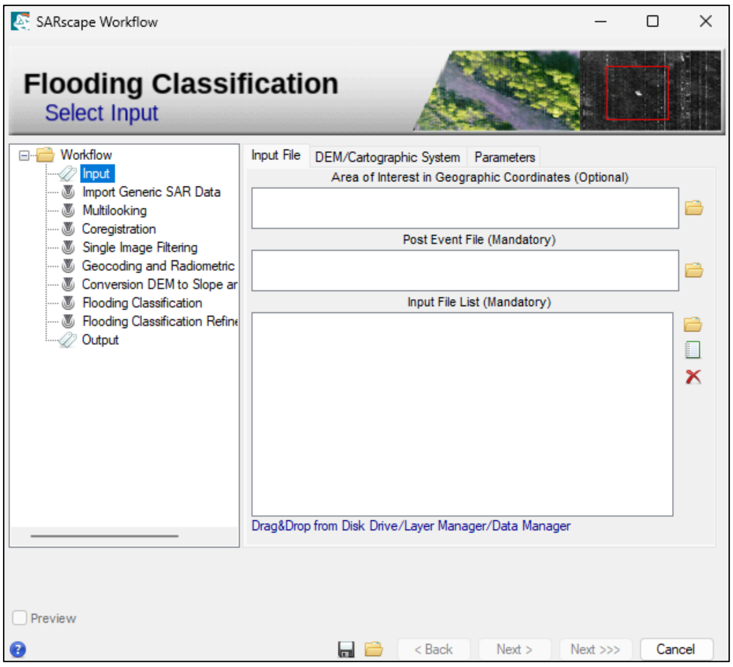

Figure 22 Flooding classification workflow panel.